



Equalizing voltage levels in MV distribution network of Elektra Zagreb

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1. Introduction

Switching part of 10 kV network's supply from one substation (110/10 kV or 30/10 kV) to another can cause change of voltage levels in that network part. For example, one 10/0,4 kV substation that was at the beginning of a line can after the switching operation end up at the end of another line. Due to voltage drop along the line, voltage level in that substation can be significantly lowered.

Change of voltage levels induced by switching can be also caused by different voltage levels on medium voltage (MV) bus-bars of 110/10 kV or 30/10 kV substations.

This problem was noticed after several customers connected to LV network started complaining on problems with supply voltage. Number of complaints rose in the past decade due to large number of consumer electronics used in households that are very sensitive to voltage change. Number of 10/0,4 kV substations Elektra Zagreb is in charge is approximately 2500.

Considering networks topology and interconnected 110 and 30 kV substations through 10 kV network in Distribution Area Elektra Zagreb, it was noticed that most customers' complaints could have been avoided by equalizing voltage levels in MV distribution network.

With the help of data from Elektra Zagreb's permanent power quality monitoring system and additional voltage measurements, equalization of voltage levels in MV distribution network was being conducted.

Key words

MV voltage levels, switching, customers' complaints, voltage measurements, power quality monitoring system

2. Description of the problem

HEP-ODS Distribution Area Elektra Zagreb is in charge of few tens of 110 and 30 kV substations that can be interconnected over 10 kV medium voltage network. In normal operation, due to maintenance or faults in network, switching operations are conducted on daily basis.

These 110 and 30 kV substations supply different types of customers: mostly residential areas, industrial zones or areas used mostly for commercial purposes. Also, some substations supply MV networks that consist mostly of cable lines, but few of them supply large number of overhead lines.

Voltage levels on MV bus-bars supplying industrial customers or overhead lines are generally higher than those which supply cable network. When a switching operation in MV network occurs that as a consequence has supplying overhead line from bus-bars that usually power cable network, voltage level in overhead line can be lowered.

Lowering voltage levels in MV network is transferred to LV network and, depending on tap changer position on 10/0,4 kV transformer, can cause voltages to cross allowed limits.

On fig. 1 is shown an example of voltage drop on 0,4 kV bus-bars in 10/0,4 kV substation due to switching in MV network that powers it. Graph shows 10-min RMS voltage values.

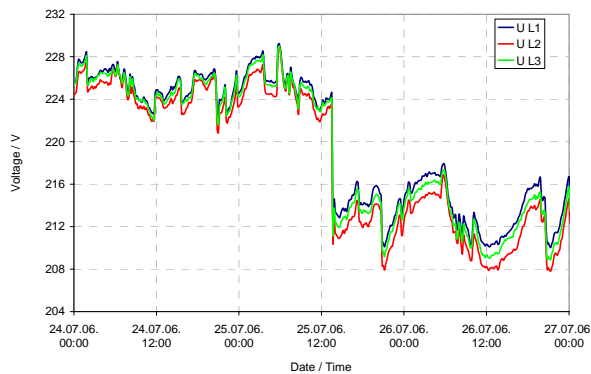


Fig. 1 Voltage on 0,4 kV bus-bars in 10/0,4 kV substation caused by switching in MV network

In order to establish the state of the MV network's voltage in which most customers will not feel any voltage change caused by switching operations, overall voltage measurements were conducted.

3. Measurements

As Distribution Area Elektra Zagreb has few tens of 110 and 30 kV substations interconnected over 10 kV MV network, voltage measurements on all MV bus-bars weren't conducted at the same time. The distribution network was divided into 3 groups based on interconnected 10 kV networks. An example of such group is shown on fig. 2.

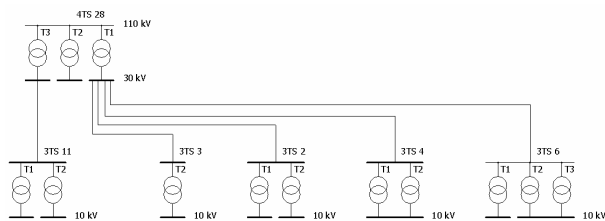


Fig. 2 Part of network in which were simultaneously conducted voltage measurements

Instruments for measuring voltages were connected on 10 kV bus-bars in 30/10 kV and 110/10 kV substations. In some substation measuring instruments are permanently installed, and are part of power quality monitoring system in Elektra Zagreb. Data collected by this system was also used for getting the overview of voltage levels on 10 kV bus-bars.

As different instruments were used, all the data was transformed into Excel format, so graphs and analysis was conducted much easier.

On fig. 3 is a graph showing measurement results from one set of the measurement in MV network. 10-min RMS voltage values are shown during 6 consecutive days. It is visible from the figure that the biggest voltage difference is around 400 V, or in percentage around 7 %.

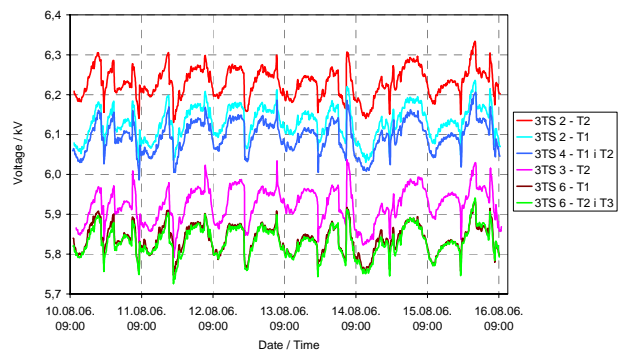


Fig. 3 Voltages during 6 days on 10 kV side of 6 transformers in 4 substations

Knowing that allowed limits of voltage levels in LV network is $230(400 \text{ V}) \pm 10 \%$ [2], change of voltage in amount of 7 % could cause limit's crossing.

Based on measurement results, average voltage values were calculated and one optimal value for MV network's voltage level was selected. This value required least adjustments on different substation transformer's tap changer positions.

4. Conclusion

Power quality is based on voltage quality. Voltage value is usually the first thing customers complain about.

In this article some everyday switching operations were described, that resulted in customers' complaints on voltage quality. This could have easily been avoided by equalizing voltage levels in MV network.

In order to avoid LV customers' complaints caused by severe voltage level changes due to changing supply points in MV network, equalization of MV voltage levels on bus-bars was carried through.

After doing so, number of LV customers' complaints was lowered and possible law suits and compensation requests were avoided.

After this was done, level of power quality in LV network was raised and MV distribution network gained more flexibility.

References

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