IEC 61850 at work

The goal of IEC 61850 is to facilitate interoperability of substation devices while simplifying engineering and maintenance. The examples described in this section present some of the standard's successes.

Retrofitting for the future

It is inevitable that as substations age, their parts will need to be replaced. The 380/220 kV air-insulated substation (AIS) located in the Alps in Sils, Switzerland was one such case. Its secondary infrastructure – ie, protection, control and metering – and parts of its primary equipment at the 380 kV level – ie, switchgear, power transformers and circuit breakers – had reached the end of their life cycles. The operator KHR (Kraftwerke Hinterrhein) thus turned to ABB for an economically feasible, standardized and forward-looking solution for one of the most important nodes of the Swiss transmission network. The answer: a substation automation retrofit using IEC 61850 technology.

Implementing the IEC 61850 standard enables availability of all necessary information – which supports extensions, replacements or upgrades of all or part of the substation automation system – and enables integration of products from different suppliers. It also ensures data consistency within the complete system and defines the

engineering processes, helping to keep data and data flow consistent for the whole substation. In this project, the horizontal bay-to-bay communication model GOOSE was used to considerably reduce the copper wiring between the bays. All information for interlocking between bays is now exchanged between the ABB Relion® 670 series IEDs on the IEC 61850 bus via GOOSE messages.

Although testing was a major part of the retrofit, the greater challenge was to avoid a shutdown during commissioning. Outage time of individual feeders had to be minimized and coordinated with the grid operator months in advance. The complete system was manufactured and delivered to the site where, except for the connection to the AIS interfaces, it was installed. Once the dedicated bay was commissioned, the new IEDs were connected to the primary equipment. The substation was configured to enable concurrent operation of the existing and new equipment during this transition phase.

After successfully retrofitting the 380 kV substation, the 220 kV part was integrated into the new control system. The existing IEDs were equipped with a new IEC 61850 communication interface, allowing communication with the new MicroSCADA control system and ensuring that both the 380 kV and 220 kV switchyards could be operated and monitored from the central control system. A hot standby system was put in place to provide backup should a failure occur.

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Challenges build partnerships

In 2006, ABB supplied a pioneering substation-automation project to the Brazilian government power transmission utility, Eletrosul. This utility is responsible for electrical transmission in the south of Brazil. The projects delivered were based on the IEC 61850 standard, with applications using messages between IEDs, GOOSE [1], redundant control units and featuring interoperability between systems from different vendors.

The first project consisted of three substations, “Atlântida 2”, “Gravataí 3” and “Osório 2”. These are 230 kV and 138 kV transmission substations. “Atlântida 2” uses 60 IEDs (14 with redundancy and 32 without) for protection, acquisition and control. These are mapped to 13,683 dynamic objects from a total of 28,786 objects available in the IED. About 3,300 of these were distributed to centers of higher hierarchy.

Redundant control

Redundant control was one of the special challenges of this project. This philosophy, used by Eletrosul for many years, uses two control terminals (for ABB’s projects this meant two REC670s). These have exactly the same functionality in terms of control logic, interlocking and automatisms for controlling a certain number of bays. Both units are active, but just one is monitored by the supervisory system. In case of unavailability of a terminal, the SCADA system switches to the other IED.

Based on this philosophy, Eletrosul clearly defines how a system should react, for example, in contingency situations. Briefly, the terminal managed by the supervisory system is monitored and executes remote commands. In case of interlocks, the two redundant terminals send signals to external bays. This affects the philosophy of treatment of these redundant signals by the receiving logic.

In this project, GOOSE was widely used both for monitoring the active terminal and for interlocks and automatic logics. This permitted a considerable saving of cables, as twice as many signals are generated and received in this philosophy versus a philosophy of simple control.

Interoperability

Eletrosul uses SAGE (an open-source energy-management system) as SCADA software. SAGE was developed by CEPEL, a Brazilian government research center. The MMS protocol defined in IEC 61850 was implemented in SAGE in 2006. The ABB project was thus a test of the standard’s interoperability. This test was passed successfully.

Results

Another request from Eletrosul was to minimize the number of hours required for the preparation of texts in the system database. For this, it encouraged the use of generic signs (GGIOs) to be minimized. Even so, in the control terminals that use many monitoring aspects not defined in the standard (mostly complex interlocks and automatic logic) the use of GGIOs is still very high. It is hoped that as the IEC 61850 standard evolves, more standard signs will be provided. In IED protection, it was found that the use of GGIOs was reduced because of the standard, and because ABB IEDs use standards for all protection functions.

The three substation projects fostered a spirit of partnership between Eletrosul and ABB, resulting in new projects being carried out together delivering the benefits of IEC 61850.

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Footnote
1 GOOSE: Generic Object Oriented Substation Event

Portuguese transmission substations

REN is the main Portuguese utility for electrical energy transmission. ABB supplied the utility's first IEC 61850 system, installing it at the 400/220 kV Lagoaça substation. The installation is responsible for some of the most important interconnection points with the Spanish grid on the 400 kV voltage level.

Of all the benefits of migrating substation automation systems to the new standard, the customer was especially focused on one in particular: standardizing the system architecture, ie, using the same network topology and overall arrangement independently of the supplier.

ABB brought much experience into this project that it had built up in previous deliveries to the customer. The previous platform may have been different, but marked an excellent starting point and permitted ABB to quickly identify the required solution.

The Lagoaça substation uses a system based on a decentralized Ethernet ring. The main products from ABB are:
- MicroSCADA Pro for local HMI, and automated sequences
- COM500i as Gateway, for communication with network control center
- IED's 670 for control and protection units
- REB 500 Systems for busbar protection

Third party products used were:
- Switches and routers from RUGGEDCOM
- Meinberg GPS servers for SNTP time synchronization
- Computers with no-moving parts running Windows XP Embedded platform
- KVM switches and fallback switches from Black-Box
- Industrial computers from Advantech, for remote access and engineering stations.
- RTU servers and local-event printing system from SYCOMP Germany (REN mandatory).

- Remote access via RX1000 routers from RUGGEDCOM

The adoption of IEC 61850 was clearly beneficial. It allows both customers and vendors to retain extensive functional freedom in their definitions and philosophies. It also assures independence from single suppliers as well as cost savings in both engineering and maintenance.

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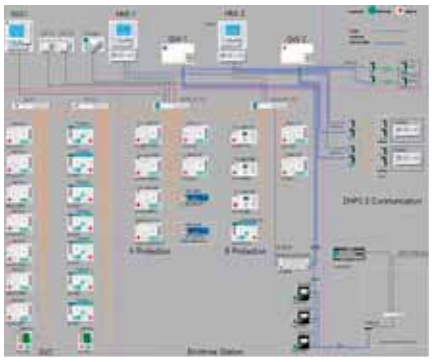
Wuskwatim transmission system

In order to strengthen the existing 230kV network, Manitoba Hydro main utility in Manitoba contracted with ABB for the design, engineering, supply and commissioning of Wuskwatim Transmission System Complex, comprising three new stations and expansion of four existing ones. The new stations featured distributed control, bay protection and a bay controller concept. The entire control and communication process used the IEC 61850 standard.

Protection devices were sourced from three different manufacturers. In fact the use of different suppliers was a requirement of the protection redundancy concept. Prior to IEC 61850 such integration would have been challenging if not impossible, especially for large systems due to inconsistency of data and engineering.

The IEC 61850 engineering approach and data structure using SCL language significantly facilitated the engineering of interfaces between different units. The descriptive power of the SCL language enabled part of the integration to occur without having access to all devices or bay level information.

Because design, manufacturing and testing of the two SA systems was completed in close colaboration between ABB and Manitoba Hydro, an attuned and future-proof system was delivered. The IEC 61850 standard made it possible to combine and integrate ABB, Siemens and Areva Protection IEDs within the SA and thus to fulfill safety requirements. The use of GOOSE



messages for bay-to-bay interlocking and intertrip reduced the amount of copper wiring required. The complete communication of the substations are now described and documented in SCD-files, which is of advantage for the future maintenance and extension of the stations that are now in service.

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The Star of Laufenburg shines

The 380 kV Laufenburg substation – one of the largest and most important in Europe – boosts several world premieres. Staying abreast of the development and extension of IEC 61850, its owners, the Swiss utility EGL AG, were the first to equip a high-voltage substation with an IEC 61850 automation system, doing so shortly after the release of the standard in 2004, and even opting for a multi-vendor solution. Two years on, the utility issued the very first open tender based on a SCD (substation configuration description) file, and most recently implemented the 9-2 process bus.

When built in 1967 at the inception of the European grid, the Laufenburg substation, with its key position in terms of interconnection and metering, was dubbed the “Star of Laufenburg”. It was extended and upgraded from 1979 to 1981. From 2004 to 2009, EGL undertook the following refurbishment work:

- Step 1: retrofit of primary and secondary equipment
- Step 2: replacement of old station HMI
- Step 3: pilot project for IEC 61850-9-2

Step 1: Bay retrofit

Both primary and secondary equipment of the 17 feeders was replaced in a bay-by-bay manner, warranting an almost interruption-free retrofit. The migration was supported by a compact hybrid solution that connects the new gas-insulated switchgear (GIS) modules to the existing air-insulated switchgear (AIS) busbar using silicon bushings. The GIS modules comprising circuit breaker, disconnector, earthing switch and instrument transformers were pre-tested to enable short installation times. They offer maximum operational safety and high immunity to environmental conditions. They also require less space and simplify maintenance as replacement of a complete pole can be performed in less than 24 hours.

The future-proof secondary retrofit concept addressed the varying lifecycles of bay and station-level equipment. With the latter equipment being retained, ABB integrated its new IEC 61850 compliant bay control and protection IEDs (Intelligent Electronic Devices) to the third-party control system using a gateway converting IEC 61850 to IEC 60870-5-101. ABB also successfully integrated a third-party main protection device with an IEC 61850 interface. Consistency of bay data during the stepwise upgrade was supported by pre-configuring and pre-testing using an SCL-based tool.

Step 2: Station-level replacement

In 2007, ABB won an open tender for the replacement of the old station HMI (human-machine-interface). ABB installed a new IEC 61850 HMI fully re-using the engineering data from the SCD file generated for the bay retrofit.

Step 3: Introduction of process bus

The pilot installation contains a selection of products and systems ready for the IEC 61850 process bus. On the primary side, there is a combined and fully redundant CP-3 current and voltage sensor with merging units for protection and metering. On the secondary side, a REL670 line distance protection IED and a REB500 busbar protection system with three bay units are in operation. Metering is performed by an L+G energy meter. For supervision and easy access, a SAS using IEC 61850 station bus completes the pilot installation.

The pilot is running in parallel to the conventional control and protection system and enables collection of long-term real-life experience as well as comparison of behavior. Since its commissioning in 2009, the system has been in continuous operation.

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