



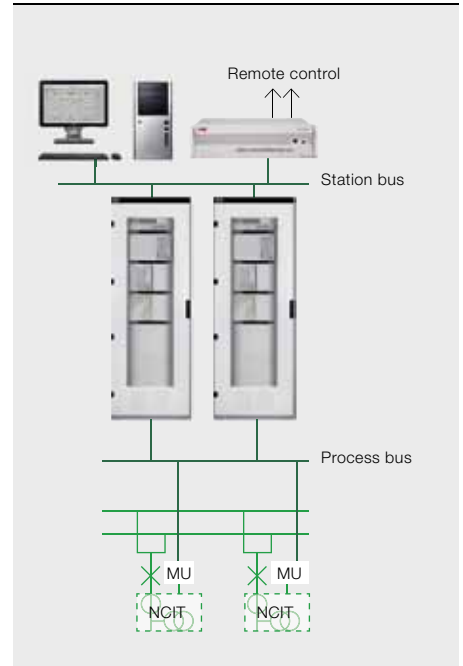
# Sharing values

ABB is implementing the first commercial installation of IEC 61850-9-2 LE process-bus technology

STEFAN MEIER – The introduction of the IEC 61850 standard represents a great step forward in substation automation – and the process is continuing. One example is the application of the standard's subsection, IEC 61850-9-2, for the sharing of sampled analog values using Ethernet. By integrating this technology into its substation automation systems, ABB has combined over 10 years of experience in producing non-conventional instrument transformers for

current and voltage measurement with the latest communications technologies. It is now possible to connect primary (high-voltage) equipment to ABB's field-proven substation protection and control devices more effectively, improving the reliability and availability of optimized substations. Combining these vital technologies in the world's first commercial implementation of IEC 61850-9-2 LE, ABB is refurbishing a substation it first commissioned in 1999.

## 1 Station and process bus in substations



control IEDs<sup>2)</sup> of a substation automation system. This optical communication network is used to transmit analog data (such as current and voltage measurements). The network can also be used to transmit binary data (such as the switch-gear's position indications) and trip-and-close commands (to operate the circuit breakers and disconnectors), but this is not part of current process bus implementations. In today's conventional substations, this information is exchanged through extensive parallel copper cabling. The use of fiber-optic networks not only eliminates vast parts of the copper cabling, it also increases operational safety by isolating the primary from the secondary process → 1.

The ELK-CP sensor families are based on redundant sets of Rogowsky coils<sup>3)</sup> for current measurement and two independent capacitive dividers for voltage measurement. As it contains no oil, this equipment is both environmentally friendly and extremely safe. The fully redundant design of the sensors (including the associated electronics) permits application of two completely independent and parallel protection systems, boosting the availability of the secondary system. As sensor electronics can be replaced independently and without requiring a shutdown of the entire protection system, repair activities require less time and, because no live parts need to be handled, these activities are also much safer → 2.

ABB installed more than 300 such electronic sensors in Powerlink's substations. Notably, in more than 10 years of service, none of the primary converters ever failed. Based on experience values, the mean time between failures (MTBF) of the sensor electronics is almost 300 years. This demonstrates the extreme reliability and high availability of the sensors, even under the very demanding environmental conditions of the Australian climate.

### The upgrade

Powerlink launched an upgrade project that involved replacing secondary equipment in the hybrid substations, including

the process-oriented electronics that connect to the process bus. A central requirement of this upgrade is its full compliance with international standards, especially the implementation of the process bus for sampled analog values, which has to comply with IEC 61850-9-2 LE → 3.

Powerlink awarded the contract for upgrading the first iPASS substation to ABB. This project represents the world's first commercial implementation of a process bus according to IEC 61850-9-2 LE. Its implementation is now well under way.

### Process bus according to IEC 61850-9-2 LE

The publication of the international standard for communication networks and systems in substations, IEC 61850, began a new chapter in describing substation functionality and communications. For the first time, there is now a standard supporting true interoperability between devices from different vendors, along with a future-proof design. The standard has rapidly gained market acceptance<sup>4)</sup>.

**A** pioneer in the fields of NCIT<sup>1)</sup> and process bus technology, ABB began commissioning a series of six outdoor substations with process bus and NCIT technology in 1999. The mixed technology, or "hybrid" substations supplied to the Australian utility, Powerlink Queensland, were based on ABB's intelligent plug-and-switch system (iPASS). Electronic modules integrated into the drives of the circuit breaker, disconnector and earthing switch of the iPASS modules could communicate using a proprietary optical process bus. Further-

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more, the iPASS modules were equipped with ABB's ELK-CP sensor for voltage and current measurement, also connected to the process bus.

A process bus is the communication network between primary equipment (such as instrument transformers) and secondary equipment (such as protection and

### Footnotes

- 1 NCIT: non-conventional instrument transformer
- 2 IED: intelligent electronic device
- 3 The Rogowski coil is a device used to measure alternating current. It comprises a toroidal winding. The current-carrying conductor is arranged to pass through the center of the toroid. The output of the sensor is a voltage, which is proportional to the derivative of the current.
- 4 See also *ABB Review Special Report IEC 61850*

ABB played an important part in the creation of the standard and continues to be a driving force in its maintenance and further development. Since installing the world's first multivendor project in 2004, ABB has gone on to deliver more than 1,000 systems with an IEC 61850-compliant station bus to sites in about 70 countries.

Following the successful introduction of IEC 61850 at the station level, its importance in process-oriented communication using process bus is increasing rapidly. Completing the standard's ability to define all necessary time-critical signal exchanges between the process and bay levels, the standard's part 9-2 focuses on the exchange of sampled analog values through an Ethernet network.

IEC 61850-9-2 requires that analog samples are transmitted by so-called merging units (MUs). The MU time correlates and merges analog data from individual phases or measuring points in the substation before transmitting them via the Ethernet network, from where the data can be accessed by protection and control devices. With the introduction of the CP-MUP, ABB is the first company to offer a conformance-tested, UCA-certified<sup>5</sup> merging unit.

IEC 61850-9-2 has made it possible to exchange signals from NCITs in a standardized way, supporting the eminent advantages of NCIT technology. These include the highest levels of accuracy throughout the complete measuring range, a space-saving design and dramatically improved safety compared to conventional equipment.

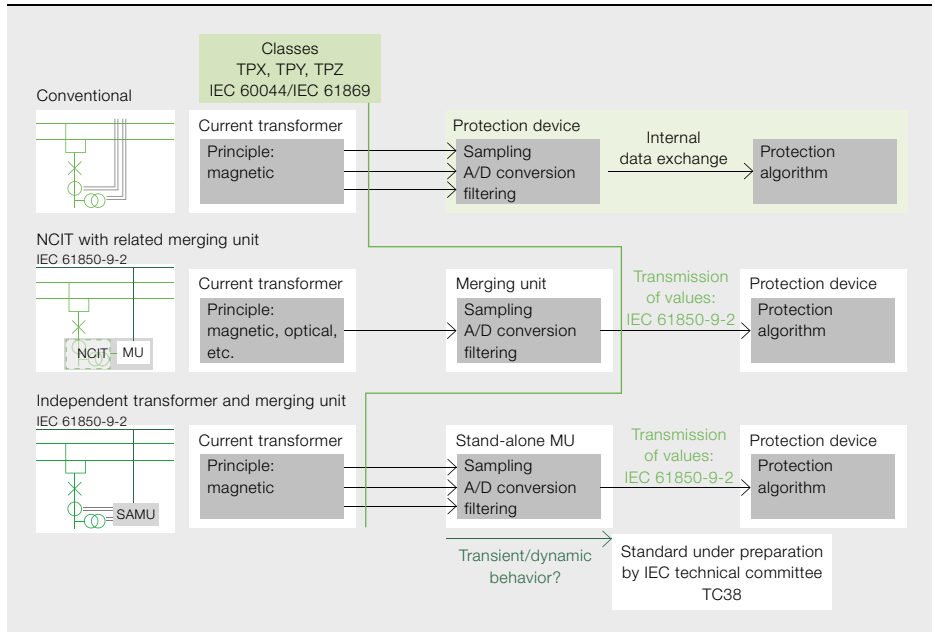
To facilitate implementation of part 9-2 of the standard, and to simplify its application, the UCA International Users Group has developed an implementation guideline for IEC 61850-9-2. The guideline provides additional information on how to implement the standard and defines a subset of the same. This document is referred to as IEC 61850-9-2 LE (for light edition) and is predominant among today's 9-2 implementations.

Because the NCIT merging units are tailor-made for a specific type of NCIT, they form a single entity that can be jointly developed and type tested, permitting the behavior of the complete

## 2 ELK-CP3 combined current and voltage NCITs with IEC 61850-9-2 LE merging unit



## 3 Standardization of transient performance and communication interfaces



measuring chain at the IEC 61850 port to be defined.

This is in contrast to stand-alone merging units (SAMUs), which interface to conventional CTs<sup>6</sup> and VTs<sup>7</sup>. SAMUs sample the analog signals and supply them to the process bus. Inevitably the conversion of analog values to digital samples influences the transient response of the measuring chain. This dynamic behavior of the SAMU is not covered by the IEC 61850 standard. Activities to address this are ongoing in the relevant IEC and Cigré technical committees and working groups. The definition will be incorporated in a future release of IEC 61869, the international standard for instrument transformers → 3.

Using fiber optic networks not only eliminates vast parts of the copper cabling, it also increases operational safety.

### Footnotes

- 5 The UCA International Users Group is a not-for-profit corporation focused on assisting users and vendors in the deployment of standards for real-time applications for several industries with related requirements.
- 6 CT: current transformer
- 7 VT: voltage transformer



**4 Substation automation system for a 1½ breaker switchgear with one of two redundant protection systems**

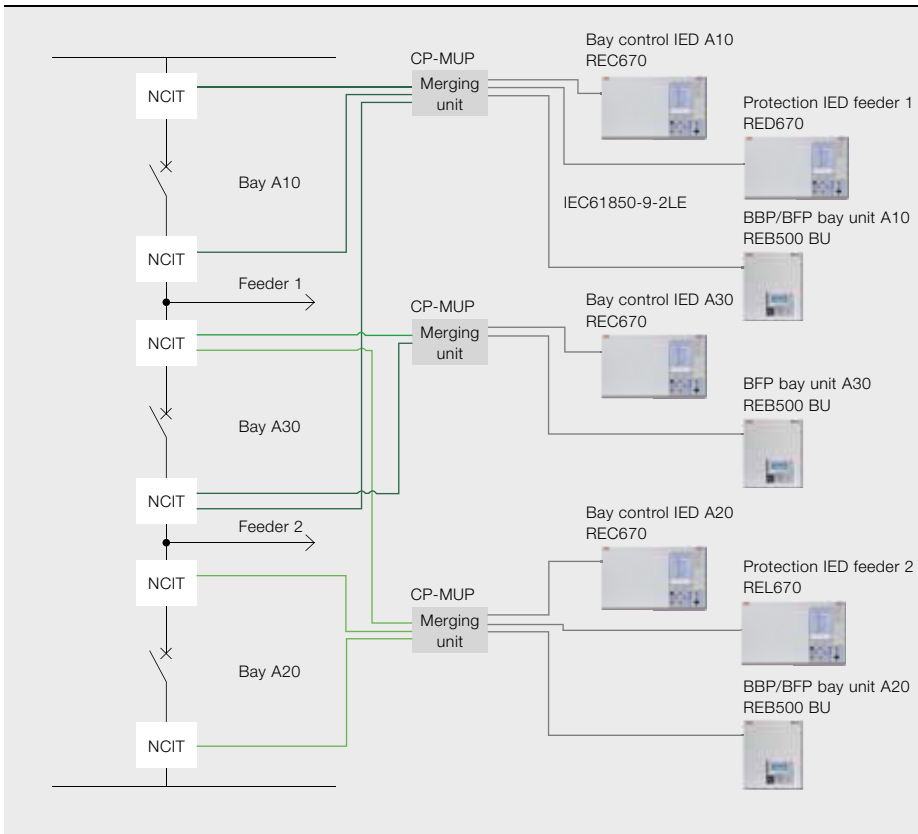


ABB played an important part in the creation of the IEC 61850 standard and continues to be a driving force in its maintenance and further development.

**Extension of proven sensor technology with state-of-the-art process bus**  
In the upgrade project for Powerlink, ABB is building on its extensive experience with NCITs and will replace the originally installed proprietary process bus with IEC 61850 technology. The new IEC 61850-compliant system will handle communications at both the station and process levels.

In the Powerlink Queensland project, ABB will use its SAS600 substation automation system, protection and control IEDs from its Relion® 670 series and its REB500 decentralized busbar and breaker-failure protection system. All protection and control devices in the system will connect to the IEC 61850-9-2 LE process bus and receive sampled analog values from ABB’s CP-MUP merging units. The MUs will interface with the existing combined current and voltage sensors through new sensor electronics. In this way, modifications to the primary apparatus can be kept to a minimum → 5.

A substation automation system for a 1½ breaker arrangement, similar to that used for the secondary system upgrade in Australia, is shown in → 4. Using the embedded redundant design of ABB’s

NCITs, a second fully independent system of merging units and protection IEDs is used to meet the customer’s redundancy requirements.

To demonstrate the suitability of components and prove the concepts to be used in the Powerlink project, additional measures to verify the new technology were taken.

A series of pilot installations featuring NCITs and IEDs connected to the process bus were commissioned to gain experience with the new technology in real-life substation environments. Among these was the upgrade of a feeder at one of Powerlink’s 275kV substations with new sensor electronics, merging units and protection IEDs from ABB’s Relion® range. Besides helping customers to gain important experience and confidence, the pilot installations are also delivering vital information on the long-term stability and behavior of the pilot equipment compared with conventional or non-conventional devices.

All ABB protection and control equipment undergoes rigorous product and system verification testing in ABB’s own UCA-certified system verification center<sup>8</sup>. In addition, a concept test was performed for the Powerlink secondary system upgrade project in ABB’s test field with experts from both companies. Special attention was paid to the behavior of the system under various fault conditions.

The system behaved reliably, as specified, and under no condition did it overreact or issue incorrect tripping signals. Such erroneous signals could, in a real-life situation, lead to blackouts in the power network.

During the simulation of the various potential failure conditions, permanent and detailed supervision of all system components proved its importance in enabling the fast and accurate identification of faults. Continuous system supervision drastically reduces the need for periodic maintenance activities and tremendously simplifies maintenance by guiding substation personnel to the precise location of faults.

**Footnote**  
8 See also “Verified and validated: ABB has its own verification and validation center” on pages 23–28 of *ABB Review Special Report IEC 61850*.



### Testing and maintenance of process bus installations

The replacement of copper wires by fiber optic cables and the description of the transferred information according to IEC 61850 open new opportunities for intelligent testing tools that support the commissioning and maintenance of substation automation systems.

ABB was quick to release the integrated testing toolbox, ITT600<sup>9</sup>, containing a comprehensive suite of tools to help users fully benefit from the advantages of IEC 61850.

ITT600 masks the underlying complexity of the IEC 61850 standard and provides testing and maintenance personnel with a clear view of the data available in the sys-

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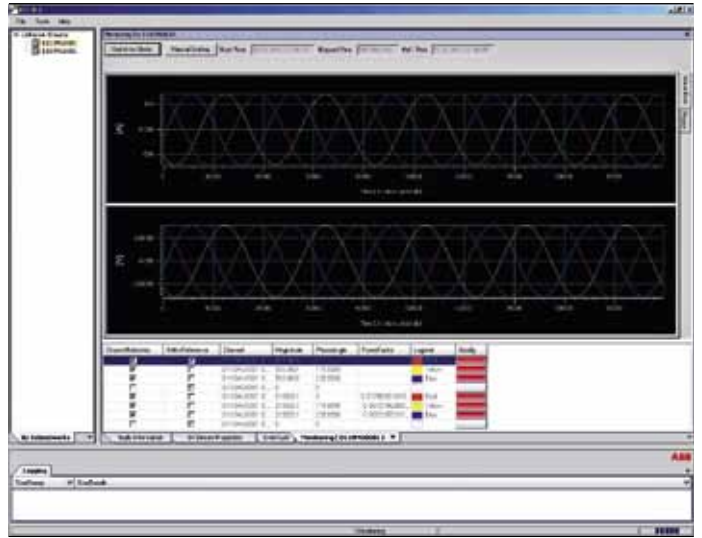
tem. For example, it facilitates the verification of consistency of the installation with the station configuration description (SCD), and helps to analyze communication between IEDs and the station-level system.

Since the introduction of the process bus for sampled analog values, the corresponding tools have been added to the

toolbox. This is particularly important in a scenario where measurements are provided by NCITs using an optical connection to the merging units. In such a situation, all conventional CT and VT terminals are rendered obsolete and all analysis is done on the IEC 61850-9-2 network. Drawing on its extensive experience with the integration of IEC 61850 and the development of testing tools, ABB is developing a feature-rich analyzer for sampled analog values → 6.

The advantage of analyzing values on the process bus versus conventional current and voltage measurement begins when the measurement points need to be accessed. With the values available on the process bus network, it is no longer necessary to access live components

and no CT terminals need to be short-circuited and opened. By connecting the Ethernet port of the analysis tool to the process bus network, or directly to the merging unit, the maintenance engineer can easily access all sampled value streams. In contrast to analysis by amp- or volt-meter, the 9-2 analyzer readily displays data that were previously not directly available. These include views of current and voltages of all phases at once, phasor diagrams and in-depth information on the transmitted telegrams. This last information gives vital insights into the sys-



tem's health and can, for example, indicate that parts of the system are undergoing testing.

### Future trends

Using the full potential of the process bus concept and its definition in IEC 61850, binary data can also be transmitted through the optical communication network between primary process and protection and control IEDs. By placing binary input and output modules close to the primary process, virtually all copper cabling can be avoided, resulting in additional advantages such as the ability to electrically isolate process- and bay-level systems, and the continuous supervision of all signals.

By combining its cutting-edge application of IEC 61850 technologies on the station as well as the process level with vast experience in the field of NCIT technology, ABB is building intelligent, future-proof offerings to meet customer demands for more reliable, efficient and safe solutions, maximizing the benefits and value of their assets.

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### Footnote

<sup>9</sup> See also "A testing environment: ABB's comprehensive suite of software testing and commissioning tools for substation automation systems" on pages 29–32 of *ABB Review Special Report IEC 61850*.