Case Study by Alan Fernandes Teixeira and Leandro Henrique Monaco*

Improved operations and asset health using System 800xA with IEC 61850

Vale´s Solebo copper mine in Brazil, utilizing the System 800xA IEC 61850 solution.

Vale demonstrates how to make industrial automation more efficient, using integrated information from both process and electrical systems, based on IEC 61850 Standard.

Introduction – "The Power of Integration"

Substation automation systems are composed of many elements: those that protect equipment and those that control switches, circuit breakers and transformers are key to operation. All of these require supervision and monitoring in respect to performance and limitations.

There are two common architectures when it comes to substation automation. The first commonly applies to new plants, in which the designer defines the network and infrastructure topology. This circumstance is best in order to mitigate risks, compile information from the electrical system and optimize implementation costs. The second scenario more often applies to older plants, or those in operation for a number of years. Here, plants are often without a dedicated infrastructure for electrical automation. In these plants, it is common to find several automation systems for each substation. They often utilize PLCs from various vendors as supervisory systems. The lack of a central system to manage all substations makes information exchange troublesome and plant management, as a whole, much more difficult.

In today's technology environment, it is essential to have an automation system capable of integrating all available information into a single platform, regardless of protection relay model or protocol. Integrating substation automation with the process control system builds a single database, allowing for complete plant management, in terms of both operation and maintenance. Making information available anywhere in the plant also facilitates remote operation, further enhancing monitoring capabilities.

Electrical Automation Integrated System – IEC61850 standard

The best-case scenario, having equipment from multiple vendors integrated into a single system, has become reality with the advent of IEC 61850 and evolution of substation equipment like IEDs (Intelligent Electronic Devices) and digital meters. Such integration allows several substations, with IEDs from different vendors, to be grouped into a single system. Known as "interoperability," this strategy allows for maintenance of the electrical system to be done using information from the whole plant, making operation easier than ever.

* Reprint of an article published in Issue No 146 of the Brazilian ISA InTech magazine.

“It’s essential to have an automation system capable of integrating all available information into a single platform.”

Leandro Monaco and Alan Fernandes.

The IEC 61850 standard is sometimes misinterpreted as solely communication protocol; however, it goes beyond that. In order to standardize communication in substation automation, IEC 61850 is based on three principles: interoperability; freedom of configuration and long-term stability. Interoperability, as discussed, describes the ability for IEDs from different vendors to communicate with each other. Freedom of configuration describes the ability for vendors to use different methods and philosophies for the internal programming of the logic performed by IEDs, allowing the freedom to allocate functions to one or more IEDs. Long-term stability refers to the process of keeping communication protocol up-to-date in such a rapidly advancing technological field.

About the authors

Alan Fernandes Teixeira is an application engineer of electrical automation in the mining segment of ABB’s Process Automation division. Located in Brazil, he graduated from São Judas Tadeu University with a degree in Electrical Engineering – Electrotechnics.

Leandro Henrique Monaco is the electrical automation engineering manager in the mining segment of ABB’s Process Automation division in Brazil. He graduated from The Polytechnic School of University of São Paulo, with a degree in Electrical Engineering – Automation and Control and Master of Science in Systems Engineering.

The three principles build upon one another, freedom of configuration cannot be achieved without interoperability and long-term stability is accomplished only after the first two are adopted protocol.

For these plant-wide goals to be met, the way devices exchange data is standardized through the use of a Logical Node. A Logical Node is “the smallest part of a function that exchanges data” (IEC 61850-SER ed1.0, 2010). Each substation function is broken into smaller parts; the way data is exchanged between each part is standardized, without affecting operation. This ensures interoperability, freedom of configuration and, of course, long-term stability.

In order to facilitate information exchange between devices, two communication protocols are defined: one for communication between IED and the supervisory system, MMS; and another for fast communication between IEDs for interlocks and logic selectivity, GOOSE. MMS protocol (Manufacturing Message Specification) is used for communication between IEDs and the supervisory system based on client-server philosophy, i.e., the IED becomes a server for the information available and the supervisory system becomes a client for that information; it is used for supervision and operational data. GOOSE protocol (Generic Object Oriented Substation Events) is used to exchange the critical time-information between IEDs inside the network for protection, for interlocking and logic selectivity purposes. This communication is based on MAC addresses, and allows the transmission of packets in the network as fast as 3 ms.

GOOSE protocol is one of the great advantages of IEC 61850, reducing the amount of wiring between cubicles in a substation to perform logic selectivity schemes greatly reduces installation time and maintenance costs.

All communication between the devices is accomplished following Ethernet network protocol globally recognized in both enterprise and industry environments. At this point, it's important to note the network configuration on an industrial project. Today, it is no longer possible to foresee an industrial scenario without communication possibilities offered by industrial networks. The need for information integration (achieved long ago in IT scenarios) has become crucial in industrial scenarios, and will become increasingly so in the future.

Figure 1 presents a generic and minimalistic topology of an electrical automation project. Included is substation equipment like circuit breakers, switchgears etc., (given by iPASS Switchgear boxes) as well as measurement instruments like CTs and VTs (MUPX and MUPY boxes), these are physically connected to the protection and control IEDs (given by boxes Bay Controller, Prot X and Prot Y), which are connected to an Ethernet switch. The switches of each substation are part of a network that is connected to protocol gateways and to human-machine interface equipment (HMI). GPS devices are also commonly used to synchronize time on the IEDs in order to allow the sequence of events (SoE).

Advantages for the electrical system

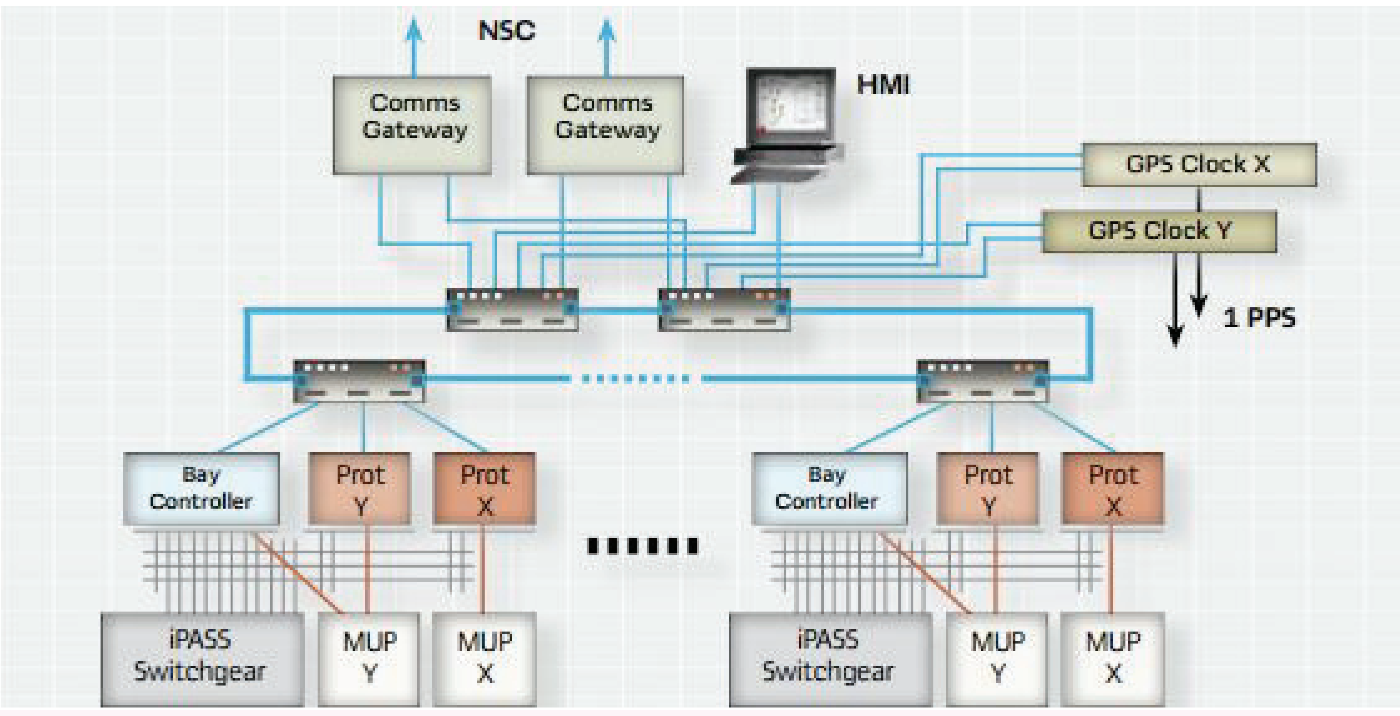
As intelligence for protection and logic selectivity is distributed to and amongst the IEDs, the DCS can be in-charge of power management and other logics that require a higher level system view. Some functions such as load shedding, generator control, turbine management and transformer tap control can be run on the DCS. Some controllers have GOOSE interface, achieving operating times faster than 10 ms. This reduces selectivity adjustment times, taking care of the mechanical health of cabling, circuit breakers, switchgears and machines, without using hardwires.

Another advantage provided with the advent of IEC 61850 is the generation of trend data for all equipment in the electrical system. Digital meters already have communication drivers, soon CTs, VTs, circuit breakers and switchgears will enter the market with the same. Soon, operators will be able to see a system even more integrated than currently possible, through a single standard of network connection.

Case Study: Itabira integrated system

Information integration brought by the use of IEC 61850 protocols, especially interoperability, is better visualized through a real-life example. This section covers the integrated electrical automation system of Itabira, the iron ore beneficiation plant in the city of Itabira-MG, Brazil. In this particular system, six substations were integrated into a single system. The involved substations are located in different places throughout the city, separated by distances up to 30 km.

Figure 1: Network Topology of the Automation System in IEC 61850.



IEDs in use are from two different vendors, because retrofits were made at different periods and under different contracts.

The supervisory system is from a third vendor, it communicates with the IEDs via MMS protocol for system operation and supervision. Due to the large distance between the substations and the risk of lost or weak communication signals, a contingency solution is in place for each substation.

This contingency plan consists of a human machine interface touch-screen panel and a controller with GOOSE interface able to transfer data to and from IEDs, ensuring remote operation of circuit breakers and switches. This achieves the main project goal: to keep the operator away from the electrical cubicle, and consequently, away from electrical risk.

With IEC 61850, it was possible to get all the available information gathered in the same system, making electrical system operation possible regardless of where the operator is. Protocol adoption also allowed for the communication between IEDs, from different vendors, located in substations with notable distances between them. With the information centralized through Ethernet networks, the creation of a remote operating room was possible. From this room an operator can view everything that is happening in the system. IEDs can be parameterized and configured from anywhere with access to the system, adding yet another benefit to this standard.

After the project was completed, remote operation and maintenance was guaranteed and information from six different substations was integrated into one single system.

Electrical and Process integration

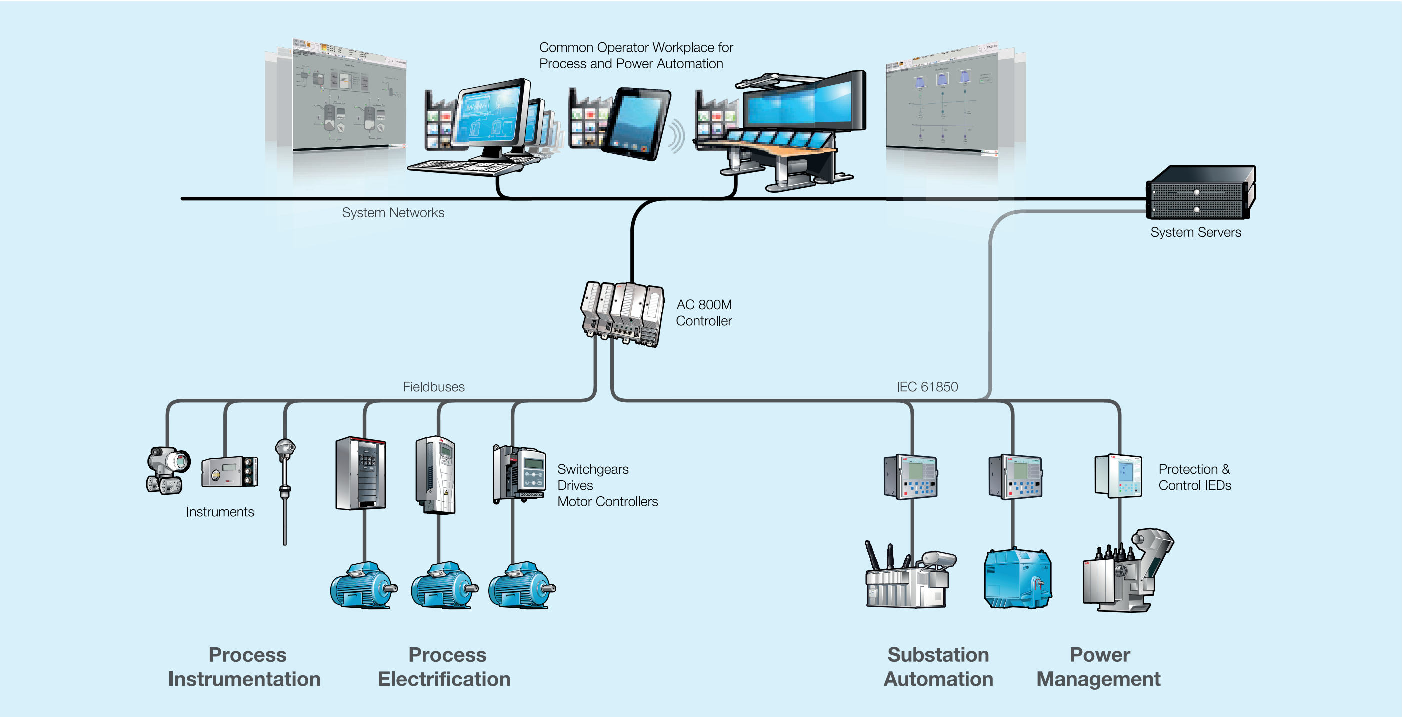
The adoption of Ethernet-based systems allows open protocols to be used more often, creating more complete automation systems, and thus, optimizing costs and information availability in plants of all sizes.

There still remains a strong separation between the electrical automation system, responsible for power management, and the process automation system, more focused on the production, in a way that there is little or no exchange of information between the two. Increasingly, plant operators are opting to have a single system manage the entire plant, looking for excellent performance in both Process and Electrical automation, through a unique DCS system.

Advantages for the process control system

Among the advantages stemming from integration; cost reduction is key. This includes indirect costs shared between areas, such as training and investment. In addition, new features can be implemented with the combination of information.

Figure 2: Full plant integration of process automation and power automation with System 800xA as implemented at Vale´s Itabira plant in Brazil. Note the common process and power automation workplace. The use of open standards means an end to tiresome device-by-device implementation and far less hard-wiring.



An example of this can be found in the adoption of medium voltage protection relays for motor control in IEC 61850, in which it's possible to use all the benefits of GOOSE messaging between IEDs without losing the interaction with process equipment, such as instrumentation, valves, and inverters.

A real case for this functionality can be given by a conveyor that handles ore, steel or any other goods.

In these cases, it is not uncommon for big medium voltage motors to be required for operation. In the event of failure, replacement is almost never immediate, causing damage and loss of production. Using features from the substation automation environment, like logic selectivity and interlocks, it's possible to preserve equipment health.

Figures 3 and 4 show that, using IEC 61850, it is possible to switch off motors before over-current effects are detected by CTs, lowering the impact on the motors, thus increasing their life cycle. This reduces the likelihood of damaged windings or more serious problems that would demand replacement or extended downtime.

Conclusion

The availability of quality system data is necessary to day-to-day operation, increasing demand for useful information in all areas including the industrial environment, and causing dramatic changes in established practice.

With the advent of IEC 61850, more information is collected from the electrical automation system, with Ethernet communication and data standardization. This enables interoperability and allows for freedom of configuration with IEDs from different vendors. With such a wealth of data available in supervisory systems, the information integration between automation systems allows multidisciplinary decisions to be made. This provides better efficiency. Moreover, applications developed for the electrical environment can be used in process control system as well, which is seen in the examples described.

IEC 61850 allows for a huge jump in quality, and changes the way we think of automation.

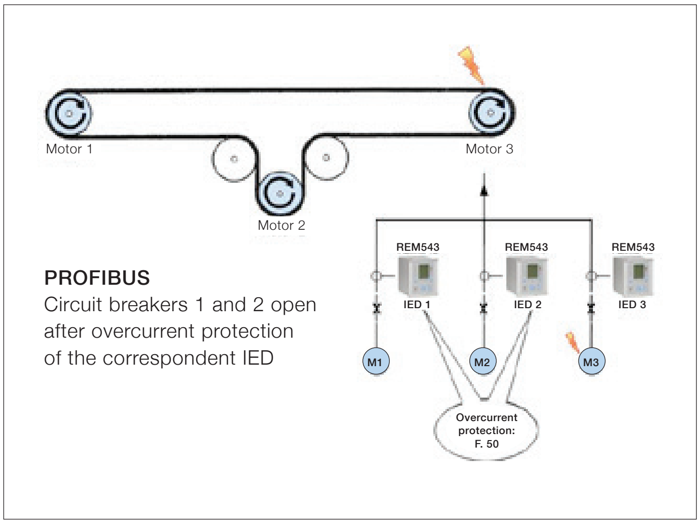
References

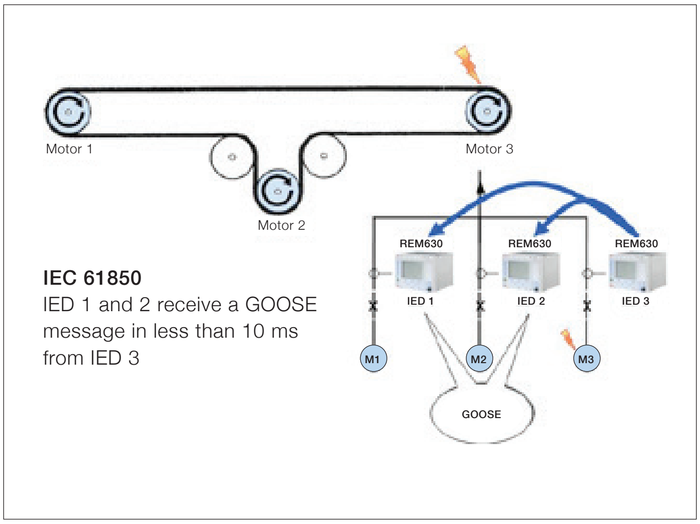
IEC 61850-SER ed1.0: Communication networks and systems in substations – ALL PARTS; Switzerland: International Electrotechnical Commission, 2010.

MONACO, L.H. Integração com IEC61850 – Fluxo de Engenharia. In: 13º. Seminário de Automação de Processos ABM 2009, São Paulo, Brazil, Set 2009 (in Portuguese)

MONACO, L. H. Estudo de caso: sistema integrado de automação de subestações usando a norma IEC61850 aplicado na usina da Vale Itabira-MG.
In: 15º Congresso Internacional de Automação, Sistemas e Instrumentação, Brazil Automation ISA 2011, São Paulo, Brazil, 8-10 Nov 2011 (in Portuguese).

Figure 3: Conveyor motors interlocking according to a traditional fashion. | Figure 4: Conveyor motors interlocking using IEC 61850.





Contact us

ABB Automation LLC
Control Technologies
Abu Dhabi, United Arab Emirates
Phone: +971 (0) 2 4938 000
E-Mail: processautomation@ae.abb.com
www.abb.com/controlsystems

ABB Pte. Ltd.
Control Technologies
Singapore
Phone: +65 6776 5711
E-Mail: processautomation@sg.abb.com
www.abb.com/controlsystems

ABB China Ltd
Control Technologies
Beijing, China
Phone: +86 (0) 10 84566688-2193
www.abb.com.cn/controlsystems

ABB Inc.
Control Technologies
Wickliffe, Ohio, USA
Phone: +1 440 585 8500
E-Mail: industrialitsolutions@us.abb.com
www.abb.com/controlsystems

ABB AB
Control Technologies
Västerås, Sweden
Phone: +46 (0) 21 32 50 00
E-Mail: processautomation@se.abb.com
www.abb.com/controlsystems

ABB Automation GmbH
Control Technologies
Mannheim, Germany
Phone: +49 1805 26 67 76
E-Mail:
marketing.control-products@de.abb.com
www.abb.de/controlsystems

ABB S.P.A.
Control Technologies
Sesto San Giovanni (MI), Italy
Phone: +39 02 24147 555
E-Mail: controlsystems@it.abb.com
www.abb.it/controlsystems

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