# VLBA ACQUISITION MEMO #152

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To: VLBA Data Acquisition Group

From: Alan E.E. Rogers

Subject: A Magnetic circuit model for the VLBA headstack

The VLBA narrow track headstacks have a gap length of 0.33 $\mu$m, width of 38 $\mu$m and thus a gap reluctance *Rg* = 180 Ma/Wb (mega amp-turn/weber) for a depth of gap equal to 38 $\mu$m reluctance for the rest of the magnetic circuit as follows (assuming a relative permeability of ferrite equal to 700).

$R_c$ (ferrite through coil) $\approx$ 5 Ma/Wb

$R_t$ (ferrite in tip plate) $\approx$ 2x30 Ma/Wb

unless there is significant reluctance in the contact gap between the "tip" plate and "fluxor". For example:

$R_b$ (contact gap) = 160 Ma/Wb for 30 $\mu$m

contact thickness. Figure 1 shows the magnetic circuit geometry. In addition to the gap reluctance and series reluctance there is magnetic field leakage which acts as reluctance in parallel. I estimate the following leakage field reluctances:

$R_a$ (apex angle leakage) $\approx$ 3000 Ma/Wb

$R_o$ (head coupling) $\approx$ 150 Ma/Wb

The leakage reluctance is primarily between heads with two paths from one head to each adjacent head. The Table gives the magnetic flux paths, their reluctance and the inductances which results from these paths. Figure 2, the equivalent circuits for evaluating the head efficiency as a function of the gap reluctance and the cross-talk between heads.

In summary the series reluctance in the ferrite tip plate results in about 3 dB loss for an initial depth of gap of 38 microns, so that the head performance is expected to improve by 3 dB as the head wears. The leakage between heads can produce significant record cross-talk of about -4 dB in the worst case when interference from adjacent heads are in phase. The record cross-talk can be eliminated by ensuring that the circuitry connected to the undriven head produces only a small current in response to the voltage cross-talk and steps are being taken to reduce the loading of the undriven heads in both the MKIIIA and VLBA recorders. It might also be possible to eliminate the record cross-talk by reducing the speed of the record current risetime. [The record cross-talk consists of very narrow ($\approx$8 ns) pulses which are just sufficiently strong to magnetize the particles

in the gap at the time of the pulse.] In the long term it may also be possible to reduce the flux leakage between heads by reducing the cross section of the fluxor ferrite in future headstack designs.

| Item | Length μm | Area μm x μm | Relative Permeability | Reluctance Ma/W | Inductance μH |
|---|---|---|---|---|---|
| Head Gap | 0.33 | 38 x 38 | 1 | 180 | |
| Tip Plate | 150 | 150 x 38 | 700 | 30+ | |
| Coil | 400 | 300 x 300 | 700 | 5 | |
| Leakage between heads | 400 | 800 x 1400 *(1200 x 1800) | 1 | 150 | |
| Apex leakage | | | 3000 | | |
| Coil | | | | | 23 |
| Mutual between heads | | | | | 7 |

*Effective Cross Section Area
+Approximate estimate only - geometry is complicated

Table. The Reluctance of Magnetic Flux Paths in the VLBA Heads

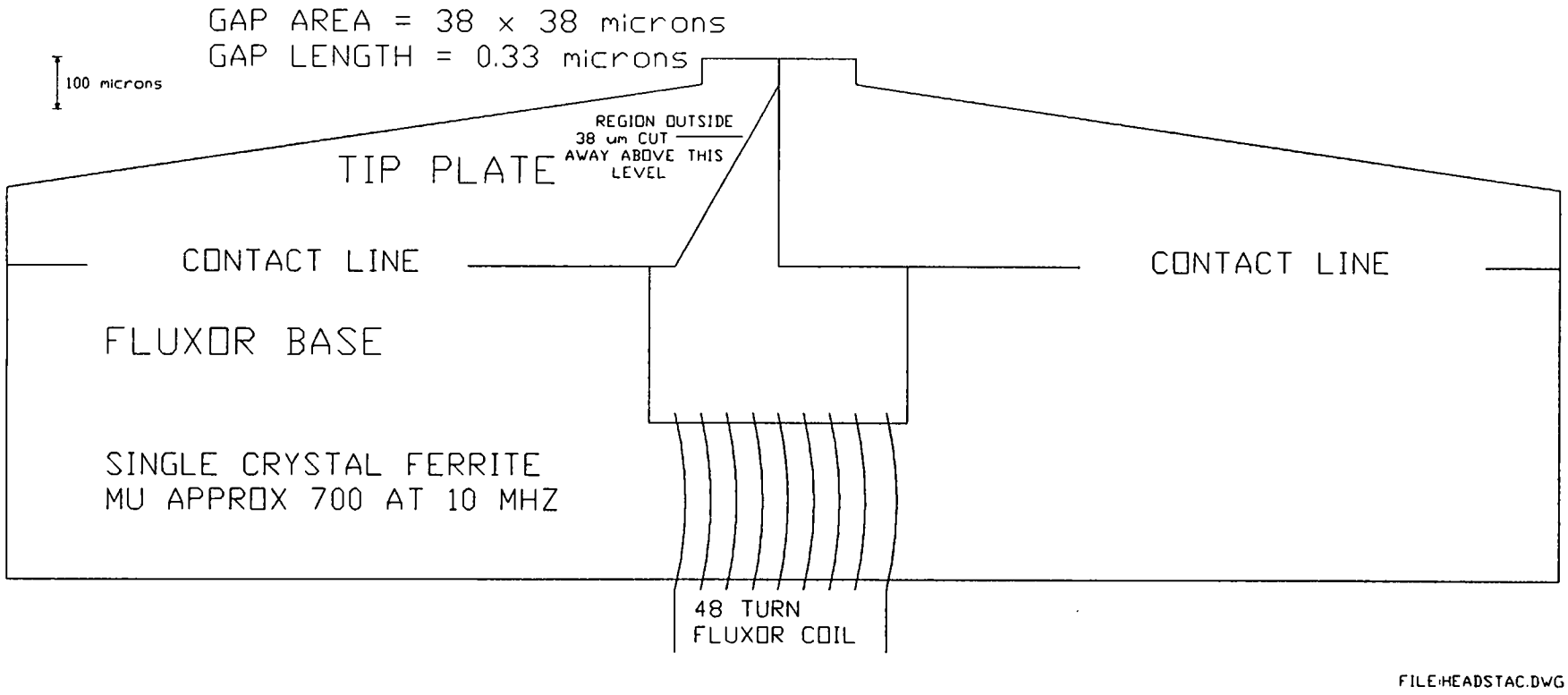
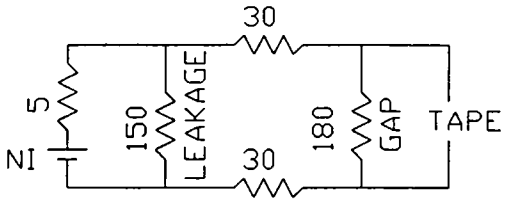
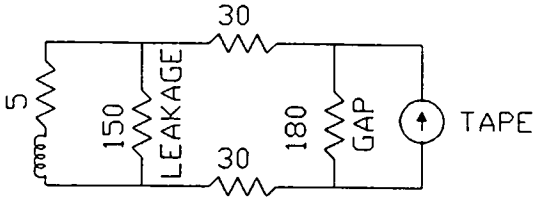


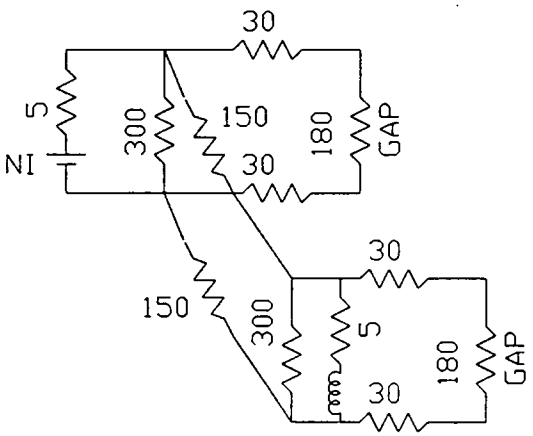

FIGURE 1 MAGNETIC CIRCUIT GEOMETRY (GAP AREA SHOWN FOR DEPTH OF GAP = 38 MICRONS)



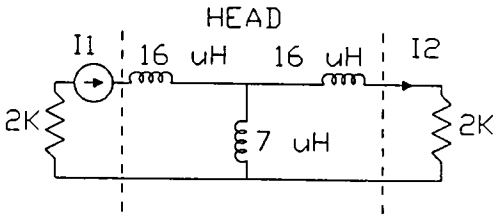

"DC" FIELD CIRCUIT FOR RECORD EFFICIENCY AND INDUCTANCE
(-3 dB relative to zero gap depth, inductance = 23 mH )



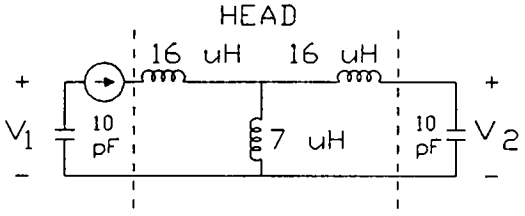

"DC" FIELD CIRCUIT FOR REPRO EFFICIENCY
(-3 dB relative to zero gap depth )



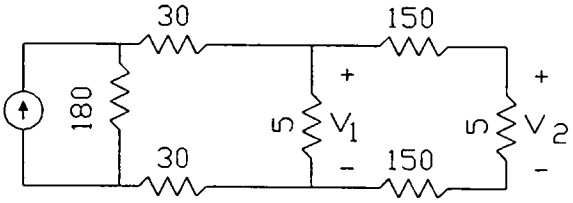

"DC" FIELD CIRCUIT FOR ESTIMATION OF MUTUAL INDUCTANCE
(coupling coeff. 0.3
mutual inductance = 7 uH )




EQUIVALENT CIRCUIT FOR RECORD CROSS-TALK
(record cross-talk = I2/I1 = -10 dB in HF limit or -4 dB from "in phase" interference from both adjacent heads)




EQUIVALENT CIRCUIT FOR HF REPRO CROSS-TALK TO BE ADDED TO LF CROSS-TALK
(V2/V1 = -27 dB at 4 MHz)




EQUIVALENT CIRCUIT FOR LF REPRO CROSS-TALK
(V2/V1 = -36 dB )

file:magcir.dwg

FIGURE 2 EQUIVALENT CIRCUITS FOR VLBA RECORDER HEADS