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A New Technique for Elimination of Harmonics Using Three Phase Shunt Active Filter

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Abstract: This paper describes the current-detection algorithm based on the time-domain approach for three-phase shunt active power filters (APFs). It aims at eliminating harmonics and/or correct power factor and/or balance asymmetrical loads are analyzed. An overview and assessment of the performance of existing current-detection algorithms for active power filters are presented. According to different complicated power quality issues and various compensation purposes, a new current-detection algorithm is recommended. Different compensating current references can be accurately obtained by adopting the proposed algorithm. It make sure that the shunt APF can very well achieve different compensation purposes. Simulation results obtained with MATLAB and testing results on an experimental shunt APF are presented to validate the proposed algorithm.

Key words: Active Power Filter (APF) · Current-detection algorithm · Harmonic compensation · Reactive power compensation · Time domain

INTRODUCTION

With the proliferation of nonlinear loads such as diode / thyristor rectifiers, non-sinusoidal currents degrade power quality in power transmission/distribution systems. Traditionally, passive filters have been used to attenuate the harmonic distortion and compensate the active power, but passive filters are bulky, detune with age and can resonate with the supply Impedance. The active power filters are great tools for the compensation not only of current harmonics produced by distorting loads but also of reactive power and unbalance of nonlinear and fluctuating loads [1]. The shunt APFs (SAPFs) are used most widely. The performance of SAPF strictly depends on the features of the current-detection algorithms and controllers. A novel current-detection algorithm of SAPF for harmonic elimination, power factor correction and balancing of nonlinear loads is proposed [2-4].

Traditional and Proposed Current Detection Algorithms: The existing methods of current-detection algorithm are, Analogue methods, in which recision is not satisfactory (i.e.) the derived component has magnitude and phase errors, Instantaneous Reactive Power Theory-Based method requires co-ordinate transformations between the a,b,c and p,q coordinates which increases the complexity of designing the APF controller, Fourier Transform Based Methods, which has good precision but one complete main cycle delay is unavoidable for the algorithm, Modified Fourier transform-based methods can improve dynamic response, but one main cycle is required to track the load change completely, Other methods such as fuzzy control, adaptive and the wavelet and neural network algorithms have better dynamic response than FFT, but they require a large amount of calculation [5]. The Proposed algorithm based on time domain for determining the APF reference compensating currents has response time delay less than one main cycle which is high in DFT and in IRPT. This algorithm does not need the coordinate transformation as in IRPT. Comparing with existing algorithms, this algorithm has shorter response time delay.

Shunt Active Power Filter Control System: The derived mathematical equations can be implemented using MATLAB/Simulink. The control system of the proposed current detection algorithm is shown in Fig. 1.

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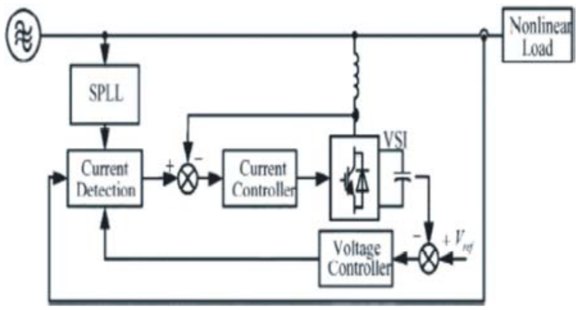

Fig. 2.1: SAPF Control System

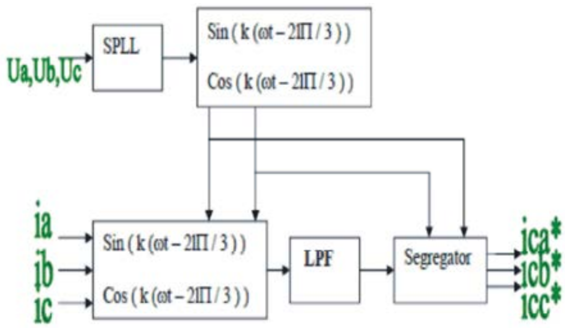

Fig. 2: Block diagram of the proposed current detection algorithm

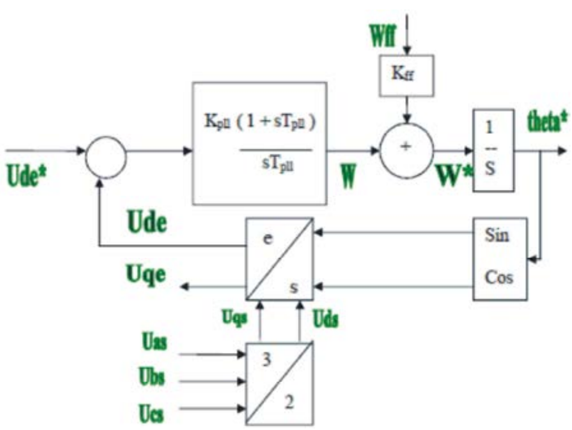

Fig. 3: Control diagram of the phase locked loop

Operation Principle of the Proposed Algorithm: In the three-phase three-wire system, the instantaneous load currents of phase “a,” “b,” “c” (*ia,ib* and *ic*) can be disassembled into positive-sequence and negativesequence components according to the symmetrical weigh law, which was proposed by Fortescue separately.

$$i_x(n) = \sum_{t=1}^{x}\left[I_{lk} Sin\left(\frac{2\pi nk}{N} + \varphi_{ik} - \frac{2l\pi}{3}\right) + I_{2k} Sin\left(\frac{2\pi nk}{N} + \varphi_{2k} + \frac{2l\pi}{3}\right)\right]$$

where

$$I = \begin{cases} 0 & x = a \\ 1 & x = b \\ 2 & x = c \end{cases}$$

The subscripts 1 and 2 represent the positive-sequence and negative sequence,respectively. *‘K’* represents harmonic order. *‘I’* Represents the peak value of the current and *‘Ø’* is the initial phase (*‘Ø ’* is determined as the initial phase between the positive sequence fundamental voltage of phase “a” in order to explain the physical meaning).*’N’*is the number of sampling point in one fundamental cycle and *‘n’* is the count value of sampling *(n=0, 1,…N-1)*. Commonly, only the positive-sequence, negative-sequence, active power and reactive power of the fundamental current are cared and it is not necessary to decompose the harmonic.Then, the fundamental current component is expressed as follows

$$i_{x1}(n) = I_{11} Sin\left(\frac{2\pi}{N}n + \varphi_{11} - \frac{2l\pi}{3}\right) + I_{21} Sin\left(\frac{2\pi}{N}n + \varphi_{21} + \frac{2l\pi}{3}\right)$$

$$= I_{11} Sin\left(\frac{2\pi}{N}n - \frac{2l\pi}{3}\right) Cos\varphi_{11}$$
$$+ I_{11} Cos\left(\frac{2\pi}{N}n - \frac{2l\pi}{3}\right) Sin\varphi_{11}$$
$$+ I_{21} Sin\left(\frac{2\pi}{N}n - \frac{2l\pi}{3}\right) Cos\left(\varphi_{21} - \frac{2l\pi}{3}\right)$$
$$+ I_{21} Cos\left(\frac{2\pi}{N}n - \frac{2l\pi}{3}\right) Sin\left(\varphi_{21} - \frac{2l\pi}{3}\right)$$

Fig. 2 shows the block diagram of the proposed current-detection algorithm, where '$Sin\frac{2l\pi}{3}n$' is synchronous with the positive-sequence fundamental voltage of phase “a,” which determines the calculation precision of active and reactive power components. The low-pass filter used determines the performance of the system. According to different compensation purposes, the segregator will obtain different components expediently, which is superior to the algorithm based on the instantaneous reactive power theory. The synchronous signals can be obtained by soft phase loop lock (SPLL).

Principle of Operation of Spll: reference frame voltages are then transformed to voltages Ude, Uqe using the 3/2 and e / s transformations. The angle θ used in these transformations is obtained by integrating a frequency

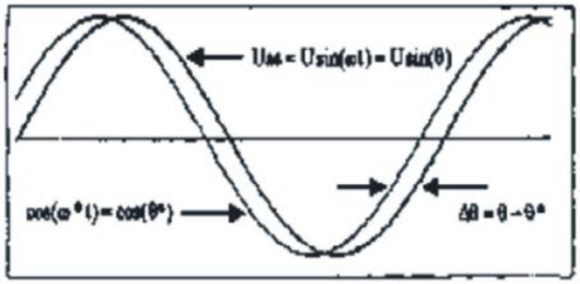

Fig. 4: Input phase voltage and PLL output

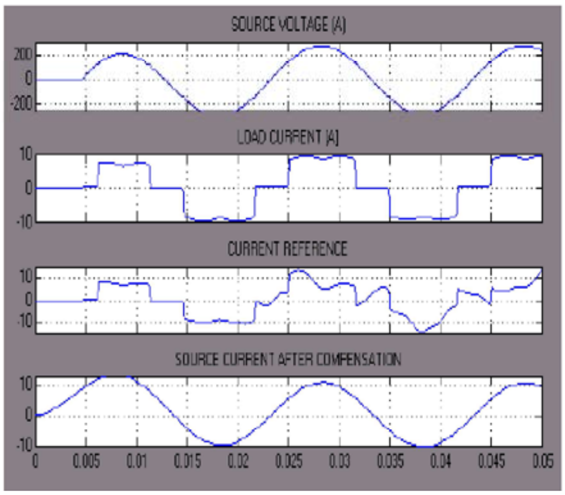

Fig. 5: Source voltage, load current, Current reference and Source current after compensation for phase A

command ω. If the frequency command ω is identical to the utility frequency, the voltages Ude and Uqe, appear as dc values depending on the angle θ. In this method, a PI regulator can be obtained that value of θ (or ω) which drives the feedback voltage Ude to a commanded value Ude*. The Magnitude of the controlled quantity Ude determines the phase difference between the utility voltages and sin(θ) or cos(θ). The method results not only in the utility frequency ω but also allows one to lock at an arbitrary phase angle □θ * with respect to the utility angle θ. The angle Δθ (Fig. 4.) is controlled by the commanded values Ude*

The basic configuration of the PLL system is shown in Fig. 3. The phase voltages Uas, Ubs, Ucs are obtained from sampled line-to-line voltages [6]. These stationary

Simulation Results

Simulation Conditions: The purpose of the simulation is to show the usefulness of the proposed SAPF control strategy. Two test cases are taken into consideration with different source voltages and load conditions [7]. The source voltages are sinusoidal and balanced with a magnitude of 230 V and a frequency of nonlinear load.

Simulation Results for Sinusoidal, Balanced Source Voltages: The balanced and sinusoidal three phase voltages considered are,

$V_a = 230 \sin(\omega t)$
$V_b = 230 \sin(\omega t - 120^o)$
$V_c = 230 \sin(\omega t + 120^o)$

The load used is a bridge rectifier which acts as a nonlinear imbalanced load. The simulation results have been plotted separately for a clear study [8]. Fig.6 exhibit the source voltage, line current, reference compensation current and source current after compensation for phase A. Similarly the same shape of waveforms are obtained for remaining phases.

CONCLUSION

The thesis has outlined the mathematical modeling and design of the reference compensation current controllers for shunt active power filters based on time domain approach in detail. The simulation results of the proposed method are compared with that of the available results of Generalized Instantaneous Reactive Power Theory based method, Synchronous Reference Frame method and the Synchronous Current Detection methods [9-13]. From the results it can be concluded that the delay resulting from the proposed algorithm is less than half of the main cycle, which is half of that of DFT and the same as that of the algorithm based on IRPT. From the analysis and simulation it is found that the algorithm presented in this thesis has the advantages of flexibility, accuracy and easy implementation. Since the reference compensation currents are determined in the 'a-b-c' reference frame, there is no reference frame transformation is required.Therefore, it results in less complexity in realizing the control circuit of SAPF and still maintains good filter performance.

REFERENCES

1. Peng, F.Z. and J.S. Lai, 1996. Generalized instantaneous reactive power theory for three-phase power systems, IEEE Trans. Instrum. Meas., 45(1): 293-297.

2. Kaura, V. and V. Blasko, 1997. Operation of a phase locked loop system under distorded utility conditions, IEEE Trans.Instrum.Meas., 33(3): 58-63.
3. Jintakosonwit, P., H. Fujita and H. Akagi, 2002. Control and performance of a fullydigital- controlled shunt active filter for installation on a power distribution system, IEEE Trans. Instrum. Meas., 17(1): 132-140.
4. Mattavelli, P., 2001. A Closed-loop selective harmonic compensation for active filters, IEEE Trans.Instrum.Meas., 37(1): 81-89.
5. Vijayaragavan, S.P., B. Karthik, T.V.U. Kiran Kumar and M. Sundar Raj, 2013. Analysis of Chaotic DC-DC Converter Using Wavelet Transform, Middle-East Journal of Scientific Research, ISSN:1990-9233, 16(12): 1813-1819.
6. Vijayaragavan, S.P., B. Karthik, T.V.U. Kiran Kumar and M. Sundar Raj, 2013. Robotic Surveillance For Patient Care In Hospitals, Middle-East Journal of Scientific Research, ISSN: 1990-9233, 6(12): 1820-1824.
7. Vijayaragavan, S.P., T.V.U. Kiran Kumar and M. Sundar Raj, 2013. Study of effect of MAI and its reduction in an OCDMA system, Middle-East Journal of Scientific Research, ISSN: 1990-9233, 16(12): 1807-1812.
8. Vijayaragavan, S.P., T.V.U. Kiran kumar and M. Sundar Raj, 2013. Study of Effect of Mai and its reduction in an OCDMA System, Middle-East Journal of Scientific Research, ISSN: 1990-9233, 15(12): 1803-1808.
9. Sokeng, S.D., D. Lontsi, P.F. Moundipa, H.B. Jatsa, P. Watcho and P. Kamtchouing, 2007. Hypoglycemic Effect of Anacardium occidentale L. Methanol Extract and Fractions on Streptozotocin-induced Diabetic Rats, Global Journal of Pharmacology, 1(1): 01-05.
10. Prajapati Hetal Ritesh, Brahmkshatriya Pathik Subhashchandra, Vaidya Hitesh Bharatbhai and V. Thakkar Dinesh, 2008. Avian Influenza (Bird Flu) in Humans: Recent Scenario, Global Journal of Pharmacology, 2(1): 01-05.
11. Okafor, P.N., K. Anoruo, A.O. Bonire and E.N. Maduagwu, 2008. The Role of Low-Protein and Cassava-Cyanide Intake in the Aetiology of Tropical Pancreatitis, Global Journal of Pharmacology, 2(1): 06-10.
12. Nahed, M.A., Hassanein, Roba M. Talaat and Mohamed R. Hamed, 2008. Roles of Interleukin-1 (Il-1) and Nitric Oxide (No) in the Anti-Inflammatory Dynamics of Acetylsalicylic Acid Against Carrageenan Induced Paw Oedema in Mice, Global Journal of Pharmacology, 2(1): 11-19.
13. Panda, B.B., Kalpesh Gaur, M.L. Kori, L.K. Tyagi, R.K. Nema, C.S. Sharma and A.K. Jain, 2009. Anti-Inflammatory and Analgesic Activity of Jatropha gossypifolia in Experimental Animal Models, Global Journal of Pharmacology, 3(1): 01-05.