ELECTRONICS AND ELECTRICAL ENGINEERING
ISSN 1392 – 1215 2011. No. 2(108)
ELEKTRONIKA IR ELEKTROTECHNIKA

T 190 ELECTRICAL ENGINEERING
ELEKTROS INŽINERIJA

Wavelet Based Reference Current Calculation Method for Active Compensation Systems

G. Gokmen
Department of Electrical Education, Technical Education Faculty, Marmara University,
Goztepe Campus, 34722 Kadıkoy, Istanbul, Turkey, phone: +90 216 336 57 70 (265), e-mail:gokhang@marmara.edu.tr

Introduction

Active compensation and filtering systems have been becoming more important day by day for ensuring high quality in power generation and reducing its cost. Passive compensation and filter circuits have been replaced by SCR-based circuits as a result of development in semi-conductor technology. Determining reference current for these circuits is quite important for filter and compensation circuits [1–12].

Reference current can be defined as total of all instantaneous active and reactive currents drawn due to unbalanced loads or harmonic distortions. An active compensation circuit is run in a way that it generates this reference current. Most frequently preferred methods for obtain reference current are p-q theory, Peng theory, Park Power theory etc. PWM technique is generally preferred in compensator current control [1–12]. p-q theory, which is most prevalent calculation method, was took reference in this study.

p-q Theory

p-q theory is based on finding power values by converting voltage and current from a, b, c phase plane into α, β, 0 plane [7,13,14].

Voltage and current vectors are expressed as the following to show three-phase instantaneous voltage values v_a, v_b, v_c and three-phase instantaneous current values i_a, i_b, i_c

$$\vec{v}=\begin{bmatrix} v_a & v_b & v_c \end{bmatrix}^T, \ \vec{i}=\begin{bmatrix} i_a & i_b & i_c \end{bmatrix}^T. \tag{1}$$

This voltage's and current's α, β and 0 values are expressed as (2–3).

Instantaneous active power is found by scalar multiplication (.) of voltage and current vectors while reactive power is found by vector multiplication of them (×) (4).

$$\begin{bmatrix} v_\alpha \\ v_\beta \\ v_0 \end{bmatrix}=\sqrt{\frac{2}{3}}\begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{3}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix}\begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix}, \tag{2}$$

$$\begin{bmatrix} i_\alpha \\ i_\beta \\ i_0 \end{bmatrix}=\sqrt{\frac{2}{3}}\begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{3}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix}\begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix}, \tag{3}$$

$$p=\vec{v}_{\alpha\beta0}.\vec{i}_{\alpha\beta0}, \ \vec{q}=\vec{v}_{\alpha\beta0}\times\vec{i}_{\alpha\beta0}. \tag{4}$$

Instantaneous active and reactive power can be expressed as the following for the systems without 0 component

$$p=v_\alpha.i_\alpha+v_\beta.i_\beta=\bar{p}+\tilde{p} \ \text{and} \ q=v_\beta.i_\alpha-v_\alpha.i_\beta=\bar{q}+\tilde{q}. \tag{5}$$

In this equation, $\bar{p}$ stands for mean instantaneous active power while $\tilde{p}$ represents alternating active power, $\bar{q}$ represents mean instantaneous reactive power and $\tilde{q}$ represents alternating reactive power. All powers must be compensated except $\bar{p}$ [1-14]. Fundamental current drawn from the source ($\vec{i}_f$) and shunt-compensator's reference current are calculated by using $\bar{p}$ mean instantaneous active power

$$\vec{i}_f=\frac{\bar{p}}{\left|\vec{v}\right|^2}.\vec{v} \ \text{and} \ \vec{i}_R=\vec{i}-\vec{i}_f. \tag{6}$$

Discrete Wavelet Packet Transformation

Wavelet transformation is one of the most recently developed methods for signal analysis. It is prevalently used in many areas like mathematics, physics and engineering [15].

Wavelet packet transformation is an expression of digital signal with time scale. The signal resolution is changed by filtering process while its scale is replaced by down sampling process. Output of cascaded filter banks depends on the main wavelet and high- and low-frequency components of the system. The procedure is started by passing a N-length discrete signal $s(n)$ through an impulse response high-pass filter $h(n)$ and an impulse response low-pass filter $g(n)$ [16]. Responses of high-pass and low-pass filters constitute first-stage decomposition of the discrete signal and expressed as the following [17, 18]

$$s_0^1(n)=\sum_k s(k)h(2n-k)\,,\; s_1^1(n)=\sum_k s(k)g(2n-k)\,. \quad (7)$$

Extension functions ($\phi_{j,k}(x)$ and $\psi_{j,k}(x)$) are not seen in this equation. This allows simulations to be performed through digital filter banks on computer environment [17, 18]. $s_0^1(n)$ and $s_1^1(n)$ sequences are more decomposed at second stage of wavelet packet transformation:

$$\begin{cases} s_{00}^2(n)=\sum_k s_0^1(k)h(2n-k)\,,\\ s_{01}^2(n)=\sum_k s_0^1(k)g(2n-k)\,,\\ s_{10}^2(n)=\sum_k s_1^1(k)h(2n-k)\,,\\ s_{11}^2(n)=\sum_k s_1^1(k)g(2n-k)\,. \end{cases} \quad (8)$$

The entire wavelet packet decomposition can be produced by following similar procedure;

$$\begin{cases} s(n),\\ s_0^1(n),s_1^1(n),\\ s_{00}^2(n),s_{01}^2(n),s_{10}^2(n),s_{11}^2(n),\\ s_{000}^3(n),s_{001}^3(n),s_{010}^3(n),s_{011}^3(n),s_{100}^3(n),s_{101}^3(n),s_{110}^3(n),s_{111}^3(n). \end{cases} \quad (9)$$

The decompositions from the sequence $s_n^i(n)$ at stage i into the sequences $s_{m0}^{i+1}(n)$ and $s_{m1}^{i+1}(n)$ at stage $i+1$ using the two decomposition quadrature filters are given by [17, 18]:

$$s_{m0}^{i+1}(n)=\sum_k s_m^i(k)h(2n-k)\,, \quad (10)$$

$$s_{m1}^{i+1}(n)=\sum_k s_m^i(k)g(2n-k)\,. \quad (11)$$

Proposed Method

The proposed method is, first of all, based on calculation of instantaneous active and reactive powers according to Peng's generalized reactive power theory with no need for p-q transformation. Instantaneous active power is calculated as the following [6, 7]

$$p=\vec{v}.\vec{i} \;\text{ or }\; p=v_a.i_a+v_b.i_b+v_c.i_c\,. \quad (12)$$

Instantaneous active power is a scalar magnitude according to the equation above. Instantaneous reactive power is calculated as the following [6,7]

$$\vec{q}=\vec{v}\times\vec{i}=\begin{bmatrix}\begin{vmatrix}v_b & v_c\\ i_b & i_c\end{vmatrix}\\ \begin{vmatrix}v_c & v_a\\ i_c & i_a\end{vmatrix}\\ \begin{vmatrix}v_a & v_b\\ i_a & i_b\end{vmatrix}\end{bmatrix}=\begin{bmatrix}q_a\\ q_b\\ q_c\end{bmatrix},\; |\vec{q}|=\sqrt{q_a^2+q_b^2+q_c^2}\,. \quad (13)$$

Reactive power is a vector magnitude and $|\vec{q}|$ represents magnitude of instantaneous reactive power for three phases [6,7]. DWPT decompositions of instantaneous active power at third stage can be written as

$$p=p_{000}^3(n)+p_{001}^3(n)+p_{010}^3(n)+p_{011}^3(n)+p_{100}^3(n)+ \\ +p_{101}^3(n)+p_{110}^3(n)+p_{111}^3(n). \quad (14)$$

DWPT decompositions of instantaneous reactive power for each phase at third stage can be written as;

$$\begin{cases} q_a=q_{a000}^3(n)+q_{a001}^3(n)+q_{a010}^3(n)+q_{a011}^3(n)+q_{a100}^3(n)+\\ +q_{a101}^3(n)+q_{a110}^3(n)+q_{a111}^3(n),\\ q_b=q_{b000}^3(n)+q_{b001}^3(n)+q_{b010}^3(n)+q_{b011}^3(n)+q_{b100}^3(n)+\\ +q_{b101}^3(n)+q_{b110}^3(n)+q_{b111}^3(n),\\ q_c=q_{c000}^3(n)+q_{c001}^3(n)+q_{c010}^3(n)+q_{c011}^3(n)+\\ +q_{c100}^3(n)+q_{c101}^3(n)+q_{c110}^3(n)+q_{c111}^3(n), \end{cases} \quad (15)$$

where $\overrightarrow{q_{000}^3}=\begin{bmatrix}q_{a000}^3(n)\\ q_{b000}^3(n)\\ q_{c000}^3(n)\end{bmatrix}$, $\overrightarrow{q_{001}^3}=\begin{bmatrix}q_{a001}^3(n)\\ q_{b001}^3(n)\\ q_{c001}^3(n)\end{bmatrix}$, $\overrightarrow{q_{010}^3}=\begin{bmatrix}q_{a010}^3(n)\\ q_{b010}^3(n)\\ q_{c010}^3(n)\end{bmatrix}$, $\overrightarrow{q_{011}^3}=\begin{bmatrix}q_{a011}^3(n)\\ q_{b011}^3(n)\\ q_{c011}^3(n)\end{bmatrix}$, $\overrightarrow{q_{100}^3}=\begin{bmatrix}q_{a100}^3(n)\\ q_{b100}^3(n)\\ q_{c100}^3(n)\end{bmatrix}$, $\overrightarrow{q_{101}^3}=\begin{bmatrix}q_{a101}^3(n)\\ q_{b101}^3(n)\\ q_{c101}^3(n)\end{bmatrix}$, $\overrightarrow{q_{110}^3}=\begin{bmatrix}q_{a110}^3(n)\\ q_{b110}^3(n)\\ q_{c110}^3(n)\end{bmatrix}$, $\overrightarrow{q_{111}^3}=\begin{bmatrix}q_{a111}^3(n)\\ q_{b111}^3(n)\\ q_{c111}^3(n)\end{bmatrix}$.

$$\vec{q}=\overrightarrow{q_{000}^3}+\overrightarrow{q_{001}^3}+\overrightarrow{q_{010}^3}+\overrightarrow{q_{011}^3}+\overrightarrow{q_{100}^3}+\overrightarrow{q_{101}^3}+\overrightarrow{q_{110}^3}+\overrightarrow{q_{111}^3}\,, \quad (16)$$

where instantaneous active currents drawn for each decomposition of instantaneous active power: $\overrightarrow{i_{p000}^3}=\dfrac{p_{000}^3(n)}{|\vec{v}|^2}.\vec{v}$, $\overrightarrow{i_{p001}^3}=\dfrac{p_{001}^3(n)}{|\vec{v}|^2}.\vec{v}$, $\overrightarrow{i_{p010}^3}=\dfrac{p_{010}^3(n)}{|\vec{v}|^2}.\vec{v}$,

$$\overrightarrow{i_{p011}^{3}}=\frac{p_{011}^{3}(n)}{\left|\vec{v}\right|^{2}}.\vec{v},\ \overrightarrow{i_{p100}^{3}}=\frac{p_{100}^{3}(n)}{\left|\vec{v}\right|^{2}}.\vec{v},\ \overrightarrow{i_{p101}^{3}}=\frac{p_{101}^{3}(n)}{\left|\vec{v}\right|^{2}}.\vec{v},$$

$$\overrightarrow{i_{p110}^{3}}=\frac{p_{110}^{3}(n)}{\left|\vec{v}\right|^{2}}.\vec{v},\ \overrightarrow{i_{p111}^{3}}=\frac{p_{111}^{3}(n)}{\left|\vec{v}\right|^{2}}.\vec{v},$$

$$\vec{v}=\left[v_a(n)\quad v_b(n)\quad v_c(n)\right]^T.$$

Sum of these currents yields value of the drawn instantaneous active current

$$\vec{i}_p=\overrightarrow{i_{p000}^{3}}+\overrightarrow{i_{p001}^{3}}+\overrightarrow{i_{p010}^{3}}+\overrightarrow{i_{p011}^{3}}+\overrightarrow{i_{p100}^{3}}+\overrightarrow{i_{p101}^{3}}+\overrightarrow{i_{p110}^{3}}+\overrightarrow{i_{p111}^{3}}. \quad (17)$$

where instantaneous reactive currents drawn for each decomposition of instantaneous reactive power:

$$\overrightarrow{i_{q000}^{3}}=\frac{\overrightarrow{q_{000}^{3}}}{\left|\vec{v}\right|^{2}}\times\vec{v},\quad \overrightarrow{i_{q001}^{3}}=\frac{\overrightarrow{q_{001}^{3}}}{\left|\vec{v}\right|^{2}}\times\vec{v},\quad \overrightarrow{i_{q010}^{3}}=\frac{\overrightarrow{q_{010}^{3}}}{\left|\vec{v}\right|^{2}}\times\vec{v},$$

$$\overrightarrow{i_{q011}^{3}}=\frac{\overrightarrow{q_{011}^{3}}}{\left|\vec{v}\right|^{2}}\times\vec{v},\quad \overrightarrow{i_{q100}^{3}}=\frac{\overrightarrow{q_{100}^{3}}}{\left|\vec{v}\right|^{2}}\times\vec{v},\quad \overrightarrow{i_{q101}^{3}}=\frac{\overrightarrow{q_{101}^{3}}}{\left|\vec{v}\right|^{2}}\times\vec{v},$$

$$\overrightarrow{i_{q110}^{3}}=\frac{\overrightarrow{q_{110}^{3}}}{\left|\vec{v}\right|^{2}}\times\vec{v},\quad \overrightarrow{i_{q111}^{3}}=\frac{\overrightarrow{q_{111}^{3}}}{\left|\vec{v}\right|^{2}}\times\vec{v},$$

$$\vec{v}=\left[v_a(n)\quad v_b(n)\quad v_c(n)\right]^T.$$

Sum of these currents yields value of the drawn instantaneous reactive current

$$\vec{i}_q=\overrightarrow{i_{q000}^{3}}+\overrightarrow{i_{q001}^{3}}+\overrightarrow{i_{q010}^{3}}+\overrightarrow{i_{q011}^{3}}+\overrightarrow{i_{q100}^{3}}+\overrightarrow{i_{q101}^{3}}+\overrightarrow{i_{q110}^{3}}+\overrightarrow{i_{q111}^{3}}. \quad (18)$$

Frequency ranges of current decompositions for sampling rate of 0.000625 seconds are given in Table 1 [19].

Table 1. Wavelet packet decompositions of currents and their frequency ranges

Decomposition	Frequency Range (Hz)	Harmonic Order
$i_{p000}^{3}, i_{q000}^{3}$	700 ~ 800	15
$i_{p001}^{3}, i_{q001}^{3}$	600 ~ 700	13
$i_{p010}^{3}, i_{q010}^{3}$	500 ~ 600	11
$i_{p011}^{3}, i_{q011}^{3}$	400 ~ 500	9
$i_{p100}^{3}, i_{q100}^{3}$	300 ~ 400	7
$i_{p101}^{3}, i_{q101}^{3}$	200 ~ 300	5
$i_{p110}^{3}, i_{q110}^{3}$	100 ~ 200	3
$i_{p111}^{3}, i_{q111}^{3}$	0 ~ 100	1

As seen in the table, currents are decomposed into 100 Hz equal frequency ranges. Therefore, currents of $\overrightarrow{i_{p111}^{3}}$, $\overrightarrow{i_{q111}^{3}}$ are active and reactive currents drawn at fundamental frequency of 50 Hz. These currents cause $\bar{p}$ ve $\bar{q}$ powers from which the load requires from the source and consequently, all currents must be compensated except $\overrightarrow{i_{p111}^{3}}$ [19, 20, 21]. If $\vec{i_S}$ is the source current, $\vec{i_L}$ is the load current and $\vec{i_C}$ is the compensation current then

$$\vec{i}_L=\vec{i}_S+\vec{i}_C. \quad (19)$$

Because the load current is equal to sum of active and reactive currents then

$$\vec{i}_L=\vec{i}_p+\vec{i}_q,$$

$$\begin{aligned}\vec{i}_L=&\left(\overrightarrow{i_{p000}^{3}}+\overrightarrow{i_{p001}^{3}}+\overrightarrow{i_{p010}^{3}}\ldots\ldots+\overrightarrow{i_{p111}^{3}}\right)+\\&+\left(\overrightarrow{i_{q000}^{3}}+\overrightarrow{i_{q001}^{3}}+\overrightarrow{i_{q010}^{3}}+\ldots\ldots+\overrightarrow{i_{q111}^{3}}\right).\end{aligned} \quad (20)$$

Because we aim that only the basic frequency $\overrightarrow{i_{p111}^{3}}$ active current is drawn from the source, all other current components account for shunt compensator's reference current ($\vec{i_R}$). Thus,

$$\begin{cases}\vec{i}_L=\overrightarrow{i_{p111}^{3}}+\underbrace{\begin{pmatrix}\overrightarrow{i_{p000}^{3}}+\overrightarrow{i_{p001}^{3}}+\overrightarrow{i_{p010}^{3}}\ldots\ldots\overrightarrow{i_{p110}^{3}}+\overrightarrow{i_{q000}^{3}}+\\ \overrightarrow{i_{q001}^{3}}+\overrightarrow{i_{q010}^{3}}+\ldots\ldots+\overrightarrow{i_{q111}^{3}}\end{pmatrix}}_{\vec{i}_R},\\ \vec{i}_R=\overrightarrow{i_{p000}^{3}}+\overrightarrow{i_{p001}^{3}}+\overrightarrow{i_{p010}^{3}}\ldots\ldots\overrightarrow{i_{p110}^{3}}+\overrightarrow{i_{q000}^{3}}+\ldots\ldots+\overrightarrow{i_{q111}^{3}}.\end{cases} \quad (21)$$

Working principle of DWPT-based reactive power and harmonic compensator is given in Fig. 1.

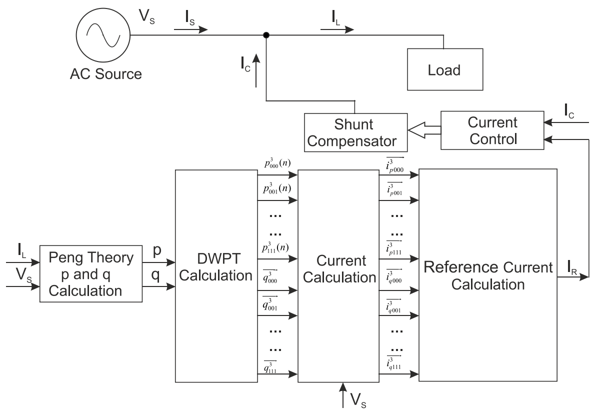

Fig. 1. DWPT based reactive power and harmonic compensator

Simulation results

Calculations and simulations were carried out according to p-q theory, as first, and then, according to the proposed method. Then, the results were compared. db20 was used in all DWPT simulations.

Phase-neutral effective value of source voltage is 2400 V and frequency is 50 Hz. Fig. 2 shows configuration of the compensation system. It was assumed that the compensator can track the reference current at instantaneously at infinite speed. Fig. 3 shows the source voltage and non-linear load current.

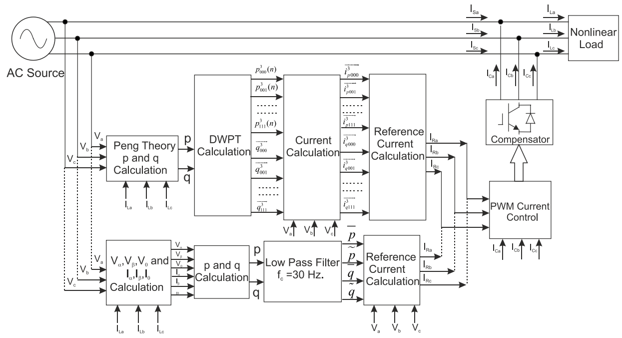

Fig. 2. Three phase reactive and harmonic compensation system

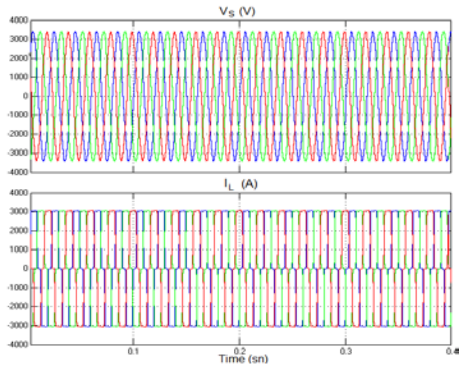

Fig. 3. Three phase source voltage and load current

p and q powers produced through (1–5) based on p-q theory are given in Fig. 4.

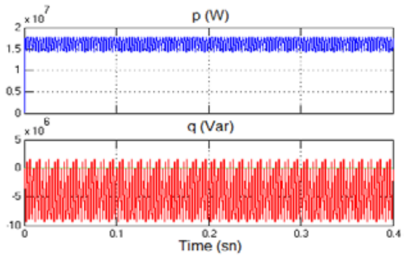

Fig. 4. Three phase instantaneous active and reactive power according to p-q theory

To find $\overline{p}$, p signal was made pass through a low-pass filter, whose cut-off frequency was 30 Hz. Fig. 5 shows fundamental frequency instantaneous active current, ($\vec{i}_f$) and compensator's reference current ($\vec{i}_R$) obtained by using (6).

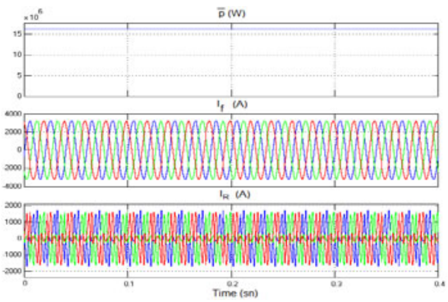

Fig. 5. Obtained $\overline{p}$, $\vec{i}_f$ and $\vec{i}_R$ values according to p-q theory

Fig. 6 and 7 show DWPT decompositions of instantaneous active and reactive powers found by using (12–16) according to generalized reactive power theory.

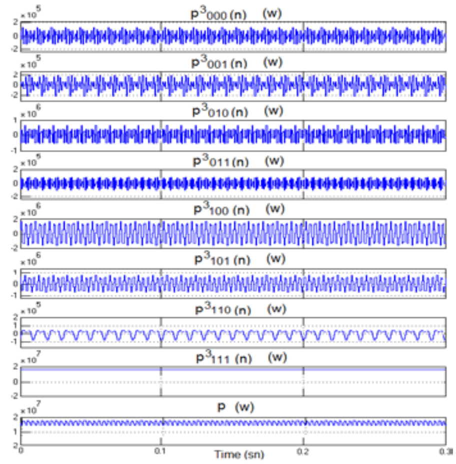

Fig. 6. Decompositions of instantaneous active power according to generalized reactive power theory

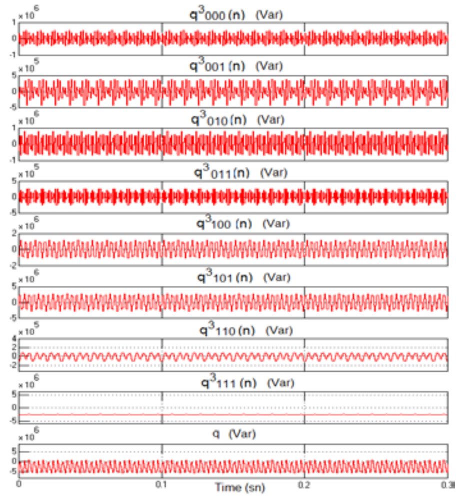

Fig. 7. DWPT decompositions of instantaneous reactive power according to generalized reactive power theory

Fig. 8 and 9 show DWPT decompositions of instantaneous active and reactive currents found by using (17–18) according to generalized reactive power theory.

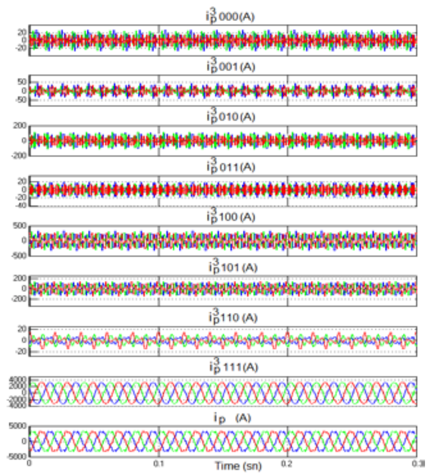

Fig. 8. DWPT decompositions of instantaneous active current according to generalized reactive power theory

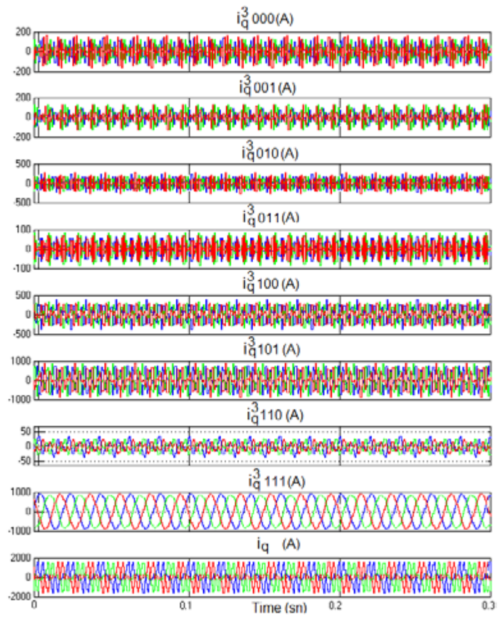

Fig. 9. DWPT decompositions of instantaneous reactive current according to generalized reactive power theory

Fig. 10 shows compensator's reference current $\vec{i_R}$ values calculated according to the proposed method considering $\overline{p} = p_{111}^{3}(n)$ and $\vec{i_f} = \overrightarrow{i_{p111}^{3}}$.

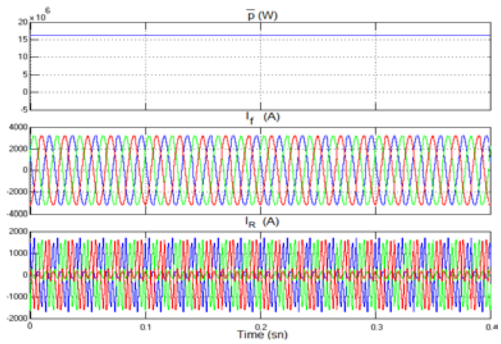

Fig. 10. Obtained $\overline{p}$ $(p_{111}^{3}(n))$, $\vec{i_f}$ $(\overrightarrow{i_{p111}^{3}})$ and $\vec{i_R}$ values according to proposed method

Fig. 11 shows the compensation results obtained through both of the methods

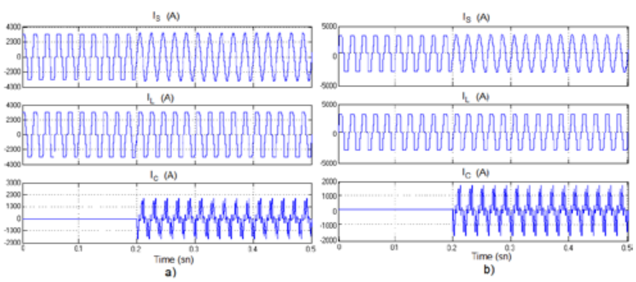

Fig. 11. A phase currents of $\vec{i_S}$, $\vec{i_L}$, $\vec{i_C}$ a) p-q theory b) proposed method

The biggest difference value in of both compensation currents is around ± 7 A (Fig. 12).

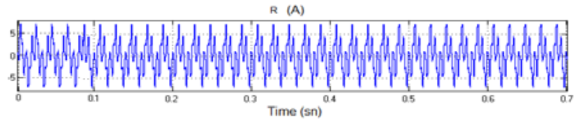

Fig. 12. Residual of compensation currents

Conclusions

In this study, a DWPT-based method was proposed for calculating reference current for active compensation systems. Unlike classical methods, mean instantaneous active power ($\overline{p}$) was obtained directly through DWPT and moreover, instantaneous active power signal (p) does not require to be made pass through low-pass filter. Fundamental frequency instantaneous active current ($\vec{i_f}$), reference current ($\vec{i_R}$) and other currents can be calculated easily by using proposed method. In comparison of the obtained compensation current with that, which is obtained according to p-q theory, maximum variation in current is ± 7 A. This accounts for very small and negligible error as 0.43% according to maximum compensation current, ± 1600 A. Thus, the proposed method can be used in active harmonic and compensation systems.

References

1. **Bayındır K. Ç., Ermiş M.** Understanding the Modelling and Analysis of a Shunt Active Power Filter Using MATLAB/Simulink // International Journal of Electrical Engineering Education, 2006. – Vol. 43 (3). – P. 185–205.
2. **George M., Basu K. P.** Three-Phase Shunt Active Power Filter // American Journal of Applied Sciences, 2008. – Vol. 5(8). – P. 909–916.
3. **Syed M. K., Ram B. S.** Instantaneous Power Theory Based Active Power Filter: a Matlab/ Simulink Approach // Journal of Theoretical and Applied Information Technology, 2008. – Vol. 4(6). – P. 536–541.
4. **George M., Basu K. P.** Modeling and Control of Three-Phase Shunt Active Power Filter // American Journal of Applied Sciences, 2008. – Vol. 5(8). – P. 1064–1070.
5. **Afonso J. L., Freitas M. J. S., Martins J. S.** p-q Theory Power Components Calculations // ISIE'2003 - IEEE International Symposium on Industrial Electronics. – Rio de Janeiro, Brasil, 2003, – Vol. 1. – P. 385 – 390.
6. **Peng F. Z., Lai, J. S.** Reactive Power and Harmonic Compensation Based on Generalized Instantaneous Reactive Power Theory for Three-Phase Power Systems // 7th international conference on harmonic and quality of power. – Las Vegas, United States, 1996. – P. 1–7.
7. **Tolbert L. M., Habetler T. M.** Comparison of Time Based Non-Active Power Definitions for Active Filtering // Power Electronics Congress, VII IEEE International, 2000. – P. 73–79.
8. **Xu L., Han Y., Pan J., Chen C., Yao G., Zhou L.D.** Selective Compensation Strategies for the 3-Phase Cascaded Multilevel Active Power Filter using ANF-based Sequence Decoupling Scheme // Electronics and Electrical Engineering. – Kaunas: Technologija, 2010. – No. 2(98). – P. 15–20.
9. **Han Y., Xu L., Yao G., Zhou L. D., Mansoor, Chen C.** Operation Principles and Control Strategies of Cascaded H-bridge Multilevel Active Power Filter // Electronics and Electrical Engineering. – Kaunas: Technologija, 2009. – No. 3(91). – P. 71–76.

10. **Han Y., Xu L., Yao G., Zhou L.D., Khan MM., Chen C.** The Adaptive Signal Processing Scheme for Power Quality Conditioning Applications Based on Active Noise Control (ANC) // Electronics and Electrical Engineering. – Kaunas: Technologija, 2009. – No. 8(96). – P. 9–14.
11. **Benslimane T.** Open Switch Faults Detection and Localization Algorithm for Three Phases Shunt Active Power Filter based on Two Level Voltage Source Inverter // Electronics and Electrical Engineering. – Kaunas: Technologija, 2007. – No. 2(74). – P. 21–24.
12. **Driesen J., Belmans R.** Active Power Filter Control Algorithms using Wavelet-Based Power Definitions // 10th International Conference on Harmonics and Quality of Power (ICHQP). – Rio de Janeiro, Brazil, 2002. – Vol. 2. – P. 466 – 471.
13. **Pou F., J.** Modulation and Control of Three-Phase PWM Multilevel Converters // Technical University of Catalonia, PhD. Thesis. – Barcelona, 2002. – P. 193–200.
14. **Tahri A., Draou A.** Design of a Simple Measuring Technique of The Instantaneous Power in Three Phase System // Journal of Electrical Engineering, 2005. – Vol. 56. – No.7–8. – P. 221–224.
15. **Janicek F., Mucha M., Ostrozlik M.** A New Protection Relay Based on a Fault Transient Analysis Using Wavelet Transform // Journal of Electrical Engineering, 2007. – Vol. 58. – No. 5. – P. 271–278.
16. **Khan M. A. S. K., Radwan T. S., Rahman M. A.** Wavelet Packet Transform Based Protection of Disturbances Three-Phase Interior Permanent Magnet Motor Fed From Sinusoidal PWM Voltage Source Inverter // Electrical and Computer Engineering, CCECE'06. – Canadian Conference, 2006. – P. 178–181.
17. **Deng H., Ling H.** Fast Solution of Electromagnetic Integral Equations Using Adaptive Wavelet Packet Transform // IEEE Transaction on Antennas and Propagation, 1999. – Vol. 47. – P. 674–682.
18. **Onat N., Kıyak İ., Gökmen G.** Experimental Wavelet Packet Transient-State Analysis of Electrical Machines Directly Fed by Photovoltaic Cells // International Review of Electrical Engineering (I.R.E.E.), 2010. – Vol. 5. – No. 5. – Part 1. – P. 2081 –2087.
19. **Barros J., Diego R. J.** Analysis of Harmonics in Power Systems Using the Wavelet Packet Transform // Proceedings of the IEEE Instrumentation and Measurement Technology Conference, IMTC 2005. – Vol. 2. – P. 1484–1488.
20. **Gligor A.** Design and Simulation of a Shunt Active Filter in Application for Control of Harmonic Levels // Electrical and Mechanical Engineering, 2009. – Vol. 1. – P. 53–63.
21. **Couto E. F., Martins J. S., Afonso J. L.** Simulation Result of a Shunt Active Power Filter with Control Based on p-q Theory // International Conference on Renewable Energies and Power Quality, ICREPQ'03. – Vigo, 2003. – P. 1–6.

Received 2010 10 22

G. Gokmen. Wavelet Based Reference Current Calculation Method for Active Compensation Systems // Electronics and Electrical Engineering. – Kaunas: Technologija, 2011. – No. 2(108). – P. 61–66.

Today, active compensation systems have become more preferable compared with passive compensation systems. Performance of an active compensation system depends on current control method of the compensator as well as how this current is generated. In this study, a Discrete Wavelet Packets Transform (DWPT) based method was proposed for calculating reference current of active compensation systems and the results were compared with the currents produced from classical p-q theory. According to the obtained results, the proposed method can be used in active compensation systems without using an additional signal processing and filtering method. Ill. 12, bibl. 21, tabl. 1 (in English; abstracts in English and Lithuanian).

G. Gokmen. Vilnelių šaltinio srovės apskaičiavimo metodo taikymas aktyviosioms kompensavimo sistemoms // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 2(108). – P. 61–66.

Aktyviosios kompensavimo sistemos taikomos vis plačiau nei pasyviosios kompensavimo sistemos. Aktyviųjų kompensavimo sistemų našumas tiesiogiai priklauso nuo metodo taikomo srovei valdyti kompensatoriuje ir nuo generuojamos srovės dydžio. Šaltinio srovei apskaičiuoti aktyviosiose kompensavimo sistemose buvo pasiūlytas diskretinis vilnelių transformacijos paketų metodas. Gauti rezultatai palyginti su rezultatais, gautais taikant klasikinę p-q teoriją. Nustatyta, kad pasiūlytas metodas gali būti taikomas aktyviosiose kompensavimo sistemose be papildomų signalų apdorojimo ir filtravimo metodų. Il. 12, bibl. 21, lent. 1 (anglų kalba; santraukos anglų ir lietuvių k.).