STANDARDIZATION TO REDUCE LIFECYCLE COST AND LEAD TIME WITH IMPROVED QUALITY, EFFICIENCY AND FLEXIBILITY

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ABSTRACT

Alliander carries out a large standardization framework for primary and control and protection equipment and has chosen for separation of concerns when integrating the secondary systems into substations and distribution stations. Alliander considers this as the method to reduce lifecycle costs and lead time of projects with improved quality, efficiency and flexibility. By doing so a reliable power system can be achieved while using limited resources which are so scarce.

The standardization framework stretches from grid topology to component and software parameters. The framework is based on modular design of grid topology, substation and distribution station design. With a set of standard building blocks an entire substation can be built. But these concept based on building blocks also makes it less complicated to extend it or build it in stages. This is nowadays especially attractive because of the uncertainty to predict load and local generation, due to the energy transition.

By separating secondary from primary systems Alliander manage to cope with the challenges represented by the increasing gap between them in terms of lifetime expectancy. A switchgear has a lifetime of 60 years, while control and protection equipment will nowadays barely reach 15 years. Installing control and protection equipment in separated compartments or cabinets is economically more advantageous than integrating them into the switchgear. Despite the slightly higher investment costs this solution has lower life cycle costs (LCC and it also makes it possible to apply control and protection equipment from any manufacturer. In substations the control and protection equipment is mounted on a mounting plate in the secondary compartment of the primary MV switchgear. In distribution stations the control and protection equipment is mounted in a wall mounted cubicle. An essential element to make work this concept properly is the standard interface between the primary and control and protection installation.

Implementing this standardization strategy has cost a lot of effort, but it has already brought valuable benefits about. These benefits are tangible in the stations that have already been built.

INTRODUCTION

Engineering and equipment are critical elements for the reliability of the MV-grid. Achieving a system to fully rely on, usually asks for well skilled resources. This often represents a challenge to the DSO because of shortage of qualified engineers and mechanics.

By limiting the amount of custom made solutions and making these as simple and flexible as possible it is feasible to get reliable power systems while using less resources. In this way also the making of detailed drawings, assembly and mounting can be outsourced.

Moreover this results in much favourable integral life cycle costs (LLC) for the whole system: from MV-grid to primary and secondary systems.

For these reasons Alliander carries out a large standardization framework for primary and control and protection equipment and has chosen for separation of concerns when integrating the secondary systems into substations and distribution stations.

LAUNCHING LARGE STANDARDIZATION FRAMEWORK

Alliander faces several challenges. The energy transition requires quick response to a wide range of requirements from the customers. A higher level of intelligence will be implemented in the grids. This requires more automation. The lifetime expectancy of automation and software is short, compared to primary equipment. So during the lifetime of primary equipment it should be possible to replace or adapt the automation and the software. Besides that it’s difficult to find enough skilled staff.

To meet these challenges Alliander launched a large standardization framework program. Well defined interfaces between primary equipment and automation (including control and protection) is a key pillar in the programs. In highly standardized substations or distribution stations fault repairing can be done in shorter time. This enables a higher availability of the grid. Other more trivial benefits are savings in costs and labour.

The standardization framework stretches from grid topology on the highest level to component and software parameters on the lowest level. The framework is based on modular design of grid topology, substation and distribution station design.

In this concept a substation is built from several modules (see figure 1). Each module consists of one or more building blocks. A building block is functional entity (Lego®-like).

For example the module transformer box consists of the following buildings blocks:

- Power transformer
- Control box of the power transformer
- Earthing transformer
- Oil basement
- Civil foundation
- Refractionary walls
- Cables, primary
- Cables, secondary

A building block is the lowest level and consists of one or more components or software parameters (like I/O-list).

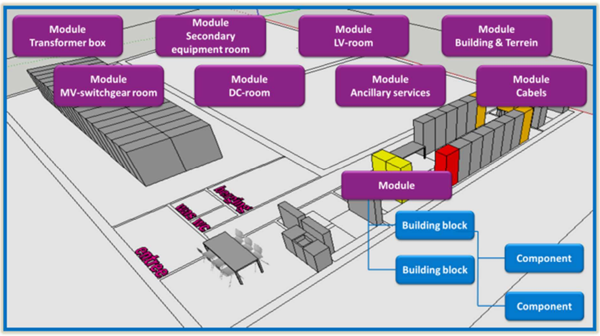


Figure 1: Standardization framework of a substation

As well as for the design of a substation out of different modules, also for the design of the different modules out of the building blocks a multidisciplinary approach is necessary. Engineering teams with different specialties (multidisciplinary teams) and decision making teams are formed. A well-structured design documents package has been developed and changing processes have been implemented.

Not only the engineering and construction but also procurement, software, testing, maintenance and service are submitted to standardization. Software testing is done in an in-house test lab.

The modular concept enables building substations in different stages. Due to the energy transition long term prediction of load and local generation is very uncertain. Flexibility is an important benefit from using standard modules. Figure 2 demonstrates the flexibility provided by building using 20 MVA modules for 20/10kV substations. The smallest substation with 20 MVA modules (A) has two transformer box modules with 20/10kV transformers and one MV switchgear room module with a 10kV switchgear. If there is need for more power a third module transformer box and a second module MV switchgear room can be added (C). If there is a need for a 20kV-switchgear with incoming feeders a module MV switchgear room can be added (B).

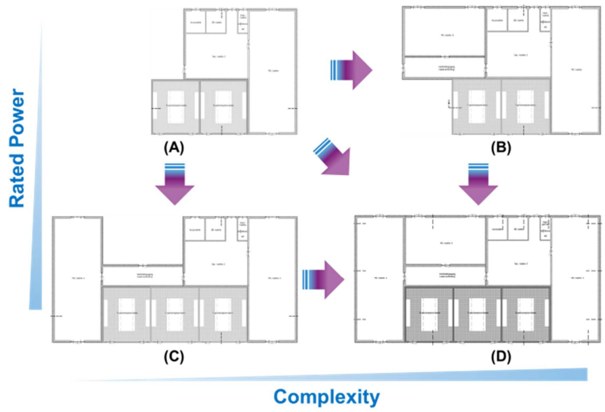


Figure 2: 20/10kV substations. Different substations can be constructed from the standard 20MVA modules.
(A) Two 20MVA-transfomer boxes and one MV switchgear room with outgoing feeders.
(B) Two 20MVA-transfomer boxes, one MV switchgear room with outgoing feeders and a switchgear room with incoming feeders
(C) Three 20MVA-transfomer boxes and two MV switchgear rooms with outgoing feeders.
(D) Three 20MVA-transfomer boxes, two MV switchgear rooms with outgoing feeders and a switchgear room with incoming feeders

SEPARATION OF CONCERNS

Technology for control and protection is evolving faster and faster in the last years. That's why the lifetime of new control and protection equipment is strongly shortened compared to earlier generations. The gap between the aging rate of secondary and primary equipment is therefore increasing. A switchgear is in average replaced after 60 years, while control and protection equipment will nowadays barely reach 15 years. This means secondary equipment in substations and distribution stations should be replaced about three times before the switchgear.

In conventional designs with control and protection systems fully integrated within the switchgear, replacement of the entire secondary system or some equipment leads to significant investments. This is in many cases very labour-intensive, demanding the use of the already so critical technical staff. This also frequently means the switchgear must be taken out of service during a prolonged period of time. To ensure continuity of supply additional and costly measures have then to be taken.

For the same reasons repairing secondary equipment during its lifetime when it is fully integrated in the switchgear involves high costs as well.

An LCC approach for substation and distribution station design proves that installing control and protection equipment in separated compartments or cabinets is economically more advantageous. By means of the LCC approach not only the initial costs like materials, engineering, construction and assembly are taken into account. Also the costs of repair, maintenance and fault repair during the entire lifetime of the substation or distribution station are involved. These costs cannot be neglected.

Alliander is therefore stepping over form full integration to separation of concerns in all new substations and distribution stations. The designs being applied are flexible, which makes it easy to renew the control and protection system after 15 years or by malfunction of damage. This concept enables applying control and protection equipment from any manufacturer. Crucial element of this design is the standard interface between the primary and control and protection installation.

Substations

In a substation the control and protection equipment of the outgoing bays is mounted on a mounting plate in the secondary compartment of the 20 or 10 kV switchgear (see figure 3). For the incoming bays, with a more complex protection scheme, the control and protection equipment is placed in separate cabinets.

(A) (B) (C)

Figure 3: (A) Double busbar switchgear with mounted plates (B) inside view of the secondary compartment with two plates mounted on the door and one plate into the compartment (C) two door plates seen from outside the compartment

The interface between the primary and control and protection installation is a terminal strip which is standardized. When the terminal strip is defined each discipline can perform independent. This makes it easy to refurbish the control and protection equipment after 15 years. At that moment we can easily replace the existing mounting plate by a new one with new equipment.

Each bay has a separate main protection and a bay controller with all the control functionality and a back-up protection function. It depends on the type of bay which type of main protection is used. Overcurrent-, distance- and differential protection are supported in the typicals. There is no communication between the protection and the RTU, except for alarms (hardwired) (see figure 4)

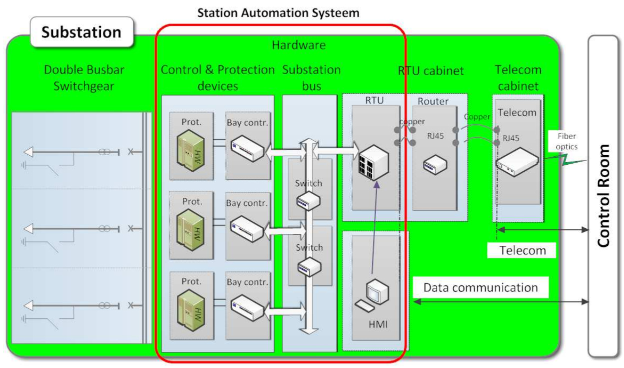


Figure 4: Substation control and protection - overview

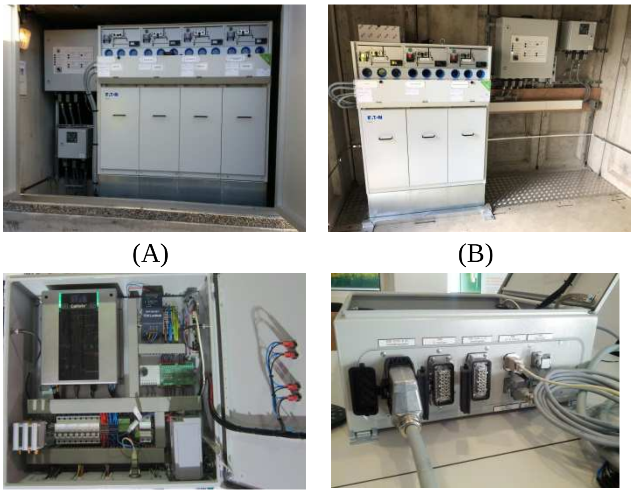
Voltage control is done by a separate voltage controller which gives commands to the control switch of the feeding powertransformer.

The equipment of all the bays are together with the RTU connected with the substation network (IEC 61850). The RTU communicates with the control rooms (IEC 870-5-104).

Distribution Stations (DS)

In a distribution station there are a cubicle for control and a cubicle for protection. Both cubicles are wall mounted and connected with the 20 or 10 kV Ring Main Unit (RMU) through cables with robust connectors (see figure 5). The connectors are the interface between the RMU and the control and protection systems. This makes it easy to refurbish the control and protection equipment after 15 years. At that moment we can fast and easily replace the existing cubicles by new ones with new equipment.

The control cubicle consists of a RTU, 24 V battery and battery charger. The RTU has all control functionality including a short circuit indication function (in software) and has wireless communication (CDMA) with the control rooms. The protection cubicle contains the overcurrent protections for the bays which need a protection. There is no communication between the protection and the RTU, except for alarms (hardwired).



(A) (B) (C) (D)

Figure 5: (A) RMU with control and protection cubicles in a compact distribution station (B) RMU with control and protection cubicles in an accessible distribution station (C) inside view of a control cabinet (B) connector for interface between control equipment and switchgear

RESULTS, LESSONS LEARNED, AND NEXT STEPS

The first new substations and distribution stations are built according to the standardization framework. For substation automation and protection highly detailed standards are necessary due to the amount of different signals needed.

These substations and distribution stations are future proof designed. Adapting them to future needs can easily be done. Due to the modular concept subsequent expansion can be done by adding additional modules. Upgrading functionality in the software or replacing the control and protection equipment is no longer a major challenge due to the well-designed interfaces.

Implementing the standardization framework has cost a lot of effort before getting the benefits. A high level of discipline and management attention is necessary to reach the goals.

The benefits already reached are: reduced costs and labour (less rework), better frame contracts with suppliers, shorter lead times and higher quality levels of the substations.

The standardization framework is now completely implemented for the most common substations and distribution stations. Next step is to complete the framework for all substations and distribution stations and the refurbishment of old stations. Refurbishment is often a challenge due to the amount of different standards.

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