Mark IIIA and VLBA High-Density Recording

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ABSTRACT. The wideband Mark III recorder has been improved by the development at Haystack Observatory of a narrow-track recording system. Using 56 MHz bandwidth, more than 3 hours of VLBI data may be recorded on one tape. The same headstacks with new, thinner "digital video" tape allow recording at 128 Mbit/sec for 16 hours on one reel for the VLBA. New electronics for control, signal switching, and record/playback have been designed. Up to 2 Gbit/sec could be recorded by modular expansion.

1. Introduction

Haystack Observatory under NASA sponsorship has developed a narrow-track headstack which, using standard video tape, allows up to a 16-fold improvement in the area density of bits written with the Mark III VLBI wideband recorder. This permits operation with correspondingly fewer tape changes and greatly reduced costs of handling and shipping. The groundwork has also been layed for further improvements, including the recording system for the VLBA.

2. The Mark IIIA System

The Mark III wideband recorder writes 28 tracks of data at rates up to 8 Mbit/sec/track longitudinally on 1-inch videotape. With modern tape, the signal-to-noise ratio is much higher than required for good performance in a VLBI system. Haystack therefore undertook to increase the bit density by retrofitting with narrow-track headstacks and positioner. The headstacks were originally to be developed commercially, but failure after two years forced Haystack to undertake the development and participate in the manufacture of these critical components.

The crucial head tip trimming operation is performed at Haystack using a dicing saw custom-fitted with a laser interferometer position readout, a 2000× microscope for edge measurement, and intimate computer control. Ferrite "gapped bars" are precision-trimmed to an average edge placement accuracy of 0.5 μ; the tips are only 38 μ wide. The head tip array is fastened to a base containing the ferrite coils which complete the magnetic circuits.

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In addition, a precision positioning mechanism has been built to move the headstack between passes and control the position to better than 1 μ accuracy. This incorporates a piezoelectric motor, a linear variable differential transformer position sensor, and the necessary electronics. A headblock containing the headstack, actuator, sensor, and intimate interface electronics substitutes for the fixed wide-track Honeywell head assembly. The positioner and new, electrically cleaner power supplies and shields mount in the tape transport rack. This upgrade constitutes a "Mark IIIA" recorder.

This system typically provides >25 dB SNR at band-edge frequency for a Mark IIIA recording. Typical error performance is $< 3 \times 10^{-4}$ fraction of bits discarded due to synchronization loss, and a residual bit error rate of 5×10^{-5}, which is quite satisfactory for VLBI. The integrity of the VLBI scientific results is not easily compromised even when performance is seriously degraded by tape defects, clogged heads, electronic interference, *etc.*

3. The VLBA system

The same head and tape technology is being applied by Haystack under NRAO sponsorship to meet VLBA requirements. These include 100 Mbit/sec average record rate and 24-hour unattended recording. The VLBA recorder has all 36 heads connected instead of the 28 used by Mark IIIA, providing 32 data tracks and 4 system tracks which may substitute for dead tracks or record transverse parity. The VLBA recorder uses a new VME-based controller using a 68000 microprocessor for controlling transport, headstacks, and signal switching. The analog data electronics are new designs. The VLBA recorder must be reliable; MTBF $> 10^4$ hours appears achievable. The flexible formatting and decoding of the VLBA system will allow compatibility of the recordings made on either system in Mark IIIA mode.

The VLBA will probably use the new "digital video" tape which permits 50% higher longitudinal bit density and is half the present standard thickness. Packaged on a 16-inch reel, one volume will hold 8 *km* of tape and run 16 hours at 128 Mbit/sec. Each site will have 2 recorders, providing a maximum recording rate of 512 Mbit/sec. The system is expandable in a modular fashion and with additional headstacks and modules could record up to 2 Gbit/sec.

Even higher densities may be achieved by using "metal-in-gap" heads and metal particle tape. 12-hour continuous recordings at 1 Gbit/sec on one reel is projected if this new consumer head and tape technology is adapted for the VLBA.

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