Innovation highlights

ABB's top innovations for 2013

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

Edison's conundrum solved

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

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

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

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

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

Watchful algorithms

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

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

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

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

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

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

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

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

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

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

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

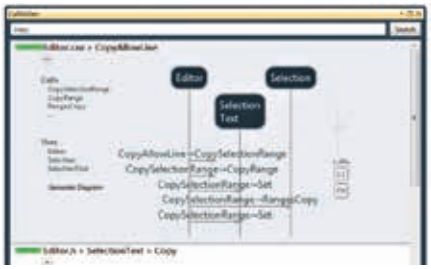
Context searches save time, reduce software maintenance costs

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

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

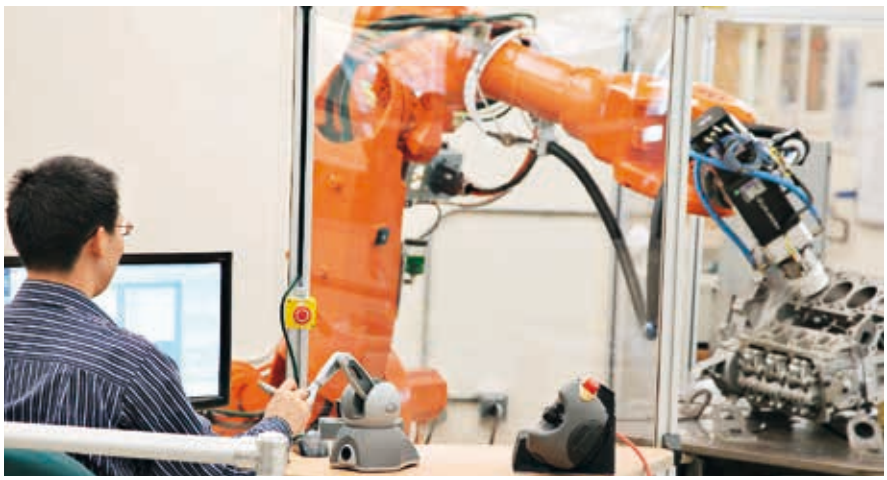
ABB's Industrial Software Systems (ISS) team has developed an advanced search tool called CoMoGen which saves time and money by eliminating manual exploration for context by automatically generating the context for each search result, helping developers make more informed decisions faster. The tool also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

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



Human skill, robot strength

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

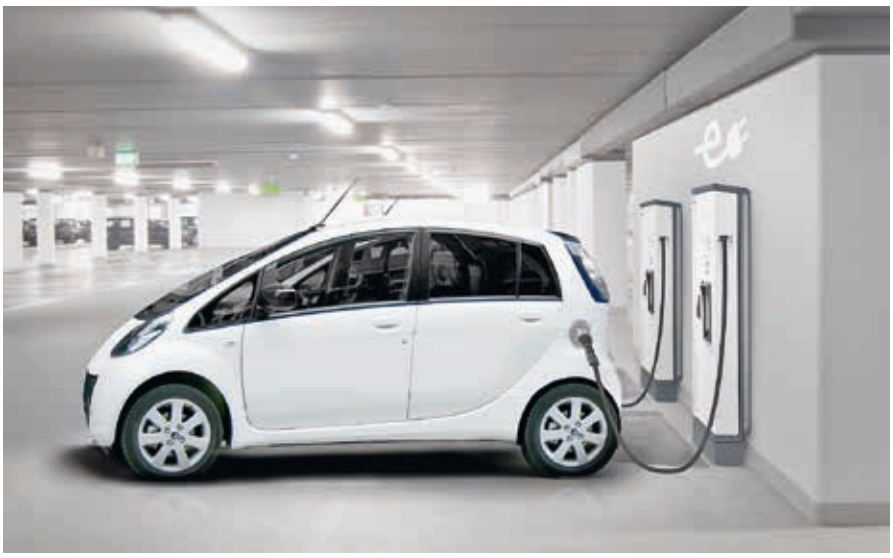


Industrial robots are currently designed for well structured environments to perform repetitive tasks. Automating dynamic and non-repetitive tasks is desirable, but has not been practical or cost effective to date. In these cases a human operator would like to directly operate the robot.

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

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

Cloud-based connectivity for EV charging



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

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

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

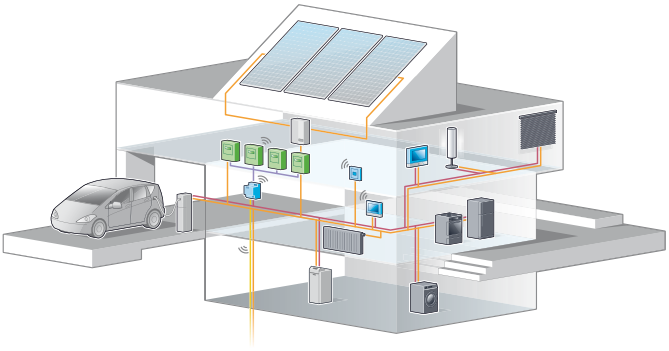
Included in ABB's cloud-based offering are remote maintenance and diagnostics, and interfaces to service providers to enable subscriber man-agement applications. Data protection complies with the highest Internet security standard (ISO 27001).

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

Residential demand response

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

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



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

I/O to suit

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

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

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

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

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

You wear it well

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

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

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

Mine ventilation

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

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

Light measures current

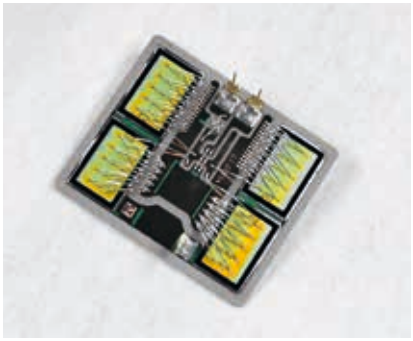
In 2005, ABB introduced a high-performance fiber-optic current sensor (FOCS) for the measurement of DC up to 600 kA, particularly in the area of electro-winning of metals. This sensor – based on the Faraday effect, where the magnetic field caused by the flowing current affects the speed of light in an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

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

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

Integrating for higher power – BIGT

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



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

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

Footnote

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