«RadioComm Tecnologies» Ltd.

APPROVED

ТИШЖ.464349.109 ОМ

BEACON TRACKING RECEIVER

L-BAND

OPERATION AND MAINTENANCE MANUAL

ТИШЖ.464349.109 ОМ

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THIS OPERATION MANUAL (HEREINAFTER REFERRED TO AS OM) IS DESIGNED TO STUDY THE RULES OF PROPER USE, MAINTENANCE, REPAIR, STORAGE AND TRANSPORTATION OF BEACON TRACKING RECEIVER L-BAND (HEREINAFTER BTR).

OM CURRENTLY INCLUDES INFORMATION ON THE MAIN PARAMETERS AND CHARACTERISTICS OF THE DEVICE, COMPOSITION, PRINCIPLES AND CONDITIONS OF THE PRODUCT BTR, AS WELL AS ITS COMPONENT PARTS TO THE EXTENT NECESSARY TO ENSURE PROPER AND SAFE OPERATION, MAKE FULL USE OF THE TECHNICAL CAPABILITIES OF BTR.

TO OPERATE WITH THE PRODUCT FOR MAINTENANCE AND ROUTINE MAINTENANCE BY TRAINED PERSONNEL SHOULD BE INVOLVED IN GROUP III FOR ELECTRICAL SAFETY IN ACCORDANCE WITH REGULATION DOCUMENT, AND EXPLORE THE FULL OPERATIONAL DOCUMENTATION ON THE BTR.

DANGEROUS EFFECTS DURING OPERATION RELATES HIGH VOLTAGE 220 V AC 50 HZ.

LIST OF ABBREVIATIONS AND A LIST OF REFERENCE NORMATIVE DOCUMENTS LISTED AT THE END OF THIS OM.

OM SHOULD RESIDE WITH THE PRODUCT.

1 DESCRIPTION AND OPERATION

1.1 Description and operation beacon tracking receiver BTR

1.1.1 Purpose of BTR

1.1.1.1 The Beacon Tracking Receiver (BTR) is designed for operation in the AP satellite TV and L, S, C, X and Ku-band frequencies and a signal pointing proportional to the level of the received RF signal AP, antenna pointing systems (APS) reflector antennas with a diameter of up to 12 m.

1.1.1.2 BTR should be operate in the :

a) Operating Temperature 1 to 40 °C;

b) Storage Temperature - 40 to + 80 °C;

c) Pressure atmospheric (750±30) mm Hg;

d) Relative humidity up to 80% at temperature +25 °C;

1.1.2 Specifications

1.1.2.1 Main parameters of the BTR are presented in Table 1.1.

Table 1.1 – Main parameters of the BTR

Name of parameter, dimension	Nominal value , limits
Input frequency range, MHz	950 to 2175
Frequency step size, kHz	1
Frequency accuracy	10^{-5}
Bandwidth: - mode « Narrow Band» - mode « Broad Band»	 3 kHz (fixed) 70 kHz (fixed), from 10 to 70 MHz with step 2 MHz
Level Input signal for mode «Narrow Band», dBm	- 100 to - 20
Level Input signal for mode «Broad Band», dBm	- 85 to 0
Output DC Voltage Level, V	0 to 10

Name of parameter, dimension	Nominal value , limits
Output slope, V/dB	0,25
Non-linearity output voltage, %,	5
Resolution of tracking signal, mV	0,4
Bandwidth PLL (for mode « Narrow Band»), kHz	± 50
Minimal ratio S/N for lock PLL (for mode «Narrow Band»), not more, dB	8
Mirror channel rejection(for mode «Narrow Band»), not lower, dB	40
Modes of control and management	Local and Remote
Remote control interface	RS-485
Impedance, Ohm	50
VSWR input, not more	2
Load Impedance analog output signal (0-10) V, kOhm, not more	10
Power supply from AC mains 50 Hz, V	88 to 264
Power Loss,W	20
Size (without connectors), HxWxD, mm	482 x 423 x 44
Weight, kg	3,0

1.1.3 Parts List

1.1.3.1 The beacon Tracking Receiver BTR is a unit mounted in a standard rack 19 " 1U.

The parts included in the BTR are presented in Table 1.2.

Table 1.2 – Parts List of the BTR.

Name of parts	Designation design document	Qty.
Beacon Tracking Receiver BTR	ТИШЖ.464349.1091	1
Passport	ТИШЖ.464349.109 PS	1
Operation Manual	ТИШЖ.464349.109 O&M	1
Power cable		1

1.1.4 Design and operation of the product

1.1.4.1 The appearance of the BTR is presented on Figure 1.1.

Figure 1.1 – The appearance of the BTR (Front and rear view)

1.1.4.2 The connectors on the rear panel of the BTR, are presented in Table 1.3

Table 1.3

Connector	Type of connector	Annotation
220V, 50 Hz	PSCM4 «Valleman»	
INPUT L-BAND	N(f)	
TS analog (0-10) V	DB-9F	
M&C RS-485	DB-9F	

1.1.4.3 Functional description of the receiver.

BTR guidance signal receiver is a receiver of the heterodyne type, and comprises two separate receive path: broadband path (includes switchable filters from 1 to 70 MHz) and a narrowband path (fixed-band detector to equal 3 kHz)

Receiver BTR in its RF path incorporates an amplifier with software adjustable gain (adjustment range (0-50) dB). It also incorporates a wideband logarithmic detector with wide dynamic range and 16-bit ADCs to digitize the signal.

For the mode "Narrow band" (mode "beacon"), the system of search and signal acquisition is applied in the receiver, as well as phase-locked loop (PLL), designed to compensate the frequency offset of the signal. This frequency offset is due to the effect of Doppler, the instability of reference generators receiver and etc.

The receiver has a non-volatile memory and stores the configuration entered after a power off.

The main output of the receiver signal is an analog voltage signal (0-10V) in proportional to the received signal. This analog signal is generated by a 16-bit DAC. In addition, the receiver comprises a serial RS-485 interface intended for exchanging data with other components, the configuration of the receiver and updates the firmware.

Functional diagram scheme L-Band Beacon Receiver BTR is shown in Figure 1.2.

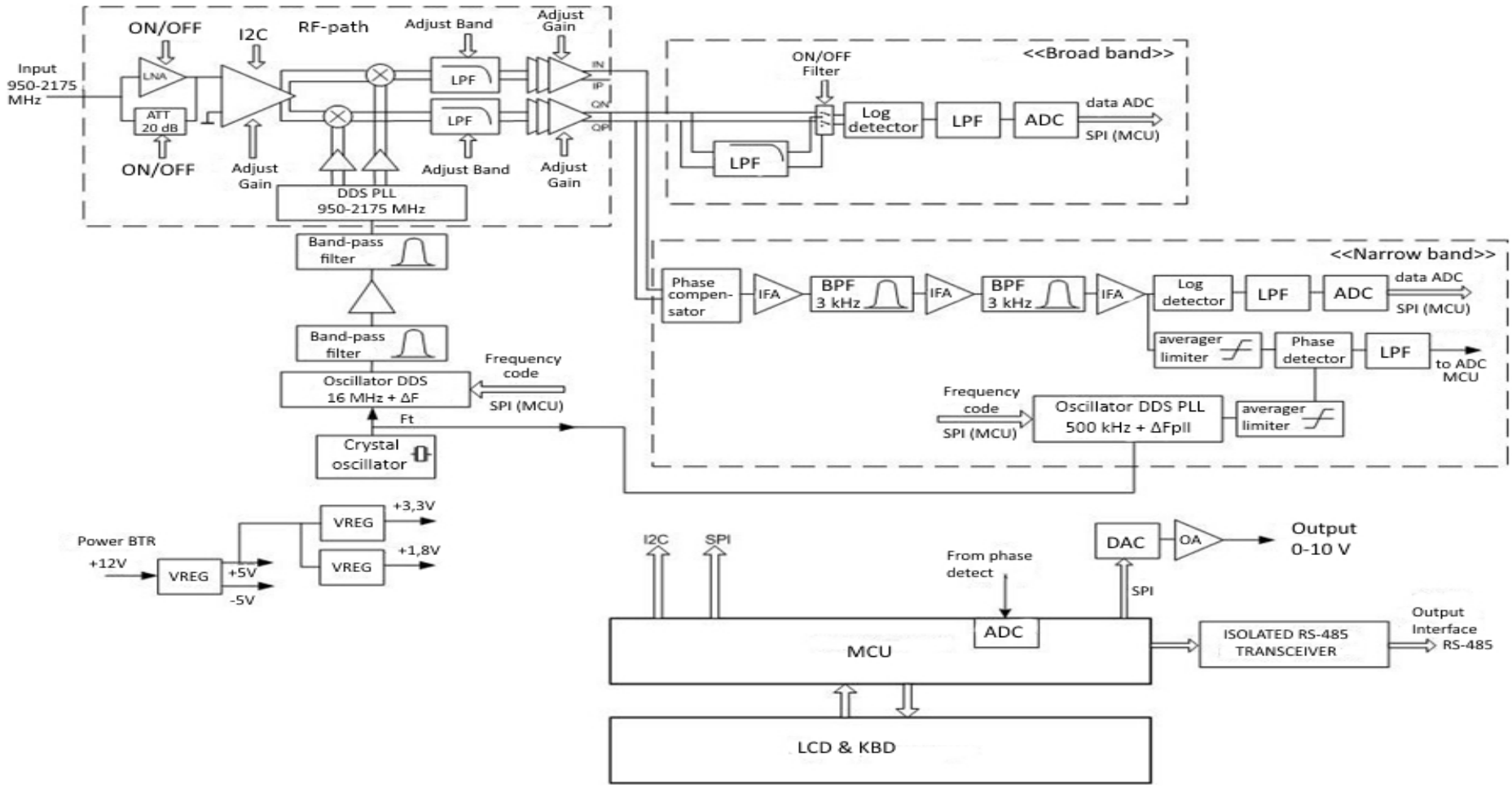


Figure 1.2 – Functional diagram scheme L-Band Beacon Receiver BTR

The input signal of the L-band (950-2175) MHz is fed to the input of converter direct synthesizer. At the entrance of the converter, there is the structure of the parallel connection of a low noise amplifier (LNA), and attenuator, which are switched by digital signal, based on the circuit of logic «OR». Switching from the LNA to the attenuator provides additional attenuation of about 20 dB in the input path and thus the absolute value of the input power may be no more than 0 dBm. A higher value of input power can damage the receiver.

Further, the input signal is applied to the RF amplifier, which has adjustable amplification factor (gain adjustment coefficient is from 0 to 50 dB). The amplifier provides the output signal level required for the quadrature mixer.

The second input of the mixer receives the local oscillator quadrature signal (phase shifted by 90 degrees). The local oscillator is controlled oscillator covered loop PLL (PLL-synthesizer). A local oscillator generates quadrature signals in the frequency range from 950 to 2175 MHz (frequency grid in increments of 125 kHz), installed software.

Signals are applied to the low pass filters from the output of the mixer. The band of these filters is programmable adjusted in the range of 10 to 72MHz. Next, signals are sent to the output buffer amplifier, whose gain is also could be set by software.

DDS converter is programmed and configured by a two-wire serial interface such as I2C.

Then the signal is distributed into two paths: broadband and narrowband.

A) Broadband path of processing:

A signal comes to the input of the logarithmic detector at the wideband signal-processing path Inasmuch as this detector has a pair phase input, signals (QN and QP) is used to increase the sensitivity. The detector has a wide band (from 0 to 400 MHz) and dynamic range of 90 dB. The voltage on the detector output is proportional to the input signal power. The detected voltage is input to the post detected filter (LPF-filter) with a constant time at about 0.1 sec and then is fed to a 16-bit analog-to-digital converter (ADC). The ADC output digital value is sent to the microcontroller where it is further filtered and processed.

Thus, the formation of the guidance signal, which is proportional to the power of the input signal in a wide band, is carry out in the broadband. This band is determined by LPF filters in a converter (10 to 72 MHz) path.

In some applications, there is a need to limit the band narrower value (for example, when operating on the types of signals 2 Mb/sec with modulation 16QAM, 8PSK and etc.). For this path an optional (additional) LPF is provided, connected via a high-frequency switch command processor. Additional band of LPF is about 1 MHz or can be changed when ordering.

B) A narrowband path of processing:

The narrowband processing path is designed to operate with the signals of spacecraft (SC) beacon. The beacon signal is an unmodulated carrier, usually located in the frequency plan of the transponders between spacecraft. The power of the beacon signal is relatively low and to provide the required signal/noise ratio (10 dB or higher) before-detected processing of this signal must be carried out in a narrow frequency band. In this receiver, bandwidth of the detector is chosen equal to 3 kHz and determined both filters bands and also the frequency oscillation of signal and heterodyne (including Doppler shift).

The frequency 501.5 kHz was selected as an intermediate frequency in the narrow band path, due to the characteristics of the filters. At the same time (as the method of direct conversion is used in this converter) a mirror received channel appears. It is frequency-shifted by the amount 2x501.5kHz = 1.03MHz. Phase compensation method is used to suppress this channel. Antiphase quadrature signals IN and QP are applied to the phase shifter from the output of the amplifier of the convertor, in which an additional phase shift between the signals at 90 degrees is provided. Then these signals are summed up in the operational amplifier (op amp) of the first cascade of the intermediate frequency amplifier (IF). The mirror channel is suppressed at the same time. The suppression is about -40 dB. Due to the fact that the beacon is typically located at a frequency between the frequencies of the spacecraft transponders, there are no strong signals at the frequency position of the mirror -channel, so the degree of suppression is sufficient for the receiver.

Then the signal is applied to a 1-st stage narrow-band filter with bandwidth of 1 to 3 kHz. The output signal of this filter is fed to a second IF amplifier and further notch filter stage 2 and the strip 3 kHz. The need of two filters usage is dictated by the high degree of suppression of out of band signal SC. This out of band signals can significantly exceed the power of the "beacon", and the degree of suppression in single filter is about 60 dB, which is not enough, because a broadband detector is used further in the part, and unsuppressed "remnants" out of band signals can degrade the sensitivity of the "beacon" signal.

The signal from the output of filter stage two is supplied to the third stage IF amplifier and then to logarithmic detector, the LPF and ADC, similar to those used in the broadband path. Digital code is transferred from output ADC (by SPI bus) to microcontroller for subsequent filtering and processing.

Due to the fact that the frequency band of the received narrowband tract is 3 kHz, it is necessary to compensate the frequency instability of both the signal (instability of “beacon signal”, the frequency offset caused by Doppler shift), and the instability of local oscillator of the receiver itself for holding the received signal in the receive band. For this system, it is provided in the receiver phase-locked loop (PLL), which operates as follows.

The signal from the output of the third stage of the IF amplifier is fed to a limiting amplifier, whose output signal is fed to the phase detector.

The second input of the phase detector is fed by the reference frequency from the reference oscillator PLL, constructed according to the scheme as direct synthesis (DDS). The nominal value of the reference frequency is 501.5 kHz that corresponds to the middle path bandwidth. From the output of the phase detector, the signal of discrepancy is input through a PLL filter to the 10 bit ADC, is built into the controller. When mismatch of the signal frequency relative to the nominal value of 501.5 kHz occurs, the signal of deviation appears at the output of the detector, and a controller adjusts the frequency of the main oscillator (16 MHz), providing compensation for this error.

The main oscillator receiver, as well as a reference oscillator PLL circuit, which is both tunable digitally is formed as direct synthesis (DDS). It generates a clock frequency for PLL-synthesizer the direct conversion transformer from reference frequency of the quartz resonator (16 MHz). Due to the fact that the output voltage of the generator, built on the principles of DDS, provides a sufficiently high level of harmonics and "Spur", which lead to the emergence of "the affected spots" in the frequency range of reception, a two-stage filtration concept with a buffer amplifier is used. This concept provides the required spectral purity of the oscillator signal. Two second order band pass filters is used as filters with a nominal frequency of 16 MHz or 400 kHz band with a buffer amplifier between them. The following tasks are implemented with involvement of the main oscillator of the receiver:

a) Providing a grid frequency of receiver configuration with step of 1 kHz (using its adjustment);

b) Providing stable operation PLL circuit;

c) Providing stable operation of search circuit and signal acquisition (for narrowband mode).

Insomuch as the PLL-synthesizer converter has a grid of 125 kHz, for the frequency grid receiver settings in increments of 1 kHz, an additional adjustment of the main oscillator is used in the following way: Controller receiver calculates the error between the desired frequency tuning signal of the receiver and the nearest PLL frequency synthesizer, a multiple of 125 kHz. The resulting mismatch (with conversion to the division ratio synthesizer) is introduced into the primary oscillator so as to match the frequency of the formed desired frequency setting signal with an accuracy of 1 kHz.

For operation of the PLL, controller inputs the additional tuning to the main heterodyne with such a value, that the value of the intermediate frequency in a narrow band path correspond to the frequency reference oscillator PLL (precise up to phase).

The method of searching and tracking of the signal.

Due to the fact that the initial frequency discrepancy of the input signal is as a rule not known, there is a system for search and capture the signal for an initial fine tuning of a receiver. The system operates as follows:

A microcontroller realizes a frequency's scanning by the narrow-band 3 kHz filter in the frequency band search (of +/- 50 kHz, can be changed by software settings of the receiver), measuring the voltage at each frequency position. Then, after scanning, the processor calculates the frequency position of the maximum signal level and if this level exceeds the threshold capture (software can change the settings of the receiver), the command of capture is produced and this frequency is transmitted to the position tracking system PLL.

The output analog signal receiver, the voltage of which (0-10) is proportional V input power L-band, is formed as follows: the processed signal to digital form is supplied to 16-bits Digital-to-analog converter (DAC), the output of which produces an analog voltage signal (0-2,5) V. Further, at the output op-amp signal scaling is performed to the standard range (0 10) V.

For data exchange configuration and programming, there is RS-485 interface in the receiver. The interface is galvanically isolated. Baud rate and address of the BTR may be set by software.

1.1.4.4 The main PCB of the BTR is powered from the secondary power supply with voltage of 12 V.

1.1.4.5 Controls of the receiver BTR can be done by pressing the keyboard, located on the front panel. Settable parameters are displayed via a two-line alphanumeric LCD.

The LCD may display these options:

- Displays the current value of the signal level guidance, the current tuning frequency band of the filter and mode of operation;
- Alarms (serviceability or failure) of the receiver BTR;
- Indication of the data exchange via RS-485.

The list of the managed and controlled parameters:

- Frequency tracking (950-2175) MHz;
- Bandwidth filter (3 kHz, 1 MHz, 10-72 MHz with step 2 MHz);
- Gain filter (from 0 to 9 dB);
- Input attenuator (0 or 20 dB);
- Main attenuator (0 to 50 dB with step 5 dB);
- Operating mode of RCV («Broad band» - «Narrow band»);
- Mode of PLL (ON/OFF);
- Tracking signal (ON/OFF, only for mode «Narrow band»);

- Dimension of the filter (0 - 250 dotes);
- Threshold for noise (0-65535);
- Frequency of the main heterodyne;
- Step search AFC;
- Bandwidth search AFC;
- Local oscillator frequency PLL;
- Baud rate and address of the beacon receiver over M&C;

A summarized fault signal is displayed on the LED "Alarm". When a fault occur, the LED "Alarm" is lights as red. The LCD module and LED are situated on the front panel of RCV.

After the power up, the buttons indicated by the arrows "left", "right» («←», «→», respectively) can carry out the possible movement of the mode sets the parameters in both directions. Use the keys "up" and "down» («↑», «↓», respectively) - Change the setting up or down, respectively.

1.1.4.6 Frequency response of RCV

Frequency responses of tracking receiver for modes «Narrow band» and «Broad band» are given in Figures 1.3-1.7.

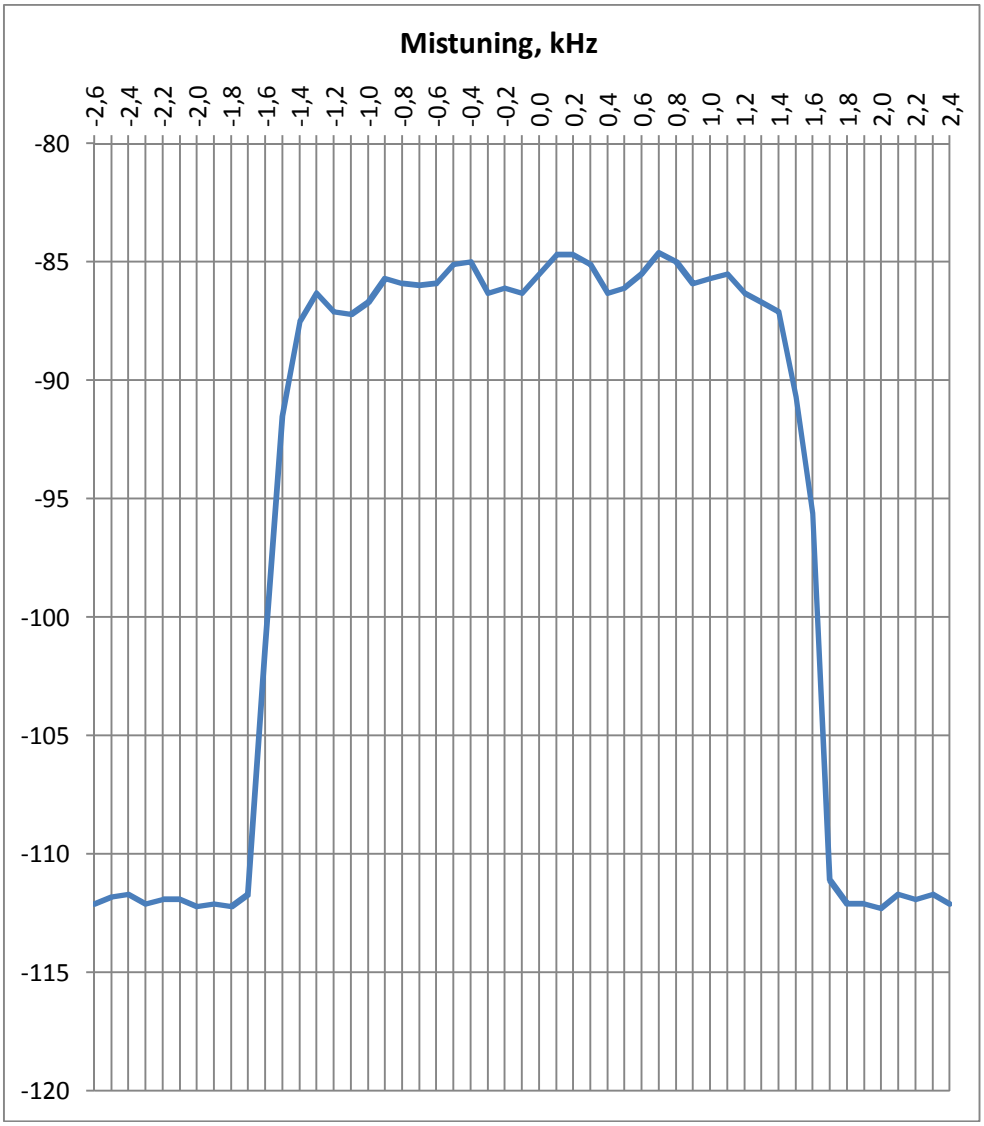


Figure 1.3 – Frequency response of RCV of path « Narrow band » (3 kHz)
(By ordinate axe– value in dBm, by abscissa axe– value of detuning relative of carrier input signal frequency)

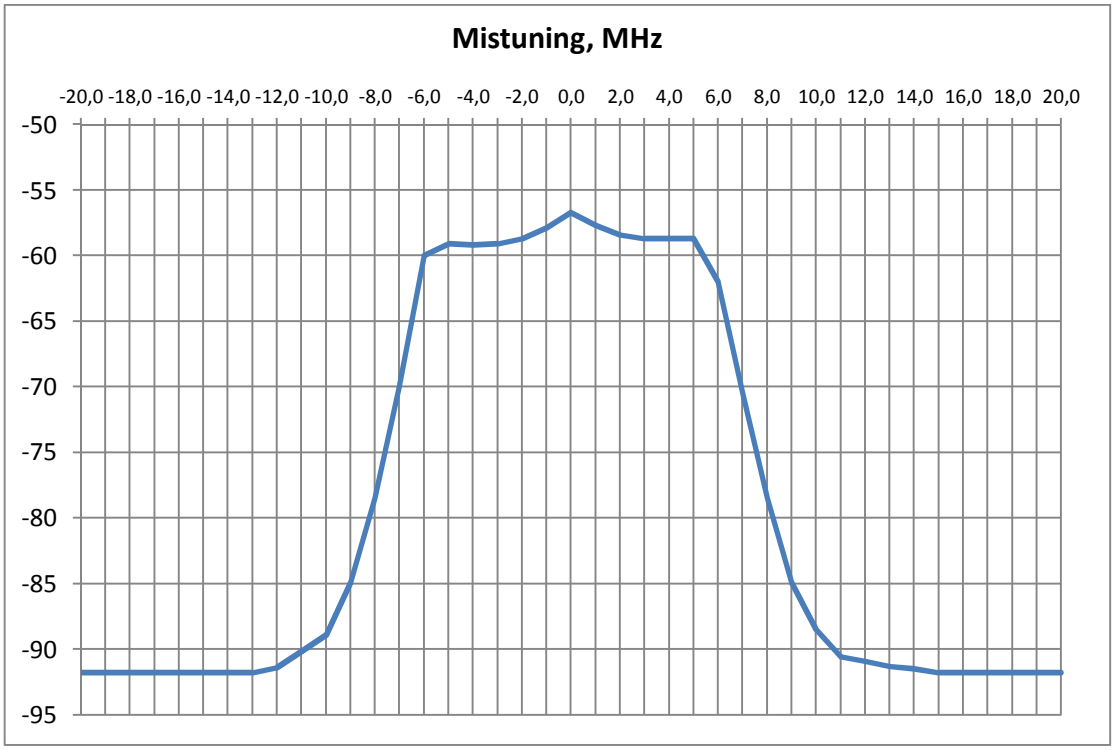


Figure 1.4 – Frequency response of RCV
By path «Broad band» for filter 10 MHz
(By ordinate axe – value in dBm, by abscissa axe – value of detuning relative of carrier input signal frequency)

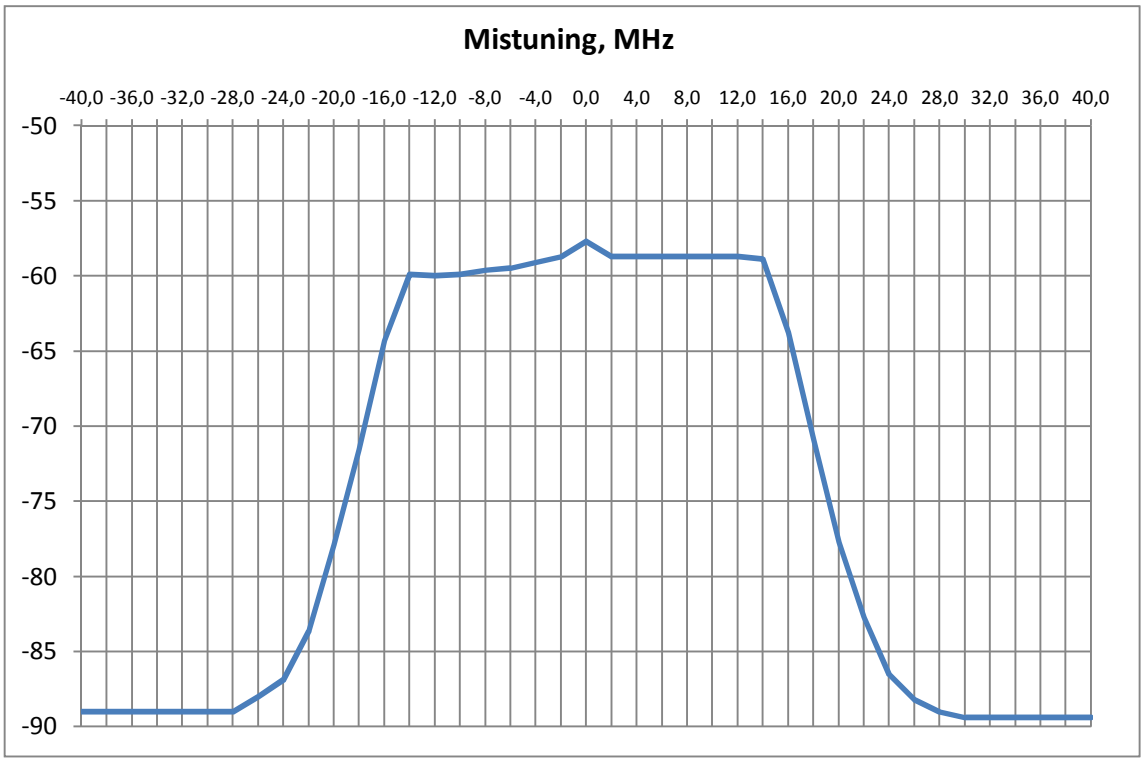


Figure 1.5 – Frequency response of RCV
By path «Broad band» for filter 30 MHz
(By ordinate axe – value in dBm, by abscissa axe – value of detuning relative of carrier input signal frequency)

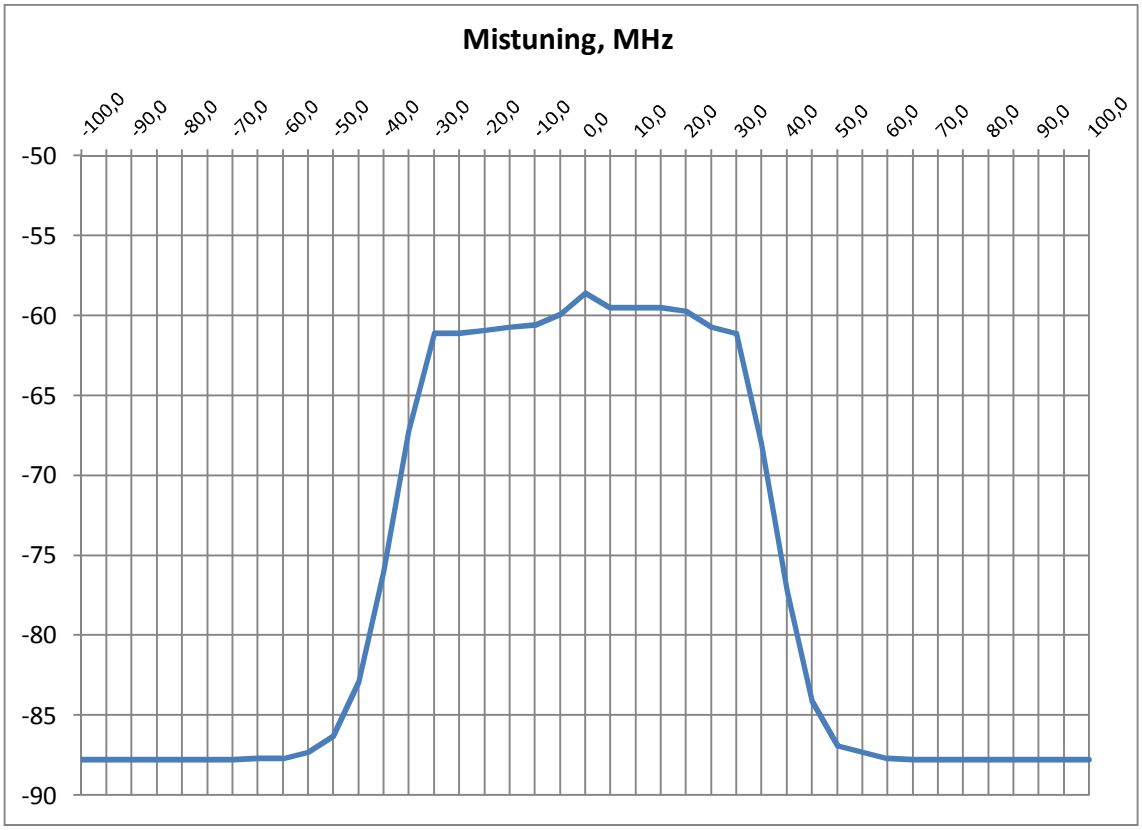


Figure 1.6 – Frequency response of RCV
By path «Broad band» for filter 70 MHz
(By ordinate axe – value in dBm, by abscissa axe – value of detuning relative of carrier frequency of input signal)

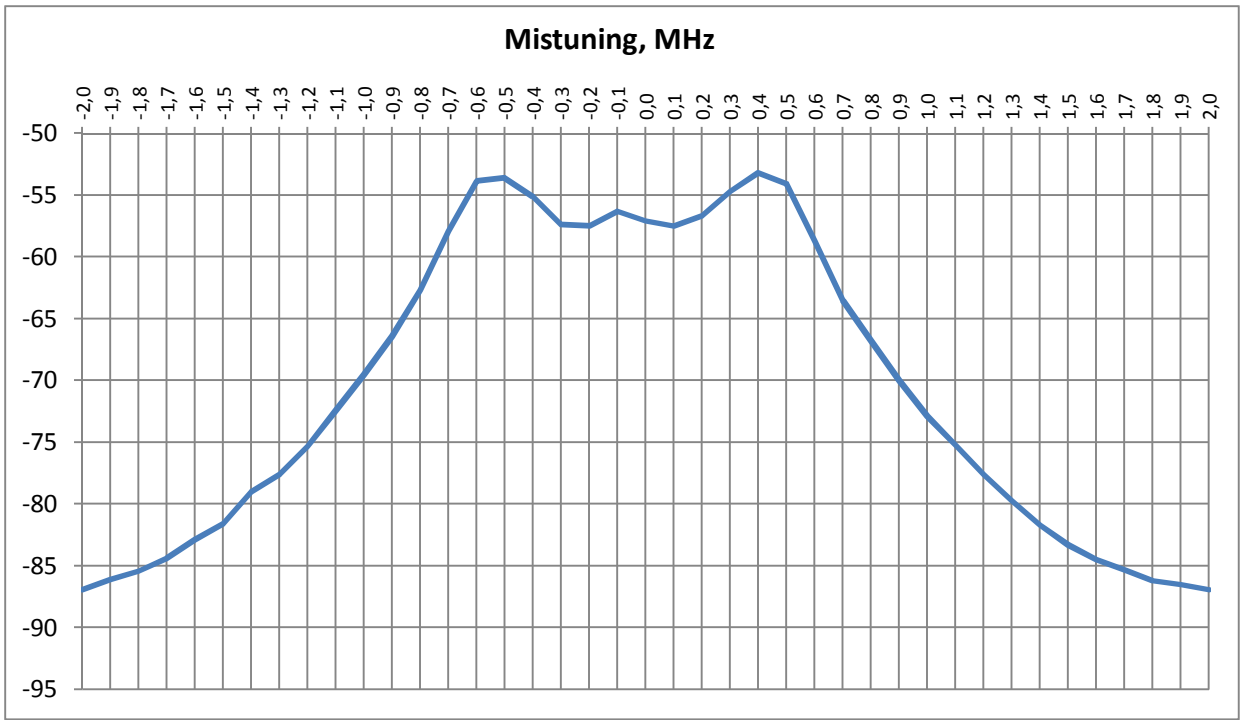


Figure 1.7 – Frequency response of RCV
By path «Broad band» for filter 700 kHz
(By ordinate axe – value in dBm, by abscissa axe – value of detuning relative of carrier input signal frequency)

1.1.4.7 Frequency response of RCV.

Mode «Narrow band».

An amplitude characteristic of RCV for «Narrow band» mode is given in Figure 1.8.

The dynamic range for the input signal power situated between -100 dBm (at the Ku = 999) to -20 dBm (with Ku = 0).

For a given Ku, linear operational area of characteristics in mode "Narrow band" is about 30 dB on the input signal.

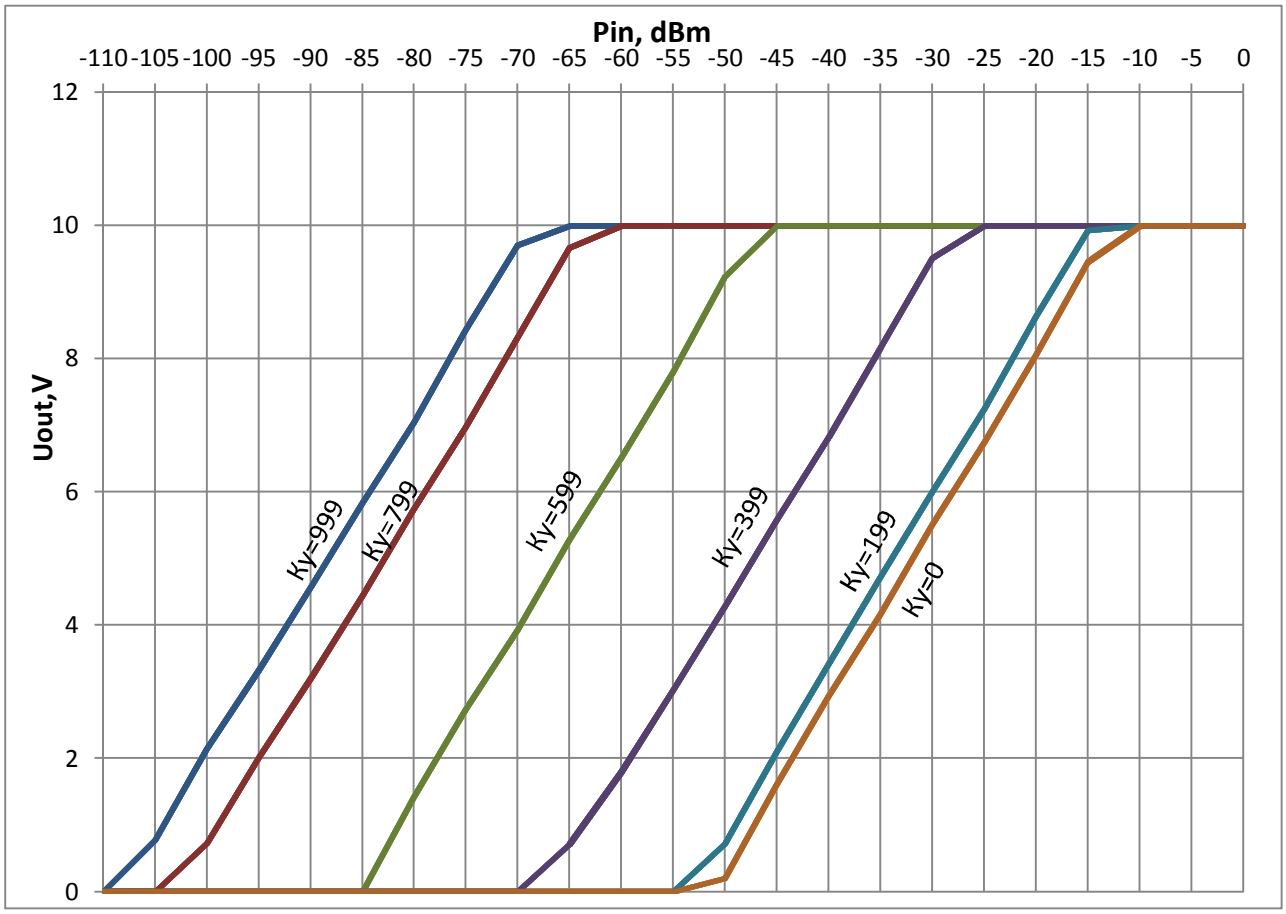


Figure 1.8 – Frequency response of RCV
for «Narrow band» mode for various values of gain Ku (By ordinate axe – value of output analog signal in Volts, by abscissa axe – level of input signal, dBm)

Mode «Broad band».

Frequency response of RCV for « Broad band » mode is given in Figure 1.9.

The operating range for input power ranges from minus 90 dBm (in Ku = 999) and 0 dBm (at Ku = 0).

For a given Ku, linear operational area of characteristics in «Broad band» is about 30 dB on the input signal.

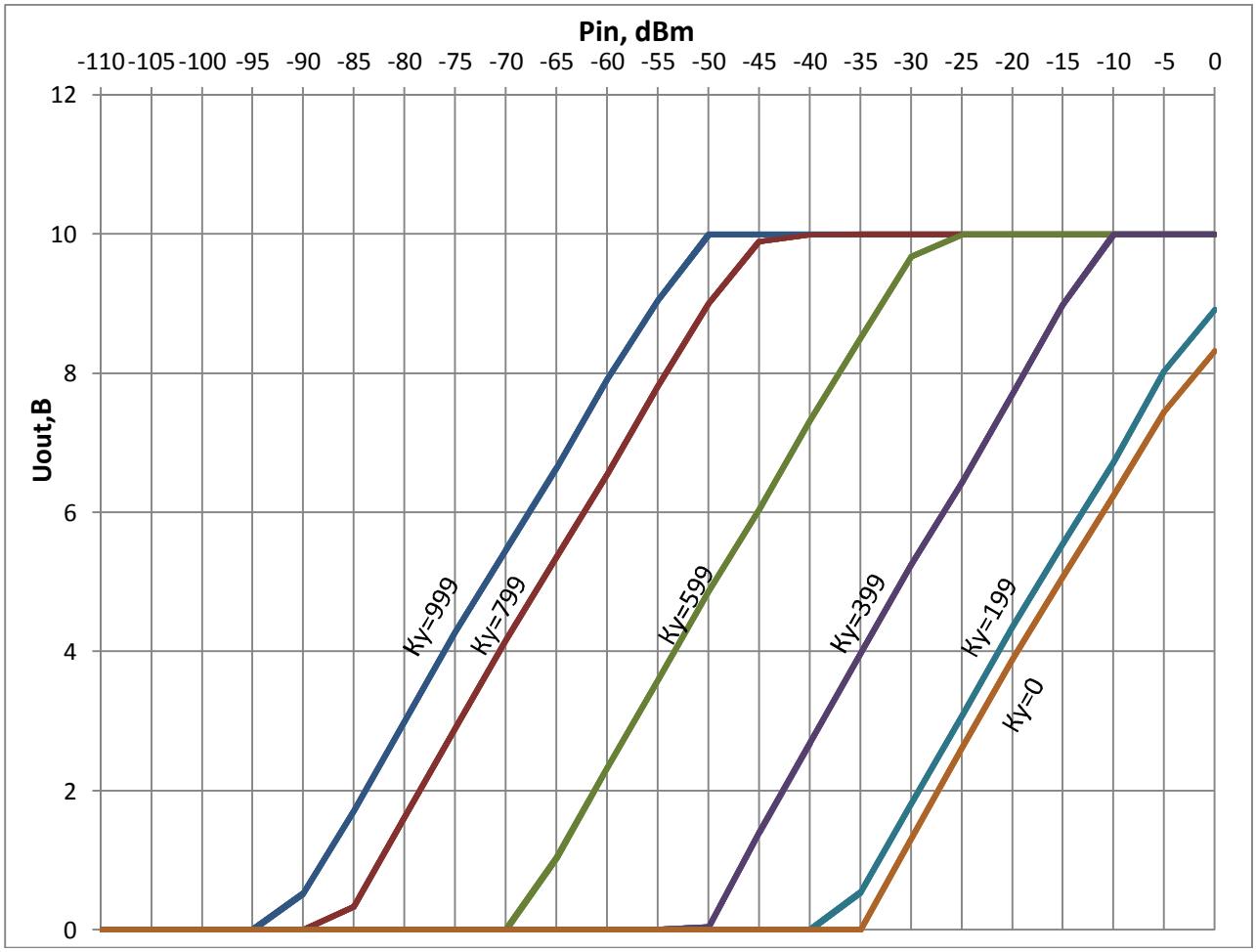


Figure 1.9 – Frequency response of RCV
for mode «Broad band» for various values of gain Ку
(By ordinate axe – value of output analog signal in Volts,
by abscissa axe – level of input signal, dBm)

To indicate the power level of the received signal, the measured value of the input signal power is displayed at the receiver front LCD screen. The maximum error of the measurement of input signal power at a ratio of S/N = 30 dB is not more than ± 4 dB.

1.1.5 Marking and sealing of the BTR.

Marking receiver tracking signal BTR is made in accordance with the requirements of the design documentation.

If necessary, additional protection may be filling the receiver and guidance by means of BTR - paper seals (labels) or restoratives cups with non-drying putty.

1.1.6 Package.

Receiver BTR comes in a standard transport packaging manufacturer which made in accordance with the operational documentation for this product.

It should be labeled on the package of the BTR

- Gross weight in transport condition;
- Conditional index of products (if necessary).

2 INTENDED USE BTR.

2.1 Operating limitations

2.1.1 The maximum input power level at the input could not be more than 15 dBm. It does not lead to failure of the BTR.

2.1.2 Minimum load of BTR for analog signal output should not be less than 10 kOhm.

2.2 Preparation of BTR to use.

2.2.1 Safety instructions.

2.2.1.1 Special safety instructions for prepare of BTR for the intended use is not provided.

2.2.1.2 Persons must be at least 18 years to operate with the receiver BTR. They must be certified by the rules of electrical safety and safety by assigning the qualifying group is not lower than the third, passed the credit to conduct independent operate with the electrical voltage up to 1000 V and studied the receiver BTR in the scope of this guide to operation.

2.2.1.3 The BTR must be connected to the ground bus.

2.2.1.4 Service personnel are prohibited:

- to apply the abnormal and defective measuring devices that do not have marks on their timely verification;
- to touch the connector pins with bare hands or clothes, without taking measures to protect against static electricity, and lean against the connectors to surfaces in relation to dangerous accumulation of static electricity.

2.2.2 The rules and the procedures for verification of readiness to use the BTR.

2.2.2.1 Check the correct connection of 220 V and the ground connection to the receiver BTR.

2.2.2.2 Connect the connectors to the «Receiver BTR. 0-10 V» and «M & C RS485» the appropriate cables. Wiring cables refer to Appendix A.

2.2.2.3 Applied to the input connector "INPUT L-BAND» signal with a frequency in the range from 950 to 2175 MHz and a level ranging from minus 100 dBm to 0 dBm (e.g. LNB output from an earth station).

2.2.2.4 Set the power switch 220V on the rear panel of the receiver to "1". The receiver is ready for operation not earlier than 10 minutes after the power is turned on (warming reference oscillators is needed).

Nominal accuracy of the measurement of the power level of the input signal is set within 30 minutes of continuous operation after power up the BTR.

2.3 Verifying the BTR.

2.3.1 To verify the BTR the user need to test the possibility of setting modes in accordance with paragraph. 1.1.4.5 Use the controls on the front panel, and the characters on the LCD display for reference.

2.4 Operation with the BTR.

2.4.1 For operation with the BTR, it is necessary to conduct p. 2.2, apply voltage of 220 V 50 Hz and turn the receiver button "On/Off" on the rear panel of the unit, setting it to "1". Then, if necessary, install or control unit variables of the receiver in accordance with paragraph. 1.1.4.5..

2.4.2 Tuning the RCV.

In the menu "Settings" -> "Basic Settings" set the following settings:

A) the tuning frequency

Set the desired frequency.

B) RCV mode (“Narrow band” or “Broad band”)

Depending on the type of the signal that will be used for operation of the system the user must set the desired mode:

If operation is carried out on a beacon signal (or any other unmodulated carrier), the mode "Narrow band" must be set.

Note – For mode “Narrow band” of the search and the system PLL are enabled (factory settings).

If the user operate on a broadband signal (on the trunk of the spacecraft or part of the trunk), the mode «Broad band» must be set.

C) Filter bandwidth for mode «Broad band».

If the «Broad band», is selected, it is needed to set the bandwidth of the filter the most closely matched to the band used (received) signal. If «Narrow band» is selected, this item must be ignored

D) The gain of RCV.

Set required gain Ku of the receiver as follows: enter the menu "RCV Gain" and changing the gain so that the output analog voltage (0-10) V is in the range from 5 to 7.5 V.

Note - AP antenna must be induced on the spacecraft maximum pattern.

E) Then switch to the menu "View the current status "Setting up the receiver is completed.

The output of the receiver is an analog voltage (0-10) V and it is proportional to the received signal power, which is issued to the connector "RCV 0-10 "**.**

Furthermore, this voltage into a digital form can be obtained from the connector «M&C RS485» by sending a request to the protocol format according to Appendix G.

2.5 The list of possible failures and recommendations for action when they are occur.

2.5.1 Red LED "Alarm" in the operating mode indicates a malfunction of the receiver. If the output level and the input signal power has the odd value, there is the possibility of the other malfunction

2.5.2 If there is inconsistence between the BTR and requirements of this guidance in the process of testing or operation of the product, one must ensure that all devices and systems interfaced with it operate properly.

2.5.3 In the event of any failure, be ensure of the presence of the mains voltage power, cable is not faulty and serviceability of fuses.

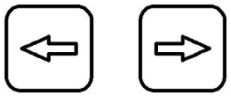
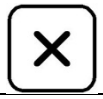
2.5.4 When a fault is determined, the BTR must be replaced with a faultless set of spare parts, and the faulty receiver is sent in for repair.

2.6 Operation with the BTR.

2.6.1 The keypad of the BTR.

To control the receiver BTR use the keypad on the front panel of the unit. The button functions of the keypad are shown in Table 2.1. Operating parameters are displayed on the LCD located on the front panel of the unit (see Figure 1.1).

Table 2.1 – Button functions of the keypad.

№ Button	Icons of button	Function
1, 2		- navigating the menu bar;
3, 4		- menu selection; - increase or decrease in value of the parameter when editing
5		out of a menu item to a higher level
6		Displays a list of current alarms
7		Entrance to the editing mode settings
8		- the entrance to the menu; - enter the changed value of the parameter
9		Escape

2.6.2 Description of the Menu.

The Main Menu consists of:

- «Main menu view»;
- «Setting parameters»;
- «End Menu»

The item «Main menu view» is basic for the display mode of the receiver:

For mode «Narrow band»

```
U=5.91V  S=-85.4 dBm      +++
F=2010.000MHz    dF=3kHz
```

«U=5.91V» - Output analog signal level, Volts.

«S=-85.4dBm» - Signal level, dBm.

«F=2010.000 MHz» - Input signal frequency.

«dF=3kHz» - Filter bandwidth.

The symbols +++ indicates the current status of the search engines and PLL receiver.

The first symbol indicates the mode of tracking signal (On/Off).

The second symbol indicates status of locking signal (capture/no capture).

The third symbol indicates the mode of the system PLL (On/Off).

The various possible status of indication symbols are presented in Table 2.2

Table 2.2 - Indication current modes the system of searching and tracking.

Displayed symbols	Description
+++ or **++***	Signal search mode enabled Lock signal is present System PLL enabled (tracking signal system PLL third symbol changes from "+" to "*" at an interval of 1 time per second)
++o	Signal search mode enabled Lock signal is present System PLL OFF
+--	Signal search mode enabled No Lock PLL not tracking
oxx	Signal search mode disabled Lock signal ignored PLL ignored
oxo	Signal search mode disabled Lock signal ignored System PLL OFF

The first symbol «+» means that the signal search mode is enabled, when the search mode is turned off, then the symbol «o» is displayed in this position of character.

The second symbol «+» means that the system PLL is enabled. When the system PLL is off, then the symbol «o» is displayed in this position of character.

The third symbol «+» means that there is a signal acquisition system PLL, if the seizure is not, then the symbol «-» is displayed in this position of character.

If the input signal at terminal «Input L-BAND» is not sufficient for normal operation of the receiver, the display on the second line 1 every 2 seconds will blink "Low level, no Lock". It is necessary to increase the level of the input signal (or increase the gain of the receiver).

If the signal is too large, and the receiver is overloaded, the display will be flashing on the second line 1 every 2 sec "Overload by input signal". It is necessary to lower the input signal level (or reduce the receiver gain).

For mode «Broad band»

```
U=4.38V  S=-74.6 dBm       BB
F=2010.000MHz    dF=10 MHz
```

«U=4.38V» - Output analog signal level, Volts.

«S=-74.6 dBm» - Signal level, dBm.

«F=2010.000 MHz» - Input signal frequency.

«dF=10 MHz» - Filter bandwidth.

The symbol BB indicates that the BTR operates in mode «Broad band».

Annotation – In the mode «Broad band» the system of searching and tracking (PLL) does not operate.

If the input signal at terminal «INPUT L-BAND» is not sufficient for normal operation of the RCV, a message like: «Low level, no Lock» will blink on the LCD in the second line at 1 time every 2 seconds It is necessary to increase the level of the input signal (or increase the gain of the RCV).

If the signal is too large, and the receiver is overloaded, a message like «Overload by input signal» will blink on the LCD in the second line one time every 2 seconds. It is necessary to decrease the input signal level (or reduce the gain of the RCV).

If press the button  from current view status an additional view for the current state like this:

```
Ku=999  Ks=0.25V/dB
ADC=05468  Search=1, PLL=1
```

will be displayed on the LCD

«Ky=999» - Current value of Gain Ku of RCV.

«Ks=0.25V/dB» - Slope Ks of RCV.

«ADC=05468» - local units of ADC (by signal).

«Search=1» - Operate mode of searching system, 1- ON, 0 – OFF.

«PLL=1» - Operate mode for PLL, 1- ON, 0 – OFF.

Exit from this menu back to view the current status by the button 

.

2.6.3 Description menu «Setting parameters»

The item of menu «Setting parameters» consists of the next sub-items:

- «Main parameters»
- «Additional parameters»
- «Parameters RS485»
- «Identification Firmware»
- «End menu»

The sub-item of menu «Main parameters» allows the user to adjust the following parameters:

- «Frequency»
- «Gain Ku»
- «Mode RCV (BB/NB)»
- «Bandwidth filter mode BB»

The sub-item of menu «Additional parameters» allows the user to configure the following parameters:

- «Slope Ks»
- «Input attenuator»
- «Gain LPF»
- «Searching signal (NB)»
- «Bandwidth AFC (NB)»
- «Step AFC (NB)»
- «Mode PLL (NB)»
- «Settling time PLL»
- «Width integrator»
- «Frequency main oscillator»
- «Frequency oscillator PLL»

The sub-item of menu «Parameters RS485» allows the user to configure the following parameters:

- «Baud rate RS485»;
- «Address RS-485»;
- «Baud rate TLM»;
- «Period data TLM»;

To adjust any of the settings, choose the appropriate menu item by press the buttons “3” and “4” (Table 2.1) and then press button “8” (Table 2.1). Next, using the buttons “1”, “2”, “3”, “4” (Table 2.1) is necessary to set the desired value and enter it by pressing the button “8” (Table 2.1).

2.6.4 Description menu «Main parameters»

«Frequency»

When setting the item Frequency, a message like:

Frequency 1005.000 (950 – 2175 MHz)

is displayed on LCD.

The frequency can be selected from range 950 to 2175 MHz

Setting step – 1 kHz.

«Gain Ku»

When setting the Gain Ku, a message like:

Gain Ku (0-999) 999 U=2.21V NB+++

is displayed on LCD.

The gain can be selected in the range of 0-999 by buttons 1,2,3,4. Here, for convenience, the current value of the output voltage (0-10) and in the mode of the receiver (SHP - Broad band, NC - a narrow strip) is shown next to the gain. NB mode is displayed mode tracking and tracing systems (see Table 2.2).

«Mode RCV (BB/NB)»

When setting the mode RCV (BB – Broad band, NB-Narrow band), a message like:

Mode RCV (0-BB, 1-NB) 1 (0-BB, 1-NB)

is displayed on LCD.

If the mode is changed from the NB-narrow band mode to BB - Broad band search signal system and system of PLL are switched off automatically. When the reverse mode is changed from BB- Broad band mode to NB-narrow band search signal system and the system PLL automatically return to the mode that was set for them in the appropriate menu items.

Annotation - If the mode is changed, the tuning frequency and the current value of the gain is stored. However, it should be understood that the coefficient of transmission path and the narrow band Broad band differs by 17 dB.

«Bandwidth filter BB»

When set the value Bandwidth filter for mode BB – Broad band, a message like:

Bandwidth filter BB 01 Bandwidth=10 MHz

is displayed on LCD.

Valid values for bandwidth filter as follows:

00 Bandwidth= 700 kHz

01 Bandwidth = 10 MHz

02 Bandwidth = 12 MHz

… with step 2 MHz

31 Bandwidth = 70 MHz

2.6.5 Description menu «Additional parameters»

ATTENTION! Additional options are designed for initial setup of the receiver pointing and when changes need, one must take special care.

«Slope Ks»

Annotation - In this version of the firmware, this option is not available.

«Input attenuator»

When setting the input attenuator a message like:

Input attenuator -20dB 0 (0-OFF 1 – ON)

is displayed on LCD.

Valid values: 0 – attenuator OFF , 1- attenuator ON

«Gain LPF»

When setting the Gain LPF, a message like:

Gain LPF 0 Gain = 0.0 dB

is displayed on LCD.

Valid values:

0 Gain = 0.0 dB

1 Gain = 1.6 dB

2 Gain = 3.0 dB

3 Gain = 4.6 dB

4 Gain = 6.3 dB

5 Gain = 7.3 dB

6 Gain = 8.2 dB

7 Gain = 8.5 dB

8 Gain = 8.8 dB

9 Gain = 9.0 dB

«Searching signal (NB)»

When setting the item «Searching signal, a message like:

Searching signal NB 1 (0-OFF, 1-ON)

is displayed on LCD.

Valid values: 0 – searching system OFF, 1- searching system ON.

Annotation – Searching signal system operate only in mode «Narrow Band».

«Bandwidth AFC (NB)»

When setting the item «Bandwidth AFC», a message like:

Bandwidth AFC 0000040000

is displayed on LCD.

Value « Bandwidth AFC » is set in nominal units. The value = 40000 is matched to search band +/- 50 kHz.

«Step AFC (NB)»

When set the value «Step AFC», a message like:

Step AFC 0000000050

is displayed on LCD.

Value «Step AFC» is set in nominal units.

«Mode PLL (NB) »

When setting the item «Mode PLL», a message like:

Mode PLL (NB) 1 (0-OFF, 1-ON)

is displayed on LCD.

Valid values: 0 – PLL OFF, 1- PLL ON.

Annotation - PLL can operate only in mode «Narrow band».

«Settling time PLL»

When setting the value «Settling time PLL», a message like:

Settling time PLL 001 (0-255)*5ms

is displayed on LCD.

Value can be set in intervals by 5 msec.
Valid values from 0 to 255.

«Width integrator»

When set the value «Width integrator» on LCD displayed a message like:

Width integrator 00500 (0 to 500)

Value « Width integrator » is set in nominal units. Valid values from 0 to 500.

«Frequency main oscillator»

When set the value «Frequency main oscillator» a message like:

Frequency main oscillator 1600013351 (Hz*100)

is displayed on LCD.

Value «Frequency main oscillator» is set in nominal units equal Hz*100. Installation of the frequency is necessary for correct operation of the PLL circuit of high-frequency module.

«Frequency oscillator PLL»

When set the value «Frequency oscillator PLL», a message like:

Frequency oscillator PLL 0050150000

is displayed on LCD.

Value «Frequency oscillator PLL» is set in nominal units equal Hz*100. Setting of the frequency oscillator is needed to fine tune the oscillator PLL to the carrier frequency of narrowband filter.

2.6.6 Description menu «Parameters RS485».

In Sub-menu «Parameters RS485» user can set next parameters: «Baud rate RS485» and «Address RS-485».

When setting the Baud Rate, a message like:

Baud Rate, bit/sec 6 Baud Rate=38400

is displayed on LCD.

Possible values for baud rate are selected from the standard range:

0 - 2400 bit/sec

1 - 4800 bit/sec

2 - 9600 bit/sec

3 - 14400 bit/sec

4 - 19200 bit/sec

5 - 28800 bit/sec

6 - 38400 bit/sec

7 - 57600 bit/sec

8 - 76800 bit/sec

9 – 115200 bit/sec

When setting the address, a message like:

Address (0-255) 003 (255-common address)

is displayed on LCD.

Valid addresses 0-254. Address 255 is common for the search and the receiver on the bus RS-485 and its initial configuration (it will issue a response to the receiver, regardless of his fixed address).

«Baud rate RS-485 TLM».

When setting the exchange Baud rate TLM, a message like:

Baud rate TLM, bps 4 Baud rate=115200

is displayed on LCD.

Possible values for “Baud rate TLM”:

0 - 9600 bps

1 - 19200 bps

2 - 38400 bps

3 - 57600 bps

4 - 115200 bps

5 - 230400 bps

6 - 460800 bps

7 - 500000 bps

8 - 576000 bps

9 - 921600 bps

«Period output data TLM».

When you configure period output data TLM, a message like:

Period data TLM (0.1 msec) 00000

is displayed on LCD

Possible values 0-65535 in intervals by 100 microseconds.

2.6.7 Description menu «Identification Firmware»

Sub-menu "Identification Firmware" contains the following options: «ID-number controller", "User Key" and "Factory settings." Parameter «ID-number controller» contains the identification number of the controller and is used to unlock the firmware and a message like:

ID-number controller 0003278653

is displayed on LCD.

Parameter «User Key» is individual for each BTR a message like:

User Key 1623687199

is displayed on LCD.

It is forbidden to change the value of the user key of the controller. When issuing a message on the LCD «Attention! Invalid key», refer to the specialists of «RadioComm Technologies» Ltd.

Parameter «Factory settings» is used to reset the BTR to factory settings and the following message:

Apply factory settings? Yes – OK, No - ESC

is displayed on LCD

2.6.7 LED's indicator.

The LED indicator «ALARM» is situated on a front panel of the BTR.

When alarms occur, then the red LED "ALARM" is lighting.

To see the detailed list of alarms on the front panel of the BTR user need to press a button 

. A list of alarms appears on the screen. Then, pressing buttons «up» and «down» arrows, user can scroll the list of current alarms. If there is no alarm, then the list will be displayed like: "No current alarms".

The list of possible alarms:

«Failure oscillator DDS»

«Failure ADC Broadband»

«Failure ADC Narrow band»

«Failure DAC output»

«Failure DAC Gain»

«Failure of RF module over I2C»

«RF module: No signal»

«Bit is set POR=1»

«No lock PLL in TDA»

«Bit is set ERRORCAL»

When the red LED «ALARM» is lighting, further operation of the BTR is not possible, so long as the cause of the alarm would be eliminated.

The green LED "M & C" is situated on the front panel of the BTR.

During the data exchange with the BTR via RS-485 LED "M & C" is flashing green. This LED blinks only if the packet, received by the BTR, is correct (has a regular structure, the correct address, register and checksum).

3 MAINTENANCE AND SERVICING INSTRUCTIONS.

3.1 General instructions.

3.1.1 The main purpose of equipment maintenance is ensuring the smooth and reliable operation of the receiver BTR in constant readiness for use for other purposes.

3.1.2 Problems solved during the servicing are:

- Exception conditions and defects that are potentially harmful to the proper functioning of the BTR;
- Identification of elements (blocks) that are on the brink of failure, and advance their replacement;
- Check the technical condition of the elements and nodes, because it cannot checked of the BTR itself.

3.1.3 On the basis of the requirements of this manual and in accordance with the internal regulations of the operating company it is recommended to release the schedule of activities of maintenance BTR, and the necessary additional processing documents regulating the work of the staff (instructions to the operator or dispatcher, operator instructions for the implementation of certain manufacturing operations and so forth.).

3.1.4 All works for maintenance must be carried out in full and in accordance with the instructions in this guide technology.

3.1.5 Maintenance activities related to the violation of seals equipment under warranty, take place only after the warranty period.

3.1.6 When carrying out a standard tool once used according to the bill sets of spare parts and materials (rags, grease, ethyl alcohol, etc.) According to the norms of material consumption products of BTR.

3.1.7 The results of the MSO identified faults and all transactions made on individual items of equipment repair and troubleshooting, are entered in the relevant sections of the passport with the indication of use the product at the time of that. All faults and deficiencies identified during the maintenance should be eliminated.

3.1.8 Maintenance suggests the following activities:

- Current Maintenance;
- Planned preventive examinations;
- Current repairss and tuning.

3.1.9 Current MSO is assumed direct daily manipulation carried out by the product and service personnel in accordance with the schedule of MSO.

3.1.10 Representatives of manufacturer of the equipment can be involved for maintenance if that necessary (in agreement).

3.1.11 Routine check-ups and working on the product is carried out at a frequency determined by the internal documents of the operating organization, but not less than once every six months.

3.1.12 Product repair should be carried out with the involvement of representatives of the established procedure of the manufacturer (supplier) BTR.

Repair and holding something with access to the internal parts of the product must be performed only by qualified service personnel, which have been certified to carry out these works of the manufacturer of the receiver BTR.

Operators of receiver BTR should not have access to the internal components of the product.

3.2 Safety instructions.

3.2.1 When carrying out maintenance action, always follow safety precautions set forth in Sec. 2.2.1, regulations on labor protection [8, 9] and guidelines set out in the documentation of the manufacturer.

3.2.2 Basic safety instructions for maintenance:

а) Before disassembling the device for maintenance be sure to disconnect it from the power supply;

б) all operations related to the installation of portable devices and measurements should exclude accidental contact with live parts of the open areas of the body;

в) It is prohibited:

- To replace the removable elements of the device while it under voltage;
- To use faulty tools and measuring instruments;
- To Power up the device when removed a protective housing or protective cover is removed.

3.2.3 To ensure fire safety during it is necessary to follow the rules and instructions on fire safety instructions at the operating organization.

3.3 Maintenance and service procedures.

3.3.1During the operation provides continuous monitoring of the state of the equipment and maintenance of the product during the BTR MSO satellite earth station, but at least twice a year.

3.3.2 MSO for the BTR is performed when the equipment is power up and provides:

a) External inspection of the equipment, removal by a clean cloth dust and dirt from the external surfaces of the indoor and outdoor equipment;

b) Monitoring the temperature of the room in which the product is taken, by means of thermometer located therein (in the product BTR not included);

c) The reliability of the RF cable connection;

d) Fuses, power switch, control buttons, reliability and correctness of the ground connection.

e) Checking records in the passport of device.

During the visual inspection by a) paragraph 4.3.3 next items must be checked:

- For damage or cracks on parts and mounting block products and violations of coatings;

- Correct connection of the connecting cables and grounding products in accordance with the marking and the scheme [4];

- The absence of violations of isolation of connection cables, particularly in areas connected to the mains and putting in equipment;

- Clogged ventilation grilles on the product.

If necessary, tighten the nut connecting the RF cable and fasteners.

Estimated labor costs for carrying out MSO is 0.25 person-hours.

The above rules of span to carry out MSO are tentative and subject to change in the operation.

4. STORAGE

4.1 Storage Products should be packaged in enterprise-supplier in dry heated and ventilated rooms at temperatures from 5 to 35° C and a relative humidity of less than 80% at + 25 ° C, in the absence of atmospheric dust, vapors, acids, alkalis and other aggressive corrosive agents.

4.2 During storage unit connectors and cables should be closed by technological lid which protect the contacts from damage and dust from the internal cavity of the connectors.

4.3 In the long term (over 3 months) storage should be taken to dismantle the product and protection from mechanical damage and the impact of external climatic conditions according to the operational documentation.

Shelf life of the product should not exceed 12 months.

4.5 After a long storage of the product, it should be carried out an installation, provisioning and verification of readiness of the product for operation according to this manual.

5. TRANSPORTATION

5.1 Transportation of goods must be in a standard manufacturer (supplier) packaging by sea, river, railway and air transport as well as road transport by road paved roads without speed limits and distances, and the cobblestone and dirt roads for a distance of not more than 250 km at a speed not exceeding 20 km / h at a temperature of from -50 to + 50 ° C at a relative humidity of 85% at a temperature of 25° C.

5.2 Stowage and transport container ensure its stable position and prevents movement during transport.

5.3 When transporting, product must be protected from moisture, rodents, dust and exposure to precipitation and direct sunlight.

For transportation by sea transport product must be placed in the hold and packed in a sealed plastic bag.

Appendix A

Connectors of BTR

Table A1 – Connector DB-9F «Tracking receiver 0-10 V»

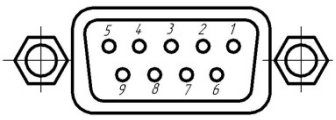
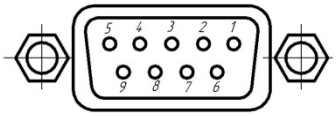
Connector	Pin	Net	Annotation
DB-9F 	1	U -	
	2		Not Used
	3		Not Used
	4	U +	
	5		Not Used
	6		Not Used
	7		Not Used
	8		Not Used
	9		Not Used

Table A2 – Connector DB-9F «M&C RS-485»

Connector	Pin	Net	Annotation
DB-9F 	1	RS-485 A+	
	2		Not Used
	3		Not Used
	4	RS-485 B-	
	5	GND	
	6		Not Used
	7		Not Used
	8		Not Used
	9		Not Used

Appendix B

Update firmware of BTR.

The BTR has a mode to firmware upgrade via RS-485 “M & C” interface. Update firmware of BTR is performed through connector “M & C” of BTR connected to the COM port of a personal computer (PC), standard modem cable DB9F-DB9M or RJ45-DB9M.

To update the firmware of the BTR user needs to perform the steps below.

1) Turn off the BTR if it was turned on.
2) Connect connector “M & C” of the BTR to the COM-port of PC.
3) Run on PC the application “LDR.exe”.

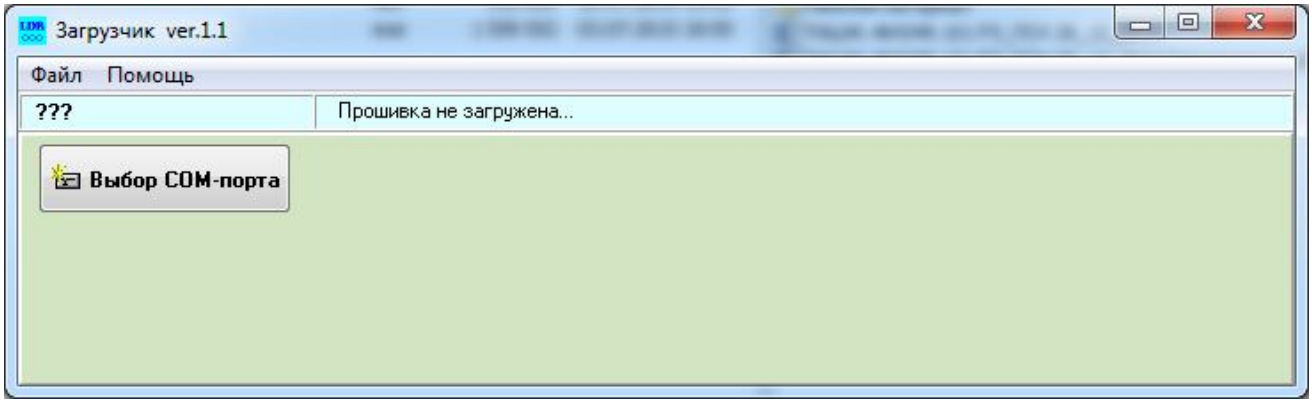


Figure B1

4) Open the desired COM port on user PC. The baud rate of the COM port is factory default (115200 bps).

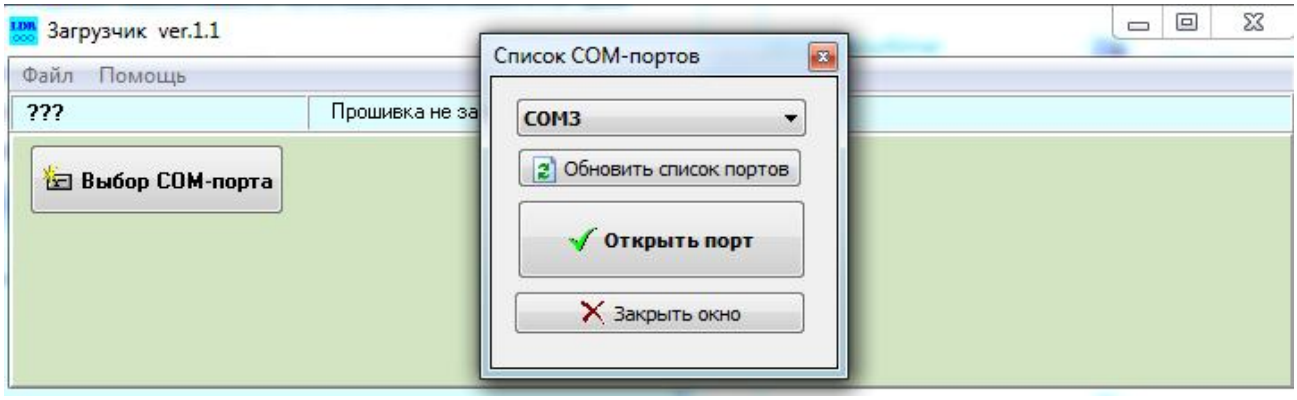


Figure B2

5) Click on the button "Select firmware" in the window that opens, select the desired firmware file (with the extension “* .bin”) and then click the button "Open".

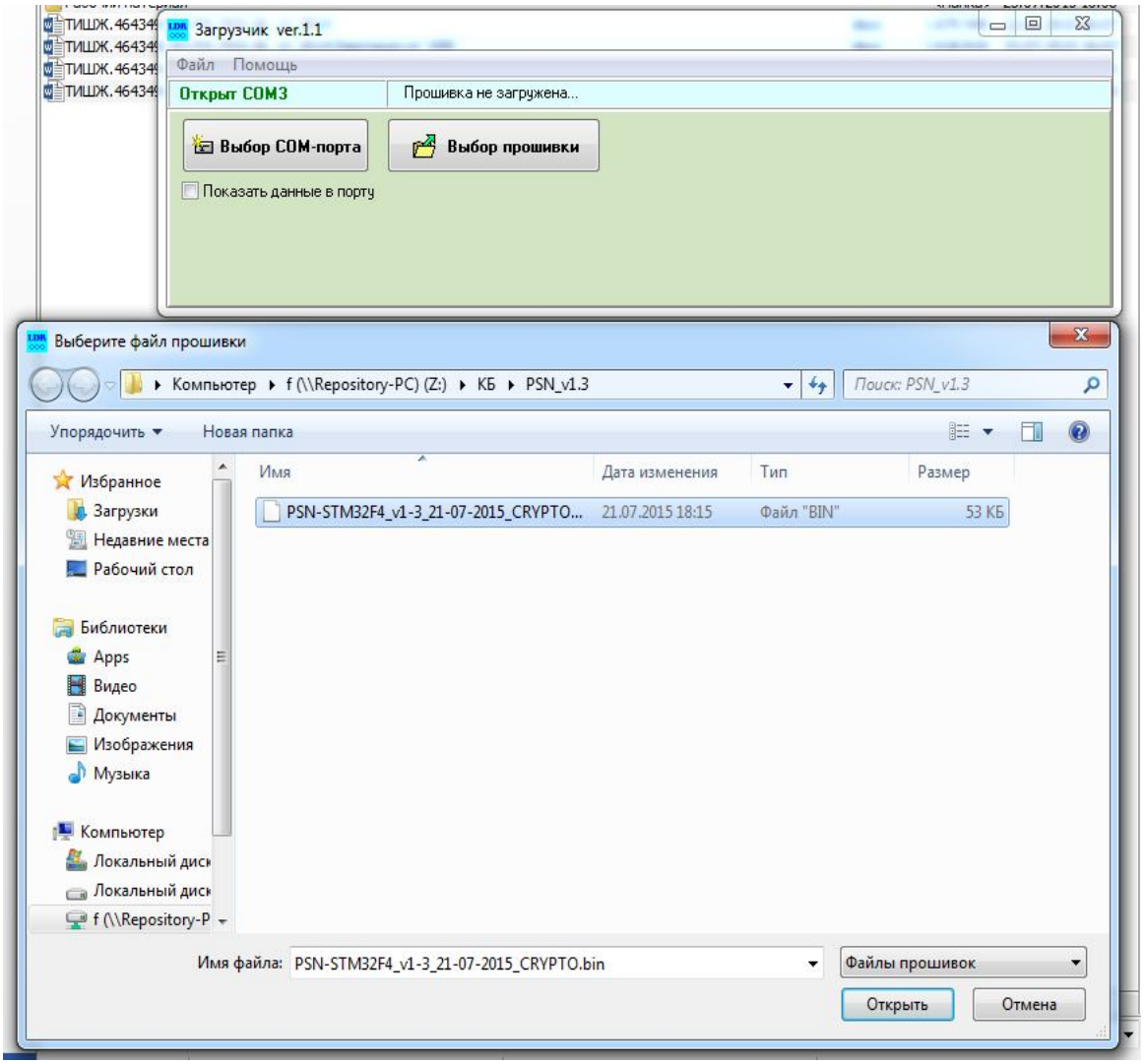


Figure B3

6) In the window that opens, click on "Reprogramming". The application expects to turn on the BTR.

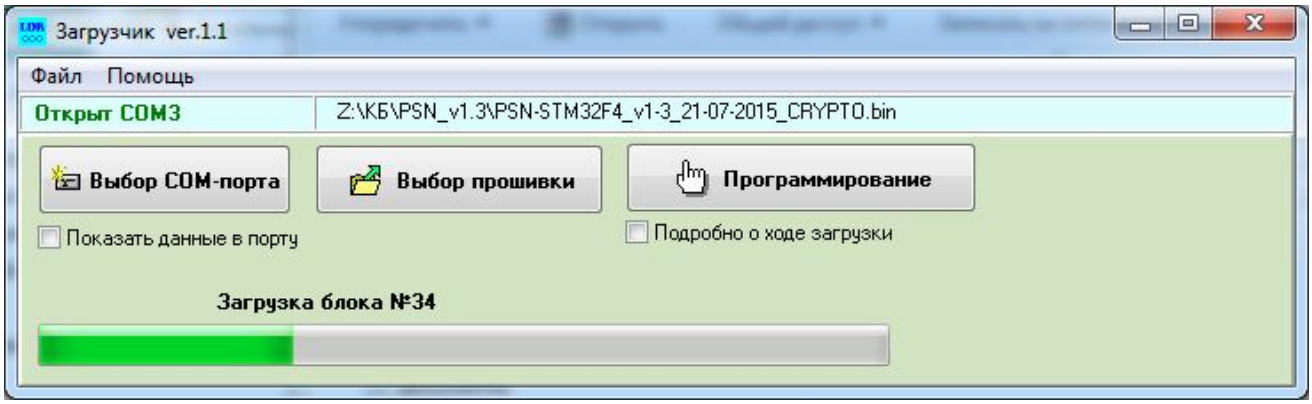


Figure B4

7) Turn on the BTR.

After turning on the BTR, built-in loader starts, and it is active 2 seconds after turn on. The application "LDR.exe" detects it and starts the process of firmware upgrading automatically. When download the new firmware and reprogramming BTR is displayed on the PC and also displayed on LCD of the BTR.

8) Wait while download and programming of the BTR are performed.

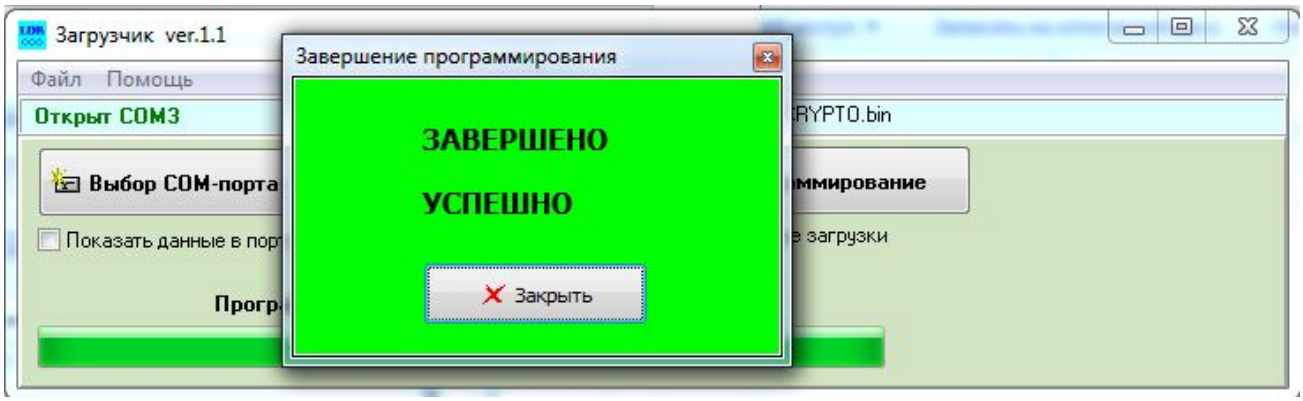


Рисунок В5

9) After completion of the programming, turn off the BTR.

10) Close application “LDR.exe”.

11) Disconnect connector on BTR “M & C” from PC.

12) Updates Firmware BTR are performed.

ATTENTION!

After performing firmware updates of the BTR, all parameters are automatically set to the original (factory) settings.

Appendix C

PROTOCOL OF EXCHANGE

between the beacon tracking receiver and the remote control device.

This document defines a communication protocol via RS-485 MODBUS between the beacon tracking receiver (BTR) and the remote control device (RCD).

1. Description of protocol.

Physical Interface: half-duplex RS-485.

Organization of network: master - RCD, slave - BTR.

Initiate the transfer can only master. The slave responds to the request, if the command involves the issuance of a response.

Data structure: 8N2 (8 bit data, without parity, 2 stop bits)

Baud rate: programmed. Possible baud rate (bps): 1200, 1800, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800, 576000, 921600

Baud rate = 115200 bps is default baud rate (factory setting).

Addressing:

Address BTR can be programmed. Valid values for address: 0x01-0xFF.

Address 0xFF is circular and can be used for packets from control device.

Packets with address = 0xFF received all BTR's.

Address = 0 is unallowed for address of BTR.

2. Packet structure.

The structure of the packet transferred to the device or received from the device contains the following fields:

START	ADR_1	ADR_2	DATA	CRC	STOP
2 bytes	1 byte	1 byte	N bytes	2 bytes	2 bytes

Description of fields:

Field START – start packet flag. Consist of 2 bytes: 0xFE 0xFE

Field ADR_1 – address of the sender Consist of 1 byte.

Field ADR_2 – address of the recipient. Consist of 1 byte.

Field DATA – Payload data. The size of the field is determined by the type of query.

Field CRC – checksum of the fields of packet: START, ADR_1, ADR_2, DATA. The algorithm for computing the checksum is given in Section 6.

Field STOP – stop packet flag. Consist of 2 bytes: 0xFC 0xFC.

Annotation 1: If fields START, ADR_1, ADR_2, DATA, CRC byte 0xFE occurs or 0xFC, after it is added with a value of byte 0x00. Accordingly, when receiving the packet from the packet byte is withdrawn (byte-stuffing).

Annotation 2: At transferring byte-stuffing is used after calculating the checksum. At reception – at first byte stuffing is used, and then the calculation of the checksum.

3. TYPES AND STRUCTURE OF REQUESTS (field DATA)

3.1.Command Read register.

Command «Read register»	Number of register
0x03	0xHHHH
1 byte	2 bytes

Where: 0x03 – option code for command «Read register».

0xHHHH – Number of register (possible addresses of registers 0x0000-0xFFFF)

3.2. Request on command read register.

Command «Request on read register»	Number of register	Data from register
0x04	0xHHHH	Data_from_Registr

1byte	2 bytes	N bytes

Where: 0x04 – option code for command Request on read register.

0xHHHH – Number of register

Data_from_Registr – data reading from register. The length of data determined by the number of register and can be up to 255 bytes.

3.3. Command to write register.

Command «Write register»	Number of register	Data to register
0x05	0xHHHH	Data_In_Registr
1 byte	2 bytes	N байт

Where: 0x05 – option code for command to write register.

0xHHHH – Number of register

Data_In_Registr – Data to write to register (up to 255 bytes).

3.4. Request on command to write register.

Command «Request on write register»	Number of register	Data from register
0x06	0xHHHH	Data_from_Registr
1 byte	2 bytes	N bytes

Where: 0x06 – option code for command request to write register

0xHHHH – Number of register.

Data_from_Registr - data read from the register after it writing (up to 255 bytes).

Annotation: The order of bytes is the following: First least significant byte.

4. Exchange error

When error is occurring while exchange, the BTR sends the packet with the following structure of the field DATA:

Command «Attribute error»	Error code
0x0A	0xHHHH
1 byte	2 bytes

Where: 0x0A – Attribute error

0xHHHH – error code.

List of error codes

Error code	Description
0x02	Reading the register is not possible or can't be found Register
0x03	Writing the register is not possible or can't be found Register
0x04	The attempt to read the register is failed
0x05	The attempt to write the register is failed
0x06	Invalid number of bytes in a request to the DATA field in the write register
0x07	Invalid value in the DATA field in the write register

5. Registers of BTR.

Number, dec	At-tribute	Description registers	Length, bytes
0	**R**	**<u>Status register of BTR</u>** **Byte 0 – Status1 BTR** (unsigned char) Bit 0 – Status of attenuator 0 – OFF 1 – ON Bit 1 – Alarm «Failure FLASH-memory» 0 – not set 1 – Set Bit 2 – Alarm «Failure RF-module by supply» 0 – нет 1 – установлена Bit 3 – Alarm «No lock PLL in RF-module» 0 – not set 1 – Set Bit 4 – Alarm «Error PLL in RF-module» 0 – not set 1 – Set Bit 5 – Attribute «Overload by input signal» 0 – not set 1 – Set Bit 6 – Attribute «Searching» 0 – OFF 1 – ON Bit 7 – Attribute «Low level signal» 0 – not set 1 – Set **Byte 1 – Status2 BTR** (unsigned char) Bit 0 – Attribute «Lock» 0 – no lock 1 – lock Bit 1 – Flag common alarm 0 – not set 1 – Set Bit 2 – Operate mode	**14**

		0 – Broad band 1 – Narrow band Bit 3 – PLL 0 – OFF 1 – ON Bit 4 – reserved Bit 5 - reserved Bit 6 – reserved Bit 7 – reserved **Bytes 2-3** - Level of signal in units of ADC (unsigned short 2 bytes) **Bytes 4-7** - Input frequency of RCV, kHz Values from 950000 to 2175000 (in kHz) unsigned long **Bytes 8-9** - Level of input signal in dBm Values transferred as positive integer's Xin. Conversion in dBm: Pin=Xin*(-100) (unsigned short 2 bytes) **Bytes 10-13** – The current frequency of the main oscillator unsigned long **Bytes 14 – Bandwidth filter** unsigned char **Bytes 15-16** – Output voltage (Volts*100, rounded to nearest whole) unsigned short	
1	**R**	**<u>Register of LCD of BTR</u>** Consist of 48 bytes of LCD of the BTR.	**48**
2	**R**	**<u>Status register of BTR+ Register of LCD of BTR</u>** Consist of 10 bytes of status register and 48 bytes of LCD of BTR	**16+48**

3	**R/W**	**<u>Register of buttons BTR</u>** (unsigned char) 0 – Button ButtonNULL 1 – Button ButtonLeft 2 – Button ButtonUP 3 – Button ButtonRight 4 – Button ButtonDown 5 – Button ButtonOK 6 – Button ButtonRedit 7 – Button ButtonALARM 8 – Button ButtonKrest 9 – Button ButtonESCAPE 10 – Button ButtonAR 11-255 - reserved	**1**
4	**R/W**	Gain Filter for mode «Broad band» Possible value for Gain (0-9): 00 Gain = 0.0 dB 01 Gain = 1.6 dB 02 Gain = 3.0 dB 03 Gain = 4.6 dB 04 Gain = 6.3 dB 05 Gain = 7.3 dB 06 Gain = 8.2 dB 07 Gain = 8.5 dB 08 Gain = 8.8 dB 09 Gain = 9.0 dB	**1**
5	**R/W**	**Byte 0** Operate mode of RCV 0 - Broad band (BB) 1 – Narrow band (NB) unsigned char (0-255)	**1**
6	**R/W**	**Byte 0** Mode PLL (only for NB) 0 - PLL disabled 1 - PLL enabled unsigned char (0-255)	**1**

7	**R/W**	**Bytes 0-3** Step searching AFC (only for NB) Values from 0 to 0xFFFFFFFF unsigned long	**4**
8	**R/W**	**Bytes 0-3** Bandwidth (only for NB) Values from 0 to 0xFFFFFFFF unsigned long	**4**
9	**R/W**	**Bytes 0-3** Carrier frequency of main oscillator Values from 0 to 0xFFFFFFFF unsigned long	**4**
10	**R/W**	**Bytes 0-3** Carrier frequency of oscillator PLL Values from 0 to 0xFFFFFFFF unsigned long	**4**
11	**R/W**	**Byte 0** System signal searching (only for mode NB) 0 - OFF 1 - ON	**1**
12	**R/W**	**Bytes 0-1** Slope Ks In this version of firmware is not used.	**2**
13	**R/W**	**Bytes 0-1** Depths of filter by signal (от 0 до 5000) unsigned short (0-65535)	**2**
14	**R/W**	**Byte 0** Input attenuator 0 - OFF 1 - ON unsigned char (0-255)	**1**
15	**R/W**	**Bytes 0-1** Gain Ku BTR Values from 0 to 999	**2**

		unsigned short	
16	**R/W**	**Bytes 0-1** Settling time for PLL (Intervals by 5ms) Values from 1 to 254 unsigned char (0-255)	**2**
17	**R/W**	Bandwidth of filter for mode «Broad band» Possible values (0-31) 00 Bandwidth= 1 MHz 01 Bandwidth = 12 MHz 02 Bandwidth = 14 MHz … and then with step = 2 MHz 31 Bandwidth = 72 MHz unsigned char (0-255)	**1**
18	**R/W**	Input frequency of RCV, kHz Values from 950000 to 2175000 (in kHz) unsigned long	**4**
19-31	**R/W**	Reserved	
32	**R/W**	**Byte 0** Baud rate for M&C (unsigned char 1 байт) Possible values: 0: 9.6 кBit/s 1: 19.2 кBit/s 2: 38.4 кBit/s 3: 57.6 кBit/s 4: 115.2 кBit/s 5: 230.4 кBit/s 6: 460.8 кBit/s 7: 500 кBit/s 8: 576 кBit/s 9: 921.6 кBit/s Default Baud rate - 115.2 кBit/s	**1**

33	**R/W**	**Byte 0** Baud rate TLM from BTR (unsigned char 1 byte) Possible values: 0: 9.6 кBit/s 1: 19.2 кBit/s 2: 38.4 кBit/s 3: 57.6 кBit/s 4: 115.2 кBit/s 5: 230.4 кBit/s 6: 460.8 кBit/s 7: 500 кBit/s 8: 576 кBit/s 9: 921.6 кBit/s Default Baud rate - 115.2 кBit/s	**1**
34	**R/W**	**Byte 0** Address of BTR in RS485 (M&C) (unsigned char 1 byte) Default address – 6 Value = 0xFF is circular address.	**1**
35	**R/W**	**Bytes 0-1** Period output data for TLM, Intervals by 100 microseconds. unsigned short (0-65535)	**2**
36 **…** **65531**	**…**	Reserved	
65532	**R**	ID - number of controller. unsigned long	4
65533	**R**	Attribute validation of user key 0 - valid 1 - invalid unsigned char	1

65534	**R/W**	**User key** 0xXXXXXXXX unsigned long	4
65535	**R/W**	Register of reload the BTR (writing to this register will reload the BTR) unsigned char (0-255)	**1**

Attribute: **R** – only Read, **W/R** – Write and Read.

6. Calculating of CRC.

Examples of procedures for calculating the checksum in the ANSI C language are listed below.

```
unsigned int crc_chk(unsigned char* data, unsigned char length)
{//calculate CRC
 int j;
 unsigned int reg_crc=0xFFFF;
 while(length--)
 {
  reg_crc ^= *data++;
  for(j=0;j<8;j++)
  {
   if(reg_crc & 0x01) reg_crc=(reg_crc>>1) ^ 0xA001;
   else   reg_crc=reg_crc>>1;
  }//for j
 }//while(length--)
return reg_crc;
}
```

Where: data – payload data, length – the length of data.

Examples of procedures for calculating the checksum in the Pascal language are listed below.

```
function C485Modbus(unCRC_temp,unData:integer):integer;
//additional function
Var   LSB:integer;
      i:integer;
begin
   unCRC_temp:=((unCRC_temp xor unData) or $FF00) and (unCRC_temp or
$FF);
    for i:=1 to 8 do begin
     LSB:=unCRC_temp and $1;
     unCRC_temp:=unCRC_temp shr 1;
     if (LSB<>0) then unCRC_temp:=unCRC_temp xor $A001;
    end;//for i
    C485Modbus:=unCRC_temp;
end;
/=======================================================
```

```
function CRC_Modbus(LenDat:integer;DATAsend: array[1..100] of inte-
ger):integer;
//calculate CRC
Var  CRC:word;
     i:integer;
begin
   CRC:=$FFFF;
   for i:=1 to LenDat do CRC:=C485Modbus(CRC,DATAsend[i]);
   CRC_Modbus:=CRC;
end;
```

7. The description of the communication protocol for output data TLM.

Physical Layer: RS-485 half-duplex.

Organization of network: Master - BTR

Master issues packets of data TLM with the period specified in register «35» of section 5 of this document.

Byte structure of data: 8N2 (8 bit data, no parity, 2 stop bits).

Baud rate communication: programmed in register «33» of section 5 of this document.

Structure of packet data TLM.

The structure of packet TLM consists of next fields:

Status	CRC
16 bytes	2 bytes

Description of fields:

Field Status – Content of register 0.

Field CRC – checksum of all bytes in the packet. The algorithm for computing the checksum is given in Section 6.

List of symbols

ADC - Analog-to-Digital Converter

LCD - Liquid Crystal Display

UPS - Uninterruptible Power Source

SC - Space craft

GA - Gain Amplifier

ES - Earth Station

LO - Low Frequency

OA - Operational Amplifier

RCV - Receiver

RF - Radiofrequency

OM - Operation Manual

TS - Tracking Signal

APS - Antenna Pointing System

IFA - Intermediate-Frequency Amplifier

PLL - Phase-looked Loop

AFC - Automatic Frequency Control

LPF - Low Pass Filter

DDS - Direct Digital Synthesizer

DAC - Digital-to-analog Converter

TLM - Telemetry data

RCD - Remote Control Device

MSO - Maintenance and Service Operation