ABOUT QUALITY OF ELECTRICAL POWER IN GRIDS WITH CONNECTED PHOTOVOLTAIC SOURCES

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Abstract. *This report provides an analysis on the power quality in electrical grids with connected photovoltaic sources. Measurements were made of the main normed indicators of power quality in power grids for medium and low voltage. Comparisons are made between normed and measured values. Based on the obtained results are derived conclusions.*

Keywords*: electric power, DC-AC inverters, photovoltaic sources, higher harmonics, voltage levels*

1. INTRODUCTION

The large number of connected photovoltaic sources to electricity networks of low and medium voltage, during the last years inevitably also affected the operation of the electricity distribution network and to consumers connected to it. The connected decentralized sources to MV or LV grids have only a local influence as after transformation LV/MV, MV/HV, HV/UHV, the impact of small decentralized generating sources is negligible in HV and UHV grids and voltages in the HV and UHV grids is automatically maintained within limits in each substation [3].

The main problems that arise when working on electrical networks connected photovoltaic sources, along with the requirement for the regular operations of the system is the need for high quality of supplied electricity to consumers. With the advent in households and industry more sensitive electronic and communication technique, more increased requirements for quality of power supply.

Accession of photovoltaic sources to electricity networks through inverter DC-AC converters containing elements with nonlinear characteristics are sources of non-sinusoidal interference. Therefore require a detailed assessment of the overall behavior of the electricity distribution network connected photovoltaic containing sources as well to assess the consequences which would arise as a result of using the same type inverters or inverters with poor technical parameters [2]. Made in this regard, research suggests that levels of harmonics in the network increases significantly when inverters are the same type, while the use of inverters of different types lead to a reduction in the level of generated harmonics [4], [5].

A need for accurate assessment of the level of arisen electromagnetic interference that degrade the quality indicators of electrical devices.

Depending on the point of connection and working conditions are affecting at the level a voltage in the network.

Results in [6] show that in case of failure of the voltage, the output voltage of the inverter before it is turned off, can exceed 200% of the nominal value. The peak of the voltage is obtained then the photovoltaic production of electricity. Power is greater than the power consumption at the moment before the drop of voltage. The overvoltage is so the greater, as the greater is disbalance between production and consumption. Upon consumption greater than production observed decrease of the voltage [6].

Realized are "auxiliary tasks" consisting in improving the stability of power distribution networks and maintain an appropriate level of tension in the connected nodes, which would save additional capital investments for their compensation.

The report is structured as follows:

In the next part presents dependencies directly determine the quality of electricity.

In the part titled Results are presented summarizes measurements made in different branches of the distribution network medium and low voltage.

The last part provides conclusions and recommendations.

2.THEORETICAL DEPENDENCE

2.1. Non-sinusoidal modes of the voltage

Non-sinusoidal regimes electric circuits arise in a electrical circuit in the following cases:

– Where in the circuit has sources of non-sinusoidal voltages and currents, and all elements are linear i.e. does not depend on the value of the current.

– Where in the circuit has sources of sinusoidal electromotive voltages and currents, but the elements are nonlinear i.e. have periodic changing parameter.

Upon the harmonic analysis of electric circuits used forms of development in order Fourier [1]:

$$u(t) = \sum_{k=0}^{\infty} u_{km} \sin(k\omega t + \psi_{Ku}) \tag{1}$$

or

$$u(t) = \frac{A_o}{2} + \sum_{k=1}^{\infty} (A_k \cos k\omega t + C_k \sin k\omega t) \tag{2}$$

where: u_{km} is the amplitude value of the k- harmonic, and ψ_{Ku} - its starting phase.

The total coefficient of distortion (clear factor) of the mains voltage, calculated by:

$$THD = \frac{\sqrt{\sum_{\nu=2}^{n} (U_\nu)^2}}{U_1} \tag{3}$$

need to be in the range $\pm 8\%$ (U_υ is the effective value of the harmonics with order number $\upsilon \geq 2$, but, U_1 the effective value of the first harmonic.

For experimental determination and presentation graphically of dependence of the amplitudes and phases of harmonics of frequency when non-sinusoidal function is in the form of an electrical signal using harmonic analysts. The measured results must satisfy the requirements of EN 50160.

2.2. Size and change of the supply voltage

Grids for low and medium voltage under normal operating conditions, with the exception of condition due to damage or interruption of voltage:

– 95% of the average effective value of the supply voltage for 10 minutes should be in the range of $Un \pm 10\%$ of each period of one week.

The range of variation of the nominal voltage is given by:

$$Un = \frac{+10\%}{-15\%} \tag{4}$$

Upon remote areas with long lines voltage can be calculated beyond (4) [7].

3. RESULTS

We have measured the quality of the electricity in different branches of distribution grid for low and medium voltage , with connected photovoltaic sources. The measurements were performed with a network analyzer meeting the requirements of standard IEC 61000-4-30 relating to measurements of power quality.

For purposes of analysis takes into account the requirements of limits values according to Standard EN 50160, by which is made a description of the electrical characteristics of power distribution grids.

3.1. Summarized measurements made in the electrical medium voltage networks

For a nominal reference voltage in determining the limits is accepted voltage 20kV. Analysis of the overall results for the voltages in the three phases shows the mean statistical distribution of the voltage near to upper limit value and, in isolated cases, and in excess of them. The results of the tests for the three phases separately are shown in Fig. 1 – Fig. 3.

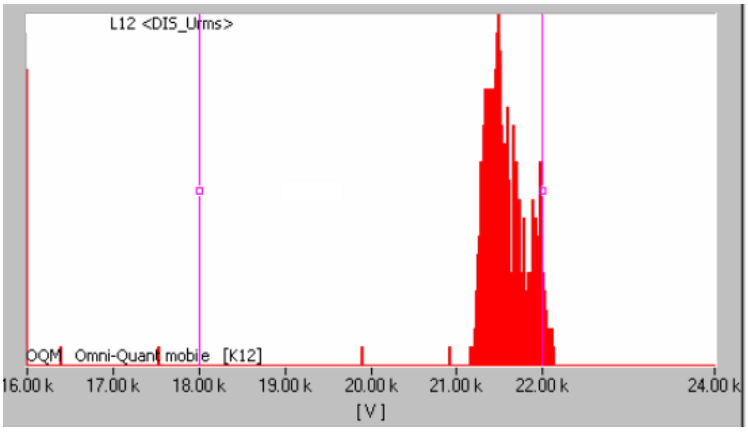

Fig. 1

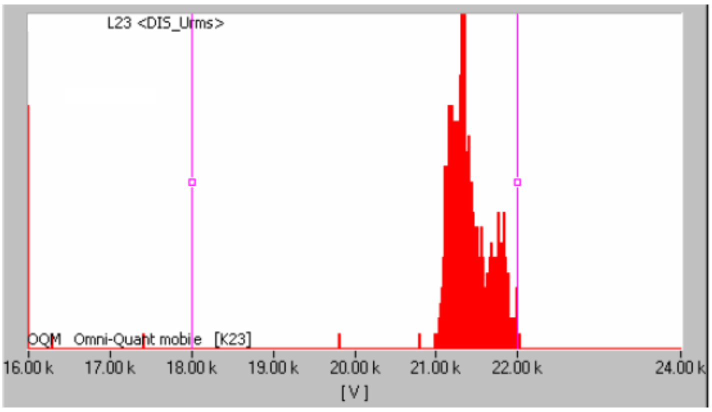

Fig. 2

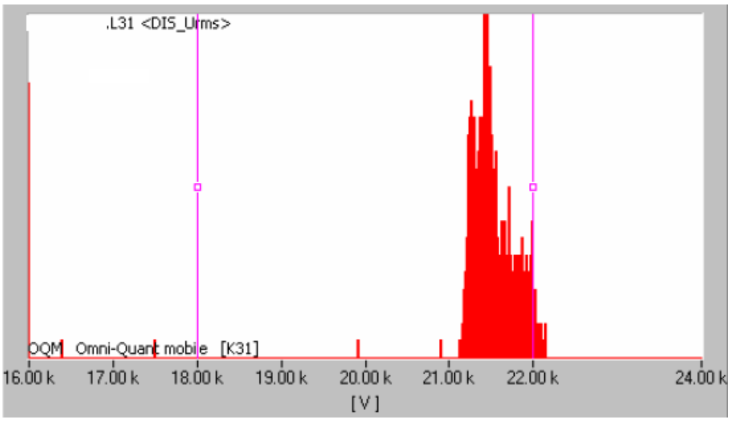

Fig. 3

The made statistical tests to harmonics THD of three phases, ranging set values in the range 2-5%. In rare cases, observed values above the limit of 8%.

3.2 Summarized measurements made in low voltage electrical networks.

For a nominal reference voltage in setting the limit values used support rated voltage of 230V. Overall results of the analysis for the three phase voltages show the mean statistical distribution of their values near to their nominal value. The results of the study of the magnitudes of the phase voltages are presented in fig. 4 – fig. 6.

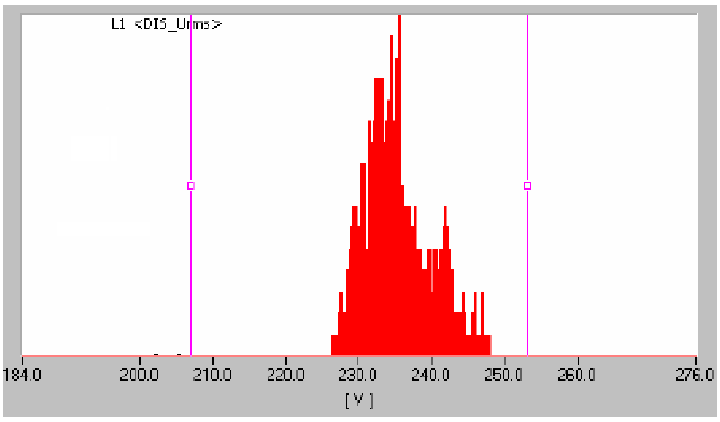

Fig. 4

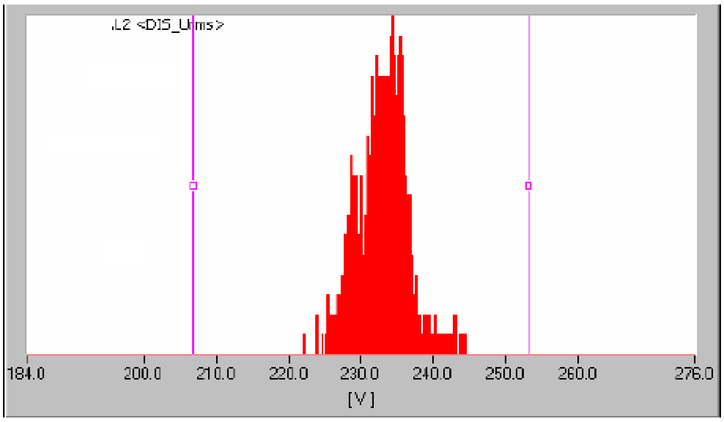

Fig. 5

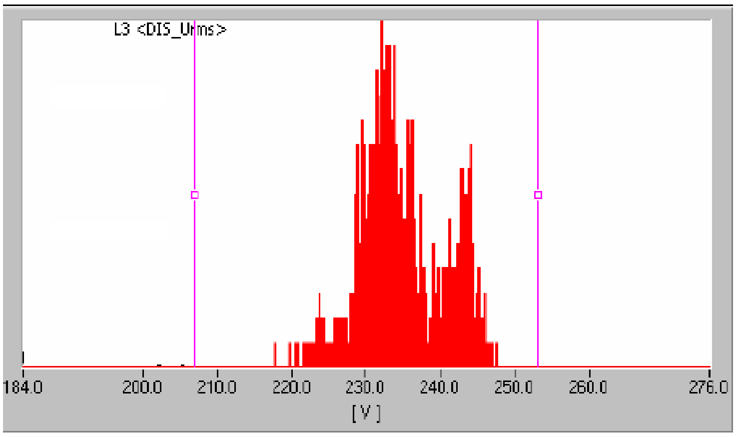

Fig. 6

The content of harmonics THD in three phases, is within 1.2-2.5%. In rare cases, for short periods observed peak levels over the limit 8%.

4. CONCLUSIONS

Based on research and summary results can be drawn the following conclusions:

- Effective voltage values in the studied branches of low voltage networks connected photovoltaic sources do not exceed the limit values, while the medium voltage exist a case of a voltage exceeding the maximum permissible limit.
- The quality of electricity concerning the t maintenance of voltage within the limit values is satisfactory.
- It is necessary to refine the level of penetration of photovoltaic energy in medium voltage networks to limit permanent overvoltage's
- In terms of presence of harmonics in networks connected photovoltaic power source quality of energy is good.

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Reviewer: Assoc. Prof. PhD I. Iatcheva