VLBA ACQUISITION MEMO #184

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To: VLBA Data Acquisition Group

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Subject: Wavelength dependence of D1 and MET - VLBA "Headcurves"

Introduction

The wavelength response of the VLBA recorder can be measured by recording a square wave of a fixed frequency for various record speeds and playing back at the same speed as used for record. This method has the advantage that it is free from errors in the calibration of the frequency response of the heads and electronics since the measurements are always made at the same frequency and only the wavelength is changed. The relative response as a function of wavelength is often called a "headcurve".

Headcurves for DIK and MET

Figure 1 shows the headcurves made on VLBA REC #3 for D1K and MET. These curves were made with the optimum record current for a wavelength of 1 μm.

Parameterization of results

The curves of Figure 1 have been fit to a 4 parameter model according to the playback model of H. Neal Bertram (Proc. IEEE, 74, 11, 1494-1512, 1986) as follows:

The model is the product of the following voltage terms:

a] Gap loss

Due to finite gap length

$$\sin(1.11\ kg/2)/(1.11\ kg/2)$$

where

k	=	wave number ($2\pi/\lambda$)
1.11g	=	effective gap length = 0.394 microns as determined by the gap null

b] Recording depth

$$(1 - e^{-k\delta})/(k\delta)$$

where

δ = record depth or magnetic layer thickness (whichever is the smaller)

c] Spacing loss

The account for the physical spacing between the gap and the magnetic media, any effective dead layer on the head and the tape transition length.

e^{-kd} (55 dB per wavelength)

where

d = spacing loss

d] Overall scale or efficiency

$$(2\sqrt{2/\pi})\ N\ \varepsilon\ Wv\mu o\ MK\delta$$

(see Bertram for definitions)

noting that

$$vk = \omega$$

where

$(\omega/2\pi)$ = recording frequency

<u>Interpretation of results</u>

The data are fairly well fit by

δ = 0.3 μm

d = 0.15 μm

for D1K and S-VHS tape

and δ = 0.15 μm

d = 0.13 μm

for evaporated metal tape.

While the spacing loss is much smaller than predicted for longitudinal magnetization (see Bertram equation 89) it is much larger than might be expected for vertical magnetization in which the median transition length should be very short. For longitudinal recording the theoretical transition length depends on the spacing during record. A careful test was made with the VLBA recorder in which the head was temporarily contoured to provide an extra 0.1 μm spacing which was verified by the added short wavelength loss on a pre-recorded tape. Under these conditions a new short wavelength recording was made which also initially showed the added spacing loss, however, after recontouring the head to remove the 0.1 μm spacing, the playback of the original recording and that made with 0.1 μm extra spacing were virtually indistinguishable.

My interpretation is that the spacing on record only effects the record depth. This is, the medium is only recorded to a depth at which the head field is greater than the coercivity or about 0.3 μm and so recording with an extra spacing merely reduces the record depth which in turn has little effect on the playback of short wavelengths. I think this interpretation is consistent with the vertical recording mechanism discussed by Bertram. The mystery is, 'why are we limited to a spacing loss greater than 0.1 μm, if the transition length is much less than 0.1 μm'? I can think of possible explanations:

a) There is always a layer of air or an effective flying height,
b) There is always a layer of water or lubricant between head and tape,
c) There is a "dead" or Bielby layer of inactive material on the head,
d) Tape roughness.

The first possibility, a), has been excluded by making measurement of the short wavelength response down to speeds as slow as 2 ips. With our "Hinteregger step", there is no evidence of flying below speeds of about 270 ips (see Acquisition Memo #146).

The second possibility, b), is unlikely as I have been unable to find any significant dependence of the spacing loss on humidity - except at very high humidity (>80%) at which point the spacing loss may increase by about 0.05 μm.

If the third possibility, c), is the cause, then the loss may depend on the roughness of the head since the formation of a dead layer often depends on the surface finish (see Wada, IEEE, MAG-16, 5, 1980).

Undoubtably some spacing loss can still be attributed to tape roughness, but both manufacturers' data and my own data (using optical interferometry), indicate that the peak roughness is less than 0.06 μm. However, perhaps the head roughness (which I have yet to measure) should be added.

Atch. (1) Figure 1. Wavelength in Microns

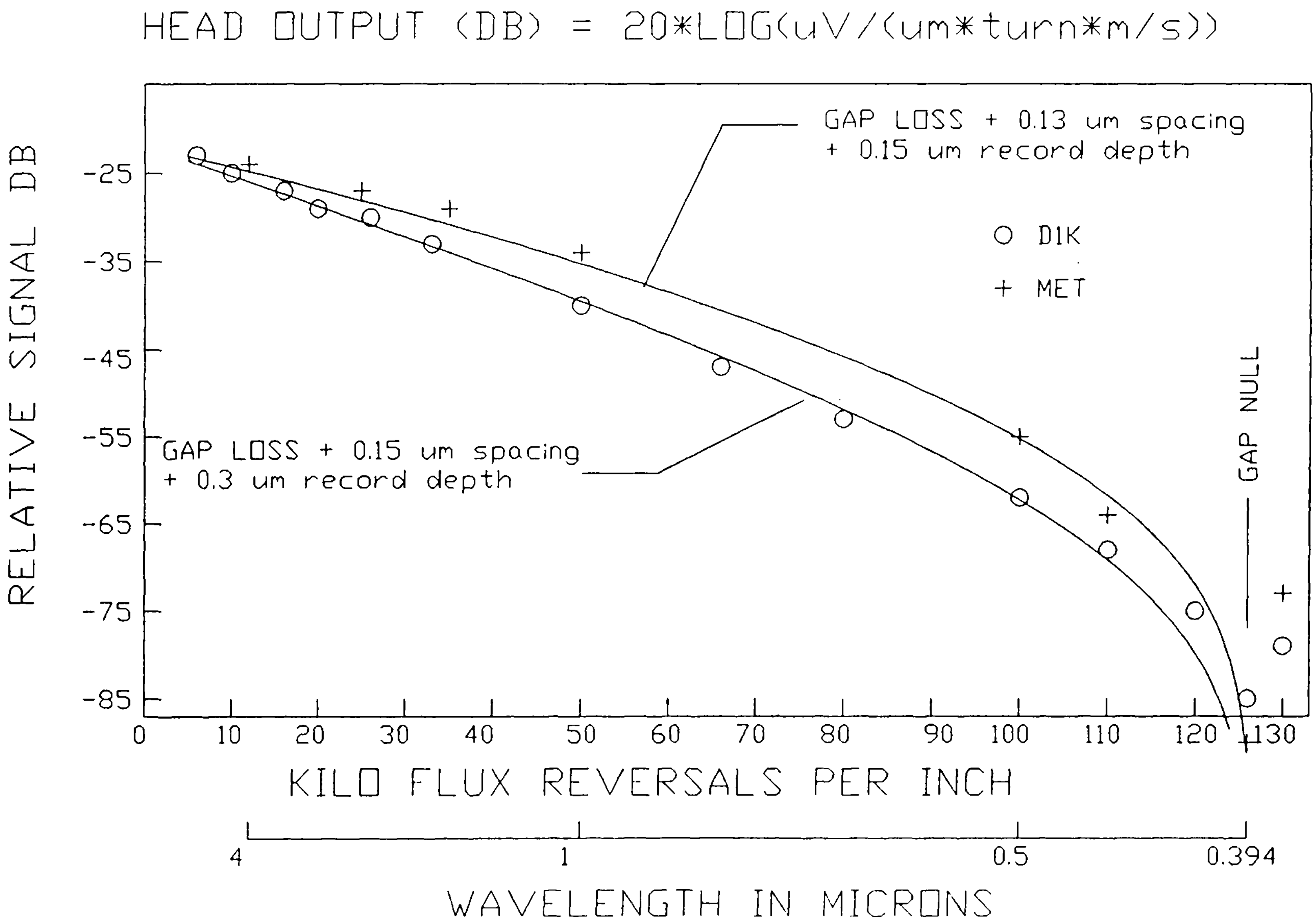
HEAD OUTPUT (DB) = 20*LOG(uV/(um*turn*m/s))
RELATIVE SIGNAL DB
-25
-35
-45
-55
-65
-75
-85
GAP LOSS + 0.13 um spacing
+ 0.15 um record depth
O D1K
+ MET
GAP LOSS + 0.15 um spacing
+ 0.3 um record depth
GAP NULL
0
10
20
30
40
50
60
70
80
90
100
110
120
130
KILO FLUX REVERSALS PER INCH
4
1
0.5
0.394
WAVELENGTH IN MICRONS

Figure 1.