OPTIMIZATION OF VOLTAGE REGULATORS SETTINGS AND TRANSFORMER TAP ZONES IN DISTRIBUTION SYSTEMS WITH GREAT LOAD VARIATION USING THE SMART GRIDS INITIATIVES

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ABSTRACT

The crescent development of intelligent equipments and supervision technologies, control and communication in real time it brought great contribution for the introduction of the concept of smart grids in the distribution systems. In this paper the authors intend to present a methodology that uses the potential of the smart grids applied to the increase of the efficiency of the voltage control in the distribution systems. It is intended to reach a better quality of the rendered services and consequently the customers' larger satisfaction.

INTRODUCTION

The Brazilian systems of distribution of energy are characterized by very long networks, heterogeneous loads no uniformity distributed, factors that result in high voltage drop and great variations among the landings of light and heavy load. Due to these characteristics and the legal demands, in the last years the control of the voltage levels has been study object in all of the operation levels.

Among the techniques used now by the electric utilities for control of the voltage levels in the distribution systems meet: the voltage control in the substation, use of voltage regulators, application of capacitors banks, alteration of TAP's of the distribution transformers and FACTS applied in distribution systems.

Besides the application of resources for optimization of the voltage regulators allocation and other equipments destined to the improvement of the quality of the energy supply, they are also developing tools to increase the efficiency of the settings of these equipments.

Given the evolution of the equipments, use of supervisory systems, remote control and monitoring becomes possible the integration of the several control means allied to a range of other devices supplying information about the conditions of the distribution system.

In this context this paper presents the initial step of an advanced methodology that uses the potential of the smart grids applied on the voltage control of the distribution systems. The work proposes the development of a more efficient control than it makes possible to enlarge and to turn more appropriate the administration in real time of the voltage control in the distribution networks allied to the knowledge of the network obtained thanks to smart grid.

ANALISYS PROCESS

In this section, will be presented the necessary considerations for the evaluation of the voltage levels along the distribution feeders. The relevant elements related to the voltage regulators will be described, the methodology proposed for definition of TAP Zones, as well as the results obtained after the application.

Voltage Regulators

The voltage regulators are means of voltage control used for practically all of the distributing companies of energy. In many situations are adjusted in a simplified way, considering only three parameters: the set voltage, the insensibility level and the time delay. Such approach can be considered satisfactory for feeders where the variation of the load is not very accentuated. However, when applying the regulator on a place with great variation among the light and heavy load, this simplified form of settings doesn't present satisfactory results, as it can be seen in the Figure 1. Once in the heavy load time the output voltage (VOut) locates very close of the lower limit of the regulation range, while in light load time it takes the voltage tends to stay close to the upper limit that can cause over voltage the some consumers.

For the feeder with these characteristics of load variation becomes desirable that the voltage is higher in the times of larger load, in order to compensate the line drop. Most of the traditional regulators, as well as the new regulators of multiple settings or still the asymmetrical regulators, it has the resources to assist this need through the use of the LDC.

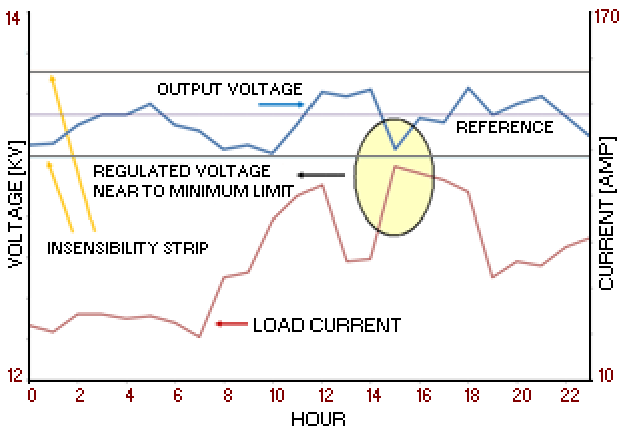

Fig. 1 – Regulated voltage vs load current, using simplified setting

With the LDC resources activated, besides using the voltage measure, it is also considered the load current, turning the output voltage a function that depends directly on the voltage and measured current. Like this, the use of LDC can be defined as a variable adjustment of the reference voltage.
Being used in this definition, the Figure 2 presents the regulation range for the same situation of the Figure 1, however considering the influence of the load and the LDC parameters.

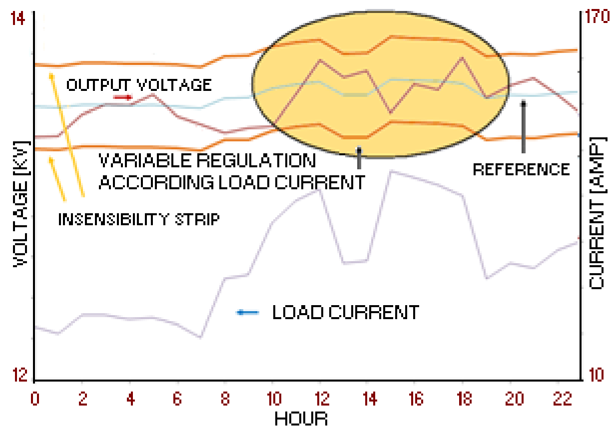

Fig. 2 – Regulated voltage vs load current, using LDC.

With this approach, maintaining the same insensibility range, a displacement of the reference voltage can be observed, due to the elevation of the load current. Besides the values of primary voltage, the definition of the settings of the regulators should take in our bill reflex in the secondary voltage, considering TAP's used in the distribution transformers. In order to guarantee the appropriate supply to the consumers assisted in low voltage (LV), TAP Zones are defined through which appropriate TAP will be indicated for each transformer.
This adjustment mode of the voltage regulators can be defined following two possible configurations:

- To maximize the voltage altering the TAP Zones.
- To maximize the voltage maintaining to TAP Zones.

The second situation is preferred in many cases for operational reasons due to smallest interventions need in the transformers, once the primary voltage will be adjusted for the current configuration of the system. Being opted to maintain the current TAP zone the LDC application just presents a voltage gain regarding the variation of the load of the feeder, once the set voltage will be adjusted for a very close of the actual value.
However, when considering the alteration of TAP Zones it becomes possible the obtaining of larger gain as the elevation of the voltage levels in the whole primary line, guaranteeing the range of appropriate voltage for the consumers assisted medium voltage (MV) and consequently reducing the levels of technical losses.

TAP Zones

The TAP Zones, shown in the example of the Figure 3, they are established with the purpose of maintaining the secondary voltage inside of the appropriate limits, considering the voltage received by the primary of the transformer, preferentially inside of a optimized voltage range.

For the definition of appropriate TAP it is used a routine computational that verifies, with base in the power flow of the feeder, the applied primary voltage in each transformer for the different load landings (light and heavy load or the consideration of the 24 hours of the day).

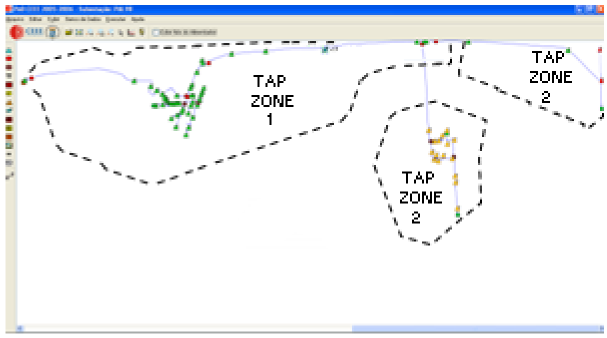

Fig. 3 – Distribution feeder and TAP zones

Of ownership of these values of primary voltage, it is simulated in the secondary voltage of the transformer, for each TAP, comparing with the established limits for the module 8 of PRODIST [1]. After the simulation it will be defined TAP that to present the best levels of secondary voltage.
For to include a new voltage regulator or to alter the adjustments of a regulator already existent, the developed analysis and presented to follow part of the current configuration of the feeder. Through simulations the most suitable configuration will be defined for each situation.
After the accomplishment of the simulations, the new configuration of the feeder is presented, containing the new TAP Zones and indicating the new adjustments of the voltage regulators. After the accomplishment of the evaluation of the feeder and the analysis of the current situation, using simulations of power flow and SMART METERS obtained data, they are defined the voltage levels wanted starting from the specification of the TAP Zones for each voltage regulator. After this definition, a routine computational presents the parameters of reference voltage and LDC for each regulator.

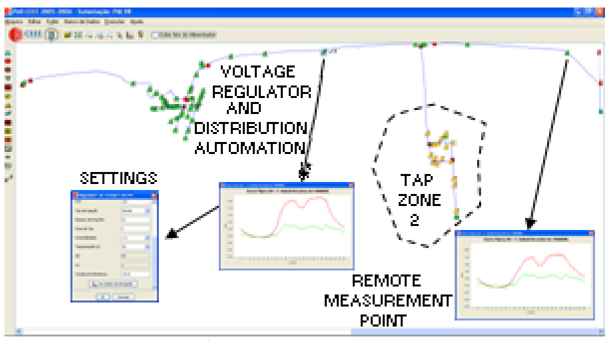

Fig. 4 – Overal view of intelligent distribution system

Once defined the parameters, for a conventional system there was the need to send a team for the execution of the equipment configuration and once put in operation the attendance of the effectiveness of the proposed adjustments is accomplished. However through the distribution automation the voltage regulators are remotely set up and the attendance of the effects on the network is accomplished through the monitoring of the voltage levels in the own regulator and in

the consumers through SMART METERS.
For validation of the study equipments of measurement of greatness are installed in MV or in LV, together with measurements of revenue, allowing the evaluation of the voltage range on load side of the equipment and the propagation of their effects in other points of the feeder.
The application of the methodology presents satisfactory results under view of improvement of the conditions of operation of the electric system, supplying more quality to the energy supplied the consumers. However this process demands time of execution and costs with displacement of teams.

Voltage Control and Smart Grid

The development of intelligent meters and the new technologies used for distribution come as a solution highly promising for the distribution systems. A new range of possibilities appears starting from the application of equipments and intelligent systems so much in quality terms and reliability of the service rendered on the part of the distribution companies as in terms of knowledge of the distribution networks. In the Figure 5 a general vision of SMART GRID on the voltage control is presented, illustrating some of their components.

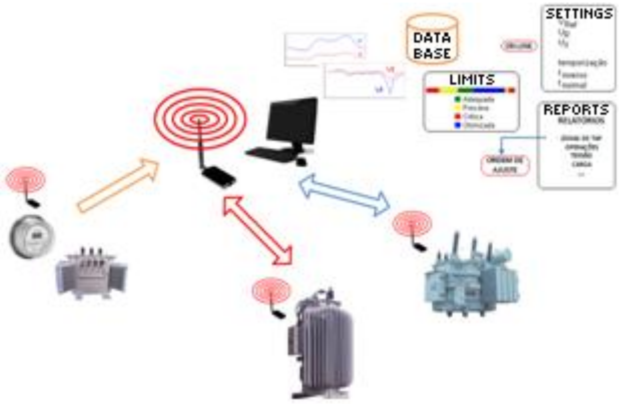

Fig. 5 - Integration among voltage control and SMART GRID

The SCADA, located in the Central of Operation and Control, it allows to the operators the supervising of electric greatness in real time, the quickly execution of switching and interventions in the network, a larger agility in the location of defects and allocation of maintenance teams.
With the association between SMART GRIDS and the voltage control becomes possible the closing of the mesh of voltage control in the distribution systems. Through the greatness registered by the intelligent meters the for the other automated devices the feedback of the distribution regulators will be accomplished evaluating in real time the voltage levels supplied, the number of commutations and the used time definition, without the need of displacement of teams for the installation of special meters. This mode it becomes possible to operate with a adaptative control, changing settings of the regulator when necessary.
With the use of this architecture, it becomes also possible to integrate the several existent control means in the feeders, allowing the application of other techniques as hierarchical control and the optimization of the operation of the regulators, monitoring the number of commutations and altering the insensibility range and the time definition type conveniently in agreement with the need.
The methodology proposed for the integration of the voltage control in the distribution networks and of the knowledge obtained through SMART GRID can be explained by the diagram of the Figure 6, with the main blocks that compose the system.
Each one of these blocks has a specific function to accomplish for it is obtained the best acting of the equipments, assisting the commitment between the power quality and the durability of the equipments.

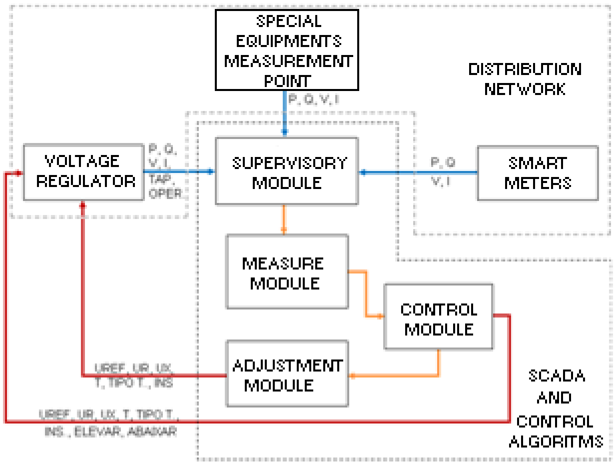

Fig. 6 – Modules of integrated voltage control

The supervisory module is responsible for to monitor and to store all of the obtained information, be of the special equipments, belong to the consumers.
The treatment of the measure module accomplishes the due statistical treatment of the greatness monitored in the several points of the network to supply of the necessary knowledge for the socket of decision regarding the parameters of control of the equipments.
In this module the task of knowledge extraction is accomplished starting from the data available by the intelligent meters and other measures points aiding the following modules in the process of socket of decision.
As much the module of adjustments as the control module it has the function of defining the voltage regulators settings, however the control module has the extra attribution of assuming the control of the system temporarily, sending commands to elevate or to lower, in agreement with the need.

CONCLUSIONS

The use of the available resources in the traditional voltage regulators, allied the an integrated planning of definition of TAP Zones, it defines clearly which will be the function of the voltage regulator and which the expected result, besides guaranteeing a better use of the assets providing improvement in the quality of the supplied energy, with economy. However, they can be obtained resulted still more effective with the use of the intelligent networks.
The energy distribution systems are in evolution and the optimization of the operation of the equipments has fundamental paper in the rational use of the available resources.

The presented methodology allows the optimization of the voltage levels inside of the regulation area of the voltage regulator and the integration of the control means in system level, providing conditions for the economical development of the assisted areas, together with the reduction of the number of voltage complaints and supply of energy with quality.
The integration among the techniques of optimization of the equipments, simulation tools, data acquisition and the distribution automation represents the future of the distribution of the electric energy presenting a more robust and reliable electric system, the energy supply with more quality and the better use of the equipments.

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