Application of high frequency chain transformer in aviation power supply

XiaoShuangWang¹*, Jing Zhao², XiaoGangYang³, Shuai Ren⁴, NingYan Wang⁵, Yin HuiXue⁶ and LuYA Zhang⁷

¹School of Information and Communication, National University of Defense Technology, Xi'an City, shanxi, No. 5 Guangming Road, Wangqu Town, Chang'an District, 710106, China
²School of Information and Communication, National University of Defense Technology, Xi'an City, shanxi, No. 5 Guangming Road, Wangqu Town, Chang'an District, 710106, China
³Western Theater, 19 Shengli Road East, Kuche County, Urumqi, Xinjiang, 842000, China
⁴School of Information and Communication, National University of Defense Technology, Xi'an City, shanxi, No. 5 Guangming Road, Wangqu Town, Chang'an District, 710106, China
⁵School of Information and Communication, National University of Defense Technology, Xi'an City, shanxi, No. 5 Guangming Road, Wangqu Town, Chang'an District, 710106, China
⁶School of Information and Communication, National University of Defense Technology, Xi'an City, shanxi, No. 5 Guangming Road, Wangqu Town, Chang'an District, 710106, China
⁷School of Information and Communication, National University of Defense Technology, Xi'an City, shanxi, No. 5 Guangming Road, Wangqu Town, Chang'an District, 710106, China

*Corresponding author’s e-mail: wxs163jundui@163.com

Abstract. This paper introduces the application of the high frequency chain transformer in the aviation power supply. The soft switch technology is used to reduce the electromagnetic interference of the converter, solve the power supply problem of the rotating circuit which has no physical contact with the static power supply, and extend the service life and reliability of the aviation power supply. Experiments show that the non-contact rotary high frequency chain transformer can completely replace the brush and slip ring in the power supply situation of the rotating mechanism, which has high application value.

1. Introduction
In order to make the most of the solar energy, the solar panel must always be facing the direction of the sun. With the change of satellite position in orbit, the servo mechanism adjusts the orientation of solar panel in real time. The electric energy transfer between the solar panel and the satellite is realized...
by the contact between the graphite brush and the copper slip ring. The wear of the graphite brush is inevitable because of the relative motion. The wear leads to the falling of carbon powder and the loosening of contact, which leads to the unstable power supply of the circuit and the generation of electric sparks and other adverse effects. The continuous wear eventually leads to the separation of the brush from the slip ring. The method of power supply has become the bottleneck of satellite life extension. The problem of contact wear can be fundamentally solved by the non-contact rotating high frequency chain transformer. Non-contact rotary high-frequency chain converter can also be used in all fields that need to provide electrical energy to the rotary mechanism, such as: the power supply of sensors and test equipment on the rotary mechanism of oil drilling, paper-making machinery, helicopter rotor, etc., and the occasions where satellite and radar need to transfer electrical energy to the rotary electrical equipment, etc.

2. Structure and basic principle of high frequency chain transformer

The working frequency of the non-contact rotary high frequency chain transformer is about 90KHz, so the magnetic material used in the transformer is manganese zinc ferrite. The material has the characteristics of high permeability, high resistivity and low coercive force. The exciting current of winding can produce higher magnetic induction intensity, transfer larger power, and have smaller iron loss and eddy current loss. The internal structure of the rotating high frequency chain transformer is shown in 'Figure 1'. It is mainly composed of static circuit, rotating circuit and bearing[1].

There is a gap between the positions of the winding to prevent accidental friction. The output of the winding of the rotating part is connected with the rotating circuit through the rotating spindle, and the output of the static winding needs to be led out through the hole on the magnetic core. The magnetic core is wrapped with a metal shield, which can not only prevent dust from falling into the air gap and affect the operation of the transformer, but also suppress the electromagnetic interference caused by the air gap and the input and output wires, and increase the mechanical strength of the rotating high-frequency chain transformer.

Because the primary side of the high-frequency chain transformer is directly connected with the input, the primary side is in the static state; the secondary side is connected with the rotating mechanism, so the secondary side is in the rotating motion state. An alternating current is introduced into the primary winding, which generates an alternating magnetic field in the transformer through the primary winding. The induced current is induced by the alternating magnetic field at the secondary side of the transformer, and the energy is transferred from the primary side to the secondary side.
3. Application of high frequency chain transformer in aviation power supply

The application of high frequency chain transformer in satellite is shown in ‘Figure 2’. The converter consists of a DC / DC full bridge converter, a non-contact rotary high frequency transformer, an SPWM inverter and an output filter. The converter has the characteristics of unidirectional power flow and three-stage power conversion (DC-HFAC-DC-LFAC) [2][3]. The inverter adopts the control strategy of sinusoidal pulse width modulation (SPWM), which has the advantages of simple circuit topology and small filter elements.

![Figure 2. Main circuit structure diagram.](image)

The input 28.5V DC is boosted to 182V DC after phase-shifting full bridge DC / DC conversion, providing DC voltage for the next stage SPWM inverter. After the SPWM inverter and the L and C filter, the DC voltage is converted to 115V / 400Hz single-phase AC output. The system structure of the power supply is shown ‘Figure 3’, and the dotted box includes the rotating circuit.

![Figure 3. The system structure block diagram.](image)

The rotating circuit includes the rectifying circuit of the phase-shifting full bridge DC / DC converter, the SPWM inverter control circuit, the inverter main circuit, the AC output filter circuit and the auxiliary power circuit of the rotating part[4][5][6]. Among them, the SPWM inverter control circuit adopts the digital control method, and uses the look-up table method to generate the trigger pulse of SPWM. The switching frequency of SPWM is independent of the switching frequency of DC / DC converter due to the independent oscillation source of the circuit.

4. Experimental results

Using the above main circuit structure and control mode, a prototype with output power of 350W, output frequency of 400Hz, output single-phase voltage of 115V and switching frequency of 120kHz is developed. The output of the power supply vibrates slightly during the rotating operation, and the voltage regulation rate deviates from the design requirements to a certain extent. After improving the
coupling condition of the original and secondary sides, these problems are solved. The output frequency of the power supply is stable, the output harmonic content is small, and there is no obvious heating under the output rated power. The main waveform of each working point of the power supply is shown ‘Figure 4’, ‘Figure 5’ and ‘Figure 6’.

![Figure 4. SPWM trigger waveform.](image1)

![Figure 5. AC voltage output waveform.](image2)

![Figure 6. Output AC current waveform.](image3)

5. Conclusion
The experimental results show that the application of non-contact resolver in satellite power supply not only realizes the mechanical wear-free and maintenance free, but also inherits the advantages of small size, light weight, high power density and high efficiency of switching power supply.

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