LCE-04-2017

Innovation Action

flexitranstore

An Integrated Platform for Increased FLEXIbility in smart TRANSmission grids with STORage Entities and large penetration of Renewable Energy Sources

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 774407

D7.2 Laboratory results, technical-economic analysis of sensors

Report Identifier:	D7.2		
Work-package, Task:	WP7	**Status – Version:**	1.0
Distribution Security:	CO	**Deliverable Type:**	***Publishable summary***
Editor:	BME		
Contributors:	C&G, ELJ, TUS, ESO		
Reviewers:	STER, SC		
Quality Reviewer:	ED		
Keywords:	d7.2, deliverable, line monitoring sensors, sensor testing		
Project website: www.FLEXITRANSTORE.eu			

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Executive summary

1.1 Scope of the demonstration

The aim of WP7 is to demonstrate a novel Dynamic Line Rating method to extend and increase the reliability of both distribution and transmission grids, especially in case of unpredictable – even extreme – weather conditions, such as **icing events**. The demo has two main goals: to demonstrate sensor technology for power system operators (both at DSO and TSO levels) to effectively handle and prevent sudden, and often fatal failures, especially during icing weather condition and to increase security of system and network reliability by reducing icing phenomena.

Dynamic line rating (DLR) technology requires different measuring equipment in order to calculate the actual ampacity of the selected line [1]. For this purpose, weather stations and line monitoring sensors are placed on the lattice structure of the towers (former case), or on the live phase conductors (latter case). Therefore, weather stations should be resistant only against the weather parameters, while the line monitoring sensors need to bear safely the EM stresses caused by electric and magnetic fields in the vicinity of the energized conductors.

Line monitoring sensors are applied for different grid management strategies on high voltage overhead lines [2]. Most of the line monitoring sensors commercially available today are used for DLR system implementation. However, sensor manufacturers implement more and more new features into the devices in order to make the grid management system more reliable.

There is no unified regulation regarding the laboratory testing in case of line monitoring sensors. This provides the motivation to create a unified laboratory test methodology, which can be performed on all types of DLR sensors. The scope of this demonstration is to perform several mechanical, environmental and electrical tests on DLR sensors to conclude the results as a basis for standardization in the future.

1.2 Concept and methodology

A major requirement for dynamic line rating (DLR) systems is the continuous operation of the sensors. For this purpose, most of the manufacturers use energy harvesting from the phase conductor itself, while others use built-in batteries, which offers 5 to 10 years operation time without any maintenance. The most proper way is the combination of the current transformer with the battery; therefore, the sensors can operate even when the line is deenergized, too. In this case the lifetime of the battery does not limit the operation of the device.

The transmission of the gathered data is always realized via wireless technologies to the central database. The manufacturers use several solutions to implement it, while the most common technologies are based on GSM and LoRa communication protocols.

Besides these fundamental functions, the sensor manufacturers implement new features into their devices to make the grid management system more reliable and endowed with extra functionalities.

There are several parameters which affect the rate of return of the DLR sensors both from technical and economic aspect. Primarily, the number of installed sensors and their accuracy determines the

economical side of a DLR system. Increasing number of installed sensors increase the accuracy of the whole system through the detection of hot spots and local thermal overloads. On the other hand, every subsequent installed device has less and less impact on the whole system. Therefore, the key issues are the elaboration of optimal sensor placement concept. Furthermore, it is worth considering that the number of sensors is limited for pilot projects, while other technical aspects of the project requires all sensors' operation from the beginning.

Another aspect is the maintenance conducted on the sensors. In this case, it is worth to consider whether the given sensor can be repaired or replaced by live-line work method on the energized line, or it requires to switch off of the line. There are some sensor manufacturers which apply only battery as the power supply of their device. In this case, the lifetime of the battery is the main question during the estimation of the costs of the required interventions.

1.3 Key activities

Laboratory tests of DLR sensors performed in the framework of this demonstration can summarized by category, based on the relevant international standards [3]-[24]:

- Mechanical tests
  - Testing the mechanical fitting, sensor mounting
  - Vibration test
  - Drop and free fall test

- Environmental tests
  - High temperature test
  - Low temperature test
  - Thermal shock test
  - IP protection test
  - Salt-mist test
  - Solar radiation test
  - Raining test
  - Humidity test
  - Icing test

- Electrical tests
  - Radiated emission test
  - Power frequency magnetic field immunity test
  - Radiated, radiofrequency, electromagnetic field immunity test
  - Pulse magnetic field immunity test
  - Damped oscillatory magnetic field immunity test
  - Immunity induced by radio frequency disturbances
  - ESD test
  - Electrical Fast Transient test
  - Lightning impulse test
  - Installation by live-line maintenance

Figure 1 – Sensor tests were performed on the OTLM line monitoring device at BME's High Voltage Laboratory

1.4 Key results/Main findings

Based on the findings of laboratory tests performed, two categories have been formed: mandatory tests and recommended tests.

1.4.1 Mandatory tests

In terms of mechanical tests, testing the mechanical fitting, sensor mounting and vibration test is suggested to be mandatory.

From environmental tests, high temperature test, low temperature test, temperature shock test, salt mist test, rain and precipitation test, humidity test and icing, freezing test has been selected.

The mandatory electrical tests consist of power-frequency magnetic field immunity test, electromagnetic surge discharge test, impulse voltage tests, overvoltage test, high voltage AC test, functional test and live-line installation test.

1.4.2 Recommended tests

Several other tests have been selected as “recommended” as they are not essential, but provide more information about the quality of the sensor inspected.

These are the following: drop test and free fall test in terms of mechanical tests; IP protection and solar radiation test from mechanical aspects.

From electrical tests, radiated emission test, TEM or GTEM cell measurements-radiated emissions, radiated radio frequency EM field immunity test, pulse magnetic field immunity test, damped oscillatory magnetic field immunity test, immunity induced by radio frequency disturbances, electrical fast transient test, determination of ignition and shutdown voltage of visible corona, heat test, permanent thermal current and resistance test to short-circuit currents has been selected as recommended inspections.

1.5 Conclusions

During the **standardization process**, it is important to find out which tests are mandatory to be performed before the first installation of the given line monitoring sensors. The main aspect during the partition of mandatory and recommended tests was the primary effect of the test. The tests which have possibly harmful effects on the device are only selected to the mandatory group if their primary effect is exposed to the sensor for almost the entire lifetime. On the other hand, the tests which offer nearly the same outcome than some more important mandatory test, are classified as recommended.

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