

SC B5 – Protection and Automation

- **1.** General Annual Meeting SC
- **2.** Group Discussion Meeting

PS1 : Addressing protection related challenges in network with low-inertia and low fault-current levels

PS2: Applications of emerging technology for Protection, Automation and Control (PAC)

PS3: Integration of intelligence on substations (joint with B3)







Voted new working groups:

- "Obsolescence management for Protection, Automation & Control Systems".
- "Education, Qualification and Continuing Professional Development of Engineers in Protection, Automation and Control".
- "Protection Principles to be applied in Distribution Networks in the Future".



Selection of new preferential subjects for the Paris Meeting 2024:

- Preferential subject 1 for Paris 2024 Session: "Process bus: practical experiences, new developments, and possible synergies with virtualization and hardware consolidation" (topic al covered by WG B5.69, final report will be issued before Session 2024).
- Preferential subject 2 for Paris 2024 Session: "Acceptance, Commissioning, and Field Testing for Protection and Automation Systems: Challenges and Perspectives for a new era of Digital Substations".



Country Report:

- Digital substation general observation : some pilot of Process Bus technology, but no large-scale development
- Interest in virtualized protections and digital twins
- Finland: first synchronous compensator put in operation
- Norway: tests of protections on MPLS telecommunication system for teleprotections and differential protections
- United Kingdom : analysis of interactions between full converter electronic-based equipment and protections
- France : discussions about firmware/software compatibility of PACS solutions

• • • •

Complete Country Report Summary in attachment

Possibility to take contact with the B5 member of these countries in order to get more information.



• B5 reference list: B5 related text books and standards

https://cigregroups.org/x/v4tGC (open to all KMS users)

- Cigré Symposium 2023 Cairns themes:
 - Learning from experiences
 - Developing practices, functionalities and applications
 - Towards a sustainable power system



Preferential subject 1 (PS1): Addressing protection related challenges in network with low-inertia and low fault-current levels

Scope:

- Grid protection impacts of increasing inverted-based resources
- Modelling of inverters for protection coordination studies
- **Decreasing grid inertia Impact on transient stability** and consequences on protection performance requirements.
- Role of grid codes and the impact of inverter characteristics and specifications.
- Detection and Protection against **unintentional islanding** of inverted-based resources



Preferential subject 1 (PS1): Addressing protection related challenges in network with low-inertia and low fault-current levels

- **Special Reporter: S. McGuinness** (Convenor B5.72 "Modelling, Assessment, and Mitigation of Protection Performance Issues caused by power plants during Dynamic Grid Events")
- 12 papers from 10 countries some of them very interesting, e.g. Paper 10147 (B5-PS1) (BR): Lessons learned about the impact of inverted-based wind turbine generators on the protection of interconnecting lines



Impacts of inverted-based resources on grid protections

- Existing protection principles and algorithms will work in the vast majority of the applications if configured appropriately.
- However, it can be necessary to revise or update the design of some protections: underfrequency load shedding, islanding detection and distance protections (esp. polarization).
- The majority of issues are related to **distance protection maloperation**. Several papers investigated the impact of inverter-based resources on distance protection in great detail. Similar conclusions were drawn with regard to challenges in determining fault type, polarization, and frequency tracking. The risk of maloperation seems to be the greatest in grid areas nearby inverted based resources: at the location of the renewable power plant grid transformer and on transmission lines and cables, especially in case of radial connections.
- Possible solutions in case of issues could be to apply line differential protections as main 1 and 2 together with a distance protection as back-up or to slightly delay the distance protection if used as main protection.



Impacts of inverted-based resources on grid protections

- Impact on protection sensitivity can occur elsewhere in the grid, due to reduced short-circuit levels.
- The key message is to understand your grid and your relays.
- Inverted-based resources **should inject negative sequence current** together with positive sequence current to avoid issues with distance protections.



Managing inverter-model uncertainty for protection studies

- Inverter-based resource models in phasor-domain and EMT simulation tools: significant progress has been made in recent years to introduce and improve models.
- Key issue: proprietary inverter controllers making it challenging to implement accurate models.
- With different grid code and interconnection requirements in use around the world, the same inverter hardware can exhibit different characteristics during nearby short circuit faults depending on how the controller was parameterised for that region of the world. For this reason, inverter models and conclusions from protection performance studies using regulations in one part of the world may not be directly applied elsewhere.
- Improved phasor domain invertor models are sufficient for most of protection coordination studies. However, accurate EMT simulation of inverters could be needed to capture inverter transient behaviour, to understand relay behaviour and to identify maloperation risks.



Key considerations for securing RoCoF against maloperation

- Increase grid inertia to reduce RoCoF during grid disturbances e.g. see Finland case
- Bench-testing of algorithms!
- There is a trend to increase the min. RoCoF trip setting (e.g. 1,5Hz/s in South Africa)
- Longer time windows can improve RoCoF security, e.g. measure over 0,5 seconds (if configurable)
- These figures are quite comparable to the Belgium settings (1..2Hz/s and 0,2s time window)
- An interesting 'variable RoCoF' study has been done in Japan, see paper 10611
 - Changing the RoCoF setting by the DER output
 - Experimental validation assuming the loss of large-scale generation





Preferential subject 2 (PS2):

Applications of emerging technology for Protection, Automation and Control (PAC)

Preferential subject 3 (PS3):

Integration of intelligence on substations (joint with B3)

Scope:

- Benefits of new technology
- Biggest challenges in adopting new technology
- Training & experiencing of personnel

Problems & challenges in the development of digital substations

- Digital substation is in the next phase of the 'hype cycle'
- Current challenges related to:
 - LPIT integration
 - Virtualisation
 - Field staff availability and training
 o Key topic; see also the 2014 Cigré TB 599
 - Time synchronisation





Interesting papers regarding to Digital Substations:

- 10675, Virtualization as an enabler for digital substation deployment (CH)
 - Describes multiple crucial aspects of virtualization, interesting for all PAC architects / engineers
- 10266, CPC Architectures for Small Distribution Substations (CA)
 - Relevant for BE/NL asset owners who are considering CPC architectures
- 10802, Experiences with the deployment of centralized protection systems (SE)
 - Main conclusion of the paper: low availability of Process Interface Units are currently a limiting factor











What are the expected benefits of using Digital Substation concepts?

- Exactly the same question raised within PS2 as PS3
- In papers from FR, RU, GB, CH and BR, some insights are given
 - Savings on the procurement procedures (use of specification file SSD and substation configuration file SCD)
 - Reduction in construction time and effort
 - Higher efficiency of factory and site acceptance tests
 - Reduction of carbon footprint: less infrastructure, less copper wiring, less trenching, reduced panels in relay house and as a consequence possibility to apply modular buildings
 - Asset monitoring, remote maintenance capabilities and possibilities to develop predictive maintenance
 - Simplification in amount of boxes; highly depens on the skills of the company

However:

- Hard to compare
- Difference in primary / secondary setup
- Common understanding of where the benefits could be, but not quantified



New technology for fault identification and location

• From large TSO grids (USA, BR) interesting utilization of Synchrophasor data for fault location

Attachment: SC B5 Country Report Summary Paris Session, August 2022





Country	Activities Related to SC B5
Australia	36 organisations attended panel meeting 26 th and 27 th July (online). Local experiences shared including Essential Energy's IEC 61850 Journey with their evolved digital substation design and installation. 15 June 2022 the AU B5 panel (in association with CIGRE Australia) organised a free online industry webinar titled 'Frequency protection down under – new challenges. AU B5 continue to support complementary NZ B5 panel.
Belgium	SPACS 3 standardised bay protection cubicle framework with functional integration and IEC 61850 "light" – first FATs and SATs. Study and labs tests over interactions between HVDC converter and distance protections. Virtual substation: on-site test of piggy-back mode substation based on process bus. Start Belgian CIGRE NGN initiative.
Brazil	Network generation statistics presented. First "Full" Digital Substation in the Brazilian Interconnected System. Brazilian Grid Code Review – review of Brazilian Grid Procedures for substations with voltages equal to or above 230 kV. June 2022 the Brazilian B5 held its internal seminar in preparation for Brazilian participation in the SC B5 session at the Biennial 2022.



Country	Activities Related to SC B5
China	Generation statistics provided. Grid forming inverter is now a hot topic - some pilot projects are under construction
Columbia	DG statistics presented and adaptive protections to be considered. New transmission systems planned (HVDC?) to connect remote generation. Lack of standardization and guidelines for tertiary transformer winding protection applications, increasing risk of maloperation; planned to hold webinar in October 2022 where the results will be shared with the community of the electrical sector.
Finland	Record high investments to green energy and to transmission grid. First synchronous compensator will be commissioned in 2024 to address low equivalent short circuit ratios in parts of the grid. Finnish TSO using type approved and version locked PACS for the approval period of 2021-2024 (option to prolong to end of 2027)



Country	Activities Related to SC B5
France	Two internal French SC B5 meeting (January 2022 and June 2022). New private HVDC link between France and Great Britain under commercial transmission operation (ELECLINK). New HVDC link between France and Italy is under final acceptance test. First offshore wind farm (St NAZAIRE) in operation since may 2022. No blackouts but some substation inability to deliver the basic service, during software updates on PACSleading to trip CB lines
Germany	National German VDE CIGRE DAK B5 meets this year three times: online meeting in February, June after important German conference Protection and Control Tutorial and planned to have meeting during CIGRE/CIRED Information event in autumn. Digital twins of protection and control devices have been presented to some German TSO, DSO and industrial customers



Country	Activities Related to SC B5
Italy	Project "OT security" introduced last year and providing cybersecurity facilities and functions at substation level, has been validated and is under a wide deployment phase to retrofit operating SAS. SAS2021 project - 4 out of 6 prototypes validated and first installations scheduled by end of 2022. Definition of a new standard to allow the connection of up coming RES power plants at 36kV voltage level. Well-known problem related to shortage of chips and electronic components having an impact on SAS delivery times. CIGRE National committee workshop held in May. CIGRE NGN Italy and NGN Denmark online conference held in June.
Japan	Huge earthquake hit Fukushima March 16, 2022 - around 5 GW of power plants tripped. Outages caused frequency drop from 50.05 Hz to 48.43 Hz. Emergency power flow control systems started up as designed at HVDC stations connected to adjacent areas. Affected utilities received around 0.7 GW of electricity successfully but support was not enough to balance supply and demand – UFRs disconnected ~ 2.5 GW of demand. Electricity restored to all customers in 2.5 hours. SC B5 Domestic Annual Meeting planned Dec., 2022



Country	Activities Related to SC B5
Korea	KEPCO (T/D Power Utility) has more than 160 new 154kV-class substations in operation by applying IEC 61850 communication to the actual system in a stable manner. KEPCO Electric Power Company has decided to introduce a product that supports Edition 2.0 from 2023 on IEC 61850-based IED and Client products to the field and decided on the purchase standard. In July 2022, KEPCO started a research project to determine standards and conduct demonstration tests to stably introduce Process Bus based Full Digital Substation. Digital Substation Specialist Research Group established under the Korea Cigre Committee Jun. 29 / 2022 – 220 members.
Netherlands	 Key topics are: Energy transition and the impact on materials and staff Congestion management, direct interfacing between DER and Grid Operator, and impact on protection schemes Vendor independent top-down engineering Full-scale Distribution Automation roll-out Thematic meeting in April 2022 about the energy transition and the impact on realization ~75 attendees. Another planned for 2023.



Country	Activities Related to SC B5
Norway	Statnett testing MPLS as communication for teleprotection and line differential devices. Large R&D project on digital substation run by SINTEF with participants from several Norwegian utilities. Several pilot installations are being built to investigate the advantages of a digital substation. Statnett participating in a larger science project on cybersecurity in collaboration with several other infrastructure companies in Norway.
New Zealand	NZ B5 has 30 active panel members, holds monthly meetings and provides KMS training. Workshop B5 Session was held on 8 th April 2022. National WG "Protection of Downed Distribution Lines" formed. CIGRE NZ 2021 Conference & B5 Symposium (24 th – 26 th November 2021, Online). CIGRE NZ 2022 Autumn Workshop B5 Session (8 th April 2022, Christchurch & Online)



Country	Activities Related to SC B5
Slovenia	 ELES, Slovenian TSO cooperates on some important international projects, the most important between them are: The SINCRO.GRID project(H2020 project) NEDO phase II OneNet one network for Europe 15th Conference of Slovenian Electric Power Engineers CIGRE-CIRED was held on October 19-21, 2021 in Laško. 41st International CIGRE Symposium related to "Reshaping the Electric Power System Infrastructure" was held in Ljubljana, Slovenia November 21-24 2021.
South Africa	Integration of renewable energy sources to the national grid now ~ 6100MW. Implementation of integrated protection, tele-control and substation automation solutions using IEC61850 for Transmission substations continues. First deployments anticipated this year and include digitising primary plant status/alarms close to the primary plant, communicating this to the substation control via fibre optic cables. Similar for Distribution substations to start this year.



CountryActivities Related to SC B5SpainAccording to the grid code for emergency, substations named "essentials" for service
restoration plan should have a guaranteed uninterrupted supply for 24 hours - utilities
working to achieved it before the end of year. Due to "calima" (dust in atmosphere
from Sahara) during a few days in March, there was a loss of 50% in PV generation
and 100% in solar thermal. CIGRE Spanish National Committee organized a two-day
Technical Session November 2021 in Madrid. CIGRE Spanish National Committee
organized a one-day session about "Practices and experience with protection and
control based on IEC 61850 process bus" in May.



Country	Activities Related to SC B5
Sweden	Swedish reference group of SC B5 is B5 Member's main interface – meets once a year. IEC 61850 is very much established as the station bus standard. Some of the largest Dx Utilities have taken steps towards process bus - pilot installations are expected 2023-2026 and the rollout of fully digital substations still about five years into the future. Several energy storages and microgrids being implemented. The prognoses indicates that the energy need will double in Sweden within just a few decades. Several areas (mostly large cities) already experience problems with network capacity. Stability of the frequency has decreased. TSO Svenska Kraftnät is introducing a system for management of protection settings. TSO Svenska Kraftnät set the ambition, within a few years, be able to manage an annual investment volume of 300 km transmission line and 20 substations.
Switzerland	Active in many WGs. CIGRE SteerCo-Meeting in Zurich in May.



Country	Activities Related to SC B5
Thailand	Four 115 kV substations under the renovation of EGAT's conventional substation to the IEC 61850-based digital substation project – first expected to be in service October, one by end of year and other 2 early 2023. NCIT has been introduced into the system, which is the first time for EGAT. Remote Terminal Unit device developed by EGAT, has been deployed to disconnect very small power plants (VSPPs) from distribution system when islanding conditions are detected at remote substations, and supports reclosing process.
United Kingdom	 Considerable interest in the industry around: Centralised Protection, also widening into "virtualised protection" and digital twins Operation of distance protection with the increase on REN. Will the current algorithms respond correctly Impact of Cyber Security on PAC's Continuing evolvement of IEC standards Process bus rollout –when and at what voltage will it become business as usual? Integration of Protection and Communication systems Next Liaison Meeting Nov 22 (TBD) – Plan to combine with D2