THE ROLE OF SYSTEM AUTOMATION IN POWER QUALITY

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SUMMARY

Delivering quality power to consumers has become an increasingly concern for specialists, due to the rising demands of customers.
The power quality supplied to consumers with its two components: voltage quality and supply service quality, present a particular interest for industrial electricity consumers, since many of its processes are strongly influenced by the quality indicators of electrical power supply terminals.
In the same time, consumers who use modern technologies are sources of disturbance to adjacent users of the same distribution network.
For this reason, both the consumer and the supplier of electricity are interested to monitoring electrical power supply quality in common point of connection.
One of the methods used by distribution companies in order to ensure the supply service quality and the electrical power quality at the delimitation point between the supplier and consumer is the equipping of power distribution networks with modern automation systems.
This paper presents researches and results obtained by the specialists from Electrica Distribution South Transylvania to improve the electrical power quality supplied to consumers, using embedded automation systems.
KeyWords: power quality, supply service quality, distribution networks system automation , automatic tuning equipments

INTRODUCTION

The power quality is a complex problem. The complexity results from:

- many factors influencing the power quality;
- factors interdependence;
- the lack of methods and ways to obtain the accurate information about power quality indicators [14].

Power quality supplied to consumers, with its two components: voltage quality and supply quality service, represent a particular concern for the electricity consumer, taking in account that many of its processes are strongly influenced by the quality indicators of the power supply rails [1].

In the same time, consumers using modern technologies are electromagnetic interferences sources, that can affect the power quality delivered to other consumers connected in the same network distribution.

In this regard, both the consumer and the electricity supplier are interested in monitoring the power quality in the common point of connection.

Today computers are essential in production and health of the nation. Virtually all operations controlled by computers require power quality and does not tolerate increases or decreases in electrical power parameters and especially can not tolerate total disruptions of power supply, even they are short. Most of IT devices contribute to power quality deterioration by producing electrical distortions, called harmonics. The number of such devices in operation is high, so the cummulative effect can cause serious problems. Electricity demand related to the digital domain will represent in the future almost 50% of electricity consumed.

Seven types of disturbances that affect the power quality have been identified:

- voltage imbalances;
- frequency variations;
- short interruptions;
- long interruptions;
- waveformdistorsions (harmonics);
- voltage fluctuations;
- transients (impulses, oscillations).

The final goal is to find effective solutions to reduce and/or eliminate these disturbances.

Conventional electricity meters, used by consumers do not register disturbances in supply networks. Using the electronic meters that can monitor electrical power parameteres, it is possible that both - suppliers and electricity consumers – can identify and understand the causes of such disturbances.

Customers think that is the responsibility of the electric company to solve any problem on power quality. But to maintain the electrical power parameters within the quality standards limits [16], costs from both the supplier and the consummer are necessary.

A power system is not perfect and, economically, it is not feasible to make it perfect. For this reason, it is the responsibility of suppliers, energy consumers and equipment manufacturers to contribute in finding solutions for a harmonious coexistence in current energy environment.

In the Electricity Distribution Branch South Transylvania, the power quality issues were not priority. Due to equipment aging, the priority was to maintain them in operation and to eliminate interruptions in electricity supply to consumers. These interruptions (short, medium or long) that represent an important indicator of quality power supply service have a major impact both on consumers [12] (equipment damage, production loss, discomfort) and the Electricity Distribution Branch South Transylvania (damage the company image, losses caused by unsold power, maneuvers and repair costs, etc.).

IMPROVING POWER QUALITY USING SPECIFIC AUTOMATION FOR POWER SYSTEM

A. AAR automation system

An AAR automation system has been designed, developed and embedded on transformers and medium voltage (6 kV and 20 kV) couplers in most electric transformer stations equipped with two or more power transformers.

This automation allows station to operate with a single power transformer when consumption permits (especially on Saturday and Sunday), and the second power transformer is turn off, but is ready to be turn on when all conditions required by the schema are accomplished.

Operation of equipment with AAR reduces the own company's technological consumption and eliminates the losses due to undelivered power. It ensures also consumers refueling after an AAR break (3.5 seconds) at a trigger of transformer in service.

Also it is avoid the intervention time of operational staff in all equipments without remote control, which are coordinated by the dispatcher and a human error can occur in maneuvers. Losses in production, raw materials and equipment damage, discomfort from consumers are avoided.

B. DRRI automation system

In several electric transformer stations, a DRRI schema is used on the cells of 110 kV, in order to limit the extension of any damage to the 110 kV systems, and avoiding the outbreak of the equipment from the adjacent stations that are sources.

When a trigger switch from a 110 kV line is refused (mechanical failure, lack of drive agent pressure), after the operation time of protections, a trigger pulse is given at 110 kV couple, in order to separate and save the half of station.

Another option is to give a trigger impulse, with the start protections control, to the electric station transformer or to 110 kV switches of lines on the bar of 110 kV, depending on the station scheme. The reliability of primary equipment contributes to the success of this automation.

C. DASf automation system

The frequency decrease is an important parameter of power quality and in power system can have catastrophic consequences on the stability, when power demand exceeds the possibly available power at a time in power plants. It is an important safety measure for saving power system in extreme situations.
In the Electricity Distribution Branch South Transylvania performing frequency relays have been installed in power plants. Medium voltage cells are divided into three frequency trances and they are automatically disconnected when the frequency on that trance decreases [16].
All electrical transformer stations are equipped with local frequency relays manufacturing ABB, Siemens, Microstiintifica Electica (Italia). These relays are improved with optimization circuits and external schemes, to optimize to avoid unexpected operation when the voltage returns to its nominal value.

D. Automatic tuning of voltage transformers (RATT automation system)

Maintaining the voltage within the standards is a major concern of power quality. Power transformers in transformer stations are equipped with devices that provide automatic tuning of voltage to maintain it in normal limits [16].
Automation schemes for voltage automatic tuning and supply schemes of plots switch are done to ensure the maintenance of blood within normal limits.
By introducing a voltage that does not correspond to a normal value in the supply network of consumers leads to destruction of consumers equipment. In this case, if a digital control relay for automatic tuning of voltage is introduced, correlated with modern equipment for switching under load plots, this risk is reduced. This is an obvious example of ensuring power quality to consumer.

E. Automation with remote separators and reclosers.

Automation system for medium voltage distribution network covers all primary and secondary equipment, and telecommunications integrated into a coherent identification system that selectively isolates defects in medium voltage networks.
This system present the following advantages:

- improve performances of distribution network;
- reduce the undelivered power to consumers;
- decrease the operating costs (maintenance, equipment replacement, identification and liquidation of damages, reducing network losses);
- reduce the number of interruptions in the electricity supply process for consumers;
- limit the number of consumers affected by the incident;
- inform the operational service staff on the event, in order to take a decision;
- the possibility of intervention on the network, to rapid refueling of consumers.

Consumers from rural areas, supplied by air networks, are more affected than urban consumers, in terms of power quality supply, due to numerous interruptions, difficulties in separating damaged areas and restore electricity supply. Thus, a defect on a branch will automatically isolate the defect in the derivative and the remaining consumers are supplied.
One of the main problems present in the medium voltage network is the network response in case of defects. In most cases any defect appeared generates trigger switch of the transformer station, affecting a large number of consumers.
The defect detection is also very difficult due to lack of information about the event. Times to eliminate the defects are very large, requiring several maneuvers and movements of the intervention teams.
An important reason for the automation is the steady increase in recent years of electricity consumption by consumer’s appearance with performing plants. Due to the small initial investment, most of consumers choose as solution the connection to the existing medium voltage network.
In these conditions, the increased consumer demands are becoming more difficult to satisfy, and if consumers are demanding damages for undelivered energy, this can generate significant financial loss for the supplier. All of this involve reconsidering the automation necessity in the medium voltage network, because in this case the investments are quickly recovered.
The criteria that led to the selection of medium voltage lines (MT) to be integrated in an automation system are economic distribution of power quality, service electricity distribution quality and follow to achieve maximum economic efficiency.

These criteria are the following:

- lenght of MT airline analyzed;
- tranzited power on LEA;
- the average refueling consumers period after a permanently incident;
- the number of permanent defects on the analyzed MT LEA.

Remote load switches [2] and automatic also, are usually embedded in the distribution networks with relatively important loads, with a high frequency of disconnections and to which the access is difficult. Load switches have associated primary equipment (current and voltage transformers) and secondary equipment consisting of protections (fault indicators), proper operational sources and remote equipments (RTU) [3].
The operating regime of these separators is [4]:

- remote (from local dispatcher);
- automatically, with automatic disconnect in the second break of the station switch RAR, when a permanent defect downstream appear).

If a permanent short circuit appears, all defects indicators, related to separators located between the station and the place of the defect, sign to the dispatcher the pass of a defect current. Separator closest to the defect, meaning from the source point of vu, is disconnected automatically (if it is scheduled to operate in this mode) or remote by dispatcher. Usually the recloser operates as an automatic switch and is interposed into the distribution lines, so that the defects from downstream are eliminated by selective triggering of recloser, restoring automatically the supply from the health part of the network.
In long networks the intercalation in line of two or three reclosers is possible. Reclosers are equipped with performing digital protection RAR, which enable to ensure the necessary selectivity between them and from the station switch, depending on the fault line. Reclosers can have also remote equippement.

F. Automatic tuning of Petersen coils from electric stations

In medium voltage networks, having the neutral through petersen coils, În reţelele de medie tensiune, având neutrul tratat prin bobine Petersen, when is a grounding voltage phase, the voltage on healthy phases increase of $\sqrt{3}$ times, that leads to damage of equipment insulation .
Theory, that a medium voltage network having neutral earthed with Petersen coil can work more hours to ground, is no more available in terms of power quality. The voltage decrease on phase grounded and the voltage increase on healthy phases are undesirable aspects.
Petersen coil with continuously tuning is designed to deliver, in case of one phase grounding, an inductive current out of phase with angle π to the capacitive current of the network, in order to extinguish the arc, contributing to insulation restore. Capacitive current of an electrical network can be changed by connecting or disconnecting of some sections, using maneuver determined by the necessity of defects detection or accidentally by protection and specific automation operation.
Petersen coil restoration is made by operational staff in transformer stations or with Telecomm equipment that automatically realizes this operation [13].

For a proper operation of the equipment, the use of the following parameters is required:

- deplacement voltage of neutral point of medium voltage network, taken from voltage transformers included in Petersen coils;
- the current through the Petersen coils;
- the AC voltage, proportional with the position tuning of Petersen coil;
- extreme positions of the Petersen coils, taken as numerical information from limiters (positions - minimum and maximum plot).

In the middle voltage networks with earthed neutral through Petersen coil, the inductance coil can form, under certain conditions, a resonant circuit with equivalent capacitance network. The amplitude and the phase shift angle of the neutral displacement voltage, which is the voltage across the coil Petersen, and a reference voltage vary according to the compensation degree.

Using the folowing notations:
UB – Petersen coil volotage;

IL – inductive current intensity trough coil;
IC – capacitive current intensity of medium voltage network;
α - phase shift angle between the voltage across the coil and a reference voltage,

the voltage on Petersen coil reaches a maximum, Umax, for case $\frac{I_L}{I_C} = 1$ that correspond to a resonance condition (Fig.1).

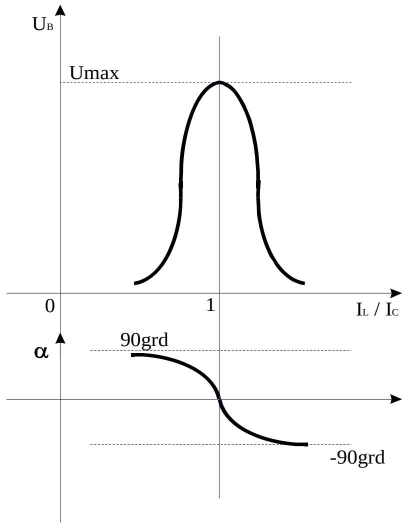

Fig. 1 Circuit LC at resonance.

The voltage on the Petersen coil terminals decreases even more the difference between the coil current and capacitive current of the network is higher. If $\frac{I_L}{I_C} > 1$ the network is over-compensate, as is shown in Fig.2. If $\frac{I_L}{I_C} < 1$ the network is under-compensated, as is presented in Fig. 3.
By continuously monitoring of the phase shift angle of voltage across the Petersen coil it is possible to arrange automatically the coil to the concrete conditions of the network.
Thus, when an agreement at resonnace appear, the decrease of capacitive current network is possible (eg, following the retiring from service of medium voltage lines), in this case $\frac{I_L}{I_C} > 1$, as point a from Fig.2. The displacement voltage amplitude corresponds to the point “a”, and phase shift angle correpsond to the point “b”.

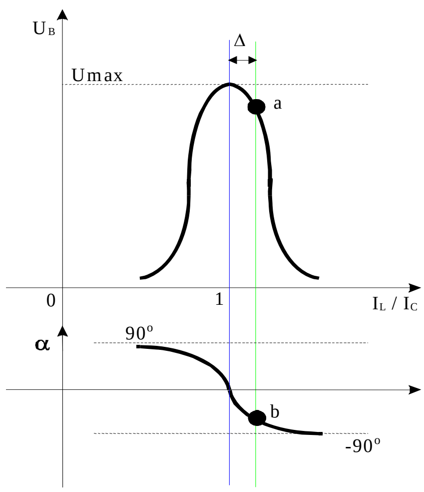

Fig. 2. Operating regime of over-compensation.

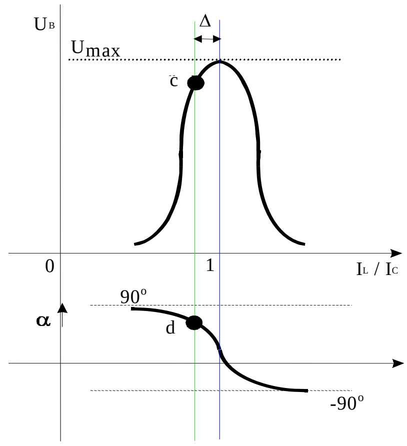

Fig. 3. Operating regime of under-compensation.

Increasing the angle of phase shift is used to control setting off coils, in order to return to normal operation (setting required) by decreasing the current through Petersen coil.
If is an agreement at resonance, it is assumed the increase of capacitive current network (eg, due to the re-working of a medium voltage lines), where $\frac{I_L}{I_C} < 1$, point “c” from Fig. 3.
In this case, the deplacement voltage amplitude corresponds to the point “c”, and phase shift angle correpsond to the point “d”.
The increase of phase shift angle is used to control the Petersen coil tuning, in order to return to the normal position (required setting) by increasing the current through the coil.
Principle of operation for this equipment is based on continuous measurements of phase shift between the voltage across the Petersen coil and comparison with a reference voltage, required by regulation.
If this angle is different from that required by the control, the equipment will give drive commands to Petersen coil, in order to respect the required angle. Sense of control depends on the phase shift angle sign, measured at a time.
Main schema equivalent to the software implementation is presented in Fig. 4.

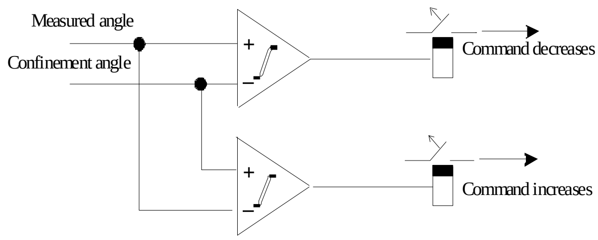

Fig. 4 Schema principială de funcţionare

The equipment sensitivity to disagreement phase shift can be controlled using the difference between the confinement value and the phase shift angle value measured at a time.
The equipment allows to determine automatically the desired agreement point respecting the overcompensation or undercompensation desired value expressed as a percentage from the agreement value at resonance.

CONCLUSION

One of the methods used by the distribution and electricity supply companies to ensure the quality of the supply service and the power quality across consumers is to equip the electrical distribution networks with automation systems. These provide to the electricity supplier the possibility to reduce the number of interruptions in the supply process, the time of interruptions, the number of affected consumers, the undelivered quantity of electrical energy quantity and thus limit to a minimum the damages and the inconvenience appeared.
Automations must be extended in all distribution networks, their good effect proving that the investiment is recovered in short time and represent an importnat stpet in ensuring power quality.

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