The ATNF Long Baseline Array Correlator

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1 The Australian Long Baseline Array

The Long Baseline Array (LBA) was an important component of the original specification of the Australia Telescope, construction of which commenced in 1983 following funding by the Australian Federal Government.

The LBA was originally conceived as an array of three telescopes connected by microwave links. The telescopes were the Parkes 64M antenna, the Mopra 22M antenna and the ATNF Compact Array at Narrabri. It was also envisaged that a fourth telescope, from the NASA Deep Space Tracking Station at Tidbinbilla, would be able to join the array when available. As design of this system progressed, and as more telescopes became available for possible inclusion in the array—in particular the 26M antenna at Hobart—and as it was realised that a good imaging capability required at least six stations, the inflexibility of the connected element interferometer became more and more apparent. This led to the decision to modify the LBA to a tape based VLBI array.

Three VLBI tape recording systems were evaluated for use in the LBA. These were the reel based VLBA recorder and the cassette based K4 system from Japan and S2 system from Canada. The S2 system—a system capable of recording at a maximum data rate of 128MBits/sec for 5 hours on standard S-VHS cassette tapes—was finally chosen as the only option which satisfied the technical specifications and allowed the outfitting of a sufficient number of stations within the funding available. The funding from the original AT construction budget had by this time (1992) been augmented by an Australian Research Council grant to a consortium of universities led by the University of Tasmania. This allowed the purchase of a total of five record terminals, six playback terminals and six data acquisition systems. The three element ATNF LBA had become a six element Australian LBA.

2 Development of the LBA Correlator

The first two S2 record terminals were delivered to ATNF in July 1992. In August of that year they were installed at Narrabri and Mopra and used in an experiment which attempted to detect, and perhaps resolve, the supernova remnant SN1987A. On-line fringe rotation was performed on the Compact Array antennas at Narrabri, with the Mopra antenna defined as the reference antenna. Two polarisations at 4MHz bandwidth with 2 bit quantisation were recorded at Mopra and from four of the six antennas at Narrabri. This made use of the full 128MBits/sec recording capability at Narrabri, whereas at Mopra the recorded data rate was 32MBits/sec. The data was correlated in Sydney on the ATNF test correlator using the same two record terminals. As the record terminals have only a limited playback capability, with a maximum playback data rate of 16MBits/sec, multiple passes were required. It was, however, the availability of this playback function which allowed the experiment to be undertaken. The experiment failed to detect SN1987A, but did detect a number of weak sources contained within the primary beam. It was judged a resounding success in its demonstration of the flexibility of the S2 systems in their first use in astronomy.

In May 1993 three S2 playback terminals were delivered to ATNF and a record terminal was delivered to Hobart. In October 1993 a test VLBI experiment was carried out between Hobart and Parkes. This data was correlated on a single baseline correlator which had been developed at ATNF as a prototype for the LBA correlator. In November 1993 the first S2 intercontinental VLBI experiment was carried out between Parkes, Hobart and the 70M antenna at Ussuriysk, involving a collaboration of the Russian Astro Space Centre, the Institute of Space and Terrestrial Science, Canada, the University on Tasmania and the ATNF. Initial correlation of this data was carried out on the single baseline prototype correlator, but by May 1994 this system had been extended to a three baseline system.

In October 1994 regular scheduled observations with the LBA commenced, initially with three stations. The first six station experiment was carried out in July 1995. The final six station correlator is now in place and will be officially opened at this meeting.

3 The LBA Correlator System

A block diagram of the system is shown in Figure 1. Although the current system is configured for six stations (i.e. six S2 playback terminals) it can be expanded to a maximum of twelve stations. The bulk station delay is taken out in the S2 terminals whilst the delay unit handles the incremental delay during a scan by means of sample insertion. The output of the delay units is connected via a bus structure to a large crossbar switch which allows a highly fexible routing of station signals to the baseline components.

The baseline component contains the fringe rotators, the data validity processors, the vernier delay components, a sideband inversion facility and the recirculation memories. The fringe rotators use four level sine, cosine functions and produce real and imaginary rotated outputs for the complex correlator which follows. Recirculation is only used at bandwidths less than 4MHz. An expansion path is available by way of adding an additional crossbar switch/baseline component/correlator, as shown in the block diagram.

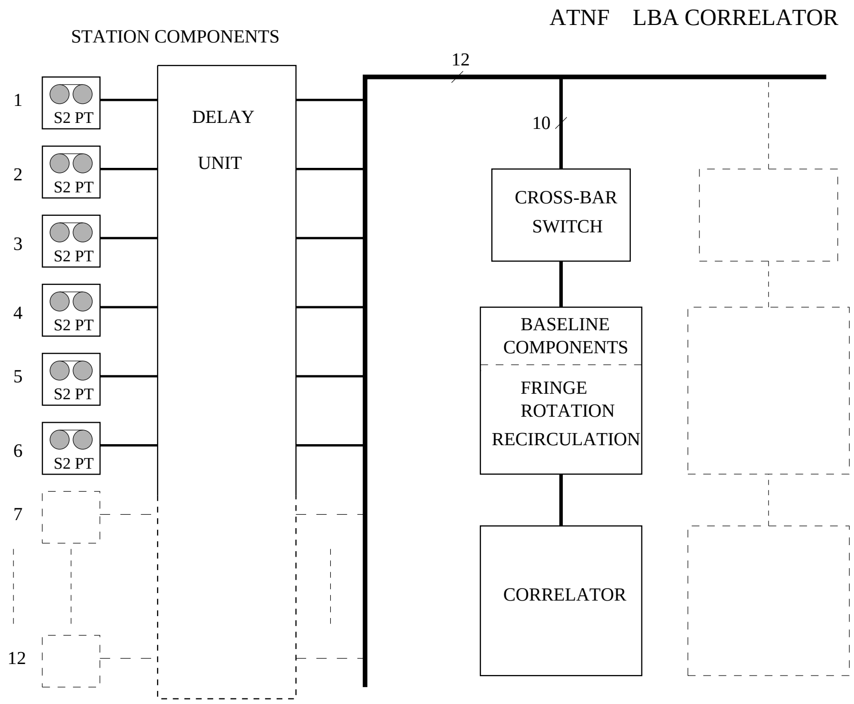

Figure 1: Block Diagram

4 Specifications

- Up to 4 input data channels per station.
- Maximum bandwidth 16MHz on any one channel.
- 1 or 2 bit samples.
- Maximum total data rate of 128MBits/sec per station.
- Normal operating modes:
  - 1,2 or 4 frequencies x 1 polarisation.
  - 1 or 2 frequencies x 2 polarisations.
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Input data channels	Maximum baselines	Maximum stations
1	64	10
2	32	8
4	16	6

5 Correlator

The correlator is made up from 8 standard ATNF correlator blocks containing 64 correlator module boards. It has the following specifications:

- Total frequency channels

Bandwidth	Real	Complex
16MHz	8192	4096
4MHz	32768	16384

- Continuum: Channels per product at maximum number of stations

Bandwidth	2 Stokes	Full Stokes
16MHz	64	32
8MHz	128	64

- Line: Channels per product at 6 stations—2 products per baseline

Bandwidth	
8MHz	256
4MHz	512
2MHz	1024
1MHz	2048
0.5MHz	4096