

Cooperation Between Hybrid and Pure Active Power Filter Under Unbalanced Load Conditions

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Abstract In the paper the conception of parallel running of pure active power filter (APF) and hybrid active power filter (HAPF) in 3-phase energetic power system with unbalanced load was presented. Purpose of filters is elimination of source current harmonics and compensation of reactive power in source-load system, with assumed efficient division of filtering task between both filters. HAPF filter is designed for rough filtration – it filters 5th harmonic only, however remaining harmonics are eliminated by APF filter. Using SLPS interface, control system of filters was modeled in MATLAB-Simulink environment, however 3-phase energetic power system with source, load and filters was implemented in OrCAD-Capture&PSpice environment.

Keywords active power filter (APF), hybrid active power filter (HAPF), parallel running, SLPS interface.

I. INTRODUCTION

In the paper parallel running [1], [13], [16] of active power filter (APF) [6], [7] and hybrid active power filter (HAPF) [3], [8], [15] in 3-phase power system with unbalanced load was considered. The aim of this cooperation is elimination of source current (i_{s1} , i_{s2} , i_{s3}) harmonics, compensation of reactive power (for 1st

reactive power compensator for fundamental harmonic. Maximal output voltages were limited to $\pm v_{k \max} = \pm 50$ V.

- APF reduces all harmonics of currents excepting 5th harmonic, compensates reactive power and it is used for load symmetrization. Maximal output currents were limited to $i_{k \max} = \pm 20$ A. Reactive power of HAPF is taken into consideration in control system.

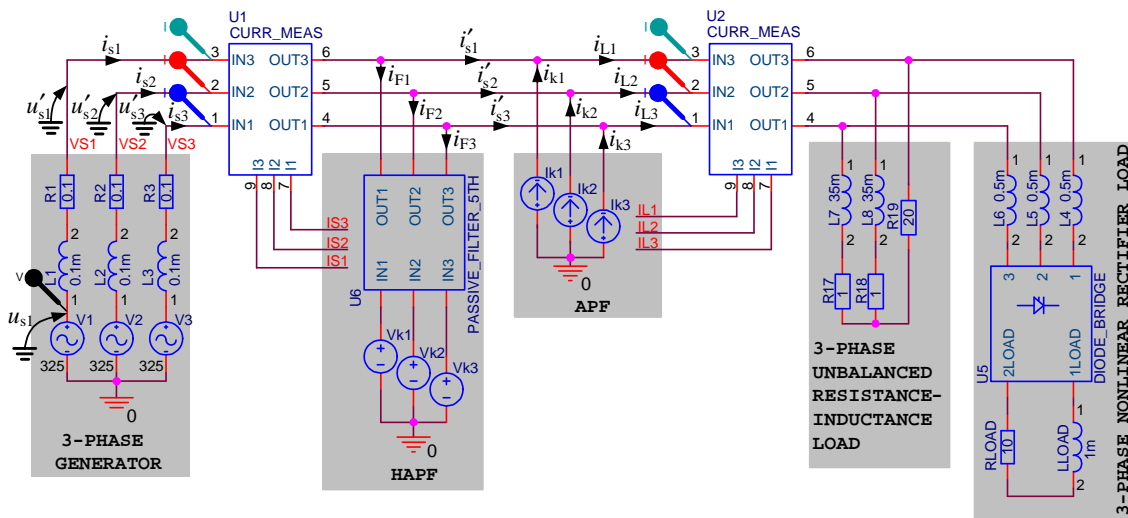


Fig. 1. Simulation model of 3-phase power system APF and HAPF included (OrCAD-Capture&PSpice environment)

harmonic) in source-load system and symmetrization of load. Parallel running of filters was analyzed in typical 3-phase energetic powers systems including 3-phase source (generator), APF and HAPF filters, nonlinear rectifier load and unbalanced resistance-inductance load. This 3-phase system was modelled in Cadence Capture-PSpice environment [9] (Fig.1).

With these assumptions hybrid power filter compensates dominant i.e. 5th harmonic of load currents while the rest of harmonics are compensated by active power filter. Moreover, HAPF is a static reactive power comparator while APF with proper controlling can reduce reactive power dynamically.

It is possible to reduce APF power rate in this case and cooperation between both filters is well-founded.

II. ASSUMPTIONS OF APF AND HAPF PARALLEL RUNNING

For effective use of pure active power filter and hybrid power filter, following assumptions were set:

- connecting in system: first HAPF, next APF looking from source side,
- HAPF reduces 5th harmonic of currents (passive filter for 5th harmonic was used) and it is a static

III. CONTROL SYSTEM

Control system of APF and HAPF filters, based on synchronous reference frame [3], [4], [5], [10], [12] with suitable modifications was implemented in MATLAB-Simulink environment [11] (Fig. 2 and Fig. 3). The modifications were made in APF control (Fig. 2) and concern:

- removing 5th harmonic from APF current (i_{k1} , i_{k2} , i_{k3}),
- taking HAPF reactive power into consideration.

Symmetrization of load achieved by APF causes that modification in HAPF control system is unnecessary.

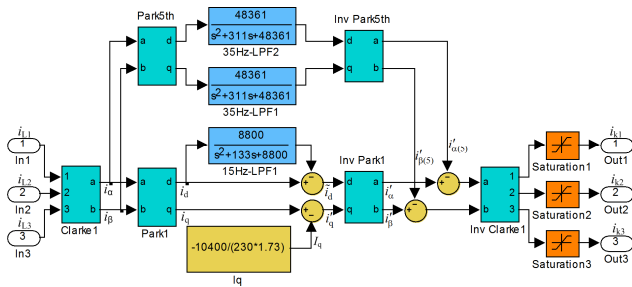


Fig. 2. Simulation model of APF control system (MATLAB-Simulink environment)

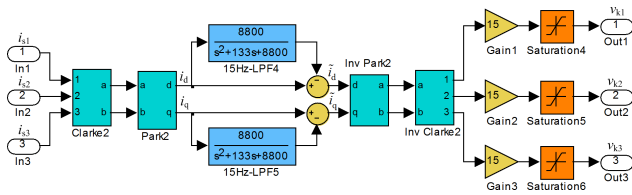


Fig. 3. Simulation model of HAPF control system (MATLAB-Simulink environment)

IV. SIMULATION RESULTS

The proposed conception of parallel running of HAPF and APF filters was simulated in MATLAB-Simulink and OrCAD-Capture&PSpice environment using SLPS interface [2], [14]. The simulation results were presented in Fig. 4.

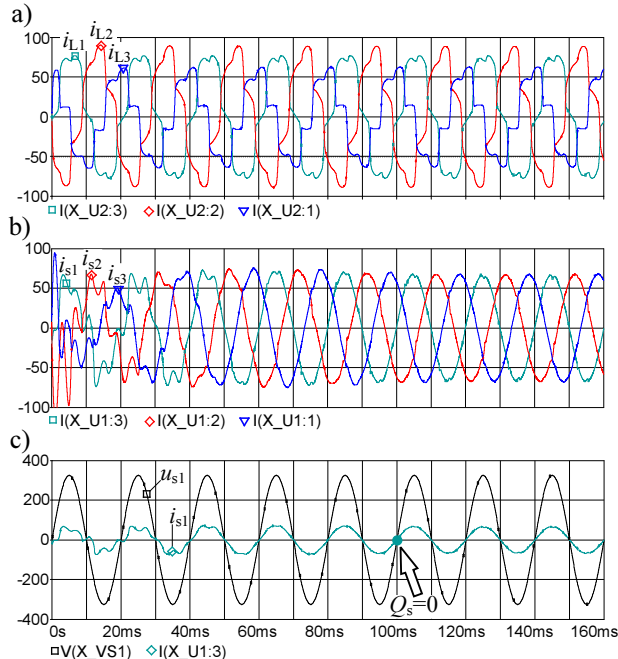


Fig. 4. Waveforms obtained in Cadence Capture-PSpice environment: a) unsymmetrical non-sinusoidal load currents i_{L1} , i_{L2} , i_{L3} ; b) symmetrical sinusoidal source currents i_{s1} , i_{s2} , i_{s3} ; c) for L1 wire: sinusoidal source voltage u_{s1} and source current i_{s1} with zero phase shift (total reactive power of source $Q_s = 0$)

Source current waveforms presented in Fig. 4b showed that all tasks assumed for the analyzed filters were

performed i.e.: higher harmonics were reduced, currents are symmetrical, reactive power was compensated.

V. CONCLUSION

In this paper concept of cooperation between hybrid (HAPF) and pure active power filter (APF) under unbalanced conditions was presented. The hardware part of suitable complete 3-phase electric power system was modeled in Capture-PSpice environment (Fig. 1). Block diagrams of the control system of APF and HAPF were created in MATLAB-Simulink environment (Fig. 2, Fig. 3). Exemplary simulation results obtained in Capture-PSpice environment (Fig. 4) confirm that the assumed purpose of filters cooperation was achieved.

Using active power filter and hybrid filter in one application is possible with proper controlling and allows effective work of both filters with efficient division of filtering task.

It should be mentioned that the presented analysis is only a example and obtained results depend on particular case as well as on assumptions for voltage and currents limits.

VI. REFERENCES

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