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# **ADP<sup>TM</sup> (Acoustic Doppler Profiler)**

## **Operation Manual**

### **Firmware Version 7.1**

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## WARRANTY, TERMS AND CONDITIONS

Thank you for purchasing a SonTek Acoustic Doppler Velocity sensor. The instrument was thoroughly tested at the factory and found to be in excellent working condition. If the shipping crate appears damaged or if the system is not operating properly, please contact SonTek immediately.

The System you have purchased is covered under a one year limited warranty that extends to all parts and labor for any malfunction due to workmanship or errors in the manufacturing process. The warranty does not cover shortcomings that are due to the design, nor does it cover any form of incidental damage as a result of errors in the measurements.

In case your System is not functioning properly, first try to identify the source of the problem (refer to the appropriate section of the manual for a trouble shooting advice). If additional support is required, we encourage you to contact us immediately if a problem is detected and we will work to resolve the problem as quickly as possible. Most problems can be resolved without a system being returned to us.

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# INTRODUCTION

This manual is organized into the following sections:

- **Section 1. ADP Components, Terminology, and Sampling** - naming conventions and terms used in this manual, and a general description of ADP sampling strategies.
- **Section 2. Getting Started** – general instructions for collecting data with the ADP in the most common configurations.
- **Section 3. Direct Command Interface for the ADP** - direct communication with the ADP, including command format, options and output data format.
- **Section 4. Compass/Tilt Sensor Operation** - concerns and procedures relating to the internal compass and tilt sensor.
- **Section 5. ADP Hardware** – description of the ADP electronics, cables, connectors, internal jumpers/switches, and instructions for accessing system components.
- **Section 6. Operational Considerations** - concerns and procedures relating to power supply, instrument mounting, coordinate systems, external sensors, maintenance and troubleshooting.
- **Section 7. Autonomous Deployment** – instructions for initiating an autonomous deployment.
- **Section 8. ADP Optional Features**– describes ADP optional wave package SONWAVE, bottom track and external sensors.
- **Section 9. Additional Support** – contact information for additional customer support.
- **Appendix A ADP Binary Data File Format** – a detailed description of the ADP binary data file format.
- **Appendix B PC-ADP Settings and Operational Considerations** – a description of operational differences between the standard ADP and a pulse-coherent ADP.
- **Appendix C L-ADP Settings and Operational Considerations** – a description of operational differences between the standard ADP and a Lowered-ADP system.

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## SECTION 1. ADP Components, Terminology and Sampling

### 1.1. ADP Components

The ADP includes a number of different components, the exact nature of which vary with instrument configuration. The list below gives a brief description of all major system components and their function.

- ADP sensor - The sensor consists of two or three acoustic transducers (for 2D or 3D profiling) and receiver electronics. The transducers are mounted in an aluminum head that is anodized and polyester powder coated. The head is mounted to the ADP housing the size of which varies with system configuration; the housing is anodized, polyester power coated, and includes zinc anodes for corrosion protection. The compass/tilt sensor is mounted inside the sensor housing.
- ADP processor - The ADP processor can be packaged two ways: in a splash-proof (non-submersible) housing (“Low Profile ADP”) or in the same underwater housing as the ADP sensor (“Stand-alone ADP”). The electronics consist of three printed circuit (PC) boards with an optional fourth board for internal recording. The processor sends and receives signals from the ADP sensor, performs Doppler calculations to compute the velocity profile, controls the operation of all other sensors, and outputs the data over the serial port and to the internal recorder.
- High-frequency cable - This cable, used with the Low Profile ADP only, carries analog signals between the ADP sensor and processor. Because of the nature of the analog signals, the cable has a maximum length of 60 m. This is a custom shielded cable designed specifically for this application and should not be modified by the user.
- Power and communication cable - This cable carries DC input power (12-24 V) and 2-way serial communication between the ADP processor and the controlling computer. The ADP supports RS232 serial communication for cable lengths to 100 m (300 ft) and RS422 for cable lengths 1500 m (4500 ft).
- Splitter cable - This cable connects the Stand-alone ADP to an external battery back for autonomous operation. The cable has one connector to the ADP, one to the battery pack, and a third to the power and communication cable (sealed with a dummy plug during deployment).
- Temperature sensor - The temperature sensor, standard on all ADPs, is mounted internally in the ADP sensor housing. Temperature data automatically compensate for changes in sound speed; sound speed converts Doppler shift to water velocity. See section 6.5 for more details on the temperature sensor.
- Compass/tilt sensor - This optional sensor measures magnetic heading and 2-axis tilt (maximum tilt  $\pm 50^\circ$ ); it is mounted in the same underwater housing as the ADP sensor. This allows the ADP to report velocity measurements in Earth (East - North - Up) coordinates. The compass includes a built-in calibration feature to compensate for ambient magnetic fields (see section 4.4). See SECTION 4 for more details on the compass/tilt sensor.
- Pressure sensor - The optional pressure sensor is mounted in the ADP sensor head between the acoustic transducers. A small signal processing board for the pressure sensor is installed near the receiver board. See section 6.5 for more details on the pressure sensor.

- Battery power - The ADP can include battery power for autonomous deployment or to act as a backup in the event of shore power failure. The batteries can be housed in an external canister connected by a splitter cable, or in the same extended underwater housing as the ADP processor. See section 7.2 for details on autonomous operation from battery power. See Appendix 2 for details on battery pack construction. See section 5.9 for details on accessing the batteries.

## 1.2. Definitions and Terminology

This section defines terms commonly used when working with the ADP.

- Direct command interface - direct serial communication with the ADP processor.
- BREAK - a serial communication signal that causes a hardware reset in the ADP electronics and returns the system to command mode. A BREAK consists of holding the ADP input serial communication line high for a period of at least 300 milliseconds.
- Ping - a single estimate of the water velocity profile. A ping consists of each transducer sending a short acoustic pulse, calculating the along-beam velocity profiles, and combining data from all beams (and the internal compass/tilt sensor if enabled) to compute the velocity profile.
- Profile - in addition to its more general use, profile refers to the collection of a number of pings to produce a mean estimate of the water velocity at each depth cell. A profile includes velocity, standard deviation, and signal strength data.
- Temperature - water temperature, in °C. Either default temperature inputted by the user, or measured using an internal sensor. Mean and standard deviation of measured temperature are recorded with each profile. Temperature is used for sound speed calculations.
- Salinity - water salinity, in ppt. The value input by the user is for sound speed calculations.
- Sound speed - speed of sound, at the transducer face, in m/s. This converts Doppler shift to water velocity. Sound speed is either calculated from user-specified temperature and salinity, or from measured temperature and user-input salinity (see the command “TempMode” in section 3.7). See the ADP Principles of Operation for details on the effects of sound speed.
- Blanking distance - the region in front of the transducers where no measurements can be made, in meters (m). This is measured as the vertical distance from the ADP transducers to the start of the first depth cell. The blanking region is required for the transducers and electronics to recover from the transmit pulse.
- Depth cell size - this defines the resolution of the velocity profile, in m. This is specified as the vertical distance from the ADP, and not the range along the path of the acoustic beams. See ADP Principles of Operation for details on the exact definition of ADP depth cells.
- Number of cells - the number of cells collected in each profile.
- Depth cell location - to calculate the location of the center of each depth cell, multiply the depth cell number (starting with 1 closest to the ADP) by the depth cell size and add the blanking distance. See “ADP Principles of Operation” for details regarding depth cell size and location.
- Pinging rate - the number of pings per second, in Hz. This is normally determined by the propagation speed of sound, although the variable “Ping Interval” can be selected to achieve a slower pinging rate for certain applications (see sections 3.7, 7.1 and 7.2).

- Profile time - the ADP records date and time from its internal clock with each profile. The recorded time represents the start of the averaging interval.
- Averaging interval - the period of time, in seconds, over which the ADP averages data to compute a mean velocity profile.
- Profile interval - the time between sequential profiles, in seconds. This is given as the time from the start of one profile to the start of the next profile, and must be greater than or equal to the averaging interval (or averaging interval will take precedence).
- Ping interval - the minimum time between sequential pings, in seconds. The default setting of 0.0 seconds causes the ADP to ping as rapidly as possible. Although not common, this can save power in applications where long averaging intervals are required to remove real variations in water velocity (see sections 3.7, 7.1, and 7.2).
- Burst sampling - this sampling method allows the user to record a number of profiles in rapid succession, and then put the ADP in sleep mode for an extended period of time. This is to record data on the short-term and long-term variation of water velocity, while maintaining a reduced duty cycle to conserve battery power and limit data storage requirements.
- Burst interval - the period of time, in seconds, between each sampling burst (when burst sampling is enabled). This is measured from the start of one burst to the start of the next burst, and must be greater than the time required for each burst.
- Profiles per burst - the number of profiles recorded during each burst, used only when burst sampling is enabled.

### 1.3. ADP Sampling Strategies

A number of the terms defined in section 1.2 determine the exact sampling strategy used by the ADP. These include ping, ping interval, averaging interval, profile interval, burst interval, and profiles per burst. These terms, and the different sampling strategies used by the ADP, are illustrated in Figure 1.

The ADP supports three basic sampling strategies. Continuous sampling is used for real-time data collection when connected to shore power or for autonomous deployments without power or data limitations. For continuous operation, the ADP profile interval is set to the same value as the averaging interval, and the ADP is actively collecting data at all times (except for the ~1 sec overhead time required for each profile).

For typical autonomous deployments, the ADP operates using a reduced duty cycle where the profile interval is greater than the averaging interval. When the ADP is not collecting data, it enters a sleep mode where power consumption is less than 1 mW. Duty cycle is calculated as the ratio of the averaging interval to the profile interval. Battery life is extended by the inverse of the duty cycle. For example, an averaging interval of 5 minutes with a profile interval of 15 minutes gives a 33% duty cycle and extends battery life by a factor of 3.

The final sampling strategy, burst sampling, enables the user to obtain information about short-term flow variation without requiring continuous operation. In this mode, the ADP collects a number of profiles in rapid succession and then enters a sleep mode to conserve power. Duty cycle is calculated by the following formula.

$$\text{Duty cycle} = (\text{Profiles\_per\_burst} * \text{Averaging\_interval}) / \text{Burst\_interval}$$

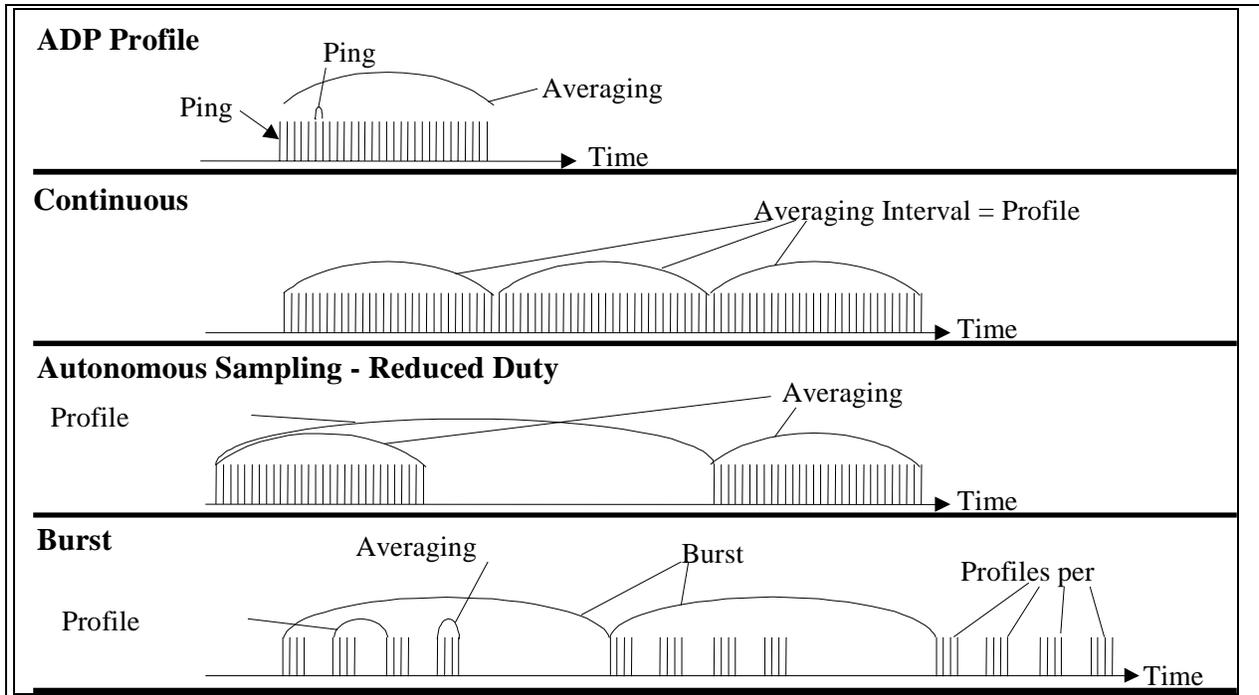


Figure 1 - ADP Sampling Strategies

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## SECTION 2. Getting Started

This section contains basic instructions for collecting data with the ADP in three of the most common configurations. These instructions are not intended to be comprehensive, but should be sufficient to get started and collect data for preliminary analysis.

Note that the testing described here can be done with the system in air without any damage to the ADP, although the velocity data from the instrument will be meaningless. When becoming familiar with ADP operation, we suggest that you begin with some basic testing with the system in the air and then move to preliminary field tests (from a dock or small boat) to gain experience.

### 2.1. Real-Time Data Collection with SonTek Software

The easiest way to collect ADP data is with the real-time data collection software, ADPSA.EXE. This software is described in detail in the ADP Software Manual. Basic instructions for collecting data using ADPSA are given below.

1. Copy all files from the ADP software diskette to a directory on the controlling computer. Place the computer in a dedicated DOS mode (not a DOS prompt within Windows).
2. Connect the ADP power and communication cable from the instrument to COM1 of the controlling computer and to the external power supply included with the system.
3. Type "ADPSA" at the DOS prompt. The software will establish communication with the ADP and download the current system configuration.
4. Select the desired operating parameters from the setup menu. For initial testing, we recommend using a relatively short averaging interval (perhaps 10-15 seconds) to speed up the data collection process. Specify a recording file to capture data to the computer hard disk.
5. Select "Start Data Acquisition" from the setup menu. The software will configure the ADP and begin data collection. Allow the ADP to collect several minutes of data.
6. Stop data collection by pressing Alt+F10. After confirmation, the program will return to the setup menu. Select "Exit Data Acquisition" to return to the DOS prompt.
7. Use the GADP\_\_\_.EXE programs to extract different portions of the binary data file to ASCII format. See the ADP Software Manual for details on program operation, and the ADP Principles of Operation for details on interpreting the different types of ADP data.

### 2.2. Real-Time Data Collection using Serial Output Data

For real-time data collection, the ADP is often integrated with a variety of data collection systems using the direct command interface and serial output data. For this type of integration, it may be helpful to gain experience with the system using the terminal emulator SONTERM included with the ADP software. Basic instructions for getting started are given below. For more information on the direct command interface and output data format, see SECTION 3.

1. Copy all files from the ADP software diskette to a directory on the controlling computer. Place the computer in a dedicated DOS mode (not a DOS prompt within Windows).
2. Connect the ADP power and communication cable from the instrument to COM1 of the controlling computer and to the external power supply included with the system.
3. Type "SONTERM" at the DOS prompt.

4. Capture all communication with the ADP to a file for future reference using the Alt+F option in SONTERM.
5. Press Alt+B to send a BREAK to the ADP and bring the system into command mode (the ADP command prompt is ">").
6. Begin using the direct command interface by typing "Help" at the command prompt. This will lead you into a number of menus displaying available commands.
7. Use the four "Show" commands ("Show Conf", "Show System", "Show Setup", and "Show Deploy") to display all ADP hardware and operating parameter settings.
8. Type "Compass CONT" to display data from the internal compass/tilt sensor. Rotate and tilt the ADP to verify compass operation (see section 4.1). Press any key to stop data output.
9. Type "Sensor CONT" to display data from the temperature, pressure, and battery voltage sensors (see sections 3.10 and 6.5). Press any key to stop data output.
10. Type "Dir" to view the contents of the internal recorder, if installed.
11. Select reasonable operating parameters for trial data collection. Use relatively small values for averaging interval and profile interval (10-15 seconds), and collect a relatively small number of cells (~10). Select the output format as ASCII.
12. Begin data collection immediately with the "Start" command.
13. Allow the ADP to output a number of profiles, then exit SONTERM (Alt+X) and take a closer look at the output data in the file specified earlier.

### **2.3. Autonomous Deployment**

Autonomous deployments use the optional ADP internal recorder and battery power. SECTION 7 contains detailed instructions for initiating autonomous deployments. This section provides a brief overview of the steps used to collect a sample deployment from external power. It assumes the user has already followed the steps in Section 2.2 and has a basic familiarity with the direct command interface.

1. Copy all files from the ADP software diskette to a directory on the controlling computer. Place the computer in a dedicated DOS mode (not a DOS prompt within Windows or Windows95).
2. Connect the ADP power and communication cable from the instrument to COM1 of the controlling computer and to the external power supply included with the system.
3. Type "SONTERM" at the DOS prompt.
4. Capture all communication with the ADP to a file for future reference using the Alt+F option in SONTERM.
5. Press Alt+B to send a BREAK to the ADP and bring the system into command mode (the ADP command prompt is ">").
6. Use the four "Show" commands ("Show Conf", "Show System", "Show Setup", and "Show Deploy") to display all ADP hardware and operating parameter settings.
7. Set reasonable values for cell size and the number of cells. Select relatively short values for averaging interval and profile interval (10-15 seconds) and disable burst sampling. Make sure the deployment start-date and time are before the current date and time shown on the ADP internal clock. Specify a deployment name for the recorded data.
8. Begin autonomous data collection with the "Deploy" command.
9. Allow the ADP to output a number of profiles, then exit SONTERM (Alt+X).

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10. Type "SONREC 1" at the DOS prompt to start the recorder data retrieval software. When the directory is displayed, mark the file you have just generated using the SPACE key and download by pressing the F3 key. See the ADP Software Manual for more details. When the data file has been downloaded, exit SONREC by pressing the ESC key.
  11. Use the GADP\_\_\_\_.EXE programs to extract different portions of the binary data file to ASCII format. See the ADP Software Manual for details on program operation, and the ADP Principles of Operation for details on interpreting the different types of ADP data.

## SECTION 3. Direct Command Interface

The ADP communicates with external devices using RS232 or RS422 serial communication protocol. The choice of protocol is set using jumpers in the ADP electronics (see section 5.7). The baud rate is set using a rotary switch in the ADP electronics (see section 5.6); the default setting is 9600. The fixed communication parameters are: 8 data bits, no parity, 2 stop bits.

Prior to data collection, the user must set a number of operational parameters. This can be done using direct commands or using the software provided with the ADP. This section describes the direct command interface using a terminal or terminal emulator (such as SONTERM supplied with the ADP software).

Section 3.1 gives an overview of the operational modes of the ADP. Section 3.2 gives an important notice about the behavior of the ADP when the power is source is changed. Section 3.3 presents the syntax rules for the command interface. Section 3.4 gives a summary of all available commands. The remaining parts of this section (3.5 through 3.14) describe each command in detail and give a detailed description of the output data format.

### 3.1. Modes of Operation

The ADP has four operational modes:

- Command Mode
- Data Acquisition Mode
- Deployment Mode
- Sleep Mode

Each is described below. See section 3.3 for details regarding command syntax and the definition of a BREAK.

#### *Command mode*

In command mode the ADP can send and receive commands related to all aspects of instrument operation. The user can enter the command mode from any other mode by sending a BREAK. The user can put the ADP into any of the other modes only from the command mode. The user can enter the command mode from the data acquisition mode or the deployment mode by sending a BREAK or the run time command “+++”.

To enter the data acquisition mode from the command mode, use the command “Start”. To enter the deployment mode from the command mode, use the command “Deploy”. To enter the sleep mode from the command mode, use the command “PowerOff”. If the ADP is left idle in the command mode for more than 5 minutes, it will automatically enter the sleep mode to conserve power.

#### *Data acquisition mode*

Data acquisition mode is for real-time data collection. Data acquisition mode is entered from command mode with the command “Start”. After receiving the “Start” command, the ADP takes a few seconds to initialize and then begins data collection. In data acquisition mode, the ADP ignores the deployment parameters “StartDate” and “StartTime”. If the internal recorder is installed and has been enabled (“Recorder ON”), profile data are output both over the serial port and to the internal recorder. If the recorder is not installed or has been disabled (“Recorder

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OFF”), data are sent only to the serial port. The user can exit the data acquisition mode and return to the command mode by sending a BREAK or by using the run time command “+++”.

While in data acquisition mode, the ADP can enter a power saving state if there is sufficient time between profiles. This power saving state is similar to, although not the same as, the sleep mode. The ADP will enter the power saving state if there is more than 10 seconds between profiles and the system command “AutoSleep” is set to ON (the default setting).

While collecting data, several run-time commands are available to simplify ADP integration with external data acquisition systems. These commands are accessed by sending one or more characters to the ADP over the serial communication line; see section 3.13 for details. Run-time commands cannot be accessed if the ADP is in the power saving state.

#### *Deployment mode*

Deployment mode is for autonomous data collection. Deployment mode is entered from command mode using the command “Deploy”. In deployment mode, the instrument will begin collection with the most recently entered setup parameters at the date and time specified by “StartDate” and “StartTime”. If the current date and time are after the specified start date and time, the system will begin data collection immediately. Deployment mode can only be used when the ADP includes the internal recorder. In deployment mode, data are always stored to the internal recorder regardless of the setting of the “Recorder ON/OFF” parameter.

In deployment mode, the ADP will enter a power saving state whenever there is more than 10 seconds between profiles (regardless of the setting of the “AutoSleep” parameter). The same run time commands are available in deployment mode as in data acquisition mode. The user can exit the deployment mode and enter command mode by sending a BREAK or by using the run time command “+++”. Run-time commands cannot be accessed if the ADP is in the power saving state between profiles.

#### *Sleep mode*

Sleep mode is to conserve power when the ADP is not in use. The sleep mode is entered from the command mode using the command “PowerOff”. In the sleep mode, the ADP consumes less than 1 mW of power. The user can exit the sleep mode and enter command mode by sending a BREAK. When in sleep mode, the ADP will not respond to any external commands except a BREAK. The only exception to this is if the primary system power is switched off and on (see Section 3.2). If the ADP is left idle in command mode for more than 5 minutes, it will automatically enter the sleep mode to conserve power.

### **3.2. Special Notice When Changing Power Sources**

When the main power to the ADP is turned off and on (i.e. when changing batteries or switching power supplies), the ADP will enter the mode it was in before power was lost. If previously in command mode or sleep mode, it will re-enter command mode. If previously in data acquisition mode, it will enter data acquisition mode and immediately start real-time data collection. If previously in deployment mode, it will start a new deployment using the stored operating parameters with the exception of “StartDate” and “StartTime”. These parameters are ignored and the new deployment will begin immediately. This is a safety feature to avoid data loss in the event of clock reset caused by a problem with the real-time clock backup battery.

The ADP real-time data collection software leaves the instrument in data acquisition mode upon exiting. Thus, if power is cycled after running the data acquisition software, the ADP will immediately start real-time data collection. In some applications, particularly when interfacing the ADP with a data logger, the start and stop of data collection may be controlled by cycling the system power. For these applications, be sure that the ADP is in data acquisition mode prior to turning power off to ensure that data collection will begin immediately when power is applied.

When changing batteries, always establish communication and place the ADP in sleep mode after the change to prevent draining the batteries.

**IMPORTANT:** When many computers and data loggers are turned on or off, they send a signal out the serial port that can be interpreted as a BREAK. If the ADP is connected to the serial port, this can interrupt data collection or bring the ADP out of sleep mode. This may cause the loss of data or the draining of batteries. Always disconnect the ADP from the computer or data logger prior to turning it on or off.

### 3.3. Command Syntax

These are the basic rules for communication between the ADP and an external terminal, terminal emulator, or interface program.

Throughout this manual, we refer to a BREAK when discussing direct communications with the ADP. The BREAK is a serial communication signal that causes a reset in the ADP processor and places the instrument in command mode. A BREAK consists of holding the data input line high for a period of at least 300 milliseconds. Most terminal emulator programs have a key combination that sends a BREAK; the program SONTERM (supplied with the ADP software) uses Alt+B.

1. The ADP can be brought into the command mode from any other mode by sending a BREAK.
2. All commands consist of a single keyword that may be followed by one or more ASCII parameters. The commands and parameters are not case sensitive.
3. When the ADP has completed a command and is ready to accept another command, it will send the prompt character ">".
4. Parameters may be numeric (either integer or floating point), alphanumeric, or a combination (for example, a date or time string).
5. Commands must be terminated by a <CR>.
6. The ADP echoes every character as it is received (except for run-time commands received during data collection – see section 3.13).
7. After receiving the <CR> that signals the end of the command string, the ADP echoes an additional <LF>.
8. If the ADP recognizes a command as valid it will transmit: <LF>OK<CR><LF>.
9. If a command is not recognized, the parameters are out of range, or if the command cannot be executed in the present state, the ADP returns an error-message followed by <CR><LF>.

**IMPORTANT:** When many computers and data loggers are turned on or off, they send a signal out the serial port that can be interpreted as a BREAK. If the ADP is connected to the serial port, this can interrupt data collection or bring the ADP out of sleep mode. This may cause the loss of data or the draining of batteries. Always disconnect the ADP from the computer or data logger prior to turning it on or off.

### 3.4. Direct Command Summary

The tables below summarize all direct commands that can be used with the ADP, including any abbreviations (shorter versions of the same command). These commands are split into different sections, and different tables, based upon their function. Further details on individual commands are provided in the sections that follow.

The following abbreviations are input parameters to the ADP.

- d                    Integer input (i.e. 30)
- d.d                 Decimal real number input (i.e. 0.33, 1.5)
- yy/mm/dd         Date as year, month, and day (i.e. 1996/05/20 or 96/05/20)
- hh:mm:ss         24-hour clock with hour, minute, and second (i.e. 18:15:00)

#### Help Commands (Section 3.5)

Command	Short	Function
Help	H or ?	Available help categories
Help System	H/? System	General system commands
Help Setup	H/? Setup	Real-time data collection commands
Help Deploy	H/? Deploy	Autonomous deployment commands
Help Recorder	H/? Recorder	Data recorder commands
Help Sensor	H/? Sensor	Peripheral sensor commands
Help Compass	H/? Compass	Compass/tilt sensor commands
Help Show	H/? Show	Commands to display system configuration

#### System Commands (Section 3.6)

Command	Short	Function	Parameters
Start	(none)	Starts real-time data collection (enters data acquisition mode)	
Deploy	(none)	Starts autonomous deployment (enters deployment mode)	
Test	(none)	Perform built-in system test	
SaveSetup	(none)	Save current parameters to EEPROM	
Defaults	DEF	Sets all parameters to factory defaults	
Ver	(none)	Shows CPU firmware version	
DSPVer	(none)	Shows DSP firmware version	
BoardRev	(none)	Shows electronics board revision number	
SerNum	(none)	Returns ADP sensor serial number	
Date <date>	(none)	Sets system clock date	yy/mm/dd
Time <time>	(none)	Sets system clock time	hh:mm:ss
PowerOff	(none)	Puts ADP in sleep mode	
AutoSleep <mode>	AS	If ON, ADP enters reduced power state during gaps in data collection	ON or OFF
OutFormat <format>	OF	Specifies output data format	ASCII or BINARY
OutMode <mode>	OM	Selects data output mode	AUTO or

**System Commands (Section 3.6)**

<b>Command</b>	<b>Short</b>	<b>Function</b>	<b>Parameters</b>
			POLLED
Recorder <status>	(none)	Turns internal recording on or off	ON or OFF
RecMode <mode>	(none)	Sets recording mode	NORMAL or BUFFER

**Setup Commands (Section 3.7)**

<b>Command</b>	<b>Short</b>	<b>Function</b>	<b>Parameters</b>
Temp <temperature>	(none)	Sets default water temperature (°C)	d.d
Sal <salinity>	(none)	Sets default water salinity (ppt)	d.d
Ncells <number>	NC	Number of depth cells to record	d
CellSize <size>	CS	Vertical size of depth cells (m)	d.d
BlankDistance <distance>	BD	Distance to start of first cell (m)	d.d
AvgInterval <seconds>	AI	Profile averaging interval (s)	d
ProfileInterval <seconds>	PRI	Time between profiles (s)	d
PingInterval <seconds>	PGI	Time between pings (s)	d.d
CoordSystem <system>	CY	Coordinate system for velocities	BEAM, XYZ or ENU
TempMode <mode>	TM	Temperature for computing sound speed	USER or MEASURED

**Deployment Commands (Section 3.8)**

<b>Command</b>	<b>Short</b>	<b>Function</b>	<b>Parameters</b>
Deployment <name>	(none)	Set deployment name for internal recorder	ASCII text
Comments	(none)	Enter deployment comments	ASCII text
StartDate <date>	SD	Date when data collection begins	yy/mm/dd
StartTime <time>	ST	Time when data collection begins	hh:mm:ss
AvgInterval <seconds>	AI	Profile averaging interval (s)	d
ProfileInterval <seconds>	PRI	Time between profiles (s)	d
PingInterval <seconds>	PGI	Time between pings (s)	d.d
BurstMode <mode>	BM	Enables or disables burst sampling	YES or NO
BurstInterval <seconds>	BI	Time between sampling bursts (s)	d
ProfilesPerBurst <number>	PPB	Number of profiles per burst	d

### Recorder Commands (Section 3.9)

Command	Short	Function	Parameters
Dir	(none)	List deployments currently on recorder	
LD	(none)	List deployments currently on recorder	
Format	(none)	Erase all data from recorder, re-format PCMCIA card for new data	
RecStatus	(none)	Show recorder size and free space left	
Recorder <status>	(none)	Turns internal recording on or off	ON or OFF
RecMode <mode>	(none)	Sets recording mode	NORMAL or BUFFER
OD <name>	(none)	Open deployment to access data	< deployment name>
CD	(none)	Return name of current open deployment	
RC	(none)	Retrieve configuration and setup information from currently open file	
RPA [N]	(none)	Retrieve next N profiles from file, ASCII format	<number of profiles>
RPB [N]	(none)	Retrieve next N profiles from file, binary format	<number of profiles>
FP	(none)	Go to first profile in deployment	
LP	(none)	Go to last profile in deployment	
GP <profile number>	(none)	Go to <profile number> in deployment	
CP	(none)	Return current profile number	
NP	(none)	Return number of profiles in deployment	

### Sensor Commands (Section 3.10)

Command	Short	Function	Parameters
Sensor	(none)	Display most recent temperature, pressure, and battery voltage data	
Sensor CONT	(none)	Display continuous temperature, pressure, and battery voltage data	
PressOffset	(none)	Display pressure sensor calibration offset	
PressScale	(none)	Display pressure sensor calibration 1 <sup>st</sup> order coefficient	
PressScale_2	(none)	Display pressure sensor calibration 2 <sup>nd</sup> order coefficient	

### Compass Commands (Section 3.11)

Command	Short	Function
Compass	(none)	Display most recent heading, pitch, and roll data
Compass CONT	(none)	Display continuous heading, pitch, and roll data
Compass CAL	(none)	Perform a compass calibration

### Show Commands (Section 3.12)

Command	Short	Function
Show Conf	S Conf	Display hardware configuration parameters
Show System	S System	Display general system parameters
Show Setup	S Setup	Display real-time data collection parameters
Show Deploy	S Deploy	Display autonomous deployment parameters

### Run Time Commands (Section 3.13)

Command *	Short	Function
+++	(none)	Return the ADP to command mode (stop data collection)
O	(none)	Transmit last profile
T	(none)	Transmit ADP date and time
C+	(none)	Adjust real-time clock +1 second
C-	(none)	Adjust real-time clock -1 second
N	(none)	Transmit profile number of last averaged profile
A	(none)	Transmit time left in current averaging interval (seconds)

\* These commands available only in data acquisition and deployment modes

## 3.5. Help Commands

The ADP direct command interface contains a number of on-line help commands. These are designed such that, by starting with “Help” at the direct command interface, the user will be led through a series of menus that show all ADP commands. There are a total of 9 help commands that display all commands the user would normally use for any aspect of ADP operation.

- “Help” Listing of help menus available
- “Help System” General system commands
- “Help Setup” Real-time data collection commands
- “Help Deploy” Autonomous deployment commands
- “Help Recorder” Data recorder commands
- “Help Sensor” Peripheral sensor commands
- “Help Compass” Compass/tilt sensor commands
- “Help CTD” External CTD sensor commands
- “Help Wave” SonWave commands
- “Help Show” Commands to display system configuration

The output of these commands is self-explanatory. For more details on individual commands, see the remaining portions of SECTION 3.

### 3.6. System Commands

System commands relate to general operational concerns of the ADP. These functions include setting the clock, displaying the serial number, data output, recorder settings, and starting data collection. In this section, each command is shown (with any command line options) in *Italics*. Short versions of these commands, if they exist, are shown in parenthesis on the same line.

#### *Start*

This command starts real-time data collection, putting the ADP into data acquisition mode (see section 3.1). The ADP first saves all recently entered commands (commands will not be lost if a “SaveSetup” is not done prior to starting data collection). When using the start command, data collection begins immediately (Start Date and Time are ignored), and burst sampling cannot be used. Data will be stored to the recorder if it has been enabled (“Recorder ON”).

#### *Deploy*

This command starts autonomous data collection, putting the ADP into deployment mode (see section 3.1). The ADP first saves all recently entered commands (commands will not be lost if a “SaveSetup” is not done prior to starting data collection). When using the deploy command, data collection will begin when the ADP clock reaches the specified Start Date and Time. If the current date and time is after the specified start date and time, data collection will begin immediately. When in deployment mode, ADP data are always stored to the recorder regardless of the recorder setting and the system will always enter a reduced power state if there is sufficient time between profiles (“AutoSleep” is forced ON).

#### *Test*

This performs a built-in test of all major ADP functions. These include CPU and DSP operation, as well as compass and recorder operation (if installed). It displays individual results from each test. We suggest using this command when preparing for any autonomous deployment (see section 7.3).

#### *SaveSetup*

This command saves all current parameter settings to EEPROM. This must be done before the system is shut down (or before a BREAK is sent) or any recently entered commands will be lost. This is performed automatically as part of the “Start” and “Deploy” commands.

#### *Defaults* (short command “DEF”)

This sets all ADP parameters to their default values. See the individual command descriptions for default values.

#### *Ver*

This outputs the version number of the CPU firmware.

#### *DSPVer*

This outputs the version number of the DSP firmware.

#### *BoardRev*

This outputs the revision number of the ADP electronics boards.

#### *SerNum*

This command returns the instrument serial number from memory (should match the serial number stamped on the transducer head).

*Date <yy/mm/dd>*

When this command is given without argument, it returns the date from the ADP clock. When given a date in the form “yy/mm/dd” (where yy = year (2 or 4 digits), mm = month (2 digits), and dd = day (2 digits)), it resets the date in the computer clock. Example: “date 1995/09/08” or “date 95/09/08” are equivalent commands setting the date to September 8, 1995.

*Time <hh:mm:ss>*

When this command is given without argument, it returns the time from the ADP clock. When given a time in the form of “hh:mm:ss” (24-hour clock where hh = hour (2 digits), mm = minute (2 digits), and ss = seconds (2 digits)), it resets the time in the computer clock. Example: “time 16:24:08” sets the ADP time to 16:24:08 (4:24:08 p.m.).

*PowerOff*

This command puts the ADP into sleep mode, where power consumption is less than 1 mW. See section 3.1 for a description of sleep mode. We recommend placing the ADP in sleep mode whenever not in use (it will automatically enter sleep mode if left idle in command mode for more than 5 minutes).

*AutoSleep ON / OFF* (short command “AS”)

When this command is given without argument, it returns the current AutoSleep setting. This setting determines whether the ADP enters a reduced power state during data collection. If AutoSleep is ON, the ADP will enter this state when there is a period of at least 10 seconds when the ADP is not actively sampling (i.e. profile interval is 10 seconds greater than averaging interval). Power consumption is less than 1 mW in the reduced power state. If AutoSleep is OFF, the ADP electronics remain active even when not collecting data. The default setting is ON. In deployment mode, AutoSleep is forced ON.

*OutFormat BINARY / ASCII* (short command “OF”)

When this command is given without argument, it returns the current output format setting. This setting determines the format of data output over the serial port; either BINARY or ASCII. Data stored on the internal recorder are always stored in binary format. See section 3.14 for a description of output data formats. The default setting is ASCII.

*OutMode AUTO / POLLED* (short command “OM”)

When this command is given without argument, it returns the current output mode setting. This setting determines whether data are sent over the serial port immediately after the completion of a profile (AUTO), or only sent when a specific run time command is received (POLLED). The run time command “O” causes the output of the last mean profile from the buffer; see section 3.13 for a detailed description of run time commands. The default setting is AUTO.

*Recorder ON / OFF*

When given without an argument, this command returns the current recorder setting. When the recorder is ON, all data collected by the ADP will be stored on the internal recorder. When OFF, any data collected in data acquisition mode (i.e. using the “Start” command) will not be stored to the recorder (but will be output to the serial port). When in deployment mode (i.e. using the “Deploy” command), data are always stored on the internal recorder. The default setting is ON if a recorder is installed, or OFF if a recorder is not installed.

*RecMode NORMAL | BUFFER*

When this command is given without argument, it returns the current recorder mode setting. Recorder mode specifies what happens when all available space on the recorder is filled. If the recorder is in NORMAL mode, any data collected after the recorder is filled will be sent to the serial port but will not be stored on the internal recorder. In BUFFER mode, any data collected after the recorder is filled will overwrite the oldest data on the recorder. The default setting is NORMAL.

**3.7. Setup Commands**

Setup commands affect the real-time data collection parameters of the ADP. These include temperature, salinity, number of depth cells, depth cell size, averaging interval, profile interval, and ping interval. The timing commands (averaging interval, profile interval, and ping interval) are also listed under deployment commands. In this section, each command is shown (with any command line options) in *Italics*. Short versions of these commands, if they exist, are shown in parenthesis on the same line.

*Temp <d.d>*

When this command is given without argument, it returns the current user-specified temperature. When given with an input argument in the appropriate range ( $-5.0^{\circ}\text{C} < \text{temperature} < 50.0^{\circ}\text{C}$ ) it sets the user-specified temperature to this value. This temperature is for calculating sound speed if the temperature mode (“TempMode”) is set to USER. Default setting is  $20.0^{\circ}\text{C}$ . See the ADP Principles of Operation for details on the effects of sound speed on ADP operation.

*Sal <d.d>*

When this command is given without argument, it returns the current user-specified salinity setting. When given with an input argument in the appropriate range ( $0 \text{ ppt} \leq \text{salinity} \leq 60 \text{ ppt}$ ) it sets the salinity to this value. This salinity is for calculating sound speed. Default setting is 34.5 ppt. See the ADP Principles of Operation for details on the effects of sound speed on ADP operation.

*Ncells <d>* (short command “NC”)

When this command is given without argument, it returns the current number of depth cells recorded with each profile. When given with an appropriate input argument (integer 1-100) it sets the number of cells in each profile. Default setting depends upon acoustic frequency (see table below).

*CellSize <d.d>* (short command “CS”)

When this command is given without argument, it returns the current depth cell size (in meters). When given with a numerical argument in the appropriate range, it sets the depth cell size to this value. Depth cell size is specified in vertical distance from the ADP. The range and default values for cell size depend upon acoustic frequency (see table below).

*BlankDistance <d.d>* (short command “BD”)

When this command is given without argument, it returns the current blanking distance (in meters). When given with a numerical argument in the appropriate range, it sets the current blanking distance. The minimum blanking distance and default settings depend upon acoustic frequency (see table below).

The table below summarizes the default values for blanking distance, cell size, and number of cells for each ADP acoustic frequency.

**ADP Profile Definition Variable Input Range and Default Values**

Acoustic Frequency	Blanking Distance	Cells Size	Number of Cells
3.0 MHz	Range 0.2 - 2.0 m Default 0.2 m	Range 0.15 - 2.0 m Default 0.5 m	Range 1 – 100 Default 12
1.5 MHz	Range 0.4 - 4.0 m Default 0.4 m	Range 0.25 - 4.0 m Default 1.0 m	Range 1 – 100 Default 20
1.0 MHz	Range 0.5 - 6.0 m Default 0.5 m	Range 0.4 - 5.0 m Default 1.0 m	Range 1 – 100 Default 25
500 kHz	Range 1.0 - 12.0 m Default 1.0 m	Range 1.0 - 12.0 m Default 4.0 m	Range 1 – 100 Default 30
250 kHz	Range 1.5 - 20.0 m Default 1.5 m	Range 1.0 - 20.0 m Default 4.0 m	Range 1 – 100 Default 30

*AvgInterval* <d> (short command “AF”)

When this command is given without argument, it returns the current averaging interval (in seconds). When given with an integer argument, it sets the averaging interval to this value (in seconds). See the ADP Principles of Operation for the averaging interval required for a desired accuracy. The acceptable range of values is 1 to 43200; the default value is 120 seconds.

*ProfileInterval* <d> (short command “PRI”)

When this command is given without argument, it returns the current profile interval (in seconds). When given with an integer argument, it sets the profile interval to this value (in seconds). Profile interval is defined as the time between the start of successive profiles (see sections 1.2 and 1.3). The acceptable range is 1 to 43200 s; the default is 1200 s. Note that if averaging interval is greater than profile interval, averaging interval will take precedence.

*PingInterval* <d.d> (short command “PGI”)

When this command is given without argument, it returns the current ping interval setting (in seconds). See section 1.2 and 1.3 for a description of ping interval. When given with a numerical argument, it sets the minimum time between pings in a profile (in seconds). The acceptable range is 0.0 to 10.0 s; the default is 0.0 s. Settings of less than 0.5 s will cause the ADP to sample (ping) as rapidly as possible. Settings from 0.5 s to 10.0 s will set the minimum time between pings; within this range, ping rate is the inverse of ping interval. See the ADP Principles of Operation for details on the effect of ping rate on uncertainty in velocity data.

Ping interval is to reduce power consumption in environments where real variations in water velocity require long averaging intervals. Settings other than 0.0 seconds are uncommon and should only be selected by experienced users. See sections 7.1 and 7.2 for details about the power savings achieved using reduced pinging rates.

*CoordSystem* BEAM / XYZ / ENU (short command “CY”)

When this command is given without argument, it returns the current coordinate system setting. When given with an appropriate argument, it sets the coordinate system to this value. This affects the velocity data output to the serial port and stored to the internal recorder (if enabled). BEAM causes velocity data to be stored as along beam velocities. XYZ causes velocity data to

be recorded in the Cartesian coordinate system relative to the ADP. ENU causes the system to use the compass data to transfer velocity data to earth (east-north-up) coordinates. See section 4.3 and 6.3 for details on the different coordinate systems. The default setting is ENU. Settings other than ENU are selected only for specialized applications.

*TempMode USER / MEASURED* (short command “TM”)

When this command is given without argument, it returns the current temperature mode setting. When given with an appropriate argument, it sets the temperature mode to this value. USER specifies that sound speed should be calculated from the user-input temperature. MEASURED specifies that sound speed should be calculated using data from the ADP temperature sensor. The default setting is MEASURED.

The standard ADP temperature sensor is sufficiently accurate and reliable ( $\pm 0.2^{\circ}\text{C}$ ) for sound speed calculations. The most common reason for selecting a temperature mode of USER is to simplify post-processing corrections using data collected by other sensors. Note that sound speed is recorded with each profile, so post processing corrections are possible with either setting.

### 3.8. Deployment Commands

Deployment commands affect data collection parameters used for autonomous deployment. These include deployment name, averaging interval, profile interval, ping interval, start date and time, and burst sampling parameters. Note that several of the timing commands (averaging interval, profile interval, and ping interval) are also listed under setup commands. In this section, each command is shown (with any command line options) in *Italics*. Short versions of these commands, if they exist, are shown in parenthesis on the same line.

*Deployment <name>*

When this command is given without argument, it returns the current deployment name. When entered with an ASCII text input (no more than 5 letters or numbers) it sets the deployment name. This determines the file name under which data are stored to the internal recorder. All data from a single “Deploy” or “Start” command are stored in one data file. The file name on the recorder is the deployment name combined with a 3-digit number indicating the sequence of files under this deployment name. For example, if the deployment name is “LAKE” the data from the first “Deploy” or “Start” command will be stored in a file named “LAKE001”. If data collection is stopped and re-started without changing deployment name, the file name will increment; i.e. “LAKE002” and “LAKE003”. Default name is DEF.

*Comments*

This command allows the user to input comments that will be stored in the data file. There are three comment lines, each with a maximum of 60 characters.

*StartDate <yy/mm/dd>* (short command “SD”)

When entered without an argument, this command returns the current deployment start date. When given with a date in the correct format (see “date” command), it sets the date on which data collection will begin. This date is used only in deployment mode (data collection started with the “Deploy” command). If the start date and time are before the current date and time, data collection will begin immediately. Default value is January 1, 1995.

*StartTime* <hh:mm:ss> (short command “ST”)

When given without an argument, this command returns the current deployment start time. When given with a time in the correct format (see “time” command), it sets the time at which data collection is to begin. This time is used only in the deployment mode (i.e. data collection started with the “Deploy” command). If the start date and time are before the current date and time, data collection will begin immediately. Default value is 00:00:00.

*AvgInterval* <d> (short command “AI”)

See description under setup commands (section 3.7).

*ProfileInterval* <d> (short command “PRI”)

See description under setup commands (section 3.7).

*PingInterval* <d.d> (short command “PGI”)

See description under setup commands (section 3.7).

*BurstMode* NO / YES (short command “BM”)

When given without an input argument, this command returns the current burst mode setting. An input argument of NO disables the burst sampling mode. An input argument of YES enables the burst sampling mode. See sections 1.2 and 1.3 for a description of burst sampling. Note that burst sampling can only be used in deployment mode (data collection started with the “Deploy” command). In data acquisition mode, this parameter is ignored. The default setting is NO.

*BurstInterval* <d> (short command “BI”)

When given without an input argument, this command returns the current burst interval (in seconds). When entered with an integer argument, this sets the burst interval to this value (in seconds). See sections 1.2 and 1.3 for a description of burst sampling. The acceptable range of values is 1 to 43200 seconds. The default setting is 1200.

*ProfilesPerBurst* <d> (short command “PPB”)

When given without an input argument, this command returns the current number of profiles per burst. When given with an integer argument, this sets the number of profiles per burst. See sections 1.2 and 1.3 for a description of burst sampling. The acceptable range of values is 1 to 1000. The default setting is 1.

### 3.9. Recorder Commands

Recorder commands allow direct access to data stored in the ADP internal recorder. This includes accessing files, checking recorder capacity, and extracting data. In this section, each command is shown (with any command line options) in **Italics**. The motivation for the abbreviated names is shown in parenthesis on the same line. The end of this section gives examples of how recorder commands can be operated to access data.

*Dir* (for directory)

List deployments currently stored on the recorder. Note that this command will take a few seconds to scan the entire recorder.

*LD* (for list deployments)

List deployments currently stored on the recorder. Note that this command will take a few seconds to scan the entire recorder. Exactly the same as “Dir”.

---

*Format*

Erase all data from the recorder card. Naturally, you should take some care before executing this command. Upon execution it will prompt for confirmation of erasing all data. The ADP will give an updated display showing progress in re-formatting the memory card (the process will take a few seconds).

*RecStatus*

Show the installed recorder size and the amount of free space remaining.

*Recorder ON / OFF*

See description under system commands (section 3.6).

*RecMode NORMAL / BUFFER*

See description under system commands (section 3.6).

*OD <name>* (for open deployment)

When given an existing deployment name on the ADP recorder, this command allows access to data files within that deployment. A deployment must first be opened before any of the following recorder commands can be used. When first opened, the file marker is placed on the first profile in the specified data file (for retrieval using the RPA or RPB commands).

*CD* (for current deployment)

Show what deployment is currently open.

*RC* (for retrieve configuration)

Retrieve configuration and setup information from the currently open file. This includes all information in the file header that is stored only once per data file (same as retrieved by the software program GADPCTL – see the ADP Software Manual). The information is retrieved in a self-explanatory ASCII format.

*RPA [N]* (for retrieve profile ASCII)

Retrieve N profiles from the current file in ASCII format. If N is not specified, one profile is retrieved. The first profile retrieved will be the one given by the file marker; after executing this command, this file marker will be moved to the profile immediately following the profiles just retrieved. The ADP will first send the profile header and then the profile data; see section 3.14 for a description of the output data format.

*RPB [N]* (for retrieve profile binary)

Retrieve N profiles from the current file in BINARY format. If N is not specified, one profile is retrieved. The first profile retrieved will be the one given by the file marker; after executing this command, this file marker will be moved to the profile immediately following the profiles just retrieved. The ADP will first send the profile header and then the profile data; see section 3.14 for a description of the output data format.

*FP* (for first profile)

Moves the file marker to the first profile in the file.

*LP* (for last profile)

Moves the file marker to the last profile in the file.

*GP <profile number>* (for go to profile)

Moves the file marker to the profile number given on the command line; this profile will be the next profile retrieved with the “RPA” or “RPB” commands.

*CP* (for current profile)

Returns the number of the current profile shown by the file marker.

*NP* (for number of profiles)

Returns the number of profiles in the currently open file (takes a few seconds to scan the file).

The following are examples of how to access recorder data from the direct command interface. The ADP software includes a program to download data files (SONREC – see the ADP Software Manual) and the direct access commands shown here are not needed for most applications.

Example 1: Retrieve configuration data from deployment LAKE001.ADP

*LD* to list deployments;  
*OD LAKE001* to open the deployment;  
*RC* to retrieve configuration

Example 2: Retrieve the last 5 profiles in ASCII format from deployment LAKE001.ADP

*LD* to list deployments;  
*OD LAKE001* to open deployment LAKE001.ADP;  
*NP* to retrieve the number of profiles (NP) recorder in the file (assume the ADP returns 1355 for this example);  
*GP 1351* to go to profile number 1351 in this file (fifth from the last profile);  
*RPA 5* to retrieve the last 5 profiles in ASCII format.

### 3.10. Sensor Commands

In normal ADP operation all commands to the optional sensors are handled automatically, and no direct commands need to be sent. These commands are provided for diagnostic purposes only.

#### *Sensor*

Display most recent temperature (°C), pressure (dbar), and battery voltage (V DC) data. Note that the battery voltage is measured after the voltage drop from an isolation diode, and thus will typically be 0.6-0.8 V lower than the voltage level input into the ADP.

#### *Sensor CONT*

Display continuous temperature (°C), pressure (dbar), and battery voltage (V DC) data. Note that the battery voltage is measured after the voltage drop from an isolation diode, and thus will typically be 0.6-0.8 V lower than the voltage level input into the ADP. Press any key to stop the output of sensor data.

#### *PressOffset*

Display the pressure sensor calibration offset value. See section 6.5 for details on the pressure sensor calibration constants.

#### *PressScale*

Display the pressure sensor calibration 1<sup>st</sup> order coefficient value. See section 6.5 for details on the pressure sensor calibration constants.

#### *PressScale\_2*

Display the pressure sensor calibration 2<sup>nd</sup> order coefficient value. See section 6.5 for details on the pressure sensor calibration constants.

### 3.11. Compass Commands

In normal operation all commands to the compass are sent automatically and no direct commands need to be sent. The commands in this section are provided to assist in diagnosing problems and for greater flexibility in ADP operations. For a detailed description of the optional compass/tilt sensor, see SECTION 4.

#### *Compass*

Display most recent heading, pitch, and roll data from compass/tilt sensor. Data are output in a self-explanatory, ASCII text format.

#### *Compass CONT*

Display continuous heading, pitch, and roll data from compass/tilt sensor (updated twice per second). Data are output in a self-explanatory, ASCII text format. Press any key to stop data output and return to command mode.

#### *Compass CAL*

Perform a compass/tilt sensor calibration. This is done to account for ambient magnetic fields that will affect compass heading (typically caused by ferrous metals) and should be performed prior to any deployment. The ADP will output basic instructions for performing the calibration and provide a continuous display of heading, pitch, and roll. Press any key to terminate the calibration, view the calibration score, and return to command mode. (Refer to section 4.4 for more information about compass calibration and for details on interpreting the calibration score.)

### 3.12. Show Commands

There are 4 commands to display current ADP parameter settings, known as the “show” commands. Samples of these commands and their outputs are shown below. As is done throughout the manual, commands and responses to the ADP are shown in a different font (*courier*) and comments are set in the same font as the main portion of this manual (times new roman). For more information about individual command settings, see sections 3.6 through 3.8.

“Show Conf” displays the current ADP hardware configuration (see section 5.1 for more information about individual command settings).

```
>show conf

HARDWARE CONFIGURATION PARAMETERS
-----
Sensor serial # ----- C18
Sensor type -- (kHz) ----- 1500
Number of beams ----- 3
Beam Geometry ----- 3_BEAMS
Slant angle -- (deg) ----- 25.0
Orientation ----- DOWN
Compass/Tilt sensor ----- YES
Recorder sensor ----- YES
Temperature sensor ----- YES
Pressure sensor ----- YES
PressOffset - (dbar) ----- -1.050000
PressScale -- (dbar/count) --- 0.000744
PressScale_2 (pdbar/count^2) - 153
External sensors ----- NO
Paros pressure sensor ----- NO
Microcat CTD ----- NO
```

“Show system” displays the current system parameters.

```
>show system

CURRENT SYSTEM PARAMETERS
-----
CPU Ver ---- ADP 5.3
DSP Ver ---- DSP 4.0
Board Rev. - REV D
Date ----- 1997/10/13
Time ----- 18:23:38
AutoSleep -- YES
OutFormat -- ASCII
OutMode ---- AUTO
Recorder --- ON
RecMode ---- NORMAL
```

“Show setup” displays the current data collection setup parameters.

```
>show setup

CURRENT ADP SETUP PARAMETERS
-----
Temp ----- (deg C) - 20.00
Sal ----- (ppt) --- 34.50
TempMode ----- MEASURED
Sound Speed ---- (m/s) --- 1520.90
CellSize ----- (m) ----- 1.00
BlankDistance -- (m) ----- 0.40
Ncells ----- 20
AvgInterval ---- (s) ----- 120
ProfileInterval- (s) ----- 1200
PingInterval --- (s) ----- 0.0
CoordSystem ----- ENU
```

“Show deploy” displays the current deployment parameters.

```
>show deploy

CURRENT DEPLOYMENT PARAMETERS
-----
Deployment ----- LAPIZ
StartDate ----- 1997/10/13
StartTime ----- 20:00:00
AvgInterval ----- (s) - 120
ProfileInterval - (s) - 1200
PingInterval ---- (s) - 0.0
BurstMode ----- DISABLED
BurstInterval --- (s) - 1200
ProfilesPerBurst ----- 1
Comments:
Buenos tardes, senior. Como esta?
Muy bien, gracias. Pero tengo mucho sed, amigo.
Si, claro. Una cerveza, no?
```

### 3.13. Run Time Commands

The commands shown here can be entered while the ADP is in data acquisition mode or deployment mode. These commands can be issued without causing any delay or interruption of data collection (except for a few milliseconds that the system spends in executing the command). The ADP will not respond if it is in the reduced power mode between profiles (i.e. if profile interval is greater than averaging interval). ADP responses to any of these commands may be delayed up to one second (this is the frequency at which the incoming command buffer is checked); allow for up to a 1 second delay after sending one of these commands.

These commands are provided to meet the needs of several specialized applications of the ADP, and are not needed by most ADP users.

+++

Sending three + characters in succession will cause the ADP to terminate data collection and return to the command mode. There is no time limit during which the characters must arrive. This command is provided as an alternative to sending a BREAK when relaying data over a modem (where sending a BREAK command may not be easily done).

O

At the end of each averaging interval the ADP places the profile in an output buffer in whatever format has been specified by the "OutFormat" command (BINARY or ASCII). If the "OutMode" command is set to AUTO, the ADP immediately transmits the contents of this buffer through the serial port. If "OutMode" is set to POLLED, the ADP continues normal data collection without transmitting the contents of the buffer.

In either output mode (AUTO or POLLED) the last mean profile remains in the output buffer until the next profile is completed. At this time, the contents of the buffer will be replaced with the new profile. At any time during data collection, the ADP can transmit the contents of the buffer. This is done by sending the character 'O' to the ADP through the serial port. This can be done as many times as desired without significantly affecting data collection, since the ADP uses only a few milliseconds of processing time to re-transmit the entire buffer. The output data format for both ASCII and BINARY is described in section 3.14.

Since the buffer is automatically updated at the end of each averaging interval, it is the responsibility of the user to request transmission of the buffer after each profile is collected, and before the averaging interval for the next profile is completed.

T

Sending the character T during data collection causes the ADP to output the current Date and Time in the ADP clock. The clock is read immediately before the date/time data are output, which can be up to 1 second after the T command is sent. The date/time output will in BINARY or ASCII format depending on the current setting of the OutFormat parameter.

In BINARY format, the following 10 bytes will be sent:

In ASCII format, the following line will be sent (using the standard ADP date and time format):

```
yyyy/mm/dd hh:mm:ss.hh <CR> <LF>
```

### Run Time Command “T” Binary Output Record

Field	Offset	Length	Description
Year	0	2	Four digit calendar year (i.e. 1995)
Month	2	1	
Day	3	1	
Hour	4	1	
Minute	5	1	
Second	6	1	
Hundredths	7	1	Hundredths of a second
Checksum	8	2	2-byte CheckSum of preceding 8 bytes (see appendix 1 regarding Checksum calculation)

#### *C+ and C*

The C command is to steer the ADP clock. C+ advances the clock 1 second, C- sets the clock back 1 second. After a successful completion of this command the ADP will output the acknowledgment "OK <CR> <LF>".

#### *N*

Sending the character N during data collection causes the ADP to output the profile number of the last mean profile, the one currently in the output buffer. The number is output in either BINARY or ASCII format depending upon the setting of “OutFormat”. In BINARY format, the following 6 bytes will be sent:

### Run Time Command “N” Binary Output Record

Field	Offset	Length	Description
Profile number	0	4	Profile number as a 4 byte integer
Checksum	4	2	2-byte CheckSum of preceding 4 bytes (see appendix 1 regarding Checksum calculation)

In ASCII format, the following line will be sent:

```
<ProfileNumber> <CR> <LF>
```

Where <ProfileNumber> is an integer value without leading spaces.

#### *A*

Sending the character A during data collection causes the ADP to output the time left in the current averaging interval, in seconds. The number is output in either BINARY or ASCII format depending upon the setting of “OutFormat”. In BINARY format, the following bytes will be sent:

### Run Time Command “A” Binary Output Record

Field	Offset	Length	Description
Time left	0	4	Time left in seconds as a 4 byte integer
Checksum	4	2	2-byte CheckSum of preceding 4 bytes (see appendix 1 regarding Checksum calculation)

In ASCII format, the following line will be sent:

```
<TimeLeft> <CR> <LF>
```

Where <TimeLeft> is an integer value without leading spaces.

### 3.14. Output Data Format

The ADP will output data over the serial port using either binary or ASCII format based on the setting of the system parameter “OutFormat”. The setting of “OutFormat” affects only data sent to the serial port; data written to the internal recorder are always stored in binary format. The setting of “OutFormat” will affect the data sent to the serial port during data collection, data retrieved using the run time commands (see section 3.13), and the data extracted from the recorder using recorder commands (see section 3.9).

#### 3.14.1. Binary Data

Binary data files generated by the ADP, using either the real-time data collection software or the internal recorder, use the same format. See Appendix 1 for a detailed description of the ADP binary file format. Most of the binary structures output by the ADP over the serial port follow a format defined for the binary data file, and will refer to this appendix for a precise definition.

This section describes only the binary profile data output over the ADP serial port during data collection, using the run-time commands (see section 3.13), and using the recorder commands (see section 3.9). Each ADP profile is sent from the serial port as a single binary record as described below.

The exact size of each ADP profile record depends upon the hardware configuration (the number of acoustic beams - NB), the user configuration (the number of cells collected - NC), and whether the optional CTD/Bottom Track/SonWave options are installed. The basic layout of each profile record is shown in the table below. The following abbreviations are listed in this table.

**ADP Profile Binary Data Structure**

Field	Offset	Length	Description
Profile header	0	80	Profile header data
CTD data	80	16	CTD data (*if installed)
Bottom Track			Bottom Track data (*if installed)
Velocity	$80 + (16^*)$	$2^*NB^*NC$	Velocity data
Standard deviation	$80 + (16^*) + 2^*NB^*NC$	$NB^*NC$	Standard deviation data
Signal amplitude	$80 + (16^*) + 3^*NB^*NC$	$NB^*NC$	Signal amplitude data
Pressure series			Pressure series (*if installed)
Checksum	$80 + (16^*) + 4^*NB^*NC$	2	2-byte CheckSum of preceding $(80 + (16^*) + 4^*NB^*NC)$ bytes

Each data type is defined in detail (using the C language structure definition) in Appendix 1. The list below shows the structures indicated for each data type.

- Profile header [ProfileHdrType]
- CTD [CtdType] (if present)
- BottomTrack [BTrackType] (if enabled)
- Velocity [ProfileData.Vel]
- Standard deviation [ProfileData.VelStd]
- Signal amplitude [ProfileData.Amp]
- Wave Header [WaveHeaderType] (if enabled)
- Pressure time series [WseriesType] (if enabled)

Appendix 1 also includes details on the calculation of the CheckSum sent with each binary profile record to ensure accurate data transmission.

### 3.14.2. ASCII Data

When outputting ADP data over the serial port in ASCII format, there are two data output types. First is the hardware configuration and user setup parameters. This is output using the recorder command “RC” and contains all ADP hardware configuration settings (serial number, frequency, number of beams, etc.) and user setup parameters (cell size, number of cells, default temperature and salinity, etc.). The output is presented in a self-explanatory text format.

The second output type contains data from one ADP profile including the profile header, averaged velocity and standard deviation, signal amplitude data, CTD, Bottom Track and Pressure series data (if available). This is output over the serial port when each profile is collected and is also output using the recorder command “RPA” (see section 3.9). A sample of this output is shown below.

#### Regular Profile

```
Header1      16          C23          1 1997 10 15 10 49 53 3 1 1 2
Header1      30   100    40    60   400
Header1     1751   -10   -30  1879 2799  13    5    6    2    9 14931
Header1      0  0  0  0  67 200  66 200  24  21  24  0 161 231  0 117
```

#### OPTIONAL CTD data (if present)

```
87514  468151      0  351354
```

#### OPTIONAL: Bottom Track data (if enabled)

```
100    221    220    220    0    115  116  140  0

Cell 1    1      2    -22    -11  15  14    4 116 113 111
Cell 2    2     24   -13    -8  14  14    4 121 123 118
Cell 3    3     12    9     -4  13  14    4 114 114 110
...
Cell N    N      6     -4     0  13  12    4  65  71  61
```

#### OPTIONAL: Wave Record (if enabled)

```
Wave header  32 DEFAULT C23          1 1997 10 15 10 49 0 1 6 1 1 150
Pressure series 2000    2000    2000    2000    2000    2000
```

The information contained in the profile header (first four lines) is described below.

- Header Line 1:  
 data type (internal use),  
 system serial number (“c23”),  
 profile number,  
 6 values for profile time (year, month, day, hour, minute, second),  
 number of beams (2, 3 or 4),  
 orientation (0=down, 1=up, 2=side),  
 temperature mode (0=user, 1=measured),  
 coordinate system (0=beam, 1=xyz, 2=enu)
  
- Header Line 2:  
 number of cells,  
 cell size (in cm),  
 blanking distance (in cm),  
 averaging interval (in seconds),  
 number of pings in this profile.
  
- Header Line 3:  
 3 values for mean heading, pitch, and roll (in 0.1°)  
 mean temperature (in 0.01°C)  
 mean pressure (counts)  
 3 values for standard deviation of heading, pitch and roll (in 0.1°)  
 std temperature (in 0.01°)  
 std pressure (counts),  
 sound speed (in 0.1 m/s).
  
- Header Line 4: this line contains system variables relating to internal system operation;  
 the last value on the line is measured battery voltage in units of 0.2 V (i.e. 117 = 23.4 V)

The format of the CTD, Bottom Track and Pressure series is documented in SECTION 8.

#### ADP ASCII Output Profile Data

Column #	Contents
1	Depth cell number
2	Velocity data (V1 or Vx or Veast) in mm/s
3	Velocity data (V2 or Vy or Vnorth) in mm/s
4	Velocity data (V3 or Vz or Vup) in mm/s
5	Standard deviation data (SD1 or SDx or SDeast) in mm/s
6	Standard deviation data (SD2 or SDy or SDnorth) in mm/s
7	Standard deviation data (SD3 or SDz or SDup) in mm/s
8	Amplitude (signal strength) data (beam 1) in counts (1 count = 0.43 dB)
9	Amplitude (signal strength) data (beam 2) in counts (1 count = 0.43 dB)
10	Amplitude (signal strength) data (beam 3) in counts (1 count = 0.43 dB)

## SECTION 4. Compass/Tilt Sensor

The ADP can be equipped with a compass and 2-axis tilt sensor to provide heading, pitch, and roll data. The sensor is the Precision Navigation TCM2. Compass data are to translate velocity from the instrument XYZ coordinate system to an Earth coordinate system (East-North-Up or ENU). For more information about the ENU coordinate system, see section 4.3.

While the TCM2 provides excellent quality data, there are some limitations to keep in mind. Most important is to be sure that the compass is correctly mounted for the orientation of the ADP (up- or down-looking), and that the installation matches the hardware switch settings (see section 5.5). See section 4.2 for details about compass installation and ADP orientation.

The compass includes a built-in calibration feature to account for the effects of ambient magnetic field (i.e. nearby ferrous metals). We recommend performing a compass calibration prior to each deployment. When properly calibrated, the compass provides heading accurate to  $\pm 2.0^\circ$  and pitch and roll accurate to  $\pm 1.0^\circ$  up to  $50^\circ$ . See section 4.4 for details about compass calibration.

Because the compass communicates with the ADP system through an RS-232 interface, it is possible for the user to communicate directly with the compass through the ADP. All communication with the compass is handled automatically by the ADP, and direct communication with the compass should not normally be necessary. For a discussion of how to communicate directly with the TCM2, see section 4.5.

### 4.1. Testing Compass Operation

This section describes a simple procedure to verify compass operation using a continuous display of heading, pitch, and roll. The display can be obtained using the direct command interface or the compass calibration software. If using the direct command interface, the command “Compass CONT” gives a continuous output of heading, pitch, and roll (see section 3.11). The compass calibration software (COMPCAL, see the ADP Software Manual) provides a graphical display of compass data.

For this test, first start the display of compass data. Point the ADP X-axis (marked on the transducer head) towards each compass direction (North, South, East, and West) and compare the compass output with the expected reading. Test the pitch and roll sensors by tilting the ADP about the X-axis (roll) and Y-axis (pitch) respectively, and compare the output measurements with the estimated tilt angles.

For this test be sure that the compass is physically oriented up (which means the ADP will be oriented down if the compass is installed for down-looking operation) and the hardware orientation switches match the compass installation. Refer to section 4.2 for details about compass mounting and the definition of the compass coordinate system.

This test should be conducted in an area predominantly free of magnetic material. The data should appear reasonable within the accuracy of this type of experiment ( $\pm 10^\circ$  heading,  $\pm 5^\circ$  tilt). Large errors or a lack of response indicate a problem with the compass. This is not intended as a precise test of compass accuracy, but a means to evaluate basic performance. For best results, we recommend performing a compass calibration prior to any deployment (see section 4.4).

## 4.2. Compass Installation and ADP Orientation

**IMPORTANT:** Whenever opening and closing the ADP, it is essential that the transducer head be correctly aligned. When correctly aligned, the ADP X-axis (as stamped on the transducer head) will point away from the underwater connector into the ADP housing. If the head is incorrectly aligned, compass data will be incorrectly interpreted and this will contaminate velocity data.

The ADP is configured at the factory for up or down-looking operation following user instructions. The user can determine the current configuration by using the “Show Conf” command from the direct command interface (see section 3.12). Both the installation of the compass and the setting of the hardware switches **must** be modified if the ADP is switched between up and down-looking operation. This section describes the compass installation; refer to section 5.5 regarding the hardware switch settings.

### 4.2.1. Compass Coordinate System

The critical part of compass installation is to maintain a known orientation relative to the acoustic transducers. This allows the ADP to use the compass data to translate velocity data from the XYZ coordinate system (relative to the ADP) to the ENU coordinate system.

Figure 2 illustrates the compass/tilt sensor layout and its XYZ coordinate system. **The compass must be operated with the component side facing upwards** (within the  $\pm 50^\circ$  tilt limit); operation in any other orientation will result in invalid compass data and corrupted velocity data when using the ENU coordinate system (non-recoverable data loss).

The compass has a 10-pin connector at one end for communication with the ADP (using an RS232 interface). The positive X-axis is defined along the long axis of the compass board from the connector towards the magnetic coils. The positive Z-axis is defined perpendicular to the compass board, upwards from the side with the connector, coils, and tilt sensor. The positive Y-axis is defined for a right hand coordinate system.

Pitch is defined as a rotation about the Y-axis; positive pitch raises the magnetic coils above the connector. Roll is defined as a rotation about the X-axis; positive roll raises the magnetic coils above the tilt sensor.

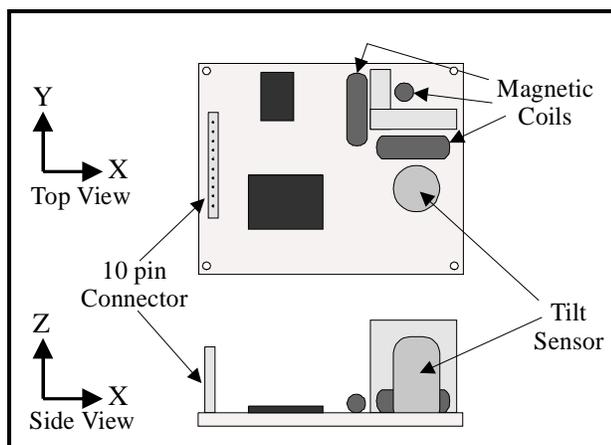


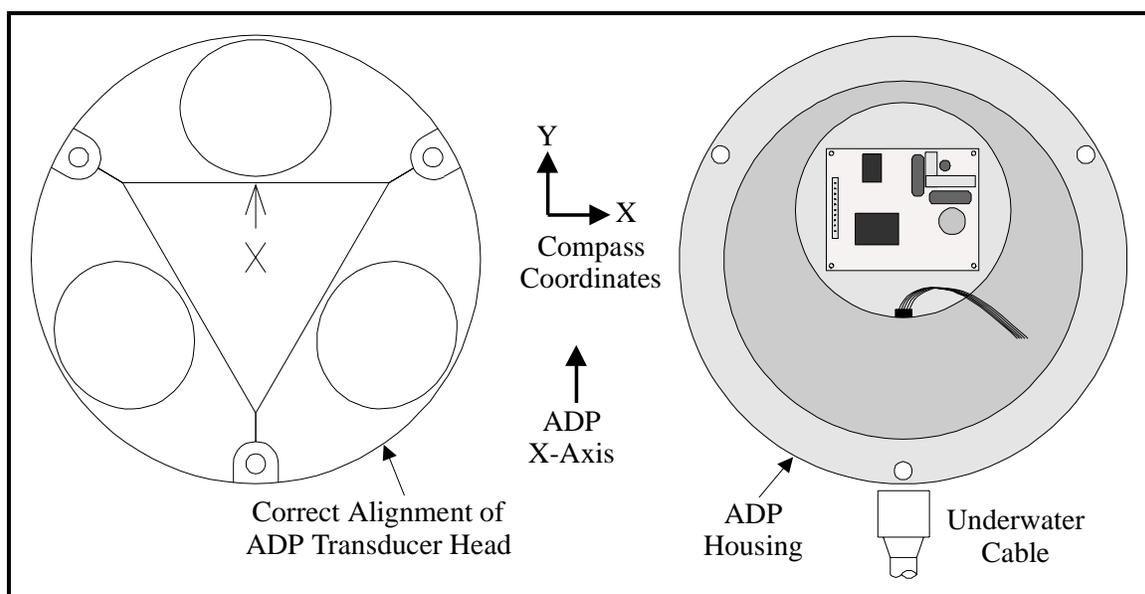
Figure 2– Compass Coordinate System

### 4.2.2. Up-Looking Compass Installation

Figure 3 illustrates the installation of the compass/tilt sensor for up-looking operation. The component side of the compass board is mounted away from the bottom of the ADP housing. This ensures that the compass is facing upward when the ADP is deployed looking up.

For up-looking operation, the compass is mounted directly to the threaded inserts on the bottom of the ADP housing (no additional standoffs are required). The inserts raise the compass 3/8" off the bottom of the housing. The positive Y-axis of the compass is aligned with the positive X-axis of the ADP. The positive X-axis of the compass is aligned 90° clockwise of the positive X-axis of the ADP.

When installing the compass, the board is secured using short #4-40 screws (spares are included in the ADP tool kit). Install fiber washers on both sides of the compass board for protection. It may be helpful to stick the washers to the compass board with a small amount of silicon grease before putting the compass into the housing (the o-ring grease in the ADP tool kit works well). The same grease can stick the #4-40 screws to the wrench when reaching into the canister. The compass mounting screws should be tightened securely but not over-tightened.



**Figure 3 – ADP Up-Looking Compass Installation**

When closing the ADP, be certain that the positive X-axis as marked on the transducer head is aligned as shown in Figure 3, and that the compass installation matches the desired deployment orientation and the sensor orientation as set in the ADP hardware switches (see section 5.5).

### 4.2.3. Down-Looking Compass Installation

Figure 4 illustrates the installation of the compass/tilt sensor for down-looking operation. The component side of the compass board is mounted towards the bottom of the ADP housing. This ensures that the compass is facing upward when the ADP is deployed looking down. Note that

compass components that are below the board (and hence are not directly visible when the compass is installed) are drawn with dashed lines in Figure 4.

For down-looking operation, a set of 1" hex standoffs (included in the ADP tool kit) must be installed onto the threaded inserts on the bottom of the ADP housing. This provides the necessary clearance to install the compass with the components facing down. These standoffs should be snugly screwed into the threaded inserts, but take care not to over-torque as this may strip the standoff threads.

For down-looking operation, the positive Y-axis of the compass should match the positive X-axis of the ADP. The positive X-axis of the compass is aligned 90° counter-clockwise of the ADP X-axis.

When installing the compass, the board is secured using short #4-40 screws (spares are included in the ADP tool kit). Install fiber washers on both sides of the compass board for protection. It may be helpful to stick the washers to the compass board with a small amount of silicon grease before putting the compass into the housing (the o-ring grease in the ADP tool kit works well). The same grease can stick the #4-40 screws to the wrench when reaching into the canister. The compass mounting screws should be tightened securely but not over-tightened.

When closing the ADP, be certain that the positive X-axis as marked on the transducer head is aligned as shown in Figure 4, and that the compass installation matches the desired deployment orientation and the sensor orientation as set in the ADP hardware switches (see section 5.5).

### 4.3. The ENU Coordinate System

The translation of velocity data from XYZ to Earth (ENU) coordinates is enabled or disabled through commands to the ADP and is transparent to the user. Selection of the coordinate system is done using the "CoordSystem" command (see section 3.7) or by a menu item in the data

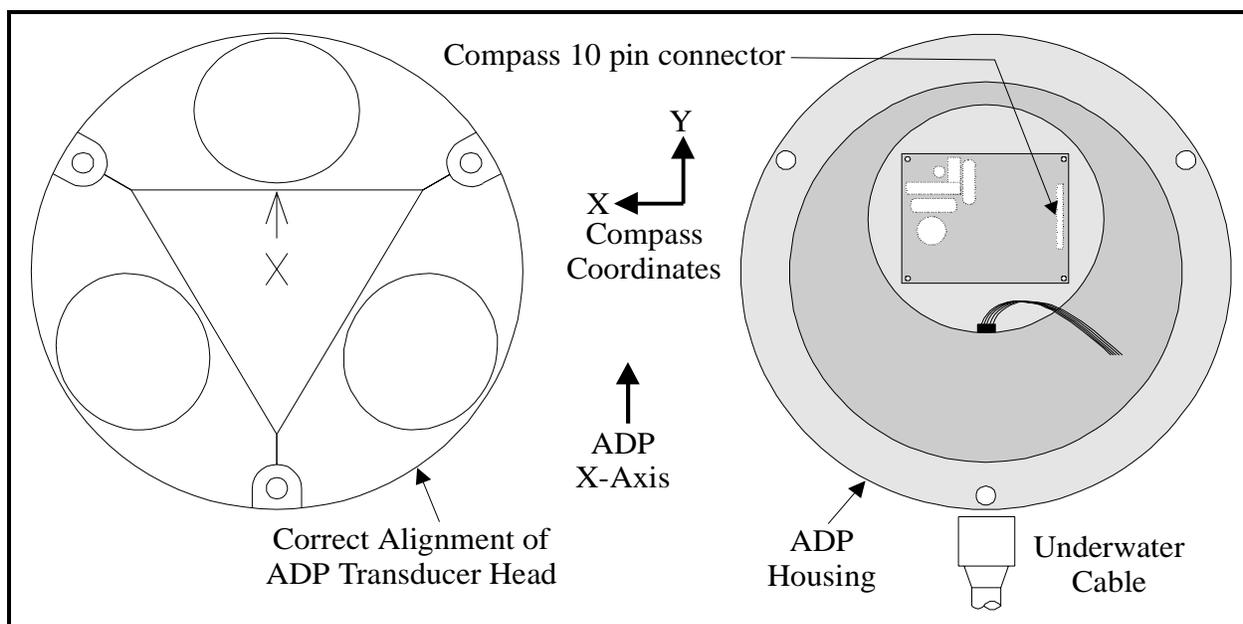


Figure 4 - Down-Looking Compass Installation

acquisition software (see the ADP Software Manual). When the compass is installed, data are stored with each profile regardless of the coordinate system setting.

When using the ENU coordinate system, velocity is reported in Earth coordinates regardless of the physical orientation of the ADP (within the operational limits of the compass).

Consequently, an ADP that is mounted with variable orientation will provide velocity data consistent with the direction and speed of the water current itself, regardless of the orientation when measuring the current.

Additionally, velocity data in each profile are averaged using continually updated compass data. If the ADP changes orientation during a profile, velocity data will be averaged in Earth coordinates and will not be contaminated by instrument motion. Using any other coordinate system (BEAM or XYZ) eliminates this vector averaging and can contaminate data if the ADP moves during the course of an averaging interval. We recommend using the ENU coordinate system except for specialized applications.

#### **4.4. Compass Calibration**

The compass can be calibrated to compensate for ambient magnetic fields, which may cause errors in heading measurements. Magnetic distortion is most commonly caused by ferrous metal near the ADP. If the ADP is mounted on or near anything that contains magnetic material or generates a magnetic field, the compass should be calibrated prior to starting data collection. Additionally, the compass should be calibrated when moved to a different environment or mounting apparatus.

There are two methods for compass calibration. The first is to use the compass calibration software, described in the ADP Software Manual. Alternatively, the operator can use the compass commands from the direct command interface.

To begin a compass calibration using the compass commands, establish communication with the ADP. Type the command “`compass cal`” and press ENTER. The program will display necessary instructions for the calibration, and give a continually updated output of heading, pitch, and roll. The compass is now in multiple-point calibration mode and is collecting sample points. Rotate the compass slowly through 360 degrees at least twice, varying the pitch and roll as much as possible, so that a complete rotation takes at least one minute to complete. When this has been completed, press any key to terminate the calibration. The ADP will respond with a calibration score, which will look like the following.

```
H9V9M5 . 3 :
```

The number following the ‘H’ and ‘V’ should be high (scale of 0 following the ‘M’ should be low (on a scale of 0 to 100)). The number following the H reflects the quality of the horizontal calibration, the number following the V reflects the quality of the vertical calibration, and the number following the M reflect the amount of magnetic distortion present. While scores will vary, if either H or V is below 6, or if M is greater than 30.0, you should repeat the calibration. If the results do not improve, consider changing the location or modifying the mounting structure.

The compass calibration software follows an essentially identical procedure, and reports the same calibration score. (See the ADP Software Manual for details.)

---

## 4.5. Communicating Directly with the Compass

All communication for compass operation is done automatically by the ADP; under normal circumstances, the user should not need to communicate directly with the compass. Should the need arise, the user can communicate with the compass through the ADP by establishing communication and bypassing the ADP processor for a direct link to the compass.

To communicate with the TCM2, place the ADP in command mode. Send the following command to establish a direct link with the compass.

```
> echo compass
```

If the compass is operating properly, it should be continuously sending data to the ADP, which will be redirected to the user. The data will look something like:

```
$C143.2P3.4R5.5T24.5*3f  
$C142.2P3.4R5.5T24.5*3e
```

The compass will now accept direct commands. For details on communicating with the compass, or for a copy of the compass manual, contact SonTek. When communication with the compass is no longer desired, typing three plus signs in succession (“+++”) or sending a BREAK will return the ADP to command mode.

## SECTION 5. ADP Hardware

### 5.1. ADP Hardware Configuration Settings

The exact hardware configuration of the ADP depends upon the requirements of the application. ADP hardware configuration settings can be displayed using the “Show Conf” command from the direct command interface (see section 3.12). A sample output of this command is given below.

```
>show conf

HARDWARE CONFIGURATION PARAMETERS
-----
Sensor serial # ----- C18
Sensor type -- (kHz) ----- 1500
Number of beams ----- 3
Beam Geometry ----- 3_BEAMS
Slant angle -- (deg) ----- 25.0
Orientation ----- DOWN
Compass/Tilt sensor ----- YES
Recorder sensor ----- YES
Temperature sensor ----- YES
Pressure sensor ----- YES
PressOffset - (dbar) ----- -1.050000
PressScale -- (dbar/count) --- 0.000744
PressScale_2 (pdbar/count^2) - 153
External sensors ----- NO
Paros pressure sensor ----- NO
Microcat CTD ----- NO
```

A brief description of each of these parameters and possible settings is given below.

- Sensor serial number: The ADP serial number is stamped on the transducer head.
- Sensor type: This specifies the acoustic frequency of the ADP in kHz (3000, 1500, 1000, 750, 500, or 250).
- Number of beams / Beam geometry: Most ADPs use 3 beams for vertical profiling. Horizontal current profiling can be done using 2 beam systems. Specialized applications will use 4 beam systems in several different configurations (3+1 vertical, 4 Janus).
- Slant angle: The mounting angle (off vertical) of the ADP transducers (25° is standard).
- Orientation: Profiling orientation of the system for up-looking, down-looking, or side-looking operation. Note that this setting must match the compass installation for correct operation (see section 4.2). Also note that the orientation will affect the definition of the XYZ coordinate system (see section 6.3).
- Compass/tilt / Recorder / Temperature / Pressure sensor: These settings specify which optional sensors have been installed (see section 5.5).
- PressOffset / PressScale / PressScale\_2: Factory calibration parameters for the optional pressure sensor (see section 6.5 for details).
- External / Paros pressure / Microcat CTD sensors: These settings specify the status of a number of optional external sensors that can be integrated with the ADP (see section 8.2 for details).

## 5.2. ADP Internal Electronics and Wiring Overview

### Stand-Alone ADP

The Stand-Alone ADP is our most popular configuration where the processor, recorder (optional), compass/tilt sensor, and pressure sensor (optional) are all housed in a single underwater canister. Figure 5 illustrates the internal mounting of the Stand-Alone ADP. All electronics except the compass/tilt sensor are mounted to the transducer head; the compass/tilt sensor is mounted to the bottom of the ADP housing as described in section 4.2.

The (circular) receiver board is mounted on three standoffs directly to the transducer head. Above the receiver board is the internal mounting hardware (all made of anodized aluminum), which consists of a circular plate above the receiver board with a rectangular plate attached at a right angle. The ADP processor is mounted on standoffs from the rectangular plate. If the ADP includes an internal recorder, a small right angle bracket is to keep the PCMCIA recorder card from being accidentally shaken loose. If the ADP includes a pressure sensor, a small electronics board for this sensor is mounted opposite the ADP processor.

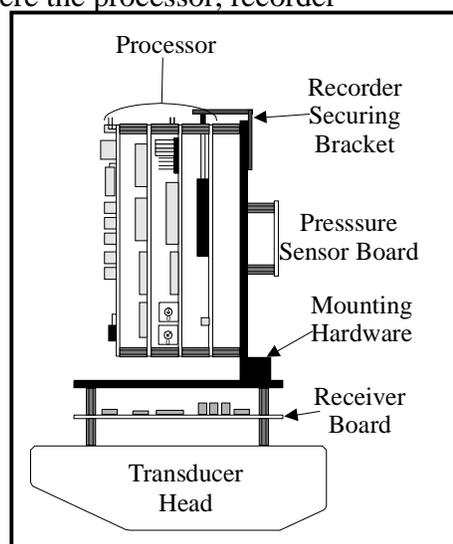


Figure 5

The ADP transducers are wired directly to the receiver board. The temperature sensor is connected to the receiver board using a red 2-pin connector. Two connectors on the receiver board (a 3-pin red and a 10-pin black) connect through a wiring harness to the ADP processor. The pressure sensor board connects at one side to the pressure sensor (mounted in the transducer head) and at the other side to a connector on the ADP processor. The ADP processor also has connectors to the compass/tilt sensor, and for external power and serial communication.

The Stand-Alone ADP also includes a grounding wire connected from one standoff on the receiver board to the housing. This establishes electrical conductivity between the two housings, and thus ensures that both the transducer head and housing are corrosion protected by the same zinc anodes.

For more details on the wiring of the ADP processor, see the complete processor description in section 5.3.

### Low Profile ADP

In the low profile ADP, the transducer head housing includes only the receiver board, compass/tilt, and pressure sensor board (optional). The processing electronics are installed in a separate splash-proof housing (non-submersible). The transducer head and processor are connected using a custom-shielded cable up to 60 m long.

The receiver board is mounted as shown in Figure 5; the compass/tilt sensor is mounted directly to the housing as described in section 4.2. The pressure sensor board, if included, is mounted on a circular plate above the receiver board. As with the Stand-Alone ADP, the transducers are wired directly to the receiver board and the temperature sensor is connected to the receiver board

using a red 2-pin connector. All wiring from the receiver board and the compass/tilt sensor connect directly to the underwater connector on the housing. The pressure sensor board connects on one side to the pressure sensor (in the transducer head) and on the other side to the underwater connector.

The low profile ADP also includes a grounding wire connected from one standoff on the receiver board to the housing. This establishes electrical conductivity between the two housings, and thus ensures that both the transducer head and housing are corrosion protected by the same zinc anodes.

### 5.3. ADP Processor

The ADP processor consists of three printed circuit (PC) boards with an optional fourth board for the internal recorder. The internal recorder is available only with the Stand-Alone ADP, and not with the low profile ADP.

Figure 6 illustrates the general layout of the ADP processor. The processing module consists of three printed circuit (PC) boards, with an optional fourth board for internal recording. These boards are connected in a vertical stack using connectors at one or both ends of the boards. From the top, they are called the analog board, the DSP board, the CPU board, and the recorder board. The name and revision level of each board is shown in white lettering along one edge. The rectangular board dimensions are 10.1 x 15.2 cm (4 x 6 in), and within the stack each board is separated by 1.3 cm (0.5 in).

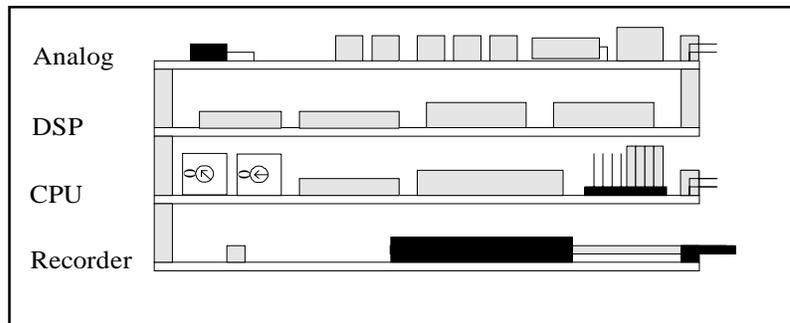


Figure 6 – ADP Processor

There are three places in the ADP processing module where hardware settings affect system operation. A set of switches on the analog board determines ADP profiling orientation and what additional sensors are installed (see section 5.5). Two hex rotary switches on the CPU are to set the communication baud rate and the address for RS485 communication (see section 5.6). Lastly, a set of jumpers on the CPU board determines whether the ADP uses RS232 or RS422 serial communication protocol (see section 5.7). See section 5.8 for instructions on accessing the processor.

A general description of the function of each board, along with the board layout and the location of important components are given below. The following sections also describe the connectors on each board and their function.

## Analog board

Figure 7 shows the layout of the ADP analog board with a number of important features labeled. The analog board generates the acoustic transmit signals, receives the high frequency return signals, and performs the preliminary signal conditioning before the return signal is sent to the DSP board. The important features of the analog board are discussed below.

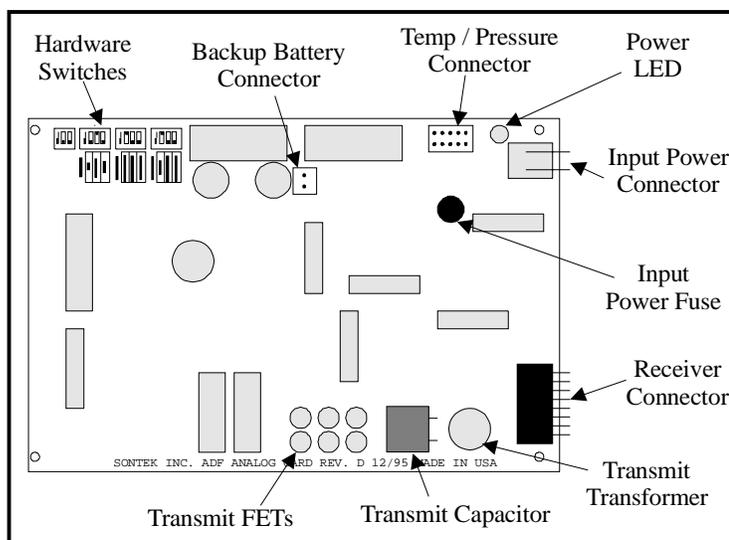


Figure 7 – ADP Analog Board

- **Hardware switches** - there are several sets of switches in the upper left corner of the board that determine ADP orientation and which optional components are installed (compass, recorder, temperature, and pressure). Refer to section 5.5 for details on setting these switches.)
- **Temperature / Pressure connector** - The 10-pin black connector in the upper right portion of the board receives signals from the temperature and pressure sensors. This connector is not keyed, so be sure to make note of its orientation before removing. The cable from this connector should lead to the receiver board, and to the pressure sensor board (if installed).
- **Backup battery connector** - The 2-pin red connector near the top center of the board is wired to a backup battery for the system clock. The connector is keyed and can only be installed in one direction.
- **Power LED** - The LED in the upper right corner will light if the ADP electronics has at least 12 V at the input power connector.
- **Power connector** - The 2-pin red connector in the upper right corner accepts DC input power (12-24 V). The polarity for each pin is labeled on the analog board. The mating connector is keyed and can only be installed in one direction. The cable from this connector will lead either to the input power connector (processor in the splash-proof housing for the Low Profile ADP) or to the underwater connector on the housing (Stand-Alone ADP).
- **Input power fuse** - The input power fuse is a black, cylindrical plug-in fuse (about 0.5 cm / 0.25 in diameter) located near the input power connector. The fuse is 3.15 A; 250 V. The fuse can be tested by lifting out of the socket and checking for continuity between the pins. Spare fuses are included in the ADP tool kit. The fuse should never be blown in normal operation, so a blown fuse may be an indicator of some other problem.
- **Receiver connector** - The black, 16-pin rectangular connector in the bottom right corner carries high frequency analog signals to and from the ADP receiver board. These signals are highly sensitive to noise; the cables and connectors should not be modified without contacting SonTek. The connector is keyed and can only be installed in one direction. For the Stand-Alone ADP, the cable from this connector will lead directly to the receiver board. For the ADP processor in the splash-proof housing, this connector is wired to the DB25 connector on the front end plate.

### DSP board

Figure 8 shows the layout of the ADP DSP board with a number of important features labeled. The DSP board digitizes the return signal and performs Doppler calculations to determine velocity. The important features of the DSP board are discussed below.

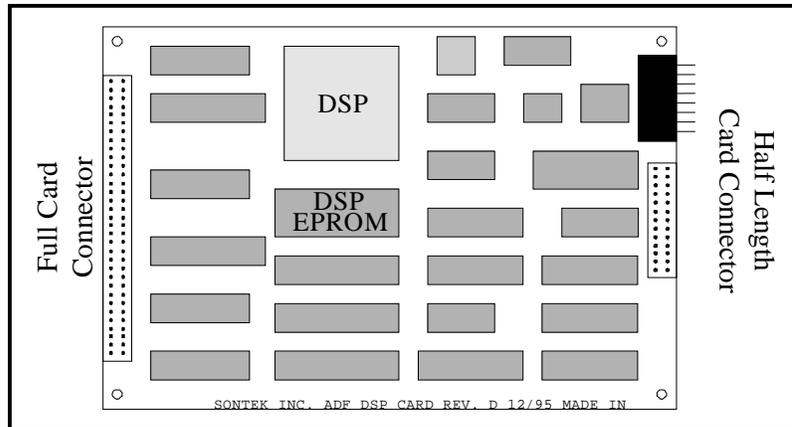


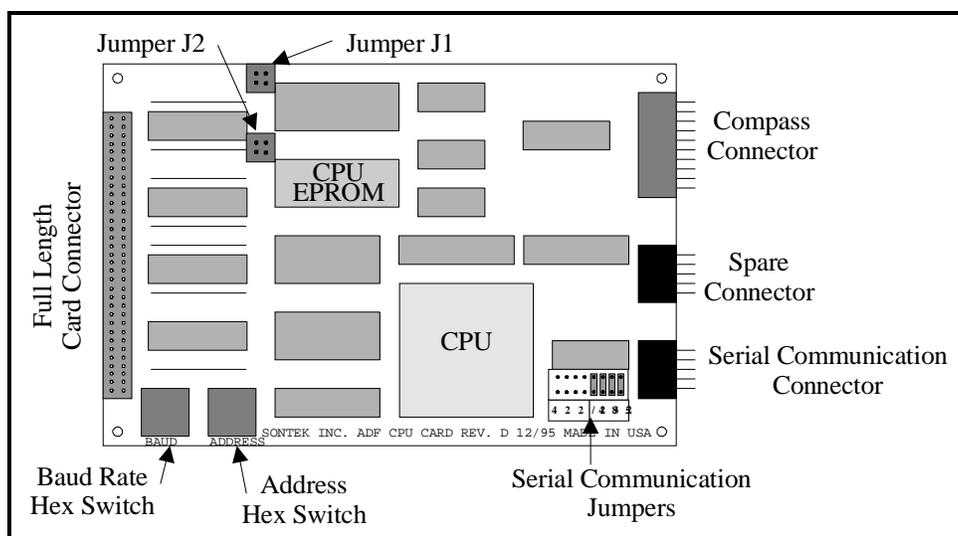
Figure 8 – ADP DSP Board

- DSP - The digital signal processing (DSP) chip provides the major computational power of the ADP processor.
- DSP EPROM - This EPROM stores the digital processing algorithms used by the ADP to measure velocity. Upgrades for this EPROM may be available periodically. To change the EPROM, use a small flat blade screwdriver to carefully remove the old EPROM. Be certain to align the half circle on the new chip with the identical mark on the processor board. Take care when installing the chip that all pins are intact and securely connected.
- The 16-pin, black rectangular connector in the upper right portion of the board is not used by the ADP.
- Half length card connector - The half length card connector (26 pins) on the right side of the board mates above to a connector on the bottom of the analog board.
- Full length card connector - The full length card connector (64 pins) on the left side of the board mates above to a connector on the bottom of the analog board, and below to a connector on the CPU board.

### CPU board

Figure 9 shows the layout of the ADP CPU board with a number of important features labeled. The CPU provides the overall control of ADP operation including data collection, user interface, compass, and recorder control. The important features of the CPU board are discussed below.

- CPU - The central processing unit (CPU) chip controls all major ADP functions including data collection, user interface, compass, and recorder.
- CPU EPROM - The CPU EPROM stores the algorithms to control ADP operation. Upgrades for this EPROM may be available periodically. To change the EPROM, use a small flat blade screwdriver to carefully remove the old EPROM. Be certain to align the half circle on the new chip with the identical mark on the DSP board. Take care when installing the chip that all pins are intact, not bent and securely connected.
- Compass connector - The 10-pin red connector in the upper right portion of the board carries power and serial communication to and from the compass/tilt sensor. The connector is keyed and can only be installed in one direction. For the Stand-Alone ADP, the cable from this connector should lead directly to the compass. For the ADP processor in the splash-proof housing, the cable from the connector should lead to the DB25 connector on the front end plate.



**Figure 9 – ADP CPU Board**

- Spare connector - The 10-pin, black rectangular connector in the right center portion of the board is not used.
- Serial communication connector - The 10-pin, black rectangular connector in the lower right corner of the board carries the serial communication signals for the external user interface. This is the same connector type as the spare connector listed above. The connector is keyed and can only be installed in one direction. For the Stand-Alone ADP, the cable from this connector should lead to the underwater connector on the housing. For the ADP processor in the splash-proof housing, the cable from this connector should lead to the DB9 serial communication connector on the front end plate.
- Full length card connector - The full length card connector (64 pins) on the left side of the board mates above to a connector on the bottom of the DSP board, and below to a connector on the recorder board.
- Baud rate hex switch - This hex rotary switch is to set the serial communication baud rate. The default setting is 9600 baud (setting 3). The switch is positioned so that it can be accessed while the processing module is assembled (see section 5.6).
- Address hex switch - This hex rotary switch is to set the system address for RS485 communication. The default setting is 0 (when using for RS232 or RS422 communication). Refer to section 5.6 for details on switch settings.
- Serial communication jumpers - The jumpers located in the bottom right corner of the board select the serial communication protocol; the defaults setting is for RS232. The jumpers cannot be accessed while the processing module is assembled. Refer to section 5.7 for details on jumper settings.
- Jumpers J1 and J2 – Jumper J1 should be left open (no pins connected). Jumper J2 should have the left two pins connected (closest to the full length card connector).

### Recorder board

Figure 10 shows the layout of the ADP recorder board with important features labeled. The optional recorder board is for internal data storage during autonomous deployment.

- PCMCIA flash card - The recorder uses this non-volatile memory for data storage. Recorder sizes from 10 to 80 Mbytes are available.
- Card release switch - This switch is to eject the PCMCIA card from its mounting fixture. When assembled, the card is physically secured using an external bracket. The card should not need to be removed during normal operation.
- Full length card connector - The full length card connector (64 pins) on the left side of the board mates above to a connector on the bottom of the CPU board.

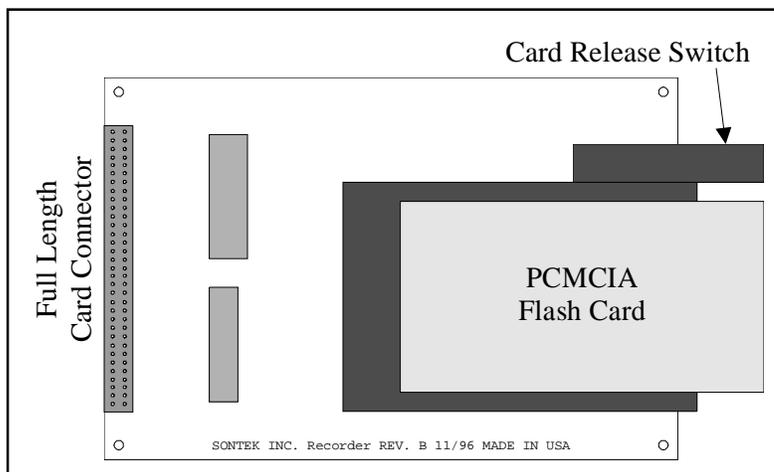


Figure 10 – ADP Recorder Board

## 5.4. Cables and Connectors

The information in this section is intended to allow customers to construct their own cables for interfacing to the ADP. The ADP is supplied with all cables required for normal operations, but some applications (particularly with long cables) will require the user to build or purchase additional cables.

### 5.4.1. Stand-Alone ADP

The Stand-Alone ADP uses one external connector to supply DC power and serial communications. This is either an 8-pin or a 16-pin underwater mateable connector manufactured by Impulse Enterprises. Details on the connectors are given below.

#### Stand-Alone ADP Connector Type

Connector Type	Cable Connector Part Number	Bulkhead Connector Part Number (for info. only)
8 pin underwater mateable	IL-8-MP (with male locking sleeve)	BH-8-FS
16 pin underwater mateable	MIL-16-MP (with male locking sleeve)	MBH-16-FS

Impulse Enterprises manufactures all connectors and assembles all cables used by SonTek. Their address is given below.

Impulse Enterprises  
 8254 Ronson Road, San Diego, CA 92111, USA  
 Phone (619) 565-7050, Fax (619) 565-1649

The table below shows the pin out used for each connector type for RS232 and RS422 communication protocols. The wire colors shown are for the standard SonTek power and communication cable. Data transfer is listed relative to the ADP (Tx/Data Out refer to data being sent by the ADP, Rx/Data In refer to commands being received by the ADP).

#### Stand-Alone ADP Connector Wiring

IL-8-MP Pin number	MIL-16-MP Pin number	Wire color	RS232 function	RS422 function
1	1	Red	Vpower	Vpower
2	10	White	Data out	Tx+
3	11	Violet	Data in	Tx-
4	4 & 9	Drain	Drain	Drain
5	5	Yellow	Not used	Not used
6	6	Green	Not used	Rx+
7	14	Blue	Not used	Rx-
8	16	Black	Ground	Ground

When the ADP uses RS232 serial communication, the computer end of the power and communication cable is terminated with a DB9 connector for communication and a coaxial power plug for DC input power. The coaxial power connector accepts 12-24 V DC power input. The connector has the positive terminal on the inside and the negative terminal on the outside; it matches the output of the supply included with the ADP.

The DB9 connector follows the standard RS232 wiring protocol, as shown in the table below.

#### ADP Power and Communication Cable– DB9 Wiring

Pin #	Signal	Pin #	Signal	Pin #	Signal
1	Not used	4	Not used	7	Not used
2	Data Out	5	Ground	8	Not used
3	Data In	6	Not used	9	Not used

If the user has requested the system be setup for RS422 serial communication, the power and communication cable will replace the DB9 with a DB25 connector wired for RS422. Any ADP ordered with RS422 will also include a RS232/RS422 converter (which has DB25 connectors on each end) and a DB25 to DB9 converted cable; this allows the power and communication cable to be plugged directly into the serial communication port of any PC. Note that the RS232/RS422 converter includes a separate 12 V power supply that must be connected for the converter to work.

### 5.4.2. Splash-Proof Processor (Low Profile ADP)

The front of the ADP splash-proof housing has four connectors, a power switch, and a diode power light. The DB25 connector mates with the high-frequency cable from the ADP transducer head. The high-frequency cable is a custom shielded cable that is very sensitive to noise; neither the cable nor connector should be modified without contacting SonTek.

The coaxial power connector accepts 12-24 V DC power input. The connector has the positive terminal on the inside and the negative terminal on the outside; it matches the output of the supply included with the ADP. The diode on the front panel will light if the system is powered up and the power switch is on. The toggle switch on the splash-proof housing allows the system to be turned off and on when power is connected.

The DB9 connector provides access to the serial communication lines of the ADP. This connector has been wired following standard serial communication protocol. When using RS232, a simple pin-to-pin cable can connect the ADP to the DB9 serial port on a PC-compatible computer (a ribbon cable is provided with the system for this purpose). The table below gives the pin out for the DB9 connector.

**Splash-Proof ADP Processor Housing DB9 Connector Wiring**

Pin #	Signal	Pin #	Signal	Pin #	Signal
1	Rx-	4	Not used	7	Not used
2	Data Out / Tx+	5	Ground	8	Not used
3	Data In / Tx-	6	Not used	9	Rx+

The last connector on the splash-proof housing (a DB15) is not used by the ADP.

### 5.5. Hardware Configuration Switches (Analog Board)

Figure 11 shows a diagram of the hardware configuration switches on the ADP analog board (see section 5.3 for a description of the ADP processing electronics; see section 5.8 for details on accessing the ADP electronics). The switches are divided into three sets of three. Placing any switch to the right is ON (logical “1”), and to the left is OFF (logical “0”). The switch settings shown in Figure 11 are for an upward looking ADP, with compass, temperature, and recorder installed; no pressure sensor is installed.

The first set of three switches defines ADP orientation. Only one of these switches should be ON at any given time. Switch #1 indicates that the system is deployed looking up (i.e. mounted on the bottom profiling up towards the surface). Switch #2 indicates that the system is looking down (i.e. mounted on the surface profiling down towards the bottom). Switch #3 indicates that the system has been deployed looking to the side (for 2 beam, 2D ADPs only).

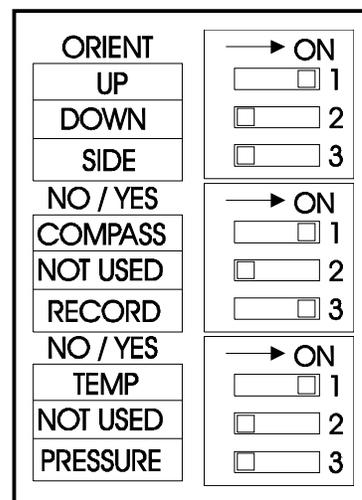


Figure 11

**IMPORTANT:** When switching between up and down-looking, the user must set the correct switch and change the physical mounting of the compass (see section 4.2 for details on changing compass orientation).

The second set of switches specifies which optional sensors have been installed. If switch #1 is ON, the system will look for the internal compass and tilt sensor. If the ADP cannot detect this sensor, it will return an error message when entering the command mode. Switch #2 is not currently used. Switch #3 indicates whether the internal recorder is installed.

The last set of switches specifies which of the analog sensors are installed. Switch #1 should be ON if the temperature sensor has been installed; all ADPs include temperature sensors. Switch #2 is not currently used. Switch #3 should be ON if the optional pressure sensor has been installed.

All switches are set to the appropriate value at the factory. The only settings that should be changed by the user are the orientation switches; these are changed whenever the user changes the ADP profiling orientation (up versus down-looking).

## 5.6. Baud Rate and Address Hex Rotary Switches (CPU Board)

Two hex rotary switches are mounted on the side of the CPU board; these switches can be accessed without disassembling the processor electronics. One switch is labeled “BAUD” and the other “ADDRESS”. The switch labeled “BAUD” is to change the communication baud rate; settings are shown in the table below. The default setting is 9600 bps (setting 3). Use a small flat blade screwdriver to rotate the switch to the desired setting.

**Baud Rate Hex Switch Settings (CPU Board)**

Hex setting	Baud rate	Hex setting	Baud rate	Hex setting	Baud rate
0	1200	3	9600	6	57600
1	2400	4	19200	7	115200
2	4800	5	39400		

The second hex rotary switch, “ADDRESS”, is intended for multiple system operation using RS485 protocol. RS485 operation is not covered in this manual. The ADDRESS switch should always be set to 0 for standard RS232 or RS422 operation.

## 5.7. Communication Protocol Jumpers (CPU board)

The ADP can use one of two serial communication protocols: RS232 (default) and RS422. RS232 is the standard protocol used by most computers; it is reliable over cable lengths to about 100 m. RS422 uses differential voltage levels to allow communications over longer cables (up to 1500 m). RS232/RS422 converters are available that let you run a RS422 system from the standard (RS232) serial port of a computer. Information for purchasing these converters is shown below.

B&B Electronics  
707 Payton Rd.  
Ottawa, IL 61350 USA  
Phone (815) 434-0846  
Fax (815) 434-7094  
Converted Part # 422COR,  
Power Supply Part # 422PS2

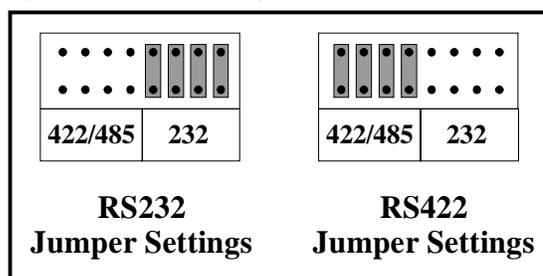


Figure 12: Communication Protocol Jumpers

The communication protocol jumpers consist of eight 2-pin pairs. Figure 12 illustrates the jumper configuration for each communication protocol. To access the jumpers, the user must disassemble the processor (see section 5.8 for details). The ADP tool kit contains everything required for this task.

## 5.8. Accessing ADP Electronics

### 5.8.1. Stand-Alone ADP

#### Opening the sensor housing

To access the Stand-Alone ADP electronics use the following steps. Although the system can be opened and closed by one person, it may be helpful to have a second person available to help with the internal wiring of the ADP (particularly for the 250 and 500-kHz systems where the transducer head is notably heavier).

1. Whenever opening the ADP, work in a clean and static free environment.
2. Refer to section 5.1 for a description of the ADP electronics internal mounting.
3. Use the wrench and hex driver from the ADP tool kit to remove the three bolts holding the transducer head to the sensor housing. Extra mounting hardware is included in the tool kit; under normal conditions the hardware should not need to be replaced.
4. Lift the transducer head straight up from the sensor housing. While lifting the head, take care not to damage the following three things: the o-rings and o-ring surfaces, the connectors to the ADP electronics, and the ground wire to the sensor housing.
5. Disconnect the ground wire from the tab on the transducer head. Note that this tab may be somewhat difficult to disconnect; if it is, try rocking the connector back and forth to loosen it.
6. There are two connectors to the processing electronics: a black 10-pin connector (serial communication) to the CPU board and a red 2-pin (input power) connector to the analog board. Remove both of these connectors. Note that the power connector may be secured with a plastic wire tie; cut this prior to removing the connector.
7. Remove the transducer head (with attached electronics) and set on a static free surface.
8. While open, take care to protect all o-rings and o-ring surfaces from damage.

#### Closing the sensor housing

1. Before closing, check that all internal hardware is in place and secure. Verify that all connectors are correctly and securely installed.
2. Check that all hardware switches are correctly set, particularly for instrument orientation (see sections 4.2 and 5.5).
3. A desiccant bag is mounted near the ADP processor. Replace the desiccant if you suspect that it may be saturated. If practical, purge the ADP housing with a dry, inert gas (Nitrogen, Argon, etc.) prior to re-assembly.
4. Clean all o-rings and o-ring surfaces, and inspect for damage. Replace the o-rings if necessary (spare o-rings are included in the tool kit). Apply a thin layer of grease to the o-rings to hold them in place during assembly (a small amount of Dow Corning #111 Valve Lubricant and Sealant is included with the tool kit).

5. Re-connect the serial communication connector (black 10-pin) to the outside connector of the CPU board (see section 5.3 for the exact connector location).
6. Re-connect the power connector (red 2-pin) to the analog board. Secure with a small, plastic wire tie.
7. Connect the ground wire from the sensor housing to the tab on the transducer head.
8. Set the transducer head onto the housing, taking care that no wires are caught between the two surfaces.
9. **IMPORTANT:** Correctly align the ADP X-axis with respect to the canister. The X-axis as stamped on the transducer head should point away from the underwater connector on the sensor housing. For an illustration of this alignment, see sections 4.2.2 and 4.2.3.
10. Install the securing hardware. There should be plastic isolating sleeves on both the head and housing sides. Tighten the bolts to be snug, but do not over torque (tighten sufficiently to compress the lock washers).

### Disassembling the processor

Following are instructions for disassembling the ADP processor. Note that the ADP internal mounting does not need to be removed from the transducer head to perform the following steps. When accessing the electronics, disassemble the system only as far as is necessary for the required maintenance.

1. Refer to section 5.3 for a detailed description of the ADP processor.
2. Whenever accessing the electronics, be sure to work in a clean, static safe environment to avoid damage to the system.
3. Disconnect the receiver board wiring harness from the black, 16-pin connector on the analog board. This connector is keyed and can only be installed in one direction.
4. Disconnect the temperature/pressure connector from the top of the analog board. This connector is not keyed, so be sure to note its alignment prior to removal. The tab on the connector should be placed towards the inside of the analog board.
5. Using the hex wrench from the ADP tool kit, remove the four screws (with flat and lock washers) from the corners of the analog board.
6. Carefully lift the analog board straight up from the DSP board. Note that it is connected to the DSP using edge connectors at each end. Take care not to bend the pins on these connectors during removal.
7. Use a ¼-inch wrench to remove the four standoffs securing the corners of the DSP board.
8. Carefully lift the DSP board straight up from the CPU board. Note that it is connected to the CPU using an edge connector at the end nearest the transducer head. Take care not to bend the pins on these connectors during removal.
9. Use a ¼-inch wrench to remove the four standoffs securing the corners of the CPU board.
10. Carefully lift the CPU board straight up from the recorder board. Note that it is connected to the recorder using an edge connector at the end nearest the transducer head. Take care not to bend the pins on these connectors during removal.
11. Use a ¼-inch wrench to remove the four standoffs securing the corners of the recorder board.
12. Lift the recorder board off the mounting hardware.

### Assembling the processor

1. Place the recorder board so that the corners align with the four standoffs on the internal mounting frame. The board should be aligned so that the PCMCIA card is furthest from the transducer head.
2. Secure the recorder board at each corner with a standoff. Tighten securely, but do not over torque as this can damage the board.
3. Place the CPU board on top of the recorder board. Take care to align all pins on the edge connector; be certain that no pins are bent or damaged. Securely press the CPU board onto the recorder board so that the connector is fully seated.
4. Secure the CPU board at each corner with a standoff. Tighten securely, but do not over torque as this can damage the board.
5. Place the DSP board on top of the CPU board. Take care to align all pins on the edge connector; be certain that no pins are bent or damaged. Securely press the DSP board onto the CPU board so that the connector is fully seated.
6. Secure the DSP board at each corner with a standoff. Tighten securely, but do not over torque as this can damage the board.
7. Place the analog board on top of the DSP board. Note that these boards are joined by edge connectors at each end. Take care to align all pins on each connector; be certain that no pins are bent or damaged. Securely press the analog board onto the DSP board so that the connectors are fully seated.
8. Secure the analog board at each corner with a screw (with flat and lock washer). Place a small amount of blue locktite on each screw before installing. This will prevent screws from coming loose due to vibration (but will still allow the system to be disassembled later). Tighten securely, but do not over torque as this can damage the board.
9. Connect the temperature/pressure connector to the top of the analog board. This connector is not keyed, so be sure to maintain its original alignment. The tab on the connector should be placed towards the inside of the analog board.
10. Connect the receiver board wiring harness to the black, 16-pin connector on the analog board. This connector is keyed and can only be installed in one direction.

### **5.8.2. Low Profile ADP with Splash-Proof Processor**

#### Opening the sensor housing

To access the Low Profile ADP sensor use the following steps. Although the system can be opened and closed by one person, it may be helpful to have a second person available to help with the internal wiring of the ADP (particularly for the 250 and 500-kHz systems where the transducer head is notably heavier).

1. Whenever opening the ADP, work in a clean and static free environment.
2. Use the wrench and hex driver from the ADP tool kit to remove the three bolts holding the transducer head to the sensor housing. Extra mounting hardware is included in the tool kit; under normal conditions the hardware should not need to be replaced.
3. Lift the transducer head straight up from the sensor housing. While lifting the head, take of the following three things: the o-rings and o-ring surfaces, the connectors to the ADP receiver board, and the ground wire to the sensor housing.

4. Disconnect the ground wire from the receiver board if necessary (the wire may be sufficiently long to allow access without removing this wire).
5. There are two connectors to the receiver board: a black 10-pin and a red 3 pin connector. Remove both of these connectors. Remove the transducer head (with attached electronics) and set on a static free surface.
6. While open, take care to protect all o-rings and o-ring surfaces from damage.

#### Closing the sensor housing

1. Before closing, check that all internal hardware is in place and secure. Verify that all connectors are correctly and securely installed.
2. A desiccant bag is mounted inside the housing. Replace the desiccant if you suspect that it may be saturated. If practical, purge the ADP housing with a dry, inert gas (Nitrogen, Argon, etc.) prior to re-assembly.
3. Clean all seal and o-ring surfaces, and inspect for damage. Replace the o-rings if necessary (spare o-rings are included in the tool kit). Apply a thin layer of grease to the o-rings to hold them in place during assembly (a small amount of Dow Corning #111 Valve Lubricant and Sealant is included with the tool kit).
4. Re-connect the black 10-pin connector to the receiver board.
5. Re-connect the red 3-pin connector to the receiver board.
6. Connect the ground wire from the sensor housing to the receiver board, if it has been removed.
7. Set the transducer head onto the housing, taking care that no wires are caught between the two surfaces.
8. **IMPORTANT:** Correctly align the ADP X-axis with respect to the canister. The X-axis as stamped on the transducer head should point away from the underwater connector on the sensor housing. For an illustration of this alignment, see sections 4.2.2 and 4.2.3.
9. Install the securing hardware. There should be plastic isolating sleeves on both the head and housing sides. Tighten the bolts to be snug but do not over torque (tighten sufficiently to compress the lock washers).

#### Opening the splash-proof processor housing

1. Remove the four screws at each corner of the front end plate.
2. Lift the front end plate from the housing. The junction between the end plate and housing is sealed with a gasket (waterproof but not intended for submersion), so it may take some effort remove the plate; prying one edge up is a good way to start.
3. Pull the end plate straight out from the housing. A number of cables join the end plate to the electronics, and the electronics should slide smoothly out of the housing. Remove the electronics completely from the housing and place the end plate / electronics assembly in a static safe area.

### Closing the splash-proof processor housing

1. Install the board stack (with end plate attached) by aligning the board edges with the extruded slots on the inside of the housing. The analog board should be the closest to the top of the housing. The boards should be installed such that the components on the analog board just clear the inside of the housing, while the pins on the bottom of the CPU board do not touch the housing at any point.
2. Align the end plate mounting holes to the four threaded inserts at each corner of the housing. Be sure that the sealing gasket is installed and in good condition.
3. Secure the end plate using the four #4-40 screws. Tighten securely but do not over torque as this can damage the threaded inserts.

### Disassembling the processor

Following are instructions for disassembling the ADP processor. When accessing the electronics, disassemble the system only as far as is necessary for the required maintenance.

1. Refer to section 5.3 for a detailed description of the ADP processor.
2. Whenever accessing the electronics, be sure to work in a clean, static safe environment to avoid damage to the system.
3. Disconnect the black, 16-pin connector from the analog board. This connector is keyed and can only be installed in one direction.
4. Disconnect the temperature/pressure connector from the top of the analog board. This connector is not keyed, so be sure to note its alignment prior to removal. The tab on the connector should be placed towards the inside of the analog board.
5. Carefully lift the analog board straight up from the DSP board. Note that it is connected to the DSP using edge connectors at each end. Take care not to bend the pins on these connectors during removal.
6. Carefully lift the DSP board straight up from the CPU board. Note that it is connected to the CPU using an edge connector at the end nearest the transducer head. Take care not to bend the pins on these connectors during removal.

### Assembling the processor

1. Place the DSP board on top of the CPU board. Take care to align all pins on the edge connector; be certain that no pins are bent or damaged. Securely press the DSP board onto the CPU board so that the connector is fully seated.
2. Place the analog board on top of the DSP board. Note that these boards are joined by edge connectors at each end. Take care to align all pins on each connector; be certain that no pins are bent or damaged. Securely press the analog board onto the DSP board so that the connectors are fully seated.
3. Connect the temperature/pressure connector to the top of the analog board. This connector is not keyed, so be sure to maintain its original alignment. The tab on the connector should be placed towards the inside of the analog board.
4. Connect the black, 16-pin connector to the analog board. This connector is keyed and can only be installed in one direction.

### **5.8.3. Replacing ADP Processor EPROMs**

Periodically, there may be an upgrade available for either EPROM (CPU or DSP) in the ADP processor. These upgrades can either be installed by the user, or the system can be sent to SonTek to install the upgrade. Whenever an upgrade is installed at SonTek, a complete test of the system will be performed to verify all aspects of ADP performance.

1. Perform the upgrade in a clean, static-safe environment.
2. Follow the instructions in sections 5.8.1 and 5.8.2 to open the ADP housing and disassemble the processor card stack.
3. Locate the EPROM to be changed on either the CPU or DSP board; refer to section 5.3 to find the appropriate chip.
4. Remove the old EPROM using a small flat blade screw drive. Carefully lift up each edge of the EPROM until you can lift the chip up by hand. Set the old chip aside in a safe location until you have verified system operation with the new chip.
5. Install the new chip into the appropriate socket. Align the half circle on the chip with the half circle on the socket and on the board. Take care not to damage or bend any pins while installing the chip. Seat the chip securely into the socket with your fingers.
6. Follow the instructions in sections 5.8.1 or 5.8.2 to assemble the processor card stack and close the ADP housing.
7. Establish communication with the system and verify that you can start data collection before discarding the old EPROM.

### **5.9. Battery Pack Access and Installation**

This section discusses accessing and replacing battery packs in the external battery housing. ADP battery packs, either alkaline or lithium, consist of 36 D-cell batteries welded together. Alkaline battery packs are wired to provide a nominal 18 V output, while lithium packs provide 21.6 V. Refer to Appendix 2 for details about battery pack construction.

The external ADP battery housing is constructed from PVC and is designed to hold three battery packs. The bottom end cap is permanently attached. The top end cap, with the 2-pin underwater mateable connector, screws into the housing and is sealed with a face seal o-ring. The battery housing is rated for deployment depths to 200 m. Internally, the battery packs are held in place using compressive foam pads and a retaining ring.

#### Opening the battery housing.

1. Vent off any differential pressure within the housing by loosening (or removing) the vent screw on the top end cap.
2. To remove the cap, turn the cap counterclockwise while holding the housing still.
3. If more leverage is needed, insert steel dowel pins (included with the ADP tool kit) into the holes on the end cap. Use a bar wedged between the pins as a lever arm to loosen the cap. Tapping lightly with a hammer on this bar while holding the cylinder will loosen the cap.
4. Once started, the cap should turn easily.
5. Upon removal of the cap, disconnect the wires to the battery packs and place the cap in a suitable location, which will protect the o-ring groove and threads from damage.
6. Ensure the o-ring seating surface on the housing is protected from mechanical damage while the cap is removed.

### Closing the battery housing

1. Clean the o-rings and o-ring surfaces, and inspect for damage. Replace the o-rings if necessary (spare o-rings are included in the tool kit). Apply a thin layer of grease or the o-rings to hold in place during assembly (a small amount of Dow Corning #111 Valve Lubricant and Sealant is included with the tool kit).
2. Connect the battery pack leads to the connectors on the battery cap.
3. Ensuring that the o-ring seating surface on the housing is protected from mechanical damage, place the cap on the housing.
4. Rotate the cap counterclockwise 1-2 turns. This will help to align the threads on the cap with the threads in the housing and prevent cross threading.
5. Tighten the cap (clockwise) with your hands as far as possible.
6. Place the two dowel pins in the holes provided in the cap. Tighten further by using a bar between the dowel pins as a lever. Tighten the cap until it has bottomed out on the housing; this is sufficient to ensure the o-ring seal is in place. Do not over torque as this will make the housing difficult to open in the future.
7. Ensure the vent screw is tightened.

### Battery pack removal

1. Use a large flat bladed screwdriver to lift the notched end of the retaining ring away from the housing wall. With the other hand, insert a small flat blade screwdriver between the retaining ring and the retaining plate. Lift the retaining ring up towards the top of the housing.
2. After removing one end of the retaining ring from the groove, the entire ring can be removed using a spiraling motion. Take care to avoid damage to the thread and o-ring surfaces while removing the retaining ring.
3. Remove the retaining plate and cushioning pads from the top of the battery packs.
4. Remove each battery pack using the Velcro handle provided.

### Battery pack installation

1. Place one cushioning pad on the bottom of the housing before installing any battery packs.
2. Place the three packs into the housing on top of one another. During installation, align the wires from each back along the same side of the housing.
3. Place a number of cushioning pads on top of the upper battery pack. The pads should be slightly above the retaining ring groove (1-2 cm / 0.5-1.0 in).
4. Feed the battery leads through the large hole in the retaining plate and compress the cushioning pads with the battery cover until the retaining ring groove is exposed.
5. Insert the retaining ring into the retaining ring groove while keeping the retaining plate pressed down on the cushion pads. The ring will snap easily into place if pressed onto the retaining plate until the groove is exposed.
6. Ensure that the retaining ring is securely set into the groove around the entire diameter of the housing.
7. Check that the batteries are securely held in the housing by lifting the housing and gently shaking it from side to side.

### Spare parts kit

The following parts relating to the battery housing are included with the ADP tool kit.

- 4 - 1/4" x 1 3/4" stainless steel dowel pins
- 2 - 2-258 nitrile rubber o-ring
- O-ring silicon lubricant.

For information only: The retaining ring is a Spirolox UR-575 Retaining Ring, and the vent plug is a Parker 4 HP50N 316 Stainless Steel Plug.

## SECTION 6. Operational Considerations

### 6.1. Power Supply and Real-time Clock Backup Battery

The ADP operates on 12-24 V DC input power. The exact power consumption varies with system frequency and user operating parameters, but is typically in the range from 1.5-3 W (see section 7.2). In sleep mode it consumes less than 1 mW. If the input voltage is less than 12 V, the ADP will not operate reliably. A supply voltage greater than 24 V can damage the ADP electronics. The ADP measures and stores the input voltage; this can be accessed from the direct command interface (see section 3.10) and the binary data files (see the ADP Software Manual).

When running the ADP from batteries, keep track of battery capacity to prevent the loss of data because of insufficient power. Note that the ADP internal recorder uses a solid state PCMCIA card for data storage and will not be affected if the batteries are drained. See section 7.2 for details about estimating power consumption and battery life.

The ADP also includes a backup battery (one lithium AA cell) to power the system clock when main power is unavailable. Under normal operating conditions, this battery can be expected to last for many years; however, we recommend replacing it every 2-3 years for safety. If the backup battery dies, the system clock will reset when main power is disconnected. The replacement battery should provide a minimum output voltage of 3.5 V.

Note that when the ADP power supply is cycled (turned off and on), it will enter whatever mode it was in previously (command mode, data acquisition mode, deployment mode). If the ADP was in sleep mode before cycling the input power, it will enter command mode. If the ADP was in deployment mode, on power up the ADP will enter deployment mode and begin data collection immediately (ignoring the start date and time settings). This is to avoid data loss in the event that the ADP clock is reset (see section 3.2).

### 6.2. Mounting and Handling the Sensor

The ADP has been designed for easy mounting and deployment. The following is general advice to simplify deployment procedures and avoid instrument damage.

- All acoustic transducers must be completely submerged during data collection. Operating with the transducers out of water will not cause damage, but will result in meaningless data.
- When mounting the ADP near underwater obstructions (bridges, piers, lines, cables, etc.) take care that the acoustic beams will not see the obstructions. The ADP transducers generate acoustic beams where the majority of the energy is concentrated in a cone only a few degrees wide. The center axis of each beam is perpendicular to the face of the transducer; transducers are slanted 25° from the vertical. Although these beams are very narrow, obstructions near the beams may interfere with velocity measurements. Additionally, large obstructions will cause significant flow interference, which can have a major impact on velocity data. In general, we suggest that the ADP is deployed a distance of at least 2-3 times the water depth from any major underwater obstructions.
- With the exception of 2 beam systems (for horizontal profiling), the ADP is designed for vertical profiling either looking up or down. Deployments resulting in non-vertical profiling must be carefully considered, and are not encouraged.

- For most vertical profiling applications, the instrument should be as close to as level as possible (ideally within 10°). Although the tilt sensor can measure tilt angles to 50°, installation tilts of more than 15-20° may have a significant impact on velocity data.

There are three mounting holes on the bottom of the ADP housing, each aligned with one acoustic beam. The mounting holes are designed for use with 1/4" bolts with plastic screw isolators. The isolators protect the canister from damage and serve to electrically isolate the instrument from the mounting frame and bolts. Additional isolators are included in the ADP tool kit.

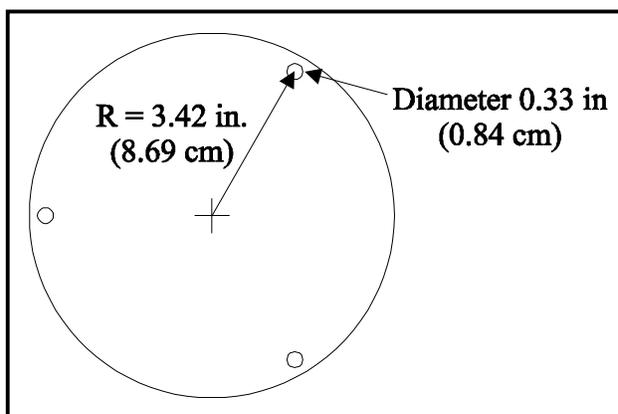


Figure 13 – ADP Mounting Bolt Pattern

Figure 13 shows the bolt pattern for the mounting plate. The sensor can be mounted a variety of ways, but always be careful not to damage the transducers or the sensor housing. In all mounting operations, take care to provide protection for the underwater cable and connector. The cable and connector should never be used to raise or lower the ADP, or as a structural part of a mounting frame.

When using the optional compass/tilt sensor, we do not recommend the use of magnetic material in the construction of the mounting frame. If magnetic material must be used, be sure to perform a compass calibration while the ADP is attached to the mounting frame to attempt to remove any interference in compass heading measurements (see section 4.4).

### 6.3. ADP Coordinate System

The ADP supports three coordinate systems for velocity data: ENU (East-North-Up), XYZ, and BEAM. The coordinate system setting is determined in the setup menu of the real-time software (see the ADP Software Manual) or using the “CoordSystem” command from the direct command interface (see section 3.7).

#### ENU (East-North-Up) coordinate system

For systems with the optional compass/tilt sensor, velocity can be recorded in ENU (East-North-Up) coordinates. Using the ENU coordinate system allows the ADP to report velocity data independent of instrument orientation (within limitations – see SECTION 4).

Using the ENU coordinate system also allows the ADP to vector average samples within each profile (using updated compass/tilt information); if ADP orientation changes during the averaging interval, velocity data will still reflect the true water velocity. When using the XYZ or BEAM coordinate system, velocity data can be corrupted if the ADP orientation changes during the averaging interval. SonTek recommends using the ENU coordinate system except for specialized applications by experienced users.

Whenever using the ENU coordinate system, or whenever recording data from the internal compass/tilt sensor, be sure that the compass installation matches the hardware orientation settings. See sections 4.2 and 5.5 for details.

### XYZ coordinate system

When using the XYZ coordinate system, velocity measurements are stored using a right handed Cartesian coordinate system relative to the ADP. The positive X-axis is stamped into the transducer head for easy reference. When the transducer head has been properly installed, the X-axis should point away from the underwater connector on the ADP housing (see section 4.2).

The definition of the XYZ coordinate system depends upon the setting of the hardware orientation switch (see section 5.5). For up-looking operation, the positive Z-axis is defined as upwards along the axis of the sensor housing away from the transducer head. For down-looking operation, the positive Z-axis is defined along the axis of the sensor housing from the top of the transducer head into the housing. In both cases, the positive Z-axis is vertically up based upon the orientation of the system. The Y-axis is always defined from the X and Z-axes to give a right hand coordinate system.

Note that the alignment of the Y and Z-axes with respect to the ADP housing reverse depending on the ADP orientation.

For 2-beam side-looking systems, the positive Y-axis is defined along the axis of the sensor housing away from the transducer head. For a normal deployment orientation (with the cable from the sensor housing going vertically up), this results in the standard configuration of the positive Z-axis as vertically up (although 2 beam system measure velocity only in the XY plane).

### BEAM coordinate system

When using the BEAM coordinate system, the ADP reports along beam velocity; positive velocity is away from the ADP, negative is towards the ADP. The X-axis stamped on the transducer head always points to beam number 1. If the ADP is placed on the floor with the transducer looking up (with the user looking down at the systems) the transducer are number clockwise from #1.

Beam numbering is identical for a 2-beam, 3-beam or 4-beam Janus configuration (clockwise from beam 1). For a 4-beam system with a vertical beam, the slanted beams are numbered 1-3 as described above and the vertical beam is number 4.

## **6.4. Serial Communication Protocol**

The ADP supports RS232 and RS422 serial communication protocols. Switching between RS232 and RS422 changes the electrical interface and has no effect on the command interface of the ADV. The default setting is for RS232; this is the same protocol used by the standard serial ports on PC-compatible computers and is considered reliable for cable lengths to about 100 m.

RS422 communication uses differential voltage signals to increase immunity to external noise. This allows operation over longer cables; RS422 is considered reliable for cable lengths to 1500 m. RS232 to RS422 converters are available commercially and allow an ADP using RS422 communication to be connected to the RS232 serial port of a PC-compatible computer. One supplier for this type of converter is shown below.

B&B Electronics

707 Payton Rd.

Ottawa, IL 61350 USA

Converted Part # 422COR, Power Supply Part # 422PS2

Phone (815) 434-0846

Fax (815) 434-7094

Refer to section 5.7 for information on jumpers used to change the ADP serial communication protocol.

## 6.5. Temperature and Pressure Sensors

### Temperature sensor

To measure temperature, the ADP uses a thermistor mounted on the inside of the transducer head. For systems constructed from plastic, the thermistor is mounted in a counter-bore hole on the inside of the transducer head very close to the exposed surface (to minimize the insulating effects of the plastic). The temperature sensor has a specified accuracy of  $\pm 0.1^{\circ}\text{C}$ , which is more than sufficient for sound speed measurements (for details on the effects of sound speed, see the ADP Principles of Operation). Temperature data are sampled once per second during the averaging interval; mean and standard deviation of these samples are recorded with each profile.

### Pressure sensor

If the optional strain gage pressure sensor is installed, it is mounted in a recessed hole on the top transducer head. The pressure sensor is connected to a small printed circuit board mounted on the back of the ADP processor (Stand-Alone ADP) or above the receiver board (Low Profile ADP). Outputs from the pressure sensor board are connected to the temperature/pressure connector on the ADP analog board (see sections 5.1 and 5.3 for details).

The pressure sensor is mounted in the ADP transducer head as pictured in Figure 14. The sensor is recessed and isolated from the water (for corrosion protection) by a diaphragm and silicon oil reservoir. The diaphragm is held in place by a plastic retaining plug that screws into the end cap. The pressure sensor forms a water tight seal using a bore seal o-ring. For added leak protection, the path into the ADP housing is filled with epoxy. Under normal conditions, the user should not need to access the sensor directly. If you suspect problems, please contact SonTek before trying to access the sensor.

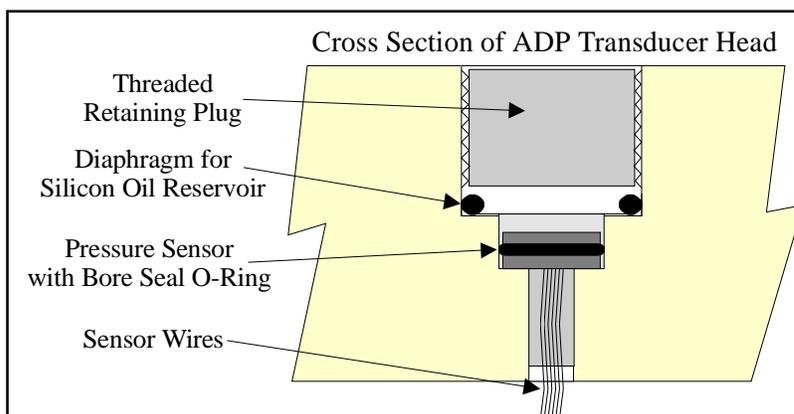


Figure 14

Data from the pressure sensor is sampled by the ADP electronics using a 12-bit A/D converter. Data is converted to a 2-byte integer scaling the A/D counts by 16 (giving a total count range of 0-65520, with a step size of 16 counts). Pressure data are stored in counts that must be converted to physical units (decibar) using three calibration constants. Pressure in counts is converted to decibar using the following formula.

$$\text{dbar} = \text{PressOffset} + (\text{PressScale} \times \text{Counts}) + (\text{PressScale}_2 \times (\text{Counts}^2))$$

where

dbar = measured pressure (decibar)

PressOffset = offset calibration constant set at factory (decibar)

PressScale = linear (1<sup>st</sup> order) calibration constant set at factory (decibar/count)

PressScale\_2 = quadratic (2nd order) calibration constant set at factory (decibar /count<sup>2</sup>)

Counts = measured pressure (counts)

The values for PressOffset, PressScale and PressScale\_2 can be accessed three ways: through the direct command interface (see section 3.10), from the data conversion software \*.CTL file (see the ADV Software Manual), or directly from the binary data file. In the first two methods, PressOffset and PressScale are output with the units shown above and can be entered directly in the formula above. PressScale\_2 is output with units of (10<sup>-12</sup> decibar/count<sup>2</sup>) and must be multiplied by (10<sup>-12</sup>) before using in the above formula.

When using the binary data directly, each constant is stored as a long integer and must be converted to the appropriate units before using. PressOffset is stored in units of microbar and must be multiplied by 10<sup>-5</sup>. PressScale is stored with units of (nanobar / count) and must be multiplied by 10<sup>-8</sup>. PressScale\_2 is output with units of (pico-decibar/count<sup>2</sup>) and must be multiplied by (10<sup>-12</sup>). See Appendix 2 for details on the binary data format.

When using the data conversion software to extract ADP binary data files into ASCII format, the conversion from counts to decibar is done automatically by the software.

## 6.6. Routine Maintenance

Under normal conditions, the ADP requires little maintenance for years of reliable performance. Normal wear does not change performance and the instrument never requires re-calibration for velocity data. This section discusses a number of routine maintenance procedures we suggest following.

### Zinc anodes

The ADP housing includes sacrificial zinc anodes for corrosion protection. Under normal operating conditions, these anodes will last for several years. However, the lifetime of zinc anodes is highly variable depending upon the deployment environment. Anodes should be checked regularly - to check anode condition, scratch the anode with a screwdriver. If large pieces of the anode can be removed, the anode should be replaced. The anodes are a standard size that can be purchased through most marine supply stores. Please contact SonTek if you have trouble locating replacement anodes.

### Cleaning the transducers

Biological growth on the transducers does not affect velocity measurements, but can decrease acoustic signal strength and reduce the effective profiling range of the ADP. Periodic cleaning of the ADP transducers may be needed to maintain optimal performance in areas of high biological activity.

High frequency ADP transducers (1.5 and 3.0 MHz) and encapsulated in an epoxy that is impervious to damage from barnacles or other types of growth. To remove growth, simply clean with a stiff (non-metallic) brush. The transducer epoxy is very durable and cannot be easily damaged except by direct impact.

The 250 and 500-kHz ADP transducers are encapsulated in polyurethane (to increase efficiency at the lower acoustic frequency). The polyurethane is softer than the epoxy used with higher frequency transducers, and more susceptible to damage. Extended barnacle growth on the 250 and 500-kHz transducers can potentially cause serious transducer damage. Take care when removing growth to avoid damage to the transducer. Carefully clean 250 and 500-kHz transducers with a stiff (non-metallic) brush.

We recommend coating the transducers with anti-fouling paint for deployments in regions of high biological activity (see section 6.8).

### Cables

The underwater cables used with the ADP are often the most vulnerable portion of the system. All standard SonTek cables use a durable polyurethane jacket that provides excellent long-term wear and abrasion resistance. However, any underwater cable is susceptible to damage and reasonable precautions should be taken. Inspect all ADP cables and connectors for damage on a regular basis, and replace if necessary.

### O-rings

All ADP housings use a dual (redundant) o-ring seal wherever possible. All SonTek o-ring seals are designed for full ocean depth pressures, even if the housings and transducers have much lower pressure ratings. The o-rings will provide faultless performance as long as care is taken whenever the system is opened. Whenever the housing is opened, clean and inspect all o-rings and o-ring surfaces; replace o-rings when necessary. While the system is open, protect o-ring surfaces from scratches or other damage. Spare o-rings are included in the ADP tool kit.

### Condensation in ADP Housings

Moisture in the air can potentially damage ADP electronics if it is allowed to condense inside the ADP housing. To prevent this, all underwater housing include an internal desiccant pack to absorb moisture. Whenever opening the ADP housing, take care to minimize the exposure of the desiccant to humid air. If you suspect the desiccant has been exposed sufficiently to saturate, replace the packet before closing the housing (spare desiccant is included in the ADP tool kit). When possible, purge the housing with a dry, inert gas (Nitrogen, Argon) before closing.

## **6.7. Trouble Shooting**

This section provides some basic pointers for trouble shooting problems with the ADP, and should be useful in establishing the exact cause of most typical problems. If you have trouble finding the source of a problem with the ADP, please contact SonTek directly.

### Cannot communicate with the ADP

If you are unable to establish communications with the ADP, the following list may help in identifying the problem.

- Power source - be sure that the power supply is providing between 12-24 V DC. When power is first connected to the ADP, it should automatically wake up and enter the last mode it was in (command mode, data acquisition mode, or deployment mode – see sections 3.1 and 3.2). Measure the input current when power is applied – it should typically be 50-200 mA. Try using an alternative power source if possible.

- Computer – be certain that the computer serial port is functioning correctly; ports on some laptop computers have been known to have problems. Try using another computer if possible.
- Communication parameters - be certain that the baud rate, communication serial port, and other operating parameters match ADP settings (see SECTION 3).
- Cable connections - be sure that all wiring to the ADP is securely connected and that each connector is properly wired.
- If the ADP software programs are unable to establish communications (ADPSA, COMPCAL, SONREC), try direct communications using a terminal emulator (SONTERM). When power is applied, see if the ADP will respond to a BREAK.
- Fuse - there is an input power fuse on the top corner of the analog board (see section 5.3). The fuse can be pulled directly from the socket on the board and tested for conductivity. Spare fuses are included with the ADP tool kit.

#### Compass/tilt sensor

If you suspect a problem with the ADP compass/tilt sensor, follow the procedure outlined in section 4.1 for a basic function test. Performing the test using both the output from the terminal emulator and the compass calibration software. If problems with heading data are apparent, perform a compass calibration and re-test compass function. A bad compass calibration can cause a major distortion to the heading data. Whenever testing compass operation, be sure the ADP is oriented properly based upon compass installation (up or down looking – see section 4.2).

#### Unreasonable velocity data

If the velocity data from the ADP does not appear reasonable, the following list may be helpful in establishing the source of the problem.

- Check the signal amplitude and signal to noise ratio (SNR) data. See the ADP Principles of Operation for a description of the expected behavior of these data. Be sure that the data have a sufficient SNR for reliable operation. Check that no large objects (structures, lines, fish, etc.) are interfering with the ADP acoustic beams.
- Check the standard deviation data. See the ADP Principles of Operation for a description of the expected behavior of these data. Check that the standard deviation values are reasonable based upon the values of averaging interval and cell size (see the ADP Principles of Operation to calculate the expected standard deviation). Large standard deviation values (with sufficient SNR levels) may be caused by motion of the deployment package. Look at the compass/tilt sensor data to see if the system orientation shows large changes.
- Look at the compass/tilt sensor data. In particular, look for large tilt values that may indicate that the deployment package is not laying flat (or is even upside down). Also observe how these values change with time to see if the deployment package is moving.
- Consider any possible influences of the deployment environment. Common problems include underwater structures, deployment lines and cables, and schools of fish attracted by underwater moorings. Also consider possible nearby sources of flow interference (bridges, piers, etc.) that might change the expected velocity signal. Areas of highly turbulent flow and large amounts of submerged bubbles can also affect velocity data.
- Look at the data from the temperature and pressure (if installed) sensors to see if the sensors are reporting reasonable values.

- Re-evaluate the deployment parameters (particularly cell size, number of cells, and all timing parameters) to see if these might have had some unforeseen effect on ADP performance.

#### Cannot retrieve data from internal recorder

There are several common causes of communication errors when retrieving data from the ADP internal recorder, as listed below.

- The software is being run from a DOS prompt within Windows rather than a dedicated DOS environment. Memory resident features of Windows interfere with serial port operation. All ADP software should be run from a dedicated DOS environment.
- The data extraction baud rate is too high for reliable operation. This can be a function of the length and quality of cables, the computer, and the operating environment (for external sources of noise). Run SONREC using a lower extraction rate (see the ADP Software Manual).
- Some computers have poor quality serial ports and are unable to retrieve large amounts of data at high baud rates. Run the data retrieval software using a lower extraction rate (see the ADP Software Manual). If problem persists, use another computer if possible.

If you are still unable to retrieve data from the internal recorder using SONREC, establish direct communications with the ADP and use the recorder commands to access data files directly (see section 3.9). Check that the file size and number of profiles recorded is reasonable based upon the deployment length and user setup parameters. Download the configuration and some portion of the data manually to verify that all data are present.

#### Missing data from autonomous deployment

The ADP internal recorder was designed for extremely high reliability, and we have not had a single recorder failure to date. The only data losses have occurred because of problems with the ADP power supply. If you have a deployment that appears to be missing some data, look at the date/time and battery voltage recorded with each profile. Check that these values are reasonable based upon the type of power supply used and the length of the deployment. If you cannot determine exactly what has occurred, place the data file (or a portion of it) on our FTP site and contact SonTek directly (see SECTION 89). We will look at the data as soon as possible.

### **6.8. Protection from Biological Fouling**

The ADP has excellent resistance to biological fouling and can operate reliably even with biological growth on the transducers. Biological growth causes a loss in signal strength (reducing the signal to noise ratio (SNR)), but does not affect velocity measurements. The loss of signal strength will act to reduce the maximum profiling range of the ADP.

Both the ADP transducers and the underwater housings can be coated with commercial anti-fouling paints to prevent biological growth. If applied properly, the paint will have no effect on the instrument housing, although it can potentially decrease the lifetime of the sacrificial zinc anodes. Thick layers of anti-fouling paint on the transducers will cause a decrease in acoustic signal strength and will reduce the effective profiling range of the ADP. However, for most applications the loss of signal strength caused by anti-fouling paint does not have a significant effect on instrument performance (typical loss is 5-10% of maximum profiling range).

Within the United States, we recommend using an anti-fouling paint called Interlux Tri-Lux II on all areas except 250 and 500-kHz transducer (see below). This contains a biocide, a copper derivative, which allows its use on all metals, including aluminum. For information on Interlux paints, contact:

Courtaulds Coatings  
2270 Morris Avenue  
Union, NJ 07083 USA  
Phone (908) 686-1300  
Fax (908) 686-8545

Normal anti-fouling paints, which use cuprous oxide based biocides, cannot be applied on aluminum as they cause galvanic corrosion. Outside the United States, anti-fouling paints containing TBT can be applied on aluminum systems with a suitable primer. On plastic systems, any type of anti-fouling paint can be used.

**IMPORTANT:** For 250 and 500-kHz transducers, use only an anti-fouling paint approved for urethane transducers. These special types of paints are available from most marine supply stores. One suitable paint is MDR Transducer Anti-Fouling Paint available from West Marine (contact information is below).

West Marine  
P.O. Box 50050  
Watsonville, CA 95077-5050 USA  
Phone (800) 538-0775 / (408) 728-4430  
Fax (408) 728-4360

When painting metal housings, a suitable conversion layer must be applied to the metal for adhesion and to isolate the metal from the anti-fouling paint. If the metal has been powder coated (as the ADP transducers, head, and housing are), this acts as an excellent conversion layer. If no powder coat is present, or if the powder coat has been damaged, we suggest Interlux 360 Underwater Metal Primer. The primer should be applied to all exposed metal surfaces **except** sacrificial zinc anodes. The primer should not be applied to the transducers, the cable, or to areas where the powder coat is intact. Apply the anti-fouling paint to all surfaces of the instrument that require protection. Follow the instructions on the paint container with the following exceptions.

- Apply only **one** coat of anti-fouling paint to the transducers. Each layer of paint will cause some loss in signal strength and multiple layers can potentially affect system performance. Ensure that the paint has a smooth, even surface with no air bubbles.
- **IMPORTANT:** Do not paint the sacrificial zinc anode. Doing so will remove all corrosion protection.

If anti-fouling protection is desired for some portion of the cable, the paint can be applied directly to the polyurethane jacket without primer.

---

## SECTION 7. Autonomous Deployment

### 7.1. Selecting ADP Operating Parameters

The choice of ADP operating parameters depends upon the nature of the deployment and the goal of the study. While many applications would prefer the finest possible spatial and temporal resolution, this must be balanced with instrument performance, battery power limitations, and data storage requirements. Some guidelines for selecting the most important ADP operating parameters are given below. For more information about each parameter, see SECTION 3.

*System parameters: output mode, output format, recorder, recorder mode*

The settings of output mode (Auto/Polled) and output format (ASCII/Binary) are not important for autonomous deployment, as they affect only the data output over the serial port and not data stored to the internal recorder. The recorder setting (On/Off) only affects data collection initiated with the “Start” command; all autonomous deployments should be initiated with the “Deploy” command which will force the recorder “On”. The recorder mode setting (Normal/Buffer) is typically “Normal” for autonomous deployments; the system stops recording data when the recorder is full. Buffer mode, where the oldest data are overwritten when the recorder is full, is typically selected when the recorder is acting as a data backup for real-time data installations.

*Sound speed: temperature, salinity, and temperature mode*

For most ADP deployments, temperature mode is set to “Measured” and the user-specified temperature has no effect on instrument operation. User input salinity should be as accurate as is practical; in regions with large variations, a mean value should be entered. A salinity error of 12 ppt results in a velocity error of 1%, so salinity variations typically have a minimal effect. If precise temperature and salinity records are available, ADP velocity data can be easily corrected for sound speed errors in post-processing (see ADP Principles of Operation).

*Coordinate system*

For most ADP deployments, the ENU (East-North-Up) coordinate system should be selected. This allows the instrument to perform a vector average of velocity data during each averaging interval. If ADP orientation changes, the mean profile reflects the true velocity and is not contaminated by instrument motion. Other coordinate system settings (BEAM or XYZ) are intended for experienced users in specialized applications.

*Profile definition: blanking distance, cell size, and number of cells*

For most ADP deployments, the blanking distance is left at the minimum (default) setting. Cell size is chosen based upon the desired resolution, profiling range, averaging interval, and accuracy. If the total water depth is near the maximum profiling range of the ADP, a larger cell size uses a longer pulse and will give a longer effective profiling range. See the ADP Principles of Operation for details on calculating the expected accuracy based upon the cell size and averaging interval.

The number of cells selected is based upon the cell size and the expected profiling range. SonTek recommends recording several cells beyond the expected end of the profile. This ensures that all meaningful velocity data are recorded and provides useful diagnostic data for post-processing. However, the number of cells should not be extended considerably beyond the expected profiling range, as this will increase data storage requirements and can potentially reduce the system pinging rate and increase the uncertainty in velocity data.

*Timing parameters: averaging interval, profile interval, and burst sampling*

As mentioned above, the choice of averaging interval is coupled with cell size and the desired accuracy. However, in many environments the required averaging time is not determined by the ADP, but by real variations in the flow. All of these factors should be taken into consideration when determining the averaging interval for a given deployment.

For most autonomous deployments, the combination of averaging interval and profile interval determines the instrument duty cycle and thus the total battery life. Burst sampling (collecting a number of profiles in rapid succession followed by a sleep period) allows the user to monitor both the short-term and long-term variations in flow, while maintaining a low overall duty cycle. Burst sampling increases the amount of data recorded and may encounter limitations on storage space. The increased data storage requirements and retrieval time required for burst sampling may have a significant impact on field operations. For details on storage requirements, see section 7.2. For details on data retrieval times, see the ADP Software Manual.

*Pinging rate and ping interval*

For most ADP applications, ping interval is left at the default value of 0.0 seconds, allowing the ADP to ping as rapidly as possible. Using other settings can reduce power consumption, but at the cost of reducing the number of samples, thereby increasing the uncertainty in velocity data. Section 7.2 gives an idea of the power savings that can be expected using a reduced pinging rate. For most applications, we recommend using the default setting of 0.0 seconds.

## 7.2. Calculating Battery Life and Data Storage Requirements

### Power consumption

ADP power consumption varies primarily with acoustic frequency, cell size, and pinging rate. It also varies slightly among systems of the same frequency using the same operating parameters. Other factors that influence power consumption are mode of operation (e.g.; bottom-track on or off), internal and external sensor use, and battery temperature.

The ADP ping rate can be adjusted using the ping interval parameter (see section 3.7). The default setting of 0.0 seconds causes the ADP to ping as rapidly as possible (20, 9, 14, 6, and 2.5 Hz for the 3000, 1500, 1000, 500, and 250-kHz systems, respectively). Other settings set the minimum time between pings; a setting of 0.5 seconds gives a ping rate of 2 Hz, while a setting of 1.0 second gives a ping rate of 1 Hz. Settings less than 0.5 seconds are not used by the ADP and will result in the maximum ping rate. Settings as high as 10.0 seconds are allowed (ping rate 0.1 Hz). However, we do not normally recommend settings higher than 1.0 second, as this can cause aliasing if the ADP is deployed in a wave environment.

For most applications, we recommend using the maximum ping rate (ping interval 0.0 seconds). The power savings achieved with a lower ping rate are offset by the loss of precision in velocity data caused by the reduced number of samples. Other ping interval settings are for special applications by experienced users. If you have any questions, please contact SonTek.

Typical power consumption values for all ADP frequencies (at two cell size settings and a number of ping rates) are shown in the following table. When using ping interval to control pinging rate, power consumption scales linearly with the ping rate.

### ADP Power Consumption (W)

Frequency (kHz)	Cell Size (m)	Standard ADP	Parallel-Pinging ADP	
		Maximum Ping Rate	Maximum Ping Rate	1 Hz Ping Rate
3000	0.25	<b>2.5</b>	-	-
3000	0.5	<b>3.0</b>	-	-
1500	0.5	<b>2.0</b>	-	-
1500	1.0	<b>2.5</b>	-	-
1000	1.0	<b>2.5</b>	3.5	2.0
1000	2.0	<b>3.0</b>	4.5	2.5
500	2.0	<b>2.5</b>	5.5	2.5
500	4.0	<b>3.0</b>	7.5	3.0
250	2.0	<b>2.5</b>	5.5	2.5
250	4.0	<b>3.0</b>	7.5	3.0

#### Battery life

SonTek alkaline battery packs are wired for 18 V with a nominal capacity of 42 Ah; lithium packs output 21.6 V with a nominal capacity of 84 Ah (see Appendix 2 for battery back construction). When calculating battery life, we recommend using 80% of the nominal capacity to allow for temperature variations (nominal capacities are at 20°C) and a reasonable safety margin. Thus alkaline and lithium packs have working capacities of  $(0.8 * 18 * 42 = 600 \text{ Wh})$  and  $(0.8 * 21.6 \text{ V} * 84 \text{ Ah} = 1450 \text{ Wh})$ , respectively.

Autonomous ADP systems hold three battery packs with a total capacity of 1800 and 4350 Wh for alkaline and lithium batteries, respectively. Battery life for continuous operation is simply the total capacity divided by the system power consumption. Thus a 1.5 MHz ADP with a 1.0 m cell, using the maximum ping rate for a power consumption of 2.5 W, can operate continuously for about 30 days on three alkaline battery packs.

For most applications, the ADP can use a reduced duty cycle to conserve battery power and extend deployment length (refer to section 1.3 to calculate the duty cycle.) When not actively collecting data, the ADP consumes less than 1 mW of power; battery life increases proportionally with the duty cycle. A 50% duty cycle will double the battery life; a 10% duty cycle increases battery life by a factor of 10.

With alkaline batteries, output voltage decays with use and can be an indicator of remaining battery life. Battery voltage as measured by the ADP (see section 3.10) will typically start at a level of about 17.4 V for new alkaline batteries. Alkaline battery packs typically stop working at a measured voltage of about 14 V; capacity is roughly linear within this range. Thus alkaline battery packs with a measured output voltage of 16 V can be estimated to have slightly more than 50% of the original capacity remaining. Note that these numbers are approximate only and will vary considerably, particularly with the temperature of the deployment.

When using lithium batteries, the voltage remains relatively constant throughout battery life and does not provide an indicator of remaining battery life.

### Data storage

The amount of data per profile is a function of the number of acoustic beam (2, 3, or 4) and the number of depth cells recorded (1 to 100). The ADP profile header size is 82 bytes and the profile size is:

$$\text{PROFILE\_SIZE} = 82 + (\text{N\_BEAMS} * \text{N\_CELLS} * 4) \text{ (basic configuration)}$$
$$\text{FILE\_SIZE} = (\text{N\_PROFILES} * \text{PROFILE SIZE}) + 416$$

The profile size will also vary if the ADP includes CTD/Bottom Track/SONWAVE options. For more detail on data storage with optional features please refer to section 8.4.

The total file size is then the profile size multiplied by the number of profiles plus the file header (416 bytes). The ADP recorder is available in sizes ranging from 10 to 80 Mbytes and can accommodate a wide range of sampling strategies and deployment lengths.

The ADP recorder is divided into blocks of 64 Kbytes; only one data file can be written in each block, although one data file may occupy multiple blocks. Thus the recorder has a maximum number of files that can be stored based upon the recorder size (160 files for a recorder with 10 Mbytes capacity). If you record a large number of small data files (less than 64 Kbytes per file), the recorder will fill before reaching the rated maximum capacity.

### **7.3. Starting an Autonomous Deployment**

Autonomous deployments are started from the ADP direct command interface using a terminal or terminal emulator. The ADP software includes a DOS based terminal emulator called SONTERM (see the ADP Software Manual). See SECTION 3 regarding the direct command interface.

To start an autonomous deployment, establish direct communication with the ADP. There are four “Show” commands that display all operating parameters.

- “Show Conf” - hardware configuration parameters
- “Show System” - system operating parameters
- “Show Setup” - data collection parameters
- “Show Deploy” - autonomous deployment parameters

If you verify the settings of the parameters shown by the four commands above, you can be confident of a successful deployment. Refer to section 3.12 for sample outputs of the “Show” commands. Below is a list of recommended steps when starting an autonomous deployment. These include redundant checks to verify all aspects of ADP operation.

1. **IMPORTANT:** Always perform the deployment procedure with the ADP connected to and operating from the battery pack that will be used for deployment. Do not disconnect the battery pack after initiating the deployment (see section 3.2 for details).
2. Prior to deployment, perform a compass calibration (see section 4.4). If practical, this should be done with the system mounted in the deployment frame with batteries and other instrumentation installed.
3. Record all communication with the ADP for future reference. This can be done using the Alt+F option in SONTERM (see the ADP Software Manual).

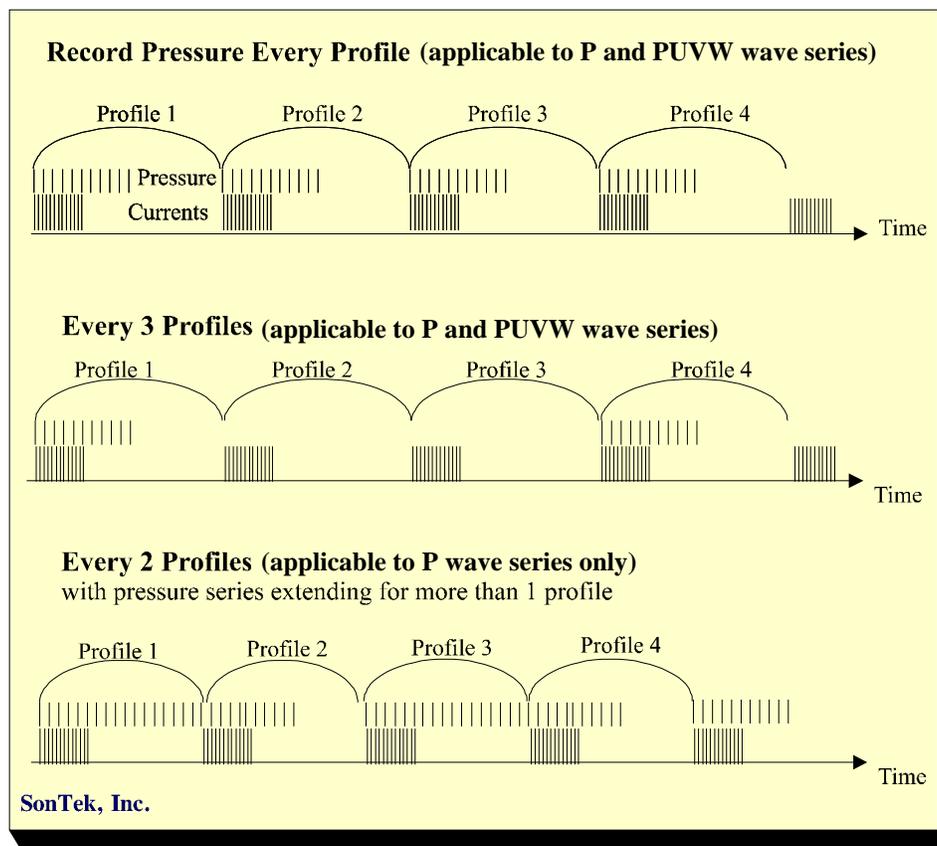
4. Send a **BREAK** to wake the system up and establish communication.
5. Send the “Show Conf” command; check parameters to see they match desired/expected settings.
6. Send the “Show System” command; check parameters to see that they match desired settings. Of particular importance are the ADP date/time and the recorder mode setting. Modify parameters as needed.
7. Send the “Show Setup” command; check parameters to see that they match desired settings. Of particular importance are cell size, number of cells, averaging interval, profile interval, and ping interval. Modify parameters as needed.
8. Send the “Show Deploy” command; check parameters to see that they match desired settings. Of particular importance are deployment name, start date and time, and the timing parameters (averaging interval, profile interval, ping interval, and burst sampling parameters). Modify parameters as needed.
9. Send “Save Setup” command to save all entered parameters (this is redundant - done automatically by “Deploy” command).
10. Check compass operation by sending “Compass CONT”. Rotate and tilt the ADP to verify performance (see section 4.1). Press any key to stop output.
11. Check recorder status using the “Dir” command. Make sure there is sufficient space for the data from this deployment; format the recorder if necessary.
12. Check overall system performance by sending the “Test” command.
13. Verify settings in all four “Show” commands one final time.
14. Send “Deploy” command to initiate the deployment. Watch for any error messages or for any unexpected response. If practical, leave the computer connected to the ADP until the first profile has been output.
15. **IMPORTANT:** Disconnect the cable from the computer prior to turning the computer off. Some computers will send the equivalent of a **BREAK** over the serial port when turned off, which can interrupt the deployment and cause the loss of data.
16. Disconnect the communication cable, install the dummy plug, and deploy the ADP.

## SECTION 8. ADP Optional Features

### 8.1. ADP Wave Package: SONWAVE / SONWAVEPRO

The SONWAVE/SONWAVEPRO wave data collection packages allow the ADP to collect wave height data, including the wave-frequency spectra. To facilitate wave measurements and reduce demands on power and storage capacity of the ADP, SonTek implemented the following scheme for pressure data collection. Beginning with firmware version 7.1 (February, 2001), commands were added to process wave times-series data for pressure (P) and horizontal (UV) velocities. When wave data collection is enabled, the ADP samples the pressure sensor at a specified rate for a specified duration and stores raw pressure data in the recorder. You can choose how often the pressure series needs to be collected: one pressure record every  $n^{\text{th}}$  profiles (Figure 15).

When recording of pressure time series is enabled, the ADP records the mean and the standard deviation of pressure over the averaging interval and stores them with the header information.



**Figure 15: Examples of different sampling strategies for recording pressure time series using the SONWAVE/SONWAVEPRO package.**

After uploading the data from the ADP to a PC, you can get a wave-frequency or directional spectrum, and/or extract the raw pressure time series, using the software provided as a part of the SONWAVE/SONWAVEPRO package. The following section describes the commands used for wave data collection with the ADP.

### 8.1.1. Setting up ADP to Collect Pressure Time Series

Wave setup commands that affect pressure time series data collection of the ADP. In this section, each command is shown (with any command line options) in *Italic*. Short versions of these commands, if they exist, are shown in parenthesis on the same line.

#### Summary of the ADP Wave Data Collection Commands

Command	Shortcut	Function
Help Wave	H wave	Help on wave data collection commands
Show Wave	S wave	Displays current setting of wave data collection
RecordWseries	RWS	Enables wave data collection and specifies how often pressure time series data is collected
WseriesRate	WSR	Sampling rate for wave (P or PUVW) time series collection; Hz
WseriesLength	WSL	Number of samples (128-4096) in wave series (P or PUVW). Note: Wave series length in seconds equals WSL/WSR.
WseriesType	WST	Selects the wave series type: P_SERIES or PUV_SERIES
OutPseriesMode	OPM	Pseries acquisition mode; AUTO or POLL

#### *S wave*

This command displays the currently active wave parameter settings.

#### *RWS <d >*

This command controls collection/recording of the pressure series data. Given without argument, RWS returns the current setting. When entered with a valid argument ( $d > 0$ ), the pressure data will be collected every  $d$  profiles (note that the time between successive pressure records will be  $d \times \text{PRI}$ , where PRI is profiling interval in s). If  $d = 0$  is specified, no pressure data is collected.

#### *WSR <d >*

This command specifies the sampling rate for the wave (P or PUVW) time series collection. When given without argument, WSR returns the current sampling rate [Hz] for collecting wave time series. When entered with a valid argument (1, 2, or 4 Hz), WSR sets the sampling rate.

#### *WSL <d >*

This command sets the length of the wave time series (in samples). When given without argument, WSL returns the current length of the wave time series. The length of the wave series in seconds equals  $\text{WSL} / \text{WSR}$ . When entered with a valid argument (128-4096 samples), WSL sets the time series length. Because the SONWAVE wave extraction software uses 128-second data segments, we recommend that WSL be a multiple of that number. For more accurate wave parameter estimation, we also recommend a minimum wave series length of 1024 seconds. However, you may choose smaller values if desired.

#### *WST <P\_SERIES / PUV\_SERIES >*

This command sets the wave series type. P\_SERIES tells the system to collect pressure series data only. PUV\_SERIES tells the system to collect pressure, U, V, and W data.

#### *OPM <AUTO/POLL >*

Pressure series acquisition mode: AUTO or POLL. A POLL mode enables a user to request wave data exactly when required.

### 8.1.2. SONWAVE/SONWAVEPRO *Output ASCII Data Format*

This section describes the format of the ADP ASCII SONWAVE data coming over a serial port when either acquiring data in real-time using a terminal emulator or reading the data from the recorder using recorder commands. This description is complimentary to Section 3.14.2. The SonWave data comes immediately after the corresponding profile data (see Section 3.14.2).

```
Wave header      32   DEFAULT      C23                1 1997 10 15 10 49 0 1 6 1 1 150
Pressure series  2000   2000      2000      2000      2000      2000
```

The header format is as follows:

- Data Type (internal)
- Number of bytes (internal)
- System serial number (c23)
- ProfileNumber
- 6 values for profile time (year, month, day, hour, minute, second)
- SensorType: 0-Strain gage, 1-Paros, 2-Druck
- WseriesRate in Hz (1, 2, or 4)
- WseriesLength in samples (128-4096)
- Wave Spectra Recorded (0-No, 1-yes)
- Water Depth (cm)
- 10 wave spectral amplitude bands (cm)
- Wave significant height Hmo (cm) and peak period (s)

A wave Header is followed by a pressure time series (P\_SERIES) consisting of WseriesLength 3-byte unsigned integers. Each integer will contain:

- For Strain-gauge, raw A/D converter counts
- For Serial Paros, pressure in 0.001 dbars
- For Druck, frequency in 0.001 Hz

If WseriesType (WST) is set to PUV\_SERIES, the above-mentioned P\_SERIES data is followed by U, V, and W data consisting of WseriesLength 2-byte unsigned integers that contain:

- U data in mm/s
- V data in mm/s
- W data in mm/s

### 8.1.3. *Wave Data Conversion: GADPPRES, GADPPUV, and GADPWAVE*

In order to extract wave information the following programs are provided:

- GADPPRES Extracts raw pressure time series.
- GADPPUV Extracts raw PUVW time series data.
- GADPWAVE Computes wave frequency spectra using recorded pressure time series.

If the name of any of these programs is entered by itself, the program will display information on its usage and a description of the parameters that can be specified on the command line.

*Pressure (or PUVW) Time Series Conversion: GADPPRES (or GADPPUV)*

This program extracts the pressure time series (or PUVW) data recorded in the ADP file and outputs data into an ASCII file in a tabular form. Each time-series can occupy several consecutive lines with each line containing the profile number corresponding to the profile when the time-series was started, followed by eight consecutive pressure values (in dbars) for GADPPRES. If GADPPUV is run, three additional lines are extracted that contain the U, V, and W data respectively (in mm/s). The command syntax is as follows.

```
GADPPRES <ADP file> <-Ooutput file> <-Nfirst_series:last_series> or
GADPPUV  <ADP file> <-Ooutput file> <-Nfirst_series:last_series>
```

Where

- <ADP file > specifies name of the ADP raw data file without an extension (.adp is assumed). This argument is mandatory.
- <-Ooutput file> specifies name of the output data file without an extension (.pts is appended for GADPPRES; .puv is appended for GADPPUV). This argument is optional, when omitted the name of the input file is used.
- <-Nfirst\_series:last\_series> allows to extract a portion of the data: first series and last series specify the first and the last series to extract. If no series number is specified the program extracts all profiles in the file.

The following example extracts pressure records from 21 to 100 from the file test001.adp, and outputs data to file test001.pts (or test001.puv if GADPPUV is used).

```
GADPPRES test001 -N21:100
```

*Wave Height Spectra Extraction: GADPWAVE*

This program extracts the pressure time series recorded in the ADP file, computes wave frequency spectra, and stores them in an ASCII file in a tabular form. Note that GADPWAVE only computes wave height spectra (non-directional); to compute wave directional spectra, use the *ViewADPPro* postprocessing software (Windows-based). Each wave record line contains the profile number (at the start of the time series), followed by wave amplitude values (cm) for 10 consecutive period bands, significant wave height (cm), and wave peak period (s). Typical command formats are as follows.

```
GADPWAVE <ADP file> <-Dwater_depth> <-Ooutput file>
GADPWAVE <ADP file> <-Dwater_depth> <-Nfirst_profile:last_profile>
GADPWAVE <ADP file> <-Dwater_depth> <-Pfilename>
```

- <ADP file > specifies name of the ADP raw data file without an extension (.ADP is assumed). This argument is mandatory.
- <-Ooutput file> specifies name of the output data file without an extension (.WAV is appended). This argument is optional, when omitted the name of the input file is used.
- <-Nfirst\_series:last\_series> allows to extract a portion of the data: first series and last series specify the first and the last series to extract. If no series number is specified the program extracts all profiles in the file.
- <-Dwaterdepth> Specifies the water depth at the deployment site. This parameter is necessary for choosing the appropriate dispersion relation in wave spectra computations. If not given, ADP depth (from mean pressure) is used. Water depth < 0 is interpreted as the height of the

ADP above the bottom (height of the ADP within the mooring structure), and it is used together with the mean pressure to determine the true water depth. Last option is most commonly used when the exact depth of the site is unknown.

- <-Pfilename> Druck or Frequency Paros calibration file. This is needed to convert the raw frequency data to actual pressure. The program assumes the filename extension is .DRK

The following example extracts pressure records from 21 to 100 from the file test001.adp, and outputs data to file test001.wav using a wave dispersion corresponding to water depth of 20 m; uses calibration file 11845261 to convert raw frequency data to actual pressure from a Druck/Paros pressure sensor.

```
GADPWAVE test001 -D20 N21-100 -P11845261
```

#### *Wave Frequency Spectra Calculations (SonWave/SonWavePro)*

The wave-frequency spectra are estimated using standard methods appropriate to simple linear theory. It includes: segmentation of the data into 256-sample segments with at least 128-samples overlap between consecutive segments; application of Hanning window to each segment with constant energy correction; and correction for sensor/water depth using a generalized first order dispersion relationship for surface waves.

The wave spectral estimates are presented as an array of coefficients, each giving the mean wave amplitude (proportional to square root of the energy) within a period band. Ten bands are used, which correspond to wave periods in the range:

Band #	Period range [s]
1	2 - 4
2	4 - 6
3	6 - 8
4	8 - 10
5	10 - 12
6	12 - 14
7	14 - 16
8	16 - 18
9	18 - 20
10	20 or longer

For each band the software computes the mean wave amplitude  $A$ , which is an integral of wave contributions within the period range in the band. If  $A_i$  is the amplitude for band  $i$ , the total wave energy is simply given by:

$$Total\ Energy\ (\sigma_A^2) = 0.5 \sum_{i=1}^{10} A_i^2$$

SONWAVE/SONWAVEPRO outputs the band amplitudes in cm for consistency with velocity data, which are reported in cm/s. A generally accepted estimate of the significant wave height can be easily obtained from the amplitudes using:

$$H_{mo} = 4\sqrt{Total\ energy}$$

For a complete description of directional wave computations, refer to the SonWavePro Application Note (SonWavePro.pdf) included in the *ViewADPPro* software directory.

#### **8.1.4. Considerations when collecting pressure data**

When wave data collection is enabled, the ADP will collect raw pressure samples spectral data at a specified interval. This has the following consequences:

##### *Data storage*

Since recording the pressure time series data requires additional memory the maximum number of profiles that can be stored in the ADP recorder is therefore reduced. To calculate recorder capacity with SonWave enabled refer to Section 8.5.

##### *Power consumption.*

With RecordWseries disabled, the ADP consumes power only during the averaging interval (power consumption during sleep is negligible- 1mW). When record pressure series is enabled, the ADP typically consumes the same amount of power during an averaging interval as when this feature is disabled. However, if the pressure series extends beyond the averaging interval the ADP will consume approximately 1 W, instead of 1 mW. This must be taken into account when calculating power requirements for a deployment.

##### *Profiling interval*

The duration of the pressure time series  $T_p$  must be at least 15 s less than the time between successive time series PRI. Also, the time between successive pressure records must differ by at least 15 s from can the duration of the profiling interval. For example, if PRI=300 s, RWS=1 (record pressure every profile), the maximum time duration of the wave series WSL must be less than 285 s. If PRI=300 and RWS=2 (record pressure every other profile), then  $315 < WSL < 585$  or  $WSL < 285$ .

## **8.2. ADP Bottom Track**

In order to perform current surveys covering large areas vessel-mounted ADPs are often employed. However an ADP profiling from the moving vessel or platform measures relative current velocities that are comprised of the water velocity plus the motion of the vessel or platform. Thus, it is important to independently measure the platform velocity so that it can be subtracted from the raw velocity measurements to yield the residual absolute currents relative to the fixed Earth. Understandably, it is desirable to perform these calculations in real-time.

SonTek now offers a Bottom Track option for ADPs that allows a user to get real-time vessel-speed over ground simultaneously with the current measurements without any external additional hardware. While bottom tracking, the ADP measures the Doppler shift of reflected acoustic energy (from the bottom of a river, harbor, etc.) to infer the vessel speed. In contrast, when an ADP is current profiling, it is measuring acoustic reflections from suspended material in the water column to determine the velocity of the water with respect to the ADP.

In bottom tracking mode the ADP determines bottom velocity once every second. At the end of the averaging interval all these estimates are averaged for each beam stored together with the rest of the profile data.

### 8.2.1. Setting up ADP to Bottom Track

In this section, each command is shown (with any command line options) in *Italic*. Short versions of these commands, if they exist, are shown in parenthesis on the same line.

#### Summary of the ADP Bottom Track Commands

Command	Shortcut	Function
BottomTrack	BT	Enables & disables Bottom Tracking mode, with or without shallow water ping data.

*BT <YES/NO/SW\_PING>*

This command enables & disables the Bottom Tracking mode. When this command is given without argument, it returns the current setting. When entered with an input argument YES or NO the Bottom Tracking will be enabled or disabled. Setting the argument to SW\_PING tells the system to enable Bottom Tracking and to also collect Shallow Water ping data.

### 8.2.2. Bottom Track Output ASCII Data Format

This section describes the format of the ADP ASCII bottom track data coming over a serial port when either acquiring data in real-time using a terminal emulator or reading the data stored in the recorder using recorder commands. This description is complimentary to the SECTION 3.14.2. The bottom track data is stored in the line immediately preceding the profile data (see p. 28).

```
(BT=YES or SW_PING) 100  221  220  220  0  115  116  140  0
(BT=SW_PING)       500  771  350  100  1650 234  150  500
(BT=SW_PING)       0    0    0    0    53   14   29   0   0   1   1   0
```

The data format is as follows:

- Line 1 (when BT=YES or SW\_PING) – Bottom track status (% good pings, indicating quality of bottom tracking); vertical range to the bottom (in mm) for each beam, bottom velocity (mm/s) for each beam.
- Line 2 (only when BT=SW\_PING) – Shallow-Water (SW) ping pulse lag (mm); ambiguity velocity corresponding to the pulse lag (velocity range) in mm/s; beginning position and length (two values) of the SW cell (mm); remaining fields are spare diagnostic fields for SonTek's in-house use.
- Line 3 (only when BT=SW\_PING) – Range to the bottom for each beam (four values in mm); velocity from the SW pulse for each beam (four values in mm/s); correlation from the SW pulse for each beam (four values in %).

### 8.2.3. Bottom Track Data Conversion: GADPBT

To extract bottom track information from the ADP data file, the following program is provided:

- GADPBT           Extracts bottom track data from the ADP data file .

GADPBT extracts the bottom track data recorded in the ADP file and outputs the data into an ASCII file in a tabular form. Each record contains bottom track information corresponding to a consecutive current profile. If the name of the program is entered by itself, the program will display information on its usage and a description of the parameters that can be specified on the command line. The command syntax is as follows.

```
GADPBT <ADP file>
GADPBT <ADP file> <output file>
GADPBT <ADP file> <output file> <-Nfirst profile:last profile> <-Mmagdecl>
GADPBT <ADP file> <output file> <-Mmagdecl> <-Ccoord system>
```

Where

- <ADP file > specifies name of the ADP raw data file without an extension (.ADP is assumed). This argument is mandatory.
- <-Ooutput file> specifies name of the output data file without an extension (.BT is appended). This argument is optional, when omitted the name of the input file is used.
- <-Nfirst\_series:last\_series> allows to extract a portion of the data: first series and last series specify the first and the last series to extract. If no series number is specified the program extracts all profiles in the file.
- <-Mddd.d> Magnetic declination in degrees. Default is *MagDecl* stored within the ADP data file. (Note: only the real-time program allows the inclusion of magnetic declination).
- <-Ccoord system> Change out put coordinates to XYZ or ENU. Default is to output data in the coordinates they were collected.

Example:

```
GADPBT test1 -O\data\test1 -M11.3 -N21:100 -CENU
```

extracts bottom track data for profiles 21 to 100 from the file test1.adp, and outputs data to file \data\test1.bt in ENU coordinates and uses 11.3° magnetic declination.

The extracted bottom track data are stored in a tabular format. The output file has a total of 9 columns, and 1 row for each profile is recorded. The table below describes the data.

**ADP Bottom Track Output Profile Data**

Column	Contents
1	Profile number
2	Bottom track status (percentage of 'good' bottom track pings during profile average)
3-5	Vertical range to the bottom (depth) [in meters] as detected by each of the 3 beams
6-8	Velocity of the bottom with respect to the ADP (in either Beam, XYZ or ENU coordinates) in cm/s

Notes:

Depth: Differences in range indicate either a non-flat bottom or that the ADP is tilted.

Velocity: Note: this is velocity of the *bottom* relative to ADP therefore it will normally be in the opposite direction from the actual velocity of the boat.

### 8.2.4. Considerations When Operating In Bottom Tracking Mode

#### *Data storage*

To store the bottom track data requires additional  $4 * \text{NUMBEROFBEAMS} + 2$  bytes to each profile, which results in a slight reduction in the maximum number of profiles that can be stored in the ADP recorder. To calculate recorder capacity with Bottom Track enabled see Section 8.5.

#### *Power consumption.*

With Bottom Tracking enabled the ADP consumes almost the same amount of power as without bottom track. Therefore, the same power consumption algorithms can be used.

#### *Profiling interval*

Since ADP tracks bottom once every second, to achieve stable performance it is advisable to have minimal averaging interval no smaller than 3 s.

### 8.2.5. Using GPS while bottom tracking with an ADP

The ADP is capable of recording GPS data while simultaneously bottom tracking. This not only provides a check between the two navigational methods, but it allows use of the GPS when the bottom is out of range. You then have all the advantages of both methods and the ADP software easily works with both data sets.

## 8.3. High-Resolution Ping Control (for Waves and SW Pings)

When using the ADP to collect wave data or shallow-water ping data, additional commands are available that relate to the coherent pulse parameters. These commands are described in this section and shown in the following table.

**Special Parameters for Collecting Wave Data and Shallow-Water Ping Data**

CBD value	CohBlankDistance – Sets desired coherent-pulse blanking distance (m)
CCS value	CohCellSize – Sets desired coherent-pulse cell size (m)
CPG value	CohPulseLag – Sets desired coherent-pulse lag (m)
CPL value	CohPulseLength – Sets desired coherent-pulse length (m)
MCL value	MinimumCorrelationLevel – Sets minimum acceptable correlation value (%)
SCP	ShowCohPulse – Shows the above-mentioned coherent-pulse settings

*CohBlankDistance* <d.dd> and *CohCellSize* <d.dd> (short commands “CBD” and “CCS”)

Because of the higher spatial resolution required for wave data and shallow-water ping data, the ADP allows the use of smaller cell sizes and blanking distances.

*CohPulseLag* <d.dd> (short command “CPG”)

CPG sets the lag between the ambiguity resolution pulses (coarse velocity measurements). This parameter will ultimately determine the maximum velocity range of the measurements. The ADP transmits an ambiguity resolution pulse before each profile and collects one velocity measurement in a single cell.

---

*CohPulseLength* <d.dd> (short command “CPL”)

Sets the length of the coherent pulse. This command is normally not set in a standard ADP, where CS=PL. However, this parameter can be manually set for specialized applications such as wave data collection and shallow-water ping data.

*MinimumCorrelationLevel* <dd %> (short command “MCL”)

MCL sets the minimum acceptable correlation value. During operation, the ADP transmits a series of pings. The results are averaged into an accumulator and stored at the end of the averaging interval. MCL lets you set the correlations level, below which the raw samples are not included in the average. A lower MCL means more data will be accepted, a higher MCL means more data will be rejected. When given without an input argument, MCL returns the current setting. Caution: Turbulent flows can cause low correlation values, which are due to the natural variability of the flow and may be acceptable for data collection.

*ShowCohPulse* (short command “SCP”)

This command displays the values of the parameters CPG, CPL, CCS, CBD, and MCL in addition to the regular ADP setup (see Section 3.7). It will also display the maximum vertical and horizontal velocities corresponding to the specified pulse lag.

## 8.4. Optional Sensors: CTD, Resonance Pressure Sensors, External Analog

The ADP can include a number of externally mounted, integrated sensors (the sensors connected to the ADP using special interface cables). Two common sensors (the SeaBird MicroCat CTD and the Paroscientific pressure sensor) are integrated using an RS232 serial interface. The Druck resonance pressure sensor is integrated using a separate board. Other sensors (OBS, transmissometer, conductivity, etc.) are integrated using analog output voltages. Depending on the type of sensor, it may receive input power from the ADP or it may use a separate power supply. For details on available sensors and configurations, contact SonTek directly.

### 8.4.1. SeaBird MicroCat CTD

The SeaBird MicroCat CTD with RS232 serial interface provides high quality conductivity, temperature, salinity, and pressure (optional) data. When integrated with the ADP, the MicroCat is sampled at the beginning of each averaging interval. Data are integrated in a CTD data structure within each ADP profile.

#### *CTD Commands*

Described below are commands necessary to setup the ADP for acquiring the CTD data. In normal operation all commands to the optional external CTD sensor are sent automatically and no direct commands need to be sent. The commands in this section are provided to assist in diagnosing problems and to give greater flexibility in ADP operations.

#### CTD Commands

Command	Shortcut	Function	
Help CTD	H/? CTD	External CTD sensor commands	
CTD	(none)	Display most recent CTD reading	
CTD CONT	(none)	Display continuous CTD readings	
CTD Talk	(none)	Direct serial communication with CTD	

#### *H CTD*

Displays help on external CTD sensor commands.

#### *CTD*

Display most recent temperature (°C), conductivity (Siemens per meter), pressure (decibar), and salinity (ppt) data from the external CTD sensor. Data are output in a self-explanatory, ASCII text format.

#### *CTD CONT*

Display most recent temperature (°C), conductivity (Siemens per meter), pressure (decibar), and salinity (ppt) data from the external CTD sensor. Data are output in a self-explanatory, ASCII text format. Press any key to stop data output and return to command mode.

#### *CTD Talk*

Establish direct serial communication with the external CTD. A manual for the CTD sensor is included; refer to this manual for more details on direct commands to the CTD. See section 8.2 for more details about the external CTD sensor. To return to command mode, type “+++” or send a BREAK to the ADP.

### 8.4.2. CTD Output ASCII Data Format

This section describes the format of the ADP ASCII CTD data coming over a serial port when either acquiring data in real-time using a terminal emulator or reading the data stored in the recorder using recorder commands. This description is complimentary to the SECTION 3.14.2, p 28. The CTD sensor data (if present) are given in a single line following the profile header data.

```
      87514    468151          0    351354
```

The data format is as follows:

- CTD Temperature (units 0.0001 °C)
- CTD Conductivity (units of 0.00001 Siemens per meter)
- CTD Pressure (units of 0.001 decibar) (note the CTD may not include a pressure sensor)
- CTD Salinity (units of 0.0001 ppt)

### 8.4.3. Resonance Pressure Sensor

#### *Paroscientific*

Paroscientific pressure sensors are the standard for long-term tidal measurements because of their accuracy and excellent stability. A Paroscientific sensor of any range can be integrated with the ADP using a RS232 interface. Pressure data are sampled once per second during the averaging interval; mean and standard deviation of pressure are recorded. Paroscientific pressure data are integrated within the ADP profile header.

#### *Druck*

Druck resonance pressure sensors can provide an attractive alternative to rather expensive and bulky Paroscientific sensor. Although Druck sensors do not have a long history their accuracy and precision is well beyond that of the strain gage. In addition, due to a fruitful collaboration with Druck engineers, we now offer a resonance pressure sensor which is integrated into the ADP head. No external hardware and wiring required!

### 8.4.4. External analog sensors

Depending on system configuration, the ADP has up to 2 available analog input channels (0-4 V DC) for integrating a variety of sensors with analog output voltages. Common applications include OBS or transmissometer data for suspended sediment studies. Data are sampled once per second during the averaging interval; mean and standard deviation are recorded with each profile. For information on available sensors, contact SonTek directly.

## 8.5. ADP Recorder Capacity With Optional Features

This section describes how to calculate the ADP recorder capacity taking into account the data from the ADP optional features.

When SonWave is enabled,

the P\_SERIES wave type of it extra PressureHeaderSize+WSL\*3 bytes to each N<sup>th</sup> profile; and

the PUV\_SERIES wave type adds PressureHeaderSize+WSL\*9 bytes to each N<sup>th</sup> profile.

Therefore, the profile size needs to be adjusted accordingly.

When the Bottom Track is enabled, 18 extra bytes are added to each profile. When a CTD is installed, 16 extra bytes are added to each profile.

The equation for computing the data storage requirements needs to be modified as follows:

$$\begin{aligned}\text{PROFILE\_SIZE} &= 82 + (\text{N\_BEAMS} * \text{N\_CELLS} * 4) + \\ &\quad 16 \text{ (if CTD data is present)} + \\ &\quad 18 \text{ (if Bottom Track is enabled)} \\ \\ \text{WAVESERIES\_SIZE} &= 82 + (3 * \text{WSL}) \text{ (when WST is P\_SERIES)} \\ \text{WAVESERIES\_SIZE} &= 82 + (9 * \text{WSL}) \text{ (when WST is PUV\_SERIES)}\end{aligned}$$

Where WSL is Wave Series Length (in samples).

The total file size then the profile size multiplied by the number of profiles plus the file header (416 bytes) plus the pressure series length multiplied by the relative fraction of pressure records expressed as the ratio of the total number of profiles / RecordWseries parameter.

$$\begin{aligned}\text{FILE\_SIZE} &= 416 + (\text{N\_PROFILES} * \text{PROFILE SIZE}) + \\ &\quad \text{NPROFILES/RWS} * \text{WAVESERIES\_SIZE} \text{ (if RWS >0)}\end{aligned}$$

Where RWS is Record Wave Series parameter, determining how often the wave time series are recorded.

---

## SECTION 9. Additional Support

Any additional questions can be directed to SonTek by phone, FAX, or e-mail. Regular business hours are 8:00 am to 5:00 p.m., Pacific Standard Time, Monday through Friday.

Phone	(858) 546-8327
FAX	(858) 546-8150
E-mail	<a href="mailto:inquiry@sontek.com">inquiry@sontek.com</a>
World Wide Web	<a href="http://www.sontek.com">http://www.sontek.com</a>
FTP	<a href="ftp://ftp.sontek.com/pub">ftp://ftp.sontek.com/pub</a>

See our web page for information concerning new products and software / firmware upgrades. SonTek also maintains an FTP site for software upgrades and data exchanges. You can either access the FTP site through our Web page or by an anonymous login to our FTP site at *ftp.sontek.com*, use your email address as a password, and use the path */pub*.

The FTP site includes a directory called “incoming” with external write privileges to accept incoming files. Note there are no external read privileges for this directory, so you will not be able to see the file after sending it to this directory. After sending the file, notify us by phone, fax, or e-mail and we will look at the data file as soon as possible.

There are a number of other directories on the FTP site providing software upgrades, demonstration software, and a variety of other information. In each directory is a file called “README” that provides information on what information is available and where to find it.

## APPENDIX A. ADP Binary Data File Format

The file format described in this appendix is valid for ADP CPU firmware versions 3.0 and higher. The data conversion software (and source code) provided with the ADP will interpret all data files, for CPU firmware versions before and after 3.0. For more information about changes in the ADP data file format, contact SonTek directly.

### A1. Overview

The basic structure of an ADP binary file with N profiles is shown below. The size of each profile is a function of the number of acoustic beams (NB can be 2, 3, or 4), the number of cells recorded (NC can be 1 to 100), and whether the file includes CTD and/or GPS data.

```
File Header 416 bytes
Profile 1 (NB*NC*4 + 82 + 16 (if CTD present) + 40 (if GPS present) (if
    Btrack is enabled) + PSL*3+80 (if SonWave is enabled)) bytes
Profile 2 (NB*NC*4 + 82 + 16 (if CTD present) + 40 (if GPS present) (if
    Btrack is enabled) + PSL*3+80 (if SonWave is enabled)) bytes
...
Profile N (NB*NC*4 + 82 + 16 (if CTD present) + 40 (if GPS present) (if
    Btrack is enabled) + PSL*3+80 (if SonWave is enabled)) bytes
```

The ADP file header consists of three binary structures in the following order.

```
ADP Sensor Configuration 96 bytes
ADP Operation Configuration 64 bytes
ADP User Setup Parameters 256 bytes
```

An ADP profile consists of three to five binary structures, depending upon whether CTD and/or GPS data are present.

```
Profile Header          80 bytes
CTD Data               16 bytes (if present)
GPS Data               40 bytes (if present)
Bottom Track Data     18 bytes (if enabled)
Profile Data           (NB*NC*4) bytes
SonWave Data          PSL*3+80 bytes (if enabled)
Profile CheckSum       2 bytes
```

Each of the structures mentioned above are described in detail (using their C language definitions) in the remainder of this appendix.

### A2. File Header Structures

Each ADP file header structure is described below using the C language definition. The first structure, “ADP Date and Time Structure,” is referenced by other structures.

#### ADP date and time structure (8 bytes)

```
typedef struct {
    int year;
    char day,
        month,
        minute,
        hour,
        sec100,
        second;
} DateTimeType;
```

ADP sensor configuration structure (96 bytes)

```

typedef struct {
    char    ConfigType;          /* Type      0x10      */
    char    ConfigVer;          /* Version   0x02      */
    int     Nbytes;             /* Bytes in configuration */
    DateTimeType    ConfigTime; /* Date created or modified */
    unsigned char   SoftwareVerNum; /* Ver number of CPU firmware*/
    unsigned char   DspSoftwareVerNum; /* Ver number of DSP firmware*/
    char           BoardRev;      /* Electronics board revision*/
    char    SerialNumber[10];
    char    AdpType;             /* 0-3; 1-1.5; 2-750; 3-500; */
                                /* 4-250; */
    char    Nbeams;             /* 2 or 3 or 4 */
    char    BeamGeometry;      /* 0- 2 Beams; 1- 3 Beams */
                                /* 2- 4 Beams, 1 Vertical */
                                /* 3- 4 Beams, Janus */
    int     SlantAngle;        /* in 0.1 deg */
    char    SensorOrientation; /* 0-down; 1-up; 2-side */
    char    CompassInstalled; /* 0-No; 1-Yes */
    char    RecorderInstalled; /* 0-No; 1-Yes */
    char    TempInstalled;    /* 0-No; 1-Yes */
    char    PressInstalled;   /* 0-No; 1-Yes */
    char    Spare1[1];        /* set to all 0s */
    int     XformMat[16];     /* From Beam to XYZ veloc. */
    int     CompassOffset;    /* Degress to East of North */
    long    PressScale;       /* Nanobar per count */
    long    PressOffset;     /* Microbar */
    char    PowerSaveMove;    /* if 1 ADP turns off after */
                                /* 5 min idle in command mode*/
    char    ExtSensorInstalled; /* 0-No; 1-Yes */
    char    ParosSensorInstalled; /* 0-No; 1-Yes */
    char    CtdSensorInstalled; /* 0-No; 1-Yes */
    unsigned int PressScale_2; /* pico dbar per count^2 */
    char    Spare2[12];      /* set to all 0s */
} AdpSensorConfigType;

```

ADP operation configuration structure (64 bytes)

```

typedef struct {
    unsigned char Bpar[64];
} AdpOperationConfigType;

```

User setup parameters structure (256 bytes)

```

typedef struct {
    unsigned char    ConfigType; /* Type      0x12      */
    unsigned char    ConfigVer; /* Version   0x01      */
    unsigned int     Nbytes;    /* Bytes in configuration */
    DateTimeType    ConfigTime; /* Date created or modified */
    int             Temp;      /* 0.1 deg C */
    int             Sal;       /* 0.1 ppt */
    int             Cw;        /* 0.1 m/s */
    unsigned int    Ncells;    /* # of depth cells in profile */
    unsigned int    CellSize; /* in cm */
    unsigned int    BlankDistance; /* in cm */
    long           SensorDepth; /* in cm      (PC ver only) */
    char           TempMode;   /* 0- User value 1- Measured */

    unsigned int    AvgInterval; /* in s */
    unsigned int    ProfileInterval; /* in s */

```

```

unsigned int   PingInterval;    /* in 0.1 s          */
unsigned int   BurstMode;       /* 0-Disabled; 1-enabled */
unsigned int   BurstInterval;   /* in s              */
unsigned int   ProfilesPerBurst;

char           CoordSystem;     /* 0-Beam; 1-XYZ; 2-ENU */
char           OutMode;         /* 0-Auto; 1-Polled     */
char           OutFormat;       /* 0-Binary; 1-Ascii    */
char           RecorderEnabled; /* 0-DISABLED; 1-ENABLED */
char           RecorderMode;    /* 0-NORMAL MODE;1-BUFFER MODE*/

char           DeploymentMode;  /* 0-Disabled; 1-enabled */
char           DeploymentName[9]; /* Dir name in recorder */
DateTimeType   BeginDeploymentDateTime;
char           CommentLine1[60];
char           CommentLine2[60];
char           CommentLine3[60];

char           AutoSleep;
char           Spare[11];       /* set to all 0s      */
} AdpUserSetupType;

```

### A3. Profile Header/CTD/GPS/Bottom Track,/SonWave/Profile Data Structures

Each structure used to record the ADP profile data is given below. Note that the profile header structure refers to the “ADP Date and Time Structure” defined in A1.2.

#### ADP profile header structure (80 bytes)

```

typedef struct
{
  unsigned char SyncChar;      /* 0xA5              */
  unsigned char DataType;     /* 0x10              */
  unsigned int  Nbytes;        /* In profile header */
  char          SerialNumber[10];
  unsigned long ProfileNumber; /* From start of data collection*/
  DateTimeType  ProfileTime;  /* At start of avg interval  */

  char          Nbeams;        /* 2/3/4            */
  char          SensorOrientation; /* 0-down; 1-up; 2-side */
  char          TempMode;      /* 0-User value 1- Measured*/
  char          CoordSystem;   /* 0-Beam; 1-XYZ; 2-ENU */
  unsigned int  Ncells;        /* # of depth cells in profile*/
  unsigned int  CellSize;      /* in cm            */
  unsigned int  BlankDistance; /* in cm            */
  unsigned int  AvgInterval;   /* in s             */

  unsigned int  Npings;        /* Averaged in profile */
  int           MeanHeading;    /* in 0.1 deg        */
  int           MeanPitch;     /* in 0.1 deg        */
  int           MeanRoll;      /* in 0.1 deg        */
  int           MeanTemp;      /* in 0.01 deg       */
  unsigned int  MeanPress;     /* in counts (0-65535) */
  unsigned char StdHeading;    /* in 0.1 deg        */
  unsigned char StdPitch;      /* in 0.1 deg        */
  unsigned char StdRoll;       /* in 0.1 deg        */
  unsigned char StdTemp;       /* in 0.1 deg        */
  unsigned int  StdPress;      /* in counts         */
  unsigned int  SoundSpeed;    /* in 0.1 m/s        */
  unsigned char Spare[2];      /* Reserved, set to 0 */
  unsigned char Status[20];    /* TroubleShooting data */
}

```

```

        /* The 16th element in this array, Status[15],*/
        /* is battery voltage in units of 0.2 V      */
        /* Thus a value of 98 gives 19.6 V          */
    } ProfileHdrType;

```

### CTD data structure (16 bytes)

```

typedef struct {
    long    Temperature;    /* 0.0001 degrees C      */
    long    Conductivity;  /* 0.00001 Siemens per m */
    long    Pressure;      /* 0.001 decibar         */
    long    Salinity;      /* 0.0001 ppt            */
} CtdType;

```

### GPS data structure (40 bytes)

```

typedef struct{
    long    StartUtc;      /* Profile start time, UTC seconds */
    double  StartLat;     /* Position at start of profile    */
    double  StartLon;     /* Decimal degrees                 */
    long    EndUtc;        /* Profile end time, UTC seconds   */
    double  EndLat;       /* Position at end of profile      */
    double  EndLon;       /* Decimal degrees                 */
} ProfileGpsType;

```

### Bottom track data structure (18 bytes)

```

typedef struct{
    int    Status;        /* % good btrack pings in average */
    unsigned int Range[MAX_BEAMS]; /* in cm                          */
    int    Vel[MAX_BEAMS]; /* in mm/s                         */
} BtrackType;

```

### Profile data structure (4\*N\_Beam\*N\_Cells bytes)

```

typedef struct
{
    int    Vel[N_BEAMS][N_CELLS]; /* in 1 mm/s */
    unsigned char VelStd[N_BEAMS][N_CELLS]; /* in 1 mm/s */
    unsigned char Amp[N_BEAMS][N_CELLS]; /* in counts */
} ProfileType;

```

### SonWave header structure (80 bytes)

A wave Header is followed by a Pressure time series consisting of PseriesLength 3-byte unsigned integers. Each insteger will contain: For Strain-gauge raw A/D converter counts. For Serial Paros pressure in 0.001 dbars; For Druck frequency in 0.001 Hz. After the time series a 2-byte checksum is added

```

typedef struct{
    unsigned char SyncChar; /* 0xA5 */
    unsigned char DataType; /* 0x20 */
    unsigned int  Nbytes; /* In profile header */
    char          SerialNumber[10];
    unsigned long ProfileNumber; /* At the start of time series */
    DateTimeType ProfileTime; /* At start of time series */

    int    SensorType; /* 0- strain gauge
                       /* 1- Paros
                       /* 2- Druck

    int    PseriesRate; /* 1/2/4 Hz

```

```

int          PseriesLength;      /* 1024/2048/4096/9192 points */
char        PseriesRecorded;    /* 0- No                      */
                                     /* 1- Pressure series follows this */
                                     /* header. 3 bytes per point      */
char        WaveSpectraRecorded; /* 0- No                      */
                                     /* 1- Period bands computed      */

unsigned int WaterDepth;        /* in cm                      */
unsigned int Aband[12];        /* 10 period-band amplitudes in */
                                     /* cm, followed by significant   */
                                     /* wave height and mean period   */
char        Spare[20];        /* set to all 0s              */
} WaveHeaderType;

```

#### A4. CheckSum Calculation

The ADP uses a CheckSum with each profile and whenever transmitting binary data over a serial port. The CheckSum is computed with the C function "ComputeCheckSum", included at the end of this section. To understand how the CheckSum is computed, assume that a profile has been placed in a segment of memory (i.e. a character array). The CheckSum value is stored as the last two bytes in this array. The CheckSum is computed by the following C program statement.

```
CheckSum = ComputeCheckSum( buffer, Profile_Length - 2 );
```

In this statement, "buffer" is a pointer to the memory location where the profile begins (i.e. the name of the character array where the profile was placed). "ComputeCheckSum" adds the first "Profile\_Length-2" bytes starting at location buffer, then adds the value 0xA596. The result of this summation is truncated to an unsigned two-byte integer and returned. The addition of the value 0xA596 is done so that an all-zeros profile does not produce a valid CheckSum.

```

#define CHECK_SUM_OFFSET  0xA596
unsigned int ComputeCheckSum( unsigned char *buf, int n )
{
    int i;
    unsigned int ChkSum = CHECK_SUM_OFFSET;
    for(i=0;i<n;i++) ChkSum += buf[i];
    return(ChkSum);
}

```

## APPENDIX B. PC-ADP Settings and Operational Considerations

The Pulse-Coherent Acoustic Doppler Profiler (PC-ADP) is designed to support all features of a regular ADP (with the exception of bottom-tracking), and it shares similar a user interface with the ADP. However, because of fundamental differences in data processing, the PC-ADP accepts different values for some of its operating parameters and has several additional settings that are described in this appendix.

### B1. PC-ADP Settings

The following sections define setting differences between the standard ADP and the PC-ADP.

#### B1.1. Changes to Common Settings

*AvgInterval* <*d*> (short command “AI”)

In PC-ADP mode, AI can be set between 0.5 s (2-Hz sampling) and 3600 s.

*CellSize and Blanking Distance* <*d.dd*>

Because of higher spatial resolution, the PC-ADP allows the use of smaller cell sizes and blanking distances when compared to a conventional ADP. Table B-1 summarizes the default values for blanking distance, cell size, and number of cells for each PC-ADP acoustic frequency.

**Table B-1: PC-ADP variables defining profile resolution**

Acoustic Frequency	Blanking Distance	Cells Size	Number of Cells
3.0 MHz	Range 0.02 - 5.0 m Default 0.02 m	Range 0.01 – 2.0 m Default 0.05 m	Range 1 – 100 Default 12
1.5 MHz	Range 0.05 - 10.0 m Default 0.05 m	Range 0.02 - 4.0 m Default 0.10 m	Range 1 – 100 Default 20
500 kHz	Range 0.20 – 30.0 m Default 0.20 m	Range 0.20 - 12.0 m Default 0.30 m	Range 1 – 100 Default 25

#### B1.2. Additional PC-ADP Commands and Parameters

*PCMode* <YES | NO> (short command “PM”)

Switches between conventional (incoherent) and pulse-coherent modes. When given without an input argument, this command returns the current setting. An input argument of NO (default) enables conventional sampling mode. An input argument of YES enables the pulse-coherent mode. When the mode settings is changed the system will load the default values (e.g.; cell size, blanking distance, etc.) that are appropriate for the chosen mode.

Pulse Lag and Velocity Range: In pulse-coherent mode, the ADP transmits pairs of pulses for each velocity profile and computes velocity as a function of range using pulse-coherent processing techniques. The velocity range of the measurements (e.g.; the maximum velocity that can be measured) depends on the time delay between the pulses (pulse lag)  $\tau$  as follows:

$$U_{\max} = C / 4f \tau. \quad (1)$$

where  $C$  is the speed of sound,  $f$  is the system frequency and  $\tau$  is the time between the consecutive pulses (pulse lag).

Longer lags result in smaller velocity ranges but better accuracy according to Eq (1). As such, we implement a dual-lag scheme where two pairs of pulses are transmitted, each at a different lag (Figure B-1b). The first pair has a shorter lag and is used to determine an approximate magnitude of the flow. The second pair, which has a longer lag, gives a more accurate velocity, which can be subjected to velocity ambiguity. The velocity values obtained from the first lag are then used to correct for the ambiguities that might arise. This technique results in more accuracy and is less affected by ambiguity velocity data when compared with only one lag.

When the sampling parameters are entered, the system computes the *sampling range* SR which is

$$SR = BD + CS * NC \quad (2)$$

If the specified pulse lag is smaller than the sampling range ( $PG < SR$ ), the system issues a warning message and sets  $SR = PG$ . Figure B-1 describes blanking, sampling, and profiling range.

*ResPulseLag* <d.dd> (short command “RPG”)

RPG sets the lag between the ambiguity resolution pulses (coarse velocity measurements). This parameter will ultimately determine the maximum velocity range of the measurements. The PC-ADP transmits an ambiguity resolution pulse before each profile and collects one velocity measurement in a single cell.

*PulseLag* <d.dd> (short command “PG”)

Sets lag between the pulses for the profiling. This parameter affects velocity accuracy of the profile velocity measurements.

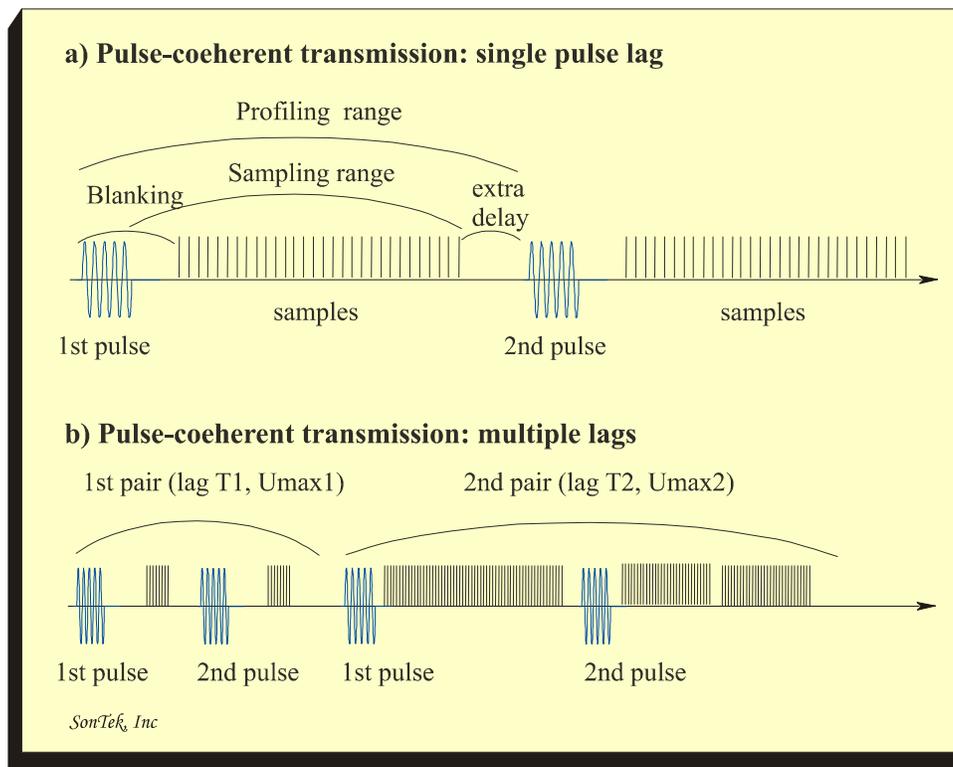


Figure B-1: Pulse-coherent processing: profiling and sampling ranges. a) single pulse pair (single lag) ; b) multiple pulse pairs (dual-lag).

*MinimumCorrelationLevel* <dd %> (short command “MCL”)

MCL sets the minimum acceptable correlation value. During operation, the PC-ADP transmits a series of pings. The results are averaged into an accumulator and stored at the end of the averaging interval. MCL lets you set the correlations level, below which the raw samples are not included in the average. A lower MCL means more data will be accepted, a higher MCL means more data will be rejected. When given without an input argument, MCL returns the current setting. Caution: Turbulent flows can cause low correlation values, which are due to the natural variability of the flow and may be acceptable for data collection.

*s setup*

When pulse-coherent mode is selected, the *s setup* command will display the values of the parameters SR, PG, and MCL in addition to the regular ADP setup (see Section 3.7). It will also display the maximum vertical and horizontal velocities corresponding to the specified pulse lag according to (Eq. 2). An example of *s setup* output in pulse-coherent mode is shown below.

```

CURRENT ADP SETUP PARAMETERS
-----
Temp ----- (deg C) - 20.00
Sal ----- (ppt) --- 34.50
TempMode ----- USER
Sound Speed ---- (m/s) --- 1520.90
CellSize ----- (m) ----- 0.05
BlankDistance -- (m) ----- 0.15
Ncells ----- 30
AvgInterval ---- (s) ----- 1.0
ProfileInterval- (s) ----- 1.0
CoordSystem ----- BEAM

Pulse Coherent Mode ----- YES
Pulse length --- (m) ----- 0.02
Max range ----- (m) ----- 1.65
Pulse Lag ----- (m) ----- 1.65
AmbRes Lag ----- (m) ----- 0.50
MaxVertVel ----- (m/s) --- 0.77
MaxHorizVel ---- (m/s) --- 2.98
MinCorrLevel --- (%) ----- 25

```

### B1.3. Setting Up PC-ADP Mode

The following commands shows how to set up a PC-ADP in the pulse-coherent mode.

```
>PCMODE YES
```

This command tells the system to operate in PC mode and to initialize the default profiling parameters with the values shown in Table B-1. After switching to PCMODE, set the desired sampling parameters shown in Table B-2.

Other deployment parameters are set in the same way as for the regular ADP mode (see Section 3.8 for details).

To switch back to the standard ADP mode of operation use the command:

```
>PCMODE NO
```

The system will initialize the default profiling parameters with the values shown in Section 3.7.

**Table B-2: Setup sampling parameters for the PC-ADP**

BD value	Sets desired blanking distance (m)
CS value	Sets desired cell size (m)
NC value	Sets desired number of cells
PG value	Sets desired profiling range (if necessary)
AI value	Sets desired averaging interval (s)
PRI value	Sets desired profiling interval (s)
CY beam	Sets velocity coordinate system to beam; required for fast sampling with AI<10 s
savesetup	Stores setup parameters in the system EEPROM

## B2. Considerations When Operating in PC Mode

This section discusses issues that are specific to use of the ADP in Pulse-Coherent mode.

### *Long Profiling Range And Short Averaging Interval*

The Doppler processing techniques used by SonTek are very computation-intensive. This places some restrictions on how much data can be collected in a given time. A combination of short averaging intervals and long profiling ranges can cause situations where the system does not have enough time to complete the current profile before the next one begins. To avoid the possibility of “out of sync” data collection, a safeguard exists in PC-mode – before starting data collection, the PC-ADP collects a single profile and estimates the time required to process the data. If the total time is longer than the time between the profiles (AI), the system issues an error message asking you to reduce the profiling range or to increase the averaging interval.

### *Collecting Data in ENU*

Conversion from XYZ to ENU coordinates is a time-consuming process. If data collection at fast rates are required, you may want to consider collecting data in XYZ coordinates instead. Because the compass reading for each profile is recorded, and because the PC-ADP is normally not subjected to significant motion during the averaging interval, velocity data can be converted to ENU coordinates in post-processing using the software provided by SonTek.

### *Collecting Compass Data*

When averaging interval (AI) is set to less than 10-s and AI=profiling interval the PC-ADP uses a ‘fast’ data collection loop. As a result the heading information is not updated for each of the profile, and the values from the first profile are used throughout. This is designed to maximize number of raw pings collected in the ‘fast’ mode. During long deployments, when the burst mode is used, the compass data are updated at the beginning of each burst.

### *Collecting Pressure Time-Series*

When using a short averaging interval (AI≤10s), pressure time-series collection is not supported. However, pressure is sampled and stored with every profile.

### Operating Near Boundaries

The PC-ADP determines distance to the boundary at the beginning of each burst. This information can be used by the PC-ADP to adjust the lag of the pulse-coherent pulses to avoid boundary interference. Since the range to the boundary is stored within the burst header, it can be used later as an acoustic altimeter.

### Data Output Mode

To increase the number of pings in the average when using a short averaging interval, we recommend you set OutMode to POLLED if a recorder is present. This will prevent single profile data from being sent to the serial port, thereby decreasing the profile overhead time.

## B3. PC-ADP Operating Sequence and Data Structure

To use PC-ADP acoustic altimetry and a fast sampling rate, we recommend that burst-mode data collection be used. The PC-ADP operating sequence in the burst mode is as follows (Figure B-2):

- After DEPLOY o, is executed the system goes to sleep until the start time.
- At the beginning of each burst, the system transmits a boundary detection pulse (bottom track) and determines the distance to the boundary for each beam.
- The PC-ADP starts the profile data collection loop, which gathers data until the end of the averaging interval is reached.
- The profile data is output.
- Profiles are collected until the *Profiles Per Burst* number of profiles are collected.
- System goes to sleep until the next burst.

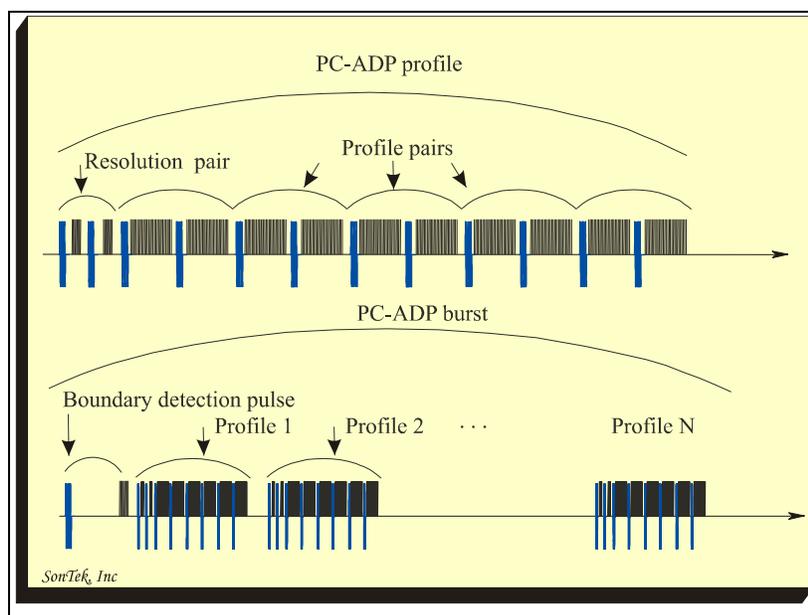


Figure B-2: PC-ADP data collection sequence

## B4. PC-ADP Real-Time ASCII Data

At end of each averaging interval the PC-ADP outputs the PC-ADP data sample, which consists of the profile header, PC-record, and profile data.

**Header** – The information contained in the profile header (first four lines) is described below.

```
Header 1 16      DEFAULT          1 1995  1  1  3 29 31  86 3 0 0 0
Header 2 10      5    15    10    22
Header 3 0       0     0     0     0     0     0  0  0  0 15209
Header 4 0       0     0     0 122 125 127 129  7  7  7  0 152 245  0 52
```

- Header Line 1:
  - data type (internal use)
  - system serial number (“c23”)
  - profile number
  - 6 values for profile time (year, month, day, hour, minute, second, 100<sup>th</sup> of a second)
  - number of beams (2, 3 or 4)
  - orientation (0=down, 1=up, 2=side)
  - temperature mode (0=user, 1=measured)
  - coordinate system (0=beam, 1=xyz, 2=enu)
- Header Line 2:
  - number of cells
  - cell size (in cm)
  - blanking distance (in cm)
  - averaging interval (in 0.1 of a second)
  - number of pings in this profile
- Header Line 3:
  - mean heading, pitch, and roll (in 0.1°)
  - mean temperature (in 0.01°C)
  - mean pressure (counts)
  - standard deviation of heading, pitch and roll (in 0.1°)
  - std temperature (in 0.01°)
  - std pressure (counts)
  - sound speed (in 0.1 m/s)
- Header Line 4: This line contains system variables relating to internal system operation; the last value on the line is measured battery voltage in units of 0.2 V (i.e.; 117 = 23.4 V).

**PC-Record** – The information contained in the PC-Record (lines 5 and 6) is described below.

```
PC Rec 1 500    771    350    100  1650  234  150  500
PC Rec 2 0      0      0      0    53    14    29    0  1  1  1  0
```

- PC record Line 1:  
 Ambiguity resolution pulse lag in mm  
 Ambiguity velocity corresponding to the resolution lag (velocity range) in mm/s  
 Beginning position and length (2 values) of the resolution cell in mm  
 Profile pulse lag in mm  
 Ambiguity velocity in mm/s corresponding and to the profile lag  
 Beginning and length (2 values) of the profiling range in mm
- PC record Line 2:  
 Range to the bottom for each beam (4 values) in mm  
 Velocity from the resolution pulse for each beam (4 values) in mm/s  
 Correlation from the resolution pulse for each beam (4 values) in %

**Profile data** – See Table B-3.

```

Cell 1   1    20    17    19    1    1    1    7    7    7
Cell 2   2   -87   -45   -76    1    1    1    7    7    7
.....
Cell 10 10     5    -5     0    1    1    1    7    7    7

```

**Table B-3. ADP ASCII Output Profile Data**

Column #	Contents
1	Depth cell number
2	Velocity data (V1 or Vx or Veast) in mm/s
3	Velocity data (V2 or Vy or Vnorth) in mm/s
4	Velocity data (V3 or Vz or Vup) in mm/s
5	Correlation data in %
6	Correlation data in %
7	Correlation data in %
8	Amplitude (signal strength) data (beam 1) in counts (1 count = 0.43 dB)
9	Amplitude (signal strength) data (beam 2) in counts (1 count = 0.43 dB)
10	Amplitude (signal strength) data (beam 3) in counts (1 count = 0.43 dB)

After the profile is enabled, the following data may be output as well.

OPTIONAL CTD data (if present)

```
87514 468151 0 351354
```

OPTIONAL: Wave Record (if enabled)

```
Wave header 32 DEFAULT C23 1 1997 10 15 10 49 0 1 6 1 1 150
Pressure series 2000 2000 2000 2000 2000 2000
```

The format of the CTD, Bottom Track and Pressure series is documented in the ADP Operations Manual, Section 8.

## B5. Changes to the Data Extraction Routines

The PC-ADP uses the same data extraction routines as the regular ADP with 2 exceptions: (1) In PC-MODE, the correlations (in %) are stored/extracted instead of the standard deviation (in cm/s), and (2) Additional PC-record data are extracted.

## B6. PC-Record Conversion: GADPPC

This program extracts the PC header information that is recorded with each velocity profile in the pulse-coherent mode only. This information includes pulse lag, ambiguity velocity, resolution velocity, and distance to the boundary. The command format is:

```
GADPPC <ADP file>
GADPPC <ADP file> <output file>
GADPPC <ADP file> <output file> <first profile> <last profile>
```

File names must be given without extension. GADPPC generates an ASCII *output file* with the extension .PC. The program assumes that the *ADP file* has extension .ADP. If no output file name is specified, the program uses the same name as the binary data file. *First profile* and *last profile* let you extract a subset of the data. If the profile range is not specified, the program extracts all profiles in the file.

The ASCII tabular output file has one line per profile. There are no headers so that commercial processing programs (Lotus, Matlab, etc.) can easily access the data. There are 20 columns of data output in the header file. Table B-4 shows the contents and units of each column.

**Table B-4. GADPPC Tabular Data Output Format**

Column	Variable
1	Profile Number
2	Ambiguity resolution pulse lag in m
3	Ambiguity velocity corresponding to the resolution lag (velocity range) in cm/s
4	Beginning position of the resolution cell in m
5	Length of the resolution cell in m
6	Profile pulse lag in m
7	Ambiguity velocity in m corresponding and to the profile lag
8-9	Beginning and length of the profiling range in m
10-13	Range to the bottom (in m) for beams 1 through 4
14-17	Velocity from the resolution pulse (cm/s) for beams 1 through 4
18-21	Correlation from the resolution pulse (%) for beams 1 through 4

## B7. PC-ADP Interface for LISST-100 Sensor

LISST-100 is a Laser Interferometry and Transmissometry particle distribution measurement device, designed by Sequoia Scientific. This document describes operational procedure for using LISST sensor together with the PC-ADP.

### B7.1. Additional LISST-Related Commands and Parameters

*LISSTSENSORINSTALLED SET* <YES | NO> ()

Enables/disables LISST interface. Because LISST is a serial instrument and uses the second COM port on the PC-ADP CPU, board other serial devices (such as PAROS or Microcat CTD) must be disabled. Whenever LISSTSENSORINSTALLED is set to YES, LISSTBUFFERSIZE is set to 80 bytes (default).

*LISSTBUFFERSIZE* <nbytes> (LBS)

Sets the size of list sample buffer. If entered without an argument the command returns current settings for the LISST buffer size.

### B7.2. LISST-Related Setup and Operation Sequence

The following sections describe the setup and operation sequence when the PC-ADP is used with a LISST sensor.

#### B7.2.1. Download LISST Control Program

The HYDRA.TTB program will need to be loaded into the LISST-100. This needs be done before connecting to the HYDRA/PCADP system. The loading is simply a transmission of the ASCII characters to the LISST-100 with occasional pauses to allow the LISST-100 to process the lines. The NEW command, (NEW <CR>), clears the current program from memory before the new program is loaded. The LIST command can be used to print the currently loaded program to the screen. TTOOLS program provided by Sequoia Scientific is best suited for this download.

- Connect LISST sensor to a serial port on your computer.
- Connect external power source to the LISST (if applicable).
- Start TTOOLS program provided by Sequoia Scientific.
- Choose Load Program (Alt-L) option under Tattletale menu and choose HYDRA.TTB file.

#### B7.2.2. Connect LISST to a PC-ADP

Attach the external sensor harness to the ADP electronics housing (8-pin male UW connector). Connect the LISST-100 sensor to the serial cable on the harness using LISST-CTD adaptor cable. The external cable harness is manufactured to accommodate the CTD sensor. Because the CTD and the LISST are sharing the same serial port on the ADP and have a different pin out, an adaptor cable is required to connect the LISST to the harness. Connect the external power source to the LISST (if applicable).

Connect the ADP electronics to your computer and a power source using the ADP power and communications cable. On your computer, establish communications with the ADP using *SONTERM*. In *SONTERM*, enable the LISST sensor using the LISSTSENSORINSTALLED

command. Verify that both the PAROS and Microcat CTD serial sensors are disabled. (PAROSFREQ is a frequency sensor and it can be operated simultaneously with the LISST).

Verify that you can communicate with the LISST via ADP COM port 1. To do this, issue the ECHO 1 command at the ADP command prompt. In echo mode, you can send commands and receive responses from the LISST sensor. To exit the echo mode send a break.

### B7.2.3. Set Up PC-ADP for use with LISST

LISST data collection is only supported when the PC-ADP operates in burst mode. If burst mode is not enabled, and the LISST sensor option is enabled, the data collection loop will not start. The data collection sequence is as follows.

When the ADP detects the beginning of the burst interval, it tries to communicate with the LISST sensor. If communication was successful, the ADP sends the number of samples (Profiles Per Burst, PPB) and sampling rate (averaging interval) to the LISST along with a start data collection request. The ADP then proceeds with its own burst data collection loop. At the end of the burst, the ADP communicates with LISST and uploads the PPB samples. If the ADP was not able to establish communication with the LISST at the beginning or at the end of the burst, PPB blank samples are stored in the recorder to preserve the integrity of the ADP file. Note that the data upload from the LISST needs to be completed before the next burst can be initiated; this effectively increases the length of the burst. Make sure you allow for this extra time (approximately 120 s for 1,200 LISST samples) when setting the burst interval.

To set the PC-ADP for data collection with the LISST:

- Set AI = PRI.
- Set Burst Mode (BM) to YES.
- Set PPB to a value between 2 and
- Set Burst Interval to be longer than  $(PRI * PPB) + \text{DownLoad Time}$ .
- Set other PC-ADP settings (PG, RPG, nCells, etc).

Initiate deployment by issuing a START or DEPLOY command. Note that if the ADP cannot establish communication with the LISST after a START or DEPLOY command is issued, the ADP will abort the data acquisition loop with an error message.

---

## APPENDIX C. L-ADP Settings and Operational Considerations

A Lowered-ADP (L-ADP) is very similar to a regular ADP system in the way it is operated and maintained. The main difference is that the L-ADP is used for the specific application of collecting current profiles while the system is being lowered (and raised) by a cable. Most of the documentation that applies to an ADP also applies to the L-ADP. However, there are a few aspects of the L-ADP that are not covered in the general ADP manual. This appendix supplements the ADP documentation contained within this manual.

The differences between an ADP and an L-ADP are mostly in hardware – different beam angles, specialized electronics, and a specialized mode of operation (firmware). With the L-ADP mode enabled (done at the factory), you have access to a few additional commands that would normally be controlled automatically in a standard ADP. The remainder of this appendix explains L-ADP history and operation.

### C1. L-ADP History

Normally, standard ADPs can only profile over ranges of up to a few hundred meters due to practical limitations in frequency (which determines acoustic propagation losses) and the size of the transducers. The L-ADP method overcomes this range limitation and permits you to obtain absolute current profiles over full-ocean depth ranges (up to several thousand meters in depth). This method was originally developed by Dr. Eric Firing at the University of Hawaii.

In the L-ADP method, one or two ADPs are lowered by cable from a surface vessel down to the desired depth (typically down to just above the bottom). During the descent, and later during the ascent, the ADP(s) continuously collect profiles of relative current velocities (relative to the instrument). Although these velocities contain the unknown, instantaneous velocity of the instrument package, the shears ( $dU/dz$ ) computed within each profile are independent of instrument motion as long as accelerations are small.

By combining all the profiles collected during a down/up cast of the ADP(s), we obtain a full shear profile from very close to the surface down to the deepest point of the cast (plus one ADP profiling range). Using GPS positions of the surface vessel, this shear profile can be integrated to compute a profile of ground-referenced currents.

### C2. L-ADP Package Configuration

When using the L-ADP method of casting, you would typically mount one or two ADPs on a water-sampling Rosette. Although there is nothing that prevents the lowering of the ADPs by themselves, mounting them in Rosettes is common because many different measurements can be done simultaneously, thereby reducing operational costs and time.

The simplest configuration consists of mounting just one ADP at the bottom of the Rosette with its beams looking down. A more robust and higher-performance configuration also adds a second ADP at the top of the Rosette with its beams looking up. In addition to the ADP(s), an external battery pack is mounted on the Rosette to supply power to the instrument package. The battery pack contains rechargeable lead-acid batteries that can be recharged while the package is on deck between casts.

### C3. L-ADP Operation

Compared to an ADP, the L-ADP pings faster internally (using more power) and records single-ping data (instead of long averages). This is necessary for lowered-ADP applications because the system is continually changing its vertical position while being lowered or raised.

During these down/up casts, the ADP(s) continuously collect and store velocity data to its internal recorder. Typically, the single-ping (or one-second averaged) profiles that are collected result in large amounts of data being gathered during the 2-6 hours usually needed for a deep cast.

After the instrument package is back on deck, and while the vessel moves to a new station, the data from the ADP(s) are downloaded to a personal computer, and the batteries are recharged in preparation for a new cast. The ADP data now in the personal computer are combined with GPS positions collected during the cast to produce best-estimates of absolute current profiles throughout the vertical extent of the cast.

An example of a setup for a typical cast (lowering of the system) using a 250-kHz L-ADP is shown here:

CS 10     (10-m cell size; standard ADP command)  
NC 20     (20 cells collected per profile; standard ADP command)  
PL 10     (10-m pulse length; see Note 1)  
NPPB 4    (4 pings per beam; see Note 2)

Notes:

1. Pulse Length – This command is normally not set in a standard ADP. In a standard ADP, CS=PL. However, in an L-ADP, this parameter can be manually set by the user for this specialized application.
2. Number of Pings Per Beam – This command sets the number of raw pings averaged internally in the DSP (digital signal processor). This parameter is normally set by the system automatically (if NPPB=0, system will calculate optimum). However, with an L-ADP, the user can manually set this parameter.
3. With an L-ADP, both the PL and NPPB commands require the user to have extensive knowledge of acoustic systems and the processing of the resulting data.
4. The standard mode of operation in an L-ADP is to acquire data as quickly as possible. As such, the Averaging Interval (AI) and Profiling Interval (PRI) commands are disabled. Although you are able to change AI and PRI in the setup, the values are ignored by the L-ADP during data collection. The rate at which the L-ADP outputs data can be controlled by the NPPB command. Although the rate at which the instrument profiles is dependent on the number of cells (NC) and the cell size (CS), a 250-kHz L-ADP with a standard setup will output approximately one profile per second when NPPB is set to 4 (averages 4 pings together in the DSP before storing the data).

In L-ADPs, CPU usage and data handling tasks are processor-intensive. As such, we recommend that you turn off data output to the serial port. Turning off the serial port output lets the system collect data faster. The command to turn off the port is: OM POLLED.

## C4. Dual L-ADP Synchronization

One typical configuration of a dual L-ADP system is to mount one system pointing in the upward direction and the second system pointing in the downward direction (see Section 4 for information on how to change instrument orientation). The two L-ADPs and the battery housing are already wired for synchronization of the systems. One wire goes through cables/battery housing to connect the sync ports of both L-ADPs. To control the level of synchronization (synchronization mode), a new parameter (SyncMode) must be used:

*SyncMode* <DISABLE | MASTER | SLAVE> (short command “SM”)

Argument definitions:

- DISABLE – The ADP will operate independently and ping as quickly as possible.
- MASTER – The ADP will send a sync signal to any slaves just prior to starting a ping.
- SLAVE – The ADP will wait for a sync signal to arrive before starting a new ping.

Considerations when using the MASTER/SLAVE mode:

- The duration of a ping in the SLAVE must not be longer than the duration of a ping in the MASTER. Therefore, in the case of a multi-frequency arrangement, we recommend that the 250-kHz system be set as the master, and the 500-kHz system be set as the slave (i.e.; the lower frequency system is the master and the higher frequency is the slave).
- The sync protocol requires adding some delays in both the MASTER and the SLAVE so that the pinging rate will be slower in this configuration (about 30% slower). If the systems are working independently, they should be set to DISABLE so that they can achieve maximum pinging rate.
- NPPB should be set to 1 when using MASTER/SLAVE. The reason for this is that synchronization occurs only at the first ping in a NPPB sequence.
- When using synchronization, you should “START” the slave first, and then the master. This will assure a one-to-one correspondence from ping number 1.

## C5. Bottom-Tracking and L-ADPs

Due to the nature of the L-ADP system, and the requirement for the system to ping as rapidly as possible, the L-ADP does not bottom track. A traditional bottom-track would cause the L-ADP to ping slower because of the system’s need to switch between bottom-track pulses and water-track pulses throughout the entire cast (the system is only within the range of the bottom for a brief time relative to the rest of the cast).

## C6. Additional Information about L-ADP Applications and Operation

More details about processing L-ADP data and the setup of these specialized instruments can be found on the Internet with L-ADP user groups and web sites dedicated to the operation and data processing of these systems. An example of one of these web sites that is available to the general public is: <http://www.ldeo.columbia.edu/~visbeck/ladcp>.

## C7. Rechargeable L-ADP Battery

The L-ADP has significant power demands. As such, the L-ADP uses rechargeable gel-cell batteries that have significant instantaneous current capability. The general guidelines included

below must be followed to ensure that the system continues to work properly. The following procedures are for a typical charging scheme. It is important that the batteries are kept as close to full-charged as much as possible to ensure good battery performance for many casts.

1. When disconnecting and re-connecting the L-ADP to the battery pack, be sure to perform the connections in the following order:

*Connecting:* Connect the cable to the L-ADP before connecting it to the battery housing.

*Disconnecting:* Disconnect the cable from the battery housing before you disconnect it from the L-ADP.

***WARNING: Severe damage to the system can occur if the above procedure is not followed.***

2. Dry the lid of the battery canister and the area around the vent, being certain that there is no water around seat of the vent plug. Open the vent plug in the top of the battery canister using the supplied hex driver (key). Be certain not to allow water from the surrounding environment to enter into the vent hole at any time.

***WARNING: Severe damage or explosion can occur if the above procedure is not followed.***

3. Plug the power/communication/charge cable into the center 8-pin, wet-mateable connector in the top of the battery canister. Plug the charger into the mating 3-pin DIN plug. Plug the charger into an AC source. The state of the batteries will determine the amount of current the charger will drive the batteries with. It should be noted that due to losses in cables longer than 50 meters, the charger will be unable to fully charge the batteries. To fully charge the batteries, use cables shorter than 50 meters.
4. While the system is charging, you can use the system as necessary to perform tasks such as downloading data or system configuration for the next deployment. The charger provided will automatically limit the current going to the battery depending on the battery status. Therefore, we suggest that the batteries be charged between each of the deployments.
5. Before a deployment, you should remove power to the charger, be certain the vent plug is clean, apply grease to the O-ring, and fully tightened the vent.
6. When you are certain that the above steps have been completed, the system can be set up and deployed. After the power and communication cable is removed, make sure the connector is replaced with a well-greased dummy plug (be certain that all unused exposed connectors are plugged with well-greased dummy connectors). *It is extremely important that you are certain all power is removed from the power/communications cable before it is disconnected from the battery pack.*

**WARNING: SEVERE DAMAGE TO THE ENTIRE SYSTEM WILL OCCUR IF IT IS DEPLOYED WITHOUT THE VENT PLUG IN THE BATTERY CANISTER FULLY CLOSED!**