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HARMONICS AT THE COMPENSATION OF TS 35/10 kV BIHAĆ

- Harmonic analyze of voltages and currents as one of the conditions for selection of condensator batteries-

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INTRODUCTION

During the realization of project "Technical and economical justification of the compensation of reactive power and load at the transformer stations 35/10 kV in the area of Una-Sana canton", 35/10 kV Bihac, 3x4 MVA is chosen for compensation embedding because of high consumption of reactive power and bad load factor.
To do the proper embedding of compensation it is necessary to analyse harmonics, in fact, harmonic analyse of voltages and currents is one of the conditions for selection of condensator batteries.
In purpose of defining the installed capacity of condensator batteries the measuring on the 10 kV bars of this transformer station were carried out, and after performed measuring the needed installed capacity of condensator batteries was defined on the 2.4 MVAr.
In the measuring results there is evident high level of harmonics, especially during the earth fault. Procentual share of 3-rd, 5-th and 7-th harmonics was higher than 5%, what requested a detailed analyse.
On the Figure 2 is given consumption of active and reactive power and load factor for transformer station 35/10 Bihac in 2003.

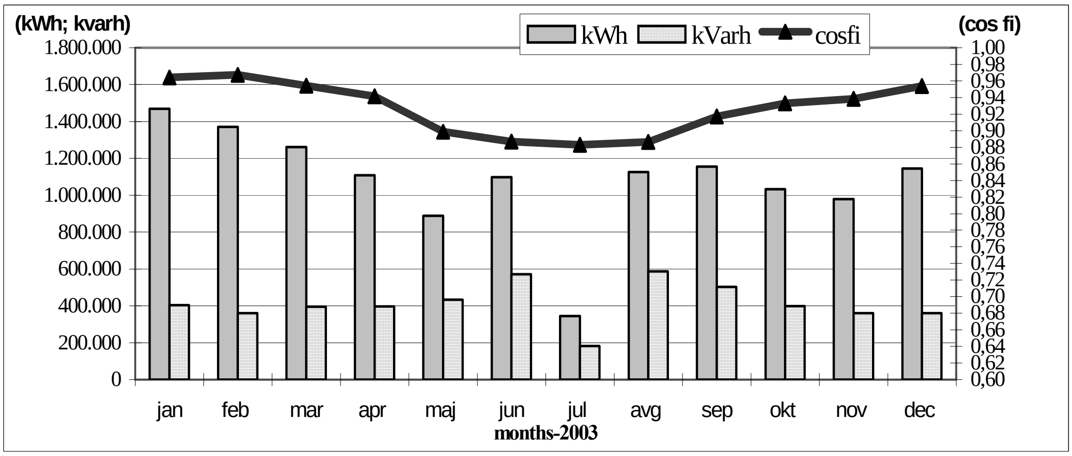

Figure 2. Consumption of active and reactive powers and load factor for transformer station 35/10 Bihac in 2003

2. DIAGRAMS OF MEASURING BY NETWORK ANALYSER METREL

The diagrams below show measuring on the 10 kV bars that were carried out on January 18, 19, 2004 in transformer station 35/10 Bihac. By using the measuring device METREL MI 2092 (FW ver:1.63)- Power Harmonics Analyzer, the measuring of voltages, currents, loads, load factors and harmonics are done. Figure 3 shows voltage measuring with visible voltage dips during the earth fault, and Figures 4,5,6 show values (%) of 3-rd, 5-th and 7-th harmonics for the earth fault.

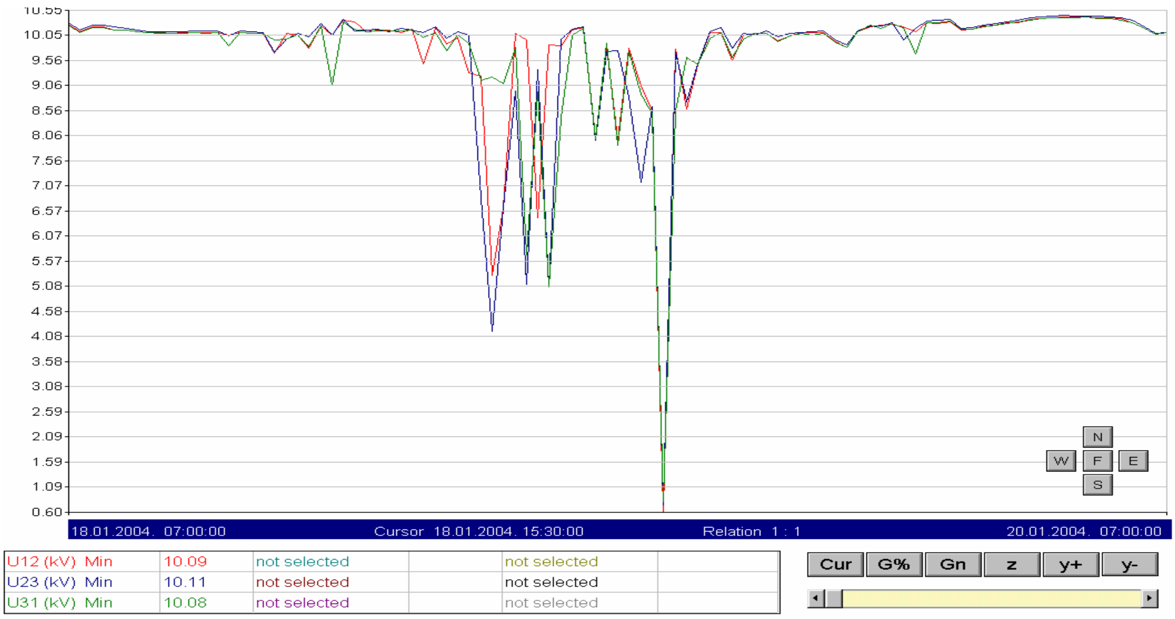

Figure 3. Voltage variations during the earth fault

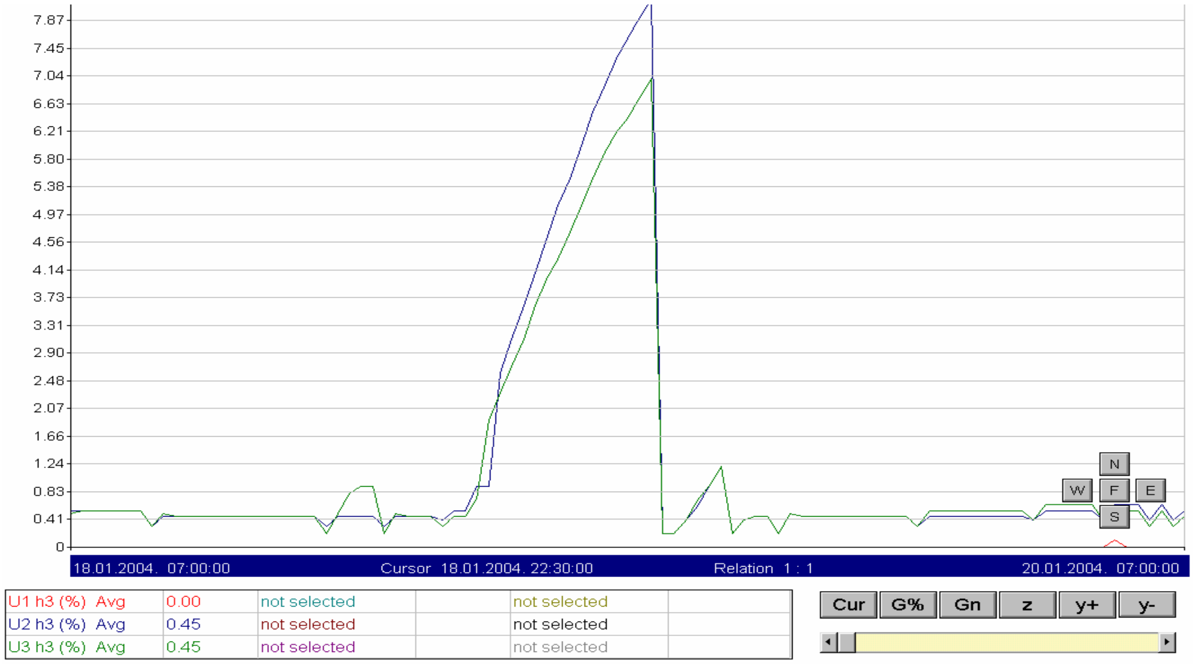

Figure 4. 3-rd harmonic (%)

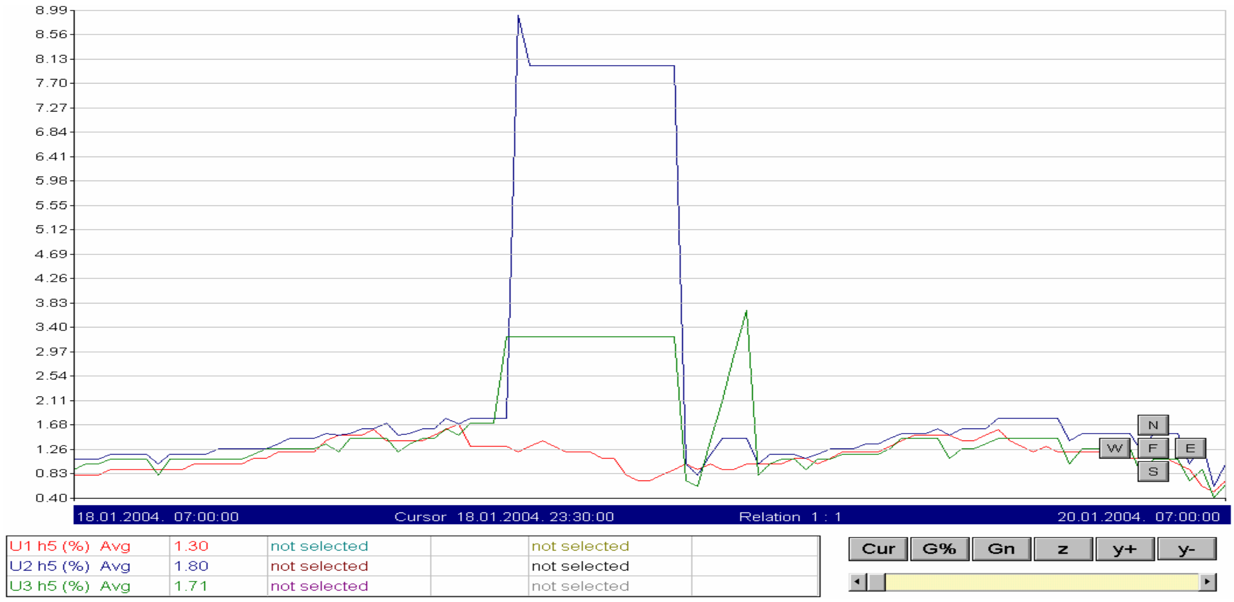

Figure 5. 5-th harmonic (%)

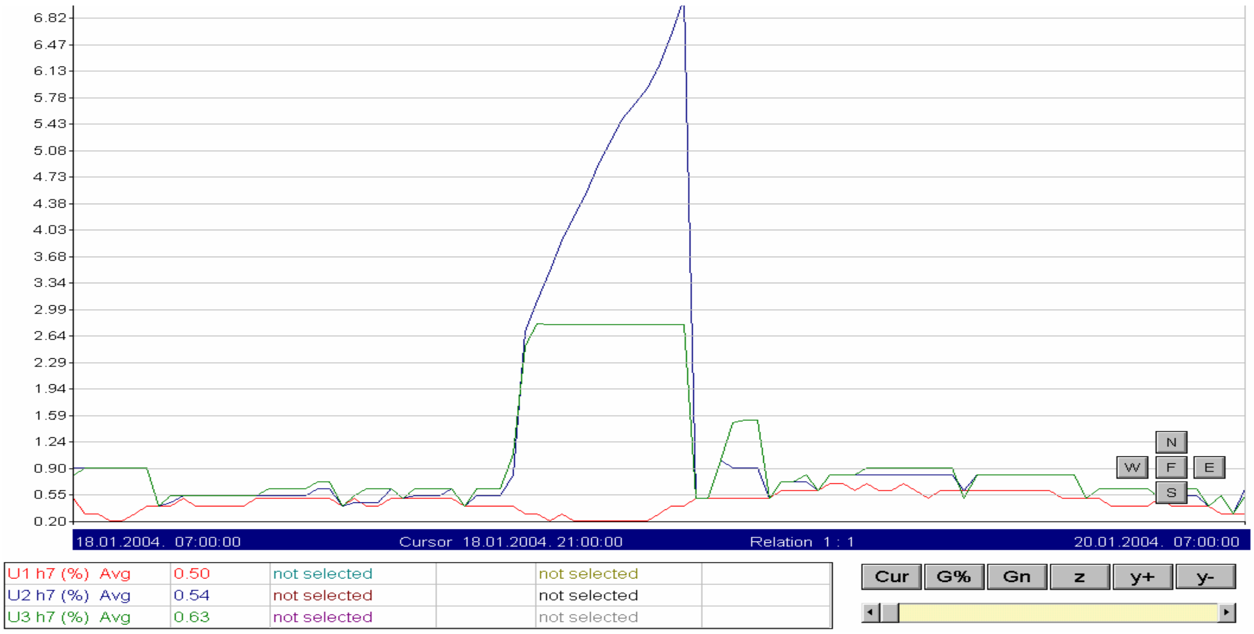

Figure 6. 7-th harmonic (%)

3. MODEL OF DISTRIBUTION NETWORK IN MATLAB

In purpose to research the occurrence of harmonics at earth fault, the distribution network of considered area 35/10 kV Bihac, was modeled in program package Matlab, version 6.0.0.88 (R12).
MATLAB® (The Language of Technical Computing) is the software of high performances, which is developed and widely used in USA for technical computing. Version 6.0.0.88 gives very large possibilities for three phase power system modeling, and graphical presentation of obtained results.
In this work, for distribution network modeling was used Simulink/Power System Blockset.

3.1 Transient processes in the moment of the earth fault occurrence

Earth fault starts with the insulation breakdown or when a foreign object comes to the contact with the conductor. Immediately before the fault phase voltages are of equal amplitude and are symmetrical in terms of the phase displacement. Load currents are lagging to the voltage with the angle, which depends on the load character. For the MV distribution feeders it is usually 30-40°. Neutral current and voltage are small and depend on the nonsymmetry degree. Resistance between the phase observed and earth is theoretically of infinite value. In the moment of the fault, the resistance suddenly decreases, and for the metal contact gets the value of Rf =0. This happens through the transient process of change of all measured quantities. Earth fault is established when the faulted phase voltage gets the peak value. Faulted phase voltage decreases from the value of u=Um to the value which ranges from Uff=0 for the metal contact fault to Uff=Un for the high resistance earth fault. Neutral voltage gets symmetrical value which ranges from Uo=0 for the normal (a fault) condition to Uo =Un for the fault with R_f=0. In the moment of the fault earth fault current has a peak value, and then follows a transient process with the expressive presence of high harmonic components. Initial fault is established through the arc, since momentary establishing of the fault current with R_f=0 is not possible. For the transient faults, fault resistance is falling down to zero, and then increases to infinite value, i.e. to no fault condition. There are also given U_{0rms} and I_{0rms}, and also the value of the line - ground resistance prior the fault, during and after the fault (i.e. trees – conductor contact). Transient current and voltages in the moment of the fault occurrence and clearance,

as well as the real relations during the arching are not presented. These relations are given in the higher harmonic analysis of fault currents and voltages.
In the transient process even harmonics are dominant, second current harmonic especially. High level of 5th current harmonic is also present. Second harmonic as well as other even harmonics are evident in Uo voltage, as well as in healthy phases and faulted phase current, depending on how long the arc exists. That is to say, if arc last for a longer time (no self-extinction), leading phase is being caught by the arc and the process is prolonged. During the first three to five periods of fault current, second harmonic takes up an average 60% of its magnitude. In some cases of intensive arching, second harmonic of current could be considerably greater than the base harmonic. Other even harmonics are present in the arching current having the same polarity, so the rms values are being summarized. In the stationary interval of the fault current (3-5th period forward) 5th harmonic is dominant and it equals 10 – 40% of the fault current. 5th harmonic of the fault current is significantly present in the transient process of the fault establishing. This proportion is especially evident for the smaller values of the fault resistance.

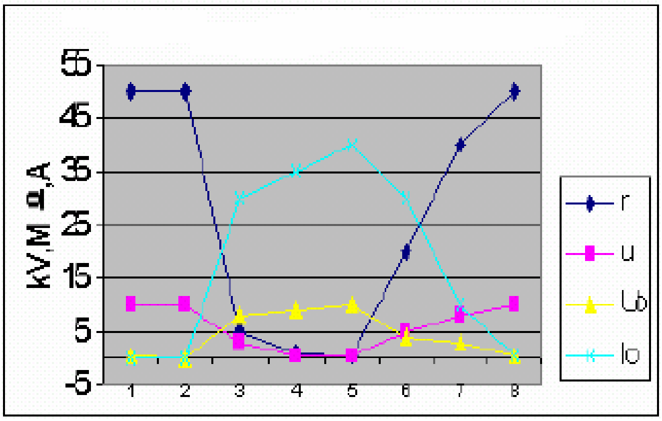

Figure 7. Voltages and current during the earth fault

Above considerations prove presence of higher harmonics in the earth fault current. In normal condition higher harmonics are predominately caused by the load. They depend of the time of the day and the load character. There is also significant influence of the power system elements, such as generators, transformers, overhead lines, underground cables etc. Higher harmonics from HV network may contribute as well, especially if specific industry (presence of various converters) or railway substation is near. However, harmonics caused by the arching are much more significant for the matter of the earth fault detection. Soil characteristics are also important for the magnitude of the earth fault current. Earth fault current is a sum of several current components as follows:

Ifh = **I**hload + **I**hHV + **I**hMV + **I**h arc

Participation of every high harmonic in the fault current depends on zero sequence resistance for each harmonic, fault resistance and fault character, which mostly depends on the fault site.

4.1 Simulation of putting in work of condensator batteries with filters and by the earth fault in one phase on 10kV and 35 kV voltage level

Simulation of putting in work of condensation batteries with filters and by the earth fault in one phase on 10kV and 35 kV voltage level, is considered on the network model, developed in Power Block Set of program package Matlab- Figure 8.

Beside this model, the authors also consider the earth fault simulation on 35 kV voltage level, with harmonics generated from the network and from the consumers' side, but from objective reasons that results are not presented in this work.

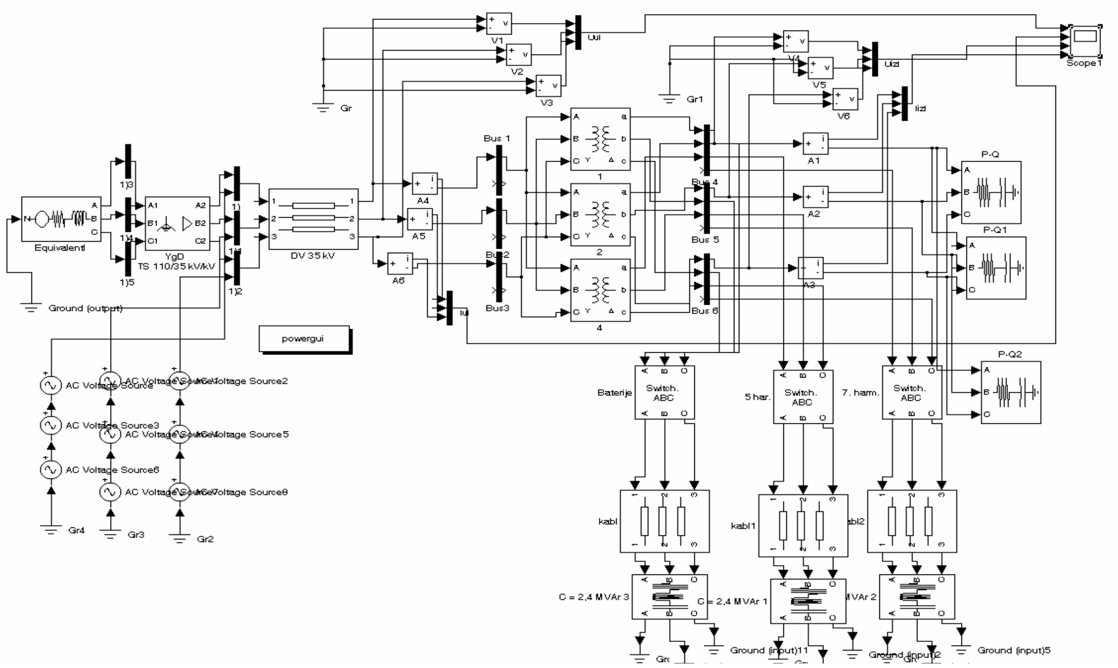

Figure 8. Network model in Matlab

On the next figures there are given simulation results of earth fault in one phase on the 10 kV and 35 kV voltage level, as well as putting in work filters and condensator batteries.

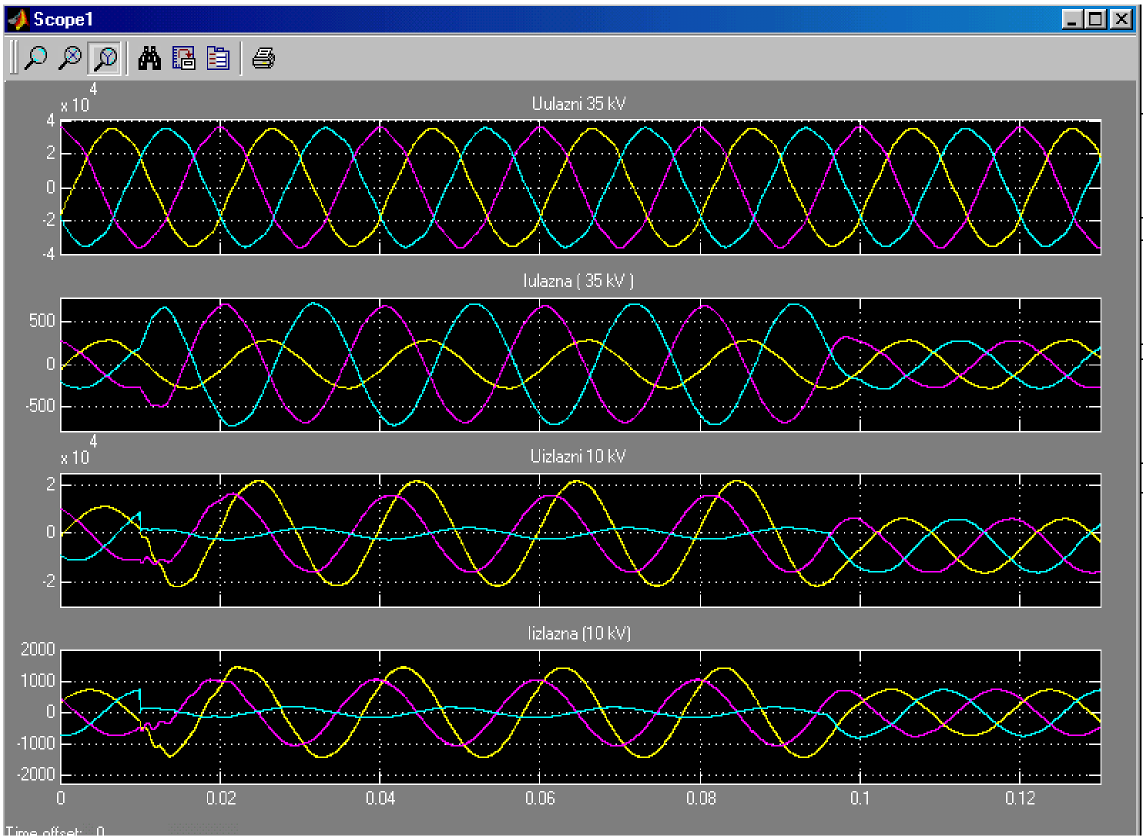

Figure 9. Earth fault in one phase on 10 kV voltage level (0.01-0.09 s)

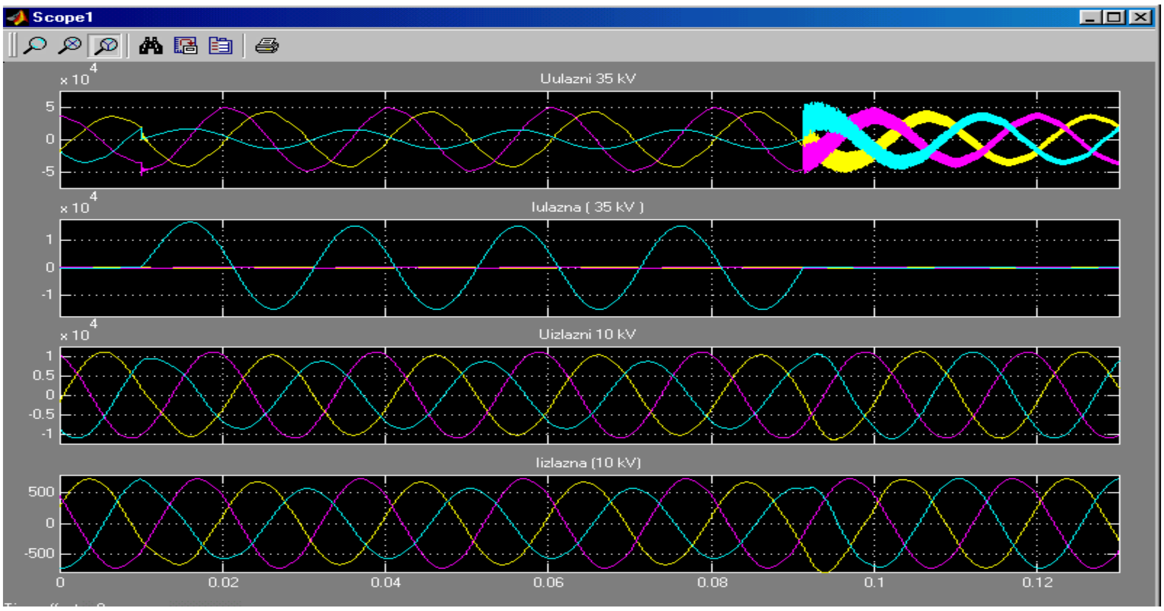

Figure 10. Earth fault in one phase on 35 kV voltage level (0.01-0.09 s)

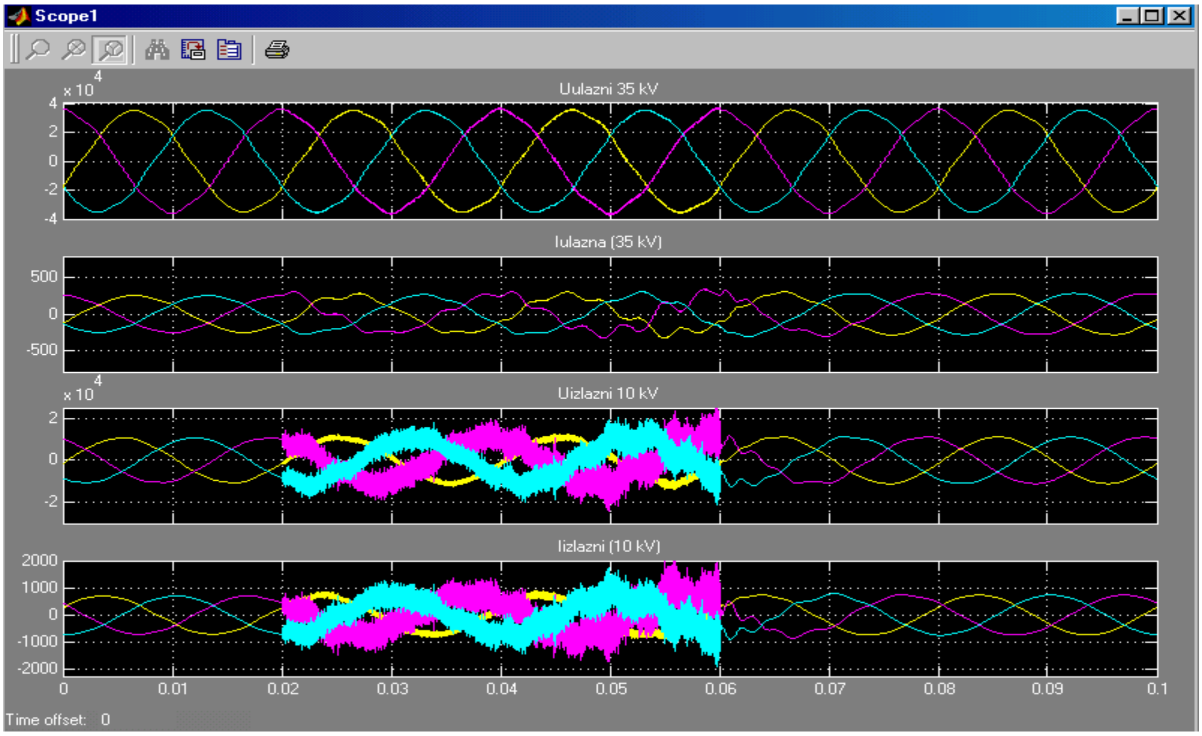

Figure 11. Putting in work the filters and condensator batteries (0.02 s-filter for 5-th harmonic, 0.04 s- - filter for 7-th harmonic and 0.06 s- condensator batteries)

The earth fault simulation time supposed in this model is short, and at real conditions it is probably longer, but in any case, on the presented graphics are evident disturbances, manifested by increased voltages and currents in two phases, and increased level of curves' distortion, what is for sure, a problem for condensator facilities.

After transient process, which is a consequence of earth fault, it could be seen that the output values are completely sinusoidal shaped, and satisfy conditions from European norm EN 50-160.

As a consequence of compensation in this transformer station, there is slowly increase of output voltage, what finally leads to the increased realization of electric power.

5. CONCLUSION

Oscillating occurrences and transient processes that happen during the putting in work of condesator batteries and filter facilities should be especially considered, and in this work is analysed just one small part of this wide problematics.
Although in Bosnia and Herzegovina there are still not adopted the regulations considering voltage and current distortions caused by harmonics (EN 50-160), power companies should give the special attention to this problematics.
Compensation embedding should be considered as an integral problematics with realization of facilities, which along with reactive power compensation in the same time eliminate harmful influences of harmonics in the network.

LIST OF REFERENCES

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2. Avdakovic S., Dedovic E, Alihodzic A., 2004, "Ocjena tehnokonomske opravdanosti kompenzacije tansformatorskih stanica 35/10 kV na podrucju Unsko sanskog kantona", "JP Elektroprivreda BiH", 61