New C-band receiver for RT-32 radio telescope IAA RAS Quasar network

Anton Berdnikov, Alexander Evstigneev, Olga Evstigneeva, Vyacheslav Mardyshkin, Dmitry Marshalov

The report focuses on the new equipment developed in IAA RAS for the astrophysics VLBI 4.5-5.5 GHz (6.2 cm, C-band) band receivers in radiointerferometric complex «Quasar». The purpose was to improve the operational receiver reliability, to improve the technical characteristics and to expand the operating frequency band from 500 to 900 MHz. Low noise amplifiers in cryoelectronic frontend units were replaced with modern and more reliable ones. New dual channel frequency conversion units with integrated local oscillators were designed. Spectral characteristics of local oscillators were improved. Dual channel noise generators units with amplified compensating noise density were developed, their design and technical parameters are given.

Modernization of the C-band receivers reduced the number of receiver units and increased overall operational reliability. Due to extended 900 MHz band the improvement of all basic receiving channel parameters is expected.

Introduction

New C-band receiver designed in IAA RAS is purposed for replacement of previous generation receiver equipment [1] in QUASAR VLBI network RT-32 radio telescopes. These radio telescopes are based in «Svetloe», «Zelinskoye» and «Shagary» stations. It is supposed, that new receiver will solve the following problems:
- extending the operating bandwidth from 500 to 900 MHz;
- improving technical parameters, such as phase characteristics of local oscillators;
- reducing the total number of units and increasing operational reliability.

Receiver configuration

Schematic diagrams of new and previous generation C-band receivers are shown on the fig. 1-2. Both receivers include units followed:
- cryoelectronic frontend unit (cryounit, fig. 3) for primary amplification of signal with minimum noise;
- FCUs (frequency conversion units) for downconversion of input 4.5-5.5 GHz C-band to 100-600 MHz (for old receiver) or 100-900 MHz (new one). New FCUs are dual-channel with integrated local oscillator;
- NGUs (noise generator units) for generation of amplitude calibration signal. This signal injects to calibration input of cryounit. New NGUs are made dual-channel;
- PCM (power, control and management) subsystem units, including power unit, control unit and distributing unit. These units support +25±10% power and contains controller and gather status information from all receiver units.

For connecting PCM subsystem with central computer supervisor unit is used. The supervisor unit is able to communicate with 10 sets of PCM subsystem simultaneously.

Cryounit

Noise temperature and gain of cryounit here the most influence on the total system parameters. Ncyn units must match the requirements following:
- external input SWR less than 1.3 in working bandwidth;
- noise temperature below 15 K;
- noise level below 10^-6 in working bandwidth;
- noise temperature below 100000 K.

Noise generator unit

NGU is purposed for generation, adjusting and mixing together two separate noise signals. One of them is relatively high noise measured at subunit output exceeds 1000000 K. In addition to this, external picosecond pulses of phase calibration signal are also mixed. Total signal is injected to receiver input through cryounit calibration port, with 25 dB loss at the directional coupler.

Like the FCU submodules, NGUs were developed as microstrip modules. In these modules two IMPATT diodes generate noise in 4.5-5.5 GHz band, which is adjusted by p-a-at attenuators with voltage control. Mixing of all noise signals and phase calibration pulses is designed as microstrip directional coupler.

NGUs are made dual-channel to increase the operational receiver reliability. Due to extended 900 MHz band the improvement of all basic receiving channel parameters is expected.

The spectral density of NGU noise is high enough to have no effect on total noise temperature. The results of spectral characteristics measured are shown on fig. 6. The spectral density of NGU noise is higher than nominal noise from IMPATT diode and covers extended bandwidth of 4.5-6.5 GHz.

Power, control and monitoring system

Deep changes made in receiver FCU and NGU led to another PCM units. Power unit, providing different dual-polarity voltages for old receiver units, now uses two similar sets of +24V power supply and thermal stability unit. Thermal stability unit is used to provide fixed temperature to all elements of receiver. Control unit and NGU were adapted to work with new PCM subsystem.

Conclusion

The development of new C-band receiver led to positive changes following:
- cryounits were implemented with new LNAs with 900 MHz bandwidth;
- receiving channels bandwidth was extended up to 900 MHz. Two channel with LO were united in one dual-channel FCU. The spectral characteristics of LO were improved;
- new PCM system with Ethernet interface and high-controlling abilities was developed.

References