Mark 5A System User's Manual

MIT Haystack Observatory
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1. Introduction

The Mark 5A disk-based VLBI data system is designed as a direct replacement for a Mark 4 or VLBA tape transport, both for recording and playback. The Mark 5A has the following characteristics:

- Data rate capability to 1024 Mbps onto a single '8-pack' disk module (Figure 1)
- Uses inexpensive consumer-grade ATA disks
- Strips parity bits from input formatted bit streams (from Mark4 or VLBA formatter) for more efficient storage; restores parity bits on reproduce.
- System is housed in a single 5U chassis (Figure 1) which holds two '8-pack' modules
- Ping-pong switching is supported between the two modules for continuous recording
- e-VLBI support
- Based on a standard PC platform using mostly COTS components
- Linux (Red Hat) OS

The Mark 5A is designed to be used with a Mark 4 or VLBA formatter as the data source and supports recording in 8, 16, 32, and 64-track modes. With the Mark 4 formatter as a host, the Mark 5A can record 64 tracks at 16 Mbps/track for a maximum user data rate of 1024 Mbps. With the VLBA formatter, which supports a maximum of 64 tracks at 8 Mbps/track, the maximum user data rate is 512 Mbps.

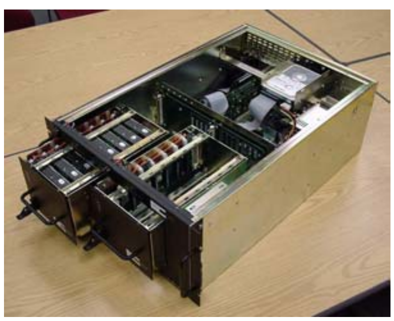

Figure 1: Mark 5A chassis and '8-pack' disk module

2. Brief Theory of Operation

The Mark 5A is based on a standard PC platform and using a combination of COTS and custom-designed interface cards.

The heart of the system is a 'StreamStor' disk interface card from Conduant Corp that is specially designed for high-speed real-time data-collection and playback. The StreamStor card supports three physical interfaces in a 'triangle of connectivity' as shown is Figure 2:

1. Data Port/FPDP: This port is present as a 32-bit card-top bus which supports the industry-standard 'Front-Panel Data Port' interface specification. This is a two-way port through which high-speed real-time data may be either input or output. All 32-bits of the FPDP bus are always active.
2. Disk array: This port supports up to 16 standard IDE disks for reading or writing, arranged in two '8-pack' modules of 4 master/slave pairs each.

3. PCI bus: This is the standard connection to the host PC platform, however the StreamStor card supports a 64-bit/66MHz bus, though it is backwards compatible with standard 32-bit/33MHz buses.

The 'triangle of connectivity' shows that data may be moved in either direction between any two of the three ports. The StreamStor card supports a maximum sustained data transfer rate of up to ~1200 Mbps between any two ports, though only one connection path may be exercised at a time and the maximum data rate for VLBI usage is anticipated to be ~1152 Mbps (1024 Mbps x 9/8 with parity included). The path that is exercised for traditional VLBI observations is between the FPDP bus and the disk array; note that in this mode, the VLBI data never touch the PCI bus, so the speed of the PC platform is largely irrelevant. Of course, the path between the disk array and the PCI bus allows the PC to read and verify VLBI data written to the disks via the FPDP port. The direct connection of FPDP bus to PCI bus will be used in upcoming e-VLBI experiments where data are transferred directly to a high-speed network and are not recorded locally. An on-board 512 MB buffer provides the necessary 'elasticity' between the three connection nodes to support full real-time operation.

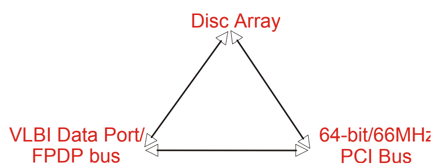

Figure 2: 'Triangle of connectivity'

In order to record or playback VLBI data, a translation must be made between 'normal' VLBI data interfaces (formatters, correlators, VSI) and the 32-bit FPDP bus. This is done by a custom-designed PCI board called the 'I/O Board' which is connected to the StreamStor via the card-top FPDP bus, as shown in Figure 3. The I/O Board accepts data from the output of a Mark 4 or VLBA formatter and translates it to FPDP-bus format. Conversely, the I/O Board accepts data from the FPDP bus (from either the I/O Board or the StreamStor) and translates it back into a form usable by existing Mark 4/VLBA correlators. The I/O Board allows 100% disk utilization when recording 8, 16, 32 or 64 tracks from a formatter by always fanning-in or fanning-out data, as necessary, to the 32-bit wide FPDP bus. Parity bits are stripped before recording improve data capacity by ~12%; parity bits are restored on playback.

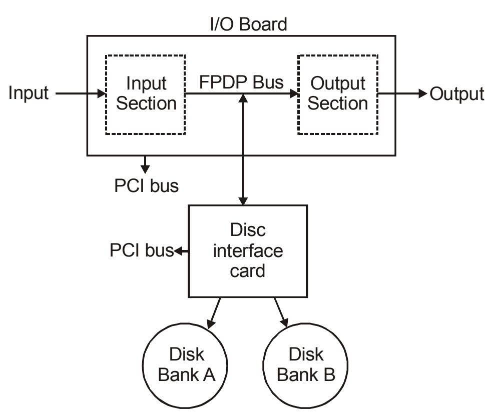

Figure 3: Simplified block diagram of the Mark 5A system

The format of the data recorded to disk is such that barrel-rolling and/or data modulation are not necessary. The StreamStor card collects data from all 'tracks' into blocks of 0xFFF8 bytes and writes these blocks sequentially in a 'round-robin' fashion to the disk array. Therefore barrel-rolling is not necessary; if barrel-rolling is applied, it actually complicates any post-recording analysis by the host PC. Similarly, 'data modulation' is not needed and should not be used.

When recording data to disks, the set of mounted disks records data in much the same way as magnetic tape. That is to say, scans are recorded sequentially, one after another. Once recorded, individual scans may not be erased; only an entire module may be erased.

A scan directory is maintained by the Mark 5A that allows individual scans to be named when recorded. Once recorded, individual scans may be randomly accessed by scan name or sequential scan number. All or part of any scan may be reproduced. The data set may be extended at any time with additional recording, including after removing and re-inserting the disk set.

Data recorded to disks is in a special format optimized for high-speed real-time performance. In addition, the format allows load shifting away from slow or failed disks to maintain error-free recording under less than optimal conditions. However, the data format on disk is entirely transparent to the user.

Several features exist in the Mark 5A system to ensure data integrity and continuity:

1. If a disk becomes slow or fails during recording, the recording load is dynamically adjusted among the disks so that no data are lost [implemented, but not yet enabled].
2. If a disk fails or is missing during playback, the Mark 5 will fill any data gaps with a preset data pattern that can be detected and cause the data to be invalidated at the correlators.

2.1 <u>Operating modes</u>

For normal operation with disks, the Mark 5A system has three basic operating modes (see Figure 4:

- <u>Idle</u> – When the system is 'idle' (i.e. not recording or playing back), the data entering the Input Section passes through the FPDP bus and is re-created (with a delay of a few clocks cycles) at the Output Section. This is also known as 'bypass' or 'pass-through' mode and allows multiple Mark 5A systems to be daisy-chained together to increase overall data capacity.
- <u>Record</u> – This mode is identical to 'idle' mode' except that the disks record the data on the FPDP bus; *recording has no effect on the data on the FPDP bus*. This mode is sometimes referred to as Record/Bypass mode since 'bypass' or 'pass-through' is active while data are being recorded.
- <u>Playback</u> – Data pre-recorded on disk is played back to the FPDP bus and then to the Output Section. In this mode, the playback rate is controlled by a clock provided by the Output Section (either on-board or external) and is independent of the record clock rate.

When recording, the Mark 5A *always* adds a new scan (recording) after the end of the previous scan. No deletion or erasure of individual scans is allowed; an 'erase' command deletes all scans.

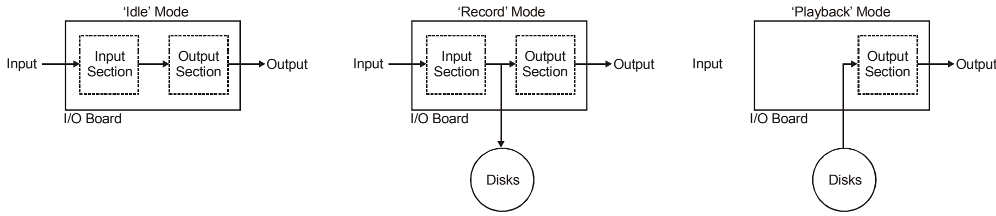

Figure 4: Data paths for the three Mark 5A operating modes

2.2 Data Modes

The Mark 5A can be operated in several different data modes, expressed as a data mode and data submode. The data mode is set by the 'mode' command, which is of the form:

'mode=<data mode>:<data submode>'

1. 'tvg' – (test-vector generator; see Figure 5) an on-board tvg produces a standard VSI test pattern that can be recorded and checked on disk with Mark 5A software.
2. 'st' – ('straight-through' Mark 4 data; see Figure 6) headstack 1 tracks 2-33 are directly recorded using the 32-bit wide FPDP bus connected to the StreamStor card. The data are not massaged in any way; all parity bits are recorded. At the Mark 5A output, the data are duplicated on headstack 2 tracks 2-33. In 'st' mode, the input data may be of any format, but for VLBI usage it will usually be data from a Mark 4 or VLBA formatter. 'mark4' and 'vlba' are defined as two data submodes for the purpose of Mark 5A software being able to interpret data recorded on disk.
3. 'mark4' – (parity-stripped Mark4-format data; see Figure 7) data from a Mark 4 formatter are parity-stripped before being placed on the 32-bit FPDP bus. Data coming off the FPDP bus (in either 'bypass' or 'playback' mode) have parity restored before being output. There are four 'mark4' submodes, corresponding to different numbers of active Mark 4 tracks:
   a. 'mark4:8' – (parity-stripped Mark 4, 8 trks) headstack 1 tracks 2-17 even are parity-stripped and fanned-out across the 32-bit FPDP bus. At the Mark 5A output, parity is restored and data are duplicated on all other track groups (e.g. headstack 1, tracks 2-17 odd, 18-33 even, 18-33 odd; similarly, duplicated four times on headstack 2).
   b. 'mark4:16' – (parity-stripped Mark 4, 16 trks) headstack 1 tracks 2-33 even are parity-stripped and fanned-out across the 32-bit FPDP bus. At the Mark 5A output, parity is restored and data are duplicated on all other track groups (e.g. headstack 1, tracks 2-33 odd; headstack 2, tracks 2-33 even and 2-33 odd).
   c. 'mark4:32' – (parity-stripped Mark 4, 32 trks) headstack 1 tracks 2-33 are parity-stripped before being placed on the 32-bit FPDP bus. At the Mark 5A output, parity is restored and data are duplicated on headstack 2 tracks 2-33.
   d. 'mark4:64' – (parity-stripped Mark 4, 64 trks) headstacks 1 and 2, tracks 2-33 are parity-stripped and fanned-in to the 32-bit FPDP bus. At the Mark 5A output, parity is restored.
4. 'vlba' – (parity-stripped VLBA-format data; see Figure 7) same as 'mark4' mode except data are in VLBA format. There are four corresponding 'vlba' submodes, directly corresponding to their 'mark4' analogs:
   a. 'vlba:8' – (parity-stripped VLBA, 8 trks)
   b. 'vlba:16' – (parity-stripped VLBA, 16 trks)

c. ‘vlba:32’ – (parity-stripped VLBA, 32 trks)
d. ‘vlba:64’ – (parity-stripped VLBA, 64 trks)

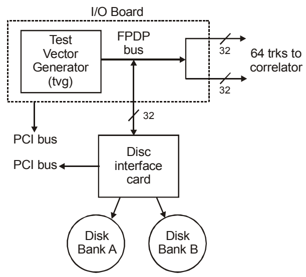

Figure 5: Diagram of 'tvg' data mode

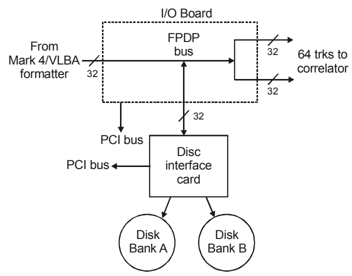

Figure 6: Diagram of 'st' data mode

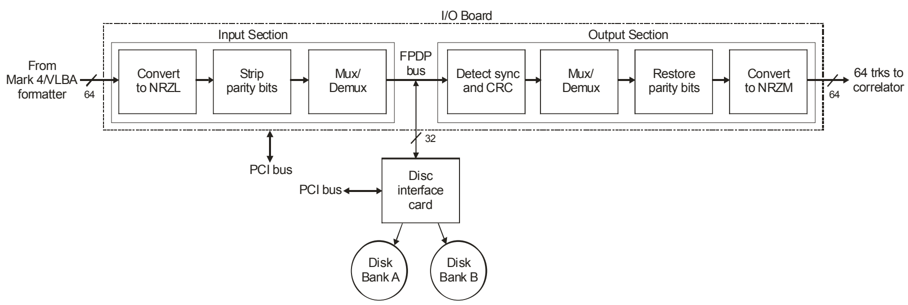

Figure 7: Diagram of 'mark4' and 'vlba' data modes

In the ‘mark4’ and ‘vlba’ data modes, there is active massaging of the data by the Input Section before the data go onto the FPDP bus and active massaging of the data by the Output Section after the data are retrieved from the FPDP bus. In particular, as is shown in Figure 7, the NRZM coding on the formatter output is removed and track-parity bits are stripped before the data are recorded on disk. On playback, the parity bits are restored and coding is restored to NRZM.

2.3 Input Section

The Input Section of the I/O Board receives data either from its internal test-vector generator (tvg) or externally through the I/O Panel and processes it, as necessary, before placing it onto the FPDP bus.

2.3.1 Functional Summary

In ‘tvg’ mode, the internal test vector generator creates a 32-bit wide pattern that is placed directly onto the FPDP bus and recorded by the disks; the clock rate of the tvg is controlled by an on-board clock generator that is shared with the Output Section.

In ‘st’ mode, the 32-bit wide input data stream is placed directly onto the FPDP bus with no processing.

In parity-stripped modes ('mark4:xx' or 'vlba:xx') the track-parity bits are stripped and the data are multiplexed (fanned-in or fanned-out), as necessary, to 32-bit-wide words before being placed onto the FPDP bus.

2.3.2 Brief Theory of Operation

Operation for both 'mark4:xx' or 'vlba:xx' modes are nearly identical and consist of the following steps:

1. Find sync word: Track 16 is examined for a sync word in the track frame header. The detection of a sync word establishes byte framing and allows the parity bit to stripped. This process is repeated each track frame.
2. Multiplex the data to 32-bit-wide field: The parity-stripped data are multiplexed into a 32-bit wide data field before being placed onto the FPDP bus. This maximizes the efficiency of the transfer and guarantees 100% disk utilization for 8, 16, 32 or 64 tracks. Table 1 shows how the data are multiplexed onto the FPDP bus for each of the available data modes.

Data mode	**Active input trk#'s**	**FPDP bit-stream format**	Comments
'st'	2-33 all (Set 1)	Correspond to FPDP bit streams 0-31, respectively; only mode available for Mark 5P	Parity not stripped.
'tvg'	-	32-bit wide data stream onto FPDP bit streams 0-31	No data massaging. Uses on-board clock generator
'mark4:8' or 'vlba:8'	2-17 even (Set 1)	Trk 2 bits distributed to FPDP streams 0,8,16,24, in sequence; trk 4 to 1,9,17,25; etc.	Parity-stripped.
'mark4:16' or 'vlba:16'	2-33 even (Set 1)	Trk 2 bits distributed to FPDP streams 0,16, in sequence; trk 4 to 1,17; etc.	Parity-stripped.
'mark4:32' or 'vlba:32'	2-33 all (Set 1)	Correspond to FPDP bit streams 0-31, respectively	Parity-stripped.
'mark4:64' or 'vlba:64'	2-33 (Sets 1 and 2)	Trks 2 from both hdstks mux'ed to FPDP bit stream 0, etc.	Parity-stripped.

Table 1: Data multiplexing format to FPDP bus for each data mode ('Set' is equivalent to 'headstack')

Note: *It is imperative that Mark 4 rack ID be set to an even value when parity-strip mode is used.* In the Mark 4 tape-frame format, the formatter ID is placed in the byte immediately preceding the sync word. If the ID is odd, the parity-stripped sync word (0xffffffff) has a '1' immediately in front of it which considerably complicates the data recovery and parity-reinsertion process of the Ouput Section. It is not possible to simply set that bit to '0' since it is part of the CRC calculation and would require recalculating the CRC for every track. Therefore, in 'mark4:xx' modes the Input Section detects the presence of a '1' in that position and sets a flag which allows the Mark 5A control software to prohibit operation and warn the user. This is not a problem in 'vlba:xx' mode since the VLBA track format already mandates a '0' immediately ahead of the sync word.

2.3.3 Controls and Status

The following controls are available for the Input Section:

Data Mode: the data modes of the 'st', 'tvg', plus the four 'mark4:xx' and four 'vlba:xx' modes. The tvg clock is derived from the internal clock generator. All other modes are driven by external clocks.

Clock generator frequency: The clock generator frequency may be set from 0 to ~45.4 MHz in increments of $100\text{MHz}/2^{32} \approx 23$ milliHz.

The User may read the following status information from the Input Section:

Odd Rack ID: 1-bit flag indicating an odd-numbered rack ID has been detected in a Mark 4 data stream

Design revision: 8-bit Input Section design revision level

2.4 Output Section

The Output Section of the I/O Board receives data from the FPDP bus and processes it as necessary to re-construct the data sent to the output tracks.

2.4.1 Functional Summary

All 64 output tracks are always active regardless of the Data Mode. The 'primary' output tracks are images of the corresponding input tracks, but for modes with fewer than 64 active input tracks, groups of output tracks are duplicated so that all 64 output tracks are always active (see Table 2).

Data Mode	Primary output tracks	Duplicated output tracks
'mark4:8' or 'vlba:8'	2-16 even (Set 1)	3-17 odd, 18-32 even, 19-33 odd on Set 1; Set 2 is duplicate of Set 1
'mark4:16' or 'vlba:16'	2-33 even (Set 1)	2-33 even on Set 1; Set 2 is duplicate of Set 1
'mark4:32' or 'vlba:32'	2-33 all (Set 1)	Set 1 output is duplicated to Set 2
'mark4:64' or 'vlba:64'	2-33 (Set 1 and 2)	None
'st'	2-33 all (Set 1)	Set 1 output is duplicated to Set 2
'tvg'	equivalent to tracks 2-33	Set 1 output is duplicated to Set 2

Table 2: Output tracks for each Data Mode ('Set' is equivalent to 'headstack')

In addition, any two of the 64 output tracks may be selected to go to the Mark 4 decoder (via a return path through the cables connecting the Mark 5A to the Mark 4 formatter) or the VLBA DQA (via a separate connector on the Mark 5A I/O Panel).

In Bypass mode (idle or recording), the data rate of the output is constrained to be the same as the input; in this case, the clock for the Output Section is simply passed across the FPDP bus from the Input Section to the Output Section. When not in Bypass mode (playback or network-to-output) the data output rate may be controlled either by an on-board clock generator or an external clock. In all but 'mark4:64' and 'vlba:64' modes, the clock-generator or external-clock frequency corresponds directly to the output clock rate; in the 64-track modes, the clock-generator or external-clock frequency is twice the output clock rate.

2.4.2 Brief Theory of Operation

For 'tvg' and 'st' modes, the Output Section does nothing except pass the data through to the output (with a few clock cycles of delay).

In all parity-stripped modes ('mark4' and 'vlba' modes), however, the Output Section must synchronize to the data and restore parity. This is a multi-step process, as follows:

1. Set the Data Mode: The Data Mode of the Output Section is set by the user to according to the data expected on the FPDP bus[1]
2. Decode the 32-bit wide FPDP data into 'track' data streams: Except in the 64-track case, there is no ambiguity. In the 64-track case, two tracks are multiplexed on to each FPDP bit stream and, until further processing is done, the corresponding output track assignments have a 2-way ambiguity.
3. Choose a track pair to examine for synchronization: In 8 and 16-track modes, the track-pair selection cycles through Set 1 track-pairs (2,4), (6,8), (10,12) and (14,16) until synchronization is found on *both* tracks in the pair. In 32-track mode, the track-pairs are (2,3), (4,5), (6,7), (8,9); in 64-track mode, (2,102), (3,103), (4,104), (5,105)[2].
4. Attempt to find simultaneous valid track frame headers in the selected track pair: A valid frame header is indicated by a sync word (0xffff with parity removed) followed by a valid CRC character. Synchronization detection is declared successful if this occurs simultaneously on both selected tracks[3]. If synchronization fails after three frame-header periods, increment the track-pair selection and return to Step 4.
5. Re-insert proper parity: As required by the Mark 4 and VLBA tape-frame formats, even byte parity is reinserted during the sync word and odd byte parity elsewhere.
6. Check for continuing valid frame headers: Synchronization is maintained so long as both selected tracks continue to have valid track frame headers. If an invalid frame header is detected, renew the track-pair selection[4] and return to Step 4.

2.4.3 Controls and Status

The following controls are available for the Output Section:

Data Mode: the data modes of the Output Section are 'st' plus the four 'mark4:xx' and four 'vlba:xx' modes. So-called 'tvg' mode is really just 'st' mode.

Seek Sync: Enables the Output Section to seek synchronization; enables Sync Counter. A transition from 0 to 1 clears the Sync Counter; if already in sync, a transition from 0 to 1 does not force a re-sync. A transition from 1 to 0 clears the 'Sync'ed' status bit; if already in sync, sync will be maintained but, if sync is lost, no effort will be made reacquire sync.

Select tracks to decoder/DQA: Any two of the 64 output tracks may be selected.

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[1] The Data Mode setting for the Input Section and Output Section may be set independently, however the output data may be non-sensical if they are set differently. For some diagnostics tests or special applications, it may be useful to set them differently.

[2] The addition of '100' indicates Set 2 (headstack 2), consistent with the designation used by Mark 5A software. In the 64-track mode note that, as shown in Table 1, track pair (n,100+n) are multiplexed into a single FPDP bit stream.

[3] In 64-track mode: If valid frame headers are detected simultaneously on both examined track, the output track assignment is correct. If the detections are staggered by one clock cycle, the output track assignment must be swapped. This resolves the 2-fold track-assignment ambiguity mentioned earlier.

[4] The track-pair selection remains the same until three frame-header periods of re-sync attempts (perhaps interspersed by successful periods of synchronization) is accumulated, at which time the track-pair selection is incremented as explained in Step 3.

Clear: Re-normalizes Output Section and forces a re-sync. Does not affect Data Mode or Sync Counter.

Clock select: Selects clock to use during playback – either internal clock generator or external clock (SMB connector J12 on I/O board; TTL into 50Ω)

Clock generator frequency: The clock generator, which sets the playback clock rate when the internal clock option is selected, is shared with the Input Section and controlled through the Input Section. The clock-generator frequency may be set from 0 to ~45.4 MHz in increments of $100\text{MHz}/2^{32} \approx 23$ milliHz and corresponds directly to the playback clock rate for all modes *except* the 64-track modes; in the 64-track modes, the playback clock rate is half the clock-generator frequency.

The User may read the following status information from the Output Section:

Sync'ed: A 1-bit indicator that the Output Section is synchronized; irrelevant in 'st' mode.

Sync Count: 16-bit counter which increments each time a successful synchronization event takes place, including the initial synchronization and any required re-syncs[5]; the count saturates at 0xffff and does not rollover.

Design revision: 8-bit Output Section design revision level

2.4.4 Playback Fill Pattern

When playing back a disk set, the StreamStor is designed to cope with slow or misbehaving disks. In particular, if a requested data block of 0xFFF8 bytes from a particular disk is not available in time to be placed on the FPDP bus, the StreamStor card instead replaces the missing block with a repeating 32-bit wide pattern (0x11223344). This pattern is chosen such that it is unlikely to be repeated on the FPDP bus in valid data.

The Output Section of the Mark 5A I/O card detects this fill pattern on the 32-bit wide FPDP bus during playback[6]. On the detection of 17 adjacent fill-pattern words[7], the Output Section substitutes a repeating serial 9-bit even-parity pattern[8] on all output tracks until three successive non-fill-pattern FPDP words are detected, at which point the output returns to normal. The amount of inserted data exactly matches the amount of missing data so that data synchronization is faithfully maintained. The correlator can be set to discard data with even parity, so that nearly all invalid data can be discarded while valid data is accepted.

2.5 Disk Bank Management

The Mark 5A accommodates two '8-pack' disk modules, which may be inserted into either or both 'Disk Bank A' and 'Disk Bank B'. A disk module may contain from 1 to 8 disks, depending on the desired data capacities and record/playback data rates (see Appendix A). In the normal Mark 5A 'bank mode' of operation, either Bank A or Bank B may be chosen to be the

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[5] In general, any data discontinuity will cause a re-sync event, including a 'skip' command used to bring the Mark 5A into synchronization with a correlator.

[6] During bypass/record operation, this capability is always disabled and input data are always passed through to the output unmodified.

[7] This is true in all modes except the 64-track modes; in 64-track mode, the detection criteria is 17 'every-other' FPDP words of fill pattern. The number 17 arises from historical precedent; the first fill pattern used in tests was 0x00000000, which can legally occur on 16 successive FPDP words in 'straight-through' Mark 4 or VLBA data (i.e. not parity stripped), but not 17.

[8] The repeating serial pattern placed on each track is hex 'A5' followed by a single-bit '1', which has the property of even parity regardless of the phase of the pattern.

‘active’ Bank for recording or playing while the other Bank is either idle or dismounted; an idle Bank may be dismounted, replaced with another module, and remounted without disturbing the operation of the ‘active’ Bank. Switching the ‘active’ Bank to the other may be done either under software control or automatically (NYI) when the end of one Bank is reached when either recording or playing; a small amount (few seconds) of data is lost in the switching process. If the Bank switching is done under automatic control, data may be recorded or played continuously for an indefinite period of time, with only small gaps at bank changes, limited only by the available number of disk modules.

A ‘legacy’ (non-bank) mode of operation is available in the Mark 5P system which considers all mounted disks as a single set of up to 16 disks. For compatibility with data recorded in ‘bank-mode’ operation, it is recommended that Mark 5P systems use only the first 8 disk slots, adhering to the same disk configurations supported by Mark 5A.

3. Mark 5A Assembly and Setup

3.1 Unpacking and Assembly

Normally, the Mark 5A is shipped in the same double-walled cardboard box in which the chassis was originally purchased. The I/O Panel which normally attaches to the rear of the chassis is placed inside the chasses for shipping and must be retrieved and properly attached and connected. The following steps should be taken:

1. Remove the top cover by removing the screws on the top cover and carefully removing the cover.
2. Find and remove the I/O Panel, which is separately packed, from inside the chassis.
3. Inspect the chassis carefully for any external or internal damage. Especially make sure that the PCI boards are all completely seated into their sockets.
4. Attach the I/O Panel to the rear of the chassis (see Figure 8) with the supplied screws.

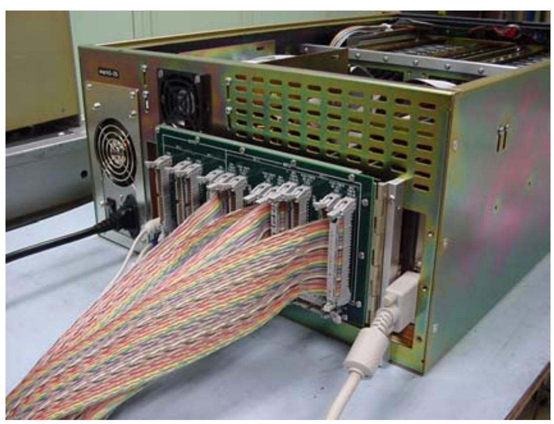

Figure 8: I/O Panel Attachment (may vary somewhat)

5. Normally, the interconnecting cables between the I/O Board and I/O Panel are pre-connected to the I/O Board. Find these cables, route them carefully through the open slot nearest the I/O Panel mounting point, and connect them to the I/O Panel. [The connectors should normally be labeled; if not, see the next section detailing connections between the I/O Board and I/O Panel.

6. Making sure that no cables are binding, swing the I/O Panel into its operational position and lock it down with the supplied standoff.When positioning for operation, make sure there is plenty of free space in front and back of the unit for ventilation.
7. Make sure the switch(es) on the power supplies on the rear are turned off. Connect the two power cords. The power supplies are universal and will accept 100-240V 50-60 Hz, though some have a rear-panel switch that must be set according to the supply voltage. Some power supplies have more than one power cord and they must both be connected. The power supplies are typically 500-550W high-efficiency supplies. Maximum power drawn by a Mark 5A is ~500W; average power is ~150-300W depending on the number of active disks.

3.2 I/O Board and I/O Panel

The I/O Panel is designed to work with the Mark 5A I/O Board to record and playback up to 64 tracks as two sets of 32 tracks from either a Mark 4 and VLBA formatters.

The I/O Board, illustrated in Figure 9, is a standard 32-bit PCI card that plugs into the motherboard PCI bus. A board-top FPDP connector connects to the corresponding connector on the StreamStor board. User input and output signals are transferred to the I/O board via five cables from the I/O Panel.

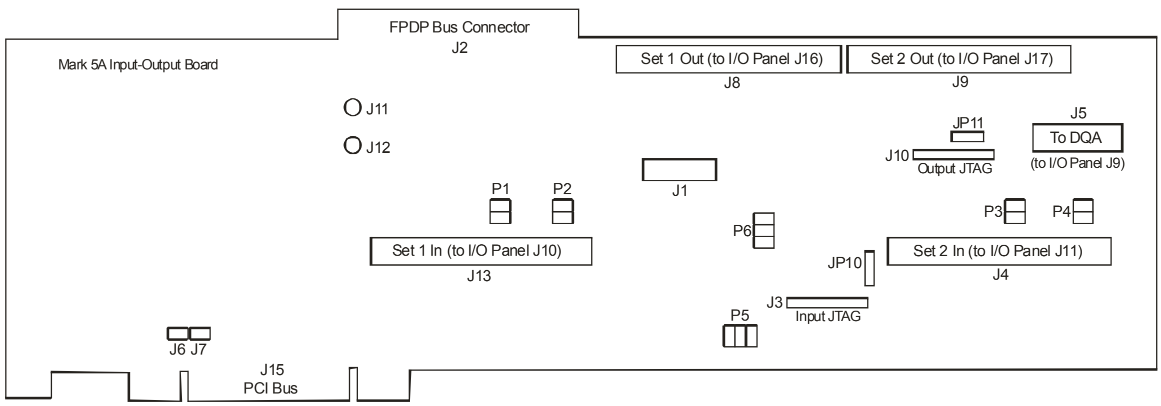

Figure 9: Mark 5A I/O Board

The I/O Panel, shown in Figure 10, is divided into separate sections as follows:

- The INPUT section of the I/O Panel is divided into two independent sets of 32 tracks each, named ‘Set 1’ and ‘Set 2’. Set 1 (comprised of connectors J1, J2, J5 and J6, each carrying 16 tracks) is normally used to connect to the ‘headstack 1’ output of a formatter, while Set 2 (comprised of connectors J3, J4, J7 and J8) is normally used to connect to the ‘headstack 2’ output of a formatter. Set 1 and Set 2 are each connected to the Input Section through a separate 68-pin connector (J10 and J11, respectively) on the back of the I/O Panel.
- The OUTPUT section of the I/O Panel is, likewise, divided into two sections of 32 tracks - Set 1 (comprised of connectors J12, J13, J16) and Set 2 (comprised of connectors J14, J15, J17). These connectors are designed to connect directly to a Mark 4 station unit.
- Connector ‘TO VLBA DQA’ (J18) is used to provide selected data signals from the Output Section to the VLBA Data-Quality analyzer. A separate cable connects this port to the I/O Board.

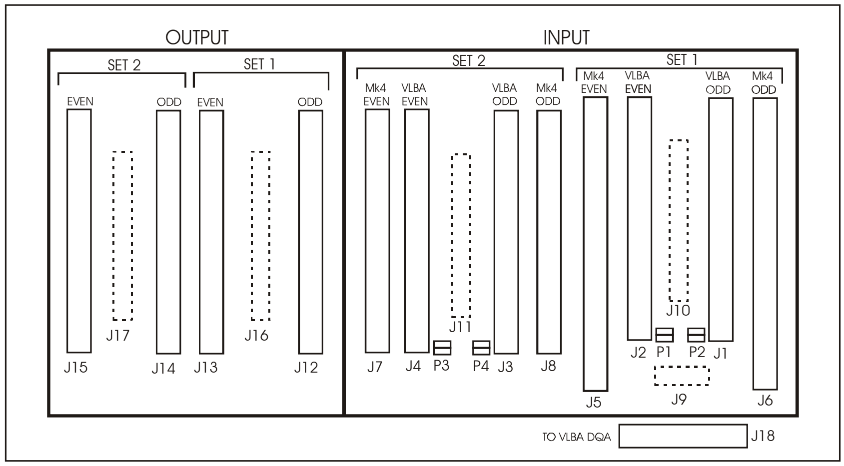

Figure 10: Mark 5A I/O Panel (dashed lines are connectors on backside of panel)

3.2.1 Connections to the I/O Board and I/O Panel

The standard connections between the I/O Board and I/O Panel are detailed in Table 3. The connections between the I/O Panel and the Mark 4 or VLBA formatter are detailed in Table 4 and Table 5.

I/O Board	**I/O Panel**	**Comments**
J13	J10	68 conductor cable; 32 Set 1 tracks Input; clock is taken from Pins 33, 34
J4	J11	68 conductor cable; 32 Set 2 tracks Input
J8	J16	68-conductor cable; 32 Set 1 tracks Output
J9	J17	68-conductor cable; 32 Set 2 tracks Output
J5	J9	20 conductor cable; 2 selected channels to VLBA DQA or Mark 4 decoder

Table 3: I/O Board to I/O Panel connections (‘Set’ is equivalent to ‘headstack’)

I/O Panel	**Mark 4 frmtr**	**Comments**
J5	J5	50-conductor; Set 1 tracks 2-33 even; clock is taken from Pins 17, 18
J6	J6	50-conductor; Set 1 tracks 2-33 odd’; clock ignored.
J7	J7	40-conductor; Set 2 tracks 2-33 even; clock ignored.
J8	J8	40-conductor; Set 2 tracks 2-33 odd’; clock ignored.

Table 4: Mark 4 formatter to I/O Panel connections (‘Set’ is equivalent to ‘headstack’)

I/O Panel	**VLBA I/O Panel**	**Comments**
J1	Recorder 1 Odd	40-conductor; Set 1 tracks 2-33 odd’; clock is taken from Pins 39, 40
J2	Recorder 1 Even	40-conductor; Set 1 tracks 2-33 even; clock ignored
J3	Recorder 2 Odd	40-conductor; Set 2 tracks 2-33 odd’; clock ignored
J4	Recorder 2 Even	40-conductor; Set 2 tracks 2-33 even; clock ignored

Table 5: VLBA formatter to I/O Panel connection ('Set' is equivalent to 'headstack')

Warning: Mark 4 formatters *must* be connected to the 'Mark 4' input connectors and VLBA formatters must be connected to the 'VLBA' input connectors. A violation of this rule will result in missing and mis-assigned tracks!

3.2.2 Jumper Configuration on I/O Board

Table 6 shows the jumper configuration required on the Mark 5A I/O Board; refer to Figure 9 for the positions of the jumper blocks.

Jumper Block	Installed jumpers	Comments
J6	1-2	
J7	1-2	
P1	none	Present only on early boards
P2	1-2, 3-4	Present only on early boards
P3	1-2, 3-4	Present only on early boards
P4	1-2, 3-4	Present only on early boards
P5	1-2, 3-4, 5-6	
P6	1-2, 3-4, 5-6	

Table 6: Jumper configuration on Mark 5A I/O Board

3.2.3 Jumper Configuration on I/O Panel

Table 7 shows the jumper configuration required on the Mark 5A I/O Panel; refer to Figure 10 for the positions of the jumper blocks.

Jumper Block	Installed jumpers	Comments
P1	1-2, 3-4	
P2	1-2, 3-4	
P3	1-2, 3-4	
P4	1-2, 3-4	

Table 7: Jumper configuration on Mark 5A I/O Panel

3.2.4 Notes on Clocks

1. tvg mode: When recording in 'tvg' mode, the data clock is supplied by the on-board clock generator, which is set by the 'play_rate' command.
2. External data input: When data are input from an external data source, only the clock on the Set 1 Even connector is used by Mark 5A [pins 17,18 (differential) on the Mark 4 connector, pins 39,40 (differential) on the VLBA connector].
3. Playback: When playing back, the data clock may be supplied either by the on-board clock generator or by an external clock (SMB connector J12 on I/O board; TTL into 50Ω); output clock signals are generated on all 4 Output connectors (on same pins as Mark 4 or VLBA formatters).

3.3 Internal Chassis Connections

3.3.1 Front-Panel to motherboard connections

Dell motherboard

Most of the early Mark 5 units used a Dell motherboard with on-board video. Located at the front edge of the motherboard is a connector labeled 'FRONT PANEL'. Table 8 shows the connections to the front panel:

Function	Pins
Power LED	2(+), 4
Reset switch	5(+), 7
Power switch	6(+), 8

Table 8: Dell motherboard front-panel connections

SuperMicro P3TDLE motherboard

(NYI)

3.3.2 Disk Connections (non-Streamstor) to motherboard

The Linux OS disk is configured as 'Master' and connects to the 'Primary' IDE connector on the motherboard with a standard 80-conductor ATA cable

If a secondary disk is installed, it is suggested that it be configured as 'Master' and connected to the 'Secondary' IDE connector on the motherboard with a standard 80-conductor ATA cable.

Note that standard 80-conductor ATA cables use color-coded connector to indicated type:
- blue – connects to motherboard
- black – connects to Master (always at end of cable)
- gray – connects to Slave (if present, this connector is always between blue and black connectors)

Do not use the same cables that connect the StreamStor card to the chassis backplane; those are special cables.

3.3.3 I/O Card Placement

The StreamStor card is normally plugged into the first 64-bit PCI slot (leftmost as viewed from the rear of the chassis). The Mark 5A I/O is normally plugged into the first 32-bit PCI slot, which is separated from the SS card by two slot positions (due to the many cables coming from the StreamStor card, they cannot be in adjacent slots).

3.3.4 FPDP Bus

An 80-conductor FPDP cardtop-bus cable is connected between the StreamStor card and the I/O card.

3.3.5 Chassis Backplane Connections

Figure 11 shows the connections on the chassis backplane. Please refer to this figure in the following discussion.

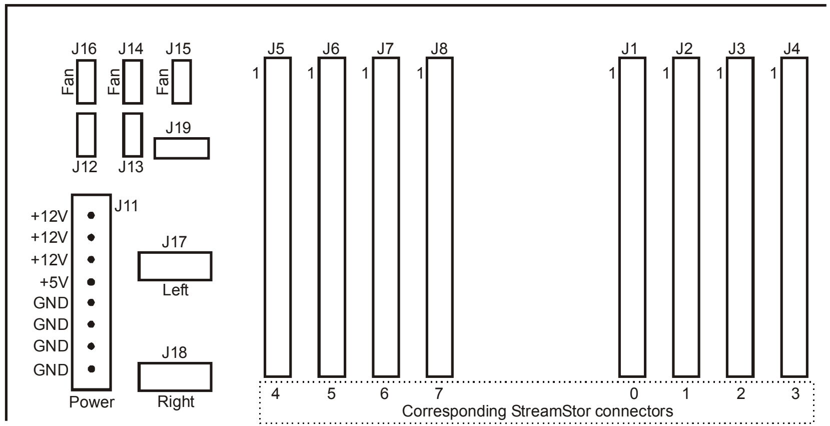

Figure 11: Chassis backplane connectors (as viewed from rear of chassis)

3.3.6 StreamStor Card

There are eight 80-conductor cables connecting the StreamStor to the chassis backplane. Though these are ATA bus cables, *they are special cables with black connectors on each end*. They are connected as shown in Figure 11 and Table 9.

Chassis backplane connectors (in order, L-to-R, as viewed from rear of chassis)	J5	J6	J7	J8	J1	J2	J3	J4
StreamStor connectors (0 to 7, top to bottom, respectively)	4	5	6	7	0	1	2	3

Table 9: Connections from Chassis Backplane to StreamStor card

3.3.7 Power connections

Power connections from the chassis power supply to the chassis backplane are made via an 8-pin connector on the chassis backplane. Figure 11 shows the connections. *Important: Cut off the standard plugs on the power supply wires and connect the wires directly to the chassis-backplane power connector.*

3.3.8 Front-Panel LED Connections

The cables from the Bank A (left) and Bank B (right) LED's connect to J17 and J18 (Figure 11), respectively.

3.3.9 Fan Connections

Fan connectors J14, J15 and J16 (see Figure 11) provide power to sets of fans. The fan connectors are all identical; by convention, the following connections are made:

J14 Dual fans under disk Bank A (left)
J16 Dual fans under disk Bank B (right)
J15 Fan behind system disk

3.4 Front-Panel Controls and Indicators

Please refer to the front-panel diagram in Figure 12 for the following discussion.

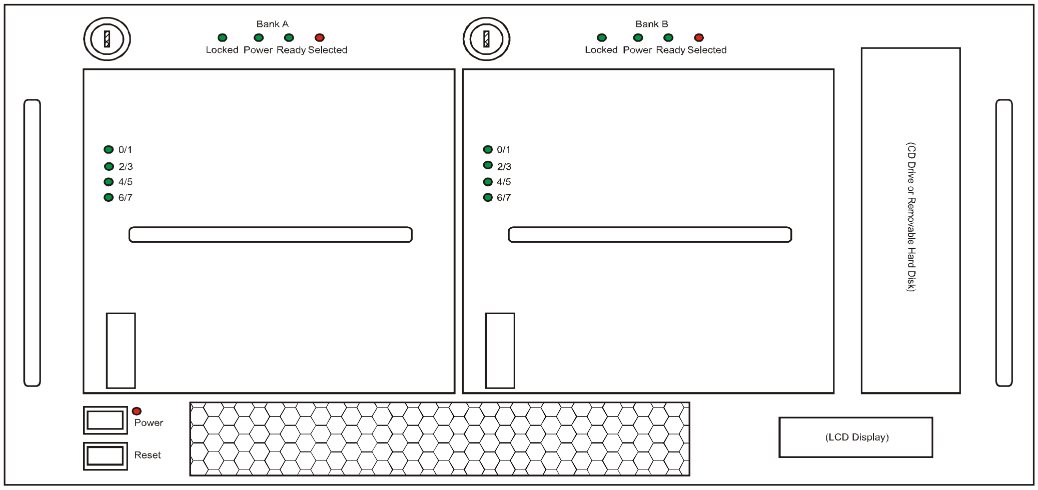

Figure 12: Mark 5A Front Panel Layout

3.4.1 Power and Reset Switches and LED's

The POWER switch applies power to the unit, illuminating the corresponding LED. If the POWER switch is held depressed for several seconds while power is already applied, power will be shut off.

The RESET switch applies a reset to the motherboard, which causes it to re-boot.

3.4.2 Disk Bank Switches and LED's

Associated with each disk bank is one keyswitch and four LED's. When operating in 'bank mode' these function as explained in Table 10:

Keyswitch	When moved to 'locked' position, physically locks the module into place and initiates mounting process; *no attempt should be made to remove the module when the keyswitch is in the 'locked' position.* When moved to 'unlock' position, physically unlocks module and initiates module power-down and dismount; *under no circumstances should the keyswitch be moved to the 'unlock' position while the module is actively recording or playing. The module must not be physically removed until power is removed ('Power' LED is off).*
'Locked' LED (green)	Indicates keyswitch is in 'locked' position
'Power' LED (green)	Indicates power is applied to module; power is applied sequentially to four disks at a time to reduce load on the power supply.
'Ready' LED (green)	Indicates the module has been successfully initialized and all drives are ready
'Selected' LED (red)	Indicates module is selected as 'active' module – DO NOT TOUCH!

Table 10: Disk bank switches and indicators when operating in 'bank mode'

Note: On some early chassis, the LED's are marked 'Power' 'Ready' 'Selected' and 'Full'. They must be re-labeled to correspond to Table 10, namely 'Locked' 'Power' 'Ready' and 'Selected'.

Some systems have been modified by users to add two additional LED's to the left of each group of four LED's. These two LED's are connected directly to +5V power on each set of four disks in the module and directly show that power is applied.

When operating in 'legacy' (non-bank) mode, the functions of these controls and indicators are somewhat different (see Appendix B).

3.4.3 Chassis-Backplane Power-Indicator LED's

When a module bank is empty, two LED's are visible on the chassis backplane (into which the module plugs). These LED's indicate that +5V and +12V are applied to the module and should never be illuminated when no module is present. ***If either of these LED's is 'on' for any reason, do not insert a module.***

3.4.4 Disk-Module LED's

Each disk module has four LED's, each LED indicates disk activity on the corresponding Master/Slave disk pair. '0/1' corresponds to the first and second disks from the front of the module; '6/7' corresponds to the rearmost pair of disks.

3.4.5 LCD Display

A 2-line, 16 char/line LCD display may be mounted in the lower-right corner of the front panel. This display is driven from the standard serial port on the motherboard and will be supported in future Mark 5A software releases.

3.5 Cascading Mark 5 systems

Mark 5A systems may be cascaded by connecting the output signals of one system to the corresponding 'VLBA' inputs of the next using four 40-conductor ribbon cables, as shown in Figure 13[9]. This allows the unattended recording capacity to be increased correspondingly. When the upstream system is in 'idle' or 'record' mode, the upstream input signals will be automatically reproduced to the downstream system. When the upstream system is in playback mode, the downstream system will receive the played-back signals. Any number of Mark 5A systems may be cascaded in this manner.

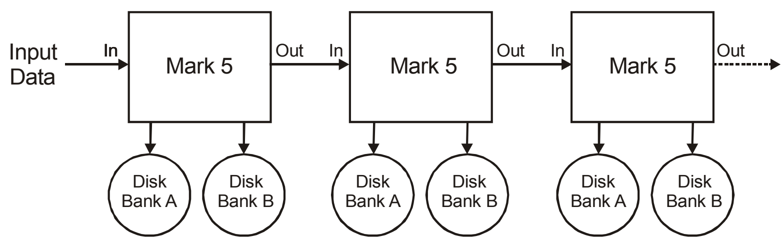

Figure 13: Cascaded Mark 5 systems

4. Mark 5A Software Support

4.1 Operating System

Each Mark 5 system is normally shipped with a full installation of Red Hat Linux and the current version of Mark 5 software. However, each Mark 5 must be configured with an IP address and domain name supplied by your system administrator. In some cases, this information may have been provided before shipping, in which case the system may already be pre-configured. A convention has been adopted to assign Mark 5 system names in the format 'mark5-xx' where 'xx' is the serial number of the particular Mark 5 unit; it is preferable if you can maintain that name as it helps to keep track of the Mark 5 systems and their configurations. Instructions for

[9] If fewer than 4 cables are connected, at the least Set 1 VLBA Even cable must be connected to the downstream unit to provide a clock to the downstream unit.

local network, time-zone and ntp configuration is available at http://web.haystack.mit.edu/mark5/software.html.

4.2 Mark 5A Software

The Mark 5A is normally controlled by a program called 'Mark5A', which may be downloaded and installed with a simple procedure. Detailed information installing and updating the 'Mark5A' software is available at http://web.haystack.mit.edu/mark5/software.html. For best operation of the Mark 5A system, it is recommended that 'Mark5A' be regularly updated.

4.3 Utility and Test Programs

tstMark5A <machine> - where *<machine>* is the target Mark 5A system (defaults to localhost). Mark 5A must be running on *<machine>*. *tstMark5A* accepts manually entered Mark 5A commands and queries.

ssopen – initializes StreamStor card and mounted disks (from Conduant)

sstest – 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. (From Conduant)

SSReset – standalone StreamStor reset program. *Mark5A* must not be running

SSErase – standalone disk-erase and disk-conditioning program. Mark5A must not be running.

DirList – reads the Mark 5A directory and list the contents.

Net2file <filename> – accepts a connection from a Mark 5A machine and write the received data to *<filename>*.

File2Net <machine> [*<filename>* [*<startbyte>* [*<endbyte>*]]] – sends a file or part of a file to the Mark 5A disks.

For more detailed information on auxiliary and test programs please see http://web.haystack.mit.edu/mark5/software.html.

5. Operating the Mark 5A System

5.1 System Boot

Booting will take place automatically when power is turned on. The first time you boot the Mark 5A it is recommended that you attached a monitor and keyboard so that you can observe that it is booting properly. No intervention from the keyboard should be necessary during the boot process; if keyboard intervention is necessary, it may not be possible to boot the system 'headless' (without monitor or keyboard), which is often the standard mode of operation. If you need help, please contact Richard Crowley at Haystack (rcrowley@haystack.mit.edu).

If the system boots into X-windows, you must force a normal Linux prompt with <Cntl><Alt><F1>.

5.2 Using 'Mark 5A'

The main Mark 5A control program is called 'Mark5A', which must be started before the system will respond to normal Mark 5A commands. 'Mark 5A' may be started either locally or remotely through a terminal session.

1. Login name: *oper*

Login password: ------

Contact Richard Crowley (rcrowley@haystack.mit.edu) for a password, if needed.

2. Issue *'script –f [filename]'* if you wish to retain a record of your session (use '*-af'* to append to current file). Default file name is 'typescript' in the default directory.
3. If this is your first time starting up a new system, the following steps are recommended. Once the system is known to operate properly, this step may be skipped:
   a. Run *'ssopen'*
      This initializes the StreamStor (may take 10 or so seconds).
      If successful, 'StreamStor opened successfully' will be reported.
   b. If '*ssopen*' fails, try '*SSReset*' to reset the StreamStor card; then try *'ssopen'* again.
4. Start *Mark5A,* which is the primary control program for the Mark 5 system:
   a. Revision 2.3 and earlier (operate only in obsolete Mark 5P 'non-bank' mode):

      'Mark5A <message level> <syntax> &'

      where

      <*message level*> = (same as Rev. 2.4 – see below)

      <*syntax*>= 0-'informal' syntax; 1-formal VSI-S syntax[10]

      & - runs *Mark5A* in background[11]

   b. Revision 2.4 and later:

   'Mark5A –m [-1|0|1|2|3] *–f* [0|1] *–s* [1|2|3|4|5|6|7] &' (defaults underlined)

      where

      m – message level (range –1 to 3, default 1)
      - -1 A vast quantity of debug
      - 0 Some debug
      - 1 Normal operation; warnings and errors
      - 2 Only errors and operational messages
      - 3 Only fatal errors when the program dies

      f – parsing mode (0–'informal' syntax; 1–formal VSI-S syntax[10]; default 1)

      s – maximum number of allowed socket connections (range 1 to 7; default 7)

      & - runs *Mark5A* in background[11]

   When executed in a TK200 chassis (with '8-pack' disk modules), operation is supported only in so-called 'bank mode'. When executed in an obsolete Anova chassis, operation is supported only in the obsolete Mark5P 'non-bank mode'.

[10] Some early versions of Field System support for Mark 5 require 'informal' syntax. 'Informal' syntax allows spaces to be used in place of colons and does note require a semi-colon terminator; in addition, defaulted parameters in commands are specified by a '-'. 'Informal' syntax mode will actually handle 'formal' syntax properly except for defaulted parameters (null or white space between colon delimiters). All examples in this document are in 'formal' (VSI-specified) syntax.

[11] '&' may be omitted if another terminal or a network connections is used to send commands to the Mark 5. After 'Mark5A' is running, it will respond to socket request from the Field System or the correlator.

5. Run '*tstMark5A*'
   tstMark5A is small standalone program[12] with a simple operator interface that allows commands to be sent and responses to be received from *Mark5A*. 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 Mark 5A command set (*http://web.haystack.mit.edu/mark5/software.html*)

   Type '*status?;*' to query system status.
   Return should be *'!status?=0:0x001;'* (*0x001* indicates 'ready' status)

   Important: Determine software version
   Type '*DTS_id'?;*'. Return should be something like
   '*!DTS_id? 0 : Mark5A : 2003y044d20h : 1 : mark4-18 : 1 : 1 : 2.4 : 1 : 1;'*
   The value '2.4' in this example specifies the revision level of the command set that corresponds to this particular version of Mark 5A control software[13]; this value is updated at each new command set update.

6. Program 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 may create confusion.

7. System Shutdown:
   From a local console, enter '*halt*'; system will halt but power will not shutdown. From a local or remote console issue '*su*' to become root, then use the normal Linux shutdown *'/sbin/shutdown –h now'*; system will be halted and powered down. Root password will be supplied on phone or e-mail request.

5.3 Mark 5A Control Syntax

The Mark 5A command and query syntax is based on the VSI-S syntax[14], which is worthwhile becoming acquainted with if you wish to directly exercise the Mark 5A system through its command set. A summary of this syntax is given in the 'Mark 5A command set' (available at http://web.haystack.mit.edu/mark5/software.html.

5.4 Getting Started – Some Basic Commands

We briefly describe here some commonly-used commands and queries in normal Mark 5A operation. For complete details of all Mark 5A commands, refer to the memo 'Mark 5A

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[12] '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.

[13] Software versions earlier than 2.4 do not return this command-set revision level; for these earlier versions, the date returned by the 'DTS_id' query ('*2003y044d20h' in the example*) must be compared with release dates in the Mark 5A software update file (http://fourier.haystack.edu/Mark5/UpdateMark5.html). Earlier versions of the command set are available in the Mark 5 memo series at http://web.haystack.mit.edu/mark5/software.html. It is the users responsibility to keep the Mark 5A control software up-to-date.

[14] The full VSI-S specification is available at http://web.haystack.edu/vsi/index.html. Though the Mark 5A system uses the VSI-S communications protocol and syntax, the Mark 5A is not VSI-compatible and does not use the VSI-S command set. The Mark 5B will implement the VSI-S command set.

command set' (available at http://web.haystack.mit.edu/mark5/software.html). Management of disk-modules in 'bank-mode' operation is detailed in Section 5.6.

5.4.1 Select active bank

bank_set=A;	Select bank A as active bank (assumes Bank A is ready)
bank_set=B;	Select bank B as active bank (assumes Bank B is ready)
bank_set=inc;	'Increment' active bank (switches to alternate bank)

5.4.2 Show disk serial numbers in module

disk_serial?; Returns serial numbers of all mounted disks

5.4.3 Erase all disks in module

reset=erase; Erases all data on the mounted disks.

5.4.4 Set data mode

mode=<data mode>:<data submode>; (example: '*mode='mark4:64'*')

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

mode?; – returns *<data mode>,<data submode>* and other information.

5.4.5 Record data

record=on:<scan name>;

Starts recording from end of last recorded scan. The assigned scan name is stored in a directory on the disk set. Recording mode is controlled by the *mode* command.

record=off; Stop recording

record?;

Returns *<recording status>, <scan number>, <scan name>*

5.4.6 Set playback rate

play_rate=clock:<freq(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.

play_rate?;

Returns *<track data rate>* (sans parity),*<clock rate>* (including parity), and *<clock generator freq>*.

5.4.7 Set playback for a particular scan

scan_set=<scan_name>;

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

scan_set?;

Returns *<scan number>, <scan name>, <start byte#>, <end byte#>*

5.4.8 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.

play?;

Returns current play status

5.4.9 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.

5.4.10 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.

'*track_set=inc:inc;*'

Increments 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*>

5.4.11 Check tracks recorded on disk set

track_check?; Check current <*track A*>

Returns <*data mode*>, <*data submode*>, <*data time*> and other information about the track as read from the current play position on the disk set.

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 will return detailed information about the data recorded from the target track, including data mode, time, etc.

5.4.12 Check record and play pointers

position?;

Returns current value of *<record pointer>, <play pointer>*

The Mark 5A maintains both a 'record' and 'play' 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. The command set memo contains detailed information on the meaning and use of 'record' and 'play' pointers.

5.4.13 Get system 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'.

5.5 Examples of some simple procedures

In this section are a few examples of simple procedures you can try. Consult the appropriate Mark 5A command set document for detailed explanations.

5.5.1 Get system and disk information

DTS_id?;	Get system information
disk_serial?;	Get disk serial numbers
disk_size?;	Get disk sizes (bytes)
status?;	Get current system status

5.5.2 Record two successive scans (assume connected to Mark 4 formatter)

mode=mark4:64;	Set data mode to Mark 4, 64-track
record=on:testscan1;	Start recording; assign scan name '*testscan1*'
record=off;	Stop recording
scan_check?;	Do cursory check on just-recorded data
record=on:testscan2;	Start recording; assign scan name '*testscan2*'
record=off;	Stop recording
scan_check?;	Do cursory check on just-recorded data

5.5.3 Check recorded scans

scan_set=testscan1;	Select 'testscan1'
scan_check?;	Do cursory check on recorded data

scan_set=inc;	Increment to next scan ('*testscan2*')
scan_check?;	Do cursory check on recorded data

5.5.4 Playback scans

play_rate=clock: 18;	Set playback clock rate to 18 MHz
scan_set=testscan1;	Select '*testscan1*'
mode=mark4:64;	Set data mode
scan_play;	Play scan '*testscan1*' (stops at end of scan)
scan_set=testscan2;	Select '*testscan2*'
mode=mark4:8;	Set data mode
scan_play;	Play scan '*testscan2*' (stops at end of scan)

5.6 Bank management procedures

Each Mark 5A system support two 'banks', labeled 'Bank A' and 'Bank B'. Only a single bank may be 'active' at a single time, as indicated by the 'Selected' LED above each bank. All commands issued to the Mark 5A are focused only on the active bank with the exception only of the 'bank_set' command, which selects the active bank, and the 'bank_switch' command (NYI), which manages optional automatic bank-switching. The following rules apply to operation of the module banks:

1. The control program *Mark5A* may be started with any combination of modules present and 'Locked' (none, A, B, or both). The modules will be initialized; 'A' will be 'Selected' if present and 'Ready', otherwise 'B' will be 'Selected' if present and 'Ready'. If no modules are present, none will be 'Selected'; in this case, the first module to be inserted and 'Locked' will be made 'Ready' and 'Selected'.
2. A keyswitch should be turned to the 'Locked' position only if a module is present in the associated bank. Turning the keyswitch to the 'Locked' position will cause the module to be powered, initialized and made 'Ready'; however, the module will be 'Selected' only if another module is not already 'Selected'. When the keyswitch is turned to the 'Locked' position, the following should be observed on the LED's associated with that module:
    a. 'Locked' and 'Power' LED's will illuminate quickly; all 'activity' LED's on module will illuminate (for all buses with installed disks).
    b. 'Activity' LED's will extinguish one-by-one from top to bottom; this should progress smoothly and take no more than a few seconds. If this process stalls or significantly hestitates, there may be a problem with the disk pack.
    c. The 'Ready' LED illuminates; this signifies the module is ready to be used.
    d. If the other module is not already 'Selected', the 'Selected' LED will illuminate and the module is made active; otherwise it sits ready to be activated.
3. A keyswitch should never be turned to the 'unlocked' position when the associated module is actively recording or playing; data may be lost or corrupted.
4. An inserted module in the 'unlocked' state is not recognized by the system.

5. No attempt should be made to remove a module unless the associated keyswitch is unlocked and the 'Power' LED is extinguished.
6. Only one bank may be 'Selected' at any one time.
7. If both 'A' and 'B' are both present, 'Ready', and quiescent (i.e. not recording or playing), the 'bank_set' command may be used to change the active ('Selected') bank. A '*bank_set=inc*' command will switch to the alternate bank.
8. If a module fails to come 'Ready' after more than ~15 seconds, unlock the keyswitch, wait ~10 seconds, and try again.
9. Recording on the 'Selected' module will always append to any existing recording.
10. A 'reset=erase' command will erase all data on the 'Selected' module.
11. A 'reset=erase_last_scan' command will erase the last recorded scan on the 'Selected module. This command may be issued repeatedly to erase multiple scans.
12. Do not attempt to use the 'reset=mount' or 'reset=dismount' commands (these commands will soon be completely eliminated). All mount and dismount operations are controlled by the keyswitches.
13. Do not attempt to enter non-bank mode (non-bank mode operation will soon be completely eliminated).

Appendix A: Disk Requirements and Recording Times

Table 11 shows the minimum number of disks required in each operating mode based on sustained transfer rate of 20 MB/sec for each disk[15]. Table 12 shows the recording time per disk at various total data rates for various common disk capacities.

Data Mode[16]	Submode[16]	Data rate[17] (Mbps/track)	Total data rate[18] (Mbps)	Minimum # of disks required
'st'	'mark4' or 'vlba'	2	72	1
		4	144	1
		8	288	2
		16	576	4
'mark4' or 'vlba'	8	2	16	1
		4	32	1
		8	64	1
		16	128	1
	16	2	32	1
		4	64	1
		8	128	1
		16	256	2
	32	2	64	1
		4	128	1
		8	256	2
		16	512	4
	64	2	128	1
		4	256	2
		8	512	4
		16	1024	8[19]

Table 11: Minimum number of disks required in each operating mode

Total data rate (Mbps)	Record time per disk (minutes) (multiply by #disks for total record time)		
	120GB disk	200GB disk	300 GB disk
16	1000.0	1666.7	2500.0
32	500.0	833.3	1250.0
64	250.0	416.7	625.0
72	222.2	370.4	555.6
128	125.0	208.3	312.5
144	111.1	185.2	277.8
256	62.5	104.2	156.3
288	55.6	92.6	138.9
512	31.3	52.1	78.1
576	27.8	46.3	69.4
1024	15.6	26.0	39.1

Table 12: Record time per disk for various total data rates (1 GB = 10^9 bytes)

[15] The Western Digital 120GB and 200GB disks commonly used in Mark 5 systems will, if properly operating, actually sustain ~30MB/sec/disk (240Mbps) over the entire surface of the disk. We have chosen to use a more conservative rate of ~18 MB/sec/disk to allow for the possibility of slowing or failing disks to be better accommodated. The WD 120GB sustained-rate capability varies from ~48MB/sec to ~30MB/sec as the disk fills from the outer to the inner circumference of the platters. The WD 200GB sustained-rate capability varies from ~56MB/sec to ~30MB/sec in the same manner.

[16] Set as a parameter in 'mode' command.

[17] This is the 'play_rate' for 'data' and also corresponds to the formatter's track data rate (without parity). The track data rate is the (channel) sample rate divided by the fan-out ratio (1, 2 or 4).

[18] Total data rate recorded/played from disks (includes parity in 'st' mode).

[19] Theoretically, 7 disks can support 1024 Mbps, but 7 is not an allowable number in an '8-pack' module; if any M/S pairs exist in module, then all installed disks must be in M/S pairs.