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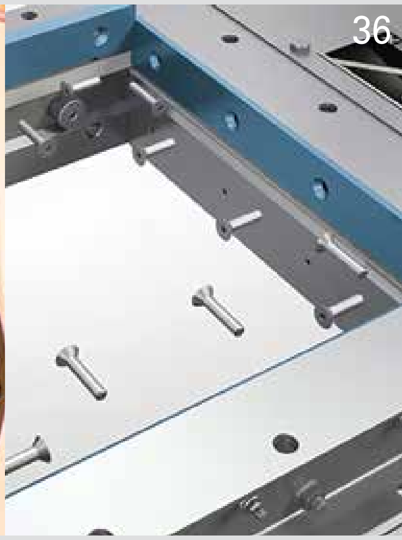
CONTENTS



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Cover

The only manufacturer of circuit breakers and related devices in Africa, **CBi-electric** is a truly South African success story. *Read more on page 17.*

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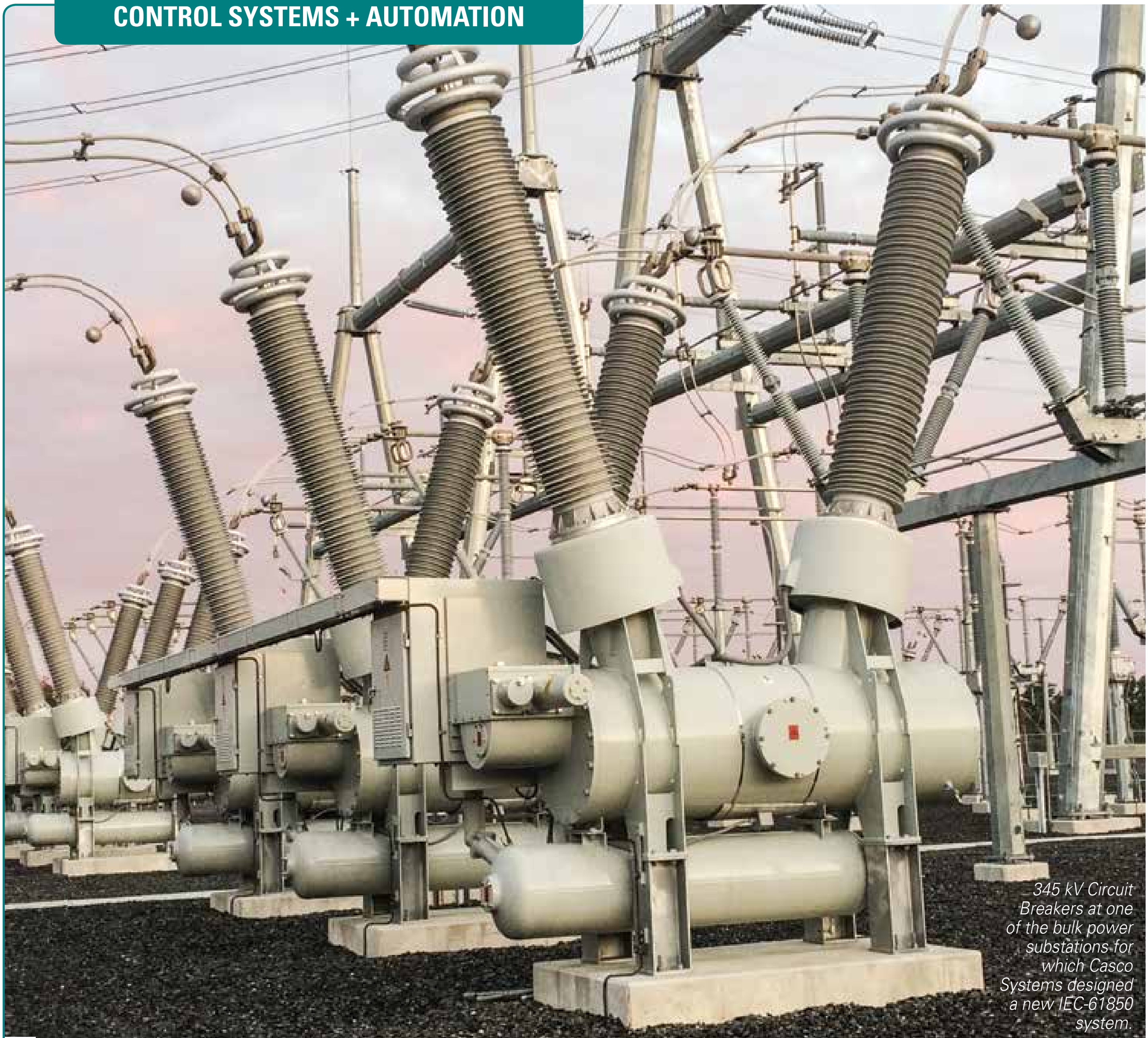


345 kV Circuit Breakers at one of the bulk power substations for which Casco Systems designed a new IEC-61850 system.

IEC-61850: Promise and pitfalls

By K Mahoney, Casco Systems, LLC

Whereas control systems have long been a part of our industry, relying on complex measurement and information systems, only within the past few decades have robust standards been developed to transfer some features into the national grid. This takes automation of the network to a new, smart level. The IEC-61850 [1] standard promises a future of standard data models, automatic device configuration, lower costs and increased functionality. But the question remains, does it deliver?

A communication protocol defines a common language used to exchange information. If you can envision trying to speak Spanish while visiting Japan, you can understand how critical selecting the right protocol for a given task is to your ultimate success. Pick the wrong protocol and you cannot communicate at all, select a protocol with limited functionality and you may be able to get some, but not all, of the information you want. Selecting the right protocol, with the right mix of features and functions, will enable the exchange of all desired data and ultimately decide the success of any substation automation project.

The electric utility industry has a long history of applying many different protocols, however; these protocols have historically been proprietary, limited in functionality and difficult to replicate across manufacturers. Using multiple protocols in one location or project adds cost and presents a number of problems that the IEC-61850 [1] standard seeks to address. As you can imagine that while two native Spanish speakers can hold a conversation quite easily they will struggle to communicate with a Japanese speaking colleague. The IEC-61850 [1] protocol holds forth the promise of being the universal lingua franca of the electric substation and perhaps across the entire

ACSI – Abstract communication service interface
APCS – Advanced Protection and Control System
BC – Block Close
BFI – Breaker Failure Initiate
BFT – Breaker Failure Trip
BFTT – Breaker Failure Transfer Trip
CT – Current Transformer
GOOSE – Generic Object Oriented Substation Events
HMI – Human Machine Interface
IEC – International Technical Commission
IED – Intelligent Electronic Device
ISO – International Standards Organisation
MMS – Manufacturing Message Specification
PT – Power Transformer
RI – Reclose Initiate
RTU – Remote Terminal Unit
SCADA – Supervisory Control and Data Acquisition
SCSM – Specific Communication Service Mapping
SMV – Sampled Measured Values

Abbreviations/Acronyms

power industry. However along with this potential comes risk, added costs and pitfalls that should be fully considered before committing to build an 'IEC-61850 [1] substation'.

Promise

As an international standard for substation automation, IEC-61850 [1] defines the exchange of information between disparate systems from multiple vendors. Having a common method of communication that allows interoperability between all devices, regardless of manufacturer, opens the potential for new protection, control, automation and integration functions. It also promises lower cost of implementation and ownership, greater flexibility, and the ability to adapt as new applications are defined. This standards-based approach enables integration of modern protection, control, metering and supervisory equipment into a total substation solution. This total solution will enable the next generation of utility Smart Grid functionality including dynamic equipment and line rating, automatic grid restoration, advanced predictive equipment maintenance, fault and SER logging, and many other features yet to be defined.

A common misconception is that the IEC-61850 [1] standard is a 'protocol'. In fact it is a standard for the design of an electrical substation that defines abstract data models which are mapped to a number of specific communication protocols. The approach defined by the standard takes advantage of an object-oriented data model and Ethernet networks, enabling a reduction of configuration and maintenance costs while enabling enhanced functionality.

Selecting the right protocol, with the right mix of features and functions, will enable the exchange of all desired data and ultimately decide the success of any substation automation project.

In addition to the data model the standard also defines a number of specific communication protocols, each with a specific niche focus designed to enable various facets of substation communication. These protocols include the Manufacturing Message Specification (MMS), Generic Object Oriented Substation Events (GOOSE), Sampled Measured Values (SMV) and Web Services. Each of these protocols provides different capabilities targeted to address applications within the substation environment. For example the IEC-61850 [1] MMS protocol is targeted at supervisory level communication while GOOSE is designed for high speed (< 4 ms) peer to peer communication.

345 kV Substation Yard showing 'A' frame transmission line structure, circuit breakers and reactor bank.

The IEC-61850 [1] standard is divided into multiple sections that collectively define the overall solution:

- IEC 61850-1: Introduction and overview
- IEC 61850-2: Glossary
- IEC 61850-3: General requirements
- IEC 61850-4: System and project management
- IEC 61850-5: Communication requirements for functions and device models
- IEC 61850-6: Configuration description language for communication in electrical substations related to IEDs
- IEC 61850-7: Basic communication structure for substations
    - o IEC 61850-7-1: Principles and models
    - o IEC 61850-7-2: Abstract Communication Service Interface (ACSI)
    - o IEC 61850-7-3: Common data classes
    - o IEC 61850-7-4: Compatible logical node classes and data classes

- IEC 61850-8 Specific Communication Service Mapping (SCSM)
  - o IEC 61850-8-1: Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3
- IEC 61850-9: Specific Communication Service Mapping (SCSM)
  - o IEC 61850-9-1: Sampled values over serial unidirectional multidrop point to point link
  - o IEC 61850-9-2: Sampled values over ISO/IEC 8802-3
- IEC 61850-10: Conformance testing

So the IEC-61850 [1] standard promises a future of standard data models, automatic device configuration, lower costs and increased functionality. But the question remains, does it deliver?

Pitfalls

The IEC-61850 [1] standard and its associated protocols provide for great flexibility to allow it to be adapted to almost any application.

However this flexibility comes at the cost of complexity and confusion. Written with the help of many integration and protection engineers from across the globe, the standard has been in various stages of development since 1995. Given the long history and wide scope of issues the standard intends to address, the standard itself can and has been interpreted differently by each hardware and software vendor. That is the first of several pitfalls to understand each vendor while being compliant with the IEC-61850 [1] standard may have its own unique flavour. This often leads to confusion for users accustomed to simple, address based protocols like DNP3 or Modbus. In fact on a recent large project with IEC-61850 [1], IEDs from seven major manufacturers, we found eight distinct implementations of how each device implemented the standard!

Another point to consider when moving to an IEC-61850 [1] solution is the merging of traditional 'protection' and 'integration' functions. In many past projects these two realms, while closely interrelated, were treated as separate domains and often designed by different engineering teams. With this new approach the configuration of protection and integration settings are often combined into a single setting file. By its very nature IEC-61850 [1] has forced the 'protection' engineers to work much closer with the 'integration' engineers. The result is that changes in one area may have unintended consequences in another. What was formerly a 'quick' change to add an integration feature (or fix a problem) must now be carefully considered in the context of the entire Protection and Control scheme.

Kevin Coyne, integration engineer Casco Systems and Kevin Mahoney, founder and President of Casco Systems, with the IEC-61850 Simulation System used for Research and Development. This lab configuration was used to prototype and validate all of the integration and protection settings for the project.

Consideration must also be given to how this new system will be documented. Given that much of the wiring is being replaced with messaging, how will this critical information be documented for future troubleshooting, modifications and testing? With prints no longer reflecting the full detail of system interconnections a documentation method must be developed based on logic diagrams, tables, flow charts or some other method that will adequately reflect how the system works.

Other factors to take into account are the differing levels of internal support and expertise among vendors; overall maturity of the standard's offerings provide by different vendors, plan to work through bugs in firmware and software, and the critical need to perform detailed lab testing prior to field commissioning in order to work out all integration issues prior to becoming part of the project's critical path.

Last ,and perhaps most importantly, careful planning must go into deciding how the new platform will be commissioned, maintained, modified and routinely tested in the future. How will relays using 'virtual wires' be isolated for relay maintenance or replacement? How will commissioning be performed and what equipment is necessary? What new training, tools and techniques are necessary to safely work on a platform of this nature. These are all questions that must be answered and solutions designed into the platform from the outset.

Conclusion

Casco Systems took part in the development of an Advanced Protection and Control System (APCS) as part of a multi-year, $1,4 billion United States transmission system upgrade. This project involved the construction of 440 miles (708,111 km) of transmission lines and multiple new 115 and 345 kV bulk power substations. Working with the owner and other project stakeholders the entire concept of substation protection, control, automation, integration and security was examined in light of the desired functionality, requirements and IEC-61850 [1] technology.

Included in the initial engineering effort was the development of new standards for the Substation Remote Terminal Unit (RTU), Human Machine Interface (HMI), Protective Relay Logic, Intelligent Electronic Devices (IED), Communication Networks, Data Collection and Cybersecurity. The APCS platform utilised the latest technology for application in the utility class substation environment including IEC-61850 [1] based communication protocols for all intra-substation device to device communications. While the DNP3 protocol was used for backwards compatibility and communication to the SCADA Master Station, the project goal was to use IEC-61850 [1] everywhere possible inside the substation.

This platform was designed with advanced features and limits the use of hardwired interconnects and devices, moving all but the most critical tripping and sensing 'onto the wire'. Breaker trip circuits,

Kevin Mahoney testing the IEC-61850 based Advanced Protection and Control System (APCS) during 345 kV substation commissioning.

as well as PT & CT sensing circuits remained hardwired, but all other interconnection wiring was moved 'onto the network'. All IED to IED communication including Breaker Failure Initiate (BFI), Breaker Failure Trip (BFT), Breaker Failure Transfer Trip (BFTT), Reclose Initiate (RI), Block Close (BC), and many other functions were implemented using 'virtual wires' over the Ethernet based IEC-61850 [1] network.

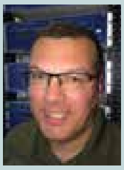
The end result is an advanced protection and control platform with a much simpler (and lower cost) hardware design. The project included advanced features such as equipment monitoring and data logging, fault event record automatic retrieval and storage, breaker switch operation event logging, cyber security monitoring and control, and remote engineering access to all relays, meters, remote terminal units, human machine interfaces, and other intelligent electronic devices (IEDs). The platform is a sophisticated implementation that brings 'smart' to the 'grid' for a comprehensive substation protection, control and monitoring solution.

Reference

[1] IEC-61850 (Standard). 1995. Design of Electrical Substation Automation. (Multiple sections listed within article).

take note

- Control and automation technologies must be applied to bulk electricity supply networks.
- Standards exist to ensure that system design and management are optimal.
- Utilities continue to supply the primary source of energy to our industry and it is critical that they have smart grid functionality.



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Enquiries: visit the company profile on the Industrial Automation Exchange.