A new generation of instrument transformers under experimentation

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Abstract

Résumé:
In 2017, Rte commissioned its first low power instrument transformers in a fully digital substation, in real operational conditions. This is the result of Rte’s long term interest in alternative technologies of instrument transformers, with the aim of emergence of cost-effective, safe, and reliable solutions. This intention was materialised by a series of pilot projects started two decades ago. This paper presents the most noticeable ones, and their expectations and the lessons learned.

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A new generation of instrument transformers under experimentation Guillaume VALEMBOIS Substation Department Rte Paris, France Laurent ROUX Protection and Automation Department Rte Paris, France Abstract—In 2017, Rte commissioned its first low power instrument transformers in a fully digital substation, in real operational conditions. This is the result of Rte’s long term interest in alternative technologies of instrument transformers, with the aim of emergence of cost-effective, safe, and reliable solutions. This intention was materialised by a series of pilot projects started two decades ago. This paper presents the most noticeable ones, and their expectations and the lessons learned. Keywords—instrument transformers; low power instrument transformers; LPIT; 61850 I. INTRODUCTION A large majority of instrument transformers (ITs) used in power transmission systems are of inductive type, except for capacitive voltage transformers. The long term reliability and accuracy of these devices is a major concern in HV substations since the correct operation of protective relays relies on it. Despite several decades of experience, some weaknesses still impact the reliability of ITs, due to reasons intrinsic to the technologies and to quality issues. In particular, explosive events continue to occur, causing severe risks to the operators and a degradation of the transmission system efficiency. Alternative technologies of ITs, known as low power instrument transformers (LPITs), have been investigated over the past few decades and promising solutions were developed, often using a digital output. Nevertheless, the protection and automation systems were not compatible with these digital outputs, and only a restricted number of applications were possible. Nowadays, in a context characterised by the rise of Smart Grid concept and energy transition, Rte engaged a process of digitalisation of protection and automation systems using 61850 process bus and renewing at the same time the opportunity to investigate the installation of LPITs in the light of the latest technologies. II. EXPERIMENTATIONS Rte has shown a constant interest in LPIT over the past decades, starting several pilot projects. This section is focused on the most noticeable ones, which are still in service today. A. Vielmoulin pilot project The first long term experimentation of LPIT with digital output started in 1999 in Vielmoulin 400 kV air insulated substation. It consists of an optical current transformer using “Faraday effect” Ring Glass sensor, optically connected to an electronic, interfaced in Point-to-Point with protective relays. It is redundant with the inductive ITs and not active on the circuit breakers. In a first step, the experimentation aimed to compare the operation of a conventional protective chain including inductive ITs and conventional protective relays with the operation of the digital protective chain. From 2000 to 2003, the 50 events detected by the two chains were identical and no untimely trip was recorded. In a second step, it was decided to experiment a metering chain, by interfacing digital meters with the LPITs and compare it with an analogue meter connected to the conventional ITs. In order to minimise the cumulative errors Optical CT Inductive CT from all three phases, only one phase was connected. The difference between conventional and digital meters, recorded from 2004 to 2007, was between the limits defined by a type B evaluation of uncertainty. Consequently, the result of the experimentation was considered satisfactory. New recordings of protective relays and meters, performed over 2016 and 2017, after a refurbishment of the LPIT electronic, were also satisfactory. B. Saumade pilot project The combined electronic LPIT of Saumade 225 kV gas insulated substation was commissioned in 2006. It consists of a Rogowski coil and a capacitive voltage probe connected to a primary converter directed installed on the GIS box. The signal coming from sensors are digitalised by this primary converter and transmitted by optical link to a secondary converter, in charge of signal processing and publication of the sampled values, compliant with IEC 61850 requirements. Again, the experimentation is not active on the circuit breakers. By using a similar method for Vielmoulin experimentation, the digital meter interfaced with the LPITs was compared with a conventional meter connected to inductive ITs. The difference between the two chains was recorded from 2006 to 2008 and in 2017. The result was always within the acceptance limit. The GIS being connected to underground insulated cables, it is very unlikely to detect any fault, thus, the protective function has not been investigated. C. Smart Substation project Smart Substation project aims to experiment a fully digital 61850 substations, with, among others innovative technologies, LPITs installed in real condition of operation, interfaced with protective relays active on the circuit breakers. In this context, a fully optical combined instrument transformer was commissioned in 2017 in Blocaux 90 kV air-insulated substation. It is composed of an optical Ring Glass sensor for the current measurement and of a low power capacitive voltage divider, combined with an optical “Pockels” cell for the voltage measurement. The optical sensors are connected to a remote electronic, which convert the optical signals into 61850-9-2LE Sampled Values, published on a process bus. Since the commissioning, the operation of protective relays using the output of these LPIT has been compared with the operation of the protective relays located at the other side of the line, connected to conventional ITs. This has confirmed that the recorded trip are legitimate. III. RTE’S EXPECTATIONS AND LESSONS LEARNED Depending on the technology and design, LPITs may have several advantages in comparison to conventional ITs, in particular: • A safety improvement by reducing/suppressing insulating oil volume and replacement of electrical secondary cables by optical links, • A compactness and a reduction of natural resources’ use, • A larger measurement bandwidth. However, in order to install LPITs in a large scale, utilities need cost-effective and reliable products. In particular, ease of maintenance is a very critical topic. Particular attention to this issue should be given by manufacturers during the design process. As an example, since periodic calibration or accuracy verification is not achievable given the complexity of on-site primary injections, properly calibrated measurement devices are needed, and the overall cost of such an operation should be evaluated beforehand. One
challenge with LPITs is the mid-life replacement of electronics due to the risk of component obsolescence and to Optical CT Inductive CT Inductive VT the complexity of replacement procedures. The replacement of the electronics of Vielmoulin LPIT after a long period of operation demonstrated the feasibility of such an operation, but this needs to be extended to an industrial level. The key expectation of these pilot projects was the verification of the evolution of the experimentation objects‘ behaviour over time. It was established that some design of LPIT can be used on a long term basis without any significant deviation of accuracy. Based on these observations, Rte decided to carry on the investigations about LPITs with the follow-up of Smart Substation project in Merlatière substation, including the installation of several 90 kV and 225 kV LPIT.

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