INTELLIGENT SYSTEM FOR MANAGEMENT OF RECLOSERS AND MANEUVER PROPOSITION TO SUPPORT OPERATIONS TEAMS

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ABSTRACT

In order to face the increasing demand for higher quality, AES Eletropaulo utility company responsible for power distribution in the city of São Paulo, has been using advanced technological resources, such as reclosers on feeders. Currently over 2500 equipment of this nature are installed.
To optimize the results provided by these devices, it was developed a switch management system that allows: evaluating their performance by monitoring through reports with collective and individual indicators, assessment of the merits of the allocation of devices based on its performance, supporting maintenance policies of switches, collection, processing and consolidation of measurements allowing better management of the system.
It has also developed a module to support manoeuvre to aid operation, integrated into the SCADA system with the update status information of the switches, in addition to the loads measured. From the instant of fault it is possible to identify the pre-fault instant and make the necessary adjustments in demand for this moment. This makes possible the load off estimation and to propose the optimal sequence of manoeuvres to reduce the fault impacts.

INTRODUCTION

In Brazil, ensuring quality of service delivery of electricity is a regulatory requirement established by the National Electric Energy Agency (ANEEL) and a concern of Distribution utilities, especially with regard to measuring the quality of power supply through continuity indicators.
In order to meet this growing demand for higher quality services, AES Eletropaulo, distribution utility that serves the metropolitan area of São Paulo, has been making use of advanced technological resources, such as the automation of medium voltage switches. In previous projects, the company has managed to reduce the service time for contingencies and thus restore consumers not directly linked to faulty equipment.

AES Eletropaulo already has around 1500 automated switches in operation to manoeuvres in its energy distribution system, expecting to be about 3,000 by the end of 2012.

With this context in mind, this paper aims to present the developments and computational systems on two different aspects, namely:

- Management of switches installed in medium voltage system
- Proposition of manoeuvres of load blocks in contingency situations to support the network operation

For optimizing the use of these devices, a switches management system allows: evaluate their performance individually and collectively through statistical monitoring reports, through the assessment of the merits of the location of the switches in the network through supervision of occurrences of shutdowns and operations of switches, support directions to take corrective or preventive maintenance actions with network reconfiguration, collect, treat and consist information from measurements and by switches operations and to improve the management of distribution system in both design and maintenance aspects. The system for manoeuvres proposition to support network operation, in turn, is integrated with data of switches states and other measurements from SCADA supervisory system. This paper presents the basic features of these systems.

SWITCHES MANAGEMENT SYSTEM

The central object of the management system of switches is a group of reclosers installed in radial feeders, grouped as follows:
Equipment installed in the primary distribution network capable to be sectionalized on short circuit, loaded or without voltage conditions, through manual or automatic actions, remote controlled or not. Switches can be motorized by its own power supply, having meters or programmable processors, including data transmission.
Radial circuits, in which the switches are installed, are composed in an arborescent way by the main and lateral

feeders. The main feeder consists of sequential segments (called blocks), capable of being reconfigured by the operation of switches that connect it to neighbouring feeders. On the segments of the main feeder extensions are connected extensions, usually by means of fuses. Along the main feeder there are no fuses.
The switches are individually identified, and may be either in operation in a particular network location, or out of service (in stock or under maintenance).
The location where the switch is installed is characterized by its coordinates {x, y} or by the pair {Alim, Dist}, where Alim is the feeder code and Dist is the length from the feeder substation to the switch.

Processes related to Switch Management

The Switch Management System proposed aims to operationalize the processes related to the management of such devices since its acquisition, installation and maintenance on the network until its withdrawal operation. The following areas of the company are candidates to use the proposed system:

- Area A: Purchase, receipt and storage
  - ✓ Buy
  - ✓ Receive
  - ✓ Register switch
  - ✓ Register Switching Module
  - ✓ Register Control Module
- Area B: Study Systems
  - ✓ Conduct studies to locate switch
  - ✓ Set a new location in the network
  - ✓ Conduct studies related to new protection switch
  - ✓ Request installation of a new switch
- Area C: Design, installation and commissioning
  - ✓ Consult switch Available in stock
  - ✓ Order switch
  - ✓ Register switch network (“as design")
  - ✓ Register settings of the protection settings switch
  - ✓ Install and commission switch
- Area D: Operation and Maintenance
  - ✓ Fault register in switch
  - ✓ Request removal and replacement of switch
  - ✓ Register maintenance service held at switch
  - ✓ Register new switch in the network
  - ✓ Keep history of switch: operations, related measurements, maintenance, local, etc.
- Area E: Switches Assessment
  - ✓ Evaluate the performance of the switches, the merit of their locations, the corrective or preventive maintenance performed and the network configuration used
  - ✓ Obtain registration data
  - ✓ Get settings and protection settings
  - ✓ Getting locations
  - ✓ Obtain measurements
  - ✓ Get events
  - ✓ Obtain maintenance services
  - ✓ Apply evaluation rules
  - ✓ Produce reports with statistical and individual data:
  - ✓ Operating Condition in Steady State
  - ✓ Operating Condition of switching
  - ✓ Interventions and anomalies.

Software

The software for the management of switches includes the following features:

- Registration of Switches
  Insert the register of a particular switch, and its main parameters. Registration involves: manufacturer, model and documentation.
- Location of switches in Network
  Allows, from the switches already registered in stock, assign them to a network location that was loaded.
- Switch measurements reports
  Allows, from the switches already installed, configure and visualize the measurements in the switch that was selected.
- Protection’s Adjustments reports
  Allows, from the switches already installed, configure and view the protection settings for the switch that was selected.
- Switch events reports
  Allows, from the switches already installed, configure and view the events for the switch that was selected.

Figure 1 presents an example of screen view of the system.

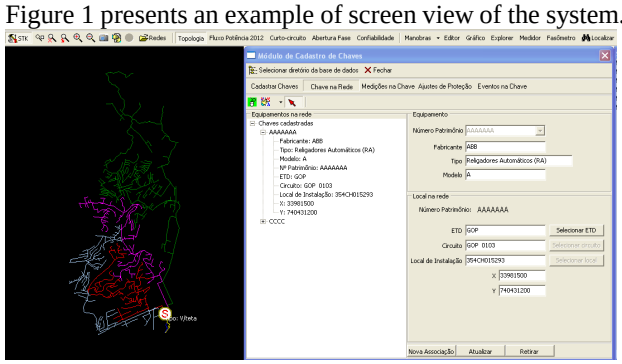

Figure 1 - Screen view of Switches Management System

MODULE TO SUPPORT OPERATION

This section will present the developments related to the Maneuver Support Module, which consists of software able to define a set of maneuvers to reestablish downstream turned off load blocks, caused from an upstream failure block, previously isolated.

The optimal maneuver proposition problem

The problem of proposing optimum maneuver in a MV radial distribution network remains on the definition of a set of reclosure maneuvers for recovering a group of turned off blocks as a result of an upstream failure, previously isolated. The reclosing solutions should be determined to minimize the non-supplied energy or, alternatively, the average duration of outages (SAIDI), maintaining radial topology and loading within acceptable limits during the repair of the

failure.
In most of the cases there are a great number of switches involved which makes the combinatorial problem impracticable to be investigated thoroughly. Consequently it was adopted a technique based on genetic algorithms in order to direct the search for a good solution and a consequent good proposition of maneuver for the operator.

Software

The software for the management of switches includes the following features:

- SCADA Interface
  Updates information on the state of the switches and demand data form SCADA system and the SinapGrid platform
- Demand adjustment
  Allows demand adjustment on the selected network based on SCADA measurements for a specific time.
- Assistance to Manoeuvre
  Manoeuvres strategies are proposed for restoring load blocks turned off as a consequence of a failure on the network.

The functionality of SCADA interface allows the importation of real-time information to the SinapGrid platform. Network and Measurement Information from SCADA pre-saved files are updated through this interface to be used in the support manoeuvre module.
Network information captured from SCADA are composed by the type and condition of the network switches.

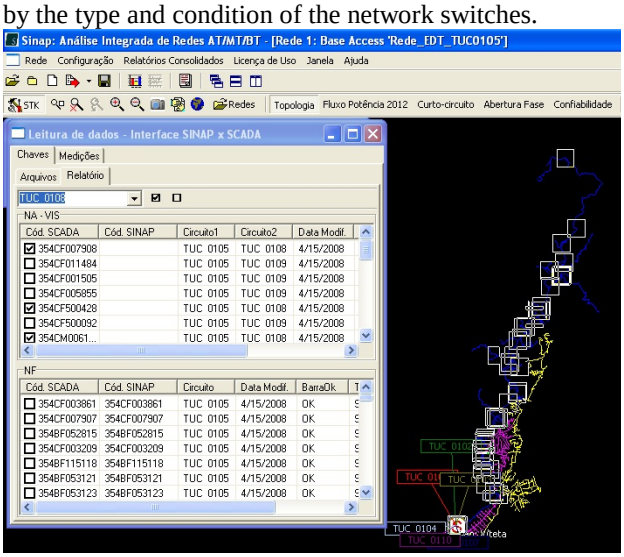

Figure 2 – Identification of switches

The measurement information refers to those available in automatic switches and is of great value to the functionality of demand adjustment, especially to characterize the condition of pre-fault load. Figure 3 below shows a list of measurements imported.

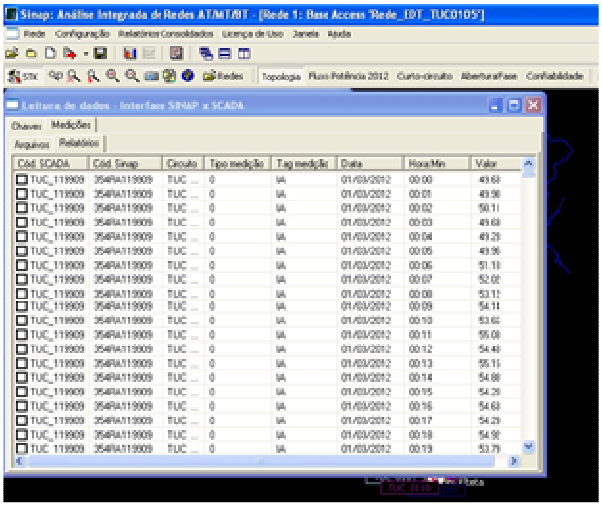

Figure 3 – Measurement Information

The adjustment proceeds by choosing the feeder whose demand should be adjusted and measurements of switches to be used for this procedure, is shown bellow by figure 4.

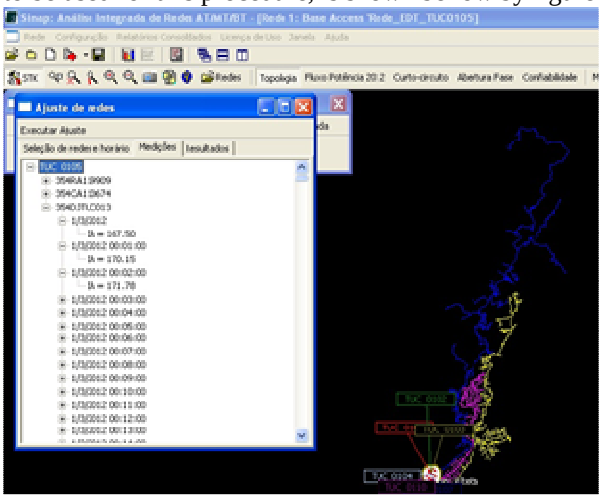

Figure 4 – Measurement Selection

Adjusted demands and updated states of the switches installed on the network characterize the pre-fault situation that is used as a basis to the alternatives evaluation of manoeuvre sequence for the downstream failure blocks recovery. This basis construction is done through a load flow calculation in the SinapGrid Platform and the estimation of the remaining capacities on normally opened switches, based on neighbouring MV circuits. As the main methodological points are already described, the steps to use the module are depicted bellow.
Initially the weights of attributes to be considered in the optimization process have to be defined, namely: Non-Supplied Energy, SAIDI and number of manoeuvres, with the proper restraint of feeders loading.
The next step is to identify the load block in failure, as shown in figure below. If the block which occurs the fault has no blocks downstream, the system issues a warning to the operator that no manoeuvres needs to be performed.

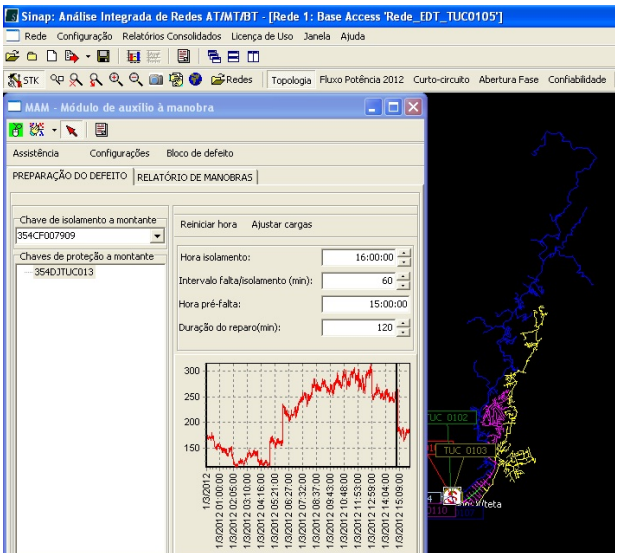

Figure 5 – Selection of load block in fault

After selecting the failure block and an upstream isolation switch some parameters must be set:

- Instant of isolation: the instant that the switch is opened for executions of repairs
- Time between fault / isolation: the period between the hour of occurrence of the fault and hour that the repair is finished.
- Pre-fault time: time that the fault occurred.
- Duration of repair: the period in which the switch will be opened for repairs.

From the time of isolation information, it is possible to determine the pre-fault demand based on acquired measurements from SCADA system, as shown in figure 6 below.

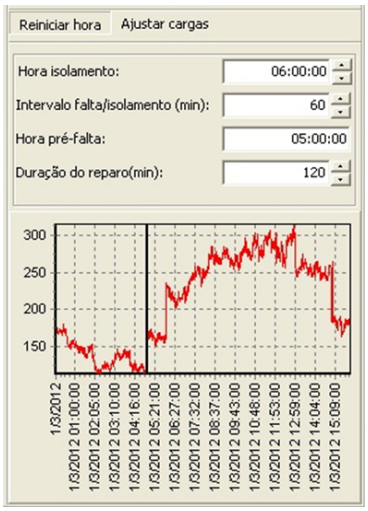

Figure 6 – Definition of isolation time

Thus, the feeder demands are adjusted and the optimized possible maneuver strategies are proposed, ordered from best to worst, according to the set optimization parameters, as shown in figure below.

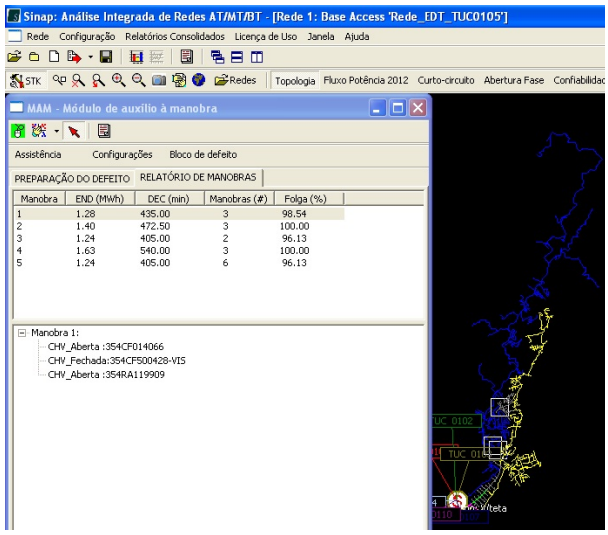

Figure 7 – Report with proposed manoeuvres strategies

CONCLUSIONS

The present study was designed and developed to support the operation and maintenance teams in a new network reality, with a strong presence of automated switches devices coupled with IT and telecommunications infrastructure.

The development of a switch management system that allows the monitoring of the performance of each device and its installation history on the network, aims to subsidize maintenance policies based on the condition and relocation studies in order to optimize its performance.

The Manoeuvre Support Module allows, based on real information extracted from the SCADA system, the proposition of optimal manoeuvre strategies in contingency situations, to enable the restoration of power supply in load blocks not affected by the fault.

The developments made are of great value given the regulatory framework that expresses an increasingly forceful demand for improved quality of service, and are aligned with technical advances seen in the industry and mirrored by increasing the degree of automation of the distribution system

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