VLBA Acquisition Memo # 110

# Tape Track Formats

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## 1 Introduction

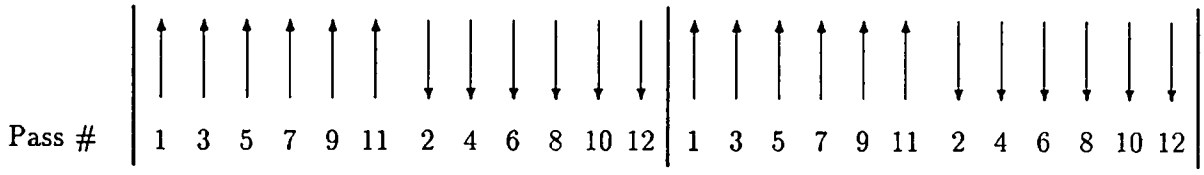
There has been considerable confusion about exactly where on the tape the tracks, which are defined as the magnetized strips, are written. This discussion is intended to relieve some of this confusion and eliminate some inconsistency in present usage. First, Mark IIIA track locations are discussed, since these are in use both for Mark IIIA and initial VLBA recordings. Finally, the extension to full VLBA track format is elucidated.

## 2 Concepts for Mark IIIA

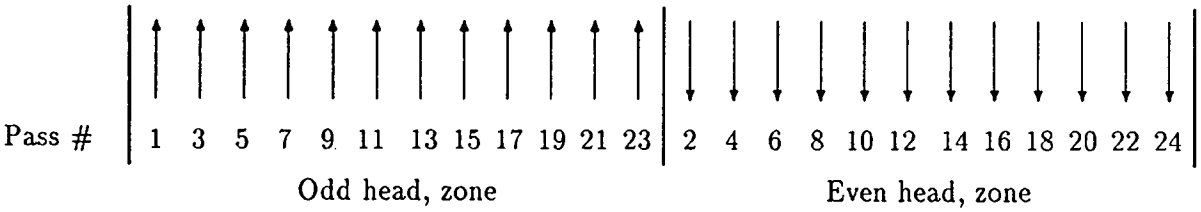
The present Mark IIIA track format uses 28 zones across the width of the tape. Each zone is 698.5 $\mu$m wide, equal to one head pitch. Within zone $n$, $n$=1,...,28, head $n$ writes at each of 12 index positions. Tracks are thus uniquely identified by the ordered pair consisting of zone number and index number. These positions are currently 55 $\mu$m apart, providing a 17 $\mu$m guard band with the present 38-$\mu$m-wide heads. A small additional offset is provided to separate forward and reverse passes within a given zone.

There are two presently supported multi-track modes, A and B (pass numbers and offsets are the same for Mode C). As defined in the programs HSX and HSXA, and within the Field System, the tracks are laid down on the tape as follows, where the arrows indicate direction of tape motion (up is forward).

Mark IIIA Mode A

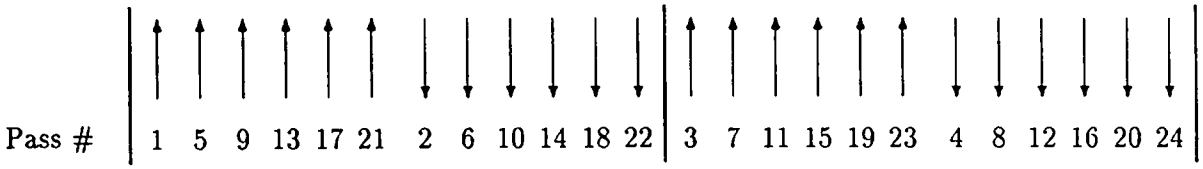



Mark IIIA Mode B or C



Note that there is a basic inconsistency in the track locations specified by these schemes, in that an odd-numbered zone contains only forward tracks, evenly spaced, in Mode B, but contains both forward and reverse tracks, with a special guard band between them, in Mode A. This is for historical reasons based on non-moving wide track heads. In order to make track locations consistent for all modes, Mark IIIA Mode B should be modified (this is only software) to the following:

Modified Mark IIIA Mode B or C



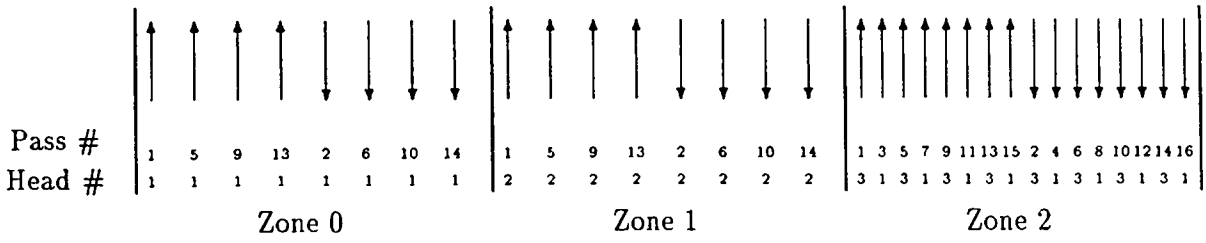

This fills up index positions in the same order as Mode A and makes the track positions consistent between Mode A and Mode B (it also works for Mode C and Mode D).

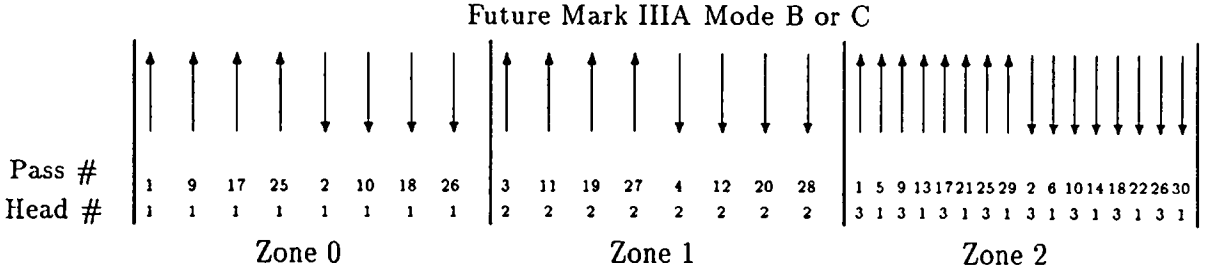
Tapes written by VLBA recorders to be processed in Mark IIIA modes must currently be written with this convention. In particular, the tracking process requires Mark IIIA-sized guard bands. The offsets must in all cases be adjusted to conform to the standard calibration tapes.

In order to use much narrower guard bands, some Mark IIIA head mounts (present on Westford, Mojave, and one Washington correlator drive) must be changed to the final version, which permits a larger range of head motion than the earlier version. When this is done, a new standard can be used which will permit the use of narrower guard bands.

In order to accomplish this in Mark IIIA, zones on either end of the normal zones numbered 1 to 28 must be used. The idea is that on alternate groups of 4 successive passes, the headstack will be moved by one full head pitch in either direction with respect to the convention defined above. Then, for Mode B, head 1 will write only in zones 0 and 2; head 3 will write in zones 2 and 4; and so on. In zone 0, only half the passes will be written, so that a guard band greater than one head width will be present for tracking. On alternate groups of 4 passes, tracks in zone 28 (written by head 27) will have this property. For the even heads, the corresponding guide zones will be 1 and 29. With 38-$\mu$m-wide heads and 4 $\mu$m guard bands, a total of 32 passes instead of the present 24 is possible. Let us attempt to illustrate this.

Future Mark IIIA Mode A






# 3 Algorithms for Mark IIIA

The previous discussion indicated only in a general fashion where the tracks should be located. Here, an exact set of definitions will be provided and algorithms suitable for computer implementation described. All units are expressed in $\mu$m.

Let forward offset $x_{of}$ be defined as the offset which places the center of any head at the zero point (outer edge) of its correspondingly-numbered zone, assuming forward tape motion. Let reverse offset $x_{or}$ be the corresponding number for reverse tape motion. These offsets will typically be about $-349$ $\mu$m (half a head pitch) plus a small correction for the particular LVDT and electronics mounted on a particular drive. They may be measured using a standard calibration tape.

Index positions 1 through 12 are presently defined for Mark IIIA. For the modified mode described in the first section above, in which consistency between index positions for Mode A and Mode B is forced, the center-of-track position $x_i$ corresponding to index $i$ is given by

$i < 7$: $x_i = 37 + 55(i-1) + x_{of}$

$i \geq 7$: $x_i = 386 + 55(i-7) + x_{or}$

In order to find index $i$ for a given pass $p$, calculations will be different depending on the mode.

For Mode A: $i = \text{int}((p+1)/2) + 6(1 - \text{mod}(p,2))$

For Mode B or C: $i = \text{int}((p+3)/4) + 6(1 - \text{mod}(p,2))$

And also for Mode B or C, let $k = \text{mod}(\text{int}((p+1)/2),2)$ and make odd heads active if $k = 1$, even heads active if $k = 0$.

For 16-pass operation in Mark IIIA mode for both Mark IIIA and VLBA systems, find index $i$ as follows:

$i < 9$: $x_i = 28 + 42(i-1) + x_{of} + (698.5 - 1397k)$

$i \geq 9$: $x_i = 377 + 42(i-1) + x_{or} + (698.5 - 1397k)$

where $k$ is defined separately for the two cases below.

For Mode A: $i = \text{int}((p+1)/2) + 8(1 - \text{mod}(p,2))$

and also $k = \text{mod}(p,2)$

For Mode B or C: $i = \text{int}((p+3)/4) + 8(1 - \text{mod}(p,2))$

and also $k = \text{mod}(\text{int}((p+1)/2),2)$

Again, odd heads are active if $k = 1$ and evens if $k = 0$.

With these definitions and algorithms, tracks will be placed at positions allowing sufficient guard bands in each direction to guarantee non-overlap of recordings provided the proper pre-passing of the tape has been performed to allow tracking to stabilize.

# 4 Extension to VLBA

The extension of the previous discussion to VLBA format is straightforward. The VLBA headstack contains 36 heads, and the 1-inch-wide tape is divided into 36 zones, numbered 0 to 35. Zone 1 for Mark IIIA is the same as zone 5 for VLBA. Strips nominally 127 $\mu$m wide at each edge of the tape are not used.

Within each zone, indices 1 through 16 are defined exactly as in the 16-pass Mark IIIA operation, and have the same characteristic offsets. Clearly, if all 36 heads write simultaneously, there will be no head-width-sized guard bands anywhere if all passes are written. We therefore reserve the outermost heads for special uses and confine this discussion to the use of 32 data heads plus 2 system heads. Let us consider only two possible multi-track modes, namely the two analogs of Mark IIIA Modes A and B (or C). The full 34-track mode will be called Mode $V_A$ and the 17-track mode with alternate passes in groups of 4 will be called Mode $V_B$.

Again, the permitted range of headstack motion is greater than $\pm 2$ head pitches. Displacements of up to $\pm 1.5$ head pitches will be required relative to the position in which each head is centered in its correspondingly-numbered zone. This position should also be very close to the zero point of the LVDT. In Mode $V_A$, zone-sized displacements on consecutive forward passes will alternate between $-698.5$ and $+698.5$ $\mu$m, just as in Mark IIIA Mode A. Thus, head 1 will alternately write in VLBA zones 0 and 2, while head 34 alternately writes in VLBA zones 33 and 35.

In Mode $V_B$, odd and even heads are each alternately active for passes in groups of 4, just as in Mark III Mode B. Offsets again alternate between $-698.5$ and $+698.5$ $\mu$m so that head 1 alternates between VLBA zones 0 and 2, while head 33 alternates between VLBA zones 32 and 34. Head 2 alternates between VLBA zones 1 and 3, while head 34 alternates between VLBA zones 33 and 35.

Note that if all tracks are written, then guiding information is available at *both* edges of the tape. It should be clear that the playback power level provides a peak response where there is a full-head-width guard band. However, it is also true that, at the opposite edge of

the tape, there will be a head which will lie *between* two tracks, on nominally unrecorded tape. The dithering of the head position required to produce a positive power peak using a head at one edge of the tape will thus produce a power null in a head at the opposite edge; this information can be used for tracking as well, since the reproduce electronics allow the selection of two separate reproduced tracks, and their power levels are available simultaneously.

If fewer than 17 tracks are to be written, an additional zone must be freed, presumably by eliminating a system track. Since tape consumption should not be an issue when low data rates are required, it is recommended that the minimum number of tracks recorded at any time be 16 data plus 1 system track. For spectroscopic observations needing fewer tracks, data may simply be recorded redundantly for greater immunity from malfunctions.