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Performance Evaluation of Active Power Filters under Overload Condition using Limiting and Scaling Power Algorithm

Tri Desmana Rachmildha*, M. Ivan Fikriadi,Yanuarsyah Haroen

Electrical Power Engineering, School of Electrical Engineering and Informatics, Bandung Institute of Technology
Jl. Ganesha 10, Bandung 40132, Indonesia

Abstract

Active Power Filters (APFs) are widely used in power systems that require best power quality. This is because the APFs have the ability to bring the system having unity power factor, to balance the system and to eliminate the harmonic phase currents. However, the rating of an APF depends to the corresponding load where the APF should be able to provide the compensating the required power. If more loads are to be installed on the system, it is possible that the rating of the existing APF is no longer sufficient. Thus, the protection mechanism will work and release the APF from the network, and the APF system will no longer contribute to the system. Therefore, it is necessary to find an algorithm that is able to work under overload conditions without damaging the APF. In this paper 2 algorithms for APF used for overload conditions are proposed. These algorithms are developed based on PQ0 theory for 3 phase 4 wire system. APF will continue to contribute in power compensation although the load exceeds the capabilities of the APF without the need to shutdown the APF. Simulation results are shown to verify the performance of the proposed method.

Keywords: *Active Filter; PQ0 theory; Limiting; Scaling; THD; PF .*

* Corresponding author. Tel.: +62-813-175-24687
E-mail address: trides@konversi.ee.itb.ac.id

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1. Introduction

A lot of non-linear loads are now installed in industries such as variable speed drives (VSDs), static power converters, rectifiers, DC choppers, inverters. These devices will provide harmonic pollutions to the electric network system causing some disturbances to power system as additional losses in the transmission or heating in the transformer cores. Therefore the industries require a device to improve the power quality that is able to compensate the harmonic. There has been some compensator that can be installed on a network such as tuned passive filters, conventional active filters, and active power filters (APFs). However, the APF has the ability to force the system to have unity power factor, to eliminate harmonics, to balance the load, and to help the system during transient conditions i.e. motor starting.

Like other equipment, the APFs only work on specific rating which is defined based on the power it should provide to the corresponding loads. Therefore, if the required power is beyond the ability of the APF, the system protection will work to release the APF from the network and the APF cannot contribute to the system. This is unfortunate because in actual fact, APF can still provide some reactive powers to the system. It is still possible to operate the APF in this overload situation so that it can still provide compensation without releasing or damaging the APF.

In this paper, there are two overload algorithm methods proposed. The first strategy is done by limiting the APF's instantaneous apparent power based on the required compensating power. This apparent power value will be limited in accordance to the rating of the APF. Once it is restricted, this value will be returned back to the new reference for the APF. The second method is by scaling the power. When the value of the instantaneous apparent power is obtained, this value will be multiplied by a certain constant, so that the value of the new instantaneous apparent power will follow the shape of the old value but with a smaller magnitude.

Both methods will be tested by simulation on several conditions to show their performance on harmonic elimination and power factor correction.

2. Compensation Strategy in APF Using Instantaneous PQ0 Power Theory

The PQ0 theory is introduced by Akagi [2,3] and developed by the other [1] to be used in three-phase four-wire system. The power definition [1] can be written as:

$$\begin{bmatrix} p \\ q \\ p_0 \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta & 0 \\ -v_\beta & v_\alpha & 0 \\ 0 & 0 & v_0 \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \\ i_0 \end{bmatrix} \tag{1}$$

All values ($\alpha\beta 0$) reference can be obtained using this formula:

$$\begin{bmatrix} X_\alpha \\ X_\beta \\ X_0 \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & \sqrt{3}/2 \\ 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} \begin{bmatrix} X_a \\ X_b \\ X_c \end{bmatrix} \tag{2}$$

Where:

- X_a, X_b, X_c : the voltage (V) or current (I) variables of the source in the (abc) reference,
- X_a, X_b, X_c : the voltage (V) or current (I) variables in the ($\alpha\beta 0$) reference,
- p : instantaneous active power
- q : instantaneous reactive (imaginary) power
- p_0 : zero-sequence instantaneous real power

The active power filters calculate the powers that absorbed by the load, then compensate it. The compensation strategy is showed in Fig. 1.