VLBI Standard Software Interface Specification – VSI-S

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1. Introduction

The VSI-S specification is the software counterpart of the VSI-H specification [Reference 1], which specifies the standardized hardware interfaces of a VLBI Data Transmission System (DTS). Systems adhering to both the VSI-H and VSI-S specifications should be interchangeable with minimal effort at both data-acquisition and data-processing sites.

Reference 1 should be reviewed with respect to all terms and acronyms used in this specification.

2. Intent of the VSI-S Specification

The goal of VSI-S is to specify a robust, reliable communications protocol to control a VSI-H-compliant DTS. In this regard, VSI-S must address three issues:

1. Specify a communications structure and protocol.
2. Specify a generalized command and response syntax model to be used by the DTS.
3. Specify a base set of commands to configure and operate a generic DTS adhering to the VSI-H specification.

The base set of VSI-S commands is intended to address those functions of a DTS which are common to most VSI-H DTS's. It is recognized that there may be some necessary modifications and/or additions to VSI-S commands and command sets to support specific DTS's of varying technologies. Implementation of the suggested VSI-S command set is on a best-effort basis consistent with the technology in use by a specific DTS.

3. Communications Model

3.1 DTS Communication ports

The VSI-S communications model specifies three communication paths to/from the DTS:

1. The Control Interface, which supports 2-way communications through either an Ethernet TCP/IP connection or through an RS-232 communications port to a Controller. For purposes of VSI-S, the DTS acts as *server*. The communications protocol is fundamentally half-duplex, though full-duplex systems will obviously work equally well.
2. A PDATA serial-data line into the DIM from a DAS. This is strictly a one-way communications link.
3. A QDATA serial-data line from the DOM to a DPS. This is strictly a one-way communication link.

3.2 Layered Communication Protocol

The DTS communications protocol is specified in layers analogous to the well-known OSI communications model as follows:

	Control Interface		PDATA	QDATA
	Ethernet	**RS-232 Port**	**-**	**-**
Layer 1 (physical)	10/100 Base-T	RS-232, 8-bit, 2-way 1 stop bit, no parity, >=9.6 kbaud	RS-232, 8-bit 1 stop bit, no parity, 115 kbaud	RS-232, 8-bit, 1 stop bit, no parity, 115 kbaud
Layer 2 (data link)	Ethernet	null	null	null
Layer 3 (network)	IP	Packet structure	Packet structure	Packet structure
Layer 4 (transport)	TCP	Acknowledgement, timeouts, retries, etc.	1-way only (to DIM)	1-way only (from DOM)

Layer 5 and higher are the actual command/query and response messages, which are common to all the interfaces and are defined in Section 6.

4. Data-Link Protocols

All communications to/from the DPS are packaged as individual messages formatted as either a <command/query> message (always from the Controller) or a <response> message (always from the DTS) which, for purposes of this document, are simply referred to as '<command/response>' messages. The data-link protocol packages these messages as necessary for transmission over the chosen communication path.

4.1 Ethernet

The IP protocol provides the infrastructure to package the <command/response> messages to/from the DTS control interface and place them in the hands of Layer 4 (TCP). No further specification is needed within VSI-S.

4.1 RS-232

At the user's option, the RS-232 packet structure may be chosen to be Type 1 or Type 2. Type 1 packets enforce a higher level of accountability and error detection than Type 2 packets.

4.1.1 RS-232 Type 1 Packet Structure

Each communication to/from the DTS is a packet of the form:

<SOH><command/response><C><CR>

where

<SOH> is the 'start-of-packet' character, ASCII char 0x01 ('start of header')

<command/response> is a command (or query) from the Controller or a response from the DTS, consisting completely of ASCII printable characters in the range 0x20 to 0x7d (excludes 0x7e – tilda character)

<C> is an checksum code represented by a single printable ASCII character in the range 0x20 to 0x7e, computed as ((sum % 0x5f) + 0x20), where 'sum' is the sum of all ASCII-character values in the <command/response> message (all characters following <SOH> and preceding <C>).

<CR> is 'end-of-packet' character, ASCII char 0x0d (carriage return)

4.1.2 RS-232 Type 2 Packet Structure

In cases where the RS-232 link is known to be of high integrity and effectively error free, the user may choose to operate with a 'Type 2' packet structure which strips all error-control features, and is of the form:

<command/response><CR>

When operating in Type 2 mode, the DTS will also accept and check Type 1 packets (receipt of an <SOH> character will cause the DTS to expect a Type 1 packet); however, all transmissions from the DTS will be Type 2 packets.

At the user's option, the RS-232 Control Interface and PDATA/QDATA ports may be chosen independently to operate in with either Type 1 or Type 2 packet structures.

5. Transport Protocols

5.1 Control Interface

TCP/IP provides an infrastructure to guarantee that messages are transmitted between the Controller and DTS in the correct order and are delivered error-free. RS-232 communications require more direct vigilance by the user. In either case, the following rules for communications between the Controller and the DTS apply:

1. Each packet contains one, and only one, <command/response> message.
2. The DTS must respond to *every* recognized command/query packet within 50 milliseconds or 100 character periods, whichever is greater; this period is defined as the *response window*.[1]
3. The maximum length of any DTS response is 64 characters, not including any header, trailer or checksum characters.
4. The DTS will *not* transmit any packet except in response to a command/query packet. For RS-232, this implies no response except to a recognized <CR>
5. The DTS will transmit one, and only one, response to every received packet. For RS-232, this corresponds to each recognized <CR>
6. In the event of a normal reply from the DTS, the Controller may immediately issue a new command/query.
7. In the event of a non-reply from the DTS within the response window, the Controller may issue a new command/query (i.e. the Controller must remain silent during the response window).

[1] The specification of '100 character periods' is relevant to RS-232 only. Additionally, for RS-232 communications, the beginning of the response window starts upon the receipt of *any* recognized <CR> character; the DTS response must be *complete* within the response window.

8. If the DTS receives a packet not adhering to the specification, the DTS will respond with an appropriate error response (see Section 6.2).
9. RS-232 only: The receipt of *any* <SOH> character will cause the DTS to expect and check for a proper Type 1 packet.
10. Two commands, 'DOTset' and 'ROTset' (see Sections 9.3 and 9.5), are time critical in that they must be issued *between* DOT/ROT ticks and apply their action at the *next* DOT/ROT 1pps tick. The *safe window* for the issuance of these commands is defined to start at the instant of a DOT/ROT tick and extend for 75% of the tick period[2]. For RS-232, this implies the terminating <CR> of the DOTset/ROTset command must occur within this safe window.

Comments:

a. All *commands/queries* are from the Controller, all *responses* are from the DTS.
b. No time-out period is specified for the Controller. The minimum time-out period is the length of the response window, but specific communications situations may require a longer time-out period (network communications, for example).
c. There are no limits on retries; this is left to the discretion of the Controller.
d. In the case of a Controller timeout, it cannot be clear whether the DTS improperly received the command or whether the Controller improperly received a DTS response. In either case, the proper response is for the Controller to repeat the command.
e. Special care must taken to avoid commands (especially status requests) which cause status conditions to cleared or quantities to be incremented/decremented within the DTS. Such a condition could cause the response to a repeated command to differ from the original response, resulting in possible confusion.

5.2 PDATA/QDATA

Both PDATA and QDATA are strictly one-way serial data channels, PDATA *into* the DIM and QDATA *from* the DOM. They are used primarily for the transmission of 'informational' commands (see Section 6.4), but also may accept or issue 'operational' commands. The primary usage of 'operational' commands is expected to be setting the DOT clock with the 'DOTset' command in conjunction with media copying procedures.

The user may specify either Type 1 or Type 2 packet structure for PDATA/QDATA operation. However, PDATA will always accept and check Type 1 packet structures (defined by a leading <SOH> character).

No command acknowledgements or responses to PDATA/QDATA commands are possible. It is the responsibility of the Controller to ascertain that the desired actions have transpired.

The 'safe window' rules specified in Section 5.1.10 for issuance of DOTset/ROTset commands by the Controller also apply to PDATA/QDATA.

[2] ROT clock may be speeded up or slowed down, so tick period is not necessarily an actual second. Media-copying operations at speeds different from real-time may potentially result also in a DOT clock period which is not an actual second.

6. Command, Query and Response Syntax

6.1 Command Syntax

Commands are of the form

<keyword> = <field> : <field> : …. ;

where <keyword> is a VSI-S command keyword. The number of fields may either be fixed or indefinite; fields are separated by colons and terminated with a semi-colon. A field may be of type decimal integer, decimal real, integer hex, character, literal ASCII or a special 'time' code (see Section 7.2). White space between tokens in the command line is ignored. VSI-S keywords are listed in Section 9.

6.2 Command-Response Syntax

Each command recognized by the DTS will elicit a response of the form

!<keyword> = < return code > [:<DTS-specific return> :….] ;

where

<keyword> is a defined VSI-S query keyword (see Section 9 for list)

<return code> is an ASCII integer as follows:

0 - command not implemented or not relevant to this DTS

1 - action successfully initiated, but not completed ('delayed completion')

2 - action successfully completed

3 - checksum error (RS-232 Type 1 packets only)

4 - syntax or parameter error

5 - 'get_PDATA': no PDATA message to return; see Section 8.1.5
'send_QDATA': prescribed time in outside of allowed window; see Section 8.2.2

6 - 'soft' (non-catastrophic) error encountered

7 - 'hard' (catastrophic) error encountered

<DTS-specific return> - one or more optional fields specific to the particular DTS; fields may be of any type, but should be informative about the details of the action or error.

White space between tokens in the command-response is ignored.

'Delayed completion' commands are defined as those commands which cannot be complete within the allotted DTS 'response window' (tape positioning, for example). For these commands, an immediate response is triggered with a return code 1. The Controller may follow up with subsequent queries to learn of the current status and (presumed) subsequent completion of the commanded action.

The repetition of the keyword in the response is redundant, but is included for readability of communication logs which may be kept by the Controller or DTS.

6.3 Query and Query-Response Syntax

Queries are of the form

<keyword>?;

with a response of the form

!<keyword> ? <field> : <field> : ….;

White space between tokens in the query and query response is ignored.

Notes:

1. Queries are used to establish the current status of some parameter(s) and have no effect on DTS actions.
2. Special care must taken to avoid queries which cause status conditions to cleared or quantities to be incremented/decremented within the DTS. Such a condition could cause the response to a repeated query to differ from the original response, resulting in possible confusion.

6.4 'Operational' vs 'Informational' Commands

Most commands cause the DTS to take some kind of action; these commands are called 'operational' commands.

A second class of commands, which only convey information to the DTS and which have been specified only for user convenience, are classed as 'informational' commands. These commands are used to specify useful VLBI observing parameters such as station name, source, recording mode names, media ID, user comments, etc. This information may be of particular utility when used in conjunction with the PDATA/QDATA facilities of the DTS or with internal logging within the DTS.

By convention, keywords corresponding to informational commands begin with an asterisk ('*') character.

7. Keyword and Field Rules

7.1 Keyword Length

Individual keywords are limited to 16 characters.

7.2 Field Types

Each field in a command or return statement may be one of the following six types:

Integer – a simple positive, negative or zero decimal integer (examples: '12', '-25'; of course, no quotes in actual usage).

Real – number with a decimal point and/or possible exponent (examples: '1.12', '-2.23e-6')

Hex – in standard 'C' format (example: '0x4a32'); by definition, bit 0 is LSB.

Character – prescribed character string (examples: 'on', 'off'); limited to 16 characters.

Literal ASCII – arbitrary ASCII string enclosed within single or double quotes (examples: ‘This is a literal ASCII string’ and “This is also a literal ASCII string”); . Any ASCII character in the range 0x20 to 0x7f is allowed, except that any occurrence of the ‘enclosing’ quote character must be ‘escaped’ with a leading backslash (example: ‘This string contains both a \’ and “ character’ or “This string contains both a ‘ and \” character”).[3]

Time – following the vex format, time is specified as ‘..y..d..h..m..s’, where the ‘..’ fields represent integer year, day-of-year, hour, minute and real second, respectively. Leading zeroes may be dropped. Examples: ‘2000y212d19h03m’, ‘2003y91d9h23m13.093s’.

7.3 Character Set

Keywords and fields, except literal ASCII fields, may be composed of any standard printable ASCII characters in the range 0x20 to 0x7f except white space and any of the 8 characters ‘’=:;!”? (including the single-quote and double-quote characters) may be used in keywords and fields. Case is *not* significant except in literal ASCII fields.

8. PDATA/QDATA Usage

8.1 PDATA

The PDATA serial-data line into the DIM may be used to transmit commands to the DIM, either of the ‘operational’ or ‘informational’ variety (see Section 6.4). PDATA transmissions operate under the following rules:

1. The format of PDATA data must conform to the same packet specification as commands/queries. Type 1 packets are always accepted and checked; Type 2 packets are accepted only if the user has specified Type 2 packets for PDATA/QDATA operation.
2. Only standard VSI-S commands are recognized.
3. Since PDATA is a one-way communication channel, there will never be a response to a packet received via PDATA.
4. At the user’s option, commands transmitted via PDATA may either be accepted or ignored by the DIM; operational and informational commands may be specified separately in this regard, with the ‘DOTset’ command as a special case. The ‘DOT_set’ command has a special option that allows the DOT clock in the DIM to be set by a ‘DOT_set’ command received via PDATA; this option is particularly useful for media copying.
5. A returned bit in the response to a general ‘status’ request indicates that one or more PDATA packets have been received, which may be retrieved, in order, with a ‘get_PDATA’ query. The DTS should provide a reasonably-sized buffer for collecting PDATA to be retrieved with the ‘get_PDATA’ command (suggest minimum 4096 bytes).

[3] Allowing either a single-quote or double-quote as the enclosing character permits a literal ASCII string to contain a literal ASCII string itself, which is a potentially useful construct for specifying QDATA (see Section 9.2)

8.2 QDATA

The QDATA serial-data line from the DOM may be used to transmit commands to a DPS, or to the DIM of another DTS for media-copying purposes or data-transmission purposes. QDATA transmissions operate under the following rules:

1. The 'send_QDATA' command allows the user to specify a literal ASCII string to be transmitted via QDATA. The DTS does no checking of the string, but strips the leading and trailing single/double quotes and embeds the result within the operating packet structure (i.e. adds a leading <SOH>, a checksum, and trailing <CR>, as necessary according to packet type).
2. A 'send_QDATA' command may prescribe QDATA to be transmitted either on 'next ROT tick', in which case the specified packet will be transmitted immediately following the next ROT tick, or immediately following a ROT tick corresponding to a prescribed ROT clock reading. If a ROT clock time is prescribed, the 'send_QDATA' command must be applied no earlier than 60 seconds preceding the prescribed time, nor no later than the close of the 'safe window' for the prescribed time; otherwise, an error will occur.
3. A 'send_QDATA' command requesting to transmit QDATA on the 'next ROT tick' must be sent to the DTS within the 'safe window' preceding the target ROT tick. Otherwise, the time of the actual QDATA transmission may be ambiguous.
4. For systems which have the capability, PDATA may be passed through to QDATA; in this case, a PDATA packet must be received by the DIM within the 'safe window' period of the DOM in order for the transmission to have an unambiguous epoch. The packet will be transmitted via QDATA on the *next* ROT tick. *Note that the all QDATA packets created in this fashion will be shifted one tick later with respect to the time tag originally assigned in the DIM input data stream*[4].
5. The DOM may enable transmission of a 'DOTset' command immediately following each ROT1PPS tick, which is useful for media copying. In this case, the transmitted time will be adjusted forward by one second for proper setting of the DOT clock.
6. A returned bit in the response to a general 'status' request indicates that a QDATA packet has been sent, which may be retrieved for inspection with the 'get_QDATA' query. The DTS should provide a reasonably-sized buffer for collecting QDATA to be retrieved with the 'get_QDATA' command (suggest minimum 4096 bytes).

[4] Since P/QDATA are normally used for transmitting slowly-changing information (source, recording mode, etc.), this should not normally be a problem. If this 'epoch shift' of P/QDATA is not acceptable, it is the responsibility of the user to take whatever special actions may be required.

9. VSI-S Command/Response Keywords and Formats

The following tables detail the VSI-S command set. Field numbers in square parenthesis ('[]') are optional.

9.1 System Commands

These commands are 'system level' commands not specific to either the DIM or DOM.

Keyword	Field #	Description	Type	Allowed values	Default	DTS-specific?	Comments
packet_type	1	Set RS-232 packet type	int	1 | 2	2	No	1 – RS-232: Accept Type 1 packets only; transmit Type 1 packets 2 – RS-232: Accept Type 1 or 2 packets; transmit Type 2 packets
	2	P/QDATA comm. mode	int	1 | 2	2	No	1 – RS-232: Accept Type 1 packets only; transmit Type 1 packets 2 – RS-232: Accept Type 1 or 2 packets; transmit Type 2 packets
diagnostic	1	Perform diagnostic self-test	hex		0	Yes	Bits set in field 1 specify test(s) to be performed

Notes:

1. It is the responsibility of the DTS to allow initial Controller communications through either the Ethernet or RS-232 port, according to user preference.
2. In the case of RS-232, the DTS must include some method or procedure to set a compatible baud rate with the Controller.
3. Simultaneous use of Ethernet and RS-232 control interface is not encouraged as it can lead to timing conflicts. Any simultaneous use of Ethernet and RS-232 may have to adhere to DTS-specific rules outside the scope of the VSI-S specification.

9.2 System Queries and Responses

These queries are 'system level' queries not specific to either the DIM or DOM.

Keyword	Returned Field #	Description	Type	DTS-specific?	Comments
DTS_id	1	System ID	literal ASCII	Yes	Example response: 'S2-REC'
	2	System revision level	Real		Example response: '2.1'
	3	Media type	Int	No	0 – magnetic tape 1 – magnetic disc 2 – real-time (non-recording) 3 – other (to be defined?)

status	1	General status query	hex		Bit 0 – error (use 'get_error' command for details of error) Bit 1 – one or more PDATA packet received (use 'get_PDATA' command to retrieve) Bit 2 – QDATA packet sent (use 'get_QDATA' command to retrieve) Bit 3 – tvg report pending (use 'get_tvr' command to retrieve)
get_error	1	Get error details	int	Yes	DTS-specific error code
	[2]	ASCII error explanation	literal ASCII	Yes	DTS-specific error explanation

9.3 DIM Setup and Operating Commands

Keyword	Field #	Description	Type	Allowed values	Default	DTS-specific?	Comments
1PPS_source	1	Specify second-tick sync source	char	1pps | alt1pps	1pps	No	
CLOCK_frq	1	CLOCK frequency	int	2|4|8|16| 32[|64|128]	-	No	Units are MHz. 64 and 128 MHz may be supported by some units.
	[2]	Ratio of CLOCK freq to Bit-stream information rate (BSIR)	int	1,2,4,8,16	1	No	Minimum BSIR is 2 MHz
DOT_set	1	Set DOT clock to specified time	time	Valid time	-	No	Sets specified time into DOT clock on *next* DOT second tick; time must always be integral second. Response code will normally be 1 (delayed completion)
	[2]	Time source	int			No	0 – set DOT clock according to field 1 1 – one-time set DOT clock according DOT_set command(s) in PDATA 2 – auto-set DOT clock according to DOT_set command(s) in PDATA (i.e. reset DOT clock at clock discontinuities); for media copying
DOT_inc	1	Increment DOT clock	int		0	No	>0 – advance DOT clock by specified number of seconds <0 – retard DOT clock by specified number of seconds
BS_mask	1	Bit-stream receive mask	hex	32-bit hex	0xffffffff	No	Specifies bit-streams to be received (recorded) by DIM; VSI-H allows selection of any 1, 2, 4, 8, 16 or 32 bit streams
PVALID	1	PVALID line active/inactive	char	on | off	off	No	If 'on', PVALID signal indicates data validity. PVALID may be ignored by some systems.
PDATA_cntl	1	Set PDATA control mask	hex	0x00 to 0x07	0x0	No	Bit mask: 0x01 – Enable PDATA to be received 0x02 – Accept DIM operational commands via PDATA, except DOT_set. See DOTset command for usage with PDATA

tvr	1	Test-vector receiver reporting period	integer secs	>=0	0	No	Sets tvr analysis period to specified number of DOT seconds. Value of 0 stops tvr reporting immediately.
	[2]	Number of periodic tvr reports to be created	int	>=1	1	No	Default = 1 report
	{[3]}	Bit-stream mask	hex	0x00000001 to 0xffffffff	0x00000001	Yes	Default is DTS dependent (some systems may only be able to analyze a single bit-stream at a time).
	{[4]}	Analysis mask	hex	0x1 to 0x7	0x3	Yes	LSB – error rate analysis MSB – DC-level analysis Default = 0x3 (full analysis)
	{[5]}	Bit-stream rotation	int	0-31	0	Yes	Rotate full set of 32 bit-streams to the left by specified number of positions before entering tvr. For example, '2' places BS0 in place of BS2 before entering tvr, BS1 in place of BS3, BS30 in place of BS1, etc. This capability is useful for unscrambling misdirected bit-streams, but may not exist in some systems or may be implemented in a different fashion.
receive	1	Start/stop data receive (record)	char	on | off			
	[2]	Record speed, density, etc	int			Yes	DTS-specific

9.4 DIM Queries and Responses

Keyword	Returned Field #	Description	Type	DTS-specific?	Comments
1PPS_source	1	Select second-tick sync source	char	No	Returns current value
CLOCK_frq	1	CLOCK frequency	int	No	Returns current value
	2	Ratio of CLOCK freq to Bit-stream information rate (BSIR)	int	No	Returns current value
DOT_set	1	Get current DOT clock time	time	No	Responds with current DOT clock reading to at least millisecond resolution.
BS_mask	1	Bit-stream receive mask	hex	No	Returns current value
PVALID	1	PVALID line active/inactive	char	No	Returns current value
PDATA_cntl	1	PDATA control mask	hex	No	Returns current value of PDATA control mask

get_PDATA	1	Response code	int	No	Standard VSI-S response code (see Section 6.2); only return codes 2 and 6 are relevant
	2	DOT clock reading	time	No	DOT clock reading when PDATA packet was received
	3	PDATA data	literal ASCII	No	PDATA packet data (with any <SOH>,<C>,<CR> stripped)
	4	Number of unretrieved packets	int	No	Number of PDATA packets remaining unretrieved by Controller
	5	Number packets lost since last get_PDATA	int	No	Number of packets lost due to buffer overflow (oldest packets are always discarded first in buffer overflow situation)
tvr	1	Test-vector receiver reporting period	integer secs	No	Returns current value
	2	Number of periodic tvr reports to be created	int	No	Returns *remaining number* of tvr reports to be transmitted
	3	Bit-stream mask	hex	Yes	Returns current value
	4	Analysis mask	hex	Yes	Returns current value
	5	Bit-stream rotation	int	Yes	Returns current value
get_tvr	1	Response code	int	No	Standard VSI-S response code (see Section 6.2); only return codes 2 and 6 are relevant
	2	End time of reporting period	time	No	
	3	Bit-stream number	int	No	
	4	Analysis period in DOT seconds	int	No	
	5	Error rate	int	Yes	Interpretation may be DTS-specific
	6	DC offset	int	Yes	Interpretation may be DTS-specific
	7	Number of pending tvr reports	int	No	Number of get_tvr data packets lost due to buffer overflow (oldest packets are always discarded first in buffer overflow situation)
	8	Number of tvr report lost since last get_tvr	int	No	Number of reports lost due to buffer overflow (oldest reports are always discarded first in buffer overflow situation)
receive	1	Receive (record) status	char	No	
	[2]	Record speed, density, etc.	int	Yes	

9.5 DOM Setup and Operating Commands

Keyword	Field #	Description	Type	Allowed values	Default	DTS-specific?	Comments
DPSCLOCK	1	Select DPSCLOCK source	char	dpsclock | dpsclockx | qctrl	dpsclock	No	'qctrl' puts clock source under control of QCTRL, as specified by VSI-H.
	2	DPSCLOCK freq	int	2|4|8|16| 32[|64|128]	-	No	Units are MHz. 64 and 128 MHz may be supported by some units.
DPS1PPS_sync	1	Select DOM second-tick sync source	char	dps1pps | dpsclockx | qctrl	dps1pps	No	'qctrl' puts sync source under control of QCTRL, as specified by VSI-H.
RCLOCK_ratio	1	DPSCLOCK to RCLOCK ratio	int	1|2|4|8|16	-	No	Sets output clock rate
	[2]	$\log_2$(DOM speedup factor)	int	-4 to +4	0	Yes	Default=0 (no speedup); capabilities are very DTS-specific. Speedup factor is necessary for ROT clock to increment properly.
ROT_set	1	Set ROT clock to specified time	time	Valid time	-	No	Sets specified time into ROT clock on *next* DPSCLOCK/DPSCLOCKX tick. Response code will normally be 1 (delayed completion)
ROT_inc	1	Increment ROT clock	int				>0 – advance ROT clock by specified number of seconds <0 – retard ROT clock by specified number of seconds
delay	1	Specified data delay wrt ROT clock	int	See comments to right	0	Perhaps	Units are sample bits; >0 indicates data delayed relative to ROT clock. Specified delay is set on *next* ROT1PPS tick. Implemented range should be sufficient to cover +/-0.5*ROT1PPS.
crossbar	1	Select bit-stream RBS0	int	0-31	0	No	Causes specified DIM input bit-stream to be directed to RBS0
	2	Select bit-stream RBS1	int	0-31	1	No	Causes specified DIM input bit-stream to be directed to RBS1
	…..						
	32	Select bit-stream RBS31	int	0-31	31	No	Causes specified DIM input bit-stream to be directed to RBS31
QVALID_cntl	1	QVALID control mask	hex	0x0-0x7	0x2	No	Bit 0 – set QVALID line high Bit 1 – enable DOM to manage QVALID Bit 2 – set QVALID according to PVALID (system dependent) If bits 1 and 2 set, QVALID is AND of DOM/PVALID

QDATA_cntl	1	Set QDATA control mask	hex	0x00 to 0x0f	0x0	No	Bit mask: Bit 0 - Bit 0 – Pass media-embedded PDATA informational commands through to QDATA Bit 1 – Pass media-embedded PDATA operational commands through to QDATA Bit 2 – Pass all media-embedded PDATA packets through to QDATA Bit 3 – Enable transmission of DOT_set command at each ROT1PPS tick (with time adjusted forward by one second for proper setting of DOT clock); useful for media copying
send_QDATA	1	Send string to QDATA	literal ASCII			No	Causes specified string to be transmitted via QDATA
	[2]	Prescibed ROT time at which to send QDATA string	time			No	If specified, will send QDATA following specified ROT tick (see Notes); fractional seconds are ignored. If not specified, will be sent immediately following next ROT tick.
tvg	1	Test-vector generator on/off	char	on | off	off	No	If 'on', replaces DOM output data with TVG data
transmit	1	Start/stop data transmit (playback)	char	on | off	off	No	

Notes:

1. Note that 'position' command is common for DIM and DOM.
2. A 'send_QDATA' command including a prescribed ROT time must be applied to the DTS no earlier than 60 seconds prior to prescribed time, nor no later than the close of the 'safe window' for the prescribed time; otherwise, an error will occur.

9.6 DOM Queries and Responses

Keyword	Returned Field #	Description	Type	DTS-specific?	Comments
DOM_clock	1	Select DOM clock source	char	No	Returns current value
DOM_sync	1	Select DOM second-tick sync source	char		Returns current value
RCLOCK_frq	1	DOM clock frequency	int		Returns current value
	2	$\log_2$(DOM speedup factor)	int		Returns current value
ROT_set	1	Set ROT clock to specified time	time		Responds current ROT clock reading to at least millisecond resolution..

	2	Delay data wrt ROT clock	int		Responds with delay value in place at *next* ROT clock second tick.
crossbar	1	Select bit-stream RBS0	int		Returns current value
	2	Select bit-stream RBS1	int		Returns current value
	…..				
	31	Select bit-stream RBS31	int		Returns current value
QVALID	1	QVALID line active/inactive	char		Returns current value
get_QDATA	1	Response code	int	No	Standard VSI-S response code (see Section 6.2); only return codes 2 and 6 are relevant
	1	ROT clock reading	time	No	ROT clock reading when QDATA packet was sent. Since QDATA data is always buffered until the *next* ROT tick, this will always be an integral second.
	2	QDATA data	literal ASCII	No	QDATA packet data (with any <SOH>,<C>,<CR> stripped)
	3	Number of unretrieved packets	int	No	Number of QDATA packets remaining unretrieved
	4	Number of unretrieved packets since last get_QDATA	int	No	Number of packets lost due to buffer overflow (oldest packets are always discarded first in buffer overflow situation)
tvg	1	Test-vector generator on/off	char		Returns current value
transmit	1	Data transmit (playback) status	char	No	

9.7 Media-Management Commands

Keyword	Field #	Description	Type	Allowed values	Default	DTS-specific?	Comments
media	1	Set media status	char	load | unload | pos | stop		Somewhat	
	2	Set media position (positioning)	int			Yes	Position and speed are both in DTS-specific units; speed probably relevant only for tape systems

9.8 Media-Management Queries and Responses

c	Returned Field #	Description	Type	DTS-specific?	Comments
media	1	Media status	char	Yes	'loading', 'unloading', 'unloaded', 'positioning', 'idle' are suggested; perhaps other DTS-specific responses
	[2]	Current media position	int	Yes	Returns current media position in DTS-specfic units, as relevant
	[3]	Media speed	int	Yes	Returns current media speed in DTS-specfic units, as relevant

9.9 Informational Commands

Informational commands are no-op commands that specify certain types of potentially useful information to the DTS.

Keyword	Field #	Description	Type	Allowed values	DTS-specific?	Comments
*media_id	1-n	Media label or serial #'s	literal ASCII			This command useful only if media is not self identified by the DTS; if n media units (such a multiple discs), need to specify n fields
*mode	1	Data/recording mode	literal ASCII		Yes	DTS-specific
*source	1	Celestial source name	literal ASCII		No	Source currently being observed
	2	On/off source	char	on | off	No	Specifies whether time in field 3 is on-source or off-source time
	3	Time	time		No	On/off source time
*cal	1	On/off	char	on | off	No	Specifies whether time in field 2 is cal-on or cal-off time
	2	Time				On/off cal time
*station	1	Station ID	literal ASCII		No	Standard 2-char VLBI station ID
*comment	1	User comment	literal ASCII		No	Arbitrary user comment

9.10 Informational Queries and Responses

These queries simply respond with the current values associated with the informational keyword, irregardless of the source of the information (Controller or PDATA).

Keyword	Returned Field #	Description	Type	DTS-specific?	Comments
*media_id	1-n	Media label or serial #'s	literal ASCII		If n media units (such a multiple discs), will return n fields
*mode	1	Data/recording mode	literal ASCII	Yes	Returns mode
*source	1	Celestial source name	literal ASCII	No	Returns source name
	2	On/off source	char	No	Current on/off source status
*cal	1	On/off	char	No	Current cal status
*station	1	Station ID	literal ASCII	No	Current station ID

References:

1. 'VLBI Standard Hardware Interface Specification – VSI-H', Rev 1.0, 7 August 2000