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Editorial

Control Strategies Applied to Active Power Filters

Dawid Buła [1,*] and Marcin Zygmanowski [2]

1 Electrical Engineering and Computer Science Department, Faculty of Electrical Engineering, Silesian University of Technology, 44-100 Gliwice, Poland
2 Power Electronics, Electrical Drives and Robotics Department, Faculty of Electrical Engineering, Silesian University of Technology, 44-100 Gliwice, Poland; marcin.zygmanowski@polsl.pl
* Correspondence: dawid.bula@polsl.pl

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Almost 50 years have passed since the first works on active power filters were published [1–3] but only in the last few years, due to the enormous progress in power electronics and microcontrollers, have these systems been gaining great popularity in different applications. The same technological progress is also responsible for the emergence of problems related to power quality, which are higher harmonics in supply network currents and voltages as well as the reactive power consumed by consumers. Although the basic idea of active filters remains unchanged, it turns out that it is still a challenge to properly control these systems depending on the configuration (shunt, series, hybrid filters in various combinations, etc.) and the network system (single-phase, three and four-wire three-phase). This challenge is related, on the one hand, to the determination of reference signals on the basis of frequency and time methods as well as indirect methods. Various methods work correctly in different conditions; they require a different number of measurement signals and computing power. On the other hand, the next challenge is to properly control the output inverter of active power filter. It is not always easy to generate currents or voltages according to the reference signals with adequate accuracy when the device is working under distorted voltage and when there are time delays in computing, especially if high accuracy is required in a wide range of output currents and frequencies.

The Special Issue "Control Strategies Applied to Active Power Filters" includes four papers [4–7], which each present completely different aspects of active filter control. These four papers are sufficient to cover the main APF control issues that exist in a wide range of applications.

The first paper [4] is related to the generation of the APF reference current using the currents' physical components (CPC) theory. The authors proposed the solution based on the cooperation of two systems: the minimizing balancing compensator (MBC) and the active power filter. Due to the use of the solution into four-wire systems, the structure of MBC is divided into two substructures referred to as the STAR-MBC and DELTA-MBC. The first compensator, which is connected to star configuration, is responsible for minimizing and balancing the zero-sequence components of the reactive current and the unbalanced current. The second compensator, which is connected to delta configuration, is applied to minimizing the unbalanced current components of the negative-sequence and the positive-sequence components. These two substructures of MBC significantly reduce the currents associated with the reactive components, i.e., reactive current and the unbalanced current. To bring about the preferable effects of the compensation of both current components, the MBC compensators cooperate with the APF forming the hybrid active power filter (HAPF).

The second paper [5] is related to the multimodular three-phase active power filter with seven-level cascade H-bridge converter. In this case, the authors are focused on the converter control, which combines the concepts of model-based predictive control, voltage vector phase-shifted pulse width modulation, and dc-link voltage control. The proposed scheme of multimodular APF simplifies the overall control system, making it well suited for compensating harmonic current distortion at the grid side.

The authors in [6] show the example of a control strategy applied to a hybrid active power filter connected to the medium-voltage grid. The main focus is on the HAPF control system with particular emphasis on the influence of grid voltage distortions and time delays in control on the effectiveness of harmonic reduction. A method of time delay compensation in the HAPF reference voltage determination system has been presented. The proposed control system was tested and verified on a real prototype.

The last paper [7] is devoted to the control system of the four-wire three-phase active power filter based on the three-phase neutral point clamped T-type converter. The use of such a converter allows us to reduce power losses and reduce the ripple of the grid currents. The control method allows us to obtain reactive power compensation and/or reduction in higher harmonics in each phase independently, with the possibility of controlling the power factor coefficient tan(φ). The theoretical results presented in the paper are confirmed by the laboratory test results.

It is believed that in the future, the directions of research in the field of active power filter control will still concern improved methods of determining reference signals and methods of controlling converters of various topologies. A large area of research is expected to occur in the issues of smart grid and global control. It is expected that research on filters will concern the use of high-efficiency converters with SiC and GaN transistors switched at very high frequencies. Such solutions will be smaller in size due to the reduction in power losses and the reduction in passive filters. In active power filters operating with very high frequencies, apart from reactive power compensation and harmonic reduction, it will be possible to actively compensate electromagnetic disturbances.

Another direction of research will be to increase the use of active filters to compensate undesirable components not on the basis of signals measured directly in the active filter, but on the basis of signals occurring in various places of local power grids, sometimes far away from the filters themselves. In such systems, the time delays in measuring the signals can be significant and the algorithms for the filters can be complex. It is anticipated that algorithms will be applied in which the compensation of delays will be carried out in an adaptive manner. Additionally, there may be one or several active filters in the electrical network, which should operate globally so that the losses in the network are as small as possible, but not necessarily completely compensating for the undesirable components in their vicinity.

Another research direction will be the use of multi-level converters. Such solutions are already being used, but they are not common. There are many topologies for multi-level converters with different properties, but new topologies continue to emerge. Among these new topologies are topologies using transistors made using various technologies, e.g., MOSFETs and IGBTs.

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References

1. Sasaki, H.; Machida, T. A new method to eliminate AC harmonic currents by magnetic flux compensation-considerations on basic design. *IEEE Trans. Power Apparat. Syst.* **1971**, *PAS-90*, 2009–2019. [CrossRef]
2. Gyugyi, L.; Strycula, E.C. Active AC power filters. In Proceedings of the IEEE IAS Annual Meeting, Chicago, IL, USA, 11–14 October 1976; p. 529.
3. Harashima, F.; Inaba, H.; Tsuboi, K. A Closed-loop control system for the reduction of reactive power required by electronic converters. *IEEE Trans. Ind. Electron. Control Instrum.* **1976**, *IECI-23*, 162–166. [CrossRef]
4. Sołjan, Z.; Hołdyński, G.; Zajkowski, M. CPC-based minimizing of balancing compensators in four-wire nonsinusoidal asymmetrical systems. *Energies* **2021**, *14*, 1815. [CrossRef]

5. Gregor, R.; Pacher, J.; Espinoza, A.; Renault, A.; Comparatore, L.; Ayala, M. Harmonics compensation by using a multi-modular H-bridge-based multilevel converter. *Energies* **2021**, *14*, 4698. [CrossRef]
6. Buła, D.; Michalak, J.; Zygmanowski, M.; Adrikowski, T.; Jarek, G.; Jeleń, M. Control strategy of 1 kV hybrid active power filter for mining applications. *Energies* **2021**, *14*, 4994. [CrossRef]
7. Buła, D.; Jarek, G.; Michalak, J.; Zygmanowski, M. Control method of four wire active power filter based on three-phase neutral point clamped T-type converter. *Energies* **2021**, *14*, 8427. [CrossRef]