Simplified Mark 5A System Testing Procedures

Alan R. Whitney
MIT Haystack Observatory
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This memo describes a set of simple procedures for verifying the proper operation of a Mark 5A VLBI system as a <u>data-acquisition system</u>. For more complete procedures, including testing as a playback system into a correlator, see the Mark 5 web site at http://web.haystack.mit.edu/mark5/Mark5.htm.

Equipment Requirements

The minimum equipment required to perform a full test suite, not including the unit under test (UUT), includes:

1. One Mark 5A unit under test (UUT).
2. One Mark 4 decoder.
3. One Mark 4 formatter
4. One 'scratch' disk module loaded with 8 disks.

Note: *All Mark 5A units with I/O Panels must have all 8 jumpers installed on the I/O Panel.*

Note: *Terminator blocks should be installed on all four I/O Panel output connectors.*

Testing strategy

Testing of the Mark 5A is broken into four separate tests:

1. <u>Initial bank testing</u>

    Tests rudimentary functionality of Banks A and B.

2. <u>Test with internal tvg</u>

    Record a small amount of data on from internal Mark 5A test vector generator (tvg) and perform a software check of the recorded data.

3. <u>Test in 'bypass' mode</u>

    With a known good data source and a Mark 4 decoder, test that all 64 UUT input tracks function properly.

4. <u>Record and playback test data on UUT</u>

    Record data to disks and playback to decoder.

Important concepts that will ease understanding test results

The reader is urged to study the basic concepts of the Mark 5A system as explained in the Mark 5A User's Manual. This will help in understanding the tests in this document.

Commands used during testing

We briefly describe here the basic commands and procedures needed to do the testing. For complete details of all Mark 5A commands, refer to the memo 'Mark 5A command set' memo. *Any command may be issued through the Field System by preceding it with "mark5=".*

1. Select active bank

bank_set=A or *bank_set=B*

The disk module in the selected bank must be ready. The keyswitches may also be used to select the active bank.

2. Show VSN

VSN?   Show extended-VSN of module

3. Show disk serial numbers

disk_serial?   Show disk serial numbers on mounted module

4. Erase disks:

reset=erase   Erase *all* data on the selected module.

5. Set data mode

mode=<data mode>:<data submode>

   The Mark 5A must always be set to the data mode that the user desires. Ordinarily, data recorded in a particular data mode must be played back in the same data mode, otherwise the reproduced data will be non-sensical.

mode?   Get current data mode

6. Record data:

'record=on:<scan name>'

   Starts recording from end of current data set. The assigned scan name is stored in a directory on the disk set.

'record=off'   Stop recording

7. Set playback rate

play_rate=clock:<MHz>

   Sets the track-clock rate for playback; default is 9 MHz; range is 0 to 40 MHz (though max VLBI playback clock rate is a function of data mode). Also sets clock frequency of on-board tvg.

8. Set playback for a particular scan

scan_set=<scan_name> (or <scan_number)

   Sets the scan pointer (and play pointer) to the beginning of the named scan.

scan_set? – returns current value

9. Play back single scan

scan_play

> Plays back last recorded scan or scan named in preceding '*scan_set*' command. Stops at end of scan or on '*play=off*' command.

play=on

> Starts playback from current play pointer position. Continues playing subsequent scans until end of recording is reached or '*play=off*' is issued.

play=*off*

> Stops playback and updates play pointer to position at which playback stops.

10. Quick scan check

scan_check?

> This is probably the most useful general check for a recorded scan. To use it, first point to the scan of interest with the command '*scan_set=<scan_name>*'. Then issue the '*scan_check?*' query, which will sample data near both the beginning and end of the scan and return such information as data mode, scan start time, scan length, and track data rate. By examining time tags at the beginning and end of the scan and counting the number of bytes in between, it also determines whether there are any missing or extra bytes in the recorded data.

11. Check tracks with decoder

track_set=<track A>:<track B>

> Set tracks to be examined at Mark 5A output. If track is in headstack 2, add 100. These two tracks are selected to go to decoder channels A and B, respectively, for examination. Note that all 64 output tracks are active in all operational modes (idle, recording, playback) and may be examined at any time.

> Useful shortcut: '*track_set=inc:inc*' will increment the current values of <track A> and <track B>, which is very useful when cycling through tracks for checking purposes.

track_set? - returns current value of *<track A>* and *<track B>*

12. Check tracks recorded on disks

track_check?

> This is the most useful command for checking the data on individual tracks recorded from a formatter. To use it, first set the play pointer to the beginning of the scan of interest with '*scan_set=<scan_name>*'. The track to be examined is *<track A>* as set by the '*track_set*' command and should correspond to a track actually recorded from the formatter (not a duplicated track at the Mark 5A output). The 'track_check' query returns detailed information about the data recorded from the target track, including data mode, time, etc.

13. Check record and playback pointers:

'position?'

> The Mark 5A maintains both a 'record' and 'playback' pointer (in bytes from the beginning of the data set) which indicates the present recording or playback position. Normally, it is not necessary to access these pointers since all scans are referenced by name. However, during initial testing, it is sometime useful to examine the position of the 'record' pointer while recording to see that it is incrementing properly.

14. Check remaining record time

'rtime?'

> Returns remaining record time (in seconds) in the current mode and data rate. Also returns remaining GB, mode:submode, assumed tract data rate (set by *'play_rate'* command), and total recording rate. Note that the Mark 5A has no knowledge of the recording clock rate when recording from the formatter; it simply follows the clock provided by the formatter. Therefore, in order for the *'rtime?'* query to provide an accurate estimate of the remaining recording time, you must specify the track clock rate with a *'play_rate=clock:<rate>'* command.

15. Status

status?

> Returns system status as a hex number. Useful for diagnostic purposes, but you must decode the bits - see 'Mark 5A command set' memo for details'.

Operating the Mark 5A

Refer to the *Mark 5A User's Manual* for details of the operation of the Mark 5A system.

Initialization and Startup[1]

1. Insert a module in Bank A and turn the keyswitch to 'on'.
2. Login name: ****
   Login password: ********
   Contact Richard Crowley (mailto:rcrowley@haystack.mit.edu) or John Ball (mailto:jball@haystack.mit.edu) for logins and passwords.
3. Issue *'script –f [filename]'* if you wish to retain a record of your session. Default file name is 'typescript' in the default directory.
4. Run *'ssopen'*
   This initializes the StreamStor (may take 20 seconds or so).
   If successful, 'StreamStor opened successfully' will be reported.
5. If '*ssopen*' fails, try '*SSReset*' to reset the StreamStor card; then try *'ssopen'* again.
6. Run[2] 'Mark5A -m0 &' ('-m0' turns on debug printout; '&' forces to background[3])

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[1] See the Mark 5A User's Manual at http://web.haystack.mit.edu/mark5/mark5.htm for more details and operating the Mark 5A system.
[2] The Mark5A run string given here is for version 2.4 and later; see Mark 5A Users Manual for earlier versions.

'Mark5A' is the primary operations program for the Mark 5 system and will accept normal Mark 5 commands with VSI-specified syntax.

7. Run *'tstMark5A'*
    tstMark5A is small standalone program[4] with a simple operator interface that allows commands to be sent and responses to be received from Mark5A[5]. It provides the operator with a convenient '>' prompt and accepts the normal Mark 5 commands, but does not require the normal termination semi-colons required by VSI syntax. You may type any command or query from the Mark 5A command set[6].

Test 1 - Initial bank testing

Test that both Banks A and B appear to initialize properly[7]:

With Bank B empty, insert a known-good 8-disk module into Bank A and turn the keyswitch to 'On'. You should observe the following:

a. 'Locked' and 'Power' LED's should illuminate quickly; all 'activity' LED's on module should illuminate (for all buses with installed disks).

b. 'Activity' LED's should extinguish one-by-one from top to bottom; this should progress smoothly, with perhaps a slight hesitation between 2/3 and 4/5, and take no more than a few seconds. If this process stalls or significantly hestitates, there may be a problem.

c. The 'Ready' LED should illuminate, signifying the module is ready to be used.

d. The 'Selected' LED should illuminate indicating it is the active module.

e. Read the VSN – enter *'VSN?'*

Turn the keyswitch to 'Off'; wait for the 'Power' lite to extinguish and give disks a few seconds to spin down. Remove the module, place it in Bank B and repeat the test.

Notes:

This test verifies only some aspects of the operation of the StreamStor board and is entirely independent of the I/O board. The I/O board must be in place for the *Mark5A* program to be happy, but the FPDP jumper cable between the StreamStor board and the I/O board need not be present.

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[3] If you forget to type the '&', you can kill 'Mark5A' by typing Cntl-Z to get a prompt, then 'bg' to put 'Mark5A' into the background, then 'EndM5'.
[4] 'tstMark5A' can be run on the same computer as 'Mark5A' or on a different computer such as ccc. It connects to an m5drive tcp socket on a prescribed computer with Mark5A running, accepts Mark5A commands typed into the controlling terminal, sends these through the socket to Mark5A, and prints replies from Mark5A as read from the socket. The socket configuration in 'tstMark5A.c' can be used as a model for other programs that connect to Mark5A's socket.
[5] The operator interface to *tstMark5A* is a simple text interface. The up-arrow key may be used to scroll back through previous commands, which may be edited and re-executed by pressing 'Enter'. Multiple commands may be entered on the same line, separated by semi-colons. *'tstMark5A <file'* will take commands from *file*.
[6] The complete Mark 5A command set is available at http://web.haystack.mit.edu/mark5/mark5.htm.
[7] Disk bank management is described in detail in the Mark 5A User's Manual, available at http://web.haystack.mit.edu/mark5/mark5.htm.

Test 2 - Test with internal tvg

This test uses the internal tvg as a data source for a test recording.

Requirements: Standalone UUT with scratch module ready in Bank A. Disconnect any cables to formatter.

Procedure

1. *bank_set=A;*   (if bank A not already selected)
2. *reset=erase;*   Erase disk module
3. *mode=tvg;*   Set to tvg mode
4. *play_rate=clock:9;*   Set tvg rate to 9 MHz
5. *record=on:tvg-9;*   Record tvg data (288 Mbps aggregate rate) for 30 secs or so
6. Observe that disk activity LED's on front of module; they should show roughly equal activity.
7. *record=off;*   Turn recording off
8. *scan_check?;*   Check data. Last three returned parameters should be ':0:n1:n2' where *n1* and *n2* have the same value.
9. Repeat steps 4-8, but with *'play_rate=clock:32'* (1024 Mbps aggregate rate).
10. Turn keyswitch A to 'Off', move the module to Bank B, set keyswitch B to 'On' to select. Repeat steps 5-8 with the disk module in Bank B. This verifies that both banks write and read properly at clock rates up to 32 MHz.

Notes:

Testing with the internal tvg verifies operation of the StreamStor board and the Input Section of the I/O board.

Test 3 - Test UUT in 'bypass' mode

Setup:

Set up as shown in Figure 1. Set up the Mark 4 formatter according to Appendix B (64-tracks, 18 Mbps/trk clock rate)

Procedure:

For each 'UUT Data mode' listed in Table 1, perform the following procedure:

1. *mode=<UUT Data mode>;*   Set UUT data mode from Table 1

2. *track_set=2:102;*   Select track 2 from Set 1 and Set2

3. Examine decoder channels A and B for error-free data from the selected tracks (see Appendices C and D)

4. *track_set=inc:inc;*   Increment selected tracks (check current with *'track_set?'* if necessary

5. Repeat above steps 3 and 4 until all 64 output tracks are examined. Note that embedded track numbers in duplicate output track sets will contain the original track numbers.

For a thorough test, repeat this procedure for each 'UUT Data mode' in Table 1.

Notes:

This test is entirely independent of the StreamStor board; the FPDP jumper cable between the StreamStor board and the I/O board need not be present.

The *formatter must provide a clock signal* to the I/O board in order for this test to be successful. The I/O board <u>always</u> takes the clock from the formatter on pins 17 and 18 of the Set 1 Even connector; if the Set 1 Even connector is not connected or no clock is present, this test will fail. The Mark 4 formatter was designed to work with the Mark 4 tape transport by turning off the clock on unused groups of tracks. Therefore, you must be sure that the proper commands are issued to enable tracks and turn the clock on. Note also the issuing an 'et' command to the Field System will turn clocks off!
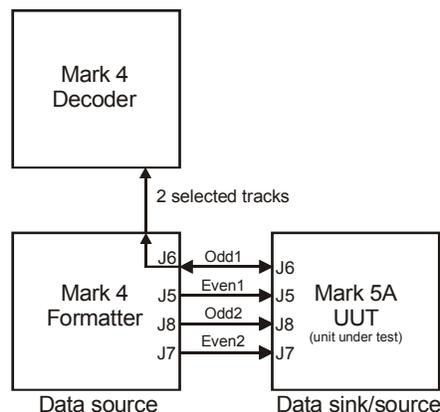
Figure 1: Setup with Mark 4 formatter and decoder

Test 4 – Record and playback data on UUT

<u>Setup:</u>

Set up as shown in Figure 1. Set up the Mark 4 formatter according to Appendix B (64-tracks, 18 Mbps/trk clock rate)

<u>Procedure:</u>

For each 'UUT Data mode' listed in Table 1, perform the following procedure:

1. *mode=<UUT Data mode>;*   Set UUT data mode

2. *play_rate=clock:18;*   Set playback rate so 'rtime' command will work

3. *rtime?;*   Get remaining record time (wait few seconds)

4. *rtime?;*   Make sure record time is diminishing as expected

5. *record=on:<TDM scan name>;*   Start recording, assign same scan name

6. *record=off;*   Turn off recording (after a few minutes)

7. Software check of recording on disk:

   a. *scan_check?;*   Check scan for proper recording (not exhaustive)

   b. *track_set=2; track_check?;*   Set to lowest-number track recorded

   c. *track_set=inc; track_check?;*   Increment selected tracks (check current with *'track_set?'* if necessary); repeat as necessary

8. Check playback to decoder:

   a. *scan_play;*   Initiate scan playback

   b. *track_set=2:102;*   Initialize track selection (check results on decoder)

   c. *track_set=inc:inc;*   Repeat this as necessary to cycle through tracks; check for proper results on decoder

<u>Notes:</u>

This test does not check for proper playback through the I/O Panel Ouput connectors; if this is important, see full Mark 5A testing procedure at the Mark 5 web site.

If you observe a "record pointer not incrementing" while you are trying to record, this probably means that no clock from the formatter is reaching the Mark 5A; see Notes under Test 3.

TDM scan name	KWU Data mode	UUT Data mode	#trks	Clock rate (MHz)	Total recorded data rate (Mbps)	Input tracks		Output tracks	
						Set 1	Set 2	Set 1	Set 2
st-mark4	st:mark4	st:mark4	32	18	576	2-33	-	2-33	2-33
st-mark4	st:mark4	mark4:8	8	18	128	2-17 even	-	2-16 even 3-17 odd 18-32 even 19-33 odd	2-16 even 3-17 odd 18-32 even 19-33 odd
st-mark4	st:mark4	mark4:16	16	18	256	2-33 even	-	2-32 even 3-33 odd	2-32 even 3-33 odd
st-mark4	st:mark4	mark4:32	32	18	512	2-33	-	2-33	2-33
mark4-64	mark4:64	mark4:64	64	18	1024	2-33	2-33	2-33	2-33

Table 1: Test data modes

Shutdown

To end *'tstMark5A'*, type *<Ctrl C>*. This should bring you back to a system prompt.

Then, to end *Mark5A*, type *'EndM5'*. Do not use just <Ctrl C> to try to end *Mark5A* because this sends interrupts to all threads and creates a mess.

To shutdown the OS: From a local console, enter *'halt'* or, from a local or remote console issue *'su'* to become root, then use the normal Linux shutdown *'/sbin/shutdown –h now'*. Root password will be supplied on phone or e-mail request.

Other Utility and Test Programs

'sstest' – erase modules, then writes a small (~30 MB) amount of 'StreamStor test data' to the disks from main memory. Reported as 'SS' on *data_check*, *track_check* and *scan_check* queries.

'SSReset' – standalone SS reset program

'SSErase' – standalone disk-erase and disk-conditioning program; also reports number of disks.

'DirList' – standalone directory listing

Appendix A – Mark 5A cable testing and debugging

Cables and connectors are common sources of problems that are sometimes overlooked during debugging. The following tests and procedures are suggested:

1. Test each new cable by swapping it into a Known Working Unit.

2. If a cable fails, make sure that all connector contacts are clean. Clean as necessary.

3. <u>Check procedures for 68-conductor input cables</u> from I/O Panel to I/O Board (in an otherwise KWU Mark 5A):

<u>Method 1</u>: With a KWU Mark 5A and Mark 4 decoder

Setup: Connect as shown in Figure 2. On the KWU, mount a disk module with a known good recording made in 'mark4:64' mode.

On KWU -

1.	*scan_set=<TDM scan name>;*	Select desired scan (e.g. *'mark4-64'*)
2.	*mode=mark4:64;*	Set data mode
3.	*scan_play;*	Play test scan into UUT

On UUT -

1.	*mode=mark4:64;*	Set data mode
2.	*track_select=2:102;*	Select tracks; there should be no errors on decoder; verify track numbers on decoder (see Appendices C and D)
3.	*track_select=inc:inc;*	Increment tracks; check on decoder; repeat this command until all 64 tracks are checked

<u>Method 2</u>: With only a KWU Mark 5A

Setup: Connect as shown in Figure 2 but without a decoder. On the KWU, mount a disk module with a known good recording made in 'mark4:64' mode. On UUT, mount a scratch disk module.

On KWU -

1.	*scan_set=<TDM scan name>;*	Select desired scan (e.g. *'mark4-64'*)
2.	*mode=mark4:64;*	Set data mode
3.	*scan_play;*	Play test scan into UUT

On UUT -

1.	*mode=mark4:64;*	Set data mode
2.	*record=on:mark4-64;*	Start recording; record for few minutes
3.	*record=off;*	Stop recording
4.	*scan_play=;*	Play scan
5.	*track_select=2; track_check?;*	Select track and do track check
6.	*track_select=inc; track_check?;*	Increment track and do track check; repeat this command until all 64 tracks are checked

Method 3: With KWU Mark 4 formatter and Mark 4 decoder

Setup: Connect as shown in Figure 1. Set formatter for 64-track operation (see Appendix B).
A disk module is not needed.

On UUT -

1.	*mode=mark4:64;*	Set data mode
2.	*track_select=2:102;*	Select tracks; there should be no errors on decoder; verify correct data on decoder (see Appendices C and D)
3.	*track_select=inc:inc;*	Increment tracks; check on decoder; repeat this command until all 64 tracks are checked

4. Check procedure for 68-conductor output cables from I/O Board to I/O Panel (in an otherwise KWU Mark 5A):

Method 1: With KWU Mark 5A and Mark 4 decoder

Setup: Connect as shown in Figure 3. On the UUT, mount a disk module with a known good recording made in 'mark4:64' mode.

On UUT -

1.	*scan_set=<TDM scan name>;*	Select desired scan (e.g. *'mark4-64'*)
2.	*mode=mark4:64;*	Set data mode
3.	*scan_play;*	Play test scan into KWU

On KWU -

1.	*mode=mark4:64;*	Set data mode
2.	*track_select=2:102;*	Select tracks; there should be no errors on decoder; verify track numbers on decoder (see Appendices C and D)
3.	*track_select=inc:inc;*	Increment tracks; check on decoder; repeat this command until all 64 tracks are checked

Method 2: With KWU Mark 5A only

Setup: Connect as shown in Figure 4. On the UUT, mount a disk module with a known good recording made in 'mark4:64' mode.

On UUT -

1.	*scan_set=<TDM scan name>;*	Select desired scan (e.g. *'mark4-64'*)
2.	*mode=mark4:64;*	Set data mode
3.	*scan_play;*	Play test scan into KWU

On KWU -

1.	*mode=mark4:64;*	Set data mode
2.	*track_select=2:102;*	Select tracks; there should be no errors on decoder; verify track numbers on decoder (see Appendices C and D)

3. *track_select=inc:inc;* Increment tracks; check on decoder; repeat this command until all 64 tracks are checked

5. Check procedure for 20-pin decoder cables from I/O Board to I/O Panel (in an otherwise KWU Mark 5A):

Setup: Using four known good 40-conductor cables, configure as shown in Figure 4. On the UUT, mount a disk module with a known good recording made in 'mark4:64' mode.

On UUT -
1. *scan_set=<TDM scan name>;* Select desired scan (e.g. *'mark4-64'*)
2. *mode=mark4:64;* Set data mode
3. *scan_play;* Play test scan into KWU

On KWU -
1. *mode=mark4:64;* Set data mode
2. *track_select=2:102;* Select tracks; there should be no errors on decoder; verify track numbers on decoder (see Appendices C and D)

6. Check procedure for FPDP cable (in an otherwise KWU):

Setup: Install cable under test in otherwise KWU. Insert scratch disk module.

On UUT -
1. *play_rate=clock:8;* Set playback rate 8 MHz
2. *mode=tvg;* Set mode to 'tvg'
3. *record=on:tvgtest;* Start recording; record for 30 seconds or so
4. *record=off;* Stop recording
5. *data_check;* Perform data check

If *data_check* passes, the return will be of the form:

!data_check? 0 : tvg : 0 : n : m ; where $n=m$; if n and m are different, there is likely a problem with the FPDP cable

Appendix B - Mark 4 formatter setup procedure

Issue the following commands to the formatter (each is followed by a <CR>):

#92/sta	show status
/lim 99	disable 1pps sync check (if no 1pss present)
/sta	

Sample response: '0x8016 0x8000 0x9207 41 1 8000 11 0 0 0

('8000' is sample rate in kHz)

/rec 1	turns on clock lines to Mark 5
/tim	request current formatter time
/tim 2002 203 17 35 00	set time
/con 210	set to mode 2104 (64 trks, 2 bits/sample, 1:1 fanout)
/rat 16000	enable sample rate to 32MHz
/con 0	set sample rate

Note that these commands may also be issued through the Field System preceded by "form4=".

Appendix C – Interpreting the Mark 4 Decoder Display

The Mark 4 decoder displays information from the two tracks designated by the *'track_set=<trackA>:<trackB>.'* command in the Mark 5A system. Figure 10 shows a view of the display/control portion of the Mark 4 decoder. For purposes of testing Mark 5A systems, the following is important:

The function of the Mark IV decoder is perhaps most easily understood by reference to the front-panel display in shown in Figure 2.

Display

The display is a backlit LCD with 4 lines of 20 characters each.

Display Modes

The desired display mode is selected by repeatedly pressing the 'Mode' button, which cycles through the display modes. The available display modes are as follows:

1. 'A' - displays information derived from tape-track channel A.

2. 'B' - displays information derived from tape-track channel B.

3. 'FRMTR' - displays information derived from four channels of raw-sampled data from the Mark IV formatter (not relevant for Mark 5A checkout).

In the 'A' and 'B' modes, the following information is continuously displayed for the selected channel (see Figure 2):

- 'Time' - decoded time/CRC information. The 'Freeze' button allows the user to 'freeze' the display at a random time to examine, for example, the validity of lower-order time digits. The display is 'frozen' whenever the 'Freeze' button is pushed and held; normal display resumes upon its release.

- 'Aux Data' - displays the current decoded auxiliary-data field. The display is frozen whenever the 'Freeze' button is depressed and held; normal display resumes upon its release. When the 'Freeze' button is depressed, the 'Time' and 'Aux' data displayed are from the same tape frame header. For Mark 5A testing, the most important part of this data is the track number embedded in the auxiliary data, which in Figure 2 are the two digits enclosed by a small rectangle. Set 1 (Headstack1) tracks 2-33 display as '2-33', respectively; Set 2 (Headstack2) tracks 2-33 display as '42-73', respectively.

- 'Errors' - displays four 4-digit error counts for the displayed channel. Counts are cleared when 'Clear' button is pushed; error counting resumes when released. The displayed parity-error count is the number of parity errors over sequential intervals of 400 (default) tape frames; all other error types simply accumulate; however, the parity-error count available through the external RS-232 interface simply accumulates until read. If error counts exceed the available display field, the error count divided by 1000 (and properly rounded) is displayed, followed by a 'k' (e.g. 35kP indicates ~35000 parity errors).

- 'PCAL' - extracts 10 kHz phase-cal amplitude and phase from the decoded data stream and displays results. The last field of the PCAL line alternately displays the track data rate (without parity) in MHz and the data sample rate (Msamples/sec) inferred from the header data.

Errors

Four types of errors are displayed on LED's for each of the decoder channels A and B. Upon the occurrence of each type of error, the corresponding LED will illuminate for *one full tape frame*. The detected error types are as follows:

- 'Parity' -   parity error threshold (software settable, default=0) exceeded in preceding tape frame

- 'NoSync' -detection of a missing 'sync' word (i.e. sync word not detected where expected) in the preceding tape frame.

- 'ReSync' - detection of unexpected sync word in the preceding tape frame.

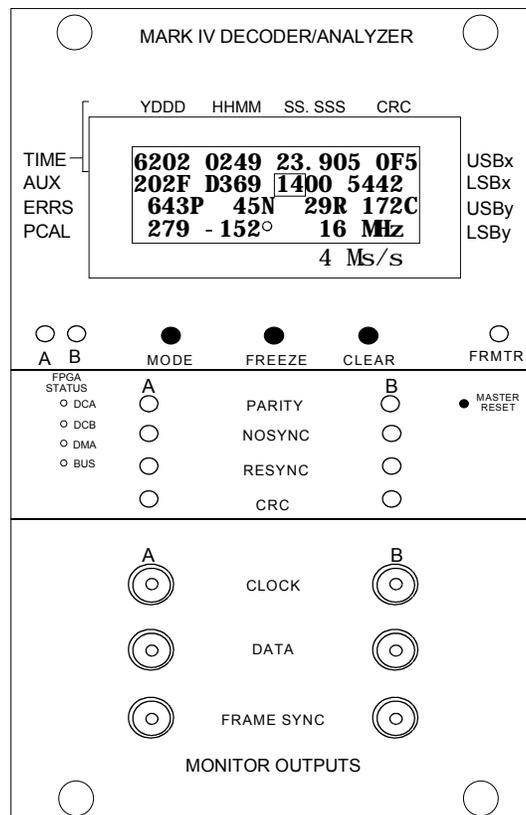- 'CRC' -   detection of cyclic redundancy code error (in Mark 4 tape frame header) in preceding tape frame

Figure 2: Mark 4 decoder front panel

Appendix D – Decoder 'track' numbers as function of 'track_set' values

For each of the Mark 5A data mode, Table 2 lists the track numbers that should be displayed on Channels A and B of the decoder as a function of the 'track_set' values.

'track_set' values	Expected corresponding Decoder Chan A:Chan B 'track' numbers				
	st:mark4	mark4:8	mark4:16	mark4:32	mark4:64
2:102	2:2	2:2	2:2	2:2	2:42
3:103	3:3	2:2	2:2	3:3	3:43
4:104	4:4	4:4	4:4	4:4	4:44
5:105	5:5	4:4	4:4	5:5	5:45
6:106	6:6	6:6	6:6	6:6	6:46
7:107	7:7	6:6	6:6	7:7	7:47
8:108	8:8	8:8	8:8	8:8	8:48
9:109	9:9	8:8	8:8	9:9	9:49
10:110	10:10	10:10	10:10	10:10	10:50
11:111	11:11	10:10	10:10	11:11	11:51
12:112	12:12	12:12	12:12	12:12	12:52
13:113	13:33	12:12	12:12	13:33	13:53
14:114	14:14	14:14	14:14	14:14	14:54
15:115	15:15	14:14	14:14	15:15	15:55
16:116	16:16	16:16	16:16	16:16	16:56
17:117	17:17	16:16	16:16	17:17	17:57
18:118	18:18	2:2	18:18	18:18	18:58
19:119	19:19	2:2	18:18	19:19	19:59
20:120	20:20	4:4	20:20	20:20	20:60
21:121	21:21	4:4	20:20	21:21	21:61
22:122	22:22	6:6	22:22	22:22	22:62
23:123	23:23	6:6	22:22	23:23	23:63
24:124	24:24	8:8	24:24	24:24	24:64
25:125	25:25	8:8	24:24	25:25	25:65
26:126	26:26	10:10	26:26	26:26	26:66
27:127	27:27	10:10	26:26	27:27	27:67
28:128	28:28	12:12	28:28	28:28	28:68
29:129	29:29	12:12	28:28	29:29	29:69
30:130	30:30	14:14	30:30	30:30	30:70
31:131	31:31	14:14	30:30	31:31	31:71
32:132	32:32	16:16	32:32	32:32	32:72
33:133	33:33	16:16	32:32	33:33	33:73

Table 2: Decoder track numbers as function of 'track_set values