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The Mark 5B VLBI Data System

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Abstract. The Mark 5B VLBI data system is now being developed at MIT Haystack Observatory. It is based on the same physical platform and uses the same disk-modules as the Mark 5A; it also supports the same maximum data rate of 1024 Mbps. However, the Mark 5B will incorporate a VSI standard interface and command set. This will allow VLBA systems to bypass any existing formatter and connect directly to the output of VLBA samplers (through a simple interface) at a maximum data rate of 1024 Mbps. For existing 14-BBC Mark 4 systems, the Mark 5B will allow connection of all 14 BBCs to two Mark 5Bs for a total aggregate data rate of 1792 Mbps. In addition, the Mark 5B is being designed to support all critical functionality of the Mark 4 Station Unit, including phase-cal extraction, so that the Mark 5B may played back directly to the Mark 4 correlator through a simple interface. Mark 5B systems are expected to be available in early 2005.

1. Mark 5 VLBI Data System

Incorporating primarily low-cost PC-based components, the Mark 5 system [Ref 1] supports data rates up to 1024 Mbps, recording to an array of inexpensive removable IDE/ATA disks. The general goals of the Mark 5 system are:

- Low cost
- Based primarily on unmodified COTS components
- Modular, easily upgradeable
- Robust operation, low maintenance cost
- Easy transportability
- Conformance to VSI specification [Refs 2,3]
- Compatibility with existing VLBI systems during transition
- Flexibility to support e-VLBI
- Minimum of 1 Gbps data rate
- 24-hour unattended operation at 1 Gbps

All but the last goal are achievable with today's technology; 24-hour unattended operation at 1 Gbps is expected to arrive within ~1-2 years with continued development in high-capacity disk technology.

Figure 1 shows a photograph of the prototype Mark 5A system with its two removable '8-pack' disk modules; the Mark 5B will look the same. A Mark 5A system may be upgraded to a Mark 5B system simply by replacing an Input/Output PCI board in the host PC.

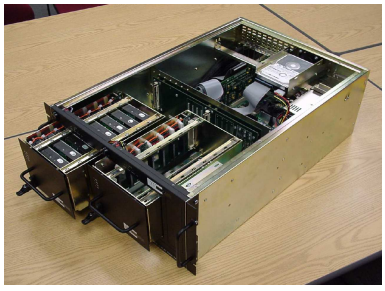

Fig. 1. Mark 5A VLBI data system

2. Characteristics of the Mark 5B Data System

The Mark 5B system has the following characteristics:

- Uses the same chassis and disk packs as the Mark 5A
- Implements the VLBI Interface Standards (VSI-H, VSI-S and VSI-E)
- Maximum record/playback data-rate is 1024 Mbps (same as Mark 5A)
- Eliminates the need for an external formatter (but requires mating VSI interfaces)
- With a 14-BBC Mark 4 or VLBA system, up to 1792 Mbps can be recorded with two parallel Mark 5B systems
- Mark 4 Station Unit capabilities are being designed into the Mark 5B so that Mark 5B systems can be connected to Mark 4 correlators without the use of a Mark 4 Station Unit.
- Built-in phase-cal extraction for 16 simultaneous tones and state-counting during recording and playback
- Xilinx FPGA design will be updateable via software download from PC

3. Station Unit Emulation Capability

The Mark 4 Station Unit acts as the interface between data from Mark 4/VLBA tape-format data (from either tape or Mark 5A disk systems) and the Mark 4 correlator proper. It has several functions:

- Delays the data according to a fifth-order spline polynomial supplied to the Station Unit before presentation to the correlator proper
- Inserts headers into the data stream with model information used by the correlator proper
- Extracts up to 16 phase-calibration signals from each channel
- Counts state statistics to aid in post-correlation correlation-coefficient normalization

This functionality is being built into the Mark 5B to allow the Mark 5B to connect to a Mark 4 correlator without the use

of a standard Mark 4 Station Unit. The implementation of these functions is aided by an on-board 256 MB memory which will allow dynamic changes in the data-delay at intervals specified by the controlling delay model.

4. Compatibility with Mark 5A

The Mark 5B is being designed so that disk modules recorded on a Mark 5B can be played back on a Mark 5A unit. The playback format on the Mark 5A unit will be in VLBA track format and all common modes will be supported. Existing Mark 5A units will need to be upgraded to support this compatibility path. This compatibility mode will allow data recorded on Mark 5B systems to be correlated on existing Mark 5A correlators during the transition period to Mark 5B.

5. VSI Interfaces to Existing Mark 4 and VLBA Systems

In order to use the Mark 5B with existing VLBA or Mark 4 systems, a VSI interface providing sampled data, clock and 1 pps must be available for connection to the Mark 5B. These interfaces are also being developed at Haystack Observatory as part of the Mark5B development project:

VLBA systems (8 BBC's with VLBA formatter): An interface based on the Metsahovi VSI-C converter board will be used. The VSI connector will carry the 2-bit USB and LSB samples from BBCs 1 to 8.

Mark 4 or VLBA4 systems (with existing Mark 4 formatter): The interface will use the existing samplers, plus 32 MHz and 1pps synthesizers in the Mark 4 formatter chassis, and will add a communications and control board. It will support two data modes:

1. 'Astronomy' mode: 2-bit USB/LSB from BBC's 1 to 8 on VSI output 1; 2-bit USB/LSB from BBC's 9 to 14 on VSI output 2; max recording rate 2048 Mbps with two parallel Mark 5B systems
2. 'Geodetic' mode: 2-bit USB from BBC's 1 to 14 and 2-bit LSB from BBC's 1 and 8

6. Interface to Mark 4 Correlator

A Correlator Interface Board (CIM) is necessary to convert the VSI-format output of the Mark 5B system into the form necessary for input into the Mark 4 correlator. The CIM will be housed in a separate chassis and connect to the VSI-output connector of the Mark 5B.

7. Summary

The Mark 5B system is the second in the line of Mark 5 VLBI data systems and the first to implement the VSI standard. Built on the same platform as the Mark 5A, the Mark 5B offers both a simple migration path for existing Mark 5A users and an inexpensive VSI-compatible VLBI data system for new installations. In addition, a Mark 5B/Mark 5A compatibility path has been established to ease in the transition from Mark 5A to Mark 5B. The Mark 5 system is being developed with support from BKG, JPL, KVN, MPI, NASA, JIVE, NRAO and USNO.

8. References

1. The Mark 5 web site contains additional information regarding the System at: http://web.haystack.mit.edu/mark5/Mark5.htm.
2. VLBI Standard Hardware Interface Specification-VSI-H, Revision 1.0, 7 August 2000, available at http://dopey.haystack.edu/vsi/index.html.
3. VLBI Standard Software Interface Specification - VSI-S, Revision 1.0, 13 February 2003, available at http://dopey.haystack.edu/vsi/index.html.