Non-conventional instrument transformers
Advanced GIS substations with IEC 61850-9-2 LE process bus
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On the way to digital GIS substations
Non-conventional instrument transformers (NCITs) and IEC61850-9-2LE process bus for gas-insulated switchgear substations

By providing complete solutions with IEC61850-9-2LE\(^1\) process integration, as part of substations with non-conventional instrument transformers (NCIT), ABB proves its market and technology leading position in high-voltage substations and substation automation systems.

With more than ten years of in-service experience with NCITs for transmission level applications and the largest installed base of IEC61850 substation automation systems, ABB combines the two technologies in its offerings with NCIT and process bus for sampled analog values.

As defined by IEC61850-9-2, sampled analog values are transmitted by so-called merging units (MUs). The MU time correlates and merges analog data from individual phases or measuring points in the substation before transmitting them via the Ethernet network, where the data can be accessed by protection and control devices. In the case of ABB’s gas-insulated switchgear (GIS) installations, the merging units receive their data through optical connections from the NCITs. Because this connection is optical, the location of the MU is virtually independent of the cable length.

\(^1\) IEC61850-9-2LE is used to denote the implementation guideline for the digital interface to instrument transformers using IEC61850-9-2, published by UCA International Users Group. The guideline describes an application profile of IEC61850-9-2, facilitating implementation and interoperability. The UCA International Users Group is a non-profit corporation focused on assisting users and vendors in the deployment of standards for real-time applications for industries sharing common requirements.
Optimized substation design
Transmission level substations with NCITs and process bus for sampled analog values

Substations are key nodes in transmission and distribution networks. ABB has the specialist knowledge and global experience necessary to build, upgrade and extend substations, wherever they are needed.

To optimize the performance of transmission substations ABB has introduced new NCITs and process bus solutions. The ELK-CP series of NCITs, for GIS substations, and process bus solutions, for sampled analog values according to IEC61850-9-2LE, bring the benefits of the most economic and modern technologies. IEC61850-9-2LE is fully integrated in ABB’s REB500 and Relion® series protection and control devices.

The fully redundant, combined current and voltage NCITs and process bus bring multiple benefits, as demonstrated in numerous installations around the world.

Enhanced operational safety
By replacing conventional current and voltage transformers with non-conventional equipment, operational safety is elevated to new levels.

One example is the connecting of NCITs to protection and control devices via fiber optic cables. This isolates the devices from the process and therefore no secondary CT and VT circuits need to be handled.

Reduced life-cycle costs and increased availability
Permanent real-time system-wide supervision of all electronic components in the complete measuring chain lowers routine maintenance requirements and enables fast and exact fault finding across the entire station automation, protection and control system. Information on system health can be transferred to remote control and maintenance centers, supporting efficient management and maintenance of resources.
The primary sensor’s lifetime and availability goes far beyond those of conventional equipment, especially of voltage transformers. ABB’s well-designed and redundant sensor electronics (secondary converter) allow replacement without the need to interrupt power, re-configure or re-calibrate, helping to reduce outage time and increase system availability.

The ability to adjust nominal values of the NCIT using software, dramatically reduces the efforts and costs associated with rating changes.

**Highest accuracy for protection and metering**

With linear characteristics across the complete measurement range of voltages and currents, ABB’s NCITs combine the wide dynamic range required for protection with the high accuracy for metering applications in a single device.

The transmission of sampled values according to IEC 61850-9-2LE, through a fiber optic network, guarantees permanently supervised communication that is immune to electro-magnetic disturbances and virtually independent of the cable length.

**Space-saving design**

Installing NCITs in place of conventional equipment reduces the total weight of equipment and minimizes space requirements of the switchgear.

**Reduced copper cabling**

The optical connections between NCITs and merging units and the fiber optic Ethernet network of the process bus, eliminate parallel copper wiring for current and voltage measurement. This reduces not only the number of copper cables in the substation, it also allows the use of narrower cable trenches.

**Additional environmental benefits**

Thanks to the compact design of ABB’s NCITs, the required volume of SF₆ gas is considerably reduced. On-site gas handling can also be reduced, because the NCIT can be installed in the factory and it does not need to be disassembled for HV testing.

Compared to conventional current and voltage transformers, the NCITs and merging unit suffer lower the power losses in substations and therefore safe energy during their entire lifetime.
NCITs for gas-insulated switchgears
ABB’s ELK-CP14 and ELK-CP3 non-conventional instrument transformers

The features of the ELK-CP14 and ELK-CP3 NCITs are proof of ABB’s extensive expertise in the field of high-voltage technology and non-conventional instrument transformers.

Fully redundant combined current and voltage NCITs
ABB’s NCITs are based on two independent sets of Rogowski coils for current measurement and capacitive sensors for voltage measurement. The redundant measuring path is complemented by two independent, ruggedized sensor electronics, the so-called secondary converters.

Integral part of ABB’s GIS
Designed for ABB’s ELK-14 and ELK-3 single-phase encapsulated GIS, the ELK-CP14 and ELK-CP3 are some of the cornerstones of ABB’s enhanced NCIT and process bus systems. They cover nominal voltages ranging 170kV to 550kV and nominal currents up to 4,000A.

Highest accuracy
ABB’s ELK-CP14 and ELK-CP3 combined current and voltage sensors feature the highest accuracy and linearity throughout the entire measuring range, supporting protection as well as revenue metering applications.

Seamless maintenance
The redundant secondary converter (sensor electronics) can be replaced during normal operation with no need for re-calibration or re-configuration.

Efficient configuration
Software-configurable ratios support efficient design of the switchgear, independent of CT and VT calculations.

Configurable current ratings enable future adaptation of CT ratios without needing to replace CT cores or to open gas compartments.
Vast experience
Over 300 of ABB’s ELK-CP NCITs have been in continuous service for more than a decade. This installed base is an invaluable source of experience in the field of non-conventional instrument transformers.

The first UCA certified merging unit
The merging unit time-correlates and merges sampled values from individual phases and/or measuring points in the substation before transmitting them via the Ethernet network to the protection and control devices. ABB’s CP-MU merging unit is the first to be verified by an independent test lab and certified as IEC61850-9-2LE compliant by the UCA International Users Group.

The CP-MU follows the IEC 61850-9-2 implementation according to the UCA International Users Group’s implementation guideline, also referred to as IEC61850-9-2LE.

One merging unit for ELK-CP14 and ELK-CP3
The CP-MU merging unit is designed for ABB’s ELK-CP14 and ELK-CP3 NCITs. It can interface with up to three independent three-phase voltage and current measuring points, allowing for optimal system design with a minimum of components in 1½-breaker- as well as double-busbar-switchgear arrangements.

Built-in flexibility
The design of protection and control systems can be optimized, thanks to the large number of IEC61850-9-2LE ports of the merging unit, and the flexibility of sample synchronisation. The merging unit can act as time master, where it autonomously generates a 1PPS¹ signal, or it can work as time slave, if the synchronisation is performed elsewhere eg, by a GPS clock.

Further more, the merging unit is capable of calculating summated currents from any NCIT inputs and dispatch them via its Ethernet ports to protection and control devices.

Fit for retrofit
Applying non-conventional instrument transformers in substation retrofits simplifies the process and therefore reduces outage times, by avoiding the need to change ratios.

¹ PPL: Point-to-point link, the optical connection between NCIT and merging unit.
² 1PPS: One pulse per second, used to synchronized sampling by different devices
Protection and control portfolio
Feeder protection and control with IEC61850-9-2 LE process bus

ABB’s portfolio of IEC61850-9-2 LE compliant protection and control IEDs includes the Relion®670 series of advanced protection and control IEDs, as well as the decentralized REB500 busbar protection system. With these products and systems ABB comprehensively covers all protection and control applications using IEC61850-9-2 LE.

Relion® 670 series protection and control IEDs
The Relion® 670 series of protection and control IEDs provides versatile functionality, and maximum flexibility and performance to meet the highest requirements in generation and transmission protection systems. Relion® 670 series IEDs are:

- Equipped with functionality specifically required in transmission applications, e.g., series compensation and 1- and 3-phase tripping, voltage control, extended disturbance recording, as well as binary and analog data transfer between IEDs
- Capacity for GOOSE¹ messaging for horizontal communication
- Equipped with powerful and flexible hardware.

The following Relion® 670 series protection and control IEDs fully support IEC61850-9-2 LE:

- Bay control IED: REC670
- Line distance protection IED: REL670
- Line differential protection IED: RED670
- Transformer protection IED: RET670

For synchronized sampling all IEDs feature a one-pulse-per-second (1PPS) input.

All devices support mixed configuration with IEC61850-9-2 LE and conventional CT and VT interfaces. This is used, for example, in transformer differential protection applications with NCITs on the high-voltage side and conventional CTs and VTs on the low-voltage side, as shown in the diagram above.

Line differential protection runs with both conventional as well as IEC61850-9-2 LE-based remote-end substations.

¹GOOSE: Generic object oriented substation event, for the fast exchange of information between IEC61850 servers.
Busbar and breaker failure protection with IEC 61850-9-2 LE process bus

REB500 decentralized busbar protection system
REB500 IEDs provide reliable and proven busbar protection for different switchgear configurations.

The IEC61850 enabled REB500 IED is designed to support different protection philosophies. Distributed protection solutions with bay units assigned to dedicated bay cubicles are supported, as are integrated solutions where all necessary functionality is contained within a single cubicle.

The versatile hardware and distributed functionality of REB500 IEDs enables its application in all types of switchgear configurations, including single-, double- and triple-busbar plus transfer bus-, quadruple-busbar arrangements and 1½-breaker schemes.

In addition to low-impedance busbar differential protection, REB500 integrates comprehensive backup protection functionality, including both breaker failure and end-fault protection, reducing both wiring and cabling.

REB500 busbar protection system is fully compliant with IEC 61850-9-2 LE.

The seamless combination of bay units with IEC61850-9-2 LE and conventional bay units in a single system allows the flexible extensions of conventional substations.
Protection and control concepts
Enhanced substation automation, protection and control systems with IEC61850-9-2 LE

Extensive experience in high-voltage substations, combined with in-depth expertise in IEC61850 technology make ABB a leading supplier of substation automation, control and protection systems. Building on this sound base, ABB offers complete NCIT and IEC61850-9-2LE solutions for transmission level GIS substations.

Worldwide experience substation automation with IEC61850
More than a thousand IEC61850 compliant substation automation systems delivered for new installations and retrofit projects worldwide make ABB the leading provider of enhanced automation, control and protection solutions for substations of all voltage levels.

Protection and control concepts, meeting your needs
ABB provides safe, reliable and efficient solutions to meet your performance needs and your regulatory requirements. ABB can design protection and control solutions for any voltage level, accommodating a broad range of operational philosophies and different environmental conditions.

Enhancing automation, protection and control systems with IEC61850-9-2 LE process bus
Building on our long experience in substation automation, control and protection, ABB builds complete system solutions with NCITs, IEC61850-9-2 LE process bus and leading-edge protection and control devices.

ABB’s substation automation systems: more than IEC61850 compliant
ABB’s advanced station level solutions are designed for maximum safety, efficiency and reliability in local as well as remote control and monitoring of your substation. The solutions benefit from ABB’s global presence in this domain, vast expertise in IEC61850 and proven system integration capabilities.
Full redundancy across the complete metering, control and protection chain
The fully redundancy of ABB’s combined current and voltage NCIT is the basis for designing completely independent systems for main 1 and main 2 protection functions. This maximizes system availability by avoiding interdependency between the redundant devices.

Permanent supervision of the entire system minimizes maintenance requirements
All-embracing supervision of all intelligent components of the complete measuring and automation, protection and control systems allows periodic maintenance activities to be reduced to a minimum.

Efficient system design with minimum components
Thanks to the number of communication ports available on the merging unit, on both the NCIT and the IEC61850-9-2LE side, efficient solutions can be designed with a minimum of external Ethernet switches in the process bus network. This enables the number of components to be limited and availability is optimized.

Safe access to all analog values increases operational safety
IEC61850-9-2 LE makes all analog values available on an Ethernet network. For analysis purposes, PC-based tools can simply be connected to the network, eg, to one of the ABB merging unit’s numerous Ethernet ports. Once connected, the current and voltage values of all phases are available at once, without touching any CT or VT circuits.

Safe process isolation, minimizing outage requirements
The distribution of analog values through the process bus Ethernet network allows simple isolation of individual pieces of equipment without disturbing the transmission of current and voltage values to other parts of the substation. This enables more accurate maintenance of individual system components without disruption of service.

By replacing of copper cables with optical fibers for the transmission of current and voltage measurements, the secondary equipment can be fully isolated from the primary process, rendering manipulation of CT terminals obsolete.
## Technical data

### Non-conventional instrument transformers and merging units

<table>
<thead>
<tr>
<th>Non-conventional instrument transformer</th>
<th>ELK-CP3</th>
<th>ELK-CP14</th>
</tr>
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<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest voltage for equipment (U_m)</td>
<td>kV</td>
<td>550</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage (peak)</td>
<td>kV</td>
<td>1,550</td>
</tr>
<tr>
<td>Rated switching impulse withstand voltage (peak)</td>
<td>kV</td>
<td>1,250</td>
</tr>
<tr>
<td>Rated frequency (f)</td>
<td>Hz</td>
<td>50/60</td>
</tr>
<tr>
<td>Measurement bandwidth (-3dB)</td>
<td>Hz</td>
<td>1,000</td>
</tr>
<tr>
<td>Rated continuous thermal current (metering)</td>
<td>A</td>
<td>4,000</td>
</tr>
<tr>
<td>Rated continuous thermal current (protection/control)</td>
<td>A</td>
<td>6,300</td>
</tr>
<tr>
<td>Rated short-time thermal current (I_{th, RMS})</td>
<td>kA</td>
<td>63</td>
</tr>
<tr>
<td>Rated dynamic current (I_{dyn, peak})</td>
<td>kA</td>
<td>170</td>
</tr>
<tr>
<td>Ambient temperature range °C</td>
<td></td>
<td>-40...+40</td>
</tr>
<tr>
<td>Weight kg</td>
<td></td>
<td>250</td>
</tr>
<tr>
<td>Protection class of housing</td>
<td></td>
<td>IP65</td>
</tr>
</tbody>
</table>

### Current measurement (IEC60044-8)

| Protection data link                      |         |         |
| Rated primary current I_pr (configurable) | A (with metering) | 100...4,000 | 100...4,000 |
|                                            | A (without metering) | 100...6,300 | 100...4,000 |
| Accuracy class                            |         | 5P TPE  | 5P TPE  |
| Rated extended primary current factor (K_{ext}) | 1.0      | 1.0      |
| Rated symmetrical short-circuit current factor (K_{sym}) | Configuration-dependent | Configuration-dependent |
| Rated primary time constant (t_{pr}) ms   |         | 60TPZ/120TPZ | 60TPZ/120TPZ |
| Rated duty cycle                          |         | No limitation | No limitation |

### Metering data link

| Rated primary current I_pr (configurable) | A | 100...4,000 | 100...4,000 |
| Accuracy class for metering              |   | 0.2 (0.2S for Ipr > 400 A) | 0.2 (0.2S for Ipr > 300 A) |
| Rated phase offset (ϕ)                   | 0° | 0° |
| Rated wake-up time                        | none | none |

### Voltage measurement (IEC60044-7)

| Rated primary voltage U_{pn} (configurable) | kV/√3 | 330...550 | 170...300 |
| Protection data link (PPL1) Accuracy class for protection | 3P | 3P |
| Metering data link (PPL2) Accuracy class for metering | 0.2 | 0.2 |

### Merging Unit CP-MU

| Number of inputs (PPL) | 9 |
| Output interface       | IEC61850-9-2 |
| Sampling rate (for 50 and 60 Hz) | sample/cycle | 80 |
| Number of independent measuring points (configurable) | 1...3 |
| Rated delay time ms    | 0...3 |
| Ethernet medium        | 100BaseFx |
| Ambient temperature range °C | -5...+55 |
| Protection class of housing | IP40 |

### Standards

IEC60044-7, IEC60044-8, IEC61850-9-2

For more information please contact:

ABB Switzerland Ltd
Power Systems
Bruggerstrasse 72
CH-5400 Baden, Switzerland
Phone: +41 58 585 77 44
Fax: +41 58 585 55 77
E-Mail: substation.automation@ch.abb.com

www.abb.com/substationautomation