Research on Space Wireless Drive Mechanism Based on Wireless Measurement and Control Network Technology

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Abstract. In this paper, a new design scheme based on ZIGBEE network technology is proposed for the space wireless drive assembly, and preliminary experimental verification is obtained. The space wireless drive assembly based on ZIGBEE network technology can effectively reduce the weight of the drive assembly, improve the life, and compare the performance of the traditional drive assembly with the wireless drive assembly, which provides a useful basis for subsequent research.

1. Introduction
The space drive mechanism needs to transmit electric power and electric signals between the fixed portion and the rotating portion of the mechanism, and currently relies mainly on a conductive slip ring. With the development of China's aerospace industry, the requirements for the speed and life of various types of drive mechanisms are gradually increasing. The traditional conductive slip rings have a limited life span and are increasingly unable to meet the requirements of use. High-performance imported conductive slip rings are also expensive. Therefore, it is urgent to develop a non-contact electric transmission system for a drive mechanism, and to break through key technologies such as high-efficiency transmission of electric power and high-performance transmission of electric signals to fill the domestic gap.

2. Research objectives
The wireless drive mechanism adopts a non-contact signal acquisition and transmission system, and its performance and life are not affected by the relative rotational speed of the fixed part and the rotating part, which can solve the bottleneck problem of the life of the traditional conductive slip ring, and can also be applied to various types of electrical signal transmission requirements.

At the same time, the wireless node installation location is flexible, and can be intelligent, to achieve fault self-diagnosis, mutual diagnosis and signal pre-processing functions, etc., can be used for some temporary changes and operations such as health monitoring and troubleshooting of the drive mechanism; Intelligent drive mechanism and system integration. This technology can be used in wireless communication occasions other than the drive mechanism, such as satellite internal communication, large antenna communication and other space occasions.

Research on the key technologies of the wireless structure measurement and control network of space structure mechanism, with the background of the drive mechanism, replace the signal transmission mode of the signal ring by wireless transmission, save the signal loop resources, improve the reliability of the drive mechanism, and establish a wireless structure control network for the space structure mechanism.
3. Wireless drive mechanism design

3.1. System Design
As shown in Figure 1, the wireless drive mechanism can replace the part of the signal ring in the slip ring, thereby reducing the size and weight of the drive mechanism. It is only necessary to add a wireless transmitter and a wireless receiver outside the drive mechanism to complete the cable transmission. The signal is data, and the application of wireless measurement and control technology in spatial structure mechanism is realized.

![Figure 1. Solar wing drive mechanism configuration.](image1)

The wireless drive mechanism adopts a modular approach to maximize the adaptability of the drive mechanism task. The overall design block diagram is as follows:

![Figure 2. Overall design block diagram of the wireless drive mechanism.](image2)
The wireless drive mechanism mainly uses the wireless method to replace the existing RS422 communication, command signal, analog signal (cell signal, temperature signal, angle signal) that needs to be wired. The system is divided into two parts, the satellite battery array part (A end) and satellite star part (B end). The satellite battery array acquires RS422 data, command signals and analog signals through multiple MCUs. The MCU controls the ZIGBEE communication module to wirelessly transmit the aggregated data to the star part; the satellite star part decomposes the data of the antenna part through the ZIGBEE communication module. The RS422 communication data is distributed to the corresponding RS422 channels of the star to realize the wireless transmission of the RS422 data. The step signal and the digitized analog signal are digitized by the A-terminal MCU of the star part, and then directly transmitted through the RS422 channel of the B end for wireless transmission.

3.2. ZIGBEE Network Design
The ZIGBEE network is based on TI's CC2530 chip, a system-on-a-chip (SoC) solution based on 2.4-GHz IEEE 802.15.4, ZIGBEE and RF4CE applications. With low power consumption, low cost, short delay, large network capacity, safe and reliable.

3.3. MCU Circuit Design
The central controller adopts Silicon Lab’s C8051F040, which is a fully integrated SOC type MCU with 64 digital I/O pins and an on-chip integrated CAN2.0B controller with good expansion performance.

4. Research results
At present, the prototype of the wireless drive mechanism is built, and the analog, digital command and RS422 data are transmitted wirelessly. The effect is shown in Figure 6. The prototype can realize 16 analog signals, 16 command signals, and two RS422 signals. Wireless transmission function.

5. Key Technology Outlook

5.1. Wireless transmission reliability design
The communication frequency adopted by the wireless transmission network needs to comply with the frequency band specification of the wireless communication between the satellite and the transmitting base to avoid interference with the existing system; the node has low transmission power and is easily interfered by the high-power wireless signal of the external system. In the application process, the signal attenuation caused by multi-path reflection in a closed environment, the bandwidth competition of other wireless signals in the same frequency band and the strong noise of the system equipment during operation may affect the reliability of data transmission.

At the same time, how to improve the reliability of information transmission by optimizing the network communication protocol, performing reliability quantitative evaluation and designing the failure handling mechanism; how to achieve redundancy through node redundancy design, topology redundancy design and wireless transmission and wired transmission redundancy Designed to ensure that systems with high reliability requirements work properly. In addition, the core components of
wireless transmission are industrial grade devices, and the radiation resistance of the transmission system is also a problem to be considered.

5.2. Multi-sensor data fusion algorithm
On the one hand, the wireless communication network serves as a means of data transmission and a tool for device communication, and on the other hand provides a corresponding network platform for further data analysis. For related sensors or devices, how to establish sensor faults in network environment by comparing the horizontal performance between nodes and nodes, between devices and devices, using pattern recognition and computational intelligence technology, combined with multi-sensor fusion theory in the network environment. The mutual diagnosis model provides decision support for other application systems and conducts tentative research on information sharing among multiple systems.

5.3. Spacecraft self-diagnosis, mutual diagnosis model, health monitoring
In the actual engineering application process, how to automatically analyze the performance state of the drive mechanism; how to distinguish the drive mechanism fault and signal anomaly; how to judge the abnormal state of the signal and random interference; how to normal and abnormal state of the data Setting the boundary; how to extract the feature of the signal for the mutual comparison between the nodes is a difficult problem to be solved when establishing the fault mutual diagnosis health monitoring model.

6. Conclusion
This paper has carried out preliminary exploration in the direction of space wireless drive mechanism, basically verified the feasibility of the wireless drive mechanism, and clarified the structure of the subsequent model products, which can be used for the technical improvement of the subsequent space drive mechanism.

References
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