MEĐUNARODNO REGIONALNO SAVETOVANJE O ELEKTRODISTRIBUTIVNIM MREŽAMA

REGIONAL CONFERENCE AND EXHIBITION ON ELECTRICITY DISTRIBUTION

Crna Gora, Herceg Novi, 5 - 8. oktobar 2004. / ***Montenegro, Herceg Novi, October 5 - 8, 2004***
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ACTUAL ISSUES ON POWER QUALITY MONITORING IN ROMANIA

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1. INTRODUCTION

The ample process of restructuring the Romanian power system via separation of electricity generation, transmission and distribution activities, setting up of private electricity suppliers and increased requirements of the electricity consumers triggered the increase of the interest and concern about power quality evaluation and adoption of effective measures to get the disturbing consumers observe the allowed disturbance limits.

The experimental determinations carried out in significant points of the power system concerning level of harmonics, flicker and unbalance as well as short and long time dips and interruptions pointed out the necessity to carry on the studies in the field and prepare norms, in compliance with the European normative acts so that the electricity market participants may be offered the necessary tools to evaluate the power quality at the interface points.

There is also the need to design specific equipment to monitor the power quality and disturbance levels, compliant with the processing algorithms in the prepared normative acts.

The voltage analysis in the power network points, in default of reactive power control and FACTS devices reveals the exceeding of the allowed range upper limit mainly during low load hours.

To this effect, the determinations carried out emphasized the necessity to prepare clear instructions to control the reactive power circulation and increase the responsibility of the area dispatchers for the control of the reactive power sources.

The paper deals with the presentation of some specific aspects revealed by the experimental studies conclusions, may of processing the data, some proposals for results interpretation, equipment used for the study as well as elements regarding work to be carried out.

2. POWER QUALITY

Power quality has been, ever more, one of the most important parameters in the suppliers' offers to the consumers and many times it is decisive in selecting the supplier on the power market. In this respect, the norm EN 50160 defines the power standard quality within the supplier – consumers relationship yet, the supplier can provide a higher quality under a special rate terms.
The power quality level provided by the suppliers cannot be achieved but under secured technical and maintenance conditions met by the distribution operator, transmission operator and producer. Thus, the quality indicators monitoring at the interface points between the transmission and distribution operators, as well as the quality degree assurance in these points are decisive for securing the quality degree provided by the supplier. Certainly, to know the quality indicators at the interface points between the producer and the transmitter is of special interest in the evaluation of power quality at the connecting points with power distributors.
At the same time, power quality has an important impact on the economic indicators of the transmission network and a characteristic parameter for estimating its performances.
To a great extent, disturbances which lead to power quality diminishing, are caused by consumers' action, (harmonics, unbalance, flicker, s.f.) but also the power generation, transmission and distribution systems, due to their specific, occurring stress (lightning, wind, ice layers, failures, s.f.) represent a source of disturbances, under the form of short-circuits, voltage dips, over-voltages, voltage and frequency variations.
On exceeding the permitted voltage band, the transmission network can be also a source for voltage harmonics, both through corona discharge and through the non-linear magnetic circuits.
The power transmission network development shall have in view the security of power quality standard at the interface points with the distribution network.
To know the quality indicators, the determination practical modality, the interpretation of their monitoring results, to know the disturbances permitted limits is of high interest for securing a standard, quality power, as well as for decisions on the actions to be adopted with the view to reach the demanded quality standard.
A special care shall be taken of the great disturbing consumers (metallurgical industry, aluminum industry) which are directly connected to the high voltage network.
The disturbances caused by these consumers are spread throughout the high and very high voltage network, with an impact on the power quality over big clearances, compared to the consumer's connecting point.
The calculation of disturbances level allowed to these consumers (harmonics, flicker), the disturbances boundary point monitoring and their compliance with the allowed limits play an important role for reducing the active losses in the transmission network, limiting the disturbances fond in the network and securing the quality standard for all system consumers.
The experiment determinations at the connecting points of the big disturbing consumers emphasized that, at present, the disturbances level is not exceeded, compared with the permitted values, mainly due to the reduced production activity of these consumers.
Thus, figure 1 presents the results of measuring made in a power supply point of one big, industrial consumer, using arc furnaces.

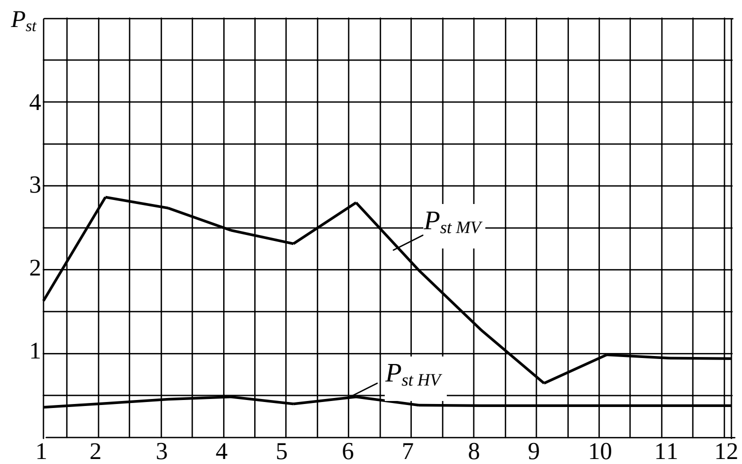

Fig. 1 – Variation flicker indicator on the medium voltage and high voltage bus bars.

Although, on the medium voltage power supply bus bars, in the consumer's network, the short-term planned flicker level P_{st} has been exceeded ($L_{Pst\ MT}$ = 0,9), the values recorded on the high voltage, power supply bus bar do not exceed the permitted values ($L_{Pst\ IT}$ = 0,8).
The data of fig.1, obtained over 120 min. (12 measuring windows of 10 min. each one) cannot completely characterize the consumer as a disturbance source.
Only by monitoring over big time periods (one week at least) and by statistically processing the results can someone provide the necessary information for making decisions on the consumers' compliance with the assigned limits.
The variation of electrical parameters of the power network and the aleatory superposition of disturbances, determined by various consumers result in a value, of 95% probability, to be the basic value for making decisions on the development of network and the means for limiting the electromagnetic disturbances.
In this respect, it is accepted that the allowed values can be exceeded in 5% of the cases.
The electrical parameters monitoring in the power system points demands the use of specialized equipment to assure the data procurement and processing over big time periods.
The actual monitoring equipment are, in fact, specialized computer systems on which a special attention shall be paid to know in detail the processing algorithm of the acquired samples.
This aspect is mainly imposed by the fact that, in the world there are considerable differences in terms of definition of some indicators, used for characterizing the nodes of the power and the consumers' network.
The performance of equipment, starting from the parameters different definitions leads to very different results.

3. ELECTRICAL PARAMETERS

The main parameters, used for characterizing the points of the power network, with different definitions, implemented to the monitoring equipment, are:

- Aparent, three-phase power S_{trifaz}

    a) algebric sum of powers per phase

$$S_{trifaz1} = \left|\underline{S}_A\right| + \left|\underline{S}_B\right| + \left|\underline{S}_C\right|; \qquad (1)$$

    b) vector sum of powers per phase

$$S_{trifaz2} = \left|\underline{S}_A + \underline{S}_B + \underline{S}_C\right|; \qquad (2)$$

    c) equivalent, three-phase, apparent power

$$S_{trifaz3} = 3 \cdot U_e \cdot I_e; \qquad (3)$$

with

$$U_e = \sqrt{\frac{U_A^2 + U_B^2 + U_C^2}{3}}; \quad I_e = \sqrt{\frac{I_A^2 + I_B^2 + I_C^2}{3}}; \qquad (4)$$

    d) average three-phase apparent power

$$S_{trifazat4} = 3 \cdot 1{,}1 \cdot U_{avg} \cdot I_{avg}; \qquad (5)$$

in which

$$U_{avg} = \frac{U_A + U_B + U_C}{3}; \quad I_{avg} = \frac{I_A + I_B + I_C}{3}. \qquad (6)$$

Under real conditions, the four definitions of the three-phase, apparent power result in different values, with the suitable impact on the acquired information quality.

Under non-symmetric conditions, $S_{trifaz2} < S_{trifaz1}$ and the three-phase power factor, calculated on the basis of the apparent power $S_{trifaz2}$ is correspondingly higher than the three-phase power factor, calculated on the basis of the apparent power $S_{trifaz1}$.

- Reactive power per phase

  a) the sum of harmonics reactive powers (Budeanu definition)

$$Q_1 = \sum_{k=1}^{\infty} U_k \cdot I_k \cdot \sin\varphi_k \ ; \tag{7}$$

  b) difference between the apparent power and the active power (IEEE definition);

$$Q_2 = \sqrt{S^2 - P^2} \ ; \tag{8}$$

Under non-sinusoidal conditions, the two parameters can much differ, the value Q_2 (including the distorting power) is always bigger than Q_1 . The use of reactive power Q_1 or Q_2 for calculating the apparent power and the power factor lead, under non-sinusoidal conditions, on a wide scale in the power network, to values with possible big differences.

- Unbalance

  a) negative and zero unbalance factors, calculated on the basis of positive (+), negative (-) and zero (0) components

$$k_s^- = \frac{U^-}{U^+} \ ; \ k_s^0 = \frac{U^0}{U^+} \ ; \tag{9}$$

  b) unbalance factor calculated on the basis of voltage deviation per phase, compared with the average value

$$k_s = \frac{\text{maxim deviation reffered to average value}}{\text{average value}} \ . \tag{10}$$

In the real cases, the difference between unbalance factors, calculated by the two methods, can be essential.
To know, in detail, the calculation algorithm of the monitored or metered parameters permits the equipment validation compared with the norms agreed by the European power operators.
The quality of the acquired information also depends, to a great extent, on the data acquiring modality.
The analysis made, by means of several monitoring equipment, underlined the fact that, for the actual shape of the electrical parameters curves, the accurate determination of the quality indicators requested the obtaining of 126 samples per period, at least and the use of digital analogue converters on each equipment inlet.
On making the decision with respect to the compliance with the power quality standard, we must take into account that in the power transmission network, the information transmitted by the monitoring equipment, connected to the secondary circuits of the voltage and current measuring transformers, are distorted by the existence of these transmitters.
Having in view the frequency characteristics of the measuring transformers we have to assume that the power quality information, indicated by the monitoring equipment, connected to the secondary circuits of thy measuring transformers are always optimistic compared with the real values of the high voltage points. In this respect, the transmission operator shall take care of replacing the actual measuring transformers (especially TECU voltage transformers) with transmission operators providing true information on the high voltage values.
As an example, figure 2 presents the frequency characteristic, determined for one TECU 110 kV voltage transformer.
One can notice that the correct data transfer occurs only at the rated frequency of 50 Hz. All the other harmonics are transmitted in a distorted manner which accounts for IEC recommendation that such measuring transformers shall no more be used for measuring the distorted parameters.

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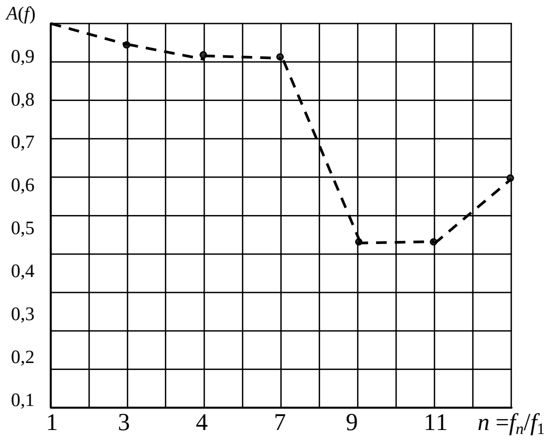

Fig. 2 – The frequency characteristic of one TECU 110 kV voltage transformer

The actual solutions using optical transmission transmitters can provide correct information up to higher frequencies (10 000 Hz) than the pertinent field (2000 Hz) for the electrical parameters of the power network.

4. CONCLUSIONS

The decisions making with respect to the power transmission network development shall be based on correct information, determined for big time periods and statistically processed. The main parameters, taken into calculation, for the network dimensioning is the value of 95% probability.
Having in view the existence of a great number of monitoring equipment on the market, operating with different data processing algorithms, it is necessary for validating them, compared with the definitions agreed by the European operators.
The existence of the actual voltage and current transformers as an element in-between the high voltage parameters for the monitoring equipment, determines optimistic resulting information compared with the real ones.
By replacing these transmitters, especially the TECU voltage transformers, the accuracy degree of the operating data for developing the power network, will increase.

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