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The Data Acquisition System Developed for Quasar Network

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Abstract

The new data acquisition system developed at IAA RAS is described. This system contains 8 base band converters (BBC) for both (lower and upper) side bands. Input IF is from 100 MHz to 1000 MHz. Bandwidths are 0.25 MHz, 2 MHz, 8 MHz or 16 MHz. There are two-bit samplers and 32 MHz clock and 1 PPS synchronizers. There are detectors for IF and video signals control in BBC channels. There are narrow bandwidth channels to select a phase calibration signal. The DAS is controlled by computer with Mark IV Field System software.

In 2003 the IAA Technology Development Center (TDC) finished designing of the data acquisition system (DAS) for the S2-RT recording terminal. This DAS includes main module and up to 3 added modules. Each of modules contains distributor for 2 input IF signals (100–1000 MHz), 2 base band converters, control unit and power-supply unit (fig. 1).

The input signal distributor has two channels, each of which contains a 100–1000 MHz input band-pass filter, a controlled attenuator, a low-noise amplifier, a power divider (splitter) and an electronic switch (fig. 1). The gain irregularity of the entire amplification path is reduced to 1.3 dB in the 100–1000 MHz frequency range. But it is <0.2 dB in any 32-MHz part of the frequency range, which is quite acceptable for VLBI. The amplitude characteristic of the distributor channel is linear in a dynamic range of 33 dB, but the acceptable level of input signals can be additionally increased by a least 18 dB using the controllable attenuator. The dynamic range of the input signals is in good agreement with the levels of the intermediate-frequency signals that arrive from the radio astronomy receiver outputs.

The DAS may include from 2 up to 8 BBCs. The BBC consists of 2 cassettes: the BBC itself and a Local Oscillator (LO) with a control instruction decoder. The first cassette includes an amplifier-preselector and an image-rejection mixer board and 2 identical video amplifier boards with signal samplers. The amplifier-preselector has a gain of 20 dB and wide dynamic range. The low intrinsic noise level (noise factor < 3 dB) makes it possible to operate at a signal-noise temperature/intrinsic amplifier noise temperature ratio of > 30 dB, which virtually excludes any influence of the latter factor. In this case, a sufficient dynamic range margin of > 30 dB also remains. The irregularity of the frequency response in the 100–1000 MHz range is 1–1.5 dB, and is < 0.2 dB in any 32-MHz part of the frequency range. The preselector filters are set to attenuate spurious signals up to 33 dB. This spurious signals are formed in mixers at the LO voltage harmonics. SSBM includes U2794 integrated circuit and five-stage phase-shifting video amplifiers. This guarantees a image rejection of > 23 dB and a corresponding sensitivity loss due to the image channel noise of $< 0.5\%$. In practice, the channel decoupling is > 26 dB in most cases (fig. 2).

The video amplifier board contains switchable filters with passbands of 0.25, 2, 8 and 16 MHz and 2-bit signal sampler. In the central part of the passband the irregularity of the frequency response is 0.3 dB, while the nonlinearity of the phase-frequency characteristics is less than 2

degrees. The slope of the edges of the frequency response is 30 dB/octave. These parameters where confirmed during tests by radio instruments and the correlation processing of data from observations of actual noise signals. The high quality of the samplers has been confirmed by their prolonged operation as components of the Kvazar complex's radio telescopes VLBI equipment. LO cassette contains one hybrid-strip board, which incorporates 2 controllable self-excited oscillators with a digital phase-locked loop, an output frequency divider with switchable filters, a synchronism indicator and a control-code decoder. Root-mean-squares of LO phase noises were reduced to 1.2 degrees (fig. 3) for reducing the phase coherence loss to less then 0.34%. This fully corresponds to the requirements imposed on terminals of the Mark IV - Mark 5 class.

Main DAS module contains the digital signals level meter to control input IF signals and video signals. Added modules contain only video signals level meter. The measurement error of these levels is 0.1%. Main DAS module also contains the 32 MHz clock with 1 PPS synchronizer for S2-RT and filters for selection of the harmonic phase calibration signals.

The DAS is controlled by a microprocessor connected to the radio telescope's central computer, or by the operator's individual PC through an RS-232 interface. The system's software is compatible with the package of the Mark IV Field System observation programs that are widely used in international observing practice.

Parameters of this DAS are showed in table 1.

Table 1. Parameters of the new DAS

Intermediate frequency range	100–1000 MHz
Number of IF inputs	2
Number of modules	from 1 up to 4
Number of base band converters	from 2 up to 8
Connection of base band converters to IF inputs	electronic switch
Sidebands	upper and lower
Image rejection	more then 26 dB
Bandwidths	0.25; 2; 8 and 16 MHz
Number of digitizer bits	2
IF attenuator's range on distributor inputs	0–18 dB
IF attenuator's range on base band converter's input	0–15 dB
Attenuation step	1 dB
Error of signal level measure	0.1%
Phase noise of local oscillator	less then 1.2 degree rms
Clock Frequency for signal's record	32 MHz
Number of two-bits output streams	up to 16
Max Total Output Data Rate	1 Gbit/s
Module Dimension	$300 \times 445 \times 465$ mm

First module of new DAS was tested in the Svetloe and Zelenchukskaya observatories. In 2003 DAS of 4 modules (8 BBCs) for the S2-RT recording terminal was produced (fig. 4). Now it is being tuned and tested by IAA TDC. We are planning to install new DAS at the Badary observatory in summer or in autumn 2004.

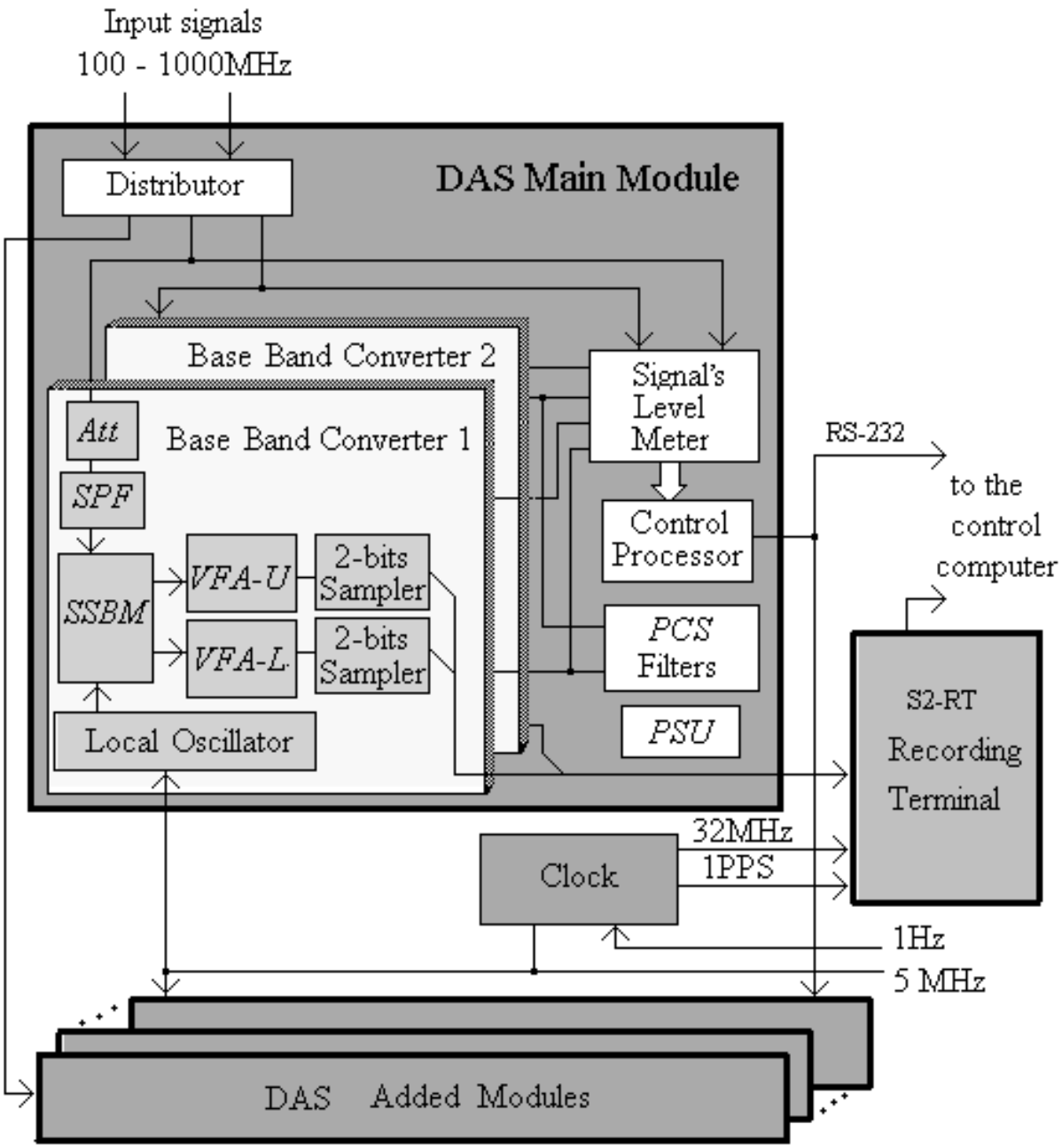

Figure 1. Blok diagram of the data-acquisition and record system: Att — controlled attenuator, SPF — switchable preselector filtres, $SSBM$ — single side band mixer, $VFA-U$ — video frequensy amplifier for upper-side-band signal, $VFA-L$ — video frequensy amplifier for lower-side-band signal, PCS Filters — filter for phase calibration signal, PSU — power-supply unit.

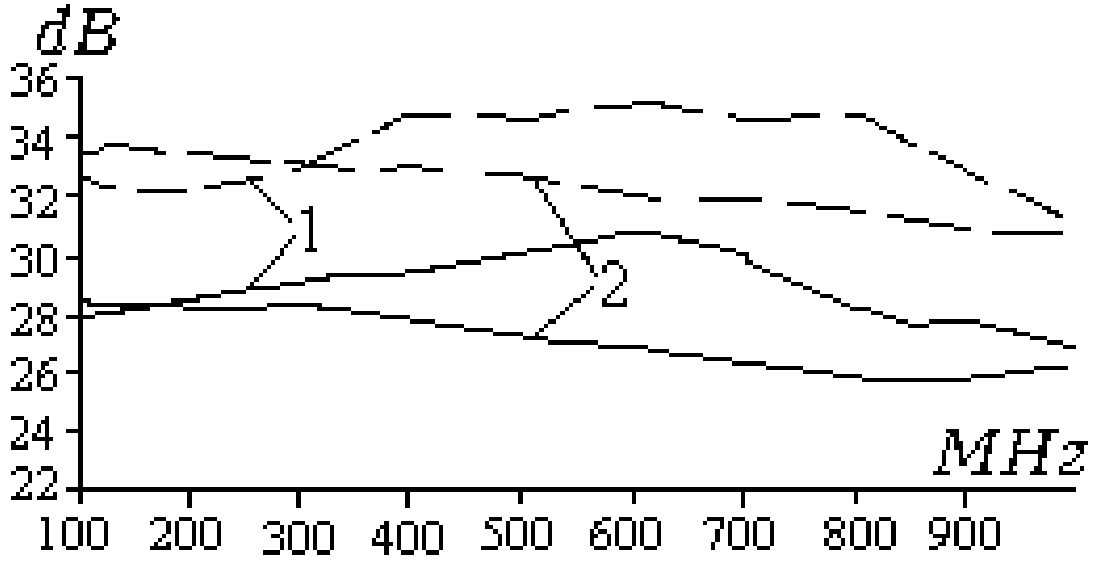

Figure 2. Experimental curves of image rejection for the reception of signals in the upper (1) and lower (2) side bands by two BBCs.

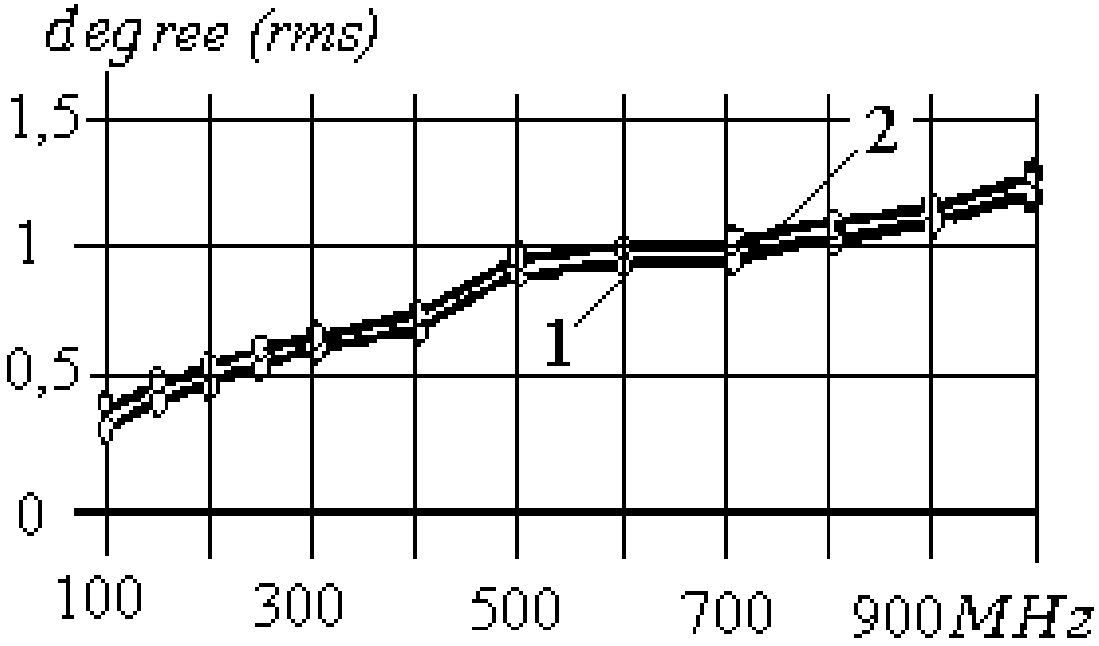

Figure 3. Measured phase noise of the LO in bands 0.01–2 MHz (1) and 0.01–16 MHz (2).

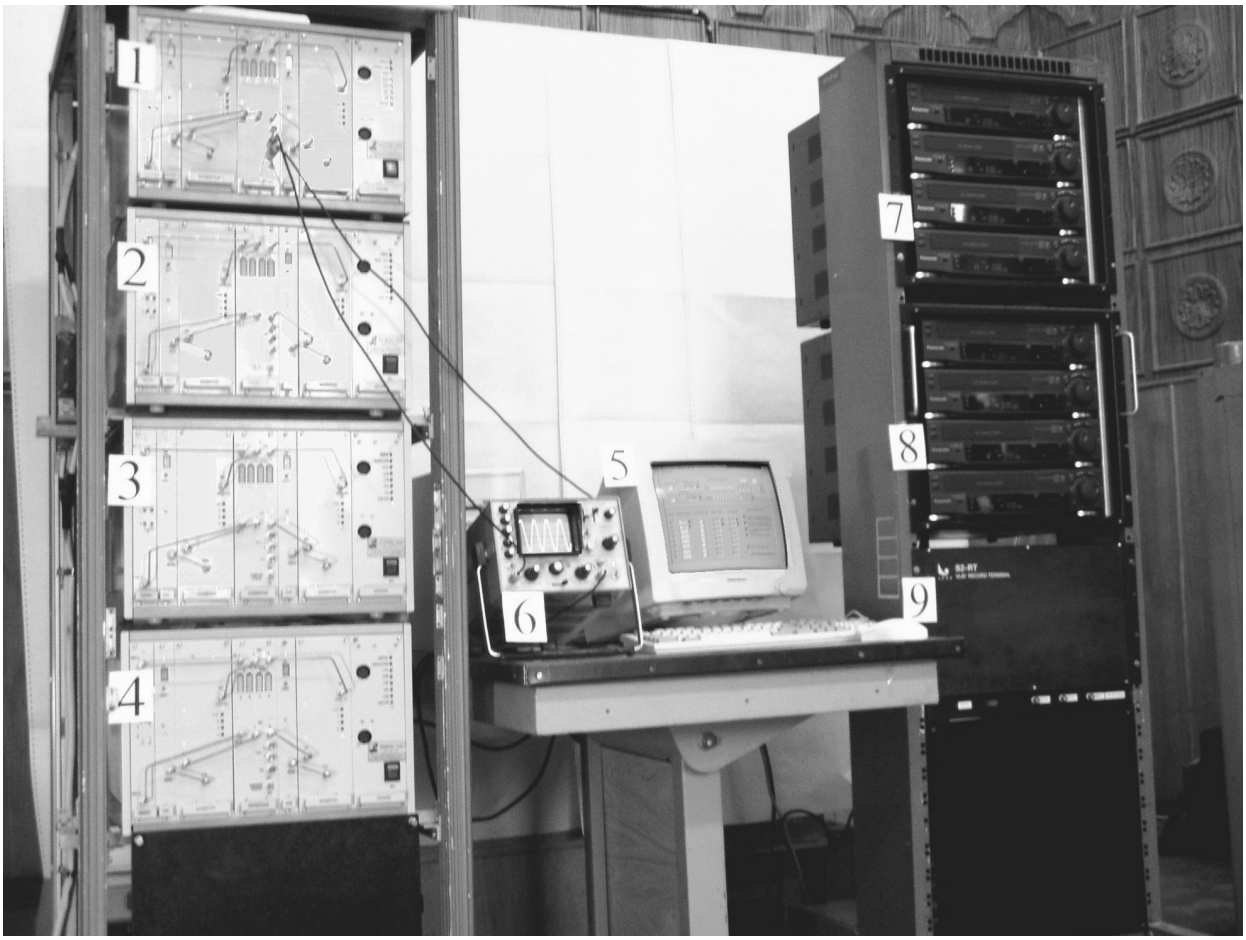

Figure 4. 8-chanel DAS with S2-Rt recoding terminal: **1, 2, 3, 4** — DAS modules; **5** — control PC; **6** — oscilloscope for phase calibration signal monitorng; **7, 8, 9** — S2-RT modules.