Increased interoperability and future security

Digital Substations - their significance and benefits

The term ‘digital substation’ is used more and more when talking about the supply with electrical energy. Numerous articles, marketing media and internet pages showcase the most important innovations and highlight the benefits for the customer. This paper shows the most important benefits of a digital substation.

A substation consists of the primary technology (including switchgear, GIS, AIS and transformers), the secondary technology (including power system protection, automation and RTUs, voltage regulators, energy meters and communication equipment) and the related infrastructure. The various primary and secondary components interact to fulfill the main task of a substation, which is to ensure the availability of the supply with electrical energy under the given circumstances - available power (generation / distribution), environmental factors (weather), defects and faults in the supply system. Aside from the functional tasks, the safety of persons and the investment have top priority, followed by economic aspects. How does a traditional substation become a digital substation or when can you call a substation ‘digital’?

This is where digitalization comes into play, which has triggered an innovation boost of products and systems in industrial areas like process automation that offers new opportunities for implementing efficient processes. The use of Ethernet-based communication and as a result the simplified connection of components is only one example.

A similar development can now be observed in the area of power supply, where digitalization creates new concepts and products which in the end help to increase the economic efficiency and profitability of power supply systems.

More than ten years ago, IEC 61850 was introduced by the International Electrotechnical Commission (IEC). It is an international standard of a transmission protocol for the communication within electric substations for medium and high voltage and at the same time acts as a milestone for the digitalization of substations.

Apart from the exchange of information via Ethernet for protection, monitoring, control and measuring, the standard also defines the general description of substations. IEC 61850 is a uniform communication protocol ensuring interoperability of the products of different manufacturers. Worth mentioning: Peer-to-peer services are also possible with this standard.

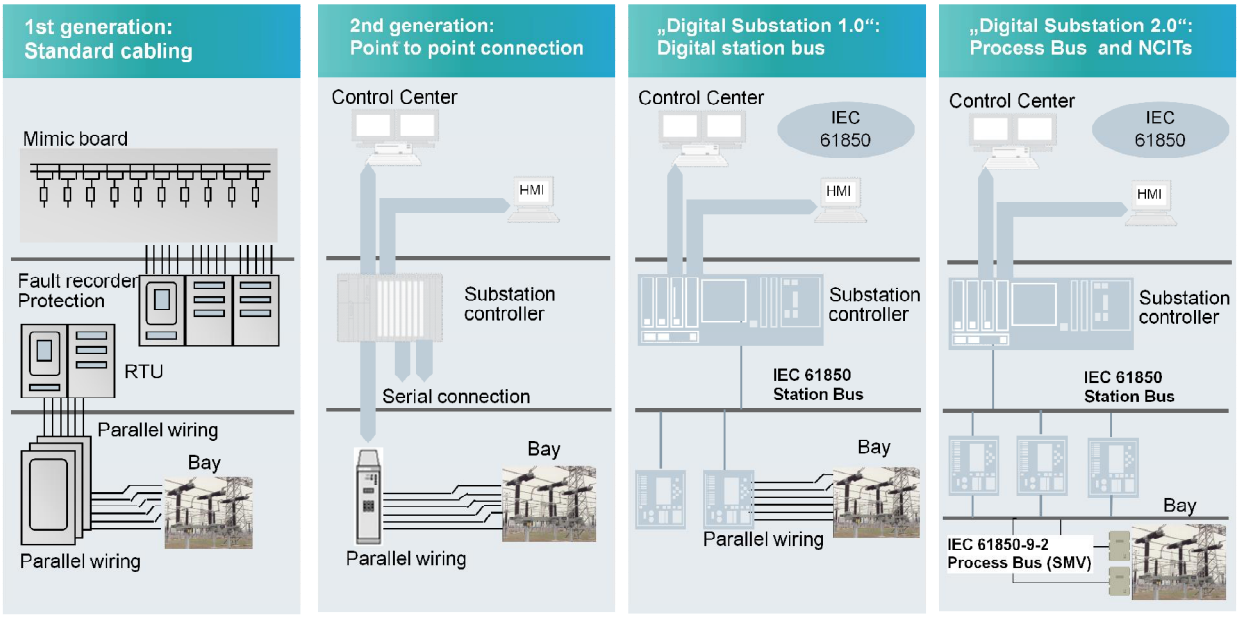


Figure 1. The evolution of substations: from traditional technology to digital substation

Technical article published in the German magazine ew 9/2017

So-called GOOSE messages (generic object oriented system events) communicate information about status and measured values to other participants via the station bus. This is an easy and most of all quick way of exchanging information without having to use additional signal cables.

In addition, IEC 61850 is today the only protocol for the communication in substations that is constantly evolved by different manufacturers in the standardization committees. In recent years, IEC 61850 has been expanded to include the communication between different substations, for example, the connection of control centers or decentralized generation plants as well as aspects from the area of power quality (Figure 1).

From Digital Substation 1.0 to Digital Substation 2.0

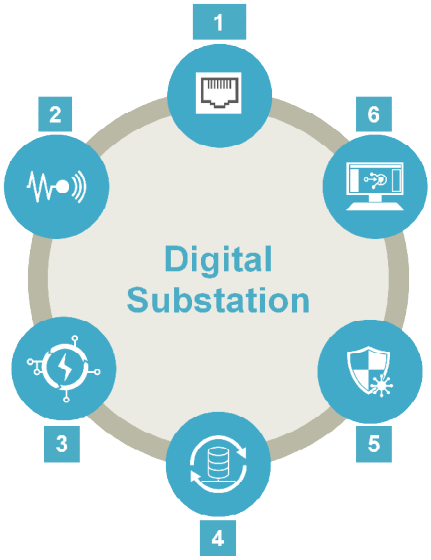
One base element of a digital substation is therefore the implementation of IEC 61850. An internationally valid data exchange format and data model that ensures interoperability between the products and systems of different manufacturers. IEC 61850 fulfills all requirements for an up-to-date substation and is flexible enough to be ready for new requirements and functions in the future. The introduction of the standard IEC 61850 was the foundation stone for a Digital Substation 1.0.

Digital Substation 2.0: the logical next step

As mentioned above, the IEC 61850 standard is constantly developed. The introduction of new technologies - for example non-conventional transformers (NCIT) and process bus communication - is the next step in the evolution of substations.

Section IEC 61850-9-2, for example, defines the transmission of sample measured values (SMV) of the primary technology. Analog variables of the current and voltage transformers of the primary technology are converted to measured variables that can be processed digitally, close to the process and are communicated within a substation via process bus. This makes them available to the different applications - for example protection and automation - for further processing. The combination with high-performance and high-availability communication technology based on optical fiber technology and the use of redundancy technologies like PRP (Parallel Redundancy Protocol) and HSR (High Availability Seamless Redundancy) makes this a technology that enables even time-critical applications. It is therefore another important contribution to digitalizing a substation.

The process bus technology is not really new, and there have been developments in this area for many years, but the breakthrough has only happened now. The decisive factor for this is before all the existence of powerful processor and communication technology as well as standardization enabling different manufacturers to develop processes and products to guarantee interoperability. This ensures that customers invest in a technology that is supported by different vendors and that is continuously developed.



1. Ethernet-based communication on IEC 61850
   Digitalization of station level
2. Digitalization of process level
   Introduction of process bus and NCITs
3. Asset management support
   Use of data from the digital substation for asset management
4. Integrated engineering
   Consistent, efficient engineering
5. Cyber Security
   Prerequisite and integral part of any digital substation
6. Network control support
   Use of data from the digital substation supports network control

Figure 2. The six core aspects of a digital substation

Six core aspects of a digital substation

Digitalization is one of the biggest influencing factors when realizing a digital substation. The reason is that digitalization has a significant impact on the product design and product functionality. And it offers completely new approaches for the efficient implementation and operation of a substation (Figure 2).

Benefits of a digital substation

Digitalization allows the power supply sector - like other industries - to use new technologies, methods and processes, particularly in substations, that increase the operational efficiency of the station. Compared to a conventional substation, a digital substation offers the following benefits:

Reduced investment and operating costs

- Decrease in the use of copper signal cables
- Easier and quicker commissioning including engineering and system testing
- Saves space and weight, in particular for primary technology, by using state-of-the-art converter technology (NCIT)
- Optimized grid control because important measurement data are available with state-of-the-art evaluation and analysis procedures
- Improved asset management and maintenance due to up-to-date measurement data of the equipment.

Increased interoperability and future security

- Implementation of IEC 61850 as internationally recognized data model and exchange format
- Simpler adaptation and expandable with new technologies

Increased personal and property safety

- Digitalization of process values and use of optical fibers for communication of process values for protection and substation control
- Implementation of a cyber security policy. This ensures that the system is always state-of-the-art.

Summary

A digital substation ensures that it is reliable and before all economically efficient over its entire life cycle by using secondary technology (like digital protection devices, sensors and automation components) as well as Ethernet-based communication technologies and standard communication protocols (like IEC 61850, Goose). Apart from secondary technology, new primary technology developments like non-conventional current and voltage transformers and NCIT for gas and air insulated substations are used to utilize the additional potential of a substation regarding operational efficiency and safety.

A digital substation uses technologies and methods that enable the economically optimal operation of electrical power supply grids (Ca-pex, Opex) and at the same time improve the required system safety.

A digital substation is not a static construct that does not change throughout its life cycle. Instead it is an agile component in the electrical power supply network that continuously adapts to the requirements and conditions over its entire life cycle. Cyber security is the most prominent aspect in this respect, because the objective is to keep the system with all its products up to date at any time to reduce the risk of outages.

The future of digital substations leads to expect that there will be more technologies and developments, for example centralized protection, that allow substations, or rather, digital substations to evolve to make them even more efficient and safe.

Dipl.-Ing.
Manfred Unterweger,

Head of Sales Consulting, Siemens Energy Management Division, Business Unit Digital Grid, Siemens AG, Nürnberg

>> manfred.unterweger@siemens.com
>> www.siemens.com

Technical article published in the German magazine ew 9/2017