ABB review

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The corporate technical journal

Food & beverage

Food and beverages form a fundamental part of our lives and lifestyle – although they are so important to us, we rarely reflect on where they come from or on the complex and intricate technologies that make their industrial manufacture possible. This issue of ABB Review sets out to shed light on this broad and fascinating topic and highlight ABB's contribution.

The front cover shows olive oil being bottled. The inside cover shows a conveyor spiral at Poole's Pies of Wigan, United Kingdom – a spiral powered by an ABB drive.

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How we serve the food and beverage segment

Bazmi Husain

Dear Reader,

Food and beverage is not only a large and fast-growing industry, it typically continues its growth trajectory even when other industries are in a downturn. We experience the industry's products several times a day, and expect industry to meet very high standards in terms of food safety and traceability of ingredients. At the same time, manufacturers are constantly under pressure to optimize productivity, without sacrificing the quality of the final product. The current issue of ABB Review presents some of the technologies that help make this possible.

ABB is already an established participant in this industry on multiple fronts. At one end of the spectrum, we supply many important discrete components associated with food storage, handling and preparation. These components are designed to be reliable and efficient, and also to meet rigorous hygiene and other requirements associated with the food and beverage industry.

At the other end of the spectrum, we offer a number of overarching control and enterprise management systems, which serve to optimize production processes and plant operations. These systems contribute to the emerging Internet of Things, Services and People, and enable our customers to participate more fully in the ongoing digital transformation of industry as a whole. In addition to these products, ABB offers a range of supporting services, such as in the field of remote monitoring, which can help customers plan their maintenance schedules.

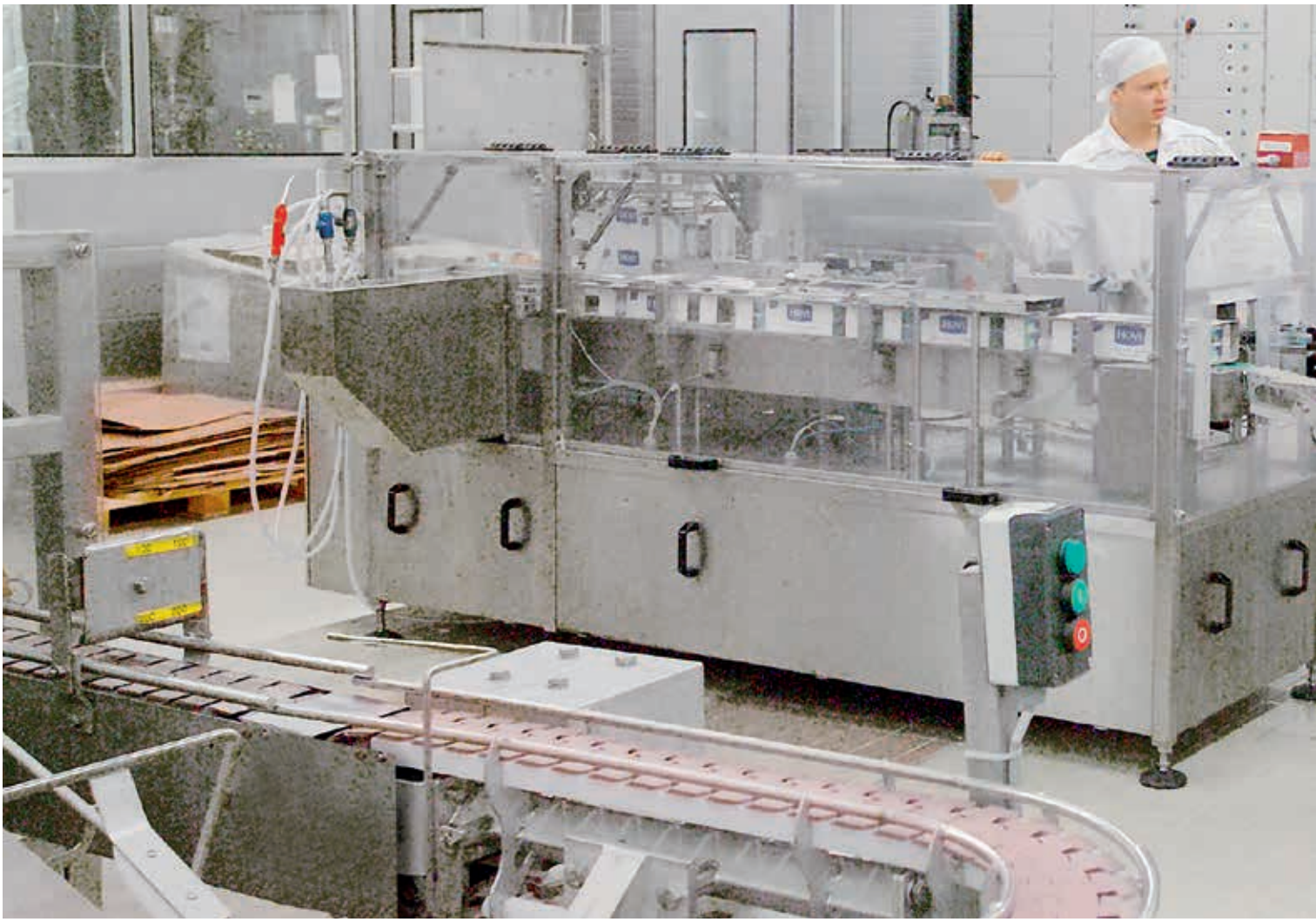
Of course, many of the product lines in question also have applications that extend far beyond the food and beverage segment, reflecting broader trends in industry and developments that touch on multiple sectors.

Several features in this issue delve into other important topics connected with ABB's longtime role as a pioneering technology leader. It is 125 years since the founding of BBC, one of ABB's predecessor companies, and while ABB Review's third issue of the year will cover this milestone in more detail, we have included a brief section in the present issue as a preview of what is coming.

Other areas covered include the integration of IT and OT and a look at where matters stand in the ongoing search for a new insulating gas for use in electrical switchgear. We also conclude our four-part series on oscillations with a look at techniques employed to avoid resonance in low-voltage converters.

I am confident that this issue of ABB Review will whet your appetite for a deeper understanding of the food and beverage industry, among other interesting subjects, and I hope you enjoy reading it.

Bazmi Husain
Chief Technology Officer
ABB Group



A healthy choice

ABB's close relationship with the food and beverage industry is getting closer

TATJANA MILENOVIC – For many years, ABB has been involved with the food and beverage industry. Much development effort and collaboration has gone into products and services that help the industry become safer and more efficient. Now, as announced in its Next Level strategy, ABB is placing a special focus on this sector to intensify the relationship and support its customers in achieving their sustainability, operational and financial targets, embrace digitalization and benefit daily from predictive, condition-based maintenance with reliability in focus.

ABB's offering supports food and beverage companies to use resources and assets more efficiently, reduce waste and improve final product quality.

In late 2014, ABB presented its Next Level strategy and financial targets for the 2015 – 2020 period. These are aimed at accelerating sustainable value creation. The strategy calls for the company to drive profitable growth by shifting its center of gravity toward high-growth end markets, enhancing competitiveness and lowering risk in business models. The strategy puts a special focus on the food and beverage industry.

Sustainability and social responsibility

Optimized use of scarce resources like energy and water, together with waste reduction and utilization of renewable energy sources is tightly linked to food companies' performance. From proven and established power technologies and renewables to innovative microgrids solutions, automation and Internet of Things, Services and People, ABB customers enjoy holistic approach to sustainable production.

ABB's products and solutions

ABB's offering for the food and beverage industry control the machines, control the process in which the machines find themselves and make the machines safe for people to work with → 1. ABB supports its customers so they can prevent "out of stock" situations, have reliable power and run uninterrupted critical processes. Furthermore, ABB enables its customers to implement full tracking and traceability of products and processes, improve productivity and reduce operational cost.

Food safety and efficient asset utilization is particularly important.

Food safety

Food safety is particularly important and ABB offers solutions that support production of safe food – from products that have specially welded seams and surfaces that allow water to drip off and prevent food from sneaking into tiny crevices, to products that can be detected by metal or vision scanning systems. This means that if a cable tie breaks and drops onto a food conveyor, it will be found and the food will be disposed of before it is packaged. This is not only the most cost-effective course of action but is also far preferable to the cable tie ending up on the consumer's fork, with the associated reputational damage for the company.

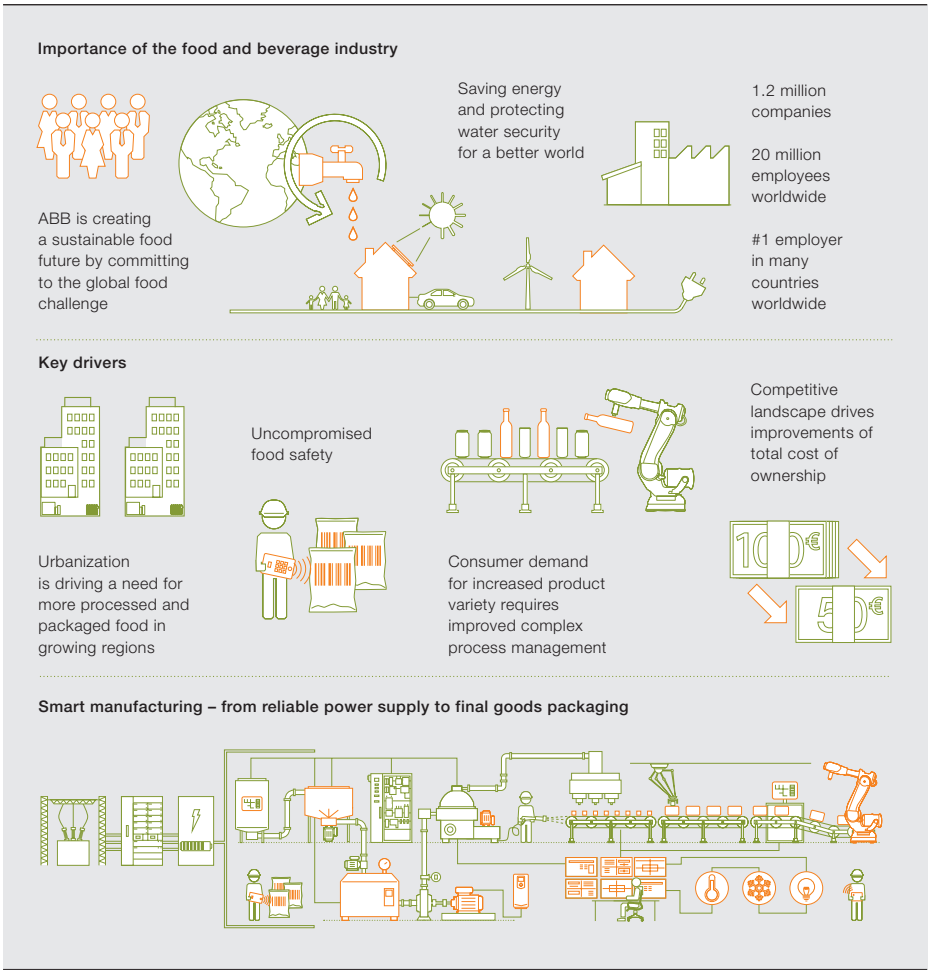
Efficient use of resources

ABB's offering enables manufacturers to use their raw ingredients more precisely, reduce waste and improve the quality of

Title picture
ABB, already deeply involved with the food and beverage sector, is set to intensify the relationship as part of its Next Level strategy.

ABB offers a holistic approach and innovative technologies for a sustainable food future.

1 The importance of the food and beverage industry to ABB



the overall processes and products. From variable-speed drives that control a flow wrapper to instruments that measure incoming raw milk more accurately to save the dairy money, and from robots that stack and palletize final products more efficiently to a mixer operator's onscreen instructions that check the dosed ingredient against the recipe to make sure the correct ingredient and correct amount are added at the correct time, ABB continuously addresses industry challenges.

Focusing people on productive, value-added tasks

Automation can take the repetition out of tedious jobs like sorting, picking and packing. Robotic automation solutions relieve the operator of the stress that comes from staring at a conveyor belt and picking product, hour after hour, day after day – stress that can result in either poor sorting, and thus lower-quality product being shipped, or safety risks. Robots will sort all day without complaint. They can work next to hot ovens or cold freezers without needing gloves. They can even work with the lights off, saving more energy. Robotic picking helps improve open food safety.

ABB also makes running the plant easier for the maintenance teams, with service options that are adapted to the customer's specific maintenance needs, from keeping spare parts on hand to advanced condition-based and remote monitoring, preventive and predictive maintenance solutions.

A global network with experience

In short, ABB supports improved food safety, more efficient use of production assets and improved product quality. With many years' experience in the sector, the company has accumulated a wealth of process knowledge that food producers, machine builders and process line integrators can benefit from.

ABB's global supply network makes it easy to obtain products and a global service network provides a safety net to keep production up and running, and, more importantly, help prevent unexpected downtime in the first place.

The world has a constantly growing and rapidly urbanizing population that is creating an ever-increasing demand for more, and a wider variety of, food and drink products. This demand is driving greater complexity in the production process, where ABB offers innovative solutions from process control, interoperability to simulations and virtual models for testing set-ups and performance before actual investment is made.

Further, global food safety regulations continue to improve. Meeting new, stricter mandatory regulations often means that processes, production lines and even ingredient traceability systems need to be futureproof or, at least, anticipate what the future may bring – another area where ABB's offering makes an impact and support food companies in meeting evolving challenges. After all, everyone has an interest in making sure that the only surprise in a box of cereal is the free gift.

With its special focus on the food and beverage industry, ABB continues to serve industry and work together with food and beverage producers towards sustainable food future with power and productivity solutions for a better world.

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When bytes meet bites

What the Internet of Things, Services and People means for the food and beverage industry

DOMINIQUE STUCKI – What do food and beverage plants produce in large quantities – besides food and beverage of course? The answer is digital data. With virtually every device today having some level of digitalization, there is electronic data literally everywhere. Collecting and analyzing it can unlock information about every aspect of the process as well as of the condition and performance of the equipment. However, in many cases much of this data remains on the factory floor, marooned in so-called “islands of information”. But all this is changing.

1 A modern food or beverage factory represents a complex choreography of different interconnected processes.

The food and beverage industry is facing a plethora of challenges. These include the unrelenting drive for greater profitability through better utilization of assets and inventory, the addressing of production bottlenecks as well as the tightening of regulatory demands for greater traceability of products and ingredients. All of these requirements can be met through transparency and access to timely and actionable information.

The degree of automation of a plant may vary from factory to factory, and even between installations within the same site. Disparate systems reflecting different designs, ages and manufacturers present a variety of data protocols. Information is rarely shared automatically, and data gathering, inventory and analysis remains a slow and manual task. Such manual collection of data not only implies delays but also raises concerns over the quality of the data as errors are easily made and difficult to detect.

Sharing knowledge, building predictability

In this digitalized age, virtually every device in a factory relates to form of electronic data. Every sensor, every actuator and every controller is continuously generating, consuming or processing electronic information. But although the devices themselves are more digital than their predecessors, it remains the Achilles heel of process plants that information is often not suitably shared or analyzed. The most important enabler of change in this area is what ABB calls the “Internet of Things, Services and People” (IoTSP).

Just like the conventional Internet, the IoTSP enables communications between disparate devices for a range of different purposes. One important concern in a food and beverage plant is keeping track of inventory and equipment → 1. For example an employee’s misjudgment might lead to the wrong ingredient being added to a mixer, or the right ingredient added in the wrong quantity or at the wrong time, or incompatible ingredients being mixed. Such errors can be avoided if a positive identification of the ingredient is required before it is added, for example by an employee scanning a bar code on the package using a handheld scanner – or even better, by using an intelligent device on the ingredient’s container permitting it to “talk” directly to the mixer.

In this digitalized age, virtually every device in a factory has some form of electronic data.

Title picture
Where does that food item on the supermarket shelf come from? What ingredients and what machines were used in preparing it? These facts can be vital for food safety, especially if a recall is necessary, but they also unlock savings and efficiency for the manufacturer. The Internet of Things, Services and People (IoTSP) is making this possible.

2 Management is supported in its decision making by readily available information.

Incorrect or expired ingredients can be excluded from the process and the exact provenance and history of any ingredient can be instantly traced.

Attempted incorrect actions can lead to an alarm being raised or, better still, to the action being disallowed completely (for example by an access flap refusing to open).

This not only means that incorrect or expired ingredients can be excluded from the process, but also that the exact provenance and history of any ingredient can be instantly traced, making it easier to identify the precise batches and even individual units in case of safety incidents. Without this traceability, far larger quantities would have to be recalled leading to a greater waste of resources and financial damage as well repercussions for a company's reputation.

Besides the ingredients, the status of the equipment itself can be tracked. By maintaining knowledge of when a piece of equipment, for example the mixer mentioned previously, was last washed and keeping track of which ingredients have been mixed in it since, a plant can on the one hand avoid downtime and water use through unnecessary washing while on the other hand ensure there is no risk of contamination. This can include keeping better track of ingredients that may contain allergens and other special ingredients.

Traceability can also be extended to people. If equipment is aware of the identity of the human controlling it, operators can be excluded from equipment they are not qualified to work on. Such a system can also keep track of and remember which employees tended certain equipment or spent time in critical locations. If it is discovered subsequently, for example, that an employee was ill while at work, the ability to identify the areas and process steps where contamination could have occurred can help contain the damage and initiate a focused recall.

Besides safeguarding the quality of food, the IoTSP can also improve safety for employees. If an employee's clothing contains embedded intelligence, this can talk to the IoTSP and verify that the employee is wearing the appropriate protective garments for his or her tasks. For example, certain tasks may require a hard hat while others may require breathing masks. The same method can also be used to ensure that clothes and tools have been cleaned appropriately and not used in a contaminated area or with incompatible ingredients.

Food for thought

With all electronic devices within a plant sharing information in real time, plant management is able to oversee a plant's activities and is able to schedule them more effectively. A few mouse clicks suffice to identify overall equipment effectiveness or reveal the exact quantity and locations of a given ingredient or product within the plant and track even the smallest of delays → 2.

3 Example of a view of part of a factory. Drilling down reveals further data.

Operators can be excluded from equipment they are not qualified to work on.

Such measures do not just add predictability and accountability to the flow of ingredients within the complex choreography of a production plant, but also have significant cost saving potential. A central focus of supply chain management is on keeping down costs by minimizing inventory. Many volumes have been written about “just in time production”, extolling the advantages of minimizing or eliminating stockpiles. Such stockpiles are often held “just in case” at every production step to compensate for the unpredictability of, or insufficient knowledge concerning upstream and downstream activities. In other words, stockpiles are a symptom of insufficient data sharing and lack of synchronization between manufacturing steps. Stockpiles represent capital needlessly tied up, not only in the value of the inventory itself but also of the floor space and supporting facilities required. In the case of food and beverage this is even more pertinent than in many other industries as freezing and cooling rooms often represent the costliest part of a factory.

The implications of the IoTSP can extend far beyond the factory. By sharing data from the production process of an ingredient’s supplier, supply delays can be predicted and activities rescheduled to accommodate them. Similarly, if the trucks delivering ingredients can be tracked, delays can be anticipated. Looking downstream, if distribution centers and supermarkets agree to share their inventory data in real time, a factory can anticipate replenishment orders before they are placed, rather than producing to fill a warehouse.

Broader external data can also be acted on. For example if weather data is taken into account, a sudden increase in ice cream sales can be predicted.

The IoTSP also makes it easier to collect statistics and present and analyze them. Long term trends can thus be observed and outliers or long-term shifts flagged for investigation. With all data available electronically, it is easy to “drill down” and look at individual indicators and data streams and identify the causes of anomalous behavior before too much inventory is lost → 3.

Predictive maintenance

Much of what applies to processes and activities can also be said of the equipment itself. Its condition is often insufficiently understood and degradation and

4 Wander (here showing the company's Caotina brand) uses manufacturing execution systems (MES) from ABB. [Picture source: Wander]

Picture source: Wander

failures are not predicted. Maintenance is thus reactive rather than proactive and unplanned downtime causes costly losses of production.

Much of this can be avoided simply by making better use of data that is already being collected. With its vast experience in the field, ABB can proactively recognize the symptoms of different types of equipment defect and predict failures before they occur. Analysis of a drive's torque data can, for example, reveal the telltale signature of a bearing that is likely to fail soon, or a belt that is encountering too much friction.

Besides harvesting existing "marooned" data, specific additional data can support service and diagnostics. For example, ABB supplies smart devices for motors that capture vibrations and share these for analysis. Data captured is made available to an ABB service center that can warn the customer of necessary maintenance actions long before a failure occurs.

Another example is remote monitoring for ABB robotics installations ensuring reliable operations and improved yield.

Simulation

When changes need to be made to a plant, for example by adding new equipment or including a completely new line, the owner wants to be sure that this will harmonize with the existing equipment as well as wanting to know the exact performance and space required. The owner wishes to perform tests as early as in the design phase as possible to reduce risk and verify anticipated return on investment. Ideally, this should be achieved prior to any investment transaction.

This is where the power of simulation and the virtual world comes into play. Setups can be simulated and equipment tested in a mixed hardware and simulation environment. ABB offers simulation packages. Besides its value in preparing installation, simulation is also a powerful tool for training operators.

Appetite for the IoTSP

With its long experience in automation for process industries, ABB is well placed to provide IoTSP services for the food and beverage industry and help them overcome the challenges of the coming years → 4.

Long-term trends can be observed and outliers or long-term shifts flagged for investigation.

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Mix and MES

An ABB manufacturing execution system raises productivity for DSM Nutritional Products

MATILDA STEINER – It is often said that knowledge is power. For a manufacturer, knowledge is definitely the key to unlocking greater efficiency through asset utilization, traceability and transparency. Unfortunately, that is easier said than done, and a lot of relevant and up-to-date data remains stranded in so-called islands of automation while management must make decisions based on outdated reports or estimates. Manufacturing execution systems (MES) operate at the level between ERP (enterprise resource planning) and SCADA (supervisory control and data acquisition) and provide a real-time overview of equipment and inventory utilization.

DSM Nutritional Products is a major supplier of vitamins and carotenoids (natural colorants) for the cosmetics, pharmaceutical, and food and beverage industries. The company operates a major plant in Village-Neuf in Alsace (France) where vitamins and carotenoids and produced and mixed. The site, which also includes laboratories and research installations, employs around 500 people. About 70 of these work in the domain of premixing vitamins. Premixes are manufactured in direct response to customer orders. There is thus no actual storage of premix on-site.

Shipments must leave the works within a maximum of four weeks following order reception, including the time to deliver the necessary analysis certificates. At the Village-Neuf site, more than 1,000 recipes can be assembled from around 200 raw ingredients. Seven different mixers are available with capacities from 240 up to 8,000 L. The plant's operation requires reliable planning. The traceability of each production step must be assured and logistics must be accurate.

Title picture
ABB's MES system is helping DSM Nutritional Products meet tightening deadlines. In this view the product is being packaged at the company's Village-Neuf plant in France.

Between ERP and SCADA

Until 2013, the premix plant used a tailor-made process-control system, which required a strictly sequential execution of process steps. To improve efficiency and to be prepared for future demands, various MES offerings were evaluated.

Shipments must leave the works within a maximum of four weeks following order reception, including the time to deliver the necessary analysis certificates.

An MES represents the process-control layer located between the business level of the plant with its ERP system and the local process control level with its SCADA system.

DSM Nutritional Products chose ABB from among four competing suppliers and ordered the company's cpmPlus Enterprise Connectivity System (ECS). This system provides standardized interfaces to the customer's ERP system according to the ISA95 standard as supported by SAP for the vertical integration of process automation.

The premix team took the implementation of the new MES as an opportunity to reassess and optimize the implementation of their processes. The new implementation may create the appearance of being "overengineered" with respect to current requirements, but Gilles Nodot, responsible product manager at the premix plant, explains, "This approach facilitates our adaptation to the future tightening of requirements in process safety and traceability."

Huge gains in flexibility

What has changed in terms of the MES? Some steps of the production process can now be performed in parallel. For example, in the past, all raw materials required for a production lot needed to be available on-site at the same time for production to begin. Now weighing and portioning can begin as soon as the first components are unpacked. This massively increases the flexibility of scheduling at the weighing stations, and thus alleviates a bottleneck.

"With the new MES, we now have real-time information about the entire process, which is furthermore more reliable and transparent," explains Nodot. "We know at any time how much of what material is at which process step. This permits a detailed planning process with much reduced demands for storage of raw materials."

While implementing the system, ABB staff worked closely with the Premix employees in order to realize the best implementation.

ABB's delivery includes seven stations for the Extended Automation System 800xA control system in combination with cpmPlus ECS as well as 15 other stations purely for cpmPlus ECS. The MES solution is based on virtualized servers.

"It is difficult to quantify the efficiency gain from the MES, since we have at the same time optimized the processes themselves," Gilles Nodot concludes. "But we believe as a percentage it is in the double digits. Above all, we are extremely pleased with the functioning of the new solution."

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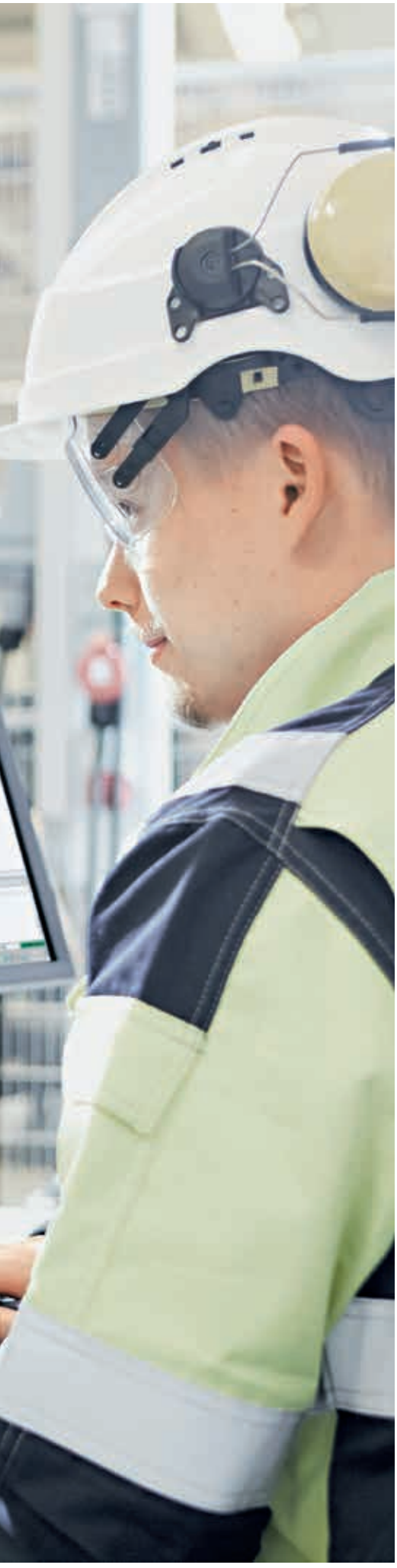

Assembling flavors

Industry 4.0 based on IoTSP enables Automation Builder to rapidly virtualize discrete production processes and machinery in the food industry and beyond

SOENKE KOCK – Headlines are regularly generated by the latest leap forward in factory automation. What is often forgotten is that behind each of these stories lies a tale of complex automation of increasingly elaborate processes. In these processes, an array of engineering tools are employed for programming, configuration and commissioning equipment that is becoming ever more decentralized, independent and intelligent. This equipment often comes from a variety of vendors, which makes data exchange and testing difficult. On top of this comes a high software content – often leading to long development times, high risk and the inability to test at an early stage because the necessary hardware is not ready. The answer to this challenge comes in the form of virtualization. ABB's Automation Builder is a comprehensive, integrated software suite that enables machine builders and system integrators to virtualize and automate complex applications with a minimum of fuss. Automation Builder can be used to great effect not only in the food industry, but in any application requiring nontrivial automation.

Title picture
Automation projects are becoming extremely complex. IIndustry 4.0, based on IoTSP, and virtual commissioning hold the key to making them manageable – in terms of both time and cost.

1 New tools are needed to master increasing complexity in automation projects.

Industrial automation has been around for decades and the food industry has been one notable beneficiary. However, many processes have now become so intricate that the job of automating them within the allotted time span has simply become too complex for traditional approaches ➔ 1. This complexity also means that no one supplier can supply all the components of the production line so these will come from different vendors, raising potential incompatibility issues.

Industry 4.0

To address this and other, related issues, the United States and Germany started the Smart Manufacturing and Industry 4.0 initiatives, respectively. These initiatives use, as a foundation, the Industrial Internet of Things (IIoT), which links machines, sensors and actuators via Internet protocols. These two initiatives have one important common denominator: they allow the easy connection and interaction of all the components – sensors, actuators, controllers, production equipment, etc. – in a plant.

It is necessary to fulfill two key engineering conditions to ensure efficient and effective execution of automation projects in this new, connected world with an ever increasing demand for shorter project execution times:

– Development work in the relevant disciplines – eg., mechanical engineering, electronics and software – needs to be more parallelized. This requires, among other things, that the overall conceptual design covers all disciplines and that interdependencies between disciplines are described explicitly.

It must be possible to test the distributed control logic design without real control hardware.

– Virtual prototypes have to be available in all phases of the engineering process so that the required functionality can be tested as soon as it is developed. Also, due to the trend toward increasingly decentralized control functionality, it must be possible to test the distributed control logic design without real control hardware.

The second point predicates the development of a virtual model of the process with all its actuators and sensors, or of the control system, or both. ABB's Automation Builder helps do this.

Automation Builder

ABB Automation Builder is an integrated software suite for machine builders and system integrators who want to automate their machines and systems in a productive way ➔ 2.

Automation Builder combines the tools required for configuring, programming, debugging and maintaining automation projects under a common intuitive interface. Automation Builder can integrate AC500 programmable logic controllers, programmable drives, control panels and robots into one coherent automation solution. This includes data management as well as the exchange of data with the mechanical and electrical elements of the system. By linking these data sets, virtual models for commissioning or prototype testing can be generated and processed faster. Automation Builder is capable of virtualizing machines or whole production lines and it addresses the largest single cost element in most of today's industrial automation projects: software.

2 Automation Builder provides a more rapid and simple way for industry to automate processes.

ABB Automation Builder is an integrated software suite for machine builders and system integrators who want to automate their machines and systems in a productive way.

Industry 4.0 facilitates the implementation of Automation Builder in several ways.

Automation Builder is available for download and in various editions suitable for different scales of project. A convenient setup helps to configure the installation and handle license registration, maintenance and software updates.

All relevant data from Automation Builder are transferred into a model of the system. Data from ABB's offline robot programming and simulation tool, RobotStudio®, is also included. RobotStudio, which is included in the Automation Builder distribution, serves as a 3-D simulation engine where virtual controllers, HMI and drives meet the virtual mechanical prototypes and interact with each other and with the virtual world. To allow for scalability without needing ultrafast computers, the concept of virtual time is introduced. Using virtual as opposed to real time enables the execution speed of the simulation to be reduced when the performance limits of the PC are reached.

Automation Builder is an open software: Missing components for system simulation of any complexity can be created by the user or downloaded from the online RobotStudio community; software libraries are available, as are PowerPac add-ins; and various interfaces are available for device and signal data exchange – eg, Microsoft Excel, various CAD formats like for EPLAN Electric P8 or Zuken E3, and MATLAB/Simulink.

Industry 4.0 facilitates the implementation of Automation Builder in several ways. For example, it enables devices and tools from different vendors to communicate certain sets of standardized data. Further, the wider bandwidth of the Ethernet-based communication used by Industry 4.0 allows large quantities of data to be transferred easily.

Where mutual-help organizations have sprung up in social networking communities for a whole range of other activities, so too are they expected to appear to assist those engaged in automating factories. Indeed, ABB has already gone some way down this road with RobotApps™, which offers a whole range of useful apps for robot developers.

Virtualization opens up completely new horizons for businesses. For example, resource-intensive simulations of process scenarios can be outsourced to the cloud, obviating the need for the user to have his own computing power. Or the current production setup can be virtualized and then played with to see what the effects are of changing various parameters or pieces of equipment. In this way, energy usage could be optimized, throughput maximized or the total cost of production minimized. Even operator training can be performed on virtual equipment.

ABB Review will return to Automation Builder in a future issue for a more detailed look at the capabilities of this automation software suite that allows the possibility of engineering in the virtual world in virtual time.

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A safe investment

Food-safe components in washdown applications

STEFANIE BURNS – All consumers have the right to expect safe, good-quality food that has been processed under the best hygienic conditions. This places cleaning, disinfection and sterilization at the top of food processors' priorities. Washdown is the main weapon in the fight for best-practice hygiene standards, especially in meat-processing plants, but washdown is extremely tough on equipment as it uses hot, high-pressure sprays that will eat away at protective coatings. No type of paint can withstand a 1,000 psi washdown for very long. For this reason, ABB has placed great emphasis on three design aspects that are critical for making equipment food-safe: material and housing design, lubricants and sealing technology.

1 Poultry plant with stainless steel motors that can withstand the harshest washdown conditions.

Food producers and handlers are very conscious of food safety and have measures in place to ensure best practice. For example, good hygiene practice (GHP), good manufacturing practice (GMP), and hazard analysis and critical control point (HACCP) are all an integral part of disinfecting premises and equipment, and are considered the most important activities in many food- and meat-processing plants.

Washdown

The main tool used in the quest for hygiene in food-processing facilities is washdown. So important is washdown that large meat-processing companies, such as Tyson, Cargill Meat, JBS, Kraft Foods, etc., though competitors, collaborate through the North American Meat Institute (NAMI) to standardize the basic requirements for washdown equipment. These companies understand that painted or coated units will not withstand continuous caustic washdown and they lead the food industry in the move from traditional corrosion-resistant coatings on cast iron and aluminum components to a world of all-stainless (and sometimes ventless) mechanical and electrical designs for food-processing equipment → 1.

The location of equipment and the process used to keep the area clean will determine how robust equipment must be. For instance, a packaging area at the end of the line will require very little washdown. The processing section of a food plant, on the other hand, may need a thorough washdown, though the type of washdown will depend on the food processed: Meat and poultry areas can require disinfection; and confectionery chocolate and bakery plants may have processes that get sticky and need special cleaning.

The main tool used in the quest for hygiene in food-processing facilities is washdown.

Food-safe design

According to the guidelines being developed by NAMI and the European Hygienic Engineering and Design Group (EHEDG), there are three areas of particular interest regarding the design of food-safe equipment.

Frame design and material

Cast iron and aluminum do not perform well in washdown environments because they corrode. Many suppliers turn to epoxy paints, powder-coating and electrocoating but nothing is more durable than an all-stainless-steel design, making it the preferred housing type.

Using stainless steel does not, in itself, guarantee a good product – the steel has to be of a high enough grade and, equally importantly, the housing must be designed such that liquids do not collect – they must be able to drain and spill on their own. Likewise, welds must be smooth so as not to trap bacteria.

Further, the cooling fins utilized to cool electric motors can trap contaminants, so the designs ABB chooses for the food and beverage industry are preferentially non-vented and finless. In general, cavities, dead areas, crevices and other irregularities are to be avoided; a smooth frame design will ensure that contaminants are washed off the products properly.

Title picture

Appropriate design is essential if food-safe equipment is to withstand the rigorous washdown regimes employed in food-processing plants and the ingress of foreign materials.

Painted or coated units will not withstand regular caustic washdown – the food industry is moving into a world of all-stainless-steel designs for food-processing equipment.

2 Product unsuitability might be spotted too late.

Lubricants

Food-grade lubricants have properties that make them safe for incidental food contact. However, their performance regarding heat transfer and dissipation, wear, friction, corrosion, etc., is relatively weak compared with traditional lubricants. Nevertheless, with proper monitoring and maintenance they can be used without concern.

To assist the food industry, government organizations such as the FDA (Food and Drug Administration) and the USDA (United States Department of Agriculture) have created food-grade lubricant designations:

- H1 lubricants are used in food-processing environments for incidental food contact.
- H2 lubricants are used in equipment and machine parts in locations where there is no possibility of contact.
- H3 lubricants are typically classified as edible oils and can be used to prevent rust on hooks, trolleys and similar equipment.

Sealing technology

The most common causes of equipment failure relate to issues surrounding lubrication. For this reason, careful attention needs to be given to seals so that the lubricants stay in and contaminants stay out. Harsh washdown poses a special risk to seals as wash jets can force fluids and contaminants through the seals. Good seals are, therefore, a critical factor. When searching for a well-sealed product, some important questions to ask are:

- How many contact points do the seal lips provide?
- Of what material is the seal made?
- What is the design of lubricant flow through the seals? Is it a labyrinth design? Can the seal purge excess lubrication to avoid pressurized blowout?
- Is there added protection for the seal ie, rubberized flingers, end-covers, etc?

The combination of good housing material and design, H1 food-grade lubricants and a superior sealing design is what makes a product safe for the food-processing environment.

Food safety and violations

There are various types of regulations and standards that help control and regulate food-processing plants and ensure they are in compliance with food safety practices. These are driven by different bodies, for example:

- Governmental: In the United States, the USDA and the FDA have regulatory authority over food-processing practices. The USDA regulates meat, poultry, egg and cheese; the FDA regulates other foods.
- Public health and non-profit organizations: The National Sanitation Foundation International (NSF), 3-A Sanitary Standards, Inc. (an independent, not-for-profit corporation dedicated to advancing hygienic equipment design) and the Baking Industry Sanitation Standards Committee (BISSC) are organizations that provide standards and product certifications.
- Food-processing organizations: The NAMI industry trade association is a major player in the United States and is made up of food-processing companies that collaborate to define and write their own sanitary design principles.

Not all areas of the plant require extreme washdown-resistant products. It would be imprudent to select a high-specification product for a standard non-washdown application. On the other hand, skimping on equipment components in harsh washdown environments can turn out to be a very expensive business indeed. Food safety violations are serious and can have a devastating impact not only on the initial perpetrator but on the food-processing business as a whole.

What do food safety violations look like?

Not all violations are easy to spot right away. Sometimes, it can be difficult to tell if a product is stainless steel or just steel coated with zinc, nickel, or TDC (thin dense chrome). The product in → 2 seemed to be a stainless-steel-housed mounted ball-bearing unit until it was pressure washed many times, when the

3 Some products may appear to be stainless steel, but are not, leading to potentially serious violations.

nickel coating started to chip off. The question then arises – where did the material go?

Another example is found in what appeared to be a polymer-housed unit with stainless steel inserts – except the inserts are not made of stainless steel at all and the unit is now rusting ➔ 3. Because it appears to have some level of corrosion resistance, this product may have been perfectly fine in a less-toxic washdown environment, but it is not suitable for use in its present location.

Using a standard-grade product in a washdown environment is never a good idea. The housing material and coating type may not be appropriate, the sealing technology may not withstand the high-pressure washdown, fugitive coating materials may contaminate the food and potentially non-food-grade lubricants may spill onto the processing lines.

Food for thought

Food violations arising from harsh washdown can happen to even the most disciplined of companies. However, with careful selection of frame design and material, lubricants and sealing technology, the likelihood of a potentially very expensive violation can be minimized. Products need to be selected carefully to match the application environment. Regulations and expectations are increasing in the food safety world and the trend is shifting relentlessly toward a more feature-rich, all-stainless-steel design for mechanical and electrical components in food-processing facilities. This approach is one that is fully supported by ABB.

The stainless steel has to be of a high enough grade and, equally importantly, the housing must be designed such that liquids do not collect.

Nothing is more durable than an all-stainless-steel design, making it the preferred housing type.

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Palletizing for the palate

Selecting ABB's IRB 460 robot stacks up

SARA GÖRANSSON – Orkla Foods in Örebro, Sweden, needed to build an additional production line to accommodate a new snack product range. The line had to be fully automated, capable of performing an entirely new type of job and very flexible. A further challenge arose when the startup date was brought forward by four months. Experts from ABB, Orkla Foods and Front Automation – a systems integrator specializing in the food industry – formed a team to take on this mission. Their choice of an IRB 460 – the world's fastest palletizing robot – to perform the final operations in the line was decisive for the success of the project.

1 The IRB 460 takes the heavy lifting and repetition of many tasks away from workers.

Traditionally, the food industry lags other industries when it comes to introducing new technology. However, advances in hardware technology and control capabilities, combined with a tighter regulatory environment and higher consumer expectations, mean that the food industry is now often at the forefront of new technology adoption.

Other changes in the industry are afoot too: Consolidation is becoming more common, companies and factories are getting bigger and items are being produced around the clock.

To satisfy the demands imposed by this metamorphosis, many enterprises have transformed their operational approach in order to integrate isolated and islanded batch operations into a more coherent whole. A further key advance has been the rapid uptake of automation. Not only does automation improve quality and throughput, but it also improves the workplace environment and relieves employees of heavy and monotonous tasks ➔ 1.

Robotics form an important part of factory automation – a fact well recognized by the already heavily automated Orkla Foods factories. It was the implementation of ABB's IRB 460 palletizing robot that enabled the full automation of a new production line in Orkla Foods factory in Örebro, Sweden to be accomplished in record time. This line was the first at Orkla Foods to be automated from end to end.

Not only does automation improve quality and throughput, but it also improves the workplace environment.

Food processor

Orkla Foods Sweden, part of the Norwegian Orkla Group, has annual sales of approximately $560 million and employs around 1,500 people. The Orkla Foods factory in Örebro, Sweden has been used since 2000 to produce Risifrutti – a two-component snack based on rice or semolina and a fruit puree.

The Swedish food industry as a whole is completely dependent on automation to be able to compete – for reasons of greater efficiency, but also of greater control as automation enables incorrect marking to be reduced and quality increased. For these reasons, the Örebro factory always had a high degree of automation in place.

Risifrutti became the best-known snack brand in Sweden. In Spring 2014, Orkla launched Yummifrutti, a two-component snack with a spoon and some ingredients in the lid.

During the preparation for the Yummifrutti launch, Orkla Foods management decided that the product launch date should be moved up by four months, which posed a challenge that could only be met by installing an extra production line. System integrator Front Automation and ABB's IRB 460 robot – the world's fastest palletizing robot – were selected to accomplish this task.

The automation in front

Front Automation specializes in the automation of picking, packing and palletizing. The company delivers everything from simple palletizing applications to complete packing lines for customers all over Scandinavia. Front Automation in Jönköping, together with sister company Fröjd & Wester, is part of the industrial Fröjdia Group.

Title picture
ABB and system integrator Front Automation collaborated to install a new, fully automated production line in an Orkla Foods factory in Sweden. ABB's IRB 460 – the world's fastest palletizing robot – proved to be the most significant component in the new production line.

2 The containers are sent into a new cell where they are fitted with the plastic lid containing grains, labeled, palletized and retrieved. Everything is automated.

© Andreas Varro

The automation project at the Orkla Foods factory in Örebro, Sweden was accomplished in record time.

Front Automation works exclusively with robots from ABB, a choice that is due in part to the robots themselves and in part, perhaps more importantly, to the close collaboration and good support offered by ABB. Front Automation has installed roughly 100 robots in the past five years. The company can handle most applications and problems on their own, but sometimes they need to obtain support directly from the technical and development departments at the ABB robot factory. Production lines that use oatmeal, for example, cannot stop – oatmeal preparation continues no matter what – so if something malfunctions, the problem has to be resolved immediately, making rapid and effective technical assistance essential.

In addition to the tight schedule, the new product line had to be based on an existing product, Risifrutti, including the set dimensions and existing packaging. Usually, when a new production line is built, it is possible to influence the design of the product, but in this case, however, there was no such opportunity – the containers already existed and changing the factory to suit a new production line was not an option.

The four-axis IRB 460 can lift 48 containers at a time, with their tray, using suction cups, then stack the trays on the pallet with millimeter precision.

IRB 460 – it all stacks up

The production line constructed at Orkla entails the containers being sent into a new cell where the lids are put on and the containers marked before being palletized such that they fit straight onto the grocery store's shelves. The machines also perform several other operations, so they need to be flexible enough to switch function easily and dependably.

The four-axis IRB 460, which can handle weights up to 110 kg, performs the final operations in the line. Using suction cups, it can lift 48 containers at a time, with their tray, then stack the trays on the pallet with millimeter precision → 2–3.

3 The IRB 460 uses suction cups to lift the containers.

When a pallet is full, the robot changes function and uses the gripper to lift the new pallet into place. The robot can fill one pallet in 10 minutes, corresponding to a total of 8,500 products an hour.

Flexible, experienced and local

Despite the challenging timescales and the technical hurdles that were presented, the line was successfully and safely installed and the product launch took place on time.

Yummifrutti never really found its place in the market, so, in its stead, in 2015, Orkla Foods launched Havrefrutti, which also has a filled lid. This is the product now being assembled, at a rate of two per second, in the line and stacked and palletized by the IRB 460. The switchover from Yummifrutti to Havrefrutti was achieved with minimal fuss thanks to the flexibility of the IRB 460 automation solution.

The collaboration between Front Automation, Orkla Foods and ABB enabled the tight schedule to be met and the customer expectations to be fulfilled. The IRB 460 robot is by far the most significant component of the line and a major contributor to the success of the enterprise.

One important consideration was the cooperation between ABB and Front Automation, and the latter's experience in system integration. Further, the ready availability of suppliers located in Sweden with whom the customer can easily cooperate and who are available to provide support proved also to be a significant positive factor.

The robot can fill one pallet in 10 minutes, corresponding to a total of 8,500 products an hour.

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An ingredient called innovation

Innovations for the food and beverage industry

GERNUT VAN LAAK – It is easy to assume that food and beverage manufacturing is a bit like cooking at home, only that everything is on a bigger scale. Making food is about both art and science, and in an industrial size operation, the physics side presents challenges concerning such topics as thermodynamics and fluid dynamics. A selection of ABB's innovative solutions in these areas are presented here.

Cavitation stops here

It is often said that time is money. In the logistics of drinks manufacturing, speed is also money. A liquid sluggishly moving along a pipe or a tank taking a long time to drain do not represent a good utilization of equipment and resources. When a truck of milk arrives at a dairy, for example, it would appear logical that it should be emptied as rapidly as possible so that the truck can be released for its next trip and the milk transferred to the next process step. Physics, however, disagrees. If pumped too quickly, foam forms, which disrupts the process further downstream. So is there a way to pump faster without such repercussions? ABB offers a solution involving variable-speed drives combined with algorithms respecting the sensitivity of the fluid.

Anybody working with fluid dynamics is sooner or later likely to encounter the problem of cavitation. Simply put, the faster a liquid flows, the lower its pressure drops. A sudden increase in flow velocity can cause shockwaves in the liquid. In the case of fluids such as milk or beer this can lead to the formation of bubbles or foam, or worse still, irreversibly damage the product.

ABB has developed algorithms to control variable-speed drives ensuring that the pressure and speed of the fluid remain within a defined envelope. These algorithms automatically adjust pump speed to react to any change in pressure caused by the flow of draining vortex. The result is better protection of the product while optimizing pumping speeds. ABB estimates a return on investment of three months.

When is a bottle full?

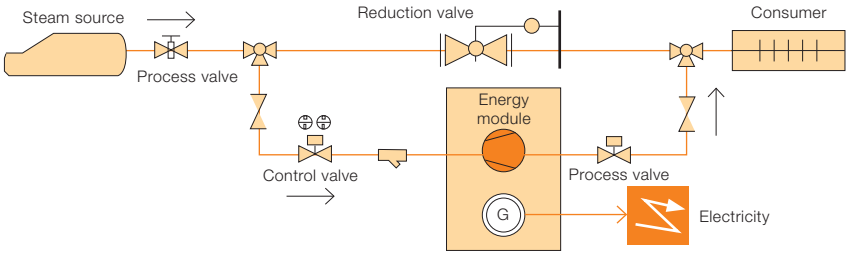
How much juice is there in a one liter bottle of juice? What may sound like a trivial or a trick question can in fact make a difference of tens of thousands of dollars per year, per filling machine for the bottling plant.

A bottling plant typically fills marginally more than the nominal volume to allow for variability in the process. Tackling that variability means reducing the necessary margin and thus having more filled bottles to sell.

Much of this variability comes from the measurement method. Fluids with low conductivity, high oil or alcohol content or suspended matter are especially difficult to measure with great accuracy.

ABB offers a solution involving a highly accurate mass flowmeter combined with control algorithms for mass compensation, and also including installation and testing. ABB estimates a return on investment of eight months.

Full steam ahead in saving energy



Process steam is ubiquitous in the food and beverage industry. It serves as a source of heat and sterilization in numerous scenarios. Typically, steam is generated in a central boiler and piped to the various points of application where it is reduced to the required pressure. This reduction mostly occurs through mechanical reduction valves (typical pressures being 6, 3 and 1 bar). Although this method works well, dissipation in valves is a wasteful use of valuable energy resources.

ABB has, in partnership with the German company ENVA Energy, created an alternative. Rather than using a valve, pressure is reduced using a turbine and the energy recovered provides electricity. This means some of the energy invested in the production of steam can be reused productively elsewhere in the plant or even sold to the grid, reducing both energy bills and carbon emissions. The turbine was created by ENVA Energy and the generator and electrical systems by ABB.

Calculations by ABB show that a customer can on average recover the costs in as little as two years.

Of yeast and yield

Fermentation is a central process in the brewing of beer. Brewery owners want to optimize this process to improve throughput and yield. Fermentation involves the mash being digested by yeast organisms. So how can brewers keep track of what these tiny organisms are doing?

One of the telltale signs of fermentation activity is the production of carbon dioxide. This gas is typically already captured during fermentation because it can be used elsewhere in the process and is costly to purchase. So the trick to keeping track of fermentation is to use this existing capture to closely observe the quantity produced.

ABB can supply a complete solution to this involving its CO_2 mass flowmeter, Sensyflow, as well as its controller and application libraries.

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Fish tale

ABB maintenance and operational services for Marine Harvest

MATILDA STEINER, KNUT-ROBERT MATHISEN – With the world's appetite for fish products growing daily and marine natural resources coming under increasing pressure, the business of fish farming is booming. Norway-based Marine Harvest ASA – one of the largest seafood companies and the largest producer of Atlantic salmon globally – operates a large number of fish farms. The company is now extending its business to produce the fish feed that is used in these farms. To this end, Marine Harvest has opened a new fish feed factory in Norway. The plant operates 24 hours a day in the high season, so reliable operation and full productivity are vital. Marine Harvest has now signed an agreement with ABB to service the ABB installed base in the factory – including drives, the automation and decision support system, and the 22 kV system that powers the new production facility.

As marine resources come under pressure and demand for fish and fish protein shows no signs of abating, fish farms are becoming a vital part of the world's food supply chain. From its many farms, Marine Harvest ASA – one of the largest seafood companies in the world – produces farmed salmon and a variety of processed seafood. Employing over 10,000 workers, it is represented in 22 countries and, with 24 percent of the global market, is the world's largest producer of Atlantic salmon. The company has decided to start supplying its own fish feed and, for this purpose, has built a $120 million production facility at Valsneset in Norway that is capable of producing 270,000 tons of feed per year on two production lines → 1. This production volume covers 80 percent of the needs of Marine Harvest's Norwegian fish farms.

The new, fully automated facility allows the company to extend its quality control all the way from fish food to the final delivery of portioned fish to retail customers.

ABB was the main supplier of power and automation solutions to the new factory. The scope of supply included transformers, frequency converters, 22 kV switchgear, motor control, drives and computer networks. The automation system encompasses about 5,000 signals from processes in the factory and is integrated into the company's overall business system using ABB cpmPlus Enterprise Connectivity, a decision support system for manufacturing companies.

ABB has now signed a service and operation agreement with Marine Harvest for the drives, and automation and decision support system, as well as for the operation of the 22 kV system that supplies the facility with power. The agreement has a duration of three years and involves round-the-clock phone support with guaranteed response times and a dedicated contract manager.

The new, fully automated facility extends quality control all the way from fish food to the final delivery of portioned fish to retail customers.

The control and decision support system lies at the heart of factory operations and is vital to achieving high productivity, energy efficiency and reliable operation.

Title picture
Marine Harvest's new fish feed production facility in Norway will supply the company's fish farms. ABB supplied most of the power and automation to the new factory.

1 The new Marine Harvest facility

Marine Harvest has now signed an agreement with ABB to service the ABB installed base in the factory.

Control and decision support system

Feed production is a complex process that handles many ingredients and mixing ratios, and which is subject to full traceability. To make production as efficient as possible, one batch of a particular feed is produced at a time. To control the process, the factory uses Marine Harvest's own version of ABB's Extended Automation System 800xA. The control system not only runs the processes in the factory but also integrates these processes into the company's overall business system.

The control system ensures that the factory adheres to the company's rules, guidelines and quality standards. It also enables:

- Fast and correct decisions based on real-time production data and critical process information
- Agile paperless operation that can respond rapidly to changing customer demands
- Full product and process genealogy
- On-the-job support for operators by providing up-to-date information, instructions, material lists, notifications and checklists
- Operation visibility and plant performance analysis to help realize continuous improvements
- Close monitoring and control of material consumption and warehouse status

Traceability

As is common in the world of food production, every stage of farming and production adheres to strict best practice and guidelines. One of the most critical best practices revolves around traceability at all levels and every stage of the process. In a food operation, traceability relies heavily on a meticulous and efficacious use of data:

- Horizontal and vertical traceability at all stages of the production process
- Integration with external systems for extended information correlation
- Visibility in the production process and accessibility of real-time data
- Easy accessibility for all relevant parties to all critical process data

2 ABB motors and drives are part of the automation solution.

3 ABB supplied most of the power and automation for the new factory.

To control the process, the factory uses Marine Harvest's own version of ABB's System 800xA.

The control and decision support system lies at the heart of factory operations and is vital to achieving high productivity, energy efficiency and reliable operation.

Food processor

The installation of the ABB drives, power supply, and automation and decision support system in the new facility was performed with the full collaboration of the customer, which allowed a short and smooth implementation time, and meant the factory was up and running before scheduled completion dat ➔ 2–3. A simple user interface eased the training process for the new operators.

The service and operation agreement with Marine Harvest will ensure that ABB support is always at hand to keep the new production facility working round-the-clock to supply feed for the company's fish farms throughout Norway.

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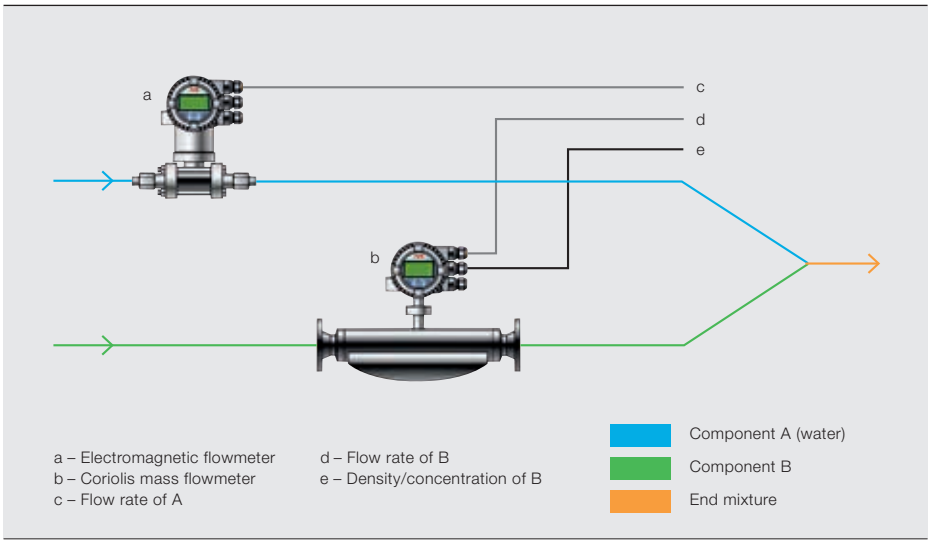
Recipe for success

Simultaneous mass flow rate and density measurement for the food and beverage industry

FRANK FRENZEL – Makers of food and drink like to have consistency in their products. For a consistent taste or texture to be achieved, the concentrations of a product's constituent components have to be kept constant so that the proportions in the final mixture are exactly correct. This is relatively straightforward to achieve using volumetric, gravimetric or simple mass flow measurements if the individual components have stable concentrations. However, nature does not always play ball and often the concentrations of the individual components themselves vary. These variations must be detected and volume adjustments performed as early as possible in the mixing process in order to avoid subsequent analyses, calculations and corrections. ABB's mass flowmeters CoriolisMaster FCB/FCH 150 and FCB/FCH 450 supply accurate density measurements that make them ideal for dosing tasks of this kind.

1 Mixture of two components with different concentrations



Makers of foods and beverages strive to maintain consistency of taste, texture, appearance, etc., in their products. If, for example, a brand of orange juice tastes different from month to month, consumers may switch to a rival product.

In some cases, the components that are mixed to make food and drink products may display concentration deviations, such as slight variations in water content. However, density measurements can be used to calculate concentrations so that concentration discrepancies can be corrected during the manufacturing process.

Title picture
Consistency is the watchword in the food and beverage industry. ABB's Coriolis mass flowmeters help correct for variability in the components of a product. Shown is ABB's new FCB400 Coriolis meter.

CoriolisMaster FCB/FCH150 and FCB/FCH450

ABB's CoriolisMaster FCB/FCH150 and FCB/FCH450 are ideally suited to online concentration correction applications in the food and beverage industry. As well as accurately measuring mass flow by exploiting the Coriolis effect, these devices also make an independent density measurement using the resonant frequency of the meter at the given fluid density.

The CoriolisMaster FCB/FCH150 and FCB/FCH450 – which can operate with media up to 205 °C – have a flow rate measurement accuracy of 0.1 percent. Accuracy of density measurements for liquids is 0.002 kg/l and 0.001 kg/l, with 0.0005 kg/l possible with field adjustment.

Maintaining concentration

In → 1, two components (A and B) are to be blended. The concentration of component A (which we can assume is water) is constant. Component B itself contains water and this water fraction can vary slightly. So that the final product has the correct proportions according to the recipe, the variation in the proportion of water in component B has to be corrected for. This is done by measuring the component B concentration and adjusting the quantity of component A added.

Solution solution

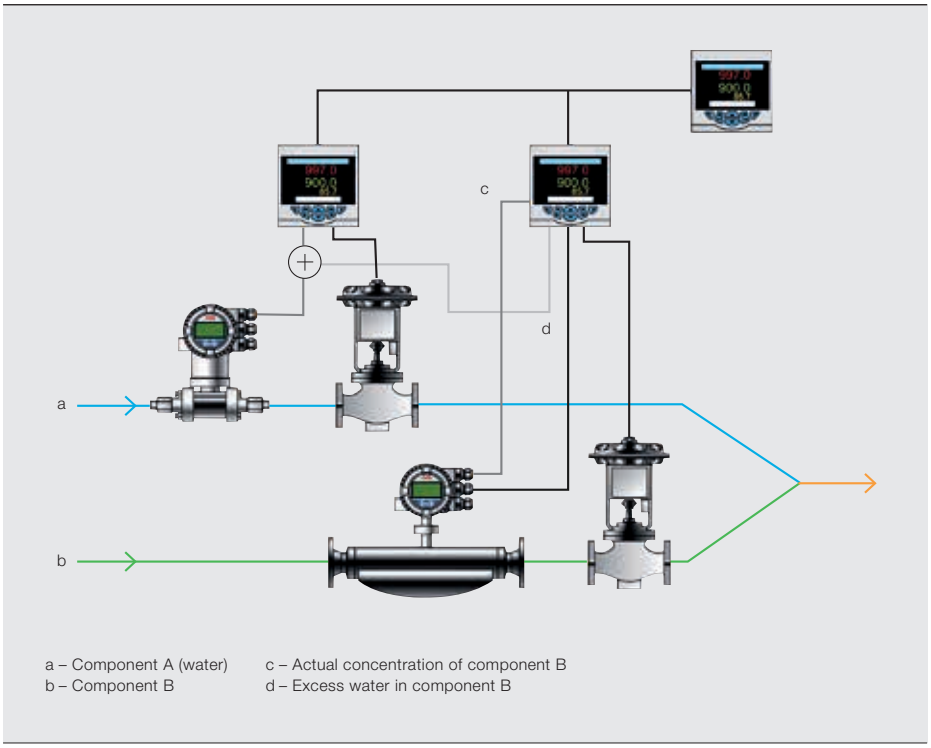
The stable concentration of component A can be measured using an electromagnetic flowmeter. The slightly varying concentration of component B is measured using a Coriolis mass flowmeter. This is achieved by measuring the mass flow and converting it into an equivalent volume flow. At the same time, the Coriolis mass flowmeter records the actual density of component B and, by combining this measurement with the equivalent volume flow value, produces a result for the concentration. Temperature compensation is performed using a table stored in the transponder. This measurement procedure generally results in an exact concentration value. If slight disparities arise for process-related reasons, adjustments can be made to the table.

ABB's CoriolisMaster measures mass flow using the Coriolis effect and makes an independent density measurement using the resonant frequency of the filled system.

The measurement characteristic curves may shift slightly when the device is used in a normal operating environment instead of in a testing/laboratory setting because the medium may contain small amounts of gases, for example, or there may be a slight variation in density in concentrates

Temperature compensation is performed using a table stored in the transponder.

2 Possible control circuit with correction. As C varies, the signal D is used to vary the quantity of component A to be added as compensation.



a – Component A (water)
b – Component B
c – Actual concentration of component B
d – Excess water in component B

The concentration is transmitted to the process control system and compared with the value in the recipe so that the appropriate corrective measures can be taken.

for the same Brix content (Brix is the percentage of sucrose by weight in a solution). Such discrepancies can be easily corrected for by comparing field and laboratory density measurements.

The concentration can then be transmitted to the process control system and compared with the value in the recipe so that the appropriate corrective measures can be taken.

A control diagram involving the calculation of excess water quantities and the compensation thereof is shown in ➔ 2. At the same time as recording the concentration of the relevant components, the mass flowmeter also records the mass or volume flow of the medium in which they flow. This negates the need for an additional flowmeter. All of the calculations are performed by the controllers without any add-on components. The level of accuracy can be substantially increased by using a blend line control method with error storage and subsequent compensation of transient deviations.

With margins in the food and beverage industry constantly tightening, consumer expectations rising and legislative control increasing, manufacturers are becoming ever more reliant on technology to support their production lines. ABB's CoriolisMaster mass flowmeters provide a key tool for food and drink producers to maintain the consistency and quality in their brands upon which their business success depends.

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Same again?

Consistent flavor is essential in any distilling or brewing operation

FRANK FRENZEL – Across the food and beverage industry, consistency of product taste is a critical factor – and this is particularly the case where beer is concerned: Consumers expect their favorite tipple to taste the same regardless of where it was brewed or how it was bottled, transported, stored and poured. However, brewers have to cope with naturally grown products that can vary by harvest, soil type, storage conditions and so on. Even beers with few ingredients – like the German beers brewed according to the German beer purity law, which contain only barley, hops, yeast and water – require great diligence on the part of the brewer to ensure consistency of taste from batch to batch. Brewing a good beer is part art but there is also a good deal of science involved and this requires precise process control and repeatable, standard solutions that can be deployed across multiple production sites. ABB's comprehensive range of instrumentation can help beverage makers achieve consistency and quality while lowering production costs.

Beer makers have to make sure that their products are of top quality and consistency if they want to retain loyal customers and gain new ones.

1 A robot stacking kegs concludes the chain of ABB automation that assists the beer maker.

With origins thousands of years old, brewing has now evolved into a global multibillion-dollar business. Competition between brewers is fierce and beer drinkers have become more discerning, so beer makers have to make sure that their products are of top quality and consistency if they want to retain loyal customers and gain new ones.

The process of making beer is at once simple but complicated. Each step of brewing is relatively straightforward and the ingredients are usually few – just barley, hops, yeast and water in the case of German beers. Conspiring against the production of the perfect pint, however, are the vagaries of the ingredients – natural variations in the cereals, yeast and water used – and the criticality of parameters such as temperature, concentrations and quantities in the process itself.

To ensure top quality and consistency, a modern brewery will be equipped with the very best control, sensing and instrumentation technology available. This automation technology will also facilitate three other major ambitions of brewers: optimized raw material use, reduction in energy use and maximized brewery availability.

The beer industry represents a significant customer base for ABB and the company has developed a comprehensive range of products to meet the needs of the sector. The products ABB offers support the beer maker all the way from the arrival of raw materials at the brewery to the shipment of the packaged product → 1. In particular, ABB automation instrumentation enables the user to maintain consistency and high quality and run his process in the most efficient manner.

Go with the flow meter

Effective control of flows in the brewery is one of the most critical elements of the beer making process. ABB offers a range of flowmeters that exploit a number of fundamental principles and that are suitable for different tasks. The ABB mass flow CoriolisMaster Hygienic FCH400 meter, described in detail on pages 34–36 of this issue of ABB Review, for example, uses the Coriolis effect to simultaneously measure flow rate and density, and deliver concentration values. This stainless steel, European Hygienic Engineering and Design Group (EHEDG) – approved, precision device has an accuracy of up to 1 g/l or, with field calibration, 0.5 g/l. In common with other ABB instrumentation for the food and beverage industry, the CoriolisMaster communicates via a 4 to 20 mA loop or a variety of other outputs. The CoriolisMaster is used, for example, to measure the density of the wort (the liquid extracted from the mashing process) or to control hop extract dosage.

Operating on a magnetic-inductive principle and designed specifically for the food and beverage, pharmaceutical and biotechnical industries, ABB's HygienicMaster FEH300 flowmeter can be found in almost every part of the brewing process – dosing the water added during

The products ABB offers support the beer maker all the way from the arrival of raw materials at the brewery to the shipment of the packaged product.

Title picture
ABB's wide range of instrumentation helps brewers and distillers ensure consistency of taste in their products.

2 Probes for pH measurement

3 23/24 regulator valve with TZIDC electro-pneumatic positioner

mashing, monitoring the amount of water flowing into the wort boiling process and so on. Manufactured from FDA-approved materials and certified in accordance with EHEDG and 3-A for the dairy and food industry, this flowmeter is available in an integral mount or remote mount design. The HygienicMaster FEH500 version provides enhanced functionality and extended diagnostic functions.

Where a more robust flowmeter is needed, the magnetic-inductive FSM4000 can be used. The FSM4000 uses AC technology in combination with DSP (digital signal processor) data processing, which makes it very suitable for processes that change rapidly and require fast response times or short-term dosing – for example where the cyclic nature of pumps causes feedstock variations.

A vortex principle is used in the VortexMaster FSV430/450 flowmeter. The FSV430/450 has a high turndown ratio and, having no moving parts, is very suitable for use in steam lines or other challenging applications. Its brother, the SwirlMaster FSS430/450, can be installed with hardly any straight inlet or outlet sections. Similarly, the ABB VA Master FAM540 metal cone variable-area flowmeter can be used for liquid, steam or gases, especially when aggressive or opaque fluids are to be metered. In breweries it is used, for example, to control the flow of sterile air. Gases can also be metered with the ABB FMT400-VTCS, which delivers a direct mass flow measurement. The FMT400-VTCS requires no additional pressure and temperature compensation, and because it has no moving parts it exhibits no wear and is maintenance-free.

ABB's Hygienic-Master FEH flowmeter can be found in almost every part of the brewing process.

Sensors and transmitters

Control of process temperature in a brewery is as critical as flow control and for this, ABB has a selection of temperature sensors and transmitters, such as the TSP121 – available in a range of versions including Pt100 and Pt1000 – and the TTH300 two-wire transmitter. These devices enable the brewer to keep a close eye on the critical temperatures throughout the brewing process.

ABB pressure sensors, level sensors, and probes and analyzers for pH are found in multiple locations in the typical brewery. Valves, such as the TZIDC family of electro-pneumatic positioners, and the Screenmaster SM500F recorder, round out the selection of ABB automation instrumentation products that can be used by the brewer → 2–3.

Integrated instrumentation

Though beer is usually made from just four basic ingredients, brewing it is by no means a simple task. Multiple parameters throughout the process have to be tightly monitored and controlled for the final product to taste just right and for quality and consistency to be maintained. ABB is a one-stop-shop for a wide range of integrated automation instrumentation that helps achieve these targets as well as enables the brewer to optimize raw material use, reduce energy consumption and maximize the brewery uptime.

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The whey forward

Reliable and accurate instrumentation for the dairy industry

FRANK FRENZEL – Milk is a complex mixture of substances that is processed to make a large variety of finished products such as butter, yogurt, cheese, cream and so on. In larger dairies, milk is treated in largely automated, closed production lines. Due to the complexity of some of the process steps, the delicate nature of the raw product and the need to adhere to strict hygiene regulations, the instruments that measure, monitor, regulate and control the process line must be accurate, reliable, robust and designed for hygiene. ABB supplies a wide range of such instruments, the characteristics of which can be explored by describing how they are used

ABB's pressure and temperature products are ideal for most stages of the milk treatment process.

For many parts of the world, milk is an important source of nutrition. Milk contains water, fat, protein, milk sugar (lactose), enzymes, vitamins, minerals and trace elements. It can be processed to produce butter, cream, cheese, yogurt, etc. Much of this processing is carried out in large dairies that employ a high degree of automation. The complex composition of milk and the potential danger to health should something go wrong in the processing means that great care has to be taken at each step as the raw milk is turned into the finished product. In larger dairies, to ensure good quality and product consistency, most parts of the process are instrumented.

Most parts of the dairy – milk processing, cheese making, yogurt production, etc. – are similar in terms of instrumentation. Looking in detail at one part – the milk production line, for instance – gives a good indication of how ABB instruments can help dairy operations as a whole → 1.

Delivery and pasteurization

Raw milk is delivered to the dairy in tankers and is immediately tested for bacteria or other contaminants. Subsequently, if suitable, it is transferred to storage tanks or goes straight into the process. At this point, the delivery quantities will usually be determined by a magnetic-inductive flowmeter such as the ABB HygienicMaster FEH300/500. The HygienicMaster has a coating of vacuum resistant PFA and employs stainless steel elements to maintain hygiene. It is the most common flowmeter found in an ABB-equipped dairy. If the milk has warmed in transit, it is cooled to 5 °C and stored in agitated tanks. ABB level/pressure monitoring devices, eg, SMW and 261GG/AG types, can be used to monitor tank levels here and throughout the dairy.

The HygienicMaster FEH has a coating of Teflon PFA and employs stainless steel elements to maintain hygiene.

Pasteurization is a core activity of any dairy. Here, the raw milk is processed into drinking milk or is prepared for use in other products, such as cheese, etc. Pasteurization involves heating the milk for 15 to 30 s to around 74 C and then immediately cooling it to kill any harmful organisms. When cooling, much of the heat energy is won back by carefully

Title picture
Dairy operations are delicate and thus require the very best instrumentation. ABB has products to monitor and control every stage of the processes that turns milk into cream, yogurt, butter and cheese.

The CoriolisMaster is well suited to online cream concentration correction.

1 Milk processing is a delicate operation that needs the best instrumentation.

controlled heat exchangers. Overpressure is applied to the treated milk to ensure it never comes in contact with untreated milk. ABB's pressure and temperature products such as the 261GG/AG gauge pressure transmitter, SensyTemp TSHY thermometer for sanitary applications and the TTH300 head-mount temperature transmitter are ideal for most stages of the milk treatment process.

Here, and throughout the dairy, flows can be controlled with the ABB TZDIC intelligent digital positioner. These stainless steel smart positioners combine high accuracy and adaptable control functions, and their auto-stroke functions make them easy to commission. The TZIDC requires little maintenance and works over a wide temperature range, making it suitable for the milk production line.

The TZIDC requires little maintenance and works over a wide temperature range, making it suitable for the milk production line.

Separation and standardization

To clean the milk of contaminants and to isolate components of individual interest – such as cream and skimmed milk – the milk goes through a separation procedure. The milk then has to be standardized: Raw milk has a higher fat content than the law recommends for drinking milk so after the cream is removed from the milk it is added in again in a controlled manner to achieve the correct fat levels.

To keep within the law and to not "waste" valuable cream by adding too much, this blending process has to be tightly controlled. As well as using the instrumentation described above, this stage of the process also utilizes the ABB CoriolisMaster FCB/FCH150 or FCB/FCH450, described in detail on pages 34 – 36 of this issue of ABB Review. The CoriolisMaster is well suited to online cream concentration correction: As well as accurately measuring mass flow by exploiting the Coriolis effect, the device also makes an independent density measurement using the resonant frequency of the filled system thus making it easy to track the changing cream concentration. The device has a flow rate measurement accuracy of 0.1 percent (FCB/FCH150 and FCB/FCH450). The CoriolisMaster is

2 Just some of ABB's wide range of flow and control products commonly used in dairies.

ABB level/pressure monitoring devices, eg, SMW and 261GG/AG types, can be used to monitor tank levels throughout the dairy.

also less prone than other flowmeters to give erroneous readings when gas bubbles are entrained in the flow, though large cavitation events will skew measurements → 2.

Homogenization and packaging

To prevent the cream in the milk from separating and floating to the top in the finished product the milk is passed through a fine sieve under pressure to break up the larger fat globules. A cavitation technique further breaks up the globules so that they are distributed throughout the medium and have less tendency to collect at the top. The milk is then filled into its final container.

The instrumentation described earlier is used in these process steps too to measure flow, pressure and level. The ability of the instruments to withstand high pressures while maintaining hygienic levels is an important consideration.

Hygiene

Rigorous daily cleaning and sterilization is an essential aspect of the dairy business. Temperature sensors and flowmeters ensure that the cleaning materials are of sufficient temperature and that they reach all parts intended. Conductivity measurements can determine flushed impurity levels and can ascertain if contamination levels are high enough to warrant the addition of further cleaning agents.

Service

As well as delivering the instruments themselves, ABB also organizes the installation and commissioning of the automation instrumentation, as well as provides regular maintenance and repair.

Optimizing many aspects

Milk is a complex product to process. To successfully cater for the critical parameters involved in milk processing – such as temperature, concentrations and flow quantities – and ensure top quality and hygiene, a dairy will be equipped with the very best control, sensing and instrumentation technology. This automation technology will also help optimize raw milk use, reduce energy consumption and ease daily tasks like cleaning. ABB's wide range of instrumentation fits in well with the rigorous demands of the milk processing industry.

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ABB

Food power

ABB's rugged UPS PowerLine DPA ensures food and beverage production facilities keep running

DIANA GARCIA – For many industries such as food and beverage, the consequences of electrical power loss can be disastrous: Production lines may have to go through a complex and costly restart; expensive products may be ruined; valuable production time can be lost; process equipment can be damaged; and safety issues may arise. Because a reliable supply of clean power usually cannot be guaranteed by the grid, many enterprises turn to uninterruptible power supplies (UPSs) to make sure that their operation keeps running. For critical industrial applications, ABB has now introduced the rugged PowerLine DPA UPS, built to withstand the rough conditions encountered in many industrial settings. PowerLine DPA is based on ABB's proven decentralized parallel architecture (DPA) for UPSs. DPA is a modular architecture that, by its nature, provides not only the best availability but also the best serviceability and flexibility. Taken together, these features will deliver a low total cost of ownership (TCO) over the 15 years' lifetime of the PowerLine DPA UPS.

Title picture
ABB's rugged PowerLine DPA UPS ensures a constant supply of good-quality power for many rough industrial environments, such as food production facilities.

There are few events more disruptive to a manufacturing or a production process than a power disturbance. And power disturbances come in many guises: On top of total power outages, the voltage may sag or swell over short periods. It may also do so over longer periods – so-called brownouts or overvoltages. Moreover, there can be electrical noise on the line, or frequency variation or harmonics may appear in the voltage. Such events can result in data loss, production downtime, unavailability of essential services, risk to hardware, financial losses and safety concerns. For these reasons, most professional enterprises protect their power supply with a UPS.

However, a UPS can itself become a focus of reliability and availability concerns. This is why ABB has developed an architecture that ensures the very best UPS design in terms of availability, flexibility, cost and ease of use – DPA.

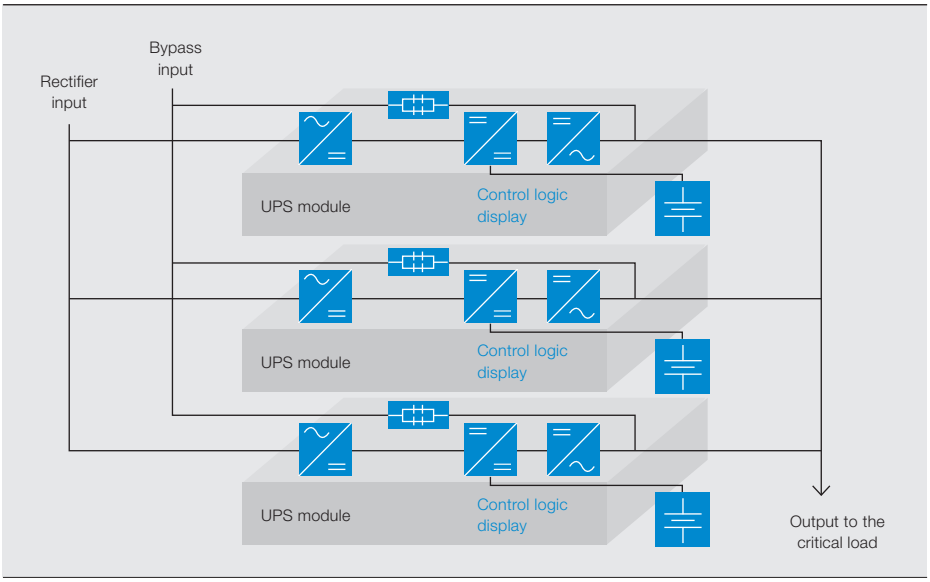
A UPS itself can become a focus of reliability and availability concerns. This is why ABB has developed an architecture that ensures the very best UPS design – DPA.

DPA

UPS systems with a centralized parallel architecture (CPA) have some degree of hierarchical, centralized control or hardware (eg, a static bypass). This makes CPA devices vulnerable should a failure arise on one of these centralized components; one fault can bring down the entire UPS. With DPA, on the other hand, the UPS is modularized and each module has all the hardware and software needed for autonomous operation: rectifier, inverter, battery converter, static bypass switch, backfeed protection, control logic, display, and mimic diagram for monitoring and control → 1. A module's output is not affected by failures elsewhere in the UPS. If one module is lost, the others take up its load. In other words, a multimodule system is fault tolerant and there are no single points of failure. Availability is maximized.

With DPA, the UPS is modularized and each module has all the hardware and software needed for autonomous operation.

1 Each UPS module has all the hardware and software it needs for autonomous operation; there are no shared critical elements.



The only UPS elements common to all modules are contained in the mechanical frame that accommodates the UPS modules – I/O connection, customer interface signaling, maintenance bypass and a system display. These elements are noncritical for UPS operation.

DPA – serviceability

One major advantage of DPA is that the modules can be swapped online, ie, removed or inserted without the need to power down or transfer to raw mains supply and without risk to the critical load. This unique aspect of modularity directly addresses continuous uptime requirements, significantly reduces MTTR (mean time to repair), reduces inventory levels of specialist spare parts and simplifies system upgrades. Modularity pays off too when it comes to serviceability: Local service personnel do not need special skills, visiting service engineers spend less time on site, and any risks of data or production loss are minimized.

DPA – scalability

As UPS power requirements change – eg, if a new process line is opened – the modular nature of DPA makes it simple to add modules and increase power capability. This means the initial configuration does not have to be overspecified to cater for future expansion – modules are simply added (or removed, if power requirements shrink) when needed. In this way, the user only cables, powers and cools what is needed. Power consumption is a topic of great concern for many operators and the energy savings made by the modular expansion approach over the service life of the UPS are substantial.

One major advantage of DPA is that the modules can be swapped online without risk to the critical load and without the need to power down or transfer to raw mains supply.

This online-swap technology, as well as having a significant impact on overall costs, can also help achieve so-called six nines (99.9999 percent) availability – a highly desirable target for installations in pursuit of zero downtime.

2 ABB's PowerLine DPA

ABB's new PowerLine DPA UPS is based on DPA and has been designed specifically to overcome the many challenges faced when deploying such sophisticated electrical equipment in rough industrial settings.

PowerLine DPA

ABB already markets power protection products that are based on DPA and the ABB PowerLine DPA UPS is the latest addition to this product portfolio → 2–3. The PowerLine DPA UPS is specifically designed to overcome the many environmental challenges faced when deploying such sophisticated electrical equipment in a rough industrial setting.

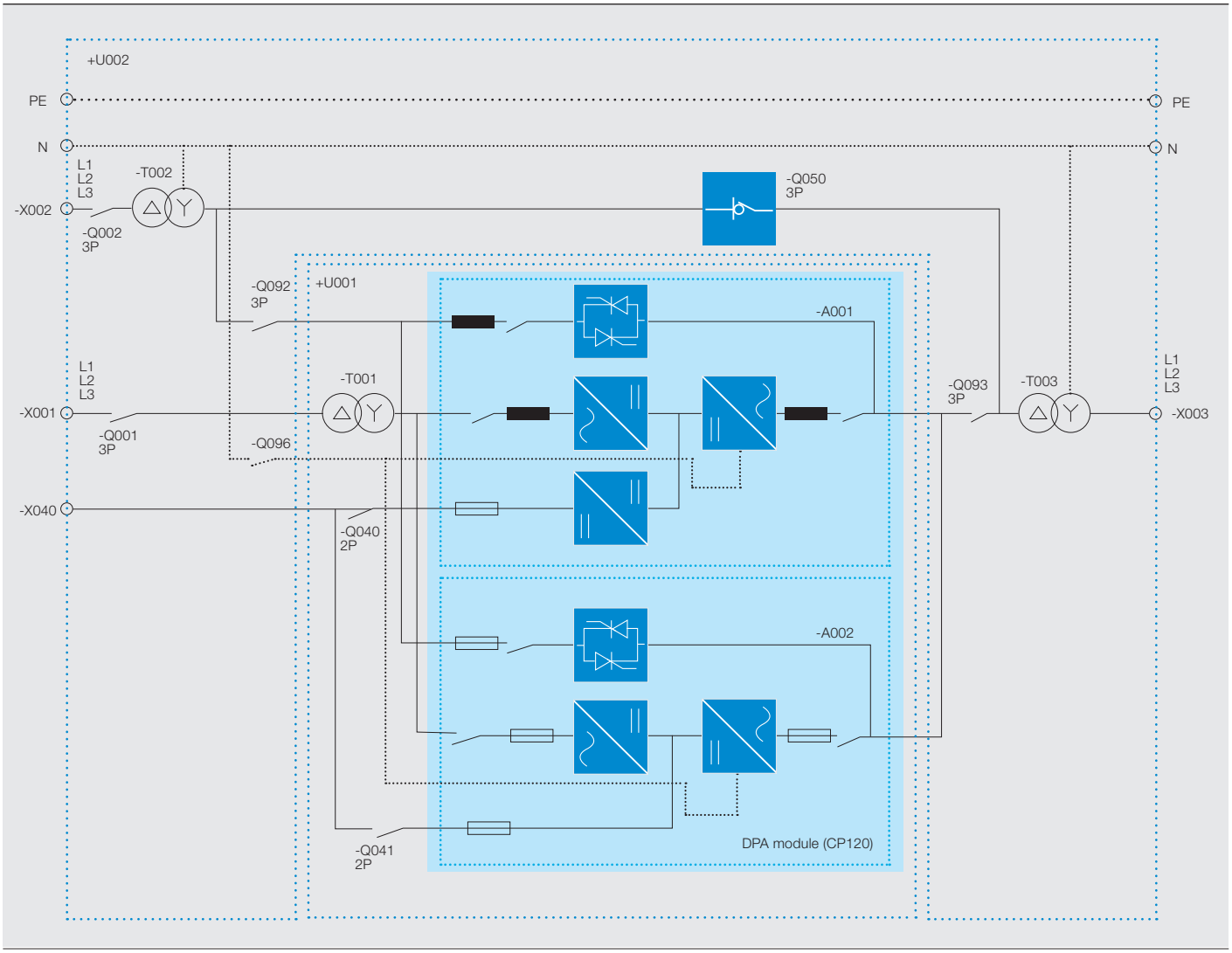
Survivability is crucial, so particular attention has been paid to physical robustness. PowerLine DPA's IP31 protection can easily cope with dust, water condensation, excessive humidity (up to 95 percent), corrosive air contamination and rough manhandling. The UPS is designed to operate in a temperature range of –5 to +45 °C. High priority has been given to safety and PowerLine DPA features a high degree of protection for users and maintenance staff. The device's compliance with the relevant standards – IEC/EN 62040-1 for general and safety aspects, IEC/EN 62040-2 for EMC and IEC/EN 62040-3 for performance and test – has been verified.

Real estate for electrical equipment is often a limited or expensive commodity. The PowerLine DPA UPS has not only a small footprint but also cable access at the front (top and bottom), which eliminates the necessity for rear access and the associated extra space this entails.

PowerLine DPA is an online double conversion UPS: The incoming AC is first converted to DC, from which the output AC is then synthesized – giving a clean sinusoid. These two conversion steps give rise to the "double conversion" term and isolate the output voltage waveform from any disturbances on the input AC side.

The UPS is based on a pulse-width modulation (PWM) principle and uses power electronic components that reduce harmonic content in the input current to under 3 percent, thus decreasing any mains voltage distortion that might affect the operation of other equipment connected to the mains supply. Input/output isolation transformers can be installed inside the UPS to increase

3 PowerLine DPA UPS single-line diagram



safety levels, and to provide galvanic isolation for the UPS and the downstream load. This might be necessary, for example, where the UPS AC input power comes from switchgear or a motor control center and shares bus connections with electrically noisy loads such as variable-speed drives.

Step-up/down transformers are available to meet specific voltage requirements. In addition, PowerLine DPA has a high overload capacity and robust short-circuit capability, and is available with rated powers of 20 to 120 kVA. With input and output (three-phase) voltages in the range of 220 to 415 VAC the UPS requires no onerous electrical installation considerations and is straightforward to service.

PowerLine DPA's IP31-rated protection can easily cope with dust, water condensation, humidity up to 95 percent, corrosive air contamination and rough manhandling.

An anti-condensation heater, lifting eyelets, dust filters, IP42 protection, halogen-free cables and black start capability are some of PowerLine DPA's other features that are designed specifically for deployment in demanding industrial situations.

Battery bank

Most industrial processes will draw substantial amounts of power from a UPS. Therefore, PowerLine DPA is equipped with valve-regulated lead-acid (VLRA) or NiCad batteries to support autonomy times up to 10 h. Fast recharging is also catered for to get the UPS battery bank back up to operational levels as quickly as possible.

Remote monitoring

In a power fail situation, it is important for all relevant personnel to be quickly and fully informed of the system status. For this reason, the PowerLine DPA UPS can be supplied with relay boards and a network management card that provide connection to a DCS (distributed control system) or SCADA (supervisory control and data acquisition) system via SNMP, Modbus TCP or Modbus RS 485. These interfaces allow environmental monitoring, extensive alarm handling and dispatching, redundant UPS monitoring, integration of PowerLine DPA into multivendor and multiplatform environments and the supply of UPS data to Web applications.

The PowerLine DPA UPS has not only a small footprint but has cable access at the front, which eliminates the necessity for rear access and the associated extra space this entails.

Connectivity via interfaces such as Modbus and SNMP allows the UPS to be a part of the IoTSP (Internet of Things, Services and People) too. This makes the UPS part of a network that enables industrial production systems to exchange information and interact. The IoTSP allows the UPS to work together with the process control system and makes UPS data available throughout the entire value chain and supply chain in real time. A presence on the network enhances the overall capabilities of data acquisition, operations, maintenance and advanced service.

Local control and metering are provided via an HMI (human-machine interface) consisting of a graphical display showing the UPS mimic diagram, UPS operating status (normal, battery and bypass), and programmable alarms.

A UPS for the future

The guarantee of a continuous supply of clean power for their critical operations has become an essential prerequisite for the success of many enterprises – transportation, mining, and the food and beverage industry to name but a few. The PowerLine DPA UPS, designed to withstand the rigors of rough industrial environments, can provide this guarantee. PowerLine DPA's modular architecture makes it simple to service or expand and because its online swapping attributes mean it never has to be switched off (it is designed to run up to 15 years continuously), first-class availability is achieved.

With its efficiency of up to 97 percent and unity power factor, the PowerLine DPA UPS offers improved efficiency and optimization of investment as well as ease-of-use and enhanced safety in a wide variety of industrial environments. Combined with ease of serviceability these characteristics mean PowerLine delivers a very low TCO over the lifetime of the product.

PowerLine DPA is equipped with VLRA or NiCad batteries to support long autonomy times of 1 to 10 h.

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Stirred, not shaken

Ultralow harmonic drives keep harmful harmonics out of food and beverages

TIMO HOLTTINEN – Customers expect their equipment to handle their products with care and avoid unnecessary shaking or vibrations. While this requirement is an obvious one for the food and beverages on the production line, it is also true for the electrical supply that keeps the plant working. Electricity networks can easily be affected by harmonics, or higher-order oscillations introduced by various types of equipment. Harmonics can have negative effects, such as overheating and malfunctioning, on other equipment connected to the grid. Although solutions exist to counter or mitigate harmonics, the better solution is to employ equipment that doesn't cause them in the first place. ABB offers a range of ultralow harmonic drives.

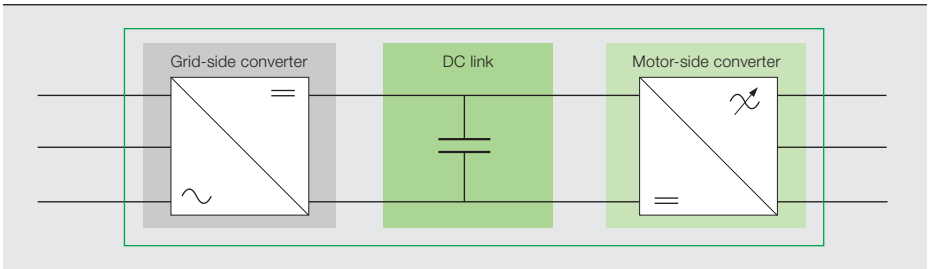
Many phenomena in nature occur in cycles. Examples include a rotating wheel, waves on the sea or the changing seasons. The term "cycle" suggests a rotation at constant speed, something mathematicians describe using the sine function. However, the above examples would not (with the possible exception of the wheel) be adequately described by this function alone. The aberration takes the form of superimposed higher frequencies, which are themselves also sine functions. One way of picturing this would be that the outdoor temperature follows the slow cycle of the seasons throughout the year but is also affected by the much shorter cycle of day and night.

Harmonics are not in themselves a problem. Without harmonics, musical instruments would all sound the same, musicians wouldn't be able to play chords and surfers wouldn't have much pleasure on the waves. But in electrical systems, harmonics could wreak a lot of havoc. Because the generators in power plants rotate at constant and regulated speed, the current in an AC grid is sine shaped in the ideal case. However, in reality it often isn't because harmonics are introduced into the grid through various effects. Equipment that introduces harmonics includes motor starters, variable-speed drives, welding equipment, uninterrupted power supplies and computers. The harmonics they cause can negatively affect other devices and systems connected to the grid. In motors, transformers and other equipment they cause heat, which is wasteful of energy, requires additional cooling and can ultimately damage the equipment. Displays and lighting can flicker, circuit breakers can trip and measurement devices can give false readings.

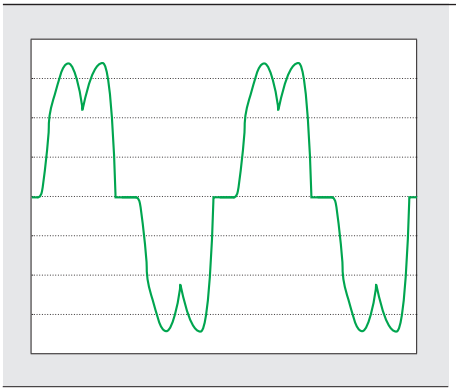
> Harmonics can negatively affect other devices and systems connected to the grid.

Why does a variable-speed drive cause harmonics? Such a drive converts a fixed voltage and fixed frequency input (from the grid) to a variable voltage and frequency output (typically to control and power a motor). This is usually achieved through the intermediary of a DC link: Two converters are arranged back-to-

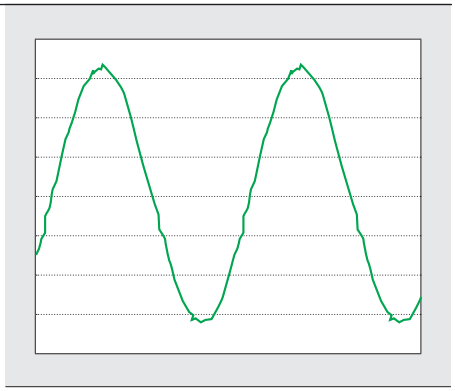
1 The grid-side converter can introduce harmonics to the grid.



2 Harmonics are reduced from 30 to 50 percent to just 5 percent.

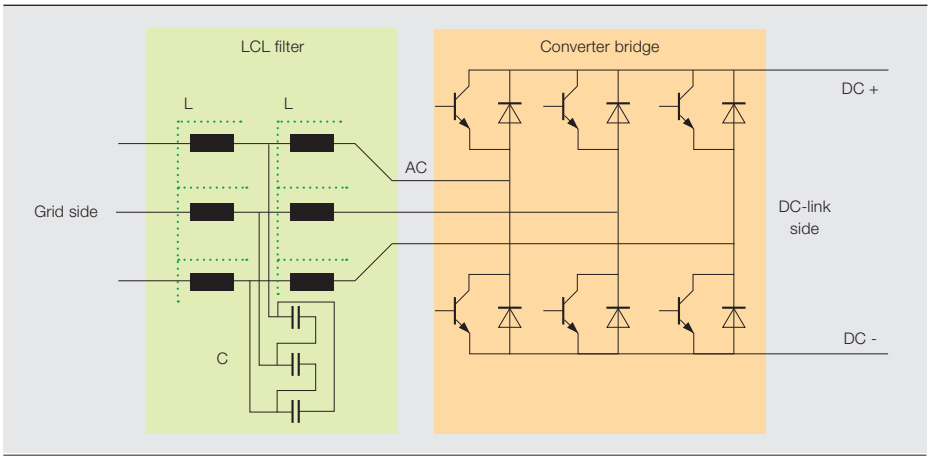


2a Diode supply



2b Active supply

3 The grid-side converter and built-in filter.



back with the AC grid input being converted to DC in the first converter and then converted back to AC at the required voltage and frequency in the second ➔ 1. In conventional drives, the grid-side converter uses a six-pulse diode bridge. The drawback of this solution is that it introduces current harmonics into the grid ➔ 2a. Especially prevalent are the so-called fifth and seventh harmonics (ie, they have five and seven times the grid frequency, respectively). The resulting distortion can account for 30 to 50 percent of total current.

The problem of harmonics is far from new and multiple solutions exist, including active and passive filters, chokes and multi-pulse methods with multi-winding transformers. But prevention is better than cure and thus ABB offers ultralow harmonic drives created to avoid these harmonics by design. Such a converter, combined with the drive's built-in active supply unit together with the line filter, can reduce the current distortion to below 5 percent ➔ 2b–3. The input converters of ultralow harmonic drives do not use diodes but IGBTs[1] that can be used to actively modulate smoother waveforms.

Footnote

1 See also page 58.

4 The ACS800-31 drive

ABB offers a family of ultralow harmonic devices, an example of which is the ACS800-31, a wall-mounted drive for up to 110 kW. It includes EMC filters and I/O extension modules and is available with an IP21 protection rating, making it suitable for several applications in a food and beverage environment.

For higher power requirements, the cabinet-mounted ACS800-37 drive for up to 2,800 kW is available with a protection rating up to IP54.

ABB's drives are easy to set up and configure and are suitable for a broad range of working environments and power classes.

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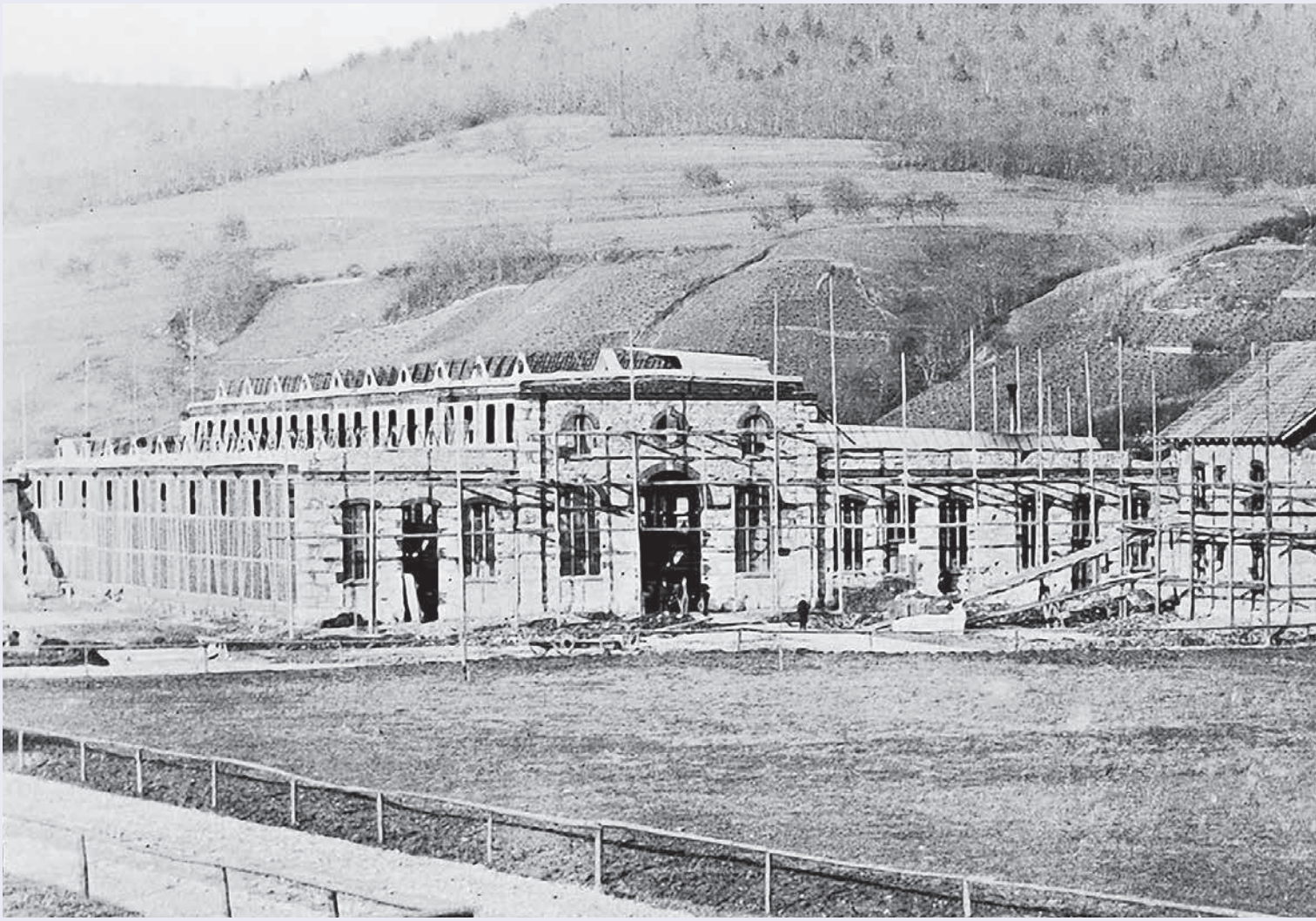
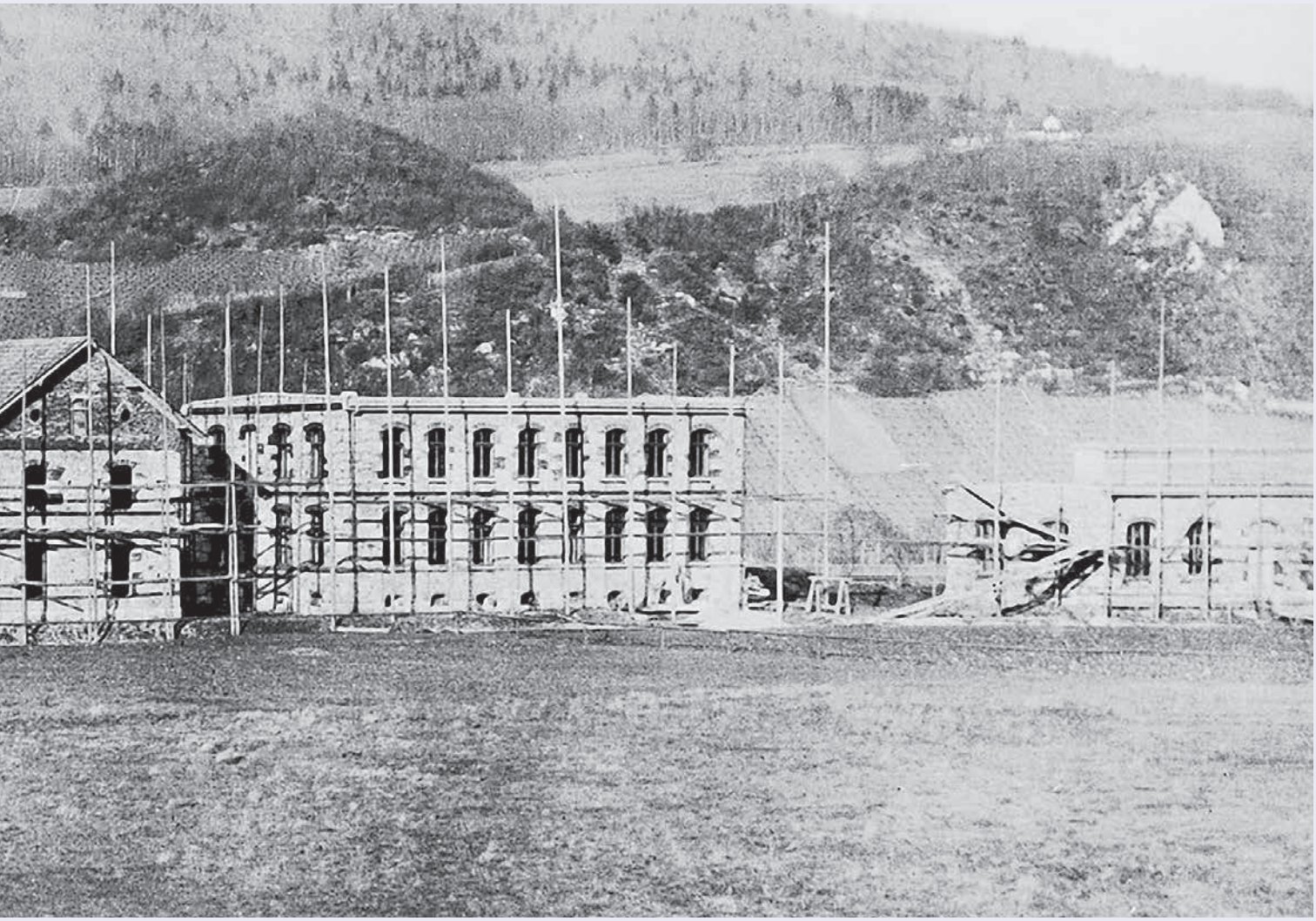


125 years

ABB celebrates 125 years in Switzerland

MALCOLM SHEARMUR – In 1891, Charles Brown and Walter Boveri created a start-up in Baden, Switzerland, to tap the opportunities of a promising new technology – electricity. Thanks to the vision and entrepreneurial spirit of its founders, Brown Boveri & Cie. (BBC) quickly became a success, pioneering many innovations that power the modern world. Some years before the BBC genesis, in 1883, ASEA was founded in Västerås, Sweden, by Ludvig Fredholm as a manufacturer of electrical light products and generators. ASEA was also a pioneer and the company continued to produce a stream of innovations for power and industrial applications until its merger with BBC in 1988 to form ABB. In this article – the first in a series to look at some of the main achievements of ABB and its progenitors over the past 125 years – the impact on modern society of ABB developments over the past century-and-a-quarter are assessed.



Brown and Boveri complemented each other perfectly: The former was an inspired engineer who designed the transformer and generator for the first power station to transmit high-voltage power (in Lauffen, Germany); the latter – also technically gifted – was a visionary businessman who drove the European expansion of BBC.

BBC was a pioneer from its earliest days: Within a year of its founding on October 2, 1891, it had electrified its own factory and enabled the first power station in the town of Baden to come into existence. By 1895, it was supplying electrical equipment for the tram system in the Swiss city of Lugano and, in 1897, BBC developed the first high-voltage oil circuit breaker, which was the foundation of ABB's expertise in switchgear and substations.

Title picture
1891: The construction of the first BBC offices and production facility in Baden, Switzerland.

Belief in the power of electricity

BBC's success was in large part down to the founders' belief that electricity was going to change the world. Indeed, so convinced were they that steam locomotives would be replaced by electric ones that, in 1905, BBC electrified the newly completed Simplon rail tunnel between Switzerland and Italy at its own expense. Six years earlier, the company had developed an electrically powered locomotive that was used on Europe's first electrified standard-gauge track on the Burgdorf-Thun line, beginning a new era in railway electrification.

> BBC's success was in large part down to the founders' belief that electricity was going to change the world.

These innovations were among many pioneering technological developments that made BBC and later ABB a byword for innovation. In the 1940s, BBC developed the first high-speed locomotive with a direct-drive system, improving efficiency and reliability, and in the 1960s, it pioneered the first gearless-drive cement mills. The company built the world's most powerful transformer in the 1970s and provided power generation and transmission systems for the world's largest hydropower station in the 1980s.

ASEA innovations

Since its foundation in 1883, ASEA also followed a path of innovation, making early advances in three-phase generators, motors and transformers. ASEA built and commissioned entire nuclear plants and recognized early on the potential of robotics – introducing its first industrial robot in 1974.

BBC developed the first high-speed locomotive with a direct-drive system, improving efficiency and reliability, and in the 1960s, it pioneered the first gearless-drive cement mills.

Innovation continues at ABB

Since the merger of BBC with Sweden's ASEA in 1988 to form ABB, the company has continued to drive innovation in its core segments of power and automation. It has developed technologies that allow customers to provide reliable power supplies and improve productivity while lowering environmental impact. ABB has retained technology and market leadership in many leading areas, such as industrial robotics, which improves quality and safety in manufacturing; variable-speed drives, which slash the energy consumption of electric motors; automation systems, which run factories cost-effectively; and high-voltage direct current technology which allows power to be transmitted over long distances with low losses.

In short, many of the benefits taken for granted in daily life, from electricity at the touch of a switch to the consistently high quality of industrial goods, were made possible by technology developed by ABB, and its predecessors ASEA and BBC, over the past 125 years.

ABB is everywhere

Today, ABB equipment is orbiting the earth and working beneath it, as well as crossing oceans and operating on the seabed. ABB technology is found in homes, offices and factories; in the plants that generate power and process water; in the fields that grow food; and in the trains and buses that are so critical to the transport network.

ABB believes in building long-lasting, value-creating partnerships with customers, suppliers, business partners, employees and the communities in which the company operates. ABB's goal in this milestone year is to celebrate with all those who have contributed to the company's success.

A year of anniversary events

ABB will mark the 125th anniversary in 2016 with a number of events in Switzerland and around the world. These include a gala event for customers, public officials and other key stakeholders in October. The company also participated in the opening, in Switzerland, of the world's longest tunnel – the new Gotthard rail tunnel. BBC played an important role in the electrification of the first Gotthard tunnel – opened in the late 19th century – and ABB is a major supplier to the latest project.

At these events, ABB will also feature some of the changes being driven by the company's 8,500 technologists. For example, with the surge in demand for renewable energy, power grids are becoming increasingly complex so ABB is providing new solutions to improve the efficiency and reliability of the power supply that is so critical to the wellbeing of families and businesses around the globe.

Further, in industry, the revolution in digital technology is opening up new ways to increase productivity. A new industrial era is being shaped in which machines are increasingly able to perceive their surroundings and interact with human beings, creating the Internet of Things, Services and People.

ABB is a multicultural team that spans the globe, working in a fascinating world of high technology. Together with all stakeholders, ABB looks forward to celebrating the achievements of the last 125 years and to sharing the company's excitement about the prospects for the future.

125
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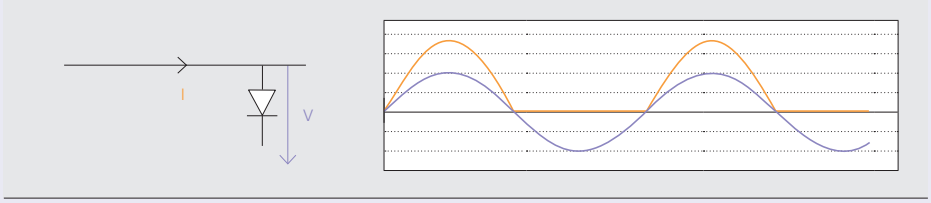
Power semiconductors

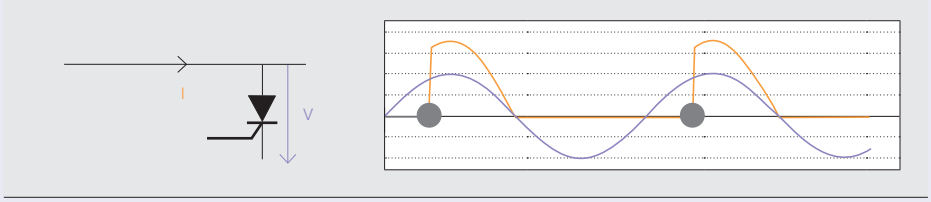
The past and present of power semiconductors at ABB

ANDREAS MOGLESTUE, MUNAF RAHIMO, SVEN KLAKA, CHRISTOPH HOLTMANN – What do a locomotive, an HVDC station and a phone charger have in common? They all feature the conversion of electrical power from one form to another and, if they are of recent construction, they almost certainly use power electronics. For more than 60 years now, ABB and its predecessor companies have been developing and manufacturing power semiconductors, the small and sturdy switching elements at the heart of power converters.

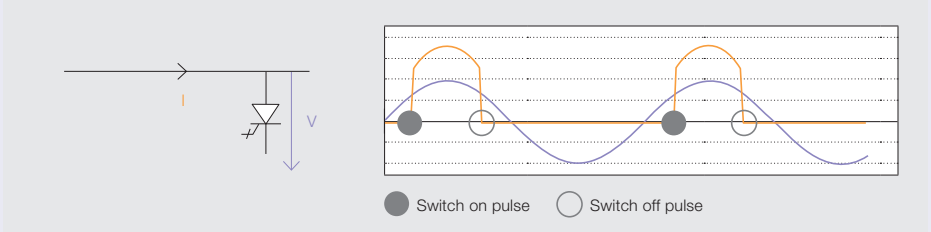
1 Comparison of the application capabilities of diode, thyristor and GTO



1a Diode



1b Thyristor



1c GTO

The term “semiconductor revolution” is often associated with the recewnt and rapid emergence of new technologies in communications, data processing and entertainment. Unprecedented numbers of people are using social media or partaking in online commerce thanks to the ability to manufacture semiconductors at high levels of integration and low unit prices. Maybe less immediately visible, but equally fundamental to the far-reaching changes of recent decades, is another ongoing semiconductor revolution: power electronics.

Power electronics permits the transformation of electricity between different frequencies and voltage levels in a safe, efficient and cost-effective manner. For example it is estimated that 65 percent of all electrical power generated is used by electric motors. Being able to control motors more efficiently using power-electronics presents a huge savings potential in terms of resources and emissions. Similarly, the use of power electronics in the electric grid (for example through FACTS and HVDC) increases the controllability of power flow and means more power can be transmitted at lower losses. Turning to renewable energy, the vast growth of solar and wind generation of recent years would not have been viable without power-electronic converters to connect them to the grid.

But what exactly are semiconductors?

Semiconductors

A semiconductor is a material displaying an intermediate level of conductivity between a conductor and a non-conductor. The level of conductivity can be influenced by such factors such as material impurities, geometry, electrical fields, temperature, pressure and light. This makes them suitable for many sensor applications. More importantly, the interdependency of input and output variables

> Without power semiconductors, the present revolution in renewable energy would not be possible.

Title picture
The Lenzburg factory, with the original bipolar plant on the left and the new BiMOS plant on the right

2 Milestones from ABB's history in semiconductors

1954	Semiconductor development commences in Ludvika (ASEA) and Baden (BBC)
1956	BBC launches its first diode (100 V / 100 A)
1961	First BBC thyristor introduced (1,200 V / 100 A)
	Diodes reach 650 V / 200 A
1969	New plant opened in Lampertheim (BBC)
1970	Thyristors reach 3,000 V / 800 A
1976	Neutron transmutation doping introduced (BBC)
1977	New plant opened in Lenzburg (BBC)
1980	Thyristors reach 5 kV / 2 kA
1988	ASEA and BBC merge to form ABB
1990	Lampertheim plant is sold to IXYS
1991	ABB's semiconductor activities are concentrated in Lenzburg
1992	4.5 kV / 600 A IGBT sample is presented
1995	First samples of 4.5 kV / 3 kA IGCT are presented
1996	GTO and diode offering reaches 4.5 kV / 4 kA
	3.3 kV / 1.2 kA IGBT module for traction is introduced
	Bidirectional controlled thyristor (BCT) technology is introduced
1997	ABB launches a complete line of IGCTs from 500 kW to 9 MW
	4.5 kV / 1.2 kA IGBT module for traction with integrated heat sink is introduced
	2.5 kV / 700 A IGBT for HVDC Light® is introduced
1998	5 inch IGBT wafer fab opens in Lenzburg
2000	2.5 kV StakPak modules for HVDC light are introduced
2001	1.2 kV – 1.7 kV thin wafer soft punch-through platform (SPT) IGBT is launched
2003	High-voltage SPT IGBT/diode platform is launched (with record-breaking safe operating area)
	2.5 kV – 3.3 kV SPT-IGBT HiPak module platform is launched
2005	Lenzburg upgrades to 6 inch IGBT wafer fab
	3.3 kV-6.5 kV SPT IGBT HV-HiPak module platform is launched
2006	1.2 kV – 6.5 kV low loss SPT+ IGBT platform is launched
2007	High-power technology (HPT) IGCT platform is introduced
2009	8.5 kV / 8 kA thyristor is introduced
	High-voltage BIGT technology is introduced
2010	Capacity extension is added at Lenzburg and Polovodice is acquired
	4.5 kV StakPak modules for HVDC Light are introduced
	10 kV IGCT technology is demonstrated
2011	BIGT is demonstrated for HVDC breaker
2013	Ground is broken for WBG lab in Baden-Dättwil Improved HiPak 2013 is introduced
	BGCT technology (IGCT with reverse-conduction diode on the same wafer) is introduced
2014	Enhanced-trench IGBT technology is introduced

3 BBC thyristors from the 1970s

BBC produced its first thyristor in 1961.

Both of ABB's predecessor companies, BBC and ASEA, commenced development of semiconductor diodes in 1954, with commercial production beginning in 1956 → 2.

The diode

The diode is the most basic of all power electronic devices. It simply conducts current in one direction and blocks it in the other → 1a. This makes it suitable for rectification (conversion of AC to DC). The concept of the diode has been known since 1874 when Karl Ferdinand Braun observed rectification in metal sulfides. Semiconductor diodes suitable for power applications did not emerge until the 1950s.

makes them inherently controllable. The transistor, maybe the best known of all semiconductor device families, can be used to make a simple amplifier. A weak signal picked up by an antenna (and suitably filtered and rectified) can be input into a transistor where it is amplified to a stronger output capable of being played on a loudspeaker, forming a basic radio.

Power electronics requires devices that display a somewhat different functionality. Power conversion must be as energy efficient as possible, both for reasons of economy and because losses translate directly into heat and hence damage to the device. Power semiconductors are thus designed to act as physical switches (being either on or off) rather than as amplifiers.

The thyristor

One of the drawbacks of diode rectifiers is that their power output is not controllable. The thyristor is a device that adds the ability to be switched on. This is done by applying a current at a third contact called the gate. The reader may wonder what the value of a switch is that can be turned on but not off. Who would install, for example, a light switch that cannot be turned off? In fact, many dimmer switches for lights do use thyristors. The trick is that the current does not need to be forcibly switched off because it extinguishes at the zero crossing → 1b. By varying the phase angle of the ignition, the average power takeup of the light can be controlled. Besides such AC to DC conversions, thyristors can also be used in DC to AC conversion (inversion), but only if there is local commutation (for example, local generation) on the AC side.

The thyristor was first described by William Shockley in 1950. BBC began production in 1961.

The GTO

Although the thyristor has found many applications, there is nevertheless a case for devices that can be turned off. For example when implementing pulse-width modulation (PWM) for converting DC to AC without the support of local

4 GTOs of different diameters

5 HiPak IGBT modules

In 1998 that a new wafer fab was inaugurated, permitting the entire IGBT manufacturing process to be performed in-house.

commutation (and furthermore being kinder on harmonics, reducing the need for filters).

The gate turn-off thyristor (GTO) makes this possible. It is similar in operation to the thyristor, but can be switched off with a reverse current at the gate ➔ 1c.

GTOs have existed since the 1960s, but both ASEA and BBC were latecomers to the field. BBC launched its first GTO in 1980.

The IGBT

A new device entered the power electronics scene in the 1990s. The integrated-gate bipolar transistor (IGBT) is controlled by voltage rather than current, greatly simplifying the control circuitry. It is also more operationally stable than the earlier devices described above (collectively known as bipolar technology) as the IGBT's voltage increases during short circuit, inherently limiting the current. This reduces the complexity of the protective circuitry required. Furthermore, by virtue of not needing to be mounted in pressure stacks, IGBTS are easier to install and replace.

ABB made its first forays into IGBT manufacturing in 1992. In 1998 a new wafer fab was opened in Lenzburg, Switzerland, permitting the entire manufacturing process to be performed in-house.

In their early days, IGBTs were used mostly in drive applications, but with the introduction of HVDC Light in 1997, they also began to play a part in power networks.

The IGCT

One might be forgiven for assuming that the rapid rise of the IGBT would lead to a similarly rapid demise of the GTO. But there is still demand for the technology, especially in the higher power classes not well served by IGBTs.

In 1997, ABB launched the integrated gate-commutated thyristor (IGCT). The IGCT is essentially a GTO but has an integrated (rather than external) gate unit that supplies current pulses to the gate. The closer spatial integration leads to lower inductance and thus permits faster switching cycles and lower harmonics. The IGCT is well suited for high-power drive applications.

ABB continues to develop all of these families of switching devices ➔ 6.

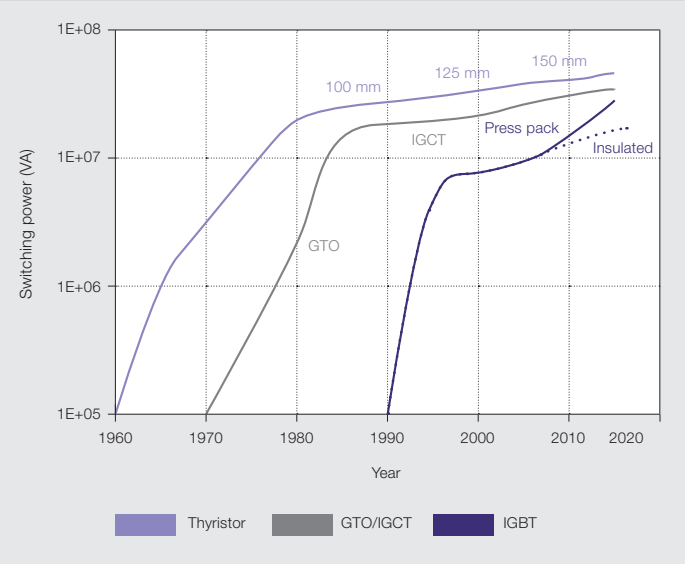
Manufacture of semiconductors

The manufacture of power semiconductors is a complex process requiring high precision and a controlled and very clean environment. The base material is a pure momocrystalline silicon semiconductor in wafer form, whose electrical properties are modified by inserting atoms of a dopant material into the crystal structure. Numerous steps are required to produce the complex power semiconductor structure ➔ 7. Following completion of the wafer, the semiconductors are cut, tested and packaged.

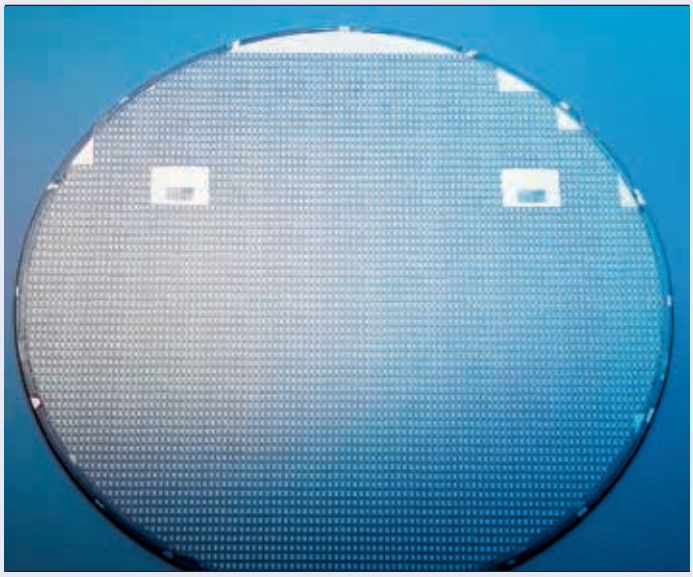
Semiconductors at ABB

ABB's two predecessor companies (ASEA and BBC) entered the field of

6 Evolution of switching power



7 An IGBT wafer before being sawed into chips



The IGCT is essentially a GTO but has an integrated (rather than external) gate unit.

semiconductor research and manufacturing independently in 1954 ➔ 2. At the time of the merger in 1988, there were three active manufacturing sites. These had been consolidated into the Lenzburg (Switzerland) factory by 1991. Previously, the research in and manufacture of semiconductors had primarily been considered supportive of ABB's other activities. By forming a subsidiary, ABB Semiconductors Ltd, ABB was able to grow its semiconductors activities to also serve external customers directly.

A BiMOS (IGBT and diode factory) was added to the Lenzburg site in 1998 ➔ title picture. ABB added a second manufacturing location in 2010 when it acquired the Prague-based company, Polovodice. Today bipolar manufacturing occurs in both Prague and Lenzburg, and BiMOS is manufactured in Lenzburg.

Wide bandgap materials

Besides some early diodes made of germanium, all ABB semiconductors described in this article so far used silicon as base material. In 2014, ABB opened a new lab at its corporate research center in Baden-Dättwil (Switzerland) for the development of wide bandgap materials. Devices using such materials promise lower losses and better heat tolerance than silicon, permitting them to achieve even higher performances.

After more than 60 years of development, the semiconductor revolution is showing no signs of slowing down.

This article is partly based on "Semiconductor generations: ABB looks back on 60 years of progress in semiconductors", published in ABB Review 3/14.

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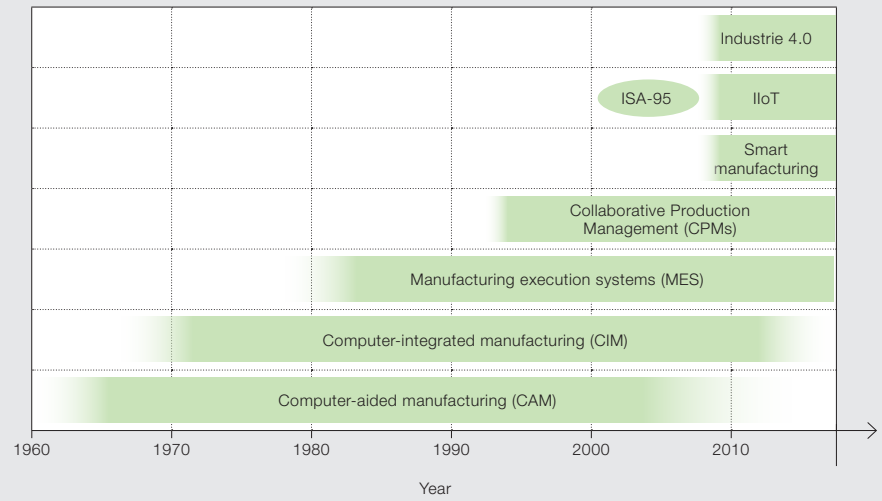
Integrating IT and OT

Leveraging operational technology integration with Decathlon Services

MARGRET BAUER, WERNER SCHMIDT, JAN-CHRISTOPH SCHLAKE, PER LARSEN, CHRISTIAN JOHANSSON – Gathering and providing industrial production data has historically been an expensive undertaking – not because of costly sensors but rather due to the cost of setting up power and communication cables, establishing connections to controllers and gateways, and integrating measurements into the automation architecture. Given all of this effort, it may be surprising to learn that the data gathered and stored remains largely unused. In the future, low-cost sensing technology will provide even more data. It is estimated that a modern wind farm equipped with new sensor technology may generate 150,000 data points every second [1]. The keys to managing and creating value from large amounts of such operational data are to provide easy access and portability of data, combine operational data with data based on IT (information technology), and define business intelligence and logic based on data. ABB's Decathlon Services platform provides the technology to implement all three elements.

Title picture
ABB's Decathlon Services platform enables plants like these to make good business decisions by integrating often-neglected operational data with information technology.

1 Timeline of initiatives regarding the integration of software solutions in the process industries



The market research company Gartner has called the data that is gathered and stored but left unused, "dark data." Gartner suggests that the cost of storing and securing operational data is greater than the value it brings unless business intelligence is added to leverage the information contained in the data.

From CIM to the Internet of Things, Services and People

Dark data remains in the data "graveyard" when – on its own – it can only be interpreted by operators or engineers who are very familiar with the production facility from which the data originates. These experts often manually combine information from maintenance logs, piping and instrumentation diagrams, as well as process trends and alarms. In short, data needs to be embedded in the context of all software systems to create meaning and generate value.

Computers and IT have been present in many areas of manufacturing and processing companies for a long time, from making business decisions to managing production on an operational level. Initially, individual software solutions managed production, plant assets, energy use, raw materials and the safety of the operation, among many other elements.

However, these are all interconnected on a fundamental level – the actual process. Their common goal is to increase throughput and lower the cost of operation.

In the past, software solutions that supported business processes and plant operation all started as independent "island" programs and were typically purpose-built, bottom-up solutions. The idea to build bridges between these islands arose as soon as these islands started growing bigger and closer together, eventually overlapping.

Data needs to be embedded in the context of all software systems to create meaning and generate value.

→ 1 shows the timeline of integration initiatives – both government- and industry-driven. Computer-integrated manufacturing (CIM) builds on different aspects such as computer-aided manufacturing and lean manufacturing. In different terminology, some aspects of CIM are called manufacturing execution systems (MESs) or, as of the 1990s, Collaborative Production Management (CPM). Around 2000, the standard ISA-95 was published by the International Society of Automation to describe the interface between enterprise and control system. ISA-95 realizes the Purdue reference model, which was a result of CIM discussions and initiatives [2].

Very recently, governments in the United States and Germany started the Smart Manufacturing and Industrie 4.0 initiatives, respectively. Both build on the enabling technologies of the Industrial Internet of Things (IIoT), which links machines, sensors and actuators via Internet protocols. Industry 4.0 and Smart Manufacturing comprise many different elements, but one important commonality is the ease of connection and interaction of all components – sensors, actuators, controllers, production equipment, and so on – in a plant. ABB defines the effort to connect all aspects of production via the Internet as the Internet of Things, Services and People (IoTSP), highlighting the fact that data analytics or business intelligence (services) are applied to equipment (things) and are used by decision makers (people).

The challenges of integration

There is nothing new about the idea of integration – it has been around for at least 30 years. Industrie 4.0 has, indeed, been described by critics as "old wine in a new bottle" [3]. So why is it only being talked about but not exploited in most areas of potential application?

2 Decathlon Launchpad is a collection of software applications for production processes.

There are major hurdles that need to be overcome to make two or more software components work together.

There are major hurdles that need to be overcome to make two or more software components work together. Technology is one aspect that hinders integration, but there are several others relating to business decisions and organizational issues as well.

Legacy of existing systems

On any industrial production site there are many existing software systems that deal with different aspects of production – the automation system, enterprise resource planning, production and maintenance planning, as well as asset, alarm and energy management. These systems will not be replaced in one fell swoop. However, some of them may provide an interface so that data becomes available. Often, the common denominator and only means of data exchange is Microsoft Excel or files in comma-separated value (CSV) format.

Integration spans the complete value chain

Integration affects all aspects of running a production plant, from order management, planning and scheduling to control, maintenance and quality management. This spread results in not only differing business objectives but also the involvement of people from various parts of the organization. The challenge is to capture the main requirements of each aspect, sift out nonessential requirements, and find a standard that will satisfy all critical tasks.

Unquantifiable business value

In brownfield applications, existing software systems run the plant as efficiently as possible. To economically justify integration, concrete examples are required that show that exchanging data either reduces the cost of operation or increases the production throughput or quality. Often, the benefit only becomes evident once the integration is complete; this is due to synergies and collaboration of people as well as business processes.

Technical challenges

There are numerous technical challenges, but they can be addressed using modern technology. The question is whether the expense is justifiable. Technical issues include:

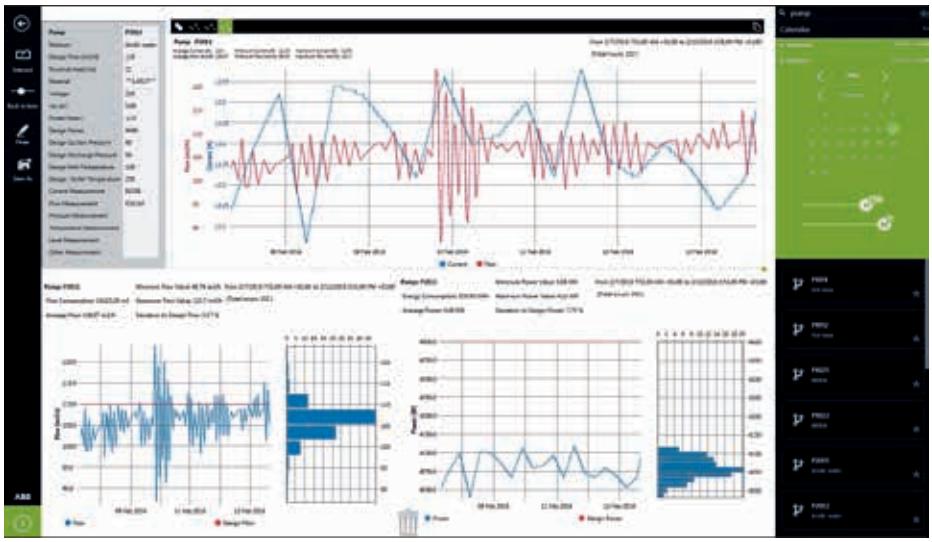
- Data integrity, safety and reliability requirements
- Data security and control system cyber security
- Standardized descriptions and definitions of components
- Integration over different timescales
- Incorporation of human intervention
- Integration of enterprise and process models

Requirements of an integration platform

With recent technology advances and ongoing developments in the area of big data, technological challenges are being addressed. This is why, after decades of more or less fruitless attempts, integration across IT and automation system infrastructure is closer to realization than ever before. To overcome the hurdles relating to the business value, an integration platform has to fulfill the following criteria:

The key to integrating existing IT and operational technology (OT) infrastructures is not to replace them but to establish connectors that require no configuration effort.

3 Interactive dashboard with drag-and-drop items



Simple to install, upgrade and work with

No expert user is going to readily give up a system that she has worked on for a long time unless the new system is significantly easier to use. In the age of smartphones, expectations relating to usability are very high. Industrial software has a lot of catching up to do to reach the same level as privately used technology.

Connection to existing systems

The key to integrating existing IT and operational technology (OT) infrastructures is not to replace them – at least not initially – but to establish connectors that require no configuration effort. The fact that the system is designed to run in parallel to existing solutions also means that the data to be accessed is not simply copied but truly accessed – that is, data is retrieved, analyzed and displayed on demand only.

Implementation of business intelligence

Once the data from the various parts of the production is centrally available, it needs to be combined and analyzed to realize business intelligence. Business intelligence is often logic that is applied manually by trained personnel – eg, "If condition A is fulfilled and a process measurement B exceeds its limit, then act." This logic has to be configured and managed intuitively in configuration tools, which should be accessible to all users.

New business value generation

The platform should reveal opportunities to lower production cost by aligning operational processes, or increase production by using assets more effectively. These goals may be achieved by combining information from different systems – for example, asset and operational information – to create added value.

Internet of services for industrial automation

ABB Decathlon Services is a platform that addresses the challenges of integration with state-of-the-art technology.

Launchpad for industrial software

Decathlon Services provides an environment for embedding applications related to the same production process – eg, alarm management and resource allocation. The software applications, or apps, are located in the Decathlon Launchpad, which is the single access point for desktop users to apps, reports, documentation and other data. The look and feel is that of modern operating systems such as Microsoft design language or Android or iOS smartphones ➔ 2. The apps on the Launchpad are centrally managed and can be personalized for each user profile.

Search all data

Just like an Internet search engine, the Decathlon search engine takes a keyword and returns relevant result pages or tiles (graphical representations). Users can search for generic terms such as "KPI" and "pump," which returns all KPIs (key performance indicators) and pumps in a plant, or for specific items such as a sensor measurement, eg, "LC1006," which complies with the ISA-5.1-2009 standard – a level (L) measurement used for control (C).

4 ABB's Collaboration Table with Decathlon software

In general, a plant search tool is more straightforward than an Internet search engine. Each variable – process measurement, KPI, physical asset or image – has a known ID and name. For example, a lactic acid reactor in a plant, which is connected with a number of sensors and actuators, can be found by searching for "lactic acid." For a specific temperature reading, a user might search for "lactic acid" and "temperature," or "TC" if it is a controlled temperature. In Decathlon, the search functionality is integrated into the Dashboard but can also be accessed from other applications.

Interactive dashboard

A production plant operator utilizes a dashboard to display key information. The Decathlon Dashboard App and an example of a configured dashboard are shown in ➔ 3. The starting point is the search function in the top right corner. Entering, for example, the search term "pump" generates a list of all pumps in the plant. The pump tile is displayed when dragging and dropping the search results onto the empty canvas. There is more than one way to represent the search results, which are displayed as tabs in the top left corner of the tile.

By accessing, combining and interpreting trends, the dashboard brings value to dark data. The data is taken from the data graveyard and can be handled by people who are not deeply familiar with the process. The data is available to all and can be examined carefully to reveal information about the production process.

ABB Decathlon Services is a platform that addresses the challenges of integration with state-of-the-art technology.

Collaborative environment

Integrating IT and OT can be a challenge, as the integration must span several parts of the supply chain. It involves the collaboration of people as well as IT/OT systems throughout the organization. Even if it is possible to exchange data between various sources, expert knowledge is required to interpret the data. Getting all involved parties to the table for comprehensive decision-making processes can be a challenge.

Decathlon Services is optimized for use on ABB's Collaboration Table ➔ 4 – 5. The Collaboration Table integrates OT data straight from the control system domain and sets a new standard for how this industry-based data can be used in an office environment.

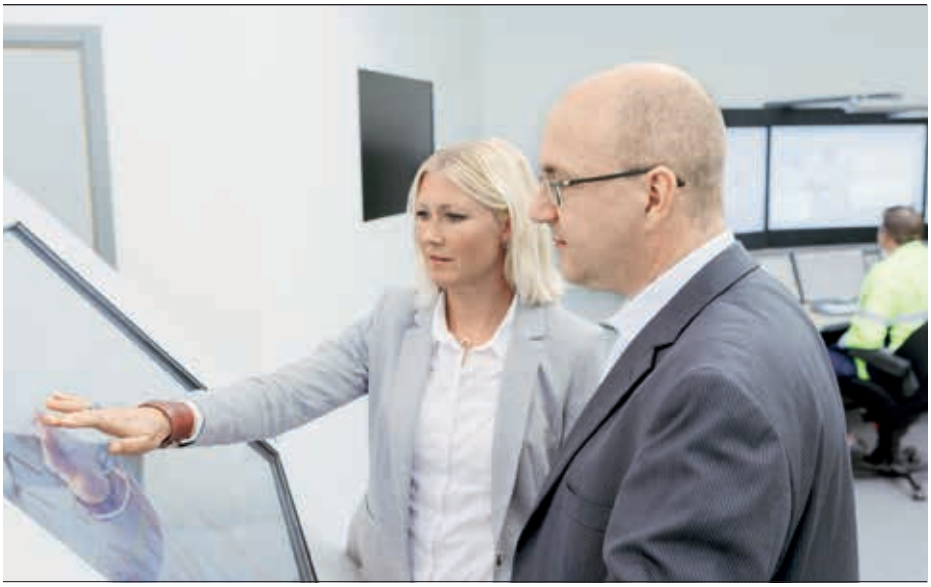
Integration technologies

Technological advances have helped the integration of various types of industrial software, which had previously been used independently of each other, al-

By accessing, combining and interpreting trends, the dashboard brings value to dark data.

Integrating IT and OT involves the collaboration of people as well as IT/OT systems throughout the organization.

5 With its 55-inch touch screen and ergonomic design for 24/7 environments, the ABB Collaboration Table enables users to interact with and explore IT/OT data.



though integration efforts have been attempted for several decades. → 6 lists key novelties in designing software. An important result of technology advancement is improved life cycle. Often, data analysis tools become outdated quickly because they cannot be easily adapted to plant changes. The split between user interaction and business intelligence should eliminate the problem because it links only available data sources and keeps the algorithm intact and functional.

Easy app implementation

Two examples of areas in which the Decathlon Services app can provide valuable decision making information are energy monitoring and KPI management.

Energy monitoring

With increasing energy costs and new regulations that govern energy consumption, production processes have to monitor, plan and optimize energy usage. Production processes must be closely monitored, requiring measurements from the process control system to be obtained. Current, power or gas supply measurements give the exact energy use of each asset. These measurements are aggregated by section and made available in ABB's Energy Monitor. The app follows the ISO 50001:2011 standard for implementing, maintaining and improving an energy management system. The energy consumption directly impacts production scheduling, plant asset management and other aspects of production. With Decathlon, information about the energy usage is made directly available to planning and scheduling as well as to asset monitoring systems.

KPI management

A production manager needs to monitor the performance of a plant or several plants across the enterprise. This requires access to plant production data such as product throughput, asset availability and resource consumption. These production KPIs are defined in the ISO 22400 standard. A Decathlon Services app provides an easy KPI configuration tool, which defines KPIs based on online production data. These KPIs are available on the configurable dashboard and reports can be easily compiled with the drag-and-drop function. Related time trends of other process measurements can be included in the report. This view on combined data enables the production manager to find the root causes of KPIs that are below target.

Decathlon Services app can provide valuable decision making information are energy monitoring and KPI management.

6 Key novelties in designing software

IoTSP feature	Benefits
Software ecosystem and user experience	Decathlon furthers the evolution of an industrial software ecosystem, ie, "a collection of software systems, which are developed and co-evolve in the same environment" [4]. It provides the technology for a positive user experience through an interactive design, which includes a drag-and-drop feature, one-click interaction and zooming options.
Software development kit (SDK)	One of the factors of Apple's success was the concept of a software development kit. An SDK is a set of tools that enables the construction of apps for a specific software framework or operating system. Apple first published its SDK for iOS in March 2008 and the App Store opened a few months later. By June 2015 there were 1.4 million apps available. Decathlon Services offers an SDK that allows third-party developers – customers, universities and private persons alike – to write industrial software that integrates all operational data.
Data accessors	Data accessors are connectors to databases. Databases are third-party process-data historians in enterprise resource planning (ERP) systems. They can be written in SQL, NoSQL or NewSQL. The data accessor makes the data contained in the database available to the native apps as well as to the configurable dashboard.

Overcoming the hurdles of integration

Decathlon Services is easy to install and configure. More importantly, the functionalities of existing programs are kept in apps that can be downloaded and installed. Apps are independent of platform changes and can be added and removed individually. The Dashboard App enables the display and analysis of data using an intuitive drag-and-drop function.

The concept of accessors allows the connection to existing databases from any app within Decathlon. Data points from sensors or even calculated data can be located through the search functionality.

Business logic can be implemented in the apps. Process data and other data is available, and logical connections can be established. For example, if the operating hours of a pump exceed a certain value, a maintenance request can be triggered. Decathlon comes with an SDK that allows the user, independent software companies as well as academic institutions to develop new apps.

Integrating different applications enables the interconnection of production data from various systems. The flexibility of the Decathlon Services platform enables the expansion of values and business opportunities. In addition to its integration capabilities, it applies analytics to the integrated data – a unique offering. No matter where the data is stored, no matter where the data is processed (locally or in the cloud), Decathlon Services provides the means to be the control and monitoring center for operational and asset data. None of this would be possible without the integration of IT and OT.

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Further reading

http://new.abb.com/decathlon
http://www.isa-95.com/

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An alternative to SF_6 as an insulation and switching medium in electrical switchgear

THOMAS DIGGELMANN, DENIS TEHLAR, JOCELYN CHANG, SEBASTIAN ZACHE –
For decades, the unique properties of sulfur hexafluoride (SF_6) have made it popular as an insulation and switching medium for electrical switchgear. However, SF_6 is a greenhouse gas and there are life-cycle management costs associated with its use. For some years, ABB has been conducting research into alternatives with lower environmental impact but with insulation and arc interruption properties similar to those of SF_6. This mission has now been accomplished and the world's first gas-insulated switchgear (GIS) pilot installation to use a new gas mixture has recently been commissioned in Switzerland.

An SF_6 alternative is needed that can be used in all cases.

Across utilities and industry, rising awareness of global warming and climate change is driving the replacement of many products by more environmentally friendly alternatives. The ubiquitous insulation and switching medium, SF_6, a manmade gas developed in the early 20th century, is no exception to this trend. Due to its excellent properties for electric insulation and arc interruption, SF_6 enables safe and reliable operations while making it possible to significantly reduce the size of switchgear installations.

Title picture
SF_6 has proven its worth as an insulating medium in electrical switchgear. However, the global warming implications of SF_6 are coming under scrutiny. ABB has now developed an alternative that in certain cases comes close to the performance of SF_6. Shown is high-voltage GIS.

However, SF_6 is a greenhouse gas and the life-cycle management costs incurred when handling SF_6, particularly when decommissioning aging substations, are increasing. These costs will rise further as the demand for electricity, and, thus, for gas-filled high-voltage and medium-voltage switchgear, increases. This factor makes the search for an environmentally friendly alternative to SF_6 all the more urgent.

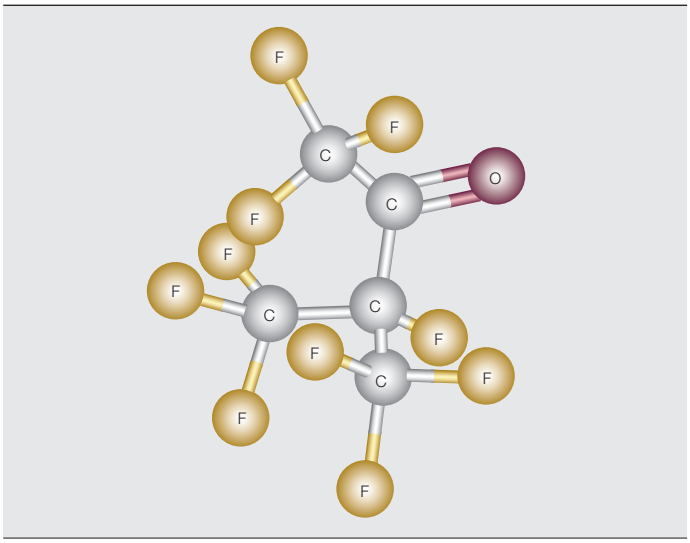
ABB has already developed and commissioned air-insulated high-voltage circuit breakers that use carbon dioxide (CO_2) as an insulating and arc-quenching medium, and medium-voltage ring main units (RMUs) that utilize air in a gas-insulated switchgear design. However, these solutions are only part of the picture – an SF_6 alternative is needed that can be used in a wider field of applications.

The search for an insulating and switching medium

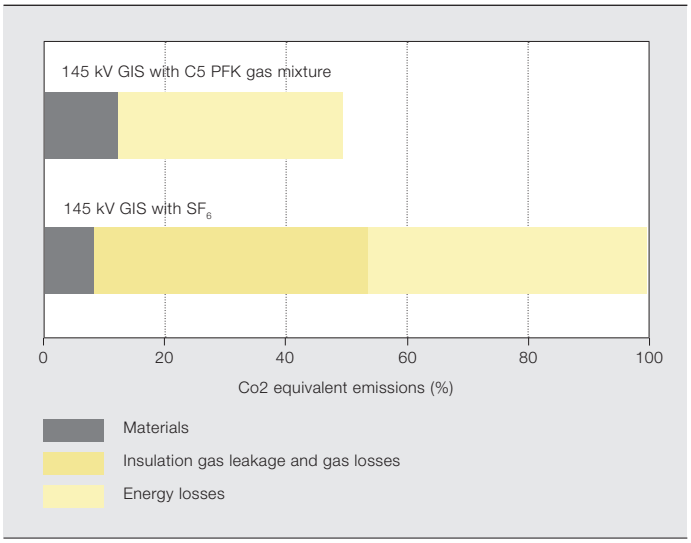
The key technical parameters for an insulation gas in switchgear are its dielectric strength and arc-quenching capabilities. For use in GIS, there are other, less obvious, but equally important properties – such as low boiling point, low toxicity, stability, low flammability, zero ozone depletion potential (ODP) and very low global warming potential (GWP) [1]. GWP is expressed as the ratio of the amount of heat trapped by a certain mass of the gas in question to the amount trapped by a similar mass of CO_2. It is calculated over a specific time interval – commonly 20, 50 or 100 years.

Considerable efforts have been made by research groups around the world to find a suitable alternative for SF_6 → 2 – 4. Until now, no one-to-one replacement that fulfills all the required properties has been discovered.

1 Molecular model of $C_5F_{10}O$



2 Relative contributions to CO_2-equivalent emissions



After many years of research, ABB has identified a gas mixture that is a suitable alternative to SF_6 and that matches all the required properties.

A fluoroketone-based gas mixture

To assist the search for an SF_6 replacement, efficient computational procedures were developed (by third parties) to screen molecules appropriate for high-voltage insulation [5]. These procedures involve virtual screening of molecules for GWP, toxicity, flammability, etc., followed by a study of their breakdown field and boiling point. Early on, a family of compounds based on fluoro-alkenes, fluoro-alkyl sulfides, fluoro-alcohols and fluoro-alkylamines was considered as a promising source from which a possible candidate could emerge [5].

After many years of research, ABB identified an environmentally friendly alternative to SF_6 that matches all the required properties. The gas mixture is based on a product from the company 3M called Novec 5110 Dielectric Fluid – a perfluorinated ketone with five carbon atoms (C5 PFK) [1,6] → 1. Delivered as a fluid, it is vaporized and mixed during the filling process. The fluoroketone-based gas mixture for switchgear applications was developed in collaboration with 3M and has been named AirPlus.

The new gas mixture contains:
- Fluoroketone, carbon dioxide and oxygen for high-voltage (HV) GIS
- Fluoroketone, nitrogen and oxygen for medium-voltage (MV) GIS

This fluorinated molecule rapidly decomposes under ultraviolet light in the lower atmosphere. Therefore, the molecule's atmospheric lifetime is short (around 15 days, versus 3,200 years for SF_6). It decomposes into CO_2 that remains in the atmosphere and other molecules that are washed out. Quantities of both are low so global warming contributions are negligible. Because of this, the GWP of the new gas mixture is less than 1, which is even lower than CO_2 (GWP = 1). Also, the fluorinated molecule is practically nontoxic, noninflammable and neither the substance itself nor its decomposition products deplete the ozone layer.

Demonstrations in ABB laboratories have shown the high potential of the fluoroketone-based mixtures as a switching and arc interruption medium at transmission and distribution power ratings. The gas mixture does not compromise equipment quality and reliability, and has an extremely low GWP. It is the only insulation available so far with a GWP ≤1 that has been type tested according to IEC standards and that meets performance criteria similar to those set for SF_6.

Life-cycle assessment (LCA)

According to the ISO 14040 environmental management standard, LCA considers three major contributors to CO_2-equivalent emissions:
- Materials
- Insulation gas leakage and gas handling losses
- Energy losses

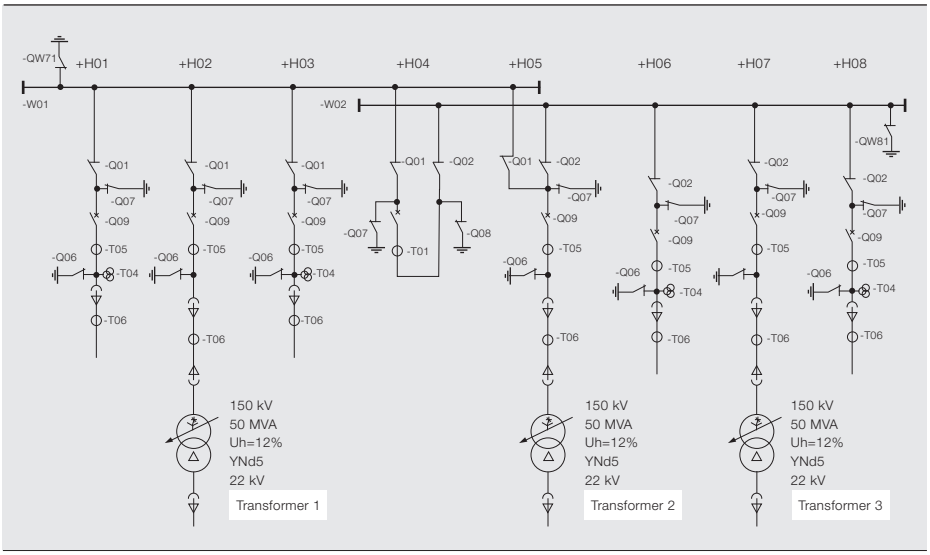
The boundary conditions assumed for HV GIS are:
- 30-year equipment lifetime
- A gas leakage rate of 0.1 percent per annum, 1 percent gas loss during handling and 1 percent loss during decommissioning

3 GIS with the new gas mixture installed in Zurich

3a 170 kV HV GIS

3b 24 kV MV GIS

4 A single-line overview of the HV switchgear installed in the ewz substation



The gas mixture is based on a perfluorinated ketone with five carbon atoms and was developed in collaboration with 3M.

– Operation at 50 percent of the rated current flow over 30 years

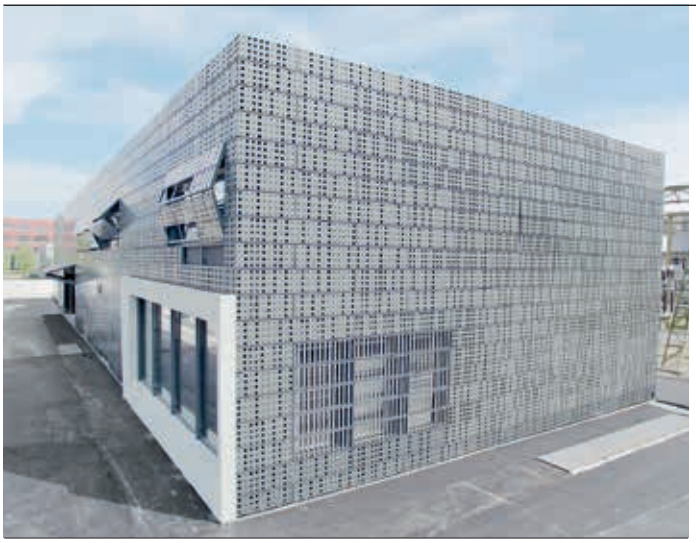
LCA indicates that the deployment of high-voltage GIS with AirPlus can lower CO_2 equivalent emissions by up to 50 percent. The 50 percent remaining is attributed to raw materials, manufacturing and thermal losses.

Although the contribution of materials to the CO_2-equivalent emissions is slightly higher for the PFK gas mixture GIS, the energy losses are lower and the leakage and handling losses disappear almost entirely ➔ 2.

Also, in MV equipment, which has lower gas pressures and gas quantities, AirPlus helps reduce the CO_2-equivalent emissions over the switchgear lifetime. Further, in cases where gas handling is outside of the manufacturer's responsibility or control, the new gas mixture ensures that the climate impact of any escaping gas is reduced by almost 100 percent.

The new technology brings other benefits too:
– Regulatory procedures specifically required for SF_6 – such as maintaining inventory records, special handling requirements, and measures to be taken when filling and decommissioning equipment – are avoided.
– The SF_6-related taxes that are applicable in some countries can be avoided.

5 ewz substation in Zurich – the world's first pilot switchgear installation with the SF_6-replacement gas mixture



5a The Oerlikon substation building

5b The ABB HV GIS factory can be seen behind the substation.

World's first GIS installation with the new gas mixture

When the development of the new technology began, Swiss utility ewz was in the early planning phase of a new substation to replace a 1940s air-insulated switchgear (AIS) installation in Zurich. The utility had set a goal to utilize innovative technologies with low carbon footprint in the substation, in line with its vision to provide sustainable energy wherever possible. New technologies that were not yet available on the market were also taken into account.

ABB's new technology was the perfect fit for ewz – reliable GIS with a compact footprint and low environmental impact, both on the HV and MV side. Both companies collaborated to integrate the new technology into the grid in a pilot installation. The newly commissioned substation in Zurich consists of eight HV GIS bays and 50 MV GIS bays → 3-4. The substation comprises all components of typical GIS with cable terminals.

While the MV panels come from ABB's modern GIS factory in Ratingen, Germany, the HV GIS was manufactured in ABB's state-of-the-art GIS factory in Oerlikon, Switzerland, located next door to ewz's new substation → 5. The GIS bays were energized in the summer of 2015 and started transmitting and supplying electricity to the city of Zurich a couple of months later.

The pilot substation is an important milestone in the path to an SF_6 alternative and it will provide long-term operational experience of grid operation. In the coming years, ewz and ABB will use this experience to further improve the carbon footprint of switchgear installations.

Future grid carbon footprint

SF_6 switchgear has been used for decades and is well accepted in the electrical power industry. Its compact design and low environmental impact make GIS a sustainable solution. Closed-loop handling and low leakage rates result in a small carbon footprint over the lifetime of the GIS. For this reason, SF_6 will remain the main insulation medium for GIS for years to come. However, an alternative such as AirPlus could further reduce the carbon footprint of the power grid.

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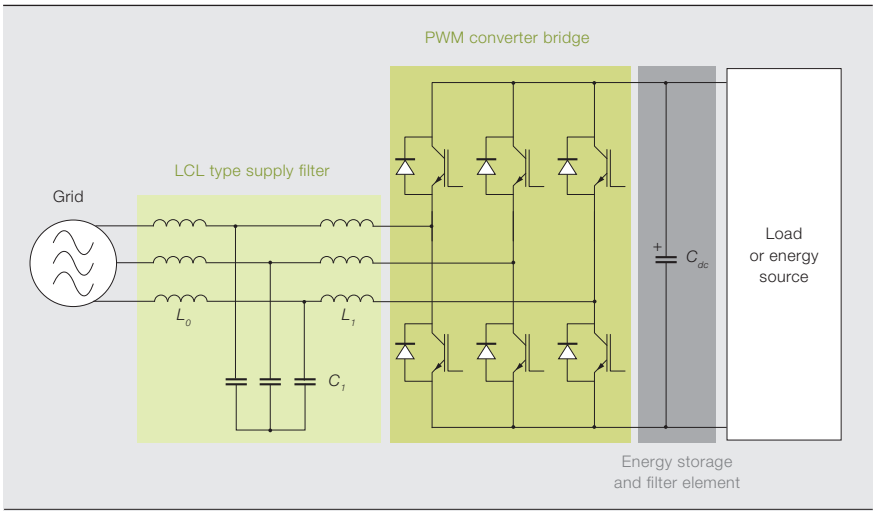
TAMING THE POWER
ABB Review series
Part IV

Putting a damper on resonance

Advanced control methods guarantee stable operation of grid-connected low-voltage converters

SAMI PETTERSSON – Resonant-type filters are used as supply filters in grid-connected, pulse-width modulated (PWM) power converters to ensure compliance with power quality requirements set by international and country-specific standards. New semiconductor devices with lower power losses, as well as multilevel converter topologies, enable power converter designs with higher switching frequencies. Because the requirements for passive filtering are then reduced, higher power densities can be achieved. However, supply filters with high resonance frequencies in these devices may cause problems for existing control systems. This article – the fourth and final one in the "Taming the power" series – describes advanced control methods developed by ABB that solve these resonance problems.

1 Main circuit of a typical grid-connected LV PWM converter



Grid-connected, low-voltage (LV) power conversion systems with a PWM active front-end are nowadays used in various applications, many of which are found in ABB's product portfolio: four-quadrant motor drives, wind power converters, photovoltaic (PV) inverters, uninterruptible power supply (UPS) systems and active power quality conditioners, for example.

An active front-end in a grid-connected power conversion system makes it possible to fully utilize the energy transfer capacity of the system and maximize the power quality. Furthermore, it enables bidirectional energy flow, ie, to and from the grid.

The main circuit of a typical grid-connected LV converter is depicted in ➔ 1.

Title picture
Power converters are used in many applications, such as the photovoltaic power plant shown here. The possibility of resonance frequencies arising in these converters can be eliminated by advanced control methods.

When using a PWM converter to interface to a power distribution grid, a supply filter between the converter and the grid is usually required so that the grid currents can be controlled and the power quality requirements set by international and country-specific standards can be met. The most commonly used supply filter structure is the so-called LCL filter, which consists of two sets of inductors with filter capacitors placed between them.

The LCL filter is a resonant-type filter whose resonance frequency is typically tuned to be between 20 and 40 percent of the PWM frequency. This guarantees sufficient attenuation of the undesired high-frequency current components generated by the PWM converter. The drawback of resonant filters is that, without a proper damping, they may cause unwanted resonance in the system and make the grid current control unstable.

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Resonance damping

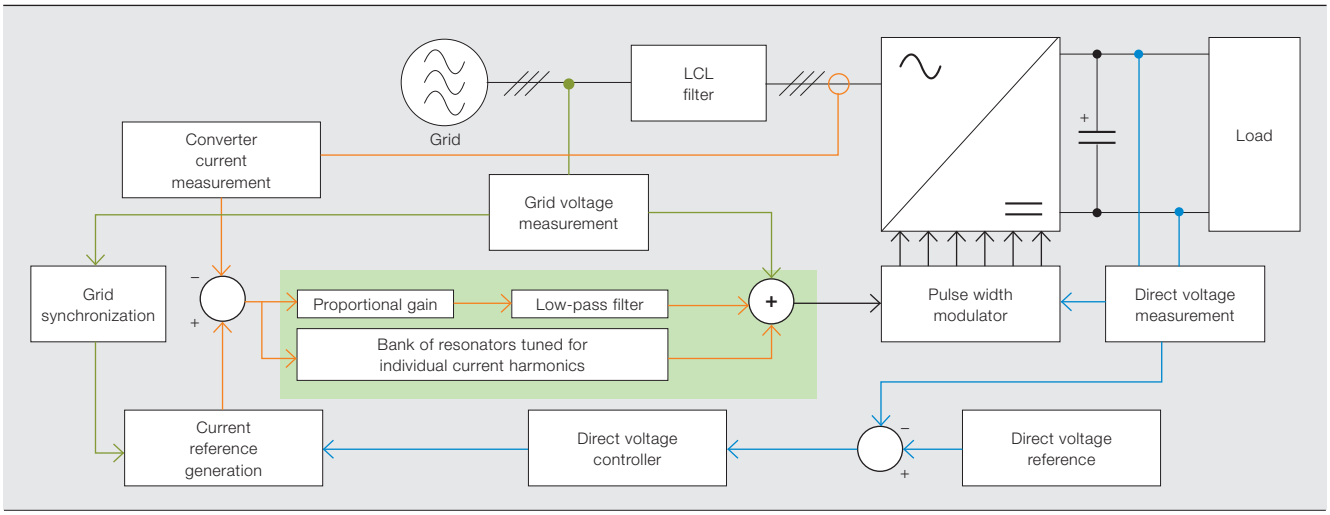
There are two basic approaches used to combat unwanted resonances: passive damping and active damping. In the former, resistors are added to the filter structure to passively damp the resonance. However, these resistors consume additional power and the overall filtering performance is inferior to that of the active damping approach.

Active damping methods are implemented in the control system without the need to physically modify the supply filter. The idea is either to limit the bandwidth of the current controller so that the PWM converter does not excite the resonance of the LCL filter or to actively damp the resonance with feedback, eg, from the LCL filter capacitor voltage or current.

Method A: control bandwidth limitation

The simplest method of dealing with the LCL filter resonance is to limit the bandwidth of the current controller so that it is below that of the resonance frequency. This can be done by add-

2 Grid current control with a low-pass filter in series with the proportional gain of the current controller. The current controller is highlighted.



ing a low-pass filter (LPF) in series with the proportional gain of the current controller ➔ 2.

In this case, the LPF affects only the proportional gain, not the parallel-connected resonator bank that tracks individual current components at selected frequencies.

The drawback of this method is that it is not adaptive and, therefore, information on the LCL filter and grid parameters is required for the LPF design. However, the implementation of this method does not require significant modification of the control system, heavy computational effort or additional measurements.

The impact of the LPF on the frequency response of the current controller is illustrated in ➔ 3.

When properly designed, the LPF attenuates very effectively the peak caused by the LCL filter resonance and makes the controller less sensitive to high-frequency disturbances.

Method B: active resonance damping

Active resonance damping methods typically utilize information about the LCL filter capacitor voltage or current. These parameters can be either measured or estimated. Because additional measurements increase the system cost, estimation methods are usually preferred in commercial products.

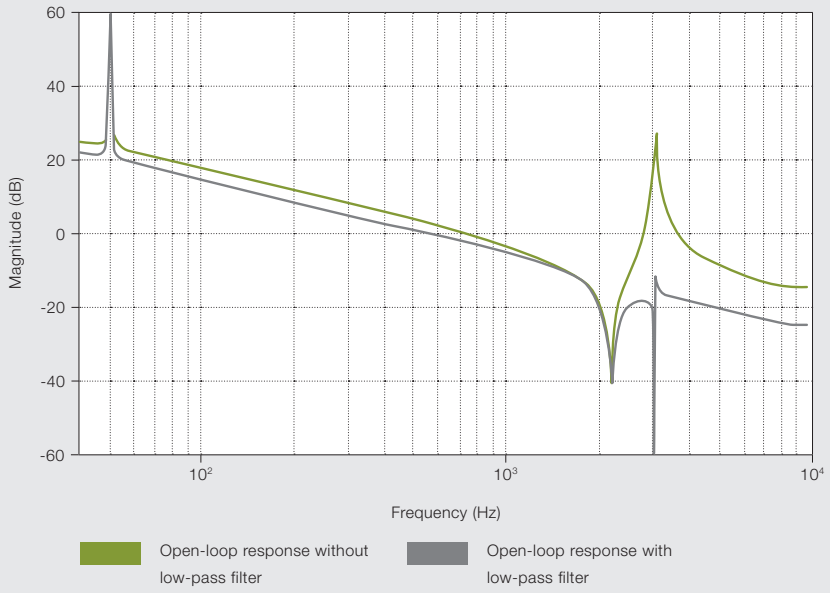
➔ 4 presents a block diagram of a grid current control system with active resonance damping based on the LCL filter capacitor voltage feedback. To avoid the need for additional measurements, an observer is used to estimate the LCL filter capacitor voltage on the basis of the converter voltage reference, and the measured grid voltage and converter current [1,2].

There are two basic approaches used to combat unwanted resonances: passive damping and active damping.

The operating principle of active damping is that if any resonance starts to appear in the LCL filter capacitor voltage, the active damping mechanism will modify the converter voltage reference so that the resonance disappears.

Because active damping should only react to voltage harmonics, a notch filter is used to remove the funda-

3 Simulated open-loop response from the converter voltage to the converter side current



mental component from the capacitor voltage estimate. The effect of active damping on the frequency response of the current control is shown in ➔ 5. When active damping is included in the control system, the peak caused by the LCL filter resonance is reduced, which improves the stability of the grid current control.

The major benefit of active damping is its adaptive nature, which also makes it effective against disturbances originating from the grid. As in the case of all active methods, the bandwidth of active damping is limited by the sampling and PWM carrier frequencies. Therefore, to ensure good performance, the PWM carrier frequency should be at least three to four times higher than the LCL filter resonance frequency.

Experimental verification

The performances of the two control methods introduced above have been experimentally verified in a 40 kVA grid-connected, three-phase PWM rectifier with a resistive load. The converter is connected to a standard three-phase 400 V LV grid. The control system has been implemented with a 300 MHz 32-bit floating-point digital signal processor.

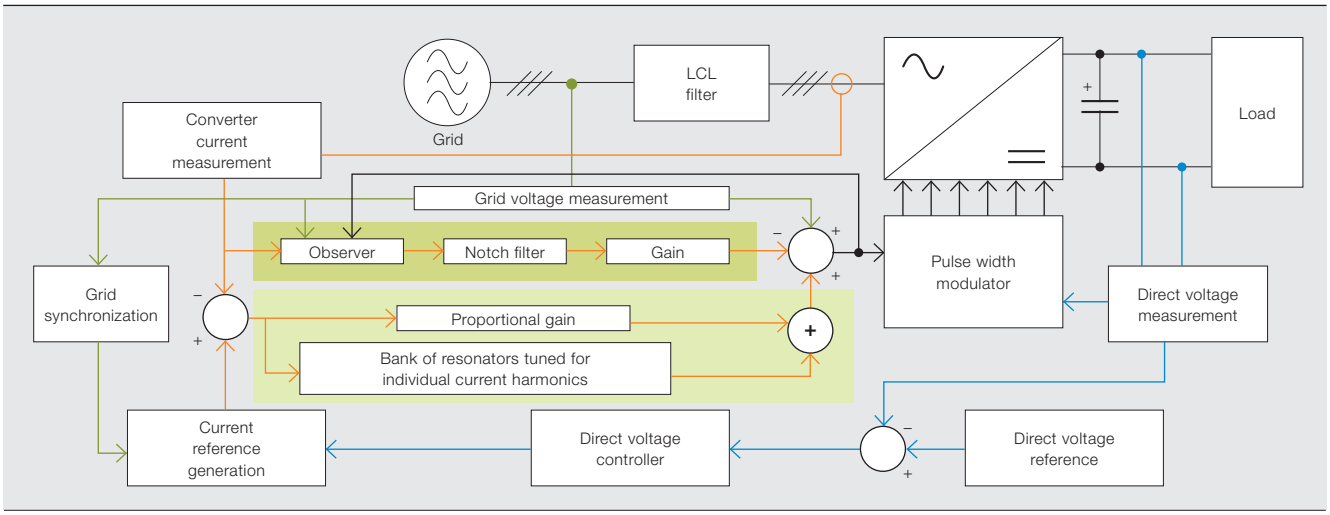
The PWM carrier frequency is 10 kHz and the sampling and control execution frequency 20 kHz. The resonance frequency of the LCL filter is approximately 3.2 kHz.

Active damping methods are implemented in the control system without the need to physically modify the supply filter.

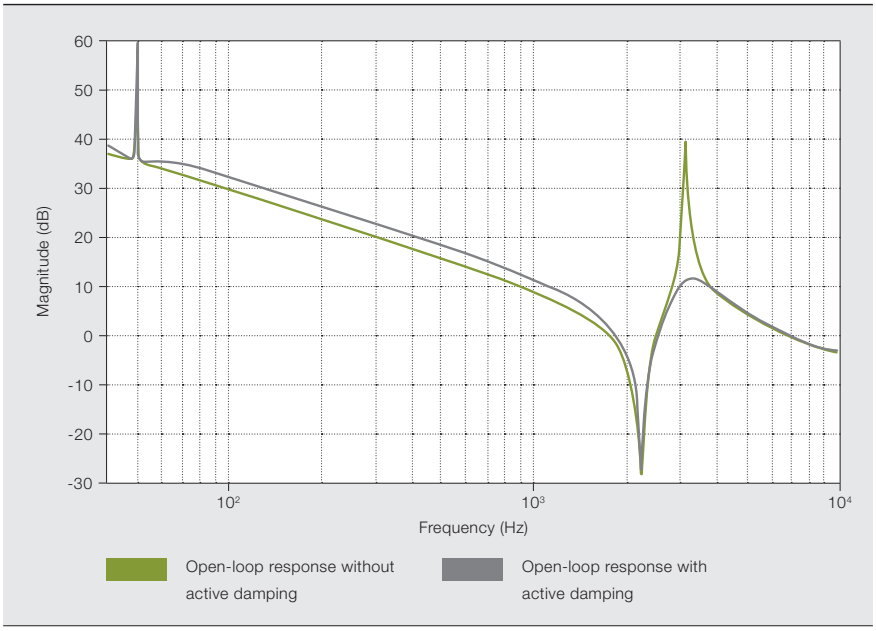
➔ 6 demonstrates what happens if the LCL filter resonance is not taken into account in the control system. The grid current control is unstable and the converter stops because of an overcurrent trip caused by the resonating grid currents.

➔ 7 shows that when a properly designed LPF is placed in series with the proportional gain of the current controller, no resonance occurs in the grid currents and the converter can

4 Active resonance damping based on the LCL filter capacitor voltage feedback. The active damping part is highlighted.



5 Simulated open-loop response from the converter voltage to the converter side current with and without active resonance damping



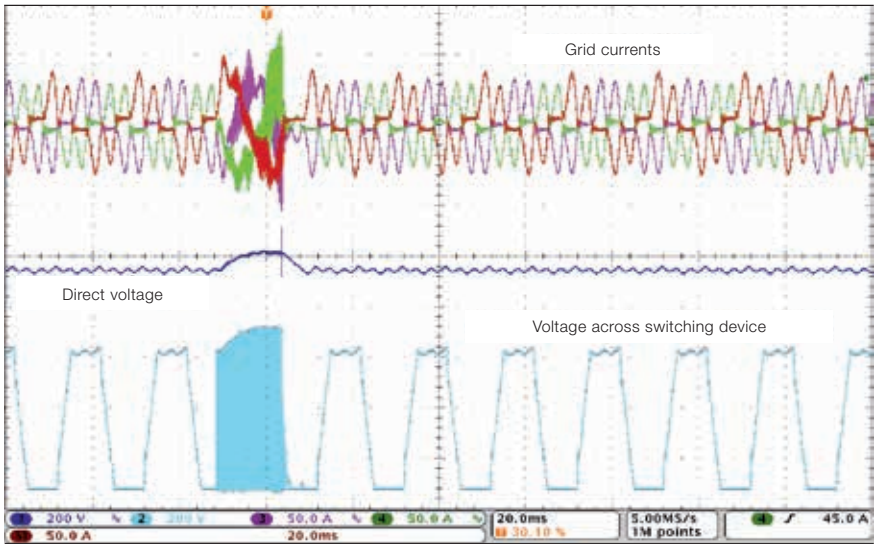
start up normally. An almost identical startup behavior can also be achieved using active damping. However, only active damping can deal with resonances originating from the grid and adapt to a changing resonance frequency.

Complementary methods

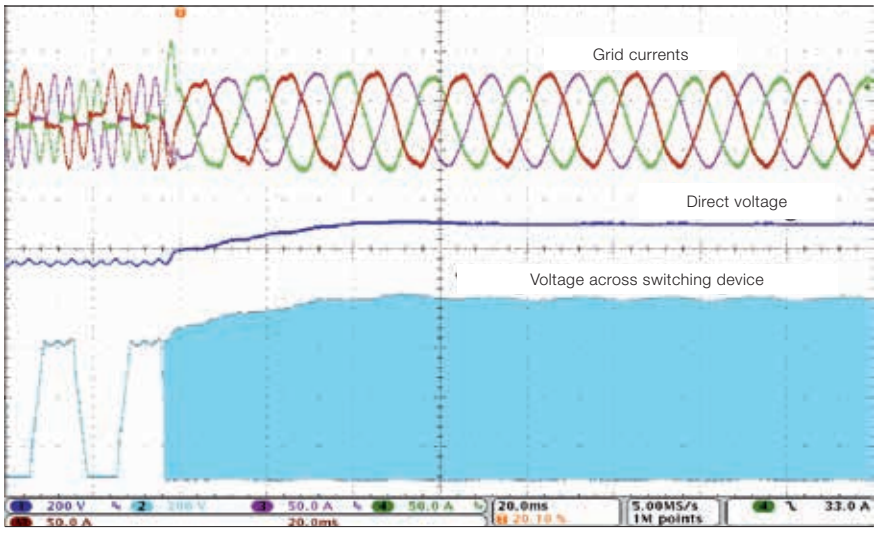
Grid-connected power converters that have compact supply filters operating at high switching frequencies introduce new challenges to grid current control. Dealing with high filter resonance frequencies requires a wide control bandwidth, but at the same time the control should not be-

Active resonance damping methods typically utilize information about the LCL filter capacitor voltage or current. These parameters can be either measured or estimated.

6 Converter startup attempt without taking into account the LCL filter resonance in the control system



7 Converter startup when a properly designed low-pass filter is placed in series with the proportional gain of the current controller



come too sensitive to high-frequency disturbances. The two methods presented above are specifically developed for this type of situation.

Their implementation requires only marginal computational effort from modern-day processors and no additional voltage or current sensing equipment is needed.

Even though the methods have been presented as separate, they are in reality complementary. When used together, the LPF makes the current control less sensitive to high-frequency disturbances, whereas the active damping deals with all disturbances that can be detected in the LCL filter capacitor voltage. This renders the precise design of the LPF unnecessary.

Experimental tests have proven that both methods can provide a stable grid current control with a compact LCL filter without compromising the dynamic response of the control system.

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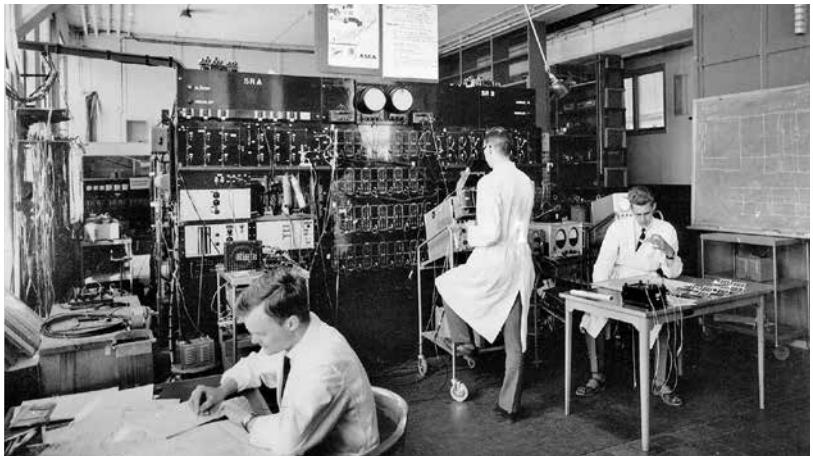

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Two anniversaries

The year 2016 is a double cause of celebration for ABB. It was 125 years since BBC (one of ABB's two predecessor companies) was founded in Baden, Switzerland, and it was also 100 years since ASEA (the other of the predecessor companies) launched ABB's first corporate research center.

ABB Review 3/2016 will be dedicated to these two anniversaries and look at many of the exciting discoveries and developments that were made throughout the company's rich and fascinating history.

Anniversaries are a time to look back and celebrate what was achieved, but also a time to look forwards at what lies ahead. Besides historical perspectives, the anniversary issue will cover present and future trends in research and technology.

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