As technology continues to drive innovations, industrial enterprises must continue to keep pace to remain competitive in an ever-changing marketplace. The technology trend is to replace yesterday’s systems with higher-performance, low-cost, option-rich devices that shorten the return on investment and offer more flexibility. As control system technology evolves, systems migrate to functions that are being increasingly distributed to smarter, more granular, control-system components capable of performing localized operations.

Industrial facilities are under increasing pressure to reduce overall costs, boost productivity and quality, and improve personnel safety. One systematic approach for reaching these goals is automating and integrating facilities from the plant floor through the management of process information. Device-level integration through digital communication is the key to unlocking the full potential in the electronic controls being installed in industrial plants today. New advancements in device-level status monitoring and communications have boosted process throughput, system practicality, and affordability of complete plant-level integration.

Furthermore, while the industrial automation space was being transformed by networks and communications, so, too, was the electrical infrastructure market. The challenge that remains is how to effectively integrate these two systems in an optimized, intuitive fashion. If one compares the evolution of heavier-than-air vehicles, adding more powerful engines was not a solution when there was lack of proper and efficient flight controls. Without a review of the entire system, such as with the power and process systems of a modern facility, the overall system will lack high performance.

**POWER AND PROCESS TRENDS TODAY**

Today, many industrial processes are controlled by a combination of systems working together (hopefully, in sync) to produce a target yield or product. Examples of these systems include continuous and discreet process control systems, electrical protection, SCADA, historian for archiving, and reporting tools for data trending. Traditionally, these subsystems have been logically separated as seen in Figure 1. The red boxes in Figure 1 depict the process automation system with intelligent motor control (IMC) devices — e.g., variable frequency drives, overloads, starters, etc. — feeding a process controller. This process controller feeds data to higher level systems to archive and report on the data. The blue boxes represent the power automation system where
intelligent electrical devices (IEDs) feed a power automation controller. This controller, in turn, feeds similar higher-level systems to archive and report on the data. Although these two systems are within the same facility, they are logically isolated.

Figure 2 shows that, although the process and power automation systems have been logically isolated by industry, they are closely coupled to each other. It is very difficult to logically separate power from process, as they are intermingled within each other. The figure represents the power automation network in red and the process automation network in green. The red arrow suggests the linkage needed to realize the full potential of these industrial systems.

THE EVOLUTION OF POWER AND PROCESS AUTOMATION

Advancements in technology have created a society where companies want to collect a large amount of real-time data, sort this data — and with the advent of the discrete event data — turn this into actionable information. Today, there is a push to archive this discrete data so that it can be trended at a later time, as well as used for modeling of the overall process. From an industrial manufacturing standpoint, electrical protection and SCADA data is crucial to identify operating points, create predictive maintenance models, identify load-shedding opportunities, and manage energy consumption and root-cause analysis.

As the information age has evolved, so has the technology used to transmit data from the electrical protection system to SCADA systems. Power system and industrial-based electrical protection devices have evolved over the past three decades from electromechanical to microprocessor-based relays. In parallel, the communication networks for electrical protection have also evolved. Electrical protection architectures have developed from hard-wired contacts to communication networks using serial protocols, such as Modbus. Serial communication has evolved to communication protocols over the TCP/IP stack, such as Modbus TCP and DNP3 LAN/WAN, which then allowed substation devices to communicate in a peer-to-peer manner to share data.

The IEC 61850 standard has become more prevalent in recent years. These examples and applications show that an Ethernet-based standard, such as IEC 61850, can be used for protection, command and control, and SCADA gathering of data over the same redundant wire pair. As this real-time data is provided to the central controller or SCADA master in the system, graphics can be populated to alert engineers and operations to system status in a time-synchronized fashion. Additionally, this data can be used to make command-and-control decisions in an industrial application. Furthermore, leveraging power and process in a unified solution provides users many benefits while reducing the overall total cost of ownership.
A UNIFIED SOLUTION FOR POWER AND PROCESS

By using data from process and power controllers, an iterative evaluation of overall system efficiency, process-stage efficiency, and product quality can be performed. The result can help eliminate process bottlenecks and inefficient process steps, and reduce energy usage while maximizing overall system or plant output performance. Installing more efficient machines in one process step may actually be detrimental to the overall system performance without the review and collaboration of data from both data sources. Furthermore, harmonizing the upper layers of visualization, archiving, reporting, and enterprise services reduces cost and overhead for industrial process owners. The value of the unified system can be realized in the visualization, archiving, and reporting systems (Figure 3).

VISUALIZATION

Although automation control companies have developed solutions for process visualization, this solution takes process visualization one step further into the electrical distribution system. The IEC 61850 standard allows for the visual representation of reports and alarms at the process control level. With the development of more sophisticated human-machine interface (HMI) screens, global objects have been introduced into the automation graphics. The use of these global objects has allowed for the creation of faceplates, defined as reusable standard objects.

Examples of process faceplates can be seen in Figure 4. The left side of Figure 4 shows the representation of a low-voltage power circuit breaker with its command-and-control functions. The right side of Figure 4 depicts a faceplate of a low-voltage, variable-frequency drive. Each faceplate was constructed with multiple tabs to change between home, engineering, and diagnostic screens. Graphics were designed to provide a user experience similar to interacting with the physical device. The advantage of the faceplate is that it is a familiar, standard, prebuilt object that can be implemented repeatedly for similar engineering designs.

The common naming convention and logical model of IEC 61850 allow for a vendor-independent implementation of electrical distribution equipment, e.g., circuit breakers, relays, power monitors, etc. This information can be simultaneously displayed with process information provided by IMC devices, e.g., drives, overloads, starters, etc. Providing a unified visualization environment allows all pertinent information to be displayed in one place where data can be effectively acted on as actionable information.

Figure 3: Unified Visualization, Archiving, and Reporting

Figure 4: Graphical Faceplates
ARCHIVING
Time stamping of event data can be placed in a process historian, even if the act of event detection is a distributed system component. This enables reporting and key performance indicator (KPI) calculations based on energy data, as well as manufacturing processes variables. The impact of manufacturing intelligence with power systems data will yield relationships that, to date, have not been available in typical reporting environments. IEDs are critical to the management and control of industrial and commercial power systems, and can provide value in an environment with process historians.

Highly accurate and time-synchronized energy consumption and energy balance data can be used to determine overall process efficiencies for various production or process operations. Data from trip and alarm events can be deterministically used to establish maintenance schedules to prolong equipment life. Additionally, machine or production-flow characteristics can be refined and monitored to enhance production rates and maximize specific machine capabilities.

ASSET-BASED MODELING
The Industrial Internet of Things (IIoT) has created an environment where more data from assets is available than ever before. KPIs have traditionally been used to define metrics of industrial petrochemical facilities. The IIoT can present a number of KPIs for facility assets that are not uniform across similar types of equipment. Consequently, users have been seeking consistent application of KPI solutions across their enterprise assets. The definition of an asset template allows for consistent representation of a device across the industrial enterprise. Furthermore, this allows for comparison between assets or control processes in a standard fashion, thus optimizing reporting capabilities.

Asset models for equipment remove the concept of flat tags in a historian, replacing it with an object-oriented model. Tags that are monitored and archived are now associated with a physical piece of equipment or process, allowing context to be immediately applied (Figure 5). Furthermore, analytics can now be trended on each asset. Additionally, asset performance can now be compared at multiple levels: asset to asset, process line to process line, and facility to facility. The concept of asset modeling can be applied to power and process automation, thus providing standardization across the industrial enterprise.

REPORTING
The large quantity of data generated by modern automation systems makes it possible to apply a broad range of plant analytics to the automation systems and processes that make up an industrial enterprise or business. Reports, charts, and other human-readable formats are often available or may be created for plant personnel and others to monitor and review the generated data in either a real-time mode or at a later time after the data has been stored.

A report created to display the data of a given industrial automation system may find it difficult to find and display similar data of another industrial automation system. Objects and other components of the other system may be similar or even identical to the first system. However, due to even slight variations in component names (for example, during the system setup stage), a disconnect can exist between the data stored in the system and a pre-generated report designed to look for specifically named objects in the system. Thus, reports previously created may not display all the data they were designed to show.

Creating new reports or even fixing pre-generated reports to show the data generated by a particular system can be a laborious and tedious
manual process. This process can require setting up individual connections between system data points and the parameter value to be reported for hundreds of parameters or more.

The benefit of the IEC 61850 standard is that the logical model allows for standard reporting across vendors in a specific format. This means that an IED of a specific type from Vendor A can be reported on the same way as an IED of the same type from Vendor B. IEC 61850 allows for asset-based reporting models and type-based reporting, where reporting systems have the context of devices on which they are reporting. By creating type-based reports, users can associate content in the form of trends, graphs, and analysis on a particular type of device. When it is instantiated within the enterprise system, the reports come pre-populated and wired to system tags due to the common naming convention of the standard. This provides a substantial design time savings for implementers of a unified system.

**UNIFIED POWER AND PROCESS REPORTING**

Even more powerful reports can now be created in a unified environment. These reports may provide additional insight into cause and effect of how changes in the power automation system affect process automation and vice versa. These reports will allow process owners to provide better predictive and preventive maintenance, as well as optimize their overall process to new levels. The ability to obtain electrical information within the unified system allows for energy inputs into the facility optimization state space equation.

For example, in Figure 6, a unified system, a process owner can realize instantaneous profit, as they know all of the process yields (gross profit blue line), as well as the total costs to produce (red line). The area between these two curves provides the owner the instantaneous system profit in a timely fashion. This information can feed additional control loops to take corrective action and further optimize the process. Now, electrical distribution parameters can be effectively used in process optimization schemes. Furthermore, this electrical data can now be used in overall efficiency calculations and asset liability, and can be presented in dashboard format as seen in Figure 7. This data can be used to compare not only process line data, but also can be extrapolated in a facility-to-facility comparison providing a true enterprise comparison for process owners.
CONCLUSION

A common connected architecture across the process control and power control infrastructure creates a straightforward method for an organization to securely integrate and manage information flow across the entire connected enterprise.

Captured enterprise-wide data — starting from the most critical assets to the smallest shop-floor sensors — can provide the most relevant working data capital needed to deliver complete plant- and enterprise-wide automation and process efficiency. The true value of this enterprise-wide data lies not in the data itself, but in which analytics can be applied to the data. In this way, the raw information reveals areas where process and control transformation can be applied to identify points where power and process optimization can be employed.

This working data capital is easily displayed and analyzed by those decision makers, at many levels of the enterprise, who can put it to best use. Using the most relevant interconnected technologies enables more efficient analysis, communication, and visualization of this valuable and scalable working data capital across the entire enterprise.

REFERENCES


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