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Investigation of the Electromagnetic Compatibility of a Frequency-controlled Electric Drive with Supercapacitors

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Abstract

In the paper, the electromagnetic compatibility of a frequency converter with a power supply is investigated. Comparison of the variants of the electric drive with conventional capacitors and supercapacitors, which are connected directly to the DC link of the frequency converter, is given. The simulation results in the MATLAB package and the experimental study of the electric drive with using the power quality analyzer are presented. The paper presents the forms of currents and voltages at the input of the frequency converter, as well as their harmonics composition. Conclusions about the influence of the supercapacitor block on the electromagnetic compatibility of electric drive to the mains are made.

Keywords: Energy, Intelligent Systems, electric power industry, modelling and simulation.

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1. Introduction

According to various estimations, the different types of electric drives consume about 60-70% of all the generated energy [1]. At the same time, the most modern and widely used electric drive system is a frequency-controlled electric drive. The proportion of such electric drive systems at the modern plants is quite high and is typically greater than 25 %.

At the same time, it is known that in addition to well-known advantages, associated with high energy and technical-economic indicators, the frequency-controlled electric drive negatively affects on the power supply and is a source of high-frequency harmonics. This is connected with the fact that the frequency converter with an uncontrolled rectifier at the input consumes from the power supply a non-sinusoidal current in the form of pulses, which leads to a distortion in the supply voltage. And since the specific power of frequency-controlled electric drives is constantly growing, the problems of electromagnetic compatibility between frequency converters and the mains are becoming more important.

Of course, frequency converters with active voltage rectifiers do not have such drawbacks, since they consume almost sinusoidal current from the mains and the total harmonic distortion for current for them is about 5 % [5, 6]. However, they have a significantly higher cost and their installed power at the enterprises is significantly lower in comparison with converters with a bridge uncontrolled rectification circuit at the input, the total current distortion factor for which can exceed 60 %, even when using smoothing reactors [6].

The problem of electromagnetic compatibility of a frequency-controlled electric drive with a power supply network has been well studied and the main solutions for reducing the influence of frequency converters to the mains have been well developed, starting from the using of filters at the input and ending with active semiconductor filters [5-8]. The purpose of this work is to analyze the influence of the electric drive with supercapacitors on the power network and compare its effect with conventional frequency converters.

One must mention, that the harmonic composition of the input currents and its waveform has some slight differences from the simulation results (See Fig. 3), which is connected with the fact, that the simulation does not accurately account all factors, affecting on the form of the input currents.

In Fig. 11 shows the form of the supply voltage on a part of the power supply period, which can be displayed by means of an energy quality analyzer.

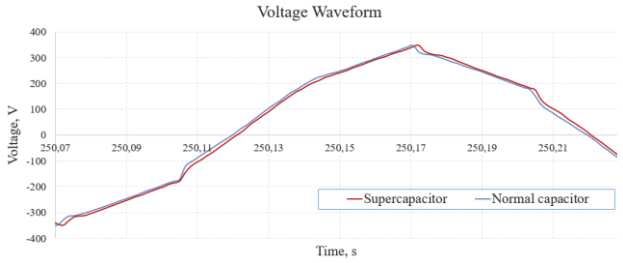

Figure 11. Voltage waveform on the input of frequency converter

In the form of voltage, we can see the distortions, caused by the connection to the network of a frequency-controlled electric drive. As in previous cases, the distortion results for the drive with supercapacitors are practically the same as for the electric drive with conventional capacitors, which is also confirmed by the harmonics of the power supply voltages, which are shown in Fig. 12.

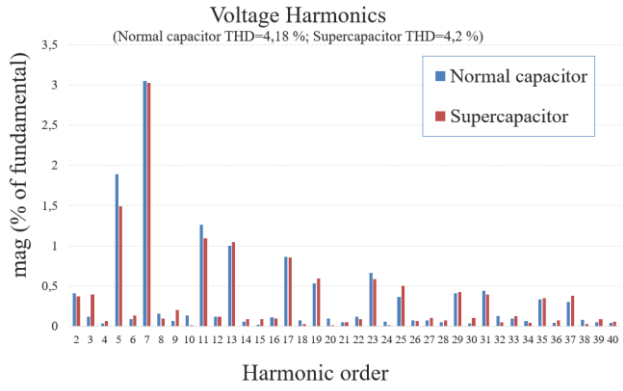

Figure 12. Input voltage harmonics

Conclusions

It is known that the using of supercapacitors in a frequency-controlled electric drive leads to a significant reduction in power consumption in comparison with an electric drive, where the braking energy dissipates on the external resistance. At the same time, the constantly growing specific power of semiconductor converters at enterprises forces to pay more attention to the problem of electromagnetic compatibility of semiconductor converters with a power supply.

The results of simulation and experimental investigations show that the direct connection of supercapacitors to the DC link of the frequency converter does not have a more significant influence on the power supply compared with electric drive with conventional capacitors. This is explained by the fact, that the voltage form in the DC link of the converter with the supercapacitor, in spite of the significantly lower level of pulsations, has almost the same form as in the frequency converter with conventional capacitors.

In order to reduce the influence of the electric drive with supercapacitors on the power supply, it is possible to use the same measures that are used for traditional electric drives, such as the installation of smoothing reactors at the input or in the DC link of frequency converters.

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