A YSI Environmental Company

SonTek/YSI ADVField/Hydra
Acoustic Doppler Velocimeter (Field)
Technical Documentation

SonTek®

A YSI Environmental Company

Getting Started with the ADVField/Hydra System

Thank you for purchasing a SonTek/YSI Acoustic Doppler Velocimeter (ADV). We are confident you will find it powerful, accurate, reliable, and easy to use. If you have questions, comments, or suggestions, please let us know.

Please Note: The documentation in this binder applies primarily to our ADV "Field" and "Hydra" units (used primarily in outdoor applications) and not to our ADV "Lab" units (used primarily in laboratory experiments).

1) Suggested Reading

- We encourage you to read the *ADVField Principles of Operation*. It provides valuable background for using the instrument and analyzing data.
- Refer to the *ADVField Operation Manual* and the *ADVField Software Manual* as needed for specific information about using the ADVField/Hydra system.
- See the *ADVField Operation Manual* (Section 2) for more "Getting Started" instructions.

2) Software Installation

- To install the DOS and Windows software on a <u>Windows-based</u> computer:
  - Insert the distribution CD in your computer.
  - An installation menu should automatically appear after the CD has been inserted. If not, click **Start | Run** and type **d:\install.exe** where **d:** is your CD-ROM drive.
  - Click the programs that you would like to install on your computer. Follow the on-screen instructions. If prompted, insert the Probe Definition disk in your floppy drive.
  - See the *ADVField Software Manual* for details about the DOS and Windows programs.

- To install the DOS software on a <u>DOS-only</u> computer:
  - Insert the CD in your computer.
  - List the files/directories contained on the CD (e.g., **dir d:**, where **d:** is the CD drive).
  - Copy all files/subdirectories from the **d:\ADF-DOS** directory to an appropriate directory on your computer. For example: **XCOPY D:\ADF-DOS*.*   C:\SONTEK\ADVF-770\ /s**
  - Using the above syntax will copy all DOS program files from the CD to:
    C:\SONTEK\ADVF-770\DEPLOY*.   and   **C:\SONTEK\ADVF-770\REALTIME*.***

3) ADVField System Interconnection

- Refer to Sections 2 and 5 of the *ADVField Operation Manual* for details.
- Connect the cable from the probe to the processor.
- Connect the power and communications cables – use the DC power supply included with the system and connect the serial cable to COM1 of your computer.
- Place the probe in a bucket or tank of water for testing.

4) Real-Time Data Acquisition Software

- Refer to Section 2 of the *ADVField Operation Manual* and to Section 2 of the *ADVField Software Manual* for details.
- To run the data acquisition software, type `ADF` (ADVField) at the DOS prompt.
- The first screen allows you to set ADV operating parameters. Highlight the **Start Data Acquisition** option and press <Enter>.
- The second screen displays the distance from the probe to the boundary; press <F10> to complete this screen.
- At the third screen, press <Enter> to start data collection.
- Move the probe, or set up motion in the water, and watch the velocity traces on the screen.
- Use the active keys listed at the bottom of the screen to modify display parameters.

5) Real-Time Data Conversion Software

- Refer to Section 3 of the *ADVField Software Manual* for details.
- Store ADV velocity data to the computer hard disk using the data acquisition software.
- Use the `GET___` programs to convert the binary data to an easily-read ASCII format.
- Analyze these files using a text editor or data processing software.

6) Autonomous Data Collection

- Refer to Section 2 of the *ADVField Operation Manual* for details.
- This applies to ADVField systems with the optional internal recorder and battery power.
- Establish direct communication with the ADV using `SONTERM`. Follow the instructions in the manual to set deployment parameters and perform a test deployment.
- Use the autonomous data extraction and conversion software (Section 9 of the *ADVField Software Manual*) to retrieve the data from the recorder and view the output data files.

7) Diagnostic Software

- Refer to Section 4 of the *ADVField Software Manual* for details.
- Mount the ADV probe in a small tank of water with a little seeding material, ideally with the probe (20-30 cm / 8-12 in) from a boundary.
- Run the `ADFCHECK` program.

SonTek/YSI, Inc.
6837 Nancy Ridge Drive, Suite A, San Diego, CA 92121-3217 USA
Telephone (858) 546-8327 ● Fax (858) 546-8150
E-mail: inquiry@sontek.com ● Internet: http://www.sontek.com

A YSI Environmental Company

SonTek/YSI
ADVField/Hydra
Operation Manual
(Firmware version 7.9 and later)

RECORD OF CHANGES

Effective	Description
01 SEP 1999	Base document: ADVField firmware version 4.0
01 SEP 2001	ADVField firmware version 7.9
11 OCT 2001	CTD command and data output corrections

INTRODUCTION

Thank you for purchasing a SonTek Acoustic Doppler Velocimeter (ADV). Your instrument was thoroughly tested at the factory and was found to be in excellent working condition. If the shipping crate appears to have been damaged in transit, or if the ADV is not operating properly, please contact us immediately.

This Operation Manual contains the following chapters and appendices:

- **Section 1. ADV Components, Terminology, and Sampling** – Definition of terms used in this manual and a description of ADV sampling strategies

- **Section 2. Getting Started – Installation/Configuration/Operation** – Instructions for installing, operating, and collecting data with the ADV in a variety of configurations

- **Section 3. Direct Command Interface for ADVField** – Direct communication with the ADVField processor using a terminal or terminal emulator including command format and options

- **Section 4. ADVField System Hardware** – Detailed description of hardware components including processing modules, cables, probes, options, and special configurations

- **Section 5. Operational Considerations** – Concerns and procedures relating to coordinate systems, communication protocol, multiple system operation, analog output data, external synchronization, mounting, optional sensors, seeding requirements, anti-fouling protection, maintenance, and troubleshooting

- **Section 6. Additional Support** – SonTek contact information for customer support, general inquiries, and how to send a system back to the factory

- **Appendix 1. ADVField Real-Time Data Output Formats**

- **Appendix 2. ADVField Autonomous Data Output Formats**

WARRANTY

The ADV is covered under a one-year limited warranty that extends to all parts and labor, and covers any malfunction due to poor 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 consequential damage as a result of errors in the measurements.

If there is a problem with your ADV, first try to identify the problem by following the procedures outlined in this manual. Contact SonTek immediately if you detect a hardware problem or if you need additional help in identifying a problem with your ADV. Please obtain a Return Merchandise Authorization (RMA) number before returning the system to the factory (see Section 6).

We encourage you to contact us immediately if a problem is detected and we will do our best to minimize any downtime.

NOTES

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Section 1. ADV Components, Terminology, and Sampling

1.1. ADV Components

SonTek Acoustic Doppler Velocimeter (ADV) systems can be of two types – "Field" systems or "Lab" systems. This manual applies only to our ADVField systems. Throughout this manual, the terms *ADV* and *ADVField* can be considered synonymous (unless specifically noted otherwise).

ADVField systems can be of three types – *splash-proof*, *underwater*, or *autonomous* (Hydra) systems. The hardware for these systems is composed of two main components: *signal processing hardware* and *probe hardware*. Note: The term Hydra refers to an ADVField system that has a recorder and optional sensors installed.

The signal processing hardware (Figure 1) can be contained in a splash-proof housing or an underwater canister. The probe hardware (Figure 2 through Figure 6) can be of three basic types: a 16-MHz MicroADV probe, a 10-MHz ADV probe, or a 5-MHz ADVOcean probe.

1.1.1. Signal Processing Hardware

The signal processing hardware performs the signal generation and processing required for the ADV to make velocity measurements. This includes generating the electrical signals that are converted to acoustic energy at the transducers, digitizing the return signal, performing Doppler processing to calculate velocity, and averaging samples together before data output.

Figure 1 shows two configurations of the ADVField signal processing hardware (also known as the *processor* or *processing module*) – the *splash-proof housing* and the *underwater canister*. The electronics are configured to operate at either 16 MHz, 10 MHz, or 5 MHz for use with either a 16-MHz MicroADV probe, a 10-MHz ADV probe, or a 5-MHz ADVOcean probe, respectively. Any probe of a given frequency can be used with a processing module of that frequency, if the cables and connectors are compatible, and if the appropriate probe configuration has been loaded into the processor.

Splash-Proof Housing   **Underwater Canister**
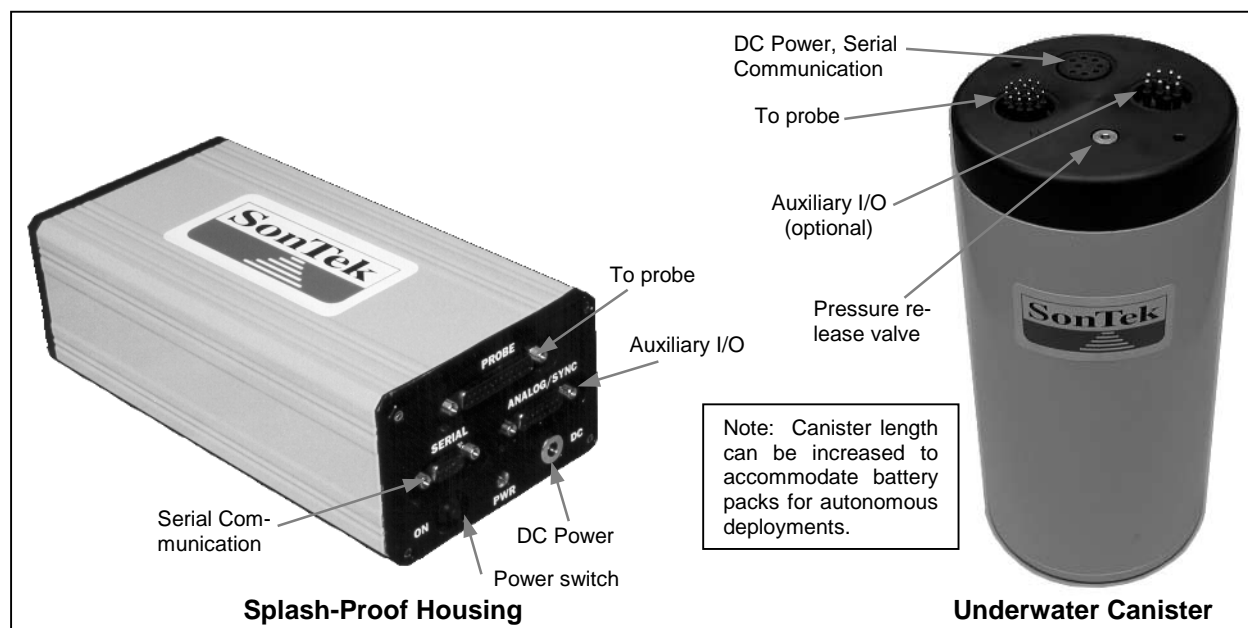
Figure 1 – ADVField Processors

- *Splash-Proof Housing*: The typical ADVField processor in this configuration consists of three printed circuit (PC) cards enclosed in a splash-proof container (22x11x7 cm; 8.5x4.5x2.8 in). The housing is safe from incidental water contact, but should not be submerged. There are four external connectors on the housing: one to the probe, one for serial communication with the controlling computer, one for DC power input, and one for auxiliary input/output functions (analog output voltages and external synchronization).

  Splash-proof systems can also be equipped with an optional rechargeable battery (§4.5), which provides 8 hours of operating power. The size of the splash-proof container for this option is 32x11x7 cm (12.5x4.5x2.8 in).

- *Underwater Canister*: The typical ADVField processor in this configuration consists of three printed circuit (PC) cards enclosed in a submergible housing. In the underwater canister, the processor may include an optional card for internal data recording and internal battery packs for autonomous operation. Three housings are available for different system configurations – a rectangular housing for real-time systems (15x15x25 cm; 5.8x5.8x9.8 in), a cylindrical housing for real-time systems (17-cm dia. x 32-cm tall; 6.6x12.5 in), and a cylindrical housing with batteries for autonomous deployment (17-cm dia. x 72-cm tall; 6.6x28.5 in).

  Underwater canister systems, including all cables and connectors, can be operated when fully submerged. There are two or three (depending on external sensors) external connectors on the underwater canister: one to the probe, and the other to a multi-purpose cable for DC power (e.g., to an external battery canister), serial communication, and auxiliary input/output functions (analog output voltages and external synchronization). The ADVField processor in the underwater canister can include a compass/tilt sensor mounted inside the canister; this sensor may also be mounted in the probe housing as described in the following paragraphs.

1.1.2. 16-MHz MicroADV Probe and 10-MHz ADV Probe

Note: The 16-MHz MicroADV Probe (Figure 2) is identical in both form and function to the 10-MHz ADV Probe. The difference between the two is the acoustic frequency, the sampling rate, and the sampling volume. Table 1 compares the three major ADV models. Unless specifically identified, the descriptions in this section apply to both the 16-MHz MicroADV Probe and the 10-MHz ADV Probe.

The 16/10-MHz ADV probe configurations are divided into two groups: with or without optional sensors (compass/tilt, pressure, and temperature). Within these groups are several sensor configurations. The 16/10-MHz ADV probe is used for field measurements where shallow-water operation or high spatial resolution is required. Figure 2 shows the standard 16/10-MHz ADV probe.
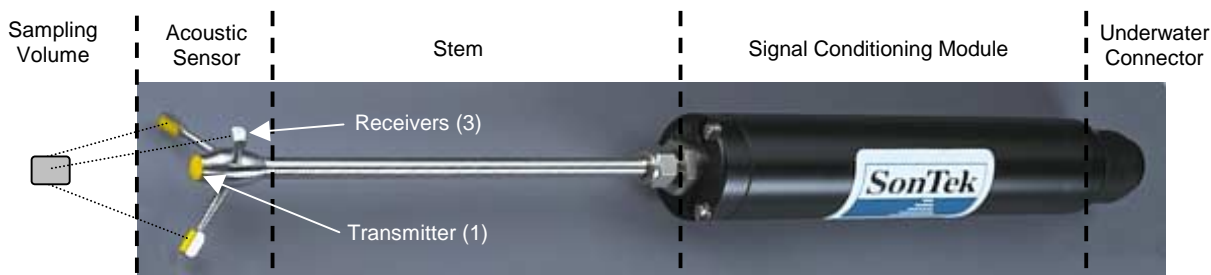
Figure 2 – Typical ADVField Probe (both 16-MHz and 10-MHz)

Table 1. ADVField Processing Comparison (based on acoustic frequency)

Parameter	16-MHz MicroADV	10-MHz ADV	5-MHz ADVOcean
Sampling rate (Hz)	0.1 to 50	0.1 to 25	0.1 to 25
Sampling volume (cc)	0.09	0.25	2.0
Distance to sampling volume (cm)	5	5 or 10	18
Resolution (cm/s)	0.01	0.01	0.01
Programmable velocity range (cm/s)	3, 10, 30, 100, 250	3, 10, 30, 100, 250	5, 20, 50, 200, 500
Accuracy	1% of measured velocity, ±0.25 cm/s		

16/10-MHz Probe Configuration without Optional Sensors:

- The acoustic sensor (Figure 3) consists of two or three acoustic receivers (for 2D or 3D probes) and one acoustic transmitter. The sensor can be mounted on a stainless steel stem (25 or 40-cm long) or on a 100-cm flexible cable. The acoustic sensor can be oriented looking down, to the side (mounted on a 90° adapter), or up (with a bent stem and a 90° adapter).
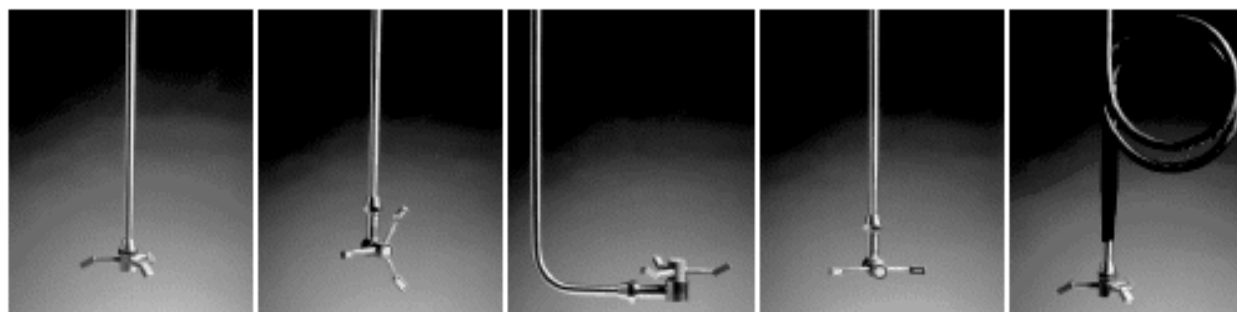
Figure 3 – Probes: (a) Down-looking 3D, (b) Side-looking 3D, (c) Up-looking 3D, (d) Side-Looking 2D, (e) Cable-Mounted

- The sampling volume is the volume of water (≈0.3 cm^3) in which the ADV makes velocity measurements. Depending on probe configuration, this volume is nominally located either 5 cm or 10 cm (10-MHz systems only) from the acoustic transmitter.

- The standard 16/10-MHz ADV probe consists of the acoustic sensor, the stem (or cable), and the end cap attached to the signal-conditioning module. The probe serial number is stamped on the end cap. For probes that will be deployed in saline environments, a sacrificial zinc anode is attached to the stem for corrosion protection.

- The probe coordinate system (§5.1) depends on the probe configuration.

- The signal-conditioning module is a cylindrical Delrin housing with internal receiver electronics. The probe is mounted at one end of the Delrin housing, while the other end cap is connected to a high-frequency cable using a 16-pin wet-mateable connector. The signal conditioning module is 5.3 cm (2.09 in) in diameter by 28.5 cm (11.2 in) long. The dimensions of the probe vary with 2D and 3D probes, distance to the sampling volume, stem or cable length, and sensor orientation.

- The high-frequency cable to the processing module carries analog signals from the probe to the digital processing electronics. This cable is highly sensitive to noise and should not be modified without instruction from SonTek. The cable is connected to the signal-conditioning module using a 16-pin wet-mateable connector.

16/10-MHz Probe Configuration with Optional Sensors: For field applications, the 16/10-MHz ADV probe can include up to three internal optional sensors (compass/tilt, pressure, temperature) mounted in a modified signal-processing module (Figure 4). The compass/tilt sensor allows the ADV to report velocity data in Earth coordinates (East-North-Up or ENU), regardless of instrument orientation. The pressure sensor provides simultaneous pressure and 3D velocity measurements (PUVW for directional wave spectra). The temperature sensor is used for sound speed corrections in long deployments with large temperature fluctuations.

- The acoustic sensor contains two or three acoustic receivers (for 2D or 3D probes) and one acoustic transmitter. The sensor can be mounted on a stainless steel stem 25 or 40-cm long. The acoustic sensor can be oriented looking down, to the side (mounted on a 90° adapter), or up (with a bent stem and a 90° adapter).

- The sampling volume is the volume of water (≈ 0.3 cm^3) in which the ADV makes velocity measurements. Depending on probe configuration, this volume is nominally located either 5 cm or 10 cm (10-MHz systems only) from the acoustic transmitter. Note: The 10-cm probes are only available in the standard down-looking configuration or on side-looking cables.

- The 16/10-MHz ADV probe with optional sensors includes the acoustic sensor, the mounting stem, the end cap, and the signal-conditioning module with optional sensors. The probe serial number is stamped on the end cap closest to the acoustic transducers. Sacrificial zinc anodes are attached to the stem and the end cap for corrosion protection. If the processor end of the high-frequency cable is compatible, 16/10-MHz ADV probes with and without the optional sensors can be used from the same ADVField processor.

- The probe X-axis is defined by the direction of the arm of receiver #1, which is painted red. When looking from the sampling volume towards the acoustic transmitter, the receivers are numbered 1, 2, and 3 moving clockwise from #1. The probe's X-axis is also stamped on the end cap next to the cable connector. (See §5.1 for coordinate system details.)

- The signal-conditioning module is a Delrin housing with internal receiver electronics and optional sensors. The ADV mounting stem is permanently fixed to the lower end cap and the high-frequency cable to the processing module is connected to the larger end cap using an underwater mateable connector.
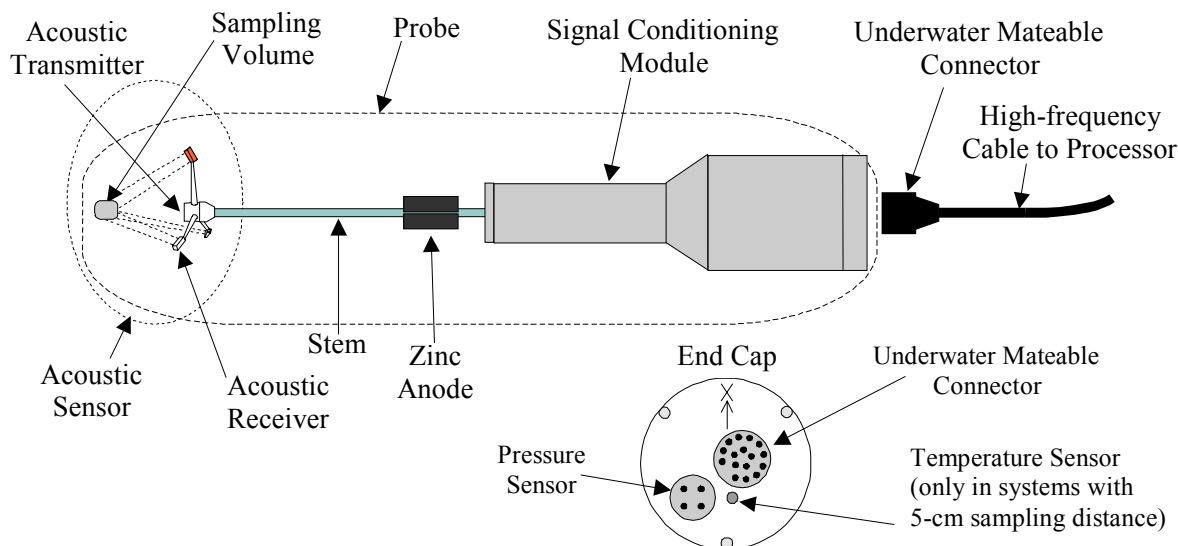
Figure 4 – 10-MHz ADV Probe with Optional Sensors

- The optional pressure sensor is installed on the upper end cap of the conditioning module, near the underwater cable connector. Note that because the pressure sensor is mounted some distance from the sampling volume, this distance may need to be taken into account when processing the combined pressure and velocity data.

- The optional temperature sensor (a thermistor) is mounted inside the upper end cap of the conditioning module, next to the underwater cable connector on probes that have a sampling distance of 5 cm. When using this type of temperature sensor, be certain that the conditioning module is completely submerged. On probes that have a sampling distance of 10 cm, the temperature sensor is potted inside the acoustic sensor head.

- The high-frequency cable to the processing module carries analog signals from the probe to the digital processing electronics. This cable is highly sensitive to noise and should not be modified without instruction from SonTek.

- The signal-conditioning module has a maximum diameter of 10.1 cm (4.0 in) and is 33.0 cm (13.0 in) long. The outside of the housing is ribbed for easier handling and more secure mounting. The overall dimensions of the probe vary with 2D and 3D probes, distance to the sampling volume, stem length, and sensor orientation.

1.1.3. 5-MHz ADVOcean Probe

The 5-MHz ADVOcean probe configurations are divided into two groups: with or without optional sensors (compass/tilt, pressure). The 5-MHz ADVOcean probe is used for field applications where a rugged probe that is resistant to physical damage is needed. Figure 5 shows the standard ADVOcean probe. The ADVOcean probe is made of stainless steel. However, the conditioning module can be made of stainless steel or plastic if weight is a concern.

5-MHz ADVOcean Probe Configuration without Optional Sensors:

- The ADVOcean probe consists of an acoustic sensor head (which includes a temperature sensing thermistor), a signal conditioning module, and an underwater mateable connector to a high-frequency cable. The probe serial number is engraved on the housing near the acoustic transmitter. All ADVOcean probes having a stainless steel conditioning module include a sacrificial zinc anode attached to the signal-conditioning module for corrosion protection. Probes with plastic conditioning modules require you to provide appropriate protection, if applicable.

- The acoustic sensor head contains three acoustic receivers and one acoustic transmitter. The sensor head is mounted directly to the end of the signal-conditioning module.
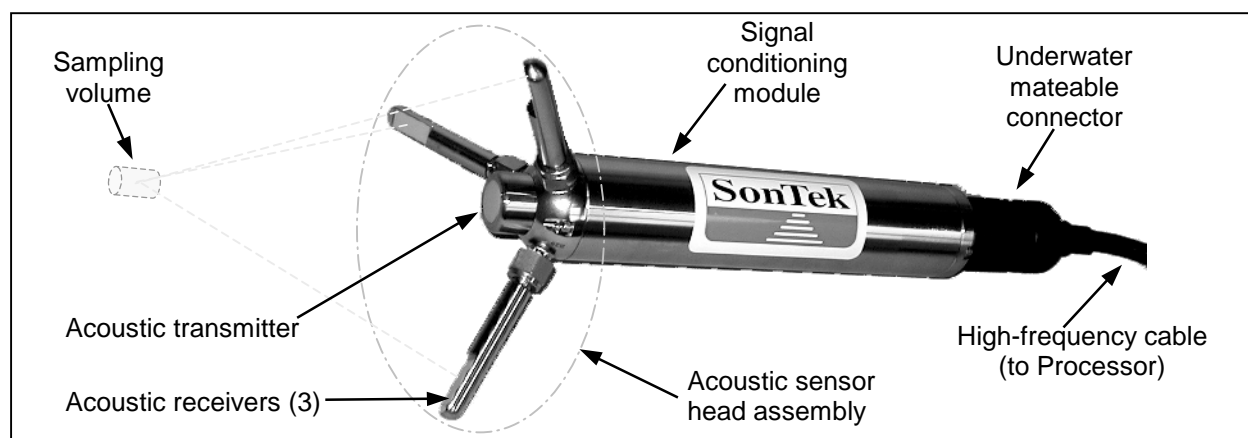
Figure 5 – Standard 5-MHz ADVOcean Probe

- The sampling volume is the volume of water ($\approx$2 cm^3) in which the ADV makes velocity measurements. This volume is nominally located 18 cm from the acoustic transmitter.

- The probe X-axis is defined by the direction of receiver #1, which is marked with a small indentation on the sensor head. When looking from the sampling volume towards the acoustic transmitter, the receivers are numbered 1, 2, and 3 moving clockwise from #1. (See §5.1 for coordinate system details.)

- The signal-conditioning module is a cylindrical housing with internal receiver electronics. The acoustic sensor head is mounted at one end of the housing, while the other end cap is connected to a high-frequency cable using a 16-pin wet-mateable connector. The temperature sensor potted inside the sensor head is used for sound speed corrections in long deployments with large temperature fluctuations.

- The high-frequency cable to the processing module carries analog signals from the probe to the digital processing electronics. This cable is highly sensitive to noise and should not be modified, extended, or shortened without instruction from SonTek. The cable is connected to the signal-conditioning module using an underwater mateable connector.

- The stainless steel ADVOcean probe has a total length of 33 cm (13.1 in), a housing diameter of 4.5 cm (1.8 in), and a maximum arm diameter of 20 cm (7.8 in) for the circle about the ends of the three receiver arms. The ADVOcean probe with the plastic conditioning module housing has the same dimensions, except the housing diameter is 5.3 cm (2.1 in).

5-MHz ADVOcean Probe Configuration with Optional Sensors: The 5-MHz ADVOcean probe can include up to two optional built-in sensors: compass/tilt and pressure. These sensors are mounted in a modified signal-conditioning module (Figure 6). The compass/tilt sensor allows the ADV to report velocity data in Earth coordinates (East-North-Up or ENU), regardless of instrument orientation. The pressure sensor with optional depth ranges and accessories gives simultaneous pressure and 3D velocity measurements (PUVW for directional wave spectra).

- The ADVOcean probe consists of an acoustic sensor head (which includes a temperature sensing thermistor), a signal-conditioning module with the optional sensors, and an underwater mateable connector to a high-frequency cable. The probe serial number is engraved on the housing near the acoustic transmitter.
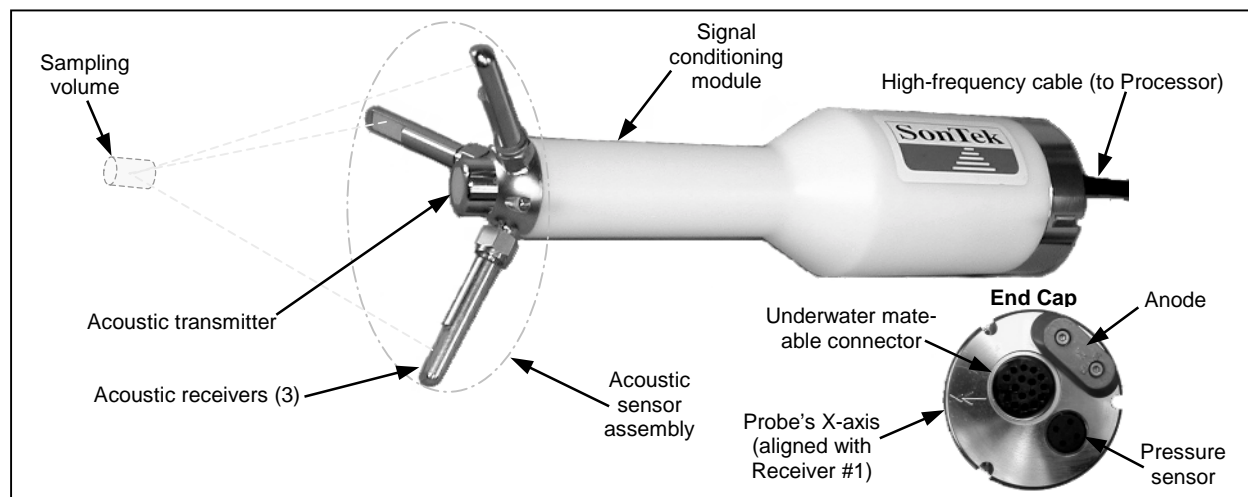
Figure 6 – 5-MHz ADVOcean Probe with Optional Sensors

- The acoustic sensor head contains three acoustic receivers and one acoustic transmitter. The sensor head is mounted directly to the end of the signal-conditioning module.

- The sampling volume is the volume of water (≈ 2 cm^3) in which the ADV makes velocity measurements. This volume is nominally located 18 cm from the acoustic transmitter.

- The probe X-axis is defined by the direction of receiver #1, which is marked with a small indentation on the sensor head. When looking from the sampling volume towards the acoustic transmitter, the receivers are numbered 1, 2, and 3 moving clockwise from #1. The probe's X-axis is also stamped on the end cap next to the cable connector. (See §5.1 for coordinate system details.)

- The signal-conditioning module is a plastic housing with internal receiver electronics and optional sensors. The acoustic sensor is permanently mounted to the lower end cap. The other end has an underwater mateable connector for the high-frequency cable.

- The optional pressure sensor is installed in the upper end cap (made of stainless steel) of the conditioning module near the underwater connector to the high-frequency cable. Note that since the pressure sensor is mounted away from the sampling volume, you may need to account for this distance when processing the combined pressure and velocity data.

- The high-frequency cable to the processing module carries analog signals from the probe to the digital processing electronics. This cable is highly sensitive to noise and should not be modified, extended, or shortened without instruction from SonTek. The cable is connected to the signal-conditioning module using an underwater mateable connector.

- The ADVOcean probe with optional sensors has a total length of 39 cm (15.3 in), a maximum housing diameter of 10 cm (4.0 in), and a maximum arm diameter of 20 cm (7.8 in) for the circle about the ends of the three receiver arms.

- The probe housing has mounting grooves to allow for easier and more secure mounting.

1.2. Definitions and Terminology

This section defines terms commonly used with the SonTek ADV.

- *Ping* - A single estimate of water velocity.

- *Sample* - A sample refers to the collection of several pings to produce a mean estimate of the water velocity. This mean value is output for storage and analysis. In addition to velocity, signal amplitude and correlation coefficient are output with each sample.

- *Pinging rate* - The number of pings per second in Hz. The ADV is designed to ping as quickly as possible. The pinging rate for the ADV under normal operating conditions ranges from 80 to 500 Hz, depending on acoustic frequency and velocity range (see §1.3).

- *Sampling rate* - The output rate for mean velocity data. This rate is user-programmable in the range from 0.1 to 50.0 Hz, depending on the acoustic frequency of the ADV.

- *Sampling interval* - The period, in seconds, over which the ADV averages data before computing the mean velocity. This is the inverse of the sampling rate (a sampling rate of 25 Hz gives a sampling interval of 0.040 second). The number of pings averaged per sample is a function of the sampling interval and pinging rate (a sampling interval of 0.040 s and a pinging rate of 250 Hz gives 10 pings for each sample). Decreasing the sampling rate (and hence increasing the sampling interval) increases the number of pings averaged and reduces the noise in each sample.

- *Temperature* - Water temperature in °C; used for sound speed calculations. It can be either a manual input or measured automatically by the temperature sensor (option on some systems).

- *Salinity* - Water salinity in parts per thousand (ppt). This manual entry is used for sound speed calculations.

- *Sound speed* - Speed of sound in water in m/s; calculated from temperature and salinity. This is used to convert the Doppler shift to velocity. See the *ADV Principles of Operation* for information on how sound speed affects ADV velocity measurements.

- *Probe configuration file* - A binary file loaded by the ADV data acquisition software (and stored in EEPROM memory by the ADVField processor) used to specify all probe-specific parameters. This includes probe geometry, sampling volume location, sampling volume size, and velocity range settings. See the *ADVField Software Manual* for details. **CAUTION:** If an incorrect probe configuration file is specified, velocity data will be invalid.

- *Sampling volume* - The volume of water in which the ADV makes velocity measurements. The center of the sampling volume (in terms of its vertical extent along the axis of the acoustic transmitter) is nominally located a fixed distance from the probe tip: 5 cm for 10-MHz and 16-MHz ADV probes; 10 cm for 10-MHz ADV probes; or 18 cm for 5-MHz ADVOcean probes. The exact distance from the probe tip to the center of the sampling volume is encoded in the probe configuration file. The sampling volume is cylindrical shaped, with the axis along the axis of the acoustic transmitter. For the 10-MHz and 16-MHz ADV probes, the cylinder is about 6 mm in diameter and 9 mm long. For the 5-MHz ADVOcean, the diameter of this cylinder is about 12 mm and the height is 18 mm. See *ADV Principles of Operation* for details.

- *Direct command interface* - Direct serial communication with the ADVField processor using a terminal or terminal emulator (e.g., **SONTERM** [DOS] or *Terminal* [Windows]).

- *BREAK* - A serial communication signal that causes a reset in the ADVField electronics and returns the system to command mode. A **BREAK** requires holding the transmit serial communication lines high for a period of at least 300 ms. A **BREAK** can be sent from the software program, **SONTERM**, by pressing **ALT+B**. or by sending three **+** characters in succession (i.e., **+++**). See the *ADVField Software Manual* for details.

  Note: The 300-ms break period is longer than that used by most standard terminals. If you use a terminal emulator other than **SONTERM**, and are have difficulty waking the system, either reconfigure your emulator for a longer break period or use **SONTERM**.

1.3.   ADV Sampling Strategies

During data collection, the ADV pings as rapidly as possible and averages pings together to output velocity data at the user-specified sampling rate. Each sample is calculated as the block average of pings during the sampling interval. No filtering or averaging is done on adjacent samples.

The ADV uses two clocks: a real-time clock to mark the start of data collection, and a high frequency sampling clock for the timing of each sample. The separate sampling clock is required because of the digital processing requirements of the ADV. The high-speed sampling clock is accurate to 1 part in 50,000 (about 2 seconds per day) and thus can introduce drift over long periods. The ADV data acquisition software uses the controlling computer for the real-time clock, while the ADVField internal real-time clock is used during autonomous deployments.

The ADVField can include internal memory and battery power for autonomous operation. Since the sampling clock may drift over long periods, the ADV uses burst sampling during autonomous deployments to provide a periodic reference to its real-time clock. In burst mode, the ADV collects a fixed number of samples at the user-specified rate (a burst) at an interval specified by the user. Data analysis, memory requirements, and battery limitations also make continuous sampling impractical for many deployments; thus the autonomous ADV has been designed to accommodate a variety of sampling strategies as described below.

Figure 7 shows ADV sampling strategies for real-time data collection and autonomous deployments. In the first example (real-time data collection), the ADV outputs data continuously at the user-specified sampling rate until terminated by the user. Data is stored on an external device (computer or data logger). The ADV relies on its sampling clock for the relative timing of remaining samples – recording the real-time clock only at the beginning of data collection.

Continuous sampling for an autonomous system is not practical for two reasons. First, the quantity of data generated is, in most cases, prohibitively large for storage and analysis. Second, the sampling clock may drift with time, and the data needs to be periodically referenced to the real-time clock. Therefore, all autonomous deployments use burst sampling. In burst sampling, you must specify three values: the sampling rate, the number of samples per burst, and the time between the start of successive bursts (called the *burst interval*). These values must meet the following criteria.

$$\text{Burst Interval} \leq \text{Overhead} + (\text{Number of Samples} / \text{Sampling Rate})$$

Overhead is the combination of the time required to prepare the system for data collection at the start of each burst and to calculate statistics at the end of each burst. An overhead time of about five seconds is required for each burst.
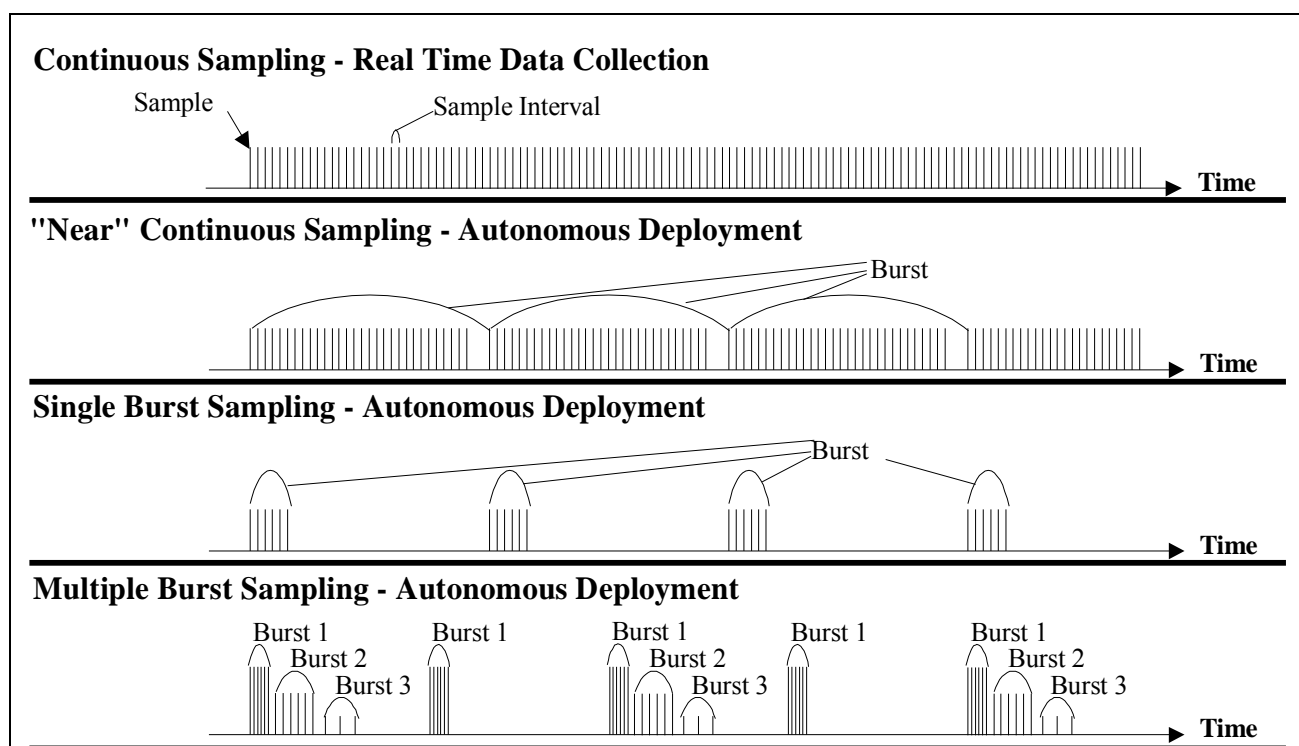
Figure 7 – ADV Sampling Strategies

The second type of sampling shown in Figure 7 is "near" continuous sampling for an autonomous ADV. The sampling parameters are set such that the ADV is sampling at all times except during the burst overhead. For near-continuous data collection, a burst interval of about one hour is recommended. This provides a regular reference to the real-time clock without a significant loss of data from the burst overhead. For example, to collect near-continuous data at 2 Hz you might set the following parameters: burst interval = 3600 seconds, sampling rate = 2 Hz, and samples per burst = 7180. This allows ten seconds of overhead with each burst, although the overhead is typically five seconds, a small safety factor is recommended.

The advantage of continuous sampling is complete coverage of the deployment period. However, continuous sampling creates huge data sets and drains battery power relatively quickly. The sampling parameters shown above generate between 1.4 and 3.8 MB of data per day (depending on what data is recorded – see §2.4.2). At the maximum sampling rate of 50 Hz, the ADV generates between 34 and 94 MB of data per day! These data rates quickly fill the internal recorder and present a daunting task for analysis. Therefore, most applications use a limited duty cycle to reduce memory requirements and increase battery life.

The third sampling strategy in Figure 7 shows burst sampling with a reduced duty cycle. The duty cycle is calculated as shown below.

$$\text{Sampling Time} = \text{Number of Samples} / \text{Sampling Rate} + \text{Overhead}$$

$$\text{Duty Cycle (\%)} = 100 * \text{Sampling Time} / \text{Burst Interval}$$

A typical example of the parameters might be: burst interval = 3600 seconds, sampling rate = 2 Hz, samples per burst = 1200. With these settings, the ADV records data at 2 Hz for 10 minutes each hour. This gives a duty cycle of about 17%, increasing battery life by a factor of six (the

ADV enters a low power standby mode when not collecting data). Using the above parameters, the ADV generates between 230 and 630 KB of data per day.

Users are often interested in different aspects of the velocity field that require different sampling schemes. Examples might include mean currents (requiring slow sampling rate), waves (requiring a moderate sampling rate; 2-5 Hz), and turbulence (requiring a rapid sampling rate; ≈25 Hz). The autonomous ADV has been designed to allow up to three different burst types to be collected in a single deployment. Each burst type has independent values for burst interval, sampling rate, and samples per burst. To avoid conflicts, these parameters are subject to the following rules.

1. The burst intervals for types 2 and 3 must be integer multiples of the burst interval for type 1.
2. The sum of the three sampling times must be at least 15 seconds less than the burst interval for type 1 (to allow an overhead of 5 seconds for each burst).

The last type of sampling in Figure 7 shows multiple-burst sampling; lines of different heights represent different burst types. Multiple burst sampling is best described with an example.

Suppose you are interested in mean currents, waves, and turbulence for a particular deployment. For mean currents, you might sample at 0.2 Hz (every 5 seconds) for a period of 2 minutes, and repeat the sampling every 20 minutes. For waves, you might sample at 4 Hz for a period of 5 minutes, and repeat the sampling every hour. For turbulence, you might sample at 25 Hz for a period of 5 minutes, and repeat the sampling every two hours. To do this, you could set the parameters shown in Table 2.

Note: Changing the sampling rate does not effect power consumption. As described earlier, the ADV pings as rapidly as it can, given a certain velocity range and configuration settings, regardless of the sampling rate. However, changing the velocity range does change the power consumption.

To calculate the total duty cycle, add the duty cycle from each burst (for this example, it is about 23%). When calculating memory requirements, the burst interval as well as the amount of data must to be taken into account. The example shown here would generate 0.8 to 2.3 MB of data per day, depending on what parameters are recorded (see §3.7). All data is stored in one file, and the data conversion software accesses each burst type independently to simplify its presentation and to separate the burst types for analysis (see *ADVField Software Manual* for details). Multiple-burst sampling supports a wide variety of sampling strategies in a reliable and easy to use format.

Table 2. Example Parameters for Multiple-Burst Sampling Strategy

	Burst Type 1: Mean Currents	Burst Type 2: Waves	Burst Type 3: Turbulence
Sampling Rate (Hz)	0.2	2.0	25.0
Samples per Burst	24	600	7500
Burst Interval (s)	1200	3600	7200
Sample Time (s)	120	300	300
Burst Duty Cycle (%)	10.4%	8.5%	4.3%
Kbytes per Burst	0.2 - 0.5	4.8 - 13.2	60 - 160

Section 2. Getting Started – Installation/Configuration/Operation

This section provides information for getting started and collecting data with the ADVField in real-time or autonomously. For details about commands, software, hardware, or deployment procedures, refer to the references provided in this section.

The following list shows the basic guidelines needed to collect data with the ADVField.

- Unpack the system from its shipping crate. Notify SonTek of damaged or missing items.
- Install the DOS-based and/or Windows-based software on your computer (§2.1).
- Review the operational considerations as they pertain to your application (Section 5).
- Interconnect the system and apply power.
- Determine your application's data collection parameters (see *ADV Principles of Operation*).
- Send the data collection parameters to your system.
- Deploy the system.
- Retrieve/View/Analyze the collected data.

2.1. Software Installation

To install the DOS and Windows software on a <u>Windows-based</u> computer:

- Insert the distribution CD in your computer.
- An installation menu should automatically appear after the CD has been inserted. If not, click **Start | Run** and type **d:\install.exe** where **d:** is your CD-ROM drive.
- Click the appropriate programs that you would like to install on your computer. Follow the on-screen instructions. If prompted, insert the Probe Definition disk in your floppy drive.
- See the *ADVField Software Manual* for details about the DOS and Windows programs.

To install the DOS software on a <u>DOS-only</u> computer:

- Insert the CD in your computer.
- List the files/directories contained on the CD (e.g., **dir d:**, where **d:** is the CD drive).
- Copy all files/subdirectories from the **d:\ADF-DOS** directory to an appropriate directory on your computer. For example: **XCOPY D:\ADF-DOS*.* C:\SONTEK\ADVF-770\ /s**
- Using the above syntax will copy all DOS program files from the CD to:
  C:\SONTEK\ADVF-770\DEPLOY*.*   and   **C:\SONTEK\ADVF-770\REALTIME*.***

Note: A .pdf copy of this manual is available on the CD-ROM disk in the \Documents directory.

2.2. System Preparation, Interconnection, and Setup

Before connecting your system for data collection, review the operational considerations listed in Section 5 that may affect your deployment. These considerations include the velocity data coordinate system, optional temperature and pressure sensors, serial communication protocol, multiple system operation (RS485), optional analog outputs, optional external synchronization, sensor mounting, routine maintenance, seeding, anti-fouling protection, and troubleshooting problems.

Depending on the ADV model you have and on how you plan to deploy it, power and cable connections will vary for each system. Some typical methods and setups for collecting data are described in §2.3 and §2.4. Additionally, certain switches and jumpers may need to be set to configure your system for communication protocols and installed options. Section 4.2 describes the internal switches and jumpers relating to hardware configuration and serial communication.

2.3. ADVField Real-Time Data Collection Setup

The ADVField (with 16-MHz MicroADV, 10-MHz ADV, or 5-MHz ADVOcean probe) uses a processing module that consists of three printed circuit boards. The processing module can be enclosed in a splash-proof housing or in an underwater canister. The two mechanical versions use different cables and connectors (see §4.3), but the basic operation is identical. Please note that real-time data collection is identical for ADVField systems that include the optional internal recorder and battery power for autonomous operation. The internal recorder in real-time systems can be used during data collection as a backup in case communications are lost.

For real-time data collection, the ADVField typically uses an external power source supplying 12-24 VDC. Any power source supplying 12-24 VDC with sufficient capacity can be used. During continuous operation, the instrument (regardless of acoustic frequency) consumes 3-5 W. The connectors on the splash-proof housing and the cable from the underwater canister match the power supply included with the ADV.

The ADVField with splash-proof housing can also be configured with a rechargeable battery for field data collection; the battery has capacity for about 8 hours of operation. A battery charger is included with any ADV equipped with the rechargeable battery. See §4.5 for information about the ADV with rechargeable battery. See §2.4.1 for details on calculating power requirements.

2.3.1. Preparing the ADVField for Real-Time Operation

1. As necessary, review the operational considerations presented in Section 5.
2. Connect the high-frequency cable from the probe to the processing module. Connect the high-frequency cable to the probe. For the underwater ADVField, connect the power and communication cable to the underwater canister. See §4.3 for cables and connector details.
3. Connect the serial port of the ADVField to an available serial port on the controlling computer. For the splash-proof ADVField, this is done by directly attaching a ribbon cable from the processor to the computer serial port. For the underwater ADVField, the power and communication cable from the underwater processor is terminated with a DB9 connector that can be connected directly to your computer.
4. If you are using the system directly out of the box, go to Step 5; otherwise, you may need to edit the ASCII text file **ADVPROBE.DEF**. This file should contain one line that looks similar to **PROBE 0 A001.PRO**. The number **0** indicates the address of the ADV to which you are establishing communications (only applicable for RS-485 operation). **A001.PRO** is the probe configuration file included on the software diskette. Be sure the name of this file corresponds with the serial number of the probe connected to the ADV processor, and that the probe configuration file is in the ADV software directory and is for the most-recent calibration.

> **CAUTION**
> **To collect valid velocity data, you must load the correct probe configuration file. You can use the `ADF.EXE` data acquisition software with the configuration file specified in `ADV-PROBE.DEF`, or use `SonUtils|Terminal|Load Probe Config`. Once loaded, the configuration file is stored in memory in the processing module. If you have multiple probes, be sure to load the correct configuration file before you start data collection.**

5. Supply power to the system using the power supply included with the system, or by pressing the power switch on the splash-proof ADVField with the optional rechargeable battery.
6. Enter your data collection parameters using the software that has been provided (§2.3.2) or by using the direct command interface via a dumb terminal or terminal emulator (§2.5).
7. Deploy the instrument and start data collection and analysis.

2.3.2. Real-Time Operation Using SonTek Software

The simplest way to operate the ADVField is to use the data acquisition software (**ADF.EXE**). The following steps explain how to test the ADV and how to collect data in a DOS environment. See the *ADVField Software Manual* for details about all software associated with the ADV. For testing purposes, you should have a bucket of water on hand.

1. If necessary, install the DOS software on your computer (§2.1).
2. If you are simply testing ADV operation, suspend the probe head in a bucket of water (at least 30-cm deep for 16/10-MHz ADV probes; 45 cm for the 5-MHz ADVOcean probe) with a teaspoon of seeding material. <u>Note</u>: Operating the probe out of water will not cause any damage, although the velocity data will be meaningless.
3. Before every use/deployment of the ADVField, we suggest you run the **ADFCHECK** diagnostic program. Run the program by typing **ADFCHECK -p1** at the DOS prompt, where **1** is the serial port for the ADV (**-p1** for COM1, **-p2** for COM2). Place the ADV probe in a bucket of water, and compare the output with the examples in the *ADVField Software Manual*.

NOTE
The most common communication problem is an incorrect baud rate or COM port setting.
A simple way to determine the correct settings is through the SonUtils|Terminal program.

4. Now run the data acquisition program **ADF.EXE** by typing **ADF** at the DOS prompt. This will place you in the program's *Setup Mode*. At this point, you would enter the data collection parameters for your application. Use the *ADV Principles of Operation* and the *ADVField Software Manual* as guidelines for selecting these parameters. <u>Note</u>: If you are just making a quick check to see if the ADV is functioning, you can set the **Sampling Rate** to 10 Hz and the **Velocity Range** to 100 cm/s.
5. After entering your data collection parameters, select the **START Data Acquisition** button and press <**Enter**> to start data collection. This will place you in the *Boundary Adjustment Mode*.
6. In the *Boundary Adjustment Mode*, the ADV continuously scans the region in front of the probe to detect the presence of a solid or surface boundary. The screen will display the distances from the tip of the probe to the boundary and from the center of the sampling volume to that boundary. If no boundary is detected, a **NOT DETECTED** message is displayed. This boundary check is necessary because the ADV must adjust its operation to prevent boundary reflections from interfering with signals from the sampling volume. For more information about the *Boundary Adjustment Mode*, see the *ADVField Software Manual*.
7. After viewing the boundary information (and making any changes to probe positioning if necessary), press <**F10**> to exit the *Boundary Adjustment Mode* and to enter the *Data Acquisition Mode*. The real-time data display should now be shown.
8. Now press <**Enter**> to start real-time data collection. The on-screen information will begin to change based on the information received by the probe. From within the *Data Collection Mode*, several on-screen options are available to you. Refer to the *ADVField Software Manual* for details. <u>Note</u>: If you are just making a quick check to see if the ADV is functioning, you can move the probe within the bucket of water and watch the velocity traces change.

For more details, see the *ADVField Software Manual*. The ADV and its software are designed to be reasonably robust; as such, we recommend that you familiarize yourself with the operation of the instrument and its software.

2.4.   ADVField Autonomous Data Collection Setup

An autonomous (i.e., stand-alone or remote) deployment requires more forethought than a real-time deployment. For example, during real-time operation, you can change your data collection parameters "on-the-fly", operate 24 hours per day, and collect a virtually unlimited amount of data. However, when you deploy your system for autonomous data collection, you will not be able to change your data collection parameters (in most cases) without first retrieving your system. Additionally, in an autonomous deployment, you have a limited amount of battery power and data-storage memory.

The following sections explain how to calculate power and memory requirements, and how to prepare, set up, and deploy an ADVField for an autonomous deployment.

2.4.1. Calculating Power Requirements

During data collection, the ADV has a mean power consumption ranging from 3.5 to 5 W, depending on the velocity range setting. Table 3 lists the approximate power consumption for each velocity range.

Table 3. Approximate Power Consumption vs. Velocity Range

16/10-MHz ADV Velocity Range	5-MHz ADVOcean Velocity Range	Power Consumption
±3 cm/s	±5 cm/s	3.5 W
±10 cm/s	±20 cm/s	3.8 W
±30 cm/s	±50 cm/s	4.0 W
±100 cm/s	±200 cm/s	4.5 W
±250 cm/s	±500 cm/s	5.0 W

The standard alkaline battery packs supply 18 V with a nominal capacity of 42 Ah. Lithium packs supply 21.6 V with a nominal capacity of 84 Ah. When calculating battery life, we recommend using 80% of the nominal capacity. This allows 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 Wh) and (0.8 * 21.6 V * 84 Ah = 1450 Wh) respectively.

The standard system configuration uses either two alkaline or two lithium battery packs wired in parallel. Two alkaline packs have sufficient power for 10-14 days of continuous operation; two lithium packs have sufficient power for 24-34 days of continuous operation (both depending on the velocity range setting).

For most applications, the ADVField uses a reduced duty cycle to conserve battery power and extend deployment length. See §1.3 for a description of how to calculate the duty cycle. When not actively collecting data, the ADV consumes less than 1 mW of power. The 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.

2.4.2. Calculating Memory Requirements

The ADV records between 8 and 22 bytes of data per sample. See §3.7 for a description of the recording options and to help determine the number of bytes that will be stored with each sample. Computing the amount of memory required for a deployment is done in three steps.

1. Determine the number of bytes recorded per sample (§3.7).
2. Calculate the number of bytes to be recorded per burst (below).
3. Calculate the total file size based on expected number of bursts (below).

Number of bytes per burst is calculated based on the bytes per sample (SAMP_SIZE) from Step 1 above, the number of samples per burst (N_SAMP), and whether burst statistics are re-corded. If burst statistics are <u>not</u> recorded, use the formula:

BURST_SIZE = 62 + (N_SAMP*SAMP_SIZE)

If burst statistics <u>are</u> recorded, use the formula:

BURST_SIZE = 98 + (N_SAMP*SAMP_SIZE)

Total file size is the number of bursts multiplied by the bytes for each burst plus the file header (441 bytes). When using multiple-burst sampling, you must calculate the burst size and number of bursts for each burst type. See §A2.2 for a detailed description of the data file format.

The ADV recorder is available in sizes ranging from 20 to 880 MB, and therefore can accommo-date a wide range of sampling strategies and deployment lengths. The ADVField recorder is di-vided into blocks of 64 KB each; only one data file can be written in one block, although one data file can occupy multiple blocks.

Bear in mind that the recorder also has a maximum number of *files* that can be stored. This num-ber is computed by dividing the recorder size by 64 KB. If you record a large number of small data files (less than 64 KB per file), the recorder will fill before reaching the rated maximum ca-pacity. Be sure to format the recorder to erase all files before any extended deployment.

2.4.3. Preparing the ADVField for Autonomous Operation

This section assumes that the ADVField system includes the internal recorder in the same un-derwater housing as the ADVField processing module. The instructions below assume that you will use an external power supply to set up your system before deployment (or testing). If your system is equipped with the internal battery option, the deployment (or testing) setup can be done from battery power simply by not connecting the external power supply.

1. Determine the power requirements (§2.4.1) and memory requirements (§2.4.2) for your ap-plication. Also, review the operational considerations presented in Section 5.
2. Connect the high-frequency probe cable to the underwater canister. Connect the other end of the high-frequency cable to the probe. Connect the power and communication cable to the underwater canister. See §4.3 for cables and connector details.
3. Connect the DB9 connector on the power and communication cable to an available serial port on your computer. <u>Note</u>: For RS422/485 systems, use the RS232/422 adaptor provided with the system.
4. Connect the coaxial power connector on the power and communication cable to the power supply included with the system. Plug the supply into an available 110/220 VAC outlet. The external power supply is used if its voltage is greater than the internal battery packs. The standard ADV battery packs are wired for 18 VDC; the power supply included with the sys-tem supplies 24 VDC. <u>Note</u>: If desired, you can skip this step if you want to set up the ADV for deployment (or testing) using the battery packs instead of an external power supply.
5. If you are using the system directly out of the box, go to Step 6; otherwise, you may need to edit the ASCII text file **ADVPROBE.DEF**. This file should contain one line that looks similar to **PROBE 0 A001.PRO**. The number **0** indicates the address of the ADV to which you are estab-

lishing communications (only applicable for RS-485 operation). `A001.PRO` is the probe configuration file included on the software diskette. Be sure the name of this file corresponds with the serial number of the probe connected to the ADV processor, and that the probe configuration file is in the ADV software directory and is for the most-recent calibration.

CAUTION

To collect valid velocity data, you must load the correct probe configuration file. You can use the `ADF.EXE` data acquisition software with the configuration file specified in `ADV-PROBE.DEF,` or use `SonUtils|Terminal|Load Probe Config`. Once loaded, the configuration file is stored in memory in the processing module. If you have multiple probes, be sure to load the correct configuration file before you start data collection.

6. Before every use/deployment of the ADVField, we suggest you run the diagnostic program included with the system (`ADFCHECK`). Run the diagnostic program by typing `ADFCHECK -p1` at the DOS prompt, where `1` is the serial port the ADV is connected to (`-p1` for COM1, `-p2` for COM2). Place the ADV probe in the bucket of water, and compare the output with the examples in the *ADVField Software Manual*. In addition to its diagnostic capabilities, this program is an excellent way to learn about the operational principles of the ADV.

7. Enter your data collection parameters using the software that has been provided (§2.4.4).

2.4.4. Autonomous Operation Using SonTek Software

Autonomous deployments are started from the ADVField direct command interface (Section 3) using a dumb terminal or terminal emulator. ADV software includes a terminal emulator program for both DOS [`SONTERM`] and Windows [*SonUtils|Terminal*]. See the *ADVField Software Manual* for details on its operation. To start an autonomous deployment:

1. Be sure you have completed the preliminary steps outlined in sections 2.4.1 through 2.4.3.
2. Establish communication with the ADV using `SONTERM`. Send a `BREAK` (**Alt+B**) to place the ADV in command mode. Type `HELP` to see menus for setting data collection parameters.
3. Send `Compass CAL` to perform a compass calibration (§4.7.5).
4. Send another `BREAK` to place the system in a known state.
5. At this point, you may wish to use `SONTERM` to capture all communication with the ADV to a log file (**Alt+F**) for future reference.
6. Use the `show` commands to check the currently loaded parameters. If any parameter needs to be changed, use the appropriate command to change its setting (Section 3).
   - `Show Conf` – Hardware configuration parameters.
   - `Show System` – System operating parameters. Of importance is the ADV clock date/time.
   - `Show Setup` – Data collection parameters. Of importance are the velocity range and coordinate system.
   - `Show Deploy` – Autonomous deployment parameters. Of importance are deployment name, start date/time, sampling rate, burst interval, and samples per burst. Verify settings of the data recording options to meet data analysis needs and any memory limitations.

   Note: If you are just making a quick check to see if the ADV is functioning, the set data collection parameters for a short-term deployment. Sample parameters might be: burst interval 60 seconds, sampling rate 10 Hz, samples per burst 300. For this configuration, each burst collects 30 seconds of data at 10 Hz, with one burst per minute.

7. Check compass operation by sending `Compass CONT`. Rotate and tilt the sensor to verify reasonable values (§4.7.1). Press any key to stop output.
8. As necessary, check external sensor operation by sending the appropriate command(s).

- **PAROS CONT** or **DRUCK CONT** or **PAROSFREQ CONT**
- **CTD CONT**
- **ExtSensor CONT**

9. Send **save setup** to save all entered parameters. This is redundant as it is done automatically by the **Deploy** command below, but gives you some assurance your settings have been saved.

10. Double check system clock date/time and deployment start date/time. Verify settings in all four **show** commands one final time.

11. Send **Deploy** to start the deployment. Watch for any error messages or for any unexpected response. If practical, leave the computer connected with the terminal emulator recording ADV output until the first burst has been started. <u>Note</u>: To stop the deployment, send a **BREAK**.

12. Disconnect the cable from the computer <u>before</u> turning the computer off.

13. Install the dummy plug and deploy the ADV.

14. After the deployment: recover the ADV, interconnect the system as described in §2.4.3, and use **SONTERM** to send a **BREAK** to the ADV to stop data collection (although you may first want to observe a collection cycle or two to confirm that the ADV is still collecting data).

15. You can now use **SONTERM** to extract the data from the recorder. Use the data conversion software to look at the recorded data (see *ADVField Software Manual*).

2.5.   Operating the ADVField Using the Direct Command Interface

As an alternative to the SonTek data acquisition software, you can write your own software using the serial communication protocol and command interface documented in Section 3. This allows the ADV to be controlled from a terminal emulator, data logger, or other custom program.

For a quick check using a terminal emulator, connect the serial cables as described in §2.3.1 (for real-time operation) or §2.4.3 (for autonomous operation), set the terminal emulator software (e.g., **SONTERM**) to the correct serial port, and apply power. The default communication parameters are: no parity, 8 data bits, 2 stop bits, 19200 baud (see §4.2 to change baud rate).

To establish communication, send a **BREAK** (**Alt+B** in **SONTERM**). The response should look similar to the following.

```
ADVField
SonTek
Copyright 1994-2001
>
```

Start by typing **HELP** at the prompt. See Section 3 for details on the direct command interface. The direct command interface allows access to all data collection parameters.

After each **SaveSetup**, **Start**, or **Deploy** (autonomous systems only) command, the data collection parameters are stored to an EEPROM in the processing module. For instruments without the internal recorder, the ADV enters the data collection mode immediately after powering up. Whenever power is applied to ADVs with the internal recorder, the ADV enters the last operational state. The three operational states are: command mode (ready for input commands over the serial port), data acquisition mode (actively collecting and outputting real-time data), and deployment mode (for autonomous deployment using battery power and the optional internal recorder). If the ADV (before being powered off) was collecting data in data acquisition or deployment mode, it will load the last data collection parameters from EEPROM and immediately begin data collection. Therefore, it is only necessary to send commands at startup when data collection parameters need to be changed.

Section 3. Direct Command Interface for ADVField Systems

The direct command interface refers to the command inputs and response / data outputs for communicating with the ADVField using its serial communication port. The command interface shown in this section is used for either RS232 or RS422 communication protocol. The interface used for RS485 protocol is not included in this manual. See §5.2 for the serial communication protocols supported by the ADVField.

You can access the direct command interface using a dumb terminal or terminal emulator program (e.g.; **SONTERM**). The default communication parameters for the ADVField are: 8 data bits, no parity, and 2 stop bits. The baud rate defaults are 9600 for firmware v6.8 and earlier, or 19200 for firmware after v6.8. The baud rate can be changed using the BAUD rotary switch on the CPU board (see §4.2).

Before data collection, you must set a few operational parameters. For real-time data collection, this is normally done using the SonTek data acquisition software (**ADF.EXE**), but can also be done using the direct command interface. Autonomous deployments (see §2.4) are configured and started using the direct command interface. This section gives a detailed description of all aspects of the direct command interface.

When using the ADVField, it is important that the correct probe configuration file has been loaded into the system. The configuration file is loaded when data collection is started using the SonTek data acquisition software (**ADF.EXE**) as described in the *ADVField Software Manual*. The configuration file is stored in EEPROM memory until overwritten by a new configuration file.

CAUTION
Using an incorrect probe configuration file will result in invalid velocity data. If you are collecting data using the direct command interface, be sure the probe serial number listed by the Show Conf command matches the serial number of the probe being used and confirm that the correct configuration file has been loaded.

Section 3.1 gives an overview of the operational modes of the ADVField. Section 3.2 presents the syntax rules for the command interface. A summary of all commands is provided in §3.3. The remaining parts of Section 3 describe the commands and output data format in detail.

3.1. Modes of Operation

The ADVField has four operational modes – *command mode*, *data acquisition mode*, *deployment mode*, and *sleep mode*.

3.1.1. Command Mode

In command mode, the ADVField can receive commands relating to all aspects of instrument operation. You can enter the command mode from data acquisition or deployment mode by sending a **BREAK** (§1.2) or three **+** characters in succession (**+++** - see §3.12). You can enter command mode from the sleep mode by sending a **BREAK** or by cycling the system power (see below). You can put the ADVField into any of the other modes only from the command mode.

To enter the data acquisition mode (for real-time data collection) from the command mode, use the command **start**. To enter the deployment mode (for autonomous data collection) from the command mode, use the command **Deploy**. To enter the sleep mode from the command mode, use the command **PowerOff**. If the ADVField remains inactive in command mode for more than five minutes, it automatically enters the sleep mode.

3.1.2. Data Acquisition Mode

Data acquisition mode indicates that the ADVField is involved in *real-time* data collection. Data acquisition mode is entered from the command mode with the command `start`. In data acquisition mode, the ADVField ignores all deployment parameters (§3.7) and proceeds with data collection based on the setup parameters (§3.6). During real-time data collection, data is output both through the ADVField serial port and as analog output voltages, but cannot be written to the optional internal recorder. You can exit the data acquisition mode and return to the command mode by sending a `BREAK` or by using the run-time command `+++`.

3.1.3. Deployment Mode

Deployment mode is used for *autonomous* data collection. Deployment mode is entered from command mode using the command `Deploy`. In deployment mode, the ADVField uses both the setup and deployment parameters (§3.6 and §3.7) to configure data collection. You can exit the deployment mode and return to the command mode by sending a `BREAK` or by using the run-time command `+++`. In deployment mode, data is written to the internal recorder, and the burst header is output over the serial port.

3.1.4. Sleep Mode

The sleep mode is used to conserve power when the instrument is not in use. To manually enter this mode, use the command `PowerOff`. The ADVField will also enter the sleep mode automatically if left inactive in command mode for more than five minutes. In sleep mode, the ADV uses less than 1 mW of power. You can exit sleep mode and enter command mode by sending a `BREAK`. When in sleep mode, the ADV will not perform or respond until a `BREAK` is received (unless ADV power is cycled; see §3.1.5). If the ADV is being powered by batteries, you should place the ADV in sleep mode before storing the instrument to prevent draining the batteries.

3.1.5. System Responses to Power Application and Break Signals

The following items should be kept in mind regarding the application/removal of power and regarding ADV reactions to `BREAK` signals.

- The response of the ADV to a power-up depends on whether it has an internal recorder.

  - *Without Internal Recorder* – The ADV will immediately enter deployment mode and start data collection when power is applied.

  - *With Internal Recorder* – The ADV will enter the last mode it was in before power was lost/removed. If the ADV was previously in:

    - Command mode or sleep mode: The ADV will re-enter command mode.
    - Data acquisition mode: The ADV will enter data acquisition mode and immediately start real-time data collection.
    - Deployment mode: The ADV will start a new deployment using the stored deployment and setup 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 the loss of data in the event of a clock reset caused by a problem with the real-time clock backup battery.

- After changing batteries, establish communication with the ADV and place it in sleep mode to prevent draining the batteries.

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

- The ADV has an "accidental **BREAK** protection" feature. If the system was in data acquisition mode or deployment mode, and a **BREAK** (or **+++**) is received (either manually or through electronic noise), the system will resume data collection unless a valid command is received within the ensuing five-minute interval.

3.2. Command Syntax

The following are rules needed for communicating between the ADV and an external dumb terminal or terminal emulator program (e.g., **SONTERM**).

- The ADV can be brought into the command mode from any other state by sending a **BREAK** (see §1.2 for definition) to the system. The **BREAK** requires holding the ADV serial input lines high for at least 300 ms.

- The ADV can be brought into the command mode from data acquisition or deployment mode by sending three **+** characters (**+++**, see §3.12).

- All commands consist of one keyword that may be followed by one or more ASCII parameters. The commands are <u>not</u> case sensitive.

- When the ADV has completed a command and is ready to accept another command, it will send the prompt character (**>**).

- Parameters may be numeric (either integer or decimal real number), alphanumeric, or a combination (e.g., a date or time string).

- Commands must be terminated by a carriage return (e.g., **<CR>** or **<Enter>**).

- The ADV echoes every character as it is received.

- After receiving the **<CR>** that signals the end of the command string, the ADV echoes an additional line feed character, **<LF>**.

- If the ADV recognizes a command as valid, it will transmit: **<LF>OK<CR><LF>**

- If a command is not recognized, or if the parameters are out of range, or if the command cannot be executed in the present state, the ADV returns an error message followed by **<CR><LF>** and the prompt character (**>**).

3.3. Direct Command Summary

The following tables summarize all commands that can be used with the ADVField, including any abbreviations (short versions of the same command). These commands are grouped into different tables based on their function. Further details on individual commands are provided in the paragraphs that follow.

The following abbreviations are used for input parameters.

$$
\begin{aligned}
d &= \text{integer input (e.g., 30)} \\
d.d &= \text{decimal real number input (e.g., 0.33, 1.5)} \\
yy/mm/dd &= \text{date as year, month, and day (e.g., 2001/05/20 or 01/05/20)} \\
hh:mm:ss &= \text{24-hour clock with hour, minute, and second (e.g., 18:15:00)}
\end{aligned}
$$

Table 4. Help Commands (§3.4)

Command	Short	Function
Help	H or ?	Information about available help categories
Help System	H/? System	Information about general system commands
Help Setup	H/? Setup	Information about real-time data collection commands
Help Deploy	H/? Deploy	Information about autonomous deployment commands
Help Recorder	H/? Recorder	Information about internal recorder commands
Help Sensor	H/? Sensor	Information about peripheral sensor commands
Help Compass	H/? Compass	Information about compass/tilt sensor commands
Help CTD	H/? CTD	Information about CTD sensor commands
Help Show	H/? Show	Information on how to display system configuration

Table 5. System Commands (§3.5)

Command	Short	Function	Parameters
Start		Start real-time data collection (enter data acquisition mode)	
Deploy		Start autonomous deployment (enter deployment mode)	
SaveSetup		Save current parameters to EEPROM	
Cal		Calibrate analog output voltages	
Defaults	DEF	Set all parameters to factory defaults	
Ver		Show CPU firmware version	
DSPVer		Show DSP firmware version	
BoardRev		Show electronics PC board revision	
SerNum		Return ADV probe serial number	
Boundary		Measure and return distance to boundary	
Date <date>		Set/display system clock date	yy/mm/dd
Time <time>		Set/display system clock time	hh:mm:ss
PowerOff		Place ADV in sleep mode	
OutFormat <format>	OF	Specify output data format	ASCII, BINARY
The following system commands are not shown in the ADVField on-line help			
Setup		Prepare the ADV to begin data collection	
Go		Start data collection immediately (enter data acquisition mode)	

Table 6. Setup Commands (§3.6)

Command	Short	Function	Parameters
Temp <temperature>		Set default temperature (°C)	d.d
Sal <salinity>		Set default salinity (ppt)	d.d
VelRange <range>	VR	Set ADV velocity range value (index)	d <0 to 4>
SampRate <rate>	SR	Set ADV sampling rate (Hz)	d.d
CoordSystem<system>	CY	Set coordinate system for velocity data	BEAM, XYZ, ENU
TempMode <mode>	TM	Set temperature used in sound speed calculations	USER, MEASURED
SyncMode <mode>	SM	Specify external synchronization mode (real-time data acquisition only)	START, SAMPLE, DISABLE

Table 7. Deployment Commands (§3.7)

Command	Short	Function	Parameters
Deployment <name>		Set deployment file name	ASCII text
Comments		Enter deployment comments	ASCII text
StartDate <date>	SD	Set deployment start date	yy/mm/dd
StartTime <time>	ST	Set deployment start time	hh:mm:ss
SampRate <rate>	SR	Set ADV sampling rate (Hz)	d.d
BurstInterval<seconds>	BI	Set time between bursts (seconds)	d
SamplesPerBurst <num.>	SB	Set number of samples per burst	d
RecordAmpCorr <mode>		Set mode to record amplitude and correlation for all beams with each sample	YES, NO
RecordCompass <mode>		Set mode to record compass/tilt sensor data with each sample	YES, NO
RecordSensor <mode>		Set mode to record temperature and pressure data with each sample	YES, NO
RecordStat <mode>		Set mode to record statistics with each burst	YES, NO
RecordExtSensor<mode>		Set mode to record external sensor data	YES, NO
RecordExtPress <mode>		Set mode to record external pressure sensor data	YES, NO
RecordCTD <mode>		Set mode to record external CTD data	YES, NO
RecordLISST <mode>		Set mode to record LISST-100 sensor data	YES, NO

Table 8. Recorder Commands (§3.8)

Command	Short	Function
LD or Dir		List deployments currently on recorder
Format		Erase all data from recorder
RecStatus		Show recorder size and type

Table 9. Sensor Commands (§3.9)

Command	Short	Function
Sensor		Show most recent temperature, pressure, and battery voltage
Sensor CONT		Show temperature, pressure, and battery voltage continuously
PressScale		Output scaling factor used to convert pressure counts to dBar
PressOffset		Output offset used to convert pressure counts to dBar
CTD		Show most recent temperature (°C), conductivity (S/m), pressure (decibar), and salinity (ppt) data from external CTD sensor
CTD CONT		Show CTD data continuously
CTD Talk		Establish direct serial communications with CTD sensor
ExtSensorInstalled		Enables/Disables external sensor
ExtSensor [CONT]		Show most recent data from external sensor [continuously]
Druck [CONT]		Show most recent data from Druck pressure sensor [continuously]
Paros [CONT]		Show most recent data from Paros pressure sensor [continuously]
ParosFreq [CONT]		Show most recent data from Paros pressure sensor [continuously]
ExtPressureSensorInstalled		Enables/Disables external pressure sensor
CTDSensorInstalled		Enables/Disables external CTD sensor
LisstSensorInstalled		Enables/Disables external LISST-100 sensor

Table 10. Compass Commands (§3.9.5)

Command	Short	Function
Compass [CONT]		Show most recent heading, pitch, and roll [continuously]
Compass CAL		Perform compass/tilt sensor calibration

Table 11. Show Commands (§3.11)

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
Show Druck	S Druck	Display frequency pressure sensor calibration

Table 12. Run Time Commands (§3.12)

Command	Short	Function
+++		Return ADVField to command mode (stop data collection)

3.4. Help Commands

The ADVField direct-command interface contains several on-line help commands. These are designed such that, by starting with `Help` (or `H` or `?`), you are led through a series of menus that show all ADVField commands. The following help commands display all commands you would normally use for any aspect of ADVField operation. Entering any of these commands at the direct-command prompt (`>`) will display the appropriate help menus.

- `Help System` – General system commands (§3.5)
- `Help Setup` – Real-time data collection commands (§3.6)
- `Help Deploy` – Autonomous deployment commands (§3.7)
- `Help Recorder` – Data recorder commands (§3.8)
- `Help Sensor` – Peripheral sensor commands (§3.9)
- `Help Compass` – Compass/tilt sensor commands (§3.9.5)
- `Help Show` – Commands to display system configuration (§3.11)

3.5. System Commands

System commands relate to general operation of the ADVField.

- Starting data collection
- Entering sleep mode
- Displaying serial number and revision numbers
- Setting the clock
- Data output and storage

Each command is shown with its full name, short name (if one exists), optional parameters (in brackets), and appropriate descriptions.

`Start`

- Places the ADV in data acquisition mode (§3.1.2) and starts *real-time* data collection.
- The ADV first saves all recently entered commands (i.e., does a `SaveSetup`).
- Data collection begins automatically thereafter, ignoring all deployment parameters (§3.7) and using the most recently entered setup parameters (§3.6).
- A delay of about two seconds is required for the ADV to initialize and check for potential boundary interference. If precise control of start time is required, see the `Setup` and `Go` commands (below).
- Note: The `Run` command (which is equivalent to `start`) is still supported to maintain compatibility with previous firmware versions.

`Deploy`

- Places the ADV in deployment mode (§3.1.3) and starts *autonomous* data collection.
- The ADV first saves all recently entered commands (i.e., does a `SaveSetup`).
- Data collection begins when the ADV clock reaches the specified `startDate` and `Start-Time` using the most recently specified setup (§3.6) and deployment parameters (§3.7). If the current date and time is <u>after</u> the specified start date and time, data collection begins immediately (actually, there is a delay of about 2 seconds to initialize the system and look for potential boundary interference).
- In deployment mode (§3.1.3), data is stored to the internal recorder. As such, `Deploy` can only be used if the optional internal recorder is installed.
- Note: Do not confuse this command with the `Deployment` command (§3.7)

`SaveSetup`

- Saves all current parameter settings to the ADV's internal memory (EEPROM).
- Must be done before the system is shut down (or before a `BREAK` is sent) or any recently entered commands will be lost.
- Is done automatically as part of the `start` and `Deploy` commands.

`Cal`

- Places the ADV in calibration mode for the analog output voltages.
- You are instructed to press `H`, `M`, or `L`, which sets all four analog output voltage lines to their high (nominally 5.0 V), mid (nominally 2.5 V), and low (nominally 0.0 V) levels.
- For more information about analog output calibration, see §5.4.

Defaults *or* **DEF**
- Sets all ADV parameters to their factory default values.
- See the individual command descriptions for their default values.

Ver
- Reports the version number of the ADV's CPU firmware.

DSPVer
- Reports the version number of the ADV's DSP firmware.

BoardRev
- Reports the PC board revision of the ADV's processing module (§4.1).
- Normally, all boards within the processing module have the same revision. Some systems may use a combination of revisions. For these, the output reflects the CPU board revision.

SerNum
- Reports the serial number of the ADV probe configuration file stored in EEPROM memory. This should match the serial number of the probe connected to the processing module.
- **CAUTION:** If the incorrect probe configuration file is specified, velocity data will be invalid.

Boundary
- Reports the range from the ADV probe to a physical boundary (e.g., bottom, surface, wall).
- Boundaries can be detected within about 25 cm for the 16-MHz MicroADV probe, 45 cm for the 10-MHz ADV probe, and 100 cm for the 5-MHz ADVOcean probe.
- Requires about two seconds to detect a boundary.
- Two values are returned, in cm: (1) distance from probe tip (i.e., acoustic transmitter) to boundary, and (2) distance from center of sampling volume to boundary. If no boundary is detected, **-100.00** is returned for both values.
- **CAUTION:** Accurate boundary measurements require that the correct probe configuration file has been loaded into the ADV; otherwise, the reported boundary values will be invalid.

Date [yy/mm/dd | yyyy/mm/dd]
- Without parameter: returns the date from the ADV's real-time clock.
- When given with a date in a valid format, where yy = year (2 or 4 digits), mm = month (2 digits), and dd = day (2 digits): sets the clock date.
- Example: **Date 2001/09/08** or **Date 01/09/08** are equivalent commands setting the ADV's real-time clock date to September 8, 2001.

Time [hh:mm:ss]
- Without parameter: returns the time from the ADV's real-time clock.
- When given with a time in a valid format, where hh = hour (2 digits; 24-hour clock), mm = minute (2 digits), and ss = seconds (2 digits): sets the clock time.
- Example: **Time 13:05:00** sets the ADV's real-time clock to exactly 1:05 p.m.

PowerOff
- Puts the ADV into sleep mode (§3.1.4), where power consumption is less than 1 mW. The system does not output any response to this command.
- The ADV will enter sleep mode if left idle in command mode more than 5 minutes.
- To avoid draining batteries, place the ADV in sleep mode whenever it is not in use.

OutFormat *or* **OF [BINARY|ASCII]**
- Default parameter: **ASCII**
- When given without parameter: returns the current output format setting.
- This setting determines the format of the data output through the serial port during *real-time* data collection (data acquisition mode; §3.1.2).
- Section 4 describes the output data formats (**BINARY** or **ASCII**).
- When in deployment mode (*autonomous* data collection; §3.1.3), the ADV outputs only the burst header data through the serial port and is always in **ASCII** format (§Section 4).
- The **ASCII** output format requires almost three times as many bytes as the **BINARY** format. As such, when communicating at a baud rate of 9600, the ADV is not able to output **ASCII** data at 25 Hz. The data output requirements are greater than the communication rate can handle. The maximum **ASCII** output rate when using 9600 baud is about 5 Hz. If higher sampling rates are required, either use **BINARY** format or increase the baud rate (§4.2).

Setup
- This command is equivalent to the **start** command, except it does not start data collection.
- Combining the **setup** command with the **Go** command (below) accomplishes the same actions as the **start** command. This combination can be used to precisely control the start time for ADV sampling. While not required for most applications, this combination may be useful in certain situations.
- Note: This command is not listed in on-line help.

Go
- Starts immediate data collection (i.e., enters data acquisition mode; §3.1.2).
- This command should only be sent immediately after sending a **setup** command (above).
- The combination of **setup** and **Go** can be used to precisely control the start time for ADV sampling. The first sample will start within a few milliseconds of receiving the **Go** command. It is not required for most applications, but may be useful in certain situations.
- Note: This command is not listed in on-line help.

3.6. Setup Commands

Setup commands affect the real-time data collection parameters of the ADVField:

- Temperature
- Salinity
- Velocity range
- Sampling rate (also a Deployment command; §3.7)
- Coordinate system
- External synchronization

Each command is shown with its full name, short name (if one exists), optional parameters (in brackets), and appropriate descriptions.

Temp [d.d]

- Default parameter: **20.0** (°C)
- Parameter range: **-2.0** to **50.0** (°C)
- Without parameter: returns its current setting.
- When used with a valid parameter, the user-specified temperature is set to this value.
- This temperature is used to calculate sound speed if **TempMode** is set to **USER**.
- Generally, a temperature change of 5°C results in a change in sound speed of 1% (see *ADV Principles of Operation* regarding the effect of sound speed on velocity data).

Sal [d.d]

- Default parameter: **34.5** (parts per thousand; ppt)
- Parameter range: **0.0** to **60.0** (ppt)
- Without parameter: returns its current setting.
- When used with a valid parameter, the salinity is set to this value.
- This salinity value is used to calculate sound speed.
- Generally, a salinity change of 12 ppt results in a change in sound speed of 1% (see *ADV Principles of Operation* regarding the effect of sound speed on velocity data).

VelRange *or* **VR [d]**

- Default parameter: **4** (see Table 13 to translate this index value for your system)
- Parameter range: **0** to **4** (see Table 13)
- Without parameter: returns its current setting.
- When used with a valid parameter, sets the maximum velocity range based on the values in Table 13. Each index value corresponds to the velocity range settings specified in the ADV probe configuration file. **CAUTION:** If an incorrect probe configuration file is specified, velocity data will be invalid.
- See *ADV Principles of Operation* for details about velocity range settings.

Table 13. Velocity Range Index Values

Index	16-MHz & 10-MHz ADV Maximum Velocity Values			5-MHz ADVOcean Maximum Velocity Values		
	Vel. Range	Horizontal	Vertical	Vel. Range	Horizontal	Vertical
0	±3 cm/s	±30 cm/s	±8 cm/s	±5 cm/s	±30 cm/s	±8 cm/s
1	±10 cm/s	±60 cm/s	±15 cm/s	±20 cm/s	±40 cm/s	±10 cm/s
2	±30 cm/s	±120 cm/s	±30 cm/s	±50 cm/s	±80 cm/s	±20 cm/s
3	±100 cm/s	±300 cm/s	±75 cm/s	±200 cm/s	±300 cm/s	±75 cm/s
4	±250 cm/s	±360 cm/s	±90 cm/s	±500 cm/s	±500 cm/s	±120 cm/s

`SampRate` *or* **`SR [d.d]`**
- Default parameter: **`10.0`** (Hz)
- Parameter range: **`0.1`** to **`50.0`** (Hz)
- Without parameter: returns its current setting.
- When used with a valid parameter, sets the sampling rate in Hz. This setting determines the rate at which data is output from the ADV.
- The ADV will ping as rapidly as possible and average pings to meet the specified sampling rate (see §1.3)
- **`SampRate`** is also listed under deployment commands (§3.7). For autonomous deployments, the ADVField supports up to three sampling rates for three burst types (see §1.3 for a description of multiple-burst sampling). For real-time data collection, only the first of these three sampling rates is used (this is the rate listed by the **`Show Setup`** command).
- **Note:** When the following optional sensors are used, the maximum sampling rate is limited to the listed value. To collect data at higher rates, you can disable the pressure sensor using the **`ExtPressureSensorInstalled`** command (see §3.9).
  - Serial Paros external pressure sensor: 4 Hz
  - Frequency pressure sensor: 10 Hz

`CoordSystem` *or* **`CY [XYZ|ENU]`**
- Default parameter:
  - <u>No</u> compass/tilt sensor installed: **`XYZ`**
  - <u>With</u> compass/tilt sensor installed: **`ENU`**
- Without parameter: returns its current setting.
- When used with a valid parameter, sets the coordinate system to this value. This value affects the velocity data output to both the serial port during real-time data collection and stored to the internal recorder during deployment mode.
  - **`XYZ`** causes velocity data to be recorded and output in the Cartesian coordinate system relative to the ADV probe.
  - **`ENU`** causes the ADVField to use data from the optional compass/tilt sensor to transform velocity data to Earth (East-North-Up or ENU) coordinates.

`TempMode` *or* **`TM [USER|MEASURED]`**
- Default parameter:
  - <u>No</u> temperature sensor installed: **`USER`**
  - <u>With</u> temperature sensor installed: **`MEASURED`**
- Without parameter: returns its current setting.
- When used with a valid parameter, sets the temperature mode. The selected mode determines the source of the temperature data used for sound speed calculations.
  - **`USER`** takes the temperature value entered through the **`Temp`** command.
  - **`MEASURED`** takes the real-time value from the optional temperature sensor.
- If using the optional temperature sensor (which is mounted on the upper end cap of the conditioning module), be certain it is submerged. If not submerged, the sensor may not provide an accurate water temperature, which could introduce errors in the velocity data.
- Generally, a temperature change of 5°C results in a change in sound speed of 1%.
- The temperature sensor is specified as accurate to ±0.2°C.

`SyncMode` *or* **`SM [DISABLE|START|SAMPLE]`**
- Default parameter: **`DISABLE`**
- Without parameter: returns its current setting.
- When used with a valid parameter, sets the external synchronization mode. The ADVField processing module includes a sync input line (SyncIn) to allow external hardware control of ADV data collection.
  - **`DISABLE`** indicates that data collection is completely under internal software control.
  - **`START`** indicates that data collection starts with the rising edge of the first input sync pulse and continues at the software-programmed sampling rate.
  - **`SAMPLE`** indicates that data collection starts with the rising edge of the first input sync pulse and continues at a rate determined by the time between the rising edge of successive input sync pulses.
- See §5.5 for information about external synchronization.

3.7.   Deployment Commands

Deployment commands affect the parameters used for *autonomous* deployment. These include:

- Deployment name
- Start date and time
- Sampling rate (also a Setup command; §3.6)
- Burst sampling parameters
- Data recording options

Deployment commands are accessible only if the optional internal recorder has been installed. Additionally, several of the deployment commands (sampling rate, burst interval, samples per burst, and the data recording options) can have from one to three input parameters, depending on the number of different burst types that will be recorded. See §1.3 for a description of the different types of burst sampling supported by an autonomous ADVField system.

Deployment [name]
- Default parameter: **DEF**
- Without parameter: returns its current setting.
- When used with an ASCII string of no more than five characters (letters or numbers), sets the deployment name to this string. This string determines the file name under which data is stored to the internal recorder.
- All data from a single **Deploy** command (§3.5) is stored in one file.
- The file name on the recorder is the user-entered deployment name plus a 3-digit number indicating the sequence of files under this name. For example, if the deployment name is **LAKE**, the data from the first **Deploy** command will be stored in a file named **LAKE001**. If data collection is stopped and re-started without changing the deployment name, the numbers will increment (e.g., **LAKE002**, **LAKE003**, etc).
- **Note:** Do not confuse this command with the **Deploy** command (§3.5).

Comments
- This command lets you enter remarks that will be stored in the data file.
- There are three comment lines, each with a maximum of 60 characters.

StartDate *or* **SD [yy/mm/dd | yyyy/mm/dd]**
- Default parameter: **1995/01/01** (January 1, 1995)
- Without parameter: returns the current deployment's starting date.
- When given with a date in a valid format, where yy=year (2 or 4 digits), mm=month (2 digits), and dd=day (2 digits): sets the date on which autonomous data collection will begin.
- If **startDate** and **startTime** are before the current date and time, data collection will begin immediately following a 2-3 second delay for ADV initialization.
- Example: **SD 2001/09/08** and **SD 01/09/08** are equivalent commands telling the ADV to start data collection on September 8, 2001.
- **Note:** If the power supply is cycled while in deployment mode, the ADVField will automatically enter deployment mode on power-up and ignore **startDate** and **startTime**. This is a safety precaution to avoid data loss in the event of a real-time clock error during power-down (see §3.1 for more details about ADV response when the supply power is changed).

StartTime *or* **ST [hh:mm:ss]**
- Default parameter: `00:00:00` (midnight)
- Without parameter: returns the current deployment's starting time.
- When given with a time in a valid format, where hh=hour (2 digits; 24-hour clock), mm=minute (2 digits), and ss=seconds (2 digits): sets the time data collection will begin.
- If `startDate` and `startTime` are before the current date and time, data collection will begin immediately following a 2-3 second delay for ADV initialization.
- Example: `ST 13:05:00` tells the ADV to start data collection at 1:05 p.m.
- See Note for the `startDate` command (above).

SampRate *or* **SR [d.d] [d.d] [d.d]**
- Default parameters: `10.0 0.0 0.0` (Hz)
- Parameter range: `0.1` to `50.0` (Hz)
- Without parameter: returns its current settings for each burst type.
- When used with from one to three valid parameters, sets the sampling rate in Hz for each burst type. This setting determines the rate at which ADV velocity data is recorded.
- The ADV will ping as rapidly as possible and average pings to meet the specified sampling rate (see §1.3)
- `SampRate` is also listed under setup commands (§3.6). For autonomous deployments, the ADVField supports up to three sampling rates for three burst types (see §1.3 for a description of multiple-burst sampling). For real-time data collection, only the first of these three sampling rates is used (this is the rate listed by the `Show Setup` command).
- To select multiple-burst sampling, enter a separate sampling rate for each burst type desired. For example, `SR 0.2 2.0 25.0` sets the sampling rate for burst type #1 to 0.2 Hz, for burst type #2 to 2.0 Hz, and for burst type #3 to 25.0 Hz. If only one or two input arguments are specified, the values for the other burst types are set to 0, disabling that burst type.
- **Note:** When the following optional sensors are used, the maximum sampling rate is limited to the listed value. To collect data at higher rates, you can disable the pressure sensor using the `ExtPressureSensorInstalled` command (see §3.9).
  - Serial Paros external pressure sensor: 4 Hz
  - Frequency pressure sensor: 10 Hz

BurstInterval *or* **BI [d] [d] [d]**
- Default parameters: `1200 0 0` (seconds; 20 minutes)
- Parameter range: `5` to `43200` (seconds; maximum is equivalent to 12 hours)
- Without parameter: returns its current settings for each burst type.
- When used with from one to three valid parameters, the burst interval for each burst type is set to its corresponding value (in seconds). See §1.3 for a description of burst sampling.
- For autonomous deployments, the ADVField supports up to three burst interval values for three burst types. Burst interval is not used during real-time data collection.
- To select multiple-burst sampling, enter a separate burst interval for each burst type desired. For example: `BI 1200 3600 7200` sets the burst interval for burst type #1 to 1200 seconds (20 minutes), for burst type #2 to 3600 seconds (1 hour), and for burst type #3 to 7200 seconds (2 hours). If only one or two input arguments are specified, the values for the other burst types are set to 0, disabling that burst type.

`SamplesPerBurst` *or* **`SPB [d] [d] [d]`**
- Default parameters: **`1200 0 0`**
- Parameter range: **`1`** to **`32000`**
- Without parameter: returns its current settings for each burst type.
- When used with from one to three valid parameters, sets the number of samples per burst for each burst type. See §1.3 for a description of burst sampling.
- For autonomous deployments, the ADVField supports up to three samples per burst values for three burst types. Samples per burst are not used during real-time data collection.
- To select multiple-burst sampling, enter a separate samples-per-burst for each burst type desired. Example: **`SPB 24 600 7500`** sets the samples per burst for burst type #1 to 24, for burst type #2 to 600, for burst type #3 to 7500. If only one or two input arguments are specified, the values for the other burst types are set to 0, disabling that burst type.

`RecordAmpCorr [YES|NO] [YES|NO] [YES|NO]`
- Default parameters: **`YES YES YES`**
- Without parameter: returns its current settings for each burst type.
- When used with from one to three valid parameters, tells the ADV whether to record amplitude and correlation data. See §1.3 for a description of burst sampling.
  - ○ **`YES`** tells the ADV to record amplitude and correlation data for each receiver with each sample for the selected burst types. **`YES`** increases the size of each sample by 4 bytes.
  - ○ **`NO`** tells the ADV to record <u>only</u> the mean amplitude (from all 3 receivers) and the mean correlation (from all 3 receivers) with each sample for the selected burst types.
- This parameter is used only in deployment mode; it has no affect on real-time data collection.
- If only one or two input arguments are specified, it does not change the settings for the non-specified burst types.
- Appendix 2 has a description of the data recorded based on the **`Record`** command settings.

`RecordCompass [YES|NO] [YES|NO] [YES|NO]`
- Default parameters:
  - ○ <u>No</u> compass/tilt sensor installed: **`NO NO NO`**
  - ○ <u>With</u> compass/tile sensor installed: **`YES YES YES`**
- Without parameter: returns its current settings for each burst type.
- When used with from one to three valid parameters, tells the ADV whether to record compass/tilt sensor data. See §1.3 for a description of burst sampling.
  - ○ **`YES`** tells the ADV to record compass/tilt sensor data (heading, pitch, roll) for each velocity sample for the selected burst types. **`YES`** increases the size of each sample by 6 bytes.
  - ○ **`NO`** tells the ADV not to record compass/tilt sensor data for the selected burst types.
  - ○ Regardless of this setting, the ADV will always record <u>velocity</u> data in either XYZ or ENU coordinates based on the setting of the **`CoordSystem`** setup parameter (see §3.6).
- This parameter is used only in deployment mode; it has no affect on real-time data collection.
- If only one or two input arguments are specified, it does not change the settings for the non-specified burst types.
- Appendix 2 has a description of the data recorded based on the **`Record`** command settings.

RecordSensor [YES|NO] [YES|NO] [YES|NO]
- Default parameters:
  - Neither a temperature or pressure sensor installed: **NO NO NO**
  - With temperature and/or pressure sensor installed: **YES YES YES**
- Without parameter: returns its current settings for each burst type.
- When used with from one to three valid parameters, tells the ADV whether to record temperature and/or pressure sensor data. See §1.3 for a description of burst sampling.
  - **YES** tells the ADV to record temperature and/or pressure data (if either or both are installed) for each velocity sample for the selected burst types. **YES** increases the size of each sample by 4 bytes.
  - **NO** tells the ADV not to record temperature/pressure data for the selected burst types.
- This parameter is used only in deployment mode; it has no affect on real-time data collection.
- If only one or two input arguments are specified, it does not change the settings for the non-specified burst types.
- Appendix 2 has a description of the data recorded based on the **Record** command settings.

RecordStat [YES|NO] [YES|NO] [YES|NO]
- Default parameters: **YES YES YES**
- Without parameter: returns its current settings for each burst type.
- When used with from one to three valid parameters, tells the ADV whether to record statistics at the end of each burst. See §1.3 for a description of burst sampling.
  - **YES** tells the ADV to record several statistics at the end of each burst. The statistics include the mean and standard deviation values for the following parameters (assuming appropriate sensors are installed): amplitude and correlation for each receiver, heading, pitch, roll, temperature, and pressure. **YES** increases the size of each sample by 36 bytes.
  - **NO** tells the ADV not to record statistics data for the selected burst types.
- This parameter is used only in deployment mode; it has no affect on real-time data collection.
- If only one or two input arguments are specified, it does not change the settings for the non-specified burst types.
- Appendix 2 has a description of the data recorded based on the **Record** command settings.

RecordExtSensor [YES|NO] [YES|NO] [YES|NO]
- Default parameters: **NO NO NO**
- Without parameter: returns its current settings for each burst type.
- When used with from one to three valid parameters, tells the ADV whether to record data from an optional, external sensor. See §1.3 for a description of burst sampling.
  - **YES** tells the ADV to record external sensor data for each velocity sample for the selected burst types. **YES** increases the size of each sample by 4 bytes.
  - **NO** tells the ADV not to record external sensor data for the selected burst types.
- This parameter is used only in deployment mode; it has no affect on real-time data collection.
- If only one or two input arguments are specified, it does not change the settings for the non-specified burst types.
- Appendix 2 has a description of the data recorded based on the **Record** command settings.

RecordExtPress [YES|NO] [YES|NO] [YES|NO]
- Default parameters: **NO NO NO**
- Without parameter: returns its current settings for each burst type.
- When used with from one to three valid parameters, tells the ADV whether to record data from an optional, external pressure sensor. See §1.3 for a description of burst sampling.
  - ○ **YES** tells the ADV to record external pressure sensor data for each velocity sample for the selected burst types. **YES** increases the size of each sample by 3 bytes.
  - ○ **NO** tells the ADV not to record external pressure sensor data for the selected burst types.
- This parameter is used only in deployment mode; it has no affect on real-time data collection.
- If only one or two input arguments are specified, it does not change the settings for the non-specified burst types.
- Appendix 2 has a description of the data recorded based on the **Record** command settings.

RecordCTD [YES|NO] [YES|NO] [YES|NO]
- Default parameters: **NO NO NO**
- Without parameter: returns its current settings for each burst type.
- When used with from one to three valid parameters, tells the ADV whether to record data from an optional CTD sensor. See §1.3 for a description of burst sampling.
  - ○ **YES** tells the ADV to record optional CTD data for each velocity sample for the selected burst types. **YES** increases the size of each sample by x bytes, where x is dependent on the type of CTD sensor being used.
  - ○ **NO** tells the ADV not to record CTD data for the selected burst types.
- This parameter is used only in deployment mode; it has no affect on real-time data collection.
- If only one or two input arguments are specified, it does not change the settings for the non-specified burst types.
- Appendix 2 has a description of the data recorded based on the **Record** command settings.

RecordLisst [YES|NO] [YES|NO] [YES|NO]
- Default parameters: **NO NO NO**
- Without parameter: returns its current settings for each burst type.
- When used with from one to three valid parameters, tells the ADV whether to record data from an optional LISST-100 sensor. See §1.3 for a description of burst sampling.
  - ○ **YES** tells the ADV to record optional LISST data for each velocity sample for the selected burst types. **YES** increases the size of each sample by 80 bytes.
  - ○ **NO** tells the ADV not to record LISST data for the selected burst types.
- This parameter is used only in deployment mode; it has no affect on real-time data collection.
- If only one or two input arguments are specified, it does not change the settings for the non-specified burst types.
- Appendix 2 has a description of the data recorded based on the **Record** command settings.

3.8. Recorder Commands

Recorder commands interface with the optional ADVField internal recorder. These functions include showing the directory of files and erasing the recorder.

Dir *or* **LD**
- Lists a directory of the deployments currently stored on the recorder.
- This command takes a few seconds to scan the entire recorder.

Format
- Erases all data from the recorder.
- Make sure you download and backup any important data before executing this command.
- Upon execution, you are prompted for confirmation. The ADVField will show an updated progress display while re-formatting the memory card.

RecStatus
- Displays the installed recorder type and size.

Note: Because of the relatively complicated binary file format used for burst sampling with ADVField autonomous systems, it is not possible for you to directly access data on the internal recorder. The ADV software includes a program (**SonRec** or *Recorder*) to download data from the internal recorder to the computer hard disk and several conversion programs to output this data in an easily accessible ASCII format. See the *ADVField Software Manual* for details.

3.9.   Sensor Commands

Sensor commands output data from the ADVField's optional internal sensors: temperature, pressure, and battery voltage. Additionally, a variety of optional external sensors can be controlled through the direct command interface.

3.9.1. Internal Sensor Commands

Sensor [CONT]
- Without parameter: Display <u>once</u> the current temperature (°C), pressure (dBar), and battery voltage (VDC) data.
- With **CONT** parameter: Display <u>continuously</u> (updated twice per second) the temperature (°C), pressure (dBar), and battery voltage (VDC) data. Press any key to stop data output and return to command mode.
- Data is output in a self-explanatory, ASCII-text format.
- Note: If **ExtSensor = 3_OBS**, the pressure and battery voltage readings will display **N/A**.

PressScale
- Displays the pressure-scaling factor used to convert counts to dBar. The scaling factor is shown in units of dBar/count (see §4.8 for data conversion details).

PressOffset
- Displays the pressure offset used to convert pressure counts to dBar. The offset is shown in units of dBar (see §4.8 for data conversion details).

3.9.2. External Sensor Commands – Overall Control

These commands are common to all external sensors.

ExtSensor [NONE|STANDARD|3_OBS]
- Without parameter: returns current setting.
- When used with a valid parameter, tells the ADV processor what type of external sensor(s) are installed.
  - ○ **NONE** – No external sensors are installed.
  - ○ **STANDARD** – One or two of the more typical external sensors is installed: SeaBird Micro-Cat CTD (§3.9.3), a resonance pressure sensor (§3.9.4), a LISST sensor (§3.9.5).
  - ○ **3_OBS** – Three external sensors are installed. Note that with this option selected:
    - ▪ **Sensor [CONT]** will display pressure and battery voltage readings as **N/A**.
    - ▪ The real-time and deployment extraction software will store the Channel 3 sensor data in the pressure column, but will not apply any pressure scaling to the data.

3.9.3. External Sensor Commands – SeaBird MicroCat CTD

H CTD
- Displays help information for the CTD commands.

CTD [CONT]
- Without parameter: Display <u>once</u> the most recent temperature (°C), conductivity (Siemens per meter), pressure (decibar), and salinity (ppt) from the external CTD sensor.
- With **CONT** parameter: Display <u>continuously</u> temperature (°C), conductivity (Siemens per meter), pressure (decibar), and salinity (ppt) from the external CTD sensor. Press any key to stop data output and return to command mode.

- Data is output in ASCII-text in the following, single-line format. Example:

```
87514      468151      0       351354
```
  ○ CTD temperature in units of 0.0001°C
  ○ CTD conductivity in units of 0.00001 Siemens per meter
  ○ CTD pressure in units of 0.001 decibar
  ○ CTD salinity in units of 0.0001 ppt
- After data collection begins, there is a delay of about 10 seconds before the CTD data sample is transmitted.
- Note that the CTD sensor may not include a pressure sensor.

CTD TALK
- Establishes direct serial communication with the external CTD. Refer to the CTD's technical for available commands.
- To return to the ADV command mode, send a **BREAK**.

CTDSensorInstalled Set [YES|NO]
- Selects or disables the CTD sensor.
- Set at the factory. Does not need to be changed except in some special cases.

3.9.4. External Sensor Commands – Resonance Pressure Sensors

These commands apply to systems that have an external pressure sensor installed (§4.9).

ExtPressureSensorInstalled Set [NONE|PAROS|DRUCK|PAROSFREQ]
- Selects or disables the external pressure sensor type (§4.9).
- Set at the factory. Does not need to be changed except in some special cases.
- The external pressure sensor option limits the maximum sampling rate of an ADV to 4 Hz for the PAROS and to 10 Hz for a DRUCK or PAROSFREQ. To collect data at faster rates, you must disable the external pressure sensor option.

PressFreqOffset Set [d]
- Default parameters (in kHz): **0** (for DRUCK); **21** (for PAROSFREQ)
- Sets/displays frequency offset (in kHz).
- This parameter is set at the factory and should not be changed by the user.

PAROS CONT *or* **DRUCK CONT** *or* **PAROSFREQ CONT**
- This command provides a useful tool to verify and troubleshoot the frequency sensor.
- For PAROS sensors:
  ○ This command continually outputs pressure reading in dbar.
  ○ If the pressure reading is zero, the connection between the sensor and the processing electronics may be damaged (or open).
- For DRUCK and PAROSFREQ sensors:
  ○ This command outputs a sample consisting of converted pressure (dbar), temperature (°C), and raw frequency counts (Hz) in the following format:

```
Druck Press =      10.03192     Temp = 22.11     Freq =   8055.674
```

  ○ The DRUCK frequency range (in air) is 7 to 10 kHz; the PAROSFREQ is 35 to 38 kHz.
  ○ If the frequency reading is zero or outside its range, the connection between the sensor and processing electronics may be damaged/open or the frequency offset is incorrect.

○ If the frequency reading is reasonable, but the corresponding pressure is not, this indicates that the appropriate calibration is not loaded into the processor. Use the LDDRUCK program (see *ADVField Software Manual*) to load the DRUCK calibration.

Show DRUCK *or* **Show PAROSFREQ**
- Displays DRUCK/PAROSFREQ calibration data in the following format:

```
Druck pressure sensor calibration data
--------------------------------------
SN:    1276950
F0:       1.200e+07
X:   8.4410000e+03
Y:   5.6000000e+02
T0: -1.0000000e+01
D0:  6.2900000e+02
DT: -2.2100000e+00
K00:  1.5962190e+03    K01: -2.6693000e-02
K10:  1.6820332e+00    K11: -1.0395800e-05
K20:  3.9933779e-04    K21: -4.9470601e-09
K30:  8.0327140e-08    K31: -1.4093000e-12
K40:  1.7388157e-11    K41:  2.2691999e-16
K50:  2.5953699e-15    K51:  1.3877999e-19
K02:  3.1005999e-05    K03:  2.6474001e-07
K12:  1.8332999e-08    K13:  8.2459997e-11
K22:  1.6572001e-11    K23: -1.7079999e-14
K32: -7.7020003e-15    K33: -9.9870002e-17
K42: -4.0642002e-18    K43: -1.0678000e-19
K52:  5.3660002e-21    K53: -2.8249999e-23
```

3.9.5. External Sensor Commands – LISST-100 Sensor

These commands apply to systems that have an external LISST sensor installed (§4.12). The LISST-100 is a Laser Interferometry and Transmissometry particle distribution measurement device designed by Sequoia Scientific.

LisstSensorInstalled Set [YES|NO]
- Selects or disables the LISST sensor (§4.12).
- Set at the factory. Does not need to be changed except in some special cases.
- The LISST sensor is a serial instrument that uses the second COM port on the ADVField's CPU board. As such, other serial devices (e.g., Paros, MicroCat CTD) must be disabled.
- When set to YES, LisstBufferSize is automatically set to 80 bytes (default).

LisstBufferSize *or* **LBS [d]**
- Default parameter: **80** bytes
- Without parameter: returns its current setting.
- When used with a valid parameter, sets the size of the LISST sample buffer.

3.10. 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 to give greater flexibility in ADVField operations. For a detailed description of the optional compass/tilt sensor, see §4.7.

`Compass [CONT]`
- Without parameter: Display <u>once</u> the most recent heading, pitch, and roll data from the optional compass/tilt sensor.
- With `CONT` parameter: Display <u>continuously</u> (updated twice per second) the heading, pitch, and roll data from the compass/tilt sensor. Press any key to stop data output and return to command mode.
- Data is output in a self-explanatory, ASCII-text format.

`Compass CAL`
- Performs 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 before any deployment.
- The ADV will output basic instructions for performing the calibration and provide a continuous display of heading, pitch, and roll.
- Press any key to terminate calibration, view calibration score, and return to command mode.
- See §4.7.5 for more information about compass calibration.

3.11. Show Commands

There are four "show" commands to display current ADVField parameter settings. Samples of these commands and their outputs are show below.

Note: The examples shown here may differ for your system. The number of items shown by each Show command may vary depending on the firmware version being used and depending on the optional sensors that you have installed on your system.

Show Conf
- Displays the current ADVField hardware configuration.
- Example:

```
>show conf

HARDWARE CONFIGURATION PARAMETERS
---------------------------------
Probe serial # --------------- A383F
Probe type ------------------- Micro DOWN  XYZ 5cm
Probe Orientation ------------ DOWN
Compass     sensor ----------- NO
Recorder    sensor ----------- YES
Temperature sensor ----------- YES
Pressure    sensor ----------- NO
PressOffset  (dbar) ---------- 0.000000
PressScale   (dbar/count) ---- 0.000000
PressScale_2 (pdbar/count^2) -      0
External Pressure Sensor ----- NO
External    sensors ---------- STANDARD
Microcat CTD ----------------- NO
LISST Sensor ----------------- NO
```

Show System
- Displays the current system parameters.
- Example:

```
>show system

CURRENT SYSTEM PARAMETERS
-------------------------
CPU Version - ADV 7.9
DSP Version - DSP 4.0
Date -------- 2001/07/05
Time -------- 17:50:37
OutFormat --- BINARY
OutMode ----- POLLED
```

Show Setup
- Displays the current real-time data collection parameters.
- Example:

```
>show setup

CURRENT ADV SETUP PARAMETERS
----------------------------
Temp -------- 22.7 deg C
Sal --------- 0.0 ppt
TempMode ---- USER
Sound Speed - 1490.3 m/s
VelRange ---- 3 (+-100 cm/s)
SampRate ---- 2.00 Hz
CoordSystem - XYZ
SyncMode ---- DISABLE
```

Show Deploy
- Displays the current autonomous deployment parameters.
- Example:

```
>show deploy

CURRENT DEPLOYMENT PARAMETERS
-----------------------------
Deployment - BA383
StartDate -- 2001/07/05
StartTime -- 17:44:10
-----------------------Sampling 1-----Sampling 2-----Sampling 3
SampRate (Hz) -----             2.00            0.00            0.00
BurstInterval (s) -            1800               0               0
SamplesPerBurst ---            2048               0               0
RecordAmpCorr -----             YES             YES             YES
RecordCompass -----              NO              NO              NO
RecordSensor ------             YES             YES             YES
RecordExtSensor ---             YES              NO              NO
RecordExtPress ----              NO              NO              NO
RecordStat --------             YES             YES             YES
RecordCtd ---------              NO              NO              NO
RecordLisst--------              NO              NO              NO
Burst Length (s) --            1024               0               0
Bytes per Burst ---           41058               0               0
Comments:
   SonTek ADVField Autonomous System
   We know how fast the water moves.
   Do you?
```

3.12. Run Time Commands

The command shown here can be used while the ADVField is in data collection or deployment mode. It is an alternative way to bring the instrument into command mode if it is not possible to send a **BREAK** (e.g., if operating the system via a modem).

+++ *(alternative **BREAK** command)*
- Sending three + characters in succession causes the ADV to terminate data collection and re-turn to the command mode.
- This command can be sent at any time during real-time data collection.
- In deployment mode, this command can only be used while the ADV is awake. It will not work if the instrument is in the reduced power state between bursts.
- While the ADV is awake, there is no maximum time period during which the characters must arrive.

Section 4. ADVField System Hardware

4.1. ADVField Processing Module Overview

Figure 8 shows the general layout of the ADVField processing module. The processing module consists of three printed circuit (PC) boards with an optional fourth board for internal recording. The boards are connected in a vertical stack using multiple conductor connectors at one or both ends of the boards. The top-down board order is: Analog, DSP, CPU, and Recorder. Each board is labeled in white letters. The board dimensions are 10.1 x 15.2 cm (4 x 6 in) and are separated vertically by 1.3 cm (0.5 in). A general description of the function and layout of each board follows.

Figure 8 - ADVField Processing Module

Analog Board

Figure 9 shows the layout of the Analog board with a few important features labeled. The Analog board generates the acoustic transmit signals, receives the high-frequency return signals, and does preliminary signal conditioning before the return signal is sent to the DSP. Important features of the Analog board include:

- Hardware Configuration Switches – These switches are used to set the orientation of the probe and to select the installed optional sensors (compass, recorder, temperature, pressure). See §4.2 for details on setting these switches.

Figure 9 - ADVField Analog Board

- CPU Backup Battery Connector – This keyed, 2-pin, red connector is wired to a backup battery for systems with the internal recorder; it is not used in real-time systems. (Note: This is the same connector as for the front end-plate diode on the ADVField splash-proof housing; the backup battery cannot be installed in the splash-proof housing.)

- Temp/Pressure Connector – This 10-pin, black connector receives signals from the optional temperature and pressure sensors. This connector is not keyed, so note its orientation before removal. The cable from this connector goes to the probe.

- Power Diode / Connector – This diode will light if the ADV electronics has at least 12V input power. For the ADVField splash-proof housing, this diode is replaced with a red, 2-pin connector leading to a diode on the front end-plate. This is the same connector as for the backup battery, but not the same connector used for input power.
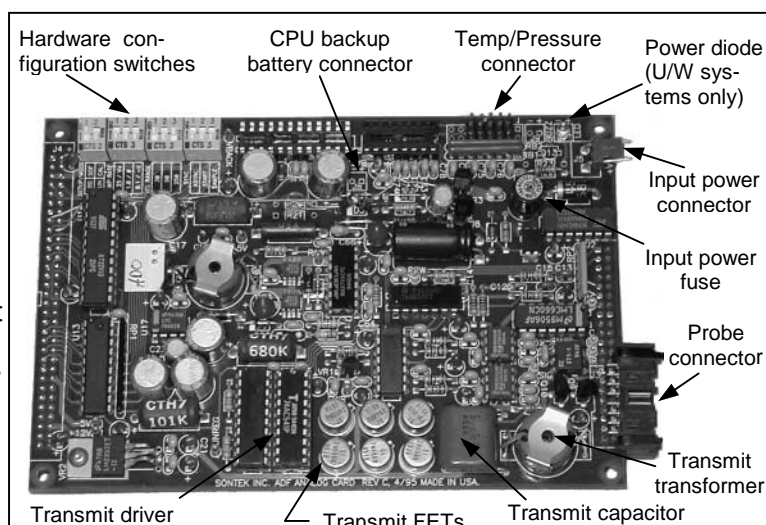
- Input Power Connector – This keyed, 2-pin, red connector accepts DC input power (12-24 V). The polarity for each pin is labeled. The cable from this connector will lead either to the input power connector (ADVField in splash-proof housing) or to the power and communications underwater connector (ADVField in underwater canister).

- Input Power Fuse – This black, cylindrical, plug-in fuse is rated at 3.15A, 250V. To test the fuse, remove it from its socket and test for continuity between the pins. Spare fuses are included in the ADV tool kit. A blown fuse most often indicates a problem with the power supply or that interference is causing a short in the ADV processing module.

- Probe Connector – This keyed, 16-pin, black rectangular connector carries high-frequency analog signals to/from the probe. These signals are highly sensitive to noise; do not modify the cables or connectors without first contacting SonTek. The cable from this connector goes to the probe. (Note: The connector used is the same as one of the connectors on the DSP board.)

DSP Board

Figure 10 shows the layout of the DSP board with a few important features labeled. The DSP digitizes the return signal and performs Doppler calculations to determine velocity. The important features of the DSP board include:
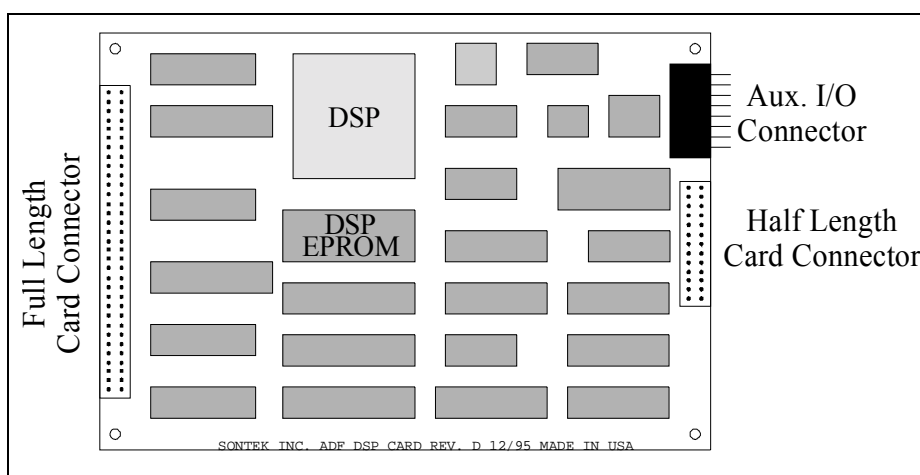

Figure 10 - ADVField DSP Board

- DSP – The digital signal processor chip provides the major computational power of the ADV electronics.

- DSP EPROM – This chip stores the digital processing algorithms used by the ADV to measure velocity. Upgrades for this EPROM may be available periodically. See §4.4.7 for replacement instructions.

- Aux. I/O Connector – This keyed, 16-pin, black rectangular connector carries the analog output voltages and synchronization signals (SyncIn and SyncOut; see §5.4 and §5.5 for details). The cable from this connector goes to the DB15 auxiliary input/output connector (ADVField in splash-proof housing) or to the power/communications connector (ADVField in underwater canister). (Note: This connector is the same as one of the connectors on the Analog board.)

- Half-Length Card Connector – This 26-pin connector mates to a connector on the bottom of the Analog board.

- Full-Length Card Connector – This 64-pin connector mates to a connector on the bottom of the Analog board and to a connector on the CPU board.

CPU Board

Figure 11 shows the layout of the CPU board with a few important features labeled. The CPU provides the overall control of ADV operation including data collection, user interface, compass, and recorder control. Important features include:
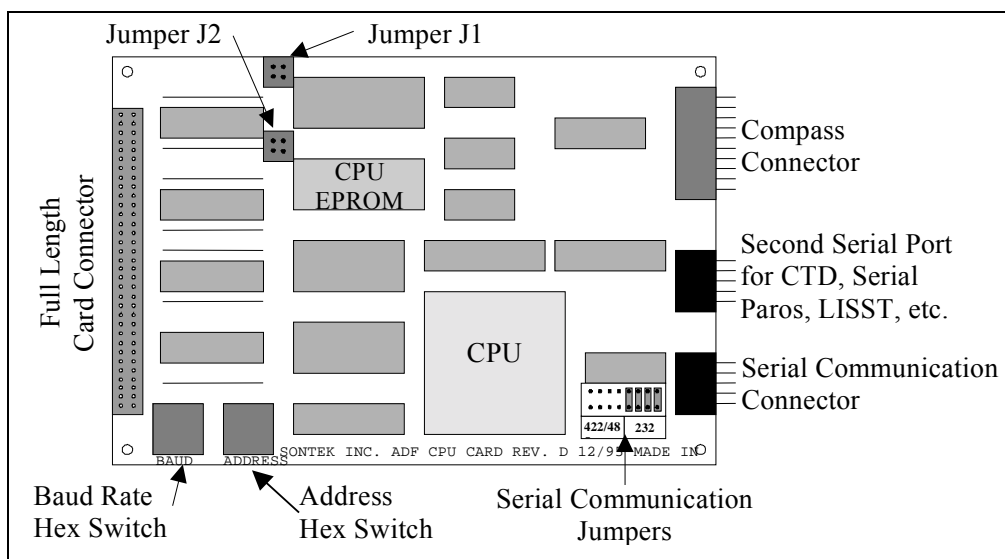

Figure 11 - ADVFieldCPU Board

- CPU – The central processing unit controls all major ADV functions and peripherals including data collection, user interface, compass, and recorder.

- CPU EPROM – This chip stores the algorithms used to control ADV operation. Upgrades for this EPROM may be available periodically. See §4.4.7 for replacement instructions.

- Compass Connector – The keyed, 10-pin, red connector carries power and serial communications to/from the optional compass/tilt sensor. The cable from this connector goes to the probe cable (when the compass/tilt sensor is installed in the conditioning module) or directly to the compass (when installed in the underwater canister).

- Second Serial Port – The keyed, 10-pin, black rectangular connector is used only if an optional device is installed (e.g., CTD, serial Paros pressure sensor, LISST, etc.)

- Serial Communication Connector – The keyed, 10-pin, black rectangular connector carries the serial communications signals for the external user interface. This is the same connector type as the spare connector listed above. The cable from this connector goes to the DB9 serial communications connector (ADVField in splash-proof housing) or to the power and communications connector (ADVField in underwater canister).

- Full-Length Card Connector – This 64-pin connector mates to a connector on the DSP board and to a connector on the Recorder board.

- Baud Rate Hex Switch – This rotary switch sets the serial communication baud rate. The switch can be accessed while the processing module is assembled. Defaults: 9600 (for firmware v6.8 and earlier); 19200 (firmware after v6.8). See §4.2 for details on switch settings.

- Address Hex Switch – This rotary switch sets the system address for RS485 communication. The default is 0 (for RS232 or RS422). The switch is positioned so it can be accessed while the processing module is assembled. See §4.2 for details on switch settings.

- Serial Communication Jumpers – These jumpers are used to select the serial communication protocol; the default is RS232. The jumpers cannot be accessed while the processing module is assembled. See §4.2 for details.

- Jumpers J1 and J2 – These jumpers are not used and should be left open (no pins connected).

Recorder/External Pressure Sensor Board

Figure 12 shows the layout of the Recorder board with important features labeled. The optional Recorder board is used for internal data storage during autonomous deployments.

- PCMCIA/Compass Flash Card – The recorder uses this non-volatile memory for data storage. Presently, recorder sizes from 10 MB to 1.2 GB are available (call SonTek for latest information).
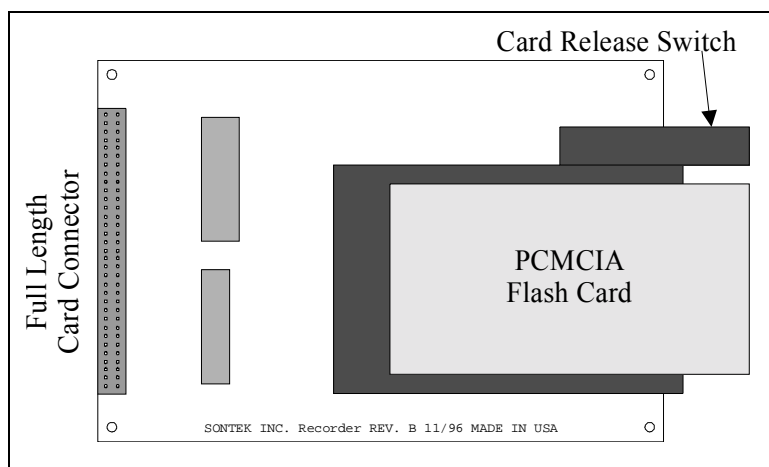

Figure 12 - ADV Recorder/Ext. Pressure Sensor Board

- Card Release Switch – This switch ejects 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 – This 64-pin connector mates to a connector on the bottom of the CPU board.

4.2. ADVField Hardware Switches and Jumpers

The general layout of the ADVField processing module is given in §4.1. There are three places in the processing module where hardware settings determine system configuration. Switches on the Analog board select probe orientation and select the installed optional sensors. Two rotary dials on the CPU board set the communications baud rate and the address for RS485 communication. Finally, jumpers on the CPU board determine whether the ADV uses RS232, RS422, or RS485 serial communications protocol. See §4.4 for instructions on accessing the processing module.

Hardware Configuration Switches (Analog Board)

Figure 13 shows a diagram of the hardware configuration switches on the Analog board. The switches are divided into one set of two, and three sets of three. The top set (of two) is not used by the ADVField. Placing any switch to the right (as shown in Figure 13) is ON and to the left is OFF.

The first set of three switches defines the orientation of the compass with respect to the ADV probe. These switches are only used if the optional compass is installed. If the compass is not installed, the ADV will always show an orientation of DOWN, and velocity data will be reported in the XYZ coordinate system relative to the probe orientation (see §5.1). Only one of the orientation switches should be ON at any time. Switch #1 indicates the system is deployed looking up, switch #2 indicates the system is looking down, and switch #3 indicates the system is deployed looking to the side.

Note: When switching to up, down, or side-looking, you must set the correct switch and change the physical mounting of the compass. See §4.7.2 for details on changing compass orientation and to ensure that the physical orientation of the compass, the orientation switch setting, and the probe deployment orientation are the same.

Figure 13 - ADVField Analog Board Switches

The second set of switches defines which optional sensors have been installed. If switch #1 is ON, the system will look for the internal compass and tilt sensor. If the ADV cannot detect this sensor, it will return an error message when entering the Command Mode. Switch #2 is not used. Switch #3 indicates whether the internal recorder is installed. This switch must be set to ON to use the internal recorder.

The last set of switches specifies which peripheral sensors are installed. Switch #1 should be ON if the ADV includes the optional temperature sensor. Switch #2 is not used. Switch #3 should be ON if the ADV includes the optional pressure sensor.

All switches are set to the appropriate value at the factory. The only settings that would normally be changed by the user are the orientation switches. The switch settings shown in Figure 13 indicate a down-looking ADV with the optional compass and temperature sensors installed (no recorder or pressure sensor).
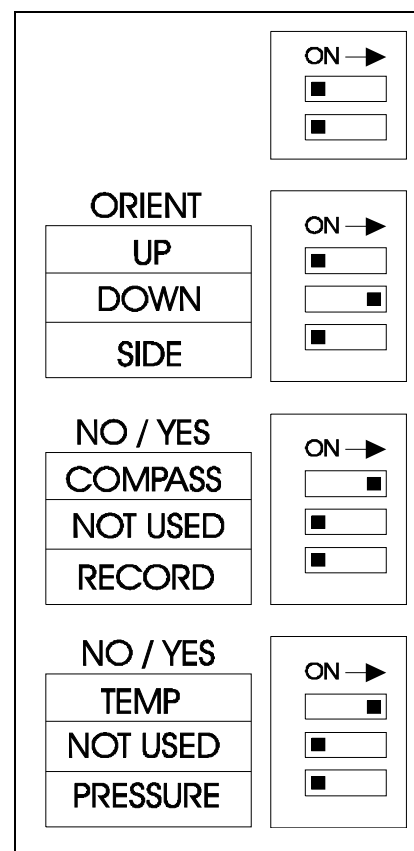
Baud Rate and Address Hex Rotary Dials (CPU Board)

Two hex rotary dials are mounted on the side of the CPU board (Figure 11). These dials can be accessed without disassembling the processing module. One hex dial is labeled **BAUD**, and the other, **ADDRESS**. The **BAUD** dial changes the communication baud rate; settings are shown in Table 14. Use a small flat-head screwdriver to rotate the dial to the desired setting. Defaults: 9600 baud (firmware v6.8 and earlier; hex setting **3**); 19200 (firmware after v6.8; hex setting **4**).

Table 14. BAUD Dial Settings

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

The **ADDRESS** switch is used for multiple system operation with RS485 communications protocol. For single system operation using RS232 or RS422, this switch should be set to **0**. For RS485, the communication protocol jumpers (see below) must be set to RS422 / RS485 and the address switch must be set to a hex value from **1** to **F**.

Communication Protocol Jumpers (CPU Board)

The ADVField supports three serial communication protocols: RS232 (default), RS422, and RS485 (see §5.2 for information about the different protocols).

The communication protocol jumpers consist of eight, 2-pin pairs. Figure 14 shows the jumper configuration for each protocol. The same jumper configuration is used for RS422 and RS485. If the jumpers are set for **422/485**, the ADV will use the **ADDRESS** setting (see above) to determine which protocol is used. An **ADDRESS** setting of **0** will use RS422, while any other settings (**1** through **F**) will use RS485. To access the jumpers, you must disassemble the processor (§4.4). The ADV tool kit contains everything required for this task.
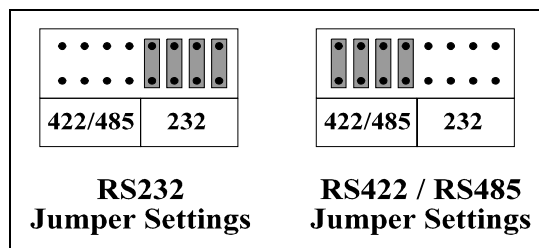

RS232 Jumper Settings   **RS422 / RS485 Jumper Settings**

Figure 14 - Communication Jumpers

Note: Use of the RS485 protocol for multiple system operation requires special software and cabling; if you are interested in this option, please contact SonTek for more details.

4.3. Input / Output Signals, Cables, and Connectors

Table 15 summarizes the input and output signal lines used with the ADV. This also establishes the naming convention used in the remainder of §4.3. Sections 4.3.1 and 4.3.2 describe how to access these signals from the cables and connectors supplied with each type of ADV processing module (ADVField splash proof housing and ADVField underwater canister).

Table 15. ADV Input/Output Signal Lines

Signal	Description
Vx	Analog output voltage proportional to Vx (or Veast) velocity component (§5.4)
Vy	Analog output voltage proportional to Vy (or Vnorth) velocity component (§5.4)
Vz	Analog output voltage proportional to Vz (or Vup) velocity component (§5.4)
Amp	Analog output voltage proportional to the mean signal amplitude from the three acoustic receivers
SyncOut	Output synchronization signal generated by the ADV that is a short 5V pulse at the end of each sample (§5.5)
SyncIn	Input synchronization signal received by the ADV that triggers on the rising edge of a 5V square wave (§5.5)
Ground	The ADV uses a common ground for power and serial communication.
+5 V	5V power supply from the ADV processing module. This output has minimal drive capability; a typical use is to trigger SyncIn (§5.5).
Vpower	Input power to the ADV (12-24 VDC)
Data Out	RS232 serial data output from ADV
Data In	RS232 serial data input to ADV
Rx+	RS422 serial data input to ADV - positive wire (differential signal)
Rx-	RS422 serial data input to ADV - negative wire (differential signal)
Tx+	RS422 serial data output from ADV - positive wire (differential signal)
Tx-	RS422 serial data output from ADV - negative wire (differential signal)

4.3.1. ADVField Splash-Proof Housing

The front of the ADVField splash-proof housing (Figure 1) has four connectors, a power switch, and a diode power light. The DB25 connector mates with the high-frequency cable from the probe. 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 VDC power input. The connector has the positive terminal on the inside and the negative terminal on the outside, matching the output of the supply included with the ADV. 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 communications lines of the ADV. This connector has been wired following standard serial communications protocol. When using RS232 communications, a simple pin-to-pin cable can be used to connect the ADV to the DB9 serial port on a PC-compatible computer (a ribbon cable is provided with the system for this purpose). Table 16 lists the pin-out for the DB9 connector.

Table 16. DB9 Connector Pin-outs for Serial Communications

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, gives access to auxiliary input / output signals. Table 17 lists the pin out for the DB15 connector.

Table 17. DB15 Connector Pin-outs for Auxiliary I/O Signals

Pin #	Signal	Pin #	Signal	Pin #	Signal
1	Vx	6	SyncIn	11	Ground
2	Vy	7	SyncOut	12	Ground
3	Vz	8	+5 V	13	Ground
4	Amp	9	Ground	14	Ground
5	Ground	10	Ground	15	Ground

4.3.2. ADVField Underwater Canister

There are two connectors on the ADVField underwater canister: one to the probe and the other for power, serial communications, and auxiliary input / output functions. Underwater mateable connectors are used for both (some older ADVs used different connectors; contact SonTek if you have any questions about the connectors used on your system). The high-frequency cable from the ADVField underwater canister to the probe is a custom-shielded, highly noise-sensitive cable. Contact SonTek before making any modifications to this cable or connector.

SonTek uses underwater connectors made by Impulse Enterprises. Contact information for Impulse (if ordering items directly) is:

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

Two different types of connectors are used for power and communications.
- For most autonomous ADVField systems (with internal recorder and battery power):
  - The external power and communication connector is a female, 8-pin, underwater mateable connector (although some use the female, 16-pin connector described below).
  - The bulkhead connector used is an Impulse BH-8-FS.
  - The mating connector on the cable is an Impulse IL-8-MP (with locking sleeve).
  - Table 18 gives the pin-out for this connector.

Table 18. Impulse IL-8-MP Connector Pin-outs

Pin #	Signal	Pin #	Signal	Pin #	Signal
1	Vpower	4	Drain	7	Rx-
2	Data Out / Tx+	5	SyncIn	8	Ground
3	Data In / Tx-	6	Rx+		

- For older, real-time ADVField systems (without the internal recorder or battery power):
  - o The connector is a female 16-pin underwater mateable connector.
  - o The bulkhead connector used is an Impulse MBH-16-FS.
  - o The mating connector on the cable is an Impulse MIL-16-MP (with locking sleeve).
  - o Table 19 gives the pin-out for this connector.
  - o Note: This cable has been discontinued.

Table 19. Impulse MIL-16-MP Connector Pin-outs

Pin #	Signal	Pin #	Signal	Pin #	Signal
1	Vpower	7	Vz	13	Not Used
2	Vx	8	Amp	14	Rx-
3	Vy	9	Ground	15	SyncOut
4	Ground	10	Data Out / Tx+	16	Ground
5	SyncIn	11	Data In / Tx-		
6	Rx+	12	Ground		

The standard termination for the power/communication cable uses a DB9 connector for RS232 serial communication and a coaxial connector for power. The DB9 connector has the same pin-out as the DB9 connector on the ADVField splash-proof housing (§4.3.1). The coaxial connector uses the center conductor as positive and the outer conductor as negative. Contact SonTek for more information about custom cable wiring and access to the auxiliary input/output signals.

4.3.3. External Sensor Connector

Systems with external sensors may use different cables/connectors depending on the sensor being used. Two of the more common connector pin-outs are shown in the following tables. If you are unsure of your connector type, contact SonTek.

Table 20. Sensor Connector Pin-outs (8-pin, underwater, male)

Pin #	Signal	Pin #	Signal	Pin #	Signal
1	Sensor power out	4	Ext Sensor Chan 1	7	Sync In
2	Ext Serial Data In	5	Ext Sensor Chan 2	8	Ground
3	Ext Serial Data Out	6	Sync Out		

Table 21. Sensor Connector Pin-outs (16-pin, underwater, female)

Pin #	Signal	Pin #	Signal	Pin #	Signal
1	Not used	7	Paros temperature	13	Not used
2	Ext Sensor Chan 1	8	Paros pressure	14	Not used
3	Ext Sensor Chan 2	9	Ground	15	Ext Serial Data Out
4	Sync Out	10	Not used	16	Ground
5	Sync In	11	Not used		
6	Not used	12	Ext Serial Data In		

4.4.   Accessing the ADVField Processing Module

Under normal operating conditions, you should not need to access the ADVField processing module. The most common reason for accessing the processing module is to change batteries for autonomous systems. It may occasionally be necessary to check the input power fuse located on the Analog board, or to install a new EPROM on the CPU or DSP board. This section provides instructions to access the electronics, perform typical internal operations, and close the system. The instructions are divided into sections for each different system configuration and for the most common internal operations that need to be performed.

- Accessing the ADVField splash-proof housing
- Accessing the ADVField rectangular underwater canister
- Accessing the ADVField round underwater canister
- Changing batteries in the ADVField round underwater canister
- Accessing the hardware switches and jumpers
- Testing the input power fuse
- Replacing the CPU and/or DSP EPROM

4.4.1. Accessing the ADVField Splash-Proof Housing

The following instructions are for the ADVField in the splash-proof housing without the rechargeable battery; see §4.5 for systems with the rechargeable battery.

To open the housing:
1. Remove the four #4-40 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. Several 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 assembly in a static-safe area.

To disassemble the processor board stack:
1. Note the position and orientation of the cables from the end plate to the electronics. See §4.1 for the location of the connectors referred to below.
2. Remove the red, 2-pin input power connector from the Analog board. This cable goes to the power switch on the end plate.
3. Remove the red, 2-pin diode connector from the Analog board. This cable goes to the diode on the end plate.
4. Remove the black, 16-pin probe connector from the Analog board. This cable goes to the DB25 connector on the end plate.
5. If present (i.e., temperature or pressure sensor is installed), remove the black, 10-pin temperature/pressure connector from the Analog board. This cable goes to the DB25 connector on the end plate. This connector is **not** keyed. It should be oriented such that the two wires are connected to the pins farthest from the input power connector.
6. Remove the black, 16-pin auxiliary input/output connector from the DSP board. This cable goes to the DB15 connector on the end plate.
7. Remove the black, 10-pin serial communication connector from the CPU board. This cable goes to the DB9 connector on the end plate. The end plate should now be completely disconnected from the board stack.

8. Remove the Analog board by lifting straight up from the DSP board. These two boards are joined by card connectors at each end. Be careful not to bend any pins.
9. Remove the DSP board by lifting straight up from the CPU board. These two boards are joined by a card connector on one end. Be careful not to bend any pins.

To reassemble the processor board stack:
1. Connect the DSP and CPU boards (DSP on top) by aligning and securely seating the card connector. Be sure that all pins are firmly set, and that no pins have been bent or damaged.
2. Connect the Analog board to the top of the DSP board by aligning and securely seating the card connectors at each end. Be sure that all pins are firmly set, and that no pins have been bent or damaged.
3. Connect the red, 2-pin input power connector to the Analog board. This cable goes to the power switch on the end plate.
4. Connect the red, 2-pin diode connector to the Analog board. This cable goes to the diode on the end plate.
5. Connect the black, 16-pin probe connector to the Analog board. This cable goes to the DB25 connector on the end plate.
6. If present, connect the black, 10-pin temperature/pressure connector to the Analog board. This cable goes to the DB25 connector on the end plate. This connector is **not** keyed; it should be oriented such that the two wires are connected to the pins farthest from the input power connector.
7. Connect the black, 16-pin auxiliary input/output connector to the DSP board. This cable goes to the DB15 connector on the end plate.
8. Connect the black, 10-pin serial communication connector to the CPU board. This cable goes to the DB9 connector on the end plate.

To close the 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 is the board 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.

4.4.2. Accessing the ADVField Round Underwater Canister

The following instructions are for the ADVField in the round underwater canister, either with or without the internal battery packs.

To open the canister:
1. Vent any differential pressure using the vent screw in the center of the end cap. Loosen the screw using the hex driver provided with the tool kit. After venting, but before opening the canister, tighten the vent screw.
2. The end cap screws into the canister and must be unscrewed to remove it. Insert the 1/4" steel dowel pins into the two blind holes in the end cap. Use these with a large wrench or other lever to loosen the cap (counterclockwise). At the start, you may need one person to hold the

canister while another unscrews the lid. Once started, the end cap should rotate easily; it requires about four turns to undo all threads.

3. Lift the end cap away from the canister. Be careful not to damage the o-ring seal between the end cap and canister. The end cap is connected to a plate on which the processing electronics are mounted.

4. Pull the end plate and electronics completely out of the canister. If the system includes internal batteries, disconnect the cables from the two battery packs to the processing electronics. Place the end plate / electronics assembly in a static-safe area.

To disassemble the processor board stack:

1. Note the position and orientation of the cables from the end plate to the electronics. See §4.1 for the location of the connectors referred to below.

2. Remove the red, 2-pin input power connector from the Analog board. This cable goes to the power and communication connector on the end plate.

3. Remove the red, 2-pin battery backup connector from the Analog board (systems with internal recorder only). This cable goes to the backup battery mounted under the electronics.

4. Remove the black, 16-pin probe connector from the Analog board. This cable goes to the probe connector on the end plate.

5. Remove the black, 10-pin temperature/pressure connector from the Analog board. This cable goes to the probe connector on the end plate. This connector is **not** keyed; it is oriented such that the two wires are connected to the pins farthest from the input power connector.

6. Remove the black, 16-pin auxiliary input/output connector from the DSP board. This cable goes to the power and communication connector on the end plate.

7. Remove the black, 10-pin serial communication connector from the CPU board. This cable goes to the power and communication connector on the end plate. All cables from the end plate to the board stack should now be disconnected.

8. Remove the four #4-40 screws securing the four corners of the Analog board.

9. Remove the Analog board by lifting straight up from the DSP board. These two boards are joined by card connectors at each end; be careful not to bend any pins.

10. Remove the four hex standoffs (1/4" wrench size, 1/2" tall, #4-40 thread) securing the four corners of the DSP board.

11. Remove the DSP board by lifting straight up from the CPU board. These two boards are joined by a card connector at one end; be careful not to bend any pins.

12. Remove the four hex standoffs (1/4" wrench size, 1/2" tall, #4-40 thread) securing the four corners of the CPU board.

13. Remove the CPU board by lifting straight up from the Recorder board (if installed). These two boards are joined by a card connector at one end; be careful not to bend any pins. If the recorder is not installed, the CPU can be removed directly.

14. If necessary, remove the Recorder board by removing the four hex standoffs (1/4" wrench size, 1/2" tall, #4-40 thread).

To re-assemble the processor board stack:

1. Install the Recorder board and secure with four hex standoffs (1/4" wrench size, 1/2" tall, #4-40 thread). Be certain to install this board in the same orientation in which it was previously installed (with the PCMCIA card at the opposite end from the end cap).

2. If the Recorder is present, connect the CPU board to the Recorder board by aligning and securely seating the card connector. Be sure that all pins are firmly set and that no pins have been bent or damaged. If no recorder is present, install the CPU and secure with four hex

standoffs (1/4" wrench size, 1/2" tall, #4-40 thread). Be certain to install this board in the same orientation in which it was previously installed (with the connectors at the end opposite the end cap).

3. Connect the DSP board to the top of the CPU board by aligning and securely seating the card connector at one end. Be sure that all pins are firmly set, and that no pins have been bent or damaged. Secure with four hex standoffs (1/4" wrench size, 1/2" tall, #4-40 thread).

4. Connect the Analog board to the top of the DSP board by aligning and securely seating the card connectors at each end. Be sure that all pins are firmly set, and that no pins have been bent or damaged. Secure with four #4-40 screws using flat and lock washers on each screw.

5. Connect the red, 2-pin input power connector to the Analog board. This cable goes to the power and communication connector on the end plate.

6. Connect the red, 2-pin battery backup connector to the Analog board (systems with internal recorder only). This cable goes to the backup battery mounted below the electronics.

7. Connect the black, 16-pin probe connector to the Analog board. This cable goes to the probe connector on the end plate.

8. Connect the black, 10-pin temperature/pressure connector to the Analog board. This cable goes to the probe connector on the end plate. This connector is **not** keyed; orient it such that the two wires are connected to the pins farthest from the input power connector.

9. Connect the black, 16-pin auxiliary input/output connector to the DSP board. This cable goes to the power and communication connector on the end plate.

10. Connect the black, 10-pin serial communication connector to the CPU board. This cable goes to the power and communication connector on the end plate.

To close the canister:
1. Clean and inspect the o-ring and o-ring surfaces on the end cap and the canister. Replace the o-ring if necessary.

2. If the system includes internal battery packs, connect the cables from the two packs to the wiring harness on the processing electronics. The order of connections does not matter.

3. Install the end cap assembly in the canister and screw the cap down. The threads should turn easily for about four turns; if the end cap is hard to turn, either the threads are not aligned correctly or something is blocking the threads.

4. Tighten the threads until the end cap sits directly on the canister. Use the 1/4" steel dowel pins with a large wrench or other lever to do the final tightening.

5. If using a system with internal batteries, establish communication with the ADV and place it in sleep mode when the system has been completely closed to avoid draining the batteries.

6. Ensure the vent screw is tightened securely.

4.4.3. Accessing the ADVField Rectangular Underwater Canister [Discontinued]

The following instructions are for the ADVField in the rectangular underwater canister. Note: This canister has been discontinued.

To open the canister:
1. Remove the four 1/4"-20 screws from the four tabs on the front end plate.

2. Pull the front end plate away from the canister. Be careful not to damage the o-ring seal between the end plate and canister. The end plate is connected to a horizontal plate that matches groves in the canister. The electronics are mounted to this plate.

3. Pull the end plate and electronics completely out of the canister. Place the end plate/electronics assembly in a static-safe area.

To disassemble the processor board stack:

1. Note the position and orientation of the cables from the end plate to the electronics. See §4.1 for the location of the connectors referred to below.
2. Remove the red, 2-pin input power connector from the Analog board. This cable goes to the power and communications connector on the end plate.
3. Remove the red, 2-pin battery backup connector from the Analog board (systems with internal recorder only). This cable goes to the backup battery mounted on the end plate.
4. Remove the black, 16-pin probe connector from the Analog board. This cable goes to the probe connector on the end plate.
5. Remove the black, 10-pin temperature/pressure connector from the Analog board. This cable goes to the probe connector on the end plate. This connector is **not** keyed; it is oriented such that the two wires are connected to the pins farthest from the input power connector.
6. Remove the black, 16-pin auxiliary input/output connector from the DSP board. This cable goes to the power and communication connector on the end plate.
7. Remove the black, 10-pin serial communication connector from the CPU board. This cable goes to the power and communication connector on the end plate. All cables from the end plate to the board stack should now be disconnected.
8. Remove the four #4-40 screws securing the four corners of the Analog board.
9. Remove the Analog board by lifting straight up from the DSP board. These two boards are joined by card connectors at each end; be careful not to bend any pins.
10. Remove the four hex standoffs (1/4" wrench size, 1/2" tall, #4-40 thread) securing the four corners of the DSP board.
11. Remove the DSP board by lifting straight up from the CPU board. These two boards are joined by a card connector at one end; be careful not to bend any pins.
12. Remove the four hex standoffs (1/4" wrench size, 1/2" tall, #4-40 thread) securing the four corners of the CPU board.
13. Remove the CPU board by lifting straight up from the Recorder board (if installed). These two boards are joined by a card connector at one end; be careful not to bend any pins. If the recorder is not installed, the CPU can be removed directly.
14. If necessary, remove the Recorder board by removing the four hex standoffs (1/4" wrench size, 1/2" tall, #4-40 thread).

To re-assemble the processor board stack:

1. If removed, install the Recorder board and secure with four hex standoffs (1/4" wrench size, 1/2" tall, #4-40 thread). Be certain to install this board in the same orientation in which it was previously installed (with the PCMCIA card next to the end plate).
2. Connect the CPU board to the Recorder board by aligning and securely seating the card connector. Be sure that all pins are firmly set and that no pins have been bent or damaged. If no recorder is present, install the CPU board (if it was removed) and secure with four hex standoffs (1/4" wrench size, 1/2" tall, #4-40 thread). Be certain to install this board in the same orientation in which it was previously installed (with the connectors next to the end plate).
3. Connect the DSP board to the top of the CPU board by aligning and securely seating the card connector at one end. Be sure that all pins are firmly set, and that no pins have been bent or damaged. Secure with four hex standoffs (1/4" wrench size, 1/2" tall, #4-40 thread).
4. Connect the Analog board to the top of the DSP board by aligning and securely seating the card connectors at each end. Be sure that all pins are firmly set, and that no pins have been bent or damaged. Secure with four #4-40 screws using flat and lock washers on each screw.

5. Connect the red, 2-pin input power connector to the Analog board. This cable goes to the power and communication connector on the end plate.
6. Connect the red, 2-pin battery backup connector to the Analog board (systems with internal recorder only). This cable goes to the backup battery mounted on the end plate.
7. Connect the black, 16-pin probe connector to the Analog board. This cable goes to the probe connector on the end plate.
8. Connect the black, 10-pin temperature/pressure connector to the Analog board. This cable goes to the probe connector on the end plate. This connector is **not** keyed; orient it such that the two wires are connected to the pins farthest from the input power connector.
9. Connect the black, 16-pin auxiliary input/output connector to the DSP board. This cable goes to the power and communication connector on the end plate.
10. Connect the black, 10-pin serial communication connector to the CPU board. This cable goes to the power and communication connector on the end plate.

To close the canister:
1. Clean and inspect the o-ring and o-ring surfaces on the end plate and the canister. Replace the o-ring if necessary.
2. Slide the end plate assembly into the canister by aligning the horizontal plate with the ex-truded slots on the inside of the canister. Be careful that no cables or connectors catch on the inside of the canister. The assembly should slide smoothly into the canister until the end plate rests against the canister.
3. Secure the end plate using the four 1/4"-20 screws. Tighten securely (at least until the lock washers have been completely flattened) without over tightening.

4.4.4. Changing Batteries in the ADVField Round Underwater Canister

These instructions apply to the ADVField in the round underwater canister with internal batteries. Figure 15 shows the layout of the underwater canister with internal batteries.

To remove the battery packs:
1. Vent any differential pressure using the vent screw in the center of the end cap. After venting, but before opening the canister, tighten the vent screw.
2. Open the underwater canister, remove the end cap assembly, and disconnect the battery cables.
3. Remove the retaining ring by placing a large flat-blade screwdriver against the notched end of the ring and turning the screwdriver 90°. Insert a second screwdriver or small tool between the exposed edge of the ring and canister. With the ring held open, it can be lifted with either your fingers or using a small flat-blade screwdriver. Once started, the rest of the ring can be easily removed from the slot using a spiral motion. Lift the ring out of the canister taking care not to damage the o-ring surfaces or threads.
4. Remove the battery cover and pads, and lift out the battery packs. SonTek packs have straps attached to them for easy removal; if these are not present, tilt the canister to slide out the packs.

To install new batteries:
1. Place one foam pad on the bottom of the case.
2. Install the two packs in the case. Align the cables from the two packs on the same side of the canister.
3. Place several foam pads on top of the battery packs. The number of pads needed will vary, as the dimensions of the battery packs can vary (particularly between alkaline and lithium).
4. Install the retaining plate on top of the foam pads, running the battery cables through the largest hole in the plate. There should be enough pads so that the plate requires moderate compression to give access to the retaining ring slot.
5. Install the retaining ring, taking care to avoid damage to the o-ring surfaces and threads.
6. Connect the battery cables to the wiring harness from the electronics and close the system.
7. When the system has been completely closed, be sure to establish communication with the ADV and place it in sleep mode to avoid draining the batteries.
8. Ensure the vent screw is tightened securely.

Figure 15 - ADVField with Internal Batteries

4.4.5. Accessing the Hardware Switches and Jumpers

Hardware settings (in three places on the ADVField processing module) are used to determine the system configuration. See §4.1 for the exact location of each of these areas and §4.2 for details on individual switch and jumper settings.

A set of switches on the Analog board determines system orientation and which optional sensors are installed. These switches can be accessed by opening the processing module, but without disassembling the board stack. Use a small flat-blade screwdriver to change the switch settings.

Two hex rotary switches on the CPU board are used to set the baud rate for serial communication and the address for RS485 communication protocol. These switches are accessed from the side, and can be changed by opening the processing module, but without disassembling the board stack. Use a small flat-blade screwdriver to change the switch settings.

A set of eight jumpers on the CPU board is used to determine the serial communication protocol. The processing module must be opened and the board stack disassembled to access these jumpers. Use your fingers or a pair of needle nose pliers to remove and install the jumpers.

4.4.6. Testing the Input Power Fuse

The ADVField electronics has an input power fuse to protect the electronics from high input voltages or surges in input current. The fuse is located on the Analog board near the red, 2-pin input power connector (see §4.1). A 3.15A, fast-acting fuse in a black cylindrical package (0.8 cm; 0.3" diameter) is used. The fuse has two pins that plug into a socket on the Analog board. The orientation of the fuse in this socket does not matter.

If you are unable to establish communication with the ADVField, and measurements show that the processing module is not drawing any current when input power is applied, the fuse may be blown. Test, and if necessary, replace the fuse using the following steps.

1. Open the processing module (see applicable part of §4.4).
2. Lift the fuse from its socket on the Analog board and test for continuity between the two pins. If the circuit is open, the fuse has been blown and needs to be replaced. Spare fuses are included in the ADV tool kit.
3. Re-install the old fuse (if intact) or a new fuse into the Analog board socket.
4. Close the processing module.

4.4.7. Replacing the CPU or DSP EPROM

Periodically, SonTek may provide firmware upgrades for the EPROM used to control the CPU or DSP. These are done to provide access to new data collection features or to enable custom capabilities (the CPU firmware is more commonly replaced; DSP firmware changes are quite rare). The EPROM is replaced using the following steps.

1. Open the processing module (see applicable part of §4.4).
2. Disassemble the processing module board stack to provide access to the DSP or CPU board, depending on which EPROM needs to be replaced.
3. Locate the chip to be replaced on the DSP or CPU board. The EPROM should have a label on the chip that clearly identifies it (see the diagrams in §4.1 for the exact locations)
4. Carefully remove the old EPROM. This is done using a small flat-blade screwdriver to gradually lift each end of the chip until it can be removed by hand. Store the old EPROM in a static-safe environment until system operation has been tested using the new EPROM.

5. Install the new EPROM into the socket. Align the half circle on one end of the EPROM with the half circle on the socket and electronics board. Operation with the incorrect alignment can potentially damage the processing module. Align all pins with the socket before installing; if the pins are too wide for the socket, they can be bent in by carefully pressing one side of the chip on a table or other hard surface. When all pins are aligned, firmly seat the EPROM in the socket while supporting the board from underneath with your fingers.
6. Re-assemble the board stack and close the processing module.
7. Test all aspects of system operation including: real-time data collection using SonTek software, system diagnostics using **ADFCHECK**, and autonomous data collection (systems with internal recorder only). When satisfied that everything is functioning properly, the old EPROM can be discarded.

4.5.   ADVField Splash-Proof with Rechargeable Batteries

The ADVField in the splash-proof housing can be equipped with a rechargeable battery for data collection. The battery is mounted inside the housing directly to the rear end plate. The housing has overall dimensions of 32x11x7 cm (12.5x4.5x2.8 in). The rear end plate has a coaxial connector for the battery charger input and a vent plug to be opened during charging. The front end plate has four connectors, a power switch, and a diode. These are described in §4.3.1.

There are two coaxial connectors on systems with the rechargeable battery: the input power connector on the front panel and the battery charger connector on the back panel. Different size connectors are used to prevent the power supply being connected to the internal battery. The front panel connector is for use with the 24 V power supply included with the ADV (or any other 12-24 VDC external power supply) for continuous system operation. The rear panel connector and battery are isolated from the front panel supply. The front panel supply will not charge the battery and will not produce a live voltage on the rear panel connector.

The rear panel connector is wired directly to the rechargeable battery and (through an isolating diode) to the ADV electronics. The front panel power connector is isolated from the rear panel input and battery; the rear panel input and battery will not produce a live voltage on the front panel connector. The rear panel is intended for use only with the battery charger supplied with the system.

The system uses a 12 V, 3.0 Ah rechargeable lead acid battery. When fully charged, it has power for 6-10 hours of operation (depending on system configuration and velocity range setting). Complete recharging with the SonTek supplied battery charger takes 4-6 hours.

Important Note When Charging the Battery

Always open the vent plug on the rear panel when recharging the internal battery. Use the 12 V battery charger included with the system. While charging, the ADV can be operated either using the 12 V battery charger or the 24 V power supply included with the system. The two supplies are isolated; if both are present, the ADV will draw power from the front panel supply while the battery is charged from the rear panel input. If operating the ADV from an external supply for an extended period of time, use the front panel connector. SonTek does not recommend leaving the battery charger connected through the rear panel for more than 12 hours. Be sure to close the vent plug after disconnecting the battery charger.

The power switch on the front panel will disconnect the ADV from any external supply and from the internal rechargeable battery. Make sure this switch is off (the diode on the front panel is lit if the switch is on and the ADV has input power) when not being used to prevent draining the rechargeable battery. The switch does not affect the connection between the rear-panel battery charger input and the internal battery.

Accessing the processing module for systems with the rechargeable battery is done using the same procedure given in §4.4. The only difference in internal wiring is a connector from the front panel wiring over the top of the Analog board. This connector mates with a connector from the front panel and battery, and should be disconnected while removing the ADVField electronics.

4.6.   Accessing the Signal Conditioning Module

The ADV signal-conditioning module contains the receiver electronics and any optional sensors (compass/tilt, pressure, and temperature). It should not need to be accessed during normal operation. The only common reason is to change the orientation of the internal compass/tilt sensor or to change probes (16-MHz or 10-MHz ADV without optional sensors only).

16-MHz MicroADV or 10-MHz ADV without Optional Sensors

The conditioning module for the 16/10-MHz ADV systems without optional sensors is a cylinder with dimensions of 6.4 cm (2.5 in) in diameter by 28.5 cm (11.2 in) long. The probe is mounted from the bottom end cap; the end cap is an integral part of the probe assembly. The high-frequency cable from the processing module is connected to the top end cap using a non-removable penetrator. The receiver electronics are directly mounted to the top end cap / cable assembly, and are connected to the probe end cap using an edge connector on the receiver board.

5 MHz-ADVOcean without Optional Sensors

The conditioning module of the ADVOcean without optional sensors should not need to be accessed under normal operating conditions; instructions are not provided in this manual. If you have questions about the ADVOcean probe, or think you need to access the conditioning module, please contact SonTek.

16-MHz MicroADV or 10-MHz ADV or 5-MHz ADVOcean with Optional Sensors

For the 16/10/5-MHz ADV system probe with compass/tilt sensor, you may need to access the conditioning module to change compass orientation. (See §4.7.2 for details on internal compass mounting for different probe orientations.) To access the conditioning module, only the connector end cap needs to be removed.

You should not remove the sensor end cap on which the acoustic sensors are mounted. The receiver electronics are mounted directly to this end cap, and the alignment of the end cap with respect to the housing is set at the factory. Instructions for removing the sensor end cap are not provided in this manual; if you think you need to remove this end cap, please contact SonTek.

The connector end cap is secured to the housing by three #6-32 screws. To access the conditioning module, remove these screws using the screwdriver provided in the ADV tool kit. Lift the end cap directly out from the housing. The compass/tilt sensor and the pressure/temperature sensor board are mounted directly to the end cap as described in §4.7.2. When removing the end cap,

you will need to disconnect the cable from the underwater connector to the receiver board. This cable is highly sensitive to noise and should not be modified.

To close the conditioning module, first inspect and clean all o-rings and o-ring surfaces. Replace the o-rings if necessary. Next, connect the cable from the underwater connector to the receiver board and make certain all cables from the optional sensors are securely connected (see §4.7.2 for a description of these cables). The three screws that secure the end cap to the conditioning module housing are slightly asymmetric and can only be installed in one orientation; this ensures the correct alignment of the compass/tilt sensor with respect to the probe. Install the end cap and secure with the three #6-32 screws.

Note: The cables and electronics in the conditioning module are very sensitive to noise and should not be modified. If you have any questions, contact SonTek. When opening the conditioning module, be sure to install a fresh bag of desiccant and/or purge the housing with nitrogen before closing. This is particularly important in humid climates to prevent condensation.

4.7.   Optional Compass/Tilt Sensor for the ADVField

The ADVField can be equipped with a compass/tilt sensor to translate data from the probe's XYZ coordinate system to an Earth (East-North-Up or ENU) coordinate system. The sensor used is the Precision Navigation TCM2 Electric Compass Module.

- Communication with the ADV is through an RS-232 interface. Although direct communication with the compass is not required under normal conditions, this interface lets you "talk" directly with the compass (see §4.7.6).
- When properly calibrated, the TCM2 provides accurate heading data (±2.0°) and accurate pitch/roll data (±0.1° up to 50°).
- There are limitations when using the ADV with a compass. Foremost is the 50° limit on pitch/roll. Any pitch/roll beyond this will produce unpredictable results.
- It is essential that the compass be correctly mounted relative to probe orientation to ensure accurate compass data and the correct rotation of XYZ velocity data (see §4.7.2).
- Care should be taken to limit how fast the orientation of the ADV changes because high-frequency motion can distort compass data. The compass/tilt sensor has a maximum frequency response of about 2 Hz.
- Remember that the ADV measures velocity relative to its own speed – if the ADV is moving, the recorded velocity is the vector sum of the ADV velocity and the true water motion.

4.7.1. Testing Compass Operation

This section describes a simple procedure to verify basic compass operation performed using a continuous display of compass data (heading, pitch, and roll). The display can be obtained using the direct command interface, the DOS-based compass calibration software (COMPCAL), or the Windows-based compass calibration software (*Compass*, part of *SonUtils*). If using the direct command interface, the command Compass CONT gives a continuous output of heading, pitch, and roll. COMPCAL and *Compass* (see *ADVField Software Manual*) provide continuously updated graphical and tabular displays of compass data. Guidelines to running this test:

- Be sure the compass is oriented vertically (§4.7.2) and the hardware orientation switches (§4.2) match the compass installation.
- The area around the ADV should be predominantly free of magnetic material.
- Start the display of compass data.
- Point the probe's X-axis (if compass is mounted in conditioning module) or the underwater canister's X-axis (if the compass is mounted with the processing module) towards each compass direction (north, south, east, and west).
- Compare the compass output with the expected reading.
- Test the pitch/roll sensors by tilting the ADV about the X-axis (roll) and Y-axis (pitch).
- The compass and tilt data should appear reasonable to within the accuracy of the sensor (±10° heading, ±5° tilt). Large errors or a lack of response indicates a problem.
- This is not a precise test of compass accuracy, but a means to evaluate basic performance.
- For best results, we recommend performing a compass calibration before every deployment.

4.7.2. Compass Installation and Instrument Mounting

There are several ways to mount the compass in the ADVField. The mountings vary with the system configuration and the intended orientation of the probe. Most newer ADV systems have the compass mounted within the conditioning module as described in §1.1.2 and §1.1.3. These systems are discussed in §4.7.3. Some older ADV systems have the compass mounted in the same underwater canister with the ADV processing module. For information on accessing the processing and signal conditioning modules, see §4.4 and §4.6.

The essential part of compass mounting is to maintain an exact orientation relative to the ADV probe. This allows the processor to use the compass data to translate velocity data from the XYZ coordinate system (relative to the probe) to the ENU coordinate system.

Figure 16 shows the compass/tilt sensor layout and its XYZ coordinate system. **The compass must be operated with the component side facing upwards** (within the ±50° tilt limit). Operation with the compass sideways or upside down will result in invalid compass data and invalid velocity data when using the ENU coordinate system (unrecoverable data loss).

The compass has a 10-pin connector for power and communication between the compass and ADV electronics (using an

Figure 16 - Compass Coordinate System

RS232 interface). The compass X and Y-axes are labeled near the magnetic coils. The positive X-axis is defined from the connector towards the magnetic coils; the positive Z-axis is perpendicular to the compass board. 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.

4.7.3. Compass Mounted in ADV Probe Signal Conditioning Module

This section describes the compass mounting for each of the three probe orientations. These compass mountings need to be changed whenever the probe orientation is changed. Unless otherwise requested, ADV probes are configured at the factory for up-looking operation. Whenever changing compass orientation, be sure to correctly set the hardware orientation switch (§4.2) and verify compass operation (§4.7.1) before collecting data.

When installed in the signal-conditioning module, the compass can be oriented three ways depending on the desired probe orientation. Figure 17 shows the probe orientations for up, down, and side-looking operation.

The remainder of this section describes: internal end cap design, up-looking mounting, down-looking mounting, side-looking mounting, and conditioning module wiring.
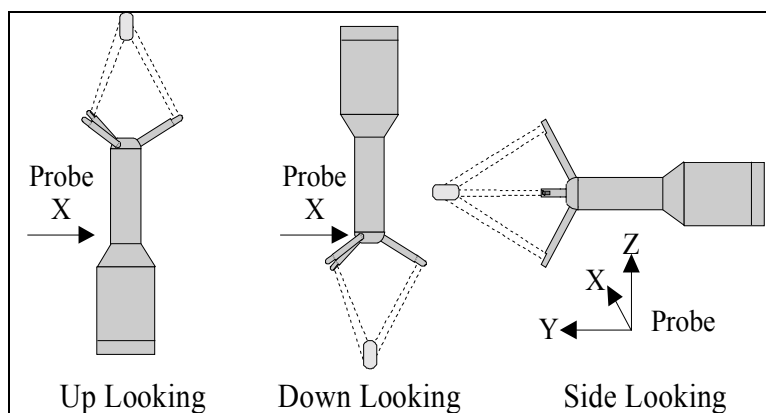
Figure 17 - ADV / ADVOcean Probe Orientations

Internal End Cap Design

Figure 18 shows the inside of the conditioning module's end cap. The items on this end cap will be referenced when describing compass installation. The three holes around the diameter are for mounting the end cap to the body of the conditioning module. Near the center of the end cap, the back of the underwater mateable connector protrudes slightly with several wires coming from it. If a pressure sensor is installed, there is a hole with six wires from this sensor.

The end cap has several drilled and tapped holes to accommodate the various compass-mounting arrangements. These holes are divided into three groups, with holes for each group labeled 1, 2, and 3.

Group 1 consists of four holes with threaded inserts for #4-40 bolts. These holes are in a rectangular pattern to match the mounting pattern

Figure 18 - Conditioning Module End Cap

of the compass card, and are used for mounting the compass for up or down-looking operation. Group 2 consists of two holes with threaded inserts for #6-32 bolts; these holes are 1.75" apart. They match the right-angle mounting bracket used for side-looking compass installation. Group 3 consists of five holes that are not used; these holes are present only in the first production run of the ADV with compass and tilt sensor.

All mounting holes use self-locking threaded inserts. These inserts give some resistance when tightening the last portion of the threads. The self-locking inserts are used to prevent loosening due to vibration and eliminate the need for lock washers.

The three mounting holes that secure the end cap to the body of the conditioning module are slightly asymmetric; the end cap can only be installed in one direction. This ensures that the probe X-axis as stamped on the end cap matches the probe X-axis as determined by the orientation of receiver arm #1. The upper end cap and the position of receiver arm #1 are aligned at the factory; these should never be modified without first contacting SonTek.
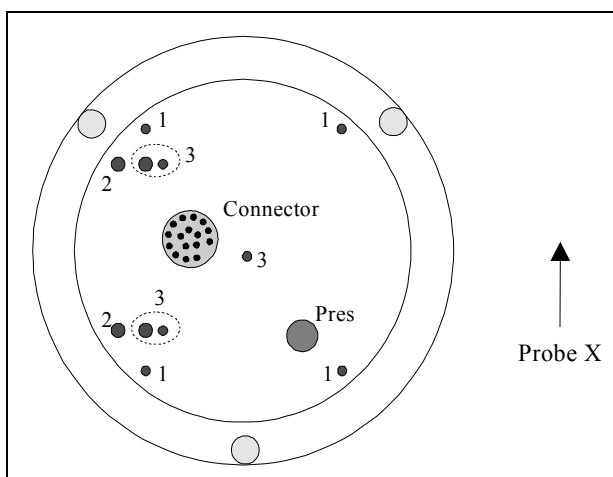
Up-Looking Mounting

Figure 11 shows the compass/tilt sensor mounted for up-looking operation. The mounting is in two layers on the end cap of the conditioning module. Four standoffs (#4-40 x 3/8") are screwed into the end cap (Group 1 holes). The pressure / temperature sensor is installed on these standoffs; board orientation does not matter. Atop this board are four standoffs (#4-40 x 1/2"). Last, the compass/ tilt sensor is secured by four screws (#4-40 x 3/8") with fiber washers on each side.

To ensure correct compass data, align the compass's positive X-axis (from the connector to the magnetic coils) with the probe's positive X-axis (as stamped on the end cap).
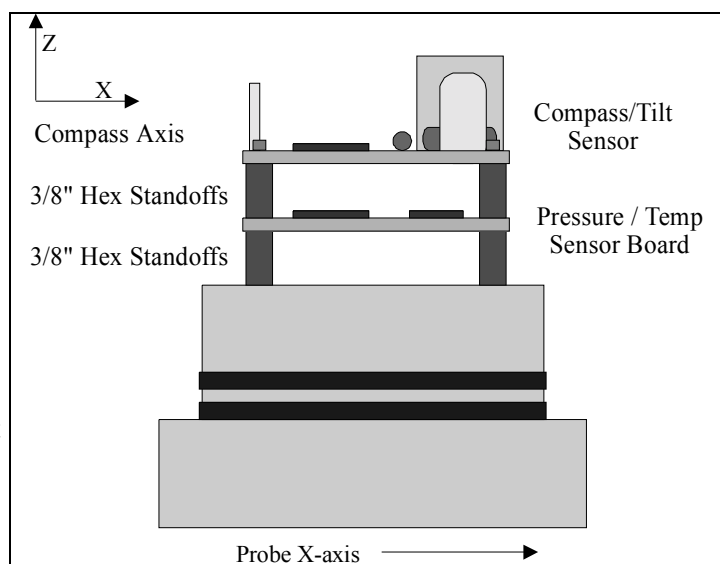
Figure 19 - Compass/Tilt Sensor Mounting, Up-Looking

Down-Looking Mounting

Figure 12 shows the compass/tilt sensor mounted for down-looking operation. The mounting is in two layers on the end cap of the conditioning module. Four standoffs (#4-40 x 3/8") are screwed into the end cap (Group 1 holes). The pressure/temperature sensor is installed on these standoffs; board orientation does not matter. Atop this board are two sets of standoffs; first are the same standoffs used for up-looking operation (#4-40 x 1/2"), second is a set of longer standoffs (#4-40 x 1") used to clear the height of the board components. The compass is mounted to the last set of standoffs and secured by four screws (#4-40 x 3/8") with fiber washers on each side.
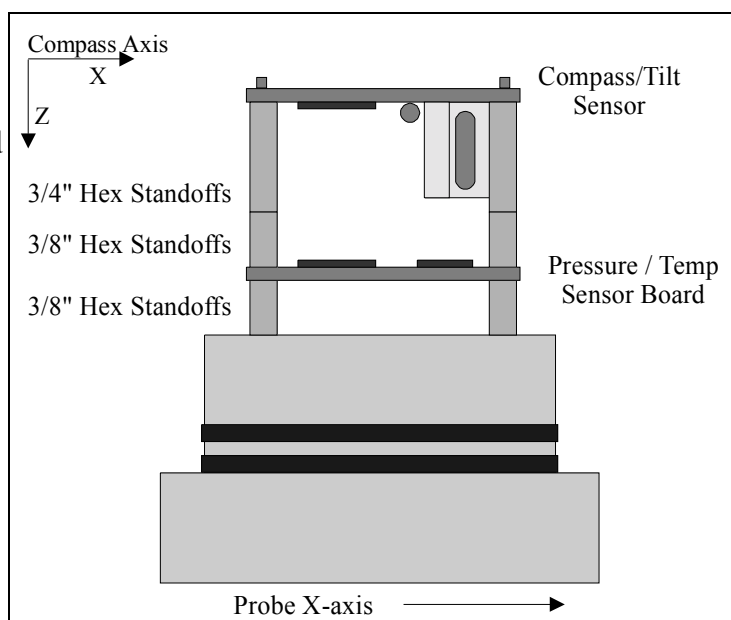
Figure 20 - Compass/Tilt Sensor Mounting, Down Looking

To ensure correct compass data, align the compass positive X-axis (from the connector to the magnetic coils) with the probe positive X-axis (as stamped on the end cap).

Side-Looking Mounting

Figure 21 shows the compass/tilt sensor mounted for side-looking operation. The mounting uses a right-angle bracket (included in the ADV tool kit). This bracket (already assembled) consists of two aluminum pieces secured together by #6-32 screws.

The right-angle bracket is secured to the end cap using two #6-32 x 1/2" screws (Group 2 holes). The compass and pressure/temperature sensor boards are installed in two layers. First, a set of four standoffs (#4-40 x 3/8") is attached to the bracket. The pressure sensor is mounted to these
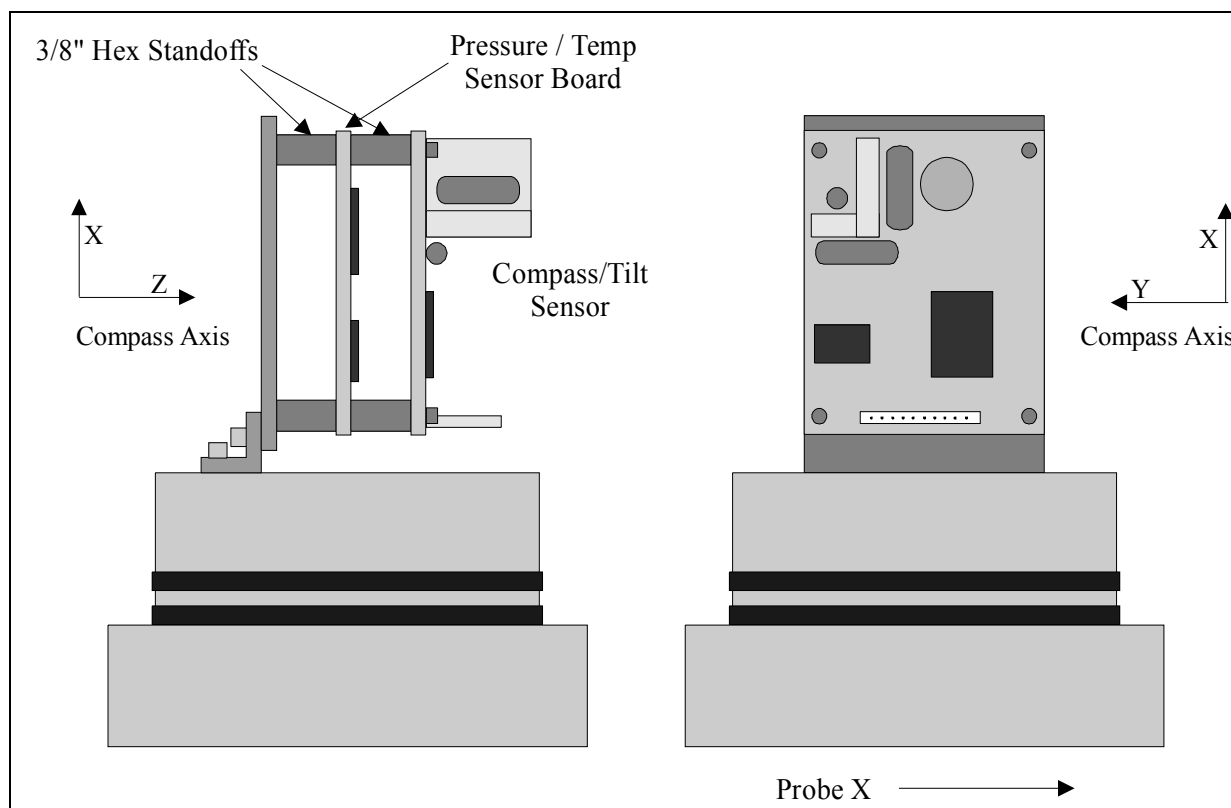
Figure 21 - Compass/Tilt Sensor, Side-Looking Mounting

standoffs; board orientation does not matter. Above the sensor board are four standoffs (#4-40 x 1/2"). Last is the compass, secured by four #4-40 x 3/8" bolts, with fiber washers on each side.

Align the compass as shown in Figure 21. For side-looking operation, it is not possible to align the compass X-axis with the probe X-axis. Instead, the probe X-axis is aligned with the compass negative Y-axis. Assuming the orientation switch is set for side-looking operation (§4.2), this alignment is accounted for internally.

In side-looking operation, you must ensure the probe's X-axis (stamped on the end cap and defined by receiver arm #1) is in the horizontal plane (within the ±50° limits of the tilt sensor). When looking at the rear end cap, the pressure sensor should be in the position shown in Figure 22. If the system does not have a pressure sensor, make sure the X-axis points to the right of the underwater connector. Figure 22 shows the orientation. If the system is not oriented correctly, the compass will be upside down and will give invalid data.
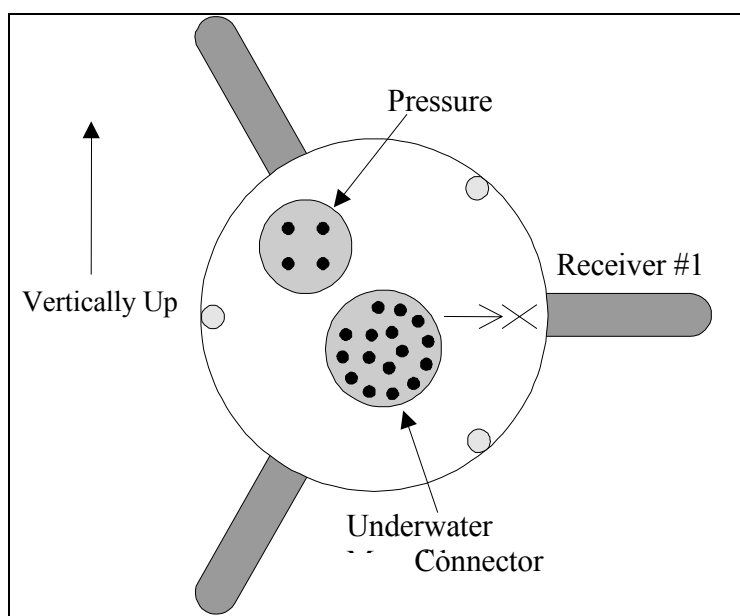
Figure 22 - Probe Mounting, Side-Looking Compass

<u>Conditioning Module Wiring</u>

There are four connectors in the signal-conditioning module that must be correctly mated for the system to operate properly. Please note the position of all connectors and cables before disconnecting them so they can be re-assembled in the same manner.

First is a keyed, 16-pin, black, rectangular connector from the underwater connector to the ADV receiver board. This carries high-frequency signals between the probe and processing module. It may be possible to modify the compass mounting without removing this connector.

Second is a keyed, 10-pin, red connector from the compass to the underwater connector. This carries power and communications between the compass and processing module. (<u>Note</u>: This connector is the same connector type as one on the sensor board. To ensure correct installation, be sure the compass board is connected to the wires coming directly from the back side of the underwater connector and not from the temperature or pressure sensor.)

Third is a 10-pin, red connector from the temperature and pressure sensors to the sensor board. This connects the two wires from the temperature sensor and the six wires from the pressure sensor (optional) to the sensor board. The sensor board conditions these signals before going to the processing electronics. (<u>Note</u>: This connector is the same connector type used by the compass. To ensure correct installation, make sure the pressure/temperature sensor board is connected to the wires coming directly from the back side of the temperature and pressure sensors.)

Last is a keyed, 5-pin connector from the sensor board to the underwater connector. This carries the conditioned temperature and pressure signals to the processing module for sampling.

4.7.4. ENU Coordinate System

The translation of velocity data from XYZ to Earth (ENU) coordinates is enabled or disabled through commands to the ADVField and is transparent to the user. Selection of the coordinate system is done using the `CoordSystem` command (§3.6) or by a menu item in the data acquisition software (see *ADVField Software Manual*). For real-time data collection, compass data are output with each sample whenever the compass is installed. For autonomous data collection, recording of compass data can be enabled or disabled using the data recording options (§3.7).

When using the ENU coordinate system, velocity is reported relative to magnetic East-North-Up regardless of the physical orientation of the ADV (as long as the system remains within the operational limits of the compass). As a result, an ADV that is mounted with variable orientation will provide velocity data consistent with the direction and speed of the water current itself, regardless of ADV orientation when measuring the current.

4.7.5. Compass Calibration

The TCM2 can be calibrated to compensate for magnetic distortion that may cause errors in heading measurements. Magnetic distortion is most commonly caused by ferrous metal near the ADV. If the ADV is mounted on or near anything that contains magnetic material or generates a magnetic field, the compass should be calibrated before starting data collection. The compass should also be calibrated if it is moved to a different environment or mounting apparatus.

There are two ways to calibrate the compass. The simplest way is to use the compass calibration software described in the *ADVField Software Manual*. Alternatively, you can use the compass commands from the direct command interface.

To begin a compass calibration using the compass commands, establish communications with the ADV. Enter the command `Compass CAL`. The system will display basic 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° 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 done, press any key to terminate the calibration. The ADV will respond with a calibration "score" similar to the following.

> H9V9M12.3

This score is an indication of calibration quality. The values following the `H` and `V` should be high (scale: 0 to 9). The value following the `M` should be low (scale: 0 to 100). `H` is the quality of the horizontal calibration, `V` is the quality of the vertical calibration, and `M` is 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 ADV location or modifying the mounting structure.

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

4.7.6. *Communicating Directly with the Compass*

All communications for compass operation is done automatically by the ADV. In most cases, you should not need to communicate directly with the compass. Should the need arise, you can communicate with the compass through the ADV by establishing communication and bypassing the processor for a direct link to the compass.

To communicate with the TCM2, place the ADV 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 ADV, which will be redirected to the user. The data will look similar to the following:

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

The compass will now accept direct commands. For more details on communicating with the compass, or for a copy of the compass operation manual, contact SonTek. When communications with the compass is no longer desired, type three plus signs in succession (+++) or send a `BREAK` to return the ADV to command mode.

4.8.   Optional Sensors (Internal): Temperature and Pressure

All ADVField systems (16/10/5-MHz) can include temperature and pressure sensors in the signal conditioning module as described in §1.1.2 and §1.1.3. The temperature sensor is used for sound speed corrections. The pressure sensor provides simultaneous pressure and 3D velocity measurements (PUVW for directional wave spectra).

The temperature sensor uses a thermistor installed in the conditioning module end cap coupled to a titanium pin that is exposed to the water. A titanium pin is used to eliminate any corrosion concerns. This design allows the thermistor to be mounted internally, while avoiding the insulating effect of the plastic housing. Even with this coupling, the temperature sensor does require some time (≈5 minutes) to stabilize to the true water temperature. The pin is mounted through a hole in the end cap. The back of the hole (leading into the conditioning module) is filled with epoxy to create a watertight seal. The two wires from the temperature sensor are connected to the pressure/ temperature sensor board as described below.

For the temperature sensor to function properly, the entire conditioning module must be submerged. Under normal operating conditions, the temperature sensor has a specified accuracy of ±0.2°C over the range of -5.0 to 50.0°C. Temperature data is stored with a precision of 0.01°C. The specified accuracy corresponds to a sound speed accuracy (for temperature considerations only) of less than ±0.1%.

The pressure sensor is mounted in the conditioning module end cap (Figure 23). The sensor is recessed within the end cap 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 sensor forms a watertight seal using a bore seal o-ring. For added leak protection, the path into the conditioning module is filled with epoxy.
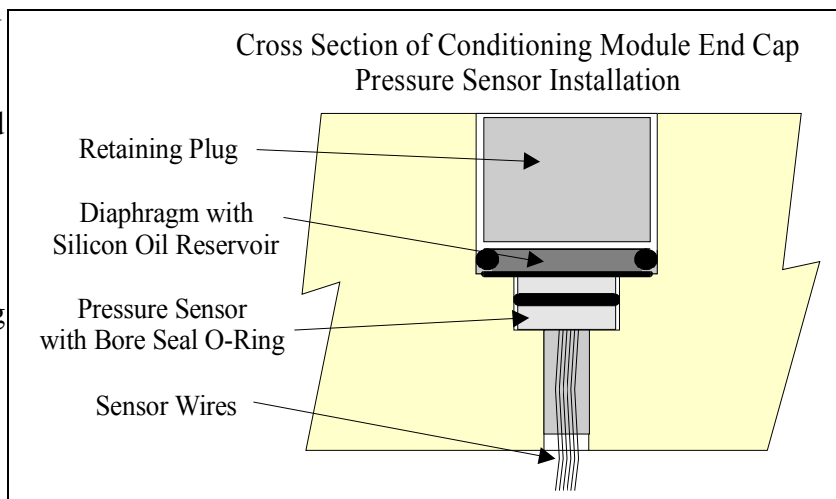

Figure 23 - ADV Pressure Sensor Installation

The two wires from the temperature sensor and the six wires from the pressure sensor go into a 10-pin connector that mates with the pressure/temperature sensor circuit board. This board conditions the signals from the sensor before going through the cable to the processing module. A 5-pin connector from the pressure/temperature sensor board goes to the conditioning module connector and to the processing module. See §4.7.3 for more information about the internal wiring of the signal conditioning module and the mounting of the pressure/temperature sensor board.

Pressure sensor data is stored in units of counts that must be converted to physical units (dBar) using two calibration constants. Pressure is stored as counts to maintain high resolution for a wide range of pressure sensors (from 10 to 6000-m depth ratings). Pressure is converted to dBar using the following formula.

$$Pressure\_dBar = Pressure\_Offset + (Pressure\_Scale * Pressure\_Counts)$$

where

Pressure_dBar = measured pressure in dBar

Pressure_Offset = offset calibration constant set at factory

Pressure_Scale = scaling calibration constant set a factory

Pressure_Counts = measured pressure in counts as output over the serial port and stored in the binary data files

The values for Pressure_Offset and Pressure_Scale can be accessed three ways: through the direct command interface (using **PressScale** and **PressOffset**; see §3.9), from the data conversion software ***.CTL** file (see *ADVField Software Manual*), or directly from the binary data file. In the first two methods, the constants are output with units of (dBar) and (dBar/count) respectively and can be used directly in the formula above. When using the binary data directly: Pressure_Offset is stored in units of μBar and must be multiplied by 10^5; Pressure_Scale is stored in units of (nanoBar/count) and must be multiplied by 10^8 before using in the above equation.

When using the data conversion software to extract ADV binary data files into ASCII format, the software automatically does the conversion from counts to dBar (see *ADVField Software Manual*).

Note that since the pressure sensor is located in the end cap of the conditioning module, it will not necessarily be at the same depth as the sampling volume. The difference will depend on the probe configuration and the orientation of the probe. Be sure to consider this when processing combined velocity and pressure data.

4.9.   Optional Sensors (External): Resonance/Frequency Pressure Sensors

This section describes the use of *frequency pressure sensors* with ADVField systems. SonTek supports two types of frequency pressure sensors: (1) the Druck RPT (DRUCK), a silicon resonant transducer made by Druck, Inc and (2) the Paroscientific digiquartz transducer (PAROSFREQ) made by Paroscientific, Inc.

Internal pressure sensor
(strain gage or Druck RPT)

External Paroscientific
Pressure Sensor

Power and
communication cable

SonTek ADVO

**Figure 24 - ADVOcean with
external pressure sensors**

4.9.1. Overview

Typically, SonTek systems include *analog pressure sensors* (strain gage) that provide sufficient accuracy and stability (0.1 to 0.25 %) at a moderate cost. These sensors are usually installed within the system head (Figure 24). They are internal to the system and are usually referred to as PRESSURE or PRESSURE SENSOR in our documents and command interface.

Some applications, however, require better long-term stability (e.g., tide studies, wave interaction with topography, long-term water-level monitoring). To accommodate these needs, SonTek has integrated *frequency pressure sensors*, which offer an order of magnitude better accuracy and stability (0.01%). The first supported sensor was the Paroscientific digiquartz with a serial interface (PAROS). These sensors did not fit inside our systems and were mounted externally (Figure 24). The next supported sensor, the Druck RPT, did fit inside an ADVOcean head. However, for historical purposes, all *non-strain gage sensors* are usually referred to as EXTERNAL PRESSURE SENSOR in our documents and direct command interface (§3.9.4).
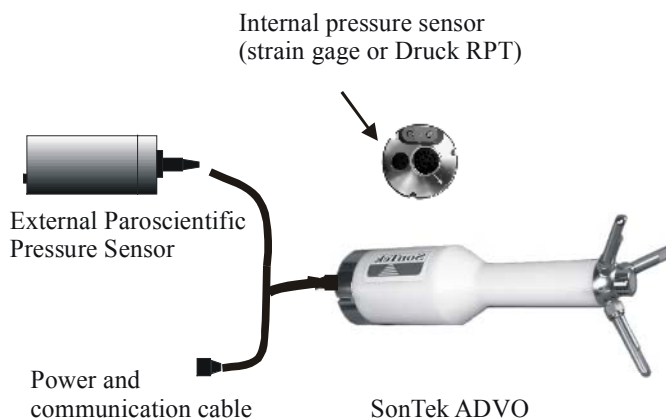
4.9.2. Serial External Pressure Sensors (PAROS)

As mentioned, the first external pressure sensor we supported was the PAROS. The PAROS is connected to an ADVField by a short cable. The differences, when compared with a strain-gage are:

- The PAROS is an absolute sensor. It reads 1 dbar in air; a strain gage reports 0 dbars in air.
- Sampling rate is limited to 4 Hz (ADVs and Hydras) due to serial interface limitations.

4.9.3. Druck RPT External Frequency Pressure Sensor (DRUCK)

Although the PAROS provides the required accuracy, its size and external location cause additional complications when mounting and deploying a system. SonTek, in collaboration with Druck, Inc., now offers the Druck RPT (resonant pressure transducer). This sensor is very compact and fits inside the same mounting socket as the regular strain gage (Figure 24). The DRUCK sensors are available for Hydra systems. The differences, when compared with a strain-gage are:

- The DRUCK is an absolute sensor. It reads 1 dbar in air; a strain gage reports 0 dbars in air.
- Requires a special interface to sample the frequency signal (installed on Recorder board).
- Sampling rate is limited to 10 Hz (ADVs and Hydras) because of the time required to sample the frequency signal with sufficient precision.
- Requires calibration matrix (specific to each sensor) to be loaded into the processor (system CPU or a user PC) to obtain valid pressure readings.
- Available in 50-psia pressure rating only (equivalent to ≈22-m sealed gage).

Each current meter purchased from SonTek that has the DRUCK sensor installed already has the appropriate calibration coefficients loaded into the processor. If this information is lost, you can use the calibration sheet provided by the pressure sensor vendor to construct your own calibration file. The structure of the DRUCK calibration file, required by SonTek systems, is as follows.

- Pressure Sensor Serial Number
- Oscillator Frequency (in Hz)
- X
- Y
- Low end of temperature range
- Corresponding voltage of the diode
- Diode sensitivity
- K00 K01 K02 K03
- K10 K11 K12 K13
- K20 K21 K22 K23
- K30 K31 K32 K33
- K40 K41 K42 K43
- K50 K51 K52 K53

> Note: The X, Y, and K coefficients can be found on the Druck calibration sheet.

Example – Druck calibration file **1145118.drk**:

```
1145118
12.0000000E+06
+8.8880000E+03
+5.5200000E+02
-10
622
-2.21
+1.6214761E+03   -2.0699499E-02   +5.5220000E-05   -5.6160001E-08
+1.8251241E+00   -5.8612000E-06   +3.6197001E-08   -3.8715001E-10
+3.8615943E-04   -1.5274000E-09   -4.7059999E-12   -1.3233001E-13
+7.0553313E-08   -1.9064000E-12   -4.0058001E-14   +9.0119996E-16
+1.7913088E-11   -1.3525000E-15   +1.7647000E-17   +3.8552999E-19
+3.7756621E-15   +1.9573000E-19   +3.6951001E-20   -3.3300999E-22
```

4.9.4. Paroscientific Digiquartz Ext. Freq. Pressure Sensor (PAROSFREQ)

User requirements for deeper ratings (compared to DRUCK) and faster response (compared to PAROS) convinced SonTek to offer the Paroscientific digiquartz sensor with frequency output (PAROSFREQ). Functionally, the interface for the PAROSFREQ is identical to the interface for the DRUCK, as both are frequency-based sensors. The PAROSFREQ sensors are available for ADV and Hydra systems. The differences, when compared with a strain-gage sensor, are:

- The PAROSFREQ is an absolute sensor. It reads 1 dbar in air; a strain gage reports 0 dbars.
- Requires a special interface to sample the frequency signal.
- Requires a special frequency splitter cable.
- Sampling rate is limited to 10 Hz (ADVs and Hydras) because of the time required to sample the frequency signal with sufficient precision.
- Requires a calibration (specific to each sensor) to be loaded into the processor (system CPU or a user PC) to obtain valid pressure readings.
- Available in 50-psia (≈22-m sealed gage) and 100-psia (≈60-m sealed gage) pressure ratings.

The structure of the calibration file corresponding to the PAROSFREQ sensor (see below) is similar to the DRUCK. For historic reasons, PAROSFREQ calibration file uses the .drk extension.

- Pressure Sensor Serial Number
- Oscillator Frequency (in Hz)
- U0
- N/A
- N/A
- N/A
- N/A
- Y1 Y2 Y3 N/A
- C1 C2 C3 N/A
- D1 D2 N/A N/A
- T1 T2 T3 T4
- N/A N/A N/A N/A
- N/A N/A N/A N/A

> Note: The U, Y, C, D, and T coefficients can be found on the Paroscientific calibration sheet.

Example – Paroscientific calibration file **p68888.drk**:

```
P68888
12.0000000E+06
5.880670
0.0
0.0
0.0
0.0
-3898.415      -10940.31         0.0          0.0
  224.5927        6.013600   -245.2861        0.0
    0.041219      0.0          0.0          0.0
   27.94067       0.859765    20.65914     26.99304
    0.0           0.0          0.0          0.0
    0.0           0.0          0.0          0.0
```

4.9.5. Direct Command Interface for External Pressure Sensors

Operation of external pressure sensors can be controlled through the direct command interface. See §3.9.4 for a description of these commands.

4.9.6. External Pressure Sensor Software

Additional software is required to use external frequency pressure sensors (DRUCK/PAROSFREQ) with SonTek instruments. Refer to the *ADVField Software Manual* for details on these programs:

- **LDDRUCK** (DOS) – Loads the DRUCK/PAROSFREQ calibration file into the ADVField
- **GTDRUCK** (DOS) – Gets (downloads) the DRUCK/PAROSFREQ calibration file from the ADVField to the user's computer.
- **GADVTS** (DOS) – Gets (extracts and converts) DRUCK/PAROSFREQ pressure series data from the ADVField's recorded data file.
- **GADVHDR** (DOS) – Gets (extracts) DRUCK/PAROSFREQ header data from the ADVField's recorded data file.
- *Terminal* (Windows; part of *SonUtils*) – Can be used to load the DRUCK/PAROSFREQ calibration file into the ADVField.
- *ViewHydra* (Windows) – Lets you view/postprocess Hydra data, including pressure data.

4.10. Optional Sensors (External): CTD

The SeaBird MicroCat CTD with RS232 serial interface provides high quality conductivity, temperature, salinity, and pressure (optional) data. When integrated with the ADV, MicroCat data is collected at the beginning of each sampling interval. Data are integrated in a CTD data structure within the ADV data set. See §3.9.2 for the commands used to control the CTD.

4.11. Optional Sensors (External): Analog Sensors

Depending on system configuration, the ADVField can have up to three available analog input channels (0-4 VDC) 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 also recorded. For information on available sensors, contact SonTek.

4.12. Optional Sensors (External): LISST-100 Sensors

The LISST-100 sensor is a Laser Interferometry and Transmissometry particle distribution measurement device designed by Sequoia Scientific. This section describes the operational procedures for using a LISST sensor with an ADVField/Hydra system. See §3.9.5 for the commands used to control the LISST-to-ADVField interface.

4.12.1.   Download LISST Control Program

The **HYDRA.TTB** program will need to be loaded into the LISST-100. This must be done before connecting the LISST to the ADVField/Hydra system. The loading process is simply a transmission of the ASCII characters to the LISST-100 with occasional pauses to allow the LIST-100 time to process the lines. The **NEW** command 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. The **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 the **Tattletale|Load Program** (Alt+L) option and choose the **HYDRA.TTB** file.

4.12.2.   Connect LISST to ADVField/Hydra

Attach the external sensor harness to the ADVField/Hydra electronics housing (8-pin male underwater connector). Connect the LISST-100 sensor to the serial cable on the harness using the 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 ADVField and have a different pin-out, and adaptor cable is required to connect the LISST to the harness. Connect the external power source to the LISST (if applicable).

Connect the ADVField to your computer and a power source using the ADVField power and communications cable. On your computer, establish communications with the ADVField using **SONTERM**. In **SONTERM**, enable the LISST sensor using the LisstSensorInstalled command §3.9.5. Verify that both the Paros and MicroCat CTD serial sensors are disabled. Note: The ParosFreq is a frequency sensor and it can be operated simultaneously with the LISST.

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

4.12.3. Set Up ADVField/Hydra for use with LISST

LISST data collection is only supported when the ADVField/Hydra 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 ADVField detects the beginning of the burst interval, it tries to communicate with the LISST sensor. If communication was successful, the ADVField sends the number of samples (profiles per burst or PPB) and sampling rate (averaging interval) to the LISST along with a start data collection request. The ADVField then proceeds with its own burst data collection loop. At the end of the burst, the ADVField communicates with the LISST and uploads the PPB samples. If the ADVField 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 ADVField 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 1200 LISST samples) when setting the burst interval.

To set the ADVField/Hydra for data collection with the LISST:

- Set AI = PRI
- Set Burst Mode (BM) = YES
- Set PPB to a value between 2 and
- Set Burst Interval to be longer than (PRI * PPB) + Download Time
- Set other ADVField/Hydra settings (PG, RPG, nCells, etc).

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

Section 5. Operational Considerations

5.1. Velocity Data Coordinate System

The ADVFizeld normally reports velocity data in a Cartesian (XYZ) coordinate system relative to probe orientation. The definition of this coordinate system depends on the probe configuration. Definitions of the coordinate systems for all standard probe configurations are given below. If the optional compass/tilt sensor is installed, velocity can be reported in Earth (ENU) coordinates; see §4.7 for details.

If the ADV coordinate system is set to XYZ (using the command **CoordSystem** from §3.6 or the ADV data acquisition software), the instrument reports velocity data relative to probe orientation. If the ADV has the optional compass/tilt sensor, and the coordinate system is set to ENU, it uses the hardware orientation switches (§4.2) to determine probe orientation. This is combined with the compass data and the probe coordinate system to translate data to Earth coordinates.

When using Earth coordinates, be certain: the compass is correctly installed (§4.7.2), the hardware configuration switches are correctly set (§4.2), and the correct probe configuration file has been loaded into the system (§1.2 and *ADVField Software Manual*). If any of these are incorrect, it will result in incorrect velocity transformation and cause unrecoverable errors in velocity data.

5.1.1. 16-MHz MicroADV and 10-MHz ADV Probe

The coordinate system definitions below are the same for 5 or 10-cm sampling volume distance.

- 3D Down-Looking - The positive Z-axis is defined upwards along the mounting stem or cable (from the sensor towards the signal conditioning module). The positive X-axis is defined from the acoustic transmitter to acoustic receiver #1 (painted red). The positive Y-axis is defined to give a right-hand coordinate system.

- 3D Side-Looking - The positive Z-axis is defined along the axis of the acoustic transmitter from the sampling volume towards the ADV sensor. The positive X-axis is defined vertically down along the axis of the mounting stem or cable (from the conditioning module towards the acoustic sensor). The positive Y-axis is defined to give a right-hand coordinate system.

- 3D Up-Looking - The positive Z-axis is defined vertically up along the vertical portion of the mounting stem (which is the same as the axis of the conditioning module) from the acoustic sensor towards the conditioning module. The positive X-axis is along the horizontal portion of the stem (after the bend) from the bend towards the sensor. The positive Y-axis is defined to give a right-hand coordinate system.

- 2D Down-Looking - The positive X-axis is defined from the acoustic transmitter to acoustic receiver #1 (painted red). The positive Y-axis is defined along the axis of the acoustic transmitter from the sampling volume towards the ADV sensor (and hence vertically up along the mounting stem or cable).

- 2D Side-Looking - The positive X-axis is defined from the acoustic transmitter to acoustic receiver #1 (painted red). The positive Y-axis is defined along the axis of the acoustic transmitter from the ADV sensor towards the sampling volume.

- 2D Up-Looking - The positive X-axis is defined from the acoustic transmitter to acoustic receiver #1 (painted red). The positive Y-axis is defined along the axis of the acoustic transmitter from the ADV sensor towards the sampling volume.

5.1.2. 5-MHz ADVOcean Probe

When collecting data in beam or XYZ coordinates, the positive Z-axis of the ADVOcean probe is defined along the axis of the acoustic transmitter from the sampling volume towards the acoustic sensor. The positive X-axis is defined from the acoustic transmitter to receiver #1 (marked by a machined dimple on the sensor head). The positive Y-axis is defined to give a right-hand coordinate system.

5.2.   Serial Communication Protocol

The ADVField processing module supports RS232, RS422, and RS485 serial communication protocols. Switching between RS232 and RS422 changes only the electrical interface and has no effect on the command interface. RS485 communication uses a modified command interface and modified data acquisition software. See §4.2 for information about the hardware switches and jumpers used to change the serial communication protocol.

RS232 is the default protocol setting. This is the same protocol used by 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 about 1500 m (when using twisted, shielded wires). RS422 communication affects only the electrical signals used for communication and has no effect on the command interface or data acquisition software. RS232-to-RS422 converters are available commercially and allow an ADV using RS422 communication to be connected to the RS232 serial port of a PC-compatible computer. One supplier for this type of converter is:

B&B Electronics	Phone: (815) 434-0846	Part numbers:
707 Payton Rd	Fax: (815) 434-7094	Converter – 422COR
Ottawa, IL 61350 USA	www.bb-elec.com	Power supply – 422PS2

RS485 communication uses the same electrical protocol as RS422, but adds an address message to each transmission to allow multiple instruments to be controlled with one communication line. This requires a modified command interface and modified data acquisition software that is not presented in this manual. See §5.3 for a general description of the RS485 interface.

5.3.   Multiple System Operation Using RS485

The ADVField processing module supports three serial communication protocols: RS232, RS422, and RS485. The standard protocol used by PC-compatible computers is RS232, and is reliable over cable lengths to about 100 m (using high-quality, twisted, shielded cable similar to the cable provided by SonTek). RS422 uses differential voltage signals to increase resistance to external interference and is reliable with cable lengths to about 1500 m. RS485 uses the same electrical interface as RS422 and can also be used with long cables, but has the added feature of message addressing that allows several instruments (each with a unique address) to be controlled from one serial communication line.

In the ADVField, RS485 allows synchronized data collection from several ADV systems using one computer. Cable length and sampling rate determine the maximum number of ADVs that can be connected to a single port.

Configuring multiple ADVs for data collection using RS485 requires special cabling and software (see Appendix 3).

5.4. Analog Output Data

SonTek always recommends collecting ADVField data using the digital outputs (serial communication). Digital data provides improved resolution of velocity data by avoiding the digital-to-analog-to-digital conversion required by analog data collection. Using the digital outputs also allows access to additional diagnostic data (three signal amplitude values and three correlation values instead of one mean signal amplitude line). These advantages become increasingly important in high-performance applications with fast sampling rates.

However, there are applications where analog outputs are desired. As such, all ADV systems generate analog output voltages as an optional means to collect data. The ADV's processing module provides four analog output voltages. These voltages are single-ended (referenced to a common ground) and are generated using a 12-bit digital-to-analog converter. The D/A converter is updated at the end of each ADV sample.

Three of these voltages are proportional to the three velocity components. The fourth voltage is proportional to the mean signal strength from the three (or two) acoustic receivers on the ADV probe. The analog output voltages have a drive capability of about 4 mA, and should be connected to a termination of at least 10 kΩ. The output voltage range is fixed at 0 to 5 V.

When analyzing high-frequency ADV data, note that the analog output voltages are filtered to avoid "step" changes in the output voltage signal. Each analog output signal is filtered using a first-order RC filter with a corner frequency at 15 Hz. The filter should not have any significant impact on ADV data quality, but it will introduce a phase lag for high-frequency data (e.g., when sampling at 25 Hz). For applications with high sampling rates, we recommend using the digital output data, which has no filtering.

Converting analog output voltages to velocity data uses the voltage range values and the velocity range setting. The velocity for a given output voltage can be calculated from the formula:

$$Velocity = Range \times \frac{Vmeas - ((Vhigh + Vlow)/2)}{(Vhigh - Vlow)/2}$$

where
    Velocity = Velocity calculated from output voltage.
    Range = ADV velocity range setting (i.e.; use 30 cm/s for velocity range of ± 30 cm/s).
    Vmeas = Measured analog output voltage.
    Vhigh = Maximum analog output voltage (+5 V for ADVField).
    Vlow = Minimum analog output voltage (0 V for ADVField)

For example, if the velocity range is set to ±30 cm/s, a 3 V output from an ADV gives a velocity of 6 cm/s.

The ADV includes a fourth analog output line for mean signal amplitude from the three acoustic receivers. To convert the output voltage from this line to units of counts (internal units used by the ADV in digital data, 1 count equals 0.43 dB), use the formula:

$$Counts = 255 \times \frac{Vmeas - Vlow}{Vhigh - Vlow}$$

The voltage level read by the user-supplied analog data acquisition system may be slightly different from the voltage output of the ADV. These differences can be caused by temperature changes or by variations in the impedance of cables and the digitizing circuit. The analog outputs of the ADV should be calibrated before every experiment to compensate for these small variations.

Calibration is performed by running the program `ADFCALAO` (see *ADVField Software Manual*), or by using the `Cal` command from the direct command interface (§3.5). Either will set the analog outputs to three predetermined voltages corresponding to the maximum negative velocity, zero velocity, and maximum positive velocity. The voltages measured by the data acquisition system at these three settings can be designated Vneg, Vzero, and Vpos. The calibration voltage values can then be used when computing velocity values from the following formula.

$$Velocity = Range \times \frac{Vmeas - Vzero}{(Vpos - Vneg)/2}$$

If the calibration voltages are measured with a very accurate voltmeter, or a precision A/D converter (more than 12-bit resolution), the zero velocity calibration can be used to verify the linearity of the analog outputs. The linearity check is expressed as

$$[Vzero - 0.5*(Vpos - Vneg)]$$

and should be less than Vpos / 2048.

5.5. External Synchronization

ADV data collection can be synchronized with other instruments using the SyncIn and SyncOut signals. SyncOut is a ≈1 ms, 5V pulse at the completion of each sample. For example, if the ADV is collecting data at 25 Hz (sampling interval 40 ms), it will average pings for 39 ms and then raise the SyncOut line to signal the completion of a sample. If precise synchronization is important, you must take into account that the SyncOut pulse occurs at the end of the sampling interval, while the measured velocity corresponds to the center of the averaging interval.

The SyncIn signal permits external control of ADV sampling. Two control options are available: at the start of ADV sampling on receipt of an input pulse (*Start on Sync*) or full external control of the data collection rate (*Sample on Sync*). An externally supplied 5V TTL pulse is normally used to trigger data collection; alternatively, the 5V supply (accessed from the auxiliary I/O connector; §4.3) can be used with a remote switch to start data collection at the push of a button.

The SyncOut signal is always generated by the ADV for any operating parameters. The SyncIn line is treated differently by the ADV depending on the synchronization setting. The setting can be changed either in the data acquisition software (see *ADVField Software Manual*) or using the command `SyncMode` (§3.6). There are three settings:

- Disable - The ADV ignores the SyncIn line and data collection starts under software control.

- Start on Sync - The ADV waits for the rising edge of a 5V pulse on the SyncIn line to start data collection. Data collection then proceeds under software control at the user-specified sampling rate. The rising edge of the first pulse triggers the start of the first sample. Any further signals on the SyncIn line are ignored.

- Sample on Sync - The ADV outputs a sample after the rising edge of each 5V pulse on the SyncIn line. The first rising edge triggers the start of the first sample, the second rising edge triggers the end of the first sample and the start of the second sample, and so on. In this manner, the sampling rate of the ADV is completely controlled by the SyncIn signal. The ADV does **not** record or output the accurate time with each sample.

5.6. Mounting and Handling the Sensor

Before starting routine data collection, we recommend building a mounting bracket that clamps onto the conditioning module. Simple mounting arrangements often use hose clamps attached to a rigid bar. For these, cover the conditioning module to protect it from damage. More complex mounting arranges may use pillow block clamps to secure the conditioning module and may be coupled to traversing systems for measuring at different locations. The overall design will vary considerably depending on the environment in which the ADV is to be used and the forces to which the instrument will be exposed. The following list gives some basic advice for mounting and handling the ADV.

- All three acoustic receivers and the transmitter must be submerged for proper operation.
- The path from the acoustic sensor to the sampling volume, and the area around the sampling volume, should be free from obstructions. Objects in this area can cause both acoustic interference (if in or near the acoustic travel paths) and can introduce flow distortion in the sampling volume.
- Take care not to damage the acoustic sensors. These are the most delicate part of the ADV. If you suspect that the sensor may be bent or damaged, run **ADFCHECK**. See §5.11 and the *ADV-Field Software Manual* for details.
- Clean the acoustic elements to remove deposits of seeding material, bubbles, or other material. For field deployments, biological deposits can be removed with a stiff brush (non-metallic) without damaging the sensor. Carefully remove barnacles by scraping with a knife or by soaking the probe in vinegar.
- The system can be operated with the acoustic sensor out of the water without damage, although the velocity data will be meaningless.
- Make sure a zinc anode is installed and in good condition when operating the ADV in salt water. If you have any concern about the condition of the zinc anode, replace it. Always rinse the probe in fresh water after use in salt water.

5.7. Optional Integrated Sensors

The ADVField can include a variety of integrated sensors, both internal and external. The sensors are connected to the ADV using special interface cables or boards. Other sensors may be integrated using analog output voltages. Depending on the sensor, input power may come from the ADV or may require a separate power supply. A few of the more common external sensors are described below. For details on available sensors and configurations, contact SonTek. Some of the optional sensors available for use with ADVField systems, include:

- Temperature sensor – Used for sound speed corrections in long deployments with large temperature fluctuations. Internal or external CTD types are available. Typical configurations are described in §4.8.
- Pressure sensor – Provides simultaneous pressure and 3D velocity measurements (PUVW for directional wave spectra). Internal, external, analog (strain gage), and frequency (resonance) types are available. Typical configurations are described in §4.8 and §4.9.
- CTD – Provides high-quality conductivity, temperature, salinity, and pressure data. Typical configurations are described in §4.10.
- OBS, transmissometer, conductivity, etc – Many of these types of sensors can be integrated using analog output voltages. Common applications include OBS or transmissometer data for suspended sediment studies. See §4.11 for more information.

5.8. Seeding Requirements

If ADV velocity data appears "noisy", it may be due to a lack of scattering material in the water (see the *ADV Principles of Operation* for general information about the ADV). This can be remedied by adding seeding material. When collecting data at 25 Hz under good operating conditions, the ADV noise level is expected to be about 1% of the velocity range (i.e.; each 25-Hz sample has noise of about ±1 cm/s when using the ±100 cm/s velocity range). If there is insufficient scattering material in the water, resulting in low SNR values (less than 5-10 dB), noise levels will increase.

In most laboratory applications, and almost all field applications, there is sufficient scattering material naturally present for ADV operation. In large, quiet basins, the water may need to have seeding material added. When practical, we recommend using particles that have a density close to that of water and a mean diameter of 10-20 μm. Neutrally-buoyant particles remain in suspension without additional stirring and are ideal for low-flow experiments. The choice of size is motivated by the relatively strong echo that these particles generate per unit of concentration. Smaller particles (e.g.; 1 μm particles used for Laser Doppler systems) are not recommended because the required concentration is quite high.

A small bottle of seeding material is included with the ADV and should be sufficient for general testing purposes. The recommended seeding level is 10-50 mg/L. This material consists of hollow glass spheres with a mean diameter of about 10 μm. Additional seeding material (for small quantities) is available from SonTek. The seeding material has not been found to have any adverse effects on the performance of Laser Doppler Velocimeters. For applications requiring large quantities of seeding material, you can order directly from the manufacturer listed below.

Potters Industries	Phone: (610) 651-4709	Part number: 10030
PO Box 840	Fax: (610) 408-9723	
Valley Forge, PA 19842 USA	www.pottersbeads.com	

5.9. Anti-Fouling Protection

The ADV has excellent fouling resistance 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 the accuracy of the velocity measurements unless the SNR is very low (less than 5 dB). To prevent biological growth, the ADV can be painted with anti-fouling paint following the procedure below.

Within the United States, we recommend using an anti-fouling paint called Interlux Tri-Lux II. This contains a biocide that is a copper derivative that can be used on all metals, including aluminum. For information on Interlux paints, contact:

Interlux Yacht Finishes	Phone: (908) 686-1300
2270 Morris Avenue	Fax: (908) 686-8545
Union, NJ 07083 USA	www.yachtpaint.com

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

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 many ADV components are), this acts as an excellent conversion layer. If no powder coat is present, or if the powder coating has been damaged, we suggest Interlux 360 Underwater Metal Primer. The primer should be applied to all metal surfaces **except** transducer faces, sacrificial zinc anodes, cable, and areas where the powder coating is in good condition. 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.

5.10. Routine Maintenance

The ADV is designed to provide years of reliable performance with minimal maintenance. Unless mechanically damaged, the ADV never requires recalibration. This section provides some general guidelines for taking care of the ADV to ensure a long life and reliable performance.

The ADV acoustic sensor should be protected from mechanical impact. If the receiver arms are bent, the geometry of the sensor will change, and the factory-supplied calibration will no longer be accurate. To check for sensor damage, run `ADFCHECK` on a routine basis (at the start of each working day is a good habit). See §5.11 and the *ADVField Software Manual* for details.

The transducers are encapsulated in epoxy and generally have excellent resistance to abrasion and normal wear and tear. If necessary, the transducers can be cleaned with a non-metallic brush. Barnacles and other hard-shelled organisms can be carefully scraped off with a knife.

Check all o-rings and o-ring surfaces whenever opening any submergible portion of the system. Replace old or damaged o-rings, and look for any scratches or damage to the o-ring surfaces.

For salt-water deployments, make sure all metallic parts have a zinc anode in good condition. The outer appearance of the anode can be misleading. Scrape the anode with a screwdriver to test its strength and replace the anode if there are any doubts.

Try to avoid water condensation on the circuit boards. Purge canisters with nitrogen if they have been opened, and place bags of desiccant where suitable.

5.11. Troubleshooting

This section contains suggestions for diagnosing common problems encountered with the ADV. If you are unable to determine the exact nature of the problem, contract SonTek for assistance. This section is divided into the following areas based on the type of problem.

- ADVField Setup and Configuration
- Diagnostic Software
- Excessive Noise in Velocity Data
- Low Signal-to-Noise Ratio (SNR)
- Low Correlation

5.11.1. ADVField Setup and Configuration

Most operational problems with the ADV can be traced to either the power supply or the serial communications interface. If the ADV software does not operate properly, make sure the power supply is above 12 V. If there is a suspicion that a battery supply is low, use an external power supply. If using a system with the processor in the splash-proof box, the diode on the front panel should only light up if the voltage level is above 12 V. Try swapping power supplies, or running the software from a different computer to narrow down the source of the problem.

The software will not run if using the wrong serial port. The port is set in the **ADVPROBE.DEF** file. For example, if the serial communications cable is connected to serial port #1 on the computer, the file should read **PROBE 1 1084.PRO**, where 1084 is the probe number. See §2.3.2 and the *ADVField Software Manual* for details.

You can also test operation by talking directly to the ADV using the direct command interface (Section 3). SonTek software includes a terminal emulator program (**SONTERM**) for this purpose. If you are unable to use the data acquisition software, try to establish communications with a terminal emulator.

When the system is awake, it should consume 3-5 W of power. If there is no response with the ADV software, look at the current draw into the ADV. If no current is being drawn, it most commonly indicates either a problem with the power supply or the cables. Additionally, the fuse in the ADV electronics could be blown. See §4.1 for details on testing the fuse.

Some ADV software is written for the DOS operating system, and some is written for the Windows environment. Some software (such as the data conversion programs) can be run from a DOS prompt within Windows. However, the data acquisition software will not operate reliably from within a DOS-prompt window. When using the DOS version of the ADV data acquisition software, exit Windows and restart the computer in DOS mode.

5.11.2. General Diagnostics Software

Included with the ADV software is a diagnostics program that can be used to precisely identify most ADV hardware problems. This program (**ADFCHECK**) is described in the *ADVField Software Manual*. In addition to diagnosing problems, this program is an excellent way to verify system operation and to gain an understanding of how the ADV works. We strongly encourage you to become familiar with this software and to use it on a regular basis.

5.11.3. Excessive Noise in Velocity Data

Some random variation (noise) is expected in ADV velocity measurements. Generally, under good operating conditions, the noise for data output at 25 Hz (50 Hz for MicroADVs) should be about 1% of the velocity range setting (i.e.; ±1 cm/s when using the ±100 cm/s velocity range). The variations in velocity are a combination of instrument noise and real variations in the flow. It is often helpful to operate the probe in a small, quiet tank of water with a small amount of seeding material for diagnostics. A "known" velocity can then be generated by moving the probe.

Below is a list of some basic checks if ADV velocity data seems particularly noisy.

- Make sure the probe is submerged and all cables are securely connected.
- Add seeding if the SNR is low (less than 5-10 dB).
- Make sure the velocity range is larger than the actual velocities (see *ADV Principles of Operation*).
- Run **ADFCHECK** to look for potential hardware problems.

If in doubt as to whether the velocity fluctuations are real or are generated by the ADV, collect a time series and calculate the power spectrum. Instrument-generated noise is purely random (white), and its signature is a flat power spectrum.

5.11.4. Low Signal-to-Noise Ratio (SNR)

A low SNR, typically considered less than 5-10 dB, can cause increased noise in the velocity data. SNR is a function of the amount of scattering material in the water. In very clear water, the ADV will not be able to make accurate velocity measurements. If the SNR is low, check the following areas.

- Clean the faces of the acoustic sensors.
- Add seeding material.
- Check the probe using **ADFCHECK** to look for hardware problems.

See the *ADV Principles of Operation* for more details.

5.11.5. Low Correlation

Correlation data is a direct measure of the quality of ADV velocity data. Low correlation data indicates something is affecting the ADV's ability to accurately measure velocity. For moderate flows with low turbulence, correlation will typically be 90% or greater. High turbulence, low SNR values, and a few other factors will decrease correlation values. In general, correlation values above 70% are desired for good velocity data. In some situations, correlation values as low as 30-40% will still yield good results (although with a higher noise level). If the SNR seems low, check the following areas.

- Clean the transducers for accumulated bubbles.
- Check for low SNR values.
- Check probe using **ADFCHECK** to look for hardware problems.

Low correlation values can occur without consequence for data quality if the ADV is being used only for mean velocity measurements. See the *ADV Principles of Operation* for more details.

Section 6. Additional Support / Repair Information

Any questions regarding the ADV can be directed to SonTek by phone, fax, or email. Regular business hours are 8:00 a.m. to 5:00 p.m., Pacific Standard Time, Monday through Friday.

Phone	+1 (858) 546-8327
Fax	+1 (858) 546-8150
E-mail	inquiry@sontek.com
Internet	www.sontek.com

Visit our web site Support page for information concerning software / firmware updates.

If there is a problem with your ADV, first try to identify the problem by following the procedures outlined in this manual. Contact SonTek immediately if you detect a hardware problem or if you need additional help in identifying a problem with your ADV. Please obtain a Return Merchandise Authorization (RMA) number before returning the system to the factory.

If it becomes necessary for you to return your system to the factory, please package the instrument in the original container in which it was shipped. If it is not possible to use the original container, please package the instrument securely in a sturdy container with substantial packing material to prevent damage during shipping. If the instrument is shipped to SonTek without such precautions, SonTek reserves the right to refuse the shipment and/or charge for proper packaging upon the instrument's return to you. Additional shipping instructions will be provided to you when you are issued the RMA number.

Appendix 1. ADVField Real-Time Data Output Formats

This appendix describes the various formats of the output data generated by the ADVField during *real-time* data collection. The format is the same for all ADVField configurations and models. See Appendix 2 for the output data formats generated during *autonomous* data collection. For a description of the real-time binary *output data file* format that is generated by the ADV data acquisition software, see the *ADVField Software Manual*.

During real-time data collection, the ADVField sends data outputs over the serial port in either ASCII or binary format depending on the setting of the **OutFormat** command (§3.5).

- Section A1.1 describes the real-time ASCII output format over the serial port.
- Section A1.2 describes the real-time binary output format over the serial port.

A1.1. Real-Time Output Data – ASCII Format (to Serial Port)

If **OutFormat** = **ASCII**, the ADV will send output data to the serial port in a tab-delimited ASCII format with one line of data for each sample.

- After each velocity sample is collected, the ADV outputs one line of data to the serial port. The length of the line varies depending on which optional sensors are installed (compass/tilt, temperature, pressure, external sensors).
- Each line of data is formatted such that a series of samples forms a tabular output that can be easily loaded by data analysis software.
- The maximum ASCII output rate when using 9600 baud is about 5 Hz. If higher sampling rates are required, either use binary output or increase the baud rate (see §4.2).
- Table 22 shows what data values are output in each column based on which optional sensors are installed.

The following list defines each data type shown in Table 22.

- *Sample Number* – The sequence of samples from the start of data collection (0 to 65535).
- (*Vx* or *Veast*), (*Vy* or *Vnorth*), (*Vz* or *Vup*) – The three velocity components (Vx/Vy/Vz if the coordinate system is XYZ; Veast/Vnorth/Vup if the coordinate system is ENU) in units of 0.1 mm/s (range: -32767 to 32767).
- *Amplitude 1/2/3* – Signal strength for each of the three acoustic receivers in units of counts (0 to 255). One count is equal to 0.43 dB.
- *Correlation 1/2/3* – Correlation values for each of the three acoustic receivers as a percentage (0 to 100). See the *ADV Principles of Operation* for a description of the correlation data.
- *Heading*, *Pitch*, *Roll* – Heading, pitch, and roll data from the optional compass/tilt sensor in units of 0.1°. Heading range is 0 to 3600 (0.0 to 360.0°), pitch and roll are -500 to 500 (-50.0° to 50.0°).
- *Temperature* – Temperature from the optional sensor in units of 0.01°C.
- *Pressure* – Pressure from the optional sensor in counts. Pressure data is stored and output as counts to accommodate a variety of pressure sensor ranges. Counts can be converted to dBar using the pressure calibration constants stored in the file header (see §4.8 for details).

Table 22. Data Outputs Based on Installed Sensors

Col.	No Sensors	Compass	Temperature and/or Pressure	Compass and Temperature and/or Pressure	External Sensor	External Pressure Sensor	CTD
1	Sample No.	Sample No.	Sample No.	Sample No.	Sample No.	Sample No.	Sample No.
2	Vx or Veast	Vx or Veast	Vx or Veast	Vx or Veast	Vx or Veast	Vx or Veast	Vx or Veast
3	Vy or Vnorth	Vy or Vnorth	Vy or Vnorth	Vy or Vnorth	Vy or Vnorth	Vy or Vnorth	Vy or Vnorth
4	Vz or Vup	Vz or Vup	Vz or Vup	Vz or Vup	Vz or Vup	Vz or Vup	Vz or Vup
5	Amplitude 1	Amplitude 1	Amplitude 1	Amplitude 1	Amplitude 1	Amplitude 1	Amplitude 1
6	Amplitude 2	Amplitude 2	Amplitude 2	Amplitude 2	Amplitude 2	Amplitude 2	Amplitude 2
7	Amplitude 3	Amplitude 3	Amplitude 3	Amplitude 3	Amplitude 3	Amplitude 3	Amplitude 3
8	Correlation 1	Correlation 1	Correlation 1	Correlation 1	Correlation 1	Correlation 1	Correlation 1
9	Correlation 2	Correlation 2	Correlation 2	Correlation 2	Correlation 2	Correlation 2	Correlation 2
10	Correlation 3	Correlation 3	Correlation 3	Correlation 3	Correlation 3	Correlation 3	Correlation 3
11		Heading	Temperature	Heading	Ext. Sensor 1	Ext. Pressure	CTD Temp.
12		Pitch	Pressure	Pitch	Ext. Sensor 2		CTD Cond.
13		Roll		Roll			CTD Press.
14				Temperature			CTD Sal.
15				Pressure			

A1.2. Real-Time Output Data – Binary Format (to Serial Port)

If **OutFormat** = **BINARY**, the ADV sends a block of data to the serial port after each velocity sample. The size of the binary-format data block varies depending on which optional sensors (compass/tilt, temperature, pressure) are installed. Section A1.2.1 describes the data block formats.

A1.2.1   Block Structures

This section defines the format of each type of binary data block structure in the "C" programming language. There are four possible types of output blocks.

- ADV data with no optional sensors installed.
- ADV data with the optional compass/tilt sensor installed.
- ADV data with the optional temperature and/or pressure sensors installed.
- ADV data with the optional compass/tilt sensor and with the optional temperature and/or pressure sensors installed.

Notice that each of the following structures uses a checksum to ensure accurate data transmission. See §A1.2.2 for details on computing the checksum.

ADV data with no optional sensors installed

The structure ADVNoSensors (below) is used when no optional sensors are installed (18 bytes).

```
typedef struct {
  unsigned char Id;        /* Data record ID, 0x81          */
  unsigned char Nbytes;    /* Number of bytes in record = 18 */
  unsigned int  SampleNum; /* From start of data collection  */
  int           XYZVel[3]; /* x/y/z vel in 0.1 mm/s          */
  unsigned char Amp[3];    /* Amplitude 1, 2, 3              */
  unsigned char Cm[3];     /* Correlation 1, 2, 3            */
  unsigned int  ChkSum;    /* 2 byte checksum of preceding 16 bytes */
} ADVNoSensors;
```

ADV data with compass/tilt sensor installed

The structure `ADVCompass` (below) is used when the optional compass/tilt sensor is installed (total size 24 bytes).

```
typedef struct {
  unsigned char Id;        /* Data record ID, 0x83           */
  unsigned char Nbytes;    /* Number of bytes in record = 24 */
  unsigned int  SampleNum; /* From start of data collection  */
  int           XYZVel[3]; /* x/y/z vel in 0.1 mm/s          */
  unsigned char Amp[3];    /* Amplitude 1, 2, 3              */
  unsigned char Cm[3];     /* Correlation 1, 2, 3           */
  int           Heading;   /* in 0.1 deg                    */
  int           Pitch;     /* in 0.1 deg                    */
  int           Roll;      /* in 0.1 deg                    */
  unsigned int  ChkSum;    /* 2 byte checksum of preceding 22 bytes */
} ADVCompass;
```

ADV data with temperature and/or pressure sensors installed

The structure `ADVTempPres` (below) is used when the optional temperature and/or pressure sensors are installed (total size 22 bytes).

```
typedef struct {
  unsigned char Id;        /* Data record ID, 0x85           */
  unsigned char Nbytes;    /* Number of bytes in record = 22 */
  unsigned int  SampleNum; /* From start of data collection  */
  int           XYZVel[3]; /* x/y/z vel in 0.1 mm/s          */
  unsigned char Amp[3];    /* Amplitude 1, 2, 3              */
  unsigned char Cm[3];     /* Correlation 1, 2, 3           */
  int           Temp;      /* in 0.01 deg C                 */
  unsigned int  Press;     /* in counts (0-65535)           */
  unsigned int  ChkSum;    /* 2 byte checksum of preceding 20 bytes */
} ADVTempPres;
```

ADV data with compass/tilt sensor and with temperature and/or pressure sensors installed

The structure `ADVCompassTempPres` (below) is used when the optional compass/tilt sensor, and the optional temperature and/or pressure sensors are installed (total size 28 bytes).

```
typedef struct {
  unsigned char Id;        /* Data record ID, 0x87           */
  unsigned char Nbytes;    /* Number of bytes in record = 28 */
  unsigned int  SampleNum; /* From start of data collection  */
  int           XYZVel[3]; /* x/y/z vel in 0.1 mm/s          */
  unsigned char Amp[3];    /* Amplitude 1, 2, 3              */
  unsigned char Cm[3];     /* Correlation 1, 2, 3           */
  int           Heading;   /* in 0.1 deg                    */
  int           Pitch;     /* in 0.1 deg                    */
  int           Roll;      /* in 0.1 deg                    */
  int           Temp;      /* in 0.01 deg C                 */
  unsigned int  Press;     /* in counts (0-65535)           */
  unsigned int  ChkSum;    /* 2 byte checksum of preceding 26 bytes */
} ADVCompassTempPres;
```

A1.2.2   Checksum Calculation

The ADV uses a checksum when sending binary data over a serial port. The checksum is computed with the C function ComputeCheckSum shown below. To understand how the checksum is computed, assume that a sample has been placed in a segment of memory (i.e.; a character array) in the format shown in §A1.2. The checksum is computed by the following statement in C.

```
CheckSum = ComputeCheckSum( buf, Sample_Length - 2 );
```

In this example, buf 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 simply adds the first Sample_Length-2 bytes starting at location buf, and then adds the value 0xA596. The result of this summation is then truncated to a two-byte integer and returned. The addition of the value 0xA596 is to ensure 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 2. ADVFeld Autonomous Data Output Formats

This appendix describes the various formats of the output data generated by the ADVFeld during *autonomous* data collection. The format is the same for all ADVFeld configurations and models. See Appendix 1 for the output data formats generated during *real-time* data collection.

During autonomous data collection, the ADVFeld sends ASCII burst header data via the serial port and binary output data to the internal recorder.

- Section A2.1 describes the real-time ASCII output format to the serial port.
- Section A2.2 describes the real-time binary output format to the internal recorder.

A2.1. Autonomous Output Data – ASCII Format (to Serial Port)

During autonomous data collection, the ADV sends burst header data via the serial port at the start of each burst. The header is always sent in ASCII format. No additional data is sent over the serial port during autonomous deployments. Below is a sample of the burst header output, followed by a description of the data shown on each line.

```
0013            1 2001 02 03 14 30 51
4      0  1000  1200    2    23 15209    -1    -1
0   0   0   0 219 220 219 220 24 24 24 219 199 240   0   92  0   0   0   0
```

Line 1: Serial number, burst number, year, month, day, hour, minute, second. Note that the time recorded represents the start of the first sample in the burst.

Line 2: Velocity range, spare byte (set to 0), sampling rate (0.01 Hz), samples per burst, coordinate system (1=XYZ, 2=ENU), recorded-data byte (see below), sound speed (0.1 m/s), probe distance to boundary, sampling volume distance to boundary (see below)

Line 3: System diagnostic data - the only value of interest to the user is the 16th item on this line, which is battery voltage in units of 0.2 V (e.g., output of 92 = 18.4 V)

Recorded-data byte – This parameter uses one byte to identify the user-selected data recording options. Each item sets a bit to 1 if enabled or 0 if disabled. With bit 7 as the MSB and bit 0 as the LSB: RecordCTD (or RecordLISST) uses bit 7; RecordExtPress=bit 6; RecordExtSensor=bit 5; RecordStat=bit 4; (bit 3 not used); RecordSensor=bit 2; RecordCompass=bit 1; RecordAmpCorr=bit 0. Examples: a value of 23 (binary 11110111) means all data recording was enabled; a value of 2 (00000010) means that only RecordCompass was enabled. See Table 23.

Distance-to-boundary data is reported in two values: distance from the probe tip to the boundary and distance from the center of the sampling volume to the boundary. Both are output with the burst header in units of 0.1 mm. A value of -1 indicates that the boundary was not detected.

A2.2. Autonomous Output Data – Binary Format (to Internal Recorder)

Data recorded on the internal recorder during *autonomous* deployments use a different file format than that used for *real-time* data collection. The reasons for this are listed below. For a description of the sampling strategies used by the autonomous ADVFeld, see §1.3.

- Additional information is needed to describe ADV autonomous data collection.
- Data must be periodically referenced to the real-time clock. In real-time collection, the data rely on the sampling clock; this clock is not accurate enough for long-term deployments.
- Different data formats are required to support multiple-burst sampling.
- Data recording options have been included to optimize storage requirements.

A2.2.1   Recorded Data Files

Each time a new deployment is started (i.e., by the **Deploy** command), the ADVField firmware creates a new file (or deployment) on the internal recorder. The name of the file is constructed by adding a 3-digit sequence number to the name of the deployment (set using the **Deployment** command). For example, if the deployment name is **WAVES**, the first time the **Deploy** command is used a file named **WAVES001** will be created. If subsequent deployments are initiated with the same deployment name, new files will be created with increasing sequence numbers (e.g., **WAVES002**, **WAVES003**, etc.).

A2.2.2   Data Block Description

Each deployment file contains two types of data blocks. The first block contains the ADV deployment configuration. This is created when you execute the **Deploy** command. It contains a complete description of the ADV as well as the current settings for all parameters. The configuration block has a total size of 441 bytes.

After the configuration block, the ADV records one data block for each sampling burst. These blocks contain the burst header information including date and time from the real-time clock, a time-series of samples collected during the burst, and statistics calculated at the end of each burst. The type and amount of data recorded with each sample will vary depending on the setting of the data recording parameters (see §3.7).

Each burst data block begins with a header record (60 bytes) that contains the date/time at the start of the burst, parameters that describe the data contained in the block, and the status of the ADV. Following the header are as many consecutive sample records as specified by **Samples-PerBurst**. If the **RecordStat** = **YES**, an additional record is stored after the last sample with the statistics for the burst. The last part of the burst is a 2-byte checksum the burst data.

- Configuration Block (441 bytes)
    - o Hardware configuration (24 bytes)
    - o Probe configuration (164 bytes)
    - o Deployment parameters (253 bytes)
- Data Block for Burst 1 (variable size)
    - o Burst header (60 bytes)
    - o Sample 1 (variable size)
    - o Sample 2 (variable size)
    - o   ↓   ↓   ↓   ↓   ↓
    - o Sample <SamplesPerBurst> (variable size)
    - o Burst statistics (optional; 36 bytes)
    - o Checksum (2 bytes) [see §A1.2.2 for details on computing the checksum]
- Data Block for Burst 2 (variable size)
- •   ↓   ↓   ↓   ↓   ↓   ↓   ↓   ↓
- Data Block for Burst N (variable size)

A large amount of data of various types can be collected by the ADV. However, the storage capacity of your recorder may force you to limit the types of data that are collected. The following parameters let you select which data are recorded (§3.7). Obviously, some of these parameters require that their associated optional sensor has been installed on your system. Table 23 lists the number of bytes recorded per sample for each selected parameter. Section 2.4.2 explains how to determine the amount of memory required for a particular deployment.

- RecordAmpCorr – Records amplitude and correlation for each beam with each sample.
- RecordCompass – Records heading, pitch, and roll with each sample.
- RecordSensor – Records temperature and pressure data with each sample. Note: If **ExtSensor** = **3_OBS**, the pressure and battery voltage readings will display **N/A**.
- RecordStat – Provides a record at the end of the burst with the mean and standard deviation of amplitude, correlation, heading, pitch, roll, temperature, and pressure.
- RecordExtSensor – Records analog data from an optional, external sensor with each sample.
- RecordExtPress – Records data from an optional, external pressure sensor with each sample.
- RecordCTD – Records CTD data from an optional CTD sensor with each sample.
- RecordLISST – Records data from an optional LISST-100 sensor with each sample.

Table 23. Bytes Recorded per Sample Based on Selected Parameters

Binary Bit	Dec.	Recorded Parameter (set to YES)	Bytes (per sample)
7 6 5 4 3 2 1 0			
– – – – 0 – – 1 =	1	RecordAmpCorr	4
– – – – 0 – 1 – =	2	RecordCompass	6
– – – – 0 1 – – =	4	RecordSensor	4
– – – 1 0 – – – =	16	RecordStat	36
– – 1 – 0 – – – =	32	RecordExtSensor	4
– 1 – – 0 – – – =	64	RecordExtPress	3
1 – – – 0 – – – =	128	RecordCTD or RecordLISST	CTD dependent or 80 characters

All Record Parameters Set to NO

When all the **Record…** parameters are set to **NO**, the minimum amount of data is recorded (8 bytes). The minimum amount of data includes:

```
  Datum      Bytes  Description
   Vx          2    Velocity components expressed as 2-byte,
   Vy          2      signed integers,
   Vz          2      in units of 0.01 cm/s
 Mean Amp      1    Mean amplitude for the three beams (counts)
 Mean Corr     1    Mean correlation for the three beams (%)
              ==
               8
```

RecordAmpCorr Set to YES

If **RecordAmpCorr** = **YES**, the mean amplitude and correlation parameters (listed above) are replaced by the individual values for each beam. In effect, this increases the size of the data record by four bytes. In this case, the amplitude and correlation data stored is:

```
  Datum      Bytes  Description
   A1          1    Signal amplitude,
   A2          1      for each of the beams,
   A3          1      in units of counts
   C1          1    Correlation score,
   C2          1      for each of the beams,
   C3          1      expressed as a percentage (%)
              ==
               6
```

RecordCompass Set to YES

If **RecordCompass** = **YES**, an additional six bytes of data are recorded with each sample (assumes the optional compass/tilt sensor is installed).

```
  Datum     Bytes  Description
 Heading      2    Heading angle in units of 0.1 degree
  Pitch       2    Pitch angle in units of 0.1 degree
  Roll        2    Roll angle in units of 0.1 degree
             ==
              6
```

RecordSensor Set to YES

If **RecordSensor** = **YES**, an additional four bytes of data are recorded with each sample (assumes the optional temperature and/or pressure sensor is installed).

```
  Datum      Bytes  Description
Temperature    2    Temperature in units of 0.01°C
 Pressure*     2    Pressure in units of counts (0-65535)
              ==    *Note: If ExtSensor = 3_OBS, raw Ad Chan 3 data is displayed here.
               4
```

RecordExtSensor Set to YES

If **RecordExtSensor** = **YES**, an additional four bytes of data are recorded with each sample (assumes at least one optional external sensor is installed). The data corresponds to raw counts from a 12-bit analog-to-digital converter.

```
  Datum     Bytes  Description
Ad Chan 1     2    Data from sensor channel #1 in units of counts (0-65535)
Ad Chan 2     2    Data from sensor channel #2 in units of counts (0-65535)
             ==
              4
```

RecordExtPress Set to YES

If **RecordExtPress** = **YES**, an additional three bytes of data are recorded with each sample (assumes an optional external pressure sensor is installed).

```
  Datum      Bytes  Description
ExtPressure     3   Data from external pressure sensor in milli-dbars (for
               ==   Paros) or milli-Hz (for Druck and ParosFreq)
                3
```

RecordCTD Set to YES

If **RecordCTD** = **YES**, an additional four bytes of data are recorded in a single record at the end of the burst (i.e., <u>not</u> at the end of each sample). This data contains the mean temperature, conductivity, pressure, and salinity measured by an external MicroCat CTD throughout the burst.

```
 Datum    Bytes  Description
 Temp       1    Mean temperature from CTD sensor in 0.0001°C
 Cond       1    Mean conductivity from CTD sensor in 0.00001 Siemen
 Press      1    Mean pressure from CTD sensor in 0.001 dbar
  Sal       1    Mean salinity from CTD sensor in 0.0001 psu
           ==
            4
```

RecordStat Set to YES

If **RecordStat** = **YES**, an additional 36 bytes of data are recorded in a single record at the end of the burst (i.e., <u>not</u> at the end of each sample). This data contains the means and standard deviations of amplitudes, correlations, heading, pitch, roll, temperature, and pressure for the burst (assumes the appropriate optional sensors are installed).

```
     Datum      Bytes  Description
   MeanAmp[3]     3    Mean amplitude in counts for 3 beams
   MeanCorr[3]    3    Mean correlation in counts for 3 beams
   MeanHeading    2    Mean heading in 0.1°
   MeanPitch      2    Mean pitch in 0.1°
   MeanRoll       2    Mean roll in 0.1°
   MeanTemp       2    Mean temperature in 0.01°
   MeanPress      4    Mean pressure in counts, 0-4095
   StdAmp[3]      3    Standard deviation of amplitude in counts for 3 beams
   StdCorr[3]     3    Standard deviation of correlation in counts for 3 beams
   StdHeading     2    Standard deviation of heading in 0.1°
   StdPitch       2    Standard deviation of pitch in 0.1°
   StdRoll        2    Standard deviation of roll in 0.1°
   StdTemp        2    Standard deviation of temperature in 0.01°
   StdPress       2    Standard deviation of pressure in counts, 0-4095
   SoundSpeed     2    Sound speed in 0.1 m/s
                 ==
                 36
```

All Record Parameters Set to YES

When all the **Record…** parameters are set to **YES**, the maximum amount of data is recorded (33 bytes).

```
    Datum      Bytes  Description
     Vx          2    Velocity components expressed as 2-byte,
     Vy          2       signed integers,
     Vz          2       in units of 0.01 cm/s
     A1          1    Signal amplitude,
     A2          1       for each of the beams,
     A3          1       in units of counts
     C1          1    Correlation score,
     C2          1       for each of the beams,
     C3          1       expressed as a percentage (%)
   Heading       2    Heading angle in units of 0.1 degree
    Pitch        2    Pitch angle in units of 0.1 degree
     Roll        2    Roll angle in units of 0.1 degree
  Temperature    2    Temperature in units of 0.01°C
   Pressure*     2    Pressure in units of counts (0-65535)
   Ad Chan 1     2    Data from sensor channel #1 in units of counts (0-65535)
   Ad Chan 2     2    Data from sensor channel #2 in units of counts (0-65535)
  ExtPressure    3    Data from external pressure sensor in milli-dbars
  CTD or LISST   4    CTD: Temperature, salinity, pressure, and conductivity
                ==    LISST: Optical transmission, pressure, and temperature
                33
```

*Note: If **ExtSensor** = **3_OBS**, raw Ad Chan 3 data is displayed here.

A2.2.3   Data Block Structures

This section defines the various data block structures in the "C" programming language.

The structure *AdvSystemConfigType* defines the hardware configuration parameters (24 bytes).

```
typedef struct {
  unsigned char SoftwareVerNum;
  unsigned char DspSoftwareVerNum;
  char      AdvType;                 /* 0-10MHz,5cm 1-10MHz,10cm 2-OCEAN */
  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                */
  long      PressScale;              /* nano bar   per count         */
  long      PressOffset;             /* micro bar                    */
  int       CompassOffset;           /* Degress to East of North     */
  char      PressFreqOffset;         /* Frequency Pres Sensor Offset kHz */
  char      ExtSensorInstalled;      /* External sensors on AD channels: */
                                     /*   0 None                     */
                                     /*   1 Standard (ch 1/3)        */
                                     /* 2-5 OBS (ch 1, 2, 3)         */
  char      ExtPressInstalled;       /* Ext Press sensor:            */
                                     /*   1-Paros 2-Druck 3-ParosFreq */
  int       PressScale_2;            /* pico bar   per count^2       */
  char      CtdSensorInstalled;      /* 1 if MicroCat CTD, 2 if LISST */
} AdvSystemConfigType;
```

The structure *AdvConfType* defines the probe configuration information (164 bytes).

```
typedef struct {
  unsigned char FileType;
  unsigned char FileVer;
  DateType      FileDate;
  long          FileNbytes;
  char          SerialNum[6];
  char          ProbeType;           /* 3/2-d orientation            */
  char          ProbeSize;           /* 0-5cm probe; 1-10cm probe    */
  int           ProbeNbeams;
  int           NomPeakPos;          /* in Timing cycles             */
  int           Nsamp;               /* Samples per pulse            */
  int           SampInterval;        /* Ram cycles between samples   */
  int           PulseLag[5][3];      /* Up to 3 lags per range       */
  int           Nxmt[5][3];          /* Pulse length                 */
  int           LagDelay[5][3];      /* Up to 3 lags per range       */
  int           BeamDelay;           /* Additional delay between beams*/
  int           PingDelay;           /* Additional delay between pings*/
  float         XformMat[9];         /* From Beam to XYZ veloc.      */
  float         XmtRecDist;          /* in m                         */
  float         CalCw;               /* Cal Sound speed (m/s)        */
} AdvConfType;
```

The structure *AdvDeploymentSetupType* defines deployment configuration parameters (253 bytes).

```
typedef struct {
  unsigned   char        ConfigType; /* Type      0x12               */
  unsigned   char        ConfigVer;  /* Version   0x01               */
  unsigned   int         Nbytes;     /* Bytes in configuration       */
  DateTimeType           ConfigTime; /* Date created or last modified */
  int           Temp;                /* 0.1 deg C                    */
  int           Sal;                 /* 0.1 ppt                      */
  int           Cw;                  /* 0.1 m/s                      */
```

```
      unsigned char  TempMode;              /* 0- User value  1- Measured      */
      unsigned char  VelRangeInd;           /* Velocity range list index       */
      char           SyncMode;              /* 0-Disable; 1-Start; 2-Sample     */
      char           CoordSystem;           /* 0-Beam;      1-XYZ; 2-ENU        */
      unsigned int   SampRate[3];           /* in units of 0.1 Hz              */
      unsigned int   BurstInterval[3];      /* in s                            */
      unsigned int   SamplesPerBurst[3];
      unsigned char  RecordedData[3];       /* Data included in time series    */
                                            /* Bit 0 - Amp/Corr  for 3 beams   */
                                            /* Bit 1 - Compass data            */
                                            /* Bit 2 - Temp/Press data         */
                                            /* Bit 4 - Time series statistics  */
                                            /* Bit 5 - External analog sensors */
                                            /* Bit 6 - External pressure sensor */
                                            /* Bit 7 - Ctd or Lisst sensor     */
      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];         /*                             */
      DateTimeType   BeginDeploymentDateTime;   /*                             */
      char           CommentLine1[60];
      char           CommentLine2[60];
      char           CommentLine3[60];
      char           AutoSleep;
      char           Spare[7];              /* set to all 0s                   */
   } AdvDeploymentSetupType;
```

The structure *DateTimeType* defines real-time clock date and time and is referenced in other structures (8 bytes).

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

The structure *DateType* defines the real-time clock data and is used in other structures (4 bytes).

```
   typedef struct {
      int  year;
      char day,
           month,
   } DateType;
```

The structure *BurstHeader* defines the burst header information (60 bytes).

```
   typedef struct {
      unsigned char  SyncChar;            /* 0xA5                             */
      unsigned char  DataType;            /* 0x10                            */
      unsigned int   Nbytes;              /* In header                       */
      char           SerialNumber[10];    /* of probe                        */
      unsigned long  BurstNumber;         /* From start of data collection   */
      DateTimeType   BurstTime;           /* At the beginning of burst       */
      unsigned char  VelRangeInd;         /* Velocity range list index       */
      unsigned char  Spare;               /* Set to 0                        */
      unsigned int   SampRate;            /* in units of 0.1 Hz              */
      unsigned int   SamplesPerBurst;
```

```
    char            CoordSystem;        /* 0-Beam;     1-XYZ; 2-ENU       */
    char            RecordedData;       /* Data included in time series    */
                                        /* Bit 0 - Amp/Corr  for 3 beams   */
                                        /* Bit 1 - Compass data            */
                                        /* Bit 2 - Temp/Press data         */
                                        /* Bit 4 - Time series statistics  */
    unsigned int    SoundSpeed;         /* in 0.1 m/s units                */
    int             BoundaryRange;      /* in 0.1 mm                       */
    int             VolumeBoundaryRange;/* in 0.1 mm                       */
    unsigned char   Status[20];         /* System variables(TroubleShooting)*/
} BurstHdrType;
```

The structure *AdvStatType* defines the burst statistics data (36 bytes).

```
typedef struct {
    unsigned char  MeanAmp[3];          /* in counts for the 3 beams       */
    unsigned char  MeanCorr[3];         /* in counts for the 3 beams       */
    int            MeanHeading;         /* in 0.1  deg                     */
    int            MeanPitch;           /* in 0.1  deg                     */
    int            MeanRoll;            /* in 0.1  deg                     */
    int            MeanTemp;            /* in 0.01 deg                     */
    long           MeanPress;           /* in counts 0-4095                */
    unsigned char  StdAmp[3];           /* in counts for the 3 beams       */
    unsigned char  StdCorr[3];          /* in counts for the 3 beams       */
    int            StdHeading;          /* in 0.1  deg                     */
    int            StdPitch;            /* in 0.1  deg                     */
    int            StdRoll;             /* in 0.1  deg                     */
    int            StdTemp;             /* in 0.01 deg                     */
    int            StdPress;            /* in counts, 0-4095               */
    unsigned int   SoundSpeed;          /* in 0.1  m/s                     */
} AdvStatType;
```

The exact structure used to record each sample depends on the settings of the data recording options: *RecordAmpCorr*, *RecordCompass*, *RecordSensor*, etc. See §3.7 for information about these options. Table 24 provides information on the size, and the order in which data are recorded when a parameter has been selected for recorded (i.e., record option set to when, and in which order, data are recorded, for all possible combinations of these variables. The defined structure for each data type is given at the end of this section.

Table 24. Data Recording Order Based on Selected Parameters

Order	Structure	When Recorded	Bytes
1	Velocity	Always	6
2	MeanAmpCorr	Always	2
3	AllAmpCorr	RecordAmpCorr=YES	6
4	Compass	RecordCompass=YES	6
5	TempPressure	RecordSensor=YES	4
6	ExtSensor	RecordExtSensor=YES	4
7	ExtPress	RecordExtPress=YES	3
8	CTD or LISST	RecordCTD=YES or RecordLisst=YES	CTD dependent 80 char
9	Statistics	RecordStat=YES	36

Velocity (6 bytes)
```
int       Vel[3];                 /* velocity in 0.1 mm/s */
```

MeanAmpCorr (2 bytes)
```
unsigned char     MeanAmp;        /* mean amplitude, counts     */
unsigned char     MeanCorr;       /* mean correlation, percent  */
```

AllAmpCorr (6 bytes)
```
unsigned char     Amp[3];         /* amplitude beams 1-3, counts     */
unsigned char     Corr[3];        /* correlation beams 1-3, percent  */
```

Compass (6 bytes)
```
int       Heading;      /* heading in 0.1 deg */
int       Pitch;        /* pitch in 0.1 deg   */
int       Roll;         /* roll in 0.1 deg    */
```

TempPressure (4 bytes)
```
int       Temperature;  /* temperature in 0.01 deg C */
int       Pressure;     /* pressure in counts        */
```

ExtSensor (4 bytes)
```
unsigned int   ExtAdCh[2]; /* Ch1/Ch2 sensor data, counts (0-65535) */
```

ExtPress (3 bytes)
```
char      ExtPress[3];   /* millidbars(Paros) or milliHz(Druck/Parosfreq) */
```

CTD (4 bytes)
```
          Temp;          /* 0.0001 of deg C  */
          Cond;          /* 0.00001 siemens  */
          Press;         /* 0.001 dbar       */
          Sal;           /* 0.0001 PSU       */
```

LISST (80 char)
```
char      LisstBuff[80];
```

Statistics (36 bytes)
```
unsigned char  MeanAmp[3];        /* in counts for the 3 beams */
unsigned char  MeanCorr[3];       /* in counts for the 3 beams */
int            MeanHeading;       /* 0.1  deg                  */
int            MeanPitch;         /* in 0.1  deg               */
int            MeanRoll;          /* in 0.1  deg               */
int            MeanTemp;          /* in 0.01 deg               */
long           MeanPress;         /* in counts 0-4095          */
unsigned char  StdAmp[3];         /* in counts for the 3 beams */
unsigned char  StdCorr[3];        /* in counts for the 3 beams */
int            StdHeading;        /* in 0.1  deg               */
int            StdPitch;          /* in 0.1  deg               */
int            StdRoll;           /* in 0.1  deg               */
int            StdTemp;           /* in 0.01 deg               */
int            StdPress;          /* in counts, 0-4095         */
unsigned int   SoundSpeed;        /* in 0.1  m/s               */
```

Appendix 3. Multiple ADVField/Hydra Operation using RS485

This appendix describes the simultaneous operation of multiple ADVFields/Hydras in RS485 mode. Each system must be hardwired at the factory to use RS485 protocol.

A3.1. Overview

RS485 serial communication protocol allows multiple systems to be controlled from a single communication line.

- RS485 uses the same electrical communication protocol as RS422, allowing operation over total cable lengths up to 1500 m (4500 feet).
- A RS422/RS232 converter is used to connect the RS485 ADVField/Hydra systems to a standard PC serial port.
- Each ADVField/Hydra is configured with a unique system address.
- All communication is prefaced with a system address; each ADVField/Hydra responds only to commands directed to its specific address.
- Operation and data collection for all systems is controlled from a single PC. Data from each system is stored in a separate data file on the PC.
- Multiple systems are "daisy-chained" together as shown in Figure 25.
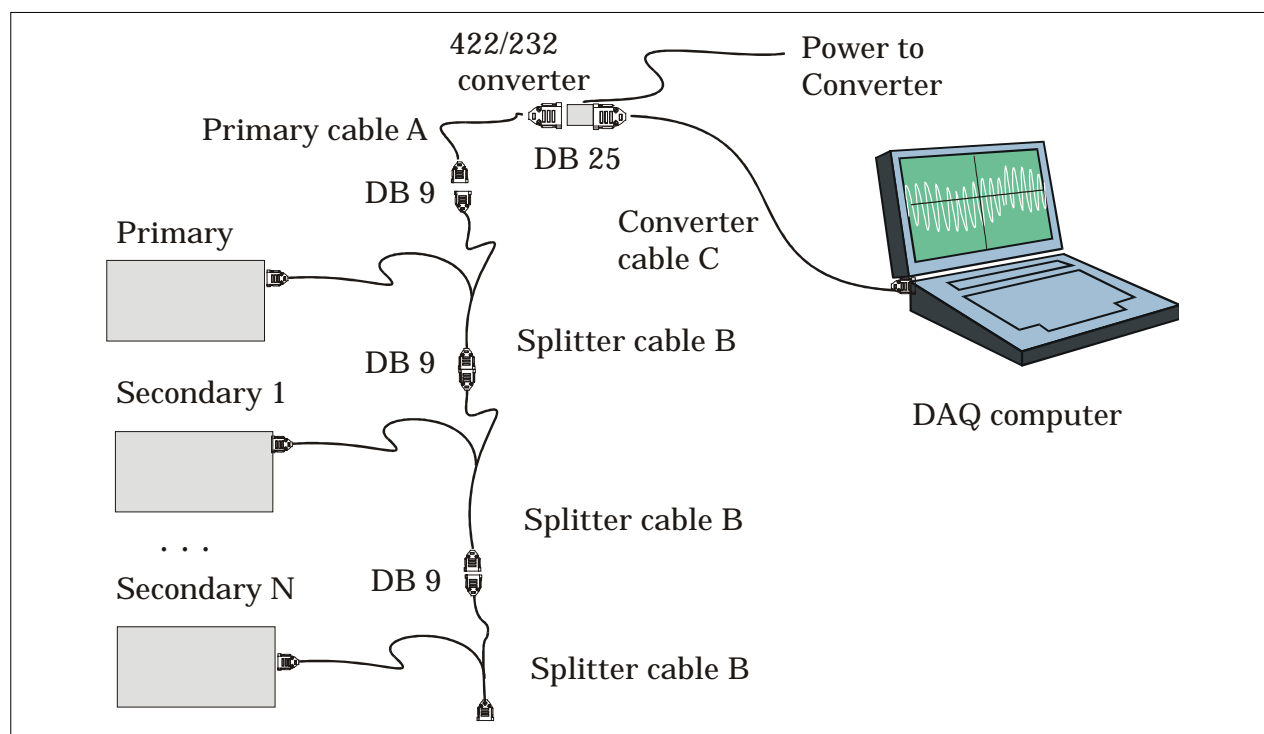
Figure 25 – RS485 Overview

A3.2. Setting System Address

When RS485 systems are ordered, each ADVField/Hydra is configured at the factory to a unique CPU address (from 1 to 99). To change or verify this setting, use the following command to return the current CPU address.

```
>cpuaddress
```

To set the ADVField to a particular address, use the following command, where N is the desired address (1 to 99). Setting an address of 0 will disable RS485 mode (for single system operation).

```
>cpuaddress set N
```

A3.3. Cables and Connections

To use multiple ADVFields/Hydras in RS485 mode, you need to connect the systems together using the cables provided (Figure 25).

- Connect the DB25 of *Primary Cable A* to the serial port of your PC using the RS232 / RS422 converter. Connect power to the RS232 / RS422 converter using the small 12 V power supply provided with the system. You may need to use a DB25 to DB9 converter cable (*Converter Cable C*).
- Connect the DB9 of *Primary Cable A* to the female connector of *Splitter Cable B*.
- Connect the male connector of *Splitter Cable B* to the primary ADVField/Hydra.
- Continue connecting the splitter cables to all ADVFields/Hydras in the chain.
- Connect power to each of the ADVField/Hydra units (for systems without internal batteries).

A3.4. RS485 Software – General

Only the ADVField/Hydra DOS-based, real-time software supports RS485 operation at this time; the Windows based real-time software does not support multi-system operation.

Operation of the software in RS485 mode is as described in the *ADVField Software Manual*, with a few minor exceptions noted in the following sections.

A3.5. SonTerm – RS485 Operation

When using **SONTERM** to communicate with a particular system on a RS485 chain, use the following steps.

- Send a **BREAK** (Alt+B) to the system.
- Use Alt+F1 to select a RS485 address.
- Send commands to that address as needed.
- To switch to a different system, again send a **BREAK**, and then select a new address using Alt+F1.

A3.6. Real-Time Data Acquisition Software – RS485

The following relates only to the DOS-based data collection software; the Windows real-time software does not support RS485 multi-system operation.

- To run several ADVFields/Hydras simultaneously, you need to create/edit an ASCII text file named **ADVPROBE.DEF**.
- The **ADVPROBE.DEF** definition file contains one line of code for each ADVField system included in the RS485 chain. Each line specifies the address and probe configuration file that each individual system will use. The file should look something like the following, where the probe at address 1 is using configuration file **A001.PRO**, the probe at address 2 is using file **A123.PRO**, and the probe at address 3 is using configuration file **A456.PRO**.

```
PROBE 1 A001.PRO
PROBE 2 A123.PRO
PROBE 3 A456.PRO
```

A3.7. ADFCheck and SonRec – RS485

The DOS diagnostic software **ADFCHECK** and the **SONREC** recorder extraction program have an additional –*address* command line option to specify the system address.

To run **ADFCHECK** on CPU address 2 and COM port 1 (-p1) use the following command line:

```
adfcheck –p1 –a2
```

To run **SONREC** on CPU address 3 and COM port 1 (-p1) use the following command line:

```
sonrec –p1 –a3
```

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A YSI Environmental Company

SonTek/YSI
ADVField Software Manual
(for use with software version 7.7)

RECORD OF CHANGES

Effective	Description
01 SEP 1999	Base document: ADVField software version 7.1
01 SEP 2001	ADVField firmware v7.9; ADVField software v7.7; Windows software added

TABLE OF CONTENTS

INTRODUCTION

Thank you for buying an ADVField/Hydra from SonTek. Included with your system is the software designed to provide a user-friendly interface. All software is written for DOS running on PC-compatible computers. Software for the different ADV configurations operates in essentially the same manner, and is intended to be self-explanatory. It is our hope that this manual will be needed only as a reference.

This manual is divided into the following sections.

- **Section 1. Software Installation and Overview** – Provides a summary of the programs included with the software version listed on the title page of this manual.

- **Section 2. Real-Time Data Acquisition (ADF.EXE)** – Software for data collection while connected to a PC-compatible computer. The programs provide a menu driven format to set operating parameters and a graphical display of velocity data and quality parameters.

- **Section 3. Real-Time Data Conversion (GET___.EXE)** – Software to convert ADV binary data files collected with the real-time data acquisition software to an ASCII format.

- **Section 4. Hardware Diagnostics (ADFCHECK.EXE)** – Software to verify ADV performance and to check for damaged probes or other hardware problems.

- **Section 5. Analog Output Calibration (ADFCALAO.EXE)** – Software to calibrate the analog output voltages for the effects of long cables and temperature fluctuations.

- **Section 6. Compass Calibration (COMPCAL.EXE)** – A program to calibrate the optional compass/tilt sensor for the ADVField.

- **Section 7. Terminal Emulator (SONTERM.EXE)** – A program to access the direct command interface of the ADVField through the computer serial port.

- **Section 8. Recorder Data Extraction (SONREC.EXE)** – Software to download ADV binary data files from the optional internal recorder to the computer hard disk.

- **Section 9. Autonomous Data Conversion** – Software to convert ADV binary data files collected using the internal recorder to an ASCII format.

- **Section 10. Probe Configuration Download (ADFSET.EXE)** – Software used to load a probe configuration file into the ADVField processing module.

- **Section 11. SonUtils Utility Software (Windows)** – Windows-based utility software.

- **Section 12. ViewHydra / ViewHydraPro (Windows)** – Windows-based data postprocessing software.

- **Section 13. Additional Support** – Provides contact information for additional support.

- **Appendix 1. Automatic File Naming Convention** – Describes the file naming convention (based up date and time) used when the automatic file recording is specified in the real-time data acquisition software.

- **Appendix 2. ADV Real-Time Binary Data File Format** – Describes the format of the binary files generated by the ADV data acquisition software.

NOTES

Section 1. Software Installation and Overview

The software package for SonTek/YSI ADVField and Hydra systems includes both DOS and Windows-based programs that control all common system functions. All software is written for operation on PC-compatible computers.

- DOS software is written for DOS version 6.0 and later. DOS software is best run from a dedicated DOS computer (or a Windows computer restarted in DOS mode). While our DOS-based programs may work from a DOS prompt within Windows, background processes in Windows may interfere with program operation, especially during real-time data collection.
- Windows software is Windows 95/98/2000/NT compatible.

1.1. ADVField/Hydra Software Installation

All ADVField/Hydra software comes on a single CD-ROM. Additionally, system-specific files are provided on a separate, 3.5" floppy disk. The system-specific files pertain to probe definition data (*.def), probe configuration data (*.pro), pressure sensor data (*.drk), and special settings (*.set). Note that depending on your system's configuration, this separate floppy disk may or may not be included, and may or may not contain all files mentioned here.

To install the DOS and Windows software on a <u>Windows-based</u> computer:

- Insert the distribution CD in your computer.
- An installation menu (Figure 1) should automatically appear after the CD has been inserted.
  - o If the menu does not appear in a few seconds, click **Start|Run** and type **d:\install.exe** where **d:** is your CD-ROM drive.
- Click the appropriate programs that you would like to install on your computer. Follow the on-screen instructions. If prompted, insert the Probe Definition disk in your floppy drive.
- You can also choose to browse the CD, view the "readme" file, view a PDF version of this manual, or go to our web site.

To install the DOS software on a <u>DOS-only</u> computer:

- Insert the CD in your computer.
- Get a listing of the files/directories contained on the CD. For example, **dir d:**, where **d:** is your CD-ROM drive.
- Copy all files and subdirectories from the **d:\ADF-DOS** directory to an appropriate directory on your computer. For example: **XCOPY D:\ADF-DOS*.* C:\SONTEK\ADVF-770\ /s**
- Using the above syntax will copy all DOS program files from the CD to: **C:\SONTEK\ADVF-770\DEPLOY*.*** and **C:\SONTEK\ADVF-770\REALTIME*.***
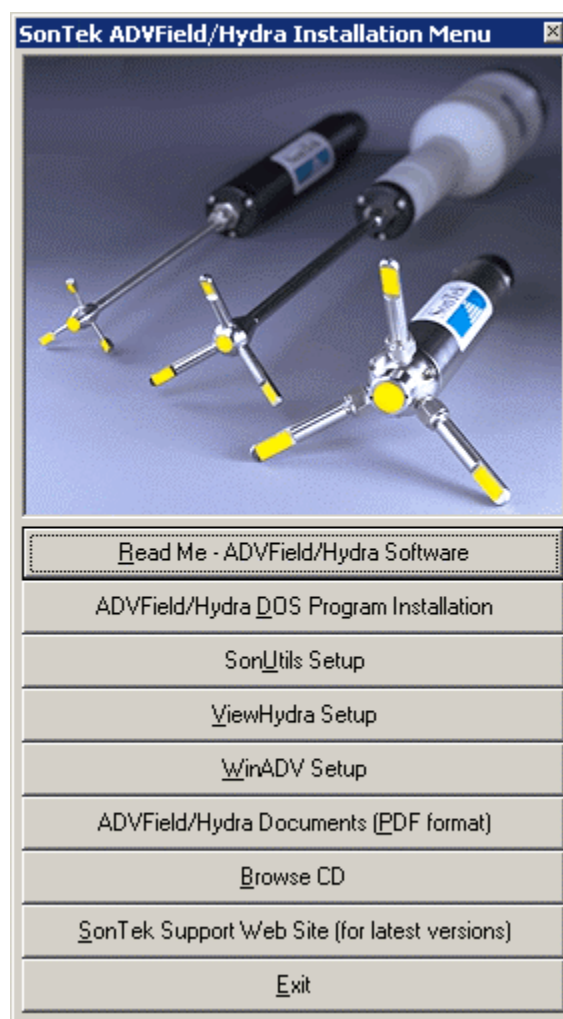

Figure 1 - ADVField/Hydra Software Installation Menu

1.2. ADVField/Hydra DOS Software

The following DOS programs/files are included on the ADVField/Hydra software distribution disk (CD-ROM). These programs are mostly self-explanatory. To learn about program use, enter the name at the DOS prompt. If the program requires command line parameters, a help screen will show the required inputs and their format.

- **ADF.EXE** - Real-time data acquisition program (Section 2).
- **ADFSX.EXE** – Same as **ADF**, but for computers without a math co-processor (Section 2).
- **GETCTL.EXE** - Data conversion program for files from the real-time data acquisition software to convert file header information to ASCII format (Section 3).
- **GETAMP.EXE** - Data conversion program for files from the real-time data acquisition software to convert signal amplitude data to ASCII format (Section 3).
- **GETCOR.EXE** - Data conversion program for files from the real-time data acquisition software to convert correlation data to ASCII format (Section 3).
- **GETHPR.EXE** - Data conversion program for files from the real-time data acquisition software to convert heading, pitch, and roll data to ASCII format.
- **GETSEN.EXE** - Data conversion program for files from the real-time data acquisition software to convert sensor data (compass/tilt, temperature, and pressure) to ASCII format (Section 3).
- **GETSNR.EXE** - Data conversion program for files from the real-time data acquisition software to convert signal to noise ratio (SNR) data to ASCII format (Section 3).
- **GETVEL.EXE** - Data conversion program for files from the real-time data acquisition software to convert velocity data to ASCII format (Section 3).
- **ADFCHECK.EXE** - Diagnostic program to test system performance (Section 4).
- **ADFCALAO.EXE** - Calibration program for analog output voltages (Section 5).
- **COMPCAL.EXE** - Calibration program for optional compass/tilt sensor (Section 6).
- **SONTERM.EXE** - Terminal emulator for accessing the direct command interface (Section 7).
- **ADFSET.EXE** - Probe configuration download program (Section 10).

For ADVField systems with the optional internal recorder for autonomous deployments, the system includes a second diskette with software for autonomous deployment. This diskette includes the following files.

- **SONREC.EXE** - Data extraction program for the ADVField internal recorder (Section 8).
- **GADVCTL.EXE** - Data conversion program for autonomous data files to convert file header information to ASCII format (Section 9).
- **GADVHDR.EXE** - Data conversion program for autonomous data files to convert burst header and statistics data to ASCII format (Section 9).
- **GADVLIST.EXE** - Data conversion program for autonomous data files to convert LISST sensor data to ASCII format.
- **GADVTS.EXE** - Data conversion program for autonomous data files to convert time series data, including velocity and data quality parameters, to ASCII format (Section 9).
- **GTDRUCK.EXE** - Program used to get (download) the Druck/ParosFreq pressure sensor calibration file from the ADVField's processor to the local computer.
- **LDDRUCK.EXE** - Program used to load the Druck/ParosFreq pressure sensor calibration file into the ADVField's processor.
- **COMPCAL.EXE** - Calibration program for optional compass/tilt sensor (Section 6).
- **SONTERM.EXE** - Terminal emulator for accessing the direct command interface (Section 7).

- **SRC** - Source code (in C) for the autonomous data conversion software. Allows you to write software to directly access the binary data files. The programs are internally documented and should be easily interpreted by anyone familiar with the C programming language.

1.3. ADVFkield/Hydra Windows Software

The following Windows-based programs are included on the ADVField/Hydra software distribution disk (CD-ROM). These programs are mostly self-explanatory. To learn more about a program, use the program's **Help** menu (of press **F1**).

- *SonUtils* – This utility program contains a terminal emulator module (*Terminal*), a compass calibration module (*Compass*), and a internal recorder data extraction module (*Recorder*). See Section 11 for details. Note: Previously, the modules within *SonUtils* were named *SonTermW* (now *Terminal*), *CompCalW* (now *Compass*), and *SonRecW* (now *Recorder*).

- *ViewHydra* – *ViewHydra* is a data display and analysis program. This post-processing package is designed specifically for use with the data collected by a SonTek Hydra system. *ViewHydra* lets you quickly and easily look at Hydra data in a variety of ways: as time-series graphs, as tabular displays, or as an ASCII text file. See Section 12 for details. Note: Hydra systems that have the directional waves option installed use an advanced version of this program: *ViewHydraPro*.

- *WinADV* – This data post-processing package was written by Tony Wahl of the U.S. Bureau of Reclamation. *WinADV* provides an integrated environment for viewing, reviewing, and processing data collected using an ADV. *WinADV* provides the capability to quickly view time-series graphs, histograms, or FFTs of the various velocity data. *WinADV* is not described in this manual; for details about *WinADV* go to: www.usbr.gov/wrrl/twahl/winadv.

1.4. Common System-Specific Files

If applicable, the following system-specific files are included on a separate 3.5" floppy disk.

- **ADVPROBE.DEF** – ADV probe definition file used with data acquisition software (Section 2).
- **XXXX.PRO** – Probe configuration file (*XXXX* is the probe serial number) containing calibration information (Section 2).
- ***.DRK** – Calibration files for an optional frequency pressure sensor (e.g., Druck RPT, Parosfreq).
- ***.SET** – Special "settings" files for certain systems.

1.5. Documents (PDF Format)

An "electronic" version of the ADVField/Hydra manuals is available on the CD-ROM distribution disk. These manuals are in a .pdf format and require that Adobe's Acrobat Reader be installed on your computer. The manuals are in the \Documents folder.

Section 2. Real-Time Data Acquisition (ADF.EXE)

The most common method of collecting ADV data is using SonTek's real-time data acquisition software, ADVField (`ADF.EXE`). This program is written for DOS on a PC-compatible computer with the minimum hardware requirements shown below.

- 33 MHz 386/387 with math co-processor
- 640K RAM
- Hard disk
- Color VGA graphics
- One available serial communication port

The ADVField software also includes a version of the program compiled for 386/387 computers without the math co-processor (`ADFSX.EXE`). When possible, we recommend using a computer with the minimum hardware outlined above.

The data acquisition software has three modes of operation: setup, boundary adjustment, and data acquisition. The program starts in the setup mode, where you are presented with a menu to specify data collection parameters. Once complete, you enter the boundary adjustment mode by selecting **START Data Acquisition**. In the boundary adjustment mode, the ADV searches for the presence of a boundary (bottom, surface, or side) in front of the probe while displaying the distance to the boundary on the screen. Data acquisition mode is entered from the boundary adjustment mode by pressing **F10**. In the data acquisition mode, the program collects, displays, and records (if enabled) velocity data until stopped by the operator. While data are being collected, you can change the display without interrupting the sampling or recording of the data.

The description of the data acquisition software is divided into the following sections.

- Probe Configuration Files (§2.1) – A description of the ADV probe configuration files that must be specified before starting the data acquisition software.

- Command Line Options and Software Parameter Files (§2.2) – A description of options that can be added to the DOS command line to modify the operation of the data acquisition software and of files generated by the software to record user parameter settings.

- Setup Mode (§2.3) – The first data acquisition screen that allows modification of ADV data collection parameters (temperature, salinity, sampling rate, velocity range, etc.).

- Boundary Adjustment Mode (§2.4) – The second data acquisition screen that displays the range from the ADV probe to the boundary (if detected).

- Data Acquisition Mode (§2.5) – The final data acquisition screen that provides a real-time tabular and graphical display of ADV data.

- Recorded Data (§2.6) – A description of the data recorded in the ADV binary files.

2.1. Probe Configuration Files

Before running the data acquisition software, you must specify which ADVField probe is being used. This is done in the ASCII probe definition file **ADVPROBE.DEF**, which is read by the data acquisition software upon execution. The probe configuration files (**.PRO**) are supplied by Son-Tek with each probe and should reside in the directory from which the software is run.

The probe definition file consists of one line that specifies the communications port to which the ADV is connected and the name of the probe configuration file for the ADV probe. The example shown here indicates that probe serial number 1102 is connected to the ADV processor module through serial port COM1 (1 for COM1, 2 for COM2).

```
PROBE 1 1102.PRO
```

After the proper probe definition file has been created, you can start the ADV data acquisition program by entering the program name (**ADF**) at the DOS prompt.

2.2. Command Line Options and Software Parameter Files

Command Line Options

For normal operation, simply type the name of the program at the DOS prompt to run the data acquisition software. You can use a few optional command line parameters (Table 1) to access special functions of the software. These command line options are added as one or more characters following the program name at the DOS prompt.

Command line options are listed following a hyphen (-) after the program name (e.g., ADF -w). You can enter multiple command line options by listing all desired options following a single hyphen (e.g., ADF -wg).

Table 1 . ADF Command Line Options

Command	Function
ADF -w	*Black and white display* – This runs the data acquisition software using a black and white display for monochrome monitors. This may be useful when working outdoors.
ADF -f	*Automatic file recording* – This option causes the program to automatically select a file name for recording to the computer hard disk. See below for details on the file naming convention.
ADF -g	*Automatic start of data collection* – This option, which includes the automatic file recording option mentioned above, causes the program to skip the setup and boundary adjustment modes and immediately begin data collection. The ADV will use the same data collection parameters previously used (stored in a file on the computer hard disk). If you place a line that reads ADV -g at the end of the **AUTOEXEC.BAT** file, data collection will resume automatically following a temporary power failure (assuming the computer boots directly to a dedicated DOS mode).

Automatic file recording – When using the automatic file-recording feature (-f or -g), you must create a file named **ADVFILE.DEF** to specify details relating to data file recording. This is a single line ASCII text file, an example of which follows.

```
c:\adv\aa  HOURLY
```

The first portion specifies the path (`c:\adv\`) and the first two characters (`aa`) in the ADV file name. The remainder of the file name is generated using the date and time (see Appendix 1). The second word on this line specifies the interval at which new ADV files are created. The interval can either be at the start of each hour (`HOURLY`), or when the file reaches a particular size (`SIZE <in KB>`). For example, `c:\adv\aa SIZE 1400` will create a new file each time the data file reaches 1400 KB.

When this option is used, the **Record To File** item in the setup mode will be blocked. To disable recording, you must exit the program and run it again without this option. Before using this feature, make sure the computer clock is set to the correct date and time. As a precaution, the program will NEVER overwrite an existing data file. Execution will STOP if the new data file already exists. The program should never encounter an existing data file unless you run the program, stop it, and then run it again all within one minute; or if there is a problem with the PC clock and by coincidence, the program gets the same time from the PC in different runs.

Software Parameter Files

The parameters used by the ADV data acquisition software are divided into two areas: ADV configuration parameters and display parameters.

The ADV configuration parameters consist of all items specified in the setup menu. These are stored in a software-generated binary file named **ADVUSER.SET**. This file is updated each time data collection is started, and when you exit the data acquisition software. When the software is started, it scans for this file and loads these parameters if the file is present; if it is not present, it loads a default parameter set.

The display parameters consist of all settings used to control the data acquisition display. These are stored in a software-generated binary file named **DISPLAY.SET**. This file is updated when you exit the data acquisition software. When the software is started, it scans for this file and uses these display parameters if the file is present; if it is not present, it uses a default parameter set.

2.3. *Setup Mode*

Figure 2 shows the setup screen for the ADVField software program.


```
ADV Data Acquisition System, Ver: ADF 4.0, Copyright SonTek, Inc. 1993-1996

Units System                    Metric        Date    3/20/1997
                                              Time    15:31:44
Water Temperature (°C)            20.0
Water Salinity    (ppt)           34.5        Probe 1:  5025           Ready
Speed of Sound    (m/s)         1520.9

Sampling Rate     (Hz)          10.000
Velocity Range  (cm/s)             250
External Synchronization      DISABLED
Coordinate System                  XYZ

Recording Mode                CONTINOUS
Samples per Burst                 1200

Record To File   advtest.ADV
File Comment 1   The ADV is a truly wonderful system
File Comment 2   Every home should have several for the kids to use
File Comment 3   Call SonTek to order yours today!


               START Data Acquisition
               EXIT  Data Acquisition

       << Press  ENTER  to Start Data Acquisition >>
       << Use  ↑ ↓ or PgUp/PgDn  to Move thru Items >>
```

Figure 2 - Data Acquisition Software "Setup Mode"

The upper right part of the screen shows the current PC date and time, as well as the ADV specified in `ADVPROBE.DEF`. **Ready** indicates the ADV is properly installed and operational. **Fail** indicates that the processing module was not found or that it failed an internal test.

Upon startup, `ADF.EXE` runs a built-in test on the ADV defined in the probe definition file. The program displays this information on the screen, but does not try to communicate with the ADV until after you execute **START Data Acquisition**. At that time, the program tries to wake up the ADV and send your data collection parameters. While this is being done, the program displays and records (in a file named `ADF.LOG`) all commands sent to the ADV.

The left of the screen shows the data collection parameters you can set. To change these parameters, move through the menu using the up/down arrow (or PgUp/PgDn) keys. The highlighted item can be executed/changed by pressing <Enter>. After pressing <Enter>, you are prompted to enter a new value or to choose from a set of alternative values. If you accidentally select an option, you may recover by pressing <Esc> to leave the parameter unchanged. A description of each item in this menu follows.

Units System   (Multiple choice)
Sets the units displayed as **Metric** (cm/s, cm, °C) or **English** (ft/s, inches, °F). This also affects the units extracted from the binary data file using the data conversion software (Section 3).

Water Temperature / Salinity (Enter value)
Temperature and salinity are used to calculate the speed of sound, which determines the scale factor used to convert the Doppler shift to velocity. You can enter temperature in °C or °F, depending on the selected *Units System* (-2 to 50°C; 28 to 122°F). Salinity is entered in parts per thousand (0 to 60 ppt). See the *ADVFie ld Principles of Operation* for information about the effect of sound speed on ADV velocity measurements.

Speed of Sound   (Derived value)
The speed of sound in water is shown in the menu for information purposes only. It is computed from the user-input values of temperature and salinity and cannot be changed.

Sampling Rate   (Enter value; 0.1 to 25 Hz)
ADV velocity measurements are vector-averaged internally and output at this rate. If recording is selected, this rate also determines the rate at which data are recorded.

Velocity Range   (Multiple choice)
The statistical uncertainty (noise) of ADV velocity measurements is approximately proportional to the maximum velocity that the ADV can measure. As such, we recommend you set the ADV's velocity range to the minimum value that covers the range of velocities expected in a given experiment. The velocity range for the 16/10-MHz ADV probe can be set to either ±3, ±10, ±30, ±100, or ±250 cm/s (±0.1, ±0.3, ±1.0, ±3, ±8 ft/s). The velocity range for the 5-MHz ADVOcean probe can be set to ±5, ±20, ±50, ±200, or ±500 cm/s (±0.2, ±0.5, ±2, ±5, ±20 ft/s). See the *ADVField Principles of Operation* for more details about velocity range.

External Synchronization (Multiple choice)
You can synchronize the ADV with either an external data acquisition system or a remote trigger through the SyncIn line provided in the processing module. You can set external synchronization to the following three modes (see *ADVField Operation Manual* for details).

- **DISABLED** - The state of the SyncIn line is ignored.
- **START ON SYNC** - The ADV waits for the first sync pulse to start data collection.
- **SAMPLE ON SYNC** - The ADV waits for a sync pulse to trigger the start of each successive sample. The ADV does **not** record an accurate time stamp with each sample when using this option.

Coordinate System   (Multiple choice)
This determines the coordinate system used for the display and recording of ADV velocity data. **XYZ** specifies the Cartesian coordinate system relative to probe orientation. **ENU** (East-North-Up) specifies an Earth coordinate system that is independent of probe orientation. **ENU** can be used only on systems with the optional compass/tilt sensor. When using **ENU**, be sure that the compass is correctly installed and the probe is correctly oriented with respect to the compass. Incorrect installation can result in corrupted data. See the *ADVField Operation Manual* for details.

Recording Mode   (Multiple choice)
This determines the mode for recording ADV velocity data to the computer disk. Two keys affect data recording in data acquisition mode: Ctrl+Q and Ctrl+S. The effect of these keys depends on the recording mode: **CONTINUOUS** or **BURST** (described below).

Samples per Burst   (Enter value)
This determines the number of samples recorded per burst when using the **BURST** recording mode. This parameter is ignored when using the **CONTINUOUS** recording mode.

CONTINUOUS Recording Mode: In continuous mode, the ADV begins to record data upon starting data collection and will continue to record data until stopped by the operator. Pressing Ctrl+S will stop data recording to the disk, but the system will stay in the data acquisition mode and continue to display real-time data. During this period, the status window at the bottom of the screen will flash **NOT RECORDING**. Pressing Ctrl+Q will restart recording to the same file.

Note: The time stored by the ADV will **not** show the correct time when stopped and started. If data collection is stopped and restarted, the only indication within the data file is that the event counter will be incremented by 10 (see ¶2.4).

BURST Recording Mode: In burst mode, the ADV begins to record data upon starting data collection and will record the number of samples specified by *Samples Per Burst* (SPB). After recording SPB samples, the software will continue to display real-time velocity data, but will **not** record data to disk. During this period, the status window will flash **NOT RECORDING**. You can start another burst by pressing Ctrl+Q, at which point the ADV will start recording data until the SPB samples have been recorded. Recording will then stop, but continue to show the real-time display. There is no limit to the number of bursts per file that can be recorded.

Note: In burst mode, the ADV does **not** record the exact timing for each sample after the first burst. Later bursts will show a time relative to the start of the file that does not account for the period during which data were recorded. The event counter in the ADV data file is incremented by 10 at the start of each burst (the first burst starts at 0).

Pressing Ctrl+S while a burst is being recorded stops data recording, but the system stays in the data acquisition mode and continues to display real-time data. (Note: This will change the number of samples recorded in that burst.) Subsequently pressing Ctrl+Q starts the recording of another burst. The start of each burst increments the event counter by 10.

In any recording mode, you can stop data collection completely by pressing Alt+F10, and then confirming "Yes" from within the multiple choice window. This exits the data acquisition mode and returns you to the setup mode.

Record To File (Enter filename)
This item assigns a disk file for recording ADV data. Several checks ensure that a valid filename is given, the file can be created, and an existing file is not accidentally overwritten. If, after assigning a recording file, you want to turn off recording, do not enter a response to the filename prompt. The file name must be entered without extension; all ADV data files use the extension `.ADV`. (Note: This option is disabled if the automatic file recording has been enabled, see ¶2.2). File names must follow DOS conventions and are limited to a maximum of eight characters.

File Comment 1 / 2 / 3 (Enter text)
These items permit you to enter up to three 60-character lines of text, which will be included in the data file for documenting the data set.

START Data Acquisition (Press ENTER to execute)
When satisfied with all data collection parameters, press <Enter> on this item to start data acquisition. The program initializes the ADV and enters the boundary adjustment mode.

EXIT (Press ENTER to execute)
Pressing <Enter> on this item terminates the program and returns to DOS. On exiting, the program saves the current values of all menu parameters (except the recording file) so that they need not be re-entered each time the program is run.

2.4.   Boundary Adjustment Mode

Figure 3 shows the boundary adjustment screen. In boundary adjustment mode, the ADV continuously scans the region in front of the probe to detect the presence of a solid or surface boundary. The screen displays the probe number from the probe definition file (**ADVPROBE.DEF**), the distance from the tip of the probe to the boundary, the distance from the center of the sampling volume to that boundary, and the velocity range setting (see below). If no boundary is detected, it displays **NOT DETECTED**.

The ADV can typically detect a boundary within 25 cm for the 16/10-MHz ADV or 50 cm for the 5-MHz ADVOcean. Boundary information is useful for positioning the probe near the surface or a solid boundary. The distance measurements are accurate to about ±1 mm for the 16/10-MHz ADV and ±2 mm for the 5-MHz ADVOcean.

The boundary adjustment mode is necessary because the ADV must adjust its operation to prevent boundary reflections from interfering with signals from the sampling volume. Under some conditions, the presence of a boundary too close to the sampling volume may force the ADV to reduce the user-selected velocity range. For this reason, the effective velocity range is also shown on the screen. See the *ADVFeld Principles of Operation* for more information about boundaries and the velocity range setting.

From this mode, you can proceed to the data acquisition mode by pressing <F10>, or go back to the setup mode by pressing <Esc>. The program may take a few seconds to respond.
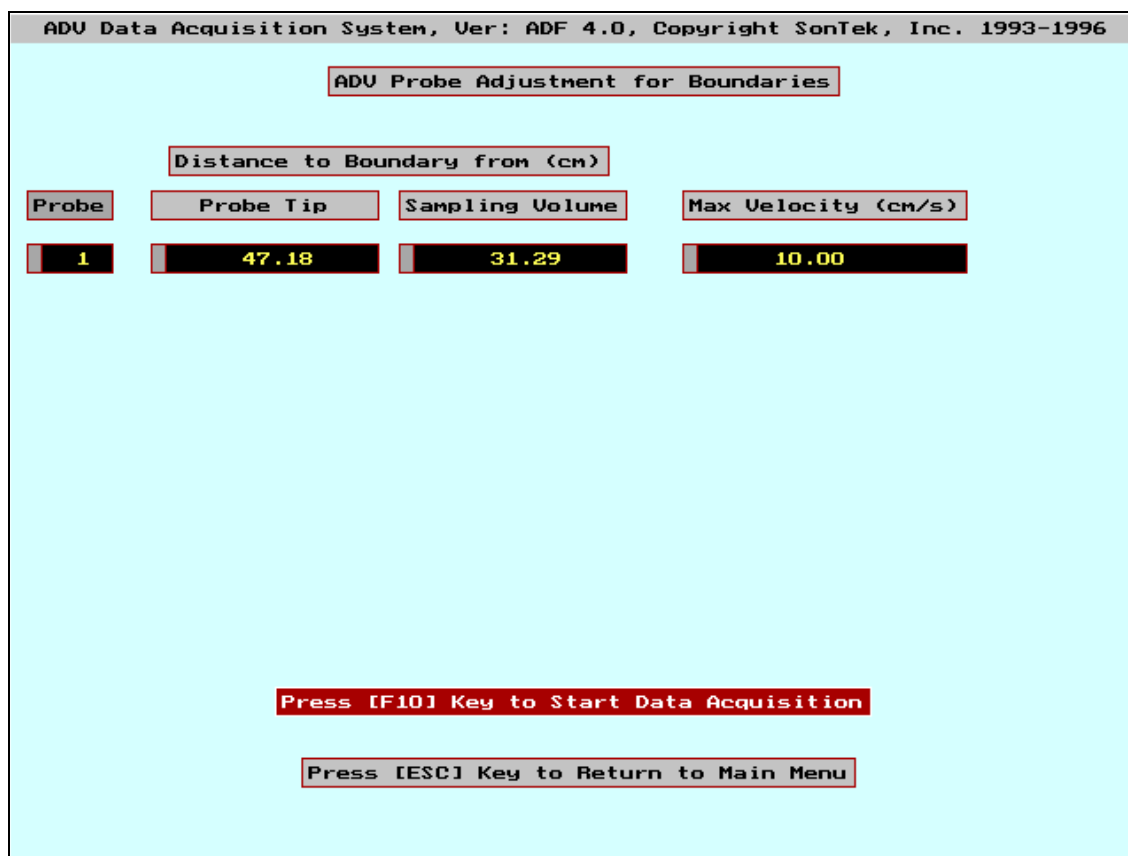

Figure 3 - Data Acquisition Software "Boundary Adjustment Mode"

2.5.   *Data Acquisition Mode*

Figure 4 shows the data acquisition screen. After completing the boundary adjustment by pressing <F10>, the data acquisition software shows the real-time display screen. It then waits for you to press <Enter> before starting data collection. The extra step of pressing <Enter> has been included to provide precise timing for the first data sample, independent of computer speed. After <Enter> is pressed, the ADV begins collecting the first data sample within a few milliseconds if external synchronization is **DISABLED**. If external synchronization is **ENABLED**, the ADV will wait for the first sync pulse before starting data collection.

The data acquisition screen is divided into four sections. The top displays information on the status of data acquisition. Below this, the tabular data section displays values of velocity and diagnostic data. The middle presents real-time plots of SNR, correlation, and velocity data. The bottom shows which keys are active during data acquisition and their functions.

Status Information

The status information is updated after each sample, but not more than once per second.

Recording To File
The file in which data are being recorded. If recording is disabled, **NOT RECORDING** is displayed.

File Size / Disk Space / Recording Time Left
These fields display information only if recording is enabled. **File Size** shows the current size of the data file in KB. **Disk Space** displays the amount of space left on the disk on which the data file resides. **Recording Time Left** tells you how many hours of data can be collected at the present rate before the disk becomes full.
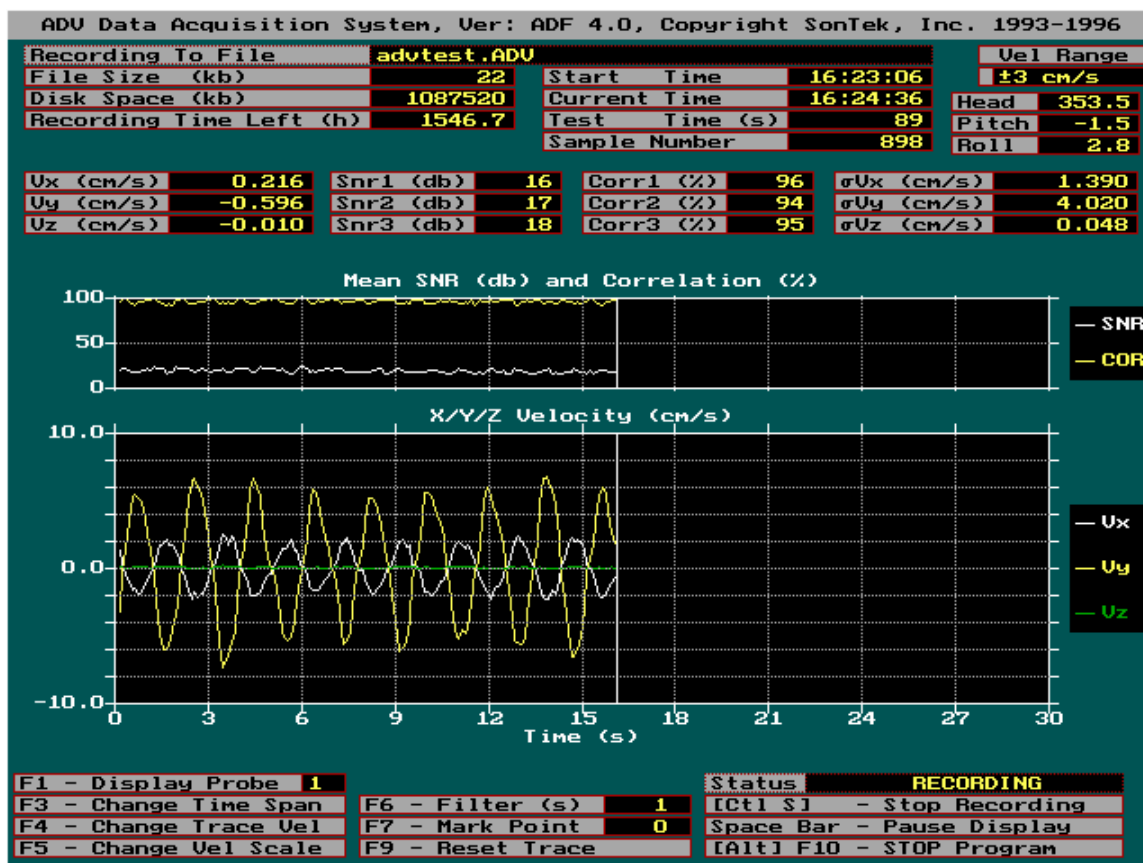

Figure 4 - Data Acquisition Software "Data Acquisition Mode"

Start Time / Current Time
These times are obtained from the computer's clock. **Start Time** is the time at which data acquisition was started (time of first sample). **Current Time** is the time of the last screen update (screen is updated with each sample, but no more than once per second).

Test Time
This is the total length, in seconds, of the velocity time series collected. It is derived from the ADV sampling clock rather than from the computer's clock.

Sample Number
The number of the last velocity sample recorded (if recording is enabled) or displayed (if recording is not enabled).

Vel Range
The current velocity range setting.

Heading / Pitch / Roll
These windows display data from the optional compass/tilt sensor (heading, pitch, and roll). Data are displayed in degrees and are updated with each sample or, at most, once per second.

Tabular Data

The tabular data display is updated after every sample, or no more than once per second. The values shown are the result of smoothing the ADV data with a recursive exponential filter with the time constant specified in the *Filter* selection (see Active Keys below). This filter allows you to set a time scale for estimating mean velocities from the display during data collection. This filtering process is only used for the tabular data display. It is **not** applied to the graphic display or to the recorded data.

If the display is paused (see Space Bar below), the smoothed data values are replaced by the unfiltered ADV data values for the last sample (except for standard deviations, which retain the filtered data).

Vx / Vy / Vz or E / N / Up
These are the smoothed / last values of the three velocity components in units corresponding to the units system selected in the setup mode (cm/s or ft/s), using the coordinate system specified in the setup mode (**XYZ** or **ENU**).

SNR1 / SNR2 / SNR3
These are the smoothed / last signal-to-noise ratio (SNR) measured at each of the three receivers. The values are given in dB.

Corr1 / Corr2 / Corr3
These are the smoothed / last values of the correlation coefficient for each of the three receivers. The values are given as a percent, where 100 means perfect correlation.

σVx / σVy / σVz
These are the standard deviations of the three velocity components within the time scale defined by the filter time constant. They may be useful as an indicator of turbulence or wave orbital velocities. The units are in cm/s or ft/s, depending upon the setting in the setup mode.

Graphical Display

The main portion of the screen displays two plots. The upper plot represents the mean value for signal-to-noise ratio (SNR) from the three receivers (in dB) and the mean value for correlation for the three receivers (percent). The lower plot is the time-series of the three velocity components. Both graphs are plotted left to right against time. A vertical bar identifies the current (most recent) point. If the full span of the plot is reached (right end), plotting resumes on the left side.

If the ADV has the optional pressure sensor installed, the lower graph will include a fourth plot for pressure data. This pressure data is plotted in units of counts with the axis set to full scale (bottom of the plot corresponds to zero pressure, top corresponds to maximum pressure).

Active Keys

Several active keys (or key combinations) may be used during data collection. Note: Two of the keys (Ctrl+S and Ctrl+Q) affect data recording while the program is in the data acquisition mode.

F1 - Display Probe　　　(Multiple choice)
Not used by ADVField systems.

F3 - Change Time Span　(Multiple choice)
This key lets you change the time span of the real-time trace from several preset alternatives.

F4 - Change Trace Vel　(Multiple choice)
This key lets you change which velocity components are plotted. You can display all three components simultaneously or any single component.

F5 - Change Vel Scale　(Multiple choice)
This key lets you change the full velocity scale of the trace from several preset alternatives.

F6 - Filter　　　　　　(Multiple choice)
The data shown in the tabular display are filtered to allow you to estimate the mean data values over a time scale that is determined by the filter setting. <F6> allows you to change the filter time constant from several preset alternatives.

The filter used for the tabular display is a first-order recursive filter of the form:

$y(i+1)=y(i)*a+x(i+1)*(1-a)$; where $y(1) = x(1)$

and where x(i) are the individual data samples from the ADV (for velocity, signal-to-noise ratio, and correlation). The values y(i) are the mean values for each of these variables shown in the tabular display. The standard deviation of velocity data is calculated as:

$y2(i+1)=y2(i)*a+x(i+1)*x(i+1)*(1-a)$; where $y2(1) = x(1)*x(1)$;

$sqrt(y2(i+1) - y(i+1)*y(i+1))$

If *dt* is the sampling interval (1/sampling frequency), and *Nfilt* is the total number of samples within the filter width (Tfilt) (i.e., Nfilt=Tfilt/dt), then

$a = (Nfilt-1)/Nfilt.$

For example, for a 10-second filter when sampling at 25 Hz, a = 249/250. If a<0, a=0.

F7 - Mark Data Point   (executed when key pressed)

This key is active only when data are being recorded. Pressing <F7> marks the current sample so it can be easily located when the data are later analyzed. On the graphical plot, this mark is shown as a colored vertical bar. Each time <F7> is pressed, the event counter (shown to the left of the active key) is incremented by one (it starts at 0). If data are being recorded, the marked data point can be easily located in the data by the value of the event counter recorded with each sample (see Section 3). The event counter has a maximum value of 999 and will start over at 0 if incremented beyond this value.

Note: The event counter is incremented by 10 whenever data recording is stopped and started (using the Ctrl+S and Ctrl+Q keys described below).

F9 - Reset Trace   (key pressed)

This key resets the graphical plots. That is, the traces are erased and plotting proceeds from the left side.

Space Bar - Pause Display   (executed when space bar pressed)

Pressing the space bar will freeze the screen display. Pressing the space bar again will resume the display update. After a pause, there may be a discontinuity in the traces because data collected during the pause are lost for display. During a pause, the program is still collecting and recording data (if enabled).

Status

This is not an active key, but an indicator of the current state of the ADV. If external synchronization has been enabled, and the ADV is waiting for the first sync pulse, it will show **WAITING FOR SYNC**. If data collection has been started and recording has not been enabled, it will show **NOT RECORDING**. If data collection has been started, recording has been enabled, and data are currently being written to the computer disk, it will show **RECORDING**.

If data collection has been started, recording has been enabled, but data are not currently being written to the computer disk, it will show **NOT RECORDING** and will alternatively flash this portion of the display. This can occur during burst sampling when recording is stopped between bursts or during continuous sampling if recording has been turned off with the Ctrl+S key.

Ctrl+Q

This will start recording from within the data acquisition mode, and is most commonly used in burst recording mode (see ¶2.3). It can also be used when continuous recording has been stopped using Ctrl+S. Note: When the Ctrl+Q key is used to start data collection, the event counter is incremented by 10. The current value of the event counter is displayed next to **F7-Mark Point**.

Ctrl+S

This key stops data recording, but keeps the system in data acquisition mode. After pressing Ctrl+S, the software will continue to display real-time velocity data, but data will **not** be written to disk. See the description of continuous and burst recording modes (¶2.3) for more information.

Alt+F10 - Stop Program   (Confirm Yes/No)

To stop data acquisition, press the Alt+F10. You will then be prompted to confirm your intention to stop data collection. Data collection proceeds normally until the confirmation is given. Once stopped, the program returns to the setup mode.

2.6.   Recorded Data

The ADV data acquisition software records data in an efficient binary file format. <u>Note</u>: A different file format is used for autonomous data collection with the ADVField internal recorder. See the *ADVField Operation Manual* for a description of all data file formats.

At the start of data acquisition, the data acquisition software records several internal configuration settings, as well as the user-specified data collection parameters. In the boundary adjustment mode, the software records the last measured distance to the boundary. With each sample, the program records a binary record containing velocity data (three components), SNR data (three values, one for each receiver), correlation data (three values, one for each receiver), and the current value of the event counter. If the ADV has the optional compass/tilt, temperature, or pressure sensors installed, data from any of these installed sensors will also be recorded with each sample. All the information contained in these data files can be accessed by the data conversion programs discussed in Section 3.

Section 3. Real-Time Data Conversion (GET___.EXE)

The ADV real-time data conversion programs (known as the **GET** programs) extract specific portions of data from the ADV binary files and convert the data to easily read ASCII files. Data collected using the ADV internal recorder use a different file format (see Section 9). The following conversion routines are provided for real-time data files.

- **GETCTL** - Extracts file configuration and setup information
- **GETAMP** - Extracts signal amplitude data
- **GETCOR** - Extracts correlation data
- **GETHPR** - Extracts optional heading, pitch, and roll data
- **GETSEN** - Extracts optional sensor data - heading, pitch, roll, temperature, and pressure
- **GETSNR** - Extracts signal to noise ratio (SNR) data
- **GETVEL** - Extracts velocity data

If the name of any of these programs is entered by itself, the program displays information on its use and a description of the parameters specified on the command line. These programs can be run from any PC-compatible computer using the DOS operating system.

Be aware that the data conversion software will overwrite an existing file of the same name **without** prompting you for confirmation. Since the output files always use the same file name extensions, and normally use the same name as the binary data file, this is not usually a concern. If you modify any of the output files during analysis, be careful that the modified file is not accidentally overwritten when extracting other portions of the data.

3.1. *File Header Conversion (GETCTL.EXE)*

This program extracts the file configuration (i.e., "control") information stored at the beginning of each ADV binary data file. The following command syntax starts the **GETCTL** program.

```
GETCTL [ADV file] [output file]
```

File names must be given without an extension. **GETCTL** assumes the ADV data file has extension **.ADV**, and it assigns the extension **.CTL** to the output file. For example,

```
GETCTL WAVEDATA TEST
```

extracts the configuration information from binary file **WAVEDATA.ADV** and places the output in an ASCII file named **TEST.CTL**. If [output file] is not specified, **GETCTL** creates an output file with the same root name as the ADV data file. For example,

```
GETCTL WAVEDATA
```

extracts the configuration information to output file **WAVEDATA.CTL**. The output from **GETCTL** is in a self-explanatory ASCII text format.

3.2. *Data Sample Conversion (GETAMP, GETCOR, GETHPR, GETSEN, GETSNR, GETVEL)*

These programs extract different portions of the ADV data that are recorded with each sample. The following command lines can be used to execute any of these programs.

```
GET___ [ADV file]
GET___ [ADV file] [output file]
GET___ [ADV file] [output file] [probe #]
GET___ [ADV file] [output file] [probe #] [first sample] [last sample]
```

File names must be given without an extension. The programs assume the ADV binary data file has the extension **.ADV** and assigns the output file an extension based on the type of data being extracted (extensions are **.AMP**, **.COR**, **.HPR**, **.SEN**, **.SNR**, and **.VEL**). If no output file is specified, the programs assign the same root name as the binary data file.

<u>Note</u>: The [probe #] parameter is only used with ADVLab systems, which are not discussed in this document.

The [first sample] and [last sample] permit you to extract a limited portion of the data. If they are not specified, the programs extract all samples contained in the binary data file.

For example,

```
GETVEL TEST1 TEST 100 199
```

extracts the velocity data for samples 100 through 199 in the binary data file **TEST1.ADV** and sends the output to ASCII file **TEST.VEL**.

Similarly, the command

```
GETSNR TEST1 TEST
```

extracts the SNR data from all samples from binary data file **TEST1.ADV** and sends the output to ASCII file **TEST.SNR**.

These programs generate output files in a tabular ASCII format with one line per sample. With the exception of the programs **GETHPR** and **GETSEN** (which are discussed at the end of this section), the output files use the following format for each line.

```
T Event Probe# DATA1 DATA2 DATA3 Probe# DATA1 DATA2 DATA3
```

where T is the time in seconds from the start of the first sample, and Event is the value of the event counter (for marking points during the data file using <F7>) at the time the sample was collected. The rest of the line contains the probe number followed by its corresponding data. Table 2 summarizes the values and units output by the data sample conversion programs.

Table 2 . Conversion Programs Data Output Summary

Program	DATA1	DATA2	DATA3	UNITS
GETAMP	Amplitude Beam 1	Amplitude Beam 2	Amplitude Beam 3	Counts (1 count = 0.43 dB)
GETCOR	Correlation Beam 1	Correlation Beam 2	Correlation Beam 3	Percentage (0-100%)
GETSNR	SNR Beam 1	SNR Beam 2	SNR Beam 3	dB
GETVEL	Vx or Veast	Vy or Vnorth	Vz or Vup	cm/s or ft/s

The programs **GETHPR** and **GETSEN** extract data from the optional sensors on the ADVField. The first three values on each line are time (in seconds from the start of the file), event counter, and probe number. If the compass/tilt sensor is installed, both **GETHPR** and **GETSEN** extract heading, pitch, and roll (in degrees) as the next three data values. If either the temperature or pressure sensor is installed, but the compass/tilt sensor is not, **GETSEN** extracts temperature (in either °C or °F) and pressure (in either dBar or psi) as the next two data values. If compass/tilt, temperature, and pressure <u>are</u> installed, **GETSEN** extracts five data values in the following order: heading, pitch, roll, temperature, and pressure.

Some specific notes for the conversion programs are given below. For additional information about the different types of data, see the *ADVField Principles of Operation*.

- **GETAMP** - Retrieves signal strength from each of the three receivers in units of counts. One count is equal to 0.43 dB. If you are using signal strength data to estimate suspended sediment concentration, the signal amplitude should be used instead of SNR because changes in the electronic noise level may affect SNR data.

- **GETCOR** - Correlation is a data quality parameter that can be used to monitor the quality of velocity data and to edit data in post processing.

- **GETSNR** - Retrieves signal strength data from each of the three receivers as a signal-to-noise ratio (SNR) in dB. SNR is calculated from signal amplitude by subtracting the noise level and converting to units of dB. For high-frequency velocity measurements (i.e.; sampling at 25 Hz), SNR should be above 15 dB; and for mean velocity measurements (i.e.; sampling at 1 Hz), SNR should be above 5 dB.

- **GETVEL** - Velocity data are output in either the XYZ or ENU coordinate system, depending on the setting used during data collection. See the *ADVField Operations Manual* for more details about the ADV coordinate system. Velocity data are output in either cm/s or ft/s, depending on the selection specified in the data acquisition setup menu. See Section 2 for details about parameter settings during data collection.

Section 4. Hardware Diagnostics (ADFCHECK.EXE)

Included with the ADVField software is a diagnostic program (**ADFCHECK.EXE**) that can be used to verify ADV performance and identify most hardware problems. **ADFCHECK** is the same program used at SonTek during system testing. It provides you with a powerful tool for understanding and verifying system performance. We recommend you become familiar with **ADFCHECK** and use it on a regular basis during data collection. Checking the ADV before every experiment can identify problems that could cause the loss or corruption of data.

For ideal testing conditions, mount the ADV such that the probe is submerged in water with a boundary (surface, side, or bottom) within view. Ideally, the boundary should be placed 10-20 cm beyond the ADV sampling volume. **ADFCHECK** command line syntax is:

        ADFCHECK [com port] [output file]

The [com port] parameter is the communication port to which the instrument is connected (1 for COM1, 2 for COM2).

The optional [output file] parameter gives the file name to which signal strength profiles will be written. If no output file is specified, **ADFCHECK** will not record the profile data. The output file uses a tabular ASCII format with four columns. The first column is the sample location in ADV timing units. The next three columns are the signal strength (in ADV signal strength counts) for the three receivers at that location. See ¶4.1 for a description of ADV units.

This program can be run continuously. You do not need to turn off the computer or shut down the program when replacing probes or connecting cables. Running this program while changing probes (10-MHz ADV only) is a good way to ensure the probe is properly installed.

See the ADV Principles of Operation for more information about the signal strength profiles.

4.1. Sample Program Output

The ADV sends a pulse of sound, and **ADFCHECK** plots the return signal strength for each of the three receivers as a function of time following the transmit pulse. The output plot shows several features: increased signal strength in a bell-shaped curve corresponding to the sampling volume, a sharp spike from the boundary reflection if within range, and signal leveling to the electronic noise level. The display is updated every 1-2 seconds and each plot is the average of a number of samples. Figure 5 shows an example of this output using data from a 10-MHz ADV with a 5-cm distance to the sampling volume.

The horizontal axis is given in ADV timing units – time corresponds to the distance from the transmitter where the return signal is generated. One count on the axis corresponds as follows:

     5-MHz ADVOcean Probe: 1.2 mm
    10-MHz ADV Probe: 0.6 mm
    16-MHz MicroADV Probe: 0.375 mm

The vertical axis is given in ADV signal strength units. These are the same units output by the data conversion program **GETAMP.EXE**. One count for signal strength is equal to 0.43 dB.
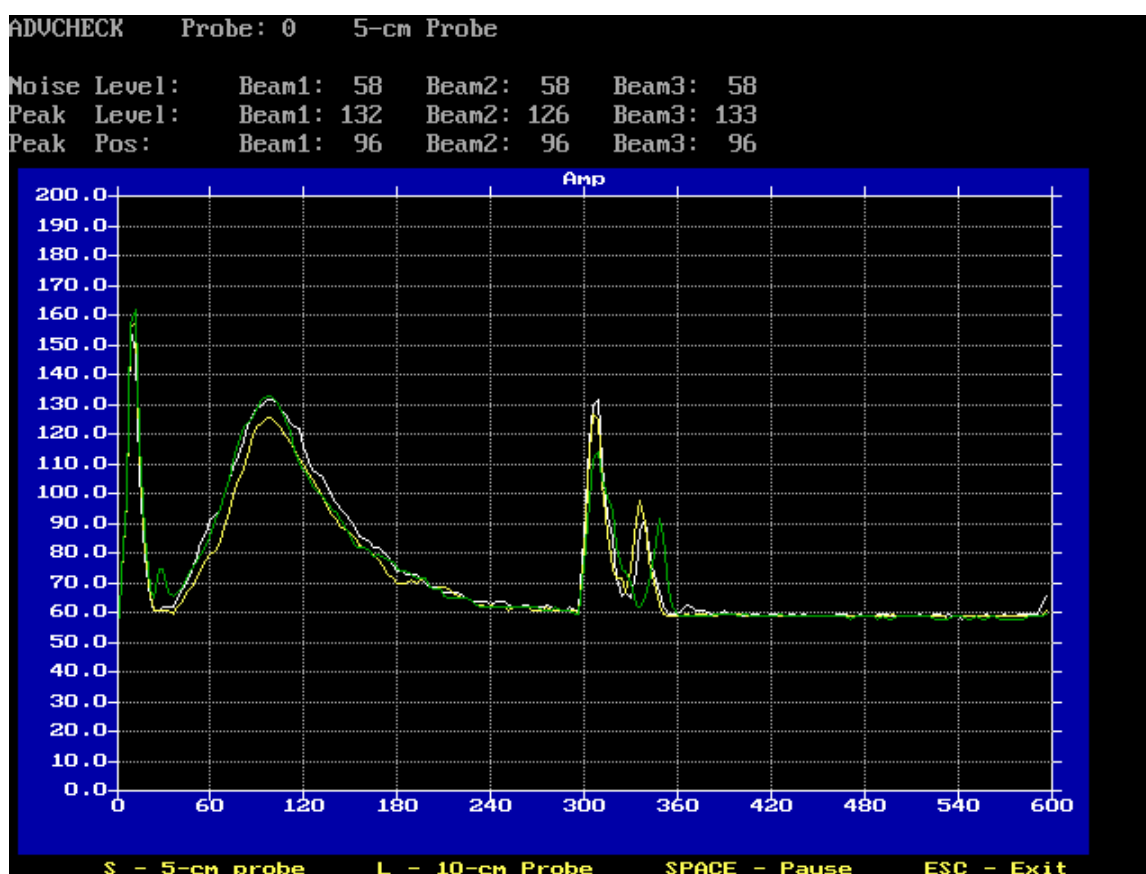
Figure 5 – ADFCHECK Display

Several important features can be identified in Figure 5. Each of these is described below, starting at the left side of the plot.

- The first ≈20 counts of the horizontal axis shows "ringing" following the transmit pulse. The transmit pulse is generated by a strong electrical signal and requires time for the electronics and transducers to recover.

- When there is sufficient scattering material in the water, there will be an increase in signal strength in a bell shaped curve that corresponds to the transmit pulse passing through the focal point of the receivers. The peak of this curve corresponds to the center of the sampling volume. The exact location of the center of the sampling volume depends on the exact probe geometry. For the 10-MHz ADV, the peak is typically located at 90-105 counts for 5-cm probes, and at 175-195 counts for 10-cm probes. For 5-MHz ADVOcean probes, the peak is typically located at 140-160 counts. All three receivers should see the peak in the same location, although there will be variation in the height and shape of the curve. It is possible to calculate the signal to noise ratio (SNR) from the height of this curve and the noise level (see below). For the example in Figure 5, the mean height of the curve is about 130 counts and the noise level is about 58 counts. SNR is then calculated by (130-58)*0.43, or about 31 dB.

- If the ADV is reasonably close to a boundary (bottom, surface, or side), a sharp reflection should be seen in **ADFCHECK**. The size and shape of this reflection will vary depending on the nature of the boundary, its distance from the ADV, and the acoustic conditions of the water. We can estimate the distance from the probe to the boundary by the location of the front edge of the boundary reflection. In Figure 5, this occurs at about 300 counts or 18 cm from the

probe tip (this example uses a 10-MHz ADV probe). In normal conditions, a 16/10-MHz ADV can detect the boundary at a range up to about 25 cm, while the 5-MHz ADVOcean can detect the boundary at a range up to about 50 cm.

- After the boundary reflection, the signal strength flattens out in the region where there is no reflected signal from the water. The value at which it flattens out is the electronics noise level. For the ADVField, this level is typically 50-60 counts; for the ADVOcean it is typically 60-70 counts. An easy way to measure the instrument noise level is to run **ADFCHECK** when the probe is not in the water. In this case, the entire plot should show a constant return (after the transmit pulse ringing) at the instrument's noise level.

When using **ADFCHECK**, it is important to understand that the output plot will show considerable variation because of the highly variable nature of the acoustic scattering. The shape and height of the return signal, particularly the bell curve for the sampling volume, will show considerable variation between updates. When using the program for diagnostics, look at the general shape of the curve and for features that are consistently present.

The bottom of the screen shows which keys are active during program operation. Each of these keys is described below.

- S - 5-cm Probe - The program uses a simple algorithm to locate the peak of the sampling volume. For this algorithm to work, the program must know what type of probe is being used. Pressing <S> tells the program that a 10-MHz ADV with a 5-cm distance to the sampling volume is being used. If the probe type is not correctly specified, the peak position and level shown at the top of the screen will not be correct.

- L - 10-cm Probe - Pressing <L> tells the program that a 10-MHz ADV with a 10-cm distance to the sampling volume is being used.

- O- ADVOcean Probe - Pressing <O> tells the program that a 5-MHz ADVOcean with an 18-cm distance to the sampling volume is being used.

- SPACE - Pause - Pressing the space bar will pause the program display; pressing any key resumes the display updates.

- ESC - Exit - Pressing the escape key will exit the program; note that the program takes a few seconds to terminate.

The top of the screen displays a tabular output of diagnostic parameters for each of the three acoustic receivers. The information shown for each receiver is described below. Note: Peak level and peak position will not be correct if the probe type has not been correctly specified using the <S>, <L>, or <O> keys described above.

- Noise Level - This gives the electronics noise level for each receiver, determined by the signal strength when the ADV is not receiving any return reflection from the water. This should match the signal strength for the flat portion of the graph beyond the boundary.

- Peak Level - This is the height of the peak for the sampling volume for each of the three receivers. This will vary depending upon the amount of scattering material in the water.

- Peak Pos - This is the location of the center of the peak for the sampling volume for each of the three receivers. The position should be about the same for each receiver; variations of up to about five counts are typical.

Included with each ADV is a calibration sheet that shows the results from the factory calibration. One portion of this sheet includes values for noise level, peak level, and peak position during the factory calibration. The values for noise level and peak position should match those shown on the calibration sheet to within about five counts.

4.2.   Diagnosing Hardware Problems

ADFCHECK can be used to detect almost any problem that can occur with an ADV. This section describes the program output for some of the most common situations. When appropriate, figures showing the program output are included.

Case A: Signal conditioning module not connected
If the high-frequency probe cable is not connected to the ADV processing module, the program shows zero signal strength across the entire profile for all three receivers. This appears as a blank graph in **ADFCHECK**, although there may be some noise at low signal strengths (less than 30 counts). This can also occur if the high-frequency cable has been damaged.

Case B: Probe not connected
This situation can occur after changing probes (for 10-MHz ADV probes only) and appears as a flat response in all receivers after the initial transmit pulse ringing (no change for the sampling volume or boundary reflection). The signal strength in the flat area will be 10-15 counts lower than the normal noise level. We recommend running **ADFCHECK** while replacing probes, to be certain the probe is properly connected. Be aware that this situation can be confused with a faulty transmitter (case D).

Case C: Weak scattering (Figure 6)
If there is insufficient scattering material (i.e.; very clear, quite water), the peak normally seen around the sampling volume will be small or non-existent. This situation can be confused with a malfunctioning transmitter (case D) unless the bottom is in view of the probe.

Case D: Malfunctioning receiver(s) (Figure 7)
The signal from each receiver should have about the same strength as the sampling volume. If the differences exceed 10-20 counts, clean off the each transducer and make sure the beams are not physically blocked before calling the factory.

Case E: Malfunctioning transmitter (Figure 8)
This appears as a flat response with signal strength at the normal noise level. This can be confused with a disconnected probe (case A) or weak scattering (case C). Note the absence of a boundary reflection to distinguish this from Case C.
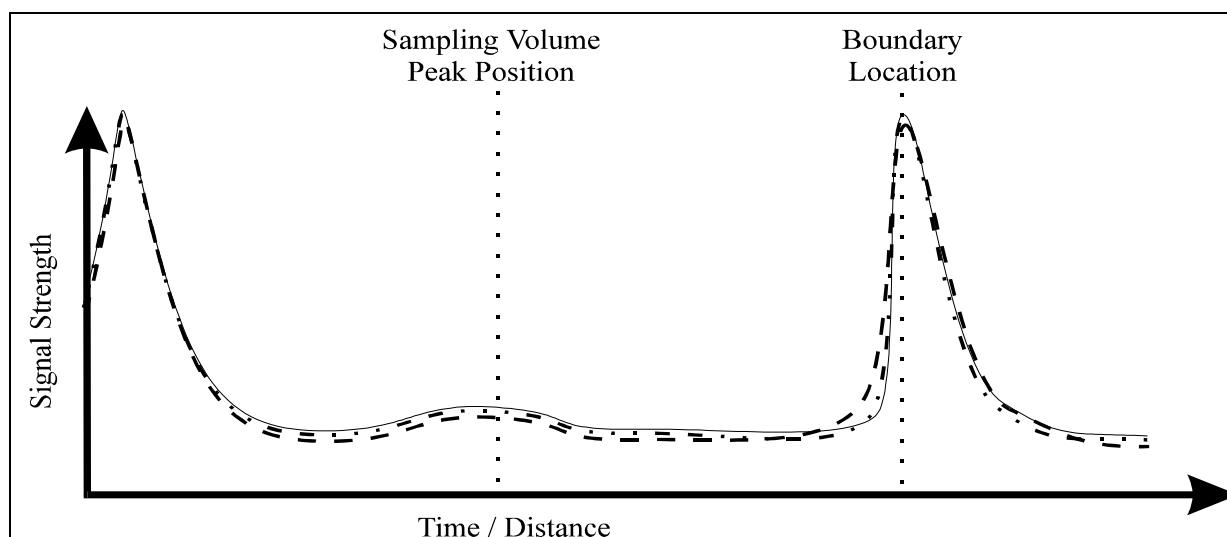
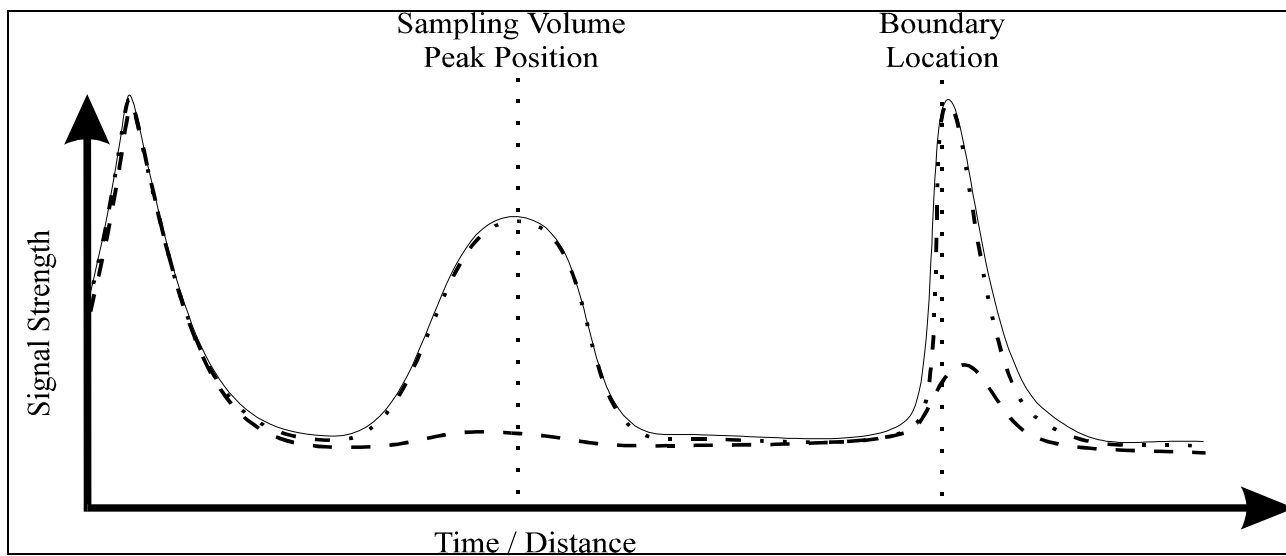**Figure 6 - ADFCHECK with Low Scattering Strength**

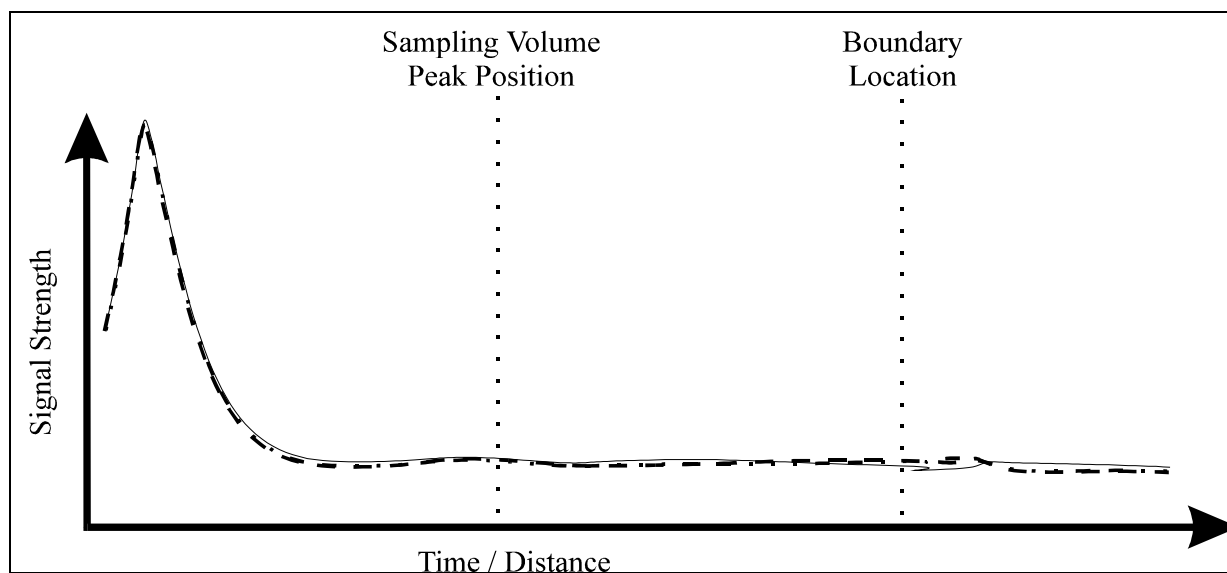**Figure 7 - ADFCHECK with Malfunctioning Acoustic Receiver**

Figure 8 - ADFCHECK with Malfunctioning Acoustic Transmitter

Case F: Damaged receiver arm (Figure 9)

If the sampling volume in one receiver is offset along the horizontal axis, the receiver arm has been physically bent. Often, bent probes can be repaired quickly and inexpensively by unbending the arm and recalibrating the probe. Contact SonTek if you have a damaged probe for details about repair options.

Case G: Excessive noise

If the noise is more than 10 counts above its normal level, it may be a sign that something is wrong with the probe, the signal-conditioning module, or the cable. The noise level may also be higher than normal because of external (electromagnetic) interference, or because water has condensed on the receiver electronics. Coil any extra high frequency probe cable to minimize the noise and keep the electronics dry by putting a fresh bag of desiccant inside the conditioning module.

Case H: High signal strength past the boundary (Figure 10)

If the signal strength does not fall off rapidly past the boundary, the additional acoustic noise can potentially increase the noise in velocity measurements. This additional acoustic noise is most commonly seen in small tanks, particularly when built from acrylic or glass. To improve the situation, cover the boundary with a piece of cloth, a rubber mat, or a sheet of acoustically absorbing material.
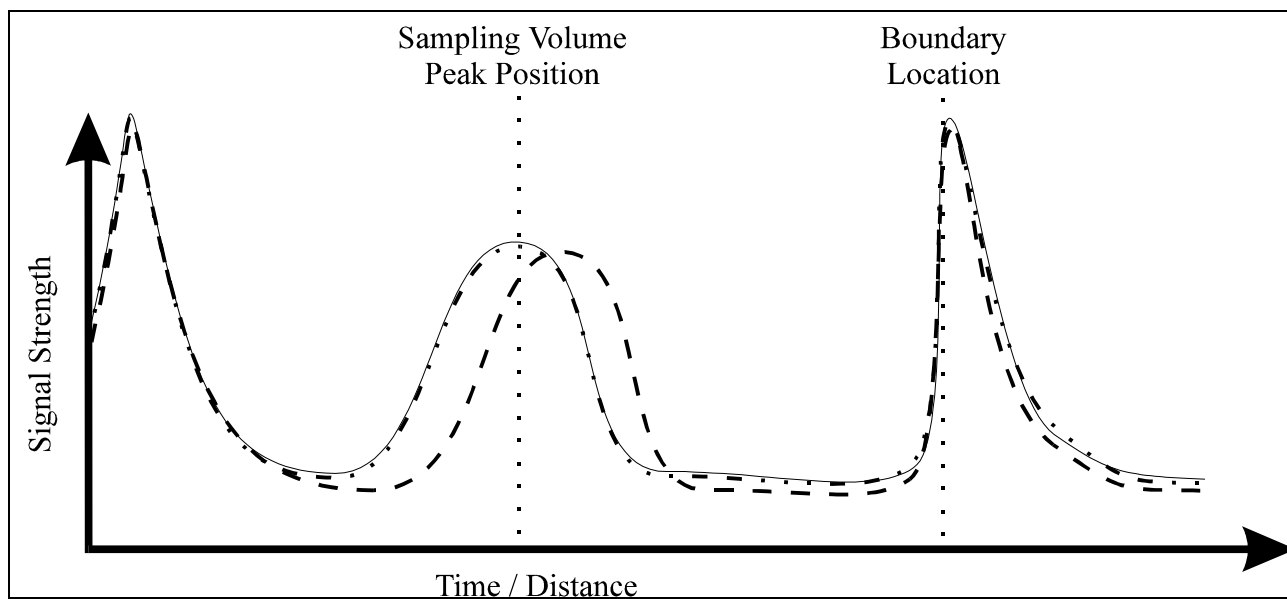
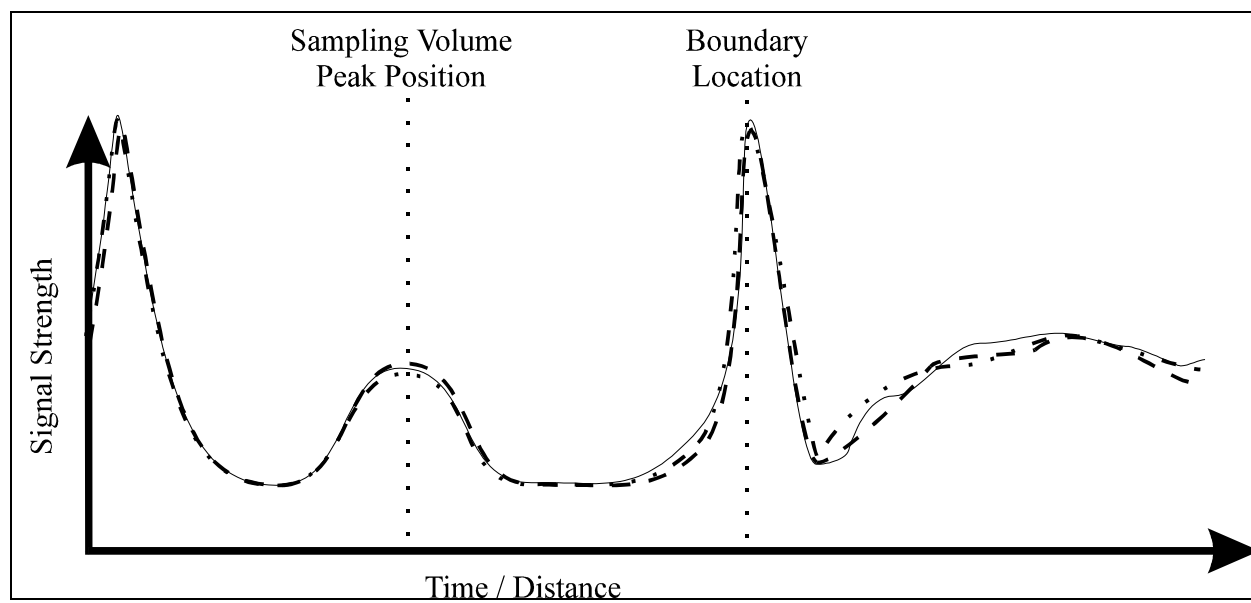**Figure 9 - ADFCHECK with Bent Receiver Arm**

Figure 10 - ADFCHECK with Excessive Acoustic Noise in Tank

Section 5. Analog Output Calibration (ADFCALAO.EXE)

All ADVField systems generate analog output voltages. The analog outputs include three lines for the three velocity components, and one line proportional to the mean signal amplitude. Sampling these voltage lines with an external analog data acquisition system provides an alternative means of recording ADV data. When possible, we recommend using the digital velocity data as this provides improved resolution (avoiding a digital-to-analog-to-digital conversion) and additional diagnostic data (three signal amplitude and three correlation values). See the *ADVField Operation Manual* for detailed information about the analog output voltages.

The ADV software includes a program (**ADFCALAO.EXE**) for calibrating the analog output voltages. Calibration of the analog outputs is required to compensate for minor changes in the output voltage levels caused by cables and temperature fluctuations. To run the calibration program, type the following command at the DOS prompt.

```
ADFCALAO [com port]
```

The [com port] parameter is the communication port to which the instrument is connected (1 for COM1, 2 for COM2).

ADFCALAO accesses the ADV and forces all analog outputs to their low, mid, or high-level voltages. The low voltage corresponds to maximum negative velocity; mid to zero velocity; and high to maximum positive velocity. The operator sets the level by simply pressing the L, M, or H key. After pressing one of these keys, the program will set the analog outputs of the ADV to the corresponding level, so the actual output voltage can be measured by a data acquisition system or a precision voltmeter. See *ADVField Operation Manual* for details on applying the output voltage calibration.

To exit the program, press <Esc>.

Section 6. Compass Calibration (COMPCAL.EXE)

A program (**COMPCAL.EXE**) has been provided that lets you calibrate the optional compass/tilt sensor. Calibration minimizes the effects of ambient magnetic fields on compass data. We recommend you perform a compass calibration before each ADV deployment.

COMPCAL gives a graphical display of instrument orientation that can be used to ensure the compass and tilt sensors are functioning correctly. To run the calibration program, make sure the instrument is powered up and connected to a computer serial port. Here is the command syntax.

        COMPCAL [com port] [baud rate]

The [com port] parameter is the communication port being used on your computer (i.e.; 1 for COM1, 2 for COM2); [baud rate] is the ADP communication rate (9600 is the default).

Once started, **COMPCAL** shows a graphical display of compass orientation. At this point, the compass is not in calibration mode; it is in a monitoring mode where instrument orientation is output in real-time. The graphical display provides three perspectives. To the right is a compass that indicates the direction the X-axis is pointing. To the left are tabular and graphical displays of pitch and roll. In the center is a 3D box with an X on the side corresponding to north. When this side is facing into the screen, the instrument X-axis is facing north.

To begin the calibration, press <F1>. **COMPCAL** will put the compass in calibration mode, the display will resume, and instructions are provided for instrument rotation at the bottom of the screen. The calibration procedure involves rotating the ADV slowly through two complete circles while varying the pitch and roll as much as possible. Each turn should take about one minute; the exact starting and ending orientations are not important.

To end the calibration, either press <F1> again (to remain in the graphical display) or press <Esc> to exit with the calibration results. Pressing <Esc> at any time will exit the program and display the results of the most recent calibration. See the *ADVField Operation Manual* for more information about compass calibration and for information on how to interpret the calibration score.

Section 7. Terminal Emulator (SONTERM.EXE)

SONTERM is used for direct communication with the ADV through a computer serial port. Direct communication can be used to verify all aspects of system operation and to initiate autonomous deployments (see the *ADVField Operation Manual* for details). To establish direct communication with the ADV, simply connect the cable from the instrument to COM1 on your computer, run **SONTERM**, and press <Alt-B> to send a **BREAK** to establish communication.

SONTERM displays user commands in yellow type, and instrument output in blue type. There are several active keys for special functions within **SONTERM**; these are shown in Table 3. One function, Alt-S, enables you to change communications settings; details of this are shown in Table 4. The default settings match the default communication parameters of the ADV.

Table 3. SONTERM Function Keys

Key	Function
Alt-B	Sends a **BREAK** over the serial port. This involves holding the input data line high for a period of 500 ms. A **BREAK** causes the ADV to terminate any ongoing operations and enter the command mode.
Alt-F	Open or close a log file. If no log file is currently open, the program prompts you to enter a file name. Everything that appears on the screen will be written to this file. If a log file is currently open, this function closes the file. At start up, no log file is used. Confirmation is required before the program will overwrite an existing log file.
Alt-C	Loads commands from an ASCII file. You are prompted to enter the file name. The file specified should be an ASCII text file with each line containing one command for the ADV. The program reads the commands from the specified file and sends them, in order, to the ADV. This is useful to ensure that a precise series of commands are sent to the ADV.
Alt-S	Sets communication parameters, such as port number and baud rate. See the table below for details.
Alt-X	Exit the program.

To change communication parameters within **SONTERM**, press <Alt-S>. This displays a menu that lets you select the communication port, baud rate, parity, number of data bits, and number of stop bits. The default baud rate is 9600 baud; this can be changed using hardware switches in the processing module (see the *ADVField Operation Manual*). The other default communication parameters are no parity, 8 data bits, and 2 stop bits. Table 4 shows the keys that set the values for these parameters. When the desired parameters have been set, press <Esc> to return to normal **SONTERM** operation. The most recent parameter settings are saved to the computer disk and used when running **SONTERM**.

Table 4. Changing Communication Parameters (Alt-S)

Parameter	Keystroke and Function		
Communication port	F1 – COM1	F2 – COM2	
Baud rate	1 – 300 2 – 1200 3 – 2400	4 – 4800 5 – 9600 6 – 19200	7 – 38400 8 – 57600 9 –115200
Parity	N – none E – even	O – odd H – high	L – low
Data bits	Alt-F7 – 7	Alt-F8 – 8	
Stop bits	Alt-F1 – 1	Alt-F2 – 2	
Defaults	D - Return all settings to default values (COM1, 9600 baud, no parity, 8 data bits, 2 stop bits)		

Section 8. Recorder Data Extraction (SONREC.EXE)

SONREC extracts data from the optional internal recorder to a computer disk. To learn about its operation, type **SONREC** at the DOS prompt. The command syntax is:

```
SONREC [com port] [baud rate] [extraction rate]
```

where

- `[com port]` is the serial port to which the ADV is connected (1 for COM1; 2 for COM2).
- `[baud rate]` is the communication baud rate setting of the ADV (default is 9600 baud).
- `[extraction rate]` is the baud rate at which data files will be retrieved from the recorder (default is 115200 baud).

For short cables, the default extraction rate of 115200 baud provides the fastest downloading time (about 4800 bytes per second). For longer cables, you may need to use a slower baud rate to ensure reliable communication. If the program encounters errors while retrieving data, it will terminate the retrieval.

Upon execution, **SONREC** wakes the ADV and establishes a direct link to the recorder at the extraction rate. **SONREC** then downloads a directory of the files stored on the recorder, which may take a few seconds. After the directory has been downloaded, **SONREC** shows a list of files currently stored on the recorder. The directory screen presents the following information.

- Number of files on recorder
- List of files including name, size, and date/time of creation
- Recorder size (bytes)
- Recorder free space (bytes)
- Baud rate used for data extraction
- Active keys and their function, as listed below
  - ESC - exit program
  - SPACE BAR - mark and unmark files for extraction
  - F3 - retrieve all marked files
  - DEL - format the recorder and erase all data

Use the up/down arrow keys or PgUp/PgDn keys to move between files. The space bar will mark and unmark one or more files for retrieval. Pressing F3 retrieves all marked files. **SONREC** prompts you to enter a destination path for the files; if no path is given, the current directory is used. While retrieving data files, **SONREC** displays its progress.

Pressing <Del> will format the recorder and delete all data files. Before the files are deleted, you are prompted to enter the complete word "Yes" for confirmation. Be certain that all data are backed up before erasing the recorder. Data cannot be recovered after formatting the recorder. Pressing <Esc> will exit the program.

Data files extracted from the ADVField internal recorder are automatically assigned the extension **.ADR**.

Section 9. Autonomous Data Conversion

The following ADVField autonomous data conversion programs extract and convert specific portions of the data from the binary files stored on the internal recorder to easily read ASCII files.

- **GADVCTL** - Extracts file configuration and setup information.
- **GADVHDR** - Extracts burst header and burst statistics data.
- **GADVTS** - Extracts time series data, including velocity and diagnostic parameters.
- **GADVLIST** - Extracts optional LISST sensor data.

Files stored on the recorder use a different format than those created using the real-time data acquisition software. The reasons for this are:

- More information is needed to describe ADV operation during autonomous deployments.
- The need to time-stamp data using the real-time clock. (In real-time mode, the software relies on the sampling clock used to determine sampling frequency, but this clock is too inaccurate for long-term autonomous deployments.)
- Support for temperature and pressure measurements.
- Minimization of storage requirements (i.e., data stored in binary format).

If the name of any of these programs is entered by itself, the program displays information on its use and a description of the parameters specified on the command line. These programs can be run from any PC-compatible computer using the DOS operating system.

Each time a new deployment is started (e.g., `DEPLOY` command), a new file is created on the recorder. The file name is constructed by appending a 3-digit sequence number to the deployment name specified with the `DEPLOYMENT` command. For example, if the deployment name is **WAVES**, the first time the `DEPLOY` command is used, a file named **WAVES001.ADR** will be created. If subsequent deployments are initiated with the same deployment name, new files will be created with increasing sequence numbers (i.e., **WAVES002.ADR**, **WAVES003.ADR**, …).

Be aware that the data conversion software will overwrite an existing file of the same name **without** prompting you for confirmation. Since the output files always use the same file name extensions, and normally use the same name as the binary data file, this is not usually a concern. If you modify any of the output files during analysis, be careful that the modified file is not accidentally overwritten when extracting other portions of the data.

9.1. *Extracting Setup and Configuration Data (GADVCTL)*

The **GADVCTL** program extracts the configuration information stored at the beginning of each autonomous ADVField data file. The output from **GADVCTL** is in a self-explanatory ASCII text format. The command syntax is:

```
GADVCTL   [ADV data file]  [output file]
```
File names must be given without an extension. The program assumes the autonomous ADV data file has extension **.ADR** and it assigns the extension **.CTL** to the output file. For example,

```
GADVCTL WAVES001 TEST
```
extracts the configuration information from **WAVES001.ADR** and places the output in an ASCII file named **TEST.CTL**. If [output file] is not specified, the program creates an output file with the same root name as the ADV data file. For example,

```
GADVCTL WAVES001
```
stores the configuration information into the output file **WAVES001.CTL**.

9.2. *Extracting Burst Data (GADVHDR)*

The **GADVHDR** program extracts the burst header and burst statistics data from an autonomous ADV data file. The command syntax is:

```
GADVHDR [ADV file] [burst type] [output file] [first burst] [last burst]
```

File names must be given without an extension. The program assumes the autonomous ADV data file has extension **.ADR**, and it assigns the extension **.HDR** to the output file.

If [burst type] is not specified, **GADVHDR** will extract data for burst type #1 (acceptable burst types are 1 through 3). See the *ADVField Operation Manual* for a description of multiple burst sampling. Data for only one burst type can be converted at one time.

If [output file] is not specified, **GADVHDR** uses the same file name as the data file. If [first burst] and [last burst] are not specified, it will extract data for all bursts. For example,

```
GADVHDR WAVES001
```

extracts all burst header and statistics data for burst type 1 from **WAVES001.ADR** and places the output in an ASCII file named **WAVES001.HDR**. As another example,

```
GADVHDR WAVES001 2 WAVES 10 50
```

extracts burst header and statistics data for burst type 2, bursts 10 through 50, from file **WAVES001.ADR** to file **WAVES.HDR**.

The output file displays one line for each burst. A series of lines forms a table that can be easily read by a variety of analysis programs. The following paragraphs describe the ADVField's autonomous deployment data structure.

9.3. *Recorded Data Structure*

Each deployment file contains two types of blocks. The first block in the file contains the hardware and setup configuration for the deployment. This configuration block is created immediately after you execute the DEPLOY command. This block contains a complete description of the ADV as well as the current settings for all parameters.

After the configuration block, the ADV records one data block for each sampling burst. These blocks contain the time-series samples collected during the burst as well as the date/time at the beginning of the burst and other miscellaneous data for the burst:

```
Configuration Block
Data Block for Burst 1
Data Block for Burst 2
 :    :    :    :    :
Data Block for Burst N
```

9.3.1. Configuration Block

The "configuration block" of the recorded data structure contains the following information:

- Hardware Configuration (24 bytes)
- Probe Configuration (164 bytes)
- Deployment Parameters (253 bytes)

See Appendix 2 in the *ADVField Operation Manual* for a complete description of the various formats of the output data generated by the ADVField during autonomous data collection.

9.3.2. Burst Data Block

Each "Burst Data Block" of the recorded data structure begins with a *Header Record* that contains the date/time at the beginning of the burst as well as a few parameters that describe the data contained in the block and the status of the ADV (built-in tests).

Following the *Header Record*, there are as many consecutive *Sample Records* as specified by the `SamplesPerBurst` command. If specified by the `RecordStat` command, an additional *Burst Statistics Data Record* is stored after the last sample record that contains the statistics for the burst.

- Header Record (60 bytes)
- Sample Record 1 (variable size depending on user-selected data recording options)
- Sample Record 2
-       :   :   :
- Sample Record <SamplesPerBurst>
- Burst Statistics Data Record (36 bytes)
- CTD Data Record
- Checksum

See Appendix 2 in the *ADVField Operation Manual* for a complete description of the various formats of the output data generated by the ADVField during autonomous data collection.

9.4.   Sample Records and Recorded Data Types

Due to the large amounts of data that can be collected by the ADV, we have provided several options for the types of data that are recorded with each sample. This lets you record only the data that are required, which can extend the maximum length of the deployment because deployments are typically limited by storage capacity. The selection of which data are recorded is done by setting the following command parameters.

- `RecordAmpCorr` – Records signal amplitude and correlation for each of the three beams with each sample.
- `RecordCompass` – Records compass, pitch, and roll with each sample (only if the optional compass/tilt module is installed).
- `RecordSensor` – Records temperature and pressure data with each sample (only if the optional temperature or pressure sensors are installed).
- `RecordExtSensor` – Records data from up to two external sensors with each sample. The data correspond to raw counts from a 12-bit AD converter.
- `RecordExtPress` – Records data from an external pressure sensor with each sample. Data are stored as a 3-byte integer representing the compensated pressure reading in millidBar.
- `RecordStat` – Records a single record at the end of the burst with the means and standard deviations of amplitudes, correlations, heading, pitch, roll, temperature, and pressure for the burst.
- `RecordCTD` – Records a single record at the end of the burst with the mean temperature, conductivity, pressure, and salinity measured by an external MicroCat CTD throughout the burst.
- `RecordLISST` – Records data from an optional LISST-100 sensor with each sample

See Appendix 2 in the *ADVField Operation Manual* for a complete description of the various formats of the output data generated by the ADVField during autonomous data collection.

9.5. *Extracting Time-Series Data (GADVTS)*

The **GADVTS** program extracts the time-series data from an autonomous ADVField data file. This includes all data recorded with each sample: velocity, signal amplitude, correlation, compass data (if enabled), and sensor data (if enabled). The command syntax is:

```
GADVTS [ADV file] [burst type] [output file] [first burst] [last burst]
```

File names must be given without an extension. **GADVTS** assumes the autonomous ADV data file has extension **.ADR**, and it assigns the extension **.TS** to the output file.

If `[burst type]` is not specified, it will extract data for burst type #1 (acceptable burst types are 1 through 3). See the *ADVField Operation Manual* for a description of multiple-burst sampling. Data for only one burst type can be converted at one time.

If `[output file]` is not specified, **GADVTS** uses the same root name as the data file. If `[first burst]` and `[last burst]` are not specified, it will extract data for all bursts. For example,

```
GADVTS WAVES001
```

extracts all time-series data for burst type 1 from **WAVES001.ADR** and places the output in an AS-CII file named **WAVES001.TS**. As another example,

```
GADVTS WAVES001 2 WAVES 10 50
```

extracts time-series data for burst type 2, bursts 10 through 50, from the file **WAVES001.ADR** to file **WAVES.TS**.

The output file format has one line for each sample. A series of lines forms a table that can be easily read by a variety of analysis programs. The number of values per line (and hence the number of columns per table) will vary depending on which recording options were enabled. The first two columns are always burst number and sample number within that burst.

Appendix 2 of the *ADVField Operation Manual* has a table that shows what type of data are extracted and in what order based on the selected recording options. A description of each type of data are also included in the appendix.

Section 10.   Probe Configuration Download (ADFSET.EXE)

The **ADFSET** program allows you to download a probe configuration file to the ADVField when operating from a PC-compatible computer using only a text interface (e.g., a palmtop computer). This may be useful when changing probes in the field with limited computer access. When operating the ADV from the direct command interface (e.g.; using a data logger), it is important to download the correct probe configuration file before starting data collection. If the wrong configuration file is used, velocity data will be corrupted. The command line syntax is:

```
ADFSET [com port] [conf. file]
```

The [com port] parameter is the communication port being used on the computer (1 for COM1, 2 for COM2). The [conf. file] parameter is the name of the probe configuration file to be downloaded to the ADV (e.g., **1102.PRO** when using probe serial number 1102). The probe configuration file must be located in the directory from which **ADFSET** is run.

After execution, **ADFSET** displays the series of commands sent to the ADV. It then shows the resulting probe configuration as output by the ADV, starts ADV data collection (leaving the ADV in data acquisition mode), and returns to the DOS prompt.

Section 11.   SonUtils Utility Software (Windows)

11.1. Overview

Upon startup, *SonUtils* displays the opening menu shown in Figure 11. From this menu, you can start the following programs.

- *Terminal* – Dumb terminal emulator (§11.2) [previously named *SonTermW*]
- *Compass* – Compass calibration (§11.3) [previously named *CompCalW*]
- *Recorder* – Internal recorder data extraction (§11.4) [previously named *SonRecW*]

Figure 11 – *SonUtils* Main Menu

11.2. Terminal – *Dumb Terminal Emulator*

Terminal is a terminal emulator used for direct communication with the ADVField. Note: This software was formerly named *SonTermW*.

- All major ADVField functions can be accessed from a terminal or terminal emulator.
- The ADVField uses a simple, text-driven command interface described in detail in the *AD-VField Operation Manual*.

The *Terminal* window is divided into several sections (Figure 12).

- The top-left area is used to set basic communication parameters.
- The middle-left area contains a few of the most used commands that can quickly be sent to the instrument with a click of the button.
- The large blue area at the upper right shows instrument output. The ADVField echoes all commands as they are received.
- The white area at the lower right is used for manually entering commands.
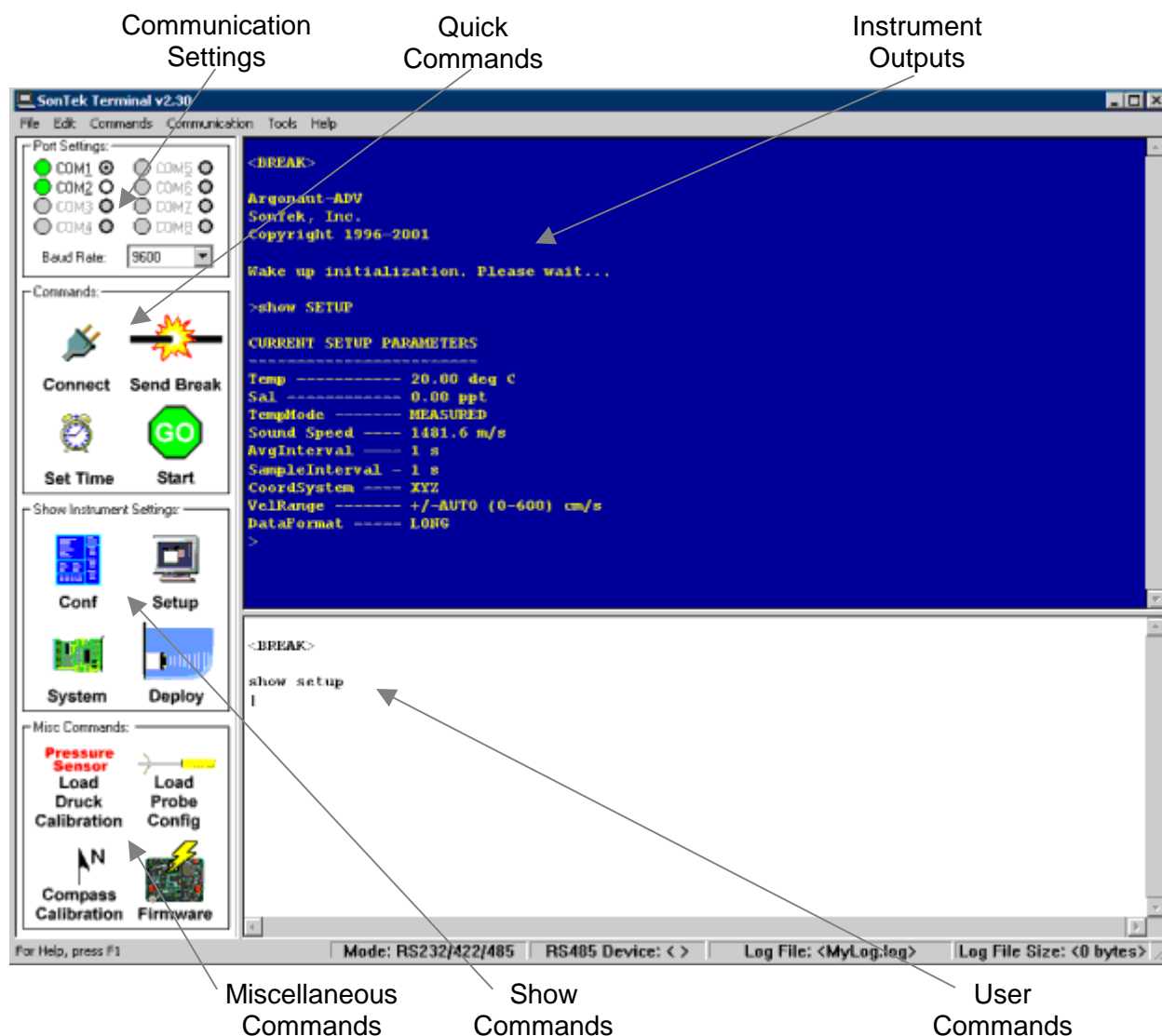
Figure 12 – *Terminal* (Dumb Terminal Emulator) Main Window

<u>Communication parameters</u>

- COM port and baud rate settings can be modified in the upper left area of the screen.
- Access to all communication settings (data bits, stop bits, etc.) can be set using **Communication|Settings** (Alt+S).

<u>Quick/Show/Misc Command Icons</u>

- **Connect** establishes software control of the PC serial port.
- **Send Break** sends a break (transmit line held high for >300 ms) to wake the system up and place it in command mode.
- **Set Time** opens a window with the PC date and time displayed. The user can press **OK** to set the ADVField clock to this time, or modify the displayed time and press **OK** to set the ADV-Field clock to the desired time.
- **Start** sends the command to begin real-time data collection and place the system in data acquisition mode.
- **Conf** sends the command to show hardware configuration parameters.
- **Setup** sends the command to show setup parameter settings.
- **System** sends the command to show system parameter settings.
- **Deploy** sends the command to shows deployment parameter settings.
- **Load Druck Calibration** uploads the optional frequency pressure sensor's calibration file to the ADVField's processor. These files (.drk extension) are used with Druck RPT and Parosfreq pressure sensors.
- **Load Probe Config** uploads the ADVField's probe configuration file (.pro extension).
- **Compass Calibration** runs a calibration routine for systems equipped with the optional compass/tilt sensor.
- **Firmware** uploads a firmware update file (.hex extension) to the ADVField's processor. Your system must have the "flash firmware" type of EPROM chip installed. Contact SonTek or visit our web site (www.sontek.com) to see if a firmware update is available for your system. Note: When updating your firmware using this icon, you will be prompted to select the .hex file, enter an access code, and select the Transfer Mode (use BIN). After uploading the .hex file, make sure you send a **BREAK** to the instrument to reset its parameters.

<u>Log Files and Command Files</u>

- Use **File|Log File** (Alt+L) to specify a log file (.log extension) in which to record all instrument output. All information shown on the blue screen is written to an ASCII text file.
- Use **File|Command File** (Alt+C) to specify a command file (.cmd extension) to send to the instrument. The file should be an ASCII text file with one command per line. This option lets you automate system configuration and deployment.
- Use **Tools|Text Editor** (Ctrl+T) to create, open, edit, save, or run a command file "on-the-fly" from within *Terminal*. These files use a .cmd extension.

<u>RS485 Multiple System Operation</u>

- Use **File|Select RS485 Device** to specify the RS485 address used for multi-system operation.
- An address setting of 0 indicates RS485 is not being used. An address setting of from 1 through 15 prefaces all commands with that system address.
- See the *ADVField Operation Manual* for details on RS485 multi-system operation.

11.3. Compass – *Compass Calibration*

Compass is used to calibrate the optional internal compass/tilt sensor for the effects of ambient magnetic fields. Note: This software was formerly named *CompCalW*.

- *Compass* establishes communication and starts a display of compass data.
- *Compass* gives calibration instructions and displays compass data.
- At the end of calibration, *Compass* reports a calibration score. See the *ADVField Operation Manual* for information about compass operation and calibration.
- *Compass* records all compass calibration data and results to a log file.

The *Compass* window is divided into several areas (Figure 13).

- The top area contains communication controls and parameters. This area also displays compass and tilt sensor data.
- The gray area at the bottom displays calibration instructions and program status.
- The **Connect** icon establishes communication with the ADVField and starts the display of compass data.
- The **Go** icon starts the compass calibration procedure; **Stop** ends calibration.
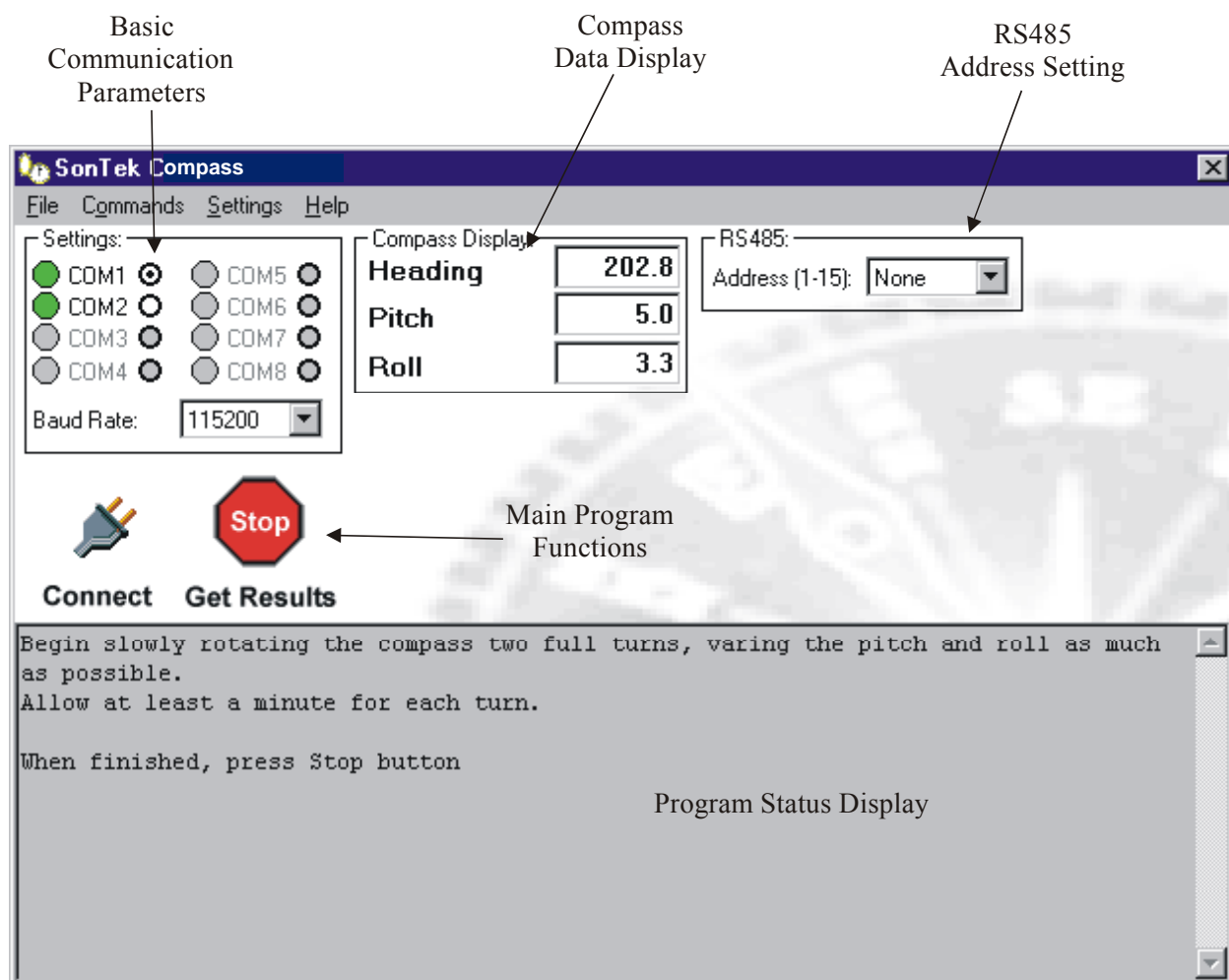
Figure 13 – *Compass* **(Compass Calibration) Main Window**

Communication Parameters

- COM port and baud rate settings can be modified in the upper left portion of the screen.
- Access to all communication settings (data bits, stop bits, etc.) can be set using the **Settings|Port Settings** menu.

RS485 Multiple System Operation

- The top right of the screen specifies the RS485 system communication address.
- An address setting of 0 indicates RS485 is not being used. An address setting of from 1 through 15 prefaces all commands with that system address.
- See the *ADVFieldOperation Manual* for details on RS485 multi-system operation.

Basic Calibration Instructions

- Start *Compass*.
- Click **Connect** to establish communication.
- Click **Go** to start the compass calibration and the display of compass data.
- Follow the instructions for calibration.
  - o The ADVField should be rotated through at least two complete rotations, varying pitch and roll as much as is practical (within the ±50° sensor limit).
  - o If possible, calibration should be performed with the ADVField installed in the mounting frame that will be used during deployment.
- At the end of calibration, press **Stop**. *Compass* reports a calibration score. See the *ADVField Operation Manual* for information about the calibration score.
- *Compass* records all compass calibration data and results to a log file. These log files are generally used for quality assurance purposes, but are not essential to program operation (i.e., you can delete them). The log file name is in the format of year/month/day/ hour/minute.cmp. For example, 0011061311.cmp stores data that was collected on November 6, 2000 at 13:11 (1:11 pm). The file can be viewed with any ASCII text editor.

11.4. Recorder – *Internal Recorder Data Extraction*

Recorder is used to download binary data files from the optional internal recorder. Note: This software was formerly named *SonRecW*.

- *Recorder* establishes communication and displays a directory of the files currently stored on the ADVField's internal recorder.
- You select the files you wish to download and where to place them.
- *Recorder* enters a special download mode at a higher baud rate (usually 115200) and downloads the specified files.

The *Recorder* window is divided into several areas (Figure 14).

- The top area shows communication parameters.
- The gray area on the left displays program status.
- The white area on the right displays a directory of the files on the internal recorder.
- The area on the lower right contains control buttons and shows the destination path.
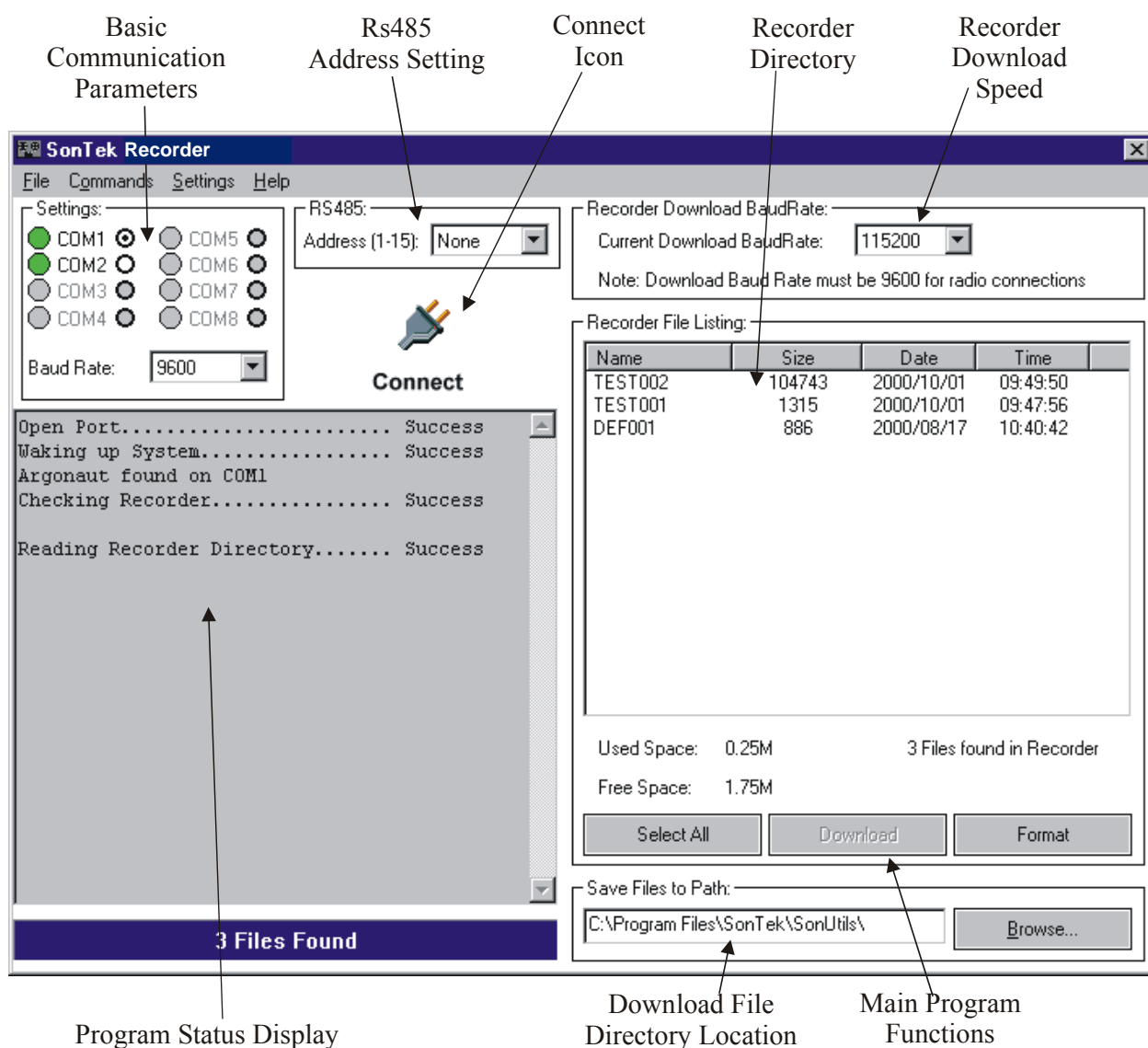
Figure 14 – *Recorder* (Internal Recorder Data Extraction) Main Window

Basic Downloading Instructions

- Click **Connect** to establish communication and display the recorder's directory.
- Specify a destination directory on the bottom right (or use the **Browse** button).
- Select one or more files from the display list. Files can be selected several ways.
  - Click a file to select a single file.
  - Hold the Control or Shift key and click a series of files to select more than one file.
  - Click **Select All** to select all files on the recorder.
- Click **Download** to copy all selected files to the specified directory.
- Watch the program status area on the left as files are downloaded.

Formatting the Internal Recorder

- The **Format** button on the bottom right erases the internal recorder.
- Be certain that all files have been downloaded and backed up before erasing the recorder.
- Files cannot be recovered after the recorder has been erased.
- To erase the recorder, click **Format**, and then **OK** to confirm your decision when the warning window appears.

Download Baud Rate

- *Recorder* uses a higher baud rate to download data files (compared to the one used for standard system communication). The default download baud rate is 115200.
- High baud rates can only be used with high-quality, relatively short cables (such as the cables normally supplied with the ADVField).
- If you have trouble downloading data, try using a slower download baud rate.

Communication parameters

- COM port and baud rate settings can be modified in the upper left area of the screen.
- Access to all communication settings (data bits, stop bits, etc.) can be set using the **Settings|Port Settings** menu.

RS485 Multiple System Operation

- The top center area of the screen specifies the RS485 system communication address.
- An address setting of 0 indicates RS485 is not being used. An address setting of from 1 through 15 prefaces all commands with that system address.
- See the *ADVField Operation Manual* for details on RS485 multi-system operation.

Section 12.   ViewHydra / ViewHydraPro (Windows)

ViewHydra is a data display and analysis program (Figure 15). This post-processing package is designed specifically for use with the data collected by a SonTek Hydra system. *ViewHydra* lets you quickly and easily look at Hydra data in a variety of ways: as time-series graphs, as tabular displays, or as an ASCII text file. ViewHydra never alters your original data file. The program only uses your data for display and analysis purposes. Note: Hydra systems that have the directional waves option installed use an advanced version of this program: *ViewHydraPro*.

12.1. Getting Started with ViewHydra

To start viewing Hydra data:

1. Open a Hydra Data File. To open a file you can:

    a. Use **File|Open** or the **Open** icon to select a Hydra file.
    b. Use **File|1** (or 2, 3, etc.) to select a previously opened file.

2. Select File Loading Options.

    a. When you first open a file, you will be shown a dialog box containing **Hydra File** and **Sampling Information** (Table 5) about the currently loaded data set. Note: If you have previously opened the current data file, and saved its workspace, you can skip to Step 3.
    b. **Load ExtPres CalFile** - If applicable (i.e., the button is enabled), use this option to load the appropriate calibration file for the external pressure sensor used during data collection. If no calibration file is loaded, you will be shown a warning message that pressure values will not be correctly calibrated.
    c. **Select Burst Type** - If data for more than one burst type was collected, use this option to select which burst-type data set (1/2/3) you wish to view. Note: To view different burst types simultaneously, you can run a separate copy of *ViewHydra*.
    d. **Select Burst Range** - Use this option to select the range of bursts you wish to view for the selected data set. The default is to show all bursts; otherwise, use **Selected Bursts**, and then enter the **Start Burst Number** and the **End Burst Number**.
    e. **Compute Burst Statistics** - This button must be pressed to compute the burst statistics for the selected Burst-Type data set (1/2/3). This usually needs to be done only when *ViewHydra* is first used to load this particular data set. A statistics file with an extension of .st1, .st2, or .st3 is created in the same directory as the parent data file when this button is pressed. If the statistics file already exists, there is no need to press this button (i.e.; you only need to press **OK**).

        Notes:
        (1) If the burst statistics were filtered in a previous session, a message will appear under the burst statistics file name telling you the file has been filtered. To restore a filtered burst statistics file to its original format, press the **Compute Burst Statistics** button.
        (2) You can change the baseline of how your data is displayed by first using the **Data Smoothing**, **Data Screening**, and **Mean Removal** options in the **Processing Menu**, and then recomputing the burst statistics file. See Processing Menu (§12.3.4) for details.

    f. **Wave Setup** - Used to set the SonWave processing parameters for systems that collected wave data (available only in *ViewHydraPro*).
    g. Press **OK** to load the data file. Note: This button will be grayed-out if the statistics file mentioned in the previous step has not been created.
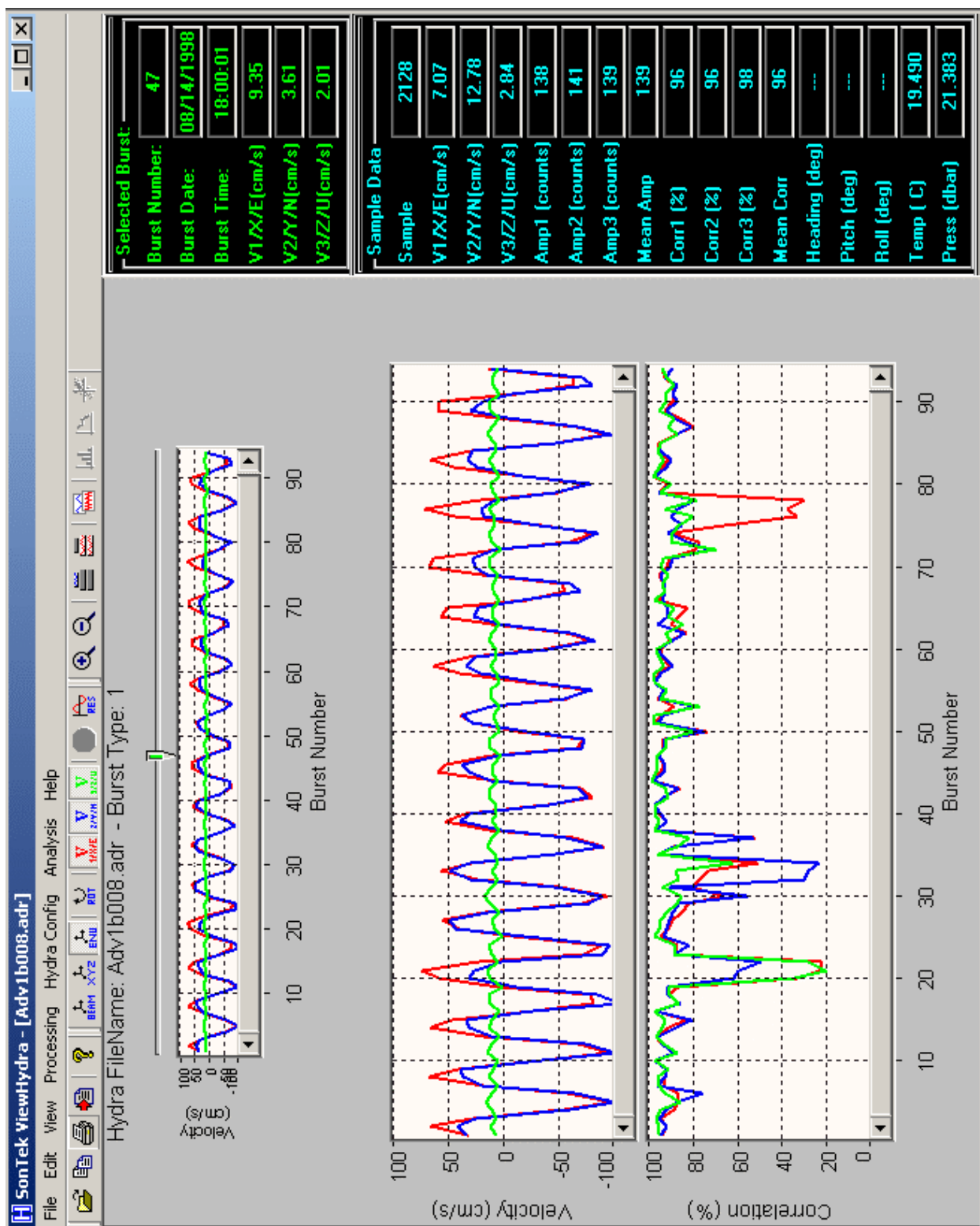
Figure 15 – ViewHydra Screen Shot

3. **Load Workspace?** If you have previously opened the current data file, and saved its work-space, you will be prompted as to whether you want to reload your previous set of settings (Yes - Burst Type 1/2/3) or return all settings to their default state (No). Note: If you never want to save your last-used settings (i.e.; workspace), you can uncheck the **File|Configuration|Use WorkSpaces** box.

4. Select Display and Processing Options. After the file is loaded, the selected range of burst data will be shown on the various graphs. You can now use the menu and tool bars to:

   a. Change the display.
   b. Smooth/Screen the display data.
   c. Export selected data in an ASCII-text file format.
   d. Print the display.
   e. Copy displays to the clipboard for use in other programs such as Word or PowerPoint.
   f. Note that your original data files are never modified; any editing/smoothing applies only to the display of data.

5. Exiting Program. When you **Close** or **Exit** the program, you will be prompted with **Save Workspace?** or **Overwrite Existing Workspace?** This assumes you have chosen to save your settings via the **File|Configuration|Use WorkSpaces** checkbox. Choosing to overwrite your existing workspace (Yes) will replace your previous settings with your current settings. Choosing not to overwrite your existing workspace (No) will retain your previous settings and abandon your current settings. Note: Workspaces are saved in the same directory as their parent data file with an extension of wsp.

Table 5. Hydra File and Sampling Information

File Information
- File size (in bytes)
- Number of Bursts
- Time of First/Last Burst
- Probe Type
- Serial Number
- Check boxes for data collected: Compass, Pressure Sensor, External Sensor, CTD, External Pressure Sensor
- Comments - User-entered notes during instrument set-up
- Select Burst Type – Data for up to three burst types can be collected/recorded. Only the burst types collected during the deployment are available for selection.
- Select Burst Range – Lets you select all bursts or a selected range of bursts for processing/display.
- Burst Statistics – Data for up to three burst types can be collected/recorded. Before viewing the data the first time, you will need to compute the burst statistics for the selected burst type.

Sampling Information
- Number of Bursts – Shows the number of burst records that were collected for each of the three burst types (Sampling 1, Sampling 2, Sampling 3).
- Sample Rate – The rate (in Hz) at which the ADV velocity measurements are vector-averaged internally and output for each of the burst types (1/2/3).
- Burst Interval – Shows time between the start of successive bursts for each of the burst types (1/2/3).
- Samples per Burst – Shows the number of samples recorded per burst for each of the burst types (1/2/3).
- Record Amp Correlation – Shows if amplitude / correlation data were recorded for each of the burst types (1/2/3).
- Record Compass – Shows if compass/tilt sensor data were recorded for each of the burst types (1/2/3).
- Record Sensor – Shows if internal sensor data for temperature and pressure were recorded for each of the burst types (1/2/3).
- Record Stat – Shows if statistical data for the mean and standard deviation values for amplitude, correlation, heading, pitch, roll, temperature, and pressure were recorded for each of the burst types (1/2/3).
- Record Ext Sensor – Shows if external sensor data were recorded for each of the burst types (1/2/3).
- Record Ext Pressure – Shows if external pressure sensor data were recorded for each of the burst types (1/2/3).
- Record CTD – Shows if external CTD data were recorded for each of the burst types (1/2/3).
- Bytes per Burst – Shows number of bytes of disk space used per burst for each of the burst types (1/2/3).

12.2. *What Am I Looking At?*

After loading a data file, ViewHydra will display the following (Figure 15).

- Burst Data Time-Series Graph (top; §12.2.1)
- Sample Data Time-Series Graphs (middle & bottom; §12.2.2)
- Burst Tabular Data (upper right, but movable; §12.2.3)
- Sample Tabular Data (lower right, but movable; §12.2.4)

Notes:
(1) Use the **View Menu** (§12.3.3) to show(hide) graphs, tabular displays, tool bars, beam components; to select graph axis variables; and to show burst/sample data on the lower graphs.
(2) Use the **Processing Menu** (§12.3.4) to perform data display editing/smoothing functions.

12.2.1. *Burst Data Time-Series Graph*

The Burst Data Time-Series Graph (top of screen; Figure 15) lets you view the data points of a user-selected variable for the selected range of burst data over time. Several variables are available, of which two can be viewed at the same time – one on the left axis, one on the right axis. Use **View|Select Top Graph Variable** (or its toolbar icon) to select the parameters to be displayed.

The variables are arranged in "tabs" in the **Select Time Series Variables** dialog box and include the following. Note: Depending on your system's configuration, not all tabs/variables may be available.

- Velocity (Velocity, Velocity Standard Deviation, Speed, Direction)
- Signal (Signal Amplitude, Signal Amplitude Standard Deviation, Correlation, Correlation Standard Deviation, Noise Level)
- Sensors (Temperature, Temperature Standard Deviation, Pressure, Pressure Standard Deviation, External Pressure, External Pressure Standard Deviation)
- Compass (Heading, Heading Standard Deviation, Pitch, Pitch Standard Deviation, Roll, Roll Standard Deviation)
- CTD (CTD Salinity, CTD Temperature, CTD Conductivity, CTD Depth)
- Ext Sensors (External Sensor 1/2/3, External Sensor 1/2/3 Standard Deviation)
- Misc (Distance from Probe to Boundary, Distance from Sampling Volume to Boundary, Battery Voltage)

Notes:
(1) Moving the burst-data time-series marker (green pointer) will set the Burst Tabular Data (§12.2.3) to the selected burst number, and will set the displayed Sample Data Time-Series Graphs (§12.2.2) to the range of samples contained in the selected burst.
(2) Left-axis variables are displayed using a solid line; right-axis variables are displayed using a dashed line. The axis scale can be changed by double-clicking on the appropriate axis scale. The left-axis variable also determines which parameters are displayed in the Burst Tabular Data (§12.2.3) dialog box.
(3) To magnify an area of the Burst Time-Series Graph: (a) Select the Zoom-In icon from the tool bar, (b) Click and drag your cursor from the desired starting point to the desired ending point on the Burst Time-Series Graph, (c) Release the cursor. You can now use the horizontal scroll bar to view data to the left and right of the current position. To return the graph to its full size, select the Zoom-Out icon from the tool bar.

12.2.2. Sample Data Time-Series Graphs

The two Sample Data Time-Series Graphs (middle and bottom of screen) let you view data points over time for a user-selected variable over the range of samples contained in the selected burst. Several variables are available, of which two can be displayed at the same time on each graph - one on the left axis and one on the right axis of each graph. Use the **View|Select Mid/Bot Graph Variable** (or its tool bar icon) to select the parameters to be displayed. The variables are arranged in "tabs" in the Select Time Series Variables dialog box, and include the following. Note: Depending on your system's configuration, not all tabs and/or variables may be available.

- Velocity (Velocity, Speed, Direction)
- Signal (Signal Amplitude, Mean Signal Amplitude, Correlation, Mean Correlation)
- Sensors (Temperature, Pressure, External Pressure)
- Compass (Heading, Pitch, Roll)
- Ext Sensors (External Sensor 1, External Sensor 2, External Sensor 3)

Notes:
(1) Moving the sample-data time-series marker (light blue pointer) will set the Sample Tabular Data (§12.2.4) to the selected sample.
(2) Left-axis variables are displayed using a solid line; right-axis variables are displayed using a dashed line. The axis scale can be changed by double-clicking on the appropriate axis scale.
(3) To magnify an area of the Sample Time-Series Graphs: (a) Select the Zoom-In icon from the tool bar, (b) Click and drag your cursor from the desired starting point to the desired ending point on either of the Sample Time-Series Graphs, (c) Release the cursor. You can now use the horizontal scroll bar to view data to the left and right of the current position. To return the graph to its full size, select the Zoom-Out icon from the tool bar.
(4) You can change the Sample Data Time-Series Graph to show burst data (i.e.; data on the top graph can be shown on bottom graphs) by using **View|Show Samples/Bursts** or toolbar icon.

12.2.3. Burst Tabular Data

Information about each burst can be found in the Burst Information dialog box (upper right, but movable). To move this dialog box, click and drag its "gripper" bar located at the top of the box.

Depending on the left-axis variable you have chosen for the Burst Data Time-Series Graph (§12.2.1), the Burst Information dialog box can include the following tabular data. Note: Depending on your system's configuration, not all listed variables may be available.

- Burst number - To quickly move to a specific burst number, double-click the burst number and enter a new value.
- Burst Date - Date the selected burst began
- Burst Time - Time the selected burst began
- V1/X/E, V2/Y/N, V3/Z/U - Velocity components of selected burst in cm/s (if left-axis = Velocity). The specific component depends on the selected velocity coordinate system.
- VelStD1, VelStD2, VelStD3 - Velocity standard deviation components of selected burst in cm/s (if left-axis = Vel StD)
- Amp1, Amp2, Amp3 - Signal amplitude components of selected burst in counts (if left-axis = Sig Amp)
- Amp StD1, Amp StD2, Amp StD3 - Signal amplitude standard deviation components of selected burst in counts (if left-axis = Sig Amp StD)

- Corr1, Corr2, Corr3 - Correlation components of selected burst as a percentage (if left-axis = Correlation)
- Corr StD1, Corr StD2, Corr StD3 - Correlation standard deviation components of selected burst as a percentage (if left-axis = Corr StD)
- Speed - Averaged water-current speed for selected burst in cm/s (if left-axis = Speed)
- Dir - Averaged water-current direction for selected burst in degrees (if left-axis = Direction)
- Temp - Averaged water temperature for selected burst in degrees C (if left-axis = Temp.)
- Temp StD - Temperature standard deviation for selected burst in degrees C (if left-axis = Temp StD)
- Press - Averaged pressure for selected burst in dbar (if left-axis = Pressure or Ext Pressure)
- Ext P StD - Pressure standard deviation for selected burst in dbar (if left-axis = Press StD or Ext Press StD)
- Head - averaged heading for selected burst in degrees (if left-axis = Heading)
- H StD - Heading standard deviation for selected burst in degrees (if left-axis = Heading StD)
- Pitch - Averaged pitch for selected burst in degrees (if left-axis = Pitch)
- P StD - Pitch standard deviation for selected burst in degrees (if left-axis = Pitch StD)
- Roll - Averaged roll for selected burst in degrees (if left-axis = Roll)
- R StD - Roll standard deviation for selected burst in degrees (if left-axis = Roll StD)
- CTD Sal - Averaged CTD salinity value in parts-per-thousand (ppt) for selected burst (if left-axis = CTD Salinity)
- CTD Temp - Averaged CTD temperature value in degrees C for selected burst (if left-axis = CTD Temp)
- CTD Cond - Averaged CTD conductivity value in Siemens/meter for selected burst (if left-axis = CTD Conduct)
- CTD Depth - Averaged CTD depth value in meters for selected burst (if left-axis = CTD Depth)
- Ext1, Ext2, Ext3 - Averaged reading from the user-defined External Sensor 1/2/3 in counts for selected burst (if left-axis = Ext Sen1/2/3)
- Ext1StD, Ext2StD, Ext3StD - Averaged reading from the user-defined External Sensor 1/2/3 standard deviation in counts for selected burst (if left-axis = Ext Sen1/2/3 StD)
- Dist - Averaged distance from either the probe to the boundary or from the sampling volume to the boundary for selected burst in cm (depends on where left-axis = Dist:Probe-Boundary or Dist:SVol-Boundary)
- Volt - Averaged battery voltage during selected burst in volts (if left-axis = Battery Voltage)

12.2.4.   Sample Tabular Data

Information about each sample within the selected burst can be found in the Sample Information dialog box (lower right, but is movable). You can move this dialog box by clicking on and dragging the title bar (or "gripper") located at the top of the box. The Sample Information dialog box includes the following tabular data:

- Sample number - Note: You can quickly move to a specific sample number within the selected burst by double-clicking on the sample number and entering a new value.
- V1/X/E, V2/Y/N, V3/Z/U - Velocity components of the selected sample in cm/s. The specific component depends on the selected velocity coordinate system.
- Amp1/Amp2/Amp3 - Signal amplitude components of the selected sample in counts

- Mean Amp - The mean of the signal amplitude components of the selected sample in counts
- Corr1/Corr2/Corr3 - Correlation components of the selected sample as a percentage
- Mean Corr - The mean of the correlation components of the selected sample as a percentage
- Heading - Averaged heading for the selected sample in degrees
- Pitch - Averaged pitch for the selected sample in degrees
- Roll - Averaged roll for the selected sample in degrees
- Temp - Averaged water temperature for the selected sample in degrees C
- Press - Averaged pressure for the selected sample in dbar

12.3. Menu Item Descriptions

This section explains each *ViewHydra* / *ViewHydraPro* menu item in detail. Note that items marked with an asterisk (*) only apply to the *ViewHydraPro* program.

12.3.1. File Menu

The File Menu contains the following options:

- Open… (Ctrl+O) - Opens a Hydra data file (*.adr) for display.
- Close - Closes the data file, but does not exit the ViewHydra program.
- Print (Ctrl+P) - Prints the currently selected .adr file to the selected printer.
  Notes:
  (1) A "landscape" printout is recommended.
  (2) If the printout is not of good quality, you can copy the display to the clipboard, and then paste it into another program (e.g.; graphic editor, presentation program, word processor) for further processing. See the Edit|Copy Screen to Clipboard (§12.3.2) option.
- Print Preview - Lets you view the graphic display as it will look when printed. Depending on the speed of your computer, and the number of data points in your graph, it may take from several seconds to several minutes before the preview is displayed.
- Print Setup - Lets you modify the printer selection and its parameters before printing.
- Export Data - Allows you to create ASCII (or MatLab* with ViewHydraPro) file outputs for any or all of the items shown in Table 6. Individual files are created using the data file name with the appropriate extension. You can choose to create a file just for the selected variable (Export Selected Variable), or to create files for all the output variables at the same time (Export All Variables).

  To create the ASCII file output(s): (a) Enter the path where you want to save the file(s), (b) Enter the file name (but not the extension), (c) Enter the burst range to process, (d) Enter the desired output variables and format (ASCII or Matlab*) to export the selected variable, or export all variables, (e) Press the appropriate Export button.

- Configuration - Allows you to activate various settings to save user workspace and default display preferences. Use Workspaces allows you to retain your settings from session to session for the active data file. Save Current Display Settings as Default lets you set the default display for all data files that you open; however, if the file you are opening already has a saved workspace, the workspace settings will override these default settings.
- 1, 2, 3, 4 - Lists the last four .adr files that were accessed. Selecting one of these items will open the associated file.
- Exit - Closes the data file and then exits the ViewHydra program.

Table 6. ViewHydra/ViewHydraPro ASCII Output Files

Output Variables	Extension	Notes
Configuration Data	.ctl	
Header Data	.hd1, .hd2, .hd3	Numeric extension applies to the appropriate burst type. Note: Matlab* files will use *filename*-hd*n*.mat, where *n* = burst type.
Time-Series Data	.st1, .st2, .st3	Numeric extension applies to the appropriate burst type. Note: Matlab* files will use *filename*-ts*n*.mat, where *n* = burst type.
Wave Data*	.sw1, .sw2, .sw3	Numeric extension applies to the appropriate burst type. Only available in ViewHydraPro.

12.3.2. Edit Menu

The Edit Menu contains the following option:

- Copy Screen to Clipboard (Ctrl+C) - Use this feature to copy the graphics display of the currently selected data file to the clipboard. You can then paste the display into another program for further processing, presentations, or reports. Typical programs that could make use of this feature are Microsoft's Word and PowerPoint programs.

12.3.3. View Menu

The View Menu contains the following options:

- Show … Graphs - Use this option to select which graph/s will be shown in the display. The default is to Show All Graphs. Selecting any of the other choices will display only that graph (Top, Middle, Bottom). This may be helpful when you wish to magnify a particular data set.
- Select … Graph Variable - Lets you select which variable(s) you would like to display in the Top/Middle/Bottom Time-Series Graphs. This selection is also available on the tool bar. For a description of the variables available in each graph, see the following help sections:
  - o Burst Data Time-Series Graph (§12.2.1)
  - o Sample Data Time-Series Graphs (§12.2.2)
  - o Burst Tabular Data (§12.2.3)
  - o Sample Tabular Data (§12.2.4)
- Show Components - Allows you to show/hide the individual components of the velocity data (Beam1/X/E, Beam2/Y/N, Beam3/Z/U) for the selected velocity coordinate system.
- Display Burst X-Axis Using - Lets you switch the burst graph's X-axis between Burst Number and Date/Time.
- Display Sample X-Axis Using - Lets you switch the sample graph's X-axis between Sample Number and Date/Time.
- Show Burst/Samples - Lets you switch the middle and bottom graphs between showing burst data or sample data. This selection is also available on the tool bar.
- Show Burst Info - Shows/Hides the Burst Information tabular display. See Burst Tabular Data (§12.2.3) for a description of the information contained in this display.
- Show Sample Info - Shows/Hides the Sample Information tabular display. See Sample Tabular Data (§12.2.4) for a description of the information contained in this display.
- Show … Toolbar - Use this option to select which toolbar/s will be shown in the display. The default is to show all toolbars. Selecting any of the other choices will display only that toolbar (File, Processing, or Controls).

12.3.4.   Processing Menu

The Processing Menu contains the following options. Note that all items in this menu affect the burst statistics file that is used to display your data. See the Recompute Burst Statistics File option (below) for more information.

- Velocity Coordinate System - Lets you select the coordinate system in which to display velocity data. Options are Beam, XYZ, and ENU. The appropriate toolbar icon stays depressed for the selected coordinate system.
- User Specified Rotation - When activated, lets you rotate all velocity profiles by a user-selected angle (0-360°). The User Specified Rotation icon stays depressed as long as the selected rotation is in effect. This feature is useful when analyzing current data along a channel.
- Data Smoothing - Lets you smooth the time-series data using a low-pass, adjacent-averaging filter. Two filters are available: uniform weighting (Box Filter) and Gaussian distributed weighting (Gaussian). The amount of filtering can be controlled through the Filter Width and Filter Limits settings. See Recompute Burst Statistics File (below) if you want your Data Smoothing changes to become the new baseline for your display of data.
- Data Screening - Lets you discard (mask) a portion of a profile using selected criteria. Selections include: Discard Range of Samples, Low Amplitude, and Low Correlation. Most selections let you set either the starting/ending sample or a threshold. See Recompute Burst Statistics File (below) if you want your Data Screening changes to become the new baseline for your display of data.
- Mean Removal - When activated, this option will subtract the mean from all displayed data. The mean is calculated based on the full range of samples for the displayed burst. See Recompute Burst Statistics File (below) if you want your Mean Removal changes to become the new baseline for your display of data.
- Data Despiking* - (Available only in ViewHydraPro) When activated, lets you refine readily apparent data spikes into more meaningful data. You select a range of samples over which to interpolate the refining of data based on a user-selected standard deviation. The default window width is 7; the default StdDev is also 7.
- Sound Speed Correction - Lets you correct velocity data for erroneous sound speed that may have occurred due to an incorrect salinity or temperature data.
- Recompute Burst Statistics File - Executing this option will recompute the burst statistics file for the currently loaded Hydra data set. Any data smoothing, screening, or mean removal entries you made (see above options) will be included in the new statistics file. In effect, you will create a new baseline for the display of your data. However, your original .adr data file will not be modified; only the statistics file will be affected.
- Sensor Calibration Settings - Lets you adjust any calibration settings for the various sensors (temperature, pressure, external pressure, external sensor 1/2/3, CTD temperature). Calibration coefficients that are adjustable include offset, slope, and quadratic term.
- SonWave Processing Setup - Lets you set the parameters used to process wave data (available only in ViewHydraPRO; contact SonTek Sales for details). This feature lets you plot and display wave data in a variety of formats. Plot types include: 3D-Polar, 3D-Contour, 3D-Surface, 2D-Time Series, 2D-Spectra. You can also choose to: Show Frequency Spectra, Show Wave Direction, and Compare 2D Spectra. You are also allowed to modify certain variables and filters, including: Fmin, Rp Cut Off, NFFT, Window Type (Hanning, Hamming, Cosine, Rectangle, Triangular), Water Depth, Burst Length, Start Burst, End Burst, Directional Weighting Exponent.

To begin:
1. Enter any modifications to the Processing Settings.
2. Select the burst number to display.
3. Press Compute Spectra.
4. Select the plot/display you would like to view.
5. Press Display Burst Graph.
6. Some of the displays let you zoom-in/out using the right and left mouse buttons, or by clicking and dragging a selection box around the area to be magnified.
7. Choosing the Compare 2D Spectra option lets you compare separate bursts by using the burst data time-series marker (green pointer) and the Add Current Burst button. You can also export Hydra wave spectra data to an ASCII file. The file name format is DataFile-Name_wsd.dat.
8. You can choose Close Graphs to close all open graphs and Save Settings to save your current graph settings.

Note: For more information about SonWave and its computations, see the file Son-WavePro.pdf, which has been included on the software distribution CD-ROM.

12.3.5.   Hydra Config Menu

This menu contains the following items, which display configuration information that was recorded during data collection.

- Standard Information - Gives an overview about the data collected in the file:
    - File Name
    - File Size
    - Number of Bursts collected in file
    - Time of First Burst in file
    - Time of Last Burst in file
    - Compass data present in file: Yes/No
    - Pressure Sensor data present in file: Yes/No
    - External Sensor data present in file: Yes/No
    - CTD Data present in file: Yes/No
    - External Pressure Sensor data present in file: Yes/No
    - Comments (enter during data collection)
- Hardware Configuration - Lists configuration of Hydra hardware during data collection:
    - CPU Software Version - Central Processing Unit firmware version
    - DSP Software Version - Digital Signal Processor firmware version
    - Serial Number of the probe
    - Probe type
    - Pressure frequency offset
    - Transformation matrix
    - Probe orientation (up/down)
    - Temperature sensor installed (yes/no)
    - Recorder installed (yes/no)
    - Pressure sensor installed (yes/no)
    - Pressure sensor offset
    - Pressure sensor scale
    - External pressure sensor installed (type)

- User Setup - Lists the setup used during data collection for each sampling burst type (1/2/3):
  - Number of bursts
  - Sample rate (Hz)
  - Burst interval (s)
  - Samples per burst
  - Record (Yes/No) - Amplitude / Correlation data, Compass data, Sensor data, Statistical data, External Sensor data, External Pressure data, CTD data
  - Number of bytes per burst
  - Velocity range index
  - Output format
  - Magnetic Declination - Can be changed during post-processing.
  - Coordinate System - Beam, XYZ, or ENU (East-North-Up)
  - Advanced - Shows the Temperature Mode, Default Water Temperature, Default Water Salinity, and Default Speed of Sound.

12.3.6. Analysis Menu

This menu lets you view data in various formats. Each of these selections has its own criteria for which parameters to view. These items are available only in ViewHydraPro.

- Histograms - Allows you to view histograms of velocity, amplitude, correlation, magnitude, direction, temperature, and external pressure. Various options are available while viewing the histogram, including beam/coordinate selection, normal distribution, alter grade values, export the data in an ASCII format, copy to clipboard, print the graph. Table 7 lists the file-naming format for exported histogram files.
- Spectra - Allows you to view graphs of auto-spectra (U, V, W), cross-spectra (U-V, U-W, V-W), coherence function (U-V, U-W, V-W), and transfer function (U-V, U-W, V-W). Various options are available while viewing the graph, including: Get Slope (drag cursor over the area of interest), 5/3 Slope (drag cursor over the area of interest), NFFT, Window Type, export the data in an ASCII format, copy to clipboard, print the graph, zoom-in/out. Table 7 lists the file-naming format for exported spectra files.
- Scatter Diagrams - Allows you to view scatter diagrams based on X-Y, X-Z, or Y-Z axes. You can also choose to show/hide the mean vector, copy to clipboard, or print the graph.

Table 7. File Naming Format for Exported ViewHydraPro Data

Output Variables	File Name and Extension Format
Histograms	*DataFilename_**hist_amp.dat**, for Amplitude *DataFilename_**hist_cor.dat**, for Correlation *DataFilename_**hist_mag.dat**, for Magnitude *DataFilename_**hist_snr.dat**, for SNR *DataFilename_**hist_vel.dat**, for Velocity *DataFilename_**hist_stress_uv.dat**, for U'V' *DataFilename_**hist_stress_uw.dat**, for U'W' *DataFilename_**hist_stress_vw.dat**, for V'W'
Spectra	*DataFilename_**aps.dat**, for Auto-Spectra *DataFilename_**cps.dat**, for Cross-Spectra *DataFilename_**coher.dat**, for Coherence Function *DataFilename_**trans.dat**, for Transfer Function

12.3.7. *Toolbar Icons*

The toolbar contains the following icons:

- File Toolbar (§12.3.1):
    - Open
    - Copy
    - Print
    - Export Data
    - About – Displays software version number
- Processing Toolbar (§12.3.4):
    - Beam Coordinate System
    - XYZ Coordinate System
    - ENU Coordinate System
    - User Specified Rotation
    - Show(Hide) Beam1/X/East Component
    - Show(Hide) Beam2/Y/North Component
    - Show(Hide) Beam3/Z/Up Component
    - Compute and Display Waves
- Controls Toolbar:
    - Zoom In - To magnify an area of the either the Burst Time-Series Graph or Sample Time-Series Graph: (a) Select the Zoom-In icon from the tool bar, (b) Click and drag your cursor from the desired starting point to the desired ending point on the Time-Series Graph, (c) Release the cursor. You can now use the horizontal scroll bar to view data to the left and right of the current position. To return the graph to its full size, select the Zoom-Out icon from the tool bar.
    - Zoom Out
    - Select Top Graph Variable
    - Select Middle/Bottom Graphs Variable
    - Show Samples or Bursts
    - Histograms
    - Spectra
    - Scatter Diagrams

Section 13. Additional Support

Any questions regarding the ADVField can be directed to SonTek/YSI by telephone, FAX, or email. Regular business hours are 8:00 a.m. to 5:00 p.m., Pacific Standard Time, Monday through Friday.

Phone   +1 (858) 546-8327
FAX   +1 (858) 546-8150
Email   inquiry@sontek.com
Internet   http://www.sontek.com

Appendix 1. Automatic File Naming Convention

When automatically generating file names for data storage (using data acquisition software with the -f or -g command line options), the ADV uses a convention where the file name is based on the date and time at which the file was created. Unless the clock has been reset such that two files are started within the same minute, it is not possible to have a repeated file name. An example of this convention is shown below.

        AA5ADM23.ADV

where

        AA = starting two characters as specified in the file **ADVFILE.DEF** (See ¶2.2).
        5 = last digit of year (i.e., 1995)
        A = month (i.e., A = 10 = October)
        D = day (i.e., D = 13)
        M = hour (i.e., M = 22)
        23 = minute
        .ADV = all ADV data files use the same extension

The above file name is for a file started at 22:23 on October 13, 1995. Tables showing the abbreviations for month, day, and hour are shown below.

Month

1 = January	4 = April	7 = July	A = October
2 = February	5 = May	8 = August	B = November
3 = March	6 = June	9 = September	C = December

Day

1 = 1	5 = 5	9 = 9	D = 13	H = 17	L = 21	P = 25	T = 29
2 = 2	6 = 6	A = 10	E = 14	I = 18	M = 22	Q = 26	U = 30
3 = 3	7 = 7	B = 11	F = 15	J = 19	N = 23	R = 27	V = 31
4 = 4	8 = 8	C = 12	G = 16	K = 20	O = 24	S = 28	

Hour

0 = 0	3 = 3	6 = 6	9 = 9	C = 12	F = 15	I = 18	L = 21
1 = 1	4 = 4	7 = 7	A = 10	D = 13	G = 16	J = 19	M = 22
2 = 2	5 = 5	8 = 8	B = 11	E = 14	H = 17	K = 20	N = 23

Appendix 2. ADV Real-Time Binary Data File Format

This appendix describes the format of the binary files generated by the ADV data acquisition software. The format is the same for all ADV configurations.

A2.1. Overview of Binary File Format

There are four basic data types in the ADV real-time binary files: file configuration, data sample, event counter, and analog input sample.

- File Configuration Structure (578 bytes)
- Data Sample 1 (18-30 bytes)
- Event Counter 1 (2 bytes)
- Data Sample 2 (18-30 bytes)
- Event Counter 2 (2 bytes)
-    ↓   ↓   ↓   ↓   ↓
- Data Sample N (18-30 bytes)
- Event Counter N (2 bytes)

A2.1.1 File Configuration Structure

ADV system configuration data is recorded once at the beginning of each binary data file. The file configuration structure is split into two areas: user setup parameters (324 bytes) and probe configuration parameters (254 bytes). The User Setup and Probe Configuration structure definitions are given below in the C language code used to access the data files.

User Setup Structure (324 bytes)

```
typedef struct {
  char        SoftVer[8];
  DateTimeType  StartTime;
  unsigned char ProbeStatus[8];    /* 1 if installed, 0 if not       */
  unsigned char CpuSoftwareVerNum;
  unsigned char DspSoftwareVerNum;
  char        AdvType;             /* 0-10MHz,5cm  1-10MHz,10cm  2-OCEAN */
  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                  */
  long        PressScale;          /* nano bar   per count           */
  long        PressOffset;         /* micro bar                      */
  int         CompassOffset;       /* Degress to East of North       */
  unsigned char Spare[6];
  int         UN;                  /* Units System 0-Metric 1-English */
  float       Temp,                /* Water Temperature              */
              Sal,                 /* Water Salinity                 */
              Cw,                  /* Speed of Sound                 */
              SR;                  /* Sampling Rate                  */
  int         Ivr;                 /* Velocity range list index      */
  int         Isy;                 /* External synchronization       */
  int         AdOn;                /* A/D enable flag                */
  int         CoordSystem;         /* Coordinate system; 1-xyx;  2-enu */
  int         Spare2;              /* Spare field                    */
  char        RF[40];              /* Recording file name            */
  char        FC1[60],             /* File Comments 1                */
              FC2[60],             /* File Comment 2                 */
              FC3[60];             /* File Comment 3                 */
  char        AdvSysPar[10];
  char        AdvProcPar[18];
} UserSetupType;
```

Probe Configuration Structure (254 bytes)
```
typedef struct {
  unsigned char   Spare[10];
  char            SerialNum[6];
  unsigned char   Bpar[226];
  float           Fpar[3]
} ProbeConfType;
```

Date / Time Structure (referenced above) (8 bytes)
```
typedef struct {
    int  year;
    char day,
         month,
         minute,
         hour,
         sec100,
         second;
} DateTimeType;
```

A2.1.2   Data Sample, Event Counter, and Analog Input Module Structures

An ADV data sample includes one to three structures based on which optional sensors are installed: ADV data structure, compass structure, and sensor structure. The optional sensors are available only with the ADVField. The data sample can take one of the four forms shown below.

No Sensors Installed (18 bytes)

- ADV data structure

Compass Installed (24 bytes)

- ADV data structure
- Compass structure

Temperature and/or Pressure Installed (24 bytes)

- ADV data structure
- Sensor structure
- External sensors structure

Compass Installed and Temperature and/or Pressure Installed (30 bytes)

- ADV data structure
- Compass structure
- Sensor structure

The exact form of each of the three structures is shown below its C language definition.

ADV Data structure (18 bytes)
```
typedef struct {
  float           XYZVel[3];                /* x/y/z vel in m/s        */
  unsigned char Amp[3];                     /* Log of signal Amp       */
  unsigned char Cm[3];                      /* Correlation Score 0-100 */
} AdvDatType;
```

Compass structure (6 bytes)
```
typedef struct {
    int          Heading;          /* In 0.1 deg              */
    int          Pitch;            /* In 0.1 deg              */
    int          Roll;             /* In 0.1 deg              */
} CompDatType;
```

Sensor structure (6 bytes)
```
typedef struct {
    int          Temp;             /* In 0.1 deg              */
    float        Press;            /* In dbar                 */
} SensorDatType;
```

The following 2-byte structure (*EventCounterType*) is used to store the event counter.
```
typedef struct {
    unsigned int   EventCounter;              /* Counter starts at 0   */
} EventCounterType;
```

The following 16-byte structure (*AnalogDatType*) is used to store the optional analog input module data.
```
typedef struct {
    int          Analog[8];                   /* In counts (0-4095)    */
} AnalogDatType;
```

INDEX

SonTek/YSI, Inc.
Acoustic Doppler Velocimeter Principles of Operation

Table of Contents

1. Introduction

The SonTek/YSI Acoustic Doppler Velocimeter (ADV) is a single-point, high-resolution, 3D Doppler current meter. The Doppler processing techniques used by the ADV provide several advantages: accurate, fast, 3D velocity measurements in a remote sampling volume; invariant factory calibration - no periodic calibration required; simple operation; direct calculation of turbulent parameters such as Reynolds stress; and excellent low-flow performance.

This document presents the basic operating principles and specifications of the SonTek ADV. It does not attempt to provide a detailed discussion of all technical issues, nor does it provide a detailed description of ADV operation. To learn more about specific ADV configurations and applications, please contact SonTek.

2. The Doppler Shift and Bistatic Current Meters

The ADV measures the velocity of water using a physical principle called the Doppler effect. If a source of sound is moving relative to the receiver, the frequency of the sound at the receiver is shifted from the transmit frequency by the amount:

$$F_{doppler} = -F_{source} (V / C)$$

where

$F_{doppler}$ = change in received frequency (Doppler shift)
F_{source} = frequency of transmitted sound
V = velocity of source relative to receiver
C = speed of sound

The velocity V represents the relative speed between source and receiver (i.e., motion that changes the distance between the two). Motion perpendicular to the line connecting source and receiver does not introduce a Doppler shift. If the distance between the two objects is decreasing, frequency increases; if the distance is increasing, frequency decreases.
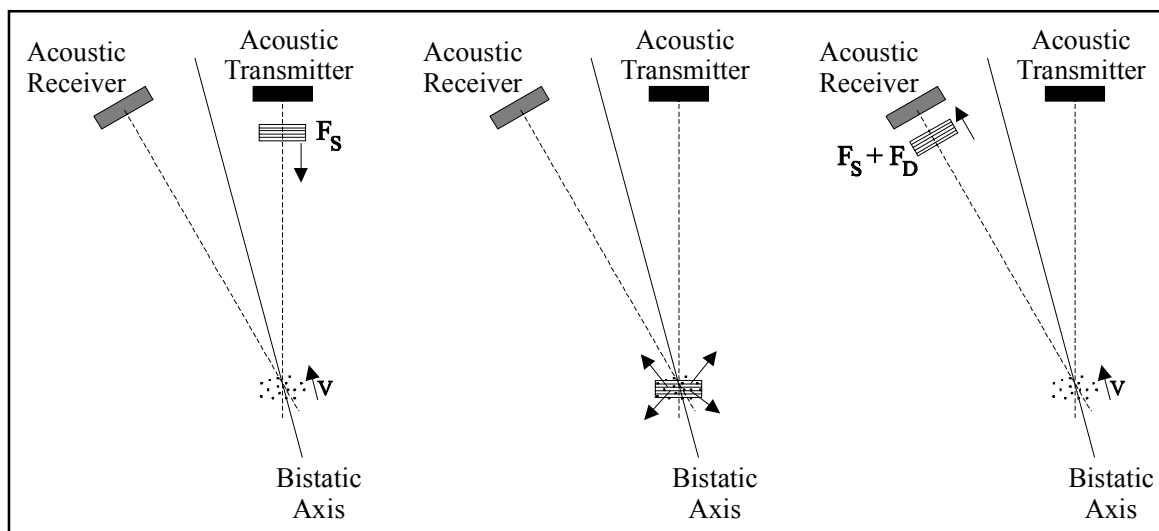

Figure 1 – Basic Operation of a Bistatic Doppler Current Meter

Figure 1 shows the operation of a bistatic Doppler current meter, such as the ADV. The term *bistatic* refers to the fact that the ADV uses separate acoustic transducers to transmit and to receive. Both transmitter and receiver are constructed to generate very narrow beam patterns. The transmitter generates sound with the majority of the energy concentrated in a narrow cone, while the receiver is most sensitive to sound coming from a very narrow angular range. The transducers are mounted such that their beams intersect at a volume of water located some distance away. This beam intersection determines the location of the sampling volume (the volume of water in which measurements are made).

The transmitter generates a short pulse of sound at a known frequency, which propagates through the water along the axis of its beam. As the pulse passes through the sampling volume, the acoustic energy is reflected in all directions by particulate matter (sediment, small organisms, bubbles, etc.). Some portion of the reflected energy travels back along the receiver axis, where it is sampled by the ADV and the processing electronics measure the change in frequency. The Doppler shift measured by one receiver is proportional to the velocity of the particles along the bistatic axis of the receiver and transmitter. The bistatic axis is located halfway between the axes of the transmit and receive beams.

Figure 2 shows a typical profile of signal strength versus time for one ADV receiver. The horizontal axis shows time after the transmit pulse, while the vertical axis shows the return signal strength measured by the receiver. As the transmit pulse travels through the water, some portion of the energy is reflected in all directions. Immediately following the transmit pulse, the reflections that hit the receive transducer come from an angle outside its sensitive range; thus the receiver measures only the ambient noise level. As the pulse moves towards the sampling volume, the

Figure 2 – ADV Signal Strength Profile

return signal starts to come from a direction close to the receiver's peak sensitivity; thus, the receiver sees an increase in signal strength. The signal strength reaches a maximum when the pulse crosses the center of the receive beam; afterwards, the reflections move out of the receive beam pattern and signal strength decays. The peak of the bell-shaped curve occurs when reflections are coming from the intersection of transmit and receive beams. By sampling the return signal at this time, the ADV makes measurements in the remote sampling volume defined by the intersection of transmit and receive beams.

3. Beam Geometry and 3D Velocity Measurements

A single transmit/receive pair measures the projection of the water velocity onto its bistatic axis. The ADV uses one transmitter and two or three acoustic receivers (for 2D or 3D probes). The receivers are aligned to intersect with the transmit beam pattern at a common sampling volume. The ADV combines velocity measurements from each receiver, knowing the relative orientation of the three bistatic axes, to calculate the 3D water velocity at the sampling volume.

Figure 3 shows the geometry of a 2D ADV. The axis of each receiver is slanted 30° relative to the transmitter. The bistatic axis for each receiver is in the middle of the transmitter and receiver axes (slanted 15° off the transmitter axis). The receivers are focused on a volume located 5, 10, or 18 cm below the transmitter (the distance varies depending on probe configuration). For 3D probes, each receiver is slanted 30° off the transmitter and the receivers are rotated at 120° relative azimuth angles.
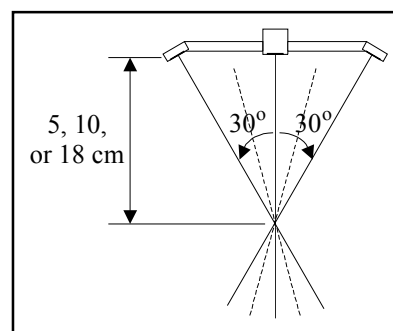

Figure 3 – ADV Probe Geometry

When analyzing ADV velocity data, it helps to understand the effect of probe geometry. We define the vertical direction as the axis of the transmitter, and the horizontal direction as perpendicular to this axis. The ADV measures bistatic velocities, each along axes 15° off the vertical axis, and converts these to Cartesian velocities using probe geometry. Bistatic velocities are more sensitive to vertical motion than horizontal motion by roughly a factor of four ($\tan(15°) = 0.27$). Thus, noise in horizontal measurements is 4 times larger than in vertical measurements, and the maximum horizontal velocity that can be measured by the ADV is 4 times larger than the maximum vertical velocity (see §6.1.1).

The velocity measured by each receiver is referred to as the bistatic velocity, and is the projection of the 3D velocity vector onto the bistatic axis of the acoustic receiver. Bistatic velocities are output directly by the ADV only in specialized applications; normally they are converted to Cartesian (XYZ) velocities using probe geometry. Cartesian velocities give the 3D velocity field relative to the orientation of the ADV probe. As it is not always possible to control instrument orientation, the ADV can be equipped with an internal compass and tilt sensor. Knowing instrument orientation allows the ADV to report velocity data in an Earth (East-North-Up or ENU) coordinate system, independent of probe orientation.

4. Sampling Volume Definition

The size of the ADV sampling volume is determined by four factors: transmit beam pattern, receive beam pattern, pulse length, and the receive window (the period of time over which the return signal is sampled). Figure 4 shows a 2D illustration of the effect of each of these factors.

The ADV sampling volume does not have clearly defined horizontal boundaries. These boundaries are determined by the intersection of the transmit and receive beam patterns. The precise definition of the beam pattern intersection is not easily modeled; for our purposes, it is approximated from the transmit beam pattern as a cylinder the size of the transmit ceramic (6-mm dia. for 10-MHz ADVs; 12-mm for

Figure 4 – ADV Sampling Volume Definition

5-MHz ADVOceans). While this is a simplification, the results are reasonably accurate especially since the vertical limits of the sampling volume are typically most important. It is important to remember that the horizontal boundaries of the sampling volume are not precisely defined and that objects near these boundaries can potentially interfere with velocity measurements.
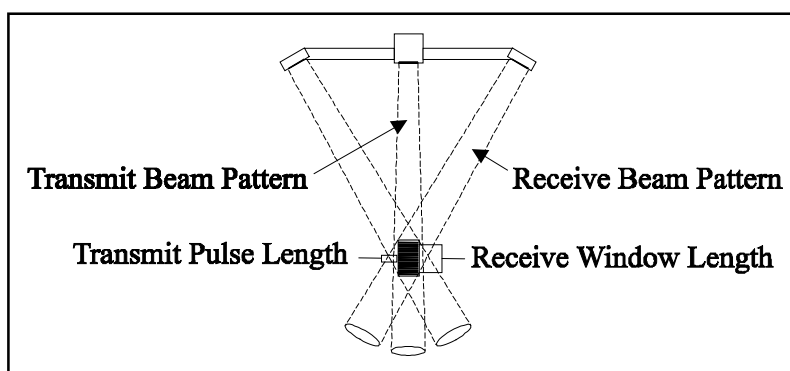
The vertical extent of the sampling volume is defined by the convolution of the acoustic pulse length with the receive window over which the return signal is sampled. Both of these are precisely controlled by the ADV software (within the limits of the transducer bandwidth). The total height of the sampling volume for the 16-MHz and 10-MHz ADVs is 9 mm; for the 5-MHz ADVOcean probe, it is 18 mm. The vertical edges of the sampling volume can be considered defined to ±0.5 mm for the 16/10-MHz ADV probes, and to ±1.0 mm for the 5-MHz ADVOcean probe. Since the pulse length and receive window are controlled by software, the height of the sampling volume can be reduced with changes in the data acquisition software (see §7.4).

It is important to note that for all measurements given by the ADV, the sampling volume location is specified as the vertical center of the sampling volume. For example, if the 10-MHz ADV shows the sampling volume to be located 2.0 cm from the boundary, the leading edge of the sampling volume will be [2.0 cm – (0.5 * 9 mm)] ≈ 1.5 cm from the boundary.

5. Pulse-Coherent Processing

The description of ADV operation given in Section 2 is a simplification of the way in which velocity is actually measured. Section 2 describes incoherent Doppler processing: the transducer sends a single pulse of sound and measures the frequency change of the return signal. In reality, the ADV uses a technique called pulse-coherent (or pure-coherent) processing. In this technique, the instrument sends two pulses of sound separated by a time lag; it then measures the phase of the return signal from each pulse. The change in phase divided by the time between pulses is directly proportional to the velocity of the particles in the water. Pulse-coherent processing is used because it provides the best possible spatial and temporal resolution.

This section does not attempt to provide a detailed description of pulse-coherent processing. It presents a general overview with a focus on how this affects ADV operation. SonTek can provide additional references on pulse-coherent processing upon request.

There are several aspects of pulse-coherent processing that affect ADV operation. First is the inherent limitation on the maximum velocity that can be measured. Pulse coherent processing measures the phase of return signals; phase measurements are limited to a range of $[-\pi, \pi]$. If phase exceeds these limits, it will "wrap around" (i.e. if phase increases to just above π, the ADV measures a phase of $-\pi$). This is known as an ambiguity jump, where (for example) the ADV will measure a negative velocity rather than the true, larger positive velocity.

The maximum unambiguous velocity is a function of the time lag between the two pulses. The ADV offers the user a choice of a number of pre-set velocity ranges, each of which corresponds to a particular pulse lag. All operational changes required for the different velocity ranges are handled automatically by the ADV.

As is discussed in §6.1.1 and §6.1.4, the instrument noise level scales directly with the velocity range setting (higher velocity ranges have a higher noise for each sample). Thus, you should always select the lowest velocity range that meets the requirements of the particular experiment.

Pulse-coherent processing affects ADV operation in two other situations. When making near-boundary measurements, there is a potential that the reflection of one pulse from the boundary could interfere with the other pulse; this is discussed in §7.3. Additionally, the ability to adjust the time lag between pulses gives the ADV excellent performance for applications with low flow velocities; this is discussed in §7.5.

6. ADV Data

The ADV records nine values with each sample: three velocity values (one for each component), three signal strength values (one for each receiver), and three correlation values (one for each receiver). Naturally, the velocity data are of foremost interest. Concerns relating to the use of the velocity data are discussed in §6.1. Signal strength and correlation are used to monitor data quality and to edit potentially corrupted data, which are discussed in §6.2 and §6.3, respectively.

6.1. Velocity

ADV velocity data can be output in Cartesian coordinates (XYZ) relative to probe orientation or in Earth coordinates (East-North-Up or ENU) for systems with the optional compass. In general, the velocity data output by the ADV can be used directly without postprocessing. The ADV calibration does not change unless the probe has been physically damaged. The only time postprocessing corrections are required is when sound speed has been incorrectly specified (§7.2).

Several aspects of ADV operation affect the quality of velocity data. Most important of these is the velocity range setting (discussed in §6.1.1). ADV sampling rate, accuracy of velocity data, and instrument-generated noise are discussed in sections 6.1.2 through 6.1.4.

6.1.1. Velocity Range

One of the most important ADV parameters is the velocity range setting. This determines the maximum velocity that can be measured by the instrument. Standard velocity range settings for the 16/10-MHz ADVs are ±3, ±10, ±30, ±100, and ±250 cm/s; for the 5-MHz ADVOcean, the standard velocity range settings are ±5, ±20, ±50, ±200, and ±500 cm/s. In general, you should select the lowest velocity range setting that will cover the maximum velocity expected in a given experiment. As will be discussed in §6.1.4, the instrument-generated noise in velocity data is proportional to the velocity range setting; higher velocity ranges have higher noise levels.

The velocity range settings are nominal values; the true maximum velocity depends on the direction of flow relative to the probe. The ADV measures velocities along the bistatic axis of each receiver; the maximum velocity limitations are for bistatic velocities. Since the bistatic axes are 15° off the probe vertical axis, the ADV is more sensitive to vertical flow, and has a lower maximum velocity for vertical flow. The tables below shows the maximum velocities that can be measured in each ADV velocity ranges for purely vertical or purely horizontal flow.

ADV Velocity Range	Max. Horizontal Velocity	Max. Vertical Velocity
±3 cm/s	±30 cm/s	±8 cm/s
±10 cm/s	±60 cm/s	±15 cm/s
±30 cm/s	±120 cm/s	±30 cm/s
±100 cm/s	±300 cm/s	±75 cm/s
±250 cm/s	±360 cm/s	±90 cm/s

ADVOcean Velocity Range	Max. Horizontal Velocity	Max. Vertical Velocity
±5 cm/s	±30 cm/s	±8 cm/s
±20 cm/s	±40 cm/s	±10 cm/s
±50 cm/s	±80 cm/s	±20 cm/s
±200 cm/s	±300 cm/s	±75 cm/s
±500 cm/s	±500 cm/s	±120 cm/s

When operating in highly turbulent flows, the ADV may show low correlation values that indicate increased noise in velocity measurements. For turbulent flow, the noise level may be reduced by increasing the velocity range. The magnitude of the turbulent fluctuations can be approximated by the standard deviation of velocity data displayed by the ADV data acquisition software. If these are 5% or more of the velocity range setting (i.e., greater than 5 cm/s when using the ±100 cm/s velocity range), performance should improve by changing to the next higher velocity range. This change should increase the correlation coefficient and reduce the noise in the velocity data.

6.1.2. Sampling

The ADV is designed to measure velocity as rapidly as possible. A single estimate of the 3D velocity field is referred to as a *ping*. The ADV pings 150-250 times per second (the rate varies with velocity range setting). As the noise in a single ping is too high for practical use, the ADV averages a number of pings to reduce the noise level in each output velocity sample. The number of pings averaged is set to meet the user-specified *sampling rate*, within the range of 0.1 to 25 Hz. For example, when sampling at 25 Hz the ADV will collect as many pings as possible over a 40-ms period, average these values together, and output the average as one *sample*.

An important result of the ADV sampling scheme is that reducing the sampling rate decreases the noise in each sample (by increasing the number of pings averaged per sample). The instrument-generated noise, also referred to as Doppler noise, is random; averaging multiple points will converge towards the true value without introducing bias. The noise level decreases with the square root of the number of samples averaged; thus, data output at 1 Hz has about one-fifth the noise of data output at 25 Hz.

6.1.3. Short Term Uncertainty (Noise)

All Doppler systems have an inherent measurement noise that is a result of the physical process by which the sound waves are scattered from particles in the water. This is referred to as Doppler noise. Doppler noise is purely random and can be assumed to follow a Gaussian distribution. Averaging multiple data points converges to the true value without introducing bias.

Under good operating conditions (i.e., SNR > 15 dB, correlation greater than 70%), the noise in ADV horizontal velocity data is estimated at 1% of the velocity range when outputting data at 25 Hz. For example, individual samples at 25 Hz will have horizontal velocity noise of about ±1 cm/s if using the ±100 cm/s velocity range (or about ±0.3 cm/s if using the 30 cm/s velocity range). As mentioned in §6.1.2, noise decreases with the square root of the number of pings averaged per sample; thus, individual samples at 1 Hz would have noise of about ±0.2 cm/s when using the 100 cm/s velocity range.

Note that the above noise estimates are for horizontal velocity. Since the bistatic axes of the ADV receivers are 15° off the vertical axis, noise in horizontal velocity measurements is larger than in vertical velocity measurements by approximately a factor of four.

6.1.4. Accuracy

Accuracy for ADV velocity data refers to the presence of a bias in mean velocity measurements after removing instrument-generated noise. Two main factors influence the accuracy of ADV velocity measurements: sound speed and probe geometry. Sound speed is a user input parameter; errors in user input sound speed will cause errors in velocity measurements that can be corrected

in post processing (see §7.2). Probe geometry is calibrated at the factory for each ADV; no re-calibration is required unless the probe has been physically damaged.

The accuracy of the probe geometry, with factory calibration, is specified to ±1.0% of the measured velocity (i.e., an accuracy of ±1.0 cm/s on a measured velocity of 100 cm/s). This represents the limits of the calibration procedure to determine the angular alignment of the acoustic transmitter and receivers.

The ADV specifications state a maximum zero offset velocity of ±0.25 cm/s. With Doppler processing, there is no potential for zero offset in velocity measurements; this specification is included because of the difficulty in generating calibrated velocities at low flows. See §7.5 for additional information about using the ADV to measure low flow velocities.

6.2. Signal Strength

Signal strength, recorded for each ADV receiver, is a measure of the intensity of the reflected acoustic signal. This is recorded as raw signal amplitude in internal logarithmic units of *counts*; one count is equal to 0.43 dB. With the ADV software, signal strength can be accessed either as signal amplitude in counts or as signal-to-noise ratio (SNR) in dB. SNR is derived from signal amplitude by subtracting the ambient noise level and converting to units of dB.

The main function of signal strength data is to verify there is sufficient particulate matter in the water. If the water is too clear, the return signal may not be stronger than the ambient electronics noise level. Without sufficient signal strength, the ADV is unable to make accurate velocity measurements. As SNR decreases, the noise in ADV velocity measurements will increase. For high-resolution measurements (e.g., sampling at 25 Hz), we recommend maintaining SNR of at least 15 dB. For mean current measurements (e.g., sampling at 0.5 Hz, or once every 2 seconds), the ADV can operate reliably with the SNR as low as 5 dB.

The strength of the return signal is a function of the amount and type of particulate matter in the water. Signal strength values can be used as a measure of sediment concentration when the type of sediment is known. While ADV signal strength data cannot be immediately converted to sediment concentration, it does provide an excellent qualitative picture of sediment fluctuations and, with proper calibration, can be used for reasonably accurate estimates of sediment concentration. For more information about sediment concentration, contact SonTek.

6.3. Correlation Coefficient

The ADV correlation coefficient is a data quality parameter that is a direct output of the Doppler velocity calculations. The ADV computes three correlation values, one for each acoustic receiver, with each velocity sample. Correlation is expressed as a percentage: perfect correlation of 100% indicates reliable, low noise velocity measurements; 0% correlation indicates the output velocity value is dominated by noise (no coherent signal). Correlation can be used to monitor data quality during collection and to edit data in postprocessing. For example, if the ADV is being used in waves where it is periodically out of the water, correlation values can be used to determine what portions of the data can be used.

Ideally, correlation values should be between 70 and 100%. Values below 70% indicate that the ADV is operating in a difficult measurement regime, the probe is out of the water, the SNR is too low, or that something may be wrong with the ADV. In some environments (highly turbulent flow, highly aerated water), it may not be possible to achieve high correlation values. Low corre-

lation values will affect the short-term variability in velocity data (e.g., increase the noise), but will not bias the mean velocity measurements. For mean velocity measurements, correlation values as low as about 30% can be used.

The description given above is intended to provide general guidelines when using the correlation coefficient as a data quality parameter. To understand the exact meaning of the correlation coefficient, and all factors affecting it, requires an in-depth discussion of pulse-coherent Doppler processing. Additional information and references are available from SonTek.

7. Special Considerations

This section addresses several aspects of the ADV that require special attention. Section 7.1 describes the different 16-MHz and 10-MHz ADV probe configurations, and the environments in which they are used. Section 7.2 discusses the effect of sound speed on ADV velocity data. Section 7.3 describes concerns related to near boundary measurements, and the type of performance that can be expected. Section 7.4 discusses software modifications to reduce the size of the sampling volume. Section 7.5 discusses the use of the ADV for low flow applications.

7.1. *Alternate Probe Configurations*

The 16-MHz and 10-MHz ADV probes, used in a variety of laboratory and field experiments, are available in several configurations for different measurement needs. These variations are divided into four areas: location of the sampling volume, acoustic sensor mounting, sensor orientation, and coordinate resolution. Probes can be configured with almost any combination of these. The 5-MHz ADVOcean probe uses a single, rugged configuration: 3D sensor, oriented looking down, with an 18-cm distance to the sampling volume.

Sampling volume location. The sampling volume can be located either 5 or 10 cm from the tip of the acoustic sensor. The 5-cm sensor can be used in shallower water and gives a stronger return signal by about 6 dB. The 10-cm sensor has less potential for flow interference in oscillatory flow.

Sensor mounting. The sensor can be mounted on a 25 or 40-cm long stainless steel stem, or on a 100-cm flexible cable. The 40-cm stem is used in laboratory applications to reduce the amount of equipment in the water. The 25-cm stem is used in field applications where a more rigid mounting is required. The 100-cm cable allows increased flexibility in the sensor orientation, but requires more complicated mounting arrangements.

Sensor orientation. The ADV acoustic sensor can be oriented looking up, down, or to the side. Down is most common as it allows for easy mounting and measurements close to the bottom boundary. Side-looking is typically used in wave tanks with the sensor mounted looking across the direction of propagation, reducing the chance of flow interference. Up-looking is typically used for measurements near the surface, under a layer of ice, or near the bottom of a vessel or structure.

Coordinate resolution. The ADV can be built to measure either 2D or 3D fluid flow, using two or three acoustic receivers respectively. 3D is the most common configuration; 2D is most commonly used for very shallow water (minimum 3 cm) with a side-looking sensor, or for very narrow channels using a down-looking sensor.

7.2. Sound Speed

The ADV uses sound speed to compute velocity from the measured Doppler shift. This section discusses how to correct ADV velocity data for errors in the sound speed value used for data collection. Any errors in sound speed are typically very small, so postprocessing corrections are rarely required.

The speed of sound in water is primarily a function of temperature and salinity. Figure 5 shows sound speed as a function of temperature (at several salinity levels). Figure 6 shows sound speed as a function of salinity (at several temperature levels). Generally, a temperature change of 5°C, or a salinity change of 12 ppt, results in a change in sound speed of 1%. The full range of typical temperature and salinity levels, from -5 to 50°C and 0 to 60 ppt, gives a sound speed range of 1375 to 1600 m/s (total change of 14%).
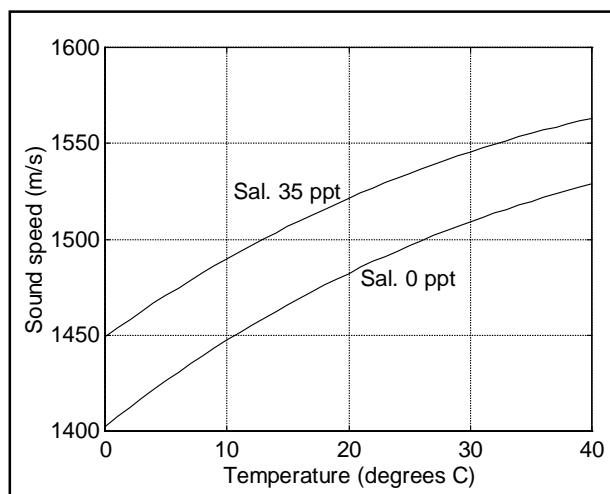
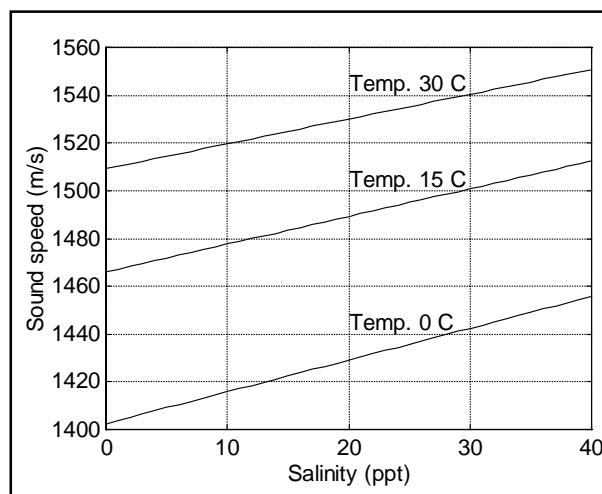**Figure 5 – Sound Speed vs. Temperature**   **Figure 6 – Sound Speed vs. Salinity**

Changes in sound speed affect ADV velocity measurements in two ways: conversion of the Doppler shift to velocity, and measurement geometry as determined by the location of the sampling volume. The geometry change occurs since the ADV sampling time is determined by the specified sound speed. If sound speed is incorrect, the true location of the sampling volume will differ from the location assumed in the probe calibration file. The change in geometry causes sound speed errors to have an increased effect on the accuracy of velocity data.

Correcting ADV velocity for sound speed errors can be done two ways. The first method uses a best-fit approximation of the geometry change. This correction, shown below, is accurate to about 0.5% for sound speed errors up to about 5%.

Horizontal velocity correction (Vx and Vy for 3D probes; Vx for 2D probes):
$$V_{true} = V_{orig} * (1 + 1.93 * ((C_{true} / C_{orig}) - 1))$$
Vertical velocity correction (Vz for 3D probes; Vy for 2D probes):
$$V_{true} = V_{orig} * (1 + 0.94 * ((C_{true} / C_{orig}) - 1))$$
Where:
V_{true} = Corrected velocity value
V_{orig} = Un-corrected (original) velocity value
C_{true} = True speed of sound
C_{orig} = Speed of sound used in original calculations

A more precise method to correct ADV velocity involves calculating the exact geometry change and re-computing the Cartesian velocity values. This is done in four steps.

1. Transform Cartesian (XYZ) velocities back to bistatic velocities.
2. Scale bistatic velocities for correct sound speed.
3. Compute corrected transformation matrix for geometry change.
4. Transform bistatic velocities to Cartesian (XYZ) velocities using corrected matrix.

This algorithm uses the transformation matrix and bistatic angles unique to each ADV probe. A documented program for this correction is available upon request.

7.3.   Near-Boundary Measurements

Because of the remote, 3D velocity measurements made by the ADV, the instrument is extremely well suited to flow studies in boundary layers. The ADV can be used for detailed boundary layer studies and make direct measurements of turbulent parameters such as Reynolds stress. However, making accurate measurements near a boundary does require some additional care. This section describes the potential sources for error and the overall system performance.

The most obvious source of interference with ADV measurements is when the sampling volume includes the boundary. In this case, the ADV will be measuring the Doppler shift of the boundary reflection rather than the reflection from particles in the water. This will typically bias velocities towards zero (since the boundary is normally stationary), although this is not completely predictable (particularly if dealing with non-stationary or non-uniform boundaries).

Under good operating conditions, the leading edge of the sampling volume can be placed within about 1 mm of a boundary for 16-MHz /10-MHz ADVs, and about 2 mm for 5-MHz ADV-Oceans. As discussed in Section 4, the vertical extent of the sampling volume is precisely defined, so this leading edge can be placed very close to a boundary without interference. When making near boundary measurements, it is important that the distance from the probe to the boundary is constant. If making measurements near the surface or near a moving bed, where the height of the boundary can change with time, this will typically be the limiting factor in how close measurements can be made.

Figure 7 shows the profile of signal strength for one ADV receiver when operating near a boundary. This is the same as shown in Figure 2, although we now see a sharp reflection corresponding to the reflection from the boundary. The exact size and shape of the boundary reflection will vary with range, the type of boundary, and the relative orientation of the probe. Although the boundary reflection comes from a direction outside the peak receiver sensitivity, the strength of the reflection is far stronger than the return signal from the water so its return can be as strong (or potentially stronger) than the return from the sampling volume. The distance between the sampling volume peak and the bottom reflection peak is used by the ADV to measure the distance from the sampling volume to the boundary.

When working close to a boundary, measuring the distance from the sampling volume to the boundary becomes very important. The ADV measures and reports the distance from the center of the sampling volume to the boundary. This measurement is accurate to about ±1 mm for 16-MHz/10-MHz ADVs, and about ±2 mm for the 5-MHz ADVOcean. However, this accuracy only holds if the center of the sampling volume is more than about 2 cm from the boundary. At closer ranges, the ADV cannot distinguish the boundary from the sampling volume. To position the ADV sampling volume very close to a boundary, use the ADV measured distance at a greater range and move the probe a controlled distance to achieve the desired measurement location.
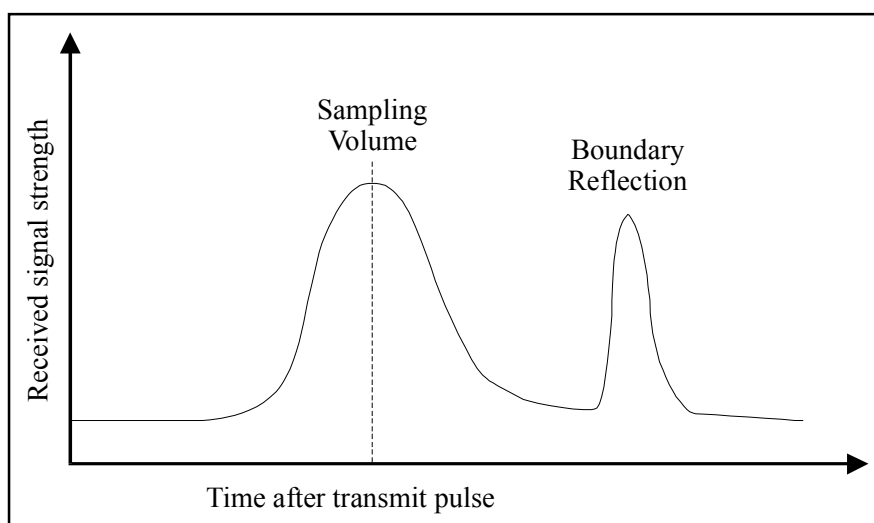
Figure 7 – ADV Signal Strength Profile with Boundary Return

There is a second, less obvious, source of boundary interference for ADV measurements. The ADV sends two pulses for each velocity measurement (see Section 5). Thus it is possible that the reflection of the first pulse from the boundary may arrive at the same time as the return of the second pulse from the sampling volume. This illustrated in Figure 8 below.

Figure 8 shows three possible cases for ADV operation near boundaries. In Case 1, the distance between the two pulses (known as the pulse lag) is shorter than the distance from the sampling volume to the boundary. In Case 2, the pulse lag is greater than the distance to the boundary. In either of these cases, the ADV is able to make velocity measurements without interference. In Case 3, the pulse lag matches the distance to the boundary, so the ADV will be receiving the reflection of the first pulse from the boundary when it is sampling the second pulse. This contamination appears as very high noise levels, typically making it impossible to interpret velocity data.

The ADV has been designed to look for the interference shown in Case 3. Before starting data collection, the instrument looks for a boundary and, if present, measures the distance to the boundary. If that distance matches the pulse lag (determined by the velocity range setting), the ADV will automatically adjust the pulse lag to avoid interference. When possible, it will adjust the lag to a higher velocity range. However, when working very near the boundary it may not be
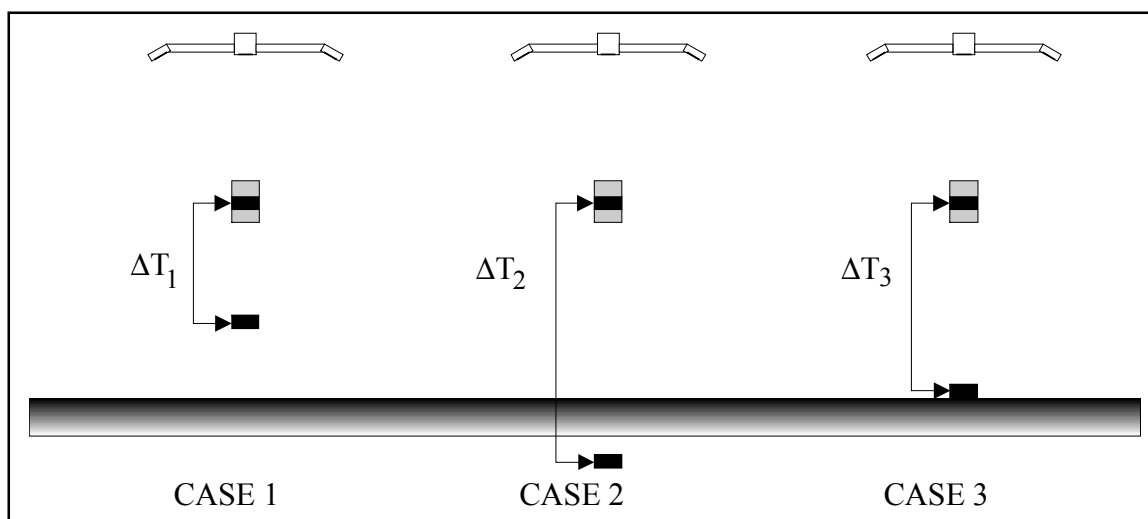

Figure 8 – ADV Multiple Pulse Boundary Considerations

possible to use a higher velocity range and the ADV will be forced to use a reduced velocity range. The most significant limitations occur when trying to measure high flows (> 1 m/s) very close to the boundary. These measurements can typically be made, but require careful adjustment and monitoring.

One important result of the potential boundary interference described above is that changes in the distance from the sampling volume to the boundary during data collection can potentially cause problems. This is because the ADV only checks for interference at the start of data collection. If the probe is moved with the respect to the boundary (e.g., making a profile), data collection should be restarted at each depth. This allows the ADV to check for interference and adapts its operation to avoid it. Care should also be taken when working near moving beds or near the surface, where the height of the boundary can change with time.

7.4. Reduced Sampling Volume

As described in Section 4, the horizontal extent of the sampling volume is defined by the transmitter beam pattern and the vertical extent by the convolution of the pulse length with the receive window size. Both pulse length and receive window size are controlled by the ADV software. Thus, with software modifications, we can reduce the vertical extent of the sampling volume. This section describes the changes that can be made, and the tradeoffs associated with them.

When altering the vertical extent of the sampling volume, we can reduce both the length of the acoustic pulse and the time window over which the return is sampled. Reducing both of these as much as possible makes the height of the sampling volume 1.2 mm for 16-MHz/10-MHz ADVs, and 2.4 mm for 5-MHz ADVOceans.

There are two effects associated with reducing the size of the sampling volume. First, by reducing the receive window, we reduce the number of points averaged for velocity calculations and increase the temporal variability (noise) of the measurements. Reducing the receive window to its minimum value increases the noise in individual measurements by a factor of about two.

The second effect occurs because of shrinking the size of the transmit pulse; using a shorter pulse reduces the strength of the return signal from the water. Reducing the length of the acoustic pulse to its minimum level reduces the instrument Signal-to-Noise Ratio (SNR) by about 6 dB. This is not a concern in applications where signal strength is high (SNR > 15 dB), but it can be a factor in relatively clear water as it can introduce or increase seeding requirements. If the SNR ratio remains sufficiently high, reducing the length of the transmit pulse has no effect on the noise in velocity measurements.

7.5. Low Flow Measurements

One significant advantage of Doppler current meters, particularly when using pulse-coherent processing, is that there is no minimum measurable velocity. Doppler systems have no potential for a zero offset or zero drift. Since they compare the return signal from the water with the transmitted signal, a change in the transmit signal (which might be thought to cause a drift) will have no significant effect since the instrument is looking at the change in frequency.

The ADV specifications state that the zero offset velocity is ±0.25 cm/s. This is done largely because it is very difficult to establish what the true flow is at very low velocities; there is no potential for any zero offset. In laboratory experiments, the ADV has been used to measure calibrated flows as low as to 0.04 cm/s.

The lowest ADV velocity range, ±3 cm/s, will yield good results for flows down to about 0.1 cm/s. If working in an environment with lower flows, the ADV software can be modified to use lower velocity ranges that will improve performance in flows less than 0.1 cm/s. For more information about using the ADV for low flow applications, contact SonTek.

Using Frequency Pressure Sensors with SonTek/YSI ADPs, Hydras, and Argonauts

This document describes the use of *frequency pressure sensors* with SonTek acoustic Doppler current meters. SonTek supports two types of frequency pressure sensors: (1) the Druck RPT, a silicon resonant transducer (referred to as DRUCK) manufactured by Druck, Inc. and (2) the Paroscientific digiquartz transducer (referred to as PAROSFREQ) manufactured by Paroscientific, Inc.

1. Overview

Typically, SonTek instruments include *analog pressure sensors* (e.g., strain gage) that provide sufficient accuracy and stability (0.1 to 0.25 %) at a moderate cost. These sensors are usually installed within the system head (Figure 1). They are internal to the system and are usually referred to as PRESSURE or PRESSURE SENSOR within our documents and system command interface.

Some applications, however, require better long-term stability (e.g., tide studies, wave interaction with topography, long-term water-level monitoring, etc.). To accommodate these needs, SonTek has integrated *frequency pressure sensors*, which offer an order of magnitude better accuracy and stability (0.01%). The first supported sensor was the Paroscientific digiquartz with a serial interface (PAROS). These sensors, because of their size did not fit inside our systems and were mounted externally (Figure 1). The next supported sensor, the Druck RPT, did fit inside an ADP or ADVOcean head. However, for historical purposes, all *non-strain gage sensors* are usually referred to as EXTERNAL PRESSURE SENSOR within our documents and system command interface.

2. Serial External Pressure Sensors (PAROS)

As mentioned, the first external pressure sensor supported by SonTek was the Paroscientific digiquartz with serial interface (PAROS). The PAROS is connected to a system by a 1 to 2-m cable. The PAROS is available for ADP, PC-ADP, and Hydra systems. The differences, when compared with a strain-gage sensor, are as follows:

- The PAROS is an absolute sensor. It reads 1 dbar in air; a strain gage reports 0 dbars in air.
- Sampling rate is limited to 4 Hz (ADVs and Hydras) due to serial interface limitations.
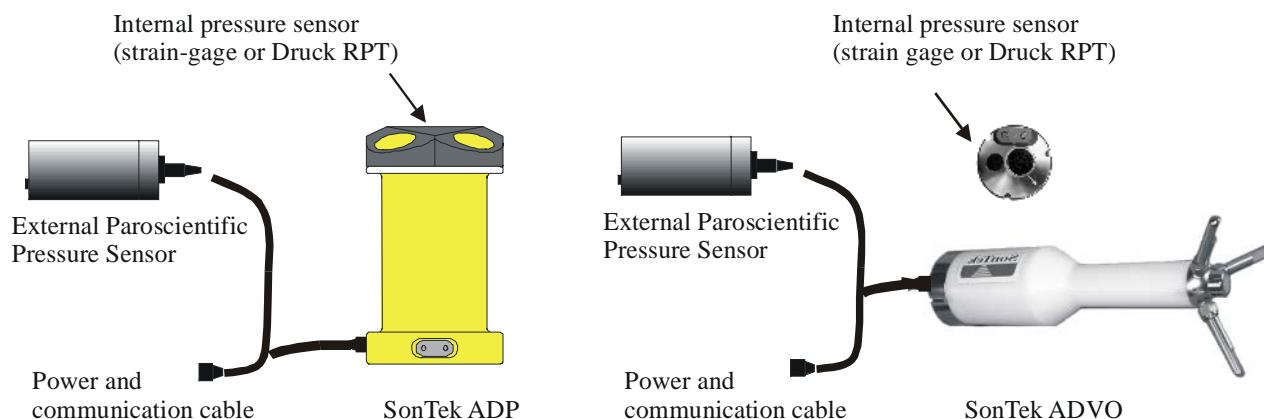

Figure 1: ADP and ADVOcean with external pressure sensors.

3. Frequency External Pressure Sensors

3.1. The Druck RPT (DRUCK)

Although the PAROS provides the required accuracy, its size and external location cause additional complications when mounting and deploying a system. SonTek, in collaboration with Druck, Inc., now offers the Druck RPT (resonant pressure transducer) sensor. This sensor is very compact and fits inside the same mounting socket as the regular strain gage (Figure 1). The DRUCK sensors are available for ADP, PC-ADP, Argonaut SL/XR, and Hydra systems. The differences, when compared with a strain-gage sensor, are as follows:

- The DRUCK is an absolute sensor. It reads 1 dbar in air; a strain gage reports 0 dbars in air.
- Requires a special interface to sample the frequency signal.
- Sampling rate is limited to 10 Hz (ADVs and Hydras) because of the time required to sample the frequency signal with sufficient precision.
- Requires calibration matrix (specific to each sensor) to be loaded into the processor (system CPU or a user PC) to obtain valid pressure readings.
- Available in 50-psia pressure rating only (equivalent to ≈22 dbar strain gage).

3.1.1. Sensor Calibration Template

Each current meter purchased from SonTek that has the DRUCK sensor installed already has the appropriate calibration coefficients loaded into the processor. If this information is lost, you can use the calibration sheet provided by the pressure sensor vendor to construct your own calibration file. The structure of the DRUCK calibration file, required by SonTek systems, is as follows.

- Pressure Sensor Serial Number
- Oscillator Frequency (in Hz)
- X
- Y
- Low end of temperature range
- Corresponding voltage of the diode
- Diode sensitivity
- K00 K01 K02 K03
- K10 K11 K12 K13
- K20 K21 K22 K23
- K30 K31 K32 K33
- K40 K41 K42 K43
- K50 K51 K52 K53

> Note: The X, Y, and K coefficients can be found on the Druck calibration sheet.

Example – Druck calibration file **1145118.drk**:

```
1145118
12.0000000E+06
+8.8880000E+03
+5.5200000E+02
-10
622
-2.21
+1.6214761E+03   -2.0699499E-02   +5.5220000E-05   -5.6160001E-08
+1.8251241E+00   -5.8612000E-06   +3.6197001E-08   -3.8715001E-10
+3.8615943E-04   -1.5274000E-09   -4.7059999E-12   -1.3233001E-13
+7.0553313E-08   -1.9064000E-12   -4.0058001E-14   +9.0119996E-16
+1.7913088E-11   -1.3525000E-15   +1.7647000E-17   +3.8552999E-19
+3.7756621E-15   +1.9573000E-19   +3.6951001E-20   -3.3300999E-22
```

3.2. The Paroscientific Digiquartz (PAROSFREQ)

User requirements for deeper ratings (compared to DRUCK) and faster response (compared to PAROS) convinced SonTek to offer the Paroscientific digiquartz sensor with frequency output (PAROSFREQ). Functionally, the interface for the PAROSFREQ is identical to the interface for the DRUCK, as both are frequency-based sensors. The PAROSFREQ sensors are available for ADP, PC-ADP, and Hydra systems. The differences, when compared with a strain-gage sensor, are as follows:

- The PAROSFREQ is an absolute sensor. It reads 1 dbar in air; a strain gage reports 0 dbars.
- Requires a special interface to sample the frequency signal.
- Requires a special frequency splitter cable.
- Sampling rate is limited to 10 Hz (ADVs and Hydras) because of the time required to sample the frequency signal with sufficient precision.
- Requires a calibration (specific to each sensor) to be loaded into the processor (system CPU or a user PC) to obtain valid pressure readings.
- Available in 50-psia (≈22 dbar strain gage) and 100-psia (≈60-m strain gage) pressure ratings.

The structure of the calibration file corresponding to the PAROSFREQ sensor is similar to the DRUCK. For historic reasons, PAROSFREQ calibration file uses the .drk extension.

- Pressure Sensor Serial Number
- Oscillator Frequency (in Hz)
- U0
- N/A
- N/A
- N/A
- N/A

> Note: The U, Y, C, D, and T coefficients can be found on the Paroscientific calibration sheet.

- Y1 Y2 Y3 N/A
- C1 C2 C3 N/A
- D1 D2 N/A N/A
- T1 T2 T3 T4
- N/A N/A N/A N/A
- N/A N/A N/A N/A

Example – Paroscientific calibration file **p68888.drk**:

```
P68888
12.0000000E+06
5.880670
0.0
0.0
0.0
0.0
-3898.415      -10940.31        0.0          0.0
  224.5927        6.013600    -245.2861       0.0
    0.041219      0.0           0.0           0.0
   27.94067       0.859765     20.65914      26.99304
    0.0           0.0           0.0           0.0
    0.0           0.0           0.0           0.0
```

4. Additional System Commands

This section describes the system commands used for external pressure sensor operation.

4.1. ADPs and Hydras

The following commands apply to ADP and Hydra (ADVOcean) systems that have an external pressure sensor installed.

ExtPressureSensorInstalled Set [NONE|PAROS|DRUCK|PAROSFREQ]
- Selects or disables the external pressure sensor type.
- Set at the factory. Does not need to be changed except in some special cases.
- The external pressure sensor option limits the maximum sampling rate of an ADV to 4 Hz for the PAROS and to 10 Hz for a DRUCK or PAROSFREQ. To collect data at faster rates, you must disable the external pressure sensor option.

PressFreqOffset Set [d]
- Default parameters (in kHz): **0** (for DRUCK); **21** (for PAROSFREQ)
- Sets/displays frequency offset (in kHz).
- This parameter is set at the factory and should not be changed by the user.

PAROS CONT *or* **DRUCK CONT** *or* **PAROSFREQ CONT**
- This command provides a useful tool to verify and troubleshoot the frequency sensor.
- For PAROS sensors:
  - This command continually outputs pressure reading in dbar.
  - If the pressure reading is zero, the connection between the sensor and the processing electronics may be damaged (or open).
- For DRUCK and PAROSFREQ sensors:
  - This command outputs a sample consisting of converted pressure (dbar), temperature (°C), and raw frequency counts (Hz) in the following format:

    ```
    Druck Press =    10.03192    Temp = 22.11    Freq =   8055.674
    ```

  - The DRUCK frequency range (in air) is 7 to 10 kHz; the PAROSFREQ is 35 to 38 kHz.
  - If the frequency reading is zero, or is outside the range, the connection between the sensor and processing electronics may be damaged (or open).
  - If the frequency reading is reasonable, but the corresponding pressure is not, this indicates that the appropriate calibration is not loaded into the processor. Section 5 describes how to load the DRUCK calibration.

Show DRUCK *or* **Show PAROSFREQ**
- Displays DRUCK/PAROSFREQ calibration data in the following format:

```
Druck pressure sensor calibration data
--------------------------------------
SN:    1276950
F0:       1.200e+07
X:    8.4410000e+03
Y:    5.6000000e+02
T0: -1.0000000e+01
D0:  6.2900000e+02
DT: -2.2100000e+00

K00:  1.5962190e+03   K01: -2.6693000e-02
K10:  1.6820332e+00   K11: -1.0395800e-05
K20:  3.9933779e-04   K21: -4.9470601e-09
K30:  8.0327140e-08   K31: -1.4093000e-12
K40:  1.7388157e-11   K41:  2.2691999e-16
K50:  2.5953699e-15   K51:  1.3877999e-19

K02:  3.1005999e-05   K03:  2.6474001e-07
K12:  1.8332999e-08   K13:  8.2459997e-11
K22:  1.6572001e-11   K23: -1.7079999e-14
K32: -7.7020003e-15   K33: -9.9870002e-17
K42: -4.0642002e-18   K43: -1.0678000e-19
K52:  5.3660002e-21   K53: -2.8249999e-23
```

4.2. Argonaut SL/XR

The following command applies to Argonaut SL and XR systems that have an external pressure sensor installed.

ExtPressInstalled [NONE|PAROS|DRUCK]
- Selects or disables the frequency pressure sensor type.
- Set at the factory. Does not need to be changed.

5. Additional Software

This section describes additional software required to use external frequency pressure sensors (DRUCK/PAROSFREQ) with SonTek instruments.

5.1. Downloading and Extracting Druck Calibration: LDDRUCK/GTDRUCK

The **LDDRUCK.EXE** program *loads* the DRUCK/PAROSFREQ calibration file into the instrument's processor. The command syntax is:

```
LDDRUCK [DruckCalFile] [-COM port] [-Baud Rate] [-Address]
```

where

- `DruckCalFile` is the name of the calibration file (no extension).
- `-COM port` is the serial port to which the system is connected (1=COM1; 2= COM2).
- `-Baud Rate` is the communication baud rate setting of the system. If no value is given, the program assumes the default setting of 9600 baud. Acceptable baud rate settings are 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200.
- `-Address` is the address for a RS-485 system.

Example: **LDDRUCK P84567 –p1 –b19200 –a2** will download the file **P84567.DRK** onto the system at address **2** connected to COM port **1** at **19200** baud.

The **GTDRUCK.EXE** program *gets* (downloads) the DRUCK/PAROSFREQ calibration file from the instrument's processor to the user's PC. The command syntax is:

```
GTDRUCK [MyCalFile] [-COM port] [-Baud Rate] [-Address]
```

where

- `MyCalFile` is the name of the calibration file (no extension).
- `-COM port` is the serial port to which the system is connected (1=COM1; 2= COM2).
- `-Baud Rate` is the communication baud rate setting of the system. If no value is given, the program assumes the default setting of 9600 baud. Acceptable baud rate settings are 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200.
- `-Address` is the address for a RS-485 system.

Example: **GTDRUCK B199 –p2 –b19200** will retrieve the calibration data from the system connected to COM port **2** at **19200** baud and store the data into file **B199.DRK**.

5.2.   PC-ADP Header Extraction: GADPHDR

During data collection, standard ADPs store mean pressure data (converted into dbars) in the header. PC-ADPs, however, usually profile at much faster rates. As such, the pressure data from the DRUCK or PAROSFREQ sensor is stored in raw frequency counts as a way to increase system performance. The extraction program **GADPHDR.EXE** lets you specify the DRUCK/PAROSFREQ calibration file so the pressure data can be converted into dbars during the data extraction process. The command syntax is:

```
GADPHDR [DataFile] [-P]
```

where

- `DataFile` is the name of the PC-ADP data file being extracted (.adp extension implied).
- `-P` is the name of the pressure sensor calibration file (.drk extension implied).

Example: **GADPHDR MYDATA -Pp87654** will extract header data from the **MYDATA.ADP** data file using DRUCK/PAROSFREQ calibration data from the **p87654.DRK** file. Note: If incorrect calibration data is used, the pressure data will not be correct.

5.3.   ADP Wave Data Extraction: GADPWAVE/GADPPRES

To increase system performance when collecting wave or pressure series data, the ADP stores wave and pressure series data in raw frequency counts (DRUCK/PAROSFREQ sensors only). To extract the data, use the **-P** command line option to specify the DRUCK/PAROSFREQ calibration file so the data can be converted to dbars during the data extraction process. Examples:

```
GADPWAVE ADPWAVE -Pp87654
```

will extract wave data from the **ADPWAVE.ADP** using DRUCK/PAROSFREQ calibration from the **p87654.DRK** file.

```
GADPPRES ADPWAVE -Pp87654
```

will extract pressure series data from the **ADPWAVE.ADP** using DRUCK/PAROSFREQ calibration from the **p87654.DRK** file.

Note that in both cases that if incorrect calibration data is used, the output data will be invalid.

5.4.   Hydra Data Extraction: GADVTS/GADVHDR

To increase system performance, the Hydra stores pressure series data in raw frequency counts (DRUCK/PAROSFREQ sensors only). To extract pressure series data, use the **-D** command line option to specify the DRUCK/PAROSFREQ calibration file so the data can be converted to dbars during the data extraction process. Examples:

```
GADVTS HYDRAFILE -Dp87654
```

will extract time-series data from the **HYDRAFILE.ADR** using DRUCK/PAROSFREQ calibration from the **p87654.DRK** file.

```
GADVHDR HYDRAFILE -Dp87654
```

will extract header data from the **HYDRAFILE.ADR** using DRUCK/PAROSFREQ calibration from the **p87654.DRK** file.

Note that in both cases that if incorrect calibration data is used, the output data will be invalid.

5.5. Windows Software Support

SonTek Windows-based software offers an alternative to the DOS extraction programs for handling the external pressure sensor calibration data.

5.5.1. Downloading Calibration File Using SonUtils

The *Terminal* module within *SonUtils* provides an easy way to load the frequency pressure sensor calibration file into the system processor. Simply establish communication with the system in *Terminal*, click the **Load Druck Calibration** icon, choose the appropriate file, and the load process will be performed.

5.5.2. Specifying Calibration File When Using ViewHydra

When opening a data file (.adr) with *ViewHydra*, you must supply a sensor calibration file (.drk) to convert pressure data to dbars. If no pressure calibration is provided, all pressure data will be displayed in raw frequency counts. *ViewHydra* lets you save the calibration data in an associated data file workspace, so the calibration data is loaded automatically the next time the data file is opened.

After the data file is loaded, you can select the sensor offset from the processing menu to convert the absolute pressure reading.

1. Run DRUCK/PAROSFREQ in *Terminal* and make note of the pressure reading with the system in the air (say 10.025 dbar for this example).
2. In the **Processing|Sensor Calibration Settings…** menu, set **Sensor Type** to **Ext Pressure**, and then enter a value of **–10.025** (for this example) in the **Offset** field to convert pressure data into strain gage data (relative to the atmosphere).
3. Now use the **Processing|Recompute Burst Statistics File…** option to propagate the changes into the burst-averaged data.
4. When exiting the program, use the **Save (Overwrite) Workspace** option to store the calibration and offset data. The program will now remember this information for this data set.

5.5.3. Using ViewADP with PCADP Data and Waves

Data collected by a standard ADP stores mean pressure data in dbars; no additional conversion is needed. However, PC-ADP data and ADP wave series data (P-SERIES & PUV-Series) require pressure calibration.

When opening a data file with *ViewADP*, click the **Load ExtPres CalFile** button to specify the calibration file.

Notes:

1. If pressure calibration is not loaded, all pressure data will be displayed as raw frequencies.
2. If pressure calibration data is not loaded, wave data processing is disabled.
3. *ViewADP* will save the calibration data in the associated data file's workspace. This allows the calibration data to load automatically the next time the data file is opened.