A Discussion on Strategies for Compensation on the Phase Voltage in ACIM

Xiaozhuang Wu, Peng Zhang, Xiaobin Ran, Dafang Wang and Cheng Zhu

ABSTRACT

This paper analyzes the problem with phase voltage distortion in an ACIM (Alternating Current Induction Motor) and points out the main reasons for the distortion. It also classifies the strategies for solutions to the distortion - primarily the solutions based on principle analysis and on model observation. It then analyzes and compares various principles and characteristics of the strategies offer by the two solutions.

INTRODUCTION

With the development of power electronics, micro electronic technology, digital control technology and control theory, AC (Alternating Current) drive systems' dynamic and static t characteristics are able to parallel DC (Direct Current) drive systems. AC induction motors are widely and it becomes realistic to replace DC drive systems with AC drive systems[1-2].

However, despite the fact that the present control theories of AC induction motors become increasingly mature, the whole performance of AC induction motors in practical applications still remain at low levels. These control algorithms idealizes the properties of the inverter when they are being built, so they normally cannot produce expected control effects in real systems[3].
In recent years, assorted compensation methods have been proposed and proved to be successful to some extent[4]. Each of the methods has its own characteristic and in practical use they should be selected according to specific requirements so that more ideal effects will result. For this reason, comprehensive analysis of different compensation strategies is of critical importance. This paper will analyze and compare the present compensation strategies of AC induction motors and figure out the pros and cons and point out their prospects.

**Mechanism of Phase Voltage Distortion**

To make sure VSI is in normal operation, usually dead time is introduced into the ideal PWM signal. The dead time is a period introduced to avoid short circuit of the upper and lower bridge arms. In order to ensure the driver module is reliable, normally signal isolation and signal multiplication modules are needed to be added between the PWM module and power output module. These factors all inevitably contribute to the distortion of VSI output waveform[5].

Figure 1 shows the Reasons for phase voltage distortion. And the reasons for PWM waves carrier distortion are listed as follows:

1) Insertion of dead-time.
2) Non-ideal characteristics of parts placed between MCU and VSI (Transfer Links). Different parts have different turn-on/off delays.
3) VSI’s nonlinearity switching characteristics.
4) Saturated voltage drop and anti-parallel diode drop of VSI.

Adding such error voltage to the ideal voltage waveform is bound to weaken the output quality of inverters, and in turn trigger the current waveform distortion, negatively affecting the performance of the AC drive system. Therefore, phase voltage compensation becomes indispensable to improving performance of AC drive systems.
PHASE VOLTAGE COMPENSATION STRATEGIES

Compensation Method Based on Principle Analysis.

The compensation method based on principle analysis first analyzes quantitatively various factors' effects on the waveform with the principle of dead time occurring; then it figures out the value of error voltage by using mean value theorem; last it starts the feed-forward compensation. The effects of this method are determined by the measurement of the error voltage value and the judgment of the current direction.

Measuring the error voltage is usually done with the help of the auxiliary hardware circuit that completes voltage compensation. The present methods take advantage of a simple voltage measuring circuit designed by Optocouplers or use the internal setting of MCU in the hardware circuit to obtain the error voltage through edge acquisition of the phase voltage by MCU[6]. In addition, there is another method called off-line measuring that executes fixed value compensation after error voltage is obtained by experiment.

The judgment of the current polarity has many methods, such as the compensation method using the terminal voltage [7][8], the compensation method of the current prediction control[9], and the compensation method based on phase current reconstruction[5][10]. These methods can provide the accurate ZCP moment, further reducing the ZCP distortion. And these methods can also provide good results of phase voltage compensation. But these methods use the value at
moment to calculate the error next moment, so it ineluctably leads to one period delay of the phase voltage error compensation.

**Compensation Method Based on Model Observation**

This method uses a motor model or observer to estimate the error voltage resulting from the dead time and VSI non-linear characteristics, and then transmits feed-forward to the target voltage to complete the dead time compensation.

The disturbance observer uses known data to obtain the agitation error by observing according to the mathematical model of an induction motor. In this way the error voltage on d-q set of axes can be obtained by using disturbance observer[11]. The observer has a gain coefficient, adjusting the value of which can change the convergence rate of the observer. We can also use the error voltage on d-q set of axes that is observed by the disturbance observer to figure out the compensating time.

The compensation method based on pulse technology adjusts the triggering time of MCU's pulse counter generator to disabuse the pulse width. The refined pulse width is determined by the present counter state, count value and the current polarity[12].

A Compensation Method for Voltage Error of Full Order Observer [13] figures out the relationship between the stator voltage error and the current observation error by setting the full-order observer and thus obtains the fundamental wave amplitude error with Fourier transformation.

These methods have a simple structure, easy-to-use feature and strong applicability. But with the gain coefficient of the disturbance observer existing, it is a demanding challenge to find an appropriate gain coefficient. Besides, the use of the simplified motor model makes it hard to respond in time to resistance change caused by temperature rise.

**CONCLUSION**

(1) Compensation methods based on principle analysis can provide good results of phase voltage compensation. But these methods use the value at moment to calculate the error next moment, so it ineluctably leads to one period delay of the phase voltage error compensation.

(2) Compensation methods based on model observation have a simple structure, easy-to-use feature. But it is a demanding challenge to find an appropriate gain coefficient. Besides, it is hard to respond in time to resistance change caused by temperature rise.

(3) Research on the phase voltage distortion of ACIM is important for the motors to improve their system performance. And the choices of methods should be suitable.
ACKNOWLEDGEMENTS

1. The National international scientific and technological cooperation projects of China(2014DFB70120).
2. The Science and Technology Development Plan Project of Weihai City(2014DXGJ02).
3. The Science and Technology Development Plan Project of Shandong Province(2014GGX105002).
4. The National Natural Science Foundation of China(51305457).

REFERENCES