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Measurement and calculation of harmonics in distribution power system with connected small co-generation facility Etan

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Abstract Etan is a gas refining facility. Power supply is provided by two turbo generators and each of them can independently cover the consumption of Etan. Etan usually works in insular operation, but it can also work parallel to the distribution system, especially in cases of maintenance of generator units. Etan is connected to the MV distribution power system (10 kV bus in substation 35/10 kV Ivanic Grad) through a 4,5 km long cable. Load in Etan consist mostly of induction motors. Power electronic devices are used for control of motor loads. The working process of the refinery is always the same so the load is not varying with time.
It is very important to know the influence of this kind of industrial consumers with distributed generation on power quality.
Power quality measurements were performed at three measurement points with the power quality analyzer ION 7650 of company Power Measurement.
The aim of this paper is to compare the harmonic measurements and calculation at all three measuring points in different operating conditions depending on the production of generator in Etan.

Key words

Distributed generation, power quality, harmonic measurements, harmonic calculation.

1. Introduction

Etan now usually works in insular operation, but in the future, the refinery should operate parallel to the distribution system, with option of exporting energy to the power system. Turbo generators in Etan have rated power of 3,325 MVA each. They are connected directly to a 10 kV bus without power transformers. The generators always work separately. The maximum consumption of Etan is 1,6 MW, so that one generator is more than enough to cover consumption of the refinery. Load in Etan that consists mostly of induction motors is connected to a LV busses through two power transformers 10/0,4 kV, of rated power 1,6 MVA each. Etan is connected to the MV distribution power system through a 4,5 km long cable on 10 kV bus in substation 35/10 kV Ivanic Grad. Cable conection is the reserved for power supply of Etan in case of reconstruction of generators. Etan facility is connected to a power transformer which has loaded tertiary winding. The rated power of the transformer is 8/4/4 MVA. Secondary and tertiary windings have separated busses. Etan – industrial consumer is connected to secondary winding, and distribution loads like household consumers are connected to tertiary winding. The high percentage of motor loads and power electronic devices suggests that harmonics may represent a significant problem for all loads connected to distribution system, in case when Etan is working parallel to the distribution system.

2. Measurement

The measurements were performed for determination of power quality parameters, especially harmonics in the distribution power system. The measurements were performed in cases when Etan is not connected to the system and when Etan is working parallel to the system. In case when Etan is working parallel to the system, measurements were carried out for three different situations: with generation power of 1,9 MW (more than consumption of Etan), with generation power of 0,3 MW (less than consumption of Etan) and with generation power of 0 MW (all consumption is covered from the distribution system). Figure 1. shows the measuring points in the distribution power system and in the Etan refinery. The instruments were set at three measuring points and the measurements were taken simultaneously at all measuring points. First measuring point was on the 35 kV bus in the substation Ivanic Grad - MT1, second measuring point was on the 10 kV bus in substation Ivanic Grad (secondary transformer winding) – MT2 and

the third measuring point was on the 10 kV bus in Etan refinery – MT3. Power quality analyzers ION 7650 were used for the measurements.

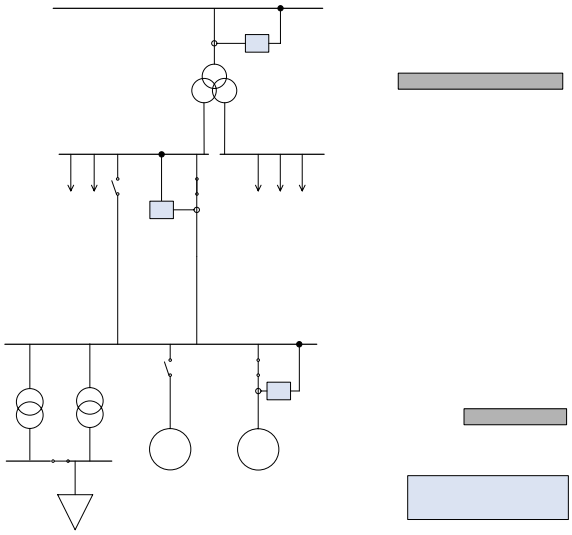

Fig. 1. Measuring points in distribution power system with connection of Etan refinery

Figure 2. shows the measurement results of harmonics (peak value in percentage of nominal voltage) on the 10 kV bus in Etan refinery (MT3) in case when Etan is working parallel to the system, for all three different cases.

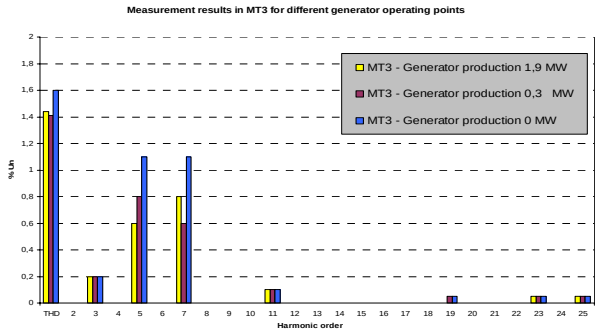

Fig. 2. Measurement results of harmonics on the 10 kV bus in Etan refinery (MT3) for three different cases

3. Calculation

The harmonic analysis was carried out using ETAP Power Station simulation software.

Figure 3. shows the simulation model for harmonic analysis of the distribution power system with connected Etan refinery.

An indispensible precondition while carrying out calculation of harmonic propagation in power systems is the good knowledge of the system parameters. Simulation model was made with data that was available at the time, while remaining data was assumed..

Figure 4. shows the simulation results of harmonics (in percentage of nominal voltage) on the 10 kV bus in Etan refinery (MT3) in case of Etan working parallel to the system, for all three different cases.

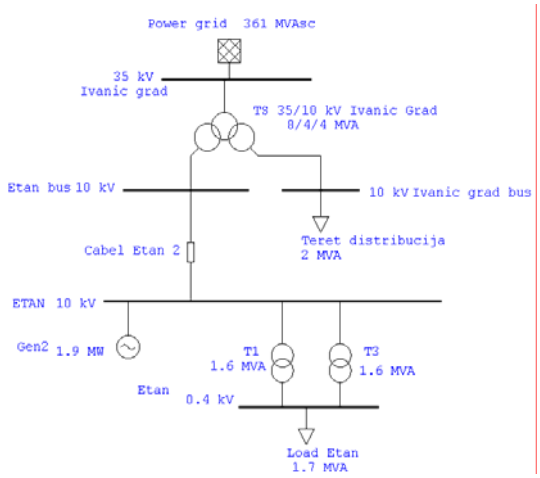

Fig. 3. Simulation model for harmonic analysis in distribution power system with connection of Etan

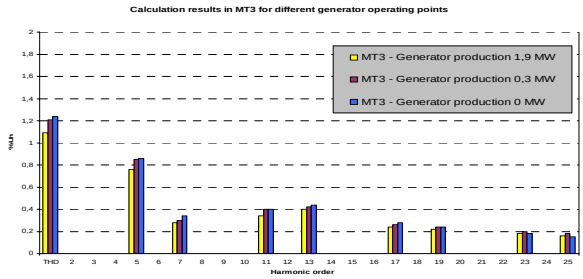

Fig. 4. Simulation results of harmonics on the 10 kV bus in Etan refinery (MT3) in three different cases

4. Conclusion

Simulation results of harmonic analyses were compared with harmonic measurement results, at all three measuring points. Both, results of measurements and results of simulations are within the limits of EN 50160. Measurement results for total harmonic distortion are consistent with values of the simulation, but results of individual harmonic values differ. Differences in measurement and simulation results are present due to lack of data. It is obvious that the parameters of transformers, cables and lines are known exactly. The load in the system however is subject to changes and cannot be represented exactly in calculations. The variation of load, which is normal in power systems, is seen as an important part in the analysis.

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