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The Harmonic Current Detection Method based on Improved SVSLMS Algorithm

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Abstract

Harmonic current detection method plays a very important role in the harmonic compensation effect. This paper presents an improved Sigmoid Variable Step-size Least Mean Square (SVSLMS) harmonic current detecting method based on the analysis of the steady-state error generated by traditional SVSLMS, This method re-define and select the feedback error coefficient, By using a frequency-selective filter for filtering the original feedback error, to reduce the effects of harmonics on detection performance, further improve the response speed and steady precision. Simulation results verify the effectiveness and practicality of this method.

Keywords: *improved SVSLMS algorithm, harmonic, detection*

1. Introduction

1950s, Howells is first proposed principle of adaptive cancellation in order to eliminate sidelobe antenna signal. Then based on the Least Mean Square (LMS) adaptive noise cancellation technology have been widely applicated in the field of signal processing. Because of such adaptive algorithm has a simple structure and a strong adaptive learning ability, in recent years, the applicaton of this method are more and more in the power system harmonics and reactive current detection [1-9]. In order to overcome the shortcoming that traditional fixed step size LMS algorithm can not meet the convergence speed and steady-state error is small request, achieve both fast convergence and small steady state error detection results, factor can be changed in real time step size.

The Reference [2] create a linear relationship between step factor $e(n)$ and the errorμ, that is to say, the larger the step when the error factor greater. The initial stage of the algorithm, Since larger error, so the step size factor is also larger, maked the convergence became fast; When the error is reduced, step factor also followed the decrease, approaching the steady state value, at this point the error approaches to zero, the step length is close to zero, thus ensuring steady precision smaller. However, this method particularly sensitive to disturbance of the input terminal, easily lead to larger error noise parameters. The Reference [4] establishing the non-linear function between step factor L and the error signal, proposed a new variable step size Least Mean Square (LMS) algorithm, The algorithm has the characteristics of time-varying step size automatically increases steady state small steps in initial phase and the phase of the unknown system, and overcome the defects that S-function variable step size LMS algorithm in adaptive steady-state phase $L(n)$ value is too large, achieved the effect better than the traditional LMS algorithm convergence speed and accuracy, However, there is still a big step change in the steady-state phase. The Reference [5] proposed a improved SVSLMS algorithm, by resetting the covariance matrix update equation and adding exponential forgetting factor, deduced a least squares algorithm with adaptive variable forgetting factor recursive, And it's application in a decision feedback equalizer DFE, in the time-varying channel environment with good tracking capability and a smaller transmission error rate. This paper analyzes the causes of traditional SVSLMS harmonic and reactive current detection method produces steady-state error, and on this basis proposes an improved adaptive harmonic current detection method, to filtering the original feedback error processing reduces harmonic detection performance by

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using a frequency-selective filter, in order to further improve the response speed and steady precision.

2. SVSLMS Algorithm Harmonic Current Detection Method

In order to overcome the shortcoming that traditional fixed step size LMS algorithm can not meet the convergence speed and steady-state error is small request, achieve both fast convergence and small steady state error detection results, factor can be changed in real time step size, establishing the relationship between step size μ and the error $e(n)$ is: $e(n)$ is large, take a larger μ, to accelerate the dynamic convergence speed; $e(n)$ is small, take a smaller μ, to improve steady-state precision of convergence. A number of different methods of dynamically changing steps be made in practice, as more representative of SVSLMS algorithm, the step update equation of the method is [9]:

$$\mu(k+1)=\beta\left(\frac{1}{1+\exp\left(-\alpha|e(k)|^m\right)}-0.5\right), \alpha\geq 0\ , \beta\in(0,1) \tag{1}$$

Where, α is a constant controlling function-shaped, β is a constant control function scope.

Thus obtained the variable update equation of SVSLMS algorithm:

$$\begin{cases} y(n)=W^T(n)X(n) \\ e(n)=i_l(n)-y(n) \\ W(n+1)=W(n)+2\mu e(n)X(n) \\ \mu(k+1)=\beta\left(\frac{1}{1+\exp\left(-\alpha|e(k)|^m\right)}-0.5\right) \end{cases}, \alpha\geq 0\ ,\ \beta\in(0,1) \tag{2}$$

The algorithm is applied to the harmonic current detection, can get SVSLMS algorithm harmonic detection schematic, as shown in Figure 1.

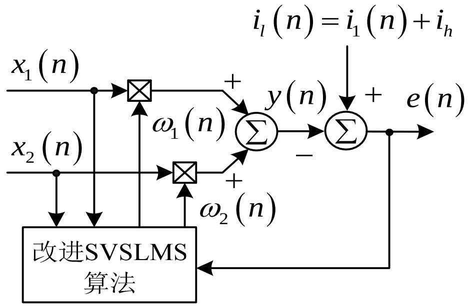


Figure 1. The SVSLMS Algorithm Harmonic Detection Schematic

Compared with the traditional LMS algorithm, the harmonic current detection method based on SVSLMS algorithm had fast convergence rate, dynamic response rate became significantly faster. However, steady-state error is still large, especially in the early iterations; identification results compared with the actual system parameters had larger error.

3. Improved SVSLMS Algorithm Harmonic Current Detection Method

By the adaptive harmonic current detection principle can be known, we are using the method what the fundamental active current and reactive currents to approximate the fundamental current to achieve harmonic current detection. So there is a problem, when the fundamental active current and fundamental reactive currents have been close to the actual fundamental current, where the error e (n) is the harmonic current, but, the harmonic current as the detection target, if its size is not zero, so when fed back will cause step instability in SVSLMS algorithm, eventually lead to a larger steady-state error [9]. However harmonic current detected actually, Changes of the harmonic size in the moments, so to solve this problem must be redefined and selection feedback error:

$$e(n) = i_l(n) - i_{1p}^{'} - i_{1q}^{'} = i_{1p} + i_{1q} + i_h - \left(i_{1p}^{'} + i_{1q}^{'}\right) \quad (3)$$

$$e(n) = \xi + i_h \quad (4)$$

As can be seen from the above formula, real feedback error should be selected in the ξ, so when the fundamental active and reactive currents close to the actual fundamental current, feedback error approached zero, thereby the entire detection system became stabilized. To this end, can made $e(n)$ to a filtering process, to reduce higher harmonics which impact on the detection system, at the same time Retained the fundamental current whit no attenuation, no phase shift, thus uses a frequency-selective filter [7,8] for $e(n)$ to a filtering process, this filter can be achieved on the input signal without static error tracking. The working Principle as shown in Figure 2.

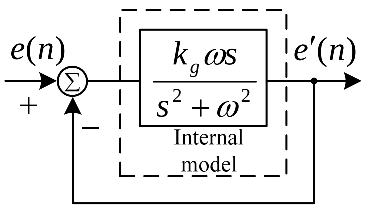


Figure 2. The Schematic of Frequency-selective Filter

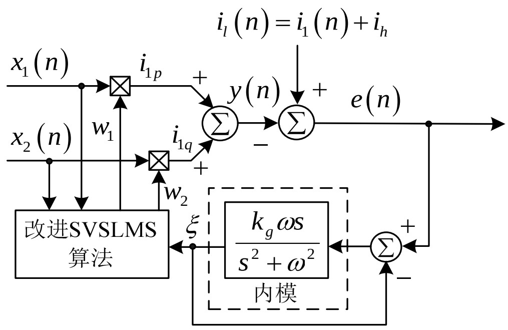


Figure 3. The Improved SVSLMS Algorithm Harmonic Detection Schematic

The frequency-selective filter transfer function can be drawn from Figure 5.

$$G(s) = \frac{k_g \omega s}{s^2 + k_g \omega s + \omega^2} \quad (5)$$

Where, ω is the fundamental angular frequency, k_g is the adjustment coefficient.

Increased frequency-selective filters in traditional SVSLMS harmonic current detection diagram, the new adaptive harmonic current detection method diagram as shown in Figure 3. As the selected frequency filter can well suppress high-frequency signal, can effectively suppress high-frequency signal of the detecting means, added a feedback link, thus greatly improving the accuracy of harmonic detection. And reduce the amount of calculation of SVSLMS algorithms, the dynamic response speed also increased.

Since this method is through fundamental active and reactive currents to approximate the fundamental current, this method can also be used for detection of the reactive current, fundamental active current.

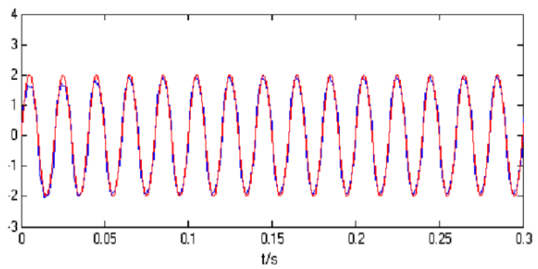
4. Simulation Analysis

4.1. The Simulation Analysis of SVSLMS Harmonic Detection

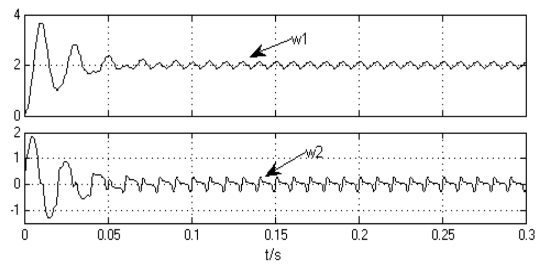
In matlab 7.1 environment for SVSLMS harmonic current detection method for simulation, the main parameters selected as $m = 2$, $\alpha = 50$, $\beta = 0.2$, and take the:

$$i_l(n) = 2\sin(100\pi t) + 0.22\sin(300\pi t) + 0.12\sin(500\pi t) + 0.05\sin(700\pi t) \qquad (6)$$

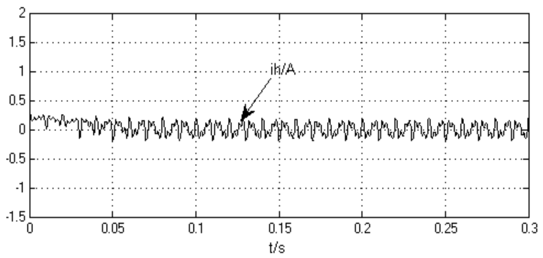
Where, $t = kT_s$, sampling time constant $T_s = 50e-6s$, reference input vector $X(t) = [\sin(100\pi t), \cos(100\pi t)]$, Weight vector $W(t) = [w1(t), w2(t)]$, take the initial value of zero. The simulation results as shown in Figure 4, seen from the figure, the harmonic current detection method based on SVSLMS algorithm converges faster, however, steady-state error is also larger. As shown in Figure 4(a), the red curve is the desired signal.



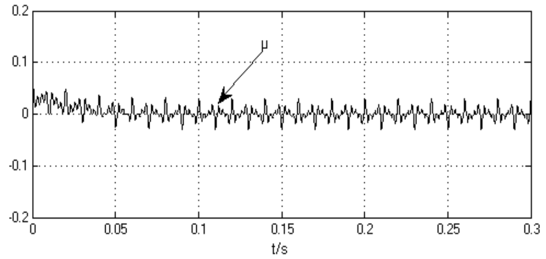
(a) Output signal waveform



(b) Weights adjustment waveform



(c) Harmonic current waveform



(d) Step adjustment waveform

Figure 4. Simulation Waveforms

4.2. The Simulation Analysis of Improved SVSLMS Harmonic Detection

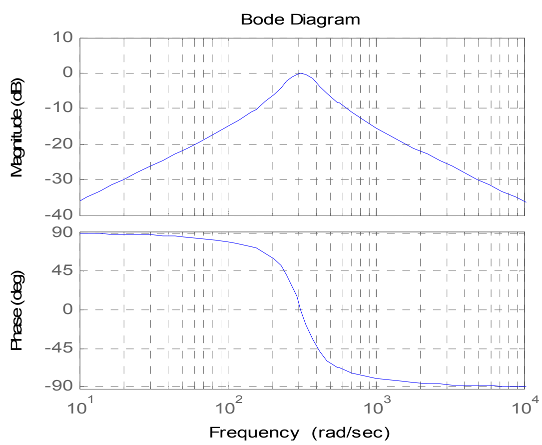
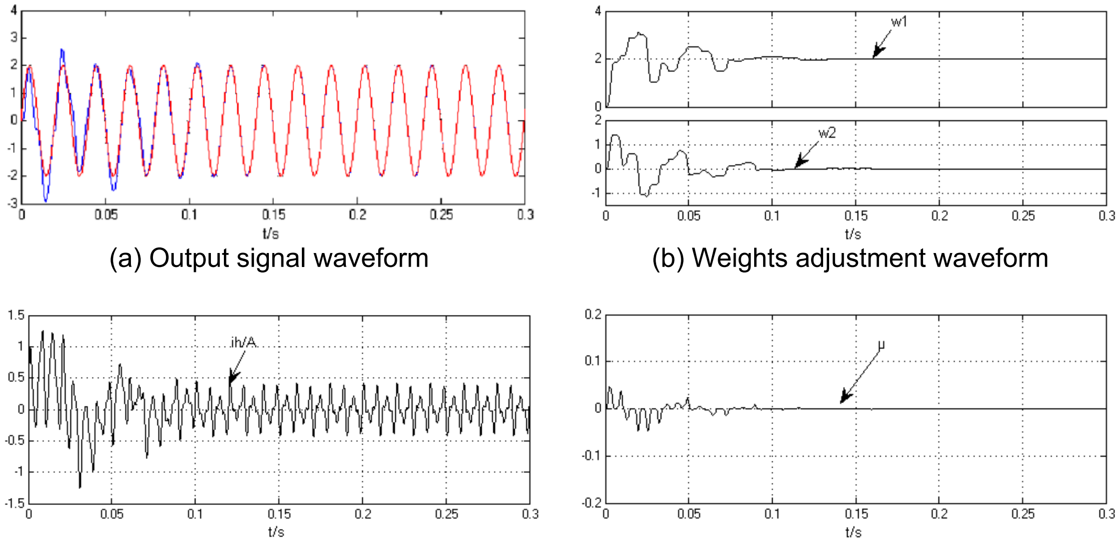


Figure 5. Bode Plot of Frequency Selective Filter

In matlab7.1 environment for improved SVSLMS harmonic current detection method for simulation, through simulation debugging repeatedly, Take $k_g = 0.5$ is better, using matlab to plot the Bode diagram of frequency-selective filters as shown in Figure 5. As can be seen from figure, the attenuation and phase shift of fundamental component are almost zero by frequency selective filter, and there is a significant attenuation of the harmonics, comply with the above requirements of the filter, can greatly reduce the effects of harmonics on detection system.

In matlab7.1 environment, current Value, sampling time constant, reference input vector, weight vector and initial value all with the former. The simulation results as shown in Figure 6. Seen from the figure, compared with the traditional SVSLMS algorithm, the improved adaptive harmonic current detection method had fast convergence rate, dynamic response rate became significantly faster, steady state error almost of zero, which verifies the proposed method is reasonable and effective. As shown in Figure 6(a), the red curve is the desired signal.



(a) Output signal waveform (b) Weights adjustment waveform

(c) Harmonic current waveform (d) Step adjustment waveform

Figure 6. Simulation Waveforms

5. Conclusion

Aim to the traditional SVSLMS harmonic current detection methods can not take into account the problem of convergence speed and detection accuracy, this paper proposed a improved SVSLMS harmonic current detection method. Compared with traditional SVSLMS method, this method by using a frequency-selective filter for filtering the original feedback error, to reduce the effects of harmonics on detection performance, further improve the response speed and steady precision.

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