IEC 61850 unites low- and medium-voltage

IEC 61850 can be used with ABB’s low-voltage (LV) intelligent electronic devices (IEDs) such as REF medium-voltage (MV) protection relays and Emax 2 LV circuit breakers to design and operate a fully integrated protection and supervision system that spans the LV and MV worlds.

Already a well-established standard in high-voltage (HV) and medium-voltage (MV) protection, IEC 61850 is now being increasingly used in low-voltage (LV) applications, thus greatly extending its reach. Equipment now benefitting from IEC 61850 functionality includes ABB’s intelligent electronic devices (IEDs) such as REF MV protection relays as well as Emax 2 LV circuit breakers. Together, these two devices make it possible to design and operate a fully integrated protection and supervision system that spans the LV and MV worlds. This comprehensive approach is made possible by exploiting IEC 61850 to create features such as advanced logic selectivity based on device-to-device communication, real-time diagnostics and integrated engineering. A significant deployment of this innovative technology recently took place in Italy, where ABB installed an IEC 61850-based LV and MV protection system in an ice-cream factory.
IEC 61850 is a well-established communications standard for substation automation. However, rather than merely embodying a set of dry rules, IEC 61850 can also form the bedrock of a complete electrical design concept that includes the entire protection, control and supervision system. In contrast to other industrial automation protocols, IEC 61850 was specifically designed to meet the needs of substation automation, which are relentless in their increasing complexity. Also, interoperability is considered at a very basic level to enable equipment from different vendors to be integrated into the same system without custom-designed gateways or other engineering-intensive complications.

While designed for substation automation, IEC 61850 is potentially applicable to protection systems in all electrical installations, including those in industrial and commercial arenas. In fact, its increased reliability, finer selectivity, shorter fault reaction times and the possibility to implement fault tolerance and integrated diagnostics make IEC 61850 the protocol of choice for many critical process control systems in chemical plants, oil installations, data centers and marine applications, etc.

GOOSE
From the data communication point of view, IEC 61850 has been designed to fulfill the needs of electrical protection systems. However, there are some basic differences between these systems and process control systems that influence how communications should be implemented. Process control is typically designed for the implementation of control loops: Measured samples from sensors need to be transferred to a controller that runs control algorithms and produces output to be sent to actuators. These actions are repeated cyclically, with adherence to sampling frequency and cycle time a paramount requirement. When a network or field bus is used to connect controllers, sensors and actuators, many interlaced control loops share the available bandwidth in a round-robin fashion. Designing this kind of system often involves scheduling as many cyclic data packets as possible into the available bandwidth.

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01 Adoption of IEC 61850 for LV equipment has greatly enhanced protection and supervision systems. Shown is LV and MV switchgear ABB recently provided to a customer site.

02 Simplified single-line diagram of GOOSE communication.

03 GOOSE-based LV/MV diagnostics.
In each cycle, sensors are read and actuators are operated only at fixed times, with the step interval determined by the cycle duration. This cycle time, determined in the system design phase, introduces a delay between a change in the measured quantity and the operation of the relevant actuator. Such a delay is of no concern as long as it is compatible with the time constants of the process under control.

Protection systems, as well as the supervision of electrical installations, follow a different concept: Electrical quantities are measured by the supervision system in cycles that are relatively slow and the measured quantities are typically not used in control loops. When a fault occurs, however, the protection devices that detected it suddenly need to transmit fault information as quickly as possible because other devices must receive the information and decide which breaker should trip. Arranging such transmissions in a round-robin or other cyclical fashion, which requires the device to wait its turn for access to the communication media, would introduce unacceptable delays. The effective handling of such unscheduled, on-event communication is one of the differentiating features of IEC 61850 and it is implemented using special data packets named GOOSE (generic object oriented substation event) messages. Instead of cycle time, with GOOSE messages the key engineering characteristic is latency, i.e., the delay between an event and the transmission of relevant information on the network →2.

A key feature of GOOSE messages is that they can be used for horizontal (i.e., peer-to-peer) communication between devices in addition to the usual vertical communication from devices to a supervision system. So, a logic selectivity or an interlock between two circuit breakers can be implemented by direct message exchange between the relevant devices without relying on a central processing unit to manage the process. Horizontal communication improves both performance (shorter overall reaction time and more efficient use of the communication channel) and reliability (as a failure of the central processing unit would impair the whole protection scheme).

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In addition to fault signaling, GOOSE messages can be used to implement a built-in diagnostic mechanism in the protection system. Each device can be configured to send a GOOSE message to others on a regular basis (eg, every second) to report that its status is normal. If the relevant devices fail to receive the appropriate message they may send alarm messages, switch to a predefined safe mode or take other actions as required →3. Diagnostic messages use the same communication medium as other data packets, so no additional hardware is required.

Interoperability is considered at a very basic level to enable equipment from different vendors to be integrated into the same system without custom-designed gateways or other engineering-intensive complications.

Engineering and configuration
Additional advantages of IEC 61850 are related to engineering and configuration processes. Because of the complexity and number of the devices involved, designing a protection system without a structured, computer-assisted process would be impossible. The sheer number of configuration and working details would overwhelm the engineer and cause critical errors. To prevent this, IEC 61850 relies on standardization of objects and data types, and on formal electronic descriptions.

IEDs used for protection can be very complex. Their complexity is managed in IEC 61850 by describing each device as a set of logical objects, which can be published to the final application. Such objects are abstract enough to be applicable to devices of different types or from different vendors, yet realistic enough to be applicable to the engineering job in hand. Examples of such objects are overcurrent protection, current and voltage measurement, control of a switch, etc.
At the cornerstone of the IEC 61850 data model is a catalog of standardized logical objects with well-defined meanings, and applicable parameters and data items. All devices compliant with IEC 61850 use the same objects to implement the same function, making it possible to combine objects in a common way in a final application. Such standardization goes down to object names (e.g., PTOC always represents an overcurrent protection), which makes them easy to recognize and use by the design engineer. Data types are also set by IEC 61850, so that, for example, the result of a measurement is defined together with its name, measurement units, quality indications and so on, thus reducing the probability of errors.
To complement such standardization, IEC 61850 describes a common electronic format in which devices and systems are described.

All devices – i.e., all IEDs in this case – are each described by a file, written in SCL (Substation Configuration Description Language), that lists all its properties and logical objects.

SCL files can be read and manipulated by IEC 61850 software engineering tools, allowing a smooth process and a reduced number of errors.

Such a formalized electronic description language has the important side effect of easing interoperability between devices from different vendors: As long as the objects they implement are described by the SCL file, the user need not be concerned with their inner workings.

**IEC 61850 joining the LV and MV worlds**

Most existing IEDs are protection relays used in MV installations. However, significant advantages are achieved when IEC 61850 is applied in the LV world. This is now possible by using ABB Emax 2 circuit breakers – the first air circuit breakers to implement a native IEC 61850 interface.

Further, ABB’s Ekip digital protection unit, which can be installed on Emax 2 breakers ranging from 800 A to 6,300 A and fitted with a choice of communication protocols, also comes with IEC 61850. Full integration between LV and MV protection and supervision systems can finally be attained, with significant improvement in reliability and a smoother, unified interface to supervision systems.
IEC 61850 for an ice-cream factory

A particularly significant example of such integration is the LV and MV switchgear ABB recently provided to a customer site in Ferentino, Italy. The plant, one of the largest of its kind, is an ice-cream factory producing some of the best-known brands in Italy.

The installation includes a main 20 kV panel with UniSec switchgear for connection to the main grid and a second panel feeding several 4 MVA and 3 MVA transformers. The transformers, in turn, power a 6 kV panel that supplies process motors and the main LV switchboards. The LV switchboards are supplied by a third-party panel builder and use ABB Emax 2 circuit breakers. All the MV relays (REF611, REF542+ and RIO600) and REM motor protection devices are connected by an IEC 61850 bus, which also connects the three main Emax 2 circuit breakers serving as main incomers for the LV part →4 – 6.

ABB’s Emax 2 circuit breakers are the first air circuit breakers to implement a native 61850 interface.

Using IEC 61850 across the LV and MV protection systems allows implementation of a number of advanced features, the most important of which is logic selectivity when a short circuit occurs. Should a short circuit occur on one of the MV motor feeders, its protection relay immediately sends a GOOSE message to the upstream protective devices (REFs used for transformer protection and interface protection), so that they refrain from tripping; only the circuit breaker installed closest to the fault is instructed to open →7. Unnecessary loss of power on other parts of the plant is thus avoided and process availability is maximized.

Similarly, in the case of a short circuit on the LV side, the affected Emax 2, while clearing the fault, sends a GOOSE message to the REFs, so that no MV breaker trips unnecessarily.

In addition to improved logic selectivity and a higher overall reliability, use of a single protocol offers a common interface for plant supervision and monitoring, providing more and better quality data to operators so they can run the plant in an optimum way. ●