Innovation Design Method for Controlling the Motor Speed

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Keywords: Super-synchronous speed, Multiplier circuit, Energy-saving

Abstract. The motor working in super-synchronous speed need the frequency converter with frequency power supply, but the high fee of the converter lead poor engineering economy. Design a simple and reliable method to make sure the motor could work in twice of original speed. The frequency multiplication power electronic circuits could change the frequency of the 50Hz frequency power which input to the motor, and it can exchange the motor speed to twice of the original speed. The test results show that the frequency multiplication power electronic circuits can effectively change the frequency and amplitude of the voltage input to the motor to meet the super-synchronous speed operation, it can achieve the purpose of multiply increase the motor speed. Speed control system designed by common power electronic components, and it has advantage in energy-saving and high engineering value.

Introduction

With 50Hz frequency power supply, the maximum synchronous speed of two-pole motor is 3000r/min. For some high-speed load, the motor speed is needed increase to 6000,12000r/min, etc. In addition, without using the frequency converter to adjust the input voltage frequency, there is no other technology can be used. But the frequency converter is not suitable for small motors because of its expensive price. To solve these problems, design a simple and reliable method to make sure the motor could working in twice of original speed. It has important significance for small motors to exchange the motor speed to surpass the synchronous speed, and it can simplify the speed control system.

The principle of the speed control system

Simply and effective method to increase the motor speed is through control the input voltage frequency to exchange the motor speed, with the voltage frequency increase, enabling the motor speed increase followed by the frequency. Rectifier bridge circuit could exchange 50Hz frequency power to 100Hz. Firstly, process the supply voltage through the rectifier bridge circuit, secondly filter out the DC component of the rectified voltage, and then adjust the AC voltage component in order to reduce the residual distortion to meet the quality requirements of the voltage to drive the motor. Motor operates at 100Hz frequency power, the motor could work in twice of original speed. The principle of the design method is shown in Fig.1.

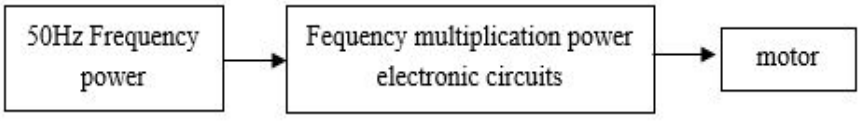

Fig.1 The theory of multiply increase the motor speed method

In order to verify the feasibility of the method to increase the motor speed, this section will use the software to simulate frequency multiplication power electronic circuits.The frequency multiplication power electronic circuits is shown in Fig.2.

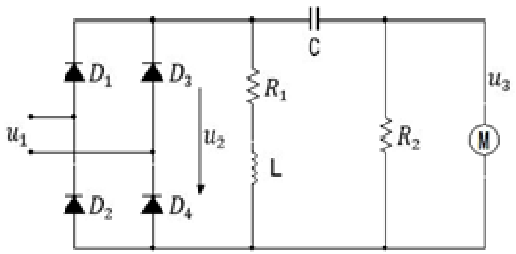

Fig.2 Frequency multiplication power electronic circuits

The rectifier bridge circuit is formed by Diode 1-4.L is a inductor,C is a capacitor, R_1 and R_2 are resistors. C, L, R_1 and R_2 constitute the control circuits, M is two-pole induction motor. u_1 is 50Hz frequency power voltage, u_2 is the output voltage of the rectifier bridge circuit, u_3 is the motor input voltage.

Filter DC component with the function of the inductor, and deplete it with R_1. Exchange and filter the higher harmonics with the function of capacitance, and the DC component of the voltage is further filtered off. The resistor R_2 is to release the electric charge in capacitance to protect the safety of components and personal. The results of the u_1 and u_3 waveform simulation by MATLAB are shown in Fig.3 and Fig.4.

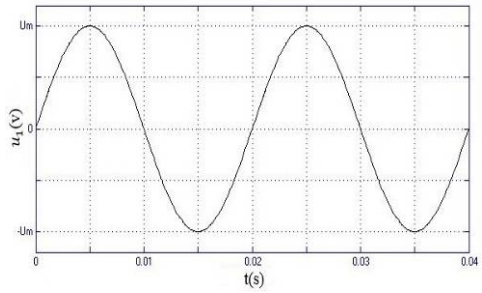

Fig.3 The waveform of u_1 voltage

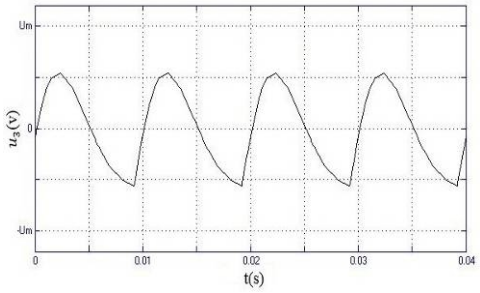

Fig.4 The waveform of u_3 voltage

Experiment study of the speed control system

The characteristics and parameters of the various components in electronic circuits can lead to great impact on its multiplier effect, in order to eliminate uncertain factors of the system, it is difficult to accurately calculate and determine these parameter values. Therefore, it need the experiment to adjust the parameters in prototype system. Experimental circuit of prototype system is shown in Fig.5.

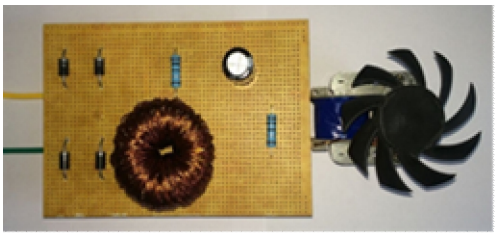

Fig.5 Experimental circuit of the prototype system

Motor use an ordinary small shaded pole motor YJF4808, and change the motor windings to reduce the operating voltage below 36V which is under the prescribed safety voltage to protect the safety of the experimental personnel. The reconstruction after the transformation of motor is shown in 50Hz frequency power supply situation in Table 1.The inductor formed with the iron and copper wires, taking into the inductance value should be possible large and the resistance should be possible small,

the inductor winding value measured is 400mH, the internal resistance is 2.7Ω. Under certain inductor, study the effect of inductance, capacitance and resistance by change their parameters, through experiment study variation of parameters on the multiplier effect of the circuit operation. To ensure accuracy and eliminate contingency in experiment, arraying capacitor and resistors, combine the parameters and arrang 100 experiments with the choice of five kinds of capacitor: 470μF, 220μF, 133μF, 100μF, 33μF; five kinds of resistor R_1: 1Ω, 5Ω, 10Ω, 50Ω, 100Ω; four kinds of resistor R_2: 50Ω, 100Ω, 5.1kΩ, 20kΩ.

The waveform of the output voltage is fine when the resistor R_1 is less than 10Ω, and motor can work in twice of original speed. After considering the voltage drive capability and degree sinusoidal of the waveform, select the component parameters of frequency multiplication power electronic circuits: capacitor C is 133μF, resistor R_1 is 10Ω, resistor R_2 is 5.1kΩ. At this point, the motor running reconstruction is shown in 100Hz frequency power supply situation in Table 1. The output voltage of frequency multiplication power electronic circuits is measured by Oscilloscope. Sampling waveform is shown in Fig.6.

Table 1 Prototype system speed test result

Voltage Frequency (Hz)	voltage (V)	current (A)	speed (r/min)	Synchronous speed (r/min)
50	28	0.9	2100	3000
100	28	0.7	4085	6000

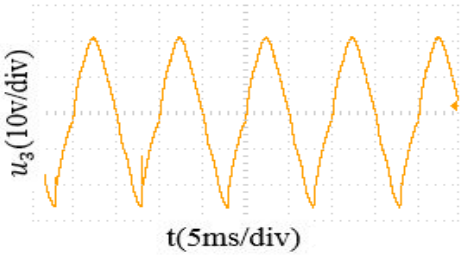

Fig.6 The sampled waveform of frequency multiplication circuits output voltage

Fig.6 shows that the circuits output voltage waveform cycle is 10ms, the frequency is 100Hz, the circuits can achieve expected results. Through prototype system speed results in table 1 can found that motor speed increase from 2100r/min to 4085r/min with the frequency power exchange after the frequency multiplication power electronic circuits. Therefore the power electronic circuits can achieve doubling the motor speed which is close to twice of original speed. The harmonic analysis result of voltage is analyzed and calculated by Matlab software shown in Fig.7, and the calculation of the voltage waveform distortion rate is 2.11%, comply with the provision of less than 5% rate of state regulations.

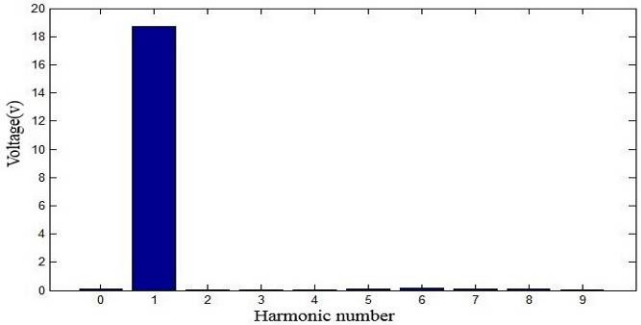

Fig.7 The harmonic analysis chart of the frequency

Through the above analysis, the effect of the frequency multiplication power electronic circuits doubling frequency power is quite good, with low waveform distortion, and it is suitable for motor working in twice of original speed. The motor speed control system is simple in principle, with the use of common power electronic components, it cost low fee, and it has easy-to-marketing applications. It is important to simplify the speed control system and reduce the fee in control systems.

Conclusions

This paper proposes the method to multiply increase the two-pole motor speed with the 50Hz frequency power supply. Voltage and frequency adjustment based on the idea of adjusting the voltage frequency to control the motor speed, design the ideal frequency multiplication power electronic circuits. Through software emulate and the experimental prototype system, verify the feasibility of the method to increase the motor speed with the frequency multiplication power electronic circuits. Because the DC component of the output voltage by rectifier bridge circuits can not be used, so the DC component is consumed by resistor. Filter out high-order harmonic components only used one capacitor, there will be a small number of high-order harmonics input to motor. How to deal with DC component and high harmonics more reasonable and effective need further study.

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