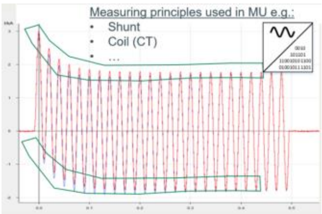
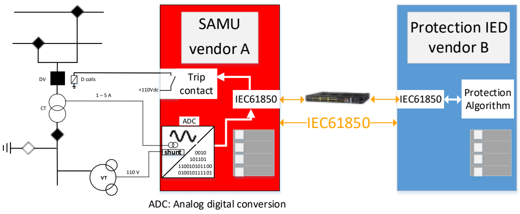
NAME :
Name: Dieter Binon
COUNTRY : Belgium
REGISTRATION NUMBER : **DLG5745**

GROUP REF. : B5
PREF. SUBJECT : PS2
QUESTION N° : Question 2.01

Functional chain availability: To determine the desired architecture of a digital substation based on process bus, the first step is to determine the required availability of the system. When using process bus technology, extra components are introduced in the functional chain of the secondary system. A comparative analysis between the theoretical availability of the functional chains in conventional concept and concept based on seamless redundant process bus network (HSR / PRP) and MU shows the limited added value of adding redundant MU for main protection functions P1 and P2. For functional chains that are not redundant (e.g. BCU), the lower availability due to extra components, could be compensated by adding redundant SCU's. However, this comes at a cost (complexity, additional wiring, larger field cabinet, etc. …) that has to be evaluated against the reduced theoretical availability of some functional chains.

Align IED and MU/SCU behavior: Introducing MU or SCU introduces the possibility to combine MU/SCU and IED from different vendors. MU's might use different type of measurement principles. (e.g. coil, shunt, …) The resultant SV during transient phenomena on the electrical grid can be different. The IEC 61850-9-2 Ed 2.1 has added some elements to model the behavior of the MU in SCL (e.g. Clip, HoldTmms, ScndTmms). This approach allows the subscriber to compensate for the difference in behavior between MU of different vendors. However, an approach where the compensation is done at the SV publishers' side, and not the subscriber, seems preferable, because this way all other potential subscribers will get the compensated values.





To achieve harmonized multivendor solution it is important to specify the desired behavior and preferably to align between vendors on these elements. Other examples where alignment is needed are for example:

- Polarity of the neutral component can differ between MU of different types or vendors
- Implementation of test- and simulation mode
- Interaction between IED algorithms and the IEC 61850 data-model (e.g. values for quality of information)
- System response during holdover of re-synchronization to back-up grand master clock

Retro-compatibility: When issuing additional features in new editions, retro-compatibility with existing devices is an important requirement. For example in SV where, according to IEC 61850-9-2 Ed 2.1, a new optional field SynchSrcID is introduced. When combining IEC 61850-9-2LE Ed 2.0 subscriber with an IEC 61850-9-2 Ed 2.1 publisher, the optional field SynchSrcID should not be included in the SV stream messages, otherwise the subscriber might not be able to process this additional information in the SV stream. The end user needs to be aware of potential incompatibilities between editions in order to achieve backward compatibility. If the SCL files would allow to specify the supported or required SV profiles the SCT could prevent incompatible combinations.

Network architecture: A digital substation consists of a station and a process level with different (time) criticality. The station and process bus can be integrated in the same hardware. However, the applications and type of information running on them is different. The separation between both networks can be done physically or virtually. The physical separation is often chosen for simplicity, it brings extra costs and complexity (e.g. to monitoring MU, SCU). Therefore, an optimal solution could be to merge both station and process bus on the same physical hardware and to perform separation in a virtual way. Since traffic management is already a requirement at the process bus level, adding the data of the station bus is deemed to be feasible. Concerning the bandwidth management, the interfaces of the IED and MU/SCU interfaces are the limiting factor, not the network switches.

Time synchronization becomes a determining element in the architecture of the digital substation. Therefore, it is advisable to foresee a redundant solution with more than one clock in the system. It is important to take care of the alignment of each clock source and to perform switchover tests during qualification or even during commissioning of the digital substation. From the point of required synchronization, different types of functions exist in the substation: functions that require **relative** synchronism, functions that require **absolute** synchronism and functions that do not require synchronism. To avoid malfunction of a certain functionality it is important that the SmpSynch information is evaluated by each functionality. Additionally once a trip has been issued by a protection system it has to follow through even when going through unsynchronized conditions.

	Relative synchronism required		**Absolute synchronism required**
SmpSynch value	**1 SV publisher**	**> 1 SV publisher**	
2 = SV synchronized by a global area clock signal (e.g. MC synchronized to absolute reference)	Function can continue to operate (e.g. Distance, BB Diff, Back up, synchro check)		Function can continue to operate (e.g. Line diff)
1 = SV synchronized by a local area clock signal (e.g. MC **NOT** synchronized to absolute reference)	Function can continue to operate (e.g. Distance, BB Diff, Back up, synchro check)		Function should be blocked and alarm raised (e.g. Line diff)
0 = SV not synchronized by an external clock signal (e.g. SAMU **NOT** synchronized, using internal reference)	Function can continue to operate (e.g. Distance)	Function should be blocked and alarm raised (e.g. BB Diff, Back-up, synchro check)	

MU near HV equipment come with extra ergonomic and safety considerations. In some cases the MU/SCU are placed in field cubicles outside in the proximity of HV equipment . Additionally in AIS the exposure to natural elements have to be taken in to account. Therefore, it is important to avoid interventions in the field cubicle as much as possible. Interventions on the protection IED's (inside the relay building) are possible using simulation and test mode, leaving the bay in service.

Efficient engineering from specification to commissioning is required in order to move on to a large scale roll-out of digital substations in a TSO context. TSO's use bay templates and are bound to strict procurement procedures. Therefore, modeling of the concept using ASD, FSD and BehD and the extended ISD file formats are considered as a requirement. Traceability from templates towards particularized configuration, version management and file exchange are a big challenge today, especially in a multi-vendor environment.

Testing of a digital substation still requires too many manual verifications and diverse testing tools. Testing tools should accommodate further automation of tests, for example by being able to apply specified testing scenario's to multiple bays of the same type that are used in different substations. Furthermore, the testing tool could identify the elements in the bay and adapt the testing scenario intelligently.

User readable, context dependent documentation should be generated from SCL source files. End users are used to a certain type of documentation (e.g. infolists). Today not enough flexible tools exist to generate similar or user friendly documentation. A dynamic, live visualization of the SCL files is a key element to support the engineering and commissioning phase. Perhaps in different format depending on the phase in the engineering process.

The **impact** on the organization and people could be huge. However, knowledge of the electrical system remains the key competence and the conventional substations will remain on the grid for a long time, smoothening the transition. A step-by-step approach is preferred.