IAA Correlator Center

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Abstract

The technical characteristics of 3-station S2 correlator, developed and put into the action in IAA in 1993, new correlator PARSEC and some VLBI data processing activities are given. The perspectives of the use of the correlator and the IAA S2 terminal installed on 32-m radio telescope of Svetloe and Zelenchukskaya observatories, the 64-m radio telescopes of Kalyazin and Bear Lake observatories and 70-m radio telescope of Russian Space Agency (RSA) in Ussurijsk, as it is equipped with S/X receivers (compatible with QUASAR ones).

1. General Information

The S2/Mark-3 correlator of the Institute of Applied Astronomy (IAA), located in Saint-Petersburg, is supported by the Russian Academy of Sciences, by the Russian Foundation of Basic Research and by the Russian Ministry of Sciences and Technologies. The general role of the correlator is an operational processor for VLBI experiments in Russia. Furthermore, IAA correlator serves the new VLBI observation technologies, applications and correlation modes.

2. S2 Tape-based VLBI Correlation System

The design of 3-station Mark-3 correlator (TISS-1M), was developed in Institute of Applied Astronomy in 1989-1994 in the frame of the Russian national VLBI project QUASAR. The correlator was designed in standard Mark-3 and its basic operation mode is 3 stations x 30 channels x 4 Mbit/s. Correlator gives the additional possibilities for multistation data processing (4x10x4, 5x6x4, 6x2x4) and for spectral line processing in the band of analysis 2–56 MHz with 1024 channels.

Table 1 presents the specifications of the IAA TISS-1M correlator. As the TISS-1M correlator was designed for processing VLBI data in Mark-3 format, it is capable to operate with Mark-3 and Mark-3 compatible playbacks. At the present IAA has three conventional S2 recording and playback terminals. The last ones were unified with correlator TISS-1M in S2 VLBI geodetic X/F correlator.

For the calculation of group delay and fringe frequency model for correlator the program package ERA developed at the IAA is used. The extraction of observables and the post processing analysis of raw data are executed by program package NewPROUT designed at the IAA.

3. Experiments Done

IAA S2 geodetic correlator has been carefully tested and used in VLBI data processing during 1993–2002. The first successful experience was obtained in 1993 with processing of differential VLBI observation of GRANAT spacecraft on the wavelength of 5.9 GHz (Ussurijsk–Eupatoria baseline with 70-m antennas). The IAA tape recording terminal RT-1 was used in that experiment.

The first S2 testing for VLBI observations on the stations Bear Lakes RT-64 and Tidbinbilla RT-70 was conducted at 18 cm wavelength in June 1996. The best results were obtained for the following sources: 0235+164, 0552+398 (DA 193), 0400+258.

Table 1. The specifications of the IAA TISS-1M correlator.

Main Characteristics:	
Stations	2–6
Channels/station	1–28
Sample rate, Mbit/s	0.25, 0.5, 1.0, 2.0, 4.0
Integration time (min/max), ms	50/1024
Tracking:	
Delay range:	
by hardware, ms	±64
via playback offset	unlimited
Delay rate range:	
coarse, sample/s	$\pm 1 \cdot 10^6$
fine, sample/s	±1/2
Fine Delay Accuracy, turn	0.002
Phase Accuracy, deg	$1.44 \cdot 10^{-7}$
Fringe Range, MHz	1
Fringe Rate Range, Hz/s	±12
Subnetworks	2
Playback System	3 S2-PT, 3 x 128 Mbit/s

VLBI observations of GPS/GLONASS satellites have been made in 1996–2002 for the development of phase differential VLBI observation with IAA SIRIUS-M VLBI system on the baselines of Svetloe-Zelenchukskaya-IAA Saint-Petersburg.

The spectral line observations at 18 cm (OH maser), 21 cm (HII), 1.35 (H2O maser) in single dish mode at Svetloe observatory were processed in spectral mode of correlator.

Extragalactic source structure investigations were made at 3.5 cm/13 cm wavelength on the VLBI network Svetloe–Zelenchukskaya-Kalyazin in January 2002. The first test radar VLBI Venus and Mars observations on 6 cm wavelength were made in June 1999 with radar VLBI system Evpatoria–Svetloe–Seshan.

At the present time we are capable to involve in permanent geodetic observations the 32-m radio telescope of Svetloe and Zelenchukskaya observatories, the 64-m radio telescopes of Kalyazin and Bear Lake observatories and 70-m radio telescope of the Russian Space Agency (RSA) in Ussurijsk, as it is equipped with S/X receivers (compatible with QUASAR ones).

4. New Correlator PARSEC

IAA started to build a new-generation correlator named PARSEC as a part of QUASAR VLBI network with Mark-4 specification. This system will include 3 S2 playback terminals and 3-baseline and 3-station correlation capability. Options are included for expansion up to 6 stations and 15 baselines capability, along with options for 6 additional new Mark-4 compatible playback systems and/or development of new real-time technique using IP network.

The PARSEC correlator system will offer the following features:

1. A new PCI-bus correlator board supporting 16 cross-correlation channels for 3 stations will

provide processing capacity and productivity superior to those for TISS-1M.

2. Operation at input data rates to 64 Msamples/sec/channel, 1 or 2-bit sampling.
3. Integrated input data rates to 1 Gsamples/sec/station, 1 or 2bit sampling.
4. Compatibility with Mark-4, K-4, VLBA, S3 via VLBI Standard Interface (VSI).
5. Both 'baseline-based' and 'station-based' electronics can provide the most economical and adaptive future expansion path for large or individual correlator system.
6. Modern Linux-based and/or Windows NT-based computer control system.

The base correlator unit consists of 6 correlator modules, 4 station modules and 1 multiplexing module. Each correlator module includes 16 correlator chips in FPGA of Altera EP1K100FC 256-1, RAM for 32 data-streams delay according to a polynomial model and matrix switch for '64 input x 32 output' 2-bit streams. The correlator chip has one 2-bit 64-lag or 3 2-bit 16-lag complex cross-correlators including fringe rotator and vernier time delay in general mode. The correlator, station and switch modules will be housed on PCI-bus panels in 8-slots CompactPCI control computer.

In January 2003 testing was started on the MicroPARSEC correlator board for personal computer PCI-bus, as designed prototype of the PARSEC correlator module. The MicroPARSEC correlator will be used as "single baseline x two channel" station mobile correlator for station hardware testing and spectral line processing data in single dish observation mode.