Aspect Medical Systems

BIS™ MONITOR

Serial Port Technical Specification

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SECTION 1 INTRODUCTION

The BIS VISTA™, BIS VIEW™ and A-2000™ Bispectral Index™ (BIS™) monitors[1] have one RS-232 serial port located on the rear panel of the instrument. This document describes the physical interface and the formats of the data transmitted from and received by the serial port. The emphasis of this document is on the general use of the serial port as a means of extracting raw EEG data and computed spectral data by external devices capable of storing, displaying or printing large amounts of data.

The purpose of the serial port is to provide access to raw and calculated EEG data through a universal interface connection. This document covers only the interface and the data formats of the serial port. The information in this document can be used by programmers designing an interface program or an algorithm to decode an archived file. The well known RS-232(C) standard[2] will not be discussed in detail in this document unless it has pertinence to the subject of transmitting and receiving EEG data.

The Monitor serial port can operate with one of two protocols: ASCII or Binary. (VIEW supports only the ASCII protocol.) The protocol is menu selectable (Advanced Setup Menu in A-2000; Maintenance Menu in VISTA); the initial default protocol is ASCII, but Binary can be selected and made the institutional default. To maintain backward compatibility, the monitor may be able to output multiple revisions of a given protocol, refer to section 2.4 “Serial Protocol Revision Compatibility Matrix” for details on the protocol and/or revisions supported by your monitor.

[1] Hereinafter, the A-2000, BIS VISTA and BIS VIEW Monitors shall be referred to collectively as the “Monitor”.

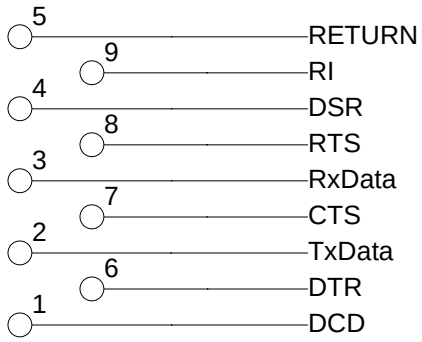
[2] Electronics Industries Association, "EIA Standard RS-232-C Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Data Interchange", August 1969

SECTION 2 INTERFACE SPECIFICATIONS

2.1 Connector Pinouts

The Monitor serial port is an asynchronous serial communications port with signals equivalent to RS-232 levels. The port has a DB-9 female connector wired as a DCE, with pinouts as defined below.

DB-9 female



The state of the terminal and flow control signals is as show in the table below:

PIN	Name	A-2000	VISTA/VIEW
1	DCD	MARK (-12 V)	Not Connected
4	DSR	Not Connected	Not Connected
6	DTR	MARK (-12 V)	Connected
7	CTS	Not Connected	Connected
8	RTS	MARK (-12 V)	Connected
9	RI	SPACE (+12V)	Do not connect – Internal Use Only

If the data collection hardware or software requires that any of the control lines be terminated in some other fashion at the data collection hardware end, those connections should be made in the cable. The shell of the DB-9 connector is the cable shield contact.

WARNING!
WHEN CONNECTING EXTERNAL EQUIPMENT (e.g., DATA CAPTURE COMPUTER), THE SYSTEM LEAKAGE CURRENT MUST BE CHECKED AND MUST BE LESS THAN THE IEC 60601-1-1 LIMIT.

2.2 Cable Wiring

To connect the Monitor to a computer or terminal with a 9-pin D connector, use a “straight” (modem) cable wired as follows:

Monitor Connector Pins		Computer Connector Pins
2	- - - - - - - - - - - - - - - -	2
3	- - - - - - - - - - - - - - - -	3
5	- - - - - - - - - - - - - - - -	5

To connect the Monitor to a computer or terminal with a 25-pin D connector, a similar cable must be used:

Monitor Connector Pins		Computer Connector Pins
2	- - - - - - - - - - - - - - - -	3
3	- - - - - - - - - - - - - - - -	2
5	- - - - - - - - - - - - - - - -	7

2.3 Communication Port Settings

The serial port settings are as follows (both transmit and receive are the same):

	ASCII Protocol	Binary Protocol
Baud Rate	9600	57,600
Data Bits	8	8
Stop Bits	1	1
Parity	No Parity	No Parity
Flow Control	None	None

2.4 Serial Protocol Revision Number

The entire umbrella of serial communication functionality (both ASCII and Binary protocols) is tracked through a single revision number referred to as the Serial Protocol Revision Number. The serial protocol functionality is integral to the Monitor software, and therefore, the Serial Protocol Revision Number may be used to determine whether a version of Monitor software is compatible with a given data acquisition program. (See Version Number Record for details).

2.4.1 Serial Protocol Revision Number Format

The Serial Protocol Revision Number has two parts: a major revision level and a minor revision level.

Example 1.08

The *major revision level* is specified by the number to the left of the decimal point. If the new Monitor serial protocol is not backward compatible, the major revision level will be incremented.

The *minor revision level* is specified by the number to the right of the decimal point. The minor revision level is incremented if the Monitor software contains new commands and responses but is otherwise backward compatible with previous revisions.

For example, revision1.10 protocol is backwards compatible with revision 1.08; revision 2.00 protocol may not be compatible with revision 1.08.

2.4.2 Serial Protocol Revision Compatibility Matrix

Table 1: A-2000 Monitor Revision History

Serial Protocol Revision	A-2000 Software Revisions	ASCII Protocol Feature(s) Added	Binary Protocol Feature(s) Added
(none)	1.04, 1.05	(Serial Protocol Revision not implemented)	(Serial Protocol Revision not implemented)
(none)	1.06, 1.07, 1.08, 2.00	ASCII protocol introduced.	Snippet messages added to Binary protocol
1.04	1.10, 2.01	Serial Protocol Revision added	Serial Protocol Revision added
1.06	2.10, 2.21	Alarm status added to ASCII protocol	BIS History messages added to Binary protocol
1.07	3.00, 3.11, 3.12, 3.21, 3.23	Event records added, SEND_PROCESSED_VARS spectra_flag implemented	Event records added, BIS History records expanded from 12 to 16 bytes, SEND_PROCESSED_VARS spectra_flag implemented
1.08	3.30, 3.31	New variables added to processed variables messages. New variables must be enabled by a command.	New variables added to processed variables messages, BIS History data messages and snippet processed data. New variables must be enabled by a command.

Table 2: VISTA Monitor Revision History

Serial Protocol Revision	VISTA Software Revisions	ASCII Protocol Feature(s) Added	Binary Protocol Feature(s) Added
1.08	1.02	First Release – A-2000-compatible ASCII only	Not included
1.08/1.09	2.00	Include initial A-2000-compatible (1.08) and VISTA (1.09) ASCII support (includes ASCII “m” command)	Initial VISTA (1.09) Binary support.
1.08/1.10	3.00	Bilateral Sensor Support	Includes both “Legacy Protocol” at 1.08 and updated Binary Protocol 1.10 which includes Bilateral Sensor Support

Table 3: VIEW Monitor Revision History

Serial Protocol Revision	VIEW Software Revisions	ASCII Protocol Feature(s) Added	Binary Protocol Feature(s) Added
1.08	1.00, 1.01	A-2000-compatible ASCII only	Not Applicable. The VIEW does not support Binary Protocol.

SECTION 3 GENERAL DISPLAY GUIDANCE OF MONITOR DATA

The Monitor uses several methods to check the quality and validity of the data it displays. This ensures that the clinician using the Monitor has the best information possible on which to base decisions. When data is acquired from the Monitor for display, it is important to use at least some of these methods in order to avoid misleading the clinician. The two most important measures of the quality of the BIS are SQI and EMG. See Appendix B for a complete list and description of the processed EEG variables.

3.1 Channel 1, Channel 2, and Channel 12

When the Aspect Monitor is reporting two-channels of information (ex. 2 channel sensor connected or 4 channel sensor connected but reporting in Legacy Mode), the Monitor serial port protocols have provisions for 2 channels of data and a "combined" channel. The data set for the combined channel (Ch. 12) must be used for data display and archiving. The data set for Channel 2 (Ch. 2) must be ignored.

3.2 BIS

The Monitor calculates three different Bispectral Index values, but only one of them should be displayed. When using the ASCII protocol, only one BIS is transmitted, so there should be no confusion. When using the Binary protocol, all three BIS variables (bispectral_index, bispectral_alternate_index, and bispectral_alternate2_index) are transmitted, but the alternate indexes normally contain an illegal value (-3276.8). Only bispectral_index should be displayed.

3.3 SQI

The Monitor calculates the Bispectral Index (BIS) and other processed EEG variables based on artifact-free epochs of data, where each epoch is 2 seconds. Each calculated value is based on an average of the last n epochs, where n represents approximately 60 seconds of data. In order to judge the quality of the raw data, and hence the reliability of the processed variables, the Monitor calculates a Signal Quality Index (SQI), which is the percentage of good epochs in the last 120 epochs.

The A-2000 displays the SQI as a bar graph, and uses it to qualify the display of BIS, Suppression Ratio (SR), Burst Count (BURST), Spectral Edge Frequency (SEF) and Total Power (TOTPOW). If the SQI is between 50% and 100%, the BIS number is displayed using "solid" digits and is trended. This indicates that the signal quality is good, and the values are reliable. If the SQI is between 15% and 50%, then the BIS number is displayed using "hollow" digits, and a "hatched" artifact bar is drawn at the bottom of the trend graph. This indicates that the signal quality is poor, but the values are still usable. If the SQI is less than 15%, then the BIS number and trend are not displayed, and a solid artifact bar is drawn at the bottom of the trend graph. This indicates that the signal quality is bad, and the values are not usable.

VISTA and VIEW similarly qualify the BIS value and other processed variables using SQI. However, the BIS number is displayed using "solid" digits and the BIS is trended unless the SQI is less than 15%, in which case the BIS number and trend are not displayed. Warning messages are displayed for the low levels of SQI.

Any external device that displays BIS should display the SQI, and must not display the affected processed variables when the SQI is less than 15%, in order to inform the clinician of the quality of the raw and

processed EEG.

3.4 EMG

The Monitor also measures EMG, which is the power (in decibels) in the frequency range of 70 – 110 Hz. This frequency range contains power from muscle activity (i.e., electromyography or EMG) as well as power from other high-frequency sources. When present, this high-frequency signal significantly interferes with EEG measurements, and can bias the BIS high. The Monitor displays the EMG variable as a bar graph, ranging from a value of 30 dB to 55 dB, and as a secondary trend, ranging from 30 dB to 80 dB.

It is recommended that any external device that displays BIS also display the EMG value in some fashion, in order to alert the clinician as to the presence of high-frequency signals.

3.5 Burst Count

Beginning with protocol revision 1.08, the A-2000 and VISTA calculate and display a Burst Count parameter (BURST) in addition to the Suppression Ratio (SR) when an Extend Sensor (or Bilateral for VISTA) is connected. A command must be sent to the Monitor via the serial port to enable transmission of Burst Count. Burst Count is an integer number of EEG bursts in the last 60 seconds, and is updated every second. Burst Count must be qualified by SQI (see Section 3.2) and by SR: if SR is less than 5%, Burst Count must not be displayed.

3.6 Bilateral Sensor

The Aspect Bilateral Sensor is supported only by the four-channel VISTA monitoring system beginning with VISTA Monitor revision 3.00. The serial protocol supports this sensor using two modes: “A-2000 compatibility mode” and “full four-channel data mode.”

In the *full four-channel mode*, Channel 1 contains the data from the left hemisphere and Channel 3 contains the data from the right hemisphere.

In the *A-2000 compatibility mode*, data is limited to the existing three-channel data structures. Therefore, Channel 1 contains data from the left hemisphere, Channel 2 contains data from the right hemisphere, and Channel 12 contains data from the hemisphere being viewed on the VISTA monitor screen. The Asymmetry variable is not transmitted in this mode.

SECTION 4 SECTION 4 ASCII PROTOCOL

The ASCII protocol is a simple method for acquiring processed EEG data from the Monitor, and can be used with terminal programs and serial printers. In the ASCII protocol, all data is transmitted from the monitor in ASCII character format in specified structures also referred to as "records." The ASCII protocol also defines commands that can be received from an interfacing PC or system that alter the type of data transmitted by the monitor. This section describes the format of the ASCII protocol data, records, and commands. See Appendix C for a recommended data capture technique.

4.1 ASCII Protocol Backward Compatibility

VISTA and VIEW Monitors remains backward compatible with interfacing systems initially developed for communication with the A-2000.

The VIEW only supports a single ASCII Mode which is A-2000 compatible (revision 1.08)

The VISTA supports 2 ASCII Modes: a backwards compatible "A-2000 compatibility mode" and a "VISTA Mode." In *A-2000 compatibility mode*, the VISTA emulates the last Serial Protocol revision supported by the A-2000. The last Serial Protocol revision supported by the A-2000 was 1.08.

In *VISTA Mode*, the VISTA enables new features (e.g. support for Bilateral Sensor), that were not previously available for the A-2000. VISTA mode is enabled using a new ASCII command ('m'). The 'm' command, in conjunction with the 'V' command, can be used to determine VISTA presence in addition to enabling the new features.

4.2 ASCII Protocol Commands

There are several commands that can be sent to the Monitor via the serial port. These commands alter the types of records that are transmitted via the serial port. Each command is a single ASCII character. The commands are as follows:

Table 4: ASCII Protocol Commands

Commands	Code (ASCII)	Description
Clear All Output	C (0x43)	Turns off all output.
Header Request	D (0x44)	Causes the Monitor to transmit Header Record and begin transmitting Data Records (default).
Error Records ON	E (0x45)	Turns on Error Record output.
Error Records OFF	e (0x65)	Turns off Error Record output (default).
VISTA Mode Select	m (0x6D)	Turns on VISTA Protocol Support. Protocol Rev. 1.09 or higher.
Event Records ON	N (0x4E)	Turns on Event Record output. Protocol Rev. 1.07 or higher. Not supported by VIEW.
Event Records OFF	n (0x6E)	Turns off Event Record output (default). Protocol Rev. 1.07 or higher. Not supported by VIEW.
Update Output ON	U (0x55)	Turns on all output. Does not turn on Extra Variables ('X' command) Does not turn on Event Records ('N' command) Retransmits Header ('D' command)
Version Request	V (0x56)	Transmits software revision numbers.
Extra Variables ON	X (0x58)	Enables extra variables in two-channel Data Records. Protocol Rev. 1.08 and higher. Retransmits Header ('D' command)
Extra Variables OFF	x (0x78)	Disables extra variables in two-channel Data Records (default). Protocol Rev. 1.08 and higher. Retransmits Header ('D' command)
Impedance Records ON	Z (0x5A)	Turns on Impedance Record output.
Impedance Records OFF	z (0x7A)	Turns off Impedance Record output (default).

4.3 ASCII Protocol Records

The data transmitted from the monitor to the interfacing PC or system is grouped in specified structures or "records." There are six basic types of records transmitted by the ASCII protocol:

Header Record	- describes each field of the Data Record
Data Record	- contains all processed EEG variables
Impedance Record	- contains impedance values from the impedance check
Error Record	- contains an error code
Version Number Record	- contains the version numbers for Monitor software packages
Event Record	- indicates the time at which an event was marked on the Monitor (A-2000 or VISTA only)

4.3.1 General ASCII Record Format

Each record consists of either 1 or 2 lines of data. Each line of data starts with a unique string of single byte characters, and ends with a Carriage Return (<CR>), followed by a Line Feed (<LF>) character.

NOTE: A null character may be transmitted following the <LF> at the end of ASCII records.

Fields within the records are delimited using the "vertical bar" character ("|", ASCII 0x7C). Each field is 8 characters wide (not including the delimiter characters).

All records are designed for easy importation into a spreadsheet program, and may also be displayed or printed on a device that automatically wraps long lines.

4.3.2 Header Record

The Header Record provides a description (or label) for the information included in the Data Record. The Header Record is available in two structures: "A-2000 Compatibility Mode Header" and "VISTA Mode Header."

The *A-2000 Compatibility Mode Header* is supported by A-2000, VIEW, and VISTA Monitors. The key information of the A-2000 Compatibility Mode Header is that the A-2000 system software version number is reported regardless of the monitor transmitting the data. This enables the Header Record to appear as if it is being sent by the A-2000 monitor. The A-2000 Compatibility Mode Header is the default Header Record sent by the A-2000, VIEW, and VISTA Monitors.

The *VISTA Mode Header* is supported only by the VISTA Monitor. The key information of the VISTA Mode Header is that the VISTA and BISx software version numbers are reported instead of the A-2000 system software version number. The VISTA mode Header can only be sent by the VISTA monitor, and it must be enabled by the interfacing PC or system.

Both the *A-2000 Compatibility Mode Header* and *VISTA Mode Header* can include extra variables if requested by the interfacing PC or system (See Section 4.3.2.3 Extra Variables for details).

4.3.2.1 A-2000 Compatibility Mode Header Record

Specification	Data
Starting Unique String of Characters	S_HDR3 (for line 1), TIME (for line 2)
# of Lines	2
Transmission Details	• Default Header Record for A-2000, VISTA, and VIEW • Transmitted once upon monitor startup • Transmitted once in response to Header Request command, D (0x44) • Transmitted once in response to Update Output ON command, U (0x55) • Transmitted once in response to Extra Variables ON command, X (0x58) • Transmitted once in response to Extra Variables OFF command, x (0x78) • Transmission of the Header Record also enables transmission of the Data Record
Data Details	• The A-2000 system software version number reported by the A-2000 is the actual version installed on the A-2000 monitor. • The VISTA & VIEW monitors report a fixed A-2000 system software version number of 3.30 (SYS 3.30).

4.3.2.1.1 A-2000 Compatibility Mode Header- LINE 1 Details

The first line of the A-2000 Compatibility Mode Header starts with the unique string "S_HDR3", and contains the ***A-2000 system software version number***, along with channel numbers that indicate where the data for each channel starts in the Data Record.

Note that the Header Record includes a fixed ***A-2000 system software version number***.

Example:

```
S_HDR3            |SYS 3.30|       |       |       |       |       |
Ch. 1   |       |       |       |       |       |       |       |
Ch. 2   |       |       |       |       |       |       |       |
Ch. 12  |       |       |       |       |       |       |       |<CR><LF>
```

4.3.2.1.2 A-2000 Compatibility Mode Header- LINE 2 Details

The second line starts with the unique string "Time", and contains the names of each of the fields in the Data Record. The name of each variable ends in a two-digit number that is the revision number of the algorithm that calculated that variable.

NOTE: When the BISx is not connected, VISTA and VIEW will transmit a default Header Record, i.e. the variable revision numbers and other fields may differ from those provided by BISx.

Example:

```
TIME              |DSC     |PIC     |Filters |Alarm   |Lo-Limit|Hi-Limit|Silence |
SR12    |SEF07    |BISBIT00|BIS     |TOTPOW07|EMGLOW01|SQI10   |IMPEDNCE|ARTF2   |
```

```
SR12    |SEF07   |BISBIT00|BIS     |TOTPOW07|EMGLOW01|SQI10   |IMPEDNCE|ARTF2   |

SR12    |SEF07   |BISBIT00|BIS     |TOTPOW07|EMGLOW01|SQI10   |IMPEDNCE|ARTF2   |<CR><LF>
```

When the two header lines are aligned, they should look like this:

```
S_HDR3             |SYS 3.30|        |        |        |        |        |
TIME               |DSC     |PIC     |Filters |Alarm   |Lo-Limit|Hi-Limit|Silence |

Ch. 1   |        |        |        |        |        |        |        |        |
SR12    |SEF07   |BISBIT00|BIS     |TOTPOW07|EMGLOW01|SQI10   |IMPEDNCE|ARTF2   |

Ch. 2   |        |        |        |        |        |        |        |        |
SR12    |SEF07   |BISBIT00|BIS     |TOTPOW07|EMGLOW01|SQI10   |IMPEDNCE|ARTF2   |

Ch. 12  |        |        |        |        |        |        |        |        |<CR><LF>
SR12    |SEF07   |BISBIT00|BIS     |TOTPOW07|EMGLOW01|SQI10   |IMPEDNCE|ARTF2   |<CR><LF>
```

4.3.2.2 VISTA Mode Header Record

The *VISTA Mode Header* is identical to the *A-2000 Compatibility Mode Header* with the exceptions of the reported system software version number, and when a Bilateral Sensor is attached to the system (See 4.3.2.3.2 VISTA Mode Header Record w/ Bilateral Sensor for details) The VISTA Mode Header reports the VISTA system software version number and the BISx software version number.

Specification	Data
Starting Unique String of Characters	S_HDR3 (for line 1), TIME (for line 2)
# of Lines	2
Transmission Details	• ONLY supported by the VISTA monitor. • Must be enabled by interfacing PC or system. • Transmitted once in response to Header Request command, D (0x44) • Transmitted once in response to Update Output ON command, U (0x55) • Transmitted once in response to Extra Variables ON command, X (0x58) • Transmitted once in response to Extra Variables OFF command, x (0x78) • Transmission of the Header Record also enables transmission of the Data Record
Data Details	• The VISTA system software version number reported by the VISTA is the actual version installed on the VISTA monitor. • The BISx software version number reported by the VISTA is the actual version installed on the BISx (if connected).

The default Header Record sent by the A-2000, VISTA, and VIEW monitors is the A-2000 Compatibility Mode Header record. Only the VISTA can send the VISTA Mode Header and this must be enabled by the interfacing PC or system by using the VISTA Mode Select command m (0x6D). If VISTA additional features are enabled using 'm' command, the Header Record is modified in the second and third fields:

```
S_HDR3             |VA  3.00|BX  1.11|        |        |        |        |        |
```

Where the highlighted fields represent:

field 2 Application Software Revision (VISTA 3.0 shown; VA == VISTA)

field 3 BISx Software Revision (BISx 1.11 shown)

When the BISx is not connected, the header record 3rd field is as follows:

```
S_HDR3              |VA  3.00|BX ??.??|        |        |        |        |        |
```

During demo mode, the header record 3rd field is as follows:

```
S_HDR3              |VA  3.00|BX      |        |        |        |        |        |
```

4.3.2.3 Header Record w/ Bilateral Sensor

Bilateral Sensor information can be sent in A-2000 Compatibility Mode or when additional VISTA features are enabled.

4.3.2.3.1 A-2000 Compatibility Mode Header Record w/ Bilateral Sensor

In order to remain backward compatible, the A-2000 Compatibility Mode Header Record does not change if a Bilateral Sensor is connected to the system. Only the reported information being sent in the Data Record will differ (See section 4.3.3.3.1 A-2000 Compatibility Mode Data Record w/ Bilateral Sensor).

4.3.2.3.2 VISTA Mode Header Record w/ Bilateral Sensor

The VISTA monitor will only provide additional Bilateral specific variable labels in the Header if 1) the VISTA additional features are enabled by the interfacing PC or system by using the VISTA Mode Select command m (0x6D), and 2) a Bilateral Sensor is connected.

If VISTA additional features are enabled using ‘m’ command and a Bilateral Sensor is connected to VISTA via a BISx4, a Bilateral header is transmitted.

Example:

```
S_HDR3             |VA   2.00|BX   1.10|        |        |        |        |        |
Ch. 1   |        |        |        |        |        |        |        |        |
Ch. 2   |        |        |        |        |        |        |        |        |
Ch. 3   |        |        |        |        |        |        |        |        |
Ch. 4   |        |        |        |        |        |        |        |        |
TIME               |DSC      |PIC      |Filters |Alarm    |Lo-Limit|Hi-Limit|Silence |
ASYM    |BILBITS |
SR12    |SEF07   |BISBIT00|BIS      |TOTPOW07|EMGLOW01|SQI10    |IMPEDNCE|ARTF2    |BURST    |
RESVAR0 |    SBIS |     SEMG|         |        |
SR12    |SEF07   |BISBIT00|BIS      |TOTPOW07|EMGLOW01|SQI10    |IMPEDNCE|ARTF2    |BURST    |
RESVAR0 |    SBIS |     SEMG|         |        |
SR12    |SEF07   |BISBIT00|BIS      |TOTPOW07|EMGLOW01|SQI10    |IMPEDNCE|ARTF2    |BURST    |
RESVAR0 |    SBIS |     SEMG|        |        |
SR12    |SEF07   |BISBIT00|BIS      |TOTPOW07|EMGLOW01|SQI10    |IMPEDNCE|ARTF2    |BURST    |
RESVAR0 |    SBIS |     SEMG|         |        |<CR><LF>
```

where additional Bilateral fields are highlighted.

ASYM, RESVAR0, SBIS and SEMG are described in Description of Processed EEG Variables). BILBITS are a 2-digit hexadecimal value that describes the type of sensor in use and which hemisphere the data on the monitor screen come from. The bits in the hexadecimal value are defined as follows:

- bit:0 Sensor Type (always 1=bilateral)
- bit:1 Active Hemisphere (0=left, 1=right)

4.3.2.4 Header Record w/ Extra Variables

Both the A-2000 Compatibility Mode Header and VISTA Mode Header can include “extra variables” (ex. Burst Count) if requested by the Extra Variables ON command, X (0x58). When extra variables are requested the header records are expanded to include the names of the extra variables.

NOTE: Since VIEW does not support the Burst Count feature of the Extend Sensor, the BURST label is blanked (replaced by space characters) in the Header Records transmitted from the VIEW.

NOTE: When the BISx is not connected, VISTA and VIEW will transmit a default Header Record, i.e. the variable revision numbers and other fields may differ from those provided by BISx.

When extra variables are transmitted, the two header lines look like this:

```
S_HDR3              |SYS 3.30|        |         |         |         |         |         |
TIME                |DSC     |PIC     |Filters |Alarm    |Lo-Limit|Hi-Limit|Silence |

Ch. 1    |         |         |         |         |         |         |         |         |         |
SR12     |SEF07    |BISBIT00|BIS      |TOTPOW07|EMGLOW01|SQI10    |IMPEDNCE|ARTF2    |BURST    |         |

         |         |         |         |Ch. 2    |         |         |         |         |         |         |
         |         |         |         |SR09     |SEF06    |BISBIT00|BIS      |TOTPOW06|EMGLOW01|SQI07    |

         |         |         |         |         |         |         |         |Ch. 12   |         |         |
IMPEDNCE|ARTF2    |BURST    |         |         |         |         |         |SR09     |SEF06    |BISBIT00|

         |         |         |         |         |         |         |         |         |         |         |
BIS      |TOTPOW06|EMGLOW01|SQI07    |IMPEDNCE|ARTF2    |BURST    |         |         |         |         |

         |<CR><LF>
         |<CR><LF>
```

4.3.3 Data Record

The Data Record provides all of the processed EEG variables for 2 channels plus 1 combined channel. The Data Record is available in two structures: “A-2000 Compatibility Mode Data Record” and “VISTA Mode Record.”

The *A-2000 Compatibility Mode Data Record* is supported by A-2000, VIEW, and VISTA Monitors. The A-2000 Compatibility Mode Data Record is the default Data Record sent by the A-2000, VIEW, and VISTA Monitors.

The *VISTA Mode Data Record* is supported only by the VISTA Monitor, and it must be enabled by the interfacing PC or system.

Both the *A-2000 Compatibility Mode Data Record* and *VISTA Mode Data Record* can include extra variables if requested by the interfacing PC or system (See Section 4.3.3.3 Extra Variables for details).

4.3.3.1 A-2000 Compatibility Mode Data Record

Specification	Data
Starting Unique String of Characters	Current Date and Time (MM/DD/YYYY HH:MM:SS)
# of Lines	1
Transmission Details	• Default Data Record for A-2000, VISTA, and VIEW • Transmitted once every 5 sec immediately following the transmission of the Header Record. o Follows transmission of default header record upon monitor startup o Follows transmission of header record in response to Header Request command, D (0x44) o Follows transmission of header record in response to Update Output ON command, U (0x55) o Follows transmission of header record in response to Extra Variables ON command, X (0x58) o Follows transmission of header record in response to Extra Variables OFF command, x (0x78)
Data Details	• Data Record contains all of the processed EEG variables for 2 channels plus 1 combined channel. • All processed EEG variables except the BIS bits and the artifact flags are right-justified decimal numbers. • Impedance values are in Kohms. • The 16-bit BIS bits and 32-bit artifact flags are represented as 4-digit and 8-digit hexadecimal numbers, respectively (see Appendix B for artifact flag definitions). • The value for Filters is either the string "Off" or the string “On”. • The value for Alarm is one of three strings: "None", meaning no alarms are active, "High", meaning the high limit alarm is active, or "Low", meaning the low limit alarm is active. • The values for Lo-Limit and Hi-Limit are either a numeric value between 1 and 99, or the string "Off". • The value for Silence is either the string "No", meaning alarms are not silenced, or "Yes", meaning the alarms are silenced. • Fields for which there are no valid values may contain spaces, “-32768.0”, “-3276.8”, or “-327.7”. (The value -32768 is used to represent “Not a Number”, and it may be divided by 10 or 100 and rounded.) • The following variables shall be set to zero (0) if SQI is less than 15: o Spectral Edge (SEF) o BIS o Total Power o EMG

Example:

```
01/23/2005 12:34:56|       8|      46|On      |None    |Off     |Off     |No      |
   100.0|    28.6|    0000|    45.6|    21.7|    24.3|     0.8|      18|10000020|
```

```
100.0|    28.6|    0000|    13.9|     9.3|    22.9|     0.8|       1|10000020|
100.0|    28.6|    0000|    29.3|    15.5|    23.6|     0.8|       0|10000020|<CR><LF>
```

NOTE: When the DSC is not connected, the A-2000 shall set the DSC and PIC fields to zero.

NOTE: When the BISx is not connected, both the VISTA and VIEW shall set the DSC and PIC fields to zero and transmit the following Data Record. (Header Record is shown in gray as a reference.)

Example:

```
TIME                |DSC     |PIC     |Filters |Alarm   |Lo-Limit|Hi-Limit|Silence |
01/15/2006 12:19:24|       0|       0|On      |None    |Off     |Off     |Yes     |

SR12    |SEF07   |BISBIT00|BIS     |TOTPOW07|EMGLOW01|SQI10   |IMPEDNCE|ARTF2   |
     0.0|     0.0|    0000|     0.0|     0.0|     0.0|     0.0|       1|00000000|
     0.0|     0.0|    0000|     0.0|     0.0|     0.0|     0.0|       1|00000000|
     0.0|     0.0|    0000|     0.0|     0.0|     0.0|     0.0|       0|00000000|<CR><LF>
```

4.3.3.2 VISTA Mode Data Record

The *VISTA Mode Data Record* is identical to the *A-2000 Compatibility Mode Data Record* except when a Bilateral Sensor is connected.

The default Data Record sent by the A-2000, VISTA, and VIEW monitors is the A-2000 Compatibility Mode Data Record. Only the VISTA can send the VISTA Mode Data Record and this must be enabled by the interfacing PC or system by using the VISTA Mode Select command m (0x6D).

4.3.3.3 Data Record w/ Bilateral Sensor

Bilateral Sensor information can only be sent by the VISTA monitor in either the A-2000 Compatibility Mode Data Record or the VISTA Mode Data Record formats.

4.3.3.3.1 A-2000 Compatibility Mode Data Record w/ Bilateral Sensor

When reporting Bilateral Sensor information in the default A-2000 Compatibility Mode, the Data Record structure is not expanded. Instead the structure is mapped from the Bilateral Sensor as follows:

- Active hemisphere is Left:
  - Channel 1 <- Bilateral LT (Left Temple)
  - Channel 2 <- Bilateral RT (Right Temple)
  - Channel 12 <- Bilateral LT
- Active hemisphere is Right:
  - Channel 1 <- Bilateral LT
  - Channel 2 <- Bilateral RT
  - Channel 12 <- Bilateral RT

The “active” hemisphere is the one being viewed on the VISTA screen.

4.3.3.3.2 VISTA Mode Data Record w/ Bilateral Sensor

When reporting Bilateral Sensor information with additional VISTA features enabled, the Data Record structure is expanded to include additional Bilateral Processed Variables.

Example:

```
08/23/2006 17:53:53|      13|      147|On      |None    |Off     |Off     |No      |
     55.5|      01|
      0.0|    25.7|    040e|    96.7|    57.7|    27.0|    75.0|       6|00000080|       0|
        0|     7.6|     3.4|        |        |
      0.0|     0.2|    040e|    96.7|    57.7|    27.0|   100.0|       8|00000080|       0|
        0|     7.6|     3.4|        |        |
      0.0|     0.2|    0000|    96.7|    57.7|    27.0|    75.0|       0|00000000|       0|
        0|     7.6|     3.4|        |        |
      0.0|     0.2|    0000|    96.7|    57.7|    27.0|    75.0|       0|00000000|       0|
        0|     7.6|     3.4|        |        |<CR><LF>
```

where additional bilateral fields are highlighted

NOTE: On a VISTA with Bilateral Sensor, if SQI is less than or equal to 14, ASYM shall be set to -32768.0 and should be treated as an invalid value.

4.3.3.4 Data Record w/ Extra Variables

Both the A-2000 Compatibility Mode Data Record and VISTA Mode Data Record can include “extra variables” (ex. Burst Count) if requested by the Extra Variables ON command, X (0x58). When extra variables are requested, the Data Records are expanded to include the values of the extra variables.

NOTE: Since VIEW does not support the Burst Count feature of the Extend Sensor, therefore, VIEW will always transmit a BURST value of “–3276.8”.

NOTE: When a non-Extend sensor is connected to the monitor, the A-2000 and VISTA will transmit a BURST value of “–3276.8”.

NOTE: When the DSC is not connected, A-2000 will transmit a BURST value of “–3276.8”.
NOTE: When the BISx is not connected, VISTA will transmit a BURST value of “–3276.8”.
NOTE: Unused extra variables will transmit a value of “-32768.0”

The following extra variables shall be set to zero (0) if SQI is less than or equal to 14:

- BURST

When the extra variables (including Burst Count) are enabled, the Data Record is expanded to look like the following example.

Example:

```
04/17/2008 18:34:49|      10|      57|On      |None    |Off     |Off     |No      |
     0.0|    22.6|    0661|    72.4|    58.1|    25.0|    93.3|       9|00000200| -3276.8|
-32768.0|-32768.0|-32768.0|-32768.0|-32768.0|
     0.0|     0.2|    0661|    72.4|    58.1|    25.0|   100.0|       7|00000000| -3276.8|
-32768.0|-32768.0|-32768.0|-32768.0|-32768.0|
     0.0|    22.6|    0661|    72.4|    58.1|    25.0|    93.3|       0|00000200| -3276.8|
-32768.0|-32768.0|-32768.0|-32768.0|-32768.0|<CR><LF>
```

4.3.4 Impedance Records

The *Impedance Record* provides the electrode impedance values. The *Impedance Record* is identical when in A-2000 Compatibility Mode or when VISTA features are enabled except when a Bilateral Sensor is connected.

Specification	Data
Starting Unique String of Characters	IMPEDNCE
# of Lines	1
Transmission Details	• Impedance records are not transmitted by default. They must be enabled by the interfacing PC or system if desired. • Transmission is enabled using the Impedance Records ON command, Z (0x5A). • Transmission is enabled using the Update Output ON command, U (0x55). • Transmission is disabled using the Impedance Records OFF command, z (0x7A). • Transmitted only when a Sensor Check or continuous ground check are in progress. • Separate records are transmitted for the positive electrodes, the negative electrodes and the ground electrode.
Data Details	• Contains the current date and time (MM/DD/YYYY HH:MM:SS) • The impedance values are right-justified. • The impedance values may be decimal numbers (in ohms). • The impedance values may also be non-numeric strings o "LDOFF" (when a lead is off) o “NOISE” (when the signal is clipping) • The impedance values may also include a sign prefix o "+" (for positive electrodes) o "-" (for negative electrodes) o “g” (for ground electrode).

Each Impedance Record starts with the unique string "IMPEDNCE", and includes the current date and time (MM/DD/YYYY HH:MM:SS) and the impedance values for 2 or 4 channels.

NOTE: The ground electrode is measured and reported only on channel 1.

Examples:

```
IMPEDNCE|01/23/2001 12:34:56|+   5000|+  LDOFF<CR><LF>
IMPEDNCE|01/23/2001 12:34:56|-  NOISE|-  12000<CR><LF>
IMPEDNCE|01/23/2001 12:34:56|g  50000<CR><LF>
```

4.3.4.1 Impedance Record w/ Bilateral Sensor

Bilateral Sensor Impedance information can only be sent by the VISTA monitor in either the A-2000 Compatibility Mode or when VISTA features are enabled.

4.3.4.1.1 A-2000 Compatibility Mode Impedance Record w/ Bilateral Sensor

When reporting Bilateral Sensor information in the default A-2000 Compatibility Mode, the Impedance Record structure is not expanded. Instead the structure is mapped from the Bilateral Sensor to the default two-channel impedance message as follows:

- '+' electrode <- Bilateral C (Center)
- 'ground' electrode <- Bilateral G (Ground)
- Active hemisphere is Left: '-' electrodes <- Bilateral LT (Left Temple), LE (Left Eyebrow)
- Active hemisphere is Right: '-' electrodes <- Bilateral RT (Right Temple), RE (Right Eyebrow)

Example for Left hemisphere active:

```
IMPEDNCE|01/23/2001 12:34:56|-  NOISE|-  12000<CR><LF>
                              LT       LE
```

4.3.4.1.2 VISTA Mode Impedance Record w/ Bilateral Sensor

When reporting Bilateral Sensor Impedance information with additional VISTA features enabled, the Impedance Record structure is expanded to include impedances during sensor or ground check for the 6 bilateral sensor electrodes: (+) is electrode C , (-) are electrodes LT, LE, RT, and RE, and (g) or ground is electrode G.

```
IMPEDNCE|01/23/2001 12:34:56|-   5000|- LDOFF|-   5000|-  LDOFF<CR><LF>
IMPEDNCE|01/23/2001 12:34:56|+  NOISE <CR><LF>
IMPEDNCE|01/23/2001 12:34:56|g  50000
```

4.3.5 Error Records

The *Error Record* provides notification of detected errors and when they are cleared. There are two types of Error Records: Error Set and Error Clear.

Error Set Records are transmitted when an error is detected.

Error Clear Records are transmitted when an error condition goes away.

4.3.5.1 Error Set Record

Specification	Data
Starting Unique String of Characters	ERROR
# of Lines	1
Transmission Details	• Error records are NOT transmitted by default. They must be enabled by the interfacing PC or system if not desired. • Transmission is enabled using the Error Records ON command, E (0x45). • Transmission is enabled using the Update Output ON command, U (0x55). • Transmission is disabled using the Error Records OFF command, e (0x65). • Transmitted only when an error is detected. • May be transmitted multiple times for a persistent error.

Data Details	• Contains the current date and time (MM/DD/YYYY HH:MM:SS) • Contains the error in 8-bit ASCII text • Contains the numeric error code

NOTE: Some errors are transient, occurring only briefly (e.g. DSC Error), while others may persist for a long time (e.g. Re-Prep Sensor).

NOTE: Error strings are transmitted in the current monitor language setting except for languages that cannot be mapped to 8-bit ASCII (e.g., Chinese). Such Monitors revert to English.

Example:

```
ERROR   |01/23/2001 12:34:56|DSC Not Connected (E01)<CR><LF>
```

4.3.5.2 Error Clear Record

Specification	Data
Starting Unique String of Characters	CLEAR
# of Lines	1
Transmission Details	• Error records are NOT transmitted by default. They must be enabled by the interfacing PC or system if not desired. • Transmission is enabled using the Error Records ON command, E (0x45). • Transmission is enabled using the Update Output ON command, U (0x55). • Transmission is disabled using the Error Records OFF command, e (0x65). • Transmitted only when an error is cleared.
Data Details	• Contains the current date and time (MM/DD/YYYY HH:MM:SS) • Contains the error in 8-bit ASCII text • Contains the numeric error code

NOTE: Error strings are transmitted in the current monitor language setting except for languages that cannot be mapped to 8-bit ASCII (e.g., Chinese). Such Monitors revert to English.

Example:

```
CLEAR   |01/23/2001 12:34:56|DSC Not Connected (E01)<CR><LF>
```

4.3.6 Version Number Record

The Version Record provides the version numbers for the Monitor software packages. The Version Record is available in two structures: "A-2000 Compatibility Mode Version Record" and "VISTA Mode Version Record."

The *A-2000 Compatibility Mode Version Record* is supported by A-2000, VIEW, and VISTA Monitors. The key information of the A-2000 Compatibility Mode Version Record is that A-2000/BIS Engine/DSC applicable software version numbers are reported regardless of the monitor transmitting the data. This enables the Version Record to appear as if it is being sent by the A-2000 monitor. The A-2000 Compatibility Mode Version Record is the default Version Record sent by the A-2000, VIEW, and VISTA Monitors.

The *VISTA Mode Version Record* is supported only by the VISTA Monitor. The key information of the VISTA Mode Version Record is that the VISTA and BISx software version numbers are reported instead of A-2000/BIS Engine/DSC applicable software version numbers. The VISTA Mode Version Record can only be sent by the VISTA monitor, and it must be enabled by the interfacing PC or system.

4.3.6.1 A-2000 Compatibility Mode Version Number Record

Specification	Data
Starting Unique String of Characters	VERSION
# of Lines	1
Transmission Details	• Version records are only transmitted once in response to the Version Request command, V (0x56).
Data Details	• Contains the current date and time (MM/DD/YYYY HH:MM:SS) • Contains the A-2000 system software revision number. • Contains the A-2000 host software revision number. • Contains the BIS Engine software revision number. • Contains the serial protocol revision number. o NOTE: In the serial protocol revision number (formerly the FPGA revision number), a change in the number to the left of the decimal point indicates a major revision that is not backward compatible, while a change in the number to the right of the decimal point indicates a change that is backward compatible. • Contains the Boot software revision number. • Contains the hardware revision number. • Contains the monitor's serial number. o The serial number consists of an alphabetic characters followed by 6 decimal digits.

Example:

```
VERSION |01/23/2005 12:34:56|    3.30|    3.30|    1.23|    1.08|    3.14|    2.00|C012345 <CR><LF>
```

4.3.6.2 VISTA Mode Version Number Record

The VISTA Mode Version Number record exactly matches the A-2000 Compatibility Mode Version Number record in the unique starting character string and structure. However, instead of sending the A-2000/BIS Engine/DSC applicable software version numbers, the data is remapped to the applicable VISTA/BISx software version numbers.

If the VISTA Mode Select command 'm' has been transmitted prior to the transmission of the Version Request command, the transmitted VISTA Version Number Record includes the following re-mapped data:

A-2000 Compatibility Mode Data	VISTA Mode Data
System SW Revision	Master Revision
Host SW Revision	Application Revision
BIS Engine SW Revision	BISx Software Revision
Serial Protocol Revision	VISTA Serial Protocol Revision
Boot Software Revision	BISx Serial Number
Hardware Revision	Motherboard Revision
Serial Number	Monitor Serial Number

Example:

```
VERSION |01/10/2006 16:17:32|    2.10|    2.10|    1.10|    1.09| BX03576|    2.00|VT01006 <CR><LF>
```

The BISx Serial Number and Software Revision are replaced by question marks if no BISx is connected.

Example:

```
VERSION |01/10/2006 16:17:32|    2.10|    2.10|   ??.??|    1.09|   ???? |    2.00|VT01006 <CR><LF>
```

Demo Mode

During demo mode, the BISx fields are blanked and "Demo Ca" replaces the BISx serial number.

```
VERSION |01/08/2008 17:35:55|    3.00|    3.00|        |    1.09|Demo Ca |    3.00|VT01006 <CR><LF>
```

4.3.7 Event Records

The *Event Record* provides notification of a user marked event on the monitor. The *Event Record* is identical when in A-2000 Compatibility Mode or when VISTA features are enabled.

The *Event Record* is supported by A-2000, and VISTA Monitors. The View does not support this feature.

Specification	Data
Starting Unique String of Characters	EVENT
# of Lines	1

Transmission Details	• Event records are NOT transmitted by default. They must be enabled by the interfacing PC or system if desired. • Transmission is enabled using the Event Records ON command, N (0x4E). • Transmission is disabled using the Event Records OFF command, n (0x6E). • Transmitted only when an event is marked by the user.
Data Details	• Contains the current date and time (MM/DD/YYYY HH:MM:SS)

Once enabled, an Event Record will be transmitted whenever the user marks an event on the A-2000 or a Snapshot on the VISTA. An Event Record consists of the word “EVENT” followed by the date and time (MM/DD/YYYY HH:MM:SS) at which the event was marked.

Example:

```
EVENT   |01/23/2001 12:34:56<CR><LF>
```

SECTION 5 SECTION 5 BINARY PROTOCOL

This section describes the Binary protocol. The Binary protocol is a binary, packet-oriented protocol. With the Binary protocol, raw EEG data as well as processed EEG variables can be captured. BIS Monitors are little-endian devices: multi-byte values are transmitted least-significant byte first, most-significant byte last.

On the A-2000, the Binary protocol is also the only method for accessing BIS History and EEG snippet[3] data. An EEG snippet is a piece of raw EEG data approximately 10 minutes long, along with the corresponding processed EEG data, that is stored in the A-2000's memory when an event is marked.

The VISTA Monitor supports two different binary protocols, selectable via the Maintenance Menu. The "Legacy Binary" button selects an A-2000 compatible mode (Protocol Rev. 1.08), while the "VISTA Binary" button selects a VISTA mode (Protocol Rev. 1.09) that supports advanced features (e.g. Bilateral Sensor support). Raw EEG data is not available for a Bilateral Sensor in Legacy Binary mode.

Note that the VIEW Monitor does not support Serial Binary Protocol.

5.1 Protocol

In the Binary protocol, information is exchanged via packets. There are three basic types of packets: data packets, ACK (acknowledgement) packets, and NAK (negative acknowledgement) packets. The receiver of each data packet must respond with an ACK packet (if the received packet is correct), or a NAK packet (if there is an error in the received packet). An ACK packet must be received by the originator of the data packet within 1/32 of a second (31.25 ms.), or a NAK will be assumed.

If a NAK packet is received by (or a timeout occurs in) the external device, the last command packet must be re-transmitted; the next command must not be transmitted until a valid ACK has been received.

The VISTA and A-2000 Monitors transmit too much data to allow for re-transmissions, so a NAK packet sent to the Monitor (or a time-out) is the equivalent of an ACK packet; the Monitor will proceed to transmit the next data packet. Therefore, it is not necessary to send ACK/NAK packets to the Monitor.

5.2 Packet Structure

Binary packets have a multi-layered format, facilitating isolation of software and data necessary in systems with multiple processes and/or processors (such as the A-2000 Host processor.)

Of the three layers in a message, layer 1 (at the bottom of the hierarchy) is the physical layer concerned with the transmission of data over the serial link. Layer 2 provides routing information that may be used for routing the message in a system with multiple processes or processors. Layer 3 (at the top of the hierarchy) is the application layer concerned with the exchange of application-specific data.

---

[3] "Snippet" is referred to as "snapshot" on the VISTA. The VIEW Monitor does not support this feature. VISTA snapshot must be exported to a USB Flash Drive.

5.2.1 Layer 1 (Physical)

The Layer 1 packet format is as follows:

Packet Field	# of bits	Description
Start of packet identifier	16	START_OF_PACKET (0xabba)
Packet Sequence ID	16	Range: 0x0000 - 0xffff
# of Bytes of Optional Data	16	Number of bytes in Layers 2 and 3. Range: 0 – 0x0800
Layer 1 Directive	16	There are 3 different types: 1 = L1_DATA_PACKET - For application data. The sender of this packet is to expect an acknowledgement within a period of 31.25 ms. 2 = L1_ACK_PACKET - To acknowledge receipt of a L1_DATA_PACKET. The sequence number of the received packet is used as the sequence number for this packet. The number of bytes of optional data for this packet is 0 (no Level 2 or Level 3 structures). 3 = L1_NAK_PACKET - When the received packet has errors. The sequence number for this packet should be equal to the sequence number of the last packet correctly received plus one. The number of bytes of optional data for this packet is also 0.
Optional Data	vari-able	
Checksum	16	Sum of bytes of the following fields: Packet Sequence ID, # of Bytes of Optional Data, Layer 1 Directive, Optional Data

The sequence number is set to zero at startup. For every L1_DATA_PACKET sent across the interface, the sequence number is incremented by one. The sequence number in packet layer 1 allows tracking of packets at the physical level.

5.2.2 Layer 2 (Routing)

5.2.2.1 Packet Field	# of bits	Description
Routing Identifier	32	Identifier that is used to identify a specific task or mailbox to which a command or the results of a command are to be directed.
Application Data	vari-able	

Every message has a routing identifier in layer 2 of the message.

5.2.3 Layer 3 (Application)

Packet Field	# of bits	Description
Message ID	32	Indicates the type of application data in the packet.
Sequence number	16	Range: 0 - 0xFFFF. A separate sequence number is maintained for every message ID.
Length	16	Number of bytes of message dependent data Range: 0 - 0x800
Message Dependent Data	variable	

The sequence numbers for all message IDs are set to zero at startup. For every message sent across the interface, the sequence number corresponding to the message ID is incremented by one. While the sequence number in packet layer 1 allows tracking of packets at the physical level, this sequence number in layer 3 allows the same at the application level. For example, the external device could use the layer 3 sequence numbers to check for any missing raw EEG packets or processed variables packets, and make any adjustments to keep the EEG data and the processed data synchronized before it is used for display or other purposes.

NOTE: The Layer 3 sequence ID is shared by all variations of the M_PROCESSED_VARS message (M_PROCESSED_VARS, M_PROCESSED_VARS_AND_SPECTRA, etc.)

5.3 Messages from External Device to Monitor

All commands sent from the External Device to the Monitor have a unique message ID. The 'message dependent data' field, in layer 3 of the packet, may have parameters specific to the command, with the number of bytes of parameters specified by the 'length' field. If the command has no parameters, the 'length' field is set to zero.

When commands received from the External Device have either an illegal command type or illegal values for command parameters, the Monitor responds with an error message.

For the command descriptions below, the response is a description of the processing done by the Monitor when the particular command is received with valid parameters.

Table 5: Messages from External Device to Monitor

Commands	ID	Comment
SEND RAW EEG	111	Request Raw EEG data . Data are transmitted 8 packets/sec, with two or four channels of interleaved EEG data.
STOP RAW EEG	112	Stop sending raw EEG
SEND PROCESSED VARS	115	Send Processed Variables
STOP PROCESSED VARS	116	Stop sending Processed Variables
TURN ON IMPED MSG	1000	Starts sending impedance records once per second during Sensor Check and Ground Check.
TURN OFF IMPED MSG	1001	Stops sending impedance records
TURN ON ERROR MSG	1002	Starts sending error records (when errors occur).
TURN OFF ERROR MSG	1003	Stops sending error records
SEND REVISION INFO	1004	Request to send revision information
SEND PROCESSED VARS LABELS	133	Sends the variable label header record
SEND EEG SNIPPET	1006	Starts sending EEG snippet data (A-2000 only)
SEND NEXT EEG SNIPPET PKT	1007	Send next EEG snipped data (A-2000 only)
SEND BIS HISTORY	1009	Start sending BIS History data (A-2000 only, Protocol Rev. 1.06 and higher)
SEND NEXT HISTORY PKT	1010	Send next BIS History data (A-2000 only, Protocol Rev. 1.06 and higher)
SEND NEXT BIG HISTORY PKT	1011	Send next big BIS History data (A-2000 only, Protocol Rev. 1.06 and higher)
TURN ON SEND EVENT	1014	Starts transmission of event records (Protocol Rev. 1.07 and higher)
TURN OFF SEND EVENT	1015	Stops transmission of event records (Protocol Rev. 1.07 and higher)
SEND EXTRA VARIABLES	1019	Starts transmitting extra variables (including Burst Count) in the processed variables messages and processed variables labels messages (Protocol Rev. 1.08 and higher)
STOP EXTRA VARIABLES	1020	Stops transmission of extra variables (Protocol Rev. 1.08 and higher)
SEND_PROCESSED_VARS_4B	1025	Enable Bilateral Processed Variables Packets and other 4-channel messages (Protocol Rev. 1.09 – "VISTA Binary")
SEND_PROCESSED_VARS_LABELS_4B	1026	Sends Bilateral variable label header record (Protocol Rev. 1.09 – "VISTA Binary")

5.3.1 SEND_RAW_EEG

Field	Possible Values
Routing ID	4
Message ID	111
Length	2
Message dependent data: 2 bytes - unsigned short rate	 128, 256

Response: Raw EEG data are sent 8 packets/sec. Two channels of interleaved EEG data are transmitted
VISTA w/Bilateral Sensor will transmit four channels of EEG if VISTA Binary Mode is selected AND 4 channel Processed Variables has been requested.
Raw EEG data are not available for a Bilateral Sensor in Legacy Binary Mode

NOTE: 256 samples per second rate is not supported by VISTA.

5.3.2 STOP_RAW_EEG

Field	Possible Values
Routing ID	4
Message ID	112
Length	0

Response: Stops sending raw EEG data packets.

5.3.3 SEND_PROCESSED_VARS

Field	Possible Values
Routing ID	4
Message ID	115
Length	1
Message dependent data: 1 byte - unsigned char spectra_flag	0 - send the processed variables packet (without the spectra) 1 - send the processed variables and spectra packet

Response: Sends the processed variables (with or without spectra) packet once every second.
For 2-channel VISTA (ie 2 channel sensor connected), 2 spectra datasets are reported, but only the 1st dataset is valid (corresponds to channel 1). The 2nd dataset is all 0.
For 4-channel VISTA (4 channel sensor is connected), 2 spectra datasets are reported, and both datasets are valid. 1st dataset = channel 1, and 2nd dataset = channel 3.

NOTE: Prior to Serial Protocol Rev. 1.07, the spectra_flag was ignored, and spectra were always transmitted.

5.3.4 STOP_PROCESSED_VARS

Field	Possible Values
Routing ID	4
Message ID	116
Length	0

Response: Stops sending the processed variables (with or without spectra) packet.

5.3.5 TURN_ON_IMPED_MSG

Field	Possible Values
Routing ID	6
Message ID	1000
Length	0

Response: Starts sending impedance records once per second during Sensor Check and Ground Check.

5.3.6 TURN_OFF_IMPED_MSG

Field	Possible Values
Routing ID	6
Message ID	1001
Length	0

Response: Stops sending impedance records.

5.3.7 TURN_ON_ERROR_MSG

Field	Possible Values
Routing ID	6
Message ID	1002
Length	0

Response: Starts sending error records (when errors occur).

5.3.8 TURN_OFF_ERROR_MSG

Field	Possible Values
Routing ID	6
Message ID	1003
Length	0

Response: Stops sending error records.

5.3.9 SEND_REVISION_INFO

Field	Possible Values
Routing ID	6
Message ID	1004
Length	0

Response: Sends the revision information message.

5.3.10 SEND_PROCESSED_VARS_LABELS

Field	Possible Values
Routing ID	4
Message ID	133
Length	0

Response: Sends the variable label header record.

5.3.11 SEND_EEG_SNIPPET

Field	Possible Values
Routing ID	9
Message ID	1006
Length	0

Response: If an EEG snippet has been recorded, and the data is valid, starts sending the EEG snippet data (header record). Not supported by VISTA

NOTE: A-2000 only

5.3.12 SEND_NEXT_EEG_SNIPPET_PKT

Field	Possible Values
Routing ID	9
Message ID	1007
Length	0

Response: Causes the A-2000 to send the next EEG snippet data packet (raw EEG records, then processed EEG records). The external device sends this command following the SEND_EEG_SNIPPET command. Not supported by VISTA.

NOTE: A-2000 only

5.3.13 SEND_BIS_HISTORY

Field	Possible Values
Routing ID	10
Message ID	1009
Length	0

Response: If there are BIS History data in memory, the BIS History header is sent; otherwise, SER_NO_HISTORY is sent. Not supported by VISTA.

NOTE: A-2000 only

5.3.14 SEND_NEXT_HISTORY_PKT

Field	Possible Values
Routing ID	10
Message ID	1010
Length	0

Response: Causes the A-2000 to send the next small BIS History data packet, containing up to 5 data records. The external device sends this command following the SEND_BIS_HISTORY command. Not supported by VISTA.

NOTE: A-2000 only

5.3.15 SEND_NEXT_BIG_HISTORY_PKT

Field	Possible Values
Routing ID	10
Message ID	1011
Length	0

Response: Causes the A-2000 to send the next big BIS History data packet, containing up to 85 data records. The external device sends this command following the SEND_BIS_HISTORY command. Not supported by VISTA

NOTE: A-2000 only

5.3.16 TURN_ON_SEND_EVENT

Field	Possible Values
Routing ID	6
Message ID	1014
Length	0

Response: Starts transmission of event records when events are marked on the Monitor.

NOTE: Protocol Rev. 1.07 and higher

5.3.17 TURN_OFF_SEND_EVENT

Field	Possible Values
Routing ID	6
Message ID	1015
Length	0

Response: Stops transmission of event records.

NOTE: Protocol Rev. 1.07 and higher

5.3.18 SEND_EXTRA_VARIABLES

Field	Possible Values
Routing ID	5
Message ID	1019
Length	0

Response: Starts transmitting extra variables (including Burst Count) in the 2-channel processed variables messages, processed variables labels messages, snippet processed variables messages and BIS history data records.

NOTE: Protocol Rev. 1.08 and higher

5.3.19 STOP_EXTRA_VARIABLES

Field	Possible Values
Routing ID	5
Message ID	1020
Length	0

Response: Stops transmission of extra variables in the 2-channel processed variables messages, processed variables labels messages, snippet processed variables messages and BIS history data records.

NOTE: Protocol Rev. 1.08 and higher

5.3.20 SEND_PROCESSED_VARS_4B

Field	Possible Values
Routing ID	4
Message ID	1025
Length	1
Message dependent data: 1 byte - unsigned char spectra_flag	0 - send the processed variables packet (without the spectra) 1 - send the processed variables and spectra packet

Response: Request to send processed variable M_PROCESSED_VARS_4B or M_PROCESSED_VARS_4B_AND_SPECTRA packet once every second. Also enables 4-channel raw EEG data.

NOTE: A VISTA with a two-channel sensor, or VISTA and BISx, will continue to transmit the two-channel ("Legacy Binary") packets.

NOTE: Command supported only by VISTA when Serial Protocol is set to "VISTA Binary" mode. This command is not supported in Protocol Revision 1.08.

5.3.21 SEND_PROCESSED_VARS_LABELS_4B

Field	Possible Values
Routing ID	4
Message ID	1026
Length	0

Response: Request to send the bilateral variable label header record. If no Bilateral sensor is inserted, the response will be same as the SEND_PROCESSED_VARS_LABELS command.

NOTE: Command supported only by VISTA when Serial Protocol is set to "VISTA Binary" mode. This command is not supported in Protocol Revision 1.08.

5.4 Messages from Monitor to External Device

All messages sent from the Monitor to the External Device have a unique message ID. The 'length' field in layer 3 of the packet specifies the number of 8-bit bytes in the 'message dependent data' field.

Table 6: Serial Binary Responses

Responses	ID	Comment
M_DATA_RAW	50	Raw EEG data, 8 packets per second If VISTA Legacy Binary Mode is selected and a bilateral sensor is connected, VISTA will send a 2 channel EEG message but the data will be invalid. To get raw EEG data for a Bilateral Sensor, use the VISTA Binary Mode
M_PROCESSED_VARS	52	Processed Variables once per second
M_PROCESSED_VARS_AND_SPECTRA	53	Processed Variables and Spectra once per second
SER_IMPED_MSG	1100	Impedance values from Sensor Check or Continuous Ground Check
SER_ERROR_MSG	1101	Error Messages
SER_REVISION_INFO	1102	Software / System Revision Info
M_PROCESSED_VARS_LABELS	63	Labels
SER_EEG_SNIPPET_HEADER	1104	EEG Snippet Header (A-2000 Only)
SER_EEG_SNIPPET_RAW_DATA	1105	EEG Snippet Data (A-2000 Only)
SER_EEG_SNIPPET_PROCESSED_DATA	1106	EEG Snippet Processed Variables (A-2000 Only)
SER_NO_SNIPPET	1107	No EEG Snippet Present (A-2000 Only)
SER_SNIPPET_CORRUPTED	1108	EEG Snippet Error (A-2000 Only)
SER_BIS_HISTORY_HEADER	1109	BIS History Header (A-2000 Only, Protocol Rev. 1.06 and higher)
SER_BIS_HISTORY_DATA	1110	BIS History Data (A-2000 Only, Protocol Rev. 1.06 and higher)
SER_NO_HISTORY	1111	No BIS History (A-2000 Only, Protocol Rev. 1.06 and higher)
SER_EVENT_MSG	1115	Indicates that an event was marked on the A-2000 or VISTA at the time specified (Protocol Rev. 1.07 and higher)
M_PROCESSED_VARS_WITH_EXTRA_VARS	1120	Processed Variables with Burst (Protocol Rev. 1.08 and higher)
M_PROCESSED_VARS_AND_SPECTRA_WITH_EXTRA_VAR	1121	Processed Variables with Burst and Spectra (Protocol Rev. 1.08 and higher)

S		
M_PROCESSED_VARS_4B	1122	Bilateral Processed Variables (Protocol Rev. 1.09 – "VISTA Binary")
M_PROCESSED_VARS_4B_AND_SPECTRA	1123	Bilateral Processed Variables and Spectra (Protocol Rev. 1.09 – "VISTA Binary")
M_PROCESSED_VARS_LABELS_4B	1124	Bilateral Labels (Protocol Rev. 1.09 – "VISTA Binary")

5.4.1 M_DATA_RAW

Description: Raw EEG data in 16-bit two's complement signed integer format. The data are interleaved. For 2-channel sensors, the first integer is an EEG value for channel 1, the second integer is the corresponding EEG value for channel 2, the third integer is another EEG value for channel 1, etc. For 4-channel sensors (e.g. Bilateral), the first integer is an EEG value for channel 1, the second integer is the corresponding EEG value for channel 2, the third integer is the corresponding EEG value for channel 3, the fourth integer is the corresponding EEG value for channel 4, the fifth integer is another EEG value for channel 1, etc.

Field	Possible values or format of data in the field
Message ID	50
Length	4 + ((rate/8) * number of channels * 2)
Message dependent data: 2 bytes - unsigned short number of channels 2 bytes - unsigned short rate Remaining bytes:	 2 or 4 128 or 256 samples/second. EEG data in 16-bit two's complement signed integer format.

NOTE: 256 samples/second rates supported by A-2000 only.

VISTA Bilateral Support

If VISTA Legacy Binary Mode is selected and a bilateral sensor is connected, VISTA will send a 2 channel EEG message but the data will be invalid. To get raw EEG data for a Bilateral Sensor, use the VISTA Binary Mode.

5.4.2 M_PROCESSED_VARS

Description: Processed variables sent to the Host once every second.

Field	Possible values or format of data in the field
Message ID	52
Length	SIZE_M_PROCESSED_VARS
Message dependent data	struct processed_vars_msg - Refer to description in Appendix A.

VISTA Bilateral Support

For backwards compatibility, a bilateral sensor will generate an M_PROCESSED_VARS in the case when SEND_PROCESSED_VARS_4B has not been sent. The processed variables message is then mapped as follows:

- Active hemisphere is Left:
  - Channel 1 <- Bilateral LT (Left Temple)
  - Channel 2 <- Bilateral RT (Right Temple)
  - Channel 12 <- Bilateral LT
- Active hemisphere is Right:
  - Channel 1 <- Bilateral LT
  - Channel 2 <- Bilateral RT
  - Channel 12 <- Bilateral RT
- Negative electrode impedances only sent from actively-viewed Bilateral electrodes (LT, LE or RT, RE)
- Additional Bilateral Processed Variables (e.g., Asymmetry) not transmitted

5.4.3 M_PROCESSED_VARS_AND_SPECTRA

Description: Processed variables and spectra sent to the Host once every second.

Field	Possible values or format of data in the field
Message ID	53
Length	SIZE_M_PROCESSED_VARS_AND_SPECTRA
Message dependent data	struct processed_vars_and_spectra_msg - Refer to description in Appendix A.

NOTE: 2 spectra datasets are reported, but with a 2-channel sensor connected only the 1st dataset is valid (corresponds to channel 1). The 2nd dataset is all 0.
With a 4-channel sensor connected, both datasets are valid. 1st dataset = channel 1, and 2nd dataset = channel 3.

VISTA Bilateral Support
Same as M_PROCESSED_VARS, see section 5.4.2 for details.
.

5.4.4 SER_IMPED_MSG

Description: Impedance values from Sensor Check or Ground Check.

Field	Possible values or format of data in the field
Message ID	1100
Length	Variable
Message dependent data	ASCII string (see Impedance Records section 4.3.4).

NOTE: For VISTA with a Bilateral sensor attached, set the VISTA to "VISTA Binary Mode" to see the full Bilateral impedance record as described in section 4.3.4.1.2. In "Legacy Binary" mode, the impedance record is mapped to a 2 channel records as described in section 4.3.4.1.1.

NOTE: Only a single impedance record is reported per SER_IMPED_MSG. Therefore, each message will report the +, -, or g electrode impedance values. See section 4.3.4 for details.

5.4.5 SER_ERROR_MSG

Description: Error message.

Field	Possible values or format of data in the field
Message ID	1101
Length	Variable
Message dependent data	ASCII string (see Error Records section 4.3.5).

5.4.6 SER_REVISION_INFO

Description: Revision information for software, firmware and hardware, and serial number.

Field	Possible values or format of data in the field
Message ID	1102
Length	REVISION_INFO_DATA_LEN
Message dependent data	Struct revision_info_msg - Refer to description in Appendix A.

NOTES: When VISTA is in “Legacy Binary” mode the following revisions remain constant, emulating an A-2000:

System revision	3.31
Host revision	3.30
Bis engine revision	1.25
Protocol revision	1.08
Boot revision	3.15
Hardware revision	3.00

NOTES: When VISTA is in “VISTA Binary” mode the Boot_Revision parameter is the BISx/BISx4 Serial Number, and must be interpreted the same way as the Serial_Number parameter, where the first 3 bytes make up a 24-bit unsigned integer (LSB first), and the last byte is an alphabetic char (typ. ‘A’).

5.4.7 M_PROCESSED_VARS_LABELS

Description: Names and revision numbers for processed EEG variables.

Field	Possible values or format of data in the field
Message ID	63
Length	SIZE_M_PROCESSED_VARS_LABELS
Message dependent data	Struct be_trend_variables_labels Refer to description in Appendix A.

5.4.8 SER_EEG_SNIPPET_HEADER

Description: Header information for EEG snippet.

Field	Possible values or format of data in the field
Message ID	1104
Length	EEG_SNIPPET_HEADER_DATA_LEN
Message dependent data	struct snippet_info_msg - Refer to description in Appendix A.

NOTE: A-2000 only

5.4.9 SER_EEG_SNIPPET_RAW_DATA

Description: Raw EEG data from EEG snippet. Same format as M_DATA_RAW.

Field	Possible values or format of data in the field
Message ID	1105
Length	68
Message dependent data 2 bytes - unsigned short numofchan 2 bytes - unsigned short rate Remaining bytes:	 2 128 EEG data in 16-bit two's complement signed integer format.

NOTE: A-2000 only

5.4.10 SER_EEG_SNIPPET_PROCESSED_DATA

Description: Processed EEG data from EEG snippet.

Field	Possible values or format of data in the field
Message ID	1106
Length	EEG_SNIPPET_PROCESSED_DATA_LEN
Message dependent data	struct snippet_processed_vars_msg or

	struct snippet_processed_extra_vars_msg (if extra variables have been requested) - Refer to description in Appendix A.

NOTE: A-2000 only

5.4.11 SER_NO_SNIPPET

Description: Indicates that no EEG snippet data have been recorded.

Field	Possible values or format of data in the field
Message ID	1107
Length	0
Message dependent data	None.

NOTE: A-2000 only

5.4.12 SER_SNIPPET_CORRUPTED

Description: Indicates that a checksum error was found in the EEG snippet data.

Field	Possible values or format of data in the field
Message ID	1108
Length	0
Message dependent data	None.

NOTE: A-2000 only

5.4.13 SER_BIS_HISTORY_HEADER

Description: Header information for BIS History data.

Field	Possible values or format of data in the field
Message ID	1109
Length	BIS_HIST_HEADER_DATA_LEN
Message dependent data	struct history_info_msg – Refer to description in Appendix A.

NOTE: A-2000 only

5.4.14 SER_BIS_HISTORY_DATA

Description: Contains BIS History data records.

Field	Possible values or format of data in the field
Message ID	1110
Length	Variable – multiple of 12 bytes, up to MAX_BIS_HISTORY_DATA_LEN
Message dependent data	struct history_data_msg – Refer to description in Appendix A.

NOTE: A-2000 only

5.4.15 SER_NO_HISTORY

Description: Indicates that no BIS History data have been recorded.

Field	Possible values or format of data in the field
Message ID	1111
Length	0
Message dependent data	None.

NOTE: A-2000 only

5.4.16 SER_EVENT_MSG

Description: Indicates that an event was marked on the A-2000 or VISTA at the time specified.

Field	Possible values or format of data in the field
Message ID	1115
Length	EVENT_MSG_DATA_LEN
Message dependent data	ASCII string (see Section 4.1.6).

5.4.17 M_PROCESSED_VARS_WITH_EXTRA_VARS

Description: Processed variables with extra variables (including Burst Count), sent to the Host once every second.

Field	Possible values or format of data in the field
Message ID	1120
Length	SIZE_M_PROCESSED_VARS_WITH_EXTRA_VARS
Message dependent data	struct processed_vars_with_extra_vars_msg - Refer to description in Appendix A.

5.4.18 M_PROCESSED_VARS_AND_SPECTRA_WITH_EXTRA_VARS

Description: Processed variables and spectra with extra variables (including Burst Count), sent to the Host once every second.

Field	Possible values or format of data in the field
Message ID	1121
Length	SIZE_M_PROCESSED_VARS_AND_SPECTRA_WITH_EXTRA_VARS
Message dependent data	struct processed_vars_and_spectra_with_extra_vars_msg - Refer to description in Appendix A.

NOTE: 2 spectra datasets are reported, but with a 2-channel sensor connected only the 1st dataset is valid (corresponds to channel 1). The 2nd dataset is all 0.
With a 4-channel sensor connected, both datasets are valid. 1st dataset = channel 1, and 2nd dataset = channel 3.

5.4.19 M_PROCESSED_VARS_4B

Description: Bilateral processed variables sent to the Host once every second. VISTA in "VISTA Binary" mode with Bilateral Sensor only.

Field	Possible values or format of data in the field
Message ID	1122
Length	SIZE_M_PROCESSED_VARS_AND_SPECTRA
Message dependent data	struct processed_vars_and_spectra_msg_4B - Refer to description in Appendix A.

NOTE: In the Bilateral data, the Burst Count variable has 2 bits that indicate whether the variable is enabled and whether it should be blanked on the display. These bits should be checked and then masked out before displaying Burst Count. See the be_bilateral_trend_variables_info structure in Appendix A for more details.

5.4.20 M_PROCESSED_VARS_4B_AND_SPECTRA

Description: Bilateral processed variables and spectra sent to the Host once every second. Supported by VISTA in "VISTA Binary" mode with Bilateral sensor only.

Field	Possible values or format of data in the field
Message ID	1123
Length	SIZE_M_PROCESSED_VARS_AND_SPECTRA
Message dependent data	struct processed_vars_and_spectra_msg_4B - Refer to description in Appendix A.

NOTE: In the Bilateral data, the Burst Count variable has 2 bits that indicate whether the variable is enabled and whether it should be blanked on the display. These bits should be checked and then masked out before displaying Burst Count. See the be_bilateral_trend_variables_info structure in Appendix A for more details.

NOTE: For 4-channel VISTA, 2 spectra datasets are reported, and both datasets are valid. 1st dataset = channel 1, and 2nd dataset = channel 3.

5.4.21 M_PROCESSED_VARS_LABELS_4B

Description: Names and revision numbers for processed EEG variables. VISTA in "VISTA Binary" mode with Bilateral sensor only.

Field	Possible values or format of data in the field
Message ID	1124
Length	SIZE_M_PROCESSED_VARS_LABELS_4B
Message dependent data	struct be_bilateral_trend_variables_labels - Refer to description in Appendix A.

5.5 Data Flow Diagrams

Note: ACK responses not shown in the data flow figure below for clarity.

“A-2000 compatibility mode” Data Flow is an example of an A-2000 or a VISTA with a 2-channel sensor communicating with the External Device.

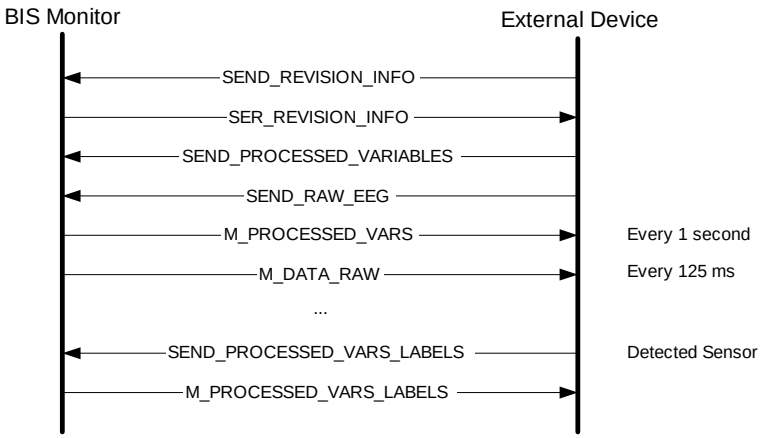


Figure 1: A-2000 Compatibility Mode Data Flow

VISTA Bilateral Mode is an example of a VISTA with a Bilateral Sensor communicating with the External Device. The VISTA monitor must be in “VISTA Binary” mode, which sets the Serial Protocol revision to 1.09 or greater. Note that two-channel processed variables messages can be used to detect the presence of a Bilateral Sensor (Sensor Type 147). Once such a sensor is detected the Bilateral (_4B) commands may be sent to the BIS Monitor. Alternatively, the Bilateral commands can be sent initially; VISTA will transmit either two-channel or Bilateral processed variables messages depending on the type of sensor in use. When the sensor type is changed, however, the processed variables labels should be requested, as they are different for two-channel and Bilateral sensors.

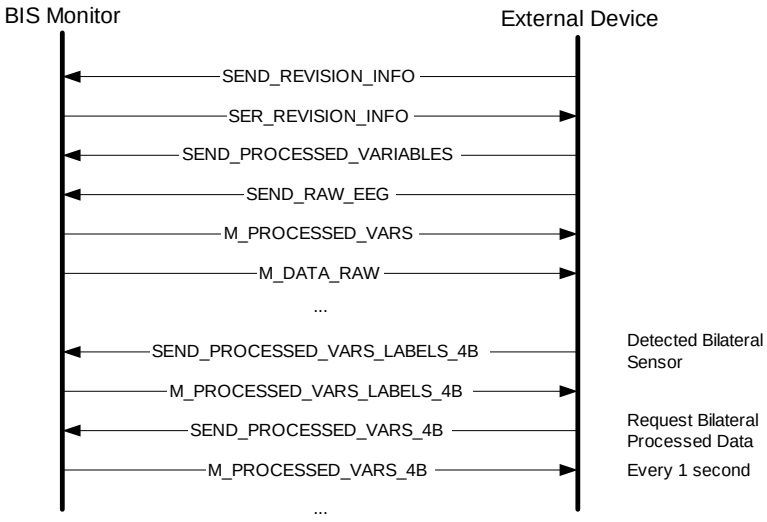


Figure 2: VISTA Bilateral Mode

Appendix A Structures and Definitions

```
#define L1_DATA_PACKET   1 /* Layer 1 directive for data/command packets */
#define L1_ACK_PACKET    2 /* Layer 1 directive for ACK packets */
#define L1_NAK_PACKET    3 /* Layer 1 directive for NAK packets */

#define SIZE_OF_HOST_POWER_SPECTRUM 60 /* 60 values for 0.5 hz - 30.0 hz */
#define SPECTRA_NUMOFCHAN    2   /* Number of spectra per message */
#define SIZE_M_SPECTRA ((SIZE_OF_HOST_POWER_SPECTRUM + 1)*4)
#define SIZE_M_PROCESSED_VARS    120
#define SIZE_M_PROCESSED_VARS_AND_SPECTRA  (SIZE_M_PROCESSED_VARS + SIZE_M_SPECTRA)
#define SIZE_M_PROCESSED_VARS_WITH_EXTRA_VARS  156
#define SIZE_M_PROCESSED_VARS_AND_SPECTRA_WITH_EXTRA_VARS
       (SIZE_M_PROCESSED_VARS_WITH_EXTRA_VARS + SIZE_M_SPECTRA)
#define SIZE_M_PROCESSED_VARS_LABELS    120
#define SIZE_M_PROCESSED_EXTRA_VARS_LABELS     192
#define PERCENT_DIVISOR 10
#define DB_POWER_DIVISOR 100
#define FREQUENCY_DIVISOR 100
#define IMPED_MSG_DATA_LEN 49    /* Lengths of message-dependent data in bytes */
#define ERROR_MSG_DATA_LEN 62
#define REVISION_INFO_DATA_LEN 28
#define EEG_SNIPPET_HEADER_DATA_LEN 28
#define EEG_SNIPPET_PROCESSED_DATA_LEN 40
#define EEG_SNIPPET_PROCESSED_DATA_WITH_EXTRA_VARS_LEN 64
#define BIS_HISTORY_HEADER_DATA_LEN 24
#define MAX_BIS_HISTORY_DATA_LEN 1020
#define MAX_BIS_HISTORY_DATA_RECORDS 85 /* Max records per big History message */
#define EVENT_MSG_DATA_LEN 31

#define START_CASE_RECORD 1
#define DATA_RECORD 2
#define EVENT_RECORD 3
#define CLOCK_ADJUST_RECORD 5
#define TIME_RECORD 6



struct processed_vars_and_spectra_msg
{
  struct processed_vars_msg processed_vars;
  struct spectra_msg spectra;
};


struct processed_vars_and_spectra_with_extra_vars_msg
{
  struct processed_vars_with_extra_vars_msg processed_vars_extra;
  struct spectra_msg spectra;
};


struct processed_vars_msg
{
   struct dsc_info_struct proc_dsc_info;  /* Info. on dsc, pic and selftest */

   /* Impedance info for 2 channels. */
   struct impedance_info_struct impedance_info[2];

   /* Host filter settings:
      Byte 0 (LSByte) - High pass filter setting
                        0 - 0.25 Hz
                        1 - 1.00 Hz
                        2 - 2.00 Hz
```

```
                        3 - 2.5 Hz
      Byte 1 - Low pass filter setting
                        0 - none
                        1 - 30 Hz
                        2 - 50 Hz
                        3 - 70 Hz
      Byte 2 - Notch filter setting
                        0 - none
                        1 - 50 Hz
                        2 - 60 Hz
                        3 - 50 & 60 Hz */
   unsigned long host_filt_setting;

   /* Spectral and Bispectral smoothing rates:
      Byte 0 (LSByte) - Spectral smoothing rate
                        0 – 0 seconds
                        1 – 5 seconds
                        2 – 10 seconds (default)
                        3 – 30 seconds
                        4 – 60 seconds
      Byte 1          - Bispectral smoothing rate
                        0 – 15 seconds (default)
                        1 – 30 seconds
                        2 – 60 seconds
                        3 – 10 seconds */
   unsigned long host_smoothing_setting;

   /* Spectral and Bispectral artifact detection masks. */
   unsigned long host_spectral_art_mask;
   unsigned long host_bispectral_art_mask;

   /*-------------------------------------------------------------+
   |  trend variables for 3 channels (ch1, ch2 and ch12 combined)  |
   +-------------------------------------------------------------*/

   struct be_trend_variables_info trend_variables[3];
};


struct processed_vars_with_extra_vars_msg
{
   struct dsc_info_struct proc_dsc_info;  /* Info. on dsc, pic and selftest */

   /* Impedance info for 2 channels. */
   struct impedance_info_struct impedance_info[2];

   /* Host filter settings:
      Byte 0 (LSByte) - High pass filter setting
                        0 - 0.25 Hz
                        1 - 1.00 Hz
                        2 - 2.00 Hz
                        3 - 2.5 Hz
      Byte 1 - Low pass filter setting
                        0 - none
                        1 - 30 Hz
                        2 - 50 Hz
                        3 - 70 Hz
      Byte 2 - Notch filter setting
                        0 - none
                        1 - 50 Hz
                        2 - 60 Hz
                        3 - 50 & 60 Hz */
   unsigned long host_filt_setting;

   /* Spectral and Bispectral smoothing rates:
      Byte 0 (LSByte) - Spectral smoothing rate
```

```
                        0 – 0 seconds
                        1 – 5 seconds
                        2 – 10 seconds (default)
                        3 – 30 seconds
                        4 – 60 seconds
      Byte 1          - Bispectral smoothing rate
                        0 – 15 seconds (default)
                        1 – 30 seconds
                        2 – 60 seconds
                        3 – 10 seconds */
   unsigned long host_smoothing_setting;

   /* Spectral and Bispectral artifact detection masks. */
   unsigned long host_spectral_art_mask;
   unsigned long host_bispectral_art_mask;

   /*-------------------------------------------------------------+
   |  trend variables for 3 channels (ch1, ch2 and ch12 combined)  |
   |  with extra variables                                        |
   +-------------------------------------------------------------*/

   struct be_trend_variables_extra_info trend_variables_extra[3];
};


struct dsc_info_struct
{
  unsigned char dsc_id;          /* DSC ID from status nibble 1 */
  unsigned char dsc_id_legal;    /* Flag when non-zero indicates that a legal
                                    dsc is connected */
  unsigned char pic_id;          /* (Sensor Type * 10)+ PIC ID */

#define SINGLE_CHANNEL_OR_SENSOR_TYPE                1      /* Sensor Plus */
#define DUAL_CHANNEL_OR_SENSOR_TYPE                  2      /* Quatro */
#define PEDIATRIC_OR_SENSOR_TYPE                     3      /* Pediatric */
#define DUAL_CHANNEL_ICU_SENSOR_TYPE                 4      /* Extend */
#define DEMO_SENSOR_TYPE                             5      /* Demo (Plus) */
#define PEDIATRIC_XP_SENSOR_TYPE                     7      /* Pediatric XP */
#define SINGLE_CHANNEL_SENSOR_SIMULATOR              8      /* Plus Simulator */
#define DUAL_CHANNEL_SENSOR_SIMULATOR                9      /* Quatro Sim. */
#define SEMI_REUSABLE_SENSOR_TYPE                    12     /* SRS  Type 1*/
#define EXTEND_DEMO_SENSOR_TYPE                      13     /* Demo (Extend) */
#define BILATERAL_SENSOR_TYPE                        14     /* Bilateral */
#define BILATERAL_SENSOR_TYPE_1                      16     /* new Bilateral */
#define FOUR_CHANNEL_SENSOR_SIMULATOR                17     /* 4 channel Sim. */

  unsigned char pic_id_legal;    /* if non-zero, a legal pic is connected. */
  unsigned short dsc_numofchan;  /* Number of channels on the DSC connected.
                                    Valid only when dsc_id is legal. */
  unsigned short quick_test_result; /* If zero, test passed.
                                       If non-zero, the bit fields in the
                                         result indicate which test(s) failed. */

#define QUICK_SELFTEST_PASS   0
#define QUICK_GAIN_TEST_BIT   0x1   /* Set when avg noise test fails. */
#define QUICK_NOISE_TEST_BIT  0x2   /* Set when blocked gain test fails. */
#define QUICK_TEST_FAIL_BIT   0x4   /* Set for timeout, DSC disconnect and
                                       other failures during the test .*/
#define QUICK_TEST_RESULT_VALID_BIT 0x8  /* Set when the quick test has not
                                       been run at all. Cleared when the test
                                       is done at least once. */


  /* DSC gain (in uV/ADC) = dsc_gain_num/dsc_gain_divisor */
  signed long dsc_gain_num;
  signed long dsc_gain_divisor;
```

```
  /* DSC offset (in uV/ADC) = dsc_offset_num/dsc_offset_divisor */
  signed long dsc_offset_num;
  signed long dsc_offset_divisor;
};



struct impedance_info_struct
{
   /*-----------------------------------------------------------+
   |  Impedance in units of 100 Ohms (or 1000 Ohms for ground  |
   |  impedances).                                             |
   +-----------------------------------------------------------*/
#define GND_SCALE       1000
#define NON_GND_SCALE   100

/* Limits for the impedance values */
#define MAX_GND_VALUE   100.0   /* in Kohms */
#define MAX_COM_VALUE   150.0   /* in 100 ohms */
#define MAX_POS_VALUE   75.0   /* in 100 ohms */

   unsigned short impedance_value; /* This is the value of the
                                      impedance for the channel */
   unsigned short imped_test_result; /* Result of the impedance test.
                                        If zero, test passed.
                                        If non-zero, the bit fields in the
                                         result indicate which test(s) failed. */

#define  IMPED_TEST_PASS         0    /* Test passed */
#define  IMPED_TEST_FAIL         0x1  /* High impedance  */
#define  IMPED_TEST_FAIL_CLIP    0x2  /* Noise */
#define  IMPED_TEST_FAIL_LEADOFF   0x4  /* Lead off */
};


struct be_trend_variables_info
{
   signed short burst_suppress_ratio; /* index variable giving percent of
                                         suppressed seconds in last 63 sec.
                                         for selected channel. range from
                                         0 - 1000 in .1% steps */
   signed short spectral_edge_95; /* in HZ ranged from 0-30.0 Hz in
                                     units of 0.01 Hz */
   signed short bis_bits; /* BIS field debug data */
   signed short bispectral_index;  /* Ranges from 0 - 100 */
   signed short bispectral_alternate_index;  /* same as above */
   signed short bispectral_alternate2_index;  /* same as above */
   signed short total_power; /* in dB with respect to .01 uV rms. ranged
                                from 0 to 100 dB in 0.01 units */
   signed short emg_low; /* in dB with respect to .01 uV rms. ranged
                            from 0 to 100 dB in 0.01 units */
   signed long bis_signal_quality; /* index variable giving the signal
                                      quality of the bisIndex which is
                                      combined with BSR 0 - 1000 in .1%
                                      steps */
   unsigned long second_artifact; /* bit field indicating TYPE OF ARTIFACT
                                     for the last second. */
};


struct be_trend_variables_extra_info
{
   signed short burst_suppress_ratio; /* index variable giving percent of
                                         suppressed seconds in last 63 sec.
                                         for selected channel. range from
```

```
                                        0 - 1000 in .1% steps */
   signed short spectral_edge_95; /* in HZ ranged from 0-30.0 Hz in
                                     units of 0.01 Hz */
   signed short bis_bits; /* BIS field debug data */
   signed short bispectral_index;  /* Ranges from 0 - 100 */
   signed short bispectral_alternate_index;  /* same as above */
   signed short bispectral_alternate2_index;  /* same as above */
   signed short total_power; /* in dB with respect to .01 uV rms. ranged
                                from 0 to 100 dB in 0.01 units */
   signed short emg_low; /* in dB with respect to .01 uV rms. ranged
                            from 0 to 100 dB in 0.01 units */
   signed long bis_signal_quality; /* index variable giving the signal
                                      quality of the bisIndex which is
                                      combined with BSR 0 - 1000 in .1%
                                      steps */
   unsigned long second_artifact; /* bit field indicating TYPE OF ARTIFACT
                                     for the last second. */
   signed short burst_per_min;   /* ranges from 0 to 30 */
   signed short rfu1;            /* reserved for future use */
   signed short rfu2;
   signed short rfu3;
   signed short rfu4;
   signed short rfu5;
};



struct spectra_msg
{
   unsigned short spect_numofchan;
   unsigned short spect_size;
   signed short power_spectrum[SPECTRA_NUMOFCHAN][SIZE_OF_HOST_POWER_SPECTRUM];
};


struct revision_info_msg
{
   char system_revision[4];      /* Binary bytes: first is major rev. number, */
   char host_revision[4];        /* second is minor rev. number, third is */
   char bis_eng_revision[4];     /* not defined, fourth is always 0. */
   char protocol_revision[4];     /* Displayed as major.minor */
   char boot_revision[4];
   char hardware_revision[4];
   char serial_number[4];        /* First 3 bytes make up a 24-bit unsigned         */
};                               /* integer (LSB first), last byte is an alphabetic */
                                 /* char (typ. 'A').                                */
                                  /* Displayed as char followed by integer.         */

struct be_trend_variables_labels
{
   char burst_suppress_ratio_label[12];       /* ASCII strings */
   char spectral_edge_95_label[12];
   char bis_bits_label[12];
   char bispectral_index_label[12];
   char bispectral_alternate_index_label[12];
   char bispectral_alternate2_index_label[12];
   char total_power_label[12];
   char emg_low_label[12];
   char bis_signal_quality_label[12];
   char second_artifact_label[12];
};


struct be_trend_variables_extra_labels
{
    char burst_suppress_ratio_label[12];      /* ASCII strings */
```

```
    char spectral_edge_95_label[12];
    char bis_bits_label[12];
    char bispectral_index_label[12];
    char bispectral_alternate_index_label[12];
    char bispectral_alternate2_index_label[12];
    char total_power_label[12];
    char emg_low_label[12];
    char bis_signal_quality_label[12];
    char second_artifact_label[12];
    char burst_per_min_label[12];
    char rfu1_label[12];
    char rfu2_label[12];
    char rfu3_label[12];
    char rfu4_label[12];
    char rfu5_label[12];
};


struct time_date
{
   short second;    /* second, 0 - 59 */
   short minute;    /* minute, 0 - 59 */
   short hour;      /* hour, 0 - 23 */
   short day;       /* day, 1 - 31 */
   short month;     /* month, 1 - 12 */
   short year;      /* 4-digit year (with century) */
};


struct snippet_info_msg
{
   struct time_date event_date_time;  /* Date/Time */
   char system_revision[4];   /* System revision number */
   char serial_number[4];     /* Monitor serial number */
   short num_raw_records;     /* Number of raw data records */
   short num_proc_records;    /* Number of processed data records */
   unsigned char dsc_id;      /* DSC ID */
   unsigned char pic_id;      /* PIC ID */
   short padding;             /* fills out last word */
};


struct snippet_processed_vars_msg
{
   struct snippet_trend_variables_info snippet_vars[2];
};


struct snippet_trend_variables_info
{
   short impedance_value;
   short burst_suppress_ratio;
   short bis_bits;
   short bispectral_index;
   short bispectral_alternate_index;
   short bispectral_alternate2_index;
   short emg_low;
   short bis_signal_quality;
   unsigned long second_artifact;
};


struct snippet_processed_extra_vars_msg
{
   struct snippet_trend_extra_variables_info snippet_vars[2];
};
```

```
struct snippet_trend_extra_variables_info
{
   short impedance_value;
   short burst_suppress_ratio;
   short bis_bits;
   short bispectral_index;
   short bispectral_alternate_index;
   short bispectral_alternate2_index;
   short emg_low;
   short bis_signal_quality;
   unsigned long second_artifact;
   short burst_per_min;
   short rfu_1;
   short rfu_2;
   short rfu_3;
   short rfu_4;
   short rfu_5;
};


struct history_info_msg
{
   struct time_date date_time;    /* Date/Time */
   char system_revision[4];       /* System revision number */
   char serial_number[4];         /* Monitor serial number */
   long num_records;              /* Number of data records */
};


struct history_data_msg
{
   unsigned long num_records;
   struct bh_record_struct data[MAX_BIS_HISTORY_DATA_RECORDS];
};

struct bh_record_struct
{
   union bh_record_body {
      struct bh_startcase_or_clockadjust start;
      struct bh_data data;
   } body;
};


struct bh_startcase_or_clockadjust
{
   unsigned char type;     /* Record type (start case = 1, clock adjust = 5) */
   unsigned char pad1;     /* padding */
   short pad2;             /* padding */
   long time;              /* Time of start case or new clock time, as utime */
   long case_id;           /* Case ID */
   long pad3;              /* padding */
};


struct bh_data
{
   unsigned char type;           /* Record type (data = 2) */
   unsigned char avg_bis;        /* Average BIS for 1 minute */
   unsigned char min_bis;        /* Minimum BIS for 1 minute */
   unsigned char max_bis;        /* Maximum BIS for 1 minute */
   unsigned char avg_bisalt;     /* Average BISALT for 1 minute */
   unsigned char avg_bisalt2;    /* Average BISALT2 for 1 minute */
   unsigned char avg_sqi;        /* Average SQI for 1 minute */
```

```
   unsigned char avg_emg;         /* Average EMG for 1 minute */
   unsigned char avg_sr;          /* Average SR for 1 minute */
   unsigned char avg_imped[2];    /* Average combined impedances for 1 minute */
   short bis_bits;                /* BIS Bits from last update in minute */
   byte avg_burst_per_min;        /* Unused if extra vars have not been requested */
   byte reserved;                 /* Reserved for future use */
};
```

/* VISTA Binary Mode Structures */

```
#define SIZE_M_PROCESSED_VARS_4B    288
#define SIZE_M_PROCESSED_VARS_AND_SPECTRA_4B  (SIZE_M_PROCESSED_VARS_4B + SIZE_M_SPECTRA)


struct revision_info_msg
{                                  /* Binary bytes: first is major rev. number, */
                                   /* second is minor rev. number
                                   /* third and fourth are always 0.            */
                                   /* Displayed as major.minor                  */
   char system_revision[4];        /* VISTA Master Software Revision            */
   char host_revision[4];          /* VISTA Application Revision                */
   char bis_eng_revision[4];       /* BISx Software Revision                    */
   char protocol_revision[4];      /* Serial Protocol Revision                  */
   char boot_revision[4];          /* BISx Serial Number - see serial_number below
                                      BISx   last digit is 'B'
                                      BISx4  last digit is '4'                   */
   char hardware_revision[4];      // VISTA Hardware Revision
   char serial_number[4];          /* First 3 bytes make up a 24-bit unsigned */
                                   /* integer (LSB first), last byte is first alphabetic */
                                   /* char.  Displayed as char followed by integer. */
                                   /* e.g. VT01234 -> 0xD2 0x04 0x00 0x56 */
                                   /* VISTA: last byte is 'V'           */
};


struct be_bilateral_trend_variables_labels
{
  char burst_suppress_ratio_label[12];
  char spectral_edge_95_label[12];
  char spectral_edge_50_label[12];
  char bis_bits_label[12];
  char bispectral_index_label[12];
  char bispectral_alternate_index_label[12];
  char bispectral_alternate2_index_label[12];
  char total_power_label[12];
  char emg_low_label[12];
  char bis_signal_quality_label[12];
  char second_artifact_label[12];
  char burst_per_min_label[6];
  char reserved_label[6];
  char asym_label[12];
  char std_bis_label[12];
  char std_emg_label[12];
  char reserved_label_0[12];
  char reserved_label_1[12];
  char reserved_label_2[12];
 };


struct processed_vars_and_spectra_msg_4b
{
  struct processed_vars_msg_4b processed_vars;
  struct spectra_msg           spectra;
};


struct processed_vars_msg_4b
{
   struct dsc_bilateral_info_struct proc_dsc_info;  /* Info. on dsc, pic and selftest */

   /* Impedance info for up to 4 channels. */
   struct impedance_info_struct impedance_info[4];
```

```
   /* Host filter settings:
      Byte 0 (LSByte) - High pass filter setting
                        0 - 0.25 Hz
                        1 - 1.00 Hz
                        2 - 2.00 Hz
                        3 - 2.5 Hz
      Byte 1 - Low pass filter setting
                        0 - none
                        1 - 30 Hz
                        2 - 50 Hz
                        3 - 70 Hz
      Byte 2 - Notch filter setting
                        0 - none
                        1 - 50 Hz
                        2 - 60 Hz
                        3 - 50 & 60 Hz
      Byte 3 - Operating environment: OPERATING_ENV_OR or OPERATING_ENV_ICU
   */
   unsigned long host_filt_setting;

   /* Spectral and Bispectral smoothing rates:
      Byte 0 (LSByte) - Spectral smoothing rate
      Byte 1          - Bispectral smoothing rate
   */
   unsigned long host_smoothing_setting;
   /*
       Spectral smoothing rates    Bispectral smoothing rates
       Option   Rate (in sec)      Option   Rate (in sec)
       0        0                  0        15
       1        5                  1        30
       2        10                 2        60
       3        30                 3        10
       4        60
       */

# define MIN_SPECT_SMOOTHING_RATE  0
# define MAX_SPECT_SMOOTHING_RATE  4
# define MIN_BISPECT_SMOOTHING_RATE  0
# define MAX_BISPECT_SMOOTHING_RATE  3

   /* Spectral and Bispectral artifact detection masks.
      These are provided for validation purposes only and should be ignored
      during normal monitoring. */

   unsigned long host_spectral_art_mask;
   unsigned long host_bispectral_art_mask;

   /*-----------------------------------------------------------------+
   |  trend variables for up to 4 channels (ch1, ch2, ch3, ch4)
   +-----------------------------------------------------------------*/

   struct be_bilateral_trend_variables_info trend_variables[4];

   unsigned short sqi_left_index;  /* Index into trend_variables for selecting
                                      the 'bis_signal_quality' variable to use for
                                      sqi threshold comparisons.
                                      Possible values: 0 - 4 */
   unsigned short sqi_right_index; /* Index into trend_variables for selecting
                                      the 'bis_signal_quality' variable to use for
                                      sqi threshold comparisons.
                                      Possible values: 0 - 4 */
   unsigned short bis_left_index;   /* Index into trend_variables for selecting
                                      the 'bispectral_index' variable to display as BIS.
                                      Possible values: 0 - 4 */
   unsigned short bis_right_index; /* Index into trend_variables for selecting
```

```
                                    the 'bispectral_index' variable to display as BIS.
                                    Possible values: 0 - 4 */
 };


struct dsc_bilateral_info_struct
{
  unsigned char dsc_id;    /* DSC ID from status nibble 1 */

#define DSC_NONE_ID  0           /* No DSC connected */
#define DSC_BISX4_ID 13

       /* Only DSC IDs of DSC_NONE_ID or DSC_BISX4_ID are considered legal;
              For all other values, dsc_id_legal is set to zero to indicate
              illegal DSC ID. */

  unsigned char dsc_id_legal; /* Flag when non-zero indicates that a legal
                                 dsc is connected */
  unsigned char pic_id;       /* Sensor/pigtail ID */

#define PIC_NONE_ID     0
#define PIC_SS_ID       7

  /* Legal PIC IDs are:
     PIC_NONE_ID
     PIC_SS_ID + (Sensor Type * 10)
     For all other IDs, pic_id_legal is set to zero. */

  unsigned char pic_id_legal;    /* if non-zero, a legal pic is connected. */
  unsigned short dsc_numofchan;  /* Number of channels on the DSC connected.
                                    Valid only when dsc_id is legal. */
  unsigned short quick_test_result; /* If zero, test passed.
                                       If non-zero, the bit fields in the
                                        result indicate which test(s) failed. */

#define QUICK_SELFTEST_PASS   0
#define QUICK_GAIN_TEST_BIT   0x1   /* Set when avg noise test fails. */
#define QUICK_NOISE_TEST_BIT  0x2   /* Set when blocked gain test fails. */
#define QUICK_TEST_FAIL_BIT   0x4   /* Set for timeout, DSC disconnect and
                                       other failures during the test .*/
#define QUICK_TEST_RESULT_VALID_BIT 0x8  /* Set when the quick test has not
                                     been run at all. Cleared when the test
                                     is done atleast once. */

  unsigned short dsc_update_status;      /* Bit field indicating DSC update status. */
#define  DSC_UPDATE_DONE                    0
#define  DSC_UPDATE_IN_PROGRESS             0x1
#define  DSC_UPDATE_FAILED                  0x2
  unsigned short pad1;     // for alignment

  /* DSC gain (in uV/ADC) = dsc_gain_num/dsc_gain_divisor */
  signed long dsc_gain_num;
  signed long dsc_gain_divisor;

  /* DSC offset (in uV/ADC) = dsc_offset_num/dsc_offset_divisor */
  signed long dsc_offset_num;
  signed long dsc_offset_divisor;

  /****************/
  /* Sensor Info  */
  /****************/

  unsigned short sensor_status; /* high nibble is status nibble 5 */

#define SENSOR_VALID             0
#define SENSOR_INVALID                 1
```

```
#define TOO_MANY_USES            2
#define SENSOR_EXPIRED                 3

        /* Nibble-5 status              Bit # */
#define SENSOR_POWERED_OFF       12
#define SENSOR_OVERCURRENT_BIT   13
#define SENSOR_POS_GND_FAULT_BIT 14
#define SENSOR_NEG_GND_FAULT_BIT 15

#define SENSOR_UNSUPPORTED           0x20     /* Bit 5: Unsupported sensor */
#define SRS_ELECTRODES_NOT_CONNECTED 0x40     /* Bit 6: 0 if electrodes
                                                        detected, 1 if not
                                                        detected. */
#define NEW_VALIDITY_UNKNOWN         0x3f
#define EXTEND_TYPE_SENSOR           0x200    /* Bit 9: Sensor activates
                                                        Burst Count features */
#define SENSOR_SIMULATOR             0x400    /* Bit 10: BIS values are blanked */
#define DEMO_DEVICE                  0x800    /* Bit 11: Must display Demo
                                                        Device message */


#define NEW_SS_BITS_MASK   (0xffff080 | SRS_ELECTRODES_NOT_CONNECTED |\
                            SRS_TYPE_SENSOR |\
                            EXTEND_TYPE_SENSOR |\
                            SENSOR_SIMULATOR |\
                            DEMO_DEVICE)
   struct bilateral_sensor_description_struct sensor_desc;
   unsigned short pad2;    // for alignment
   unsigned long lot_code;
   unsigned short shelf_life;
   unsigned short serial_number;
   unsigned long usage_count;
};


struct bilateral_sensor_description_struct
{
  unsigned char sensor_name[12];
  /* 12 character alpabetic string uniquely identifying the sensor. */

  unsigned char sensor_type;     /* Unique sensor identifier. */

#define BILATERAL_SENSOR_TYPE                  14  /* Bilateral */

  unsigned char sensor_graphic_type;
  /* Number of channels to display during impedance checking.
        If sensor_graphic_type is 6, impedance values should be checked for
     channel 1,channel 2, channel 3 and channel 4.
  */

  unsigned char sensor_eeg_channels;
  /* Number of channels of filtered EEG to be displayed. */

  unsigned char eeg_left_display_index;
  unsigned char eeg_right_display_index;
  /* This index indicates the channel to be displayed. */

  unsigned char sensor_sqi_channels;
  /* Number of channels of SQI values to be displayed. */

  unsigned char sqi_left_display_index;
  unsigned char sqi_right_display_index;
  /* Use this as an index into the
     channel data structure with sqi value. */

  unsigned char sensor_emg_channels;
```

```
  /* Number of channels of EMG values to be displayed. */

  unsigned char emg_left_display_index;
  unsigned char emg_right_display_index;

  unsigned char pad1;
  /* Use this as an index into the
     channel data structure with emg value. */

  unsigned char case_id[4];
  /* Alphanumeric characters representing case ID formed by combining
     sensor serial number and BIS Engine serial number.
     Display format: xxxx
  */
};


struct be_bilateral_trend_variables_info
{
  signed short burst_suppress_ratio; /* index variable giving percent of
                                        suppressed seconds in last 63 sec.
                                        for selected channel. range from
                                        0 - 1000 in .1% steps */
  signed short spectral_edge_95; /* in HZ ranged from 0-30.0 Hz in
                                    units of 0.01 Hz */
  signed short spectral_edge_50; /* in HZ ranged from 0-30.0 Hz in
                                    units of 0.01 Hz */
  signed short bis_bits; /* BIS field debug data */
  signed short bispectral_index;  /* Ranges from 0 - 100 */
  signed short bispectral_alternate_index;  /* same as above */
  signed short bispectral_alternate2_index;  /* same as above */
  signed short total_power; /* in dB with respect to .01 uv rms. ranged
                               from 0 to 100 dB in 0.01 units */
  signed short emg_low; /* in dB with respect to .01 uv rms. ranged
                           from 0 to 100 dB in 0.01 units */
  unsigned short pad1;     /* for alignment */
  signed long bis_signal_quality; /* index variable giving the signal
                                     quality of the bisIndex which is
                                     combined with BSR 0 - 1000 in .1%
                                     steps */
  unsigned long second_artifact; /* bit field indicating TYPE OF ARTIFACT
                                    for the last second. */

  unsigned char burst_count;      /* bursts/minute 0 - 30 */
#define BURST_COUNT_MASK   0x3f   /* mask for burst count value */
#define BURST_COUNT_BLANK  0x40   /* burst count blanked if this bit is set */
#define BURST_COUNT_ENABLE 0x80   /* burst count enabled if this bit is set */
  unsigned char reserved_byte_var;      /* reserved*/
  signed short asym_index;
  signed short std_bis;                 /* standard deviation of BIS */
  signed short std_emg;                 /* standard deviation of EMG */
  signed short reserved_short_var_0;
  signed short reserved_short_var_1;
  signed short reserved_short_var_2;
  unsigned short pad2;                  /* for alignment */
};
```

Appendix B Description of Processed EEG Variables

Variable Name	Description	Range	Divisor
Suppression Ratio (SR)	The percentage of epochs in the past 63 seconds in which the EEG signal is considered suppressed.	0.0 - 100.0 %	10
Burst Count (BURST)[4]	An alternate means of measuring suppression: number of EEG bursts in the last 60 seconds. Enabled only by the Extend (A-2000, VISTA Only) and Bilateral (VISTA) sensors.	0 – 30 bursts/minute	1
Spectral Edge Frequency (SEF)	The frequency at which 95% of the total power lies below it and 5% lies above it.	0.50 - 30.00 Hz	100
BIS bits (BISBIT)	These bits indicate the state of the Bispectral Index algorithm. (Aspect use only.)		n.a.
Bispectral Index (BIS) (displayed on screen as BIS; transmitted as B34… or DB1…)	This variable gives a bispectral index.	0.0 - 100.0	10
Bispectral Alternate Index (BISALT)	This variable gives an alternate bispectral index. (Aspect use only – not in ASCII data records.)	-3276.7 (0.0 - 100.0 when enabled)	10
Bispectral Alternate 2 Index (BISAL2)	This variable gives another alternate bispectral index. (Aspect use only – not in ASCII data records.)	-3276.7 (0.0 - 100.0 when enabled)	10
Total Power (TOTPOW)	A measure of the absolute total power in the frequency range from 0.5 to 30.0 Hz. Value is in dB with respect to 0.0001 μV^2.	40.00 - 100.00 dB	100
EMG Low (EMGLOW)	The absolute power in the 70 - 110 Hz range. Value is in dB with respect to 0.0001 μV^2.	30.00 - 80.00 dB	100
Signal Quality Index (SQI)	The percentage of good epochs and suppressed epochs in the last 120 (61.5 seconds) that could be used in the Bispectral Index calculation.	0.0 - 100.0 %	10

[4] BURST in the bilateral M_PROCESSED_VARS_4B and M_PROCESSED_VARS_4B_AND_SPECTRA messages includes status bits which must be checked. See struct be_bilateral_trend_variables_info in Appendix A for details.

Impedance (IMPEDNCE)	The combined impedance (sum of signal and reference electrode impedances) for the last second.	0 - 1000 Kohms	1
Artifact Flags (ARTF2)	See below.	See below.	n.a.
sBIS (VISTA Bilateral Only)	A BIS variability index calculated for each side of the head. The index represents the standard deviation of the BIS variable over the last minute.	0.0 to 10.0 BIS units	10
sEMG (VISTA Bilateral Only)	An EMG variability index calculated for each side of the head. The index represents the standard deviation of the EMG values over the last minute.	0.0 to 10.0 dB with respect to 0.001 μV^2	10
RESVAR0	Reserved data field	0.0	10
ASYM (VISTA Bilateral Only)	The percentage of EEG power present in left or right hemispheres. Calculated by BISx4 as: (Total Power Left / Total Power Left + Right) *1000 Displayed by VISTA as: ASYM > 500: xxL where xx = $((ASYM_{BISx4} / 10) - 50) * 2$ ASYM < 500: xxR where xx = $(50 – (ASYM_{BISx4} / 10)) * 2$	ASCII Protocol: 0.0 to 100.0, where 0.0 is 100% right, 100.0 is 100% left, 50.0 is equal power. Binary Protocol: 0 to 1000, where 0 is 100% right, 1000 is 100% left, 500 is equal power.	10
BILBITS (VISTA Bilateral Only)	Supplemental Bilateral Bits Bit 0: 1 indicates Bilateral Sensor Bit 1: 0 indicates Left Hemisphere, 1 indicates Right Hemisphere	Hex Display	n.a.

The Processed EEG variables are transmitted as integers, and must be divided by the specified divisor before being displayed.

The Artifact Flags indicate the types of artifacts (if any) detected within the previous update period. These flags are bit-mapped as follows:

Bit#	Signal	Description
0	(unused)	
1	Out Of Range	Each sample is checked for values out of range (limit is +1 mV and -1 mV). If the value is out of range then the current second and the next 4 seconds of data are labeled BAD_SECONDs if blocking does not occur. The next 4 seconds are labeled BAD_SECONDs to allow for hardware settling. Even though these seconds are BAD_SECONDS they are still checked to see if additional seconds must be also labeled BAD_SECONDs.
2	Bad Slope	The slew rate of the signal is too high.
3	EKG/Pacer	EKG or pacer artifact has been detected in this epoch.
4	Throw Away	A previous artifact has caused this second to be artifacted.
5	Suppressed	The standard deviation for the entire second is below a minimum value.
6	Start Up	The monitor has just started up. For the first few seconds there is an artifact.
7	(unused)	
8	Total Power Too Small	When the smoothed power in the band from 0.5 - 30 Hz goes below 1 μV rms, then spectral variables are considered to be noise.
9	Motion	A sudden change has occurred in the power of the band from 1 to 10 Hz.
10	Glitch	A sudden change has occurred in the power of the band from 20 to 45 Hz.
11	Negative Leadoff Clipping	The raw EEG has been out of range in the negative direction for 5 seconds. It is assumed that the lead is off and the amplifier has saturated.
12	Positive Leadoff Clipping	The raw EEG has been out of range in the positive direction for 5 seconds. It is assumed that the lead is off and the amplifier has saturated.
13	Combined Impedance Too High	The combined impedance of the negative and positive leads is greater than 15 Kohms.
14	(unused)	
15	Clipping	The raw EEG data has been out of range during the last second, and the data has been clipped at the largest positive or negative value.
16	Framing Error	The current frame of data from the DSC is bad. This signal is polled at a 16Khz rate.
17	DSC Busy	The DSC cannot receive commands. This signal is checked whenever commands are written to the DSC. Commands are written to the DSC at a 128 Hz rate. The DSC should always be ready to receive commands.

18	No DSC Interrupt	The DSC is not interrupting the IPU.
19	DSC Interface Error	The interface between the DSC and monitor is malfunctioning.
20	DSC Power Regulation Fault	The voltage regulators on the DSC are malfunctioning. If this error persists for 1/4 second, the monitor turns off the DSC. Every 5 seconds, the monitor will attempt to turn the DSC on. If the error continues to occur, the monitor gives up after 3 tries.
21	(unused)	
22	DSC Overcurrent	The DSC is drawing too much current. The DSC is automatically turned off by hardware. After 5 seconds, the monitor will attempt to turn the DSC on. If the error persists, the monitor will give up after 3 tries.
23	DSC Receiver Overrun	Data in the DSC receive buffer was not read before it was overwritten with new data.
24	No DSC Status	This signal indicates that a status nibble from the DSC was requested but was not received. Status nibbles are requested at 128 Hz rate. This artifact can also occur during the DSC test.
25	Blocking	The DSC is in Blocking mode. The monitor puts the DSC in the blocking state when both channels 1 and 2 are clipped. When either channel 1 or 2 is unclipped for 1 second then blocking is turned off, but the blocking artifact bit is left on for another second for settling. In blocking mode the high pass filter becomes a much higher high pass filter in order for the signal to settle quickly.
26	Zero Amplifiers	The inputs to the DSC amplifiers are shorted together (for test purposes).
27	Amplifier Test	A 2 Hz square wave signal is injected into the DSC amplifiers (for test purposes).
28	Bipolar/Referential	If 0, a bipolar montage has been selected; else, a referential montage has been selected. (Montage selection is dependent on the PIC/Sensor connected to the DSC.)
29	Impedance State Bit 0	See below.
30	Impedance State Bit 1	See below.
31	(unused)	

The Monitor Impedance State Bits are encoded as follows:

Value	Impedance State
00000000	Combined positive and negative electrodes
20000000	Off
40000000	Positive electrodes
60000000	Ground electrode

Appendix C Aspect Monitor Serial Port Data Capture Technique

It is possible to capture the ASCII-formatted processed EEG variables from the BIS Monitor using the software within the Microsoft Windows® personal computer environment; specifically, the HyperTerminal Communications program for capture, and the Microsoft Excel® program for presentation and data handling.

Requirements:

A-2000 Bispectral Index (BIS) Monitor (with software Rev. 1.06 or above)
or BIS VISTA Monitor (with software 1.02 or above)
or BIS VIEW Monitor (with software 1.00 or above)
A-2000 Operating Manual (070-0015)
or BIS VISTA Operating Manual (070-0069)
or BIS VIEW Operating Manual (070-0089)
Serial cable (modem configuration), see Section 2.2
Personal Computer (PC) with available serial port (e.g., COM1 or COM2)
HyperTerminal Communications program or equivalent
Microsoft Excel® program or equivalent

Setup

Connect Monitor RS-232 serial port to the PC serial port using a modem serial cable.
Turn On Monitor.
Turn On PC.

Data Capture Procedure (assuming Windows environment)

1. Open HyperTerminal program.
   Click on **Start/Programs/Accessories/Communications/HyperTerminal**. (Note: Depending on the version of Windows used, HyperTerminal may be in a different folder, but it is always under Start/Programs/Accessories.)

2. If a HyperTerminal session has not yet been set up for the Monitor:
   Enter the name (e.g. “A-2000 data”) and Icon for the connection session, then click on the OK button.
   In the **Connect using** field select the COM port to use (i.e. COM1 or COM2) then click on the OK button.
   Set the Port settings:
   9600 baud, 8 data bits, parity none, 1 stop bit, no flow control
   and click on the OK button.

Else:
   Double-click on the saved (e.g., A-2000) icon in the HyperTerminal window.

At this point data from the Monitor is being received and visible on the computer screen.

2. Capture Data to a disk file (you must capture data to disk in order to view/process it in Excel).
   Highlight **Transfer** and select **Capture Text**
   Enter path and name e.g. C:\EEG\patient1.txt, then click on the START button.

At this point data from the Monitor is being received and written to the disk file. You will see columns of data without headings. To identify the columns, you need to insert headings.

3. Insert Header Records into data for the disk file (recommended to provide column headings for spreadsheet).

On keyboard enter an **upper case D** (observe header record 1 and 2 are visible on screen)
Note: Other commands are also available to control Monitor (see Section 4.).

4. Before you exit HyperTerminal, you need to end data capture to the disk file.

Highlight **Transfer** and select **Capture Text**, then select **Stop**.

Before exiting HyperTerminal the first time, you may save this connection session so that you can use the same settings next time.

Click on **File**, then click on **Save**.

Data view procedure from disk file with Excel

1. Open Excel

File Open e.g. C:\EEG\patient1.txt
Select file data **Delimited** select **Next >** Button
Select delimiter **Other (Pipe (|) character),** select **Finished** Button

At this point the captured data in the disk file can be viewed and manipulated with Excel.
The requested Header Records should be found near the beginning of the file.
The data records prior to the Header Records can be deleted if they are unnecessary, or moved to below the Header Records if desired.

Note: The Date & Time "Column A" can be re-formatted in Excel to show the seconds detail:

a. Select entire "**Column A**"
b. Select **Format/Cells/Custom**
c. Select Type: **m/d/yy h:mm**
d. Modify Type, for example: **mm/dd/yyyy hh:mm:ss**
e. Click on **OK**

Note: On computers that are using Regional Settings other than English(United States), you need to replace all decimal points in the data with commas:

a. Select all data columns
b. Select **Edit/Replace**
c. In the **Find what:** box, enter a decimal point (period)
d. In the **Replace with:** box, enter a comma
e. Click on **Replace All**

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