Workhorse

Acoustic Doppler Current Profiler

Technical Manual

P/N 957-6000-00 (January 1998) Change 2

Chapter 1

Introduction

1-1 Introduction

Thank you for purchasing the RD Instruments (RDI) Workhorse Monitor (Direct-Reading) or Sentinel (Self-Contained) Broadband Acoustic Doppler Current Profiler (ADCP). This chapter is designed to help first time Workhorse users to unpack, set up, and test their ADCP.

1-2 Initial Equipment Inspection

When you receive your Workhorse, use this section to unpack and inspect the Workhorse.

1-2.1 Unpacking Inspection

Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, they should be kept until the contents of the shipment have been checked for completeness and the system has been checked mechanically and electrically.

If the contents are incomplete or there is mechanical damage, notify RDI. If the shipping container is damaged, or the cushioning material shows sign of stress, notify the carrier and RDI. Keep the shipping materials for the carrier's inspection.

1-2.2 Unpacking

When unpacking, use care to prevent physical damage to the transducer faces and connector. Use the protective cover and a soft pad to protect the transducer faces. When handling any electronics modules, follow electrostatic discharge (ESD) prevention measures.

1-2.3 Inventory

You should have the following items.

- Workhorse (One 10 MB PC Card will be installed if ordered)
- Battery Pack (Shipped separately)
- Dummy Plug (installed on the Workhorse I/O connector)
- Protective Cover (installed over transducer cups)
- I/O Cable (length specified on the Setup Card)
- Power supply
- Manuals, reference cards, and software
- Tool Bag (includes tools and standard spare parts kit)
- Spare Boards Kit (if ordered, may be shipped separately)
- RS-232 to RS-422 converter (Monitor systems only)
- Shipping Crate (Please save all foam for reshipping use)

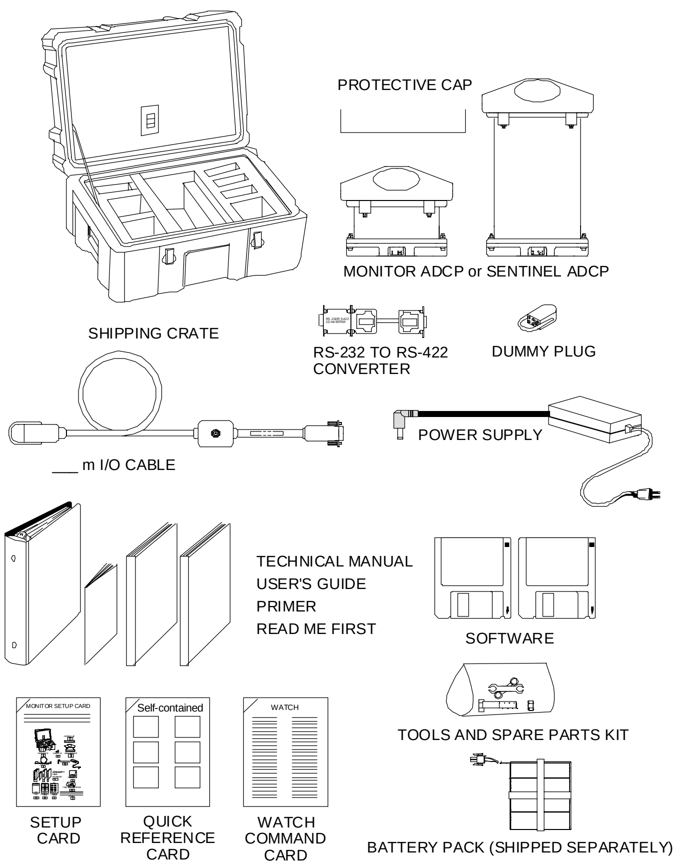


Figure 1-1.   Workhorse Inventory

1-2.4 Visual Inspection of the Workhorse

Inspect the Workhorse using the following table and Figure 1-2 and Figure 1-3. If you find any discrepancies, call RDI for instructions.

Table 1-1. Visual Inspection Criteria

Item	Inspection Criteria
Transducer head	Check the urethane surface of each transducer face. There should be no gouges, dents, scrapes, or peeling.
I/O connector	Check the I/O connector for cracks or bent pins.
Temperature indicator	The Workhorse should not be subjected to temperatures over 75° C. Check the temperature indicator located inside the shipping crate lid before using the Workhorse. Verify that the temperature window has remained white. If any of the squares on the indicator have turned black, call RDI for instructions.

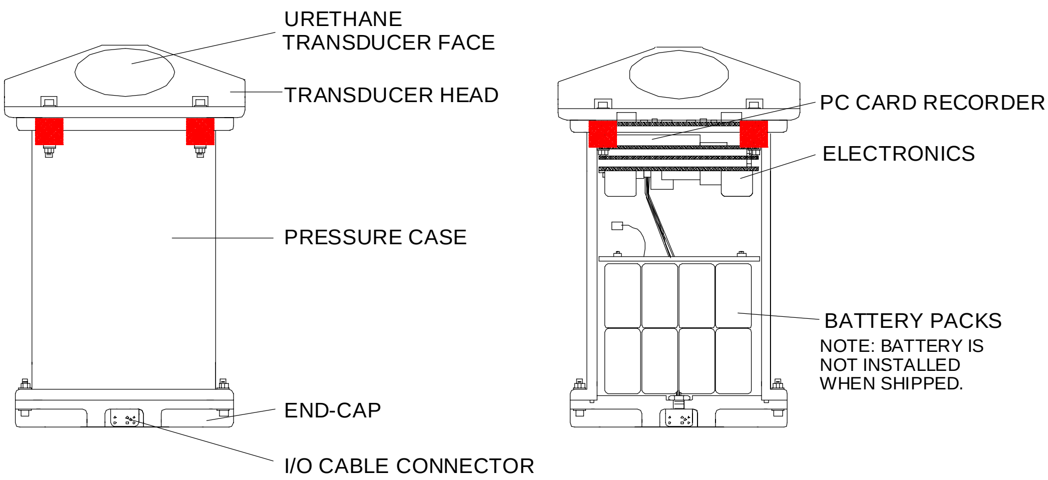


Figure 1-2. Overview of the Sentinel Workhorse

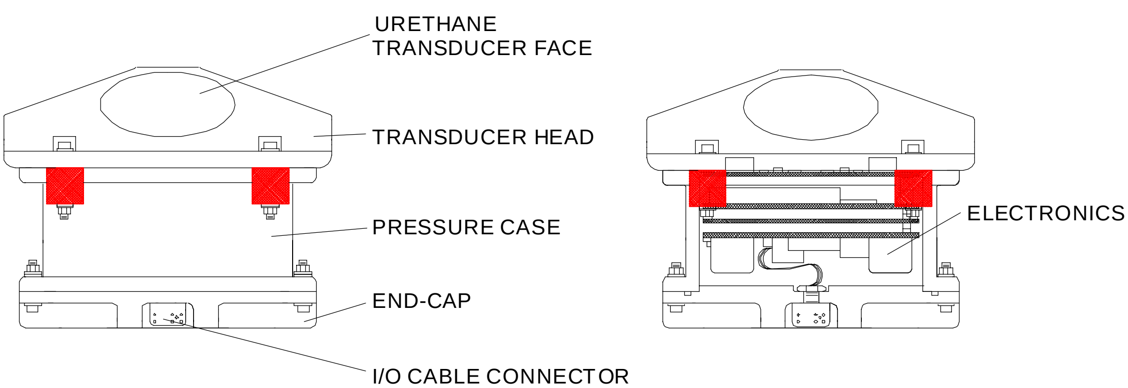


Figure 1-3. Overview of the Monitor Workhorse

1-3 Self-Contained VS Real-Time

The Monitor is a direct-reading version of the Sentinel that is less than half as long. By adding internal recording and an external battery case, the Monitor can be used the same as a Sentinel. Alternatively, the Sentinel can be used in direct-reading mode the same as a Monitor with internal batteries and/or recording for back-up.

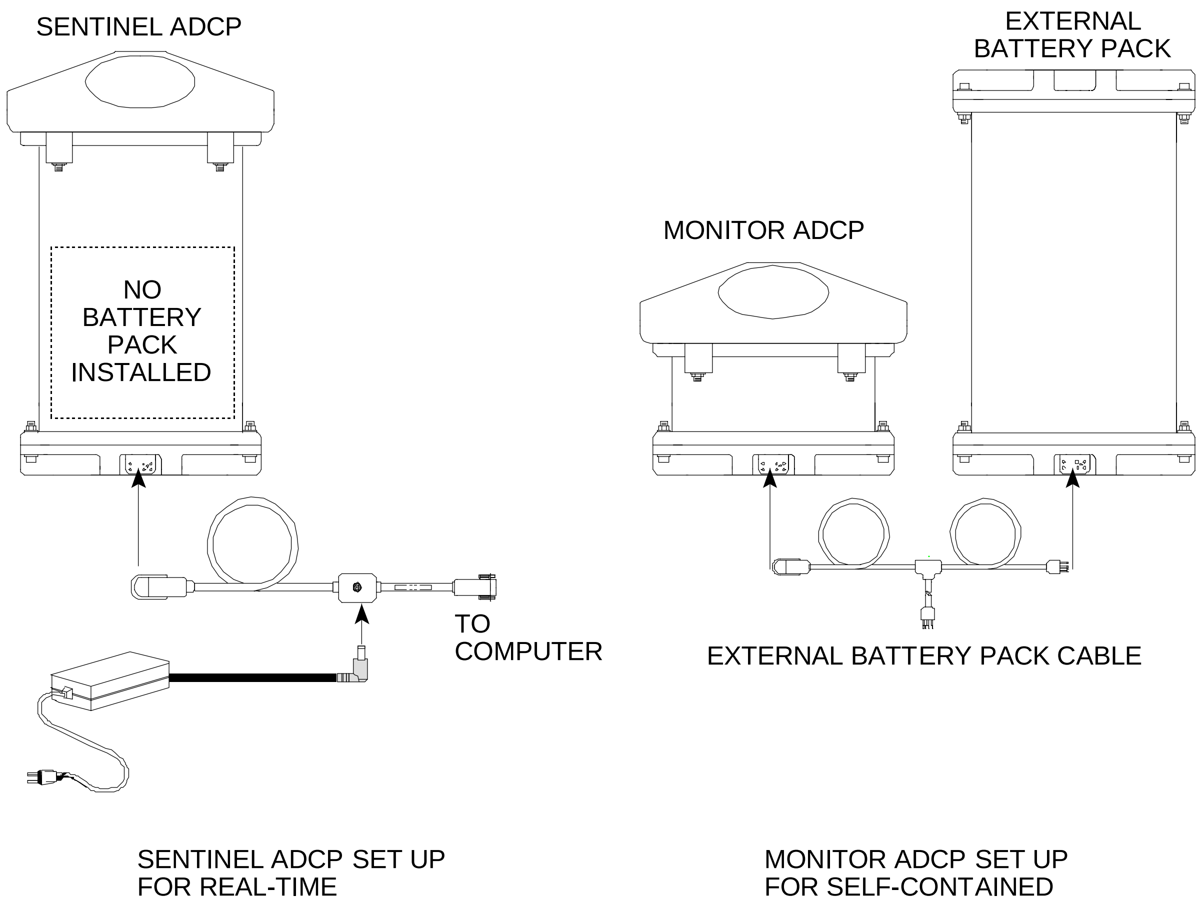


Figure 1-4. Real-Time Versus Self-Contained Setup

> **NOTE**
>
> *Keep the external battery case at least 30-cm away from the ADCP to avoid affecting the compass.*

1-4 Workhorse Care

This section contains a list of items you should be aware of every time you handle, use, or deploy your Workhorse. *Please refer to this list often.*

- Never set the transducer faces on a hard or rough surface. The urethane faces may be damaged.
- Do not expose the transducer faces to prolonged sunlight. The urethane faces may develop cracks. Cover the transducer faces on the Workhorse if it will be exposed to sunlight.
- Do not expose the I/O connector to prolonged sunlight. The plastic may become brittle. Cover the connector on the Workhorse if it will be exposed to sunlight.
- Do not scratch or damage the plastic o-ring surfaces or grooves. All o-ring grooves and surfaces must be inspected for scratches or damages on every re-assembly. If scratches or damage exist, they must be sanded out using 400 to 600 grit sandpaper. If the damage can not be repaired, contact RDI. Do not risk a deployment with damaged o-ring surfaces.
- A light amount of DC-111 lubricant on the underwater-connect cable and dummy plug connector pins (rubber portion only) will make them easier to connect or remove.
- Always remove the retaining strap on the underwater-connect cable and dummy plug when disconnecting them. Failure to do so will break the retainer strap.
- Do not lift or support a Workhorse by the external I/O cable. The connector will break.
- Do not over tighten the transducer or end-cap mounting hardware. If you over-tighten the bolts, you can crack or break the plastic flanges. The plastic bushing must not be damaged or warped. Over a long period, over-tightening can cause the plastic to creep (permanent deformations are formed primarily at the edges of washers). Conversely, under-torquing the transducer or end-cap mounting hardware can cause the Workhorse to flood.
- Make sure the O-rings stay in their groove when you re-assembly the Workhorse. Tighten the hardware as specified.
- Align the compass whenever the battery pack is replaced.
- The AC power adapter is not designed to withstand water. Use caution when using on decks in wet conditions.
- Avoid using ferro-magnetic materials in the mounting fixtures or near the Workhorse. They effect the compass.

1-5 Set Up the Sentinel Workhorse

To setup the Sentinel Workhorse, do the following steps.

a. Turn OFF or disconnect all power to all Workhorse system equipment.

b. Use Figure 1-5 to connect the Workhorse I/O cable and the computer.

c. Apply power to all equipment.

d. For testing purposes, you will need a container of water large enough to submerge the transducer head.

CAUTION

If both the battery and power supply are connected, the Workhorse will select the highest voltage source for use. The batteries (when fresh) supply +42 VDC and the power supply output is +24 VDC. The Workhorse will draw all power from the battery if the battery voltage is above +24 VDC (the power supply will have no effect).

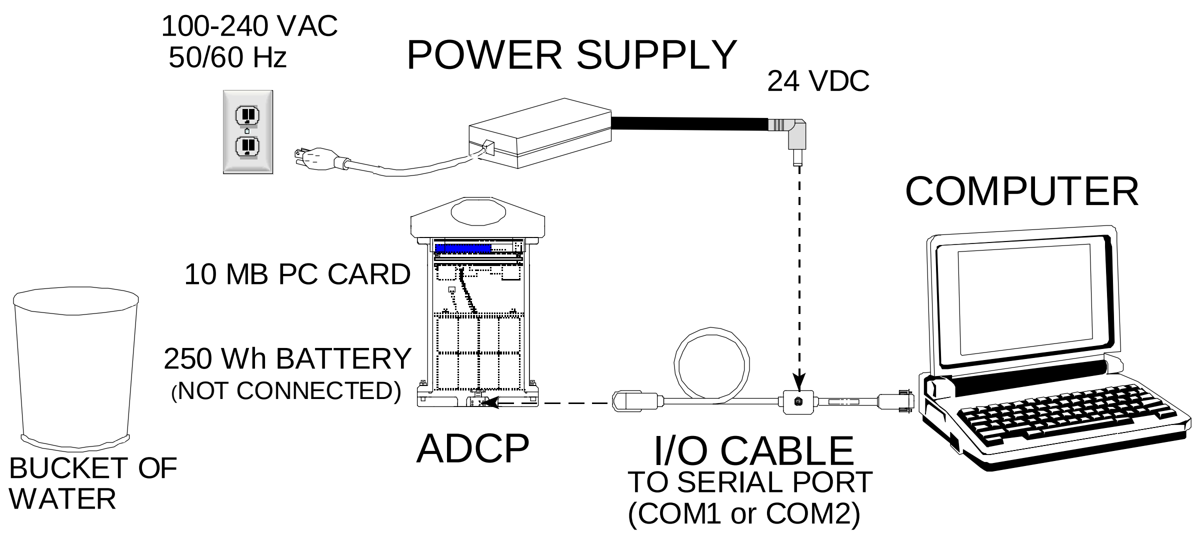


Figure 1-5. Sentinel Workhorse Connections

NOTE

The battery pack is not installed when the Sentinel ADCP is shipped. Please refer to Chapter 4 for instructions on battery installation.

1-6 Set Up the Monitor Workhorse

To setup the Monitor Workhorse, do the following steps.

a. Turn OFF or disconnect all power to all Workhorse system equipment.

b. Use Figure 1-6 to connect the Workhorse I/O cable and the computer.

c. Apply power to all equipment.

d. For testing purposes, you will need a container of water large enough to submerge the transducer head.

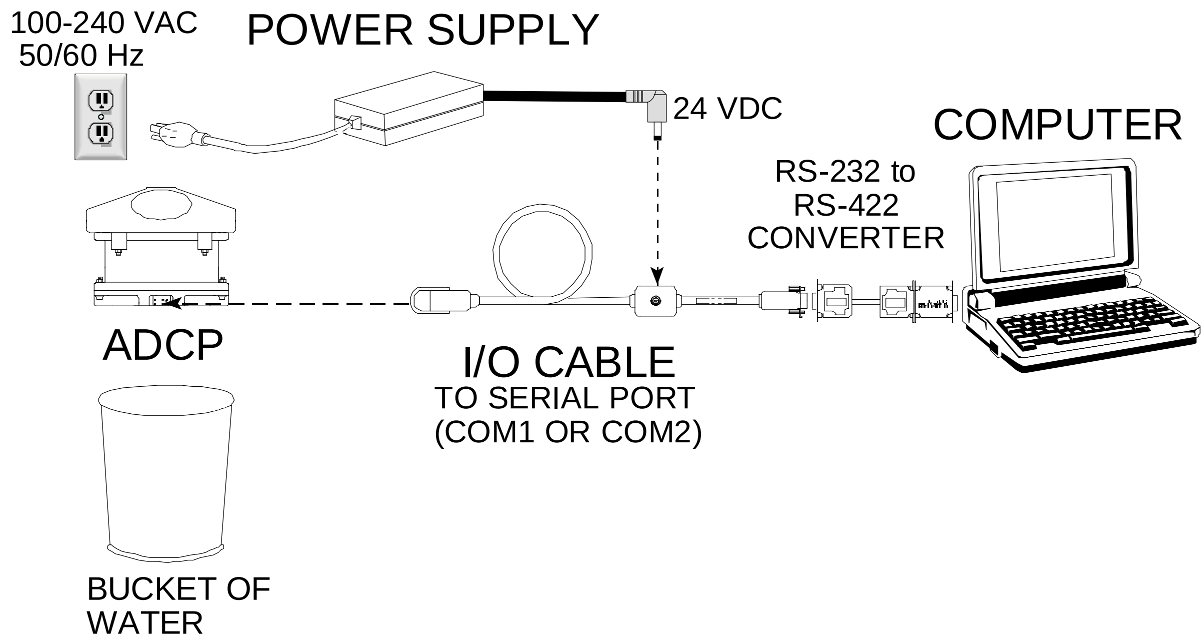


Figure 1-6. Monitor Workhorse Connections

1-7 Install the Software

Before you can use the RDI programs, they must be installed on a hard drive. The programs on the distribution disk are compressed. By using the *INSTALL* program, all the programs will be installed to the directory you specify.

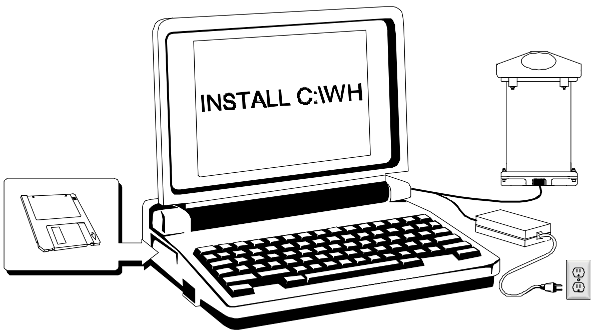


Figure 1-7. Installing the Software

Table 1-2. Workhorse Software Main Modules

Program Name	Description
BBBATCH	Batch program uses BBLIST .FMT files to convert data to ASCII
BBLIST	View and convert ADCP data files to ASCII
BBTALK	Terminal emulation program, talk to ADCP, runs script files
CHECKDAT	Checks ADCP data file integrity
CONNECT	Finds ADCP serial port, sets baud rate to 9600, saves settings for other Workhorse software, runs ADCP system test
DEPLOY	Calls INITADCP to start the ADCP for a self-contained deployment
ERASEMEM	Erases the internal ADCP recorder
INITADCP	Performs checks and start the ADCP data collection cycles (used by DEPLOY and START-UP)
MEM-INFO	Lists what files are on the ADCP internal recorder
PLAN	Plan and create a configuration command file with choices -vs- consequences
QUIKLOOK	Calls WATCH to look at recorded data using a predefined display format
RECOVER	Recover data from the internal recorder
RESET	Resets the ADCP serial settings (also displays information about ADCP)
START-UP	Calls INITADCP to start a real-time deployment and starts the WATCH program
TESTADCP	Performs comprehensive ADCP tests
WATCH	Collect, monitor and playback ADCP data

1-7.1 Software Compatibility

If you have a RDI Broadband ADCP, some Broadband software can be used on a Workhorse and vice versa. The following table shows software compatibility.

Table 1-3. Software Compatibility

SOFTWARE	SYSTEM
BBSC	BB only
BBTEST	BB only
BBLIST	BB and WH
BBTALK	BB and WH
PLAYBACK	BB and WH
TRANSECT	BB (and WH without bottom-track)
WATCH	BB and WH
PLAN	WH only
DEPLOY	WH only
STARTUP	WH only
RECOVER	WH only

1-7.2 Windows vs DOS

Some Workhorse software works in Windows 95. If not, click “Shut Down...”, then “Restart the computer in MS-DOS mode”. You can also press the F8 function key during boot-up; this will display a menu that lets you start the computer in MS-DOS mode. If you still have problems, remove (actually, rename) your computer's AUTOEXEC.BAT and CONFIG.SYS files. This forces Windows 95 to use default values and also removes other programs that may be interfering with Workhorse software operation. International users should load the appropriate keyboard driver (e.g., those in Italy would run KEYB IT).

If your computer is using Windows 95, you may get an error message “Not enough environment space” when installing RDI software. Some computers do not have enough environment space set aside (usually done through the CONFIG.SYS or AUTOEXEC.BAT files). To get the install routine to work, do the following.

a. At the DOS prompt type, COMMAND /E:2048

b. Install the software as normal (i.e.; switch to the floppy drive and type INSTALL C:\dirname.

c. After installing the software, type EXIT at the prompt. The computer is returned to the initial conditions.

1-7.3 Installing Programs

a. Place the Workhorse software disk in the disk drive (usually the "A" drive).

b. Switch to the source drive (usually "A" drive) by typing A:ENTER .

c. Type INSTALL *destination directory*. For example, typing INSTALLSPACE C:\WHENTER installs programs to the C:\WH directory. If the destination directory name does not exist, install will create the directory for you.

To run the Workhorse software from any directory, include the destination directory in your DOS directory path (defined in the AUTOEXEC.BAT file).

When the installation is complete, you should see a message similar to the following. **The file README.TXT lists all of the files that were installed.**

```
RD Instruments   ----   Acoustic Doppler Current Profilers
9855 Businesspark Avenue,   San Diego,   CA,  USA,   92131
Tel (619) 693-1178  Fax (619) 695-1459  BBS (619) 693-6879  rdi@rdinstruments.com
                                                              Abort:Ctrl-Break

Checking destination directory please wait . . .

Installing Workhorse software to c:\wh

PLAN.......Plan with choices -vs- consequences. . . . . . .OK
INITADCP...Start ADCP pinging (recorder/serial) . . . . . .OK
RECOVER....Recover data from internal recorder . . . . . . OK
BBTALK.....Terminal program, talk directly to ADCP. . . . .OK
BBLIST.....View / convert to ASCII ADCP data files. . . . .OK
WATCH......Collect, Monitor and Playback ADCP data. . . . .OK
CHECKDAT...Check ADCP data file integrity . . . . . . . . .OK
RESET......Find ADCP on serial port. . . . . . . . . . . . OK
ERASEMEM...Erase internal recorder . . . . . . . . . . . . OK
copying BATCH FILES . . . . . . . . . . . . . . . . . . . .OK

Workhorse software installation successful.

Would you like to wakeup your ADCP now (y/n) ? n

Workhorse Software, DOS Version(s) (c) RD Instruments 1996 All Rights Reserved

Prepare to collect data....
----------------------------
PLAN      Plan a configuration with choices -vs- consequences
INITADCP  Configure and start a Workhorse pinging (collecting data)

After data collection....
--------------------------
RECOVER   Recover data from internal recorder
CHECKDAT  Check ADCP data file integrity
ERASEMEM  Erase internal ADCP recorder
WATCH     Collect, monitor and playback ADCP data
RESET     Find ADCP on serial port and restore to 9600 baud
BBLIST    View and convert to ASCII ADCP data files
BBTALK    Terminal emulation program, talk directly to ADCP

HELP: Remember, follow these programs with a /? on the command line for help.
RD Instruments Phone:619-693-1178 Fax:619-695-1459 Net:rdi@rdinstruments.com
```

1-7.4 Run CONNECT

CONNECT is a batch file that establishes communication with the Workhorse and runs the System Test diagnostic.

a. Set up the Workhorse as shown in Figure 1-5, page 1-6 (Sentinel) or Figure 1-6, page 1-7 (Monitor).

b. Place the Workhorse's transducer head in enough water (approximately two to three inches) to cover the beams. *If you do not put the Workhorse in water, step four (Workhorse diagnostics) will fail several tests*. This will not harm the Workhorse, but will not assure you the Workhorse is functioning properly.

c. Type CONNECT ENTER. Follow the prompts to connect and test the Workhorse.

> **NOTE**
>
> *CONNECT will run automatically when the Install program is ran. You can use this batch file separately by typing CONNECT*ENTER.

You should see a message similar to the following.

```
CONNECT.BAT         (c)1996 RD Instruments       All rights reserved
         Licensed for exclusive use with RD Instruments products or data
         This batch file will assist you in waking up and testing your ADCP.
         To use: at the DOS prompt type CONNECT and press Enter key
```

```
STEP 1: CONNECT ADCP TO COMPUTER AND APPLY POWER
Connect your ADCP to your computer serial port and apply power.  See the connection
diagram on your Installation Reference Card or in the User's Guide.
Are you ready to continue (y/n) Y
```

```
STEP 2: Find ADCP Com Port and Baud Rate
We will now run RESET which will find your ADCP on serial ports COM1 and COM2, and
then wake it up.
Are you ready to continue (y/n) Y
RESET Version 1.20
1996 RD Instruments.  All rights reserved.
Find ADCP on COM1 or COM2 and reset baud rate
Mouse driver detected using COM1
Connecting to ADCP (press Esc key several times to abort) . . .
Trying to wake up ADCP (COM2, 9600)   CONNECTED
ADCP Wakeup message:
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 8.17
RD Instruments (c) 1997
All rights reserved.
>{}
ADCP date, time     : 96/02/21, 07:51:28
ADCP frequency (Hz) : 307200
ADCP recorder info  : 4 bytes used, 10403840 bytes free
Current ADCP serial : COM2, 9500 baud
RESET Successful. Are you ready to continue (y/n) Y
```

```
STEP 3: Save ADCP Communications Settings
BBTALK will now save the ADCP port and baud rate settings.  The other software will
look for these settings (in the file BBTALK.PTR) to find out how to communicate with
the ADCP.
```

```
Are you ready to continue (y/n) Y
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 8.17
RD Instruments (c) 1997
All rights reserved.
>{}
```

STEP 4: Perform system test to see if your ADCP works

```
The SYS-TEST batch file will now call BBTALK and run a brief series of tests on your
ADCP hardware. The results of these tests will be displayed on your screen and logged
to the file SYS-TEST.LOG.
Would you like to run the system test (y/n) Y
ADCPTEST.BAT         (c)1995 RD Instruments       (DOS VERSION 01FEB96)
This batch file will assist you in waking up and testing your ADCP.
To use: at the DOS prompt type ADCPTEST and press Enter key
           Results: saved to file ADCPTEST.LOG
Press any key to continue . . .
{}
{TESTADCP.SCR: Results are being logged to ADCPTEST.LOG...}
>
>{}
{Sending BREAK to wake ADCP...}
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 8.17
RD Instruments (c) 1997
All rights reserved.
>{}
{CF command telling ADCP to be in ASCII output mode...}
>CF11010
>
>{}
{Running ADCP Self-tests using the PA command...look for PASS}
PA
PRE-DEPLOYMENT TESTS
CPU TESTS:
  RTC.....................................PASS
  RAM.....................................PASS
  ROM.....................................PASS
RECORDER TESTS:
  PC Card #0..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
  PC Card #1..............................NOT DETECTED
  Timing RAM..............................PASS
  Demod  RAM..............................PASS
  Demod  REG..............................PASS
  FIFOs...................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Receive Loop-Back.......................PASS
  Wide Bandwidth..........................PASS
  Narrow Bandwidth........................PASS
  RSSI Filter.............................PASS
  Transmit................................PASS
SENSOR TESTS:
  H/W Operation...........................PASS
>
All tests should pass if the transducer face is immersed in water
Press ESC or ALT-X to exit BBTALK
```

1-7.5 What to do if the Workhorse Will Not Wake-up

Wakeup is the process by which the Workhorse sets up communication with a computer. Sending a BREAK signal to the Workhorse on the serial communication line begins the wake-up process. Pressing END while using *BBTALK* sends the BREAK. A BREAK is a high-voltage state (usually +3 volts) on the serial IN line. The Workhorse recognizes a BREAK that lasts 300 ms or longer. Each time you press END, you should see a message similar to the following.

```
[BREAK Wakeup A]
Workhorse Broadband ADCP Version 8.17
RD Instruments (c) 1996
All rights reserved.
>
```

If the wake-up message does not appear, check the following items.

- Is the I/O cable connected from your computer's COM port to the Workhorse? You may need to use a 25-pin to 9-pin adapter to connect the cable.
- Is power (either battery or power supply) connected to the Workhorse? Remember that Sentinel Workhorse batteries are not installed when first shipped.
- Run *RESET*. Is the Workhorse connected to COM 1 or COM 2? If you are using another COM port, *RESET* will not find the Workhorse. You must use *BBTALK* and set the communication port.
- Check the communication setup using *BBTALK*. See Chapter 5 for detailed help on using *BBTALK*. The computer and the Workhorse must be using the same baud rate and COM port (*CONNECT* and *RESET* only check COM1 and COM2). To check the communication setup, do the following.
  a. Press F5 to view the SETUP menu.
  b. Use the up/down arrow keys to select the parameter to change.
  c. Use the ENTER or SPACE key to change the parameter.
  d. Press ESC to exit the setup menu.
  e. To permanently save this setup to the BBTALK.PTR configuration file, press F6. The configuration file is saved to the directory where *BBTALK* resides.
- If wakeup still does not occur, use Chapter 6 in the Workhorse Technical Manual to troubleshoot.

NOTES

Chapter 2

Collecting Data

2-1 Introduction

This chapter is designed to help you set up the Workhorse for a practice deployment. Refer to the User's Guides and Quick Reference Card — these explain the steps required to deploy the Workhorse.

We strongly encourage you to develop your command files using *PLAN*. Using *PLAN* allows you to set the command values and see the result of your choices before deploying the ADCP. *PLAN* also adds some commands to ensure the ADCP is properly configured. You should be aware that if the command file is modified using a text editor to add, delete, or modify commands, you can not use *PLAN* to edit the file again. You may want to save the original command file using another name.

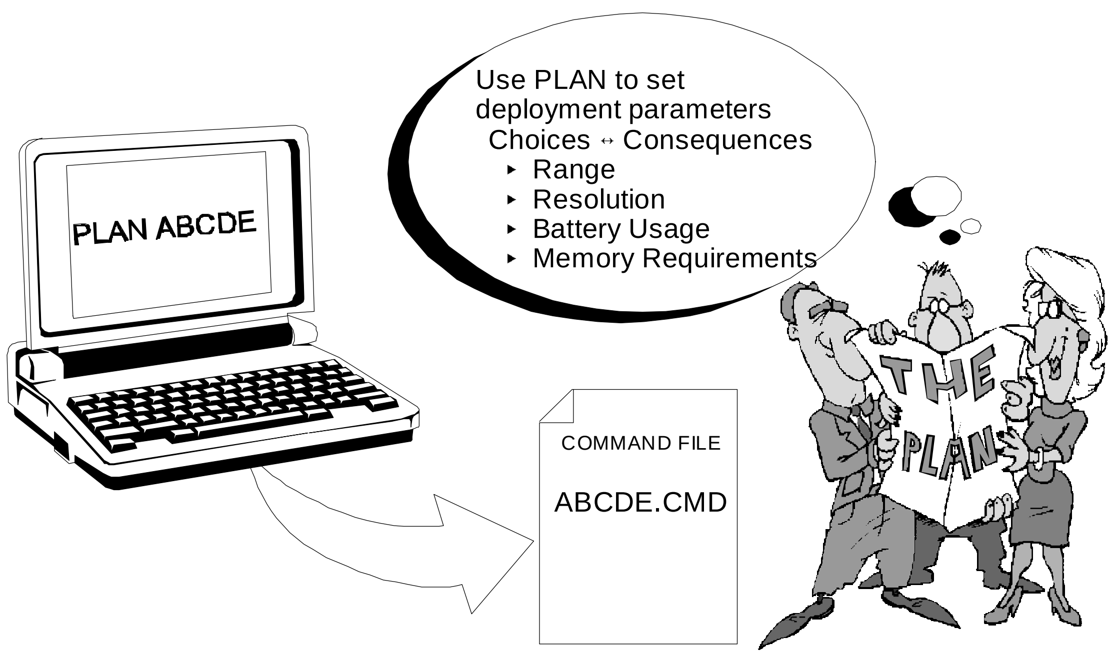


Figure 2-1. Using PLAN to Create a Command File

2.2 Creating the Command File

To create a command file, do the following steps.

a. Start PLAN.

   Decide on a command file name. The name must be *exactly* five characters or *PLAN* will not start. Where shown, substitute your five-character name for ABCDE. If the file already exists, *PLAN* will allow changes to be made (as long as the file has not been modified by other means).

   Start *PLAN* by typing the following command at the DOS prompt;
   PLAN[SPACE] ABCDE[ENTER] .

   When you start PLAN, select the frequency of your ADCP. The default settings and consequences are based upon the ADCP frequency.

b. Adjust the bin size and number of bins to match the deployment environment.

   1. Set the bin size. Adjust the bin size as necessary to get at least 10 bins. Larger bin sizes decreases the standard deviation, but shallow water situations may need to use small bins to get more data points.

   2. Set the number of bins so that the consequence *last bin range* is approximately 10% greater than the *expected max range*.

   Keep in mind the following:

   - The Maximum range is dependent on the ADCP frequency, water salinity, water temperature, and the depth of the ADCP.
   - The depth to the middle of the first bin (below the surface) is First bin range + Transducer depth. The bin size and the WF (blank) command in the command file primarily effect it.
   - The last bin range is determined from the number of bins, bin size and first bin range.
   - Standard deviation is dependent on bin size and number of pings per ensemble.

c. Adjust the number of pings to get the desired Standard Deviation. The pings are uniformly time-spaced over the ensemble interval. To increase the expected accuracy of the velocity measurement (reduce the Standard Deviation), you can increase either Pings per ensemble, Bin size or both.

d. Select the ensemble interval. This sets the (minimum) interval over which the Workhorse will collect and average the Pings per Ensemble and record data.

e. Enter the Deployment Parameters.

<u>Deployment Duration</u> **-** Enter the expected duration of the Workhorse deployment from the time of the first water profiling ping (either immediately or first ping date/time). This duration *does not* produce a Workhorse command to instruct the Workhorse to stop data collection; it is for estimating consequences only. This duration is used to estimate the following *consequences*:

- Battery usage.
- Ensembles.
- Storage required.

<u>Transducer Depth</u> **-** The ADCP uses depth in its speed of sound calculations. Some ADCPs may be equipped with an internal pressure sensor. If a pressure sensor is not available, the ADCP uses the manual depth setting.

<u>Water Salinity and Temperature</u> **-** Water salinity and temperature effects the maximum range and to a lesser extent, the battery usage. Fresh water is 0 ppt, salt water is typically 35 ppt. Press the F6 key to change the water temperature.

<u>Magnetic Variation</u> **-** Use the magnetic variation command to counteract the effects of magnetic declination on the internal Workhorse compass at the deployment site.

f. Select whether to start the deployment immediately or delayed. Entering a date and time in this field enables a delay from the start of a deployment to the first water profiling ping. When enabled, the Workhorse will begin collecting velocity data at the date and time specified by the first ping date and time. The Workhorse will sleep from the time the commands are sent to the Workhorse until the first ping date and time

g. Select where the data will be sent. Data can be stored internally, sent out the serial port, or both.

- Workhorse Sentinel ADCPs have 10-MB (standard) storage on the internal PC card recorder. This can be upgraded to 160 MB by installing two 80-MB cards.
- Monitor ADCPs usually store data on the computer's hard drive, but can have up to 160 MB on the internal PC card recorder.

h. Check the battery capacity is sufficient for the deployment.

To determine if you have sufficient battery capacity for the deployment, you must know the approximate water temperature at the deployment site and then use the following table to determine the watt-hours available (based on a fresh battery pack). A fresh battery pack has 300 watt-hours of capacity at 0° C. The external battery case can hold an additional two battery packs.

Table 2-1. Battery Capacity

Temperature	Watt-Hours	Temperature	Watt-Hours
0	300	16	417
1	305	17	430
2	310	18	444
3	315	19	457
4	320	20	470
5	325	21	477
6	330	22	485
7	335	23	492
8	340	24	500
9	345	25	508
10	350	26	515
11	355	27	523
12	365	28	530
13	378	29	538
14	391	30	545
15	404	31	552

i. Review the following consequences.

- ***Ensembles*** - Shows the expected number of ensembles generated over the duration of the deployment. Each ensemble is recorded/transmitted by the Workhorse.
- ***Start Deployment*** - Shows the expected time the Workhorse will begin pinging and taking measurements. "Immediately" means after the Workhorse is given the user CHOICES (using either *DEPLOY* or *START-UP*) the Workhorse will start pinging and taking measurements immediately. If a First ping time and date is set, *DEPLOY* or *START-UP* will show the time until data collection begins.
- ***Storage*** - Shows the amount of storage space required in megabytes (MB) to record the data generated by the Workhorse over the duration of the deployment. This value should be compared to the free space available on the internal Workhorse PC card recorder and/or free space on the Computer logging the data transmitted to the serial interface. Free space on the Workhorse internal recorder can be determined by using the RS-command.

j. Move the cursor to the Notes section. Use the area to include notes about the command file or deployment.

k. Press ALT S to save the command file.

l. Press ALT X to exit PLAN.

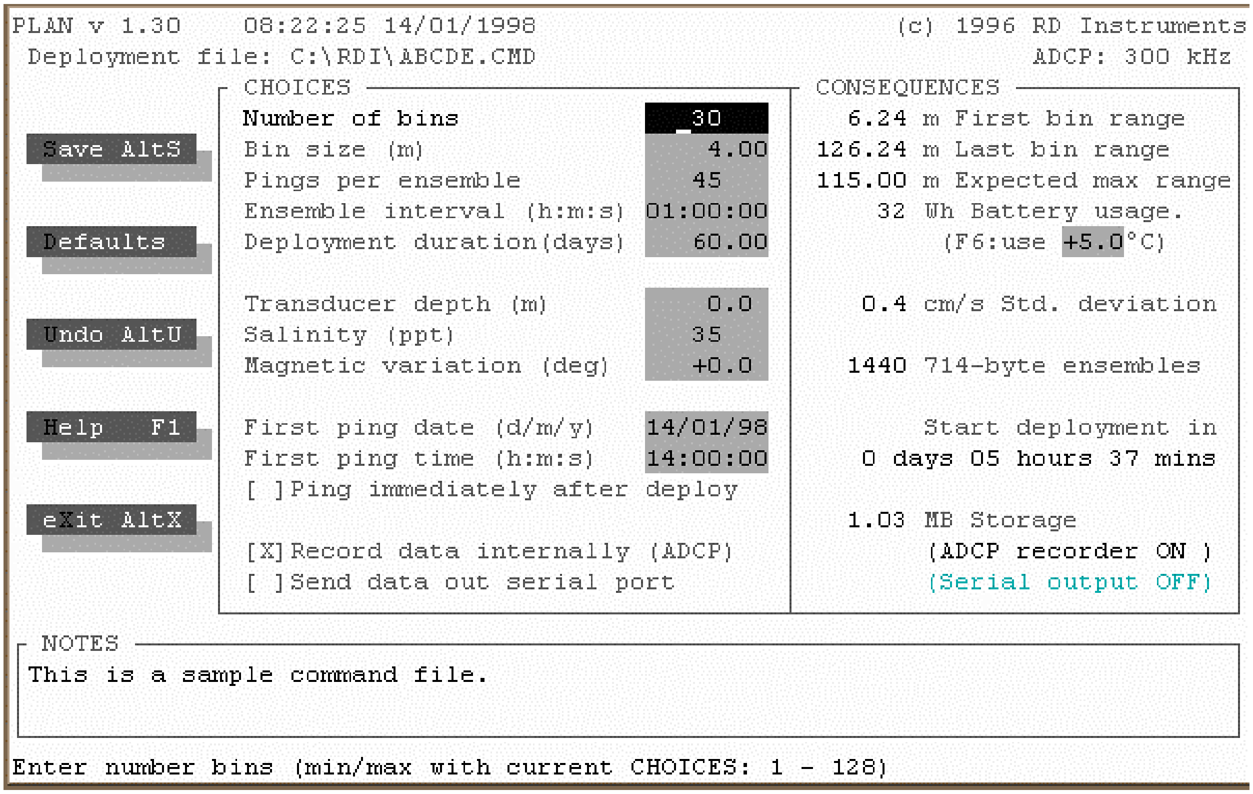


Figure 2-2. Entering Choices Using PLAN (Default Settings Shown)

2-3 Sample Printout of ABCDE.CMD

Once you have entered all of your choices using *PLAN* and saved the file, you can view the command file using any text editor. Lines beginning with a semicolon (;) are comments.

```
;This is a sample command file.
;  CR1
CR1
;  ED0000
ED0000
;  ES35
ES35
;  EX11111
EX11111
;  TE01:00:00.00
TE01:00:00.00
;  TP01:19.98
TP01:19.98
;  WD111100000
WD111100000
;  WP00045
WP00045
;  WN030
WN030
;  WS0400
WS0400
;  WF0176
WF0176
;  WV170
WV170
;  EZ1111111
EZ1111111
;  EA00000
EA00000
;  EB00000
EB00000
;  CF11101
CF11101
;  CK
CK
;  TF98/01/14,14:00:00
TF98/01/14,14:00:00
;  CS
CS

;Created as: ABCDE.CMD (1998/01/14 12:56:02.09  PLAN Version 1.30 )
;Deployment hours = 1440.00
;Temperature      = 5.00
;Frequency        = 307200.00
```

The commands shown in Table 2-2 explain each command set or added by *PLAN*. These commands directly effect the range of the ADCP, standard deviation (accuracy) of the data, and battery usage. Table 2-2 explains the commands used in the sample command file ABCDE. This command file uses the default settings for a 300kHz ADCP.

Table 2-2. Command File Created Using PLAN

Command	Choices	Description
CR1	Sets factory defaults	This is the first command sent to the ADCP to place it in a "known" state.
ED0000	Transducer depth	Manually set depth of the transducer. If a pressure sensor is installed, the ED-command will be used only if the depth sensor fails.
ES35	Salinity	Salinity of water is set to 35 (saltwater).
EX11111	Coordinate transformations	Sets Earth coordinates, use tilts, allow 3-beam solutions, and allow bin mapping to ON.
TE01:00:00.00	Time per ensemble	Ensemble interval is set to one hour.
TP01:19.98	Time between pings	Plan automatically sets the time between pings to spread the pings evenly throughout the ensemble.
WD111 100 000	Data out	Sets the ADCP to collect velocity, correlation magnitude, echo intensity, and percent-good data. Status data is not used.
WP00045	Pings per ensemble	The ADCP will ping 45 times per ensemble.
WN030	Number of depth cells	Number of bins is set to 30.
WS0400	Depth cell size	Bin size is set to 4 meters.
WF0176	Blank after transmit	Moves the location of the first depth cell 176 cm away from the transducer head.
WV170	Ambiguity velocity	Sets the maximum relative horizontal velocity between water-current speed and Workhorse speed to 170 cm/s.
EZ1111111	Sensor source	Calculate speed of sound from readings, use pressure sensor (if installed), internal compass, internal tilt sensor, and transducer temprature sensor.
EA00000	Heading alignment	Use beam-3 as the heading alignment.
EB00000	Heading bias	Magnetic variation.
CF11101	Flow control	Record data internally on the PC card recorder.
CK	Keep parameters as user defaults	If power is lost and then restored, all commands will be restored as last sent. Sent right before the CS-command.
TF98/01/14, 14:00:00	Time and date of first ping	First ping date and first ping time is set to January 14, 1998 at 2:00 pm.
CS	Start pinging	Last command sent to begin collecting data.

2-4 Power Consumption

While the Workhorse is awake and responding to commands, it consumes approximately 2.2 watts. A single internal battery pack will supply this power level for approximately *five days*. When the Workhorse is asleep, it consumes approximately 1 milli-watt. A standard battery pack will supply this power level for years. The Workhorse will “sleep” at every available opportunity to conserve power.

The Sentinel system uses battery packs to provide power. Batteries should be replaced when the voltage falls below 30 VDC (measured across the battery connector under no-load conditions). A fresh battery pack should measure 42 VDC and will supply 300 watt-hours at 0°C (see Table 2-1, page 2-4).

NOTE

You must open the Workhorse and install the battery pack before you deploy the Workhorse. See Chapter 4 for instructions on opening the Workhorse and battery connection. If you are testing or practicing with the Workhorse, use the power supply to conserve the battery.

2-5 Using the External Battery Case

The external battery case can hold up to two battery packs. Use Figure 2-3 to connect the battery pack to the ADCP. Install the dummy plug on the computer-side connector during deployments.

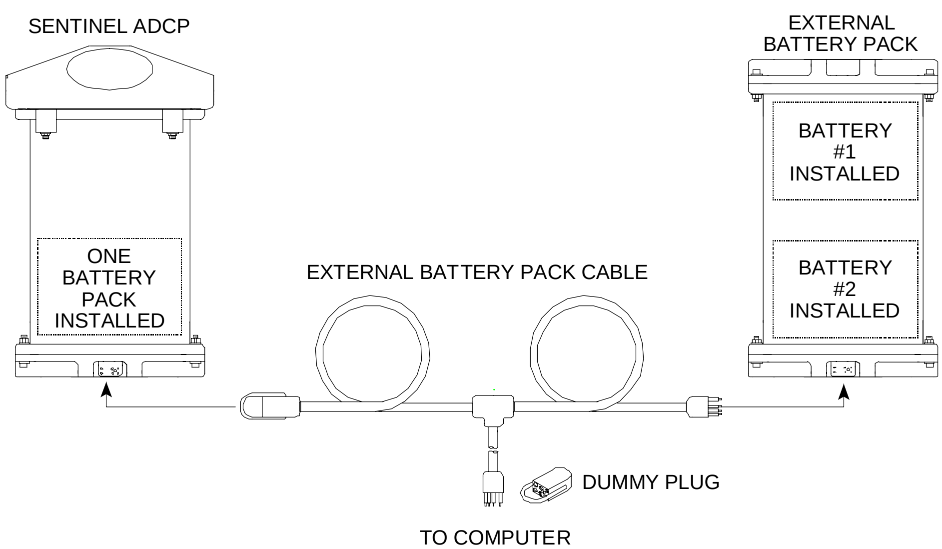


Figure 2-3. External Battery Pack Connection

NOTE

Keep the external battery pack at least 30-cm away from the ADCP to avoid affecting the compass.

2-6 Sending Deployment Commands to the Workhorse

There are two ways to send the commands to the Workhorse. If you are using the Workhorse for a self-contained deployment, use *DEPLOY*. If you are using the Workhorse for a real-time deployment, use *START-UP*. Both of these batch files call the program *INITADCP*.

2-6.1 Using DEPLOY

Set up the Workhorse as shown in Chapter 1. Start the Workhorse pinging by entering the following at the DOS prompt; DEPLOY[SPACE] ABCDE[ENTER] (substitute your 5-character command file name for ABCDE).

DEPLOY will wakeup the Workhorse, and do the following:

- Prompt you to set the date and time on your computer. The computer's date and time is used to set the ADCP's clock.
- Checks the battery voltage (it will give you a warning if it thinks the battery is not connected or the voltage level is low).
- Checks the recorder.
- Sends the commands from your command file. If the Workhorse is using the same command file as a previous deployment, you will be prompted to change the name of your command file. This prevents you from overwriting previously recorded data.
- Sets the deployment name to ABCDE. Data on the PC card recorder will be in the ABCDE directory.
- Creates the deployment log file (ABCDE.DLG). If you see the prompt "THERE WAS A PROBLEM WITH YOUR DEPLOYMENT," view the deployment log file for details of the error.
- Starts the Workhorse pinging. You should hear the Workhorse "beep" every ping. If a date and time of first ping was entered, the ADCP will wait to begin pinging.

2-6.2 Using START-UP

Start the Workhorse pinging by entering the following at the DOS prompt; START-UP[SPACE] ABCDE[ENTER] . (Substitute your 5-character command file name for ABCDE).

START-UP will wakeup the Workhorse, and does the following:

- Sends the commands from your command file.
- Creates a directory on the computer's hard drive named ABCDE.
- Creates the deployment log file (ABCDE.DLG). If you see the prompt "INITADCP failed, START-UP batch file aborted," view the deployment log file for details of the error.
- Starts the Workhorse pinging. You should hear the Workhorse "beep" every ping.
- Starts *WATCH* (collect and view real-time data). See Chapter 3 for more information on using *WATCH*.

2-6.3 Deployment LOG File

INITADCP (called by *DEPLOY* or *START-UP*) creates a log file that contains all of the codes sent to the Workhorse, Workhorse hardware settings, and the results of each command.

To view the log file, use a text editor or type the following at the DOS prompt, TYPE ABCDE.DLG MORE (substitute your 5-character name for ABCDE). You should see a message similar to the following.

> **NOTE**
>
> *For this example, the Sentinel Workhorse was started using the power supply rather than batteries. If the battery is connected and you still get the warning about low battery voltage, DO NOT DEPLOY THE ADCP. Replace the battery before deploying the Workhorse.*

```
04 MAR 1996 13:33:30.91 ------- INITADCP STARTED ------

04 MAR 1996 13:33:30.91 Deployment file: ABCDE.CMD
04 MAR 1996 13:33:30.91 DOS command line: ABCDE

04 MAR 1996 13:46:49.41 ------- INITADCP STARTED ------

04 MAR 1996 13:46:49.41 Deployment file: ABCDE.CMD
04 MAR 1996 13:46:49.41 DOS command line: ABCDE
04 MAR 1996 13:46:51.39
WARNING! Your ADCP appears to have a low battery voltage.
One of the following conditions is possible:
  (1) You have not plugged in your battery (inside the ADCP), and you
      are using the AC power supply instead.

  (2) You are reusing an old battery.
(user question) Do you wish to continue with this deployment (y/n) ?
04 MAR 1996 13:47:01.17 INITADCP:(user response) y
04 MAR 1996 13:47:01.17 Continuing with INITADCP deployment.

04 MAR 1996 13:47:02.43 CR1...OK
04 MAR 1996 13:47:02.49 ED0000...OK
04 MAR 1996 13:47:02.54 ES35...OK
04 MAR 1996 13:47:02.54 EX11111...OK
04 MAR 1996 13:47:02.54 TE01:00:00.00...OK
04 MAR 1996 13:47:02.60 TP00:59.99...OK
04 MAR 1996 13:47:02.65 WD111100000...OK
04 MAR 1996 13:47:02.71 WP00060...OK
04 MAR 1996 13:47:02.71 WN030...OK
04 MAR 1996 13:47:02.71 WS0400...OK
04 MAR 1996 13:47:02.76 WF0176...OK
04 MAR 1996 13:47:02.76 WV170...OK
04 MAR 1996 13:47:02.76 EZ1111111...OK
04 MAR 1996 13:47:02.82 EA00000...OK
04 MAR 1996 13:47:02.87 EB00000...OK
04 MAR 1996 13:47:02.98 CF11101...OK
04 MAR 1996 13:47:02.98 CK...OK
04 MAR 1996 13:47:03.53 Data is present on the ADCP recorder:
04 MAR 1996 13:47:03.64 ADCP recorder info: 6642610 bytes used, 3727360 bytes free
04 MAR 1996 13:47:03.75 (user prompted) Do you wish to continue with this deployment
(y/n) ? 04 MAR 1996 13:47:08.75 INITADCP:(user response) y
04 MAR 1996 13:47:08.80 Continuing with INITADCP deployment.

04 MAR 1996 13:47:08.80 INITADCP: Set ADCP clock = PC clock
04 MAR 1996 13:47:08.91  ,  96/03/04,13:47:08  (PC time , ADCP time)
```

```
04 MAR 1996 13:47:08.97 INITADCP: Setting deployment name to ABCDE  ...OK

04 MAR 1996 13:47:09.02 ADCP Hardware information begin ---------------

04 MAR 1996 13:47:09.08 Sent command (RF) with ADCP response:
RF = 6642610,3727360 ------ Rec space used (bytes), free (bytes)

>04 MAR 1996 13:47:09.13 Sent command (RR) with ADCP response:
Recorder Directory:
Volume serial number for device #0 is 0005-6a07

  _RDI_000 000           9696 02-29-96  12:54:28a r  a [    2]
  _RDI_001 000           8260 02-29-96  12:55:00a r  a [    5]
  _RDI_002 000           8978 02-29-96  12:55:36a r  a [    8]
  _RDI_003 000           8260 02-29-96  12:56:00a r  a [   11]
  _RDI_004 000           8260 02-29-96   3:02:04p r  a [   14]
  _RDI_005 000        2756764 03-01-96   5:14:00a r  a [   17]
  _RDI_006 000           8260 03-01-96   7:33:58a r  a [  691]
  _RDI_007 000           8978 03-01-96   7:34:50a r  a [  694]
  _RDI_008 000         162630 03-01-96   8:24:02a r  a [  697]
  _RDI_009 000           8260 03-01-96   2:13:10p r  a [  737]
  _RDI_010 000        3654264 03-04-96   5:42:02a r  a [  740]

  Bytes used on device #0 = 6642610
Total capacity   =   10407936 bytes
Total bytes used =    6642610 bytes in 11 files
Total bytes free =    3727360 bytes

>04 MAR 1996 13:47:10.12 Sent command (PS0) with ADCP response:
    Frequency:  307200 HZ
Configuration:  4 BEAM, JANUS
  Match Layer:  10
   Beam Angle:  20 DEGREES
 Beam Pattern:  CONVEX
  Orientation:  UP
    Sensor(s):  HEADING  TILT 1  TILT 2  TEMPERATURE
 CPU Firmware:   8.09 [0]
Boot Code Ver:  Required:  1.08   Actual:  1.08
 DEMOD #1 Ver:  ad47, Type:  1f
 DEMOD #2 Ver:  ad47, Type:  1f
 PWRTIMG  Ver:  85d3, Type:   6

Board Serial Number Data:
   F2  00 00 00 09 A1 5C  09 REC727-1000-04A
   A0  00 00 00 02 6A 46  09 PIO727-3000-00B
   E4  00 00 00 09 9C C6  09 CPU727-2000-00D
   7A  00 00 00 0E 19 43  09 DSP727-2001-04C
>04 MAR 1996 13:47:10.89 Sent command (PS3) with ADCP response:
Beam Width:   3.7 degrees

Beam     Elevation     Azimuth
  1         -70.00      270.00
  2         -70.00       90.00
  3         -70.00        0.01
  4         -70.00      180.00

Beam Directional Matrix (Down):
  0.3420    0.0000    0.9397    0.2419
 -0.3420    0.0000    0.9397    0.2419
  0.0000   -0.3420    0.9397   -0.2419
  0.0000    0.3420    0.9397   -0.2419
```

```
Instrument Transformation Matrix (Down):    Q14:
  1.4619   -1.4619    0.0000    0.0000       23952  -23952       0       0
  0.0000    0.0000   -1.4619    1.4619           0       0  -23952   23952
  0.2661    0.2661    0.2661    0.2661        4359    4359    4359    4359
  1.0337    1.0337   -1.0337   -1.0337       16936   16936  -16936  -16936
Beam Angle Corrections Are NOT Loaded.
>04 MAR 1996 13:47:11.82 Sent command (AC) with ADCP response:

              ACTIVE FLUXGATE CALIBRATION MATRICES in FLASH
               Calibration date and time: 2/22/1996  08:13:57
                             S inverse
          |                                                   |
     Bx   |   3.3105e-01  2.5584e-01  3.8850e-02  4.7877e-01 |
     By   |   2.3839e-01  2.8003e-01 -6.0672e-02 -5.1236e-01 |
     Bz   |  -2.3848e-01  2.3026e-01  2.2571e-01 -2.8975e-02 |
     Err  |   3.9384e-01 -3.9382e-01  8.0161e-01 -1.2692e-01 |
          |                                                   |
                             Coil Offset
                         |                |
                         |   3.3642e+04   |
                         |   3.3653e+04   |
                         |   3.3346e+04   |
                         |   3.4267e+04   |
                         |                |
                             Electrical Null
                              |       |
                              | 33710 |
                              |       |
                    TILT CALIBRATION MATRICES in FLASH
                Calibration date and time: 2/14/1996  07:04:26
              Average Temperature During Calibration was   24.7 °C

                  Up                              Down

        |                            |     |                            |
 Roll   |  -3.1251e-05  -3.5439e-05 |     |   3.5838e-05   4.0113e-05 |
 Pitch  |  -3.3888e-05   3.0772e-05 |     |  -4.0277e-05   3.5970e-05 |
        |                            |     |                            |

        |                            |     |                            |
 Offset |   2.9373e+04   3.2054e+04 |     |   3.0903e+04   3.1871e+04 |
        |                            |     |                            |

                             |       |
                      Null   | 33120 |
                             |       |


>04 MAR 1996 13:47:13.86 Sent command (RN?) with ADCP response:
Current deployment name = ABCDE

>04 MAR 1996 13:47:13.91 Sent command (DEPLOY?) with ADCP response:
Deployment Commands:

PA ----------------------- Pre-Deployment Tests

RE ----------------------- Recorder ErAsE
RN ----------------------- Set Deployment Name

WF = 0176 ---------------- Blank After Transmit (cm)
WN = 030 ----------------- Number of depth cells (1-128)
WP = 00060 --------------- Pings per Ensemble (0-16384)
WS = 0400 ---------------- Depth Cell Size (cm)
```

```
WV = 170 ----------------- Mode 1 Ambiguity Vel (cm/s radial)

TE = 01:00:00.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TF = **/**/**,**:**:** --- Time of First Ping (yr/mon/day,hour:min:sec)
TP = 00:59.99 ------------ Time per Ping (min:sec.sec/100)
TS = 96/03/04,13:47:13 --- Time Set (yr/mon/day,hour:min:sec)

ES = 35 ------------------ Salinity (0-40 pp thousand)

CF = 11101 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
CS ----------------------- Start Deployment

>04 MAR 1996 13:47:14.90 ADCP Hardware information end -----------------

04 MAR 1996 13:47:15.12 ADCP recorder info: 6642610 bytes used, 3727360 bytes free
04 MAR 1996 13:47:16.00 ADCP data to serial interface : OFF

04 MAR 1996 13:47:16.00 ADCP data to internal recorder: ON

04 MAR 1996 13:47:35.88 CS Command sent successfully
04 MAR 1996 13:47:35.88 INITADCP successful.
04 MAR 1996 13:47:35.88 ADCP is now pinging.

04 MAR 1996 13:47:35.88 ----- INITADCP TERMINATED ----- (exitcode = 0)
```

2-7 Deploying the Workhorse

Will you fix the instrument rigidly in place or mount it on a swaying mooring line? Will it face up or down? In any case, you must plan how to handle and deploy the Workhorse. Here are examples of mounting hardware available from RDI. Use the outline installation drawings (Appendix A) if you are designing your own mounts.

Bottom Mount. An economic non-gimbaled bottom mount for either the Sentinel or Monitor is available. The frame is available as a kit consisting of PVC fittings and pipe sections, assembly hardware, instructions, and a machined PVC bottom plate. The user supplies ballast (up to 68 kg). There are four lifting eyebolts to help deploy the unit. This frame is not designed for floatation or release.

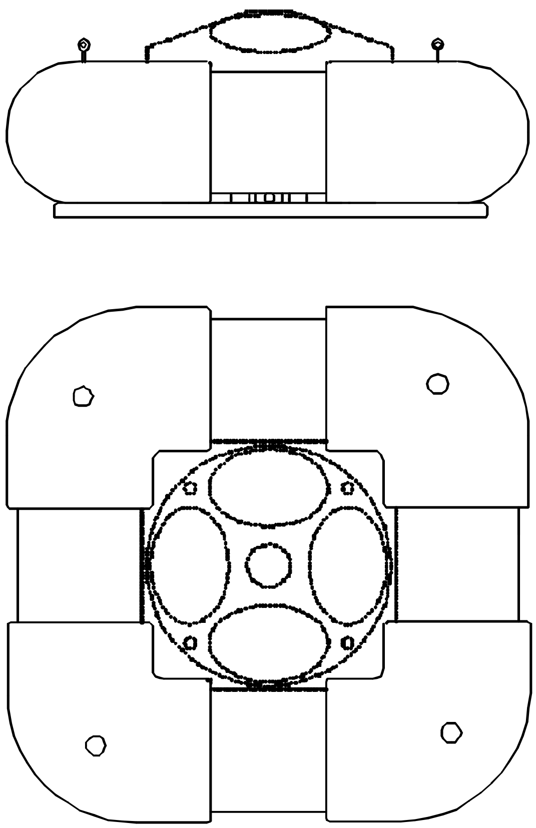


Figure 2-4. Bottom Mount

Trawl-Resistance Bottom Mount. A trawl resistant bottom mount for either the Sentinel or Monitor is available. The frame is gimbaled for up to 15 degrees of tilt. The base unit weighs 200 lbs. (in air) and 125 lbs. (unballasted weight in water). Acoustic releases are available (sold separately).

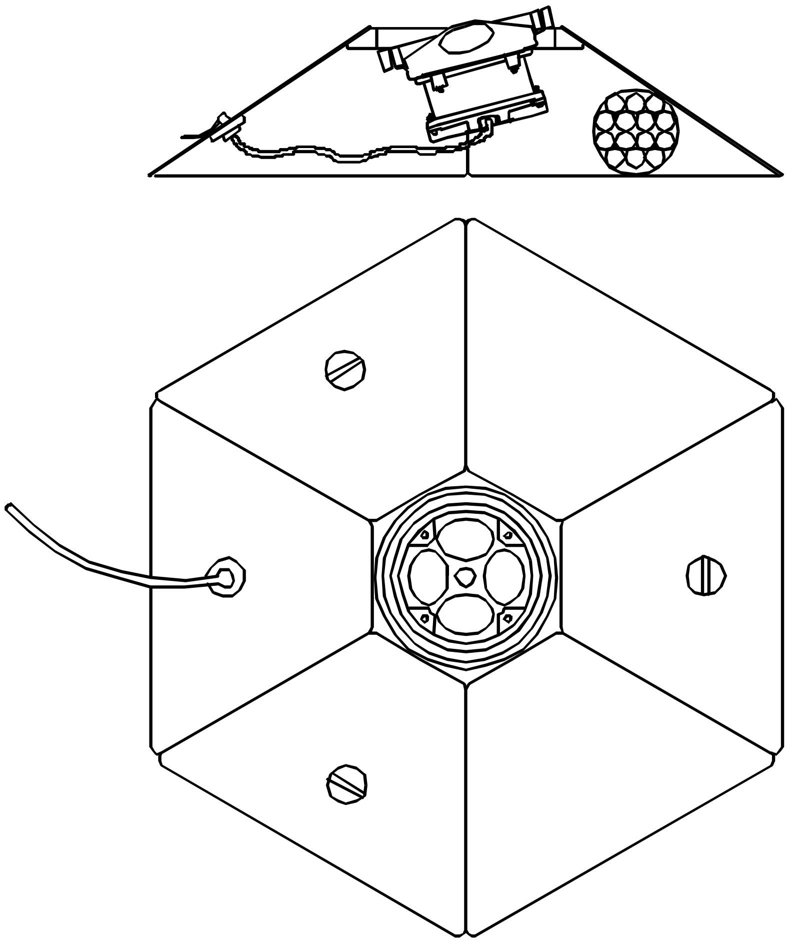


Figure 2-5. Trawl-Resistance Bottom Mount

Foam Buoy and Frame. Two spherical buoys are designed to hold up the top of a mooring while allowing the Workhorse to profile the water above. The syntactic foam spheres are available in 24-inch or 32-inch diameter (24-lbs./cu. ft. material). The buoys use a two-hemisphere design.

The frame is designed to allow the Workhorse to profile unobstructed by the mooring hardware. The frame is available for both the 24 and 32-inch buoy and in either 316 stainless steel or titanium.

Table 2-3. Buoy Frames

Buoy Size	Buoyancy (lb.)	Material	Working Load (lb.)	Weight air (lb.)	Weight water (lb.)
24	115	316 stainless steel	3,500	15	13
32	305	316 stainless steel	3,500	16	14
24	115	Titanium	14,000	8	6
32	305	Titanium	14,000	9	7

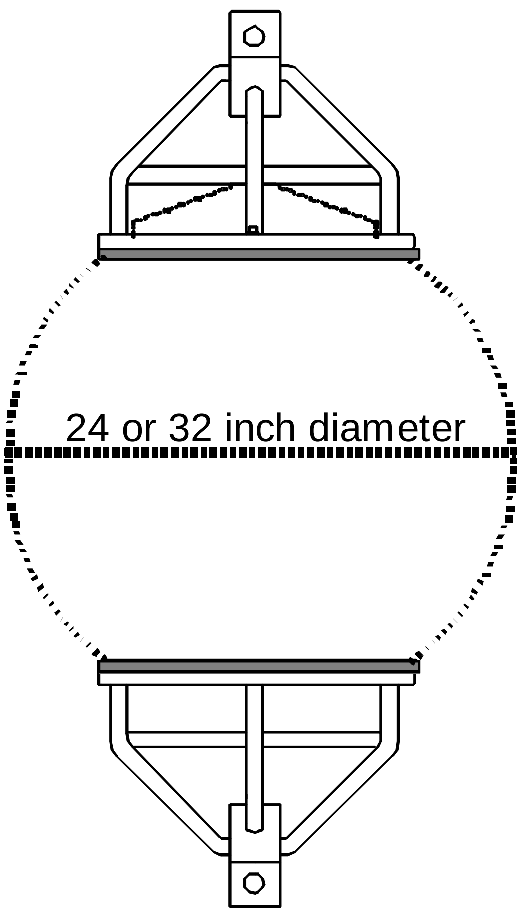


Figure 2-6. Buoy and Frame

Load Cage. A shorter version of the same load cage that is used for the buoys is used as an in-line load cage. The frame is designed to allow the Workhorse to profile unobstructed by the mooring hardware.

Table 2-4. Load Cage

Material	Working Load (lb.)	Weight air (lb.)	Weight water (lb.)
316 stainless steel	4,500	16	14
Titanium	19,000	9	7

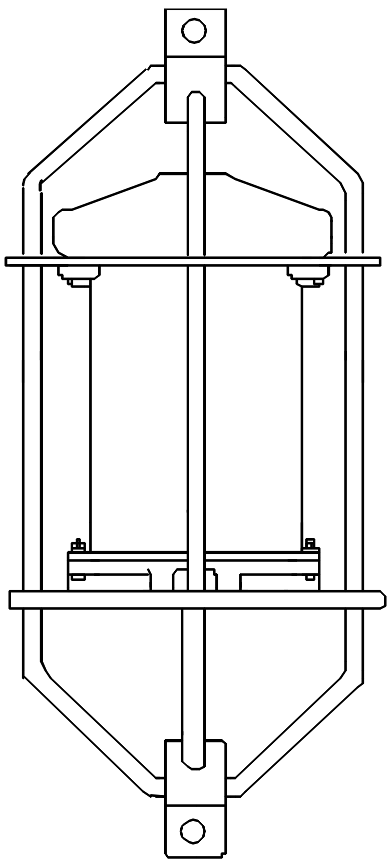


Figure 2-7. Load Cage

2-8 Recovering Self-Contained Data

Once you have recovered the Workhorse, you should refer to Chapter 4 for instruction on cleaning the Workhorse exterior. Once the Workhorse is clean, use *RECOVER* (Figure 2-8). *RECOVER* reads the data from the Workhorse PC Card recorder and transfers the data to the computer's hard disk. It creates a new directory on the computer's hard drive using the deployment name as the name of the directory. When it is finished, you will find the original deployment configuration file, the file created when the Workhorse was being set up for deployment and your data files in sequential order (i.e., ABCDE`000.000`, ABCDE`000.001`, etc.).

a. Connect and power up the Workhorse.

b. To start *RECOVER*, type RECOVER ENTER .

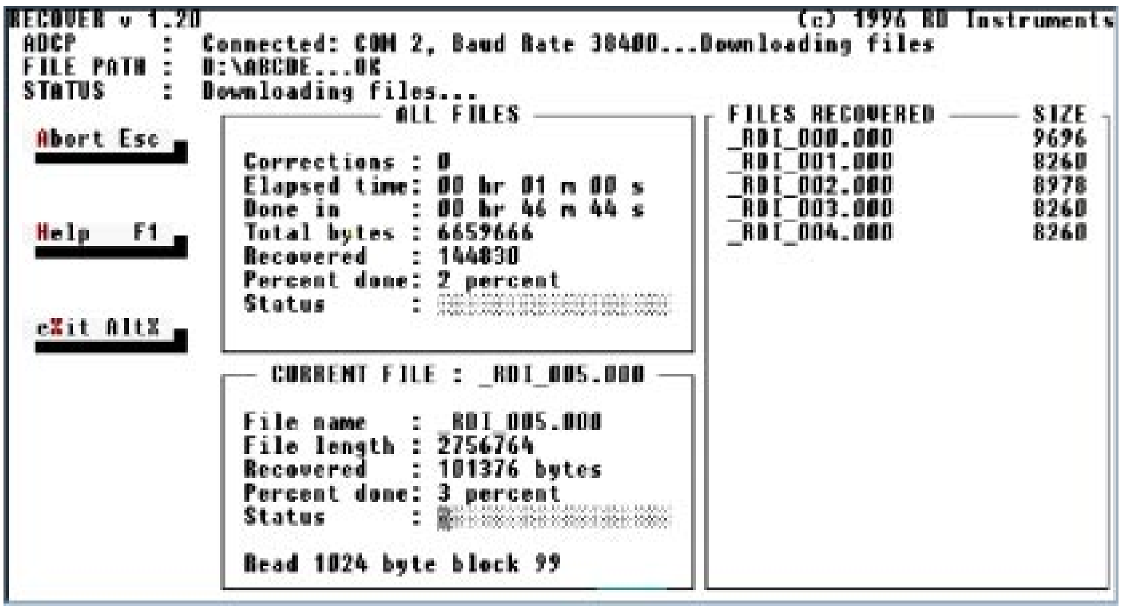


Figure 2-8. RECOVER Program

2-9 Verify, Convert and Viewing Data

Use the *BBLIST* program to create your own ASCII output files in a tabular format. *BBLIST* is explained in Chapter 3 of the Workhorse Technical Manual.

Use RDI's *QUIKLOOK* program to replay Sentinel recorded data or real-time Monitor data in a variety of different formats (i.e. profiles and color contour plots). *QUIKLOOK* is explained in Chapter 3 of the Workhorse Technical Manual.

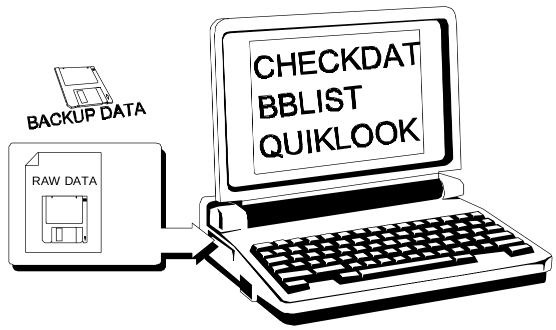


Figure 2-9. Programs to View & Check Data

CHECKDAT checks your data files for integrity and quality. It does some simple error and problem checking. You should use *CHECKDAT* on your data files *before* you erase the original data files on your recorder.

Start *CHECKDAT* by typing *CHECKDAT raw data filename* [ENTER]. For example, to check the raw data file demo011r.000, start *CHECKDAT* by typing CHECKDAT[SPACE] demo011r.000[ENTER].

You should see a message similar to the following.

```
D:\RDI>CHECKDAT demo011r.000

CHECKDAT checking demo011r.000 . . . press ESC to pause

NO ERRORS FOUND:  demo011r.000

DATA FILE INFORMATION: demo011r.000

DATA TYPES RECORDED (Length information in bytes)
ID# (hex)   Offset        Length      Name
0               18            36      Fixed leader
80              54            38      Variable leader
100             92           322      Velocity
200            414           162      Correlation
300            576           162      Intensity
600            738            72      Bottom track
Ensemble size 812 bytes

CHECKDAT done.
D:\RDI>
```

2-10 Erasing the Recorder

Once all data has been recovered, the recorder can be erased. *Once erased, the data is not recoverable.*

- Recover or backup all data.
- Type ERASEMEM[ENTER]. You should see a message similar to the following.

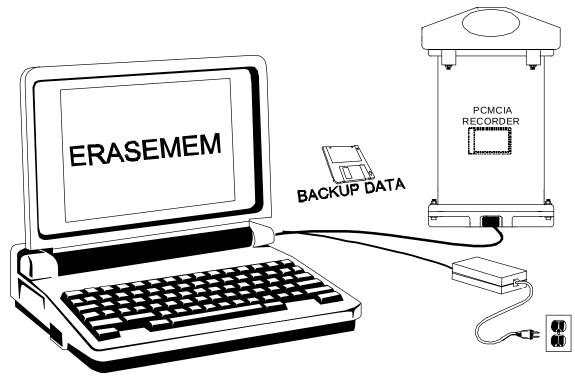


Figure 2-10. Erasing the Recorder

```
ERASEMEM Version 1.00
 (c) 1995 RD Instruments.  All rights reserved.
Erase all data from internal ADCP recorder

Connecting to ADCP...COM#, 9600
ADCP recorder info:
  Recorder bytes used = # bytes
  Recorder bytes free = # bytes
Erase ADCP recorder in 10 seconds...PRESS ANY KEY TO ABORT ERASE
10...9...8...7...6...5...4...3...2...1...0
BBERASE successful.
ADCP recorder info:
  Recorder bytes used = # bytes
  Recorder bytes free = # bytes
Restoring ADCP communication to 9600 baud...
```

A ten-second countdown will begin. Pressing any key while the countdown is occurring will stop the *ERASEMEM* program.

Once the countdown is done, the entire recorder is erased. *Data is not recoverable after erasing.*

Chapter
3

Viewing Data

3-1 Introduction

WATCH provides a configurable and flexible data presentation program for data collection and playback.

- Allow users to customize display and plot settings - and load and save these settings depending on the application.
- Allow users to take full advantage of *BBLIST's* flexible ASCII formatting for playback or real-time applications including displaying, logging and sending to serial port *BBLIST* decoded and formatted data.
- Provides a simple method for importing display and data into DOS and Windows documents.
- Records Workhorse data to raw and processed (averaged) data files.
- Send ASCII ensemble-out data to a selected serial port.
- Allows changing graphic scales and displays in real-time to enhance visual information to help track important processes.
- Change the averaging interval for displays and processed data files.

You also should be aware of the following processes while in *WATCH*.

- User controls change the displays but not the data collected.
- If the Workhorse collects data in beam coordinates, *WATCH* converts the data to earth coordinates before display. The raw data files preserve the Workhorse coordinate system (earth or beam).
- *WATCH* updates displays after every averaging interval (segment). For example, if you select an averaging interval of 60 seconds, *WATCH* updates the displays every 60 seconds.
- Each time you exit *WATCH,* the display setting are saved to the DEFAULT.PT file.
- *WATCH* stops data collection if communication is interrupted (data collection only stops if the Workhorse is interrupted).

- *WATCH* can lose communication with the Workhorse during data collection under the following conditions.
    a. Collecting a high volume of data (128 depth cells, all output data types selected) at a slow serial baud rate (1200 and below) using a slow computer (less than 12 MHz).
    b. Collecting a high volume of data while operating from floppy disks.

3-2 Starting WATCH

Command line parameters:

WATCH [Command Parameters]

Table 3-1. WATCH Command Line Parameters

Command Parameter	Description
filename	Data file to play back. The name can include drive and directory
/GO	Start playback immediately
/Avs	Average display (not recording!) using interval of s seconds
/COM#	COM port to read data from (uses default port if not specified)
/B#	Workhorse baud rate: 1200, 2400, 4800, 9600, 19200, 38400, 57600, or 115200 (uses default baud if not specified)
/RECPATHp	Record Workhorse data to path p. Default is the current directory. Workhorse data files are given a default file name (see below REAL-TIME DATA COLLECTION)
/M	Monochrome display (Black background)
/W	Reverse monochrome display (White background). Best for Cut/Paste/Print.
/CFG<name>	Load Transect configuration file
/PF<name>	Load watch plots settings file
/FMT<name>	Load BBLIST format file to activate formatted ASCII data output (see examples below)
/OUTCOM#	Send ASCII data to serial port OUTCOM# (see examples below)
/OUTB#	Set baud rate for ASCII output port: 1200, 2400, 4800, 9600, 19200, 38400, 57600, or 115200.
/OUTFILE<name>	Write ASCII data to text file

The command parameters /COM and /B are not usually required because *WATCH* will obtain the current communications settings from the file BBTALK.PTR. BBTALK.PTR can be created by running *BBTALK* and saving the communications setup (see Chapter 5). *WATCH* will not work if it is given the wrong parameters—it does not search for the correct communications settings.

3-2.1 Sample Files

WATCH.EXE	WATCH executable program
WATCH.TXT	WATCH help document
F1HELP.PCX	WATCH run-time help screen (displays when you press F1)
MAGDIR.FMT	Sample BBLIST Format file that decodes velocity mag/direction
EXAMPLE.CFG	Transect Configuration file for EXAMPLE.000
EXAMPLE.000	Workhorse upward looking data from Finland
INTSTUDY.PF	Sample plot settings file that displays beam intensity data
QUIKLOOK.PF	General-purpose velocity display screen
QUIKLOOK.BAT	General-purpose velocity data playback using QUIKVIEW.PF

3-2.2 Examples

WATCH EXAMPLE.000
Plays back file EXAMPLE.000

WATCH EXAMPLE.000 /CFGEXAMPLE.000
Plays back file EXAMPLE.000, load settings from EXAMPLE.000

QUIKLOOK EXAMPLE.000
Plays back EXAMPLE.000 using a general-purpose velocity display screen design saved in QUIKLOOK.PF.

WATCH /PFQUIKLOOK.PF /FMTMAGDIR.FMT /OUTCOM2 /OUTFILETEST.TXT
Listen for real-time Workhorse data on the default COM port (which must be COM1 for this example to work), display data using QUIKLOOK.PF to format the screen display and output formatted ASCII data to the file test.txt using the format stored in the file MAGDIR.FMT.

3-3 Using START-UP to Run WATCH

Start the Workhorse pinging and load *WATCH* by entering the following at the DOS prompt; START-UP[SPACE] ABCDE[ENTER] . (Substitute your 5-character command file name for ABCDE).

START-UP will wakeup the Workhorse, and does the following:

- Sends the commands from your command file.
- Creates the deployment log file. If you see the prompt “INITADCP failed, START-UP batch file aborted”, view the deployment log file for details of the error.
- Starts the Workhorse pinging. You should hear the Workhorse “beep” every ping.
- Starts *WATCH* using the QUIKLOOK.PF plot file. *You will not see any data displayed until the first ensemble is finished.*

3-4 WATCH Commands and Control Keys

Program Commands

0-9	: Delay 0-9 seconds between ensembles in playback
Alt-A	: Change averaging interval
Alt-G	: Grid toggle
Alt-P	: Save .PCX screen dump file
Alt-R	: Toggle velocity reference (None/Bottom)
Alt-W	: Rewind data file
Alt-X	: Exit program
Alt-Z	: Toggle plot Zooming in/out
Ctrl-F6	: Toggle plot Resizing on/off for active plot window
F4	: Toggle playback: pause(spacebar/step) or timed
F6	: Toggle Scale changing on/off
Spacebar	: Step to next ensemble if playback
TAB	: Change active plot (handles on 4 corners)

Plot File Commands

Alt-F10	: Save plots (size, scales) to plot file
F10	: Load plot file

Plot types

I	: Change Active plot to intensity contour
M	: Change Active plot to time-series of velocity
P	: Change Active plot to profile plot
S	: Change Active plot to shiptrack
T	: Change Active plot to tabular display Alt-
V	: Change Active plot to velocity contour

Number of Plot Windows

Alt-1	: Display 1 full-screen plot window
Alt-2	: Display 2 ‘horizontal’ plot windows
Alt-3	: Display 3 ‘horizontal’ plot windows
Alt-4	: Display 4 plot windows
Alt-5	: Display 2 ‘vertical’ plot windows
Alt-6	: Display 3 ‘vertical’ plot windows
Alt-7	: Display 3 plot windows
Alt-8	: Display 8 plot windows

Color Schemes

Alt-F1	: RDI Color scheme (blue background)
Alt-F2	: 16 color gray scale with black background
Alt-F3	: 16 color gray scale with white background
Alt-F4	: 2-color monochrome with black background
Alt-F5	: 2-color monochrome with white background
Alt-F6	: Color display with white background

Scales Controls:

TAB	: Change active scale
F6	: Scales off (Esc and Enter do the same)
+	: Increase range of active scale
-	: Decrease range of active scale
Scroll Lock ON	: Fine Scale adjustment
Shift Key down	: Large Scale adjustment
Right/Left Arrow	: Move graph right/left
Up/Down Arrow	: Move graph up/down

Plot Resizing/Move Controls:

TAB	: Change axes to resize (top-left, bottom-right)
Crtl-F6	: Accept resizing and replot window (Enter does the same)
Esc	: Abort resizing and replots window
Scroll Lock ON	: Fine Scale resize/move
Arrow Keys	: Resize axes
Shift-Arrow Keys	: Move plot

Profile Plot controls:

A	: East/West/North/South velocity profiles
B	: Beam 1-4 Intensity profiles
C	: Velocity magnitude/direction profiles
D	: Percent good profile
E	: Discharge profile

Shiptrack plot controls:

A	: Normal path color
B	: Velocity Magnitude path coloration
C	: Average intensity path coloration
PgUp	: Move depth of shiptrack up (shallower) one bin
PgDn	: Move depth of shiptrack down (deeper) one bin

Velocity Contour Plot controls:

A	: East/West velocity contour plot
B	: North/South velocity contour plot
C	: Vertical velocity contour plot
D	: Error velocity contour plot
E	: Projected velocity contour plot

Intensity Contour Plot controls:

A	: Beam 1 intensity contour plot
B	: Beam 2 intensity contour plot
C	: Beam 3 intensity contour plot
D	: Beam 4 intensity contour plot
E	: Beam 1-4 average intensity contour plot

Time Series Plot Controls:

A	: East/West velocity time series plot
B	: North/South velocity time series plot
C	: Vertical velocity time series plot
D	: Error velocity time series plot
E	: Projected velocity time series plot
PgUp	: Move velocity time series up (shallower)
PgDn	: Move velocity time series down (deeper)
+	: Increase depth separation by one bin
-	: Decrease depth separation by one bin

Tabular Plot Controls:

A	: Depth/East West/North South/Vertical/Error display
B	: Depth/Intensity Beam 1/2/3/4 display
C	: Depth/Correlation Beam 1/2/3/4 display
D	: Depth/Velocity Magnitude/Direction/% Good display
E	: BBLIST Formatted output display
PgUp	: Move display up one bin
PgDn	: Move display down one bin

3-5 Profile Plots

A profile plot is a line graph of a selected parameter versus depth. *WATCH* updates the profile plot after every averaging interval (segment). Averaging is off by default. The following profile plots are available.

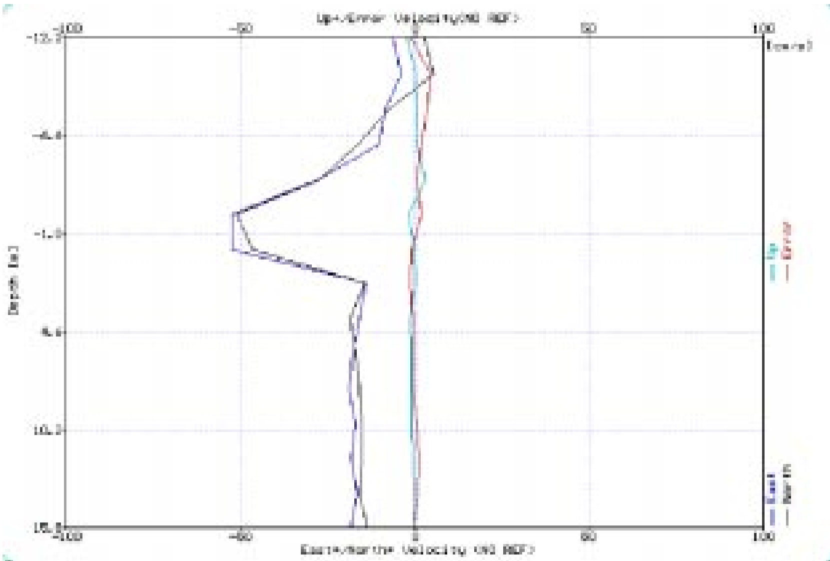


Figure 3-1. Profile Plot

Velocities. The velocity profiles show the earth-coordinate velocity components (east, north, vertical, and error). The velocity units can be in either cm/s (metric) or ft/s (English). All graph scales are user-selectable in real-time through the F6 key. Scaling for the top horizontal axis on the plot (UP and ERROR) uses either the VERTICAL VELOCITY or ERROR VELOCITY minimum/maximum scale values, depending on which one has the largest magnitude. Similarly, the bottom horizontal axis (EAST and NORTH) uses either the EAST VELOCITY or NORTH VELOCITY scale values.

Intensities. *WATCH* displays the intensity profiles for all four Workhorse beams.

Magnitude and Direction. This profile plot displays the horizontal velocity magnitude and direction versus depth. The velocity magnitude and direction are the east and north velocity components in polar coordinates. Scaling for the top horizontal axis on the plot (Velocity Magnitude) uses either the East Velocity or North Velocity minimum/maximum scale values, depending on which one has the largest magnitude. The scale for Velocity Direction is fixed on the graph from 0 to 360 degrees.

Percent Good Average. The percent-good data are the average percentage of good three and four-beam solutions used. The scale for Average Percent Good is fixed on the graph from 0 to 100 percent. *WATCH* also displays the east and north velocity components on the percent-good profile graph.

Discharge. This display shows a discharge profile for every Workhorse ensemble, including the unmeasured areas (top and bottom). If Top Discharge Estimate or Bottom Discharge Estimate is set to Power in the *TRANSECT* configuration file, *WATCH* also displays a cross-product profile and its associated power-curve fit.

3-6 Velocity Plots

The available velocity contour plots are the four earth-referenced velocity components (east, north, vertical, and error) or the velocity component for a selected direction (projected). All graph scales are user-selectable in real-time by using the F6 key. Use ALT R to select the velocity reference) Bottom (bottom-track from Workhorse (not available)), or None (no reference). The following are the velocity contour plot options.

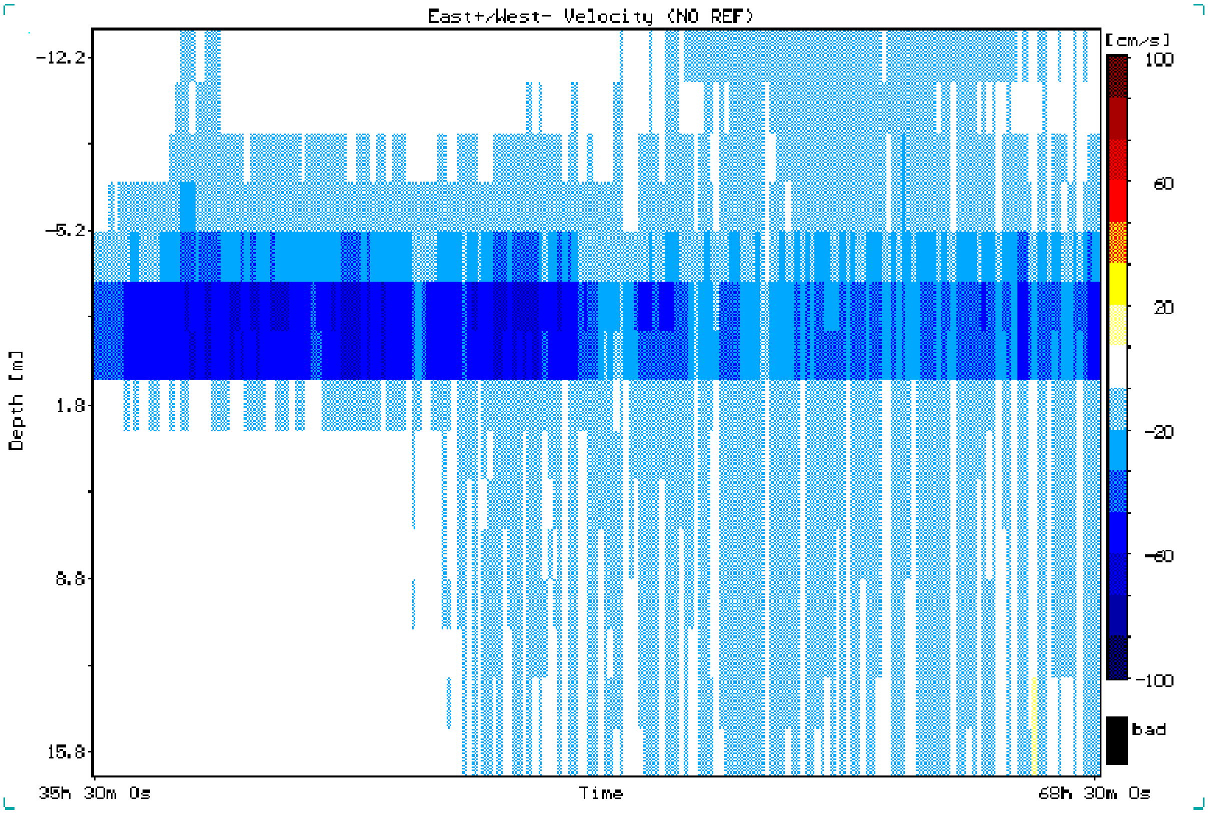


Figure 3-2. Velocity Plot

East/West. East is positive; west is negative.

North/South. North is positive; south is negative.

Vertical. Up is positive; down is negative.

Error. This velocity component is a measure of "data reasonableness." There is no velocity reference for this value. It is determined from the three orthogonal velocity components. The error velocity calculation depends on transducer orientation and beam pattern.

Projected. This velocity component is a user-selected direction specified by the PROJECTED ANGLE. To determine a useful projection angle, you may find it helpful to view the SHIPTRACK plot and note the main direction of the current sticks. For example; a transect across a river, a useful velocity component is the one perpendicular to the ship-track course, or parallel to the shoreline. By selecting a projection angle equal to this velocity component, the contour plot would show this information.

3-7 Intensity Plots

Intensity plots lets you select the type of echo intensity contour plot to display. Echo intensity can be range normalized before display. The five intensity plots are:

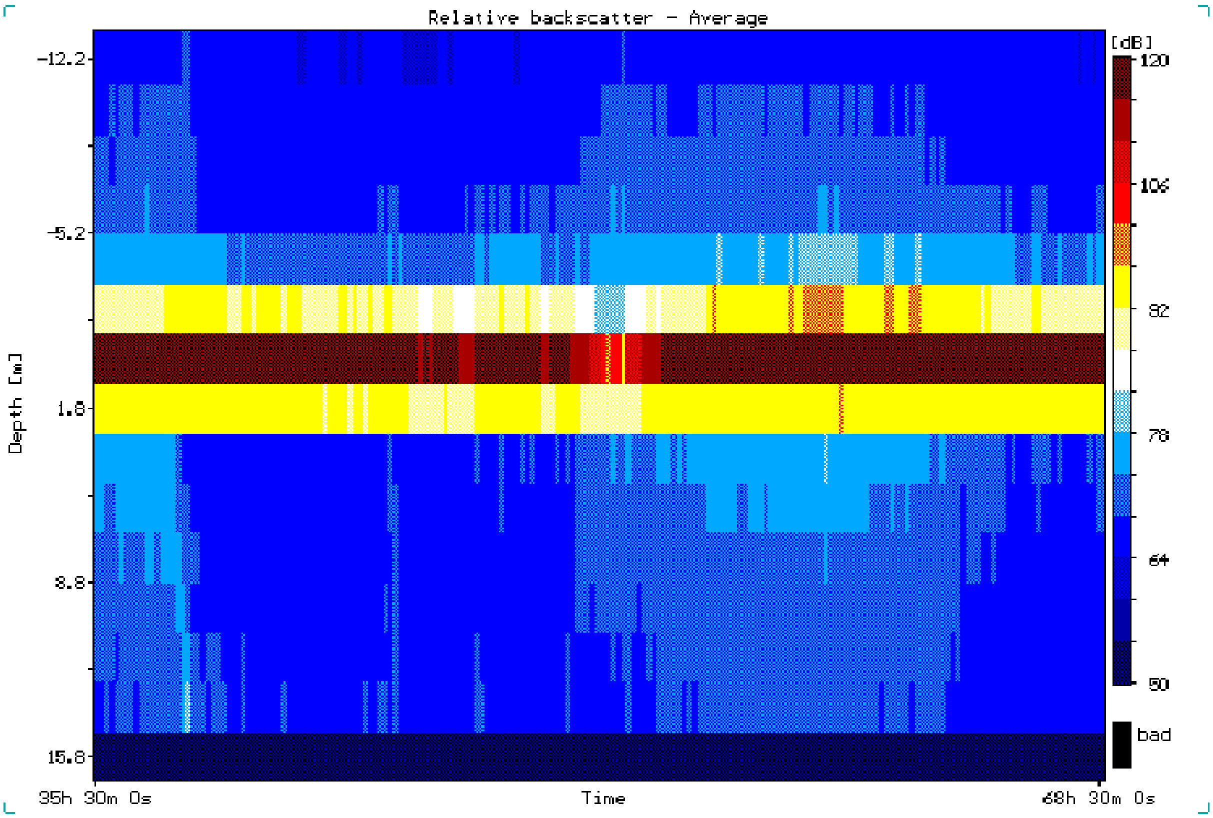


Figure 3-3. Intensity Plot

Beam 1. Echo intensity contour plot for beam 1.

Beam 2. Echo intensity contour plot for beam 2.

Beam 3. Echo intensity contour plot for beam 3.

Beam 4. Echo intensity contour plot for beam 4.

Average. Averaged echo intensity contour plot for all four beams.

3-8 Shiptrack Plots

The shiptrack plot displays a time series of relative motion based on bottom-track velocities. *Bottom-track is optional for Workhorse ADCPs (contact RDI for information on bottom-track options)*. *WATCH* divides the ship-track axes into DISPLACEMENT EAST and DISPLACEMENT NORTH. The ship-track menu has the following options.

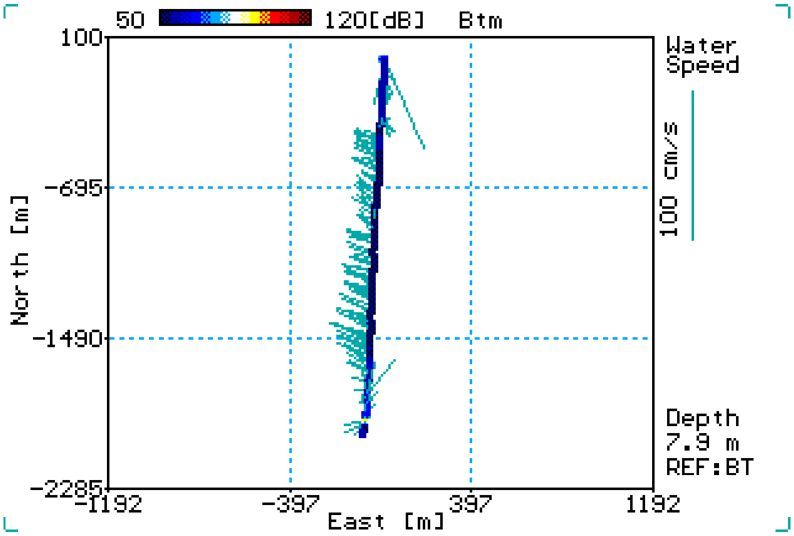


Figure 3-4. Shiptrack Plot

Normal. This is a ship-track plot with the path of the ship shown in a constant color.

Velocity Magnitude. The path of the ship is shown in a range of colors that depict the average current speed for the selected depth.

Average Intensity. The path of the ship is shown in a range of colors that depict the average echo intensity for the selected depth.

Special Notes for Processing of the Ship-Track Plots:

- *Resizing* - *WATCH* resizes the ship-track plot every time the ship path extends beyond the current min/max values for east/north displacement. The resizing method keeps the scales "square," so the ship-track plot is not distorted. You can set the min/max displacement values using the F6 key.
- *Clipping* - *WATCH* assigns memory for the displays. The amount of memory available, the number of bins (depth cells), and the data selected for output from the Workhorse determines the number of "columns" in the contour plot. The contour plot scrolls when the assigned memory is full. The ship-track plot displays the same amount of Workhorse data as the contour plot, so when the contour plot is scrolling, changing to a ship-track plot shows only the data now on the contour plot display. The part of the contour plot that scrolls off the screen will be "clipped" off the ship-track plot when it is displayed.

3-9 Tabular Plots

The tabular plot shows the data for the last transect averaging interval (segment) in tabular form. *WATCH* displays as *bad* the data flagged bad by the Workhorse. *WATCH* also displays depth, percent good (%), and discharge data on the tabular display. The tabular display options are:

Depth	Echo intensity [dB]			
[m]	Beam1	Beam2	Beam3	Beam4
0.9	69.7	68.9	66.7	69.3
1.4	67.7	68.5	64.2	67.7
1.9	65.2	66.5	61.7	67.3
2.4	64.2	67.2	61.7	71.1
2.9	65.9	80.1	70.2	88.7
3.4	71.2	91.4	76.7	97.8
3.9	73.6	77.5	74.9	80.5
4.4	72.1	79.0	73.0	74.3
4.9	73.5	80.4	77.4	69.2
5.4	83.8	69.2	87.2	65.7
5.9	103.9	64.8	88.0	63.5
6.4	106.8	66.4	74.5	65.9
6.9	78.2	63.6	62.3	63.1
7.4	60.3	57.7	56.0	60.7
7.9	52.3	54.4	52.3	57.0
8.4	48.1	54.1	49.8	55.8
8.9	48.6	57.6	50.3	55.9
9.4	52.5	62.4	53.8	61.1
9.9	56.0	64.1	56.4	63.7
10.4	57.7	62.8	58.1	61.6
10.9	58.5	59.0	59.4	57.2
11.4	60.6	56.3	58.9	53.3
11.9	63.2	53.7	57.1	50.3

Figure 3-5. Tabular Plot

- Depth/East West/North South/Vertical/Error display
- Depth/Intensity Beam 1/2/3/4 display
- Depth/Correlation Beam 1/2/3/4 display
- Depth/Velocity Magnitude/Direction/Percent Good display
- BBLIST formatted output display

3-10 Time-series Plots

The time-series plot is similar to a strip-chart recorder. The display shows water-current velocity along a projected angle (seismic line) at selected depth layers. This display can help you determine the effects of water currents on a line towed by a vessel. The time-series options are:

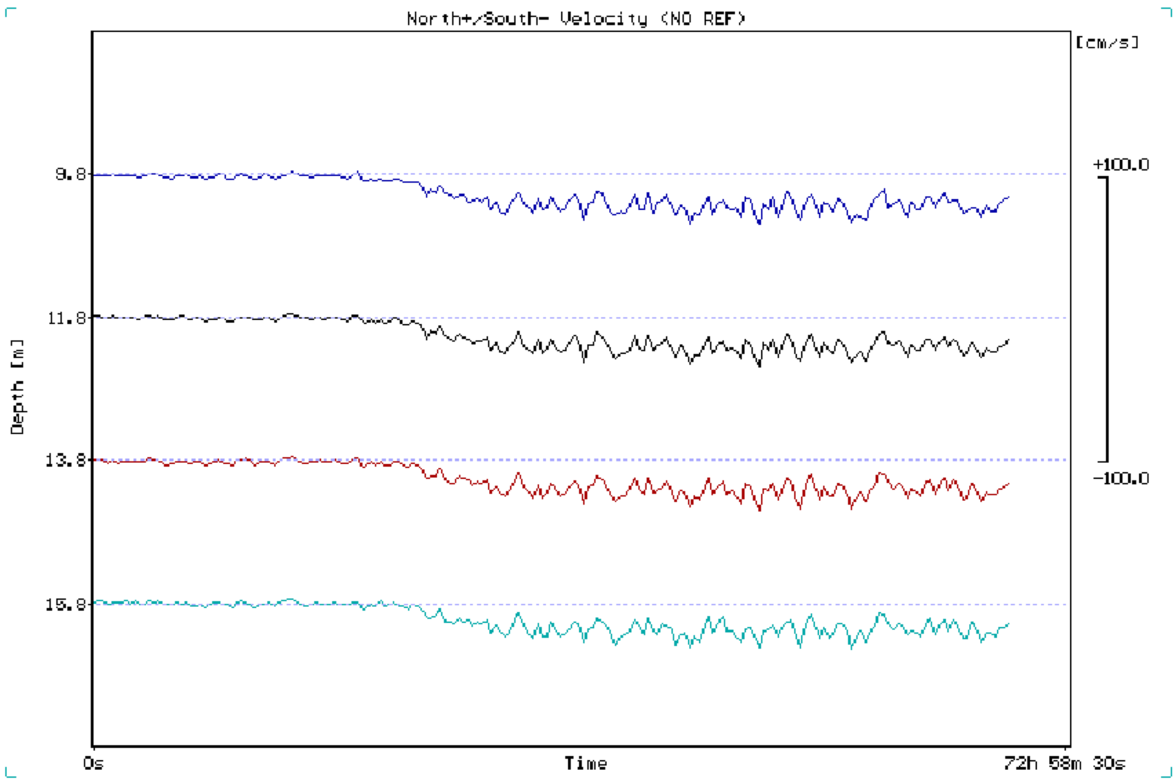


Figure 3-6. Time Series Plot

- East/West velocity time series plot
- North/South velocity time series plot
- Vertical velocity time series plot
- Error velocity time series plot
- Projected velocity time series plot

3-11 Creating Custom Plot Files

Each time you exit *WATCH*, the display setting are saved to the default plot file setting. This way, when you restart *WATCH*, the setting will be as they were the last time *WATCH* was used. You can create your own custom settings dependent on your needs and save the setting to a plot file.

Set up *WATCH* as you desire.

- Select the number of plots to be displayed.
- Select the plot types (Intensity contour, Time-series, Profile, Shiptrack, Tabular, Velocity contour).
- Select the scales control for each plot.
- Select a color scheme.

a. Press ALT F10 to save the plot file. Name the file (example; ship.PF) using a .PF extension.

b. Switch between plot file settings by pressing F10 to load the plot file. Type in the name of the plot file (example; ship.PF).

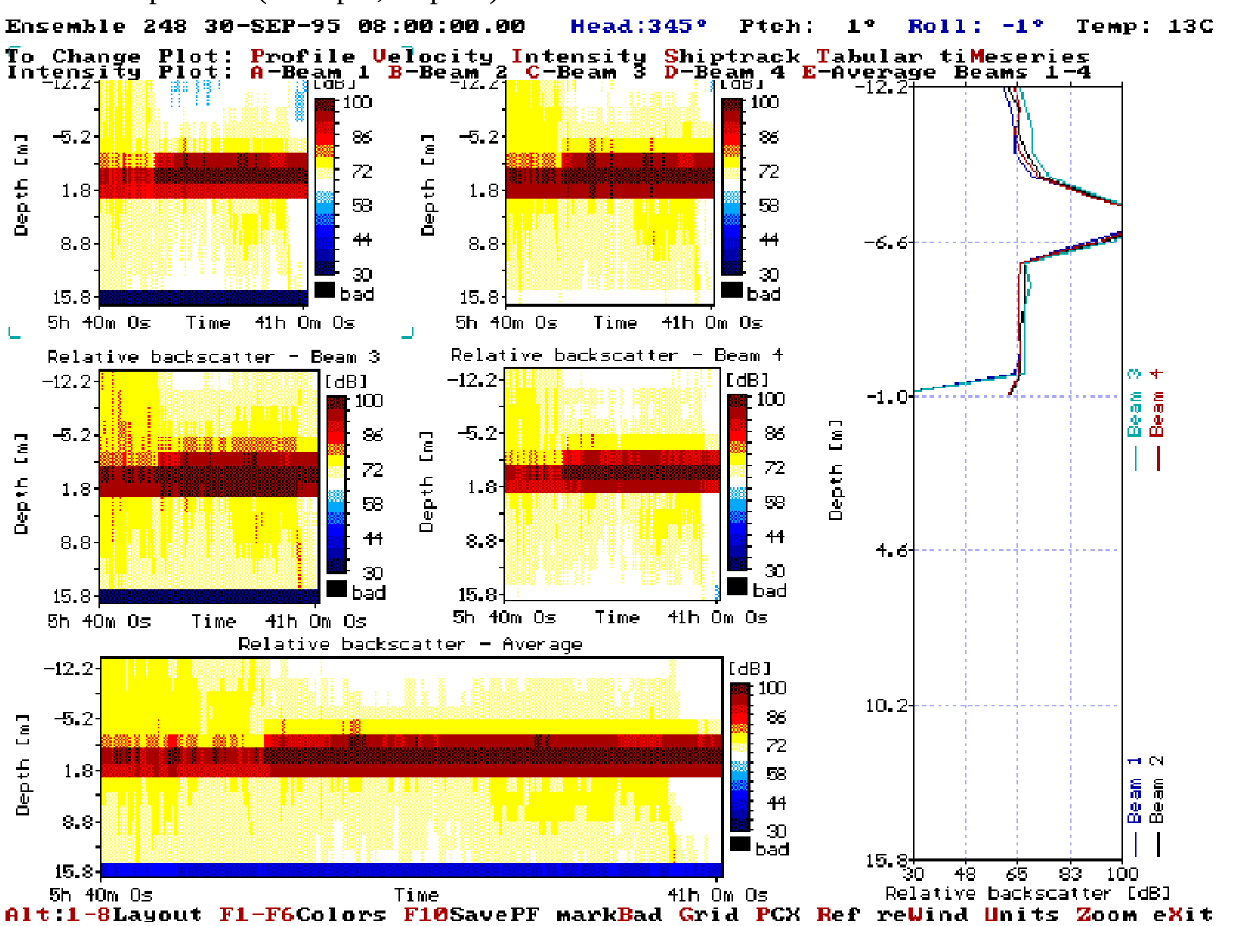


Figure 3-7. Using a Custom Plot File (INTSTUDY.PF Shown)

3-12 Importing Plots into Windows Documents

a. Set up the *WATCH* display the way you want it to look.

b. Select the *WATCH* color scheme (suggestions: for Black and White press [ALT] [F3], for Color press [ALT] [F6]).

c. Press [ALT] [P] and type the name of the .PCX file (example: bbdata.pcx). This will make a copy of the entire screen (including the menu).

d. Press [ALT] [⇆] to switch to Program Manager or Windows Desktop.

e. Run Windows Paint program (or another drawing program that can open .pcx files) and maximize the window.

f. From within Windows paint, select File, Open.

g. In the Open dialog box, bottom left, for 'Files of Type', select PCX files (*.PCX). Open the PCX file you just created in *WATCH*.

h. Use the Cut tool  and enclose out the area of the PCX file you want to import into your Word document. Select Edit-Copy to send to the Windows clipboard.

i. Run the program you want to paste the plot into (example, MS Word). Go to where you want the plot and select Edit-Paste.

3-13 BBLIST

BBLIST takes the binary data files created by our Workhorse and lets you convert selected data fields to common units of measurement in an ASCII-text format. You can then use the ASCII files in programs that accept this format. *BBLIST never* alters your original Workhorse binary data files. *BBLIST* lets you:

- Set processing parameters.
- Transform velocity data.
- Select the display/conversion limitations (e.g., data fields bin range, ensemble range, output file size).
- Select the Workhorse data fields to display or convert.
- Monitor and control the conversion process.
- Look at radial beam data.

3-13.1 Starting BBLIST

To start *BBLIST*, do the following:

- **BBLIST**ENTER - Starts *BBLIST* and lets you select the Workhorse binary data file from within the program.
- **BBLIST C:\BBDATA\TEST.000 /M**ENTER - Starts *BBLIST* and loads the TEST.000 file located on the C: drive in the BBDATA directory. The /M forces *BBLIST* to use monochrome screens.

When you run the program the first time, *BBLIST* displays its introduction and copyright screen. During operation, *BBLIST* creates/updates a pointer file named BBLIST.PTR. This file saves the current working directory, the name of the last binary file used, the name of the format file (*.FMT) last used, and the color selection. This may help save you time by automatically calling up the files you used last. If you need to see the introduction screen again, you must first delete or rename the BBLIST.PTR file.

Extensive help is available while using *BBLIST* by pressing F1. The help screen lists all of the menus and a description of each option available. You may also print the help screen file by printing the file BBLIST.DOC.

3-13.2 BBLIST Menus

BBLIST has four main menus (Figure 3-8) to guide you through the steps needed to convert an Workhorse binary raw data file to an ASCII data file.

File Menu. Use this menu to save your menu settings and conversion layout selections to a configuration format file (*.FMT), to load a BBADCP binary data file or format file, to display the file information screen, or to exit *BBLIST*.

Process Menu. Use this menu to set the processing parameters for *BBLIST*. You can set the velocity reference, magnetic variation (declination), velocity measurement units, and depth measurement units.

Display Menu. Use this menu to select the type of data to view. Data available for display include Workhorse setup, sensors, reference layer, bottom-track, and profile.

Convert Menu. Use this menu to convert the binary Workhorse data set into ASCII. Before starting the conversion process, you can define the conversion limitations and the output format.

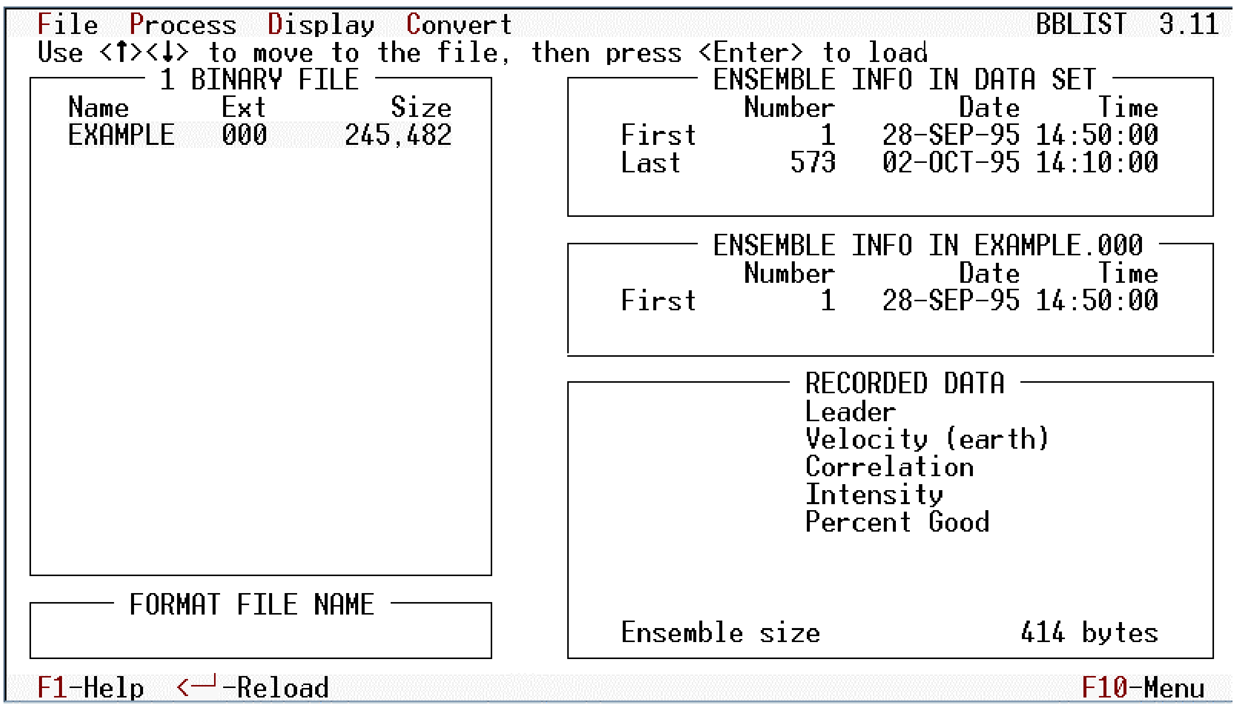


Figure 3-8. BBLIST Display

3-13.3 Using BBLIST to Convert Files

This is an example of how to convert the binary file EXAMPLE.000 to ASCII delimited text. For this example, we have chosen to extract only the magnitude, direction, and range data. Remember that *BBLIST* never changes your original data file — you can convert the raw data to as many different ASCII formats as desired.

Start BBLIST. To start *BBLIST*, type BBLIST ENTER.

Load EXAMPLE.000 binary file. Press F3 to load the binary file.

Set the processing parameters. Use the PROCESS menu (Figure 3-9, page 3-18) to set the velocity reference, magnetic variation, velocity measurement units, and depth measurement units. Use SPACE to toggle each setting. Make sure that MARK BELOW BOTTOM is set to NO (Workhorse ADCPs do not collect bottom-track data).

Set the conversion parameters. Use the CONVERT, LIMITS menu (Figure 3-10, page 3-19) to set the conversion limitations and parameters. You may want to increase the Max file size to 1000 kB if you plan to back up the ASCII data to floppy disks.

Define the format. Consider the following:

- What data do you want to extract? For this example, we choose *magnitude*, *direction*, and *range*.
- What program will you export the ASCII data to? Does the program support space, tab, or comma-delimited text? We choose space-delimited text for the example. To change, select Field delimiter and press SPACE to toggle between tab, comma, and space.
- Do you want vertical or horizontal placed data? For this example, we choose a vertical data format. To change, select Bin layout and press SPACE to toggle between vertical and horizontal.

Begin defining the format by doing the following;

a. Select CONVERT, DEFINE FORMAT. When you first enter this screen, *BBLIST* displays only a FORMAT END marker. To begin entering data fields, press ENTER to display the DEFINE FORMAT selection menu (Figure 3-11, page 3-19). If you make a mistake, select delete block and re-enter your choice.

b. Select ensemble info and press ENTER. Select Number and press ENTER.

c. Move the cursor to the FORMAT END marker and press ENTER.

d. Select Profiles, Mag and Dir. Select M for magnitude and press ENTER.

e. Move the cursor to LINE END and press ENTER.

f. Select Profiles, Mag and Dir. Select D for direction and press ENTER.

g. Move the cursor to LINE END and press ENTER.

h. Select Profiles, Depth ref. Select R for range and press ENTER. Your display should look like Figure 3-12, page 3-20.

View the format. Press F9 to view the format before converting (Figure 3-13, page 3-20). Use the + and − keys to increase the ensemble number. Press F9 again to return to the define format screen.

Save the format. Save the format to a *.FMT file for future use by pressing F2 and naming the file (example; MYFORMAT).

Begin the conversion. Select CONVERT, START CONVERSION. Enter a file name for the ASCII file data set. **Be sure to use a file name that differs from any existing file name.** Do not use the name of the binary data set. If *BBLIST* detects that the file name already exists, you are given the option to overwrite the existing files.

3-13.4 Using a BBLIST Format File to Convert Files

Once you have created a format file, you can use this file to convert other data files.

Start BBLIST. To start *BBLIST*, type BBLIST ENTER .

Load EXAMPLE.000 binary file. Press F3 to load the binary file.

Load Format file. Press F3 to load the format file.

Begin the conversion. Select CONVERT, START CONVERSION. Enter a file name for the ASCII file data set. **Be sure to use a file name that differs from any existing file name.** Do not use the name of the binary data set. If *BBLIST* detects that the file name already exists, you are given the option to overwrite the existing files.

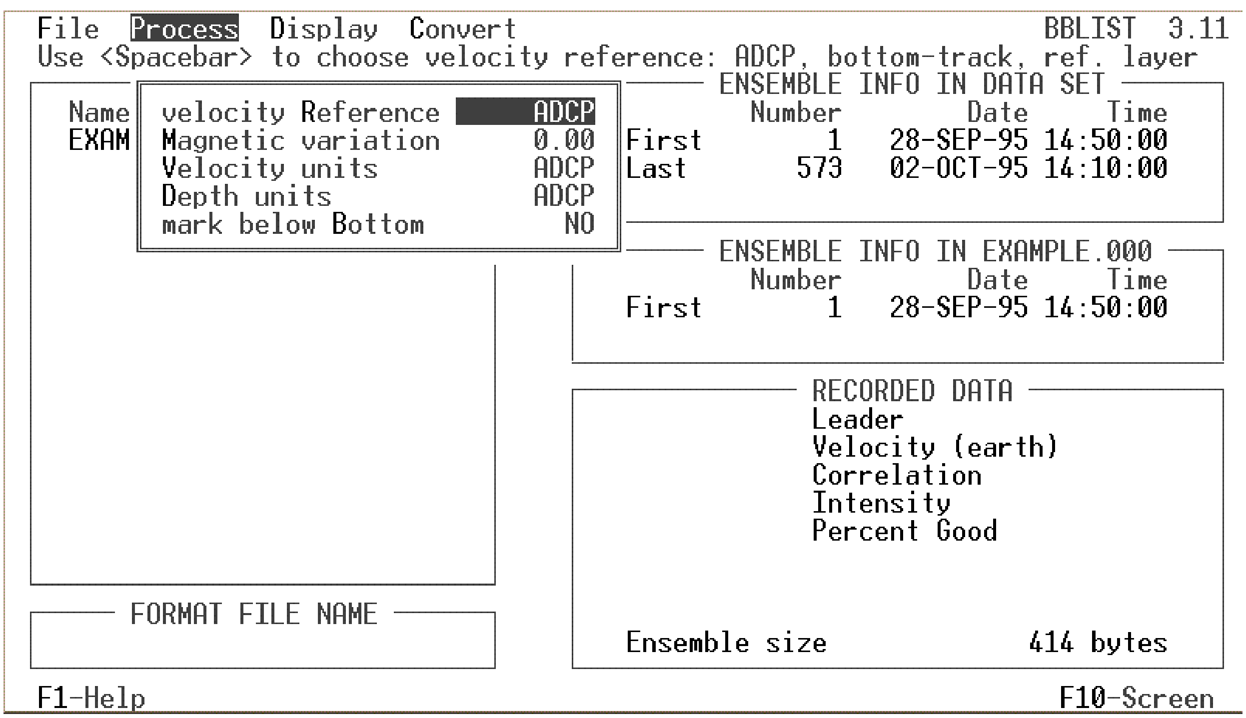


Figure 3-9. Set the Processing Parameters

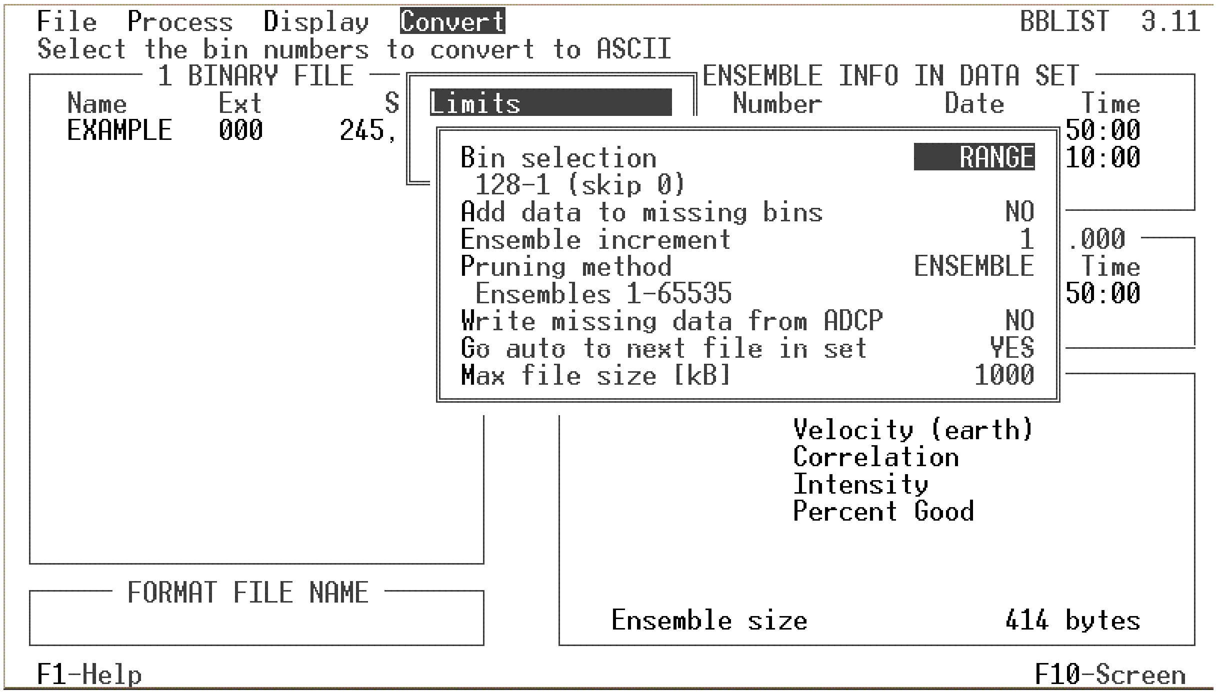


Figure 3-10. Set the Conversion Limitations and Parameters

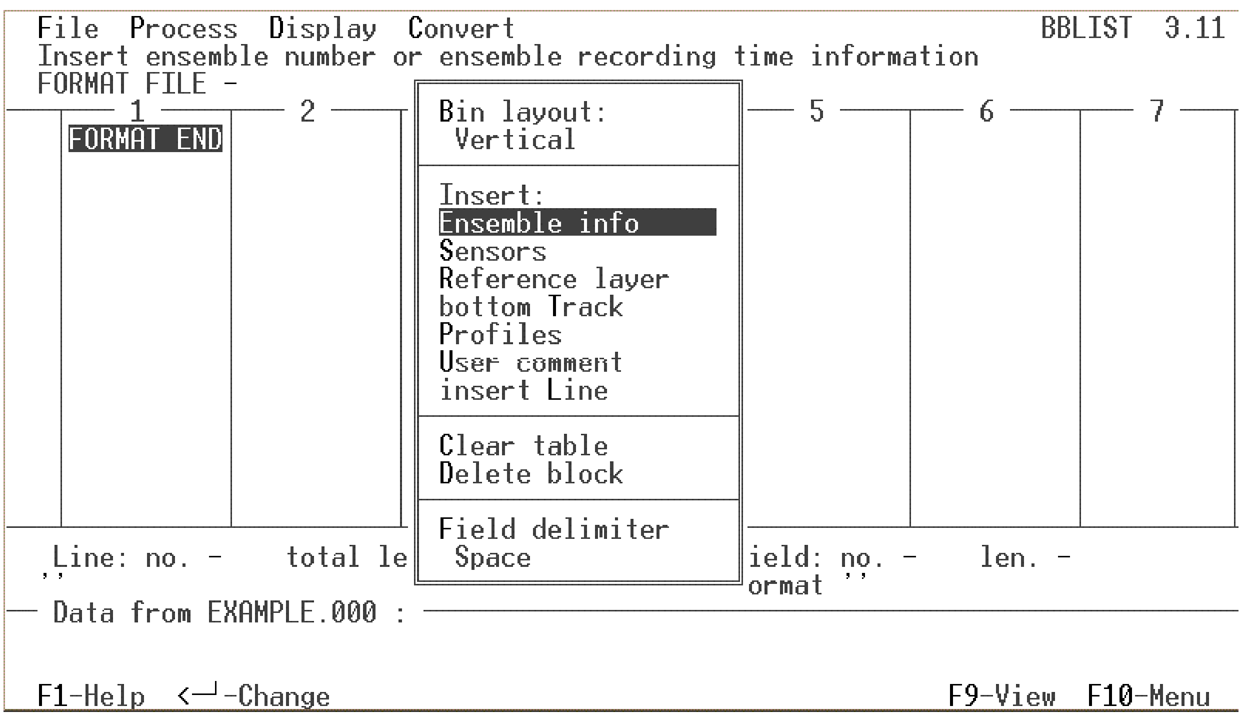


Figure 3-11. Define Format Selection Menu

```
 File  Process  Display  Convert                               BBLIST  3.11
 Use <↑><↓><←><→> to move bar, <Enter> to change fields, <F9> to view format
 FORMAT FILE
─────── 1 ────────── 2 ────────── 3 ────────── 4 ────────── 5 ────────── 6 ────────── 7 ───
  1 │Ens no.    │LINE END   │           │           │           │           │           │
  2 │Mag     15 │Dir     15 │Range   15 │LINE END   │           │           │           │
  3 │Mag     14 │Dir     14 │Range   14 │LINE END   │           │           │           │
  4 │Mag     13 │Dir     13 │Range   13 │LINE END   │           │           │           │
  5 │Mag     12 │Dir     12 │Range   12 │LINE END   │           │           │           │
  6 │Mag     11 │Dir     11 │Range   11 │LINE END   │           │           │           │
  7 │Mag     10 │Dir     10 │Range   10 │LINE END   │           │           │           │
  8 │Mag      9 │Dir      9 │Range    9 │LINE END   │           │           │           │
  9 │Mag      8 │Dir      8 │Range    8 │LINE END   │           │           │           │
 10 │Mag      7 │Dir      7 │Range    7 │LINE END   │           │           │           │
 11 │Mag      6 │Dir      6 │Range    6 │LINE END   │           │           │           │
 12 │Mag      5 │Dir      5 │Range    5 │LINE END   │           │           │           │
 13 │Mag      4 │Dir      4 │Range    4 │LINE END   │           │           │           │
 14 │Mag      3 │Dir      3 │Range    3 │LINE END   │           │           │           │

   Line: no. 2    total length 25                    Field: no. 4    len. 2
  'End of line: <CR><LF>'                            Format ''
── Data from EXAMPLE.000 : ──────────────────────────────────────────────────────
       79    216.7   3221
····•····1····•····2····•····3····•····4····•····5····•····6····•····7····•····8
 F1-Help  <┘-Change                                           F9-View  F10-Menu
```

Figure 3-12. Defining the Format

```
 File  Process  Display  Convert                               BBLIST  3.11
 Use cursor control keys to move bar, <Tab>/<Shift-Tab> to scroll left/right
 ENSEMBLE ◄38►          TIME 28-SEP-95 21:00:00.00   BINARY FILE EXAMPLE.000
───────────────────────────────────────────────────────────────────────────────
    38
       154     175.5   3221
       161     173.6   3021
       160     178.2   2821
       184     177.5   2621
       208     174.8   2421
       213     179.2   2221
        91     181.3   2021
       122     185.2   1821
       228     183.8   1621
       203     184.8   1421
       186     182.2   1221
       194     175.6   1021
       193     172.8    821
       195     175.6    621
       184     174.1    421

───────────────────────────────────────────────────────────────────────────────
 F1-Help  -/+-Ensemble  J-Jump  A,T,L,V...-Display         F9-Format  F10-Menu
```

Figure 3-13. View the Format before Converting

3-13.5 Report File

When the conversion process is complete, *BBLIST* creates an ASCII report file (*.RPT). You can view this file with any text editor. This file contains the following information about the settings and data in the converted files.

- *Workhorse information* - system frequency, beam angle, number of profiling beams, transducer orientation (up/down), transducer pattern (concave/convex), transducer connection (connected/disconnected), and CPU firmware version number.
- *Workhorse setup* - number of bins, bin length, blank after transmit length, pings per ensemble, time per ping, and profiling mode.
- *ASCII file data format* - a description on the contents of each line in the converted data file (for one ensemble).
- *Processing parameters* - velocity units, velocity reference, depth units, bin sequence, magnetic variation.

Sample BBLIST report file:

```
REPORT FOR ASCII DATA CONVERSION
--------------------------------

1. ADCP INFORMATION:

   Frequency 300 kHz
   Beam angle 20 deg
   4 beam system
   Up-looking orientation
   Convex beam pattern
   Transducer head connected
   CPU firmware 8.01

2. ADCP SETUP:
   Number of bins 15
   Bin length 200 cm
   Blank after transmit 200 cm
   Distance to first bin 421 cm
   Transmit length 207 cm
   Pings per ensemble 300
   Time per ping 1.99 s
   Profiling mode 1

3. ASCII FILE DATA FORMAT:

   Line 1: Ensemble number
   Line 2-16: Magnitude, Direction, Bin range

4. PROCESSING PARAMETERS:

   Velocity units: ADCP
   Velocity reference: BT
   Depth units: ADCP
   Bins: From 128 to 1 skip 0 bin
   Magnetic variation 0.00 deg
   Do not mark data below bottom

END OF REPORT
-------------
```

3-13.6 BBBATCH Program

When you have mastered the *BBLIST* program, you can use *BBBATCH* to convert binary data sets to ASCII data sets in a DOS batch mode. This comes in handy when you have several data sets to convert or have a large data set that you want to convert overnight. Here is the syntax for *BBBATCH*:

BBBATCH SPACE BinaryFileName SPACE FormatFileName SPACE AsciiFileName

- BinaryFileName = name of the binary data set to convert (no extension needed)
- FormatFileName = name of the format file to use
- AsciiFileName = name of the ASCII data set (unique name)
- Running *BBBATCH* without any command line parameters displays the syntax.

Chapter

4

Maintenance and Repair

4-1 Introduction

This chapter explains how to prepare the Workhorse for deployment, how to do certain maintenance, repair, and equipment modification procedures, and how to prepare the Workhorse for storage or shipment.

Several procedures in this chapter reference the same figures, so all figures are at the end of the chapter. Table 4-1 lists the items in the tools and spares parts kit. Use this kit when doing routine Workhorse maintenance.

4-2 Workhorse Disassembly

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

4-2.1 End-cap Removal Procedures

To remove the end-cap, do the following steps. Use Figures 4-1 and Figure 4-2 for parts identification.

NOTE

When you need access to the electronics, RDI recommends removing the transducer head assembly (see "Transducer Head Assembly Removal," page 4-2).

a. Dry the outside of the Workhorse.

b. Stand the Workhorse on its transducer face on a soft pad.

c. Remove all power to the Workhorse.

d. Loosen and remove the four end-cap bolts (6-mm).

NOTE

Make sure you save all hardware removed during this procedure for re-assembly.

e. Carefully pull the end-cap away from the pressure case until you can gain access to the connector jack on the common mode choke. Use care; the plastic mating surfaces scratch easily. Do not damage the mating surfaces. Remove any water from the o-ring grooves with a soft, lint-free cloth.

f. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap aside.

g. When recovering the Workhorse from a deployment, remove any water from the end-cap O-ring grooves. Clean the O-ring mating surfaces. Inspect the surfaces for damage. Even small scratches can cause leakage around the O-ring seal.

4-2.2 Transducer Head Assembly Removal

a. Remove all power to the Workhorse.

b. Stand the Workhorse on its end-cap.

c. Loosen and remove the four bolts (8-mm) that attaches the pressure case flange to the transducer head assembly.

d. Carefully lift the transducer assembly straight up and away from the pressure case until you can gain access to the connector jack on the common mode choke. Use care; the plastic mating surfaces scratch easily. Do not damage the mating surfaces.

e. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap assembly aside. Set the transducer assembly (transducer face down) on a soft pad.

f. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage.

g. When you are ready to re-assemble the workhorse, see “Workhorse Re-assembly,” page 4-3.

4-3 Workhorse Re-assembly

To replace the end-cap and transducer head, proceed as follows. Use Figures 4-1 and 4-2 for parts identification.

a. If you are sealing the Workhorse for a deployment, be sure you have done all appropriate maintenance items (see "Sealing the Workhorse for a Deployment," page 4-11).

b. Make sure all printed circuit boards, spacers, cables, and screws have been installed.

c. Install two fresh bags of desiccant just before closing the Workhorse (see "Desiccant Bags," page 4-9).

4-3.1 End-cap Replacement

a. Stand the Workhorse on its transducer face on a soft pad.

b. Connect the internal I/O connector to the plug on the common mode choke.

c. Place the end-cap on the pressure case, aligning the mating holes and the beam 3 number embossed on the end-cap with the beam 3 number embossed on the transducer head. When mating the end-cap with the pressure case flange, try to apply equal pressure to all parts of the O-rings. Make sure the face O-ring remains in its retaining groove.

> **NOTE**
>
> *We recommend you use new 2-260 O-rings if you are preparing for a deployment.*

d. Examine the end-cap assembly nuts, bolts, and washers (6 mm) for corrosion; replace if necessary. Figure 4-1 and 4-2 shows the assembly order of the end-cap mounting hardware. *All* the hardware items are needed to seal the Workhorse properly. Install all four sets of hardware until "finger-tight." In rotation, tighten the bolts until the split washer flattens out, and then tighten ¼ turn more to compress the face seal O-ring evenly. Do not over tighten the bolts. Do not deform the plastic pressure case.

> **CAUTION**
>
> *Do not over tighten the bolts that hold the transducer, pressure case and end cap together. If you tighten too far, you can crack or break the plastic. Over a longer period, over tightening can cause the plastic to creep. This is a less serious problem in which permanent deformations are formed primarily at the edges of washers. Conversely, leaving the bolts too loose can cause the ADCP to flood. Tighten the hardware to the recommended torque value.*

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

4-3.2 Transducer Head Assembly Replacement

a. Stand the Workhorse pressure case on its end-cap.

b. Connect the internal I/O connector to the plug on the common mode choke.

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

NOTE

We recommend you use new 2-260 O-rings if you are preparing for a deployment.

d. Examine the transducer assembly nuts, bolts, and washers (8 mm) for corrosion; replace if necessary. Figure 4-1 and 4-2 shows the assembly order of the transducer mounting hardware. *All* hardware items are needed to seal the Workhorse properly. Install all four sets of hardware until “finger tight.” In rotation, tighten the bolts until the split washer flattens out, and then tighten ¼ turn more to compress the face seal O-ring evenly. Do not over tighten the bolts. Do not deform the plastic bushings.

CAUTION

Do not over tighten the bolts that hold the transducer, pressure case and end cap together. If you tighten too far, you can crack or break the plastic. Over a longer period, over tightening can cause the plastic to creep. This is a less serious problem in which permanent deformations are formed primarily at the edges of washers. Conversely, leaving the bolts too loose can cause the ADCP to flood. Tighten the hardware to the recommended torque value.

NOTE

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

4-4 Battery Packs

The Sentinel system uses battery packs to provide power. Batteries should be replaced when the voltage falls below 30 VDC (measured across the battery connector under no-load conditions). To replace the battery pack, do the following steps.

a. Remove the end-cap (see “End-cap Removal Procedures,” page 4-1).

b. Disconnect the battery cable going to the common mode choke.

c. Remove the four wing nuts, lock washers, and washers holding the battery pack onto the posts (Figure 4-5, page 4-23).

d. Remove the support plate.

e. Slide out the used battery pack.

f. Slide a new battery pack onto the four posts making sure that the arrow on the battery pack is pointing at beam 3. Make sure the I/O cable is not pinched by the battery pack. Use the large rubber bands (supplied with each new pack) to hold the cables in place.

g. Position the support plate over the four posts.

h. Place a flat washer, lock washer and wing nut on each of the four posts. Tighten the nuts to hold the battery in place.

i. Connect the battery cable going to the common mode choke (see Figure 4-4, page 4-22).

j. Install the end-cap (see “End-cap Replacement,” page 4-3).

k. Align the compass (see “Compass Calibration,” page 4-6).

4-5 External Battery Case Battery Replacement

The external battery case holds two battery packs to provide power. Batteries should be replaced when the voltage falls below 30 VDC (measured across the battery connector under no-load conditions). To replace the battery packs, do the following steps.

a. Remove one end-cap from the external battery pack (see “End-cap Removal Procedures,” page 4-1).

b. Place the external battery case on its side and carefully pull out the battery pack (attached to the end-cap).

c. Disconnect the battery power cable from the wiring harness.

d. Remove the four wing nuts, lock washers, and washers holding the battery pack onto the posts (see Figure 4-3, page 4-21).

e. Remove the support plate.

f. Slide out the used battery pack.

g. Slide a new battery pack onto the four posts. Make sure the wiring harness is not pinched by the battery pack. Use the large rubber bands (supplied with each new pack) to hold the cables in place.

h. Position the support plate over the four posts.

i. Place a flat washer, lock washer and wing nut on each of the four posts. Tighten the nuts to hold the battery in place.

j. Connect the battery power cable to the wiring harness.

k. Install the end-cap/battery pack assembly (see “End-cap Replacement,” page 4-3).

l. Repeat steps a through k to replace the other battery pack.

m. Replace the desiccant bags on each battery just before sealing the external battery case (see “Desiccant Bags,” page 4-9).

4-6 Compass Calibration

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. You should be aware of the following items:

- We recommend against calibrating the Workhorse while on a ship. The ship’s motion and magnetic fields from the hull and engine will likely prevent successful calibration.
- If you think your mounting fixture or frame has some magnetic field or magnetic permeability, calibrate the Workhorse inside the fixture. Depending on the strength and complexity of the fixture’s field, the calibration procedure may be able to correct it.
- If you will deploy your Workhorse looking up, calibrate it looking up. If you will deploy it looking down, calibrate it looking down.

4-6.1 Preparing for Calibration

Place the Workhorse on a piece of strong cardboard on top of a smooth wooden (non-magnetic) table. If a wooden table is not available, place the Workhorse on the floor as far away from metal objects as possible. Use the cardboard to rotate the Workhorse during calibration—this way you will not scratch the Workhorse.

a. Connect the Workhorse as shown in Chapter 1.

b. Start *TESTADCP* (which runs *BBTALK*, wakes up the Workhorse and starts logging to the file TESTADCP.DAT). See Chapter 5 for assistance on using *TESTADCP*.

4-6.2 Compass Calibration Verification

Compass calibration verification is an automated built-in test that measures how well the compass is calibrated. The procedure measures compass parameters at every 5º of rotation for a full 360º rotation. When it has collected data for all required directions, the Workhorse computes and displays the results. Start the test with the AX-command and follow the instructions. The Workhorse can be vertical (it can rest on its end cap), or it can be tilted (it could rest on a transducer face). Whatever its tilt, the tilt must remain constant as you rotate the Workhorse. When prompted, rotate the Workhorse smoothly and slowly. Pay particular attention to the Overall Error. For example;

```
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°
```

If the overall error is < 5°, the compass does not *require* alignment unless you have just replaced the battery. You can align the compass to reduce the overall error even more (if desired).

4-6.3 Compass Calibration Procedure

The built-in automated compass calibration procedures are similar to the alignment verification, but requires three rotations instead of one. The Workhorse 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 for the two calibration rotations, the Workhorse 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.

a. Start *BBTALK*.

a. Start the test with the AF-command and choose the calibration type**.**

b. When prompted, rotate the Workhorse slowly 360°.

c. The second rotation requires the Workhorse to be tilted on an adjacent beam. Follow the on-screen instructions to orient the unit correctly. Tilt an upward-looking Workhorse with a block under one side of the end cap. A 35-mm block gives you an 11º tilt. When prompted, rotate the Workhorse slowly 360°.

d. If the calibration procedure is successful, it records the new calibration matrix to non-volatile memory. The Workhorse will not change its matrix unless the calibration is properly carried out.

e. If the calibration procedure is not successful, return your Workhorse to the original factory calibration, by using the AR-command. Try using the AR-command if you have trouble calibrating your compass. In some circumstances, a defective compass calibration matrix can prevent proper calibration.

4-7 Fuse Replacement

PIO Board. There is one fuse on the PIO Board that protects the Workhorse from excessive incoming power. If this fuse continues to blow, check your input power before applying power again.

a. Turn off the power.

b. Remove the transducer head (see “Transducer Head Assembly Removal,” page 4-2).

c. The PIO board fuse is located next to the internal I/O connector. Use a small flat-blade screwdriver to open the fuse housing. Turn the end 180° counter-clockwise to open the fuse housing.

d. Gently pull the fuse housing out. Turn the housing to remove the fuse.

e. Replace the fuse with the correct voltage and amperage fuse (Table 4-1 item 19).

f. Install the transducer head (see “Transducer Head Assembly Replacement,” page 4-4).

g. Test the system (Chapter 5).

External Battery Pack. There is one fuse in the external battery pack that protects the Workhorse from excessive incoming power. If this fuse continues to blow, check your battery packs before connecting the external battery case again.

a. Remove one end-cap from the external battery pack.

b. Carefully lift out the battery pack (attached to the end-cap).

c. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse (Table 4-1 item 19).

d. Install the end-cap (see “End-cap Replacement,” page 4-3)

e. Measure the voltage output of the external battery case across pin 3 (+) and pin 7 (-) on the external connector. If both battery packs are fresh, you should measure approximately 42 VDC.

4-8 Communications Setting

There is a switch on the PIO board (see Figure 4-4, page 4-22) that changes the communication settings between RS-232 and RS-422. Your computer and the Workhorse must both be set to the same communication setting. Use the RS-232-to-RS-422 converter if the Workhorse is using RS-422 communications and you computer only has an RS-232 COM port.

4-9 Firmware Upgrades

The firmware for Workhorse ADCPs in located on flash RAM chips on the CPU board. Firmware must be downloaded. When new firmware is required, you will be supplied with a program and the firmware file to download to the Workhorse.

4-10 Changing the Up/Down Transducer Orientation

The Workhorse uses an automatic sensor switch to determine up/down transducer orientation. No manual changes are needed when switching the orientation.

4-11 PC Card Recorder

The PC Card recorder is located on the Digital Signal Processor (DSP) board inside the Workhorse's electronics. To recover data, the card can be removed and used in a personal computer (PC), or left in the Workhorse, and accessed by using *RECOVER* (see Chapter 2). To remove or install a PC card, do the following.

a. Turn off power to the Workhorse.

b. Remove the transducer head (see "Transducer Head Assembly Removal," page 4-2).

c. Remove the PC cards by pushing the button on the side of the PCMCIA card slot. The card should "pop" out of the connector. If you cannot reach the release button with your finger, use a plastic pen or non-conductive tool to depress the button. Do not try to force the card in or out of the connector. When PC cards are properly oriented, they slide easily in or out.

d. When you are finished recovering the data, install the PC card back into the DSP board. PC cards install with the label side toward the face of the transducer.

e. Install the transducer head (see "Transducer Head Assembly Replacement," page 4-4).

NOTE

RDI uses true 16-bit PCMCIA/ATA, 5-volt, type 2 memory cards made by SANDISK (old name was SUNDISK). These cards must be formatted before using in the Workhorse. Other cards may work but we have not had any success. You can use 10, 20, 40 or 80-MB cards (up to two cards).

The Workhorse Monitor comes with no memory cards, but has the same capacity for memory cards as a Sentinel.

4-12 Desiccant Bags

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

The average dry weight of a new desiccant bag is 7.2 grams (± 5%). The weight increases to 8.4 to 9 grams for a "used" desiccant bag. Used desiccant bags may be dried at 250° for 14 hours. As a minimum, replace the desiccant bags (Table 4-1, item 17) whenever you are preparing to deploy or store the Workhorse for an extended time.

WARNING

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

NOTE

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

a. Remove the transducer head (see "Transducer Head Assembly Removal," page 4-2).

b. Remove the new desiccant bags from the airtight aluminum bag.

c. Remove the old desiccant bags and install two new ones. Place the desiccant bags (Table 4-1, item 17) between the PIO board and the end-cap.

d. Install the transducer head (see "Transducer Head Assembly Replacement," page 4-4).

4-13 O-ring Inspection and Replacement

This section explains how to inspect/replace the Workhorse O-rings. A successful deployment depends on the condition of two O-rings and their retaining grooves. See Figure 4-1 and Figure 4-2 for the locations of the following O-rings. Read all instructions *before* doing the required actions.

- Transducer assembly, face, 2-260 (Table 4-1, item 3)
- End-cap assembly, face, 2-260 (Table 4-1, item 3)

We strongly recommend replacing these O-rings whenever you disassemble the Workhorse. Inspecting and replacing the O-rings should be the last maintenance task done before sealing the Workhorse.

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

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

If a scratch is on the plastic pressure case flange o-ring groove, it may be gently sanded using 600 grit (wet) sandpaper. Use care not to cause further damage.

Lubricate the O-ring with a thin coat of DC-111 lubricant (Table 4-1, item 18). Apply the lubricant using latex gloves. Do not let loose fibers or lint stick to the O-ring. Fibers can provide a leakage path.

NOTE

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

4-14 Transducer Head Inspection

The urethane coating on the transducer faces is important to Workhorse watertight integrity. Mishandling, chemicals, abrasive cleaners, and excessive depth pressures can damage the transducer ceramics or urethane coating. Inspect the transducer faces for dents, chipping, peeling, urethane shrinkage, hairline cracks, and damage that may affect watertight integrity or transducer operation. Repair of the transducer faces should only be done by RDI.

CAUTION

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

4-15 Sealing the Workhorse for a Deployment

Use Figure 4-1 and 4-2 and the following steps to seal the Workhorse for a deployment.

a. Check the Workhorse electronics; there should be no loose screws or missing hardware.

b. Install the PC card(s) (Sentinel ADCPs only, see “PC Card Recorder,” page 4-9).

c. Replace the battery pack or connect the battery cable (Sentinel ADCPs only, see “Battery Packs,” page 4-5).

d. Add two fresh desiccant bags inside the Workhorse pressure case (see “Desiccant Bags,” page 4-9).

e. Install the transducer head assembly and end-cap (see “Workhorse Re-assembly,” page 4-3).

f. The Workhorse is now ready for deployment unless you want to take steps to prevent bio-fouling (see “Prevention of Biofouling,” page 4-12).

g. Use Chapter 1 to connect the Workhorse system. Use Chapter 5 to test the Workhorse before the deployment.

4-16 Installing the I/O Cable or Dummy Plug

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

When connecting the cable or dummy plug to the connector, first apply a light coat of DC-111 lubricant to the rubber portion of the connector pins. This will help seat the connector. When connecting the cable, use a slight side-to-side “wiggle” motion if there is resistance. When the cable is fully set (no gap between the connectors) the retainer strap can be pulled over into place.

When removing the cable or dummy plug, first pull the retainer strap over the connector. Failure to release the retainer strap will cause it to break. When removing the dummy plug, use a sid-to-side wiggle action if you have difficulty removing the plug. The dummy plug should be installed any time the I/O cable is removed. Use the dummy plug when the Workhorse is in storage or is being handled.

4-17 Prevention of Biofouling

This section explains how to prevent the buildup of organic sea life (biofouling) on the transducer faces. Objects deployed within about 100 meters (≈328 feet) of the surface are subject to biofouling, especially in warm, shallow water.

Deep Water Deployments. Biofouling is not usually a problem in deep water (more than 100 meters). Soft-bodied organisms usually cause no problems. Do not apply antifouling grease if deploying the Workhorse in deep water.

Shallow Water Deployments. Soft-bodied organisms usually cause no problems, but barnacles can cut through the urethane transducer face causing failure to the transducer and leakage into the Workhorse.

In shallow-water applications, the use of antifouling grease may be appropriate if you cannot clean the transducer faces often (weekly), and if the antifouling grease meets all of your local safety and environmental laws (see the following cautions).

Controlling Biofouling. The best-known way to control biofouling is cleaning the Workhorse transducer faces often. However, in many cases this is not possible. The following options can help reduce biofouling.

- Coat the entire Workhorse with cuprous oxide or related paints such as copper, chrome, or arsenic. Make sure that the paint is applied in an even coat over the transducer faces.
- Cover the transducer faces using tributyl-tin (TBT) paint. The EPA and many other government agencies outlaw TBT paint. Some organizations have obtained permission to apply TBT paint to their equipment, but this requires getting a license and special handling training as well as obtaining a change to the accepted uses by the EPA. If you are interested in this method, you will need to contact your local EPA office.
- Apply a thin coat (≈4 mm; ≈0.16 in.) of either a 50:50 mix of chili powder and petroleum jelly or chili powder and silicone grease to the transducer faces. The chili powder should be the hottest that can be found. Water flowing across the transducers will wash this mix away over time. The silicone mixture tends to last longer.

If using antifouling grease, remove the grease immediately after recovering the Workhorse from its deployment. Remove the grease with soapy water. Be sure to wear protective gloves and a face shield.

CAUTIONS

1. *Do not arbitrarily use antifouling grease for deep-water applications. For shallow-water applications, barnacles are a threat to the transducer faces; using antifouling grease may be appropriate if you cannot clean the Workhorse regularly (weekly). If using antifouling grease, remove it immediately after recovering the Workhorse.*
2. *Antifouling grease is toxic. Read the product safety data sheet before using the grease. Wear gloves and a face shield when applying the grease. If the skin comes in contact with the grease, immediately wash the affected area with warm, soapy water.*
3. *All U.S. coastal states prohibit the use of tributyl-tins on boat hulls. The European Economic Commission has released a draft directive that would prohibit the use of many organo-tins after July 1989. We strongly recommend you obey your local laws.*

4-18 Storage and Shipping Maintenance

This section lists the maintenance items to do before storing the Workhorse. These maintenance items include:

- Cleaning the Workhorse with fresh, soapy water.
- Removing biofouling (see "Removal of Biofouling").
- Inspecting the transducer head (see "Transducer Head Inspection," page 4-11).
- Inspecting/replacing the O-rings (see "O-ring Inspection and Replacement," page 4-10).
- Preparing the Workhorse for final storage or shipping (see "Final Storage or Shipping Preparation," page 4-14).

4-19 Removal of Biofouling

Before storing or shipping the Workhorse, remove all foreign matter and biofouling. Remove soft-bodied marine growth or foreign matter with soapy water. Waterless hand cleaners remove most petroleum-based fouling. Rinse with fresh water to remove soap residue. Dry the transducer faces with low-pressure compressed air or soft lint-free towels.

CAUTION

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

If there is heavy fouling or marine growth, the transducer faces may need a thorough cleaning to restore acoustic performance. Barnacles do not usually affect Workhorse operation. We do, however, recommend removal of the barnacles to prevent water leakage through the transducer face. Lime dissolving liquids such as Lime-Away™ break down the shell-like parts. Scrubbing with a medium stiffness brush usually removes the soft-bodied parts. Do NOT use a brush stiffer than a hand cleaning brush. Scrubbing, alternated with soaking in Lime-Away™, effectively removes large barnacles. After using Lime-Away™, rinse the Workhorse with fresh water to remove all residues. If barnacles have entered more than 1.0-1.5 mm (0.04-0.06 in.) into the transducer face urethane, you should send the Workhorse to us for repair. If you do not think you can remove barnacles without damaging the transducer faces, contact RDI.

4-20 Final Storage or Shipping Preparation

This section explains how to store or ship the Workhorse. Clean and inspect the I/O connector for water or salt residue (Figure 4-1 and 4-2).

WARNING

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

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

NOTE

RDI strongly recommends using the original shipping crate whenever transporting the Workhorse.

If you need to ship or store the Workhorse, use the original shipping crate whenever possible. If the original packaging material is unavailable or unserviceable, additional material is available through RDI.

For repackaging with commercially available materials, use the following procedure:

a. Use a strong shipping container made out of wood or plastic.

b. Install a layer of shock-absorbing static-shielding material, 70-mm to 100-mm thick, around all sides of the instrument to firmly cushion and prevent movement inside the container.

c. Seal the shipping container securely.

d. Mark the container FRAGILE to ensure careful handing.

e. In any correspondence, refer to the Workhorse by model and serial number.

4-21 Returning Workhorses to RDI for Service

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

4-21.1 Domestic Shipments

Step 1 - Get a Return Authorization

The best way to make sure RDI is aware of your intentions to ship equipment is to obtain a Return Authorization (RA) before sending the shipment. Return Authorizations are issued by Sales Administration or Customer Service and are used to notify us of your needs in advance of arrival so we can provide a faster turnaround. When requesting a Return Authorization, please give us the following information.

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What problem(s) need correction
- When you need the instrument returned

When the Return Authorization is issued, we will tell you the RA number. Please include this number on all packages and correspondence.

Step 2 - Ship via air freight, prepaid

WARNING; never *ship the Workhorse with lithium batteries inside*. Lithium batteries must be packaged and shipped according to the hazardous materials regulations of the International Air Traffic Association (IATA) via Air Cargo *only*.

Urgent Shipments should be shipped direct to RDI via any of several overnight or priority air services. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, you will save money, but may lose up to three days in transit time.

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

Mark the Package(s)

To: RD Instruments, Inc. (*RA Number*)
9855 Businesspark Avenue
San Diego, CA 92131-1101

Step 3 - Urgent shipments

Send the following information by fax or telephone to RDI.

Attention: Sales Administration
Fax: (619) 695-1459
Phone: (619) 693-1178

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

4-21.2 International Shipments

Step 1 - Get a Return Authorization

The best way to make sure RDI is aware of your intentions to ship equipment is to obtain a Return Authorization (RA) before sending the shipment. Return Authorizations are issued by Sales Administration or Customer Service and are used to notify us of your needs in advance of arrival so we can provide a faster turnaround. When requesting a Return Authorization, please give us the following information.

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What problem(s) need correction
- When you need the instrument returned

When the Return Authorization is issued, we will tell you the RA number. Please include this number on all packages and correspondence.

Step 2 - Ship Via Air Freight, Prepaid

WARNING; *never ship the Workhorse with lithium batteries inside*. Lithium batteries must be packaged and shipped according to the hazardous materials regulations of the International Air Traffic Association (IATA) via Air Cargo *only*.

Urgent Shipments should be shipped direct. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, you will save money, but may lose up to five days in transit time.

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

Mark the package(s) as follows:

To: RD Instruments, Inc. (*RA Number*)
9855 Businesspark Avenue
San Diego, CA 92131-1101 USA

C/O: Paxton, Shreve & Hays
Lindbergh Field, San Diego Airport
2361 Airlane Drive, #D
San Diego, CA 92101

Notify upon arrival

Phone: 619-692-3113

Fax: 619-692-0539

Step 3 - Include Proper Customs Documentation

The Customs statement should be completed very carefully. It should accurately and truthfully contain the following information.

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

Step 4 - Send the Following Information by Fax or Telephone to RDI

Attention: Sales Administration

Fax: (619) 695-1459

Phone: (619) 693-1178

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

4-22 Spare Parts

Table 4-1. Workhorse Spare Parts

Item #	Qty	Part number	Description
1	1	14800	Tool box, 14-1/2 H 7-1/2 H 5-1/2
2	4	810-4004-00	Bushing, instrument housing
3	2	2-260	O-ring, face
4	1	M13COMBINATION	Wrench, 13 mm combination
5	1	M10COMBINATION	Wrench, 10 mm combination
6	1	M5ALLENDRIVER	Ball type, metric
7	1	M6ALLENDRIVER	Ball type, metric
8	1	5503A39	Wrench, 3 mm, ball end, L
9	4	M8X1.25X70SH	Screw, socket head, stainless steel 316
10	4	M8WASHSPL	Washer, split lock, stainless steel 316
11	8	M8WASHSTD	Washer, flat, M8, 17 mm OD, stainless steel 316
12	4	M8X1.25NUT	Nut, hex, stainless steel 316
13	4	M6X1.0X45SH	Screw, socket head, stainless steel 316
14	8	M6WASHSTD	Washer, flat, 12.5 mm OD, stainless steel
15	4	M6WASHSPL	Washer, split lock, stainless steel 316
16	4	M6X1.0NUT	Nut, hex, stainless steel 316
17	1	DES3	Desiccant, sealed bag
18	1	DC-111	Lubricant, silicone, 5.3 oz, Dow-Corning
19	2	GMA-3A	Fuse, 3.0 Amp, 250V

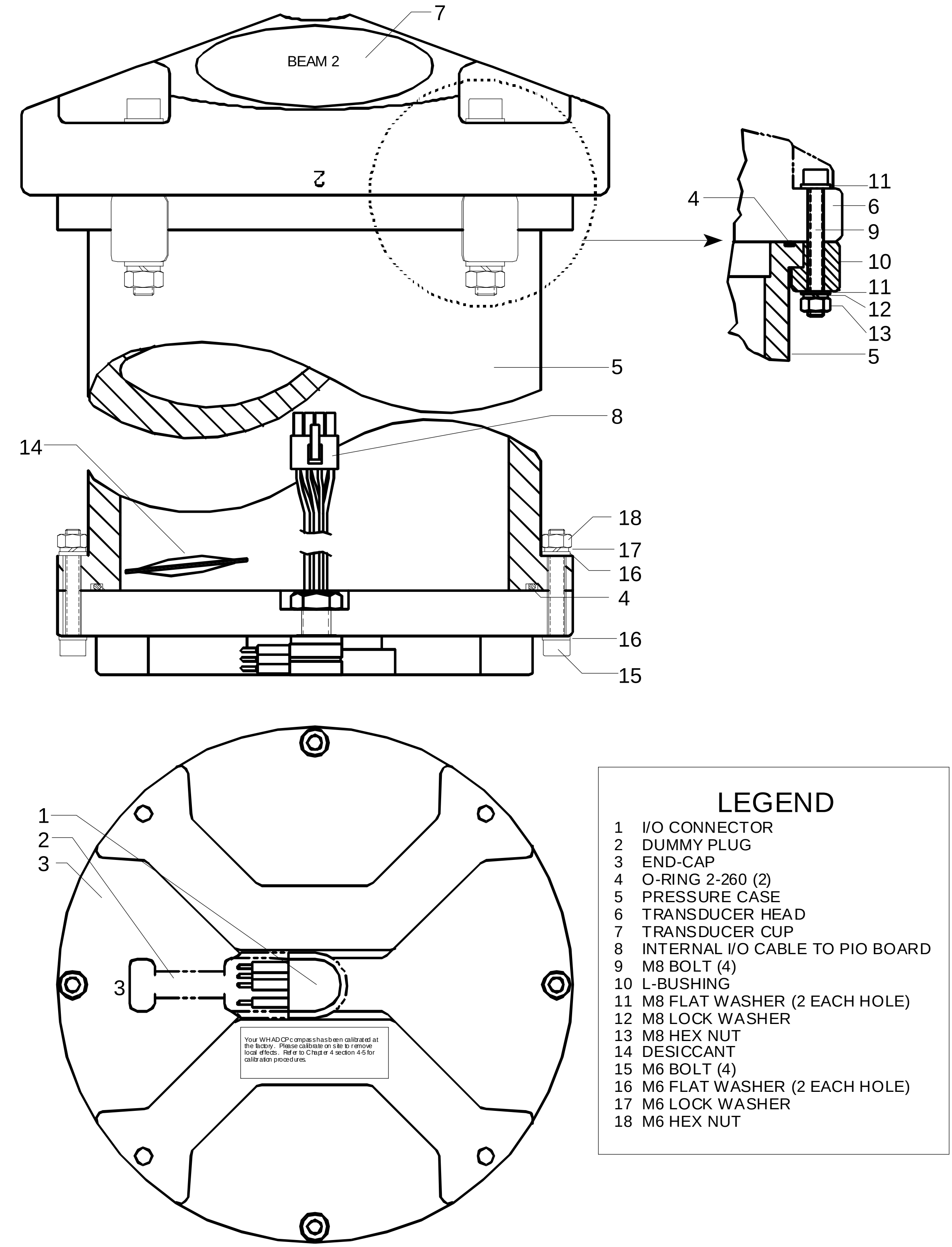
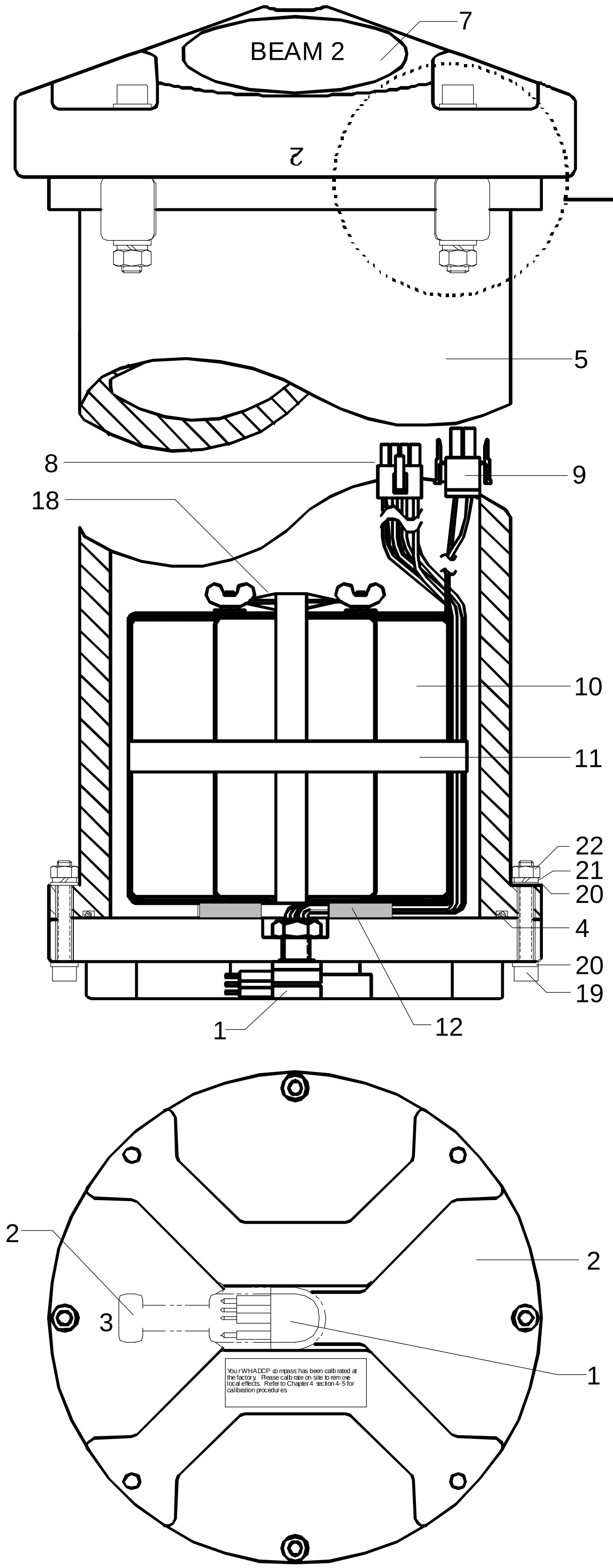
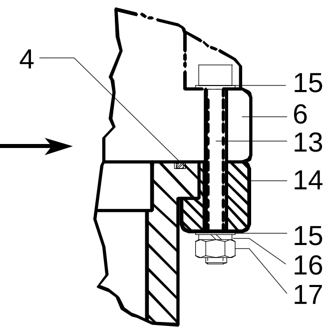


Figure 4-1. Monitor Workhorse Parts Location





LEGEND

1 I/O CONNECTOR
2 DUMMY PLUG
3 END-CAP
4 O-RING 2-260 (2)
5 PRESSURE CASE
6 TRANSDUCER HEAD
7 TRANSDUCER CUP
8 INTERNAL I/O CABLE TO PIO BOARD
9 BATTERY CABLE TO PIO BOARD
10 BATTERY PACK
11 RUBBER BANDS
12 SPACERS (4)
13 M8 BOLT (4)
14 L-BUSHING
15 M8 FLAT WASHER (2 EACH HOLE)
16 M8 LOCK WASHER
17 M8 HEX NUT
18 DESICCANT (UNDER RUBBER BAND)
19 M6 BOLT (4)
20 M6 FLAT WASHER (2 EACH HOLE)
21 M6 LOCK WASHER
22 M6 HEX NUT

Figure 4-2. Sentinel Parts Location

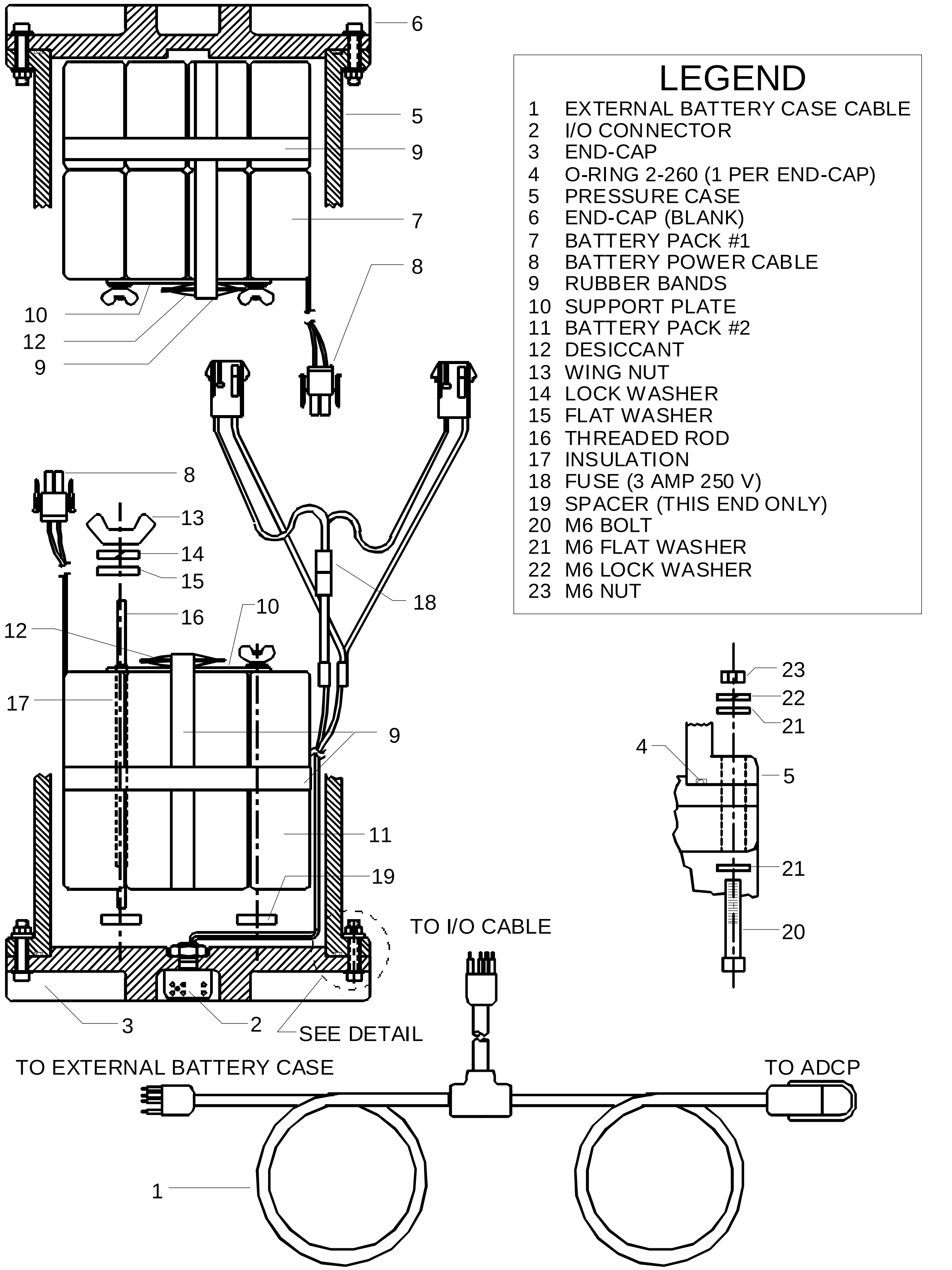


Figure 4-3. External Battery Pack Parts Location

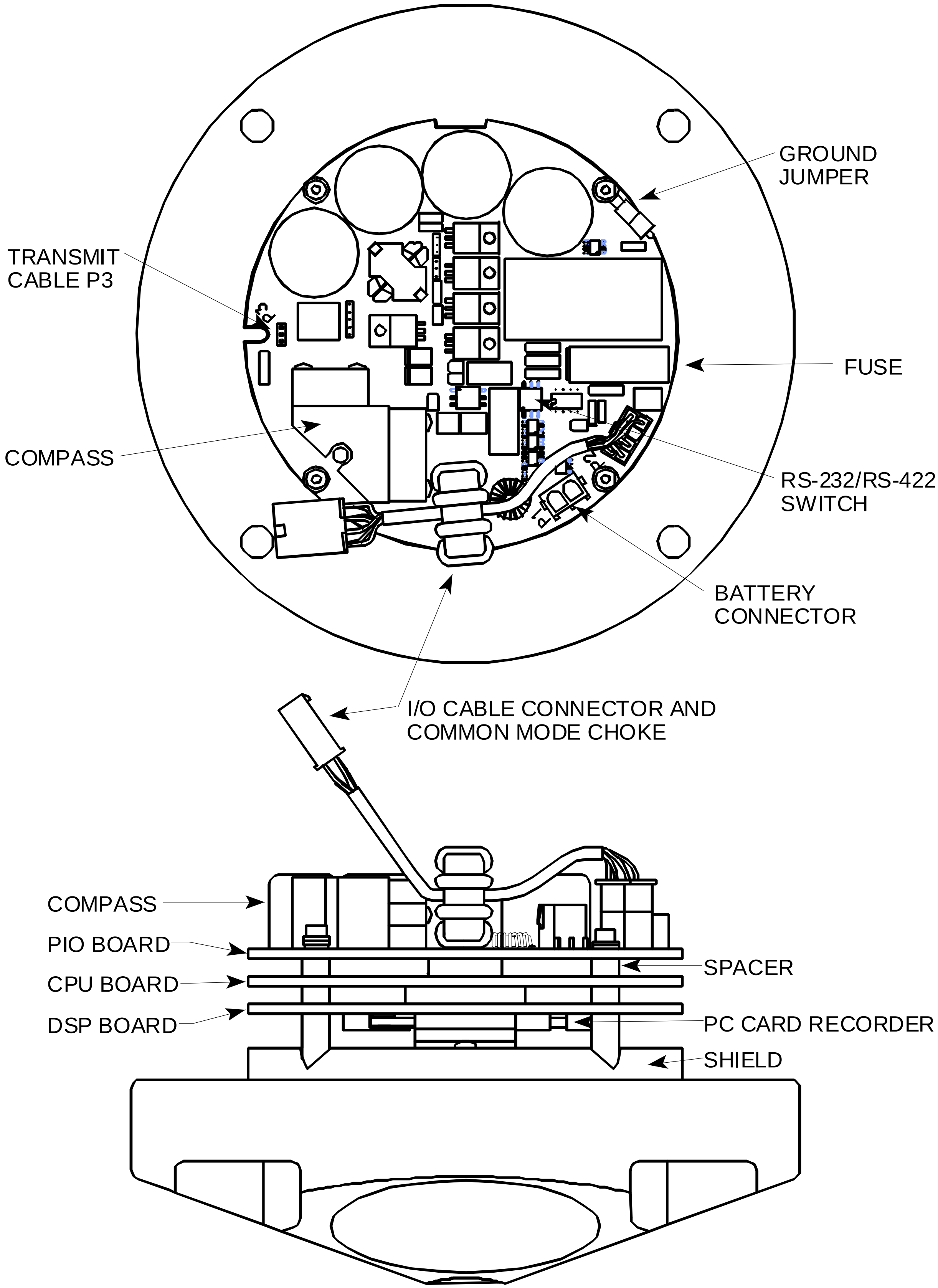


Figure 4-4. Workhorse Board Locations

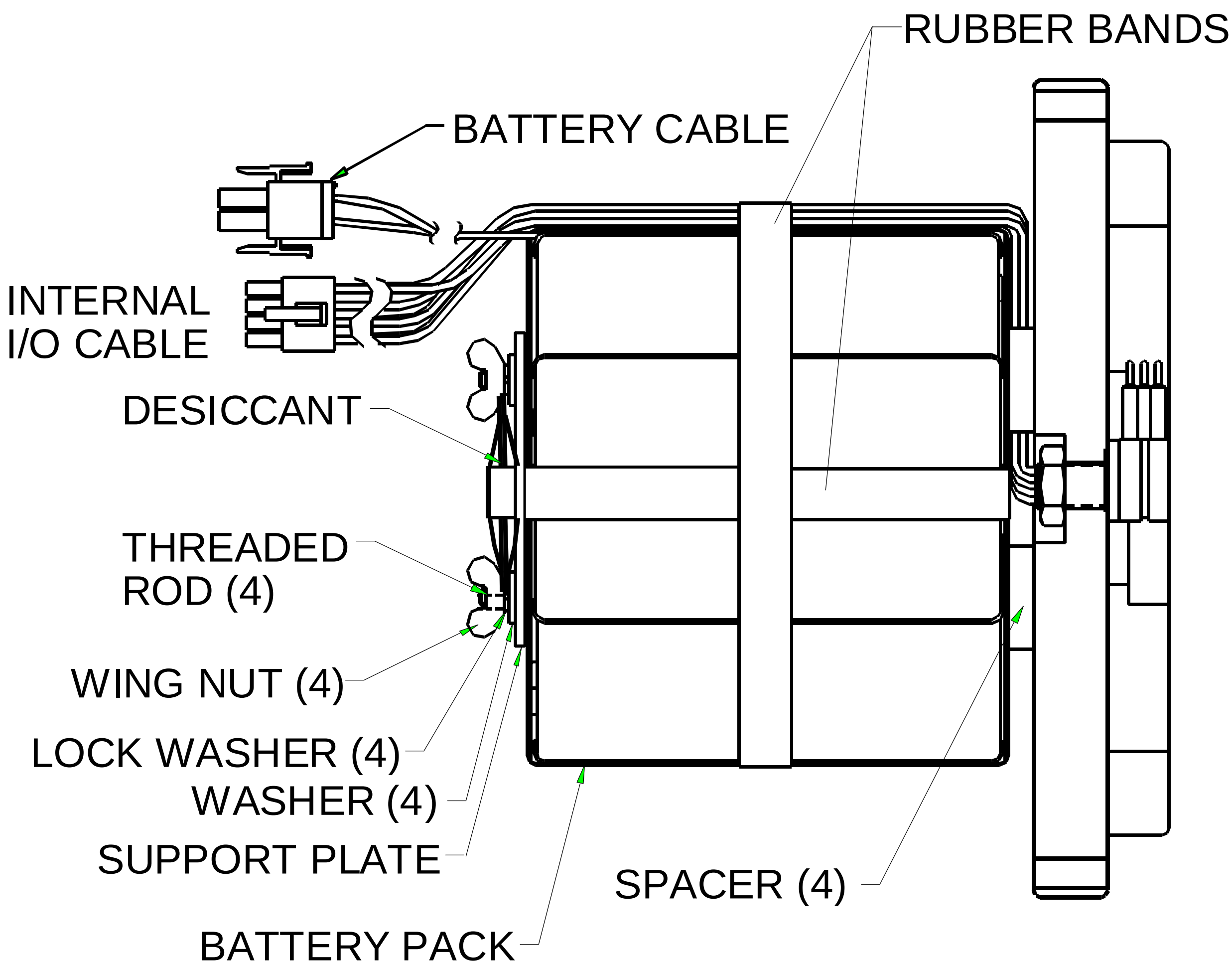


Figure 4-5. Sentinel End-cap and Battery Pack Parts Location

NOTES

Chapter
5

Test Procedures

5-1 Introduction

This chapter explains how to test the Workhorse using direct commands and the *TESTADCP* program. These tests thoroughly check the Workhorse in a laboratory environment, but are no substitute for a practice deployment. These tests do not calibrate the Workhorse. You should test the Workhorse:

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

These test procedures assume all equipment is working. The tests can help you isolate problems to a major functional area of the Workhorse. For troubleshooting information, see Chapter 6.

> **NOTE**
>
> *The built-in tests require you to immerse the transducer faces in water. If you do not, some of the tests may fail. Running the tests in air will not harm the ADCP.*

5-2 Test Setup

Use the following steps to connect the Workhorse system and to place the Workhorse in a known state.

a. Connect and apply power to the system as described in Chapter 1.

b. Place the Workhorse in enough water to cover the transducer faces.

c. Type TESTADCP[ENTER].

You should see a display similar to the following.

```
[BREAK Wakeup A]

WorkHorse Broadband ADCP Version 8.xx
RD Instruments (c) 1996
All rights reserved.
>{                                                                      -}
{                      TESTADCP                                         -}
{                                                                       -}
{      Results are being logged to TESTADCP.DAT                         -}
{                                                                       -}
{      You may now do any of the following:                             -}
{         1) Press [Esc] to perform automated tests                     -}
{              PA    System test                                        -}
{              PC2   Display heading, pitch, and roll                   -}
{              RR    Show recorder directory and free space             -}
{              PC1   Beam continuity test                               -}
{         2) Enter direct commands to ADCP                              -}
{         3) Press alt-X to quit.                                       -}
{                                                                       -}
```

You have the following options;

- Press the ESC key to run all of the tests.
- Press ENTER to run each test manually or run other direct commands.
- Press ALT X to exit *TESTADCP*.

When you are done testing the Workhorse, all of the test results will be saved to the file TESTADCP.DAT. You should save and view this file before deploying the Workhorse.

5-2.1 Pre-deployment Test

The pre-deployment test checks the major Workhorse modules and signal paths. We recommend you run this test before a deployment. This test checks the following boards/paths. If any test fails, call RDI for further troubleshooting information.

- 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.

Type PA ENTER . A message similar to the following should appear.

```
>PA

PRE-DEPLOYMENT TESTS

CPU TESTS:
  RTC.....................................PASS
  RAM.....................................PASS
  ROM.....................................PASS
RECORDER TESTS:
  PC Card #0..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
  PC Card #1..............................NOT DETECTED
DSP TESTS:
  Timing RAM..............................PASS
  Demod  RAM..............................PASS
  Demod  REG..............................PASS
  FIFOs...................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Receive Loop-Back.......................PASS
  Wide Bandwidth..........................PASS
  Narrow Bandwidth........................PASS
  RSSI Filter.............................PASS
  Transmit................................PASS
SENSOR TESTS:
  H/W Operation...........................PASS
>
```

NOTE

If the Workhorse fails the PA test, make sure that the Workhorse is in water and run the test again. If the failure continues, try turning off other test equipment (interference may cause failures).

Receive Path Failure

Many users tell us their ADCP reports a FAIL condition during the self-tests that check the ADCP's "receive path." In most cases, the cause of the failure is external interference. A "noisy" environment, such as in a lab usually causes this external interference. You can take a few simple steps to find out if the FAIL condition is being caused by external interference or by a problem with the ADCP.

The following procedure explains how to conduct the PA test to reduce the likelihood of a false failure.

a. Turn off any nearby equipment (monitors, radios, etc.) that is not needed to conduct the test.

b. The pressure case should be on the ADCP to help shield the circuit boards from external electronic "noise."

c. The ADCP transducer head must be immersed in water. Ensure there are little or no air bubbles on the transducer faces.

d. If the transducer is immersed in a bucket of water that is resting on the floor, noise can be coupled into the ADCP. As such, you should shield the bucket from the floor by inserting a piece of hard foam between the bucket and the floor.

e. Run the PA test.

f. If the test fails, "spin" the ADCP 180 degrees. If the failure goes away, it is "probably" safe to say the failure was caused by external interference, and it should be all right to deploy the ADCP.

g. If possible, you may also want to move the ADCP to a different room, or at least to a different part of the lab to see if the fail condition goes away.

h. If after following the above procedure, your ADCP still fails the receive tests, contact RDI for assistance.

> **NOTE**
>
> *Although rare, we had a case where a system was being tested in a lab. The cable was apparently picking up interference from the floor. When the cable was isolated from the floor by placing it on a chair, the test passed.*

5-2.2 Display Heading, Pitch, and Roll

This test checks the internal Workhorse sensors (up/down orientation, heading, pitch, roll, and temperature). For this test, you must place the Workhorse in the expected deployment orientation (up or down). Take care to protect the transducer faces and to provide support for the I/O cable connector.

a. Type PC2 [ENTER] – This command lets you view sensor data and scale factor calculations while the Workhorse is operating.

b. Verify these readings are present and correct. You can vary the heading and tilt angles as follows.

- Heading – Turn the Workhorse clockwise to increase the heading values (counter-clockwise to decrease the heading values).
- Tilts – Tilt the Workhorse to confirm the values change in both the positive and negative directions. The sign of the tilts depends on the orientation of the Workhorse. The following table lists the correct tilt signs.

Unit Facing	+Pitch	+Roll
Down	Beam 3 higher than Beam 4	Beam 1 higher than Beam 2
Up	Beam 3 higher than Beam 4	Beam 2 higher than Beam 1

```
>PC2

Press any key to quit sensor display ...

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

5-2.3 Recorder Directory

This test reads the directory of files and free space on the recorder — it does not test the recorder or destroy any data.

a. Type RR [ENTER] . This command lets you reads the directory of files and free space on the recorder

b. Verify the directory and free space is what was expected.

```
>RR
Recorder Directory:
Volume serial number for device #0 is 0005-77ee

  No files found.

  Bytes used on device #0 = 0
Total capacity   =   10407936 bytes
Total bytes used =          0 bytes in 0 files
Total bytes free =   10407936 bytes

>
```

5-2.4 Beam Continuity Test

This tests the beam continuity by measuring the quiescent Receiver Signal Strength Indicator (RSSI) levels and then waits for a change of more than 30 counts when the transducer face is rubbed. If any test fails, call RDI for further troubleshooting information.

a. Type PC1 ENTER .

b. When prompted, rub the face of each beam.

> **NOTE**
>
> *This test must be run with the transducer faces in the air.*

```
>PC1

BEAM CONTINUITY TEST

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

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

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

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

> **NOTE**
>
> *1200kHz ADCPs may have a hard time passing this test. Try rubbing the beam faces with a soft shop rag or a piece of closed-cell foam. If this does not help, use a test hydrophone and synthesizer to inject a 500-milli watt peak-to-peak sinusoidal test signal at 1,228,800 Hz into the beam. Use silicone grease between the beam face and hydrophone. Be sure to clean off the grease before deploying the ADCP.*

5-2.5 Other Tests

TESTADCP allows you to send any direct command to the Workhorse. You may use the following commands to further test the Workhorse.

Display System Parameters

Type PS0 ENTER. This tells the Workhorse to display specific information about your Workhorse. For example:

```
>PS0
       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  TEMPERATURE
Temp Sens Offset:  -0.38 degrees C
    CPU Firmware:   8.17 [0]
   Boot Code Ver:  Required:  1.12   Actual:  1.12
    DEMOD #1 Ver:  ad48, Type:  1f
    DEMOD #2 Ver:  ad48, Type:  1f
    PWRTIMG  Ver:  85d3, Type:   6

Board Serial Number Data:
   21  00 00 00 09 99 EE  09 CPU727-2000-00F
   28  00 00 00 09 9F 71  09 PIO727-3000-00C
   63  00 00 00 09 9D CB  09 DSP727-2001-04D
   CD  00 00 00 09 99 5B  09 REC727-1000-04A
>
```

Verify the information is consistent with what you know about the setup of your system. If PS0 does *not* list all your sensors, there is a problem with either the communications to the transducer assembly or a problem with the Receiver board.

5-2.6 Interference Test

If you are using the Workhorse ADCP in close proximity to another sensor, you can use the following test to determine if the sensor will cause interference with the ADCP.

a. Place both the ADCP and the second device in the same “bucket” of water (both systems OFF).

b. Start the *BBTALK* program and establish communications with the ADCP (press END).

c. Send the following commands to the ADCP:
   CR1 (sets ADCP to factory defaults)
   CK (saves factory defaults)
   PT103 (runs our interference test continuously)

d. You will see a new test run every five seconds. This test should say PASS.

e. Turn ON the second device.

f. If the ADCP interference test FAILS, the second device interferes. If the test continues to PASS, interference is not a problem.

g. You can make a copy of the test results by pressing F3 to capture data in *BBTALK*. If you have questions, you can fax or e-mail these results to RDI Field Service.

h. Send a BREAK to stop the test.

5-3 Using BBTALK

BBTALK is a dumb terminal emulator program. This IBM-compatible program can capture raw data files and help troubleshoot configuration problems. You can use *BBTALK* for serial or parallel communications in either an ASCII or BINARY mode. A binary-to-hexadecimal conversion feature lets you view and record the binary output data in a hexadecimal format. A LOG feature lets you record data to a disk file.

5-3.1 Running BBTALK

Access the drive/directory containing the *BBTALK* program. Type BBTALK ENTER at the DOS prompt. The program will load, and a blank communications screen will appear (Figure 5-1).

```
F1-? F2-Script F3-Log F4-ASCII F5- COM1:  9600,N,8,1 F6-Save END-BRK AltX-Exit
```

Figure 5-1. BBTALK Menu

BBTALK Help

BBTALK has a built-in help screen.

- Press F1 at any time to display *BBTALK's* help menu.
- Press any key when done.

```
═══════════ BBTALK v2.25 Help Screen ═══════════
  Copyright (c) 1994-1995, RD Instruments
           All rights reserved.
F1 - This screen
F2 - Run script file
F3 - Toggle logging data stream to disk
F4 - Toggle HEX and ASCII display
F5 - Setup serial port
                 ↑/↓ - Select Parameter
  <Space> or <Enter> - Change Setting
               <Esc> - Accept entry
F6 - Save serial port configuration
F8 - Clear data screen
Alt-Fx - Run script file "ALT-Fx.SCR"
<Ctrl-PgDn> - YModem Receive
      <End> - Send BREAK
                     ASCII Data
      COLORS:         HEX Data
                Communications Error
             AltX - Exit BBTALK
═══════════ Press any key to continue ═══════════
```

Figure 5-2. BBTALK Help Screen

Wakeup the ADCP

Wakeup is the process of establishing communication with the Workhorse. Immediately after you apply power to the Workhorse, it enters the STANDBY mode. Sending a BREAK signal from a terminal/program awakens the Workhorse. When the Workhorse receives a BREAK signal, it responds with the wake-up message. The Workhorse is now ready to accept commands at the “>” prompt from either a terminal or computer program. Press END to send the wakeup command (BREAK) to the Workhorse.

The Workhorse wake-up (copyright) message should appear.

```
WorkHorse Broadband ADCP Version 8.xx
RD Instruments (c) 1996
All rights reserved.
>
```

If there is no response from the Workhorse, check the communications setup in the SETUP MENU F5 and the Workhorse (see Chapter 4 for RS232 or RS422 switch settings on the PIO board). Both setups must be the same.

Communication Parameters

This menu sets the communications protocol between the Workhorse and the computer.

a. Press F5 to view the SETUP MENU.

b. Use the Up/Down arrow keys to select the parameter to change.

c. Use the ENTER or SPACE key to change the parameter.

d. Press ESC to exit the SETUP MENU

e. To permanently save this setup to the BBTALK.PTR configuration file, press F6. The configuration file is saved to the directory where *BBTALK* resides.

```
 Serial Port Setup
Port            COM1
Baud Rate       9600
Parity          NONE
Data Bits          8
Stop Bits          1
--------------------
 <SPACE> to Change
<HOME> Saved Defaults
   <ESC> to Accept
```

Figure 5-3. BBTALK Communication Setup Menu

BBTALK LOG Files

The LOG feature lets you record data to a disk file. You name the file (DOS convention) by pressing the F3 key. You can enable logging at any time. The help line shows the CAPTURE status. To use LOG, do the following steps.

a. Press F3 to enable LOG function.

b. Enter the DRIVE (if other than current drive) and FILENAME.EXT. For example, type C:\ADCP\SAMPLE.TXT <Enter>.

Figure 5-4. BBTALK Log File

c. If the file already exists, the program asks you if you want to overwrite the existing file.

d. All data sent to the screen will now be written to the file you specified. You can enable the CAPTURE feature at any time, even if the ADCP is already sending data.

e. To disable CAPTURE, press F3, and then press ENTER without entering a file name.

> **NOTE**
>
> *When a high baud rate is being used, LOG may lose some data.*

5-3.2 BBTALK Script Files

You can control what *BBTALK* sends and captures by writing *BBTALK* script files. Script files are simply ASCII files produced by ASCII editors such as MS-DOS EDIT or EDLIN. In general, they contain ASCII characters that are sent out through the serial port. In addition, *BBTALK* script files can contain embedded commands that control the behavior of *BBTALK* as it interprets the script file:

a. All lines in the script file except those beginning with a ‘$’ or a ‘;’ character are sent out through the serial port delimited with a Carriage Return <CR> (A line feed character <LF> = ASCII 10 decimal is NOT sent).

b. Lines containing a semi-colon ‘;’ = ASCII 59. If the first character of a line containing a semi-colon is not a '$' character, then all characters preceding the semi-colon are sent followed by a <CR>. All characters following the semi-colon (including the semi-colon) are ignored. This feature is to provide file comments that the user may insert for script file clarity.

c. Lines beginning with a dollar sign ‘$’ = ASCII 36 decimal are script file control commands.

d. To use a script file, type BBTALK SPACE *script file name* ENTER .

Script Commands

The following are legal script commands:

$B. Sends a <BREAK>

$COMx:bbbbb,p,d,s. Sets up BBTALK communication parameters:

> x = com port number (1 through 4)
> bbbbb = baud rate (1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200)
> p = parity (N = none, E = even, O = odd)
> d = number of data bits (7 or 8)
> s = number of stop bits (1 or 2)

$Dnnnn. Delays nnnn seconds

$H**.** Toggle HEX/ASCII

$L**.** Toggle logging. If logging is to be turned on, then a window pops up asking for the log file name. Type in the file name and press the enter key to continue.

$Gscript.ext**.** Chains scripting to “script.ext” (remainder of current script file is ignored.) Settings of current script file are retained.

$lfilname.ext. Opens “filname.ext” for logging. If another file is currently open for logging, the file is closed. If “filname.ext” already exists, logging is APPENDED to the file.

$Lfilname.ext**.** Opens “filname.ext” for logging. If another file is currently open for logging, it is closed. If “filname.ext” already exists, it is OVERWRITTEN.

$Ptext to screen**.** Prints “{text to screen}” on the screen and also in log file if logging (useful for comments)

$R**.** Repeats script file (remainder of script file is ignored

$S**.** Save serial port/screen parameters to .PTR file

$T**.** Display PC time on screen (save to file if logging (e.g. {13:34:23})

$Wnnn**.** Waits for ASCII nnn (where nnn is the decimal representation) to be last character in receive buffer before proceeding. The Workhorse prompt is ‘>’ which is ASCII 62. If the character is not received, the user may type <ESC>. This character will not be transmitted, but the script file will continue. Any other characters typed by user are transmitted.

$X**.** Exits BBTALK. Will close log file if active.

$Y**.** Initiates Y-Modem receive protocol. Saves file in local current directory.

$$**.** Literal. Sends everything after "$$" this can be used to send a "$" as first character a line. It also can be used as on the BBTALK command line to send lines of ASCII characters.

Example Script File

When a script file is running, the letters "SCRIPT" at the bottom of the *BBTALK* screen flash in capital letters. If no extension is given for the script file an extension of ".SCR" is assumed.

```
;MYTEST.SCR  BBTALK script file to test ADCP
;
;Append log to file MYTEST.TXT
$LMYTEST.TXT
;
;Wakeup ADCP
$B
;
;Wait 1 second
$D1
;
;Print to screen the following message:
$P   PLACE ADCP IN WATER BEFORE RUNNING TEST
;run PA test
PA
```

Chapter
6

Troubleshooting

6-1 Introduction

This chapter explains how to troubleshoot and fault isolate problems that may occur with the Workhorse. Before troubleshooting, review the procedures, figures, and tables in this section.

6-2 Troubleshooting Tips

Use Chapter 5 to test the Workhorse. Before troubleshooting a Workhorse, try the following;

- Do not panic if the Workhorse fails the system test (PA) while in an out-of-water environment or while in a laboratory. The Workhorse is sensitive to electronic “noise”.
- Turn off the power to the Workhorse. Try the tests again in a half-hour (cycling the power sometimes helps “reset” the Workhorse).
- Do not swap PC boards between different ADCPs. Each system is specifically tuned using one set of boards.
- Check that your power supply output is “clean”. Check the power supply for voltage spikes or noise while it’s under a load condition.

6-2.1 Troubleshooting Safety

Follow all safety rules while troubleshooting.

- There can be dangerous voltage levels inside the AC power supply. Do not attempt to open or service the power supply.
- Always turn off the power while removing or replacing boards.
- Water and electricity are a dangerous combination. Find a dry area to work in. Dry the Workhorse before opening the pressure case.
- Never force a board into a connector. If it does not seem to seat correctly, STOP! Check that the board is in the proper slot, and facing the correct direction.

6-2.2 Workhorse Monitors Vs. Workhorse Sentinels

The difference between Monitors and Sentinels is that Sentinels have a longer canister that provides room for an internal battery and has a PC Card recorder installed. Both ADCPs have a connector on the Power I/O board for an internal battery and the same I/O connector on the end-cap to connect the Workhorse to a computer.

6-3 Can Not Establish Communications to the Workhorse

If you can not talk to the Workhorse (i.e., no wakeup message), you need to isolate the problem to either a computer fault, power or cable failure, or a Workhorse problem. Check the following items:

a. Connect the Workhorse to a computer according to Chapter 1.

b. Is the Workhorse external power supply working? If it is powered from an AC source, will that source run a lamp or other load? Is the voltage between 100 and 240 VAC? Is the output level 24 VDC?

c. If the Workhorse is running from a battery, check that the voltage is above 30 Volts DC. Workhorse ADCPs will work at 20 volts, however, both lithium or alkaline battery packs with voltages below 30 volts are at or near their end of life and are approaching uselessness.

d. Is the computer hooked up properly? Does it have power?

e. If the Workhorse is not drawing current (at least 20 to 200 ma), it should when you send a break. If it is using current, when you send a break the current should change.

f. When you send a break and the data is garbled, you may have a baud rate or parity mismatch between the Workhorse and the computer, or the Workhorse may be set for RS-422 instead of RS-232. Check the RS-232/422 switch on the PIO card inside the Workhorse.

NOTE

The desiccant pack inside the Workhorse is not tied to anything. A potential problem exists when the pack is jostled against the RS-422/RS-232 switch and changes the setting or places the switch in an in-between state. Check that the switch is fully in the correct position and try to wakeup the ADCP again.

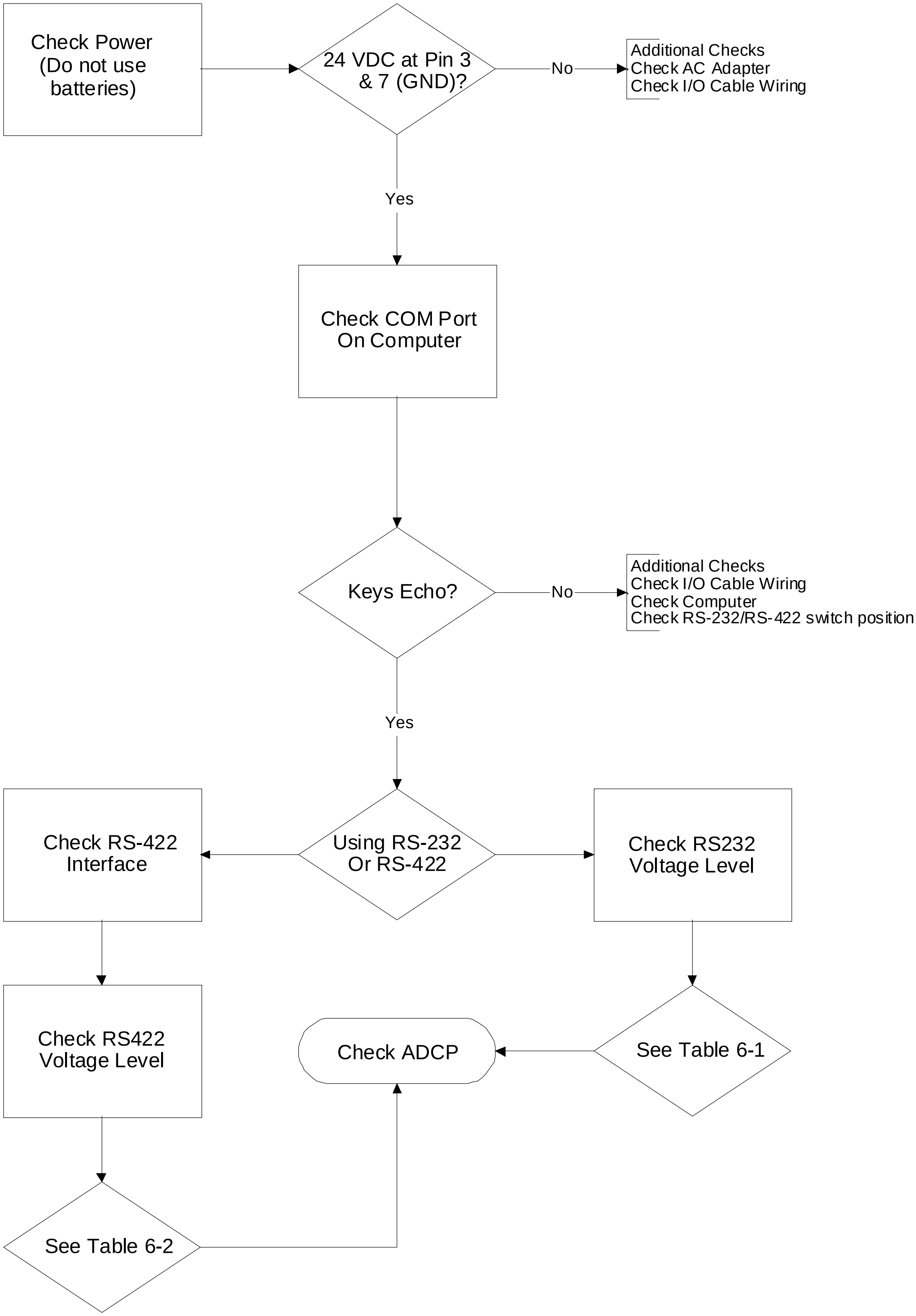


Figure 6-1. Troubleshooting Flow Chart

6-3.1 Check the Power

The following test can be done with a voltmeter to check the power supply.

Check the power going into the system by measuring the voltage on the end of the cable that connects to the Workhorse at Pins 3 and 7 (GND). The voltage should be 24 VDC (using the AC adapter). If not, check the voltage at the other end of the cable and the AC adapter.

6-3.2 Check the Serial Communications Channels

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

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

NOTE

If you have just received your Workhorse from RDI, the standard configuration is RS-232 for Sentinels and RS-422 for Monitors.

If you are using a high baud rate and/or a long cable (greater then 50 meters) RS-232 may not work. Switch to RS-422 and try to wakeup the Workhorse again.

The following conditions may indicate a communications mismatch.

- Sending a break causes “garbage” to appear on the screen. The “garbage” text may keep scrolling. This happens when the computer is using RS-232 and the ADCP is set for RS-422 or vice-versa. Check the RS-232/RS-422 switch on the PIO board.
- Sending a break causes “garbage” to appear on the screen. You can hear the ADCP “beep” when the break is sent. The “garbage” text does not keep scrolling. Check that the ADCP and computer are both using the same baud rate. See “Set Communication Parameters”, page 5-17.

6-3.3 Check the Cable for RS-232 Communication

This test will check the RS-232 communication between the computer and Workhorse.

a. Remove the underwater I/O cable from the Workhorse.

b. Load *BBTALK* on your computer. Select the proper communications port using F5.

c. Short pins 1 and 2 together on the female 7-pin connector that was plugged into the Workhorse.

d. Type any characters on the keyboard. The keys you type should be echoed on the screen. If you see characters, but not correctly (garbage), the cable may be too long for the baud rate. Try a lower baud rate. If this works disconnect the jumper on pins 1 and 2 and then push any keys on the keyboard. You should NOT see anything you type. (If the cable is long, you may see some garbage, but it should go away if you connect pin 2 to pin 4).

e. If the keys are echoed correctly on the screen, the computer and the communication cable are good. Re-connect the I/O cable to the Workhorse. If the Workhorse still will not wakeup, there could still be a power problem or pins 2-3 could be reversed.

6-3.4 Check the RS-232 Voltage Levels

a. Disconnect the underwater cable from the Workhorse.

b. With the host computer connected to the other end of the cable, connect the negative voltmeter lead to pin 4 of the underwater connector. Connect the positive voltmeter lead to pin 1 of the underwater connector.

c. You should measure the idle state as shown in Table 6-1. If this voltage is not present, then the computer is not working or there is a wiring/cable problem (possibly pins 2-3 is reversed at the computer end).

d. To check for this reversal, repeat the above step with the positive voltmeter lead connected to pin 2 and the negative lead connected to pin 4. If the voltage is present, then pins 2 and 3 at the computer end of the cable need to be exchanged. If this voltage cannot be found, see "Check the Computer RS-232 Interface".

e. If pins 2 and 3 are not reversed, and you send a break (END key on the computer keyboard if you are using *BBTALK*) you should see your voltmeter attempt to respond. The voltmeter probably is not fast enough to accurately measure the mark state (use an oscilloscope to accurately measure this), but it should do something when a break is issued by the host computer. If this is OK, your computer is working and these two pins are not reversed. It the negative voltage is present, but nothing happens when a break is sent, the wrong serial channel on the computer may be used.

6-3.5 Check the RS-422 Computer Interface

Most IBM compatible computers do not have an RS-422 interface. However, RS-422 cards for IBM compatibles may be bought or RS-232 to RS-422 (or RS-485) adapters may be used. The Workhorse Monitor is shipped with an adapter.

To check out the cable and the interface do the following.

a. Connect a jumper between pin 2 to pin 6 and another jumper between pin 1 to pin 5 of the underwater connector at the Workhorse end of the cable.

b. While running *BBTALK*, push any key on the keyboard. You should see what you type on the screen. Remove the connections. You should NOT see what you type. If this is correct, your computer interface works.

6-3.6 Check the Computer RS-232 Interface

This test will check if the computer's RS-232 interface is functioning properly.

a. Connect pins 2 and 3 on your RS-232 interface board together with a jumper.

b. While running *BBTALK*, push any key on the keyboard. You should see what you type on the screen. Remove the connections. You should NOT see what you type. If this is correct, your computer interface works.

c. To verify which pin is which (we expect it to be as in this table), connect your voltmeter negative lead to the "Common" pin and the positive lead to the "Out" lead. You should measure the voltages shown in Table 6-1.

Table 6-1. RS-232 Voltages

25-pin connector	9-pin connector	Voltage (idle)	Voltage (break)
Pin 2 (+) Pin 7 (-)	Pin 3 (+) Pin 5 (-)	-3 to -12 VDC	+3 to +12 VDC

If your computer has a RS-422 interface, connect your voltmeter negative lead to the "OUT B" pin and the positive lead to the "OUT A" pin. You should measure the voltages shown in Table 6-2.

Table 6-2. RS-422 Voltages

422 Out A (+)	Voltage (idle)	Voltage (Break)
422 Out B (-)	-2 to -5 VDC	+2 to +5 VDC

6-4 ADCP Checks

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

Cold Start the ADCP

a. Remove the transducer head to gain access to the PC boards.

b. Remove *all* power to the ADCP.

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

c. Short TP10 to TP11 on the PIO board for 10 seconds. These test points are located close to the P1 and P2 connectors.

d. Remove the jumper.

e. Connect the computer and connect power to the ADCP. Send a break to the ADCP. This should start the ADCP in the "cold start" mode.

Boot Code Error

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

6-5 Troubleshooting a Built-In Test Failure

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

When to use the Spare Boards Kit

Use this Kit whenever you have any of the following problems:

- Cannot communicate to the Workhorse and you have ensured that the serial port on the computer, Workhorse Cable, and Workhorse RS-232 to RS-422 converter (if applicable) are all working properly.
- Your Workhorse fails any of the following PA tests at any time:

CPU TESTS:
RTC
RAM
ROM

DSP TESTS:
Timing RAM
Demod RAM
Demod REG
FIFOs

SYSTEM TESTS:
XILINK Interrupts
Receive Loop Back Test

- Your Workhorse fails any of the following PA tests provided the items indicated by {} have been checked:

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

SYSTEM TESTS:
Transmit {if the Workhorse fails when it is in water and air bubbles have been rubbed from the faces}

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

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

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

SYSTEM TESTS:
Wide Bandwidth {bandwidth tests may fail due to external interference (see “Receive Path Failure”, page 5-4)}

Narrow Bandwidth {bandwidth tests may fail due to external interference (see “Receive Path Failure”, page 5-4)}

RSSI Filter

Table 6-3. Predeployment Test (PA) Possible Cause of Failures

PA Test Name	Possible Cause of Failure
PRE-DEPLOYMENT TESTS CPU TESTS: RTC RAM ROM	CPU board failed
RECORDER TESTS: PC Card #0 Card Detect Communication DOS Structure Sector Test (short) PC Card #1 Card Detect Communication DOS Structure Sector Test (short)	PC card not plugged in PC card failed DSP board failed
DSP TESTS: Timing RAM Demod RAM Demod REG FIFOs	DSP board failed
SYSTEM TESTS: XILINX Interrupts	DSP or CPU board failed
Receive Loop-Back	DSP or CPU board failed
Wide Bandwidth	Not in water external interference DSP or Receiver board failed
Narrow Bandwidth	
RSSI Filter	
Transmit	Not in water or PIO board failed
SENSOR TESTS: H/W Operation	PIO board failed Receiver board failed Pressure sensor failed

6-5.1 Fails Beam Continuity Test

If the beam continuity test fails, a bad DSP board, Receiver board, or a bad beam may cause the failure. If replacing the DSP board (included with the spare boards kit) does not fix the problem, the ADCP must be returned to RDI for repair.

```
>PC1

BEAM CONTINUITY TEST

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

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

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

Rub Beam 1 = PASS |   NOTE – Possible cause of failure
Rub Beam 2 = PASS |          DSP Board
Rub Beam 3 = PASS |          Receiver Board
Rub Beam 4 = PASS |          Beam
>
```

6-5.2 Fails a Sensor Test

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

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

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

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

Fault Log

To determine why a sensor failed, view the fault log. To view the fault log, Start BBTALK and type the following commands: CR1, FC, PA, FD. The fault log will be displayed by the FD-command.

```
[BREAK Wakeup A]

WorkHorse Broadband ADCP Version 8.20a
RD Instruments (c) 1996-1997
All rights reserved.
>CR1
>FC
>PA
⋮         (PA test results (not shown))
⋮
>FD
Total Unique Faults   =     2
Overflow Count        =     0
Time of first fault:   97/11/05,11:01:57.70
Time of last fault:    97/11/05,11:01:57.70

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

6-6 Technical Support

If you have technical problems with your instrument, contact our field service group in any of the following ways:

- Phone: 619-693-1178
- Fax: 619-578-4016
- Internet: rdifs@rdinstruments.com
- FTP: ftp.cts.com/pub/rdifs (contains our latest field service bulletins)

If your instrument works and you have questions involving a specific application, you may call either the field service group (above) or our sales/marketing staff.

- Phone: 619-693-1178
- Fax: 619-695-1459
- Internet: rdi@rdinstruments.com (we read our mail every work day at around 0800 local time).

6-7 Workhorse Cables

This section has information on Workhorse cabling. Special user-requests may cause changes to the basic wiring system and may not be shown here. We provide these drawings only as a guide in troubleshooting the ADCP. If you feel there is a conflict, contact RDI for specific information about your system. Where shown, the color code is for reference only; your cable may be different. The following figures show various Workhorse cable locations, connectors, and pin-outs.

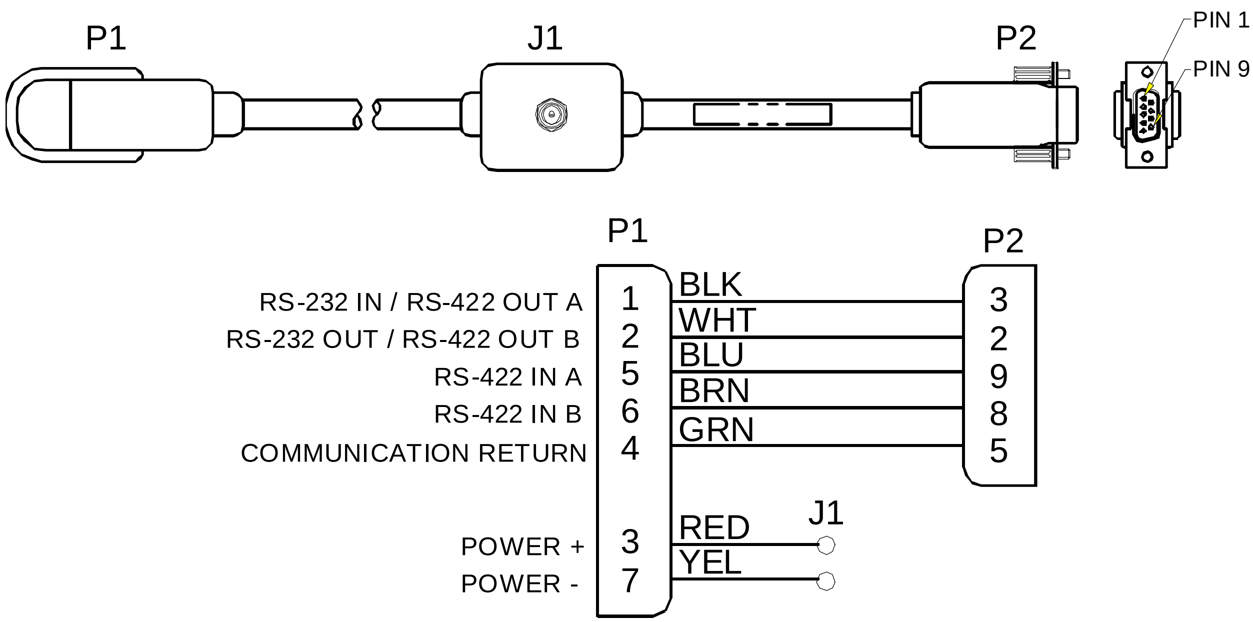


Figure 6-2. External I/O Cable Wiring

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

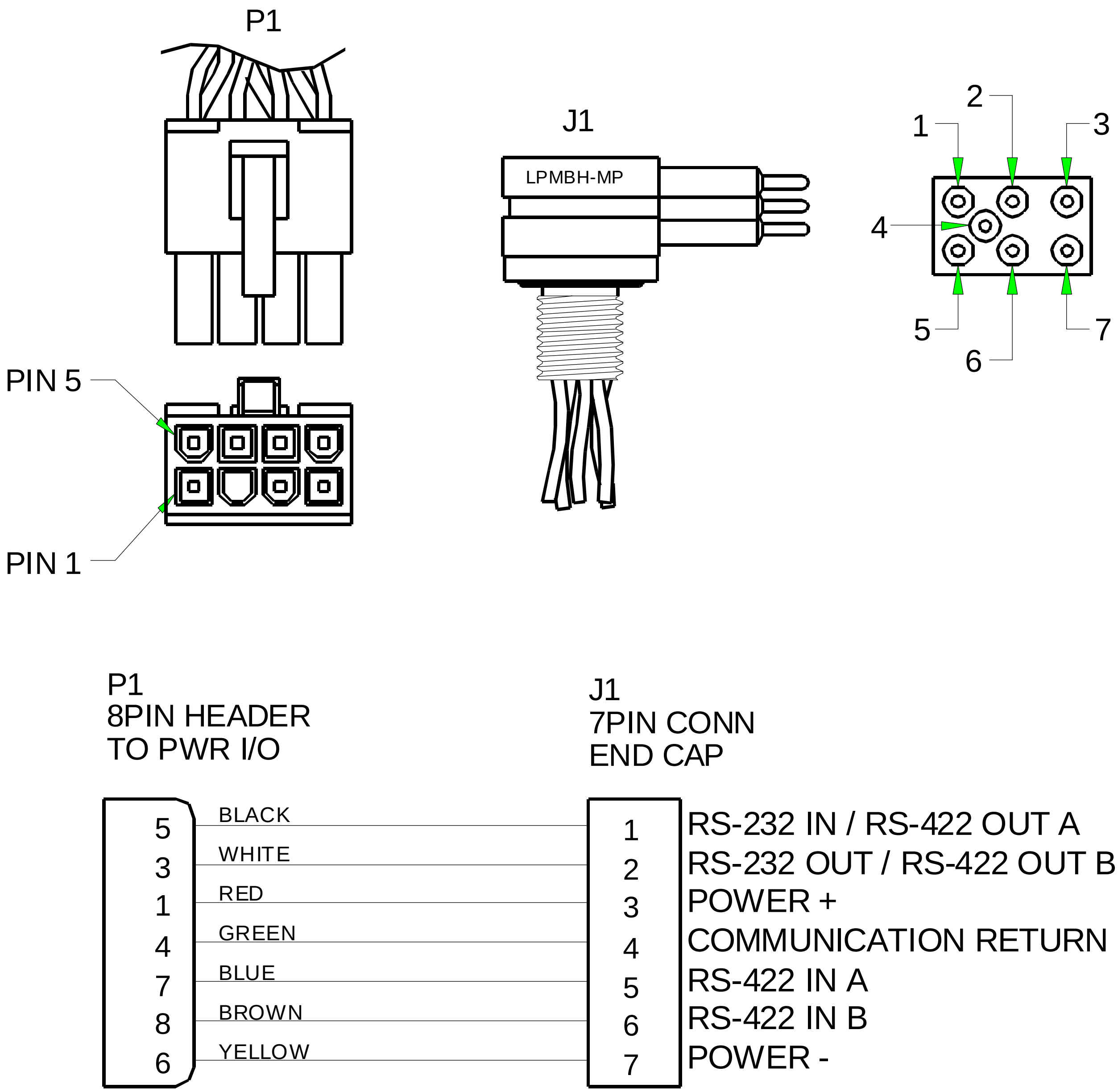


Figure 6-3. Internal I/O Cable (End-cap to PIO Board) Wiring

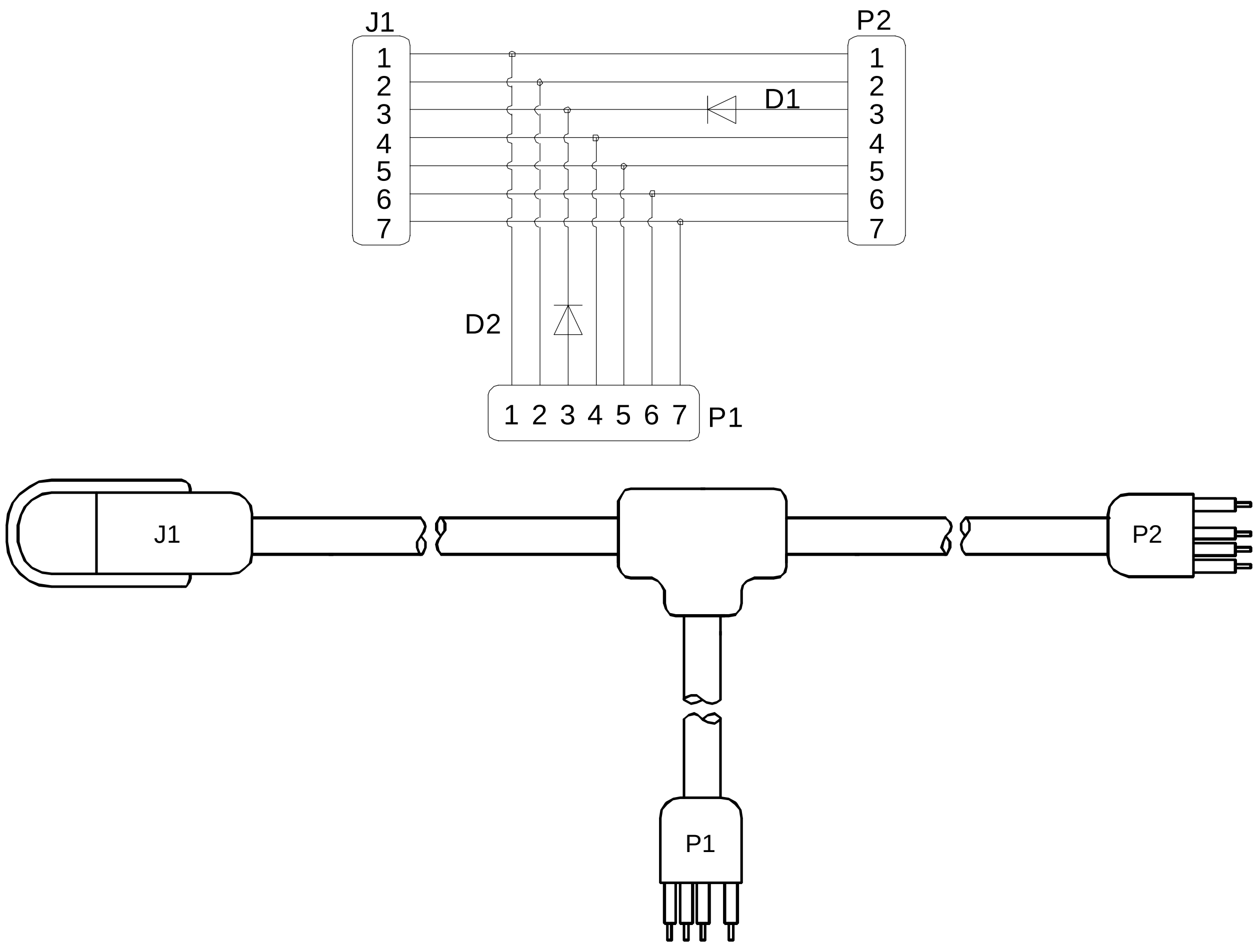
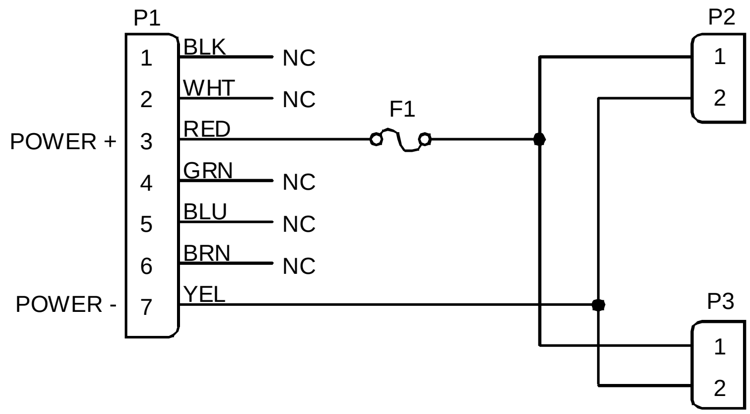


Figure 6-4. External Battery Pack "Y" Cable



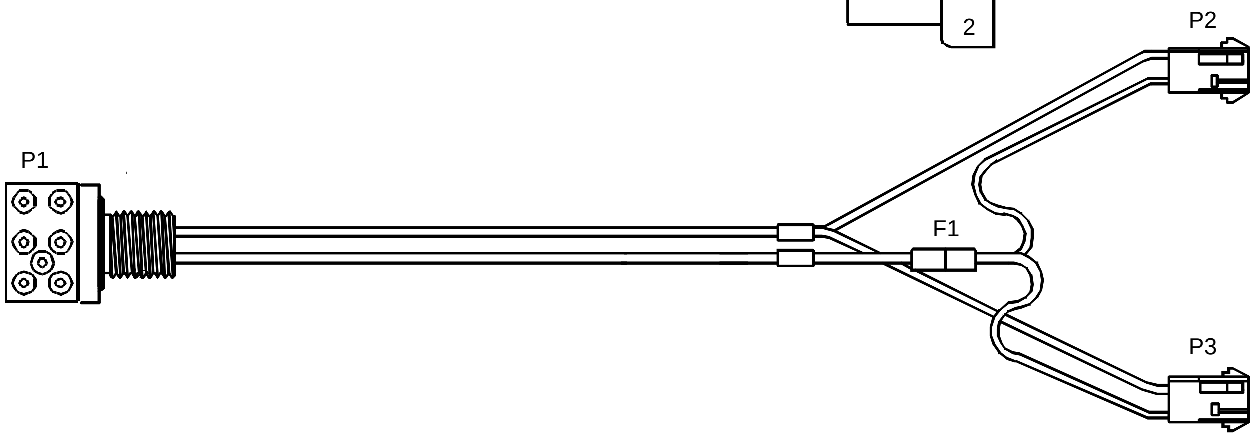


Figure 6-5.   External Battery Case Internal Wiring

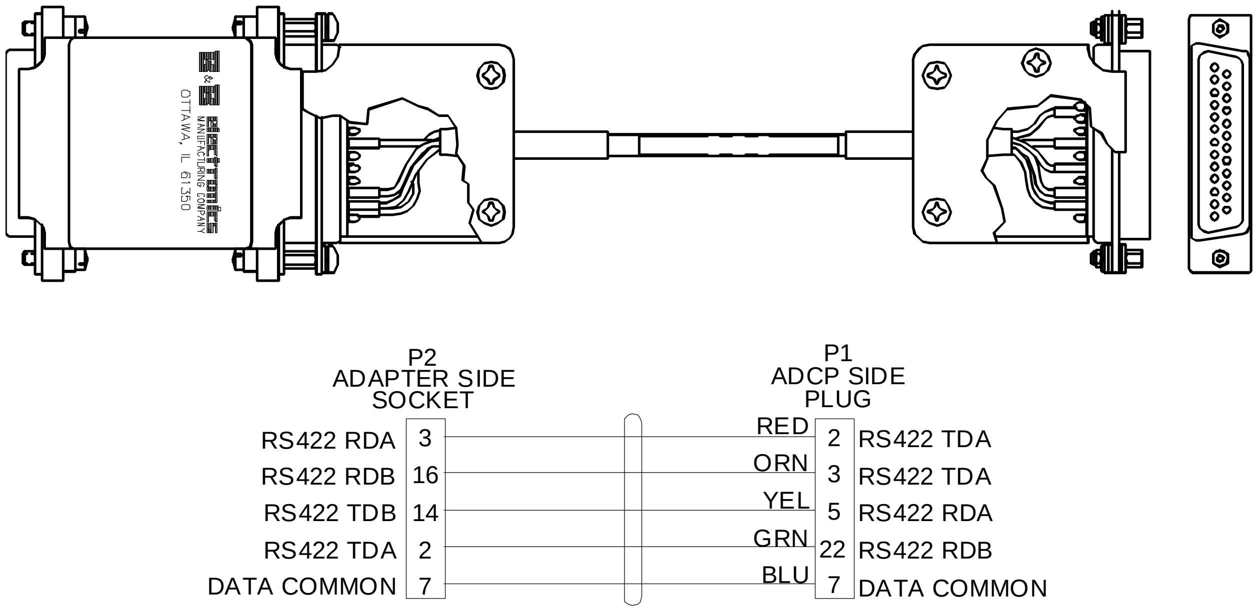


Figure 6-6. RS232-to-RS422 Converter Wiring (25-Pin to 25-Pin)

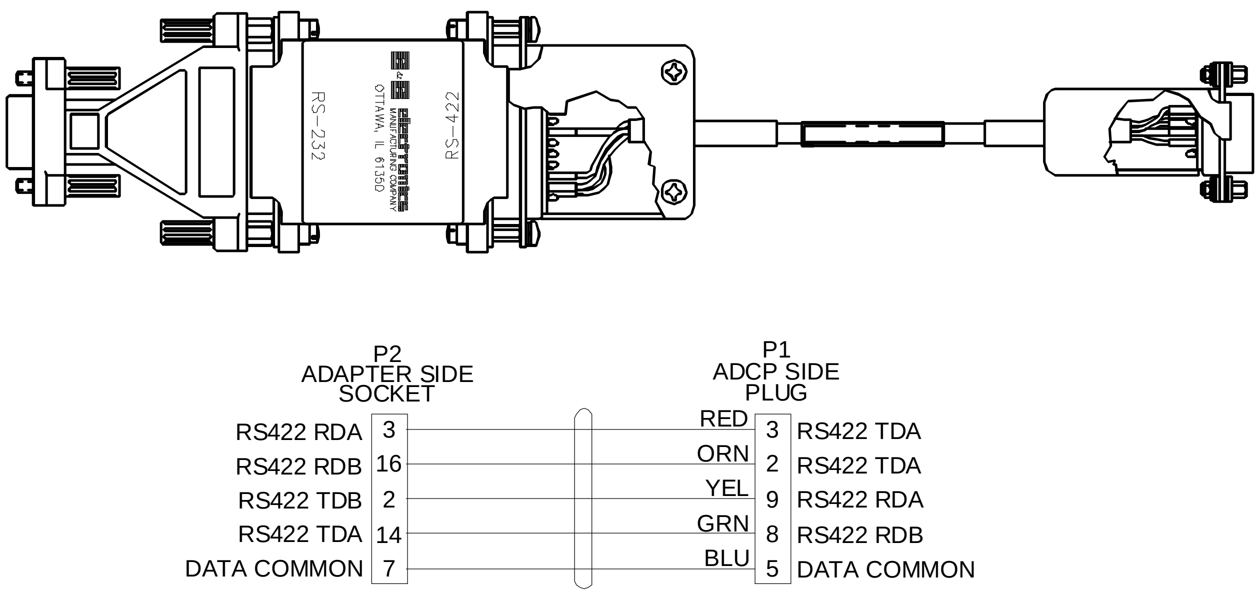


Figure 6-7. RS232-to-RS422 Converter Wiring (25-Pin to 9-Pin)

Chapter 7

Data Analysis

7-1 Introduction

This chapter presents an *overview* on processing the ADCP's recorded data after a deployment. The most efficient way to process ADCP data is through a computer program such as our *WATCH* or *BBLIST* program.

Besides processing data in real-time with *WATCH*, you can use this program to replay recorded data. Use the *BBLIST* program to create your own ASCII output files. Refer to Chapter 3 for information on how to use these programs. If you are developing your own program to process data, Appendix-D provides detailed information on the output format of ADCP data.

7-2 Backing Up Data

Once you have stopped recording data to your computer's hard drive (or recover data from the internal PC Card recorder), you should get in the habit of backing up all data files. Here are several examples of how to backup data.

- Use *PKZIP* (available on RDI's Web Site) to condense the files and store them on floppy disks. *PKZIP* has the ability to store large files (span) onto several disks.
- Remove the original PC Card containing data and store it in a safe place. Install another PC Card in its place.
- Backup your data to a tape drive or other device.
- Use the DOS backup command.
- Download the data to another computer.

7-3 Data Analysis

This section introduces you to data analysis and describes the data produced by a BroadBand ADCP. This data includes the following four different kinds of standard profile data:

- Velocity
- Echo intensity
- Correlation
- Percent good

Velocity data are output in units of mm/s. Depending on your requirements, you can record data in one of the following formats. See the EX-command for details.

- *Beam coordinates* — Velocity is output parallel to each beam.

> **NOTE**
>
> *RDI does not recommend collecting data in beam coordinates. Each Workhorse uses its own beam calibration matrix to correct data for beam pointing errors (e.g., if the beams erroneously point toward 21 deg. instead of 20 deg.). 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. RDI has no software that uses the beam calibration matrix to correct data in a personal computer.*

- *Earth coordinates* — Velocity is converted into north, east, and up components.
- *ADCP coordinates* — Similar to earth coordinates except that velocity is converted to forward, sideways, and up components, relative to the ADCP. ADCP forward is the direction toward which beam 3 faces. ADCP sideways is to the right of forward.
- *Ship coordinates* — Similar to ADCP coordinates except that heading is rotated into ship's forward and sideways. If beam 3 faces toward the bow of the ship, ADCP and ship coordinates are the same.

Echo intensity data are output in units proportional to decibels (dB). Data are obtained from the receiver's received signal strength indicator (RSSI) circuit.

Correlation is a measure of data quality, and its output is scaled in units such that the expected correlation (given high signal/noise ratio, S/N) is 128.

Percent-good data tell you what fraction of data passed a variety of criteria. Rejection criteria include low correlation, large error velocity and fish detection (false target threshold). Default thresholds differ for each ADCP; each threshold has an associated command.

7-3.1 Relationship Between Echo Intensity, Correlation, and Percent Good

When looking at the data you can confirm that the ADCP's range was limited because of signal strength by looking at the echo intensity data. The echo intensity data gives you information as to what the signal strength appears as to the ADCP. When the echo intensity becomes a constant value for several bins (what we refer to as "flattening out") then you have reached the *noise floor* of the ADCP. The signal-to-noise ratio is very low in this area and the ADCP cannot pick out the signal.

It is at this point that your ADCP will stop collecting valid data. By comparing the echo intensity to the correlation, you will see that they both fall off (drop to a low value) at approximately the same rate. In fact, when the instruments echo intensity "flattens out" you should see that the correlation values have fallen below 64 counts.

Comparing both the echo intensity value and the correlation values to percent good you will notice that it too will fall off. The percent good data should drop to zero at about the same time the echo intensity flattens out and the correlation falls below 64 counts.

This becomes the range of the system. The signal has become too weak to process and the ADCP is unable to work any deeper. It should be noted that noisy environments would raise the noise floor of the system. Noisy environments include:

- Moving platforms such as ships.
- Areas where there is background noise such as on dynamically positioned oil rigs.
- Waves may cause the background noise to raise.

The higher the background noise the less range the system will be able to profile. The reason being is the signal to noise ratio will be decreased with higher background noise. When the echo intensity flattens out, you have an indication of the relative background noise and know that the signal now equals noise.

7-3.2 Picking Out the Last Depth Cell(s)

In a perfect world, all data collected in every depth cell would be valid. In reality, at some point the data collected is invalid. The echo intensity values tell you why the range has been limited. The correlation values tell you the last good bin to use as long as the bottom is not in range. A good rule of thumb or first pass cut-off of the data is to look first at the correlation values. Any time the correlation goes below 64 counts for any beam, you should cut-off the data at that point. Be careful here — it is possible to get bad correlations on a beam in an upper bin. Before discarding any depth cell data, you should look at the echo intensity. If you are near the noise floor of the system, then you can safely say this is good point to cut-off the data. Please note there can be useful data beyond this point, but as a first pass, this is a good place to start.

When the bottom is in range the echo intensity will increase again. That is to say, you can reach the noise floor of the system and then when the ADCP signal hits the bottom the signal strength will increase again. The correlation will also increase in these areas. There are times that you will never reach the noise floor of the system, as the bottom is too close. The best way to know when to cut-off the data when the bottom is in range of the system is to use the following formula:

Last good bin = (COS (beam angle) * (distance from ADCP to bottom)) + (1 depth cell)

7-3.3 Velocity Data Processing

This section describes various processing steps that may be needed to convert raw radial beam velocity data to the desired form. Most of these steps are optionally performed by the ADCP, but may alternatively be performed by a Data Acquisition System (DAS) program such as *TRANSECT* or in a post-processing program such as *BBLIST*. Read this section if you want to understand what the ADCP has done or is able to do, or if you are designing a DAS or post-processing program to process the raw velocity data.

You may want to consider the following velocity processing steps. Except where indicated, they apply both to water velocity and bottom-track velocity.

Adjustment for Incorrect Speed of Sound

To determine the true velocity data, the ADCP needs to know the speed of sound in water. You can tell the ADCP the speed of sound, or the ADCP can compute the speed of sound from temperature, salinity, and depth data. If the ADCP is not given a speed of sound, it uses a default value of 1500 m/s. If the ADCP uses an incorrect speed of sound value, you can correct velocity data for the actual speed of sound by using the speed of sound measured at the transducer. To correct ADCP velocity data for the actual speed of sound, use the formula:

$$V_{CORRECTED} = V_{UNCORRECTED} - (C / C_A)$$

Where C is the real sound speed at the transducer, and C_A is the speed of sound used by the ADCP. You can calculate the speed of sound in m/s, c, using the equation (Urick, 1983):

$$c = 1449.2 + 4.6\mathbf{T} - 0.055\mathbf{T}^2 + 0.00029\mathbf{T}^3 + (1.34 - 0.01\mathbf{T})(\mathbf{S} - 35) + 0.016\mathbf{D}$$

Where: D = Depth, in meters
S = Salinity, in parts per thousand
T = Temperature, in °C

Depth Cell Mapping

Under conditions of severe pitch and roll, measurements from each beam at the same range may come from different depths, resulting in a smearing out (loss of spatial resolution) of the average velocity profile. If high-quality ping-synchronized pitch and roll data is available (from a vertical gyro, for instance) and if each ping is recorded in a separate ensemble, this effect can be countered by re-mapping each beam's range cell from the actual to the nominal depth. Note that the internal tilt sensors are affected by lateral accelerations, so wave-frequency tilts may not be sufficiently well measured by them for depth cell mapping to be of advantage.

Depth cell mapping is enabled using the last bit of the EX-command. When this bit is set, the ADCP implements depth cell mapping by choosing the range cell in each beam calculated to lie closest to the nominal position of the depth cell. (No interpolation is done.)

Screening

The ADCP performs four kinds of screening on velocity data: the correlation test, the fish rejection algorithm, the error velocity test, and the percent good test.

The correlation test compares the correlation level of each of the four beams to the threshold set by the WC-command. If less, that beam velocity is marked bad. Low correlation may be caused by poor signal-to-noise ratio or by excess speed when the ambiguity velocity is low.

The fish rejection algorithm compares the echo intensity measurements among the beams and may mark one or all beams as bad (see the WA-command). This algorithm does not apply to bottom-track velocities.

The error velocity test compares the error velocity to the threshold set by the WE-command. If greater, all four velocities are marked bad.

If after the first three screening tests, only one beam velocity in a particular depth cell is marked bad, a three-beam solution is still possible if enabled. In all other cases of bad data, none of the velocity components will be included from the ping in the ensemble average for the particular range cell or bottom-track velocity.

The percent good test is enabled only for radial beam velocity output (EX00xxx command). After ensemble averaging, the percentage of good values in the average is compared to the threshold set by the WC command. If the percentage of water-track pings that are good in an ensemble is less than WC, the velocity is marked bad. This test operates independently for each beam and for each depth cell.

Beam-to-Instrument Transformation

The vector of beam velocities is transformed to the vector of velocity components in a coordinate system fixed to the instrument (with error velocity appended) through multiplication by the instrument transformation matrix. The instrument coordinate system is described in the *ADCP Coordinate Transformation* booklet (see "Velocity Data Coordinates Axes"). The instrument transformation matrix is displayed by the PS3 command. Unless the ADCP has been calibrated to compensate for small beam misalignments, the instrument transformation matrix has the following nominal value:

Table 7-1. Instrument Transformation Matrix

component	beam 1	beam 2	beam 3	beam 4
X	c*a	-c*a	0	0
Y	0	0	-c*a	c*a
Z	b	b	b	b
e	d	d	-d	-d

Where: c = +1 for a convex transducer head, -1 for concave

$a = 1/[2\sin(\theta_0)] = 1.4619$ for $\theta_0 = 20°$, 1.0000 for $\theta_0 = 30°$

$b = 1/[4\cos(\theta_0)] = 0.2660$ for $\theta_0 = 20°$, 0.2887 for $\theta_0 = 30°$

$d = a/\sqrt{2} = 1.0337$ for $\theta_0 = 20°$, 0.7071 for $\theta_0 = 30°$

The first three rows are the generalized inverse of the beam directional matrix representing the components of each beam in the instrument coordinate system (see PS3 command). The last row representing the error velocity is orthogonal to the other three rows and has been normalized so that its magnitude (root-mean-square) matches the mean of the magnitudes of the first two rows. This normalization has been chosen so that in horizontally homogeneous flows, the variance of the error velocity will indicate the portion of the variance of each of the nominally horizontal components (X and Y) attributable to instrument noise (short-term error).

The velocity will be left in instrument coordinates if the EX01xxx command is selected. Usually, an additional rotation is desired. This is accomplished by multiplying the instrument transformation matrix on the left by the rotation matrix M described in section 5.6 of the *ADCP Coordinate Transformation* booklet before using it to transform the velocity components of each depth cell and the bottom track velocity.

Three-Beam Solutions

A three-beam solution is calculated by the ADCP if exactly one beam has been marked bad in the screening step due to low correlation or fish detection, and if enabled by the EXxxx1x command. This is accomplished by replacing the bad radial beam velocity with a value calculated from the last row of the instrument transformation matrix to force the error velocity to zero. Of course, the actual error velocity cannot be computed in this case, because there is no longer any redundant information. The X, Y, and Z components in the instrument coordinates are then compared in the usual way using the first three rows of the instrument transformation matrix.

Rotation of Velocity Components to a Different System

Use available pitch, roll, and heading information to resolve the velocities in the ship or earth coordinate system. Resolving the velocity components in a stable coordinate system will prevent platform attitude fluctuations from causing bias during subsequent averaging.

Averaging

Often the average velocity over a record of many pings is desired. The ADCP can average an arbitrary number of pings into an ensemble, and the user can average ensembles together. Care should be taken to properly handle bad data. For current profiles with bad data and variable platform velocity, it has been found advantageous to average the velocity profile relative to a reference layer with relatively few bad data points. Then add the average reference layer velocity back in.

Addition of Platform Velocity to Water Velocity

To measure currents, the platform velocity must be added to the water velocity measurement, which is relative to the platform on which the instrument is mounted. If the ADCP recorded bottom-track data, the platform velocity is found by negating all components of the bottom velocity. The ADCP cannot perform this step, but *BBLIST* can. Alternatively, the platform velocity measurement may come from a separate navigation instrument such as GPS (Global Positioning System).

Profile Inversion

The ADCP always stores the data from the depth cell closest to the transducer first. In some cases, it may be desirable to reverse the order of the depth cells, so that the farthest depth cell is first. *BBLIST* can perform this step.

7-4 Commands Used to Exclude Data

Several internal ADCP thresholds *exclude* information from the Workhorse data output stream.

Table 7-2. Commands to Exclude Data

Data Type	Command	Default Setting
Error Velocity	WE	WE1000 = 1000 mm/s
Fish Rejection	WA	WA25 = 50 echo intensity counts
Correlation	WC	WC064 = 64 correlation counts

RDI recommends that you never change the settings for Correlation Threshold (WC-command). You can set all other commands. However, take care when adjusting Error Velocity (WE) and Fish Rejection (WA). A setting that is too low will exclude data that really is valid. For more details, see Appendix-C.

7-5 Finding the Surface

You can use the ADCP’s backscatter data to find the sea surface. Use the program SURFACE.EXE, available at our FTP site. SURFACE works as long as the surface is within the range of the ADCP, and the length of the profile extends at least one bin beyond the surface.

7-6 Broadband Data Handling Tools Disk

The BBTOOLS disk has programs designed to help you decode and analyze your data. Files on this disk are self-extracting executable files. To install, change directory to the source drive (e.g., A:) and type: INSTALL [*destination directory*]. For example, typing: "INSTALL[SPACE] C:\RDI" will install all programs to the C:\RDI directory.

Table 7-3. List of BBTOOLS Executable Files

File Name	Description
BBCHECK	BBCHECK searches for errors in the Broadband ADCP raw data file.
BBCONV	BBCONV converts a BroadBand raw data file to comma delimited ASCII text. Once the file is converted, you can use a text editor to manipulate the data.
BBDECODE	BBDECODE is an example program using the RDI C++ decoding library. The library file "RDI.LIB" is compiled using Borland C++ 3.1 Large Memory Model. The program displays the contents of a BroadBand raw binary data file. It may be modified to suit the user's needs.
BBHXVIEW	BBHXVIEW allows a "quick look" at the data set. This program displays the data in hex-ASCII individual data structures within the BroadBand ADCP ensembles.
BBMERGE	BBMERGE merges the ASCII comma delimited data from BBCONV back into RDI's raw data format.
BBSLICE	BBLICE reads an input file and creates consecutively numbered "deployments" based on consecutive ensemble numbers.
BBSUB	BBSUB allows you to make a data subset file of any consectutive numbered ensembles.

7-6.1 Using BBCHECK

BBCHECK checks your data files for integrity and quality. It does some simple error and problem checking.

Start *BBCHECK* by typing *BBCHECK*[SPACE] *raw data filename* [ENTER]. For example, to check the raw data file data.001, start *BBCHECK* by typing BBCHECK[SPACE] data.001[ENTER].

You should see a message similar to the following.

```
D:\RDI>BBCHECK data.001
BB ADCP data: data.001          (Processing ensemble: 108)
0 error(s) detect reading and decoding BBADCP data.
```

7-6.2 Using BBHXVIEW

BBHXVIEW displays the raw data file in hex-ascii individual data structures within BroadBand ADCP ensembles.

Start *BBHXVIEW* by typing *BBHXVIEW*[SPACE] *raw data filename* [ENTER]. For example, to look at the raw data file data.001, start *BBHXVIEW* by typing BBHXVIEW[SPACE] data.001[ENTER].

Sample display:

```
C:\RDI\BBHXVIEW DATA.001
[+/-] NEXT/PREV ENSEMBLE           [PqDn/PqUp] NEXT/PREV SCREEN          <ESC> - Exit
C:\RDI\DATA.001 Ensemble #1
Data Index #1, Size: 42

ABS REL
0018 0000 00 00 02 54 4c 42 00 33 04 3c 01 00 19 00 32 00 . . .
0028 0010 02 19 02 19 d3 01 00 00 00 00 00 00 00 00 7f ld . . .
0038 0020 60 00 2b 00 00 05 32 00 16 00                   . . .
```

7-6.3 Using BBDECODE

BBDECODE displays the contents of a BroadBand raw binary data file.

Command syntax: BBDECODE[SPACE] drive:\path[SPACE] filename[SPACE] [screen][ENTER]

Where:

drive: - drive containing BroadBand binary data file
path - DOS directory path to BroadBand binary data file
filename - Filename of BroadBand ADCP raw binary data
screen - Initial screen to display (optional):

1 - Header Information
2 - System Information
3 - Water Profiling Setup
4 - Variable Leader (Sensors Data)
5 - Bottom Track
6 - Velocity Profile
7 - Correlation Profile
8 - Echo Intensity Profile
9 - Percent Good Profile
10 - Status Profile

Example display:

```
C:\BBDECODE data.001 1
[+/-] NEXT/PREV ENSEMBLE           [PgDn/PgUp] NEXT/PREV SCREEN          <ESC> - Exit
C:\RDI\DATA.001 Ensemble #1: HEADER INFORMATION

Number of data types recorded: 9

              DATA RECORDED
     ID#(hex)    Offset  Length    Name
        0          24      42      Fixed leader
       80          66      42      Variable leader
      100         108     482      Velocity
      200         590     242      Correlation
      300         832     242      Intensity
      600        1074      72      Bottom track
      701        1146      42      Not known
      702        1188     462      Not known
     1001        1650       2      Not known

Ensemble size       1654
Decoded checksum    27392
Computed checksum   27392
```

7-6.4 Using BBSUB

BBSUB is a raw data file subsectioning utility. *BBSUB* starts copying ensembles from “infilename” to “outfilename” starting with the ensemble whose number is “start”. If “start” is specified to 0, *BBSUB* starts copying from the first read ensemble. *BBSUB* will continue copying ensembles until it reaches ensemble number “end”. If “end” is not specified, it copies until the end of the file.

Syntax: BBSUB[SPACE] infilename[SPACE] outfilename[SPACE] start[SPACE] [end][ENTER]

Where:

infilename	Filename of BroadBand ADCP raw data.
outfilename	Filename of subsectioned file. If this filename contains an extension, only one file will be used for output. If no extension is stated, then sequential extensions will be used (.000, .001, etc.) with each file being about 1 MB long.
start	Starting ensemble number.
end	Ending ensemble number (optional).

Sample BBSUB display:

```
C: \RDI BBSUB data.001 NEW 5 15
BBSUB Version 1.22
Copyright (c) 1994-1995 by RD Instruments.
<ESC> aborts processing
Processing C:\RDI\DATA.001 to NEW.000

Ens #10 Subsectioning ... COMPLETE
BBSUB terminated normally.
```

7-6.5 Using BBSLICE

BBSLICE reads an input file and creates consecutively numbered “deployments” based on *consecutive* ensemble numbers. *BBSLICE* creates an “outprefix.LOG” summarizing the output files’ beginning and ending ensemble numbers and date-times.

Command syntax: BBSLICE[SPACE] infilename[SPACE] outprefix[ENTER]

infilename	Filename of BroadBand ADCP raw data.
outprefix	Prefix (1 to 5 characters) of output files Output files will have the form NAMExxx.000 Where “NAME” is the prefix and “xxx” is the deployment number. Resulting files will contained only consecutively numbered ensembles.

Sample display:

```
BBSLICE Version 1.20 Copyright (c) 1995-96 by RD Instruments.
<ESC> aborts processing
Processing C:\RDI\DATA.001. Writing to ...
   NEW000.000: ..........
Slicing ... COMPLETE
BBSLICE terminated normally.
```

Sample printout of BBSLICE LOG file:

```
C:\RDI>type new.log
BBSLICE Log: Input = data.001, Output = NEW
NEW000.000: 1 (1900/01/01 04:05:19.38) thru 108 (1900/01/01 04:07:06.65)
BBSLICE completed.
```

7-6.6 Using BBCONV

BBCONV is a BroadBand raw data to ASCII conversion program. It uses a decoder file (.DEC) to determine how to convert the data. A decoder file simply contains interpreted instructions for converting to ASCII.

Command syntax: BBCONV[SPACE] decfilename[SPACE] infilename[SPACE] [> outfilename][ENTER]

Where:

decfilename - Decoder File Name
infilename - Filename of BroadBand ADCP raw data
outfilename - Name of ASCII file to output

A typical decoder file may contain the following:

```
;  Bottom Track Data Decoder File
;  The following indicated SIGNED 2 byte numbers (note the -2 for type)
;
0600,25,-2   ; Beam #1/East/Stbd BT Vel (mm/s) 25th byte of structure 0600h
0600,27,-2   ; Beam #2/North/Fwd BT Vel (mm/s) 27th byte of structure 0600h
$L
;  This begins the next line of comma delimited data.
0080,3,2    ; Ensemble Number:  3rd byte of structure 0080, unsigned 2 bytes
```

- Lines beginning with a semicolon (;) are ignored and are for user comments.
- In addition, decoder lines may be followed by semi-colons for comments.
- Blank lines are ignored.
- "$L" signifies a CR/LF should be output before outputting more data
- Lines containing decoding instructions are broken down as follows: id,offset,size where:

id — Data Structure identifier in hex (e.g. 0600). This information is presented MSB-LSB. Be careful, since the data stream outputs LSB followed by MSB.

offset — The byte # from the first byte of the data structure (e.g. The first data byte in the structure following;
the id is byte #3 .
Byte #1 is the LSB of the ID
Byte #2 is the MSB of the ID
Byte #3 is the first data byte of the structure.

size — The number of bytes contiguous bytes contained in the data (LSB to MSB). A negative number indicates signed data, a positive number indicates unsigned data.

Each ensemble processed will show a dot (.) on the screen. These will not appear in the output file if the output is routed to a file. See the included decoder files (.DEC) for examples. To create your own decoder file, simply cut and paste the appropriate offset information into your own ASCII decoder file. The figures in Appendix D should aid in creating decoding files.

7-6.7 Using BBMERGE

BBMERGE merges the ASCII comma delimited format data (created by using *BBCONV)*, back into the raw data file format, resulting in a new raw data file called "outfilename".

The ASCII text file and the BroadBand data input file should have the same number of records. If the text file contains less records, then zero values will be merged into the remaining BroadBand data file records. If the BroadBand data file has less records, then the remaining ASCII text file will be ignored.

Syntax: BBMERGE[SPACE] decfilename[SPACE] asciifilename[SPACE] infilename[SPACE] outfilename[ENTER]

Where:

decfilename	- Decoder File Name
asciifilename	- File name of ASCII text file to merge
infilename	- Filename of BroadBand ADCP raw data
outfilename	- Name of ASCII file to output

7-6.8 Example Using BBCONV and BBMERGE

RD Instruments' software only reads the first ensemble to determine the orientation of the ADCP. If your system started pinging and recording data before it was in the correct orientation, then the programs will display the data upside down. If you collected data in beam coordinates, our software will also display the velocity components with the wrong sign. To correct this you must convert the configuration byte in the ADCP leader data containing the orientation setting to the correct value. The following paragraphs explain how to use *BBCONV* and *BBMERGE* to convert the configuration byte in the ADCP data set to either all up or all down.

a. You must first determine which ensemble number has the proper setting of the configuration byte. Use the *BBLIST* program to view your ADCP data. Once your data is loaded press [ALT] [D] and then [A] to enter the ADCP setup screen in *BBLIST*. Look at the setting in the ADCP HARDWARE AND FIRMWARE window for the ADCP orientation.

   Now, press the [+] key until you move to the ensemble that has the correct orientation for your deployment. Record this ensemble number for future use.

b. Use *BBCONV* to copy the configuration byte from the ADCP binary data file to an ASCII data file. Use the following example of what to enter at the DOS command line. For this example, we will assume that your raw data file name is TEST.000.

   BBCONV[SPACE] UPDWN.DEC[SPACE] TEST.000[SPACE] >UPDWN.DAT[ENTER]

   Example UPDWN.DEC file:

```
;  Binary Fixed & Variable Leader Decode File
0080,3,2                         ; Ensemble Number
0000,5,2                         ; System Configuration
$L
```

An ASCII text file called UPDWN.DAT will be created. It will have 2 columns of data. The first column will be the ensemble number and the second column will be the configuration byte.

> **NOTE**
>
> BBCONV *will automatically go to the next extension (i.e. TEST.001) if it exists.*

c. Use a text editor to edit the UPDWN.DAT file so that the configuration byte is the same for all ensembles. Locate the ensemble number you recorded in Step “a” and copy the configuration byte setting to all of the other ensembles. Most text editors will allow you to use a “find and replace” option.

   After all of the configuration bytes have been changed, save the file. Be sure to not add any other characters to the file.

d. Now use *BBMERGE* to write the new configuration byte back into your data set. *BBMERGE* will write the data into a *new* data file. It will not effect the original raw data file. To do this use the following example of what to enter at the DOS command line.

   BBMERGE[SPACE] UPDOWN.DEC[SPACE] UPDWN.DAT[SPACE] TEST.000[SPACE] NEW.000[ENTER]

   The file NEW.000 will be the corrected data file.

> **NOTE**
>
> BBMERGE *will automatically go to the next extension (i.e. TEST.001) if it exists.*

e. You can now playback your data and the orientation will be correct. If you collected data in beam coordinates, the velocity data will now have the correct signs.

NOTES

Appendix

A

Specifications and Dimensions

A-1 Introduction

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

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

The Workhorse emits an acoustic pulse called a *ping*. Scatterers that float ambiently with the water currents reflect some of the energy from the ping back to the Workhorse. The Workhorse uses the return signal to calculate a velocity. The energy in this signal is the *echo intensity*. Echo intensity is sometimes used to determine information about the scatterers.

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

The Workhorse does not measure velocity at a single point; it measures velocities throughout the water column. The Workhorse measures velocities from its transducer head to a specified range and divides this range into uniform segments called *depth cells* (or *bins*). The collection of depth cells yields a *profile*. The Workhorse produces two profiles, one for velocity and one for echo intensity.

Table A-1 through Table A-10 list the specifications for both models of the Workhorse ADCPs. About the specifications:

a. All these specifications assume minimal Workhorse motion - pitch, roll, heave, rotation, and translation.

b. Except where noted, this specification table applies to typical setups and conditions. Typical setups use the default input values for each parameter (exceptions include Pings Per Ensemble and Number of Depth Cells). Typical conditions assume uniform seawater velocities at a given depth, moderate shear, moderate Workhorse motion, and typical echo intensity levels.

c. The total measurement error of the Workhorse is the sum of:

- Long-term instrument error (as limited by instrument accuracy).
- The remaining statistical uncertainty after averaging.
- Errors introduced by measurement of Workhorse heading and motion.
- Because individual pings are independent, the statistical uncertainty of the measurement can be reduced according to the equation:

$$\frac{\textit{Statistical uncertainty for one ping}}{\sqrt{\textit{number of pings}}}$$

A-2 Specifications

Table A-1.Water Velocity Profiles

	300-kHz	1200-kHz
Depth cell size	0.2 - 8 m	0.05 - 4 m
Number of depth cells	1 to 128 cells	1 to 128 cells
Velocity range	+/-5 m/s default +/-20 m/s max	+/-5 m/s default +/-20 m/s max.
Ping rate	>2 Hz (typical)	5 Hz (typical)
Maximum ping interval	3599.99 s	3599.99 s
Minimum ping interval	0.12 s plus the sound travel time. Use 1.4ms/m of range; multiply sound travel time by 1.8 for 1 meter cells.	

Table A-2. Measurement Performance

Frequency (kHz)	Depth cell size (m)	Standard Dev (mm/s)[1]	First cell range (m)[2]	Min. depth (m)[3]	Max range(m)[4]
300	1	120	3	4	70
	2	60	4	6	90
	4	30	6	10	110
	8	20	10	18	120
1200	0.25	120	0.55	0.85	12
	0.5	60	0.8	1.4	13
	1	30	1.3	2.5	14
	2	20	2.3	4.6	16

Notes:

1) Standard deviation is ADCP uncertainty given a single-ping.

2) The first cell range is the distance from the transducer to the center of the first cell.

3) The minimum depth assumes one good depth cell.

4) Maximum range is a nominal value based on typical oceanic backscatter; actual range will vary depending on environmental conditions. Assuming the ADCP is pointed vertically (0º tilt), the maximum range is limited to 94% of the distance to the surface.

Table A-3. Echo Intensity Specifications

Item	Specification
Sampling	Uses same depth cells and time intervals as velocity
Uncertainity	±1.5 dB

Table A-4. Transducer and Hardware Specifications

Item	Specification
Frequencies	300-kHz and 1200-kHz
Bandwidths	75-kHz and 300-kHz
Beam angle	20°
Configuration	4-beam, convex
Max tilt	20°
Housing and transducer material	composite plastic
External connector	7-pin low-profile

Table A-5. Data Communication Specifications

Item	Specification
Interface	RS-232 or RS-422 serial communications
Baud rate	300 to 115,200 (9600 is default)
Input data format	ASCII commands (see Appendix-C)
Output data format	Binary or ASCII
Internal data storage	Capacity (Standard) 10 , 20 or 40 megabytes PCMCIA flash memory cards (2). Total storage available = 80 megabytes.

Table A-6. Power Specifications

Item	Specification
DC input	20 to 60 VDC
Internal (Sentinel models)	Alkaline battery packs supplying 42 VDC
Power required	
Process	2.2 W
Standby	1 mW
Transmit power	
300-kHz	115 W @ 35 V
1200-kHz	36 W @ 35 V
Approximate energy consumption	
E = Np(aB + ßNb + yR + §) + gD	
Where:	E = energy consumption (W-hours) Np = total number of pings per deployment Nb = number of bins B = depth cell size (m) R = profiling range (m) D = deployment duration (days) a = 4.6 x 10-5 W-hour/m ß = 1.4 x 10-6 W-hour/my=9.0 x 10-7 W-hour/day § = 1.0 x 10-4 W-hour/ping g = 2.4 x 10-2 W-hour/day Note: multiply R by 1.8 for 1-m cells

Table A-7. Maximum Resistance of Power Conductor

Depth cell (m)	Maximum cable resistance (Ω)
1	100
2	88
4	71
8	42

The peak current depends on the transmit pulse which depends on the cell depth size. The maximum cable resistance (the sum of both power conductors) assumes a ping rate of 2/second, a supply voltage of 48 VDC and a voltage drop across the cable of 15 VDC.

Table A-8. Sensors Specifications

Water Level (optional)	
Type	Strain Guage
Range	0 to 256 m
Accuracy	±5 m over 0-200m depth
Resolution	0.25 m
Temperature (Transducer Mounted)	
Range	-5° to 45° C
Uncertainity	±0.4° C
Tilt	
Range	±15°
Uncertainity	±2°
Compass (Downloadable user calibration)	
Type	flux gate
Uncertainity	±5° @ 60° magnetic dip angle
Max tilt	20°

Table A-9. Environmental Specifications

Item	Specification
Maximum depth	200 m
Operating temperature	-5 to +45°C
Storage temperature	-30 to +75°C
Humidity	Must be non-condensing
Vibration	MIL-STD-167-1, type 1
Shock	20 g static

A-3 Dimensions

Table A-10. Outline Installation Drawings

Description	Drawing Number
Workhorse 300kHz	967-6001
Workhorse 1200kHz	967-6002
Workhorse External Battery Case	967-6007

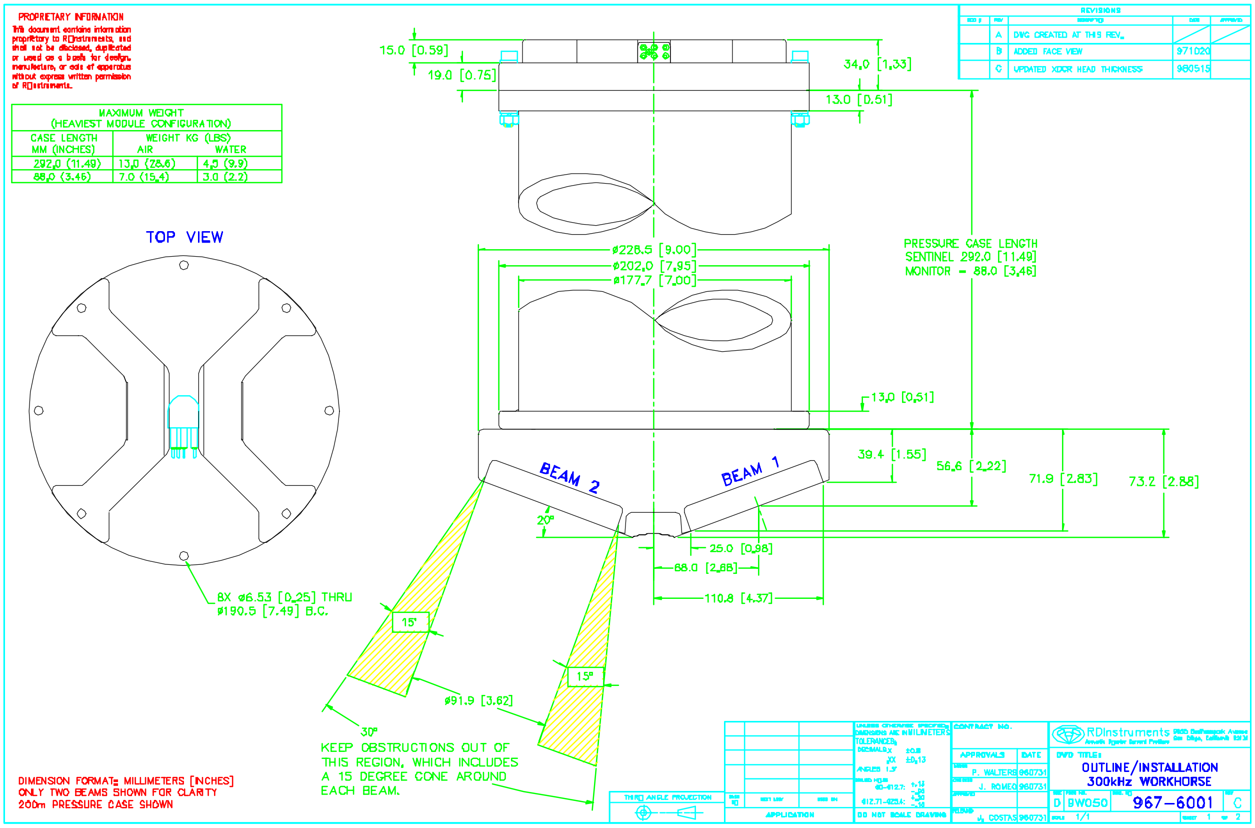


Figure A-1. 967-6001 (page 1)

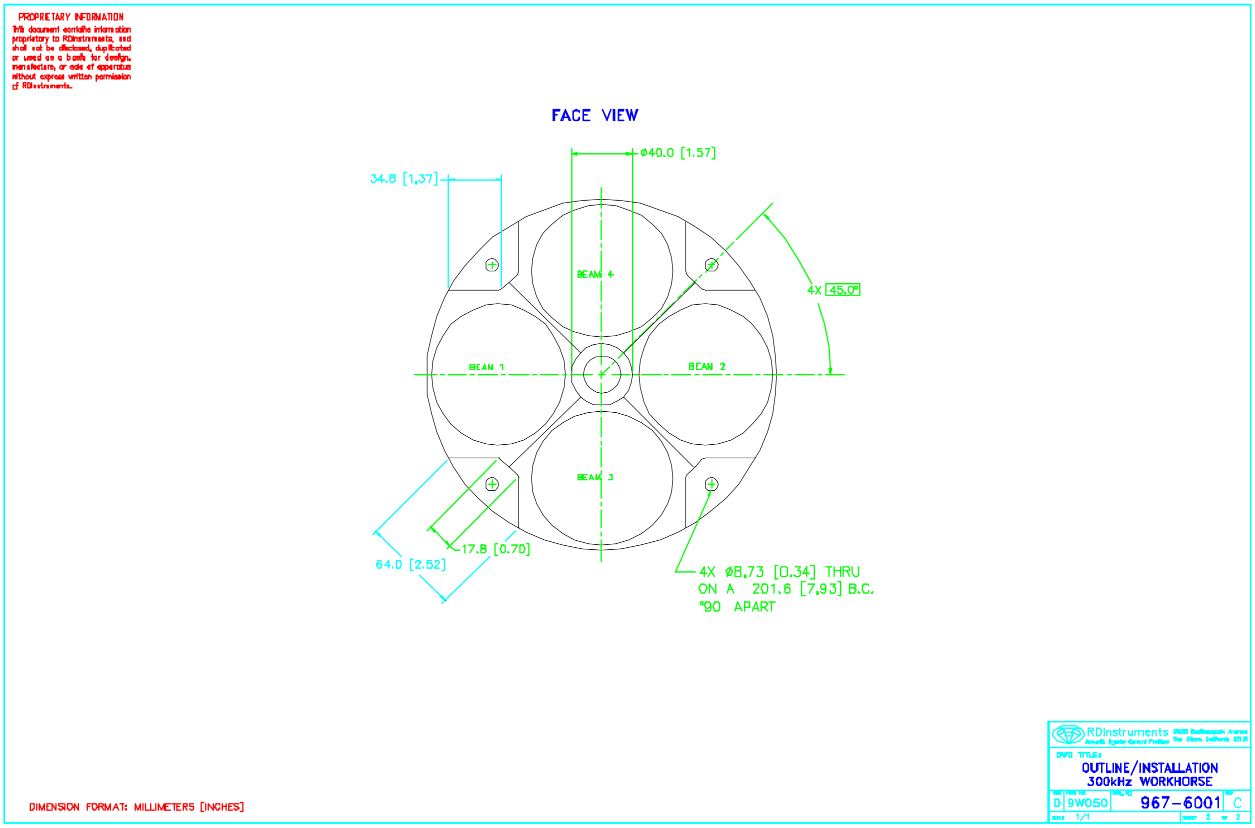


Figure A-2. 967-6001 (page 2)

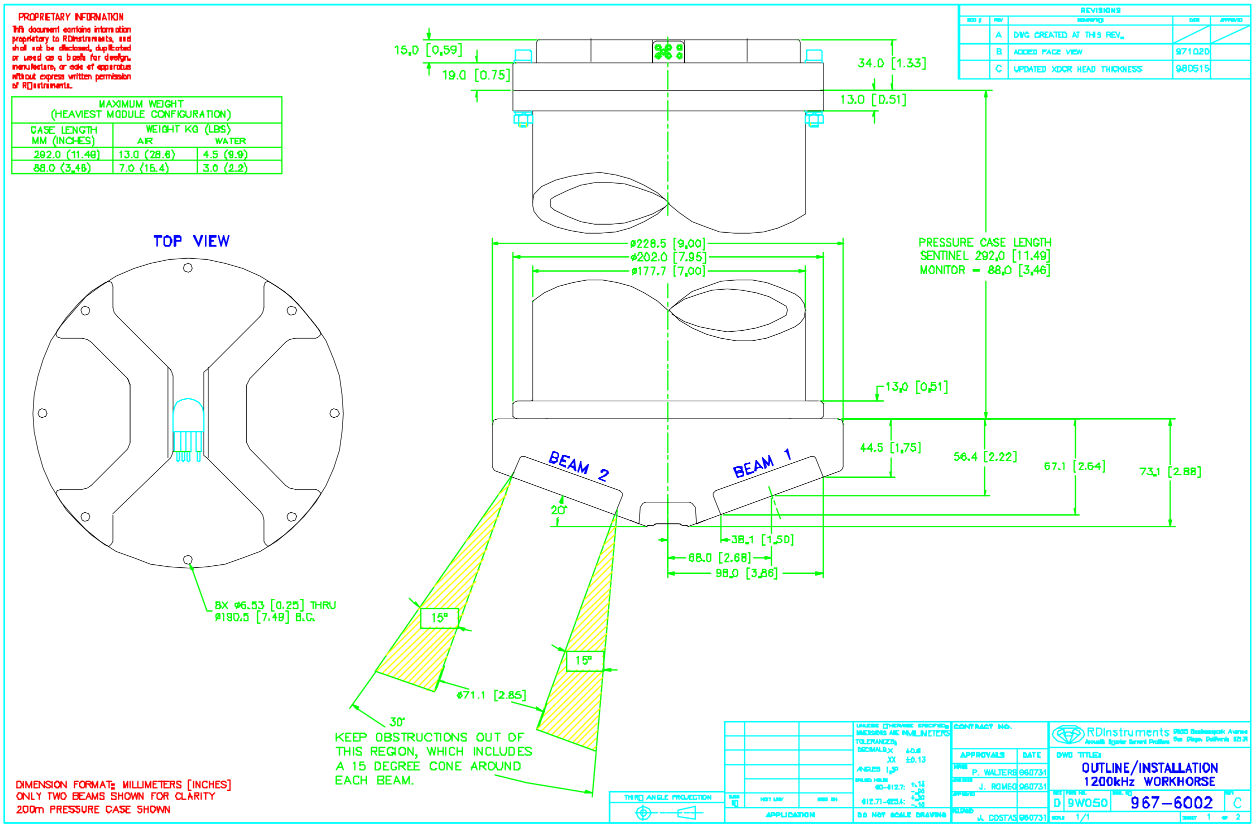


Figure A-3. 967-6002 (page 1)

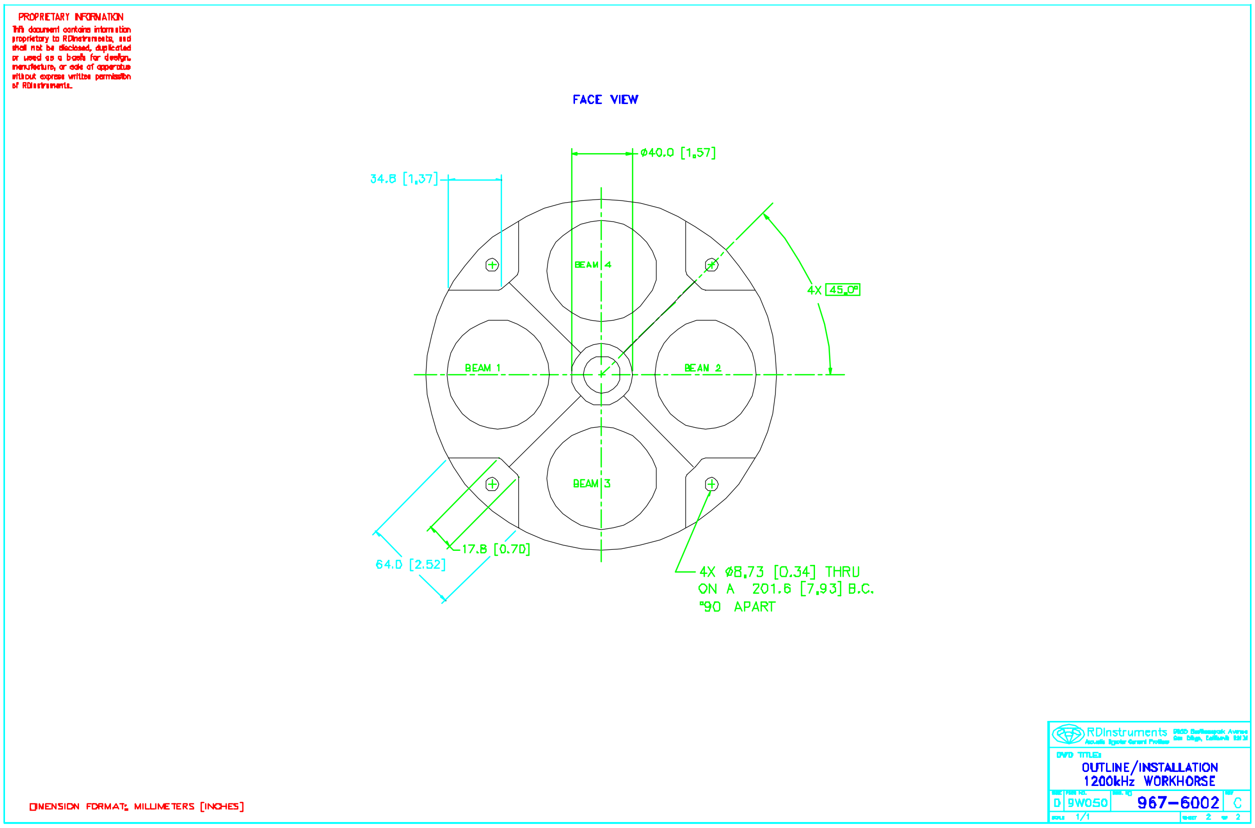


Figure A-4. 967-6002 (page 2)

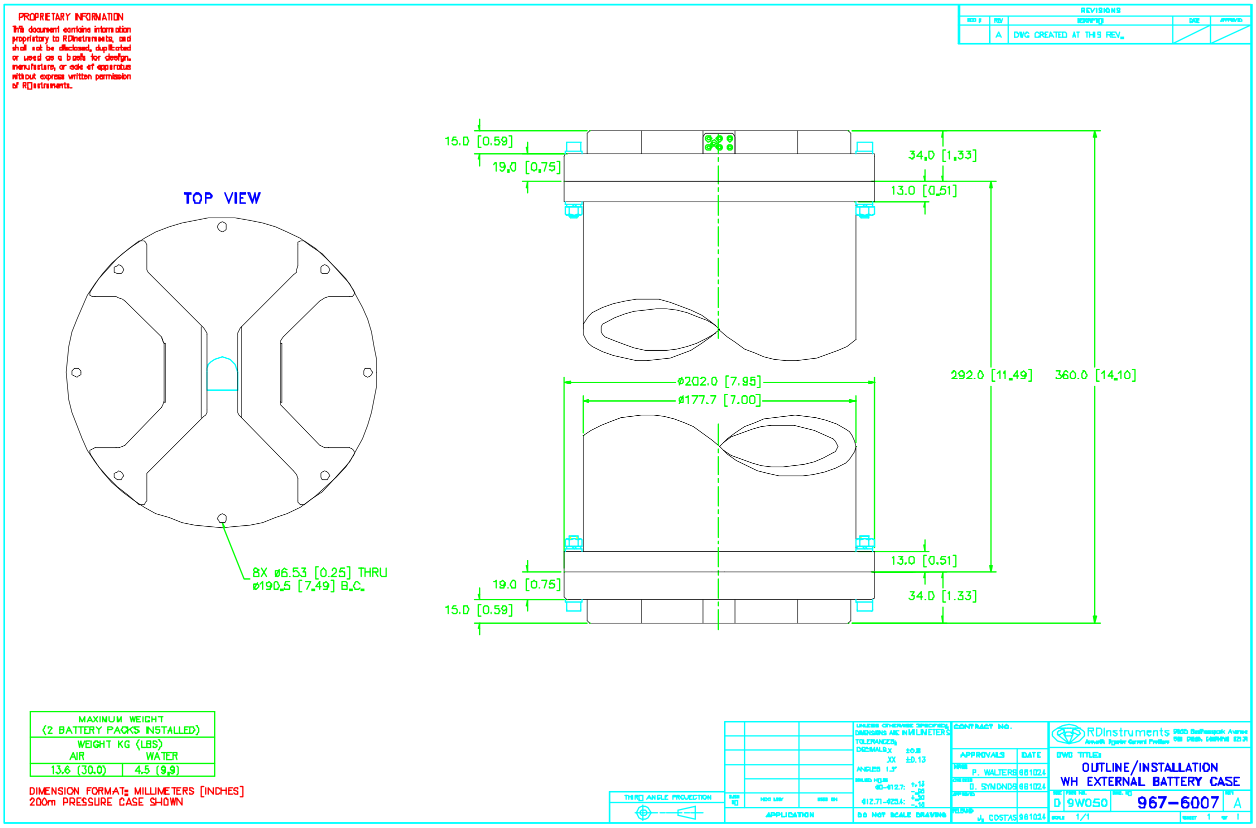


Figure A-5. 967-6007

NOTES

Appendix

B

System Overview

B-1 Introduction

This appendix presents a functional description of Monitor and Sentinel operation using block diagrams.

B-2 Operating Modes

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

B-2.1 Command Mode

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

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

B-2.2 Ping Mode

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

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

B-3 Overview of Normal Workhorse Operation

Refer to Figures B-1 through B-8. The following events occur during a typical data collection cycle.

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

   Figure B-1 shows a flow chart of the wake-up logic used by the Workhorse. The Workhorse determines what to do based on where the wake-up came from (either a Break, CS-command, battery saver timer, or watch-dog timer was detected).

b. On the PIO Board, the POWER REGULATOR circuit sends a transmit command to the POWER AMPLIFIER circuit. This tells the Workhorse to start acoustic transmissions (pinging) on all TRANSDUCERS.

c. The TRANSDUCERS receive echoes from the backscatter. The RECEIVER board amplifies and translates the echoes into a base-band frequency.

d. The CPU board processes the received echoes.

e. After echo reception, the Workhorse injects a self-test signal into the RECEIVER board and processes the signal as normal data for test purposes.

f. The THERMISTOR measures water temperature at the transducer head and sends it to the CPU via the DSP Board.

g. The PIO Board sends pitch and roll from the TILT SENSOR and Workhorse heading from the COMPASS to the DSP Board. The DSP Board digitizes this information and sends it to the CPU for processing.

h. The CPU repeats steps “b” through “g” for a user-defined number of pings. The CPU averages the data from each ping to produce an ensemble data set.

i. At the end of the ensemble (sampling) interval, the CPU sends the collected data to the serial I/O connector or PCMCIA recorder.

B-4 Functional Description of Operation

The following paragraphs describe how the Workhorse operates and interacts with its modules. Refer to Figures B-1 through B-8 throughout this description.

B-4.1 Input Power

The Workhorse requires a DC supply between 20 volts and 60 volts. Either an external DC power supply or internal battery packs can provide this power. Figure B-2 shows the DC voltage power distribution path.

Monitor External DC Power Supply. – With an external supply, power is applied to pins 3 (positive) and 7 (negative) on the external connector (see Figure B-2). The power then goes through an electromagnetic interference (EMI) filter on the PIO Board. This filter reduces the chance that external noise sources associated with the external power source can disrupt Workhorse operation.

Sentinel Internal Battery Packs. – Each internal battery pack uses 28 alkaline “D” cells. Each pack supplies a nominal output voltage of 42 volts open circuit when fresh. The diode-isolated battery packs can only power the Workhorse; they cannot “charge” each other.

B-4.2 Board Descriptions

PIO Board. (Figure B-5)

- Receives the filtered/internal power.
- Uses a diode "OR" gate to determine which power source to use (external or internal). With both sources connected, the OR gate selects the "higher" voltage for Workhorse use.
- Limits the in-rush of current to the Workhorse and provides over- and negative-voltage protection. Either condition will blow a protective fuse. However, damage could occur to other circuits before the fuse blows. Please ensure you apply only voltages within the specified range (+20 to +60 VDC).
- Converts the operating power supply (filtered/isolated 20-60 VDC) in a DC-to-DC converter to the +5 VDC (Vcc) used to power all other Workhorse circuits.
- Uses the Power Amplifier circuit on the PIO board to generate the high-amplitude pulse AC signal that drives the sonar transducers. The Power Amplifier sends the drive signal to the Receiver Board.
- RS-232/RS-422 switch.

CPU Board. (Figure B-6)

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

DSP Board. (Figure B-7)

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

Receiver Board. (Figure B-8)

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

B-4.3 Sensors

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

Temperature Sensor (thermistor) – Used to measure the water temperature. The system uses this data to calculate the speed of sound.

Up/Down Sensor – Determines whether the transducer head is facing up or down.

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

Attitude Sensor – Determines the tilt angles of the Workhorse. The attitude sensor uses a pitch and roll liquid-filled sensor. This sensor is functional to an angle of ±20° from vertical.

Pressure Sensor (optional) – Measures pressure at the Workhorse transducer.

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

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

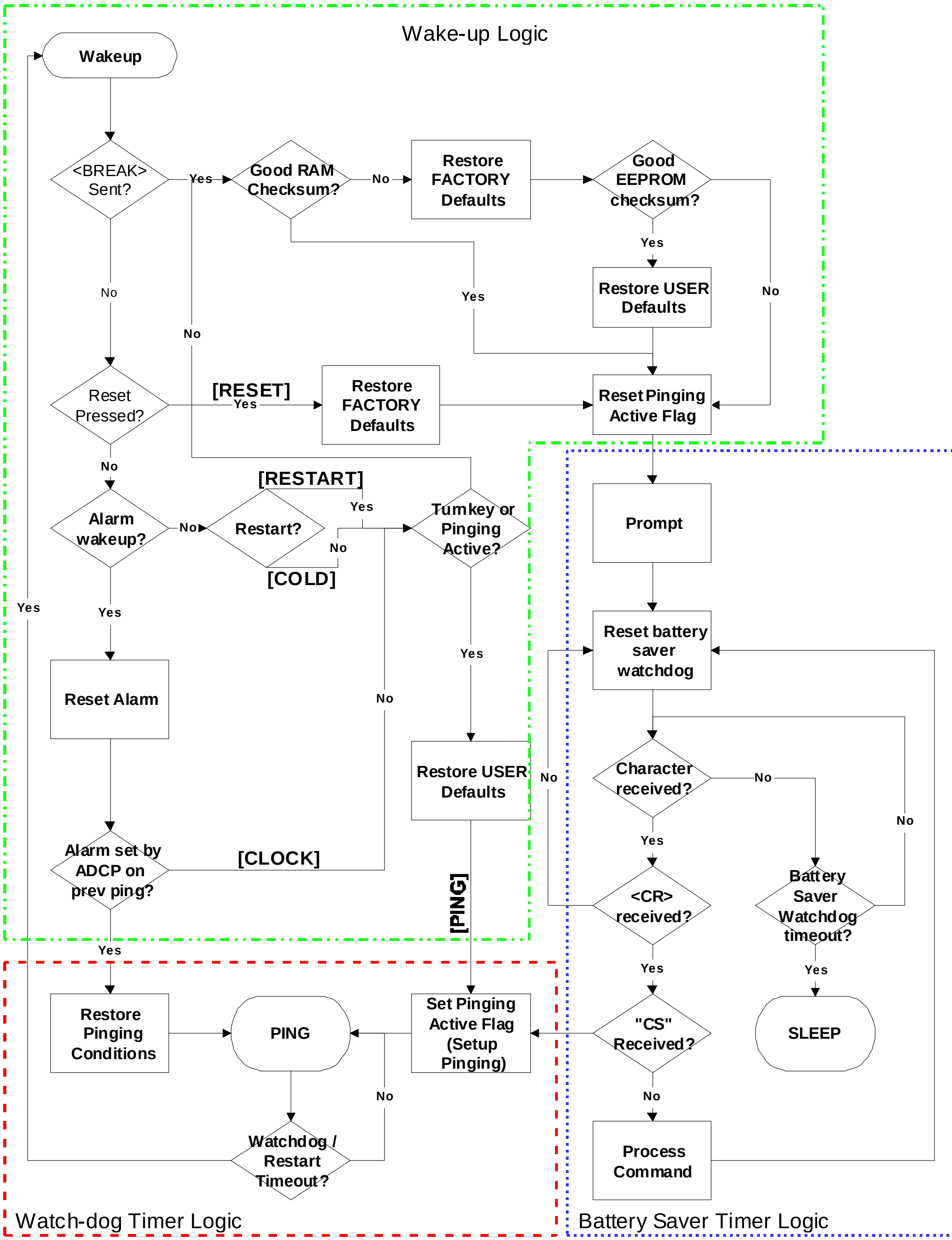


Figure B-1. Workhorse Wake-up and Timer Logic

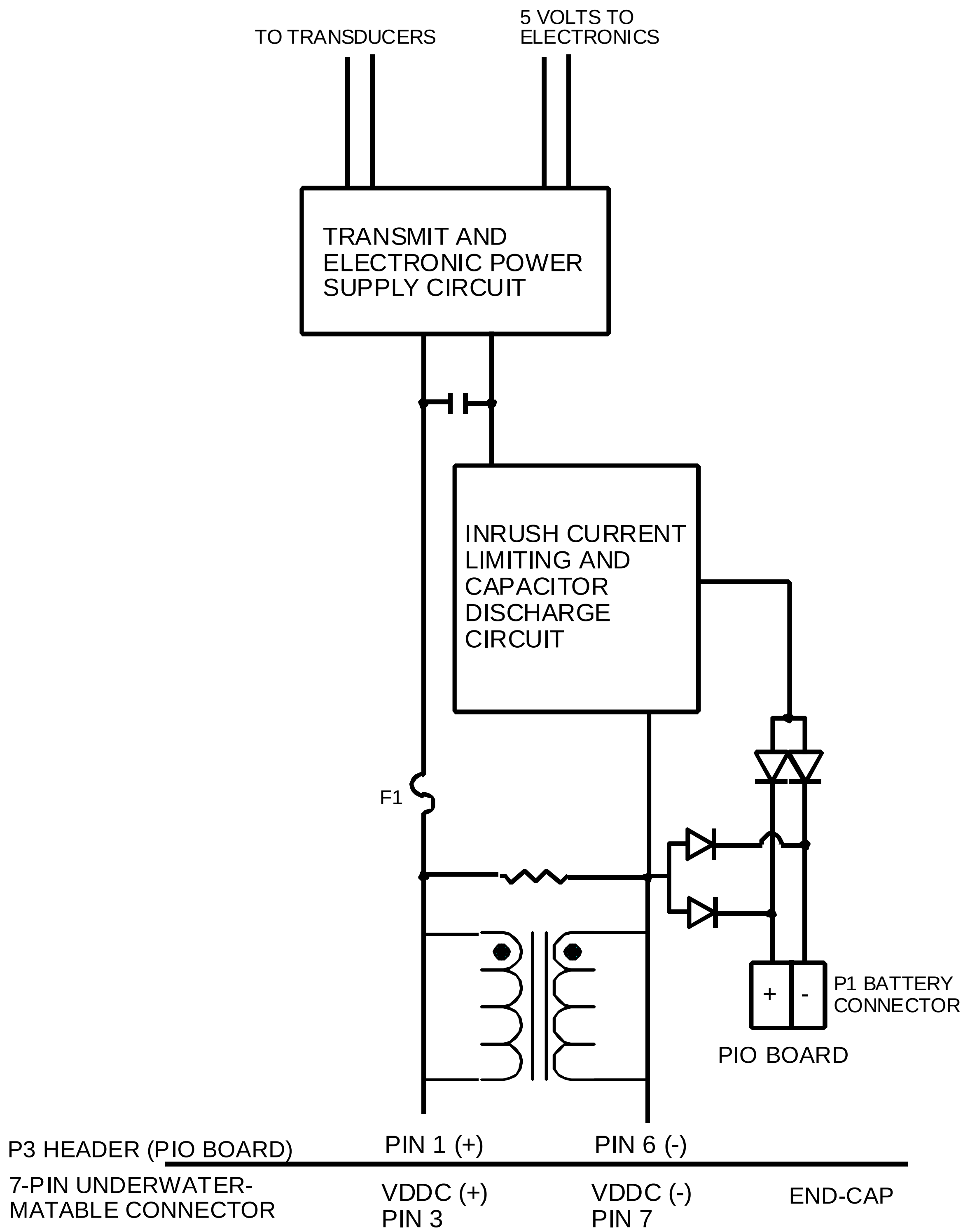


Figure B-2. DC Power Path

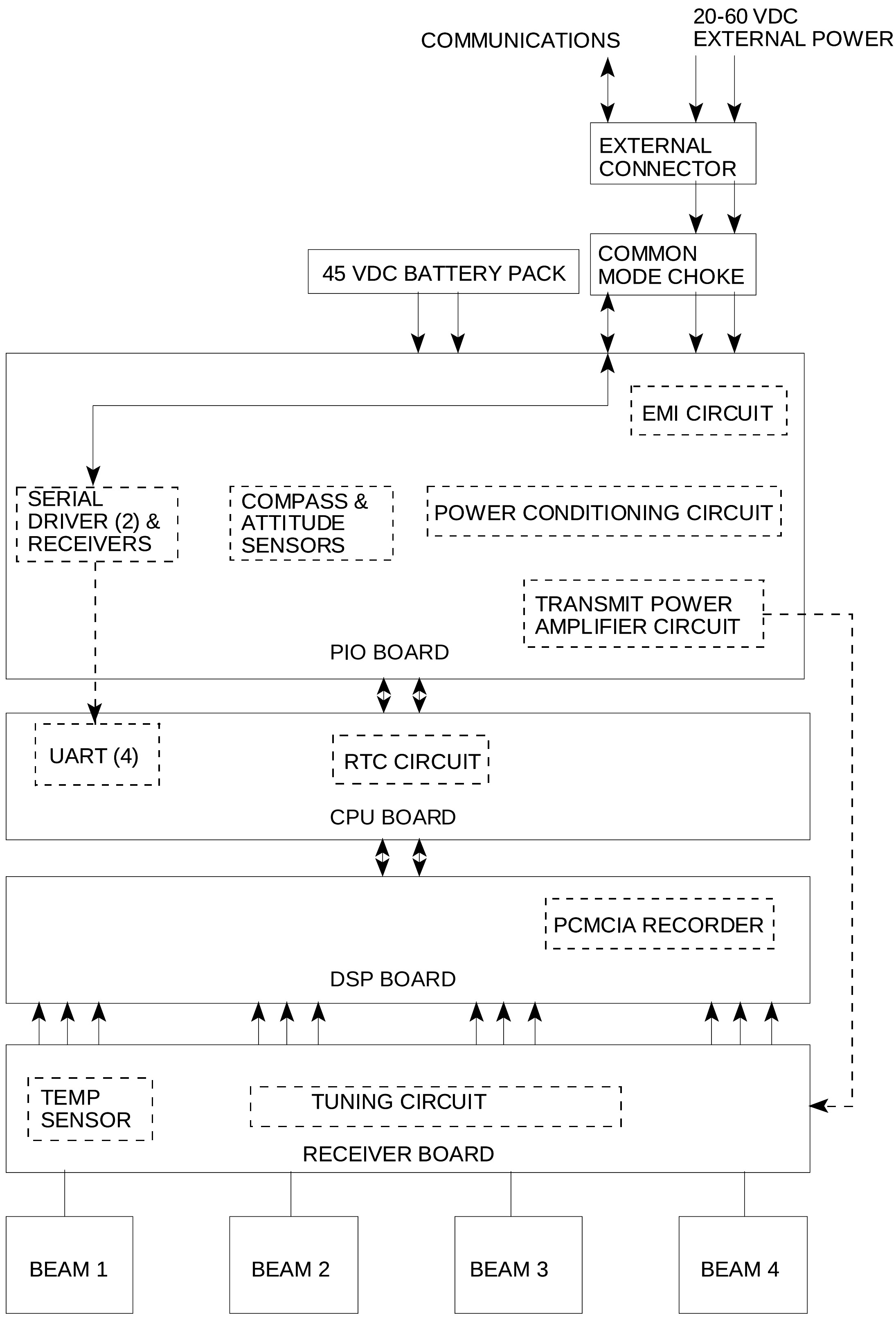


Figure B-3. Workhorse Block Diagram

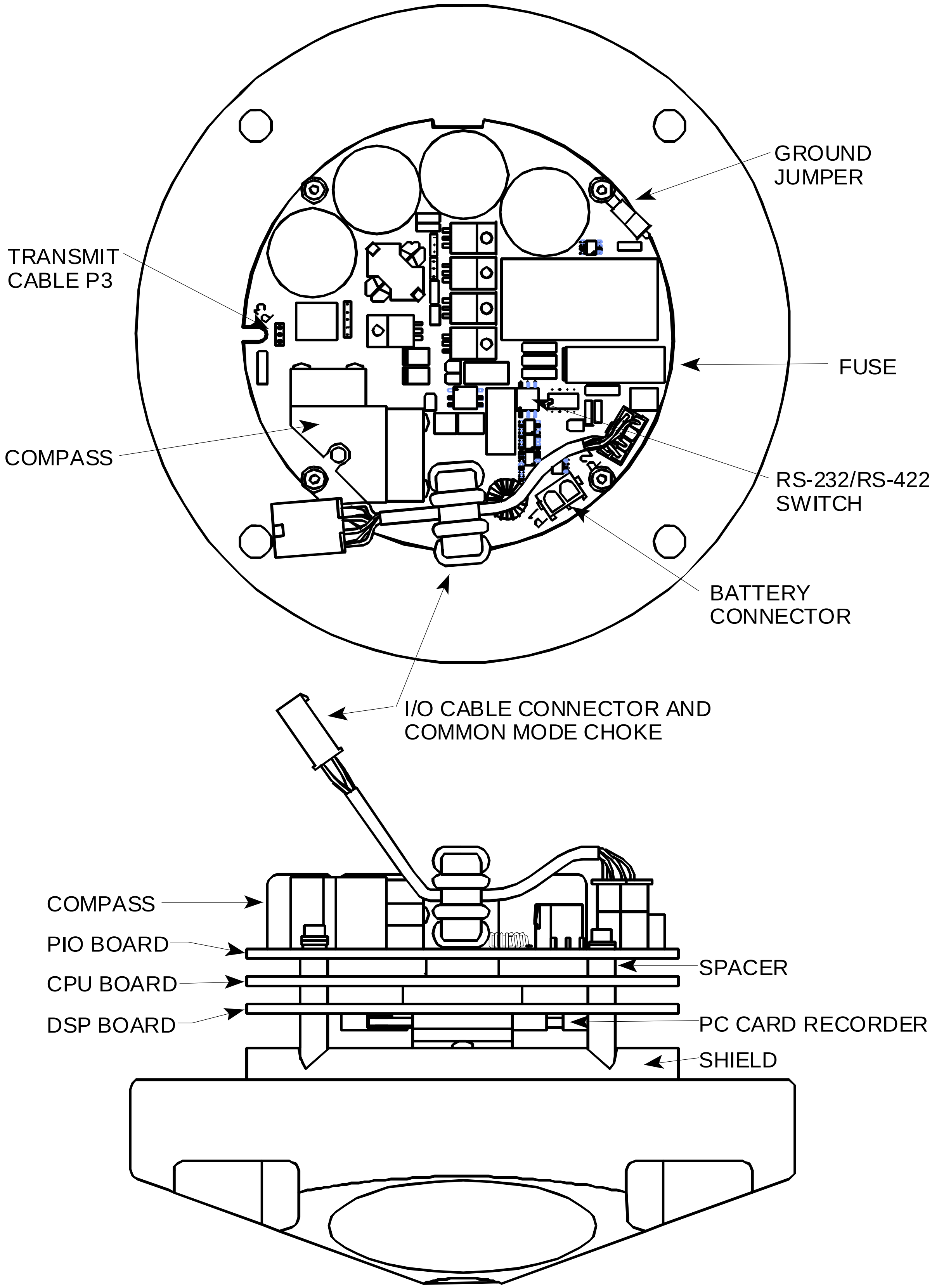
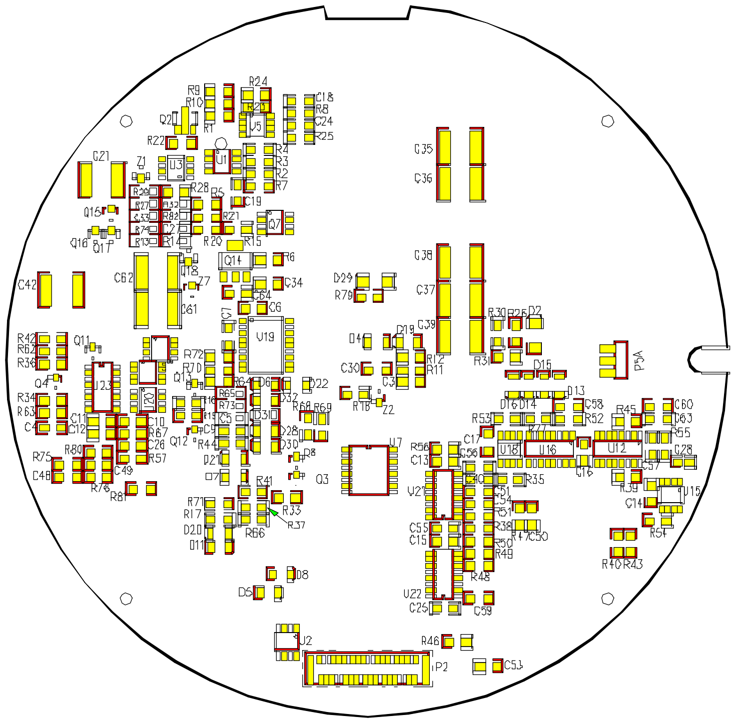
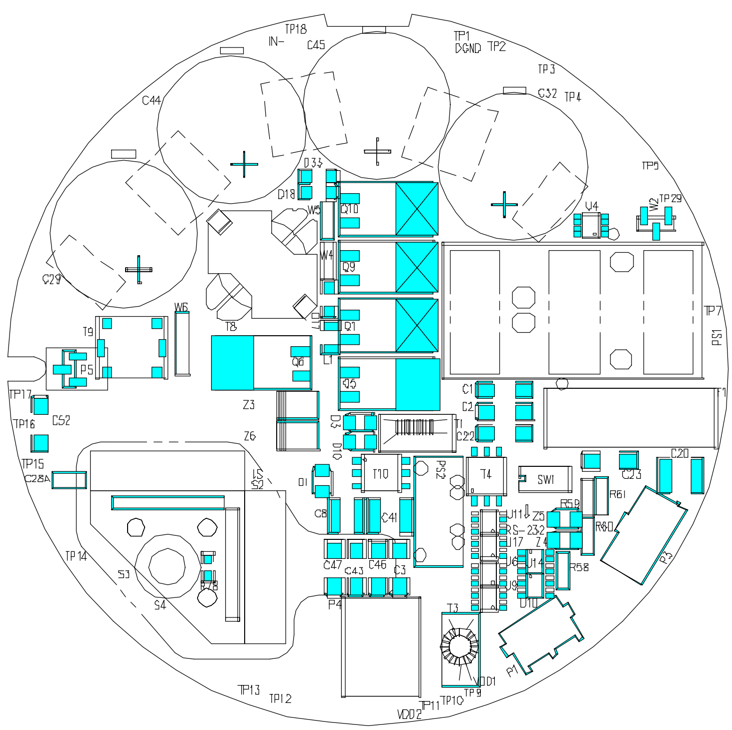


Figure B-4. Workhorse PC Board Locations

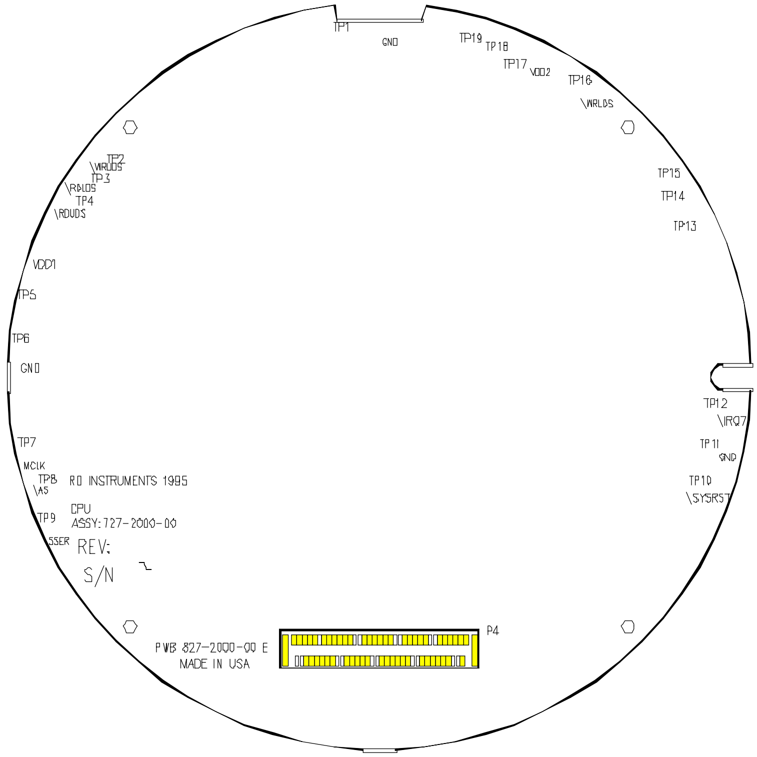


TOP SIDE

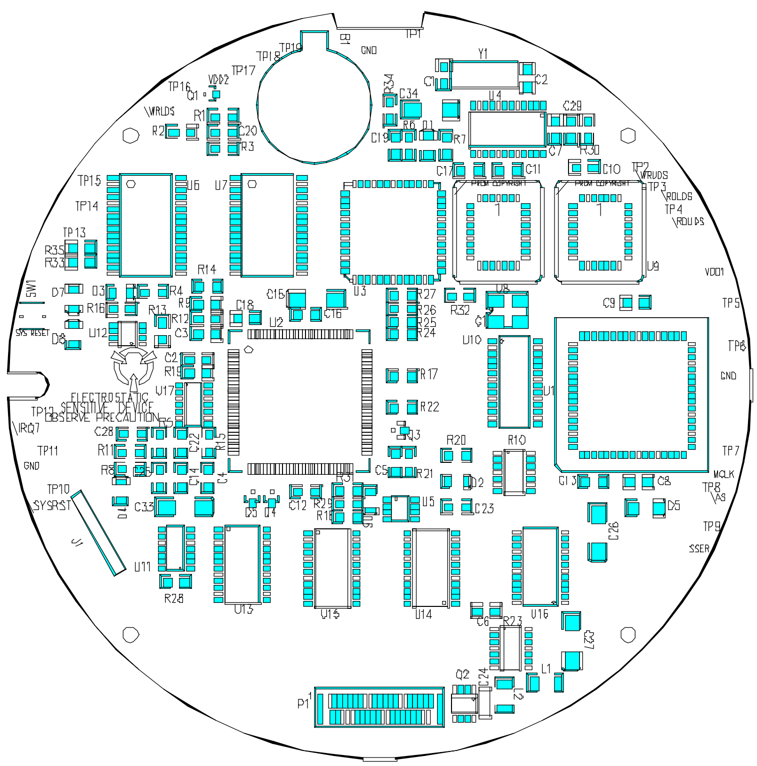


BOTTOM SIDE

Figure B-5. PIO Board

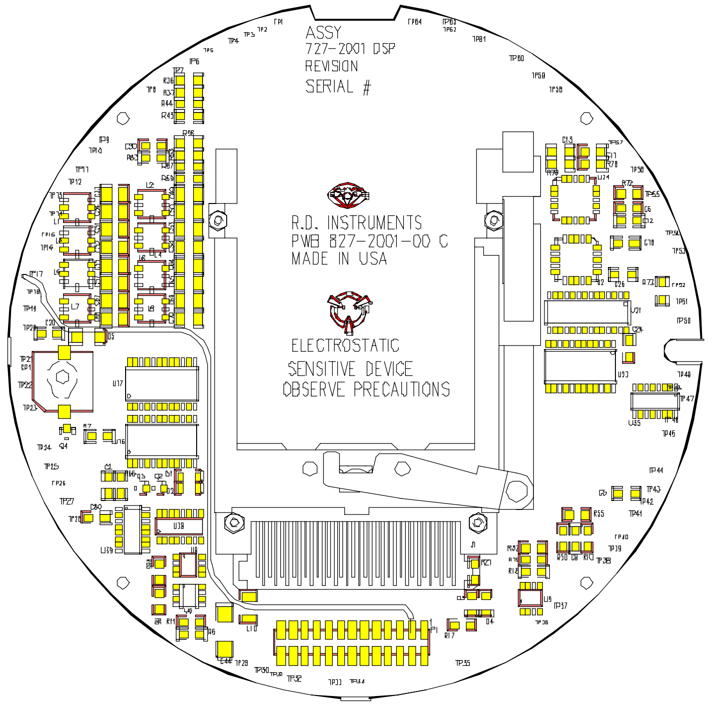


TOP SIDE

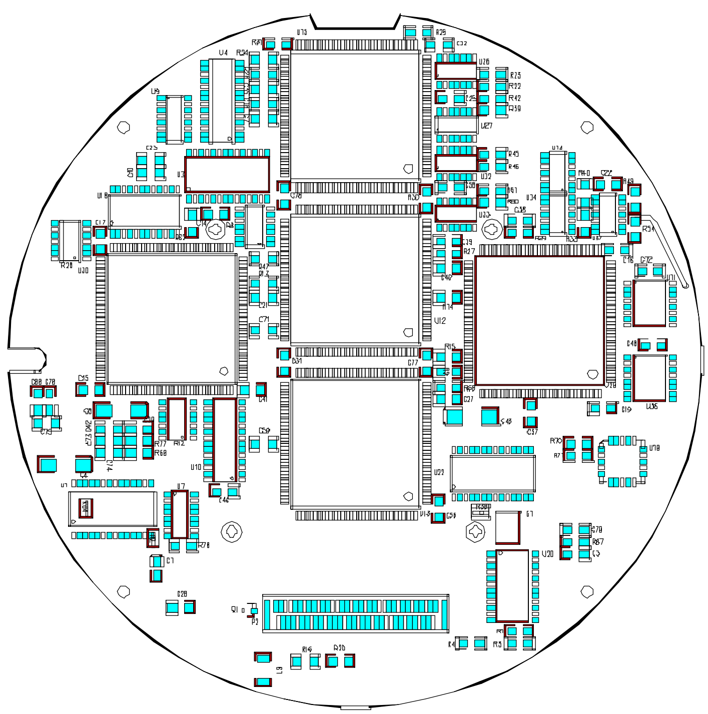


BOTTOM SIDE

Figure B-6. CPU Board

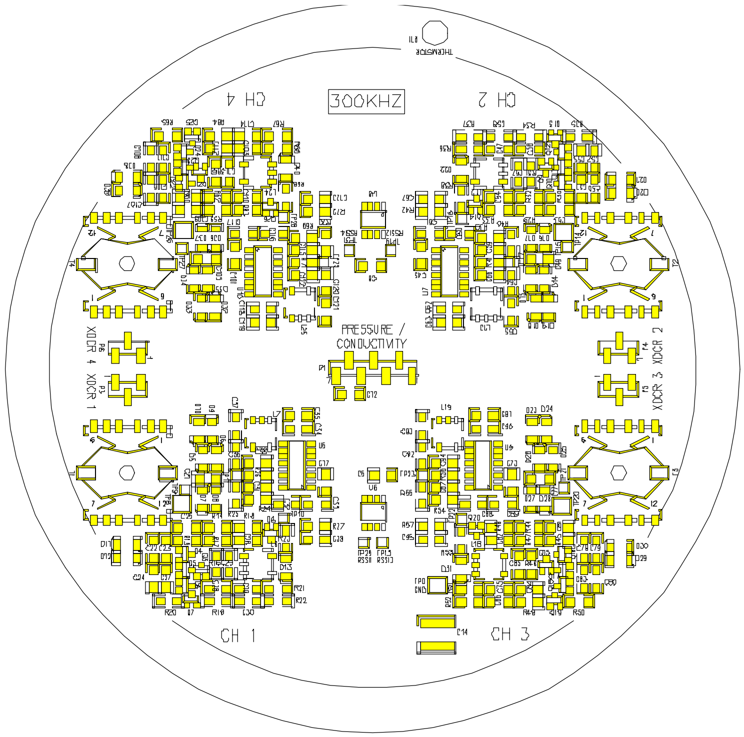


TOP SIDE

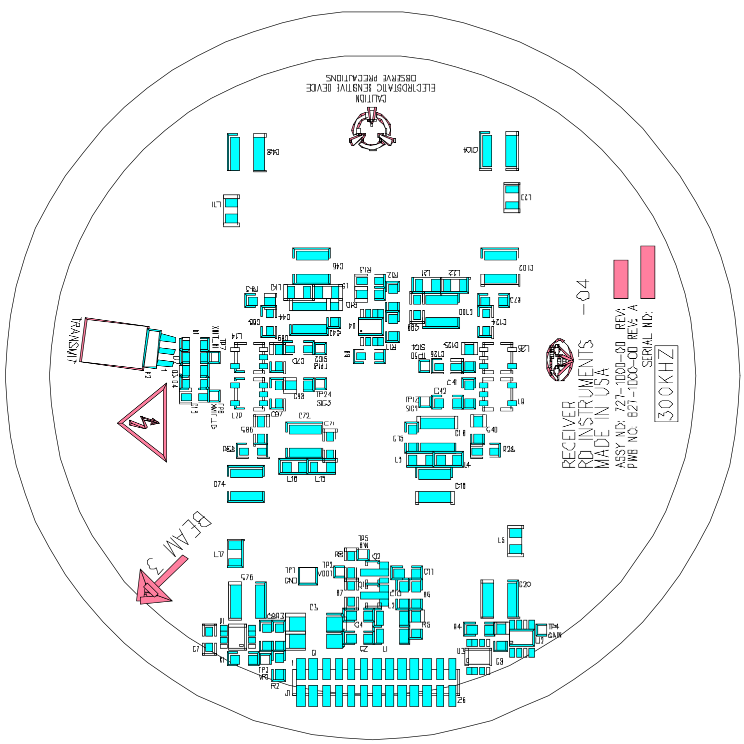


BOTTOM SIDE

Figure B-7. DSP Board



TOP SIDE



BOTTOM SIDE

Figure B-8. Receiver Board

NOTES

Appendix C

Commands

C-1 Introduction

This appendix defines the commands used by the Workhorse ADCP. These commands (Table C-1) let you set up and control the Workhorse without using an external software program such as our *PLAN* program. However, we recommend you use *PLAN* to control the Workhorse because entering commands directly from a terminal can be difficult. Most Workhorse settings use factory-set values (Table C-2). If you change these values without thought, you could ruin your deployment. *Be sure you know what effect each command has* *before* *using it*. Call RDI if you do not understand the function of any command.

Although this appendix lists *all* of the commands available for the Workhorse, only the commands listed in Table C-3 and C-4 are required for a successful deployment. Using *PLAN* to develop the command file will ensure that the Workhorse is set up correctly. The commands shown in Table C-3 directly effect the range of the ADCP, the standard deviation (accuracy) of the data, and battery usage. Using *PLAN* allows you to set the command values and see the result of your choices before deploying the ADCP.

NOTE

This appendix applies to firmware version 8.20 or lower. When new firmware versions are released, some commands may be modified or added. Read the README file on the upgrade disk, check RDI's web site, or read the "Read Me First" booklet for the latest changes.

C-2 Data Communication And Command Format

You can enter commands with an IBM-compatible computer running a terminal emulator program such as RDI's *BBTALK*. The Workhorse communicates with the computer through an RS-232 (or RS-422) serial interface. We initially set the Workhorse at the factory to communicate at 9600 baud, no parity, and 1 stop bit.

Immediately after you apply power to the Workhorse, it enters the STANDBY mode. Sending a BREAK signal from a terminal/program awakens the Workhorse (press END using *BBTALK*). The BREAK signal must last at least 300 ms. When the Workhorse receives a BREAK signal, it responds with a wake-up message similar to the one shown below. The Workhorse is now ready to accept commands at the ">" prompt from either a terminal or computer program.

```
Workhorse Broadband ADCP Version 8.xx
RD Instruments (c) 1998
All rights reserved.
>
```

C-2.1 Command Input Processing

Input commands set Workhorse operating parameters, start data collection, run built-in tests (BIT), and asks for output data. All commands (Table C-1) are ASCII character(s) and must end with a carriage return (CR). For example,

```
>WP0001<CR> [Your input]
```

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

```
>WP00001<CR>     [Your original input]
>                [Workhorse response to a valid, no-output command]
```

If you enter a valid command that produces output data, the Workhorse 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 responds with an error message similar to the following.

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

After correctly entering all the commands for your application, you would send the CS-command (or ) to begin the data collection cycle.

C-2.2 Data Output Processing

After the Workhorse 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 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. 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. Data is always recorded in binary format on the internal recorder.

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

The Workhorse automatically stores the last set of commands used in RAM. The Workhorse will continue to be configured from RAM until it receives a CR-command or until the RAM loses its backup power. If the Workhorse 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 receives a CR1, it will load into RAM the factory default command set stored in ROM (permanent or factory settings).

Table C-1 gives a summary of the Workhorse input commands, their format, and a brief description of the parameters they control. Refer to the listed page for more information about a command. Table C-2 lists the factory default command settings.

Table C-1. Workhorse Input Command Summary

Command	Description	Page
?	Shows command menu (deploy or system)	C-6
<BREAK>	Interrupts or wakes up workhorse and loads last settings used	C-7
AF	Field calibrate to remove hard iron error	C-8
AR	Restore factory fluxgate calibration data	C-12
AX	Examine compass performance	C-12
AZ	Zero Pressure sensor	C-13
CBnnn	Serial port control (baud rate/parity/stop bits)	C-14
CFnnnnn	Flow control	C-15
CK	Keep parameters as user defaults	C-16
CPn	Polled Mode (1=ON, 0=OFF; BREAK resets)	C-17
CRn	Retrieve parameters (0 = user, 1 = factory)	C-17
CS or <TAB>	Start pinging	C-18
CZ	Power down Workhorse	C-18
EAnnnnn	Heading Alignment (1/100 deg)	C-19
EBnnnnn	Heading Bias (1/100 deg)	C-19
EDnnnnn	Transducer Depth (0 – 65535 dm)	C-20
ESnn	Salinity (0 to 40 parts per thousand)	C-20
EXnnnnn	Coord Transform (Xform:Type; Tilts; 3Bm; Map)	C-20
EZnnnnnnn	Sensor Source (C;D;H;P;R;S;T)	C-23
FC	Clear Fault Log	C-24
FD	Display Fault Log	C-24
PA	Pre-deployment tests	C-25
PCn	User-Interactive Built-in tests	C-26
PSn	Display system parameters	C-27
RE ErAsE	Erase all recorder memory	C-29
RF	Recorder free space (bytes)	C-29
RN aaaaa	Set deployment name to aaaaa (must be five characters)	C-30
RR	Show recorder file directory (dos style)	C-30
RY	Upload recorder files (uses y-modem protocol)	C-30
TEhh:mm:ss.ff	Time per ensemble (hours:minutes:seconds.100th of seconds)	C-31
TFyy/mm/dd, hh:mm:ss	Time of first ping (year/month/day, hour:minute:second)	C-31
TPmm:ss.ff	Time between pings (minutes:seconds.100th of seconds)	C-32
TSyy/mm/dd, hh:mm:ss	Set real-time clock (year/month/day, hour:minute:second)	C-33
WDnnn nnn nnn	Data Out (Vel;Cor;Amp PG;St;P0 P1;P2;P3)	C-34
WFnnnn	Blank after transmit (0-9999 cm)	C-34
WNnnn	Number of depth cells (1-128)	C-35
WPnnnnn	Pings per ensemble (0-16384)	C-35
WSnnnn	Depth cell size (0-9999 cm)	C-35
WVnnn	Ambiguity velocity (cm/s radial)	C-36

NOTE

This table applies to Workhorse firmware version 8.20 or lower. When newer firmware versions are released, some commands may be modified or added. Read the README file on the upgrade disk, check RDI's web site, or read the "Read Me First" booklet for the latest changes.

Table C-2. Workhorse Factory Defaults

Command	300kHz Default Setting	1200kHz Default Setting
CBnnn	411	411
CFnnnnn	11111	11111
ESnn	35	35
RN	_RDI_	_RDI_
TEhh:mm:ss.ff	01:00:00.00	01:00:00.00
TPmm:ss.ff	01:20.00	01:20.00
WFnnnn	0176	0044
WNnnn	030	030
WPnnnnn	00045	00045
WSnnnn [min, max]	0400 [20, 800]	0100 [5, 400]
WVnnn	175	175

NOTE

This table applies to Workhorse firmware version 8.20 or lower. When newer firmware versions are released, some commands may be modified or added. Read the README file on the upgrade disk, check RDI's web site, or read the "Read Me First" booklet for the latest changes.

C-3 Commands Modified by PLAN

The following commands are modified by *PLAN*. We strongly encourge you to develop your command files using *PLAN*. Once you have created and saved the command file, you can view it using any text editor. See "Sample Printout of ABCDE.CMD" page 2-7.

The commands shown in Table C-3 directly effect the range of the ADCP, the standard deviation (accuracy) of the data, and battery usage. Using *PLAN* allows you to set the command values and see the result of your choices before deploying the ADCP.

Table C-3. Commands Modified by PLAN

Command	Description	Page
CF	Flow control	C-15
EB	Heading bias	C-19
ED	Transducer depth	C-20
ES	Salinity	C-20
TE	Time per ensemble	C-31
TF	Time of first ping	C-31
TP	Time between pings	C-32
WN	Number of depth cells	C-35
WP	Pings per ensemble	C-35
WS	Depth cell size	C-35

In addition to the commands modified by *PLAN* listed in Table C-3, the following commands are *added* to the command file.

Table C-4. Commands Added by PLAN

Command	Description	Page
CK	Keep parameters as user defaults	C-16
CR1	Sets factory defaults	C-17
CS	Start pinging	C-18
EA00000	Heading alignment	C-19
EX11111	Coordinate transformations	C-20
EZ1111111	Sensor source	C-23
WD111 100 000	Data out	C-34
WF0176	Blank after transmit	C-34
WV170	Ambiguity velocity	C-36

NOTE

Although the ADCP default is WV175, PLAN sets the WV-command to WV170. This is the recommended setting.

C-4 Command Descriptions

Although this appendix lists *all* of the commands available for the Workhorse, only the commands listed in Table C-3 and C-4 are required for a successful deployment. Using PLAN to develop the command file will ensure these commands are set properly.

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 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 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.

```
>?
DEPLOY? ------------------ Deployment Commands
SYSTEM? ------------------ System Control, Data Recovery and Testing Commands

>deploy?
Deployment Commands:
RE ----------------------- Recorder ErAsE
RN ----------------------- Set Deployment Name

WD = 111 100 000 --------- Data Out (Vel,Cor,Amp; PG,St,P0; P1,P2,P3)
WF = 0176 ---------------- Blank After Transmit (cm)
WN = 030 ----------------- Number of depth cells (1-128)
WP = 00045 --------------- Pings per Ensemble (0-16384)
WS = 0400 ---------------- Depth Cell Size (cm)
WV = 175 ----------------- Mode 1 Ambiguity Vel (cm/s radial)

TE = 01:00:00.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TF = **/**/**,**:**:** --- Time of First Ping (yr/mon/day,hour:min:sec)
TP = 01:20.00 ------------ Time per Ping (min:sec.sec/100)
TS = 98/01/06,11:07:10 --- Time Set (yr/mon/day,hour:min:sec)

EA = +00000 -------------- Heading Alignment (1/100 deg)
EB = +00000 -------------- Heading Bias (1/100 deg)
ED = 00000 --------------- Transducer Depth (0 - 65535 dm)
ES = 35 ------------------ Salinity (0-40 pp thousand)
EX = 11111 --------------- Coord Transform (Xform: Type,Tilts,3 Bm,Map)
EZ = 1011101 ------------- Sensor Source (C,D,H,P,R,S,T)

CF = 11111 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
CK ----------------------- Keep Parameters as USER Defaults
CR # --------------------- Retrieve Parameters (0 = USER, 1 = FACTORY)
CS ----------------------- Start Deployment
```

```
>system?
System Control, Data Recovery and Testing Commands:
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

CB = 411 ----------------- Serial Port Control (Baud; Par; Stop)
CP # --------------------- Polled Mode (0 = NORMAL, 1 = POLLED)
CZ  ---------------------- Power Down Instrument

RR ----------------------- Recorder Directory
RF ----------------------- Recorder Space used/free (bytes)
RY ----------------------- Upload Recorder Files to Host

PA ----------------------- Pre-Deployment Tests
PC1 ---------------------- Beam Continuity
PC2 ---------------------- Sensor Data
PS0 ---------------------- System Configuration
PS3 ---------------------- Transformation Matrices

OL ----------------------- Display Features List
FC ----------------------- Clear Fault Log
FD ----------------------- Display Fault Log
```

Break

Purpose : Interrupts Workhorse without erasing present settings.

Format : <BREAK>

Description : A BREAK signal interrupts Workhorse 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 in the DATA I/O mode. The BREAK command does not erase any settings or data. Using *BBTALK*, pressing the END key sends a BREAK.

Example : <BREAK>

```
Workhorse Broadband ADCP Version 8.xx
RD Instruments (c) 1997
All rights reserved.
>
```

OL - Features

Purpose : Lists special firmware upgrades that are installed.

Format : OL

Description : See your upgrade manual or contact RDI for information on how to install additional capability in your WorkHorse.

Examples : See below.

```
>OL
Feature                                                           Installed
----------------------------------------------------------------------------
Bottom Track                                                          No
Water Profile                                                         Yes
High Resolution Water Modes                                           No
```

C-4.1 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.

AF – Field Calibrate Compass

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

Format : AF

Description : The built-in automated compass calibration procedures are similar to the alignment verification, but requires three rotations instead of one. The Workhorse 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 for the two calibration rotations, the Workhorse 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.

Recommended Setting : Use as needed. The compass must be calibrated if the batteries have been replaced.

Example : >AF

```
>af
-------------------------------------------------------------------------------
                         Field Calibration Procedure
Choose calibration method:
     a.  Remove hard iron error (single cycle) only.
     b.  Remove hard and soft iron error (single + double cycle).
     c.  Help.
     d.  Quit.
b
```

```
------------------------------------------------------------------------------
                         Field Calibration Procedure
                        Hard and Soft Iron Calibration
Select one:
     a.  Start calibration procedure.
     b.  Instructions.
     c.  Quit.
b
------------------------------------------------------------------------------
                         Field Calibration Procedure
                        Hard and Soft Iron Calibration

What you need:
  a. Non-magnetic table or other smooth non-magnetic surface.
  b. The magnetic field where you will calibrate the compass must be free
     of local field variations.  To check this, note the deflection of a
     handheld compass as you slide the compass 15 cm against the straight
     edge of a book.  The direction should vary no more than 1 degree over
     this distance.
  c. Piece of stiff cardboard.
  d. Non-magnetic block 20-40 mm thick (upward facing calibrations only).

Procedure:
  a. If you will deploy the ADCP looking up, calibrate it looking up. If you
     will deploy the ADCP looking down, calibrate it looking down.
  b. Place the ADCP on the stiff cardboard on top of the table.
  c. When you are instructed to tilt the ADCP, place the block under the ADCP
     on one side of the end cap.  If the ADCP is facing down, place the ADCP
     flat on one of the transducer faces (do not use a block)--the transducer
     face gives you an appropriate tilt.
Press any key to continue ...
------------------------------------------------------------------------------
                         Field Calibration Procedure
                        Hard and Soft Iron Calibration

Select one:
     a.  Start calibration procedure.
     b.  Instructions.
     c.  Quit.
a
------------------------------------------------------------------------------
                         Field Calibration Procedure
                        Hard and Soft Iron Calibration
                           Setup for First Rotation


Tilt the unit any direction so that the combined tilt magnitude is within
   the 10°-20° range indicated below.
0°                  10°                 20°                 30°
^                    ^***** ok tilt *****^                    ^
                                         ♦
  0.4° Pitch and  19.1° Roll are acceptable.  Ok to continue [y, n]?

------------------------------------------------------------------------------
                         Field Calibration Procedure
                        Hard and Soft Iron Calibration
                                First Rotation

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 before calibration:   0.2° <<<
Press D for details or any other key to continue...

HEADING ERROR ESTIMATE BEFORE THE FIELD CALIBRATION UPDATE:

   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5°):  ± 1.58°

   DETAILED ERROR SUMMARY:
      Single Cycle Error:                                ± 1.57°
      Double Cycle Error:                                ± 0.07°
      Largest Double plus Single Cycle Error:            ± 1.64°
      RMS of 3rd Order and Higher + Random Error:        ± 0.35°

      Orientation:    Down
      Average Pitch: -19.26°        Pitch Standard Dev:   0.30°
      Average Roll:   -0.64°         Roll Standard Dev:   0.24°

Successfully evaluated compass performance before the field calibration update.
Press any key to continue...
--------------------------------------------------------------------------------
                         Field Calibration Procedure
                        Hard and Soft Iron Calibration
                          Setup for Second Rotation

Now tilt the unit at least 10° in a different direction.

SUGGESTIONS:
  Facing up: place the block under the end cap to either side of where the
             block was for the first rotation - not on the opposite side
             of the end cap!.

  Facing down: place the ADCP facing down on either of the two beams that
               are closest to the one you just used.  Do not place the ADCP
               on the opposite beam.

 -0.3° Pitch °  19.1° Roll. Tilt NOT OK. Change tilt, then press any key ...
-19.3° Pitch and  -0.5° Roll. Tilt is OK. Wait...    Press any key to continue...

--------------------------------------------------------------------------------
                         Field Calibration Procedure
                        Hard and Soft Iron Calibration
                               Second Rotation

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 before calibration:   0.3° <<<

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

HEADING ERROR ESTIMATE BEFORE THE FIELD CALIBRATION UPDATE:

   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5°):  ± 2.30°

   DETAILED ERROR SUMMARY:
      Single Cycle Error:                                 ± 2.27°
      Double Cycle Error:                                 ± 0.20°
      Largest Double plus Single Cycle Error:             ± 2.47°
      RMS of 3rd Order and Higher + Random Error:         ± 0.47°

      Orientation:    Down
      Average Pitch:  -0.12°        Pitch Standard Dev:    0.42°
      Average Roll:   18.99°        Roll Standard Dev:     0.28°

Successfully evaluated compass performance before the field calibration update.
Press any key to continue...

Calculating new calibration parameters.
------------------------------------------------------------------------------
                         Field Calibration Procedure
                        Hard and Soft Iron Calibration
                            Verification Rotation

Temporarily loading new calibration parameters into RAM...

You do not need to change the tilt.

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 after calibration:   0.2° <<<

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

HEADING ERROR ESTIMATE AFTER THE FIELD CALIBRATION UPDATE:

   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5°):  ± 0.20°

   DETAILED ERROR SUMMARY:
      Single Cycle Error:                                ± 0.18°
      Double Cycle Error:                                ± 0.07°
      Largest Double plus Single Cycle Error:            ± 0.24°
      RMS of 3rd Order and Higher + Random Error:        ± 0.32°
```

```
      Orientation:    Down
      Average Pitch: -19.13°         Pitch Standard Dev:    0.23°
      Average Roll:   -0.43°         Roll Standard Dev:     0.25°

Successfully evaluated compass performance after the field calibration update.
Press any key to continue...
Making new calibration parameters permanent.
Calibration parameters have been updated in RAM and Flash.

------------------------------------------------------------------------------
                         Field Calibration Procedure
                        Hard and Soft Iron Calibration

Compass field calibration procedure is complete.

>>> Total error before calibration:   2.3° <<<
>>> Total error after calibration:    0.2° <<<
```

AR – Return to Factory Calibration

Purpose : Returns to the factory calibration matrix.

Format : AR

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

Recommended Setting: Use as needed.

AX – Examine Compass Calibration

Purpose : Used to verify the compass calibration.

Format : AX

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

Recommended Setting: Use as needed.

Example : >AX

```
------------------------------------------------------------------------------
                    RDI 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

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

Recommended Setting: Use as needed.

C-4.2 Control System

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

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

Description : The Workhorse 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 responds with a “>” prompt. You may now change the external device’s communication parameters to match the Workhorse parameters <u>before</u> sending another command.

Recommended Setting: Leave at default settings for most applications.

Table C-5. 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 = High	
5 = 19200	5 = Low	
6 = 38400		
7 = 57600		
8 = 115200		

<u>Setting The Baud Rate In The Workhorse</u>. The Workhorse 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. This procedure assumes that you will be using the program *BBTALK* that is supplied by RD Instruments.

a. Connect the Workhorse to the computer and apply power (see Chapter 1).

b. Start the *BBTALK* program and wakeup the Workhorse by sending a break signal with the END key.

c. Send the command <u>CR1</u> to place the Workhorse in the factory default setup.

d. 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 C-6. 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

e. Press the F5 function key to open the *BBTALK* communication port setup window. Change the communication port settings to match your new CB command setting.

f. Press the ESC key to exit the communication port setup window.

g. Send the command CK to save the new baud rate setting.

The Workhorse 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.

Notes : 1. If you send a BREAK before changing the external device's communication parameters, the Workhorse returns to the communication parameters stored in non-volatile memory (user settings).

2. To save the new Workhorse communication parameters, use the CK-command <u>after</u> changing the external device's communication parameters to match the new values.

CF - Flow Control

Purpose : Sets various Workhorse data flow-control parameters.

Format : CF*nnnnn*

Range : Firmware switches (see description)

Default : CF11111

Description : The CF-command defines whether the Workhorse: 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).

Recommended Setting : Set using *PLAN*.

Table C-7. 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.
CFØxxxx	Manual Ensemble Cycling – Enters the STANDBY mode after transmission of the data ensemble, displays the “>” promp and waits for a new command.
CFx1xxx	Automatic Ping Cycling – Pings immediately when ready.
CFxØxxx	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 Workhorse is not echoed. This feature lets you manually control ping timing within the ensemble.
CFxx1xx	Binary Data Output – Sends the ensemble in binary format, if serial output is enabled (see below).
CFxxØxx	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.
CFxxxØx	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).
CFxxxxØ	Disable Data Recorder – No data ensembles are recorded on the recorder.
Example	CFØ1Ø1Ø selects manual ensemble cycling, automatic ping cycling, Hex-ASCII data output, enables serial output, and disables data recording.

CK - Keep Parameters

Purpose : Stores present parameters to non-volatile memory.

Format : CK

Description : CK saves the present user command parameters to non-volatile memory on the CPU board. The Workhorse 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 CRØ-command. When CRØ is sent, the commands shown below are restored to values previously saved to non-volatile memory. *Other* commands are set to their default values (see Table C-2).

Recommended Setting : Use as needed.

Table C-8. Keep Parameters

CB	CF	ES	TE	TP
WF	WN	WP	WS	WV

CP – Polled Mode

Purpose: : Allows the unit to be polled for data.

Format : CP*n*

Range : *n* = 0 (OFF), 1 (ON)

Default : CP0

Description : The CP command allows a unit to be polled for data. A complete description of polled mode operation is beyond the scope of this document. If you have a need for polled mode operation, contact RDI for assistance in setting up your deployment.

Recommended Setting: Special applications only.

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

CR – Retrieve Parameters

Purpose : Resets the Workhorse command set to factory settings.

Format : CR*n*

Range : *n* = 0 (USER), 1 (FACTORY)

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

Recommended Setting: Use as needed.

Table C-9. Retrieve Parameters

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

Note : 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 maintains communications with the terminal/computer.

CS – Start Pinging (Go

Purpose : Starts the data collection cycle (same as the TAB key).)

Format : CS

Description : Use CS (or TAB key) to tell the Workhorse 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 waits until it reaches the TF time before beginning the data collection cycle.

Recommended Setting: Use *PLAN* to create the command file. The CS command will be added to the end of the command file.

Notes : 1. After a CS-command is sent to the Workhorse, 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 will *not* start pinging and will return a *RECORDER NOT READY* message.

CZ – Power Down Workhorse

Purpose : Tells the Workhorse to power down.

Format : CZ

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

Recommended Setting: Use as needed.

Example : >CZ

```
[POWERING DOWN .....]
```

Notes : 1. When powered down using the CZ-command, the Workhorse 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 will draw up to 50 milli-amps of current. *A new battery will be discharged in a few days.*

NOTE

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. RDI recommends disconnecting the batteries and using the AC power adapter while testing the ADCP or recovering data.

C-4.3 Environmental Commands

The Workhorse uses the following commands to control the environmental and positional information that affects internal data processing.

EA - Heading Alignment

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

Format : EA±*nnnnn*

Range : ±*nnnnn* = -179.99 to 180.00 degrees

Default : EA00000

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).

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 using *PLAN*.

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* = -179.99 to 180.00 degrees

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.

Recommended Setting: Use EB to counteract the effects of magnetic declination at the deployment site. Set using *PLAN*.

Examples : A bottom-mounted ADCP is receiving heading from its internal compass. A magnetic declination map for the deployment area shows a declination of W3.5° (-3.5°). To counteract the effects of this magnetic field, you must enter a heading bias value of -3.5°. To convert -3.5° to an EB-command value, multiply the desired bias angle in degrees by 100: EB = -3.5 × 100 = -350 = EB-350.

ED - Depth of Transducer

Purpose : Sets the ADCP transducer depth.

Format : ED*nnnnn*

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

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.

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

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.

ES – Salinity

Purpose : Sets the water's salinity value.

Format : ES*nn*

Range : *nn* = 0 to 40 parts per thousand

Default : ES35

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

Recommended Setting: Set using *PLAN*.

EX – Coordinate Transformation

Purpose : Sets the coordinate transformation processing flags.

Format : EX*nnnnn*

Range : Firmware switches (see description)

Default : EX11111

Description : EX sets firmware switches that control the coordinate transformation processing for velocity (Table D-4) and percent-good (Table D-7) data.

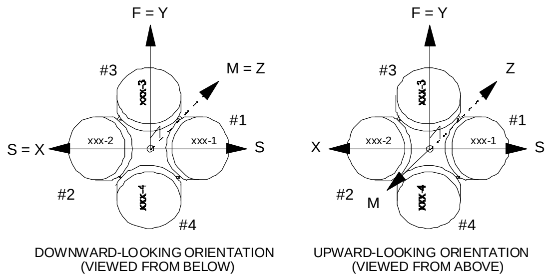
Recommended Setting: This command is added to the command file by *PLAN*.

Table C-10. Coordinate Transformation Processing Flags

Setting	Description
EX00xxx	No transformation. Radial beam coordinates, I.E., 1, 2, 3, 4. Heading/Pitch/Roll not applied.
EX01xxx	Instrument coordinates. X, Y, Z vectors relative to the ADCP. Heading/Pitch/Roll not applied.
EX10xxx	Ship coordinates (Note 1) X, Y, Z vectors relative to the ship. Heading not applied. EA-command used, but not the EB-command. If Bit 3 of the EX-command is a 1, then Pitch/Roll applied.
EX11xxx	Earth coordinates (Note 1) East, North, Vertical vectors relative to Earth. Heading applied. EA and EB-commands used. If Bit 3 of the EX-command is a 1, then Pitch/Roll applied.
EXxx1xx	Use tilts (pitch and roll) in transformation (Note 2)
EXxxx1x	Allows 3-beam solutions if one beam is below the correlation threshold set by WC
EXxxxx1	Allow bin mapping

Notes :

1. For ship and earth-coordinate transformations to work properly, you must set 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 2 (Use Tilts) to 1 lets you collect tilt data without using it in the ship or earth-coordinate transformations.
3. Each Workhorse uses its own beam calibration matrix to correct data for beam pointing errors (e.g., if the beams erroneously point toward 21 deg. instead of 20 deg.). 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. RDI has no software that uses the beam calibration matrix to correct data in a personal computer.



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	+	-

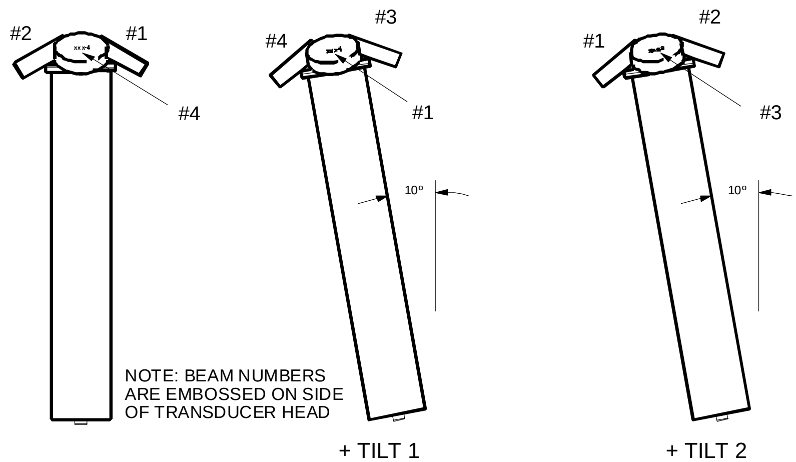


Figure C-1. ADCP Coordinate Transformation

EZ - Sensor Source

Purpose	:	Selects the source of environmental sensor data.
Format	:	EZ*cdhprst*
Default	:	EZ1111111
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.

Recommended Setting: This command is added to the command file by *PLAN*.

Table C-11. Sensor Source Switch Settings

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

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

C-4.4 Fault Log Commands

The Workhorse uses the following commands to aid in troubleshooting and testing.

FC – Clear Fault Log

Purpose : Clears the fault log.

Format : FC

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

Recommended Setting : Use as needed.

FD – Display Fault Log

Purpose : Displays the fault log.

Format : FD

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

Recommended Setting : Use as needed.

Example : >FD

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

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

C-4.5 Performance and Testing Commands

The Workhorse uses the following commands for calibration and testing.

PA – Pre-deployment Tests

Purpose : Sends/displays results of a series of Workhorse system diagnostic tests.

Format : PA

Description : These diagnostic tests check the major Workhorse 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.

Recommended Setting : Use as needed.

Example : >PA

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

PC – User-Interactive Built-In Tests

Purpose : Sends/displays results of user-interactive Workhorse system diagnostic tests.

Format : PC*nnn*

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

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

Recommended Setting : Use as needed.

Examples : See below.

PC0 – Help Menu

Sending PC0 displays the help menu.

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

PC1 – Beam Continuity

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

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

Collecting Statistical Data...
  52  48  50  43

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

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. Any key pressed exits this command and returns the user to the command prompt.

```
Press any keyz 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
```

PS – Display System Parameters

Purpose : Sends/displays Workhorse system configuration data.

Format : PS*n*

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

Recommended Setting : Use as needed.

Description : See below.

PS0 – System Configuration

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

```
>PS0
       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  TEMPERATURE
Temp Sens Offset:  -0.29 degrees C
    CPU Firmware:   8.17 [0]
   Boot Code Ver:  Required:  1.12   Actual:  1.12
    DEMOD #1 Ver:  ad48, Type:  1f
    DEMOD #2 Ver:  ad48, Type:  1f
    PWRTIMG  Ver:  85d3, Type:   6
Board Serial Number Data:
   21  00 00 00 09 99 EE  09 CPU727-2000-00F
   28  00 00 00 09 9F 71  09 PIO727-3000-00C
   63  00 00 00 09 9D CB  09 DSP727-2001-04C
   CD  00 00 00 09 99 5B  09 REC727-1000-04A
```

PS3 – Instrument Transformation Matrix

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

```
>PS3
Beam Width:   1.4 degrees

Beam     Elevation     Azimuth
  1         -60.00      -90.00
  2         -60.00       90.00
  3         -60.00        0.00
  4         -60.00      180.00

Beam Directional Matrix (Downlooking):
     0.5000     0.0000     0.8660     0.0000
    -0.5000     0.0000     0.8660     0.0000
     0.0000    -0.5000     0.8660     0.0000
     0.0000     0.5000     0.8660     0.0000

Instrument Transformation Matrix:
     1.0000    -1.0000     0.0000     0.0000
     0.0000     0.0000    -1.0000     1.0000
     0.2887     0.2887     0.2887     0.2887
     0.7071     0.7071    -0.7071    -0.7071
```

Beam Width and Beam Directional Matrix values always appear as nominal values for the nominal beam angle. If the Workhorse has beam angle errors, they are reflected in the instrument transformation matrix. This matrix, when multiplied by the raw beam data gives currents in the *x*, *y*, *z*, and *e* directions.

C-4.6 Recorder Commands

The following paragraphs list all the Workhorse Sentinel recorder commands. Here is the basic sequence for a deployment using the data recorder.

a. Use the RR-command to display the present list of files stored in the recorder and to check the free space available on the recorder.

b. If necessary (or desired), erase recorder memory (see RE-command).

c. Set up the Sentinel with the desired deployment parameters (*PLAN)*.

d. Make sure *Record data internally* (ADCP) is selected (using *PLAN*) if the Workhorse will not be interfacing through the serial port during deployment.

e. Send the commands to the Workhorse using *DEPLOY.*

f. Deploy the Sentinel.

g. Recover the Sentinel when the deployment is complete.

h. Send a <BREAK> to stop pinging (and data collection).

i. Use *RECOVER* or the RY-command to extract the data from the recorder.

RE – Erase Recorder

Purpose : Erases/initializes recorder memory.

Format : RE ErAsE

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

Recommended Setting : Use as needed.

Example : See below.

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

RF – Recorder Free Space (Bytes)

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

Format : RF

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

Recommended Setting : Use as needed.

Example : See below

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

This shows the Workhorse contains a 10-MB recorder.

RN – Set Deployment Name

Purpose : Sets the deployment name used for future deployments.

Format : RN AAAAA

Default : RN _RDI_

Description : RN sets the deployment name to be used for any future deployments. The deployment name must be exactly five characters in length, and may contain letters, numbers, or the underscore (i.e. "_") character. If no deployment name is specified, a default of "_ RDI_" is used. The deployment name is used as part of the DOS file name for data files stored on the recorder. For example, the file "_RDI_000.000" would contain data for the first deployment named "_RDI_" (the 000 in the filename indicates the first deployment). The ".000" file extension indicates that this is the first file in the deployment sequence. A ".001" extension will be used if the deployment spills over onto the second PCMCIA card in the recorder. Each PCMCIA card is set up as a separate DOS disk drive with its own DOS file structure. Deployments that are recorded completely on a single PCMCIA device will only have the ".000" file extension.

Recommended Setting : This command is set by *DEPLOY* (whice runs *INITADCP*).

RR – Show Recorder File Directory

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

Format : RR

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

Recommended Setting : Use as needed.

RY – Upload Recorder Files

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

Format : RY

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 DOS files. This command may be used to recover deployment data without opening the pressure case of the Workhorse unit. Alternatively, the PCMCIA recorder cards may be removed from the unit and placed into a PCMCIA slot in any MS-DOS based computer so equipped. The data files may then be accessed in the same manner as from any other DOS disk drive.

Recommended Setting : Use as needed or use *RECOVER.*

C-4.7 Timing Commands

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

TE – Time Per Ensemble

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

Format : TE*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

Default : TE01:00:00.00

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

Recommended Setting: Set using *PLAN*.

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

Notes : 1. The Workhorse 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, not the time of output.

TF – Time Of First Ping

Purpose : Sets the time the Workhorse wakes up to start data collection.

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

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

Description : TF delays the start of data collection. This lets you deploy the Workhorse in 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 to start pinging, TF is tested for validity. If valid, the Workhorse sets its alarm clock to TF, goes to sleep, and waits until time TF before beginning the data collection process.

Recommended Setting: Set using *PLAN*.

Example : If you want the <u>exact</u> time of the first ping to be on November 23, 1992 at 1:37:15 pm, you would enter TF92/11/23, 13:37:15. If you want the Workhorse to begin pinging immediately after receiving the CS-command (see notes), do <u>not</u> enter a TF-command value.

Notes : 1. Although you may send a TF-command to the Workhorse, you also must send the CS-command before deploying the Workhorse.

2. If the entry is not valid, the Workhorse sends an error message and does not update the wake-up time.

3. Sending a <BREAK> clears the TF time.

TP – Time Between Pings

Purpose : Sets the *minimum* time between pings.

Format : TP*mm:ss.ff*

Range : *mm* = 00 to 59 minutes
ss = 00 to 59 seconds
ff = 00 to 99 hundredths of seconds

Default : TP01:20.00

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

During the ensemble interval set by TE, the Workhorse transmits the number of pings set by the WP-command. TP determines the spacing between the pings. If TP = 0, the Workhorse 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).

Recommended Setting : Set using *PLAN*.

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

Note : The Workhorse automatically increases TE if WP x TP > TE.

TS – Set Real-Time Clock

Purpose : Sets the Workhorse's internal real-time clock.

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

Range : *yy* = year 00-99
mm = month 01-12
dd = day 01-31
hh = hour 00-23
mm = minute 00-59
ss = second 00-59

Recommended Setting : Use as needed. Verify setting is correct by viewing the deployment LOG file. See "Deployment LOG File", page 2-10.

Example : TS92/11/23, 13:15:00 sets the real-time clock to 1:15:00 pm, November 23, 1992.

Notes : 1. When the Workhorse 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. The internal clock *does* account for leap years.

3. If the entry is not valid, the Workhorse sends an error message and does not update the real-time clock.

C-4.8 Water-Profiling Commands

The following commands define the criteria used to collect the water-profile data.

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

Description : WD 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

Recommended Setting : Leave at default setting.

Example : WD 111 100 000 (default) tells the ADCP to collect velocity, correlation magnitude, echo intensity, and percent-good.

Notes :

1. Each bit can have a value of 1 or 0. 1 means output data, 0 means suppress data.
2. If WP = 0, the ADCP does not collect water-track data.
4. Spaces in the command line are allowed.
5. Status data is not used, as it does not mean anything.

WF – Blank After Transmit

Purpose : Moves the location of first depth cell away from the transducer head to allow the transmit circuits time to recover before the receive cycle begins.

Format : WF*nnnn*

Range : *nnnn* = 0-9999 cm (328 feet)

Default : WF0176 (300kHz), WF0044 (1200kHz)

Description : WF positions the start of the first depth cell at some vertical distance from the transducer head. This allows the Workhorse 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.

Recommended Setting : Set WF ≥ the default value.

Notes : 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.

WN – Number Of Depth Cells

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

Format : WN*nnn*

Range : *nnn* = 001 to 128 depth cells

Default : WN030

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

Recommended Setting: Set using *PLAN*.

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

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

Recommended Setting: Set using *PLAN*.

Notes : 1. If WP = 0 the Workhorse does not collect water-profile data.

2. The Workhorse automatically extends the ensemble interval (TE) if WP x TP > TE.

WS – Depth Cell Size

Purpose : Selects the volume of water for one measurement cell.

Format : WS*nnnn*

Range : *nnnn* = 20 to 800 cm (300kHz), 5 to 400 cm (1200kHz)

Default : WS0400 (300kHz), WS0100 (1200kHz)

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

Recommended Setting: Set by using *PLAN*.

Notes : If you set WS to a value less than its minimum value or greater than its maximum value, the Workhorse will accept the entry, but uses the appropriate minimum or maximum value. For example, if you enter WS1, the Workhorse uses a value of 20 cm for WS. Similarly, if you enter WS5000, the Workhorse uses a value of 800 cm for WS.

WV – Ambiguity Velocity

Purpose : Sets the radial ambiguity velocity.

Format : WV*nnn*

Range : *nnn* = 002 to 480 cm/s

Default : WV175

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 Workhorse speed.

Recommended Setting: Leave at default setting for most applications.

Example : If the maximum expected Workhorse 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.

Appendix

D

Output Data Format

D-1 Introduction

This Appendix shows the format of the Workhorse outputs. Workhorse output data can be in either hexadecimal-ASCII or binary format. You can select this option through the CF-command (Appendix-C). We explain the output data formats in enough detail to let you create your own data processing or analysis programs.

> **NOTE**
>
> *This appendix applies to Workhorse firmware version 8.20 or lower. When new firmware versions are released, some output data formats may be modified or added. Read the README file on the upgrade disk, check RDI's web site, or read the "Read Me First" booklet for the latest changes.*

D-2 Output Data Format

The following description is for the standard Workhorse output data format. Figures D-1 through D-10 shows the ASCII and binary data formats for the Workhorse mode. Tables D-1 through D-9 define each field in the output data structure.

After completing a data collection cycle, the Workhorse sends a data ensemble immediately. The following pages show the types and sequence of data that you may include in the Workhorse output data ensemble and the number of bytes required for each data type. The Workhorse sends all the data for a given type for all depth cells and all beams before the next data type begins.

D-3 Hexadecimal-ASCII Output Data

Use the hexadecimal-ASCII (HexAscii) format when you are viewing raw Workhorse data on a computer/dumb terminal. This format uses the standard ASCII codes for Ø 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 HexAscii mode, the Workhorse sends data in one line of ASCII characters. There are no carriage returns and/or line feed sequences (CR/LF) sent from the ADCP.

Figure D-1 shows the HexAscii data format for one ensemble, and how it looks on a CRT display. The CRT provides a CR/LF after 60 characters. The Workhorse by default is set to collect velocity, correlation data, echo intensity, and percent good data.

The data, preceded by ID code 7F7F, contains header data (explained in Table 1). The fixed and variable leader data is preceded by ID codes 0000 and 8000, (explained in Tables D-2 and D-3). The Workhorse always collects Header and Leader.

The remaining lines include velocity (ID Code: 0001), correlation magnitude (0002), echo intensity (0003), and percent-good (0004). The final field is a data-validity checksum. Tables D-4 through D-9 define these fields. Figure D-2 shows the format of the HexAscii output data for the sample data in Figure D-1. For the example shown in Figures D-1 and D-2, we collected data for five depth cells.

NOTE

Internally, the Workhorse stores data in binary format. At data transfer, the Workhorse converts the data to hexadecimal-ASCII when requested by the user.

D-4 Workhorse Binary Output Data Format

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

The Workhorse binary output data buffer contains header data, leader data, velocity, correlation magnitude, echo intensity, percent good, and a checksum. The Workhorse collects all data in the output buffer during an ensemble. Figure D-3 shows the format of this buffer and the sequence in which the Workhorse sends it. Figures D-4 through D-10 show the format of the individual items that make up the binary output buffer. Tables D-1 through D-9 list the format, bytes, fields, scaling factors, and a detailed description of every item in the binary output buffer.

```
7F7F2E001000A1A00560080009600AC00C200D80018012A012C00000011E0302000004140100640096 0001
00FF19881300000000000000000001F90064000005320008000102030405060708800001005C03020B2807
29000000FE0500000000000000002300C40900000000000000000000000000000101010110101010101010
10101000010101010201030104020102020203020403010302030303040401040204030404050105020503
050400020102030405060708090A0B0C0D0E0F10111213140003020304050607080 90A0B0C0D0E0F101112
131415000404050607080 90A0B0C0D0E0F10111213141516171234D522
```

Figure D-1. HexAscii PD0 Output Data Format (CRT Display)

NOTE

The values listed here are simulated data for one ensemble with five depth cells. Figure D-2 shows a detailed view of the data format.

<table>
<tr><td>Header Data
Table D-1</td><td>HDR Spare, No. +))))) Address Offsets for Data Types)))))),…
ID   Bytes* DT #1   #2   #3   #4   #5   #6   #7   #8   #9 #10
+)), +)),+,+, +)), +)), +)), +)), +)), +)), +)), +)), +)), +)),…
7F7F 2E001000 A1A0 0560 0800 0960 0AC0 0C20 0D80 0180 12A0 12C0…</td></tr>
<tr><td>Fixed and Variable Leader Data Tables D-2 & 3</td><td>   fr sys Spare WN   WM   WG   TP   EX   sa
FID fv | cfg PD |#bm| WP   WS   WF | WC #cr| WE mmsshh | EA EB EZ | dis1
+)), +, +, +)),+, +,+,+, +)), +)), +)), +,+, +,+,+)),+)))), +, +)),+)),+,+,+)),
0000 01 1E 030200 000414 0100 6400 9600 0100 FF198813000000 00 000000000001F900
WT WL   WA s LagD   CPU SERIAL NUMBER
+)),+)),+,+,+)),   +)))))))))))))),
6400000532000800   0102030405060708
         Recording Time ENS#MSB   StdDev
ID ENS yymmddhhmmss hh | BIT EC   ED EH EP ER   ES ET   MPT H P R
+)), +)),+))))))))))))), +, +)), +)), +)), +)),+)),+)),+)),+)),+)))))),+,+,+,
8000 0100 5C03020B2807   29 0000 00FE 0500 000000000000002300C409000000000000
ADC channels   Error   Pressure Sensor
0 1 2 3 4 5 6 7   Status Word   Spare   Average   Standard Dev.
+,+,+,+,+,+,+,+,   +)))))),   +)),   +)))))), +)))))),
0000000000000000   01010101   1010   10101010 10101010</td></tr>
<tr><td>Velocity Data
Table D-4</td><td>VEL   + Depth Cell #1 ,   + Depth Cell #2 ,   + Depth Cell #3 ,
ID   1   2   3   4   1   2   3   4   1   2   3   4
+)),   +)), +)), +)), +)),   +)), +)), +)), +)),   +)), +)), +)), +)),
0001   0101 0102 0103 0104   0201 0202 0203 0204   0301 0302 0303 0304
+ Depth Cell #4 ,   + Depth Cell #5 ,…
 1   2   3   4   1   2   3   4
+)), +)), +)), +)),   +)),+)),+)),+)),…
0401 0402 0403 0404   0501050205030504…</td></tr>
<tr><td>Correlation Magnitude Table D-5</td><td> CM   +Cell#1, +Cell#2, +Cell#3, +Cell#4, +Cell#5,…
 ID   1 2 3 4   1 2 3 4   1 2 3 4   1 2 3 4   1 2 3 4
+)),   +,+,+,+, +,+,+,+, +,+,+,+, +,+,+,+, +,+,+,+,…
0002   01020304 05060708 090A0B0C 0D0E0F10 11121314…</td></tr>
<tr><td>Echo Intensity
Table D-6</td><td>EI +Cell#1, +Cell#2, +Cell#3, +Cell#4, +Cell#5,…
ID 1 2 3 4   1 2 3 4   1 2 3 4   1 2 3 4   1 2 3 4
+)), +,+,+,+, +,+,+,+, +,+,+,+, +,+,+,+, +,+,+,+,…
0003 02030405 06070809 0A0B0C0D 0E0F1011 12131415…</td></tr>
<tr><td>Percent-Good
Data Table D-7</td><td> %GD +Cell#1, +Cell#2, +Cell#3, +Cell#4, +Cell#5,…
  ID   1 2 3 4   1 2 3 4   1 2 3 4   1 2 3 4   1 2 3 4
 +)), +,+,+,+, +,+,+,+, +,+,+,+, +,+,+,+, +,+,+,+,…
 0004 04050607 08090A0B 0C0D0E0F 10111213 14151617…</td></tr>
<tr><td>Reserved
Table D-8</td><td>1234</td></tr>
<tr><td>Checksum
Table D-9</td><td>D522</td></tr>
</table>

Figure D-2. HexAscii Standard Output Data Format

ALWAYS OUTPUT	HEADER (6 BYTES + [2 x No. OF DATA TYPES])	FIG. D-4 TAB. D-1
	FIXED LEADER DATA (50 BYTES)	FIG. D-5 TAB. D-2
	VARIABLE LEADER DATA (56 BYTES)	FIG. D-6 TAB. D-3
WD-command WP-command	VELOCITY (2 BYTES + 8 BYTES PER DEPTH CELL)	FIG. D-7 TAB. D-4
	CORRELATION MAGNITUDE (2 BYTES + 4 BYTES PER DEPTH CELL)	FIG. D-8 TAB. D-5
	ECHO INTENSITY (2 BYTES + 4 BYTES PER DEPTH CELL)	FIG. D-8 TAB. D-6
	PERCENT GOOD (2 BYTES + 4 BYTES PER DEPTH CELL)	FIG. D-8 TAB. D-7
ALWAYS OUTPUT	RESERVED (2 BYTES)	FIG. D-9 TAB. D-8
	CHECKSUM (2 BYTES)	FIG. D-10 TAB. D-9

Figure D-3. Binary Standard Output Data Buffer Format

NOTE: Some data outputs are in bytes per depth cell. For example, if the WN-command (number of depth cells) = 23, and the following data are selected for output, the required data buffer storage space is 596 bytes per ensemble:

```
WD-COMMAND =WD 111 100 000 (default)
WP-COMMAND> 0
 18 BYTES OF HEADER DATA (6+[2x No. Of Data Types])
 50 BYTES OF FIX. LEADER DATA (FIXED)
 56 BYTES OF VAR. LEADER DATA (FIXED)
186 BYTES OF VELOCITY DATA (2+8x23)
 94 BYTES OF CORRELATION MAGNITUDE DATA (2+4x23)
 94 BYTES OF ECHO INTENSITY (2+4x23)
 94 BYTES OF PERCENT-GOOD DATA (2+4x23)
  2 BYTES OF RESERVED FOR RDI USE (FIXED)
  2 BYTES OF CHECKSUM DATA (FIXED)
596 BYTES OF DATA PER ENSEMBLE
```

BIT POSITIONS

BYTE	7 6 5 4 3 2 1 0	
1	HEADER ID (7Fh)	
2	DATA SOURCE ID (7Fh)	
3	NUMBER OF BYTES IN ENSEMBLE	LSB
4		MSB
5	SPARE	
6	NUMBER OF DATA TYPES	
7	OFFSET FOR DATA TYPE #1	LSB
8		MSB
9	OFFSET FOR DATA TYPE #2	LSB
10		MSB
11	OFFSET FOR DATA TYPE #3	LSB
12		MSB
⋮	(SEQUENCE CONTINUES FOR UP TO N DATA TYPES)	⋮
2N+5	OFFSET FOR DATA TYPE #N	LSB
2N+6		MSB

SEE TABLE D-1 FOR DESCRIPTION OF FIELDS

Figure D-4. Binary Header Data Format

NOTE

This data is always output in this format.

BIT POSITIONS

BYTE	7 6 5 4 3 2 1 0	
1	FIXED LEADER ID 00h	LSB
2	00h	MSB
3	CPU F/W VER.	
4	CPU F/W REV.	
5	SYSTEM CONFIGURATION	LSB
6		MSB
7	REAL/SIM FLAG	
8	SPARE	
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	COORD TRANSFORM {EX}	

BIT POSITIONS

BYTE	7 6 5 4 3 2 1 0	
27	HEADING ALIGNMENT {EA}	LSB
28		MSB
29	HEADING BIAS {EB}	LSB
30		MSB
31	SENSOR SOURCE {EZ}	
32	SENSORS AVAIL	
33	BIN 1 DISTANCE	
34		
35	XMIT PULSE LENGTH BASED ON {WT}	LSB
36		MSB
37	(starting cell) WP REF LAYER	LSB
38	AVERAGE {WL} (ending cell)	MSB
39	FALSE TARGET THRESH {WA}	
40	SPARE	
41	TRANSMIT LAG DISTANCE	LSB
42		MSB
43	CPU BOARD SERIAL NUMBER	LSB
44		
45		
46		
47		
48		
49		
50		MSB

SEE TABLE D-2 FOR DESCRIPTION OF FIELDS

Figure D-5. Binary Fixed Leader Data Format

NOTE

This data is always output in this format.

BYTE	FIELD (BIT POSITIONS 7–0)		BYTE	FIELD (BIT POSITIONS 7–0)	
1	VARIABLE LEADER ID 80h	LSB	29	MPT MINUTES	
2	VARIABLE LEADER ID 00h	MSB	30	MPT SECONDS	
3	ENSEMBLE NUMBER	LSB	31	MPT HUNDREDTHS	
4	ENSEMBLE NUMBER	MSB	32	HDG STD DEV	
5	RTC YEAR	1st SET BY {TS}	33	PITCH STD DEV	
6	RTC MONTH		34	ROLL STD DEV	
7	RTC DAY		35	ADC CHANNEL 0	
8	RTC HOUR		36	ADC CHANNEL 1	
9	RTC MINUTE		37	ADC CHANNEL 2	
10	RTC SECOND		38	ADC CHANNEL 3	
11	RTC HUNDREDTHS		39	ADC CHANNEL 4	
12	ENSEMBLE # MSB		40	ADC CHANNEL 5	
13	BIT RESULT	LSB	41	ADC CHANNEL 6	
14	BIT RESULT	MSB	42	ADC CHANNEL 7	
15	SPEED OF SOUND {EC}	LSB	43	ERROR STATUS WORD (ESW) {CY?}	LSB
16	SPEED OF SOUND {EC}	MSB	44	ERROR STATUS WORD (ESW) {CY?}	
17	DEPTH OF TRANSDUCER {ED}	LSB	45	ERROR STATUS WORD (ESW) {CY?}	
18	DEPTH OF TRANSDUCER {ED}	MSB	46	ERROR STATUS WORD (ESW) {CY?}	MSB
19	HEADING {EH}	LSB	47	SPARE	
20	HEADING {EH}	MSB	48	RESERVED FOR RDI USE	
21	PITCH (TILT 1) {EP}	LSB	49	PRESSURE	LSB
22	PITCH (TILT 1) {EP}	MSB	50	PRESSURE	
23	ROLL (TILT 2) {ER}	LSB	51	PRESSURE	
24	ROLL (TILT 2) {ER}	MSB	52	PRESSURE	MSB
25	SALINITY {ES}	LSB	53	PRESSURE VARIANCE	LSB
26	SALINITY {ES}	MSB	54	PRESSURE VARIANCE	
27	TEMPERATURE {ET}	LSB	55	PRESSURE VARIANCE	
28	TEMPERATURE {ET}	MSB	56	PRESSURE VARIANCE	MSB

SEE TABLE 3 FOR DESCRIPTION OF FIELDS

Figure D-6. Binary Variable Leader Data Format

NOTE

This data is always output in this format.

BIT POSITIONS

BYTE	7/S	6	5	4	3	2	1	0	
1	VELOCITY ID							00h	LSB
2								01h	MSB
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 D-4 FOR DESCRIPTION OF FIELDS

Figure D-7. Binary Velocity Data Format

NOTE

The number of depth cells is set by the WN-command. See the WN-command Appendix-C.

BIT POSITIONS

BYTE	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 TABLES 5, 6, AND 7 FOR DESCRIPTION OF FIELDS

Figure D-8. Binary Correlation Magnitude, Echo Intensity, and Percent-Good Data Format

NOTE

The number of depth cells is set by the WN-command. See the WN-command Appendix-C.

BIT POSITIONS

BYTE	7	6	5	4	3	2	1	0	
1	RESERVED FOR RDI USE								LSB
2									MSB

SEE TABLE D-8 FOR DESCRIPTION OF FIELDS

Figure D-9. Workhorse Binary Reserved BIT Use

NOTE

The data is always output in this format.

BIT POSITIONS

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

SEE TABLE D-9 FOR DESCRIPTION OF FIELDS

Figure D-10. Workhorse Binary Checksum Data Format

NOTE

The data is always output in this format.

Table D-1. Workhorse Header Data Format

Hex Digit	Binary Byte	Field	Description
			GENERAL) Header information is the first item sent by the Workhorse to the output buffer. HexAscii users refer to Figures D-1 and D-2. Binary users refer to Figures D-3 and D-4. The Workhorse always sends the Least Significant Byte (LSB) first.
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).
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 D-9, Table D-10).
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 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 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 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).

Table D-2. Workhorse Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
			GENERAL) Fixed Leader data refers to the nondynamic Workhorse data that only changes when you change certain commands. Fixed Leader data also contain hardware information. The Workhorse always sends Fixed Leader data as output data (LSBs first). HexAscii users refer to Figures D-1 and D-2. Binary users refer to Figures D-3 and D-5. Appendix-C has detailed description of commands used to set these values.
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 hardware configuration. Convert this field (2 bytes, LSB first) to binary and interpret as follows.
			`LSB`
			`BITS  7 6 5 4 3 2 1 0`
			`      - - - - - 0 0 0   75-kHz SYSTEM`
			`      - - - - - 0 0 1   150-kHz SYSTEM`
			`      - - - - - 0 1 0   300-kHz SYSTEM`
			`      - - - - - 0 1 1   600-kHz SYSTEM`
			`      - - - - - 1 0 0  1200-kHz SYSTEM`
			`      - - - - - 1 0 1  2400-kHz SYSTEM`
			`      - - - - 0 - - -  CONCAVE BEAM PAT.`
			`      - - - - 1 - - -  CONVEX BEAM PAT.`
			`      - - 0 0 - - - -  SENSOR CONFIG #1`
			`      - - 0 1 - - - -  SENSOR CONFIG #2`
			`      - - 1 0 - - - -  SENSOR CONFIG #3`
			`      - 0 - - - - - -  XDCR HD NOT ATT.`
			`      - 1 - - - - - -  XDCR HD ATTACHED`
			`      0 - - - - - - -  DOWN FACING BEAM`
			`      1 - - - - - - -  UP-FACING BEAM`
			
			`MSB`
			`BITS  7 6 5 4 3 2 1 0`
			`      - - - - - - 0 0  15E BEAM ANGLE`
			`      - - - - - - 0 1  20E BEAM ANGLE`
			`      - - - - - - 1 0  30E BEAM ANGLE`
			`      - - - - - - 1 1  OTHER BEAM ANGLE`
			`      0 1 0 0 - - - -  4-BEAM JANUS CONFIG`
			`      0 1 0 1 - - - -  5-BM JANUS CFIG DEMOD)`
			`      1 1 1 1 - - - -  5-BM JANUS CFIG.(2 DEMD)`
			Example: Hex 5249 (i.e., hex 49 followed by hex 52) identifies a 150-kHz system, convex beam pattern, down-facing, 30E beam angle, 5 beams (3 demods).

13,14	7	PD / Real/Sim Flag	This field is set by default as real data (0).
15,16	8	Spare	Undefined.

Hex Digit	Binary Byte	Field	Description
17,18	9	#Bm / Number of Beams	Contains the number of beams used to calculate velocity data (not physical beams). The Workhorse 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 does not make this validity check. Table D-7 (Percent-Good Data Format) has more information.
19,20	10	WN / Number of Cells	Contains the number of depth cells over which the Workhorse collects data (WN-command). *Scaling:* LSD = 1 depth cell; Range = 1 to 128 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 does not collect the WD water-profile data. Note: The Workhorse automatically extends the ensemble interval (TE) if the product of WP and time per ping (TP) is greater than TE (i.e., if WP $\times$ TP > TE). *Scaling:* LSD = 1 ping; Range = 0 to 16,384 pings
25-28	13,14	WS / Depth Cell Length	Contains the length of one depth cell (WS-command). Scaling: LSD = 1 centimeter; Range = 1 to 6400 cm (210 feet)
29-32	15,16	WF / Blank after Transmit	Contains the blanking distance used by the Workhorse 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	Singal 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 (WG-command). *Scaling:* LSD = 1 percent; Range = 1 to 100 percent

Hex Digit	Binary Byte	Field	Description
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 flags all four beams of the affected bin as *bad*. *Scaling:* LSD = 1 mm/s; Range = 0 to 5000 mm/s
45,46	23	Minutes	These fields, set by the TP-command, contain the amount of time between ping groups in the ensemble. NOTE: The Workhorse automatically extends the ensemble interval (set by TE) if (WP x TP > TE).
47,48	24	Seconds	
49,50	25	Hundredths	

51,52	26	EX / Coord Transform	Contains the coordinate transformation processing parameters (EX-command). These firmware switches indicate how the Workhorse 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

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 uses the manual command setting. If the field = 1, the Workhorse 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 only displays a 0 (manual) or 1 (int/ext sensor).

63,64	32	sa / Sensors Avail	This field reflects what sensors are available as determined by the Transducer Controller board. The bit pattern is the same as listed for the EZ-command (above), except that the EC bit is always zero because there is no speed of sound sensor.
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 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 uses an 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

Hex Digit	Binary Byte	Field	Description
77,78	39	WA / False Tgt Thresh	Contains the threshold value used to reject data received from a false target, usually fish (WA-command; see appendix C and F). *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.

Table D-3. Workhorse Variable Leader Data Format

<table>
<tr><th>Hex Digit</th><th>Binary Byte</th><th>Field</th><th>Description</th></tr>
<tr><td></td><td></td><td></td><td>GENERAL) Variable Leader data refers to the dynamic Workhorse data (from clocks/sensors) that change with each ping. The Workhorse always sends Variable Leader data as output data (LSBs first). HexAscii users refer to Figures D-1 and D-2. Binary users refer to Figures D-3 and D-6. Appendix-C has detailed description of commands used to set these values.</td></tr>
<tr><td>1-4</td><td>1,2</td><td>VID / Variable Leader ID</td><td>Stores the Variable Leader identification word (80 00h).</td></tr>
<tr><td>5-8</td><td>3,4</td><td>Ens / Ensemble Number</td><td>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:
<code>1 = ENSEMBLE NUMBER 1</code>
<code>⋮</code>
<code>65535 = ENSEMBLE NUMBER 65,535 Ú ENSEMBLE</code>
<code>0 = ENSEMBLE NUMBER 65,536 | #MSB FIELD</code>
<code>1 = ENSEMBLE NUMBER 65,537 À (BYTE 12) INCR.</code></td></tr>
<tr><td>9,10
11,12
13,14
15,16
17,18
19,22
21,22</td><td>5
6
7
8
9
10
11</td><td>RTC Year
RTC Month
RTC Day
RTC Hour
RTC Minute
RTC Second
RTC Hundredths</td><td>These fields contain the time from the Workhorse's real-time clock (RTC) that the current data ensemble began. The TS-command (Set Real-Time Clock) initially sets the clock. The Workhorse <u>does</u> account for leap years.</td></tr>
<tr><td>23-24</td><td>12</td><td>Ensemble # MSB</td><td>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.</td></tr>
<tr><td>25-28</td><td>13,14</td><td>BIT / BIT Result</td><td>This field contains the results of the Workhorse's Built-in Test function. A zero code indicates a successful BIT result.
<code><u>BYTE 13   BYTE 14 </u> (BYTE 14 RESERVED FOR FUTURE USE)</code>
<code>1xxxxxxx xxxxxxxx = RESERVED</code>
<code>x1xxxxxx xxxxxxxx = RESERVED</code>
<code>xx1xxxxx xxxxxxxx = RESERVED</code>
<code>xxx1xxxx xxxxxxxx = DEMOD 1 ERROR</code>
<code>xxxx1xxx xxxxxxxx = DEMOD 0 ERROR</code>
<code>xxxxx1xx xxxxxxxx = RESERVED</code>
<code>xxxxxx1x xxxxxxxx = TIMING CARD ERROR</code>
<code>xxxxxxx1 xxxxxxxx = RESERVED</code></td></tr>
<tr><td>29-32</td><td>15,16</td><td>EC / Speed of Sound</td><td>Contains either manual or calculated speed of sound information (EC-command).

Scaling: LSD = 1 meter per second; Range = 1400 to 1600 m/s</td></tr>
</table>

Hex Digit	Binary Byte	Field	Description
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 pressure sensor. *Scaling:* LSD = 1 decimeter; Range = 1 to 9999 decimeters
37-40	19,20	EH / Heading	Contains the Workhorse 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 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 roll angle (ER-command). This value may be a manual setting or a reading from a tilt sensor. For up-facing Workhorses, positive values mean that Beam #2 is spatially higher than Beam #1. For down-facing Workhorses, positive values mean that Beam #1 is spatially higher than Beam #2. *Scaling:* LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
49-52	25,26	ES / Salinity	Contains the salinity value of the water at the transducer head (ES-command). This value may be a manual setting or a reading from a conductivity sensor. *Scaling:* LSD = 1 part per thousand; Range = 0 to 40 ppt
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°

Hex Digit	Binary Byte	Field	Description

69-70	35	ADC Channel 0	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, then:
			`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, 8, 2, 3`
			`⋮                       ⋮`
			Here is the description factor 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.

71-72	36	ADC Channel 1	
73-74	37	ADC Channel 2	
75-76	38	ADC Channel 3	
77-78	39	ADC Channel 4	
79-80	40	ADC Channel 5	
81-82	41	ADC Channel 6	
83-84	42	ADC Channel 7	

85-86	43	Error Status Word	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), then it indicates that <u>both</u> 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`
			`     x  x  x  x  x  x  1  x  Address Error`
			`     x  x  x  x  x  1  x  x  Illegal Instruction`
			`     x  x  x  x  1  x  x  x  Divide by Zero`
			`     x  x  x  1  x  x  x  x  Emulator`
			`     x  x  1  x  x  x  x  x  Unassigned`
			`     x  1  x  x  x  x  x  x  Not Used`
			`     1  x  x  x  x  x  x  x  Not Used`

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 1 x x x x x x x Unknown Wakeup
89-90	45		High 16 BITS LSB BITS 24 23 22 21 20 19 18 17 x x x x x x x 1 Clock Read Error 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 Not Used 1 x x x x x x x Not Used
91-92	46		High 16 BITS MSB BITS 32 31 30 29 28 27 26 25 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 Not Used x x x 1 x x x x Not Used x x 1 x x x x x Spurious UART IRQ x 1 x x x x x x Spurious CLOCK IRQ 1 x x x x x x x Power Failure
93-96	47-48	Reserved	Reserved for RDI use.
97-104	49-52	Pressure	Contains the pressure of the water at the transducer head relative to one atmosphere (sea level). Output is in deca-pascals. Scaling: LSD = 1 pascal; Range = 0 to 4,294,967,295 deca-pascals
105-112	53-56	Pressure variance	Contains the variance (deviation about the mean) of the pressure sensor data. Output is in deca-pascals. Scaling:LSD = 1 pascal; Range = 0 to 4,294,967,295 deca-pascals

Table D-4. Workhorse Velocity Data Format

<table>
<tr><th>Hex Digit</th><th>Binary Byte</th><th>Field</th><th>Description</th></tr>
<tr><td></td><td></td><td></td><td>

GENERAL) HexAscii users refer to Figures D-1 and D-2. Binary users refer to Figures D-3 and D-7. The Workhorse 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 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,

<pre>
RELATIVE WATER CURRENT VELOCITY: EAST 650 mm/s
INSTRUMENT VELOCITY   : (-) EAST 600 mm/s
ABSOLUTE WATER VELOCITY   :   EAST 50 mm/s
</pre>

The setting of the EX-command (Coordinate Transformation) determines how the Workhorse references the velocity data as shown below.

<table>
<tr><th>EX-CMD</th><th>COORD SYS</th><th>VEL 1</th><th>VEL 2</th><th>VEL 3</th><th>VEL 4</th></tr>
<tr><td>xxx00xxx</td><td>BEAM</td><td>TO BM 1</td><td>TO BEAM 2</td><td>TO BEAM 3</td><td>TO BM 4</td></tr>
<tr><td>xxx01xxx</td><td>INST</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>PRT-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

</td></tr>
<tr><td>1-4</td><td>1,2</td><td>Velocity ID</td><td>Stores the velocity data identification word (00 01h).</td></tr>
<tr><td>5-8</td><td>3,4</td><td>Depth Cell 1, Velocity 1</td><td>Stores velocity data for depth cell #1, velocity 1. See above.</td></tr>
<tr><td>9-12</td><td>5,6</td><td>Depth Cell 1, Velocity 2</td><td>Stores velocity data for depth cell #1, velocity 2. See above.</td></tr>
<tr><td>13-16</td><td>7,8</td><td>Depth Cell 1, Velocity 3</td><td>Stores velocity data for depth cell #1, velocity 3. See above.</td></tr>
<tr><td>17-20</td><td>9,10</td><td>Depth Cell 1, Velocity 4</td><td>Stores velocity data for depth cell #1, velocity 4. See above.</td></tr>
<tr><td>21-2052</td><td>11-1026</td><td>Cells 2 - 128 (if used)</td><td>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.</td></tr>
</table>

Table D-5. Workhorse Correlation Magnitude Data Format

Hex Digit	Binary Byte	Field	Description
			GENERAL) HexAscii users refer to Figures D-1 and D-2. Binary users refer to Figures D-3 and D-8. Correlation magnitude data give the magnitude of the normalized echo autocorrelation at the lag used for estimating the Doppler phase change. The Workhorse 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.
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.

Table D-6. Workhorse Echo Intensity Data Format

Hex Digit	Binary Byte	Field	Description
			GENERAL) HexAscii users refer to Figures D-1 and D-2. Binary users refer to Figures D-3 and D-8. The echo intensity scale factor is about 0.45 dB per Workhorse count. The Workhorse does not directly check for the validity of echo intensity data.
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.

Table D-7. Workhorse Percent-Good Data Format

Hex Digit	Binary Byte	Field	Description
			GENERAL) HexAscii users refer to Figures D-1 and D-2. Binary users refer to Figures D-3 and D-8. The percent-good data field is a data-quality indicator that reports the percentage (0-100) of *good* data collected for each depth cell of the velocity profile. The setting of the EX-command (Coordinate Transformation) determines how the Workhorse references percent-good data as shown below.

```
EX-CMD   |COORD| VEL 1    | VEL 2     |  VEL 3   |  VEL 4  |
         | SYS |          |           |          |         |
         |     |        PERCENTAGE OF GOOD PINGS FOR:
xxx00xxx |BEAM |BEAM 1    |BEAM 2     |BEAM 3    |BEAM 4   |
         |     |              PERCENTAGE OF:
xxx01xxx |INST |3-BEAM    |TRANSFORM- |MORE THAN |4-BEAM
xxx10xxx |SHIP |TRANSFORM-|ATIONS     |ONE BEAM  |TRANSFORM-
xxx11xxx |EARTH|ATIONS[1] |REJECTED[2]|BAD IN BIN|ATIONS   |
```

1. Because profile data did not exceed correlation threshold (WC).

2. Because the error velocity threshold (WE) was exceeded.

At the start of the velocity profile, the backscatter echo strength is typically high on all four beams. Under this condition, the Workhorse 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 Workhorse to reject some of its depth cell data. This causes the Workhorse to calculate velocities with three beams instead of four beams. When the Workhorse does 3-beam solutions, it stops calculating the error velocity because it needs four beams to do this. At some further depth cell, the Workhorse 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 not typical nor desired percentages. Typically, you would want all four beams to be about equal and greater than 25%.

Hex Digit	Binary Byte	Field	Description
			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 (45%) using 3-beam solutions because the correlation threshold (WC) was not exceeded. FIELD 2) Percentage of transformations rejected - Shows percent of error velocity (0%) that was less than the WE-command setting. WE has a default of 5000 mm/s. This large WE setting effectively prevents the Workhorse from rejecting data based on error velocity. FIELD 3) Percentage of more than one beam bad in bin – 5% of the velocity data were rejected because not enough beams had good data. FIELD 4) Percentage of good 4-beam solutions - 50% of the velocity data collected during the ensemble for depth cell 60 were calculated using four beams.
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.

Table D-8. Workhorse Reserved for RDI Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Reserved for RDI's use	HexAscii users refer to Figures D-1 and D-2. Binary users refer to Figures D-3 and D-9. This field is for RDI (internal use only).

Table D-9. Workhorse Checksum Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Checksum Data	HexAscii users refer to Figures D-1 and D-2. Binary users refer to Figures D-3 and D-10. This field contains a modulo 65536 checksum. The Workhorse computes the checksum by summing all the bytes in the output buffer excluding the checksum.

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