WORKHORSE

WORKHORSE II

MONITOR, SENTINEL, MARINER, LONG RANGER, AND QUARTERMASTER

COMMANDS AND OUTPUT DATA FORMAT

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TELEDYNE MARINE
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REVISION HISTORY

March 2025

- Corrected **Table 3**, page 9 150kHz BL default to 320,640,960, was 0,50,90.

December 2024

- Updated OL command. Removed Narrow-Bandwidth-Only (WB1) from the OL command text.

April 2024

- Removed the AS command from the compass commands. This command is for the *ISM Compass Calibration* software use only.

September 2023

- Added table showing available features.

August 2023

- Renamed High Rate Ping to High Ping Rate Profile.

July 2023

- Updated website address.

January 2023

- Updated EAR statement.

October 2022

- Added changes for Workhorse II firmware 77.xx commands (AS command, WM 5 and 8 added note that they are not available, ISM output data)
- Updated note for the EX coordinate frame on page 133.
- Added the CJ command.
- Updated RN command.
- Added the PDDecoder link. Use the Teledyne Marine library to decode Teledyne RD Instruments (TRDI) PD data types, such as PD0 and waves packets.
- Updated Firmware Update and Feature Installation sections.
- Added minimum/maximum range to TG, TT, TF, and TS commands.
- Corrected max limit of CW command to 65535.
- Corrected WO command range 2nd parameter to 0 to 100.
- Added note that TF Command does not support setting time of first ping exceeding 1 year from current date.
- Corrected TB Command Description *ff* range to 0 to 99 hundredths of seconds.
- Corrected PE command range to 1 to 65535.
- Corrected Checksum output format to modulo 65536 checksum.

January 2020

- Updated the WF command recommended blank distance to match the WorkHorse manual.

November 2018

- Added Ambient Sound Profile output.

June 2018

- Added Beam Coordinate information to the EX command.
- Added the BIT information to PD8.
- Added the Export Administration Regulations (EAR) footers.

March 2016

- Changed the minimum bin size for the WK command to 2 cm (see ICN157).
- Updated the OL command example printout.
- Added a caution to the PT5 command. The PT5 test is not a valid test and will be removed in a future firmware release.
- Updated the note on page 123. *VmDas* adds 92 bytes instead of 78 bytes of additional data plus a 2-byte offset.
- Updated how to convert ADC channels in the Variable Leader Data Format (see ICN 153).
- Updated the way the Temperature ADC Channel is documented.

- Fixed bytes 43—50 for Fixed Leader data; LSB/MSB was reversed.

March 2014

- Updated the WV formula from WV = (Max. Apparent Vel. cm/s) * sin(beam angle) * 1.2 to WV = (Max. Apparent Vel. cm/s) * sin(beam angle) * 1.5, where 1.5 is a safety factor.
- Added how to convert ADC channels to the Variable Leader Data Format (see ICN 153).
- Corrected the PD4/PD5 description binary bytes 23—30. The statement that positive velocity values indicate motion to the East (X), North (Y), and Up (Z) directions was incorrect. The coordinate frame for the PD4/PD5 velocity output depends on the EX setting, and will not always be Earth coordinates. For example, if the EX command selects BEAM data, then PD4/PD5 would output beam-radial velocities.
- Updated the PD12 velocity output description.

February 2013

- Updated styles and fonts.
- Updated BI command purpose.
- Updated BX command description.
- Updated BZ range from 0 to 999 to 1 to 160 cm/s.
- Added PS4 command description.
- Updated Recorder Commands description.
- Added warning that if PD9 is selected, there is no data written to the recorder.
- Corrected WB command default from WB0 to WB0 (300, 600, and 1200 kHz systems), WB1 (150 and 75 kHz systems).
- Added correction from ICN144 WF Command Setting for Workhorse.
- Added Surface Range Tracking information to the WM15 command.
- Corrected Fixed Leader Data Format WN command from 128 to 255 cells.
- Updated Table 29: Summary of Output Data Formats and added a row for Recorded format.
- Corrected Data Output Format (PD12) Pressure field at offset 27 from "Pressure in 0.01 kPa" to "Pressure in deca-Pascals" (100*kPa, not 0.01*kPa).
- Added Decoding Sequence Example to chapter 6.

August 2010

- Corrections to the manual for all ICNs to firmware 5x.38.
- General update to the manual.

November 2007

- Rio Grande, H-ADCP, and Navigator commands have been removed.
- Updated commands to reflect 16.30 firmware.

EXCLUSIONS AND OMISSIONS

- None

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Firmware History

See the README file on the TRDI Software Portal: https://tm-portal.force.com/TMsoftwareportal.

How to Contact Teledyne RD Instruments

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

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

Self-Service Customer Portal

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

Teledyne Marine Software Portal

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

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

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

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

CONVENTIONS USED IN THIS MANUAL

Conventions used in this documentation have been established to help you learn 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),** you would press and hold the first key while you press the second key. Words printed in italics include program names (*TRDI Toolz*) and file names (*default.txt*).

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

```
WorkHorse ADCP
Teledyne RD Instruments (c) 2022
All rights reserved.
Firmware Version: X.xx

>?
```

You will find three other visual aids that help you: Notes, Cautions, and Recommended Settings.

This paragraph format indicates additional information that may help you 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 StreamPro ADCP).

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

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Chapter 1

INTRODUCTION

In this chapter:

- Data Communication and Command Format
- Installing Firmware Updates
- Installing Feature Upgrades
- Deploying the ADCP
- Command Summary

This guide defines the commands used by the WorkHorse Monitor, Sentinel, Mariner, Quartermaster, and Long Ranger ADCPs. These commands (Table 2) let you set up and control the WorkHorse ADCP without using an external software program such as our *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)*, *WavesMon*, *VmDas*, and *WinRiver II* programs. However, TRDI recommends you use our software to control the WorkHorse ADCP because entering commands directly from a terminal can be difficult. *Make sure you read and understand* Deploying the ADCP. Most WorkHorse ADCP settings use factory-set values (Table 3). If you change these values without thought, you could ruin your deployment. *Be sure you know what effect each command has before deploying your ADCP.* Call TRDI if you do not understand the function of any command.

Using *Workhorse II Plan* for self-contained deployments or *VmDas, WavesMon,* or *WinRiver II* for real-time deployments to develop the command file will ensure that the WorkHorse ADCP is set up correctly.

The commands shown in Table 2 directly affect the range of the ADCP, the standard deviation (accuracy) of the data, and battery usage.

This guide applies to WorkHorse Monitor, Sentinel, Mariner, Quartermaster, and Long Ranger firmware version 51.42 (Monitor/Sentinel) and 52.41 (Mariner) and Workhorse II 77.xx (Monitor/Sentinel) and Workhorse II 78.xx (Mariner).

When new firmware versions are released, some commands may be modified, added, or removed. Read the README file using our online customer portal at https://tm-portal.force.com/TMsoftwareportal..

When an addition or correction to this manual is needed, download an updated version using our online customer portal at https://www.teledynemarine.com/support/RDI/technical-manuals to download manuals or other Teledyne RDI documentation.

Data Communication and Command Format

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

Immediately after you apply power to the WorkHorse ADCP, it enters the STANDBY mode. Send a BREAK signal using *TRDI Toolz* to put the ADCP in command mode. When the WorkHorse ADCP receives a BREAK signal, it responds with a wake-up message like the one shown below. The WorkHorse ADCP is now ready to accept commands at the ">" prompt from either a terminal or computer program.

```
[BREAK Wakeup A]
WorkHorse II Broadband ADCP Version 77.xx
Teledyne RD Instruments (c) 1996-2022
All Rights Reserved.

>
```

If you use a terminal/program other than *TRDI Toolz*, the BREAK length (up to down transition) must last at least 300 ms.

Command Input Processing

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

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

If you enter a valid command that produces output data, the WorkHorse 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 command is not valid, the WorkHorse ADCP responds with an error message like the following.

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

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

Data Output Processing

After the WorkHorse 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.

WorkHorse 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 you use a terminal to communicate with, and view data from the WorkHorse ADCP. The binary mode is useful for high-speed communication with a computer program. You would not use the binary mode to view data on a terminal because the terminal could interpret some binary data as control codes.

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

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

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

Installing Firmware Updates

Firmware upgrades can be downloaded from the Teledyne Marine software portal: https://tm-portal.force.com/TMsoftwareportal. Unzip the file and save to your computer.

If the firmware upgrade is not available via the web, then please contact Field Service (rdifs@teledyne.com) to request a copy.

How do I install a firmware update?

To install a firmware update:

1. Setup the communication parameters between *TRDI Toolz* and the ADCP.
2. Wake up the ADCP by pressing the button.
3. Click **Tools**, **Firmware Update**.
4. Select the **.abs* update file.

Installing Feature Upgrades

The feature upgrade installation program is used to install Bottom Tracking, Shallow Water Bottom Mode, Lowered ADCP (LADCP), High-Resolution Water-Profiling mode, High Ping Rate Profile, and Waves 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).

Shallow Water Bottom Track Mode 7 can only be installed on 1200kHz systems and requires Bottom Track enabled.

To install a feature update:

1. Setup the communication parameters between *TRDI Toolz* and the ADCP.
2. Wake up the ADCP by pressing the button.
3. Click **Tools**, **Activate Features**.
4. Select the *.*Feature* update file.
5. Verify the feature is installed by sending the OL command.

Table 1. Features

Feature	Workhorse	Workhorse II	Long Ranger
BOTTOM TRACK (HIGH ACCURACY)	Optional	Optional	N/A
BOTTOM TRACK (BASE ACCURACY)	Optional	Optional	N/A
SHALLOW BOTTOM MODE (1200kHz with BT enabled)	Optional	Included	N/A
HIGH RESOLUTION WATER MODES WM5 and WM8	Optional	N/A	N/A
HIGH PING RATE PROFILE WM12 (600/1200kHz)	Optional	Included	N/A
HIGH RESOLUTION WATER MODES WM11 (600/1200kHz)	Optional	Included	N/A
LADCP / SURFACE TRACK / WM15	Optional	Included	Optional
WATER PROFILE	Included	Included	Included
WAVE GUAGE	Optional	Optional	Optional
Communication Mode (selected when ordered)			
RS232 MODE	Yes	Yes	Yes
RS422 MODE	Yes	Yes	Yes

BT-BA (Bottom Track Base Accuracy 1.15%) (Export-Compliant) and BT-HA (Bottom Track High Accuracy 0.4%) modes are mutually exclusive. Only one may be enabled.

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

Acoustic Doppler Current Profilers 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.

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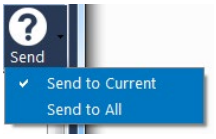
Deploying the ADCP

TRDI recommends that you use our software programs *Workhorse II Plan*, *VmDas*, or *WinRiver II*, etc. as your primary method of deployment.

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

To send multiple commands to configure the ADCP and start it pinging:

1. Use *Workhorse II Plan* to create a command file for Workhorse II systems. Use *PlanADCP* for Workhorse systems. Save the command file.
2. Set up the communication parameters between *TRDI Toolz* and the ADCP.
3. Wake up the ADCP by pressing the button.
4. On the **Tools** menu, select **Script Editor**.
5. Click the **Open** icon and select the file to run from the scroll-down list. If no extension is given for the script file, an extension of *.txt is assumed.
6. Click the **Send** icon. Clicking the drop-down menu will show the options to **Send to current** or **Send to all**. Use the **Send to all** feature to send the same script file to all connected ADCPs.



7. Use the **Layout** menu to show or hide the Ensemble Display and Terminal windows. The Ensemble Display shows limited situational data (Ensemble Time, Temperature, Heading, Pitch, Roll, Bottom track range/velocity, Vertical Beam range) in tabular form from the ADCP data stream, when present.

Note that the Ensemble Display is off when *TRDI Toolz* is first started.

Command Summary

Table 2 gives a summary of the WorkHorse ADCP input commands, their format, and a brief description of the parameters they control. **Table 3** lists the factory default command settings.

This table shows all commands including optional feature upgrades and expert commands. To see the expert commands, you must first send the command EXPERTON. Some commands may not be available for your ADCP.

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

Table 2: WorkHorse ADCP Input Command Summary

Command	Description
?	Shows command menu (deploy or system)
<BREAK> End	Interrupts or wakes up WorkHorse 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 Active Fluxgate and Tilt calibration data
AD	Display Fluxgate factory calibration
AF	Field calibrate the Fluxgate compass to remove hard iron error
AR	Restore Factory Fluxgate Calibration data
AX	Examine Fluxgate 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)
BD*nnn*	Delay Before Reacquire (0 to 999 ensembles)
BE*nnnn*	Error velocity maximum (0 to 9999 mm/s)
BF*nnnnn*	Depth guess (1 to 65535 dm, 0 = automatic)
BI*nnn*	Gain switch depth (0 to 999 meters)
BJ*nnnnn*	Bottom Blank (0 to 65535 cm)
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)
CC nnn nnn nnn	Choose External Devices (CC000 000 001 = MicroCAT)
CD*abc def ghi*	Serial data out
CE	Retrieve Most Recent Data Ensemble
CF*nnnnn*	Flow control
CH*n*	Suppress ba*nn*er (0 = Display, 1 = Suppress)
CI*nnn*	Instrument ID (0 to 255)
CJ*n*	IMM Output Enable (0 = Disable, 1 = Enable)
CK	Keep parameters as user defaults
CLn	Sleep Enable (0 = Disable, 1 = Enable, 2 see Manual)
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)

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Table 2: WorkHorse ADCP Input Command Summary

Command	Description
CS or **Tab**	Start pinging
CW*nnnnn*	Trigger Timeout (0 to 65535 milliseconds (0 = No timeout))
CX*n*	Enables/disables the low latency trigger (0 = Off, 1 = On)
CY*n*	Clear error status word (0 = Clear, 1 = Display)
CZ	Power down WorkHorse ADCP
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
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
HA*nnn*	Waves false target threshold (fish rejection)
HB*nn*	Number of automatically chosen bins (20 Max)
HD*nnn nnn nnn*	Waves selected data (Vel;Pres;Surf ;; ;;)
HF*nnnnn*	Waves Flow Control (Res;Res;Res;Ser;Rec)
HP*nnnn*	Number of pings per record
HRhh:mm:ss.ff	Time between wave bursts (hh:mm:ss.ff)
HS*nnn,nnn,nnn,nnn,nnn*	Bins selected for directional wave data recording
HThh:mm:ss.ff	Time between wave pings (hh:mm:ss.ff)
HV*nnn,nnn,nnn,nnn,nnn*	Bins selected for velocity spectrum data recording
LA*nnn*	False target threshold maximum (0 to 255)
LC*nnn*	Low correlation Threshold (0 to 255)
LD*nnn nnn nnn*	Data out (Vel;Cor;Amp PG;St;P0 P1;P2;P3)
LF*nnnn*	Blank after transmit (cm)
LJ*n*	Receiver gain select (0 = Low, 1 = High)
LN*nnn*	Number of depth cells (1-128)
LP*nnnn*	Pings per Ensemble (0 to 16384)
LS*nnnn*	Depth Cell Size (cm)
LV*nnn*	Ambiguity Velocity (cm/s radial)
LW*n*	Band Width Control (0 = Wide, 1 = Narrow)
LZ*aaa,ccc*	Amp, Corr Thresholds (0 to 255)
PA	Pre-deployment tests
PBx,y,z	PD12 bin select
PC1	Beam Continuity Built-in test
PC2	Display Heading, Pitch, Roll, and Orientation Built-in test
PD*n*	Data stream select (0 to 18)
PE*nnnn*	PD12 ensemble select (0 to 65535)
PM	Distance measurement facility
POabcd	PD12 velocity component select
PS0	Display System Configuration
PS3	Display Instrument Transformation Matrix
PT*nnn*	Built-In test (0 to 200)

Table 2: WorkHorse ADCP Input Command Summary

Command	Description
RA	Number of deployments
RB	Recorder built-in test
RDxxxxx	Create recorder file (RDOPEN, RDCLOSE)
RE ErAsE	Erase CF card recorder
RF	Recorder free space (Bytes)
RIn	Deployment auto increment (0 = Append, 1 = New File)
RN	Set deployment name
RR	Show recorder file directory
RS	Recorder free space (Megabytes)
RY	Upload recorder files
SAxyz	Synchronize before/after ping/ensemble
SB*n*	Channel B Break Interrupt Mode (0 = Disabled, 1 = Enabled)
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)
TXhh:mm:ss	Buffered Output Period (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, 15) Note: Modes 5 and 8 are not available in Workhorse II
W*Nnnn*	Number of depth cells (1 to 128)
WO*x,y*	Mode 12 parameters
WP*nnnn*	Pings per ensemble (0 to 16384)
WQ*n*	Sample ambient sound (0 = Off, 1 = On)
WS*nnnn* [min, max]	Depth cell size (80 to 3200 (75kHz), 40 to 3200 (150kHz), 20 to 800 (300kHz), 10 to 800 (600kHz), 5 to 400 (1200kHz))
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)
WZ*nnn*	Mode 5 ambiguity velocity (0 to 999 cm/s)

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Table 3: WorkHorse ADCP Factory Defaults

Com-mand	75 kHz	150 kHz	300 kHz	600 kHz	1200 kHz	2400 kHz
BA	N/A	030	030	030	030	030
BB	N/A	0640	0320	160	60	20
BC	N/A	220	220	220	220	220
BD	N/A	000	000	000	000	000
BE	N/A	1000	1000	1000	1000	1000
BF	N/A	00000	00000	00000	00000	00000
BJ	N/A	00000	00000	00000	00000	00000
BI	N/A	040	020	010	005	001
BK	N/A	0	0	0	0	0
BL	N/A	320,640,960	160,320,480	80,160,240	40,60,100	20,20,40
BM	N/A	5	5	5	5	6
BP	N/A	000	000	000	000	000
BR	N/A	0	0	0	0	0
BV	N/A	N/A	N/A	20,250,0	10,250,0	N/A
BX	N/A	5500	02000	1250	450	150
BZ	N/A	004	004	004	004	004
CB	411	411	411	411	411	411
CC	000 000 000	000 000 000	000 000 000	000 000 000	000 000 000	000 000 000
CD	000 000 000	000 000 000	000 000 000	000 000 000	000 000 000	000 000 000
CF	11111	11111	11111	11111	11111	11111
CH	0	0	0	0	0	0
CI	000	000	000	000	000	000
CJ	0	0	0	0	0	0
CL	1	1	1	1	1	1
CM	0	0	0	0	0	0
CN	0	0	0	0	0	0
CP	0	0	0	0	0	0
CQ	255	255	255	255	255	255
CW	250	250	250	250	250	250
CX	0	0	0	0	0	0
DB	411	411	411	411	411	411
DW	0	0	0	0	0	0
EA	+00000	+00000	+00000	+00000	+00000	+00000
EB	+00000	+00000	+00000	+00000	+00000	+00000
EC	1500	1500	1500	1500	1500	1500
ED	00000	00000	00000	00000	00000	00000
EH	00000	00000	00000	00000	00000	00000
EP	+0000	+0000	+0000	+0000	+0000	+0000
ER	+0000	+0000	+0000	+0000	+0000	+0000
ES	35	35	35	35	35	35
ET	+2500	+2500	+2500	+2500	+2500	+2500
EX	11111	11111	11111	11111	11111	11111
EZ	1111101	1111101	1111101	1111101	1111101	1111101
HA	255	255	255	255	255	255
HB	05	05	05	05	05	05
HD	111000000	111000000	111000000	111000000	111000000	111000000
HF	22222	22222	22222	22222	22222	22222
HP	0000	0000	0000	0000	0000	0000
HR	01:00:00.00	01:00:00.00	01:00:00.00	01:00:00.00	01:00:00.00	01:00:00.00
HS	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023
HT	00:00:00.50	00:00:00.50	00:00:00.50	00:00:00.50	00:00:00.50	00:00:00.50
HV	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023
LA	050	050	050	050	050	050
LC	064	065	064	064	064	064
LD	111 100 000	111 100 000	111 100 000	111 100 000	111 100 000	111 100 000
LF	0704	0352	0176	0088	0044	0022
LJ	1	1	1	1	1	1

Table 3: WorkHorse ADCP Factory Defaults

Com-mand	75 kHz	150 kHz	300 kHz	600 kHz	1200 kHz	2400 kHz
LN	030	030	030	030	030	030
LP	00000	00000	00000	00000	00000	00000
LS	1600	0800	0400	0200	0100	0050
LV	175	175	175	175	175	175
LW	1	1	1	1	1	1
LZ	030,220	030,220	030,220	030,220	030,220	030,220
PB	01,00,1	01,00,1	01,00,1	01,00,1	01,00,1	01,00,1
PD	00	00	00	00	00	00
PE	00001	00001	00001	00001	00001	00001
PO	1111	1111	1111	1111	1111	1111
SA	001	001	001	001	001	001
SI	00000	00000	00000	00000	00000	00000
SM	0	0	0	0	0	0
SS	0	0	0	0	0	0
ST	00000	00000	00000	00000	00000	00000
SW	00000	00000	00000	00000	00000	00000
TB	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00
TC	00000	00000	00000	00000	00000	00000
TE	01:00:00.00	01:00:00.00	01:00:00.00	01:00:00.00	01:00:00.00	01:00:00.00
TP	01:20.00	01:20.00	01:20.00	01:20.00	01:20.00	01:20.00
TX	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
WA	050	050	050	050	050	050
WB	1	1	0	0	0	0
WC	064	064	064	064	064	064
WD	111 100 000	111 100 000	111 100 000	111 100 000	111 100 000	111 100 000
WE	2000	2000	2000	2000	2000	2000
WF	0704	0352	0176	0088	0044	0022
WI	0	0	0	0	0	0
WJ	1	1	1	1	1	1
WK	0	0	0	0	0	0
WL	001,005	001,005	001,005	001,005	001,005	001,005
WM	1	1	1	1	1	Not Available
WN	030	030	030	030	030	030
WO	1,4	1,4	1,4	1,4	1,4	1,4
WP	00045	00045	00045	00045	00045	00045
WQ	0		0	0	0	0
WS	1600 [80,3200]	0800 [40,3200]	0400 [20,1600]	0200 [10,800]	0100[5,400]	0050 [5,200]
WT	0000	0000	0000	0000	0000	0000
WU	0	0	0	0	0	0
WV	175	175	175	175	175	175
WZ	010	010	010	010	010	N/A

The highlighted commands have frequency dependent defaults.

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Chapter 2

COMMAND DESCRIPTIONS

In this chapter:

- Compass Commands
- Bottom Track Commands
- Control System Commands
- Environmental Commands
- Fault Log Commands
- Performance and Testing Commands
- Recorder Commands
- Timing Commands
- Water Profiling Commands

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 WorkHorse 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 WorkHorse 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 Broadband ADCP Version X.xx
Teledyne RD Instruments (c) 1996-2012
All Rights reserved.
>?
Available Menus:
DEPLOY? ------------------ Deployment Commands
SYSTEM? ------------------ System Control, Data Recovery and Testing Commands

Available 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
>
```

Break

Purpose Interrupts WorkHorse ADCP without erasing present settings.

Format <BREAK>

Recommended Setting. Use as needed.

Description A BREAK signal interrupts WorkHorse 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 WorkHorse ADCP in the DATA I/O mode. The BREAK command does not erase any settings or data.

Using *TRDI Toolz*, press the Break icon sends a BREAK.

Example <BREAK>

```
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 77.xx
Teledyne RD Instruments (c) 1996-2021
All Rights Reserved.

>
```


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When you send a break 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 RS232 communication through the serial lines of the I/O cable
- **[BREAK Wakeup B]** => ADCP is set to send/receive RS422 communication through the serial lines of the I/O cable.
- **[BREAK Wakeup AB]** => RS232/422 switch on the top of the PIO board in the ADCP is in between two positions, but neither RS232 nor RS422. It can also mean that the ADCP received a trigger pulse while in command mode.
- **[ALARM Wakeup A]** => When you send a break, if the battery has a low voltage reading you will get the following message:

```
[ALARM Wakeup A]
WorkHorse Broadband ADCP Version 77.xx
Teledyne RD Instruments (c) 1996-2021
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. Only WorkHorse ADCP firmware 16.21 and above accepts this option.

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 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 Feature Upgrades for information on how to install additional capability in your WorkHorse ADCP.

Examples See below.

```
>ol                              FEATURES
------------------------------------------------------------------------
Feature                                                        Installed
------------------------------------------------------------------------
BT-HA (High Accuracy 0.4%)                                           Yes
Water Profile                                                        Yes
High Resolution Water Modes                                          Yes
LADCP/Surface Track/WM15                                              No
Wave Gauge Acquisition                                                No
Shallow Bottom Mode                                                  Yes
High Rate Pinging                                                    Yes
BT-BA (Base Accuracy 1.15%)                                           No

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

>ol                              FEATURES
------------------------------------------------------------------------
Feature                                                        Installed
------------------------------------------------------------------------
BT-HA (High Accuracy 0.4%)                                            No
Water Profile                                                        Yes
High Resolution Water Modes                                          Yes
LADCP/Surface Track/WM15                                              No
Wave Gauge Acquisition                                               Yes
Shallow Bottom Mode                                                  Yes
High Rate Pinging                                                    Yes
BT-BA (Base Accuracy 1.15%)                                          Yes

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

>
```

BT-BA (Bottom Track Base Accuracy 1.15%) (Export-Compliant) and BT-HA (Bottom Track High Accuracy 0.4%) modes are mutually exclusive. Only one may be enabled.

OI - Install New Feature

Purpose Install New Feature

Format OI

Example:

```
>OI
            ----+----1----+----2----+-
Enter Code:  xxxxxxxxxxxxxxxxxxxxxxxxx
... Features Set Semi-Permanently

>
```


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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.

The Workhorse detects the compass type by reading the internal part number. For Workhorse II systems with an ISM compass, use the *ISM Compass Calibration* software to calibrate the compass. For flux gate compass, use the AF command to calibrate the compass.

All Workhorse II systems include the ISM compass. You must use the *ISM Compass Calibration* software to calibrate the compass.

Available Compass Commands

This section lists the available compass commands.

Workhorse II systems with an ISM compass:

```
>a?
Available Commands:
AZ 0.000000 ------------- Zero pressure reading
A? ---------------------- Display Public Sensor Commands
>
```

The AS command is for the *ISM Compass Calibration* software use only.

The Flux Gate compass commands will return an error message if the system has an ISM compass.

```
>af? ERR 010: UNRECOGNIZED COMMAND
>ar? ERR 010: UNRECOGNIZED COMMAND
>
```

Workhorse systems with a Flux Gate compass:

```
>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 Fluxgate 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. Note this is an Expert command and will not display in the help list unless the Experton command is used.

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 Fluxgate Compass

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

Format AF

> **Recommended Setting.** This applies only to systems with a flux gate compass. For systems with an ISM compass, use the *ISM Compass Calibration* software.
>
> The fluxgate compass must be calibrated if the batteries have been replaced.
>
> 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 The built-in automated compass calibration procedures are like the AX command alignment verification but requires three rotations instead of one. The WorkHorse 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 WorkHorse ADCP for the two calibration rotations, the WorkHorse 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 two 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. 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.

For details on compass alignment, see the WorkHorse Technical Manual, Chapter 4 and the WinRiver II User's Guide. Single tilt compass calibration has been implemented in firmware version 16.30.

Use the *ISM Compass Calibration* software to calibrate a Workhorse II ISM compass.

AR – Return to Factory Fluxgate Calibration

Purpose Restores the factory fluxgate calibration data and makes the factory the active calibration data.

Format AR

Recommended Setting. Use as needed. TRDI strongly recommends sending the AR command 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 your WorkHorse ADCP to the original factory calibration, by using the AR command. Try using the AR command if you have trouble calibrating your fluxgate compass. In some circumstances, a defective compass calibration matrix can prevent proper calibration.

```
>ar
Calibration parameters have been updated in NRAM.

Do you really want to write over the active fluxgate calibration
   data [y or n]?y

Fluxgate Calibration Matrices Updated with Factory Original Values.

>
```

AX – Examine Compass Calibration

Purpose Used to verify the fluxgate compass calibration.

Format AX

Recommended Setting. Use as needed.

Description Compass calibration verification is an automated built-in test that measures how well the fluxgate 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

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WorkHorse 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.

```
>az
Pressure Offset Updated in NVRAM.

>
```

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

```
Err: No pressure sensor detected
```

Bottom Track Commands

Bottom Track is a feature upgrade for WorkHorse ADCP Monitor and Sentinel ADCPs (see Feature Upgrades). For an instrument to be able to Bottom Track, the feature must be installed (see OL - Features).

Bottom Track is not available for Long Ranger ADCPs.

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.

Mariner ADCPs use 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 off (BP0) for WorkHorse ADCPs. Send a BP1 command to turn on the bottom-tracking process.

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)
BD = 000 ----------------- Delay Re-Acquire (# Ensembles)
BE = 1000 ---------------- Max Error Velocity (mm/s)
BF = 00000 --------------- Depth Guess (0=Auto, 1-65535 = dm)
BI = 005 ----------------- Gain Switch Depth (0-999 meters)
BJ = 00000 --------------- Bottom Blank (1-65535 = cm)
BK = 0 ------------------- Layer Mode (0-Off, 1-On, 2-Lost, 3-No BT)
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 = 000 ----------------- 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 = 00450 --------------- Maximum Depth (10-65535 dm)
BZ = 004 ----------------- Coherent Ambiguity Velocity (cm/s radial)
>
```


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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 BB640 (150 kHz), BB320 (300 kHz), BB160 (600 kHz), BB60 (1200 kHz), BB20 (2400 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).

BD – Delay before Reacquire

Purpose Sets a delay period before trying to reacquire the bottom.

Format BD*nnn*

Range *nnn* = 0 to 999 ensembles

Default BD0

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

Description BD sets the number of ADCP ensembles to wait after losing the bottom before trying to track it again. In effect, BD reduces the number of bottom-track pings and increases the water-track ping rate when the bottom becomes out of range. If the ADCP loses track of the bottom, it immediately transmits a series of search pings. If the ADCP can not find the bottom after 16 pings, it will then wait BD ensembles before starting the search sequence again.

Examples If BD = 10, the ADCP waits 10 ADCP ensembles after the automatic search sequence before beginning the search sequence again. If BD = 0 (default), the ADCP continually tries to find the bottom.

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, than 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.

BI – Gain Switch Depth

Purpose Selects the range from the transducer where the gain will change from low to automatic selection (low or high).

Format BI*nnn*

Range *nnn* = 0 to 999 meters

Default BI40 (150 kHz), BI20 (300 kHz), BI10 (600 kHz), BI5 (1200 kHz), BI1 (2400 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 the BI setting, the unit operates in low gain. When the vertical range is greater than the BI setting, 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 the bottom throughout the range of the system.

BJ – Bottom Blank

Purpose Sets the blanking distance for Bottom Tracking.

Format BJ*nnnnn*

Range *nnnnn* = 0 to 65535 cm

Default BJ0

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

Description BJ blanks out bad data close to the transducer head, thus creating a window that reduces unwanted data in the ensemble. This allows the WorkHorse ADCP transmit circuits time to recover before beginning the receive cycle.

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 4: 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 BL320,640,960 (150 kHz), BL160,320,480 (300 kHz), BL80,160,240 (600 kHz), BL40,60,100 (1200kHz), BL20,20,40 (2400kHz)

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 non-zero 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 4, B), the layer compresses in size until the minimum water-mass layer size is reached. When the boundary moves closer to the transducer (Figure 4, C), no water mass ping will be sent.

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

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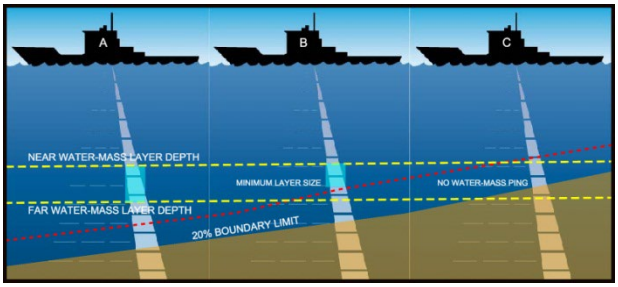

Figure 1. Water-Mass Layer Processing

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 WorkHorse ADCP ADCPs with firmware version 16.19 or higher)

Default BM5 (150, 300, 600, and 1200 kHz), BM6 (2400 kHz)

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

The BM command is not available for systems with standard Bottom Track (BT-RA - see OL command).

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 5: 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 WorkHorse ADCP ADCPs (see Feature Upgrades). Contact TRDI for information on how to install this capability in your WorkHorse ADCP. Firmware versions prior to version 16.30 allowed Bottom Mode 7 for 600 kHz ADCPs.

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 6). 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.

Table 6: BM7 Minimum Tracking Depths

Frequency	Min Tracking Depths
600kHz	0.6m
1200kHz	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 BP0

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.

When using *VmDas* with WorkHorse ADCPs that do not support bottom tracking, the BP command will fail on those WorkHorse ADCPs. This is OK if the ADCP Setup Options generates the BP command, but a failed command in the command file aborts processing of the command file. The BP command should be removed from the command file in this case. See the VmDas User's Guide for details.

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BR – Resolution

Purpose Sets the vertical depth resolution.

Format BR*n*

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, than 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, than no velocity will be output for this case.

A count value of 255 is perfect correlation.

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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 BX5500 (150 kHz), BX2000 (300 kHz), BX1250 (600 kHz), BX450 (1200 kHz), BX150 (2400 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 1250 dm for a 600 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 spending time searching down to 1250-dm (125 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.

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

BZ – Coherent Ambiguity Velocity

Purpose Sets the Bottom-Track Mode 5 ambiguity velocity.

Format BZ*nnn*

Range *nnn* = 1 to 160 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 WorkHorse ADCP uses the following commands to control certain system parameters.

Available Control System Commands

This section lists the available Control System commands.

```
>c?
CB = 811 ----------------- Serial Port Control (Baud [8=115200]; Par; Stop)
CC = 000 000 000 --------- Choose External Devices (x;x;x  x;x;x  x;x;CTD)
CD = 000 000 000 --------- Serial Data Out (Vel;Cor;Amp  PG;St;P0  P1;P2;P3)
CE ----------------------- Retrieve Last Ensemble
CF = 11100 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
CH = 0 ------------------- Suppress Banner
CI = 000 ----------------- Instrument ID (0-255)
CJ = 0 ------------------- IMM Output Enable (0=Disable,1=Enable)
CK ----------------------- Keep Parameters as USER Defaults
CL = 1 ------------------- Sleep Enable (0 = Disable, 1 = Enable, 2 See Manual)
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)
CW = 00250 --------------- Trigger Timeout (ms; 0 = no timeout)
CX = 0 ------------------- Trigger Enable (0 = OFF, 1 = ON)
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 WorkHorse ADCP and your external device (dumb terminal, computer software) MUST use the same communication parameters to *talk* to each other. After you enter valid CB parameters, the WorkHorse ADCP responds with a “>” prompt. You may now change the external device’s communication parameters to match the WorkHorse ADCP parameters before sending another command.

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Table 7: 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		

Setting the Baud Rate in the WorkHorse ADCP. The WorkHorse 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 WorkHorse ADCP. This procedure assumes that you will be using the program *BBTalk* that is supplied by Teledyne RD Instruments.

To set the Baud Rate:

1. Connect the WorkHorse ADCP to the computer and apply power (see the WorkHorse Technical Manual).
2. Start the *TRDI Toolz* program and establish communications with the ADCP. Wake up the WorkHorse ADCP by sending a break signal with the **End** key.
3. Send the command CR1 to place the WorkHorse ADCP in the factory default setup.
4. Send the CB command that selects the baud rate you wish. The following are the typical CB command settings for different baud rates with no parity and 1 stop bit:

Table 8: Baud Rate

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

5. *TRDI Toolz* will automatically change the settings to match your CB command settings and then *TRDI Toolz* will send the CK command to save the new baud rate setting.
6. Click **File**, **Close** to exit the terminal window.

The WorkHorse ADCP is now set for the new baud rate. The baud rate will stay at this setting until you change it back with the CB command.

If you send a BREAK before changing the external device's communication parameters, the WorkHorse ADCP returns to the communication parameters stored in non-volatile memory (user settings).

CC – Choose External Devices

Purpose Selects the external devices used by the ADCP.

Format CC abc def ghi

Range Firmware switches (see description)

Default CC 000 000 000

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

Description The CC command uses firmware switches to tell the ADCP the types of data to collect. Setting a bit to one tells the ADCP to collect that data type. The bits are described as follows:

a = Reserved	*d* = Reserved	*g* = Reserved
b = Reserved	e = Reserved	*h* = Reserved
c = Reserved	*f* = Reserved	*i* = Seabird MicroCAT

Example CC 000 000 001 tells the ADCP to collect Seabird MicroCAT data.

The data ID for the MicroCAT data is 0800h.

CD – Serial Data Out

Purpose Selects the serial data types output to the serial port.

Format CD abc def ghi

Range Firmware switches - Setting a bit to one tells the ADCP to output 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

Default CD 000 000 000

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

Description The CD command functions along with the WD command. Specifically, it overrides the WD command in what data is output to the serial port. If CD is left in the default state (no data selected), the WD setting controls serial and recorded data (they will be the same). If CD is set to anything else, the CD setting controls data output serially, while the WD command controls what is written to the recorder, however that data that is output must always be recorded if recording is enabled (see caution below).

If a bit (or bits) in the CD command string is set to 1, the corresponding bit (or bits) in the WD command MUST also be set to 1 or the data that is output and/or recorded will not be processed properly.

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CE – Retrieve Most Recent Data Ensemble

Purpose: Output the most recent data ensemble.

Format: CE

Description: CE outputs the most recent data ensemble via the serial communications port in either binary or Hex-ASCII mode as specified by the CF command. The WorkHorse ADCP buffers the last ensemble collected in RAM just prior to it being sent to the recorder or being output to the serial port of the ADCP.

Notes: To retrieve data with the CE command the WorkHorse ADCP must be in command mode, i.e. a break has been sent to stop the automatic ensemble mode, or the prompt has been returned in the manual ensemble mode.

No data is available in the buffer until a deployment has been started (CS command has been sent) and the first ensemble has been completed.

Retrieving the Most Recent Ensemble

The following example assumes that the WorkHorse ADCP has already been deployed and therefore is actively collecting data either on the internal recorder, out the serial port, or both.

To recover and capture the most recent ensemble:

1. Open the TRDI software program *TRDI Toolz*.
2. Configure the communications for the port that the WorkHorse ADCP is connected to.
3. Send a break to the ADCP.
4. Press the **F3** key to turn on the capture feature in *TRDI Toolz*. Enter a name and path for the file you are about to create. Press the Log icon in *TRDI Toolz* to create a log file.
5. Type the command CE and press enter. The data from the last ensemble will be transferred from the ADCP into the *TRDI Toolz* program and captured to the file you created in Step "4".
6. Press the **F3** key to close the file and press the Log icon in *TRDI Toolz*.
7. Verify the file contains a valid ensemble of data and continue to step "8".
8. Type the command CS and press enter. The ADCP will continue its deployment. Depending on the setting of the RI command, the ADCP will either append to the existing deployment file (starting at ensemble 1) or it will open a new deployment file.

If the RI command has been set to disable the auto increment (RI0) of the deployment file than you can at this time decide to close the current data file and start a new file by sending the RDOPEN command. Sending the RDCLOSE command will close the file only and a new file will not be opened until Step "8" is performed and the ADCP collects 8k bytes of data.

CF – Flow Control

Purpose Sets various WorkHorse ADCP data flow-control parameters.

Format CF*nnnnn*

Range Firmware switches (see description)

Default CF11111

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

Description The CF command defines whether the WorkHorse 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).

The *VmDas* program sets the WorkHorse ADCP to a manual ensemble mode (CF01110) so that it controls when the ensemble occurs.

Table 9: 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 ADCP is not echoed. This feature manually controls ping timing within the ensemble. Note the prompt output by the Workhorse when ready to ping is a less-than symbol (<), to distinguish it from the normal command prompt.
CFxx2xx	Hex-ASCII Data Output, Carriage Return-Linefeed delimited -- Sends the ensemble in readable hexadecimal-ASCII format with a Carriage Return-Linefeed at the end of each ensemble, if serial output is enabled (see below).
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.

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

CH – Suppress Banner

Purpose Prevents the unit from sending the wakeup message.

Format CH*n*

Range *n* = 0 (display banner), or 1 (suppress banner)

Default CH0

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

Description If CH1 is saved as part of the User Command Set, the unit will not output a banner on wakeup. The unit will still output the ">" prompt.

Suppression of the wakeup banner may cause some TRDI software to fail or function erratically.

```
>CH?
CH = 0 ------------------- Suppress Banner
>
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 77.00x
Teledyne RD Instruments (c) 1996-2021
All Rights Reserved.

>CH 1
>CH?
CH = 1 ------------------- Suppress Banner
>
>
```

CI – Instrument ID

Purpose Sets the ID for the ADCP.

Format CI*nnn*

Range *nnn* = 0 to 255

Default CI0

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

Description This command allows the user to uniquely identify a single ADCP in a network of up to 256 ADCPs. The value to which this command is set will be output in the PD12 output format.

This command has no effect if PD is set to other than PD12.

CJ – IMM Output Enable

Purpose This command enables or disables the Inductive Modem Module (IMM) output.

Format CJ*n*

Range *n* = 0 Disable, 1 = Enable

Default CJ0

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

Description Set the CJ command to CJ1 to enable the Sea-Bird IMM.

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 WorkHorse 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 Deploying the 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 if 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 – Sleep Enable

Purpose Determines whether the ADCP will attempt to conserve power by sleeping between pings.

Format CL*n*

Range *n* = 0 to 2 (Sleep Between Pings (0 = No Sleep & No Self Deploy, 1 = Sleep & Self Deploy, 2 = No Sleep & Self Deploy)

Default CL1

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

Description See table below.

Command	Description
CL0	ADCP never sleeps ADCP will not Self Deploy after 5 minutes (i.e. it will stay awake at the command prompt indefinitely waiting for user commands)
CL1	ADCP sleeps if enough time between pings ADCP times out after 5 minutes at command prompt with no input • If ADCP was pinging and only received a BREAK, then it self-deploys after timeout (auto-start mode) • If ADCP was processing commands, then it goes to sleep indefinitely after timeout (command mode)
CL2	ADCP never sleeps ADCP will Self Deploy 5 minutes if no user commands are received by the ADCP while awake and waiting at command prompt. If any command is sent, then you must include the CS command to start pinging.

For both CL0 and CL2, if a command is sent after the break, the ADCP will not redeploy until a CS command is sent.

For software breaks to work, the CL command must be set to CL0 or CL2 (see Break).

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When using the command file provided with VmDas with a WorkHorse ADCP with firmware version 16.31, if *VmDas* times out between each ensemble, adding CL0 to the command file fixes the problem.

CM – Master

Purpose Deprecated. For Lowered ADCP use, see the Lowered ADCP Commands and the Lowered ADCP User's Guide.

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 WorkHorse 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.

The CP command is only available for WorkHorse Sentinel, Monitor, and Long Ranger ADCPs.

Description The CP command allows a WorkHorse 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 10.

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 (see TP – Time Between Pings).

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 10: 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. For 75 kHz Long Ranger systems, set the Power setting and bandwidth in *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)* through the hardware selection page. See the Workhorse II Plan help file and PlanADCP User's Guide for details.

Description Allows the transmit power to be set high or low.

This command only affects 75 kHz Long Ranger systems. For information on how the CQ command affects system performance, see the Measurement Performance - Long Ranger 75 kHz specifications in the Long Ranger / QuarterMaster Operation Manual.

Although other frequency WorkHorse ADCPs allow the CQ command to be set to values other than the default, the CQ command has no effect and is not supported by *PlanADCP*.

CR – Retrieve Parameters

Purpose Resets the WorkHorse ADCP command set to factory settings.

Format CR*n*

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

Recommended Setting. Use as needed.

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

Table 11: 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 WorkHorse 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 *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)/VmDas/WinRiver II* 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 WorkHorse 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 WorkHorse ADCP waits until it reaches the TF time before beginning the data collection cycle.

1. After a CS command is sent to the WorkHorse 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 WorkHorse 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, then the 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.
4. A recorder card with a file count more than 50 files will cause a noticeable delay between the first ensemble and the Start Pinging (CS) command. If this delay is a concern, ensure that unwanted files are cleared before starting the deployment (see RE – Erase Recorder).

CW – Trigger Timeout

Purpose Sets the trigger timeout.

Format CW*nnnnn*

Range *nnnnn* = 0 to 65535

milliseconds (0 = No timeout)

Default CW00250

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

Description This command must be set when performing low latency triggering (see CX command). If the system does not receive a trigger before *nnnnn* ms, then the system will ping on its own according to the timing schedule set up with the T commands, and the trigger will be ignored.

CX – Low Latency Trigger Enable

Purpose Enables or disables the low latency trigger input.

Format CX*n*

Range *n* = 0 (off), 1 (on)

Default CX0

Recommended Setting. The default setting for this command is recommended for most applications. For more information on using the CX command, see FSA-018.

Description Turning on the Low Latency Trigger functionality allows the WorkHorse ADCP to ping within ~300µs of the rising edge of the trigger input. The trigger input needs to be on a differential signal pair that starts with a rising edge on one signal line and a falling edge on the other signal line.

The CX command inhibits the ability of the WorkHorse ADCP to sleep and conserve power. Use CX1 only when power consumption is not an issue.

If CX1 is used, the CL and SB commands must be set to CL0 and SB0 (see CL - Battery Saver Mode and (see SB –Channel B Break Interrupt Mode).

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.

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Table 12: 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 WorkHorse ADCP

Purpose Tells the WorkHorse ADCP to power down.

Format CZ

Recommended Setting. Use as needed.

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

Example See below

```
>cz

Powering Down
```

1. When powered down using the CZ command, the WorkHorse 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 WorkHorse 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.

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Environmental Commands

The WorkHorse 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 = 35 ------------------ Salinity (0-40 pp thousand)
ET = +2500 --------------- Temperature (1/100 deg Celsius)
EX = 11111 --------------- Coord Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 1111101 ------------- 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 *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)*.

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 *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)*, *VmDas*, or *WinRiver*.

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 (-9.26666 degrees). Set the EB command value to EB-00926.

10W is EB-01000
20W is EB-02000
10E is EB01000
20.7E is EB020700

```
>EB-01000
>eb?
EB = -01000 -------------- Heading Bias (1/100 deg)
>

>EB02000
>eb?
EB = +02000 -------------- Heading Bias (1/100 deg)
>
```

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.

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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 *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)*).

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)

Default EH00000

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)

Default EP0000

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)

Default ER0000

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 ES35

Recommended Setting. Set using *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)*, *VmDas*, or *WinRiver*. The default setting for this command is recommended for most applications.

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

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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 EX 11111

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.

VmDas sets the WorkHorse ADCP to Beam Coordinates (EX00001).

Table 13: Coordinate Transformation Processing Flags

Setting	Description
EX **00**xxx	No transformation. Radial beam coordinates, I.E., 1, 2, 3, 4. Heading/Pitch/Roll not applied.
EX **01**xxx	Instrument coordinates. X, Y, Z vectors relative to the ADCP. Heading/Pitch/Roll not applied.
EX **10**xxx	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.
EX **11**xxx	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.

Table 13: Coordinate Transformation Processing Flags

Setting	Description
EX xx**1**xx	Use tilts (pitch and roll) in transformation (see Note 2)
EX xxx**1**x	Allows 3-beam solutions if one beam is below the correlation threshold set by WC
EX xxxx**1**	Allow bin mapping (see Note 4 and 5)

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 WorkHorse 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 *VmDas* 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.

5. Bin mapping has been implemented for Ship Coordinate Transforms in firmware version 16.30 or higher.

Beam Coordinate Systems

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

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

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

Instrument Coordinates. (X, Y, Z) Instrument Coordinates are selected by the EX01xxx command. This set of axes is always oriented the same relative to the transducer head. Looking at the end view of the housing, the transducers are labeled clockwise in the order 3-2-4-1 (**Figure 2**). When you look at the face of the transducer head, the transducers are labeled clockwise in the order, 3-1-4-2 (see **Figure 3**, page 49). The X-axis lies in the direction from transducer Beam 1 towards transducer Beam 2 and the Y-axis lies in the direction from transducer Beam 4 towards transducer Beam 3. The Z-axis lies along the axes of symmetry of the four beams, pointing away from the water towards the housing.

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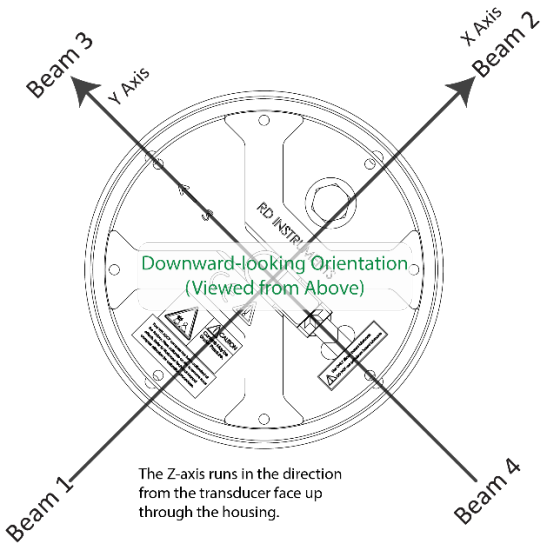

The PD0 Bottom Track output data format assumes that the instrument is stationary and the bottom is moving.

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

The PD3 through PD18 data formats assume that the bottom is stationary and that the ADCP or vessel is moving.

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

Figure 2. X, Y, and Z Velocities

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

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

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

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

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

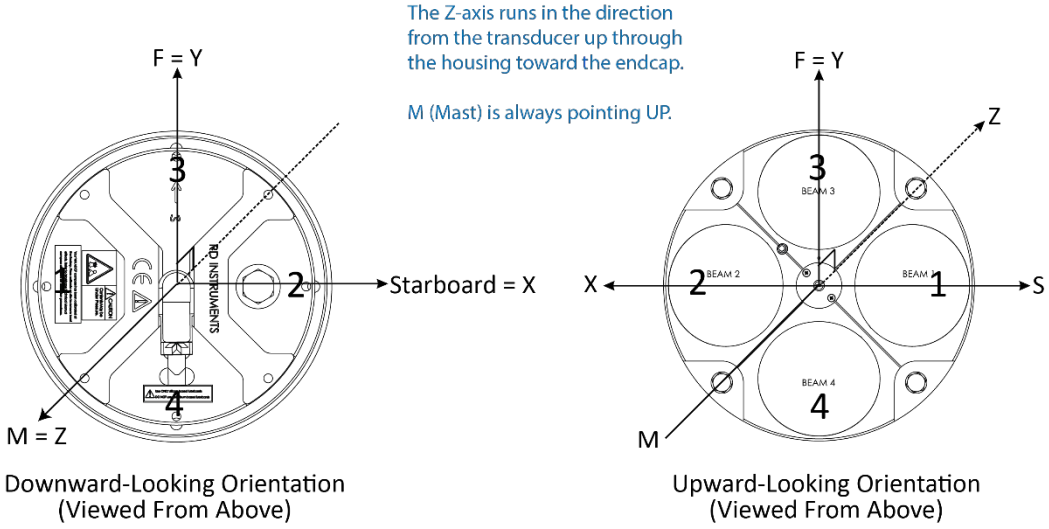

Figure 3. Ship Coordinates

The importance of the ship axis is that the attitude angles (pitch, roll, and heading) measure the orientation of the ship axes relative to the earth axes, regardless of up/down orientation. The sense of internal sensors Tilt 1 (pitch) and Tilt 2 (roll) is positive for counterclockwise tilts respectively about the S and F axes, using the right-hand rule. One can use the Ship Frame and the alignment commands to align the ADCP Ship axis with the vehicle/platform Ship axis

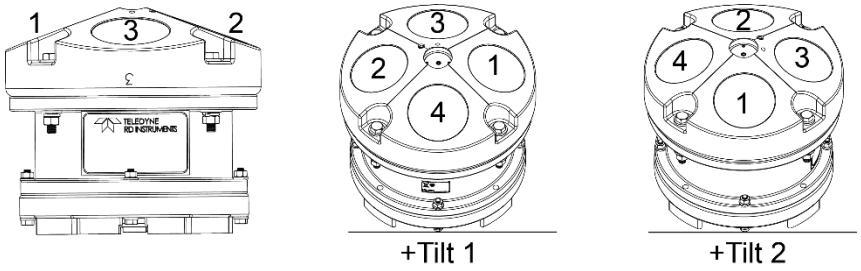

Figure 4. Pitch and Roll

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

EZ – Sensor Source

Purpose Selects the source of environmental sensor data.

Format EZ*cdhprst*

Default EZ1111101

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 14: Sensor Source Switch Settings

	Field	Value = 0	Value = 1	Value = 2	Value = 3
c	Speed Of Sound	Manual EC	Calculate using ED, ES, and ET	N/A	N/A
d	Depth	Manual ED	Depth Sensor	N/A	N/A
h	Heading	Manual EH	Internal Transducer Sensor	N/A	Use NMEA HDT
p	Pitch (Tilt 1)	Manual EP	Internal Transducer Sensor	N/A	N/A
r	Roll (Tilt 2)	Manual ER	Internal Transducer Sensor	N/A	N/A
s	Salinity	Manual ES	N/A	N/A	N/A
t	Temperature	Manual ET	Internal Transducer Sensor	N/A	N/A

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

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Setting the third parameter of the EZ command to 3 (EZxx3xxxx) allows the NMEA heading to be used rather than the ADCP's internal heading sensor. Please refer to FSA-017 – Using NMEA Heading strings with a Navigator for further details. This is available for WorkHorse ADCPs with firmware version 16.26 or higher.

Fault Log Commands

The WorkHorse 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

>
```

The FX command is no longer valid and is not documented.

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.

```
>fc ..........
 Fault Log Cleared.
Clearing buffer @0x00801000
Done [i=2048].

>
```

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   =     5
Overflow Count        =     0
Time of first fault:    21/05/13,12:32:33.18
Time of last fault:     21/07/08,13:14:43.54

Fault Log:
Entry #  0 Code=0206h  Count=    6  Delta=1414772 Time=21/05/19,15:20:36.64
 Parameter = 00018F00h
  Timeout waiting for device ready.
Entry #  1 Code=0a0ah  Count=    1  Delta=    0 Time=21/07/08,13:14:42.04
 Parameter = 00000000h
  Fluxgate circuit excessive offset drift.
Entry #  2 Code=0a0bh  Count=    1  Delta=    0 Time=21/07/08,13:14:42.54
 Parameter = 00000000h
  Tilt circuit excessive offset drift.
Entry #  3 Code=0a0dh  Count=    1  Delta=    0 Time=21/07/08,13:14:43.04
 Parameter = 00000000h
  Attitude temperature sensor out of range.
Entry #  4 Code=0a17h  Count=    1  Delta=    0 Time=21/07/08,13:14:43.54
 Parameter = 00000000h
  Ambient temperature sensor out of range.
End of fault log.
```


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Performance and Testing Commands

The WorkHorse 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
PB = 01,00,1 ------------- PD12 Bin Select (first;num;sub)
PC ### ------------------- Built In Tests, PC 0 = Help
PD = 00 ------------------ Data Stream Select (0-18)
PE = 00001 --------------- PD12 Ensemble Select (1-65535)
PO = 1111 ---------------- PD12 Velocity Component Select (v1;v2;v3;v4)
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 WorkHorse ADCP system diagnostic tests.

Format PA

Recommended Setting. Use as needed.

Description These diagnostic tests check the major WorkHorse 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
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
```

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.

PB – Bin Select for PD12, PD16, and PD18 Data Output Type

Purpose Selects which bins are output in the PD12, PD16, and PD18 data formats.

Format PB*x*,*y*,*z*

Range *x* 1 to 128
y 0 to 128
z 1 to 7

Default PB1,0,1

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

Description The PB command selects which bins are to be output by the ADCP. The *x* parameter indicates the first bin selected for output. The *y* parameter selects the number of bins to be output. A value of zero for *y* indicates that all remaining bins should be output. Beginning with bin *x*, every *z*th bin will be output until *y* total bins have been output.

1. This command has no effect if PD is set to other than PD12, PD16, or PD18.
2. You cannot output bins that have not been collected by setting the WN command.

PC – User-Interactive Built-In Tests

Purpose Sends/displays results of user-interactive WorkHorse 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.

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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.

The PC1 test is designed to measure 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 you are in 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.

If it doesn't, your system still might be okay. In this case deploy the ADCP into a bucket or container of water (preferably at least 0.5 meters deep) and record some data using *TRDI Toolz* and the log file (**F3** key), or you can record data straight to the recorder card if your ADCP has one. You can than look at the data in our *WinADCP* program and make sure that the echo amplitude counts in the 1st depth cell for all beams is between 128 and 192. If they are not, contact Field Service for further troubleshooting tips.

```
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 run while the ADCP is in air.

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 18 (see description)

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 15).

Table 15: 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
PD8	Sends ensemble data as formatted ASCII text. A new-line character terminates each line. Two new-line characters terminate an ensemble.
PD9	Sends ensemble data as formatted comma delimitated ASCII text.
PD10	Send a special DVL output data format.
PD12	Send the reduced data output format.
PD14	Send the H-ADCP Condensed 2D Output Format
PD15	The PD15 Output Data Format is designed for NDBC satellite data links.
PD16	Sea-Bird acoustic modem
PD18	PD18 is the same Output Data Format as PD16, but with the leading '$' necessary to fully comply with the NMEA format.

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

All TRDI software supports PD0 formatted data only.

The table above gives a brief overall description of the data format output. For details on the actual data output please see Output Data Format.

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PE – PD12 Ensemble Select

Purpose Selects which ensembles are output in the PD12 data format.

Format PE*nnnnn*

Range *nnnnn* = 1 to 65535

Recommended Setting. Use as needed.

Description The PE command selects which ensembles are to be output by the ADCP when PD12 is selected. Ensemble numbers 1,1+*n*,1+2*n*,... will be output.

This command has no effect if PD is set to other than PD12.

PM – Distance Measurement Facility

Purpose Lets you measure distance over the bottom.

Format PM

Recommended Setting. For TRDI use only. Not available in Workhorse II.

Description PM lets you use the ADCP to measure distances over the bottom using a dumb terminal.

PO – PD12 Velocity Component Select

Purpose: Selects the velocity components to be output in the PD12 data format.

Format: PO*abcd*

Range: 0 to 1 for *a-d*

Default PO1111

Recommended Setting. The default setting for this command is recommended for most applications. This command has no effect if PD is set to other than PD12.

Description: The PO command selects the velocity components that are output in the PD12 data format. The meaning of the four bits of this command also depends on the first two bits of the EX command as shown below.

EX00xxx - Beam Coordinates

a = beam 4 *b* = beam 3 *c* = beam 2 *d* = beam 1

EX01xxx - Instrument Coordinates

a = Error Velocity *b* = Z axis *c* = Y axis *d* = X axis

EX10xxx - Ship Coordinates

a = Error Velocity *b* = Mast *c* = Forward *d* = Starboard

EX11xxx - Earth Coordinates

a = Error Velocity *b* = Up *c* = North *d* = East

PS – Display System Parameters

Purpose Sends/displays WorkHorse ADCP system configuration data.

Format PS*n*

Range *n* = 0, 3, 4 (see description)

Recommended Setting. Use as needed.

Description See below.

PS0 – System Configuration

PS0 sends the WorkHorse ADCP hardware/firmware information. For example, the output may look like this for systems with a fluxgate compass:

```
>ps0
  Instrument S/N:  0
       Frequency:  307200 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  DOWN
       Sensor(s):  HEADING  TILT 1  TILT 2  DEPTH  TEMPERATURE  PRESSURE
Pressure Sens Coefficients:
              c3 = +0.000000E+00
              c2 = +0.000000E+00
              c1 = -2.500000E-03
          Offset = +0.000000E+00
Temp Sens Offset:  -0.20 degrees C
    CPU Firmware:  X.xx
   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:   6
Board Serial Number Data:
   08  00 00 02 C9 20 A7  09 CPU727-2000-00H
   4D  00 00 00 D4 97 37  09 PIO727-3000-03C
>
```

This example shows a Workhorse II system with ISM compass:

```
>ps0
  Instrument S/N:  0
       Frequency:  614400 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  UP
       Sensor(s):  ISM  DEPTH  TEMPERATURE  PRESSURE
Pressure Sens Coefficients:
              c3 = +0.000000E+00
              c2 = +0.000000E+00
              c1 = +8.240925E-02
          Offset = +0.000000E+00

Temp Sens Offset:  -0.13 degrees C

    CPU Firmware:  77.xx
   Boot Code Ver:  Required:  1.22   Actual:  1.22
    DEMOD #1 Ver:    2b, Type:   0
    DEMOD #2 Ver:    2b, Type:   0
    PWRTIMG  Ver:    2b, Type:   0

Board Serial Number Data:
   57  00 00 03 8F 26 DB  23 WHP727-2022-03A
   06  00 00 03 D4 C2 F9  23 PIO727-3023-13B
   07  00 00 08 D9 09 58  09 REC727-1000-03F

ISM Part Num: SNR71B-1048-61
ISM firmware version: 45.05
ISM serial number: 030000E3 23D7E86F
>
```


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PS3 – Instrument Transformation Matrix

PS3 sends information about the transducer beams. The WorkHorse 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 WorkHorse 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, download a copy of the ADCP Coordinate Transformation booklet.

PS4 – Ping Sequence

PS4 shows the water ping W and the bottom ping B sequence. For example, the output may look like this:

```
>wp30
>bp30
>ps4
Ping Sequence:  BW BW BW BW BW BW BW BW BW BW BW BW BW BW BW BW BW BW BW BW B
W BW BW BW BW BW BW BW
>
```

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 results in this 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 16: 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
```


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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 PT Test Results Error Codes) by the individual bit settings:

Table 17: 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).

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

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 non-moving water during this test to get valid test results.

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

Table 18: 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).

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

The test failure example shown below is what you would see for a missing or improperly attached transmit cable (see the WorkHorse Technical Manual – 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

The PT5 test is not a valid test and will be removed in a future firmware release.

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
```


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```
  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
```

The ADCP should be in non-moving water during this test.

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
```

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 non-moving water during this test to get valid test results.

Table 19: PT6 Receive Bandwidth Nominal Values

Bandwidth setting	WB command	75kHz	150kHz	300 kHz	600 kHz	1200 kHz
Broad	0	25	45	120	200	480
Narrow	1	7	12	28	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
>
```

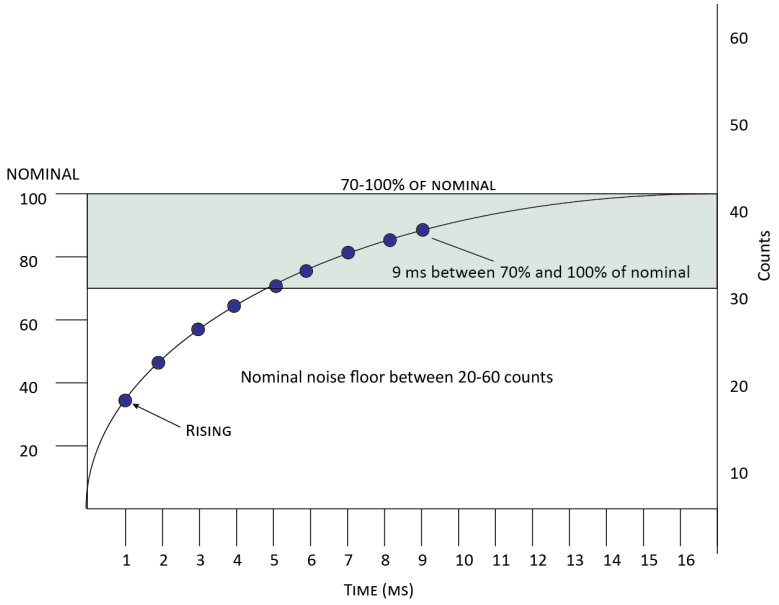

Figure 5. PT7 RSSI Bandwidth Test

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.

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Recorder Commands

The following paragraphs list all the WorkHorse ADCP CompactFlash memory card commands. The recorder is set on/off using the CF command. During a deployment, if the CompactFlash memory card(s) are full, the WorkHorse 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 CompactFlash memory card is full, the WorkHorse cannot be restarted (error message = Recorder full).

Available Recorder Commands

This section lists the available CompactFlash memory card commands.

```
>r?
Available Commands:

RA ---------------------- Number of Deployments Recorded
RB ---------------------- Recorder Built-In-Test
RD ---------------------- Open/Close Deployment File
RE ---------------------- Recorder Erase
RF ---------------------- Recorder Space used/free (bytes)
RI 1 -------------------- Auto Increment Deployment File
RN  _RDI_ --------------- Set Deployment Name
RR ---------------------- Recorder diRectory
RS ---------------------- Recorder Space used/free (Mb)
RT ---------------------- Transfer and Store ASCII Data
RY ---------------------- Upload Recorder Files to Host
R? ---------------------- Display Recorder Commands

>
```

RA – Number of Deployments

Purpose Shows the number of deployments recorded on the CompactFlash memory card.

Format RA

Recommended Setting. Use as needed.

Description RA lists the number of deployments recorded on the optional CompactFlash memory card.

Example

```
>ra
18

>
```

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, checks communication, and checks recorder functions using non-destructive methods.

Example See below.

```
>rb
RECORDER TESTS:
  PC Card #0.............................DETECTED
    Card Detect..........................PASS
    Communication........................PASS
    DOS Structure........................PASS
    Sector Test (Short)..................PASS

Recorder tests complete.
```

RD – Create Recorder File

Purpose: Opens a new deployment file or closes a currently open deployment file.

Format: RD*xxxxxx*

Range: *xxxxxx* = OPEN or CLOSE – see description

Description: RDOPEN creates a new recorder deployment file with the next increment for the current file name being used (see the RN – Set Deployment Name for information on setting the deployment name). If a file is currently open, then the RDOPEN command will cause the currently open file to close and then will open a file with the same name but the next increment number.

Example: If the deployment file _ RDI _ 000.000 was currently open and the RDOPEN command was sent than; first, the file _ RDI _ 000.000 would be closed; and second, the file _ RDI _ 001.000 would be opened. The RDCLOSE command will close the currently open file.

Deployment files are not closed automatically when using the RI0 command. Deployment files must be manually closed using the RDCLOSE command before removing the CompactFlash memory card from the WorkHorse ADCP. Failure to do this will result in the loss of the deployment data on the CompactFlash memory card.

After the RD OPEN command is sent, a Break will be necessary before the CF command can be used to reconfigure the outputs.

Example: The RDOPEN command is sent. Even after the RDCLOSE command is sent it is not possible to set CFxxxx1. Once a break is sent, the CF command can be set to enable recording.

```
>cf?
CF= 11111 ------Flow Ctrl (EnsCyc:PngCyc:Binry:Ser:Rec)
>CF11101 ERR:  014:  RD COMMAND MUST BE SET TO 0 TO ENABLE RECORDER
```


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RE – Erase Recorder

Purpose Erases and formats the CompactFlash memory card to the FAT32 format.

Format RE ErAsE <volume label>

Description RE ErAsE erases and formats the CompactFlash memory card. This command *is* case sensitive. Use RE ErAsE < volume label > to assign a volume label. The default volume label is "NO NAME ".

Use *TRDI Toolz* to download data from the CompactFlash card. **Once erased, data is not recoverable.**

Do not format or delete files from the CompactFlash card using Windows®. This may leave hidden files on the card. Always use the ADCP's RE ErAsE command to format and delete data from the CompactFlash card recorder.

A recorder card with a file count more than 50 files will cause a noticeable delay between the first ensemble and the Start Pinging (CS) command. If this delay is a concern, ensure that unwanted files are cleared before starting the deployment.

Firmware will flag an error if an unformatted, FAT16, exFAT, or another file system formatted card is installed in the Workhorse. The card can be reformatted using the RE ErAsE command.

Recommended Setting. Use as needed.

Example See below.

```
>RE ErAsE erasing...
Recorder erased.
>
>RE ErAsE volLabel erasing...
Recorder erased.
>
>RE
Must use 'RE ErAsE' or 're ErAsE' to erase recorder!
use 'RE ErAsE <name>' to assign volume label
Recorder not erased.
>
```

RF – Recorder Free Space (Bytes)

Purpose Lists the amount of used and free CompactFlash memory card 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 = 7919571,3104440320 --- Rec space used (bytes), free (bytes)

>
```

RI – Deployment Auto Increment

Purpose: Enables or Disables the deployment file increment.

Format: RIn

Range: n = 0 or 1 (0 = Append, 1 = New file)

Default: RI1

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

Description: RI1 commands the recorder to start a new deployment file on the recorder whenever a deployment has been started (CS command has been sent). RI0 commands the recorder to append to the currently open deployment file on the recorder whenever a deployment is started (CS command has been sent).

The ensemble number always initializes to ensemble 1. This means when the auto increment has been disabled (RI0) and a break has been sent to stop the current WorkHorse ADCP deployment that when the CS command is sent the next ensemble will be ensemble 1 and will be appended to the same deployment file.

Example: The RI0 command has been used and the CS command has been sent. The WH ADCP has collected 101 ensembles. The user now sends a break and uses the CE command to recover ensemble 101 from the buffer (see CE - Retrieve Most Recent Data Ensemble). The user then sends the CS command to start the deployment again. The deployment will start again, and the next ensemble written to the same deployment file will be ensemble number 1, not ensemble 102. This will not affect any TRDI software programs.

Example SC Deployment Scenario using the RI0 command

The following example describes how to use your WorkHorse ADCP in a Self-Contained deployment with TRDI Software when you do not want the deployment file number to increment.

Use TRDI's Windows software program *Workhorse II Plan* to plan the deployment. Use *TRDI Toolz* to set the clock, calibrate the compass, and test the ADCP, and start your deployment. The following steps outline the procedure.

For more information on how to use Workhorse II Plan, see the Workhorse II help file. For help with *TRDI Toolz*, click the help button.

To use the RI0 command:

1. Use *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)'s* Deployment Wizard to plan your deployment
2. Click **Save As** and name your deployment file.
3. Locate the directory that your deployment file has been saved to.
4. Open the *.txt command text file in a text editor.
5. Delete the command CR1.
6. Exit and save command file.
7. Open the TRDI software program *TRDI Toolz* and set up the software for the proper comport that the WorkHorse ADCP is connected to.
8. Use *TRDI Toolz* to set the clock, calibrate the compass, and test the WorkHorse ADCP.
9. Send a break to the ADCP.

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10. Type the command CR1 and press enter.
11. Type the command RI0 and press enter.
12. Type the command CK and press enter.
13. Once you receive the confirmation that your parameters have been saved, use the script editor to send the command file to the ADCP.

The WorkHorse ADCP will now be deployed and the RI command will have already been sent and saved in the ADCP.

Deployment files are not closed automatically when using the RI0 command. Deployment files must be manually closed using the RDCLOSE command before removing the recorder board from the WorkHorse ADCP. Failure to do this will result in the loss of the deployment data on the 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 file name for data files stored on the CompactFlash memory card. 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 second deployment file would be named "_RDI_001.000".

Example

```
>RN 123456
>RN?

Current deployment name = 12345
```

If the deployment name entered is longer than five characters, only the first five characters are used.

RR – Show Recorder File Directory

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

Format RR

Recommended Setting. Use as needed.

Description RR lists the files stored on the CompactFlash recorder in the form of a DOS directory listing.

Example: See below:

```
>rr
Recorder Directory:
Volume serial number for device #0 is ba5a-bcdb

  $$SAFE$$     <DIR>          0 01-09-48   3:02:12a rh   [     3]
  _RDI_000 000                0 05-11-21   2:01:54p r  a [     0]
  _RDI_001 000             6032 05-11-21   2:01:10p r  a [     4]
  _RDI_002 000              754 05-11-21   3:03:56p r  a [     5]
  _RDI_003 000                0 05-11-21   3:00:02p r  a [     0]
  _RDI_004 000             1508 05-11-21   3:01:50p r  a [     6]
  _RDI_005 000             1508 05-11-21   3:00:06p r  a [     7]
  _RDI_006 000             7540 05-11-21   3:02:24p r  a [     8]
  _RDI_007 000            24882 05-11-21   4:00:54p r  a [     9]
  _RDI_008 000             2262 05-11-21   4:03:34p r  a [    13]
  _RDI_009 000                0 05-11-21   4:01:00p r  a [     0]
  _RDI_010 000            16384 05-11-21   4:01:48p    a [    14]
  _RDI_011 000             4524 05-12-21   9:01:30a r  a [    16]
  _RDI_012 000            40960 05-12-21   9:01:24a    a [    17]
  _RDI_013 000           156832 05-12-21  10:02:50a r  a [    22]
  _RDI_014 000             6032 05-12-21  10:00:10a r  a [    42]
  _RDI_015 000           565500 05-12-21   2:01:30p r  a [    43]
  _RDI_016 000           401408 05-12-21   3:00:28p    a [   113]
  _RDI_017 000            64090 05-13-21  11:02:26a r  a [   162]
        B                   110 03-15-36   0:03:18a rhs  [7602176]
        _S              6619245 03-21-36   0:03:24a rhs  [7274496]
  SYSTEM~1     <DIR>          0 04-05-21   1:00:06p  hs  [ 1024]
  _RDI_018 LOG                0 07-08-21   1:01:28p r  a [     0]

  Bytes used on device #0 = 7919571
Total capacity   = 15990710272 bytes
Total bytes used =     7919571 bytes in 23 files
Total bytes free = 15989342208 bytes

>
```

RS – Recorder Free Space (Megabytes)

Purpose Lists the amount of used and free CompactFlash 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 = 002,2960 ------------- REC SPACE USED (MB), FREE (MB)

>
```


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RY – Upload Recorder Files

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

Format RY

Recommended Setting. Use *TRDI Toolz* to recover data.

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 WorkHorse ADCP unit.

Do not use Windows® to erase or format the CompactFlash memory card. Windows® sometimes creates hidden files, which will cause issues for the ADCP at the next deployment. Leave the CompactFlash memory card in the ADCP and use *TRDI Tools* to download the data and the RE ErAsE command to erase and format 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.

```
TB 00:00:00.00 --------- Time per Burst (hrs:min:sec.sec/100)
TC 00000 --------------- Ensembles Per Burst (0-65535)
TE 01:00:00.00 --------- 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 01:20.00 ------------ Time per Ping (min:sec.sec/100)
TS 21/07/08,13:27:17 --- Time Set (yr/mon/day,hour:min:sec)
TT 2021/07/08,13:27:17 - Time Set (CCYY/MM/DD,hh:mm:ss)
TX 00:00:00 ------------ Buffer Output Period: (hh:mm:ss)
T? --------------------- Display Time Help
>
```

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 99 hundredths of seconds

> **Recommended Setting.** Special applications only. Set using *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs).*

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, 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. Set using *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs).*

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 TE01:00:00.00

Recommended Setting. Set using *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs), VmDas,* or *WinRiver.*

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

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

1. The WorkHorse 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 WorkHorse ADCP wakes up to start data collection.

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

Range Minimum of 1980/01/01,00:00:00 and a maximum of 2079/12/31,23:59:59.
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 *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs).*

Description TF delays the start of data collection. This lets you deploy the WorkHorse 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 WorkHorse ADCP to start pinging, TF is tested for validity. If valid, the WorkHorse ADCP sets its alarm clock to TF, goes to sleep, and waits until time TF before beginning the data collection process. The TF Command does not support setting time of first ping exceeding 1 year from the current date.

Example If you want the exact time of the first ping to be on November 23, 1921 at 1:37:15 pm, you would enter TF21/11/23, 13:37:15. Do not enter a TF command value if you want the WorkHorse ADCP to begin pinging immediately after receiving the CS command (see notes).

1. Although you may send a TF command to the WorkHorse ADCP, you also must send the CS command before deploying the WorkHorse ADCP.
2. If the entry is not valid, the WorkHorse ADCP sends an error message and does not update the wake-up time.
3. Sending a <BREAK> clears the TF time.
4. TF Command does not support setting time of first ping exceeding 1 year from the current date.

TG – Time of First Ping (Y2K Compliant)

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

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

Range Minimum of 1980/01/01,00:00:00 and a maximum of 2079/12/31,23:59:59.

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 *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs).*

Description TG delays the start of data collection. This lets you deploy the WorkHorse 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 WorkHorse ADCP to start pinging, TG is tested for validity. If valid, the WorkHorse 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, 2021 at 1:37:15 pm, you would enter TG 2021/11/23, 13:37:15. Do not enter a TG command value if you want the WorkHorse ADCP to begin pinging immediately after receiving the CS command (see notes).

1. Although you may send a TG command to the WorkHorse ADCP, you also must send the CS command before deploying the WorkHorse ADCP.
2. If the entry is not valid, the WorkHorse ADCP sends an error message and does not update the wake-up time.
3. Sending a <BREAK> clears the TG time.

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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 TP01:20.00

Recommended Setting. Set using *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)*, *VmDas*, or *WinRiver*.

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

During the ensemble interval set by TE, the WorkHorse ADCP transmits the number of pings set by the WP command. TP determines the spacing between the pings. If TP = 0, the WorkHorse 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 WorkHorse ADCP automatically increases TE if (WP x TP) > TE.

TS – Set Real-Time Clock

Purpose Sets the WorkHorse ADCP's internal real-time clock.

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

Range Minimum of 1980/01/01,00:00:00 and a maximum of 2079/12/31,23:59:59.
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 *TRDI Toolz*, *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)*, *VmDas*, or *WinRiver*.

Example TS21/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 2021.

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

TT – Set Real-Time Clock (Y2k Compliant)

Purpose Sets the WorkHorse ADCP's internal real-time clock.

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

Range Minimum of 1980/01/01,00:00:00 and a maximum of 2079/12/31,23:59:59.

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 *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)*, *VmDas*, or *WinRiver*.

Example TT2021/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 2021.

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

TX – Buffered Output Period

Purpose Sets the minimum interval between buffered data outputs.

Format TX*hh*:*mm*:*ss*

Range *hh* = 00 to 23 hours

mm = 00 to 59 minutes

ss = unsupported – see caution below

Default TX00:00:00

Recommended Setting. This command is designed for use with the NEMO Wave Processing Module. This command may also be used for other special applications.

Avoid setting TX to values between the default TX 00:00:00 and TX 00:01:00. Values from TX 00:00:01 to TX 00:00:59 are unsupported.

Description Setting TX to zero disables the buffered output mode.

1. No data will be output during the collection of waves data.
2. Ensemble data must be in PD0 binary format.
3. The TX command will always go to the default setting after a break.

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 = 050,1 ---------------- 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 = 2000 ----------------- Error Velocity Threshold (0-5000 mm/s)
WF = 0044 ----------------- 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 = 001,005 -------------- Water Reference Layer:  Begin Cell (0=OFF), End Cell
WN = 030 ------------------ Number of depth cells (1-255)
WP = 00045 ---------------- Pings per Ensemble (0-16384)
WQ = 0 -------------------- Sample Ambient Sound (0=OFF,1=ON)
WS = 0100 ----------------- Depth Cell Size (cm)
WT = 0000 ----------------- Transmit Length (cm) [0 = Bin Length]
WU = 0 -------------------- Ping Weighting (0=Box,1=Triangle)
WV = 175 ------------------ 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)
WZ = 010 ------------------ Mode 5 Ambiguity Velocity (cm/s radial)
>
```

WA – False Target Threshold Maximum

Purpose — Sets a false target (fish) filter.

Format — WA*nnn,bbb*

Range — *nnn* = 0 to 255 counts (255 disables this filter)
bbb = 0 to 255 bins (255 disables this filter) (optional)

Default — WA050,1

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.

The optional second parameter of the WA command sets the starting bin number of the fish rejection screening. Setting the second parameter to 0 is the same as setting it to 1 (i.e. all bins will be screened for fish). Setting the second parameter to > WN and/or 255 will effectively disable fish rejection screening. Setting the first parameter without the optional second parameter will reset it to the default of 1.

A WA value of 255 turns off this feature.

WB – Mode 1 Bandwidth Control

Purpose Sets the 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 (300, 600, and 1200 kHz systems), WB1 (150 and 75 kHz systems)

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

Description See table below.

Table 20: 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.

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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 and process. The ADCP always collects header data, fixed and variable leader data, and checksum data. Setting a bit to one tells the ADCP to collect and process 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.

Each bit can have a value of one or zero. Setting a bit to one means output data, zero means suppress data.

2. This command selects which data is recorded if recording is enabled via the CF command.

3. If the CD command = zero, this command also selects which data is output. If CD is not zero, the CD command selects which data is output. See the CD command for details.

4. If WP = zero, the ADCP does not collect water-profile data.

5. Spaces in the command line are allowed.

6. Status data is not used, as it does not mean anything.

For each bit in the CD command that is enabled, the corresponding bit in the WD command must also be enabled.

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 WE2000

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

Description The WE command sets a threshold value used to flag water-current data as good or bad. If the 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 WF0704 (75 kHz), WF0352 (150 kHz), WF0176 (300 kHz), WF0088 (600 kHz), WF0044 (1200 kHz)

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

If you are using *WinRiver II*, let the 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 WorkHorse 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 21. WF-command Recommended Setting

Frequency (kHz)	200m Rated	500m Rated	1000m Rated	1500m Rated	3000m Rated	6000m Rated
1200	0.05 to 0.51m	0.05 to 0.51m	0.05 to 1.05m	n/a	n/a	0.05 to 1.05m
600	0.1 to 1.02m	0.1 to 1.02m	0.1 to 2.1m	n/a	n/a	0.1 to 2.1m
300	0.2 to 2.04m	0.2 to 2.04m	0.2 to 3.54m	n/a	n/a	0.2 to 3.54m
150	n/a	n/a	n/a	4.0m	4.00m	4.00m
75	n/a	n/a	n/a	8.0m	8.00m	n/a

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 WorkHorse 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]).

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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.

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 WL1,5

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.

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 WN030

Recommended Setting. Set using *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs), VmDas*, or *WinRiver*.

Description The range of the ADCP is set by the number of depth cells (WN) times the size of each depth cell (WS).

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 WP00045

Recommended Setting. Set using *PlanADCP* (for Workhorse ADCPs) or the *Workhorse II Plan* (for Workhorse II ADCPs), *VmDas*, or *WinRiver*.

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

	75 kHz	150 kHz	300 kHz	600 kHz	1200 kHz	2400 kHz
Range	80 to 3200 cm	40 to 3200 cm	20 to 1600 cm	10 to 800 cm	5 to 400 cm	5 to 200 cm
Default	WS1600	WS0800	WS0400	WS0200	WS0100	WS0050

Recommended Setting. Set using *PlanADCP* (for Workhorse ADCPs) or the *Workhorse II Plan* (for Workhorse II ADCPs), *VmDas*, or *WinRiver*.

Description The ADCP collects data over a variable number of depth cells. WS sets the size of each cell in vertical centimeters.

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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.

The minimum depth cells size can actually be smaller and reduced to 1 cm in water profiling mode 11 or 12 (see WK – Depth Cell Size Override).

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 WU n

Range n = 0 (Box weighting), 1 (Triangle weighting)

Default WU 0

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 22: Ping Weights

	Ping 1	Ping 2	Ping 3	Ping 4	Ping 5
WU 0	1	1	1	1	1
WU 1	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 WV175

Recommended Setting. It is strongly recommended that the WV command be left at its' default value of 175.

Description Set WV as low as possible to attain maximum performance, but not too low or ambiguity errors will occur. Rule of thumb: Set WV to the maximum relative horizontal velocity between water-current speed and ADCP speed.

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 the WV command based on the maximum apparent velocity (ADCP motion plus water speed). The following formula is used to determine the setting of the WV command:
WV = (Max. Apparent Vel. cm/s) * sin(beam angle) * 1.5, where 1.5 is a safety factor.

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.

The 1.5 value is a safety factor.

Table 23: WV command Maximum Setting (20 Degree)

WB Command	Bandwidth	WV (max cm/s)	Apparent Velocity (max cm/s)
0	25%	700	1,705
1	12%	330	804

Example If the maximum expected ADCP velocity (vessel velocity) is 250 cm/s (≈5 kt) and the maximum expected horizontal water velocity is 100 cm/s, set WV to 350 cm/s.

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High Resolution Water Profiling

This section defines the optional High-Resolution Water Profiling commands used by the WorkHorse ADCP.

High Resolution Water Profiling is a feature upgrade for other WorkHorse ADCPs (see Feature Upgrades). The highlighted commands are included with the High-Resolution Water Profiling upgrade.

```
>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 = 2000 ---------------- Error Velocity Threshold (0-5000 mm/s)
WF = 0044 ---------------- 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 = 001,005 ------------- Water Reference Layer:  Begin Cell (0=OFF), End Cell
WM = 01 ------------------ Profiling Mode (1,5,8,11,12,15)
WN = 030 ----------------- Number of depth cells (1-255)
WO = 001,004 ------------- Mode 12 Params [subpings (1-100);time (1/100th sec)]
WP = 00045 --------------- Pings per Ensemble (0-16384)
WQ = 0 ------------------- Sample Ambient Sound (0=OFF,1=ON)
WS = 0100 ---------------- Depth Cell Size (cm)
WT = 0000 ---------------- Transmit Length (cm) [0 = Bin Length]
WU = 0 ------------------- Ping Weighting (0=Box,1=Triangle)
WV = 175 ----------------- 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)
WZ = 010 ----------------- Mode 5 Ambiguity Velocity (cm/s radial)
>
```

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, or 2 cm 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. The minimum depth cell size can be 2 cm in this case. If WK is set to zero, the WS command takes precedence.

This command is only available if the High Ping Rate Profile 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.

The minimum bin size for the WK command is 2 cm. Setting the WK command to less than this will produce velocities and echo intensity results that are not correct.

WM – Profiling Mode

Purpose Selects the application-dependent profiling mode used by the ADCP.

Format WM*nn*

Range *nn* = 1, 5, 8, 11, 12, and 15 (Workhorse)
nn = 1, 11, 12, and 15 (Workhorse II)

Water Modes 5 & 8 are not available in Workhorse II firmware version 77.xx (Monitor/Sentinel) and Workhorse II 78.xx (Mariner).

Default WM1

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 24: 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 Ping Rate Profile
WM15	LADCP/Surface Track/WM15 (See Cautions below)

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.

When a WM1 or WM15 command is used in a command file, place it after the CR1 command and before any other commands to eliminate the risk of changing a previously sent parameter (see Deploying the ADCP).

For example, when the ADCP receives the WM15 command, the ADCP automatically changes several commands to LADCP appropriate values. It changes the water profile bandwidth to 6 % by setting WB and LW to 1, the number of water profile pings to 1 by setting WP and LP to 1, and the time per ensemble and time per ping to 1 second by setting TE 00:00:01.00 and TP 00:01.00 respectively.

Conversely, when the ADCP has been using WM15 and receives the WM1 command, the ADCP automatically changes the same command parameters to their factory default values (see Table 3 to view the WorkHorse ADCP factory defaults).

When the ADCP receives a WM1 or WM15 command, *the automatic command changes are transparent to the user*, who may require other bandwidth, number of pings, time per ensemble, and/or ping values.

Water Modes 11, 12 and 15 are included with the Workhorse II.

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For general information on the Water Modes, see the Principles of Operation: A Practical Primer and the WinRiver II User's Guide.

General Purpose Profiling – Mode 1

General Description - This is our most robust mode of operation. It allows for good data collection in all environments. Please refer to application note FSA-004 Mode1.pdf for more detail.

Best Use Areas - Mode 1 is good for all areas. It works well in areas of slow currents, turbulent currents, strong shears, low backscatter concentrations (or where signal returns are apt to be weak), high background noise (such as being used from a ship), and in areas where the water changes from shallow (1 m) to deep (> 6 m).

Specifics - The standard deviation determined by the bin size (WS command) and the ambiguity velocity (WV). The ambiguity velocity tells the ADCP what maximum velocity it will see. If you are operating the ADCP from a moving platform, the maximum velocity would be the ADCP's maximum speed (motion through the water) plus the maximum water speed. We call this the maximum "apparent velocity" the ADCP will see.

Setup Considerations - To set the Mode 1 ambiguity velocity correctly, you must have an idea of the maximum apparent velocity to set the WV command. Use the following formula to set the WV command:

WV = (max. apparent velocity in cm/s) * (sin B) * (1.5)

Where:

- B = Beam angle (20 degrees for the Rio Grande)
- (1.5) = Safety margin. You can reduce this safety margin if you are sure you will not exceed the maximum apparent velocity. We recommend a minimum safety margin of 1.1.

The minimum suggested setting for the WV command is 100 cm/s (WV100), which corresponds to an apparent horizontal velocity of 3 m/s.

The default setting for the WV command is 170 cm/s (WV170), which corresponds to an apparent horizontal velocity of 5 m/s.

The maximum setting for the WV command is 480 cm/s (WV480), which corresponds to an apparent horizontal velocity of 15 m/s. Higher settings will produce bad velocity data.

The values shown here do not include a safety factor.

High Resolution Profiling – Mode 5

High Resolution Water Modes 5, 8, and 11 are a feature upgrade for WorkHorse ADCPs. Contact your local sales representative if you are interested in upgrading your system. Water Modes 11, 12 and 15 are included with the Workhorse II.

Water Modes 5 is not available in Workhorse II firmware version 77.xx (Monitor/Sentinel) and Workhorse II 78.xx (Mariner).

General Description - Mode 5 is our high-precision, shallow-water mode. Mode 5 allows for very low standard deviation (less than 3 cm/s) in shallow water. Mode 5 should be used with bottom tracking enabled. Please refer to application note FSA-005 Mode5n8.pdf for more detail.

Best Use Areas - Mode 5 is ideal for shallow water with water currents less than 50 cm/s.

Mode 5 is not good for areas where there is shear, turbulence, background noise, or fast ADCP motion (above 0.5 to 1 m/s). If high shears, turbulence, background noise, or fast ADCP motion occurs, the ADCP will not collect data.

High Resolution Profiling – Mode 8

High Resolution Water Modes 5, 8, and 11 are a feature upgrade for WorkHorse ADCPs. Contact your local sales representative if you are interested in upgrading your system. Water Modes 11, 12 and 15 are included with the Workhorse II.

Water Modes 8 is not available in Workhorse II firmware version 77.xx (Monitor/Sentinel) and Workhorse II 78.xx (Mariner).

General Description - Mode 8 is our medium-precision shallow-water mode. The standard deviation of Mode 8 is about 10 times greater than Mode 5 for the same size depth cell and water speed. Mode 8 should be used with bottom tracking enabled. Please refer to application note FSA-005 Mode5n8.pdf for more detail.

Best Use Areas - Mode 8 is ideal for shallow water (8 m and less), where there is any shear, turbulence, background noise, or fast ADCP motion (maximum 1-2 m/s). Mode 8 can be used in fixed measurements or slow-moving platform measurements where the water velocity flows are very low. However, Mode 5 is better suited for those areas.

Note that if the shears, turbulence, background noise, or ADCP motion is too great, the ADCP will not collect data.

High Resolution Profiling – Mode 11

High Resolution Water Modes 5, 8, and 11 are a feature upgrade for WorkHorse ADCPs. Contact your local sales representative if you are interested in upgrading your system.

Water Mode 11 is included with the 1200 and 600 kHz Workhorse II.

General Description - Mode 11 is an evolution of Modes 5 and 8. Mode 11 allows for very low standard deviation (less than 3 cm/s) in shallow water. Mode 11 would normally be used with bottom tracking enabled. Please refer to application note FSA-013 High Resolution Water Profiling Water Mode 11.pdf for more detail.

Best Use Areas - Mode 11 is ideal for shallow water with water currents less than 100 cm/s.

Mode 11 is not good for areas where there is shear, turbulence, background noise, or fast ADCP motion (above 0.5 to 1 m/s). If high shears, turbulence, background noise, or fast ADCP motion occurs, the ADCP will not collect data.

Commands Relevant to Water Mode 11 Use

For Moving Platform users with Bottom Tracking

WM11	Selects Water Mode 11 Default =WM1
BP1	Enables Bottom Tracking. With bottom tracking enabled the transmission pulse is automatically adjusted for the depth. The system effectively “tunes” WZ for the best performance down to the default minimum of WZ5. Max. Depth is 4 m for a 1200.
WZ	If Bottom Tracking is enabled, it sets the Minimum Ambiguity velocity which is used. It is not necessary to change this command from the default WZ5 if bottom track is enabled. Default = WZ5
WK	Sets Depth Cell (Bin) size in cm, 1cm minimum (WK1). Overrides the WS command for small depth cells. If you never use depth cells less than 5cm for a 1200 or 10cm for a 600 than you can still use the WS command. Default =WK0 (uses WS)

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For Fixed Platform users

WM11	Selects Water Mode 11
WZ5	Used to adjust the characteristics of the transmission pulse for improved maximum velocity at shallower depths. With a 1200KHz ZedHed™ you would use WZ15 for depths less than 1m, WZ10 for depths up to 2m, WZ5 for depths up to 4m. Default = WZ5. Note: If WZ is changed to greater than the default WZ5 and bottom track is enabled than the range will be restricted according to the value of WZ.
BP1	Enables Bottom Tracking. With bottom tracking enabled the transmission pulse is automatically adjusted for the depth. The system effectively "tunes" WZ for the best performance down to the default Minimum of WZ5. Note: Bottom Tracking Feature is an option with some instruments.
WK	Sets Depth Cell (Bin) size in cm, 1cm minimum (WK1). Overrides the WS command for small depth cells. If you never use depth cells less than 5cm for a 1200 or 10cm for a 600 than you can still use the WS command to set the depth cell size.

WM 11 Environmental Limits

For 1200 KHz systems, a useful "rule of thumb" for determining whether the water conditions are within the envelope of Mode 11 is the Depth times Velocity product. Water Mode 11 may not work if the Depth (m) times the Velocity (m/sec) product is greater than one.

Other Environmental Limits

- Maximum relative Horizontal velocity depth <1m (1200KHz) or <2m (600KHz), 100cm/sec
- The maximum relative horizontal velocity gradually reduces with depth to approx. 25 cm/sec at 4m (1200KHz) or 8m (600KHz)
- It is important to keep in mind that with Water Mode 11, in depths less than 1 meter, the maximum beam velocity that can be reliably measured under all circumstances is 50cm/sec (this equates to 150cm/sec relative horizontal velocity as long as no vertical components are present). What this means is that the vector combination of horizontal and vertical velocities along a beam should not exceed 50cm/sec or errors may occur. As your relative horizontal velocities approach 100cm/sec in shallow water it is important to move slowly and smoothly to minimize any additional platform motion that might contribute to the relative velocity in the vertical or horizontal plane.

Other recommendations:

- Currently not recommended for 300 KHz systems.
- Maximum Depth Cell size: 0.25m (600 kHz), 0.125m (1200 kHz)
- WT can be used with the 1200 KHz ZedHed™ in shallow water (<1m) to reduce transmit pulse length. This is normally left at default WT = 0 (Transmit Pulse Length = Depth Cell Size) however if you are using small depth cells e.g., 5cm you could use WT2 to reduce the transmit pulse length to 2 cm and possibly get an extra depth cell in the profile.

High Ping Rate Profile – Mode 12

High Ping Rate Profile Mode 12 is a feature upgrade for WorkHorse ADCPs. Contact your local sales representative if you are interested in upgrading your system.

Water Mode 12 is included with the 1200 and 600 kHz Workhorse II.

General Description - Mode 12 is an evolution of our most robust water profiling Mode, Mode 1. Please refer to application note FSA-014 High Resolution Water Profiling Water Mode 12.pdf for more detail. Information on Mode 1 in the previous section can be applied to Mode 12.

Best Use Areas - Water mode 12 was designed primarily for use in short-range, small-depth cell applications. Under most conditions it can be used anywhere Mode 1 is used and due to its high ping rate results in lower standard deviation of velocity measurement for a given time period.

Specifics - Typically a Workhorse transmits pulses, collects information on the returned signal and processes this information into a velocity measurement. The process is called a ping. With Water Mode 12 we shorten the procedure and transmit and receive a series of sub-pings that are not fully processed until the desired number have been accumulated (the number is determined by the WO command). The system then averages this data and completes the final processing to produce ping velocity values, but the sub-ping raw data is not stored. Sensor data is read only once at the start of the ping and is applied to averaged sub-pings. The result is faster processing so more data can be collected for a given time and hence better measurement precision. Because of the faster ping rates with Mode 12 care must be taken not to ping too fast.

Commands Relevant to Water Mode 12 Use

WM12	Selects Water Mode 12.
WV170	Used to adjust the characteristics of the transmission pulse. A higher WV allows measurement of higher velocity currents. (100 Minimum, 480 Maximum) Default=WV170
WK1	Sets Depth Cell (Bin) size in cm, 1cm minimum (WK1). Overrides the WS command for small depth cells. If you never use depth cells less than 5cm for a 1200 or 10cm for a 600 than you can still use the WS command. Default =WK0 (uses WS)
WO pp,hh	Where pp = number of Sub pings per ping and hh = minimum number of 0.01 seconds between Sub pings. A typical setting for a 1200KHz system for use in shallow water would be WO20,4, which transmits 20 sub-pings 40msec apart and then averages them to create the ping which is recorded.

WM12 Environmental Limits

The maximum horizontal and vertical velocity is determined by the WV command. The default WV170 gives a maximum horizontal velocity measurement of +/- 5m/sec.

If Water Mode 12 is used on a platform or mooring experiencing large accelerations during the ping sampling period, then some bias may occur.

Other WM12 Considerations:

- To achieve high sampling rates (e.g., 20Hz) the number of depth cells should be less than 60 (WN command should be 60 or less).
- Maximum Sub Ping rates must be considered to avoid ping-to-ping interference.
- The sensor information is read only once at the start of the Water Mode 12 ping. Maximum duration of the Sub Pings must be considered if operating in a dynamic environment.
- Maximum duration of the Sub Pings must be considered when Bottom Tracking. If too much time separates the Water and Bottom pings “stripy data” may result. It is recommended to use BP2 in these situations.

Water Mode 15 / Lowered ADCP / Surface Tracking Feature

Water Mode 15 is a feature upgrade for WorkHorse ADCPs. Contact your local sales representative if you are interested in upgrading your system.

Water Mode 15 is included with all WorkHorse II ADCPs.

See the Lowered ADCP Guide for detailed information on using Lowered ADCP / Surface Tracking (also known as Ice Tracking) / Water Mode 15.
This guide is available for download from
https://www.teledynemarine.com/support/RDI/technical-manuals

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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 100 hundredths of seconds

Default WO 001,004

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 Ping Rate Profile feature is enabled. This command has no effect unless the WM command is set to WM12.

Water Mode 12 is included with the 1200 and 600 kHz Workhorse II.

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 must be.

NOTES

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Chapter 3

ADVANCED COMMANDS

In this chapter:

- Sound Velocity Smart Sensor Commands
- Waves Commands
- Lowered ADCP Commands
- Ping Synchronization Commands

The following sections describe the advanced commands available for the WorkHorse 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 - Serial Port Control.
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 (see CB - Serial Port Control).

If the DB command is not set to the same baud rate as the CB command, than 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 command).

The DB command is not affected by the CR command once the CK command has been sent (see CR – Retrieve Parameters).

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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 (Table 33) = 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 commands 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 uncalibrated 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.

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Waves Commands

Waves is a feature upgrade for WorkHorse ADCPs (see Feature Upgrades).

Waves requires version 16.xx or higher firmware to run. Water Modes WM5, WM11 & WM12 can be used with WAVES modes. The caveat is that more than usual care must be taken in the set-ups.

For information on how to use the Waves commands, see the WavesMon User's Guide.

Available Waves Commands

```
>h?
Available Commands:

HA 255 ------------------- Waves False Target Threshold (Fish Rejection)
HB 05 -------------------- Number of Automatically Choosen Bins (20 Max)
HD 111000000 ------------- Waves Selected Data (Vel;Pres;Surf HPR;; ;;)
HF 00000 ----------------- Waves Flow Ctrl (Res;Res;Res;Ser;Rec)
HP 0000 ------------------ Number of Pings per Record
HR 01:00:00.00 ----------- Time between Wave Bursts (hh:mm:ss.ff)
HS 001,010,021,022,023 --- Bins selected for Directional wave data recording
HT 00:00:00.50 ----------- Time between Wave Pings (hh:mm:ss.ff)
HV 001,010,021,022,023 --- Bins selected for Velocity Spectrum data recording
H? ----------------------- Display Waves Menu Help

>
```

Waves Command Descriptions

HA – Waves False Target Threshold

Purpose Sets a false target (fish) filter.

Format HA*nnn*

Range *nnn* = 0 to 255 counts (255 disables this filter)

Default HA255

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

Description The ADCP uses the HA command to screen water-track data for false targets (usually fish). HA sets the maximum difference between echo intensity readings among the four profiling beams. If the HA 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.

HB – Automatically Chosen Bins for Wave Processing

Purpose Set the number of automatically chosen bins for doing Directional Wave Spectra.

Format HB*n*

Range *n* = 1 to 20 bins (*n* = 0 disables auto-bin selection)

Default HB5

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

Description Bins are selected consecutively starting below the "contaminated area." If more than three bins are selected, and there are sufficient bins in the column, a mid column beam will be selected. If more than four bins are selected, and there are sufficient bins in the column, the first bin will be selected.

HD – Waves Data Out

Purpose Select the data output in the Waves Packet Structure.

Format HD *abc def ghi*

Range *abc def ghi* can be 1 (On) or 0 (Off).

Default HD 111 000 000

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

Description This command selects which data will be output in the waves packet data.
a – Velocity
b – Pressure
c – Surface Track
d – Heading, Pitch, and Roll
e-i – Reserved

HF – Waves Flow Control

Purpose Sets various ADCP waves data flow-control parameters.

Format HF*nnnnn*

Range Firmware switches (Res;Res;Res;Ser;Rec) see **Table 25**.

Default HF22222

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

Description The HF command is similar to the CF command (see CF - Flow Control). When the HF command is HF22222 (default), it uses the same settings as the CF command. The HF and CF commands control if the data goes to the recorder and/or to the serial port. This allows you to output Waves data (packets) independently from the standard water current profiles.

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Table 25: Waves Flow Control

Command	Description
HFxxx22	Use the same settings as the CF command (default)
HFxxx1x	Enable Serial Output – Sends the currents and waves data ensemble out the RS-232/422 serial interface.
HFxxx0x	Disable Serial Output – No waves ensemble data are sent out the RS-232/422 interface.
HFxxxx1	Enable Data Recorder – Records waves data ensembles on the recorder (if installed).
HFxxxx0	Disable Data Recorder – No waves data ensembles are recorded on the recorder.

The default HF22222 will be displayed as HF00000 when a "HF?" command is run.

HP – Waves Pings per Wave Record

Purpose Set the number of pings per wave record.

Format HP*n*

Range *n* = 0 to 8400

Default HP0

Recommended Setting. Set using *WavesMon* or *Workhorse II Plan*.

Description The command sets the number of pings collected per wave record (or burst). With this value set to zero, packets data collection is disabled.

HR – Time Between Wave Records

Purpose Set the maximum interval between the start of each wave record.

Format HR *hh*:*mm*:*ss*.*xx*
hh – hours
mm – minutes
ss – seconds
xx – hundredths of seconds

Range 00:00:00.00 – 23:59:59.99

Default HR01:00:00.00

Recommended Setting. Set using *WavesMon* or *Workhorse II Plan*.

Description This command sets the maximum interval between the start of consecutive wave records. If the number of pings per record * the time between pings is greater than the time between wave records, than the previous wave record will complete before starting the next one.

HS – Bins for Directional Wave Spectrum

Purpose Set the list of bins to use for directional wave spectrum data if the WorkHorse ADCP is not selecting bins automatically.

Format HS n1,n2...n20(Max)

Range n? = 1 - # of Water Profiling Bins (WN).

Default HS1, 10, 21, 22, 23

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

Description This command sets the bins to be used for directional wave spectrum processing if automatic bin selection is off. The list can contain a maximum of 20 bins. The limit of each element in the list is set by the number of current profiling bins being collected. This list is completely separate from the Velocity Spectrum bin list, to allow the selection of different bins for Directional Wave and Velocity Spectrum processing.

Example If automatic bin selection is turned off (HB = 0), and the WorkHorse ADCP is collecting 50 bins of current profiling data, the highest single element in the list n1-n20 is limited to 50.

HT – Time Between Wave Record Pings

Purpose Set the maximum interval between each wave ping.

Format HT *hh*:*mm*:*ss*.*xx*
hh – hours
mm – minutes
ss – seconds
xx – hundredths of seconds

Range 00:00:00.10 (0.10 sec) – 00:01:00.00 (1 minute)

Default HT00:00:00.50

Recommended Setting. Set using *WavesMon* or *Workhorse II Plan*.

Description This command sets the maximum interval between consecutive wave pings. If the number of pings per record * the time between pings is greater than the time between wave records, than the previous wave record will complete before starting the next one.

HV – Bins for Velocity Spectrum

Purpose Set the list of bins to use for velocity spectrum data if the WorkHorse ADCP is not selecting bins automatically.

Format HV n1,n2...n20(Max)

Range n? = 1 - # of Water Profiling Bins (WN).

Default HV1, 10, 21, 22, 23

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

Description This command sets the bins to be used for velocity spectrum processing if automatic bin selection is off. The list can contain a maximum of 20 bins. The limit of each element in the list is set by the number of current profiling bins being collected. This list is complete separate from the Directional Wave Spectrum bin list, to allow the selection of different bins for Directional Wave and Velocity Spectrum processing.

Example If automatic bin selection is turned off (HB = 0), and the WorkHorse ADCP is collecting 50 bins of current profiling data, the highest single element in the list n1-n20 is limited to 50.

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Lowered ADCP Commands

A standard Workhorse ADCP with firmware version 5x.xx or 7x.xx and LADCP/Surface Track/WM 15 feature upgrade installed has the capability to be set up as a Lowered ADCP (LADCP). The LADCP uses one or two Workhorse ADCPs mounted on a rosette. The rosette is lowered through the water column (one ADCP is looking up and the other is looking down). By lowering the ADCPs through the water column you can get an ocean profile that is greater in range than the systems combined. In a setup like this, you would want both ADCPs to collect data at the same time or synchronize their pinging.

Lowered ADCP is a feature upgrade for WorkHorse ADCPs (see Feature Upgrades).
Lowered ADCP is included with all WorkHorse II ADCPs.

See the Lowered ADCP Guide for detailed information on using Lowered ADCP / Surface Tracking / Water Mode 15 (also known as Ice Tracking).
This guide is available for download from
https://www.teledynemarine.com/support/RDI/technical-manuals

Available Lowered ADCP Command

```
>l?
LA = 050 ----------------- False Target Threshold (Max) (0-255 counts)
LC = 064 ----------------- Correlation Threshold
LD = 111 100 000 --------- Data Out (Vel;Cor;Amp  PG;St;P0  P1;P2;P3)
LF = 0044 ---------------- Blank After Transmit (cm)
LJ = 1 ------------------- Rcvr Gain Select (0=Low,1=High)
LN = 030 ----------------- Number of depth cells (1-128)
LP = 00000 --------------- Pings per Ensemble (0-16384)
LS = 0100 ---------------- Depth Cell Size (cm)
LV = 175 ----------------- Ambiguity Velocity (cm/s radial)
LW = 0 ------------------- Band Width Control (0=Wid,1=Nar)
LZ = 030,220 ------------- Amp, Corr Thresholds (0-255)
>
```

Lowered ADCP Command Descriptions

LA – LADCP False Target Threshold Maximum

Purpose Sets a false target (fish) filter.

Format LA*nnn*

Range *nnn* = 0 to 255 counts (255 disables this filter)

Default LA050

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

Description The ADCP uses the LA command to screen water-track data for false targets (usually fish). LA sets the maximum difference between echo intensity readings among the four profiling beams. If the LA 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 LA command value of 255 turns off this feature.

LC – LADCP Low Correlation Threshold

Purpose Sets the minimum threshold of water-track data that must meet the correlation criteria.

Format LC*nnn*

Range *nnn* = 0 to 255 counts

Default LC64

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

Description The ADCP uses LC to screen water-track data for the minimum acceptable correlation requirements. The nominal (maximum) correlation depends on system frequency and depth cell size (WS). LC 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.

LD – LADCP Data Out

Purpose Selects the data types collected by the ADCP.

Format LD *abc def ghi*

Range Firmware switches (see description)

Default LD 111 100 000

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

Description LD uses firmware switches to tell the ADCP the types of data to collect. The ADCP always collects header data, fixed/variable leader data, and checksum data. Setting a bit to 1 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 LD 111 100 000 (default) tells the ADCP to collect velocity, correlation magnitude, echo intensity, and percent good.

Each bit can have a value of one or zero; one means output data, zero means suppress data.

If the LP command is set to LP0 (zero), the ADCP does not collect water-profile data.

Spaces in the command line are allowed.

Status data is not used, as it does not mean anything.

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LF – LADCP 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 LF*nnnn*

Range *nnnn* = 0 to 9999 cm

Default LF0704 (75 kHz), LF0176 (300 kHz), LF0088 (600 kHz), LF0044 (1200 kHz), LF0022 (2400 kHz)

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

Description LF positions the start of the first depth cell at some vertical distance from the transducer head. This allows the ADCP transmit circuits time to recover before beginning the receive cycle. In effect, LF blanks out bad data close to the transducer head, thus creating a depth window that reduces unwanted data in the ensemble.

1. The distance to the middle of depth cell #1 is a function of blank after transmit (LF), depth cell size (LS), and speed of sound. The fixed leader data contains this distance.
2. Small LF values may show ringing/recovery problems in the first depth cells that cannot be screened by the ADCP.

LJ – Receiver Gain Select

Purpose Allows the ADCP to reduce receiver gain by 40 dB.

Format LJn

Range n = 0 (low), 1 (high)

Default LJ1

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

Description LJ0 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. LJ1 (the default) uses the normal receiver gain.

LN – Number of Depth Cells

Purpose Sets the number of depth cells over which the ADCP collects data.

Format LN*nnn*

Range *nnn* = 001 to 128 depth cells

Default LN030

Recommended Setting. Set using *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)*.

Description The range of the ADCP is set by the number of depth cells (LN) times the size of each depth cell (LS).

LP – Pings per Ensemble

Purpose Sets the number of pings to average in each data ensemble.

Format LP*nnnnn*

Range *nnnnn* = 0 to 16384 pings

Default LP00001

Recommended Setting. Set using *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)*.

Description LP sets the number of pings to average in each ensemble before sending/recording the data.

1. If LP = zero the ADCP does not collect water-profile data.
2. The ADCP automatically extends the ensemble interval (TE) if LP x TP > TE.

LS – Depth Cell Size

Purpose Selects the volume of water for one measurement cell.

Format LS*nnnn*

Range *nnnn* = See Table 26.

Default See Table 26.

Recommended Setting. Set using *PlanADCP (for Workhorse ADCPs) or the Workhorse II Plan (for Workhorse II ADCPs)*.

Table 26: Lowered ADCP Depth Cell Size

	300kHz	600kHz	1200kHz	2400kHz
Range	20 to 1600 cm	10 to 800 cm	5 to 400 cm	5 to 200 cm
Default	LS0400	LS0200	LS0100	LS0050

Description The ADCP collects data over a variable number of depth cells. LS sets the size of each cell in vertical centimeters.

If you set LS 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 LS1 for a 300kHz system, the ADCP uses a value of 20 cm for LS. Similarly, if you enter LS5000 for a 600kHz system, the ADCP uses a value of 800 cm for the LS command.

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LV – Ambiguity Velocity

Purpose Sets the radial ambiguity velocity.

Format LV*nnn*

Range *nnn* = 002 to 700 cm/s

Default LV175

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

Description Set LV as low as possible to attain maximum performance, but not too low or ambiguity errors will occur. Rule of thumb: Set LV to the maximum relative horizontal velocity between water-current speed and ADCP speed.

Example If the maximum expected ADCP velocity (vessel velocity) is 250 cm/s (»5 kt) and the maximum expected horizontal water velocity is 100 cm/s, set LV to 350 cm/s.

Note that the minimum setting of the LV command is LV002 and the maximum setting due to internal processing limitations is limited based on the setting of the bandwidth command, LW.

LV is limited to 330 cm/s in Narrow bandwidth mode (LW1), which increases the profiling range by 10% compared to Broad bandwidth mode (LW0).

When the LW command is set to LW0, the max value is LV700.

In either case, while you can set a value as low as 2 cm/s, this will likely cause ambiguity errors. TRDI recommends setting LV to ≥ 100cm/s for most applications.

LW – Bandwidth Control

Purpose The LW commands sets the profiling 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 LW*n*

Range *n* = 0 (Wide), 1 (Narrow)

Default LW1

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

Description See Table 27.

Table 27: Bandwidth Control

Bandwidth	Sample rate	Data variance	Profiling range
0 = Wide (25%)	High	Low	Low
1 = Narrow (6.25%)	Low	High	High

LZ – LADCP Amplitude and Correlation Thresholds

Purpose Sets the minimum correlation magnitude and threshold for good bottom-track data.

Format LZ*aaa*,*ccc*

Range *aaa* = bottom detection threshold (0 to 255 counts)

ccc = correlation magnitude (1 to 255 counts)

Default LZ030,220

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

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

The LZ command also sets the 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).

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Ping Synchronization Commands

The Teledyne RD Instruments Sleepy Sensor Synchronization (TRDS³) protocol allows a WorkHorse 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
SB = 1 ------------------- Channel B Break Interrupts are Enabled
SI = 00000 --------------- Synch Interval (0-65535)
SM = 0 ------------------- Mode Select (0=OFF,1=MASTER,2=SLAVE,3=NEMO)
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.

This command has no effect unless SM = 1 or 2.

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 28: 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.

SB – Channel B Break Interrupt Mode

Purpose Allows the ADCP to ignore a <Break> on the Channel B RS-422 lines.

Format SB*x*

Range *x* = 0 (disable hardware-break detection on Channel B)
x = 1 (enable hardware-break detection on Channel B)

Default SB1

Description Set SB0 to prevent noise from being processed as a <Break> on the RS-422 lines. This command is used when another system is connected to the ADCP over the RS-422 lines. In this configuration, disconnecting or connecting the other system can cause the ADCP to interpret this as a <Break> over Channel B. A break will cause the ADCP to stop pinging and the deployment will be interrupted.

To set the SB command to SB0, do the following.

1. Send SB0.
2. Immediately following the SB0 command, send a Break (see Break).
3. The SB0 command is now in effect and the ADCP will ignore potential <Breaks> on the Channel B RS-422 lines.

Use SB0 only when the ADCP does not conserve power (i.e. go to sleep) between samples (see CL - Battery Saver Mode and SS - RDS3 Sleep Mode).

When changing the SB command, confirm the change by immediately following the SB change with a BREAK (see Break).

The SB command must be set to SB0 to use the Master/Slave setup.

The SB command is not affected by the CR command.

The SB command is available in firmware versions 16.30 and higher.

SI – Synchronization Interval

Purpose Sets how many pings/ensembles to wait before sending the next synchronization pulse.

Format SI*nnnn*

Range *nnnn* = 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), 3 (NEMO)

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. SM3 sets the NEMO Mode and enables the SW command.

When the SM command is used, the communication switch on the ADCP's PIO board must be in the RS232 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 WorkHorse ADCP, set up 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 29: 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

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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 *TRDI Toolz* 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

RS232 Banner

```
[BREAK Wakeup A]
WorkHorse II Broadband ADCP Version 77.xx
Teledyne RD Instruments (c) 1996-2021
All Rights Reserved.
>
```

RS422 Banner

```
[BREAK Wakeup B]
WorkHorse II Broadband ADCP Version 77.xx
Teledyne RD Instruments (c) 1996-2021
All Rights Reserved.
>
```

Incomplete Banner

```
[BR
```


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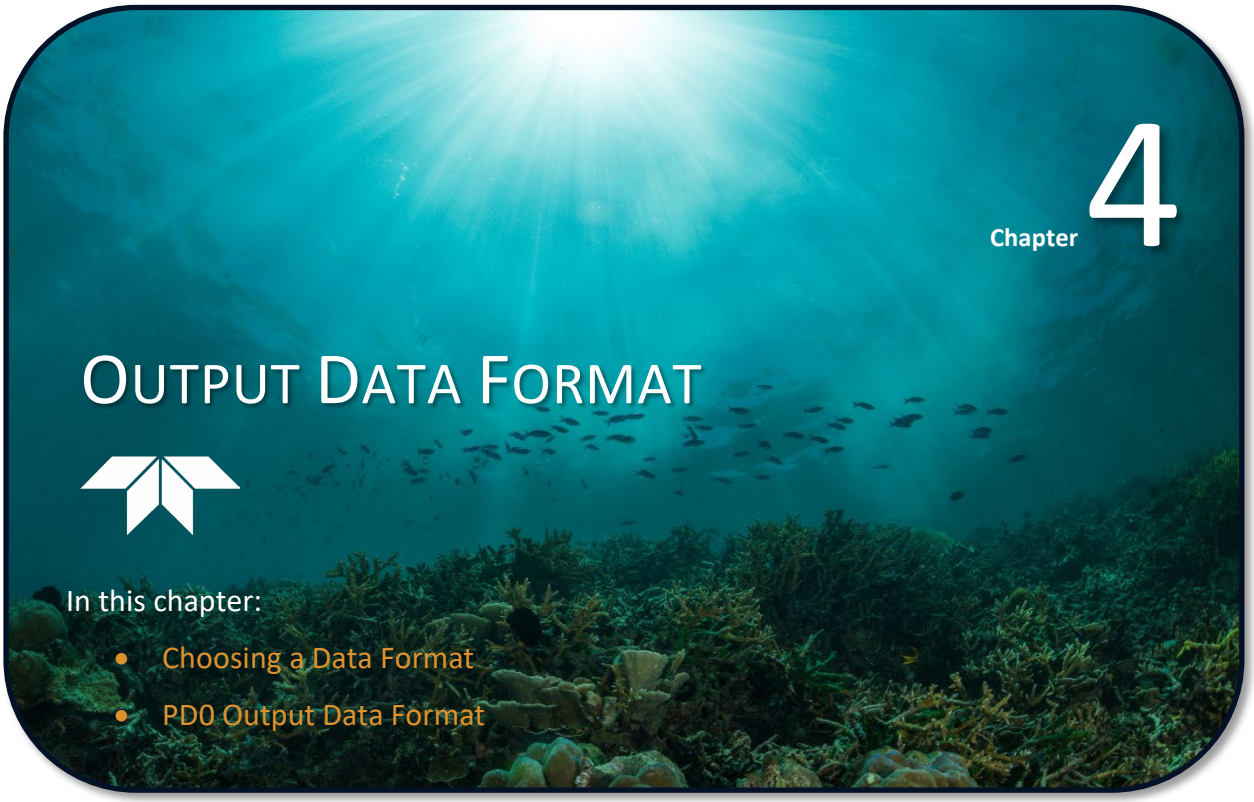

Chapter 4

OUTPUT DATA FORMAT

In this chapter:

- Choosing a Data Format
- PD0 Output Data Format

This section shows the output data format of the WorkHorse ADCP (including the Monitor/Sentinel, Quartermaster, and Long Ranger). WorkHorse ADCP output data can be in either binary or hexadecimal-ASCII format. You can select this option through the CF command (see the CF - Flow Control). We explain the output data formats in enough detail to let you create your own data processing or analysis programs (see PDDecoder).

Choosing a Data Format

The WorkHorse 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 Data Format

Use the binary format (CFxx1xx) when recording/processing WorkHorse ADCP data on an external device. The binary format uses less storage space and has a faster transmission time than the Hex ASCII format. A dumb terminal is of little use in binary format because the terminal interprets some of the data as control characters.

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

Hexadecimal-ASCII Output Data

Use the hexadecimal-ASCII (Hex ASCII) format (CFxx2xx) when you are viewing raw WorkHorse ADCP data on a computer/dumb terminal. This format uses the standard ASCII codes for 0 through F to represent numeric values as hexadecimal digits. Other standard ASCII characters (text) and control commands (carriage return, line feed, end of file, etc.) are interpreted normally. In the Hex ASCII mode, the ADCP sends data in one line of ASCII characters. There are no carriage returns and/or line feed sequences (CR/LF) sent from the ADCP. The CRT provides a CR/LF after 60 characters.

Hex ASCII PD0 data is not supported by TRDI's software.

Individual parameters within a data string may be enabled / disabled. All binary output formats have the option of outputting data in HEX-ASCII instead of true binary using the CF command (see CF - Flow Control). HEX-ASCII is an ASCII representation of the binary data. Binary output formats include PD0, 3, 4, 5 and 10. Text output formats include PD6, 8, and 9.

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.

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- **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.
- **PD8** – PD8 outputs ensemble data as formatted text. A new-line character terminates each line. Two new-line characters terminate an ensemble. PD8 data is only for serial output; the ADCP will output PD8 ASCII data out the serial port and record PD0 data to the recorder card (if enabled).
- **PD9** – PD9 is a water-profiling format meant to collect data in earth coordinates and formatted for easy parsing. All fields are fixed width, comma separated, and either zero or space padded. If PD9 is selected, there is no data written to the recorder.
- **PD10** – PD10 is similar to PD3 but with the addition of pressure and depth fields. If PD10 is selected, there is no data written to the recorder.

Special Application Output Formats

- **PD12** – is suitable for use in applications where communications bandwidth is an issue, such as acoustic modems and radio modems.
- **PD15** – is for use with NDBC satellite data links.
- **PD16** and **PD18** – are for use with Sea-Bird acoustic modems.

The following table is a summary of the type of data outputted by PD0 through PD10 data output formats. Note that this is not an exhaustive list and it is advised to check out the full description of a format before choosing it above another.

Table 30: Summary of Output Data Formats

	PD0	PD3	PD4	PD5	PD6	PD8	PD9	PD10	PD12	PD15	PD16	PD18
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				☑								
Sea-Bird											☑	☑
Binary	☑	☑	☑	☑				☑	☑	☑		
ASCII					☑	☑	☑				☑	
NMEA												☑
Serial Output	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Recorded on PC Card	PD0	None	PD4	PD5	None	PD0	None	None	PD0	PD0	PD0	PD0

*SOG = Speed Over Ground
*STW = Speed Through Water

PD0 Output Data Format

The following description is for the standard PD0 WorkHorse ADCP output data format. Figure 8 through Figure 15 shows the ASCII and binary data formats for the WorkHorse ADCP PD0 mode. Table 31 through Table 41 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 WorkHorse 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 you the choice between jumping down to the data type using the offsets or detecting the data type ID after you have detected 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)
WQ command	**AMBIENT SOUND PROFILE** (6 BYTES)
If system has ISM compass installed	**ISM** (21 BYTES)
ALWAYS OUTPUT	**RESERVED** (2 BYTES)
	CHECKSUM (2 BYTES)

Figure 6. PD0 Standard Output Data Buffer Format

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Some data outputs are in bytes per depth cell. For example, a system with an ISM compass and when the WN command (number of depth cells) = 30 (default), WD command = WD 111 100 000 (default), WP command > 0, BP command > 0, and the WQ command = 0 (default), the required data buffer storage space is 862 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)
  21  BYTES OF ISM DATA (FIXED)
   2  BYTES OF RESERVED FOR TRDI USE (FIXED)
   2  BYTES OF CHECKSUM DATA (FIXED)
-----------------------------------------------
 862  BYTES OF DATA PER ENSEMBLE
```

WinRiver II and *VmDas* 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.

VmDas adds 92 bytes of Navigation data (data ID 2000 hex) just before the Reserved/Checksum data and a two-byte offset in the header for this data type. The ENR file (raw data from the ADCP) does not have these bytes, only the ENS, ENX, STA and LTA files. *VmDas* output data format is described in the *VmDas* User's Guide.

PDDecoder Library in C language

The Teledyne Marine PDDecoder library is an open-source library written in C language to decode the PD0 data formats that are commonly output by Teledyne Marine/Teledyne RD Instruments ADCPs.

Available for download from: https://tm-portal.force.com/TMsoftwareportal

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 31 for a description of the fields.

Figure 7. Header Data Format

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Header information is the first item sent by the ADCP to the output buffer. The WorkHorse ADCP always sends the Least Significant Byte (LSB) first.

Table 31: Header Data Format

Hex Digit	Binary Byte	Field	Description
1,2	1	HDR ID / Header ID	Stores the header identification byte (7Fh).
3,4	2	HDR ID / Data Source ID	Stores the data source identification byte (7Fh for the WorkHorse 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 15).
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 WorkHorse 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 WorkHorse 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 WorkHorse 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

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BYTE	BIT POSITIONS 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								MSB
↓									↓
50									LSB
51	SYSTEM BANDWIDTH {WB}								LSB
52									MSB
53	SYSTEM POWER {CQ}								
54	SPARE								
55	INSTRUMENT SERIAL NUMBER								
↓									
58									
59	BEAM ANGLE								

See Table 32 for a description of the fields

Figure 8. Fixed Leader Data Format

Fixed Leader data refers to the non-dynamic WorkHorse ADCP data that only changes when you change certain commands. Fixed Leader data also contain hardware information. The WorkHorse ADCP always sends Fixed Leader data as output data (LSBs first).

Table 32: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	FID / Fixed Leader ID	Stores the Fixed Leader identification word (00 00h).
5,6	3	fv / CPU F/W Ver.	Contains the version number of the CPU firmware.
7,8	4	fr / CPU F/W Rev.	Contains the revision number of the CPU firmware.
9-12	5,6	Sys Cfg / System Configuration	This field defines the WorkHorse 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). Note: XDCR HD ATTACHED refers to whether the chassis and transducer are delivered as one piece; This is not a sensor detect.
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 WorkHorse 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 WorkHorse ADCP does not make this validity check. Table 37 (Percent-Good Data Format) has more information.
19,20	10	WN / Number of Cells	Contains the number of depth cells over which the WorkHorse 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 WorkHorse ADCP does not collect the WD water-profile data. Note: The WorkHorse 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

Table 32: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
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)
29-32	15,16	WF / Blank after Transmit	Contains the blanking distance used by the WorkHorse 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 WorkHorse 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 WorkHorse 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 WorkHorse 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 32: 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 WorkHorse ADCP uses the manual command setting. If the field = 1, the WorkHorse 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 WorkHorse 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 WorkHorse 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 WorkHorse 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. The CPU Board Serial number is stored in Big Endian (MSB sent first).
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 WorkHorse ADCP 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

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Variable Leader Data Format

BYTE	BIT POSITIONS 7	6	5	4	3	2	1	0	
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 33 for a description of the fields.

Figure 9. Variable Leader Data Format

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Variable Leader data refers to the dynamic WorkHorse ADCP data (from clocks/sensors) that change with each ping. The WorkHorse ADCP always sends Variable Leader data as output data (LSBs first).

Table 33: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	VID / Variable Leader ID	Stores the Variable Leader identification word (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 WorkHorse ADCP's real-time clock (RTC) that the current data ensemble began. The TS command (Set Real-Time Clock) initially sets the clock. The WorkHorse 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 WorkHorse 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 Transducer	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 WorkHorse 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 WorkHorse 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 WorkHorse ADCP roll angle (ER command). This value may be a manual setting or a reading from a tilt sensor. For up-facing WorkHorse ADCPs, positive values mean that Beam #2 is spatially higher than Beam #1. For down-facing WorkHorse 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

Table 33: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
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
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. See Converting ADC Channels for more information.
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

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Table 33: 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 WorkHorse 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 WorkHorse 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 WorkHorse 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	

Converting ADC Channels

The ADC channels in the Workhorse ADCP are defined as follows:

Channel	Signal
0	Transmit current
1	Transmit voltage
2	Ambient Temperature
3	Pressure High (+)
4	Pressure Low (-)
5	Attitude Temperature
6	Attitude Mux (X & Y tilts)
7	Contamination Sensor

Note that while each Workhorse ADC channel is 16-bits, and the full 16-bit values are used for most internal calculations (except for IXmt and VXmt), the raw counts that get output in the PD0 data are truncated to just the upper 8-bits. It is not possible to get the exact value from the ADC outputs.

XMT Voltage and Current Channels:

The Workhorse uses a frequency-indexed table to set the scale factors for the Transmit voltage and Transmit current ADC channels:

Transmit voltage	Transmit current	Frequency (kHz)
2092719	43838	76.8
592157	11451	153.6
592157	11451	307.2
380667	11451	614.4
253765	11451	1228.8
253765	11451	2457.6

The transmit voltage and current values are calculated for the built-in-test by multiplying the ADC upper 8-bit value by the scale factor (they are very rough values). However, the transmit voltage and current measurements are not necessarily accurate, since the sampling is not synchronized to the phasing of the inputs. The voltage and current tables are scaled by 1000000.

Examples (for a 600 kHz WorkHorse ADCP):

Transmit Voltage:

(90 counts * 380667) / 1000000 ➔ 34.26 Volts

Transmit Current:

(103 counts * 11451) / 1000000 ➔ 1.795 Amps

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Temperature Channels:

The temperature values are produced by plugging the 16-bit raw ADC count value into a second-order polynomial whose coefficients are hard-coded, plus an additional offset that is observed as part of the PS0 command output:

$$\text{Temperature} = \text{offset} + ((a3*x + a2)*x + a1)*x + a0$$

where:

a0 = 9.82697464E1
a1 = -5.86074151382E-3
a2 = 1.60433886495E-7
a3 = -2.32924716883E-12

Pressure Channel:

Pressure sensor internal factory reference points only; no user support.

Attitude Mux Channel:

This channel is multiplexed between the X and Y tilt signals, and the ADC values for this channel in the output data are therefore not meaningful.

Contamination Sensor:

This data is not used. The readings are generally not consistent.

How Does the WorkHorse ADCP Sample Depth and Pressure?

The WorkHorse ADCP has two options for depth. The first is to use the fixed value the user inputs into the WorkHorse through the ED command. The second is to calculate the depth based on the pressure sensor that is in the WorkHorse transducer. The WorkHorse will store both the depth (fixed or calculated) AND the pressure sensor raw kpa output.

The *WinADCP* program detects in the WorkHorse data set whether an external pressure sensor or a fixed value have been used for the depth calculation. If a fixed value is used then it will display/export the depth as found in the WorkHorse data. If a pressure sensor has been used then it will calculate the depth itself and display/export that value.

1. For each ping, the Analog-to-digital converter (ADC) located on the DSP board 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	BIT POSITIONS 7/S	6	5	4	3	2	1	0	
1	VELOCITY ID								LSB 00h
2									MSB 01h
3	DEPTH CELL #1, VELOCITY 1								LSB
4									MSB
5	DEPTH CELL #1, VELOCITY 2								LSB
6									MSB
7	DEPTH CELL #1, VELOCITY 3								LSB
8									MSB
9	DEPTH CELL #1, VELOCITY 4								LSB
10									MSB
11	DEPTH CELL #2, VELOCITY 1								LSB
12									MSB
13	DEPTH CELL #2, VELOCITY 2								LSB
14									MSB
15	DEPTH CELL #2, VELOCITY 3								LSB
16									MSB
17	DEPTH CELL #2, VELOCITY 4								LSB
18									MSB
↓	(SEQUENCE CONTINUES FOR UP TO 128 CELLS)								↓
1019	DEPTH CELL #128, VELOCITY 1								LSB
1020									MSB
1021	DEPTH CELL #128, VELOCITY 2								LSB
1022									MSB
1023	DEPTH CELL #128, VELOCITY 3								LSB
1024									MSB
1025	DEPTH CELL #128, VELOCITY 4								LSB
1026									MSB

See Table 34 for description of fields

Figure 10. Velocity Data Format

The number of depth cells is set by the WN command.

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The WorkHorse 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 WorkHorse 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 WorkHorse 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

In BEAM, if the flow along a beam is toward the ADCP center, it is a positive along the beam velocity.

In Earth (EX11xxx) coordinate frame, the ADCP outputs the East velocity component and the North velocity component. When the water flows to North, the North component is positive. When the water flows to South, the North component is negative. Similarly, if the water flows to East, the East component is positive. When the water flows to West, the East component is negative.

For Horizontal ADCP systems, use the following table.

EX-CMD	COORD SYS	VEL 1	VEL 2	VEL 3	VEL 4
EX00xxx	BEAM	TO BEAM 1	TO BEAM 2	TO BEAM 3	0
EX01xxx	INST	X AXIS	Y AXIS	0	ERROR VEL
EX10xxx	SHIP	X AXIS	Y AXIS	VERTICAL	ERROR VEL (tilt applied)
EX11xxx	EARTH	EAST	NORTH	VERTICAL	ERROR VEL (heading applied)

Positive values indicate water movement toward the ADCP.

Table 34: 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	BIT POSITIONS 7/S	6	5	4	3	2	1	0	
1	ID CODE								LSB
2									MSB
3	DEPTH CELL #1, FIELD #1								
4	DEPTH CELL #1, FIELD #2								
5	DEPTH CELL #1, FIELD #3								
6	DEPTH CELL #1, FIELD #4								
7	DEPTH CELL #2, FIELD #1								
8	DEPTH CELL #2, FIELD #2								
9	DEPTH CELL #2, FIELD #3								
10	DEPTH CELL #2, FIELD #4								
↓	(SEQUENCE CONTINUES FOR UP TO 128 BINS)								↓
511	DEPTH CELL #128, FIELD #1								
512	DEPTH CELL #128, FIELD #2								
513	DEPTH CELL #128, FIELD #3								
514	DEPTH CELL #128, FIELD #4								

See Table 35 through Table 37 for a description of the fields.

Figure 11. 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 WorkHorse 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 35: 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 WorkHorse ADCP count. The WorkHorse ADCP does not directly check for the validity of echo intensity data.

Table 36: Echo Intensity Data Format

Hex Digit	Binary Byte	Field	Description
1 – 4	1,2	ID Code	Stores the echo intensity data identification word (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 WorkHorse 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:

Field 1 – Percentage of good 3-beam solutions – Shows percentage of successful velocity calculations (50%) using 3-beam solutions because the correlation threshold (WC command) was not exceeded.

Field 2 – Percentage of transformations rejected – Shows percent of error velocity (5%) that was less than the WE command setting. WE has a default of 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 37: 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 38: 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

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BYTE	BIT POSITIONS 7/S	6	5	4	3	2	1	0	
73	BM#1 RSSI AMP								
74	BM#2 RSSI AMP								
75	BM#3 RSSI AMP								
76	BM#4 RSSI AMP								
77	GAIN								
78	(*SEE BYTE 17)								MSB
79	(*SEE BYTE 19)								MSB
80	(*SEE BYTE 21)								MSB
81	(*SEE BYTE 23)								MSB
82	RESERVED								
83									
84									
85									

Figure 12. Bottom-Track Data Format

This data is output only if the BP command is > 0 and PD0 is selected. See Table 39 for a description of the fields.

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

Bottom Track is a feature upgrade for WorkHorse ADCP Monitor and Sentinel ADCPs (see Feature Upgrades).

Bottom Track is not available for Long Ranger ADCPs.

This data is output only if the BP command is greater than zero and PD0 is selected. The LSB is always sent first.

Table 39: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the bottom-track data identification word (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

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Table 39: 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 34). 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 (Table 5).
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

Ambient Sound Profile Format

BYTE	BIT POSITIONS 7	6	5	4	3	2	1	0	
1	AMBIENT SOUND PROFILE ID CODE								LSB 0Ch
2									MSB 02h
3	AMBIENT RSSI BEAM #1								
4	AMBIENT RSSI BEAM #2								
5	AMBIENT RSSI BEAM #3								
6	AMBIENT RSSI BEAM #4								

Figure 13. Ambient Sound Profile Format

This data is output only if the WQ-command is set to WQ1 and PD0 is selected (see WQ command).

These fields contain information about the ambient sound "cell" (8 meters averaging time).

Table 40: Ambient Sound Profile

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the status data identification word (0C 02h).
5-6	3	Ambient RSSI Beam 1	Stores ambient sound data for RSSI Beam #1.
7-8	4	Ambient RSSI Beam 2	Stores ambient sound data for RSSI Beam #2.
9-10	5	Ambient RSSI Beam 3	Stores ambient sound data for RSSI Beam #3.
11-12	6	Ambient RSSI Beam 4	Stores ambient sound data for RSSI Beam #4.

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Binary ISM Data format

This contains the full heading, pitch, roll, and magnetometer data captured during the ping.

BYTE#	BIT POSITIONS 7	6	5	4	3	2	1	0	
1	ISM ID						01h		LSB
2							59h		MSB
3	Data Valid Flag								
4	X ACCELEROMETER READING								LSB
5									
6									
7									MSB
8	Y ACCELEROMETER READING								LSB
9									
10									
11									MSB
12	Z ACCELEROMETER READING								LSB
13									
14									
15									MSB
16	X MAGNETOMETER READING								LSB
17									MSB
18	Y MAGNETOMETER READING								LSB
19									MSB
20	Z MAGNETOMETER READING								LSB
21									MSB

Figure 14. ISM Data Format

Table 41: Binary ISM Data Format

Binary Byte	Field	Description
1,2	ISM ID	Stores the ISM data identification word 0x5901
3	Valid Flag	Flags whether data was received from ISM and recorded
4-7	Acc_X1	Stores the x-axis accelerometer reading
8-11	Acc_Y1	Stores the y-axis accelerometer reading
12-15	Acc_Z1	Stores the z-axis accelerometer reading
16,17	Mag_X1	Stores the x-axis magnetometer reading
18,19	Mag_Y1	Stores the y-axis magnetometer reading
20,21	Mag_Z1	Stores the z-axis magnetometer reading

The ISM calibration routine is expecting all these values to be floats (or scaled integers, i.e. the resolution is higher than pure integer values), except for the magnetometer readings, where it is expecting an INT32. Use *ISM Compass Calibration* to post-correct data to remove magnetic influences.

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Reserved BIT Data Format

	BIT POSITIONS								
BYTE	7	6	5	4	3	2	1	0	
1	RESERVED FOR TRDI USE								LSB
2									MSB

Figure 15. Reserved BIT Data Format

The data is always output. See Table 40 for a description of the fields.

Table 42: 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

	BIT POSITIONS								
BYTE	7	6	5	4	3	2	1	0	
1	CHECKSUM DATA								LSB
2									MSB

Figure 16. Checksum Data Format

The data is always output. See Table 41 for a description of the fields.

Table 43: Checksum Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Checksum Data	This field contains a modulo 65536 checksum. The WorkHorse ADCP computes the checksum by summing all the bytes in the output buffer excluding the checksum.

NOTES

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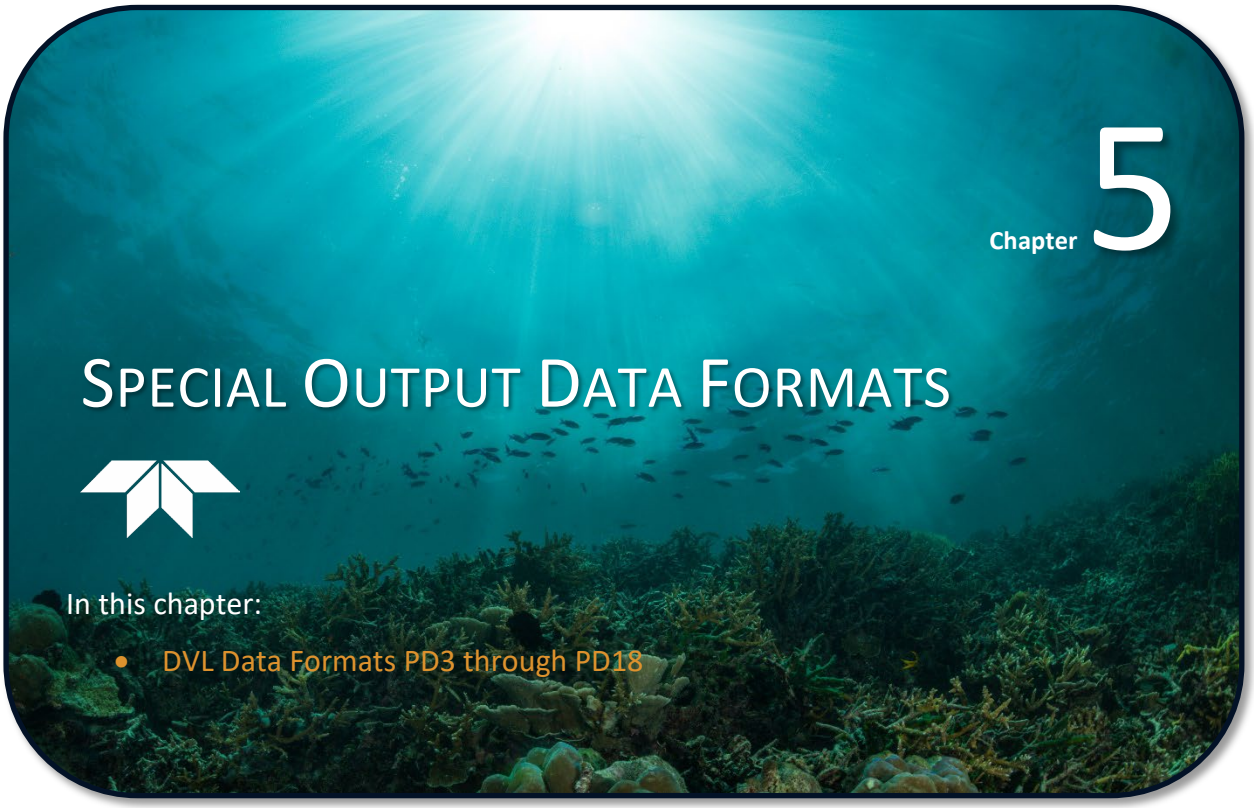

Chapter 5

SPECIAL OUTPUT DATA FORMATS

In this chapter:

- DVL Data Formats PD3 through PD18

The PD3, PD4, PD5, PD6, PD9, and PD10, commands select the desired DVL (speed log) output data format. PD8 and PD9 are special ASCII output data formats. PD12 is a reduced data output format. PD14 is a condensed 2D output format for H-ADCPs only. The PD15 Output Data Format is designed for NDBC satellite data links. PD16 and PD18 are for use with Sea-Bird acoustic modems.

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 16 through Figure 18 shows the format of these buffers and the sequence in which the ADCP sends the data. Table 42 through Table 47 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.

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DVL Data Format (PD3)

Byte	BIT POSITION 7	6	5	4	3	2	1	0	
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
48	PITCH								LSB

Byte	BIT POSITION 7	6	5	4	3	2	1	0	
49									MSB
50	ROLL								LSB
51									MSB
52	TEMPERATURE								LSB
53									MSB
54	BIT RESULTS								LSB
55									MSB
56	CHECKSUM								LSB
57									MSB

Figure 17. 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 44: 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	15,16	Bm1	† 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
33-36	17,18	Bm2 Rng to	
37-40	19,20	Bm3 Bottom	
41-44	21,22	Bm4	
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

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Table 44: 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)

	BIT POSITION								
Byte	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								

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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 18. DVL Data Format (PD4/PD5)

*If 0, than PD4 (Bytes 1-47)
*If 1, than PD5 (Bytes 1-45 + Table 44)

DVL Output Data Format (PD4/PD5) Details

The ADCP sends this data format only when the PD4 or PD5 command is used.

Table 45: 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 17. 1 = PD5 = Bytes 1 through 45 from Figure 17 and bytes 46 through 88 from Figure 18. Note: PD6 is ASCII-only; see Table 45.
5-8	3,4	No. of Bytes	Contains the number of bytes sent in this data structure, not including the final check-sum.
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

Table 45: DVL Output Data Format (PD4/PD5) Details

<table>
<tr><th>Hex Digit</th><th>Binary Byte</th><th>Field</th><th>Description</th></tr>
<tr><td>11-14
15-18
19-22
23-26</td><td>6,7
8,9
10,11
12,13</td><td>X-Vel Btm
Y-Vel Btm
Z-Vel Btm
E-Vel Btm</td><td>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).</td></tr>
<tr><td>27-30
31-34
35-38
39-42</td><td>14,15
16,17
18,19
20,21</td><td>Bm1
Bm2 Rng to
Bm3 Bottom
Bm4</td><td>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</td></tr>
<tr><td>43,44</td><td>22</td><td>Bottom Status</td><td>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</td></tr>
<tr><td>45-48
49-52
53-56
57-60</td><td>23,24
25,26
27,28
29,30</td><td>Velocity 1
Velocity 2
Velocity 3
Velocity 4</td><td>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 WorkHorse references the velocity data.
<table>
<tr><th>EX-CMD</th><th>COORD SYS</th><th>Velocity 1</th><th>Velocity 2</th><th>Velocity 3</th><th>Velocity 4</th></tr>
<tr><td>xxx00xxx</td><td>Beam</td><td>To Beam 1</td><td>To Beam 2</td><td>To Beam 3</td><td>To Beam 4</td></tr>
<tr><td>xxx01xxx</td><td>Instrument</td><td>Bm1-Bm2</td><td>Bm4-Bm3</td><td>To Xducer</td><td>Err Vel</td></tr>
<tr><td>xxx10xxx</td><td>Ship</td><td>Port-Stbd</td><td>Aft-Fwd</td><td>To Surface</td><td>Err Vel</td></tr>
<tr><td>xxx11xxx</td><td>Earth</td><td>To East</td><td>To North</td><td>To Surface</td><td>Err Vel</td></tr>
</table>
Positive values indicate water movement (see notes at end of this table).</td></tr>
<tr><td>61-64
65-68</td><td>31,32
33,34</td><td>Ref Layer Start
Ref Layer End</td><td>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</td></tr>
<tr><td>69,70</td><td>35</td><td>Ref Layer Status</td><td>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</td></tr>
<tr><td>71,72
73,74
75,76
77,78</td><td>36
37
38
39</td><td>TOFP Hour
TOFP Minute
TOFP Second
TOFP Hundredth</td><td>These fields contain the time of the first ping of the current ensemble.</td></tr>
<tr><td>79-82</td><td>40,41</td><td>BIT Results</td><td>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</td></tr>
</table>

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Table 45: DVL Output Data Format (PD4/PD5) Details

Hex Digit	Binary Byte	Field	Description
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 44.

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)

	BIT POSITION								
Byte	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									

Byte	BIT POSITION 7	6	5	4	3	2	1	0	
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									
82									MSB
83	DISTANCE MADE GOOD/REF (ERROR)								LSB
84									
85									
86									MSB
87	CHECKSUM								LSB
88									MSB

Figure 19. DVL Data Format (PD5)

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DVL Output Data Format (PD5) Details

The ADCP sends this data format (Figure 17 and Figure 18) only when the PD5 command is used. Table 43 explains the first part of this data structure.

Table 46: 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 47: 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 47: 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 WorkHorse 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
```

PD8 ASCII Output

The ADCP sends this data format only when the PD8 command is used. PD8 outputs ensemble data as formatted text. A new-line character terminates each line. Two new-line characters terminate an ensemble.

PD8 data is only for serial output. If you select PD8 and set the CF command to CFxxx11 (serial output on, recorder on), the ADCP will output PD8 ASCII data out the serial port and record PD0 data to the recorder card. You can then use the PD0 data to troubleshoot any setup problems with the ADCP.

```
1997/02/28 11:16:50.07 00001
Hdg: 209.1 Pitch: 9.6 Roll: -9.1
Temp: 22.8 SoS: 1529 BIT: 00
Bin    Dir    Mag     E/W     N/S    Vert     Err   Echo1  Echo2  Echo3  Echo4
  1     --     --  -32768  -32768  -32768  -32768      43     49     46     43
  2     --     --  -32768  -32768  -32768  -32768      44     41     45     44
  3     --     --  -32768  -32768  -32768  -32768      43     41     45     43
  4     --     --  -32768  -32768  -32768  -32768      43     41     46     43
  5     --     --  -32768  -32768  -32768  -32768      43     41     45     43
  6     --     --  -32768  -32768  -32768  -32768      42     41     46     43
  7     --     --  -32768  -32768  -32768  -32768      43     42     46     43
  8     --     --  -32768  -32768  -32768  -32768      43     40     46     43
  9     --     --  -32768  -32768  -32768  -32768      43     41     45     44
 10     --     --  -32768  -32768  -32768  -32768      44     41     46     44
```

If all four beams have good data, than direction and magnitude are output as well.

The BIT can output the following numbers depending on conditions:

- 00 = good
- 02 = Timing card error
- 08 = Demod 0 error
- 10 = Demod 1 error

PD8 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.

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PD9 ASCII Output

PD9 is a water-profiling format meant to collect data in earth coordinates and formatted for easy parsing. All fields are fixed width, comma separated, and either zero or space padded. PD9 data is for serial output only.

PD9 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.

The header information of Date, Time, Temp, Heading, and Tilts total is 55 bytes. The water-profiling information is 34 bytes per bin of data.

```
CCYY/MM/DD,HH:mm:ss,
T:ttt.t,H:ddd.d,P:+pp.p,R:+rr.r,
nnn,+vvvvv,+vvvvv,+vvvvv,+vvvvv,
.
.
.
nnn,+vvvvv,+vvvvv,+vvvvv,+vvvvv,
```

-Repeated for each ensemble-

Where

Field	Description
CC	= Fixed length (zero padded) Century
YY	= Fixed length (zero padded) Year
MM	= Fixed length (zero padded) Month
DD	= Fixed length (zero padded) Day of Month
HH	= Fixed length (zero padded) Hour
mm	= Fixed length (zero padded) Minutes
ss	= Fixed length (zero padded) Seconds
T:	= Signifies Temperature.
ttt.t	= Fixed length (space padded) Temperature in Deg C.
H:	= Signifies Heading.
ddd.d	= Fixed length (space padded) Heading in Deg.
P:	= Signifies Pitch.
+pp.p	= Fixed length (space padded) signed Pitch in Deg.
R:	= Signifies Roll.
+rr.r	= Fixed length (space padded) signed Roll in Deg.
nnn	= Fixed length (zero padded) Bin Number.
+vvvvv	= Fixed length (zero padded) signed velocity in mm/s. Beam, Inst, Ship or Earth.

Example

```
1999/04/08,14:53:04,
T: 24.3,H:185.4,P: -3.5,R: +6.7,
001,-00577,+00974,-00044,-00622,
002,-01589,-01546,-00157,+00182,
003,-00404,-00338,-00132,-00290,
004,-01055,-00931,+00103,-00004,
005,+00280,+01290,-00655,+00339,
006,+00538,+00714,+00738,+00825,
007,+01825,+00025,+00397,+00160,
008,+00371,+01181,+01169,+00892,
009,-00218,-00716,+00627,+00375,
010,-00979,+03923,-00452,-00038,
...
090,-00990,-04774,+00925,-00457,
091,-05175,-04205,+00541,+00201,
092,-06582,+01245,+00581,-00802,
093,-03221,-00999,+00141,-00467,
094,-02362,-04466,+00572,-00204,
095,-04809,-08065,+01812,-01061,
096,-08233,+04324,+02969,-00893,
097,-01679,-03700,-00573,+00401,
098,+01733,+04916,-00325,-00520,
099,-05380,+00337,-00599,-00943,
100,-00702,+03590,+00358,+00955,
```

DVL Data Format (PD10)

BYTE	BIT POSITION								
	7	6	5	4	3	2	1	0	
1	DVL DATA ID 78h								
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
48	PITCH								LSB

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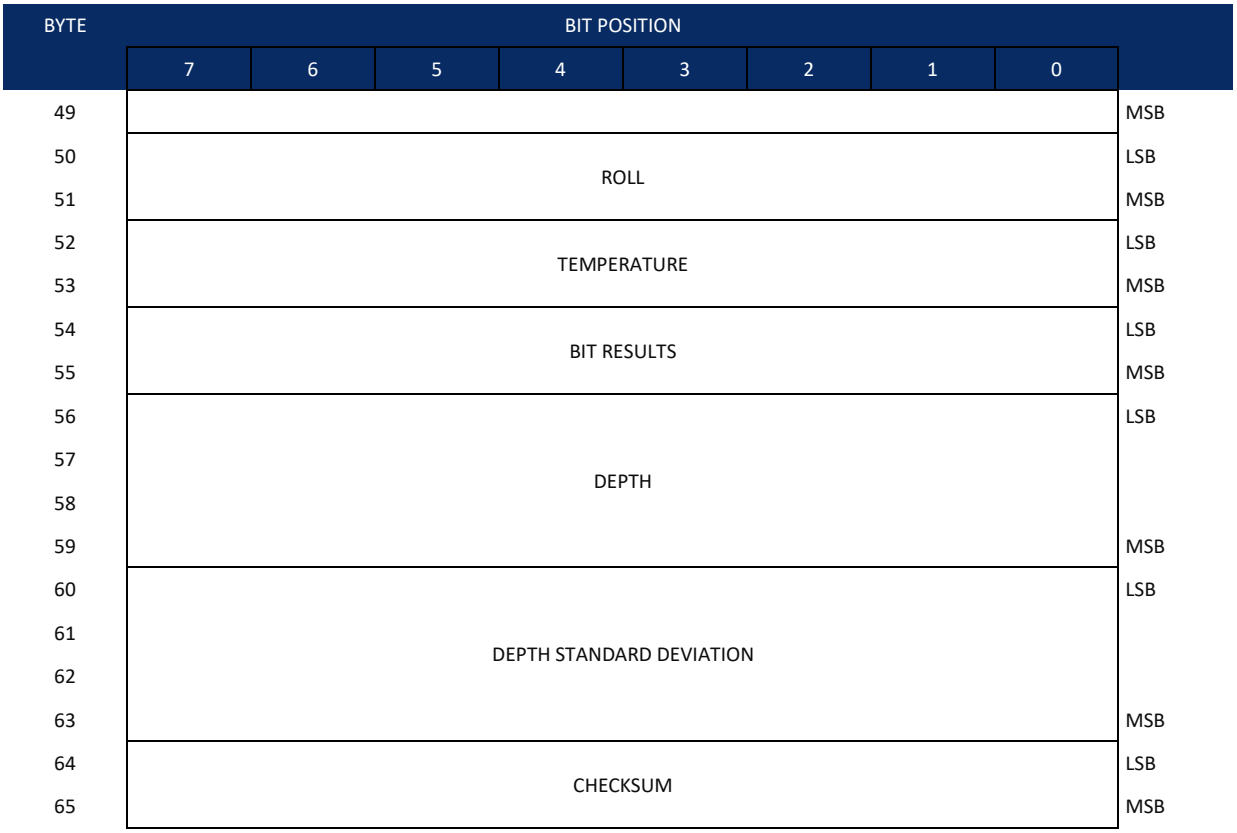

Figure 20. DVL Data Format (PD10)

PD10 Output Data Format is not available for WorkHorse ADCP Monitor/Sentinel systems with 8.xx firmware.

DVL Output Data Format (PD10) Details

The ADCP/DVL sends this data format only when the PD10 command is used. In multiple byte parameters, the least significant byte always comes before the more significant bytes.

PD10 Output Data Format is not available for WorkHorse ADCP Monitor/Sentinel systems with 8.xx firmware.

Table 48: DVL Output Data Format (PD10) Details

Hex Digit	Binary Byte	Field	Description
1,2	1	DVL Data ID	Stores the DVL (speed log) identification word (78h)
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, and (Z) Upward.
9-12	5,6	Y-Vel Btm	

Table 48: DVL Output Data Format (PD10) Details

Hex Digit	Binary Byte	Field	Description
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	15,16	Bm1	† 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
33-36	17,18	Bm2 Rng to	
37-40	19,20	Bm3 Bottom	
41-44	21,22	Bm4	
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
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: These fields contains the Heading in hundredths of degrees.
95-98	48,49	Pitch	‡ Sensor/Other Data Bit #2: These fields contains the Pitch in hundredths of degrees.
99-102	50,51	Roll	‡ Sensor/Other Data Bit #3: These fields contains the Roll in hundredths of degrees.
103-106	52,53	Temp	‡ Sensor/Other Data Bit #4: These fields contains the Temperature in hundredths of degrees.
107-110	54,55	BIT results	‡ Sensor/Other Data Bit #5: These fields 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
111-118	56-59	Depth	Depth data in decimeters.
119-126	60-63	Depth Std Dev.	Standard deviation of depth in decimeters
127-130	64,65	Checksum	This is the 16-bit checksum of all the preceding binary bytes.

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Reduced Data Output Format (PD12)

The PD12 format is suitable for use in applications where communications bandwidth is an issue, such as acoustic modems and radio modems. Setting PD12 enables the reduced data output format. Each ensemble shall be output according to Table 47. Data will continue to be recorded in the standard PD0 format. All data will be in Intel (little-endian) binary format.

Velocity data will be output according to the PB and PO commands. The PB command determines which velocity bins are output, while the PO command determines which velocity components are to be output. Each selected bin requires two bytes per velocity component. Only the components selected by the PO command will be output. All of the selected bins for each component will be output contiguously. For example, when you select to output “East “ and “North” velocities from your Data, the data will be outputted like this:

```
East Bin1
East Bin 2
East Bin 3
East bin N
North Bin 1
North Bin2
North Bin 3
North Bin N
```

The **ensemble size** is a function of the parameters supplied by the PB command, the number of data types selected by the PO command, and the number of bins selected for recording by the WN command. The ensemble size will vary as shown below.

x = start bin (first parameter of PB command)
y = number of bins for output (second parameter of PB command)
z = sub-sampling parameter (third parameter of PB command)
d = number of data types (from the PO command)
n = number of bins for recording (WN command)

If $0 < y < ((n - x) / z)$:

Size = $34 + 2 * d * y$

Otherwise:

Size = $34 + 2 * d * ((n - x) / z)$

The size calculated above is the value reported in the Size field of the ensemble format. It does not include the checksum.

The **Unit ID field** of the PD12 format is used to allow each ADCP in a network of instruments to uniquely identify itself. The field is one byte wide and is set by the CI command.

To further assist in bandwidth conservation, the CH command has been added to allow **suppression of the wakeup message**. If CH1 is saved to the user command set (via the CK command), the unit will only output a “>” when a break is sent or power is applied. It should be noted that much of the software provided by TRDI for interfacing with the ADCP relies on keywords in the wakeup banner to distinguish one type of ADCP from another. Suppression of the wakeup banner may cause this software to fail or function erratically. CH should be left at its factory default unless the user is certain that suppression of the wakeup banner will not interfere with the operation of the instrument.

Table 49: Reduced Data Output Format (PD12)

Location	Size	Field	Description
0	2	ID	Always 7F6E.
2	2	Size	Size of ensemble in bytes including ID but not including checksum.
4	4	Number	Ensemble Number
8	1	Unit ID	The ID of the ADCP as set by the CI command.
9	1	FW Vers	CPU Firmware Version.
10	1	FW Rev	CPU Firmware Revision.
11	2	Year	4-digit year of ensemble time-stamp.
13	1	Month	Month (1 – 12) of ensemble time-stamp.
14	1	Day	Day of month (1 – 31) of ensemble time-stamp.
15	1	Hour	Hour (0 – 23) of ensemble time-stamp.
16	1	Minute	Minute (0 – 59) of ensemble time-stamp.
17	1	Second	Second (0 - 59) of ensemble time-stamp.
18	1	Hsec	Hundredths of seconds (0 - 99) of ensemble time-stamp.
19	2	Heading	Heading in units of 0.01°.
21	2	Pitch	Pitch in units of 0.01°.
23	2	Roll	Roll in units of 0.01°.
25	2	Temp	Temperature in units of 0.01 °C
27	4	Pressure	Pressure in deca-Pascals (100*kPa)

31	1	Components	Bits 0-3 contain the velocity component flags of the PO command.
			Bits 4-7 contain the bin subsampling parameter of the PB command
			`bit 7 6 5 4  3 2 1 0`
			`x x x x  1 x x x  component 4`
			`x x x x  x 1 x x  component 3`
			`x x x x  x x 1 x  component 2`
			`x x x x  x x x 1  component 1`
			`n n n n  x x x x  sub-sampling parameter`

32	1	Start Bin	The first bin parameter from the PB command.
33	1	Bins	The number of bins parameter from the PB command.
34	2*N*D	Data	Velocity data. N = number of bins. D = number of velocity components selected.
34 + 2*N*D	2	Checksum	Checksum.

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Output Data Format (PD15)

The PD15 Output Data Format is designed for NDBC satellite data links. It contains the same data as the PD0 format; however the binary data is remapped using a special algorithm onto the 7-bit ASCII character set. This is done by taking groups of three 8-bit binary bytes (24 data bits), and repackaging them into four 8-bit bytes (32 bits) where the most significant two bits in each encoded byte are set to “01”, and the least significant six bits in each encoded byte contain the original data. A <CR> is then added at end of the ensemble. The reverse algorithm needs to be applied on the host end to decode the PD15 data into its original PD0 form.

Here is an example (shown both in hex and binary) of how the PD0 data is encoded to product the PD15 format (each group of three PD0 bytes are encoded into four PD15 bytes):

Hex:

```
PD0: 7F 7F 12 34 56 78    ==>    PD15: 5F 77 7C 52 4D 45 59 78"
```

Binary:

```
PD0:  01111111 01111111 00010010 00110100 01010110 01111000 ==>
PD15: 01011111 01110111 01111100 01010010 01001101 01000101 01011001
01111000
```

Output Data Format (PD16)

PD16 will NOT output data when the system is in Beam Coordinates (see EX – Coordinate Transformation). The data has to have been transformed to output meaningful data.

When configured for PD16 and recording data to the recorder (CF11111), CS will start outputting data even if the card is full or missing.

The current generation of Sea-Bird acoustic modems uses the '$' as a command terminator. This prevents them from handling the NMEA standard messages which all start with the '$' character. Consequently, the current PD16 format is:

PRDIK,sn,yyddmm,hhmmss.ss,b_1,m_1,d_1,b_2,m_2,d_2,...,b_n,m_n,d_n*xx<cr><lf>

Where:

sn	= Serial Number
yyddmm	= Date
hhmmss.ss	= Time
b_x	= Bin Number
m_x	= Magnitude (mm/s)
d_x	= Direction
xx	= NMEA checksum

- In the event of bad data, the appropriate field will be left empty, with the commas present to indicate the absence of data.
- The bins to be displayed are selected using the PB command as in the case of PD12.
- The maximum length for the message is 480 bytes.

Sea-Bird Electronics has acknowledged that they have a problem and are said to be changing their firmware to support the NMEA standard. At that time, use PD18 to meet the NMEA standard.

Output Data Format (PD18)

PD18 is the same Output Data Format as PD16, but with the leading '$' necessary to fully comply with the NMEA format.

PD18 will NOT output data when the system is in Beam Coordinates (see EX – Coordinate Transformation). The data has to have been transformed to output meaningful data.

When configured for PD18 and recording data to the recorder (CF11111), CS will start outputting data even if the card is full or missing.

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