Process Bus Implementation for Statnett

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Introduction:

The adoption of IEC61850 as the reference standard for digital substations caused a major shift in the design, commissioning and maintenance of protection and metering systems.

One of the main changes was the use of the Process Bus to exchange digital measurement data (Sampled Values) binary status information and commands over an Ethernet network that connects the switchyard and the bay control cabinets, thus making hardwiring signals between the switchyard elements and the control elements unnecessary. This is one of the main advantages of extending the adoption of IEC61850 to the Process Bus and it has clear benefits in terms of safety, reduction of wiring complexity and, ultimately, cost.

Process Bus: IEC61850-9-2LE vs. IEC61869-9

IEC61850-9-2 ed.2 defined this Process Bus, but the standard was leaving too much freedom for different interpretations by developers which, ultimately prevented utilities from getting the benefits of truly interoperable multi-vendor systems.

The UCA defined an “Implementation guideline for digital interface to instrument transformers using IEC 61850-9-2” (commonly known as IEC61850-9-2LE) which allowed the desired interoperability, but the market was still lacking a standard that would ensure interoperability between digital instrument transformers and the IEDs that are connected to them. This was solved in 2016 when the IEC61869-9 standard was approved to define the requirements for the “Digital Interface for Instrument Transformers”. IEC61869-9 specifies parameters that were left open by IEC61850-9-2 such as the sampling rates that should be supported by the Digital Instrument Transformers, the time synchronization that should be used, the content of the dataset that is sent with each Sampled Value etc.

The main differences between IEC61850-9-2LE and IEC61869-9 are related with the preferred sample rates and the preferred synchronization method.

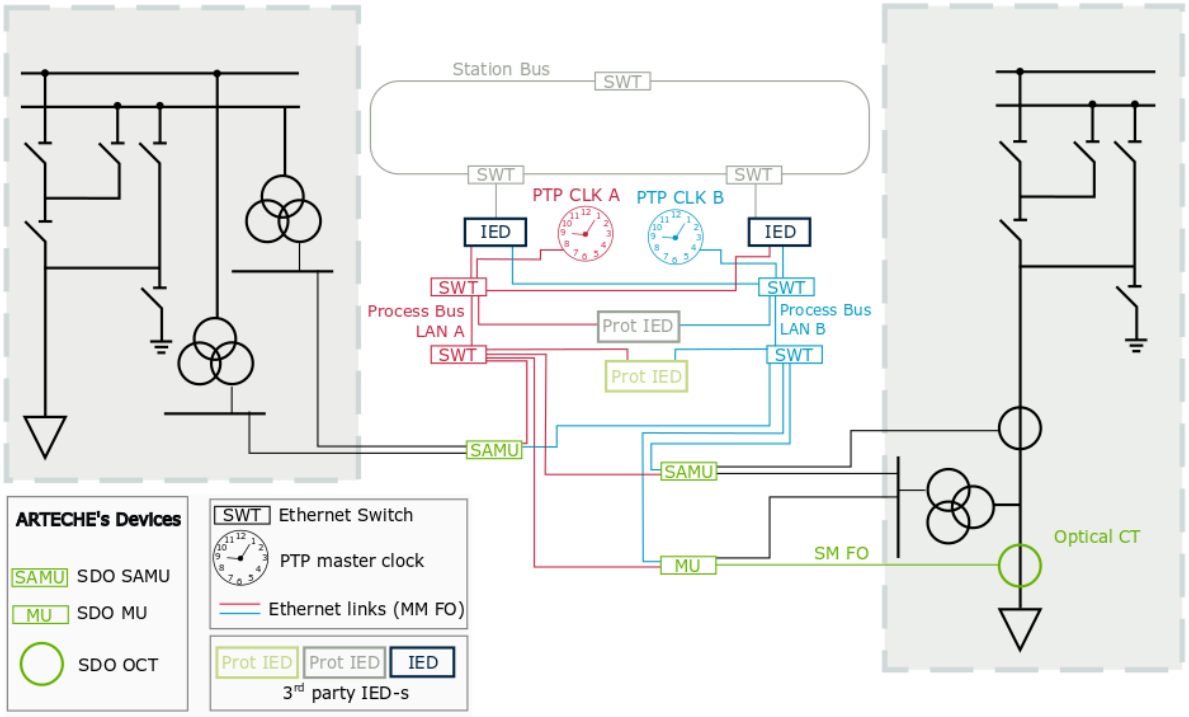
IEC61850-9-2LE specified PPS as synchronization method while IEC61869-9 introduces the IEC61850-9-3 profile of IEC61588:2009 (known as PTP or 1588).

On the other hand IEC61869-9 retains the sample rates specified in 9-2LE for backward compatibility but giving preference to 4800Hz for protection and 14400Hz for power quality metering (it also introduces 96000Hz for DC control applications). IEC61869-9 also recommends frames with 2 or 6 ASDUs (instead of 1 or 8 in 9-2LE) and short svIDs in order to preserve bandwidth.

The project

Statnett, the Norwegian TSO, decided to validate the concept of a standard-based IEC61850-9-2 Process Bus. The goal was to test a multi-vendor digital substation and to learn from the experience during a 2 year period when the pilot would be running in parallel to the conventional protection and control system.

An independent contractor (Jacobsen Elektro) was set on charge of the project and ARTECHE was selected as the independent instrument transformer manufacturer who would supply IEC61869-9 Digital Current Transformers. ARTECHE supplied its Non-Conventional (Optical) Instrument transformer solutions (based on the SDO-ICT optical current transformer and the SDO-MU Merging Unit) as well as the SAMU Stand-Alone Merging Units that were used to digitalize the output of conventional CT-s and VTs.



Simplified diagram (the project consisted of 4 Protection IEDs, 2 of them with synchro and auto-reclose functions).

The whole system was based on the exchange of Sampled Values as per IEC61869-9 requirements between ARTECHE's Merging Units and Stand-Alone Merging Units and the protection and control IEDs from 3 different vendors.

The synchronization was solved using PTP (IEEE1588v2) based time synchronization with redundant master clocks to ensure the resiliency of the system. As for communications, PRP was used to ensure redundancy in this multi-vendor pilot.

Additional benefits of the SDO OCT

Additionally to the benefits of the adoption of digital measurement, the customer could benefit from some other features ARTECHE's SDO OCT optical current transformers. Since no conducting material is used to connect the sensing part of the transformer head to the Merging Unit, it is possible to use the same sensor head for any given voltage level (just by selecting the right insulator). Thanks to the underlying technology, the SDO OCT does not saturate and is able to provide metering Class 0.2 accuracy measurement and allows accurate measurements over a wide dynamic range including protection class accuracy. This means that the same Optical CT model can be used for any given current and voltage level of the customer both for metering and protection applications.

Another secondary benefit is the use of solid and dry insulation. Thanks to this, no maintenance is required and there is no environmental or safety risk (no risk of leakage or explosive failure modes).

Results of the project

The pilot was successfully commissioned on September 2017 and the system has been running since then.

The technical and economic feasibility of the concept have been proven and the system is being continually monitored to assess its performance, maintenance requirements etc.

Voltage	300kV
SDO OCT Inom	2000 A
Frequency	50Hz
Accuracy of the OCT	Cl 0.2
Sampled Values	F4800S2I4U4
SV as per	IEC61869-9 (2016)
Time Synchronization	PTP (IEEE1588v2) (2 master clocks)
Comms. Redundancy	PRP
Interoperability with IED-s from	ABB, SIEMENS, SPRECHER