FAULT SENSORS

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ABSTRACT

This article is addressed to Session1, Network Components, more precisely the medium and high voltage Intelligent Fault Sensors. It is about a pilot project of Elektro which can reduce up to 50% of total time to locate the failure in the distribution grid and high voltage lines(Transmission Lines), meaning a decrease of around 10% of total outage time.

INTRODUCTION

Elektro has used local fault detection systems for years, but always limited to the lightning indication on the pole. In 2014, Elektro decided to test and homologate a new technology of Intelligent Fault Sensors, which monitor and also instantly notify the Distribution Operations Center, DOC (in Campinas-SP). Three suppliers, TecSys, Schneider and Tollgrade, were selected to test their equipment in an integrated way with DOC supervision SCADA system.

The pilot project of the Fault Sensor forecast the installation of 8 sets of TecSys, 11 from Schneider and 10 from Tollgrade, which 7 from Tecsys installed on 69KV Transmission Line and 1 on 13.8KV distribution grid, while the Schneider were installed on 13.8KV and the Tollgrade installed on 13.8KV, 34.5KV and 69KV Transmission Lines.

Since the 2000s Elektro has invested in the centralized control of distribution operations through tele supervision and control systems. In 2011, was initiated the project of implementing automatic network re-composition systems, known as Self-Healing, which has set the Distribution Automation and Telecommunications at an essential level for the energy distribution business. In parallel with this system, local fault indicators (lighting) began to be installed in order to detect current surge that had passed through the equipment, signalling fault location in a more assertive way and ensuring re-composition in the shortest time possible.

Over the years, experience in these equipment was acquired, and it was identified that effectiveness in this type of equipment was relatively low, so that often in the reinstatement procedure, the technical crew found the indicators with lights off, indicating a false interpretation where the Fault Current was not flow by that point, consequently increasing the time of fault location, directly impacting the Interruption Duration Indexes, e.g. SAIDI, as consequence, people who lives in the cities or neighbours supplied by that grid will be without energy for more time.

Given this scenario and new technologies, Elektro understood that it made sense to test new technologies and evaluate company' benefits before making a major acquisition, so it was important to evaluate different equipment and suppliers, and validate the information sent by the equipment, as well as communication's type used to send data from field to Distribution Operations Center, DOC.

Intelligent Fault Sensors are the next generation of Local Fault Indicators, capable to identify the surge fault current according to adjusted levels, plus other events, such as momentary fault, permanent fault, shutdown/outage, power disturbance and capacitor bank switching and even discard Reclosers operations during a reinstatement, all of this analyses been reported online to DOC over 2/3G Cell and Satellite telecommunication technologies.

DEVELOPMENT

Project

Distribution Automation is based on three main actions: Fault Location, Isolation and Service Reinstatement. This means that in order to have an efficient automation system we have to ensure that the three actions must be able to run efficiently. To do so, still based on the principles of automation and control, we need sensors and actuators efficiently distributed in the grid, partial communicating with each other and totally communicating with Distribution Operations Center over the Supervisory Systems, such as SCADA. Summary, more sensors we have installed along the network/grid, more efficient will be the location of the fault for a fast reestablishment of the network.

Combining efforts and cooperation between departments, a study was done to identify distribution networks and transmission lines with major problems of power outage and /or power failure, so that intelligent fault sensors could be installed.

In the case of Distribution Networks, it was chosen points where there was already protection and automation supervised equipment, such as Reclosers, allowing a comparison of voltage and current data, both in normal operation and Surge/Fault. In addition to Reclosers, in the specific case of 13.8KV network, installation points were chosen where there were local fault indicators (light signalling). In the Transmission Lines, there was no availability of equipment for comparison due to the high voltage class being 69KV.

The selected lines received a set of intelligent sensor in

certain stretches that had availability of 2G and/or 3G cellular signal and although with no difficulty to access the poles, even though the equipment were under test which means that they could require interaction for some functionalities or even because of necessity to be re-configured or problems in the telecommunication system. Sensors were installed in the CENTRAL, SOUTH, EAST and WEST regions (Elektro's denomination), with the following distribution:

- 15 Sets of Sensors in 13.8KV Distribution Grid.
- 5 Sets of sensors in 34.5KV Distribution Grid.
- 9 Sets of sensors in 69KV Transmission Line.

Figure 1 – Installation of Fault Sensors on Distribution Grid

Figure 2 – Installation of Fault Sensors on Transmission Line

In parallel with the installation of the Fault sensors, the DNP3 communication and visual projects were developed in the SCADA Supervisory System used by Elektro, so that data sent from the field could be supervised by DOC through 2G/3G cellular communication or even satellite, in cases where there were no signal available from any carrier, usually on 69KV lines. Selected suppliers had distinct characteristics which were necessary to develop Hardware and Software for them to work integrated with Elektro infra-structure. It could be listed Satellite and WiFi systems as the major developments, since the satellite has a TCP/IP communication port while equipment has a RS-232 port and Industrial WiFi-3G Gateway integrated with telecommunication infra-structure.

Figure 3 – Fault Sensors SCADA project

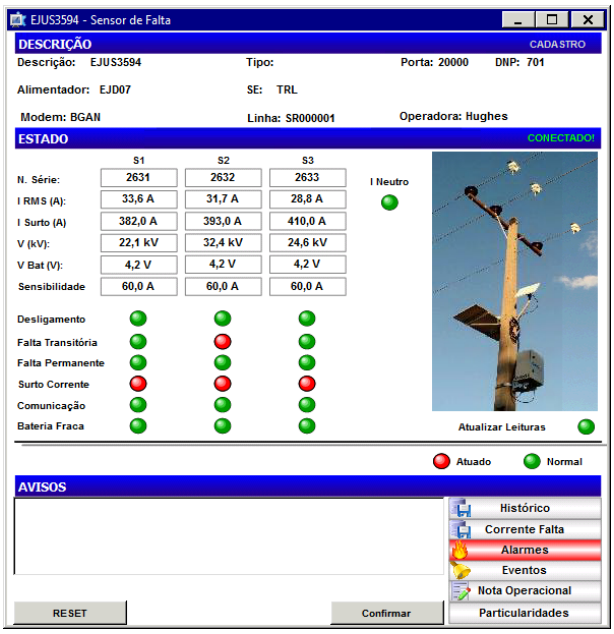

Figure 4 –SCADA Project – Tecsys equipment

Figure 5 – SCADA Project – Schneider equipment

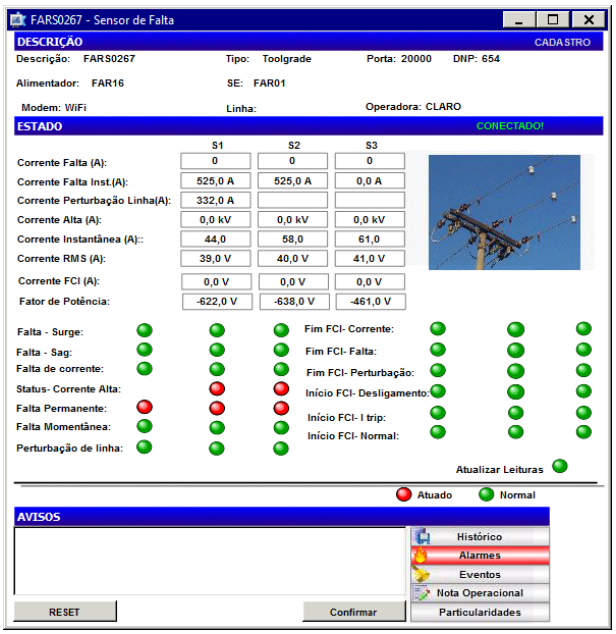

Figure 6 – SCADA Project – Tollgrade equipment

Manufacturers of Fault Sensors TecSys and Tollgrade have a software system with data analysis which could be used to check other status of the equipment and the electrical network where sensors are installed, such as current waveform analysis or voltage/current history graphically.

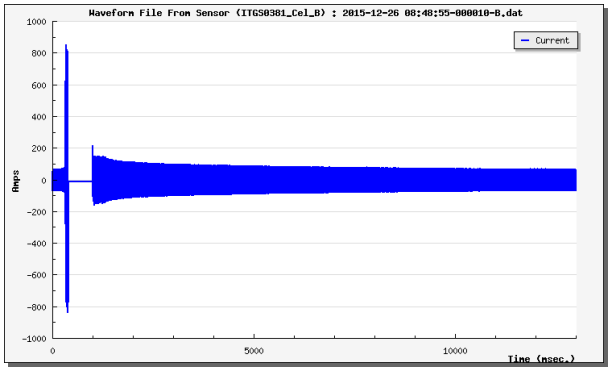

Figure 7 – Momentary Fault Current graph by Tollgrade Toll

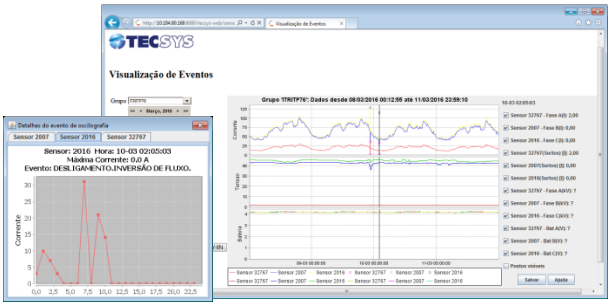

Figure 8 – Voltage and Current History and Events View

Tollgrade Analysis System has an interesting feature of sending e-mails to registered people and/or groups, in order to notify the events and alarms configured and detected by the software system. This system was widely used during project development at SCADA, and is still used by DOC staff and others involved even after SCADA integration project completion.

Results

Twelve months later after the installation on distribution networks and transmission lines we were able to compare data sent by the Intelligent Fault Sensors with the data from Reclosers and Local Fault Indicators (lightning) and they have showed totally reliable, obviously, following an installation and commissioning process to ensure such reliability. Those results were so reliable, that a case of Fault, equipment correctly informed the permanent fault, but once the system was in a test, and at the same point there was a Fault Indicator (light) not triggered, led team to make the wrong decision and go through another stretch of the line/grid when the fault was effectively in that stretch on. This fact helped to prove low reliability of the local fault indicators.

For the effective communication of the sensor with DOC, it is essential that communication cellular tower from operator (Radio Base Station) to be used is not supplied by the distribution network or transmission line in order to avoid communication losses due to "Shutdown of the tower". In case of knowledge of this deficiency, the solution adopted by Elektro was the use of satellite system.

In places where there is a low voltage power supply

(127/220Vca), the use of batteries to keep the system energized for sending fault data is a basic requirement, otherwise the sensor information will not reach DOC. The places without low voltage available, the use of solar panels is an alternative, which also, requires bigger battery storage setup, to keep energy stored during the night and rainy days.

Sensors with built-in 2G/3G communication have limited application because the signal coverage of cellular operators is very restricted when the installation point is far from urban areas and/or near roads/highways.

With the aid of Network Analysis Software, and obviously with the Elektro network properly modelled in this application, the data from the sensors were used to estimate the fault location. In practice, it is possible to check the effectiveness of this fault location mechanism, guaranteeing the effective dispatch of the teams to the fault place, avoiding several tech crew teams to be allocated and run the network until they find fault.

Theoretical studies related to fault monitoring by fault sensors indicate that it is possible to reduce the recovery time by up to 50% [1], when properly applied in an integrated manner with distribution automation and being supported by Planning and Operations Team.

Some sets of sensors installed in 69KV lines presented issues and stopped working after a short period of time. In an investigative work conducted by supplier and supported by Elektro has identified them and addressed by mechanical, electrical, electronic and constructive improvements. As conclusion of the investigative work that installation's methodology could safeguard the correct operation of the equipment after install.

CONCLUSION

Intelligent fault sensors had proved their ability to identify faults and surges. Their installations are justified mainly in the Transmission Lines, due to the high number of customers involved in the 69KV Line. The 34.5KV Distribution Networks also showed a return of investment, but lower than in the 69KV Lines.

The use of more than one set of sensors along the network/line significantly reduces the time to identify the point of failure, and consequently, also reduces the operational cost due to assertive dispatch of the field team, when the expected is to dispatch one team at that point, excluding the necessity to run entire network/line. Obviously there is a balance between the amount of sensor set to be installed and the reduction of the time in the reinstatement.

Elektro has approved the Intelligent Fault Sensors technology and by the end of 2016 will have additional 40 sensors installed and supervised via SCADA at DOC, and it is planned another 50 equipment to expand the monitoring by half of 2017. The points used in the pilot project are being reviewed and will be reallocated to priority points, following procedures and studies done by responsible teams.

The main communication technology will be satellite, since the best points of installation for supervision are usually remote and isolated from urban centers. At this way, communication reliability and availability of sensor sets are guaranteed. As mentioned, due to development for system's integration, there are enhancements ongoing to comply with reliability requirement, and to correct address the data usage restriction of satellite technology.

Studies in other communication technologies are also planned to happen along 2017, such as Mesh Network, VHF and UHF Radios, trying to figure out reliable and profitable solutions.

At this way, Elektro enhances the Quality of the Energy Distribution, increasing the satisfaction of its clients/customers and bring the benefits for the entire society by its electrical systems.

Finally, the installation and use of Intelligent Fault Sensors is been treated as a revolution for the Energy Distribution Sector, taking this pilot project as a technical reference for the sector.

REFERENCES

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[2] Equipment's manual – Tecsys TS100

[3] Equipment's manual – Tollgrage MV Lighthouse Sensor

[4] Equipment's manual – Schneider FLITE116 and G200