**Piotr GRUGEL, Jan MUĆKO**

Bydgoszcz University of Science and Technology

# Selected static characteristics of a parallel active filter with feedback from the supply voltage

***Abstract***. *The article presents selected static characteristics of a parallel active filter with voltage control in the supply line (VPAPF) as a function of parameters of the supply network. The tests were performed on the basis of a simulation model of the network and a suitable compensator. Test results showed that VPAPF filters are most suitable for use in soft networks, maintaining an almost constant level of voltage distortion regardless of the value of the network impedance. Moreover, the influence of the parameter G value corresponding to the value of conductance suppressing higher harmonics of the network voltage on the operation of the active filter was determined.*

**Keywords:** power quality, distorted waveforms, voltage distortion, higher harmonics, active power filters, harmonic compensation, mathematical modelling, simulation techniques.

## Active filter with feedback from the supply voltage

Active power filters are power converters used to widely understood improvement of power quality at the point of their connection. Their main (but not the only one) task is to compensate undesirable harmonics in the current and/or voltage waveforms [1-3]. Described in the article, parallel active power filters controlled on the basis of the identification of network voltage distortions at the connection point PCC (*Voltage Parallel Active Power Filter*, *VPAPF*), also called conductance-controlled filters [1, 4-8] are an alternative to conventionally controlled converters operating based on the identification of distortions in the supply current waveforms. Such systems behave as selective conductance [7, 8], the value of which is low for the fundamental harmonic of the supply voltage, and relatively high (equal to the *G* value) for higher order harmonics. These filters work best in networks with low short-circuit power (so-called weak networks). The idea of controlling such a compensator is shown in fig. 1.

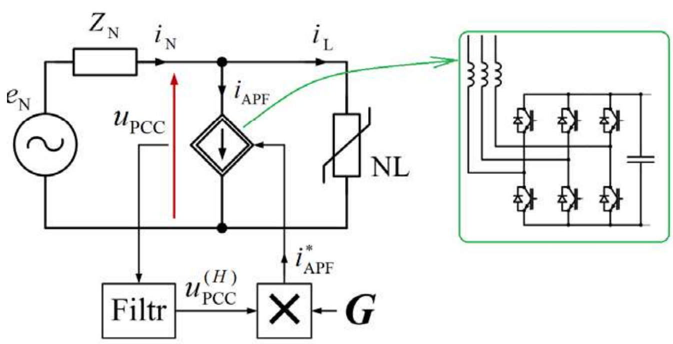


Fig. 1 Schematic diagram of a parallel active filter with voltage control in the supply line

The reference current $i^*_{APF}(t)$ injected to the selected node is determined according to the following relation:

$$i^*_{APF}(t) = G \cdot u^{(H)}_{PCC}(t)$$

where $u^{(H)}_{PCC}(t)$ – network voltage harmonic component, $G$ – value of the conductance suppressing unwanted voltage harmonics.

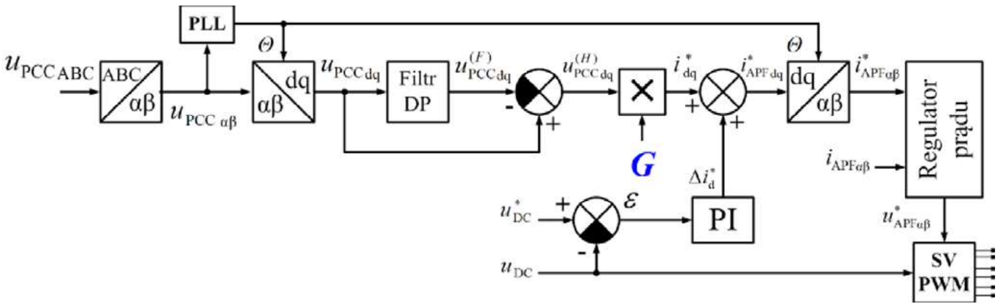


Fig. 2 shows the control algorithm for such a converter.
The algorithm for a three-phase, parallel active filter implementing the conductance control.

**Results**

In order to perform the tests, a power grid (with different parameters $R_N$ and $X_N$) and a VPAPF active filter system controlled in accordance with the algorithm in Fig. 2 were modeled. The load connected to the network was a non-linear energy receiver. The influence of changes in the resultant resistance $R_N$ and reactance (for the fundamental harmonic) $X_N$ of the network on voltage distortions was investigated. The level of these distortions was expressed by the value of the $THD_{(U_{PCC})}$ coefficient. The result of the above is shown in the characteristic in fig. 3a. Then, at a selected coupling point in the network, an active filter was connected, and a number of characteristics were designated. One of the most important, showing the level of distortion of the supply voltage with the same changes in network resistance and reactance as before, is shown in fig. 3b. The article also includes other characteristics determined in the course of research, showing the usefulness of an active filter controlled based on the identification of voltage distortions.

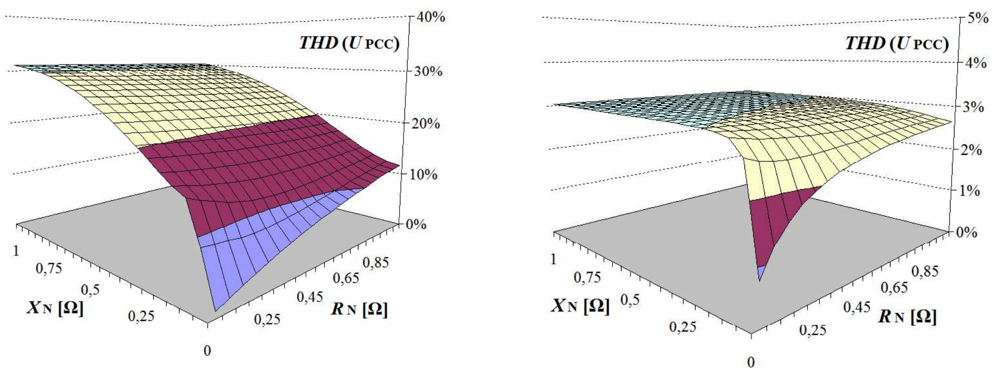


Fig.3. Static characteristics showing the *THD* of the supply voltage at the PCC point, with different values of equivalent resistance and reactance of the low voltage supply network, without (a) and with (b) active power filter.

**Conclusion**

The test results showed that VPAPF filters are the most suitable for operation in so-called weak networks, maintaining an almost constant level of voltage distortion regardless of the value of the network impedance. In addition, the article shows the influence of the value of the gain parameter *G* (corresponding to the conductance value suppressing higher harmonics of the mains voltage, according to the relation (1)) on the operation of the active filter. It was also showed that working with too high value of *G* is energetically and economically unjustified and can even be harmful.

**References**


1. Akagi H., Watanabe E. H., Aredas M., *Instantaneous Power Theory and Applications to Power Conditioning*, IEEE Press & Wiley-Interscience A John Wiley & Sons Inc., ISBN: 978-0-470-10761-4, 2007.
2. Strzelecki R., Supronowicz H., *Filtracja Harmonicznych w Sieciach Zasilających Prądu Przemiennego*, Wydawnictwo Adam Marszałek, ISBN: 53-7174-280-0, Toruń 1999.
3. Adrikowski T., Buła D., Dębowski K., Maciążek M., Pasko M., *Analiza wybranych właściwości energetycznych filtrów aktywnych*, Wydawnictwo Politechniki Śląskiej, ISBN: 978-83-7335-791-4, Gliwice 2011.
4. Grugel P., Strzelecka N., *The comparative analysis of Parallel Active Power Filters - typical and voltage-based - in various operating conditions*", 9th International Conference on Compatibility and Power Electronics, CPE 2015, ISSN: 2166-9538, 24-26.06.2015.
5. L i Y., He J., Liu Y, *Hybrid APF Background Harmonic Voltage Damping Control Method*, IEEE 9th International Power Electronics and Motion Control Conference, IPEMC 2020 - ECCE 2020 Asia, ISBN: 978-1-7281-5302-5, E-ISBN: 978-1-7281-5301-8, 29.11-2.12.2020.
6. Suryawanshi S., Mahajan S.K., *Reduction of Various Harmonic Resonances in a Power Distribution System by Current Control Method*, 4th International Conference on Inventive Systems and Control, ICISC 2020, ISBN: 978-1-7281-2814-6, E-ISBN: 978-1-7281-2813-9, 8-10.01.2020.
7. Iturra R.G., Cruse M., Mutze K., Thiemann P., Dresely C., *Power Balance of Shunt Active Power Filter based on Voltage Detection: a Harmonic Power Recycler Device*, IEEE Applied Power Electronics Conference and Exposition, APEC 2019, ISBN: 978-1-5386-8331-6, E-ISBN: 978-1-5386-8330-9, USB-ISBN: 978-1-5386-8329-3, 17-21.03.2019.
8. Ren B., Wu D., Zhang R., Sun X., Zhang Q., *An Adaptive Droop Control and Virtual Harmonic Resistance Method in Islanding Microgrid*, 13th IEEE Conference on Industrial Electronics and Applications, ICIEA 2018, ISBN: 978-1-5386-3759-3, E-ISBN: 978-1-5386-3758-6, USB-ISBN: 978-1-5386-3757-9, E-ISSN: 2158-2297, 31.05-2.06.2018.



***Authors**: dr inż. Piotr Grugel, Bydgoszcz University of Science and Technology, Bydgoszcz, Kaliskiego 7, 85-796 Bydgoszcz, e-mail: p.gr@pbs.edu.pl; dr hab. inż. Jan Mućko, profesor PBŚ, Bydgoszcz University of Science and Technology, Bydgoszcz, Kaliskiego 7, 85-796 Bydgoszcz, e-mail: mucko@pbs.edu.pl.*