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An Improvement Detection Technology of APF based on the Digital Sliding Filter

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Abstract

With the use of the power electronic device, the grid is more and more serious from the harmonic. In this paper, we improve the related link of active filter on the basis of the predecessors. And we get an ideal effect. Firstly, the traditional method uses low pass filter in the filtering process of harmonic detection technology. We introduce a digital moving average filter in this paper. Secondly, the traditional method uses the Hysteresis comparison control and triangle carrier wave control on the current control strategy. We introduce the comparison of timing control to this paper, It can easily control the sampling frequency.

Keywords: *APF, harmonic detection, current control, timing control*

1. Introduction

Whether we can quickly and accurately detect harmonic current or not is the key to the overall performance of the active filter. We only need to detect the total distortion of wave current beyond the base on the harmonic detection. Based on the instantaneous reactive power theory is the main detection method today. This method has litter effect from the change of the power frequency, has simple circuit, has short delay, has well real-time. It was the most widely used methods of the harmonic detection recently. The low pass filter has largely effect on the testing result. The traditional method of low pass filter has butterworth filter, chebyshev filter, elliptic function filter, although they have higher detection accuracy, the response is slow. We introduce a new detection method to improve situation, it is the sliding average low pass filter.

2. The Principle of Harmonic Detection

The research object is three-phase three-wire system harmonic detection in this paper, this paper discusses two kinds of circumstance: symmetrical load and unsymmetrical load. The instantaneous reactive power theory detection principle diagram is shown in 1-1.

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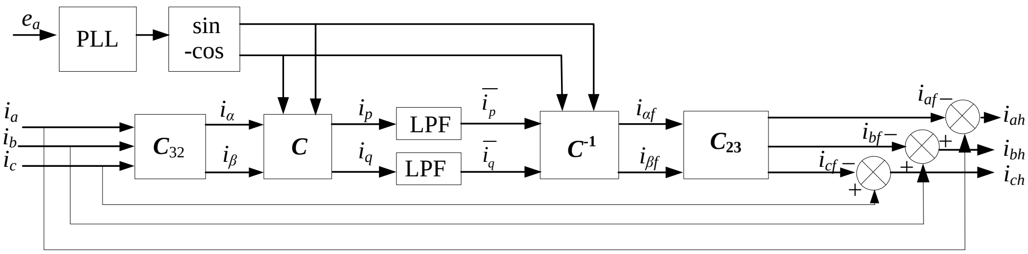

Figure 1-1. the instantaneous reactive power theory detection principle diagram

This paper uses i_p-i_q to test. We got the same phase of sine and cosine signal after a phase voltage of power grid e_a passes a phase locked loop. We use the measured for three-phase load current turn into i_p-i_q through coordinate change. The active i_p-i_q becomes DC component $\bar{i}_p$-$\bar{i}_q$ through low pass filter. Then we get the fundamental component i_{af}, i_{bf}, i_{cf} through the coordinate reverse change. Using the load current subtracts the fundamental component. We get the compensation of the current instruction value i_{ah}, i_{bh}, i_{ch} .

Which

$$\boldsymbol{C}_{32} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \tag{1}$$

$$C = \begin{bmatrix} \sin\omega t & -\cos\omega t \\ -\cos\omega t & -\sin\omega t \end{bmatrix} \tag{2}$$

3. The Improved Harmonic Detection Method

Considering three phase three wire system with three-phase symmetrical load, it contains (3k)th、(6k±1)th harmonic, (3k)th harmonic is zero sequence component, (6k-1)th harmonic is negative sequence component, (6k-1)th harmonic is positive sequence component. through synchronous rotating coordinate transformation, the times of zero sequence component is zero, compared with fundamental wave, the times of positive sequence component subtracts 1 ,the times of negative sequence component add 1,so the times of harmonic is 6 times after system transformation. The average filtering method to extract the fundamental component diagram is shown as Figure 1-2.

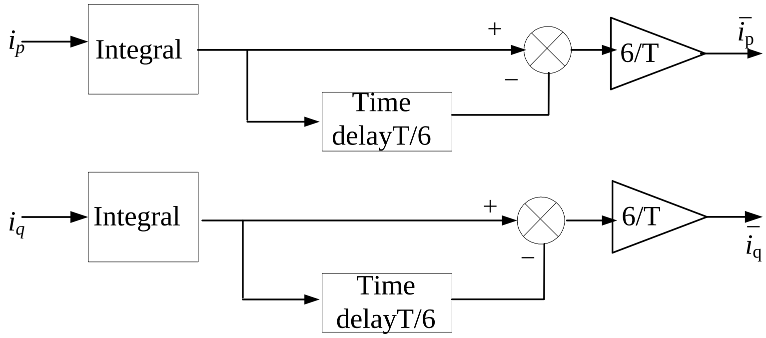

Figure 1-2. Schematic diagram of algorithm extracts fundamental current

From the figure, to integrate i_p-i_q, when the load is the symmetrical, the 1/6 of the power grid cycle (T) is the integral period. When the load is the unsymmetrical, the 1/3 of the power grid cycle (T) is the integral period.

Average filtering algorithm is:

$$y_{average} = \frac{1}{T}\int_{t}^{t+T} x(t)dt \tag{3}$$

After the discrete, we get the digital average filtering algorithm.

$$y_{average} = \frac{1}{N}\sum_{i=k}^{k+N} x(i) \tag{4}$$

In order to meet the requirement of the real-time of the APF, we use the ideas of sliding window of data. Sampling data of windows of sliding mean filter is shown as Figure 1-3.

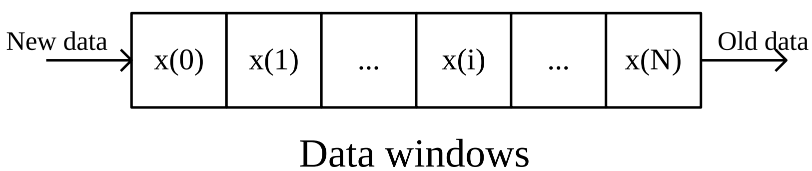

Figure 1-3. Sampling data window of sliding mean filter

From the figure, the first data of the next cycle replace the first of point of the first cycle after the first cycle has completed. And so on, a new sampling data replaces the old one. The point of the calculation is N. This method has less calculation and has better real-time.

4. The Result of Simulation Analysis

4.1. Compared with the result of two kinds of the filter

We compared the digital low pass filter with the sliding average filter in this paper, the characteristic of the low pass filter is shown as Figure 1-4,and the characteristic of the sliding average filter is shown ad Figure 1-5.

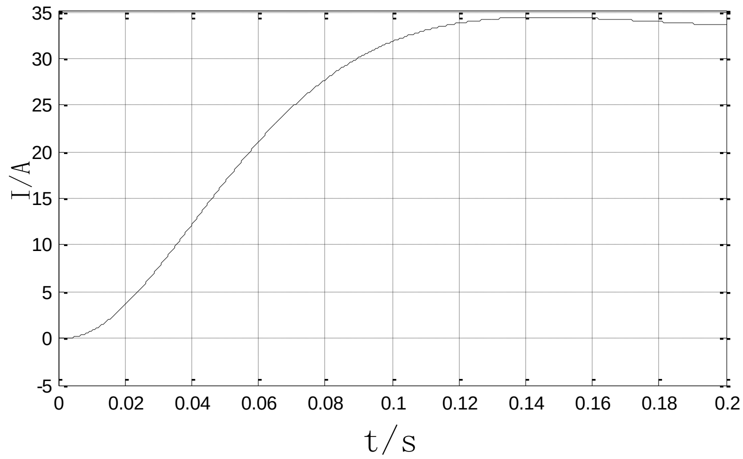

Figure 1-4. Filter characteristic of low pass filter

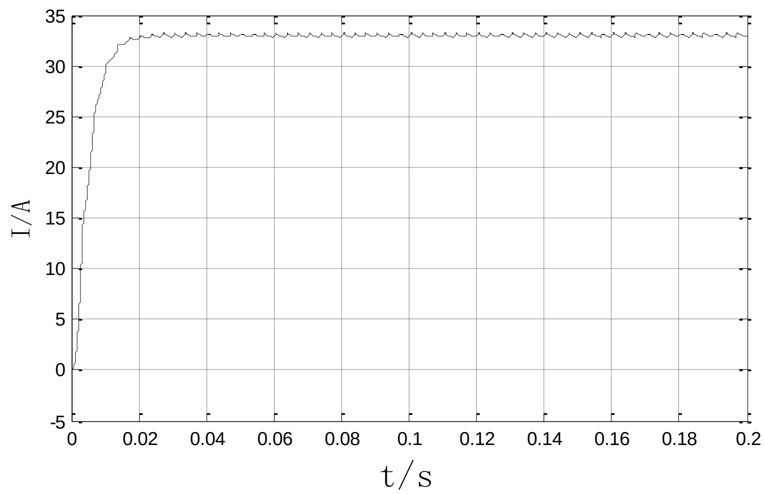

Figure 1-5. Filter characteristic of sliding mean filter

From the comparison of two figures, we can see that the dynamic response of the sliding average filter is less than the low pass filter. We can get that the low pass filter need two cycles to achieve stable, but the sliding average filter needs only one. And it has better filtering character.

4.2. System simulation

4.2.1. Symmetrical load

We choose the three-phase power is 380V, the frequency is 50Hz, the load is inductance series three-phase bridge rectifier circuit. Which the load is the symmetrical, the inductance value is 2.5mH, through the simulation research, we get the currents waveform and the FFT spectrum analysis figure of A phase between pre and post compensation. It is shown from 1-6 to 1-9.

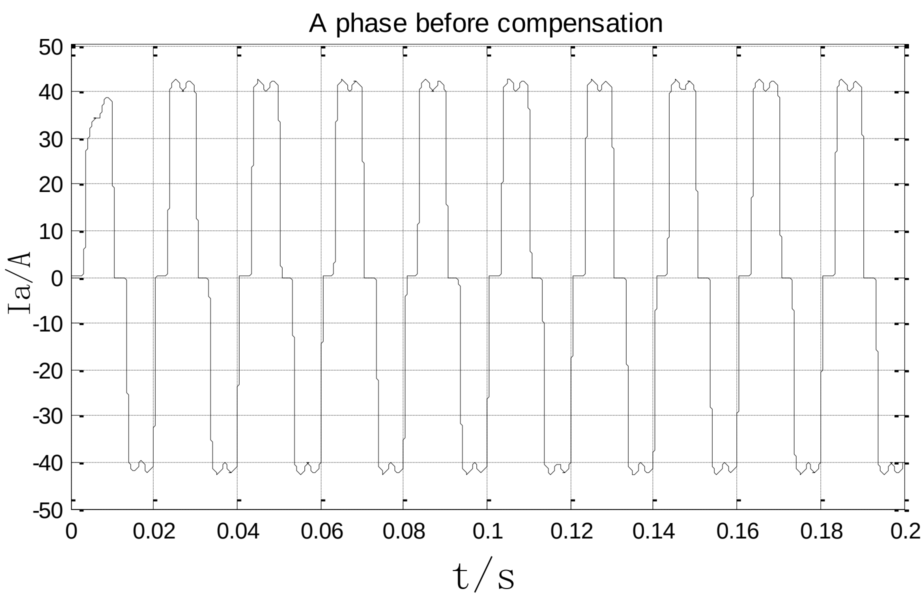

Figure 1-6. Current simulation diagram of A-phase before compensation

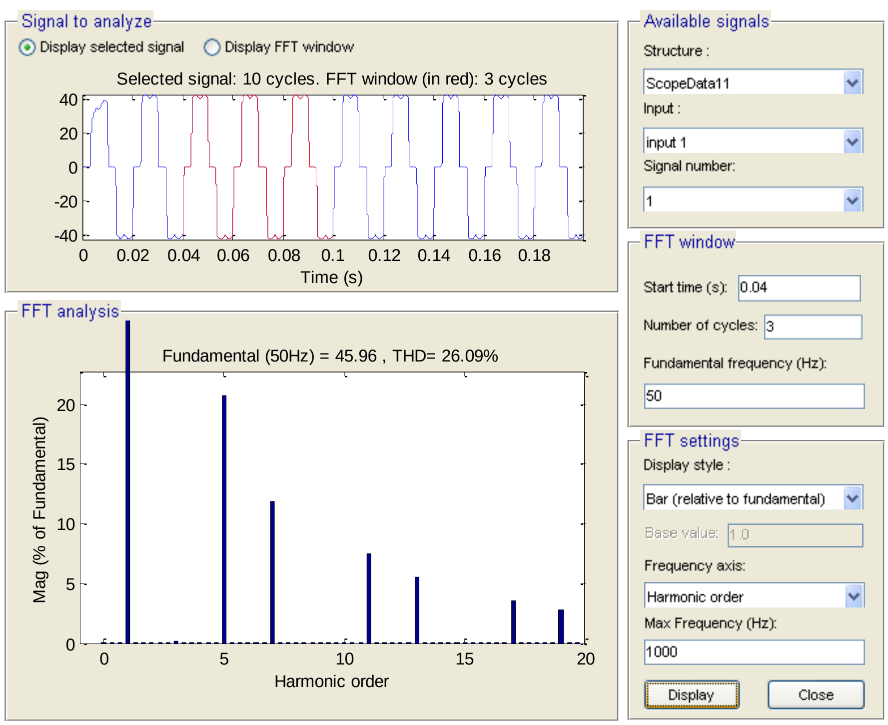

Figure 1-7. the FFT spectrum diagram of A-phase before compensation

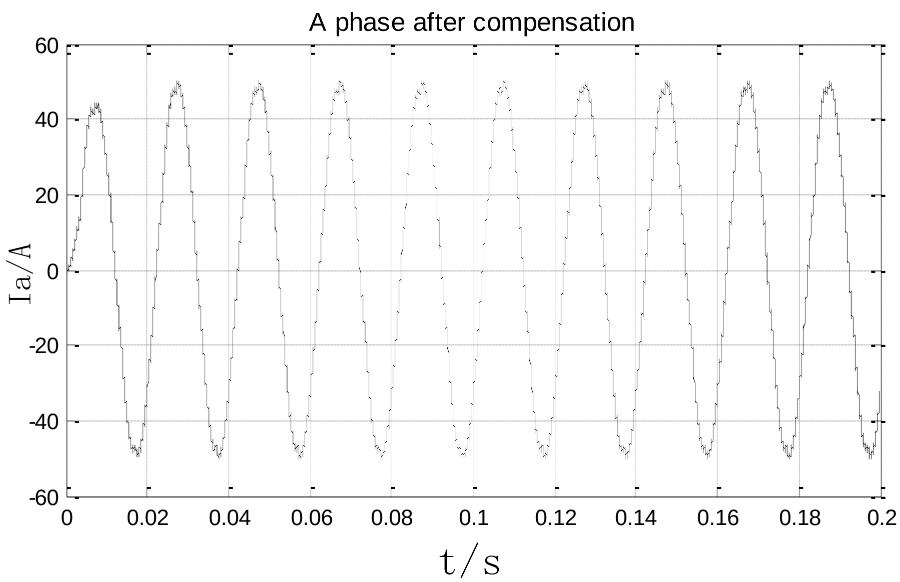

Figure 1-8. Current simulation diagram of A-phase after compensation

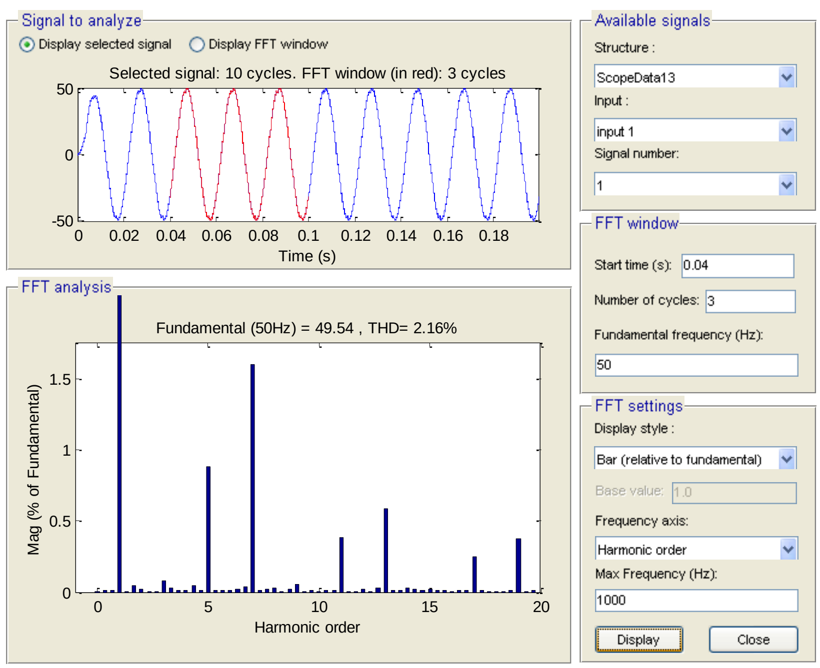

Figure 1-9. the FFT spectrum diagram of A-phase after compensation

4.2.2. Unsymmetrical load

We choose the three-phase power is 380V, the frequency is 50Hz, load is inductance series three-phase bridge rectifier circuit. To A phase, the resistance value takes 20 W, the inductance value takes 2.5mH, to B and C phase, the resistance value takes 10 W, the inductance value takes 2mH. Through the simulation research, we get the current waveform and the FFT spectrum figures between pre and post compensation. It is shown from 1-10 to 1-13.

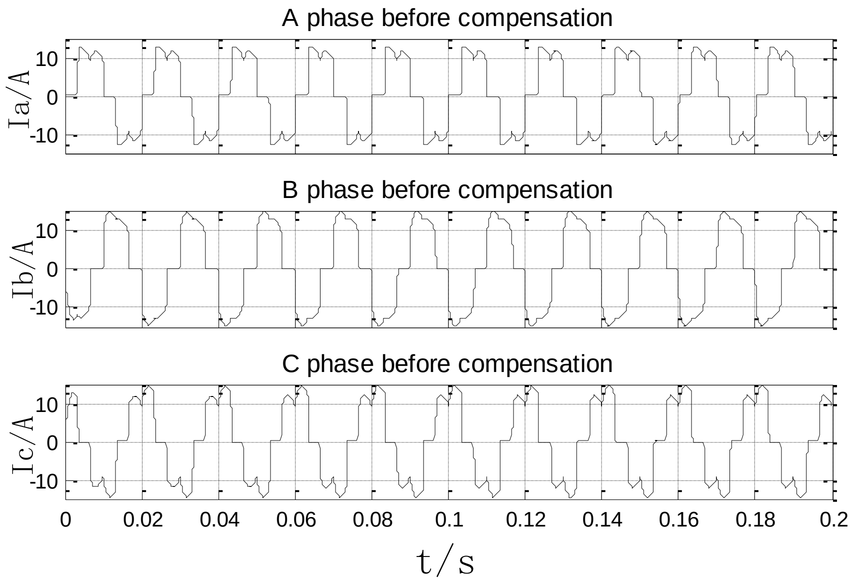

Figure 1-10. Current simulation diagram of three-phase before compensation

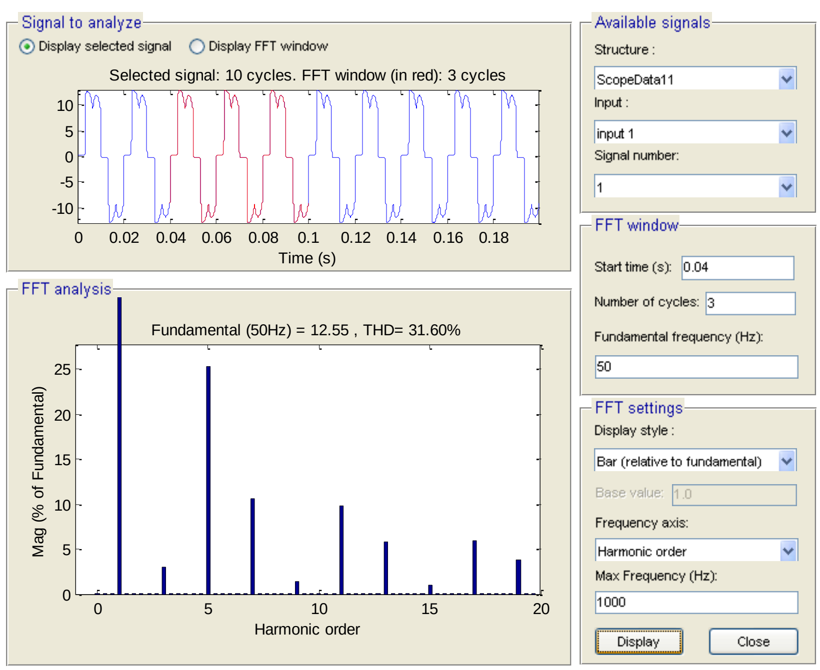

Figure 1-11. FFT spectrum diagram of three-phase before compensation

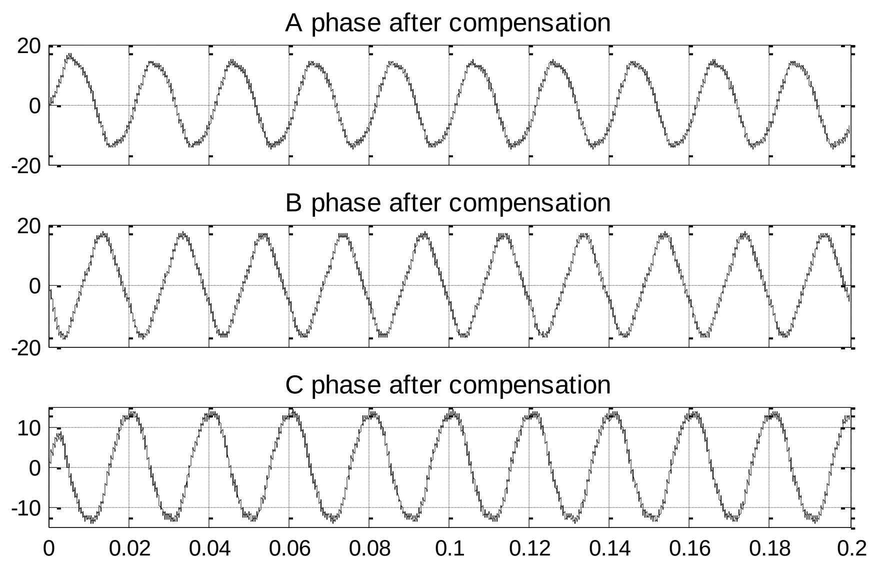

Figure 1-12. Current simulation diagram of three-phase after compensation

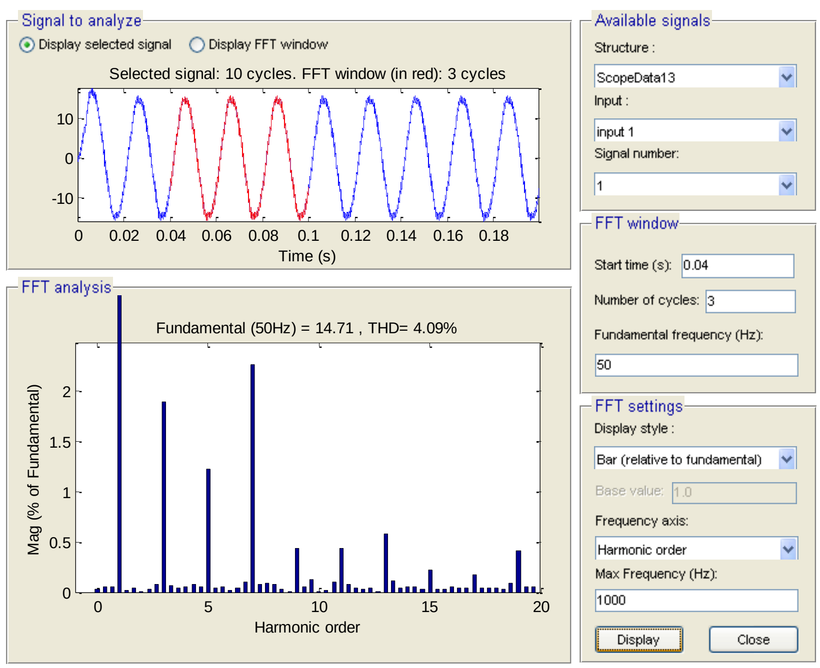

Figure 1-13. FFT spectrum diagram of three-phase after compensation

5. Conclusion

From the result of the simulation, we get that the new method has better result that the traditional one. It proves that the new method has the advantage in the future application. We need have some improvement in future to enhance the real-time .such as: introduction the self-adaptive algorithm, it may enhance the real-time more effective.

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