IEC-61850 CONTROL SYSTEM AT ST WINDYHILL, SCOTLAND

Javier BOTICARIO
Arteche – Spain
javierb@arteche.es

Joe CUNNINGHAM
SP Energy Networks – UK
joe.cunningham@sppowersystems.com

Javier LORENZO
Arteche – Spain
javier.lorenzo@arteche.es

Santiago REMENTERÍA
Arteche - Spain
sr@arteche.es

INTRODUCTION

This paper describes the Integrated Control and Protection System from the Windyhill 132 kV substation of the Scottish Power EN substation network.

IEC61850 STANDARD

IEC-61850 is a standard for the design of electrical substation automation. It is more than a protocol and is a new approach to the solution needed for the digital substation. One of the goals of the standard is to give a better solution in substation automation based on improved performance and lowering the cost of the solution.

Some of the main points defined on the standard are:

1) The communication interface all the IEDs (Intelligent Electronic Device) must use to send and receive all its information.
2) The way you must name all the elements of the substation. The standardized object names are defined to relate the data.
3) The use of two different ways to communicate the IEDs. A fast way to send information and to assure precise transmission and also speed and reliability (GOOSE). And a way to do standard communications in real time over Ethernet networks (MMS).
4) Interoperability between vendors. It is one of the goals of the standard.

The most common implementations of 61850 follow the main rules of the 61850 standard but one of the main goals which was the interoperability between different vendors is not being followed in all the installations. It is very common to find mono-vendor solutions that work under 61850, but also they include some vendor specific features, so it is not a real plug-and-play solution, and limits the opportunity of the electrical companies.

WINDYHILL SUBSTATION SOLUTION

The challenge faced was the integration of a distributed system, multi-supplier, under the IEC-61850 standard, with the management of the different IEDs configurations which composed the system, diverse synchronization options (IRIG-B, SNTP), redundant SCU (Substation Control Unit), IEC-101 communications with the control unit and a web server for the local operation.

Other challenge of the solution was to provide a solution following the standard defined by the Spanish company Iberdrola, but also a solution that fits the requirements of the Scottish company SP Energy Networks.

One of the main points also was that this was the first implementation of IEC61850 in Scottish Power, so the protocol is not mainly used yet. And this is one of the disadvantages of the standard. It is the complexity of the initial research and the needed development before you can implement and operate a complete solution based on the standard.

The most suitable IEDs were used in each of the positions, depending on the function of control and/or protection which had to be done. Every IED communicated through IEC-61850 with a redundant SCU in charge of concentrating the information to be sent to the master control system through IEC-101. Also, the selected IEDs were coordinated with Iberdrola, between the group of manufacturers and devices that were approved for its use in the system.

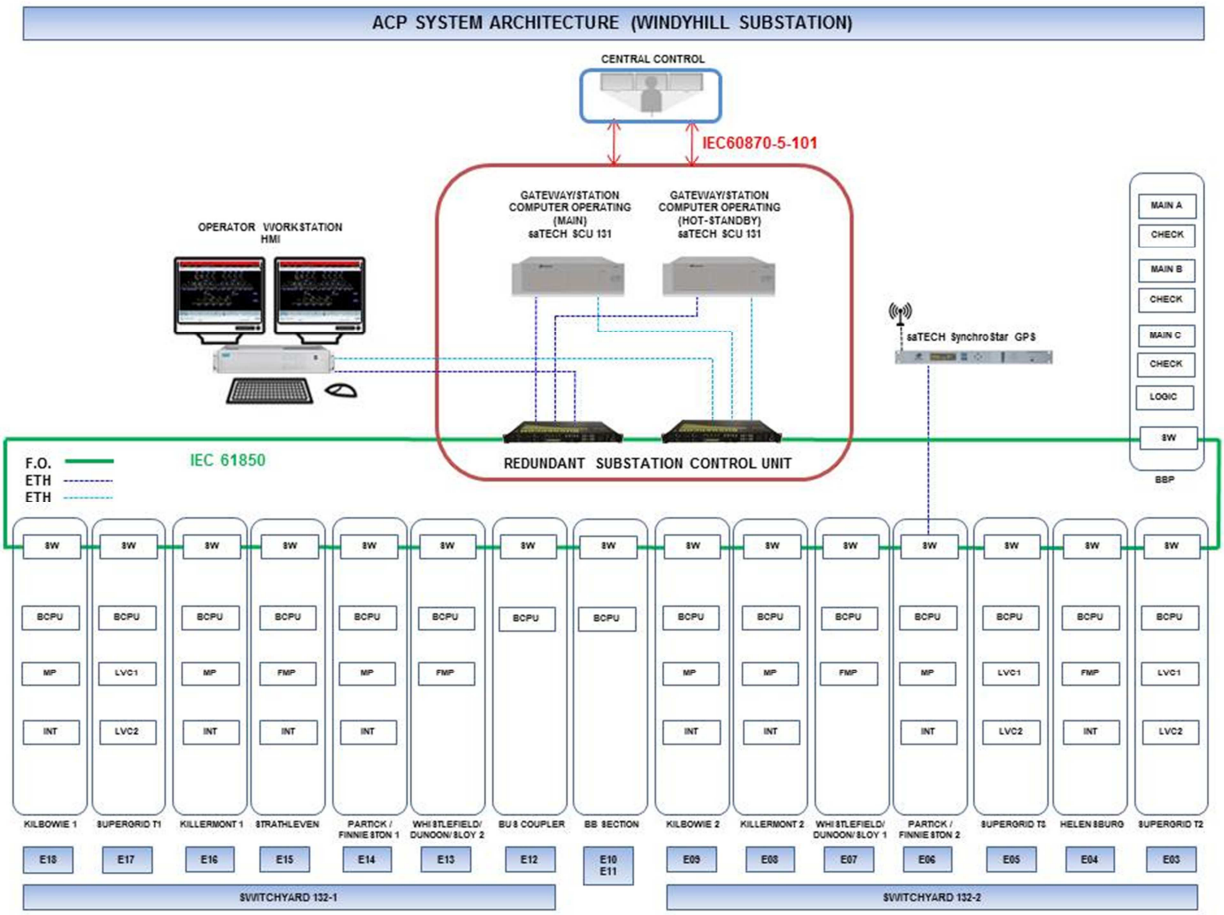
System Architecture

The architecture used in the Windyhill project is not very different from any standard solution based on legacy protocol.

It is composed with a simple ring which communicates all the IEDs of the substation. They are grouped in 17 cabinets where all the protection and control relays are installed. It also has the Substation Central Unit and all the equipment used for the synchronization network.

There was no need to include redundancy network protocols as PRP or HSR, in the solution, as part of the IEDs does not comply with these redundancy protocols, so a simple RSTP protocol was configured in the switches used on the ring.

In the next image you can see a schema of the Windyhill final architecture.



Main IEDs of the System

SCU

The SCU is the substation central unit of the system and it is the device used to concentrate all the information got from the IEDs of the substation and it is the responsible to send this information to the Electrical Company Control Center. It is the heart of the control system.

In this case the SCU is from the manufacturer Arteche, and was composed of two devices working on a "Hot-StandBy" redundant way, without external arbitrators, making use of the services offered by the IEC-61850 in order to avoid the loss of events in case of a commutation.

At IEC-101 level a principal channel was available with another redundant channel with the purpose of increasing the reliability of the system's remote control.

The device offered the web service for the local operation, being able to operate the components of the substation and to manage the status of the alarms, events and communications.

In addition, we found the "UCSCONF" facility, defined by the client, with which it is possible to manage the configurations of each system IED, to send a new configuration or to download the existing configuration of each device.

Any device used as SCU of a transmission substation must comply with several of the next requirements to assure its reliability:

- If it is possible, to have redundant power supply so the system can work in case of a single failure of a Power Supply.

- As the IEC61850 standard needs higher computation capacities than legacy protocols, the SCU must comply with these capacities. Also it would be useful to have high memory capacities to allow communications with a high number of different IEDs (to guarantee 100 IEDs communicating at the same time).
- It must include several network possibilities (optical fiber or Ethernet RJ45 connectors) to allow independent and simultaneous connection to several networks (for example, redundant rings, independent synchronization network, possible TCP/IP connection to control center, substation private LAN …)
- Another good option an SCU can have is the possibility to offer serial interfaces, so the device can communicate to IEDs using legacy protocols or to Electrical Control Centers with serial protocols as Serial DNP3 or IEC101.

HMI

The HMI in the Windyhill substation is based on a local webserver offered by the SCU, so you can control all the user actions using a remote client.

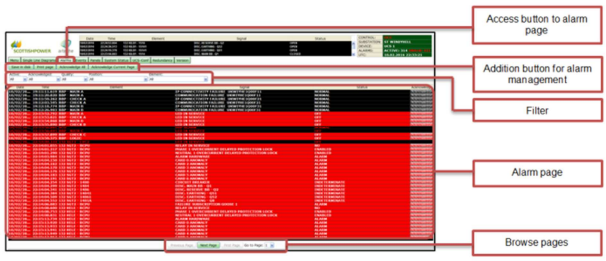
This remote client could be a local PC in the substation or a remote place if the client network communications is ready to establish remote connections (using a VPN or other secure connection).

This HMI offers an easy way to control the substation containing several independent screens with different functions. The main ones are.

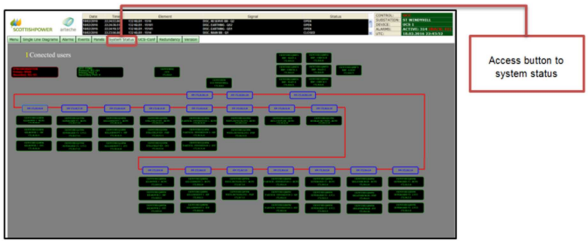
Single Line Diagram: an easy way to navigate through all the substation equipment and to view the state of all the devices and measures. Also it offers a simple interface to make commands in the substation.

Alarms view. The system offers a list with all the alarms in the substation including its timestamp, its state, and the possibility to interact with all of them.

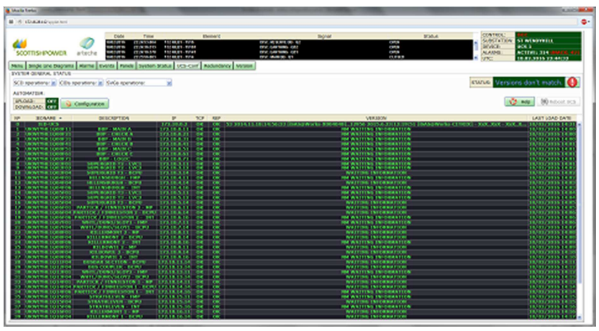
It also include a panel view with all the cabinets and the state of all the IEDs contained in that cabinet, so you will detect very fast if there exists any alarm in any point of the substation.



System status information: This screen shows the user a view of the architecture of the substation. It will show a quick view of the ring, the position of every IED, and also will alert the user if a problem exists.



Other important screens are the **events** register display where the user can follow the complete sequence of operations developed in the substation, or the included repository information of all the configured IEDs in the system (**UCSConf**).



Switches

All the ring of the substation was made with Ruggedcom (Siemens) switches. This network ring was configured with RSTP protocol to assure the reliability and fast recover of the ring, in case of a single failure.

Protections and Relay

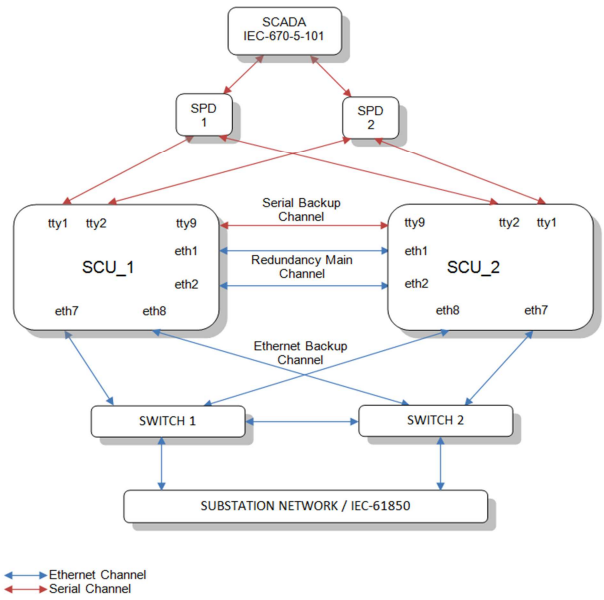
One of the main points of the system was to include a real multi-vendor system with Protections relays and Bay Control Units from several manufacturers.

In this case the Relays and Bay Units used were from these manufacturers:

- GE
- Alstom
- Siemens
- Ingeteam

Redundancy System

Windyhill SCU is a redundant one working in a Hot-Standby configuration. In the next schema you can see the different redundant channels available to guarantee the good behaviour of the system. This redundancy must be assured to the upper levels (Control Center) and to the IEC61850 ring.



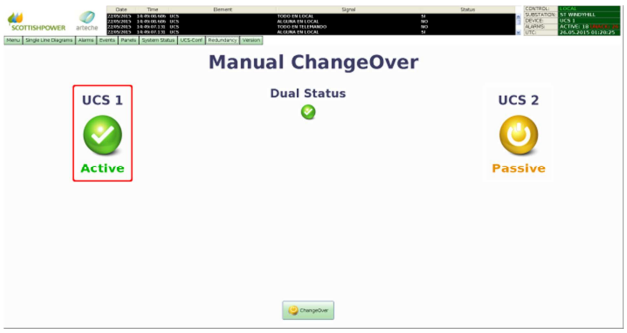
Redundancy Schema

To the upper levels, the SCU uses two different serial ports in both SCU. These serial ports are communicated with a modem (SPD) which broadcast all the information received from the active SCU.

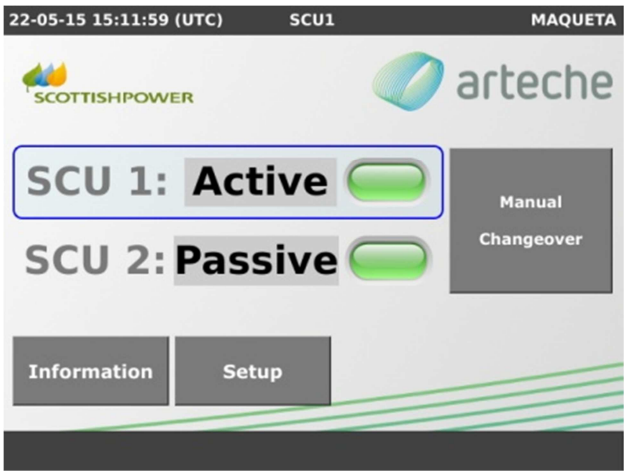
In the lower level (IEC61850 ring), there are three different independent channels to guarantee redundancy. First and main one, is a direct Ethernet redundant connection (two wires). This is the channel used to send all the information and to exchange the data base of both SCU.
Second one is a backup Ethernet channel through the substation network. So using this channel, both devices can exchange the status of the equipment.
Third one is a direct serial connection between both SCU. It is used just in case it happens any problem with the direct or substation Ethernet connections.

To view the state of the redundancy system, you have two different Graphical User Interfaces.

First one is using the connection offered through the webserver, with an HMI connected. It includes an easy way to view the state of the simple SCU, and also it offers the possibility to make a changeover in the redundant SCU



The second one, is a very useful way to know the state of the redundancy system, even if there is no HMI available. It is a frontal display included in the SCU that inform you about the state of the devices and also let you do some easy configuration tasks.



Synchronization Network

The synchronization network used in Windyhill is a simple classical network using IRIG-B to synchronize all the IEDs. It is also available an SNTP server available from a GPS clock (the same that offers the IRIG-B signal).

Also the SCU can be SNTP servers so in case a failure of the GPS clock, they can synchronize all the IEDs.

For IEDs which allowed both synchronization sources (SNTP and IRIG-B), a system of priorities is applied with the purpose of avoiding conflicts between both time references.

Configuration and SCL

The generation of the system's IEDs' configurations, single line diagrams, logics, remote control configurations, alarms and events, where done with the IsasWorks tool developed by SPEN-Iberdrola

Also, as the system is compliance with the IEC61850 standard, other manufacturer's System Configuration Tools (SCT) could be used to configure any of the IEDs.

The SCU is also ready to communicate with IEDs using edition 1 or edition 2 of the IEC61850 standard.

All the management of the complete configuration of the substation (CID and SCD files from all the IEDs) is done using the USCConf facility which offers a central repository to store and to upload or download the new and old CIDs to each of the substation IEDs.

CONCLUSIONS

- First IEC-61850 based solution successfully in service in SP Energy Networks.
- Normalized system, where a high level of interoperability is guaranteed thanks to the IEC-61850 standard.
- Multi-supplier system (GE, Alstom, IngeTeam, Arteche).
- IsasWorks configuration tool which allows setting up the IEDs in unified terms.
- Configuration management tool which allows you to manage through repository of the different configurations loaded on the IEDs of the substation.
- Easy maintenance with the local operations Web Console.
- Reliable substation remote control with a redundant system at the SCU level.
- GPS clock with possibility to synchronize by IRIG-B and SNTP at the same time.