WORKHORSE RIO GRANDE

ADCP GUIDE

P/N 957-6241-00 (September 2013)

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Revision History

September 2013

- Renamed manual from WorkHorse Rio Grande Technical Manual to Rio Grande ADCP Guide.
- Combined Rio Grande User's Guide into the ADCP guide.
- Added corrections for ICN 083 (Notice of Compliance).
- Added corrections for ICN 143 (WV command settings) and ICN144 (WF command)
- Added corrections for ICN 145 (I/O Connector Lubricant)
- Updated Installation chapter.
- Updated the maintenance procedures and parts location drawings.
- Updated Commands and Output Data Format guide to 10.17 firmware.
- Corrected the CF command description in Table 26, page 118. The CFxx2xx setting is not available in the Rio Grande firmware.
- General editing and revisions made to text.
- Updated styles and fonts.

November 2007

- Initial release

Exclusions and Omissions

This manual covers the Rio Grande hardware and firmware. For instructions on using a laptop computer running the *WinRiver II* software, see the WinRiver II User's Guide. For information on using the *SxS Pro* software, see the SxS Software User's Guide.

NOTES

Chapter 1

AT A GLANCE

In this chapter:

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:

Teledyne RD Instruments	Teledyne RD Instruments Europe
14020 Stowe Drive Poway, California 92064	2A Les Nertieres 5 Avenue Hector Pintus 06610 La Gaude, France
Phone +1 (858) 842-2600	Phone +33(0) 492-110-930
FAX +1 (858) 842-2822	FAX +33(0) 492-110-931
Sales – rdisales@teledyne.com	Sales – rdie@teledyne.com
Field Service – rdifs@teledyne.com	Field Service – rdiefs@teledyne.com

Client Services Administration – rdicsadmin@teledyne.com

Web: http://www.rdinstruments.com

24 Hour Emergency Support +1 (858) 842-2700

Conventions Used in this Manual

Conventions used in this documentation have been established to help explain how to use the system quickly and easily.

Software menu items are printed in bold: **File** menu, **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 (*WinRiver II*) and file names (*default.txt*).

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

```
[BREAK Wakeup A]
WorkHorse Rio Grande ADCP Version 10.17
Teledyne RD Instruments (c) 1996-2013
All Rights Reserved.
>
```

There are four visual aids to help:

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 Rio Grande ADCP).

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

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

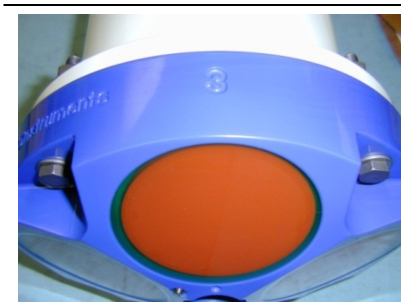
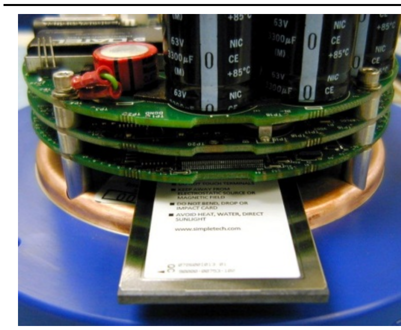
Inventory

Included with the WorkHorse Rio Grande system:

Part Number	Name	Description
WHR600-I WHR1200-I	Rio Grande 600/1200 kHz system	 The Rio Grande system includes the transducer, dummy plug, and protective cap. When unpacking, use care to prevent physical damage to the transducer face and connector. Use a soft pad to protect the transducer.
737-3027-005	I/O cable	The I/O cable is used for serial communications.
737-3028-00	Lighter Adapter Cable	12 VDC lighter adapter cable.
717-7000-00	Shipping case	Shipping case with custom foam cutouts.
907-8077-00	Rio Grande Documentation CD	This CD has PDF versions of all of the Rio Grande documentation including the Rio Grande ADCP Guide. Please read the manual!
907-8075-00	WinRiver II Software CD	TRDI's river and coastal data acquisition software package where the primary use is for discharge calculation. Although this is its primary function, it can be used for general coastal survey applications.
907-8040-00	RDI Tools Software CD	Utility and testing software package including *BBTalk* that can be used to test the ADCP.
907-8080-00	SxS Pro Software CD (optional)	Section-by-Section (SxS) Pro is a stationary ADCP discharge data collection and processing program. This CD will be included with the SxS Pro upgrade (registration code is required to collect data).
957-6168-00	Rio Grande Reference Card	A printed reference card showing Rio Grande operational overview and inventory. A PDF version is included on the Rio Grande documentation CD.
957-6274-00	Serial Communications Setup Card	A printed quick reference card showing serial communications setup. A PDF version is included on the WinRiver II CD.
757K6078-00	Tools and Spare Parts Kit	See Tools and Spare Parts for a list of parts included in the kit.

Rio Grande Overview

The ADCP transducer assembly contains the end-cap, housing, transducer ceramics, and electronics. The standard acoustic frequencies are 1200 and 600 kHz. See the Outline Installation Drawings for dimensions and weights.

Picture	Description
	The Input/Output (I/O) cable connects the Rio Grande ADCP to the computer and external power supply. When the cable is not connected, use the dummy plug to protect the connector.
	The end-cap holds the I/O cable connector. When assembling the unit, match the Beam 3 mark on the end-cap with beam 3 number on the transducer.
	The Thermistor measures the water temperature.
	The orange urethane faces covers the transducer ceramics. Never set the transducer on a hard surface. The urethane faces may be damaged.
	The Rio Grande electronics and transducer ceramics are mounted to the transducer head. The numbers embossed on the edge of the transducer indicate the beam number. When assembling the unit, match the transducer beam number 3 with the Beam 3 mark on the end-cap.
	Memory cards are not included with the Rio Grande ADCP. Two PCMCIA memory cards slots are available. The maximum memory for each slot is 2GB, with the total memory capacity not to exceed 4GB.

Computer Overview

TRDI designed the Rio Grande ADCP to use a Windows® compatible computer. The computer controls the ADCP and displays its data, usually through our *WinRiver II* or *SxS Pro* programs.

Minimum Computer Hardware Requirements:

- Windows XP®, Windows 7®, Windows 8® Desktop, Laptop, or Netbook computer
- Pentium III 600 MHz class PC (higher recommended)
- 1GB of RAM (2GB RAM recommended)
- 50 MB Free Disk Space plus space for data files (A large, fast hard disk is recommended
- Screen resolution above 1024x768
- Mouse or other pointing device
- One Serial Port (two or more High Speed UART Serial Port recommended)

Power Overview

The Rio Grande ADCP requires a DC supply between 10.5 volts and 18 volts. Either an external DC power supply or battery can provide this power. If using a battery, use the largest rated amp-hour battery as possible. A car battery should last one to two days powering a 600 kHz ADCP.

Check that the battery voltage is above 10.5 Volts DC. Rio Grande ADCPs will work at 10.5 VDC with at least 400 milli amps; however, batteries with voltages below 11 VDC are at or near their end of life, and are approaching uselessness.

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 ADCP. The capacitors provide a store of energy for use during transmit. The inrush current is as high as 3 Amps rms. The ADCP will draw this amperage until its capacitors are fully charged.

If the power supply limits the current or the power drop on the cable is significant, then the power on cycle will take longer. It can take up to one minute. If the power shuts down during the inrush current draw, this may not allow the ADCP's electronics to start.

Rio Grande Options

- **Shallow Water Bottom Track Mode 7** – This upgrade allows the Rio Grande 1200 kHz ADCP to bottom track in water as shallow as 30cm.
- **High Ping Rate Water Mode** – This upgrade allows the Rio Grande to collect water profiles using Water Mode 12.
- **SxS Pro** – The *SxS Pro* software can be used in place of the *WinRiver II* software. To purchase a registration code to enable the software's full capability, please contact field service at: e-mail: rdifs@teledyne.com | Tel. +1-858-842-2700.

  SxS Pro software can be downloaded at: http://www.rdinstruments.com/support/softwarefirmware/cc_software.aspx **Item 4a**

  SxS Pro Users Guide and Reference Card can be downloaded at: http://www.rdinstruments.com/support/documentation/cc_documents.aspx **Items 19F** and **19G**
- **Memory** – Memory cards are optional for the Rio Grande ADCP. Two PCMCIA memory card slots are available (see PC Card Recorder for memory card specifications). The maximum memory for each slot is 2GB, with the total memory capacity not to exceed 4GB.
- **Spare boards kit** – Contains a complete set of spare printed circuit boards for a Rio Grande ADCP. The set does not include the receiver board (not field replaceable).
- **Riverboat kit** – The Oceanscience Riverboat holds the Rio Grande ADCP and is configured for use with two 900MHz or 2.4 GHz radio modems. All required cabling, batteries, and antennae are included for easy setup. Electronics are located below deck in a watertight compartment.

Setting up the Rio Grande System

Use this section to connect the ADCP to a computer and establish communications. Install the *RDI Tools* software in order to communicate with the ADCP.

To set up the Rio Grande ADCP:

1. Connect the I/O cable to the Rio Grande ADCP. Do so by pushing straight in against the connector. Roll the retaining strap over the connector.

> Place a light amount of dry silicone lubricant spray on the connector pins (rubber portion only). This will make it easier to connect or remove the I/O cable and dummy plug. See I/O Cable and Dummy Plug for details.

2. Attach the I/O cable to the computer's communication port. The standard communications settings are RS-232, 9600-baud, no parity, 8 data bits and 1 stop bit.
3. Connect a battery or DC power supply to the power connectors.

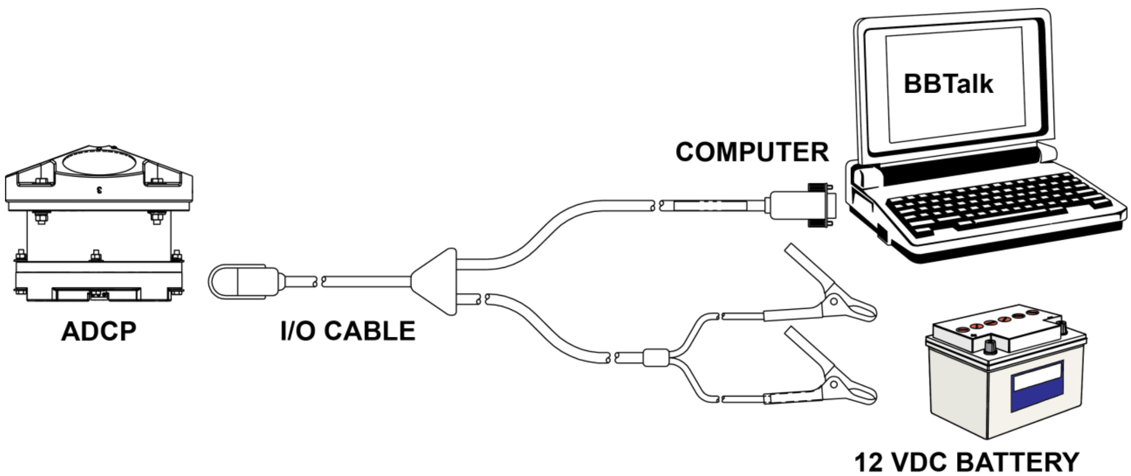
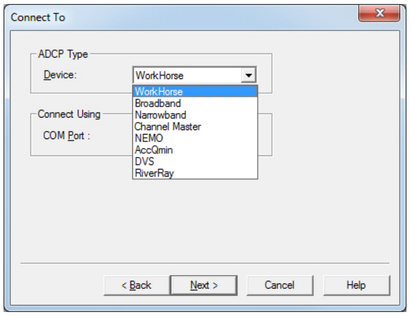


Figure 1. WorkHorse Rio Grande Connections

> For information on how to set up communications with *WinRiver II*, see the WinRiver II Serial Communications Setup Card or see Chapter 2 in the WinRiver II Software User's Guide.

Connecting to the Rio Grande

To connect to the Rio Grande ADCP using the *BBTalk* software:

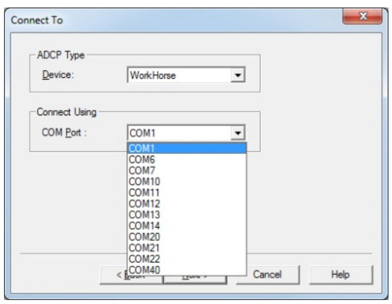


Start BBTalk

Start the *BBTalk* program.

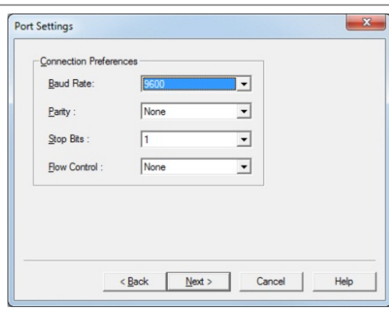
On the **Connect To** screen, select **WorkHorse**.

For help on using *BBTalk*, see the RDI Tools User's Guide.



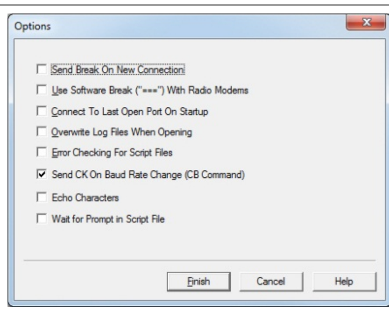
Select the COM port the Rio Grande ADCP cable is connected to.

Click **Next**.

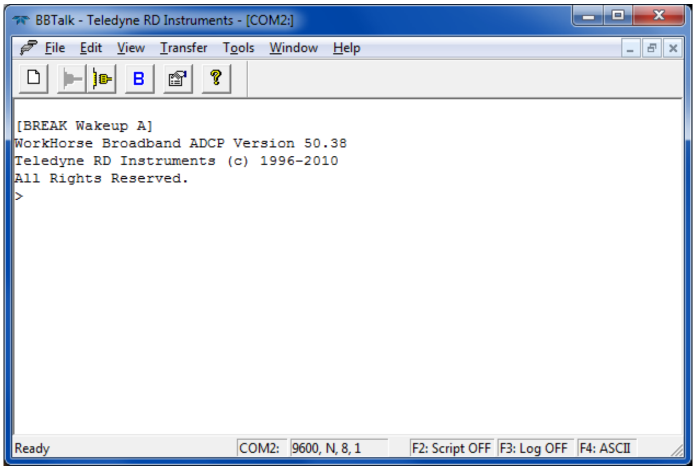


Enter the **Baud Rate**, **Parity**, **Stop Bits**, and **Flow Control**. If you are unsure of the settings, leave them at the default settings as shown.

Click **Next**.



Click **Finish**.

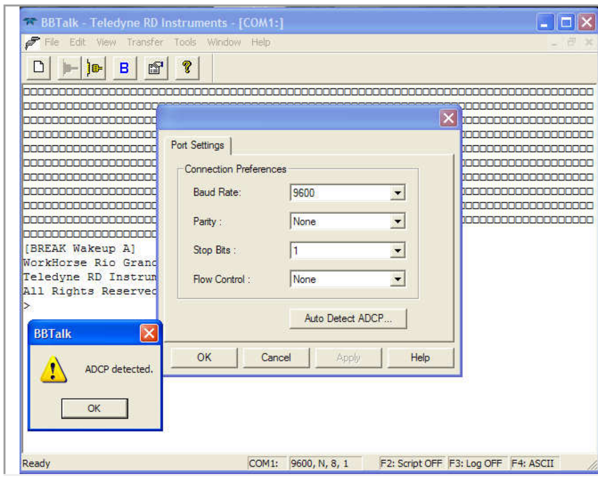


Wakeup

On the **File** menu, click **Break** (pressing the **End** key or pressing the **B** button on the Toolbar will also send a break).

The wakeup message appears on the log file window.

If the Rio Grande ADCP does not respond, check the serial port, cables, DC power supply or battery connection. If necessary, refer to the Troubleshooting section.



If the wakeup message is not readable or visible:

On the **File** menu, click **Properties**.

Click the **Auto Detect ADCP** button.

Click **OK** when the Rio Grande is detected. Try to wake up the Rio Grande again.

Both *BBTalk* and the ADCP must use the same Baud rate.

Changing the Baud Rate in the ADCPs

The ADCP can be set to communicate at baud rates from 300 to 115200. The factory default baud rate is always 9600 baud. The baud rate is controlled via the CB-command. The following procedure explains how to set the baud rate and save it in the ADCP. This procedure assumes using the program *BBTalk* that is supplied by Teledyne RD Instruments.

The Rio Grande baud rate MUST be set to match the radio baud rate when used in the Oceanscience Riverboat.

```
[BREAK Wakeup A]
WorkHorse Rio Grande Broadband ADCP Version 10.17
Teledyne RD Instruments (c) 1996-2013
All Rights Reserved.
>
>cr1
[Parameters set to FACTORY defaults]
```

Connect the ADCP to the computer and apply power.

Start the *BBTalk* program and establish communications with the ADCP.

Wake up the ADCP by sending a break signal with the **End** key.

At the ">" prompt in the communication window, type **CR1** then press the Enter key. This will set the ADCP to the factory default settings.

BAUD RATE	CB-command
300	CB011
1200	CB111
2400	CB211
4800	CB311
9600	CB411 (Default)
19200	CB511
38400	CB611
57600	CB711
115200	CB811

Send the CB-command that selects the baud rate you wish. The table on the left shows the CB-command settings for different baud rates with no parity and 1 stop bit.

For example, to change the baud rate to 115200, at the ">" prompt in the communication window, type **cb811** then press the Enter key.

The **CB?** command will identify the communication setting.

```
>cb?
CB = 411 ----------------- Serial Port Control (Baud
[4=9600]; Par; Stop)
>cb811
>CK
[Parameters saved as USER defaults]
>cb?
CB = 811 ----------------- Serial Port Control (Baud
[8=115200]; Par; Stop)
>
```

BBTalk will send the command **CK** to save the new baud rate setting.

Exit *BBTalk*.

The ADCP is now set for the new baud rate. The baud rate will stay at this setting until changed again with the CB command.

Exit *BBTalk* so the communication port is available for use with other programs.

Caring for the Rio Grande System

This section contains a list of items to be aware of every time the Rio Grande ADCP is handled, used, or deployed. *Please refer to this list often*.

General Handling Guidelines

- Never set the transducer on a hard or rough surface. **The urethane faces may be damaged.**
- Always remove the retaining strap on the underwater-connect cable and dummy plug when disconnecting them. **Failure to do so will break the retainer strap.**
- Do not apply any upward force on the end-cap connector as the I/O cable is being disconnected. **Stressing the connector may cause the ADCP to flood.**
- Do not expose the transducer faces to prolonged sunlight. **The urethane faces may develop cracks.** Cover the transducer faces on the Rio Grande if it will be exposed to sunlight.
- Do not expose the I/O connector to prolonged sunlight. **The plastic may become brittle.** Cover the connector on the Rio Grande if it will be exposed to sunlight.
- Do not store the ADCP in temperatures over 60 degrees C. **The urethane faces may be damaged.**
- Do not scratch or damage the O-ring surfaces or grooves. **If scratches or damage exists, they may provide a leakage path and cause the ADCP to flood.** Do not risk a deployment with damaged O-ring surfaces.
- Do not lift or support a Rio Grande by the external I/O cable. **The connector or cable will break.**

Assembly Guidelines

- Read the Maintenance section for details on Rio Grande re-assembly. Make sure the housing assembly O-ring stays in the groove when re-assembling the Rio Grande. Tighten the hardware as specified. **Loose, missing, stripped hardware, or a damaged O-ring can cause the Rio Grande transducer to flood.**
- Use light amounts of silicone lubricant (such as 3M™ Silicone Lubricant (Dry Type) ID No: 62-4678-4930-3) on both the male pins and female socket to help seat the cable connectors. Wipe off excessive silicone spray from the metal portions of the pins. **Regular lubrication is required**: **Apply dry type silicone lubricant prior to each connection.**
- Do not connect or disconnect the I/O cable with power applied. Connecting the cable with power applied may cause a small spark. **The connector pins may become pitted and worn**.
- The **Rio Grande** I/O cable may be connected while slightly wet; do not connect under water.

Deployment Guidelines

- Read the WinRiver II Software User's Guide or SxS Pro Software User's Guide. These guides include tutorials on how to collect data.
- A compass calibration should be conducted at every new measurement location, and whenever the ADCP mounting or adjacent ancillary equipment is changed 0r repositioned. **A properly calibrated compass is essential for conducting the Loop Moving Bed test, and for using GPS data as the navigation reference.**
- Avoid using ferro-magnetic materials in the mounting fixtures or near the RiverRay. **Ferro-magnetic materials affect the compass**.

Chapter 2

INSTALLATION

In this chapter:

- How to connect/disconnect the I/O cable
- Cable wiring diagrams
- Available mounts for the Rio Grande ADCP

I/O Cable and Dummy Plug

The underwater connector (on the end-cap) and the I/O cable and dummy plug are molded wet-mate-able connectors. The end-cap connector is a factory-installed item. TRDI does not recommend removing it for any routine maintenance.

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

To disconnect the cable:

1. Place the Rio Grande on a soft pad to protect the transducer face.
2. Release the retaining strap by pulling it over the connector.
3. Grasp the cable close to the housing.
4. Pull the cable straight out away from the housing with a gentle rocking motion. Do not apply any upward force on the connector as it is being disconnected.

To connect the cable:

1. Check all pins for signs of corrosion (greenish oxidation or pitting).
2. Use light amounts of silicone lubricant (such as 3M™ Silicone Lubricant (Dry Type) ID No: 62-4678-4930-3) on both the male pins and female socket to help seat the cable connectors. Wipe off excessive silicone spray from the metal portions of the pins. **Regular lubrication is required**: Apply dry type silicone lubricant prior to each connection.
3. Push the cable straight onto the connector.

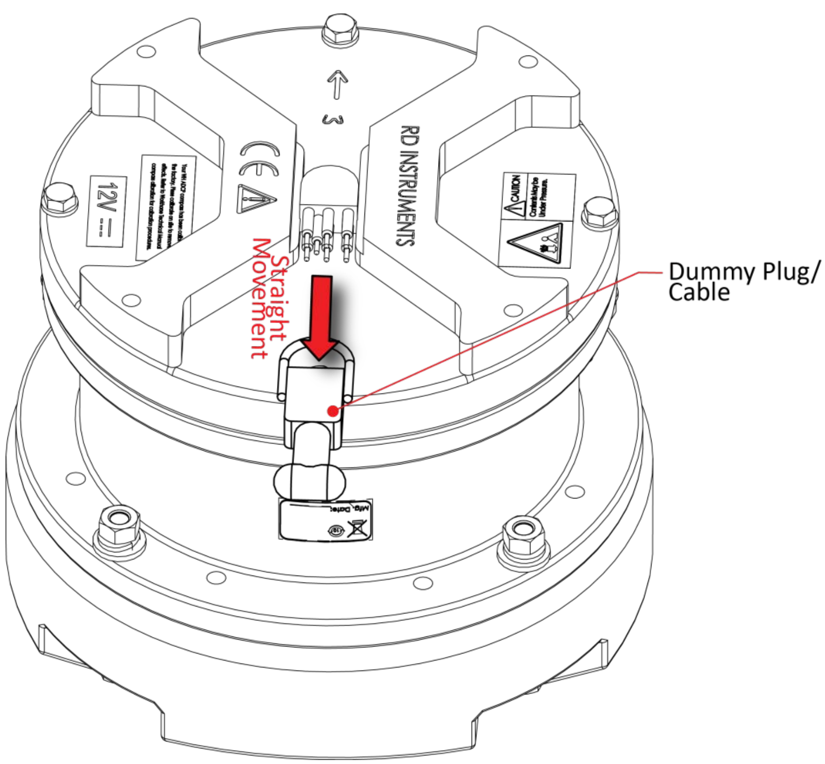


Figure 2. Removing the I/O Cable

Apply dry type silicone lubricant prior to each connection.

When the cable is connected without any lubricant, excessive force is needed to fully seat or remove the connector. This can cause several serious problems:

1. The neoprene rubber portion of the contact pin may tear from the metal pin.
2. Wiggling the cable side-to-side to overcome the friction as it is connected or disconnected may cause the neoprene rubber to tear or create pin-holes on the side of the connector.

As a result of any damage to the neoprene rubber, corrosion may occur on current carrying pins.

When connecting the Rio Grande I/O cable, do not apply any upward force on the connector as it is being pulled off. Applying an upward angle as the cable is connected puts stress on the end-cap connector. This may cause several serious problems:

1) The end-cap connector or connector pins can crack.
2) The O-ring on the bottom of the end-cap connector can be damaged.
3) The molded urethane on the end-cap connector may separate from the brass insert.

If the end-cap connector is damaged in any of these ways, the Rio Grande will flood.

Routing Cables

The input/output (I/O) cable connects the ADCP to the computer. TRDI delivers the cable with both connectors attached. The transducer-end connector is molded on, so it can be used below the waterline. The cable is custom-made in lengths specified by the user. Route this cable so:

- The cable can be installed with the connectors attached.
- It does not have kinks or sharp bends.
- Protect the cables with hose if zip-ties are used to secure them to structures (see Figure 5).
- The cable can be easily replaced if it fails.
- The wet-end connector is 3.0cm (1.18 inches) long, 2.54cm (1.00 inches) wide, 1.27cm (0.5 inches) high. Model# Impulse LPMIL-7-FS.

Figure 3. Do not use Zip-Ties Directly on Cables

When attaching the ADCP 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.

Cable Wiring Diagram

This section has information on Rio Grande cabling. Special user-requests may cause changes to the basic wiring system and may not be shown here.

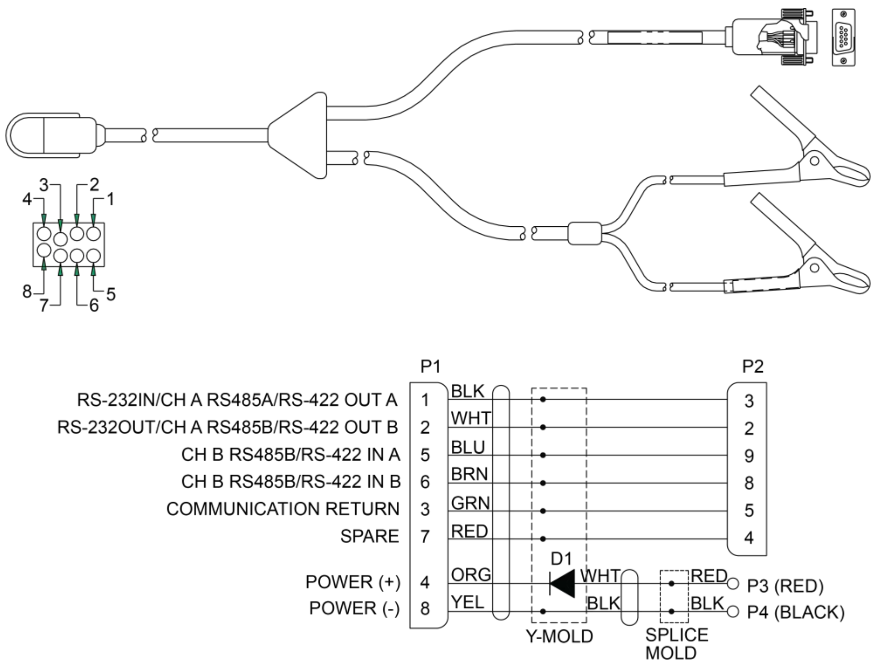


Figure 4. Rio Grande I/O Cable Wiring

Where shown, IN refers to signals going into the ADCP and OUT refers to signals coming out of the ADCP.

TRDI does not recommend using RiverRay cable if the WorkHorse Rio Grande I/O cable is not available. Even though the pin-out of the RiverRay cable is the same as a Rio Grande, it is missing the protective diode on pin 4.

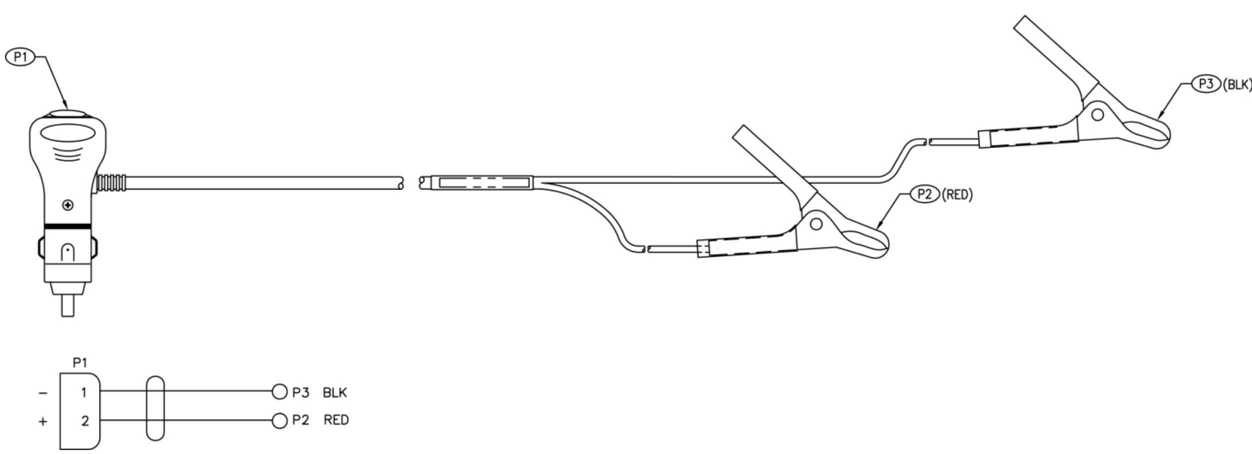


Figure 5. 12VDC Lighter Adapter Cable

Mounting the Instrument

Use the following suggestions when mounting the Rio Grande ADCP:

- It is desirable to rigidly mount the ADCP to the platform. Avoid the free spinning of the ADCP in this application. The ADCP must stay in the water at all times.
- The ADCP must be mounted deep enough so that turbulence caused by its movement through the water does not allow air bubbles to be attached to the transducer faces.
- Avoid mounting the ADCP near motors and thrusters. They cause air bubbles and will cause bias to the internal compass.
- Avoid mountings that will cause the ADCP to see severe accelerations.

Table 1. Mounting Locations

Mounting Location	Advantages	Disadvantages
Over-the-Side / Side of boat	Easy to deploy Mounts are easy to construct and are adaptable to a variety of boats ADCP draft measurement can be easily obtained	Moderate chance of directional bias in measured discharges with some boats and flows Possibly closer to ferrous metal (engines) or other sources of electromagnetic fields (EMF) Moderate-low risk of damage to ADCP from debris or obstructions in the water Susceptible to roll-induced bias in ADCP depths
Over-the-Side / Bow of boat	Minimizes the chance of directional bias in measured discharges Mounts are relatively easy to construct Usually farther away from ferrous metal or electromagnetic fields	Increased risk of damage to ADCP from debris or obstructions in the water More difficult to measure ADCP depth Susceptible to pitch-induced bias in ADCP depths, particularly at high speeds or during rough conditions (waves)
In-Hull / Well in center of boat	Protected from debris and obstructions Accurate depth measurements possible Least susceptible to pitch/roll-induced bias in ADCP depths	Often requires special modifications to boat
Tethered mount	Can be deployed from bridges, fixed cableways, or a temporary bank-operated cableway Uses Radio Modem for communications – no cables	Requires waterproof enclosure capable of housing a power supply and wireless radio modem for data telemetry Design of the ADCP mount and the power and communications enclosure should consider the increased drag on the tether that may be experienced if the boat were to flip upside down in the water. Increased chance of losing the ADCP

Over-the-Side Mounting

The over-the-side mount is common if you want the ability to move the ADCP from one platform to another. Make the mount as rigid as possible to limit the amount of pitch and roll applied to the ADCP. Although the tilt sensor can measure a ±20° influence, anything beyond 15° will cause bias to the data that cannot be removed. No matter what mounting style is used, the ADCP must be below the bubble layer. Bubbles will cling to the urethane faces of the ADCP and reduce the range to almost nothing. Usually a mount somewhere aft of amidship is used. A stern mount will cause all sorts of problems due to propeller wake, bubbles, and turbulent water conditions.

The most common over-the-side mounting method for Rio Grande ADCPs uses a Kentucky Mount style. For more information, see the following:

- http://hydroacoustics.usgs.gov/movingboat/pdfs/KYMount.pdf
- http://hydroacoustics.usgs.gov/movingboat/mbd_deployments.shtml

Our transducer assembly is sturdy, but TRDI did not design it to withstand collisions with all floating objects. TRDI strongly suggests protecting the ADCP if this is a possibility.

Avoid using ferro-magnetic materials in the mounting fixtures or near the ADCP. They affect the compass. Use 316 stainless steel hardware.

The Rio Grande has mounting holes on the end-cap. See the Outline Installation Drawings for weights.

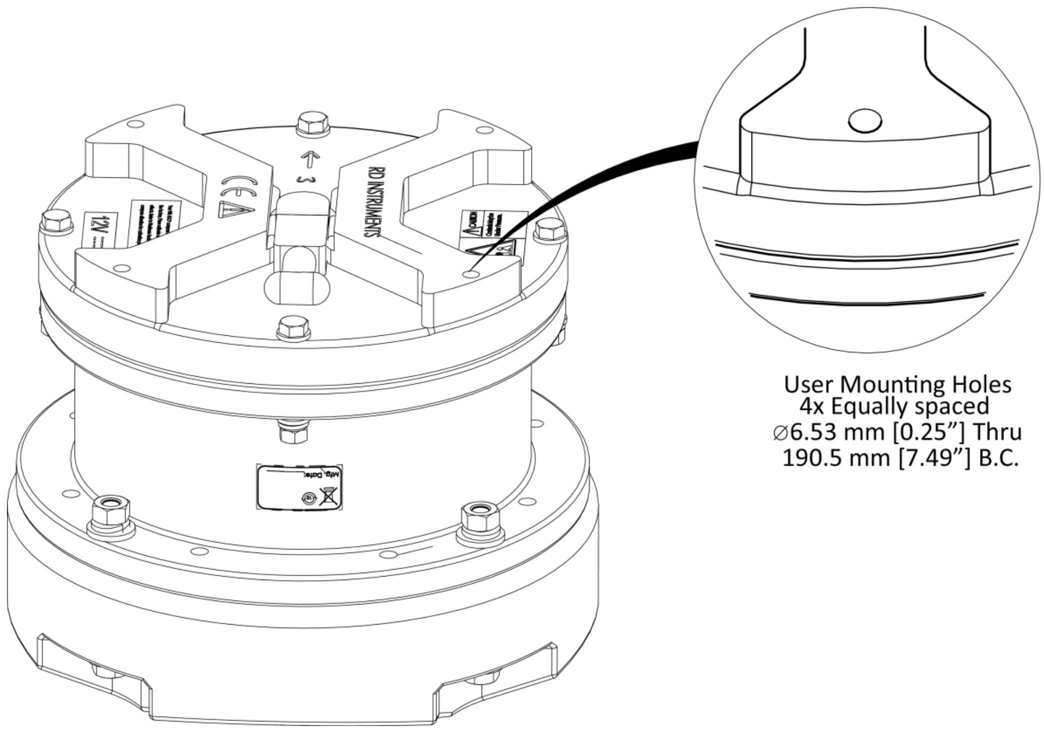


Figure 6. End-Cap User Mounting Holes

In-Hull Mounting

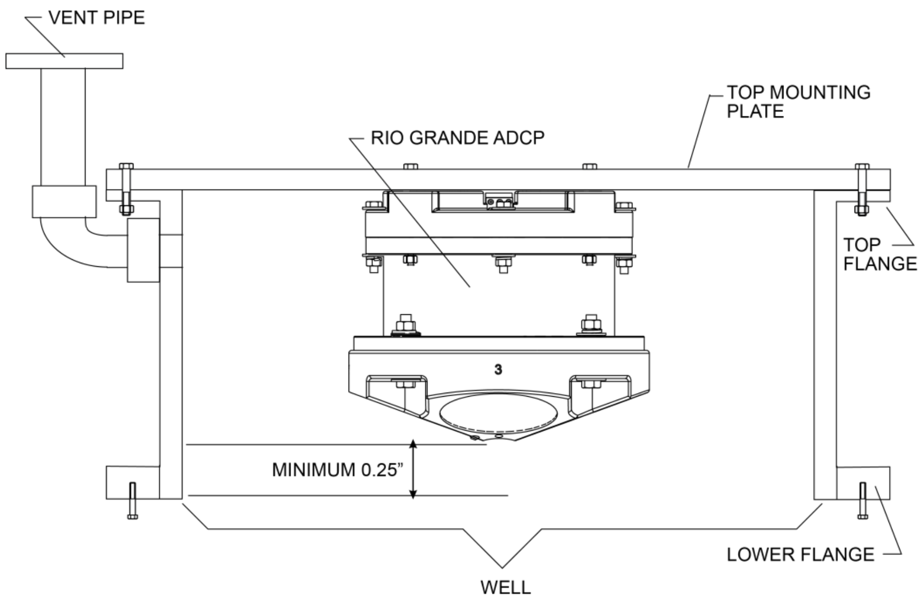
The in-hull mounted ADCP is common when it is intended to keep the system on a single vessel or when over-the-side mounting is not practical for the vessel. For this type of mounting, there are issues of beam clearance and access. Consider several potential problems before deciding where to install the transducer assembly. See the outline installation drawings for specifications on the standard ADCP transducer heads.

Ideally, install the transducer head:

- Where it is accessible both internally (for access to transducer electronics) and externally (to remove biofouling).
- Away from shipboard protrusions that reflect ADCP energy. Allow for a reflection-free clearance of 15° around each beam (see the outline installation drawings).
- Away from other acoustic/sonar devices, especially those operating at the same frequency (or harmonic) of the ADCP.
- Close to the ship's fore-to-aft centerline. As distance from the centerline increases, vertical accelerations caused by the roll of the ship also increase. These accelerations can cause additional uncertainties in ADCP velocity measurements.

Other considerations may be:

- Ease of installation.
- Portability (wanting to move the instrument from vessel to vessel).
- Permanent installation.



Tethered Mount

The Oceanscience Riverboat holds the Rio Grande ADCP and is configured for use with two 900MHz or 2.4 GHz radio modems. All required cabling, batteries, and antennae are included for easy setup. Electronics are located below deck in a watertight compartment. While collecting data, the ADCP is attached to a rope, or tether, that can be deployed from a bridge, a fixed cableway, or a temporary bank-operated cableway.

For information, see http://www.oceanscience.com/.

Chapter 3

COLLECTING DATA

In this chapter:

- Rio Grande Operation Overview
- How to collect Real-Time data

Rio Grande Operation Overview

Use the following list to collect data with the Rio Grande:

Inventory

Verify all parts are present (see the Rio Grande Reference Card for a list of parts)

Install the Software

- Install the Documentation CD
- Install WinRiver II
- Install RDI Tools
- Install SxS Pro (optional)

Mount ADCP to the Boat

Refer to the Rio Grande ADCP Guide, Chapter 2

Communication Setup

Connect the I/O cable
(refer to the WinRiver II Serial Communications Setup Card)

WinRiver II Setup

Run the WinRiver II wizard
(refer to the WinRiver II Software User's Guide, Chapter 3)

WinRiver II QA/QC

- Set the ADCP's Clock
- Test the ADCP
- Calibrate the compass

Collect Data

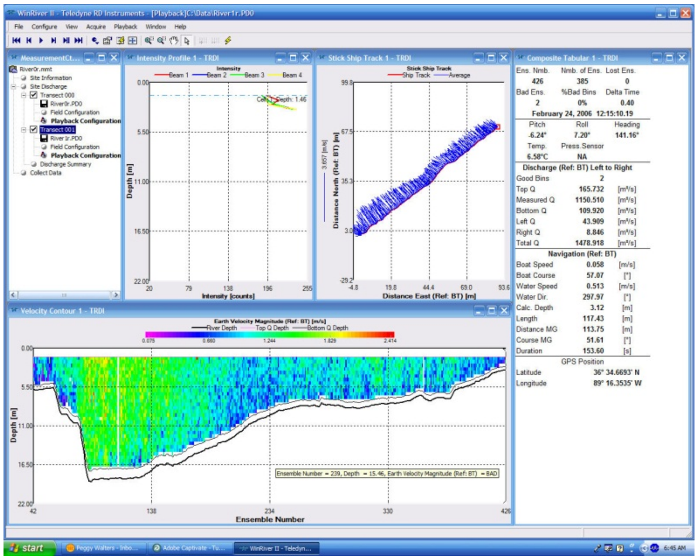
Use WinRiver II to collect at least four transects
(refer to the WinRiver II Software User's Guide, Chapter 3)

Post Process Data

Use WinRiver II
(refer to the WinRiver II Software User's Guide, Chapter 3)

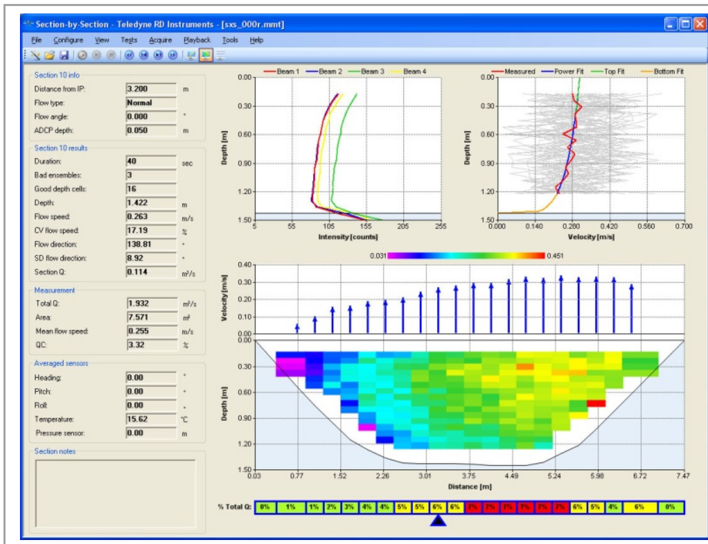
Collecting Real-Time Data

WinRiver is the most often used software package for Rio Grande ADCP setup, real-time data collection, and data review.



For detailed information on how to use *WinRiver II*, see the WinRiver II User's Guide.

SxS Pro is a stationary ADCP discharge data collection and processing program.



For detailed information on how to use *SxS Pro*, see the SxS Pro User's Guide.

NOTES

Chapter 4

MAINTENANCE

In this chapter:

- Where parts are located on the ADCP
- How to spot problems
- How to take the ADCP apart and put it back together
- How to replace the batteries
- How to do periodic maintenance items on the ADCP

Parts Location Drawings

This section is a visual overview of the inside and outside parts of the Rio Grande ADCP. Use the following figures to identify the parts used on the system.

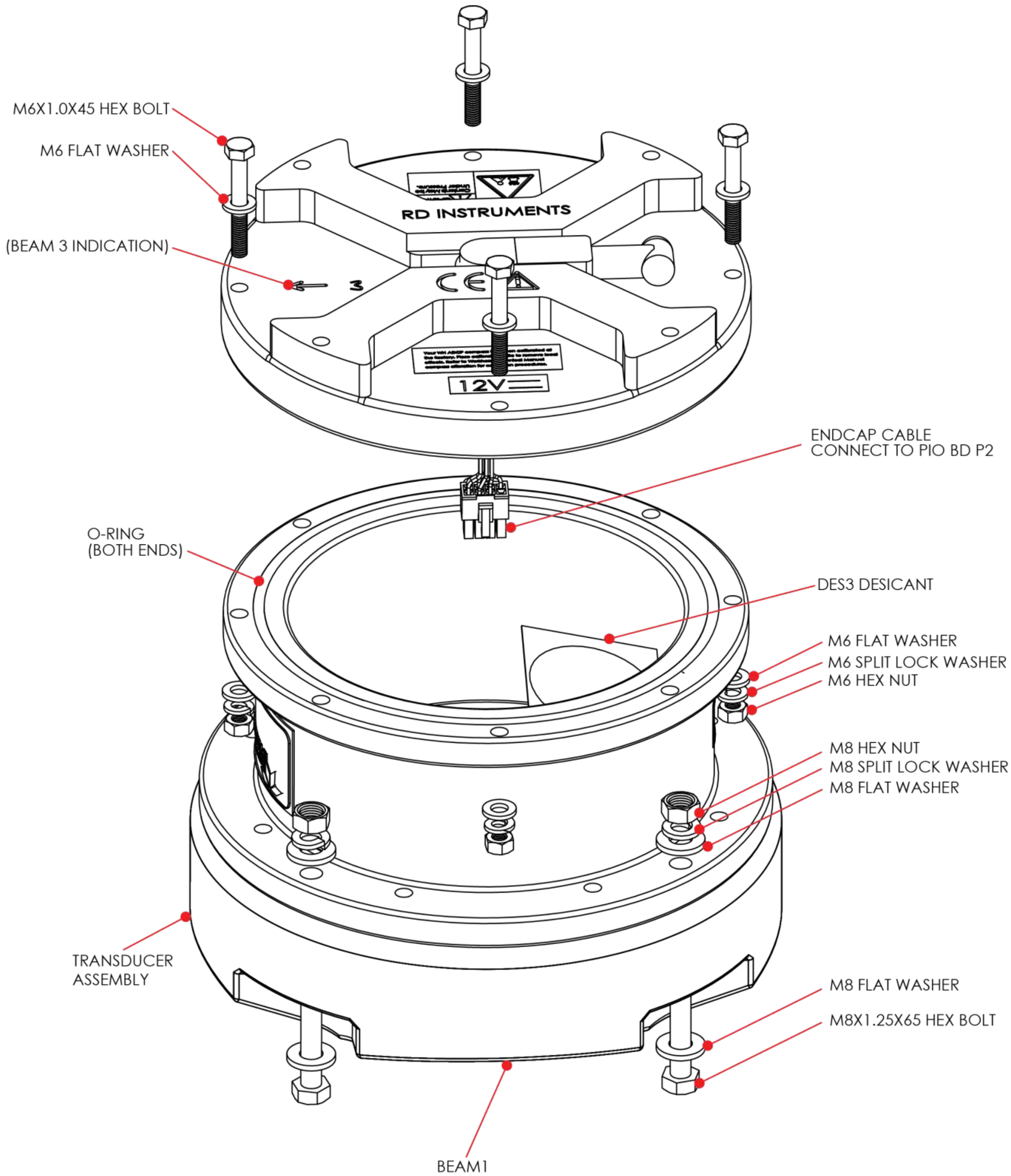


Figure 7. Rio Grande Parts Location

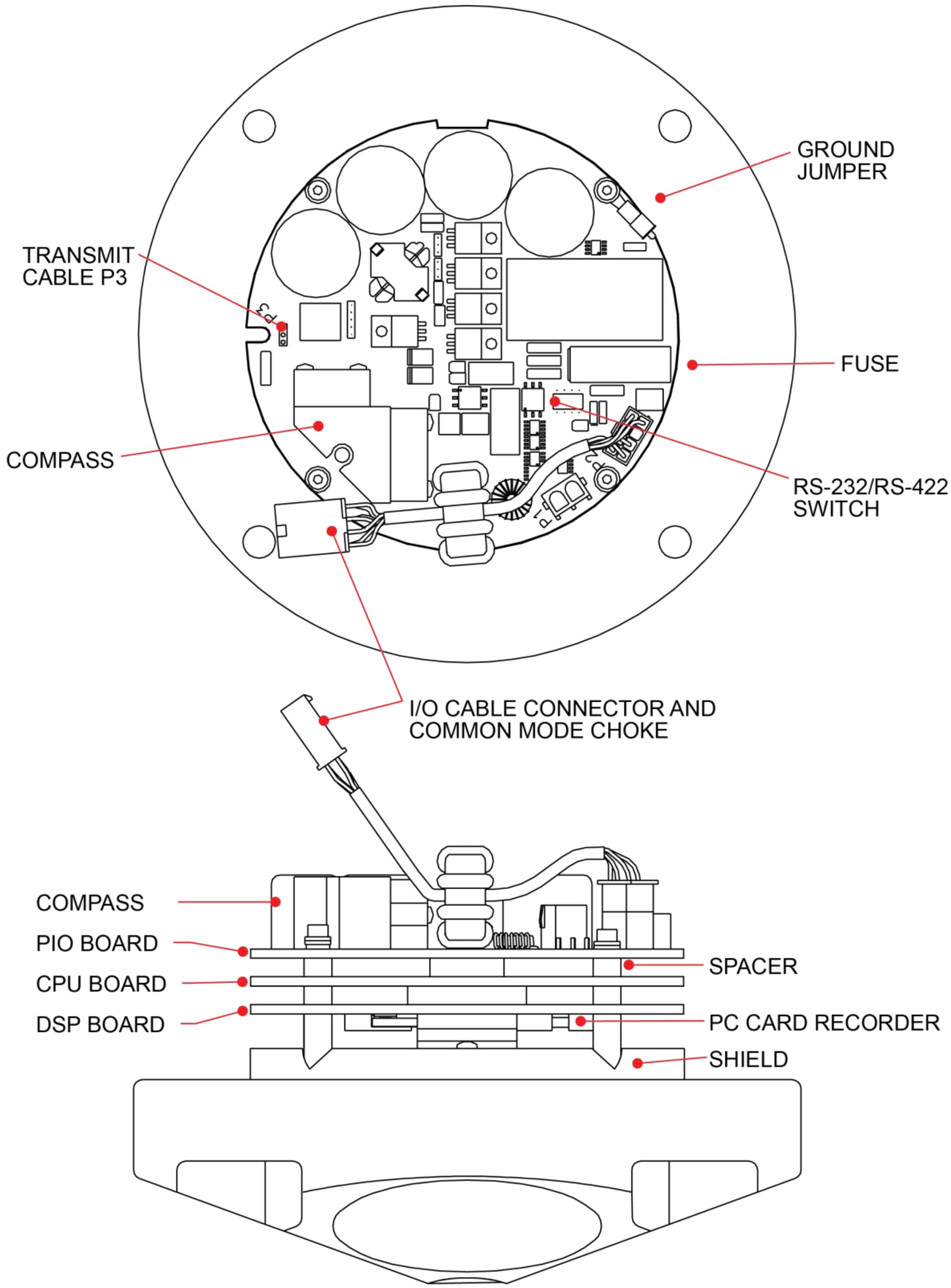


Figure 8. Rio Grande Board Locations

Maintenance Schedule

To ensure continuous optimal results from the Rio Grande, TRDI recommends that every ADCP be returned to our factory for an inspection every two to three years. TRDI's customer service will provide the unit with a thorough multi-point inspection and any refurbishment services needed to properly maintain the unit. To learn more about this service, please contact TRDI.

Calibration Items

Use the following calibration schedule:

Item	TRDI Recommended Period
Transducer Beam Angle	TRDI recommends return every two to three years for verification of velocity accuracy
Pitch & Roll (Tilt)	TRDI recommends return every two to three years for factory calibration
Temperature (Factory)	
Pressure Sensor (Factory)	
Heading (Factory)	
Heading (Field Pre-Deploy)	Field Compass Calibration (AF) performed prior to each deployment (see Compass Calibration)
Heading (Field Post-Deploy)	Field Compass Verification (AX) performed post each deployment (see Compass Calibration Verification)

Compass drift effects will accumulate over time. TRDI recommends a factory calibration be done every two to three years. Expect to have more error (due to drift) if a longer period is between factory calibrations.

For example, the fluxgate compasses accumulate an error of approximately 1% over a year.

Maintenance Items

Inspect the ADCP to spot problems:

Item	TRDI Recommended Period
Transducer Beams	The urethane coating is important to ADCP watertight integrity. 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 cups. Mishandling, chemicals, abrasive cleaners and excessive depth pressures can also damage the transducer ceramics or urethane coating. 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 (see Figure 16). 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.
O-rings	O-rings should be replaced whenever the system is opened and BEFORE they are showing any signs of wear and tear. Replace the end-cap O-ring each time the end-cap is removed. All O-rings should be replaced every one to two years maximum.
Housing and End Cap	Inspect for damage and replace as needed before each deployment.
Hardware (bolts, etc.)	Check all bolts, washers and split washers for signs of corrosion before each deployment. TRDI recommends replacement after every deployment or every year whichever is longer. Damaged hardware should never be used.
Cables and Connectors	Check the end-cap I/O connector for cracks or bent pins (see Figure 17) before each deployment. 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 before each deployment.
CPU Lithium Coin-Cell Battery	TRDI recommends replacing the lithium coin-cell battery every five years.

Figure 9. Transducer View

Figure 10. End-Cap View

Spare Parts

Periodic maintenance helps maintain the ADCP so it is ready for a deployment. Use the following tables to order replacement parts.

Table 2: Rio Grande Spare Parts

Part Number	Item Name	Where Used
SPR84-1LB	Rubber Band	Use as needed to when installing transducer head.
5020	Silicone Lubricant, 4-Pack	Housing
97Z-6052-00	O-Ring, 2-260	
M10COMBINATION	Wrench, 10MM COMB.	
M13COMBINATION	Wrench, 13MM COMB.	
M6WASHSPLTI	Washer, 6MM Split Lock, Titanium	
M6WASHSTDTI	Washer, Flat, Titanium 12.5MM OD	
M6X1.0NUTTI	Nut, Hex, Titanium 10MM	
M6X1.0X45HHTI	Screw, Hex Head, Titanium	
M8WASHSPLTI	Washer, Split Lock, Titanium	
M8WASHSTDTI	Washer, Flat, Titanium 22.9MM OD	
M8X1.25NUTTI	Nut, Hex, Titanium 13MM	
M8X1.25X65HHTI	Screw, Hex Head, Titanium Full Threads Length	
717-3008-00	Jumper, GND	Main Electronics
817-3003-00	Washer, Felt	
GMA-3A	Fuse, 5MM X 20MM 3R 250V	
DES3	Desiccant, Sealed Bag	Inside Housing
817-1067-00	Screw, Pressure Sensor	Pressure Sensor cover

Table 3: Replacement Kits

Part Number	Description	Where Used
757K6035-12	1200 kHz Spare Boards Kit	Installing the Spare Boards Kit
757K6035-13	600 kHz Spare Boards Kit	
757K6078-00	Spare Parts Kit	Replacement spare parts kit (see Table 3 for a list of included parts).
757K6113-00	Close-Up Kit	Includes needed hardware, O-rings, and desiccant to seal the ADCP.

Disassembly and Assembly Procedures

This section explains how to remove and replace the end-cap or transducer head to gain access to the ADCP's electronics and internal recorder. Read all instructions before doing the required actions.

- Transducer Head Assembly Removal
- End-Cap Removal Procedures
- O-ring Inspection and Replacement
- Transducer Head Replacement
- End-cap Replacement

Transducer Head Assembly Removal

Caution label on End-Cap

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

Rio Grande ADCPs contain Electro Static Sensitive Devices. Take accepted ESD prevention measures before opening the transducer head.

If the transducer assembly is removed, replace both the desiccant and O-ring. Use Parts Location Drawings for parts identification.

To remove the transducer head assembly:

1. Dry the outside of the ADCP.
2. Disconnect the I/O cable and install the dummy plug.
3. Stand the Rio Grande on its end-cap.
4. Inspect the transducer bolts for any signs of damage such as bending, stretched bolts, crushed or deformed bushings, etc. These signs may indicate that there is internal pressure inside the system.
5. To avoid any possible injury it is ALWAYS recommended that to loosen but not remove the four transducer bolts to allow any internal pressure to be vented from the system. **Loosen the transducer bolts two turns each in a cross-pattern. Repeat until the face seal O-ring is not compressed and the system has the opportunity to vent**. If the transducer moves as the bolts are loosened, then this may indicate that internal pressure is present. Be sure to only loosen the bolts far enough to allow the system to vent.
6. Once all four bolts have been loosened and there is no internal pressure, remove the bolts from the transducer.
7. Carefully lift the transducer assembly straight up and away from the housing. Use care; the plastic mating surfaces on the housing and transducer scratch easily. Do not damage the mating surfaces.

The cable attached to the end cap is only long enough to disconnect the internal I/O cable. There is NOT enough cable to set the transducer down next to the Housing Assembly.

8. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap/housing assembly aside. Set the transducer assembly (transducer face down) on a soft pad.
9. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage (see O-ring Inspection and Replacement).
10. When ready to re-assemble the ADCP, see Transducer Head Assembly Replacement.

End-Cap Removal Procedures

Caution label on End-Cap

Wear safety glasses and keep head and body clear of the end-cap while opening.

Any system that was deployed may have pressure inside the housing.

For access to the electronics, remove the transducer head assembly (see Transducer Head Assembly Removal).

If the end-cap assembly is removed, replace both the desiccant and O-ring. All O-rings should be replaced every one to two years maximum.

To remove the end-cap:

1. Dry the outside of the ADCP.
2. Disconnect the I/O cable and install the dummy plug.
3. Stand the ADCP on its transducer faces on a soft pad.
4. Inspect the housing and end cap bolts for any signs of damage such as bending, stretched bolts, crushed or deformed bushings, 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 not remove the four end-cap bolts to allow any internal pressure to be vented from the system. **Loosen the end-cap bolts two turns each in a cross-pattern. Repeat until the face seal O-ring is not compressed and the system has the opportunity to vent**. If the end-cap moves as the bolts are loosened, then this may indicate that internal pressure is present. Be sure to only loosen the bolts far enough to allow the system to vent.
6. Once all four end-cap bolts have been loosened and there is no internal pressure, remove the bolts from the end-cap.
7. Carefully pull the end-cap away from the housing. Use care; the plastic mating surfaces scratch easily. Do not damage the mating surfaces.
8. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap aside.
9. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage (see O-ring Inspection and Replacement). Even small scratches can cause leakage around the O-ring seal.

O-ring Inspection and Replacement

This section explains how to inspect/replace the Rio Grande O-rings. A successful deployment depends on the condition of two O-rings and their retaining grooves. See Parts Location Drawings for the locations of the following O-rings. Read all instructions before doing the required actions.

- Transducer assembly, face, 2-260
- End-cap assembly, face, 2-260

TRDI strongly recommend replacing these O-rings whenever the Rio Grande is disassembled. Inspecting and replacing the O-rings should be the last maintenance task done before sealing the Rio Grande.

TRDI recommends using new O-rings when preparing for a deployment. All O-rings should be replaced every one to two years maximum.

To replace the O-Ring:

1. 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 ADCP to flood.

2. 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 groove thoroughly. Any foreign matter in the O-ring groove will cause the ADCP to flood.

3. If a scratch is on the plastic housing flange O-ring groove, it may be gently sanded using 600-grit (wet) sandpaper. Use care not to cause further damage.
4. Lubricate the O-ring with a thin coat of silicone lubricant (Table 3). 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.

Transducer Head Assembly Replacement

To replace the transducer head:

1. Stand the Rio Grande on its end-cap.
2. Inspect, clean, and lubricate the O-ring on the housing (see O-ring Inspection and Replacement). Place the O-ring in the O-ring groove.

TRDI recommends using new O-rings when preparing for a deployment.

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.

3. Connect the internal I/O connector to the plug on the common mode choke.
4. Replace the desiccant bags (see Replacing the Desiccant Bags).

5. Gently lower the transducer head/electronics assembly into the housing, aligning the mating holes and the beam 3 number embossed on the transducer head with the beam 3 number embossed on the end-cap. When mating the housing with the transducer head flange try to apply equal pressure to all parts of the O-ring. Make sure the face O-ring remains in the retaining groove.

> Check that no wires or any other object is pinched between the transducer head assembly and the housing. Use rubber bands to hold the wiring in place as necessary. If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.

6. Examine the titanium transducer assembly nuts, bolts, and washers (8-mm) for corrosion; replace if necessary. The Parts Location Drawings shows the assembly order of the transducer mounting hardware. All hardware items are needed to seal the Rio Grande properly.
7. Install all four sets of hardware until "finger tight."
8. Tighten the bolts in small increments in a "cross" pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the face seal O-ring evenly. Tighten the bolts to the recommended torque value of 9.6 Newton-meters (85 pound-inches). Do not deform the plastic bushings.

> Apply equal pressure to the O-ring as the bolts are tightened. If one bolt is tightened more than the others, the O-ring can become pinched or torn. A damaged O-ring will cause the system to flood.

> Do not over tighten the bolts that hold the transducer, housing, and end cap together. The plastic housing can crack or break if the bolts are over-tightened. On the other hand, leaving the bolts too loose can cause the system to flood. Tighten the hardware to the recommended torque value.

> The recommended torque value for the transducer head 8-mm bolts is 9.6 Newton-meters (85 pound-inches).

End-Cap Replacement

To replace the end-cap:

1. Stand the Rio Grande on its transducer face on a soft pad.
2. Inspect, clean, and lubricate the O-ring on the housing (see O-ring Inspection and Replacement). Place the O-ring in the O-ring groove.

> TRDI recommends using new O-rings when preparing for a deployment.

> 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.

3. Connect the internal I/O connector to the plug on the common mode choke.
4. Replace the desiccant bags (see Replacing the Desiccant Bags).
5. Place the end-cap on the housing, aligning the mating holes and the beam 3 number embossed on the end-cap with the beam 3 number embossed on the transducer head. When mating the end-cap with the housing flange, try to apply equal pressure to all parts of the O-rings. Make sure the face O-ring remains in its retaining groove.

Check that no wires or any other object is pinched between the end-cap and the housing. Use rubber bands to hold the wiring in place as necessary. If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.

6. Examine the titanium end-cap assembly nuts, bolts, and washers (6-mm) for corrosion; replace if necessary. The Parts Location Drawings shows the assembly order of the end-cap mounting hardware. All the hardware items are needed to seal the Rio Grande properly.
7. Install all four sets of hardware until “finger-tight.”
8. Tighten the bolts in small increments in a “cross” pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the face seal O-ring evenly. Tighten the bolts to the recommended torque value of 5.6 Newton-meters (50 pound-inches).

Apply equal pressure to the O-ring as the bolts are tightened. If one bolt is tightened more than the others, the O-ring can become pinched or torn. A damaged O-ring will cause the system to flood.

Do not over tighten the bolts that hold the transducer, housing, and end cap together. The plastic housing can crack or break if the bolts are over-tightened. On the other hand, leaving the bolts too loose can cause the system to flood. Tighten the hardware to the recommended torque value.

The recommended torque value for the end-cap 6-mm bolts is 5.6 Newton-meters (50 pound-inches).

Periodic Maintenance Items

Calibrating the Compass

Rio Grande compass calibration corrects for distortions in the earth's magnetic fields caused by permanent magnets or ferromagnetic materials near the Rio Grande. These magnetic field distortions, if left uncorrected, will create errors in the heading data from the Rio Grande. A compass 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 Rio Grande on a manned boat 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 Rio Grande inside the fixture. Depending on the strength and complexity of the fixture's field, the calibration procedure may be able to correct it.
- 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.

In the (fairly rare) event that there is an issue with the calibration, TRDI suggests sending the AR command first and then try to align the compass. The AR command can be sent using *BBTalk*.

For detailed instructions on calibrating the compass, see the WinRiver II User's Guide.

Calibrating the Compass with WinRiver II

To calibrate the Rio Grande ADCP compass:

1. Mount the Rio Grande ADCP in the boat as it will be used to acquire data.
2. Start *WinRiver II* and use the WinRiver II Serial Communications Setup Card to establish communications with the ADCP.
3. On the **Acquire** menu, click **Execute Compass Calibration**. Click on the **Calibrate** button to begin the compass calibration.

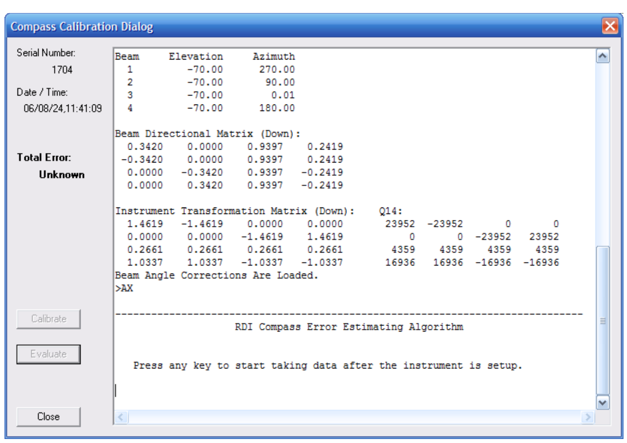


Figure 11. Compass Calibration Screen

4. During this procedure, drive the boat in continuous, small circles. Accomplish this by adjusting the throttle to just above idle and steering either hard left or hard right. Reduce any pitch and roll effects during the turn (do not move about the boat, this may cause the boat to change how it sits in the water) and avoid any accelerations. Drifting downstream while performing the circles will not affect the correction procedure.
5. While continuing to drive the boat in circles, press any key to start the compass calibration. Follow the on screen prompts.
6. Press **D** for details.

```
HEADING ERROR ESTIMATE FOR THE CURRENT COMPASS CALIBRATION:
   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5ø):  ñ 1.73ø
   DETAILED ERROR SUMMARY:
      Single Cycle Error:                                 ñ 1.70ø
      Double Cycle Error:                                 ñ 0.42ø
      Largest Double plus Single Cycle Error:             ñ 2.12ø
      RMS of 3rd Order and Higher + Random Error:         ñ 0.77ø
      Orientation:    Down
      Average Pitch:  -0.18ø         Pitch Standard Dev:    0.37ø
      Average Roll:    0.35ø         Roll Standard Dev:     0.45ø

Successfully evaluated compass performance for the current compass calibration.

Press C to display Percent Horizontal Field Components
     Relative to Calibration or any other key to continue....
Calibration parameters have been updated in NRAM.

>
```

7. Press **Close** to exit the Compass Calibration Dialog.

Rio Grande Compass Calibration Verification

Compass calibration verification is an automated built-in test that measures how well the compass is calibrated. The procedure measures compass parameters at every 5° of rotation for a full 360° rotation. When it has collected data for all required directions, the ADCP computes and displays the results.

1. On the **Acquire** menu, click **Execute Compass Calibration**. Click on the **Evaluate** button to begin the compass verification.
2. Rotate the ADCP slowly 360 degrees (approximately 5 degrees per second). Pay particular attention to the Overall Error.
3. If the overall error is less than 2°, the compass does not require alignment. The compass can be calibrated to reduce the overall error even more (if desired).

```
HEADING ERROR ESTIMATE FOR THE CURRENT COMPASS CALIBRATION:
   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5():  ( 1.55(
   DETAILED ERROR SUMMARY:
      Single Cycle Error:                                ( 1.54(
      Double Cycle Error:                                ( 0.07(
      Largest Double plus Single Cycle Error:            ( 1.61(
      RMS of 3rd Order and Higher + Random Error:        ( 0.31(
```

Replacing the Desiccant Bags

Desiccant bags are used to dehumidify the housing interior. Desiccant is essential in deployments with plastic housings. The factory-supplied desiccant lasts a year at specified Rio Grande deployment depths and temperatures. Remember that desiccant rapidly absorbs moisture from normal room air.

The average dry weight of a new desiccant bag is 7.2 grams ((5%). The weight increases to 8.4 to 9 grams for a “used” desiccant bag. Used desiccant bags may be dried at 250° for 14 hours. As a minimum, replace the desiccant bags (Table 3) whenever preparing to deploy or store the Rio Grande for an extended time.

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 until it has been dried. TRDI recommends replacing the desiccant bag just before the deployment.

To replace the desiccant:

1. Remove the transducer head (see Transducer Head Assembly Removal).
2. Remove the new desiccant bags from the airtight aluminum bag.
3. Remove the old desiccant bags and install two new ones. Place the desiccant bags (Table 3) between the PIO board and the end-cap (see Parts Location Drawings).
4. Install the transducer head (see Transducer Head Assembly Replacement).

Cleaning the Thermistor Cover

In order to respond quickly to changes in the water temperature, water must be able to flow over the sensor. Do not block the sensor or paint over it with antifouling paint. Remove any biofouling as soon as possible.

The Thermistor is embedded in the transducer head. The sensor is under a titanium cover that is highly resistant to corrosion.

Figure 12. Thermistor and Pressure Sensor

PC Card Recorder

The optional PC Card recorder is located on the Digital Signal Processor (DSP) board inside the Rio Grande's electronics (see Figure 19). To recover data, the card can be removed and used in a personal computer (PC), or left in the Rio Grande, and accessed by using *WinSC* (see the *WinSC* User's Guide).

To remove or install a PC card:

1. Turn off power to the Rio Grande.
2. Remove the transducer head (see Transducer Head Assembly Removal).
3. Remove the PC cards by pushing the button on the side of the PCMCIA card slot. The card should "pop" out of the connector. If you cannot reach the release button with your finger, use a plastic pen or non-conductive tool to depress the button. Do not try to force the card in or out of the connector. PC cards slide easily in or out when properly oriented.

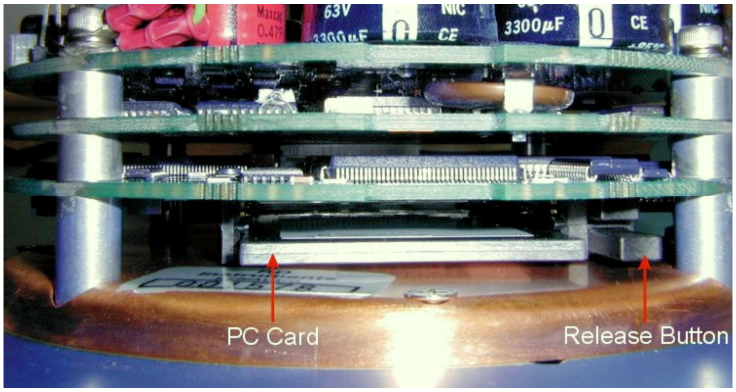


Figure 13. PC Card Recorder

4. When you are finished recovering the data, install the PC card back into the DSP board. PC cards install with the label side toward the face of the transducer.
5. Install the transducer head (see Transducer Head Assembly Replacement).

Do not use a PCMCIA adapter for compact flash cards. These do not work.

Do not delete files from the PC card using Windows®. This may leave hidden files on the card. Always use the ADCP's erase command to delete data from the PC card recorder.

Installing Firmware Upgrades

The firmware for Rio Grande ADCPs in located on flash RAM chips on the CPU board. Firmware upgrades can be downloaded from TRDI's website support page (www.rdinstruments.com). If the firmware upgrade is not available via the web, then please contact Field Service (rdifs@teledyne.com) to request a copy.

To install a firmware upgrade:

1. Connect your ADCP to the computer as shown in Setting up the Rio Grande System.
2. Start the program *WHMSLxxx.exe* (where *xxx* is the firmware number).
3. Click **Setup**. Click the **View README.TXT** button to view the Readme.txt file for details on what is new in this version of the firmware.
4. Click **Next** and follow the on-screen prompts.
5. If you are not able to install the new firmware, contact Customer Service.
6. After successfully upgrading the firmware, use *BBTalk* to test the ADCP (see Testing the Rio Grande).

Installing Feature Upgrades

The feature upgrade installation program is used to install the Shallow Water Bottom Mode or High Ping Rate capabilities in an ADCP.

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 (see **Firmware Upgrades**).

To install a feature upgrade:

1. Set up the Rio Grande as shown in Setting up the Rio Grande System.
2. Start the program *Activate_WH_xxxx.exe* (where *xxxx* is the ADCP's serial number).
3. The installation program will start (see Figure 20). The program is encoded with the ADCP's serial number and the requested feature upgrade.

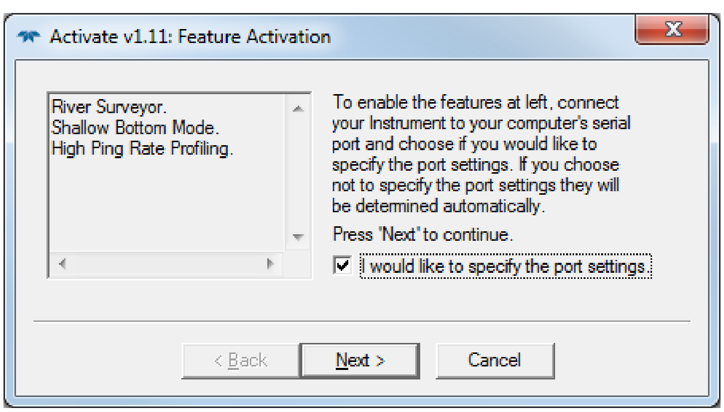
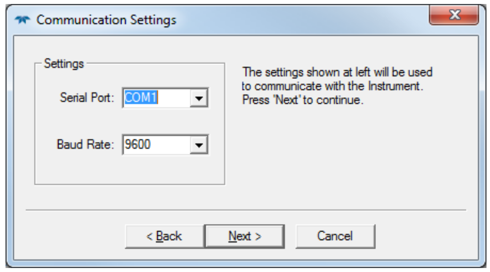


Figure 14. Installing Feature Upgrades

4. To select the port settings, select the **I would like to specify the port setting** box and click **Next**.



5. Select the **Serial Port** and **Baud Rate**.
6. Click **Next** to install the feature upgrade.
7. Click the **Finish** button to exit the program.
8. Start *BBTalk* and use the OL command (see the Rio Grande Commands and Output Data Format guide) to verify the feature upgrade has been installed.

Replacing Fuses

PIO Board. There is one fuse on the PIO Board (see Figure 15) that protects the Rio Grande from excessive incoming power. If this fuse continues to blow, check your input power before applying power again.

To replace the fuse:

1. Turn off the power.
2. Remove the transducer head (see Transducer Head Assembly Removal).
3. The PIO board fuse is located next to the internal I/O connector. Use a small flat-blade screwdriver to open the fuse housing. Turn the end 180° (counter-clockwise) to open the fuse housing.
4. Gently pull the fuse housing out. Turn the housing to remove the fuse.
5. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse (Table 3).
6. Install the transducer head (see Transducer Head Assembly Replacement).
7. Test the system (see Testing the Rio Grande).

Changing Communications Setting

A switch on the PIO board (see Figure 21) changes the communication settings between RS-232 and RS-422. The computer and the Rio Grande must both be set to the same communication setting. Use the RS-232-to-RS-422 converter if the Rio Grande is using RS-422 communications and the computer only has an RS-232 COM port.

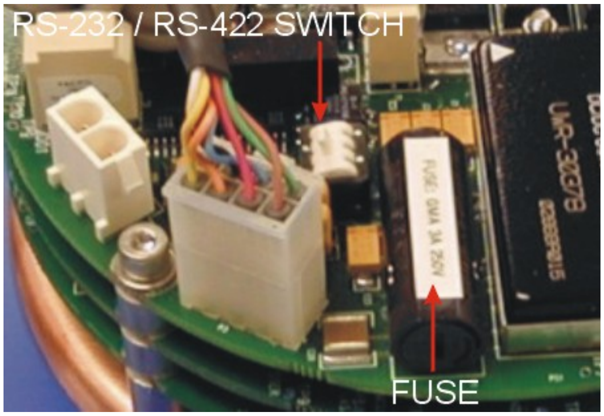


Figure 15. Communication Switch and Fuse

Preventing Biofouling

This section explains how to prevent the buildup of organic sea life (biofouling) on the transducer faces. Objects deployed within about 100 meters (≈328 feet) of the surface are subject to biofouling, especially in warm water. Soft-bodied organisms usually cause no problems, but barnacles can cut through the urethane transducer face causing failure to the transducer and leakage into the ADCP.

The best-known way to control biofouling is cleaning the ADCP transducer faces often. However, in many cases this is not possible.

The following options can help reduce biofouling:

- Coat the entire ADCP with antifouling paint. Make sure that the paint is applied in an even coat over the transducer faces and inductive modem (see Applying Antifouling Paints).
- Apply a thin coat (1 mm, 0.039 in.) of either a 50:50 mix of chili powder and petroleum jelly or chili powder and silicone grease to the transducer faces. The chili powder should be the hottest that can be found. Water flowing across the transducers will wash this mix away over time. The silicone mixture tends to last longer.
- If using antifouling grease, remove the grease immediately after recovering the ADCP from its deployment. Remove the grease with soapy water because cleaning solvents may also cause the urethane to crack. Be sure to wear protective gloves and a face shield. Tests have suggested antifouling grease may cause the urethane on the transducer faces to develop cracks. Warmer temperatures accelerate this effect.

If using antifouling grease, remove it immediately after recovering the ADCP.

Antifouling grease is toxic. Read the product safety data sheet before using the grease. Wear gloves and a face shield when applying the grease. If the skin comes in contact with the grease, immediately wash the affected area with warm, soapy water.

Antifouling Paints

Almost any EPA approved anti-fouling paint can be used on the housing or the urethane transducer faces. Contact the antifouling paint manufacturer for preparation and application procedures for this and other antifoulant paints. Interlux is one source of antifouling paint. 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 anti-fouling paint.

Manufacturer	Contact
Courtalds Finishes	Telephone: +1 (800) 468-7589
Interlux brand paints	Web Page : http://www.yachtpaint.com/usa/

Do not use antifouling paints that contain cuprous oxide on aluminum housings as it will cause galvanic corrosion.

Applying Antifouling Paints

The following tips are only general recommendations. Always follow the anti-fouling paint manufacturer's instructions on how to apply the anti-fouling paint.

TRDI recommends that any antifouling coating should be applied in as thin a layer as possible. It should be understood that applying a coating may reduce the measurement range of the ADCP (though it will not affect its accuracy in the measurable range).

As originally manufactured, the transducer faces have 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 faces. However, if an antifouling coating is desired on the transducer faces, then the faces must be lightly abraded to allow for the antifouling coating to adhere. **As a rule, the surface must be kept smooth unless an antifouling coating will be applied.**

1. Transducer Face Surface Preparation - Lightly abrade the surface using Scotch Brite® to remove gloss. Thoroughly clean the areas to be painted with soapy water and dry.
2. Surface Application:
   - Mask as necessary. Do not paint over mounting hardware or temperature sensor, etc.
   - Apply an even, thin layer (0.1mm, 4mil per coat) of antifouling paint. If more than one coat is needed to reach the maximum thickness, allow each coat to dry for 16 hours.
   - When applying paint to the urethane faces, use extra caution to apply a smooth, thin coat of paint.

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 faces 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 ADCP 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 ADCP to TRDI for repair. If the barnacles cannot 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 ADCP before placing it in the storage case to avoid fungus or mold growth. Do not store the ADCP in wet or damp locations.

Installing the Spare Boards Kit

The Spare Boards Kit has been set up to replace all three of the Rio Grande boards at once. This prevents damaging the individual boards while swapping in individual boards. The heading, pitch, and roll sensors have all been calibrated (the temperature sensor is an independent calibration and not changed by these new boards). Once the original boards are replaced, place them back in the Spare Board Kit box and contact Teledyne RD Instruments Customer Service Department to return them for repair.

> Before handling either the Spare Board Kit or the original Board Set, always wear an earth-grounding static protection strap. The electronics in the Rio Grande are very sensitive to static discharge. Static discharge can cause damage that will not be seen immediately and will result in early failure of electronic components.
>
> TRDI assumes that a qualified technician or equivalent will perform all of the following work.

The Spare Boards Set will allow the system to perform to the same velocity specifications as the original set. However, there is an offset error in the compass that can be as great as ±1.5 degrees. This error CANNOT be removed by doing the Field Calibration procedure (see the AF command and Calibrating the Compass) even though this MUST be done as part of the installation. The additional ±1.5 degrees can only be removed by TRDI at the factory. In most cases, the total compass error will still be within our original specification of ±5.0 degrees. The only way to be sure that there are smaller errors than this specification is to perform a local compass verification and correct any errors during post processing of the data.

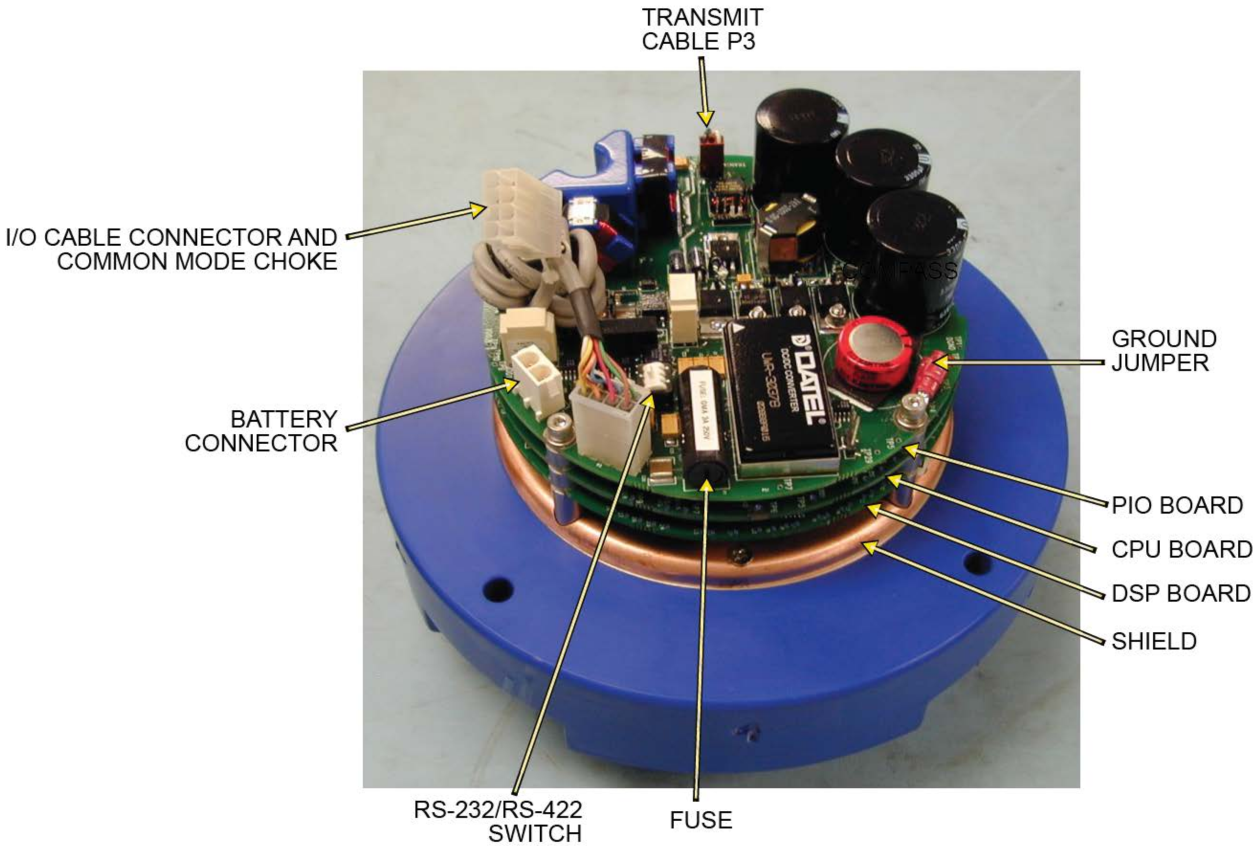


Figure 16. Rio Grande Electronics Overview

Remove the Original Set of Boards

To remove the original boards:

1. Remove the Transducer assembly from the pressure case. Use Transducer Head Assembly Removal for instructions.
2. With a earth-ground static protection strap on, use a 3mm Allen wrench to remove the four bolts that secure the three original Rio Grande boards to the Transducer assembly.
3. Note the orientation of the transmit cable connector as it is plugged into the PIO board and to the Receiver board (see Figure 23).

   This cable must be removed and it has a very tight fit. To remove this cable, lift straight up on the three boards and tilt slightly (no more than 2 cm) toward the cable. This should allow enough slack to unplug the cable from the PIO board. If this is not possible, unplug the cable from the Receiver board. Be sure to note its orientation before unplugging.

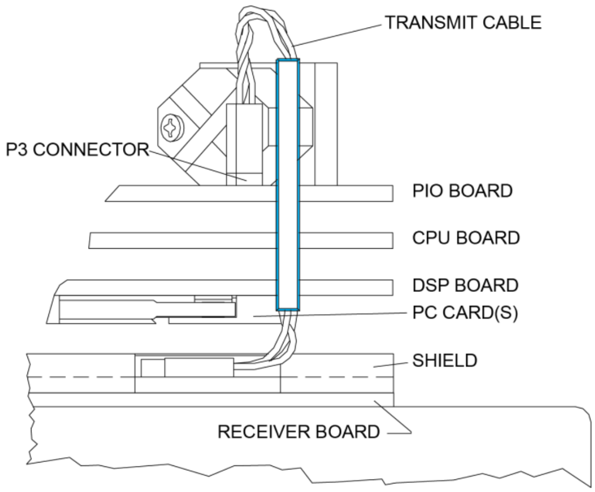


Figure 17. Transmit Cable

4. Once the transmit cable has been disconnected, remove the top three boards as a set by lifting the set straight up.

   These top three boards are connected to each other via connectors and will remain as one piece (see Figure 24). The DSP board connects to the Receiver board through a 26-pin header. The 26-pin header is a series of male pins. The 26-pin header may or may not stay connected to the DSP board when the top three boards are removed. If there are male pins sticking out of the DSP board when removing the board set, then the header has remained attached to the DSP board. If this happens, remove it and place it into the Receiver board. To remove it, gently rock it back and forth while pulling it away from the DSP board. Once removed, align it with the connector on the Receiver board and press it into place.

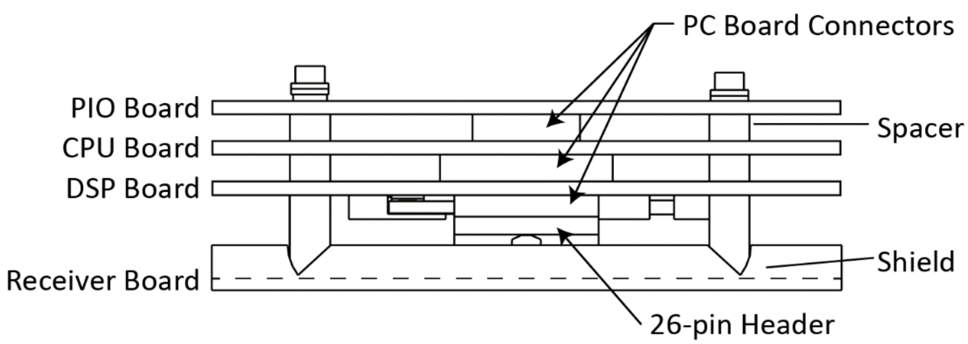


Figure 18. PC Board Connectors

5. Remove all PCMCIA card(s) from the original set of boards. These PCMCIA cards will be used again in the Spare Boards Set. The Spare Board set does NOT contain a PCMCIA card(s). The PCMCIA card(s) are located on the bottom of the DSP board. To remove the PCMCIA card(s) press the button(s) on the side of the PCMCIA card slot. Pressing this button causes the PCMCIA card to slide out. Pull the card(s) out the rest of the way once the button is depressed all the way in.
6. Set the original board set to the side for now.

Installing the Spare Board Kit

To install the spare boards kit:

1. With an earth-ground static protection strap on, remove the Spare Board Kit from the anti-static bag.
2. Using a 3 mm Allen wrench and a 7mm wrench remove the nuts from the bolts that secure the Spare Boards together. Use these bolts to secure the spare set in the system. DO NOT change the position of any of the bolts. The bolt containing the felt washers and ground jumper must remain in the same position (see Figure 25).

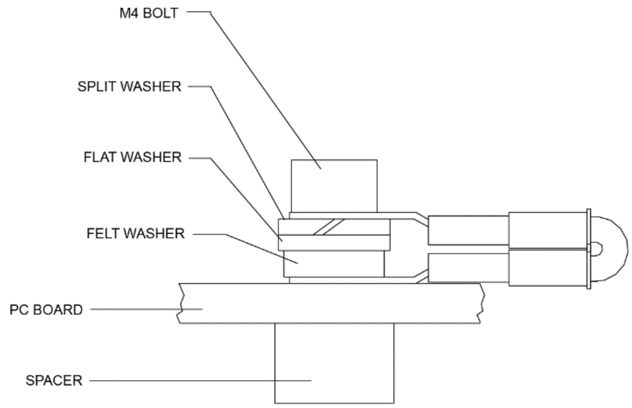


Figure 19. Ground Jumper

3. Place the nuts (just removed) on the four bolts of your original set of boards and place them into the anti-static bag. Use the new set of bolts included in the Spare Board kit to secure them to the Transducer assembly.
4. Install all optional PCMCIA cards into the PCMCIA card slots. The PCMCIA card is keyed and will only connect when it has been aligned correctly and slid all the way in. The PCMCIA card is installed with the label side pointing away from the DSP board.
5. Connect the Spare Board set to the Receiver board. Align the Spare Board set to the 26-pin header connected to the Receiver board. As the Spare Board set is connected, connect the transmit cable removed in Remove the Original Set of Boards step 3. Be sure to connect the cable in the same orientation as was installed on the original board set.

   To test that the transmit cable is connected properly, start *BBTalk* and run the PT4 test. The test failure example shown below shows a missing or improperly attached transmit cable.

```
[BREAK Wakeup A]
WorkHorse Rio Grande ADCP Version xx.xx
Teledyne RD Instruments (c) 1996-2002
All Rights Reserved.
>pt4

IXMT    =      0.0 Amps rms  [Data= 0h]
VXMT    =     19.3 Volts rms [Data=4ch]
   Z    =    999.9 Ohms
Transmit Test Results = $C0 ... FAIL
>
```

6. Insert the four new bolts and tighten to 4 Newton-meters.
7. Install the Transducer into the Pressure Case. See Transducer Head Assembly Replacement for instructions.

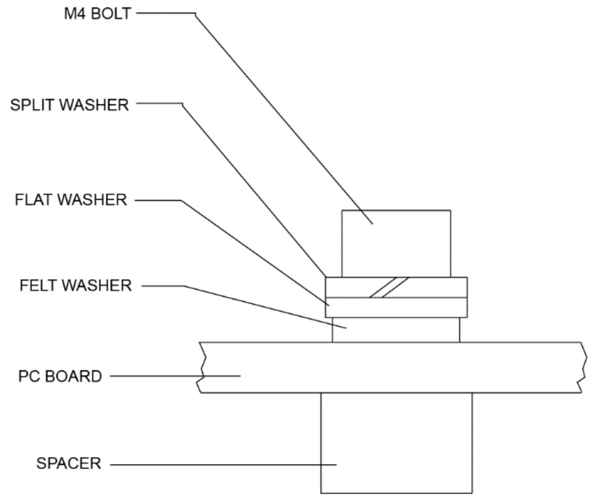


Figure 20. Mounting Hardware

Installing the Beam Cosine Matrix

The beam cosine matrix table corrects small transducer beam misalignment angles that occur during manufacturing.

To install the beam cosine matrix:

1. Connect the Rio Grande ADCP (see Setting up the Rio Grande System).
2. Start *BBTalk* and confirm that the Rio Grande ADCP is communicating normally and which communication port is used (COM 1 or COM 2).
3. Place the Beam Cosine Matrix Disk into the computer's disk drive.
4. If the ADCP is connected to COM 1, press **<F2>** and run the script file *xxxx_1.scr* (where xxxx is the system serial number).

   If the ADCP is connected to COM 2, press **<F2>** and run the script file *xxxx_2.scr* (where xxxx is the system serial number).

   The Beam Cosine Matrix table will automatically be updated in the ADCP and a file called SPRBD.LOG will be created. View the contents of this file to confirm that the data entered during the &V portion matches the contents in the PS3 results under the label Q14.

Testing the System

To test the system after replacing any board(s):

1. Install the transducer in the housing.
2. Connect the cable and power and test the ADCP as shown in Testing the Rio Grande. All PA tests should pass when run in water and the PC tests should pass with the ADCP out of water.
3. Perform a field calibration of the compass. Use Calibrating the Compass for instructions on running the AF command. Remember that there will be up to 1.5 degrees of offset error in the compass measurement. This error is not removed by the field calibration.

Once the Spare Board installation is complete, return the original boards to TRDI for repair. Please contact the Teledyne RD Instruments Customer Service Department for return shipping instructions and repair costs (see Technical Support).

Replacing the CPU Lithium Battery

This section explains how to replace the rechargeable lithium coin-cell battery in a Rio Grande system. The battery is located on the CPU board just below the PIO board transmit capacitors. The battery will recharge itself as soon as power is applied to the ADCP. Over time, the battery loses the ability to recharge and the voltage capacity drops. Therefore, TRDI recommends replacing the battery every five years.

The battery keeps the Real-Time Clock (RTC) running in case power is removed temporarily. The RTC drifts independently from the battery voltage by approximately 12 minutes/year. Clock drift does NOT indicate problems with the battery.

Equipment Required

- ESD safe work space
- Soft pad (ESD Safe) to rest Rio Grande on while dissembling and reassembly
- Anti-static ground strap
- Hex wrenches
- O-rings and desiccant for the ADCP
- Soldering iron
- Digital multi-meter
- Lithium battery VL2330

Testing the Lithium Battery Voltage

To verify that the lithium battery is working:

1. Remove the transducer head assembly.
2. Measure the voltage on the CPU board between TP17 (BAT+) and TP20 (GND). While power is not applied to the ADCP, TP17 should read approximately 3 VDC and the voltage should remain stable (see Figure 28).
3. If the voltage is below 3 VDC and visibly decreasing, then reapply power to the ADCP. While re-charging, TP17 should read approximately 5 VDC. This only takes a few seconds.
4. When the battery is done recharging, the voltage should read slightly above 3 VDC with power still applied.
5. After recharging the battery, disconnect the power and test the voltage. The voltage should hold stable at approximately 3 VDC for several hours at least, but for best results it should hold at 3 VDC for several days.

6. If the voltage is not holding for more than a week, then the battery may be defective. Before continuing, review your options:
   - Replace the Lithium battery yourself.
   - If you are uncomfortable with replacing the battery, please contact [TRDI Customer Service Administration](#) to schedule a replacement of the battery or request a Return Merchandise Authorization (RMA) directly from our website <[here](#)>.

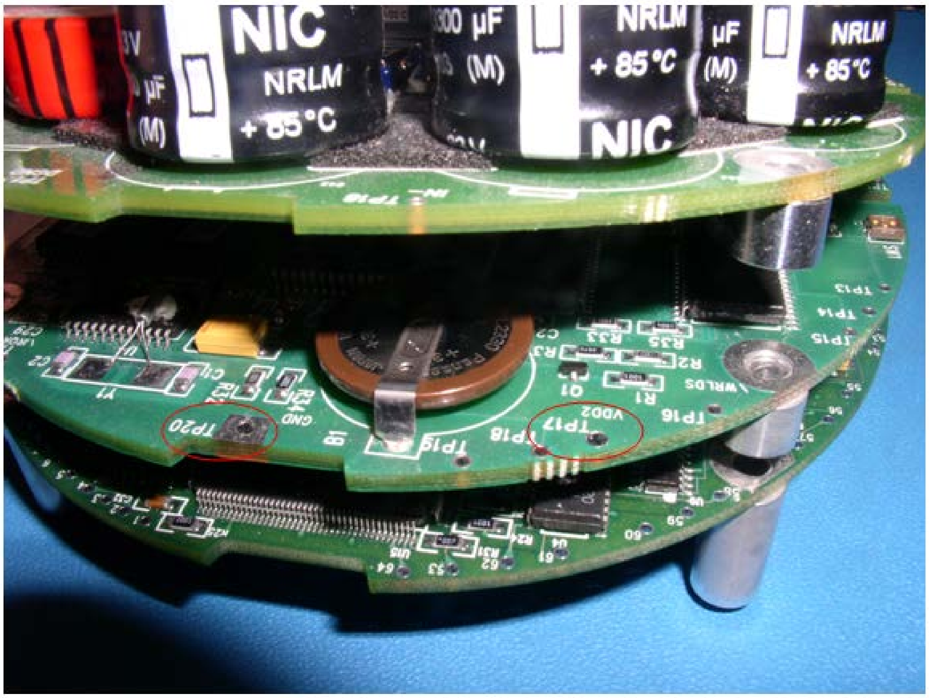


Figure 21. Lithium Battery Test Points on the CPU Board

Replacing the Lithium Battery

To replace the battery:

1. Attach an earth-grounded wrist strap.

> Always wear an earth-grounding static protection strap before handling any of the Rio Grande boards. The electronics in the Rio Grande are very sensitive to electro-static discharge (ESD). **ESD can cause damage that will not be seen immediately and will result in early failure of electronic components.**

2. Remove all power from the ADCP.

> Wait a few minutes after turning the power off before removing the electronics stack. This allows the transmit capacitors on the PIO board time to discharge.

3. Remove the transducer head assembly.
4. Remove the CPU board from the main electronic stack (see [Installing the Spare Boards Kit](#)).
5. Locate the lithium battery B1 (on the top side of the CPU board).
6. De-solder the two associated pins for B1 which are located on the underside of the CPU board.

7. Install the new battery assembly (VL2330). Please note the battery pins; the battery can only be installed one way.

Figure 22. Lithium Battery

8. Verify the voltage holds stable at approximately 3 VDC (see Testing the Lithium Battery Voltage, step 2).
9. Replace the transducer head assembly. Make sure to use new O-rings and desiccant.

Chapter 5

TESTING THE RIO GRANDE

In this chapter, you will learn:

- Testing the Rio Grande with *BBTalk*
- Test Results

This chapter explains how to test the Rio Grande using the *WinRiver II*, *SxS Pro*, and *BBTalk* programs.

Test the Rio Grande:

- When you first receive the Rio Grande.
- Before each deployment or every six months.
- When you suspect instrument problems.
- After each deployment.

These test procedures assume all equipment is working. The tests can help isolate problems to a major functional area of the Rio Grande. For troubleshooting information, see Troubleshooting.

Testing the ADCP using WinRiver II

To test the ADCP using *WinRiver II*:

1. Start *WinRiver II* and establish communications with the Rio Grande ADCP.

> For help on using *WinRiver II*, see the WinRiver II User's Guide.

2. On the **Acquire** menu, click **Execute ADCP Test** to verify the ADCP is functioning properly. Rio Grande ADCP tests should be conducted in non-moving or very slow water velocities to obtain the most accurate results.
3. Click **Close** to exit the **ADCP Test** dialog.

> The tests should be run while the Rio Grande ADCP is in non-moving water. Running the test in air will not harm the ADCP, but some tests may fail in air.

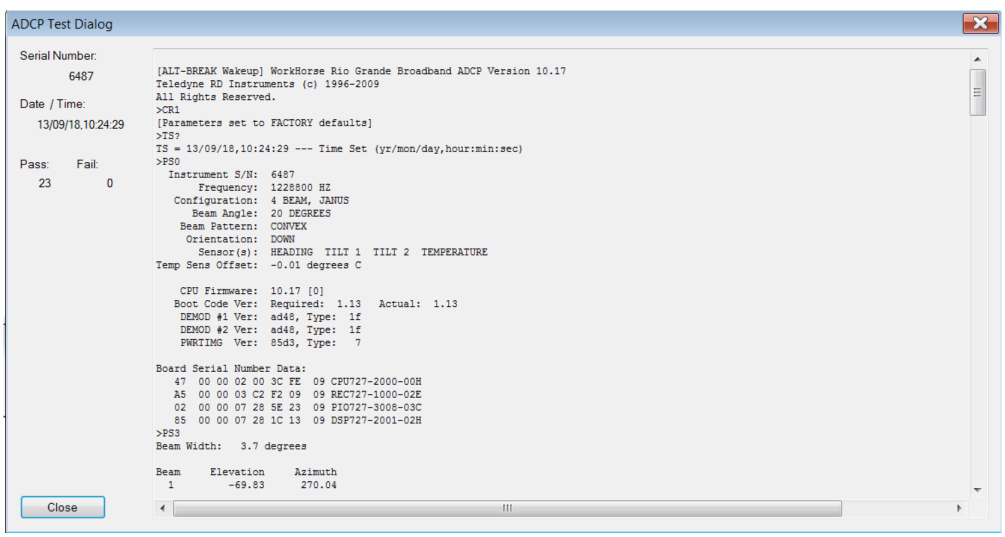


Figure 23. Testing the ADCP using WinRiver II

Testing the Rio Grande with *SxS Pro*

To test the ADCP using *SxS Pro*:

1. Start *SxS Pro* and establish communications with the Rio Grande ADCP.

> For help on using *SxS Pro*, see the SxS Pro User's Guide.

2. On the **Tests** menu, click **ADCP Tests** to verify the ADCP is functioning properly.
3. Click **Run Tests**.
4. At the end of the test, click the **Stop PC2** button to end the PC2 test. Click **Exit** to exit the **ADCP Tests** dialog.

> The tests should be run while the Rio Grande ADCP is in non-moving water. Running the test in air will not harm the ADCP, but some tests may fail in air.

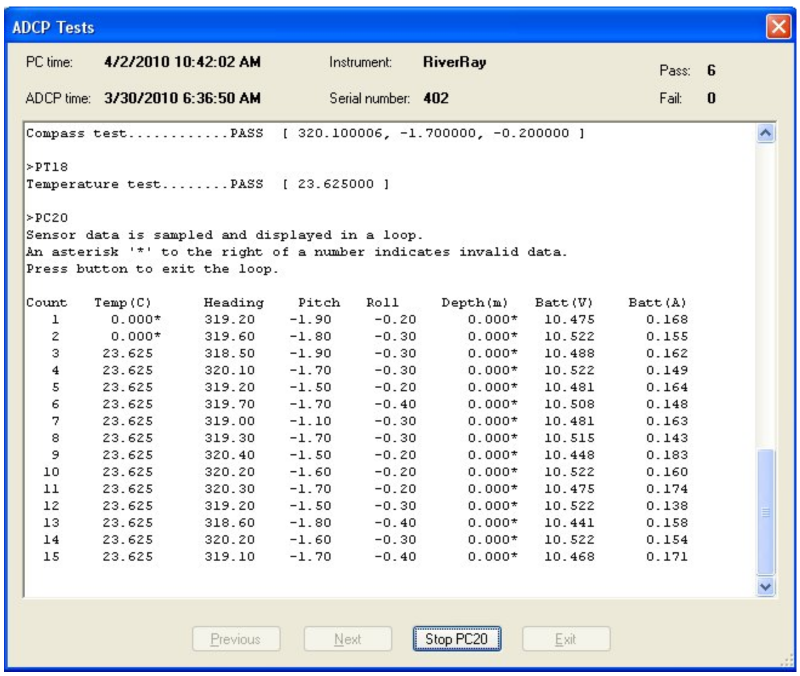


Figure 24. Testing the ADCP using SxS Pro

Testing the Rio Grande with *BBTalk*

To test the ADCP using *BBTalk*:

1. Interconnect and apply power to the system as described in Setting up the Rio Grande System.
2. Start the *BBTalk* program.
3. Press **<F2>** and run the script file *TestWH.rds*. The *TestWH.rds* script file runs PS0, PS3, PA, PC2, and the PC1 tests. The results of the tests will be displayed and saved to the log file *WH_RSLTS.txt*.

For help on using *BBTalk*, see the RDI Tools User's Guide.

BBTalk running on a Windows 7® computer will save the log file to *C:\Users\username\AppData\Local\VirtualStore\Program Files (x86)\RD Instruments\RDI Tools*.

Using Windows XP®, the *BBTalk* program saves the test results file to different locations based on how the program was started:

- When the *BBTalk* is started from the desktop icon and the test script file is used, the result log file is created on the desktop.
- If *BBTalk* is started from the start menu, the results file is put in *C:\Documents and Settings\All Users\Start Menu\Programs\RD Instruments\RDI Tools*.
- Double-clicking the *.rds file in the RDI Tools folder saves the results file to the RDI Tools folder.

To make sure the result file is always saved to the same location, see the RDI Tools User's Guide for instructions.

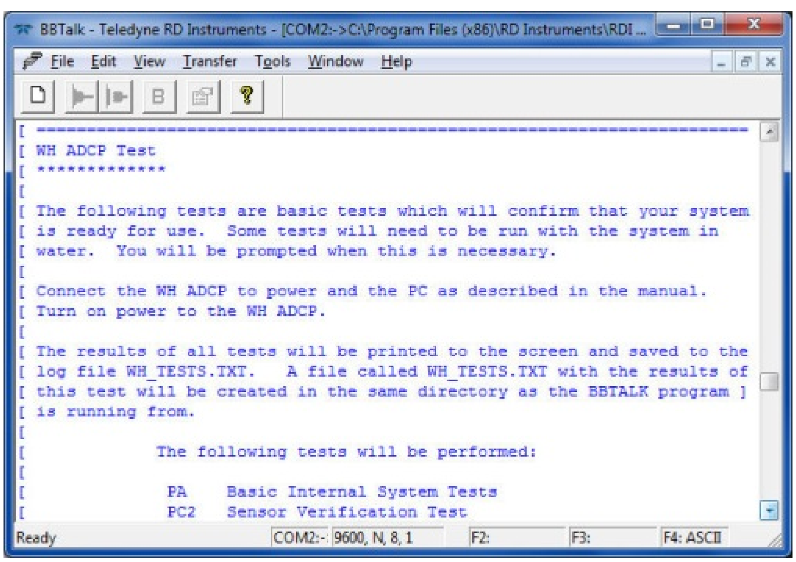


Figure 25. Using BBTalk to Test an ADCP

Test Results

This section shows an example of the test result printout after running the *BBTalk* script file *TestWH.rds*.

The built-in tests require immersing the transducer faces in water; otherwise some of the tests may fail. Running the tests in air will not harm the ADCP.

Display System Parameters

This tells the ADCP to display specific information about the ADCP. For example:

```
>ps0
  Instrument S/N:  101007
       Frequency:  1228800 HZ
   Configuration:  4 BEAM, JANUS
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  DOWN
       Sensor(s):  HEADING  TILT 1  TILT 2  TEMPERATURE
Temp Sens Offset:  -0.17 degrees C

    CPU Firmware:  10.16 [0]
   Boot Code Ver:  Required:  1.13   Actual:  1.13
    DEMOD #1 Ver:  ad48, Type:  1f
    DEMOD #2 Ver:  ad48, Type:  1f
    PWRTIMG  Ver:  85d3, Type:   5

Board Serial Number Data:
   0F  00 00 00 E7 0E F4  09 DSP727-2001-02G
   37  00 00 00 E7 09 46  09 CPU727-2000-00K
   EB  00 00 03 C3 5E F1  09 PIO727-3000-02C
   63  00 00 00 7E 72 2D  09 REC727-1000-02E
>
```

Verify the information is consistent with the configuration of the system. If PS0 does *not* list all of the sensors, there is a problem with either the communications to the transducer or a problem with the receiver board.

Instrument Transformation Matrix

PS3 sends information about the transducer beams. The Rio Grande uses this information in its coordinate-transformation calculations; for example, the output may look like this:

```
ps3
Beam Width:   3.7 degrees

Beam     Elevation     Azimuth
  1         -70.14      269.72
  2         -70.10       89.72
  3         -69.99        0.28
  4         -70.01      180.28

Beam Directional Matrix (Down):
  0.3399    0.0017    0.9405    0.2414
 -0.3405   -0.0017    0.9403    0.2410
 -0.0017   -0.3424    0.9396   -0.2411
  0.0017    0.3420    0.9398   -0.2415

Instrument Transformation Matrix (Down):    Q14:
  1.4691   -1.4705    0.0078   -0.0067       24069  -24092     127    -109
 -0.0068    0.0078   -1.4618    1.4606        -111     127  -23950   23930
  0.2663    0.2657    0.2657    0.2661        4363    4354    4353    4359
  1.0367    1.0350   -1.0359   -1.0374       16985   16957  -16972  -16996
```

```
Beam Angle Corrections Are Loaded.
>
```

If the Rio Grande has beam angle errors, they are reflected in the instrument transformation matrix and the Beam Directional matrix. This matrix, when multiplied by the raw beam data gives currents in the *x*, *y*, *z*, and *e* directions.

Pre-deployment Test

This diagnostic test checks the major Rio Grande modules and signal paths. For example, the output may look like this:

```
>PA
PRE-DEPLOYMENT TESTS
CPU TESTS:
  RTC.....................................PASS
  RAM.....................................PASS
  ROM.....................................PASS
RECORDER TESTS:
  PC Card #0..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
  PC Card #1..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
DSP TESTS:
  Timing RAM..............................PASS
  Demod  RAM..............................PASS
  Demod  REG..............................PASS
  FIFOs...................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Wide Bandwidth..........................PASS
  Narrow Bandwidth........................PASS
  RSSI Filter.............................PASS
  Transmit................................PASS
SENSOR TESTS:
  H/W Operation...........................PASS
```

Display Heading, Pitch, Roll, and Orientation

The PC2 test displays heading, pitch angle, roll angle, up/down orientation and attitude temperature in a repeating loop at approximately 0.5-sec update rate. Any key pressed exits this command and returns the user to the command prompt.

```
Press any key to quit sensor display ...
Heading   Pitch    Roll   Up/Down    Attitude Temp   Ambient Temp  Pressure
301.01°  -7.42°  -0.73°     Up          24.35°C        22.97°C        0.0 kPa
300.87°  -7.60°  -0.95°     Up          24.36°C        22.97°C        0.0 kPa
300.95°  -7.60°  -0.99°     Up          24.37°C        22.97°C        0.0 kPa
300.71°  -7.61°  -0.96°     Up          24.37°C        22.98°C        0.0 kPa
```

Beam Continuity

The PC1 tests the beam continuity by measuring the quiescent Receiver Signal Strength Indicator (RSSI) levels. There must be a change of more than 30 counts when the transducer face is rubbed. Both *WinSC* and *BBTalk* run this test.

The PC1 test is designed to measure the relative noise in the environment and then have you apply more noise by rubbing the ceramics with your hand. Sometimes your hand does not generate enough noise for the system to detect. This could be due to the environment or for other reasons. A simple, safe, and easy to find material that works very well as a replacement to your hand is packaging material (a.k.a. bubble wrap). Using this instead of your hand will very likely provide enough relative frictional difference for the system to pass.

```
BEAM CONTINUITY TEST
When prompted to do so, vigorously rub the selected
beam's face.
If a beam does not PASS the test, send any character to
the ADCP to automatically select the next beam.

Collecting Statistical Data...
  52  48  50  43

Rub Beam 1 = PASS
Rub Beam 2 = PASS
Rub Beam 3 = PASS
Rub Beam 4 = PASS
```

This test must be performed with the ADCP out of water and preferably dry.

NOTES

Chapter 6

TROUBLESHOOTING

In this chapter:

Considering the complexity of the Rio Grande, TRDI has provided as much information as practical for field repair; *fault location to the component level is beyond the scope of these instructions*. The provided information assumes that faults are isolated with a large degree of certainty to a Least Replaceable Assembly (LRA) level only. The time to repair the system will be minimized if an entire replacement unit is available in the field. If time to repair is of essence, Teledyne RD Instruments strongly advises the availability of the listed LRAs.

Table 4: List of Least Replaceable Assemblies

LRA	Description
ADCP	The entire ADCP; includes the electronics, housing, transducer ceramic assemblies, and end-cap.
I/O Cable	Connects the ADCP with the Computer.
End-Cap	Includes the end-cap, connector, and internal I/O cable.
ADCP electronics	The spare boards kit Includes the PIO, CPU, and DSP boards.
PC Card	Replaceable PC recorder card.

Since these Least Replaceable Assemblies are manufactured in different configurations, please contact Teledyne RD Instruments (see Technical Support for contact information) to obtain the correct part number for your specific system configuration. When contacting Teledyne RD Instruments about a replacement assembly, please provide the serial numbers of the ADCP and Deck Box. If you want to replace the I/O Cable only, then please provide the cable length.

Equipment Required

Special test equipment is not needed for trouble shooting and fault isolation. The required equipment is listed in Table 6. Any equipment satisfying the critical specification listed may be used.

Table 5: Required Test Equipment

Required Test Equipment	Critical Specification
DMM	Resolution: 3 ½ digit DC-Voltage Range: 200 mV, 2V, 20 V, 200V DC-Voltage Accuracy: ± 1% AC-Voltage Range: 200 V, 450 V AC-Voltage Accuracy: ± 2% Resistance Range: 200, 2 k, 20 k, 200 k, 20 MOhm Res.-Accuracy: ± 2% @ 200 Ohm to 200 kOhm Res.-Accuracy: ± 5% @ 20 Mohm Capacitance Range: 20 nF, 2 uF, 20 uF Capacitance Accuracy: ± 5%
Serial Data EIA Break-Out Box such as from International Data Sciences, Inc. 475 Jefferson Boulevard Warwick, RI 02886-1317 USA.	Model 60 or similar is recommended as it eases the troubleshooting of RS-232 communication problems significantly. Other manufacturers or models may be substituted.

The EIA Break-out Panel is not necessary, but eases RS-232 communication problems troubleshooting significantly.

Basic Steps in Troubleshooting

The first step in troubleshooting is determining what type of failure is occurring. There are four types of failures:

- Communication failure
- Built-In test failure
- Beam failure
- Sensor failure

Communication failures can be the hardest problem to solve as the problem can be in any part of the system (i.e. the computer, Rio Grande, cable, or power). The symptoms include having the system not respond, or not responding in a recognizable manner (for example "garbled" text).

Built-In test failures will appear when the system diagnostics are run. Use *BBTalk* to identify the failing test.

Beam failures can be identified when collecting data or during the user-interactive performance tests.

Sensor failures can also be identified when collecting data or during the user-interactive performance tests. The sensor may send incorrect data, or not be identified by the system.

Troubleshooting the Rio Grande

Although the Rio Grande is designed for maximum reliability, it is possible for a fault to occur. This section explains how to troubleshoot and fault isolate problems to the Least Replaceable Assembly level (see Table 5). Before troubleshooting, review the procedures, figures, and tables in this guide. Also, read the System Overview to understand how the Rio Grande processes data.

Under all circumstances, follow the safety rules listed in the Troubleshooting Safety.

Troubleshooting Safety

Follow all safety rules while troubleshooting:

Servicing instructions are for use by service-trained personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so.

Complete the ground path. The power cord and the outlet used must have functional grounds. Before power is supplied to the Rio Grande, the protective earth terminal of the instrument must be connected to the protective conductor of the power cord. The power plug must only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.

Any interruption of the earthing (grounding) conductor, inside or outside the instrument, or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury.

Only fuses with the required rated current, voltage, and specified type must be used. Do not repair fuses or short circuit fuse-holders. To do so could cause a shock or fire hazard.

Do not install substitute parts or perform any unauthorized modifications to the instrument.

Measurements described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

Do not attempt to open or service the power supply.

Any maintenance and repair of the opened instrument under voltage should be avoided as much as possible, and when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

Troubleshooting a Communication Failure

Rio Grande ADCPs communicate by means of two serial communication channels. The user can choose between RS-232 and RS-422 classes of serial interfaces with a switch on the PIO board in the ADCP.

To successfully communicate, both the host computer and the ADCP must communicate using the same class of serial interface. Standard serial interfaces in Windows® compatible computers are also RS-232.

The standard configuration for Rio Grande ADCPs is RS-232, 9600 baud when shipped.

When using a high baud rate and/or a long I/O cable (greater than 50 meters), RS-232 may not work. Switch to RS-422 and try to wake up the Rio Grande again.

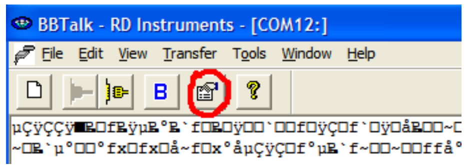
Most communication problems are associated with incorrect cabling (i.e. the serial cable is connected to the wrong port) or data protocols (i.e. the wrong baud rate is set between the ADCP and computer).

To troubleshoot a communication issue:

1. Connect the I/O cable to the ADCP.
2. Connect the alligator clips to a good 12 volt battery.
3. Connect the I/O cable serial DB9 connector to a serial port on the computer.
4. Start *BBTalk* (see Connecting to the Rio Grande).
5. Re-power the instrument (by removing and reconnecting one lead).
6. Observe the wake up message. If the banner does not display at all, go to step 9.

```
[BREAK Wakeup A]
WorkHorse Rio Grande Broadband ADCP Version 10.17
RD Instruments (c) 1996-2013
All Rights Reserved.
>
```

7. If the baud rate set in *BBTalk* does not match the ADCP, a line or two of garbage characters displays rather than the banner as shown below.



8. Click the highlighted icon and select **Auto Detect ADCP**.
9. If the banner still does not display, one of the following is an issue:
   - o bad power (see Checking the ADCP Power)
   - o bad I/O cable, cable connection or a problem with the computer serial port (see Checking the I/O Cable)
   - o an instrument problem (see Checking the ADCP)
10. After verifying these items, contact TRDI for assistance and/or an RMA number.

Checking the ADCP Power

The following test can be done with a voltmeter to check the power. Check the power going into the system by applying power to the I/O cable and measuring the voltage on Pins 4 and 8 (GND). The voltage should be 12 VDC. If not, check the voltage at the other end of the cable and the battery.

Checking the I/O Cable

This test will check the communication between the computer and Rio Grande.

To check the cable:

1. Disconnect both ends of the I/O cable and measure the continuity using a DMM (see Rio Grande Cables for the wiring diagram). Correct any problems found.
2. Reconnect the I/O cable to host computer.
3. Start *BBTalk*. Select the proper communications port (see Setting up the Rio Grande System).
4. For RS-232 communications, short pins 1 and 2 together on the female 7-pin connector that was plugged into the Rio Grande (see Rio Grande Cables). If you are using RS-422, connect a jumper between pin 2 to pin 6 and another jumper between pins 1 to pin 5 of the underwater connector at the Rio Grande end of the cable.
5. Type any characters on the keyboard. The keys typed should be echoed on the screen. If the characters are displayed, but not correctly (garbage), the cable may be too long for the baud rate. Try a lower baud rate. If this works disconnect the jumper on pins 1 and 2 and then push any keys on the keyboard. You should NOT see anything you type.
6. If the keys are echoed correctly on the screen, the computer and the communication cable are good. Re-connect the I/O cable to the Rio Grande. The above loop-back test does not show if transmit and receive pairs are interchanged. Thus, it is important to check the wiring diagrams provided in the Rio Grande Cables.

A loop-back test does not show if transmit and receive wires or pairs are interchanged, even though characters may be displayed correctly.

Checking the ADCP

Once problems with the power, I/O cable, communications settings, and the computer are eliminated, that leaves the ADCP as the source of the problem. The following checks may help in some situations.

To Cold Start the ADCP:

1. Remove the housing to gain access to the PC boards.
2. Remove *all* power to the ADCP.

Disconnect the power cables P1 and P2 on the PIO board to ensure that NO POWER is applied to the ADCP during the next step.

3. Short TP10 to TP11 on the PIO board for 10 seconds.
4. Remove the jumper.
5. Connect the computer and connect power to the ADCP. Send a break to the ADCP. This should start the ADCP in the "cold start" mode.

To check the fuse:

Check the fuse on the PIO board is not blown (see Fuse Replacement for fuse replacement procedures).

Only fuses with the required rated current, voltage, and specified type must be used. Do not repair fuses or short circuit fuse-holders. To do so could cause a shock or fire hazard.

Check for Boot Code Error:

If the ADCP gives a steady "beep" when power is applied, the ">" prompt appears on the screen, and an "X" appears when additional breaks are sent, this may indicate that the boot code has been lost. This can happen if you abort while downloading new firmware. Try downloading the firmware again.

Troubleshooting a Built-In Test Failure

The built-in diagnostic tests check the major ADCP modules and signal paths. The spare boards kit may be used to repair some failures. This kit includes:

- Spare Boards including PIO board, CPU board, and DSP board. These boards are held together with the standard M4 screw assembly and kept inside a protective anti-static bag.
- A disk containing the original beam cosine matrix table
- Tools for installation

The Spare Boards kit is not included with the system. Order the kit by contacting Teledyne RD Instruments Customer Service department (see How to Contact Teledyne RD Instruments and Table 4, page 30).

See Installing the Spare Boards Kit for instructions on how to replace the Rio Grande board stack.

When to use the Spare Boards Kit

Use this Kit whenever there are any of the following problems:

- Cannot communicate to the Rio Grande and the serial port on the computer, Rio Grande Cable, and Rio Grande RS-232 to RS-422 converter (if applicable) are all working properly.
- The Rio Grande fails any of the following PA tests at any time:

  CPU Tests:
  - RTC
  - RAM
  - ROM

  DSP Tests:
  - Timing RAM
  - Demod RAM
  - Demod REG
  - FIFOs

  System Tests:
  - XILINK Interrupts
  - Receive Loop Back Test

- The Rio Grande fails any of the following PA tests provided the items indicated by {} have been checked:

  Recorder Tests:
  Any recorder tests fails {provided that the PCMCIA card(s) have been checked for proper installation, operation and they are DOS formatted; TRDI STRONGLY recommend checking PCMCIA cards in a computer before replacing the boards}

  System Tests:
  Transmit {if the Rio Grande fails when it is in water and air bubbles have been rubbed from the faces}

  Sensor Tests:
  H/W Operation {if the Rio Grande fails when it is NOT sitting/resting on its side, or located near a large magnetic field like a motor in a boat}

The spare boards kit will not correct any of the following failures:

- A damaged beam or its urethane surface
- Damage to the transducer beam connections below the copper shield
- If it passes all PA tests and yet the data is all marked as bad
- Fails the following PA test:

System Tests:
Wide Bandwidth {bandwidth tests may fail due to external interference}

Narrow Bandwidth {bandwidth tests may fail due to external interference}

RSSI Filter

Transmit

Table 6: Pre-deployment Test (PA) Possible Cause of Failures

PA Test Name	Possible Cause of Failure

`Pre-Deployment Tests CPU Tests:`
`RTC`
`RAM`
`ROM`
	CPU board failed

`Recorder Tests:`
`PC Card #0`
`Card Detect`
`Communication`
`DOS Structure`
`Sector Test (short)`
`PC Card #1`
`Card Detect`
`Communication`
`DOS Structure`
`Sector Test (short)`
	PC card not plugged in
	PC card failed
	DSP board failed

`DSP Tests:`
`Timing RAM`
`Demod RAM`
`Demod REG`
`FIFOs`
	DSP board failed

`System Tests:` `XILINX Interrupts`	DSP or CPU board failed
`Receive Loop-Back`	DSP or CPU board failed

`Wide Bandwidth`
`Narrow Bandwidth`
`RSSI Filter`
	Not in water
	External interference
	DSP or Receiver board failed

`Transmit`	Not in water or PIO board failed
`Sensor Tests:` `H/W Operation`	PIO board failed Receiver board failed Pressure sensor failed ADCP laying on its' side

Troubleshooting a Beam Failure

The PC1 test is designed to measure the relative noise in the environment and then apply more noise by rubbing the ceramics. Sometimes your hand does not generate enough noise for the system to detect. This could be due to the environment or for other reasons. A simple, safe, and easy to find material that works very well is packaging material (a.k.a. bubble wrap). Using bubble wrap instead of your hand will very likely provide enough relative frictional difference for the system to pass.

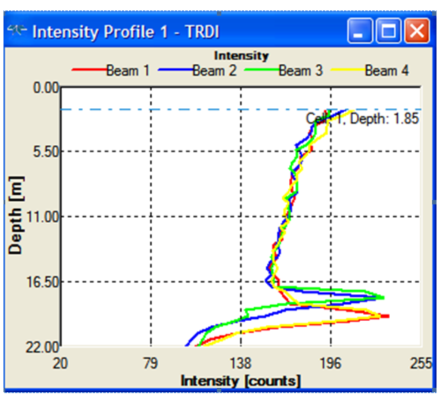
```
>PC1

BEAM CONTINUITY TEST

When prompted to do so, vigorously rub the selected
beam's face.

If a beam does not PASS the test, send any character to
the ADCP to automatically select the next beam.

Collecting Statistical Data...
  41  46  45  43  41  46  45  43  41  46  45  42  41  46  44  42

Rub Beam 1 = PASS
Rub Beam 2 = PASS
Rub Beam 3 = PASS
Rub Beam 4 = PASS
>
```

This test must be performed with the ADCP out of water and preferably dry.

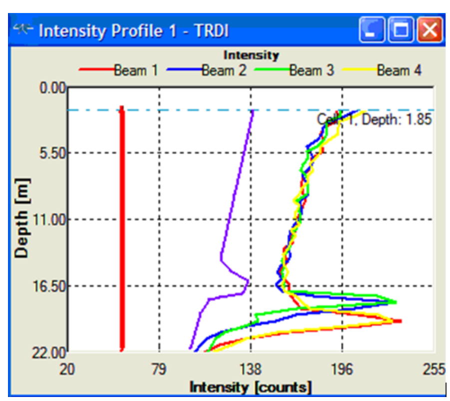
If the PC1 test fails, the system may still be okay. To verify:

1. Deploy the ADCP into a bucket or container of water (preferably at least 0.5 meters deep).
2. Start *WinRiver II* and start pinging:
3. Look at the data using *WinRiver II* and make sure that the echo amplitude counts in the 1st depth cell for all beams are between 128 and 192.

   If the beam continuity test still fails and/or the echo amplitude indicates a problem, a bad DSP board, Receiver board, PIO board, or a bad beam may cause the failure. If replacing the DSP and PIO board (included with the spare boards kit) does not fix the problem, the ADCP must be returned to TRDI for repair (see Chapter 7 - Returning Systems to TRDI for Service).



Intensities on all four beams



One beam with low intensity and noise floor

See the WinRiver II Software User's Guide, Troubleshooting chapter for more information on the Intensity Profile.

Troubleshooting a Sensor Failure

If the PA test fails the sensor test, run PC2 to isolate the problem. The ambient temperature sensor is mounted on the receiver board. This sensor is imbedded in the transducer head, and is used for water temperature reading. The attitude temperature sensor is located on the PIO board under the compass. The ADCP will use the attitude temperature if the ambient temperature sensor fails.

If one of the temperature sensors fails, the PC2 test will show both sensors at the same value.

```
>PC2
Press any key to quit sensor display ...

Heading   Pitch    Roll   Up/Down    Attitude Temp   Ambient Temp   Pressure
301.01°  -7.42°  -0.73°    Up          24.35°C        22.97°C         0.0 kPa
300.87°  -7.60°  -0.95°    Up          24.36°C        22.97°C         0.0 kPa
300.95°  -7.60°  -0.99°    Up          24.37°C        22.97°C         0.0 kPa
300.71°  -7.61°  -0.96°    Up          24.37°C        22.98°C         0.0 kPa
300.69°  -7.61°  -0.96°    Up          24.35°C        22.98°C         0.0 kPa
300.76°  -7.60°  -0.98°    Up          24.38°C        22.97°C         0.0 kPa
>
```

If the temperature sensor fails, the data can still be collected with no effects to accuracy or quality. Contact TRDI about scheduling a repair of the temperature sensor at your convenience.

Fault Log

To determine why a sensor failed, view the fault log. To view the fault log, start *BBTalk*. Press the **End** key to wake up the ADCP. Type the following commands: **CR1**, **PA**, **FD**, **FC**. The fault log will be displayed by the FD command and is cleared by the FC command.

```
[BREAK Wakeup A]
WorkHorse Rio Grande Broadband ADCP Version 10.16
Teledyne RD Instruments (c) 1996-2007
All Rights Reserved.
>CR1
>PA
|         (PA test results (not shown))
|
>FD
Total Unique Faults   =     2
Overflow Count        =     0
Time of first fault:   97/11/05,11:01:57.70
Time of last fault:    97/11/05,11:01:57.70

Fault Log:
Entry #  0 Code=0a08h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt axis X over range.
Entry #  1 Code=0a16h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt Y axis ADC under range.
End of fault log.
>FC
```

System Overview

This section presents a functional description of Rio Grande operation using block diagrams.

Operating Modes

The Rio Grande has two modes of operation: *command mode*, and *ping mode* (also referred to as "Deployment Saver" Mode). Depending on what mode the ADCP is in; it will go either to sleep, or to resume pinging.

Command Mode

Whenever you wake up your Rio Grande, power dissipation increases from less than 1 mW to around 2.2 W. If you leave the Rio Grande in command mode without sending a command for more than 5 minutes, the Rio Grande automatically goes to sleep. This protects you from inadvertently depleting batteries.

- If the ADCP receives a BREAK, it will go to the command prompt and wait for a command. The ADCP will wait at the command prompt for five minutes. If no commands have been sent, it will go to sleep (also called "Battery Saver" mode).
- If you press the reset switch (located on the CPU board), the ADCP will go to sleep.
- If the ADCP receives a CS-command, it will go into the ping mode and begin pinging. If a TF-command (Time of First Ping) was sent prior to the CS-command, then the ADCP will go to sleep until the TF time occurs.
- If the ADCP does a COLD wakeup (i.e. an unknown state), it will go to the command prompt.
- If the ADCP is asleep for approximately nine hours, it wakes up to charge the capacitor used to maintain RAM. Once the capacitor is charged (this only takes a few seconds), the ADCP goes back to sleep.

Ping Mode

After you send commands to the Rio Grande that tells it to start collecting data, the Rio Grande goes into deployment saver mode. If power is somehow removed and later restored, the Rio Grande simply picks up where it left off and continues to collect data using the same set up.

- If the ADCP receives a BREAK, it will go to the command prompt, but stays in the ping mode. If a valid command is received, the ADCP will switch to the command mode. If no valid command is received, a warning will be displayed after four minutes, indicating that the system will self-deploy. After a total of five minutes with no input, the ADCP will resume pinging.
- If you press the reset switch, and an alarm is currently set for the next ping, the ADCP will go to sleep. If no alarm is set, the system will start a new deployment and starts pinging immediately unless a TF-command had been set after the last BREAK. In this case, the ADCP will go to sleep until the TF time occurs.
- If the ADCP does a COLD wakeup, the system will start a new deployment and starts pinging immediately unless a TF-command had been set after the last BREAK. In this case, the ADCP will go to sleep until the TF time occurs if the TF time is valid (i.e., not in the past).
- If the ADCP is asleep for approximately nine hours, it wakes up to charge the capacitor used to maintain RAM. Once the capacitor is charged, if a valid alarm is set for the next ping time, the ADCP goes back to sleep and waits for the alarm. If no alarm is set, the ADCP will resume pinging immediately, or wait for the TF time (if valid), and then start pinging.

Overview of Normal Rio Grande Operation

Refer to Figure 31 through Figure 33. The following events occur during a typical data collection cycle.

1. The user or a controlling software program sends data collection parameters to the Rio Grande. The user/program then sends a CS-command to start the data collection cycle. The firmware program stored in the CPU microprocessor takes control of Rio Grande operation based on the commands received through the serial I/O cable.

   Figure 31 shows a flow chart of the wake-up logic used by the Rio Grande. The Rio Grande determines what to do based on where the wake-up came from (a Break, CS-command, battery saver timer, or watchdog timer was detected).

2. On the PIO Board, the POWER REGULATOR circuit sends a transmit command to the POWER AMPLIFIER circuit. This tells the Rio Grande to start acoustic transmissions (pinging) on all TRANSDUCERS.
3. The TRANSDUCERS receive echoes from the backscatter. The RECEIVER board amplifies and translates the echoes into a base-band frequency.
4. The CPU board processes the received echoes.
5. After echo reception, the Rio Grande injects a self-test signal into the RECEIVER board and processes the signal as normal data for test purposes.
6. The THERMISTOR measures water temperature at the transducer head and sends it to the CPU via the DSP Board.
7. The PIO Board sends pitch and roll from the TILT SENSOR and Rio Grande heading from the COMPASS to the DSP Board. The DSP Board digitizes this information and sends it to the CPU for processing.
8. The CPU repeats steps “b” through “g” for a user-defined number of pings. The CPU averages the data from each ping to produce an ensemble data set.
9. At the end of the ensemble (sampling) interval, the CPU sends the collected data to the serial I/O connector or PCMCIA recorder.

Functional Description of Operation

The following paragraphs describe how the Rio Grande operates and interacts with its modules. Refer to Figure 31 through Figure 33 throughout this description.

Input Power

The Rio Grande requires a DC supply between 10.5 volts to 18 volts. Figure 32 shows the DC voltage power distribution path.

PIO Board.

- Receives the filtered/internal power.
- Uses a diode “OR” gate to determine which power source to use (external or internal). With both sources connected, the OR gate selects the “higher” voltage for Rio Grande use.
- Limits the in-rush of current to the Rio Grande and provides over- and negative-voltage protection. Either condition will blow a protective fuse. However, damage could occur to other circuits before the fuse blows. Please ensure you apply only voltages within the specified range (10.5 volts to 18 VDC).
- Converts the operating power supply (filtered/isolated 10.5 volts to 18 VDC) in a DC-to-DC converter to the +5 VDC (Vcc) used to power all other Rio Grande circuits.

- Uses the Power Amplifier circuit on the PIO board to generate the high-amplitude pulse AC signal that drives the sonar transducers. The Power Amplifier sends the drive signal to the Receiver Board.
- RS-232/RS-422 switch.

Do not swap the PIO board between a Rio Grande and a Mariner/Monitor/Sentinel ADCP. The power requirements are different.

CPU Board.

- Real time clock.
- Generates most of the timing and logic signals used by the Rio Grande.

DSP Board.

- Contains the PCMCIA recorder slots.
- Analog to Digital converter.
- Digitizes information from sensors and sends sensor information to the CPU.

Receiver Board.

- Tuning functions
- Receiver functions
- Temperature sensor
- Interface for pressure sensor

Sensors

This section describes the standard Rio Grande sensors. The PIO and DSP boards control the environmental sensors and contain unit-specific data. Sensors include:

Temperature Sensor (Thermistor) - Used to measure the water temperature. The system uses this data to calculate the speed of sound. This sensor is embedded in the transducer head and is not field replaceable.

Up/Down Sensor - Determines whether the transducer head is facing up or down. This sensor is located on the PIO board.

Compass - Determines the Beam 3 heading angle of the Rio Grande using a flux-gate compass. This sensor is located on the PIO board. The flux-gate measured earth magnetic field vector together with the tilt sensor pitch and roll information is used to determine the heading. Since the tilt sensor data is only valid when the ADCP is ±20° from vertical, the heading information is also limited to this range.

Attitude Sensor - Determines the tilt angles of the Rio Grande. This sensor is located on the PIO board. The attitude sensor uses a pitch and roll liquid-filled sensor. This sensor is functional to an angle of ±20° from vertical.

Pressure Sensor (optional) - Measures pressure at the Rio Grande transducer. This sensor is embedded in the transducer head and is not field replaceable.

The CPU microprocessor controls a multiplexed analog-to-digital converter to accept analog data from the sensors. Digital data are taken in directly. The pressure sensor incorporates a Wheatstone Bridge strain gage to measure the water pressure at the transducer faces. Depth is calculated from pressure, with water density adjusted by the salinity (ES) setting.

Calibration data for the sensors, a beam-angle correction matrix, and unit identification parameters (frequency, serial number, firmware version, etc.) are stored in ROM.

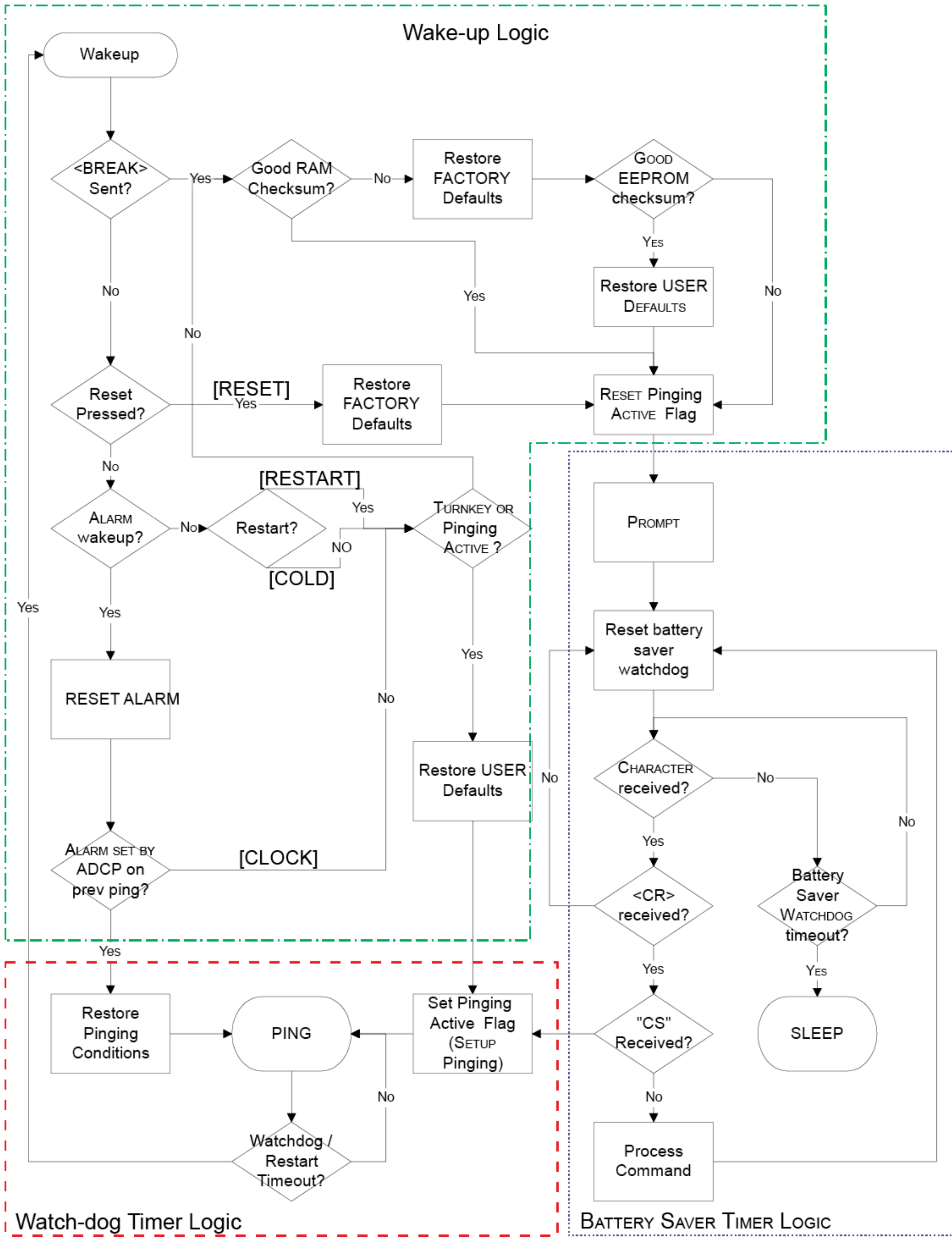


Figure 26. Rio Grande Wake-up and Timer Logic

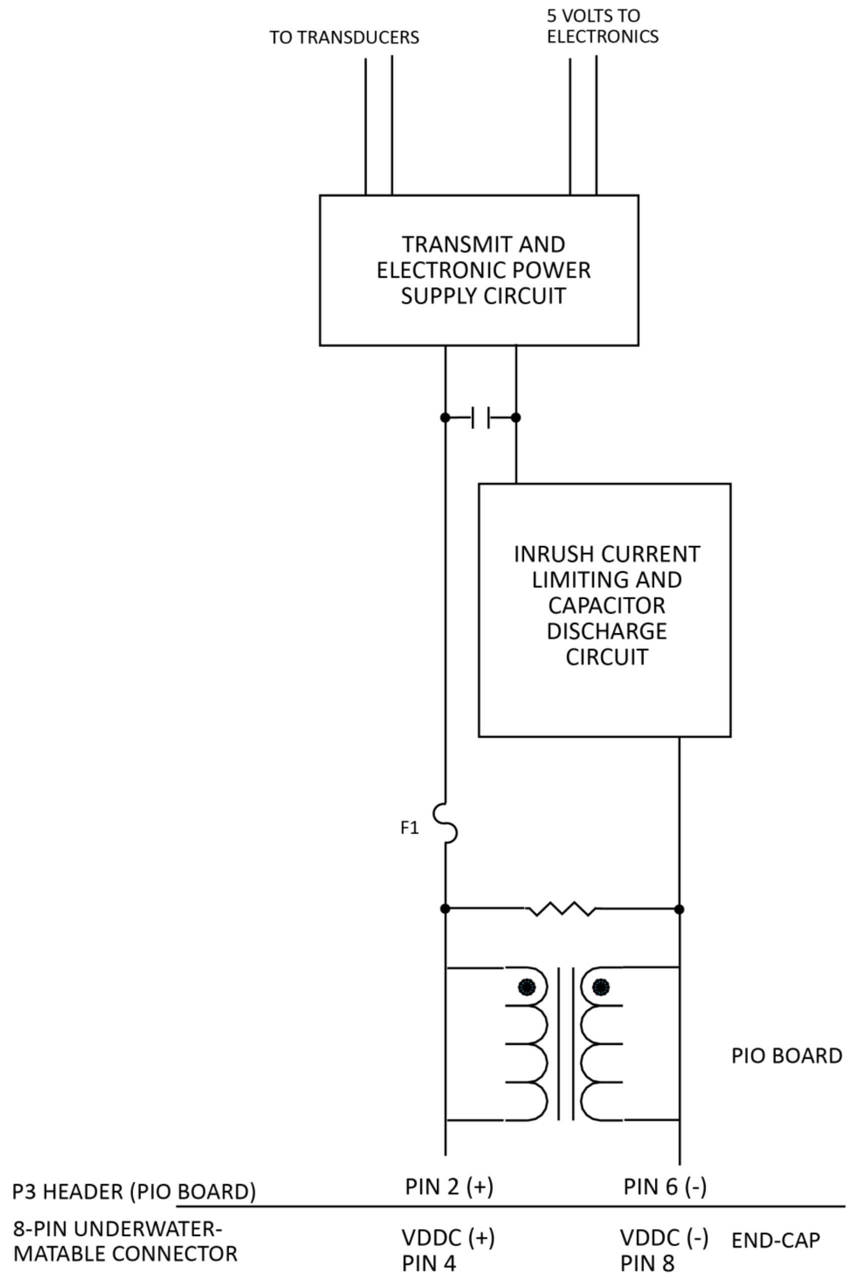


Figure 27. Rio Grande DC Power Path

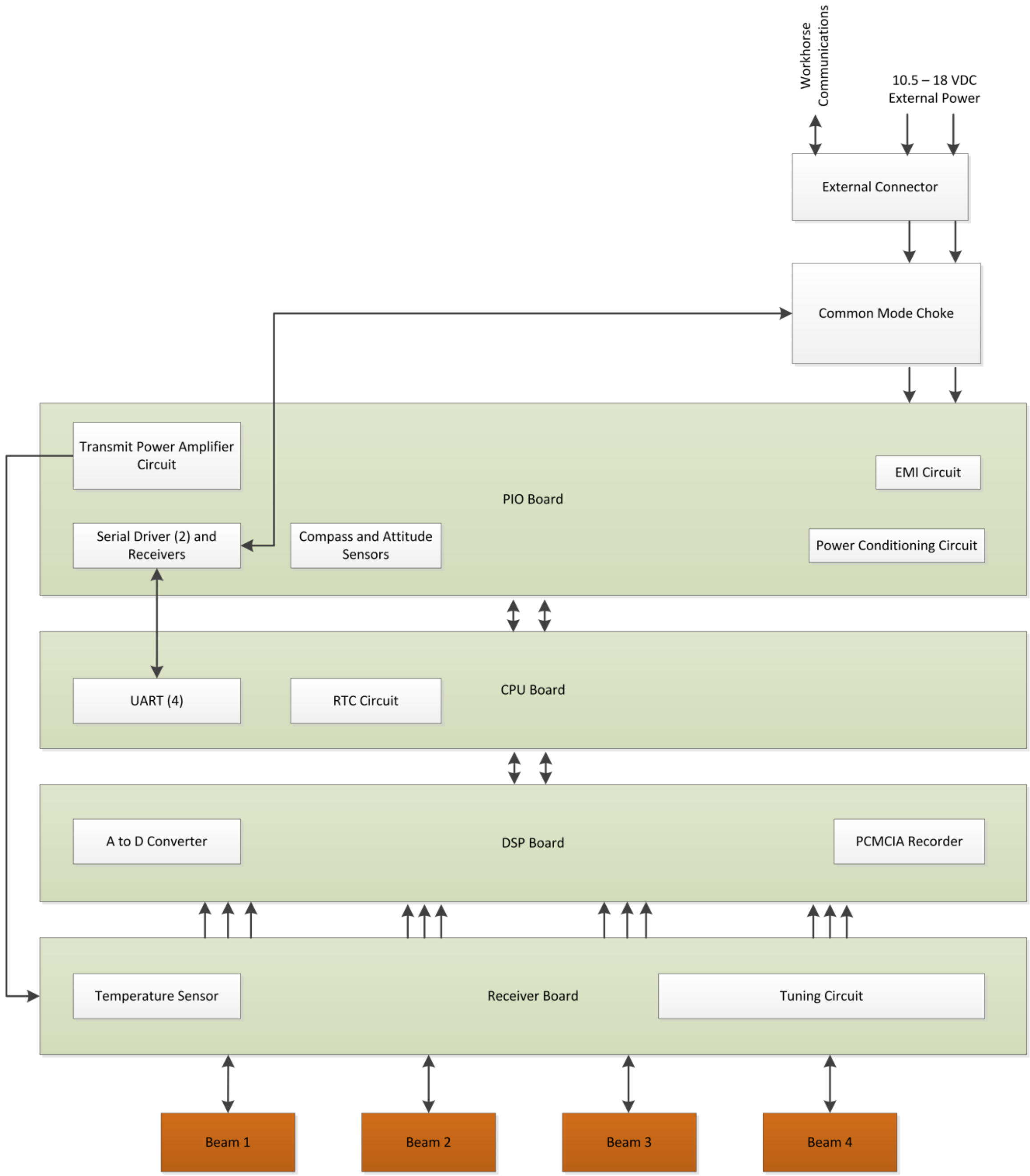


Figure 28. Rio Grande Block Diagram

Chapter 7

RETURNING SYSTEMS TO TRDI FOR SERVICE

In this chapter:

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

Shipping the ADCP

This section explains how to ship the Rio Grande ADCP.

Remove all customer-applied coatings or provide certification that the coating is nontoxic if you are shipping a Rio Grande ADCP 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 you return the equipment 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 you cannot provide certification, we will return the equipment to you or to a customer-specified cleaning facility. All costs associated with customer-applied coatings will be at the customer's expense.

When shipping the Rio Grande ADCP 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 Rio Grande ADCP.

If you need to ship the Rio Grande ADCP, use the original shipping crate whenever possible. If the original packaging material is unavailable or unserviceable, 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 handing.
5. In any correspondence, refer to the Rio Grande ADCP 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 Rio Grande ADCP 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 your 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) 842-2600

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. If you ship consolidated, it 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
Notify Paxton, Shreve and Hayes

Phone: +1 (619) 232-8941
Fax: +1 (619) 232-8976

Step 4 - Urgent shipments

Send the following information by fax or telephone to TRDI.

Attention: Customer Service Administration

Fax: +1 (858) 842-2822

Phone: +1 (858) 842-2600

- 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 Rio Grande ADCP 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 your 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. If you ship consolidated, it 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 Fax or Telephone to TRDI

Attention: Sales Administration

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

Fax: +33(0) 492-110-931

- 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 8

SPECIFICATIONS

In this chapter, you will learn:

- Specifications
- Outline Installation Drawings

A brief review of ADCP operation may help you understand the specifications listed in this section.

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

The ADCP emits an acoustic pulse called a PING. Scatterers that float ambiently with the water currents reflect some of the energy from the ping back to the ADCP. The ADCP uses the return signal to calculate a velocity. The energy in this signal is the *echo intensity*. Echo intensity 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 ADCP reduces this statistical uncertainty by averaging a collection of pings. A collection of pings averaged together is an *ensemble*. The ADCP's maximum *ping rate* limits the time required to reduce the statistical uncertainty to acceptable levels.

The ADCP does not measure velocity at a single point; it measures velocities throughout the water column. The ADCP 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 ADCP produces two profiles, one for velocity, and one for echo intensity.

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

The following tables list the specifications for the Rio Grande ADCP. About the specifications:

1. All these specifications assume minimal ADCP motion - pitch, roll, heave, rotation, and translation.
2. Except where noted, this specification table applies to typical set ups and conditions. Typical set ups 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 ADCP motion, and typical echo intensity levels.
3. The total measurement error of the ADCP is the sum of:
   - Long-term instrument error (as limited by instrument accuracy).
   - The remaining statistical uncertainty after averaging.
   - Errors introduced by measurement of ADCP heading and motion.
4. Because individual pings are independent, the statistical uncertainty of the measurement can be reduced according to the equation:

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

Table 7: Rio Grande Standard Water Profiling

Bin Size (m)	1200 kHz Rio Grande			600 kHz Rio Grande		
	1st Cell Range (m)	Max Range (m)	Std. dev. (cm/s)	1st Cell Range (m)	Max Range (m)	Std. dev. (cm/s)
0.25m	0.51	21.92	7.87			
0.50m	0.76	23.75	4.01	0.97	81.85	7.87
1.0m	1.25	25.94	2.04	1.47	89.20	4.04
2.0m	2.23	28.33	1.00	2.45	97.73	2.06
4.0m				4.43	107.22	1.00

NOTES
1. User's choice of depth cell size is not limited to the typical values specified.
2. Broad bandwidth mode is set with the WB command (WB0 by default).
3. Range, which depends on cell size, is specified here for Broad bandwidth mode at 5° C, typical river backscatter, and nominal 12 VDC battery power.
4. Water Mode 1 with 3 water pings per ensemble standard deviation.

Table 8: Rio Grande Shallow Water Mode

Bin Size (m)	1200 kHz Rio Grande			600 kHz Rio Grande		
	1st Cell Range (m)	Max Range (m)	Std. dev. (cm/s)	1st Cell Range (m)	Max Range (m)	Std. dev. (cm/s)
0.05	0.19	<4	4.12			
0.1	0.24	<4	2.98	0.34	<8	3.57
0.25	0.39	<4	1.61	0.49	<8	1.93
0.5				0.74	<8	1.49

NOTES
1. User's choice of depth cell size is not limited to the typical values specified.
2. Broad bandwidth mode is set with the WB command (WB0 by default).
3. Range, which depends on cell size, is specified here for Broad bandwidth mode at 5° C, typical river backscatter, and nominal 12 VDC battery power.
4. Water Mode 8 with 3 water pings per ensemble standard deviation.

Table 9: Rio Grande High Resolution Mode

Bin Size (m)	1200 kHz Rio Grande			600 kHz Rio Grande		
	1st Cell Range (m)	Max Range (m)	Std. dev. (cm/s)	1st Cell Range (m)	Max Range (m)	Std. dev. (cm/s)
0.05	0.19	<4	0.77			
0.1	0.24	<4	0.57	0.34	<8	0.76
0.25	0.39	<4	0.31	0.49	<8	0.42
0.5				0.74	<8	0.34

NOTES
1. User's choice of depth cell size is not limited to the typical values specified.
2. Broad bandwidth mode is set with the WB command (WB0 by default).
3. Range, which depends on cell size, is specified here for Broad bandwidth mode at 5° C, typical river backscatter, and nominal 12 VDC battery power.
4. Water Mode 11 with 3 water pings per ensemble standard deviation.

Table 10: Bottom Track Profile Parameters

System Frequency	1200 kHz	600 kHz	300 kHz
Maximum Altitude (m)	30	100	260
Minimum Altitude (m)	0.75	0.75	2

Table 11: Profile Parameters

Velocity accuracy	
1200 and 600 kHz	± 0.25% of the water velocity relative to the ADCP ± 2mm/s
300 kHz	± 0.5% of the water velocity relative to the ADCP ± 5 mm/s
Velocity resolution	l mm/s
Velocity range	± 5m/s (default), ± 20m/s (maximum)
Number of depth cells	1 to 128
Ping rate	1-2 Hz (typical)

Table 12: Echo Intensity Profile

Vertical resolution	Depth cell size
Dynamic range	80 dB
Precision	± 1.5dB (relative measure)

Table 13: Standard Sensors

Temperature (Transducer Mounted)	
Range	-5° to 45° C
Uncertainty	±0.4° C
Resolution	0.01°
Tilt	
Range	±15°
Uncertainty	±0.5° (up to 15°)
Precision	± 0.5°
Resolution	0.01°
Compass [1]	
Type	flux gate
Long-term accuracy	±2° @ 60° magnetic dip angle, 0.5G total field
Precision	± 0.50 @ 60° magnetic dip angle, 0.5G total field
Resolution	0.01°
Max tilt	± 15°

1. Includes built-in field calibration procedure. Compass uncertainty is for tilts less than 15°.

Table 14: Transducer and Hardware

Item	Specification
Beam angle	20°
Configuration	4 beam, convex
Internal memory	Memory card not included with Rio Grande models. Two PCMCIA memory card slots are available. The maximum memory for each slot is 2GB, with the total memory capacity not to exceed 4GB.
Communications	Serial port selectable by switch for RS-232 or RS-422. ASCII or binary output at 1200 to 115,200 baud.

Table 15: Environmental Specifications

Item	Specification
Operating temperature	-5° to 45°C
Storage temperature	-20° to 50°C

Table 16: Power

System	Specification
DC input	10.5 to 18 VDC
Transmit	35W @ 13V (600 kHz), 25W @ 13V (1200 kHz)

Outline Installation Drawings

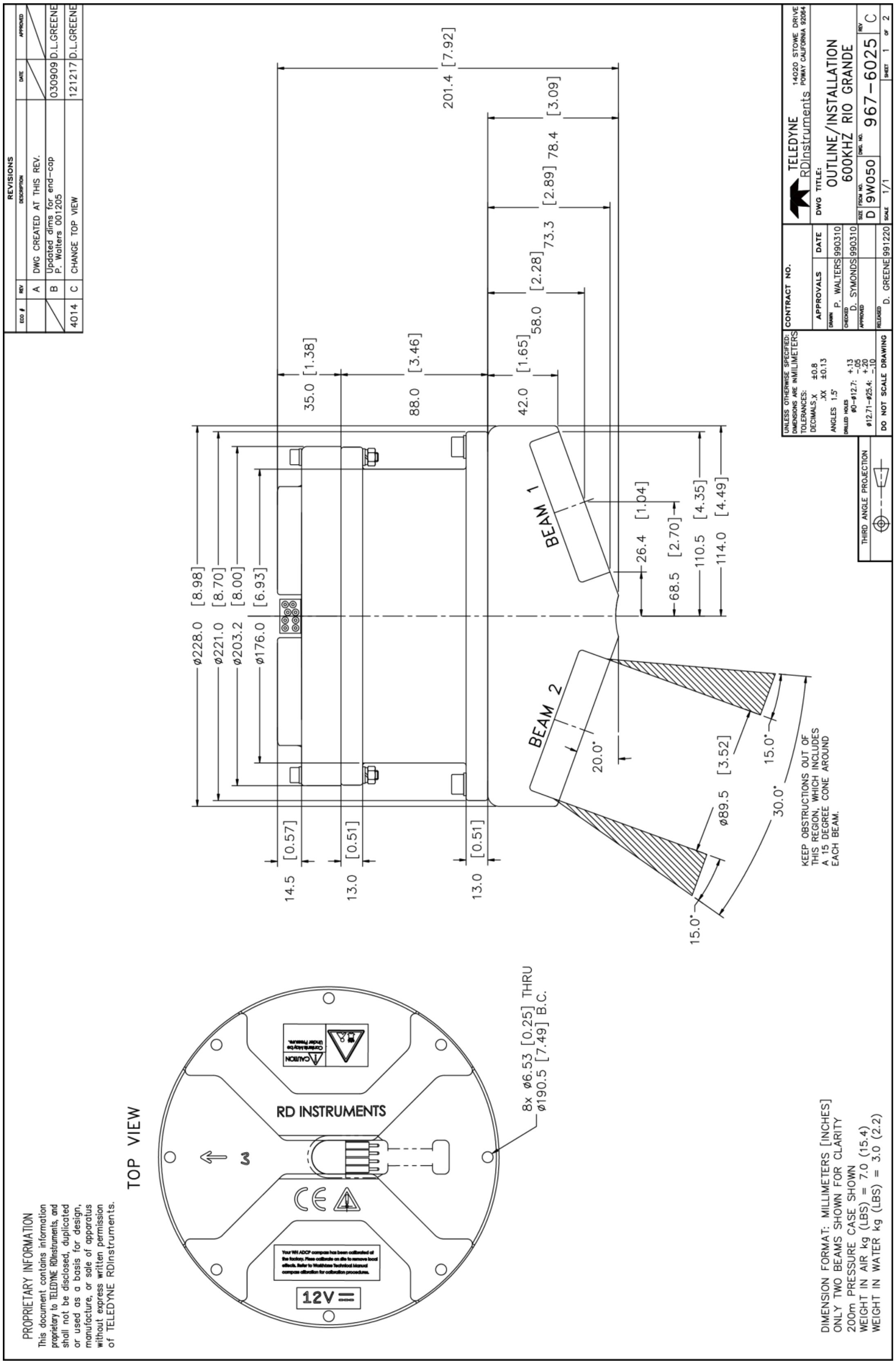
The following drawings show the standard Rio Grande dimensions and weights.

Table 17: Outline Installation Drawings

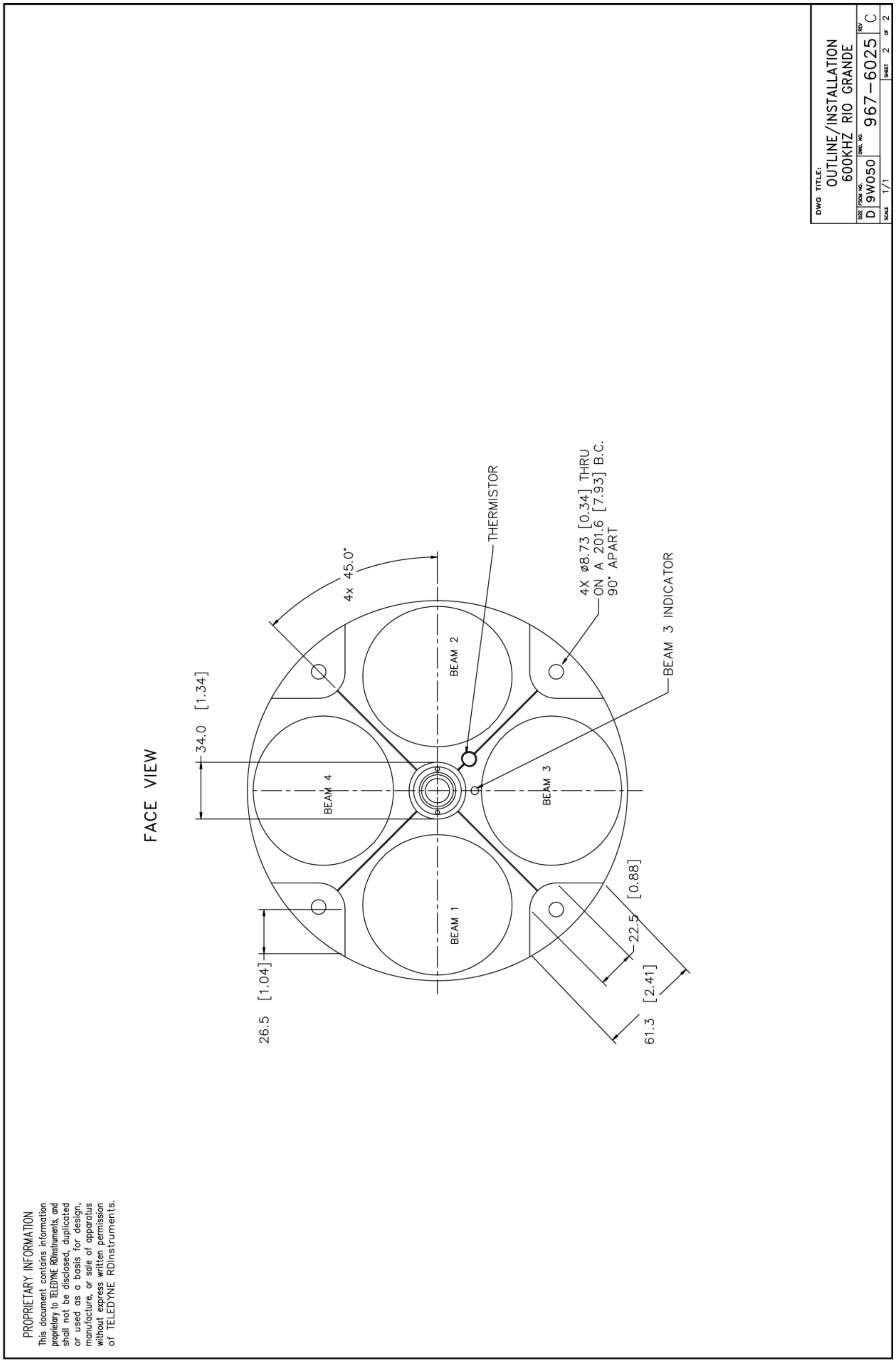
Description	Drawing #
600 kHz Rio Grande	967-6025
1200 kHz Rio Grande	967-6026

Outline Installation Drawings are subject to change without notice. Verify you have the latest version of the drawing by contacting TRDI before building mounts or other hardware.

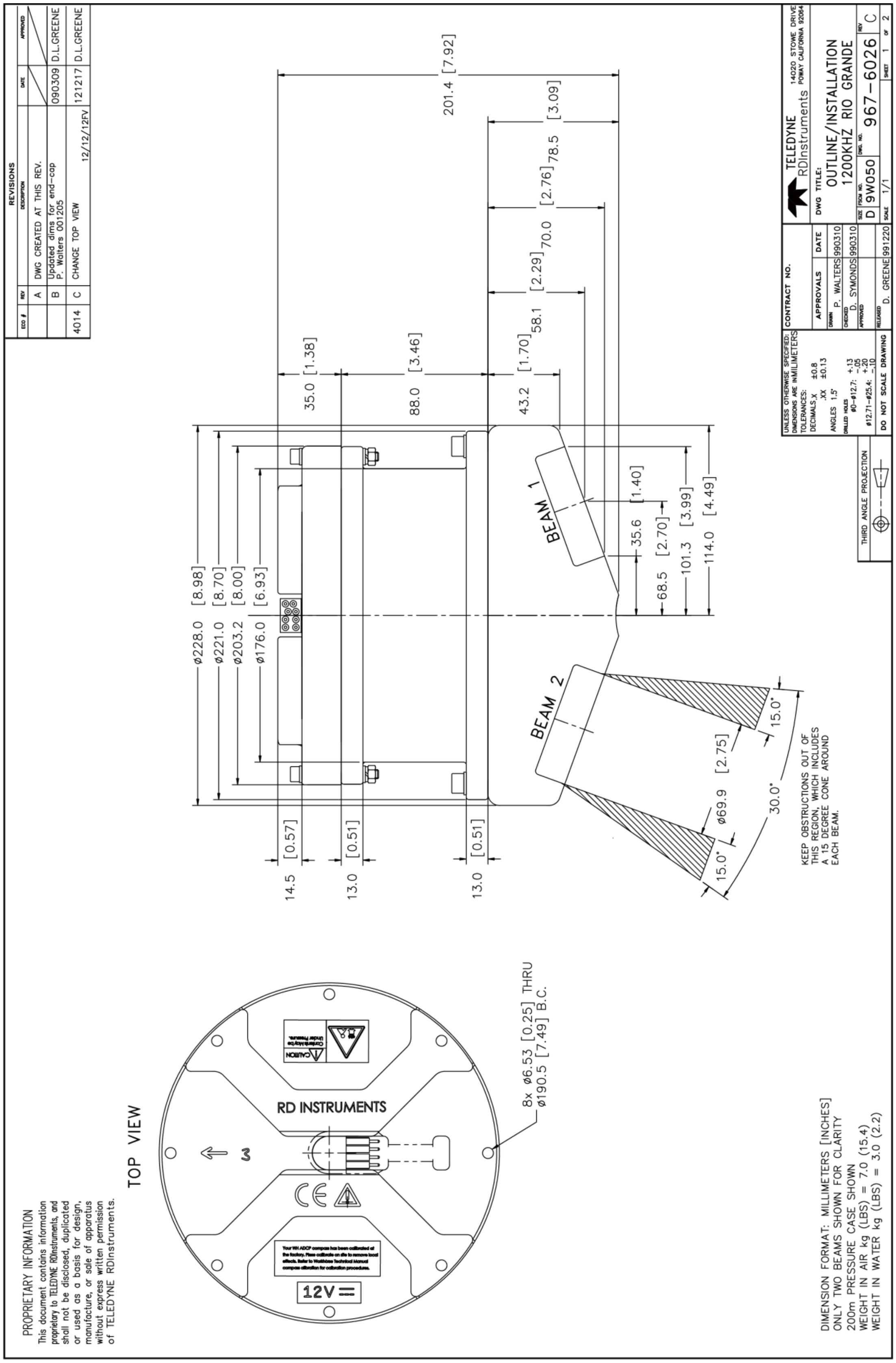
967-6025 Sheet 1



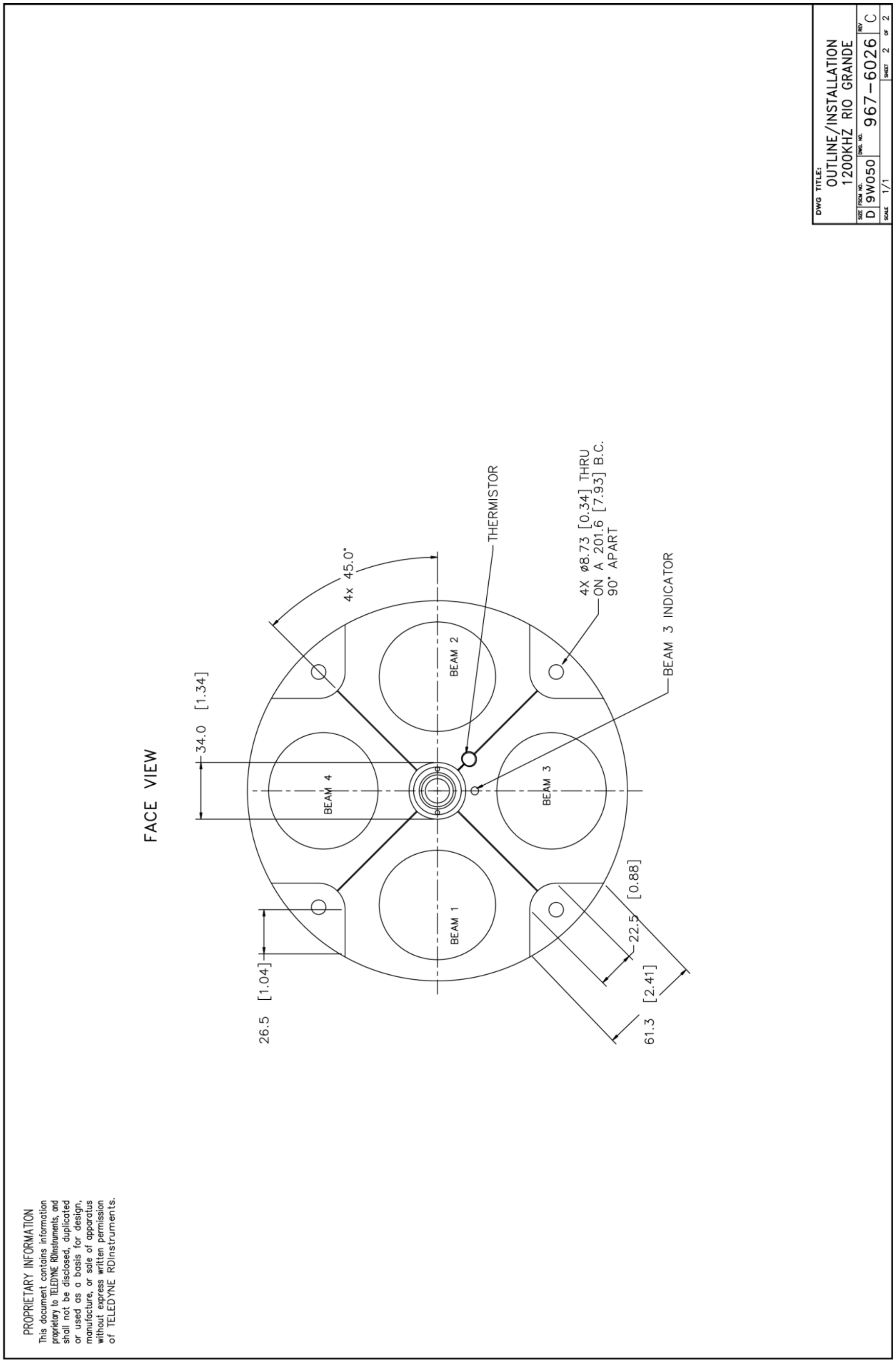
967-6025 Sheet 2



967-6026 Sheet 1



967-6026 Sheet 2



NOTES

Chapter 9

COMMANDS

In this chapter:

This guide defines the commands used by the WorkHorse Rio Grande. These commands (Table 20) up and control the ADCP without using an external software program such as our *WinRiver II* and *SxS Pro* programs. However, TRDI recommends using our software to control the ADCP because entering commands directly from a computer can be difficult. Make sure to read and understand Using Direct Commands to Deploy an ADCP before deploying the ADCP. Most ADCP settings use factory-set values (Table 21). If these values are changed without thought, the deployment could be ruined. Be sure to know what effect each command has before using it. Call TRDI for help in understanding the function of any command.

Using *WinRiver II* and *SxS Pro* for real-time deployments to develop the command file will ensure that the Rio Grande ADCP is set up correctly. The commands shown in Table 20 directly affect the range of the ADCP, the standard deviation (accuracy) of the data, and battery usage.

> This chapter applies to Rio Grande firmware 10.17.
>
> When new firmware versions are released, some commands may be modified, added, or removed. Read the README file on the upgrade disk. When an addition or correction to this manual is needed, an Interim Change Notice (ICN) will be posted to TRDI's web site. Please check TRDI's web site often at www.rdinstruments.com.

Data Communication and Command Format

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

Immediately after applying power to the Rio Grande ADCP, it enters the STANDBY mode. Send a BREAK signal using *BBTalk* by pressing the **End** key to put the ADCP in command mode. When the Rio Grande ADCP receives a BREAK signal, it responds with a wake-up message similar to the one shown below. The Rio Grande ADCP is now ready to accept commands at the ">" prompt.

```
[BREAK Wakeup A]
WorkHorse Rio Grande Broadband ADCP Version 10.17
Teledyne RD Instruments (c) 1996-2013
All Rights Reserved.
>
```

Command Input Processing

Input commands set Rio Grande ADCP 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,

```
>WP1<CR> [Your input]
```

> Leading zeros are not required. Sending WP1 and WP00001 are the equivalent.

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

```
>WP1<CR>     [Your original input]
>            [Rio Grande ADCP response to a valid, no-output command]
```

If a valid command is entered that produces output data, the Rio Grande ADCP executes the command, displays the output data, and then redisplays 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 entered command is not valid, the Rio Grande ADCP responds with an error message similar to the following.

```
>WPA<CR>                                        [Your input]
>WPA  ERR 002:  NUMBER EXPECTED<CR><LF>         [Rio Grande ADCP response]
>
```

After correctly entering all the commands for the application, send the **CS** command to put the ADCP into the ping mode and begin the data collection cycle.

Data Output Processing

After the Rio Grande ADCP completes a data collection cycle, it sends a block of data called a *data ensemble*. A data ensemble consists of the data collected and averaged during the ensemble interval (see TE-command). A data ensemble can contain header, leader, velocity, correlation magnitude, echo intensity, percent good, and status data.

Rio Grande ADCP output data can be in either hexadecimal-ASCII (Hex-ASCII) or binary format (set by CF command). The Hex-ASCII mode is useful when using a computer to communicate with, and view data from the Rio Grande ADCP. The binary mode is useful for high-speed communication with a computer program.

All of Teledyne RD Instruments' software supports binary PD0 Output Data Format only.

When data collection begins, the Rio Grande ADCP uses the settings last entered (user settings) or the factory-default settings. The same settings are used for the entire deployment.

The Rio Grande ADCP automatically stores the last set of commands used in RAM. The Rio Grande ADCP will continue to be configured from RAM until it receives a CR command or until the RAM loses its backup power. If the Rio Grande ADCP receives a CR0 it will load into RAM the command set last stored in non-volatile memory (semi-permanent user settings) through the CK command. If the Rio Grande ADCP receives a CR1, it will load into RAM the factory default command set stored in ROM (permanent or factory settings).

Using Direct Commands to Deploy an ADCP

TRDI recommends that using our software programs *WinRiver II* and *SxS Pro*, etc. as the primary method of deployment. If this is not possible in the deployment then we ***strongly recommend*** that the commands shown in Table 19 be the ***minimum*** commands sent to the instrument.

TRDI does not recommend the use of direct commands as the primary way of deploying ADCPs as any incorrect command setting can have severe consequences to the data collection.

Table 18: ADCP Minimum Required Commands for Deployments

Command	Description
CR1	This command will set the ADCP to a known factory default setting and must be the first command
	Special WM commands here –after the CR1 command and before any other commands
CFxxxxx	This command will set the ADCP collection mode; binary, recorder, etc.
EAxxxxx	This command will set the magnetic compass offset for true north
EDxxx	This command will set the ADCP depth
ESxx	This command will set the ADCP's expected salinity
EXxxxxx	This command will set the ADCP's coordinate system; earth, beam, etc.
EZxxxxxxx	This command will set what sensors will be used by the ADCP; heading, pitch, roll, temp, etc.
WBx	This command will set the water profile bandwidth between wide (0) and narrow (1)
WNxx	This command will set the number of depth cells to collect
WPxx	This command will set the number of pings to average
WSxxxx	This command will set the depth cell size to use
TExxxxxxxx	This command will set the time between ensembles
TPxxxxxx	This command will set the time between pings
CK	This command will save the setup to the internal RAM and must be the second to last command
CS	This command will start the deployment and must be the last command

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

Deployments may require additional commands and these commands can be sent after the CR1 and any special WM commands but must be placed before the CK command.

Command Summary

Table 20 gives a summary of the Rio Grande ADCP input commands, their format, and a brief description of the parameters they control. Table 21 lists the factory default command settings.

This table shows all commands including optional feature upgrades and expert commands. To see the expert commands, must first send the command EXPERTON.

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.

Table 19: Rio Grande ADCP Input Command Summary

Command	Description
?	Shows command menu (deploy or system)
<BREAK> End	Interrupts or wakes up Rio Grande ADCP and loads last settings used
EXPERTON	Turns expert mode on. All commands will be listed
EXPERTOFF	Turns expert mode off.
OL	List features/special firmware upgrades that are installed
AC	Output calibration data
AD	Display factory calibration
AF	Field calibrate compass to remove hard iron error
AR	Return to factory calibration
AX	Examine compass performance
AZ	Zero pressure sensor
BA*nnn*	Evaluation amplitude minimum (1 to 255 counts)
BB*nnnn*	High Bandwidth Maximum Depth (dm)
BC*nnn*	Correlation Magnitude minimum (0 to 255 counts)
BE*nnnn*	Error velocity maximum (0 to 9999 mm/s)
BF*nnnnn*	Depth guess (1 to 65535 dm, 0 = automatic)
BGss,dd,mmm	BM6 Shal Xmt (%), Deep Xmt (%), Deep (dm)
BHccc,aaa,lll,mmm	BM6 Thresh(cnt), S Amb(cm/s), L Amb(cm/s), MinAmb
BI*nnn*	Gain switch depth (0 to 999 meters)
BK*n*	Water-mass Layer Mode (0-Off, 1-On, 2-Lost, 3-No BT)
BL*mmm,nnnn,ffff*	Water mass layer parameters: Min Size (dm), Near (dm), Far (dm)
BM*n*	Bottom track mode (5 = Default, 4 = Default minus Coherent)
BP*nnn*	Bottom Track Pings per Ensemble
BR*n*	Resolution (0 = 4%, 1 = 2%, 2 = 1%)
BS	Clear distance traveled
BV aaaaa, bbb, c	Mode 7 Parameters
BX*nnnnn*	Maximum Tracking Depth (40 to 65535 dm)
BZ*nnn*	Coherent ambiguity velocity (cm/s radial)
CB*nnn*	Serial port control (baud rate/parity/stop bits)
CF*nnnnn*	Flow control
CK	Keep parameters as user defaults
CLn	Sleep between Pings (0 = No, 1 = Yes)
CM*n*	Not used.
CN*n*	Save NVRAM to recorder (0 = On, 1 = Off)
CP*n*	Polled mode (0 = Off, 1 = On)
CQ*nnn*	Transmit power (0 = Low, 1 to 255 = High)
CR*n*	Retrieve parameters (0 = User, 1 = Factory)
CS or **Tab**	Start pinging
CY*n*	Clear error status word (0 = Clear, 1 = Display)
CZ	Power down instrument
DB*x,y,z*	RS-485 port control
DS	Load speed of sound with SVSS sample
DWx	Current ID on RS-485 bus (0 to 31)
DX	Set SVSS to raw mode
DY	Set SVSS to real mode

Table 19: Rio Grande ADCP Input Command Summary

Command	Description
DZ	Get single scan from SVSS
EA±*nnnn*	Heading alignment (-179.99 to 180.00 degrees)
EB±*nnnn*	Heading bias (-179.99 to 180.00 degrees)
EC*nnnn*	Speed of Sound (1400 to 1600 m/s)
ED*nnnn*	Transducer Depth (0 to 65535 dm)
EH*nnnn*	Heading (000.00 to 359.99 degrees)
EP±*nnnn*	Pitch (-60.00 to +60.00 degrees)
ER±*nnnn*	Roll (-60.00 to +60.00 degrees)
ES*nn*	Salinity (0 to 40)
ET±*nnnn*	Temperature (-5.00 to +40.00 degrees C)
EX*nnnn*	Coordinate Transformation (Xform:Type; Tilts; 3Bm; Map)
EZ*nnnnnn*	Sensor Source (C;D;H;P;R;S;T)
FC	Clear Fault Log
FD	Display Fault Log
PA	Pre-deployment tests
PC1	Beam Continuity Built-in test
PC2	Display Heading, Pitch, Roll, and Orientation Built-in test
PD*n*	Data stream select (0 to 7)
PM	Distance measurement facility
PS0	Display System Configuration
PS3	Display Instrument Transformation Matrix
PT*nnn*	Built-In test (0 to 200)
RA	Number of deployments
RB	Recorder built-in test
RE ErAsE	Erase recorder
RF	Recorder free space (Bytes)
RN	Set deployment name
RR	Show recorder file directory
RS	Recorder free space (Megabytes)
RY	Upload recorder files
SAxyz	Synchronize before/after ping/ensemble
SI*nnnn*	Synchronization interval (0 to 65535 s)
SM*n*	RDS3 mode select (0 = Off, 1 = Master, 2 = Slave)
SS*x*	RDS3 sleep mode (0 = No Sleep, 1 = Sleep)
ST*n*	Slave timeout (0 to 10800 seconds)
SW*n*	Synchronization delay (0m to 65535 (1/10 milliseconds)
TBhh:mm:ss.ff	Time per burst
TC*nnnn*	Ensemble per burst (0 to 65535)
TEhh:mm:ss.ff	Time per ensemble (hours:minutes:seconds.100th of seconds)
TFyy/mm/dd, hh:mm:ss	Time of first ping (year/month/day, hours:minutes:seconds)
TGccyy/mm/dd, hh:mm:ss	Time of first ping (Y2k compatible) (century year/month/day, hours:minutes:seconds)
TPmm:ss.ff	Time between pings (minutes:seconds.100th of seconds)
TSyy/mm/dd, hh:mm:ss	Set real-time clock (year/month/day, hours:minutes:seconds)
TTccyy/mm/dd, hh:mm:ss	Set real-time clock (Y2k compatible) (century year /month/day, hours:minutes:seconds)
WA*nnn*	False target threshold maximum (0 to 255 counts)
WB*n*	Mode 1 Bandwidth Control (0 = Wide, 1 = Narrow)
WC*nnn*	Low correlation threshold (0 to 255 counts)
WD*nnn nnn nnn*	Data Out (Vel;Cor;Amp PG;St;P0 P1;P2;P3)
WE*nnnn*	Error velocity threshold (0 to 5000 mm/s)
WF*nnnn*	Blank after transmit (0 to 9999 cm)
WI*n*	Clip data past bottom (0 = Off, 1 = On)
WJ*n*	Receiver gain select (0 = Low, 1 = High)
WK*n*	Depth Cell Size Override (Mode 11/12 only)
WL*sss,eee*	Water reference layer
WM*n*	Water Profiling mode (1, 5, 8, 11, 12)
WN*nnn*	Number of depth cells (1 to 128)
WO*x,y*	Mode 12 parameters

Table 19: Rio Grande ADCP Input Command Summary

Command	Description
WP*nnnn*	Pings per ensemble (0 to 16384)
WQ*n*	Sample ambient sound (0 = Off, 1 = On)
WS*nnnn* [min, max]	Depth cell size 20 to 800 (300 kHz), 10 to 800 (600 kHz), 5 to 400 (1200 kHz)
WT*nnnn*	Transmit length (0 to 3200 cm)
WU*n*	Ping weight (0 = Box, 1 = Triangle)
WV*nnn*	Ambiguity velocity (002 to 480 cm/s radial)
WW*nnn*	Mode 1 Pings before Mode 4 Re-acquire
WX*nnn*	Mode 4 Ambiguity Vel (cm/s radial)
WY*b,nnn*	WM 1: Bandwidth (0=WB, 1=NB), Amb. Vel.(cm/s)
WZ*nnn*	Mode 5 ambiguity velocity (0 to 999 cm/s)

Table 20: Rio Grande ADCP Factory Defaults

Command	300 kHz	600 kHz	1200 kHz
BA	030	030	030
BB	0320	160	60
BC	220	220	220
BE	1000	1000	1000
BF	00000	00000	00000
BG	80,20,00030	80,20,00030	80,20,00030
BH	190,010,004,040	190,010,004,040	190,010,004,040
BI	020	010	005
BK	0	0	0
BL	160,320,480	80,160,240	40,60,100
BM	5	5	5
BP	000	000	000
BR	0	0	0
BV	N/A	20,250,0	10,250,0
BX	1200	600	300
BZ	004	004	004
CB	411	411	411
CF	11111	11111	11111
CL	1	1	1
CM	0	0	0
CN	0	0	0
CP	0	0	0
CQ	255	255	255
DB	411	411	411
DW	0	0	0
EA	+00000	+00000	+00000
EB	+00000	+00000	+00000
EC	1500	1500	1500
ED	00000	00000	00000
EH	00000	00000	00000
EP	+0000	+0000	+0000
ER	+0000	+0000	+0000
ES	00	00	00
ET	+2500	+2500	+2500
EX	10100	10100	10100
EZ	1011101	1011101	1011101
PD	00	00	00
SA	001	001	001
SI	00000	00000	00000
SM	0	0	0
SS	0	0	0
ST	00000	00000	00000
SW	00000	00000	00000

Table 20: Rio Grande ADCP Factory Defaults

Command	300 kHz	600 kHz	1200 kHz
TB	00:00:00.00	00:00:00.00	00:00:00.00
TC	00000	00000	00000
TE	00:00:00.00	00:00:00.00	00:00:00.00
TP	00:00.05	00:00.05	00:00.05
WA	050	050	050
WB	0	0	0
WC	064	064	064
WD	111 100 000	111 100 000	111 100 000
WE	2000	2000	2000
WF	50	25	25
WI	0	0	0
WJ	1	1	1
WK	0	0	0
WL	000,005	000,005	000,005
WM	1	1	1
WN	030	030	030
WO	1,4	1,4	1,4
WP	00045	00045	00045
WQ	0	0	0
WS	0100 [20,1600]	0050 [10,800]	0025[5,400]
WT	0000	0000	0000
WU	0	0	0
WV	175	175	175
WW			
WX			
WY			
WZ	010	010	010

The highlighted commands have frequency dependent defaults.

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 Rio Grande ADCP 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 you wish to view. When the Rio Grande ADCP 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 WP?.
Examples	See below.

```
[BREAK Wakeup A]
WorkHorse Rio Grande Broadband ADCP Version 10.17
Teledyne RD Instruments (c) 1996-2013
All Rights Reserved.
>?
Available Menus:
DEPLOY? ------------------ Deployment Commands
SYSTEM? ------------------ System Control, Data Recovery and Testing Commands

Available Commands:

B? ----------------------- BOTTOM TRACK Commands
C? ----------------------- CONTROL Commands
E? ----------------------- ENVIRONMENTAL SENSORS Commands
P? ----------------------- PERFORMANCE Commands
S? ----------------------- RDS^3 SYNCHRONIZATION Commands
T? ----------------------- TIMING Commands
W? ----------------------- WATER PROFILING Commands
R? ----------------------- RECORDER Commands
A? ----------------------- SENSOR/COMPASS Commands
O? ----------------------- FEATURE Commands
D? ----------------------- APPLIED MICROSYSTEMS Commands
?? ----------------------- DISPLAY Quick Menus

>wp?
WP = 00001 --------------- Pings per Ensemble (0-16384)
>
```

Break

Purpose Interrupts Rio Grande ADCP without erasing present settings.

Format <BREAK>

Recommended Setting. Use as needed.

Description A BREAK signal interrupts Rio Grande ADCP processing. It is leading-edge triggered and must last at least 300 ms. A BREAK initializes the system, sends a wake-up (copyright) message, and places the Rio Grande ADCP in the DATA I/O mode. The BREAK command does not erase any settings or data. Using *BBTalk*, pressing the **End** key sends a BREAK.

Example <BREAK>

```
[BREAK Wakeup A]
WorkHorse Rio Grande Broadband ADCP Version 10.16
Teledyne RD Instruments (c) 1996-2007
All Rights Reserved.
>
```

When a break is sent, the text inside the brackets '[...]' of the first line of the Wakeup Messages indicates the ADCP's communication configuration:

- **[BREAK Wakeup A]** => ADCP is set to send/receive RS-232 communication through the serial lines of the I/O cable
- **[BREAK Wakeup B]** => ADCP is set to send/receive RS432 communication through the serial lines of the I/O cable.
- **[BREAK Wakeup AB]** => RS-232/422 switch on the top of the PIO board in the ADCP is in between two positions, but neither RS-232 nor RS-422. It can also mean that the ADCP received a trigger pulse while in command mode.
- **[ALARM Wakeup A]** => If the battery has a low voltage reading when a break is sent, the following message is displayed:

```
[ALARM Wakeup A]
WorkHorse Rio Grande Broadband ADCP Version 10.17
Teledyne RD Instruments (c) 1996-2013
All Rights Reserved.
>
```

If this message appears after a break, it is advised not to deploy the ADCP since TRDI cannot guarantee the unit will perform to the performance specifications.

Software Breaks - The ADCP will use the "= = =" string instead of a break.

In order for the software breaks to work, the CL command must be set to CL0 (see CL - Battery Saver Mode).

Expert Mode

Purpose Turns on or off the expert mode.

Format expertoff, experton

Recommended Setting. Use as needed.

Description When the Expert Off command is used, it limits the amount of commands displayed on the help menu. When the expert mode is turned off, all commands are still available (to ensure software compatibility) but do not display. The Expert On command shows all of the available commands in the help menu.

Examples See below.

```
expertoff
Expert Mode is Off
>
experton
Expert Mode is On
>
```

OL - Features

Purpose Lists special firmware upgrades that are installed.

Format OL

Recommended Setting. Use as needed.

Description Lists special features that are installed. See Installing Feature Upgrades for information on how to install additional capability in the Rio Grande ADCP.

Examples See below.

```
>ol                                FEATURES
---------------------------------------------------------------------
Feature                                                     Installed
---------------------------------------------------------------------
Bottom Track                                                      No
Water Profile                                                    Yes
High Resolution Water Modes                                       No
River Surveyor ADCP                                              Yes
Shallow Bottom Mode                                               No
High Rate Pinging                                                 No

See your technical manual or contact RDI for information on how to
install additional capability in your WorkHorse.
```

Compass Commands

The main reason for compass calibration is battery replacement. Each new battery carries a different magnetic signature. The compass calibration algorithm corrects for the distortions caused by the battery to give you an accurate measurement.

Available Compass Commands

This section lists the available compass commands.

```
>a?
Available Commands:

AC ----------------------- Output Active Fluxgate & Tilt Calibration Data
AD ----------------------- Display Calibration Data
AF ----------------------- Field Calibrate to remove Hard and/or Soft Iron Error
AR ----------------------- Restore Factory Fluxgate Calibration data:
                              make factory the active calibration data
AX ----------------------- Examine Compass Performance
AZ   0.000000 ------------ Zero pressure reading
A? ----------------------- Display Public Sensor Commands

>
```

Compass Command Descriptions

AC – Output Active Calibration Data

Purpose Outputs active fluxgate and tilt calibration data.

Format AC

Recommended Setting. **Use as needed.**

Description The AC command is identical to the AD command except that the AC command doesn't prompt the user for Factory or Active Calibration data; it assumes active. The AC Command doesn't prompt the user to "press any key to continue..." when the screen is full.

Example See below

```
>ac

              ACTIVE FLUXGATE CALIBRATION MATRICES in NVRAM
               Calibration date and time: 4/6/2000  11:00:29
                             S inverse
          +                                                   +
     Bx   ¦   2.8071e-01 -2.8343e-01 -3.8045e-02  1.1574e-02 ¦
     By   ¦   8.6383e-04  1.8275e-03 -3.8555e-01  2.9522e-03 ¦
     Bz   ¦  -1.3365e-01 -1.2769e-01  4.9614e-03 -2.2870e-01 ¦
     Err  ¦   3.5561e-01  3.3613e-01 -6.3830e-04 -3.9550e-01 ¦
          +                                                   +
                             Coil Offset
                         +                +
                         ¦   3.4253e+04   ¦
                         ¦   3.5362e+04   ¦
                         ¦   3.5650e+04   ¦
                         ¦   3.3749e+04   ¦
                         +                +
                             Electrical Null
                              +       +
                              ¦ 34575 ¦
                              +       +
                    TILT CALIBRATION MATRICES in NVRAM
                Calibration date and time: 4/6/2000  10:58:42
              Average Temperature During Calibration was   26.6 °C

                   Up                             Down
```

```
        +                           +     +                           +
Roll    ¦  -3.2219e-07  -1.1456e-05 ¦     ¦   4.2529e-07   1.6306e-05 ¦
Pitch   ¦  -1.1477e-05   8.4276e-08 ¦     ¦  -1.6188e-05   1.9917e-07 ¦
        +                           +     +                           +

        +                           +     +                           +
Offset  ¦   3.2400e+04   3.2470e+04 ¦     ¦   3.0128e+04   3.2002e+04 ¦
        +                           +     +                           +

                           +       +
                    Null   ¦ 33336 ¦
                           +       +
```

AD – Display Factory or Active Calibration Data

Purpose Displays factory calibration or active calibration data.

Format AD

Recommended Setting. Use as needed.

Description Displays factory calibration or active calibration data.

Example >AD

```
Display factory calibration data or active calibration data [f or a]?a

              ACTIVE FLUXGATE CALIBRATION MATRICES in FLASH
               Calibration date and time: 3/8/1996  09:53:42
                             S inverse
          |                                                  |
     Bx   |   2.9102e-01  2.6325e-01  2.1267e-02  4.0145e-01 |
     By   |   2.7342e-01  2.5335e-01 -4.8691e-02 -3.9508e-01 |
     Bz   |  -1.8192e-01  2.0180e-01  2.3319e-01 -2.7045e-02 |

     Err  |   3.9761e-01 -3.9925e-01  6.4865e-01 -6.0795e-02 |
          |                                                  |
                             Coil Offset
                         |                 |
                         |   3.5076e+04    |
                         |   3.3277e+04    |
                         |   3.2996e+04    |
                         |   3.3953e+04    |
                         |                 |
                             Electrical Null
                              |       |
                              | 33901 |
                              |       |   press any key to continue...

                    TILT CALIBRATION MATRICES in FLASH
                Calibration date and time: 12/28/1995  08:13:29
              Average Temperature During Calibration was   23.4° C

                   Up                              Down

        |                            |     |                            |
Roll    |  -2.1990e-05  -2.8379e-05  |     |   2.6648e-05   3.4953e-05  |
Pitch   |  -2.9185e-05   2.2630e-05  |     |  -3.5895e-05   2.8521e-05  |
        |                            |     |                            |

        |                            |     |                            |
Offset  |   3.1747e+04   3.0144e+04  |     |   3.0434e+04   3.2971e+04  |
        |                            |     |                            |
                             |       |
                     Null    | 33408 |
                             |       |
```

AF – Field Calibrate Compass

Purpose Calibrates the compass to remove hard and soft iron effects.

Format AF

> **Recommended Setting.** Use as needed. The compass must be calibrated if the batteries have been replaced.
>
> For compass calibration procedures, see Calibrating the Compass.

Description The built-in automated compass calibration procedures are similar to the alignment verification, but require three rotations instead of one. The Rio Grande ADCP uses the first two rotations to compute a new calibration matrix and the third to verify the calibration. It will not accept the new matrix unless the calibration was carried out properly, and it asks you to verify that you want to use the new calibration if it is not as good as the previous calibration. While you are turning the Rio Grande ADCP for the two calibration rotations, the Rio Grande ADCP checks the quality of the previous calibration and displays the results. It compares these results with the results of the third calibration rotation.

There are three compass calibrations to choose from; one only corrects for hard iron while the other corrects for both hard and soft iron characteristics for materials rotating with the ADCP. The third method provides the easiest way to calibrate the compass for one-cycle errors. Hard iron effects are related to residual magnetic fields and cause single cycle errors while soft iron effects are related to magnetic permeability that distorts the earth's magnetic field and causes double cycle errors. In general, the hard iron calibration is recommended because the effect of hard iron dominates soft iron. If a large double cycle error exists, then use the combined hard and soft iron calibration.

AR – Return to Factory Calibration

Purpose Returns to the factory calibration matrix.

Format AR

> Recommended Setting. Use as needed. TRDI strongly recommends sending the AR command (compass restore) before the AF (field calibrate) command. This is done to prevent corruption of the calibration matrix due to a previous incomplete compass calibration.

Description If the calibration procedure is not successful (AF-command), return the Rio Grande ADCP to the original factory calibration, by using the AR-command. Try using the AR-command if you have trouble calibrating your compass. In some circumstances, a defective compass calibration matrix can prevent proper calibration.

AX – Examine Compass Calibration

Purpose Used to verify the compass calibration.

Format AX

> Recommended Setting. Use as needed.

Description Compass calibration verification is an automated built-in test that measures how well the compass is calibrated. The procedure measures compass parameters at every 5° of rotation for a full 360° rotation. When it has collected data for all required directions, the Rio Grande ADCP computes and displays the results. Pay particular attention to the Overall Error.

Example >AX

```
----------------------------------------------------------------------------
                    TRDI Compass Error Estimating Algorithm

   Press any key to start taking data after the instrument is setup.
   Rotate the unit in a plane until all data samples are acquired...
   rotate less than 5°/sec. Press Q to quit.

 N       NE       E        SE       S        SW       W        NW       N
 ^                ^                 ^                 ^                 ^
 *************************************************************************
Accumulating data ...
Calculating compass performance ...

                          >>> Total error:   1.5° <<<

Press D for details or any other key to continue...

HEADING ERROR ESTIMATE FOR THE CURRENT COMPASS CALIBRATION:

   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5°):  ± 1.55°
   DETAILED ERROR SUMMARY:
      Single Cycle Error:                                ± 1.54°
      Double Cycle Error:                                ± 0.07°
      Largest Double plus Single Cycle Error:            ± 1.61°
      RMS of 3rd Order and Higher + Random Error:        ± 0.31°

      Orientation:    Down
      Average Pitch: -19.29°         Pitch Standard Dev:     0.28°
      Average Roll:   -0.59°         Roll Standard Dev:      0.31°

Successfully evaluated compass performance for the current compass calibration.
Press any key to continue...
>
```

AZ – Zero Pressure Sensor

Purpose Zeros the pressure sensor.

Format AZ

Recommended Setting. **Use as needed.**

Description This command zeros the pressure sensor at the specific location where the ADCP will be used.

Example

```
[BREAK Wakeup A]
WorkHorse Rio Grande Broadband ADCP Version 10.17
Teledyne RD Instruments (c) 1996-2013
All Rights Reserved.
>az
Pressure Offset Updated in NVRAM.
```

If the pressure sensor is not installed, using the AZ command will generate the following error.

```
ERR:    Error reading NVRAM data. Please try again
>
```

Bottom Track Commands

The Rio Grande uses these commands for bottom-tracking applications. Bottom track commands tell the ADCP to collect speed-over-bottom data and detected range-to-bottom data. If the ADCP 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 Rio Grande ADCPs. Send a BP0 command to turn off the bottom-tracking process.

Acoustic Doppler Current Profiler with Bottom Track enabled firmware installed, are controlled under 'Category 6 – Sensors and Lasers' section 6A001 of the Commerce Control List (CCL) by the U.S. Department of Commerce. These products are controlled and require an U.S. Department of Commerce Export License for shipment into certain countries. For any sale, resale, export, or re-export of these Goods, both Seller and Buyer must comply with all applicable U.S. export licensing requirements.

Available Bottom Track Commands

This section lists the most often used Bottom Track commands.

```
>b?
BA = 030 ----------------- Evaluation Amplitude Min (1-255)
BB = 0060 ---------------- High Bandwidth Maximum Depth (dm)
BC = 220 ----------------- Correlation Magnitude Min (0-255)
BE = 0100 ---------------- Max Error Velocity (mm/s)
BF = 00000 --------------- Depth Guess (0=Auto, 1-65535 = dm)
BG = 80,20,00030 --------- BM6 Shal Xmt (%), Deep Xmt (%), Deep (dm)
BH = 190,010,004,040 ----- BM6 Thresh(cnt), S Amb(cm/s), L Amb(cm/s), MinAmb
BI = 005 ----------------- Gain Switch Depth (0-999 meters)
BK = 0 ------------------- Layer Mode (0-Off Only, Disabled)
BL = 040,0060,0100 ------- Layer:  Min Size (dm), Near (dm), Far (dm)
BM = 5 ------------------- Mode (4 wo/PP, 5 w/PP, 6 M1, 7 Lag Hop)
BP = 001 ----------------- Pings per Ensemble
BR = 0 ------------------- Resolution (0 = 4%, 1 = 2%, 2 = 1%)
BS ----------------------- Clear Distance Traveled
BV = 00010,250,0 --------- BM7 Blank(cm), Corr Min(0-255), Short Lag On/Off=1/0
BX = 00300 --------------- Maximum Depth (10-65535 dm)
BZ = 004 ----------------- Coherent Ambiguity Velocity (cm/s radial)
```

Bottom Track Command Descriptions

BA - Evaluation Amplitude Minimum

Purpose	Sets the minimum value for valid bottom detection.
Format	BA*nnn*
Range	*nnn* = 1 to 255 counts
Default	BA30

Recommended Setting. 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 – High Bandwidth Maximum Depth

Purpose	This command lets the user define the depth at which the ADCP switches between 25% and 50% bandwidth.
Format	BB*nnnn*
Range	*nnnn* = 0 to 9999 dm
Default	BB320 (300 kHz), BB160 (600 kHz), BB60 (1200 kHz),

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

Description	This command lets the user define the depth at which the ADCP switches between 25% and 50% bandwidth. A setting of zero disables 50% bandwidth. A setting of 9999 disables 25% bandwidth.

BC - Correlation Magnitude Minimum

Purpose	Sets minimum correlation magnitude for valid velocity data.
Format	BC*nnn*
Range	*nnn* = 0 to 255 counts
Default	BC220

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

Description	Sets a minimum threshold for good bottom-track data. The ADCP flags as bad any bottom-track data with a correlation magnitude less than this value.

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*
Range	*nnnn* = 0 to 9999 mm/s
Default	BE1000

Recommended Setting. 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 ADCP uses this parameter to determine good bottom-track velocity data. If the error velocity is greater than this value, the ADCP 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*

Range *nnnnn* = 1 to 65535 dm (0 = automatic)

Default BF0

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

Description When set to a non-zero value, the ADCP 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 ADCP uses to search for the bottom if lost.

If improperly set, the ADCP may not bottom-track at all if the bottom range varies from the input range.

BG – Bottom Mode 6 Shallow Transmit

Purpose For TRDI use only.

Format BG*ss*,*dd*,*nnnn*
ss = Shallow Transmit (%)
dd = Deep Transmit (%)
nnnn = Deep (dm)

Range Shallow Transmit (0 to 99%)
Deep Transmit (0 to 99%)
Deep (0 to 65535 dm)

Default BG80, 30, 00030

Recommended Setting. Use the default setting. Do not adjust without contacting TRDI.

Description For TRDI use only.

BH - Bottom Mode 6 Threshold

Purpose For TRDI use only.

Format BH*ttt*,*sss*,*aaa*,*mmm*
ttt = Threshold (counts)
sss = S Amb (cm/s)
aaa = L Amb (cm/s)
mmm = MinAmb (cm/s)

Range Threshold (0 to 256 counts)
Short Lag Ambiguity Velocity (3 to 160 cm/s)
Long Lag Ambiguity Velocity (3 to 160 cm/s)
Minimum Ambiguity Velocity (20 to 1300 cm/s)

Default BH190, 010, 004, 040

Recommended Setting. Use the default setting. Do not adjust without contacting TRDI.

Description For TRDI use only.

BI - Gain Switch Depth

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

Format BI*nnn*

Range *nnn* = 0 to 999 meters

Default BI20 (300 kHz), BI10 (600 kHz), BI5 (1200 kHz),

Recommended Setting. 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.

BK – Water-Mass Layer Mode

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

Format BK*n*

Range *n* = 0 to 3

Default BK0

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

Description BK selects how often the ADCP performs a water-mass layer ping while bottom tracking. The number of water-mass layer pings per ensemble is dependent on the BP-command (bottom pings per ensemble) and this command setting. Use the BL-command to set the location of the water-mass layer.

Table 21: Water-Mass Reference-Layer Modes

Command	Description
BK0	Disables the water-mass layer ping.
BK1	Sends a water-mass layer ping after every bottom-track ping
BK2	Sends a water-mass layer ping after every bottom-track ping that is unable to find the bottom.
BK3	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*

Range *mmm* = Minimum Layer Size (0 to 999 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]

Default BL160,320,480 (300 kHz), BL80,160,240 (600 kHz), BL40,60,100 (1200 kHz),

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

Description The BL-command sets a water-mass layer. You can 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 - Water-Mass Layer Mode and BP - Bottom-Track Pings Per Ensemble 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 ADCP sends Error Code 011.

The user-defined water-mass layer is used unless the minimum layer comes within 20% of the water boundary (sea floor for down-looking systems; surface for up-looking systems). As the user-defined water-mass layer comes within 20% of the boundary (Figure 34, B), the layer compresses in size until the minimum water-mass layer size is reached. When the boundary moves closer to the transducer (Figure 34, C), no water mass ping will be sent.

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

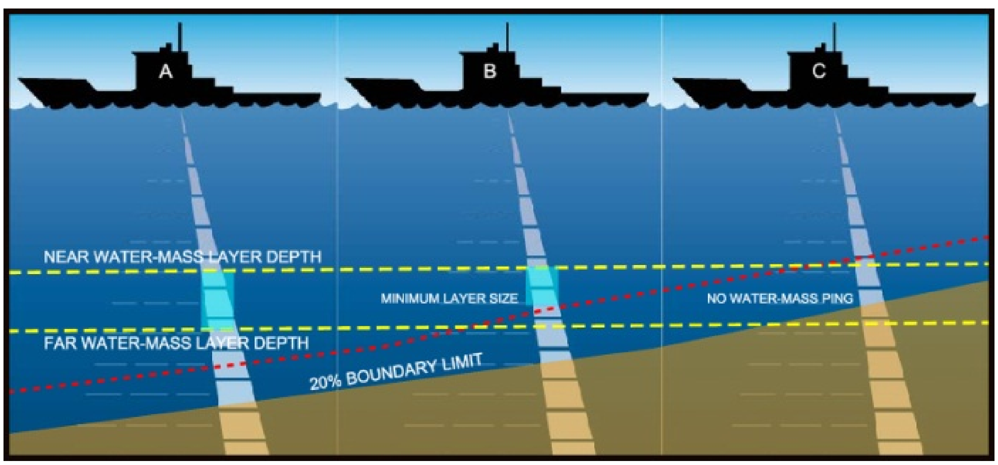


Figure 29. Water-Mass Layer Processing

BM - Bottom Track Mode

Purpose Sets the Bottom Track mode.

Format BM*n*

Range *n* = 4, 5, (see description), 7 (available as a feature upgrade for 1200 kHz Rio Grande ADCPs)

Default BM5

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

Description See below

Bottom Track Mode 4

Bottom Track Mode 4 uses the correlation side-peak position to resolve velocity ambiguities. It lengthens the lag at a predetermined depth to improve variance.

Bottom Track Mode 5

Bottom Track Mode 5 is similar to Bottom Track Mode 4, but has a lower variance in shallow water by a factor of up to four. In very shallow water at slow speeds, the variance is lower by a factor of up to 100. Bottom Track Mode 5 also has a slightly slower ping rate than Bottom Track Mode 4.

Bottom Mode 5 (default setting) will shift to Bottom Mode 4 if the conditions warrant.

The ADCP limits searching for the bottom to the value set by the BX-command (max bottom tracking altitude) + 0.5 transmit length. This allows a faster ping rate when the bottom altitude is close to the BX-command setting.

Table 22. BM4/BM5 Minimum Tracking Depths

Frequency (kHz)	BM4/BM5 Minimum Tracking Depths (m)
150	2.0
300	1.5
600	1.0
1200	0.8

Bottom Track Mode 7

Bottom Mode 7 is a feature upgrade for 1200 kHz Rio Grande ADCPs (see Installing Feature Upgrades).

Bottom Mode 7 has several advantages over BM5 in slow moving, shallow water applications.

Bottom Mode 7 was developed for even shallower applications than Mode 5 yet it retains bottom Mode 5's very precise velocity measurement (see Table 24). It addresses other shallow water issues such as bottom detection in the presence of high backscatter water, signal level control despite a wide range of bottom backscatter for various applications, and transmit/receive interference when beam depths are substantially different.

Bottom Mode 7 pings at a slower rate than Bottom Mode 5 (1/3 the rate of BM5) and the precision of its velocity measurement degrades at velocities higher than 0.2m/s. If you are interested in using this mode, please request a copy of Field Service Application Note FSA-015 Shallow Water Bottom Tracking Mode 7 (available for download at www.rdinstruments.com, Customer Support page).

Table 23. BM7 Minimum Tracking Depths

Frequency	Min Tracking Depths
600 kHz	0.6m
1200 kHz	0.3m

BP – Bottom-Track Pings per Ensemble

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

Format BP*nnn*

Range *nnn* = 0 to 999 pings

Default BP1

Recommended Setting. **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 ADCP interleaves bottom-track pings with water-track pings (see TP-command). If BP = zero, the ADCP does not collect bottom-track data. The ADCP automatically extends the ensemble interval (TE) if BP x TP > TE.

BR - Resolution

Purpose Sets the vertical depth resolution.

Format BRn

Range n = 0 to 2 (see description)

Default BR0

Recommended Setting. **The default setting for this command is recommended for most applications.**

Description BR sets the vertical depth resolution as a percentage of the overall range detected. The lower the resolution, the finer the depth reading. With BR0 set, if you had a depth of 100 meters, then the depth would read 100 meters until you passed 104 meters. If you had BR2 set, then it would change when you reached 101 meters. Setting a higher resolution (e.g. 1%) results in longer ping times.

BR0 = 4% BR1 = 2% BR2 = 1%

Resolution Setting Limitations:

1) Minimum RSSI Bin Size – The RSSI sampling interval cannot be smaller than the minimum RSSI bin size (for example, 5 cm for a 1200 kHz system). This means that you get the resolution that you command in % or 5 cm (for the above example) - whichever is larger. The minimum RSSI bin sizes vary with system frequency according to the following table:

Frequency	Min RSSI Bin Size
150	37 cm
300	18 cm
600	9 cm
1200	5 cm

2) BM5 Low Altitude Minimum RSSI Bin Size -- This limitation affects only Bottom Mode 5 operation below the following altitudes:

150 kHz -- 20 meters -- the resolution becomes 63 cm
300 kHz -- 10 meters -- the resolution becomes 16 cm
600 kHz -- 5 meters -- the resolution becomes 8 cm
1200 kHz -- 2.5 meters -- the resolution becomes 7.8 cm

BS - Clear Distance Traveled

Purpose Clears internal distance traveled accumulators.

Format BS

Recommended Setting. Use as needed.

Description Distance traveled is calculated and output in DVL output formats (PD5 and PD6). The accumulator is zeroed on <BREAK> or by using this command in the manual ensemble cycling mode.

BV – Mode 7 Parameters

Purpose Controls the behavior of Bottom Track Mode 7.

Format BV *aaaaa*, *bbb*, *c*

Range *aaaaa* = 0 to 65535
bbb = 0 to 255
c = 0 or 1 (0 = Off, 1 = On)

Default: BV10, 250, 0 (1200 kHz), BV20,250,0 (600 kHz)

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

Description: The first parameter sets the depth at which the bottom will be searched. It avoids locking onto ringing (if any) or very high backscatter water near the transducer.

The second parameter controls the correlation threshold for ambiguity resolving. A lower, fixed correlation threshold is used to determine if a lag's velocity estimate is satisfactory.

The last parameter controls whether short lag velocity estimates are output in the event the longer lag ambiguity cannot be resolved because one or more of the short lag velocity estimates have too low a correlation. If this parameter is a one, then the average of the four short lag estimates that are above a lower, fixed correlation threshold will be used. If this parameter is a zero, then no velocity will be output for this case.

A count value of 255 is perfect correlation.

BX – Maximum Tracking Depth

Purpose Limits the search range for bottom tracking.

Format BX*nnnn*

Range *nnnn* = 10 to 65535 decimeters (meters x 10)

Default BX1200 (300 kHz), BX600 (600 kHz), BX300 (1200 kHz),

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

Description The BX-command sets the maximum tracking depth used by the ADCP during bottom tracking. This prevents the ADCP from searching too long and too deep for the bottom, allowing a faster ping rate when the ADCP loses track of the bottom. If the bottom-track water reference layer is in use (BK > 0), BX must be greater than the Far Layer Boundary (BLmmm,*nnnn*,ffff), or the ADCP sends Error Code 012.

Example If you know 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 1200 dm for a 300 kHz ADCP. Now if the ADCP loses track of the bottom, it will stop searching for the bottom at 210-dm (21 m) rather than spend time searching down to 1200-dm (120 m), which is the maximum bottom-tracking range.

The BX command limits the search range for bottom tracking. If the ADCP 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 ADCP 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. Setting a BX range limit will not prevent the ADCP from tracking the bottom to its maximum range capability as long as it maintains a lock on the bottom.

BZ - Coherent Ambiguity Velocity

Purpose Sets the Bottom-Track Mode 5 ambiguity velocity.

Format BZ*nnn*

Range *nnn* = 0 to 999 cm/s radial

Default BZ004

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

Description The BZ-command selects the ambiguity velocity used by the bottom-track ping in shallow water when bottom-track Mode 5 is in use.

Control System Commands

The Rio Grande ADCP uses the following commands to control certain system parameters.

Available Control System Commands

This section lists the available Control System commands.

```
>c?
CB = 411 ----------------- Serial Port Control (Baud [8=115200]; Par; Stop)
CF = 11110 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
CK ----------------------- Keep Parameters as USER Defaults
CL = 0 ------------------- Sleep Enable (0 = Disable, 1 = Enable)
CM = 0 ------------------- RS-232 Sync Master (0 = OFF, 1 = ON)
CN = 1 ------------------- Save NVRAM to recorder (0 = ON, 1 = OFF)
CP = 0 ------------------- PolledMode (1=ON, 0=OFF;  BREAK resets)
CQ = 255 ----------------- Xmt Power (0=Low, 255=High)
CR # --------------------- Retrieve Parameters (0 = USER, 1 = FACTORY)
CS ----------------------- Go (Start Pinging)
CY # --------------------- Error Status Word (0=Clear, 1=Display)
CZ ----------------------- Power Down Instrument
>
```

Control System Command Descriptions

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: CB411

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

Description: The Rio Grande ADCP and the external device (computer, software) MUST use the same communication parameters to *talk* to each other. After entering valid CB parameters (see Changing the Baud Rate in the ADCPs), the Rio Grande ADCP responds with a ">" prompt. Then change the external device's communication parameters to match the Rio Grande ADCP parameters before sending another command.

Table 24. Serial Port Control

Baud Rate	Parity	Stop Bits
0 = 300		
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 Rio Grande ADCP data flow-control parameters.
Format	CF*nnnnn*
Range	Firmware switches (see description)
Default	CF11110

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

Description The CF-command defines whether the Rio Grande ADCP: 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; sends or does not send data to the recorder (if installed).

Table 25: Flow Control

Command	Description
CF1xxxx	Automatic Ensemble Cycling – Automatically starts the next data collection cycle after the current cycle is completed. Only a <BREAK> can stop this cycling.
CF0xxxx	Manual Ensemble Cycling – Enters the STANDBY mode after transmission of the data ensemble, displays the “>” prompt and waits for a new command.
CFx1xxx	Automatic Ping Cycling – Pings immediately when ready.
CFx0xxx	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 Rio Grande ADCP is not echoed. This feature lets you manually control ping timing within the ensemble.
CFxx1xx	Binary Data Output – Sends the ensemble in binary format, if serial output is enabled (see below).
CFxx0xx	Hex-ASCII Data Output – Sends the ensemble in readable hexadecimal-ASCII format, if serial output is enabled (see below).
CFxxx1x	Enable Serial Output – Sends the data ensemble out the RS-232/422 serial interface.
CFxxx0x	Disable Serial Output – No ensemble data are sent out the RS-232/422 interface.
CFxxxx1	Enable Data Recorder – Records data ensembles on the recorder (if installed).
CFxxxx0	Disable Data Recorder – No data ensembles are recorded on the recorder.
Example	CF01010 selects manual ensemble cycling, automatic ping cycling, Hex-ASCII data output, enables serial output, and disables data recording.

CK - Keep Parameters

Purpose	Stores present parameters to non-volatile memory.
Format	CK

Recommended Setting. Use as needed.

Description CK saves the present user command parameters to non-volatile memory on the CPU board. The Rio Grande ADCP maintains data stored in the non-volatile memory (user settings) even if power is lost. It does not need a battery. You can recall parameters stored in non-volatile memory with the CR0-command (see CR – Retrieve Parameters).

Always use the CK command in your configuration file (see **Using Direct Commands to Deploy an ADCP**).

The ADCP automatically stores the last set of commands used in RAM (volatile memory). The user can store the configuration into non-volatile memory by sending a CK command. Note that the ADCP will restart in the previous configuration even if it was not saved with a CK command as long as the volatile memory's internal battery is not discharged. This can happen after several months without any power applied to the ADCP (Note that this battery will recharge as soon as power is reapplied). If the ADCP is stopped by removing the power while pinging, it will restart pinging and output data next time power is applied.

CL - Battery Saver Mode

Purpose	Determines whether the ADCP will attempt to conserve power by sleeping between pings.
Format	CLn
Range	n = 0 to 1 (Sleep Between Pings (0 = No, 1 = Yes)
Default	CL0

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

Description CL0 means the ADCP will not make any attempt to conserve power. Setting the CL command to CL1 means the ADCP will attempt to conserve power by going to sleep at every opportunity.

In order for software breaks to work, the CL-command must be set to CL0 (see **Break**).

CM - Master

Purpose Deprecated.

CN - Save NVRAM to Recorder

Purpose:	Saves the contents of NVRAM to the recorder at the end of a deployment.
Format	CN*n*
Range	n = 0 (On), 1 (Off)
Default	CN1

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

Description The CN command allows the contents of the NVRAM (approx. 8k bytes) to be written to the recorder as part of the deployment record. This can be useful for troubleshooting purposes.

CP – Polled Mode

Purpose:	Allows the Rio Grande ADCP to be polled for data.
Format	CP*n*
Range	*n* = 0 (Off), 1 (On)
Default	CP0

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

Description The CP command allows a Rio Grande ADCP to be polled for data. Setting the CP command to CP1 places the ADCP into a mode where it doesn't sleep. Instead, the ADCP stays awake between pings listening for certain commands (and drawing more power). Polled mode is only recommended for deployments where shore power can be provided. The commands the ADCP responds to while in polled mode are shown in Table 27.

The polled mode requires sufficient time between pings to listen for the polling commands. Setting the TP command to 1 second normally gives the ADCP enough time for polling.

In the polled mode (CP1), enough time must be allowed in the ensemble cycle (TE or TP commands) to allow the system to check for serial input. If both TE and TP are set to zero for the maximum ping rate, the system will not recognize any keyboard input with the exception of a <break>.

The output of the polled mode is on demand. If the ADCP is in the middle of an ensemble when the command arrives, it will send out the last completed ensemble, even as it continues to collect data for the current ensemble. Note that the polled mode does not output data until at least one ensemble has been completed.

Table 26. Polled Mode Commands

Command	Description
!	Execute a Break reset
+	Increment internal clock by 1 second
-	Decrement internal clock by 1 second
D	Dump the last ensemble
E	Print the current ensemble number
T	Print the current time

The commands are not echoed and they don't need to be followed by a CR/LF pair. These commands are only available when CP = 1.

Enabling polled mode disables the battery saver feature. Do not enable this mode when running from batteries.

CQ – Transmit Power

Purpose Allows the transmit power to be adjusted.

Format CQ*nnn*

Range *nnn* = 0, or 1 to 255 (0 = Low, 1 to 255 = High)

Default CQ255

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

Description Allows the transmit power to be set high or low. This only affects 75 and 150 kHz systems.

CR – Retrieve Parameters

Purpose Resets the Rio Grande ADCP command set to factory settings.

Format CR*n*

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

Recommended Setting. Use as needed.

Description The Rio Grande ADCP automatically stores the last set of commands used in RAM. The Rio Grande ADCP will continue to be configured from RAM unless it receives a CR-command or until the RAM loses its power.

Table 27. Retrieve Parameters

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

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

CS – Start Pinging (Go)

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

Format CS

Recommended Setting. Use as needed. Use *WinRiver II* and *SxS Pro* to create the command file. The CS command will be added to the end of the command file or sent by the software.

Description Use CS (or the **Tab** key) to tell the Rio Grande ADCP to start pinging its transducers and collecting data as programmed by the other commands. If the TF command is set (time of first ping), the Rio Grande ADCP waits until it reaches the TF time before beginning the data collection cycle.

1. After a CS command is sent to the Rio Grande ADCP, no changes to the commands can occur until a <BREAK> is sent.
2. If you try to record data (CFxxxx1), and the recorder is full, the Rio Grande ADCP will *not* start pinging and will return a *RECORDER NOT READY* message and go back to the command prompt.
3. The ADCP will keep pinging after the recorder is full only if serial output is turned on (CFxxx1x). If the serial output is off, than the Rio Grande ADCP will shut down when the recorder is full, on the assumption that there is no sense in using up the battery if the data is not going anywhere.

CY - Clear Error Status Word

Purpose Clears the Error Status Word (ESW) stored in EEPROM on the CPU. The ESW is updated whenever an error occurs.

Format CY*n*

Range *n* = 0 (Clear), 1 (Display)

Format Use the CY1 command to display the ESW value or CY0 to clear the ESW.

Recommended Setting. **Use as needed.**

Description CY1 displays the active ESW value, which is a 32-bit value displayed in Hex ASCII.

Table 28: Error Status Word

ESW	Description
0x00000001	Bus Error Exception occurred.
0x00000002	Address Error Exception occurred.
0x00000004	Illegal Inst Exception occurred.
0x00000008	Zero Divide Exception occurred.
0x00000010	Emulator Exception occurred.
0x00000020	Unassigned Exception occurred.
0x00000040	Watchdog restart occurred.
0x00000080	Screen Save power down occurred.
0x00000100	Currently pinging.
0x00000200	Unused
0x00000400	Unused
0x00000800	Unused
0x00001000	Unused
0x00002000	Unused
0x00004000	Cold wakeup occurred.
0x00008000	Unknown wakeup occurred.
0x00010000	Clock read failure occurred.
0x00020000	Unexpected Alarm.
0x00040000	Clock jump forward.
0x00080000	Clock jump backward.
0x00100000	Unused
0x00200000	Unused
0x00400000	Unused
0x00800000	Unused
0x01000000	Unused
0x02000000	Unused
0x04000000	Unused
0x08000000	Power Fail (Unrecorded)
0x10000000	Spurious level 4 interrupt (DSP).
0x20000000	Spurious level 5 interrupt (UART).
0x40000000	Spurious level 6 interrupt (CLOCK).
0x80000000	Level 7 interrupt occurred.

In the command mode, the Error Status Word (ESW) codes can be cleared through the CY-command. In ping mode, the ESW is cleared (set to zero) between each ensemble. The values are logically OR'ed. For example, if an illegal instruction (xxx4) and a divide by zero error (xxx8) occurred since the last time the ESW was cleared, a value of "xxxC" would appear as the ESW.

ESW code 0x0000100 can only be seen if the CY-command is issued between CS-commands in the manual ping mode. This flag is used to determine if on wakeup, whether the ADCP was pinging or not previous to the present power up. A CS-command sets this bit; a <BREAK> resets the bit. This results in the following consequences:

a) A deployment must be ended with a <BREAK>. If the ADCP is pinging, and power is lost, when power is restored, the ADCP will continue to ping.

b) If the ADCP is in the command mode when power is lost, when power is restored, it will wake up in the command mode. If a timeout occurs, the ADCP will power down automatically.

In ping mode, the ESW is cleared (set to zero) between each ensemble. The ESW is written to the ensemble (see Variable Leader Data Format).

CZ – Power down Instrument

Purpose Tells the Rio Grande ADCP to power down.

Format CZ

Recommended Setting. **Use as needed.**

Description Sending the CZ-command powers down the Rio Grande ADCP. Rio Grande ADCP processing is interrupted and the Rio Grande ADCP goes in the STANDBY mode (RAM is maintained).

Example See below

```
>cz

Powering Down
```

1. When powered down using the CZ-command, the Rio Grande ADCP still draws up to 30µa, but wakes up periodically (every 8 to 12 hours) for a few seconds to maintain RAM.

2. This command should be used whenever batteries have been installed and you do not send commands to start a deployment. If you do not use the CZ-command, the Rio Grande ADCP will draw up to 50 milli-amps of current. *A new battery will be discharged in a few days*.

3. Performance and testing commands (i.e. AF, PA, PT, RB, and RY) override the battery saver functions. For example, using the RY-command to recover data from the ADCP while on battery power will disable the automatic power saver mode. If a CZ-command is not used after all data has been recovered, the ADCP will remain in the command mode. TRDI recommends disconnecting the batteries and using the AC power adapter while testing or recovering data.

Environmental Commands

The Rio Grande ADCP 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?
EA = +00000 -------------- Heading Alignment (1/100 deg)
EB = +00000 -------------- Heading Bias (1/100 deg)
EC = 1500 ---------------- Speed Of Sound (m/s)
ED = 00000 --------------- Transducer Depth (0 - 65535 dm)
EH = 00000 --------------- Heading (1/100 deg)
EP = +0000 --------------- Tilt 1 Sensor (1/100 deg)
ER = +0000 --------------- Tilt 2 Sensor (1/100 deg)
ES = 00 ------------------ Salinity (0-40 pp thousand)
ET = +2500 --------------- Temperature (1/100 deg Celsius)
EX = 10100 --------------- Coord Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 1011101 ------------- Sensor Source (C;D;H;P;R;S;T)
>
```

Environmental Command Descriptions

EA - Heading Alignment

Purpose Corrects for physical misalignment between Beam 3 and the heading reference.

Format EA±*nnnnn*

Range ±*nnnnn* = -17999 to 18000 (-179.99 to 180.00 degrees)

Default EA00000

> Recommended Setting. For systems that are stationary, EA is typically set to zero (default), since Beam 3 is used as the heading reference. This command is added to the command file using *WinSC*.

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 EB-command to correct for heading bias (e.g., magnetic declination).

Example The ADCP is mounted in place on a moving ship. Beam 3 has been rotated 45 clockwise (+45) from the ship's centerline. Use the EA command to tell the ADCP 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 × 100 = +4500 = EA+04500
```

EB - Heading Bias

Purpose Corrects for electrical/magnetic bias between the ADCP heading value and the heading reference.

Format EB±*nnnnn*

Range ±*nnnnn* = -17999 to 18000 (-179.99 to 180.00 degrees)

Default EB00000

Recommended Setting. Use EB to counteract the effects of magnetic declination at the deployment site. Set using *WinRiver II* and *SxS Pro*.

Description EB is the heading angle that counteracts the electrical bias or magnetic declination between the ADCP and the heading source. Use the EA-command to correct for physical heading misalignment between the ADCP and a vessel's centerline.

Examples A bottom-mounted ADCP is receiving heading from its internal compass. A navigation map for the deployment area shows a declination of 10°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 EB command value to EB-926.

EC - Speed of Sound

Purpose Sets the speed of sound value used for ADCP data processing.

Format EC*nnnn*

Range *nnnn* = 1400 to 1600 meters per second

Default EC1500

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

Description EC sets the sound speed value used by the ADCP to scale velocity data, depth cell size, and range to the bottom. The ADCP 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 ADCP overrides the manually-set EC value and calculates speed of sound using the values determined by transducer depth (ED), salinity (ES), and transducer temperature (ET). EZ also selects the source for ED, ES, and ET.

ED - Depth of Transducer

Purpose Sets the ADCP transducer depth.

Format ED*nnnnn*

Range *nnnnn* = 0 to 65535 decimeters (meters x 10)

Default ED00000

Recommended Setting. Use the EZ-command (set by *WinSC*).

Description ED sets the ADCP transducer depth. This measurement is taken from sea level to the transducer faces. The ADCP uses ED in its speed of sound calculations. The ADCP assumes the speed of sound reading is taken at the transducer head. See the primer for information on speed of sound calculations.

Note If the EZ *Transducer Depth* field = 1, the ADCP overrides the manually set ED value and uses depth from the internal pressure sensor. If a pressure sensor is not available, the ADCP uses the manual ED setting.

EH - Heading

Purpose Sets the ADCP heading angle.

Format EH*nnnnn*

Range *nnnnn* = 0 to 35999 (000.00 to 359.99 degrees)

Recommended Setting. Use the EZ-command.

Description EH sets the ADCP heading angle of beam 3. When mounted on a stationary platform, the ADCP assumes beam 3 points north (0).

Example Convert heading values of 34 and 3.5 to EH-command values.

```
EH = 34.00 × 100 = 3400 = EH03400
EH =  3.50 × 100 =  350 = EH00350
```

If the EZ Heading field = one, the ADCP overrides the manually set EH value and uses heading from the transducer's internal sensor. If the sensor is not available, the ADCP uses the manual EH setting.

EP - Pitch (Tilt 1)

Purpose Sets the ADCP pitch (tilt 1) angle.

Format EP±*nnnn*

Range ±*nnnn* = -6000 to 6000 (-60.00 to +60.00 degrees)

Recommended Setting. Use the EZ-command.

Description EP sets the ADCP pitch (tilt 1) angle.

Example Convert pitch values of +14 and -3.5 to EP-command values.

```
EP = 14.00 × 100 = 1400 = EP01400 (+ is understood)
EP = -3.50 × 100 = -350 = EP-00350
```

If the EZ Pitch field = 1, the ADCP overrides the manually set EP value and uses pitch from the transducer's internal tilt sensor. If the sensor is not available, the ADCP uses the manual EP setting.

ER - Roll (Tilt 2)

Purpose Sets the ADCP roll (tilt 2) angle.

Format ER±*nnnn*

Range ±*nnnn* = -6000 to 6000 (-60.00 to +60.00 degrees)

Recommended Setting. Use the EZ-command.

Description ER sets the ADCP roll (tilt 2) angle.

Example Convert roll values of +14 and -3.5 to ER-command values.

```
ER = 14.00 × 100 = 1400 = ER01400 (+ is understood)
```

```
ER = -3.50 × 100 = -350 = ER-00350
```

If the EZ Roll field = one, the ADCP overrides the manually set ER value and uses roll from the transducer's internal tilt sensor. If the sensor is not available, the ADCP uses the manual ER setting.

ES – Salinity

Purpose	Sets the water's salinity value.
Format	ES*nn*
Range	*nn* = 0 to 40
Default	ES0

Recommended Setting. Set using *WinRiver II* and *SxS Pro*. The default setting for this command is recommended for most applications.

Description ES sets the water's salinity value. The Rio Grande ADCP uses ES in its speed of sound calculations. The Rio Grande ADCP assumes the speed of sound reading is taken at the transducer head.

ET - Temperature

Purpose	Sets the water's temperature value.
Format	ET±*nnnn*
Range	±*nnnn* = -500 to 4000 (-5.00 C to +40.00 C)
Default	ET2500

Recommended Setting. Use the EZ-command.

Description ET sets the temperature value of the water. The ADCP uses ET in its speed of sound calculations (see the primer). The ADCP 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 × 100 = 1400 = ET1400 (+ is understood)
ET = -3.50 × 100 = -350 = ET-0350
```

If the EZ Temperature field = one, the ADCP overrides the manually set ET value and uses temperature from the transducer's temperature sensor. If the sensor is not available, the ADCP uses the manual ET setting.

EX – Coordinate Transformation

Purpose	Sets the coordinate transformation processing flags.
Format	EX*xxptb*
Range	*xx* = Transformation *p* = Pitch and Roll *t* = 3 beam solutions *b* = Bin mapping
Default	EX10100

Recommended Setting. 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.

Table 29. 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 ADCP. 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 EB-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 EB-commands used. If Bit 3 of the EX-command is a 1, then Pitch/Roll applied.
EXxx1xx	Use tilts (pitch and roll) in transformation (see Note 2)
EXxxx1x	Allows 3-beam solutions if one beam is below the correlation threshold set by WC
EXxxxx1	Allow bin mapping (see Note 4)

1. For ship and earth-coordinate transformations to work properly, you must set the Heading Alignment (EA) and Heading Bias (EB) correctly. You also must ensure that the tilt and heading sensors are active (EZ).

2. Setting EX bit 3 (Use Tilts) to 0 lets you collect tilt data without using it in the ship or earth-coordinate transformations.

3. Each Rio Grande ADCP uses its own beam calibration matrix to correct data for beam pointing errors (e.g., if the beams erroneously point toward 21 degrees instead of 20 degrees). Correction is applied when the data are converted from beam coordinates to earth coordinates. If you output beam-coordinate data, you will need to apply the beam corrections yourself if you want the best possible data or use the *WinRiver II* and *SxS Pro* software.

4. TRDI outputs the 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.

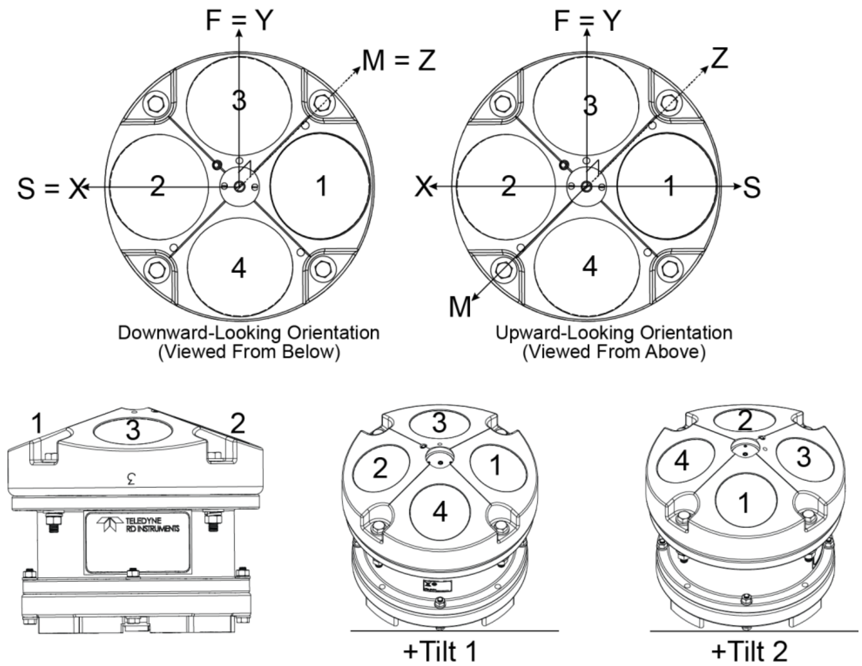


Figure 30. ADCP Coordinate Transformation

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	+	-

EZ - Sensor Source

Purpose Selects the source of environmental sensor data.

Format EZ*cdhprst*

Default EZ1011101

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

Range Firmware switches (see description)

Description Setting the EZ-command firmware switches tells the ADCP to use data from a manual setting or from an associated sensor. When a switch value is non-zero, the ADCP overrides the manual E-command setting and uses data from the appropriate sensor. If no sensor is available, the ADCP defaults to the manual E-command setting. The following table shows how to interpret the sensor source switch settings.

Table 30. Sensor Source Switch Settings

	Field	Value = 0	Value = 1	Value = 2
c	Speed Of Sound	Manual EC	Calculate using ED, ES, and ET	N/A
d	Depth	Manual ED	Depth Sensor	N/A
h	Heading	Manual EH	Internal Transducer Sensor	N/A
p	Pitch (Tilt 1)	Manual EP	Internal Transducer Sensor	N/A
r	Roll (Tilt 2)	Manual ER	Internal Transducer Sensor	N/A
s	Salinity	Manual ES	N/A	N/A
t	Temperature	Manual ET	Internal Transducer Sensor	N/A

Example EZ1111101 means calculate speed of sound from readings, use pressure sensor, transducer heading, internal tilt sensors, and transducer temperature.

Fault Log Commands

The Rio Grande ADCP uses the following commands to aid in troubleshooting and testing.

Available Fault Log Commands

This section lists the most often used Fault Log commands.

```
>f?
Available Commands:

FC ----------------------- Clear Fault Log
FD ----------------------- Display Fault Log
FX ----------------------- Toggle the Fault Log debug flag
F? ----------------------- Display Fault Log Commands

>
```

Fault Log Command Descriptions

FC – Clear Fault Log

Purpose Clears the fault log.

Format FC

Recommended Setting. Use as needed.

Description Use this command to clear the fault log of all previous entries.

FD – Display Fault Log

Purpose Displays the fault log.

Format FD

Recommended Setting. Use as needed.

Description Displaying the fault log will list why a built-in test failed. This may aid in troubleshooting.

Example >FD

```
Total Unique Faults   =     2
Overflow Count        =     0
Time of first fault:    97/11/05,11:01:57.70
Time of last fault:     97/11/05,11:01:57.70

Fault Log:
Entry #  0 Code=0a08h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt axis X over range.
Entry #  1 Code=0a16h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt Y axis ADC under range.
End of fault log.
```

Performance and Testing Commands

The Rio Grande ADCP uses the following commands for calibration and testing.

Available Performance and Testing Commands

This section lists the available Performance and Testing commands.

```
>p?
PA ---------------------- Pre-Deployment Tests
PC ### ------------------ Built In Tests, PC 0 = Help
PD = 0 ------------------ Data Stream Select (0-8)
PM ---------------------- Distance Measure Facility
PS # -------------------- Show Sys Parms (0=Xdcr,1=FLdr,2=VLdr,3=Mat,4=Seq)
PT ### ------------------ Built In Tests, PT 0 = Help
>
```

Performance and Testing Command Descriptions

PA – Pre-deployment Tests

Purpose Sends/displays results of a series of Rio Grande ADCP system diagnostic tests.

Format PA

Recommended Setting. Use as needed.

Description These diagnostic tests check the major Rio Grande ADCP modules and signal paths. We recommend you run this command before a deployment. These tests check the following boards/paths.

- CPU - CPU RAM and real-time clock.
- Recorder - verifies recorder operation.
- DSP - RAM, registers, and DSP-to-CPU Communications.
- System Tests - A test signal is routed through the DSP and back to the CPU. This checks the main electronics processor path.
- Receive Path - quiescent RSSI levels are checked for [20 < RSSI < 60 counts] and the RSSI filters are checked for proper time constants.
- Transmit Path - checks transmit voltage, current, and impedance.
- Sensors - verifies sensor operation.

Example see below

```
>PA
PRE-DEPLOYMENT TESTS
CPU TESTS:
  RTC.....................................PASS
  RAM.....................................PASS
  ROM.....................................PASS
RECORDER TESTS:
  PC Card #0..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
  PC Card #1..............................DETECTED
    Card Detect...........................PASS
```

```
     Communication.........................PASS
     DOS Structure.........................PASS
     Sector Test (short)...................PASS
DSP TESTS:
  Timing RAM...............................PASS
  Demod  RAM...............................PASS
  Demod  REG...............................PASS
  FIFOs....................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Receive Loop-Back........................PASS
  Wide Bandwidth...........................PASS
  Narrow Bandwidth.........................PASS
  RSSI Filter..............................PASS
  Transmit.................................PASS
SENSOR TESTS:
  H/W Operation............................PASS
```

Wide Bandwidth and Narrow Bandwidth may fail if transducer is not in water. H/W Operation test will fail if the transducer is on its side.

PC – User-Interactive Built-In Tests

Purpose Sends/displays results of user-interactive Rio Grande ADCP system diagnostic tests.

Format PC*nnn*

Range *nnn* = 0 to 2 (PC0 = Help menu; see below for others)

Recommended Setting. **Use as needed.**

Description These diagnostic tests check beam continuity and sensor data. Both tests require user interaction (see examples).

Examples See below.

PC0 – Help Menu

Sending PC0 displays the help menu.

```
User Interactive, Built In Tests
--------------------------------
PC0 = Help
PC1 = Beam Continuity
PC2 = Sensor Data
```

PC1 – Beam Continuity

Sending PC1 tests the beam continuity by measuring the quiescent Receiver Signal Strength Indicator (RSSI) levels. There must be a change of more than 30 counts when the transducer face is rubbed.

```
BEAM CONTINUITY TEST
When prompted to do so, vigorously rub the selected
beam's face.
If a beam does not PASS the test, send any character to
the ADCP to automatically select the next beam.

Collecting Statistical Data...
  52  48  50  43
Rub Beam 1 = PASS
Rub Beam 2 = PASS
Rub Beam 3 = PASS
Rub Beam 4 = PASS
```

This test must be performed with the ADCP out of water and preferably dry.

PC2 – Display Heading, Pitch, Roll, and Orientation

Sending PC2 displays heading, pitch angle, roll angle, up/down orientation and attitude temperature in a repeating loop at approximately 0.5-sec update rate. Press any key to exit this command and return to the command prompt.

```
Press any key to quit sensor display ...
Heading    Pitch     Roll    Up/Down     Attitude Temp   Ambient Temp  Pressure
301.01°  -7.42°  -0.73°     Up           24.35°C         22.97°C        0.0 kPa
300.87°  -7.60°  -0.95°     Up           24.36°C         22.97°C        0.0 kPa
300.95°  -7.60°  -0.99°     Up           24.37°C         22.97°C        0.0 kPa
300.71°  -7.61°  -0.96°     Up           24.37°C         22.98°C        0.0 kPa
300.69°  -7.61°  -0.96°     Up           24.35°C         22.98°C        0.0 kPa
300.76°  -7.60°  -0.98°     Up           24.38°C         22.97°C        0.0 kPa
```

The PC2 heading shows the raw (magnetic north) heading only. The EB command (Heading Bias) is not applied.

PD - Data Stream Select

Purpose: Selects the type of ensemble output data structure.

Format: PDn

Range n = 0 to 7 (see description and caution below)

Default PD0

Recommended Setting. 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 32).

Table 31: Data Stream Selections

Format	Description
PD0	Sends The real water-current data set
PD1	Sends a TRDI-defined data set that always uses the same data (except for parts of the leader data). This data set is useful during user-software development.
PD2	Not used.
PD3	Sends Paramax-DVL ensemble output data structure.
PD4	Sends CSS-DVL output data structure (without sensor and made-good data).
PD5	Sends CSS-DVL output data structure (with sensor and made-good data).
PD6	Sends a special DVL ASCII data stream
PD7	Not used

All of TRDI's software supports PD0 formatted data only.

The PD? help printout incorrectly lists the valid PD command inputs as PD0 to PD8. Only PD0 to PD7 are valid inputs. Sending PD8 will generate an error message.

```
>pd?
PD = 0 ------------------ Data Stream Select (0-8)
>pd8  ERR 001:  PARAMETER OUT OF BOUNDS
>
```

PM - Distance Measurement Facility

Purpose Measures the distance over the bottom.

Format PM

Recommended Setting. For TRDI use only.

Description PM uses the ADCP to measure distances over the bottom using a dumb terminal.

PS – Display System Parameters

Purpose Displays the Rio Grande ADCP system configuration data.

Format PS*n*

Range *n* = 0, 3 (see description)

Recommended Setting. Use as needed.

Description See below.

PS0 – System Configuration

PS0 sends the Rio Grande ADCP hardware/firmware information. For example, the output may look like this:

```
>ps0
  Instrument S/N:  101007
       Frequency:  1228800 HZ
   Configuration:  4 BEAM, JANUS
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  DOWN
       Sensor(s):  HEADING  TILT 1  TILT 2  TEMPERATURE
Temp Sens Offset:  -0.17 degrees C

    CPU Firmware:  10.16 [0]
   Boot Code Ver:  Required:  1.13   Actual:  1.13
    DEMOD #1 Ver:  ad48, Type:  1f
    DEMOD #2 Ver:  ad48, Type:  1f
    PWRTIMG  Ver:  85d3, Type:   5

Board Serial Number Data:
   0F  00 00 00 E7 0E F4  09 DSP727-2001-02G
   37  00 00 00 E7 09 46  09 CPU727-2000-00K
   EB  00 00 03 C3 5E F1  09 PIO727-3000-02C
   63  00 00 00 7E 72 2D  09 REC727-1000-02E
>
```

PS3 – Instrument Transformation Matrix

PS3 sends information about the transducer beams. The Rio Grande ADCP uses this information in its coordinate-transformation calculations; for example, the output may look like this:

```
ps3
Beam Width:   3.7 degrees

Beam     Elevation     Azimuth
  1         -70.14      269.72
  2         -70.10       89.72
  3         -69.99        0.28
  4         -70.01      180.28

Beam Directional Matrix (Down):
  0.3399    0.0017    0.9405    0.2414
 -0.3405   -0.0017    0.9403    0.2410
 -0.0017   -0.3424    0.9396   -0.2411
  0.0017    0.3420    0.9398   -0.2415

Instrument Transformation Matrix (Down):    Q14:
  1.4691   -1.4705    0.0078   -0.0067       24069  -24092     127    -109
 -0.0068    0.0078   -1.4618    1.4606        -111     127  -23950   23930
  0.2663    0.2657    0.2657    0.2661        4363    4354    4353    4359
  1.0367    1.0350   -1.0359   -1.0374       16985   16957  -16972  -16996
Beam Angle Corrections Are Loaded.
>
```

If the Rio Grande ADCP needs beam angle corrections, a TRDI calibrated beam angle matrix is loaded into the instrument. This is done when the instrument is manufactured. For more details, request a copy of the ADCP Coordinate Transformation booklet (available for download at www.rdinstruments.com).

PT - Built-In Tests

Purpose	Sends/displays results of ADCP system diagnostic test.
Format	PT*nnn*
Range	*nnn* = 0 to 200 (PT0 = Help menu)

Recommended Setting. Use as needed.

Description These diagnostic tests check the major ADCP modules and signal paths. Most of the tests give their final results in the format;

```
xxxxxxxxxx TEST RESULTS = $hhhh ... rrrr
```

Where

xxxxxxxxxx	= Module or path being tested
$hhhh	= Hexadecimal result code ($0 = PASS; see individual tests for description of bit results)
rrrr	= Overall test result (“PASS” or “FAIL”)

PT Test Results Error Codes

To find what bits are set when an error occurs, use the following tables.

Table 32. Error Code Hex to Binary Conversion

Hex Digit	Binary	Hex Digit	Binary
0	0000	8	1000
1	0001	9	1001
2	0010	A	1010
3	0011	B	1011
4	0100	C	1100
5	0101	D	1101
6	0110	E	1110
7	0111	F	1111

To convert error code $32CF (note: the dollar sign "$" signifies hexi-decimal), convert 32CF to binary. Error code $32CF has the following bits set: 13, 12, 9, 7, 6, 3, 2, 1, 0.

Hex Digit $	3				2				C				F			
Binary	0	0	**1**	**1**	0	0	**1**	0	**1**	**1**	0	0	**1**	**1**	**1**	**1**
Bit #	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

PT0 - Help

Displays the test menu (shown below). As implied by the NOTE, adding 100 to the test number repeats the test continually until the ADCP receives a <BREAK>. Sending PT200 runs all tests. PT300 runs all tests continually until the ADCP receives a <BREAK>.

```
>PT0
Built In Tests
----------------
PT0 = Help
PT1 = NA
PT2 = Ancillary System Data
PT3 = Receive Path
PT4 = Transmit Path
PT5 = Electronics Wrap Around
PT6 = Receive Bandwidth
PT7 = RSSI Bandwidth
NOTE: Add 100 for automatic test repeat
PT200 = All tests
```

PT2 - Ancillary System Data

This test displays the values for ambient and attitude temperature and the contamination sensor (TRDI use only). The ambient temperature is measured on the receiver board. This sensor is imbedded in the transducer head, and is used for water temperature reading. The attitude temperature is measured on the PIO board under the compass. If one of the sensors fails, the PC2 test will show both sensors at the same value. The ADCP will use the attitude temperature if the ambient temperature sensor fails. A reading ≥+55° may indicate a shorted sensor, and a reading ≥-32° may indicate an open sensor.

```
>PT2
  Ambient  Temperature =    21.10 Degrees C
  Attitude Temperature =    21.39 Degrees C
  Internal Moisture    = 8D50h
```

PT3 - Receive Path

This test displays receive path characteristics. The test result is given as eight nibbles (1 nibble = 4 bits). Each nibble represents the result for a particular beam (most significant nibble = beam 1, least significant nibble = beam 8) (four beam ADCPs utilize the four most significant nibbles). In this example, we only describe which bit is set for beam 2 for a given failure type. This test has three parts.

- Part 1 - The ADCP pings without transmitting and displays the result of an autocorrelation function performed over 14 lag periods (only the first 8 are displayed). Ideally, we should see high correlation at near-zero lags, and then see decorrelation as the lags get longer. High correlation values at longer lags indicate interference is present.
- Part 2 - The ADCP compares the RSSI value at high gain versus low gain. These values give the noise floor for RSSI. A high noise floor indicates possible interference or a hardware problem. A low difference between high and low RSSI values can indicate a problem in the demodulator, receiver, or RSSI switching circuitry.
- Part 3 - The ADCP displays the demodulator DAC values.

```
>PT3

Correlation Magnitude: Wide Bandwidth

               Lag  Bm1  Bm2  Bm3  Bm4
                 0  255  255  255  255
                 1  169  175  167  179
                 2   49   55   54   58
                 3   26   20   19    8
                 4   20   17   24   29
                 5   14   13   14   23
                 6    8    4   13    8
                 7    6    1   10    1

  High Gain RSSI:    43   41   40   42
   Low Gain RSSI:    19   19   17   18

  SIN Duty Cycle:    52   50   52   51
  COS Duty Cycle:    49   50   51   51

Receive Test Results = $0000 .... PASS
```

PT3 failure description - You can determine beam failure results ($>0, see **Error! Reference source not found.**) by the individual bit settings:

Table 33: PT3 Failure

Bit #	PT3 Failure Description
0	Low Correlation – Correlation at lag 1 is <70% (130 counts).
1	High Correlation - A correlation at lag 7 or above is >63 counts.
2	High Noise Floor - Noise floor for high gain is >59.
3	Low Differential Gain – Noise floor difference between high and low gains is less than 5 dB (10 counts).

A functional ADCP may fail high correlation or high noise floor when this test is run in air due to interference. This test should be run in the deployed environment to achieve good results.

PT4 - Transmit Path

This test displays transmit path characteristics. During the test, the ADCP pings and measures the resulting transmit current and voltage. For example:

```
>PT4
IXMT    =      2.0 Amps rms
VXMT    =     74.0 Volts rms
   Z    =     37.6 Ohms
Transmit Test Results = $0 ... PASS
```

The ADCP should be in water during this test to get valid test results.

PT4 failure description - You can determine failure results ($>0 see PT Test Results Error Codes) by the individual bit settings:

Table 34: PT4 Failure

Bit #	PT4 Failure Description
0	ADC TIMEOUT ERROR - The DSP Board ADC was not ready for reading when the CPU was ready to read the ADC.
1	TRANSMIT TIMEOUT - The DSP Board never indicated completion of transmission.
2	SAMPLE TIMEOUT - The DSP Board never indicated completion of sampling.
3	LCA REGISTERS CORRUPTED - The DSP Board timing registers lost their value after pinging.
4	OVER-CURRENT SHUTDOWN
5	OVER-TEMPERATURE SHUTDOWN
6	INCORRECT TRANSDUCER IMPEDANCE - Impedance (Vxmt / Ixmt) was too high (>200Ω) or too low (<20Ω).
7	LOW TRANSMIT VOLTS AND/OR CURRENT - Transmit voltage was too low (Vxmt <10V) and/or transmit current too low (Ixmt <0.1A).

Transducer should be in water when running this test.

The test failure example shown below is what you would see for a missing or improperly attached transmit cable (see the Troubleshooting section).

```
>pt4

IXMT    =      0.0 Amps rms  [Data= 0h]
VXMT    =     19.3 Volts rms [Data=4ch]
   Z    =    999.9 Ohms
Transmit Test Results = $C0 ... FAIL
>
```

PT5 - Electronics Wrap Around

This test sets up the ADCP in a test configuration in which the test output lines from the DSP Board timing generator are routed directly to the Receiver board. The receiver then processes this signal. The test output signal sends a certain correlation pattern when processed. The ideal pattern is as follows.

```
  0   0   0   0
  0   0   0   0
  0   0   0   0
  0   0   0   0
255 255 255 255
  0   0   0   0
  0   0   0   0
255 255 255 255
  0   0   0   0
  0   0   0   0
  0   0   0   0
255 255 255 255
```

Acceptable deviations from this pattern are due to deviations in sampling bandwidth and demodulator low-pass filter bandwidth variations. For example:

```
>PT5
13  13  13  13
13  13  13  13
13  13  13  13
0   0   0   0
255 255 255 255
13  13  13  13
0   0   0   0
255 255 255 255
13  13  13  13
13  13  13  13
0   0   0   0
255 255 255 255
Electronics Test Results = $0000
```

PT5 results description - Test failures indicate possible problems with the Receiver or DSP boards. You can determine failure results ($>0 see PT Test Results Error Codes) by the individual bit settings:

Table 35: PT5 Results

Bit #	PT5 Results Description
28	BEAM 1 STATUS - A high value (normally 255) was <254, or a low value (normally 0) was >20.
24	BEAM 2 STATUS - See Bit 28.
20	BEAM 3 STATUS - See Bit 28.
16	BEAM 4 STATUS - See Bit 28.
12	BEAM 5 STATUS - See Bit 28.
ALL	RECEIVER TIMEOUT – The CPU never received a “processing done” signal from the receiver.

PT6 - Receive Bandwidth

This test measure the receive bandwidth of the system. The bandwidth varies with system frequency and the WB command setting.

```
>PT6
Receive Bandwidth:
    Sample       bw     bw     bw     bw     bw
      rate   expect    Bm1    Bm2    Bm3    Bm4
       307      120     91     93     88     88 Khz
   results            PASS   PASS   PASS   PASS
```

The ADCP should be in water during this test to get valid test results.

Table 36: PT6 Receive Bandwidth Nominal Values

Bandwidth setting	WB command	150 kHz	300 kHz	600 kHz	1200 kHz
Broad	0	45	79	200	316
Narrow	1	12	14	40	112

Beam fails if <50% or >125% of nominal value.

PT7 - RSSI Bandwidth

This test checks the RSSI filter circuits are working. Values listed are the indicated RSSI sampled at 1-ms intervals after a "listen" ping.

```
>PT7
RSSI Time Constant:

RSSI Filter Strobe 1 =   38400 Hz
  time   Bm1   Bm2   Bm3   Bm4
  msec  cnts  cnts  cnts  cnts
     1     6     6     7     8
     2    11    12    14    15
     3    15    16    19    20
     4    20    21    23    25
     5    23    24    27    28
     6    26    27    30    31
     7    28    29    32    33
     8    30    31    34    35
     9    32    33    36    37
    10    34    35    37    38
   nom    43    43    42    43

result    PASS  PASS  PASS  PASS
>
```

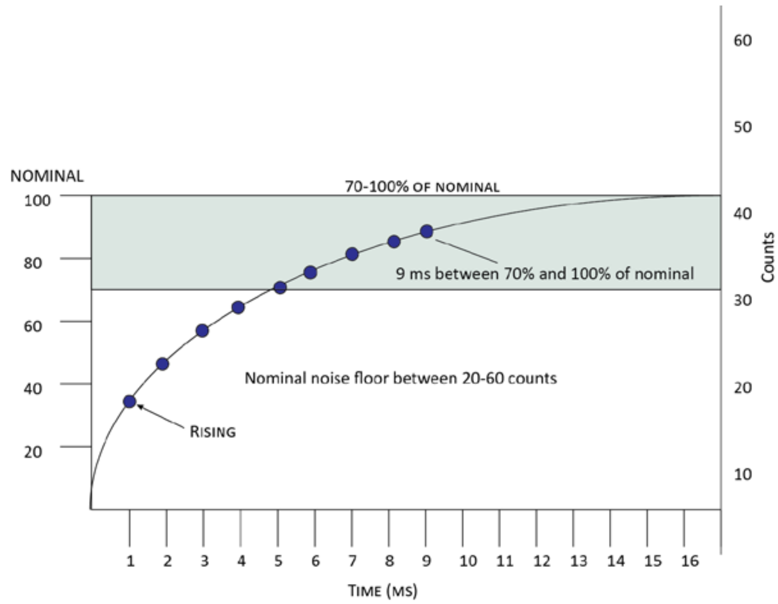


Figure 31. PT7 RSSI Bandwidth Test

Criteria for failure. Any one of the following conditions will flag failure for the beam:

- Nominal noise floor <20 or >60
- Counts for ms 1 through 4 not rising
- 9th ms sample not between 70 and 100% of nominal counts

To verify a RSSI failure, re-run the PT7 test in a different location and change the orientation 180 degrees to determine if any external interference is an issue: Even try running PT7 at a different time of day to eliminate powerful radio transmitters.

The ADCP should be in non-moving water during this test to get valid test results.

Recorder Commands

The following paragraphs list all the Rio Grande ADCP recorder commands. The recorder is set on/off using the CF command. During a deployment, if the recorder card(s) are full, the Rio Grande will stay deployed, but no more data is written to the recorder. Data will not be overwritten.

Not all data formats can be recorded. Carefully review the PD command and the output data format before setting the CF command to set the Serial Output and if the data recorder is on or off.

If the recorder card(s) are full, the Rio Grande cannot be restarted (error message = Recorder full).

Available Recorder Commands

This section lists the available Recorder commands.

```
>r?
Available Commands:

RA ----------------------- Number of Deployments Recorded
RB ----------------------- Recorder Built-In-Test
RE ----------------------- Recorder Erase
RF ----------------------- Recorder Space used/free (bytes)
RN NuNsNVþ ---------------- Set Deployment Name
RR ----------------------- Recorder diRectory
RS ----------------------- Recorder Space used/free (Mb)
RY ----------------------- Upload Recorder Files to Host
R? ----------------------- Display Recorder Commands

>
```

RA - Number of Deployments

Purpose Shows the number of deployments recorded on the internal recorder.

Format RA

Recommended Setting. Use as needed.

Description RA lists the number of deployments recorded on the optional internal recorder.

RB - Recorder Built-In Test

Purpose Tests the recorder.

Format RB

Recommended Setting. Use as needed. The recorder test is included in the PA command.

Description RB tests the recorder RAM, detects the number of memory cards, checks communication, and checks recorder functions using non-destructive methods.

Example See below.

```
>rb?
RECORDER TESTS:
  PC Card #0...............................NOT DETECTED
  PC Card #1...............................DETECTED
    Card Detect............................PASS
    Communication..........................PASS
    DOS Structure..........................PASS
    Sector Test (Short)....................PASS

Recorder tests complete.
```

RE – Erase Recorder

Purpose Erases/initializes recorder memory.

Format RE ErAsE

Description RE ErAsE erases the recorder memory. This command *is* case sensitive.

Recommended Setting. Use as needed.

Example See below.

```
>RE ErAsE
[ERASING...]
```

RF – Recorder Free Space (Bytes)

Purpose Lists the amount of used and free recorder space in bytes.

Format RF

Description RF lists the amount of recorder space used and free in bytes.

Recommended Setting. Use as needed.

Example See below

```
>RF
RF = 0,10407936 -------- REC SPACE USED (BYTES), FREE (BYTES)
```

This shows the Rio Grande ADCP contains a 10-MB recorder.

RN – Set Deployment Name

Purpose Sets the deployment name used for future deployments.

Format RN AAAAA

Default RN _RDI_

Recommended Setting. Use as needed.

Description RN sets the deployment name to be used for any future deployments. The deployment name must be exactly five characters in length, and may contain letters, numbers, or the underscore (i.e. "_") character. If no deployment name is specified, a default of "_ RDI_" is used. The deployment name is used as part of the DOS file name for data files stored on the recorder. For example, the file "_RDI_000.000" would contain data for the first deployment named "_RDI_" (the 000 in the filename indicates the first deployment). The

".000" file extension indicates that this is the first file in the deployment sequence. A ".001" extension will be used if the deployment spills over onto the second PCMCIA card in the recorder. Each PCMCIA card is set up as a separate DOS disk drive with its own DOS file structure. Deployments that are recorded completely on a single PCMCIA device will only have the ".000" file extension.

RR – Show Recorder File Directory

Purpose Lists the files on the recorder in the style of a DOS directory listing.

Format RR

Recommended Setting. Use as needed.

Description RR lists the files stored on the recorder in the form of a DOS directory listing. Each PCMCIA device is listed as a separate drive.

RS - Recorder Free Space (Megabytes)

Purpose Lists the amount of used and free recorder space in megabytes.

Format RS

Recommended Setting. Use as needed.

Description RS lists the amount of recorder space used and free in megabytes.

Example See below

```
>RS
RS = 000,010 -------- REC SPACE USED (MB), FREE (MB)
```

This shows the Rio Grande ADCP contains a 10-MB recorder.

RY – Upload Recorder Files

Purpose Uploads recorder data to a host computer using standard YMODEM protocol.

Format RY

Recommended Setting. Use as needed.

Description RY 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 binary files. This command may be used to recover deployment data without opening the pressure case of the Rio Grande ADCP unit.

Alternatively, the PCMCIA recorder cards may be removed from the unit and placed into a PCMCIA slot in any MS-DOS based computer so equipped. The data files may then be accessed in the same manner as from any other disk drive.

Do not use Windows® to erase the files on the PCMCIA card. Windows® sometimes creates hidden files, which will cause issues for the ADCP at the next deployment. Place the PCMCIA card in the ADCP and use the RE command to erase the card.

Timing Commands

The following commands let you set the timing of various profiling functions.

Available Timing Commands

This section lists the available Timing commands.

```
>t?
TB = 00:00:00.00 --------- Time per Burst (hrs:min:sec.sec/100)
TC = 00000 --------------- Ensembles Per Burst (0-65535)
TE = 00:00:00.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TF = **/**/**,**:**:** --- Time of First Ping (yr/mon/day,hour:min:sec)
TG = ****/**/**,**:**:** - Time of First Ping (CCYY/MM/DD,hh:mm:ss)
TP = 00:00.05 ------------ Time per Ping (min:sec.sec/100)
TS = 07/11/06,08:51:59 --- Time Set (yr/mon/day,hour:min:sec)
TT = 2007/11/06,08:51:59 - Time Set (CCYY/MM/DD,hh:mm:ss)
>
```

Timing Command Descriptions

TB - Time Per Burst

Purpose Sets the interval between "bursts" of pings.

Format TB hh:mm:ss.ff

Range hh = 00 to 23 hours
mm = 00 to 59 minutes
ss = 00 to 59 seconds
ff = 00 to 59 hundredths of seconds

Recommended Setting. Special applications only.

Description The TB and TC commands work together to allow the ADCP to sample in a "burst mode." In some applications, it is desirable for the ADCP to ping for a short period of time at a high ping rate ("burst"), wait for a set period of time, and then repeat the process. You also must set the time per ensemble, time between pings, and number of pings per ensemble.

Example Deployment timing example:

```
TB 01:00:00.00   (time per burst)
TC 20            (ensembles per burst)
TE 00:00:01.00   (time per ensemble)
TP 00:00.20      (time between pings)
WP 2             (pings per ensemble)
```

The ADCP will average two pings (WP-command) 0.2 seconds apart (TP-command). It then sends the ensemble to the recorder or through the I/O cable. This process is repeated once a second (TE-command) for a total of twenty ensembles (TC-command). After the 20th ensemble is processed, the ADCP sleeps for one hour (TB-command) from the time of the first ping of the first ensemble until the second burst begins.

TC - Ensemble per Burst

Purpose Sets the number of ensembles per burst.

Format TC*nnnnn*

Range 0 to 65535 ensembles per burst

Default TC0

Recommended Setting. Special applications only.

Description Setting TC to zero disables the burst mode (i.e., TB-command inactive). See the TB-command for details on how these two commands interact.

TE – Time Per Ensemble

Purpose Sets the minimum interval between data collection cycles (data ensembles).

Format TEhh:mm:ss.ff

Range
hh = 00 to 23 hours
mm = 00 to 59 minutes
ss = 00 to 59 seconds
ff = 00 to 99 hundredths of seconds

Default TE00:00:00.00

Recommended Setting. Set using *WinRiver II* and *SxS Pro*.

Description During the ensemble interval set by TE, the Rio Grande ADCP transmits the number of pings set by the WP-command. If TE = 00:00:00.00, the Rio Grande ADCP starts collecting the next ensemble immediately after processing the previous ensemble.

Example TE01:15:30.00 tells the Rio Grande ADCP to collect data ensembles every 1 hour, 15 minutes, 30 seconds.

1. The Rio Grande ADCP 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 Rio Grande ADCP wakes up to start data collection.

Format TF*yy/mm/dd, hh:mm:ss*

Range
yy = year 00-99
mm = month 01-12
dd = day 01-31 (leap years are accounted for)
hh = hour 00-23
mm = minute 00-59
ss = second 00-59

Recommended Setting. Use as needed.

Description TF delays the start of data collection. This lets you deploy the Rio Grande ADCP in the Standby mode and have it automatically start data collection at a preset time (typically used in battery operated instruments). When the command is given to the Rio Grande ADCP to start pinging, TF is tested for validity. If valid, the Rio Grande ADCP sets its alarm clock to TF, goes to sleep, and waits until time TF before beginning the data collection process.

Example To make the exact time of the first ping to be on November 23, 2013 at 1:37:15 pm, enter TF13/11/23, 13:37:15. Do not enter a TF command value if the Rio Grande ADCP is to begin pinging immediately after receiving the CS command (see notes).

1. Although sending a TF command to the Rio Grande ADCP sets the time to start pinging, the CS command must also be sent before deploying the Rio Grande ADCP.
2. If the entry is not valid, the Rio Grande ADCP sends an error message and does not update the wake-up time.
3. Sending a <BREAK> clears the TF time.

TG – Time of First Ping (Y2k Compliant)

Purpose Sets the time the Rio Grande ADCP wakes up to start data collection.

Format TG*ccyy/mm/dd, hh:mm:ss*

Range
cc = century 19 - 20
yy = year 00 - 99
mm = month 01 - 12
dd = day 01 - 31 (leap years are accounted for)
hh = hour 00 - 23
mm = minute 00 - 59
ss = second 00 – 59

Recommended Setting. Set using *WinSC*.

Description TG delays the start of data collection. This lets you deploy the Rio Grande ADCP in the Standby mode and have it automatically start data collection at a preset time (typically used in battery operated instruments). When the command is given to the Rio Grande ADCP to start pinging, TG is tested for validity. If valid, the Rio Grande ADCP sets its alarm clock to TG, goes to sleep, and waits until time TG before beginning the data collection process.

Example If you want the exact time of the first ping to be on November 23, 2013 at 1:37:15 pm, enter TG 2013/11/23, 13:37:15. Do not enter a TG command value if the Rio Grande ADCP is to begin pinging immediately after receiving the CS command (see notes).

1. Although sending a TG command to the Rio Grande ADCP sets the time to start pinging, the CS command must also be sent before deploying the Rio Grande ADCP.
2. If the entry is not valid, the Rio Grande ADCP sends an error message and does not update the wake-up time.
3. Sending a <BREAK> clears the TG time.

TP – Time Between Pings

Purpose	Sets the *minimum* time between pings.
Format	TP*mm:ss.ff*
Range	*mm* = 00 to 59 minutes *ss* = 00 to 59 seconds *ff* = 00 to 99 hundredths of seconds
Default	TP00:00.05

Recommended Setting. Set using *WinRiver II* and *SxS Pro*.

Description: The Rio Grande ADCP interleaves individual pings within a group so they are evenly spread throughout the ensemble.

During the ensemble interval set by TE, the Rio Grande ADCP transmits the number of pings set by the WP-command. TP determines the spacing between the pings. If TP = 0, the Rio Grande ADCP 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, WN, WS, and actual water depth).

Example: TP00:00.10 sets the time between pings to 0.10 second.

The Rio Grande ADCP automatically increases TE if (WP x TP) > TE.

TS – Set Real-Time Clock

Purpose	Sets the Rio Grande ADCP's internal real-time clock.
Format	TS*yy/mm/dd, hh:mm:ss*
Range	*yy* = year 00-99 *mm* = month 01-12 *dd* = day 01-31 *hh* = hour 00-23 *mm* = minute 00-59 *ss* = second 00-59

Recommended Setting. Set using *BBTalk*, *WinRiver II,* and *SxS Pro*.

Example: TS13/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 2013.

1. When the Rio Grande ADCP 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 Rio Grande ADCP sends an error message and does not update the real-time clock.

TT – Set Real-Time Clock (Y2k Compliant)

Purpose Sets the Rio Grande ADCP's internal real-time clock.

Format TT*ccyy/mm/dd, hh:mm:ss*

Range
cc = century 19 - 20
yy = year 00 - 99
mm = month 01 - 12
dd = day 01 - 31
hh = hour 00 - 23
mm = minute 00 - 59
ss = second 00 - 59

Recommended Setting. Set using *WinRiver II* and *SxS Pro*.

Example TT2013/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 2013.

1. When the Rio Grande ADCP 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 Rio Grande ADCP sends an error message and does not update the real-time clock.

Water Profiling Commands

The following commands define the criteria used to collect the water-profile data.

Standard Water Profiling Commands

This section lists the most often used Water Profiling commands.

```
>w?
WA = 050 ----------------- False Target Threshold (Max) (0-255 counts)
WB = 0 ------------------- Bandwidth Control (0=Wid,1=Nar)
WC = 064 ----------------- Correlation Threshold
WD = 111 100 000 --------- Data Out (Vel;Cor;Amp  PG;St;P0  P1;P2;P3)
WE = 1500 ---------------- Error Velocity Threshold (0-5000 mm/s)
WF = 0025 ---------------- Blank After Transmit (cm)
WI = 0 ------------------- Clip Data Past Bottom (0=OFF,1=ON)
WJ = 1 ------------------- Rcvr Gain Select (0=Low,1=High)
WK = 0000 ---------------- Mode 11,12 Depth Cell Size Override (cm) [0=Use WS]
WL = 000,005 ------------- Water Reference Layer:  Begin Cell (0=OFF), End Cell
WM = 01 ------------------ Profiling Mode (1,5,8,11,12)
WN = 060 ----------------- Number of depth cells (1-255)
WO = 001,004 ------------- Mode 12 Params [subpings(1-100);time(1/100th sec)]
WP = 00001 --------------- Pings per Ensemble (0-16384)
WQ = 0 ------------------- Sample Ambient Sound (0=OFF,1=ON)
WS = 0025 ---------------- Depth Cell Size (cm)
WT = 0000 ---------------- Transmit Length (cm) [0 = Bin Length]
WU = 0 ------------------- Ping Weighting (0=Box,1=Triangle)
WV = 170 ----------------- Mode 1 Ambiguity Vel (cm/s radial)
WW = 004 ----------------- Mode 1 Pings before Mode 4 Re-acquire
WX = 999 ----------------- Mode 4 Ambiguity Vel (cm/s radial)
WY = 0,170 --------------- WM 1: Bandwidth (0=WB, 1=NB), Amb. Vel.(cm/s)
WZ = 005 ----------------- Mode 5 Ambiguity Velocity (cm/s radial)
>
```

WA - False Target Threshold Maximum

Purpose	Sets a false target (fish) filter.
Format	WA*nnn*
Range	*nnn* = 0 to 255 counts (255 disables this filter)
Default	WA050

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

Description The ADCP uses the WA-command to screen water-track data for false targets (usually fish). The first parameter in the WA command sets the maximum difference between echo intensity readings among the four profiling beams. If the WA threshold value is exceeded, the ADCP 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.

WB - Mode 1 Bandwidth Control

Purpose Sets profiling mode 1 bandwidth (sampling rate). Smaller bandwidths allow the ADCP to profile farther, but the standard deviation is increased by as much as 2.5 times.

Format WB*n*

Range *n* = 0 (Wide), 1 (Narrow)

Default WB0

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

Description See table below.

Table 37. Bandwidth Control

Bandwidth	Sample rate	Data variance	Profiling range
0 = Wide (25%)	High	Low	Low
1 = Narrow (6.25%)	Low	High	High

WC - Low Correlation Threshold

Purpose Sets the minimum threshold of water-track data that must meet the correlation criteria.

Format WC*nnn*

Range *nnn* = 0 to 255 counts

Default WC064

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

Description The ADCP 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). WC sets the threshold of the correlation below, which the ADCP 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.

WD – Data Out

Purpose Selects the data types collected by the ADCP.

Format WD *abc def ghi*

Range Firmware switches (see description)

Default WD 111 100 000

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

Description WD uses firmware switches to tell the ADCP the types of data to collect. The ADCP always collects header data, fixed and variable leader data, and checksum data. Setting a bit to one tells the ADCP to collect that data type. The bits are described as follows:

a = Velocity	*d* = Percent good	*g* = Reserved
b = Correlation	e = Status	*h* = Reserved
c = Echo Intensity	*f* = Reserved	*I* = Reserved

Example WD 111 100 000 (default) tells the ADCP to collect velocity, correlation magnitude, echo intensity, and percent-good.

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 ADCP 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.

WE - Error Velocity Threshold

Purpose Sets the maximum error velocity for good water-current data.

Format WE*nnnn*

Range *nnnn* = 0 to 9999 mm/s

Default WE1500

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

The default setting is set purposely high. TRDI recommends 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 ADCP's error velocity value exceeds this threshold, it flags data as bad for a given depth cell. WE screens for error velocities in both beam and transformed-coordinate data. Setting the WE command to zero (WE0) disables error velocity screening.

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*nnnn*

Range *nnnn* = 0 to 9999 cm

Default WF0050 (300 kHz), WF0025 (600 kHz), WF0025 (1200 kHz)

Recommended Setting. Let the *WinRiver II* software set the WF command setting. For example, *WinRiver II* will set the WF command to WF0025 for a 600 kHz system.

Description WF positions the start of the first depth cell at some vertical distance from the transducer head. This allows the Rio Grande ADCP 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. The following table may be used as a guide to set the WF command.

Table 38. WF-command Recommended Setting

Frequency (kHz)	WF Setting
1200	0.44m
600	0.88m
300	1.76m

1. The distance to the middle of depth cell #1 is a function of blank after transmit (WF), depth cell size (WS), 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 Rio Grande ADCP.

WI - Clip Data Past Bottom

Purpose Allows the ADCP to flag velocity data from beyond the bottom as bad.

Format WIn

Range n = 0 (off), 1 (on)

Default WI0

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

Description When the WI-command is set to WI0 (default), the ADCP sends/records all velocity data readings even when the ADCP determines the data is beyond the bottom. WI1 tells the ADCP to flag data determined to be beyond the bottom as bad (data value set to -32768 [8000h]).

WJ - Receiver Gain Select

Purpose Allows the ADCP to reduce receiver gain by 40 dB.

Format WJn

Range n = 0 (low), 1 (high)

Default WJ1

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

Description WJ0 tells the ADCP 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.

WK – Depth Cell Size Override (Mode 11/12 Only)

Purpose Determines the depth cell size for Mode 11 and Mode 12 profiling.

Format WK*x*

Range *x* = 0 to frequency dependent maximum for WS command.

Default WK0000

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

Description The WK command allows a depth cell size that is smaller than the minimum allowed by the WS command. If WK is set to other than zero it overrides the depth cell size selected by the WS command. If WK is set to zero the WS command takes precedence.

This command is only available if the High Rate Ping feature or the High Resolution Water Modes feature is enabled. This command has no effect unless the WM command is set to either 11 or 12.

WL - Water Reference Layer

Purpose Sets depth cell range for water-track reference layer averaging.

Format WLsss,eee

Range sss = Starting depth cell (0 to 128; 0 disables this feature)

eee = Ending depth cell (1 to 128)

Default WL000,005

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

Description You can use the WL-command to lower the effects of transducer motion on present measurements for multiple-ping ensembles (WP > 1). The ADCP does this by averaging the velocities of a column of water and subtracting that average from each of the depth cell velocities. The ADCP accumulates the resulting average velocity and depth cell velocities. At the end on an ensemble, the ADCP adds the average reference velocity back to the normalized depth cell velocities. This results in quieter data for depth cells in which there were few good samples.

WM - Profiling Mode

Purpose Selects the application-dependent profiling mode used by the ADCP.

Format WM*n*

Range *n* = 1, 5, 8, 11, 12 (see description)

Default WM01

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

Description The WM-command lets you select an application-dependent profiling mode. The chosen mode selects the types of pings transmitted. The ping type depends on how much the water-current is changing from ping-to-ping and from cell-to-cell.

Table 39: Water Modes

Mode	Description
WM1	Dynamic Sea State
WM5	Very Low Standard Deviation, used in low flow
WM8	Very Shallow Water, used in low flow
WM11	High Resolution Mode
WM12	High Rate Ping

Water Modes 5, 8, 11, and 12 were designed for 600 and 1200 kHz ADCPs only. Using these modes on other frequency ADCPs may be possible, but only at the user's risk.

Water Mode 12 is a feature upgrade for Rio Grande ADCPs.

For general information on the Water Modes, see the *Principles of Operation: A Practical Primer* and the *WinRiver* II User's Guide. For detailed information on each Water Mode, see the following Field Service Application Notes (FSAs).

FSA-004 – WM1
FSA-005 – WM5 and WM8
FSA-013 – WM11
FSA-014 – WM12

FSAs are available for download at www.rdinstruments.com, Customer Support page.

WN – Number of Depth Cells

Purpose Sets the number of depth cells over which the ADCP collects data.

Format WN*nnn*

Range *nnn* = 1 to 255 depth cells

Default WN060

Recommended Setting. Set using *WinRiver II* and *SxS Pro*.

Description The range of the ADCP is set by the number of depth cells (WN) times the size of each depth cell (WS).

WO – Mode 12 Parameters

Purpose Controls the behavior of Mode 12 water profiling.

Format WO*x*,*y*

Range *x* = 1 to 100 sub-pings

y = 0 to 999 hundredths of seconds

Default WO001,004

Recommended Setting. Special applications only.

Description: The WO command governs the behavior of Mode 12 water profiling. In Mode 12, a number of sub-pings are transmitted very rapidly and their results are averaged internally to form a single Mode 12 ping. The number of sub-pings is determined by the *x* parameter. The *y* parameter sets the time between sub-pings in hundredths of a second.

This command is only available when the High Rate Ping feature is enabled. This command has no effect unless the WM command is set to WM12.

WP – Pings Per Ensemble

Purpose Sets the number of pings to average in each data ensemble.

Format WP*nnnnn*

Range *nnnnn* = 0 to 16384 pings

Default WP00001

Recommended Setting. Set using *WinRiver II* and *SxS Pro*.

Description WP sets the number of pings to average in each ensemble before sending/recording the data.

1. If WP = zero the ADCP does not collect water-profile data.
2. The ADCP automatically extends the ensemble interval (TE) if WP x TP > TE.

WQ - Sample Ambient Sound

Purpose Samples ambient sound.

Format WQn

Range n = 0 (Off), 1 (On)

Default WQ0

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

Description When WQ is set to 1, the ADCP samples RSSI before the water ping. WQ uses an 8-meter blank and 8-meter depth cell before sending water-profiling pings.

WS – Depth Cell Size

Purpose Selects the volume of water for one measurement cell.

Format WS*nnnn*

Range See below

Default See below

	300 kHz	600 kHz	1200 kHz
Range	20 to 1600 cm	10 to 800 cm	5 to 400 cm
Default	WS0100	WS0050	WS0025

Recommended Setting. Set using *WinRiver II* and *SxS Pro*.

Description The ADCP collects data over a variable number of depth cells. WS sets the size of each cell in vertical centimeters.

If you set WS to a value less than its minimum value or greater than its maximum value, the ADCP will accept the entry, but uses the appropriate minimum or maximum value. For example, if you enter WS1 for a 75 kHz system, the ADCP uses a value of 80 cm for WS. Similarly, if you enter WS8000, the ADCP uses a value of 3200 cm for WS.

WT - Transmit Length

Purpose Selects a transmit length different from the depth cell length (cell sampling interval) as set by the WS-command.

Format WT*nnnn*

Range *nnnn* = 0 to 3200 cm

Default WT0000

Recommended Setting. 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).

WU - Ping Weight

Purpose: Selects the weight of each ping in an ensemble.

Format WUn

Range n = 0 (Box weighting), 1 (Triangle weighting)

Default WU0

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

Description The WU command allows the user to choose the ensemble weighting method. WU0 selects Box weighting which is a simple average of the velocities in each ensemble. WU1 selects Triangle weighting, where the first and last velocities are weighted the least, and the middle velocity is weighted the most.

Example For an ensemble of 5 pings, the weights would appear as below.

Table 40: Ping Weights

	Ping 1	Ping 2	Ping 3	Ping 4	Ping 5
WU0	1	1	1	1	1
WU1	1/3	2/3	1	2/3	1/3

The velocity reported for each ensemble is calculated as the sum of the weighted velocities divided by the sum of the weights.

The WL command (Water reference layer) must be turned on when triangle weighting is used (WU1).

WV – Ambiguity Velocity

Purpose Sets the radial ambiguity velocity.

Format WV*nnn*

Range *nnn* = 2 to 700 cm/s

Default WV170

Recommended Setting. As set using the WinRiver II software or as required by the application, but never less than 100 cm/s.

Description The WV command (ambiguity velocity setting) sets the maximum velocity that can be measured along the beam when operating in Water Mode 1 (WM1). 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.

Set WV as low as possible to attain better precision, but not too low or ambiguity errors will occur. The following table may be used as a guide to set the WV command.

Table 41. WV Command Recommended Setting

Maximum apparent velocity relative to ADCP	WV setting
5 m/s	WV175 (minimum in WinRiver II)
6 m/s	WV210
7 m/s	WV245
8 m/s	WV280
9 m/s	WV315
10 m/s	WV350
15 m/s	WV525
20 m/s	WV700

This table does not include any factor of safety against ambiguity errors due to the single-ping standard deviation, vertical velocities, or instrument pitch, roll, or heave. A safety factor ranging between 1.1 and 2.0 is recommended. Larger safety factors should be used with smaller bin sizes, lower WV settings, lower water temperatures, and higher vertical velocity components. Rotation of the instrument such that no beam points in the direction of the maximum relative velocity vector may provide some inherent factor of safety but such rotation cannot normally be assured and should not be relied upon.

Note that the minimum setting of the WV command is WV002 and the maximum setting due to internal processing limitations is limited based on the setting of the bandwidth command, WB.

WV is limited to 330 cm/s in Narrow bandwidth mode (WB1), which increases the profiling range by 10% compared to Broad bandwidth mode (WB0).

When the WB command is set to WB0, the max value is WV700.

In either case, while you can set a value as low as 2 cm/s, this will likely cause ambiguity errors. TRDI recommends setting WV to ≥ 100cm/s for most applications.

WW – Mode 1 Pings before Mode 4 Re-Acquire

Purpose	Sets the number of Mode 1 pings sent before a Mode 4 ping is attempted.
Format	WW*nnn*
Range	*nnn* = 0 to 999 pings
Default	WW4
Description	WW is the number of Mode 1 pings generated by the ADCP before a Mode 4 ping is tried. The ADCP uses this value when Mode 4 is in use and the bottom is lost. If WW=0, the ADCP continually tries to generate Mode 4 pings.

WX - WT Mode 4 Ambiguity Velocity

Purpose	Sets the minimum radial ambiguity velocity for profiling Mode 4 (WM4).
Format	WX*nnn*
Range	*nnn* = 2 to 600 cm/s; 999 = auto-select
Default	WX999

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

Description	Set WX as low as possible to attain maximum performance, but not too low or ambiguity errors will occur. WX999 tells the ADCP to select the best ambiguity velocity for the selected depth cell size (WS).

WY – Mode 1 Bandwidth

Purpose	Sets the profiling Mode 1 bandwidth (sampling rate) and the radial ambiguity velocity.
Format	WY*b*,*aaa*
Range	*b* = 0 (Wide), 1 (Narrow) *aaa* = 2 to 700 cm/s (330 cm/s in Narrow mode)
Default	WY1,170

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

Description	The WY command sets the WB and WV commands using one command. For more information, see WB - Mode 1 Bandwidth Control and WV – Ambiguity Velocity.
Example	Setting the WY command to WY0,175 will set the WB command to WB0 and the WV command to WV175.

WZ - Mode 5 Ambiguity Velocity

Purpose	Sets the minimum radial ambiguity for profiling Mode 5 (WM5), Mode 8 (WM8) and Mode 11 (WM11) Ambiguity Velocity.
Format	WZ*nnn*
Range	*nnn* = 3 to 80 cm/s
Default	WZ010

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

Description	Allows for very high resolution (small bins) with very low standard deviation. The maximum value at which WM5 will work is related to bottom track depth. The larger the WZ value, the shallower the water has to be.

Advanced Commands

The following sections describe the advanced commands available for the Rio Grande ADCP series ADCPs.

Sound Velocity Smart Sensor Commands

The ADCP uses these commands for Sound Velocity Smart Sensor (SVSS) applications.

Available Sound Velocity Smart Sensor Command

```
>d?
Available Commands:

DW  0 -------------------- Current ID on RS-485 Bus
DB 411 ------------------- RS-485 Port Control (Baud; N/U; N/U)
DX ----------------------- Set SVSS to RAW Mode
DY ----------------------- Set SVSS to REAL Mode
DZ ----------------------- Get Single SCAN from SVSS
DS 1495 0 ---------------- Load SpeedOfSound with SVSS Sample (BITResult)
D? ----------------------- Display SVSS Commands

>
```

Sound Velocity Smart Sensor Command Descriptions

DB - RS-485 Port Control

Purpose	Change the communication parameters of the RS-485 bus.
Format	DBxyz
Range	x = 0 to 7 Baud Rate, see CB command. y =l to 5 Unused z =l to 2 Unused
Default	DB411

Recommended Setting. Use as needed.

Description: This command changes the communication parameters of the RS-485 bus. Currently only the Baud Rate is changed, but all parameters are still required. Set the baud rate to match the CB command.

If the DB command is not set to the same baud rate as the CB command, then the Master/Slave triggering is not reliable. When changing the DB command, confirm the change by immediately following the DB change with a CK command (see CK - Keep Parameters).

The DB command is not affected by the CR command once the CK command has been sent (see CR – Retrieve Parameters).

DS - Load SpeedOfSound with SVSS Sample (BIT Result)

Purpose Load the SpeedOfSound variable with a single real scan from the SVSS.

Format DS

Recommended Setting. Use as needed.

Description This command loads the SpeedOfSound variable with a measured value from the SVSS, in a manner similar to the manner the variable is loaded during deployment. The EZ command must be issued prior to this command or the function will be bypassed. Set the EZ command to EZ3xxxxxx. The three enables communication with the SVSS. Upon successful completion of the function call, the SpeedOfSound variable will contain the new value. Any errors in the function will result in the BIT Result = xxxxxlxx xxxxxxxx which is displayed after the value.

DW - Current ID on RS-485 Bus

Purpose Change the device ID sent out before attempting to communicate.

Format DWx

Range x = 0 to 31

Default DW0

Recommended Setting. Use as needed.

Description This command sets the RS-485 Bus ID and sends the ID out onto the bus with the parity forced high. This wakes up the slave device for communications.

DX - Set SVSS to RAW Mode

Purpose Set the SVSS to Raw mode.

Format DX

Recommended Setting. Use as needed.

Description This command sends “RA” out on the RS-485 bus. If the SVSS is listening, it will change its data output mode to RAW. RAW data is columnar un-calibrated counts.

DY - Set SVSS to REAL Mode

Purpose Set the SVSS to Real mode.

Format DY

Recommended Setting. Use as needed.

Description This command sends “RE” out on the RS-485 bus. If the SVSS is listening, it will change its data output mode to REAL. REAL data is in units of m/s and the form XXXX.XX

DZ - Get Single SCAN from SVSS

Purpose This command gets a single scan of data from the SVSS.

Format DZ

Recommended Setting. Use as needed.

Description This command sends “s” out on the RS-485 bus. If the SVSS is listening, it will respond (-23ms later) with one scan of data. The data format will be determined by the last format command (“DX” or “DY”) sent to the SVSS. The data will be echoed back by the ADCP.

Ping Synchronization Commands

The Teledyne RD Instruments Sleepy Sensor Synchronization (TRDS³) protocol allows a Rio Grande ADCP to synchronize measurements with another ADCP or any other instrument that adheres to the RDS³ specification.

Available Ping Synchronization Commands

```
>s?
SA = 001 ----------------- Synch Before/After Ping/Ensemble Bottom/Water/Both
SI = 00000 --------------- Synch Interval (0-65535)
SM = 0 ------------------- Mode Select (0=OFF,1=MASTER,2=SLAVE)
SS = 0 ------------------- RDS3 Sleep Mode (0=No Sleep)
ST = 00000 --------------- Slave Timeout (seconds,0=indefinite)
SW = 00000 --------------- Synch Delay (1/10 msec)
>
```

To see the S commands as listed above, the Experton command must be used (see Expert Mode).

Ping Synchronization Command Descriptions

SA - Synchronize Before/After Ping/Ensemble

Purpose Sets the rough timing of the synchronization pulse.

Format SA*xyz*

Range *x* = 0, 1
y = 0, 1
z = *0, 1, 2*

Default SA001

Recommended Setting. Special applications only.

Description Use the SA command to set the rough timing of the synchronization pulse. The first parameter determines whether the Master (or Slave) will send (or wait for) a synchronization pulse before or after the conditions set in parameters y and z. If the second parameter is set to Ping, the third parameter determines what kind of ping to synchronize on. If parameter y is set to Ensemble, the third parameter is ignored (but must still be entered).

Table 42: Synchronization Parameters

Parameter	Description
SA000	Send (wait for) pulse before a bottom ping.
SA001	Send (wait for) pulse before a water ping.
SA002	Send (wait for) pulse before both pings
SA100	Send (wait for) pulse after a bottom ping.
SA101	Send (wait for) pulse after a water ping.
SA102	Send (wait for) pulse after both pings.
SA01X	Send (wait for) pulse before ensemble.
SA11X	Send (wait for) pulse after ensemble.

This command has no effect unless SM = 1 or 2.

SI - Synchronization Interval

Purpose	Sets how many pings/ensembles to wait before sending the next synchronization pulse.
Format	SI*nnnnn*
Range	*nnnnn* = 0 to 65535
Default	SI0

Recommended Setting. Special applications only.

Description — Use the SI command to set how many pings/ensembles (depending on the SA command) to wait before sending the next synchronization pulse.

This command has no effect unless SM = 1

SM - RDS3 Mode Select

Purpose	Sets the RDS3 Mode.
Format	SM*n*
Range	*n* = 0 (Off), 1 (RDS3 Master), 2 (RDS3 Slave)
Default	SM0

Recommended Setting. Special applications only.

Description — SM sets the RDS3 Mode. SM0 turns off the RDS3 mode and disables all other commands on this menu. SM1 sets the RDS3 Master mode and enables the SA, SI, SS, and SW commands. SM2 sets the RDS3 Slave mode and enables the SA, SS, and ST commands.

When the SM command is used, the communication switch on the ADCP's PIO board must be in the RS-232 position.

SS - RDS3 Sleep Mode

Purpose	Sets the RDS3 Sleep Mode.
Format	SS*x*
Range	*x* = 0, 1 (0 = No Sleep, 1 = Sleep)
Default	SS0

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

Description — This command sets the RDS3 Sleep Mode. When x is set to No Sleep, the instrument remains awake while waiting for the next ping time (or synchronization pulse) in a loop. When x is set to Sleep, the instrument sleeps between pings (or synchronization pulses.) There are limitations to using the Sleep Mode. A TRDI Rio Grande ADCP, setup as a slave, can only synchronize to within 2.5 ms of the Master. When the Slave is in No Sleep Mode, the slave can ping to within 500 microseconds of the master. The benefits of power saving cost are synchronization accuracy.

Table 43: Sleep Mode Parameters

Parameter	Description
SS0	Wait between pings (synchronization pulses) in a loop.
SS1	Wait between pings (synchronization pulses) in a sleep state.

This command has no effect unless SM = 1 or 2

ST - Slave Timeout

Purpose Sets the amount of time a slave will wait to hear a synch pulse before proceeding on its own.

Format ST*n*

Range *n* = 0 to 10800 seconds

Default ST0

Recommended Setting. Special applications only.

Description ST sets the amount of time a slave will wait to hear a synch pulse before proceeding on its own. If a slave times out, it will automatically ping according to the CF, TP, TE, WP, and BP command settings. This is a fail-safe mechanism designed to allow the slave to proceed on its own should communications with the master ADCP fail. Setting ST = 0 tells the slave to wait indefinitely.

This command has no effect unless SM = 2

SW - Synchronization Delay

Purpose Sets the amount of time to wait after sending the pulse.

Format SW*n*

Range *n* = 0 to 65535 (units of 0.1 milliseconds)

Default SW00075

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

Description Use the SW command to set the amount of time to wait after sending the pulse before proceeding. For example, setting the SW command to SW20000 will add a delay of 2 seconds. This allows precise timing of measurements.

When a Master attempts to ping a slave ADCP, it sends out a pulse to the slave ADCP. The slave ADCP has a different code path than the Master ADCP and thus, they will take different amounts of time to start the ping. By adding in the default Master Delay of 7.5 ms, the code paths are evened up to allow the units to start the pings at about the same time (typically within 100 microseconds of each other).

This command has no effect unless SM = 1 or 3

Example Master/Slave Setup

To set the Master/Slave:

1. Connect the master and slave ADCPs to two PC comports via a master/slave cable.
2. Apply power to the ADCPs.
3. Establish RS-232 communications between *BBTalk* and the master and slave ADCPs.
4. Set both the master and slave ADCP to the same baud rate (see Note 1).
5. Send a BREAK to the master ADCP.
6. Verify that the master ADCP outputs the RS-232 banner (see Note 2).
7. Send a CR1 and CK command to the master ADCP.
8. Send a BREAK to the slave ADCP.
9. Verify that the slave ADCP outputs the RS-232 banner.
10. Send a CR1 and CK to the slave ADCP.
11. Send the configuration commands to the master ADCP, omitting the CS command to start sampling.
12. Send the configuration commands to the slave ADCP including the CS command to start sampling.
13. Now send the CS command to the master ADCP.

    The master samples, and triggers the slave, which samples. This continues until the power is not available, or the user or some other force intervenes.

To terminate data collection:

1. Send a BREAK to the master ADCP (see note 2).
2. Verify that the master ADCP outputs the RS-232 banner (see note 2).
3. Send a CZ command to the master ADCP.
4. Send a BREAK to the slave ADCP.
5. Verify that the slave ADCP outputs the RS-232 banner (see note 2).
6. Send the CZ command to the slave ADCP.

1. The master and slave ADCP must use the same baud rate. Baud rate options depend on whether the master and slave ADCP are allowed to go to low power mode between samples. When the master and slave cannot go to low power mode between samples, the user can select all baud rates less than 115200 (i.e. one can use 1200, 2400, 4800, 9600, 19200, 38400, or 57600 baud).

When the master and slave ADCP can go to low power mode between samples, the user can select 1200, 2400, 4800, or 9600 baud.

2. The master slave cable connects the units via an RS-485 bus so the master ADCP can trigger the slave ADCP to sample. The RS-485 bus can alternately be used for RS-422 communications. However, during initialization, when the master ADCP receives a BREAK and outputs the wakeup banner, it also may cause the slave ADCP to output an incomplete banner. When this occurs, send additional BREAKs to the master ADCP until the slave ADCP outputs a full RS-422 banner.

Example Wakeup Banners

RS-232 Banner

```
[BREAK Wakeup A]
WorkHorse Rio Grande Broadband ADCP Version 10.16
Teledyne RD Instruments (c) 1996-2007
All Rights Reserved.
>
```

RS-422 Banner

```
[BREAK Wakeup B]
WorkHorse Rio Grande Broadband ADCP Version 10.16
Teledyne RD Instruments (c) 1996-2007
All Rights Reserved.
>
```

Incomplete Banner

```
[BR
```

Chapter 10

OUTPUT DATA FORMAT

In this chapter:

Choosing a Data Format

The Rio Grande ADCP 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 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, ADCP setup, orientation, heading, pitch, roll, temperature, pressure, and self-test diagnostic results. Data fields to be output are user selectable.
- **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.

Table 44: Summary of Output Data Formats

	PD0	PD3	PD4	PD5	PD6
System Info	☑		☑	☑	
Temperature	☑	☑	☑	☑	☑
Depth	☑			☑	☑
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				☑	
Binary	☑	☑	☑	☑	
ASCII					☑
Serial Output	☑	☑	☑	☑	☑
Recorded on PC Card	PD0	None	PD4	PD5	None

*SOG = Speed Over Ground
*STW = Speed Through Water

PD0 Output Data Format

The following description is for the standard PD0 Rio Grande ADCP output data format. Figure 38 through Figure 45 shows the ASCII and binary data formats for the Rio Grande ADCP PD0 mode. Table 46 through Table 56 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 8000h. This distinction is based on the dynamic; other distinctions are present such as velocity types such as data type of leader ID 0001h which groups all the Water Profile Velocity data and leader ID 0006h stores all Bottom Track Velocity data. The Rio Grande ADCP sends all the data for a given type for all depth cells and all beams before the next data type begins.

The advantage of using the leader ID is that one can simply scan for them as the binary data is received in real time on the serial lines and then use the output data format description table to jump directly to the desired data. 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. This gives the choice between jumping down to the data type using the offsets or detecting the data type ID after detecting the header ID.

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 (BP0), then there will be no Bottom track data type in the ensemble. The table below shows which data types are always output against command dependable data types:

ALWAYS OUTPUT	**HEADER** (6 BYTES + [2 x No. OF DATA TYPES])
	FIXED LEADER DATA (59 BYTES)
	VARIABLE LEADER DATA (65 BYTES)
WD command WP command	**VELOCITY** (2 BYTES + 8 BYTES PER DEPTH CELL)
	CORRELATION MAGNITUDE (2 BYTES + 4 BYTES PER DEPTH CELL)
	ECHO INTENSITY (2 BYTES + 4 BYTES PER DEPTH CELL)
	PERCENT GOOD (2 BYTES + 4 BYTES PER DEPTH CELL)
	STATUS (2 BYTES + 4 BYTES PER DEPTH CELL)
BP command	**BOTTOM TRACK DATA** (85 BYTES)
ALWAYS OUTPUT	**RESERVED** (2 BYTES)
	CHECKSUM (2 BYTES)

Figure 32. PD0 Standard Output Data Buffer Format

Some data outputs are in bytes per depth cell. For example, if the WN-command (number of depth cells) = 30 (default), WD command = WD 111 100 000 (default), WP command > 0, BP command > 0, the required data buffer storage space is 841 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])
   59  BYTES OF FIXED LEADER DATA (FIXED)
   65  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)
   85  BYTES OF BOTTOM TRACK DATA (FIXED)
    2  BYTES OF RESERVED FOR TRDI USE (FIXED)
    2  BYTES OF CHECKSUM DATA (FIXED)
-----------------------------------------------------------------
  841  BYTES OF DATA PER ENSEMBLE
```

WinRiver II may add additional bytes.

For example, *WinRiver II* does not add any bytes to the Bottom Track data, but does insert data in place of other bytes. The Navigation NMEA strings (up to 275 bytes) are stored in the *r.000 raw data between the Bottom Track data and the Reserved/Checksum data. *WinRiver II* output data format is described in the *WinRiver II* User's Guide.

Header Data Format

BYTE	BIT POSITIONS 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 46 for a description of the fields.

Figure 33. Header Data Format

Header information is the first item sent by the ADCP to the output buffer. The Rio Grande ADCP always sends the Least Significant Byte (LSB) first.

Table 45: 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 Rio Grande ADCP).
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 45).
9,10	5	Spare	Undefined.
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 Rio Grande ADCP 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 Rio Grande ADCP 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 Rio Grande ADCP 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

BYTE	BIT POSITIONS 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 {WN}								
11	PINGS PER ENSEMBLE {WP}								LSB
12									MSB
13	DEPTH CELL LENGTH {WS}								LSB
14									MSB
15	BLANK AFTER TRANSMIT {WF}								LSB
16									MSB
17	PROFILING MODE {WM}								
18	LOW CORR THRESH {WC}								
19	NO. CODE REPS								
20	%GD MINIMUM {WG}								
21	ERROR VELOCITY MAXIMUM {WE}								LSB
22									MSB
23	TPP MINUTES								
24	TPP SECONDS								
25	TPP HUNDREDTHS {TP}								
26	COORDINATE TRANSFORM {EX}								
27	HEADING ALIGNMENT {EA}								LSB
28									MSB
29	HEADING BIAS {EB}								LSB
30									MSB
31	SENSOR SOURCE {EZ}								
32	SENSORS AVAILABLE								
33	BIN 1 DISTANCE								
34									
35	XMIT PULSE LENGTH BASED ON {WT}								LSB
36									MSB

BYTE	7	6	5	4	3	2	1	0	
37	(starting cell) WP REF LAYER AVERAGE {WL} (ending cell)								LSB
38									MSB
39	FALSE TARGET THRESH {WA}								
40	SPARE								
41	TRANSMIT LAG DISTANCE								LSB
42									MSB
43	CPU BOARD SERIAL NUMBER								LSB
↓									↓
50									MSB
51	SYSTEM BANDWIDTH {WB}								LSB
52									MSB
53	SYSTEM POWER {CQ}								
54	SPARE								
55	INSTRUMENT SERIAL NUMBER								
↓									
58									
59	BEAM ANGLE								

See Table 47 for a description of the fields

Figure 34. Fixed Leader Data Format

Fixed Leader data refers to the non-dynamic Rio Grande ADCP data that only changes when you change certain commands. Fixed Leader data also contain hardware information. The Rio Grande ADCP always sends Fixed Leader data as output data (LSBs first).

Table 46: 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	This field defines the Rio Grande ADCP hardware configuration. Convert this field (2 bytes, LSB first) to binary and interpret as follows. 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 CFIG DEMOD) 1 1 1 1 - - - - 5-BM JANUS CFIG.(2 DEMD) 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).
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. This is varied, and therefore of interest in, at a minimum, for the WM5, WM8 and WM11 and BM7 commands.
17,18	9	#Bm / Number of Beams	Contains the number of beams used to calculate velocity data (not physical beams). The Rio Grande ADCP 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 Rio Grande ADCP does not make this validity check. Table 52 (Percent-Good Data Format) has more information.
19,20	10	WN / Number of Cells	Contains the number of depth cells over which the Rio Grande ADCP collects data (WN command). 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 command). If WP = 0, the Rio Grande ADCP does not collect the WD water-profile data. Note: The Rio Grande ADCP 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 = 0 to 16,384 pings
25-28	13,14	WS / Depth Cell Length	Contains the length of one depth cell (WS command). Scaling: LSD = 1 centimeter; Range = 1 to 6400 cm (210 feet)

Table 46: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
29-32	15,16	WF / Blank after Transmit	Contains the blanking distance used by the Rio Grande ADCP to allow the transmit circuits time to recover before the receive cycle begins (WF command). 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 command). 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	WG / %Gd 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 Rio Grande ADCP flags all four beams of the affected bin as bad. Scaling: LSD = 1 mm/s; Range = 0 to 5000 mm/s
45,46 47,48 49,50	23 24 25	Minutes Seconds Hundredths	These fields, set by the TP command, contain the amount of time between ping groups in the ensemble. NOTE: The Rio Grande ADCP automatically extends the ensemble interval (set by TE) if (WP x TP > TE).
51,52	26	EX / Coord Transform	Contains the coordinate transformation processing parameters (EX command). These firmware switches indicate how the Rio Grande ADCP collected data. 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
53-56	27,28	EA / Heading Alignment	Contains a correction factor for physical heading misalignment (EA command). Scaling: LSD = 0.01 degree; Range = -179.99 to 180.00 degrees
57-60	29,30	EB / Heading Bias	Contains a correction factor for electrical/magnetic heading bias (EB command). Scaling: LSD = 0.01 degree; Range = -179.99 to 180.00 degrees

Table 46: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description

61,62	31	EZ / Sensor Source	Contains the selected source of environmental sensor data (EZ command). These firmware switches indicate the following.
			`FIELD        DESCRIPTION`
			`x1xxxxxx = CALCULATES EC (SPEED OF SOUND) FROM ED, ES, AND ET`
			`xx1xxxxx = USES ED FROM DEPTH SENSOR`
			`xxx1xxxx = USES EH FROM TRANSDUCER HEADING SENSOR`
			`xxxx1xxx = USES EP FROM TRANSDUCER PITCH SENSOR`
			`xxxxx1xx = USES ER FROM TRANSDUCER ROLL SENSOR`
			`xxxxxx1x = USES ES (SALINITY) FROM CONDUCTIVITY SENSOR`
			`xxxxxxx1 = USES ET FROM TRANSDUCER TEMPERATURE SENSOR`
			NOTE: If the field = 0, or if the sensor is not available, the Rio Grande ADCP uses the manual command setting. If the field = 1, the Rio Grande ADCP uses the reading from the internal sensor or an external synchro sensor (only applicable to heading, roll, and pitch). Although you can enter a "2" in the EZ command string, the Rio Grande ADCP only displays a 0 (manual) or 1 (int/ext sensor).

63,64	32	Sensor Avail	This field reflects which sensors are available. The bit pattern is the same as listed for the EZ command (above).
65-68	33,34	dis1 / Bin 1 distance	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. Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm (2150 feet)
69-72	35,36	WT Xmit pulse length	This field, set by the WT command, contains the length of the transmit pulse. When the Rio Grande ADCP receives a <BREAK> signal, it sets the transmit pulse length as close as possible to the depth cell length (WS command). This means the Rio Grande ADCP uses a WT command of zero. However, the WT field 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	WL / WP Ref Lyr Avg (Starting cell, Ending cell)	Contains the starting depth cell (LSB, byte 37) and the ending depth cell (MSB, byte 38) used for water reference layer averaging (WL command). Scaling: LSD = 1 depth cell; Range = 1 to 128 depth cells
77,78	39	WA / False Target Threshold	Contains the threshold value used to reject data received from a false target, usually fish (WA command). Scaling: LSD = 1 count; Range = 0 to 255 counts (255 disables)
79,80	40	Spare	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	CPU Board Serial Number	Contains the serial number of the CPU board.
101-104	51-52	WB / System Bandwidth	Contains the WB command setting. Range = 0 to 1
105-106	53	System Power	Contains the CQ command setting for Monitor/Sentinel/Long Ranger ADCPs. Range 0 to 255.
107-108	54	Spare	Spare
109-116	55-58	Serial #	Instrument serial number
117 -118	59	Beam Angle	Beam angle

Variable Leader Data Format

BYTE	7	6	5	4	3	2	1	0	
	BIT POSITIONS								
1	VARIABLE LEADER ID								80h
2									00h
3	ENSEMBLE NUMBER								LSB
4									MSB
5	RTC YEAR {TS}								
6	RTC MONTH {TS}								
7	RTC DAY {TS}								
8	RTC HOUR {TS}								
9	RTC MINUTE {TS}								
10	RTC SECOND {TS}								
11	RTC HUNDREDTHS {TS}								
12	ENSEMBLE # MSB								
13	BIT RESULT								LSB
14									MSB
15	SPEED OF SOUND {EC}								LSB
16									MSB
17	DEPTH OF TRANSDUCER {ED}								LSB
18									MSB
19	HEADING {EH}								LSB
20									MSB
21	PITCH (TILT 1) {EP}								LSB
22									MSB
23	ROLL (TILT 2) {ER}								LSB
24									MSB
25	SALINITY {ES}								LSB
26									MSB
27	TEMPERATURE {ET}								LSB
28									MSB
29	MPT MINUTES								
30	MPT SECONDS								
31	MPT HUNDREDTHS								
32	HDG STD DEV								
33	PITCH STD DEV								
34	ROLL STD DEV								

BYTE	BIT POSITIONS 7	6	5	4	3	2	1	0	
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) {CY}								LSB
44									
45									
46									MSB
47	SPARE								
48									
49	PRESSURE								LSB
50									
51									
52									MSB
53	PRESSURE SENSOR VARIANCE								LSB
54									
55									
56									MSB
57	SPARE								
58	RTC CENTURY								
59	RTC YEAR								
60	RTC MONTH								
61	RTC DAY								
62	RTC HOUR								
63	RTC MINUTE								
64	RTC SECOND								
65	RTC HUNDREDTH								

See Table 48 for a description of the fields.

Figure 35. Variable Leader Data Format

Variable Leader data refers to the dynamic Rio Grande ADCP data (from clocks/sensors) that change with each ping. The Rio Grande ADCP always sends Variable Leader data as output data (LSBs first).

Table 47: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	VID / Variable Leader ID	Stores the Variable Leader identification word (80 00h).

5-8	3,4	Ens / Ensemble Number	This field contains the sequential number of the ensemble to which the data in the output buffer apply.
			Scaling: LSD = 1 ensemble; Range = 1 to 65,535 ensembles
			NOTE: The first ensemble collected is #1. At "rollover," we have the following sequence:
			`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.`

9,10	5	RTC Year	These fields contain the time from the Rio Grande ADCP's real-time clock (RTC) that the current data ensemble began. The TS command (Set Real-Time Clock) initially sets the clock. The Rio Grande ADCP does 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.

25-28	13,14	BIT / BIT Result	This field contains the results of the Rio Grande ADCP's Built-in Test function. A zero code indicates a successful BIT result.
			`BYTE 13 BYTE 14 (BYTE 14 RESERVED FOR FUTURE USE)`
			`1xxxxxxx xxxxxxxx = RESERVED`
			`x1xxxxxx xxxxxxxx = RESERVED`
			`xx1xxxxx xxxxxxxx = RESERVED`
			`xxx1xxxx xxxxxxxx = DEMOD 1 ERROR`
			`xxxx1xxx xxxxxxxx = DEMOD 0 ERROR`
			`xxxxx1xx xxxxxxxx = RESERVED`
			`xxxxxx1x xxxxxxxx = TIMING CARD ERROR`
			`xxxxxxx1 xxxxxxxx = RESERVED`

29-32	15,16	EC / Speed of Sound	Contains either manual or calculated speed of sound information (EC command). Scaling: LSD = 1 meter per second; Range = 1400 to 1600 m/s
33-36	17,18	ED / Depth of Transduc-er	Contains the depth of the transducer below the water surface (ED command). This value may be a manual setting or a reading from a depth sensor. Scaling: LSD = 1 decimeter; Range = 1 to 65535 decimeters
37-40	19,20	EH / Heading	Contains the Rio Grande ADCP heading angle (EH command). 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
41-44	21,22	EP / Pitch (Tilt 1)	Contains the Rio Grande ADCP pitch angle (EP command). 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
45-48	23,24	ER / Roll (Tilt 2)	Contains the Rio Grande ADCP roll angle (ER command). This value may be a manu-al setting or a reading from a tilt sensor. For up-facing Rio Grande ADCPs, positive values mean that Beam #2 is spatially higher than Beam #1. For down-facing Rio Grande ADCPs, positive values mean that Beam #1 is spatially higher than Beam #2. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
49-52	25,26	ES / Salinity	Contains the salinity value of the water at the transducer head (ES command). 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

Table 47: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
53-56	27,28	ET / Temperature	Contains the temperature of the water at the transducer head (ET command). This value may be a manual setting or a reading from a temperature sensor. Scaling: LSD = 0.01 degree; Range = -5.00 to +40.00 degrees
57,58 59,60 61,62	29 30 31	MPT minutes MPT seconds MPT hundredths	This field contains the Minimum Pre-Ping Wait Time between ping groups in the ensemble.
63,64 65,66 67,68	32 33 34	H/Hdg Std Dev P/Pitch Std Dev R/Roll 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°

69-70
71-72
73-74
75-76
77-78
79-80
81-82
83-84
	35
	36
	37
	38
	39
	40
	41
	42
		ADC Channel 0
		ADC Channel 1
		ADC Channel 2
		ADC Channel 3
		ADC Channel 4
		ADC Channel 5
		ADC Channel 6
		ADC Channel 7
			These fields contain the outputs of the Analog-to-Digital Converter (ADC) located on the DSP board. The ADC sequentially samples one of the eight channels per ping group (the number of ping groups per ensemble is the maximum of the WP). These fields are zeroed at the beginning of the deployment and updated each ensemble at the rate of one channel per ping group. For example, if the ping group size is 5, than:
			`END OF ENSEMBLE No.  CHANNELS UPDATED`
			`Start                All channels = 0`
			`1                    0, 1, 2, 3, 4`
			`2                    5, 6, 7, 0, 1`
			`3                    2, 3, 4, 5, 6`
			`4                    7, 0, 1, 2, 3`
			`↓                    ↓`
			Here is the description for each channel:
			`CHANNEL  DESCRIPTION`
			`0        XMIT CURRENT`
			`1        XMIT VOLTAGE`
			`2        AMBIENT TEMP`
			`3        PRESSURE (+)`
			`4        PRESSURE (-)`
			`5        ATTITUDE TEMP`
			`6        ATTITUDE`
			`7        CONTAMINATION SENSOR`
			Note that the ADC values may be "noisy" from sample-to-sample, but are useful for detecting long-term trends.

85-86	43	Error Status Word	Contains the long word containing the bit flags for the CY Command. The ESW is cleared (set to zero) between each ensemble.
			Note that each number above represents one bit set – they may occur in combinations. For example, if the long word value is 0000C000 (hexadecimal), than it indicates that both a cold wake-up (0004000) and an unknown wake-up (00008000) occurred.
			Low 16 BITS
			LSB
			`BITS 07 06 05 04 03 02 01 00`
			`     x  x  x  x  x  x  x  1  Bus Error exception`
			`     x  x  x  x  x  x  1  x  Address Error exception`
			`     x  x  x  x  x  1  x  x  Illegal Instruction exception`
			`     x  x  x  x  1  x  x  x  Zero Divide exception`
			`     x  x  x  1  x  x  x  x  Emulator exception`
			`     x  x  1  x  x  x  x  x  Unassigned exception`
			`     x  1  x  x  x  x  x  x  Watchdog restart occurred`
			`     1  x  x  x  x  x  x  x  Battery Saver power`

Table 47: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description

87-88	44		Low 16 BITS
			MSB
			`BITS 15 14 13 12 11 10 09 08`
			`x x x x x x x 1 Pinging`
			`x x x x x x 1 x Not Used`
			`x x x x x 1 x x Not Used`
			`x x x x 1 x x x Not Used`
			`x x x 1 x x x x Not Used`
			`x x 1 x x x x x Not Used`
			`x 1 x x x x x x Cold Wakeup occurred`
			`1 x x x x x x x Unknown Wakeup occurred`

89-90	45		High 16 BITS
			LSB
			`BITS 23 22 21 20 19 18 17 16`
			`x x x x x x x 1 Clock Read error occurred`
			`x x x x x x 1 x Unexpected alarm`
			`x x x x x 1 x x Clock jump forward`
			`x x x x 1 x x x Clock jump backward`
			`x x x 1 x x x x Not Used`
			`x x 1 x x x x x Not Used`
			`x 1 x x x x x x Not Used`
			`1 x x x x x x x Not Used`

91-92	46		High 16 BITS
			MSB
			`BITS 31 30 29 28 27 26 25 24`
			`x x x x x x x 1 Not Used`
			`x x x x x x 1 x Not Used`
			`x x x x x 1 x x Not Used`
			`x x x x 1 x x x Power Fail (Unrecorded)`
			`x x x 1 x x x x Spurious level 4 intr (DSP)`
			`x x 1 x x x x x Spurious level 5 intr (UART)`
			`x 1 x x x x x x Spurious level 6 intr (CLOCK)`
			`1 x x x x x x x Level 7 interrupt occurred`

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 (see How Does the Rio Grande ADCP Sample Depth and Pressure). Scaling: LSD=1 deca-pascal; Range=0 to ± 2147483648 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 ± 2147483648 deca-pascals
113-114	57	Spare	Spare
115-116	58	RTC Century	These fields contain the time from the Rio Grande ADCP's Y2K compliant real-time clock (RTC) that the current data ensemble began. The TT command (Set Real-Time Clock) initially sets the clock. The Rio Grande ADCP does account for leap years.
117-118	59	RTC Year	
119-120	60	RTC Month	
121-122	61	RTC Day	
123-124	62	RTC Hour	
125-126	63	RTC Minute	
127-128	64	RTC Seconds	
129-130	65	RTC Hundredths	

How Does the Rio Grande ADCP Sample Depth and Pressure?

1. For each ping, the ADC samples the pressure sensor five times and averages the data. This is an attempt to reduce the Standard Deviation.
2. Using the Pressure coefficients, the pressure data from the ADC is converted to kPa.
3. That data is converted to dm and corrected for salinity with the following equation:

   Depth (dm) = Pressure(kPa) * (1.02-0.00069*ES), where ES is the Salinity setting.

   This is the depth value recorded in the PD0 variable leader when the WH is fitted with a pressure sensor and that the EZ command is set to EZx1xxxxx.
4. The pressure data is converted from kPa to deca-Pascals by multiplying it by 100. This value in deca-Pascals is recorded in the PD0 variable leader data.

Converting kpa to Depth

The formula for converting kpa to depth (using *WinADCP*) is as follows:

(kpa(1.02-0.00069*Salinity)*(1000/Fresh Water Density))/10

Velocity Data Format

BYTE	7/S	6	5	4	3	2	1	0	
	BIT POSITIONS								
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 49 for description of fields

Figure 36. Velocity Data Format

The number of depth cells is set by the WN command.

The Rio Grande ADCP 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 Rio Grande ADCP 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 Rio Grande ADCP references the velocity data as shown below.

EX-CMD	COORD SYS	VEL 1	VEL 2	VEL 3	VEL 4
EX00xxx	BEAM	TO BEAM 1	TO BEAM 2	TO BEAM 3	TO BEAM 4
EX01xxx	INSTRUMENT	Bm1-Bm2	Bm4-Bm3	TO XDUCER	ERR VEL
EX10xxx	SHIP	PRT-STBD	AFT-FWD	TO SURFACE	ERR VEL
EX11xxx	EARTH	TO EAST	TO NORTH	TO SURFACE	ERR VEL

Positive values indicate water movement toward the ADCP.

Table 48: Velocity Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Velocity ID	Stores the velocity data identification word (00 01h).
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 the WN command). These fields follow the same format as listed above for depth cell 1.

Correlation Magnitude, Echo Intensity, Percent-Good, and Status Data Format

BYTE	7/S	6	5	4	3	2	1	0	
	BIT POSITIONS								
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 50 through Table 52 for a description of the fields.

Figure 37. Correlation Magnitude, Echo Intensity, Percent-Good, and Status Data Format

The number of depth cells is set by the WN command.

Correlation magnitude data give the magnitude of the normalized echo autocorrelation at the lag used for estimating the Doppler phase change. The Rio Grande ADCP 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 49: Correlation Magnitude Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the correlation magnitude data identification word (00 02h).
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 the WN command) for all four beams. These fields follow the same format as listed above for depth cell 1.

The echo intensity scale factor is about 0.45 dB per Rio Grande ADCP count. The Rio Grande ADCP does not directly check for the validity of echo intensity data.

Table 50: Echo Intensity Data Format

Hex Digit	Binary Byte	Field	Description
1 – 4	1,2	ID Code	Stores the echo intensity data identification word (00 03h).
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 the WN command) 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 Rio Grande ADCP references percent-good data as shown below.

EX command	Coord. Sys	Velocity 1	Velocity 2	Velocity 3	Velocity 4
		Percentage Of Good Pings For:			
		Beam 1	BEAM 2	BEAM 3	BEAM 4
xxx00xxx	Beam	Percentage Of:			
xxx01xxx	Instrument	3-Beam Transformations (note 1)	Transformations Rejected (note 2)	More Than One Beam Bad In Bin	4-Beam Transformations
xxx10xxx	Ship				
xxx11xxx	Earth				

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 ADCP 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 ADCP to reject some of its depth cell data. This causes the ADCP to calculate velocities with three beams instead of four beams. When the ADCP does 3-beam solutions, it stops calculating the error velocity because it needs four beams to do this. At some further depth cell, the ADCP 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, you would want all four beams to 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:

<u>Field 1 – Percentage of good 3-beam solutions</u> – 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 5000 mm/s. This large WE setting effectively prevents the ADCP 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 51: Percent-Good Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the percent-good data identification word (00 04h).
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 the WN command), following the same format as listed above for depth cell 1.

These fields contain information about the status and quality of ADCP data. A value of 0 means the measurement was good. A value of 1 means the measurement was bad.

Table 52: Status Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the status data identification word (00 05h).
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 command) for all four beams. These fields follow the same format as listed above for depth cell 1.

Bottom-Track Data Format

BYTE	BIT POSITIONS 7/S	6	5	4	3	2	1	0	
1	BOTTOM-TRACK ID								LSB 00h
2									MSB 06h
3	BT PINGS PER ENSEMBLE {BP}								LSB
4									MSB
5	BT DELAY BEFORE RE-ACQUIRE {BD}								LSB
6									MSB
7	BT CORR MAG MIN {BC}								
8	BT EVAL AMP MIN {BA}								
9	BT PERCENT GOOD MIN {BG}								
10	BT MODE {BM}								
11	BT ERR VEL MAX {BE}								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 {BL}	LSB
46		MSB
47	REF LAYER NEAR {BL}	LSB
48		MSB
49	REF LAYER FAR {BL}	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 {BX}	LSB
72		MSB
73	BM#1 RSSI AMP	
74	BM#2 RSSI AMP	

BYTE	BIT POSITIONS 7/S	6	5	4	3	2	1	0	
75	BM#3 RSSI AMP								
76	BM#4 RSSI AMP								
77	GAIN								
78	(*SEE BYTE 17)								MSB
79	(*SEE BYTE 19)								MSB
80	(*SEE BYTE 21)								MSB
81	(*SEE BYTE 23)								MSB
82	RESERVED								
83									
84									
85									

Figure 38. Bottom-Track Data Format

This data is output only if the BP command is > 0 and PD0 is selected. See Table 54 for a description of the fields.

The PD0 output data format assumes that the instrument is stationary and the bottom is moving. DVL (Speed Log) output data formats (see Special Output Data Formats) assume that the bottom is stationary and that the ADCP 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 53: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the bottom-track data identification word (00 06h).
5-8	3,4	BP/BT Pings per ensemble	Stores the number of bottom-track pings to average together in each ensemble (BP command). If BP = 0, the ADCP does not collect bottom-track data. The ADCP automatically extends the ensemble interval (TE) if BP x TP > TE. Scaling: LSD = 1 ping; Range = 0 to 999 pings
9-12	5,6	BD/BT delay before reacquire	Stores the number of ADCP ensembles to wait after losing the bottom before trying to reacquire it (BD command). Scaling: LSD = 1 ensemble; Range = 0 to 999 ensembles
13,14	7	BC/BT Corr Mag Min	Stores the minimum correlation magnitude value (BC command). Scaling: LSD = 1 count; Range = 0 to 255 counts
15,16	8	BA/BT Eval Amp Min	Stores the minimum evaluation amplitude value (BA command). Scaling: LSD = 1 count; Range = 1 to 255 counts
17,18	9	BG/BT %Gd Minimum	Stores the minimum percentage of bottom-track pings in an ensemble that must be good to output velocity data (BG command).
19,20	10	BM/BT Mode	Stores the bottom-tracking mode (BM command). When the Lowered ADCP mode is set (WM15) the Bottom-Track mode will show up as Mode 11 (BM11). When the system uses standard Bottom-Track (BT-RA, see OL command), the Bottom-Track mode will show up as Mode 50 (BM50).
21-24	11,12	BE/BT Err Vel Max	Stores the error velocity maximum value (BE command). 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 ADCP 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 EX (coordinate system) command setting. 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, Upward, Error d) Earth Coordinates: East, North, Upward, Error
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 (Table 5).
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 ADCP's bottom-track validity algorithm during an ensemble. Scaling: LSD = 1 percent; Range = 0 to 100 percent

Table 53: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
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 BT water-reference layer (BL command). Scaling (minimum layer size): LSD = 1 dm; Range = 0-999 dm Scaling (near/far boundaries): LSD = 1 dm; Range = 0-9999 dm
101- 116	51-58	Ref Vel/Beam #1-4 Ref Layer Vel	Contains velocity data for the water reference layer for each beam. Reference layer velocities have the same format and scale factor as water-profiling velocities (Table 49). The BL command explains the water reference layer.
117- 124	59-62	RLCM/Bm #1-4 Ref Corr	Contains correlation magnitude data for the water reference layer for each beam. Reference layer 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 reference layer for each beam. Reference layer 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 reference layer for each beam. They indicate the reliability of reference layer data. It is the percentage of bottom-track pings that have passed a reference layer 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 command). Scaling: LSD = 1 decimeter; Range = 80 to 9999 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 ≈ 0.45 dB per count; Range = 0 to 255 counts
153, 154	77	GAIN	Contains the Gain level for shallow water. See WJ command.
155-162	78-81	BT Range MSB/Bm #1-4	Contains the most significant byte of the vertical range from the ADCP 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 = 65,536 cm, Range = 65,536 to 16,777,215 cm
163-170	82-85	Reserved	Reserved

Reserved BIT Data Format

BYTE	BIT POSITIONS 7	6	5	4	3	2	1	0	
1	RESERVED FOR TRDI USE								LSB
2									MSB

Figure 39. Reserved BIT Data Format

The data is always output. See Table 55 for a description of the fields.

Table 54: Reserved for TRDI Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Reserved for TRDI's use	This field is for TRDI (internal use only).

Checksum Data Format

BYTE	BIT POSITIONS 7	6	5	4	3	2	1	0	
1	CHECKSUM DATA								LSB
2									MSB

Figure 40. Checksum Data Format

The data is always output. See Table 56 for a description of the fields.

Table 55: Checksum Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Checksum Data	This field contains a modulo 65535 checksum. The Rio Grande ADCP computes the check-sum by summing all the bytes in the output buffer excluding the checksum.

Special Output Data Formats

The PD3, PD4, PD5, and PD6 commands select the desired DVL (speed log) output data format.

The DVL 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 ADCP collects all data in the output buffer during an ensemble.

Figure 46 through Figure 48 shows the format of these buffers and the sequence in which the ADCP sends the data. Table 57 through Table 60 list the format, bytes, fields, scaling factors, and a detailed description of every item in the DVL binary output buffers.

The DVL output data formats are available with or without bottom-track. However, if bottom-track is not available, they will contain no data.

The DVL output data formats assume that the bottom is stationary and that the ADCP or vessel is moving. The PD0 Bottom Track output data format (see Bottom-Track Data Format) assumes that the instrument is stationary and the bottom is moving.

DVL Data Format (PD3)

Byte	7	6	5	4	3	2	1	0	
	BIT POSITION								
1	DVL DATA ID 7Eh								
2	DATA STRUCTURE*								
3	STARBOARD/EAST VELOCITY (With Respect To BTM)								LSB
4									MSB
5	FORWARD/NORTH VELOCITY (With Respect To BTM)								LSB
6									MSB
7	UPWARD VELOCITY (With Respect To BTM)								LSB
8									MSB
9	STARBOARD/EAST VELOCITY (With Respect To WATER REF)								LSB
10									MSB
11	FORWARD/NORTH VELOCITY (With Respect To WATER REF)								LSB
12									MSB
13	UPWARD VELOCITY (With Respect To WATER REF)								LSB
14									MSB
15	BM1 RNG TO BTM								LSB
16									MSB
17	BM2 RNG TO BTM								LSB
18									MSB
19	BM3 RNG TO BTM								LSB
20									MSB
21	BM4 RNG TO BTM								LSB
22									MSB
23	RANGE TO BTM (AVERAGE)								LSB
24									MSB
25	SPARE								
↓									↓
↓									↓
40									
41	SENSOR/OTHER DATA								
42	PING TIME: HOUR								
43	MINUTE								
44	SECOND								
45	HUNDREDTH								
46	HEADING								LSB
47									MSB

Byte	7	6	5	4	3	2	1	0	
	BIT POSITION								
48	PITCH								LSB
49									MSB
50	ROLL								LSB
51									MSB
52	TEMPERATURE								LSB
53									MSB
54	BIT RESULTS								LSB
55									MSB
56	CHECKSUM								LSB
57									MSB

Figure 41. DVL Data Format (PD3)

DVL Output Data Format (PD3) Details

The ADCP sends this data format only when the PD3 command is used. In multiple byte parameters, the least significant byte always comes before the more significant bytes.

Table 56: DVL Output Data Format (PD3) Details

Hex Digit	Binary Byte	Field	Description
1,2	1	DVL Data ID	Stores the DVL (speed log) identification word (7Eh)
3,4	2	Reserved	Reserved
5-8	3,4	X-Vel Btm	† Bit #0: Always output. If the data bit is set to 0, than Ship coordinates are used. If the data bit is set to 1, than Earth coordinates are used. These fields contain the velocity of the vessel in relation to the bottom in mm/s. Positive values indicate vessel motion to (X) Starboard/East, (Y) Forward/North, (Z) Upward.
9-12	5,6	Y-Vel Btm	
13-16	7,8	Z-Vel Btm	† Bit #1: Vertical velocities.
17-20	9,10	X-Vel Water	† Bit #2: These fields contain the velocity of the vessel in relation to the water reference layer in mm/s. Positive values indicate vessel motion to (X) Starboard/East, (Y) Forward/North, (Z) Upward.
21-24	11,12	Y-Vel Water	
25-28	13,14	Z-Vel Water	† Bit #1 and Bit #2
29-32 33-36 37-40 41-44	15,16 17,18 19,20 21,22	Bm1 Bm2 Rng to Bm3 Bottom Bm4	† Bit #3: These fields contain the vertical range from the ADCP 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 centimeter; Range = 0 to 65535 cm
45-48	23,24	Avg Rng to Btm	† Bit #4: These fields contain the average vertical range from the ADCP to the bottom as determined by each beam.
49-80	25-40	Spare	Spare

Table 56: DVL Output Data Format (PD3) Details

Hex Digit	Binary Byte	Field	Description

81,82	41	Sensor/Other Data	† Output if Bit #7 of "Data to Follow" byte is set. These fields contain the Sensor/Other data.
			`Bit #`
			`0 = Time`
			`1 = Heading`
			`2 = Pitch`
			`3 = Roll`
			`4 = Temperature`
			`5 = Active Built-In-Test`

83-90	42,43	Time: HH,MM	‡ Sensor/Other Data Bit #0: These fields contains the time of the ping in Hours, Minutes Seconds, Hundredths of seconds respectively.
	44,45	Time: SS,HH	
91-94	46,47	Heading	‡ Sensor/Other Data Bit #1: this field contains the Heading in hundredths of degrees.
95-98	48,49	Pitch	‡ Sensor/Other Data Bit #2: this field contains the Pitch in hundredths of degrees.
99-102	50,51	Roll	‡ Sensor/Other Data Bit #3: this field contains the Roll in hundredths of degrees.
103-106	52,53	Temp	‡ Sensor/Other Data Bit #4: this field contains the Temperature in hundredths of degrees.

107-110	54,55	BIT results	‡ Sensor/Other Data Bit #5: this field contains the Built-In-Test results. Each bit specifies the result of built-in-test during an ensemble. If the bit is set, the test failed.
			`BYTE 54 BYTE 55 (BYTE 55 RESERVED FOR FUTURE USE)`
			`1xxxxxxx xxxxxxxx = RESERVED`
			`x1xxxxxx xxxxxxxx = RESERVED`
			`xx1xxxxx xxxxxxxx = RESERVED`
			`xxx1xxxx xxxxxxxx = DEMOD 1 ERROR`
			`xxxx1xxx xxxxxxxx = DEMOD 0 ERROR`
			`xxxxx1xx xxxxxxxx = RESERVED`
			`xxxxxx1x xxxxxxxx = DSP ERROR`
			`xxxxxxx1 xxxxxxxx = RESERVED`

111-114	56,57	Checksum	This is the 16-bit checksum of all the preceding binary bytes.

† This block of data is only output if the bit is set in the Data to Follow byte.

‡ This block of data is only output if the bit is set in the Sensor/Other Data byte.

DVL Data Format (PD4/PD5)

Byte	BIT POSITION 7 6 5 4 3 2 1 0	
1	DVL 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	
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 42. DVL Data Format (PD4/PD5)

*If 0, than PD4 (Bytes 1-47)
*If 1, than PD5 (Bytes 1-45 + Table 59)

DVL Output Data Format (PD4/PD5) Details

The ADCP sends this data format only when the PD4 or PD5 command is used.

Table 57: DVL Output Data Format (PD4/PD5) Details

Hex Digit	Binary Byte	Field	Description
1,2	1	DVL Data ID	Stores the DVL (speed log) identification word (7Dh).
3,4	2	Data Structure	Identifies which data pattern will follow based on the PD command. 0 = PD4 = Bytes 1 through 47 from Figure 47. 1 = PD5 = Bytes 1 through 45 from Figure 47 and bytes 46 through 88 from Figure 48. Note: PD6 is ASCII-only; see Table 60.
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 DVL 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 xxxxx010 300 kHz DVL xxxxx011 600 kHz DVL xxxxx100 1200 kHz DVL
11-14 15-18 19-22 23-26	6,7 8,9 10,11 12,13	X-Vel Btm Y-Vel Btm Z-Vel Btm E-Vel Btm	These fields contain the velocity of the vessel in relation to the bottom in mm/s. Positive values indicate vessel motion to east (X), north (Y), and up (Z). LSD = 1 mm/s (see NOTES at end of this table).
27-30 31-34 35-38 39-42	14,15 16,17 18,19 20,21	Bm1 Bm2 Rng to Bm3 Bottom Bm4	These fields contain the vertical range from the ADCP 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 centimeter; Range = 0 to 65535 cm
43,44	22	Bottom Status	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. BIT 76543210 1xxxxxxx BEAM 4 LOW ECHO AMPLITUDE x1xxxxxx BEAM 4 LOW CORRELATION xx1xxxxx BEAM 3 LOW ECHO AMPLITUDE xxx1xxxx BEAM 3 LOW CORRELATION xxxx1xxx BEAM 2 LOW ECHO AMPLITUDE xxxxx1xx BEAM 2 LOW CORRELATION xxxxxx1x BEAM 1 LOW ECHO AMPLITUDE xxxxxxx1 BEAM 1 LOW CORRELATION
45-48 49-52 53-56 57-60	23,24 25,26 27,28 29,30	Velocity 1 Velocity 2 Velocity 3 Velocity 4	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 Rio Grande references the velocity data.

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

Positive values indicate water movement (see notes at end of this table).

Table 57: DVL Output Data Format (PD4/PD5) Details

Hex Digit	Binary Byte	Field	Description
61-64 65-68	31,32 33,34	Ref Layer Start Ref Layer End	These fields contain the starting boundary (near surface) and the ending boundary (near bottom) of the water-mass reference layer (BL command). If the minimum size field is zero, the ADCP does not calculate reference-layer data. Scaling: LSD = 1 dm; Range = 0-9999 dm

69,70	35	Ref Layer Status	This field shows the status of reference layer depth and correlation data. Convert to binary and interpret as follows. A zero code indicates status is OK.
			`BIT 76543210`
			`xxx1xxxx ALTITUDE IS TOO SHALLOW`
			`xxxx1xxx BEAM 4 LOW CORRELATION`
			`xxxxx1xx BEAM 3 LOW CORRELATION`
			`xxxxxx1x BEAM 2 LOW CORRELATION`
			`xxxxxxx1 BEAM 1 LOW CORRELATION`

71,72 73,74 75,76 77,78	36 37 38 39	TOFP Hour TOFP Minute TOFP Second TOFP Hundredth	These fields contain the time of the first ping of the current ensemble.

79-82	40,41	BIT Results	These fields contain the results of the ADCP's Built-in Test function. A zero code indicates a successful BIT result.
			`BYTE 40  BYTE 41 (BYTE 41 RESERVED FOR FUTURE USE)`
			`1xxxxxxx xxxxxxxx = RESERVED`
			`x1xxxxxx xxxxxxxx = RESERVED`
			`xx1xxxxx xxxxxxxx = RESERVED`
			`xxx1xxxx xxxxxxxx = DEMOD 1 ERROR`
			`xxxx1xxx xxxxxxxx = DEMOD 0 ERROR`
			`xxxxx1xx xxxxxxxx = RESERVED`
			`xxxxxx1x xxxxxxxx = DSP ERROR`
			`xxxxxxx1 xxxxxxxx = RESERVED`

83-86	42,43	Speed of Sound	Contains either manual or calculated speed of sound information (EC command). Scaling: LSD = 1 meter per second; Range = 1400 to 1600 m/s
87-90	44,45	Temperature	Contains the temperature of the water at the transducer head. Scaling: LSD = 0.01 C; Range = -5.00 to +40.00 C
91-94	46,47	Checksum	This field contains a modulo 65536 checksum. The ADCP 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 59.

The ADCP packs velocity data into a two-byte, two's-complement integer [-32768, 32767] with the LSB sent first. The ADCP 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 than the Y and Z-velocities are valid; if X is not valid, Y and Z are not valid.

The ADCP allows 3-beam transformations when the fourth beam is invalid. Indication of a 3-beam transformation for bottom-track is valid bottom velocities and one and only one beam's range to bottom is marked bad (zero).

There is no indication that a 3-beam transformation was performed for water reference layer velocity data.

DVL 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
75	DISTANCE MADE GOOD/REF (NORTH)								LSB
76									
77									
78									MSB
79	DISTANCE MADE GOOD/REF (UP)								LSB
80									
81									

	BIT POSITION								
Byte	7	6	5	4	3	2	1	0	
82									MSB
83	DISTANCE MADE GOOD/REF (ERROR)								LSB
84									
85									
86									MSB
87	CHECKSUM								LSB
88									MSB

Figure 43. DVL Data Format (PD5)

DVL Output Data Format (PD5) Details

The ADCP sends this data format (Figure 47 and Figure 48) only when the PD5 command is used. Table 58 explains the first part of this data structure.

Table 58: DVL 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 command). 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 command). 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 ADCP pitch angle (EP command). 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 = -60.00 to +60.00 degrees
101-104	51,52	Roll	Contains the ADCP roll angle (ER command). This value may be a manual setting or a reading from a tilt sensor. For up-facing ADCPs, positive values mean that Beam #2 is spatially higher than Beam #1. For down-facing ADCPs, positive values mean that Beam #1 is spatially higher than Beam #2. Scaling: LSD = 0.01 degree; Range = -60.00 to +60.00 degrees
105-108	53,54	Heading	Contains the ADCP heading angle (EH command). 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>. Scaling: LSD = 1 dm; Range = -10,000,000 to 10,000,000 dm
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 reference layer since the time of the first ping after initialization or <BREAK>. Scaling: LSD = 1 dm; Range = -10,000,000 to 10,000,000 dm
173-176	87,88	Checksum	This field contains a modulo 65536 checksum. The ADCP computes the checksum by summing all the bytes in the output buffer excluding the checksum.

DVL Output Data Format (PD6)

The ADCP sends this data format only when the PD6 command is used. The ADCP outputs data in the following line order. The ADCP may not sent all data lines. Examples: (1) If BK = zero, the ADCP does not send water-mass data (line items beginning with W); (2) If BK = three, the ADCP does not send bottom-track data (line items beginning with B).

PD6 output data format cannot be recorded – it must be output through the serial port only. Do not use this output data format for a self-contained deployment.

Table 59: DVL Output Data Format (PD6)

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
2	**TIMING AND SCALING DATA** **:TS,YYMMDDHHmmsshh,SS.S,+TT.T,DDDD.D,CCCC.C,BBB <CR><LF>** where: YYMMDDHHmmsshh = 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
3	**WATER-MASS, INSTRUMENT-REFERENCED VELOCITY DATA** **:WI,±XXXXX,±YYYYY,±ZZZZZ,±EEEEE,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) ±EEEEE = 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><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,±EEEEE,±NNNNN,±UUUUU,S <CR><LF>** where: ±EEEEE = East (u-axis) velocity data in mm/s (+ = ADCP movement to east) ±NNNNN = North (v-axis) velocity data in mm/s (+ = ADCP movement to north) ±UUUUU = Upward (w-axis) velocity data in mm/s (+ = ADCP movement to surface) S = Status of velocity data (A = good, V = bad)

Table 59: DVL 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><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,±EEEEE,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) ±ZZZZZ = Z-axis velocity data in mm/s (+ = transducer movement away from bottom) ±EEEEE = 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><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,±EEEEE,±NNNNN,±UUUUU,S <CR><LF>** where: ±EEEEE = East (u-axis) velocity data in mm/s (+ = ADCP movement to east) ±NNNNN = North (v-axis) velocity data in mm/s (+ = ADCP movement to north) ±UUUUU = Upward (w-axis) velocity data in mm/s (+ = ADCP 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><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 PD6 output does not pad spaces with zeroes. The spaces are left intact. The example below shows a realistic output from a Rio Grande ADCP locked onto the bottom.

```
:SA,  -2.31,  +1.92, 75.20
:TS,04081111563644,35.0,+21.0,   0.0,1524.0,  0
:WI,-32768,-32768,-32768,-32768,V
:BI,   +24,    -6,   -20,    -4,A
:WS,-32768,-32768,-32768,V
:BS,   -13,   +21,   -20,A
:WE,-32768,-32768,-32768,V
:BE,   +17,   +18,   -20,A
:WD,       +0.00,       +0.00,       +0.00,  20.00,  0.00
:BD,       -0.02,       -0.03,       +0.02,   7.13,  0.21
```

Rules for the BroadBand Data Format PD0

Use the following information to help write your own software:

1. All data types (i.e. fixed leader, variable leader, velocity, echo intensity, correlation, percent good, etc.) will be given a specific and unique ID number. The table below shows some of the most common IDs.

Table 60: Common Data Format IDs

ID	LSB	MSB	Description
0x7F7F	7F	7F	Header
0x0000	00	00	Fixed Leader
0x0080	80	00	Variable Leader
0x0100	00	01	Velocity Profile Data
0x0200	00	02	Correlation Profile Data
0x0300	00	03	Echo Intensity Profile Data
0x0400	00	04	Percent Good Profile Data
0x0500	00	05	Status Profile Data
0x0600	00	06	Bottom Track Data

The ADCP always sends the Least Significant Byte (LSB) first.

2. Once a data type has been given an ID number and the format of that data has been published we consider the format for each field has being fixed. Fixed refers to units used for a given field, the number of bytes in a given field, and the order in which the fields appear within the data type. Fixed does not refer to the total number of bytes in the data type - see Rule 3.
3. Data may be added to an existing data type only by adding the bytes to the end of the data format. As an example, the variable leader data contains information on ensemble number, time, heading, pitch, roll, temperature, pressure, etc. The format for the bytes 1-53 are now specified by changes added in support to the WorkHorse ADCP. If additional sensor data is to be added to the variable leader data, than it must be added to the end of the data string (bytes 54-x as an example).

Note that new firmware versions may cause a change in the number of bytes and this implies that if byte-counting, requires altering your code at every change. This is not the case when using the data type IDs and offsets to navigate through the data. New variables are added at the end of a data type before the checksum. The offsets will dynamically change to reflect the change, allowing you to get to the same desired data every time.

4. The order of data types in an ensemble is not fixed. That is there is no guarantee that velocity data will always be output before correlation data.
5. The header data will include the number of data types in the files and the offset to each ID number for each data type.
6. The total number of the bytes in an ensemble minus the 2-byte checksum will be included in the header.

Decoding Sequence for PD0 Data

To decode PD0 data:

1. Locate the header data by locating the header ID number (in the case of PD0 profile data that will be 7F7F).
2. Confirm that you have the correct header ID by:
   a. Locating the total number of bytes (located in the header data) in the ensemble. This will be your offset to the next ensemble.
   b. Calculate the checksum of total number of bytes in the ensemble excluding the checksum. The checksum is calculated by adding the value of each byte. The 2-byte least significant digits that you calculate will be the checksum.
   c. Read the 2-byte checksum word at the end of the ensemble, located by using the checksum offset in the header (determined in step 2-a) and compare this checksum word to the value calculated in step 2-b.
   d. If the checksums match then you have a valid ensemble. If the checksums do not match then you do not have a valid ensemble and you need to go back to step 1 and search for the next header ID number occurrence.
3. Locate the number of data types (located in the header data).
4. Locate the offset to each data type (located in the header data).
5. Locate the data ID type you wish to decode by using the offset to each data type and confirm the data ID number at that offset matches the ID type you are looking for.
6. Once the proper ID type has been located, use this manual to understand what each byte represents in that particular data type.

Decoding Sequence Example

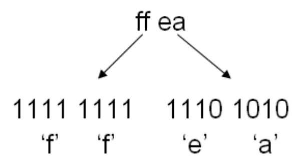
All the available binary output data formats respect the same "header/leader ID + offset to data type" structure that eliminates the need for byte-counting. As an example, let's assume you selected PD5 output format and you need to decode the Roll data from each ensemble.

Based on the documentation, PD5 data type is PD4 + PD5 data with the Leader ID of PD4 = 7Dh.

Thus, let's assume you created code that read the serial data coming from the instrument and scan for this ID. Once 7Dh is detected in the raw data, based on the PD5 output data format tables, you simply need to jump down 50 bytes to directly get to the roll data coded on bytes 51 and 52 as a 2s-complement signed variable. This "jump" can be done by adding the offset to a pointer address pointing to the leader ID.

As mentioned above, the Roll data is a 2s-complement signed variable. Let's assume the roll data that you want to decode is ea ff in the binary raw data. Since the PD5 format is LSB (Byte 51) MSB (Byte 52), it should read Roll (hexa) = ff ea.

Let's transform both hexadecimal bytes into 2 binary bytes:



The Most Significant Bit is the first bit on the left of the binary word and will decide the sign of the variable. Below is a formula that you can apply to obtain the decimal value of the Roll using the above binary word:

Decimal Roll = [(-1)x X x 2^15) + (decimal(YYY YYYY YYYY YYYY))] x Scale factor

Where the binary word is:

XYYY YYYY YYYY YYYY

Using this formula in this example, we obtain:

X = 1

Y.....Y = 111 1111 1110 1010

Scale Factor (see Table 59) = 0.01 degree

Thus,

Decimal Roll = [(-1) x 1 x 2^15 + (decimal (111 1111 1110 1010))] x 0.01deg

Decimal Roll = [-32768 + 32746] x 0.01deg

Decimal Roll = -0.22 degrees

The same method can be used for all PDx binary formats.

If you simply need to decode parts or all the data from each ensemble of your deployment PD0 data file into an ASCII file for post-processing, use RDI Tools. See item 5 on the TRDI website.

Appendix A

NOTICE OF COMPLIANCE

In this chapter, you will learn:

- 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 62.

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	**Teledyne RD Instruments Europe**	**Teledyne RD Technologies**
14020 Stowe Drive Poway, California 92064	2A Les Nertieres 5 Avenue Hector Pintus 06610 La Gaude, France	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.

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 61. Toxic or Hazardous Substances and Elements Contained in Product

零件□目(名称) Component Name	有毒有害物□或元素 Toxic or Hazardous Substances and Elements □ Lead (Pb)	汞 Mercury (Hg)	□ Cadmium (Cd)	六价□ Hexavalent Chromium (Cr^{6+})	多溴□苯 Polybrominated Biphenyls (PBB)	多溴二苯□ Polybrominated Diphenyl Ethers (PBDE)
□能器配件 Transducer Assy.	X	X	O	X	O	O
接收机□路板/数据□理器□路板 Receiver PCB/ DSP PCB	O	O	O	O	O	O
微□理器□路板/□入□出ロ□路板 CPU PCB/PIO PCB	O	O	O	O	O	O
机体装配 Housing Assy.	O	O	O	O	O	O
底座装配 End-Cap Assy.	O	O	O	O	O	O
□池□ Battery Pack	O	O	O	O	O	O
交流□□□器 AC Voltage Adapter	O	O	O	O	O	O
水下专用电缆 Underwater Cable	O	O	O	O	O	O
□用裝运箱和泡沫塑料□ Shipping Case w/Foam	O	O	O	O	O	O

O: 表示□有毒或有害物□在□部件所有均□材料中的含量均在 SJ/T 11363-2006 □准□定的限量要求以下。

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.

X: 表示□有毒或有害物□至少在□部件的某一均□材料中的含量超出 SJ/T 11363-2006 □准□定的限量要求。

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.

Notes

NOTES