CONSIDERATIONS RELATED TO USING ACTIVE FILTERS FOR COMPENSATING HARMONIC CURRENT AND VOLTAGE

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Abstract: In this paper we present some considerations related to using active filters for compensating harmonic current and voltage. To compensate current and voltage harmonics may be used serial or parallel filters. For each calculation model we will present the diagram using the Matlab/Simulink programme.

Key words: harmonic current and voltage, active filters, Fourier series, Simulink.

1. INTRODUCTION

The matters related to harmonic pollution represent some of the most important aspects in the electric energy supplier-consumer relationship, and adopting some efficient measures to ensure the quality of the electric energy in the presence of disturbing appliances preoccupies the specialists from the electro energetic field.

The industrial boom, the extensive use of modern technologies, the electric traction, the employment of quasi-conductor adjustments have led to an important growth in the number of disturbing appliances, thus generating a greater pollution of the electric network. Still, harmonic pollution is not a new phenomenon, problems regarding the components of harmonic voltage and/or current curves appearing from the very beginning of industrial usage of electrical energy.

Harmonics have been considered, throughout the development of energetic systems, the main cause of a large variety of phenomena and events in the transport and distribution electrical systems, although the manner of expression and their solutions have constantly changed. At the end of the last century, the problems were related to the harmonic tensions present in the transport and distribution system; indeed, owing to ineffective solutions, the amount of tension harmonics in generators was rather high. Later, the extensive introduction of non-linear receivers on a large scale determined the frequent occurrence of harmonic current sources.

2. ISSUES REGARDING THE QUALITY OF ELECTRIC ENERGY

Non-linear charges deform the current from the network although the feeding voltage is sinusoidal. The electric diagram of such a charge may be presented as a linear charge corresponding to the fundamental harmonic of the current and of a large amount of power supplies for each superior harmonic. On the one hand, these ones usually induce large losses by Joule effect, and on the other hand they lead to an incorrect operation of protections, and
due to voltage drop on the short-circuit impedances, deforming the tension on the condenser caps and pollute the environment with high frequency electromagnetic waste.

Voltage distortion leads to the occurrence of such phenomena:
- The operation of electric converters based on delaying the ignition angle may be imperiled;
- There is the danger that the compensation condensers of the power factor and the impedance of the network to behave as chain resonant circuits (due to voltage), which might lead to the occurrence of high current waves which might lead to the damaging of the installation and to making the consumers be out of order.

Consequently, a solution is needed to compensate the current and voltage harmonics, solutions represented by passive and active filters.

Active power filters are places in low tension distribution stations to which important users of reactive and distorted users are connected, thus achieving better parameters of electric energy, by absorbing solely the active power from the network.

Various consumers which alter the tension and current quality in low tension networks are presented in figure 1.

Next figure exemplifies these problems which appear due to uncontrolled rectifiers that feed the source in commutation, which is placed in a computer.
3. FILTERS ON LOW TENSION NETWORK

In order to compensate current and voltage harmonics, chain or parallel filters may be used.

Fig. 3. Filtering on low tension networks

Fig. 4. Power diagram

In Fig 4 we present the force circuit of an active filter. This is a controlled converter formed from a continuous current circuit with condensers and a three-arm-deck with controlled rectifier diodes and free diodes. Connectivity to the alternative current network is made through a filter which goes down. Each arm is controlled by a 5-10 KHz frequency. The filter going down ensures the isolation of this frequency from the frequency of the network.

4. THE FFT METHOD FOR CONTROLLING ACTIVE FILTERS

It is well known that a periodic signal may be decomposed in spectral components whose frequency is a multiple of the fundamental frequency. These components are also known under the name of harmonic components. A periodic signal may also be represented through a Fourier chain:
\[ V(t) = \frac{1}{2} a_0 + \sum_{k=1}^{n} \left( a_k \cos k\omega t + b_k \sin k\omega t \right) \]  \hspace{1cm} (1)

where: \( \frac{1}{2} a_0 \) is the continuous current component of the signal.

The \( a_k \) and \( b_k \) coefficients of the chain may be defined in the following way:

\[ a_0 = \frac{2}{T} \int_{t}^{t+T} v(t) \, dt \]  \hspace{1cm} (2)

\[ a_k = \frac{2}{T} \int_{t}^{t+T} v(t) \cos(k \cdot \omega \cdot t) \, dt \]  \hspace{1cm} (3)

\[ b_k = \frac{2}{T} \int_{t}^{t+T} v(t) \sin(k \cdot \omega \cdot t) \, dt \]  \hspace{1cm} (4)

The two coefficients, \( a_k \) and \( b_k \), represent the amplitudes of the spectral components of \( k \) order. The corresponding frequency of these spectral components is \( k \).

Another way to express the Fourier chain is:

\[ V(t) = \frac{1}{2} a_0 + \sum_{k=1}^{n} A_k \cos(k \omega t - \phi_k) \]  \hspace{1cm} (5)

where \( A_k \) stands for signal amplitude and \( \phi_k \) for signal phase.

We can define the two values as follows:

\[ A_k = \sqrt{a_k^2 + b_k^2} \]  \hspace{1cm} (6)

\[ \phi_k = \arctan \frac{b_k}{a_k} \]  \hspace{1cm} (6)

The transformed Fourier is calculated faster by using the FFT algorithm. Analyzing the currents on each phase through the Fourier series, it has been succeeded to decompose the algorithm into its constituent harmonics. Recomposing the signal by using solely harmonics of superior order (besides the first harmonic), results in a signal which will be introduced in the network under a changed sign, so that on the electrical network there will be a first harmonic signal.

5. SIMULATING THE SYSTEM BY USING THE MATLAB PROGRAMME

Next, we will present the diagram drawn for each calculation model and the outcome of the simulation.
The FFT block decomposes the current in the harmonics constituting it. The calculation programmed used by the Matlab Function block allows the extraction of the first harmonic. The IFFT block recomposes the signal using only superior order harmonics, thus resulting a signal which will be introduced in the network under a changed sign.

In fig. 6 we present the feeding currents from the network throughout the whole simulation process. In the (0-0.1) interval, the network current is not filtered, and at the 0.1 interval the active filter comes into function. At 0.5 the charge doubles.

In fig. 6 we present the feeding three-phase-currents without an active filter.
We may also notice that once the active filter comes into action the feeding three-phase-currents from the network become sinusoidal.

In fig. 8 we present/show the three feeding currents in the network, using an active filter for a double charge.

5. CONCLUSION

Non-linear charges deform the current from the network although the feeding voltage is sinusoidal. Solutions to compensate the current and voltage harmonics represented by passive and active filters which are places in low tension distribution stations to which important users of reactive and distorted users are connected, thus achieving better parameters of electric energy, by absorbing solely the active power from the network.

6. REFERENCES

1. Antoniu, I. s.a., Calculul circuitelor electrice în regimuri normale și anormale de funcționare, Editura Tehnica, București, 1975