VOLTAGE QUALITY PARAMETERS IN LV DISTRIBUTION GRIDS IN DEPENDENCE ON SHORT CIRCUIT IMPEDANCE

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ABSTRACT

The supply territory of the company E.ON Distribution in the Czech Republic (operated by the company E.ON Czech Republic) accounts for approximately 1.5 million customers, the most of them are connected to the low voltage (LV) distribution grid. The goal of this paper is to describe problems of voltage quality in the LV distribution grid, if exist. The survey is based on the evaluation of approximately 450 voltage quality (VQ) measurements which were made in points of LV grid with known short circuit impedance phase-earth. This short circuit impedance was measured in the each point of made VQ measurement. So it is possible to demonstrate the dependence of selected VQ parameters on phase-earth short circuit impedance by means of graphs.

INTRODUCTION

The electricity market liberalisation brings considerable pressure to introduce penalties for insufficient voltage quality parameters. In case of poor voltage quality, these penalties should be of the electricity rebate payment nature. Another issue included in this paper is the responsibility for the poor voltage quality and the consequent damage. The analysis of VQ parameters in the distribution grid is necessary for definition of interface between the customer and distribution network operator (DNO) from view of responsibility for poor VQ. We make approximately nine hundred week VQ measurements a year so we have good practice with VQ measurements in the LV distribution grid. All measurements are systematically archived and it is possible to filter them for example according to the voltage level or exceeded VQ parameters.

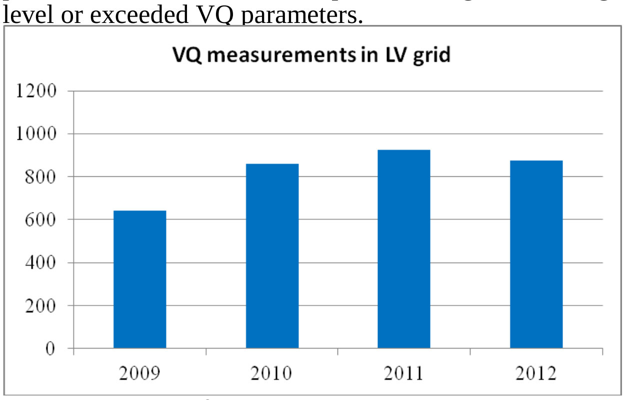

Fig. 1: number of week VQ measurements in the LV distribution grid (supply territory E.ON Distribution)

If possible short circuit impedance phase-earth is measured in the point of making VQ measurement. Special measuring instrument Zerotest 46 N is used – see Fig. 2. The impedance in all three phases is measured and average value is used in following graphs.

Fig. 2: measuring instrument Zerotest 46N for short circuit impedance (phase-earth) measurement, practical real measurement

Values of short circuit impedance are noted in the archival system to corresponding VQ measurement. So link between VQ measurement respective values of VQ parameters and short circuit impedance is available for each VQ measurement.

REFERENCE SHORT CIRCUIT IMPEDANCE

IEC 725 [1] sets the reference impedance value, or more precisely, a reference (relative) short circuit impedance (short circuit power) value for the LV distribution network and electric equipment of nominal current less than 16/75 A. It is assumed that if the required impedance value is met at the point of network connection an electric appliance will not produce any adverse retroactive impacts on the network, whereby no interference in the network will occur.

Electric equipment with nominal current	Ref. short circuit impedance $Z_{phase-earth}$
up to 16A	0,47 [Ω]
up to 75 A	0,35 [Ω]

Tab. 1: reference (relative) short circuit impedance for electric equipment with nominal current up to 16A/75A connected to the LV distribution network

The question is when is for poor voltage quality responsible the DNO and when the customer. It can be used as the guideline the reference value of short circuit impedance according to the IEC 725:1981 standard [1] but keeping of this value from the side of DNO will not guarantee voltage quality for all LV grids (see Fig. 10).

VQ PARAMETERS DEPENDENCY ON SHORT CIRCUIT IMPEDANCE

It can be demonstrated the dependence of selected VQ parameters on phase-earth short circuit impedance by means of graphs. The survey is based on the evaluation of approximately 450 VQ measurements with known (measured) short circuit impedance (phase-earth). The VQ measurements are evaluated according to the EN 50160 standard [2]. The legend for following graphs is: red horizontal line – limit value for corresponding VQ parameter, red vertical line – reference short circuit impedance 0.47Ω, black vertical line - reference short circuit impedance 0.35Ω.

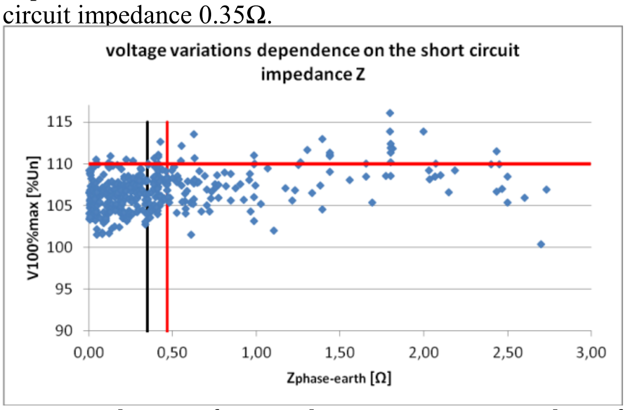

Fig. 3: Evaluation of maximal 10 min mean r.m.s. values of supply voltage (V100%max) in 450 LV grids during week measurements

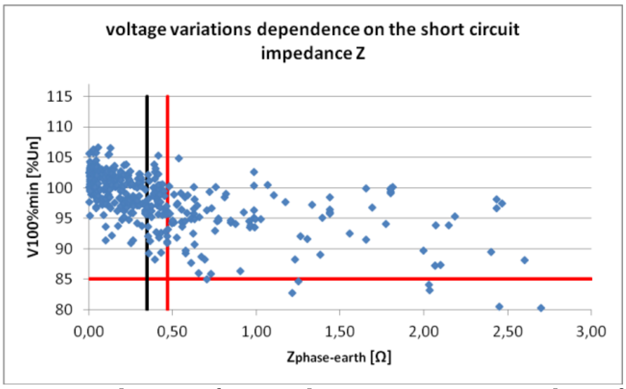

Fig. 4: Evaluation of minimal 10 min mean r.m.s. values of supply voltage (V100%min) in 450 LV grids during week measurements

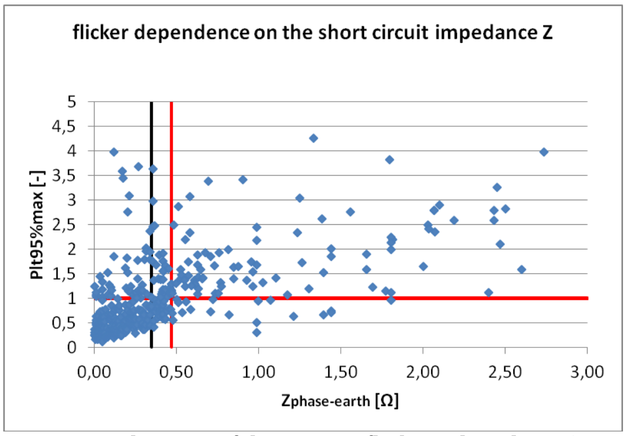

Fig. 5: Evaluation of long-time flicker Plt values (95% percentile) in 450 LV grids during week measurements

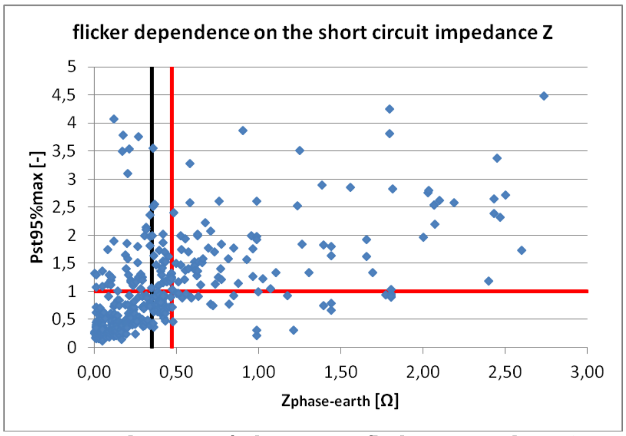

Fig. 6: Evaluation of short-time flicker Pst values (95% percentile) in 450 LV grids during week measurements

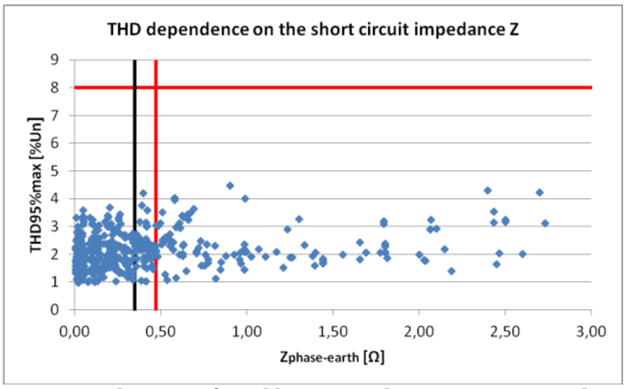

Fig. 7: Evaluation of total harmonic distortion (THD) values (95% percentile) in 450 LV grids during week measurements

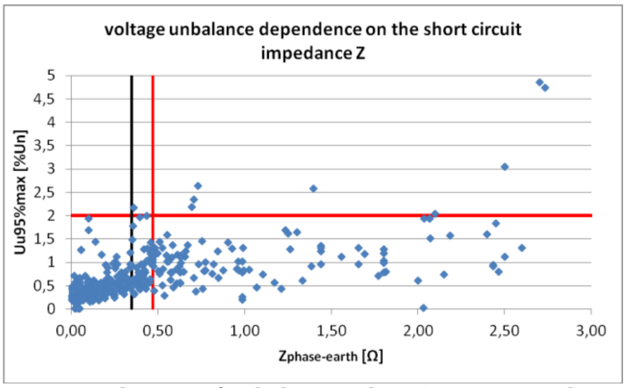

Fig. 8: Evaluation of unbalance values (95% percentile) in 450 LV grids during week measurements

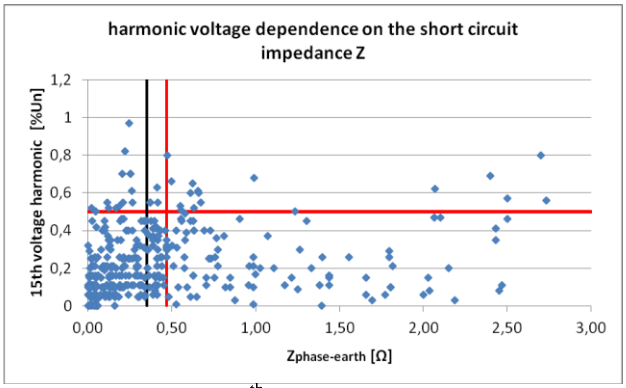

Fig. 9: Evaluation of 15th voltage harmonic (95% percentile) in 450 LV grids during week measurements

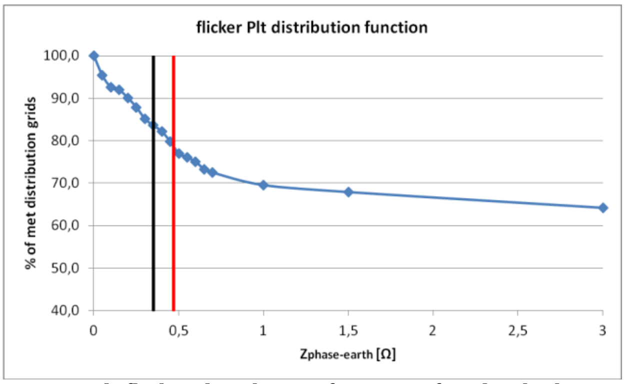

Fig. 10: Plt flicker distribution function of grids which meet EN 50160 standard requirements

CONCLUSION

From Fig. 3 you can see the problem with voltage variations (overvoltage) in LV distribution grids. Overvoltage appears in grids with better than reference short circuit impedance too. It can be caused by operation of distributed energy sources (DES) or by bad set tap changer on the MV/LV distribution transformer. The experience shows that the problem is caused from the bigger part by operation of DES.

From Fig. 4 you can see the problem with low voltage but only in grids with worse than reference short circuit impedance.

From Fig. 5 and Fig. 6 you can see the big problem with flicker. Flicker exceeds the limit value (Plt=1) in a big part of grids with better than reference short circuit impedance. The cause can be on the side of customer who operates equipments as heat pumps, granulators, sawmills or welding machines in case of better than reference short circuit impedance or the cause can be on the side of DNO in case of worse than reference short circuit impedance. From Fig. 10 you can see that keeping of the reference short circuit impedance value from the side of DNO will not guarantee voltage quality in all LV grids. Keeping of reference short circuit impedance will guarantee voltage quality (respective flicker) in accord with EN 50160 standard only in approximately 78% grids in case of keeping 0.47Ω value respective in 83% grids in case of keeping 0.35 Ω value.

From Fig. 7 you can see no problem with total harmonic distortion in low voltage distribution grids.

From Fig. 8 you can see a few LV distribution grids where voltage unbalance exceeds the limit of 2% nominal voltage. The problem was detected in most cases in grids with worse than reference short circuit impedance.

From Fig. 9 you can see the problem with 15th harmonic voltage. The problem was detected in grids with better than reference short circuit impedance too. The cause is too low set limit value for 15th harmonic voltage when measurement uncertainly for usual used power quality analyzers (class S according to the IEC 61000-4-30:2008 standard [3]) is +/-0.5% nominal voltage. The experience of DNO shows that no complaints regarding harmonic voltage were obtained. Exceeding of limit value for 15th harmonic voltage is hard perceived from side of customer and has no influence on operation of usual used electrical devices. The goal of this paper is that we have problems only with some VQ parameters in LV distribution grids and that some problems were detected in grids with good (better than reference) short circuit impedance. Following survey should be aimed to these cases.

REFERENCES

[1] IEC 725:1981 Considerations on reference impedances for use in determining the disturbance characteristics of household appliances and similar electrical equipment, International Electrotechnical Commission, Geneva, 1981

[2] EN 50160 Ed.3 Voltage characteristics of electricity supplied by public distribution systems. Brussels: European Committee for Electrotechnical Standardization, 2010. 20 p.

[3] IEC 61000-4-30 Ed.2.0 Electromagnetic compatibility (EMC): Part 4-30: Testing and measurement techniques – Power quality measurement methods. Geneva: International Electrotechnical Commission, 2008. 134 p. ISBN 2-8318-1002-0