DIGITAL REMOTE IOS TO SIMPLIFY SUBSTATION RETROITS & UPGRADES: ENEDIS PCCN EXAMPLE

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Abstract

Résumé:
The proposed paper presents the Smart Terminal Blocks architectures and explain methodologies used in ENEDIS MV substation retrofits and upgrades.
It starts with ENEDIS HV substation protection & control historical stages (Palier Classique and 86) and the actual Digital one (Palier Numérique - PCCN) descriptions including main constraints and challenges regarding the cohabitation with existing functional features. Second part presents how Mini-PCCN is held and each element is used to replace the existing product, software and system. Special attention is placed on the integration of the various IOs module in the new cubicles and how they are wired with the original elements. The direct impacts on the commissioning and site test of the digital remote IOs concept are shown with practical examples. The return on site experiences are demonstrated to explain the positive benefits of the digital remote IOs architectures. A key evolution named FAR is described and interposed on the existing test plug a digital measurement IO module connected via an optical fiber network to the Substation RTU and part of the ENEDIS grid Voltage stability plan. The last chapter and conclusion point out the future of this concept with the highlight on the capacity extension proposed, new automation schemes and the integration of asset management capabilities. Safety and security concerns are described, coupled with the direct cost reductions.
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The proposed paper presents the Smart Terminal blocks architectures and explain methodologies used in ENEDIS MV substation retrofits and upgrades. It stars with ENEDIS HV substation protection & control historical stages (Palier Classique and 86) and the actual Digital one (Palier Numérique - PCCN) descriptions including main constraints and challenges regarding the cohabitation with existing functional features. Second part presents how Mini-PCCN is held and each element is used to replace the existing product, software and system. Special attention is placed on the integration of the various IOs module in the new cubicles and how they are wired with the original elements. The direct impacts on the commissioning and site test of the digital remote IOs concept are shown with practical examples. The return on site experiences are demonstrated to explain the positive benefits of the digital remote IOs architectures. A key evolution named FAR is described and interposed on the existing test plug a digital measurement IO module connected via an optical fiber network to the Substation RTU and part of the ENEDIS grid Voltage stability plan. The last chapter and conclusion point out the future of this concept with the highlight on the capacity extension proposed, new automation schemes and the integration of asset management capabilities. Safety and security concerns are described, coupled with the direct cost reductions and advanced remote maintenance features. Keywords— Substation, Protection, remote control, Refurbishments, ENEDIS, PCCN, IEC 61850, Cyber-security, FAR I. INTRODUCTION One of the main challenge Electrical Utilities are facing in many countries is the need to upgrade the existing installation at reasonable costs. One of the possible solutions is to avoid having complete refurbishment of all substation elements but to focus only on the ones to be replace/upgrade and minimising integration cost such as wiring modification, power supply change or protection adaptations. This could be achieved while using adapted products and engineering tools to ensure an interoperability between the various elements and software. The recent experience of ENEDIS in the HV substation upgrade is described in the present paper with future concerns and possible new features possible with the proposed PCCN architecture. II. ENEDIS HV SUBSTATION PROTECTION AND AUTOMATION DIGITAL SCHEME Since end of the 70s the Protection & Control-Command part of the HV H type French substations are built in respect of technical common references. Three mains have been applied over the last 40 years: 1. The Palier Classique 2. The Palier 86 (PSAA) 3. The Palier Numérique (PCCN). Figure 1: ENEDIS Protection & Control architecture (Palier Classique) They all refer to the same HV substation protection and control organisation: • The incomers and outgoing feeder protection, measurement and automation IEDs; • The HV Power Transformer Protection, Measurement and Automation equipments; • The Remote Terminal Unit connected to the ENEDIS Dispatching for a remote control; • The Local Control and Sequence of Event Recorder; • The substation Automation cubicle with all substation security schemes. Additional modules such as Capacitor bank protection, . TCFM block (special tariff management system), etc... have been added to HV Substation technical design documents (ENEDIS paliers techniques). In the Palier Classique launched in 1979, all information are wired and the voltage reference is +127 Vdc In the Palier 86 launched in 1988, all information are wired and the voltage reference is -48 Vdc. The Palier Numérique PCCN launched in 2002 is based on an Ethernet station bus. The voltage reference is +48 Vdc. A. Palier Numérique de Protection & Contrôle-Commande - PCCN The Palier Numérique de Protection & Contrôle-Commande (PCCN) d’ENEDIS has been designed with key strategic objectives: • Quality improvement of the delivered energy, • Capability of adaptation to the grid, • Standard and technical simple evolution management. The PCCN is based on a full Digital architecture with standardized modules (Lots Rame, Transfo, Supervision, TCFM and Automatismes) and the use of ENEDIS Ethernet station bus (Réseau Fédérateur) interconnecting them together. Figure 2: ENEDIS PCCN architecture in lots 1) PCCN in Cohabitation The PCCN project consider mandatory the capability to implement some PCCN lots (lot Rame, lot Transfo) in existing substations (Palier Classique or 86) to answer customer needs • Capability to split the substation investments by partial evolutions all compatible, • Reduce the impact and unavailability of the substation during the refurbishment period. More than 500 of these lots have been installed and commissioned in Palier Classique (+127Vdc) or Palier 86 (-48Vdc) substations with hard-wired interfaces. The rest of the substation Protection & Control-Command system remain unchanged before the final evolution to a complete PCCN design. The specificity of the PCCN in cohabitation modules is to reduce to the minimum the down-time when migrating and also anticipate the future of the substations. B. ENEDIS RTU and SER obsolescence and refurbishment needs In Palier Classique and Palier 86 ENEDIS HV substations, the remote control is based on RTU (PA for ENEDIS) supporting the SCADA communication based on legacy protocols such as HNZ and X25. The Sequence of Event Recorder (SER) and Local Control is mostly done by a dedicated PLC with local display capability (PC based) and event printing (EMS /C3S). Automation schemes (Armoire Automatismes), General Service (Tranche Générale) and Tariff management (TCFM) are managed by PLCs and legacy wired devices. All these functions and applications face strong component and software obsolescence. To solve these, a new lot has been added based on the PCCN Supervision, Automation and TCFM modules with a hardwired interface to be implemented in existing Palier Classique and Palier 86. Specific functions will be configure using the appropriate tools to maintain 100% functional contability and interoperability with the existing elements. This solution has been named the Mini-PCCN and launched in 2017. III. THE MINI-PCCN SOLUTION
Mini-PCCN is the innovative solution for digitizing a ENEDIS H type substation Palier Classique or Palier 86 while minimizing the technical risks and downtime of the operation. The Mini-PCCN solution allows: • Replacement of the existing RTU/PA, C3S/SER functionalities, General Service (TG) and TCFM generator and their automatisms to solve equipment’s obsolescence, • Manage DSO/TSO separation or a need for additional I/Os when the existing RTU/PA capacity is already saturated, • Treat substation extensions by adding PCCN Feeder or Transformers lots associated with the Mini-PCCN integration, • Gradual transition for large substations to the PCCN technical level with a limited downtime of remote control points, • Regular evolutions of the RTU, Grid Code, Automation schemes, etc. ... The mini-PCCN relies on the digitization of Feeders and power Transformer Input and Output signals and their software processing to perform the substation global functions (RTU, SER, TCFM, Automation schemes, etc.). A. Mini-PCCN architecture Two mini-PCCN architectures are available: 1) Substation without Automation lot This mini-PCCN architecture solution is based on: • Standard PCCN Supervision lot providing the connection with remote control, local management, event logging, • I/Os digitization blocks of all RTU/PA signals, • I/Os digitization blocks of all SER/C3S signals, • A backup device to ensure substation local control and sequence of event recording in case of main feature failure, • PCCN lot TCFM Special tariff generator. The existing General Service cubic is kept unchanged. Figure 3: Mini-PCCN architecture without Automation 2) Substation with PCCN extension The mini-PCCN solution with Automation features: • Standard PCCN Supervision lot providing the connection with remote control, local management, event logging, • I/Os digitization blocks of all RTU/PA signals, • I/Os digitization blocks of all SER/C3S signals, • A backup device to ensure substation local control and sequence of event recording in case of main feature failure, • A complete PCCN Automation lot, • PCCN lot TCFM Special tariff generator. The existing General Service cubic is not kept. Figure 4: Mini-PCCN architecture with Automation B. I/Os Digitization blocks The solution proposed by Schneider Electric for the mini-PCCN is based on an Innovative distributed solution. Logic I/Os digitization relies on Smart Terminal Blocks (MiCOM STB DIs or DOs) on which the existing wired connectors are directly plugged without any modification and able to support the various voltage reference level of the Palier Classique and Palier 86. Dedicated Ethernet based network interconnects the Smart Terminal Blocks (MiCOM STBs) to a concentration box (MiCOM C264). The MiCOM STB architecture is a “Plug & Play” solution without any complementary wiring or modification to the existing connectors. This solution limits strongly connection error risk and directly reduces migration time to the PCCN. Figure 5: Existing connector plug on MiCOM STB with adaptator 1) Smart Terminal Block The main characteristics of the MICOM STB are: • DIs or DOs modules adapted to each type of existing RTU or SER (8, 16 or 32 connections) with led to visualize the I/Os status, • Interface adaptor (single or double) with Palier 86 or Classique voltage reference level, • Ability to monitor and control thousands of I/O points, • Time stamping 1ms & time synchronization: from SNTP server (over Ethernet), • Hot swap of the MICOM STB modules with self-configuration, • Embedded Cyber-Security. To simplify on-site test, Y wiring modules are integrated to have in parallel both systems (existing & PCCN) and could be removed after commissioning period. On site implementation demonstrates that the complete integration of the Mini-PCCN can be performed in less than 3 days and the switching time between the Palier Classique or Palier 86 solution is less than 8 hours including testing and validation. 2) Mini-PCCN engineering tools To have simple and efficient engineering of the Mini-PCCN marshaling kiosk and MiCOM STBs, dedicated Configuration and Maintenances tools have been designed to help user and simplify possible evolutions with two main applications Key features of the Mini-PCCN Configuration tool are: • Capability to read and analyze PCCN B2B5, RTU/PA and SER/C3S configuration files, • Intuitive interface for entering information and parameters changes, • Database generation and downloading, • MiCOM STB tag generation files and downloading them. Figure 6: Mini-PCCN MiCOM STB configuration tool Key features of the Mini-PCCN Maintenance Tool are • Display of the Marshaling kiosk and Smart Terminal Blocks configurations with version management, • Real-time parameters display and modification, • Trace export and printing. These Mini-PCCN engineering tools are available through a local dedicated Maintenance PC and on the cloud with appropriate cyber-securitys. IV. FUTURE EVOLUTIONS AND POSSIBLE EXTENSIONS The Mini-PCCN is future ready and anticipate technical specifications: • The FAR (Fonctions Avancées de Réseaux, Advanced Grid Functions), • Integration over IEC61850 Substation-bus, • HV Substation advanced data acquisition for Maintenance Management tools. In addition, capabilities are kept at Mini-PCCN to be able in future to be part of more advanced Substation Management tools such as Asset Management A. FAR Advanced Grid Functions The FAR (Fonctions Avancées de Réseaux/Advanced Grid Functions) are designed to improve for ENEDIS the capability of the incoming feeders to support grid power distributed generators and optimize the global grid voltage reference. A FAR module interposed on the existing test plug allows these data to be available easily and at reduced costs. Figure 7: FAR module (l) for Mini-PCCN An integrated digitisation measurement module (l) is connected via an optical fibre network to the Mini-PCCN supervision lot that permit the need calculation (average and instantaneous values of I, U, P, Q) and send them to the ENEDIS dispatching for integration in the FAR part. B. IEC61850 integration The actual Mini-PCCN is based on two independent level of communication: • The Réseau Fédérateur (RF) defined by ENEDIS and supporting interoperability capabilities of IEC 61850, • The supplier internal PCCN Lot communication under the responsibility of each selected supplier. Schneider Electric Mini-PCCN is IEC 61850 ready to support interoperability capabilities and takes benefits of the interoperability capabilities of IEC 61850. IEC61850 will improve engineering by using the standard substation description, test and maintenance procedure. V. CONCLUSION The Mini-PCCN with the distributed Smart Terminal Blocks demonstrates the capabilities today to refurbish/upgrade existing electric substations easily and at low cost. This type of architecture coupled with the use of standards such as IEC61850 can be integrated in any type of EHV & HV substations (Transmission, Distribution, Generation, Industry, etc...) to be refurbish/upgrade with near no service interruption and possibilities to be ready for future. Acknowledgments The authors gratefully acknowledge all ENEDIS & Schneider Electric team’s members that have participated to the Mini-PCCN project studies, installations and commissioning and make it a reality on site. REFERENCES [1] M. 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