MARK IV MEMO #213
VLBA ACQUISITION MEMO #388

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To: Mk4/VLBA VLBI Development, NSIC UHD Tape Program

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Re: Much Better than Expected Thin-film MR Head Performance Observed

1. Introduction

The first attempt on 12 March to use a very narrow track, 3.75 um, thin-film magneto-resistive [MR] head to reproduce a 56Kfci VLBI recording was successful well beyond expectation. With 1/10 the current VLBI read-trackwidth of 38 um, a consistently higher SNR was observed at tape speeds from 1 to 8 m/s. Though many tests, particularly for reliability and for adequate head life, remain to be done, the first tests reported here are very encouraging.

The thin-film head used in these tests is an IBM disk head being evaluated by Haystack and others for NSIC, the National Storage Industry Consortium, for potential suitability of similar technology for Ultra High Density [UHD] tape recording, with TB/in^3 as the goal.

This type of disk head is already in mass production. It was sampled in the form of a 'row-bar', one slice of a thin-film head wafer. The rectangular row-bar was used as a uncontoured [flat] headstack. At this stage of thin-film head production the bar has been lapped to a very precisely controlled and small initial depth of gap of order 2 um.

2. Initial Test Results

The row-bar on its lapping fixture was mounted with an adapter to replace a VLBI headstack. The excellent suggestion made by UHD tape program manager, Jim Eaton, on how to obtain good contact with the flat head contour was followed: Defining the trailing edge of the bar to be the one with the thin-film heads, the wrap angle on the leading edge was set to .02 radians while the trailing edge wrap was set to zero. Consistent contact was observed at speeds from 1 to 8 m/s with tape traveling in the leading-to-trailing edge direction as long as tension is above .85 N. In the opposite direction the tape flies perfectly as intended [only electronic noise as if the tape were not moving is observed]. A symmetric double-bar arrangement would seem to be practical for bidirectional contact on both gap lines.

The bandedge, 56 Kfci, SNR on random low-pass filtered VLBI data was observed to be 24-25 dB with 30 KHz resolution bandwidth at 2 m/s. Referred to one of the complementary outputs of the Silicon Systems 32R1561R MR head interface chip with nominal voltage gain of 75, tape noise output is about 1 mv rms at peak wavelength of 2.7 um and rolls off 3 dB to 0.7 v at the 0.9 um bandedge. There is no indication that either tape noise or signal spectrum roll off more rapidly at 8 m/s than at 2 m/s. This is the best indication of good speed-independent contact, that is, constancy of spacing loss. The correct direction of MR bias/sense current was determined empirically: The unequalized eye pattern looks symmetrical for the correct direction and very asymmetrical for the 'wrong' direction, but SNR and rolloff is the same either way. So far only a fixed close-to-nominal sense/bias current of 10 ma has been used.

3. Consequences and Projections

The 25 dB SNR observed with this MR head is 2 to 8 dB better than the 17 to 23 dB values measured on the same tape on various Haystack VLBI processor drives using 38 um ferrite heads, where even with only 17 dB SNR an adequately low raw error rate of about 10^{-5} is typically obtained.

For the inductive VLBI head with the VLBI preamp the dominant noise source is electronic; the noise due to running an unrecorded degaussed tape adds typically only a fraction of a dB to the noise observed with the tape stationary. When electronic or head noise dominates as it does in this case, SNR is lost at 6 dB per halving of trackwidth.

But with the MR head media noise dominates by about 12 dB. In this case SNR is lost at only 3 dB per halving of trackwidth. Thus adequate SNR of 17-19 dB should theoretically be obtained with MR read trackwidth as small as 1 um [with an otherwise equally efficient head and using the present SVHS-equivalent VLBI tapes [3M5345, SonyD1K]].

The more than 6 dB excess SNR could also be expended [less efficiently than by quartering the read trackwidth] to double the linear density with a simple 4 bits per PW50 partial response decision feedback decoding scheme which I have taken under study and hope to prototype.

The IBM 'merged' thin-film head has a 7 um wide inductive write element on top of the shielded 3.75 um wide MR read element and is intended for so-called 'write-wide, read-narrow' operation which allows +/- 1.625 um tracking error without signal loss. Tracks [passes] could for example be spaced 7 um to obtain a 6-fold increase in track density with respect to a 42 um trackspacing that can now be used to obtain 16 passes with the 36-channel 38 um VLBI headstack.

There is already considerable evidence [more will be generated with the thin-film head-array] that the tracking repeatability of the Metrum 96 is good enough as is to support this scheme, though stable operating conditions and bump-free packing [uniformly strained tape] are required. Improvements to the tape path are being pursued to place edge guide and head in much closer proximity. Tracking errors under +/- 0.1 um and reduced requirements for operating condition stability, especially for tape strain uniformity, are expected.

Head life and ability to maintain performance over life are now the most important remaining questions which will be answered with straightforward though time consuming tests.

4. Conclusion

It now appears likely -- without even going to more advanced tape -- that the density of VLBI recording can be increased by at least a factor of 8, simply by using thin-film MR disk-head technology of a type already in mass-production and head interface chips designed to go with them. This will make full-time Gb/s VLBI operation practical.