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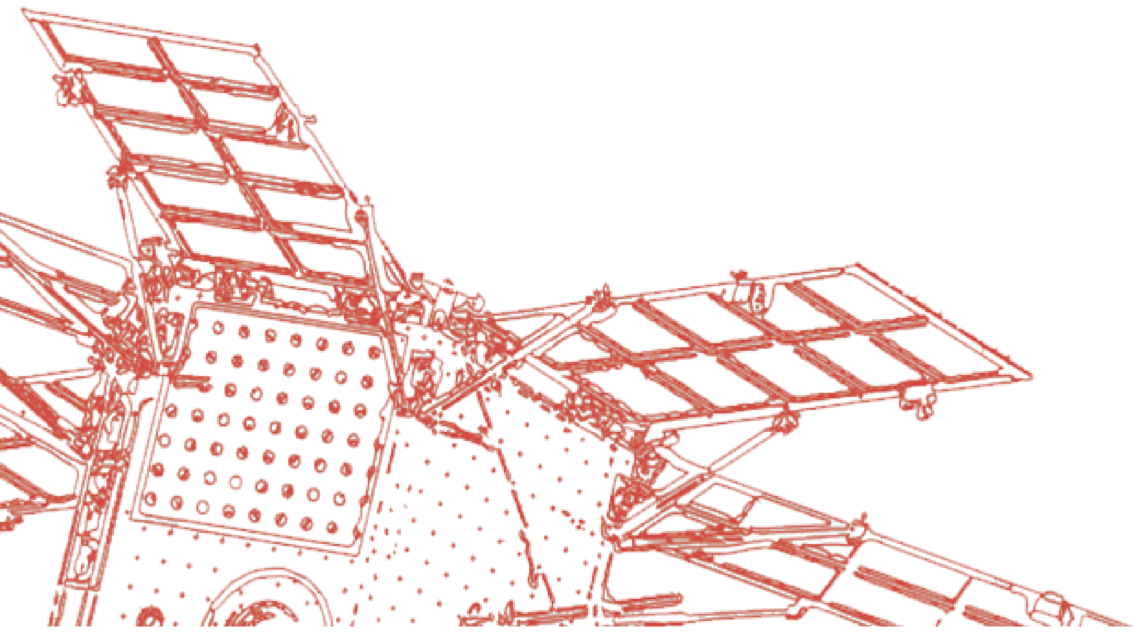
Technical Description

Data receiving and satellites controlling station

"Zavitok"



"Zavitok" complex is intended for use as part of flight control centers, as well as for educational use. The complex provides telemetry receiving from small spacecraft in low Earth orbit and control commands transmitting. The complex is designed to operate in accordance with amateur radio regulations.

Complex composition

– directional antenna w/ antenna rotator;
– set of fixed survey antennas w/ diplexer-amplifier;
– antenna rotator controller and interface;
– integrated amplifier (low-noise amplifier + power amplifier);
– power injector;
– working station;
– telecommunications cabinet;
– harnessing and cabling (incl. drop cables);
– SDR-receiver;
– SDR-transceiver;
– web-camera for visual control after directional antenna.

Properties

Directional antenna frequency range	not narrower than 435…438 MHz
Survey antennas frequency ranges	136..146 and 435…438 MHz
Max data speed rate (survey antennas)	not less than 9600 bps
Transmitter output power	not less than 4 W
Nominal rated gain (at least one antenna)	not less than 8dBi
Supported transport protocols	at least AX.25
Supported modulation types	FSK (GFSK, GMSK, etc.), PSK (QPSK, OQPSK)

Features

The complex allows:

– to receive telemetry of spacecraft using open protocols (like AX.25 and variations);

– to transmit telecommands and receive receipts via similar protocols;

– receiving and transmitting data;

– receiving NOAA-satellites shots via UHF-range by APT protocol;

– receiving Meteor-M satellites shots via UHF-range by LRPT protocol.

Hardware of the complex uses open widespread interfaces, thereby it is compliant with many of open source software:

– LRPT decoder;

– WxtoImg;

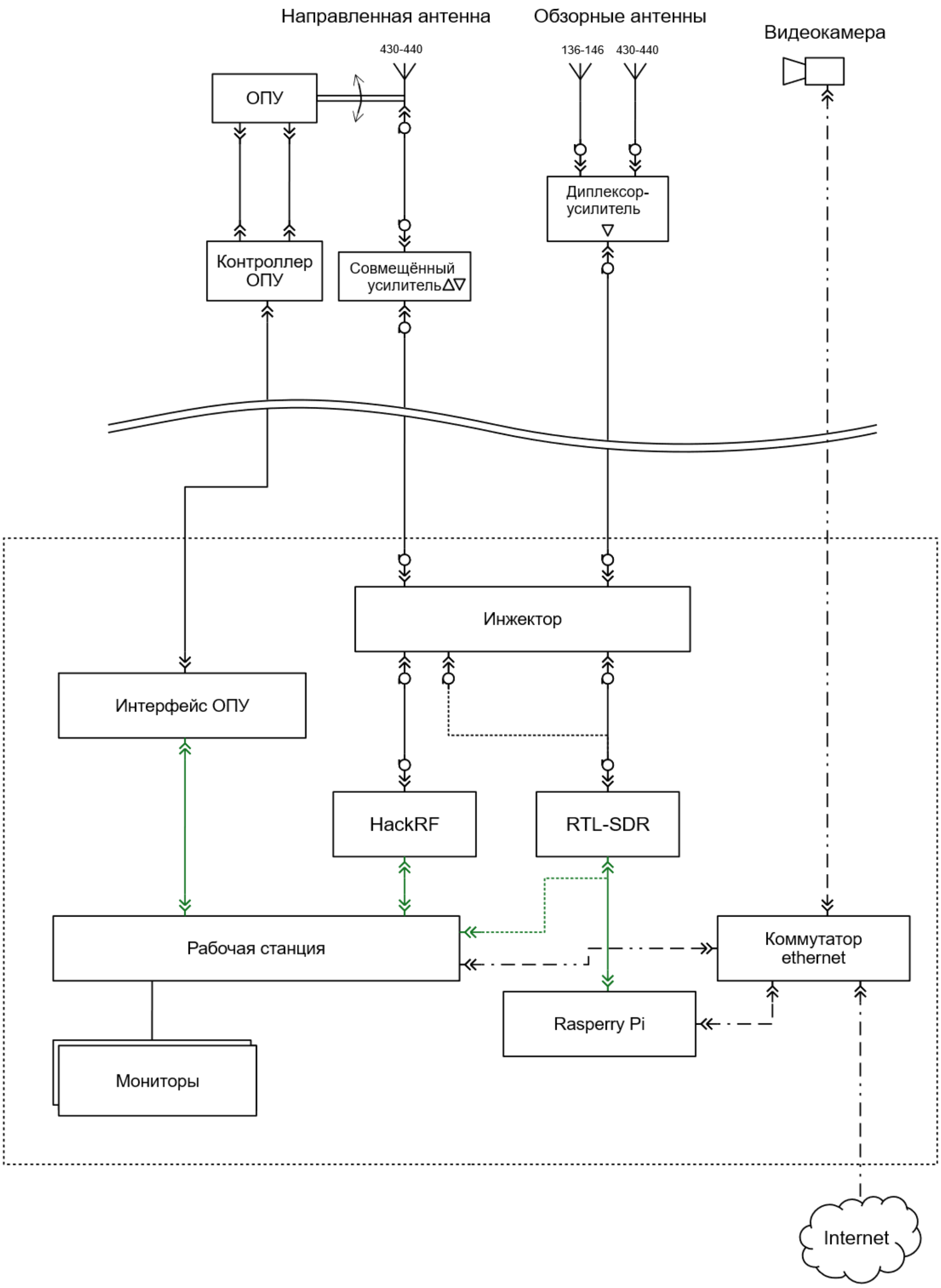
– GNURadio;

– Gpredict;

– Sound modem;

Brief description

Complex can be divided into two parts: antenna complex and radio-engineering complex. Its scheme is presented on Pic. 1.

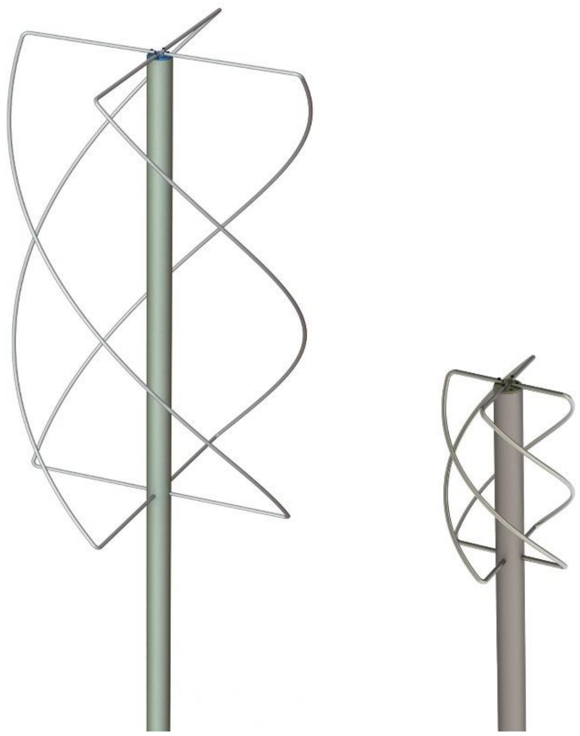


Picture 1: Scheme of "Zavitok" complex

Antenna complex contains three antennas.

Two of them are survey antennas, which are fixed quadrifilar antennas. They can be used for receiving images from meteorological NOAA and Meteor satellites, receiving telemetry from spacecraft operating in 136-146 MHz frequency range, as well as receiving telemetry from spacecraft operating in 430-440 MHz frequency range, with the elevation being limited to more than 20 … 30 degrees, but without the need for pointing the spacecraft antenna in the sky, which is convenient in the absence of data on the orbital parameters of the spacecraft and while working with several spacecraft.

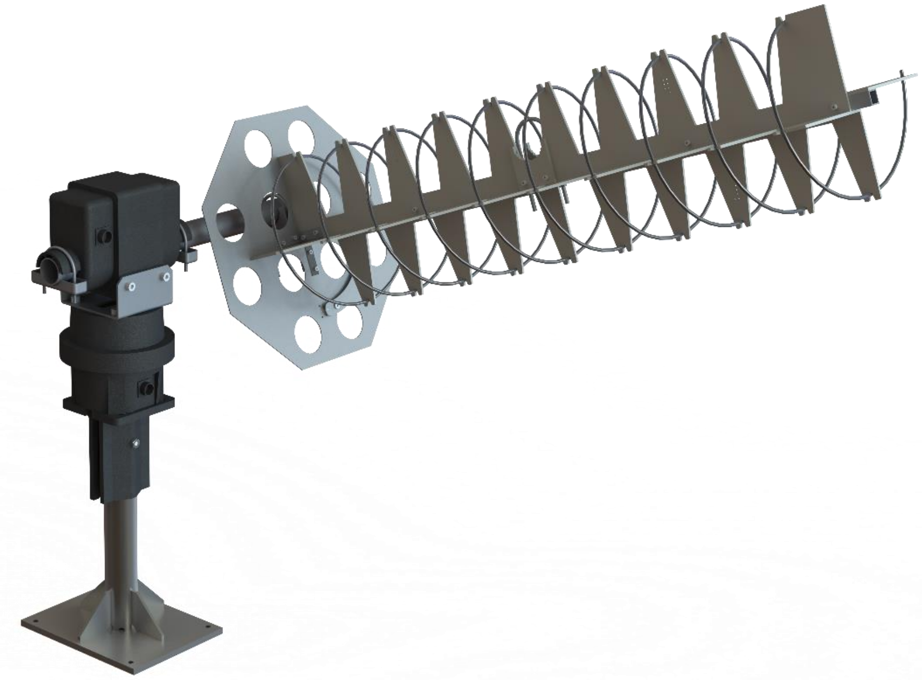
Antennas are used with a diplexer amplifier, which amplifies the received signals to compensate for losses in the drop cable and provides mixing of the signals in two ranges into one cable. Images of survey antennas are shown in Pic. 2.



Picture 2: Survey antennas

The third antenna is a directional one, of high enough amplification, so that in a typical case it will work with spacecraft in the range 430 … 440 MHz from elevation angles of about 5º. This antenna is mounted on a two-axis rotary device that allows you to point it anywhere in the sky. The directional antenna is used with a combined amplifier, which includes a low-noise amplifier with a filter and a power amplifier, as well as an automatic (VOX) receive-transmit switching circuit.

The installation of a power amplifier in the immediate vicinity of the antenna allows, observing the power limit of the transmitter of an amateur radio station of the third category, to obtain EIRP, high enough for reliable communication with spacecraft. An image of a directional antenna is shown in Pic. 3.



Picture 3: Directional antenna

A web-camera is also included in the antenna complex. It allows to control the position and condition of the antenna. This provides great entertainment, convenient in educational tasks and simplifies the work of the operator. An approximate view from the camera is shown in Pic. 4.

Picture 4: Camera view of directional antenna

The power of all devices included in the antenna complex is phantom (it is carried out via a signal cable) and low-voltage.

The basis of the radio complex is a workstation with software deployed on it. A HackRF SDR transceiver and, if necessary, an RTL-SDR SDR receiver are connected to it (Lime-SDR transceiver can be used as an alternative). SDR devices are connected to antennas through an injector, which supplies phantom power to the antenna complex devices, amplifies the transmitter signal, and serves as a patch panel for switching various station configurations, allowing you to connect any devices to any antennas.

The interface of rotating device controls the slewing ring with commands from the workstation via the USB interface and transfers data about the antenna position. Direct manual control is also provided (turns, installation in a storm position, emergency stop).

The Raspberry Pi makes it easy to integrate the station into the SatNOGS international network. A network switch provides Ethernet device connection and access outside.

Software

Determining the position of the spacecraft in the sky, based on its orbital elements, is performed by GPredict or Orbitron. Based on the calculations, a frequency correction is determined to compensate for the Doppler effect and transmitted to the receiving software. GPredict also controls the position of the directional antenna through the standard HamLib interface. To receive the signal, SDR Sharp or GnuRadio software is used. It is also possible to use other programs, such as SDR Angel or HDSDR.

SoundModem or a similar script in GnuRadio can be used to decode a demodulated signal and extract digital packets. Further, through TCP/IP, decoded telemetry can be sent to the server, sent to the SatNOGS international network and visualized in numerical or graphical form.

To get pictures, WxToIMG or LRPT decoder software is used.