

PIONEER

DOPPLER VELOCITY LOG (DVL) 150, 300 AND 600 KHz



**TELEDYNE
MARINE**
Everywhere you look™

P/N 95B-6104-00 (August 2024)

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REVISION HISTORY

August 2024

- Added BM9 minimum ranges to Table 16, page 127.

June 2024

- Updated Table 15, page 127 to match operational specifications.
- Added missing #BZ command. This command is only available in systems with the Low Altitude Bottom Track (LABT) feature.

February 2024

- Updated Returning Systems to the TRDI Factory, page 96 Brokerage address.

November 2023

- Updated Table 29, page 178.

October 2023

- Added a note to RTC Battery Low BIT error on page 195.

July 2023

- Updated website address.

May 2023

- Updated PD6 Health Monitor output.

January 2023

- Added details on Bandwidth specification in Operational specifications and Table 6, page 43.
- Removed RTV from the anode replacement procedure. Applying RTV to the anodes reduces their effectiveness which can lead to corrosion of the housing.
- Updated the EAR statement.

December 2022

- Added the optional Test Cable with USB adapter kit 75BK6143-00.
- Updated the firmware and feature update procedures.
- The Integration Guide is now download only – no printed copy included.

September 2022

- Added Center of Measurement mark to outline installation drawings.

April 2022

- 95Z-6007-00 replaces the 90Z-8000-00 CD.
- Corrected Table 32: Fixed Leader Data Format numbering for Hex digits 101 to 116.
- Corrected Table 39: Bottom-Track Data Format bytes 78 to 81 scaling from Scaling: LSD = 65,536 cm; Range = 65,536 to 16,777,215 cm to Scaling: LSD = 1 cm; Range = 0 to 167,772.15 meters.
- Corrected Table 59: Pioneer Output Data Format (PD4/PD5) Details bytes 14 to 21 scaling from Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm (300 and 150 kHz) to Scaling: LSD = 1 decimeter; Range = 0 to 65535 dm (300, 600, and 150 kHz).

February 2022

- Updated Triggering section.

August 2021

- Corrected PD5 description bytes 55 to 86. Scaling changed from “1 dm” to “1 mm”. Range changed from “-10,000,000 to 10,000,000 mm” to “-4,294,967,296 to +4,294,967,295” mm.
- Updated tables 2 and 3.

May 2021

- Fixed PD6 format with missing CR.
- Added note to CE: CE only applies to the 300 and 600 kHz systems.
- Added the PDDecoder link in the Output Data Format chapter. Use the Teledyne Marine library to decode Teledyne RD Instruments (TRDI) PD data types, such as PDO and waves packets.

December 2020

- Added 96B-9044 outline installation drawing and connector pinout for 1000-meter 150 kHz system.
- Added overview figure for the 1000-meter 150 kHz system.
- Updated 150kHz connection Figure 8.
- Updated cover picture.
- Removed Appendix B.
- Changed the Fixed Leader Data format byte 40 from SPARE to Input Trigger Enable (CX command).
- Updated NAV Parameters format byte 27 shallow operation flag to show all flag settings.
- Updated System Synchronization section.
- Updated Using the SBG Ellipse AHRS Sensor section.
- Updated the PD command to add PD11 and PD26.
- Fixed table cross references where needed.
- Added PD11 and PD26. Note that these output data formats are available with firmware version 57.18 and higher.

April 2020

- Updated the Recommended Practices for Window Use section.
- Updated connector lubrication instructions.
- Updated the PT5 command.
- Change TIME-OF-VALIDITY to Time of Validity so it will show up in a search.
- Added NavUI software to the Navigation CD.

July 2019

- Added 150 kHz command defaults and specifications
- Updated outline installation drawings 96B-9015 and 96B-9034, added 96B-9129
- Added Supported Sensors section to Chapter 1
- Added the OI command
- Added installing firmware and feature upgrades
- Updated Identifying EMI section FFT plots
- Corrected values in Table 7 Approximate Bottom Track Ping Times (in milliseconds) and added equation
- Moved Matlab Output Variable Definitions to Appendix B
- Added note to Choosing an Output Data Format: The Bottom-Track High Resolution Velocity (5803h) and Navigation Parameters Data (2013h) blocks provide aid in the velocity measurement resolution and quality information for use in an Extended Kalman Filter (EKF) Inertial Navigation System (INS) solution
- Added Time to Bottom and Time of Validity figures

- Updated the CX command with the optional ping once parameter
- Updated PC5 and PC50 voltage levels
- Updated the #SO command. The #SO command setting will only be applied to the pressure read from an external sensor
- Updated note on PC2/PC20 test to: This test can be run on the bench, on deck, or in water
- Fixed Table 35 correlation magnitude data identification word as MSB=20h LSB=00h. The MSB is 02h, not 20h
- Fixed Table 36 echo intensity data identification word as MSB=30h LSB=00h. the MSB is 03h, not 30h
- Corrected the Bottom Track Commands Output Format
- Updated the logo to Teledyne Marine

October 2018

- Updated the specifications for maximum altitude Bottom Track with the optional Extended Range Tracking (XRT) for 600 kHz and 300 kHz
- Updated the Minimum Bottom Track Altitude specification for 600 kHz to 0.2 m (<20 cm altitude mode available)
- Updated the OL command with Extended Range Tracking (XRT) mode
- Updated the BX command default with/without Extended Range Tracking (XRT) mode
- Updated #EY command - ID#11 Keller30 external sensor is not used
- Updated Table 30, Summary of Output Data Formats with PDo Speed Over Ground
- Updated the Variable Leader data, bytes 35-42
- Removed Chapter 9, External Sensors

May 2018

- Added 96B-9034 outline installation drawing for 6000-meter 300 kHz Pioneer
- Changed High Accuracy Bottom Track Long Term Accuracy specification for 600 kHz from $\pm 0.3\% \pm 0.2\text{cm/s}$ to $\pm 0.2\% \pm 0.2\text{cm/s}$

April 2018

- Updated the inventory tables
- Added using TRDI Toolz software
- Added 4500-meter system to overview, maintenance, and outline installation drawings
- Added the input trigger voltage is 3.3VDC to 7VDC
- Added how the leak sensor status can be decoded to PC5 and PC50
- Updated Figure 31 PDo Standard Output Data Buffer Format
- Added information on PDo variable leader transmit voltage, current, and impedance.
- Updated the HEM Status byte 67 in the Variable Leader data
- Updated Bottom Track/Water Track STD Deviation description in Navigation Parameters Data
- Corrected Bottom Track Command Output Data format

- Added figures for Environmental Command Parameters Output Format, Bottom Track Command Output Data Format, Bottom Track High Resolution Velocity Output Format, Bottom Track Range Output Data Format, Navigation Parameters Data Format, and Sensor Source for Doppler Processing Output Format
- Added Export Administration Regulations (EAR) footers

July 2017

- Added note: When operating in HEX mode, all console text appears in HEX - including the prompt ">" (HEX "3E") and any additional commands that are typed.
- Added #B1, #B2, #BH, and #WX commands.
- Corrected #SO command.
- Corrected ADC channel 3 and 4 description on Variable Leader Data byte 38 and 39.
- Updated description of bytes 54-85 for Navigation Parameters Data format.
- Updated description of bytes 6-13 for PD4/PD5 details.
- Updated line 2 of PD13 description of temperature – added \pm symbol).
- Added Keller pressure sensor and AHRS specifications.

July 2016

- Updated Navigation Parameters Data Format with Time-of-Validity bytes 54 to 85. See Figure 36 and Table 44.
- Updated outline installation drawings 96B-9015 and 96B-9016.
- Updated specifications.
- Fixed missing graphics on page 81.

March 2016

- Updated SM command with TRDI CTD-Nx CTDs.
- Corrected page 23 from pitch, roll, and yaw-axes to roll, pitch, and yaw-axes.
- Updated PD6 and PD13 with 0x66 Loop Recorder Full error code.
- Updated #EY command table 23. Corrected #EY c d h p r t s u to #EY c d h p r s t u.
- Updated Chapter 9, Detailed Discussion of Individual Sensors for SeaBird SBE-49 and TRDI CTD-Nx CTDs.

December 2015

- Updated PD command
- Added PD13 output
- Updated PD6 output
- Updated #EE command with additional information on bit “f” and corrected default setting.

June 2015

Preliminary Release

HOW TO CONTACT TELEDYNE RD INSTRUMENTS

If you have technical issues or questions involving a specific application or deployment with your instrument, contact our Field Service group:

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Client Services Administration – rdicsadmin@teledyne.com	

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For all your customer service needs including our emergency 24/7 technical support, call +1 (858) 842-2700

Self-Service Customer Portal

Use our online customer portal at <https://www.teledynemarine.com/support/RDI/technical-manuals> to download manuals or other Teledyne RDI documentation.

Teledyne Marine Software Portal

Teledyne RD Instruments Firmware, software, and Field Service Bulletins can be accessed only via our Teledyne Marine software portal.

To register, please go to <https://tm-portal.force.com/TMsoftwareportal> to set up your customer support account. After your account is approved, you will receive an e-mail with a link to set up your log in credentials to access the portal (this can take up to 24 hours).

Once you have secured an account, use the Teledyne Marine software portal to access this data with your unique username and password.

If you have an urgent need, please call our Technical Support hotline at +1-858-842-2700.

CONVENTIONS USED IN THIS MANUAL

Thank you for purchasing a Teledyne RD Instruments Pioneer Doppler Velocity Log (DVL). Conventions used in the Pioneer DVL Guide have been established to help learn how to use the system.

Menu items are printed in bold: **Collect Data**. Items that need to be typed by the user or keys to press will be shown as <F1>. If a key combination were joined with a plus sign (<ALT+F>), press and hold the first key while pressing the second key. Words printed in italics include program names (*TRDI Toolz*) and file names (*TestWH.rds*).

Code or sample files are printed using a fixed font. Here is an example:

```
Pioneer DVL
Teledyne RD Instruments (c) 2021
All rights reserved.
Firmware Version: 57.xx
```

>

There are four other visual aids to help: Notes, Cautions, Recommended Settings, and References.



This paragraph format indicates additional information that may help avoid problems or that should be considered in using the described features.



This paragraph format warns the reader of hazardous procedures (for example, activities that may cause loss of data or damage to the Pioneer).



This paragraph format indicates additional information that may help set command parameters.



This paragraph format tells the reader where they may find additional information.

Chapter 1

AT A GLANCE



In this chapter:

- System Overview
- Models and Options
- Computer Considerations
- Power Overview
- Setting up the Pioneer System
- How to connect and disconnect the cables
- Cable wiring diagrams
- Installing the Optional Mounting Flange
- Caring for the Pioneer System

Overview

The Pioneer transducer assembly contains the connectors with dummy plugs, housing, transducer ceramics, and electronics. The standard acoustic frequencies are 600, 300 and 150 kHz. See the [Outline Installation Drawings](#) for dimensions and weights.



The urethane face covers the transducer ceramics and provides a robust, flexible waterproof seal. Avoid setting the transducer on bumpy surfaces that may leave an indentation in the urethane or damage the urethane face, anodized finish, or paint.



The Pioneer housing contains Electrostatic Sensitive Devices. Take accepted ESD prevention measures before removing the housing.



The DVL PWR/COMM cable connects the Pioneer to the computer and external power supply. When the cables are not connected, use the dummy plugs to protect the connectors.

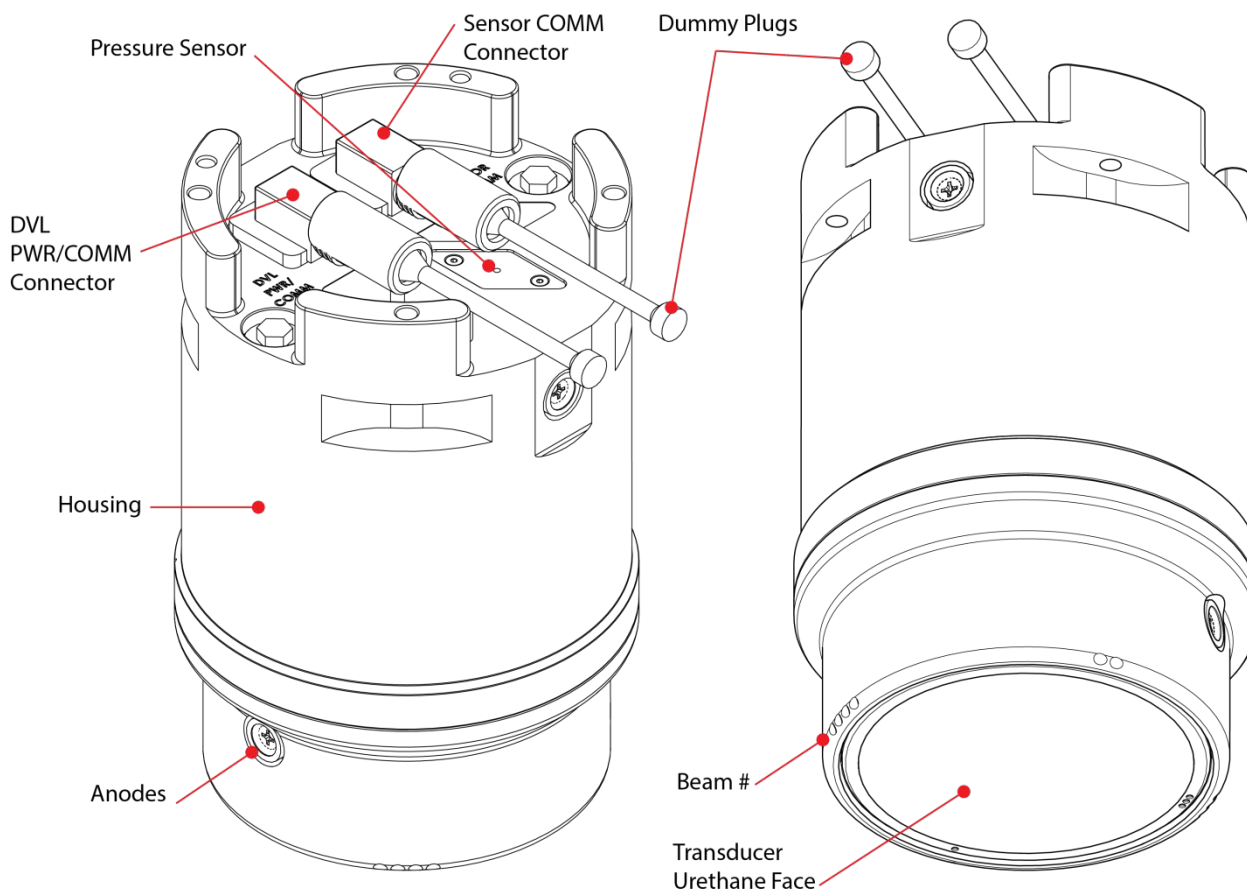


Figure 1. Pioneer 300 kHz Transducer

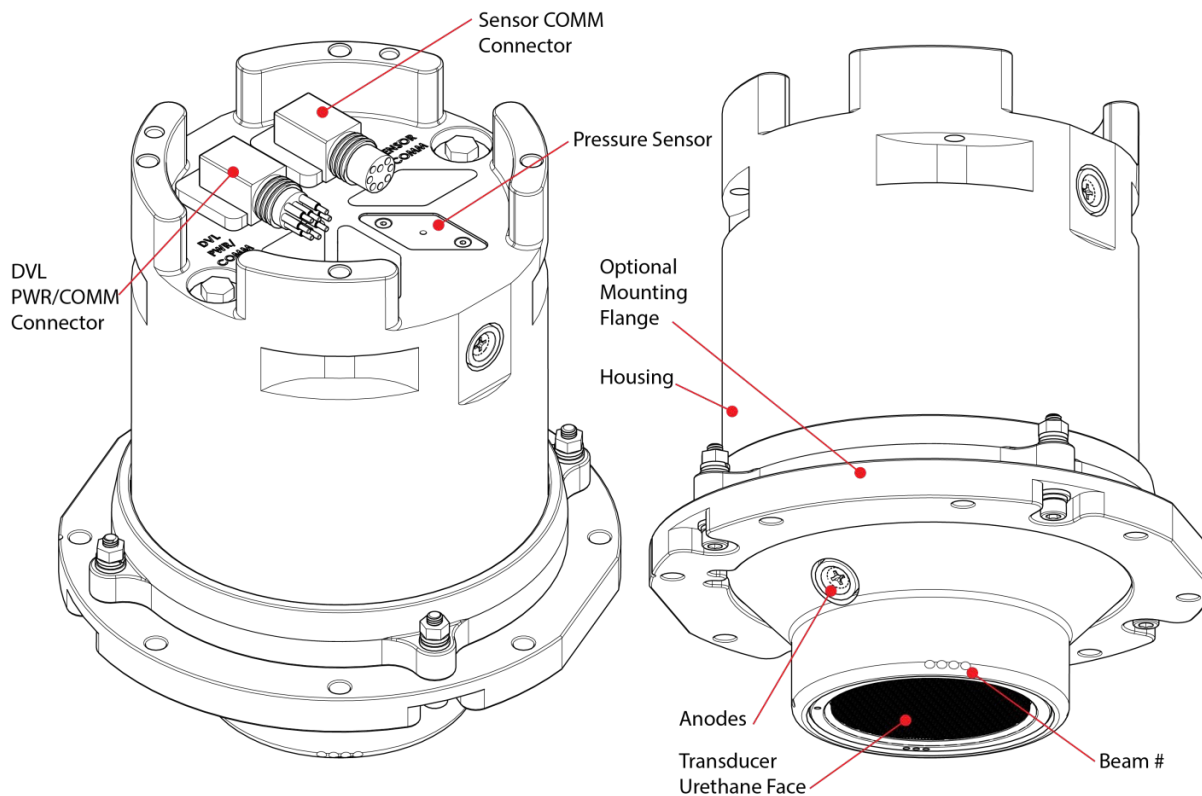


Figure 2. Pioneer 600 kHz Transducer with Optional Mounting Flange

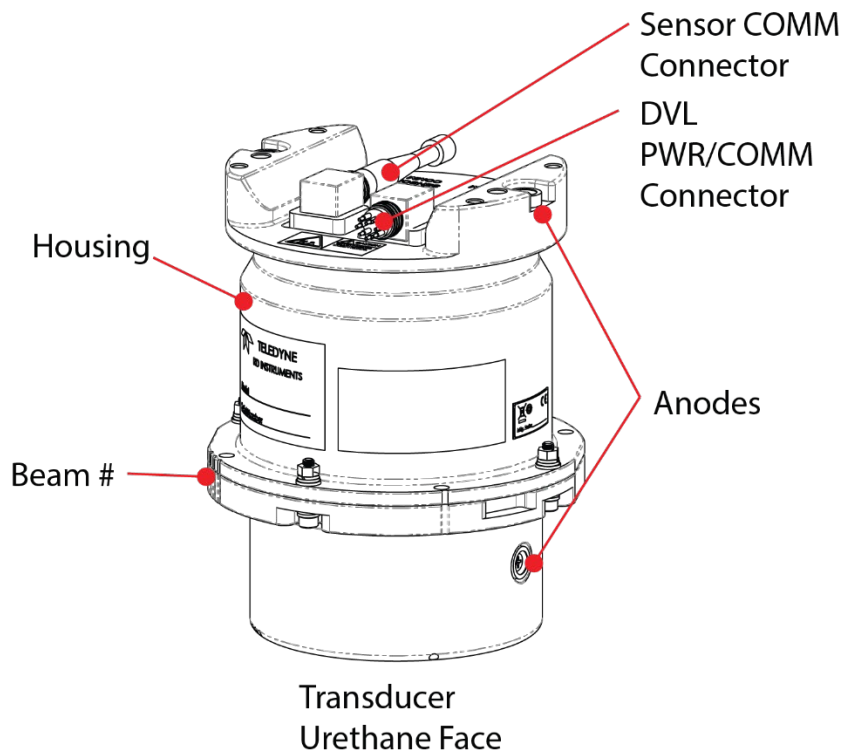


Figure 3. Pioneer 300 kHz 4500-meter Transducer

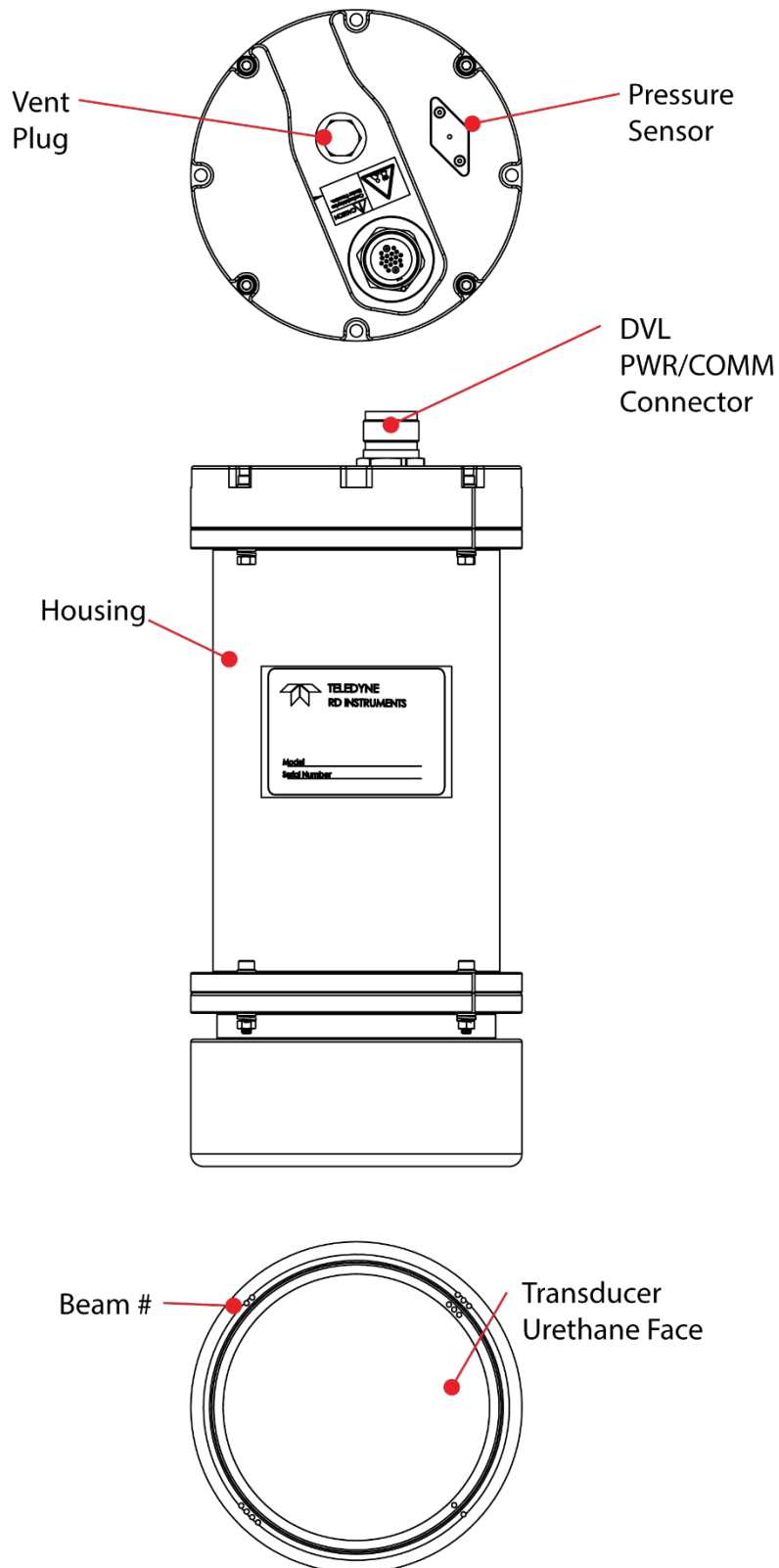


Figure 4. Pioneer 150 kHz 6000-meter Transducer

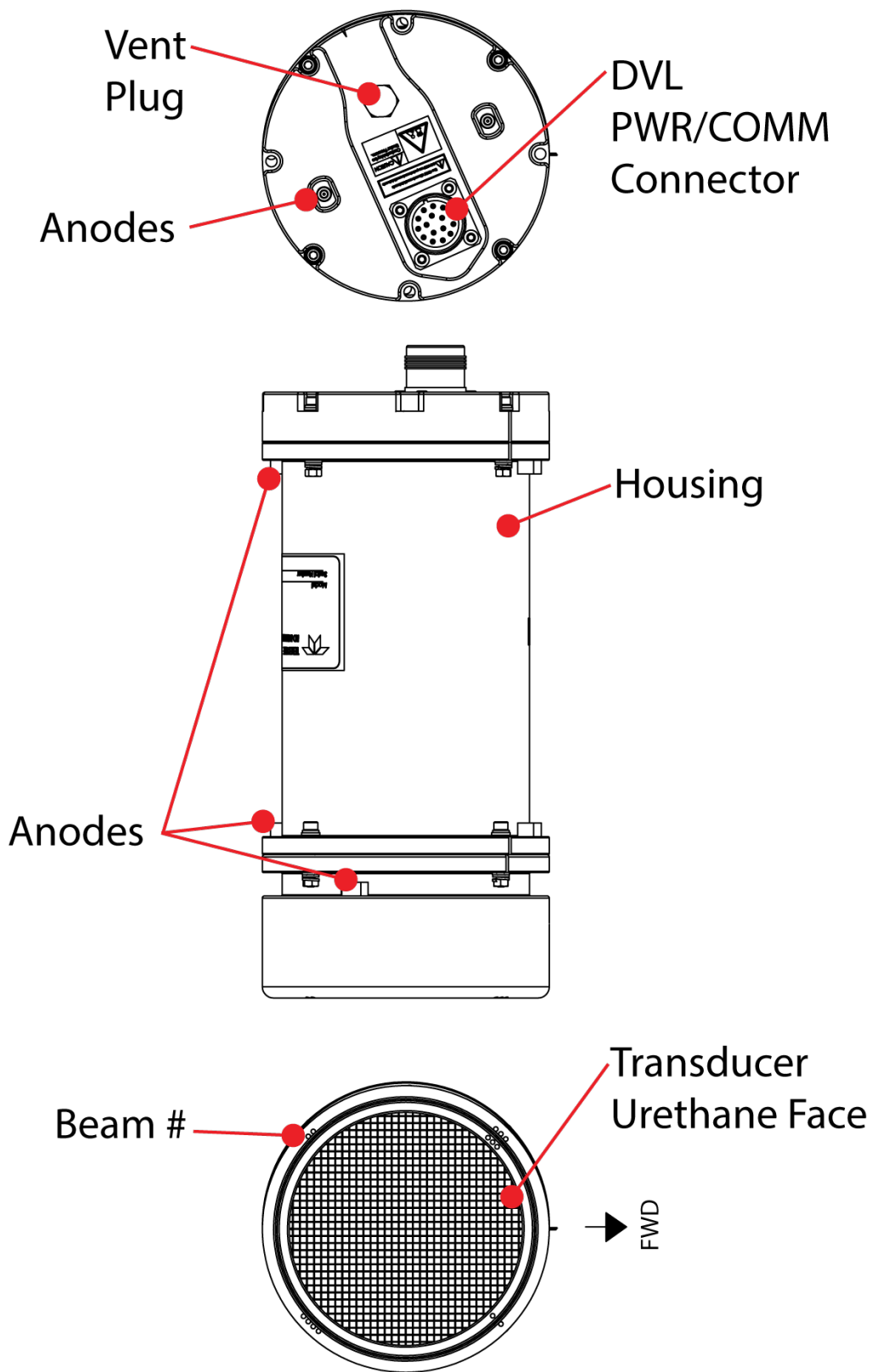


Figure 5. Pioneer 150 kHz 1000-meter Transducer

Options

The following options are available:

- SBG Ellipse-A-G4A2-B1 Attitude and Heading Reference System (AHRS) Sensor; the AHRS sensor provides heading, pitch, and roll information. This option must be selected when the system is ordered.
- Keller Pressure Sensor: Available in multiple Full-Scale ratings per manufacturer specification, 20, 50, 100 BAR. This option must be selected when the system is ordered.
- RS-232 or RS-422; Port 1 is reserved for communicating to and controlling the Pioneer DVL. This port can be configured to use either RS-232 or RS-422.
- Two-piece removable Delrin mounting flange (see Figure 2 and Figure 8) P/N 70BK5000-00.
- Current Profiling Mode firmware upgrade.
- Low-altitude firmware upgrade.
- XRT (Extended Range Tracking) firmware upgrade delivers up to a 60% increase in bottom tracking range. See [Installing Firmware and Feature Upgrades](#). This option requires FPGA version 1.00.012 installed (a factory upgrade). Systems shipped after October 2018 have this version installed. To verify if your system can be field upgraded, run the PS0 command:

```
>ps0
Serial Number: 300300
Frequency: 307200 Hz
Configuration: DVL : 4-beam velocity.
Transducer Type: PHASEDARRAY
Beamformer Rev: XA0
Beam Angle: 30 Degrees
Beam Pattern: CONVEX
Sensors: TEMP
CPU Firmware: 57.14
FPGA Version: 1.00.012 [0x100c]
```

```
Board Serial Number Data:
F5 00 00 05 D0 A8 7D 28 DS18B20 TMP SNS
D8 00 00 02 8A 32 18 23 DSP72B-2212-00C
40 00 00 01 F3 EB 98 23 PER72B-2353-01A
C8 00 00 01 E8 69 89 23 XDR72B-1001-00A
61 00 00 02 BA 18 2B 23 PIO72B-2301-03B
15 00 00 01 E1 DA 27 23 RCV72B-2243-14E
```

Supported Sensors

The following sensors are supported in the Pioneer:

Sensor	Manufacturer	Model
CTD1	Seabird	Fast Cat (SBE 49)
Temperature	TRDI Internal in Transducer	Dallas 18B20 One Wire
Pressure Sensor	Keller	Keller30 74B-111x series
AHRS	SBG	Ellipse-A AHRS
CTD2	TRDI	CTD-Nx



For more information, see the [EZ Command](#) and [#EE command](#).

Health & Environment Monitoring Sensors

Health and Environment Monitoring (HEM) Sensors monitor the health of the Pioneer 300 and 600 kHz systems.

- **Leak Detection** – Water leaking into a Pioneer DVL can not only potentially destroy the DVL, but also cause severe issues for the host vehicle that is carrying the DVL, such as loss of navigation ability. The Pioneer detects water leaking into the system and reports it in the PD0, PD4, PD5, and PD6 messages. The Pioneer also supports the [PC4](#) and [PC5 user interactive test](#) for reporting the status of the leak sensors. There are two leak sensors; one mounted near the connector end (Leak sensor A) and one mounted at the transducer end (Leak sensor B) of the DVL.
- **Transducer Monitor** – The Pioneer monitors the transmit voltage and current of the transducer. This information provides insight, in near real-time, to the status of the transducer and alerts the user should problems arise. This data is relayed back to the user in the PD0 and PD6 output data structure.
- **Operating Time** – The Pioneer system records the total time of operation in minutes where “operation” is defined as the time that the system ping loop is active (CS command has been sent). The record of the total awake time has a maximum value of 33,554,432 minutes, which corresponds to over 500,000 hours of operation. The value of the counter can be read as part of the [PS5 command](#). Although the time is stored in minutes, the operating time is reported in hours with one decimal place.
- **Pressure Cycles** – Pioneer systems with pressure sensors installed record the number of pressure cycles (dives, casts, etc.) to which a unit is exposed during operation. A pressure cycle is defined as “pressure is greater than 40% of maximum, followed by a pressure that is less than 20% of maximum”. The pressure cycle counter has a maximum value of 16,384. Use the [PS5 command](#) to read the number of pressure cycles.
- **Maximum Pressure** – Pioneer systems with pressure sensors installed monitor the pressure during operation and records the maximum pressure seen during the lifetime of the instrument. This maximum pressure is stored in non-volatile memory. The PS5 output will read N/A if no pressure was measured or recorded. Use the [PS5 command](#) to read the maximum pressure seen.
- **Over Pressure** – Pioneer systems with pressure sensors installed monitor water pressure during operation and record the number of events beyond the system’s maximum rated pressure value. The system pressure rating is defined as the maximum pressure rating of the installed pressure sensor. The system maintains a flag in non-volatile memory to indicate whenever the pressure exceeds 100% of the maximum rated value, this flag is set to a ‘1’ value, and whenever pressure is less than 80% of the maximum rated value, this flag is cleared to a ‘0’ and the over pressure cycle counter is incremented. Use the [PS5 command](#) to read the number of over pressure events seen.



The Pioneer system pressure rating is defined as the maximum pressure rating of the installed pressure sensor.

If an Over Pressure event occurs or the Maximum Pressure seen has exceeded the Pioneer’s pressure sensor depth rating, TRDI advises returning the system to us for an inspection before re-deploying.

Example PS5 output:

```
PS5
Operating time: 4327.5 hours
Maximum pressure seen: 652.378 dBar
Over-pressure events: 1
Pressure cycles: 25
```

Setting up the Pioneer System

Use this section to connect the Pioneer to a computer and establish communications. Install the *TRDI Toolz* software in order to communicate with the Pioneer.

Computer and Software Considerations

The Pioneer system includes the utility program *TRDI Toolz* to help set up, test, and troubleshoot the Pioneer. Use this program to “talk” to the Pioneer and to run script files (see [Creating or Modifying Command Files](#) and [send the Commands to the Pioneer](#)). For detailed information on how to use *TRDI Toolz*, see the *TRDI Toolz* Help file.

NavUI can be used to deploy a Pioneer DVL. *NavUI* can also be used ‘behind’ a TSS TOGSNAV or TOGSINS and the DVL data is ‘relayed’ (by the TOGS) to *NavUI* using UDP. *NavUI* can decode any DVL PDO data received from ‘the INS’ connection.



For information on *NavUI*, see the *NavUI* documentation.

TRDI designed the Pioneer to use a Windows® compatible computer. Table 1 lists the minimum computer requirements.



TRDI highly recommends downloading and installing all the critical updates, recommended updates, and the service releases for the version of Windows® being used prior to installing any TRDI software.

Table 1: Minimum Computer Hardware Requirements

Windows 10®, Windows 8®, Windows 7® Desktop, Laptop, or Netbook computer

Screen resolution above 1024x768

One Serial Port (two or more High Speed UART Serial Port recommended)

Software Installation

The Pioneer documentation and software are downloaded.

1. Follow the instruction sheet on downloading TRDI software and manuals.
2. Software is available on <https://tm-portal.force.com/TMsoftwareportal>. Install *TRDI Toolz* and *NavUI*.
3. Use our online customer portal at <https://www.teledynemarine.com/support/RDI/technical-manuals> to download manuals or other Teledyne RDI documentation. Download the Pioneer Guide. PDF versions of all Pioneer documentation are available for download.



Power Overview

The Pioneer requires a DC supply between 10.7 to 36 VDC (32 VDC typical) for the 300/600 kHz systems and 28 to 48 VDC (32 VDC typical) for the 150 kHz Pioneer. Either an external DC power supply or battery can provide this power.

- The power supply should be able to source at least 2 Amps for a bench test setup (no pinging in air).
- Assuming that typical operation will be in water, TRDI recommends a power supply that can provide 6A to 10A at 32VDC for a 300 kHz Pioneer DVL.



See **Table 4. Pioneer Nominal Voltage versus Bottom Tracking Range**, page 32 for a full review of the recommended power supply for system installation.

Power on Cycle

The power supply must be able to handle the inrush current as well. Inrush current is the current required to fully charge up the capacitors when power is applied to the Pioneer. The capacitors provide a store of energy for use during transmit. The inrush current is as much as 9 amps if plugged in after the transducer is fully discharged. The Pioneer will draw this amperage until its capacitors are fully charged (less than 200ms).



If the power supply limits the current or the power drop on the cable is significant, then the power on cycle will fail or the system will reset during pinging. Therefore, TRDI recommends a 6 to 10A power supply to cover all performance cases. For more information, see [Electrical Specifications](#).



TRDI does not recommend pinging the Pioneer system with the transducer in air. The transducer may be damaged. The transducer is pinged by sending a CS, PA, PT3, or PT5 command or if the Pioneer system is started for collecting data.



If the Pioneer system was in [turn-key mode](#) when last powered down, it will automatically resume pinging ten seconds after power is applied. To avoid pinging in air, disable the turn-key mode within ten seconds after applying power by sending a CTO command immediately after receiving the prompt following wake-up message and then send a CK command to save the new setting as the user default. Another way to stop pinging is to send a Break and then send a valid command (for example, send a Break and the OL command) to the Pioneer to stop it from pinging.



Avoid removing the transducer from water if it is actively pinging. First send a break to stop pinging before removing the Pioneer system from water.

Cables and Dummy Plugs

The underwater connectors (on the end-cap) and the cables and dummy plugs are molded wet-mate-able connectors. The end-cap connectors are a factory-installed item. TRDI does not recommend removing it for any routine maintenance.



The dummy plugs should be installed any time the cables are removed. Use the dummy plugs when the DVL is in storage or is being handled.

To disconnect the cable:

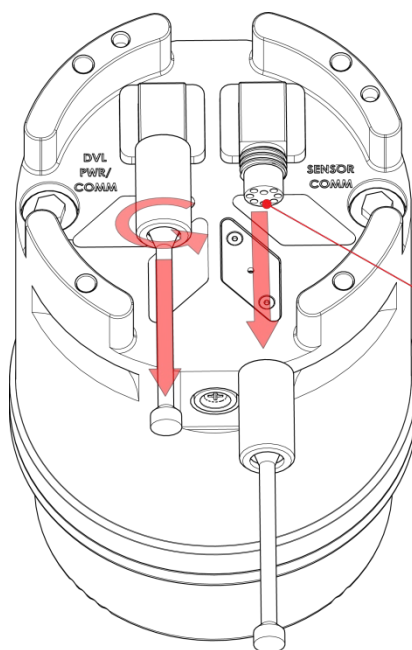
1. Place the Pioneer on a soft pad to protect the transducer face.
2. Release the cable by turning the locking sleeve counterclockwise until it can be moved away from the connector.
3. Pull the cable straight out away from the housing.

To connect the cable:

1. Check all pins for signs of damage (broken or bent pins).
2. Lubricate the connector by placing a light amount of silicone lubricant on the female cable connector mating surfaces (rubber portion only). Silicone lubricant is included in the Spare Parts kit.
3. Push the cable straight onto the connector ensuring the pins are properly aligned. While keeping a slight inward pressure on the cable connector and ensuring that the connector is straight, thread the locking sleeve onto the receptacle to complete the connection.



Do NOT use any tools to tighten the locking sleeve. It should only be “finger tight”.



Apply grease to female face of connector or dummy plug.

Verify grease is transferred to rubber portion of Male pins.

Figure 6. Removing the Cables



Apply lubricant prior to each connection. See [Cable Connector Lubrication](#).

Connecting the Pioneer Cables

To set up the Pioneer:

1. Remove the Dummy plug and lubricate the connector by placing a light amount of silicone lubricant on the female cable connector mating surfaces (rubber portion only). Silicone lubricant is included in the Spare Parts kit.
2. Place the DVL on its transducer face on a soft pad. Remove the DVL/Power/Comm dummy plug and push the cable straight onto the DVL Power/COMM connector ensuring the pins are properly aligned. While keeping a slight inward pressure on the cable connector and ensuring that the connector is straight, thread the locking sleeve onto the receptacle to complete the connection.



Do NOT use any tools to tighten the locking sleeve. It should only be “finger tight”.

3. Attach the DVL/Power/Comm cable to the computer’s serial communication port. Use an RS-422 to RS-232 adapter if the DVL is configured with port 1 as RS-422 (see [Options](#) for details).



If the Pioneer has the RS-422 option (depending on the personality board’s part number), then check to make sure the host computer supports RS-422 or use an RS-422/RS-232 converter. TRDI recommends the B&B Electronics (<http://www.bb-elec.com/>) RS-422/RS-232 converter.

4. Place the Pioneer system in water (at least 2 to 4cm to cover the transducer face).
5. Connect the power adapter cable to the DVL/Power/Comm cable power connector by pushing it all the way in until it “clicks”. Connect 10.7 to 36 VDC (32 VDC typical) for the 300/600 kHz systems and 28 to 48 VDC (32 VDC typical) for the 150 kHz Pioneer. The power supply should be able to source at least 4 Amps.

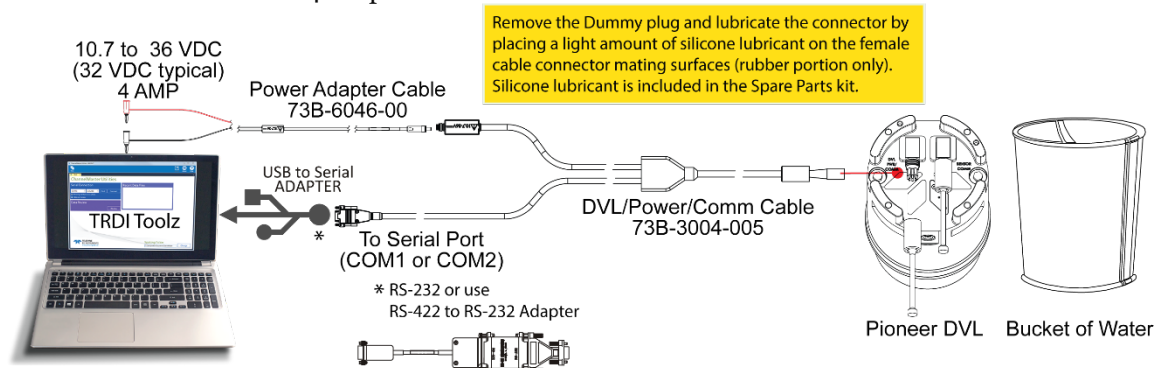


Figure 7. Pioneer 300/600 kHz Connections for Bench Test with Test Cable Kit



The Optional Test Cable Kit 75BK6143-00 includes the 73B-3004-005 test cable, 73B-6046-00 power adapter cable, and the USB adapter.

If you purchase your own USB adapter, TRDI recommends: sales@connectiveperipherals.com <https://us.connectiveperipherals.com/products/ft232r-chipset?variant=32248004476987>. Possibly any device with FTDI drivers and devices will also work.

Installing the USB Adapter Driver

If there is an available internet connection, Windows 10/11 will install the USB driver on first connection. If necessary, install the Virtual COM port (VCP) driver to make the USB adapter appear as an additional COM port. The free FTDI driver download page is available here: <https://ftdichip.com/drivers/>

Use Windows Device Manager® to determine the USB to Serial adapter COM port number. Remove the adapter, wait a moment, note the list of ports, reinsert the adapter and note the new port.

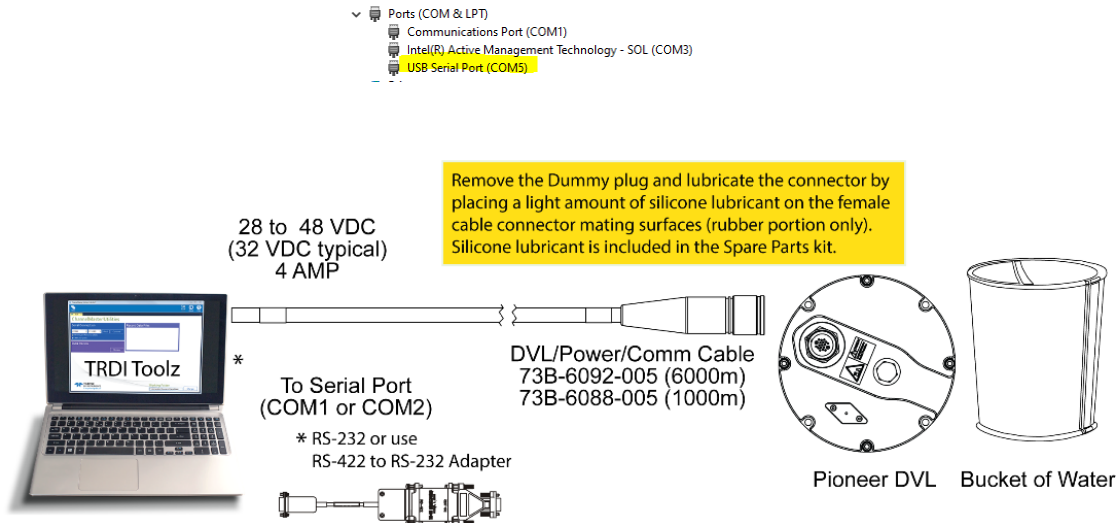


Figure 8. Pioneer 150 kHz Connections



TRDI does not recommend pinging the Pioneer system with the transducer in air. The transducer may be damaged. The transducer is pinged by sending a CS, PA, PT3, or PT5 command or if the Pioneer system is started for collecting data.



If the Pioneer system was in [turn-key mode](#) when last powered down, it will automatically resume pinging ten seconds after power is applied. To avoid pinging in air, disable the turn-key mode within ten seconds after applying power by sending a CT0 command immediately after receiving the prompt following wake-up message and then send a CK command to save the new setting as the user default. Another way to stop pinging is to send a Break and then send a valid command (for example, send a Break and the OL command) to the Pioneer to stop it from pinging.



Avoid removing the transducer from water if it is actively pinging. First send a break to stop pinging before removing the Pioneer system from water.

Cable Wiring Diagrams

This section has information on Pioneer cabling. Special user-requests may cause changes to the basic wiring system and may not be shown here. If there is a conflict, [contact TRDI](#) for specific information about the system. The following figures show various Pioneer cable locations, connectors, and pin-outs.

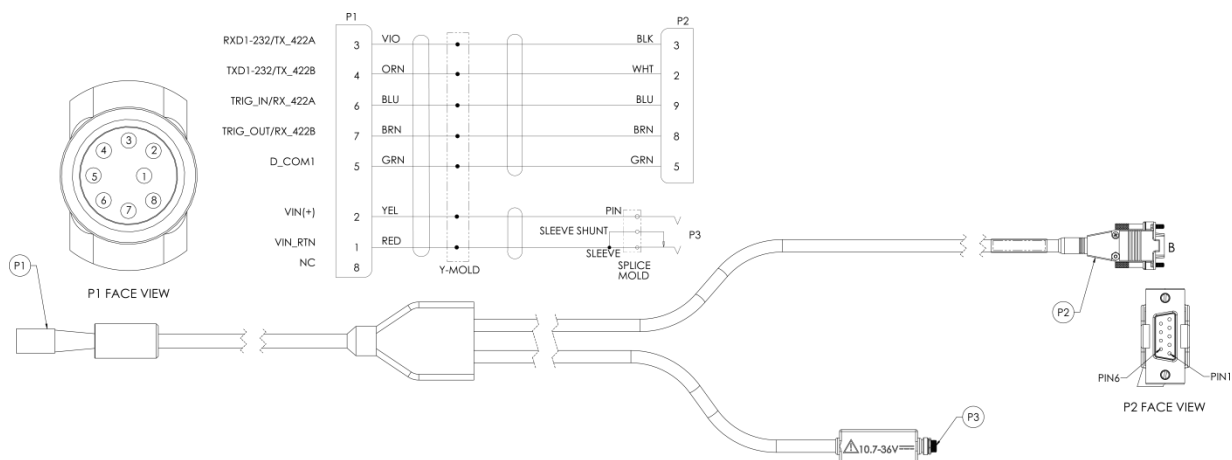


Figure 9. Pioneer DVL/Power/Comm Cable 73B-3004-005



The dummy plug should be installed any time the cables are removed. Use the dummy plug when the Pioneer is in storage or is being handled.



Where shown, RX is the incoming signal; TX is the outgoing signal.

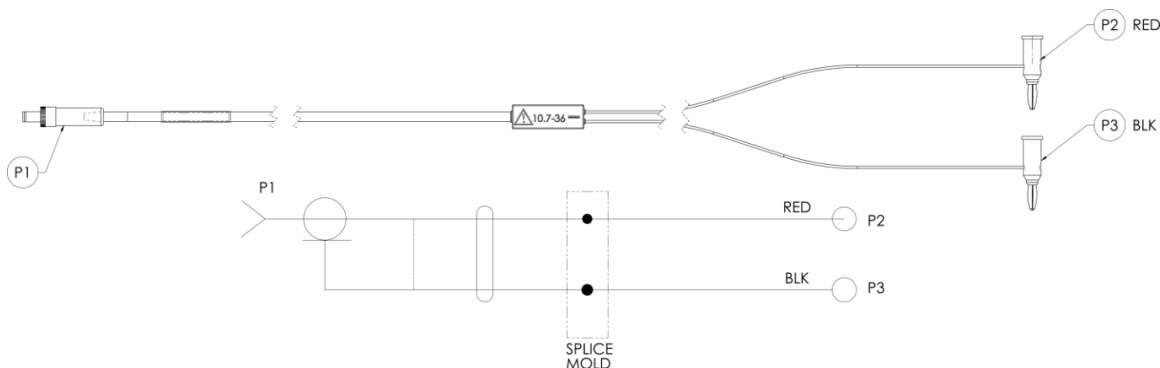


Figure 10. Power Adapter Cable 73B-6046-00

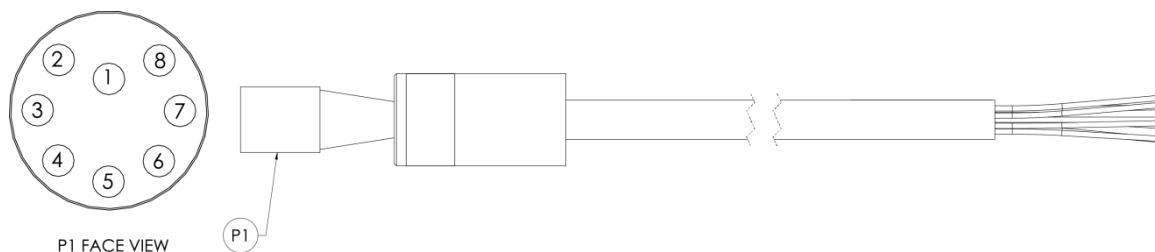


Figure 11. Pioneer DVL/Power/Communication Pigtail Cable P/N MCIL8F

Table 2. Pioneer DVL/Power/Communication Pigtail Cable Wiring

Port 1 = RS-232	Pin #	DVL/Power/Communication Cable
	1	V RETURN (-)
	2	V IN (+)
	3	DVL RS-232 RX
	8	NO CONNECTION
	5	COMM RETURN 1
	7	TRIGGER OUT
	6	TRIGGER IN
	4	DVL RS-232 TX
Port 1 = RS-422	Pin #	DVL/Power/Communication Cable
	1	V RETURN (-)
	2	V IN (+)
	3	RS-422TA
	8	NO CONNECTION
	5	COMM RETURN 1
	7	RS-422RB
	6	RS-422RA
	4	RS-422TB



Port 1 is reserved for communicating to and controlling the Pioneer DVL ONLY. This port will not support sensors. Ports 2, 3, 4 are for sensors.

Trigger In and Out lines must each be referenced to COMM RETURN 1 (pin 5 RS-232).

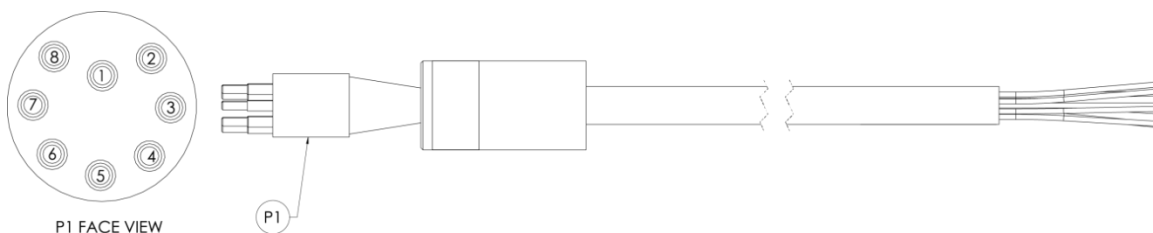


Figure 12. Pioneer Sensor Communication Pigtail Cable P/N MCIL8M

Table 3. Pioneer Sensor Communication Pigtail Cable Wiring

Port 1 = RS-232	Pin #	Sensor Communication Cable
	1	CH2 RS-232 RX
	2	CH2 RS-232 TX
	3	COMM RETURN 1
	8	CH4 RS-232 TX
	5	CH3 RS-232 RX
	7	CH4 RS-232 RX
	6	CH3 RS-232 TX
Port 1 = RS-422	4	COMM RETURN 2
	Pin #	Sensor Communication Cable
	1	TRIGGER IN
	2	TRIGGER OUT
	3	COMM RETURN 1
	8	CH4 RS-232 TX
	5	CH3 RS-232 RX
	7	CH4 RS-232 RX
	6	CH3 RS-232 TX
	4	COMM RETURN 2



Port 1 is reserved for communicating to and controlling the Pioneer DVL ONLY. This port will not support sensors. Ports 2, 3, 4 are for sensors.

Trigger In and Out lines must each be referenced to COMM RETURN 1 (pin 3 RS-422).

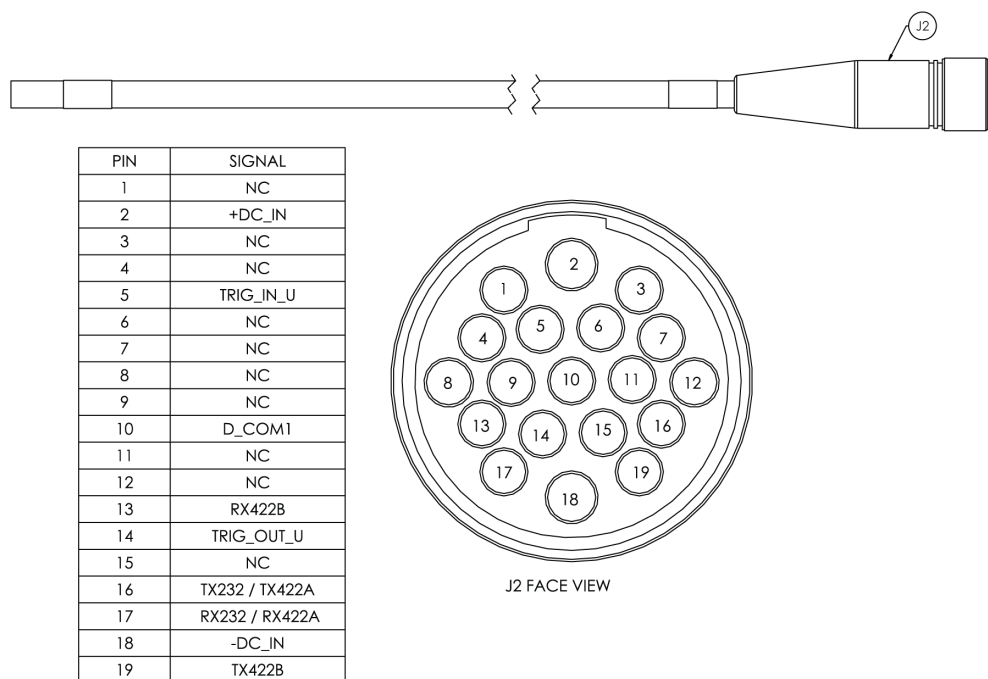


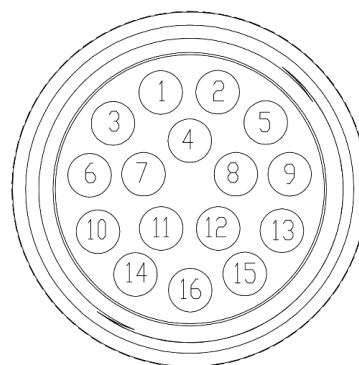
Figure 13. Pioneer 150 kHz 6000 Meter DVL/Power/Communication



Pigtail Cable P/N 73B-6092-xxx. End-Cap Connector P/N MKS(W)-519-BCR mates with MKS(W)-519-CCP Cable Connector.

J1

1	+DC_IN
2	NC
3	-DC_IN
4	TX422A
5	TX422B
6	NC
7	RX422B
8	D_COM1
9	TRIG_IN_U
10	NC
11	RX422A
12	TRIG_OUT_U
13	NC
14	NC
15	NC
16	NC



J1 CABLE CONNECTOR FACE VIEW

Figure 14. Pioneer 150 kHz 1000 Meter DVL/Power/Communication



Pigtail Cable P/N 73B-6088-xxx. End-Cap Connector P/N MKS(W)-716-BCR, mates with MKS(W)-716-CCP Cable Connector.

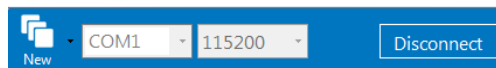
Connecting to the Pioneer

To establish communications with the Pioneer:

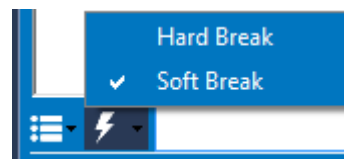
1. Connect the system and apply power.
2. Start the *TRDI Toolz* software.
3. Select **New Serial Connection**.
4. Enter the Pioneer's communication settings.

Serial Communications:

Select the **COM Port** the serial cable is connected to and set the **Baud Rate** from the drop-down list to 115200



5. Click the **Connect** button. Once connected, the button will change to **Disconnect**.
6. Click the **Break** (⚡) button. From the **Break** button drop down menu, select **Soft Break** (= = =). The wakeup banner will display in the terminal window.



```
Pioneer DVL
Teledyne RD Instruments (c) 2021
All rights reserved.
Firmware Version: 57.xx
```

>



The Pioneer DVL **must** be set to 115200 baud if the AHRS Ellipse sensor is installed. Use the [CB command](#) to change the baud rate, if needed.

Testing the Pioneer System

To test the Pioneer:

1. Interconnect the system as described in [Connecting the Pioneer Cables](#).
2. Place the Pioneer transducer in water (at least 2 to 4cm to cover the transducer face).
3. Apply power to the system.
4. Start the *TRDI Toolz* program (for help on using *TRDI Toolz*, see the TRDI Toolz Help file).
5. Click the **Break** button. The wakeup banner appears on the log file window.

```
Pioneer DVL
Teledyne RD Instruments (c) 2021
All rights reserved.
Firmware Version: 57.xx
>
```

6. At the ">" prompt in the communication window, enter the command **CR1** then press the **Enter** key. This will set the Pioneer to the factory default settings.
7. At the ">" prompt in the communication window, enter the command **CK** then press the **Enter** key. This will save the factory default setting.
8. At the ">" prompt in the communication window, enter the command **PS0** then press the **Enter** key. This will display the Pioneer system configuration data.

```
>ps0
Serial Number: 3002
Frequency: 307200 Hz
Configuration: DVL : 4-beam velocity.
Transducer Type: PHASEDARRAY
Beamformer Rev: XA0
Beam Angle: 30 Degrees
Beam Pattern: CONVEX
Sensors: AHRS TEMP PRESS 10BAR
CPU Firmware: 57.01
FPGA Version: 7.00.002 [0x7002]
```

```
Board Serial Number Data:
42 00 00 05 F5 CD 7A 28 DS18B20 TMP SNS
6C 00 00 01 E1 CA 84 23 RCV72B-2243-14E
FB 00 00 01 E8 4E EA 23 PIO72B-2301-03A
BA 00 00 01 D9 F6 1D 23 XDR72B-1001-00A
C0 00 00 01 DA 29 7D 23 DSP72B-2212-00C
34 00 00 01 DA 18 87 23 PER72B-2353-01A
```

9. At the ">" prompt in the communication window, enter the command **PA** then press the **Enter** key. This will run the Pioneer Pre-Deployment test.



Avoid running the PA test in AIR as it may damage the instrument.

Submerge the transducer face in 2 to 4cm of water. **The PA test may fail in air.** Only a failure with the transducer in water is a relevant test.



This test may fail if the Pioneer is exposed to electrical interference such as that from other acoustic devices or SONARS or other electronic devices (i.e. cellphones, radios, computers, TV's, etc.). The test may also fail if the Pioneer or its cable is exposed or installed near potential sources of EMI's such as high voltage lines like main engine cables, galley equipment, winches, engine room equipment, cranes, high voltage lighting circuit, etc. Interference from the mentioned sources may contaminate the Pioneer's data as well. Oftentimes, a noisy (i.e. non-UPS) power supply may cause failures in this test as well.

```
>PA
ROM Test...PASS [ 3aad ]
RAM test...PASS
FRAM test...PASS
Receive Buffer Test...PASSED
XMIT RAM Test...PASSED
Receive Path Test (Hard Limited)...PASSED
Transmit/Receive Continuity Check...PASSED
```

Composite Result:
GO for Deployment

10. If the wakeup displays, PSo displays, and PA message displays with a result of “GO for Deployment”, the Pioneer is functioning normally.



TRDI does not recommend pinging the Pioneer system with the transducer in air. The transducer may be damaged. The transducer is pinged by sending a CS, PA, PT3, or PT5 command or if the Pioneer system is started for collecting data.



If the Pioneer system was in [turn-key mode](#) when last powered down, it will automatically resume pinging ten seconds after power is applied. To avoid pinging in air, disable the turn-key mode within ten seconds after applying power by sending a CTO command immediately after receiving the prompt following wake-up message and then send a CK command to save the new setting as the user default. Another way to stop pinging is to send a Break and then send a valid command (for example, send a Break and the OL command) to the Pioneer to stop it from pinging.



Avoid removing the transducer from water if it is actively pinging. First send a break to stop pinging before removing the Pioneer system from water.

Installing the Optional Mounting Flange

To install the flange:

1. Slide the lower flange onto the housing and align it with the Beam 3 and Beam 1 marks. The notch on the Beam 1 side keeps the housing from twisting inside the flange.
2. Remove the dummy plugs and slide the upper flange over the housing. Install all four sets of hardware as shown in Figure 7.
3. Tighten to M6 nuts sufficiently to flatten the split washer. The flange is made from Delrin; do not over-tighten the hardware.

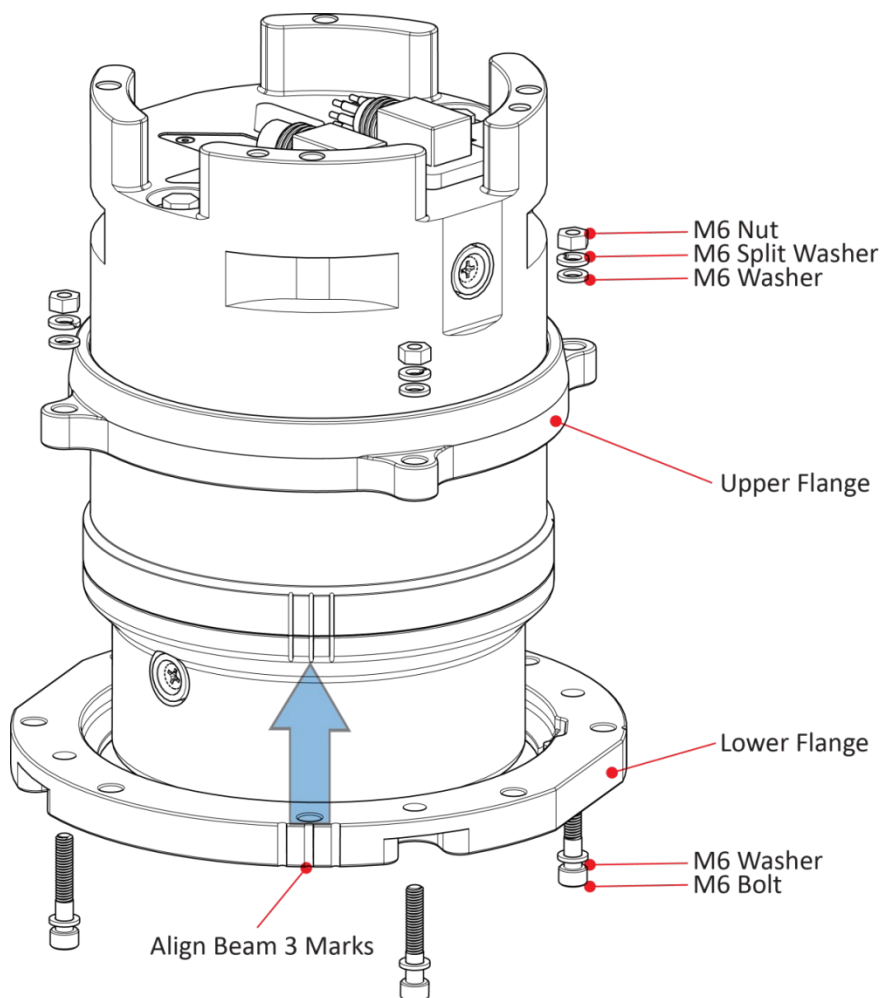


Figure 15. Installing the Optional Mounting Flange

Caring for the Pioneer System

This section contains a list of items to be aware of every time handling, using, or deploying the Pioneer. Please refer to this list often.

General Handling Guidelines



TRDI does not recommend pinging the Pioneer system with the transducer in air. The transducer may be damaged. The transducer is pinged by sending a CS, PA, PT3, or PT5 command or if the Pioneer system is started for collecting data.



If the Pioneer system was in [turn-key mode](#) when last powered down, it will automatically resume pinging ten seconds after power is applied. To avoid pinging in air, disable the turn-key mode within ten seconds after applying power by sending a CTO command immediately after receiving the prompt following wake-up message and then send a CK command to save the new setting as the user default. Another way to stop pinging is to send a Break and then send a valid command (for example, send a Break and the OL command) to the Pioneer to stop it from pinging.



Avoid removing the transducer from water if it is actively pinging. First send a break to stop pinging before removing the Pioneer system from water.

- Never set the Pioneer transducer on a hard or rough surface. **This may leave an indentation in the urethane or damage the urethane face, anodized finish, or paint.**
- Do not expose the transducer face to prolonged sunlight (24 hours or more). **The urethane face may develop cracks.** Cover the transducer face on the Pioneer if it will be exposed to sunlight.
- Do not store the Pioneer in temperatures over 60 degrees C or under -25 degrees C. **The internal components and/or urethane face may be damaged.**
- Do not scratch or damage the O-ring surface or grooves on the transducer. **If scratches or damage exists, they may provide a leakage path and cause the Pioneer to flood.** Do not risk a deployment with damaged O-ring surface.
- Do not lift or support a Pioneer by the external cables. **The connector or cable will break.**
- Apply lubricant prior to each cable connection. **Regular lubrication is required: Apply silicone lubricant prior to each connection.**
- Do not connect or disconnect the cables with power applied. When the cable is connected with power applied, it may cause a small spark. **The connector pins may become pitted and worn.**
- The cables may be connected while slightly wet; do not connect under water.

Installation Guidelines

- Loose, missing, stripped hardware or damaged O-rings can **lead to water ingress and damage the Pioneer.**
- **Do not connect other metal to the Pioneer.** Other metals may cause corrosion damage. Isolating bushings must be used when mounting the Pioneer to a metal structure if the transducer is bolted to the vehicle.

NOTES

Chapter 2

SYSTEM INTEGRATION



In this chapter:

- DVL Theory
- Mechanical Integration Considerations
- Electrical Integration Considerations
- Acoustic Integration Considerations
- Reference, Data & Timing Considerations
- Pioneer DVL Sensor Integration
- Operational and Setup Considerations

System Integration Introduction

This chapter is intended to provide both the basic operating theory and the necessary and often critical implementation and integration considerations for the use of DVL systems on various platform types. In addition, the procedures described provide a step by step guide that will enable the client to configure the Pioneer DVL sonar for optimum utilization.

DVL Theory

BroadBand Doppler

Doppler sonars by definition, measure the Doppler shift, i.e. the frequency shift due to the relative motion of the DVL to either the seabed or suspended scatter particles in the water column. TRDI uses a more precise method of measurement that is a refinement to standard Doppler phase shift measurements called BroadBand. The methodology uses time dilation, by measuring the change in arrival times from successive acoustic pulses. TRDI uses phase to measure time dilation instead of measuring frequency changes because the phase measurement gives a more precise Doppler shift measurement.

TRDI also incorporates a technique called autocorrelation for error checking and thus a further refinement of velocity measurements. Autocorrelation works by transmitting a series of coded pulses, all in sequence and inside a single long pulse. The resulting received signal is composed of many echoes from many scatterers, all combined into a single echo. The propagation delay is extracted by computing the autocorrelation at the time lag separating the coded pulses. The success of this computation requires that the different echoes from the coded pulses (all buried inside the same echo) be correlated with one another.

Bottom Tracking

Bottom tracking is implemented using separate pings from water profiling. The transmit pulse is a longer duration, and the received acoustic signal incorporates a different processing scheme.

While water-profiling uses short transmit pulses to obtain vertical resolution, bottom-tracking requires long duration pulses. Long pulses are utilized because this provides ensonification over a larger bottom area for each individual pulse (Figure 8).

If the pulse is too short or long, the echo returns first from the leading edge of the beam, followed later by the trailing edge. Because the beam has a finite beam width, the angle of the beam relative to the horizontal is different on these two edges, thus resulting in a Doppler shift that is different from one side of the beam to the other. By illuminating the bottom across the beam all at once, a long pulse produces an accurate and stable estimate of velocity, more accurate than is typically obtained from water profiles.

The disadvantage of long transmit pulses is that a considerable part of the echo can come from water-mass echoes. Where water-mass echoes are weak relative to the bottom echo, there is no adverse impact. For environments with high concentrations of suspended sediment (i.e. in some rivers) the water-mass echoes can introduce significant water bias. The added water bias causes an undesirable shift of the bottom-track velocity toward the ambient water velocity.

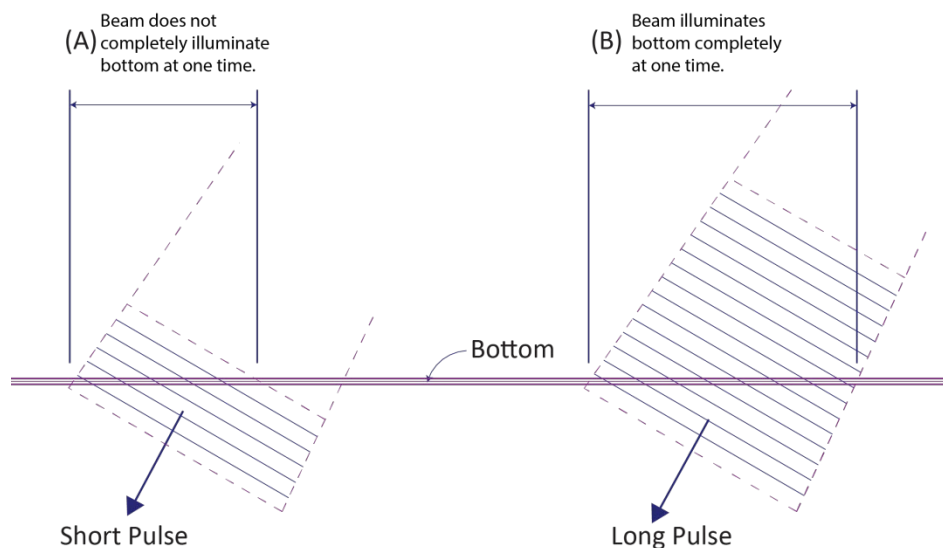


Figure 16. Short Pulse versus Long Pulse

A long Pulse is needed for the beams to ensonify (illuminate) the entire bottom all at once.

Water Tracking

Water tracking is used when the bottom is out of range or a reference velocity is desired. All TRDI DVLs are configured to provide water tracking data. Water tracking is desirable in situations where the bottom is not always within range of the DVL because of suspect bottom track data. The [BK command](#) configures how often water track pings are sent. The number of Water Track pings per ensemble is dependent on the [BP-command](#) (bottom pings per ensemble) and this command setting. Water track pinging is activated from the [BL command](#). Use the BL command to set the location of the Water Track ping.

Required Conditions for Water Tracking

Water Track ping output data is available when both the BK (Water-Mass Layer Mode) and BP (Bottom-Track Pings per Ensemble) instrument settings are nonzero values. The bottom must be at least the Minimum Layer Size + Near Layer Boundary + 20% of the reported depth away from the transducer. The Far boundary cannot exceed 80% of the range-to-bottom of the beam with the shortest altitude. If the bottom comes up so that the Far boundary does not meet this requirement, then the Far boundary is automatically adjusted to ensure this requirement is met, unless the minimum layer size cannot be maintained, in which case the water track ping is skipped and the data is marked bad.

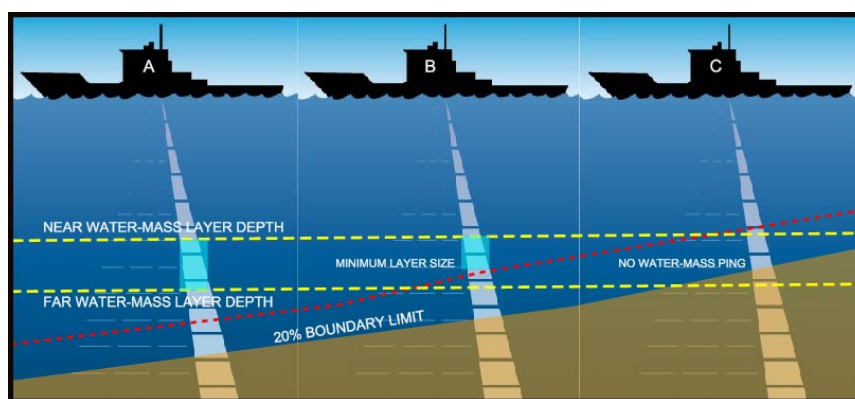


Figure 17. Water-Mass Layer Processing

Water Tracking Parameters

The parameters for DVL water tracking feature is either preset in the instrument default mode or user defined (see the [BK command](#) and Table 14, page 126). The user-defined Water Track ping layer is used unless the layer comes within 20% of the water boundary (sea floor for down-looking systems; surface for up-looking systems). As the user-defined Water Track ping layer comes within 20% of the boundary (Figure 9, B), the layer compresses in size until the minimum water-mass layer size is reached. No Water Track ping will be sent when the boundary exceeds the 20% limit (Figure 9, C).



The water-mass layer is operational only if BP > zero and BK > zero.

Current Profiling

The Pioneer DVL has optional firmware configurations that enable the instruments to measure current velocities in the water column. The DVL, as with all TRDI ADCPs, measures current by dividing the velocity profile into uniform segments called depth cells (depth cells are often called bins). Each depth cell is comparable to a single current meter. Therefore, a DVL velocity profile is like a string of current meters uniformly spaced on a mooring (Figure 10). Thus, we can make the following definitions by analogy:

Depth cell size = distance between current meters. Number of depth cells = number of current meters

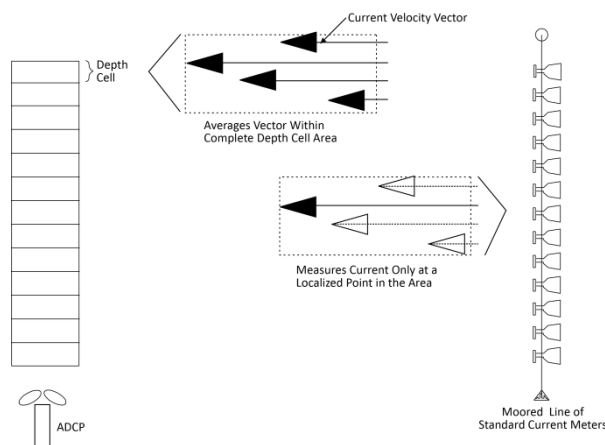


Figure 18. DVL Depth Cells for Current Measurements

The water profile data used for current measurements includes the four different kinds of standard profile data shown below. These data types can be incorporated to varying degrees, depending on the user requirements and mission.

- **Velocity** – as measured from the Doppler shift of the individual beams of the DVL/ADCP.
- **Echo intensity** – A byproduct of the ADCP system. Sometimes used to measure relative sediment, plankton or other suspended particle quantities.
- **Correlation** – an indicator of the fidelity of the ping echo, used for QA.
- **Percent good** – percent of pings that meet specified quality thresholds used for QA.

Beam Coordinate Systems

The Pioneer can produce velocity measurements in any of the following four sets of coordinate axes by setting the [EX command](#). Except for the first, they are all right-handed orthogonal systems. The user operational requirements dictate the best coordinate system to be used.

Earth Axis, also known as Geographic or Geodetic Coordinates. (E, N, U) Earth Axis are selected (default setting) with command EX11xxx. These axes are named east, north, and up. Strictly speaking, these terms refer to true orientations, although magnetic orientations are often used instead. This is the most commonly used coordinate system because it provides a stable reference frame for ensemble averaging.

Radial Beam Coordinates. (BM1, BM2, BM3, BM4) Radial Beam Coordinates are selected by the EX00xxx command. These are the “raw” velocity measurements measured independently by each transducer, in units of millimeters per second. The sense is positive when the motion is towards the transducer. These axes are not orthogonal.

Instrument Coordinates. (X, Y, Z) Instrument Coordinates are selected by the EX01xxx command. This set of axes is always oriented the same relative to the transducer head. Looking at the end view of the housing, the transducers are labeled clockwise in the order 3-2-4-1 (Figure 11). When you look at the face of the transducer head, the transducers are labeled clockwise in the order 3-1-4-2 (see Figure 12, page 28). The X-axis lies in the direction from transducer Beam 1 towards transducer Beam 2 and the Y-axis lies in the direction from transducer Beam 4 towards transducer Beam 3. The Z-axis lies along the axes of symmetry of the four beams, pointing away from the water towards the housing. The internal compass is mounted so that when the X-Y plane is level, the compass measures the orientation of the Y-axis relative to magnetic north.

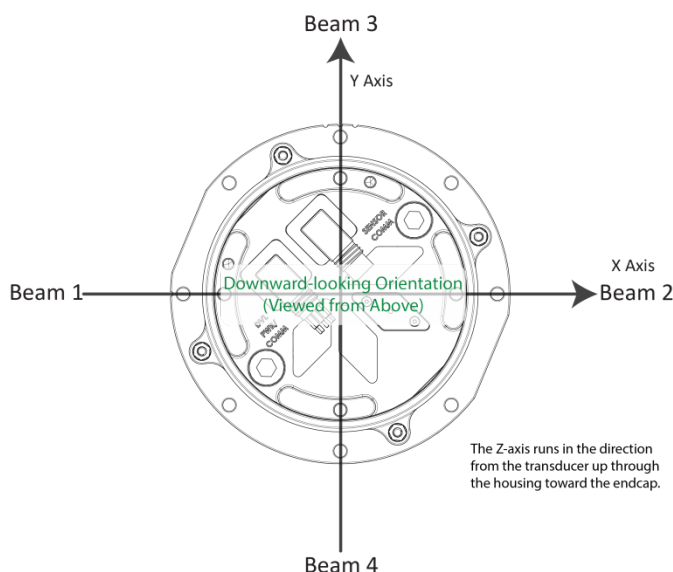


Figure 19. X, Y, and Z Velocities

The PD0 Bottom Track output data format assumes that the instrument is stationary and the bottom is moving.

- If Beam 3 is going forward, then the Y velocity is negative.
- If Beam 2 is going forward, then X velocity is negative.
- If the bottom is going towards the face of a down facing DVL, then Z is positive.

The PD0 High Resolution Bottom Track and PD3 through PD6 data formats assume that the bottom is stationary and that the DVL or vessel is moving.

- If Beam 3 is going forward, then the Y velocity is positive.
- If Beam 2 is going forward, then X velocity is positive.
- If the bottom is going towards the face of a down facing DVL, then Z is negative.

Ship Coordinates (or Righted Instrument Coordinates). (S, F, M) Ship Coordinates are selected by the EX10xxx command. TRDI uses the names Starboard, Forward, and Mast, although these axes are more commonly called the pitch, roll, and yaw-axes, respectively. Assuming that Beam 3 is aligned with the keel on the forward side of the DVL, for the downward-looking orientation, these axes are identical to the instrument axes:

$$S = X, F = Y, M = Z$$

For the upward-looking orientation, these axes are rotated 180° about the Y-axis:

$$S = -X, F = Y, M = -Z$$

The M (mast) axis points in a direction that is closer to upward than downward (mast is always in the same direction no matter if looking down or up).

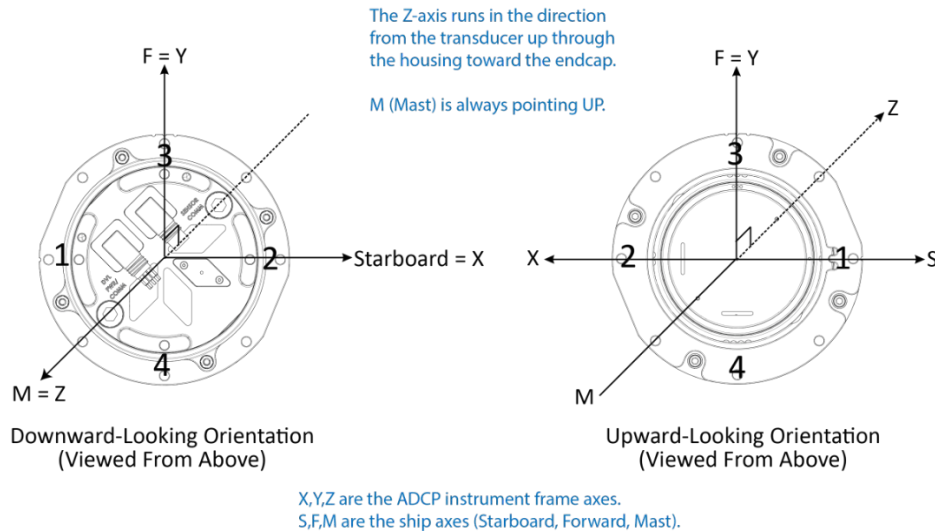


Figure 20. Pioneer Ship Coordinates

The importance of the ship axis is that the attitude angles (pitch, roll, and heading) measure the orientation of the ship axes relative to the earth axes, regardless of up/down orientation. The sense of internal sensors Tilt 1 (pitch) and Tilt 2 (roll) is positive for counterclockwise tilts respectively about the S and F axes, using the right-hand rule (see Figure 13).

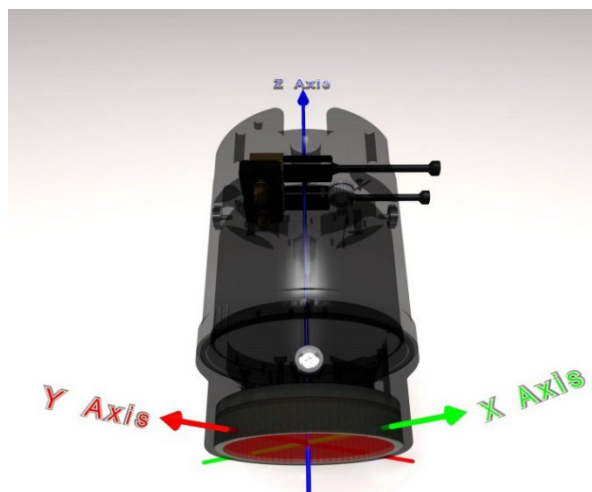


Figure 21. Pioneer Pitch and Roll

Sign of Angle for a Unit Facing	Up	Down
Tilt 1 (Pitch) Beam 3 higher than Beam 4	+	+
Tilt 2 (Roll) Beam 2 higher than Beam 1	+	-

DVL Performance and Influencing Factors

Long Term Performance

TRDI specifies the long-term velocity error of its DVL products as a combination of a percentage of speed (known as “scale factor error”) and an offset (e.g., $\pm 0.4\% \pm 0.2 \text{ cm/s}$ for the Pioneer 300 kHz bottom track measurement). The water- and bottom-track versions have the same form but may have somewhat different values. For water track, the first term scales with the speed through the water (the magnitude of the vector difference between current and boat velocity). For bottom track, it scales with the magnitude of the boat velocity over the bottom.

Almost all known bias mechanisms (other than rounding error) in DVLs approach zero as the speed approaches zero, although it is difficult to demonstrate this empirically. (Note that when the speed is exactly zero, frozen short-term error can look like bias.) The offset specification term should not be interpreted as the standard deviation of the bias at zero velocity, but rather as a way of accommodating non-linear behavior such as biases that oscillate with velocity or that give an increased scale factor bias at low velocity.

The long-term error is also known as systematic error or bias. If we assume that the predictable component of the long-term error has been subtracted out, then the long-term error can be considered to have zero mean, although it may be non-stationary, in which case the mean may not exist. An example of a bias that can be subtracted out is the beam pointing error, which can be removed using a calibrated beam-to-instrument transformation matrix. A calibration always leaves some small residual uncertainty, which can be considered to be another source of long-term error.

When measuring velocity, the bias represents a small error. When using these velocities for navigation the bias errors will accumulate and the total error will grow over time. This bias error can be mitigated using various approaches; TRDI can offer application support in this area.

Bottom Track

The most important source of long-term bottom track error is the beam angle error. TRDI measures this error and provides a beam correction matrix that reduces this error to within the system’s specified accuracy. Improvements in both scale factor and azimuth errors can be made by doing a more extensive calibration on the platform.

The bottom track velocity measurement is proportional to the speed of sound in water. Any error in the sound speed used in the DVL’s internal signal processing (for example errors in the temperature reading or salinity setting) propagates directly into scale factor error. Therefore, it is important to program an accurate salinity into the unit (the DVL has a temperature sensor). Another approach to minimizing sound speed is to incorporate a speed-of-sound sensor. This external reading of the speed of sound can be sent to the DVL, or the DVL’s sound speed can be set to a constant value and then post-processed to correct the data for the actual sound speed in the navigation system software. For most applications, setting the salinity accurately and using the DVL’s integrated temperature sensor is sufficient to yield highly accurate readings.

Water Track

Water Track accuracy is susceptible to the same error sources outlined above. The first term for long term accuracy is determined only by the uncertainty of the beam angles, which is the same for water profile, water track, and bottom track. Thus one can use the same Long Term accuracy as presented for Bottom Track above for water profile and water track. When using the Water Layer mode one must also be aware of the water movement; i.e. currents will be an additional source of error.

Short Term Performance

Short-term errors are random errors with short correlation times that quickly average to zero. They are characterized by the standard deviation. The short-term error in each beam is independent of that in every other beam. Except at very slow speeds, the short-term error in each ping is independent of that of every other ping. The correlation distances at very slow speeds are not accurately known. As the name indicates the short-term error will reduce the accuracy of instantaneous velocity readings but over larger intervals of time these errors will not affect the average velocity reading or navigation.

Bottom Track

The standard deviation of the bottom track velocity measurement varies with altitude and can vary with velocity. The default modes have two primary sub modes, one for shallow water at low speed ([Bottom Mode 8](#)) and one for other cases (Bottom Mode 9).

The Pioneer standard deviation performance depends on altitude. It generally decreases as the altitude gets greater and increases as the altitude gets lower. At the lower altitudes, it increases inversely with altitude. Below these altitudes, the systems attempt to change modes and if successful, the standard deviation drops considerably as the Pioneer flies below its deep switching altitude and then again when it flies below its shallow switching altitudes.

Water Track

The standard deviation of the velocity measurement for Water Layer will vary as the size of the Water Layer varies – see the descriptions for the [#BL command](#) to determine the Water Layer size and the following equation:

$$\text{Std. Dev.} = \frac{\text{Std. Dev. shown}}{\sqrt{\frac{\text{Water Layer Size}}{10 \text{ meters}}}}$$

Altitude Performance

The altitude (distance above the bottom) capability of TRDI DVL's is influenced by:

- Bottom type
- The average temperature and salinity of the water column from the DVL to the bottom
- The voltage supplied to the system
- The attitude of the DVL
- Bottom slope

TRDI specifies this altitude capability for:

- A typical bottom type being level
- A temperature of 5° C, a salinity of 35ppt
- An input voltage of 32v for Pioneer DVLs
- ±5° vehicle pitch or roll

Changes in these values will affect the altitude capability as discussed below.

Bottom Type & Slope

Robert J. Urick (3rd edition, 1983) shows curves of backscatter strength vs. bottom type, frequency, and grazing angle. This analysis shows that the scattering strength of bottoms can vary from approximately -10dB for bottoms of “sand and rock” to -40dB for “muddy” bottoms. A higher value (less negative) of backscatter strength means that the reflected signal from the bottom is larger and that the DVL will operate to greater altitudes. TRDI uses a reasonably conservative value of -28dB for the prediction of a DVL’s altitude performance. While our experience shows that this works in most environments, bottoms that are “bright” (some rocks and/or gravel) will allow the DVL to operate to higher altitudes while bottoms that are “dull” (mud) will limit operation to somewhat lower altitudes than are specified. In general, a 1dB change in backscatter strength will affect the altitude capability of a DVL by approximately 4m and 2m for 300 kHz and 600 kHz Pioneers respectively. Larger (less negative) values increase the altitude capability. Bottom slope also strongly affects the return.

Temperature & Salinity

The transmitted acoustic pulse from a DVL is attenuated as a function of range due to a phenomenon called absorption. Absorption is caused by the conversion of some of the transmitted acoustic energy being converted to heat while traveling through the water. This lowers the available energy for the detection and processing of the reflected pulse from the bottom and affects the DVL’s altitude capability. This absorption loss is influenced through complex physics by the frequency and the average temperature and salinity of the water column.

The 600 kHz systems are minimally affected by temperature and salinity changes. The 300 kHz system is slightly affected by an increase in temperature and salinity. Warmer temperatures continue to degrade its performance. Operation in fresh water enhances a DVL’s altitude capability; in general low-salinity waters will increase the operating range of the unit.

Pitch & Roll

The distance to the bottom of a transmitted pulse for a given beam is a function of the angle of the beam to the vertical. As the vehicle pitches and rolls, this angle can be different for the four beams. Some beams will have further to travel and others will have less. The bottom slope has similar effects. The transmitted energy density of the bottom track pulse is attenuated as it travels through the water column and the further it has to travel, the smaller the energy that is left for detection. As a result, the altitude capability of a DVL may be reduced by the effects of bottom slope, pitch, and roll.

Transmit Power

The altitude capability of a DVL will vary as the input voltage to the system varies. Table 4 below gives an approximation of the range versus battery voltage.

Table 4. Pioneer Nominal Voltage versus Bottom Tracking Range

	Transmit Voltage (V)	Supply Current (A)	Power per Beam (W)	BT Range (m)	Average Power (W)
300 kHz	10	1.4	2	235	3.2
	12	1.6	4	241	3.8
	16	2.1	6	251	5.1
	20	2.5	10	259	6.9
	24	3.0	14	265	9.0
	30	3.7	22	273	13.0
	32	4.0	25	275	14.5
	36	4.5	32	279	17.8
600 kHz	10	0.6	1	86	2.4
	12	0.6	1	89	2.6
	16	0.8	2	93	3.0
	20	0.9	3	96	3.6
	24	1.0	5	99	4.3
	30	1.2	7	102	5.5
	32	1.3	8	103	6.0
	36	1.5	10	105	7.1

Slant Range Performance

The accuracy of the altitude measurement of TRDI DVL's is not specified but has been shown to be less influenced by environmental factors. It is important to know that the systems do not measure the altitude by using a beam that is directed straight down as an altimeter might do. Rather, they measure the "slant range" along the four narrow beams that are at an angle to the vertical (normally 30°). In doing this, they measure the time it takes for the transmitted pulse to travel to the bottom, get reflected, and travel back to the instrument. This time is then multiplied by the speed of sound that either the user enters or is computed from the temperature and salinity data that the instrument has. The "slant range" is then projected into the vertical by multiplying by the Cosine of the Janus angle (normally 30°). Naturally, each beam's measurement of this "slant range" will change as the environment changes. These changes include vehicle attitude (pitch and roll), bottom slope, and changes in the speed of sound. The next sections discuss the errors that these environmental changes cause. This is followed by a brief discussion of the additional, improved outputs that the Pioneer DVLs provide.

Speed of Sound Variation

As the speed of sound changes through the water column either due to temperature or salinity changes, the time it takes for the round-trip travel time changes. For example, a decrease in sound speed will cause an increase in travel time and the instrument (not knowing about the change in sound speed) will interpret this as a longer “slant-range”. A somewhat mitigating effect is that the beams will refract as the sound speed changes. For example, a decrease in sound speed will refract the beam towards the vertical which decreases the distance the pulse has to travel and this partly offsets the change in travel time. This error is difficult to calculate because one needs to know the actual speed of sound profile in the water column. A couple of examples are given below:

Example 1: A linearly changing temperature from 15°C at the instrument to 4°C at 250m depth will cause the “slant range” measurement to read high by about 1% at an altitude of 250 meters.

Example 2: A step change in temperature of 10°C at a depth of 50 meters will increase the “slant range” measurement a little less than 1% when operating at 100m altitude.

Bottom Slope

Pioneer DVLs multiply the measured “slant range” of each beam by the Cosine of the Janus angle (normally 30°) to indicate the vertical distance. While a simple solution is to average the four beam values obtained for altitude, this is not the preferred method. The equation for this is shown as (1) below. This is reasonably accurate when there is no bottom slope, but a better algorithm is shown in (2) below for bottoms that are sloped.

$$h \approx \frac{h_1 + h_2 + h_3 + h_4}{4} \quad (1)$$

$$h = \frac{1}{\frac{1}{h_1} + \frac{1}{h_2}} + \frac{1}{\frac{1}{h_3} + \frac{1}{h_4}} = \frac{h_1 h_2}{h_1 + h_2} + \frac{h_3 h_4}{h_3 + h_4} \quad (2)$$

Where h is the altitude and the h_1, h_2, h_3, h_4 are the four beam “slant ranges” projected into the vertical. This equation is exact if the bottom is a plane surface.

Pitch & Roll

Pitch and/or roll of the instrument causes the h components shown in (1) above to change. Because it is complicated to compute the h components for all combinations of pitch, roll, and bottom slope, the worst-case relative error as calculated by equation (1) above is used and is approximately:

$$\frac{\Delta h}{h} \approx 1 + \frac{1}{2} \phi^2 \pm \beta \phi - \frac{1}{2} \beta^2 \tan^2 \theta$$

where β is the bottom slope in radians,
 ϕ is the instrument tilt in radians, and
 θ is the beam Janus angle.

This method is used in the case that tilts and bottom slope are in the same direction. Note that the error is second order in the bottom slope and tilt parameters. An 8 degree tilt will cause the simple four-beam average to be 1% long. A 14 degree bottom slope will cause it to be 1% short (when the beam Janus angle is 30°).

Resolution

The Pioneer DVLs provide two additional altitude outputs in the [Bottom Track Range Format](#). The first is called “Slant Range” which is actually a range to the bottom in the Z axis. It is a combination of the four slant ranges per equation (2) above. The second is called “Vertical Range” where the instrument pitch

and roll are used to calculate the altitude. This is the most accurate output for altitude since it compensates for the orientation of the instrument.

Mechanical Integration Considerations

Alignment

The mechanical alignment of the transducer head is important to DVL data accuracy. Mechanically mount the head as close as possible to your reference point. This is usually with the Beam 3 mark at 0° or 45° relative to the ship's fore-to-aft centerline. You also must mount the transducer head as level as possible using the ship's roll and pitch references.

TRDI recommend mounting the transducer head with Beam 3 (instrument Y axis) rotated 45° relative to the ship forward axis (Figure 22). This causes the magnitude of the signal in each beam to be about the same. This improves error rejection, reduces the effect of ringing, and increases the Pioneer's effective velocity range by a factor of 1.4. If Beam 3 is aligned at an angle other than zero, use the EA command to describe the rotation between instrument Y-axis (beam 3) and ship forward axis. Refer to [EA - Heading Alignment](#).

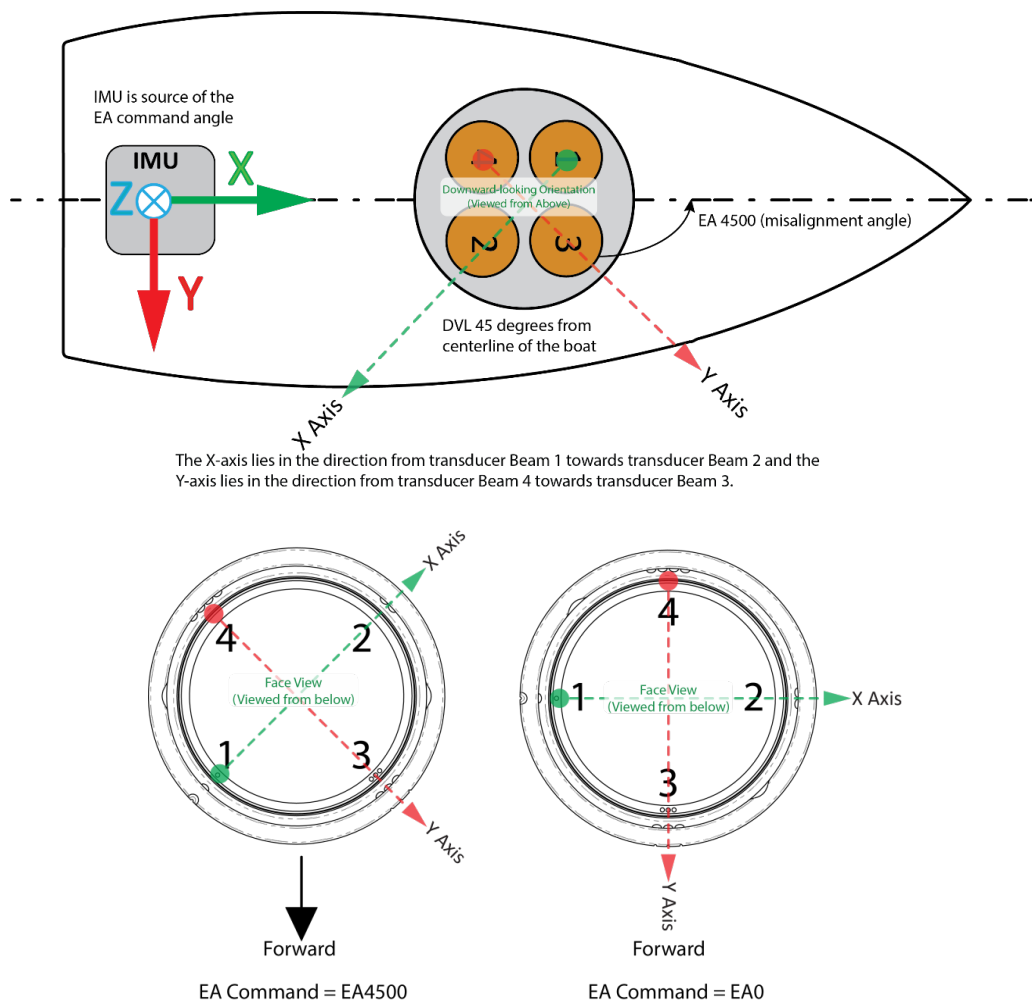


Figure 22. Transducer Alignment Reference Points

Beam Clearance

Acoustic obstacles such as cables, hull, other instruments, etc. are numerous on undersea vehicles. Special care should be observed in clearing the DVL beams of any acoustic obstacles. A 90-degree cone around the face of the transducer should be observed to account for each beam acoustic spread. This Beam clearance should be observed when Bottom Tracking, Water Tracking and Water Profiling. Any acoustic obstacle in the Main Beam and acoustic spread will interfere with the DVL measurement. DVL transducers also have side lobes, which could collect energy backscattered by acoustic obstacles in the beam clearance cone as shown in the [outline installation drawings](#).

Mounting the Instrument

There are many options for mounting the 300/600 kHz Pioneer systems and they depend on the application. One method uses the optional housing flange that grips the circumference of the housing. Another method uses the four user mounting holes and two alignment pins on the end-cap. See the [Outline Installation Drawings](#) for dimensions and weights.

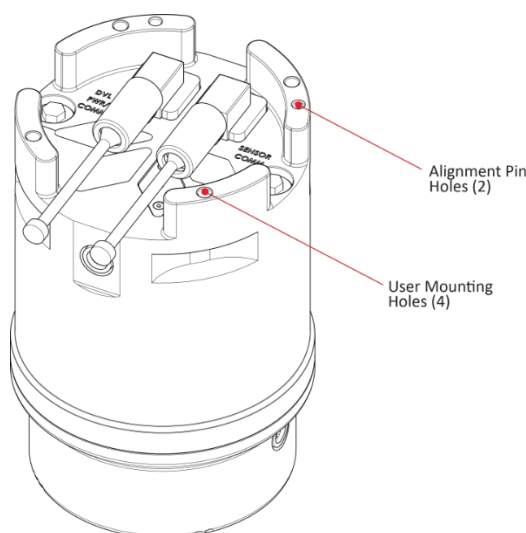


Figure 23. End-Cap view of the transducer showing mounting holes



Your Pioneer DVL transducer housing is made of aluminum that is protected by sacrificial anodes and a hard anodize coat and paint. **Do not connect other metal to the DVL.** Other metals may cause corrosion damage.

Use M6 isolating bushings and washers when mounting the DVL to a metal structure. Keep this in mind when fabricating a fixture, which materials to use, or deciding how to place it on the vehicle.

Pitch & Roll

Pitch and Roll should be limited to avoid a beam pointing vertically toward the bottom. The Pioneer DVL beams are slanted 30 degrees from the DVL vertical axes. This beam angle was selected as the best trade-off between velocity accuracy, resolution and acoustic energy throughout the water column (which is greater for greater smaller angles).

Moreover, a DVL can only measure velocity relative to itself by measuring the Doppler shift along each beam. If a DVL beam were to be pointing vertically towards the sea bottom, then it would be unable to measure the Doppler effect of a DVL motion parallel to the sea bottom. Therefore, the DVL should never

be tilted 30 degrees so that a beam would be pointing vertically at the medium of reference, i.e. sea bottom or ice.

Use the ship's roll and pitch reference to mount the transducer head aligned with the ship axes as closely as possible. If the instrument x and y axes are not in the same plane as the ship forward and starboard axes, then use the #EI (see [EI - Roll Misalignment Angle](#)) and #EJ (see [EJ - Pitch Misalignment Angle](#)) commands to align them.



If the transducer is not level, Water Profile bin-mapping will be incorrect. Large misalignments can cause large velocity measurement errors.

Routing Cables

Use care when routing cables through bulkheads, deck plates, cable runs, and watertight spaces. Make allowances in cable length and engineering design plans for cable routing. When necessary, use strain reliefs on the cables.

Route cables so:

- Cable does not have kinks or sharp bends.
- Protect the cables with hose if zip-ties are used to secure them to structures (see Figure 16).
- The Pioneer cable (or junction box, if one is used) must **NOT** be exposed or installed next to high voltage lines or circuits, motors or engines.
- If a junction box is used, make sure that all of the cable conductors are connected properly and avoid ground loop effects. Make sure that the conductors are electrically isolated from each other.
- Cable can easily be replaced if it fails.



Figure 24. Do not use Zip-Ties Directly on Cables



When attaching the Pioneer cables to a mount, do not zip-tie the cables directly to the structure. Zip-ties slowly cut through the cable's outer jacket and cause leaks.

Electrical Integration Considerations

Grounding Issues

Multiple grounds connected to a vehicle hull or to a vehicle chassis can have undesirable consequences. Grounding problems can be avoided by implementing prudent grounding schemes.

The DVL has three isolated grounds in order to achieve the desired performance levels of the instrument. The grounding systems are as follows:

- Communication ground
- Power ground
- Chassis ground

The grounded systems noted are isolated from each other. The Power Ground is isolated from the Chassis Ground by an isolation / ground noise filter circuit. This 'link' between these two grounds is susceptible to EMI from outside sources if the isolation is not properly maintained outside the DVL. If the DVL's isolation / ground noise filter circuit is shorted the DVL may experience an increased noise floor, ultimately propagating into the signal receivers.

This same isolation circuit will be shorted if the chassis (DVL GND) is in direct contact with the vehicle chassis (vehicle GND) and the Power supply ground connected to the DVL is also connected to the vehicle chassis.

Typically the DVL chassis is anodized, thereby providing electrical insulation when the instrument is mounted into what are usually metal hulls. The anodized coating is required to maintain chassis ground isolation.

Another potential electrical path bypassing the isolation/ground filter is that which can occur through sea water. The current generated can pass via the DVL anode, (or scratches in the DVL coating), through the seawater, and then back to the hull (or frame) to the vehicle. The likelihood of this ground path occurring is increased if the hull of the vehicle is connected to the Power ground of the DVL through the vehicle's grounding circuitry. Typically, this resistance is very high resulting in only a few microamperes of current and is limited by the size of the DVL anode and the distance between the Anode and the grounded hull of the vehicle (the greater the separation the greater the resistance).

For the condition described, if the exposed surface resistance is great, the DVL will not be adversely affected, as is usually the case. For conditions where the surface resistance of the DVL chassis and vehicle are low, undesired interferences will occur.

Another way that you can have undesired grounding of the DVL to the frame or hull of a vehicle is that mounting holes can lose their anodized coating by scraping of the anodized inner wall with the mounting screws. The use of an isolation plate and plastic washers are good practices to avoid this grounding path.

In summary, bypassing or shorting the DVL isolation / ground noise filter circuit will increase the noise floor in the instrument and in the data, thereby resulting in a reduced operational range and data contamination from interference. Additionally, bypassing of the DVL isolation/ground filter can lead to accelerated corrosion.



Your Pioneer DVL transducer housing is made of aluminum that is protected by sacrificial anodes and a hard anodize coat and paint. **Do not connect other metal to the DVL.** Other metals may cause corrosion damage.

Use M6 isolating bushings and washers when mounting the DVL to a metal structure. Keep this in mind when fabricating a fixture, which materials to use, or deciding how to place it on the vehicle.

Electrical and Grounding Testing Best Practices

Suggested steps to verify possible ground leakage of the Pioneer DVL:

1. Turn your Power Supply output to OFF.
2. Connect the standard power connections from the Pioneer cable to your power supply (24 volt typical but could be anywhere in Pioneer supply range).
3. Connect a single, 2ft +/-10% long, 22 gauge, wire to the - terminal of the Independent 12 volt supply or battery.
4. Add a 10K to 62kohm (+10% , 1/4W) resistor in series with this wire
5. Connect the other end of this wire (you can use an alligator clip) to one of the Anodes.
6. Connect the + of the Independent power supply or battery to the – PWR of your Pioneer i.e. also Neutral of your Power Supply (see figure below).

The goal is to create a -12 volt EMF relative to the ground of the standard DVL supply. Then use the -12 volts to check the leakage current through a kΩ resistor.

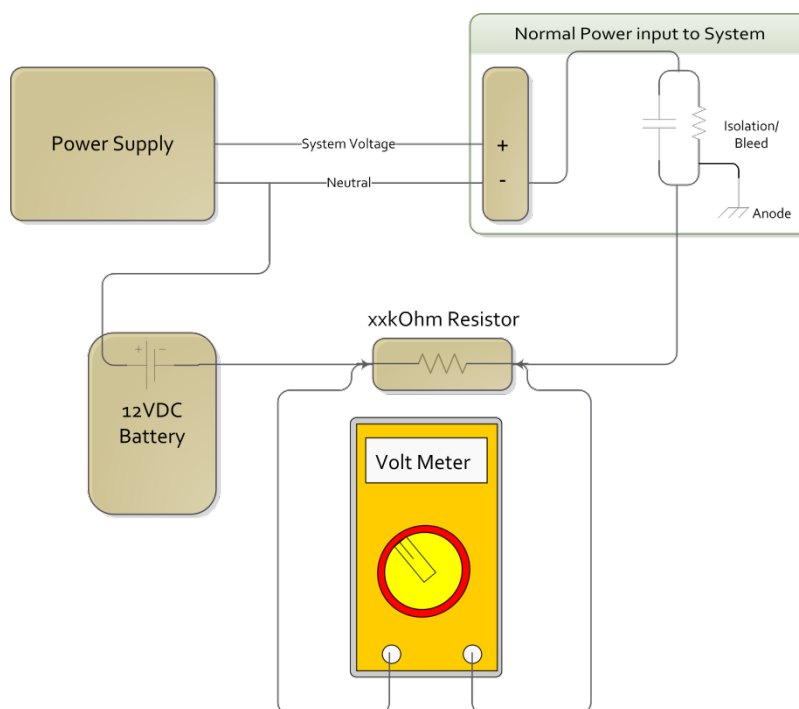


Figure 25. Ground Fault Current Check

7. After all the connections are made, turn the voltage supply output ON.
8. Assure that the DVL system is awake via *TRDI Toolz*.
9. After 30 seconds, measure the voltage across the resistor.
10. Apply the following equations to find the isolation impedance.

$$R_{Isolation / Bleed} = \frac{V_{battery} - V_r}{I_{leak}}$$

$$I_{leak} = \frac{V_r}{R}$$

Where V_r is the voltage across the resistor and $V_{battery} = 12V$ in our example.

11. The impedance noted should be 32MΩ at 32V.



Do not short the housing to any grounded surface (such as an ESD mat) or water tank while conducting this part of the test. Otherwise you create a ground short, and leakage current will rise above the acceptable limit, indicating a false failure.

Electro-Magnetic Interference (EMI)

The main sources of EMI are induced voltages from signal and power lines that are located in proximity to the effected component or signal. These problems are avoided or minimized by the proper routing of wires, proper shielding of wires and proper location of individual systems components. EMI is also caused by unwanted differences in potential on signal or ground electronic lines as is discussed below.

Cabling Issues

A remote head DVL is susceptible to interference along the length of the cable connecting the DVL to the receiver located in the electronics chassis. Interference signals injected into or adjacent to the remote cable may be increased in voltage more than 100,000 times due to the gains of the internal amplifiers. It is critical that to route all DVL/receiver connecting cables such that they are not in proximity to interfering signal sources, such as clocks, CPU's, DC-DC converters, engine controls, and hydroelectric power units. It is recommended that detailed bench trials be conducted on all cabling configurations before implementing this configuration into the operational platform.

Power Consumption

The reference for the average electrical power in Watts used by the Pioneer is that which occurs at the maximum pinging rate and maximum altitude for Pioneer systems are:

System Type	Average Power	Input Voltage
Pioneer 150 kHz	35 W @10% ping duty cycle	32V
Pioneer 300 kHz	15W @ 10% ping duty cycle	32V
Pioneer 600 kHz	6W @ 30% ping duty cycle	32V

It should also be noted that there is a constant background power consumption of 1.8 watts for the processing electronics as long as the Pioneer is not in the "sleep mode".

The average power consumption depends upon the transmit duty cycle. By reducing the ping rate, the duty cycle is reduced and therefore overall power consumption may be reduced.

Inrush Currents

The DVL power supply must be specified with consideration to the instrument inrush current. The inrush current inherent to the DVL is due to the current required to fully charge the front-end internal electronics capacitors. The capacitors store and then provide power on demand during the DVL transmit phase of

operation. The maximum inrush current of 6 to 9 amps is only seen on initial instrument startup and is required to provide the initial capacitor charge.

It is essential that the power supply used to power the Pioneer be of sufficient capacity to meet the startup inrush and operational current demands described.

Acoustic Integration Considerations

Flow Noise

Water flowing over the transducer faces increases the acoustic noise level, which in turn decreases the operational range of the DVL. Flow noise can be reduced across the transducer faces by mounting the DVL behind a sea chest, fairing, or acoustic window. Flow noise can also be reduced by optimizing the transducer head type and design to conform to the platform hull form being used. Optimized transformer heads can be custom made by Teledyne RD Instruments for specialized applications and may exist as commercial off the shelf product for more standard applications.

Cavitation

Cavitation is the formation of air bubbles due to the reduction of ambient pressure because of hydrodynamic flow conditions. Cavitation at the edges of the transducer or surrounding area near the transducer often results in increased acoustic noise, and a corresponding reduction in operating range. As with flow noise, cavitation can also be reduced by optimizing the transducer head type and design to the platform hull form being used.

Ringling

Definition: Ringling occurs in DVLs when the energy from the side lobes of the transmitted signal excites the metal portion of the DVL transducer such that a resonant condition occurs. This causes the transducer and anything attached to it to resonate at the system's transmit frequency. While some ringling is normal in DVLs its magnitude must be minimized.

It is helpful to review the transmitted acoustic signal associated with DVLs in order to fully characterize the phenomenon of ringling. The DVL transmits an acoustic pulse into the water. The main lobe of this pulse bounces off of the sea bottom (bottom track) or particles in the water column (water track) and the signals returned from these particles are used to calculate the velocity of the water.

Along with the main lobe of the transmitted pulse are many associated side lobes. It is these side lobes that come in contact with metal the housing of the DVL transducer and as noted above are the source of the ringling.

If the DVL is in the receive mode while the transducer is ringling, then it will receive both the return signals from the water and the "ringling." Both of these signals are then processed by the DVL. The ringling causes bias to the velocity data.

All DVLs "ring" for some amount of time. Therefore, each DVL requires a blanking period (time of no data processing) to keep from processing the ringling energy. During this time the transmitted pulse is traveling away from the DVL at the speed of sound, so this "blanking period" corresponds to a range near the DVL that cannot be profiled. Each DVL frequency has a different typical ringling duration.

These typical ringling values are recommended as the minimum setting for all DVLs using default setups (minimum value for the blanking period as set by the [BB command](#) and [WF command](#)).

It should be noted, on some installations the effects of ringling will last longer than the recommended settings above.

Mounting Considerations

Well Mounting: The effects of ringing will last longer if the transmit signal becomes trapped inside the transducer well. This can occur because the well itself is ringing with the transducer or when windows covering the opening of the well reflect the signal back inside the well.

The window causes the transmit signal to reflect back into the well due to the difference in acoustic impedance between the window and the water. When the transmit signal is reflected in the well it becomes trapped, and this results in longer ringing periods. To keep from processing this signal, the blanking period would have to be increased. This is possible for Water Profile using the [WF command](#) and for Bottom Track using the [BB command](#).

To mitigate the effects of ringing inside the transducer well, a sound absorbing material can be mated with a mounting plate or a clamp to reduce acoustic coupling increasing the ringing period. Also, the inside walls of the well can be lined with a sound absorbing material to damp the ringing effect. Using standard neoprene wet suit material has been found to work well.

Windows Use Considerations

Windows can be used to produce overall performance improvements in vessel-mounted DVLs. There are several advantages and disadvantages to consider before using an acoustic window.

Advantages

- Well will not fill with air bubbles caused by the ship moving through the surface water.
- Flow noise is reduced.
- The well can be filled with fresh water to limit corrosion.
- Barnacles cannot grow on the transducer faces. Barnacle growth is the number one cause of failure of the transducer beams.
- The transducer is protected from debris floating in the water.

Disadvantages

- The range of the DVL may be reduced because the window can and will absorb some of the transmit and receive energy.
- The transmit signal could be reflected into the well, causing the well to “ring”. This will cause the data being collected during the ringing to be biased. Some vessels have reported a loss in range as great as 50 meters. As noted, the ringing may be damped by applying sound absorbing material on the well walls (standard neoprene wet suit material has been found to work well).
- The transmit signal could be reflected off the window and back into the other beams.

If the well has excessive ringing (due to reflection from the window or ringing within the mechanical structure itself) the DVL can be instructed to keep from processing this signal. To do this, the blanking period of the instrument would have to be increased. This is possible for Water Profile using the [WF command](#) and for Bottom Track using the [BB command](#).

Temperature differentials should also be considered because if the water temperatures inside the window and outside the window are not the same, all four beams will be refracted and actual velocity components will be rotated into a new coordinate system. In particular, some of the horizontal velocity will appear as a vertical velocity

Recommended Practices for Window Use

Window Orientation: The acoustic window should be flat and parallel to the transducer face. Note this is not an absolute requirement but a tilted or curved acoustic window can make the transducer susceptible to differentials in the water temperature.

Window Material: Our experience has shown that Polycarbonate is very good for use as an acoustic window. The speed of sound of polycarbonate is approximately 2423 m/s. That makes a quarter lambda 0.99mm at 614.4 kHz, so the recommended thickness would be 0.5 to 0.75mm. If this is too thin to support the weight of the water inside the well then it would be better to use 0.5 lambda, rather than being exactly at a quarter (being too close to a quarter lambda will cause a strong reflection). This would be 1.97mm at 614 kHz and 3.94mm at 307 kHz.

The thickness of the Polycarbonate material depends on the frequency you intend to use and the weight of the water inside the window as noted above. Table 5 is provided as a guide for choosing the maximum thickness window to use. If additional thickness is still required due to the weight of the water in dry dock, then increase the thickness in increments of $\frac{1}{2}$ lambda. Be warned that increasing the thickness beyond the values listed in Table 5 can degrade the performance such that the system will no longer meet the performance specifications as listed in [Chapter 6 - Specifications](#). Increase window thickness at your own risk.

Table 5. Maximum Window Thickness

Frequency	Thickness
614.4 kHz	2mm
307.2 kHz	4mm
150 kHz	7.9mm



One concern with window selection is that it has be able to support the weight of the water inside the well once the ship is dry-docked. TRDI recommends that you always fill/drain the well while you are either filling/drainning the dry dock area.

Spacing between window and transducer: The primary geometrical factor in design of windows is the reflection of a beam into another beam, causing crosstalk between the beams. The distance of the transducer from the window should be at least 1cm. Never allow the transducer to touch the window. If installed farther than 1cm, then it is imperative to ensure that the window aperture is large enough to clear the beams. The farther away the transducer is from the window, the more the sound is reflected off one beam and then reflected into another beam.

Acoustically-absorbing well lining: A sound absorbing material should be used inside the well to minimize the effects of sound ringing within the well. The recommend material for both 300 and 600 kHz systems is Precision Acoustics F48 anechoic tile.

Fluid in the well: The well should be filled with fresh water. Seawater can be used, but at the cost of increased corrosion. Seawater should not be circulated through the well unless the well has been painted with anti-fouling paint. The pressure within the well should be adjusted to keep the window from bowing in and out, and thereafter, the volume should be kept constant.

SONAR Interference Considerations

Interference from other acoustic and electromagnetic devices can cause velocity and direction bias. In extreme cases interference may prevent the DVL from operating. It is possible to avoid interference by using a suitable triggering scheme. This is particularly recommended if the other device is operating within the bandwidth of our DVL receiver (in some cases up to 40% of the carrier frequency of the DVL) or if the other device has a harmonic component that is within the DVL frequency receive bandwidth. Initiating a well-conceived triggering scheme (triggering the interfering device, the DVL, or both) will keep the interfering device from operating during the DVL's transmit and receive period. It is important to note that the TRDI receivers have 90 to 110 dB of gain, which for the sake of clarity is greater than 100,000 times of voltage amplification.

Coded Signal Theory Review

In the default bottom track Broad band mode, the DVL transmits two acoustic pulses composed of a series of coded sequences. The acoustic signal transmitted into the water is composed of a series of elements, where each element consists of 16 carrier cycles. The frequency spectrum of this signal is a $\sin(x)/x$ function centered at the carrier frequency, with a -3dB bandwidth of 6.25% of the carrier frequency. As a result, any nearby sonar equipment which is sensitive to this frequency range will receive interference from the DVL transmit pulses.

TRDI DVL transducers are manufactured with the ability to transmit and receive more than the required 6.25%. Any other sonar emissions in this frequency range will potentially be received by the DVL and interfere with its operation. The following table summarizes the transmit and receive bandwidth for each frequency available for the Pioneer DVL systems:

Table 6: Transmit and Receive for Pioneer DVLs

System	Carrier Frequency	Transmit & Receive Bandwidth
150 kHz	153600 Hz	9.6 kHz (6.25%) or ± 4.8 kHz (148.8 kHz to 158.4 kHz)
300 kHz	307200 Hz	19.2 kHz (6.25%) or ± 9.6 kHz (297.6 kHz to 316.8 kHz)
600 kHz	614400 Hz	38.4 kHz (6.25%) or ± 19.2 kHz (595.2 kHz to 633.6 kHz)

Interference Detection and Mitigation

TRDI has several tools to detect and mitigate interference. One of these is a FFT software program (see [Identifying EMI](#)) that in function turns the DVL into a semi real time Fourier spectrum software analyzer. Another technique for interference detection is the use of very long water profiles.

FFT can be useful in catching continuous interference. However, its sampling is dependent on the number of FFT samples selected by the user. It may therefore update too slowly to detect an intermittent acoustic interference source. On the other hand, the long water profile may detect interference from an intermittent source as it listens for a longer period, although this method may not be effective for detecting self-interference or continuous low-level source interference. When using the water profiling technique to identify interference, the user must monitor both RSSI and Correlation in order to distinguish external interference from the DVL's own echo signal.

If interference is present from another device on the vessel, the most efficient mitigation technique is to use a triggering scheme to coordinate their operation. For example, an external trigger commands the external device and the DVL to alternate their transmissions, and this external synchronization ensures that the two devices will never interfere with each other.

Water Track Considerations

Pioneer DVLs have the capability to compute velocities off of a water track layer while Bottom Tracking. The commands for controlling this mode are [#BK](#) & [#BL](#) for Pioneer DVLs. However, there are some important consequences of enabling this mode that will be discussed.

First, the time required to complete a ping is significantly increased because two separate and independent pings are involved. TRDI does not currently have ping time models for the Water Track ping. If required, the times would have to be obtained experimentally.

Secondly, there is the opportunity for ping-to-ping interference when the Water Track is enabled. After transmitting an acoustic pulse, the Pioneer DVLs open their receivers and listen for a return (either from the bottom for a Bottom Track ping or from the water column for a Water Track ping). The return MUST be from the particular ping that is transmitted. If it is from a previous ping, interference results and the system might not work at all, or worse, might give erroneous results.

For example, on a Bottom Track ping, a return from the bottom from the previous Water Track ping might look like the return from the Bottom Track ping, but at the wrong altitude. The problem is usually worse when using Water Track and the previous Bottom Track ping is the cause of the interference. The return from the Bottom Track ping is usually much larger than that from water scattering and when the operating altitude is low, that return can make several round trips from the bottom to water surface to the bottom again and still be large enough to cause interference with the Water Track ping. TRDI recommends that the time between pings be set so that there is enough time for each ping to travel four round trips to the bottom and back when the altitude is significantly less than the specified operating altitude. This time can be calculated by doubling the altitude and then dividing by the Cosine of the Janus angle (normally 30°) and then dividing by the speed-of-sound and multiplying by four.

$$\text{Minimum Ping Time} = 8 \cdot \frac{\text{altitude}}{\cos(J) \cdot \text{SoS}}$$

When operating at altitudes approaching the altitude capability of the DVL, the ping time should be:

Minimum Ping Time > 1.5 times the round-trip time at the maximum specified operating altitude.

The long-term and short-term accuracy characteristics of the Water Track mode are discussed in the respective accuracy sections of this document.

Reference, Data & Timing Considerations

Coordinate Frames

As described in [Beam Coordinate Systems](#), a DVL can output the measured velocity vector in one of the following coordinate frames: beam, instrument, ship, leveled-ship, and geographic (“earth”) frames. The distinction between instrument and ship frames is that the latter takes into account intentional alignment angles such as the azimuth angle of Beam 3 relative to the fore-aft axes of the vehicle. The coordinate frame may be selected.

There are two main advantages to using instrument or ship coordinates. First, if the instrument has been calibrated so that the beam-to-instrument transformation matrix contains instrument-specific corrections for beam pointing errors, then these corrections will have already been applied by the DVL firmware. Second, it is easier to measure and account for separate horizontal and vertical scale factor errors if the velocity is already in instrument or ship coordinates. For the majority of applications instrument or ship coordinates will be the optimum solution.

For more advanced applications, the instrument can output velocity in beam coordinates. The advantage of using beam coordinates is that beam velocities are the fundamental quantities that the Pio-

neer measures. Even if only one beam is able to give a valid measurement, it can still provide useful information whereas a minimum of three valid beams are necessary for measurements in other coordinate frames. Using this technique an external transformation would have to be performed to obtain velocity in instrument or earth coordinates. The beam-to-instrument transformation matrix can be extracted from the Pioneer using the &V command.

Data Screening

Pioneer measurements suffer from occasional data outliers, which, although rare, can still be far more frequent than would be expected from a normal (Gaussian) probability function. To prevent the navigation system from giving undue weight to data outliers, it is important to screen the Pioneer data to detect and reject them.

Data outliers are often the result of ambient data environmental factors. The Pioneer DVLs have several internal routines to detect and account for the false data described. Unless the bottom is detectable and the correlation value is above a threshold criterion, bottom track velocity will be marked bad (0x8000 which equates to the full-scale negative value of -32768 decimal). The presence of fish in one or more beams will also cause data outliers. The Pioneer also can screen for fish using the information in the intensity data for all four beams.

For operations in coordinate frames other than beam coordinates, if all four beams pass these screening tests, the Error Velocity (representing the redundant information among the four beam velocities) is calculated and its magnitude compared to a threshold as an additional screen. Measurements exceeding this Error Velocity threshold will be rejected. When using beam coordinates this velocity screening is not done by the Pioneer firmware. It can however, be performed outside the Pioneer.

To keep the Pioneer errors as independent as possible from ping to ping, the Pioneer does not screen for unreasonably abrupt changes in altitude or velocity. These kinds of screens are most appropriately performed at the front end of a navigation system. An isolated abrupt change in altitude is most likely an outlier (fish or other false target) that should be rejected, whereas a step function with a persistent final altitude might be real (a cliff or a transition from a ship hull to the real bottom, for example). A robust algorithm will reject the isolated data outlier while quickly recovering from a persistent step. Similar screening can be done on velocities.

3-Beams Solution

The default operation of DVL's requires all four beams to be tracking and providing good data. When this occurs, the instrument screens the velocity data by comparing the magnitude of the Error Velocity to a commanded threshold. The Error Velocity has redundant information among the four beam velocities. This is done for all coordinate systems other than Beam. A 3-beam solution is produced if, on a particular ping, only three beams have good data, and in that case only, error velocity screening cannot be performed. When 3-beam solutions are enabled, the DVL still computes a 4-beam solution with error velocity screening on all pings where all four beams have good data. There are operating circumstances where due to the bottom slope and/or pitch only three beams are able to have adequate reflection from the bottom, while the fourth beam is not. The three-beam solution makes it possible to operate in such severe environments.

Ping Timing

It is usually desirable to minimize the time it takes a Pioneer to complete a ping cycle because this enables faster data update rates. It is important to note that using the Water Layer Track in addition to the Bottom Track mode significantly lowers the update rate of the Bottom Track data because there is an extra ping(s) between Bottom Track pings. Therefore, it is recommended that the Water Layer mode be commanded off when the Altitude is well within the Altitude capability of the Bottom Track (Bottom Track is providing good data).

When the maximum operating altitude is known, the [BX command](#) can be used to limit the maximum ping time in Bottom Track mode, since time to receive data from the bottom is proportional to the distance to the bottom.

For example, a 300 kHz Pioneer has a default BX altitude of 275 meters. If the user knows that the altitude will never exceed 100 meters, he can set the BX command to 100 meters and then when operating at 100 meters, potentially reduces the search time required to reacquire the bottom after bottom lock has been lost, because it bypasses the search pings that look for greater altitudes. Therefore, if BX is set to 100 meters, and if the DVL is operating at 100 meters altitude, and loses the bottom, then the search algorithm will not look at 200 meters if it does not find the bottom at 100 meters and will only search at altitudes up to 100 meters, which may result in a faster reacquisition.

Table 7 shows the approximate Bottom Track ping times for a Pioneer DVL as a function of altitude above the bottom. The data is for the case where there are no external sensors being used:

Table 7: Approximate Bottom Track Ping Times (in milliseconds)

Frequency	Altitude in meters	Ping Time in ms
150/300/600 kHz	3	110

The following equation provides an estimate for the time between pings for ranges greater than 3.8m for the 600 kHz and 7.6m for the 300 kHz (deep mode):

$$\text{Ping time (seconds)} = \text{RTB} * 3.8\text{e-}3 + 40\text{e-}3$$

Where RTB is the Range to Bottom in meters.

System Synchronization

Typically, data from the Pioneer is fed into a larger user supplied acquisition and control system, which collects data from other sources as well. In such situations, it is important to have all the data accurately referenced to a common time base.

The Pioneer data ensembles in PDO format contain a time stamp having a resolution of 10 ms that is from a reading of the real-time clock before the ping. This time stamp is of limited utility because it is difficult to keep the Pioneer clock synchronized to the navigation system clock and because the 10 ms resolution is arguably too coarse when the Pioneer is combined with an INS. The PDO [Navigation Parameter Data](#) format provides Time to Bottom (T2B) and Time of Validity (TOV) that an INS system can use for 'latency'.

The biggest advantage of system synchronization using Trig_IN is to not interfere with other acoustic sensors and sonars. The trouble with external trigger input time stamping is that the Pioneer needs multiple trigger inputs for doing more than just BP=1 bottom track ping. Note that the minimum time interval between pings (which is the maximum velocity update rate) is altitude dependent, thus the triggering scheme should be tested over the full working range of altitudes (including an altitude beyond bottom track range). These tests should be made with water mass layer measurement both on and off.

Operational and Setup Considerations

Unfavorable Environments

There are certain environmental conditions where the DVL's errors may be large or where the instrument does not function at all.

- In the surf zone where waves are actively breaking, the acoustic beams may not be able to penetrate the bubble clouds, and even if they do, the sound speed may be significantly affected by the high concentration of bubbles. This changes the Doppler scale factor.
- The dense growth of weeds or kelp on the bottom may prevent the DVL from detecting the true bottom. If the DVL locks onto the top of the weeds by mistake, they may have motion relative to the bottom due to wave action, which would give inaccurate velocity measurements.
- In areas of high salinity (>35ppt), the absorption of the sound by the water column will reduce the altitude capability of the DVL. Absorption (maximum range) can also be affected by water temperature, as outlined in [Temperature & Salinity](#).
- In areas where the salinity varies as a function of location and/or time, the Doppler scale factor will be varying, and it may be necessary to integrate a speed-of-sound sensor into the navigation system to keep the velocity measurement errors to an acceptable value. Temperature gradients can cause similar issues, as outlined in [Speed of Sound Variation](#). This is only for the Z axis velocity, as SoS does not impact 2D velocities on a Phased Array Transducer.

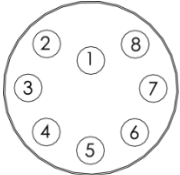
Triggering

Triggering is the most efficient mitigation technique to prevent or minimize interference between the DVL and other external (acoustic) sensors in the vehicle. For example, an external trigger commands the external device and the DVL to alternate their transmissions, and this external synchronization ensures that the two devices will never interfere with each other. There are two methods for triggering the DVL:

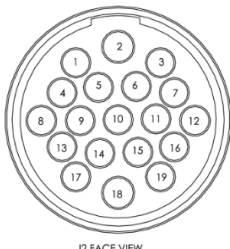
Sending ASCII Character through Serial Port. When the system is interfaced to a serial port (e.g., a navigation computer), the system can be setup to wait for an input before each ping. To setup the DVL in this fashion, clear the Auto Ping Cycle bit in the [CF command](#) by sending CFx0xxx, where the x's represent the settings of the other parameters. Start the DVL pinging with the CS command. The DVL will output a '<' before each ping and wait for input. Send any valid ASCII character to trigger the ping. The instrument will not enter sleep mode while it is waiting for the trigger. This trigger method has latencies ranging from a few milliseconds to a few hundred milliseconds, which may be excessive for high-precision applications.

Using Low-Latency Triggering. The DVL has a TRIG_IN line when using RS-232 for port 1, which accepts Low-Latency Trigger signals. TRDI has specified the input trigger voltage as 3.3VDC to 7VDC. The polarity is defined as the electrical level at the connector referenced to COMM RETURN 1 (see [Cable Wiring Diagrams](#) for the full pinout).

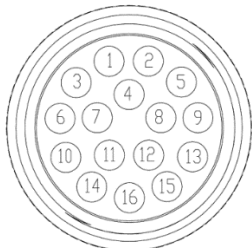
Pioneer 300/600 kHz

Pin Number	Signal Name	Standard Wire Color	Pin Location
6	TRIG IN	Blue	 <p>P1 FACE VIEW</p>
5	COMM RETURN 1	Green	

Pioneer 150 kHz 6000 meter

Pin Number	Signal Name	Standard Wire Color	Pin Location
5	TRIG IN	Brown	
10	D_COM1	Green	

Pioneer 150 kHz 1000 meter

Pin Number	Signal Name	Standard Wire Color	Pin Location
9	TRIG IN	Orange	
8	D_COM1	Black	

Trigger Pulse Length Limits. Based on our experience, the following trigger pulse works well:

- Trigger input voltage: 3.3 ~ 7Vdc, polarity referenced to COMM RETURN 1
- Trigger pulse length: 500 μ s

Our internal testing shows that the **minimum** trigger pulse length must be at least **105 μ s** for the trigger to function properly. A trigger pulse length < 105 μ s will **not** be recognized by the DVL (i.e., the DVL will not ping on trigger).

The maximum trigger pulse length depends on the trigger rate. Our internal testing shows that the **maximum** trigger pulse length is approximately **99% of the trigger period**. If the trigger pulse length is > 99% of the trigger period, the DVL may work intermittently. The following table shows some examples of various trigger rates and their corresponding approximate maximum trigger pulse lengths.

Table 8. Maximum Trigger Pulse Length

Trigger Rate (Hz)	Trigger Period (ms)	Maximum Trigger Pulse Length (ms)
1	100	990
2	500	495
5	200	198
10	100	99

To configure the DVL for low-latency triggering, set the [CX command](#) to enable trigger input.

Format: CX *n d t [p]*

Where:

n = 0 to 5 (see table below).

d = 0 to 65535 one hundredths of a second delay time.

t = 0 to 65535 one hundredths of a second time-out time. Setting “*t*” to 65535 disables the time-out.

p = 0 or 1 (optional). Setting “*p*” to 1 enables ping-once mode after time-out.

For example, set the CX command to CX 1 0 65535 0 to set the system behavior to ping after a low to high transition with no delay and the time-out is disabled. Start the DVL pinging with the CS command. The DVL will then wait for a trigger before each ping. Set the trigger lines to a break state for the recommended trigger pulse length to send the trigger. The DVL will then ping within 1 millisecond of the leading edge of the break pulse.

CX (n)	System Behavior
0	Trigger off
1	Pings after low to high transition
2	Pings after high to low transition
3	Pings after either low to high or high to low transition
4	Ping while trigger is low
5	Pings while trigger is high

Note that it is possible through the CX command settings to set a timeout for the DVL to wait for a Trigger and then if no Trigger occurs during that time, it will either Self Deploy and never look for Trigger again or Ping once and then go back to waiting for Trigger. See the [CX command](#) for details.

Design Considerations & Bench Test

To avoid problems when the DVL is installed in the final system, it is helpful to perform a bench test prior to installation. In the bench test the DVL should be exercised along with all the other components that will be installed in the final system. By performing this initial bench test EMI and acoustic interference issues can be identified and remedied while all the system components are easily accessible.

The recommended types of systems that should be bench tested are described below.

1. If possible, select components and systems that are acoustically, and RF wise “out of band”, based on the specifications from the manufacturer of that equipment.
2. It is important to test for all EMI interference that may be occurring in the system. Bench test all of the equipment in air, and see if there are interfering sources by using the FFT tool (refer to [Identifying EMI](#) for instructions on its use), after which you can plan the shielding and grounding strategy.
3. Spread out the various systems and components that you intend to use on the bench in a pattern similar to how they will work.
4. While observing the FFT use the DVL as a “probe” and pass the DVL over live components (including hydraulic actuators) you intend to use in your design. Identify any unacceptable interference.
5. While observing the FFT use the DVL as a “probe” and touch it against components or systems to check their acoustic signature. Identify any unacceptable interference.
6. Try varying bench test temperatures, so it can be determined if there are tank circuits in your system that “tunes into” our band, or visa-versa.

Troubleshooting

The purpose of this section is to provide a list of critical tests to perform when the system is not operating to either specifications or expectations. Additionally, this procedure will also provide a step by step guide to configuration of the TRDI DVL to record all available data for troubleshooting with TRDI support. The information acquired from these procedures will allow the user to solve many encountered technical problems. Should assistance from TRDI be required, the information acquired will greatly expedite our analysis and service provided.

Communications Issues

Follow the steps in [Connecting to the Pioneer](#). If you have problems communicating with the Pioneer check to make sure that you are selecting the right COM port, baud rate, parity (none), stop bits (1), flow control (none).



Windows is finicky when it comes to USB to serial adapters. Most adapters that TRDI tried did not work. One adapter that works well is <http://www.easysync-ltd.com/product/527/es-u-1001-r100.html>. Possibly any device with FTDI drivers and devices will also work.

If the Pioneer has the RS-422 option (depending on the personality board's part number), then check to make sure the host computer supports RS-422 or use an RS-422/RS-232 converter. TRDI recommends the B&B Electronics (<http://www.bb-elec.com/>) RS-422/RS-232 converter.



Initial Shakedown Deployment

Troubleshooting Checklist

This list contains the different tasks that should be performed on the site where you experience data quality issue(s):

Identify Unit

Prepare a separate log file (If using *TRDI Toolz*, press **F3**) or add at the beginning of your logged deployment data the returns from the following commands:

```
+++ or if using TRDI Toolz you can either send $B, click the Break button, or press <End> on
the keyboard
PS0
PA ;ensure transducer beams are fully submerged in water prior to performing this test
```

The returns from these commands will provide the unit Firmware version, the system operating frequency, beam matrix information and verify that the electronics are working as expected.

Run Built-In Tests

If something FAILED in the PA test, repeat the test several times rotating the unit by 90 degrees for each test. By doing so, it may be determined that the failure is directional and most likely due to external environment. Please be sure to log the results by pressing <F3> if using *TRDI Toolz* to communicate with the system.

Failures might be observed IF:

- Other magnetic or acoustic devices or high current system are in the vicinity of the unit,
- The Pioneer DVL is exposed to electrical interference such as that from other acoustic devices or SONARs or other electronic devices (i.e. cellphones, radios, computers, TV's, etc.).
- The Pioneer DVL or its cable is exposed or installed near potential sources of EMI's such as high voltage lines like main engine cables, galley equipment, winches, engine room equipment, cranes, high voltage lighting circuit, etc.
- Oftentimes, a noisy (i.e. non-UPS) power supply could cause failures in this test as well.

Strategy if Failure is found in the BIT tests:

- Power down these devices and remove or move the suspect systems at least three meters away during diagnostic testing.
- Re-run the PT300 command and log the data for about 30 seconds to 1 minute.
- Modify the log file by adding a note as of what has been done prior to a PT300 test such as: "Turning 300KHz Sonar off" for instance.



Always run the PA test with unit transducer beams submerged in water. The test may fail in air and if so, is not relevant. Only a failure with the transducer at a minimum in contact with water is a relevant test.

If possible run at least one PA test on the deployment site.

Provide Unit Setup

Provide a text file with the commands sent to the unit during deployment – Pre- or Suffix it:

Script_File_[Vehicle_or Deployment_Name_and/or_Date&Time_Goes_Here].txt

If you do not send commands and use an unknown user default setting, query the following groups of commands:

```
>B?
>#B?
>C?
>#C?
>E?
>#E?
>T?
>W?
>#W?
```

For example, the bottom track group of commands for a Pioneer DVL:

```
>b?
Available Commands:

BA 024 ----- Amplitude Threshold [0..255]
BB 0030 ----- Blanking distance (cm)
```



```

BC 220 ----- Correlation Threshold [0..255]
BE 1000 ----- Error Velocity Threshold [0-9999mm/s]
BF 00000 ----- Depth Guess [0=Auto, 1=MaxAlt dm]
BH 105,180 ----- Gain Switch Threshold (0-255cnts:lo;hi)
BI 025 ----- Gain Switch Altitude (meters)
BJ 100000000 ----- Data Out {t;c;*;h;r;n;*;*}
BK 0 ----- WMass Mode [0=off 1=WB 2=LostB 3=W]
BL 160, 320, 480 ----- WMass Params [min, near, far (dm)]
BM 8 ----- Bottom Mode [8 & 9]
BN 0,999 ----- Speed Log Hold/Drop Control
BO 025 ----- Distance Accum. Filter Tau (1/100ths)
BP 1 ----- Number of BT Pings in ensemble [0-999]
BQ -32768 ----- Set outvel when over range limit (mm/s)
BS ----- Clear Distance Traveled
BX 02750 ----- Max Depth (dm)
BY 20 ----- Transmit Length (pct)
B? ----- Display B-Command Menu

```

Describe Deployment Environment & Operational Conditions

It is important to document the deployment environment of the test or mission that has occurred. The following parameters are important:

- Location
- Water description
- Bottom Type – topography and bottom type
- Depth
- Sediment conditions
- Temperatures
- Salinity
- Proximity to ocean structures or acoustic reflectors
- Speed through water

Describe the System Installation

Provide a description of your vehicle, and more specifically a description of the system, ADCP and/or DVL, installation (coupling with the vehicle, material used for the mounting plate, beams behind a fairing, voltage sent to the unit, triggering scenario implemented, etc.).

Provide Raw Data & Describe Issue for Analysis by TRDI

- Describe the performance issue or problem.
- Recover the raw data from your instrument. This will preferably be done in the PDo output format. The information will be sent to TRDI with the complete deployment data if it is not possible to provide PDo data please identify the data format in which the data was collected.
- Provide screenshots or ensemble numbers to locate region(s) showing the unexpected data behavior.

Provide Additional Data for Analysis by TRDI

If the data you downloaded does not match alternate instrumentation providing the same data in the same reference frame, please provide the other device(s) data in a text file or an ASCII Text comma (or other ASCII character) delimited format file. If none of the above are feasible, screenshots of data plots

could be provided in place of the above. Attach a description of the data and of the instrument from which it was recorded.

Using Engineering Data for Analysis by TRDI

Re-deploy in the closest conditions and location from where the previous deployment occurred. However, prior to deployment add the following commands to your Script File or set-up commands.



If you are already decoding PDO and your decoding algorithm can handle more bytes in each ensemble [engineering data bytes] then you can record this Engineering PDO data into a file for us to review it with our Engineering software suite.

Capture the data from the instrument by opening a log file in *TRDI Toolz*. You can do this by typing **F3** and then giving a filename.

Send the following commands to the unit by copying them to the clipboard of any editor and pasting them into *TRDI Toolz* by typing **Ctrl V**:

```
CR1
BP1
;[set BX value in dm to 20% more than the water column depth]
BX00350
#BK0
EX00010
;[set the EA angle between Beam3 and forward centerline of the vehicle)
EA+13500
CF11110
;Output data format PDO or #PDx with x different from 0
#PDO
&O1000
&N3FFC
CK
CS
```

Press enter after the **CS** to start pinging.

Alternatively, you can download the commands by saving these into a text file and typing **F2** in *TRDI Toolz*. This will run them as a script file.

It is important to leave the system powered up after the command file is sent; otherwise, the &O and &N commands will be lost (these are not saved in the flash).

The process should be automatic from this point. The full data set should be about 92 ensembles. As previously mentioned in reference to the PA testing, if other devices are in the vicinity of the unit and are suspected to be the origin of the data quality issue, then those devices should be isolated to the greatest extent possible. It is best to power the device down or remove it from the area (at least 3m) and then re-deploy using either one of the above set-ups.

Recover and provide TRDI Field Service with the raw binary (PDO) data.

Identifying EMI

Purpose – Observation of the plots will provide information about interference to the DVL. This will probably NOT help in determining if the DVL emits interfering signals to other devices. The *NGSPFFT* software provides the user with a frequency domain plot (~100% bandwidth) of the Pioneer's four receiver channels during a sampling interval.



Contact TRDI Field Service for a copy of *NGSPFFT*.

Adjustments – The *NGSPFFT* software has several easy to use adjustments. For example, the **Filter** is a moving average of the last 30 samples; and the **FFT N** is the FFT sample size, with a default of 512. The FFT sample size is directly proportional to the bandwidth of the FFT resolution. Additionally, the **Hardware Bandwidth** and **Hardware Gain** and **System Frequency** can be adjusted. In addition, the communication port number and communication baud rate can be adjusted to match the communication parameters of the Pioneer.

Operation – The *NGSPFFT* software connects to the Pioneer DVL using a computer's serial port and sends the Pioneer DVL a special set of commands. The Pioneer responds with a stream of digitally processed values, from the receive portion of the circuit and firmware. The sonar transmitter is not used for the FFT, i.e. the FFT routine uses the sonar receive transducer, circuitry and firmware only, not the sonar transmit.

The *NGSPFFT* computer software processes the values it receives from the Pioneer, and then plots the resulting frequency response in a graphical form for each sonar channel, in terms of RSSI versus Frequency. RSSI is a Teledyne RD Instruments nomenclature for Received Signal Strength Intensity in A/D counts. The frequency span is centered at the carrier frequency (for Pioneer, this is 614,400 Hz) and spans $\pm 12.5\%$ bandwidth in NB mode, from (for Pioneer or other 614400 kHz systems this is 308,400 Hz to 921,600 Hz.)

Once the user learns the basics of the FFT software, you can use the Pioneer cables and transducer as probes by holding them or locating them next to equipment you would like to include in your vehicle (ROV, AUV). The user will see the effect of "in air" interference. If interference is noted, different strategies can be incorporated to mitigate the interference.

For example, separating devices or shielding may be help. Note that the transducer face (where the urethane is on the transducer) will always be submerged in water during real operation. You can simulate this in water performance by placing the transducer at the bottom of a small bucket, with just enough water to wet the urethane faces of the transducers. Often what appears to be interference when the transducer is in air may be completely gone when the transducer is submerged in water. The inverse may be true as well. If there are other sonars or mechanical devices such as hydraulic power units that create acoustic signals, these may interfere with the Pioneer system and the interference may only be detected when both our transducer and the other device are submerged in a larger bucket or tank of water or somehow acoustically coupled through a hull or structural framework.

Install the NGSPFFT Software – Use the install package. Installation of the *NGSPFFT* software is similar to installing older windows software. After successfully installing the *NGSPFFT* software there will be two folders added to your computer: C:\Program Files\RD Instruments\NGSPFFT and C:\FFT. Inside the second folder, will be a file, C:\FFT\Port.txt that stores the serial COM port number and the baud rate to be used. Please open this text file using Notepad® or similar and edit the two lines. The first line is the COM port number. Change this to number of the COM port your computer will use to talk with the Pioneer. The second number is the baud rate. Change this to 115200. Then save this file with the changes.

Using NGSPFFT to Identify Interference

Equipment needed:

- A computer with at least one serial communication port from the computer to the Pioneer's Communication Port 1 (a USB to serial converter works fine).
 - The same computer with *TRDI Toolz* software provided or from the TRDI website.
 - The same computer with the *NGSPFFT* software loaded.
 - A power supply for the Pioneer (10.7 – 36 volts DC, 1.5A is sufficient).
1. Connect to the Pioneer using *TRDI Toolz* and change the baud rate to 115200 baud.
 2. Apply power to the Pioneer 10.7 to 36 Volts DC. Set the current limit to 1.5A for Pioneer 600.
 3. Connect to the computers comport.
 4. Start the *TRDI Toolz* software and establish communication with the Pioneer. After sending a "break" you will see something like the following (The firmware version may be different):

```
Pioneer
Teledyne RD Instruments (c) 2017
All rights reserved.
Firmware Version: 67.xx
>
```

5. Type "CB811" <ENTER> then type "CK" <ENTER> you will see something like:

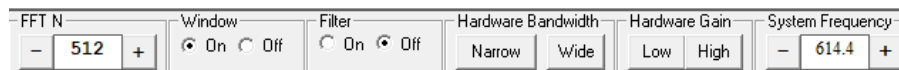
```
>cb811
>ck
[Parameters saved as USER defaults]
```

This sets the baud rate to 115200 and speeds up the FFT data transfer when using the *NGSPFFT* software.

6. Close the *TRDI Toolz.exe* program.
7. Place the transducer into a bucket of water, just deep enough to cover the urethane faces of the four transducers. This will help to properly match the acoustic impedance of the transducer and to reduce interference from radio stations or other nearby RF sources. Later, when the *NGSPFFT* software is running you can remove the transducer from the water and hold it next to a laptop or a computer terminal and see what effect these devices have on the FFT, and hence the DVL.
8. Open the *NGSPFFT.exe* program. The program will immediately attempt to establish communications and send appropriate commands. Within 30 seconds, you should see four plots of the FFT for each of the Pioneer's receive channels.
9. If no plots are generated, there is no communicating with the Pioneer. You can select by clicking on the **Comms** menu and select the port that Pioneer is connected to.
10. Click on **Comms** menu and select the baud rate (115200).
11. If you still don't see any plots after 30 seconds, try cycling the power to the DVL. If that does not help, please exit the *NGSPFFT* software and reopen *TRDI Toolz* and assure the communications are set at CB811 (115200 baud).

Check the Adjustments: At the bottom of the *NGSPFFT* window, assure the following settings:

- FFT N = 512
- Window = On
- Filter = Off
- Click the Hardware Bandwidth button **Narrow**
- Click the Hardware Gain button **High**.
- Click the + / - buttons to set the system frequency.



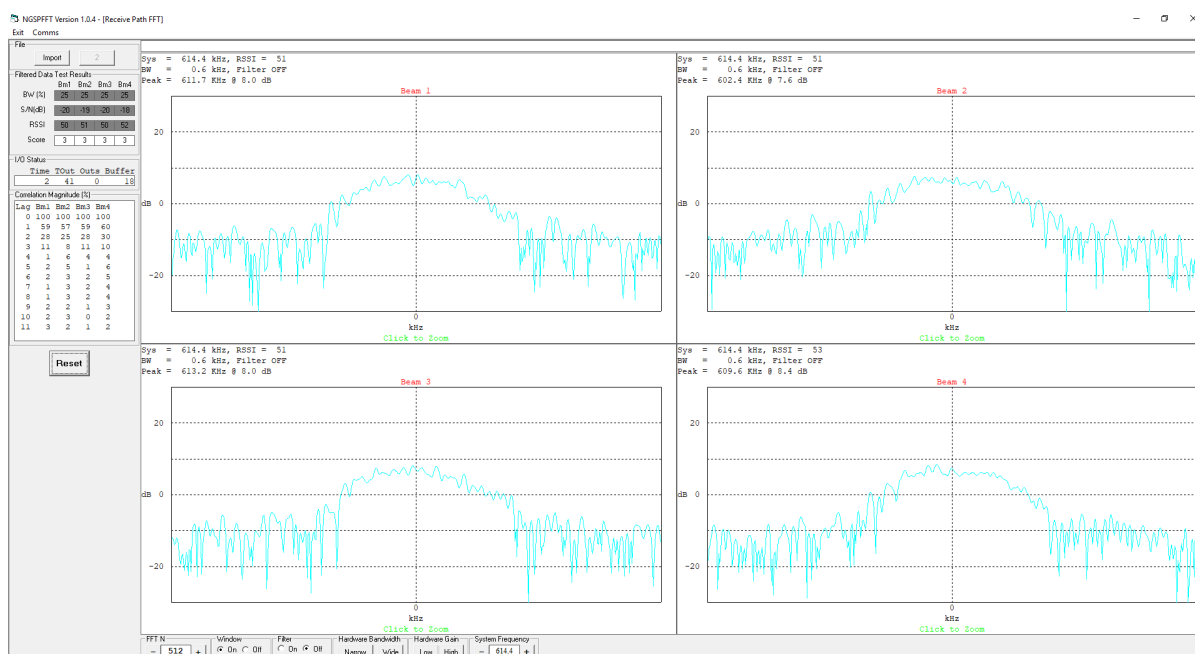
When selecting **Narrow** in *NGSPFFT*, the DVL will select the appropriate filter width for processing the data. If **Wide** is selected, then it is possible that interference terms will show up in the FFT that will not affect the DVL's accuracy.

Zoom: By clicking on the “beam” of interest, you can zoom in to see only that beam. Click again to zoom out.

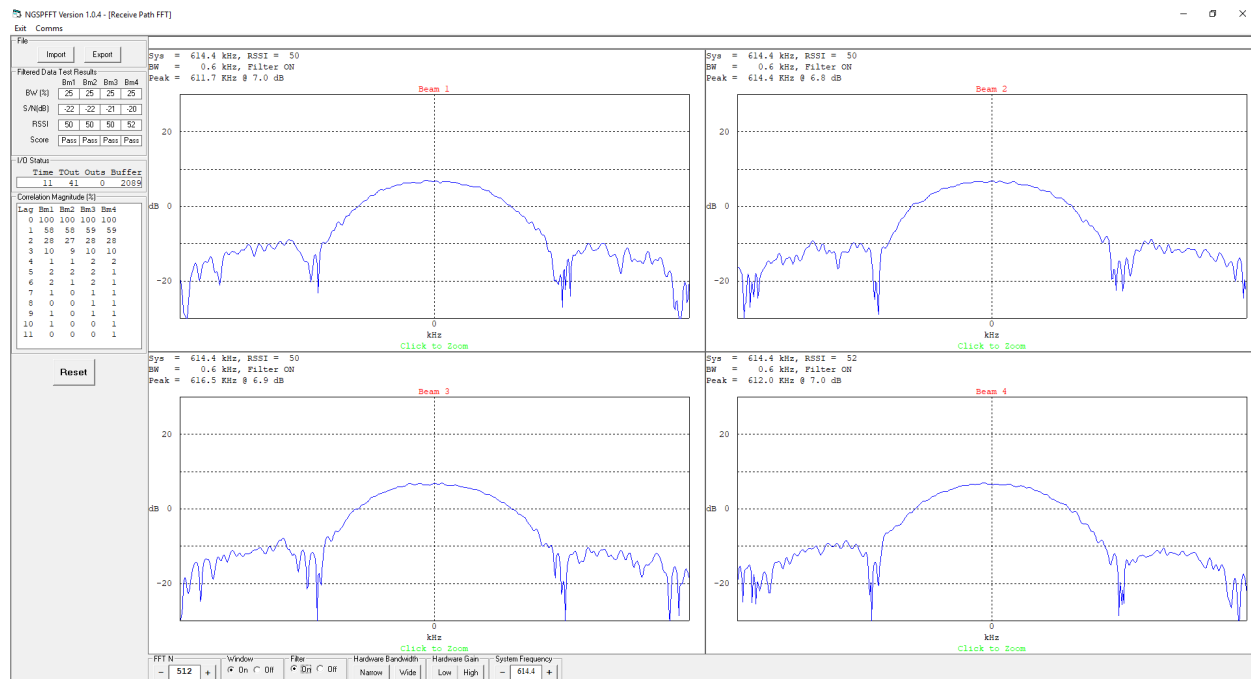
Mouse-Over: By placing the cursor over a frequency of interest, a mouse-over window will appear with more information about that frequency and amplitude.

Examples of Clean FFT Plots, No Interference

The following is a screen shot of a typical “clean”, 512 sample, FFT of a 614,400 kHz system with the **Filter** Off. The bandwidth of the plot is approximately 6.25% of the system frequency FFT in narrowband receiver mode.

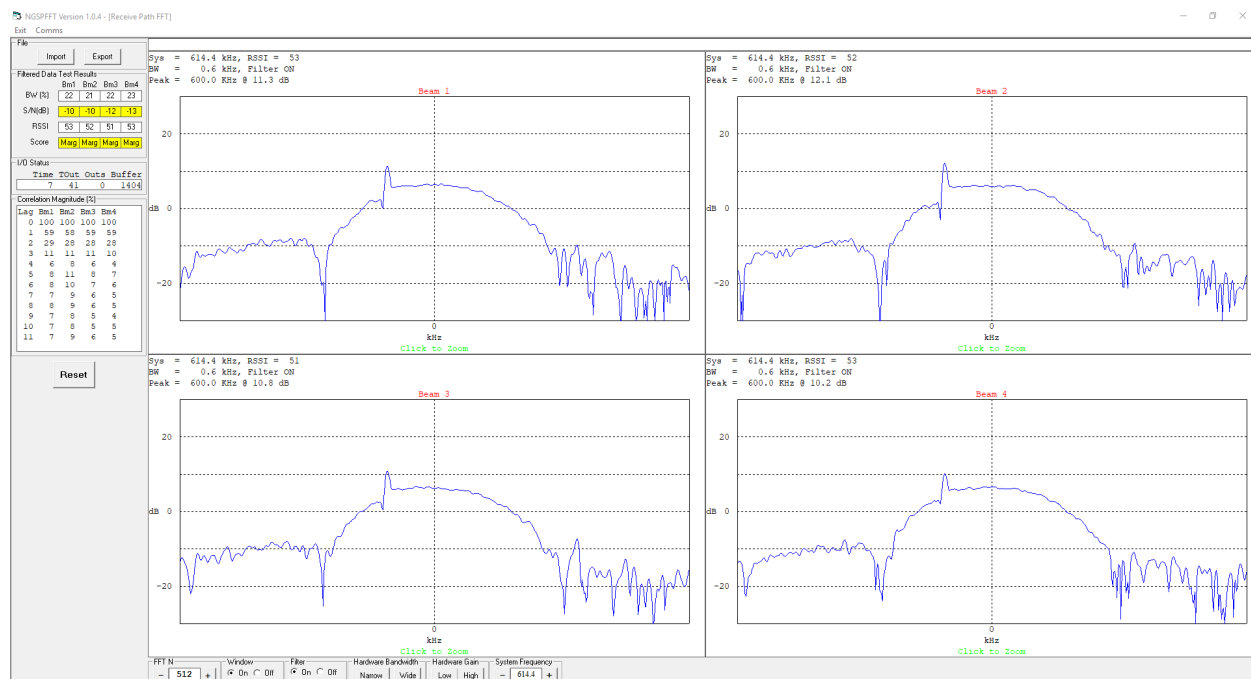


The following is the same “clean”, 512 sample FFT, with the **Filter** On radio button selected. It is simply a moving average of the last 30 FFTs. The color changes from light blue to dark blue once the FFT has acquired an average of the 30 previous (the Score will count down from 30 each time a setting is changed).



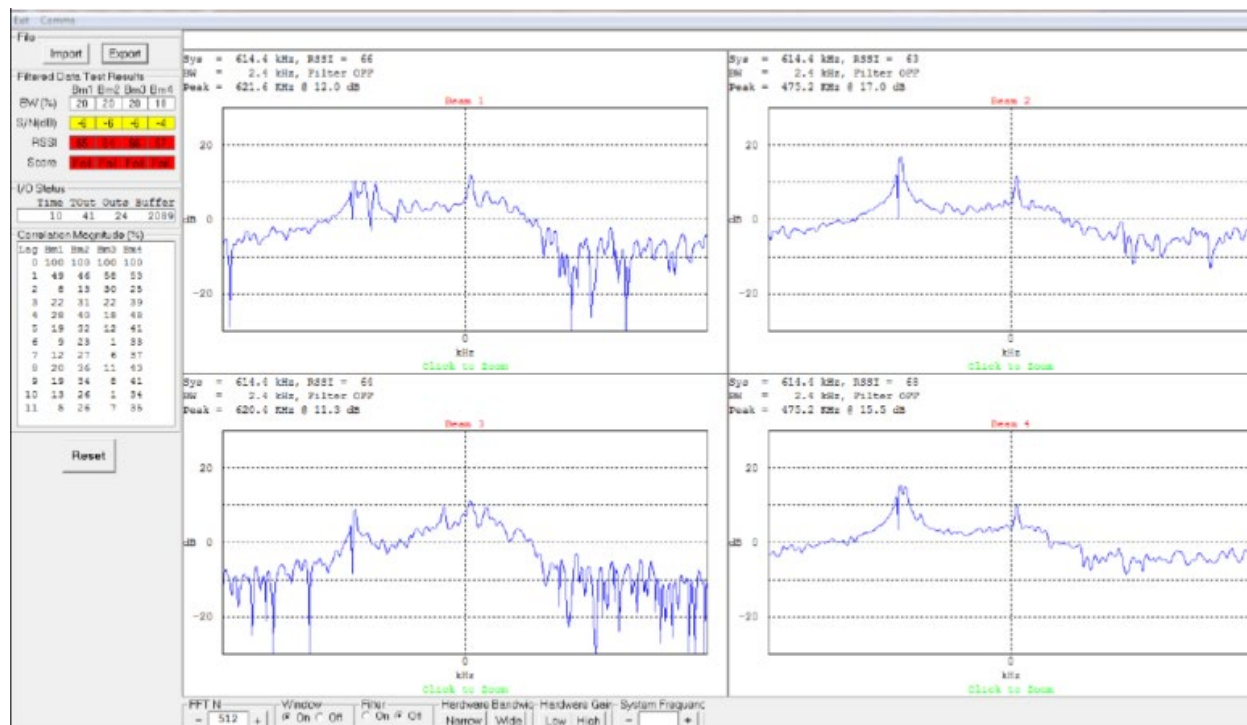
Examples of Interference

The following image shows an interference term on all channels at 601 kHz just to the left of center frequency. Notice the Filtered Data Test Results in the upper left of the screen has a yellow background color indicating Marginal for its score.



Although not ideal, the previous interfering term is small, and the DVL will still bottom track accurately if the bottom echo return amplitude is stronger than this very weak interfering term.

The following types of interference will have significant effects on accuracy of water profiling and bottom track and should cause failures of the Built in Tests. Notice that the filter function is off, and you still clearly see that you have an interference issue, and you can identify the frequency if you Mouse-Over.



Alternative FFT Tool for Virtual Comports

For those applications where the DVL is not directly connectable through a physical RS232 comport, the *NGSPFFT* will unfortunately not be able to run, as it needs a physical UART/comport to be able to send a Serial Break to the Pioneer DVL to respond and start acquiring the FFTs.

An alternative Tool exists called *QCMon*, which sends a software break instead, i.e. “+++”. The ‘look and feel’ of *QCMon* is only slightly different from the *NGSPFFT*, thus you will find similarities in data provided. You will need to change the way you run it by following these steps instead:

1. In *QCMon*, after you set **Comm > Port** and clicked on the right Baudrate using **Comm > Baudrate**, click on **Comm > BREAK** and you should see the Pioneer DVL banner as depicted below:

```
Pioneer DVL
Teledyne RD Instruments (c) 2017
All rights reserved.
Firmware Version: XX.xx
```

>

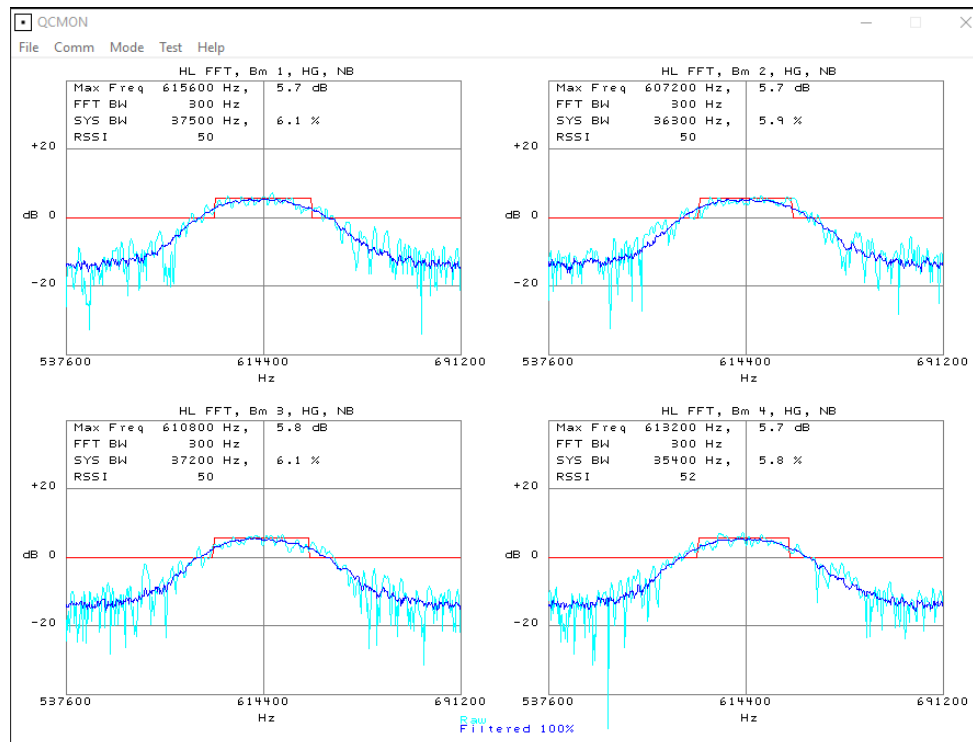
2. Then go to **Comm > Terminal** and then in the *QCMon* window type any commands (B?, TS?, etc.) like you would with *TRDI Toolz* and you should get replies from the Pioneer.
3. If this is working, send PT200.

```
>pt3
Receive Path Test (Hard Limited):
      H-Gain W-BW      L-Gain W-BW      H-Gain N-BW      L-Gain N-BW
↓
↓
RESULT...PASSED
```

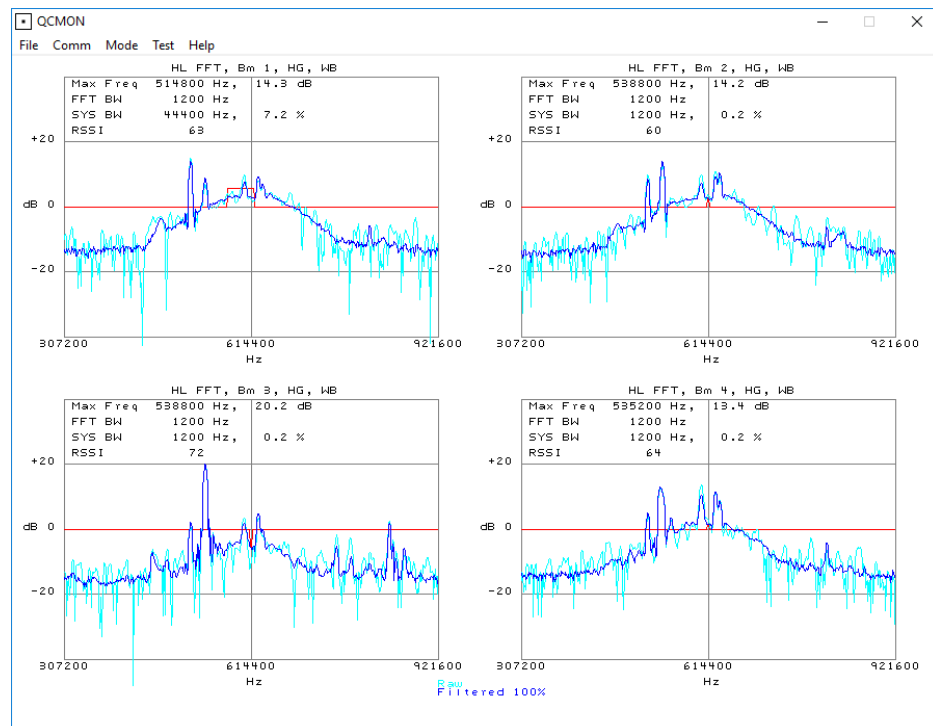
```
>pt5
Transmit/Receive Continuity Check:
↓
↓
RESULT...PASSED
```

>

4. If all this works up to this point and you have a high baudrate then go to **Test > FFT (HL) > Go** to turn the FFT spectrum analyzer mode on each beam:
 - Anything that looks different in overall shape or spikes anywhere that show on the light blue line (realtime FFT) is of concern even more when it shows on the dark blue line (averaged FFT).
 - Note that you can click on any beam to Zoom on it if this helps.
 - The way to ‘collect’ FFT data with *QCMon* is to take snapshots in different scenarios, such as take one for baseline in water with the vehicle ON but no active sensors, arms, thrusters, (or even using a known cleaner external power source) then take a snapshot for each of the major vehicle components* turned ON to active mode.
 - * anything that is powered on the vehicle and can be placed into an active mode (which usually means either or both driving more current or creating EMI or Acoustic pulses)
 - It is also advised to do the same with the DVL Built-in test and go back to the terminal and send PT200 for each of these scenarios. To do so **Go To Test > STOP** then **Go To Comm > Terminal** and then send PT200. Same as the *FFT*, you will have to take snapshots for each scenario.



Example plot with no interference



Example plot showing interference

NOTES

Chapter 3

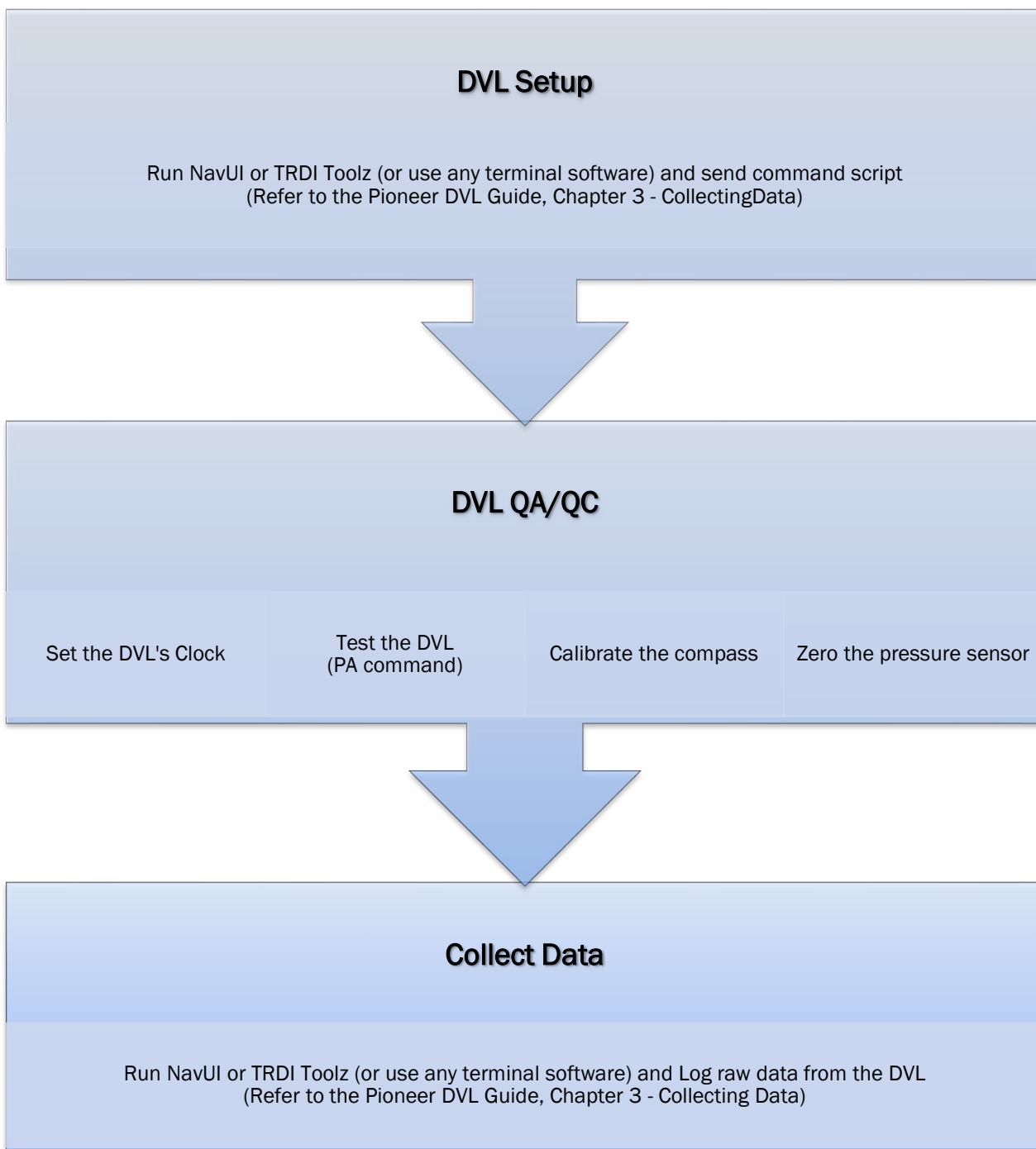
COLLECTING DATA



In this chapter:

- Pioneer General Deployment Flow
- Creating or Modifying Command Files
- Compass Calibration
- Sending Commands to the Pioneer
- External Sensor Setup

Pioneer General Deployment Flow



Creating or Modifying Command Files

Command files are simply ASCII files produced by ASCII editors such as *NotePad* that set Pioneer command parameters. In general, they contain ASCII characters that are sent out through the serial port.

To create a command file:

- Copy the example command file into *NotePad* and edit the commands as needed. Refer to the [Command Descriptions](#) for detailed information on each command.
- If the first character of a line is a semi-colon, then all characters after the semi-colon (including the semi-colon) are ignored. This feature is to provide file comments that the user may insert for clarity.
- Use one command per line.
- Save the file. Command files can have *.rds, *.txt, *.scr, or any other extension as long as they are ASCII text files.



The example command file has comments that explain the function of each command. It is a good idea to keep the comments and edit them when making command changes.

The following shows an example printout of a command file.

```

;-----
; Pioneer type:      300 kHz Pioneer
; Setup name:       Pioneer.txt
; Setup type:       Bottom Track only
;
; NOTE: Any line beginning with a semicolon in the first column is
;       treated as a comment and is ignored by the software.
; Modified Last: 18 March 2015
;-----
; *****
; Pioneer Basic Setup Commands
; *****
; Restore factory default settings in the Pioneer
CR1
; set the data collection baud rate to 15200 bps,
; no parity, one stop bit, 8 data bits
CB811
; Flow Control - set to default
CF11110
; *****
; Pioneer Bottom Track Setup Commands
; *****
; Enable single-ping bottom track,
BP001
Set maximum bottom search depth to 290 meters (300 kHz default with XRT mode off)
BX02900
; *****
; Pioneer Environment Setup Commands
; *****
; Set Heading Alignment to 0 degrees
; NOTE: If the Pioneer is rotated +45 degrees starboard
; (recommended alignment), set EA to EA+45000
EA00000
; Set manual transducer depth in case depth sensor fails
ED0000
; Set Salinity to saltwater
ES35
; Output earth coordinates, use tilts, allow 3 beam
; solutions and bin mapping
EX11111
; Set to use internal Keller pressure and SBG AHRS sensors
EZ11111010
; *****
; Pioneer Timing Setup Commands
; *****
; Set Time between Ensembles to zero (Pioneer will ping as fast as possible)
TE00000000
; Set Time between Pings to zero (Pioneer will ping as fast as possible)
TP00:00.00

```

```

; *****
; Pioneer Water Profiling Setup Commands
; *****
; Note: By default, water profiling is turned off.
;       To use water profiling, set the WP command >0
WP0
; Bin size set to 400 cm
WS0400
; Number of bins set to 50
WN050
;
; *****
; Pioneer Expert Command Section
; *****
;
; CAUTION - Editing or adding expert commands to the command file will
;           allow items that if set incorrectly can cause the data to
;           be the wrong format, bad, and/or uncorrectable even in post
;           processing.
;
; Disable Water-Mass Layer Mode (default)
BK0
; *****
; Turnkey mode on - Pioneer will ping when power turned on.
; CAUTION - Pioneer must be in water BEFORE command file is sent.
; *****
#CT1
; Environmental Data Output - sets specialized attitude data types
; Phased Array transducer default
#EE0000010
; Set Heading Bias to 0 degrees
;
; NOTE. Set #EV = [(local magnetic declaration)*100]
#EV00000
; Select type of external sensor to use
#EY 0 0 0 0 0 0 0 0
; Set output data format to #PDO
#PDO
; *****
; Pioneer Sensor Setup Commands
; *****
; See the Pioneer Operation Manual for details on the sensor commands.
; If needed, add the commands here.
;
; -----
; Save this setup to non-volatile memory in the Pioneer
CK
; Start ping
CS

```

The commands shown in Table 9 explain each command set by the example command file. These commands directly affect the range of the Pioneer, standard deviation (accuracy) of the data, ping time, and power usage.

Teledyne RD Instruments ***strongly recommends*** that the commands shown in Table 9 be the ***minimum*** commands that should be sent to the Pioneer.



Although these are TRDI's recommended minimum commands, they may not be the only commands needed for the deployment to be successful!

Editing or adding expert commands (#xx) to the command file will allow items that if set incorrectly can cause the data to be the wrong format, bad, and/or uncorrectable even in post processing.




The deployment may require additional commands and these commands can be sent any time after the CR1 command but must be placed before the CK command.

Table 9: Recommended Commands

Command	Choices	Description
CR1	Sets factory defaults	This is the first command sent to the DVL to place it in a “known” state.
CBxxx	CB111 to CB811	Sets the baud rate from 1200 to 115200 baud. Recommended to leave at default setting of 9600 baud (CB411) (see CB - Serial Port Control).
CF11110	See manual for description	Flow control - Recommended to leave at default setting of CF11110 (see CF - Flow Control).
BP1	BP0 (off) to BP999	Sets the Bottom Track Pings Ping to once per ensemble. Recommended to leave at default setting of BP1 (see BP – Bottom-Track Pings per Ensemble).
BX02900	XRT mode Off: 300 kHz = BX2900 600 kHz = BX1100 XRT mode On: BX4800 (300 kHz) BX1600 (600 kHz)	Sets the Maximum Tracking Depth to 290m (2900 decimeters) for Pioneer 300; 110m for Pioneer 600 (1100 decimeters) with the XRT mode off. If the XRT mode is on, the maximum is BX4800 (300 kHz), BX1600 (600 kHz) (see BX – Maximum Tracking Depth)
EA00000	EA-17999 to EA18000	Heading alignment uses beam-3 as the heading alignment. If the Pioneer is rotated +45 degrees starboard (recommended alignment), set EA to EA+45000 (see EA - Heading Alignment)
ED0000	ED0 to ED65535	Manually set depth of the transducer in decimeters. If a pressure sensor is available, the ED-command will be used only if the depth sensor fails (see ED - Depth of Transducer).
ES35	ES0 to ES40	Salinity of water is set to 35 (saltwater) (see ES – Salinity).
EX11111	Coordinates, Use Tilts, 3-beam solution, bin mapping	Sets coordinate system, use tilts, allow 3-beam solutions, and allow depth cell (bin) mapping (see EX – Coordinate Transformation).
EZ11111010	Sensor source	Calculate speed of sound from internal Keller pressure and SBG AHRS sensor readings (Speed of Sound, Depth, Heading, Pitch, Roll, Salinity, and Temperature). See the #EY command to override automatic selection of which sensor to use (see EZ - Sensor Source).
TE00:00:00.00	Time per ensemble	Ping as fast as possible (see TE – Time Per Ensemble).
TP00:00.00	Time per ping	Ping as fast as possible (see TP – Time Between Pings).
WP0	WP0 to WP16384	Water Profiling – The default setting WP0 will turn off water profiling (see WP – Pings Per Ensemble).
WF0400 (300 kHz) WS0200 (600 kHz)	300 kHz = WS50 to WS800 600 kHz = WS10 to WS400	Sets the depth cell size in cm. Recommended to leave at default setting (see WS – Depth Cell Size).
WN030	WN1 to WN255	Sets the number of depth cells. Recommended to leave at default setting of WN030 (see WN – Number of Depth Cells).
BKx	BK0, BK1, BK2, BK3	This command selects the when the Water-Mass Layer ping will be used. Recommended to send the BK0 (default) command to disable the Water-Mass Layer (this also disables the #BL command) (see BK - Water-Mass Layer Mode). If the Water-Mass Layer pings need to be enabled, see the BK and #BL commands.

Table 9: Recommended Commands

Command	Choices	Description
#BLmmmm,nnnn,ffff	Min, Near, Far layer boundary	This command sets the Water-Mass Layer boundaries. Recommended to leave at the default settings: #BL320,640,960 (see BL - Water-Mass Layer Parameters).
#BJtc*hrn***	Bottom Data Types	This command sets the Bottom Data Types that will be output. Recommended to leave at the default setting #BJ100 000 000 (see BJ – Data Type Output Control).
#CTx	CT0 (default) or CT1	Setting the #CT command to #CT1 turns the Turnkey mode on. The Pioneer will ping 10 seconds after power is turned on (see CT - Turnkey Operation).  Make sure the Pioneer is in water before turning on the power if turnkey mode is on. If the Turnkey mode is on, the Pioneer will start pinging automatically after 10 seconds of applying power, without the need to send any command file.
#EE0000010	Environmental data output	Selects specialized Environmental data. Recommended to leave at the default settings: default#EE0000010 (see EE - Environmental Data Output).
#EV00000	#EV-17999 to #EV18000	Sets the Heading Variation in degrees. Set #EV = [(local magnetic declination)*100] (see EV - Heading Bias).
#PDx	PD0 (default), PD4, PD5, PD6	Sets the output data format (see PD0 Output Data Format).
#EY 0 0 0 0 0 0 0	Select external sensors	Overrides the automatic sensor selection logic. Use this command to specify a sensor to use for a parameter needed in the Doppler velocity calculation (see EY – Sensor Source Override for Doppler Parameters).
CK	Keep parameters as user defaults	If power is lost and then restored, all commands will be restored as last sent (see CK - Keep Parameters). Sent right before the CS-command.
CS	Start ping	Last command sent to begin collecting data (see CS – Start Ping (Go)).



The CR1 command must be the first command sent to the Pioneer. The CK command must be sent just before the CS command. Other commands may be sent in any order.



TRDI does not recommend pinging the Pioneer system with the transducer in air. The transducer may be damaged. The transducer is pinged by sending a CS, PA, PT3, or PT5 command or if the Pioneer system is started for collecting data.




If the Pioneer system was in [turn-key mode](#) when last powered down, it will automatically resume pinging ten seconds after power is applied. To avoid pinging in air, disable the turn-key mode within ten seconds after applying power by sending a CT0 command immediately after receiving the prompt following wake-up message and then send a CK command to save the new setting as the user default. Another way to stop pinging is to send a Break and then send a valid command (for example, send a Break and the OL command) to the Pioneer to stop it from pinging.



Avoid removing the transducer from water if it is actively pinging. First send a break to stop pinging before removing the Pioneer system from water.

Sending Commands to the Pioneer

To send the commands to the Pioneer:

1. Place the Pioneer system in water.
2. Start *TRDI Toolz*.
3. Send a BREAK to the Pioneer by pressing the  icon. When the Pioneer receives a BREAK signal, it responds with a wake-up message similar to the one shown below. The Pioneer is now ready to accept commands at the ">" prompt.

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>

4. Use *TRDI Toolz* to set the clock; click **Tools, PC Time to ADCP**.
5. To test the system, use the [PA command](#).
6. Before beginning to collect data, [calibrate the compass](#).
7. If you have a pressure sensor attached, send the [SZ command](#) and then press the **Enter** key. This will zero the pressure sensor.



The pressure sensor must be zeroed at the location the closest to where the DVL will be deployed.

8. To send the command file, on the **Tools** menu, select **Script Editor**.
9. Click the **Open** icon and select the file to run from the scroll-down list. If no extension is given for the script file, an extension of *.txt is assumed.
10. Click the **Send** icon.



Teledyne RD Instruments does not recommend the use of entering commands one at a time as the primary way of deploying a Pioneer system as **any incorrect command setting can have severe consequences to data collection**. Always use a script file to send the commands. See the [Command Descriptions](#) and [Introduction to Output Data Format](#) sections for information on each command setting.



Script files can have any extension as long as they are ASCII text files.

Using the SBG Ellipse AHRS Sensor

This section describes the Attitude Heading Reference System (AHRS) sensor model “Ellipse A” manufactured by SBG which can be integrated into the Pioneer 300/600. This sensor outputs heading, pitch and roll (HPR) data which will be used by the host vehicle for navigation purposes. When the Pioneer is outputting PDO data, the [SD command](#) enables and disables additional data from the AHRS (see Table 45 through Table 56). Use the [SM command](#) to change the AHRS settings.

The SBG Ellipse AHRS, if installed, is setup automatically by the Pioneer firmware except for the working Latitude and Longitude (Set LLA & Date).

Set LLA & Date

Use the [SM command](#) to update the latitude, longitude, altitude, and date of the SBG Ellipse (used for its internal modeling of local magnetic phenomena) as follows:

Parameter	Meaning	Acceptable Values
Latitude	Latitude of present location, in degrees	-90.0 to +90.0
Longitude	Longitude of present location, in degrees	-180.0 to +180.0
Altitude	Initial altitude, in meters, above WGS84 ellipsoid.	-6000.0 to +6000.0
Year	Year at startup	2000 to 3000
Month	Month at startup	1 to 12
Day	Day in month at startup	1 to 31 depending on calendar year/month.

Example terminal session:

```
>sm 12
SBG Ellipse-A Auxiliary Menu
0 ----- Help
D ----- Display SBG Status and Settings
H ----- Display Heading, Pitch & Roll
M ----- Modify Settings
P ----- Pass-Through Mode
2 ----- 2D Magnetometer Calibration
3 ----- 3D Magnetometer Calibration
F ----- Restore Factory Settings and Calibration
T ----- Restore Internal Settings and Alignment
R ----- Reboot SBG Ellipse-A AHRS
X ----- Exit

>sm 12 m
SBG Ellipse-A Settings Menu
0 ----- Help
A ----- Set Alignments [xdir ydir rerr perr yerr xla yla zla]
L ----- Set LLA & Date [lat long alt yyyy mm dd]
X ----- Exit
x

>sm 12 m 1 ?
30.0 -126.5 0.10 2014 12 10

>sm 12 m 1 -10.0 178 -0.5 2015 02 06

>sm 12 m 1 ?
-10.0 178 -0.5 2015 02 06
```



Any changes to these settings are automatically saved to the AHRS.

The date set here does not change or need to match the Real-Time Clock time set by the [TS command](#). It is used to set the magnetic variation for the location and date.

Use <http://www.mapcoordinates.net/en> to locate your Lat/Long and Altitude.

Calibrating the AHRS Sensor

Pioneer AHRS calibration corrects for distortions in the earth's magnetic fields caused by permanent magnets or ferromagnetic materials near the Pioneer. These magnetic field distortions, if left uncorrected, will create errors in the heading data from the Pioneer. An AHRS calibration should be conducted at each measurement location, and whenever the mounting fixture, boat/float, or ancillary equipment such as batteries or radios are changed or rearranged. Be aware of the following items:

- Compass calibration is especially important when using the Pioneer on a ROV/AUV as they often have significant magnetic field distortions from the hull, engine(s), and ancillary equipment. Accurate calibration may not be possible in extreme cases.
- If the mounting fixture or frame has some magnetic field or magnetic permeability, calibrate the Pioneer inside the fixture. Depending on the strength and complexity of the fixture's field, the calibration procedure may be able to correct it.
- The compass should be calibrated in the same orientation (beams-up/beams-down) as it will be deployed. Failure to do so will cause a 2 to 4 degrees RMS error on the compass reading. In addition, the [EU command](#) must match the orientation of the compass calibration and deployment.
- Ferromagnetic structures such as bridges or sheet piling in the measurement location may interfere with proper compass operation. The compass calibration procedure can NOT correct for heading errors due to these types of structures.



Note that the magnetometer sampling design makes it impossible to reject signal frequencies above 180Hz. Ensure that high frequency noise is not disturbing the magnetometers at the sensor's location.

To calibrate the SBG Ellipse-A AHRS magnetometer:

1. Start *TRDI Toolz*.
2. Use the [SM command](#) to start the field calibration. Send SM 12 2 for a 2D calibration (no tilts required) or SM 12 3 for a 3D calibration (tilts required).
 - The 2D calibration mode is only designed to be used when roll and pitch motions are less than $\pm 5^\circ$.
 - The 3D magnetic calibration offers the best accuracy but needs at least $\pm 30^\circ$ motion on the roll and pitch angles.



If the vehicle cannot be rotated freely in all orientations, the calibration will still be accurate, but only in orientations that were covered during the calibration procedure.

3. The AHRS reports the internal latitude, longitude, and altitude (LL&A) and date and prompts to update the LL&A and date if needed. Type **Y** to update (see [Set LLA & Date](#)) or **N** to use the current setting and continue with the calibration.
4. Begin moving the system through the desired orientations to collect magnetometer data. To work correctly, the Pioneer system should be rotated through at least a full circle.



The AHRS is mounted near the end-cap and should be the center of rotation. Too much movement of the AHRS position between calibration points will lower the calibration score.

5. As the system is moved through the various orientations, the SM command provides a continual report of the number of points collected and overall data quality.
6. As the system is acquiring data, press any key to pause the acquisition process.
 - When paused, the SM command provides a quality report on the data collected thus far.
 - To resume the calibration, press any key other than <ESC>. When the calibration is resumed, then the system returns to collecting data points.
7. End the calibration process by pressing the <ESC> key. The final quality data is reported by the AHRS. The magnetic calibration **quality indicator** is computed based on the magnetic field norm deviation after calibration:
 - **Optimal** – All acquired points fit very well on a unit sphere after the calibration.
 - **Good** – Small deviations of the magnetic field norm have been detected. The magnetic calibration should although provide accurate heading.
 - **Poor** – Large deviations of the magnetic field norm have been detected. It may come from external magnetic distortions during the calibration.
 - **Invalid** – No valid magnetic calibration has been computed. It could come from too much magnetic disturbances, insufficient or invalid motions.

The better the magnetic field is mapped, the better the **confidence indicator** is. If you only cover very few portions of the 3D sphere or 2D circle, the confidence indicator will be low.

- **High** – Reported quality indicator can be trusted as enough remarkable magnetic field points have been acquired.
 - **Medium** – Few remarkable magnetic field points have been used to compute the magnetic calibration leading to a medium confidence in reported quality indicators.
 - **Low** – Even if the quality indicator could report an excellent calibration, the data set used to compute the magnetic calibration was not meaningful enough to compute meaningful quality indicators. This calibration should be used carefully.
8. Press **Y** to save and apply the calibration, or **N** to discard it and quit.

2D Calibration Example

Example calibration (user entries are indicated in BOLD):

```
>sm 12
SBG Ellipse-A Auxiliary Menu
0 ----- Help
D ----- Display SBG Status and Settings
H ----- Display Heading, Pitch & Roll
M ----- Modify Settings
P ----- Pass-Through Mode
2 ----- 2D Magnetometer Calibration
3 ----- 3D Magnetometer Calibration
F ----- Restore Factory Settings and Calibration
T ----- Restore Internal Settings and Alignment
R ----- Reboot SBG Ellipse-A AHRS
X ----- Exit
2
```

```
Verify location data:
48.8688 deg 2.1577 deg 30.00 m 2014/04/20
Do you want to change location data (y/n)?
Yes
```

SBG Ellipse: Enter new LL&A [lat long alt year month day]:

-10.0 178 -0.5 2015 02 06 (Note this is the San Diego office location: Use <http://www.latlong.net/> to enter your LLA. Enter the current date.

SBG Ellipse: New LL&A and date saved.

SBG Ellipse: Acquiring magnetic field data for a 2D calibration.

SBG Ellipse: Will use up to 1000 points for calibration.

SBG Ellipse: Press any key to pause the magnetic field acquisition.

SBG Ellipse: and display the current results.

- nPoints= 46, Q=Optimal . (NOTE this line is updated in-line with an animated text indicator)

(User presses any key on the keyboard)

Magnetic calibration report:

Quality: Optimal

Confidence: Medium

Used Points: 46

Max Points: 1000

Magnetic field deviations (degrees):

	Mean	Stdev	Max
Before	12.94	0.16	13.33
After	0.12	0.08	0.29
Accuracy	0.00	0.00	0.01

Advanced status bits: 00000000 00010100

Press ESC to quit, or any other key to continue calibration.

(User presses any key besides <ESC>)

\ nPoints= 65, Q=Optimal . (Updated in-line, as before)

(User presses any key on the keyboard)

Magnetic calibration report:

Quality: Optimal

Confidence: Medium

Used Points: 65

Max Points: 1000

Magnetic field deviations (degrees):

	Mean	Stdev	Max
Before	13.17	0.19	13.70
After	0.12	0.08	0.37
Accuracy	0.00	0.00	0.01

Advanced status bits: 00000000 00000000

Press ESC to quit, or any other key to continue calibration.

(User presses <ESC>)

Calibration quality is Optimal. Number of points collected is 65

Do you want to apply the new calibration (y/n)?

n

Calibration discarded. Rebooting the SBG Ellipse.

SBG Ellipse: system reboot

Command response time = 20 ms

Resetting DVL.

Pioneer 300/600 DVL

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3D Calibration Example

Note that the user communications for the 3D calibration are virtually indistinguishable from the 2D calibration; the only difference is the calibration mode that was commanded by the user. Example calibration (user entries are indicated in BOLD):

>sm 12

```
SBG Ellipse-A Auxiliary Menu
0 ----- Help
D ----- Display SBG Status and Settings
H ----- Display Heading, Pitch & Roll
M ----- Modify Settings
P ----- Pass-Through Mode
2 ----- 2D Magnetometer Calibration
3 ----- 3D Magnetometer Calibration
F ----- Restore Factory Settings and Calibration
R ----- Reboot SBG Ellipse-A AHRS
X ----- Exit
```

3

```
SBG Ellipse: Current LL&A and date is: -10.0 178 -0.5 2015 02 06
SBG Ellipse: Do you need to update LL&A and date(y/n)?
```

No

```
Cal started. Error Code = 0
SBG Ellipse: Acquiring magnetic field data for a 3D calibration.
SBG Ellipse: Will use up to 1000 points for calibration.
SBG Ellipse: Press any key to pause the magnetic field acquisition.
SBG Ellipse: and display the current results.
- nPoints= 46, Q=Optimal . (NOTE this is updated in-line with an animated text indicator)
```

(User presses any key on the keyboard)

```
Magnetic calibration report:
Quality: Optimal
Confidence: Medium
Used Points: 46
Max Points: 1000
Magnetic field deviations (degrees):
      Mean  Stdev  Max
Before 12.94  0.16 13.33
After  0.12  0.08  0.29
Accuracy 0.00  0.00  0.01
Advanced status bits: 00000000 00010100
Press ESC to quit, or any other key to continue calibration.
```

(User presses any key besides <ESC>)

```
\ nPoints= 65, Q=Optimal . (Updated inline, as before)
```

(User presses any key on the keyboard)

```
Magnetic calibration report:
Quality: Optimal
Confidence: Medium
Used Points: 65
Max Points: 1000
Magnetic field deviations (degrees):
      Mean  Stdev  Max
Before 13.17  0.19 13.70
After  0.12  0.08  0.37
Accuracy 0.00  0.00  0.01
Advanced status bits: 00000000 00000000
Press ESC to quit, or any other key to continue calibration.
```

(User presses <ESC>)

```
Calibration quality is Optimal. Number of points collected is 65
Do you want to save the new calibration (y/n)?
```

y

```
SBG Ellipse: The new magnetic calibration has been saved.
SBG Ellipse: system reboot
Command response time = 20 ms
Resetting DVL.
```

```
Pioneer 300/600 DVL
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All rights reserved.
```

```
>
```

Reset AHRS to Factory Defaults

In certain situations the user may wish to reset the AHRS to its factory default settings and calibration data, for example:

- User is in a magnetically poor environment and unable to successfully calibrate the unit.
- Anomalies seen during operation, suspected root cause is misconfiguration of the device.



Loading the factory calibration on the AHRS may not provide accurate heading data as the AHRS sensor would not use a calibration relevant to the field of operation. It is highly recommended to perform a user 2D or 3D calibration. A 3D calibration is always preferred when possible.

To accommodate this, use the [SM command](#) to reset the AHRS to its factory default settings and calibration. For example:

```
>sm 12
SBG Ellipse-A Auxiliary Menu
0 ----- Help
D ----- Display SBG Status and Settings
H ----- Display Heading, Pitch & Roll
M ----- Modify Settings
P ----- Pass-Through Mode
2 ----- 2D Magnetometer Calibration
3 ----- 3D Magnetometer Calibration
F ----- Restore Factory Settings and Calibration
T ----- Restore Internal Settings and Alignment
R ----- Reboot SBG Ellipse-A AHRS
X ----- Exit
F
```

The AHRS will automatically reboot on this command.



Use the **T** option (**Restore Internal Settings and Alignment**) to restore settings, but not the calibration.

NOTES

Chapter 4

MAINTENANCE



In this chapter:

- How to spot problems
- How to do periodic maintenance items on the Pioneer

Replaceable Parts

Use the following table to order replacement parts:

Table 10: Pioneer Spare Parts 300/600kHz 1000 meter Systems

Description	Part number	Where used
ANODE, PIONEER 300	81B-4146-00	Anodes for Housing Exterior
SCREW, FLAT HEAD, SST	M5X0.8X10FH	
SEALANT, SILICONE85MM, 2.7 OZ/TUBE	59530	
O-RING, 2-163, DURO 70, EPDM	2-163	O-Rings for housing
O-RING, 2-253, DURO 70, EPDM	97Z-6044-00	
O-RING TOOL, TELEDYNE	81B-6042-00	
SILICONE LUBRICANT, 4-PACK	5020	
DESICCANT, SEALED BAG,1/2 UNIT	DES1	Housing Interior
WASHER, FLAT-1/4,.495-OD SST	1/4WASHSMOD	Closing hardware for housing O-Ring for housing Plugs
NUT, 1/4-20, NYLOCK	1/4-20WASHNYLOCK	
PLUG, HOUSING, PIONEER/PATHFINDER	81B-4182-00	
O-RING, 2-017, DURO 70 , EPDM	97Z-6012-00	

Table 11. Pioneer Spare Parts 300 kHz 4500 meter Systems

Part Description	Part Number	Where used
ANODE, PIONEER 300	81B-4146-00	Anodes for Housing Exterior
SCREW, FLAT HEAD, SST	M5X0.8X10FH	
SEALANT, SILICONE85MM, 2.7 OZ/TUBE	59530	
O-RING TOOL, TELEDYNE	81B-6042-00	O-Rings for housing
O-RING, 2-164, DURO 70, EPDM SCD	97Z-6034-00	
O-RING, 2-253, DURO 70, EPDM SCD	97Z-6044-00	
SILICONE LUBRICANT, 4-PACK	5020	
DESICCANT, SEALED BAG,1/2 UNIT MIL PAK	DES1	Housing Interior
NUT, HEX, SST 316	1/4-20NUT	Closing hardware for housing O-Ring for housing Plugs
WASHER, FLAT-1/4,.495-OD SST	1/4WASHSMOD	
WASHER, SPLIT LOCK,SST316	1/4WASHSPL	
PLUG, HOUSING, PIONEER/PATHFINDER	81B-4182-00	
O-RING, 2-017, DURO 70 , EPDM SCD	97Z-6012-00	

Inspection Schedule

TRDI recommends the following regular inspection to be performed before every deployment:

Table 12: Visual Inspection Criteria

Item	Inspection Criteria
Transducer	<p>The urethane coating on the transducer face is important to Pioneer watertight integrity. Mishandling, chemicals, abrasive cleaners, and excessive depth pressures can damage the transducer ceramics or urethane coating. Inspect the transducer face for dents, chipping, peeling, urethane shrinkage, hairline cracks, and damage that may affect watertight integrity or transducer operation.</p> <p>Before each deployment, check the urethane coating on the transducer faces for dents, chipping, peeling, urethane shrinkage, hairline cracks and damage that may affect watertight integrity or transducer operation.</p> <p>Based on experience, TRDI knows that most systems need to have the urethane inspected after three to five years of field use; shorter periods may be required depending on marine growth. Repair of the transducer face should only be done by TRDI (see Figure 20).</p>
Connectors/ Cables	<p>Check the connectors for cracks or bent pins (see Figure 21). Repair of the connectors should only be done by TRDI.</p> <p>Check the cable connectors for cracks or bent pins. Inspect the full length of the cable for cuts, nicks in the insulation, and exposed conductors.</p> <p>TRDI recommends that the connectors be replaced every five years or whenever visible signs of wear or corrosion appear.</p>
Housing paint / anodize coating	<p>Inspect the end-cap, housing, and transducer assembly for corrosion, scratches, cracks, abrasions, or exposed metal (silver-colored aluminum). Be critical in judgment; the useful life of the Pioneer depends on it. Thoroughly clean the exterior of the system after retrieval. See Removing Biofouling for details.</p>
Anodes	<p>Inspect the anodes on the transducer assembly and housing for corrosion and pitting. Cover bolts with silicone sealant prior to deployment. Replace anodes whenever the mounting bolt is in less than 75% in contact with the bolt. Replace all anodes every one to two years maximum.</p>
Hardware	<p>Check all bolts, washers, housing plugs, and split washers for signs of corrosion. TRDI recommends replacement after every deployment or every year whichever is longer. Damaged hardware should never be used.</p>
O-rings	<p>O-rings should be replaced whenever the system is opened and BEFORE they are showing any signs of wear and tear.</p> <p>All O-rings should be replaced every one to two years maximum.</p>



To ensure continued optimal results from the Pioneer DVL, TRDI recommends that every system be returned to our factory for an inspection every two to three years. TRDI provides the unit with a thorough multi-point inspection, and notify you if any refurbishment services are required to properly maintain the unit. To learn more about this service, please [contact field service](#).

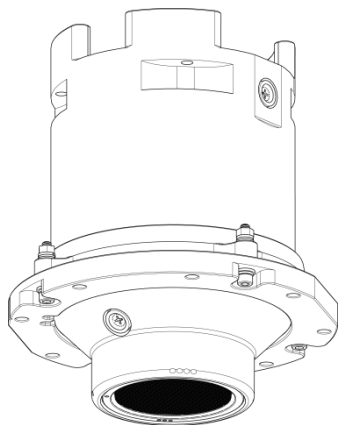


Figure 26. Transducer View

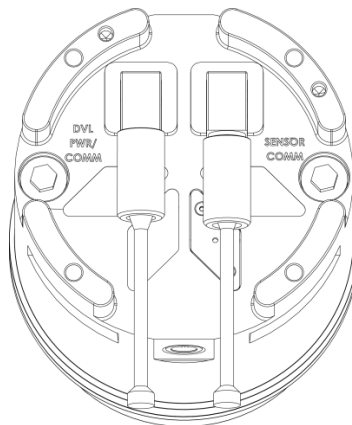


Figure 27. End-Cap View

Periodic Maintenance Items

These maintenance items should be done prior to using the DVL.

Cable Connector Lubrication

The connectors require very little maintenance. They are designed to be used in harsh environments and thus limited amounts of dirt and grit do not affect their performance.

Prior to each connection:

1. Apply a thin film of silicon-based lubricant to the face of the female cable socket mating surfaces using latex gloves. Silicon lubricant is included in the spare parts kit. Ensure that the inner edge of the female socket is completely covered, and a thin transparent layer of lubricant is left visible on the face of the connector. The lubricant should extend one to two millimeters into the socket holes of the female cable connector.
2. After lubricating, fully connect the male and cable female connector in order to spread the lubricant onto the pins and in the sockets. Wipe away any excess lubricant off the outside of the connector.
3. To confirm that the lubricant has been sufficiently applied, disconnect the cable and check for lubricant on all male pins (rubber portion). If the male pins do not have lubricant on them, apply more lubricant to the female connector and then reconnect the cable.



Use **ONLY** silicone based lubricants. **DO NOT** use petroleum based lubricants.

Do **NOT** use spray-based silicone lubricant. The use of some oil-based propellants in spray cans can cause conductivity problems in neoprene.



The dummy plug should be installed any time the cable is removed. Use the dummy plug when the Pioneer is in storage or is being handled.

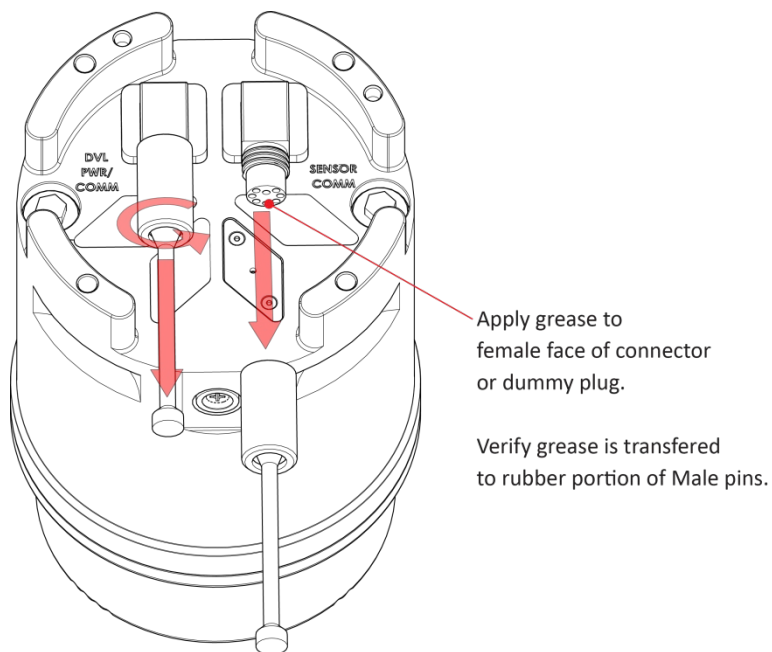


Figure 28. Cable Connector Lubricant

Cleaning the Cable Connectors

After a deployment, clean and remove any accumulated sand or mud from both the connector on the Pioneer DVL and the socket on the cable.

To clean the connectors:

1. Flush the connector pins and sockets with fresh water (deionized water if available) to remove all dirt, grit, and lubricant.
2. Use a small stiff brush to remove any sand or mud from the connector. Wipe dry using a lint-free wipe.
3. New lubricant must be applied again prior to mating.



Do NOT use spray-based contact cleaner. The use of some oil-based propellants in spray cans can cause conductivity problems in neoprene.

Transducer Inspection



Never set the transducer face on a rough surface; always use foam padding to protect the transducer.

Based on experience, TRDI knows that **most** DVLs need to have the urethane inspected after 2 to 3 years of field use. Many users are not familiar with the early signs of urethane failure. The primary damage to the urethane is from bio-fouling and long exposure to the water and sun. Damage occurs on the surface of the urethane and at the edge where the urethane bonds to the cup. By returning the system every 2 to 3 years, TRDI can inspect it for early signs of urethane failure and repair it through our Refurbishment Service. At the same time, TRDI will make any necessary upgrades to boards, assemblies, and firmware. If the Refurbishment Service is not needed, TRDI can upgrade the system as part of one of our Inspection Services. Proper care, general maintenance, and this routine service period ensures that the Pioneer system lasts for a minimum of 10 years with no loss in performance.



As originally manufactured, the transducer face has a smooth surface, which makes it inhospitable for most biofouling to develop. Preserving this smooth surface is an effective way to prevent heavy bio-growth on the transducer face. However, if an antifouling coating is desired on the transducer face, then the face must be lightly abraded to allow the antifouling coating to adhere. As a rule, the surface must be kept smooth unless an antifouling coating will be applied.

Removing Biofouling

To remove foreign matter and biofouling:

1. Remove soft-bodied marine growth or foreign matter with soapy water. Waterless hand cleaners remove most petroleum-based fouling.



Do not use power scrubbers, abrasive cleansers, scouring pads, high-pressure marine cleaning systems or brushes stiffer than hand cleaning brushes on the transducer faces. The urethane coating on the transducer face could be damaged.

If there is heavy fouling or marine growth, the transducer faces may need a thorough cleaning to restore acoustic performance. Barnacles do not usually affect Pioneer operation, but TRDI does recommend removal of the barnacles to prevent water leakage through the transducer face. Lime dissolving liquids such as Lime-Away® break down the shell-like parts. Scrubbing with a medium stiffness brush usually removes the soft-bodied parts. Do NOT use a brush stiffer than a hand cleaning brush. Scrubbing, alternated with soaking in Lime-Away®, effectively removes large barnacles.



If barnacles have entered more than 1.0 to 1.5 mm (0.06 in.) into the transducer face urethane, send the Pioneer to TRDI for repair. If the barnacles can not be removed without damaging the transducer faces, [Contact TRDI](#).

2. Rinse with fresh water to remove soap or Lime-Away® residue.
3. Dry the transducer faces with low-pressure compressed air or soft lint-free towels.



Always dry the Pioneer before placing it in the storage case to avoid fungus or mold growth. Do not store the Pioneer in wet or damp locations.

Zinc Anode Inspection and Replacement

The Pioneer has four zinc anodes on the instrument housing, two anodes on the transducer housing, and two on the housing. If the Pioneer does not have exposed bare metal, a properly installed anode helps protect the Pioneer from corrosion while deployed. Read all instructions before doing the required actions.

Zinc Anode Inspection

The life of a zinc anode is not predictable. An anode may last as long as one year, but dynamic sea conditions may reduce its life. Use a six-month period as a guide. If the total deployment time for the anodes has been six months or more, replace the anodes. If the next deployment is expected to last six months or more, replace the anodes.

To inspect the anodes:

1. Inspect the anodes on the transducer assembly and housing for corrosion and pitting. If most of an anode still exists, it may not need to be replaced.
2. If there are doubts about the condition of the anodes, remove and replace the anode.

Zinc Anode Electrical Continuity Check

Check the electrical continuity using a digital multi-meter (DMM). Measure the resistance between the two anodes attached to the same part of the instrument (transducer or housing). The resistance should be less than two ohms. If not, reinstall the affected anode.

Zinc Anode Replacement

To remove and replace the zinc anode/s:

1. Remove the screw.
2. The anode may stick to the Pioneer. To break this bond, first place a block of wood on the edge of the anode to protect the housing anodizing and paint. Carefully strike the block to loosen the anode.
3. Clean the bonding area under the anode. Remove all foreign matter and corrosion. Look for signs of corrosion such as white deposits. If corrosion caused part of the housing to be visibly damaged, do not redeploy the system. Send it back to TRDI for inspection (see [Returning DVLs to TRDI for Service](#)). Clean the mounting hole with a thin brush and lime based product. Flush the hole with the lime based product if there is no brush available. Be sure to clean and remove any signs of corrosion.



TRDI knows from our experience that it is difficult to anodize sharp edges on threaded holes such as these. In marine and fresh water environments, poor anodizing on aluminum will lead to corrosion problems. Although TRDI has rarely seen corrosion around the anode mounting holes, we would like to remind our customers that it is good practice to always inspect for corrosion in this (and all) areas between deployments.

4. Set the new anode in place and tighten the screw to 1.7 ± 0.2 N-M (15 ± 1.5 IN-LB).
5. Check the electrical continuity. If any measurement is greater than one ohm, reinstall the affected anode.



Do not connect other metal to the Pioneer. Other metals may cause corrosion damage. Use isolating bushings when mounting the Pioneer to a metal structure.



Do not use zinc anodes with an iron content of more than 0.0015%. The major factor controlling the electrical current output characteristics of zinc in seawater is the corrosion film that forms on the surface of the zinc. Corrosion product films containing iron have a high electrical resistance. As little as 0.002% iron in zinc anodes degrades the performance of the anode.

Do not use magnesium anodes. Magnesium rapidly corrodes aluminum housings.

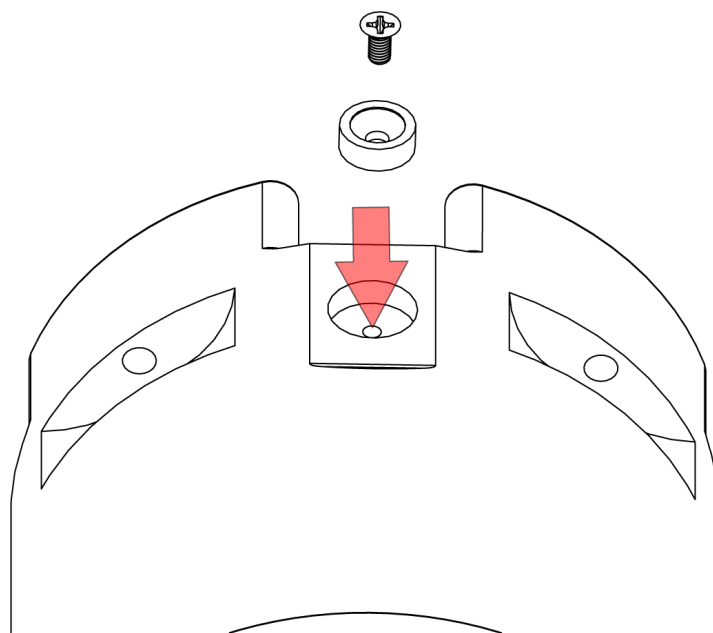


Figure 29. Replacing an Anode

Cleaning the Pressure Sensor Port

In order to read the water pressure, water must be able to flow through the copper cover on the pressure sensor. The tiny hole in the cover may at times be blocked. Use the following procedure and Figure 24 to clean the cover.



The pressure sensor is optional. It may not be included on your system.

To clean the pressure sensor port:

1. Remove the M3 nylon screws and copper cover. Look for signs of corrosion such as white deposits. If corrosion caused part of the pressure sensor housing to be visibly damaged, do not redeploy your system. Send it back to TRDI for inspection (see [Returning Systems to TRDI for Service](#)).
2. Clean both M3 screw mounting holes with a thin brush and lime based product. Flush the holes with the lime based product if you do not have a brush available. Be sure to clean and remove any signs of corrosion.
3. Gently flush the pressure sensor cavity with fresh water (deionized water if available) to remove all dirt and grit.
4. Gently clean out the hole in the copper cover with a needle.
5. Install the copper cover. Tighten the screws to 0.14 ± 0.05 N-M ($1.2 \pm .2$ in/lbs).



The pressure sensor is filled with silicone oil. Never poke a needle or other object through the copper cover while the cover is installed over the pressure sensor. You will perforate the sensor, causing it to fail.

Do not attempt to clean the surface of the pressure sensor. The diaphragm is very thin and easy to damage.

If the pressure sensor surface looks corroded or is bowed outward, then [Contact TRDI](#) for servicing. Do not attempt to remove the pressure sensor. It is not replaceable in the field.

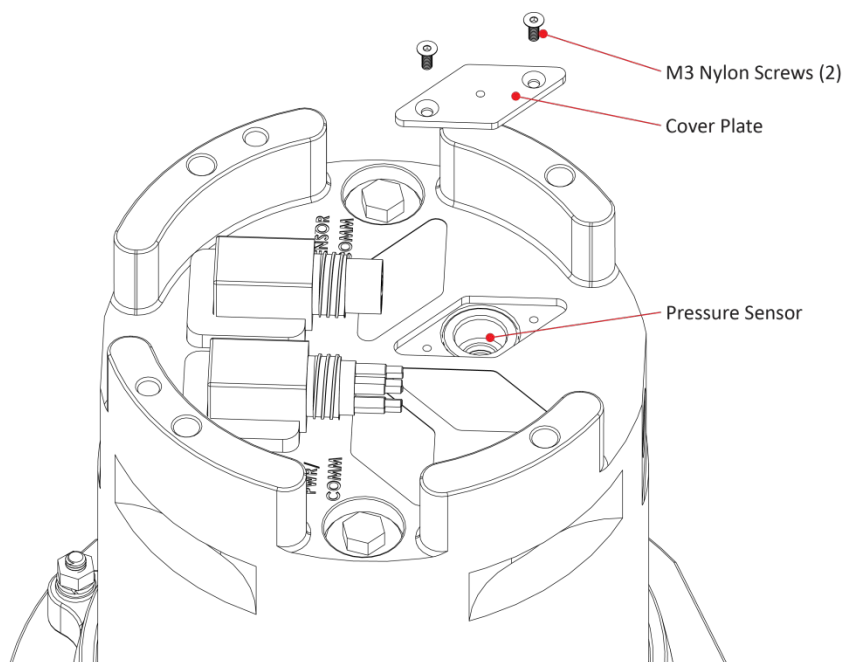


Figure 30. Cleaning the Pressure Sensor Port

Protective Coating Inspection and Repair

TRDI uses paint on the housing for identification and corrosion protection. For more protection, the case and the transducer assembly are first anodized per MIL-A-8625, Type 3, Class 1 and sealed with sodium dichromate. Do not damage the surface coatings when handling the Pioneer.

Inspect the housing, and transducer assemblies for corrosion, scratches, cracks, abrasions, paint blisters, exposed metal (silver-colored aluminum), exposed anodize (black or dark green), and exposed primer (light blue). **Be critical in your judgment; the useful life of the Pioneer depends on it.**



The procedures contained in this section apply to our standard aluminum systems. For systems made of other materials, [Contact TRDI](#). Read all instructions before doing the required actions.



The chemicals used in the following steps can be hazardous to your health. Read all material safety data sheets and manufacturer's instructions before handling these chemicals.



If there is any damage to the paint near the edges of the urethane transducer face or the connectors, **DO NOT DEPLOY THE PIONEER**. Return the system to TRDI for repair.

To repair or touch up the protective paint:

1. Remove all loose paint without damaging the anodizing. Clean and prepare the damaged area using a fine-grade abrasive cloth. Feather the edges of the paint near the damaged area. Try to have a smooth transition between the paint and the damaged area. Do not sand the anodized area. If there is damage to the anodizing, return the Pioneer to TRDI for repair.
2. Clean the area with alcohol. Do not touch the area after cleaning.
3. Mix the epoxy primer Part A and Part B using a 1:1 mix. Paint one coat of epoxy primer (see note below). Allow the primer to dry thoroughly before continuing.
4. Mix the colored paint using two parts color and 1 part catalyst. Paint with one coat of colored paint (see note below).



The catalyst (hardener) will rapidly harden in air. Mix only the amount of paint you need and work quickly.



TRDI uses two-part epoxy type paint. This paint is manufactured by Sherwin –Williams Proline Paint Store, 2426 Main St., San Diego, CA, 92113-3613, Telephone: +1 (619) 231-2313.

Primer Manufacturer's part numbers:

3061 (part A and part B)

Colored paint Manufacturer's part numbers:

4800HS Catalyst part A

4800-10, Black part B

Contact the paint manufacturer for preparation and application procedures for this and other paints. Contacting this company is done with the knowledge that Teledyne RD Instruments is not recommending them, but only offering this as a source for the paint.

Long Term Maintenance Items

The O-Rings should be replaced every two years. Firmware updates may be done when needed.

Removing the Housing

This section explains how to remove and replace the housing to gain access to the Pioneer's desiccant, O-rings, and electronics. Read all instructions before doing the required actions.



CAUTION
Contents May be Under Pressure.
Refer to Operator's Manual Prior to Servicing.
902-6038-00

Caution label on Housing



Wear safety glasses and keep head and body clear of the housing while opening.
Any system that was deployed may have pressure inside the housing.



The Pioneer housing contains Electrostatic Sensitive Devices. Take accepted ESD prevention measures before removing the housing.

To remove the housing:

1. Dry the outside of the Pioneer.
2. Disconnect the cables and install the dummy plugs.
3. Stand the Pioneer on its transducer face on a soft antistatic pad.
4. Inspect the housing and Housing Plugs (see Figure 25, page 87) for any signs of damage such as bending, bulges, crushed or deformed, etc. These signs may indicate that there is internal pressure inside the system.
5. To avoid any possible injury it is ALWAYS recommended to loosen but do not remove the two Housing Plugs to allow any internal pressure to be vented from the system. Use a 7/16 socket wrench to loosen the Housing Plugs slowly until the bottom O-ring on the Housing Plugs is not compressed and the system has the opportunity to vent. **Be sure to only loosen the Housing Plugs far enough to allow the system to vent.**
6. Once both Housing Plugs have been loosened and you are sure that there is no internal pressure, remove the plugs from the housing. Remove the bottom housing plug O-rings.
7. Use a 7/16 socket wrench to remove the two 1/4" nuts, washers, and split washers located under the Housing Plugs. You may need to tip the housing over to retrieve the nuts and washers.



Save all hardware removed during this procedure for re-assembly.

8. With a antistatic wrist strap on, carefully lift the housing away from the transducer approximately seven cm until you can gain access to the brackets (see Figure 25, page 87). Rotate the brackets out and rest the housing on the brackets as you disconnect the cables. Use care; the mating surfaces of the housing and transducer scratch easily. Do not damage the mating surfaces.
9. Squeeze the sides of the internal cable connectors to release them from the jacks. Set the housing aside on a soft pad.
10. Remove any water from the transducer O-ring grooves with a soft, lint-free cloth. Clean the O-ring mating surfaces. Inspect the surfaces for damage. Even small scratches can cause leakage around the O-ring seal.

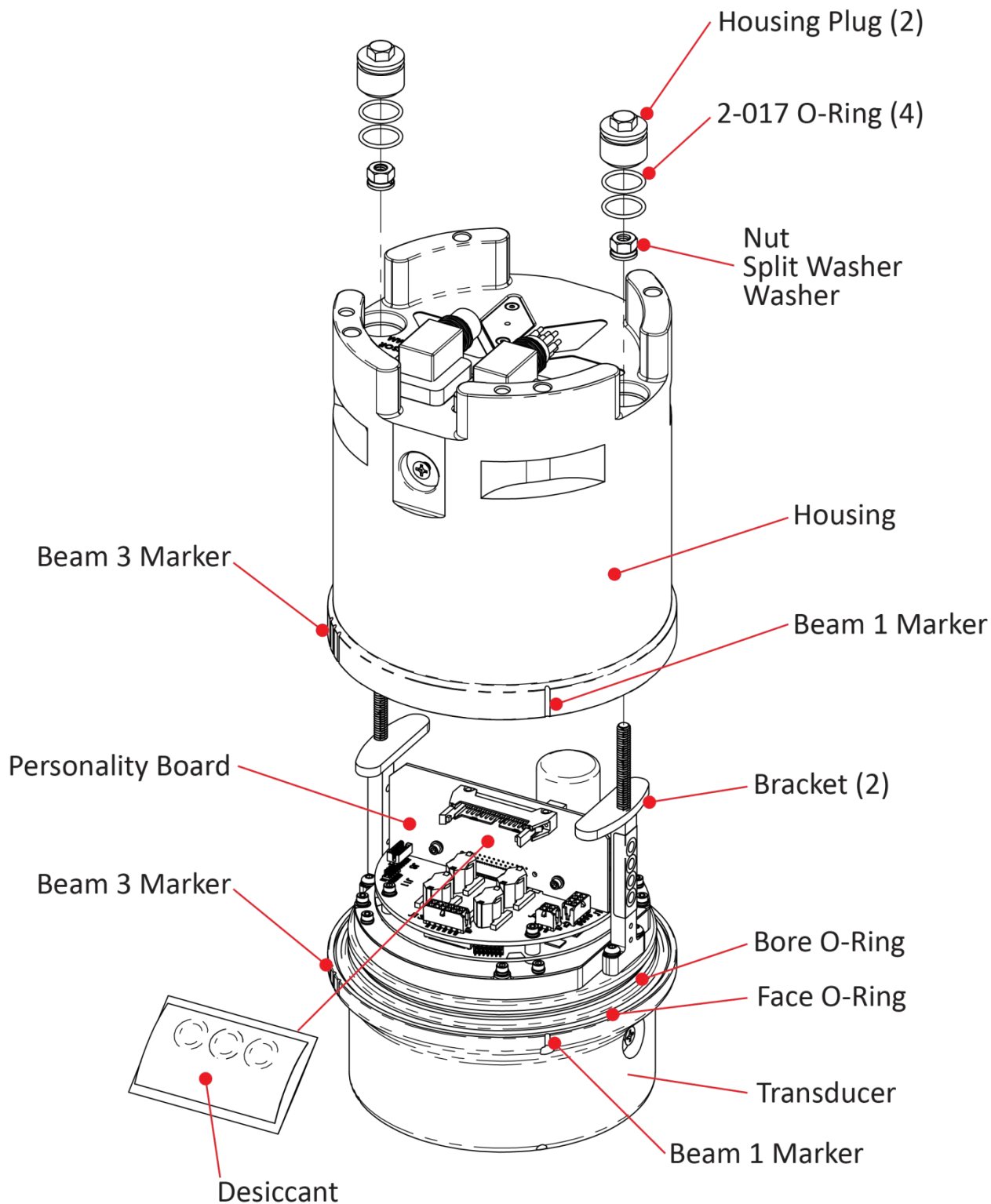


Figure 31. Pioneer Assembly 300/600 kHz 1000 Meter

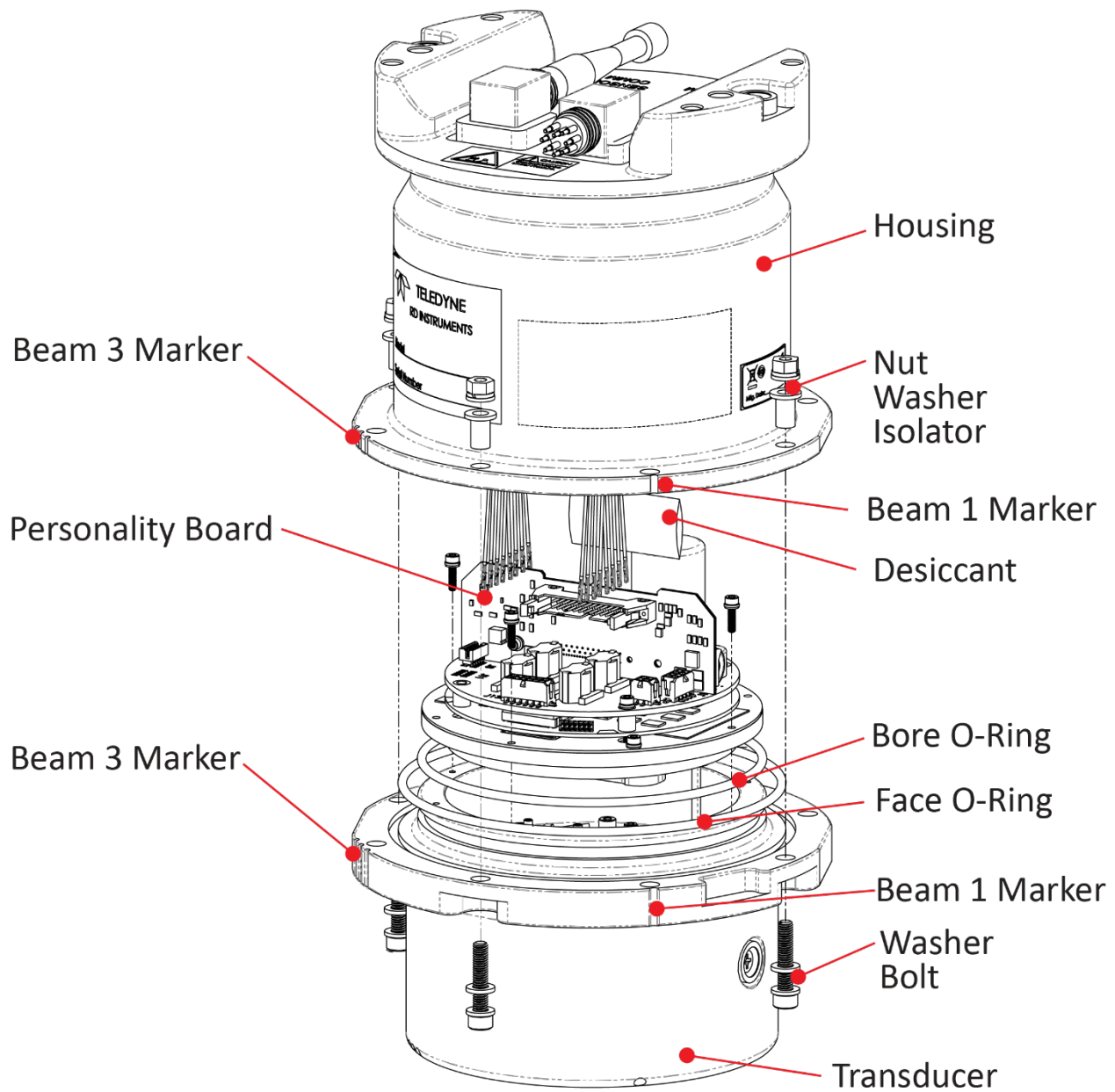


Figure 32. Pioneer Assembly 300 kHz 4500 Meter

O-Ring Inspection & Replacement

This section explains how to inspect/replace the Pioneer O-rings. A successful deployment depends on the condition of the O-rings and their retaining grooves.

- Transducer assembly, bore 2-163 (2-164 for 4500 meter systems)
- Transducer assembly, face 2-253
- Housing Plugs, 2-017



TRDI strongly recommends replacing these O-rings whenever you disassemble the Pioneer. Inspecting and replacing the O-rings should be the last maintenance task done before sealing the system.

To replace the O-rings:

1. Remove the old O-rings. The O-rings sit in a dove-tail groove. This makes it less likely to fall out when the system is opened. Insert the O-Ring tool tip on the inside edge of the groove and gently slide it around the groove perimeter to lift the O-Ring.



Never use metal tools to remove the O-rings as this may damage the O-ring groove or the housing flange.

2. Inspect the O-rings. When viewed with an unaided eye, the O-rings must be free of cuts, indentations, abrasions, foreign matter, and flow marks. The O-ring must be smooth and uniform in appearance. Defects must be less than 0.1 mm (0.004 in.).



If the O-ring appears compressed from prior use, replace it. Weak or damaged O-rings will cause the DVL to flood.

3. Clean and inspect the O-ring grooves. Be sure the grooves are free of foreign matter, scratches, indentations, corrosion, and pitting. Run your fingernail across damaged areas. If you cannot feel the defect, the damage may be minor; otherwise, the damage may need repair.



Check the O-ring grooves thoroughly. Any foreign matter in the O-ring grooves will cause the DVL to flood.

4. Lubricate the O-rings with a thin coat of silicone lubricant. Apply the lubricant using latex gloves. Do not let loose fibers or lint stick to the O-ring. Fibers can provide a leakage path.



Apply a very thin coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

5. Place the O-Rings into the groove.



During installation, do not cut or twist the O-ring. Never force O-rings over sharp corners, screw threads, keyways, slots, or other sharp edges.

Replacing the Desiccant Bags

Desiccant bags are used to dehumidify the housing interior. The factory-supplied desiccant lasts a year at specified Pioneer deployment depths and temperatures. Remember that desiccant rapidly absorbs moisture from normal room air.



Do not open the desiccant bag. Contact with the silica gel can cause nose, throat, and skin irritation.

Do not puncture or tear the desiccant bag.

Do not use desiccant bags that are torn or open.



Desiccant bags are shipped in an airtight aluminum bag to ensure maximum effectiveness. There is a moisture indicator inside the bag. If the moisture indicator is pink, do not use the desiccant bag. TRDI recommends replacing the desiccant bag just before the deployment.

To replace the desiccant:

1. Remove the Housing (see [Removing the Housing](#)).
2. Remove the new desiccant bags from the airtight aluminum bag.
3. Remove the old desiccant bag and install a new one. Use double-stick tape and tape the desiccant bags to the Personality board (see Figure 25, page 87).
4. Install the Housing.

Installing the Housing

To install the housing:

1. Stand the Pioneer on its transducer face on a soft pad.
2. [Inspect, clean, and lubricate the O-rings](#) on the transducer assembly.
3. [Replace the desiccant](#).
4. Connect the internal connectors to the plugs on the PC board.
5. Rotate the brackets inward so they are out of the way of the housing.
6. Slide the housing onto the transducer assembly, aligning the mating holes and the beam 3 and beam 1 marks embossed on the housing with the beam 3 and beam 1 marks embossed on the transducer assembly. When mating the housing with the transducer flange, apply equal pressure to all parts of the O-rings. Make sure the face and bore O-rings remain in the retaining groove.



Check that no wires or any other object is pinched between the housing and the transducer assembly. If the O-rings are not in the grooves or if a wire or other object is pinched, the Pioneer system will flood.

7. Examine the Housing Plugs, nuts, O-Rings, and washers for corrosion or damage; replace if necessary. Figure 25, page 87 shows the assembly order of the housing mounting hardware. All the hardware items are needed to seal the Pioneer properly.
8. Install both sets of hardware until “finger-tight.”
9. Tighten the nut in small increments to apply equal pressure to the O-rings. Tighten the nuts to the recommended torque value of 6.0 Newton-meters (53 pound-inches).



Apply equal pressure to the bore and face O-rings as you tighten the bolts. If one bolt is tightened more than the others, the O-rings can become pinched or torn. Damaged O-rings will cause the system to flood.

10. Lubricate and inspect all four Housing Plug O-rings. Place the bottom Housing Plug O-rings into the holes. This O-Ring rests on the bottom. Check the top Housing Plug O-ring is in the groove on the plug.
11. Install both plugs until “finger-tight.”
12. Tighten the Housing Plugs to the recommended torque value of 6.0 Newton-meters (53 pound-inches).



The recommended torque value for the Housing Plugs and nuts is 6.0 Newton-meters (53 pound-inches).

Installing Firmware and Feature Upgrades

Pioneer firmware and feature upgrades can be requested from TRDI field service. Contact Field Service at rdifs@teledyne.com or by phone 858-842 2700.

Firmware Upgrades



Firmware updates using the m0 file require *TRDI Toolz* version 1.03.00.15 or higher software.

To install a firmware upgrade:

1. Connect the Pioneer to the computer as shown in [Setting up the Pioneer System](#).
2. On *TRDI Toolz*, click **Tools, Firmware Update**.
3. Navigate to where the firmware file is located. The file name will be *PNR_xx.xx.m0*, where *xx.xx* is the firmware version.
4. Click **OK**. The firmware will install. It takes several minutes to load the new firmware and the screen may be blank during the update process. Do not close *TRDI Toolz* while the firmware is updating.
5. Once the firmware update is complete, the Pioneer will reboot. Close *TRDI Toolz* and reconnect to the Pioneer.
6. If you are not able to install the new firmware, contact Customer Service.
7. After successfully upgrading the firmware, use *TRDI Toolz* to test the ADCP (see [Testing the Pioneer System](#)).

Feature Upgrades

The feature upgrade installation program is used to install new capabilities in a Pioneer system.



Feature updates using the Feature file require *TRDI Toolz* version 1.03.00.15 or higher software.



Contact your local sales representative if you are interested in upgrading your system.



The upgrade file is specific to the unit for which it was ordered. DO NOT attempt to install this feature for any other unit.



Many feature upgrades require the latest firmware version to be installed in your ADCP. If you need to update the firmware, do this before installing the feature upgrade.



The XRT (Extended Range Tracking) feature upgrade requires FPGA version 1.00.012 installed (a factory upgrade). Systems shipped after October 2018 have this version installed. To verify if your system can be field upgraded, run the PS0 command:

```
>ps0
  Serial Number: 300300
    Frequency: 307200 Hz
↓
  CPU Firmware: 57.14
  FPGA Version: 1.00.012 [0x100c]
↓
```

To install a feature upgrade:

1. Set up the Pioneer as shown in [Setting up the Pioneer System](#).
2. Save the *PNR_XXXX.feature* file to your computer. On *TRDI Toolz*, click **Tools, Activate Features**.
3. The installation program will start. The program is encoded with the Pioneer's serial number and the requested feature upgrade. It takes several minutes to load the new feature and the screen may be blank during the update process. Do not close *TRDI Toolz* while the feature is installing.
4. Once the feature install is complete, the Pioneer will reboot. Close *TRDI Toolz* and reconnect to the Pioneer.
5. Start *TRDI Toolz* and use the [OL command](#) to verify the feature upgrade has been installed.

NOTES

Chapter 5

RETURNING SYSTEMS TO TRDI FOR SERVICE



In this chapter:

- How to pack and ship the Pioneer
- How to get a RMA number
- Where to send the Pioneer for repair

Shipping the Pioneer

This section explains how to ship the Pioneer.



Remove all customer-applied coatings or provide certification that the coating is nontoxic if shipping a Pioneer to TRDI for repair or upgrade. This certification must include the name of a contact person who is knowledgeable about the coating, the name, manufacturer of the coating and the appropriate telephone numbers. If the equipment is returned without meeting these conditions, TRDI has instructed our employees not to handle the equipment and to leave it in the original shipping container pending certification. If certification is not provided, TRDI will return the equipment or send it to a customer-specified cleaning facility. All costs associated with customer-applied coatings will be at the customer's expense.

When shipping the Pioneer through a Customs facility, be sure to place the unit so identifying labels are not covered and can be seen easily by the Customs Inspector. Failure to do so could delay transit time.



TRDI strongly recommends using the original shipping crate whenever transporting the Pioneer.

Use the original shipping crate whenever possible. If the original packaging material is unavailable or un-serviceable, additional material is available through TRDI.

For repackaging with commercially available materials:

1. Use a strong shipping container made out of wood or plastic.
2. Install a layer of shock-absorbing static-shielding material, 70-mm to 100-mm thick, around all sides of the instrument to firmly cushion and prevent movement inside the container.
3. Seal the shipping container securely.
4. Mark the container FRAGILE to ensure careful handling.
5. In any correspondence, refer to the Pioneer by model and serial number.

Returning Systems to the TRDI Factory

When shipping the system to TRDI from either inside or outside the United States, the following instructions will help ensure the Pioneer arrives with the minimum possible delay. Any deviation from these instructions increases the potential for delay.

Step 1 - Request a Return Material Authorization

To obtain a Return Material Authorization (RMA) number and shipping instructions for the return of the instrument, do one of the following:

- Open the RMA using the web link: <http://adcp.com/support/sendadcp.aspx>
- Contact Customer Service Administration at rdicsadmin@teledyne.com
- Call +1 (858) 842-2700

When requesting a RMA number, please give us the following information:

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What issue(s) need to be corrected
- Name of the Field Service Engineer that knows about the issue
- When you need the instrument returned

TRDI's Customer Service will then respond with the RMA number for the shipment. Please include this number on all packages and correspondence.

Step 2 – Provide a MSDS as necessary

Please provide a Material Safety Data Sheet (MSDS) if the system/transducer is painted with antifouling paint.

Step 3 - Ship via air freight, prepaid

Urgent Shipments should be shipped direct to TRDI via overnight or priority air services. Do not send urgent airfreight as part of a consolidated shipment. Consolidated shipping will cost less, but may lose up to three days in transit time.

Non-urgent shipments may be shipped as part of a consolidated cargo shipment to save money. In addition, some truck lines may offer equivalent delivery service at a lower cost, depending on the distance to San Diego.

Mark the Package(s)

To: Teledyne RD Instruments, Inc. (RMA Number)
14020 Stowe Drive
Poway, California 92064

Airport of Destination = San Diego
UPS Supply Chain Solutions Brokerage
15 E Oregon avenue
Philadelphia PA 19148
USA
Email: phldocreceipt@ups.com
Tel: + 1 (215) 952-1745

Step 4 - Urgent shipments

Send the following information by telephone to TRDI.

Attention: Customer Service Administration

Phone: +1 (858) 842-2700

- Detailed descriptions of what you are shipping (number of packages, sizes, weights and contents).
- The name of the freight carrier
- Master Air bill number
- Carrier route and flight numbers for all flights the package will take

Returning Systems to TRDI Europe Factory

When shipping the system to TRDI Europe, the following instructions will help ensure the Pioneer arrives with the minimum possible delay. Any deviation from these instructions increases the potential for delay.

Step 1 - Request a Return Material Authorization

To obtain a Return Material Authorization (RMA) number and shipping instructions for the return of the instrument, do one of the following:

- Open the RMA using the web link: <http://adcp.com/support/sendadcp.aspx>
- Contact Customer Service Administration at rdiefs@teledyne.com
- Call +33(0) 492-110-930

When requesting a RMA number, please give us the following information:

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What issue(s) need to be corrected
- Name of the Field Service Engineer that knows about the issue
- When you need the instrument returned

TRDI's Customer Service will then respond with the RMA number for the shipment. Please include this number on all packages and correspondence.

Step 2 – Provide a MSDS as necessary

Please provide a Material Safety Data Sheet (MSDS) if the system/transducer is painted with antifouling paint.

Step 3 - Ship Via Air Freight, Prepaid

Urgent Shipments should be shipped direct to TRDI via overnight or priority air services. Do not send urgent airfreight as part of a consolidated shipment. Consolidated shipping will cost less, but may lose up to three days in transit time.

Non-urgent shipments may be shipped as part of a consolidated cargo shipment to save money.

Mark the package(s) as follows:

To: Teledyne RD Instruments, Inc. (RMA Number)
2A Les Nertieres
5 Avenue Hector Pintus
06610 La Gaude, France

Step 4 - Include Proper Customs Documentation

The Customs statement must be completed. It should be accurate and truthfully contain the following information.

- Contents of the shipment
- Value
- Purpose of shipment (example: "American made goods returned for repair")
- Any discrepancy or inaccuracy in the Customs statement could cause the shipment to be delayed in Customs.

Step 5 - Send the Following Information by Telephone to TRDI

Attention: Sales Administration

Phone: +33(0) 492-110-930

- Detailed descriptions of what you are shipping (number of packages, sizes, weights and contents).
- The name of the freight carrier
- Master Air bill number
- Carrier route and flight numbers for all flights the package will take

NOTES

Chapter 6

SPECIFICATIONS



In this chapter:

- Operational Specifications
- Outline Installation Drawings

A brief review of Pioneer operation may help explain the specifications listed in this section. The discussion below regarding water profiling is generally applicable to bottom track as well.



The specifications and dimensions listed in this section are subject to change without notice.

The Pioneer emits an acoustic pulse called a PING. The seabed and scatterers that float ambiently with the water currents reflect some of the energy from the ping back to the Pioneer transducer. The Pioneer uses the return signal to calculate a velocity.

The energy in this signal is the *echo intensity*. The echo intensity returned from the seabed is used to detect the bottom. The echo intensity returned by floating scatterers is sometimes used to determine information about the scatterers.

The velocity calculated from each ping has a *statistical uncertainty*; however, each ping is an independent sample. The Pioneer reduces this statistical uncertainty by averaging a collection of pings. A collection of pings averaged together is an *ensemble*. The Pioneer's maximum *ping rate* limits the time required to reduce the statistical uncertainty to acceptable levels.

The Pioneer does not measure velocity at a single point; it measures its speed over the seabed, i.e. Bottom Track, its speed through the water current, i.e. Water Track and current velocities throughout the water column, i.e. Water Profile.

When bottom tracking, the Pioneer calculates velocity data relative to itself. The velocity data has both speed and direction information. If the Pioneer is moving, and is within range of the bottom, it can obtain a velocity from returns off the bottom. The bottom track information can be used to calculate the absolute velocity of the water. The Pioneer can get absolute direction information from a heading sensor.

When water profiling the Pioneer measures velocities from its transducer head to a specified range and divides this range into uniform segments called *depth cells* (or *bins*). The collection of depth cells yields a *profile*. The Pioneer produces two profiles, one for velocity, and one for echo intensity.

The following tables list the specifications for the Pioneer. About the specifications:

1. Except where noted, these specification tables applies to typical setups and conditions. Typical setups use the default input values for each parameter (exceptions include Pings per Ensemble and Number of Depth Cells). Typical conditions assume uniform seawater velocities at a given depth, moderate shear, moderate Pioneer motion, and typical echo intensity levels.
2. The total measurement error of the Pioneer is the sum of:
 - Long-term instrument error (as limited by instrument accuracy),
 - The remaining statistical uncertainty after averaging,
 - Errors introduced by measurement of Pioneer heading and motion.
3. Because individual pings are independent, the statistical uncertainty of the measurement can be reduced according to the equation:

Statistical Uncertainty for One Ping

$$\frac{\text{Statistical Uncertainty for One Ping}}{\sqrt{\text{Number of Pings}}}$$



Specifications subject to change without notice.

Operational Specifications

Bottom Tracking	150 kHz	300 kHz	600 kHz
Maximum Altitude ^(NOTE 1) ^(NOTE 3)	500 m	275 m	100 m
Maximum Altitude with XRT Mode ^(NOTE 1) ^(NOTE 3)	800 m	420 m	160 m
Minimum Altitude	3 m	0.6 m (0.3 m with low altitude option)	0.2 m (<0.2 m with low altitude option)
Velocity Range ^(NOTE 2)	±9m/s or +16 m/s upon request		
High Accuracy Bottom Track Long Term Accuracy ^(NOTE 5)	0.6 +/- .2cm/s	±0.3% ± 0.1cm/s (0.5m altitude or greater)	±0.2% ± 0.1cm/s
Base Bottom Track Long Term Accuracy ^(NOTE 6)	±1.15% ± 0.1cm/s		
Precision @ 1 m/s	0.9 cm/s @ ½ alt.	±0.6 cm/s @ ½ alt.	±0.5 cm/s @ ½ alt.
Precision @ 3 m/s	2.3 cm/s @ ½ alt.	±1.7 m/s @ ½ alt.	±1.5 cm/s @ ½ alt.
Precision @ 5 m/s	3.4 cm/s @ ½ alt.	±2.6 cm/s @ ½ alt.	±2.3 cm/s @ ½ alt.
Resolution	0.1cm/s (0.01mm/s with High Accuracy Bottom Track Enabled) ⁽⁵⁾		
Ping Rate ^(NOTE 8)	3.3 Hz max	7 Hz max	12 Hz max
Water Profiling	150 kHz	300 kHz	600 kHz
Maximum Range ^(NOTE 1) ^(NOTE 2)	275m	150 m	60 m
Minimum Range	8m	4.5 m	1.9 m
Velocity Range ^(NOTE 3)	+/- 17m/s	±17 m/s	±12 m/s
Long Term Accuracy	0.6% ± 0.2 cm/s	0.6% ± 0.2 cm/s	0.3% ± 0.2 cm/s
Standard Deviation of WP measurement at 1 m/s ^(NOTE 4)	6.5cm/s @ 8m bin size	±7.5 cm/s @ 4m bin size	±7.5 cm/s @ 2m bin size
Standard Deviation of WP measurement at 3 m/s ^(NOTE 4)	TBD	±7.6 cm/s @ 4m bin size	±7.5 cm/s @ 2m bin size
Standard Deviation of WP measurement at 5 m/s ^(NOTE 4)	TBD	±7.8 cm/s @ 4m bin size	±7.7 cm/s @ 2m bin size
Resolution	1 mm/s		
Cell Sizes	1 to 16m	0.5 to 8 m	0.1 to 4 m
Number of Depth Cells	1 to 255		
Acoustic	150 kHz	300 kHz	600 kHz
Center Frequency	153.6kHz	307.2 kHz	614.4 kHz
Source Level (re 1μPa)	221dB re 1uPa @ 1m	220 dB @ 1m	217 dB @ 1m
1-Way Beam Width	3.9°	2.7°	2.2°
Number of Beams	4-phased array	4-phased array	4-phased array
Beam Angle	30°	30°	30°
Bandwidth (nominal)	6.25% of center frequency 9.6 kHz (6.25%) or ± 4.8 kHz (148.8 kHz to 158.4 kHz)	6.25% of center frequency 19.2 kHz (6.25%) or ± 9.6 kHz (297.6 kHz to 316.8 kHz)	6.25% of center frequency 38.4 kHz (6.25%) or ± 19.2 kHz (595.2 kHz to 633.6 kHz)
Depth Rating			
Maximum Depth ^(NOTE 7)	1000 m to 6000 m		

¹ @ 5°C and 35 ppt salinity, 32V input.

² When mounted with beam 3 at 45°.

³ Maximum range may be reduced due to flow noise.

⁴ Standard deviation refers to single-ping horizontal velocity, specified at half the maximum altitude.

⁵ ECCN 6A001 export license required outside US.

⁶ ECCN 6A991 export license-free option.

⁷ For units with pressure sensors, the maximum pressure rating is considered that of the pressure sensor.

⁸ . @ 5% of maximum altitude

Environmental Specifications

Parameter	Value
Operating Temperature	-5 to 45 Degrees C
Storage Temperature	-30 to 60 Degrees C
Vibration (Operation)	IEC 60945, 4th ED, 2002-08
Vibration (Transport)	IEC 60721-3-2, 2Nd Ed, 1997-3
Shock (Transport)	IEC 60721-3-2, 2Nd Ed, 1997-3
Shock (Operation)	IEC 1010-1



Applies to 150, 300 and 600 kHz transducers.

Electrical Specifications

Parameter	150 kHz	300 kHz	600 kHz
DC Input	28 to 48 VDC (32 VDC typical)	10.7 to 36 VDC (32 VDC typical)	10.7 to 36 VDC (32 VDC typical)
Surge Current	< 6.8 A	< 6 A	< 6 A
Average Power while transmitting	35 W @ 32 VDC	9W @ 24VDC 15W @ 32 VDC	4W @ 24VDC 6W @ 32 VDC
Nominal voltage/current	TBD	32V/4A to deliver 25W/beam	32V/1.5A to deliver 8W/beam
Average Quiescent Power	1.5 W	1.8W with AHRS sensor, 1.5W without AHRS	1.8W with AHRS sensor, 1.5W without AHRS

Sensor Specifications

Pressure Sensor:	
Model	Keller PA-7LX
Resolution	0.002% FS.
Accuracy	±0.1% FS TEB (total error band) over the compensated temperature range of -10...80°C
AHRS:	
Model ⁽¹⁾	Ellipse-A-G4A2-B1 from SBG
Roll and Pitch Accuracy	±0.1° over 360°
Heading Accuracy	±0.8° (Internal Magnetometers)

¹ MEMS-based Inertial Measurement Unit (IMU) integrating three gyroscopes, three magnetometers, and three accelerometers. Running an extended Kalman filter (EKF), the Ellipse-A provides accurate orientation data in both static and dynamic conditions and some immunity to magnetic transients.



More detailed specs at the link below:

https://www.sbg-systems.com/docs/Ellipse_Series_Leaflet.pdf

Communications Specifications

Parameter	Value
Number of Ports	4
Port Protocol (Hardware Dependent)	3 RS-232 & 1 CMOS Or 1 RS-422 & 2 RS-232 & 1 CMOS (Other combinations are available)
Isolation Channels 1 & 2	200VAC / VDC between Channel 1 to (Channel 2 & 3) or Channel 4. 200VAC / VDC between (Channel 2 & 3) to Channel 4.
Transmit Trigger Level	3V CMOS- Level, 1ms Latency from Trigger to Transmit Start, referenced to COMM RETURN 1 (pin 5 RS-232 or pin 3 RS-422).
Trigger Output	3V CMOS-Level, Trigger Active During Transmit & Receive, referenced to COMM RETURN 1 (pin 5 RS-232 or pin 3 RS-422).
Master Channel Baud Rate	1200 to 115,200 bps
Ensemble Types	PD0, PD4, PD5, PD6



Applies to both 300 and 600 kHz transducers.



Port 1 is the Master Port and is the only port available for command input and ensemble output.

[illegible]

Figure 33. Outline Installation Drawing – 300 kHz Pioneer

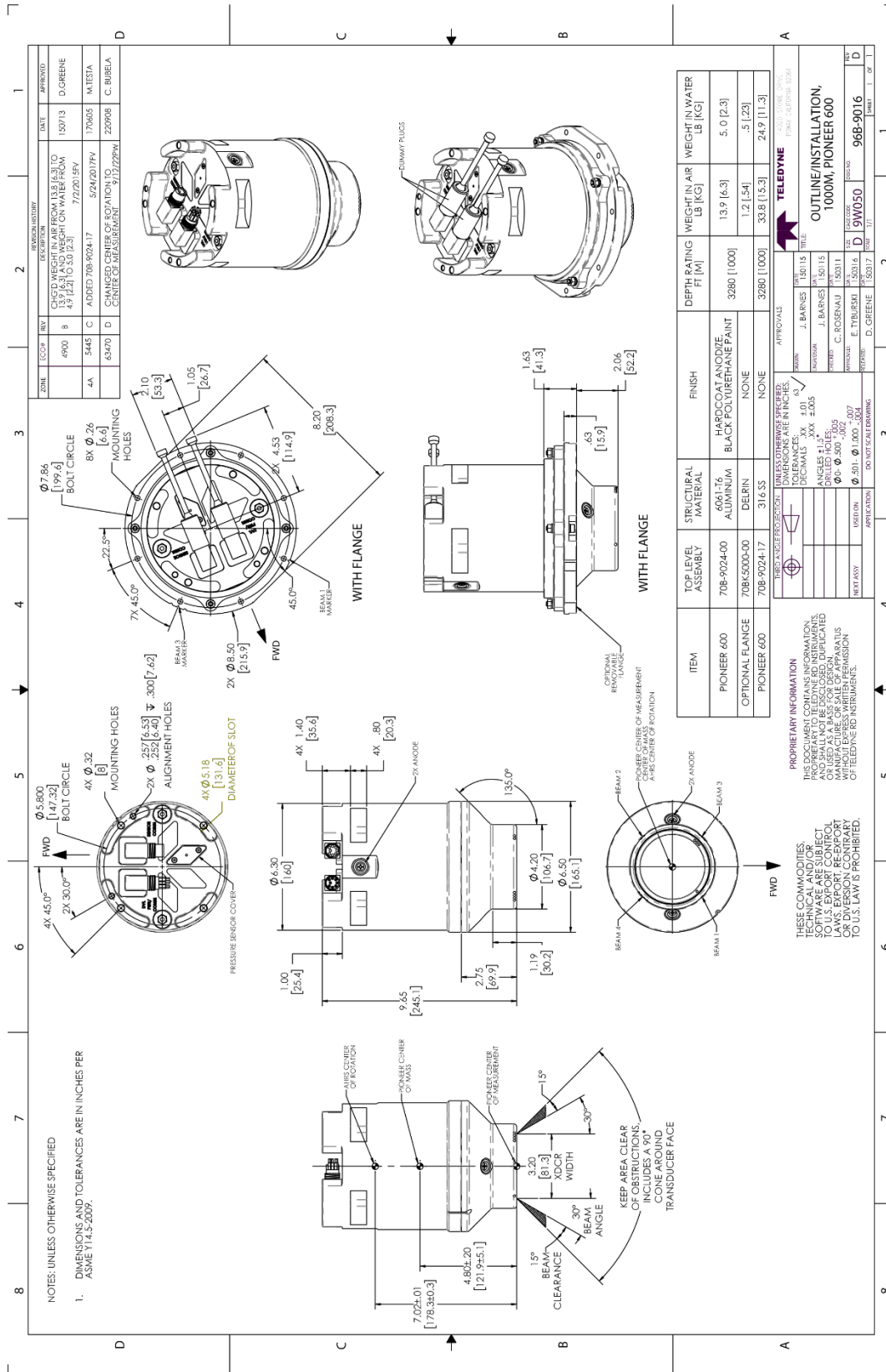


Figure 34. Outline Installation Drawing – 600 kHz Pioneer



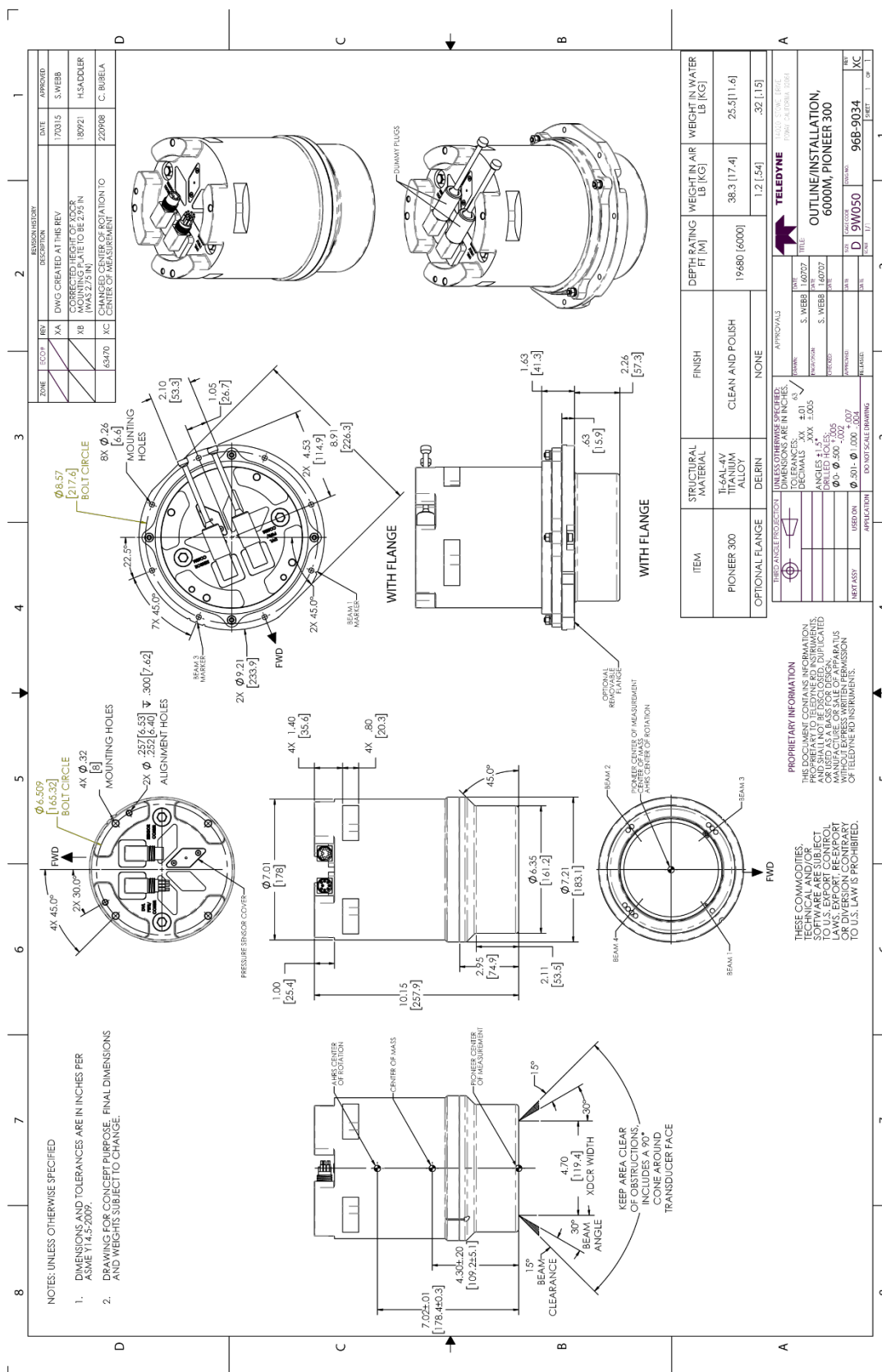


Figure 36. Outline Installation Drawing – 300 kHz Pioneer 6000 meter



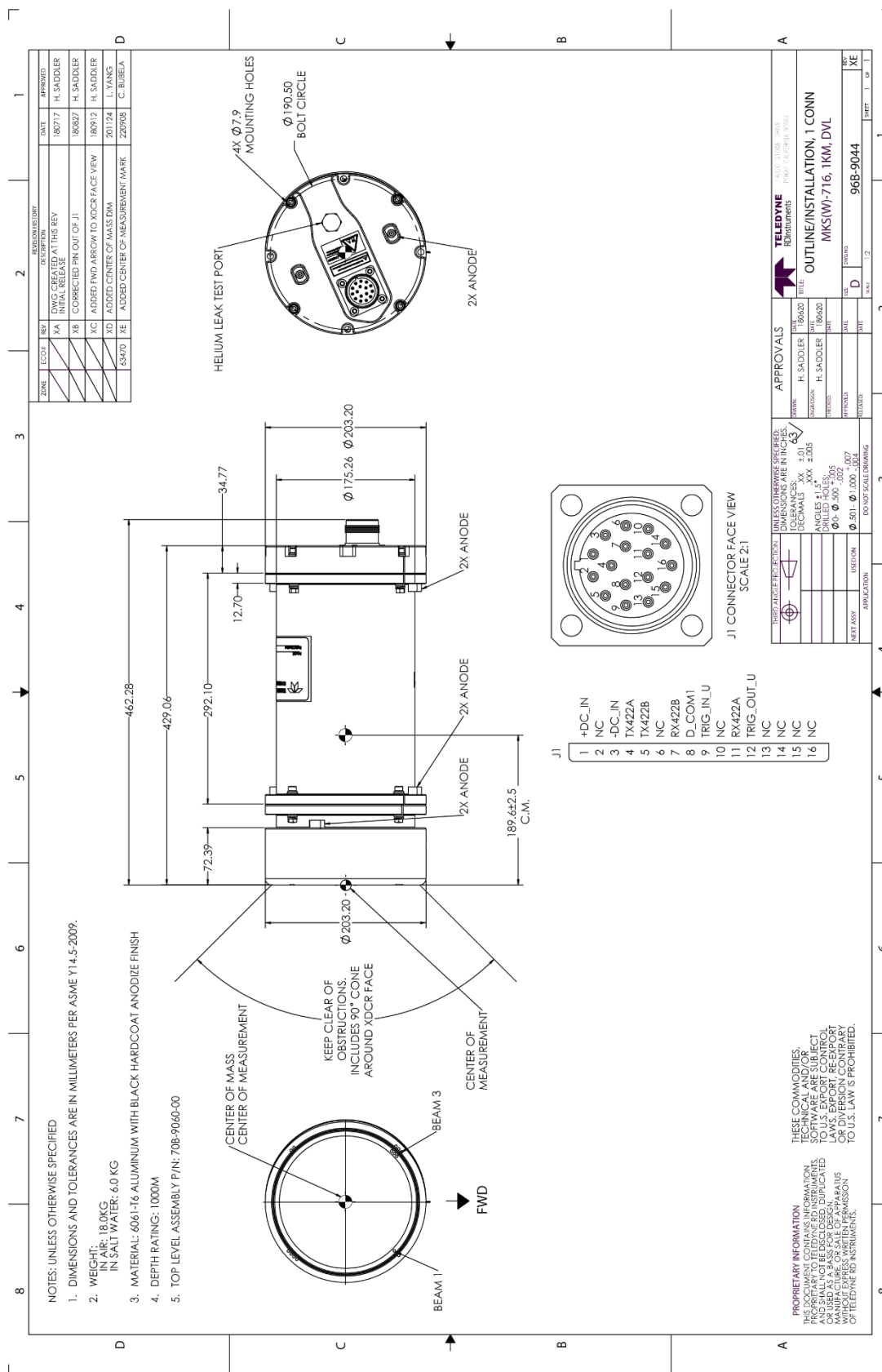


Figure 38. Outline Installation Drawing – 150 kHz Pioneer 1000 meter

NOTES

Chapter 7

COMMANDS



In this chapter:

- Command formats
- Command descriptions

This section defines the commands to set up and control the Pioneer. Teledyne RD Instruments recommend using a *TRDI Toolz* script file to control the Pioneer because entering commands directly from a terminal can be difficult. *Make sure to read and understand [Creating or Modifying Command Files](#) before deploying the Pioneer.* Most Pioneer command settings use factory-set values (Table 13). If these values are changed without thought, the deployment may be ruined. *Be sure to know what effect each command has before using it.* Call Teledyne RD Instruments for help in understanding the function of any command.



This section applies to Pioneer firmware 57.17 or above.

Data Communication and Command Format

Enter commands with a Windows®-compatible computer running TRDI's *TRDI Toolz*. The Pioneer communicates with the computer through an RS-232 (or RS-422) serial interface. TRDI initially sets the Pioneer at the factory to communicate at 9600 baud, no parity, and one stop bit.

Immediately after power is applied to the Pioneer, it enters the STANDBY mode. Send a BREAK signal using *TRDI Toolz* by pressing the **End** key. Alternately, a software break may be sent by sending either “+++” or “===”. When the Pioneer first powers up or receives a BREAK signal, it responds with a wake-up message similar to the one shown below. The Pioneer is now ready to accept commands at the “>” prompt from either a terminal or computer program.

```
Pioneer DVL
Teledyne RD Instruments (c) 2021
All rights reserved.
Firmware Version: 57.xx
```

```
>
```



If using a terminal/program other than *TRDI Toolz*, the BREAK length (up to down transition) must last at least 300 ms. The Pioneer may respond to breaks shorter than this, so care must be taken to avoid transients on the communication lines.



By default, the Turnkey mode is OFF (CT0). If Turnkey mode is ON (CT1) then the Pioneer DVL will ping within 10 seconds if a command is not received (see [CT - Turnkey Operation](#)).

Command Input Processing

Input commands set Pioneer operating parameters, start data collection, run built-in tests (BIT), and asks for output data. All commands are ASCII character(s) and must end with a carriage return <CR>. For example,

```
>BP0001<CR> [input]
```

If the entered command is valid, the Pioneer executes the command. If the command is one that does not provide output data, the Pioneer sends a carriage return line feed <CR> <LF> and displays a new “>” prompt. Continuing the example,

```
>BP00001<CR>    [the original input]
>                [Pioneer response to a valid, no-output command]
```

If a valid command is entered that produces output data, the Pioneer executes the command, displays the output data, and then redisplay the “>” prompt. Some examples of commands that produce output data are ? (help menus), CS (start pinging), PS (system configuration data), and PA (run built-in tests).

If the command is not valid, the Pioneer responds with an error message similar to the following.

```
>BPA<CR>                                [input]
>BPA ERR: Bad command parameters!<CR><LF> [Pioneer response]
>
```

After correctly entering all the commands for the application, send the CK to save the setup and then a CS command to begin the data collection cycle.

Data Output Processing

After the Pioneer completes a data collection cycle, it sends a block of data called a *data ensemble* through the serial communication lines. A data ensemble consists of the data collected, processed, and averaged during the ensemble interval (see [TE – Time Per Ensemble](#)). A data ensemble can contain header, leader, velocity, correlation magnitude, echo intensity, percent good, and status data.

Pioneer output data can be in either hexadecimal-ASCII (Hex-ASCII) or binary format (set by [CF - Flow Control](#)). The Hex-ASCII mode is useful when using a terminal to communicate with, and view data from the Pioneer. The binary mode is useful for high-speed communication with a computer program. Do not use the binary mode to view data on a terminal because the terminal could interpret some binary data as control codes.



Most of Teledyne RD Instruments' software supports binary PDO Output Data Format.

When data collection begins, the Pioneer uses the settings last entered (user settings) or the factory-default settings. The same settings are used for the entire deployment. If the user settings are saved (see [CK - Keep Parameters](#)) then the Pioneer will always use the user settings until a factory default is recalled, or use the last entered settings, if any, or until power is turned off. The following three rules apply for setting-up the Pioneer:

1. The last entered command of a particular command takes precedence,
2. The last entered commands will be kept in volatile memory until power is shutdown (only CK will keep these in non-volatile memory, see [CK - Keep Parameters](#)).
3. The user can recall the factory default-settings at any time (see [CR – Retrieve Parameters](#)).

The Pioneer will continue to be configured from volatile memory until it receives a CR-command or until the volatile memory loses its backup power. If the Pioneer receives a CRO it will load into volatile memory the command set last stored in non-volatile memory (semi-permanent user settings) through the CK-command. If the Pioneer receives a CR1, it will load into volatile memory the factory default command set stored in ROM (permanent or factory settings).

Command Summary

Table 13 gives a summary of the Pioneer input commands, their format, default setting, whether the Pioneer will follow the command change if sent while pinging, and a brief description of the parameters they control. Commands that start with the # sign are considered “expert” commands. Commands sent while pinging will be used on the next ensemble after the one during which they are received.



When newer firmware versions are released, some commands may be modified or added. Read the README file on the upgrade disk or check TRDI's web site for the latest changes.



The Pioneer DVL accepts command changes during operation without the need to stop the ping cycle (by sending a <BREAK>). This allows for dynamic setup configuration without stopping the operation of the Pioneer DVL. These dynamic setup commands are defined in the column **Dynamic Commands** in the table below.

Table 13: Pioneer DVL Input Command Summary

Command	Default 600 kHz	Default 300 kHz	Default 150 kHz	Dynamic	Description
?	N/A	N/A	N/A	N/A	Shows command menu
<BREAK> End	N/A	N/A	N/A	N/A	Interrupts or wakes up Pioneer DVL and loads last settings used
OL	N/A	N/A	N/A	N/A	Features
#BA <i>nnn</i>	024	024	024	Yes	Evaluation amplitude minimum (1 to 255 counts)
#BB <i>nnnn</i>	0005	0030	0060	Yes	Bottom Blanking Interval (cm)
#BC <i>nnn</i>	220	220	220	Yes	Bottom Correlation Magnitude minimum (0 to 255 counts)
#BE <i>nnnn</i>	1000	1000	1000	Yes	Bottom Error velocity maximum (0 to 9999 mm/s)
#BF <i>nnnnn</i>	00000	00000	00000	Yes	Bottom Depth guess (1 to 65535 dm, 0 = automatic)
#BH <i>nnn nnn</i>	105,180	105,180	105,180	Yes	Gain Switch Threshold (0-255cnts:lo;hi)
#BI <i>nnn</i>	003	025	050	Yes	Gain Switch Altitude (meters)
#BJ <i>nnnnnnnnnn</i>	100000000	100000000	100000000	No	Bottom Data Out {t;c;*;h;r;*;*;};
#BK <i>n</i>	0	0	0	Yes	WMass Mode [0=off 1=WB 2=LostB 3=W]
#BL <i>mmm,nnnn,ffff</i>	80,160, 240	160, 320, 480	320, 640, 960	Yes	Water mass layer parameters: Min Size (dm), Near (dm), Far (dm)
#BM <i>n</i>	8	8	8	Yes	Bottom Mode [8 & 9]
#BN <i>x,y</i>	0, 999	0, 999	0, 999	Yes	Speed log hold/drop control (x = hold (1), clear (0), y = 0 to 999 seconds)
#BO <i>k</i>	025	025	025	Yes	Distance measure filter constant (0 to 100 1/100 th s)
BP <i>nnn</i>	1	1	1	Yes	Bottom Track Pings per Ensemble
#BQ	-32768	-32768	-32768	Yes	Set outvel when over range limit (mm/s)
#BS	N/A	N/A	N/A	Yes	Clear distance traveled
BX <i>nnnn</i> (XRT Off)	01100	02900	06050	Yes	Max Depth (dm)
BX <i>nnnn</i> (XRT On)	01600	04800	08000		
BY <i>nn</i>	20	20	20	No	Transmit Length (pct)
#BZ <i>n</i>	1	1	1	No	Low Altitude Mode [0 = off, 1 = ON]
CB <i>nnn</i>	411	411	411	No	Serial port control (baud rate/parity/stop bits)
CF <i>nnnn</i>	11110	11110	11110	No	Flow control
CK	N/A	N/A	N/A	No	Keep parameters as user defaults
CR <i>n</i>	N/A	N/A	N/A	No	Retrieve parameters (0 = User, 1 = Factory)
CS or Tab	N/A	N/A	N/A	No	Start pinging
#CT <i>n</i>	0	0	0	No	Turnkey operation (0 = Off, 1 = On)
#CO <i>n p</i>	0 1	0 1	0 1	Yes	Set Out Trig ([0-3]=[off r/x x r], pol)
CX <i>n</i>	0 0 65535	0 0 65535	0 0 65535	Yes	Set Input Trigger [mode, dly, timeout]
EA <i>±nnnn</i>	+00000	+00000	+00000	Yes	Heading Alignment [.01 deg cw]
#EC <i>nnnn</i>	1500	1500	1500	Yes	Speed of Sound (1400 to 1600 m/s)
ED <i>nnnn</i>	00000	00000	00000	Yes	Transducer Depth (0 to 65535 dm)
#EE <i>nnnnnnnn</i>	0000010	0000010	0000010	No	Output Coordinate Frame (Att[2]; Intrap[2]; Cmd[1]; Rw/Nm[1]; Snsr Out[1])
#EH <i>nnnn,n</i>	00000,1	00000,1	00000,1	Yes	Heading {heading; frame}
#EI <i>nnnnnn</i>	+00000	+00000	+00000	Yes	Roll Misalignment Angle [.01 deg cw]
#EJ <i>nnnnnn</i>	+00000	+00000	+00000	Yes	Pitch Misalignment Angle [.01 deg cw]
#EP <i>±nnnn</i>	+00000, +00000,1	+00000, +00000,1	+00000, +00000,1	Yes	Tilts {pitch; roll; frame}
#ER <i>±nnnn</i>	+00000	+00000	+00000	Yes	Roll [.01 deg cw]
ES <i>nn</i>	35	35	35	Yes	Salinity (0 to 40 parts per thousand)
#ET <i>±nnnn</i>	2100	2100	2100	Yes	Temperature (-5.00 to +40.00 degrees C) [.01 deg C]
#EU	0	0	0	Yes	Orientation [0=Switch, 1=Up, 2=Down]
#EV	+00000	+00000	+00000	Yes	Heading Variation [.01 deg cw]
EX <i>nnnn</i>	11111	11111	11111	Yes	Coordinate Transformation (Xform:Type; Tilts; 38m; Map)
#EY <i>nnnnnnnnnn</i>	0 0 0 0 0 0 0	0 0 0 0 0 0 0	0 0 0 0 0 0 0	No	Doppler Param Source {c;d;h;p;r;s;t;u}
EZ <i>nnnnnn</i>	EZ11111010 (with internal Keller pressure and SBG AHRs sensors)			Yes	Sensor Source (C;D;H;P;R;S;T; U)
ME	N/A	N/A	N/A	No	ErAsE recorder
MM	N/A	N/A	N/A	No	Show memory usage
MN name	MN DVL_	MN DVL_	MN DVL_	No	Set file name [1..32 characters]
MR <i>n</i>	0	0	0	No	Set recorder on/off [0=off, 1=on]
MY	N/A	N/A	N/A	No	Y-Modem output

Table 13: Pioneer DVL Input Command Summary

Command	Default 600 kHz	Default 300 kHz	Default 150 kHz	Dynamic	Description
PA	N/A	N/A	N/A	No	Pre-deployment tests
PC	N/A	N/A	N/A	No	Display Pressure, Temperature, Heading, Pitch, Roll Built-in test
#PD n	PD0	PD0	PD0	No	Data stream select (0, 4, 5, 6, 13)
PS0	N/A	N/A	N/A	No	Display System Configuration
PS1	N/A	N/A	N/A	No	Display fixed leader (binary).
PT0	N/A	N/A	N/A	No	Built-In test – Help
PT3	N/A	N/A	N/A	No	Built-In test - Receive Path
PT5	N/A	N/A	N/A	No	Built-In test - Transmit/Receive Continuity
SC	N/A	N/A	N/A	No	Sensor Commands [ID Event "Command"]
SD	N/A	N/A	N/A	No	Sensor Data Out [ID abcd..., a-d=1/0]
SM	N/A	N/A	N/A	No	Aux Snsr Aux Menu [sid]
#SO	101.325	101.325	101.325	Yes	Absolute Press Sensor Offset [kPa]
SP n	0 99;0 99;0 99;0 99			No	Sensor-port Assignment [sid0 to0 ...]
SR	N/A	N/A	N/A	No	Sensor Reset [sid]
SZ	N/A	N/A	N/A	No	Zero out keller30 Pressure
TE hh:mm:ss.ff	00:00:00.00	00:00:00.00	00:00:00.00	No	Time per ensemble (hours:minutes:seconds.100 th of seconds)
TP mm:ss.ff	00:00.00	00:00.00	00:00.00	No	Time between pings (minutes:seconds.100 th of seconds)
TS yy/mm/dd, hh:mm:ss	N/A	N/A	N/A	No	Set real-time clock (year/month/day, hours:minutes:seconds)
TT ccyy/mm/dd, hh:mm:ss	N/A	N/A	N/A	No	Set real-time clock (Y2k compatible) (century year /month/day, hours:minutes:seconds)
#WA nnn	050	050	050	Yes	False target threshold maximum (0 to 255 counts)
#WC nnn	064	064	064	Yes	Correlation threshold (0 to 255 counts)
WD nnn nnn nnn	111110000	111110000	111110000	No	Data Out {v;c;a;p;s;*;*;*;}
#WE nnnn	2000	2000	2000	Yes	Error velocity threshold (0 to 5000 mm/s)
WF nnnn	0088	0176	0800	Yes	Blanking Distance [0 to 999 cm]
#WJ n	1	1	1	Yes	BroadBand Receiver gain (0 = Low, 1 = High)
WN nnn	030	030	030	Yes	Number of Bins (1 to 255)
WP nnnn	000	000	000	Yes	Pings per ensemble (0 to 16384)
WS nnnn	0200	0400	0800	Yes	Bin size 10 to 800 cm
#WT nnnn	0000	0000	0000	Yes	Transmit length (0 to 3200 cm)
WV nnn	0383	0383	0383	Yes	Ambiguity velocity (020 to 700 cm/s radial)



Yellow Highlighted commands are “expert” commands. Changing these command parameters can have severe consequences to data collection.



Blue Highlighted commands have frequency dependent default settings.



Commands queried (e.g., B?) during an ensemble will, in general, cause the Pioneer to respond with the usual description.



Editing or adding expert commands (#xx) to the command file will allow items to be set that if set incorrectly can cause the data to be the wrong format, bad, and/or uncorrectable even in post processing.

Command Descriptions

Each listing includes the command's purpose, format, default setting (if applicable) range, recommended setting, and description. When appropriate, we include amplifying notes and examples. If a numeric value follows the command, the Pioneer uses it to set a processing value (time, range, percentage, processing flags). All measurement values are in metric units (mm, cm, and dm).

? – Help Menus

Purpose	Lists the major help groups.
Format	$x?$ (see description)
Description	Entering ? by itself displays all command groups. To display help for one command group, enter $x?$, where x is the command group to view. When the Pioneer displays the help for a command group, it also shows the format and present setting of those commands. To see the help or setting for one command, enter the command followed by a question mark. For example, to view the WP command setting, enter <u>WP?</u> .
Examples	See below.

```
Pioneer DVL
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Firmware Version: 57.xx

>

>?
Available Commands:

# ----- Expert Commands
B ----- Bottom Track Commands
C ----- Control Commands
E ----- Environment Commands
M ----- Loop Recorder Commands
O ----- Feature Control
P ----- Performance Test Commands
S ----- Sensor Commands
T ----- Time Commands
W ----- Water Profiling Commands
? ----- Display Main Menu

>#C?
Available Commands:

#CO 0 1 ----- Set Out Trig ([0-3]=[off r/x x r], pol)
#CH      0 ----- Set SysFreq Override [38,75,...1200]
#CT 0 ----- Turnkey [0 = OFF, 1 = ON]
#C? ----- Display #C-Command Menu
```

Break

Purpose	Interrupts Pioneer without erasing present settings.
Format	<BREAK>
Description	A BREAK signal interrupts Pioneer processing. It is leading-edge triggered and should last at least 300 ms. Pioneer may respond to shorter breaks so care should be taken to avoid spurious signals on the communication lines. A BREAK initializes the system, sends a wake-up (copyright) message, and places the Pioneer in the DATA I/O mode. The BREAK command does not erase any settings or data. Using <i>TRDI Toolz</i> , pressing the End key sends a BREAK.
Example	<BREAK>

```
Pioneer DVL
Teledyne RD Instruments (c) 2021
All rights reserved.
Firmware Version: 57.xx
```

>

Software Breaks can be used with *TRDI Toolz*. Configure *TRDI Toolz* to use a Software break by using the **Tools, Options** screen. The Pioneer will use the "=" string instead of a break.

OI – Install Feature

Purpose	This command is used to install features.
Format	OI nnnxxxxxxxxxxxxxxxxxxxxxxxxxxx

```
>OI
-----1-----2-----+
Enter Code:
Code entered: ABBxxxxxxxxxxxxxxxxxxxxxx76
Features installed. Send <BREAK> to activate.
>
```

OL – Display Feature List

Purpose	Lists the special firmware upgrades that are installed.
Format	OL
Description	Lists special features that are installed. See Installing Firmware and Feature Upgrades for information on how to install additional capability in the Pioneer.
Examples	See below.

OL	FEATURES
Feature	Installed
Base Accuracy Bottom Track	No
Water Profile	Yes
High Accuracy Bottom Track	Yes
Low-Altitude Bottom Track	Yes
XRT Mode	Yes

See your technical manual or contact TRDI for information on how to install additional capability in your unit.

>



Base Accuracy Bottom Track (Export-Compliant) and High Accuracy Bottom Track are mutually exclusive modes. Only one may be enabled.

Bottom Track Commands

The Pioneer system uses these commands for bottom-tracking applications. Bottom track commands tell the Pioneer to collect speed-over-bottom data and detected range-to-bottom data. If the Pioneer were facing UP, all bottom-track information would apply to the surface boundary instead of the bottom boundary. The default state of bottom tracking is ON (BP1) for Pioneers. To turn OFF the bottom-tracking process, send a BPO command.

Available Bottom Track Commands

This section lists the available Bottom Track commands.

>b?

Available Commands:

```
BA 024 ----- Amplitude Threshold [0..255]
BB 0030 ----- Blanking distance (cm)
BC 220 ----- Correlation Threshold [0..255]
BE 1000 ----- Error Velocity Threshold [0-9999mm/s]
BF 00000 ----- Depth Guess [0=Auto, 1=MaxAlt dm]
BH 105,180 ----- Gain Switch Threshold (0-255cnts:lo;hi)
BI 025 ----- Gain Switch Altitude (meters)
BJ 100000000 ----- Data Out {t;c;*;h;r;n;*;*}
BK 0 ----- WMass Mode [0=off 1=WB 2=LostB 3=W]
BL 160, 320, 480 ----- WMass Params [min, near, far (dm)]
BM 8 ----- Bottom Mode [8 & 9]
BN 0,999 ----- Speed Log Hold/Drop Control
BO 025 ----- Distance Accum. Filter Tau (1/100ths)
BP 1 ----- Number of BT Pings in ensemble [0-999]
BQ -32768 ----- Set outvel when over range limit (mm/s)
BS ----- Clear Distance Traveled
BX 02750 ----- Max Depth (dm)
BY 20 ----- Transmit Length (pct)
B? ----- Display B-Command Menu
```

BP – Bottom-Track Pings per Ensemble

Purpose Sets the number of bottom-track pings to average together in each data ensemble.

Format BP *nnn*



The BP command works only without the # sign.

Range *nnn* = 0 to 999 pings

Default BP 001



The default setting for this command is recommended for most applications.

Description BP sets the number of bottom-track pings to average together in each ensemble before sending/recording bottom-track data.



The Pioneer interleaves bottom track pings with water track pings, if water-mass layer mode is enabled, and with Profile pings if water profiling is enabled. If BP = zero, the Pioneer will not collect bottom track data or water track data. Also, the Pioneer will not collect water profile data if WP=0, or if the water profile feature is not enabled (see [TP – Time Between Pings](#), [WP – Pings Per Ensemble](#) and [BK - Water-Mass Layer Mode](#)).

The Pioneer automatically extends the ensemble interval (TE) if BP x TP > TE (see [TE – Time Per Ensemble](#)).

BX – Maximum Tracking Depth

Purpose Sets the maximum tracking depth in bottom-track mode.

Format BX *nnnnn*



The BX command works only without the # sign.

Range *nnnnn* = 20 to 65535 (150 kHz), 6 to 3000 (300 kHz), 3 to 1100 (600 kHz) decimeters (meters x 10)

Default XRT mode Off: BX 6050 (150 kHz), BX 2900 (300 kHz), BX 1100 (600 kHz)
XRT mode On: BX 8000 (150 kHz), BX 4800 (300 kHz), BX 1600 (600 kHz)



Set BX to a depth slightly greater than the expected maximum depth.

Description The BX command sets the maximum tracking depth used by the Pioneer during bottom tracking depending on if the Extended Range Tracking (XRT) mode is on or off (see the [OL command](#)). This prevents the Pioneer from searching too long and too deep for the bottom, allowing a faster ping rate when the Pioneer loses track of the bottom.

Example If the maximum depth in the deployment area is 20 meters (200 decimeters) set BX to a value slightly larger than 200 dm; say 210 dm, instead of the default 2900 dm. Now if the Pioneer loses track of the bottom, it will stop searching for the bottom at 210-dm (21 m) rather than spend time searching down to 2900-dm (290 m).



The BX command limits the search range for bottom tracking. If the Pioneer loses lock on the bottom, it goes into search mode, which iteratively searches increasing ranges until either the bottom is found or the maximum range is reached, and then the process starts over at the minimum range. The BX command will prevent the Pioneer from searching to ranges beyond the BX range value, and can result in shorter search cycles if the bottom is known to be within this range.



In addition to limiting the search range, the BX command indirectly limits the bottom track range. While this does not prevent the Pioneer from bottom tracking to ranges beyond the BX range, use caution in setting this command to less than the expected maximum depth as the Pioneer will be less likely to hold a lock on the bottom if there is any slope beyond the BX range.

Expert Bottom Track Commands

This section lists the expert Bottom Track commands. Commands that start with the # sign are considered “expert” commands.

>#B?

Available Commands:

```
#B1 0 ----- Blank Range with Bad Velocity [0..1]
#B2 0 ----- Depth Memory Timeout [0=off, 1-30s]
#BA 024 ----- Amplitude Threshold [0..255]
#BB 0030 ----- Blanking distance (cm)
#BC 220 ----- Correlation Threshold [0..255]
#BE 1000 ----- Error Velocity Threshold [0-9999mm/s]
#BF 00000 ----- Depth Guess [0=Auto, 1-MaxAlt dm]
#BH 105,180 ----- Gain Switch Threshold (0-255cnts:lo;hi)
#BI 025 ----- Gain Switch Altitude (meters)
#BJ 100000000 ----- Data Out {t;c;*;h;r;n;*;*}
#BK 0 ----- WMass Mode [0=off 1=WB 2=LostB 3=W]
#BL 160, 320, 480 ----- WMass Params [min, near, far (dm)]
#BM 8 ----- Bottom Mode [8 & 9]
#BN 0,999 ----- Speed Log Hold/Drop Control
#BO 025 ----- Distance Accum. Filter Tau (1/100ths)
#BQ -32768 ----- Set outvel when over range limit (mm/s)
#BS ----- Clear Distance Traveled
#BY 20 ----- Transmit Length (pct)
#BZ 1 ----- Low Altitude Mode [0=off, 1= ON]
#B? ----- Display #B-Command Menu
```

#B1 - Blank Range with Bad Velocity

Purpose Sets the Bottom Track range to zero whenever velocity correlation drops below the minimum magnitude.

Format #B1 *n*



Correlation Magnitude Minimum is set via the CE or #CE command.

Range *n* = 0 to 1

Default #B1 0



The default setting for this command is recommended for most applications.

Description #B1 allows for filtering out ranges when velocity shows a low correlation. This is especially useful when another system in the vicinity of the DVL is causing interference which mimics a Bottom Pulse but thanks to our velocity filtering ends-up with a low correlation when processed for velocity.

#B2 - Depth Memory Timeout

Purpose	Enables Bottom Track to preserve the range-to-bottom across a Break. #B2 0 (default) disables the feature. Setting #B2 to 1 to 30 sets a timeout, in seconds, after which the device will search for the bottom as normal.
Format	#B2 <i>n</i>
Range	<i>n</i> = 0, 1 to 30
Default	#B2 0



The default setting for this command is recommended for most applications.

Description	#B2 sets a time during which the DVL can retain the last known good range when a Break is received followed by a CS command. This is especially useful as when sending a Break the DVL will search for the bottom in its default configuration, setting the #B2 allows to avoid searching for the bottom and thus benefits the user by offering a faster restart post break. In addition, this command has proven very useful to prevent the DVL from locking onto interfering signals in noisy environments.
-------------	---

#BA - Evaluation Amplitude Minimum

Purpose	Sets the minimum value for valid bottom detection.
Format	#BA <i>nnn</i>



The BA commands work with or without the # sign. For example, using BA or #BA are both valid commands.

Range	<i>nnn</i> = 1 to 255 counts
Default	#BA 24



The default setting for this command is recommended for most applications.

Description	#BA sets the minimum amplitude of an internal bottom-track filter that determines bottom detection. Reducing #BA increases the bottom-track detection range, but also may increase the possibility of false bottom detections.
-------------	--

#BB – Bottom Blanking Interval

Purpose	This command sets the near limit of bottom detection beyond the transmit pulse.
Format	#BB <i>nnnn</i>



The BB commands work with or without the # sign. For example, using BB or #BB are both valid commands.

Range	<i>nnnn</i> = 0 to 9999 cm (150 kHz), 0 to 12500 cm (300 kHz), 0 to 3200 (600 kHz)
Default	#BB 0060 (150 kHz), #BB 0030 (300 kHz), #BB 0005 (600 kHz)



The default setting for this command is recommended for most applications.

Description	The Pioneer will search for the bottom starting at the length of transmit plus this blanking interval.
-------------	--

#BC - Correlation Magnitude Minimum

Purpose Sets minimum correlation magnitude for valid velocity data.

Format #BC *nnn*



The BC commands work with or without the # sign. For example, using BC or #BC are both valid commands.

Range *nnn* = 0 to 255 counts

Default #BC 220



The default setting for this command is recommended for most applications.

Description Sets a minimum threshold for good bottom-track data. Any bottom-track data with a correlation magnitude less than this value will be flagged as bad.



A count value of 255 is a perfect correlation (i.e. solid target)

#BE - Error Velocity Maximum

Purpose Sets maximum error velocity for good bottom-track data.

Format #BE *nnnn*



The BE commands work with or without the # sign. For example, using BE or #BE are both valid commands.

Range *nnnn* = 0 to 9999 mm/s

Default #BE 1000



The default setting for this command is recommended for most applications.



The default setting is set purposely high and as a result effectively disabled. We recommend extreme caution and testing before changing this setting. **Data rejected by this command is lost and cannot be regained.**

Description The Pioneer uses this parameter to determine good bottom-track velocity data. If the error velocity is greater than this value, the Pioneer marks as bad all four beam velocities (or all four coordinate velocities, if transformed). If three beam solutions are allowed (see [EX – Coordinate Transformation](#)) and only three beams are good, then the data is accepted since four good beams are needed for error velocity calculation.

#BF - Depth Guess

Purpose Sets a “best-guess” of expected bottom range for internal calculations.

Format #BF *nnnnn*



The BF commands work with or without the # sign. For example, using BF or #BF are both valid commands.

Range *nnnnn* = 1 to Maximum Altitude dm (0 = automatic)

Default #BF 0



The default setting for this command is recommended for most applications.

Description When set to a non-zero value, the Pioneer transmits a fixed pulse based on a given bottom range. This is useful for applications with fixed range bottoms. The command reduces the amount of time the Pioneer uses to search for the bottom if lost.

#BH – Gain Switch Threshold

Purpose Sets the RSSI thresholds for switching the receiver gain for a bottom track ping.

Format #BH *nnn*, *nnn* (lo;hi)

Range *nnn* = 0 to 255 counts

Default #BH 105,180



The default setting for this command is recommended for most applications.

Description Receiver gain control for bottom track always uses low gain when the altitude over the sea bottom is less than the Gain Switch Altitude (set by the #BI command). When the altitude is above the Gain Switch Altitude:

- Switch to high gain when RSSI is below the low threshold set by the #BH command.
- Switch to low gain when RSSI is above the high threshold set by the #BH command.

Using two thresholds provides hysteresis, so that the gain does not need to switch on every ping when the RSSI is at some in-between level.

#BI - Gain Switch Altitude

Purpose Selects the maximum vertical distance from the transducer to the bottom at which the Pioneer operates at low gain.

Format #BI *nnn*



The BI commands work with or without the # sign. For example, using BI or #BI are both valid commands.

Range *nnn* = 0 to 999 meters (150kHz), 0 to 25 meters (300 kHz), 0 to 3 meters (600 kHz)

Default #BI 050 (150 kHz), #BI 025 (300 kHz), #BI 003 (600 kHz)



The default setting for this command is recommended for most applications.

Description When the vertical range to the bottom is less than #BI, the unit operates in low gain. When the vertical range is greater than #BI, internal logic determines which gain (low or high) is optimal. In high backscatter areas, it may be necessary to raise this setting in order to detect bottom throughout the range of the system.

#BJ – Data Type Output Control

Purpose: Bottom data types that will be output in the ensemble.

Format: Format #BJ *tc* hrn ****



The BJ commands work with or without the # sign. For example, using BJ or #BJ are both valid commands.

The High Accuracy Bottom Track feature must be installed for the #BJ command to be enabled (see [OL – Display Feature List](#)).

*: not used; reserved for future use (set to zero).

t: Standard bottom track output (see [Binary Bottom-Track Data Format](#))

c: Commands output (see [Bottom Track Command Output Format](#) for a definition of this data type)

h: High resolution bottom and water mass velocity and distance (note that this will cause distance to be accumulated). See [Bottom Track High Resolution Velocity Format](#) for a data type definition)

r: Range (corrected) output. See [Bottom Track Range Format](#) for a data type definition.

n: Precision Navigation Output. See [Navigation Parameters Data Format](#) for data type definition.

Range: 0 or 1 for each digit

Default: #BJ 100 000 000



The default setting for this command is recommended for most applications.

Description: This command controls the data types that are output in the ensemble.



Include the spaces between the groups of three digits for readability. The command is accepted with or without spaces.

#BK - Water-Mass Layer Mode

Purpose: Selects the ping frequency of the water-mass layer ping

Format: #BK *n*



The BK commands work with or without the # sign. For example, using BK or #BK are both valid commands.

Range: *n* = 0 to 3

Default: BK 0



The default setting for this command is recommended for most applications.

Description: The BK command selects how often the Pioneer performs a water-mass layer ping while bottom tracking. The number of water-mass layer pings per ensemble is dependent on the BP-command (see [BP – Bottom-Track Pings per Ensemble](#)) and this command setting. Use the #BL-command to set the location of the water-mass layer (see [BL - Water-Mass Layer Parameters](#)).

Table 14: Water-Mass Reference-Layer Modes

Command	Description
#BK 0	Disables the water-mass layer ping.
#BK 1	Sends a water-mass layer ping after every bottom-track ping
#BK 2	Sends a water-mass layer ping after every bottom-track ping that is unable to find the bottom.
#BK 3	Disables the bottom-track ping and enables the water-mass ping.

#BL - Water-Mass Layer Parameters

Purpose Sets bottom-track water-mass layer boundaries and minimum layer size.

Format #BL *mmm,nnnn,ffff*



The BL commands work with or without the # sign. For example, using BL or #BL are both valid commands.

Range *mmm* = Min Layer Size (1 to 640 decimeters) [meters x 10]
nnnn = Near Layer Boundary (0 to 9999 decimeters) [meters x 10]
ffff = Far Layer Boundary (0 to 9999 decimeters) [meters x 10]

In addition, the following must be true:

$$\text{Far} \geq (\text{Near} + \text{Min})$$

The Far boundary cannot exceed 80% of the range-to-bottom of the beam with the shortest altitude. If the bottom comes up so that the Far boundary does not meet this requirement, then the Far boundary is automatically adjusted to ensure this requirement is met, unless the minimum layer size cannot be maintained, in which case the water track ping is skipped and the data is marked bad.

Default #BL 320,640,960 (150 kHz), #BL 160,320,480 (300 kHz), #BL 80,160,240 (600 kHz)



The default setting for this command is recommended for most applications.

Description The #BL-command sets a water-mass layer. Use this layer as a reference point when the bottom is out of range or is incorrect. Water-mass layer output data are available when both #BK (see [BK - Water-Mass Layer Mode](#)) and BP (see [BP – Bottom-Track Pings per Ensemble](#)) commands are nonzero values, and the bottom must be at least the Minimum Layer Size + Near Layer Boundary + 20% of the reported depth away from the transducer. The Far Layer Boundary (ffff) must be less than the maximum profiling distance or the Pioneer sends Error Code 011.



For more information, see [Water Tracking](#), page 25.

#BM – Bottom Mode

Purpose: Sets the Bottom Track mode.

Format: #BM *n*



The BM commands work with or without the # sign. For example, using BM or #BM are both valid commands.

Range: *n* = 8 or 9

Default: #BM 8



The default setting for this command is recommended for most applications.

Description: Bottom Mode 8 was developed for the following improvements in shallow operations:

- Much improved accuracy by pinging Beams around, one at a time.
- Better handling of slopes by independently setting lags on each beam based on accurate bottom detection before each ping.
- Better handling of station keeping application using longer lag.
- Higher resolution Bottom Detection using short lag Bottom Feeler pings.

Table 15: BM8 Minimum Tracking Depths

Frequency	Min Tracking Depths	With Low Altitude feature
600KHz	0.2m	< 0.2 m
300KHz	0.6m	0.3 m

Bottom Mode 9 is identical to Bottom Mode 8 except that it does not have a shallow mode.

Table 16: BM9 Minimum Tracking Depths

Frequency	Min Tracking Depths
600KHz	3.8m
300KHz	7.6m

#BN - Speed Log Hold/Drop Control

Purpose: Controls the behavior of the distance measure calculation when Bottom Track is lost.

Format: #BN *x,y*



The BN commands work with or without the # sign. For example, using BN or #BN are both valid commands.

Range: *x* = 0 to 1
y = 0 to 999 seconds

Default: #BN 0,999



The default setting for this command is recommended for most applications.

Description: The #BN command governs the behavior of the earth referenced distance measurement calculation in the PD6 data format when the Pioneer can't get a lock on the bottom. The y parameter represents a timeout period during which zero is used for the current velocity measurement in the equation shown in the #BO command. After the expiration of the y timeout, the behavior is governed by the x parameter. If x is zero, then the accumulated distance is set to zero. If x is one, then the accumulated distance is maintained at its current value until the Pioneer achieves bottom lock.

#BO - Distance Measure Filter Constant

Purpose: Sets the value of the filter constant used by the distance measurement calculation in PD6.

Format: #BO k



The BO commands work with or without the # sign. For example, using BO or #BO are both valid commands.

Range: $k = 0$ to 100

Default: #BO 25



The default setting for this command is recommended for most applications.

Description: When calculating the earth referenced distance data for output in the PD6 data format, the Pioneer applies a simple exponential filter to the velocity measurements before calculating the distance. The velocity used to calculate the distance is given by the following equation:

$$v = (k \bullet v_{\text{new}} + (100 - k) \bullet v_{\text{old}}) / 100$$

Where v_{new} is the current velocity measurement, v_{old} is the value of v calculated for the previous distance calculation, and k is the value of the #BO command. Setting k to 100 effectively disables the exponential filter.

#BQ – Over Range Limit



This command is only used for 38 kHz systems.

#BS - Clear Distance Traveled

Purpose Clears internal distance traveled accumulators.

Format #BS



The BS commands work with or without the # sign. For example, using BS or #BS are both valid commands.



Use as needed.

Description Distance traveled is calculated and output in the following Pioneer output formats;

- PD0 high resolution output (see [BJ – Data Type Output Control](#) and [Bottom Track High Resolution Velocity Format](#))
- PD5 (see [Pioneer Binary Data Format \(PD5\)](#)).
- PD6 (see [Pioneer Output Data Format \(PD6\)](#))

The accumulator is zeroed on <BREAK> or by using this command in the manual ensemble cycling mode (see [CF - Flow Control](#)).

#BY – Transmit Length

Purpose Scales the bottom mode transmit.

Format #BY nn



The BY commands work with or without the # sign. For example, using BY or #BY are both valid commands.

Range: nn = 0 to 100 %

Default: #BY 20



The default setting for this command should never be changed without thorough testing, as **changes to this parameter have the potential to produce incorrect velocity and/or range data.**

Description The BY command sets the transmit length for a bottom track ping as a percentage of the altitude over the sea bottom. The default setting has been designed to optimize the tradeoff between energy consumption and the ability to detect the bottom with combined tilt/slope of up to about 15 degrees. Smaller values result in shorter transmits, which use less energy, but which may not fully ensonify the beam on the sea bottom, especially if the instrument is tilted or if the bottom has a slope, resulting in velocity bias. Larger values result in longer transmit pulses (up to a point) which may allow bottom detection at larger values of tilt/slope, but will consume more energy, and may decrease the resolution of the range-to-bottom measurement.

#BZ – Low Altitude Mode

Purpose Turns on or off the Low Altitude Bottom Track mode.

Format #BZn



The BZ command works only with the # sign.
This command is only available in systems with the Low Altitude Bottom Track (LABT) feature.

Range: $n = 0$ to 1 ($0 = \text{OFF}$, $1 = \text{ON}$)

Default: #BZ1



The default setting for this command is recommended for most applications.

Description #BZ 0 turns off the Low-Altitude bottom function. #BZ 1 turns on the Low-Altitude bottom function.

Control System Commands

The Pioneer uses the following commands to control certain system parameters.

Available Control System Commands

This section lists the available Control System commands.

>c?

Available Commands:

```
CB 811 ----- Serial Port Control {baud;parity;stop}
CF 11110 ----- Set Ctrl Flags {e;p;b;s;*}
CK ----- Save Command Parameters to Flash
CR ----- Restore Cmd defaults [0=user,1=factory]
CS ----- Start Pinging
CT 0 ----- Turnkey [0 = OFF, 1 = ON]
CX 0 0 65535 ----- Set Input Trigger [mode, dly, timeout]
C? ----- Display C-Command Menu
```

CB - Serial Port Control

Purpose Sets the RS-232/422 serial port communications parameters (Baud Rate/Parity/Stop Bits).

Format CB *nnn*

Range *nnn* = baud rate, parity, stop bits (see description)

Default CB 411



The Pioneer defaults to CB411 (9600 baud) if this parameter has never been saved to non-volatile memory. Otherwise, it uses the value last saved (i.e. the last time a [CK command](#) was issued).

Description The Pioneer can be set to communicate at baud rates from 1200 to 115200. The Pioneer and the external device (dumb terminal, computer software) **MUST** use the same communication parameters to *talk* to each other. After entering a valid CB parameters, the Pioneer responds with a ">" prompt. Then change the external device's communication parameters to match the Pioneer parameters before sending another command.



If a BREAK is sent before changing the external device's communication parameters, the Pioneer returns to the communication parameters stored in non-volatile memory (user settings).

Table 17: Serial Port Control

Baud Rate	Parity	Stop Bits
1 = 1200	1 = None (Default)	1 = 1 Bit (Default)
2 = 2400	2 = Even	2 = 2 Bits
3 = 4800	3 = Odd	
4 = 9600 (Default)	4 = Low (Space, logical 0)	
5 = 19200	5 = High (Mark, logical 1)	
6 = 38400		
7 = 57600		
8 = 115200		

CF - Flow Control

Purpose Sets various Pioneer data flow-control parameters.

Format CF *nnnnn*

Range Firmware switches (see description)

Default CF 11110



The default setting for this command is recommended for most applications.

Description The CF-command defines whether the Pioneer: generates data ensembles automatically or manually; generates pings immediately or manually; sends serial output data in binary or Hex-ASCII format; sends or does not send output data to the serial interface.

Table 18: Flow Control

Command	Description
CF 1xxxx	Automatic Ensemble Cycling – Automatically starts the next data collection cycle after the current cycle is completed. Only a <BREAK> can stop this cycling.
CF 0xxxx	Manual Ensemble Cycling – Enters the STANDBY mode after transmission of the data ensemble, displays the > prompt and waits for a new command.
CF x1xxx	Automatic Ping Cycling – Pings immediately when ready.
CF x0xxx	Manual Ping Cycling – Sends a < character to signal ready to ping, and then waits to receive an <Enter> before pinging. The <Enter> sent to the Pioneer is not echoed. This feature manually controls ping timing within the ensemble. Note the prompt output by the Pioneer when ready to ping is a less-than symbol (<), to distinguish it from the normal command prompt.
CF xx1xx	Binary Data Output – Sends the ensemble in binary format, if serial output is enabled.
CF xx0xx	Hex-ASCII Data Output – Sends the ensemble in readable hexadecimal-ASCII format, if serial output is enabled.
CF xxx1x	Enable Serial Output – Sends the data ensemble out the RS-232/422 serial interface.
CF xxx0x	Disable Serial Output – No ensemble data are sent out the RS-232/422 interface.
Example	CF01010 selects manual ensemble cycling, automatic ping cycling, Hex-ASCII data output, and enables serial output.



When operating in HEX mode, all console text appears in HEX - including the prompt ">" (HEX "3E") and any additional commands that are typed.

CK - Keep Parameters

Purpose Stores present parameters to non-volatile memory.

Format CK



The CR1 command must be the first command sent to the Pioneer. The CK command must be sent just before the CS command. Other commands may be sent in any order.

Description CK saves the present user command parameters to non-volatile memory on the CPU board. The Pioneer maintains data stored in the non-volatile memory (user settings) even if power is lost. It does not need a battery. Use the CR command to recall parameters stored in non-volatile memory (see [CR – Retrieve Parameters](#)).

CR – Retrieve Parameters

Purpose Resets the Pioneer command set to factory settings.

Format CR *n*

Range *n* = 0 (User), 1 (Factory)



The CR1 command must be the first command sent to the Pioneer. The [CK command](#) must be sent just before the CS command. Other commands may be sent in any order.

Description The Pioneer automatically stores the last set of commands used in volatile memory. The Pioneer will continue to be configured from volatile memory unless it receives a CR command or until the volatile memory loses its power.

Table 19: Retrieve Parameters

Format	Description
CR0	Loads into volatile memory the command set last stored in non-volatile memory (user settings) using the CK Command.
CR1	Loads into volatile memory the factory default command set stored in ROM (factory settings).



The CR command keeps the present baud rate and does not change it to the value stored in non-volatile memory or ROM. This ensures the Pioneer maintains communications with the terminal/computer.

CS – Start Pinging (Go)

Purpose Starts the data collection cycle (same as the **Tab** key).

Format CS



The CR1 command must be the first command sent to the Pioneer. The [CK command](#) must be sent just before the CS command. The CS command is the last command sent.

Description Use CS (or the **Tab** key) to tell the Pioneer system to start pinging its transducer and collecting data as programmed by the other commands.



TRDI does not recommend pinging the Pioneer system with the transducer in air. The transducer may be damaged. The transducer is pinged by sending a CS, PA, PT3, or PT5 command or if the Pioneer system is started for collecting data.



If the Pioneer system was in [turn-key mode](#) when last powered down, it will automatically resume pinging ten seconds after power is applied. To avoid pinging in air, disable the turn-key mode within ten seconds after applying power by sending a CTO command immediately after receiving the prompt following wake-up message and then send a CK command to save the new setting as the user default. Another way to stop pinging is to send a Break and then send a valid command (for example, send a Break and the OL command) to the Pioneer to stop it from pinging.



Avoid removing the transducer from water if it is actively pinging. First send a break to stop pinging before removing the Pioneer system from water.

CT - Turnkey Operation

Purpose Allows the Pioneer to initialize to predefined parameters and start pinging within 10 seconds after power is applied, or a break is received, if no command is entered.

Format CT *n*



The CT commands work with or without the # sign. For example, using CT or #CT are both valid commands.

Range *n* = 0 to 1 (0 = Off, 1 = Turnkey)

Default CT 0



The default setting for this command is recommended for most applications.

Description Setting the CT command to CT1 lets the Pioneer automatically initialize to a predefined command set during any power up or after a break.

To place the Pioneer in turnkey mode, first set all other commands to the desired configuration. Then send the CT1 and CK commands to save this configuration (see [CK - Keep Parameters](#)). When power is cycled or a break is sent, the Pioneer will start up with the desired configuration and begin the data collection process unless a valid command is sent within 10 seconds.

Turnkey mode can be interrupted by sending a <BREAK>. This will place the Pioneer in the command mode, ready to accept input for another 10 seconds. To turn off the turnkey mode, first send a <BREAK> to the Pioneer. Now send the CTO and CK commands to save this configuration. When power is cycled or a break is again sent, the Pioneer will NOT begin the data collection process.



TRDI does not recommend pinging the Pioneer system with the transducer in air. The transducer may be damaged. The transducer is pinged by sending a CS, PA, PT3, or PT5 command or if the Pioneer system is started for collecting data.



If the Pioneer system was in [turn-key mode](#) when last powered down, it will automatically resume pinging ten seconds after power is applied. To avoid pinging in air, disable the turn-key mode within ten seconds after applying power by sending a CTO command immediately after receiving the prompt following wake-up message and then send a CK command to save the new setting as the user default. Another way to stop pinging is to send a Break and then send a valid command (for example, send a Break and the OL command) to the Pioneer to stop it from pinging.



Avoid removing the transducer from water if it is actively pinging. First send a break to stop pinging before removing the Pioneer system from water.

CX – Input Trigger Enable

Purpose Enables or disables the trigger.

Format CX *n d t [p]*



Use as needed.

Range	<i>n</i> : <i>n</i> = 0 to 5 per Table 20.
	<i>d</i> : 0 to 65535 one hundredths of a second delay time.
	<i>t</i> : 0 to 65535 one hundredths of a second time-out time. Setting “ <i>t</i> ” to 65535 disables the time-out.
	<i>p</i> : (optional) 0 or 1. Setting “ <i>p</i> ” to 1 enables ping-once mode after time-out.
Default	CX 0 0 65535 0
Description	The unit will ping once within 1ms after the trigger transitions as indicated in Table 20 for CX = 1 to 3.
	For CX 4 to 5, the Pioneer will trigger while the trigger is in the state described in Table 20.
	If “ <i>p</i> ” set to 1, ping only once after time-out, then wait again for another Trigger or time-out. If set to 0 (default), will self-deploy normally after time-out. If not set by CX command, will default to 0.

Table 20: Input Trigger

CX (<i>n</i>)	System Behavior
0	Trigger off
1	Pings after low to high transition
2	Pings after high to low transition
3	Pings after either low to high or high to low transition
4	Ping while trigger is low
5	Pings while trigger is high



The polarity is defined as the electrical level at the 7-pin end-cap connector (see Figure 5). Note that commanded time between pings (TP) takes higher precedence than this command. That is, the unit will ping on the next trigger after TP has been satisfied.

The trigger delay causes the unit to wait after a trigger is received for pinging to start. Delay after trigger is received is valid only for first ping for CX *n*=4 or 5.

The time-out is effective the first time the time-out occurs. The unit pings without waiting for the trigger after the first time-out.

De-asserting the trigger after it has been asserted and the ping started will not stop the ping for CX *n*=4 or 5. That is, the trigger condition only delays the ping prior to transmit and will not be checked until the Pioneer unit is ready to transmit again.



Note that commanded time between pings (TP) takes higher precedence than this command. That is, the unit will ping on the next trigger after TP has been satisfied (see [TP – Time Between Pings](#)).



Trigger In and Out lines must each be referenced to COMM RETURN 1 (pin 5 RS-232 or pin 3 RS-422). See Table 3, page 15.

Expert Control System Commands

This section lists the expert Control System commands. Commands that start with the # sign are considered “expert” commands.

>#C?

Available Commands:

```
#CO 0 1 ----- Set Out Trig ([0-3]=[off r/x x r], pol)
#CH      0 ----- Set SysFreq Override [38,75,...1200]
#CT 0 ----- Turnkey [0 = OFF, 1 = ON]
#C? ----- Display #C-Command Menu
```



The #CH command is for TRDI use only and is not documented in this manual.

#CO – Output Trigger Enable

Purpose Enable or disable the output trigger. This trigger gives an approximate indication of when transmit and receive occur for the Pioneer. It is not intended to provide exact timing of transmit or receive. This trigger can be used to hold off pinging of other devices that would otherwise interfere with Pioneer operation.

Format #CO *n p*



The #CO commands work ONLY with the # sign.

Range *n*: 0 to 3 trigger event as described below.
p: 0 to 1 polarity as described below.

Default #CO 0 1



The default setting for this command is recommended for most applications.

Description The “*n*” parameter of this command can cause the system to output a trigger through the trigger out line on the 7-pin end-cap connector (see Figure 5) during transmit, receive or both transmit and receive as indicated in Table 21.

Table 21: Output Trigger State

#CO (<i>n</i>)	Output Trigger State
#CO 0	Trigger off.
#CO 1	Trigger active during transmit and receive interval.
#CO 2	Trigger active during transmit interval only. Reverts to <i>n</i> =1 for BM8 when shallow due to multi-pulse transmission.
#CO 3	Trigger active during receive interval only. Reverts to <i>n</i> =1 for BM8 when shallow due to multi-pulse transmission.

The “*p*” parameter of this command causes the polarity to be electrically high for *p* = 1 when the trigger is active, otherwise it is electrically low.

To avoid interference between the Pioneer and other devices on the vehicle in general applications, $n = 1$ is recommended.



Trigger In and Out lines must each be referenced to COMM RETURN 1 (pin 5 RS-232 or pin 3 RS-422). See Table 3, page 15.

Environmental Commands

The Pioneer uses the following commands to control the environmental and positional information that affects internal data processing.

Available Environmental Commands

This section lists the available Environmental commands.

>E?

Available Commands:

```
EA +00000 ----- Heading Alignment [.01 deg cw]
EC 1500 ----- Speed Of Sound [m/s]
ED 00000 ----- Xdcr Depth [dm]
EH 00000,1 ----- Heading {heading;frame}
EP +0000,+0000,1 ----- Tilts {pitch;roll;frame}
ER +0000 ----- Roll [.01 deg cw]
ES 35 ----- Salinity [ppt]
ET 2100 ----- Water Temperature [.01 deg C]
EU 0 ----- Orientation [0=Switch,1=Up,2=Down]
EV +00000 ----- Heading Bias [.01 deg cw]
EX 11111 ----- Coordinate Transformations
EZ 11111010 ----- Sensor Source {c;d;h;p;r;s;t;u}
E? ----- Display E-Command Menu
```

EA - Heading Alignment

Purpose Corrects for physical misalignment between Beam 3 and the heading reference.

Format EA ±nnnnn



The EA command work ONLY without the # sign.

Range ±nnnnn = -17999 to 18000 (-179.99 to 180.00 degrees)

Default EA 00000



Set as needed.

Description EA is a heading alignment angle (referenced to Beam 3) used as a new zero reference for heading output and for transformation to earth coordinates. Use the [EV - Heading Bias](#) command to correct for heading bias (e.g., magnetic declination).

Example The Pioneer is mounted on a ship/vehicle with beam 3 aligned at a +45 degree angle (i.e. clockwise) from the forward axis of the ship/vehicle. Use the EA command to tell the Pioneer where beam 3 is in relation to the ship's centerline. To convert +45 to an EA-command value, multiply the desired alignment angle in degrees by 100:

$$EA = +45.00 \times 100 = +4500 = EA+04500$$

EC - Speed of Sound

Purpose	Sets the speed of sound value used for Pioneer data processing.
Format	EC <i>nnnn</i>
Range	<i>nnnn</i> = 1400 to 1600 meters per second
Default	EC 1500



The EC command works with or without the # sign. For example, using EC or #EC are both valid commands.



The default setting for this command is recommended for most applications.

Description EC sets the sound speed value used by the Pioneer to scale velocity data, depth cell size, and range to the bottom. The Pioneer assumes the speed of sound reading is taken at the transducer head. See the primer for information on speed of sound calculations.



If the EZ Speed of Sound field = 1, the Pioneer overrides the manually-set EC value and calculates speed of sound using the values determined by ED ([ED - Depth of Transducer](#)), ES ([ES - Salinity](#)), and ET ([ET - Temperature](#)). EZ also selects the source for ED, ES, and ET.

ED - Depth of Transducer

Purpose	Sets the Pioneer transducer depth.
Format	ED <i>nnnnn</i>



The ED command work ONLY without the # sign.

Range	<i>nnnnn</i> = 0 to 65535 decimeters (meters x 10)
Default	ED 00000



Use the EZ-command (see [EZ - Sensor Source](#)).

Description ED sets the Pioneer transducer depth. This measurement is taken from sea level to the transducer face. The Pioneer uses ED in its speed of sound calculations. The Pioneer assumes the speed of sound reading is taken at the transducer head. See the primer for information on speed of sound calculations.



If the EZ *Transducer Depth* field = 1 or 2, the Pioneer overrides the manually set ED value and uses depth from the internal or external pressure sensor, respectively. If a pressure sensor is not available, the Pioneer uses pressure data from the best available sensor or ED command. See Table 24 of the #EY command for more information.

EH - Heading

Purpose Sets the Pioneer heading and the coordinate frame (instrument or ship) to which EH-command input refers.

Format EH *xxxx,y*



The EH command works with or without the # sign. For example, using EH or #EH are both valid commands.

Range *xxxx* = 0 to 35999 1/100ths of a degree

y = 0 for instrument coordinates

y = 1 for ship coordinates

Default EH 0,1



The default setting for this command is recommended for most applications.

Description EH sets the Pioneer heading and heading coordinate frame if both arguments are entered. EH sets the Pioneer heading if only one argument is entered. This heading value is assumed to be in instrument coordinates. Figure 12 shows transducer beam axis and tilt signs.

EH may be entered after the unit is commanded to ping (CS command) and will be used in subsequent pings.

Example Convert heading values of +21.5 degrees to EH-command values referenced to ship coordinates.

Heading in hundredths = $21.50^\circ \times 100 = 2150$
EH 2150, 1 (+ in front of 2150 is optional)



If the EZ Heading field = 1, the Pioneer overrides the manually set EH value and uses heading from the transducer's internal sensor. If the EZ Heading field = two the Pioneer takes heading from an external synchro. If EZ Heading field is zero the Pioneer uses the manual EH command settings.

See [EZ - Sensor Source](#) for more details and restrictions for the case of mixed heading sources.

EP - Pitch and Roll Angles

Purpose Sets the Pioneer pitch (tilt 1) and, optionally, the roll (tilt 2) and the coordinate frame (instrument or ship) to which all pitch and roll inputs (including sensors) refer. Alternatively, the EP commands may be used with single arguments, in which case it is assumed that the pitch and roll inputs represent the pitch and roll of the instrument rather than those of the ship.

Format EP \pm xxxxx, \pm yyyyy, z



The EP command works with or without the # sign. For example, using EP or #EP are both valid commands.

Range \pm xxxxx and \pm yyyyy = -17999 to +18000 hundredths of a degree

z = 0 for instrument coordinates,

z = 1 for ship coordinates

Default EP 0,0,1



Set as needed.

Description EP sets the Pioneer pitch (tilt 1) and roll (tilt 2) and the pitch/roll coordinate frame if all three arguments are entered. EP sets the Pioneer pitch (tilt 1) if only one argument is entered. This pitch value is assumed to be in instrument coordinates.

If only two fields are entered, a command entry error is issued. Figure 12 shows transducer beam axis and tilt signs.

Example Convert pitch and roll values of +14 degrees and -3.5 degrees to EP-command values referenced to ship coordinates.

Pitch in hundredths = $14.00 \times 100 = 1400$
 Roll in hundredths = $-3.50 \times 100 = -350$
 EP 1400, -350, 1 (+ in front of 1400 is optional)

ER - Roll Angle

Purpose Sets the Pioneer roll angle that will be used by the system if the corresponding EZ bit is set to 0.

Format ER $\pm nnnnn$



The ER command works with or without the # sign. For example, using ER or #ER are both valid commands.

Range $\pm nnnnn = -17999$ to $+18000$ hundredths of a degree

Default ER 0



Set as needed.

Description This command allows the user to input a roll (tilt 2) value that will be used if the roll EZ bit is set to zero. The coordinate frame of this data corresponds to the third parameter of the EP command. Roll can also be entered with pitch and the pitch/roll coordinate frame in the EP command (see [EP - Pitch and Roll Angles](#)). See the description of the EZ command ([EZ - Sensor Source](#)) to see how this commands value is used.

Example Convert roll values of +14 and -3.5 to ER command values.

#ER = $14.00 \times 100 = 1400 = \#ER01400$ (+ is understood)
 #ER = $-3.50 \times 100 = -350 = \#ER-00350$

ES – Salinity

Purpose Sets the water's salinity value.

Format ES nn



The ES command work ONLY without the # sign.

Range $nn = 0$ to 40

Default ES 35



The default setting for this command is recommended for most applications.

Description The ES command sets the water's salinity value. The Pioneer uses ES in its speed of sound calculations. The Pioneer assumes the speed of sound reading is taken at the transducer head.

ET - Temperature

Purpose Sets the water's temperature value.

Format ET $\pm nnnn$



The ET command works with or without the # sign. For example, using ET or #ET are both valid commands.

Range $\pm nnnn = -500$ to 4000 (-5.00 C to $+40.00$ C)

Default ET 2100



Use the EZ-command (see [EZ - Sensor Source](#)).

Description ET sets the temperature value of the water. The Pioneer uses ET in its speed of sound calculations (see the primer). The Pioneer assumes the speed of sound reading is taken at the transducer head.

Example Convert temperatures of $+14$ C and -3.5 C to ET-command values.

ET = $14.00 \times 100 = 1400 = \text{ET}1400$ (+ is understood)

ET = $-3.50 \times 100 = -350 = \text{ET}-0350$



If the EZ Temperature field = one, the Pioneer overrides the manually set ET value and uses temperature from the transducer's temperature sensor. If the sensor is not available, the Pioneer uses the manual ET setting.

EU - Up/Down Orientation

Purpose Sets the Pioneer up/down orientation.

Format EU n



The EU command works with or without the # sign. For example, using EU or #EU are both valid commands.

Range $n = 0$ or 1 ($0 = \text{down}$, $1 = \text{up}$)

Default EU 0



Use the EZ-command (see [EZ - Sensor Source](#)).

Description In conjunction with the EZ command, EU is used to manually specify the orientation of the Pioneer.



The EU command can be used to align an upward pointing unit (e.g., mounted on a submarine) if the roll source is in instrument coordinates. In this case, the EU command will invert instrument coordinate roll. Use the #EI command instead if the roll source is referenced to ship coordinates (see [EI - Roll Misalignment Angle](#)).

EV - Heading Bias

Purpose Corrects for electrical/magnetic bias between the Pioneer heading value and the heading reference.

Format EV $\pm nnnnn$



The EV command works with or without the # sign. For example, using EV or #EV are both valid commands.

Range $\pm nnnnn = -17999$ to 18000 1/100ths of a degree

Default EV 0



Set as needed.

Description EV is the heading angle that counteracts the local bias or magnetic variation (declination) between the Pioneer and the heading source. EV is added to heading (either in ship or instrument coordinates) for use in velocity transformation and ensemble output.

Use the EA-command to correct for physical heading misalignment between the Pioneer and a vessel's centerline (see [EA - Heading Alignment](#)).

Examples 1. A Pioneer system is receiving heading from a compass. A magnetic variation chart for the deployment area shows a variation of W3.5 (-3.5). To counteract the effects of this magnetic field, enter a heading bias value of -3.5. To convert -3.5 to a EV-command value, multiply the desired bias angle in degrees by 100: $EV = -3.5 \times 100 = -350 = EV-350$.

2. Magnetic maps (such as NOAA) usually provides these types of reading: $10^{\circ}10'W$ 1995 (9'E/year). This means the magnetic offset in the year 2001 at this location is $(- (10+10/60) + (9/60*6)) = -9.26666$ degrees. Set the EV command value to EV-926.

EX – Coordinate Transformation

Purpose Sets the coordinate transformation processing flags.

Format EX $xxptb$



The EX command work ONLY without the # sign.

Range xx = Transformation
 p = Pitch and Roll
 t = 3 beam solutions
 b = Bin mapping

Default EX 11111



The default setting for this command is recommended for most applications.

Description EX sets firmware switches that control the coordinate transformation processing for velocity and percent-good data.



For more information on coordinate transformations, see [Beam Coordinate Systems](#), page 27.

Table 22: Coordinate Transformation Processing Flags

Setting	Description
EX00xxx	No transformation. Radial beam coordinates, i.e., 1, 2, 3, 4. Heading/Pitch/Roll not applied.
EX01xxx	Instrument coordinates. X, Y, Z vectors relative to the Pioneer. Heading/Pitch/Roll not applied.
EX10xxx	Ship coordinates (Note 1) X, Y, Z vectors relative to the ship. Heading not applied. EA-command used, but not the #EV-command. If Bit 3 of the EX-command is a 1, then Pitch/Roll applied.
EX11xxx	Earth coordinates (Note 1) East, North, Vertical vectors relative to Earth. Heading applied. EA and #EV-commands used. If Bit 3 of the EX-command is a 1, then Pitch/Roll applied.
EXxx1xx	Use tilts (pitch and roll) in transformation (Note 2)
EXxxx1x	Allows 3-beam solutions if one beam is below the correlation threshold set by WC
EXxxxx1	Allow bin mapping (see Note 3)



1. For ship and earth-coordinate transformations to work properly set the Heading Alignment ([EA - Heading Alignment](#)) and Heading Bias ([EV - Heading Bias](#)) correctly. Ensure that the tilt and heading sensors are active ([EZ - Sensor Source](#)).
2. Setting EX bit 3 (Use Tilts) to 0 collects tilt data without using it in the ship or earth-coordinate transformations.
3. TRDI outputs the water profile bin 1 position for a level system only. We do not adjust the bin 1 position, or the cell sizes, for any tilt. Bin mapping attempts to combine data from sections of the beams that are at the same depth in the water, and does not make any attempt to calculate how that depth might change for a tilted system. The setting of the EX command has no effect on the reported bin 1 distance or the cell size.

EZ - Sensor Source

Purpose Selects the source of environmental sensor data.

Format EZ *cdhprstu*



The EZ command work ONLY without the # sign.

Range Firmware switches (see description)

Default EZ 11111010 (with internal Keller pressure and SBG AHRS sensors)



The default setting for this command is recommended for most applications.

Description Setting the EZ-command firmware switches tells the Pioneer to use data from a manual setting or from an associated sensor. When a switch value is nonzero, the Pioneer overrides the manual E-command setting and uses data from the appropriate sensor. If the sensor specified by this command is not available, the best alternate sensor will be used (see the [EZ – Sensor Source Override for Doppler Parameters](#) command for more information).



See [External Sensor Setup Example](#) for more details on using the EZ command.

The following table shows how to interpret the sensor source switch settings.

Table 23: Sensor Source Switch Settings

FIELD		VALUE = 0	VALUE = 1	VALUE = 2
C	Speed of sound	Manual #EC (see EC - Speed of Sound)	Calculates using available depth, salinity and temperature.	External Speed of Sound Sensor
D	Depth	Manual #ED (see ED - Depth of Transducer)	Internal Keller pressure sensor	External Depth Sensor
H	Heading	Manual #EH (see EH - Heading)	Internal SBG AHRS	External Compass
P	Pitch (tilt 1)	Manual #EP (see EP - Pitch and Roll Angles)	Internal SBG AHRS	External Compass
R	Roll (tilt 2)	Manual #ER (see ER - Roll Angle)	Not used (Roll source specified by Pitch field)	Not used (Roll source specified by Pitch field)
S	Salinity	Manual #ES (see ES - Salinity)	Not Allowed	External Salinity Sensor
T	Temp	Manual #ET (see ET - Temperature)	Internal transducer sensor	External Temp Sensor
U	Up/Down Orientation	Manual #EU (see EU - Up/Down Orientation)	Not Allowed	Not Allowed

Example

EZ 10011010 means calculate speed of sound from available depth salinity and temperature, use ED depth, EH heading, internal tilt sensors, ES command sets salinity, TRDI internal temperature sensor, manual up/down orientation set with the EU command.



When a PS1-command is sent, the displayed Fixed Leader data shows the available internal sensors connected to the Pioneer DVL. It does not show external sensors. To interpret this PS1 field, convert the value to binary.

If EZ pitch is one (internal sensor), a pendulum pitch correction will be applied that removes the effect of roll on pitch. This effect is common to most tilt sensors (electrolytic tilt and pendulum).

The pitch field of the EZ command controls the source for roll. The roll field is ignored and has only been retained for legacy purposes.

The heading coordinate frame is determined by the coordinate frame parameter of the #EH command for any heading source (command, internal or external). The pitch and roll coordinate frame is specified by the coordinate frame parameter of the #EP command for any heading source (command, internal or external). See [EH - Heading](#) and [EP - Pitch and Roll Angles](#) for more details.

Expert Environmental Commands

This section lists the expert Environmental commands. Commands that start with the # sign are considered “expert” commands.

>#E?

Available Commands:

```
#EC 1500 ----- Speed Of Sound [m/s]
#EE 0000010 ----- Rsrvd[4]; Cmd[1]; Rw/Nm[1]; Snsr Out[1]
#EH 00000,1 ----- Heading {heading;frame}
#EI +00000 ----- Roll Misalignment Angle [.01 deg cw]
#EJ +00000 ----- Pitch Misalignment Angle [.01 deg cw]
#EP +0000,+0000,1 ----- Tilts {pitch;roll;frame}
#ER +0000 ----- Roll [.01 deg cw]
#ET 2100 ----- Water Temperature [.01 deg C]
#EU 0 ----- Orientation [0=Switch,1=Up,2=Down]
#EV +00000 ----- Heading Bias [.01 deg cw]
#EY 0 0 0 0 0 0 0 0 ----- Dplr Param Override Src {c;d;h;p;r;s;t;u}
#E? ----- Display #E-Command Menu
```

#EE - Environmental Data Output

Purpose Controls output of specialized data types; controls whether a transform of velocity data to raw or nominal beam is done with associated corrections in the case of the phased array system.

Format #EE *abcdefgh*



The #EE command must be sent with the # sign.

Range Firmware switches (see description)

Default #EE 0000010



The default setting for this command is recommended for most applications.

Description Bits “a” and “b” reserved for future use.

Bits *c* and *d* are reserved for future use.

Bit *e* controls the output of Environmental Command Parameters.

Bit *e* = one causes this data type to be output. See [Environmental Command Parameters Output Format](#) for a description of this data type.

Bit *f* signifies the use of the Phased Array transducer. For Phased Array systems, bit *f* controls the type of correction performed on the beam velocity data. For phased arrays, setting bit *f* to one applies the following corrections for all coordinate transforms of all ping types:

- Speed of Sound correction to vertical component
- Phase slope error due to vertical component.

Setting bit *f* to one also results in nominal 30° beam coordinate velocities output in the ensemble, and apply the system Beam correction matrix to correct for Beam pointing errors and hence output velocities in nominal 30° Beam coordinate system.

Setting bit *f* to zero results in raw beam velocities output in the ensemble and no Speed of sound or Phase Slope corrections applied.

Bit *g* controls the output of a data type with sensor source for parameters needed for Doppler calculations. This data indicates what sensors data were used for parameters of the Doppler calculation. This may be different than specified by the EZ ([EZ - Sensor Source](#)) and EY ([EY – Sensor Source Override for Doppler Parameters](#)) commands depending on whether a sensor failed. Setting bit *g* to one causes this data type to be output. See Table 45 for a definition of this data type.

Correction for vertical speed of sound for Phased Arrays

Bit 'f' of the #EE command **must** be set to 1 for the firmware to do the internal computations required to output the correct horizontal and vertical velocities.

If the user has set a fixed speed of sound for their phased array DVL using EZ and EC (or using the default of 1500 for EC) and wants to correct the vertical velocity using the actual speed of sound, the correction formula is

$$V_{actual} = V_{output} * \frac{\sqrt{\frac{1}{C_{user}^2} - \frac{1}{4C_0^2}}}{\sqrt{\frac{1}{C_{actual}^2} - \frac{1}{4C_0^2}}}$$

Where

C_{user} is the fixed speed of sound that was set by the user

$C_0 = 1536\text{m/s}$

C_{actual} is the speed of sound from a SOS sensor or computed from measured temp and salinity

V_{output} is the vertical velocity output by the DVL

For $C_{user} = 1500$ and $C_{actual} = 1450$ the correction factor is 0.9569 while the ratio of the speeds of sound would give 0.9667 and error of 1% for the corrected speed of sound if the ratio were used instead of the above equation.

Derivation:

By design, for our phased array ADCPs, the actual beam angle in the water is given by

$$\sin(\theta) = \frac{c}{2c_0}$$

Where $c_0 = 1536\text{meters/sec}$.

Therefore

$$\cos(\theta) = \sqrt{1 - \sin^2(\theta)} = \sqrt{1 - \left(\frac{c}{2c_0}\right)^2}$$

If velocity is purely vertical, the velocity solution for a given Doppler frequency f_d is given by

$$v = \frac{f_d * c}{2f_0 \cos(\theta)} = \frac{f_d * c}{2f_0 \sqrt{1 - \left(\frac{c}{2c_0}\right)^2}} = \frac{f_d}{2f_0 \sqrt{\frac{1}{c^2} - \frac{1}{4c_0^2}}}$$

Where f_0 is the system frequency.

Taking the ratio of two vertical velocity solutions determined using different values for c obtains the equation at the top.

Vertical Range correction for Phased Arrays:

If the user setup for using manual SoS, i.e. using EC instead of sending in the actual SoS or instead of having the DVL calculate the SoS, then the equation for correcting altitude is:

$$R_{Corrected} = R_{Raw} * \frac{2}{\sqrt{3}} * \sqrt{\left(1 - \left(\frac{C_{actual}}{2 * C_{user}}\right)^2\right)}$$

Where

C_{user} is the fixed speed of sound that was set by the user

C_{actual} is the speed of sound from a SoS sensor or computed from measured temp and salinity

R_{Raw} is the vertical range to bottom obtained by the averaging the 4 vertical ranges to the bottom from DVL ('vertical' here means DVL vertical axis, i.e. not tilt corrected)

#EI - Roll Misalignment Angle

Purpose Corrects for a physical roll-like misalignment between the x-axis of the instrument and the ship's starboard axis.

Format #EI ±nnnnn



The #EI command must be sent with the # sign.

Range ±nnnnn = -17999 to 18000 1/100ths of a degree

Default #EI 0



Set as needed.

Description #EI is a rotation about the ship's forward axis. It is defined as the roll of the ship when the instrument is level.

For systems that have a roll source referenced to ship coordinates (typical for vehicles), use #EI to set the amount of rotation that the instrument's x-axis is physically offset from the ship's starboard axis. For such systems, the #EI command can also be used to align an upward pointing unit (e.g., mounted on a submarine) to the ship's axis by setting it to 18000.

For systems that have attitude referenced to internal coordinates, #EI is typically set to zero since the velocity data is referenced to either beam, instrument or geographic coordinates instead of ship coordinates.

For an upward pointing unit with instrument referenced attitude, use EU to align the instrument attitude data with the ship coordinates for use in velocity transformation.

#EJ - Pitch Misalignment Angle

Purpose Corrects for a physical pitch-like misalignment between the y-axis of the instrument and the ship's forward axis.

Format #EJ ±nnnnn



The #EJ command must be sent with the # sign.

Range ±nnnnn = -17999 to 18000 1/100ths of a degree

Default #EJ 0



Set as needed.

Description #EJ is a rotation about the ship's starboard axis. It is defined as the pitch of the ship when the instrument is level.

For systems that are fixed in place on a moving vessel and that have an external pitch source or an internal pitch source, use #EJ to set the amount of rotation that the instrument's y-axis is physically offset from the ship's forward axis.

For systems that are stationary and have an internal compass, #EJ is typically set to zero since the velocity data is referenced to either beam, instrument or geographic coordinates instead of ship coordinates. However, a non-zero value may be used if ship attitude output data is desired for other purposes (see [EE - Environmental Data Output](#)).

#EY – Sensor Source Override for Doppler Parameters

Purpose When an external sensor is selected via the EZ command, this command selects a sensor to use for a specific parameter needed for Doppler processing. This overrides the default priority selection table built in the firmware that maps sensors to parameters needed in Doppler processing. This command is only needed if more than one sensor connected to the system can supply a parameter needed for Doppler processing (e.g., many sensors can supply temperature) and the default source in Table 24 is not the desired source.

Format #1 #EY c d h p r s t u



The #EY command must be sent with the # sign.

Range Each digit is the sensor ID in the following table that identifies the sensor that is used for the parameter in [EZ - Sensor Source](#). A "2" must be in the corresponding digit of the EZ command for this command to be applied. An id of 0 disables overriding of the firmware priority selection logic: this command then has no affect. ID 1-10 specifies a sensor corresponding to Table 24:

Table 24: External Sensor Source Range (1-12)

Sensor	ID	Manufacturer	Model
Gyro Compass	1	TBD	TBD
GPS1	2	Reserved	TBD
Pressure (Press1)	3	Reserved	TBD
Speed of Sound (SoS1)	4	Reserved	TBD
Mag Compass #1	5	Reserved	TBD
CTD1	6	Seabird	Fast Cat (SBE 49)
Echo Sounder	7	Reserved	TBD
Temperature	8	Reserved	TBD
Mag Compass #2	9	Reserved	TBD
Pitch, Roll, Temp, Press	10	Reserved	TBD
Pressure Sensor	11	Reserved	Not Allowed
AHRS	12	SBG	Ellipse-A AHRS
CTD2	13	TRDI	CiTaDel CTD-Nx

Format #2 *#EY b id*

Range The “id” parameter of this command is the sensor ID in the table above that identifies the sensor that is used for the parameter corresponding to digit “b” of the EZ command. That digit must be “2” for this command to be applied. An “id” of 0 disables overriding of the firmware priority selection logic: this command then has no affect.

Default *#EY 0000 0000*



Set as needed.

Example Setting the #EY command to #EY 0 0 0 0 0 3 0 would command the unit to use the temperature data from the Paroscientific pressure sensor for temperature data in Doppler calculations. This is equivalent to the command #EY 7 3.

```
>#ey 2 10                    {sets the Depth priority to the TRDI Sensor}
>#ey 4 10                    {sets the Pitch priority to the TRDI Sensor}
>#ey 5 10                    {sets the Roll priority to the TRDI Sensor}
>#ey 7 10                    {sets the Temperature to the TRDI Sensor}
>#ey?                        {this command verifies the priority assignment}
EY 0 10 0 10 10 0 10 0 ----- Dplr Param Override Src {c;d;h;p;r;s;t;u}
```

Description Multiple sensors can output the same parameter needed for the Doppler velocity calculation. The firmware has logic that attempts to use the best sensor for each parameter needed in Doppler processing. This logic also defaults to backup sensors’ data, if available, in the case the primary sensor has failed. However, it may be the case that the user wants to override this logic and choose which sensor is used for a particular Doppler parameter.

This command overrides the primary sensor in that firmware logic with one that is selected with this command. The primary sensor and the other alternate sensors are then used as backups in case the sensor selected using this command failed.

Table 25 shows the effect of #EY on the firmware logic for selecting sensor data for a Doppler parameter:

Table 25: Selecting Sensor Data

Doppler Data Input	Source when EY bit not 0	Primary Sensor Source when EY bit 0	Alternate Source					
			#1	#2	#3	#4	#5	#6
Speed of Sound	ID of EY, entry 1	CTD1/CTD2	SoS1	RDI calc ¹	---	---	---	EC Cmd
Depth (from surface) and Pressure	ID of EY, entry 2	Press1	CTD1/CTD2	SoS1	TRDI Sensor Package	Vert Beam ²		ED Cmd
Heading	ID of EY, entry 3	Gyro Cmp	Mag Cmp 1	Mag Cmp 2	---	---	---	#EH Cmd
Pitch	ID of EY, entry 4	Gyro Cmp	Mag Cmp 1 or 2		TRDI Sensor Package	---	---	#EP Cmd
Roll	ID of EY, entry 5	Gyro Cmp	Mag Cmp 1 or 2	Mag Cmp 2	TRDI Sensor Package	---	---	#ER Cmd
Salinity	ID of EY, entry 6	CTD1/CTD2		---	---	---	---	ES Cmd
Temperature	ID of EY, entry 7	CTD1/CTD2	SoS 1	Press1	TRDI Sensor Package	Transducer One Wire	Mag Cmp 2	ET Cmd



1. The calculation for speed of sound depends on temperature, depth, and salinity. These parameters shall be used from sensors as indicated from this table, or from user defined values if the corresponding EZ bit is 0.
2. Feature that may be added later.
3. If the sensor is not assigned to a port or it is not possible to obtain the data from the sensor, then the next available sensor's data in the priority selection logic is used.

Recorder Commands

The recorder contains approximately 16 megabytes of solid-state nonvolatile memory, which can be used to continuously record data for testing only. Once the recorder is full, it will stop recording data.



The recorder is intended for troubleshooting purposes during commissioning and integration of the system. **Do not use for normal operation.** The ping rate will be very slow because writing data to the recorder is time consuming.

>M?

Available Commands:

```
ME ----- ErAsE recoder
MM ----- Show memory usage
MN DVL_ ---- Set file name [1..32 characters]
MR 0 ----- Set recorder on/off [0=off,1=on]
MY ----- Y-Modem output
M? ----- Display M-Command Menu
```

Recorder Command Descriptions

This section lists the Recorder commands.

ME – Erase Recorder

Purpose Erase the contents of the recorder.

Format ME ErAsE



Use as needed.

Description ME ErAsE erases the recorder memory. To make it more difficult to accidentally erase the data, the word “erase” must be typed with exactly one space after the “ME” (which is not case sensitive) and with alternating upper and lower case letters, as shown.

```
>ME ErAsE
[ERASING...]
```



Once erased, data is not recoverable.

MM – Show Memory Usage

Purpose Shows recorder memory usage.

Format MM



Use as needed.

Description Shows memory usage and the number of used and free pages.

```
>MM
Recorder Usage: used = 0, free = 16777216
```

>

MN – Set File Name

Purpose	Sets the file name for the recorder.
Format	MN xxx
Range	xxx = file name up to 32 characters long
Default	MN DVL_



Use as needed.

Description	<p>The MN command sets the deployment name to be used for any future deployments. The deployment name can be up to 32 characters long, and may contain letters, numbers, or the underscore (i.e. “_”) character. If no deployment name is specified a default of “DVL_” is used. The deployment name is used as part of the file name for data files when downloaded to the computer using <i>TRDI Toolz</i>.</p> <p>In order to prevent data files on the computer from being overwritten, a ten-digit time stamp is appended to the file name when OK is clicked on the Download Directory dialog box.</p> <p>For example, the file <i>Pioneer3281997475.000</i> would contain data for the deployment named “Pioneer” (the 3281997475 in the filename is the number of seconds since January 1st, 1900). The file extension is always “.000”. Waiting 25 seconds and downloading the same data again, the file name will change to <i>Pioneer3281997500.000</i>.</p>
-------------	--

MR – Set Recorder On/Off

Purpose	Turns the recorder on or off.
Format	MR n
Range	n = 0, turn recorder off; n = 1, turn recorder on
Default	MR 0



Use only as directed by TRDI Field Service.

Description	Use the MR command to turn the recorder on/off.
-------------	---

MY – Y-Modem Output

Purpose	Uploads recorder data to a host computer using standard YMODEM protocol.
Format	MY



Use *TRDI Toolz* to recover data.

Description	<p>Use the MY command to recover data from the recorder only when <i>TRDI Toolz</i> is not available to recover the data.</p> <p>The MY command uploads the entire contents of the recorder via the serial interface to a host computer using the standard YMODEM protocol for binary file transfer. Any communications program that uses the YMODEM protocol may be used to upload the recorder data. The data is transferred to the host and stored as DOS files.</p>
-------------	---

Performance and Testing Commands

The Pioneer uses the following commands for calibration and testing.

Available Performance and Testing Commands

This section lists the available Performance and Testing commands.

>P?

Available Commands:

```
PA ----- Run Go/No-Go Tests
PC ----- Built In Tests [0=help]
PD 0 ----- Data Stream Select
PS ----- System Info [0=config,1=fldr,3=xform]
PT ----- Built-in-Test Commands [PT0=help]
P? ----- Display P-Command Menu
```

PA – Run Go/No-Go Tests

Purpose Sends/displays results of a series of system diagnostic tests.

Format PA

Range N/A

Default N/A

Description These diagnostic tests check the major modules and signal paths. TRDI recommends running this command before a deployment. These tests check non-volatile memory and ROM of the processor board. Also, the transmit and receive circuitry is tested using the PT3 and PT5 tests, respectively. See [PT3 – Receive Test](#) and [PT5 – Transmit/Receive Continuity Check Test](#) for more details.



Submerge the transducer face in 2 to 4cm of water when running the PA test. **The test may fail in air and if so, is not relevant.** Only a failure with the transducer at a minimum in contact with water is a relevant test.

Example See below

```
>pa
ROM Test...PASS [ 3aad ]
RAM test...PASS
FRAM test...PASS
Receive Buffer Test...PASSED
XMIT RAM Test...PASSED
Receive Path Test (Hard Limited)...PASSED
Transmit/Receive Continuity Check...PASSED
Recorder test.....PASS
```

Composite Result:
GO for Deployment



The PA test takes a little over 10 minutes to run, since it includes the PT14 recorder test.

PC - Built-In Tests

Purpose	Allow the user to view the values of sensor data used in Doppler processing and to identify the source of the data IDs.
Format	PCnnn
Range	nnn = 0, 2, 20, 4, 40, 5, 50
Description	PC0 displays the help menu. PC1 and PC3 are reserved for TRDI use. PC2 continuously displays at approximately 1 sec update the current system temperature, pressure, depth, heading, pitch and roll. The sensor ID corresponding to their source is displayed next to each. Refer to the EY command for a list of sensors. The source of the data is assigned by the EZ and the EY commands or internal logic if the primary sensor is not available. See EY – Sensor Source Override for Doppler Parameters for a description of that logic. PC4 displays the input power information.
Example	See below.

PC2 or PC20

The PC2 test updates the data inline using cursor commands, and the PC20 test performs the same test, but output the data in a line-by-line fashion to accommodate terminals that do not properly support cursor commands.

```
>pc2
Sensor data is sampled and displayed in a loop.
The number to the right of each backslash indicates the ID of the
  sensor used for that data.
Press any key to exit the loop.

  Temp(degC)  Press(kPa)  Depth(m)  Hdg(deg)  Pitch(deg)  Roll(deg)  Vin
/  24.94/10   99.063/10   10.104/10  0.00/0    0.18/10    0.59/10   47.58

>
```



This test can be run on the bench, on deck, or in water.

PC4 or PC40

The PC4 test updates the data inline using cursor commands, and the PC40 test performs the same test, but output the data in a line-by-line fashion to accommodate terminals that do not properly support cursor commands.

```
>pc4
Battery ADC data is sampled and displayed in a loop.
Press any key to exit the loop.

Count Chan0 Chan1 Chan2 Chan3 Chan4 Chan5 Vbatt Ibatt VDD1 VDD3 Vlsu Vls1
/  4  05c6  0428  068f  0095  0d31  0b82  20.58  2.046 1.64  0.09  2.06  1.80

>
```



See **Table 33**, bytes 35 to 42 for a description of the ADC channels.

PC5 or PC 50

The PC5 test updates the data inline using cursor commands, and the PC50 test performs the same test, but output the data in a line-by-line fashion to accommodate terminals that do not properly support cursor commands.

```
>pc50
Leak detector ADC data is sampled and displayed in a loop.
Press any key to exit the loop.
DetA   DetB
0dc0   0008
0dc1   0007
0dc2   0004
>
```

The leak sensor status can be decoded as follow:

- 1- Convert hex ascii to decimal. For example:
 - a. DetA(hex) 0dc0 → to dec = 3520
 - b. DetB(hex) 0008 → to dec = 8
- 2- Convert these values to Voltages by x2.5 and /4095. For example:
 - a. DetA(hex) $3520 * 2.5 / 4095 = 2.14$
 - b. DetB(hex) $0008 * 2.5 / 4095 = 0.0048$
 - c. Compare the values to the threshold shown below to determine leak status:



Leak	No Leak	Sensor Not Connected
Less than 1.25 Volts	1.25 to 2.3 Volts	Greater than 2.3 Volts

In our example above, Leak Sensor A is operating properly and did not detect a leak while Leak Sensor B is detecting a leak.

See [Variable Leader Data](#), Bytes 68 to 71.

PS – Display System Parameters

Purpose Displays Pioneer system configuration data.

Format PS*n*

Range *n* = 0, 1, 3 to 5

PS0 – System Configuration Info

```
>ps0
Serial Number: 3002
Frequency: 307200 Hz
Configuration: DVL : 4-beam velocity.
Transducer Type: PHASEDARRAY
Beamformer Rev: XA0
Beam Angle: 30 Degrees
Beam Pattern: CONVEX
Sensors: AHRS TEMP PRESS OBAR
CPU Firmware: 57.01
FPGA Version: 7.00.002 [0x7002]
```

```
Board Serial Number Data:
42 00 00 05 F5 CD 7A 28 DS18B20 TMP SNS
6C 00 00 01 E1 CA 84 23 RCV72B-2243-14E
FB 00 00 01 E8 4E EA 23 PIO72B-2301-03A
BA 00 00 01 D9 F6 1D 23 XDR72B-1001-00A
C0 00 00 01 DA 29 7D 23 DSP72B-2212-00C
```

```
34 00 00 01 DA 18 87 23 PER72B-2353-01A
```

PS1 – Display Fixed Leader (binary)

PS1 sends the Fixed Leader parameters (i.e., fixed system commands and hardware/firmware information) in Hex-ASCII or binary format with the Least Significant Byte (LSB) first (see [Fixed Leader Data Format](#)). For example, a Hex-ASCII output may look like this:

```
>PS1
3B000001C0D4C21003502320A001900190001480300E8030000320A941100007D2D3D0023000101FF000C000
000000000000000000000000DC12000019143E
```



The output format of the PS1 command is determined by the CF command (see [CF - Flow Control](#)).



When operating in HEX mode, all console text appears in HEX - including the prompt ">" (HEX "3E") and any additional commands that are typed.

PS3 – Instrument Transformation Matrix

PS3 sends information about the transducer beams. The Pioneer uses this information in its coordinate-transformation calculations; for example, the output may look like this:

```
>ps3
Instrument Transformation Matrix:
  1.004537   -1.004879    0.005736   -0.006243
  0.007302   -0.005948   -1.000888    0.996154
  0.289602    0.288031    0.286187    0.290252
 -0.707468   -0.707612    0.706830    0.711150
```

```
>
```

PS4 – Ping Sequence

This command returns the Bottom Track and Water profile ping sequence (see example below). Send PS4 to the Pioneer anytime to get the ping sequence for one ensemble:

```
Pioneer DVL
Teledyne RD Instruments (c) 2021
All rights reserved.
Firmware Version: 57.xx
```

```
>
```

```
>B?
Available Commands:
```

```
BK 0 ----- WMass Mode [0=off 1=WB 2=LostB 3=W]
BP 1 ----- Number of BT Pings in ensemble [0-999]
BX 06500 ----- Max Depth (dm) [10-65535 dm]
B? ----- Display B-Command Menu
```

```
>ps4
Ping Sequence:  B
```

```
>WP1
>ps4
Ping Sequence:  WB
```

```
>BP2
>ps4
Ping Sequence:  B WB
```

```
>WP2
>BP1
>ps4
```

Ping Sequence: W WB

>

‘W’ stands for one single Water Profiling ping and ‘B’ stands for one single Bottom Tracking ping.

PS5 - Health and Environment Monitoring Sensors

The PS5 command reports the value of HEM sensors: S1 (operating time), S2 (over-pressure count), S3 (maximum pressure seen), and S7 (total pressure cycles). The PS5 output will read N/A for the Maximum pressure seen reading if no pressure was measured/recorded.

```
PS5
Operating time: 4327.5 hours
Maximum pressure seen: 652.378 dBar
Over-pressure events: 3
Pressure cycles: 25
```

PT – Diagnostic Tests

Purpose Displays results of the system diagnostic tests.

Format PT nnn

Range $n = 0$ to 200

Description See below

PT0 - Help

The PT0 command displays the test menu (shown below). As implied by the NOTE, adding 100 to the test number repeats the test continually until the Pioneer receives a <BREAK>. Sending PT200 runs the PT3 and PT5 tests. PT300 runs the PT3 and PT5 tests continually until the Pioneer receives a <BREAK>.

Example:

```
>pt0
Built In Tests
-----
PT0  = Help
PT3  = Receive Path Test
PT5  = Transmit/Receive Loop Test
PT9  = Transmit Memory Test
PT10 = Receive Memory Test
PT11 = FRAM Test
PT12 = RAM Test
PT13 = ROM Test
PT14 = Recorder Test
PT19 = Ringing Test
```

PT3 – Receive Test

This test displays receive path characteristics. This test must be done with the transducer in water.



Submerge the transducer face in 2 to 4cm of water when running the PT3 test. **The test may fail in air and if so, is not relevant.** Only a failure with the transducer at a minimum in contact with water is a relevant test.

Example:

```
>pt3
Receive Path Test (Hard Limited):
      H-Gain W-BW      L-Gain W-BW      H-Gain N-BW      L-Gain N-BW
Correlation Magnitude (percent)
Lag Bm1 Bm2 Bm3 Bm4   Bm1 Bm2 Bm3 Bm4   Bm1 Bm2 Bm3 Bm4   Bm1 Bm2 Bm3 Bm4
```



```

0 100 100 100 100      100 100 100 100      100 100 100 100      100 100 100 100
1  80  84  82  81      81  83  80  82      82  82  79  81      83  80  80  82
2  42  46  49  48      44  49  43  47      47  46  41  46      52  42  45  46
3  15  18  23  24      25  22  14  24      22  13  13  17      26  15  16  18
4   6   0  10  10      22  10   6  15      4  12   2   1      10   8   4   4
5   5   6   9   4      15   4  11   7      7  13   9  11      2   9   7   2
6   4  11   9   2      11   6  14   6      7  11   8  11      6   6   7   3
7   5  13   6   6      11   7  13   8      5  13  10  11      7   1   5   5
    P   P   P   P
Sin Duty Cycle (percent)
    50  49  42  43      47  47  47  43      53  49  51  53      49  46  45  50
    P   P   P   P
Cos Duty Cycle (percent)
    49  53  50  43      49  52  48  45      48  54  49  54      51  52  50  51
    P   P   P   P
RSSI Noise Floor (counts)
    54  60  69  58      38  43  53  42      65  72  80  69      43  48  58  47
    P   P   P   P
RESULT...PASSED

```

>

PT3 is considered to have normal values if:

1. Correlation at the last lag is less than 25%.
2. The duty cycle of sine and cosine does not vary from 50% by more than +/-15%.
3. RSSI noise level is less than 90 counts for the high gain, wide bandwidth setting.

PT5 – Transmit/Receive Continuity Check Test



Submerge the transducer face 2 to 4cm in water with at least 10cm between the face of the transducer and the bottom when running the PT5 test.

The test may fail in air and if so, is not relevant. Only a failure with the transducer at a minimum in contact with water is a relevant test.

The PT5 test is used to ensure continuity to the transducer and attempts to verify both transmit and receive pathways.

Example:

```

Transducer Continuity Check:
Beams 1,2: pass
Beams 3,4: pass

```

PT5 has an optional parameter:

- 1 = verbose mode
- o/no character = standard mode

Example verbose mode 300 kHz:

```

>PT5 1
Transducer Continuity Check:
300Khz criteria 6 < R (ohms) < 12
Beams 1,2: V: 20.43 (volts) I: 1.96 (amps) R: 10.8 (ohms) PASS <FAIL>
Beams 3,4: V: 20.43 (volts) I: 1.86 (amps) R: 10.8 (ohms) PASS <FAIL>
>

```

Verbose mode 600 kHz:

```

>PT5 1
Transducer Continuity Check:
600Khz criteria 13 < R (ohms) < 24
Beams 1,2: V: 19.88 (volts) I: 3.69 (amps) R: 21.0 (ohms) PASS <FAIL>
Beams 3,4: V: 19.88 (volts) I: 3.69 (amps) R: 21.0 (ohms) PASS <FAIL>
>

```

PT9 - Transmit Memory Test

The PT9 test performs a write/read test of each memory location in the transmit RAM, which is used to hold the signal pattern that is transmitted during a ping.

```
>pt9  
XMIT RAM Test...PASSED
```

PT10 - Receive Memory Test

```
>pt10  
Receive Buffer Test...PASSED
```

PT11 - FRAM Test

The PT11 command performs the following tests of the FRAM (used to store recorder directory information):

- **Pattern Test:** Writes 4 patterns to each address in the FRAM space, and reads back from these addresses to make sure the data was correctly written.
- **Address Test:** This tests the address bus by writing consecutive number to addresses that have only 1 bit set (i.e. write 1 to 0x00000001, then write 2 to 0x00000002, then write 3 to 0x00000004, and so on). After writing to these locations, we read the data back and verify that it is what we'd expect.
- **Data Test:** This tests the data bus in FRAM memory by writing data values that have only one bit set (i.e. 0x01, 0x02, 0x04) to consecutive locations in memory. Then we read back to make sure that all data was written properly.

Failure on any of these tests will produce a FAIL result for PT11.

```
>pt11  
FRAM test...PASS
```

PT12 - RAM Test

The PT12 command performs the tests described for PT11 above on the RAM.

```
>pt12  
RAM test...PASS
```

PT13 - ROM Test

The PT13 command performs a test of the flash ROM by comparing the CRC of the data in ROM with the CRC value stored in FLASH. If the values differ, PT13 will result in a FAIL.

```
>pt13  
ROM Test...PASS [ 60e0 ]
```

PT14 - Recorder Test

The PT14 recorder test takes about 10 minutes to complete, as it checks all 32768 pages of each flash chip (x2), at 256 bytes per page to ensure the chips are completely blank. It then performs a pattern test of a random sector in each flash chip, which is fairly quick. The PT14 recorder test will quickly fail with an error message if the recorder has not been erased first.

```
>pt14
```

```
Performing Recorder Flash Test...
```

```
Blank check MEM0:
```

```
65536
```

```
Blank check MEM1:
```

```
32768
```

```
Rec Flash Pattern Test:
```

```
Testing 10 addresses in sector #36
```

```
Rec Flash Pattern Test:
```

```
Testing 10 addresses in sector #33
```

```
Recorder Flash Test: PASS
```

PT19 - Ringing Test

The PT19 Ringing test is reserved for TRDI use. It has a binary output that is used by special TRDI test software, and is not meant to be run manually.

Expert Performance and Testing Commands

This section lists the expert Performance and Testing commands. Commands that start with the # sign are considered “expert” commands.

>#P?

Available Commands:

PD 0 ----- Data Stream Select
P? ----- Display P-Command Menu

#PD - Data Stream Select

Purpose Selects the type of ensemble output data structure.

Format #PD *n*



The PD command works with or without the # sign. For example, using PD or #PD are both valid commands.

Range *n* = 0, 4, 5, 6, 11, 13 and 26 (see description)

Default #PD 0



The default setting for this command is recommended for most applications.

Description #PD selects the normal output data structure, a special application data structure, or a fixed data set for transmission/display as the data ensemble (see Table 26).

Table 26: Data Stream Selections

Format	Description
PD0	PD0 output is a binary output that is somewhat configurable via other commands (such as WD, BJ, #EE), and can send all bottom track, water track, profile, and sensor data being collected by the DVL. For a full description of the PD0 format, see PD0 Output Data Format .
PD4	PD4 Sends CSS-DVL output data structure (without sensor and made-good data). For a full description of the PD4 format, see Pioneer Binary Data Format (PD4/PD5) .
PD5	PD5 Sends CSS-DVL output data structure (with sensor and made-good data). For a full description of the PD5 format, see Pioneer Binary Data Format (PD5) .
PD6	PD6 Sends an ASCII data stream containing bottom track and water layer velocity information for all coordinate transformations. For a full description of the PD6 format, see Pioneer Output Data Format (PD6) .
PD11	PD11 is a text output format. It complies with the NMEA 0183 version 2.30 standard.
PD13	PD13 outputs similar to PD6, except it adds Pressure and Range-to-bottom for all four beams, and omits System Health Monitor Data line. For a full description of the PD13 format, see Pioneer Output Data Format (PD13) .
PD26	The PD26 format includes the \$VMVBW, \$VMDBT, and \$VMVLW NMEA Speed Log Formats.

Sensor Commands

The Pioneer uses the following commands for the sensors.

Available Sensor Commands

This section lists the available Sensor commands.

>s?

Available Commands:

```
SC ----- Sensor Commands [ID Event Time-out "Command"]
SD ----- Sensor Data Out [ID abcd..., a-d=1/0]
SM ----- Sensor Auxiliary Menus [sid]
SP 0 99;0 99;0 99;0 99 ---- Sensor-port Assign [sp p sid [to]]
SR ----- Sensor Reset [sid]
S? ----- Display S-Command Menu
SZ ----- Zero out keller30 Pressure
```

SC - Sensor Command

Purpose The SC commands stores commands for individual sensors to be sent by the system to the sensor at predefined times (initialization, sampling, etc.).

Format SC *n e t "c"*

Range *n*: specifies a sensor ID corresponding to table of the EY command. Note that this id must be entered in a two digit format (zero pad, if needed).

e: 0-1 events corresponding to the following table:

Table 27: Sensor Command Bit "e"

SC (e)	Event
0	Sensor Reset (as a result of the user issuing the SR or CS commands)
1	Sensor Sample Variable Data (before each ping)

t: 0 to 65535 one hundredths of a second time out limit. A time-out value of zero defaults to the time-out limit specified by [SP - Sensor Port Assignment](#).

c: range N/A (command string in quotes that depends on each sensor – see each sensor's manual)

Default SC 01 0 0 "" (Similar for other sensors (n=>1)).



Set as needed.

Description This command allows user defined commands to be downloaded at various, predefined times during the interaction of the system with each sensor instead of the default commands.

SD - Sensor PDO Data Output

Purpose	Controls the ensemble data types that are output.
Format	SD <i>n abc def ghi</i>
Range	<i>n</i> : sensor id per Table 28. This must be entered as a two digit number. Sensors with ID less than 10 should be prefixed with a 0. <i>a-b</i> : data type per Table 28, which also indicates the tables that describes the format of the data:

Table 28: Sensor PDO Data Output

Sensor	ID	a	b	c	d
Gyro Compass	01	--	--	--	--
GPS	02	TBD	TBD	TBD	TBD
Pressure	03	TBD	TBD	N/A	N/A
Speed of Sound	04	TBD	N/A	N/A	N/A
Mag Compass #1	05	--	--	N/A	N/A
CTD	06	TBD	TBD	TBD	TBD
Echo Sounder	07	TBD	N/A	N/A	N/A
Internal Temperature	08	N/A	N/A	N/A	N/A
Mag Compass #2	09	N/A	N/A	N/A	N/A
TRDI Sensor Board (Pitch/Roll, T, Pr)	10	N/A	N/A	N/A	N/A
Keller30 Pressure Sensor	11	N/A	N/A	N/A	N/A
SBG AHRS	12	Status (Table 45)	IMU Data (Table 50)	EULER Data (Table 52)	Ship Motion (Table 55)
CiTaDel CTD-Nx	13	TBD	TBD	TBD	TBD

N/A: no data type

TBD: to be determined - no sensor selected yet.

Setup data is sampled and output only if the corresponding bit of the SD command is set;
Variable data is always sampled (if the sensor is assigned to a port) but only output if the corresponding bit of the SD command is set.

Digits e-i are reserved for future use.

Default SD *n 000 000 000*



Set as needed.

Description This command controls the output of data types in PDO binary ensembles for each sensor. Note that the sensor must be assigned to a communication port for the data to be included in the output ensemble.

Each sensor data type includes at least one 32-bit word whose individual bits show what data in the structure is valid. In addition, each data type includes at least one 32-bit word whose bits show sensor errors and errors the Pioneer has encountered trying to communicate with the sensor. One bit of the error word indicates whether the data is fresh (appearing first in this ensemble) or stale (a repeat from a previous ensemble). Stale data

may be caused by environmental sensors that are sampled at multiple ensemble intervals or by communication problems with the sensor.

SM – Auxiliary Sensor Menu

Purpose	Allow access to individual sensor auxiliary command menus, such as compass calibration commands.
Format	SM <i>n</i>
Range	1 to 12 corresponding to each of the sensors listed in EY – Sensor Source Override for Doppler Parameters .
Default	There is no default.



Set as needed. At this time, only the SBG Ellipse IMU is supported.

Description	<p>If no argument (<i>n</i>, above) is entered with the command, then a list of sensors with their corresponding numbers is presented for the user to choose.</p> <p>The user can stack command menu selections. For example SM 6 T could be entered, which accesses the Paros. 8CDP Pressure sensor command menu and then selects the terminal mode (T) of that menu.</p> <p>Note that if the sensor is not connected to the system, the sensor's menu will still be available, but some items of the menu may not execute.</p>
-------------	--

Example:

```
>sm
Sensor Auxiliary Menus
0 ----- Exit Menu
1 ----- Not Used
2 ----- Garmin G-15H GPS
3 ----- Paros. 8CDP Pressure
4 ----- AMS SVP&T
5 ----- Honeywell HMR3k Compass
6 ----- SeaBird SBE-49 Fast Cat
7 ----- Benthos PSA-916 Echo Sounder
8 ----- One Wire Temp - No Menu
9 ----- PNI TCM3/5 Compass
10 ----- TRDI Sensor Module
11 ----- Keller30 Pressure Sensor
12 ----- SBG Ellipse IMU
13 ----- TRDI CiTaDel CTD-Nx
6
```

```
Make sure sensors are initialized with SR command
once after a break before entering this menu.
SBE-49 CTD Auxiliary Menu
0 ----- Help
S 0----- Change Port Serial Params
T ----- Terminal Mode
M 0 ----- Master Mode
P 0 ----- Polled Mode
X ----- Exit
```

The sub-menu presented here for the Fast Cat SBE-49 CTD sensor, is typical of the sub-menus for each sensor. This menu allows entering a dumb terminal mode with the sensor for troubleshooting purposes and to set the baud rate of the Pioneer port that the sensor is connected to. Some sensors have special commands (e.g., compass calibration) that are supported by their respective menu.



For more information on the SBG sensor commands, see [Using the AHRS Sensor](#).

SP - Sensor Port Assignment

Purpose	This command assigns a sensor to a serial port on the system.
Format	SP <i>p sid</i> or SP <i>p sid t</i>
Range	<i>p</i> : port 2 to 4 <i>sid</i> : 0 for no sensor on the port; Corresponding to the sensor ID in Table 29. This table corresponds directly to the manufacturers and models of sensors listed in EY – Sensor Source Override for Doppler Parameters . <i>t</i> : time-out 0 to 65535 milli-seconds while waiting for a response for each command that is sent to the sensor. If omitted, a default time-out will be used specific to each sensor. The default time-outs are listed in Table 29.



COM 1 is reserved for communicating to and controlling the Pioneer ONLY. This port will not support sensors. Ports 2, 3, and 4 are for sensors.



Ports 2 and 3 on your Pioneer DVL will become unavailable when either an internal Pressure sensor or a SBG AHRS Ellipse sensor are installed and detected by the DVL. Use the [PSQ command](#) to see which sensors are detected by your DVL. When either the internal Pressure sensor or the AHRS SBG Ellipse sensor or both are detected by the DVL, respectively ports 2 or 3 or both will be allocated for these sensors automatically. No SP command is necessary to set the DVL comports for these internal sensors. Sending a SP command for any of these allocated ports will have no effect.

Send SP? to see which ports are already allocated.

Table 29: Sensor Port Assignment

Sensor	ID	Default Time Out (ms)	Sample Interval*
Gyro Compass	1	--	Ping
GPS	2	300	Ping
Pressure	3	250	Multi-Ensemble
Speed of Sound	4	450	Multi-Ensemble
Mag Compass #1	5	200	Ping
Seabird CTD	6	1500	Multi-Ensemble
Echo Sounder	7	300	Multi-Ensemble
Temperature	8	--	Multi-Ensemble
Mag Compass #2	9	110	Ping
Pitch, Roll, Temp, Press	10	--	Ping
Keller30 Pressure Sensor	11	101	Ping
SBG AHRS Ellipse	12	500	Ping
TRDI CTD-Nx	13	1500	Multi-Ensemble



The number of ensembles for multi-ensemble sampled sensors depends on the number of commands sent to the sensor. Each command requires approximately two ensembles to transmit to and receive the response from the sensor.

Default SP 1 0 99
 SP 2 0 99
 SP 3 0 99
 SP 4 0 99



Set as needed.

Description The time-out of this command is a general time-out for any sensor command sent to the sensor. However, this value is overridden by the individual time-out entered with the SC command.

Variable data (corresponding to the variable data types in the appendices) for each sensor will be sampled if the sensor is assigned to a port. Setup data will only be sampled if the corresponding bit for setup data is set in the SD command. See [SD - Sensor PDO Data Output](#) for more details.

If the sensor is assigned to more than one port, than the port with the highest port number will be used as the port for that sensor.

SR - Sensor Reset

Purpose Reset external sensors.

Format SR [n], where [] indicates an optional parameter.

Range n: specifies a sensor ID corresponding to table of the EY command (see [EY – Sensor Source Override for Doppler Parameters](#)).

Default N/A



Set as needed.

Description This command resets only one sensor if the optional parameter is entered or resets all sensors assigned by the SP port if no parameter is entered with this command.

SZ - Zero Out Keller30 Pressure

Purpose Zeros the pressure sensor.

Format SZ

Default N/A



Use as needed.

Description This command zeros the Keller30 pressure sensor at the specific location where the DVL will be used.



If the pressure sensor is not installed, using the SZ command will generate the following error.

```
>sz
Keller 30 Pressure was NOT zeroed ...
```

Expert Sensor Command Descriptions

This section lists the expert Sensor commands. Commands that start with the # sign are considered “expert” commands.

```
>#S?  
Available Commands:  
  
SO 101.325 ----- Abs Press Sensor Offset [kPa]  
S? ----- Display #S-Command Menu
```

#SO – Absolute Pressure Sensor Offset for Depth Calculation

Purpose	This command sets an offset used by the system in calculating depth from external sensors that have an absolute pressure output.
Format	#SO <i>f</i>
Range	<i>f</i> = 26.0 to 32.0 inch Hg or 88.0 to 108.4 kPa are valid pressures. A value <0.00001 may also be entered to zero the offset.
Default	SO 101.325

 Set as needed.

Description	This offset command is used with absolute pressure sensors when calculating depth. The #SO command setting will only be applied to the pressure read from an external sensor. Pressure in units of inch of mercury or kilo Pascals may be entered, but the latter is displayed when this command is queried.
-------------	--

Timing Commands

These commands set the timing of various profiling functions.

Available Timing Commands

This section lists the available Timing commands.

>T?

Available Commands:

```
TE 00:00:00.00 ----- Time Between Ensembles
TF --/--/--,--:--:-- ----- Set First Ping Time (yy/mm/dd, hh:mm:ss)
TP 00:00.00 ----- Time Between Pings
TS 15/04/21,10:15:59.14 --- Set System Date and Time
TT 2015/04/21,10:15:59.14 - Set System Date and Time (4-digit year)
T? ----- Display T-Command Menu
```

TE – Time Per Ensemble

Purpose Sets the minimum interval between data collection cycles (data ensembles).

Format TE *hh:mm:ss.ff*

Range

<i>hh</i>	= 00 to 23 hours
<i>mm</i>	= 00 to 59 minutes
<i>ss</i>	= 00 to 59 seconds
<i>ff</i>	= 00 to 99 hundredths of seconds

Default TE00:00:00.00



Set as needed.

Description During the ensemble interval set by TE, the Pioneer transmits the number of pings set by the WP-command (see [WP – Pings Per Ensemble](#)). If TE = 00:00:00.00, the Pioneer starts collecting the next ensemble immediately after processing the previous ensemble.

Example TE01:15:30.00 tells the Pioneer to collect data ensembles every 1 hour, 15 minutes, 30 seconds.



1. The Pioneer automatically increases TE if (WP x TP > TE).
2. The time tag for each ensemble is the time of the first ping of that ensemble.

TF – Time of First Ping

Purpose Sets the time the Pioneer starts data collection.

Format TF *yy/mm/dd, hh:mm:ss*

Range

<i>yy</i>	= year	00-99
<i>mm</i>	= month	01-12
<i>dd</i>	= day	01-31 (leap years are accounted for)
<i>hh</i>	= hour	00-23
<i>mm</i>	= minute	00-59
<i>ss</i>	= second	00-59

Description The TF command delays the start of data collection. The Pioneer can be deployed in the Standby mode and have it automatically start data collection at a preset time. When the command is given to the Pioneer to start pinging, TF is tested for validity. If valid, the

Pioneer sets its alarm clock to TF, goes to sleep, and waits until time TF before beginning the data collection process.

Example If the exact time of the first ping needs to be on November 23, 2013 at 1:37:15 pm, enter TF13/11/23, 13:37:15. If the Pioneer should begin pinging immediately after receiving the CS command (see notes), do not enter a TF command value.



1. Although a TF command may be sent to the Pioneer, the CS command also must be sent before deploying the Pioneer.
2. If the entry is not valid, the Pioneer sends an error message and does not update the wake-up time.
3. Sending a <BREAK> clears the TF time.
4. The delimiters are optional, and may be spaces.

TP – Time Between Pings

Purpose Sets the *minimum* time between pings.

Format TP *mm:ss.ff*

Range

<i>mm</i>	= 00 to 59 minutes
<i>ss</i>	= 00 to 59 seconds
<i>ff</i>	= 00 to 99 hundredths of seconds

Default TP 00:00.00



Set as needed.

Description The Pioneer interleaves individual pings within a group so they are evenly spread throughout the ensemble.

During the ensemble interval set by TE, the Pioneer transmits the number of pings set by the WP and BP commands (see [WP – Pings Per Ensemble](#) and [BP – Bottom-Track Pings per Ensemble](#)). TP determines the spacing between the pings. If TP = 0, the Pioneer pings as quickly as it can based on the time it takes to transmit each ping plus the overhead that occurs for processing. Several commands determine the actual ping time [WF – Blank after Transmit](#), [WN – Number of Depth Cells](#), [WS – Depth Cell Size](#), and actual water depth).

Example TP00:00.10 sets the time between pings to 0.10 second.



The Pioneer automatically increases TE if $(WP \times TP) > TE$.

TS – Set Real-Time Clock

Purpose Sets the Pioneer's internal real-time clock.

Format TS *yy/mm/dd, hh:mm:ss*

Range

<i>yy</i>	= year	00-99
<i>mm</i>	= month	01-12
<i>dd</i>	= day	01-31
<i>hh</i>	= hour	00-23
<i>mm</i>	= minute	00-59
<i>ss</i>	= second	00-59



Set using *TRDI Toolz*.

Example TS 19/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 2019.



1. When the Pioneer receives the carriage return after the TS-command, it enters the new time into the real-time clock and sets hundredths of seconds to zero.
2. If the entry is not valid, the Pioneer sends an error message and does not update the real-time clock.

TT – Set Real-Time Clock (Y2k Compliant)

Purpose Sets the Pioneer's internal real-time clock.

Format TT *ccyy/mm/dd, hh:mm:ss*

Range

<i>cc</i>	= century	19 - 20
<i>yy</i>	= year	00 - 99
<i>mm</i>	= month	01 - 12
<i>dd</i>	= day	01 - 31
<i>hh</i>	= hour	00 - 23
<i>mm</i>	= minute	00 - 59
<i>ss</i>	= second	00 - 59



Set using *TRDI Toolz*.

Example TT 2019/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 2019.



1. When the Pioneer receives the carriage return after the TT-command, it enters the new time into the real-time clock and sets hundredths of seconds to zero.
2. If the entry is not valid, the Pioneer sends an error message and does not update the real-time clock.

Water Profiling Commands

These commands define the criteria used to collect the water-profile data.

Available Water Profiling Commands

This section lists the available Water Profiling commands.

>W?

Available Commands:

```
WA 050 ----- False Target Amplitude Threshold [0-255]
WC 064 ----- Correlation Threshold [0-255]
WD 111110000 ----- Data Out {v;c;a;p;s;*;*;*}
WE 2000 ----- Error Velocity Threshold (mm/s)
WF 0176 ----- Blanking Distance [0-9999cm]
WJ 1 ----- BroadBand Rcvr Gain [0=Lo,1=Hi]
WN 030 ----- Number of Bins [1-255]
WP 000 ----- Number of Pings [0-16384]
WS 0400 ----- Bin Size [cm]
WT 0000 ----- Transmit Length (cm)
WV 0383 ----- Ambiguity Velocity [20-700cm/s]
W? ----- Display W-Command Menu
```



All water profile commands can be accessed without a leading '#' character. The descriptions for WA, WC, WE, WJ, and WT commands are described in the [Expert Water Profiling Command Descriptions](#) section.

WD – Data Out

Purpose	Selects the data types collected by the Pioneer.
Format	WD <i>abc def ghi</i>
Range	Firmware switches (see description)
Default	WD 111 110 000



The default setting for this command is recommended for most applications.

Description WD uses firmware switches to tell the Pioneer the types of data to collect. The Pioneer always collects header data, fixed and variable leader data, and checksum data. Setting a bit to one tells the Pioneer to collect that data type. The bits are described as follows:

<i>a</i> = Velocity	<i>d</i> = Percent good	<i>g</i> = Reserved
<i>b</i> = Correlation	<i>e</i> = Status	<i>h</i> = Reserved
<i>c</i> = Echo Intensity	<i>f</i> = Reserved	<i>i</i> = Reserved

Example WD 111 100 000 (default) tells the Pioneer to collect velocity, correlation magnitude, echo intensity, percent-good and status.



1. Each bit can have a value of one or zero. Setting a bit to one means output data, zero means suppress data.
2. If WP = zero, the Pioneer does not collect water-profile data.
3. Spaces in the command line are allowed.
4. Status data is not used, as it does not mean anything.

WF – Blank after Transmit

Purpose	Moves the location of first depth cell away from the transducer head to allow the transmit circuits time to recover before the receive cycle begins.
Format	WF <i>nnnn</i>
Range	<i>nnnn</i> = 0 to 9999 cm
Default	WF 0800 (150 kHz), WF 0176 (300 kHz), WF 0088 (600 kHz)



The default setting for this command is recommended for most applications.

Description	WF positions the start of the first depth cell at some vertical distance from the transducer head. This allows the Pioneer transmit circuits time to recover before beginning the receive cycle. In effect, WF blanks out bad data close to the transducer head, thus creating a depth window that reduces unwanted data in the ensemble.
-------------	---



1. The distance to the middle of depth cell #1 is a function of WF, [WS – Depth Cell Size](#), and speed of sound. The fixed leader data contains this distance.
2. Small WF values may show ringing/recovery problems in the first depth cells that cannot be screened by the Pioneer.

WN – Number of Depth Cells

Purpose	Sets the number of depth cells over which the Pioneer collects data.
Format	WN <i>nnn</i>
Range	<i>nnn</i> = 001 to 255 depth cells
Default	WN 030



Set as needed.

Description	The range of the Pioneer is set by the number of depth cells (WN) times the size of each depth cell WS – Depth Cell Size .
-------------	--



Be careful when setting up long profiles. System memory limitations will limit the amount of data actually collected. Those bins not processed will be marked invalid when output.

WP – Pings per Ensemble

Purpose	Sets the number of pings to average in each data ensemble.
Format	WP <i>nnnnn</i>
Range	<i>nnnnn</i> = 0 to 16384 pings
Default	WP 00000



Set as needed.

Description	WP sets the number of pings to average in each ensemble before sending/recording the data.
-------------	--



1. If WP = zero the Pioneer does not collect water-profile data.
2. The Pioneer automatically extends the ensemble interval [TE – Time Per Ensemble](#)) if $(WP+BP) \times TP > TE$.

WS – Depth Cell Size

Purpose	Selects the volume of water for one measurement cell.
Format	WS <i>nnnn</i>
Range	<i>nnnn</i> = WS 40 to WS 1600 (150 kHz), WS 50 to WS 800 (300 kHz), WS 10 to WS 400 (600 kHz)
Default	WS 0800 (150 kHz), WS 0400 (300 kHz), WS 0200 (600 kHz)



The default setting for this command is recommended for most applications.

Description	The Pioneer collects data over a variable number of depth cells. WS sets the size of each cell in vertical centimeters.
-------------	---

WV – Ambiguity Velocity

Purpose	Sets the radial ambiguity velocity for profile and water mass mode (see BK - Water-Mass Layer Mode).
Format	WV <i>nnn</i>
Range	<i>nnn</i> = 020 to 700 cm/s
Default	WV 383



It is strongly recommended that the WV command be left at its' default value of 383.

Description	<p>Set WV as low as possible to attain maximum performance, but not too low or ambiguity errors will occur.</p> <p>The WV command (ambiguity velocity setting) sets the maximum velocity that can be measured along the beam. WV is used to improve the single-ping standard deviation. The lower the value of the WV command, the lower the single-ping standard deviation.</p> <p>Set the WV command based on the maximum apparent velocity (Pioneer motion plus water speed). The following formula is used to determine the setting of the WV command: $WV = (\text{Max. Apparent Vel. cm/s}) * \sin(\text{beam angle}) * 1.2$ </p> <p>Be aware that the firmware will accept larger values for the WV command; however, WV values that exceed the default values will result in collecting data with ambiguity resolving errors or completely erroneous values.</p>
Example	<p>If the maximum expected Pioneer horizontal velocity (vessel velocity) is 250 cm/s (≈ 5 kt) and the maximum expected horizontal water velocity is 100 cm/s, set WV to $[(250+100)*0.5*1.2=]$ 210 cm/s.</p>

Expert Water Profiling Command Descriptions

This section lists the expert Water Profiling commands. Commands that start with the # sign are considered “expert” commands.

>#W?

Available Commands:

```
#WA 050 ----- False Target Amplitude Threshold [0-255]
#WC 064 ----- Correlation Threshold [0-255]
#WE 2000 ----- Error Velocity Threshold (mm/s)
#WJ 1 ----- BroadBand Rcvr Gain [0=Lo,1=Hi]
#WT 0000 ----- Transmit Length (cm)
#WX 0 ----- Set single-beam transmit mode
#W? ----- Display #W-Command Menu
```

#WA - False Target Threshold Maximum

Purpose Sets a false target (fish) filter.

Format #WA nnn



The WA command works with or without the # sign. For example, using WA or #WA are both valid commands.

Range nnn = 0 to 255 counts (255 disables this filter)

Default #WA 050



The default setting for this command is recommended for most applications.

Description The Pioneer uses the #WA-command to screen water-track data for false targets (usually fish). #WA sets the maximum difference between echo intensity readings among the four profiling beams. If the #WA threshold value is exceeded, the Pioneer rejects velocity data on a cell-by-cell basis for either the affected beam (fish detected in only one beam) or for the affected cell in all four beams (fish detected in more than one beam). This usually occurs when fish pass through one or more beams.



A #WA value of 255 turns off this feature.

#WC - Low Correlation Threshold

Purpose Sets the minimum threshold of water-track data that must meet the correlation criteria for profile and water mass mode (see [BK - Water-Mass Layer Mode](#)).

Format #WC nnn



The WC command works with or without the # sign. For example, using WC or #WC are both valid commands.

Range nnn = 0 to 255 counts

Default #WC 64



The default setting for this command is recommended for most applications.

Description The Pioneer uses #WC to screen water-track data for the minimum acceptable correlation requirements. The nominal (maximum) correlation depends on system frequency and depth cell size ([WS – Depth Cell Size](#)). The #WC command sets the threshold of the correlation below, which the Pioneer flags the data as bad and does not average the data into the ensemble.



The default threshold for all frequencies is 64 counts. A solid target would have a correlation of 255 counts.

#WE - Error Velocity Threshold

Purpose Sets the maximum error velocity for good water-current data.

Format WE *nnnn*



The WE command works with or without the # sign. For example, using WE or #WE are both valid commands.

Range *nnnn* = 0 to 5000 mm/s

Default #WE 2000



The default setting is set purposely high. We recommend extreme caution and testing before changing this setting. **Data rejected by this command is lost and cannot be regained.**

Description The #WE-command sets a threshold value used to flag water-current data as good or bad. If the Pioneer's error velocity value exceeds this threshold, it flags data as bad for a given depth cell. The #WE command screens for error velocities in both beam and transformed-coordinate data. Setting the #WE command to zero (#WE0) disables error velocity screening.

#WJ - Receiver Gain Select

Purpose Allows the Pioneer to reduce receiver gain by 40 dB for profile and water mass mode (see [BK - Water-Mass Layer Mode](#)).

Format #WJ *n*



The WJ command works with or without the # sign. For example, using WJ or #WJ are both valid commands.

Range *n* = 0 (low), 1 (high)

Default #WJ 1



The default setting for this command is recommended for most applications.

Description #WJ0 tells the Pioneer to reduce receiver gain by 40 dB. This may increase data reliability in shallow-water applications where there is a high content of backscatter material. #WJ1 (the default) uses the normal receiver gain.

#WT - Transmit Length

Purpose Selects a transmit length different from the depth cell length (cell sampling interval) as set by the WS command (see [WS – Depth Cell Size](#)).

Format #WT *nnnn*



The WT command works with or without the # sign. For example, using WT or #WT are both valid commands.

Range *nnnn* = 0 to 3200 cm

Default #WT 0000



The default setting for this command is recommended for most applications.

Description When #WT is set to zero, the transmit signal is set to the depth cell size (WS-command). This is the default setting. Setting #WT allows selection of a transmit length different than the area depth cell size (sampling length).

#WX – Set single-beam transmit mode

Purpose Sets the single-beam transmit mode.

Format #WX *n*



The WX command works with or without the # sign. For example, using WX or #WX are both valid commands.

Range *n* = 0 to 4

Default #WX 0



Use this command only for debugging and testing. The default setting for this command is recommended for most applications.

Description #WX 0 (default) disables the feature and transmits on all beams normally. #WX 1 to 4 selects one beam that will transmit, while data will be received on all four beams.

Chapter 8

OUTPUT DATA FORMAT



In this chapter:

- Choosing a Data Format
- PD0 Output Data Format
- Special Output Data Formats PD4, PD5, PD6, and PD13
- External Sensor Suite Interface Descriptions

Choosing a Data Format

The Pioneer can output data in several user selectable formats using the PD command (see [PD - Data Stream Select](#)). Depending on the output format selected, data will be either binary or ASCII text.

Binary Output Data Format

Use the binary format (CFxx1xx) when recording/processing Pioneer data on an external device. The binary format uses less storage space and has a faster transmission time than the Hex ASCII format. A dumb terminal is of little use in binary format because the terminal interprets some of the data as control characters.



All of TRDI's software supports binary PD0 formatted data only.

Hexadecimal-ASCII Output Data

Use the hexadecimal-ASCII (Hex ASCII) format (CFxx2xx) when viewing raw Pioneer data on a computer/dumb terminal. This format uses the standard ASCII codes for 0 through F to represent numeric values as hexadecimal digits. Other standard ASCII characters (text) and control commands (carriage return, line feed, end of file, etc.) are interpreted normally. In the Hex ASCII mode, the Pioneer sends data in one line of ASCII characters. There are no carriage returns and/or line feed sequences (CR/LF) sent from the Pioneer. The CRT provides a CR/LF after 60 characters.



When operating in HEX mode, all console text appears in HEX - including the prompt ">" (HEX "3E") and any additional commands that are typed.

Individual parameters within a data string may be enabled / disabled. All binary output formats have the option of outputting data in HEX-ASCII instead of true binary using the CF command (see [CF - Flow Control](#)). HEX-ASCII is an ASCII representation of the binary data. Binary output formats include PD0, 3, 4, and 5. Text output formats include PD6.

Deciding on which format to use depends on the needs of the deployment. The following describes the basics of the formats available.

- **PD0** – PD0 is Teledyne RD Instrument's standard format. PD0 is a binary output format. It provides the most information possible including a header, fixed and variable leader, bottom track, and water profile information. The fixed and variable leader is a recording of time, DVL setup, orientation, heading, pitch, roll, temperature, pressure, and self-test diagnostic results. Data fields to be output are user selectable. PD0 has distance made good in the output if the Bottom Track High Resolution Velocity Output Format is selected. This format is selected via the #BJ command (see [BJ – Data Type Output Control](#)).



The Bottom-Track High Resolution Velocity (5803h) and Navigation Parameters Data (2013h) blocks provide aid in the velocity measurement resolution and quality information for use in an Extended Kalman Filter (EKF) Inertial Navigation System (INS) solution.

- **PD3** – PD3 is a binary output format of bottom track speed over the bottom, speed through the water, and range to bottom information. If PD3 is selected, there is no data written to the recorder.
- **PD4** – PD4 is a binary output format of bottom track speed over the bottom, speed through the water, and range to bottom information.
- **PD5** – PD5 is a superset of PD4 and includes information on salinity, depth, pitch, roll, heading, and distance made good.

- **PD6** – PD6 is a text output format. Data is grouped into separate sentences containing system attitude data, timing and scaling, and speed through the water relative to the instrument, vehicle, and earth. Each sentence contains a unique starting delimiter and comma delimited fields. If PD6 is selected, there is no data written to the recorder.
- **PD11** is a text output format. It complies with the NMEA 0183 version 2.30 standard.
- **PD13** - PD13 outputs similar to PD6, except it adds Pressure and Range-to-bottom for all four beams and omits the System Health Monitor Data line.
- **PD26** - The PD26 format includes the \$VMVBW, \$VMDBT, and \$VMVLW NMEA Speed Log Formats.

The following table is a summary of the type of data outputted by PD0 through PD6 data output formats. Note that this is not an exhaustive list and it is advised to check out the full description of a format before choosing it above another.

Table 30: Summary of Output Data Formats

	PD0	PD4	PD5	PD6	PD11	PD13	PD26
System Info	☑	☑	☑				
Temperature	☑	☑	☑	☑		☑	
Depth	☑		☑	☑	☑	☑	☑
Pressure						☑	
Tilts (H,P,R)	☑		☑	☑	☑	☑	
Time of Ping	☑	☑	☑	☑		☑	
Speed of Sound	☑	☑	☑	☑		☑	
Water Profile Configuration	☑						
Water Profile Velocities	☑						☑
Correlation Magnitude	☑						
Echo Intensity	☑						
Percent Good	☑						
Bottom Range	☑	☑	☑	☑	☑	☑	☑
Bottom Velocity (SOG*)	☑	☑	☑	☑	☑		☑
Water-Mass Layer Velocity (STW*)	☑	☑	☑	☑			☑
Bottom Track Configuration	☑						
Distance Over Ground	☑ see note		☑		☑		☑
Sea-Bird							
High resolution bottom track velocity output	☑						
Bottom track range format	☑						
Navigation parameters	☑						
Binary	☑	☑	☑				
ASCII				☑		☑	
NMEA					☑		☑
Serial Output	☑	☑	☑	☑	☑	☑	☑
Recorded on PC Card	PD0	PD4	PD5	None	None	None	None

*SOG = Speed Over Ground

*STW = Speed Through Water



The PD0 [Bottom Track output data format](#) assumes that the instrument is stationary and the bottom is moving. See the [EX – Coordinate Transformation](#) command and [Beam Coordinate Systems](#) for details.

If Beam 3 is going forward, then the Y velocity is negative.

If Beam 2 is going forward, then X velocity is negative.

If the bottom is going towards the face of a down facing DVL, then Z is positive.

The [PD0 Bottom Track High Resolution Velocity Output](#) (velocity in 0.01mm/s) and PD3 through PD6 data formats assume that the bottom is stationary and that the DVL or vessel is moving.

If Beam 3 is going forward, then the Y velocity is positive.

If Beam 2 is going forward, then X velocity is positive.

If the bottom is going towards the face of a down facing DVL, then Z is negative.



PD0 has distance made good in the output if the Bottom Track High Resolution Velocity Output Format is selected. This format is selected via the #BJ command (see [BJ – Data Type Output Control](#)).

PD0 Output Data Format

The following description is for the standard PD0 Pioneer output data format. Figure 29 through Figure 37 shows the ASCII and binary data formats for the Pioneer PD0 mode. Table 31 through Table 58 defines each field in the output data structure.

The binary output data formats are composed of at least one data type, i.e. a group of bytes all related by their dynamic or field. For instance in the PD0 data format, variables that do not change during the deployment are stored in the [Fixed Leader](#) data type of leader ID 0000h, whereas the dynamic variables, except velocities, which dynamically change during the deployment are stored under the [Variable Leader](#) data type of leader ID 0080h. This distinction is based on the dynamic; other distinctions are present such as velocity types such as data type of leader ID 0100h which groups all the [Water Profile Velocity](#) data and leader ID 0600h stores all [Bottom Track Velocity](#) data. The Pioneer sends all the data for a given type for all depth cells and all beams before the next data type begins.

The PD0 Header ID is 7F7Fh, which makes it easy to detect. In the PD0 Header are the number of bytes in the ensemble, the number of data types and the offset respective to each data type location in the binary ensemble.

PD0 is the only binary output data format which provides a [Header](#) that describes the data included in the ensemble since some data types presence in the PD0 output are dependent on commands parameters. For example, if the number of Bottom Track pings is 0 (BPo), then there will be no Bottom track data type in the ensemble.

Some data outputs are in bytes per depth cell. For example, if the WN-command = 30 (default), WD command = WD 111 110 000 (default), WP command > 0, BP command > 0, the required data buffer storage space is 951 bytes per ensemble. There are seven data types output for this example: Fixed Leader, Variable Leader, Velocity, Correlation Magnitude, Echo Intensity, Percent Good, and Bottom Track.

20	BYTES OF HEADER DATA (6 + [2 x 7 Data Types])
58	BYTES OF FIXED LEADER DATA (FIXED)
77	BYTES OF VARIABLE LEADER DATA (FIXED)
242	BYTES OF VELOCITY DATA (2 + 8 x 30)
122	BYTES OF CORRELATION MAGNITUDE DATA (2 + 4 x 30)
122	BYTES OF ECHO INTENSITY (2 + 4 x 30)
122	BYTES OF PERCENT-GOOD DATA (2 + 4 x 30)
122	BYTES OF PROFILE STATUS DATA (2 + 4 x 30)
81	BYTES OF BOTTOM TRACK DATA (FIXED)
2	BYTES OF CHECKSUM DATA (FIXED)
968	BYTES OF DATA PER ENSEMBLE

The table below shows which data types are always output against command dependable data types:

Command	ID (MSB LSB)	Description
ALWAYS OUTPUT	7F 7Fh	HEADER (6 BYTES + [2 x No. OF DATA TYPES])
	00 00h	FIXED LEADER DATA (58 BYTES)
	00 80h	VARIABLE LEADER DATA (77 BYTES)
WATER PROFILING DATA WD command WP command	01 00h	VELOCITY (2 BYTES + 8 BYTES PER DEPTH CELL)
	02 00h	CORRELATION MAGNITUDE (2 BYTES + 4 BYTES PER DEPTH CELL)
	03 00h	ECHO INTENSITY (2 BYTES + 4 BYTES PER DEPTH CELL)
	04 00h	PERCENT GOOD (2 BYTES + 4 BYTES PER DEPTH CELL)
BP command #BJ command	06 00h	BOTTOM TRACK DATA (81 BYTES)
	58 00h	BOTTOM TRACK COMMAND OUTPUT (43 BYTES)
	58 03h	BOTTOM TRACK HIGH RESOLUTION VELOCITY (70 BYTES)
	58 04h	BOTTOM TRACK RANGE (41 BYTES)
	20 13h	NAVIGATION PARAMETERS DATA (85 BYTES)
#EE command	30 00h	ENVIRONMENT COMMAND PARAMETERS OUTPUT (47 BYTES)
	30 01h	SENSOR SOURCE FOR DOPPLER PROCESSING (62 BYTES)
SD command	54 1Ch	STATUS (24 BYTES)
	54 1Dh	IMU DATA (60 BYTES)
	54 1Eh	EULER Data (34 BYTES)
	54 1Fh	SHIP MOTION (48 BYTES)
ALWAYS OUTPUT		CHECKSUM (2 BYTES)

Figure 39. PDO Standard Output Data Buffer Format



The Pioneer always sends the Least Significant Byte (LSB) first.

Header Data Format

BIT POSITIONS									
BYTE	7	6	5	4	3	2	1	0	
1	HEADER ID (7Fh)								
2	DATA SOURCE ID (7Fh)								
3	NUMBER OF BYTES IN ENSEMBLE								LSB
4									MSB
5	SPARE								
6	NUMBER OF DATA TYPES								
7	OFFSET FOR DATA TYPE #1								LSB
8									MSB
9	OFFSET FOR DATA TYPE #2								LSB
10									MSB
11	OFFSET FOR DATA TYPE #3								LSB
12									MSB
↓	(SEQUENCE CONTINUES FOR UP TO N DATA TYPES)								↓
2N+5	OFFSET FOR DATA TYPE #N								LSB
2N+6									MSB

See Table 31 for a description of the fields.

Figure 40. Binary Header Data Format

Header information is the first item sent by the Pioneer to the output buffer. The Pioneer always sends the Least Significant Byte (LSB) first.

Table 31: Header Data Format

Hex Digit	Binary Byte	Field	Description
1,2	1	HDR ID / Header ID	Stores the header identification byte (7Fh).
3,4	2	HDR ID / Data Source ID	Stores the data source identification byte (7Fh for the Pioneer).
5-8	3,4	Bytes / Number of bytes in ensemble	This field contains the number of bytes from the start of the current ensemble up to, but not including, the 2-byte checksum (Figure 37).
9,10	5	Spare	3-byte checksum offset, which would allow the output of a very large data type in the PDO message, although no data type can start beyond the reach of a 16-bit offset word in the header.
11,12	6	No. DT / Number of Data Types	This field contains the number of data types selected for collection. By default, fixed/variable leader, velocity, correlation magnitude, echo intensity, and percent good are selected for collection. This field will therefore have a value of six (4 data types + 2 for the Fixed/Variable Leader data).
13-16	7,8	Address Offset for Data Type #1 / Offset for Data Type #1	This field contains the internal memory address offset where the Pioneer will store information for data type #1 (with this firmware, always the Fixed Leader). Adding "1" to this offset number gives the absolute Binary Byte number in the ensemble where Data Type #1 begins (the first byte of the ensemble is Binary Byte #1).
17-20	9,10	Address Offset for Data Type #2 / Offset for Data Type #2	This field contains the internal memory address offset where the Pioneer will store information for data type #2 (with this firmware, always the Variable Leader). Adding "1" to this offset number gives the absolute Binary Byte number in the ensemble where Data Type #2 begins (the first byte of the ensemble is Binary Byte #1).
21-24 thru 2n+13 to 2n+16	11,12 thru 2n+5, 2n+6	Address Offsets for Data Types #3-n / Offset for Data Type #3 through #n	These fields contain internal memory address offset where the Pioneer will store information for data type #3 through data type #n. Adding "1" to this offset number gives the absolute Binary Byte number in the ensemble where Data Types #3-n begin (first byte of ensemble is Binary Byte) #1).

Fixed Leader Data Format

BIT POSITIONS									
BYTE	7	6	5	4	3	2	1	0	
1	FIXED LEADER ID								LSB 00h
2									MSB 00h
3	CPU F/W VER.								
4	CPU F/W REV.								
5	SYSTEM CONFIGURATION								LSB
6									MSB
7	REAL/SIM FLAG								
8	LAG LENGTH								
9	NUMBER OF BEAMS								
10	NUMBER OF CELLS								
11	PINGS PER ENSEMBLE								LSB
12									MSB
13	DEPTH CELL LENGTH								LSB
14									MSB
15	BLANK AFTER TRANSMIT								LSB
16									MSB
17	PROFILING MODE								
18	LOW CORR THRESH								
19	NO. CODE REPS								
20									
21	ERROR VELOCITY MAXIMUM								LSB
22									MSB
23	TPP MINUTES								
24	TPP SECONDS								
25	TPP HUNDREDTHS								
26	COORDINATE TRANSFORM								
27	HEADING ALIGNMENT								LSB
28									MSB

BYTE	BIT POSITIONS								
	7	6	5	4	3	2	1	0	
29	HEADING BIAS								LSB
30									MSB
31	SENSOR SOURCE								
32	SENSORS AVAILABLE								
33	BIN 1 DISTANCE								
34									
35	XMIT PULSE LENGTH								LSB
36									MSB
37	SPARE								LSB
38									MSB
39	FALSE TARGET THRESH								
40	INPUT TRIGGER ENABLE								
41	TRANSMIT LAG DISTANCE								LSB
42									MSB
43	SPARE								LSB
↓									↓
50									MSB
51	SYSTEM BANDWIDTH								LSB
52									MSB
53	SPARE								
54	SPARE								
55	System Serial Number								LSB
↓									↓
58									MSB

See Table 32 for a description of the fields

Figure 41. Fixed Leader Data Format

Fixed Leader data refers to the non-dynamic Pioneer data that only changes when certain commands are changed. Fixed Leader data also contains hardware information. The Pioneer always sends Fixed Leader data as output data (LSBs first).

Table 32: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	FID / Fixed Leader ID	Stores the Fixed Leader identification word (00 00h).
5,6	3	fv / CPU F/W Ver.	Contains the version number of the CPU firmware.
7,8	4	fr / CPU F/W Rev.	Contains the revision number of the CPU firmware.
9-12	5,6	Sys Cfg / System Configuration	<p>This field defines the Pioneer hardware configuration. Convert this field (2 bytes, LSB first) to binary and interpret as follows.</p> <pre> LSB BITS 7 6 5 4 3 2 1 0 - - - - - 0 0 0 75-kHz SYSTEM - - - - - 0 0 1 150-kHz SYSTEM - - - - - 0 1 0 300-kHz SYSTEM - - - - - 0 1 1 600-kHz SYSTEM - - - - - 1 0 0 1200-kHz SYSTEM - - - - - 1 0 1 2400-kHz SYSTEM - - - - 0 - - - CONCAVE BEAM PAT. - - - - 1 - - - CONVEX BEAM PAT. - - 0 0 - - - - SENSOR CONFIG #1 - - 0 1 - - - - SENSOR CONFIG #2 - - 1 0 - - - - SENSOR CONFIG #3 - 0 - - - - - - XDCR HD NOT ATT. - 1 - - - - - - XDCR HD ATTACHED 0 - - - - - - DOWN FACING BEAM 1 - - - - - - UP-FACING BEAM MSB BITS 7 6 5 4 3 2 1 0 - - - - - 0 0 15E BEAM ANGLE - - - - - 0 1 20E BEAM ANGLE - - - - - 1 0 30E BEAM ANGLE - - - - - 1 1 OTHER BEAM ANGLE 0 1 0 0 - - - - 4-BEAM JANUS CONFIG 0 1 0 1 - - - - 5-BM JANUS CFG DEMOD) 1 1 1 1 - - - - 5-BM JANUS CFG. (2 DEMD) </pre> <p>Example: Hex 5249 (i.e., hex 49 followed by hex 52) identifies a 150-kHz system, convex beam pattern, down-facing, 30E beam angle, 5 beams (3 demods).</p>
13,14	7	PD / Real/Sim Flag	This field is set by default as real data (0).
15,16	8	Lag Length	Lag Length. The lag is the time period between sound pulses.
17,18	9	#Bm / Number of Beams	Contains the number of beams used to calculate velocity data (not physical beams). The Pioneer needs only three beams to calculate water-current velocities. The fourth beam provides an error velocity that determines data validity. If only three beams are available, the Pioneer does not make this validity check. Table 36 (Percent-Good Data Format) has more information.

Table 32: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
19,20	10	WN / Number of Cells	Contains the number of depth cells over which the Pioneer collects data (WN – Number of Depth Cells). Scaling: LSD = 1 depth cell; Range = 1 to 255 depth cells
21-24	11,12	WP / Pings Per Ensemble	Contains the number of pings averaged together during a data ensemble (WP – Pings Per Ensemble). If WP = 0, the Pioneer does not collect the WD water-profile data. Note: The Pioneer automatically extends the ensemble interval (TE) if the product of WP and time per ping (TP) is greater than TE (i.e., if WP x TP > TE). Scaling: LSD = 1 ping; Range = 1 to 16,384 pings
25-28	13,14	WS / Depth Cell Length	Contains the length of one depth cell (WS – Depth Cell Size). Scaling: LSD = 1 centimeter; Range = 1 to 1600 cm (52.5 feet)
29-32	15,16	WF / Blank after Transmit	Contains the blanking distance used by the Pioneer to allow the transmit circuits time to recover before the receive cycle begins (WF – Blank after Transmit). Scaling: LSD = 1 centimeter; Range = 0 to 9999 cm (328 feet)
33,34	17	Signal Processing Mode	Contains the Signal Processing Mode. This field will always be set to 1.
35,36	18	WC / Low Corr Thresh	Contains the minimum threshold of correlation that water-profile data can have to be considered good data (WC - Low Correlation Threshold). Scaling: LSD = 1 count; Range = 0 to 255 counts
37,38	19	cr# / No. code reps	Contains the number of code repetitions in the transmit pulse. Scaling: LSD = 1 count; Range = 0 to 255 counts
39,40	20	% Good Minimum	Contains the minimum percentage of water-profiling pings in an ensemble that must be considered good to output velocity data. Scaling: LSD = 1 percent; Range = 1 to 100 percent
41-44	21,22	WE / Error Velocity Threshold	This field, initially set by the WE-command, contains the actual threshold value used to flag water-current data as good or bad. If the error velocity value exceeds this threshold, the Pioneer flags all four beams of the affected bin as bad (see WE - Error Velocity Threshold). Scaling: LSD = 1 mm/s; Range = 0 to 5000 mm/s
45,46	23	Minutes	These fields, set by the TP-command, contain the amount of time between ping groups in the ensemble. NOTE: The Pioneer automatically extends the ensemble interval (set by TE) if (WP x TP > TE). See TP – Time Between Pings .
47,48	24	Seconds	
49,50	25	Hundredths	

Table 32: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description																		
51,52	26	EX / Coord Transform	<p>Contains the coordinate transformation processing parameters (EX – Coordinate Transformation). These firmware switches indicate how the Pioneer collected data.</p> <p>xxx00xxx = NO TRANSFORMATION (BEAM COORDINATES) xxx01xxx = INSTRUMENT COORDINATES xxx10xxx = SHIP COORDINATES xxx11xxx = EARTH COORDINATES xxxxx1xx = TILTS (PITCH AND ROLL) USED IN SHIP OR EARTH TRANSFORMATION xxxxxx1x = 3-BEAM SOLUTION USED IF ONE BEAM IS BELOW THE CORRELATION THRESHOLD SET BY THE WC-COMMAND xxxxxxx1 = BIN MAPPING USED</p>																		
53-56	27,28	EA / Heading Alignment	<p>Contains a correction factor for physical heading misalignment (EA - Heading Alignment).</p> <p>Scaling: LSD = 0.01 degree; Range = -179.99 to 180.00 degrees</p>																		
57-60	29,30	#EV / Heading Bias	<p>Contains a correction factor for electrical/magnetic heading bias (EV - Heading Bias).</p> <p>Scaling: LSD = 0.01 degree; Range = -179.99 to 180.00 degrees</p>																		
61,62	31	EZ / Sensor Source	<p>Contains the selected source of environmental sensor data (EZ - Sensor Source). These firmware switches indicate the following.</p> <table><thead><tr><th>FIELD</th><th>DESCRIPTION</th></tr></thead><tbody><tr><td>1xxxxxxx</td><td>CALCULATES EC (SPEED OF SOUND) FROM ED, ES, AND ET</td></tr><tr><td>x1xxxxxx</td><td>USES ED FROM DEPTH SENSOR</td></tr><tr><td>xx1xxxxx</td><td>USES EH FROM TRANSDUCER HEADING SENSOR</td></tr><tr><td>xxx1xxxx</td><td>USES EP FROM TRANSDUCER PITCH SENSOR</td></tr><tr><td>xxxx1xxx</td><td>USES ER FROM TRANSDUCER ROLL SENSOR</td></tr><tr><td>xxxxx1xx</td><td>USES ES (SALINITY) FROM CONDUCTIVITY SENSOR</td></tr><tr><td>xxxxxx1x</td><td>USES ET FROM TRANSDUCER TEMPERATURE SENSOR</td></tr><tr><td>xxxxxxx1</td><td>USES EU FROM TRANSDUCER TEMPERATURE SENSOR</td></tr></tbody></table> <p>NOTE: If the field = 0, or if the sensor is not available, the Pioneer uses the manual command setting. If the field = 1, the Pioneer uses the reading from the internal sensor or an external synchro sensor (only applicable to heading, roll, and pitch). Although a “2” in the EZ-command string can be entered, the Pioneer only displays a 0 (manual) or 1 (int/ext sensor).</p>	FIELD	DESCRIPTION	1xxxxxxx	CALCULATES EC (SPEED OF SOUND) FROM ED, ES, AND ET	x1xxxxxx	USES ED FROM DEPTH SENSOR	xx1xxxxx	USES EH FROM TRANSDUCER HEADING SENSOR	xxx1xxxx	USES EP FROM TRANSDUCER PITCH SENSOR	xxxx1xxx	USES ER FROM TRANSDUCER ROLL SENSOR	xxxxx1xx	USES ES (SALINITY) FROM CONDUCTIVITY SENSOR	xxxxxx1x	USES ET FROM TRANSDUCER TEMPERATURE SENSOR	xxxxxxx1	USES EU FROM TRANSDUCER TEMPERATURE SENSOR
FIELD	DESCRIPTION																				
1xxxxxxx	CALCULATES EC (SPEED OF SOUND) FROM ED, ES, AND ET																				
x1xxxxxx	USES ED FROM DEPTH SENSOR																				
xx1xxxxx	USES EH FROM TRANSDUCER HEADING SENSOR																				
xxx1xxxx	USES EP FROM TRANSDUCER PITCH SENSOR																				
xxxx1xxx	USES ER FROM TRANSDUCER ROLL SENSOR																				
xxxxx1xx	USES ES (SALINITY) FROM CONDUCTIVITY SENSOR																				
xxxxxx1x	USES ET FROM TRANSDUCER TEMPERATURE SENSOR																				
xxxxxxx1	USES EU FROM TRANSDUCER TEMPERATURE SENSOR																				
63,64	32	Sensor Avail	<p>This field reflects which sensors are available. The bit pattern is the same as listed for the EZ-command (above).</p>																		
65-68	33,34	dis1 / Bin 1 distance	<p>This field contains the distance to the middle of the first depth cell (bin). This distance is a function of depth cell length (WS), the profiling mode (WM), the blank after transmit distance (WF), and speed of sound.</p> <p>Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm (2150 feet)</p>																		

Table 32: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
69-72	35,36	WT Xmit pulse length	This field, set by the WT-command (WT - Transmit Length), contains the length of the transmit pulse. When the Pioneer receives a <BREAK> signal, it sets the transmit pulse length as close as possible to the depth cell length (WS – Depth Cell Size). This means the Pioneer uses a WT <u>command</u> of zero. However, the WT <u>field</u> contains the actual length of the transmit pulse used. Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm (2150 feet)
73,74 75,76	37,38	Spare	Spare
77,78	39	#WA / False Target Threshold	Contains the threshold value used to reject data received from a false target, usually fish (WA - False Target Threshold Maximum). Scaling: LSD = 1 count; Range = 0 to 255 counts (255 disables)
79,80	40	CX / Input Trigger Enable	Contains the CX command setting. Range = 0 to 5
81-84	41,42	LagD / Transmit lag distance	This field, determined mainly by the setting of the WM-command, contains the distance between pulse repetitions. Scaling: LSD = 1 centimeter; Range = 0 to 65535 centimeters
85-100	43-50	Spare	Spare
101-104	51-52	System Bandwidth	Contains the system bandwidth setting. Range = 0 to 1
105-106	53	Spare	Spare
107-108	54	Spare	Spare
109-116	55-58	System Serial Number	System Serial Number

Variable Leader Data Format

BIT POSITIONS									
BYTE	7	6	5	4	3	2	1	0	
1	VARIABLE LEADER ID 00 80h								LSB 80h
2									MSB 00h
3	ENSEMBLE NUMBER								LSB
4									MSB
5	RTC YEAR RTC MONTH RTC DAY RTC HOUR RTC MINUTE RTC SECOND RTC HUNDREDTHS								
6									
7									
8									
9									
10									
11	RTC HUNDREDTHS								
12	ENSEMBLE # MSB								
13	BIT RESULT								LSB
14									MSB
15	SPEED OF SOUND								LSB
16									MSB
17	DEPTH OF TRANSDUCER								LSB
18									MSB
19	HEADING								LSB
20									MSB
21	PITCH (TILT 1)								LSB
22									MSB
23	ROLL (TILT 2)								LSB
24									MSB
25	SALINITY								LSB
26									MSB
27	TEMPERATURE								LSB
28									MSB
29	MPT MINUTES MPT SECONDS MPT HUNDREDTHS								
30									
31									

BIT POSITIONS									
BYTE	7	6	5	4	3	2	1	0	
32	HDG STD DEV								
33	PITCH STD DEV								
34	ROLL STD DEV								
35	ADC CHANNEL 0								
36	ADC CHANNEL 1								
37	ADC CHANNEL 2								
38	ADC CHANNEL 3								
39	ADC CHANNEL 4								
40	ADC CHANNEL 5								
41	ADC CHANNEL 6								
42	ADC CHANNEL 7								
43	ERROR STATUS WORD (ESW)								LSB
44									
45									
46	SPARE								MSB
47									
48	PRESSURE								LSB
49									
50									
51									
52	PRESSURE SENSOR VARIANCE								MSB
53									LSB
54									
55									
56	SPARE								MSB
57									
↓									
↓									
66									

BIT POSITIONS								
BYTE	7	6	5	4	3	2	1	0
67	HEALTH STATUS							
68	LEAK A COUNT							LSB
69								MSB
70	LEAK B COUNT							LSB
71								MSB
72	TX VOLTAGE							LSB
73								MSB
74	TX CURRENT							LSB
75								MSB
76	TRANSDUCER IMPEDANCE							LSB
77								MSB

Figure 42. Variable Leader Data Format

Variable Leader data refers to the dynamic Pioneer data (from clocks/sensors) that change with each ping. The Pioneer always sends Variable Leader data as output data (LSBs first).

Table 33: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	VID / Variable Leader ID	Stores the Variable Leader identification word (MSB=00h LSB=80h).
5-8	3,4	Ens / Ensemble Number	<p>This field contains the sequential number of the ensemble to which the data in the output buffer apply.</p> <p>Scaling: LSD = 1 ensemble; Range = 1 to 65,535 ensembles</p> <p>NOTE: The first ensemble collected is #1. At “rollover,” we have the following sequence:</p> <pre> 1 = ENSEMBLE NUMBER 1 ↓ 65535 = ENSEMBLE NUMBER 65,535 ENSEMBLE 0 = ENSEMBLE NUMBER 65,536 #MSB FIELD 1 = ENSEMBLE NUMBER 65,537 (BYTE 12) INCR. </pre>
9,10	5	RTC Year	These fields contain the time from the Pioneer’s real-time clock (RTC) that the current data ensemble began. The TS-command (TS – Set Real-Time Clock) initially sets the clock. The Pioneer <u>does</u> account for leap years.
11,12	6	RTC Month	
13,14	7	RTC Day	
15,16	8	RTC Hour	
17,18	9	RTC Minute	
19,22	10	RTC Second	
21,22	11	RTC Hundredths	
23-24	12	Ensemble # MSB	This field increments each time the Ensemble Number field (bytes 3, 4) “rolls over.” This allows ensembles up to 16,777,215. See Ensemble Number field above.

Table 33: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
25-28	13,14	BIT / BIT Result	<p>This field contains the results of the Pioneer's Built-in Test function. A zero code indicates a successful BIT result. See BIT Decoding Method for non-zero values.</p> <pre> BIT bytel3 Error Code Description 0x01 Transmitter Shutdown 0x02 Transmitter Overcurrent 0x03 Transmitter Undercurrent 0x04 Transmitter Undervoltage 0x10 FIFO interrupt missed 0x11 FIFO ISR re-entry 0x21 Sensor start failure 0x22 temperature sensor failure 0x23 pressure sensor failure 0x24 tilt sensor failure 0x27 Bad Comms with sensor 0x28 Bad Comms with sensor 0x29 Sensor Cal Data checksum failure 0x2A Sensor Stream Data Fault 0x30 Stuck UART 0x31 QUART Transmit timeout 0x32 QUART IRQ Stuck 0x33 QUART Buffer stuck 0x34 QUART IRQ Active 0x35 QUART cannot clear interrupt 0x50 RTC low battery * see note at end of table, page 195 0x51 RTC time not set 0x60 Lost Nonvolatile pointers 0x61 Erase operation failed 0x62 Error writing from flash to buffer 1 0x63 Error writing from buffer 1 to flash 0x64 Timed out checking if page is erased 0x65 Bad return when checking page 0x66 Loop recorder Slate Full 0x70 Unable to write to FRAM 0x80 HEM data corrupt or not initialized. 0x81 HEM data corrupt or not initialized. 0x82 Failed to update HEM data. 0x83 Failed to update HEM data. 0x84 Failed to read HEM time data. 0x85 Failed to read HEM pressure data. 0x86 Failed to read HEM SPI state. 0x87 Operating time over max. 0x88 Pressure reading over sensor limit. 0x89 Leak detected in sensor A. 0x8A Leak detected in sensor B. 0x90 144 AHRS sensor initialization failure 0x91 145 AHRS message CRC error 0x92 146 AHRS power supply fault 0x93 147 AHRS temperature fault 0x94 148 AHRS communication port fault 0x95 149 AHRS IMU failed built-in-test 0x96 150 AHRS IMU accel/gyro out of range 0x97 151 AHRS bad message format 0x98 152 AHRS data is marked unreliable 0x99 153 AHRS using stale data 0x9A 154 AHRS no data received 0xFF Power failure BIT Number of Errors byte 14 Number of BIT errors </pre>

Table 33: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
29-32	15,16	EC / Speed of Sound	<p>Contains either manual or calculated speed of sound information (EC - Speed of Sound).</p> <p>Scaling: LSD = 1 meter per second; Range = 1400 to 1600 m/s</p>
33-36	17,18	ED / Depth of Transducer	<p>Contains the depth of the transducer below the water surface (ED - Depth of Transducer). This value may be a manual setting or a reading from a depth sensor.</p> <p>Scaling: LSD = 1 decimeter; Range = 1 to 9999 decimeters</p>
37-40	19,20	EH / Heading	<p>Contains the Pioneer heading angle. This value may be a manual setting (EH - Heading) or a reading from a heading sensor. The variation angle from the EV command is added to heading before output. The coordinate frame this data is referenced to is specified by the EH command.</p> <p>Scaling: LSD = 0.01 degree; Range = 000.00 to 359.99 degrees</p>
41-44	21,22	EP / Pitch (Tilt 1)	<p>Contains the Pioneer pitch angle. This value may be a manual setting (EP - Pitch and Roll Angles) or a reading from a tilt sensor. Positive values mean that Beam #3 is spatially higher than Beam #4. The coordinate frame this data is referenced to is specified by the EP command.</p> <p>Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees</p>
45-48	23,24	ER / Roll (Tilt 2)	<p>Contains the Pioneer roll angle. This value may be a manual setting (ER - Roll Angle) or a reading from a tilt sensor. For an up-facing Pioneer system, positive values mean that Beam #2 is above the earth's horizontal while than Beam #1 is below the earth's horizontal. For a down-facing Pioneer system, positive values mean that Beam #1 is above the earth's horizontal and then Beam #2 is below the earth's horizontal. The coordinate frame this data is referenced to is specified by the EP command.</p> <p>Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees</p>
49-52	25,26	ES / Salinity	<p>Contains the salinity value of the water at the transducer head (ES - Salinity). This value may be a manual setting or a reading from a conductivity sensor.</p> <p>Scaling: LSD = 1 part per thousand; Range = 0 to 40</p>
53-56	27,28	ET / Temperature	<p>Contains the temperature of the water at the transducer head. This value may be a manual setting (ET - Temperature) or a reading from a temperature sensor.</p> <p>Scaling: LSD = 0.01 degree; Range = -5.00 to +40.00 degrees</p>
57,58	29	MPT minutes	This field contains the <u>M</u> inimum Pre- <u>P</u> ing Wait <u>T</u> ime between ping groups in the ensemble.
59,60	30	MPT seconds	
61,62	31	MPT hundredths	

Table 33: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
63,64	32	H/Hdg Std Dev	These fields contain the standard deviation (accuracy) of the heading and tilt angles from the gyrocompass/pendulums. Scaling (Heading): LSD = 1°; Range = 0 to 180° Scaling (Tilts): LSD = 0.1°; Range = 0.0 to 20.0°
65,66	33	P/Pitch Std Dev	
67,68	34	R/Roll Std Dev	
69-70	35	ADC Channel 0	These fields contain the outputs of the Analog-to-Digital Converter (ADC). Here is the description for each channel: <div> CHANNEL DESCRIPTION 0 Not Used 1 Rounded voltage as measured during pinging 2 Not Used 3 Not Used 4 Not Used 5 Not Used 6 Not Used 7 Not Used </div> Note that the ADC values may be “noisy” from sample-to-sample, but are useful for detecting long-term trends.
71-72	36	ADC Channel 1	
73-74	37	ADC Channel 2	
75-76	38	ADC Channel 3	
77-78	39	ADC Channel 4	
79-80	40	ADC Channel 5	
81-82	41	ADC Channel 6	
83-84	42	ADC Channel 7	
85-86	43	Error Status Word	Reserved for TRDI use.
87-88	44		Reserved for TRDI use.
89-90	45		Reserved for TRDI use.
91-92	46		Reserved for TRDI use.
93-96	47-48	Reserved	Reserved for TRDI use.
97-104	49-52	Pressure	Contains the pressure of the water at the transducer head relative to one atmosphere (sea level). Output is in deca-pascals. Scaling: LSD=1 deca-pascal; Range=0 to 4,294,967,295 deca-pascals
105-112	53-56	Pressure variance	Contains the variance (deviation about the mean) of the pressure sensor data. Output is in deca-pascals. Scaling: LSD=1 deca-pascal; Range=0 to 4,294,967,295 deca-pascals
113-114	57-66	Spare	Spare
133-134	67	Health Status	Contains the leak sensor flags and flags to indicate whether the transmit voltage, transmit current, and transducer impedance have been updated. These update flags are set when the measurement is made, and cleared after each ensemble output.
			<div> BITS 07 06 05 04 03 02 01 00 * * * * * * * 1 Leak sensor A leak detected * * * * * * 1 * Leak sensor A open circuit * * * * * 1 * * Leak sensor B leak detected * * * * 1 * * * Leak sensor B open circuit * * * 1 * * * * Tx voltage updated * * 1 * * * * * Tx current updated * 1 * * * * * * Transducer impedance updated </div>

Table 33: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
135-138	68-69	Leak A Count	Raw A/D reading, in counts, for leak sensor A. See PC5 or PC 50 for information on decoding the leak sensor status.
139-142	70-71	Leak B Count	Raw A/D reading, in counts, for leak sensor B. See PC5 or PC 50 for information on decoding the leak sensor status.
143-146	72-73	Tx Voltage	Voltage delivered to transducer during transmit. See Transducer Voltage, Current, and Impedance for more information. Scaling: LSD = 0.001 volt (Value set to 0xFFFF if a valid reading is not available.)
147-150	74-75	Tx Current	Current delivered to transducer during transmit. See Transducer Voltage, Current, and Impedance for more information. Scaling: LSD = 0.001 ampere (Value set to 0xFFFF if a valid reading is not available.)
151-154	76-77	Transducer Impedance	Measured impedance of transducer, calculated by dividing voltage by current. See Transducer Voltage, Current, and Impedance for more information. Scaling: LSD = 0.001 ohm (Value set to 0xFFFF if a valid reading is not available or for any reading greater than 65.535 ohms.)



If there is more than one BIT error, then it will take several ensembles to output all the BIT errors. For example, if there are 3 BIT errors detected, then the output will be Bytes13, 14 = 03,xx on ensemble n, Bytes13, 14 = 03,yy on ensemble n+1, and Bytes13, 14 = 03,zz on ensemble n+2, where xx, yy, and zz are the three different error messages detected.

The RTC Low Battery BIT error can occur if the system is left unpowered for extended periods of time. Connect the DVL to power to recharge the battery. The RTC battery is only used when the unit sits on the shelf to keep time. If users set the time before deploying, they do not need the RTC battery. Send the [TS command](#) to set the clock.

Over time, the RTC battery loses the ability to recharge and the voltage capacity drops. Contact Field Service if the RTC battery needs to be replaced.

BIT Decoding Method

In order to verify if the system has a BIT set for an ensemble, run the file through *BBCheck.exe* or decode it from the PD0 binary output using *BBConv.exe*.



BBCheck and *BBConv* are included with RDI Tools.

In any case, one will obtain a decimal value greater than zero if a BIT was set during the ensemble.

To decode it, simply convert the decimal value to Hexadecimal and take the first number to the far left as being the number of BIT failure occurrences during the ensemble and the 2 other numbers on the far right to be the BIT code.

For example:

- BIT obtained from *BBCheck* or *BBConv.exe* is '290'.
- Converted to hexadecimal (one can use the Windows calculator for this) gives: '122'.
- Where '1' is the number of occurrences for that BIT and '22' is the BIT failure code which means "Temperature Sensor failure" (see binary bytes 13 and 14).

Transducer Voltage, Current, and Impedance

The Transmit Voltage, Transmit Current, and Transducer Impedance values output in the PD0 Variable Leader are obtained from the Transducer Health Monitor measurement, which is part of the [HEM features](#). The measurement is made at the following times:

- During the transmit pulse of a BM8 ping, if the expected altitude ≥ 20 m
- During the transmit pulse of a BM9 ping, if the expected altitude ≥ 20 m



The transmit signal needs to be at least a certain length in order to make a valid measurement.

The measurement is not made during any profile ping or water mass layer ping. Therefore, if bottom pings are not enabled (or not working), then the output of these parameters will be 0xFFFF (i.e. hex FFFF) to mark them as invalid (Note that hex FFFF is equal to decimal 65535 if interpreted as an unsigned number, or -1 if interpreted as a signed number).

If bottom pings are enabled, but the altitude never attains 20 m or above, then the outputs for these parameters will remain at their initial values of 0xFFFF.

If a bottom track ping ever sees an altitude ≥ 20 m then these parameters will be measured and output. If the altitude then goes below 20 m, the output of these parameters will remain at their last measured value; i.e. you need a bottom track ping with altitude ≥ 20 m to update these values.

Velocity Data Format

BIT POSITIONS								
BYTE	7/S	6	5	4	3	2	1	0
1	VELOCITY ID							LSB 00h
2								MSB 01h
3	DEPTH CELL #1, VELOCITY 1							LSB
4								MSB
5	DEPTH CELL #1, VELOCITY 2							LSB
6								MSB
7	DEPTH CELL #1, VELOCITY 3							LSB
8								MSB
9	DEPTH CELL #1, VELOCITY 4							LSB
10								MSB
11	DEPTH CELL #2, VELOCITY 1							LSB
12								MSB
13	DEPTH CELL #2, VELOCITY 2							LSB
14								MSB
15	DEPTH CELL #2, VELOCITY 3							LSB
16								MSB
17	DEPTH CELL #2, VELOCITY 4							LSB
18								MSB
↓	(SEQUENCE CONTINUES FOR UP TO 128 CELLS)							↓
1019	DEPTH CELL #128, VELOCITY 1							LSB
1020								MSB
1021	DEPTH CELL #128, VELOCITY 2							LSB
1022								MSB
1023	DEPTH CELL #128, VELOCITY 3							LSB
1024								MSB
1025	DEPTH CELL #128, VELOCITY 4							LSB
1026								MSB

See Table 34 for description of fields

Figure 43. Velocity Data Format



The number of depth cells is set by the WN-command ([WN – Number of Depth Cells](#)).

The Pioneer packs velocity data for each depth cell of each beam into a two-byte, two's-complement integer [-32768, 32767] with the LSB sent first. The Pioneer scales velocity data in millimeters per second (mm/s). A value of -32768 (8000h) indicates bad velocity values.

All velocities are relative based on a stationary instrument. To obtain absolute velocities, algebraically remove the velocity of the instrument. For example,

```
RELATIVE WATER CURRENT VELOCITY:    EAST 650 mm/s
INSTRUMENT VELOCITY                  : (-) EAST 600 mm/s
ABSOLUTE WATER VELOCITY               :    EAST 50 mm/s
```

The setting of the EX-command (Coordinate Transformation) determines how the Pioneer references the velocity data as shown below.

EX-CMD	COORD SYS	VEL 1	VEL 2	VEL 3	VEL 4
00xxx	BEAM	TO BEAM 1	TO BEAM 2	TO BEAM 3	TO BEAM 4
01xxx	INST	Bm1-Bm2	Bm4-Bm3	TO XDUCER	ERR VEL
10xxx	SHIP	PRT-STBD	AFT-FWD	TO SURFACE	ERR VEL
11xxx	EARTH	TO EAST	TO NORTH	TO SURFACE	ERR VEL

POSITIVE VALUES INDICATE WATER MOVEMENT

Table 34: Velocity Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Velocity ID	Stores the velocity data identification word (MSB=01h LSB=00h).
5-8	3,4	Depth Cell 1, Velocity 1	Stores velocity data for depth cell #1, velocity 1. See above.
9-12	5,6	Depth Cell 1, Velocity 2	Stores velocity data for depth cell #1, velocity 2. See above.
13-16	7,8	Depth Cell 1, Velocity 3	Stores velocity data for depth cell #1, velocity 3. See above.
17-20	9,10	Depth Cell 1, Velocity 4	Stores velocity data for depth cell #1, velocity 4. See above.
21-2052	11-1026	Cells 2 – 128 (if used)	These fields store the velocity data for depth cells 2 through 128 (depending on the setting of WN – Number of Depth Cells). These fields follow the same format as listed above for depth cell 1.

Correlation Magnitude, Echo Intensity, Percent-Good, and Status Data Format

BYTE	BIT POSITIONS								
	7/S	6	5	4	3	2	1	0	
1	ID CODE								LSB
2									MSB
3	DEPTH CELL #1, FIELD #1								
4	DEPTH CELL #1, FIELD #2								
5	DEPTH CELL #1, FIELD #3								
6	DEPTH CELL #1, FIELD #4								
7	DEPTH CELL #2, FIELD #1								
8	DEPTH CELL #2, FIELD #2								
9	DEPTH CELL #2, FIELD #3								
10	DEPTH CELL #2, FIELD #4								
↓	(SEQUENCE CONTINUES FOR UP TO 128 BINS)								↓
511	DEPTH CELL #128, FIELD #1								
512	DEPTH CELL #128, FIELD #2								
513	DEPTH CELL #128, FIELD #3								
514	DEPTH CELL #128, FIELD #4								

See Table 35 through Table 38 for a description of the fields.

Figure 44. Correlation Magnitude, Echo Intensity, Percent-Good, and Status Data Format



The number of depth cells is set by the WN-command ([WN – Number of Depth Cells](#)).

Correlation magnitude data give the magnitude of the normalized echo autocorrelation at the lag used for estimating the Doppler phase change. The Pioneer represents this magnitude by a linear scale between 0 and 255, where 255 is perfect correlation (i.e., a solid target). A value of zero indicates bad correlation values.

Table 35: Correlation Magnitude Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the correlation magnitude data identification word (MSB=02h LSB=00h).
5,6	3	Depth Cell 1, Field 1	Stores correlation magnitude data for depth cell #1, beam #1. See above.
7,8	4	Depth Cell 1, Field 2	Stores correlation magnitude data for depth cell #1, beam #2. See above.
9,10	5	Depth Cell 1, Field 3	Stores correlation magnitude data for depth cell #1, beam #3. See above.
11,12	6	Depth Cell 1, Field 4	Stores correlation magnitude data for depth cell #1, beam #4. See above.
13 – 1028	7 – 514	Cells 2 – 128 (if used)	These fields store correlation magnitude data for depth cells 2 through 128 (depending on WN – Number of Depth Cells) for all four beams. These fields follow the same format as listed above for depth cell 1.

The echo intensity scale factor is about 0.61 dB per Pioneer count. The Pioneer does not directly check for the validity of echo intensity data.

Table 36: Echo Intensity Data Format

Hex Digit	Binary Byte	Field	Description
1 – 4	1,2	ID Code	Stores the echo intensity data identification word (MSB=03h LSB=00h).
5,6	3	Depth Cell 1, Field 1	Stores echo intensity data for depth cell #1, beam #1. See above.
7,8	4	Depth Cell 1, Field 2	Stores echo intensity data for depth cell #1, beam #2. See above.
9,10	5	Depth Cell 1, Field 3	Stores echo intensity data for depth cell #1, beam #3. See above.
11,12	6	Depth Cell 1, Field 4	Stores echo intensity data for depth cell #1, beam #4. See above.
13 – 1028	7 – 514	Cells 2 – 128 (if used)	These fields store echo intensity data for depth cells 2 through 128 (depending on WN – Number of Depth Cells) for all four beams. These fields follow the same format as listed above for depth cell 1.

The percent-good data field is a data-quality indicator that reports the percentage (0 to 100) of good data collected for each depth cell of the velocity profile. The setting of the [EX-command](#) (Coordinate Transformation) determines how the Pioneer references percent-good data as shown below.

EX-Command	Coordinate System	Velocity 1	Velocity 2	Velocity 3	Velocity 4
00xxx	Beam	Beam 1	BEAM 2	BEAM 3	BEAM 4
Percentage Of Good Pings For:					
01xxx	Instrument	3-Beam	Transformations	More Than One	4-Beam
10xxx	Ship	Transformations	Rejected	Beam Bad In Bin	Transformations
11xxx	Earth	(note 1)	(note 2)		

Note 1. Because profile data did not exceed correlation threshold ([WC command](#)).

Note 2. Because the error velocity threshold was exceeded ([WE command](#)).

At the start of the velocity profile, the backscatter echo strength is typically high on all four beams. Under this condition, the DVL uses all four beams to calculate the orthogonal and error velocities. As the echo returns from far away depth cells, echo intensity decreases. At some point, the echo will be weak enough on any given beam to cause the DVL to reject some of its depth cell data. This causes the DVL to calculate velocities with three beams instead of four beams. When the DVL does 3-beam solutions, it stops calculating the error velocity because it needs four beams to do this. At some further depth cell, the DVL rejects all cell data because of the weak echo. As an example, let us assume depth cell 60 has returned the following percent-good data.

FIELD #1 = 50, FIELD #2 = 5, FIELD #3 = 0, FIELD #4 = 45

If the [EX-command](#) was set to collect velocities in BEAM coordinates, the example values show the percentage of pings having good solutions in cell 60 for each beam based on the Low Correlation Threshold ([WC command](#)). Here, beam 1=50%, beam 2=5%, beam 3=0%, and beam 4=45%. These are neither typical nor desired percentages. Typically, all four beams should be about equal and greater than 25%.

On the other hand, if velocities were collected in Instrument, Ship, or Earth coordinates, the example values show:

Field 1 – Percentage of good 3-beam solutions – Shows percentage of successful velocity calculations (50%) using 3-beam solutions because the correlation threshold ([WC command](#)) was not exceeded.

Field 2 – Percentage of transformations rejected – Shows percent of error velocity (5%) that was less than the [WE command](#) setting. WE has a default of 2000 mm/s. This large WE setting effectively prevents the DVL from rejecting data based on error velocity.

Field 3 – Percentage of more than one beam bad in bin – 0% of the velocity data were rejected because not enough beams had good data.

Field 4 – Percentage of good 4-beam solutions – 45% of the velocity data collected during the ensemble for depth cell 60 were calculated using four beams.

Table 37: Percent-Good Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the percent-good data identification word (MSB=04h LSB=00h).
5,6	3	Depth cell 1, Field 1	Stores percent-good data for depth cell #1, field 1. See above.
7,8	4	Depth cell 1, Field 2	Stores percent-good data for depth cell #1, field 2. See above.
9,10	5	Depth cell 1, Field 3	Stores percent-good data for depth cell #1, field 3. See above.
11,12	6	Depth cell 1, Field 4	Stores percent-good data for depth cell #1, field 4. See above.
13-1028	7-514	Depth cell 2 – 128 (if used)	These fields store percent-good data for depth cells 2 through 128 (depending on WN – Number of Depth Cells), following the same format as listed above for depth cell 1.

These fields contain information about the status and quality of DVL data. A value of 0 means the measurement was good. A value of 1 means the measurement was bad.

Table 38: Status Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the status data identification word (MSB=05h LSB=00h).
5,6	3	Depth cell 1, Field 1	Stores status data for depth cell #1, beam #1. See above.
7,8	4	Depth cell 1, Field 2	Stores status data for depth cell #1, beam #2. See above.
9,10	5	Depth cell 1, Field 3	Stores status data for depth cell #1, beam #3. See above.
11,12	6	Depth cell 1, Field 4	Stores status data for depth cell #1, beam #4. See above.
13-1028	7-514	Depth cell 2 – 128 (if used)	These fields store status data for depth cells 2 through 128 (depending on the WN – Number of Depth Cells) for all four beams. These fields follow the same format as listed above for depth cell 1.

Binary Bottom-Track Data Format

BYTE	BIT POSITIONS								
	7/S	6	5	4	3	2	1	0	
1	BOTTOM-TRACK ID (00 06h)								LSB 00h
2									MSB 06h
3	BT PINGS PER ENSEMBLE								LSB
4									MSB
5	RESERVED								LSB
6									MSB
7	BT CORR MAG MIN								
8	BT EVAL AMP MIN								
9	RESERVED								
10	BT MODE								
11	BT ERR VEL MAX								LSB
12									MSB
13	RESERVED								
14									
15									
16									
17	BEAM#1 BT RANGE								LSB
18									MSB
19	BEAM#2 BT RANGE								LSB
20									MSB
21	BEAM#3 BT RANGE								LSB
22									MSB
23	BEAM#4 BT RANGE								LSB
24									MSB
25	BEAM#1 BT VEL								LSB
26									MSB
27	BEAM#2 BT VEL								LSB
28									MSB
29	BEAM#3 BT VEL								LSB
30									MSB
31	BEAM#4 BT VEL								LSB
32									MSB
33	BEAM#1 BT CORR.								
34	BEAM#2 BT CORR.								
35	BEAM#3 BT CORR.								
36	BEAM#4 BT CORR.								

BYTE	BIT POSITIONS							
	7/S	6	5	4	3	2	1	0
37	BEAM#1 EVAL AMP							
38	BEAM#2 EVAL AMP							
39	BEAM#3 EVAL AMP							
40	BEAM#4 EVAL AMP							
41	BEAM#1 BT %GOOD							
42	BEAM#2 BT %GOOD							
43	BEAM#3 BT %GOOD							
44	BEAM#4 BT %GOOD							
45	REF LAYER MIN							LSB
46								MSB
47	REF LAYER NEAR							LSB
48								MSB
49	REF LAYER FAR							LSB
50								MSB
51	BEAM#1 REF LAYER VEL							LSB
52								MSB
53	BEAM #2 REF LAYER VEL							LSB
54								MSB
55	BEAM #3 REF LAYER VEL							LSB
56								MSB
57	BEAM #4 REF LAYER VEL							LSB
58								MSB
59	BM#1 REF CORR							
60	BM#2 REF CORR							
61	BM#3 REF CORR							
62	BM#4 REF CORR							
63	BM#1 REF INT							
64	BM#2 REF INT							
65	BM#3 REF INT							
66	BM#4 REF INT							
67	BM#1 REF %GOOD							
68	BM#2 REF %GOOD							
69	BM#3 REF %GOOD							
70	BM#4 REF %GOOD							
71	BT MAX. DEPTH							LSB
72								MSB

BYTE	BIT POSITIONS							
	7/S	6	5	4	3	2	1	0
73	BM#1 RSSI AMP							
74	BM#2 RSSI AMP							
75	BM#3 RSSI AMP							
76	BM#4 RSSI AMP							
77	GAIN							
78	(*SEE BYTE 17)							
79	(*SEE BYTE 19)							
80	(*SEE BYTE 21)							
81	(*SEE BYTE 23)							

Figure 45. Binary Bottom-Track Data Format



This data is output only if the BP-command is > 0 and PD0 is selected. See Table 39 for a description of the fields.



The PD0 output data format assumes that the instrument is stationary, and the bottom is moving. Pioneer (Speed Log) output data formats (see [Special Output Data Formats](#)) assume that the bottom is stationary and that the Pioneer or vessel is moving.

This data is output only if the BP-command is greater than zero and PD0 is selected. The LSB is always sent first.

Table 39: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the bottom-track data identification word (MSB=06h LSB=00h).
5-8	3,4	BP/BT Pings per ensemble	Stores the number of bottom-track pings to average together in each ensemble (BP – Bottom-Track Pings per Ensemble). If BP = 0, the Pioneer does not collect bottom-track data. The Pioneer automatically extends the ensemble interval (TE – Time Per Ensemble) if BP x TP > TE. Scaling: LSD = 1 ping; Range = 1 to 999 pings
9-12	5,6	Reserved	Reserved
13,14	7	BC/BT Corr Mag Min	Stores the minimum correlation magnitude value (BC - Correlation Magnitude Minimum). Scaling: LSD = 1 count; Range = 0 to 255 counts
15,16	8	BA/BT Eval Amp Min	Stores the minimum evaluation amplitude value (BA - Evaluation Amplitude Minimum). Scaling: LSD = 1 count; Range = 1 to 255 counts
17,18	9	Reserved	Reserved
19,20	10	BM/BT Mode	Stores the bottom-tracking mode.

Table 39: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
21-24	11,12	BE/BT Err Vel Max	Stores the error velocity maximum value (BE - Error Velocity Maximum). Scaling: LSD = 1 mm/s; Range = 0 to 5000 mm/s (0 = did not screen data)
25-32	13-16	Reserved	Reserved
33-48	17-24	BT Range/Beam #1-4 BT Range	Contains the two lower bytes of the vertical range from the Pioneer to the sea bottom (or surface) as determined by each beam. This vertical range does not consider the effects of pitch and roll. When bottom detections are bad, BT Range = 0. See bytes 78 through 81 for MSB description and scaling. Scaling: LSD = 1 cm; Range = 0 to 65535 cm
49-64	25-32	BT Velocity/Beam #1-4 BT Vel	The meaning of the velocity depends on the coordinate system command setting (EX – Coordinate Transformation). For more information on coordinate transformations, see Beam Coordinate Systems , page 27. The four velocities are as follows: a) Beam Coordinates: Beam 1, Beam 2, Beam 3, Beam 4 b) Instrument Coordinates: 1 → 2, 4 → 3, toward face, error c) Ship Coordinates: Starboard, Fwd, Mast, Error d) Earth Coordinates: East, North, Upward, Error Scaling: LSD = 1 mm/s; Range = -10,000mm/s to +10,000mm/s
65-72	33-36	BTCM/Beam #1-4 BT Corr.	Contains the correlation magnitude in relation to the sea bottom (or surface) as determined by each beam. Bottom-track correlation magnitudes have the same format and scale factor as water-profiling magnitudes.
73-80	37-40	BTEA/Beam #1-4 BT Eval Amp	Contains the evaluation amplitude of the matching filter used in determining the strength of the bottom echo. Scaling: LSD = 1 count; Range = 0 to 255 counts
81-88	41-44	BTPG/Beam #1-4 BT %Good	Contains bottom-track percent-good data for each beam, which indicate the reliability of bottom-track data. It is the percentage of bottom-track pings that have passed the Pioneer's bottom-track validity algorithm during an ensemble. Scaling: LSD = 1 percent; Range = 0 to 100 percent
89-92 93-96 97 – 100	45,46 47,48 49,50	Ref Layer (Min, Near, Far)	Stores the minimum layer size, the near boundary, and the far boundary of the bottom track water-reference layer (BL - Water-Mass Layer Parameters). Scaling (minimum layer size): LSD = 1 dm; Range = 1-999 dm Scaling (near/far boundaries): LSD = 1 dm; Range = 6-9999 dm
101- 116	51-58	Ref Vel/Beam #1-4 Ref Layer Vel	Contains velocity data for the water mass for each beam. Water mass velocities have the same format and scale factor as water-profiling velocities (Table 34). The BL-command explains the water mass.

Table 39: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
117- 124	59-62	RLCM/Bm #1-4 Ref Corr	Contains correlation magnitude data for the water mass for each beam. Water mass correlation magnitudes have the same format and scale factor as water-profiling magnitudes.
125- 132	63-66	RLEI/Bm #1-4 Ref Int	Contains echo intensity data for the Water mass for each beam. Water mass intensities have the same format and scale factor as water-profiling intensities.
133- 140	67-70	RLPG/Bm #1-4 Ref %Good	Contains percent-good data for the water mass for each beam. They indicate the reliability of water mass data. It is the percentage of bottom-track pings that have passed a water mass validity algorithm during an ensemble. Scaling: LSD = 1 percent; Range = 0 to 100 percent
141- 144	71,72	BX/BT Max. Depth	Stores the maximum tracking depth value (BX – Maximum Tracking Depth). Scaling: LSD = 1 decimeter; Range = 10 to 65535 decimeters
145-152	73-76	RSSI/Bm #1-4 RSSI Amp	Contains the Receiver Signal Strength Indicator (RSSI) value in the center of the bottom echo as determined by each beam. Scaling: LSD \approx 0.61 dB per count; Range = 0 to 255 counts
153, 154	77	GAIN	Contains the Gain level for shallow water. See WJ – Receiver Gain Select .
155-162	78-81	BT Range MSB/Bm #1-4	Contains the most significant byte of the vertical range from the Pioneer to the sea bottom (or surface) as determined by each beam. This vertical range does not consider the effects of pitch and roll. When bottom detections are bad, BT Range=0. See bytes 17 through 24 for LSB description and scaling. Scaling: LSD = 1 cm; Range = 0 to 167,772.15 meters.

Environmental Command Parameters Output Format

BIT POSITIONS																	
BYTE	7	6	5	4	3	2	1	0									
1	FIXED ATTITUDE ID								LSB 00h								
2									MSB 30h								
3	ATTITUDE OUTPUT COORDINATES and PROCESSING CONTROL USING INTERPOLATED ATTITUDE (#EE)																
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11	RESERVED																
12	FIXED HEADING SCALING (#EH)																
13																	
14	FIXED HEADING COORDINATE FRAME (#EH)																
15	ROLL MISALIGNMENT (#EI)																
16																	
17	PITCH MISALIGNMENT (#EJ)																
18																	
19	USER INPUT FOR PITCH, ROLL, and COORDINATE FRAME (#EP)																
20																	
21																	
22																	
23																	
24	USER INPUT FOR UP/DOWN ORIENTATION (#EU)																
25	USER INPUT FOR HEADING BIAS/VARIATION/SYNCHRO OFFSET (#EV)																
26																	
27	SENSOR SOURCE (EZ)								↓								
↓																	
34																	
35																	
36										TRANSDUCER DEPTH (ED)							
37																	
38																	

BYTE	BIT POSITIONS							
	7	6	5	4	3	2	1	0
39	SALINITY (ES)							
40								
41	WATER TEMPERATURE (ET)							
42								
43	SPEED OF SOUND (EC)							
44								
45	COORDINATE TRANSFORMATION (EX)							
46								
47	3 BEAM SOLUTION (EX)							
	BIN MAP (EX)							
	MSB COORDINATE TRANSFORMATION (EX)							

Figure 46. Environmental Command Parameters Output Format

Environmental Command Parameters correspond to the most useful “E” menu command parameters. The Pioneer will output Fixed Attitude data as output data (LSBs first). See [Command Descriptions](#) for detailed descriptions of commands used to set these values.

Table 40: Environmental Command Parameters Output Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	FAID / Fixed Attitude ID	Environmental Command Parameters Output word (MSB=30h, LSB=00h).
5-20	3-10	Attitude Output Coordinates	Stores the setting of the #EE command; a user input for the Variable Attitude data to be output (EE - Environmental Data Output).
21,22	11	Reserved	
23-27	12-13	Fixed Heading Scaling	Stores the setting of the #EH command; a user input for heading (EH - Heading).
28	14	Fixed Heading Coordinate Frame	Stores the setting of the #EH command coordinate frame: 1 is ship, 0 is instrument (EH - Heading).
29-32	15,16	Roll Misalignment	Stores the setting of the #EI command; a user input for the roll misalignment (EI - Roll Misalignment Angle).
33-36	17,18	Pitch Misalignment	Stores the setting of the #EJ command; a user input for the pitch misalignment (EJ - Pitch Misalignment Angle).
37-46	19-23	Pitch, Roll and Coordinate Frame	Stores the setting of the #EP command; a user input for the pitch, roll, and coordinate (instrument or ship) frame (EP - Pitch and Roll Angles).
47,48	24	Orientation	Stores the setting of the #EU command; a user input for the up/down orientation (EU - Up/Down Orientation).
49-52	25,26	Heading Offset	Stores the setting of the #EV command; a user input for the heading offset due to heading bias, variation, or synchro initialization (EV - Heading Bias).

Table 40: Environmental Command Parameters Output Format

Hex Digit	Binary Byte	Field	Description
53-68	27-34	Sensor Source	Stores the setting of the EZ command; a user input defining the use of internal, external, or fixed sensors (EZ - Sensor Source).
69-76	35-38	Transducer Depth	Stores the setting of the ED command; a user input defining depth of the transducer (see ED - Depth of Transducer).
77-78	39	Salinity	Stores the setting of the ES command; a user input defining the salinity of the water (see ES – Salinity).
79-82	40,41	Water Temp	Stores the setting of the ET command; a user input defining the temperature of the water (see ET - Temperature).
83-86	42,43	SoS	Stores the setting of the EC command; a user input defining the speed of sound (see EC - Speed of Sound).
87-88	44	Transform	Stores the setting of the right two digits of the EX command that describe the coordinate transformations (see EX – Coordinate Transformation).
89-90	45	3 Beam Solution	Stores the setting of the fourth bit of the EX command that allows 3 beams good (instead of 4) transformations.
91-92	46	Bin Map	Stores the setting of the fifth bit of the EX command that controls bin mapping.
93-94	47	MSB of EX transformation	Stores the setting of the left digit of the EX command that describes the coordinate transformations.

Bottom Track Command Output Format

BYTE	BIT POSITIONS								
	7	6	5	4	3	2	1	0	
1.	BOTTOM TRACK COMMAND ID								LSB 00h
2.									MSB 58h
3.	AMPLITUDE THRESHOLD								
4.	CORRELATION MAGNITUDE								
5.	RESERVED								
6.									
7.	ERROR VELOCITY MAXIMUM								
8.									
9.	DEPTH GUESS								
10.									
11.	RESERVED								
12.	GAIN SWITCH THRESHOLD LOW								
13.	GAIN SWITCH THRESHOLD HIGH								
14.	GAIN SWITCH ALTITUDE								
15.									
16.	WATER MASS LAYER MODE								
17.	WATER MASS LAYER MIN SIZE								
18.									
19.	WATER MASS LAYER NEAR BOUNDARY								
20.									
21.	WATER MASS LAYER FAR BOUNDARY								
22.									
23.	BOTTOM TRACK MODE								
24.	SPEED LOG HOLD TRACK								
25.	SPEED LOG TIME-OUT								
26.									
27.	SPEED LOG FILTER TIME CONSTANT								
28.	PINGS PER ENSEMBLE								
29.									

BYTE	BIT POSITIONS							
	7	6	5	4	3	2	1	0
30.	RESERVED							
31.								
32.								
33.								
34.								
35.								
36.								
37.	BT MAXIMUM TRACKING DEPTH							
38.								
39.	RESERVED							
40.								
41.	TRANSMIT LENGTH							
42.								
43.	RESERVED							

Figure 47. Bottom Track Command Output Data Format

This format is selected via the #BJ command (see [BJ – Data Type Output Control](#)).

Table 41. Bottom Track Command Output Data Format

Binary Byte	Field	Description
1-2	ID	Stores the bottom-track command identification word (MSB=58h LSB=00h)
3	Evaluation Amplitude	Stores the setting of the BA command; Units are 1 to 255 counts (see #BA – Evaluation Amplitude Minimum)
4	Correlation Magnitude	Stores the setting of the BC command; Units are 0 to 255 counts (see #BC – Correlation Magnitude Minimum)
5-6	Reserved	Reserved
7-8	Error Velocity Maximum	Stores the setting of the BE command; Units are 0 to 9999 mm/s (see #BE – Error Velocity Maximum)
9-10	Depth Guess	Stores the setting of the BF command; Units are 1 to 65535 dm (0 for automatic search) (see #BF – Depth Guess)
11	Reserved	Reserved
12	Gain Threshold Low	Stores the setting of the #BH command low threshold; Units are 0 to 255 counts (see #BH – Gain Switch Threshold)
13	Gain Threshold High	Stores the setting of the #BH command high threshold; Units are 0 to 255 counts (see #BH – Gain Switch Threshold)
14-15	Gain Switch Altitude	Stores the setting of the #BI command; Units are 0 to 25 meters (300 kHz), 0 to 3 meters (600 kHz) (see #BI – Gain Switch Altitude)

Table 41. Bottom Track Command Output Data Format

Binary Byte	Field	Description
16	Water Mass Layer Mode	Stores the setting of the #BK command; Setting are 0 to 3 [0=off, 1=WB, 2=LostB, 3=W] (see #BK – Water-Mass Layer Mode)
17-18	Water Mass Layer Min Size	Stores the setting of the #BL command; Setting are 1 to 999 dm (see #BL – Water-Mass Layer Parameters)
19-20	Water Mass Layer Near Boundary	Stores the setting of the #BL command; Setting are 6 to 9999 dm (see #BL – Water-Mass Layer Parameters)
21-22	Water Mass Layer Far Boundary	Stores the setting of the #BL command; Setting are 7 to 9999 dm (see #BL – Water-Mass Layer Parameters)
23	Bottom Track Mode	Stores the setting of the #BM command; Setting are 8 or 9 (see #BM – Bottom Mode)
24	Speed Log Hold	Stores the setting of the #BN command; Hold Distance or zero if timeout (see #BN – Speed Log Hold/Drop Control)
25-26	Speed Log Drop Control	Stores the setting of the #BN command; Speed log time-out units in 0 to 999 seconds (see #BN – Speed Log Hold/Drop Control)
27	Speed Log Time Constant	Stores the setting of the #BO command; Settings are 0 to 100 (see #BO – Distance Measure Filter Constant)
28-29	Pings Per Ensemble	Stores the setting of the BP command; Setting are 0 to 999 pings (see BP – Bottom-Track Pings per Ensemble)
30 - 36	Reserved	Reserved
37-38	Maximum Tracking Depth	Stores the setting of the BX command; Setting are 10 to 65535 dm (see BX – Maximum Tracking Depth)
39 - 40	Reserved	Reserved
41	Transmit Length	Stores the setting of the #BY command; Setting are 0 to 100% (see #BY – Transmit Length)
42-43	Reserved	Reserved

Bottom Track High Resolution Velocity Format

BIT POSITIONS									
BYTE	7	6	5	4	3	2	1	0	
1.	BOTTOM TRACK HIGH RESOLUTION VELOCITY ID								LSB 03h
2.									MSB 58h
3.	BT VELOCITY 1								
4.									
5.									
6.									
7.	BT VELOCITY 2								
8.									
9.									
10.									
11.	BT VELOCITY 3								
12.									
13.									
14.									
15.	BT VELOCITY 4								
16.									
17.									
18.									
19.	BT DISTANCE MADE GOOD 1								
20.									
21.									
22.									
23.	BT DISTANCE MADE GOOD 2								
24.									
25.									
26.									
27.	BT DISTANCE MADE GOOD 3								
28.									
29.									
30.									

BYTE	BIT POSITIONS								
	7	6	5	4	3	2	1	0	
31.	BT DISTANCE MADE GOOD 4								
32.									
33.									
34.									
35.	WATER MASS VELOCITY 1								
36.									
37.									
38.									
39.	WATER MASS VELOCITY 2								
40.									
41.									
42.									
43.	WATER MASS VELOCITY 3								
44.									
45.									
46.									
47.	WATER MASS VELOCITY 4								
48.									
49.									
50.									
51.	WATER MASS DISTANCE MADE GOOD 1								
52.									
53.									
54.									
55.	WATER MASS DISTANCE MADE GOOD 2								
56.									
57.									
58.									
59.	WATER MASS DISTANCE MADE GOOD 3								
60.									
61.									
62.									

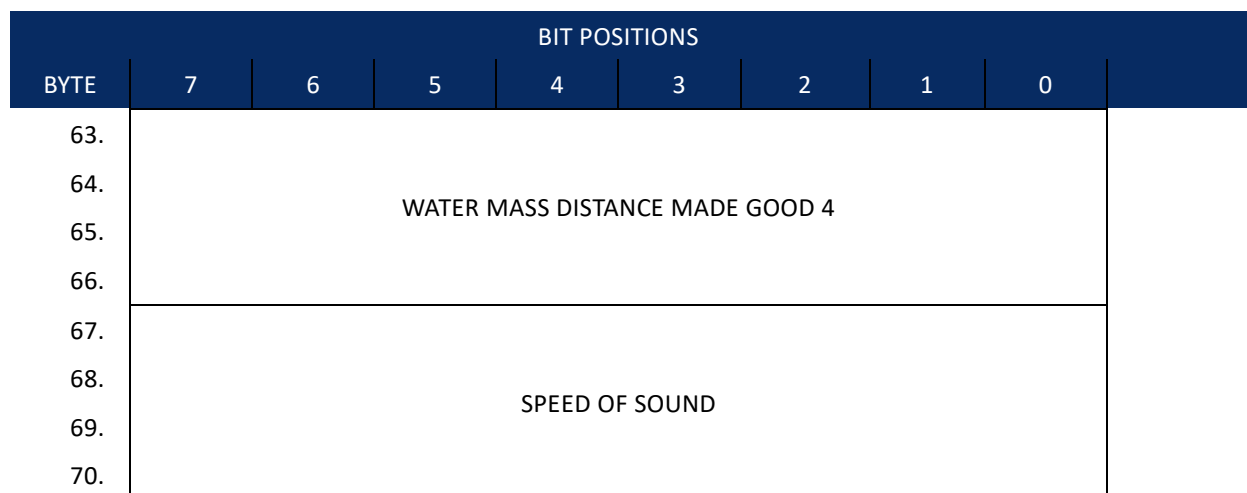


Figure 48. Bottom Track High Resolution Velocity Output Format



The sign of the bottom track and water mass layer velocities in the Bottom Track High Resolution Velocity Format indicate the direction the DVL or vessel is moving with respect to a stationary bottom and is the opposite sign of the velocities in the [Binary Bottom Track Data Format](#).

This format is selected via the #BJ command (see [BJ – Data Type Output Control](#)).

Table 42: Bottom Track High Resolution Velocity Output Format

Binary Byte	Field	Description
1-2	ID	PD0 ID (MSB=58h LSB=03h)
3-6	BT Velocity 1	Bottom Track Axis 1 Velocity in 0.01mm/s. Reference frame dependent on EX – Coordinate Transformation .
7-10	BT Velocity 2	Bottom Track Axis 2 Velocity in 0.01mm/s. Reference frame dependent on EX command.
11-14	BT Velocity 3	Bottom Track Axis 3 Velocity in 0.01mm/s. Reference frame dependent on EX command.
15-18	BT Velocity 4	Bottom Track Axis 4 Velocity in 0.01mm/s. Reference frame dependent on EX command.
19-22	BT DMG 1	Bottom Track Axis 1 Distance in 0.01mm made good. Reference frame dependent on EX command.
23-26	BT DMG 2	Bottom Track Axis 2 Distance in 0.01mm made good. Reference frame dependent on EX command.
27-30	BT DMG 3	Bottom Track Axis 3 Distance in 0.01mm made good. Reference frame dependent on EX command.
31-34	BT DMG 4	Bottom Track Axis 4 Distance in 0.01mm made good. Reference frame dependent on EX command.
35-38	WM Velocity 1	Water Mass Axis 1 Velocity in 0.01mm/s. Reference frame dependent on EX command.

Table 42: Bottom Track High Resolution Velocity Output Format

Binary Byte	Field	Description
39-42	WM Velocity 2	Water Mass Axis 2 Velocity in 0.01mm/s. Reference frame dependent on EX command.
43-46	WM Velocity 3	Water Mass Axis 3 Velocity in 0.01mm/s. Reference frame dependent on EX command.
47-50	WM Velocity 4	Water Mass Axis 4 Velocity in 0.01mm/s. Reference frame dependent on EX command.
51-54	WM DMG 1	Water Mass Axis 1 Distance in 0.01mm made good. Reference frame dependent on EX command.
55-58	WM DMG 2	Water Mass Axis 2 Distance in 0.01mm made good. Reference frame dependent on EX command.
59-62	WM DMG 3	Water Mass Axis 3 Distance in 0.01mm made good. Reference frame dependent on EX command.
63-66	WM DMG 4	Water Mass Axis 4 Distance in 0.01mm made good. Reference frame dependent on EX command.
67-70	SoS	Speed of Sound * 10 ⁶ .

Bottom Track Range Format

BYTE	BIT POSITIONS								
	7	6	5	4	3	2	1	0	
1.	BOTTOM TRACK RANGE ID								LSB 04h
2.									MSB 58h
3.	Slant Range								
4.									
5.									
6.									
7.	Axis Delta Range								
8.									
9.									
10.									
11.	Vertical Range								
12.									
13.									
14.									
15.	% Good 4 Bm								

BYTE	BIT POSITIONS							
	7	6	5	4	3	2	1	0
16.	% Good Bm 1&2							
17.	% Good Bm 3 & 4							
18.	BEAM 1 Raw Range							
19.								
20.								
21.								
22.	BEAM 2 Raw Range							
23.								
24.								
25.								
26.	BEAM 3 Raw Range							
27.								
28.								
29.								
30.	BEAM 4 Raw Range							
31.								
32.								
33.								
34.	BEAM 1 Raw Max BT Filter							
35.	BEAM 2 Raw Max BT Filter							
36.	BEAM 3 Raw Max BT Filter							
37.	BEAM 4 Raw Max BT Filter							
38.	BEAM 1 RAW MAX BT AMPLITUDE							
39.	BEAM 2 RAW MAX BT AMPLITUDE							
40.	BEAM 3 RAW MAX BT AMPLITUDE							
41.	BEAM 4 RAW MAX BT AMPLITUDE							

Figure 49. Bottom Track Range Output Data Format

This format is selected via the #BJ command (see [BJ – Data Type Output Control](#)).

Table 43: Bottom Track Range Output Data Format

Binary Bytes	Field	Description
1-2	ID	PD0 ID (MSB=58h LSB=04h)
3-6	Slant Range	Average range to bottom along the Z axis of the instrument frame, averaged over the ensemble. Valid only for at least 2 beams good on axis; zero is output for invalid data. Units are 0.1mm.
7-10	Axis Delta Range	Difference in slant range between beam 1 & 2 estimate and beam 3 & 4 estimate averaged over the ensemble. Valid only for 4 beam good pings. Units are 0.1mm.
11-14	Vertical Range	Average vertical range (altitude) of bottom depth (accounting for instrument tilt) over the ensemble. Zero is output if vertical range cannot be calculated because less than three beams are good, etc. Units are 0.1mm.
15	% Good 4 Bm	Percent Good 2 axis (4 Bm) slant range solutions.
16	% Good Bm 1&2	Percent Good axis Bm 1 & 2 slant range solutions.
17	% Good Bm 3 & 4	Percent Good axis Bm 3 & 4 slant range solutions.
18-21	BM 1 Raw Range	Slant range to the bottom along beam 1 multiplied by cos(Janus), averaged over the ensemble, even if fewer than 3 beams detect the bottom. Units 0.1mm
22-25	BM 2 Raw Range	Slant range to the bottom along beam 2 multiplied by cos(Janus), averaged over the ensemble, even if fewer than 3 beams detect the bottom. Units 0.1mm
26-29	BM 3 Raw Range	Slant range to the bottom along beam 3 multiplied by cos(Janus), averaged over the ensemble, even if fewer than 3 beams detect the bottom. Units 0.1mm
30-33	BM 4 Raw Range	Slant range to the bottom along beam [n] multiplied by cos(Janus), averaged over the ensemble, even if fewer than 3 beams detect the bottom. Units 0.1mm
34	BM 1 Raw Max BT Filter	Maximum Bottom detection filter output in counts averaged over the ensemble for beam 1 even if less than 3 beams detecting bottom.
35	BM 2 Raw Max BT Filter	Maximum Bottom detection filter output in counts averaged over the ensemble for beam 2 even if less than 3 beams detecting bottom.
36	BM 3 Raw Max BT Filter	Maximum Bottom detection filter output in counts averaged over the ensemble for beam 3 even if less than 3 beams detecting bottom.
37	BM 4 Raw Max BT Filter	Maximum Bottom detection filter output in counts averaged over the ensemble for beam 4 even if less than 3 beams detecting bottom.
38	BM 1 Raw Max BT Amp	Bottom amplitude at measured range in counts, averaged over the ensemble, for beam 1 even if fewer than 3 beams detect the bottom. Amplitude value corresponds to the middle of the bottom return.

Table 43: Bottom Track Range Output Data Format

Binary Bytes	Field	Description
39	BM 2 Raw Max BT Amp	Bottom amplitude at measured range in counts, averaged over the ensemble, for beam 2 even if fewer than 3 beams detect the bottom. Amplitude value corresponds to the middle of the bottom return.
40	BM 3 Raw Max BT Amp	Bottom amplitude at measured range in counts, averaged over the ensemble, for beam 3 even if fewer than 3 beams detect the bottom. Amplitude value corresponds to the middle of the bottom return.
41	BM 4 Raw Max BT Amp	Bottom amplitude at measured range in counts, averaged over the ensemble, for beam 4 even if fewer than 3 beams detect the bottom. Amplitude value corresponds to the middle of the bottom return.

Navigation Parameters Data Format

BYTE	BIT POSITIONS								
	7	6	5	4	3	2	1	0	
1	ID_NAV_PARAMS								LSB 13h
2									MSB 20h
3	TIME-TO-BOTTOM BEAM 1								LSB
4									
5									
6									MSB
7	TIME-TO-BOTTOM BEAM 2								LSB
8									
9									
10									MSB
11	TIME-TO-BOTTOM BEAM 3								LSB
12									
13									
14									MSB
15	TIME-TO-BOTTOM BEAM 4								LSB
16									
17									
18									MSB
19	BOTTOM TRACK STANDARD DEVIATION BEAM 1								LSB
20									MSB
21	BOTTOM TRACK STANDARD DEVIATION BEAM 2								LSB

BIT POSITIONS																									
BYTE	7	6	5	4	3	2	1	0																	
22									MSB																
23									BOTTOM TRACK STANDARD DEVIATION BEAM 3								LSB								
24	BOTTOM TRACK STANDARD DEVIATION BEAM 4																MSB								
25									SHALLOW OPERATION FLAG								LSB								
26	TIME-TO-WATER MASS LAYER BEAM 1																MSB								
27									TIME-TO-WATER MASS LAYER BEAM 2								LSB								
28																	TIME-TO-WATER MASS LAYER BEAM 3								MSB
29																									TIME-TO-WATER MASS LAYER BEAM 4
30	RANGE TO WATER MASS CELL																								
31									WATER TRACK STANDARD DEVIATION BEAM 1																
32																	WATER TRACK STANDARD DEVIATION BEAM 2								
33																									WATER TRACK STANDARD DEVIATION BEAM 3
34	WATER TRACK STANDARD DEVIATION BEAM 4																								
35																									
36																									
37																									
38																									
39																									
40																									
41																									
42																									
43																									
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49																									
50																									
51																									
52																									
53																									

BYTE	BIT POSITIONS								
	7	6	5	4	3	2	1	0	
54	BOTTOM TRACK TIME OF VALIDITY BEAM 1								LSB
55									
56									
57									MSB
58	BOTTOM TRACK TIME OF VALIDITY BEAM 2								LSB
59									
60									
61									MSB
62	BOTTOM TRACK TIME OF VALIDITY BEAM 3								LSB
63									
64									
65									MSB
66	BOTTOM TRACK TIME OF VALIDITY BEAM 4								LSB
67									
68									
69									MSB
70	WATER TRACK TIME OF VALIDITY BEAM 1								LSB
71									
72									
73									MSB
74	WATER TRACK TIME OF VALIDITY BEAM 2								LSB
75									
76									
77									MSB
78	WATER TRACK TIME OF VALIDITY BEAM 3								LSB
79									
80									
81									MSB
82	WATER TRACK TIME OF VALIDITY BEAM 4								LSB
83									
84									
85									MSB

Figure 50. Navigation Parameters Data Format

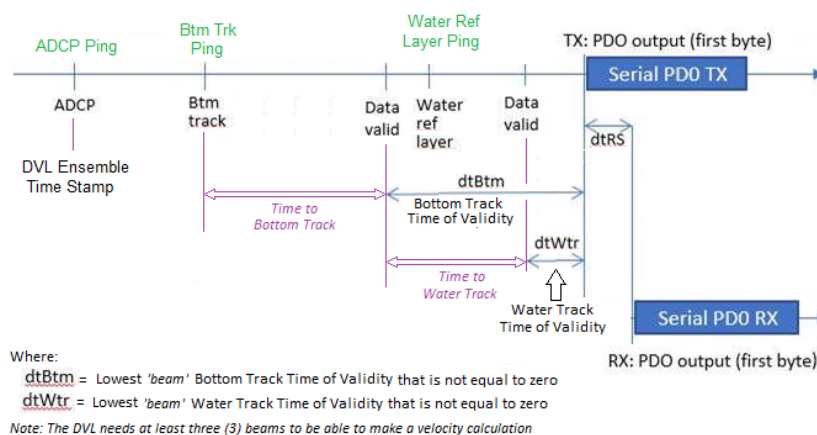
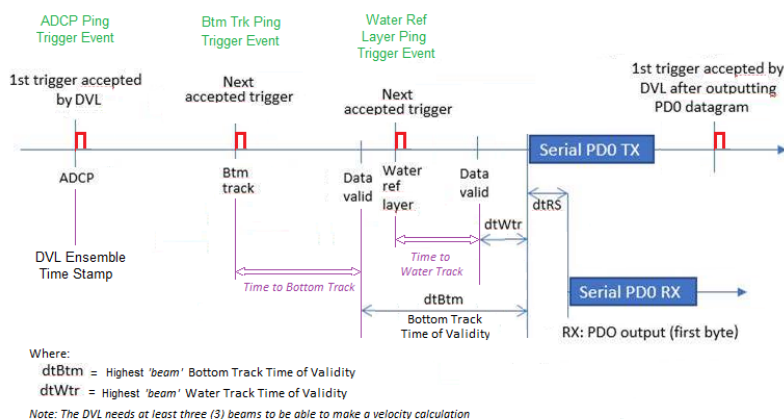
This data type is output when selecting PD0 and the High Accuracy Bottom Track feature is installed (see [OL – Display Feature List](#)) and then selected via the #BJ command (see [BJ – Data Type Output Control](#)).

Table 44. Navigation Parameters Data Format

Hex Digit	Binary Byte	Field	Description																
1-4	1, 2	ID_NAV_PARAMS / Navigation Parameters ID	Stores the navigation parameters identification word, ID_NAV_PARAMS, defined as (MSB=20h LSB=13h)																
5-36	3-18	TIME-TO-BOTTOM BEAMS 1-4	Stores T_{bot} , the time interval between the DVL Ensemble/hardware trigger and the center time, or “time the ping hits the bottom,” of the bottom track measurement for Beams 1-4 (see Figure 51 and Figure 52). Unit is 8 carrier cycles (52.08 μ s for 153.6 kHz). Unsigned integer.																
<table border="1"> <thead> <tr> <th>DVL Type</th><th>Frequency</th><th>Carrier Cycle</th><th>8 x Carrier Cycles</th></tr> </thead> <tbody> <tr> <td>600</td><td>614.4 KHz</td><td>1.628 uSec</td><td>13.02 uSec</td></tr> <tr> <td>300</td><td>307.2 KHz</td><td>3.255 uSec</td><td>26.04 uSec</td></tr> <tr> <td>150</td><td>153.6 KHz</td><td>6.510 uSec</td><td>52.08 uSec</td></tr> </tbody> </table>				DVL Type	Frequency	Carrier Cycle	8 x Carrier Cycles	600	614.4 KHz	1.628 uSec	13.02 uSec	300	307.2 KHz	3.255 uSec	26.04 uSec	150	153.6 KHz	6.510 uSec	52.08 uSec
DVL Type	Frequency	Carrier Cycle	8 x Carrier Cycles																
600	614.4 KHz	1.628 uSec	13.02 uSec																
300	307.2 KHz	3.255 uSec	26.04 uSec																
150	153.6 KHz	6.510 uSec	52.08 uSec																
37-52	19-26	BOTTOM TRACK STD DEVIATION BEAMS 1-4	Stores a prediction of the single ping bottom-track standard deviation calculated with the velocity variance model. Units are mm/sec.																
53	27	SHALLOW OPERATION FLAG	Stores the flag indicating whether the Pioneer is operating in shallow mode or not. If this value is set to 0, then the DVL is operating in BM8 Deep Mode (BM9) with all beams pinging at the same time. If this value is set to 1, then the DVL is operating in BM8 Shallow Mode (BM8) with one beam pinging at a time in sequence. If this value is set to 2, then the DVL is operating in Extended Range Tracking Mode (XRT) with all beams pinging at the same time.																
54-86	28-43	TIME-TO-WATER MASS BEAMS 1-4	Stores T_{wm} , the time interval between the hardware trigger (defined by the CX command) and the center time, or “time the ping hits the center of the water mass layer,” of the water mass measurement for Beams 1-4. Unit is 8 carrier cycles (52.08 μ s for 153.6 kHz). Unsigned integer.																
87-90	44-45	RANGE TO WATER MASS CELL	The range to the water mass cell being tracked. Units are in carrier cycles (6.51 μ s for 153.6 kHz).																
91-106	46-53	WATER TRACK STD DEVIATION BEAMS 1-4	Stores a prediction of the single ping water-track standard deviation calculated with the velocity variance model. Units are mm/sec.																

Table 44. Navigation Parameters Data Format

Hex Digit	Binary Byte	Field	Description
107-138	54-69	BOTTOM TRACK TIME OF VALIDITY BEAMS 1-4	Stores the time elapsed between when the bottom track echo is centered on the bottom and the first character in the PDO sentence. Unit is 1μsec. Accuracy is within ± 5msec. Unsigned integer. Note the value will be set to zero if the bottom track velocity for the corresponding beam is bad.
139-170	70-85	WATER TRACK TIME OF VALIDITY BEAMS 1-4	Stores the time elapsed between when the water mass layer echo is centered on the tracking bin and the first character in the PDO sentence. Unit is 1μsec. Accuracy is within ± 5msec. Unsigned integer. Note the value will be set to zero if the bottom track velocity for the corresponding beam is bad.

**Figure 51. No Trigger Timing****Figure 52. External Trigger Timing**

Sensor Source for Doppler Processing Format

BIT POSITIONS									
BYTE	7	6	5	4	3	2	1	0	
1.	SENSOR SOURCE FOR DOPPLER PROCESSING FORMAT ID								LSB 01h
2.									MSB 30h
3.	HEADING								
4.									
5.									
6.									
7.	HEADING STATUS								
8.	HEADING SOURCE								
9.									
10.	PITCH								
11.									
12.									
13.									
14.	PITCH STATUS								
15.	PITCH SOURCE								
16.									
17.	ROLL								
18.									
19.									
20.									
21.	ROLL STATUS								
22.	ROLL SOURCE								
23.									
24.	SOS								
25.									
26.									
27.									
28.	SOS STATUS								
29.	SOS SOURCE								
30.									

BIT POSITIONS								
BYTE	7	6	5	4	3	2	1	0
31.	TEMPERATURE							
32.								
33.								
34.								
35.	TEMPERATURE STATUS							
36.	TEMPERATURE SOURCE							
37.								
38.	SALINITY							
39.								
40.								
41.								
42.	SALINITY STATUS							
43.	SALINITY SOURCE							
44.								
45.	DEPTH							
46.								
47.								
48.								
49.	DEPTH STATUS							
50.	DEPTH SOURCE							
51.								
52.	PRESSURE							
53.								
54.								
55.								
56.	PRESSURE STATUS							
57.	PRESSURE SOURCE							
58.								
59.	ENSEMBLE TIMER TICKS							
60.								
61.								
62.								

This format is selected via the #EE command (see [EE - Environmental Data Output](#)).

Table 45: Sensor Source for Doppler Processing Output Format

Binary Bytes	Field	Description
1-2	ID	PD0 ID (MSB=30h LSB=01h)
3-6	Heading	Heading in 1/100ths of a degree.
7	Heading Status	A value of 0 indicates no valid data; 1 indicates sensor data valid from sensor specified by EZ - Sensor Source ; A value of 2 indicates sensor data valid from alternate sensor or user input.
8-9	Heading Source	See notes, below.
10-13	Pitch	Pitch in 1/100ths of a degree.
14	Pitch Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
15-16	Pitch Source	See notes, below.
17-20	Roll	Roll in 1/100ths of a degree.
21	Roll Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
22-23	Roll Source	See notes, below.
24-27	SOS	Speed of Sound 1/100ths of a m/s.
28	SOS Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
29-30	SOS Source	See notes, below.
31-34	Temperature	Temperature in 1/100ths of a °C.
35	Temperature Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
36-37	Temperature Source	See notes, below.
38-41	Salinity	Salinity in parts-per-ten thousand
42	Salinity Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
43-44	Salinity Source	See notes, below.
45-48	Depth	Depth in centimeters
49	Depth Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.

Table 45: Sensor Source for Doppler Processing Output Format

Binary Bytes	Field	Description
50-51	Depth Source	See notes, below.
52-55	Pressure	Pressure in kPa.
56	Pressure Status	A value of 0 indicates no valid data; A value of 1 indicates sensor data valid from sensor specified by EZ; A value of 2 indicates sensor data valid from alternate sensor or user input.
57-58	Pressure Source	See notes, below.
59-62	Ensemble Timer Ticks	Timer Ticks Recorded when the RTC clock was read at the start of the ensemble. Intended for use in matching sensor TimeTags to RTC based ensemble time.



This data corresponds to the last ping of the ensemble for those sensors sampled at ping intervals. It is intended for single ping ensembles.

Output of this data is controlled by the 7th bit of the EE command ([EE - Environmental Data Output](#)).

The sensor source is identified by the detailed list of sensors in the table of the main text or the #EY description ([EY – Sensor Source Override for Doppler Parameters](#)). In addition to the sensors in that command, a sensor ID of -1 indicates that the parameter has been calculated based on other parameters (for example, speed of sound calculated based on salinity, pressure and temperature). A sensor ID of 0 indicates the parameter is from a user input command.

SBG AHRS Sensor Data Format

This output combines all system status data, divided into six categories: General, Clock, Communications, Aiding, Solution and Heave. This log is useful for advanced status information. The [SD command](#) enables and disables this output.

Table 46: SBG Status Data

Length in Bytes	Field	Description
2	ID	2-byte Data Type ID (MSB=54h LSB=1Ch)
4	TIME STAMP	Time since sensor is powered up, in microseconds
2	GENERAL STATUS	General status bitmask and enums (see Table 47)
2	RESERVED_0	Reserved field for backward compatibility
4	COM STATUS	Communication status bitmask and enums (see Table 48)
4	AID STATUS	Aiding equipments status bitmask and enums (see Table 50)
4	RESERVED_1	Reserved field for backward compatibility
2	RESERVED	Reserved field for future use

Table 47. GENERAL_STATUS Definition

Bit	Name	Type	Description
0	SBG_ECOM_GENERAL_MAIN_POWER_OK	Mask	Set to 1 when main power supply is OK.
1	SBG_ECOM_GENERAL_IMU_POWER_OK	Mask	Set to 1 when IMU power supply is OK.
2	SBG_ECOM_GENERAL_GPS_POWER_OK	Mask	Set to 1 when GPS power supply is OK.
3	SBG_ECOM_GENERAL_SETTINGS_OK	Mask	Set to 1 if settings were correctly loaded.
4	SBG_ECOM_GENERAL_TEMPERATURE_OK	Mask	Set to 1 when temperature is within specified limits.

Table 48. COM_STATUS Definition

Bit	Name	Type	Description
0	SBG_ECOM_PORTA_VALID	Mask	Set to 0 in case of low level communications error.
1	SBG_ECOM_PORTB_VALID	Mask	Set to 0 in case of low level communications error.
2	SBG_ECOM_PORTC_VALID	Mask	Set to 0 in case of low level communications error.
3	SBG_ECOM_PORTD_VALID	Mask	Set to 0 in case of low level communications error.
4	SBG_ECOM_PORTE_VALID	Mask	Set to 0 in case of low level communications error.
5	SBG_ECOM_PORTA_RX_OK	Mask	Set to 0 in case of saturation on PORT A input.
6	SBG_ECOM_PORTA_TX_OK	Mask	Set to 0 in case of saturation on PORT A output.
7	SBG_ECOM_PORTB_RX_OK	Mask	Set to 0 in case of saturation on PORT B input.
8	SBG_ECOM_PORTB_TX_OK	Mask	Set to 0 in case of saturation on PORT B output.
9	SBG_ECOM_PORTC_RX_OK	Mask	Set to 0 in case of saturation on PORT C input.
10	SBG_ECOM_PORTC_TX_OK	Mask	Set to 0 in case of saturation on PORT C output.
11	SBG_ECOM_PORTD_RX_OK	Mask	Set to 0 in case of saturation on PORT D input.
12	SBG_ECOM_PORTD_TX_OK	Mask	Set to 0 in case of saturation on PORT D output.
25	SBG_ECOM_CAN_RX_OK	Mask	Set to 0 in case of saturation on CAN Bus output buffer
26	SBG_ECOM_CAN_TX_OK	Mask	Set to 0 in case of saturation on CAN Bus input buffer
27-29	SBG_ECOM_CAN_BUS	Enum	Define the CAN Bus status (see Table 49)

Table 49. CAN_BUS Status Definition

Value	Name	Description
0	SBG_ECOM_CAN_BUS_OFF	Bus OFF operation due to too many errors.
1	SBG_ECOM_CAN_BUS_TX_RX_ERR	Transmit or receive error.
2	SBG_ECOM_CAN_BUS_OK	The CAN bus is working correctly.
3	SBG_ECOM_CAN_BUS_ERROR	A general error has occurred on the CAN bus.

Table 50. AIDING_STATUS Definition

Bit	Name	Type	Description
0	SBG_ECOM_AIDING_GPS1_POS_RECV	Mask	Set to 1 when valid GPS 1 position data is received.
1	SBG_ECOM_AIDING_GPS1_VEL_RECV	Mask	Set to 1 when valid GPS 1 velocity data is received.
2	SBG_ECOM_AIDING_GPS1_HDT_RECV	Mask	Set to 1 when valid GPS 1 true heading data is received.
3	SBG_ECOM_AIDING_GPS1_UTC_RECV	Mask	Set to 1 when valid GPS 1 UTC time data is received.
8	SBG_ECOM_AIDING_MAG_RECV	Mask	Set to 1 when valid Magnetometer data is received.
9	SBG_ECOM_AIDING_ODO_RECV	Mask	Set to 1 when Odometer pulse is received.
10	SBG_ECOM_AIDING_DVL_RECV	Mask	Set to 1 when valid DVL data is received.

Provides accelerometers, gyros, delta angles and delta velocities data directly from the IMU. The [SD command](#) enables and disables this output.

Table 51: SBG IMU DATA

Length in Bytes	Field	Description
2	ID	2-byte Data Type ID (MSB=54h LSB=1Dh)
2	TIME_STAMP	Time since sensor is powered up in microseconds
4	IMU_STATUS	IMU Status bitmask (see Table 52)
4	ACCEL_X	Filtered Accelerometer – X axis in m/s^2 (lsb = 1E-6)
4	ACCEL_Y	Filtered Accelerometer – Y axis in m/s^2 (lsb = 1E-6)
4	ACCEL_Z	Filtered Accelerometer – Z axis in m/s^2 (lsb = 1E-6)
4	GYRO_X	Filtered Gyroscope – X axis in rad/s (lsb = 1E-6)
4	GYRO_Y	Filtered Gyroscope – Y axis in rad/s (lsb = 1E-6)
4	GYRO_Z	Filtered Gyroscope – Z axis in rad/s (lsb = 1E-6)
4	TEMP	Internal Temperature in °C (lsb = 1E-6)
4	DELTA_VEL_X	Sculling output – X axis in m/s^2 (lsb = 1E-6)
4	DELTA_VEL_Y	Sculling output – Y axis in m/s^2 (lsb = 1E-6)
4	DELTA_VEL_Z	Sculling output – Z axis in m/s^2 (lsb = 1E-6)
4	DELTA_ANGLE_X	Coning output – X axis rad/s (lsb = 1E-6)
4	DELTA_ANGLE_Y	Coning output – Y axis in rad/s (lsb = 1E-6)
4	DELTA_ANGLE_Z	Coning output – Z axis in rad/s (lsb = 1E-6)

Table 52. IMU_STATUS Definition

Bit	Name	Description
0	SBG_ECOM_IMU_COM_OK	Set to 1 if the communication with the IMU is ok.
1	SBG_ECOM_IMU_STATUS_BIT	Set to 1 if internal IMU passes Built In Test (Calibration, CPU)
2	SBG_ECOM_IMU_ACCEL_X_BIT	Set to 1 if accelerometer X passes Built In Test
3	SBG_ECOM_IMU_ACCEL_Y_BIT	Set to 1 if accelerometer Y passes Built In Test
4	SBG_ECOM_IMU_ACCEL_Z_BIT	Set to 1 if accelerometer Z passes Built In Test
5	SBG_ECOM_IMU_GYRO_X_BIT	Set to 1 if gyroscope X passes Built In Test
6	SBG_ECOM_IMU_GYRO_Y_BIT	Set to 1 if gyroscope Y passes Built In Test
7	SBG_ECOM_IMU_GYRO_Z_BIT	Set to 1 if gyroscope Z passes Built In Test
8	SBG_ECOM_IMU_ACCELS_IN_RANGE	Set to 1 if accelerometers are within operating range
9	SBG_ECOM_IMU_GYROS_IN_RANGE	Set to 1 if gyroscopes are within operating range

Provides computed orientation in Euler angles format. The [SD command](#) enables and disables this output.

Table 53: SBG Euler Data

Length in Bytes	Field	Description
2	ID	2-byte Data Type ID (MSB=54h LSB=1Eh)
4	TIME_STAMP	Time since sensor is powered up in microseconds
4	ROLL	Roll angle in radians (LSB = 1E-6)
4	PITCH	Pitch angle in radians (LSB = 1E-6)
4	YAW	Yaw angle (heading) in radians (LSB = 1E-6)
4	ROLL_ACC	1 σ Roll angle accuracy in radians (LSB = 1E-6)
4	PITCH_ACC	1 σ Pitch angle accuracy in radians (LSB = 1E-6)
4	YAW_ACC	1 σ Yaw angle accuracy in radians (LSB = 1E-6)
4	SOLUTION_STATU S	Global solution status. See SOLUTION_STATUS definition for more details.

Table 54. SOLUTION_STATUS Definition

Bit	Name	Description
0-3	SBG_ECOM_SOLUTION_MODE	Defines the Kalman filter computation mode (see Table 55).
4	SBG_ECOM_SOL_ATTITUDE_VALID	Set to 1 if Attitude data is reliable (Roll/Pitch error < 0.5 deg)
5	SBG_ECOM_SOL_HEADING_VALID	Set to 1 if Heading data is reliable (error < 1 deg)
6	SBG_ECOM_SOL_VELOCITY_VALID	Set to 1 if Velocity data is reliable (velocity error < 1.5 m/s)
7	SBG_ECOM_SOL_POSITION_VALID	Set to 1 if Position data is reliable (position error < 10 m)
8	SBG_ECOM_SOL_VERT_REF_USED	Set to 1 if vertical reference is used in solution
9	SBG_ECOM_SOL_MAG_REF_USED	Set to 1 if magnetometer is used in solution
10	SBG_ECOM_SOL_GPS1_VEL_USED	Set to 1 if GPS1 velocity is used in solution
11	SBG_ECOM_SOL_GPS1_POS_USED	Set to 1 if GPS1 position is used in solution
12	SBG_ECOM_SOL_GPS1_COURSE_USED	Set to 1 if GPS1 course is used in solution
13	SBG_ECOM_SOL_GPS1_HDT_USED	Set to 1 if GPS1 true heading is used in solution
14	SBG_ECOM_SOL_GPS2_VEL_USED	Set to 1 if GPS2 velocity heading is used in solution
15	SBG_ECOM_SOL_GPS2_POS_USED	Set to 1 if GPS2 position is used in solution
16	SBG_ECOM_SOL_GPS2_COURSE_USED	Set to 1 if GPS2 course is used in solution
17	SBG_ECOM_SOL_GPS2_HDT_USED	Set to 1 if GPS2 true heading is used in solution
18	SBG_ECOM_SOL_ODO_USED	Set to 1 if Odometer is used in solution

Table 55. SOLUTION_MODE Definition

Value	Name	Description
0	SBG_ECOM_SOL_MODE_UNINITIALIZED	The Kalman filter is not initialized and the returned; data are all invalid.
1	SBG_ECOM_SOL_MODE_VERTICAL_GYRO	The Kalman filter only relies on a vertical reference to compute roll and pitch angles. Heading and navigation data drift freely.
2	SBG_ECOM_SOL_MODE_AHRS	A heading reference is available, the Kalman filter provides full orientation but navigation data drift freely.
3	SBG_ECOM_SOL_MODE_NAV_VELOCITY	The Kalman filter computes orientation and velocity. Position is freely integrated from velocity estimation
4	SBG_ECOM_SOL_MODE_NAV_POSITION	Nominal mode, the Kalman filter computes all parameters (attitude, velocity, position). Absolution position is provided.

Provides ship motion data (heave), velocity and accelerations. The [SD command](#) enables and disables this output.

Table 56: SBG Ship Motion Data

Length in Bytes	Field	Description
2	ID	2-byte Data Type ID (MSB=54h LSB=1Fh)
4	TIME_STAMP	Time since sensor is powered up in microseconds
4	HEAVE_PERIOD	Main heave period in seconds (LSB = 1E-6)
4	SURGE	Surge at main location in meters (LSB = 1E-6). Fixed to 0
4	SWAY	Sway at main location in meters (LSB = 1E-6). Fixed to 0
4	HEAVE	Heave at main location (positive down), in meters (LSB = 1E-6)
4	ACCEL_X	Longitudinal acceleration in m/s ² (LSB = 1E-6). Fixed to 0
4	ACCEL_Y	Lateral acceleration in m/s ² (LSB = 1E-6). Fixed to 0
4	ACCEL_Z	Vertical acceleration (positive down) in m/s ² (LSB = 1E-6).
4	VEL_X	Longitudinal velocity in m/s (LSB = 1E-6). Fixed to 0
4	VEL_Y	Lateral velocity in m/s (LSB = 1E-6). - Fixed to 0
4	VEL_Z	Vertical velocity (positive down), in m/s (LSB = 1E-6)
2	STATUS	Ship motion output status (see Table 57).

Table 57. Ship Motion STATUS Definition

Bit	Name	Description
0	SBG_ECOM_HEAVE_VALID	Set to 1 after heave convergence time. Set to 0 in following conditions: <ul style="list-style-type: none"> - Turn occurred and no velocity aiding is available - Heave reached higher/lower limits - If a step is detected and filter has to re-converge - If internal failure
1	SBG_ECOM_HEAVE_VEL_AIDED	Set to 1 if heave output is compensated for transient accelerations
3	SBG_ECOM_PERIOD_AVAILABLE	Set to 1 if the swell period is provided in this output
4	SBG_ECOM_PERIOD_VALID	Set to 1 if the period returned is assumed to be valid

Binary Checksum Data Format

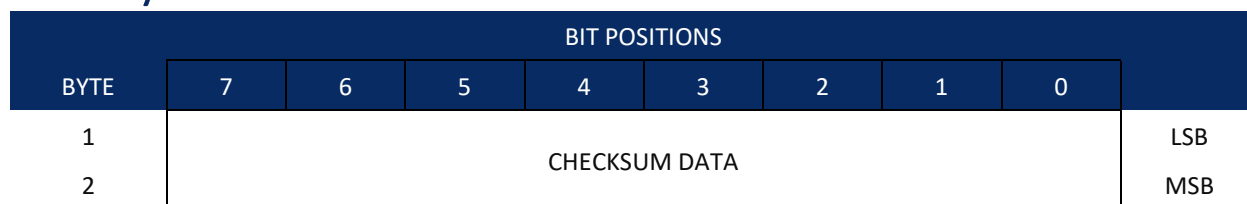


Figure 53. Binary Checksum Data Format

Table 58: Checksum Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Checksum Data	<p>This field contains a modulo 65536 checksum. If the sum is 12345678, then it is divided by 65536, and the remainder is output; For example, $12345678 / 65536 = 188.3800964 = 188 + 24910/65536$, so the number 24910, converted to hex as 614E would be output.</p> <p>An easier way to compute the checksum is using the sum 12345678; converted to hex it is the number 00BC614E. The least-significant four hex digits are output; i.e. 614E.</p>

Special Output Data Formats

The PD4, PD5 and PD6 commands select the desired Pioneer (speed log) output data format.

The Pioneer binary output data buffers can contain header, configuration, bottom-velocity, water-mass reference-layer, range to bottom, status, built-in test, sensor, and distance made good data (plus a checksum). The Pioneer collects all data in the output buffer during an ensemble.

Figure 38 through Figure 39 shows the format of these buffers and the sequence in which the Pioneer sends the data. Table 59 through Table 62 lists the format, bytes, fields, scaling factors, and a detailed description of every item in the Pioneer binary output buffers.



The Pioneer output data formats are available with or without bottom-track. However, if bottom-track is not available, they will contain no data.



The PD0 [Bottom Track output data format](#) assumes that the instrument is stationary and the bottom is moving.

- If Beam 3 is going forward, then the Y velocity is negative.
- If Beam 2 is going forward, then X velocity is negative.
- If the bottom is going towards the face of a down facing DVL, then Z is positive.

The [PD0 Bottom Track High Resolution Velocity Output](#) (velocity in 0.01mm/s) and PD3 through PD6 data formats assume that the bottom is stationary and that the DVL or vessel is moving.

- If Beam 3 is going forward, then the Y velocity is positive.
- If Beam 2 is going forward, then X velocity is positive.
- If the bottom is going towards the face of a down facing DVL, then Z is negative.



For more information on coordinate transformations, see [Beam Coordinate Systems](#), page 27.

Pioneer Binary Data Format (PD4/PD5)

Byte	BIT POSITION							
	7	6	5	4	3	2	1	0
1	Pioneer DATA ID 7Dh							
2	DATA STRUCTURE*							
3	NO. OF BYTES							LSB
4								MSB
5	SYSTEM CONFIG							
6	X-VEL BTM							LSB
7								MSB
8	Y-VEL BTM							LSB
9								MSB
10	Z-VEL BTM							LSB
11								MSB
12	E-VEL BTM							LSB
13								MSB
14	BM1 RNG TO BTM							LSB
15								MSB
16	BM2 RNG TO BTM							LSB
17								MSB
18	BM3 RNG TO BTM							LSB
19								MSB
20	BM4 RNG TO BTM							LSB
21								MSB
22	BOTTOM STATUS							
23	X-VEL REF LAYER							LSB
24								MSB
25	Y-VEL REF LAYER							
26								
27	Z-VEL REF LAYER							

Byte	BIT POSITION							
	7	6	5	4	3	2	1	0
28								
29	E-VEL REF LAYER							
30								
31	REF LAYER START							
32								
33	REF LAYER END							
34								
35	REF LAYER STATUS							
36	TOFP-HOUR							
37	TOFP-MINUTE							
38	TOFP-SECOND							
39	TOFP-HUNDREDTHS							
40	BIT RESULTS							
41								
42	SPEED OF SOUND							
43								
44	TEMPERATURE							
45								
46	CHECKSUM							
47								

Figure 54. Pioneer Binary Data Format (PD4/PD5)



*IF 0, THEN PD4 (BYTES 1-47)

*IF 1, THEN PD5 (BYTES 1-45 + Table 59)

Pioneer Output Data Format (PD4/PD5) Details

The Pioneer sends this data format only when the PD4 or PD5 command is used.

Table 59: Pioneer Output Data Format (PD4/PD5) Details

Hex Digit	Binary Byte	Field	Description																														
1,2	1	Pioneer Data ID	Stores the Pioneer (speed log) identification word (7Dh).																														
3,4	2	Data Structure	Identifies which data pattern will follow based on the PD-command (PD0 Output Data Format). 0 = PD4 = Bytes 1 through 47 from Figure 38. 1 = PD5 = Bytes 1 through 45 from Figure 38 and bytes 46 through 88 from Figure 39.																														
5-8	3,4	No. of Bytes	Contains the number of bytes sent in this data structure, not including the final checksum.																														
9,10	5	System Config	Defines the Pioneer hardware/firmware configuration. Convert to binary and interpret as follows. BIT 76543210 00xxxxxx BEAM-COORDINATE VELOCITIES 01xxxxxx INSTRUMENT-COORDINATE VELOCITIES 10xxxxxx SHIP-COORDINATE VELOCITIES 11xxxxxx EARTH-COORDINATE VELOCITIES xx0xxxxx TILT INFORMATION NOT USED IN CALCULATIONS xx1xxxxx TILT INFORMATION USED IN CALCULATIONS xxx0xxxx 3-BEAM SOLUTIONS NOT COMPUTED xxx1xxxx 3-BEAM SOLUTIONS COMPUTED xxxxx001 150-kHz Pioneer xxxxx010 300-kHz Pioneer xxxxx011 600-kHz Pioneer xxxxx100 1200-kHz Pioneer																														
11-14	6,7	X-Vel Btm	These fields contain the velocity of the vessel in relation to the bottom in mm/s. The setting of the EX-command (Coordinate Transformation) determines how the Pioneer references the velocity data .																														
15-18	8,9	Y-Vel Btm																															
19-22	10,11	Z-Vel Btm																															
23-26	12,13	E-Vel Btm																															
			<table><tr><th>EX-CMD</th><th>COORD SYS</th><th>Velocity 1</th><th>Velocity 2</th><th>Velocity 3</th><th>Velocity 4</th></tr><tr><td>xxx00xxx</td><td>Beam</td><td>To Beam 1</td><td>To Beam 2</td><td>To Beam 3</td><td>To Beam 4</td></tr><tr><td>xxx01xxx</td><td>Instrument</td><td>Bm1-Bm2</td><td>Bm4-Bm3</td><td>To Xducer</td><td>Err Vel</td></tr><tr><td>xxx10xxx</td><td>Ship</td><td>Port-Stbd</td><td>Aft-Fwd</td><td>To Surface</td><td>Err Vel</td></tr><tr><td>xxx11xxx</td><td>Earth</td><td>To East</td><td>To North</td><td>To Surface</td><td>Err Vel</td></tr></table> Positive values indicate water movement.	EX-CMD	COORD SYS	Velocity 1	Velocity 2	Velocity 3	Velocity 4	xxx00xxx	Beam	To Beam 1	To Beam 2	To Beam 3	To Beam 4	xxx01xxx	Instrument	Bm1-Bm2	Bm4-Bm3	To Xducer	Err Vel	xxx10xxx	Ship	Port-Stbd	Aft-Fwd	To Surface	Err Vel	xxx11xxx	Earth	To East	To North	To Surface	Err Vel
EX-CMD	COORD SYS	Velocity 1	Velocity 2	Velocity 3	Velocity 4																												
xxx00xxx	Beam	To Beam 1	To Beam 2	To Beam 3	To Beam 4																												
xxx01xxx	Instrument	Bm1-Bm2	Bm4-Bm3	To Xducer	Err Vel																												
xxx10xxx	Ship	Port-Stbd	Aft-Fwd	To Surface	Err Vel																												
xxx11xxx	Earth	To East	To North	To Surface	Err Vel																												
27-30	14,15	Bm1	These fields contain the vertical range from the Pioneer to the bottom as determined by each beam. This vertical range does not compensate for the effects of pitch and roll. When a bottom detection is bad, the field is set to zero. Scaling: LSD = 1 decimeter; Range = 0 to 65535 dm (300, 600, and 150 kHz)																														
31-34	16,17	Bm2 Rng to																															
35-38	18,19	Bm3 Bottom																															
39-42	20,21	Bm4																															

Table 59: Pioneer Output Data Format (PD4/PD5) Details

Hex Digit	Binary Byte	Field	Description																														
43,44	22	Bottom Status	<p>This field shows the status of bottom-referenced correlation and echo amplitude data. Convert to binary and interpret as follows. A zero code indicates status is OK.</p> <p>BIT 76543210</p> <p>1xxxxxxx BEAM 4 LOW ECHO AMPLITUDE</p> <p>x1xxxxxx BEAM 4 LOW CORRELATION</p> <p>xx1xxxxx BEAM 3 LOW ECHO AMPLITUDE</p> <p>xxx1xxxx BEAM 3 LOW CORRELATION</p> <p>xxxx1xxx BEAM 2 LOW ECHO AMPLITUDE</p> <p>xxxxx1xx BEAM 2 LOW CORRELATION</p> <p>xxxxxx1x BEAM 1 LOW ECHO AMPLITUDE</p> <p>xxxxxxx1 BEAM 1 LOW CORRELATION</p>																														
45-48	23,24	Velocity 1	<p>These fields contain the velocity of the vessel in relation to the water-mass reference layer in mm/s. The setting of the EX-command (Coordinate Transformation) determines how the Pioneer references the velocity data.</p> <table><thead><tr><th>EX-CMD</th><th>COORD SYS</th><th>Velocity 1</th><th>Velocity 2</th><th>Velocity 3</th><th>Velocity 4</th></tr></thead><tbody><tr><td>xxx00xxx</td><td>Beam</td><td>To Beam 1</td><td>To Beam 2</td><td>To Beam 3</td><td>To Beam 4</td></tr><tr><td>xxx01xxx</td><td>Instrument</td><td>Bm1-Bm2</td><td>Bm4-Bm3</td><td>To Xducer</td><td>Err Vel</td></tr><tr><td>xxx10xxx</td><td>Ship</td><td>Port-Stbd</td><td>Aft-Fwd</td><td>To Surface</td><td>Err Vel</td></tr><tr><td>xxx11xxx</td><td>Earth</td><td>To East</td><td>To North</td><td>To Surface</td><td>Err Vel</td></tr></tbody></table> <p>Positive values indicate water movement (see notes at end of this table).</p>	EX-CMD	COORD SYS	Velocity 1	Velocity 2	Velocity 3	Velocity 4	xxx00xxx	Beam	To Beam 1	To Beam 2	To Beam 3	To Beam 4	xxx01xxx	Instrument	Bm1-Bm2	Bm4-Bm3	To Xducer	Err Vel	xxx10xxx	Ship	Port-Stbd	Aft-Fwd	To Surface	Err Vel	xxx11xxx	Earth	To East	To North	To Surface	Err Vel
EX-CMD	COORD SYS	Velocity 1		Velocity 2	Velocity 3	Velocity 4																											
xxx00xxx	Beam	To Beam 1		To Beam 2	To Beam 3	To Beam 4																											
xxx01xxx	Instrument	Bm1-Bm2		Bm4-Bm3	To Xducer	Err Vel																											
xxx10xxx	Ship	Port-Stbd	Aft-Fwd	To Surface	Err Vel																												
xxx11xxx	Earth	To East	To North	To Surface	Err Vel																												
49-52	25,26	Velocity 2																															
53-56	27,28	Velocity 3																															
57-60	29,30	Velocity 4																															
61-64	31,32	Ref Layer Start	<p>These fields contain the starting boundary (near surface) and the ending boundary (near bottom) of the water-mass layer (BL-command). If the minimum size field is zero, the Pioneer does not calculate water mass data.</p> <p>Scaling: LSD = 1 dm; Range = 0-9999 dm</p>																														
65-68	33,34	Ref Layer End																															
69,70	35	Ref Layer Status	<p>This field shows the status of water mass depth and correlation data. Convert to binary and interpret as follows. A zero code indicates status is OK.</p> <p>BIT 76543210</p> <p>xxx1xxxx ALTITUDE IS TOO SHALLOW</p> <p>xxxx1xxx BEAM 4 LOW CORRELATION</p> <p>xxxxx1xx BEAM 3 LOW CORRELATION</p> <p>xxxxxx1x BEAM 2 LOW CORRELATION</p> <p>xxxxxxx1 BEAM 1 LOW CORRELATION</p>																														
71,72	36	TOFP Hour	<p>These fields contain the time of the first ping of the current ensemble.</p>																														
73,74	37	TOFP Minute																															
75,76	38	TOFP Second																															
77,78	39	TOFP Hundredth																															

Table 59: Pioneer Output Data Format (PD4/PD5) Details

Hex Digit	Binary Byte	Field	Description
79-82	40,41	BIT Results	<p>Status for leak sensors</p> <pre> BITS 07 06 05 04 03 02 01 00 x x x x x x x 1 Sensor A leak detected x x x x x x 1 x Sensor A open circuit x x x x x 1 x x Sensor B leak detected x x x x 1 x x x Sensor B open circuit </pre> <p>Upper byte (byte 41) is unused</p>
83-86	42,43	Speed of Sound	<p>Contains either manual or calculated speed of sound information (EC - Speed of Sound).</p> <p>Scaling: LSD = 1 meter per second; Range = 1400 to 1600 m/s</p>
87-90	44,45	Temperature	<p>Contains the temperature of the water at the transducer head.</p> <p>Scaling: LSD = 0.01 C; Range = -5.00 to +40.00 C</p>
91-94	46,47	Checksum	<p>This field contains a modulo 65536 checksum. The Pioneer computes the checksum by summing all the bytes in the output buffer excluding the checksum. NOTE: This field contains the checksum only when the PD4-command is used. If PD5 is used, the remaining bytes are explained in Table 60.</p>



The Pioneer packs velocity data into a two-byte, two's-complement integer [-32768, 32767] with the LSB sent first. The Pioneer scales velocity data in millimeters per second (mm/s). A value of -32768 (8000h) indicates a bad velocity.

Bottom or reference-layer velocities will be all valid or all invalid. That is, if the X-velocity is valid then the Y and Z-velocities are valid; if X is not valid, Y and Z are not valid.

The Pioneer allows 3-beam transformations when the fourth beam is invalid. If a 3-beam solution is output, the error velocity will be marked bad (since it can't be computed without four good beams). This is how you can tell, as all transformed velocity outputs include error velocity. However, there won't be any indication of which beam was bad.

Pioneer Binary Data Format (PD5)

Byte	BIT POSITION								
	7	6	5	4	3	2	1	0	
46	SALINITY								
47	DEPTH								LSB
48									MSB
49	PITCH								LSB
50									MSB
51	ROLL								LSB
52									MSB
53	HEADING								LSB
54									MSB
55	DISTANCE MADE GOOD/BTM (EAST)								LSB
56									
57									
58									MSB
59	DISTANCE MADE GOOD/BTM (NORTH)								LSB
60									
61									
62									MSB
63	DISTANCE MADE GOOD/BTM (UP)								LSB
64									
65									
66									MSB
67	DISTANCE MADE GOOD/BTM (ERROR)								LSB
68									
69									
70									MSB
71	DISTANCE MADE GOOD/REF (EAST)								LSB
72									
73									
74									MSB

BIT POSITION								
Byte	7	6	5	4	3	2	1	0
75	DISTANCE MADE GOOD/REF (NORTH)							LSB
76								
77								
78								MSB
79	DISTANCE MADE GOOD/REF (UP)							LSB
80								
81								
82								MSB
83	DISTANCE MADE GOOD/REF (ERROR)							LSB
84								
85								
86								MSB
87	CHECKSUM							LSB
88								MSB

Figure 55. Pioneer Binary Data Format (PD5)

Pioneer Output Data Format (PD5) Details

The Pioneer sends this data format (Figure 38 and Figure 39) only when the PD5 command is used. Table 59 explains the first part of this data structure.

Table 60: Pioneer Output Data Format (PD5) Details

Hex Digit	Binary Byte	Field	Description
91,92	46	Salinity	Contains the salinity value of the water at the transducer head (ES – Salinity). This value may be a manual setting or a reading from a conductivity sensor. Scaling: LSD = 1 part per thousand; Range = 0 to 40 ppt
93-96	47,48	Depth	Contains the depth of the transducer below the water surface (ED - Depth of Transducer). This value may be a manual setting or a reading from a depth sensor. Scaling: LSD = 1 decimeter; Range = 1 to 9999 decimeters
97-100	49,50	Pitch	Contains the Pioneer pitch angle (EP - Pitch and Roll Angles). This value may be a manual setting or a reading from a tilt sensor. Positive values mean that Beam #3 is spatially higher than Beam #4. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
101-104	51,52	Roll	Contains the Pioneer roll angle (ER - Roll Angle). This value may be a manual setting or a reading from a tilt sensor. For an up-facing Pioneer system, positive values mean that Beam #2 is spatially higher than Beam #1. For a down-facing Pioneer system, positive values mean that Beam #1 is spatially higher than Beam #2. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
105-108	53,54	Heading	Contains the Pioneer heading angle (EH - Heading). This value may be a manual setting or a reading from a heading sensor. Scaling: LSD = 0.01 degree; Range = 000.00 to 359.99 degrees
109-116 117-124 125-132 133-140	55-58 59-62 63-66 67-70	DMG/Btm East DMG/Btm North DMG/Btm Up DMG/Btm Error	These fields contain the Distance Made Good (DMG) over the bottom since the time of the first ping after initialization or <BREAK>. Where: (DMG X) = (Sum of all X's) (DMG Y) = (Sum of all Y's) (DMG Z) = (Sum of all Z's) Scaling: LSD = 1 mm; Range = -4,294,967,296 to +4,294,967,295 mm
141-148 149-156 157-164 165-172	71-74 75-78 79-82 83-86	DMG/Ref East DMG/Ref North DMG/Ref Up DMG/Ref Error	These fields contain the distance made good over the water-mass layer since the time of the first ping after initialization or <BREAK>. Where: (DMG X) = (Sum of all X's) (DMG Y) = (Sum of all Y's) (DMG Z) = (Sum of all Z's) Scaling: LSD = 1 mm; Range = -4,294,967,296 to +4,294,967,295 mm
173-176	87,88	Checksum	This field contains a modulo 65536 checksum. The Pioneer computes the checksum by summing all the bytes in the output buffer excluding the checksum.

Pioneer Output Data Format (PD6)

The Pioneer sends this data format only when the PD6 command is used. The Pioneer outputs data in the following line order. Note that not all data items may be displayed. Examples: (1) If #BK = zero, the Pioneer does not send water-mass data (line items beginning with W); (2) If #BK = three, the Pioneer does not send bottom-track data (line items beginning with B).



PD6 output has been reformatted in firmware version 57.03. It used a different line order versus the Workhorse Navigator (same data, but a different order). The decision was made to revert the output back to the Workhorse style output.

Table 61: Pioneer Output Data Format (PD6)

Line	Description																																																										
1	SYSTEM ATTITUDE DATA :SA,±PP.PP,±RR.RR,HH.HH <CR><CR><LF> where: PP.PP = Pitch in degrees RR.RR = Roll in degrees HHH.HH = Heading in degrees																																																										
2	TIMING AND SCALING DATA :TS,YMMDDHHmmsshh,SS.S,+TT.T,DDDD.D,CCCC.C,BBB <CR><CR><LF> where: YMMDDHHmmsshh = Year, month, day, hour, minute, second, hundredths of seconds SS.S = Salinity in parts per thousand (ppt) TT.TT = Temperature in C DDDD.D = Depth of transducer face in meters CCCC.C = Speed of sound in meters per second BBB = Built-in Test (BIT) result code where the first B on the left is the number of BIT errors (MSB) and the last 2 BB (LSB) are the actual BIT error as describe below. BIT byte13 Error <table> <tr> <th>Code</th><th>Description</th></tr> <tr> <td>0x01</td><td>Transmitter Shutdown</td></tr> <tr> <td>0x02</td><td>Transmitter Overcurrent</td></tr> <tr> <td>0x03</td><td>Transmitter Undercurrent</td></tr> <tr> <td>0x04</td><td>Transmitter Undervoltage</td></tr> <tr> <td>0x10</td><td>FIFO interrupt missed</td></tr> <tr> <td>0x11</td><td>FIFO ISR re-entry</td></tr> <tr> <td>0x21</td><td>Sensor start failure</td></tr> <tr> <td>0x22</td><td>temperature sensor failure</td></tr> <tr> <td>0x23</td><td>pressure sensor failure</td></tr> <tr> <td>0x24</td><td>tilt sensor failure</td></tr> <tr> <td>0x27</td><td>Bad Comms with sensor</td></tr> <tr> <td>0x28</td><td>Bad Comms with sensor</td></tr> <tr> <td>0x29</td><td>Sensor Cal Data checksum failure</td></tr> <tr> <td>0x2A</td><td>Sensor Stream Data Fault</td></tr> <tr> <td>0x30</td><td>Stuck UART</td></tr> <tr> <td>0x31</td><td>QUART Transmit timeout</td></tr> <tr> <td>0x32</td><td>QUART IRQ Stuck</td></tr> <tr> <td>0x33</td><td>QUART Buffer stuck</td></tr> <tr> <td>0x34</td><td>QUART IRQ Active</td></tr> <tr> <td>0x35</td><td>QUART cannot clear interrupt</td></tr> <tr> <td>0x50</td><td>RTC low battery *see note at end of table, page 195</td></tr> <tr> <td>0x51</td><td>RTC time not set</td></tr> <tr> <td>0x60</td><td>Lost Nonvolatile pointers</td></tr> <tr> <td>0x61</td><td>Erase operation failed</td></tr> <tr> <td>0x62</td><td>Error writing from flash to buffer 1</td></tr> <tr> <td>0x63</td><td>Error writing from buffer 1 to flash</td></tr> <tr> <td>0x64</td><td>Timed out checking if page is erased</td></tr> <tr> <td>0x65</td><td>Bad return when checking page</td></tr> </table>	Code	Description	0x01	Transmitter Shutdown	0x02	Transmitter Overcurrent	0x03	Transmitter Undercurrent	0x04	Transmitter Undervoltage	0x10	FIFO interrupt missed	0x11	FIFO ISR re-entry	0x21	Sensor start failure	0x22	temperature sensor failure	0x23	pressure sensor failure	0x24	tilt sensor failure	0x27	Bad Comms with sensor	0x28	Bad Comms with sensor	0x29	Sensor Cal Data checksum failure	0x2A	Sensor Stream Data Fault	0x30	Stuck UART	0x31	QUART Transmit timeout	0x32	QUART IRQ Stuck	0x33	QUART Buffer stuck	0x34	QUART IRQ Active	0x35	QUART cannot clear interrupt	0x50	RTC low battery *see note at end of table, page 195	0x51	RTC time not set	0x60	Lost Nonvolatile pointers	0x61	Erase operation failed	0x62	Error writing from flash to buffer 1	0x63	Error writing from buffer 1 to flash	0x64	Timed out checking if page is erased	0x65	Bad return when checking page
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Table 61: Pioneer Output Data Format (PD6)

Line	Description
0x66	Loop Recorder Slate Full
0x70	Unable to write to FRAM
0x80	HEM data corrupt or not initialized.
0x81	HEM data corrupt or not initialized.
0x82	Failed to update HEM data.
0x83	Failed to update HEM data.
0x84	Failed to read HEM time data.
0x85	Failed to read HEM pressure data.
0x86	Failed to read HEM SPI state
0x87	Operating time over max.
0x88	Pressure reading over sensor limit.
0x89	Leak detected in sensor A.
0x8A	Leak detected in sensor B.
0x90	144 AHRS sensor initialization failure
0x91	145 AHRS message CRC error
0x92	146 AHRS power supply fault
0x93	147 AHRS temperature fault
0x94	148 AHRS communication port fault
0x95	149 AHRS IMU failed built-in-test
0x96	150 AHRS IMU accel/gyro out of range
0x97	151 AHRS bad message format
0x98	152 AHRS data is marked unreliable
0x99	153 AHRS using stale data
0x9A	154 AHRS no data received
0xFF	Power failure
BIT Number of Errors byte 14	
Number of BIT errors	
<p>If there is more than one BIT error, then it will take several ensembles to output all the BIT errors. For example, if there are 3 BIT errors detected, then the output will be BBB = 3xx on ensemble n, BBB = 3yy on ensemble n+1, and BBB = 3zz on ensemble n+2, where xx, yy, and zz are the three different error messages detected.</p>	
3	WATER-MASS, INSTRUMENT-REFERENCED VELOCITY DATA :WI,±XXXXX,±YYYYY,±ZZZZZ,±EEEE,S <CR><CR><LF> where: ±XXXXX = X-axis vel. data in mm/s (+ = Bm1 Bm2 xdcr movement relative to water mass) ±YYYYY = Y-axis vel. data in mm/s (+ = Bm4 Bm3 xdcr movement relative to water mass) ±ZZZZZ = Z-axis vel. data in mm/s (+ = transducer movement away from water mass) ±EEEE = Error velocity data in mm/s S = Status of velocity data (A = good, V = bad)
4	WATER-MASS, SHIP-REFERENCED VELOCITY DATA :WS,±TTTTT,±LLLLL,±NNNNN,S <CR><CR><LF> where: ±TTTTT = Transverse vel. data in mm/s (+ = Port Stbd ship movement rel. to water mass) ±LLLLL = Longitudinal vel. data in mm/s (+ = Aft Fwd ship movement rel. to water mass) ±NNNNN = Normal velocity data in mm/s (+ = ship movement away from water mass) S = Status of velocity data (A = good, V = bad)
5	WATER-MASS, EARTH-REFERENCED VELOCITY DATA :WE,±EEEE,±NNNNN,±UUUUU,S <CR><CR><LF> where: ±EEEE = East (u-axis) velocity data in mm/s (+ = DVL movement to east) ±NNNNN = North (v-axis) velocity data in mm/s (+ = DVL movement to north) ±UUUUU = Upward (w-axis) velocity data in mm/s (+ = DVL movement to surface) S = Status of velocity data (A = good, V = bad)

Table 61: Pioneer Output Data Format (PD6)

Line	Description
6	WATER-MASS, EARTH-REFERENCED DISTANCE DATA :WD,±EEEEEEEE.EE,±NNNNNNNN.NN,±UUUUUUUU.UU,DDDD.DD,TTT.TT <CR><CR><LF> where: +EEEEEEEE.EE = East (u-axis) distance data in meters +NNNNNNNN.NN = North (v-axis) distance data in meters +UUUUUUUU.UU = Upward (w-axis) distance data in meters DDDD.DD = Range to water-mass center in meters TTT.TT = Time since last good-velocity estimate in seconds
7	BOTTOM-TRACK, INSTRUMENT-REFERENCED VELOCITY DATA :BI,±XXXXX,±YYYYY,±ZZZZZ,±EEEE,S <CR><CR><LF> where: ±XXXXX = X-axis velocity data in mm/s (+ = Bm1 Bm2 xdcr movement relative to bottom) ±YYYYY = Y-axis velocity data in mm/s (+ = Bm4 Bm3 xdcr movement relative to bottom) ±ZZZZZ = Z-axis velocity data in mm/s (+ = transducer movement away from bottom) ±EEEE = Error velocity data in mm/s S = Status of velocity data (A = good, V = bad)
8	BOTTOM-TRACK, SHIP-REFERENCED VELOCITY DATA :BS,±TTTTT,±LLLLL,±NNNNN,S <CR><CR><LF> where: ±TTTTT = Transverse vel. data in mm/s (+ = Port Stbd ship movement relative to bottom) ±LLLLL = Longitudinal vel. data in mm/s (+ = Aft Fwd ship movement relative to bottom) ±NNNNN = Normal velocity data in mm/s (+ = ship movement away from bottom) S = Status of velocity data (A = good, V = bad)
9	BOTTOM-TRACK, EARTH-REFERENCED VELOCITY DATA :BE,±EEEE,±NNNNN,±UUUUU,S <CR><CR><LF> where: ±EEEE = East (u-axis) velocity data in mm/s (+ = DVL movement to east) ±NNNNN = North (v-axis) velocity data in mm/s (+ = DVL movement to north) ±UUUUU = Upward (w-axis) velocity data in mm/s (+ = DVL movement to surface) S = Status of velocity data (A = good, V = bad)
10	BOTTOM-TRACK, EARTH-REFERENCED DISTANCE DATA :BD,±EEEEEEEE.EE,±NNNNNNNN.NN,±UUUUUUUU.UU,DDDD.DD,TTT.TT <CR><CR><LF> where: +EEEEEEEE.EE = East (u-axis) distance data in meters +NNNNNNNN.NN = North (v-axis) distance data in meters +UUUUUUUU.UU = Upward (w-axis) distance data in meters DDDD.DD = Range to bottom in meters TTT.TT = Time since last good-velocity estimate in seconds
11	SYSTEM HEALTH MONITOR DATA :HM,A,B,AAAA,BBBB,VV.VVV,C.CCC,RR.RRR<CR><CR><LF> where: A = Status of leak sensor A ("G" = Good, "L" = Leak detected, "D" = Disconnect) B = Status of leak sensor B ("G" = Good, "L" = Leak detected, "D" = Disconnect) AAAA = Leak sensor A raw A/D reading, as four hexadecimal digits BBBB = Leak sensor B raw A/D reading, as four hexadecimal digits VV.VVV = Transmit voltage, in volts C.CCC = Transmit current, in amperes RR.RRR = transducer impedance, in ohms. (The voltage and current readings are omitted if they are not available) (The transducer resistance reading is omitted if either the voltage or current readings are not available.) (The transducer resistance reading will saturate at 65.535 ohms, i.e. any resistance higher than that will still be reported as 65.535 ohms.)

The PD6 output does not pad spaces with zeroes. The spaces are left intact. The example below shows a realistic output from a Pioneer locked onto the bottom and the values of the System Health Monitor Data is shown in red.

```
:SA, -2.31, +1.92, 75.20
:TS,04081111563644,35.0,+21.0, 0.0,1524.0, 0
:WI,-32768,-32768,-32768,-32768,V
:WS,-32768,-32768,-32768,V
:WE,-32768,-32768,-32768,V
:WD, +0.00, +0.00, +0.00, 20.00, 0.00
:BI, +24, -6, -20, -4,A
:BS, -13, +21, -20,A
:BE, +17, +18, -20,A
:BD, -0.02, -0.03, +0.02, 7.13, 0.21
:HM,G,G,0C8E,0B2E,*33.214,*1.215,*27.337<CR><LF> ➔ 33.214 Volts, 1.215 amps, 27.337 ohms
```



The health monitor output (:HM,A,B,AAAA,BBBB,VV.VVV,C.CCC,RR.RRR<CR><CR><LF>) will output a leading '*' character before (V, C, & R) if a fresh update of data is output. Otherwise, the most recent (stale) measurement is output without a leading '*'. In the case of stale data, a leading space is output to keep the fields aligned in the output stream.

```
:HM,G,D,0e87,0ffd, 0.000, 0.000, 0.000
:HM,G,D,0e87,0ffd,*13.300,*0.479,*27.744
:HM,G,D,0e88,0ffd, 0.000, 0.000, 0.000
```

Pioneer NMEA Output (PD11)

The Pioneer sends this data format only when the PD11 command is used. Data will continue to be recorded to the internal recorder in PDO format if the recording bit is set in the CF command. Note that the DVL will ignore the serial output bit in the CF command when PD11 is set.



To get valid water-reference data, BK1 must be set in the DVL.

There are presently three sentences containing sensor and navigational data.



TRDI may add additional sentences in the future so care should be taken to correctly identify the sentence by its ID. In addition, TRDI may add fields to the existing sentences. Any such additional fields will be added after the last field and before the checksum. Care should be taken to locate the checksum by the '*' that immediately precedes it.

Sensor Data

The sensor data sentence consists of heading, pitch, roll, and depth below surface. Each data field is preceded by an identifier indicating the contents of the following fields. All values are in SI units. All data fields are variable width. Empty data fields will indicate missing or invalid data.

```
$PRDIG,H,x.x,P,x.x,R,x.x,D,x.x*hh<CR><LF>
├── H
├── x.x
├── P
├── x.x
├── R
├── x.x
├── D
├── x.x*hh
│   ├── depth
│   └── depth ID
├── roll
├── roll ID
├── pitch
├── pitch ID
├── heading
├── heading ID
└── NMEA 0183 header
```

Bottom-Track Navigational Data

The bottom-track data sentence consists of range to the bottom, speed over ground, and course over ground. Each data field is preceded by an identifier indicating the contents of the following field. All values are in SI units. All data fields are variable width. Empty data fields will indicate missing or invalid data.

```
$PRDIH,R,x.x,S,x.x,C,x.x*hh<CR><LF>
├── R
├── x.x
├── S
├── x.x
├── C
├── x.x*hh
│   ├── course over ground
│   ├── course over ground ID
│   ├── speed over ground
│   ├── speed over ground ID
│   ├── range to bottom
│   └── range to bottom ID
└── NMEA 0183 header
```

Current Referenced Navigational Data

The current referenced navigational data sentence shall consist of speed relative to the water current and course relative to the water current. Each data field will be preceded by an identifier indicating the contents of the following field. All values are in SI units. All data fields are variable width. Empty data fields will indicate missing or invalid data.

```
$PRDII,S,x.x,C,x.x*hh<CR><LF>
├── S
├── x.x
├── C
├── x.x*hh
│   ├── course relative to current
│   ├── course relative to current ID
│   ├── speed relative to current
│   └── speed relative to current ID
└── NMEA 0183 header
```

Below is an example of a valid sensor data sentence showing a heading of 197.34°, a pitch angle of -10.2°, a roll angle of -11.5° and a depth of 122.7m.

```
$PRDIG,H,197.34,P,-10.2,R,-11.5,D,122.7*7E<CR><LF>
```

This example shows a valid bottom-track sentence that contains range to bottom of 143.2m, a speed over ground of 1.485 m/s, and a course over ground of 192.93°.

```
$PRDIH,R,143.2,S,1.485,C,192.93*17<CR><LF>
```

Here is an example of a bottom-track sentence with invalid or missing data.

```
$PRDIH,R,,S,,C,*05<CR><LF>
```

This last example shows a water-reference sentence that contains speed relative to current of 1.503 m/s and a course relative to current of 203.5°.

```
$PRDII,S,1.503,C,203.5*55<CR><LF>
```

Pioneer Output Data Format (PD13)

The Pioneer sends this data format only when the PD13 command is used. The DVL outputs data in the following line order. The DVL may not send all data lines. Examples: (1) If BK = zero, the DVL does not send water-mass data (line items beginning with W); (2) If BK = three, the DVL does not send bottom-track data (line items beginning with B).

Table 62. Pioneer Output Data Format (PD13)

Line	Description																																																														
1	SYSTEM ATTITUDE DATA :SA,±PP.PP,±RR.RR,HH.HH <CR><LF> where: PP.PP = Pitch in degrees RR.RR = Roll in degrees HHH.HH = Heading in degrees																																																														
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0x64	Timed out checking if page is erased																																																														
0x65	Bad return when checking page																																																														
0x66	Loop Recorder Slate Full																																																														
0x70	Unable to write to FRAM																																																														

Table 62. Pioneer Output Data Format (PD13)

Line	Description
0x80	HEM data corrupt or not initialized.
0x81	HEM data corrupt or not initialized.
0x82	Failed to update HEM data.
0x83	Failed to update HEM data.
0x84	Failed to read HEM time data.
0x85	Failed to read HEM pressure data.
0x86	Failed to read HEM SPI state
0x87	Operating time over max.
0x88	Pressure reading over sensor limit.
0x89	Leak detected in sensor A.
0x8A	Leak detected in sensor B.
0x91	145 AHRS message CRC error
0x92	146 AHRS power supply fault
0x93	147 AHRS temperature fault
0x94	148 AHRS communication port fault
0x95	149 AHRS IMU failed built-in-test
0x96	150 AHRS IMU accel/gyro out of range
0x97	151 AHRS bad message format
0x98	152 AHRS data is marked unreliable
0x99	153 AHRS using stale data
0x9A	154 AHRS no data received
0xFF	Power failure

BIT Number of Errors byte 14
Number of BIT errors

If there is more than one BIT error, then it will take several ensembles to output all the BIT errors. For example, if there are 3 BIT errors detected, then the output will be BBB = 3xx on ensemble n, BBB = 3yy on ensemble n+1, and BBB = 3zz on ensemble n+2, where xx, yy, and zz are the three different error messages detected.

3 PRESSURE AND RANGE TO BOTTOM DATA

:RA,PPP.PP,RRRR.RR,RRRR.RR,RRRR.RR,RRRR.RR

where:

PPP.PP = Pressure in kPa

RRRR.RR = Range to the bottom in deci-meters Beam 1, Beam 2, Beam 3, Beam 4

4 WATER-MASS, INSTRUMENT-REFERENCED VELOCITY DATA

:WI,±XXXXX,±YYYY,±ZZZZ,±EEEE,S <CR><LF>

where:

±XXXXX = X-axis vel. data in mm/s (+ = Bm1 Bm2 xdcr movement relative to water mass)

±YYYYY = Y-axis vel. data in mm/s (+ = Bm4 Bm3 xdcr movement relative to water mass)

±ZZZZZ = Z-axis vel. data in mm/s (+ = transducer movement away from water mass)

±EEEE = Error velocity data in mm/s

S = Status of velocity data (A = good, V = bad)

5 WATER-MASS, SHIP-REFERENCED VELOCITY DATA

:WS,±TTTT,±LLLL,±NNNN,S <CR><LF>

where:

±TTTT = Transverse vel. data in mm/s (+ = Port Stbd ship movement rel. to water mass)

±LLLL = Longitudinal vel. data in mm/s (+ = Aft Fwd ship movement rel. to water mass)

±NNNN = Normal velocity data in mm/s (+ = ship movement away from water mass)

S = Status of velocity data (A = good, V = bad)

Table 62. Pioneer Output Data Format (PD13)

Line	Description
6	WATER-MASS, EARTH-REFERENCED VELOCITY DATA :WE,±EEEE,±NNNNN,±UUUUU,S <CR><LF> where: ±EEEE = East (u-axis) velocity data in mm/s (+ = DVL movement to east) ±NNNNN = North (v-axis) velocity data in mm/s (+ = DVL movement to north) ±UUUUU = Upward (w-axis) velocity data in mm/s (+ = DVL movement to surface) S = Status of velocity data (A = good, V = bad)
7	WATER-MASS, EARTH-REFERENCED DISTANCE DATA :WD,±EEEEEEEE.EE,±NNNNNNNN.NN,±UUUUUUUU.UU,DDDD.DD,TTT.TT <CR><LF> where: +EEEEEEEE.EE = East (u-axis) distance data in meters +NNNNNNNN.NN = North (v-axis) distance data in meters +UUUUUUUU.UU = Upward (w-axis) distance data in meters DDDD.DD = Range to water-mass center in meters TTT.TT = Time since last good-velocity estimate in seconds
8	BOTTOM-TRACK, INSTRUMENT-REFERENCED VELOCITY DATA :BI,±XXXXX,±YYYYY,±ZZZZ,±EEEE,S <CR><LF> where: ±XXXXX = X-axis velocity data in mm/s (+ = Bm1 Bm2 xdcr movement relative to bottom) ±YYYYY = Y-axis velocity data in mm/s (+ = Bm4 Bm3 xdcr movement relative to bottom) ±ZZZZ = Z-axis velocity data in mm/s (+ = transducer movement away from bottom) ±EEEE = Error velocity data in mm/s S = Status of velocity data (A = good, V = bad)
9	BOTTOM-TRACK, SHIP-REFERENCED VELOCITY DATA :BS,±TTTTT,±LLLLL,±NNNNN,S <CR><LF> where: ±TTTTT = Transverse vel. data in mm/s (+ = Port Stbd ship movement relative to bottom) ±LLLLL = Longitudinal vel. data in mm/s (+ = Aft Fwd ship movement relative to bottom) ±NNNNN = Normal velocity data in mm/s (+ = ship movement away from bottom) S = Status of velocity data (A = good, V = bad)
10	BOTTOM-TRACK, EARTH-REFERENCED VELOCITY DATA :BE,±EEEE,±NNNNN,±UUUUU,S <CR><LF> where: ±EEEE = East (u-axis) velocity data in mm/s (+ = DVL movement to east) ±NNNNN = North (v-axis) velocity data in mm/s (+ = DVL movement to north) ±UUUUU = Upward (w-axis) velocity data in mm/s (+ = DVL movement to surface) S = Status of velocity data (A = good, V = bad)

Table 62. Pioneer Output Data Format (PD13)

Line	Description
11	BOTTOM-TRACK, EARTH-REFERENCED DISTANCE DATA :BD,±EEEEEEEE.EE,±NNNNNNNN.NN,±UUUUUUUU.UU,DDDD.DD,TTT.TT <CR><LF> where: +EEEEEEEE.EE = East (u-axis) distance data in meters +NNNNNNNN.NN = North (v-axis) distance data in meters +UUUUUUUU.UU = Upward (w-axis) distance data in meters DDDD.DD = Range to bottom in meters TTT.TT = Time since last good-velocity estimate in seconds

The PD13 output does not pad spaces with zeroes. The spaces are left intact. The example below shows a realistic output from a Pioneer locked onto the bottom.

```
:SA, -2.31, +1.92, 75.20
:TS,04081111563644,35.0,+21.0, 0.0,1524.0, 0
:RA, 0.00, 71.31, 71.32, 71.32, 71.31
:WI,-32768,-32768,-32768,-32768,V
:WS,-32768,-32768,-32768,V
:WE,-32768,-32768,-32768,V
:WD, +0.00, +0.00, +0.00, 20.00, 0.00
:BI, +24, -6, -20, -4,A
:BS, -13, +21, -20,A
:BE, +17, +18, -20,A
:BD, -0.02, -0.03, +0.02, 7.13, 0.21
```

Pioneer Speed Log Format (PD26)

The Pioneer provides the ability to output the PD26 data type over the serial interface with the PD command or using the HTML interface.

\$VMVBW – Dual Ground/Water Speed

Format:

```
$VMVBW,x.xx,x.xx,A,x.xx,x.xx,A,x.xx,A,x.xx,A*hh<CR><LF>
      1    2    3 4    5    6 7    8 9    10
```

Where:

- 1 = Longitudinal water speed, knots
- 2 = Transverse water speed, knots
- 3 = Status, water speed: A=Valid, V=Invalid
- 4 = Longitudinal ground speed, knots
- 5 = Transverse ground speed, knots
- 6 = Status, ground speed: A=Valid, V=Invalid
- 7 = Stern transverse water speed, knots
- 8 = Status, stern water speed: A=Valid, V=Invalid
- 9 = Stern transverse ground speed, knots
- 10 = Status, stern ground speed: A=Valid, V=Invalid

Notes:

- The \$VMVBW longitudinal ground speeds is determined from the forward component of the ship frame bottom track velocity vector.
- The sign of the \$VMVBW longitudinal speeds is positive for forward motion of the ship relative to the bottom in the ship frame. Note that this is identical to the PD6 transverse sign convention.
- The \$VMVBW transverse ground speeds is produced from the starboard component of the ship frame velocity vector.
- The sign of the \$VMVBW transverse ground speeds is positive for motion of the ship in the starboard direction relative to the bottom in the ship frame. Note that this is identical to the PD6 transverse speed sign convention.
- The \$VMVBW ground speeds is corrected for pitch and roll.
- The pitch and roll parameters for \$VMVBW ground velocities is sourced per the EZ configuration.
- The status of \$VMVBW ground speeds is determined from the validity of a 3 or 4 beam bottom velocities; 0, 1, or 2 valid beams shall equate to invalid.
- The sign of the \$VMVBW transverse ground speeds is positive for motion of the ship in the starboard direction relative to the bottom in the ship frame. Note that this is identical to the PD6 transverse speed sign convention.
- The \$VMVBW ground speeds is corrected for pitch and roll.
- The pitch and roll parameters for \$VMVBW ground velocities is sourced per the EZ command configuration.
- The status of \$VMVBW ground speeds is determined from the validity of a 3 or 4 beam bottom velocities; 0, 1, or 2 valid beams shall equate to invalid.

\$VMDBT – Depth Below Transducer

Format:

```
$VMDBT, x.x, f, x.x, M, x.x, F*hh<CR><LF>
      1  2 3  4 5  6 7
```

Where:

1 = Depth, feet

2 = f = feet

3 = Depth, meters

4 = M = meters

5 = Depth, Fathoms

6 = F = Fathoms

7 = Checksum

Notes:

- The \$VMDBT depth is determined from the mean of the vertical range-to-bottom of each valid beam from the bottom track ping. Note this is equivalent to the PD6 BD range to bottom field.

\$VMVLW – Distance Traveled through Water

Format:

```
$VMVLW, x.x,N,x.x,N*hh<CR><LF>
      1  2 3  4 5
```

Where:

1 = Total cumulative distance

2 = N = Nautical Miles

3 = Distance since Reset

4 = N = Nautical Miles

5 = Checksum

Notes:

- The cumulative distance is calculated for each ensemble as follows:

$$LEast = 1 / 2 * (VEast[n - 1] + VEast[n]) * (T[n] - T[n - 1]) \quad (1)$$

$$LNorth = 1 / 2 * (VNorth[n - 1] + VNorth[n]) * (T[n] - T[n - 1]) \quad (2)$$

$$Length = Length + \sqrt{LEast^2 + LNorth^2} \quad (3)$$

Where:

L = length

V = velocity

n = the ensemble number

T = time

- The \$VMVLW cumulative distance is calculated from the bottom track earth referenced velocity data.
- The \$VMVLW cumulative distance will clear:
 - Upon ping initiation from CS command
 - Upon reception of a hardware or software break
 - Upon ping initiation from turnkey mode start
 - Upon receipt of a 'dynamic' BS or #BS command from serial or Ethernet port
- The \$VMVLW distance since reset shall clear upon application of power to the Pioneer (cold boot).

PDDecoder Library in C language

The Teledyne Marine PDDecoder library is an open-source library written in C language to decode the PDO data formats that are commonly output by Teledyne Marine/Teledyne RD Instruments ADCPs. The definition and details of the PDO format can be found in any of the manuals under the section, Output Data Format.

Available for download from the Teledyne software portal: <https://tm-portal.force.com/TMsoftwareportal>

Appendix A

NOTICE OF COMPLIANCE



In this chapter:

- [China RoHS requirements](#)
- [Material disclosure table](#)

Date of Manufacture

China RoHS requires that all Electrical and Electronic Products are marked with a Date of Manufacture. This is the starting point for the Environmental Friendly Use Period, described below.

Environmental Friendly Use Period (EFUP)

Per SJ/T 11364-2006 – Product Marking, the EFUP is defined as the time in years in which hazardous/toxic substances within Electrical and Electronic Products (EIP) will not, under normal operating conditions, leak out of the Product, or the Product will not change in such a way as to cause severe environmental pollution, injury to health, or great damage to property. TRDI has determined the Environmental Friendly Use Period shall be Ten (10) years.

The purpose of the marking is to assist in determining the restricted substance content, recyclability, and environmental protection use period of our covered products, as required in Chinese law, and does not reflect in any way the safety, quality, or warranty associated with these TRDI products.



Some homogenous substance within the EIP contains toxic or hazardous substances or elements above the requirements listed in SJ/T 11363-2006. These substances are identified in Table 63.

WEEE



The mark shown to the left is in compliance with the Waste Electrical and Electronic Equipment Directive 2002/96/EC (WEEE).

This symbol indicates the requirement NOT to dispose the equipment as unsorted municipal waste, but use the return and collection systems according to local law or return the unit to one of the TRDI facilities below.

Teledyne RD Instruments USA
14020 Stowe Drive
Poway, California 92064

Teledyne RD Instruments Europe
2A Les Nertieres
5 Avenue Hector Pintus
06610 La Gaude, France

Teledyne RD Technologies
1206 Holiday Inn Business
Building
899 Dongfang Road, Pu Dong
Shanghai 20122 China

CE



This product complies with the Electromagnetic Compatibility Directive 89/336/EEC, 92/31/EEC. The following Standards were used to verify compliance with the directives: EN 61326(1997), A1(1998), A2(2001) – Class “A” Radiated Emissions.



CE only applies to the 300 and 600 kHz systems.

Material Disclosure Table

In accordance with SJ/T 11364-2006, the following table disclosing toxic or hazardous substances contained in the product is provided.

Table 63. Toxic or Hazardous Substances and Elements Contained in Product

零件项目(名称) Component Name	有毒有害物质或元素 Toxic or Hazardous Substances and Elements					
	铅 Lead (Pb)	汞 Mercury (Hg)	镉 Cadmium (Cd)	六价铬 Hexavalent Chromium (Cr ⁶⁺)	多溴联苯 Polybrominated Biphenyls (PBB)	多溴二苯醚 Polybrominated Diphenyl Ethers (PBDE)
换能器配件 Transducer Assy.	X	O	O	O	O	O
换能器接口电路板 Transducer Intfc PCB	O	O	O	O	O	O
底座装配 End-Cap Assy.	X	O	O	O	O	O
接收机电路板 Receiver PCB	O	O	O	O	O	O
数据处理器电路板 DSP PCB	O	O	O	O	O	O
输入输出接口电路板 PIO PCB	O	O	O	O	O	O
通讯接口板 Personality Module	O	O	O	O	O	O
外接电缆 External Cables	X	O	O	O	O	O
专用装运箱和泡沫塑料垫 Shipping Case w/Foam	O	O	O	O	O	O
<p>O: 表示该有毒或有害物质在该部件所有均质材料中的含量均在 SJ/T 11363-2006 标准规定的限量要求以下。</p> <p>O: Indicates that the toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit required in SJ/T 11363-2006.</p> <p>X: 表示该有毒或有害物质至少在该部件的某一均质材料中的含量超出 SJ/T 11363-2006 标准规定的限量要求。</p> <p>X: Indicates that the toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in SJ/T 11363-2006.</p>						

NOTES