FULL SUBSTATION MONITORING

Jordi FARRERO
Endesa – Spain
jordi.farrero@endesa.es

Roberto VILLAFÁILA-ROBLES
CITCEA-UPC – Spain
roberto.villafila@citcea.upc.edu

Juan Lorenzo VELÁSQUEZ
CITCEA-UPC – Spain
juan.lorenzo.velasquez@citcea.upc.edu

Guillermo Nicolau
Endesa – Spain
Guillermo.nicola@endesa.es

Samuel GALCERAN-ARELLANO
CITCEA-UPC – Spain
galceran@citcea.upc.edu

Antoni SUDRIÀ-ANDREU
CITCEA-UPC – Spain
sudria@citcea.upc.edu

Pau LLORET
CITCEA-UPC – Spain
lloret@citcea.upc.edu

Andreas SUMPER
CITCEA-UPC – Spain
sumper@citcea.upc.edu

ABSTRACT
Monitoring is a key-tool for utilities in order to shift from corrective or time-based maintenance strategies to predictive maintenance. Predictive maintenance improves utilization and maintenance of power system assets, and optimizes related costs.

This paper describes an on-going full substation monitoring project developed by Endesa Distribucion at one of its substations, namely, Sant Just Desvern (Barcelona). Five power transformers and all circuit-breakers belonging to Endesa are monitored. Moreover, IEC 61850 standard for monitoring proposes is used.

The monitoring system for the whole substation has been designed based in the previous experience of Novare project. And it uses difference available commercial devices to test them.

INTRODUCTION
Maintenance is a key activity at power system in order to assure the proper operation of the system. It implies a huge amount of human and economic resources for utilities.

On one hand, liberalization and privatization of electric markets have resulted in a more competitive environment. Moreover, current infrastructure is stressing and ageing. Keep costs down, increase incomes and improve reliability means that it is needed to invest in new maintenance strategies.

On the other hand, surveys indicate that current maintenance procedures consist principally on corrective and preventive (time-based). The former is used for assets that are abundant, non essential and easy to replace, and also for those that have already had a failure, if it is reparable. The latter, the most used nowadays, consists on assessing the condition of assets according to a schedule defined by manufacturer’s specifications and utilities’ experience. Nevertheless, time-based maintenance usually means over-maintenance for new assets and under-maintenance for aged assets.

In order to improve the cost-effectiveness of the maintenance, a shift from preventive maintenance based on time (TBM) towards a maintenance based on condition (CBM) is taking place. CBM strategies permit optimizing maintenance and operation costs, while at the same time the quality and continuity of the electrical supply is improved due to a better utilization of assets.

Condition monitoring system is the core element for developing predictive maintenance and for Reliability Centred Maintenance (RCM) later on. Predictive maintenance improves utilization and maintenance of power system assets since it allows having measurements and operational parameters of them. These permit either to anticipate to breakdowns or incidents at the distribution network. RCM is a more cost-effective maintenance strategy that includes criticity and significance of assets in the whole system, besides asset condition.

A project regarding monitoring is presented following. It is focus on two main assets at substations: power transformers because their significant both technical and economical, impact and circuit-breakers because their important rate of incidents.

SUBSTATION MONITORING SYSTEM
Monitoring is the first step towards the implementation of CBM strategy. Monitoring consists basically on acquiring significant parameters from the assets of interest. The collected data allow carrying out analyses and diagnose the condition of the assets which is of great use as a support to the decision-making maintenance schedule and then, reducing failures and breakdowns.

The huge amount of features to consider makes substation monitoring complex. It can be both on-line (continuous) and off-line (discontinuous), or a combination of both, depending on the asset and the diagnosis to perform. Proper sensors and data acquisition and software to process them are also needed. Moreover, substations are built with assets from different manufacturers the usual variety of communication protocols, too.
A monitoring system can be structured in three levels:
- Level 1: Data acquisition from each asset through appropriated sensors.
- Level 2: Data storage and processing at substation level.
- Level 3: Integration of the data from different substations into the general maintenance management system of the utility.

Power transformers and circuit breakers are the normally monitored assets at substations for being those of major importance and with higher impact on the performance of the system.

PILOT PLANT

The project: ‘Substation monitoring for predictive maintenance’ has awarded with Endesa’s R+D+i international prize NOVARE 2005 in distribution networks in the category of Power Quality and reliability. It has allowed setting up a monitoring system at an Endesa’s substation, namely, Sant Just Desvern (Barcelona).

This pilot plant is shown in figure 1. It consists in a monitoring system for a 66/25 kV power transformer and a 66 kV circuit-breaker. Monitoring is done through available signals in the substation and commercial devices.

- Morgan Schaffer CALISTO for dissolved hydrogen and water in oil
- Hydran M2 for oil gases in solution.
- Voltage signal from the high-voltage transformer side.
- Transformer load current signal from current transformers.
- Refrigeration fans group current and failure signals.
- Tap-changer position and the current of its motor.

The monitoring of the circuit-breaker wants to know the number of operations, the contact ageing (i2t) and the state of the breaker mechanism. This data was accessible from operation counter, current transformers and the auxiliary contacts.

The devices destined to acquisition and concentration of data from power transformer and circuit-breaker are: Areva MS3000, Thermo-Box from Siemens, F650 from GE and SIPROTEC 7UT635 from Siemens. The last two devices are IED’s and work as a communication interface between level 1 and level 2, using fibre optics or shielded twisted pair connections. Communication is based in IEC 61850 protocol, although connection between sensors and the equipment is done using copper cable.

Communication between both levels of the monitoring system is made with 3SWT switch from µSysCom. This is especially destined to Ethernet communications networks in electrical substations following the IEC61850 standard. Data acquired in level 1 is stored in a local database at Control Room computer placed at the substation. This computer is also connected to Endesa’s communication network and allows remote visualization of the database using a web server.

IED’s concentrate data from both sensors and available signals. Data flow starts here. IED’s servers make available data in IEC 61850 standard. This data are acquired by a computer using IEC61850 client of the software SICAM PAS from Siemens. This software also has an OPC server that supplies the data received in OPC format. A specific developed OPC client is then who makes basic data processing and inserts them into a database. Finally, a web server makes possible remote visualization of the database. Here, the data is transformed into useful information as a support to the decision making process. It allows carrying out an assessment of the condition of both the transformer and the circuit breaker and by means of this diagnosis, the scheduling of the maintenance activities can be achieved.

A deeper description of this pilot plant can be found at [1]. And [2] review the application of IEC 61850 for monitoring proposes.
FULL MONITORING SYSTEM

A full monitoring system is deployed based on pilot plant experience in the same substation. The following assets are added to Sant Just Desvern substation pilot plant:

- Four power transformers and their tap changers.
- Three 66 kV circuit-breakers.
- Seven 25 kV circuit-breakers.
- Nine 25 kV SF6 circuit-breakers.

The basic monitored parameters for each kind of element are listed next:

- Transformers:
  - Oil temperature.
  - Oil moisture.
  - Oil gases in solution.

- Tap changers:
  - Oil temperature.
  - Contact ageing (i^2t).
  - Number of operations.
  - Time and speed of operation.

- Circuit-breakers:
  - Contact ageing (i^2t).
  - Number of operation.

Ambient temperature is also monitored since mathematical models include it for representing the thermal behaviour of the transformer.

The monitoring system is modular in order to be able to replicate it in other substations according to the condition of the assets and their criticality within the network.

Data acquisition is done through appropriated sensors for each case. Two integral commercial systems for monitoring power transformers will be tested: MS 3000 from Areva and TEC 2.0 from ABB. Two Tap Vision systems from MR will be used to know the condition of tap changers and the power transformers where they are installed through TrafoVision and OilVision. The measurement of oil gases in solution at power transformers will be provided by Calisto from Morgan Schaffer. Condition of the 25 kV circuit-breakers is done through Areva P132 IED’s since it facilitates the needed monitoring parameters and the communication with IEC 61850 standard.

The integration of the data from the whole substation is done through a concentrator developed by Eliop that communicates with Endesa’s telecommunication network. There is no data storage at the substation.

The experience of Sant Just Desvern substation will offer the technical and, above all, economical impact of monitoring systems. The results will determine the feasibility of monitoring for maintenance proposes and the expansion of this strategy to the other substations belonging to Endesa Distribución.

REFERENCES
