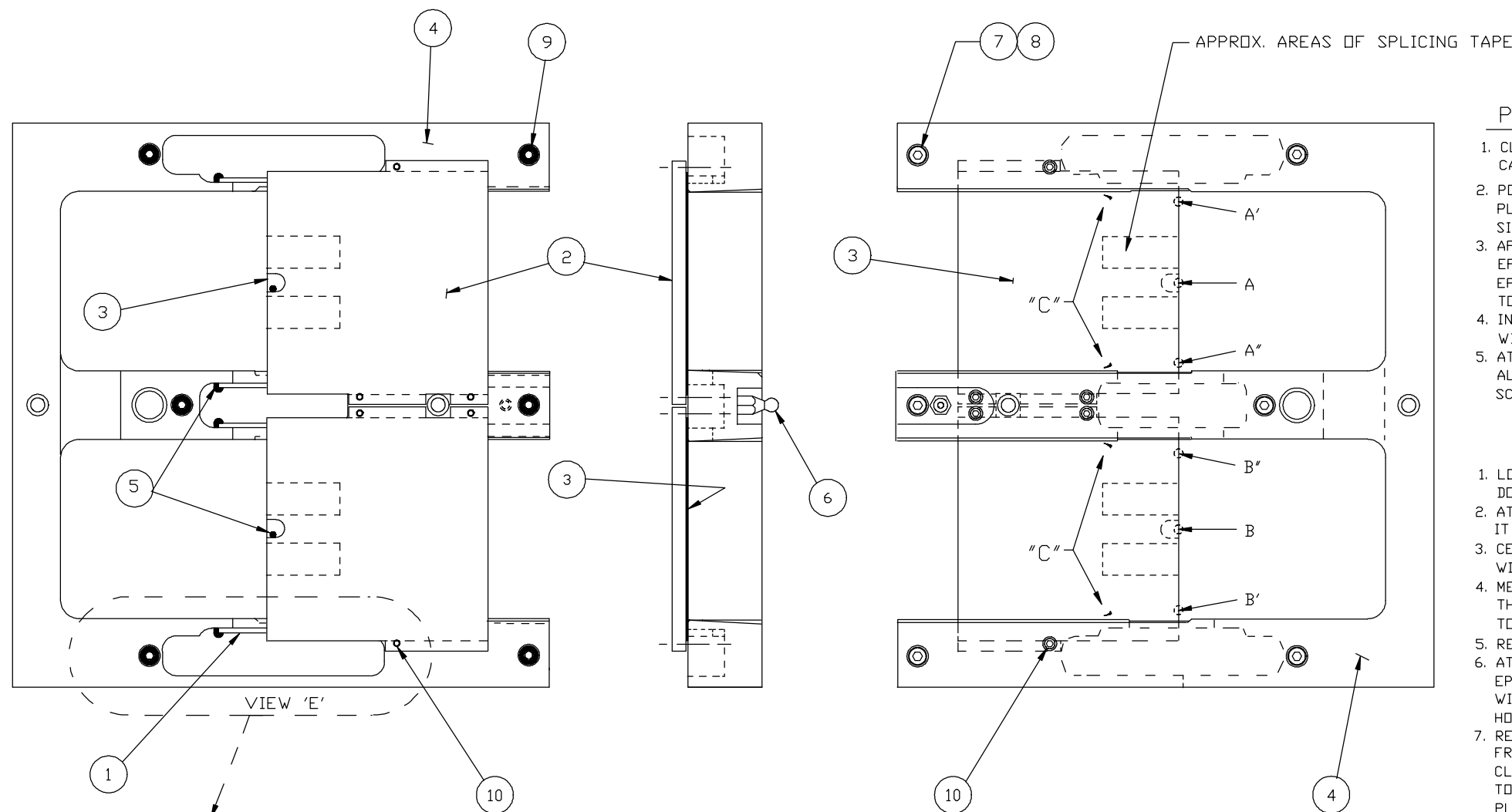


CHANGE LETTER	D'WN BY	CHK'D BY	APP'D BY	DATE	D.C.N. & DESCRIPTION
A	RJC	HFH	HFH	2/93	PART# HAY DWG A-6310-83A
					WAS 10-504599. PART# HAY
					DWG D-6310-105C WAS -105A.



### PREPARATION OF "E" CASTING FOR INSTALLATION

- CLEAN PARTS TO BE BONDED WITH ALCOHOL. ATTACH BEARING CLAMP PLATES TO "E" CASTING WITHOUT ALUMINA PLATES. TIGHTEN SECURELY.
- POSITION VACUUM COLUMN WINDOWS IN PLACE, ALIGNING THEM AGAINST BEARING PLATES. SECURE WINDOWS IN PLACE WITH A DROP OF SUPER GLUE OR DOUBLE SIDED TAPE. REMOVE BEARING CLAMP PLATES.
- APPLY A BEAD OF RECOMMENDED EPOXY ALONG THE ENDS OF EACH WINDOW. EPOXY NOT ALLOWED IN PORTION OF WINDOW VISIBLE THRU SPACER OPENING. EPOXY NOT TO PROTRUDE OUTSIDE OF WINDOW CUTOUT. ALLOW EPOXY TO SET FOR 24 HOURS.
- INSERT #6-32 x 7/8" LONG SCREWS WITH LOCKWASHERS AND SECURE IN PLACE WITH O-RINGS. ATTACH FRICTION CATCH STUD.
- ATTACH BEARING CLAMP PLATES WITH #2-56 x 3/8" LONG SCREWS. PLACE ALUMINA PLATES BETWEEN BEARING CLAMP PLATES AND "E" CASTING AND TIGHTEN SCREWS JUST ENOUGH TO KEEP ALUMINA PLATES FROM FALLING OUT.

### HARD POINT ASSEMBLY

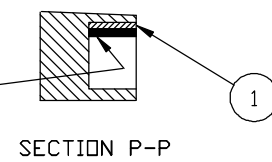
- LOOSEN BEARING CLAMP PLATE SCREWS BEING CAREFULL THAT ALUMINA PLATES DO NOT FALL OUT.
- ATTACH "E" CASTING TO A PRECISION PLATE (METRUM 16827015-001) CHECKING TO SEE THAT IT IS SITTING FIRMLY AGAINST THE PRECISION PLATE. TIGHTEN "E" CASTING SCREWS.
- CENTER ALUMINA PLATES IN CAVITIES (APPROX. EQUAL CLEARANCE ON EACH SIDE) AND TEST WITH 2 MIL TO 5 MIL SHIM STOCK. TIGHTEN BEARING CLAMP SCREWS TO 8 IN. OZ.
- MEASURE DEPTH OF "E" CASTING WITH DEPTH MICROMETER AT POINTS A, A', A" AND B, B', B". THEY SHOULD ALL AGREE TO WITHIN 1 MIL BETWEEN 1.0015" AND 1.0035". IF NOT WITHIN TOLERANCE TRY TO DETERMINE REASON - SEEK ADVICE IF NECESSARY.
- REMOVE "E" CASTING, LEAVING BEARING CLAMP PLATE SCREWS TIGHT.
- ATTACH 2 PIECES OF SPLICING TAPE TO ALUMINA PLATE, (1) ABOVE AND (1) BELOW EPOXY SLOT IN BEARING CLAMP PLATE. WRAP TAPE AROUND EDGE OF ALUMINA PLATE; WITH TAPE UNDER TENSION, ATTACH TO BACK OF BEARING CLAMP PLATE. THIS WILL HOLD ALUMINA PLATE SECURELY AGAINST BEARING CLAMP PLATE.
- RE-INSTALL "E" CASTING AND MEASURE DEPTHS AT POINTS A AND B. A CHANGE OF 1 MIL, FROM SQUEEZING OUT A WITHIN-SPEC LACK OF FLATNESS IN THE ALUMINA AND BEARING CLAMP PLATES IS POSSIBLE. IF A GREATER CHANGE IS OBSERVED START OVER AND TRY TO FIND CAUSE, (ROTATE OR FLIP ALUMINA PLATE, EXCHANGE AND FLIP BEARING CLAMP PLATES FOR EXAMPLE).
- IF DIMENSIONS ARE ACCEPTABLE AGAIN REMOVE "E" CASTING, LEAVING BEARING CLAMP PLATE SCREWS TIGHT. ALSO, LEAVE TAPE IN PLACE.
- PLACE A DROP OF RECOMMENDED EPOXY IN SLOT OF BOTH BEARING CLAMP PLATES SO THAT ALUMINA PLATE BONDS TO BEARING CLAMP PLATE. EPOXY SHOULD NOT WICK IN BETWEEN ALUMINA PLATE AND BEARING CLAMP PLATE. LET EPOXY SET FOR 24 HOURS.
- FINALLY, REMOVE TAPE AND REINSTALL "E" CASTING. TAKE MEASUREMENTS AS IN STEP 4. IF ALL MEASUREMENTS ARE WITHIN SPEC., ASSEMBLY IS COMPLETE AND SHOULD BE INTERCHANGEABLE BETWEEN MACHINES WITHOUT HARDPOINT ADJUSTMENT.

### NOTES

- THE DEPTH AT A AND B SHOULD BE CHECKED PERIODICALLY AS PREVENTIVE MAINTENANCE.
- WHEN AN ALUMINA PLATE DEVELOPS SIGNIFICANT WEAR AT THE EDGE BEARING ARCS "C" IT CAN BE REUSED BY BREAKING THE EPOXY TIE-DOWN POINT BY TWISTING THE ALUMINA PLATE OFF THE CLAMP PLATE, CLEANING THE EPOXY RESIDUE OFF, ROTATING THE HARD PLATE 90, 180, OR 270 OR FLIPPING IT OVER FOR 4 ADDITIONAL WEAR POSITIONS, AND REPEATING THE HARDPOINT ASSEMBLY INSTRUCTIONS. SIGNIFICANT WEAR AND SCRATCHES >.0005" DEEP, CAN ONLY BE DIRECTLY EVALUATED BY INSPECTION OF THE HARD-PLUS-CLAMP PLATE SUBASSEMBLIES UNDER A HIGH-POWER MICROSCOPE. OTHER SYMPTOMS SUCH AS AN INCREASE IN THE AMPLITUDE OF THE INTERCHANGE TRACKING SIGNATURE MAY INDICATE HARD POINT WEAR. ONLY THE CENTRAL EDGE BEARING ARCS ADJACENT TO THE MIDDLE LEG OF THE "E" CASTING AFFECT TRACKING.

FIND #	QTY	PART #	DESCRIPTION	SOURCE
1	4	HAY DWG A-6310-115	WINDOW, VAC. COLUMN	MONKS
2	2	HAY DWG A-6310-82	PLATE BEARING CLAMP	MONKS
3	2	HAY DWG A-6310-83A	ALUMINA BEARING PLATE	COORS
4	1	D-6310-105C	VACUUM SPACER ("E" CASTING)	MONKS
5	AS REQ.	TRA-BOND 2116	LOW VAPOR EPOXY	TRA-CON
6	1	16762807-018	STUD, CATCH, #6-32	METRUM
7	6	#6-32 x 7/8" L'NG	S'K'T H'D CAP SC'W, S.S.	LAWSON
8	6	#6	SPL'T L'KW'SH'R, S.S.	LAWSON
9	6	006	1/8 I.D. x 1/4 O.D. VITON O-RING	LAWSON
10	6	#2-56 x 3/8" L'NG	S'K'T H'D CAP SC'W, S.S.	LAWSON

VIEW 'E' OF WINDOW AREA WITH ALUMINA BEARING PLATE AND CLAMP BEARING PLATE NOT SHOWN.

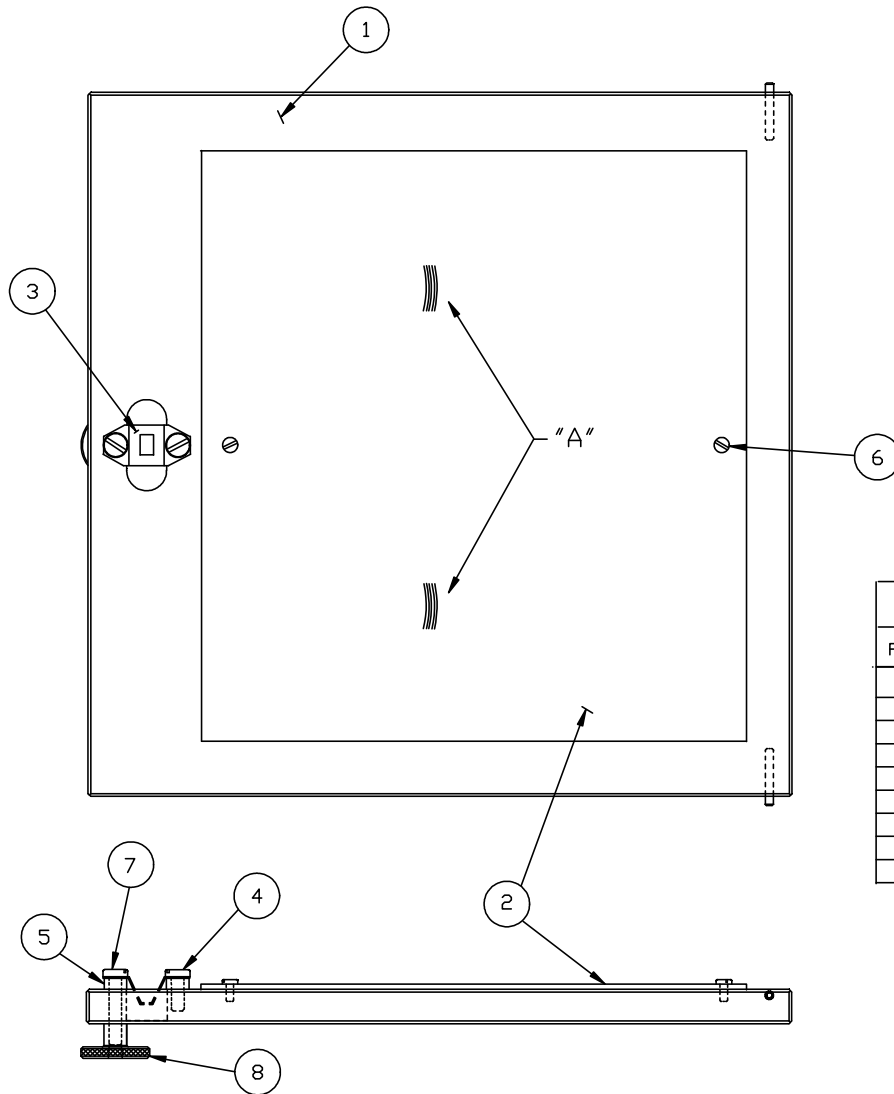


### NOTES

MATERIAL:	SHOP NOTES: UNLESS OTHERWISE SPECIFIED	USED ON:	DRAWN FOR: H.HINTEREGGER	DATE: 9/92	NORTHEAST RADIO OBSERVATORY CORPORATION
FINISH AND/OR HEAT TREATMENT:	1. DIMENSIONS ARE IN INCHES 2. TOLERANCE ON DIMENSIONS FRACTIONAL ± 1/64 DECIMAL .XX ± .01 DECIMAL .XXX ± .005 ANGULAR ± 0°30' 3. SURFACE ROUGHNESS PER MIL-STD-10 ✓ 4. REMOVE BURRS AND BREAK SHARP EDGES 1/64" MAX. 5. SCREW THREADS PER MIL-STD-9 6. ALL DIMENSIONS TO APPLY BEFORE PLATING OR CONVERSION COATING.	APPROVALS:	DRAWN BY: R.J.CADY	9/92	HAYSTACK OBSERVATORY WESTFORD, MASSACHUSETTS
		NEXT ASSEMBLY:	CHECKED BY:		ASSEMBLY - VACUUM SPACER ("E" CASTING)
		WEIGHT:	PROJECT:		
		CLASSIFICATION:	ENGINEER:		
			MAT'L & PROCESS:		
			STRUCTURES:		
			THERMAL:	6310113A	
			MECH ANALYSIS:	CAD FILE	

D-6310-113 A

CHANGE LETTER	D'WN BY	CHK'D BY	APP'D BY	DATE	D.C.N. & DESCRIPTION
A	RJC	HFH	HFH	1/93	PT # HAY C6310-108A IS NOW
					HAY C6310-108C & HAY C6310-109A
					IS NOW HAY C6310-109B.



### FRONT DOOR ASSEMBLY

- CHECK TAPE EDGE BEARING PLATE FOR BURRS. IF NECESSARY, CLEAN PLATE WITH SCOTCHBRITE AND RAZOR BLADE TO REMOVE BURRS.
- ATTACH FRICTION CATCH WITH 1/8" THICK STANDOFFS BETWEEN DOOR AND CATCH. ASSEMBLE CATCH AND STANDOFFS TO DOOR WITH #6-32 PAN HEAD SCREWS.
- ATTACH TAPE EDGE BEARING PLATE TO DOOR WITH #2-56 PAN HEAD SCREWS.

### NOTE

TAPE EDGE CONTACT AREAS "A", CAN BE ALLOWED TO WEAR TO A DEPTH OF .002" (MEASURE WITH STRAIGHTEDGE AND SHIM SLIVER PROBE). THE BEARING PLATE SHOULD THEN BE TURNED 180°, FOLLOWED BY 2 ADDITIONAL WEAR CYCLES ON THE OTHER SIDE. AFTER 4 WEAR CYCLES THE BEARING PLATE MUST BE REPLACED.

### PARTS LIST

FIND #	Q'NT'Y	PART #	DESCRIPTION	M'F'T'R
1	1	HAY C6310-108C	VACUUM DOOR	MONKS
2	1	HAY C6310-109B	TAPE EDGE BEARING PLATE	MONKS
3	1	16762805-007	RECEPTACLE, FRICTION CATCH	METRUM
4	1	#6-32 x 3/8" L'NG	PAN HEAD SCREW, S.S.	LAWSON
5	2	8500	.125 R'ND CLEAR STANDOFF	H.H.SMITH
6	2	#2-56 x 3/16" L'NG	PAN HEAD SCREW, S.S.	LAWSON
7	1	#6-32 x 3/4" L'NG	PAN HEAD SCREW, S.S.	LAWSON
8	1	PD1-7	KNURLED THUMB NUT	BERG

### NOTES

#### MATERIAL

#### FINISH AND/OR HEAT TREATMENT

#### SHOP NOTES: UNLESS OTHERWISE SPECIFIED

- DIMENSIONS ARE IN INCHES
- TOLERANCE ON DIMENSIONS  
FRACTIONAL ? 1/64  
DECIMAL .XXX ? .01  
ANGULAR ? 0°
- SURFACE ROUGHNESS  
PER MIL-STD-10
- REMOVE BURRS AND BREAK SHARP EDGES 1/64 MAX.
- SCREW THREADS PER MIL-STD-9
- ALL DIMENSIONS TO APPLY BEFORE PLATING OR CONVERSION COATING.

#### USED ON

DRAWN FOR	H.HINTEREGGER	DATE	9/92
DRAWN BY	R.JCARY	CHECKED BY	
PROJECT		ENGINEER	
MAT'L. & PROCESS		STRUCTURES	
THERMAL		MECH. ANALYSIS	

NORTHEAST RADIO OBSERVATORY CORPORATION  
HAYSTACK OBSERVATORY  
WESTFORD, MASSACHUSETTS

ASSEMBLY - VACUUM DOOR

6310114A	C	6310-114	A
CAD FILE	DWG. SIZE	DWG. NO.	REV.

C-6310-114 A

**VLBA Acquisition Memo #151.1**  
**Mark IV Memo #267**

**MASSACHUSETTS INSTITUTE OF TECHNOLOGY**  
**HAYSTACK OBSERVATORY**  
*WESTFORD, MASSACHUSETTS 01886*

January 13, 1999

*Telephone: 978-692-4764*  
*Fax: 781-981-0590*

To: Mark IIIA, MarkIV, and VLBA Tape Recorder Operators

From: Alan E.E. Rogers & Dan L. Smythe

Subject: Tape Recorder Performance Tests

**TESTS AND ADJUSTMENTS**

This section covers adjustments and tests needed to insure that a) the tape drive is working properly, or b) the installation of new parts and modifications to the tape drive have been done properly and meet specifications.

These tests have been designed to verify the performance of the tape recorder and to help diagnose problems. Some of the tests should be performed frequently and on a regular basis, while others can be performed only occasionally. This memo supersedes VLBA memo #151 and includes additional tests that were described in subsequent memos.

If you record thin tape on a regular basis, use thin tape for these tests. In particular, using thick tape for the vacuum shift test will damage a headstack contoured for thin tape usage.

**1. Tape path inspection (VLBA Acquisition Memo #301)**

Load a tape and set the vacuum to 10 inches. Run the tape in the forward direction and perform the following checks.

1. Check that the tape edge is not touching the precision plate or entrance to the vacuum column door; i.e. the edges should touch only the reel flanges, I/O flanges, edge guiding points (inside vacuum columns), and front door at turn-around.
2. Check that the tape runs over the input-output rollers without any problems, such as folding or damaging the tape.
3. Repeat steps 1. and 2. in the reverse direction.
4. Use a light to inspect the tape path to check for large forward-reverse offset. Hold the light to view the separation between the tape edge and the precision plate in the areas of the capstan, headblock, and idler roller. Reverse the direction of tape motion while observing this separation and note if there is a large forward-reverse offset. (A finer

check will be done later.)

5. Play back and peak on any recording in the forward direction and carefully slide a feeler gauge between the precision plate and the tape near the idler where the tape leaves the upper vacuum column. Find the gauge that just shifts the tracking. The distance between the tape edge and the precision plate near the vacuum column should be between.

.001 and .004 inch (0.02-0.1 mm) without the thin-tape upgrade

.008 and .014 inch (0.25-0.35 mm) with the thin-tape upgrade

Repeat with the tape moving in the reverse direction and measuring where the tape leaves the lower vacuum column. This measurement should meet the above specification and should be within 0.002 inch (0.05 mm) of the previous measurement.

## 2. Tests

1. **Forward-reverse shift test** Measure the tape position by issuing a pass command after peaking on a recorded track while moving the tape in the forward direction. Repeat in the reverse direction. The difference between these two readings must be less than 50 micrometers. Occasionally (approximately monthly, or after calibrating the head positioner), repeat this test at the beginning, middle, and end of the tape.
2. **Speed shift test.** Use 'peak' and 'pass' to measure the shift in tape position between normal (80 or 135) and double (160 or 270) speed. This shift should be less than 20 micrometers. Check in both directions. Perform this test once per observing day.
3. **Vacuum shift test.** Perform this test only occasionally, unless you can easily control the vacuum under computer control. **DO NOT USE THICK TAPE FOR THIS TEST ON A THICK-THIN TAPE RECORDER.** Measure the shift in position when changing the vacuum from 5 to 15 inches. This shift should be less than 15 micrometers. Repeat in the other direction. Reset vacuum to 10 inches when done.
4. **Door shim test** (VLBA Acquisition Memo #330). Set vacuum to 10 inches. Peak on a recorded track and watch the eye pattern on the oscilloscope while opening the vacuum column door slightly. The eye pattern should not change at all when the vacuum column door is opened by 6 mils (0.15mm). (Since it is difficult to measure the door opening at the left hand side, this is equivalent to measuring an opening of 3 mils (0.08 mm) halfway across the door from the opening to the hinge.) Also, at less than 15 mils (0.38 mm) of opening the eye pattern should be affected.

You can use two layers of paper (~80 um per layer) for a shim. Thread the tape and close the door on the shim. Peak up on a recorded track and remove the shim. The eye pattern should not change when removing a 0.15 mm (0.006-inch) shim (two layers of paper) placed near the top left, or bottom left, corner of the vacuum column. The eye pattern should change, or disappear, when removing a 0.4 mm (0.015-inch) shim.

5. **Tape shift with write stack position.** Peak up on a recorded track and move the write stack to +/- 700  $\mu\text{m}$ . The tracking should change by less than 10  $\mu\text{m}$ .
6. **Read stack calibration test.** Record 1000 feet with heads 14, 15, and 16 with 'tapeformc' 'pass=13,13'. (For a VLBA or Mark IV recorder, use 'tracks=17, 18, 19' and 'form=m'.) Reproduce with head 15 (VLBA 18), move the read stack with 'stack=,698.5,,f ' and 'stack=,-698.5,,f ' to find the tracks near +/- 700  $\mu\text{m}$ . Use 'peak' and 'stack' to verify that these tracks are at +/-698.5 +/- 10  $\mu\text{m}$ .
7. **Write stack calibration test** (for Mark IIA/IV only). Record 1000 feet with head 15 (VLBA/MK4 head 18) enabled at 'stack =0, , f '. Back up the tape 1000 feet and repeat with 'stack=-700,, f ' and with 'stack = 700,,f '. Use 'stack=,+/-700,,f ', 'peak', and 'stack' to verify that these tracks are at +/-700 +/- 10  $\mu\text{m}$ .
8. **Record margin check.** Record a forward Mode C pass followed by the next reverse pass. Measure the error rates on all 14 tracks in both directions after the reverse pass. If the forward recording is worse than the reverse recording, reduce the head voltage in 1 volt steps until the error rates for forward and reverse passes are approximately equal.

### 3. THE THEORY BEHIND THE TESTS

Visual inspection.

The tape path is designed to keep the tape from touching the precision plate or the door of the vacuum column. A properly aligned tape path will keep the tape edge away from the precision plate by a specified amount in the region between the idler roller and the capstan. Measuring this spacing provides a check on the mechanical alignment of the tape path. The most common misalignments are due to:

- a. A tilted idler roller.
- b. A tilted head stack.
- c. A tapered or tilted capstan.
- d. A strained or bent precision plate.

Forward-reverse shift.

Asymmetries in mechanical alignment are the primary cause of a forward-reverse shift, although anisotropies in the tape's elastic constants can also produce a significant forward-reverse shift. Components before the capstan affect the forward shift, while components after the capstan affect the reverse shift.

Speed shift.

At high speed, the tape is subject to additional forces due to air entrapment. Any shift in tracking with speed is a measure of tension variations across the tape that result in asymmetries in the air entrapment. These tension variations can be caused by alignment errors or capstan taper.

Vacuum shift.

A shift in tracking with vacuum is another indication of tension variation across the tape. Also, changing the vacuum moves the position of the loop in the vacuum column (since the reel servo is a first-order servo) and produces a small shift that can be greatly magnified by dirt or grooves in critical areas.

#### Door shim test.

Failure of the door shim test can be caused by a vacuum leak, which can be caused by a poorly adjusted vacuum door hinge, or by deep grooves in the aluminum plate attached to the vacuum door.

To adjust the vacuum door hinge: With vacuum on, loosen the 4 screws holding the hinge, push on the door, and re-tighten the screws.

The depth of the grooves in the tape edge contact areas on the tape edge bearing plate mounted on the vacuum door can be measured with a sliver of paper about the size of the fortune from a Chinese fortune cookie, or with two thicknesses of thick tape about the same size. These grooves can be allowed to wear to a depth of .002 inches. The bearing plate should then be turned 180 degrees, followed by 2 additional wear cycles on the other side. After 4 wear cycles the bearing plate must be replaced. A replacement plate can be made from .062-inch-thick #6061-T6 aluminum with a flatness better than .002 inches per inch (or 0.02 mm per cm). (See Haystack DWG No. 6310-109.)

# LOG RESULTS

Recorder Serial # \_\_\_\_\_ Station \_\_\_\_\_

Date of Tests \_\_\_\_\_ Performed by \_\_\_\_\_

0. Visual Inspection: O.K. Y N

Tape angle: \_\_\_\_\_ Distance from tape edge to plate \_\_\_\_\_mils

1. Forward-reverse shift: \_\_\_\_\_microns

2. 270-135 speed shift: (or 80-160) Forward \_\_\_\_\_microns

Reverse \_\_\_\_\_microns

3. 15" - 5" vacuum shift: Forward \_\_\_\_\_microns

Reverse \_\_\_\_\_microns

4. Door shim test Maximum \_\_\_\_\_mils

5. LVDT cal. Test Read LVDT error \_\_\_\_\_microns

Write LVDT error \_\_\_\_\_microns

6. Record margin check: Worst Track Per \_\_\_\_\_

Worst Track # \_\_\_\_\_

Speed \_\_\_\_\_inches/sec

Direction \_\_\_\_\_

Vacuum \_\_\_\_\_inches

Write voltage \_\_\_\_\_volts

7. Tape shift: By read stack motion \_\_\_\_\_microns

By write stack motion \_\_\_\_\_microns

Calibration constants: Please attach a copy of the HEAD.CTL file

VLBI Software Documentation

Field System

# Narrow Track Calibration

W. E. Himwich

NVI, Inc./GSFC

## Operations Manual

NASA/Goddard Space Flight Center Version 9.1

Space Geodesy Program January 1, 1996

## Table of Contents

- [1.0 Introduction](#)
- [2.0 Calibrating the Heads](#)
- [3.0 Setting Up the head.ctl Control File](#)
- [4.0 Tape Drive Set-up Checks](#)
  - [4.1 Inchworm Motion Range](#)
  - [4.2 Track Peaking](#)
  - [4.3 Reproduce Signal Level](#)
- [5.0 Handling Missing hdcalc Parameters](#)
  - [5.1 Write Head Parameters](#)
  - [5.2 Read Head Parameters](#)
    - [5.2.1 Recovering Positions From the Log](#)
    - [5.2.2 Re-measuring Positions](#)
    - [5.2.3 Starting Over](#)
    - [5.2.4 Finishing Up](#)
- [6.0 Evaluating Results of Head Calibration](#)
  - [6.1 Parity Check for Head Calibration](#)
  - [6.2 Forward-Reverse Guard Band Check](#)
  - [6.3 Repeated Calibrations](#)
- [7.0 What the Head Calibration Schedule Does](#)
  - [7.1 Assumptions](#)
  - [7.2 Sequence of Operations](#)
  - [7.3 Design Considerations](#)
    - [7.3.1 Differences From the Original Procedure](#)
    - [7.3.2 Features of the Field System Implementation](#)
- [8.0 headp](#)
- [9.0 Special Head Cal Cable for Mark III/VLBA](#)
  - [9.1 Cable](#)
  - [9.2 Connector](#)
- [10.0 Listing of hdcal.snp Schedule \(Mark III\)](#)
- [11.0 Listing of vhdcal.snp Schedule \(VLBA\)](#)
- [12.0 Listing of 3vhdcal.snp Schedule \(Mark III/VLBA\)](#)
- [13.0 Listing of v2hdcal.snp Schedule \(VLBA2\)](#)

## 1.0 Introduction

This document describes how to use the Field System to calibrate the positioning system for Narrow Track (high density) tape heads. The procedure used to calibrate the heads is covered in the next section. Other sections cover: setting-up the head.ctl control file, checking the basic functionality of the head positioning system, recovering when some of the calibrations parameters have not been calculated, evaluating the quality of the results, a detailed description of the calibration schedule, and finally a listing of the schedule. A copy of the original calibration procedure memo by Dan Smythe and Alan Whitney is included for reference.

The calibration procedure itself is very simple-minded. It is automated using a SNAP schedule and does not perform any error checking or recovery. At the end the user must evaluate whether or not it did something useful. The schedule is written to be as general and robust as was thought useful. On most drives it should perform adequately without modification. If it performs so poorly that no calibration is possible, the user can revert to performing the calibration manually, using either the detailed description of the schedule or Dan Smythe and Alan Whitney's memo as a starting point. Many of the commands used by the schedule, in particular: **stack**, **locate**, **peak**, **savev**, and **hdcalc**, would be useful for manually calibrating a tape drive. A second generation of calibration and check-out software is planned once we have some feedback on how well this one worked.

The combination of a Mark III rack and VLBA recorder requires a special cable that will only write tracks 15 and/or 16 (Mark III track numbers). The cable is documented in this manual in section 9.0.

Please note that "VLBA" as used in this manual refers generally to both the VLBA and VLBA2 drives. If a command is intended for either the VLBA or VLBA2 drive, but not both, it will be made clear in the comment.

Also note that Mark III track numbers are used throughout the text. However the type-in examples use the correct numbers for the example system.

## 2.0 Calibrating the Heads



The complete calibration process requires about two hours the first time it is attempted on a drive, including all the set-up before and clean-up afterwards. If there are severe problems the time required might extended up to four hours. Once everything is set-up, the hdcal schedule itself can be run in about 40 minutes to recheck the values. To calibrate the heads, follow these steps:

- (1) Verify that the head.ctl control file and the recorder electronics are set-up consistently. This is covered in the section below titled **Setting up the head.ctl Control File**. Restart the Field System to make sure the current head.ctl file has been read in.
- (2) If this is the first time you have calibrated this drive, perform the checks listed in the section titled **Set-up Checks** to verify that everything is working properly and that there is some chance of success with the automated procedure. You may choose to ignore this step and come back to it later if there are problems.
- (3) Mount a fresh degaussed tape. Pre-pass the tape by running it to the far low-tape sensor at high speed using the **sff** or **rec=eot** (VLBA) command. Set the low-tape sensor with **tape=low** command. The tape should stop near 9000 feet.
- (4) Clean the heads and tape path. Reload the tape. Re-establish vacuum by pressing the STOP button (Mark III) or issuing the **rec=load** command (VLBA).
- (5) For Mark III, start the calibration schedule by entering the SNAP command: **schedule=hdcal,#1**. The default copy of this schedule is distributed in /usr2/fs/st.default/sched/hdcal.snp. If you haven't done so already, you'll have to copy it to /sched/hdcal.snp before using it. For a VLBA system use vhdcal.snp, for a Mark III rack/VLBA recorder combination use 3vhdcal.snp, and for a VLBA2 system use v2hdcal.snp. Default copies of these schedule files are found in the same directory as hdcal.snp.
- (6) Wait patiently for about 15 minutes. The calibration schedule will run the system, starting and stopping the tape drive, recording and reproducing tracks. Occasionally, the system will sit idle for a minute or two. This is necessary to make the timing general enough to handle a reasonable worst case. If the tape drive drops the loop or the MAT or MCB communications fail or the head positioning fails to converge, you should stop the schedule. If this occurs, you will probably have to start the schedule over with a fresh tape. The **halt** command can be used to stop the schedule quickly. An **et** command will stop the tape drive.
- (7) After the schedule runs the tape off the far end of the reel, swap (and flip) the tape reels. The schedule will display a comment instructing you to flip the reel and re-thread the tape. The tape will have accumulated on the take-up reel. Remove the upper reel (original supply reel) and set it aside. Take the lower reel (original take-up reel) and mount it on the upper hub, flipping as you mount it so that the flange that was toward is now away from it. Mount the original supply reel, which you had set aside, on the lower hub, flipping it also so that the label, which was away from the deck is now toward it. Reload the tape. Re-establish vacuum by pressing the stop button (Mark III), by issuing the **rec=load** command (VLBA), or use the appropriate loading technique for a VLBA2 drive. Then enter **cont** to continue the schedule.
- (8) The schedule will run for about 5 more minutes. Near the end, the **hdcalc** command will be issued to calculate the calibration parameters. If there are any null, i.e. empty, parameters in **hdcalc**'s response, then some problem has occurred. See the section below titled **Handling Missing hdcalc Parameters** for information on how to handle this problem. Note that for VLBA recorders, since there is only one head, all of the read head parameters will be null, this is a normal condition.
- (9) If all the parameters have been calculated, the headp utility program can be used to format a new head.ctl control file with the new calibration information. Run headp by opening a new window and typing **headp** at the system prompt. The new calibration information is placed in /usr2/control/head.new. See section 8.0.
- (10) If the new calibration numbers are acceptable, you can purge (**rm**) or rename (**mv**) the old head.ctl file and rename head.new to head.ctl. The next time the Field System is re-started the new values will be read in and used. See the section titled **Evaluating the Results** for information on how to decide if the calibration is acceptable.
- (11) Run the tape to the end again, first issuing **tape=low** and then using the **sff** or **rec=eot** (VLBA drive) command. This will return the tape to the original supply reel. When it reaches the end unload it by entering **tape=off** and **st=for,120,off**. If you flipped the original supply reel in step (7) above when you swapped the reels, then the label should be in correct orientation relative to the tape. Exchange the reels again. Degauss the tape if you are finished with it.

### 3.0 Setting Up the head.ctl Control File

When new heads are installed, the control file head.ctl must be set-up to accurately reflect the hardware configuration. A default control file is included in /usr2/fs/st.default/control/head.ctl. The working copy is kept in /usr2/control/head.ctl. The format of head.ctl is covered in the [Control Files](#) manual. This section covers additional considerations that are important for calibrating the heads.

The first two lines of the head.ctl file contain information that depends on how your station's hardware is configured. The contents must be set correctly for the Field System and the calibration procedure to work. The remaining lines contain calibration parameters. The calibration schedule is designed to work correctly using the default values of these parameters, found in /usr2/fs/st.default/control/head.ctl. However, in some cases the actual values for these parameters may be so different from the defaults that the calibration schedule will fail. If you have some estimate of what the correct values should be, use those estimates. Note that the forward and the reverse offsets used by the Field System revision 7.2 and later do not include the differential head pitch offsets, 698.5 m, used by previous revisions. For VLBA drives **odd** and **even** only have significance for the write head. The VLBA track number differ from the Mark III track number by three. Consequently, while odd and even tracks on the VLBA recorder refer to odd and even VLBA tracks as you would expect, they refer to even and odd Mark III tracks respectively.

A significant difference between the VLBA and VLBA2 recorders is that the scales for the VLBA2 recorder should have nominal values of about 0.1 microns/kÅ.

### 4.0 Tape Drive Set-up Checks

This section covers some simple checks which should be performed before calibrating an unfamiliar tape drive. If these checks are all okay, it is likely that the automated procedure will succeed. The head.ctl file must be set-up before proceeding with these checks. See the previous section titled **Setting-up the head.ctl Control File** for more information.

Three things need to be checked: (1) that both inchworms can move over the full 10 volts range of motion, (2) that the software can successfully peak up on a track written by your drive, and (3) that the peaked reproduce power level is large enough that the software can distinguish a real peak from noise. If these three conditions are not met, you may have a hardware or software problem that should be corrected before continuing. Check with Goddard or Haystack for assistance.

#### 4.1 Inchworm Motion Range

To check that your inchworms can cover the full range of motion, use the **lvdt** command to position the heads by voltage. The VLBA2 drive does not use an inchworm, but it is still possible to check the head's range of motion. Issue the following four commands in the Field System:

for Mark III: for VLBA: for VLBA2:

**lvdt=0,0 lvdt=0 lvdt=0**

**lvdt=9,9,9,9 lvdt=9.9 lvdt=17990**

**lvdt=-9.9,-9.9 lvdt=-9.9 lvdt=-17990**

**lvdt=0,0 lvdt=0 lvdt=0**

The first of these **lvdt** commands is intended to move the heads to a "safe" position. The second and third **lvdt** commands move the inchworms over nearly the full range of possible motion. If either of these commands fails (ends with error or doesn't position the heads to the commanded positions), your inchworm may not be able to cover the full range. Record the limits of the motion for future reference. For non-VLBA2 drives, use the **lvdt** command without an = to get the position response if the positioning failed. For VLBA2 drives it is not possible to find out where the head is if the positioning fails. (For VLBA2 drives if the above commands fail, you will have to use a "divide-and-conquer" algorithm to find the limits. For example, you could start by moving halfway out in one direction and then move out in steps of one-half the remaining range until you isolate the end of the range of motion. Once you find a step where it fails, you can go back and divide the range between the last successful step and the step that failed. Repeat this process until you located the end of the range as precisely as you like, perhaps within a 1000 units of the lvdt command parameter is sufficient. The lvdt command uses units of 0.1 microns for VLBA2 drives only, so in this case 1000 units is the same as 100 microns, crude but probably sufficient without an excessive amount of trial-and-error.) The last **lvdt** command returns the heads to a "safe" position. Although the calibration schedule assumes that your inchworms can move over the full range, it may still work if they do not.

## 4.2 Track Peaking

The second check to perform is whether the software can peak-up on a track written by your drive. Load a fresh, degaussed tape. Pre-passing and cleaning are desirable, but may not be necessary. Move the tape footage ahead to 1000 feet to avoid tracking problems near the tape end. It is useful for an oscilloscope to be set-up for eye-pattern reproduce, contact Haystack for more information on the set-up.

Record a thousand feet of tape on track 15 at micron position -350:

for Mark III: for VLBA:

**stack=-350,-350,f,f stack=-350,,f**

**enable=15 enable=d15**

**repro=byp,15,15 repro=byp,18,18**

**form=c,4 form=d15,4**

**st=for,135 st=for,135**

**check= check=**

For Mark III/VLBA: use the Mark III commands above except use **enable=d15**.

Stop the tape at 2000 feet. Rewind the tape to 1000 feet. Attempt to locate the written track with the read head (write head for VLBA):

for Mark III: for VLBA:

**enable= enable=**

**repro=raw,15,15 repro=read,18,18**

**locate=201,1,40,r locate=201,1,40,w**

**peak=3,1,r peak=3,1,w**

**st=for,135,off st=for,135,off**

(wait for the tape drive to spin-up to speed)

**locate locate**

**peak peak**

**peak peak**

For Mark III/VLBA: use the VLBA commands above.

Watch the eye-pattern oscilloscope while **locate** is running. It should step through a range of positions, one of which should show some reproduce signal. **locate** will leave the read head at the position of the largest signal it measured. The **peak** command should move to the position of maximum response in a few steps. A clear eye-pattern should be visible on the oscilloscope. The second **peak** command will allow you to evaluate how stable the voltage location of the peak is. Compare the values of the last parameter on the two **peak** response lines. The values should differ by no more than 0.1 volts, which is a very generous tolerance in case the tape hasn't been pre-passed and was stored at -30. While looking for the peak, the tape footage obviously must be kept in the range of 1000-2000 feet, since this is where the recorded track is. You will have to monitor the footage, if you overshoot 2000 feet, reposition to 1000 feet and start again.

If **locate** fails to find something that looks like a track, some detective work will be necessary. You can start by looking over a wider range with the **locate** command. If the first parameter of **locate** is doubled (to 402), it will double the search range. Be sure to return the head to the starting position by re-issuing the **stack** command before you try **locate** again. If this doesn't work, you could try searching by manually moving the read head with the push-buttons on the head controller and watching for a signal on the oscilloscope. If you still can't find it, try recording from 2000-3000 feet. Watch the oscilloscope for interference from the write head. This helps verify that the head is actually writing. If you find the track and it was actually very far off from the initial position, more than 200 microns as measured by the **stack** command, you will need to increase the search ranges defined in the **locate=** commands in the hcal.snp schedule. If you never find the track, get assistance from Haystack or Goddard.

## 4.3 Reproduce Signal Level

Finally, it should be verified that the peak reproduce level is high enough that the software can unambiguously differentiate it from noise. Two voltages need to be measured for this check: the peak reproduce signal and noise level. The peak reproduce signal can be taken from the peak voltage level parameter of one of the **peak** command responses from the previous test of peaking-up. The reported voltage should be in the range of 0.5-2.0 volts for 135 ips reproduce. If it is not in this range, it may be necessary to adjust the attenuation at the input to the reproduce power detector.

For the VLBA2 drive it isn't clear at this time what will need to be done about the reproduce signal level. Probably the only viable option will be to change the threshold for the minimum peak signal level as determined in the next section. If there is a reasonable signal level for a real peak, say 0.1 volts or higher this should be the only change necessary.

Check the noise level for the reproduce power by positioning the tape to 2000 or 3000 feet, beyond any recorded tracks from previous steps, and using the **peak** command to attempt to peak-up on some blank tape:

for Mark III: for VLBA:

```
stack=-,350,,f stack=-350,,f
```

```
repro=raw,15,15 repro=read,18,18
```

```
enable= enable=
```

```
peak=3,1 peak=3,1
```

```
st=for,135,off st=for,135,off
```

(wait for spin-up)

```
peak peak
```

For Mark III/VLBA: use the VLBA commands above.

The reported peak level should be below 0.2 volts. If it is not, the default minimum peak voltage used by the **peak** command, 0.2 volts, may need to be increased. This minimum is set by one of command parameters for **peak**. A reasonable choice is a voltage at least twice the noise level or less than half the read signal level. If the default is not acceptable, the **peak=** command in the hdcalc schedule will have to be modified to use a better value.

Assuming these checks have all succeeded, you can move onto the calibration itself, section 2.0 above. This tape can be used if you haven't written on the last 4200 feet of tape.

## 5.0 Handling Missing hdcalc Parameters

If, after running the hdcalc schedule, there are null parameters in the output of the hdcalc command (other than the ones that are correctly null if you have a VLBA recorder), then the calibration procedure has failed at some point. For the VLBA drive the read head parameters should be null. This section explains how to identify what went wrong and complete the calibration. If you have any values missing, please save the log and contact Goddard. We will want to understand the problem so that a better procedure can be developed.

The response of the hdcalc command is derived from values stored by the savev command. If there are missing parameters in the hdcalc response, then there must also be missing parameters in savev response. Issue a savev command and inspect the response to determine which parameters are missing. The values are printed in the order:

```
savev/v revw,v 15rev,v 15for,v 15scale,v 13,v 15flip,v w0,v w8
```

The sub-sections below describe what to do if any of these values are missing. At this point, it is not necessary to understand what these parameters represent. They are described in detail in the section titled What the Calibration Schedule Does.

### 5.1 Write Head Parameters

The last two parameters in the savev response are write head positions. If one of them is missing and you are using a Mark III drive, then something truly disastrous has happened. These parameters are not used for the VLBA drive. Either the schedule has screwed-up or the write head positioning failed to converge. In either case, you should determine what went wrong before continuing. You can look at the log for error messages or start the calibration procedure over again and watch it to see what goes wrong. Of course, if the problem is intermittent, it may not re-appear. After fixing the problem, if it re-occurs, you should re-run the calibration schedule with a fresh tape.

### 5.2 Read Head Parameters

The first six parameters in the savev response are read head positions measured after peaking the reproduce signal. If one of these parameters is missing, the corresponding peaking operation failed to find a good peak. It is possible to recover in one of three ways: (1) look at the log produced by the schedule to see if there are usable position measurements that were not saved, (2) reposition the tape and attempt to re-measure the missing positions, (3) re-run the schedule and watch it to see which measurements are failing. The steps to take for each of these options are discussed below. After the three options are discussed, how to complete the calculation is described.

#### 5.2.1 Recovering Positions From the Log

Examining the log is the quickest method of recovering, if it works. The explanation of what to do is a bit long-winded though. For a voltage mnemonic *x* that was not successfully saved, there is some point in the schedule where a savev=*x* command was issued. Closely preceding the savev=*x* should be the results of three separate peak commands. The third peak response must have an *f* for the next to last parameter. This parameter is *f* (for false) to indicate that peak thinks the position did not correspond to a true peak, it would be *t* if it thought it was a real peak. savev will not save the position if peak indicated a false peak. (This is just about the only error detection in the whole calibration process.)

There are two reasons that peak might think that the peak was false: either the interpolated peak measurement was not well centered among the last three positions sampled, or the signal level was below that required to be considered a good peak. The minimum signal level is 0.2 volts by default, but it is a settable parameter of the peak command. You can determine if the signal level was the problem by comparing the measured peak voltage and the acceptable minimum that was used, both are displayed in peak command response. If the *f* parameter was given because the signal level was too low, there is probably no hope of recovering using this method. The peak command probably never even found the track. You should just go to the method of re-measuring the positions discussed below.

If the signal level is high enough and the second peak command indicated a true peak, then the third peak may have failed because a tracking glitch moved the interpolated peak too far away. In this case you may be able to recover. Compare the peak positions for the responses from the first and second peak commands.

If they agree within about 0.03 volts, the value reported by the second peak command should be usable. It can be input manually, by issuing a `savev=x,volts` where *volts* is the measured voltage position from the second peak command.

### 5.2.2 Re-measuring Positions

If acceptable values are not found from the log, it will be necessary to position the tape to the correct area and attempt to re-measure the values. Table 7.1 contains a list of the footage counter ranges, nominal read head positions, tape motion direction, read track, and tape orientation used for measuring the read head position for the different voltage parameters. You can reposition the tape to the appropriate footage, reset the appropriate command parameters, and attempt to measure the track location. For example to re-measure  $v_{15flip}$ , the set-up commands would be:

for Mark III: for VLBA:

tapepos=1000 rec=1000

(wait for tape to complete positioning)

stack=-,350,,f stack=-350,,f

(always use the forward calibration)

repro=raw,15,15 repro=read,18,18

st=for,135,off st=for,135,off

(wait for the tape to spin-up to speed)

(peak the reproduce signal)

For Mark III/VLBA: use the above VLBA commands.

To peak the reproduce signal you can use some combination of the read head inchworm push-buttons, the locate and peak commands, and the oscilloscope. If you finally find the peak with the peak command and peak indicates a true peak, you can save the voltage by issuing a `savev=x` command where *x* is the mnemonic for the voltage being saved. If you end up finding the peak by using the inchworm push-buttons and watching the eye pattern on the oscilloscope, you can measure the final position voltage with the `lvdt` command. The result can be saved by issuing a `savev=x,volts` command, where *volts* is the position of the read head (write head for VLBA drive) returned by the `lvdt` command.

If  $v_{15flip}$  is one of the missing values, it should be re-measured first, since the tape is already mounted in the flipped orientation at the end of the schedule. To re-measure other values, the tape will have to be returned to its normal orientation and the footage counter reset to make the footage values in Table 7.1 correct. To get the footage counter reset correctly, flip the tape back to its normal orientation. Then with all the tape on the take-up reel run the drive in reverse with the `srw` command for 2m32s, if your "super-fast" speed is 330 ips. This will place the tape at about 4200 feet from the far end. If your speed is lower than this you will have to wait longer to get the tape to the same spot. When the tape drive stops, reset the footage counter with the command: `tape=low,reset` (Mark III drive) or `rec=zero` (VLBA drive).

### 5.2.3 Starting Over

The third approach for recovering is to start over with a fresh tape and monitor the schedule as it's running. When the `savev` command(s) fail, stop the schedule with the `halt` command, reposition the tape and try to re-measure the track manually using the methods described for the preceding approach. Once the peak is located, save the value with a `savev` command. Restart the schedule after issuing a `list` command to see what is coming next. Some tape and/or schedule positioning maybe necessary to get things back on track.

### 5.2.4 Finishing Up

If you used one of the first two recovery approaches and have stored all the voltages, you will need to re-calculate the calibration parameters and inchworm speeds (the third approach does this automatically since it uses the schedule). To finish the calculations, issue these commands:

for Mark III: for VLBA: for VLBA2:

hdcalc hdcalc hdcalc

lvdt=0,0 lvdt=0

worm=write,new worm=write,new

worm worm

worm=read,new

worm

If `hdcalc` now produces a complete set of commands you can proceed with saving the calibration parameters as outlined in step (9) of the Calibrating the Heads section above.

## 6.0 Evaluating Results of Head Calibration

Once a full set of calibration parameters have been determined, they can in principle be used right away. However, they should be checked at least a little. Three checks are described in this section: (1) checking parity error rates, (2) checking forward-reverse guard bands, and (3) repeating the calibration.

### 6.1 Parity Check for Head Calibration

The most important check that should be made is to record some tracks and make sure they can be played back. For this check, take the following steps:

- (1) Install the new calibration constants in head.ctl and restart the Field System.
- (2) Mount a fresh tape, pre-pass it, and then position it to 1000 feet.
- (3) Record mode C pass 1 from 1000-2000 feet at 135 ips.
- (4) Check the parity errors with check2c1.
- (5) Record mode C pass 2 from 2000-1000 feet at 135 ips.
- (6) Check the parity error with check2c2.
- (7) Record mode C pass 23 from 1000-2000 feet at 135 ips.
- (8) Check the parity errors with check2c1.
- (9) Record mode C pass 24 from 2000-1000 feet at 135 ips.
- (10) Check the parity errors with check2c2.
- (11) Re-check the parity errors for mode C pass 2 with check2c2, after re-setting up with sx2c2=2.
- (12) Position the tape to 2000 feet.
- (13) Re-check the parity errors for mode C pass 1 with check2c1, after re-setting up sx2c1=1.
- (14) Re-check the parity errors for mode C pass 23 with check2c1, after re-setting up with sx2c1=23.

The results of all the parity checks should show acceptable rates. What is acceptable depends somewhat on the recorder and the heads, but parity error rates of less than 600 are typical. If the read head position is off a little bit, the error rates will be larger than they should be. You might try using the peak command to see if you can find a better peak response and then try the parity check again. If the level of errors in the re-check of passes 1, 2, or 23 are significantly higher than in the original checks, there may be some overwriting of adjacent forward-reverse tracks. If this is so, the forward-reverse guard band test, discussed next, is strongly recommended.

## 6.2 Forward-Reverse Guard Band Check

The forward-reverse guard band test is one of the most complete checks of the head calibration. The layout of passes for mode C is shown in a figure in the [System Setup](#) manual. Starting with the tape recorded in the parity check test discussed above, follow these steps:

- (1) Position the tape to 2000 feet.
- (2) Set-up the read head to reproduce mode C pass 2 and set-up the peak command:

for Mark III: for VLBA:

```
sx2c2=2 sx2c2=2
```

```
enable= enable=
```

```
repro=raw,16,16 repro=raw,19,19
```

```
peak=3,1 peak=3,1
```

- (3) Start the tape moving in reverse:

```
st=rev,135,off
```

If during the course of completing steps (4) through (8) below, the tape footage goes below 1000 feet, stop the tape, reposition to 2000 feet and continue where you left off.

- (4) When the tape comes up to speed, issue the peak command to find the peak response.
- (5) When peak completes, issue a pass command to measure the current head positions. The last parameter, read head delta position, indicates how far the peak is from the nominal location, typically a few microns.

(6) While the tape is moving, use the push-buttons on the head controller to move the read head away from the plate. Select: Inchworm Two, Out ("Forward" on Burleigh controllers), and Slow.

(7) With your finger over the "stop" button on the inchworm controller, watch the eye-pattern on the oscilloscope. This reproduce signal should fade away to no signal and then a new reproduce signal should start to increase. When a signal starts to appear, usually within about 5 seconds, press the "stop" button.

NOTE: You can also do steps (6) and (7) using the stack command to move the head. Check the head position, then move the head in increments of about 30 until you find the track. Be sure to specify the correct calibration type, f or r, when you move the head.

(8) Issue another peak command to find the peak of this track. The eye pattern will not be clear, because you are running in reverse over pass 23, which was recorded in forward.

(9) Issue another pass command to determine the delta for the peak of this track. The delta should be close (20 m) to 93.5 m.

(10) The difference of delta parameters from steps (5) and (9) gives the peak-to-peak distance between passes 2 and 23.

(11) Stop the tape, and reposition it to 2000 feet.

- (12) Set-up the read head to reproduce mode C pass 24:

for Mark III: for VLBA:

sx2c2=24 sx2c2=24

enable= enable=

repro=raw,16,16 repro=raw,19,19

peak=3,1 peak=3,1

(13) Start the tape running in reverse:

st=rev,135,off

(14) Repeat steps (4)-(10). This time in step (6) move the read head toward the deck plate using the "in" button (reverse on Burleigh controllers). The result calculated in step (10) is the peak-to-peak distance between passes 1-24.

Both peak-to-peak distances should be about 93.5 20 m. If this test fails or the results are marginal (the values differ by more than about 40 m), it is recommended that the calibration be tried again to see if it is repeatable. Evaluating repeated calibrations is discussed next.

### 6.3 Repeated Calibrations

It is useful to repeat the calibration procedure two or three times to see how much variation occurs in the calibration parameters. Having several samples also helps to determine if a particular calibration run is an outlier compared to the rest. Don't average different measurements to get a final value, simply choose one that is close to the mean. This reduces the chances of a data handling error.

If the hdcalc schedule ran without any problems and the hdcalc command produced all the calibration constants without additional work, then it is likely that the calibration procedure will work reliably for your tape drive. It should be easy to re-run the schedule. Be sure to use a freshly degaussed tape for each run. Repeated measurements should have less than 5 m variation in the offset constants (the first four hdcalc output parameters). The scale factors (the last two hdcalc output parameters) should vary by no more than about 1%. The calibration constants may vary systematically between different tapes.

## 7.0 What the Head Calibration Schedule Does

The procedure used to calibrate the heads was originally developed at Haystack by Dan Smythe and Alan Whitney. A copy of their memo describing the procedure is included at the end of this document. This section describes the assumptions made by the schedule, the sequence of operations performed, and design considerations for the schedule.

### 7.1 Assumptions

The schedule file hdcalc.snp should be able to calibrate any "normal" tape drive. A normal tape drive meets the following assumptions:

- (1) Mark III write head tracks 15 or 16 work.
- (2) Mark III read head track pairs 13 and 15 or 14 and 16 work.
- (3) Both inchworms can move over their full range of motion, 10 volts.
- (4) The calibrated head offsets all have an absolute value of less than about 100 m.
- (5) The voltage scales are within about 15% of the nominal 150 m per volt.
- (6) The fast inchworm speed is no less than 100 m/s.
- (7) The tape drive acceleration meets the specification of going from 270 ips to stopped in 45 5 feet.
- (8) The footage counter is reliable.
- (9) The peak reproduce power level when reproducing a track at 135 ips produces a signal level measured at the A/D of 0.5-2.0 volts.
- (10) The noise level when reproducing on a blank tape at 135 ips produces a signal level measured by the A/D of less than half the value of the peak reproduce level.
- (11) The voltage offset in the LVDT read-out has an absolute value of less than about 0.6 volts.

Tapes drives that do not meet these assumptions of "normality" can probably still be calibrated, however the hdcalc.snp schedule will probably have to be modified or the calibration done manually.

### 7.2 Sequence of Operations

The sequence of operations that are used in the schedule are described here. Table 7.1 at the end of this section summarizes the tape footage range, read track, nominal read head position, tape motion direction, and tape orientation associated with each head position voltage that is saved.

The operations performed by the schedule are (described with parallel numbering to Dan and Alan's memo).

- (0) Set-up the Field System parameters and (except for VLBA2) make an initial refinement of the inchworm speeds.
- (1) Rewind the tape 3200 feet. For VLBA or VLBA2 rewind 2200 feet.
- (2) Set the write head to a "forward calibrated" position of -350 m. Save the write head voltage position as  $v_{w0}$ .

For VLBA or VLBA2, skip to step (5).

- (3) Record track 15 for 1000 feet in the reverse direction. Reset the footage counter. The range of footage for the recorded track is 0-1000 feet after the footage counter has been reset.
- (4) Playback the track recorded in step (3) in the forward direction peaking the reproduce power with read track 15. Save the read head position voltage as  $v_{revw}$ . Footage range is 0-1000 feet. Nominal read head position -350 m.
- (5) Position the tape to 2000 feet. For VLBA set the footage to 2000 feet. For VLBA2, continue to the next step.
- (6) Record track 15 in the forward direction to the end of the tape. Footage range 2000-3800 feet.
- (7) Playback the track recorded in step (6) in reverse direction, peaking the reproduce power with read track 15. Save the read head position voltage as  $v_{15rev}$ . Footage range 3000-2000 feet. Nominal read head position -350 m.
- (8) Playback the track recorded in step (6) in the forward direction, peaking the reproduce power with read track 15. Save the read head position voltage as  $v_{15for}$ . Footage range 2000-3000 feet. Nominal read head position -350 m.

For a VLBA or VLBA2 drive, skip to step (13).

- (9) Position the tape to 1000 feet.
- (10) Set the write head stack to a "forward calibrated" micron position of 850 m. Save the write head voltage position as  $v_{w8}$ .
- (11) Record track 15 in the forward direction for 1000 feet. Footage range 1000-2000 feet.
- (12) Playback the track recorded in step (11) in the forward direction, peaking the reproduce power with read track 15. Save the read head position voltage as  $v_{15scale}$ . Footage range 1000-2000 feet. Nominal read head position 850 m.
- (13) Position the tape to 2200 feet.
- (14) Playback the track recorded in step (6) in the forward direction, peaking the reproduce power with read track 13. Save the read head position voltage as  $v_{13}$ . Footage range 2200-3200. Nominal read head position 1047 m.
- (15) Run the tape off the end of the reel. Reload it in the flipped orientation.
- (16) Playback the track recorded in step (6) in the forward direction, peaking the reproduce power with read track 15. Save the read head position voltage as  $v_{15flip}$ . Footage range 1000-2000. Nominal read head position -350 m.
- (17) Calculate the calibration parameters:

For VLBA drives only the "read" head parameters are calculated. However these are actually the correct values for the "write" head. There is only one head on a VLBA drive.

Read head voltage scale:

$$S_{read} = \frac{1397 \mu\text{m}}{(v_{13} - v_{15scale}) \text{ volt}}$$

Write head voltage scale, generalized to include the actual voltage at which the tracks were written:

$$S_{write} = S_{read} \frac{(v_{15for} - v_{15scale}) \mu\text{m}}{(v_{w8} - v_{w1}) \text{ volt}}$$

Read head reverse relative offset:

$$\delta_{read} = (v_{15rev} - v_{13})$$

relative offset:

$$\delta_{write} = (v_{15for} - v_{15rev}) S_{read} \mu\text{m}$$

Write head forward absolute offset:

$$\Delta_{write} = \frac{(v_{15for} - v_{15scale})}{2} S_{read} +$$

offset:

$$\Delta_{read} = \frac{(v_{15for} - v_{15scale})}{2} S_{read} + 350 \mu\text{m}$$

(18) Remeasure the inchworm speeds with the new voltage scale.

Table 7.1. Footage ranges, nominal read head positions, tape direction, read tracks, and tape orientation to use to find specific voltages on the calibration tape.

Voltage Mnemonic	Footage Range	Read Head Position (m)	Tape Motion Direction	MkIII Read Track	Tape Orientation
$v_{revw}$	0000-1000	-350	forward	15	normal

<i>v15rev</i>	3000-2000	-350	reverse	15	normal
<i>v15for</i>	2000-3000	-350	forward	15	normal
<i>v15scale</i>	1000-2000	850	forward	15	normal
<i>v13</i>	2200-3200	1047	forward	13	normal
<i>v15flip</i>	1000-2000	-350	forward	15	flipped

### 7.3 Design Considerations

This section describes some of the considerations that went into the design of the `hdcal.snp` schedule. This section will probably only be useful to people who wish to understand why the schedule does the things it does. The differences between Dan Smythe and Alan Whitney's original procedure are described. Features of the Field System implementation of the procedure are discussed as well.

#### 7.3.1 Differences From the Original Procedure

A few features were changed from Dan and Alan's memo:

- (1) The calibration tracks are written -350 m (out) from the positions used in the memo. This gives a more symmetric use of the position voltage range.
- (2) The positions are commanded by micron using the "forward" calibration. This automatically positions the heads with a -698.5 m offset if the heads are defined as even in the `head.ctl` control file.
- (3) For systems with even write heads, track 16 is used for writing.
- (4) The positions that the calibration tracks are written at are measured rather than assumed. This makes the calibration more robust in the presence of positioning errors and allows the location of written tracks to be moved.
- (5) The footage at which the tracks are written and reproduced were adjusted so that a full 1000 feet of recorded tape would be available for each track peaking operation without getting within 1000 feet of the tape ends. This reduces the chances that tracking problems near the ends will affect the results.
- (6) For VLBA drives only one track needs to be written and it used to determine all the parameters for the one head. The actual location where the track is written is never used.

Features (1)-(4), along with some generalization of the enable and repro Field System commands, allow the same SNAP schedule to be used for any combination, all, odd, or even, of read and write heads.

#### 7.3.2 Features of the Field System Implementation

This section discusses features of the Field System implementation of the calibration procedure beyond those discussed in the previous section.

In order to automate the original procedure for field use, new Field System commands, `locate` and `peak`, were written to support peaking up on a recorded track.

Because of variations in tape drives, inchworm speeds, head offsets, and tracking, it was necessary to make the schedule as insensitive to such variations as possible. Toward this end, the following features are incorporated in the schedule:

- (1) When attempting to peak-up the reproduce power, a coarse grid search is done with the `locate` command to find the track first. This helps find the track even in the presence of large head offsets.
- (2) The fine peaking performed by the `peak` command is done three times for each track peaked-up on. Two measurements of the peak location are needed at minimum, since the track may not be well centered during the first measurement. The third measurement can be compared to the second to evaluate how stable the measured peak position is.
- (3) After a peaking operation is complete, the tape is positioned with the `tapepos` command (Mark III) or `rec` command (VLBA) before the next operation, since the actual footage at which the peaking will complete is unpredictable. The schedule must wait for the worst case `tapepos` or `rec` to complete before continuing.
- (4) The `locate` command for peaking on the flipped tape is done in a separate pass to allow a wider range of positions to be searched. Flipping the tape magnifies the effect of a write head misalignment by a factor of two. `peak` is used on the second pass.
- (5) At the start of the schedule, a first cut is made at the inchworm speeds to make sure they aren't completely unreasonable.
- (6) The `tape` command is issued before and after writing and reproducing tracks. This is intended to provide information to assist in interpreting the log for debugging purposes.
- (7) The `hdcalc` command takes the head configuration in `head.ctl` into account when calculating the calibration parameters.

Like the original procedure, the Field System implementation includes these features:

- (1) The peaking operations, using the `locate` and `peak` commands are done on a minimum of 1000 feet of a recorded track. This allows for some variation in inchworm speeds, tape positioning, and difficulty locating the track.
- (2) Only one track is written in any footage range on the tape. This helps prevent confusion over which track is being reproduced.

## 8.0 headp

`headp` is a utility used in conjunction with the narrow track calibration software. After calibration parameters have been determined, `headp` can be used to save the results in a file.

The results are saved by default in output file `/usr2/control/head.new`. Alternatively, the user can specify the output file name when the program is invoked by typing:



**headp output**

where *output* is the pathname for the output file. If the output file already exists, headp will stop without modifying the file.

The output file for headp is in the same format as the head.ctl file described in the Control Files manual. Data from the first two records are the same as those in the most recently used head.ctl file. The remaining information comes from the most recent calibration results.

In order to help prevent partial or incorrect results from being written to disk, headp will not save the results if any of the calibration parameters have not been calculated or either inchworm has not had its speed calculated. In order to save partial results it is necessary to hand enter them into the file.

## 9.0 Special Head Cal Cable for Mark III/VLBA

In order to calibrate a VLBA recorder connected to a Mark III rack a special cable or connector is required. The connector or cable should be used to connect the J11 connector on the back of the Mark III formatter to the J2 connector on the VLBA recorder I/O panel. This will allow only Mark III track 15 to be written. To write only Mark III track 16, connect J12 to J1.

### 9.1 Cable

One end of the cable is terminated with a 50-pin connector that will fit the J11 or J12 connectors on the back of the Mark III formatter. The other end is terminated with a 40-pin connector that will fit the J2 or J1 connectors on the VLBA recorder I/O panel. Six conductor twist-flat is recommended for the cable. The required connections are:

#### Mark III Formatter VLBA Recorder

##### Back Panel I/O Panel

J11, J12 J2, J1

50-pin 40-pin

##### Function Pin Pin

GND 1 37

GND 2 38

+Clock 17 39

-Clock 18 40

+HD 15(V18), 16(V19) 19 19

-HD 15(V18), 16(V19) 20 20

### 9.2 Connector

This approach uses a single 3M Intra-connector with some pins snipped off. This is a 'T' connector with two sets of male pins connected to a female socket. Only one of the sets of male pins needs to be modified. The female socket can be attached directly to the connector on the formatter or the tape drive. The normal formatter to recorder cable can be connected to the modified pin set. The unmodified male pins can be used to connect the system for normal recording.

The connector can be placed on either the VLBA recorder I/O panel or the Mark III Formatter. For the VLBA recorder, use 3M part No. 922576-40-I and snip off pins 5-18 and 21-32. For Mark III formatter, use 3M part No. 922576-50-I and snip pins 3-16 and 21-32.

[As an aside: The connector for the Mark III formatter would also work for a Mark III formatter connected to a Mark IV recorder. Alternatively, on the Mark IV recorder side, use the 40 pin connector and snip pins 7-20 and 23-24.]

## 10.0 Listing of hdcal.snp Schedule (Mark III)

The section lists the schedule for calibrating a Mark III drive. The schedule is distributed with the Field System in /usr2/fs/st.default/sched/hdcal.snp. The local working copy which is kept in /usr2/sched/hdcal.snp may have been customized.

- [10.0 Listing of hdcal.snp Schedule \(Mark III\)](#)

## 11.0 Listing of vhdcal.snp Schedule (VLBA)

The section lists the schedule for calibrating a VLBA drive which has a VLBA DAR. The schedule is distributed with the Field System in /usr2/fs/st.default/sched/vhdcal.snp. The local working copy which is kept in /usr2/sched/vhdcal.snp may have been customized.

- [11.0 Listing of vhdcal.snp Schedule \(VLBA\)](#)

## 12.0 Listing of 3vhdcalsnp Schedule (Mark III/VLBA)

This section lists the schedule for calibrating a VLBA drive which has a Mark III rack. The schedule is distributed with the Field System in /usr2/fs/st.default/sched/3vhdcalsnp. The local working copy which is kept in /usr2/sched/3vhdcalsnp may have been customized.

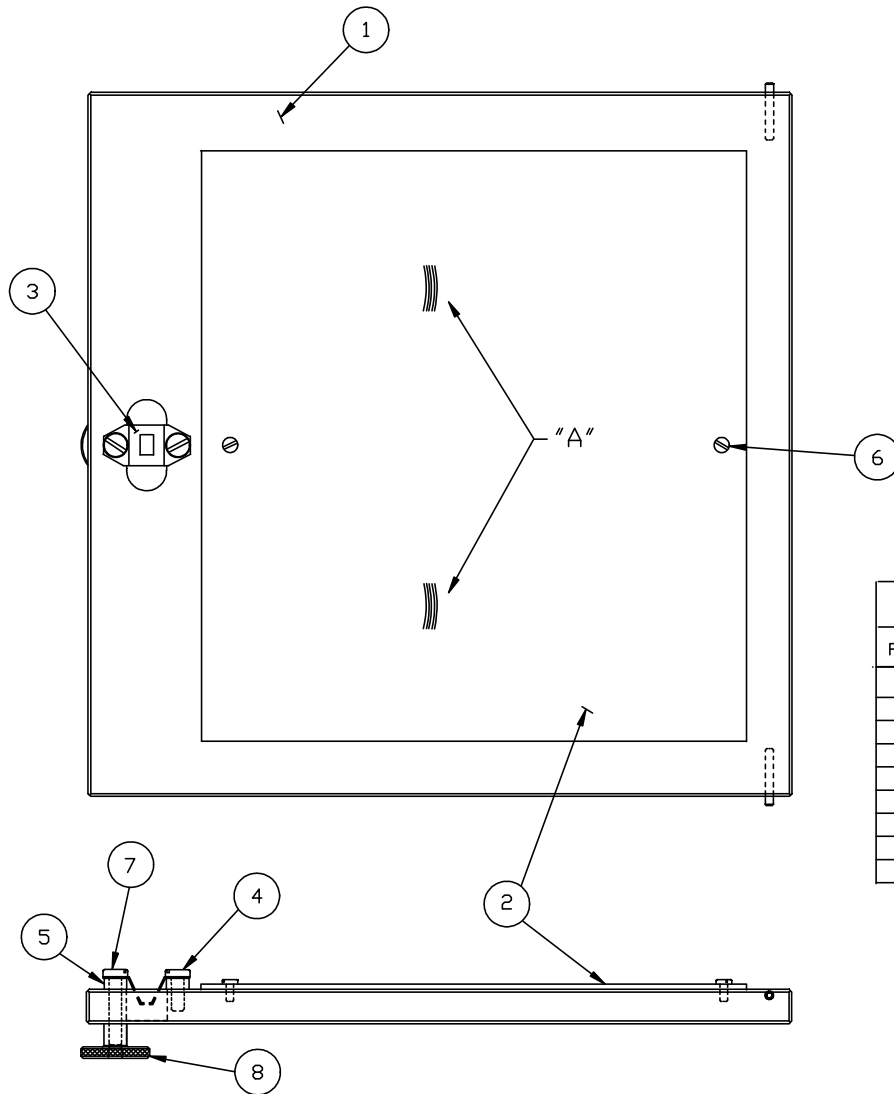
- [12.0 Listing of 3vhdcalsnp Schedule \(Mark III/VLBA\)](#)

## 13.0 Listing of v2hdcalsnp Schedule (VLBA2)

The section lists the schedule for calibrating a VLBA2 drive which has a VLBA DAR. The schedule is distributed with the Field System in /usr2/fs/st.default/sched/v2hdcalsnp. The local working copy which is kept in /usr2/sched/v2hdcalsnp may have been customized.

- [13.0 Listing of v2hdcalsnp Schedule \(VLBA2\)](#)

CHANGE LETTER	D'W'N BY	CHK'D BY	APP'D BY	DATE	D.C.N. & DESCRIPTION
A	RJC	HFH	HFH	1/93	PT # HAY C6310-108A IS NOW
					HAY C6310-108C & HAY C6310-109A
					IS NOW HAY C6310-109B.



### FRONT DOOR ASSEMBLY

- CHECK TAPE EDGE BEARING PLATE FOR BURRS. IF NECESSARY, CLEAN PLATE WITH SCOTCHBRITE AND RAZOR BLADE TO REMOVE BURRS.
- ATTACH FRICTION CATCH WITH 1/8" THICK STANDOFFS BETWEEN DOOR AND CATCH. ASSEMBLE CATCH AND STANDOFFS TO DOOR WITH #6-32 PAN HEAD SCREWS.
- ATTACH TAPE EDGE BEARING PLATE TO DOOR WITH #2-56 PAN HEAD SCREWS.

### NOTE

TAPE EDGE CONTACT AREAS "A", CAN BE ALLOWED TO WEAR TO A DEPTH OF .002" (MEASURE WITH STRAIGHTEDGE AND SHIM SLIVER PROBE). THE BEARING PLATE SHOULD THEN BE TURNED 180°, FOLLOWED BY 2 ADDITIONAL WEAR CYCLES ON THE OTHER SIDE. AFTER 4 WEAR CYCLES THE BEARING PLATE MUST BE REPLACED.

### PARTS LIST

FIND #	Q'NT'Y	PART #	DESCRIPTION	M'F'T'R
1	1	HAY C6310-108C	VACUUM DOOR	MONKS
2	1	HAY C6310-109B	TAPE EDGE BEARING PLATE	MONKS
3	1	16762805-007	RECEPTACLE, FRICTION CATCH	METRUM
4	1	#6-32 x 3/8" L'NG	PAN HEAD SCREW, S.S.	LAWSON
5	2	8500	.125 R'ND CLEAR STANDOFF	H.H.SMITH
6	2	#2-56 x 3/16" L'NG	PAN HEAD SCREW, S.S.	LAWSON
7	1	#6-32 x 3/4" L'NG	PAN HEAD SCREW, S.S.	LAWSON
8	1	PD1-7	KNURLED THUMB NUT	BERG

### NOTES

#### MATERIAL

#### FINISH AND/OR HEAT TREATMENT

#### SHOP NOTES: UNLESS OTHERWISE SPECIFIED

- DIMENSIONS ARE IN INCHES
- TOLERANCE ON DIMENSIONS  
FRACTIONAL ? 1/64  
DECIMAL .XXX ? .01  
ANGULAR ? 0°
- SURFACE ROUGHNESS  
PER MIL-STD-10
- REMOVE BURRS AND BREAK SHARP EDGES 1/64 MAX.
- SCREW THREADS PER MIL-STD-9
- ALL DIMENSIONS TO APPLY BEFORE PLATING OR CONVERSION COATING.

#### USED ON

DRAWN FOR	H.HINTEREGGER	DATE	9/92
DRAWN BY	R.JCARY	DATE	9/92
CHECKED BY			
PROJECT			
ENGINEER			
MAT'L. & PROCESS			
STRUCTURES			
THERMAL			
MECH. ANALYSIS			

NORTHEAST RADIO OBSERVATORY CORPORATION  
HAYSTACK OBSERVATORY  
WESTFORD, MASSACHUSETTS

ASSEMBLY - VACUUM DOOR

6310114A	C	6310-114	A
CAD FILE	DWG. SIZE	DWG. NO.	REV.

C-6310 - 114 A

# MARK IV Memo #272

[Go to Table of Contents](#)

# Tape Drive Manual for Operation in Field and Processor Sites

Dave Fields

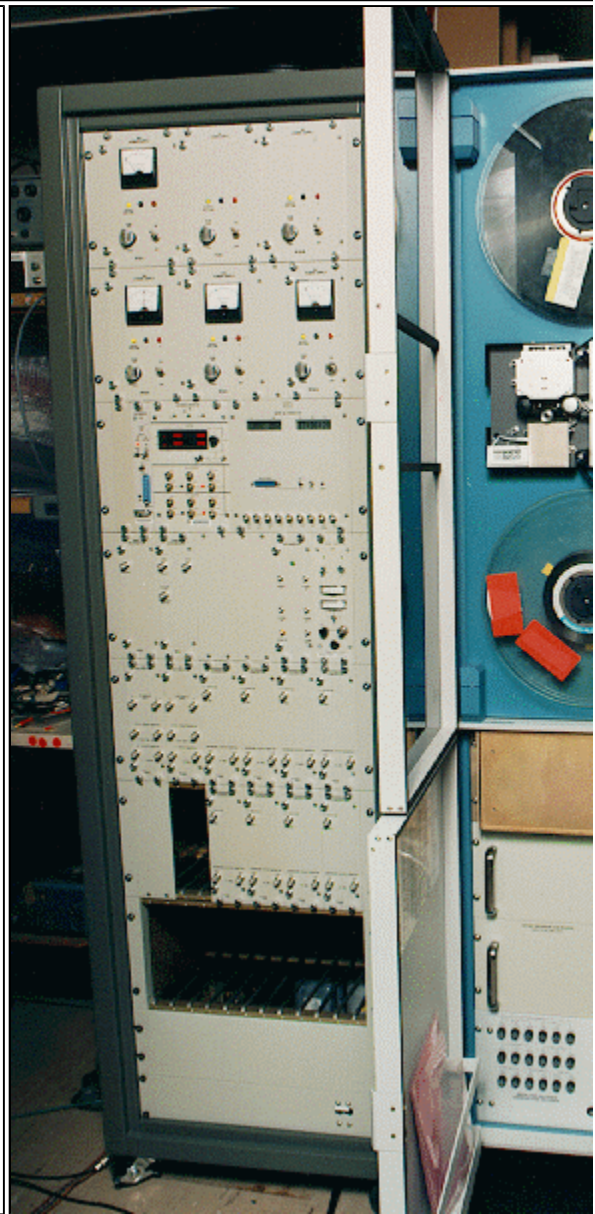
Hans Hinteregger

Revision 1.0

Ed. by A. Niell, S. Müftü, and D. Smythe

# Haystack Observatory

May 12, 1999



## Table of Contents

1. [Introduction](#)
2. [Tests and Adjustments](#)

[2.1 Tape path inspection](#)

[2.2 Tests](#)

[2.3 Reasons and Theory](#)

3. [\*Reel Servo Adjustments and Configuration\*](#)

3.1 [Tape Sensor Adjustment](#)

3.2 [Reel Servo configuration](#)

4. [\*Vacuum Setup, Control and Upgrade\*](#)

4.1

4.2 [Vacuum Motor Control Voltage](#)

5. [\*Mechanical Upgrade\*](#)

5.1 [Thin tape mechanical upgrade steps](#)

5.2 [Summary of parts, drawings, assembly drawings, and part numbers](#)

6. [\*Haystack Dry Air Kit\*](#)

7. [\*Referenced memos\*](#)

## 1. INTRODUCTION

The Tape Drive Manual for Operation in Field and Processor Sites has been compiled at Haystack Observatory of Massachusetts Institute of Technology, by people who work on these tape drives to ensure better and more reliable operation of the VLBI tape drives. Their insight and experience has been incorporated into this manual. The manual is organized in to six working chapters related to maintenance of the VLBI tape drives. Where appropriate the topics are introduced as "simple" "to-do" lists in order to obtain a useful hands-on document. Several memoranda have been referenced throughout this manual and are included in Chapter 7.

Chapter 2 describes tests and adjustments which are necessary to insure a) that the tape drive is working properly, and b) that the installation of new parts and modifications to the tape drive have been done properly. Inspection of the tape path and tests of forward-to-reverse shift, vacuum shift, door shim, and setting of record level are discussed here. This chapter ends with a brief description of the theory behind the tests and some corrective actions that can be taken.

Chapter 3 covers the adjustments for the proper operation of the tape position sensors. Spontaneous loss of vacuum can occur if the reelservo is not properly configured and adjusted. The reel servo configuration for reliable high-speed operation is also covered in this chapter.

Vacuum motor setup, control, and upgrade issues are discussed in Chapter 4. Procedures are described for setting the correct voltage for the reliable operation of the vacuum motor. Vacuum pressure switch adjustments for using the tape drive at lower tension (vacuum) values are also described in this chapter.

Using 15 m m thin tape on a Metrum tape drive requires mechanical upgrades to the tape drive. The parts required for this upgrade as well as the steps of the upgrade are given in Chapter 5.

In order to ensure a low relative humidity near the head stacks, use of the Haystack Dry Air Kit (HDAK) is recommended.

Chapter 6 discusses the issues related to HDAK implementation and gives the parts lists.

Finally, the VLBA Acquisition and Mark IV memos referenced in this manual are included in Chapter 7.

## 2. TESTS AND ADJUSTMENTS

This section covers adjustments and tests needed to insure that a) the tape drive is working properly, or b) the installation of new parts and modifications to the tape drive have been done properly and meet specifications.

These tests have been designed to verify the performance of the tape recorder and to help diagnose problems. Some of the tests should be performed frequently and on a regular basis, while others can be performed only occasionally. This memo supersedes VLBA memo #151 and includes additional tests that were described in subsequent memos.

If you record thin tape on a regular basis, use thin tape for these tests. In particular, using thick tape for the vacuum shift test will damage a headstack contoured for thin tape usage.

### 2.1 Tape path inspection (VLBA Acquisition Memo #301)

Load a tape and set the vacuum to 10 inches. Run the tape in the forward direction and perform the following checks.

1. Check that the tape edge is not touching the precision plate or entrance to the vacuum column door; i.e. the edges should touch only the reel flanges, I/O flanges, edge guiding points (inside vacuum columns), and front door at turn-around.
2. Check that the tape runs over the input-output rollers without any problems, such as folding or damaging the tape.
3. Repeat steps 1. and 2. in the reverse direction.
4. Use a light to inspect the tape path to check for large forward-reverse offset. Hold the light to view the separation between the tape edge and the precision plate in the areas of the capstan, headblock, and idler roller. Reverse the direction of tape motion while observing this separation and note if there is a large forward-reverse offset. (A finer check will be done later.)
5. Play back and peak on any recording in the forward direction and carefully slide a feeler gauge between the precision plate and the tape near the idler where the tape leaves the upper vacuum column. Find the gauge that just shifts the tracking. The distance between the tape edge and the precision plate near the vacuum column should be between.

.001 and .004 inch (0.02-0.1 mm) without the thin-tape upgrade

.010 and .014 inch (0.25-0.35 mm) with the thin-tape upgrade

Repeat with the tape moving in the reverse direction and measuring where the tape leaves the lower vacuum column. This measurement should meet the above specification and should be within 0.002 inch (0.05 mm) of the previous measurement.

### 2.2 Tests

1. **Forward-reverse shift test** Measure the tape position by issuing a pass command after peaking on a recorded track while moving the tape in the forward direction. Repeat in the reverse direction. The difference between these two readings must be less than 50 micrometers. Occasionally (approximately monthly, or after calibrating the head positioner), repeat this test at the beginning, middle, and end of the tape.

2. **Speed shift test.** Use 'peak' and 'pass' to measure the shift in tape position between normal (80 or 135) and double (160 or 270) speed. This shift should be less than 20 micrometers. Check in both directions. Perform this test once per observing day.

3. **Vacuum shift test.** Perform this test only occasionally, unless you can easily control the vacuum under computer control. **DO NOT USE THICK TAPE FOR THIS TEST ON A THICK-THIN TAPE RECORDER.** Measure the shift in position when changing the vacuum from 5 to 15 inches. This shift should be less than 15 micrometers. Repeat in the other direction. Reset vacuum to 10 inches when done.

4. **Door shim test** (VLBA Acquisition Memo #330). Set vacuum to 10 inches. Peak on a recorded track and watch the eye pattern on the oscilloscope while opening the vacuum column door slightly. The eye pattern should not change at all when the vacuum column door is opened by 6 mils (0.15mm). (Since it is difficult to measure the door opening at the left hand side, this is equivalent to measuring an opening of 3 mils (0.08 mm) halfway across the door from the opening to the hinge.) Also, at less than 15 mils (0.38 mm) of opening the eye pattern should be affected.

You can use two layers of paper (~80 um per layer) for a shim. Thread the tape and close the door on the shim. Peak up on a recorded track and remove the shim. The eye pattern should not change when removing a 0.15 mm (0.006-inch) shim (two layers of paper) placed near the top left, or bottom left, corner of the vacuum column. The eye pattern should change, or disappear, when removing a 0.4 mm (0.015-inch) shim.

5. **Tape shift with write stack position.** Peak up on a recorded track and move the write stack to +/- 700 m m. The tracking should change by less than 10 m m.

6. **Read stack calibration test.** Record 1000 feet with heads 14, 15, and 16 with 'tapeformc' 'pass=13,13'. (For a VLBA or Mark IV recorder, use 'tracks=17, 18, 19' and 'form=m'.) Reproduce with head 15 (VLBA 18), move the read stack with 'stack=,698.5,,f' and 'stack=,-698.5,,f' to find the tracks near +/- 700 m m. Use 'peak' and 'stack' to verify that these tracks are at +/-698.5 +/- 10 m m.

7. **Write stack calibration test** (for Mark IIA/IV only). Record 1000 feet with head 15 (VLBA/MK4 head 18) enabled at 'stack =0, , f '. Back up the tape 1000 feet and repeat with 'stack=-700,, f ' and with 'stack = 700,,f '. Use 'stack=,+/-700,,f ', 'peak', and 'stack' to verify that these tracks are at +/-700 +/- 10 m m.

8. **Record margin check.** Record a forward Mode C pass followed by the next reverse pass. Measure the error rates on all 14 tracks in both directions after the reverse pass. If the forward recording is worse than the reverse recording, reduce the head voltage in 1 volt steps until the error rates for forward and reverse passes are approximately equal.

### 2.3. THE THEORY BEHIND THE TEST

#### 1. Visual inspection.

The tape path is designed to keep the tape from touching the precision plate or the door of the vacuum column. A properly aligned tape path will keep the tape edge away from the precision plate by a specified amount in the region between the idler roller and the capstan. Measuring this spacing provides a check on the mechanical alignment of the tape path. The most common misalignments are due to:

- a. A tilted idler roller
- b. A tilted head stack.
- c. A tapered or tilted capstan.
- d. A strained or bent precision plate.

#### 2. Forward-reverse shift.

Asymmetries in mechanical alignment are the primary cause of a forward-reverse shift, although anisotropies in the tape's elastic constants can also produce a significant forward-reverse shift. Components before the capstan affect the forward shift,

while components after the capstan affect the reverse shift.

3. Speed shift.

At high speed, the tape is subject to additional forces due to air entrapment. Any shift in tracking with speed is a measure of tension variations across the tape that result in asymmetries in the air entrapment. These tension variations can be caused by alignment errors or capstan taper.

4. Vacuum shift.

A shift in tracking with vacuum is another indication of tension variation across the tape. Also, changing the vacuum moves the position of the loop in the vacuum column (since the reel servo is a first-order servo) and produces a small shift that can be greatly magnified by dirt or grooves in critical areas.

5. Door shim test.

Failure of the door shim test can be caused by a vacuum leak, which can be caused by a poorly adjusted vacuum door hinge, or by deep grooves in the aluminum plate attached to the vacuum door.

To adjust the vacuum door hinge: With vacuum on, loosen the 4 screws holding the hinge, push on the door, and re-tighten the screws.

The depth of the grooves in the tape edge contact areas on the tape edge bearing plate mounted on the vacuum door can be measured with a sliver of paper about the size of the fortune from a Chinese fortune cookie, or with two thicknesses of thick tape about the same size. These grooves can be allowed to wear to a depth of .002 inches. The bearing plate should then be turned 180 degrees, followed by 2 additional wear cycles on the other side. After 4 wear cycles the bearing plate must be replaced. A replacement plate can be made from .062-inch-thick #6061-T6 aluminum with a flatness better than .002 inches per inch (or 0.02 mm per cm). (See Haystack DWG No. 6310-109.)

LOG RESULTS

Recorder Serial # \_\_\_\_\_ Station \_\_\_\_\_

Date of Tests \_\_\_\_\_ Performed by \_\_\_\_\_

0. Visual Inspection: O.K.

Y	N
---	---

Tape angle: Distance from tape edge to plate \_\_\_\_\_ mils

1. Forward-reverse shift:		_____ microns
2. 270-135 speed shift: (or 80-160)	Forward	_____ microns
	Reverse	_____ microns
3. 15" - 5" vacuum shift:	Forward	_____ microns
	Reverse	_____ microns
4. Door shim test	Maximum	_____ mils
5. LVDT cal. Test	Read LVDT error	_____ microns
	Write LVDT error	_____ microns
6. Record margin check:	Worst Track Per	_____
	Worst Track #	_____
	Speed	_____ inches/sec



	Direction	
	Vacuum	_____ inches
	Write voltage	_____ volts
7. Tape shift:	By read stack motion	_____ microns
	By write stack motion	_____ microns

Calibration constants: Please attach a copy of the HEAD.CTL file

### 3. REEL SERVO ADJUSTMENTS AND CONFIGURATION

#### 3.1 Tape Sensor Adjustment

The reel servo keeps the tape loops positioned in the vacuum columns by using light from LEDs to sense the position of the loops. If this servo system is not adjusted properly, spontaneous losses of vacuum will occur. The tape position sensor adjustment procedure described below is based on pages 5-12 of the Metrum Tape Transport Maintenance Manual and VLBA Acquisition Memo #371.

#### SUPPLY and TAKEUP SENSORS

1. Adjustment to obtain a voltage difference of 1.6 ( $\pm 0.05$ ) Vdc between highest and lowest readings.
  - a. Using your hand, rotate reel clockwise until you hear a "honking" sound. Record voltage reading at "honking" sound.
  - b. Rotate reel counter-clockwise, record voltage at "honking" sound.
  - c. Add values, dropping the negative sign. The correct total is 1.6 ( $\pm 0.05$ ) Vdc.
  - d. Adjust R7 (x pot) until desired setting is obtained, repeating steps a,b and c.
2. Adjustment to obtain a voltage reading of +0.8 ( $\pm 0.05$ ) Vdc when tape is completely into the column and a voltage reading of -0.8 ( $\pm 0.05$ ) Vdc when the tape is completely out of the column.
  - a. Rotate reel clockwise to "honking" point. Record voltage reading.
  - b. Rotate reel counter-clockwise to "honking" point. Record voltage reading.
  - c. Adjust R3 (s pot) to obtain a reading of +0.8 ( $\pm 0.05$ )Vdc in one direction and -0.8 ( $\pm 0.05$ ) Vdc in the other direction, repeating steps a and b.
3. Repeat procedure for takeup sensor.
4. Run tape drive for a while and recheck settings.

The supply and takeup tape sensors in the vacuum columns each have two adjustments: gain and symmetry. The procedures in the following paragraphs explain how to make these adjustments. Figure 5-4 locates the adjustments and test points on the transport.

#### 1. Preliminary Procedures

- a. Mount tape and load

- b. Adjust the vacuum to 10" on gauge
- c. Connect digital voltmeter between (bottom wht blu lead) and (ground) Black lead for the takeup sensor, or between (top wht blu lead) and black lead (ground for the supply sensor. (See Figure 5-4).

2. Adjustment (be sure to warm up tapedrive before doing adjustment) \* See practical description below.

- a. Observe voltmeter while manually rotating the appropriate reel to move tape completely into, then out of the column.
- b. Repeat step a and adjust R7 to obtain a voltage difference of 1.6 ( $\pm 0.05$ ) Vdc between the highest and lowest readings.
- c. Repeat step a and adjust R3 to obtain a voltage reading of +0.8 ( $\pm 0.05$ ) when tape is completely into the column, and a voltage reading of -0.8 ( $\pm 0.05$ ) Vdc when tape is out of column.

#### NOTE

Repeat steps b and c until desired setting is obtained.

- d. Repeat procedure for takeup sensor.
- e. Remove the DVM.

### 3.2 Reel Servo Configuration

This section covers the reel servo/driver configuration that will provide the most reliable high-speed operation. Honeywell and Metrum have made design changes to the reel servo boards and reel servo drivers. Undesirable combinations of old and new parts and VLBI use of the 1/4" tape mode have created problems. The reel-servo and driver configuration upgrade is REQUIRED, regardless of thin-tape upgrade status.

- a. Disable 1/4" tape mode current limit halving (VLBA #371 p.5-par.4)
- b. Do 'best combo' modifications to old servo (VLBA #371 p.5-par.2) and new drivers (VLBA #371 p.3-par.3)
- c. Guarantee 105 volts minimum AC line voltage
- d. Replace 10 amp reel servo fuses with 15 amp time delay fuses.

(The original 10 amp fuses will eventually blow due to transient loads intentionally permitted by a. and b. These transients do not cause damage to anything but the original fuses. The fuse change has been extensively tested in the lab and processor drives. There is no other memo regarding the fuse change. Fuse part #MDA-15.)

- e. Check Operational Vacuum Margin: Make sure the tape loads and shuttles without difficulty up to 30" water vacuum.

Purpose:

This memo is intended glean from VLBA Acquisition Memo #371 / MK IV MEMO #167, written by Hans Hinteregger, those portions that will insure reliable tape drive operation at 320 ips. This memo is not, in any way, intended to replace Hans's memo. Rather, it is to provide a step-by step-procedure for determining the necessity of the suggested changes and to perform them is it is deemed necessary.

The number of tape drives that I am addressing is quite small when compared to the total number in use in the VLBI world today. They are older drives that were in operation when Honeywell (now Metrum) made several changes in the reel servo circuits that adversely affected our usage of the drives. The problem occurred when the new components were inadvertently mixed with the old units in the same tape drive.

In addition to the Honeywell changes in the reel servo system, an earlier modification that was installed by Haystack to limit the servo gain during acceleration was deemed detrimental to reliable high speed operation. This modification is also to be removed.

Old and New Servos and Drivers:

Honeywell's changes involve both the Dual Reel Servo circuit card: 16778850 old, 16813450 new; and the Driver/Heatsink subassemblies (one for each reel): 16776995 old, 16813453 new. A "WORSE CASE" COMBINATION HAS BEEN DETERMINED TO BE AN OLD SERVO CARD WITH A NEW DRIVER ASSEMBLY.

Both the old Servo circuit card and the new Driver assembly can be modified to bring them into a configuration that will improve their high speed reliability.

The new drivers can be easily converted to have the same low voltage drop advantage as the old version by strapping a 0.3 ohm, 3 watt resistor in parallel with each 4 ohm resistor. Both Heatsink Assemblies must be completely removed from the drive to complete this procedure. Ten (10) 0.3 ohm resistors are needed.

The Metrum modification to the new reel servo circuit card provided an increase in the overspeed margin for each motor that is sufficient enough to recommend that it be installed in the old versions. The easiest way, which can be done in place, is to clip open the output of the unnecessary inverter (pin 6 of U7) and interchange the power leads from the takeup motor (the 5th and 6th wire counting from the red edge of the ribbon cable and going normally to TB1-19 and TB1-20 respectively).

Abandonment of Gain and Current Limit Switching:

To disable low gain/current limit mode in Mk3A/Mk4 acquisition drives that are so equipped, the following hardware control must be changed: on the Honeywell Control Logic Card, the jumper from U3504 to U5012 must be unsoldered at the U35 end and connected to ground at U3607.

Additional Checks:

The following additions were included in the tape drive conversion to Mk3 in the earliest days of the program, but they are worth while verifying because they do contribute to reliable tape movement at all speeds.

Reel Servo circuit board; Insure that the ground return from the reel motors is jumpered to chassis ground. Jumpers are between TB-1 10-11 and TB1 12-13.

Vacuum column Light Sensor Assy.; There are two of these assemblies, one on each outer leg of the vacuum column "E" casting. Access is from the inside of the tape deck plate door. The printed circuit board of this assembly should be insulated from chassis ground (mounting angle bracket) with nylon screws and washers. These screws and washers are normally white in color and can be seen from the back side of the front door.

Reel Servo fuses; The +33v and -33v Reel Servo fuses marked 10A (two lower left fuses on front of main power supply should be 15A slow blow. This is to prevent indiscriminate blowing of the fuses during high current spikes, while still providing protection to the power supply from direct shorts in the Servo Driver Assemblies.

#### 4. VACUUM SETUP, CONTROL, AND UPGRADE

The wide range switchable vacuum setup can be implemented in any drive. Vacuum-switched operation is mandatory only for drives that must handle both thick and thin tapes and use the present standard single-CAP head contour. This complex operation is a stop-gap measure and is required only on MKIII/MKIV processor drives until a new thickness-insensitive

contour design head, such as the triple-CAP or flat head, eliminates the requirement.

Acquisition recorders are expected to use ONLY THICK or ONLY THIN tapes and to operate always at 10" water vacuum.

To operate a tape drive at 5" water vacuum for thin tape and 15" water vacuum for thick tape, adjustments are needed to the vacuum motor and vacuum pressure switch.

The following wide range vacuum setup is necessary for mixed thick and thin processing capability with present single-CAP head contour:

- a. Vacuum switch trip point adjust to 3" water vacuum.
- b. 3 volt minimum control voltage specification.

Details are given in the following pages.

#### **4.1 Vacuum pressure switch adjustment**

The standard cut-out setting on the vacuum pressure switch is 6" water vacuum. This needs to be lowered to  $3" \pm 0.5"$  water vacuum to be able to run tape drive reliably at 5" water vacuum for thin tapes. There is a set screw on the back of the switch that will allow this adjustment. The switch is located on the panel inside the tape drive next to the vacuum gauge.

1. Power down tape drive
  2. Loosen screws holding panel and carefully pivot down
  3. Locate the switch on the back. You will notice 2 set screws (some switch models have 3 set screws) locked with epoxy. The set screw that is "off-center" and next to the connector labeled "NO" is the screw that will need adjusting. DO NOT adjust the set screw in the center.
  4. Scrape off epoxy
  5. Lower the cut-out threshold by turning the set screw in a clockwise direction
  6. Power up tape drive.
  7. To check the level when the pressure switch will cut-out, there are a couple of methods you can use.
    - a. Load a junk tape on the drive. Lower the vacuum setting and watch the vacuum gauge to see where the vacuum cuts out. Adjust the set screw accordingly to reach the 2.5"/3.5" water vacuum setting. (You will have to reload the tape each time as you try to get the proper setting. REMEMBER to turn the vacuum setting back up to load tape.)
- Or
- b. Remove the "E-Casting" from the tape drive and cover part of the vacuum chamber on the precision plate to trick the drive into thinking a tape is loaded. Proceed to "load" and adjust the set screw to the 2.5"/3.5" water vacuum setting.
8. As a suggestion, let the tape drive warmup for a while and check the setting a couple of times.
  9. Power down the tape drive and put the panel back into position.

#### **4.2 Vacuum Motor Control Voltage**

The vacuum motor requires a minimum control of voltage of 3 volts, by manufacturers specifications, in order to start

reliably and run stably. With the control voltage set to 3 volts, the vacuum may be higher than the minimum required vacuum 4" water.

An adjustment to the vacuum motor gain trim pot is needed to bring the setting to specification. On the Ametek/Lamb brushless motor there is a gain adjustment trim pot located on the side of the motor near the power connector.

1. Locate the trim pot on the vacuum motor.
2. With the control voltage set at 3 volts, slowly turn the trim pot until 4" water is read on the vacuum gauge. A clockwise direction will decrease the vacuum and counter-clockwise will increase the vacuum.
3. Make sure the tape loads and shuttles without difficulty down to 4" water vacuum and up to 30" water vacuum for at least 20% margin.

## 5. MECHANICAL UPGRADE

### 5.1 Thin tape mechanical upgrade steps

1. Remove the head assembly - put it in a safe place.
2. Disconnect the cables and vacuum hoses going into the precision plate assembly and the capstan motor.
3. Remove the capstan motor - 3 large bolts.
4. Remove the precision plate - 3 large bolts.
5. Install the new plate - Metrum #16827015-001
6. Reel Motor Alignment:

Measure the reel table locations, as shown on the [Fig. 1](#) worksheet, with a 2' straight edge, single-flange metal reel, shim stock and/or depth micrometer. Compare the height of the reel flange near the hub with that of the precision plate. Select shim stock to the nearest 5 mil thickness increment to make these heights equal. Slip one piece, preferably with a hole for the screw, between each of the three pads on the deck-plate and the reel motor mounting flange. Make sure the flange and precision plate are in the same plane with no significant tilt of reel table. See memo #290 - Section IV Reel Alignment for more detailed information.

7. Install capstan motor (see Special Notes and Cautions #4 in the previous section)
8. Install new Idler roller - Metrum #16821285-004
9. Install new I/O roller assembly - Drawing #A4712M001
10. Install new "E"-casting - Drawing #D6310-113A
11. Install new half-moon loading blocks - Drawing #A6310-112
12. Transfer vacuum hose connectors and front door hinges from old precision plate to new plate.
13. Install new vacuum door - Drawing #C6310-114A
14. Install tape wrap angle adjuster (dummy headstack post) - Drawing #A54330M022 (VLBA Acquisition memo #220)

15. Install head assembly as per Drawing #A54330M023

16. Connect cables and vacuum hoses.

## 5.2 Summary of parts, drawings, assembly drawings, and part numbers - VLBA Acquisition Memo #349

This section contains information on the parts, assembly, installation and specifications used in upgrading tape drives for thin tape operation.

Thin Tape Upgrade associated modifications and checks:

- a. High-speed headblock for reliable contact at 320 ips. (Drawing # D54330M007RevB)
- b. Capstan surface specifications, resurfacing, tests (#4 below)
- c. Critical screw lengths, torques, (Drawing #A54330M023)

### Drawings Drawing Number

I/O Sleeve	<a href="#">C6310-101 Rev D</a>
"E" Casting (also known as vacuum spacer)	<a href="#">D6310-105 Rev C</a>
Vacuum Door	<a href="#">C6310-108 Rev C</a>
Vacuum Front Door Plate	<a href="#">C6310-109 Rev B</a>
Mods. to Loading Blocks	<a href="#">A6310-112</a>
Edge Bearing Plate	<a href="#">A6310-83A</a>
Tape Wrap Angle Adjuster (also known as dummy headstack post)	<a href="#">A54330M022</a>
Head Assy Mounting Screws Specs	<a href="#">A54330M023</a>
Head Block Modification	<a href="#">D54330M007 Rev B</a>
(for high speed recording and playback - Mark IV Memo #185)	

### Assembly Drawings:

"E"-Casting Assy & Install	<a href="#">D6310-113A</a>
Vacuum Door Assy & Install	<a href="#">C6310-114A</a>
I/O Roller Assy	<a href="#">A4712M001</a>

### Part Numbers:

Precision Plate - Metrum	16827015-001
Backing Plate - Metrum (modified according to Dwg. 6310-82 Rev A)	16827014-002
I/O Roller - Metrum	16812759-005
Idler Roller - Metrum	16821285-004
Loading Blocks - Metrum	16776407-003
Alumina Plates - Coors	A6310-83A

**Special Notes and Cautions:**

1. Be sure alumina plates are clean, especially in the area which is epoxied. **BE SURE THE EPOXY BOND IS GOOD** since, if the bond breaks, the plate might be pulled out by the vacuum far enough to damage tapes. VLBA Acquisition Memo #349
2. The slope in the depth of the vacuum column should be  $4 \pm 0.8$  mils per inch. Check, with a depth-micrometer, that depths at points C, the tape edge-bearing points (1.25" from points A', A", B', B", along the inside edges of the bearing plates), are close to 5 mils greater than at those points (A,B), and, in any case, between 1.0065" and 1.0085". The depth along the outside edge of the 3" square bearing plate is nominally 12 mils greater than along the inside edge, that is,  $1.0145" \pm 0.0029"$  (worst case sum of errors). Drawing #D6310-113 - VLBA Acquisition Memo #349
3. A new style head block is required for high speed recording and playback to prevent tape flying. The new headblock has three beveled surfaces (10, 22.5 and 67.5 degrees) nearest the tape to increase the distance of closest tape approach. If your head blocks have only a double bevel (original MKIII design), they must be replaced with the new style according to Drawing #D54330M007 revision B. (In principle, the old part can be modified to the new specification, but in practice, installation of a new head block is recommended.)
4. The old solid-urethane-surfaced capstan motor is subject to severe wear, unlike the newer urethane-impregnated porous ceramic version. A worn capstan, because it develops a severe taper at both tape edges, can cause the tape to ride into the precision plate, before or after the new thin tape upgrade parts are installed, damaging the tape. The capstan motor can be resurfaced at PTC and the tape position shift must meet the following specifications to qualify to be operational:
  - a. Forward-Reverse shift <50 m m to 320 ips.
  - b. Tape shift with speed in forward or in reverse direction <20 m m at speeds up to 320 ips.
  - c. A 10 mil shim, held in contact with the precision plate where the temporarily removed idler is mounted, must not touch (interfere with) the inside tape edge. A 14 mil shim should interfere. Otherwise, the taper-induced tape-angle change is too great in either direction.

**6. HAYSTACK DRY AIR KIT**

(Mark IV Memo #258)

The Haystack Dry Air Kit (HDAK) is recommended for use in all MK3A, VLBA, MK4 acquisition and processor tape drives in order to ensure that the relative humidity (RH) in the tape path is under 30%. The purpose of this low relative humidity is to minimize head wear rate.

Currently the stepped VLBI heads have an initial depth of gap of 25m m-35m m. In order to obtain more than 5000 hours of use from the head the wear rate must be less than about 5 nm/hour. In VLBA Acquisition Memo #369 this wear rate appears to be safely achievable for relative humidity at the head of less than 35%. Above this value the wear rate increases dramatically. Since relative humidity sensors typically have an uncertainty of about 5%, we would like to keep the relative humidity in the tape path as close to, or below, 30% as possible.

There is a relationship between air temperature and relative humidity according to which, if room air at 68°F (20°C) and 60% RH is raised to 104°F (40°C), the relative humidity of that air is reduced to about 20%. The HDAK lowers tape-path relative humidity by raising the temperature of the air blown into the tape path.

The HDAK consists of a motor to provide the heat and air supply, and tubing to get the air to the heads. The blower motor is identical to the vacuum motor. It is surrounded by porous foam sheet stock and encased in a two-piece sheet-metal housing. This packaging greatly reduces audible noise and allows the blower to be used up to full power without creating an annoyance. Rack mounting-ears, an air hose identical to the vacuum hose, a feed-through plate, and a sheet-metal air guide with a hole for thermometer probe are included. A mini DC supply and potentiometer for motor speed control are attached to one of the mounting ears.

The thermometer included in the kit measures the temperature of the blown-in air, and the relative humidity is calculated from the ambient conditions.

The speed of the blower motor should be adjusted until the blown-in air temperature is stable at 104°F +/- 1°F. The potentiometer is provided for this purpose.

Although the kit is normally mounted inside the VLBA or MK3A/MK4 tape drive, it is electrically independent of the drive. The HDAK can be used when the recorder is powered off if it is plugged into a separate AC source.

Room humidity must be kept below 60% RH for the HDAK to maintain the low relative humidity in the tape path. The room humidity should be monitored and reported in the pre-experiment checkout. If this condition cannot be maintained, Haystack can offer suggestions to alleviate the problem.

Complete documentation for the HDAK is available from Haystack (see parts list and drawing numbers below). The cost for all parts is less than \$1000.

Though not part of the kit, an inexpensive temperature and relative humidity meter for the room (not the tape-path) can be supplied on request. This humidity meter is accurate to 5% RH in mid-range, degrades to 7% accuracy at 20% RH, and does not read below 20% RH.

Better humidity meters (quoted accuracy 2% down to 0% RH) are also available for about \$300. In operational use it is unnecessary to include one of these for direct measurement of tape-path humidity. However, a slightly modified feed-through plate allows the use of such a meter for accurate experimental work.

#### Haystack Dry-Air Kit Parts List

Qty	DESCRIPTION	PART NO.	REF. DWG.
1	Housing Receptacle	6400M001A	6400M001A
1	Housing Cover	6400M002	6400M002
1	Mounting Ears Short/Long	6400M003A	6400M003A
1	Ametek Motor	6400M004	6400M004
1	Hose Mounting Plate	6400M005	6400M005
1	Air Flow Deflector	6400M006	6400M006
1	Metrum Hose Assembly	16817935-001	6400A001
1	PVC Pipe 1" dia/1.5"long	NA	6400A001
1	Motor Hose Collar	A54313M002	6400A002
1	Metrum Hose Adaptor	16738263-001	6400A002
1	Filter Screen	NA	6400A002
2	Porous Foam Filters	NA	6400A001/002
1	Foam Pieces/McMaster-Carr	8723K14	6400M007/A002
1	Terminal Strip	NA	6400S001



1	Terminal Strip Cover	NA	6400S001
1	Acopian Power Module	10E12	6400S001
1	Acopian Accessory Socket	ES-1	6400S001
2	H.H.Smith 1/4" Standoff	2330	6400S001
4	H.H. Smith 1/2" Standoff	2332	6400S001
1	C&K On/Off Switch	7201	6400S001
1	Clarostat 10K Pot.	RV6NAYSD103A	6400S001
1	3M Plug Connector 34-Pin	4634-6300	6400S001
1	3M Socket Connector 34-Pin	3414-6034	6400S001
1	AMP Socket Connector 6-Pin	6410250-6	6400S001
4	Amp Female Pins	640706-1	6400S001

## 7. REFERENCED MEMOS

### VLBA Acquisition Memo Series:

#220 Dummy headstack post for improved tracking- symmetry. (MkIV#020)

#290 Configuration of tape path for thin tape and high speed (see also #333 and #349)

#301 Mechanical upgrade steps. (MkIV#070)

#330 Capstan and Idler alignment tests.

#333 Thin tape upgrade- changes/additions to memo #290.

#349 Thin tape upgrade - summary of parts, drawings, assembly and test. (updated version of memo #333)

#371 Reel Servo/Driver Configuration and Margin Analysis, Recommendations for More Reliable Operation at 320 ips maximum

### Mark IV Series

#185 Revised Head Block Design

#258 Haystack Dry Air Kit

VLBI Software Documentation

Field System

# Narrow Track Calibration

W. E. Himwich

NVI, Inc./GSFC

## Operations Manual

NASA/Goddard Space Flight Center Version 9.1

Space Geodesy Program January 1, 1996

## Table of Contents

- [1.0 Introduction](#)
- [2.0 Calibrating the Heads](#)
- [3.0 Setting Up the head.ctl Control File](#)
- [4.0 Tape Drive Set-up Checks](#)
  - [4.1 Inchworm Motion Range](#)
  - [4.2 Track Peaking](#)
  - [4.3 Reproduce Signal Level](#)
- [5.0 Handling Missing hdcalc Parameters](#)
  - [5.1 Write Head Parameters](#)
  - [5.2 Read Head Parameters](#)
    - [5.2.1 Recovering Positions From the Log](#)
    - [5.2.2 Re-measuring Positions](#)
    - [5.2.3 Starting Over](#)
    - [5.2.4 Finishing Up](#)
- [6.0 Evaluating Results of Head Calibration](#)
  - [6.1 Parity Check for Head Calibration](#)
  - [6.2 Forward-Reverse Guard Band Check](#)
  - [6.3 Repeated Calibrations](#)
- [7.0 What the Head Calibration Schedule Does](#)
  - [7.1 Assumptions](#)
  - [7.2 Sequence of Operations](#)
  - [7.3 Design Considerations](#)
    - [7.3.1 Differences From the Original Procedure](#)
    - [7.3.2 Features of the Field System Implementation](#)
- [8.0 headp](#)
- [9.0 Special Head Cal Cable for Mark III/VLBA](#)
  - [9.1 Cable](#)
  - [9.2 Connector](#)
- [10.0 Listing of hdcal.snp Schedule \(Mark III\)](#)
- [11.0 Listing of vhdcal.snp Schedule \(VLBA\)](#)
- [12.0 Listing of 3vhdcal.snp Schedule \(Mark III/VLBA\)](#)
- [13.0 Listing of v2hdcal.snp Schedule \(VLBA2\)](#)

## 1.0 Introduction

This document describes how to use the Field System to calibrate the positioning system for Narrow Track (high density) tape heads. The procedure used to calibrate the heads is covered in the next section. Other sections cover: setting-up the head.ctl control file, checking the basic functionality of the head positioning system, recovering when some of the calibrations parameters have not been calculated, evaluating the quality of the results, a detailed description of the calibration schedule, and finally a listing of the schedule. A copy of the original calibration procedure memo by Dan Smythe and Alan Whitney is included for reference.

The calibration procedure itself is very simple-minded. It is automated using a SNAP schedule and does not perform any error checking or recovery. At the end the user must evaluate whether or not it did something useful. The schedule is written to be as general and robust as was thought useful. On most drives it should perform adequately without modification. If it performs so poorly that no calibration is possible, the user can revert to performing the calibration manually, using either the detailed description of the schedule or Dan Smythe and Alan Whitney's memo as a starting point. Many of the commands used by the schedule, in particular: **stack**, **locate**, **peak**, **savev**, and **hdcalc**, would be useful for manually calibrating a tape drive. A second generation of calibration and check-out software is planned once we have some feedback on how well this one worked.

The combination of a Mark III rack and VLBA recorder requires a special cable that will only write tracks 15 and/or 16 (Mark III track numbers). The cable is documented in this manual in section 9.0.

Please note that "VLBA" as used in this manual refers generally to both the VLBA and VLBA2 drives. If a command is intended for either the VLBA or VLBA2 drive, but not both, it will be made clear in the comment.

Also note that Mark III track numbers are used throughout the text. However the type-in examples use the correct numbers for the example system.

## 2.0 Calibrating the Heads

The complete calibration process requires about two hours the first time it is attempted on a drive, including all the set-up before and clean-up afterwards. If there are severe problems the time required might extended up to four hours. Once everything is set-up, the `hdcal` schedule itself can be run in about 40 minutes to recheck the values. To calibrate the heads, follow these steps:

- (1) Verify that the `head.ctl` control file and the recorder electronics are set-up consistently. This is covered in the section below titled **Setting up the head.ctl Control File**. Restart the Field System to make sure the current `head.ctl` file has been read in.
- (2) If this is the first time you have calibrated this drive, perform the checks listed in the section titled **Set-up Checks** to verify that everything is working properly and that there is some chance of success with the automated procedure. You may choose to ignore this step and come back to it later if there are problems.
- (3) Mount a fresh degaussed tape. Pre-pass the tape by running it to the far low-tape sensor at high speed using the `sff` or `rec=eot` (VLBA) command. Set the low-tape sensor with `tape=low` command. The tape should stop near 9000 feet.
- (4) Clean the heads and tape path. Reload the tape. Re-establish vacuum by pressing the STOP button (Mark III) or issuing the `rec=load` command (VLBA).
- (5) For Mark III, start the calibration schedule by entering the SNAP command: `schedule=hdcal,#1`. The default copy of this schedule is distributed in `/usr2/fs/st.default/sched/hdcal.snp`. If you haven't done so already, you'll have to copy it to `/sched/hdcal.snp` before using it. For a VLBA system use `vhdcal.snp`, for a Mark III rack/VLBA recorder combination use `3vhdcal.snp`, and for a VLBA2 system use `v2hdcal.snp`. Default copies of these schedule files are found in the same directory as `hdcal.snp`.
- (6) Wait patiently for about 15 minutes. The calibration schedule will run the system, starting and stopping the tape drive, recording and reproducing tracks. Occasionally, the system will sit idle for a minute or two. This is necessary to make the timing general enough to handle a reasonable worst case. If the tape drive drops the loop or the MAT or MCB communications fail or the head positioning fails to converge, you should stop the schedule. If this occurs, you will probably have to start the schedule over with a fresh tape. The `halt` command can be used to stop the schedule quickly. An `et` command will stop the tape drive.
- (7) After the schedule runs the tape off the far end of the reel, swap (and flip) the tape reels. The schedule will display a comment instructing you to flip the reel and re-thread the tape. The tape will have accumulated on the take-up reel. Remove the upper reel (original supply reel) and set it aside. Take the lower reel (original take-up reel) and mount it on the upper hub, flipping as you mount it so that the flange that was toward is now away from it. Mount the original supply reel, which you had set aside, on the lower hub, flipping it also so that the label, which was away from the deck is now toward it. Reload the tape. Re-establish vacuum by pressing the stop button (Mark III), by issuing the `rec=load` command (VLBA), or use the appropriate loading technique for a VLBA2 drive. Then enter `cont` to continue the schedule.
- (8) The schedule will run for about 5 more minutes. Near the end, the `hdcalc` command will be issued to calculate the calibration parameters. If there are any null, i.e. empty, parameters in `hdcalc`'s response, then some problem has occurred. See the section below titled **Handling Missing hdcalc Parameters** for information on how to handle this problem. Note that for VLBA recorders, since there is only one head, all of the read head parameters will be null, this is a normal condition.
- (9) If all the parameters have been calculated, the `headp` utility program can be used to format a new `head.ctl` control file with the new calibration information. Run `headp` by opening a new window and typing `headp` at the system prompt. The new calibration information is placed in `/usr2/control/head.new`. See section 8.0.
- (10) If the new calibration numbers are acceptable, you can purge (`rm`) or rename (`mv`) the old `head.ctl` file and rename `head.new` to `head.ctl`. The next time the Field System is re-started the new values will be read in and used. See the section titled **Evaluating the Results** for information on how to decide if the calibration is acceptable.
- (11) Run the tape to the end again, first issuing `tape=low` and then using the `sff` or `rec=eot` (VLBA drive) command. This will return the tape to the original supply reel. When it reaches the end unload it by entering `tape=off` and `st=for,120,off`. If you flipped the original supply reel in step (7) above when you swapped the reels, then the label should be in correct orientation relative to the tape. Exchange the reels again. Degauss the tape if you are finished with it.

### 3.0 Setting Up the head.ctl Control File

When new heads are installed, the control file `head.ctl` must be set-up to accurately reflect the hardware configuration. A default control file is included in `/usr2/fs/st.default/control/head.ctl`. The working copy is kept in `/usr2/control/head.ctl`. The format of `head.ctl` is covered in the [Control Files](#) manual. This section covers additional considerations that are important for calibrating the heads.

The first two lines of the `head.ctl` file contain information that depends on how your station's hardware is configured. The contents must be set correctly for the Field System and the calibration procedure to work. The remaining lines contain calibration parameters. The calibration schedule is designed to work correctly using the default values of these parameters, found in `/usr2/fs/st.default/control/head.ctl`. However, in some cases the actual values for these parameters may be so different from the defaults that the calibration schedule will fail. If you have some estimate of what the correct values should be, use those estimates. Note that the forward and the reverse offsets used by the Field System revision 7.2 and later do not include the differential head pitch offsets, 698.5 m, used by previous revisions. For VLBA drives **odd** and **even** only have significance for the write head. The VLBA track number differ from the Mark III track number by three. Consequently, while odd and even tracks on the VLBA recorder refer to odd and even VLBA tracks as you would expect, they refer to even and odd Mark III tracks respectively.

A significant difference between the VLBA and VLBA2 recorders is that the scales for the VLBA2 recorder should have nominal values of about 0.1 microns/kÅ.

### 4.0 Tape Drive Set-up Checks

This section covers some simple checks which should be performed before calibrating an unfamiliar tape drive. If these checks are all okay, it is likely that the automated procedure will succeed. The `head.ctl` file must be set-up before proceeding with these checks. See the previous section titled **Setting-up the head.ctl Control File** for more information.

Three things need to be checked: (1) that both inchworms can move over the full 10 volts range of motion, (2) that the software can successfully peak up on a track written by your drive, and (3) that the peaked reproduce power level is large enough that the software can distinguish a real peak from noise. If these three conditions are not met, you may have a hardware or software problem that should be corrected before continuing. Check with Goddard or Haystack for assistance.

#### 4.1 Inchworm Motion Range

To check that your inchworms can cover the full range of motion, use the `lvdt` command to position the heads by voltage. The VLBA2 drive does not use an inchworm, but it is still possible to check the head's range of motion. Issue the following four commands in the Field System:

for Mark III: for VLBA: for VLBA2:

`lvdt=0,0 lvdt=0 lvdt=0`

`lvdt=9.9,9.9 lvdt=9.9 lvdt=17990`

**lvdt=-9.9,-9.9 lvdt=-9.9 lvdt=-17990**

**lvdt=0,0 lvdt=0 lvdt=0**

The first of these **lvdt** commands is intended to move the heads to a "safe" position. The second and third **lvdt** commands move the inchworms over nearly the full range of possible motion. If either of these commands fails (ends with error or doesn't position the heads to the commanded positions), your inchworm may not be able to cover the full range. Record the limits of the motion for future reference. For non-VLBA2 drives, use the **lvdt** command without an = to get the position response if the positioning failed. For VLBA2 drives it is not possible to find out where the head is if the positioning fails. (For VLBA2 drives if the above commands fail, you will have to use a "divide-and-conquer" algorithm to find the limits. For example, you could start by moving halfway out in one direction and then move out in steps of one-half the remaining range until you isolate the end of the range of motion. Once you find a step where it fails, you can go back and divide the range between the last successful step and the step that failed. Repeat this process until you located the end of the range as precisely as you like, perhaps within a 1000 units of the lvdt command parameter is sufficient. The lvdt command uses units of 0.1 microns for VLBA2 drives only, so in this case 1000 units is the same as 100 microns, crude but probably sufficient without an excessive amount of trial-and-error.) The last **lvdt** command returns the heads to a "safe" position. Although the calibration schedule assumes that your inchworms can move over the full range, it may still work if they do not.

## 4.2 Track Peaking

The second check to perform is whether the software can peak-up on a track written by your drive. Load a fresh, degaussed tape. Pre-passing and cleaning are desirable, but may not be necessary. Move the tape footage ahead to 1000 feet to avoid tracking problems near the tape end. It is useful for an oscilloscope to be set-up for eye-pattern reproduce, contact Haystack for more information on the set-up.

Record a thousand feet of tape on track 15 at micron position -350:

for Mark III: for VLBA:

**stack=-350,-350,f,f stack=-350,,f**

**enable=15 enable=d15**

**repro=byp,15,15 repro=byp,18,18**

**form=c,4 form=d15,4**

**st=for,135 st=for,135**

**check= check=**

For Mark III/VLBA: use the Mark III commands above except use **enable=d15**.

Stop the tape at 2000 feet. Rewind the tape to 1000 feet. Attempt to locate the written track with the read head (write head for VLBA):

for Mark III: for VLBA:

**enable= enable=**

**repro=raw,15,15 repro=read,18,18**

**locate=201,1,40,r locate=201,1,40,w**

**peak=3,1,r peak=3,1,w**

**st=for,135,off st=for,135,off**

(wait for the tape drive to spin-up to speed)

**locate locate**

**peak peak**

**peak peak**

For Mark III/VLBA: use the VLBA commands above.

Watch the eye-pattern oscilloscope while **locate** is running. It should step through a range of positions, one of which should show some reproduce signal. **locate** will leave the read head at the position of the largest signal it measured. The **peak** command should move to the position of maximum response in a few steps. A clear eye-pattern should be visible on the oscilloscope. The second **peak** command will allow you to evaluate how stable the voltage location of the peak is. Compare the values of the last parameter on the two **peak** response lines. The values should differ by no more than 0.1 volts, which is a very generous tolerance in case the tape hasn't been pre-passed and was stored at -30. While looking for the peak, the tape footage obviously must be kept in the range of 1000-2000 feet, since this is where the recorded track is. You will have to monitor the footage, if you overshoot 2000 feet, reposition to 1000 feet and start again.

If **locate** fails to find something that looks like a track, some detective work will be necessary. You can start by looking over a wider range with the **locate** command. If the first parameter of **locate** is doubled (to 402), it will double the search range. Be sure to return the head to the starting position by re-issuing the **stack** command before you try **locate** again. If this doesn't work, you could try searching by manually moving the read head with the push-buttons on the head controller and watching for a signal on the oscilloscope. If you still can't find it, try recording from 2000-3000 feet. Watch the oscilloscope for interference from the write head. This helps verify that the head is actually writing. If you find the track and it was actually very far off from the initial position, more than 200 microns as measured by the **stack** command, you will need to increase the search ranges defined in the **locate=** commands in the hcal.snp schedule. If you never find the track, get assistance from Haystack or Goddard.

## 4.3 Reproduce Signal Level

Finally, it should be verified that the peak reproduce level is high enough that the software can unambiguously differentiate it from noise. Two voltages need to be measured for this check: the peak reproduce signal and noise level. The peak reproduce signal can be taken from the peak voltage level parameter of one of the **peak** command responses from the previous test of peaking-up. The reported voltage should be in the range of 0.5-2.0 volts for 135 ips reproduce. If it is not in this range, it may be necessary to adjust the attenuation at the input to the reproduce power detector.

For the VLBA2 drive it isn't clear at this time what will need to be done about the reproduce signal level. Probably the only viable option will be to change the threshold for the minimum peak signal level as determined in the next section. If there is a reasonable signal level for a real peak, say 0.1 volts or higher this should be the only change necessary.

Check the noise level for the reproduce power by positioning the tape to 2000 or 3000 feet, beyond any recorded tracks from previous steps, and using the **peak** command to attempt to peak-up on some blank tape:

for Mark III: for VLBA:

```
stack=-,350,,f stack=-350,,f
```

```
repro=raw,15,15 repro=read,18,18
```

```
enable= enable=
```

```
peak=3,1 peak=3,1
```

```
st=for,135,off st=for,135,off
```

(wait for spin-up)

```
peak peak
```

For Mark III/VLBA: use the VLBA commands above.

The reported peak level should be below 0.2 volts. If it is not, the default minimum peak voltage used by the **peak** command, 0.2 volts, may need to be increased. This minimum is set by one of command parameters for **peak**. A reasonable choice is a voltage at least twice the noise level or less than half the read signal level. If the default is not acceptable, the **peak=** command in the hdcal schedule will have to be modified to use a better value.

Assuming these checks have all succeeded, you can move onto the calibration itself, section 2.0 above. This tape can be used if you haven't written on the last 4200 feet of tape.

## 5.0 Handling Missing hdcalc Parameters

If, after running the hdcal schedule, there are null parameters in the output of the hdcalc command (other than the ones that are correctly null if you have a VLBA recorder), then the calibration procedure has failed at some point. For the VLBA drive the read head parameters should be null. This section explains how to identify what went wrong and complete the calibration. If you have any values missing, please save the log and contact Goddard. We will want to understand the problem so that a better procedure can be developed.

The response of the hdcalc command is derived from values stored by the savev command. If there are missing parameters in the hdcalc response, then there must also be missing parameters in savev response. Issue a savev command and inspect the response to determine which parameters are missing. The values are printed in the order:

```
savev/v revw,v 15rev,v 15for,v 15scale,v 13,v 15flip,v w0,v w8
```

The sub-sections below describe what to do if any of these values are missing. At this point, it is not necessary to understand what these parameters represent. They are described in detail in the section titled What the Calibration Schedule Does.

### 5.1 Write Head Parameters

The last two parameters in the savev response are write head positions. If one of them is missing and you are using a Mark III drive, then something truly disastrous has happened. These parameters are not used for the VLBA drive. Either the schedule has screwed-up or the write head positioning failed to converge. In either case, you should determine what went wrong before continuing. You can look at the log for error messages or start the calibration procedure over again and watch it to see what goes wrong. Of course, if the problem is intermittent, it may not re-appear. After fixing the problem, if it re-occurs, you should re-run the calibration schedule with a fresh tape.

### 5.2 Read Head Parameters

The first six parameters in the savev response are read head positions measured after peaking the reproduce signal. If one of these parameters is missing, the corresponding peaking operation failed to find a good peak. It is possible to recover in one of three ways: (1) look at the log produced by the schedule to see if there are usable position measurements that were not saved, (2) reposition the tape and attempt to re-measure the missing positions, (3) re-run the schedule and watch it to see which measurements are failing. The steps to take for each of these options are discussed below. After the three options are discussed, how to complete the calculation is described.

#### 5.2.1 Recovering Positions From the Log

Examining the log is the quickest method of recovering, if it works. The explanation of what to do is a bit long-winded though. For a voltage mnemonic *x* that was not successfully saved, there is some point in the schedule where a savev=*x* command was issued. Closely preceding the savev=*x* should be the results of three separate peak commands. The third peak response must have an *f* for the next to last parameter. This parameter is *f* (for false) to indicate that peak thinks the position did not correspond to a true peak, it would be *t* if it thought it was a real peak. savev will not save the position if peak indicated a false peak. (This is just about the only error detection in the whole calibration process.)

There are two reasons that peak might think that the peak was false: either the interpolated peak measurement was not well centered among the last three positions sampled, or the signal level was below that required to be considered a good peak. The minimum signal level is 0.2 volts by default, but it is a settable parameter of the peak command. You can determine if the signal level was the problem by comparing the measured peak voltage and the acceptable minimum that was used, both are displayed in peak command response. If the *f* parameter was given because the signal level was too low, there is probably no hope of recovering using this method. The peak command probably never even found the track. You should just go to the method of re-measuring the positions discussed below.

If the signal level is high enough and the second peak command indicated a true peak, then the third peak may have failed because a tracking glitch moved the interpolated peak too far away. In this case you may be able to recover. Compare the peak positions for the responses from the first and second peak commands.

If they agree within about 0.03 volts, the value reported by the second peak command should be usable. It can be input manually, by issuing a `savev=x,volts` where *volts* is the measured voltage position from the second peak command.

### 5.2.2 Re-measuring Positions

If acceptable values are not found from the log, it will be necessary to position the tape to the correct area and attempt to re-measure the values. Table 7.1 contains a list of the footage counter ranges, nominal read head positions, tape motion direction, read track, and tape orientation used for measuring the read head position for the different voltage parameters. You can reposition the tape to the appropriate footage, reset the appropriate command parameters, and attempt to measure the track location. For example to re-measure  $v_{15flip}$ , the set-up commands would be:

for Mark III: for VLBA:

tapepos=1000 rec=1000

(wait for tape to complete positioning)

stack=-, -350,,f stack=-350,,f

(always use the forward calibration)

repro=raw,15,15 repro=read,18,18

st=for,135,off st=for,135,off

(wait for the tape to spin-up to speed)

(peak the reproduce signal)

For Mark III/VLBA: use the above VLBA commands.

To peak the reproduce signal you can use some combination of the read head inchworm push-buttons, the locate and peak commands, and the oscilloscope. If you finally find the peak with the peak command and peak indicates a true peak, you can save the voltage by issuing a `savev=x` command where *x* is the mnemonic for the voltage being saved. If you end up finding the peak by using the inchworm push-buttons and watching the eye pattern on the oscilloscope, you can measure the final position voltage with the `lvdt` command. The result can be saved by issuing a `savev=x,volts` command, where *volts* is the position of the read head (write head for VLBA drive) returned by the `lvdt` command.

If  $v_{15flip}$  is one of the missing values, it should be re-measured first, since the tape is already mounted in the flipped orientation at the end of the schedule. To re-measure other values, the tape will have to be returned to its normal orientation and the footage counter reset to make the footage values in Table 7.1 correct. To get the footage counter reset correctly, flip the tape back to its normal orientation. Then with all the tape on the take-up reel run the drive in reverse with the `srw` command for 2m32s, if your "super-fast" speed is 330 ips. This will place the tape at about 4200 feet from the far end. If your speed is lower than this you will have to wait longer to get the tape to the same spot. When the tape drive stops, reset the footage counter with the command: `tape=low,reset` (Mark III drive) or `rec=zero` (VLBA drive).

### 5.2.3 Starting Over

The third approach for recovering is to start over with a fresh tape and monitor the schedule as it's running. When the `savev` command(s) fail, stop the schedule with the `halt` command, reposition the tape and try to re-measure the track manually using the methods described for the preceding approach. Once the peak is located, save the value with a `savev` command. Restart the schedule after issuing a `list` command to see what is coming next. Some tape and/or schedule positioning maybe necessary to get things back on track.

### 5.2.4 Finishing Up

If you used one of the first two recovery approaches and have stored all the voltages, you will need to re-calculate the calibration parameters and inchworm speeds (the third approach does this automatically since it uses the schedule). To finish the calculations, issue these commands:

for Mark III: for VLBA: for VLBA2:

hdcalc hdcalc hdcalc

lvdt=0,0 lvdt=0

worm=write,new worm=write,new

worm worm

worm=read,new

worm

If `hdcalc` now produces a complete set of commands you can proceed with saving the calibration parameters as outlined in step (9) of the Calibrating the Heads section above.

## 6.0 Evaluating Results of Head Calibration

Once a full set of calibration parameters have been determined, they can in principle be used right away. However, they should be checked at least a little. Three checks are described in this section: (1) checking parity error rates, (2) checking forward-reverse guard bands, and (3) repeating the calibration.

### 6.1 Parity Check for Head Calibration

The most important check that should be made is to record some tracks and make sure they can be played back. For this check, take the following steps:

- (1) Install the new calibration constants in head.ctl and restart the Field System.
- (2) Mount a fresh tape, pre-pass it, and then position it to 1000 feet.
- (3) Record mode C pass 1 from 1000-2000 feet at 135 ips.
- (4) Check the parity errors with check2c1.
- (5) Record mode C pass 2 from 2000-1000 feet at 135 ips.
- (6) Check the parity error with check2c2.
- (7) Record mode C pass 23 from 1000-2000 feet at 135 ips.
- (8) Check the parity errors with check2c1.
- (9) Record mode C pass 24 from 2000-1000 feet at 135 ips.
- (10) Check the parity errors with check2c2.
- (11) Re-check the parity errors for mode C pass 2 with check2c2, after re-setting up with sx2c2=2.
- (12) Position the tape to 2000 feet.
- (13) Re-check the parity errors for mode C pass 1 with check2c1, after re-setting up sx2c1=1.
- (14) Re-check the parity errors for mode C pass 23 with check2c1, after re-setting up with sx2c1=23.

The results of all the parity checks should show acceptable rates. What is acceptable depends somewhat on the recorder and the heads, but parity error rates of less than 600 are typical. If the read head position is off a little bit, the error rates will be larger than they should be. You might try using the peak command to see if you can find a better peak response and then try the parity check again. If the level of errors in the re-check of passes 1, 2, or 23 are significantly higher than in the original checks, there may be some overwriting of adjacent forward-reverse tracks. If this is so, the forward-reverse guard band test, discussed next, is strongly recommended.

## 6.2 Forward-Reverse Guard Band Check

The forward-reverse guard band test is one of the most complete checks of the head calibration. The layout of passes for mode C is shown in a figure in the [System Setup](#) manual. Starting with the tape recorded in the parity check test discussed above, follow these steps:

- (1) Position the tape to 2000 feet.
- (2) Set-up the read head to reproduce mode C pass 2 and set-up the peak command:

for Mark III: for VLBA:

```
sx2c2=2 sx2c2=2
```

```
enable= enable=
```

```
repro=raw,16,16 repro=raw,19,19
```

```
peak=3,1 peak=3,1
```

- (3) Start the tape moving in reverse:

```
st=rev,135,off
```

If during the course of completing steps (4) through (8) below, the tape footage goes below 1000 feet, stop the tape, reposition to 2000 feet and continue where you left off.

- (4) When the tape comes up to speed, issue the peak command to find the peak response.
- (5) When peak completes, issue a pass command to measure the current head positions. The last parameter, read head delta position, indicates how far the peak is from the nominal location, typically a few microns.

(6) While the tape is moving, use the push-buttons on the head controller to move the read head away from the plate. Select: Inchworm Two, Out ("Forward" on Burleigh controllers), and Slow.

(7) With your finger over the "stop" button on the inchworm controller, watch the eye-pattern on the oscilloscope. This reproduce signal should fade away to no signal and then a new reproduce signal should start to increase. When a signal starts to appear, usually within about 5 seconds, press the "stop" button.

NOTE: You can also do steps (6) and (7) using the stack command to move the head. Check the head position, then move the head in increments of about 30 until you find the track. Be sure to specify the correct calibration type, f or r, when you move the head.

(8) Issue another peak command to find the peak of this track. The eye pattern will not be clear, because you are running in reverse over pass 23, which was recorded in forward.

(9) Issue another pass command to determine the delta for the peak of this track. The delta should be close (20 m) to 93.5 m.

(10) The difference of delta parameters from steps (5) and (9) gives the peak-to-peak distance between passes 2 and 23.

(11) Stop the tape, and reposition it to 2000 feet.

- (12) Set-up the read head to reproduce mode C pass 24:

for Mark III: for VLBA:

sx2c2=24 sx2c2=24

enable= enable=

repro=raw,16,16 repro=raw,19,19

peak=3,1 peak=3,1

(13) Start the tape running in reverse:

st=rev,135,off

(14) Repeat steps (4)-(10). This time in step (6) move the read head toward the deck plate using the "in" button (reverse on Burleigh controllers). The result calculated in step (10) is the peak-to-peak distance between passes 1-24.

Both peak-to-peak distances should be about 93.5 20 m. If this test fails or the results are marginal (the values differ by more than about 40 m), it is recommended that the calibration be tried again to see if it is repeatable. Evaluating repeated calibrations is discussed next.

### 6.3 Repeated Calibrations

It is useful to repeat the calibration procedure two or three times to see how much variation occurs in the calibration parameters. Having several samples also helps to determine if a particular calibration run is an outlier compared to the rest. Don't average different measurements to get a final value, simply choose one that is close to the mean. This reduces the chances of a data handling error.

If the hdcalc schedule ran without any problems and the hdcalc command produced all the calibration constants without additional work, then it is likely that the calibration procedure will work reliably for your tape drive. It should be easy to re-run the schedule. Be sure to use a freshly degaussed tape for each run. Repeated measurements should have less than 5 m variation in the offset constants (the first four hdcalc output parameters). The scale factors (the last two hdcalc output parameters) should vary by no more than about 1%. The calibration constants may vary systematically between different tapes.

## 7.0 What the Head Calibration Schedule Does

The procedure used to calibrate the heads was originally developed at Haystack by Dan Smythe and Alan Whitney. A copy of their memo describing the procedure is included at the end of this document. This section describes the assumptions made by the schedule, the sequence of operations performed, and design considerations for the schedule.

### 7.1 Assumptions

The schedule file hdcalc.snp should be able to calibrate any "normal" tape drive. A normal tape drive meets the following assumptions:

- (1) Mark III write head tracks 15 or 16 work.
- (2) Mark III read head track pairs 13 and 15 or 14 and 16 work.
- (3) Both inchworms can move over their full range of motion, 10 volts.
- (4) The calibrated head offsets all have an absolute value of less than about 100 m.
- (5) The voltage scales are within about 15% of the nominal 150 m per volt.
- (6) The fast inchworm speed is no less than 100 m/s.
- (7) The tape drive acceleration meets the specification of going from 270 ips to stopped in 45 5 feet.
- (8) The footage counter is reliable.
- (9) The peak reproduce power level when reproducing a track at 135 ips produces a signal level measured at the A/D of 0.5-2.0 volts.
- (10) The noise level when reproducing on a blank tape at 135 ips produces a signal level measured by the A/D of less than half the value of the peak reproduce level.
- (11) The voltage offset in the LVDT read-out has an absolute value of less than about 0.6 volts.

Tapes drives that do not meet these assumptions of "normality" can probably still be calibrated, however the hdcalc.snp schedule will probably have to be modified or the calibration done manually.

### 7.2 Sequence of Operations

The sequence of operations that are used in the schedule are described here. Table 7.1 at the end of this section summarizes the tape footage range, read track, nominal read head position, tape motion direction, and tape orientation associated with each head position voltage that is saved.

The operations performed by the schedule are (described with parallel numbering to Dan and Alan's memo).

- (0) Set-up the Field System parameters and (except for VLBA2) make an initial refinement of the inchworm speeds.
- (1) Rewind the tape 3200 feet. For VLBA or VLBA2 rewind 2200 feet.
- (2) Set the write head to a "forward calibrated" position of -350 m. Save the write head voltage position as  $v_{w0}$ .

For VLBA or VLBA2, skip to step (5).



- (3) Record track 15 for 1000 feet in the reverse direction. Reset the footage counter. The range of footage for the recorded track is 0-1000 feet after the footage counter has been reset.
- (4) Playback the track recorded in step (3) in the forward direction peaking the reproduce power with read track 15. Save the read head position voltage as  $v_{rev}$ . Footage range is 0-1000 feet. Nominal read head position -350 m.
- (5) Position the tape to 2000 feet. For VLBA set the footage to 2000 feet. For VLBA2, continue to the next step.
- (6) Record track 15 in the forward direction to the end of the tape. Footage range 2000-3800 feet.
- (7) Playback the track recorded in step (6) in reverse direction, peaking the reproduce power with read track 15. Save the read head position voltage as  $v_{15rev}$ . Footage range 3000-2000 feet. Nominal read head position -350 m.
- (8) Playback the track recorded in step (6) in the forward direction, peaking the reproduce power with read track 15. Save the read head position voltage as  $v_{15for}$ . Footage range 2000-3000 feet. Nominal read head position -350 m.

For a VLBA or VLBA2 drive, skip to step (13).

- (9) Position the tape to 1000 feet.
- (10) Set the write head stack to a "forward calibrated" micron position of 850 m. Save the write head voltage position as  $v_{w8}$ .
- (11) Record track 15 in the forward direction for 1000 feet. Footage range 1000-2000 feet.
- (12) Playback the track recorded in step (11) in the forward direction, peaking the reproduce power with read track 15. Save the read head position voltage as  $v_{15scale}$ . Footage range 1000-2000 feet. Nominal read head position 850 m.
- (13) Position the tape to 2200 feet.
- (14) Playback the track recorded in step (6) in the forward direction, peaking the reproduce power with read track 13. Save the read head position voltage as  $v_{13}$ . Footage range 2200-3200. Nominal read head position 1047 m.
- (15) Run the tape off the end of the reel. Reload it in the flipped orientation.
- (16) Playback the track recorded in step (6) in the forward direction, peaking the reproduce power with read track 15. Save the read head position voltage as  $v_{15flip}$ . Footage range 1000-2000. Nominal read head position -350 m.
- (17) Calculate the calibration parameters:

For VLBA drives only the "read" head parameters are calculated. However these are actually the correct values for the "write" head. There is only one head on a VLBA drive.

Read head voltage scale:

$$S_{read} = \frac{1397 \mu m}{(v_{13} - v_{15scale}) \text{ volt}}$$

Write head voltage scale, generalized to include the actual voltage at which the tracks were written:

$$S_{write} = S_{read} \frac{(v_{15for} - v_{15scale}) \mu m}{(v_{w8} - v_{w8}) \text{ volt}}$$

Read head reverse relative offset:

$$\delta_{read} = (v_{15rev} - v_1)$$

relative offset:

$$\delta_{write} = (v_{15for} - v_{15rev}) S_{read} \mu m$$

Write head forward absolute offset:

$$\Delta_{write} = \frac{(v_{15for} - v_{15scale})}{2} S_{read} +$$

offset:

$$\Delta_{read} = \frac{(v_{15for} - v_{15scale})}{2} S_{read} + 350 \mu m$$

(18) Remeasure the inchworm speeds with the new voltage scale.

Table 7.1. Footage ranges, nominal read head positions, tape direction, read tracks, and tape orientation to use to find specific voltages on the calibration tape.

Voltage Mnemonic	Footage Range	Read Head Position (m)	Tape Motion Direction	MkIII Read Track	Tape Orientation
$v_{rev}$	0000-1000	-350	forward	15	normal

<i>v15rev</i>	3000-2000	-350	reverse	15	normal
<i>v15for</i>	2000-3000	-350	forward	15	normal
<i>v15scale</i>	1000-2000	850	forward	15	normal
<i>v13</i>	2200-3200	1047	forward	13	normal
<i>v15flip</i>	1000-2000	-350	forward	15	flipped

### 7.3 Design Considerations

This section describes some of the considerations that went into the design of the `hdcal.snp` schedule. This section will probably only be useful to people who wish to understand why the schedule does the things it does. The differences between Dan Smythe and Alan Whitney's original procedure are described. Features of the Field System implementation of the procedure are discussed as well.

#### 7.3.1 Differences From the Original Procedure

A few features were changed from Dan and Alan's memo:

- (1) The calibration tracks are written -350 m (out) from the positions used in the memo. This gives a more symmetric use of the position voltage range.
- (2) The positions are commanded by micron using the "forward" calibration. This automatically positions the heads with a -698.5 m offset if the heads are defined as even in the `head.ctl` control file.
- (3) For systems with even write heads, track 16 is used for writing.
- (4) The positions that the calibration tracks are written at are measured rather than assumed. This makes the calibration more robust in the presence of positioning errors and allows the location of written tracks to be moved.
- (5) The footage at which the tracks are written and reproduced were adjusted so that a full 1000 feet of recorded tape would be available for each track peaking operation without getting within 1000 feet of the tape ends. This reduces the chances that tracking problems near the ends will affect the results.
- (6) For VLBA drives only one track needs to be written and it used to determine all the parameters for the one head. The actual location where the track is written is never used.

Features (1)-(4), along with some generalization of the enable and repro Field System commands, allow the same SNAP schedule to be used for any combination, all, odd, or even, of read and write heads.

#### 7.3.2 Features of the Field System Implementation

This section discusses features of the Field System implementation of the calibration procedure beyond those discussed in the previous section.

In order to automate the original procedure for field use, new Field System commands, `locate` and `peak`, were written to support peaking up on a recorded track.

Because of variations in tape drives, inchworm speeds, head offsets, and tracking, it was necessary to make the schedule as insensitive to such variations as possible. Toward this end, the following features are incorporated in the schedule:

- (1) When attempting to peak-up the reproduce power, a coarse grid search is done with the `locate` command to find the track first. This helps find the track even in the presence of large head offsets.
- (2) The fine peaking performed by the `peak` command is done three times for each track peaked-up on. Two measurements of the peak location are needed at minimum, since the track may not be well centered during the first measurement. The third measurement can be compared to the second to evaluate how stable the measured peak position is.
- (3) After a peaking operation is complete, the tape is positioned with the `tapepos` command (Mark III) or `rec` command (VLBA) before the next operation, since the actual footage at which the peaking will complete is unpredictable. The schedule must wait for the worst case `tapepos` or `rec` to complete before continuing.
- (4) The `locate` command for peaking on the flipped tape is done in a separate pass to allow a wider range of positions to be searched. Flipping the tape magnifies the effect of a write head misalignment by a factor of two. `peak` is used on the second pass.
- (5) At the start of the schedule, a first cut is made at the inchworm speeds to make sure they aren't completely unreasonable.
- (6) The `tape` command is issued before and after writing and reproducing tracks. This is intended to provide information to assist in interpreting the log for debugging purposes.
- (7) The `hdcalc` command takes the head configuration in `head.ctl` into account when calculating the calibration parameters.

Like the original procedure, the Field System implementation includes these features:

- (1) The peaking operations, using the `locate` and `peak` commands are done on a minimum of 1000 feet of a recorded track. This allows for some variation in inchworm speeds, tape positioning, and difficulty locating the track.
- (2) Only one track is written in any footage range on the tape. This helps prevent confusion over which track is being reproduced.

## 8.0 headp

`headp` is a utility used in conjunction with the narrow track calibration software. After calibration parameters have been determined, `headp` can be used to save the results in a file.

The results are saved by default in output file `/usr2/control/head.new`. Alternatively, the user can specify the output file name when the program is invoked by typing:

**headp output**

where *output* is the pathname for the output file. If the output file already exists, headp will stop without modifying the file.

The output file for headp is in the same format as the head.ctl file described in the Control Files manual. Data from the first two records are the same as those in the most recently used head.ctl file. The remaining information comes from the most recent calibration results.

In order to help prevent partial or incorrect results from being written to disk, headp will not save the results if any of the calibration parameters have not been calculated or either inchworm has not had its speed calculated. In order to save partial results it is necessary to hand enter them into the file.

## 9.0 Special Head Cal Cable for Mark III/VLBA

In order to calibrate a VLBA recorder connected to a Mark III rack a special cable or connector is required. The connector or cable should be used to connect the J11 connector on the back of the Mark III formatter to the J2 connector on the VLBA recorder I/O panel. This will allow only Mark III track 15 to be written. To write only Mark III track 16, connect J12 to J1.

### 9.1 Cable

One end of the cable is terminated with a 50-pin connector that will fit the J11 or J12 connectors on the back of the Mark III formatter. The other end is terminated with a 40-pin connector that will fit the J2 or J1 connectors on the VLBA recorder I/O panel. Six conductor twist-flat is recommended for the cable. The required connections are:

#### Mark III Formatter VLBA Recorder

##### Back Panel I/O Panel

J11, J12 J2, J1

50-pin 40-pin

##### Function Pin Pin

GND 1 37

GND 2 38

+Clock 17 39

-Clock 18 40

+HD 15(V18), 16(V19) 19 19

-HD 15(V18), 16(V19) 20 20

### 9.2 Connector

This approach uses a single 3M Intra-connector with some pins snipped off. This is a 'T' connector with two sets of male pins connected to a female socket. Only one of the sets of male pins needs to be modified. The female socket can be attached directly to the connector on the formatter or the tape drive. The normal formatter to recorder cable can be connected to the modified pin set. The unmodified male pins can be used to connect the system for normal recording.

The connector can be placed on either the VLBA recorder I/O panel or the Mark III Formatter. For the VLBA recorder, use 3M part No. 922576-40-I and snip off pins 5-18 and 21-32. For Mark III formatter, use 3M part No. 922576-50-I and snip pins 3-16 and 21-32.

[As an aside: The connector for the Mark III formatter would also work for a Mark III formatter connected to a Mark IV recorder. Alternatively, on the Mark IV recorder side, use the 40 pin connector and snip pins 7-20 and 23-24.]

## 10.0 Listing of hdcal.snp Schedule (Mark III)

The section lists the schedule for calibrating a Mark III drive. The schedule is distributed with the Field System in /usr2/fs/st.default/sched/hdcal.snp. The local working copy which is kept in /usr2/sched/hdcal.snp may have been customized.

- [10.0 Listing of hdcal.snp Schedule \(Mark III\)](#)

## 11.0 Listing of vhdcal.snp Schedule (VLBA)

The section lists the schedule for calibrating a VLBA drive which has a VLBA DAR. The schedule is distributed with the Field System in /usr2/fs/st.default/sched/vhdcal.snp. The local working copy which is kept in /usr2/sched/vhdcal.snp may have been customized.

- [11.0 Listing of vhdcal.snp Schedule \(VLBA\)](#)

## 12.0 Listing of 3vhdcalsnp Schedule (Mark III/VLBA)

This section lists the schedule for calibrating a VLBA drive which has a Mark III rack. The schedule is distributed with the Field System in /usr2/fs/st.default/sched/3vhdcalsnp. The local working copy which is kept in /usr2/sched/3vhdcalsnp may have been customized.

- [12.0 Listing of 3vhdcalsnp Schedule \(Mark III/VLBA\)](#)

## 13.0 Listing of v2hdcalsnp Schedule (VLBA2)

The section lists the schedule for calibrating a VLBA2 drive which has a VLBA DAR. The schedule is distributed with the Field System in /usr2/fs/st.default/sched/v2hdcalsnp. The local working copy which is kept in /usr2/sched/v2hdcalsnp may have been customized.

- [13.0 Listing of v2hdcalsnp Schedule \(VLBA2\)](#)