Refined integration

State-of-the art electrical integration for a refinery
utilizing System 800xA and IEC 61850

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A reliable and dependable energy supply is vital for the functioning of any industry. Managing and controlling this supply is thus as important as managing and controlling any other significant process parameter. The integration of the electrical control system into the process control system increases productivity and availability by permitting a single strategy in the areas of engineering, maintenance and operations.

ABB has taken the lead in the domain of electrical integration with its award-winning Extended Automation System 800xA, enabling intelligent electrical devices to be integrated utilizing the global IEC 61850 standard for control and protection of substation equipment. The adoption of a global standard based on state-of-the-art technology enables lower installation and operational costs, as well as enhanced asset management capabilities.

ABB is providing process control and power management systems based on System 800xA to nine of Petrobras's 12 Brazilian refineries – solutions that will help increase production by a massive 40 percent. In this article, *ABB Review* takes a look at the project in Petrobras' REPAR refinery.

Innovation in production

Electrical integration is not a new concept. Low-, medium- and high-voltage devices have been integrated into process control systems (PCSs) for many years. Traditionally, the systems that serve process automation and power distribution within the same plant are separate, but are coupled by extensive hardwired interfaces. Due to cabling and engineering costs, the bandwidth and cost efficiency of this approach is very limited. The introduction of intelligent electrical devices (IEDs) and serial interfaces permitted much more information from the electrical system to be utilized. This approach is commonly used today in industrial and power generation applications.

A large variety of protocols and standards are used in substation automation, including IEC60870-5-10x, DNP 3.0, Modbus and various legacy protocols. The multitude of interfaces required lead to a broad variety of engineering tools, protocol converters and gateways, and hence additional hardware, maintenance and increased engineering costs. This could result in solutions having to be implemented on a project-by-project or even a device-by-device basis. **1** illustrates a scenario that has different serial protocols for communication with the IEDs, as well as a hardwired interface between the electrical and process control system.
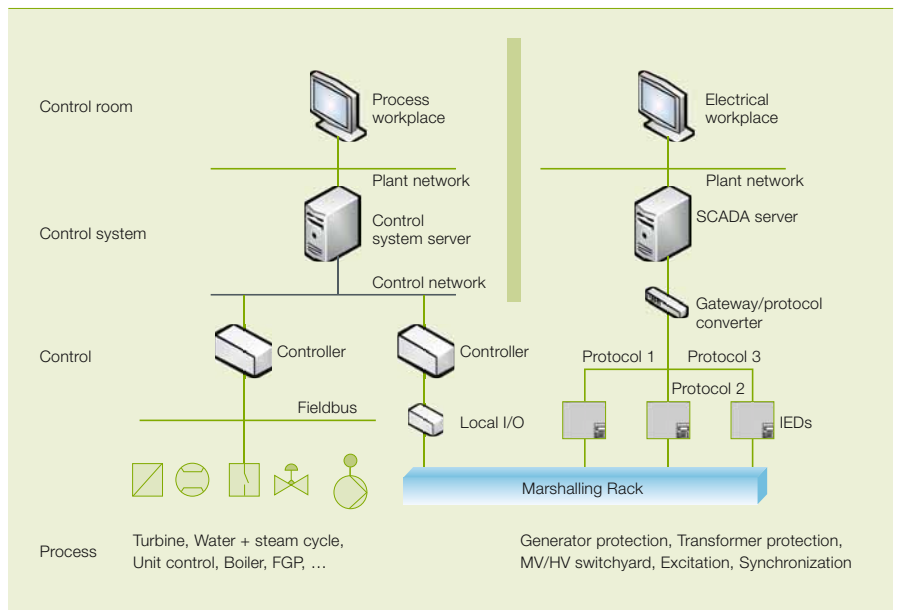
IEC 61850
The 2004 introduction of the global IEC 61850 standard for substation automation represented a huge step forward in simplifying the integration of IEDs. The standard ensures the interoperability between devices and is capable of replacing all the various protocols in the substation-automation domain.

At the core of the IEC 61850 standard is a complete object-oriented model of the IED, its data and supported communication services. These are modeled in a form that is consistent across all types and brands of IEC 61850 compliant IEDs. Interoperability is further supported by the use of a common XML-based substation configuration description language (SCL) **Factbox 1**.

1 Separate process and power automation systems using hardwired integration

Factbox 1 Mapping of data model to protocols according to the IEC 61850 standard

* Generic object oriented substation event
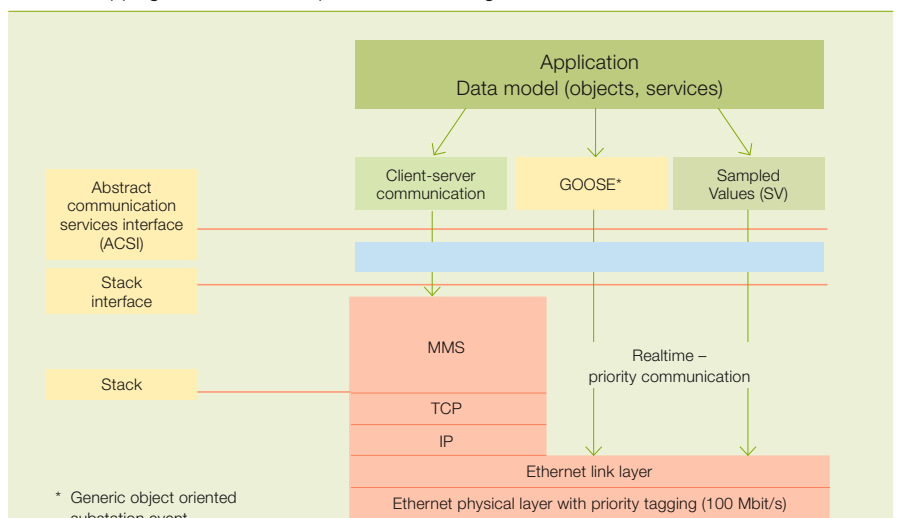
IEC 61850 communication
IEC 61850 uses mainstream communication technology MMS (Manufacturing Message Specification) over TCP/IP and Ethernet. The data model and the communication stack are linked by means of standardized mapping. This mapping is the only item that needs adaptation should the communication technology be changed. Such an approach ensures long-term stability in the face of future developments. The adopted mapping from communication services to the communication stack is shown in the adjoining figure. Client-server communication (vertical communication from the IEDs to the control system) uses a mapping from the data model to the full MMS stack (left-hand side of figure). GOOSE (Generic Object-Oriented Substation Event) and Sampled Values (SV) are further communication services, both used for real-time high-priority data – achieved by direct mappings into the Ethernet link layer and eliminating any middle-layer processing. GOOSE is used for horizontal communication between IEDs, where it replaces the traditionally hardwired signals. Sampled values are used for sending currents and voltage measurements in a high-priority fashion, mostly used in high-voltage applications.

IEC 61850's integration in System 800xA
ABB's System 800xA is the first process-control system on the market to support the IEC 61850 standard. The implementation is shown in **2**. Both vertical communication (using the full MMS stack) and horizontal communication (using GOOSE[1]) are supported.

The vertical integration is implemented using an IEC 61850 OPC server[2], which transfers the MMS data to System 800xA in the form of regular OPC data items. This means System 800xA has direct access to all selected IED data such as current and voltage measurements, status, interlocking, time-stamped alarms and events, and can also send open and close commands to the IEDs. All System 800xA display capabilities, such as freely configurable graphics, faceplates, alarms and event lists, and historian capabilities are available. Furthermore, IED parameter reading and writing can be performed remotely, as can the transfer of disturbance recording files to System 800xA.

The horizontal part of the integration is achieved with the AC 800M controller utilizing GOOSE communication. By equipping the AC 800M with an IEC 61850 interface, horizontal communication is made possible with all other IEDs on the same IEC 61850 network in a real-time fashion. Examples of application areas are fast load-shedding signals, interlocking, or even analog values needed in the controller application.

By utilizing both vertical and horizontal communication, System 800xA is equipped to use the latest state-of the art technology to communicate with IEDs according to a global standard. This means seamless integration of substation equipment, enabling true integrated process and power automation with a single-system solution. The main benefits are:

Footnotes

[1] GOOSE: Generic Object-Oriented Substation Event
[2] OPC is a standard for real-time communication between control devices from different manufacturers. Today, OPC is officially a name and not an acronym, but originally stood for OLE for Process Control.
OLE stands for Object Linking and Embedding, a document embedding and linking technology.

2 Integrated process and power automation using System 800xA with IEC 61850
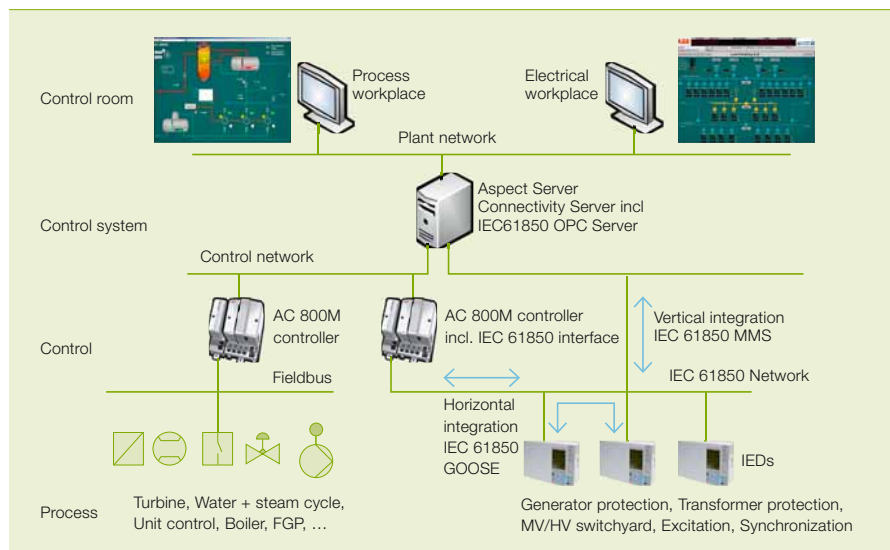
Factbox 2 What is power management?

The supply of power and energy is vital to every industry. The management of that supply is just as important. Industry's dependence on scarce energy resources, the volatility of energy costs, growing environmental concerns and more stringent legislation are just a few of the factors influencing the global drive for improved energy management.

Power management has been designed specifically for the most energy-intensive sectors in which industries operate, such as in oil and gas and petrochemicals. In many areas around the world, operations face an insufficient or unreliable public power supply. Such industries must therefore largely depend on their own generation and distribution capabilities. Power management schemes manage energy vulnerability and ensure sustainable energy for plant operations by reconciling efficiency, economic, health, safety and environmental considerations.

The power management system controls and supervises power generation and supply. One of the most important functions is load shedding, which requires fast network determination and energy balance calculations. The protection/control units can also monitor and, if necessary, invoke frequency-based load shedding. Another important function in power management is generator control (including integration with the governor and excitation controller).

ABB's Power Management System (PMS), an offering based on System 800xA meets the requirements of industries in which power management is a vital topic in terms of costs and an important prerequisite for reliable operation.

ABB's System 800xA PMS is a state-of-the-art solution with advanced features that surpass the capabilities of traditional automation systems. These include:
- Extensive scalability in size, performance and functionality
- Redundancy at all levels
- Support of multiple programming languages
- Support of legacy, standard and ongoing developments in the area of communication protocols, including OPC, Modbus, Modbus TCP, PROFIBUS DP, Profinet, TCP/IP, IEC 60870, DNP3, IEC 61850 and others
- High-speed communication capabilities
- Support of IEC 61131-3 programming languages
- Integration with process control systems
- Integration with subordinate systems, including GPS, meteorological stations and motor control centers and CMMS
- Asset optimization
- Extended security and access control

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- One user interface ensures consistency in data presentation, data access and operating procedures – meaning a significant improvement in operator effectiveness
- Data recording and archiving onto one single database for faster error analysis and capturing plant-wide sequence of events
- Lower cost of ownership due to fewer spare parts, and less training, system administration and documentation being required
- Enhanced asset-management capabilities using the electrical diagnostic data and connection to enterprise level systems such as computerized maintenance management systems (CMMS)

The REPAR refinery is one of Petrobras' most important downstream production units.

Power management for Petrobras

ABB has a large installed base of power management systems Factbox 2 in Petrobras refineries Factbox 3. Of the 12 refineries owned by Petrobras on Brazilian territory, ABB has installed the PMS in nine of them and the process control system in seven.

Three years ago, as part of their strategic growth plan, Petrobras decided to invest in increasing its production and in improving the quality of its products – mainly in the areas of diesel and gasoline – through the addition of new production units and the modernization of others in existing refineries. In February 2008, Petrobras thus signed a frame agreement with ABB for the supply of PMS and PCS. The agreement had a value of $61 million and covered the supply of hardware, software and technical services including specialized training. The contract forecast implementation of around 70 projects on nine refineries in which ABB has installed base.

The scale of the modernization program is immense. In addition to building new units for hydro treatment, cooking, desulfurization and other processes, Petrobras is constructing 50 new substations and modernizing

about 40 others using the IEC 61850 standard.

ABB's System 800xA is ideally suited for such large-scale plant-wide projects: In addition to being the leading automation platform in a wide range of process industries, it has the unique capability to integrate the process, electrical and safety systems into a single system.

This, among other things, enables refinery operators to monitor and control the systems from a single interface and run power management applications and intelligent IEC 61850 substations in the process-control system.

The operational and cost benefits of such an integrated system are huge, including optimization of all automation and electrical assets, simplified engineering, streamlined maintenance, improved energy efficiency, and lower initial investment costs compared with running non-integrated systems.

Petrobras is planning to further streamline its processes in operation, maintenance, training, optimization and quality control. System 800xA can provide data and resources to support such improvements.

ABB's System 800xA is the first process-control system on the market to support the IEC 61850 standard.

REPAR Project

The REPAR refinery is one of Petrobras' most important downstream production units. It is located in Brazil's Parana state, one of the most industrialized and most populated regions of the country. Consequently, REPAR is among the refineries to receive a larger investment in the Petrobras strategic plan.

The implementation of the growth plan of the REPAR refinery included the installation of the new PMS. This encompassed several new substations including a 230 kV intake substation, a 69 kV GIS[3)] distribution substation and 12 process substations as well as two

new turbo generators. The project almost tripled the energy available for the REPAR refinery from 26 MW to 76 MW and included the building of a new power house and 12 new substations and the modernization of eight existing substations.

The REPAR refinery adopted the IEC 61850 standard as the communi-

cation technology for its substation automation and PMS. ABB's System 800xA was ideally suited to meet REPAR's PMS needs. The new PMS was required to integrate the functionality of its predecessor system in terms of using the same database of key control features such as load-shedding responses and reactive-power control in a single and centralized solution. The old PMS thus saw its Advant stations upgraded to System 800xA, while retaining its Advant Master controllers. The new substations use System 800xA from the start 3.

The new substations use redundant AC800M controllers that have IEC 61850 interfaces and PROFIBUS DP fieldbus networks to connect to intelligent MCC[4] and drives. The IEC 61850 network is used in the following voltage levels: 69.0 kV GIS substation, 13.8 kV switchgear, 2.4 kV medium-voltage distribution-center panels and 0.48 kV distribution-center panels. Thus ABB's PMS is used to control all voltage levels of the electrical system of the refinery. The operation of System 800xA is supported by ABB's PMS Library, whose implementation builds on 24 years of experience with power-management systems in ABB.

When this project is complete, System 800xA will have 16 redundantly fitted AC800M controllers installed in 10 substations interfacing with around 460 IEDs in total.

For the operation of the new PMS and PCS, REPAR built a new centralized control room where a total of 56 System 800xA operator stations are being installed. Four of them will be exclusively used for the monitoring of electrical operations. One of the most important projects was the 69 kV GIS, based on ABB's 670 series of IEDs – the substation is already working using the new technology.

The rigorous studies connected to the introduction of IEC 61850 network architecture Factbox 4 brought automation engineers and substation engineers together to the same "project table." ABB is supporting the integration efforts by guiding substation engineers in the correct usage of the IEC 61850 data model to permit a perfect integration with System 800xA PMS.

Benefits
Some of the benefits for Petrobas are:

Standardization
The adoption of IEC 61850 technology and System 800xA permitted Petrobras to standardize various procedures in substation configuration, control logic, control libraries and operation procedures. These translated into savings in commissioning time and configuration. The object orientation of IEC 61850 supports standardized device models using names instead of object/register numbers and indexes. System 800xA,

Footnotes
[3] GIS: gas-insulated switchgear
[4] MCC: motor control center

3 PMS REPAR simplified architecture integrated with existent system

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through its IEC 61850 compliance, was able to fully support this standardization.

Lower investment cost
The use of IEC 61850 combined with System 800xA PMS brought simplicity to many phases of the project implementation. This was noticed in the definition, design and engineering phases through the common user environment, use of the Ethernet standard, the single tool for the engineering integration of all devices, less wiring and more advanced protection capabilities thanks to the use of horizontal GOOSE messaging for direct exchange of data between devices.
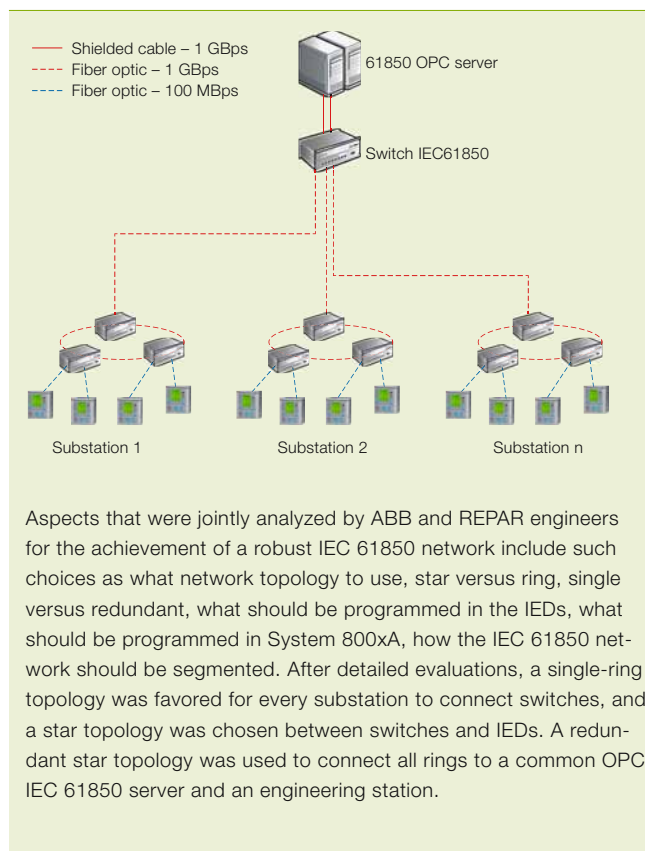
Lower life-cycle costs
One of the main benefits delivered to REPAR was optimal life-cycle management and low life-cycle cost through the use of a future-proof system with IEC 61850 interoperability. The reuse of engineering data and the use of a standard language for programming highlighted the power of IEC 61850 for REPAR projects and the associated costs savings through less need for training and reduced staff requirements.

The adoption of System 800xA also protected past investments: The existing system, based on Advant Master controllers, could be fully integrated with the new. Furthermore, the new PMS has structures ready to receive a future replacement of the legacy system controllers.

Integrated process and power automation
A unified system for process and power automation was used to combine power management, process electrification and process control into a single control environment in the REPAR Refinery. Benefits that REPAR already valued with its existent PMS, such as reduced energy costs through power management, were transferred into the new system and strengthened through the implementation of a fully

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Factbox 4 Architectural analysis

— Shielded cable – 1 GBps
---- Fiber optic – 1 GBps
---- Fiber optic – 100 MBps

61850 OPC server

Switch IEC61850

Substation 1   Substation 2   Substation n

Aspects that were jointly analyzed by ABB and REPAR engineers for the achievement of a robust IEC 61850 network include such choices as what network topology to use, star versus ring, single versus redundant, what should be programmed in the IEDs, what should be programmed in System 800xA, how the IEC 61850 network should be segmented. After detailed evaluations, a single-ring topology was favored for every substation to connect switches, and a star topology was chosen between switches and IEDs. A redundant star topology was used to connect all rings to a common OPC IEC 61850 server and an engineering station.

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integrated system. The control of drives, intelligent MCC's, medium-voltage switchgear, protection and control IEDs were all integrated on the same system. Improvements directly perceivable by REPAR include increased visibility of the process, the possibility of asset management of electrical devices, improved interface with process control and improvements in operation procedures.

> # The adoption of System 800xA protected past investments: The existing system, based on Advant Mastercontrollers, could be fully integrated with the new.

Reliability and availability
System 800xA allows the implementation of a PMS in a DCS platform. The use of this platform gives the system the highest levels of availability and reliability. The REPAR Project is based on redundant AC800M controllers, a

redundant control network, a redundant IEC 61850 OPC interface, and other arrangements in which System 800xA was tailored to meet Petrobras specifications. This and other mechanisms of availability improvements helped deliver a system to REPAR that reduced unscheduled downtime.

A digital system integrated with a powerful IEC 61850 network allowed use of remote maintenance tools, access to device diagnostics and reporting, increasing system reliability.

A successful integration
ABB has recognized the implementation of an integrated process-control and power management system based on System 800xA for the Petrobras REPAR refinery as one of its top innovations of 2009.[5] The REPAR project will be completed in 2011, with the other Petrobras projects following later. The integration of PMS and PCS will enable higher productivity through more far-reaching optimization of plant operations and will represent a model for future projects worldwide.

The photographs used in this article are of the REPAR refinery and copyright of Petrobras.

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Footnote
[5] See "An innovative 2009" on page 6 of this edition of *ABB Review*