COMPUTER SIMULATION OF SERIES ACTIVE POWER FILTER

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The possibility of hysteresis following of a reference sinusoid to control series active power filters as correctors of quality of consumed power from supply network is shown in this paper. This possibility is described using computer simulation.

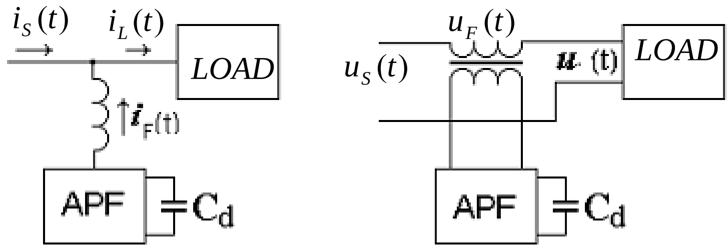
Keywords: series active power filters, hysteresis control.

1. INTRODUCTION

In recent years, an increase of number of critical equipment of electrical power has been observed. In these consumers, disturbances of quality of the electrical power leads to going out of normal operation mode and quite recently also to damages. Problems, arising into this kind of equipment, are scrutinized in [1-4].

Implementing of active power filters (APF) to improve quality of electrical power is a prospective solution and an object of quicken interest. In general, these filters are shunt and series with respect to the load (fig.1.). Shunt filter changes its current $i_F(t)$ in such a way that in every time moment it compliments load current $i_L(t)$ and in result source current $i_S(t)$ is sinusoidal and in phase with source voltage (i.e. power factor is closed to 1). During the operation of a series filter, its voltage $u_F(t)$ is added to source voltage $u_S(t)$. The result is supply voltage of the load $u(t)$ with a required quality (value, waveform, without distortions). Dependent on the number of phase, these filters are single-phase and three-phase (for three wire and four wire source voltages).

Different features concerning implementation and operation of series APF as from the standpoint of power schematic and regarding a control algorithm are studied in [6-8]. Comparison among different algorithms is made in [9,10]. Problems that arise during supplying of different loads and quality of network voltage are the study topic in [11-13]. Special attention is paid to protections while using series APF in [14]. After scrutinized analysis of the reported questions concerning these filters in different references, an idea to use sliding mode control into series APF to follow source voltage arises.



A B

Fig.1. Block schema of connections of shunt and series APF

2. AIM OF THE STUDY

The authors' aim is to study single-phase series APF using computer simulation with the purpose of investigating possibilities to implement such a filter that is control according to the given algorithm.

3. BLOCK AND SIMULATION MODELS

Fig.2 displays the block schema on which basis the simulation model is made. It includes source voltage (with disturbance quality in general), source of reference sinusoid that is in phase with the source voltage. In addition, there are hysteresis comparator and drivers used to control the filter. Load might be arbitrary, but in this particular case, an uncontrollable rectifier with an active capacitive load is used. This load is chosen, because many of the supply blocks without power factor correction of critical equipment contain such rectifier in their input. The supply voltage to the rectifier is monitoring using bias connection in every time moment and passing to compare it with reference sinusoid. Then dependent on the difference between them, stated with a certain hysteresis, power switches of APF are switched over. These switches over are perform in such a way that the reference sinusoid is followed continuously.

Fig.3. displays created model based on the block-schema. Bridge schematic of APF performed by IRF150 is used. There is also a possibility to use half-bridge schematic of filter. Supply DC voltage, simulated using ideal source, may be got by means of separate converter connected to supply network, or using another source, for example accumulator battery in combination with fuel cell or photovoltaic panel. Into the other diagonal of the transistors bridge, high band LC filter is connected. The transformer, shown at fig.1.B., is simulated using voltage source control by voltage. A source of this kind is used also to monitor input load voltage. The load is uncontrollable rectifier with active-capacitive load. Output signal of the simulated transformer for bias voltage connection is compared with reference sinusoid. The result from this comparison reacts upon hysteresis comparator. Transistor drivers are simulated using the above mentioned sources.

Dependent on the need the supply load voltage to increase above or decrease under reference sinusoid, diagonal connected pairs of switches are properly switched on. These switches on depend on a way of which the coils of the transformer are connected (fig.1.b.).

The supply voltage with disturbance quality is simulated using ideal sinusoid source upon which periodical impulse distortions are putted. It is clear, that a simulation of different change of voltage quality and operating with different loads is possible. The simulation is made by MicroSim 8.0.

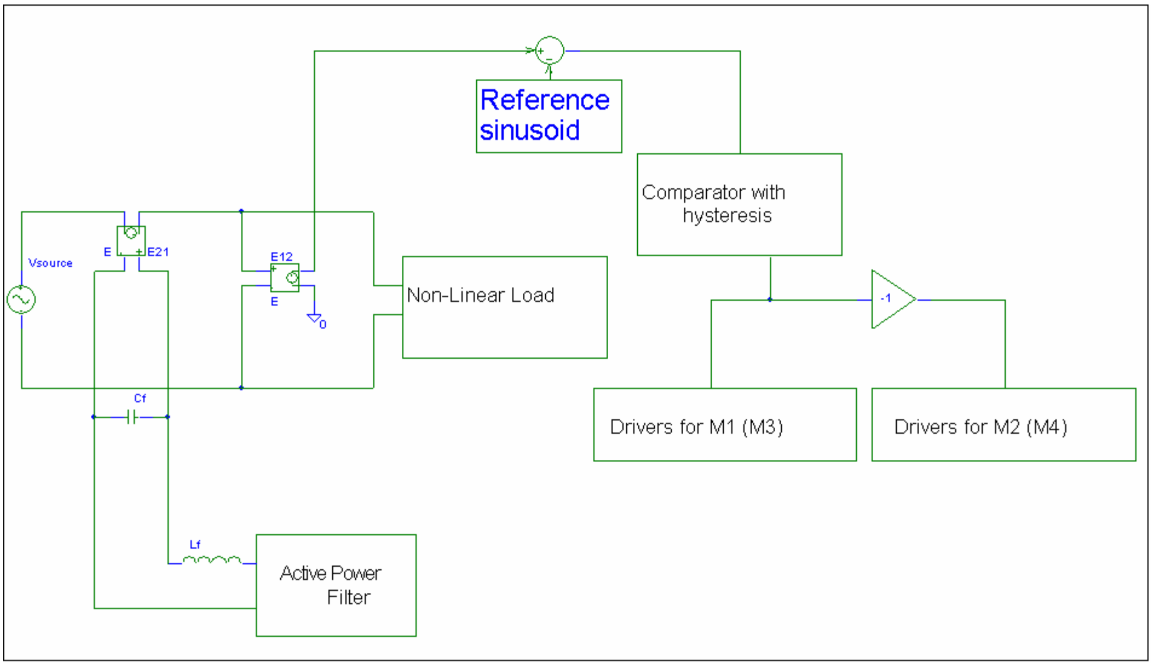


Fig.2. Block-schema

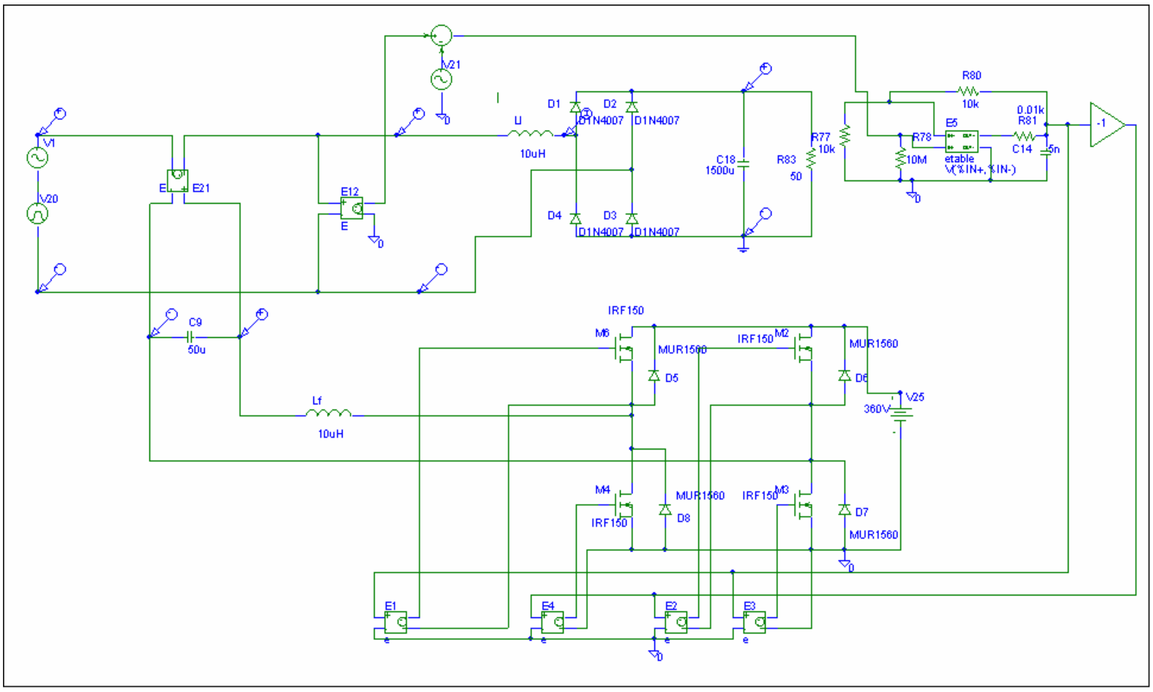


Fig.3 Simulation schematic

4. RESULTS

The results of the computer simulation show the possibility to implement series APF using the mentioned algorithm. Several problems that may arise in realization of this kind are connected with construction of the elements, models as ideal converters voltage – voltage (fig.3). The output transformer of APF has to have a width frequency band starting from network source frequency and limited from above till 100kHz. This put serious requirements to the transformer performance for high powers. The monitoring devise of bias voltage connection has to have the same frequency band, but to make possible monitoring of the voltage, which changes with a rapid speed – over 500V/μs.

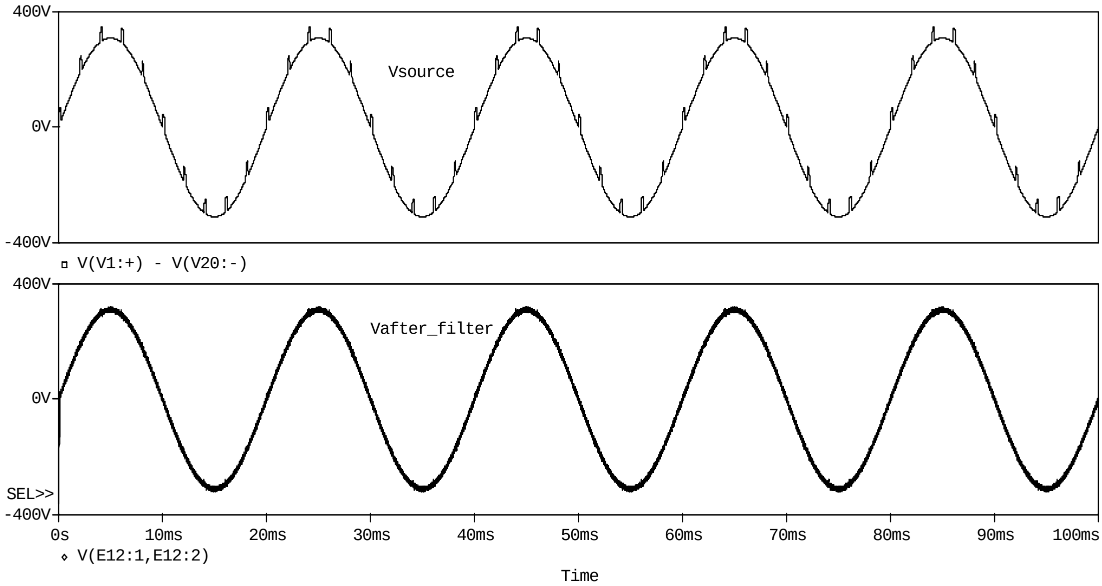


Fig.4. Simulation results when the filter is performed as bridge schema.

Because the frequency of the commented devices and of the power switches are limited, the protection of over voltages connected with international standard IEC 1000-4-5 has to be keep on putting into practice using familiar passive methods.

The way to supply the power schematic of APF from the same supply network, and to perform uninterruptible power supply to the load using the power schematis is of great interest.

4. ACKNOWLEDGMENT

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