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Compensation of Reactive Power by Excluding Higher Harmonics in a Regulated Electric Drive

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ABSTRACT: Compensation for reactive power makes it possible to provide a balance of reactive power in the company's electrical network, to reduce power and electric power losses in the power supply system, and to improve the power quality indicators in the power supply system of an industrial enterprise. In this paper, we consider the relationship between reactive power and higher harmonics that arise when there are static converters in the system. As the static converter, the most common is the frequency converter. A "frequency converter - asynchronous motor" system was developed using the Simulink package of the Matlab program. The description of the active filter is described in detail. It is connected in parallel with the AC motor. Its scheme is implemented, which includes the power part and the control system. Oscillograms of current and voltage are obtained with and without an active filter. Spectral analysis is carried out.

KEYWORDS: reactive power, higher harmonics, spectral analysis, frequency converter, asynchronous motor.

I. INTRODUCTION

There are windings in the construction of receivers and converters of electric power [1-3]. Electric motors, transformers, power electronics devices, welding machines and others have such kind of elements. These elements of the electrical network consume both active and reactive power. The presence of reactive power leads to additional losses. Payment for these losses is carried by the enterprise-consumer. Therefore, the search for options for compensation of reactive power is quite relevant [4-9].

According to [10], up to 80% of electric drives in all fields of industries of our country are equipped with static converters, in particular, converters of frequency. Reactive components of network currents due to the predominance of the reactive share of the network resistance create a voltage drop on it, causing these significant deviations of the network voltage. It is possible to eliminate higher harmonics and, together with them, reduce the influence of the reactive component due to active filters [11-14].

The aim of this article is to study the influence of active filters on the energetic indicators of the controlled electric drive.

In order to achieve this aim, it is necessary to:

- develop the model of adjustable electric drive based on common used system “frequency converter – asynchronous motor” (FC - AM);
- research the spectral composition and energetic indicators of adjustable electric drive in the presence of active filter and without it

The development of the model of researched system of adjustable electric drive

It is offered to carry out the Spectral analysis and analysis of energetic indicators using software package Matlab Simulink. The developed system “Frequency converter - asynchronous motor” with an active low-pass filter is presented on Figure 1.

As an asynchronous motor, the standard model from the library of Matlab Simulink (4 kW, 50 Hz, 1500 r / min) was chosen.

The Active filters, which are used in FC-AM systems, are explited according to the standard principle:

- power unit - two-level AIN, loaded on its own storage capacitor;
- control - is a system based on current control and second-order PWM.

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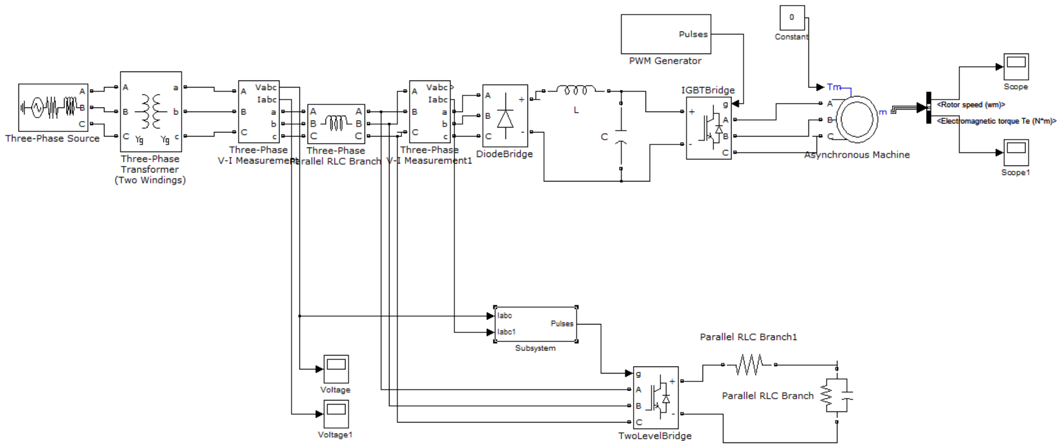

Figure 1. Model FC-AM with an active filter

The control system is represented by the bloc of Subsystem on Figure 1. is implemented by comparing the stray/interference signal and the signal of network current, describes by bloc (Figure 2) signal and the network current signal represented by the unit (Figure 2).

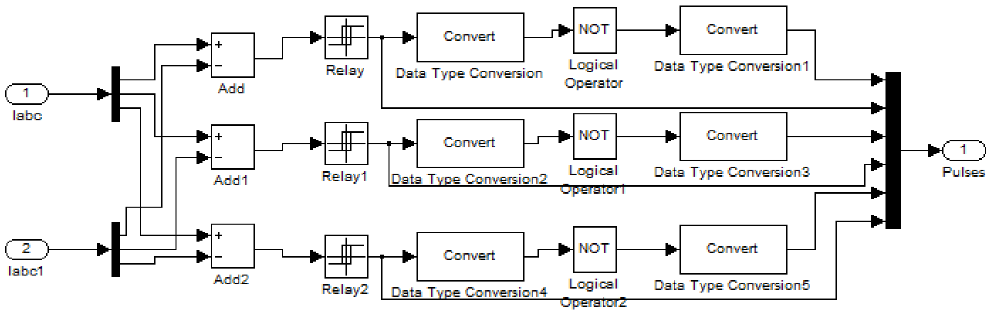

Figure 2. Implementation of the system of Active filter Management

The active filter is connected to the load in parallel , which allows to reduce the level of current harmonics formed by the presence of non-linear devices that are included to the part of the load.

The limitation of signal to the required level is realized by using Relay elements. Receiving logical signals, namely control pulses are produced with the help of converting to a logical data type. Receiving a reverse pulse is possible using the logical element "NOT".

The power part of the active filter includes a two-level AIN, which possesses an RC chain on the permanent current side .

Spectral analysis of currents and voltages

Figure 3 shows diagrams of currents' phases of the FC-AM system without a filter (a) and when the active filter is included in the scheme (b).

a

b

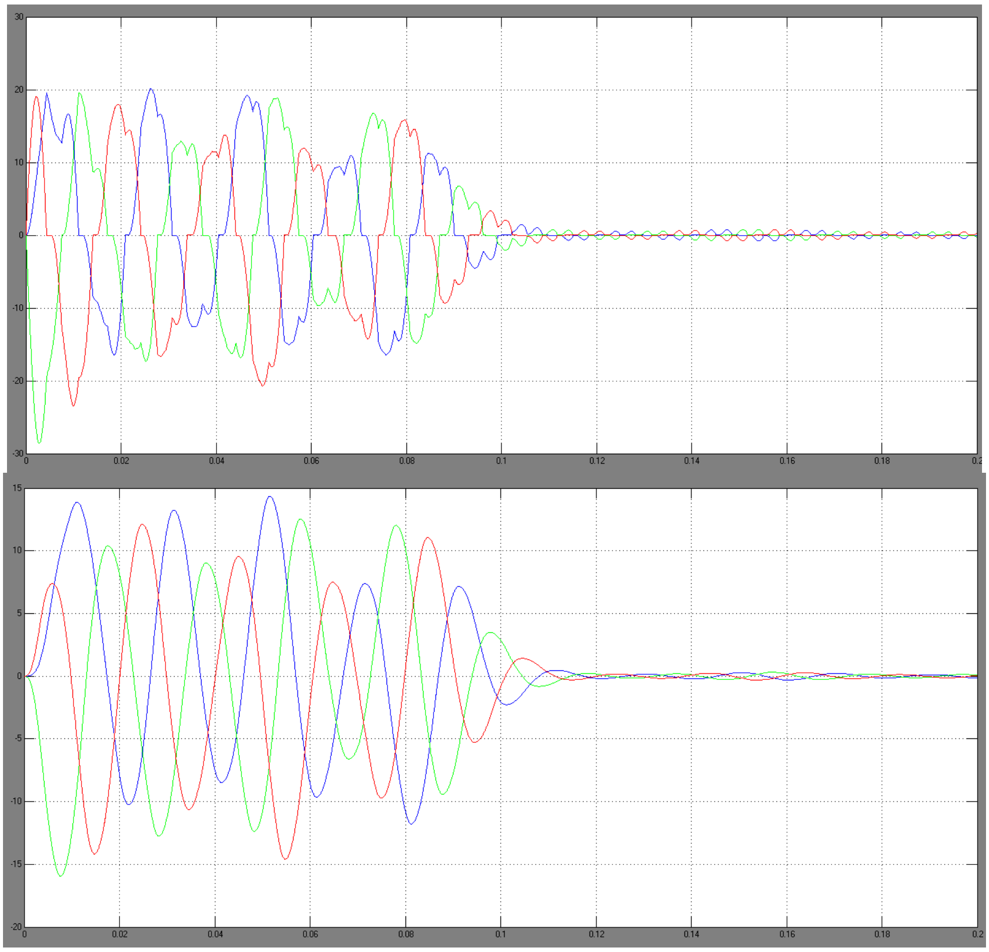

Figure 3. Phase currents of the FC-AM system without active filter (a) and when the active filter is included in the scheme (b)

With the help of scheme for measuring power losses and efficiency in Matlab Simulink, developed in [15], we got a graph of power loss changes in systems with and without a filter (Figure 4)

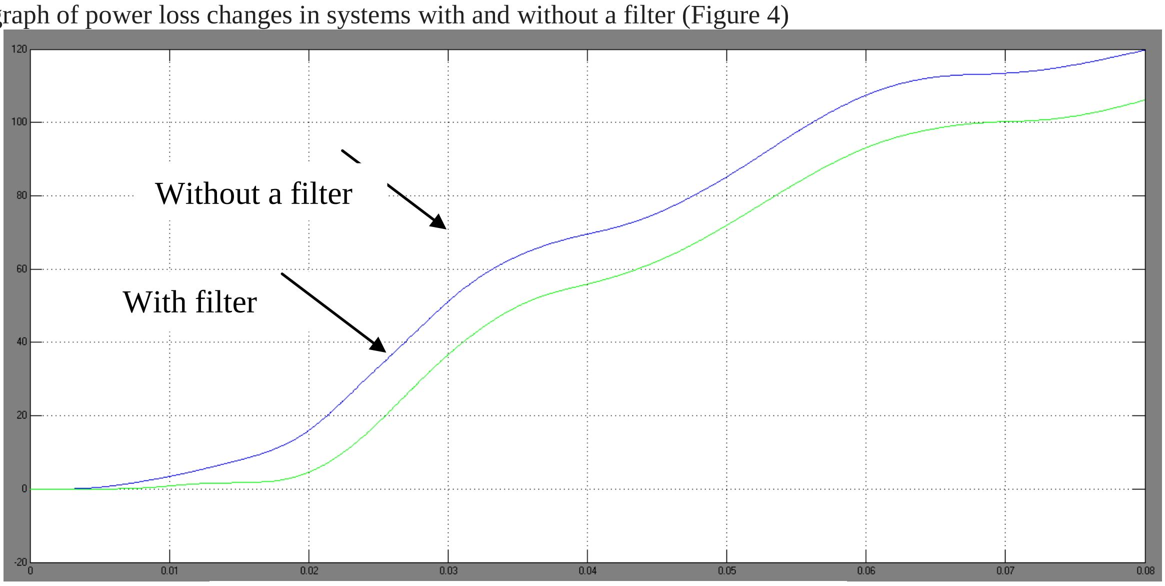

Figure 4. Graphs of changes in power losses in the systems FC-AM

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II. RELATED WORK

At the industrial enterprises the large number of publications, as in our country, and abroad is devoted to a solution of the problem of compensation of jet power. Among them it is possible to note Abramovich B.N., Altunin B.Yu., Belousova V.N., Vagin G.Ya., Vakhnina V.V. works, Venikova VA., Vorotnitsky V.E., Hermann L.A., Glushkova V.M., Gribin V. P., Dobrusina L.A., Eremin O.I., Zhezhelenko I.V., Zhelezko Yu.S., Zorin V.V., Karpov F.F., Kovalyov I.N., Kornilov G.P., Kuznetsov of A.B., Loskutova A.B., Melnikova of H.A., Pekelis V.G., Rogalsky B.S., Saltykov V.M., Serebryakov of A.C. and many others.

III.CONCLUSION

Without using active filter, none of the six analyzed harmonic components comply with the standards established in “State standards”. In the course of spectral analysis, it was found that when an active filter is connected, two of the six harmonics (11 and 13) do not exceed the limit values according to “State standards” 13109-97. At the same time, the remaining harmonics (3,5,7 and 9) decrease by 1.3 - 2 times.

The amount of loss at achievement of the nominal speed rate of AM in the system without an active filter is 114 J, and the loss in a system with an active filter equals 100 J. The difference in power loss in relative units is 14%. The high price of active filters justifies their implementation in powerful power plants, as the magnitude of the load increases of the non-sinusoidal network. The maximum efficiency from the introduction of active filters will be achieved while exploitation of AM, the stator of which is connected to the network of 6 kV and above.

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