The Ultra-Wideband Receiver System for RT-13 Radio Telescope IAA RAS "Quasar" Network

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The article describes results of receiving system development, operating in ultra-wide 3-16 GHz band (UWB). An overview of existing and developing UWB systems for VGOS network is provided. The principles of design, management, integrating with RT-13 radio telescope, control and power supply for UWB receiving system are shown. Expected and measured technical parameters are given. Special attention is focused on the frontend cryoelectronic unit, the information about the design, LNAs used, results and parameters obtained during testing is provided.

Keywords: VLBI, Geodesy, Ultra-wideband receiver, Small antenna, VGOS.

1 Introduction

The UWB (ultra-wideband) receiving system designed in IAA RAS is purposed for implementing in "Quasar" VLBI network small (13.2 m) dish radio telescopes. These radio telescopes are based in "Zelenchuckskaya" and "Badary" stations and working currently with Tri-band S/X/Ka receiving system [1]. UWB receiving system operates in 3–16 GHz band on dual linear orthogonal polarizations. It is fully compatible with RT-13 mechanical, cryogenic and electric interfaces. It is supposed, UWB system can replace Tri-band system and be replaced by it on demand.

2 The System

Like the Tri-band, UWB receiving system is made as focal container with working position near the dish secondary focus. According to schematic diagram and photo given (Fig. 1), the receiver itself consists of parts following:

— cryoelectronic focal receiving unit (cryo unit). This is hard-walled vacuum chamber that contains cooled QRFH (quad-ridged flared horn) feed [2], LNAs and directional couplers for injection of calibration signals;

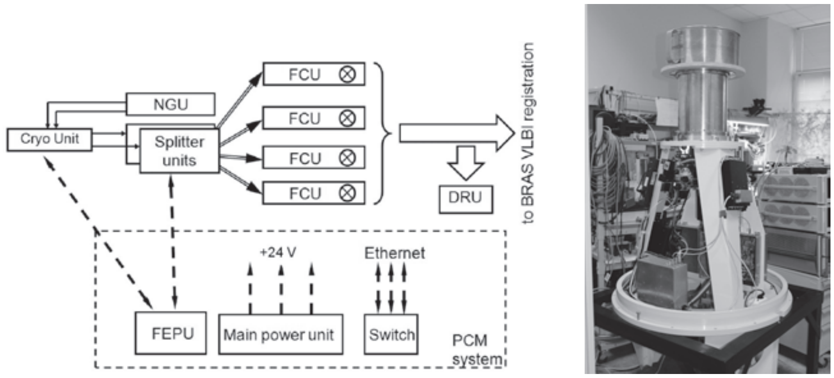

Fig. 1. The UWB receiving system block diagram and focal module

— NGU (noise generator unit) that forms amplitude and phase calibration signals. Phase calibration signals come from external unit — picosecond pulse generator (PPG);

— two 4-way splitter units, one for each polarization, which form 8 receiving channels in total;

— four dual-polarization FCUs (frequency conversion units, prototyped), that converts tunable 1 GHz band from input ultra-wide band to 1–2 GHz IF acquisition band;

— DRU (digital radiometric unit, in development) that converts part of system output radiometric signal to digital data. Agilent 1914A power meter is used as temporary replacement for DRU.

PCM (power, control and monitoring) equipment [3] includes units following:

— FEPU (frontend power unit) that provides primary power for cryo unit and splitter units as long as cryogenic temperature measurement;

— main power unit that provides supply voltage for another receiver units;

— Ethernet switch that connects all controllable units to network.

3 Operation Principle

The UWB system operates the way following. The radiation from source, focused with the dish and subreflector, comes through the radio-transparent cover of cryo unit to the focal center of QRFH feed, where it is separated to vertical and horizontal linear polarizations. Two signals, mixed with calibration signals at the direct coupler, are amplified with cryogenic LNAs and every signal is divided into 4 ways by the splitter unit. Splitter unit also includes room temperature preamplifiers. Dual-channel FCUs use up-down convertion to select from input range 3–16 GHz 1 GHz band to BRAS system [4] bandwith (1–2 GHz).

4 Calculated and Measured Parameters

The calculations of main UWB system parameters, such as gain and noise temperature, is presented in the table below.

Calculated gain and noise of UWB receiving system

Unit	Cryo unit	Splitter unit		FCU			
Element		Splitters	Preamp	Mixer	Filter	Mixer	IF2 module
Gain (loss), dB	40	-12	30	-20	-3	-6	47
Gain (loss), times	0,000	15,849	0,001	100	1,995	3,981	0,000
Physical temp., K	20	300	300	300	300	300	300
Noise temp., K	50,0	281,1	500,0	297,0	149,6	224,6	500,0
Noise contribution	50,0	0,03	0,79	0,00	0,02	0,00	0,63
Total Noise, K	**51,5**						
Total Gain, dB	**76**						

According to data given , total system noise temperature should be about 50 K with the gain of 80 dB. The highest contribution to noise comes from cryo unit. High gain of cooled cryo LNAs allows to use passive wideband splitter with 12 dB loss. Noise temperature of FCU is compensated by high gain of wideband preamplifier in splitter unit.

Noise temperature measurements were obstructed by the RFI problem that is inherent for UWB system. Despite the upshifting of receiving band-

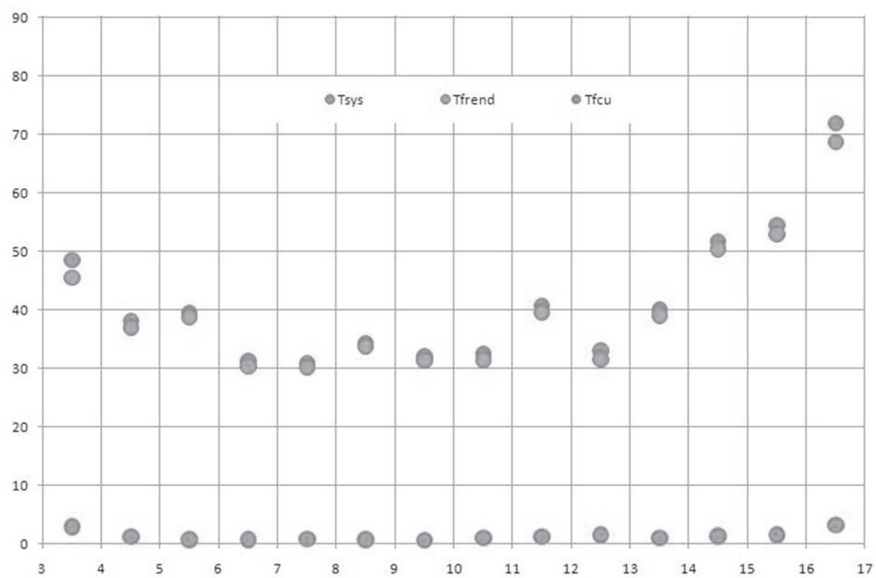

Fig. 2. Noise (K) vs. frequency (GHz) measured

with from 2–3 GHz S-band, occupied by well-known RFI sources such as Wi-Fi and 3 G, large number of RFI is observed with feed input open. This means increasing of requierements for shielding during the measurment process.

Total noise temperature measurements were made with hot and cold match load method. The results given show that total system noise is less than 50 K, that corresponds with calculations and system requierements. Noise contribution of FCU is lowered enough. Some spurs on second channel may be caused by RFIs or feed mismatch.

5 Conclusion

The focal module of new generation UWB receiving system was designed and prototyped in IAA RAS. This module contains all nesessary equipment for system functioning and it is fully compartible by cryogenic, output signal, primary power and Ethernet-control interfaces with RT-13 radiotelescope. First cycle of laboratory tests has shown good match of expected and measured parameters, revealed problems and verified solutions. The UWB system will be ready for field tests soon.

References

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