Polaris Application Program Interface Guide

Revision 5
March 2011

Revision Status

Revision Number	Date	Description
1	September 2005	Initial release. Describes the API that is compatible with Polaris combined firmware revision 024, and Polaris Vicra/Polaris Spectra API revision G.001.002.
2	July 2006	Added description of API revision G.001.003, best practices information, and more details on user parameters.
3	September 2006	Minor edits.
4	May 2007	Added description of API revision G.001.004. This API revision includes support for the hybrid Polaris Spectra System SCU, strobers, GPIO devices, and active tools.
5	March 2011	Removed references to the Polaris System. Added description of API revision G.001.005.

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Read Me First!

This guide describes the Application Program Interface (API) commands that can be used with the Polaris Vicra System, and the Polaris Spectra System. Before sending any commands to the system, read the user guide that accompanied your system to ensure that you have a full understanding of the functionality.

Read this chapter before continuing with the rest of the guide.

Warnings and Cautions

Warnings

In all NDI documentation, warnings are marked by this symbol. Follow the information in the accompanying paragraph to avoid personal injury.

1. When using reply option 0800 with the BX (page 47) or TX (page 146) command, you must take appropriate action to detect the following events: the tool or marker is out of volume, the bump sensor has been tripped, or the system is outside of the optimal operating temperature range. You must determine whether these events are detrimental to your application. If one or more of the events listed occurs, reply option 0800 enables the system to return data that may lead to inaccurate conclusions and may cause personal injury.

Cautions

Caution! **In all NDI documentation, cautions are marked with the word "Caution!". Follow the information in the accompanying paragraph to avoid damage to equipment.**

1. Before an input/output line on a synchronization port can be used as an input, its output value must be set to a high level with SETIO (page 127). If you set the input to low and use the line as an input, there will be incorrect status readings and you may cause damage to the interface electronics.

About This Guide

This guide describes firmware revisions G.001.002, G.001.003, G.001.004 and G.001.005 of the API. To determine the API revision number programmed into your system, use the APIREV command.

Conventions

Terminology

System refers to the Polaris Vicra System, or Polaris Spectra System.

Compatibility

This API guide describes several versions of the API. Some commands or options are not available for each revision of the API. In this case, compatibility is indicated in columns at the right hand side of the page. (See, for example, "List of Commands" on page 1.)

At the beginning of each command description, the systems compatible with the command are listed. Where necessary, specific compatibility differences are listed in the Compatibility Notes near the end of the command description.

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1 List of Commands

Table 1-1 lists all the API commands, and whether they are supported by each revision of the API. Compatibility is indicated as follows:

X indicates that the command is supported.

* indicates that the command is deprecated. Deprecated commands will no longer be enhanced to support new hardware devices or new API features. Support for deprecated commands may be discontinued in future releases.

Table 1-1 Alphabetical List of Commands

Command	Page	Description	G.001.002	G.001.003	G.001.004	G.001.005
3D	39	Returns the latest 3D position of either a single marker or multiple markers.	X	X	X	X
APIREV	44	Returns the API revision number that functions with your system.	X	X	X	X
BEEP	45	Sounds the system beeper.	X	X	X	X
BX	47	Returns the latest tool transformations, individual marker positions, and system status in binary format.	X	X	X	X
COMM	58	Sets the serial communication settings of the system.	X	X	X	X
DFLT	61	Restores the user parameters to factory default values.	X	X	X	X
DSTART	63	Starts Diagnostic mode.	X	X	X	X
DSTOP	64	Stops Diagnostic mode.	X	X	X	X
ECHO	65	Returns exactly what is sent with the command.	X	X	X	X
GET	66	Returns the user parameter values.	X	X	X	X
GETINFO	68	Returns descriptive information about the user parameters.	X	X	X	X
GETIO	72	Returns the current status of the input/output lines of a synchronization port.			X	X
GETLOG	74	Returns the contents of a system log file.	X	X	X	X
HCWDOG	76	Sets up a host communication timeout check.	*	*	*	*
INIT	78	Initializes the system.	X	X	X	X
IRATE	79	Sets the illuminator rate.	*	*	*	*
IRED	81	Turns the markers on a wired tool on or off.			X	X
LED	83	Changes the state of visible LEDs on a wired tool.			X	X
PDIS	85	Disables the reporting of transformations for a particular port handle.	X	X	X	X
PENA	86	Enables reporting of transformations for a particular port handle.	X	X	X	X
PFSEL	88	Sets which faces to use to track a multi-faced tool.	X	X	X	X
PHF	90	Releases system resources from an unused port handle.	X	X	X	X
PHINF	91	Returns port handle status, and information about the tool associated with the port handle, including physical port location.	X	X	X	X

Table 1-1 Alphabetical List of Commands (Continued)

Command	Page	Description	G.001.002	G.001.003	G.001.004	G.001.005
PHRQ	99	Assigns a port handle to a tool or GPIO device.	X	X	X	X
PHSR	101	Returns the number of assigned port handles and the port status for each one. Assigns a port handle to a wired tool, GPIO device, or strober.	X	X	X	X
PINIT	104	Initializes a port handle.	X	X	X	X
PPRD	106	Reads data from the SROM device in a wired tool or GPIO device.			X	X
PPWR	108	Writes data to the SROM device in a wired tool or GPIO device.			X	X
PSEL	110	Selects an SROM device as the target for reading or writing with PPRD or PPWR.			X	X
PSOUT	111	Sets the states of the general purpose input/output (GPIO) lines in a GPIO device.			X	X
PSRCH	112	Returns a list of valid SROM device IDs for a wired tool or GPIO device.			X	X
PURD	114	Reads data from the user section of the SROM device in a wired tool or GPIO device.			X	X
PUWR	116	Writes data to the user section of a tool SROM device in a wired tool or GPIO device.			X	X
PVWR	118	Assigns a tool definition file to a wireless tool, overrides a tool definition file in a wired tool or GPIO device, and can be used to test a tool definition file before permanently recording the tool definition file onto the SROM device.	X	X	X	X
RESET	120	Resets the system (can specify either a hard reset or a soft reset).	X	X	X	X
SAVE	122	Saves all non-volatile user parameters that have been changed.	X	X	X	X
SENSEL	123	Sets the IR sensitivity level, or returns the current IR sensitivity level.	*	*	*	*
Serial break	37	Resets the system (soft reset).	X	X	X	X
SET	125	Sets user parameter values.	X	X	X	X
SETIO	127	Sets the current status of the input/output lines of a synchronization port.			X	X
SFLIST	129	Returns information about the supported features of the system.	X	X	X	X
SSTAT	136	Returns the status of the system processors.	*	*	*	*
SYSLOG	138	Writes data to the Position Sensor or System Control Unit log file.	X	X	X	X
TCTST	140	Returns diagnostics on the active markers of a wired tool.			X	X
TSTART	140	Starts Tracking mode.	X	X	X	X
TSTOP	143	Stops Tracking mode.	X	X	X	X
TTCFG	144	Sets up a configuration for a wired tool, so that you can test the tool without using a tool definition file.			X	X

Table 1-1 Alphabetical List of Commands (Continued)

Command	Page	Description	G.001.002	G.001.003	G.001.004	G.001.005
TX	146	Returns the latest tool transformations, individual marker positions, and system status in text format.	X	X	X	X
VER	158	Returns the firmware revision number of critical processors installed in the system.	X	X	X	X
VGET	160	Retrieves data previously captured with VSNAP.	X	X	X	X
VSEL	163	Selects a characterized measurement volume.	*	*	*	*
VSNAP	165	Captures one complete frame sequence of video data from the sensors.	X	X	X	X

2 Changes in Implementation

This chapter describes the changes in implementation from previous versions of the API. Read this chapter if you have written an application and you wish to update it to function with a more recent version of the API.

To update an application written for:	To function with:	Read:
Polaris Vicra API revision G.001.002	Polaris Vicra or Polaris Spectra API revision G.001.003	Page 5
Polaris Vicra or Polaris Spectra API revision G.001.003	Polaris Vicra or Polaris Spectra API revision G.001.004	Page 7
Polaris Vicra or Polaris Spectra API revision G.001.004	Polaris Vicra or Polaris Spectra API revision G.001.005	Page 7

Note **If you have written an application for a Polaris combined firmware revision not listed above, contact NDI technical support.**

2.1 Differences Between Polaris Vicra/Polaris Spectra API Revision G.001.002 and G.001.003

This section lists the changes between revisions G.001.002 and G.001.003 of the API. Read this section if:

- you have written an application compatible with revision G.001.002 of the API for the Polaris Vicra or Polaris Spectra System, and
- you wish to update the application to use some or all of the new features in revision G.001.003 of the API.

These changes are additions to the API. Any applications written to function with revision G.001.002 of the API will still function with revision G.001.003.

Addition to GETINFO

The GETINFO command has the following addition: GETINFO + will return top-level user parameter categories. GETINFO <category>.+ will return the next level of categories under the specified category. For example:

Command:	***Command:***	***Command:***
`GETINFO +`	`GETINFO PS-0.+`	`GETINFO PS-0.Features.+`
Reply:	***Reply:***	***Reply:***
`Device=;4;0003;;;;`	`Features=;4;0003;;;;`	`Hardware=;4;0003;;;;`
`Config=;4;0003;;;;`	`Info=;4;0003;;;;`	`Firmware=;4;0003;;;;`
`PS-0=;4;0003;;;;2D77`	`Param=;4;0003;;;;`	`Tools=;4;0003;;;;`
	`Cmd=;4;0003;;;;31E6`	`Keys=;4;0003;;;;1DF5`

Change to PHINF

Reply option 0010 in the PHINF command now returns a value of 010 for a tool with marker wavelength 930 nm if the tool was characterized using NDI 6D Architect version 2.02 or later. Tools characterized with earlier versions of NDI 6D Architect will still have a value of 000 for a marker wavelength of 930 nm.

Changes in Concepts

1. **Device Names**: Each device in the system configuration has a device name. Use the device name as a prefix to a user parameter. This allows you to read or set user parameters for each system component separately. If you omit the device name, the system will default to the parameters for the first Position Sensor in the configuration (PS-0). In the case of a one-Position Sensor passive system, this is the only Position Sensor. See “Device Names” on page 21 for details.
2. **Keyed Features**: The system may use optional keyed features which, if enabled, may require special consideration. For details on keyed features, see “Keyed Features” on page 171 and the user guide that accompanied your system.

New User Parameters

New user parameters are as follows:

New User Parameter	Description	Access Rules
Param.Laser.Laser Status	Starts/stops firing the positioning laser. Use this parameter when the Positioning Laser keyed feature is enabled. See “Positioning Laser” on page 174 for details.	Read, write
Config.Multi Firmware.Load Combined Firmware Revision	Combined firmware revision to load on next reset (selection automatically saves when set). Use this parameter when the Multi Firmware keyed feature is enabled. See “Multi Firmware Feature” on page 172 for details.	Read, write
Config.Multi Firmware.Update Combined Firmware Revision	Combined firmware revision to replace on next upgrade or downgrade. Use this parameter when the Multi Firmware keyed feature is enabled. See “Multi Firmware Feature” on page 172 for details.	Read, write, save
Config.Password	Enter the password to enable the ability to change and save the system configuration. Use this parameter when the Password Protect keyed feature is enabled. See “Password Protect Feature” on page 174 for details.	Read, write
Config.Combined Firmware Revision	Combined firmware revision of the current system configuration.	Read
Device.Type.0	Type of device in the system configuration.	Read
Device.Instance.0	Instance of this type of device in the system configuration.	Read

2.2 Differences Between Polaris Vicra/Polaris Spectra API Revision G.001.003 and G.001.004

This section lists the changes between revisions G.001.003 and G.001.004 of the API. Read this section if:

- you have written an application compatible with revision G.001.003 of the API for the Polaris Vicra or Polaris Spectra System, and
- you wish to update the application to use some or all of the new features in revision G.001.004 of the API.

These changes are additions to the API. Any applications written to function with revision G.001.002 or G.001.003 of the API will still function with revision G.001.004.

New Commands

New commands are as follows:

New Command	Description
GETIO (page 72)	Returns the status of the input/output lines of a synchronization port.
IRED (page 81)	Turns the markers on a wired tool on or off.
LED (page 83)	Changes the state of visible LEDs on a wired tool.
PPRD (page 106)	Reads data from the SROM device in a wired tool or GPIO device.
PPWR (page 108)	Writes data to the SROM device in a wired tool or GPIO device.
PSEL (page 110)	Selects a tool SROM device as the target for reading or writing with PPRD or PPWR.
PSOUT (page 111)	Sets the states of the general purpose input/output (GPIO) lines in a GPIO device.
PSRCH (page 112)	Returns a list of valid SROM device IDs for a wired tool or GPIO device.
PURD (page 114)	Reads data from the user section of the SROM device in a wired tool or GPIO device.
PUWR (page 116)	Writes data to the user section of the SROM device in a wired tool or GPIO device.
SETIO (page 127)	Sets the status of the input/output lines of a synchronization port.
TCTST (page 140)	Returns diagnostics on the active markers of a wired tool.
TTCFG (page 144)	Sets up a configuration for a wired tool, so that you can test the tool without using a tool definition file.

Changes in Concepts

1. **Data rate**: In API revisions G.001.002 and G.001.003, it was possible to get repeated information from the system if you requested information at a faster rate than the system could update. This behaviour has been changed for the commands 3D (page 39), BX (page 47), and TX (page 146), so that the system will return a maximum of one reply per frame. This matches the behaviour of Polaris combined firmware revisions 018 and 024. For all other commands, it is still possible to request and receive a reply more than once per frame.
2. **GPIO devices**: GPIO devices can be used with the hybrid Polaris Spectra System, and are connected to the System Control Unit (SCU) or strobers. Like active tools, GPIO devices are

assigned a port handle, which must be initialized and enabled before the GPIO device can be used.

3. **Strobers**: Strobers provide an interface for active tools, and can be used with the hybrid Polaris Spectra System. Like active tools, strobers are assigned a port handle. It is not necessary to initialize and enable the port handle for a strober. The SCU contains an "internal strober"; the tool ports and GPIO port on the front of the SCU are part of this internal strober. The internal strober is also assigned a port handle.

4. **Log files**: The Position Sensor and SCU now each have their own log file. Previous versions of the API supported only the Position Sensor and so the system only had one log file. This change results in a change in the log name specified in the commands GETLOG (page 74) and SYSLOG (page 138). See these commands for details.

5. **Alerts**: The alerts in the **Info.Status.Alerts** and **Info.Status.New Alerts** user parameters are defined differently for the SCU and strober than for the Position Sensor. For details, see "Alerts User Parameters" on page 23.

6. **LED behaviour**: The behaviour of the LEDs on the Position Sensor has changed. To see which alerts now have different LED behaviour, see "Position Sensor Alerts" on page 24.

7. **Diagnostic pending bit**: The "diagnostic pending" bit (bit 8 in the BX or TX system status) now indicates whenever an alert is detected or cleared in the **Info.Status.New Alerts** user parameter. Previously, the "diagnostic pending" bit was set only when an alert was detected.

8. **VSnap User Parameters**: The user parameters **Cmd.VSnap.Illuminated Frame** and **Cmd.VSnap.Background Frame**, used to specify which frames to capture with the VSNAP (page 165) command, can now only be set when the system is in Setup mode. Previously these parameters could be set in any mode, but did not take effect until the next DSTART (page 63) or TSTART (page 142) commmand was issued.

9. **Param.Tracking.Sensitivity** and **Param.Tracking.Selected Volume**: These two user parameters can now be set only when the system is in Setup mode. Previously these user parameters could be set in any mode, but would not take effect while the system was in Tracking or Diagnostic modes.

10. **Alerts Parameters**: The system response (LEDs and error codes) to some of the Position Sensor alerts has changed. See Table 4-2 on page 24 for details. New alerts have been defined for the SCU and strobers. See Table 4-3 on page 27 and Table 4-4 on page 29 for details.

11. **Alerts System Response**: Some of the alerts indicated in the alerts parameters result in the system not returning data unless reply option 0x0800 is used with the BX or TX command (see "Alerts User Parameters" on page 23 for details). Previously, the system resumed returning data once the **Info.Status.New Alerts** parameter was read, regardless of whether the alert was actually resolved. Now the system will not return data in these cases until the alert is resolved.

Changed Commands

1. **BX (page 47) and TX (page 146)**

   - Bits 6 and 7 in <System Status> report when a port handle has become occupied or unoccupied due to an active tool, strober, or GPIO device being connected or disconnected.

   - Reply option 0x0001: For GPIO devices, <Port Status> bits 1, 2, and 3 report the status of GPIO lines defined as inputs. (For wired tools, these bits report switch status).

- Reply option 0x0004 reports the 3D position of a single, stray marker on an active tool.

2. **GETLOG (page 74)**: The way the log name is specified has changed, to allow access to the logs in both the Position Sensor and the SCU. If you specify the log name using the format from previous versions of the API, the system will retrieve the log file for the Position Sensor. This maintains backwards compatibility with previous versions of the API.
3. **PHINF (page 91)**
   - Reply option 0x0001: Strobers are reported as <main type> 08 and GPIO devices are reported as <main type> 0C.
   - Reply option 0x0001: For GPIO devices, <Port Status> bits 1, 2, and 3 report the status of GPIO lines defined as inputs. (For wired tools, these bits report switch status).
   - Reply option 0x0008: For GPIO devices, bits 1, 2, and 3 report the status of GPIO lines defined as inputs, and bits 5, 6, and 7 report the status of GPIO lines defined as outputs with feedback. (For wired tools, bits 1, 2, and 3 report switch status, and bits 5, 6, and 7 report LED status.)
   - Reply option 0x0020: For Polaris, Polaris Vicra, and passive Polaris Spectra, <hardware device> is the Position Sensor serial number. For hybrid Polaris Spectra, this is the device name of the strober that the tool is plugged into (STB-1 or STB-2). If the tool is plugged into the SCU, this is STB-0.
   - Reply option 0x0040: This new reply option reports the status of the four GPIO lines in a GPIO device.
4. **PHRQ (page 99)**: For hybrid Polaris Spectra, specifying all wildcards for the <hardware device> for a wired tool or GPIO device will default to STB-0 (the tool ports on the SCU).
5. **SYSLOG (page 138)**: A log name must now be specified, to allow access to the logs in both the Position Sensor and the SCU. If you do not specify a log name, the system will write to the log file for the Position Sensor. This maintains backwards compatibility with previous versions of the API.
6. **TCTST (page 140)**: The low threshold for marker current is now 0x0A.
7. **VER (page 158)**: Reply option 3 now reports information for the System Control Unit. The second line of the response was the Tool Interface Unit part number for Polaris. For Polaris Spectra, the second line of the response is the serial number of the System Control Unit.

New Error Code

A new error code, 0x42, indicates when the command is specific to a device that is not connected to the system.

New Device Types

The following new device types are supported:

Device Type	Hardware Device
SCU	System Control Unit
STB	Strober

In G.001.003, only a device type of PS (Position Sensor) was supported. For details on device types, see "Device Names" on page 21.

New User Parameters

New user parameters are as follows:

New User Parameter	Description	Access Rules	Hardware Device
Param.Serial Port	Hardware configuration of the serial port.	Read	SCU
Param.Strober Name	User-defined strober name (up to 31 chars).	Read, write	Strobers
Features.Firmware. Package Number	Current firmware package number	Read	Position Sensor, SCU
Features.Firmware. Available Versions	List of firmware revisions loaded in the device	Read	Position Sensor, SCU
Features.Firmware. Available Combined Firmware Revisions	List of combined firmware revisions loaded in the device.	Read	Position Sensor, SCU
Features.Firmware. Combined Firmware Revision	Current combined firmware revision of the device.	Read	Position Sensor, SCU
Param.System Ext Sync Mode	Enables/disables the external sync mode (see the user guide for details).	Read, write	SCU
Config.Multi Firmware.Available Combined Firmware Revisions	List of combined firmware revisions loaded in the system.	Read	Config (no hardware device specified.)

2.3 Differences Between Polaris Vicra/Polaris Spectra API Revision G.001.004 and G.001.005

This section lists the changes between revisions G.001.004 and G.001.005 of the API. Read this section if:

- you have written an application compatible with revision G.001.004 of the API for the Polaris Vicra or Polaris Spectra System, and
- you wish to update the application to use some or all of the new features in revision G.001.005 of the API.

These changes are additions to the API. Any applications written to function with revision G.001.002, G.001.003 or G.001.004 of the API will still function with revision G.001.005.

New User Parameters

New user parameters are as follows:

New User Parameter	Description	Access Rules	Hardware Device
Param.Default wavelength. Return Warning	Enables/disables returning a warning on PINIT if the default wavelength was selected for the tool corresponding to the port handle.	Read, write	Position Sensor
Features.Firmware. Safeloader Version	Current safeloader firmware revision number.	Read	Position Sensor, SCU

Changed Commands

1. GET (page 66) and GETINFO (page 68): On a multi-line GET or GETINFO command, there is no longer a <LF> beteen the last parameter=value pair and the <CR>.
2. PINIT (page 104): WARNING05 (In combined firmware 006 and later, WARNING05 is returned when the system selects a default marker wavelength to track a tool (if the tool's tool definition file did not specify a marker wavelength)).

3 Communicating with an NDI System

This chapter describes various aspects of communicating with an NDI system. It contains the following sections:

3.1 Communication Overview

From the application perspective, the Polaris Vicra, or Polaris Spectra System is a serial device, which is listening for incoming commands. Upon receiving a command, the system performs some action and returns the status of this action. The system never initiates communication with the application except on power up or reset, when it returns `RESET<CRC16><CR>`. (If only an SCU is connected it will return `SCUONLY<CRC16><CR>`.)

Immediately after sending a command, the application can begin to poll the serial buffer for a reply. Most commands reply almost instantaneously. After reaching the end of the reply, the application can send another command. There may be some delay in the response of the PINIT command, and the commands used to read from and write to an SROM device in a wired tool.

Note **The application must read the complete response from the system before sending another command. Failure to do so may result in an error or in unpredictable system behaviour.**

3.2 Operating Modes

The system has three modes of operation: Setup, Tracking, and Diagnostic. Some commands will only work if they are sent while the system is in a specific mode of operation. If a command is sent when the system is in a mode not valid for that command, the system returns `ERROR0C`.

Setup

Setup mode allows you to configure the system and tools. Tasks done while the system is in Setup mode may include initializing the system, writing to the SROM device on a tool, or checking the system firmware revision.

The order of the commands sent while in Setup mode is important. For example, a port handle must be initialized (PINIT) before it can be enabled (PENA).

The system enters the Setup mode either on successful power up, on sending a reset, or on exiting from Tracking or Diagnostic modes.

Tracking

In Tracking mode, the system measures the positions and orientations of tools in real time and returns the information to the host computer when requested. The BX and TX commands are the most commonly used commands in Tracking mode.

The system enters Tracking mode on successful TSTART command and exits Tracking mode on TSTOP command.

Diagnostic

Diagnostic mode allows you to control and observe tools, but not track them.

The system enters Diagnostic mode on successful DSTART command and exits Diagnostic mode on DSTOP command.

3.3 General Syntax

Commands must be sent from the host computer to the system in one of the two following formats. To ensure the integrity of data transmission, NDI recommends using format 1, as well as verifying the returned CRC on the host computer.

Format 1

```
<Command><:><Parameter1><Parameter2>...<ParameterN><CRC16><CR>
```

A <:> must be sent with every command even if no parameters are required. There are no characters or spaces separating the parameters or the individual parts of the commands, except in user parameter names and string values used with the SET, GET, GETINFO, DFLT, and SYSLOG commands. Commands and parameters are not case-sensitive, except for user parameter names and string values used with the SET, GET, GETINFO, DFLT, and SYSLOG commands.

This format requires a 16-bit CRC value and therefore may be more useful in application software. The application software can incorporate a CRC calculation and add it to the command each time a command is sent to the system. Including a CRC provides a communications check to ensure that there are no communication problems between the system and the host computer. The CRC is used in both the commands and replies. It is based on all the characters in the command, up to the CRC itself. It is calculated using the polynomial $x^{16} + x^{15} + x^2 + 1$. See “Sample C Routines” on page 175 for sample code to calculate the CRC.

Format 2

```
<Command><SPACE><Parameter1><Parameter2>...<ParameterN><CR>
```

A <SPACE> must be sent with every command even if no parameters are required. There are no characters or spaces separating the parameters or the individual parts of the commands, except in user parameter names and string values used with the SET, GET, GETINFO, DFLT, and SYSLOG commands. Commands and parameters are not case-sensitive, except for user parameter names and string values used with the SET, GET, GETINFO, DFLT, and SYSLOG commands.

It is not necessary to calculate a Cyclic Redundancy Check (CRC) value when using this format, so this format is useful for sending commands to the system in an application such as a terminal program.

3.4 Receiving System Replies

Binary Replies

Commands BX, GETLOG, and VGET return binary replies. All other commands return ASCII replies.

If a complete command is received by the system, replies are sent back in the format:

`<Reply><CRC16>`

The system always returns `<CRC16>` in the reply regardless of whether the command was sent in format 1 or format 2. The `<Reply>` will be either the requested data, or `ERROR<error code>`. The `<error code>` is a two-digit hexadecimal error number. See "Error Code Definitions" on page 167 for a listing of all the error messages associated with error numbers.

Binary replies are returned in little endian format. For example, a 32-bit reply is returned in the format:

Bits	7 - 0	15 - 8	23 - 16	31 - 24
Reply byte	n	n + 1	n + 2	n + 3

ASCII Replies

All commands return ASCII replies except BX, GETLOG, and VGET, which return binary replies.

If a complete command is received by the system, replies are sent back in the format:

`<Reply><CRC16><CR>`

The system always returns `<CRC16>` in the reply regardless of whether the command was sent in format 1 or format 2. The `<Reply>` will be either the requested data, `OKAY`, `WARNING`, `WARNING<warning code>`, or `ERROR<error code>`.

- `WARNING` is returned only with the PINIT command. See PINIT (page 104) or "Warning Code Definitions" on page 170 for details.
- `WARNING<warning code>` is returned only with the PENA command. See "Warning Code Definitions" on page 170 for a listing of the warning messages.
- The `<error code>` is a two-digit hexadecimal error number. See "Error Code Definitions" on page 167 for a listing of all the error messages associated with error numbers.

3.5 Best Practices

This section provides guidelines on how to write an application in order to minimize updates required when there are changes to the API. If your application is written correctly, it will still work when additions are made to the API; you will only need to update your application if you wish to take advantage of the new features.

- Ignore the value of any returned field that is listed as "reserved" in the API guide. The values of reserved fields may change in future API releases.
- Program the application to allow all possible values of a returned field, not only the values that are currently defined. This allows for future expansion. For example, if a field returns one character, but currently only characters 0 and 1 are defined, do not write your application such that 0 and 1 are the only acceptable values; more values may be defined in the future.
- Use the frame number, and not the host computer clock, to identify when data was collected. The frame number is incremented by 1 at a constant rate of 60 Hz. Associating a time from the host computer clock to replies from the system assumes that the duration of time between raw data collection and when the reply is received by the host computer is constant. This is not necessarily the case. The frame number is returned with the command BX (page 47) or TX (page 146).
- Use both the shape type and the shape parameters to represent the characterized measurement volume graphically. There may be multiple volumes with the same shape type. All volumes of the same shape type use the shape parameters the same way. The shape type and shape parameters are returned with the command SFLIST (page 129).
- When checking the firmware revision, check only the combined firmware revision, not the firmware revision of the individual components. The combined firmware revision ensures that all components in a system have compatible firmware. To check the combined firmware revision, read the value of the user parameter **Config.Combined Firmware Revision** or use the command VER 5 (page 158). See "User Parameters" on page 20 for information on reading user parameters.
- When checking for protocol compatibility, check for the API revision instead of the combined firmware revision. An application written for a particular API revision will function with any system that supports that API revision. See the command APIREV (page 44) for details.
- Use an application-specific parameter file to set the user parameter values every time the system is initialized. This ensures that the settings are consistent every time, and allows you to adopt new values or incorporate new parameters without having to update the application software. See "User Parameters" on page 20 for information on setting user parameters.
- Use device names to access user parameters. See "Device Names" on page 21 for instructions on how to determine the device names of the hardware devices in your system and how to access user parameters using device names.
- Use **GET Device.*** to determine which devices are in the system configuration, instead of programming device names directly into the application. This will allow the addition or removal of devices without breaking the application. When setting or reading a user parameter value for every hardware device in the system, create a loop to repeat the action for every device name determined using **GET Device.***. See "Device Names" on page 21

for instructions on how to determine the device names of the hardware devices in your system and how to access user parameters using device names.

- Read the timeout values of the API commands from the user parameter **Info.Timeout.<command name>**; do not program the timeout values directly into the application. See "User Parameters" on page 20 for information on user parameters. Note: since the timeout values are the same for every system configuration, it is not necessary to prefix the **Info.Timeout** user parameters with a device name unless you are communicating with an SCU that is not connected to a Position Sensor. (In this case you must use the SCU's device name.)
- Do not use the system log to record minor system events. The system log is intended for major milestones only, and may not have enough space to accommodate numerous minor entries. For minor entries, use the user parameters **Param.User.String0** to **Param.User.String4** as required. These parameters can be used for any purpose; the system does not make use of them. For example, an incoming inspection result might be a major milestone to be saved in the system log; a cleaning schedule might be a minor entry to be saved in a user parameter. See "User-Defined User Parameters" on page 30 for information on these user parameters.

3.6 Port Handles

About Port Handles

The system assigns each tool, GPIO device, and strober a port handle. Port handles are two characters in hexadecimal format, 0x01 to 0xFF.

Port handles can be assigned to tools only while the system is in Setup mode.

Port Handle Commands

The following commands are used for port handles:

Command	Description
PHSR (page 101)	Returns the number of assigned port handles and the port status for each one. Assigns a port handle to a wired tool or GPIO device.
PHRQ (page 99)	Assigns a port handle to a tool or GPIO device. PHRQ is followed by PVWR.
PVWR (page 118)	Assigns a tool definition file to a tool, overrides a tool definition file in a wired tool or GPIO device, and can be used to test a tool definition file before permanently recording the tool definition file onto the SROM device of a wired tool or GPIO device.
PINIT (page 104)	Initializes a port handle.
PHINF (page 91)	Returns port handle status, and information about the tool, GPIO device, or strober associated with the port handle, including physical port location.

Command	Description
PHF (page 90)	Releases system resources from an unused port handle. This is required if a tool, GPIO device, or strober is disconnected. If a tool, GPIO device, or strober is disconnected and then reconnected, the system assigns it a new port handle. The old handle is reported as disabled and should be freed using PHF.
PENA (page 86)	Enables reporting of transformations for a particular port handle.
PDIS (page 85)	Disables the reporting of transformations for a particular port handle.

The order in which these commands are used is detailed in Figure 3-1 on page 18 (for wired tools) and Figure 3-2 on page 19 (for wireless tools).

Disabled Transformations

A transformation may be reported as DISABLED if:

- the port handle was not enabled with PENA (page 86),
- the port handle has been disabled with PDIS (page 85), or
- a wired tool, GPIO device, or strober has been disconnected and the port handle has not been freed.

Unoccupied Port Handle

A port handle may be reported as UNOCCUPIED if:

- the tool, GPIO device, or strober has been disconnected and port handle information is requested using PHINF (page 91), or
- you have requested a port handle with PHRQ (page 99) but you have not yet used PVWR (page 118) to associate a tool definition file with the port handle.

Flow Charts for Port Handle Usage

Figure 3-1 details the logic for using port handles with wired tools, GPIO devices, and strobers. Initializing and enabling a strober is optional.

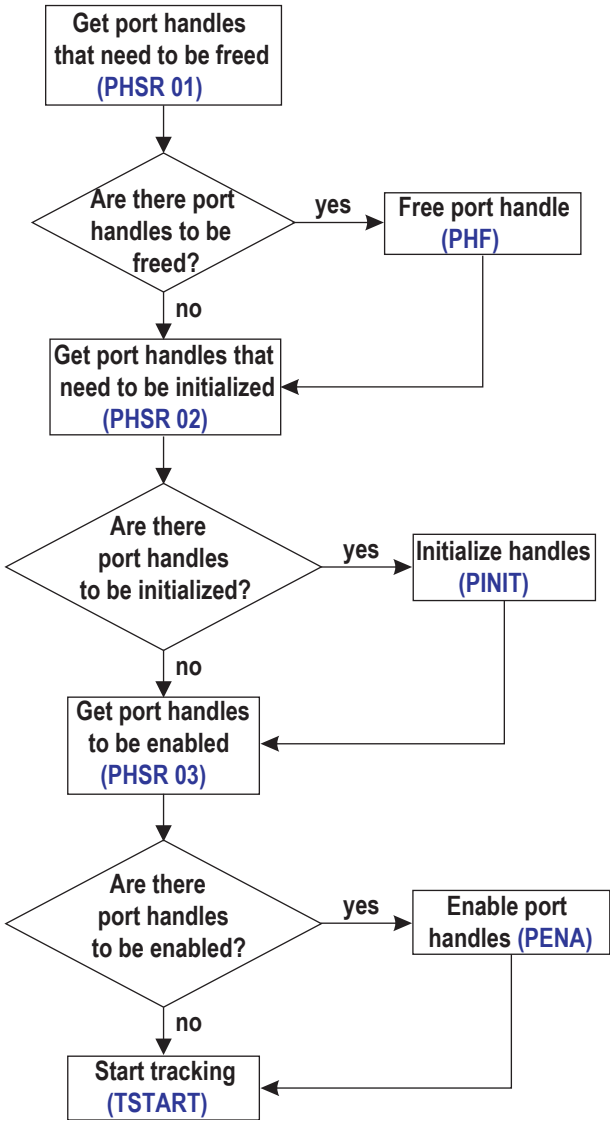


Figure 3-1 Flow Chart for Port Handle Usage - Wired Tools

Figure 3-2 details the logic for using port handles with wireless tools.

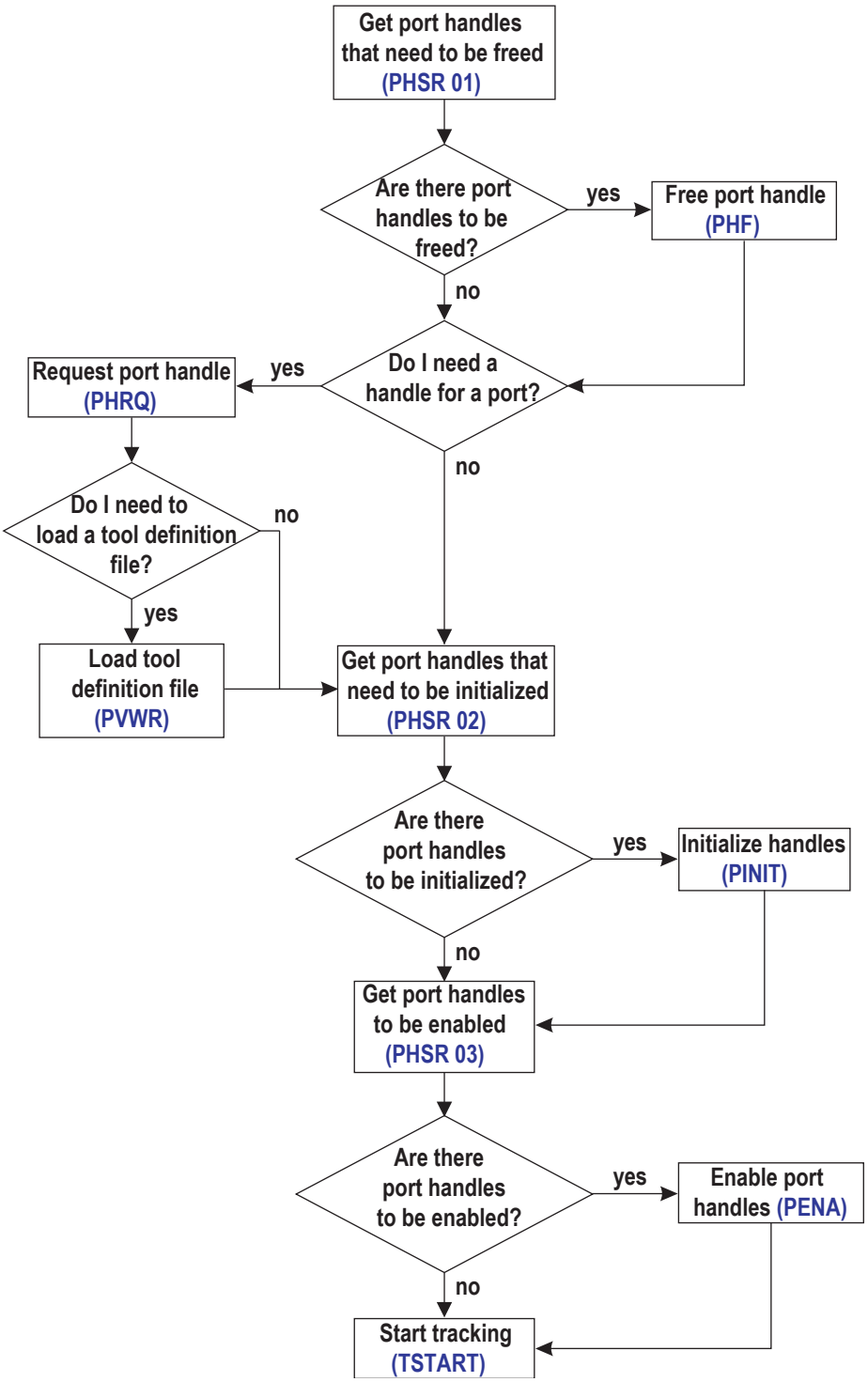


Figure 3-2 Flow Chart for Port Handle Usage - Wireless Tools

4 User Parameters

This chapter contains the following sections about user parameters:

4.1 About User Parameters

The user parameters store values for different aspects of the Polaris Vicra or Polaris Spectra System. Some user parameters store values for the full system configuration; others store values pertaining to a particular hardware device in the system. Some user parameters are read-only parameters that store useful information about the system; some user parameter values can be changed, to allow you to configure the system.

User parameters fall under the following categories:

- Image Capture User Parameters: These user parameters are used in conjunction with the VSNAP and VGET commands to store settings and values related to image capture.
- Settings User Parameters: These user parameters store settings for each hardware device in the system. For example, the illuminator rate and the available characterized measurement volumes are stored in the settings user parameters.
- Information User Parameters: These user parameters store status information for each hardware device in the system, and command timeout values.
- Features User Parameters: These user parameters store information about the features of each hardware device in the system.
- System Configuration User Parameters: These user parameters store information about the configuration of the system. These user parameters describe the configuration of the entire system, not a particular device.
- Hardware Device Information User Parameters: These user parameters store information about which hardware devices are part of the system.

For a full list of user parameters, see page 31.

4.2 User Parameter Commands

The following commands are used with the user parameters:

Command	Description
DFLT (page 61)	Restores the user parameters to factory default values.
GET (page 66)	Returns user parameter values.
GETINFO (page 68)	Returns user parameter values and descriptive information about the user parameters, including use details, possible values, and access rules.
SET (page 125)	Sets user parameter values.
SAVE (page 122)	Saves all non-volatile user parameters that have been changed.

See the individual commands for more details.

4.3 Device Names

Note **Device names are supported in API revisions G.001.003 and later.**

Each hardware device in the system configuration has a unique device name. For passive systems, the Position Sensor is the only hardware device. For hybrid systems, the Position Sensor, System Control Unit, and strobers each have a device name.

Each hardware device has its own set of user parameters. Each Position Sensor and System Control Unit has its own log file. Device names allow you to specify for which hardware device you wish to access the user parameters or log file.

Note **For information on the log files, see GETLOG (page 74) and SYSLOG (page 138).**

Determining the Devices in the System Configuration

Use the GET command to determine which hardware devices are in your system. To ensure future compatibility if more devices are integrated into your system, your application should read the list of devices every time you connect to a system, or whenever a component is connected or disconnected.

Note **The list of devices does not update while the system is in tracking mode. If a strober is connected while the system is in tracking mode, the list of devices will not show the change until the system exits tracking mode.**

The most general method of reading the list of devices to ensure consistent behaviour in the future is as follows:

Command:

```
GET Device.*
```

Reply:

```
Device.Type.0=SCU
                Device.Instance.0=0
                                  Device.Type.1=PS
                                                  Device.Instance.1=0
Device.Type.2=STB
                Device.Instance.2=0
                                  Device.Type.3=STB
                                                    Device.Instance.3=1
Device.Type.4=STB
                Device.Instance.4=2C845
```

The reply gives information about every device in the system configuration. For each device, there are two parameters:

- **Device.Type.X** describes the type of connected device. Device types are as follows:

Device.Type Parameter	Hardware Device
PS	Position Sensor
SCU	System Control Unit
STB	Strober

- **Device.Instance.X** describes the instance of that type of device in the configuration.

Parameters with the same X index value (for example, Device.Type.0 and Device.Instance.0) describe the same device.

In the example above, the reply is for a hybrid Polaris Spectra System with an a System Control Unit, a Position Sensor, and two strobers. Since the System Control Unit also contains an internal strober, a total of three strobers are enumerated.

Constructing Device Names

User parameters for a particular device can always be accessed using the full device name. To construct the device name for a particular device, use the following syntax:

```
<Device.Type.X>-<Device.Instance.X>
```

For the configuration in the example above, the device names are SCU-0, PS-0, STB-0, STB-1, and STB-2. The internal strober in the System Control Unit is always STB-0.

Accessing User Parameters Using Device Names

Each device has its own set of user parameters. To ensure that the user parameters for the correct device are accessed, prefix the parameter with the device name. All references to user parameters for a device can be made using the device name. To access the user parameters for a particular device, use the following syntax:

```
<Device.Type.X>-<Device.Instance.X>.<User Parameter>
```

For example, use `GET PS-0.Param.Tracking.Sensitivity` to check the sensitivity level for the Position Sensor.

To view information about the parameters supported by the device, use the following commands:

```
GET PS-0.*
GETINFO PS-0.+
GETINFO PS-0.*
```

Note **See the GET (page 66) and GETINFO (page 68) commands for details.**

The system configuration user parameters (beginning with Config) and the hardware device user parameters (beginning with Device) describe the configuration of the entire system. Do not prefix these user parameters with a device name.

4.4 Alerts User Parameters

The alerts user parameters describe the status of a particular hardware device in the system. To access the user parameters for a particular device, prefix the parameter with the device name as described in "Device Names" on page 21.

Alerts User Parameters

Table 4-1 describes the alerts user parameters.

Table 4-1 Alerts User Parameters

User Parameter	Description
Info.Status. Alerts	This user parameter describes the current state of the hardware device by reporting the alerts listed in Table 4-2 (for the Position Sensor), Table 4-3 (for the System Control Unit), or Table 4-4 (for the strobers). The bit corresponding to a particular alert is set when the system first detects the condition. This is accompanied by the system response detailed in Table 4-2, Table 4-3, or Table 4-4. The bit is cleared when the condition no longer exists. Note: the "bump detected" bit will be cleared only when you set the **Param.Bump Detector.Clear** Position Sensor user parameter to "1".
Info.Status. New Alerts	Read this user parameter when the diagnostic pending bit is set (bit 8 in the BX or TX system status). This user parameter lists the current alerts status whenever an alert is set or cleared. The act of reading this parameter clears both this parameter and the diagnostic pending bit. The bit corresponding to a particular alert is set when the system first detects the condition, and is cleared when the system first detects that the condition has been resolved. This is accompanied by the system response detailed in Table 4-2, Table 4-3, or Table 4-4. The act of reading this user parameter clears it.
Info.Status. Alerts Overflow	Read this user parameter if the overflow bit is set in the user parameter **Info.Status.Alerts** or **Info.Status.New Alerts** for a particular hardware device. No bits are currently defined in this parameter.
Param.Simulated Alerts	Simulates the **Info.Status.Alerts** parameter for the hardware device specified, for testing purposes. To test the response of a particular alert, set the value of this parameter to the value of the alert (see Table 4-2, Table 4-3, or Table 4-4).

Position Sensor Alerts

Table 4-2 describes the Position Sensor alerts that are returned by the **Info.Status.Alerts** and **Info.Status.New Alerts** user parameters. The returned value is an integer, which you must convert to an 8-character hexadecimal number. The hexadecimal number is made up of the following individual alert values OR'd together:

Table 4-2 Position Sensor Alerts

Hexadecimal Value	Alert	System Response	Position Sensor LED Indication
0x00000001	Non-recoverable parameter fault The system parameter file or some other critical file is missing or has been corrupted (CRC check failed).	INIT returns ERROR15	Error LED: on Status LED: off
0x00000002	Sensor parameter fault The sensor parameters were not programmed properly, or cannot be read by the system.	INIT returns ERROR15	Error LED: on Status LED: off
0x00000004	Main voltage fault The input voltage to the Position Sensor is outside of the operating range. This may be caused by a problem with the power supply.	Sets diagnostic pending bit (bit 8) in TX or BX system status. Need reply option 0800 in TX or BX to return data.	Power LED: off Status LED: on Error LED: on
0x00000008	Sensor voltage fault One of the voltages supplied to the sensor is outside of the operating range. This may be caused by a hardware failure.	Sets diagnostic pending bit (bit 8) in TX or BX system status. Need reply option 0800 in TX or BX to return data.	Error LED: on Status LED: off
0x00000010	Illuminator voltage fault The illuminator voltage is outside of operating range. This may be caused by a hardware failure.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Error LED: on Status LED: off
0x00000020	Illuminator current fault The illuminator current is outside of operating range. This may be caused by a hardware failure.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Error LED: on Status LED: off
0x00000040	Left sensor temperature fault The left sensor temperature sensor is outside of functional range.	INIT returns ERROR15 Sets diagnostic pending bit (bit 8) in TX or BX system status. The system will not return tracking data, even if reply option 0800 in TX/BX is used. (API revision G.001.003 and earlier: INIT is possible; system returns data in TX and BX if 0800 option is used.)	Error LED: on Status LED: off

Table 4-2 Position Sensor Alerts (Continued)

Hexadecimal Value	Alert	System Response	Position Sensor LED Indication
0x00000080	Right sensor temperature fault The right sensor temperature sensor is outside of functional range.	INIT returns ERROR15 Sets diagnostic pending bit (bit 8) in TX or BX system status. The system will not return tracking data, even if reply option 0800 in TX/BX is used. (API revision G.001.003 and earlier: INIT is possible; system returns data in TX and BX if 0800 option is used.)	Error LED: on Status LED: off
0x00000100	Main temperature fault The main board temperature sensor is outside of functional range.	INIT returns ERROR15 Sets diagnostic pending bit (bit 8) in TX or BX system status. The system will not return tracking data, even if reply option 0800 in TX/BX is used. (API revision G.001.003 and earlier: INIT is possible; system returns data in TX and BX if 0800 option is used.)	Error LED: on Status LED: off
0x00000200 to 0x00080000	Reserved		
0x00100000	System battery fault The system battery power is too low. This may be caused by a worn-out battery, or the battery may not be connected. This battery powers the bump sensor and the system clock.	Sets diagnostic pending bit (bit 8) in TX or BX system status. Need reply option 0800 in TX or BX to return data.	Status LED: on Error LED: flashing
0x00200000	Bump detected The bump sensor has detected a bump.	Sets diagnostic pending bit (bit 8) in TX or BX system status. Need reply option 0800 in TX or BX to return data.	Status LED: on Error LED: flashing
0x00400000	Reserved		
0x00800000	Firmware incompatible The combination of firmware on the Position Sensor is not compatible. This may be caused by a failed attempt to update the firmware.	INIT returns ERROR2E	Status LED: on Error LED: on (API revision G.001.003 and earlier: status LED is on; error LED is flashing.)

Table 4-2 Position Sensor Alerts (Continued)

Hexadecimal Value	Alert	System Response	Position Sensor LED Indication
0x01000000	Recoverable parameter fault The user parameter file has been corrupted (CRC check failed) or is missing. To correct this problem, check that the settings of the user parameters are set correctly, and save them (use SAVE (page 122)).	INIT returns ERROR15	Status LED: on Error LED: on (API revision G.001.003 and earlier: status LED is on; error LED is flashing.)
0x02000000	Internal flash memory is full The system cannot store any additional data to the file system. The flash memory can only be cleared by NDI.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: on Error LED: off (API revision G.001.003 and earlier: status LED is on; error LED is flashing.)
0x04000000	Positioning Laser battery fault The laser battery power is too low. This may be caused by a worn-out battery, or the battery may not be connected.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: on Error LED: off (API revision G.001.003 and earlier: status LED is off; error LED is flashing.)
0x08000000 and 0x10000000	Reserved		
0x20000000	Temperature characterized high The Position Sensor temperature is above the optimal operating range (see the user guide for details).	Sets temperature bit (bit 9) in TX or BX system status. Need reply option 0800 in TX or BX to return data.	Status LED: on
0x40000000	Temperature characterized low The Position Sensor temperature is below the optimal operating range (see the user guide for details).	Sets temperature bit (bit 9) in TX or BX system status. Need reply option 0800 in TX or BX to return data.	Power LED: flashes during warm-up when system is first powered on. Status LED: on
0x80000000	Overflow. Read the value of the user parameter **Info.Status.Alerts Overflow**.		Status LED: on

Note **Some of the alerts indicated in Table 4-2 result in the system not returning data unless reply option 0x0800 is used with the BX or TX command. In API revision G.001.003 and earlier, the system resumed returning data once the Info.Status.New Alerts parameter was read, regardless of whether the alert was not resolved. In API revision G.001.004 and later, the system will not return data in these cases until the alert is resolved.**

System Control Unit Alerts

Table 4-3 describes the SCU alerts that are returned by the **Info.Status.Alerts** and **Info.Status.New Alerts** user parameters. The returned value is an integer, which you must convert to an 8-character hexadecimal number. The hexadecimal number is made up of the following individual alert values OR'd together:

Table 4-3 System Control Unit Alerts

Hexadecimal Value	Alert	System Response	SCU LED Indication
0x00000001	Non-recoverable parameter fault The system parameter file or some other critical file is missing or has been corrupted (CRC check failed).	INIT returns `ERROR15`	Error LED: on Status LED: off Rear LED: amber
0x00000002	Position Sensor current fault The Position Sensor current is outside of the expected range. This may be caused by a problem with the Position Sensor, SCU, or cables.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: on Error LED: on Rear LED: amber
0x00000004	Position Sensor communication fault The SCU can detect the Position Sensor, but cannot communicate with it. This may be caused by a problem with the Position Sensor or cable.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: on Error LED: on Rear LED: amber
0x00000008	Reserved		
0x00000010	Internal strober communication fault The SCU can detect the internal strober, but cannot communicate with it.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Error LED: on Status LED: off Rear LED: amber
0x00000020	Strober communication fault The SCU can detect the strober connected to the SCU, but cannot communicate with it.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: on Error LED: on Rear LED: amber
0x00000040	Strober communication fault The SCU can detect the second connected strober, but cannot communicate with it.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: on Error LED: on Rear LED: amber
0x00000080 to 0x00080000	Reserved		
0x00100000	Too many strobers Too many strobers are connected to the system.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: on Error LED: off Rear LED: green

Table 4-3 System Control Unit Alerts (Continued)

Hexadecimal Value	Alert	System Response	SCU LED Indication
0x00200000	No strober connected to strober cable The SCU can detect a strober cable with no strober connected.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: on Error LED: off Rear LED: green
0x00400000	System firmware incompatible Not all components in the system have compatible firmware. To correct this, update the firmware, or load a different firmware revision (if the Multi Firmware feature is installed).	INIT returns `ERROR2E`	Status LED: on Error LED: on Rear LED: amber
0x00800000	Firmware incompatible The combination of firmware on the SCU is not compatible. This may be caused by a failed attempt to update the firmware.	INIT returns `ERROR2E`	Status LED: on Error LED: on Rear LED: amber
0x01000000	Recoverable parameter fault The user parameter file has been corrupted (CRC check failed) or is missing. To correct this problem, check that the settings of the user parameters are set correctly, and save them (use SAVE (page 122)).	INIT returns `ERROR15`	Status LED: on Error LED: on Rear LED: amber
0x02000000	Internal flash memory is full The system cannot store any additional data to the file system. The flash memory can only be cleared by NDI.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: on Error LED: off Rear LED: green
0x04000000	External sync frequency out-of-range The system will have aliased the out-of-range external sync frequency in order to continue to operate.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: on Error LED: off Rear LED: green
0x08000000 to 0x40000000	Reserved		
0x80000000	Overflow. Read the value of the user parameter **Info.Status.Alerts Overflow**.		Status LED: on Rear LED: green

Strober Alerts

Table 4-4 describes the strober alerts that are returned by the **Info.Status.Alerts** and **Info.Status.New Alerts** user parameters. The returned value is an integer, which you must convert to an 8-character hexadecimal number. The hexadecimal number is made up of the following individual alert values OR'd together:

Table 4-4 Strober Alerts

Hexadecimal Value	Alert	System Response	Strober LED Indication
0x00000001	Non-recoverable parameter fault The system parameter data or some other critical data is missing or has been corrupted (CRC check failed).	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: off Error LED: on
0x00000002	Marker current fault The marker current is above the limit when no markers are activated. This is a strober hardware fault.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: off Error LED: on
0x00000004	Input voltage fault. The input voltage to the strober is outside of the expected range. This may be caused by a problem with the strober, SCU, or cables.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: off Error LED: on
0x00000008	Internal voltage 1 fault The internal voltage 1 is outside of the expected range. This may be caused by a problem with the strober, SCU, or cables.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: off Error LED: on
0x00000010	Internal voltage 2 fault The internal voltage 2 is outside of the expected range. This may be caused by a problem with the strober, SCU, or cables.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: off Error LED: on
0x00000020 to 0x00400000	Reserved		
0x00800000	Firmware incompatible The combination of firmware on the strober is not compatible. This may be caused by a failed attempt to update the firmware.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: on Error LED: on
0x01000000	Recoverable parameter fault The user parameter data has been corrupted or is missing. To correct this problem, check that the settings of the user parameters are set correctly.	Sets diagnostic pending bit (bit 8) in TX or BX system status.	Status LED: on Error LED: on
0x02000000 to 0x80000000	Reserved		

4.5 Bump Sensor User Parameters

Table 4-5 lists the user parameters that relate to the bump sensor. For details on the bump sensor, see the user guide that accompanied your system.

Table 4-5 Bump Sensor User Parameters

User Parameter	Description
Info.Status.Bump Detected	This user parameter indicates when the system has detected a bump. The system sets this user parameter to "1" upon detecting a bump. The system resets this user parameter to "0" once you have set the **Param.Bump Detector.Clear** user parameter to "1".
Param.Bump Detector.Clear	Set this user parameter to clear all bumps detected up to that point. This clears the "bump detected" bit in the **Info.Status.Alerts** user parameter, and sets the **Info.Status.Bump Detected** user parameter and the **Param.Bump Detector.Bumped** user parameter to "0". Values: "1" clears all detected bumps. The system will automatically reset this user parameter to "0".
Param.Bump Detector.Bumped	This user parameter indicates when the system has detected a bump. The system sets this user parameter to "1" upon detecting a bump. The system resets this user parameter to "0" once you have set the **Param.Bump Detector.Clear** user parameter to "1."
Param.Bump Detector. Bump Detection	This user parameter enables the bump detector. Values: "1" bump detector enabled (default). "0" bump detector disabled.

4.6 User-Defined User Parameters

There are five user parameters, **Param.User.String0** to **Param.User.String4**, that can be used to store user-defined information. For example, these parameters could be used to keep track of the system maintenance or cleaning schedule. These parameters can be used for any purpose; the system does not make use of them.

The user-defined user parameters are associated with a particular hardware device in the system. To access the user parameters for a particular device, prefix the parameter with the device name as described in "Device Names" on page 21.

4.7 Complete List of User Parameters

The following tables list the user parameters for the Polaris Vicra and Polaris Spectra Systems. If you have upgraded the firmware in your system, you may have access to additional user parameters. To view a complete list of user parameters for your system, use the command GET * (for parameter names and values) or GETINFO * (for parameter names, values, and usage details).

Image Capture User Parameters

The following user parameters are used in conjunction with the VSNAP and VGET commands. See VSNAP (page 165) and VGET (page 160) for details. These user parameters apply only to the Position Sensor. To access these user parameters, prefix the user parameter name with the device name of the Position Sensor.

Table 4-6 Image Capture User Parameters

User Parameter Name	Description	Access Rules
Cmd.VSnap.Illuminated Frame	Forces the collection of a frame with illuminators on. **API revision G.001.004** and later: can only be set in Setup mode. **API revision G.001.003** and earlier: takes effect on next DSTART or TSTART.	Read, write
Cmd.VSnap.Background Frame	Forces the collection of a background frame with illuminators off. **API revision G.001.004** and later: can only be set in Setup mode. **API revision G.001.003** and earlier: takes effect on next DSTART or TSTART.	Read, write
Cmd.VSnap.Manual Shutter	Exposure time for illuminated and background frames [usec]	Read, write
Cmd.VSnap.Frame Types	Enumeration of tool classes reported in a frame sequence	Read
Cmd.VGet.Threshold.Shutter Time	Exposure time for threshold calculations [usec]	Read, write
Cmd.VGet.Threshold.Trigger	Spot detection trigger threshold [% full scale]	Read
Cmd.VGet.Threshold.Background	Background suppression threshold [% full scale]	Read
Cmd.VGet.Sensor.Color Depth	Number of bits per pixel on the video sensor	Read
Cmd.VGet.Sensor.Width	Number of horizontal pixels on the video sensor	Read
Cmd.VGet.Sensor.Height	Number of vertical pixels on the video sensor	Read
Cmd.VGet.Start X	Image capture start column	Read, write
Cmd.VGet.End X	Image capture end column	Read, write
Cmd.VGet.Color Depth	Image capture returned bits per pixel	Read, write
Cmd.VGet.Stride	Image capture horizontal pixel step	Read, write
Cmd.VGet.Sample Option	Image capture sample option for the stride; see VGET (page 160) for details.	Read, write
Cmd.VGet.Compression	Image capture returned data compression	Read, write

Settings User Parameters

The following user parameters store settings for the hardware devices indicated in the Hardware Device column. To access the user parameters for a particular device, prefix the user parameter name with the device name (see "Device Names" on page 21 for details).

Table 4-7 System Settings User Parameters

User Parameter Name	Description	Access Rules	Hardware Device
Param.Laser.Laser Status	Starts/stops firing the positioning laser. Use this parameter when the Positioning Laser keyed feature is enabled. See "Positioning Laser" on page 174 for details. The laser will turn off automatically after 60 s.	Read, write	Position Sensor
Param.User.String0	User-defined string (up to 63 chars)	Read, write, save	Position Sensor, SCU
Param.User.String1	User-defined string (up to 63 chars)	Read, write, save	Position Sensor, SCU
Param.User.String2	User-defined string (up to 63 chars)	Read, write, save	Position Sensor, SCU
Param.User.String3	User-defined string (up to 63 chars)	Read, write, save	Position Sensor, SCU
Param.User.String4	User-defined string (up to 63 chars)	Read, write, save	Position Sensor, SCU
Param.Firmware. Current Version	Current firmware revision number	Read	Position Sensor, SCU
Param.Tracking. Available Volumes	Available characterized measurement volumes	Read	Position Sensor
Param.Tracking. Selected Volume	Selects a characterized measurement volume. Can only be set in Setup mode.	Read, write	Position Sensor
Param.Tracking.Sensitivity	Background IR sensitivity level (1-highest, 7-lowest)	Read, write, save	Position Sensor
Param.Tracking.Illuminator Rate	Illuminator activation frequency [Hz] Can only be set in Setup mode.	Read, write	Position Sensor
Param.Default Wavelength. Return Warning	Enables/disables returning a warning on PINIT if the default wavelength was selected for the tool corresponding to the port handle.	Read, write	Position Sensor
Param.Bump Detector. Bump Detection	Enables the bump sensor.	Read, write, save	Position Sensor
Param.Bump Detector.Clear	Set to 'Clear' (1) to acknowledge reported bumps.	Read, write	Position Sensor
Param.Bump Detector.Bumped	Indicates if the system has detected a bump.	Read	Position Sensor

Table 4-7 System Settings User Parameters

Param.System Beeper	Enables/disables the beeper sequence on system reset.	Read, write, save	Position Sensor, SCU
Param.Watch Dog Timer	If non-zero, the Position Sensor beeps if no host communication occurs after this amount of time (sec).	Read, write	Position Sensor
Param.Simulated Alerts	Simulates the 'Info.Status.Alerts' parameter, for testing purposes.	Read, write, save (read/write only on strobers)	Position Sensor, SCU, strobers
Param.Host Connection	Communication port being used for this connection	Read	Position Sensor, SCU
Param.Serial Port	Hardware configuration of the serial port.	Read	SCU
Param.Strober Name	User-defined strober name (up to 31 chars).	Read, write (saves on write)	Strobers
Param.System Ext Sync Mode	Enables/disables the external sync mode (see the user guide for details).	Read, write	SCU

Information User Parameters

The following user parameters store status information for the hardware devices indicated in the Hardware Device column, and command timeout values. To access the user parameters for a particular device, prefix the user parameter name with the device name (see "Device Names" on page 21 for details).

Table 4-8 Information User Parameters

User Parameter Name	Description	Access Rules	Hardware Device
Info.Timeout.<command>	Timeout for the specified command (sec). For the SCU, only the following commands have timeout values: APIREV, COMM, DFLT, ECHO, GET, GETINFO, GETIO, GETLOG, INIT, SETIO, SYSLOG, RESET, SAVE, SET,VER.	Read	Position Sensor, SCU
Info.Status.System Mode	System operating mode	Read	Position Sensor
Info.Status.Alerts	System hardware and operating status flags; see "Alerts User Parameters" on page 23 for details.	Read	Position Sensor, SCU, strobers
Info.Status.New Alerts	System hardware and operating status flags; see "Alerts User Parameters" on page 23 for details.	Read	Position Sensor, SCU, strobers
Info.Status.Alerts Overflow	System hardware and operating status flags overflow; see "Alerts User Parameters" on page 23 for details.	Read	Position Sensor, SCU
Info.Status.Bump Detected	Indicates if the system has detected a bump.	Read	Position Sensor
Info.Status.New Log Entry	Indicates a new system log entry has been made; set to 'False' (0) to clear.	Read, write	Position Sensor, SCU

Features User Parameters

The following user parameters store information about the features for the hardware devices indicated in the Hardware Device column. To access the user parameters for a particular device, prefix the user parameter name with the device name (see “Device Names” on page 21 for details).

Table 4-9 Features User Parameters

User Parameter Name	Description	Access Rules	Hardware Device
Features.Keys.Installed Keys.0	'Value' is the name of the installed feature.	Read	Position Sensor, SCU
Features.Keys.Disabled Keys	List of disabled keyed features; change takes effect on next reset. See page 171 for details.	Read, write, save	Position Sensor, SCU
Features.Tools.Enabled Tools	Maximum number of tools that can be enabled simultaneously	Read	Position Sensor
Features.Tools.Active Ports	Maximum number of wired active tools that can be enabled simultaneously	Read	Position Sensor
Features.Tools.Passive Ports	Maximum number of passive tools that can be enabled simultaneously	Read	Position Sensor
Features.Tools.Wireless Ports	Maximum number wireless active tools that can be enabled simultaneously	Read	Position Sensor
Features.Firmware.Version	Current firmware revision number	Read	Position Sensor, SCU, strobers
Features.Firmware. Major Version	Current firmware major revision number	Read	Position Sensor, SCU
Features.Firmware. Minor Version	Current firmware minor revision number	Read	Position Sensor, SCU
Features.Firmware. Build Number	Current firmware build revision number	Read	Position Sensor, SCU
Features.Firmware.Available Versions	List of firmware revisions loaded in the device	Read	Position Sensor, SCU
Features.Firmware. Maximum Versions	Number of firmware revisions that may be stored in the device simultaneously	Read	Position Sensor, SCU
Features.Firmware. Configuration Check	System configuration checksum (for NDI use only)	Read	Position Sensor, SCU
Features.Firmware.Package Number	Current firmware package number	Read	Position Sensor, SCU
Features.Hardware. Serial Number	Hardware device serial number	Read	Position Sensor, SCU, strobers
Features.Hardware. OEM Number	Hardware device customer number	Read	Position Sensor, SCU, strobers
Features.Hardware.Model	Hardware device model name	Read	Position Sensor, SCU, strobers

Table 4-9 Features User Parameters (Continued)

Features.Firmware. Safeloader Version	Current safeloader firmware revision number.	Read	Position Sensor, SCU
Features.Firmware. Available Combined Firmware Revisions	List of combined firmware revisions loaded in the device.	Read	Position Sensor, SCU
Features.Firmware. Combined Firmware Revision	Current combined firmware revision of the device.	Read	Position Sensor, SCU

System Configuration User Parameters

The following user parameters store information about the configuration of the system. These user parameters describe the configuration of the entire system, not a particular device. Do not prefix these user parameters with a device name.

Table 4-10 System Configuration User Parameters

User Parameter Name	Description	Access Rules
Config.Multi Firmware. Load Combined Firmware Revision	Combined firmware revision to load on next reset (selection automatically saves when set). Use this parameter when the Multi Firmware keyed feature is enabled. See "Multi Firmware Feature" on page 172 for details.	Read, write
Config.Multi Firmware. Update Combined Firmware Revision	Combined firmware revision to replace on next upgrade or downgrade. Use this parameter when the Multi Firmware keyed feature is enabled. See "Multi Firmware Feature" on page 172 for details.	Read, write, save
Config.Password	Enter the password to enable the ability to change and save the system configuration. Use this parameter when the Password Protect keyed feature is enabled. See "Password Protect Feature" on page 174 for details.	Read, write
Config.Multi Firmware. Available Combined Firmware Revisions	List of combined firmware revisions loaded in the system.	Read
Config.Combined Firmware Revision	Current combined firmware revision of the system.	Read

Hardware Device Information User Parameters

The following user parameters store information about the hardware devices in the system. Do not prefix these user parameters with a device name. See “Device Names” on page 21 for information on how to use the hardware device user parameters.

Table 4-11 Hardware Device User Parameters

User Parameter Name	Description	Access Rules
Device.Type.0	Type of device in the system configuration	Read
Device.Instance.0	Instance of this type of device in the system configuration	Read

5 Commands

Before sending any commands to the system, read the user guide that accompanied your system to ensure that you have a full understanding of the system functionality. The user guide is available on the NDI Support Site at http://support.ndigital.com.

Resetting the System with a Serial Break

Resets the system.

Operating Mode

All modes

Compatibility

All systems

Syntax

The method depends on the host computer.

Reply

```
RESET<CRC16><CR>
```

Usage Notes

1. The serial break is a special condition, and is specific to the host computer operating system. Refer to your computer manuals to determine how to generate a serial break.
2. The serial break is a good recovery method in the following situations:
   - System warm boot: the system is powered up, but you don't know the communication setup, or which mode the system is in.
   - Synchronization error: while in the Tracking mode, the BX or TX reply status returns that synchronization errors have occurred.
   - Loss of communication: the host computer and the system can no longer communicate.
3. After a serial break:
   - All processors receive a soft reset. Use RESET 1 to perform a hard reset.
   - The system serial communication settings return to the default values: 9600 baud, 8 data bits, no parity, 1 stop bit, and no hardware handshaking.
   - Upon initialization, the SCU emits one beep, and the Position Sensor emits a distinctive 2-beep sequence. To disable the beep, use the command SET (page 125) to set the value of the user parameter **Param.System Beeper** to "0", then use the command SAVE (page 122). For more information on user parameters, see "User Parameters" on page 20.

Compatibility Notes

1. A serial break will reset the system if it is physically connected to the host computer. For systems that use a wireless connection, use RESET (page 120) to reset the system.
2. After a serial break, all processors receive a soft reset. Use RESET 1 to perform a hard reset.
3. If only an SCU is present, the reply string will be SCUONLYC3E3.

Example

Command:

N/A

Reply:

```
RESETBE6F
```

3D

Returns the latest three-dimensional marker position of a single marker or multiple markers.

Operating Mode

Diagnostic, Tracking)

Compatibility

All systems

Prerequisite Command

IRED (page 81), only for active markers in Diagnostic mode

Syntax

```
3D<SPACE><Port Handle><Reply Option><CR>
```

Parameter	Description	
Port Handle	2 hexadecimal characters. Specifies for which type of marker the system will report data (see "Usage Notes" on page 43 for details). The specified port handle must be initialized (PINIT) and enabled (PENA).	
Reply Option	Specifies which information will be returned. The reply options cannot be OR'd. **Valid Values:**	
	1	Single marker 3D data, with error value
	2	Single marker 3D data, with error value and out-of-volume information
	3	Single marker 3D data, with line separation value
	4	Single marker 3D data, with line separation value and out-of-volume information
	5	3D data for up to 50 markers, with line separation and out-of-volume information

Replies

Upon Success:

```
<Number of Visible Markers><LF>
<Reply Option n Data><CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Reply Component	Description
Number of Visible Markers	3 characters (a sign and 2 decimal digits) The number of markers detected by the system. For reply options 1 to 4, only one marker can be in view. If more than one marker is in view, the system will return 00 for the number of markers.
Reply Option n Data	The data specific to the requested reply option. See the reply option information below for details: Reply option 1 (3D data for a single marker, with error value) Reply option 2 (3D data for a single marker, with error value and out-of-volume information) Reply option 3 (3D data for a single marker, with line separation value) Reply option 4 (3D data for a single marker, with line separation value and out-of-volume information) Reply option 5 (3D data for up to 50 markers, with line separation and out-of-volume information)

Reply Option 1 - 3D data for a single marker, with error value

```
<Reply Option 1 Data> = <Tx><Ty><Tz><Error Value>
```

Reply Component	Description
Tx, Ty, Tz	9 characters each (a sign, and 8 decimal digits with an implied decimal in the position XXXX . XXXX) Position of the marker, in the coordinate system of the Position Sensor.
Error Value	4 characters (a sign, and 3 decimal digits with an implied decimal in the position X . XX) The normalized error number associated with the calculation for this marker position. Note: The Polaris Vicra and Polaris Spectra Systems will not calculate an error, and will return +000 instead. **Possible Values:** +000 (best case) to +100 (worst case)

Reply Option 2 - 3D data for a single marker, with error value and out-of-volume information

`<Reply Option 2 Data> = <Tx><Ty><Tz><Error Value><Out of Volume>`

Reply Component	Description	
`Tx, Ty, Tz`	9 characters each (a sign, and 8 decimal digits with an implied decimal in the position XXXX . XXXX) Position of the marker, in the coordinate system of the Position Sensor.	
`Error Value`	4 characters (a sign, and 3 decimal digits with an implied decimal in the position X . XX) The normalized error number associated with the calculation for this marker position. Note: The Polaris Vicra and Polaris Spectra Systems will not calculate an error, and will return +000 instead. **Possible Values:** +000 (best case) to +100 (worst case)	
`Out of Volume`	1 hexadecimal character Indicates whether the marker is outside the characterized measurement volume. **Possible Values:**	
	0	The marker is inside the characterized measurement volume.
	1	The marker is out of volume.

Reply Option 3 - 3D data for a single marker, with line separation value

`<Reply Option 3 Data> = <Tx><Ty><Tz><Line Separation>`

Reply Component	Description
`Tx, Ty, Tz`	9 characters each (a sign, and 8 decimal digits with an implied decimal in the position XXXX . XXXX) Position of the marker, in the coordinate system of the Position Sensor.
`Line Separation`	4 characters (a sign, and 3 decimal digits with an implied decimal in the position X . XX) The minimum distance (in mm) between the two lines of sight calculated from the marker image on the left and right sensor to the IR source. **Possible Values:** +000 (best case) to +999 (worst case)

Reply Option 4 - 3D data for a single marker, with line separation value and out-of-volume information

<Reply Option 4 Data> = <T_x><T_y><T_z><Line Separation><Out of Volume>

Reply Component	Description	
Tx, Ty, Tz	9 characters each (a sign, and 8 decimal digits with an implied decimal in the position XXXX . XXXX) Position of the marker, in the coordinate system of the Position Sensor.	
Line Separation	4 characters (a sign, and 3 decimal digits with an implied decimal in the position X . XX) The minimum distance (in mm) between the two lines of sight calculated from the marker image on the left and right sensor to the IR source. **Possible Values:** +000 (best case) to +999 (worst case)	
Out of Volume	1 hexadecimal character Indicates whether the marker is outside the characterized measurement volume. **Possible Values:**	
	0	The marker is inside the characterized measurement volume.
	1	The marker is out of volume.

Reply Option 5 - 3D data for up to 50 markers, with line separation value and out-of-volume information

<Reply Option 5 Data> =
<T_{x1}><T_{y1}><T_{z1}><Line Separation 1><Out of Volume 1><LF>
...
<T_{x50}><T_{y50}><T_{z50}><Line Separation 50><Out of Volume 50><LF>

Reply Component	Description
Txn, Tyn, Tzn	9 characters each (a sign, and 8 decimal digits with an implied decimal in the position XXXX . XXXX) Position of the n^{th} marker, in the coordinate system of the Position Sensor. The system will report up to 50 3D positions, including phantom markers. If the system detects more than 50 IR sources, it will only report the first 50. The IR sources are not reported in any particular order.
Line Separation n	4 characters (a sign, and 3 decimal digits with an implied decimal in the position X . XX) Line separation of the n^{th} marker. The minimum distance (in mm) between the two lines of sight calculated from the marker image on the left and right sensor to the IR source. **Possible Values:** +000 (best case) to +999 (worst case)

Reply Component	Description	
`Out of Volume n`	1 hexadecimal character Indicates whether the n^{th} marker is outside the characterized measurement volume. **Possible Values:**	
	0	The marker is inside the characterized measurement volume.
	1	The marker is out of volume.

Usage Notes

1. The specified port handle must be initialized using PINIT (page 104) and enabled using PENA (page 86).
2. You may need to use the 3D command about ten times if it is sent immediately after using IRED (page 81). This allows time for the system to implement the activation signature and optimize the signal by adjusting the range control.
3. **Reply Options 1 to 4**: You cannot have more than one marker in view. Any other IR sources in view will prevent the system from returning marker data.
4. **Reply Option 5**: The system does not distinguish between real markers, phantom markers, or other IR sources. You must determine whether the reported marker positions are valid. See the user guide for more information on phantom markers.
5. The 3D command returns data regardless of the bump status, temperature status, and other system status conditions. Before trusting the marker positions returned by the 3D command, you should check these conditions by reading the **Info.Status.Alerts** user parameter. (Use the GET (page 66) command to check the value of user parameters.) You can use the BX (page 47) or TX (page 146) command to request 3D data that is filtered when the bump status, temperature status, or other system conditions are not ideal.

Compatibility Notes

Reply Option 1 and **Reply Option 2**: The system will not calculate an error, and will return an error value of +000.

Example

Command:

```
3D 011
```

Reply:

```
+01-12345678+12345678-12345678+0954B7B
```

In this case, one marker is in view.

APIREV

Returns the API revision number that functions with your system.

Operating Mode

All modes

Compatibility

All systems

Syntax

APIREV<SPACE><CR>

Replies

Upon Success:

<Family>.<Major revision number>.<Minor revision number><CRC16><CR>

On Error:

ERROR<Error Code><CRC16><CR>

See page 167 for error code definitions.

Reply Component	Description
Family	1 ASCII character. This character is always G.. (Other types of NDI measurement systems use other characters.)
Major revision number	3 ASCII characters The major revision number is incremented whenever there is an incompatible change in the API. (Whenever a command is deprecated or when its response is changed in a way that may break an application.)
Minor revision number	3 ASCII characters The minor number is incremented whenever there is an addition to the API that is compatible with all existing applications and usage. (Compatible changes are additions to the API command or option set that will not affect any existing applications.)

Compatibility Notes

The APIREV command is compatible with the Polaris Vicra System and the Polaris Spectra System.

Example

Command:

APIREV

Reply:

G.001.004A0C0

BEEP

Sounds the system beeper.

Operating Mode

All modes

Compatibility

All systems

Syntax

`BEEP<SPACE><Number of Beeps><CR>`

Parameter	Description
`Number of Beeps`	**Valid Values:** 1 to 9

Replies

Upon Success:

`<Beep Status><CRC16><CR>`

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Reply Component	Description		G.001.002	G.001.003	G.001.004	G.001.005
`Beep Status`	**Possible Values:**					
	0	The system is busy beeping.				
	1	Beeping has started.	X	X	X	X

Usage Notes

1. The beep duration is shorter than the beep used for reset and fatal error conditions.
2. Disabling the system beeper (by setting the value of the user parameter **Param.System Beeper**) does not affect the BEEP command.

Compatibility Notes

The system will never return a beep status of 0. If you send the BEEP command while the system is busy beeping, the system will return a beep status of 1, but will not initiate the second sequence of beeps.

Example

Command:

```
BEEP 1
```

Reply:

```
1D4C1
```

BX

Returns the latest tool transformations, individual marker positions, and system status in binary format.

Operating Mode

Tracking

Compatibility

All systems

Syntax

```
BX<SPACE><Reply Option><CR>
```

Parameter	Description		G.001.002	G.001.003	G.001.004	G.001.005
Reply Option	Optional. Specifies which information will be returned. If no reply option is specified, the system returns information for reply option 0001. The reply options are hexadecimal numbers that can be OR'd. If multiple reply options are used, the replies are returned for each port handle in order of increasing option value, with the following exceptions: Reply option 0800 is not reported separately from the other options; it simply enables the system to return certain information in the other options. Reply option 1000 is reported after all handle-specific options but before the <system status> and <CRC16>. **Valid Values:**					
	0001	Transformation data (default)	X	X	X	X
	0002	Tool and marker information	X	X	X	X
	0004	3D position of a single stray active marker			X	X
	0008	3D positions of markers on tools	X	X	X	X
	0800	Transformations not normally reported	X	X	X	X
	1000	3D positions of stray passive markers	X	X	X	X

Replies

Upon Success:

```
<Start Sequence><Reply Length><Header CRC><01(Number of Handles)>
<Handle 1><Handle 1 Status><Reply Opt 0001 Data>...<Reply Opt 0008 Data>
...
<Handle n><Handle n Status><Reply Opt 0001 Data>...<Reply Opt 0008 Data>
<Reply Option 1000 Data>
<System Status><CRC16>
```

Note **The reply for the BX command is binary data.**

Note **If a handle status is "disabled," the system will not return any of <Reply Option 0001 Data>... <Reply Option 0008> for that port handle.**

On Error:

ERROR<Error Code><CRC16><CR>

See page 167 for error code definitions.

Reply Component	Description		G.001.002	G.001.003	G.001.004	G.001.005
Start Sequence	2 bytes: A5C4 Indicates the start of the BX reply.		X	X	X	X
Reply Length	2 bytes Indicates the number of bytes in the reply body between the <Header CRC> and the <CRC16>, exclusive.		X	X	X	X
Header CRC	2 bytes CRC16 of <Start Sequence> and <Reply Length>		X	X	X	X
Number of Handles	1 byte The number of port handles for which information is returned.		X	X	X	X
Handle n	1 byte The port handle whose information follows.		X	X	X	X
Handle Status	1 byte **Possible Values:**					
	01	Valid	X	X	X	X
	02	Missing	X	X	X	X
	04	Disabled	X	X	X	X

Reply Component	Description		G.001.002	G.001.003	G.001.004	G.001.005
Reply Option m Data	The data specific to the requested reply option. See the reply option information below for details:					
	Reply option 0001 (transformation data) (default)		X	X	X	X
	Reply option 0002 (tool and marker information)		X	X	X	X
	Reply option 0004 (latest 3D position of single, stray, active marker)				X	X
	Reply option 0008 (3D position of markers on tools)		X	X	X	X
	Reply option 0800 (reporting all transformations)		X	X	X	X
	Reply option 1000 (3D position of stray passive markers)		X	X	X	X
System Status	2 bytes The status of the system. **Bit field:**					
	bit 0	System communication synchronization error	X	X	X	X
	bits 1 and 2	Reserved				
	bit 3	Recoverable system processing exception.	X	X	X	X
	bits 4 and 5	Reserved				
	bit 6	Some port handle has become occupied			X	X
	bit 7	Some port handle has become unoccupied			X	X
	bit 8	Diagnostic pending	X	X	X	X
	bit 9	Temperature (system is not within operating temperature range)	X	X	X	X
	bits 10 to 15	Reserved				

Note **The “diagnostic pending” bit is set whenever an alert is detected or cleared. To view the alerts status and clear the diagnositc pending bit, use GET (page 66) to check the Info.Status.New Alerts user parameter for every hardware device in the system. See “Usage Notes” on page 56 for more details. (For API revision G.001.003 and earlier, the diagnositc pending bit did not indicate when an alert was cleared.)**

Reply Option 0001 - Transformation Data

<Reply Option 0001 Data> = <Q_0><Q_x><Q_y><Q_z><T_x><T_y><T_z><Error><Port Status>
<Frame Number>
or
<Reply Option 0001 Data> = <Port Status><Frame Number>

Reply Component	Description	G.001.002	G.001.003	G.001.004	G.001.005
Q0, Qx, Qy, Qz	4 bytes each Rotational components of the transformation, quaternion, unitless, reported as IEEE 32-bit, single precision, floating point numbers. The value for Q0 is always non-negative.	X	X	X	X
Tx, Ty, Tz	4 bytes each Translational components of the transformation, in mm, reported as IEEE 32-bit, single precision, floating point numbers.	X	X	X	X
Error	4 bytes The error is an RMS value, given in mm. It is the result of the least squares minimization between the marker geometry in the tool definition file and the data from the tool's markers measured by the system. Reported as IEEE 32-bit, single precision, floating point number.	X	X	X	X

Reply Component	Description		G.001.002	G.001.003	G.001.004	G.001.005
Port Status	4 bytes **Bit field:**					
	bit 0	Occupied	X	X	X	X
	bit 1	Switch 1 closed/GPIO line 1 active			X	X
	bit 2	Switch 2 closed/GPIO line 2 active			X	X
	bit 3	Switch 3 closed/GPIO line 3 active			X	X
	bits 4	Initialized	X	X	X	X
	bit 5	Enabled	X	X	X	X
	bit 6	Out of volume	X	X	X	X
	bit 7	Partially out of volume	X	X	X	X
	bit 8	Algorithm limitation (processing requires more buffer than is available)	X	X	X	X
	bit 9	IR interference (a large bright IR object)	X	X	X	X
	bits 10 and 11	Reserved				
	bit 12	Processing exception (same as tool information bit 7 in reply option 0002)	X	X	X	X
	bit 13	Reserved				
	bit 14	Fell behind while processing (same as tool information bit 3 in reply option 0002)	X	X	X	X
	bit 15	Data buffer limitation (too much data; for example, too many markers)	X	X	X	X
	bits 16 to 31	Reserved				
Frame Number	4 byte unsigned number The frame number is an internal counter related to data acquisition. The counter starts at power up and does not reset until the system is reset (either with RESET or a serial break), the system is powered up again, or reply option 80 is sent with the TSTART command. The frame rate is 60 Hz. The frame number corresponds to the frame in which the raw data, used to calculate the accompanying transformation, was collected.		X	X	X	X

Note **If the handle status is "missing," the system returns only the port status and the frame number.**
- Tools are reported as missing if a transformation cannot be determined.
- GPIO devices and strober port handles that are initialized and enabled are reported as missing.
- In the event of a system error that prevents tracking, all tools and GPIO devices are reported as missing.

Reply Option 0002 - Tool and Marker Information

`<Reply Option 0002 Data> = <Tool Information><Marker Information>`

Reply Component	Description		G.001.002	G.001.003	G.001.004	G.001.005
`Tool Information`	1 byte **Bit field:**					
	bit 0	Bad transformation fit	X	X	X	X
	bit 1	Not enough acceptable markers for transformation	X	X	X	X
	bit 2	IR interference—environmental IR is interfering with the system (combination of port status bits 9 and 15 in reply option 0001)	X	X	X	X
	bit 3	Fell behind while processing (same as port status bit 14 in reply option 0001)	X	X	X	X
	bits 4 to 6	Tool face used	X	X	X	X
	bit 7	Processing exception (same as port status bit 12 in reply option 0001)	X	X	X	X
`Marker Information`	10 bytes (4 bits per marker) See below for an example. **Possible Values:**					
	0000	Not used because it was missing	X	X	X	X
	0001	Not used because it exceeded the maximum marker angle	X	X	X	X
	0010	Not used because it exceeded the maximum 3D error for the tool	X	X	X	X
	0011	Used to calculate the transformation	X	X	X	X
	0100	Used to calculate the transformation, but it is out of volume	X	X	X	X
	0101	Not used because it was outside the characterized measurement volume and was not needed to calculate a transformation.	X	X	X	X

Example - Marker Information: A tool with markers located at T, R, C, and A, where all four markers were used to determine the calculation, would have the following reply:

Marker	T	S	R	Q	...	D	C	B	A
Reply	0011	0000	0011	0000	...	0000	0011	0000	0011

Reply Option 0004 - 3D Position of Single Stray Active Marker

`<Reply Option 0004 Data> = <Status><T`$_x$`><T`$_y$`><T`$_z$`>`

or

```
<Reply Option 0004 Data> = <Status>
```

Reply Component	Description		G.001.002	G.001.003	G.001.004	G.001.005
Status	1 byte The status of the stray active marker. A stray marker on an active tool is not fixed with respect to the other markers that make up the tool. **Bit field:**					
	bit 0	Valid stray active marker			X	X
	bit 1	Marker is missing			X	X
	bit 2	Reserved				
	bit 3	Marker is out of volume			X	X
	bits 4 to 7	Reserved				
Tx, Ty, Tz	4 bytes each Position of the marker in the coordinate system of the Position Sensor, reported as IEEE 32-bit, single precision, floating point numbers. The marker position is reported only if the marker status is "valid," or "out of volume" and reply option 0800 is used.				X	X

Note **If no stray active marker is defined (for example, for wireless port handles, GPIO devices, strobers, or wired tools with no stray marker defined in the tool definition file), the status is 00, and no position information is returned. If the marker is missing, or if the marker is out of volume and reply option 0800 is not used, the system returns only the status.**

Reply Option 0008 - 3D Position of Markers On Tools

<Reply Option 0008 Data> = <Number of Markers><Out of Volume><T_{xn}><T_{yn}><T_{zn}>

Reply Component	Description	G.001.002	G.001.003	G.001.004	G.001.005
Number of Markers	1 byte Number of markers used in tool transformations.	X	X	X	X
Out of Volume	1 byte/8 markers (1 bit per marker) The bit is set when the marker is outside the characterized measurement volume (see example below). Reply size = (number of markers)/8, rounded up to the nearest integer.	X	X	X	X
Txn, Tyn, and Tzn	4 bytes each Position of the n^{th} marker, reported in the coordinate system of the Position Sensor, reported as IEEE 32-bit, single precision, floating point numbers. The system will report the positions of markers used in tool transformations, as well as markers that exceeded the maximum marker angle or maximum 3D error specified in the tool definition file. See "Usage Notes" on page 56 for more information.	X	X	X	X

Example - Out of Volume The information is returned in the format illustrated in the following example: one bit per marker, in little endian format. In this example there are nine markers, all of which are out of volume:

Marker Number								9	8	7	6	5	4	3	2	1
Bit Field	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
Reply	0				1				F				F			
Reply Byte	n								n + 1							

Reply Option 0800 - Reporting All Transformations

This option enables the reporting of transformations or translations in situations where translations or transformations are calculated, but by default are not reported by the system. Such situations include:

- The tool or marker is outside of the characterized measurement volume.
- The bump sensor has been tripped.
- The system is outside of the optimal operating temperature range.

- Other system conditions are not ideal; see "Alerts User Parameters" on page 23 for a full list of these conditions.

This reply option must be OR'd with reply option 0001 to obtain transformations for tools in the situations listed above. It must be OR'd with reply options 0004, 0008, or 1000 to obtain position information for markers in the situations listed above.

When using reply option 0800 with the BX command, you must take appropriate action to detect the events listed above, and determine whether they are detrimental to your application. If one or more of the events listed above occurs, reply option 0800 enables the system to return data that may lead to inaccurate conclusions and may cause personal injury.

Appropriate action to detect the events listed above includes:

- reading the out-of-volume flag in reply options 0001 and 0002 when tracking tools
- reading the out-of-volume information in reply options 0004, 0008, and 1000 when tracking stray markers
- reading the temperature flag in the system status
- reading the diagnostic pending bit in the system status
- reading the **Info.Status.New Alerts** user parameter for every hardware device in the system when the diagnostic pending bit is set. See "Usage Notes" on page 56 for details.

Reply Option 1000 - 3D Position of Stray Passive Markers

`<Reply Option 1000 Data> = <Number of Markers><Out of Volume><`T_{xn}`><`T_{yn}`><`T_{zn}`>`

Reply Component	Description	G.001.002	G.001.003	G.001.004	G.001.005
`Number of Markers`	1 byte Number of stray markers.	X	X	X	X
`Out of Volume`	1 byte/8 markers (1 bit per marker) The bit is set when the marker is outside the characterized measurement volume (see example below). Reply size = (number of markers)/8, rounded up to the nearest integer.	X	X	X	X
`Txn, Tyn, Tzn`	4 bytes each Position of the n^{th} marker in the coordinate system of the Position Sensor, reported as IEEE 32-bit, single precision, floating point numbers.	X	X	X	X

Note **At least one passive port handle must be enabled, to activate the illuminators on the Position Sensor. If no passive port handles are enabled, <Number of Markers> will return 00 and no other data will be returned.**

Stray passive markers are defined as markers which are not used to calculate any of the transformations for any enabled, passive tools. Stray active wireless tool markers are not reported.

Example - Out of Volume The information is returned in the format illustrated in the following example: one bit per marker, in little endian format. In this example there are nine markers, all of which are out of volume:

Marker Number								9	8	7	6	5	4	3	2	1
Bit Field	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
Reply	0				1				F				F			
Reply Byte	n								n + 1							

Usage Notes

1. The BX reply format requires fewer characters than the text format; this allows transformations to be reported more quickly. For replies in text format, use TX (page 146).
2. To use the BX command, the data bits parameter must be set to 0 (8 bits) using COMM (page 58).
3. Replies are returned in little endian format.
4. By default, transformations will not be reported if the tool is either partially or wholly out of the characterized measurement volume, if the bump sensor has been tripped, if the system is outside of the optimal operating temperature range, or if certain other alerts have occurred (see "Alerts User Parameters" on page 23 for details). To report these transformations, you must use reply option 0800 OR'd with the desired reply option(s). The accuracy of these transformations is unknown.
5. **Reply Option 0001**:
   - When the "diagnostic pending" bit is set in the system status, use GET (page 66) to read the **Info.Status.New Alerts** user parameter for every hardware device in the system. The act of reading these parameters clears the parameters and the "diagnostic pending" bit. For more information on alerts and their associated user parameters, see "Alerts User Parameters" on page 23.
   - For wired tools, bits 1, 2, and 3 in the port status report switch status. For GPIO devices, these bits report the status of GPIO lines defined as inputs.
6. **Reply Option 0008**: Markers are returned in alphabetical according to how they are labelled in the tool definition file. For example, for a tool with markers labelled A, G, M and S, the system will return the marker positions in the order A G M S. Reply option 0008 only returns data for markers that the system detects. To identify which marker is which, compare the reply option 0008 data to the data returned with reply option 0002. The marker order is the same for both replies; each marker that does not have a <marker information> status of 0000 ("missing") in reply option 0002 corresponds to a marker in reply option 0008.

Compatibility Notes

1. **System Status**:
   - The external IR bit (bit 1) and system CRC error bit (bit 2) are not used by the system.
   - In API revision G.001.004 and later, the diagnostic pending bit (bit 8) is set whenever an alert is detected or cleared. In API revision G.001.003 and earlier, the diagnostic pending bit is set only when an alert is detected.
2. **Reply Option 0002**:
   - Reply 0010 means that the marker was not used because it exceeded the maximum 3D error for the tool.

Example

Command:

```
BX 0801
```

Reply:

```
A5C4005723130201013F3AF3CABE5B7209BF1C07713E635592C39E831F43332973C500511
33DA5BD9F00000031000002CC02013EA1B5D03D137D21BD787C673F72394A4286B6CB4360
6EF4C50468C13ED4E74100000031000002CD000059C9
```

This is the hexadecimal representation of the binary data being returned. This example returns data for two tools.

COMM

Sets the serial communication settings for the system.

Operating Mode

All modes

Compatibility

All systems

Syntax

```
COMM<SPACE><Baud Rate><Data Bits><Parity><Stop Bits><Hardware
Handshaking><CR>
```

Parameter	Description		G.001.002	G.001.003	G.001.004	G.001.005
Baud Rate	The data transmission rate between the system and the host computer, in bits per second. The default baud rate is 9600 bps. **Valid Values:**					
	0	9600 bps	X	X	X	X
	1	14 400 bps	X	X	X	X
	2	19 200 bps	X	X	X	X
	3	38 400 bps	X	X	X	X
	4	57 600 bps	X	X	X	X
	5	115 200 bps	X	X	X	X
	6	921 600 bps	X	X	X	X
	7	1 228 739 bps	X	X	X	X
Data Bits	The data bits must be set to 8 bits in order to use any command that returns binary data (BX, GETLOG, or VGET). The default is 8 data bits. **Valid Values:**					
	0	8 bits	X	X	X	X
	1	7 bits	X	X	X	X
Parity	The default is no parity. **Valid Values:**					
	0	None	X	X	X	X
	1	Odd	X	X	X	X
	2	Even	X	X	X	X

Parameter	Description		G.001.002	G.001.003	G.001.004	G.001.005
Stop Bits	The default is one stop bit. **Valid Values:**					
	0	1 bit	X	X	X	X
	1	2 bits	X	X	X	X
Hardware Handshaking	The default is no hardware handshaking. **Valid Values:**					
	0	Off	X	X	X	X
	1	On	X	X	X	X

Replies

Upon Success:

OKAY<CRC16><CR>

On Error:

ERROR<Error Code><CRC16><CR>

See page 167 for error code definitions.

Usage Notes

1. The system serial communication parameters have a default setting of 00000 (i.e. 9600 baud, 8 data bits, no parity, 1 stop bit, hardware handshaking off).
2. To use any command that returns binary data (BX, GETLOG, or VGET), you must set the data bits to 0 (8 bits).
3. If you change the baud rate using the COMM command, you must also change your host computer baud rate; otherwise, a system reset or other unexpected communication behaviour will occur. The host application should wait approximately 100 ms after receiving the OKAY reply from the system before changing its own communication parameters.
4. NDI strongly recommends using hardware handshaking when using the higher baud rates.
5. Most Windows applications do not allow you to choose 1.2 Mbaud. To allow you to communicate at this speed, NDI has aliased 19 200 baud to 1.2 Mbaud when using a USB connection. Thus, to communicate at 1.2 MB:
   a) Connect the system using a USB connection (this is the only option for passive systems).
   b) Set the system to 1.2 Mbaud (<baud rate> parameter value 7).
   c) Set the application on the host computer to 19 200 baud. The virtual COM driver maps the communications speed to 1.2 Mbaud, so the application will actually communicate with the system at 1.2 Mbaud.

Do not set the System to 19 200 baud when using a USB connection; if the system is set to 19 200 baud, it will be unable to communicate with the host computer, because setting the host application to 19 200 baud will result in the aliased rate of 1.2 Mbaud.

Example

Command:

```
COMM 30001
```

Reply:

```
OKAYA896
```

This changes the serial communication parameters to 38400 baud, 8 data bits, no parity, 1 stop bit, hardware handshaking on.

DFLT

Restores the user parameters to factory default values.

Operating Mode

All modes

Compatibility

All systems

Syntax

```
DFLT<SPACE><User Parameter Name><CR>
```

Parameter	Description
`User Parameter Name`	A string, identifying the name of the user parameter. May include a trailing wild card character (*) Use **DLFT *** to restore all user parameters to default values. User parameter names are case-sensitive.

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

1. The user parameter name may include a trailing wild card character (*).
2. Use **DFLT *** to return all user parameters to their default values.
3. The user parameter values set using the DFLT command persist until the system is reset or initialized. To save the user parameters at their factory default values, use SAVE (page 122) after using the DFLT command.
4. To view a list of user parameters and their current values, use **GET ***.
5. User parameter names are case-sensitive.
6. For more information on user parameters, see “User Parameters” on page 20.

Example

Command:

```
DFLT *
```

Reply:

```
OKAYA896
```

DSTART

Starts Diagnostic mode.

Operating Mode

Setup

Compatibility

All systems

Prerequisite Command

INIT (page 78)

Syntax

```
DSTART<SPACE><Reply Option><CR>
```

Parameter	Description
`Reply Option`	80 (Optional, resets the frame counter to zero)

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

If the reply option 80 is not used, only resetting the system resets the counter for the frame number. The frame number is reported in reply option 0001 of the TX (page 146) and BX (page 47) commands.

Example

Command:

```
DSTART
```

Reply:

```
OKAYA896
```

DSTOP

Stops Diagnostic mode.

Operating Mode

Diagnostic

Compatibility

All systems

Prerequisite Command

DSTART (page 63)

Syntax

`DSTOP<SPACE><CR>`

Replies

Upon Success:

`OKAY<CRC16><CR>`

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Example

Command:

`DSTOP`

Reply:

`OKAYA896`

ECHO

Returns exactly what is sent with the command.

Operating Mode

All modes

Compatibility

All systems

Syntax

```
ECHO<SPACE><Any ASCII characters><CR>
```

Replies

Upon Success:

Exactly what is sent with the command, with `<CRC16><CR>`.

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Compatibility Notes

The ECHO command can handle a maximum of 1037 characters. Exceeding this number will cause the system to return error 02.

Example

Command:

```
ECHO Testing!
```

Reply:

```
Testing!A81C
```

GET

Returns the user parameter values.

Operating Mode

All modes

Compatibility

All systems

Syntax

`GET<SPACE><User Parameter Name><CR>`

Parameter	Description
`User Parameter Name`	A string, identifying the name of the user parameter. May include a trailing wild card character (*). Use **GET *** to return all user parameter values. User parameter names are case-sensitive.

Replies

Upon Success:

`<User Parameter Name>=<value><LF> (repeated for each user parameter name, but no line feed after the last parameter)`
`<CRC16><CR>`

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Reply Component	Description
`User Parameter Name`	Variable size Full name of the user parameter
`Value`	Value of the user parameter

Usage Notes

1. The user parameter name may include a trailing wild card character (*).
2. Use **GET *** to return the names and values of all user parameters.
3. Numeric user parameter values are returned as decimal strings.
4. User parameter names are case-sensitive.

5. For descriptive information about each user parameter, including type, attributes, and possible values, use the GETINFO command.
6. For more information on user parameters, see "User Parameters" on page 20.

Compatibility Notes

Accessing parameters by prefixing them with a device name (e.g. **GET PS-0.***) is not supported by API revision G.001.002 or earlier.

Example

Command:

```
GET PS-0.Info.Status.New Alerts
```

Reply:

```
PS-0.Info.Status.New Alerts=06E75
```

GETINFO

Returns descriptive information about the user parameters.

Operating Mode

All modes

Compatibility

All systems

Syntax

`GETINFO<SPACE><User Parameter Name><CR>`

Parameter	Description
`User Parameter Name`	A string, identifying the name of the user parameter. May include a trailing wild card character (*). Use **GETINFO *** to return information for all user parameters. Use **GETINFO +** to return top-level user parameter categories. Use **GETINFO <category>.+** to return the next level of categories under the specified category. See the examples on page 70. User parameter names are case-sensitive.

Replies

Upon Success:

`<User Parameter Name>=<Value>;<Type>;<Attribute>;<Minimum>;<Maximum>;<Enumeration>;<Description><LF> (repeated for each user parameter, but no line feed after last parameter)`
`<CRC16><CR>`

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Reply Component	Description
`User Parameter Name`	Variable size Full name of the user parameter
`Value`	Variable size Value of the user parameter

Reply Component	Description	
`Type`	1 hexadecimal character Describes the data type. **Possible Values:**	
	0	Boolean
	1	Integer
	2	Float
	3	String
	4	Category
`Attribute`	1 to 4 hexadecimal characters Describes the access rules. **Bit field:**	
	bit 0	Read
	bit 1	Write
	bit 2	Save
	bit 3	Volatile
	bit 4	Keyed (cannot be changed unless key is supplied)
	bit 5	Enabled keyed parameter
	bits 6 to 15	Reserved (may not all be set to 0)
`Minimum`	Minimum allowed value of the user parameter. For a string, the minimum number of characters allowed. If minimum = maximum = 0, no range check is performed.	
`Maximum`	Maximum allowed value of the user parameter. For a string, the maximum number of characters allowed. If minimum = maximum = 0, no range check is performed.	
`Enumeration`	Comma-separated enumeration list. This is a list of possible values that the user parameter can take, and corresponds to the values in the `<Value>` field (the first item in the list corresponds to value 0, the second item corresponds to value 1, etc.).	
`Description`	Describes the user parameter's function.	

Usage Notes

1. The user parameter name may include a trailing wild card character (*).
2. Use **GETINFO *** to return information for all user parameters.
3. Use **GETINFO +** to return top-level user parameter categories. Use **GETINFO <category>.+** to return the next level of categories under the specified category. See the examples on page 70.
4. Numeric user parameter values are returned as decimal strings.
5. User parameter names are case-sensitive.
6. For list of user parameters and values without descriptive information, use the GET command.

7. For more information on user parameters, see “User Parameters” on page 20

Compatibility Notes

Accessing parameters by prefixing them with a device name (e.g. **GETINFO PS-0.***) is not supported by API revision G.001.002 or earlier.

Example 1

Command:

```
GETINFO PS-0.Info.Status.Bump Detected
```

Reply:

```
PS-0.Info.Status.Bump Detected=0;1;D;0;1;False,True;Indicates if the
system has detected a bump1865
```

The system returns descriptive information for the specified parameter.

Example 2

Command:

```
GETINFO +
```

Reply:

```
Device=;4;0003;;;;
Config=;4;0003;;;;
PS-0=;4;0003;;;;2D77
```

The system returns the top-level user parameter categories.

Example 3

Command:

```
GETINFO PS-0.+
```

Reply:

```
Features=;4;0003;;;;
Info=;4;0003;;;;
Param=;4;0003;;;;
Cmd=;4;0003;;;;31E6
```

The system returns the next level of user parameter categories for the device PS-0 (the first Position Sensor in the configuration).

Example 4

Command:

```
GETINFO PS-0.Features.+
```

Reply:

```
Hardware=;4;0003;;;;
Firmware=;4;0003;;;;
Tools=;4;0003;;;;
Keys=;4;0003;;;;1DF5
```

The system returns the next level of user parameter categories under the “Features” category for the device PS-0 (the first Position Sensor in the configuration).

GETIO

Returns the current status of the general purpose input/output lines of a synchronization port.

Operating Mode

All modes

Compatibility

hybrid Polaris Spectra System

Prerequisite Command

INIT (page 78)

Syntax

```
GETIO<SPACE><CR>
```

Replies

Upon Success:

```
<Input/Output Line Status><CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Reply Component	Description
<Input/Output Line Status>	4 hexadecimal characters (16 bits) Each bit in the 16-bit flag field represents one possible input/output line. The reply is 1 for a high level and 0 for a low level at the input line (positive logic). Currently, only bit zero of the status field is used. All unused bits will be reported as zero by default.

Usage Notes

Caution! **Before an input/output line on a synchronization port can be used as an input, its output value must be set to a high level with SETIO (page 127). If you set the input to low and use the line as an input, there will be incorrect status readings and you may cause damage to the interface electronics.**

1. The System Control Unit on the hybrid Polaris Spectra System each have one general purpose digital input/output line, on pin 2 of the synchronization port.
2. To set the GPIO line of a synchronization port to either a high or low value, use SETIO (page 127).

Compatibility Notes

The GETIO command is compatible with the hybrid Polaris Spectra System.

Example

Command:

```
GETIO
```

Reply:

```
0001<CRC16>
```

GETLOG

Returns the contents of the Position Sensor or System Control Unit log file.

Operating Mode

All modes

Compatibility

All systems

Syntax

`GETLOG<SPACE><Offset><Length><Logname><CR>`

Parameter	Description	
`Offset`	8 hexadecimal character string Specifies the offset of the data requested within the file.	
`Length`	4 hexadecimal character string Specifies the requested amount of data, in bytes. A maximum of 2048 bytes may be requested at one time.	
`Logname`	String identifying the name of the log. Log names are case-sensitive.	
	API revision	**Name of log file**
	API revision G.001.003 and earlier	sysinfo
	API revision G.001.004 and later	\<Device Name>\sysinfo (See "Device Names" on page 21 for device name details.)

Replies

Upon Success:

`<Header><Length><Header CRC><Data><Data CRC>`

Note **The reply for the GETLOG command is binary data.**

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Reply Component	Description
Header	2 bytes: A5C4 Indicates the start of the GETLOG reply.
Length	2 bytes The number of bytes of data being returned.
Header CRC	2 bytes CRC16 for header.
Data	Up to 2048 bytes of binary data
Data CRC	2 hexadecimal characters CRC16 of the <Data> section.

Usage Notes

1. To use the GETLOG command, the data bits must be set to 0 (8 bits) using COMM (page 58).
2. To read the entire log file:
   a) Start with an offset of 0, and request 2048 bytes of data.
   b) Increment the offset by 2048, and request another 2048 bytes of data.
   c) Repeat step b) until the reply length of the data is less than 2048. This indicates that you have reached the end of the log file.
3. Replies are returned in little endian format.
4. To write to a log, use SYSLOG (page 138).

Compatibility Notes

1. For API revisions G.001.003 and earlier, the log name is **sysinfo**. For API revisions G.001.004 and later, the log name is **\<Device Name>\sysinfo**. If the \<Device Name>\ is omitted, the system will retrieve the log file for hardware device PS-0 (the Position Sensor).
2. For passive systems, only the Position Sensor log file is available.

Example

Command:

```
GETLOG 000000000800\PS-0\sysinfo
```

HCWDOG

Sets up a host communication timeout check.

Operating Mode

Setup

Compatibility

All Systems (deprecated)

Syntax

`HCWDOG<SPACE><Timeout Value><CR>`

Parameter	Description
`Timeout Value`	4 hexadecimal characters The number of seconds that the system waits for a host command. A value of '0000' does not perform a check.

Replies

Upon Success:

`OKAY<CRC16><CR>`

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Usage Notes

1. If a value is set, and no host command is received before the timeout expires, the system will sound two quick beeps every three seconds until a host command is received by the system or the value is set to 0000.
2. This command provides a method to determine if the application has stopped functioning. For example, if a timeout of 10 seconds (000A) has been set and the system does not receive a command from the application within 10 seconds, the system will beep twice every three seconds.

Compatibility Notes

The HCWDOG command has been deprecated for the Polaris Vicra and Polaris Spectra Systems. To set a value for the timeout check for the Polaris Vicra or Polaris Spectra System, use the command SET (page 125) to set the user parameter **Param.Watch Dog Timer**.

Example

Command:

```
HCWDOG 000A
```

Reply:

```
OKAYA896
```

INIT

Initializes the system.

Operating Mode

All modes

Compatibility

All systems

Syntax

`INIT<SPACE><CR>`

Replies

Upon Success:

`OKAY<CRC16><CR>`

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Usage Notes

1. During power up or system reset, the system configuration is determined. The configuration includes firmware revisions and the characterized measurement volumes for which the Position Sensor has been calibrated. The INIT command ensures that the system configuration was determined successfully.
2. The system will automatically return to Setup mode after using the INIT command.
3. The INIT command sets any modified user parameters back to the saved values. To prevent modified values from being reset, send the SAVE command before sending INIT.
4. If ERROR2E or ERROR15 is returned, there may be a system fault that is indicated by the alerts in the **Info.Status. New Alerts** or **Info.Status.Alerts** user parameter on one or more devices. Use GET to read these user parameters. See "Alerts User Parameters" on page 23 for details.

Example

Command:

`INIT`

Reply:

`OKAYA896`

IRATE

Sets the illuminator rate.

Operating Mode

Setup

Compatibility

All Systems (deprecated)

Prerequisite Command

INIT (page 78)

Syntax

```
IRATE<SPACE><Illuminator Rate><CR>
```

Parameter	Description		G.001.002	G.001.003	G.001.004	G.001.005
Illuminator Rate	Sets the number of times per second that the illuminators emit IR.					
	0	20 Hz	*	*	*	*
	1	30 Hz	*	*	*	*
	2	60 Hz	*	*	*	*

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

The circuitry in the NDI active wireless tool kit limits its activation rate to 20 Hz.

Compatibility Notes

1. The IRATE command has been deprecated for the Polaris Vicra and Polaris Spectra Systems. To set the illuminator rate for the Polaris Vicra or Polaris Spectra System, use the command SET (page 125) to set the user parameter **Param.Tracking.Illuminator Rate**.
2. **Polaris Vicra**: The Polaris Vicra System does not support illuminator rates of 30 Hz or 60 Hz.

Example

Command:

```
IRATE 0
```

Reply:

```
OKAYA896
```

IRED

Turns the markers on a wired tool on or off.

Operating Mode

Diagnostic

Compatibility

hybrid Polaris Spectra System

Prerequisite Command

PENA (page 86)

Syntax

```
IRED<SPACE><Port Handle><Marker Activation Signature><CR>
```

Parameter	Description	
`Port Handle`	2 hexadecimal characters	
`Marker Activation Signature`	8 hexadecimal characters (32 bits) One bit for each marker. Set the bits corresponding to the markers you wish to activate. See example in Usage Notes. **Bit field:**	
	bit 0	Marker A
	bit 1	Marker B
	bit 2	Marker C
	...	...
	bit 19	Marker T
	bits 20 to 31	Reserved

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

There are 20 marker positions, labelled “A” to “T.” To specify that a marker should be turned on, set the bit corresponding to that marker to 1. For example, you will need to set the bit field as follows if you wanted to activate markers B, G, M and T:

Marker Location		T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
Bit	31- 20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Bit Value	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0
Activation Signature Parameter Value	0 0 0	8				1				0				4				2			

Compatibility Notes

The IRED command is compatible with the hybrid Polaris Spectra System.

Example

Command:

```
IRED 0A00081042
```

Reply:

```
OKAYA896
```

LED

Changes the state of visible LEDs on a wired tool or GPIO device.

Operating Mode

All modes

Compatibility

hybrid Polaris Spectra System

Prerequisite Command

INIT (page 78)

Syntax

```
LED<SPACE><Port Handle><LED Number><State><CR>
```

Parameter	Description	
`Port Handle`	2 hexadecimal characters	
`LED Number`	Specifies the LED. **Valid values:** 1 to 3	
`State`	Sets the state of the specified LED.	
	B	Blank (not on)
	F	Flash
	S	Solid on

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

1. For a GPIO device:
   - The LED command can only be used on a GPIO line that is defined as output, or output with feedback, in the tool definition file.
   - The LED command can only be used to set GPIO lines 1, 2, and 3.

- The “flash” state does not cause an LED on a GPIO device to flash, this state behaves like the “solid on” state.

2. The visible LEDs are only activated while the system is in Tracking and Diagnostic modes.

Compatibility Notes

The LED command is compatible with the hybrid Polaris Spectra System.

Example

Command:

```
LED 0A1S
```

Reply:

```
OKAYA896
```

PDIS

Disables the reporting of transformations for a particular port handle.

Operating Mode

Setup

Compatibility

All systems

Prerequisite Command

PENA (page 86)

Syntax

```
PDIS<SPACE><Port Handle><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Example

Command:

```
PDIS 01
```

Reply:

```
OKAYA896
```

PENA

Enables the reporting of transformations for a particular port handle.

Operating Mode

Setup

Compatibility

All systems

Prerequisite Command

PINIT (page 104)

Syntax

PENA<SPACE><Port Handle><Tool Tracking Priority><CR>

Parameter	Description	
Port Handle	2 hexadecimal characters	
Tool Tracking Priority	Describes the type of tool. **Valid Values:**	
	S	Static: a static tool is considered to be relatively immobile, e.g. a reference tool.
	D	Dynamic: a dynamic tool is considered to be in motion, e.g. a probe.
	B	Button box: a button box can have switches and LEDs, but no markers. No transformations are returned for a button box tool, but switch status is returned.

Replies

Upon Success:

OKAY<CRC16><CR>

or

WARNING02<CRC16><CR> (Indicates that the tool you are trying to enable is a unique geometry tool that doesn't meet the unique geometry requirements.)

WARNING03<CRC16><CR> (Indicates that the tool you are trying to enable is a unique geometry tool that conflicts with another unique geometry tool already loaded and enabled.)

WARNING04<CRC16><CR> (Indicates that the tool you are trying to enable is a unique geometry tool that doesn't meet the unique geometry requirements, and conflicts with another unique geometry tool already loaded and enabled.)

On Error:

ERROR<Error Code><CRC16><CR>

See page 167 for error code definitions.

Usage Notes

1. It is not necessary to enable the port handle for a strober.
2. Select a tool tracking priority of “button box” for a GPIO device.
3. A tool with a tool tracking priority of “button box” does not affect the tracking rate of the system.
4. Strober port handles and GPIO port handles do not affect the tracking rate of the system.
5. The system does not make use of the tool tracking priority. You must still specify a value, but it does not matter which tool tracking priority you choose.
6. When the PENA command is issued, the system compares the tool being enabled with currently enabled tools for conflicting unique geometry constraints. This process is almost instantaneous. If the tool doesn’t meet the unique geometry constraints, or conflicts with a tool that is already enabled, the system will issue a `WARNING02`, `WARNING03`, or `WARNING04`.
7. The system will still enable the tool when the system returns `WARNING02`, `WARNING03` or `WARNING04`; however, the tool may not track properly since the unique geometry is compromised.
8. For more information on unique geometry tools and unique geometry constraints, see the “*Polaris Tool Design Guide*.”

Example

Command:

```
PENA 01D
```

Reply:

```
OKAYA896
```

PFSEL

Sets which tool faces to use to track a multi-faced tool.

Operating Mode

Setup

Compatibility

All systems

Prerequisite Command

PINIT (page 104)

Syntax

```
PFSEL<SPACE><Port Handle><Face Selection Mask><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters
`Face Selection`	2 hexadecimal characters (8 bits) Set the bits corresponding to the faces you wish to track.

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

1. When a tool is initialized, the face selection defaults to a value of 0xFF, so all faces are tracked by default.
2. To include a tool face to be tracked, set the corresponding bit. For example, if you wish to track faces 0 and 5, the face selection value is 0x21, as shown in the following table:

Tool Face Number	7	6	5	4	3	2	1	0
Bit Value	0	0	1	0	0	0	0	1
Face Selection Hexadecimal Value	2				1			

3. If the system returns error code 23, the face selection did not include any of the valid faces of the selected tool.

Example

Command:

```
PFSEL 0121
```

Reply:

```
OKAYA896
```

PHF

Releases system resources from an unused port handle.

Operating Mode

Setup

Compatibility

All systems

Prerequisite Command

PHRQ (page 99)

Syntax

```
PHF<SPACE><Port Handle><CR>
```

Parameter	Description
Port Handle	2 hexadecimal characters

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

1. The PHF command should be used whenever a tool, GPIO device, or strober is disconnected. This optimizes the use of system resources. If PHF is not used, the system will be unable to assign a port handle after the maximum number of port handles has been reached.
2. If a tool, GPIO device, or strober is disconnected then reconnected, it is a assigned a new port handle. The old port handle is no longer in use and should be freed using PHF.

Example

Command:

```
PHF 01
```

Reply:

```
OKAYA896
```

This frees port handle 01, so it is no longer assigned.

PHINF

Returns port handle status, information about the tool associated with the port handle, and the physical location of a port handle.

Operating Mode

Setup

Compatibility

All systems

Prerequisite Command

PHSR (page 101) or PHRQ (page 99)

Syntax

```
PHINF<SPACE><Port Handle><Reply Option><CR>
```

Parameter	Description		G.001.002	G.001.003	G.001.004	G.001.005
Port Handle	2 hexadecimal characters					
Reply Option	Optional. Specifies which information will be returned. If no reply option is specified, the system returns information for reply option 0001. The reply options are hexadecimal numbers that can be OR'd. If multiple reply options are used, the replies are returned in order of increasing option value. **Valid Values:**					
	0001	Tool information (default)	X	X	X	X
	0002	Wired tool electrical information	X	X	X	X
	0004	Tool part number	X	X	X	X
	0008	Switch and visible LED information	X	X	X	X
	0010	Tool marker type and wavelength	X	X	X	X
	0020	Physical port location	X	X	X	X
	0040	GPIO device status			X	X

Replies

Upon Success:

If there is a tool definition file assigned to the port handle:

```
<Reply Option 0001 Data><Reply Option 0002 Data>...<Reply Option 0020
Data><CRC16><CR>
```

Note **The physical location of a port handle is the only information available unless PHINF has been preceded by PINIT (page 104).**

If no tool definition file is assigned to the port handle:

```
UNOCCUPIED<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Reply Option 0001 - Tool Information

<Reply Option 0001 Data> = <Tool Type><Manufacturer's ID><Tool Revision><Serial Number><Port Status>

Reply Component	Description		
Tool Type	8 characters <Tool Type> = <Main Type><Number of Switches><Number of Visible LEDs> <Reserved><Subtype>		
	Main Type	2 hexadecimal characters **Possible Values:**	
		01	Reference
		02	Probe
		03	Button box or foot switch
		04	Software-defined
		05	Microscope tracker
		06	Reserved
		07	Calibration device
		08	Strober or Tool Docking Station
		09	Isolation box
		0A	C-arm tracker
		0B	Catheter
		0C	GPIO device
		0D to FF	Reserved
	Number of Switches	1 character	
	Number of Visible LEDs	1 character	
	Reserved	2 characters	
	Subtype	2 characters	
Manufacturer's ID	12 characters		
Tool Revision	3 characters		
Serial Number	8 hexadecimal characters (32 bits) **Bit field:**		
	bits 0 to 9	Sequence number (one-based)	
	bits 10 to 18	Day of year (zero-based, e.g. Jan 1 is day 0 and Dec 31 is day 364)	
	bits 19 to 22	Month (zero-based)	
	bits 23 to 31	Year (year is <current year> - 1900, e.g. the year 2009 is 109)	

Reply Component	Description	
Port Status	2 hexadecimal characters (8 bits) **Bit field:**	
	bit 0	Tool-in-port
	bit 1	Switch 1 closed/GPIO line 1 active
	bit 2	Switch 2 closed/GPIO line 2 active
	bit 3	Switch 3 closed/GPIO line 3 active
	bit 4	Port initialized
	bit 5	Port enabled
	bit 6	Reserved
	bit 7	Tool-in-port from current sensing

Reply Option 0002 - Wired Tool Electrical Information

Reply Component	Description	
Reply Option 0002 Data	8 hexadecimal characters Wired tool electrical information. The electrical current is tested for two conditions: over and under. An “over” current condition indicates that there is a short circuit in either the cable or the marker. An “under” current condition indicates that there is either a break in the cable or the marker has burnt out. **Bit field:**	
	bits 0 to 19	Marker failed. Bit 0 = marker A, ..., bit 19 = marker T
	bits 20 to 29	Reserved
	bit 30	Under
	bit 31	Over

You can test the electrical current of all the markers on a tool using TCTST (page 140).

Reply Option 0004 - Tool Part Number

Reply Component	Description
Reply Option 0004 Data	20 characters The part number of the tool.

Reply Option 0008 - Switch and Visible LED Information

Reply Component	Description	
`Reply Option 0008 Data`	2 hexadecimal characters (8 bits) This option reports the information found in the tool description. It is not information sensed by the hardware. GPIO lines defined as inputs are reported in bits 1, 2, and 3. GPIO lines defined as outputs with feedback are reported in bits 5, 6, and 7. **Bit field:**	
	bit 0	Tool-in-port switch supported
	bit 1	Switch 1/GPIO line 1 supported
	bit 2	Switch 2/GPIO line 2 supported
	bit 3	Switch 3/GPIO line 3 supported
	bit 4	Tool tracking LED supported
	bit 5	LED 1/GPIO line 1 supported
	bit 6	LED 2/GPIO line 2 supported
	bit 7	LED 3/GPIO line 3 supported

Reply Option 0010 - Tool Marker Type and Wavelength

Reply Component	Description		G.001.002	G.001.003	G.001.004	G.001.005
Reply Option 0010 Data	2 hexadecimal characters (8 bits) **Bits 0 to 2 give information on the marker wavelength:**					
	000	9*x*0 nm (See "Compatibility Notes" on page 98.)	X	X	X	X
	001	880 nm	X	X	X	X
	010	930 nm		X	X	X
	100	870 nm	X	X	X	X
	Bits 3 to 7 give information on the marker type:					
	00000	Reserved				
	00001	NDI active	X	X	X	X
	00010	NDI ceramic	X	X	X	X
	00011	Unknown active	X	X	X	X
	00100	Unknown passive	X	X	X	X
	00101	Passive sphere	X	X	X	X
	00110	Passive disc	X	X	X	X
	00111	NDI Radix	X	X	X	X
	01000 to 11111	Reserved				

Reply Option 0020 - Physical Port Location

```
<Reply Option 0020 Data> = <Hardware Device><System Type><Tool Type>
<Port Number><Reserved>
```

Reply Component	Description
Hardware Device	8 characters For Polaris Vicra, and passive or active wireless tools used with the Polaris Spectra, this is the Position Sensor serial number. For Polaris Spectra active tools, this is the device name of the strober that the tool is plugged into (STB-1 or STB-2). If the tool is plugged into the System Control Unit, this is STB-0.
System Type	1 character **Possible values:** Reserved

Reply Component	Description	
Tool Type	1 character **Possible values:**	
	0	Wired
	1	Wireless
Port Number	2 ASCII characters **Possible values:**	
	01 to 03	Used for Polaris Spectra wired tools
	04	Used for Polaris Spectra GPIO devices
	00	Used for Polaris Spectra or Polaris Vicra wireless tools, and strobers
Reserved	2 characters	

Reply Option 0040 - GPIO Device Status

```
<Reply Option 0040 Data> = <GPIO line 1><GPIO line 2><GPIO line 3>
<GPIO line 4>
```

Reply Component	Description	
GPIO line n	1 hexadecimal character Status of the nth GPIO line in a GPIO device. **Possible Values:**	
	0	Not available, or defined as a tool tracking LED
	1	Input
	2	Output
	3	Visible LED
	4	Always high

Usage Notes

1. The physical location of a port handle is the only information available unless PHINF has been preceded by PINIT (page 104).
2. Port handles for tools that have been disconnected will be reported as UNOCCUPIED and no additional information will be returned.
3. **Reply option 0001**: For wired tools, bits 1, 2, and 3 in the port status report switch status. For GPIO devices, these bits report the status of GPIO lines defined as inputs.
4. **Reply option 0008**: For wired tools, bits 1, 2, and 3 report switch status, and bits 5, 6, and 7 report LED status. For GPIO devices, bits 1, 2, and 3 report the status of GPIO lines defined as inputs, and bits 5, 6, and 7 report the status of GPIO lines defined as outputs with feedback.

Compatibility Notes

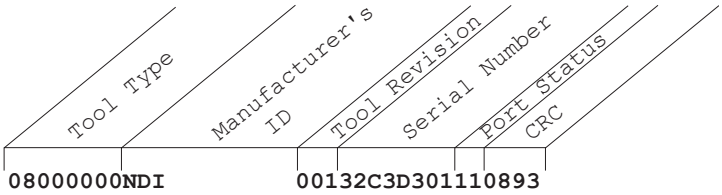
1. **Reply option 0010**: A value of 010 for marker wavelength can be returned only for tools characterized using NDI 6D Architect version 2.02 or later. Tools characterized with earlier versions of NDI 6D Architect will have a value of 000 for a marker wavelength of 930 nm.
2. **Reply option 0040**: This option is only supported by the hybrid Polaris Spectra System.

Example

Command:

```
PHINF 040001
```

Reply:



PHRQ

Assigns a port handle to a tool or GPIO device.

Operating Mode

Setup

Compatibility

All systems

Prerequisite Command

INIT (page 78)

Syntax

```
PHRQ<SPACE><Hardware Device><System Type><Tool Type><Port Number>
<Reserved><CR>
```

Parameter	Description
`Hardware Device`	8 characters The hardware device must match the one returned by PHINF (page 91) reply option 0020, or use wild card characters (*). For active tools and GPIO devices connected to the Polaris Spectra, specifying all wildcards will default to hardware device STB-0 (the tool ports on the System Control Unit).
`System Type`	1 character **Valid Values:** Use a wild card character (*).
`Tool Type`	1 character This must be specified for wireless tools. **Valid Values:** 0 — Wired 1 — Wireless (passive or active wireless) Or use wild card characters (*) for wired tools.

<table>
<tr><th>Parameter</th><th colspan="2">Description</th></tr>
<tr><td>Port Number</td><td colspan="2">2 characters

The physical port number where a wired tool is plugged in. This must be specified for wired tools.

Valid Values:</td></tr>
<tr><td></td><td>01 to 03</td><td>Used for Polaris Spectra wired tools</td></tr>
<tr><td></td><td>04</td><td>Used for Polaris Spectra GPIO devices</td></tr>
<tr><td></td><td>00 or **</td><td>Used for wireless tools</td></tr>
<tr><td>Reserved</td><td colspan="2">2 characters

Use wild card characters (*).</td></tr>
</table>

Replies

Upon Success:

```
<Port Handle><CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

1. Use PHRQ to assign a port handle to a wireless tool or to a wired tool that has neither a tool-in-port diode or a marker in position A of the tool wiring matrix. If a wired tool has a tool-in-port diode or a marker in position A of the tool wiring matrix, use PHSR (page 101) to detect the tool and assign it a port handle.
2. **Wireless tools**: You must specify the tool type. All other parameters may be left as wild card characters (*).
3. **Wired tools and GPIO devices**: You must specify the port number. All other parameters may be left as wild card characters (*).
4. After using PHRQ, you must use PVWR (page 118) to assign a tool definition file to the tool. If you do not assign a tool definition file to the tool, the port handle will be reported as unoccupied when it is initialized with PINIT (page 104).

Example

Command:

```
PHRQ *********1****
```

Reply:

```
04D715
```

This requests a port handle for a wireless tool.

PHSR

Returns the number of assigned port handles and the port status for each one. Assigns a port handle to a wired tool, GPIO device, or strober.

Operating Mode

Setup

Compatibility

All systems

Prerequisite Command

INIT (page 78)

Syntax

```
PHSR<SPACE><Reply Option><CR>
```

Parameter	Description	
Reply Option	Specifies which information will be returned. If no reply option is specified, the system returns information for reply option 00. The reply options cannot be OR'd. **Valid Values:**	
	00	Reports all allocated port handles (default)
	01	Reports port handles that need to be freed
	02	Reports port handles that are occupied, but not initialized or enabled
	03	Reports port handles that are occupied and initialized, but not enabled
	04	Reports enabled port handles

Replies

Upon Success:

```
<Number of Port Handles>
<1st Port Handle><1st Port Handle Status>
<2nd Port Handle><2nd Port Handle Status>
...
<nth Port Handle><nth Port Handle Status>
<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions

Reply Component	Description	
Number of Port Handles	2 hexadecimal characters The number of allocated port handles of the type specified in the reply option. If no reply option is specified, the number returned is the total number of allocated port handles.	
n^{th} Port Handle	2 hexadecimal characters Specifies the port handle whose status follows.	
n^{th} Port Handle Status	3 hexadecimal characters (12 bits) **Bit field:**	
	bit 0	Occupied
	bit 1	Switch 1 closed
	bit 2	Switch 2 closed
	bit 3	Switch 3 closed
	bit 4	Initialized
	bit 5	Enabled
	bit 6	Reserved
	bit 7	Tool detected from current sensing
	bit 8 to 11	Reserved

Usage Notes

1. When you send the PHSR command, the system will detect and assign port handles to any wired tools, GPIO devices and strobers that do not already have a port handle assigned (i.e. any wired tools, GPIO devices or strobers that were plugged in after the last PHSR call). It will then return the requested port handle information.
2. The system will detect a wired tool if the tool has a tool-in-port diode, or a marker in position A of the tool wiring matrix. If you are using a wired tool that does not meet this criteria, you will need to request a port handle for the tool using PHRQ.
3. If you unplug a wired tool, GPIO device, or strober while the system is in tracking mode, the port handle will be reported as “disabled” in the replies to the BX and TX commands. If you reconnect the tool, it will need a new port handle.
4. If you connect a wired tool, GPIO device, or strober to the system while the system is in tracking mode (either reconnecting a tool/GPIO device/strober that was just unplugged, or connecting a new tool/GPIO device/strober), you will have to take the following steps before the system will report the tool, GPIO device, or strober:
   a) Exit tracking mode (TSTOP).
   b) Assign, initialize, and enable a port handle for the tool, GPIO device, or strober, as outlined in Figure 3-1 on page 18. (Initializing and enabling is optional for strobers.)

c) Re-enter tracking mode (TSTART).

5. PHSR will report wireless tool ports as unoccupied if you have requested a port handle (using PHRQ (page 99)) but have not yet associated a tool definition file for the port handle (using PVWR (page 118)).

6. To obtain a port handle for a wireless tool, use PHRQ.

Examples

Command:

```
PHSR
```

Reply:

```
001414
```

In this case, there are no occupied port handles.

Command:

```
PHSR
```

Reply:

```
0101031F1AF
```

In this case, there is one occupied port handle, which is initialized and enabled.

PINIT

Initializes a port handle.

Operating Mode

Setup

Compatibility

All systems

Prerequisite Command

PVWR (page 118) or PHSR (page 101)

Syntax

`PINIT<SPACE><Port Handle><CR>`

Parameter	Description
`Port Handle`	2 hexadecimal characters

Replies

Upon Success:

`OKAY<CRC16><CR>`

or

`WARNING` (Indicates that a non-fatal tool error has been encountered, e.g. a burnt out marker.)

or

WARNING05 (In combined firmware 006 and later, WARNING05 is returned when the system selects a default marker wavelength to track a tool (if the tool's tool definition file did not specify a marker wavelength)).

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Usage Notes

1. Use PINIT in the following cases:
   a) **Wired tool**: Use PINIT to initialize a port handle for a wired tool or GPIO device after you have assigned a port handle using PHSR. If you are using PVWR to override an SROM device, use PINIT after assigning a tool definition file using PVWR.
   b) **Wireless tool**: Use PINIT to initialize a port handle for a wireless tool after you have assigned a port handle using PHRQ and assigned a tool definition file using PVWR.

2. It is not necessary to initialize the port handle for a strober.
3. If the tool description is drawn from a tool definition file that has been loaded using PVWR (page 118), initialization involves unpacking and verifying the tool definition file. This process is almost instantaneous.
4. If the tool description is drawn from an SROM device, initialization involves reading, unpacking, and verifying the tool definition file contents, and testing electrical current through all the markers to detect burnt out markers. This process takes approximately two seconds if successful, or several seconds longer if a problem is encountered and retries are attempted by the system.
5. The port handle will still initialize when the system returns WARNING. or WARNING05.

Example

Command:

```
PINIT 01
```

Reply:

```
OKAYA896
```

This initializes port handle 01.

PPRD

Reads data from the SROM device in a wired tool or GPIO device.

Operating Mode

Setup

Compatibility

hybrid Polaris Spectra System

Prerequisite Command

PSEL (page 110)

Syntax

`PPRD<SPACE><Port Handle><SROM Device Address><CR>`

Parameter	Description
`Port Handle`	2 hexadecimal characters
`SROM Device Address`	4 hexadecimal characters **Valid Values:** 0x0000 to 0x07C0

Replies

Upon Success:

`<SROM Device Data><CRC16><CR>`

The SROM device data is 64 bytes (128 hexadecimal characters) of data.

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Usage Notes

1. The SROM device is a 2-KB write-once device that must be read in 64-byte chunks. An SROM device is considered blank if its contents are all 0xFFs.
2. PPRD reads 64 bytes of data from the SROM device starting at a specified SROM device address.
3. You must select the SROM device as the reading target with PSEL (page 110) before sending the PPRD command.

Compatibility Notes

The PPRD command is fully compatible with the hybrid Polaris Spectra System

Example

Command:

```
PPRD 010000
```

Reply:

```
0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF012345678
9ABCDEF0123456789ABCDEF0123456789ABCDEF0123456789ABCDEF66A5
```

PPWR

Writes data to the SROM device in a wired tool or GPIO device.

Operating Mode

Setup

Compatibility

hybrid Polaris Spectra System

Prerequisite Command

PSEL (page 110)

Syntax

```
PPWR<SPACE><Port Handle><SROM Device Address><SROM Device Data><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters
`SROM Device Address`	4 hexadecimal characters **Valid values:** 0x0000 to 0x07C0
`SROM Device Data`	64 bytes (128 hexadecimal characters) of data

Replies

Command:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

1. PPWR writes 64 bytes of data to the SROM device starting at a specified SROM device address.
2. You must select the SROM device as the reading target with PSEL (page 110) before sending the PPWR command.
3. The data must be formatted into unsigned ASCII characters. Each byte of binary data can be represented by two hexadecimal characters, which are then sent to the system in ASCII (4 bits per ASCII character).
4. The tool description section of tool SROM device is a 1-Kbyte, write-once area that must be written in 64-byte chunks. If the information being written to the system is less than 64 bytes in

size, then the remainder of the chunk must be padded out with ones to maintain the 64-byte size before being written to the system.

5. An SROM device is considered blank if its contents are all 0xFFs.
6. The recommended procedure to follow for updating an SROM device is:
   a) Read the contents of the SROM device using PSEL (page 110) and PPRD (page 106).
   b) Modify the data.
   c) Write the modified data back to the SROM device using PSEL (page 110) and PPWR.

Compatibility Notes

The PPWR command is fully compatible with the hybrid Polaris Spectra System.

Example

Command:

```
PPWR 0100C0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000009731
```

Reply:

```
OKAYA896
```

PSEL

Selects an SROM device as the target for reading or writing with PPRD or PPWR.

Operating Mode

Setup

Compatibility

hybrid Polaris Spectra System

Prerequisite Command

INIT (page 78)

Syntax

```
PSEL<SPACE><Port Handle><SROM Device ID><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters
`Tool SROM Device ID`	16 characters Use PSRCH (page 112) to determine the SROM device ID.

Replies

Command:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Compatibility Notes

The PSEL command is fully compatible with the hybrid Polaris Spectra System.

Example

Command:

```
PSEL 010B3876530000005B
```

Reply:

```
OKAYA896
```

PSOUT

Sets the states of the output lines in a GPIO (general purpose input/output) device.

Operating Mode

All modes

Syntax

```
PSOUT<SPACE><Port Handle><GPIO 1 State><GPIO 2 State><GPIO 3 State><GPIO 4 State><CR>
```

Parameter	Description	
`Port Handle`	2 hexadecimal characters	
`GPIO n State`	State of the nth GPIO line **Valid Values:**	
	N	No change
	S	Solid on
	O	Off

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 84 for error code definitions.

Usage Notes

You can check the status of a GPIO line using PHINF (page 91), BX (page 47), or TX (page 146).

Example

Command:

```
PSOUT 0ANSNN
```

Reply:

```
OKAYA896
```

PSRCH

Returns a list of valid SROM device IDs for a wired tool or GPIO device.

Operating Mode

Setup

Compatibility

hybrid Polaris Spectra System

Prerequisite Command

INIT (page 78)

Syntax

```
PSRCH<SPACE><Port Handle><CR>
```

Parameter	Description
Port Handle	2 hexadecimal characters

Replies

Upon Success:

```
<Number of SROM devices><SROM device 1 ID><SROM device 2 ID>...<SROM
device 7 ID> <CRC16><CR>
```

Note **For a single tool or GPIO device, only the first SROM device ID is reported and the remainder are blank. The remaining six positions are reserved for special functionality.**

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Reply Component	Description
Number of SROM devices	1 character
SROM device n ID	16 characters

Usage Notes

The SROM device has an embedded ID, which is a unique, 16 character, alphanumeric identifier. The SROM device ID is used to select an SROM device as a target with PSEL (page 110).

Compatibility Notes

The PSRCH command is fully compatible with the hybrid Polaris Spectra System.

Example

Command:

```
PSRCH 01
```

Reply:

```
10B3876530000005B                                                    7FFF
```

There are 96 spaces between B and 7. The spaces are place holders for the SROM device ID numbers 2 to 7.

PURD

Reads data from the user section of the SROM device in a wired tool or GPIO device.

Operating Mode

Setup

Compatibility

hybrid Polaris Spectra System

Prerequisite Command

INIT (page 78)

Syntax

```
PURD<SPACE><Port Handle><User SROM Device Address><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters
`User SROM Device Address`	4 hexadecimal characters **Valid values:** 0x0000 to 0x03C0

Replies

Upon Success:

```
<SROM Device Data><CRC16><CR>
```

The SROM device data is 64 bytes (128 hexadecimal characters) of data.

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

1. The SROM device is automatically selected as the reading target when this command is issued, so you do not need to find and specify the SROM device ID. The SROM device address has an implied offset in the command which places the user information at the correct SROM device address.
2. The PURD command returns 64 bytes of data at a time.

Compatibility Notes

The PURD command is fully compatible with the hybrid Polaris Spectra System.

Example

Command:

```
PURD:010000
```

Reply:

```
0022446688AACCEE0022446688AACCEE0022446688AACCEE0022446688AACCEE002244668
8AACCEE0022446688AACCEE0022446688AACCEE0022446688AACCEE3CC0
```

PUWR

Writes data to the user section of the SROM device in a wired tool or GPIO device.

Operating Mode

Setup

Compatibility

hybrid Polaris Spectra System

Prerequisite Command

INIT (page 78)

Syntax

```
PUWR<SPACE><Port Handle><User SROM device address><User SROM device
Data><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters
`User SROM device address`	4 hexadecimal characters **Valid values:** 0x0000 to 0x03C0
`User SROM device data`	64 bytes of data to write (128 hexadecimal characters)

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

1. The SROM device is automatically selected as the reading target when this command is issued, so you do not need to find and specify the SROM device ID. The SROM device address has an implied offset in the command which places the user information at the correct SROM device address.
2. The data must be formatted into unsigned ASCII characters. Each byte of binary data can be represented by two hexadecimal characters, which are then sent to the system in ASCII (4 bits per ASCII character).

3. The user section of SROM devices is a 1-Kbyte, write-once area that must be written in 64-byte chunks. If the information being written to the system is less than 64 bytes in size, then the remainder of the chunk must be padded out with ones to maintain the 64-byte size before being written to the system.
4. The recommended procedure to follow for updating an SROM device is outlined below:
   a) Read the contents of the SROM device using PURD (page 114).
   b) Modify the data read.
   c) Write the modified data back to the SROM device using PUWR.

Compatibility Notes

The PUWR command is fully compatible with the hybrid Polaris Spectra System.

Example

Command:

```
PUWR 0100800000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000A927
```

Reply:

```
OKAYA896
```

PVWR

Assigns a tool definition file to a wireless tool, or overrides the SROM device in a wired tool or GPIO device.

Operating Mode

Setup

Compatibility

All systems

Prerequisite Command

PHRQ (page 99) or PHSR (page 101)

Syntax

```
PVWR<SPACE><Port Handle><Start Address><Tool Definition File Data><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters
`Start Address`	4 hexadecimal characters Increment the start address by 64 bytes with each chunk of data sent for a particular port handle. **Valid values:** 0x0000 to 0x03C0
`Tool Definition Data`	64 bytes (128 hexadecimal characters) of data

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

1. Use PVWR in the following cases:
   - To assign a tool definition file to a wireless tool after using PHRQ.
   - To assign a tool definition file to a wired tool or GPIO device, to override the SROM device in the tool.

- To assign a tool definition file to a wired tool or GPIO device, to test the tool definition file before permanently recording the tool definition file onto the SROM device.

2. The data must be formatted into unsigned ASCII characters. Each byte of binary data can be represented by two hexadecimal characters, which are then sent to the system in ASCII (4 bits per ASCII character).
3. Data is sent to the system in 64-byte chunks (128 hexadecimal characters). The last chunk must be padded out with zeroes to maintain the 64-byte size before being written to the system.
4. If a wireless tool port is the target of this command, the port becomes occupied when the first 64 bytes of information is written. Any previous initialization for the port is lost.
5. Use PVWR to assign a tool definition file to a wireless tool after using PHRQ (page 99).
6. After using PVWR, initialize (PINIT) and enable (PENA) the port handle in order to track the tool.
7. To permanently write a tool definition file to an SROM device, use PPWR (page 108).

Example

Command:

```
PVWR 0200004E444900551C000001000000000000010100000001A419335A000000030000
0003000000000000400000000000000000000000000000000000000000000000000000000000
```

Reply:

```
OKAYA896
```

RESET

Resets the system.

Operating Mode

All modes

Compatibility

All systems

Syntax

`RESET<SPACE><Reset Option><CR>`

Parameter	Description	
`Reset Option`	Optional. Specifies the type of reset. If no reset option is specified, the system performs a RESET 1. The reset options cannot be OR'd. **Valid Values:**	
	0	Generates a soft reset, and resets the baud rate to 9600. Does not power cycle the Position Sensor.
	1	Performs a board-level reset of all hardware devices, and resets the baud rate to 9600. (Default)

Replies

Upon Success:

`RESET<CRC16><CR>`

or

`SCUONLY<CRC16><CR>`

(If the SCU is connected and no Position Sensor is connected.)

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Usage Notes

1. RESET can only be used when the host computer and the system are at the same baud rate. To reset the system when the baud rates do not match or when the system is in an unknown state, use a serial break.
2. The reply will be sent at the default communications settings (9600 baud, 8 data bits, no parity, 1 stop bit, hardware handshaking off).

Example

Command:

```
RESET 0
```

Reply:

```
RESETBE6F
```

SAVE

Saves all non-volatile user parameters that have been changed (on all connected devices).

Operating Mode

All modes

Compatibility

All systems

Syntax

`SAVE<SPACE><CR>`

Replies

Upon Success:

`OKAY<CRC16><CR>`

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Usage Notes

1. To restore the user parameters to factory default values, use the DFLT (page 61) command. To save the user parameters at their factory default values, use the SAVE command after using the DFLT command.
2. On systems that have the Password Protect keyed feature enabled, user parameters can only be saved after the correct password is entered. To enter the password, use **SET Config.Password=<password>**, where <password> is the correct password. For more information on the Password Protect keyed feature, see the user guide.
3. To set user parameter values, use the SET (page 125) command.
4. For more information on user parameters, see "User Parameters" on page 20.

Example

Command:

`SAVE`

Reply:

`OKAYA896`

SENSEL

Sets the IR sensitivity level, or returns the current IR sensitivity level.

Operating Mode

Setup

Compatibility

All systems (deprecated)

Prerequisite Command

INIT (page 78)

Syntax

```
SENSEL<SPACE><Option><CR>
```

Note **For sensitivity levels corresponding to the Polaris Vicra or Polaris Spectra System, refer to the appropriate user guide. To set the sensitivity level for the Polaris Vicra or Polaris Spectra System, use the command SET to set the user parameter "Param.Tracking.Sensitivity."**

Parameter	Description	
Option	**Valid Values:**	
	0	Returns the current sensitivity level
	1-7	Refer to the appropriate user guide (Sensitivity level 4 is the default level for the Polaris Vicra and Polaris Spectra Systems.)

Replies

Upon Success:

For option 0:

```
<Current sensitivity level><CRC16><CR>
```

For options 1 to 7:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Reply Component	Description
`Current sensitivity level`	1 character The infrared light sensitivity level currently being used by the system.

Usage Notes

1. Sensitivity level 4 is the default level for the Polaris Vicra and Polaris Spectra Systems. See the user guide for full details on the sensitivity levels for these systems.
2. The level set using SENSEL persists until a RESET or INIT (page 78) command is issued.

Compatibility Notes

The SENSEL command has been deprecated for the Polaris Vicra and Polaris Spectra Systems. To set the sensitivity level for the Polaris Vicra or Polaris Spectra System, use the command SET (page 125) to set the user parameter **Param.Tracking.Sensitivity**.

Examples

Command:

```
SENSEL 3
```

Reply:

```
OKAYA896
```

Command:

```
SENSEL 0
```

Reply:

```
31540
```

SET

Sets user parameter values.

Operating Mode

All modes

Compatibility

All systems

Syntax

`SET<SPACE><User Parameter Name>=<Value><CR>`

Parameter	Description
`User Parameter Name`	A case-sensitive string, identifying the name of the user parameter.
`Value`	The value to set. Numerical values are decimal unless preceded by 0x. For boolean values, 1 is true and 0 is false.

Replies

Upon Success:

`OKAY<CRC16><CR>`

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Usage Notes

1. To view a list of user parameters and their current values, use **GET ***. For a description of the user parameters, use **GETINFO ***.
2. The user parameter values set using the SET command persist until the system is reset or initialized. To save the user parameter values, use SAVE (page 122). To reset user parameters to their default values, use DFLT (page 61).
3. User parameter names are case-sensitive.
4. For more information on user parameters, see "User Parameters" on page 20

Compatibility Notes

Accessing parameters by prefixing them with a device name (e.g. **SET PS-0.Param.Tracking.Sensitivity=1**) is not supported by API revision G.001.002 or earlier.

Example

Command:

```
SET PS-0.Param.Tracking.Sensitivity=1
```

Reply:

```
OKAYA896
```

This sets the infrared light sensitivity level to level 1 on the first Position Sensor in the configuration.

SETIO

Sets the general purpose input/output lines of a synchronization port to either a high or low value.

Operating Mode

All modes

Compatibility

hybrid Polaris Spectra System

Prerequisite Command

INIT (page 78)

Syntax

```
SETIO<SPACE><Input/Output Line Status><CR>
```

Parameter	Description
`Input/Output Line Status`	4 hexadecimal characters (16 bits) Each bit in the 16-bit flag field represents one possible input/output line. Use 1 for a high level and 0 for a low level at the input line (positive logic). Currently, only bit zero of the status field is used.

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

1. The System Control Unit on the hybrid Polaris Spectra System has one general purpose digital input/output line, on pin 2 of the synchronization port.
2. To request the current status of the general purpose input/output lines of a synchronization port use GETIO (page 72).

Compatibility Notes

The SETIO command is compatible with the hybrid Polaris Spectra System.

Example

Command:

```
SETIO 0001
```

Reply:

```
OKAYA896
```

SFLIST

Returns information about the supported features of the system.

Operating Mode

Setup

Compatibility

All systems

Syntax

`SFLIST<SPACE><Reply Option><CR>`

Parameter	Description		G.001.002	G.001.003	G.001.004	G.001.005
`Reply Option`	Specifies which information will be returned. The reply options cannot be OR'd. **Valid values:**					
	00	Summary of supported features	X	X	X	X
	01	Number of active tool ports	X	X	X	X
	02	Number of wireless tool ports	X	X	X	X
	03	Number of characterized measurement volumes and wavelengths; volume shapes and supported wavelengths	X	X	X	X
	04	The number of wired tool ports available which support tool-in-port detection from current sensing	X	X	X	X
	05	Number of active wireless tool	X	X	X	X

The reply options cannot be OR’d.

Replies

Upon Success:

`<Reply Option n Data><CRC16><CR>`

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Reply Component	Description
`Reply Option n Data`	The data specific to the requested reply option. See the reply option information below for details: Reply option 00 (Summary of supported features) Reply option 01 (Number of active tool ports) Reply option 02 (Number of wireless tool ports) Reply option 03 (Number of characterized measurement volumes and wavelengths; volume shapes and supported wavelength) Reply option 04 (The number of wired tool ports available which support tool-in-port detection from current sensing) Reply option 05 (Number of active wireless tools)

Reply Option 00 - Supported Features Summary

Reply Component	Description	
`Reply Option 00 Data`	8 hexadecimal characters (32 bits) **Bit field:**	
	bit 0	Active tool ports available
	bit 1	Passive tool ports available
	bit 2	Multiple volume characterization parameters supported
	bit 3	Tool-in-port from current sensing available
	bit 4	Active wireless tool ports available
	bit 5	Reserved
	bits 7 to 31	Reserved

Reply Option 01 - Number of Active Tool Ports

Reply Component	Description
`Reply Option 01 Data`	1 hexadecimal character The number of wired tool ports.

Reply Option 02 - Number of Wireless Tool Ports

Reply Component	Description
`Reply Option 02 Data`	1 hexadecimal character The number of wireless tool ports.

Reply Option 03 - Volumes

<Reply Option 03 Data> =
<Number of Volumes>
<1st Shape Type><1st Shape Parameter><1st Number of Wavelengths Supported><1st Supported Wavelengths><LF>
...
<nth Shape Type><nth Shape Parameter><nth Number of Wavelengths Supported><nth Supported Wavelengths><LF>

Reply Component	Description	
Number of Volumes	1 hexadecimal character	
nth Shape Type	1 hexadecimal character **Possible values:**	
	5	Pyramid or extended pyramid measurement volume (Polaris Spectra)
	7	Polaris Vicra measurement volume
nth Shape Parameter	10 parameters, 7 characters each (a sign, and six digits with an implied decimal in the position XXXX . XX) (See pages 132 to 133 for details.)	
nth Number of Wavelengths Supported	1 hexadecimal character	
nth Supported Wavelengths	1 character per wavelength supported **Possible values:**	
	0	930 nm (see "Usage Notes" on page 135)
	1	880 nm
	4	870 nm

Reply Option 04 - Number of Active Tool Ports Supporting Tool-in-Port Detection From Current Sensing

Reply Component	Description
Reply Option 04 Data	1 hexadecimal character

Reply Option 05 - Number of Active Wireless Ports

Reply Component	Description
Reply Option 05 Data	1 hexadecimal character

Polaris Vicra System - Shape Parameters

<Shape Parameter> in reply option 03 returns the following values (illustrated in Figure 5-2):

Shape Parameter	Value	Description
D1	100 mm	Half baseline
D2	582.00º	Outside volume angle - top view (scaled by 10)
D3	1099.00º	Inside volume angle - top view (scaled by 10)
D4	194.00º	Half volume angle - side view (scaled by 10)
D5 to D7		Reserved
D8	-830 mm	*z*-coordinate centre of back curve
D9	506 mm	Radius of back curve
D10	-557 mm	*z*-coordinate of front of volume

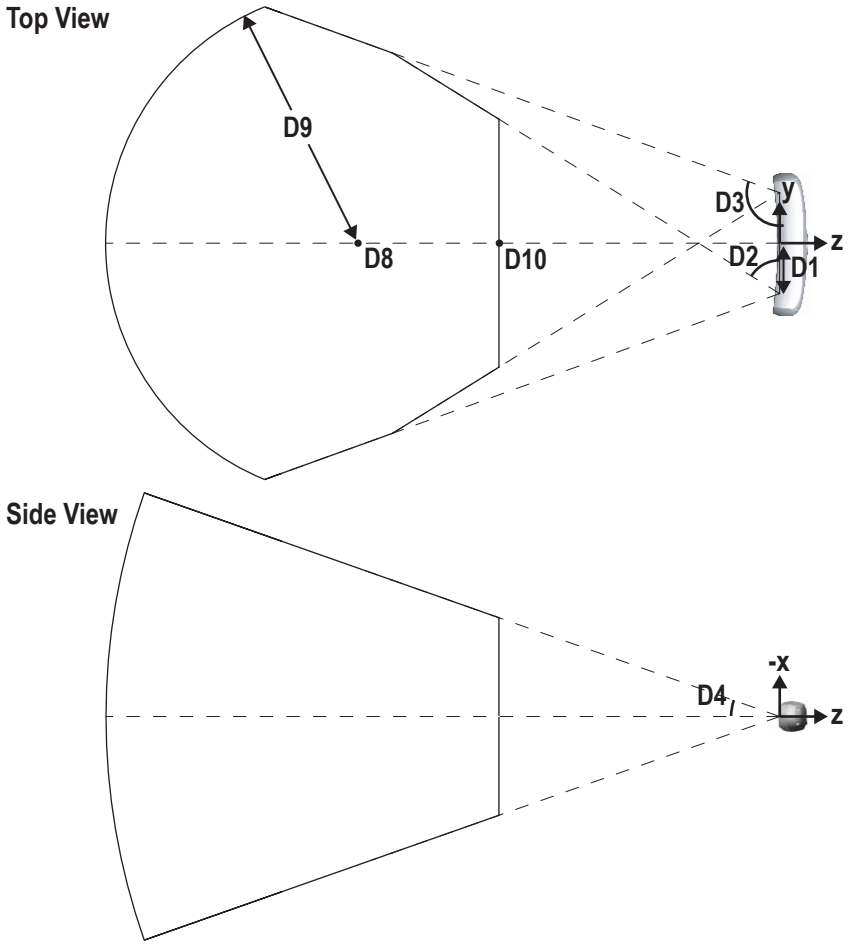


Figure 5-1 Polaris Vicra Volume Parameters

The back curve of the volume is the "visible" section of the torus defined by the equation $(D8 - \sqrt{x^2 - z^2}) + y^2 = D9^2$. "Visible" means within the Position Sensor field of view, defined by D1, D2, D3, and D4, for z < D8.

Polaris Spectra System - Shape Parameters

For the pyramid measurement volume, <Shape Parameter> in reply option 03 returns the following values (illustrated in Figure 5-2):

Shape Parameter	Value	Description
D1	-2400 mm	*z*-coordinate of back of volume
D2	-1532 mm	*z*-coordinate where sides of volume change slope
D3	-950 mm	*z*-coordinate of front of volume
D4	572 mm	Half width of volume at *z* = D2
D5	398 mm	Half height of volume *z* = D2
D6	0569.46	Slope of front part of volume sides in the *yz*-plane (scaled by 1000)
D7	0243.03	Slope of back part of volume sides in the *yz*-plane (scaled by 1000)
D8	0297.73	Slope of volume top and bottom in the *xz*-plane (scaled by 1000)
D9	9999.99 mm	Maximum half width of volume (unrestricted)
D10	9999.99 mm	Maximum half height of volume (unrestricted)

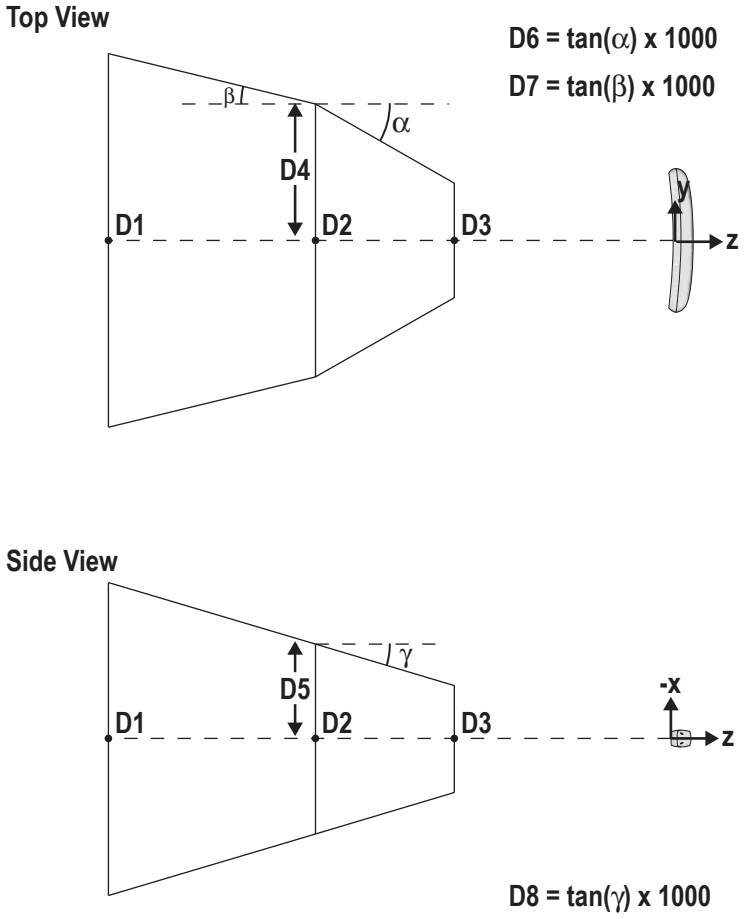


Figure 5-2 Pyramid Volume Parameters (Polaris Spectra)

For the extended pyramid measurement volume, <Shape Parameter> in reply option 03 returns the following values (illustrated in Figure 5-3):

Shape Parameter	Value	Description
D1	-3000 mm	*z*-coordinate of back of volume
D2	-1532 mm	*z*-coordinate where sides of volume change slope
D3	-950 mm	*z*-coordinate of front of volume
D4	572 mm	Half width of volume at *z* = D2
D5	398 mm	Half height of volume *z* = D2
D6	0569.46	Slope of front part of volume sides in the *yz*-plane (scaled by 1000)
D7	0243.03	Slope of back part of volume sides in the *yz*-plane (scaled by 1000)
D8	0297.73	Slope of volume top and bottom in the *xz*-plane (scaled by 1000)
D9	9999.99 mm	Maximum half width of volume (unrestricted)
D10	735 mm	Maximum half height of volume

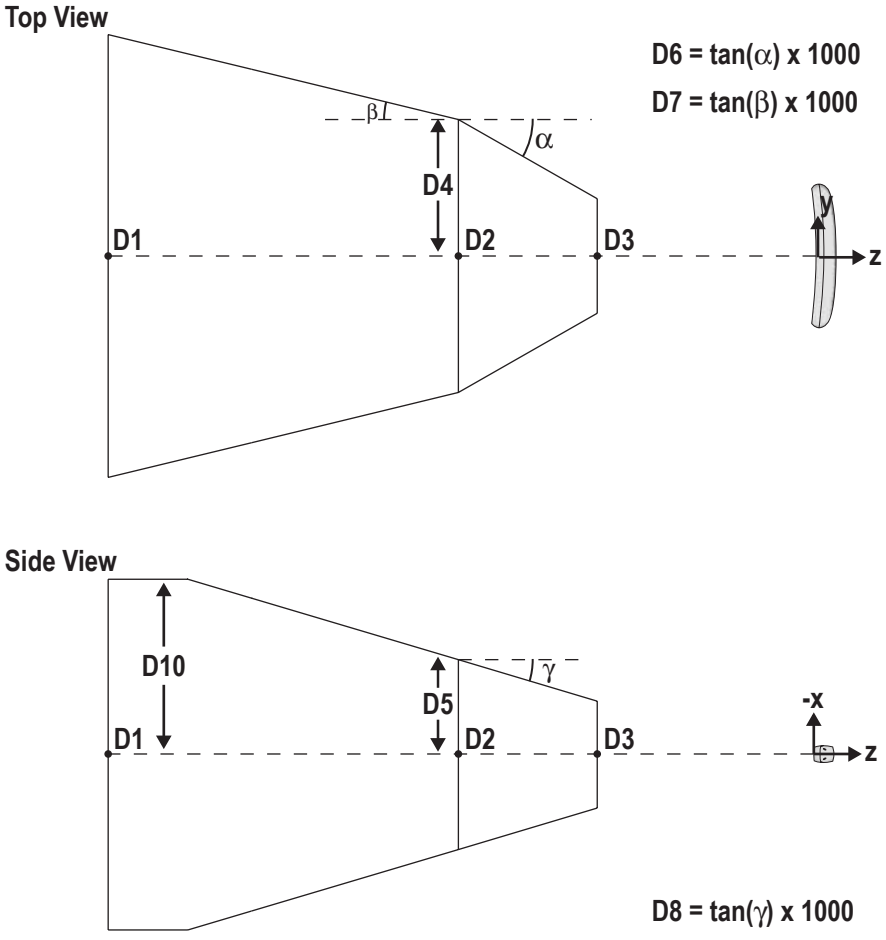


Figure 5-3 Extended Pyramid Volume Parameters (Polaris Spectra)

Usage Notes

1. Use both the shape type and the shape parameters to represent the characterized measurement volume graphically. There may be multiple volumes with the same shape type. All volumes of the same shape type use the shape parameters the same way.
2. **Reply option 03**: A characterized measurement volume that supports wavelength value 0 (930 nm) supports the wavelength values of 000 (9*x*0 nm) and 010 (930 nm) returned with PHINF (page 91).

Examples

Command:

```
SFLIST
```

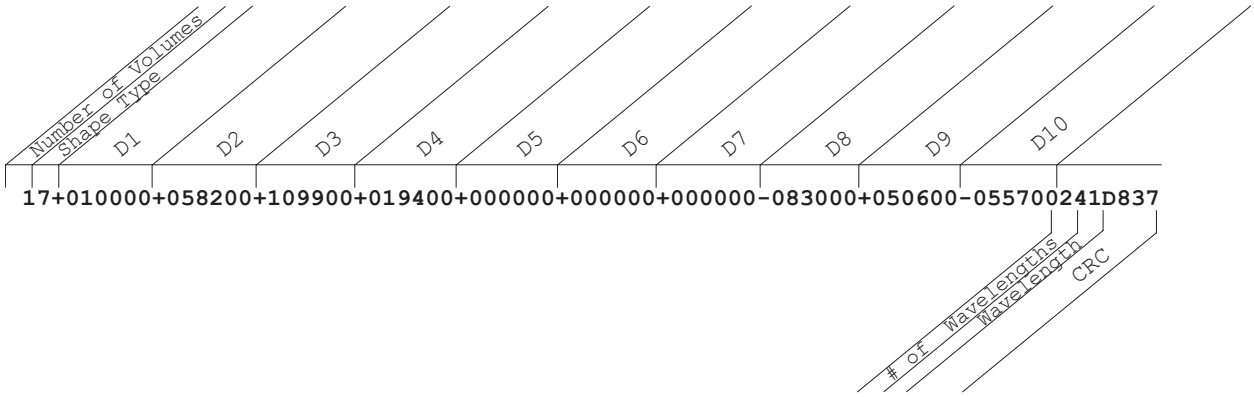
Reply:

```
0000003FEEEC
```

Command:

```
SFLIST 03
```

Reply:



SSTAT

Returns the status of the system processors.

Operating Mode

All modes

Compatibility

All systems (deprecated)

Syntax

Syntax

```
SSTAT<SPACE><Reply Option><CR>
```

Parameter	Description	
Reply Option	The reply options are hexadecimal numbers that can be OR'd. If multiple reply options are used, the replies are returned in order of increasing option value. **Valid Values:**	
	0001	Control processor status
	0002	Left and right sensor processor status
	0004	Tool Interface Unit processor status

Replies

Upon Success:

```
<Reply Option 0001 Data><Reply Option 0002 Data><Reply Option 0004
Data><CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Reply Option 0001 - Control Processor Status

Reply Component	Description	
Reply Option 0001 Data	2 hexadecimal characters (8 bits) **Bit field:**	
	bits 0 to 7	Reserved

Reply Option 0002 - Left and Right Sensor Processor Status

Reply Component	Description	
`Reply Option 0002 Data`	2 hexadecimal characters (8 bits) **Bit field:**	
	bit 0 to 7	Reserved

Reply Option 0004 - Tool Interface Unit Processor Status

Reply Component	Description	
`Reply Option 0004 Data`	2 hexadecimal characters (8 bits) **Bit field:**	
	bit 0 to 7	Reserved

Usage Notes

1. All status bits are persistent for as long as the system is turned on. They can only be cleared by a serial break or reset.
2. If any of the bits indicate a failure, reset your system and then try SSTAT again. If the problem persists, contact NDI.

Compatibility Notes

The SSTAT command has been deprecated for the Polaris Vicra and Polaris Spectra Systems. To read the status of the Polaris Vicra or Polaris Spectra System, use the command GET (page 66) to read the user parameter **Info.Status.Alerts**.

Example

Command:

```
SSTAT 0001
```

Reply:

```
001414
```

SYSLOG

Writes data to the Position Sensor or System Control Unit log file.

Operating Mode

All modes

Compatibility

All systems

Syntax

`SYSLOG<SPACE>\<Device Name>\<Category>=<Message><CR>`

(API revision G.001.004 or later)

or

`SYSLOG<SPACE><Category>=<Message><CR>`

(API revision G.001.003 or earlier)

Parameter	Description
`Device Name`	Selects a hardware device to write to. See "Device Names" on page 21 for information on device names.
`Category`	A string, up to 12 characters Specifies the log entry category or source. If you enter more than 12 characters, the system will truncate the category to 12 characters.
`Message`	A string, up to 256 characters. Contains the log message. If you enter more than 256 characters, the system will truncate the message to 256 characters.

Replies

Upon Success:

`OKAY<CRC16><CR>`

On Error:

`ERROR<Error Code><CRC16><CR>`

See page 167 for error code definitions.

Usage Notes

1. The system log in each hardware device can store up to 100 Kbytes of data. It is intended to record events central to the life of the device. The system automatically records events such as firmware updates, bump sensor events, and hardware faults in the log.
2. To read the log, use GETLOG (page 74).

Compatibility Notes

For passive systems, only the Position Sensor log file is available.

Example

Command:

```
SYSLOG \SCU-0\Test=This is a SYSLOG test!
```

Reply:

```
OKAYA896
```

TCTST

Returns diagnostics on the active markers of a wired tool.

Operating Mode

Setup

Compatibility

hybrid Polaris Spectra System

Prerequisite Command

INIT (page 78)

Syntax

```
TCTST<SPACE><Port Handle><CR>
```

Parameter	Description
`Port Handle`	2 hexadecimal characters

Replies

Upon success:

```
<Marker A Current><Marker B Current>...<Marker T Current><CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Reply Component	Description
`Marker n Current`	2 hexadecimal characters The electrical current of the markers.

Usage Notes

1. If the result is less than 0x0A either there is no marker, or there is a problem with the diode that has caused an open circuit.
2. If the result is greater than 0x0A the marker is either okay or it has short-circuited. The exact value cannot be predicted as it depends upon the System Control Unit and the tool design (cable length, number of markers, and marker configuration). This value should be determined on a historical basis for each particular tool design.
3. You cannot test a visible LED, since the System Control Unit cannot reliably test the low current of an LED because the LED current result may be corrupted from electrical noise.

Compatibility Notes

The TCTST is fully compatible with the hybrid Polaris Spectra System.

Example

Command:

```
TCTST 01
```

Reply:

```
940000000094010000009200000000940000000DF24
```

TSTART

Starts Tracking mode.

Operating Mode

Setup

Compatibility

All systems

Prerequisite Command

INIT (page 78)

Syntax

```
TSTART<SPACE><Reply Option><CR>
```

Parameter	Description
`Reply Option`	80 (Optional, resets the frame counter to zero)

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

If the reply option 80 is not used, only resetting the system resets the counter for the frame number. The frame number is reported in reply option 0001 of the TX (page 146) and BX (page 47) commands.

Example

Command:

```
TSTART
```

Reply:

```
OKAYA896
```

TSTOP

Stops tracking mode.

Operating Mode

Tracking

Compatibility

All systems

Prerequisite Command

TSTART (page 142)

Syntax

```
TSTOP<SPACE><CR>
```

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Example

Command:

```
TSTOP
```

Reply:

```
OKAYA896
```

TTCFG

Sets up a configuration for a wired tool, so that you can test the tool without using a tool definition file.

Operating Mode

Setup

Compatibility

hybrid Polaris Spectra System

Prerequisite Command

INIT (page 78)

Syntax

```
TTCFG<SPACE><Port Handle><CR>
```

Parameter	Description
Port Handle	2 hexadecimal characters

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

1. TTCFG internally sets up a test configuration for a wired tool, so that it can be tested without having a tool definition file. This is useful for testing the wiring in the tool before characterizing the tool. For example, after sending TTCFG, you can:
   - use TCTST to test the current
   - in diagnostic mode, use IRED to individually activate the markers.
2. After sending the TTCFG command, you will need to initialize (PINIT) and enable (PENA) the port handle before using any other commands that list these as prerequisites.
3. With the test configuration, the tool cannot be tracked.

Compatibility Notes

The TTCFG command is compatible with the hybrid Polaris Spectra System.

Example

Command:

```
TTCFG 0A
```

Reply:

```
OKAYA896
```

TX

Returns the latest tool transformations, individual marker positions, and system status in text format.

Operating Mode

Tracking

Compatibility

All systems

Syntax

```
TX<SPACE><Reply Option><CR>
```

Parameter	Description		G.001.002	G.001.003	G.001.004	G.001.005
Reply Option	Optional. Specifies which information will be returned. If no reply option is specified, the system returns information for reply option 0001. The reply options are hexadecimal numbers that can be OR'd. If multiple reply options are used, the replies are returned for each port handle in order of increasing option value, with the following exceptions: Reply option 0800 is not reported separately from the other options; it simply enables the system to return certain information in the other options. Reply option 1000 is reported after all handle-specific options but before the <system status> and <CRC16>. **Valid Values:**					
	0001	Transformation data (default)	X	X	X	X
	0002	Tool and marker information	X	X	X	X
	0004	3D position of a single stray active marker			X	X
	0008	3D positions of markers on tools	X	X	X	X
	0800	Transformations not normally reported	X	X	X	X
	1000	3D positions of stray passive markers	X	X	X	X

Replies

Upon Success:

```
<# of Handles><Handle 1><Reply Opt 0001 Data>...<Reply Opt 0008 Data><LF>
...
<Handle n><Reply Option 0001 Data>...<Reply Option 0008 Data><LF>
<Reply Option 1000 Data><System Status><CRC16><CR>
```

Note **If the port handle is disabled, the system returns the string DISABLED instead of <Reply Option 0001 Data>...<Reply Option 0008 Data>.**

On Error:

ERROR<Error Code><CRC16><CR>

See page 167 for error code definitions.

Reply Component	Description		G.001.002	G.001.003	G.001.004	G.001.005
Number of Handles	2 hexadecimal characters The number of port handles for which information is returned.		X	X	X	X
Handle n	2 hexadecimal characters The port handle whose information follows.		X	X	X	X
Reply Option m Data	The data specific to the requested reply option. See the reply option information below for details:					
	Reply option 0001 (transformation data) (default)		X	X	X	X
	Reply option 0002 (tool and marker information)		X	X	X	X
	Reply option 0004 (latest 3D position of single, stray, active marker)				X	X
	Reply option 0008 (3D position of markers on tools)		X	X	X	X
	Reply option 0800 (reporting all transformations)		X	X	X	X
	Reply option 1000 (3D position of stray passive markers)		X	X	X	X
System Status	4 hexadecimal characters (16 bits) The status of the system. **Bit field:**					
	bit 0	System communication synchronization error	X	X	X	X
	bits 1 and 2	Reserved				
	bit 3	Recoverable system processing exception.	X	X	X	X
	bits 4 and 5	Reserved				
	bit 6	Some port handle has become occupied			X	X
	bit 7	Some port handle has become unoccupied			X	X
	bit 8	Diagnostic pending	X	X	X	X
	bit 9	Temperature (system is not within operating temperature range)	X	X	X	X
	bits 10 to 15	Reserved				

Note **The "diagnostic pending" bit is set whenever an alert is detected or cleared. To view the alerts status and clear the diagnositc pending bit, use GET (page 66) to check the Info.Status.New Alerts user parameter for every hardware device in the system. See "Usage Notes" on page 56 for more details. (Note: For API revision G.001.003 and earlier, the diagnostic pending bit did not indicate when an alert was cleared.)**

Reply Option 0001 - Transformation Data

<Reply Option 0001 Data> = <Q_0><Q_x><Q_y><Q_z><T_x><T_y><T_z><Error><Port Status>
<Frame Number>
or
<Reply Option 0001 Data> = MISSING<Port Status><Frame Number>

Reply Component	Description	G.001.002	G.001.003	G.001.004	G.001.005
Q0, Qx, Qy, Qz	6 characters each (a sign, and 5 decimal digits with an implied decimal in the position X . XXXX) Rotational component of the transformation, quaternion, unitless. The value for Q0 is always non-negative.	X	X	X	X
Tx, Ty, Tz	7 characters each (a sign, and 6 decimal digits with an implied decimal in the position XXXX . XX) Translational components of the transformation, in mm.	X	X	X	X
Error	6 characters (a sign, and 5 decimal digits with an implied decimal in the position X . XXXX) The error is an RMS value, given in mm. It is the result of the least squares minimization between the marker geometry in the tool definition file and the data from the tool's markers measured by the system.	X	X	X	X

Reply Component	Description		G.001.002	G.001.003	G.001.004	G.001.005
Port Status	8 hexadecimal characters (32 bits) **Bit field:**					
	bit 0	Occupied	X	X	X	X
	bit 1	Switch 1 closed/GPIO line 1 active			X	X
	bit 2	Switch 2 closed/GPIO line 2 active			X	X
	bit 3	Switch 3 closed/GPIO line 3 active			X	X
	bit 4	Initialized	X	X	X	X
	bit 5	Enabled	X	X	X	X
	bit 6	Out of volume	X	X	X	X
	bit 7	Partially out of volume	X	X	X	X
	bit 8	Algorithm limitation (processing requires more buffer than is available)	X	X	X	X
	bit 9	IR interference (a large bright IR object)	X	X	X	X
	bits 10 and 11	Reserved				
	bit 12	Processing exception (same as tool information bit 7 in reply option 0002)	X	X	X	X
	bit 13	Reserved				
	bit 14	Fell behind while processing (same as tool information bit 3 in reply option 0002)	X	X	X	X
	bit 15	Data buffer limitation (too much data; for example, too many markers)	X	X	X	X
	bits 16 to 31	Reserved				
Frame Number	8 hexadecimal characters The frame number is an internal counter related to data acquisition. The counter starts at power up and does not reset until the system is reset (either with RESET or a serial break), the system is powered up again, or reply option 80 is sent with the TSTART command. The frame number corresponds to the frame in which the raw data, used to calculate the accompanying transformation, was collected.		X	X	X	X

Note **The system returns the string MISSING, followed by the port status and frame number, in the following situations:**
- Tools are reported as missing if a transformation cannot be determined.
- GPIO devices and strober port handles that are initialized and enabled are reported as missing.
- In the event of a system error that prevents tracking, all tools and GPIO devices are reported as missing.

Reply Option 0002 - Tool and Marker Information

<Reply Option 0002 Data> = <Tool Information><Marker Information>

Reply Component	Description		G.001.002	G.001.003	G.001.004	G.001.005
Tool Information	2 hexadecimal characters (8 bits) **Bit field:**					
	bit 0	Bad transformation fit	X	X	X	X
	bit 1	Not enough acceptable markers for transformation	X	X	X	X
	bit 2	IR interference—environmental IR is interfering with the system (combination of port status bits 9 and 15 in reply option 0001)	X	X	X	X
	bit 3	Fell behind while processing (same as port status bit 14 in reply option 0001)	X	X	X	X
	bits 4 to 6	Tool face used	X	X	X	X
	bit 7	Processing exception (same as port status bit 12 in reply option 0001)	X	X	X	X
Marker Information	20 hexadecimal characters (1 per marker) See below for an example. **Possible Values:**					
	0	Not used because it was missing	X	X	X	X
	1	Not used because it exceeded the maximum marker angle	X	X	X	X
	2	Not used because it exceeded the maximum 3D error for the tool	X	X	X	X
	3	Used to calculate the transformation	X	X	X	X
	4	Used to calculate the transformation, but it is out of volume	X	X	X	X
	5	Not used because it was outside the characterized measurement volume and was not needed to calculate a transformation.	X	X	X	X

Example - Marker Information: A tool with markers located at T, R, C, and A, where all four markers were used to determine the calculation, would have the reply 30300000000000000303, as illustrated:

Marker Letter	T	S	R	Q	...	D	C	B	A
Reply Char (Hex)	3	0	3	0	...	0	3	0	3

Reply Option 0004 - 3D Position of Single Stray Active Marker

<Reply Option 0004 Data> = <Status><T_x><T_y><T_z>

```
or
<Reply Option 0004 Data> = <Status>
```

Reply Component	Description		G.001.002	G.001.003	G.001.004	G.001.005
`Status`	2 hexadecimal characters (8 bits) The status of the stray active marker. A stray marker on an active tool is not fixed with respect to the other markers that make up the tool. **Bit field:**					
	bit 0	Valid stray active marker			X	X
	bit 1	Marker is missing			X	X
	bit 2	Reserved				
	bit 3	Marker is out of volume			X	X
	bits 4 to 7	Reserved				
`Tx, Ty, Tz`	7 characters each (a sign, and 6 decimal digits with an implied decimal in the position XXXX . XX) Position of the marker, reported in the coordinate system of the Position Sensor. The marker position is reported only if the marker status is “valid,” or if the status is “out of volume” and reply option 0800 is used.				X	X

Note **If no stray active marker is defined (for example, for wireless port handles, GPIO devices, or strobers, or wired tools with no stray marker defined in the tool definition file), the status is 00, and no position information is returned. If the marker is missing, or if the marker is out of volume and reply option 0800 is not used, the system returns only the status.**

Reply Option 0008 - 3D Position of Markers on Tools

<Reply Option 0008 Data> = <Number of Markers><Out of Volume><T_{xn}><T_{yn}><T_{zn}>

Reply Component	Description	G.001.002	G.001.003	G.001.004	G.001.005
Number of Markers	2 hexadecimal characters Number of markers used in tool transformations.	X	X	X	X
Out of Volume	1 hexadecimal character per 4 markers (1 bit per marker) The bit is set when the marker is outside the characterized measurement volume (see example below). Reply size = (number of markers)/4, rounded up to the nearest integer.	X	X	X	X
Txn, Tyn, and Tzn	7 characters each (a sign, and 6 decimal digits with an implied decimal in the position XXXX . XX) Position of the n^{th} marker, reported in the coordinate system of the Position Sensor. The system will report the positions of markers used in tool transformations, as well as markers that exceeded the maximum marker angle or maximum 3D error specified in the tool definition file. See "Usage Notes" on page 155 for more information. **Reply size:** If reply option 0800 is not used, reply size = (21 characters) x (number of markers inside the characterized measurement volume). If reply option 0800 is used, reply size = (21 characters) x (total number of markers).	X	X	X	X

Example - Out of Volume: The information is returned in the format illustrated in the following example: one bit per marker, in little endian format. In this example there are nine markers, all of which are out of volume:

Marker Number				9	8	7	6	5	4	3	2	1
Bit Field	0	0	0	1	1	1	1	1	1	1	1	1
Reply	1				F				F			

Reply Option 0800 - Reporting All Transformations

This option enables the reporting of transformations or translations in situations where translations or transformations are calculated, but by default are not reported by the system. Such situations include:

- The tool or marker is outside of the characterized measurement volume.
- The bump sensor has been tripped.
- The system is outside of the optimal operating temperature range.
- Other system conditions are not ideal; see "Alerts User Parameters" on page 23 for a full list of these conditions.

This reply option must be OR'd with reply option 0001 to obtain transformations for tools in the situations listed above. It must be OR'd with reply options 0004, 0008, or 1000 to obtain position information for markers in the situations listed above.

When using reply option 0800 with the TX command, you must take appropriate action to detect the events listed above, and determine whether they are detrimental to your application. If one or more of the events listed above occurs, reply option 0800 enables the system to return data that may lead to inaccurate conclusions and may cause personal injury.

Appropriate action to detect the events listed above includes:

- reading the out-of-volume flag in reply options 0001 and 0002 when tracking tools
- reading the out-of-volume information in reply options 0004, 0008, and 1000 when tracking stray markers
- reading the temperature flag in the system status
- reading the diagnostic pending bit in the system status
- reading the **Info.Status.New Alerts** user parameter for every hardware device in the system when the diagnostic pending bit is set. See "Usage Notes" on page 155 for details.

Reply Option 1000 - 3D Position of up to 50 Stray Passive Markers

<Reply Option 1000 Data> = <Number of Markers><Out of Volume><T_{xn}><T_{yn}><T_{zn}>

Reply Component	Description	G.001.002	G.001.003	G.001.004	G.001.005
Number of Markers	2 hexadecimal characters Number of stray markers.	X	X	X	X
Out of Volume	1 hexadecimal character per 4 markers (1 bit per marker) The bit is set when the marker is outside the characterized measurement volume (see example below). Reply size = (number of markers)/4, rounded up to the nearest integer.	X	X	X	X
Txn, Tyn, Tzn	7 characters each (a sign, and 6 decimal digits with an implied decimal in the position XXXX . XX) Position of the n^{th} marker, reported in the coordinate system of the Position Sensor. **Reply size:** If reply option 0800 is not used, reply size = (21 characters) x (number of markers inside the characterized measurement volume). If reply option 0800 is used, reply size = (21 characters) x (total number of markers).	X	X	X	X

Note **At least one passive port handle must be enabled, to activate the illuminators on the Position Sensor. If no passive port handles are enabled, <Number of Markers> will return 00 and no other data will be returned.**

Stray passive markers are defined as markers which are not used to calculate any of the transformations for any enabled, passive tools. Stray active wireless tool markers are not reported.

Example - Out of Volume The information is returned in the format illustrated in the following example: one bit per marker, in little endian format. In this example there are nine markers, all of which are out of volume:

Marker Number				9	8	7	6	5	4	3	2	1
Bit Field	0	0	0	1	1	1	1	1	1	1	1	1
Reply	1				F				F			

Usage Notes

1. The TX format is easier to parse than the binary format; it is useful when troubleshooting, or observing data as it is collected. For replies in binary format, use BX (page 47).
2. By default, transformations will not be reported if the tool is either partially or wholly out of the characterized measurement volume, if the bump sensor has been tripped, or if the system is outside of the optimal operating temperature range. To report these transformations, you must use reply option 0800 OR'd with the desired reply option(s). The accuracy of these transformations is unknown.
3. **Reply Option 0001**:
   - When the "diagnostic pending" bit is set in the system status, use GET (page 66) to read the **Info.Status.New Alerts** user parameter for every hardware device in the system. The act of reading these parameters clears the parameters and the "diagnostic pending" bit. For more information on alerts and their associated user parameters, see "Alerts User Parameters" on page 23.
   - For wired tools, bits 1, 2, and 3 in the port status report switch status. For GPIO devices, these bits report the status of GPIO lines defined as inputs.
4. **Reply Option 0008**: Markers are returned in alphabetical order according to how they are labelled in the tool definition file. For example, for a tool with markers labelled A, G, M and S, the system will return the marker positions in the order A G M S. Reply option 0008 only returns data for markers that the system detects. To identify which marker is which, compare the reply option 0008 data to the data returned with reply option 0002. The marker order is the same for both replies; each marker that does not have a <marker information> status of 0 ("missing") in reply option 0002 corresponds to a marker in reply option 0008
5. **Reply Option 1000**: At least one passive tool definition file must be initialized and enabled in order for the system to return stray passive marker data. If no passive tool definition files are enabled, this reply option will return 00.

Compatibility Notes

1. **System Status**:
   - In API revision G.001.004 and later, the diagnostic pending bit (bit 8) is set whenever an alert is detected or cleared. In API revision G.001.003 and earlier, the diagnostic pending bit is set only when an alert is detected.
2. **Reply Option 0002**:
   - Marker information value 2 means that the marker was not used because it exceeded the maximum 3D error for the tool.

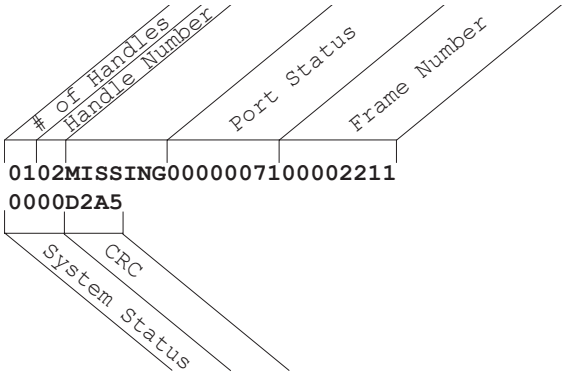
Examples

Example 1

Command:

```
TX 0001
```

Reply:



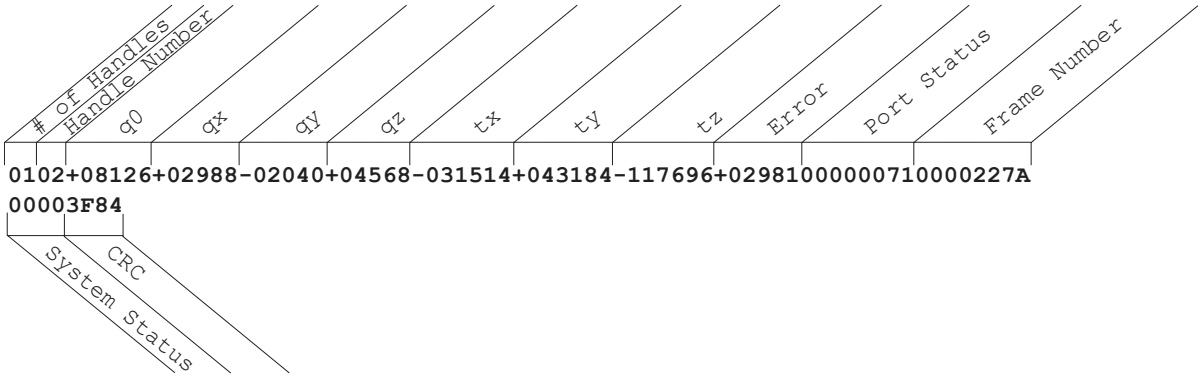
The system reports that there is one tool, which is missing. Notice the port status, which indicates that the tool is occupied, initialized, enabled, and out of volume.

Example 2

Command:

```
TX 0801
```

Reply:



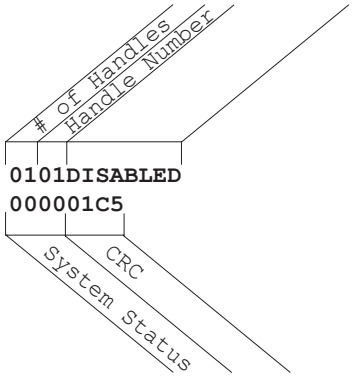
With the 0800 reply option applied, the system reports the missing tool. Notice the port status, which indicates that the tool is occupied, initialized, enabled, and out of volume.

Example 3

Command:

```
TX 0001
```

Reply:



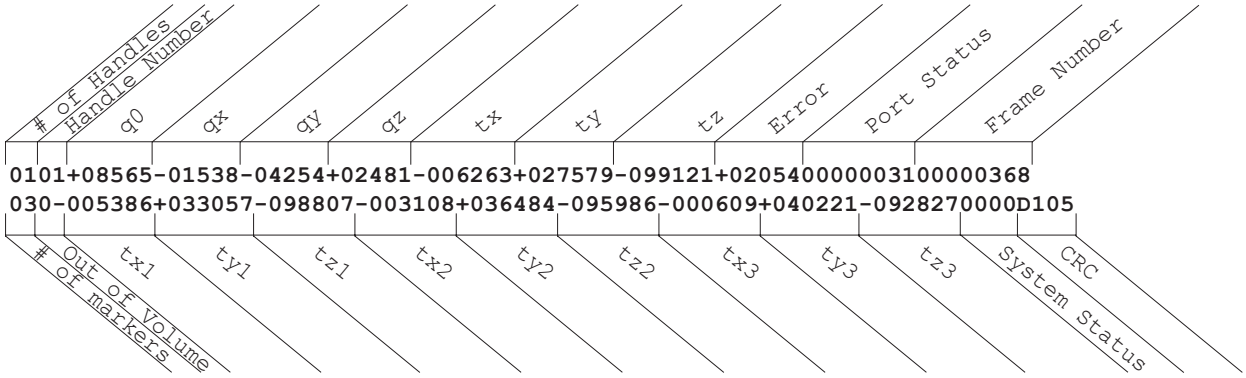
The system reports that there is one tool, whose port handle is disabled. It also reports the system status.

Example 4

Command:

```
TX 1001
```

Reply:



The system reports the transformation for one tool (first line of the reply), and the positions of three stray passive markers (second line of the reply).

VER

Returns the firmware revision number of critical processors installed in the system.

Operating Mode

Setup

Compatibility

All systems

Syntax

```
VER<SPACE><Reply Option><CR>
```

Parameter	Description		G.001.002	G.001.003	G.001.004	G.001.005
Reply Option	Specifies which information will be returned. The reply options cannot be OR'd. **Valid Values:**					
	0	System Control Processor (Position Sensor)	X	X	X	X
	1	Reserved				
	2	Reserved				
	3	System Control Unit Processor			X	X
	4	System Control Processor (Position Sensor), with enhanced revision numbering. The revision numbering is XXX.YYY, where XXX = major revision and YYY = minor revision. The major revision number is always the same as the revision number for parameter value 0.	X	X	X	X
	5	Combined firmware revision number. The revision numbering format is XXX. Only the number is reported; there is no information about the type of system.	*	*	*	*
	6	Reserved				

Replies

Upon Success:

Reply Options 0 to 4, and 6:

```
<Type of Firmware><LF>
<NDI Serial Number><LF>
<Characterization Date><LF> (included only for Reply Option 0 and 4)
<Freeze Tag><LF>
<Freeze Date><LF>
```

```
<Copyright Information><LF>
<CRC16><CR>
```

Reply Option 5:

```
<Combined Firmware Revision><CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

1. If you send the command VER 5 after the INIT command has replied with `ERROR2E`, the reply will be "???", because component versions are incompatible.

Compatibility Notes

1. You can also obtain the combined firmware revision of the system by using the command GET (page 66) to read the value of the user parameter **Config.Combined Firmware Revision**. See "User Parameters" on page 20 for more information on user parameters.
2. **Reply Options 3**: Is not supported by passive systems. For Polaris Spectra, the second line of the response is the serial number of the System Control Unit.

Examples

Command:

```
VER 4
```

Reply:

```
Polaris Spectra Control Firmware
NDI S/N: P7-00733
Characterization Date: 06/04/08
Freeze Tag: Polaris Spectra Rev 006.001
Freeze Date: 03/26/08
(C) Northern Digital Inc.
4923
```

Command:

```
VER 5
```

Reply:

```
0124A94
```

VGET

The VGET command retrieves data previously captured with VSNAP (page 165).

Operating Mode

All modes

Compatibility

All systems

Prerequisite Command

VSNAP (page 165)

Syntax

```
VGET<SPACE><Row><Sensor><Frame Index><Start Column><End
Column><Stride><CR>
```

Parameter	Description
`Row`	4 hexadecimal characters Specifies the row of data to retrieve. **Valid Values:** 0 to the value of the user parameter **Cmd.VGet.Sensor.Height** - 1.
`Sensor`	2 hexadecimal characters Specifies which sensor's data to return. **Valid values:** 0 — Left sensor 1 — Right sensor
`Frame Index`	2 hexadecimal characters The index into the array of frames captured by the VSNAP (page 165) command. Specifies which frame's data to return. The frame index is zero-based. The tool class for each frame is returned in the VSNAP reply; to retrieve information for a particular tool class, use the frame index for that frame returned in the VSNAP reply.
`Start Column`	4 hexadecimal characters Indicates the first column to retrieve. Optional (see "Usage Notes" on page 162). **Valid Values:** 0 to the value of the user parameter **Cmd.VGet.Sensor.Width** - 1.

Parameter	Description
End Column	4 hexadecimal characters Indicates the first column to retrieve. Optional (see "Usage Notes" on page 162). **Valid Values:** 0 to the value of the user parameter **Cmd.VGet.Sensor.Width** - 1.
Stride	2 hexadecimal characters Indicates the stride count to use from start to end column. A lower stride count results in a higher resolution. The stride options are described in "Usage Notes" on page 162. To specify which stride option to use, set the value of the user parameter **Cmd.VGet.Sample Option**. Optional (see "Usage Notes" on page 162).

Replies

Upon Success:

<Header><Length><HeaderCRC><Data><DataCRC>

Note **The reply for the VGET command is binary data.**

On Error:

ERROR<Error Code><CRC16><CR>

See page 167 for error code definitions.

Reply Component	Description
Header	2 bytes: A5C4 Indicates the start of the VGET reply.
Length	2 bytes Indicates data length.
Header CRC	2 bytes CRC16 for header.
Data	Up to 2048 bytes of binary data. The data is a sequence of greyscale pixel intensities. The intensity for each pixel is given by *x* bits of data, where *x* is the value of the user parameter **Cmd.VGet.Color Depth** (see "Usage Notes" on page 162). A pixel intensity of 0 is black, and an intensity of 2^x-1 is white.
DataCRC	2 bytes CRC16 of the <Data> section.

Usage Notes

1. The VGET command retrieves one row of data. To retrieve an entire image, use a sequence of VGET commands. For a lower resolution image, retrieve fewer rows.
2. To use the VGET command, the data bits must be set to 0 (8 bits) using COMM (page 58).
3. Replies are returned in little endian format.
4. The parameters <Start Column>, <End Column>, and <Stride> are optional. You can instead set the values of the user parameters **Cmd.VGet.Start X**, **Cmd.VGet.End X**, and **Cmd.VGet.Stride** for the start column, end column, and stride, respectively.
5. A lower stride count results in a higher resolution. To specify the stride option to use, set the value of the user parameter **Cmd.VGet.Sample Option**. Options are as follows:
   - Point (Cmd.VGet.Sample Option = 0): For a stride of n, returns every n^{th} pixel.
   - Average (Cmd.VGet.Sample Option = 1): For a stride of n, returns the average of the n pixels.
   - Peak (Cmd.VGet.Sample Option = 2): For a stride of n, returns the maximum value of the n pixels.
6. To adjust the number of bits per pixel returned, set the value of the user parameter **Cmd.VGet.Color Depth**. A higher value results in higher picture quality and longer reply length.
7. For diagnostic purposes, it may be helpful to colour-code the image data according to the internal thresholds used by the system. Since these thresholds are dynamic and vary with exposure time and other factors, they have to be retrieved individually for each frame. To determine the threshold values:
   a) Set the value of the user parameter **Cmd.VGet.Threshold.Shutter Time** to the exposure time for the frame and sensor whose threshold you wish to determine. The exposure time is returned in the VSNAP response.
   b) Read the value of the user parameter **Cmd.VGet.Threshold.Trigger**. This value is a function of the exposure time and the sensitivity level (described in the user guide). In order for a marker to be detected by the system, at least on pixel must exceed this threshold.
   c) Read the value of the user parameter **Cmd.VGet.Threshold.Background**. Ideally only markers exceed this threshold.
8. To read user parameter values, use GET (page 66). To set user parameter values, use SET (page 125). For more information on user parameters, see “User Parameters” on page 20.

Example

Command:

```
VGET 000100010010002001
```

VSEL

Selects a characterized measurement volume.

Operating Mode

Setup

Compatibility

All systems (deprecated)

Prerequisite Command

INIT (page 78)

Syntax

```
VSEL<SPACE><Volume Number><CR>
```

Parameter	Description
`Volume Number`	1 hexadecimal character Possible Values: 1 to the maximum returned by SFLIST (page 129)

Replies

Upon Success:

```
OKAY<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Usage Notes

Use SFLIST (page 129) to determine which measurement volumes are available.

Compatibility Notes

The VSEL command has been deprecated for the Polaris Vicra and Polaris Spectra Systems. To select a measurement volume for the Polaris Vicra or Polaris Spectra System, use the command SET (page 125) to set the user parameter **Param.Tracking.Selected Volume**.

Example

Command:

```
VSEL 1
```

Reply:

```
OKAYA896
```

VSNAP

Captures one complete sequence of video data from the sensors. (See the "Usage Notes" on page 166 for details.)

Operating Mode

Diagnostic, Tracking

Compatibility

All systems

Syntax

```
VSNAP<SPACE><CR>
```

Replies

Upon Success:

```
<Frame Number><Number of Frames><Number of Sensors>
<Frame 0 Type><Frame 0 Exposure Time 0><Frame 0 Exposure Time 1>...
<Frame 1 Type><Frame 1 Exposure Time 0><Frame 1 Exposure Time 1>...
...
<CRC16><CR>
```

On Error:

```
ERROR<Error Code><CRC16><CR>
```

See page 167 for error code definitions.

Reply Component	Description
`Frame Number`	8 hexadecimal characters The frame number of the first frame in the sequence
`Number of Frames`	2 hexadecimal characters The number of frames in the sequence
`Number of Sensors`	2 hexadecimal characters The number of sensors for each frame. This is always 2.
`Frame n Type`	2 hexadecimal characters The tool class of frame n. The list of possible values is reported as the enumeration list in user parameter **Cmd.VSnap.Frame Types**. (See GETINFO (page 68) for details on reading the enumeration list of a user parameter.) A value of 0F indicates a frame that is used only for timing purposes, and contains no useful data.

Reply Component	Description
`Frame n Exposure Time m`	4 hexadecimal characters The exposure time of the m^{th} sensor in μsec. Sensor 0 is the left sensor and sensor 1 is the right sensor, from the point of view of the Position Sensor.

Usage Notes

1. The VSNAP command captures one complete sequence of video data from the sensors. The captured data is stored in internal memory; to retrieve the data, use VGET (page 160). A complete sequence of data consists of the following frames:
   - A frame for each type of tool loaded (passive or active wireless). This allows you to see exactly what the Position Sensor detects while it is tracking.
   - An illuminated frame (illuminators are activated), if the user parameter **Cmd.VSnap.Illuminated Frame** is enabled (set to 1). This allows you to detect any infrared light sources caused by reflections.
   - A background frame (illuminators are off), if the user parameter **Cmd.VSnap.Background Frame** is enabled (set to 1). This allows you to detect any environmental infrared light.

Note **The "Cmd.VSnap.Illuminated Frame" and "Cmd.VSnap.Background Frame" user parameters can only be set when the system is in Setup mode.**

2. The exposure time (the amount of time during which the sensors collect light) for the illuminated and background frames is the value of the user parameter **Cmd.VSnap.Manual Shutter**.
3. To read user parameter values, use GET (page 66). To set user parameter values, use SET (page 125). For more information on user parameters, see "User Parameters" on page 20.

Example

Command:

```
VSNAP
```

Reply:

6 Error and Warning Code Definitions

6.1 Error Code Definitions

If the system receives an invalid command, it responds to the host with the message `ERROR<Error Code>`. Table 6-1 identifies the error codes and their definitions.

Table 6-1 Error Code Definitions

Error Code	Definition
01	Invalid command.
02	Command too long.
03	Command too short.
04	Invalid CRC calculated for command; calculated CRC does not match the one sent.
05	Time-out on command execution.
06	Unable to set up new communication parameters. This occurs if one of the communication parameters is out of range.
07	Incorrect number of parameters.
08	Invalid port handle selected.
09	Invalid mode selected. Either the tracking priority is out of range, or an incorrect priority was selected (e.g. the tool has markers defined and “button box” was selected).
0A	Invalid LED selected. The LED selected is out of range.
0B	Invalid LED state selected. The LED state selected is out of range.
0C	Command is invalid while in the current mode.
0D	No tool is assigned to the selected port handle.
0E	Selected port handle not initialized. The port handle needs to be initialized before the command is sent.
0F	Selected port handle not enabled. The port handle needs to be enabled before the command is sent.
10	System not initialized. The system must be initialized before the command is sent.
11	Unable to stop tracking. This occurs if there are hardware problems. Please contact NDI.
12	Unable to start tracking. This occurs if there are hardware problems. Please contact NDI.
13	Hardware error: unable to read the SROM device.
14	Invalid Position Sensor characterization parameters.
15	Unable to initialize the system. This occurs if: • the system could not return to Setup mode • there are internal hardware problems. Please contact NDI. • there are internal parameter errors. Use GET to read the **Info.Status.Alerts** parameter for more details.

Table 6-1 Error Code Definitions (Continued)

Error Code	Definition
16	Unable to start Diagnostic mode. This occurs if there are hardware problems. Please contact NDI.
17	Unable to stop Diagnostic mode. This occurs if there are hardware problems. Please contact NDI.
18	Reserved
19	Unable to read device's firmware version information. This occurs if: • the processor selected is out of range • the system is unable to inquire firmware version information from a processor
1A	Internal system error. This occurs when the system is unable to recover after: • too much IR • a system processing exception
1B	Reserved
1C	Unable to set marker activation signature.
1D	Unable to find SROM device IDs.
1E	Unable to read SROM device data. This occurs if the system is: • unable to auto-select the first SROM device on the given port handle as a target to read from • unable to read a page of SROM device data successfully
1F	Unable to write SROM device data. This can occur if: • the system is unable to auto-select the first SROM device on the given port handle as a target for writing to • an SROM device on the given port handle has not previously been selected with the PSEL command as a target to write to • the system is unable to write a page of SROM device data successfully
20	Unable to select SROM device for given port handle and SROM device ID.
21	Unable to test electrical current on tool.
22	Enabled tools are not supported by selected volume parameters. For example, a Position Sensor cannot track a tool if the volume parameter set does not include the marker wavelength of an enabled tool.
23	Command parameter is out of range.
24	Unable to select measurement volume. This occurs if: • the selected volume is not available • there are internal hardware errors. Please contact NDI.
25	Unable to determine the system’s supported features list. This occurs if the system is unable to read all the hardware information.
26-27	Reserved
28	Too many tools are enabled, or the configuration of tools loaded requires too many frames.

Table 6-1 Error Code Definitions (Continued)

Error Code	Definition
29	Reserved
2A	No memory is available for dynamic allocation (heap is full).
2B	The requested port handle has not been allocated.
2C	The requested port handle has become unoccupied.
2D	All handles have been allocated.
2E	Incompatible firmware versions. This can occur if: • a firmware update failed • components with incompatible firmware are connected To correct the problem, update the firmware. If the Multi Firmware feature is installed, select a valid combined firmware revision.
2F	Invalid port description.
30	Requested port is already assigned a port handle.
31	Invalid input or output state.
32	Invalid operation for the device associated with the specified port handle.
33	Feature not available.
34	User parameter does not exist.
35	Invalid value type (e.g. string instead of integer).
36	User parameter value set is out of valid range.
37	User parameter array index is out of valid range.
38	User parameter size is incorrect.
39	Permission denied; file or user parameter is read-only.
3A	Reserved
3B	File not found.
3C	Error writing to file.
3D-3F	Reserved
40	Tool definition file error. This occurs if: • the CRC failed • the file format is invalid
41	Tool characteristics not supported. This occurs when one of the following fields in the tool definition file is outside of the range supported by the system: • number of markers • number of faces • number of groups • number of markers per face (unique geometry tools only)
42	Device not present. This occurs when the command is specific to a device that is not connected to the system.

Table 6-1 Error Code Definitions (Continued)

Error Code	Definition
43-A1	Reserved
A2	General purpose input/output access on synchronization port failed.
A3-F0	Reserved
F1-FF	Reserved

6.2 Warning Code Definitions

Table 6-2 Warning Code Definitions

Warning	Definition
WARNING	A non-fatal tool error has been encountered, e.g. a burnt out marker.
WARNING02	The tool you are trying to enable is a unique geometry tool that doesn't meet the unique geometry requirements.
WARNING03	The tool you are trying to enable is a unique geometry tool that conflicts with another unique geometry tool already loaded and enabled.
WARNING04	The tool you are trying to enable is a unique geometry tool that doesn't meet the unique geometry requirements, and conflicts with another unique geometry tool already loaded and enabled.
WARNING05	The system has selected a default marker wavelength to track a tool (if the tool's tool definition file did not specify a marker wavelength). Applicable to Combined revision 006 or later.

WARNING and WARNING05 are returned with the returned with the PINIT command.

WARNING02, WARNING03, and WARNING04 are returned with the PENA command.

Appendix A Keyed Features

This section describes how to use the API commands and user parameters with the keyed features. For more information on keyed features, see the user guide that accompanied your system. For more information on user parameters, see “User Parameters” on page 20.

A.1 Disabling and Enabling Keyed Features

Disabling a keyed feature makes that feature unavailable. Enabling a keyed feature makes the feature available. A keyed feature is enabled upon installation.

To disable or enable a keyed feature:

1. Use the API command SET to set the value of the user parameter **Features.Keys.Disabled Keys**.

   The value of this parameter is a comma-separated list. To disable a keyed feature, add its name to the comma-separated list. To re-enable a keyed feature, remove its name from the comma-separated list. For example:

   “SET PS-0.Features.Keys.Disabled Keys=Multi Firmware” will disable the Multi Firmware feature. “SET PS-0.Features.Keys.Disabled Keys=Multi Firmware,Password Protect” will disable both the Multi Firmware and the Password Protect features.
   “SET PS-0.Features.Keys.Disabled Keys=” will re-enable all the installed features keys.
2. Use the API command SAVE to save the settings.
3. Reset the system (use the API command RESET or perform a serial break). The changed settings take effect upon system reset.

A.2 Multi Firmware Feature

The multi firmware feature allows the system to contain more than one combined firmware revision. When the multi firmware feature is enabled, you can specify which combined firmware revision the system will use on its next reset or power up.

Changing the Combined Firmware Revision Currently in Use

Procedure	Example
1. (Optional) Determine which combined firmware revision is currently in use: use the API command GET to read the user parameter **Config.Combined Firmware Revision**.	**Command:** GET Config.Combined Firmware Revision **Reply:** Config.Combined Firmware Revision=002<CRC16>
2. Determine which combined firmware revisions are available:	
API revision G.001.004 and later: use the API command GET (page 66) to read the user parameter **Config.Multi Firmware.Available Combined Firmware Revisions**. The list of possible firmware revisions is given in the enumerated list. In this example, the firmware revisions are 002, 003, and ???.	**Command:** GET Config.Multi Firmware.Available Combined Firmware Revisions **Reply:** 002,003,???<CRC16>
API revision G.001.003 or earlier: use GETINFO (page 68) to read the user parameter **Config.Multi Firmware.Load Combined Firmware Revision**.) The list of possible firmware revisions is given in the enumerated list returned by GETINFO. In this example, the firmware revisions are 002, 003, and ???.	**Command:** GETINFO Config.Multi Firmware.Load Combined Firmware Revision **Reply:** Config.Multi Firmware.Load Combined Firmware Revision=0;1;3;0;255;002,003,???; Combined firmware revision to load on next reset (selection automatically saves when set)<CRC16>
Note: In order to be available for use in a hybrid Polaris Spectra system, a combined firmware revision must be present in both the Position Sensor and the SCU, and must be located in the same position in the enumerated list for both components.	

Procedure	Example
3. Select the desired combined firmware revision: use the API command SET to set the value of the user parameter **Config.Multi Firmware.Load Combined Firmware Revision**. The enumeration is zero-based. For example, to select second item in the list (revision 003), set the value of the user parameter to 1. This parameter value is automatically saved when set. The selected combined firmware revision is loaded on the next reset.	**Command:** SET Config.Multi Firmware.Load Combined Firmware Revision=1 **Reply:** OKAY<CRC16>
4. Reset the system: use the API command RESET, or perform a serial break.	**Command:** RESET 0 **Reply:** RESET<CRC16>

A.3 Password Protect Feature

The password protect feature provides security against changes to the system configuration. When the password feature is enabled, you must enter the correct password before you can:

- save user parameter values,
- update the firmware, or
- install, disable, or enable a keyed feature.

If the correct password has not been entered, user parameter values can be changed (using the command SET) but not saved (using the command SAVE). The user parameters will return to their previous values upon system reset or initialization.

To enter the password, use the command SET (page 125) to set the value of the user parameter **Config.Password** to the correct password. If the system is subsequently reset or initialized, you will have to re-enter the password before you can make changes to the system configuration.

When this feature is installed, **GET Config.Password** will always return the reply Config.Password=******<CRC16>.

The password is obtained from NDI.

Note **If the multi firmware feature is also installed, you can switch between different combined firmware revisions already installed on the system without setting the password.**

A.4 RS-422 Feature

The RS-422 feature configures the serial port on the rear of the SCU to use RS-422 protocol. (When this feature is not installed or enabled, the serial port on the rear of the SCU is configured to use RS-232 protocol.)

To determine the current configuration of the serial port, read the value of the user parameter **Param.Serial Port**.

A.5 Positioning Laser

The positioning laser is located in the Polaris Spectra Position Sensor, and indicates the centre of the characterized measurement volume. This feature allows you to properly position the Position Sensor, or position objects in the measurement volume. Unlike the other keyed features, the positioning laser feature cannot be purchased after you obtain the system; the laser hardware must be installed when the system is manufactured. For full details on the positioning laser, see the user guide that accompanied your system.

Appendix B Sample C Routines

The following sample C routines are included for reference:

Table 6-3 Sample C Routines

Routine	Description
CalcCRC16	Calculates a running CRC16 using the polynomial X^16 + X^15 + X^2 + 1.
EulerAngleTrig	Determines the sine and cosine of the Euler angles.
DetermineR	Calculates the 3x3 rotation matrix which corresponds to the given Euler angles.
CvtQuatToRotationMatrix	Determines the rotation matrix that corresponds to the given quaternion values.
DetermineEuler	Calculates the Euler angles given the 3x3 rotation matrix.
CvtQuatToEulerRotation	Determines the rotation in Euler angles (degrees) that corresponds to the given quaternion rotation.

The following defines are used by the sample C routines:

```
/*
 * Conversion factors.
 */
#define RAD_TO_DEGREES        (180 / 3.1415926)

/*
 * Defined data types.
 */
typedef float
    RotationMatrix[3][3];

typedef struct Rotation
{
    float
        fRoll,      /* rotation about the object's z-axis (Euler angle) */
        fPitch,     /* rotation about the object's y-axis (Euler angle) */
        fYaw;       /* rotation about the object's x-axis (Euler angle) */
} Rotation;

typedef struct QuatRotation
{
    float
        fQ0,
        fQX,
        fQY,
        fQZ;
} QuatRotation;
```

B.1 CalcCRC16

The following is a sample C routine, for calculating a running 16 bit CRC, as used in communications between the host computer and the Polaris System.

```
/*************************************************************
Name:        CalcCRC16

Input Values:
    int
        data         :Data value to add to running CRC16.
    unsigned int
        *puCRC16     :Ptr. to running CRC16.

Output Values:
    None.

Returned Value:
    None.

Description:
    This routine calculates a running CRC16 using the polynomial
    X^16 + X^15 + X^2 + 1.

*************************************************************/
void CalcCRC16( int data, unsigned int *puCRC16 )
{
    static int
        oddparity[16] = { 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0 };

    data = (data ^ (*puCRC16 & 0xff)) & 0xff;
    *puCRC16 >>= 8;

    if ( oddparity[data & 0x0f] ^ oddparity[data >> 4] )
    {
       *puCRC16 ^=0xc001

    } /* if */
    data <<= 6;
    *puCRC16 ^= data;
    data <<= 1;
    *puCRC16 ^= data;

} /* CalcCRC16 */
```

B.2 EulerAngleTrig

```
/*****************************************************************
Name:        EulerAngleTrig

Input Values:
    Rotation
        *pdtRotationAngle :Ptr to struct containing the roll, pitch, yaw
                           Euler angles which define the required rotation.

Output Values:
    Rotation
        *pdtSinAngle :Ptr to struct containing the sine of the roll, pitch,
                      yaw Euler angles.
        *pdtCosAngle :Ptr to struct containing the cosine of the roll, pitch,
                      yaw Euler angles.

Returned Value:
    None.

Description:
    This routine determines the sine and cosine of the Euler angles.

*****************************************************************/
static void EulerAngleTrig( Rotation *pdtRotationAngle,
                Rotation *pdtSinAngle,
                Rotation *pdtCosAngle )
{
    pdtSinAngle->fRoll=    sin( pdtRotationAngle->fRoll );
    pdtSinAngle->fPitch=   sin( pdtRotationAngle->fPitch );
    pdtSinAngle->fYaw =    sin( pdtRotationAngle->fYaw );
    pdtCosAngle->fRoll=    cos( pdtRotationAngle->fRoll );
    pdtCosAngle->fPitch=   cos( pdtRotationAngle->fPitch );
    pdtCosAngle->fYaw=     cos( pdtRotationAngle->fYaw );

} /* EulerAngleTrig */
```

B.3 DetermineR

```
/*****************************************************************
Name:        DetermineR

Input Values:
    Rotation
        *pdtRotationAngle :Ptr to struct containing the roll, pitch, yaw
                           Euler angles which define the required rotation.

Output Values:
    RotationMatrix
        dtRotationMatrix :The 3x3 rotation matrix to be determined.

Returned Value:
    None.

Description:
    This routine calculates the 3x3 rotation matrix which corresponds to the
    given Euler angles.

*****************************************************************/
void DetermineR( Rotation *pdtRotationAngle, RotationMatrix
         dtRotationMatrix )
{
    Rotation
        dtSinAngle, /* the sine of the roll, pitch, and yaw angles */
        dtCosAngle; /* the cosine of the roll, pitch, and yaw angles */

/*
* Might as well determine the sine and cosine of the given Euler
*angles right from the start
*/
EulerAngleTrig( pdtRotationAngle, &dtSinAngle, &dtCosAngle );

/*
* Fill in the rotation matrix.
*/
dtRotationMatrix[0][0] = dtCosAngle.fRoll * dtCosAngle.fPitch;
dtRotationMatrix[0][1] = dtCosAngle.fRoll * dtSinAngle.fPitch *
    dtSinAngle.fYaw - dtSinAngle.fRoll * dtCosAngle.fYaw;
dtRotationMatrix[0][2] = dtCosAngle.fRoll * dtSinAngle.fPitch *
    dtCosAngle.fYaw + dtSinAngle.fRoll * dtSinAngle.fYaw;
dtRotationMatrix[1][0] = dtSinAngle.fRoll * dtCosAngle.fPitch;
dtRotationMatrix[1][1] = dtSinAngle.fRoll * dtSinAngle.fPitch *
    dtSinAngle.fYaw + dtCosAngle.fRoll * dtCosAngle.fYaw;
dtRotationMatrix[1][2] = dtSinAngle.fRoll * dtSinAngle.fPitch *
    dtCosAngle.fYaw - dtCosAngle.fRoll * dtSinAngle.fYaw;
dtRotationMatrix[2][0] = - dtSinAngle.fPitch;
dtRotationMatrix[2][1] = dtCosAngle.fPitch * dtSinAngle.fYaw;
dtRotationMatrix[2][2] = dtCosAngle.fPitch * dtCosAngle.fYaw;

} /* DetermineR */
```

B.4 CvtQuatToRotationMatrix

```
/*****************************************************************
Name:        CvtQuatToRotationMatrix

Input Values:
    QuatRotation
        *pdtQuatRot :Ptr to the quaternion rotation.

Output Values:
    RotationMatrix
        dtRotationMatrix :The 3x3 determined rotation matrix.

Returned Value:
    None.

Description:
    This routine determines the rotation matrix that corresponds
    to the given quaternion.

    Let the quaternion be represented by:

        | Q0 |
    Q = | Qx |
        | Qy |
        | Qz |

    and the rotation matrix by:

        | M00 M01 M02 |
    M = | M10 M11 M12 |
        | M20 M21 M22 |

    then assuming the quaternion, Q, has been normalized to convert
    Q to M we use the following equations:

    M00 = (Q0 * Q0) + (Qx * Qx) - (Qy * Qy) - (Qz * Qz)
    M01 = 2 * ((Qx * Qy) - (Q0 * Qz))
    M02 = 2 * ((Qx * Qz) + (Q0 * Qy))
    M10 = 2 * ((Qx * Qy) + (Q0 * Qz))
    M11 = (Q0 * Q0) - (Qx * Qx) + (Qy * Qy) - (Qz * Qz)
    M12 = 2 * ((Qy * Qz) - (Q0 * Qx))
    M20 = 2 * ((Qx * Qz) - (Q0 * Qy))
    M21 = 2 * ((Qy * Qz) + (Q0 * Qx))
    M22 = (Q0 * Q0) - (Qx * Qx) - (Qy * Qy) + (Qz * Qz)

*****************************************************************/
void CvtQuatToRotationMatrix( QuatRotation *pdtQuatRot,
                RotationMatrix dtRotMatrix )
{
    float
        fQ0Q0,
        fQxQx,
        fQyQy,
        fQzQz,
        fQ0Qx,
```

```
            fQ0Qy,
            fQ0Qz,
            fQxQy,
            fQxQz,
            fQyQz;

        /*
         * Determine some calculations done more than once.
         */
            fQ0Q0 = pdtQuatRot->fQ0 * pdtQuatRot->fQ0;
            fQxQx = pdtQuatRot->fQX * pdtQuatRot->fQX;
            fQyQy = pdtQuatRot->fQY * pdtQuatRot->fQY;
            fQzQz = pdtQuatRot->fQZ * pdtQuatRot->fQZ;
            fQ0Qx = pdtQuatRot->fQ0 * pdtQuatRot->fQX;
            fQ0Qy = pdtQuatRot->fQ0 * pdtQuatRot->fQY;
            fQ0Qz = pdtQuatRot->fQ0 * pdtQuatRot->fQZ;
            fQxQy = pdtQuatRot->fQX * pdtQuatRot->fQY;
            fQxQz = pdtQuatRot->fQX * pdtQuatRot->fQZ;
            fQyQz = pdtQuatRot->fQY * pdtQuatRot->fQZ;

        /*
         * Determine the rotation matrix elements.
         */
            dtRotMatrix[0][0] = fQ0Q0 + fQxQx - fQyQy - fQzQz;
            dtRotMatrix[0][1] = 2.0 * (-fQ0Qz + fQxQy);
            dtRotMatrix[0][2] = 2.0 * (fQ0Qy + fQxQz);
            dtRotMatrix[1][0] = 2.0 * (fQ0Qz + fQxQy);
            dtRotMatrix[1][1] = fQ0Q0 - fQxQx + fQyQy - fQzQz;
            dtRotMatrix[1][2] = 2.0 * (-fQ0Qx + fQyQz);
            dtRotMatrix[2][0] = 2.0 * (-fQ0Qy + fQxQz);
            dtRotMatrix[2][1] = 2.0 * (fQ0Qx + fQyQz);
            dtRotMatrix[2][2] = fQ0Q0 - fQxQx - fQyQy + fQzQz;

    } /* CvtQuatToRotationMatrix */
```

B.5 DetermineEuler

```
/*****************************************************************
Name:         DetermineEuler

Input Values:
    RotationMatrix
        dtRotationMatrix :The 3x3 rotation matrix to convert.

Output Values:
    Rotation
        *pdtEulerRot :Rotation is Euler angle format.
            Roll, pitch, yaw Euler angles which define the required rotation.

Returned Value:
    None.

Description:
    This routine calculates the Euler angles given the 3x3 rotation matrix.

*****************************************************************/
void DetermineEuler( RotationMatrix dtRotMatrix, Rotation *pdtEulerRot )
{
       float
        fRoll,
        fCosRoll,
        fSinRoll;

       fRoll    = atan2( dtRotMatrix[1][0], dtRotMatrix[0][0] );
       fCosRoll = cos( fRoll );
       fSinRoll = sin( fRoll );

       pdtEulerRot->fRoll  = fRoll;
       pdtEulerRot->fPitch = atan2( -dtRotMatrix[2][0],
                            (fCosRoll * dtRotMatrix[0][0]) + (fSinRoll *
       dtRotMatrix[1][0]) );
       pdtEulerRot->fYaw   = atan2(
                            (fSinRoll * dtRotMatrix[0][2]) -
                            (fCosRoll * dtRotMatrix[1][2]),
                            (-fSinRoll * dtRotMatrix[0][1]) +
                            (fCosRoll * dtRotMatrix[1][1]) );

}      /* DetermineEuler */
```

B.6 CvtQuatToEulerRotation

```
/*************************************************************
Name:        CvtQuatToEulerRotation

Input Values:
    QuatRotation
        *pdtQuatRot :Ptr to the quaternion rotation.

Output Values:
    Rotation
        *pdtEulerRot :Ptr to the determined rotation Euler angles.

Returned Value:
    None.

Description:
    This routine determines the rotation in Euler angles (degrees)that
    corresponds to the given quaternion rotation.

*************************************************************/
void CvtQuatToEulerRotation( QuatRotation *pdtQuatRot, Rotation *pdtEulerRot )
{
    RotationMatrix
        dtRotMatrix;

    CvtQuatToRotationMatrix( pdtQuatRot, dtRotMatrix );

    DetermineEuler( dtRotMatrix, pdtEulerRot );

    pdtEulerRot->fYaw   *= RAD_TO_DEGREES;
    pdtEulerRot->fPitch *= RAD_TO_DEGREES;
    pdtEulerRot->fRoll  *= RAD_TO_DEGREES;

} /* CvtQuatToEulerRotation */
```

Abbreviations and Acronyms

Abbreviation or Acronym	Definition
API	Application Program Interface
CPLD	Complex Programmable Logic Device
CRC	Cyclic Redundancy Check
EPROM	Erasable Programmable Read Only Memory
GPIO	General Purpose Input/Output
IEEE	Institute of Electrical and Electronic Engineers
IRED	Infrared light Emitting Diode
LED	Light Emitting Diode
OOV	Out of Volume
Rev xx	Combined firmware revision. For example, rev 24 refers to combined firmware revision 024.
RMS	Root Mean Square
SCU	System Control Unit
SROM	Serial Read Only Memory
TIP	Tool-In-Port

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