Terrestrial complex for receiving information from small spacecrafts

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Abstract

The work is devoted to the development of a terrestrial complex for receive and process information from small spacescrafts. The main requirement for these stations is their simplicity and maximum availability both in terms of cost and operating capabilities. Such stations provide a two-way exchange of information with spacecrafts in the frequency range 435-438 MHz, receive and process data transmitted in the VHF band by amateur and student satellites, and receive communications from the international space station crew and radio amateurs on Earth.

Keywords: *CubeSat, AIS, space receiver, marine communication systems*

1. Introduction

The Russian project "Space-Pi" is being implemented from 2022 to 2025. This project is designed to attract schoolchildren and student from universities to scientific and technical activities and popularize space research and technology among them. It is also acceptable to use software and hardware sets in the educational environment (cubesat designers, virtual twins of satellites and a test base) for work in schools, universities and development centers.

The scientific component of the project is to obtain new knowledge and its practical application in the creation of cubesats and payloads for them. It is supposed to test scientific hypotheses, develop directions for data processing due to cheaper methods of obtaining data collected by grouping cubesats, as well as increasing the reliability and miniaturization of their on-board systems.

An important part of the "Space-Pi" project is the creation of network of terrestrial stations for receiving information from small spacecrafts (Selva & Krejci (2012), Klofas et al. (2008)). The main requirement for these stations is their simplicity and maximum availability both in terms of cost and operating capabilities. Such stations provide a two-way exchange of information with spacecrafts in the frequency range 435-438 MHz, receive and process data transmitted in the VHF band by amateur and student satellites, and receive communications from the international space station crew and radio amateurs on Earth.

2. Terrestrial stations for receiving information from small spacecrafts

In the "Space-Pi" project terrestrial stations for receiving information from small spacecrafts provides:

- reception of telemetric information coming during communication sessions with the spacecraft via the radio link channel, its transmission to digital form to a long-term storage system;
- processing and temporary storage of information, its transfer in digital form to analysis;
- forecasting the movement of spacecraft in orbit,
- calculation of conditions of communication sessions,

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- display on the map of the trajectories of the spacecraft, the location and radio visibility zone of the antenna,
- diagnostics and software control of the antenna,
- scheduling communication sessions.

The station can provide processing telemetry information from amateur and student satellites to evaluate:

- parameters of the power supply system;
- temperature regime of onboard systems;
- communication system parameters;
- the impact of the satellite being in the shadow or illuminated part of the orbit;
- trends in the state of on-board systems.

The station is equipped with a directional VHF antenna located on a turntable, a low-noise amplifier (LNA) with an injector that provides its power, a transceiver electronics unit, an anti-vandal heating and processing block, a feeder line. The turntable provides possibility to point the antenna at a spacecraft flying in the radio visibility zone. The station is also equipped with a set of software necessary for control and management of space sensors, as well as for processing the received information. Fig. 1 shows the block diagram of the station.

In this project, we propose to use multi-frequency signals for organizing communications in the subpolar regions of the Earth. We consider Orthogonal frequency-division multiplexing (OFDM) signals as a general form of multi-frequency signals. Simulation model for formation and reception of OFDM signals and corresponding amplitude limiter are shown on fig. 2.

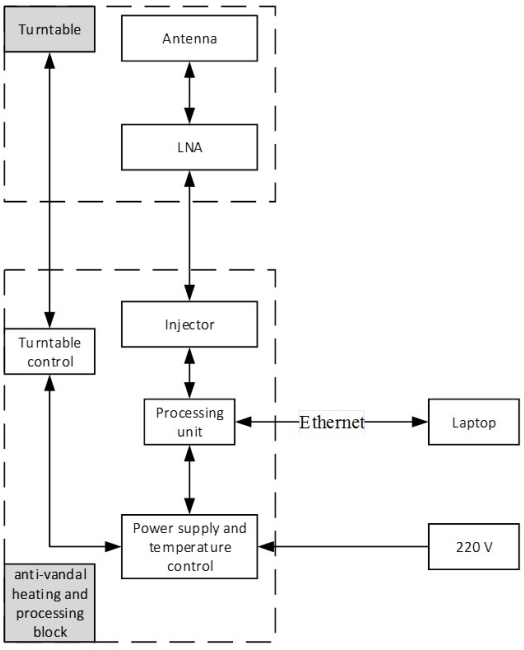

Figure 1. Meteor trails.

Fig. 2 shows the view of the antenna. The main characteristics of this antenna are as follows:

- Frequency range: 435 – 438 MHz,
- Gain: 6-8 dBi,
- Low requirements for placement,
- Easy installation, low windage, light construction, low maintenance,

Figure 2. Antenna device.

- Wide beam pattern.

The receiver is based on the SDR platform and has the following characteristics:

- Frequency range: 500 kHz to 1.7 GHz,
- Bandwidth: 3.2MHz,
- Types of modulation: NFM/AM/LSB/USB/WFM/DSB and others.
- Thermally compensated reference oscillator.

A low-noise amplifier is also necessary to improve the quality of signal reception from spacecraft. Its appearance is shown on Figure 3. Operating frequency ranges: from 136 to 148 MHz (Band 1), from 435 to 438 MHz (Band 2).

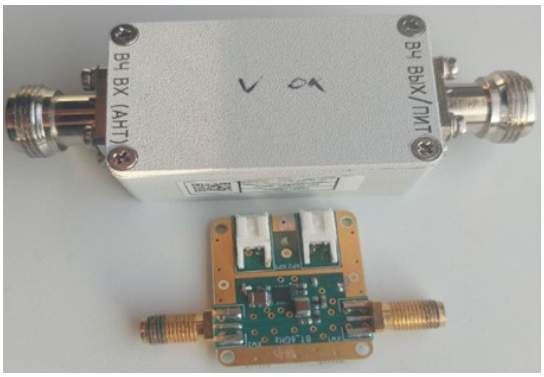

Figure 3. Low noise amplifier.

3. Conclusion

For full-fledged work with the station, it is required to obtain an amateur radio call sign and register the frequency of the ground station. The station provides possibility to work and control spacecraft in the VHF band, analyzing the received target information and the technical condition of the satellites.

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