Applying LoRA Communication Technology to UAV Telemetry System and Payload Design

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***Abstract*--**The UAV telemetry system is a completely independent Wireless Systems control module that can be installed into any UAV payload without interfering with other subsystems. In this paper, the telemetry system of the sounding rocket will be used as the experimental object. The telemetry system of the sounding rocket is designed into a small and lightweight control box and a lightweight launch console to facilitate testing and operation before launch. The console connects the launch pad and the sounding rocket module through LoRA communication technology. During the flight, LoRA telemetry monitoring signals can collect various rocket flight data (such as rocket body roll, pitch and yaw direction) and rocket internal function inspection and transmit it back to the base station. This paper will explain the components of the flight attitude measurement system of the sounding rocket guidance control system, and analyze and discuss the actual launch data of the sounding rocket.

I. INTRODUCTION

As Taiwan enters the era of sounding rockets, sounding rockets with better control performance have become a major focus in the current aerospace research field. The goal is the ability to deliver payloads to very high apogee sites, as the BBX 3-stage sounding rocket developed by NASA Goddard Space Flight Center, National Research Council of Canada, Bristol Aerospace, Swedish Aerospace and Saboscania, uses the Saab-SSC-S19 guidance system, which was originally designed for the Black Brant VC rocket, and therefore, the Saab-SSC-S19 guidance system also needs to be adjusted, to optimize flight control based on the mass, inertia, launch transients, and bending mode frequencies of sounding rockets[1~4]

The telemetry system is a completely self-contained wireless system control module that can be installed in any UAV payload without interfering with other subsystems. This article will look at the telemetry of a sounding rocket. The system consists of a compact and lightweight control box and a lightweight launch pad that uses LoRA communication technology to connect the launch pad and the sounding rocket module. During the flight, it collects and transmits various flight data back to the base station (such as roll, pitch, yaw, and internal function checks) and transmits it back to the base station.

II. SHSR-1 ROCKET FLIGHT CONTROL SYSTEM AND TELEMETRY SYSTEM AND PAYLOAD DESIGN AND TESTINGA. Synthesizing the film and analysis

In the development of the entire system, the sounding rocket flight control system is a completely independent control module, which can be directly installed in the payload bay of the rocket. At the same time, the flight control system will not interfere with other aspects of the sounding rocket. subsystem. The telemetry system of the sounding rocket proposed in this paper is designed as a small and lightweight control box and combined with a lightweight launch console to facilitate testing and operation before launch. The console connects the base station and the sounding rocket control system through LoRA communication. During the free flight of the rocket, telemetry monitoring signals can collect various rocket flight data (such as vehicle roll, pitch and yaw direction) and conduct internal functional inspections of the rocket

A. Planning and design of each sub-flight control system

The SHSR1 sounding rocket system designed in this article is stacked with different functional modules, as shown in Figure 1. It uses a 5-layer module stack, with the energy storage battery placed on the first layer; the sounding rocket main power system and the ignition relay circuit on the second layer; the third and fourth layers are the sounding rocket payload control wafer and machine The fifth layer of the 10DOF inertial navigation system (INS) carrying the inertial measurement unit (IMU) is the communication circuit. It uses LoRa low-power wide-area and ultra-long-distance wireless transmission network technology to communicate with the ground control station.

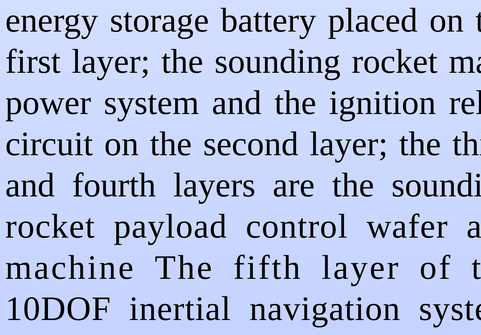


Fig. 1 The SHSR1 sounding rocket flight payload control system with different functional modules stacked designed in this paper。

B. Inertial navigation system (INS)

The inertial navigation system (INS) provides rocket attitude and angular velocity data, and the controller generates control commands for the actuators. The actuator deflects the tail through the RC servo actuator system. The block diagram of the sounding rocket guidance and control system is shown in Figure 2.The inertial navigation system (INS) provides rocket attitude and angular velocity data, and the controller generates control commands for the actuators. The actuator deflects the tail through the RC servo actuator system. The block diagram of the sounding rocket guidance and control system is shown in Figure 2.The gyro roll information is used to inertial referenced autopilot commands into rocket attitude stabilization control commands for 4 RC servo motors. These 4 RC servo motors are combined into a rocket tail attitude control actuator. Figure 3 shows the block diagram of the control function of the sounding rocket guidance control system.

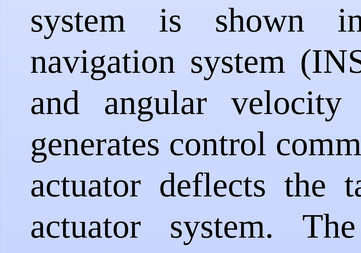


Fig. 2.Block diagram of the sounding rocket guidance and control system.

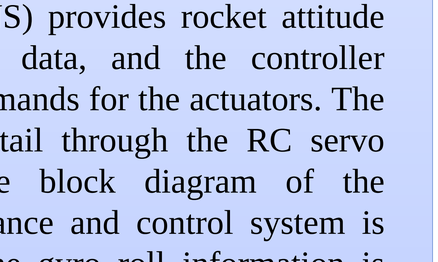
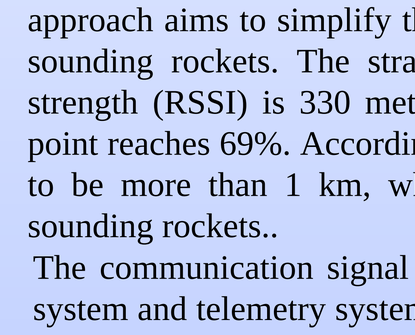


Fig. 3. Block diagram of the control function of the sounding rocket guidance control system.

III. SHSR-1 ROCKET LORA COMMUNICATION SYSTEM PAYLOAD DESIGN AND FLIGHT TEST DATA AND ANALYSIS

The research plan for the first test evaluated factors such as flight altitude, system complexity and volume. Due to the popularity and low configuration cost of LoRa, the original three-band telemetry communication system was replaced with a 433MHz, 30dB, 1W LoRa wireless transmission module. This approach aims to simplify the telemetry system and make it easier to use small sounding rockets. The straight-line distance of LoRa communication signal strength (RSSI) is 330 meters, and the communication quality at the farthest point reaches 69%. According to the data, the transmission distance is estimated to be more than 1 km, which confirms the performance of the system for sounding rockets..

The communication signal strength (RSSI) curve of the rocket flight control system and telemetry system of the SHSR1 sounding rocket is shown in Figure 5. It can be seen from the launch process that after the rocket leaves the frame, it will fly farther and farther as time goes on. It can also be seen from the data measurement that as time gets farther and farther, the system communication signal strength (RSSI) also changes. Gradually weaken. The communication quality up to the communication interruption point is 70.98%. Therefore, it can be seen that the LoRA wireless transmission module still maintains very good communication quality before the communication is interrupted.



Position	Distance	RSSI
1	0	85%
2	25	82%
3	50	78%
4	75	76%
5	100	76%
6	125	72%
7	150	71%
8	175	74%
9	200	72%
10	225	72%
11	250	72%
12	275	70%
13	300	70%
14	325	69%
15	330	69%

Fig. 4. Test data of rocket flight control system and telemetry system on Fengjia University campus

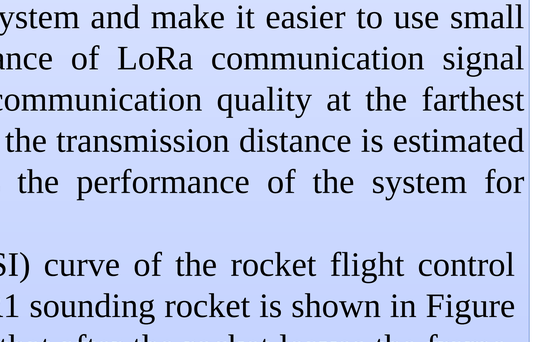


Fig. 5. SHSR1 sounding rocket rocket flight control system and telemetry system communication signal strength (RSSI) curve chart

IV. CONCLUSION

The paper focuses on the telemetry system of a sounding rocket, which is designed to be compact and lightweight for ease of testing and operation. The launch console connects to the rocket module via LoRa communication technology, enabling the collection and transmission of various flight data, such as roll, pitch, and yaw, back to the base station.During the SHSR1 sounding rocket's flight, the LoRa telemetry system was tested for communication signal strength (RSSI). As the rocket flew farther from the launch pad, the RSSI gradually weakened. However, the communication quality remained high, with a 70.98% communication quality maintained until the point of interruption, demonstrating the effectiveness of the LoRa wireless transmission module.

Reference:

[1] Choi, H. D., Bang, H., & Kim, Z. C. (1999). Design methods for rocket attitude control systems subject to actuator saturation. A.I.A.A. Journal of Guidance, Control, and Dynamics, Vol.22, pp.183-185.

[2] Kawaguchi, J., Sawai, S., & Matsuda, S. (1995). S-520-18 Design of canard control system. ISAS xfth workshop on astrodynamics and yight mechanics (pp. 223-228). Japan: Sagamihara.

[3] Ljunge, L., & Hall, L. (1984). S19 guidance of the Black Brant X sounding rocket.

[4] A.I.A.A. Journal of Guidance, Control, and Dynamics, Vol.7, pp.156-160.

[5] Meirovitch, L. (1967). Analytical methods in vibrations (pp. 126-143). New York: Macmillan.

ACKNOWLEDGMENT: This research is supported by the research project of the National Science and Technology Council of Taiwan (Project No.: NSTC112-2221-E-262-006). We would like to thank you hereby.