SonTek – a Xylem brand
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SonTek-SL

Featuring

SmartPulse$^{HD®}$

User's Manual

Firmware Version 3.0
Software Version 3.0

P/N 45-0103 REV E

WARRANTY, TERMS, AND CONDITIONS

Thank you for purchasing the SonTek-SL Intelligent Flow meter. The instrument was thoroughly tested at the factory and found to be in excellent working condition. If the shipping crate appears damaged, or if the system is not operating properly, please contact SonTek immediately.

This system is covered under a two year limited warranty that extends to all parts and labor for any malfunction due to workmanship or errors in the manufacturing process. The warranty is valid only if you properly maintain and operate this system under normal use as outlined in the User's Manual. The warranty does not cover shortcomings that are due to the design, or any incidental damages as a result of errors in the measurements.

SonTek will repair and/or replace, at its sole option, any product established to be defective with a product of like type. CLAIMS FOR LABOR COSTS AND/OR OTHER CHARGES RESULTING FROM THE USE OF SonTek GOODS AND/OR PRODUCTS ARE NOT COVERED BY THIS LIMITED WARRANTY.

SonTek DISCLAIMS ALL EXPRESS WARRANTIES OTHER THAN THOSE CONTAINED ABOVE AND ALL IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR A PARTICULAR PURPOSE. SonTek DISCLAIMS AND WILL NOT BE LIABLE, UNDER ANY CIRCUMSTANCE, IN CONTRACT, TORT OR WARRANTY, FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND, INCLUDING BUT NOT LIMITED TO LOST PROFITS, BUSINESS INTERRUPTION LOSSES, LOSS OF GOODWILL, OR LOSS OF BUSINESS OR CUSTOMER RELATIONSHIPS.

If your system is not functioning properly, first try to identify the source of the problem. If additional support is required, we encourage you to contact us immediately. We will work to resolve the problem as quickly as possible.

If the system needs to be returned to the factory, please contact SonTek to obtain a Service Request (SR) number. We reserve the right to refuse receipt of shipments without SRs. We require the system to be shipped back in the original shipping container using the original packing material with all delivery costs covered by the customer (including all taxes and duties). If the system is returned without appropriate packing, the customer will be required to cover the cost of a new packaging crate and material.

The warranty for repairs performed at an authorized SonTek Service Center is one year.

CONTACT INFORMATION

Any questions, concerns, or suggestions can be directed to SonTek by telephone, fax, or email. Office hours are 7:30 a.m. to 4:30 p.m., Pacific Time, Monday through Friday. After-hours Technical Support is available for emergencies in the field at the phone number below.

Phone : (858) 546-8327

Fax : (858) 546-8150

Email : inquiry@sontek.com (General information)

sales@sontek.com (Sales information)

support@sontek.com (After-Sales Support information)

Web : http://www.sontek.com

See our web site for information concerning new products and software/firmware upgrades.

RECORD OF CHANGES

Date	Version	Changes
June 2014	2.00	Initial release
August 2016	2.1	Firmware/Software v2.1 release
March 2017	2.2	Firmware/Software v2.2 release
October 2017	2.2	RoHS compliance on P/N's: SL15003G-I-3 or higher and SL30003G-I-2 and higher
May 2018	3.0	Firmware/Software v3.0 release

DECLARATION OF CONFORMITY

Manufacturer's Name: SonTek, a Xylem brand
Manufacturer's Address: 9940 Summers Ridge Road
San Diego, CA 92121 U.S.A.

SonTek, a Xylem brand, DECLARES THAT THE FOLLOWING PRODUCTS:

Equipment Type: Flow Meter
Model: SonTek-SL (3G)
Product Names: SL3000, SL1500

CONFORMS TO THE FOLLOWING EUROPEAN UNION COUNCIL DIRECTIVES AND STANDARDS AS OF 8/18/17:

EMC DIRECTIVE 2004/108/EC

HARMONIZED STANDARDS
EN 61326-1: 2013, Group 1, Class "A"
EN 55011:2009+A1:2010, Class "A"
EN 61000-3-2:2006+A1:2009+A2:2009
EN 61000-3-3: 2008
EN 61000-4-2:2009
EN 61000-4-3:2006 + A1:2008 + A2:2010
EN 61000-4-4: 2004+A1:2010
EN 61000-4-5: 2006
EN 61000-4-6: 2009
EN 61000-4-8: 2010
EN 61000-4-11: 2004

RoHS 2 DIRECTIVE 2011/65/EU
Per the current RoHS Directive, the SonTek-SL (3G) products are classified as Category 9 Industrial Control and Monitoring Instruments and comply with the RoHS 2 Directive. However, due to the presence of piezo electric transducers in our products, with respect to exemptions permitted in Annex IV, section 14 & 15 of the RoHS Directive, the application of lead in single crystal piezo electric materials for ultrasonic transducers is exempted from the restriction in Article 4. All other components comply with the RoHS Directive.

WEEE DIRECTIVE 2012/19/EU

E.J. Rollo
Compliance Engineer
SonTek – a Xylem brand

TABLE OF CONTENTS

Section 1. Getting Started: Operational Overview

Thank you for purchasing a SonTek-SL Series product. This instrument is an intelligent measurement device with many new automated features designed to help you get the best flow data possible. We have spent years researching and developing this new platform. It is a small but powerful acoustic system with a host of features to make measuring flow fun and easy.
Please take some time to read this manual before connecting with your SL or installing it in the field. We expect you will enjoy many years of high quality data from your new SL.

1.1. System Components

Figure 1 is an inventory of the SL and accessories that should have arrived from the factory. Please take a few minutes to make sure that all of the components are included.

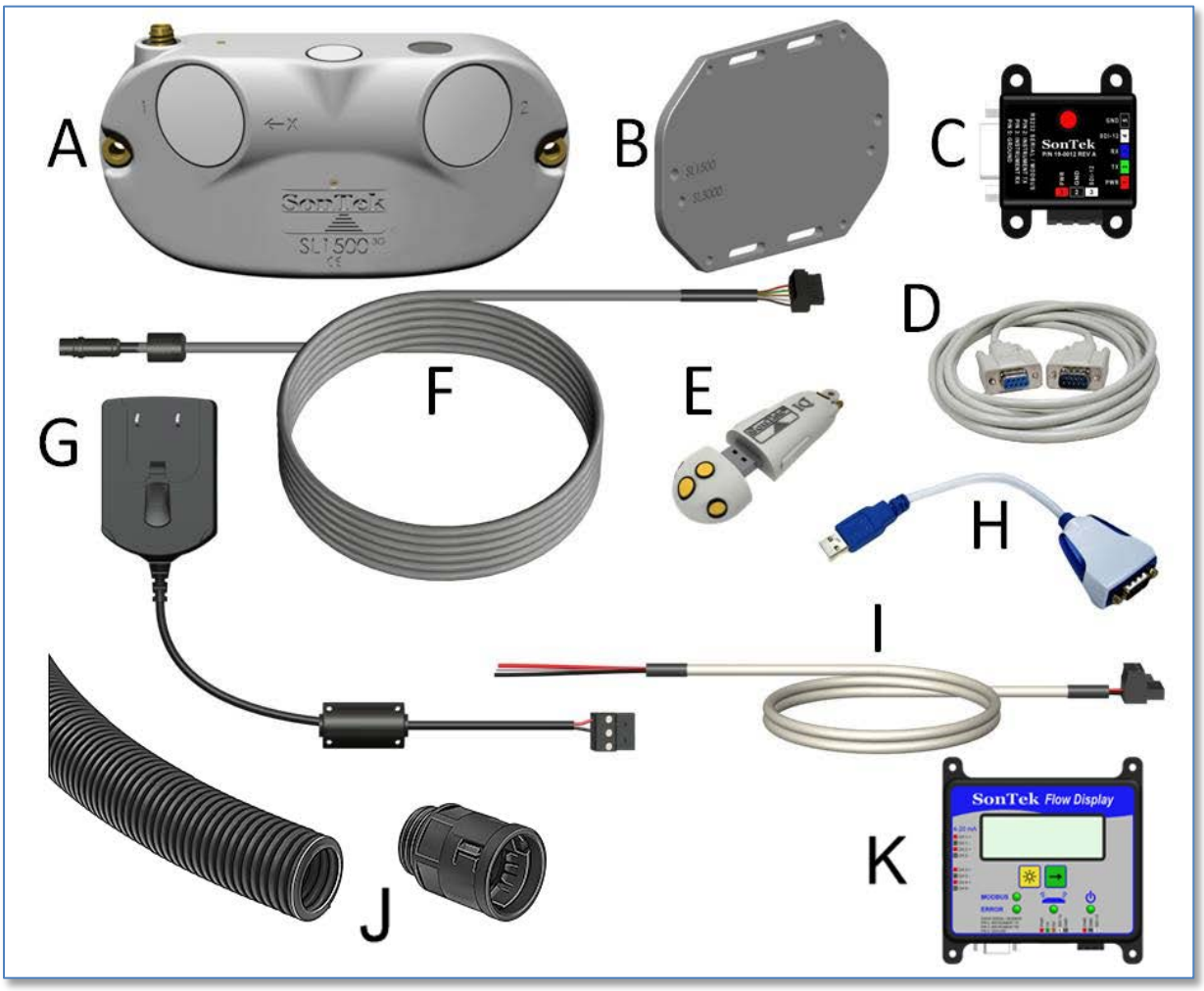


Figure 1. SL shipping box and contents

There are three SonTek-SL products available: The **SL3000,** the **SL1500** and **SL500.** The SL3000 and SL1500 have updated electronics and firmware to be compatible with the SonTek-SL software. The SL500 remains under the SL firmware and software platform for the time being. In either case, Item A represents the flow meter shipped from the factory. All other standard items shipped are the same.

Itemized list of SL components

A	SonTek -SL
B	Mounting Plate
C	Cable Adaptor
D	RS232 Cable
E	USB Thumb Drive (SL Software)
F	SL Power/Communications Cable
G	AC Power Supply
H	USB to Serial Adaptor
I	Battery Hook-up Cable
J	Cable Conduit & Fitting (SL1500 only)
K	Flow Display (Optional)
L	Tool kit & Hardware (not shown)

Item A: SonTek-SL – A side-looking acoustic flow meter with velocity and water level transducers . Redundant water level data are recorded from the vertical beam and pressure sensor. Data download and communication are available via **RS232**, **Modbus**, or **SDI-12**. The system is designed to be mounted on the side of a channel. The instrument measures water level, flow, velocity, and temperature. Flow rates and total flow volume are computed internally based upon a user-supplied survey of the channel shape and instrument location.

Figure 2. SonTek-SL3000

Figure 3. SonTek-SL1500

Item B: Mounting Plate – Attach the mounting plate to the back of the SonTek-SL3000 or SonTek-SL1500 with two mounting screws for easy installation, particularly for the sliding mount option.

Figure 4. SL mounting bracket

Item C: SL Cable Adaptor – Provides easy and convenient input for a 9-15 VDC power source and system communications. **RS-232**, **Modbus**, and **SDI-12** connections provide a simple solution for integrating an SL with a datalogger, Programmable Logic Controller (PLC), or Remote Terminal Unit (RTU). A Red LED lights up on the adaptor when the instrument is receiving power (Figure 5).

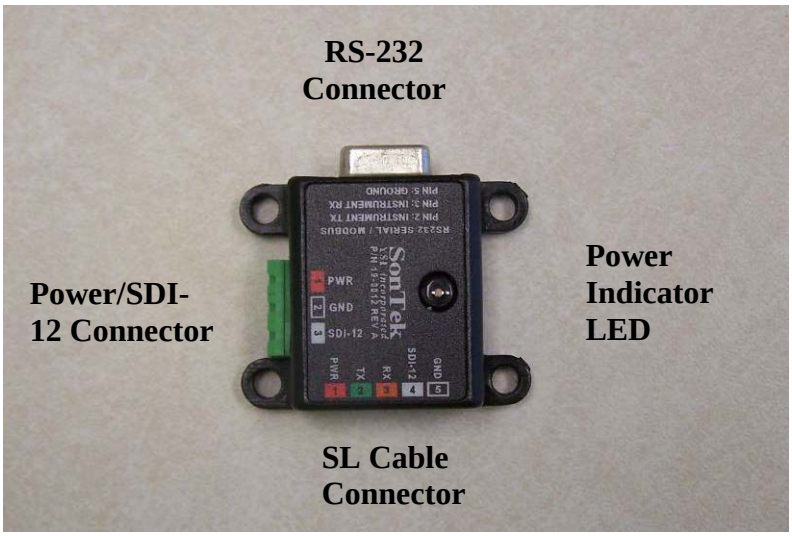


Figure 5. SL cable adaptor

Item D: RS232 cable – Connects the SL cable adaptor with a computer, laptop, datalogger, RTU, or PLC.

Item E: USB Thumb Drive / memory stick – Provides SL software installation files, USB drivers and user documentation.

Item F: SL Power and Communications Cable – Standard cable length is 10 m. The 5-pin connector is keyed for connection to the SonTek-SL and SL cable adaptor (Figure 6).

Figure 6. SL power and communication cable

Important note: The SL Connector is waterproof once it is plugged in, but **this connection is NOT wet-mateable and should NOT be done underwater**. To avoid damaging the system, please connect the SL connector to the SL in the dry air before submerging. The cable adaptor connector on the other end of the cable should never get wet. This end of the cable should be enclosed and protected from the rain and weather. The cable adaptor connector can be removed to facilitate passing the SL cable through a small conduit or pipe. The wire leads are color coded to the terminal connections on the cable adaptor (see Figure 5).

Item G: AC Power Supply – Provides users a quick and easy way to provide 12 V DC power to the SL. Simply plug the 3-pin connector into the SL cable adaptor and the other end into an outlet. The AC power adaptor comes with four slide-on adaptors for various AC power sources used around the world (Figure 7).

Figure 7. SL Power supply with international adaptors

Item H: SonTek supplied USB to Serial adapter (Shown in Figure 13) **–** Recommended for the fastest, most reliable communication. Download and run the driver as a Setup Executable from the Comments section of the table here: **http://www.ftdichip.com/Drivers/D2XX.htm**

Item I: Spare power connector/battery hookup cable (not pictured) **–** A 3-pin connector and 1.5 m (5-ft) of cable for easy battery connection to the SL cable adaptor (Figure 5). Input voltage levels are 9-15 VDC. Power (red) and ground (black) wires are provided with a third pin available to bring in SDI-12 communications.

Item J: SL1500 Cable Conduit and Fitting (Shown in Figure 59, Section 4) **–** The SL1500 connector port is equipped with 1/2-14 NPT threads to adapt directly to conduit to protect the cable and connector during deployment. SonTek provides plastic conduit fitting (McMaster-Carr P/N 3185K64) and 3ft snap in flexible conduit (McMaster-Carr P/N 3146K24).

Other items included with SonTek-SL products not shown in the inventory are the tool kit and a laminated Quick Start Guide.

Optional Item: SL Flow Display – Allows users to view data collected by the SonTek-SL without the need of connecting to a laptop. The flow display (Figure 8) essentially replaces the cable adaptor and provides an option for four channels of 4-20 mA analog outputs. In addition, the Flow Display has status indicator lights for power, SL, Modbus communications and errors.

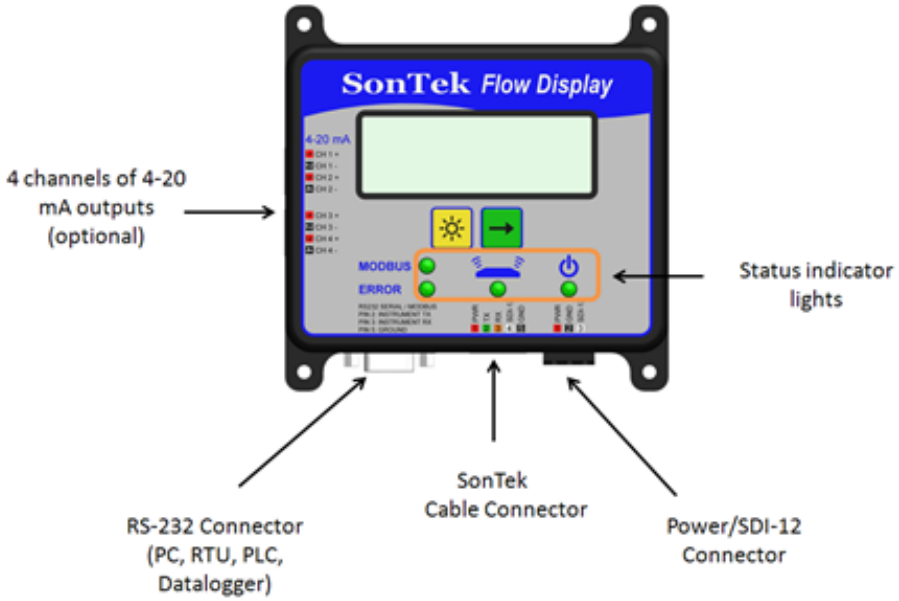


Figure 8. Optional SonTek Flow Display

Optional Item: SL Canal Mount – The optional canal mounting system allows for quicker and easier access to clean and/or remove an SL. It is shown in Figure 9.

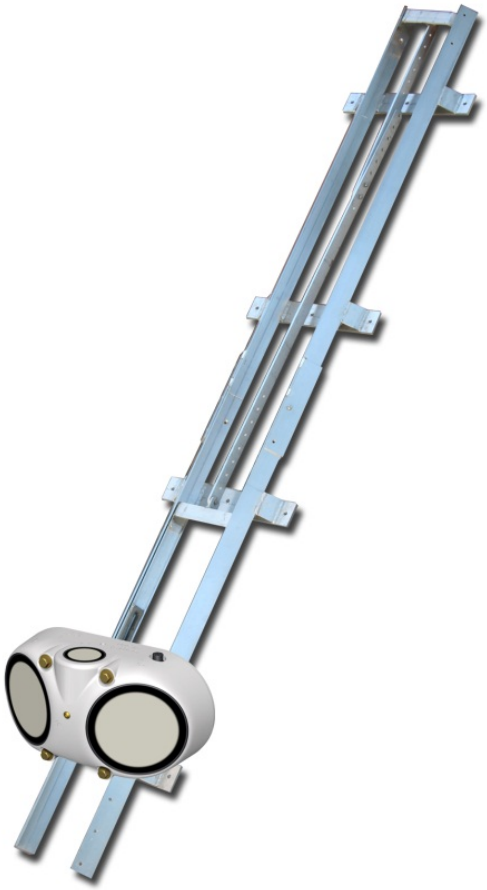


Figure 9. Optional SL Canal Mount

1.2. Interconnecting the System

Connect the cable to the SL while in the air.

- Insert the keyed cable connector into the brass underwater connector on the downstream end of the SL (this must be done in a dry environment) as seen in Figure 10.
- Tighten the locking sleeve on the cable connector by rotating clockwise until finger tight.

Figure 10. Connecting to SL to the power and communications cable

Next, connect the five-pin terminal connector to the cable adaptor (Figure 11). Be sure that all wires are tightly connected to the five pin terminal connector to ensure proper communication with the SL. If the terminal connection needs to be removed to pass the communication cable through a conduit or other device, the cable wires are color coded to match the labels on the cable adaptor or Flow Display.

In cases where the Flow Display is used, the same connections are used; the display replaces the cable adaptor and allows users to view data collected in the field without a laptop.

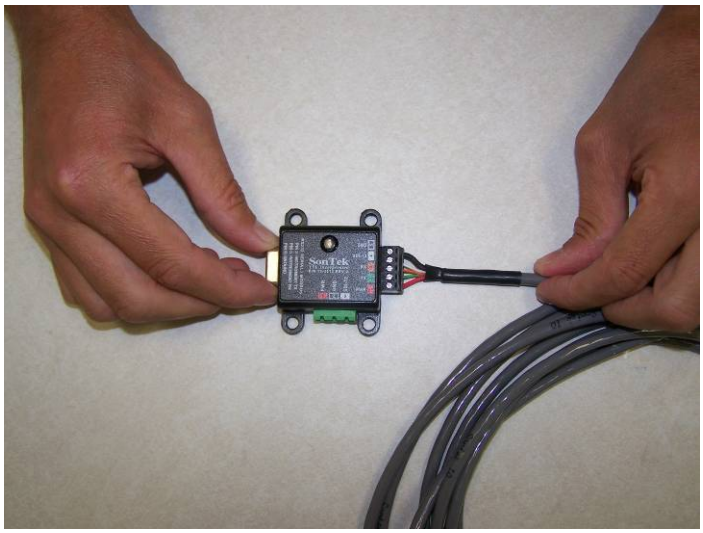


Figure 11. Connecting the SL to the cable adaptor

Connect the three-pin power connector from the power supply to the cable adaptor (Figure 12).

- The red LED on the cable adaptor will indicate when the system is receiving power.
- This connector has terminal inputs for positive, ground and SDI-12 communications.

Figure 12. Connecting the power supply to the cable adaptor

Lastly, connect the USB to Serial adaptor to the computer.

- Connect the serial (RS232) connector to the cable adaptor and the USB connector to the computer.
- If your computer has a built in serial port, we do not recommend using this port as it may not be reliable at the high data rates used by the SL. We recommend using the USB to serial converter included with the system (Figure 13).

Figure 13. Connecting the USB-Serial adaptor to cable adaptor

***Note:** The same connections are used for the SonTek-SL3000.

In cases where the Flow Display is used in place of the cable adaptor, the connections should be as presented below (Figure 14).

Figure 14. Flow Display connections

1.3. Installing the SL Software

The third generation SL3000 and SL1500 use the SonTek-SL software. The SL software is provided on the USB memory stick. To install the software, plug the USB memory stick into a computer or laptop. The software installation will normally start automatically; if it does not, double-click on the **Setup.exe** file to start the installation process. If your computer does not have the Visual C++ 2010 Runtime Libraries, these components will be installed first (Figure 15).

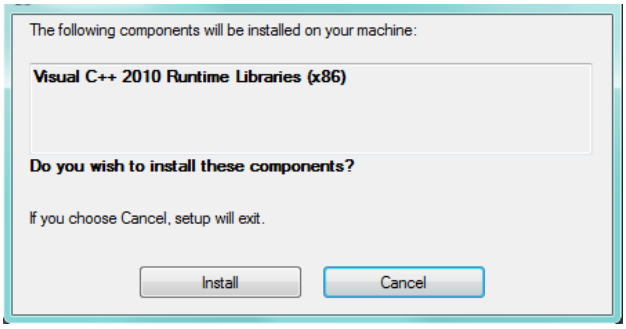


Figure 15. SL Software setup

Select the "Install" button to continue.

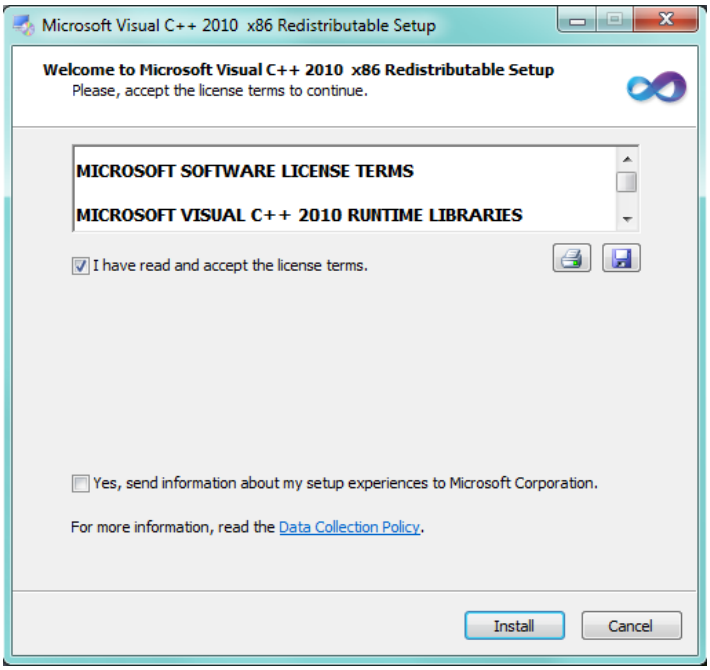


Figure 16. SL Software – License Agreement

After reading the Software License Terms, check the box next to "I have read and accept the license terms" and select the "Install" button to continue (Figure 16). After the Visual C++ Runtime libraries are installed, select the "Finish" button to continue (Figure 17).

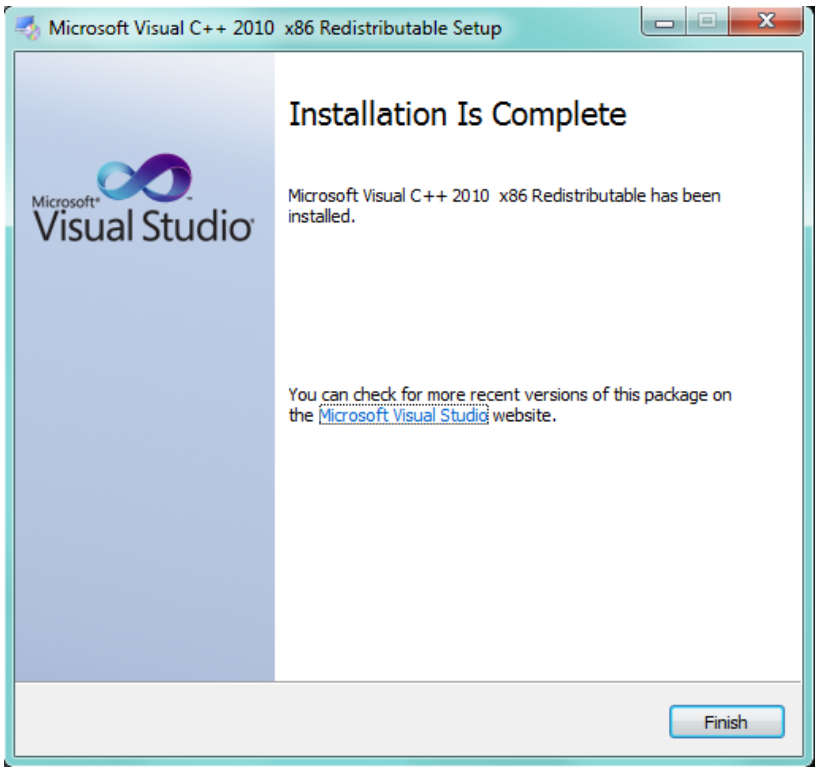


Figure 17. SL Software setup – Finish Install

Select the "Next" button to continue with the SL software installation (Figure 18).

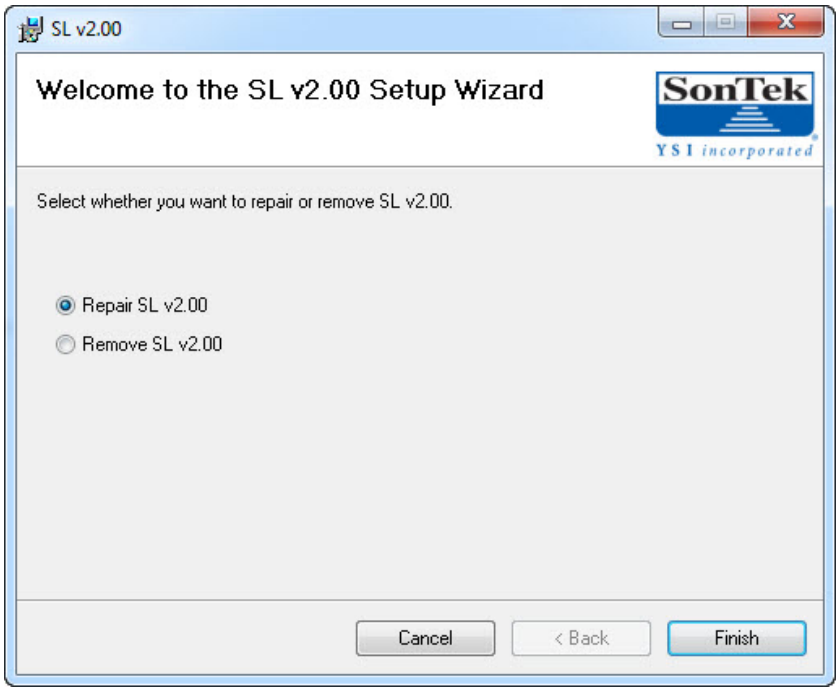


Figure 18. SL Setup Wizard

We recommend using the default folder as the installation directory in this window (Figure 19). Also, if more than one user account will need access to the SL software, please select the **Everyone** option. Select the **Next** button to continue.

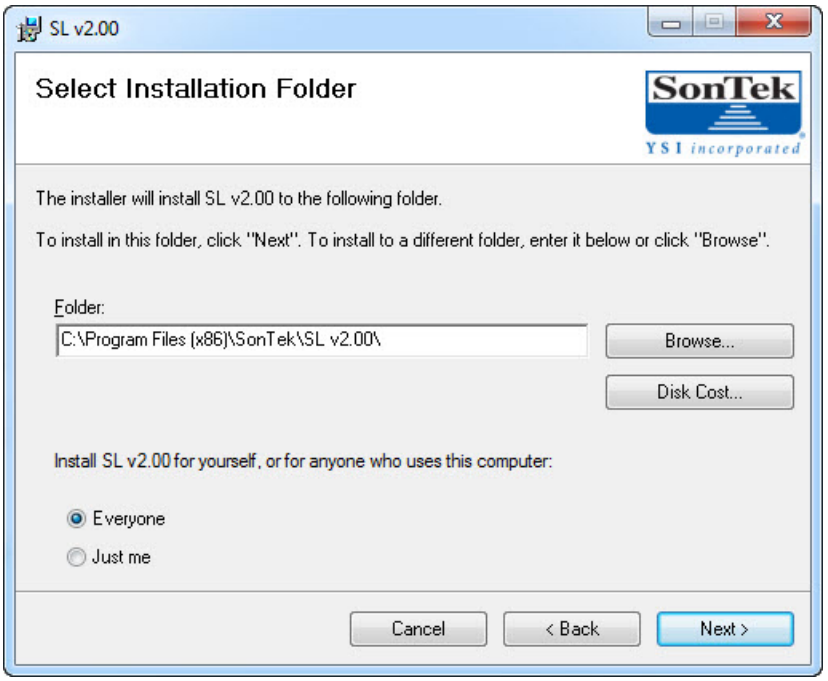


Figure 19. SL Software setup – Data Folder

After a successful installation, **Close** the dialog window and use Windows Update to check for new Microsoft updates that may be required by the SL software (Figure 20).

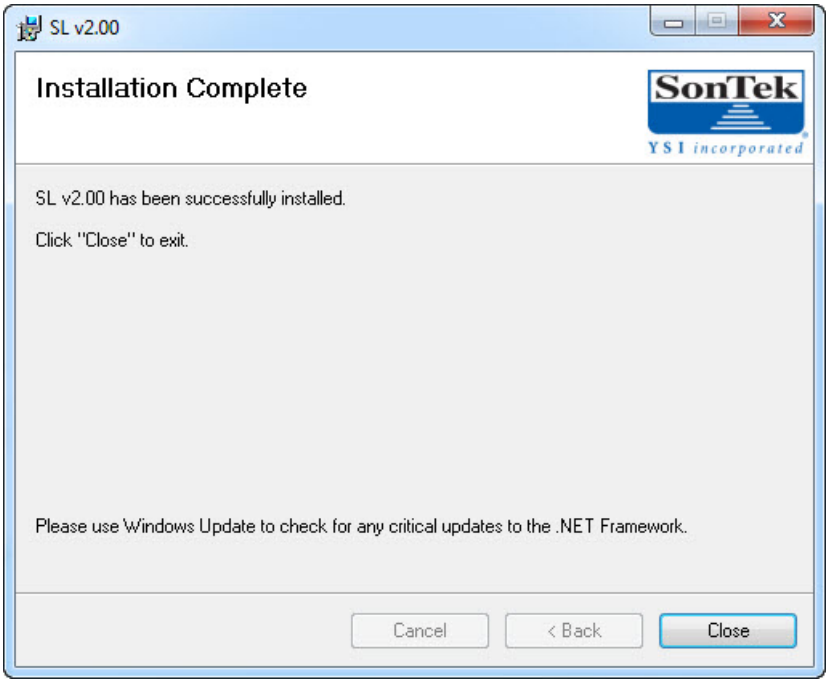


Figure 20. SL Software setup – Installation Complete

A desktop shortcut icon will appear on your computer when installation is complete. Double-click this icon with the mouse to begin using the SL software (Figure 21).

Figure 21. SL Software desktop shortcut

Once the SL software starts, you can connect to an SL, plan a deployment, view data, or perform one of many functions discussed in the following sections (Figure 22).

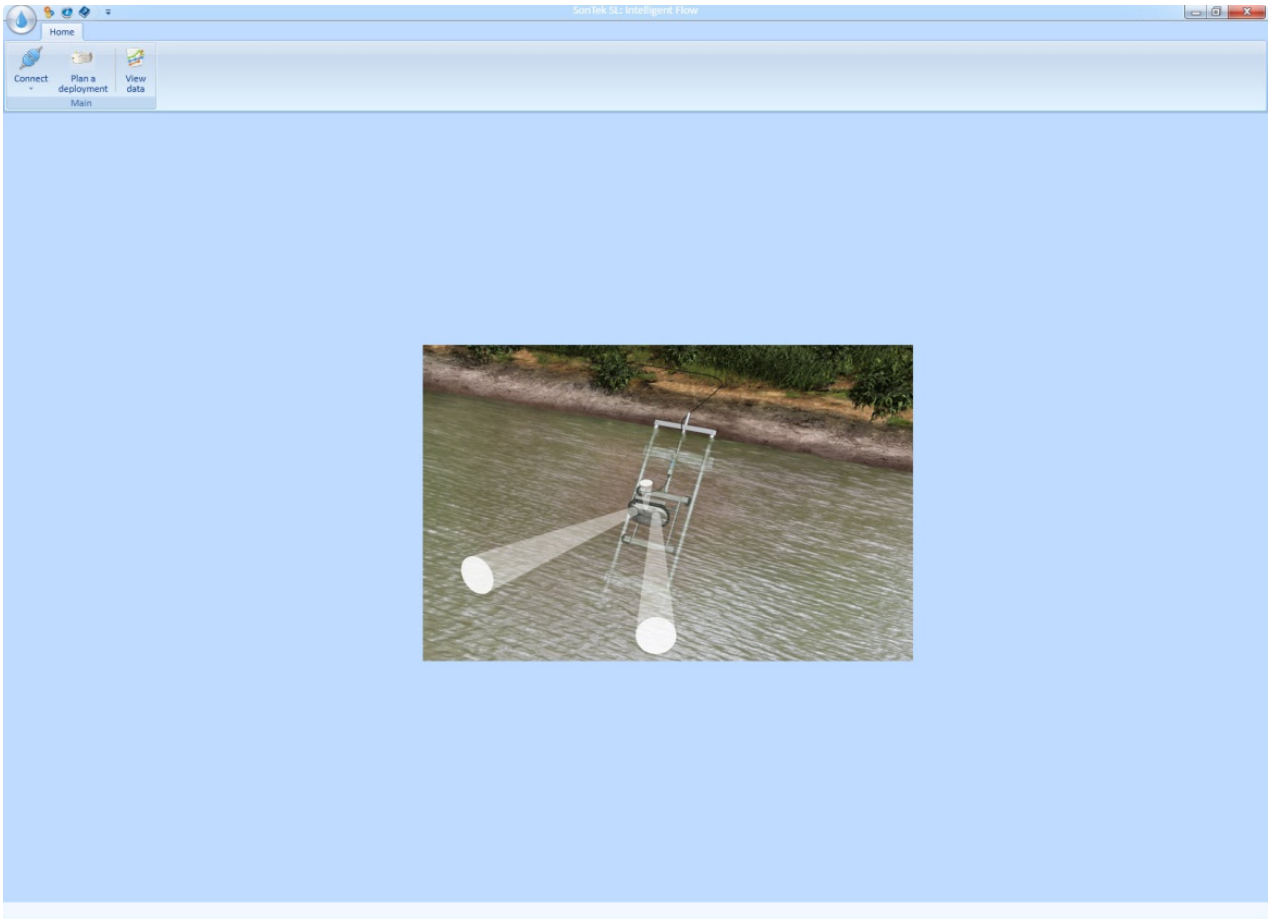


Figure 22. SL Software Main Window

Section 2. SL Software Overview

This section is designed as an overview of the features and functions of the SL software. This software is primarily used to configure the SL for flow measurements and to view the data collected. There are a number of settings and parameters that you will need to become familiar with before installing the SL in the field.

2.1. Using the SL Software

The SL Software operates like most Microsoft Windows applications. Users can navigate to menus and select items using the mouse or a laptop mouse pad. Text appearing in blue anywhere within the software will typically have a help hyperlink associated with it. When hovering over the text with the mouse, it will turn from blue to red if a hyperlink is available. Left-click on the text with the mouse to display the help hyperlink (Figure 23).

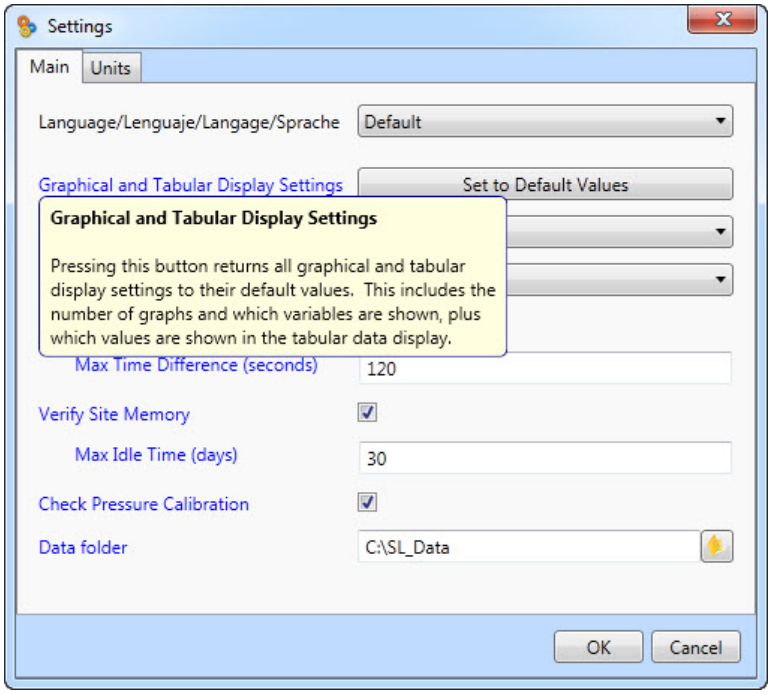


Figure 23. Help Hyperlink

Some of the icons in the software will automatically open a small help pop-up window when the mouse hovers over them (Figure 24).

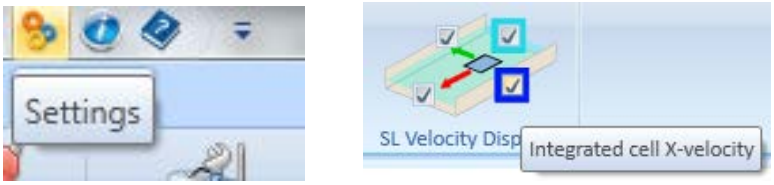


Figure 24. Help pop-up windows

Descriptions and instructions for using the software and changing settings are presented in the following sections.

2.2. Main Window

Looking at the upper left corner of the main software window, you will see several icons in the title bar and a few more large icons with text in the Main Ribbon. The title bar icons are always the same and are always accessible from any location in the software. The number of functions on the Main Ribbon will change to provide more or less functions related to the current operation (Figure 25). We will first discuss the functions of the title bar icons before moving on to the details of the Main Ribbon.

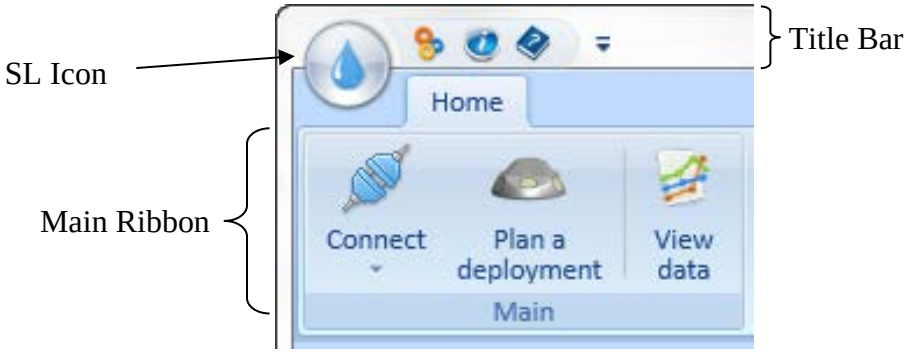


Figure 25. Title Bar and Main Ribbon Locations

2.2.1. Title Bar Quick Links

It is not necessary to connect to the instrument to view the software items discussed in this section. We begin with the general SL software settings, version information, and documentation found in the title bar (Figure 26).

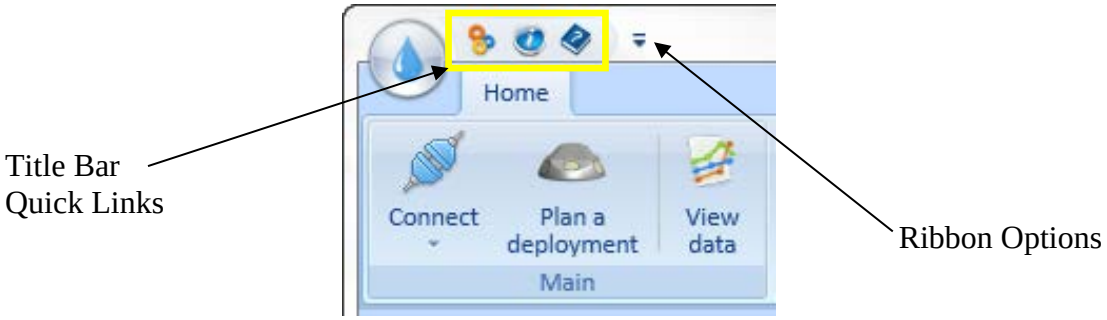


Figure 26. Quick links to settings, information, and documentation

Settings – provides a direct link to the SL Software Settings window.

About SL – provides information about the software version as well as contact information for SonTek Support.

Documentation – provides a direct link to the User's Manual in PDF format

Ribbon Options – This menu has two functions: Locate the Quick Links below the Main Ribbon and minimize the Main Ribbon. These functions can be helpful when working on a small computer screen. You can also minimize the Main Ribbon by double clicking on the Home tab. Double click the Home tab again to maximize the Main Ribbon.

2.3. General Settings

To view the SL software **Settings**, select the settings quick link icon or navigate to the settings menu from the SL Icon. The SL software settings window has two navigation tabs at the top of the window as seen in Figure 27. The Main tab has a variety of software and system parameters. The Units tab sets the displayed units for all of the graphical and tabulated data.

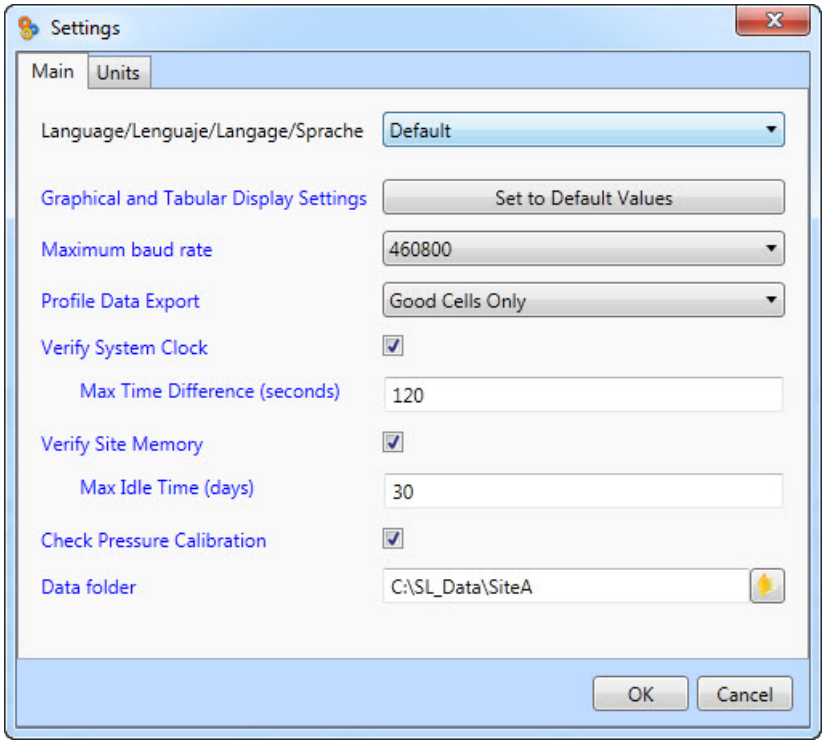


Figure 27. SL Software Main Settings

SL Settings – Main Tab

Language: The software supports multiple languages. The language displayed in the SL software is selected here from the top pull-down menu.

Set to Default Values: Select this button to reset all graphical and tabular displays in the data analysis windows to their default values. This will reset the number of graphs and the variables displayed.

Maximum Baud Rate: Defines the maximum baud rate for communications with the instrument (default is 460800). Long cable runs or noisy environments may require slower baud rates for effective communication with the SL. This setting does not affect Modbus communications; it affects only communications between the SL and the SL software.

Profile Data Export: The range of the SL is predefined at the factory. If the SL is installed in a channel that is less than the maximum profiling range, some of the measured velocity cells will extend beyond the width of the channel. To export only those cells located within the channel, use the “Good Cells Only” setting. To export all cells from the measured profile regardless of their location relative to the water surface, select “All Cells”.

Verify the System Clock: A checkbox that tells the SL software to compare the SL clock to the PC clock upon each connection.

Max Time Difference (seconds): This field allows you to define the maximum difference between the SL clock and the PC clock. If the period is greater than the user-defined interval, you will be prompted to reset the SL clock to match the computer time or you can input a time.

Verify Site Memory: This checkbox enables/disables several intelligent functions related to the Site Memory. Site Memory is an internal function that assesses the flow in the channel over time to develop a channel history. This history helps to improve the flow measurements as time passes. Initially, it takes about 5 to 30 minutes to develop a good Site Memory. If the "Verify Site Memory" parameter is enabled, the software will prompt you to reset the Site Memory when the SL determines that flow in the channel has changed significantly based on the recent Site Memory.

Max Idle Time (days): If the SL has not collected data for a period greater than this value, the software will prompt you to see if they want to reset Site Memory. You should only reset the Site Memory if conditions in the channel have changed significantly.

Check Pressure Calibration: This checkbox automatically tells the software to check to see if the pressure sensor has been recently calibrated to account for changes in atmospheric pressure. If this option is unchecked and if the pressure sensor has not been calibrated for more than one day, you will be prompted to do so the next time communication with the SL is established. Because the SL can measure water depth acoustically with the vertical beam, this data can be used to perform regular calibrations of the pressure sensor to remove atmospheric pressure changes while collecting data. It is recommended that this is enabled.

Data folder: The SL stores and accesses all downloaded data from a common folder. This setting specifies the data folder location and name.

- If you are manually transferring SL data files into the SL data folder, place the files into a subdirectory matching the SL file name.
- Example: Suppose the SL data folder is **C:\SLData**, and you manually want to transfer a data file named **SampleData_20110805_120000.SL** into your SL data directory.
  - Create a folder **C:\SLData\SampleData**.
  - Move the data file into that folder.
  - Close and re-open the SL software. You will now be able to view the data file from the **View Data** menu.

Settings – Units Tab

The **Units** tab, presented in Figure 28, allows users to customize the displayed dimensions or units for each measured parameter. Units defined here are only used in the SL software for graphical and tabular data. These settings are **NOT** applied to the RS-232 Serial/Modbus data output by the SL. Units for the output data sent to the serial port must be specified in the Output Settings section on the Smart Page when configuring the system. Changes to the settings in this window will require the software to restart before continuing. For convenience, two buttons are provided that will return all units settings to default Metric or default English.

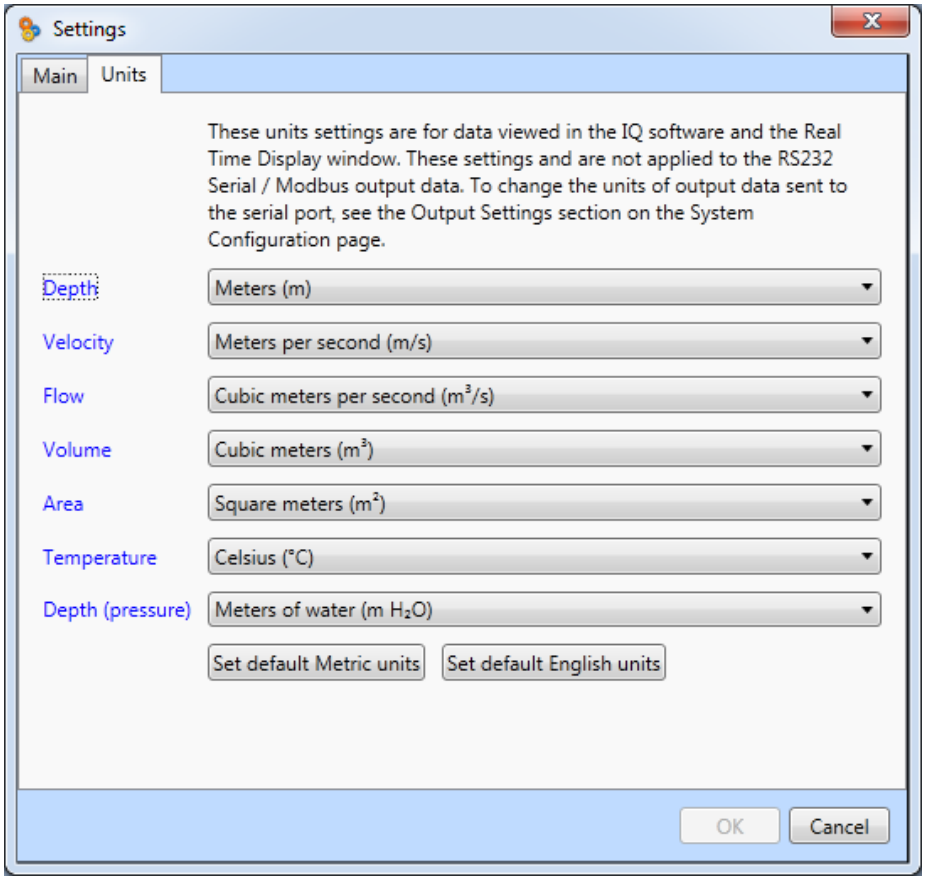


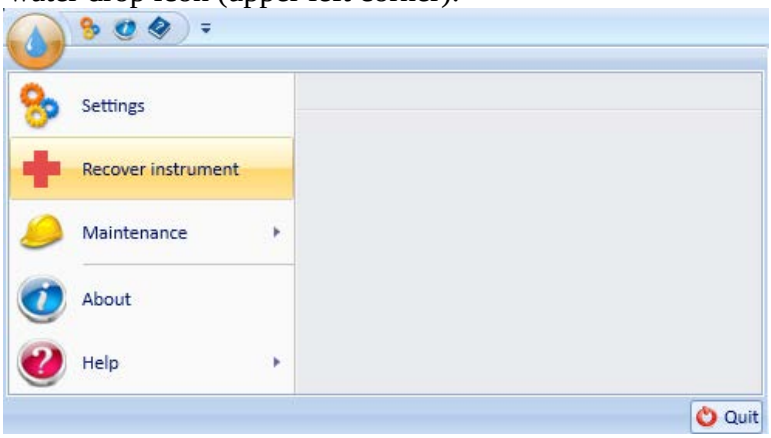
Figure 28. SL Software Units Settings

Users can also access several functions by clicking on the SL Icon in the software title bar (Figure 29).

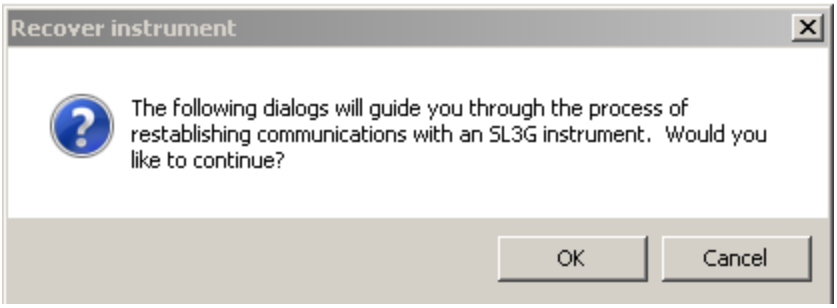
Figure 29. SL Icon

2.4. System Recovery

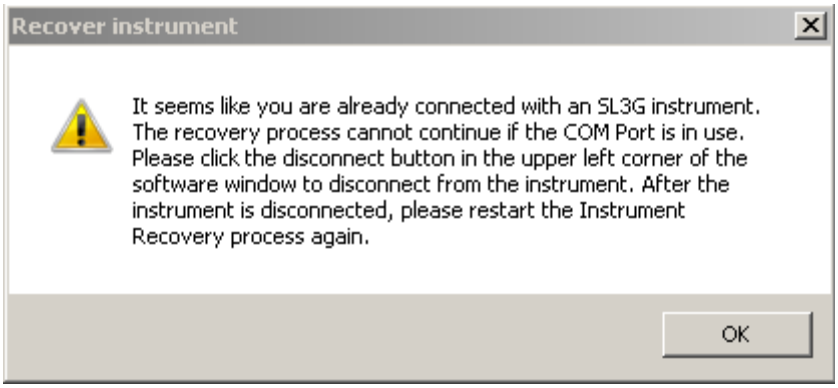
The system recovery function walks the user through the process of re-establishing communications with an instrument. The "Recover instrument" feature is located in the main menu, accessed through the water drop icon (upper left corner).



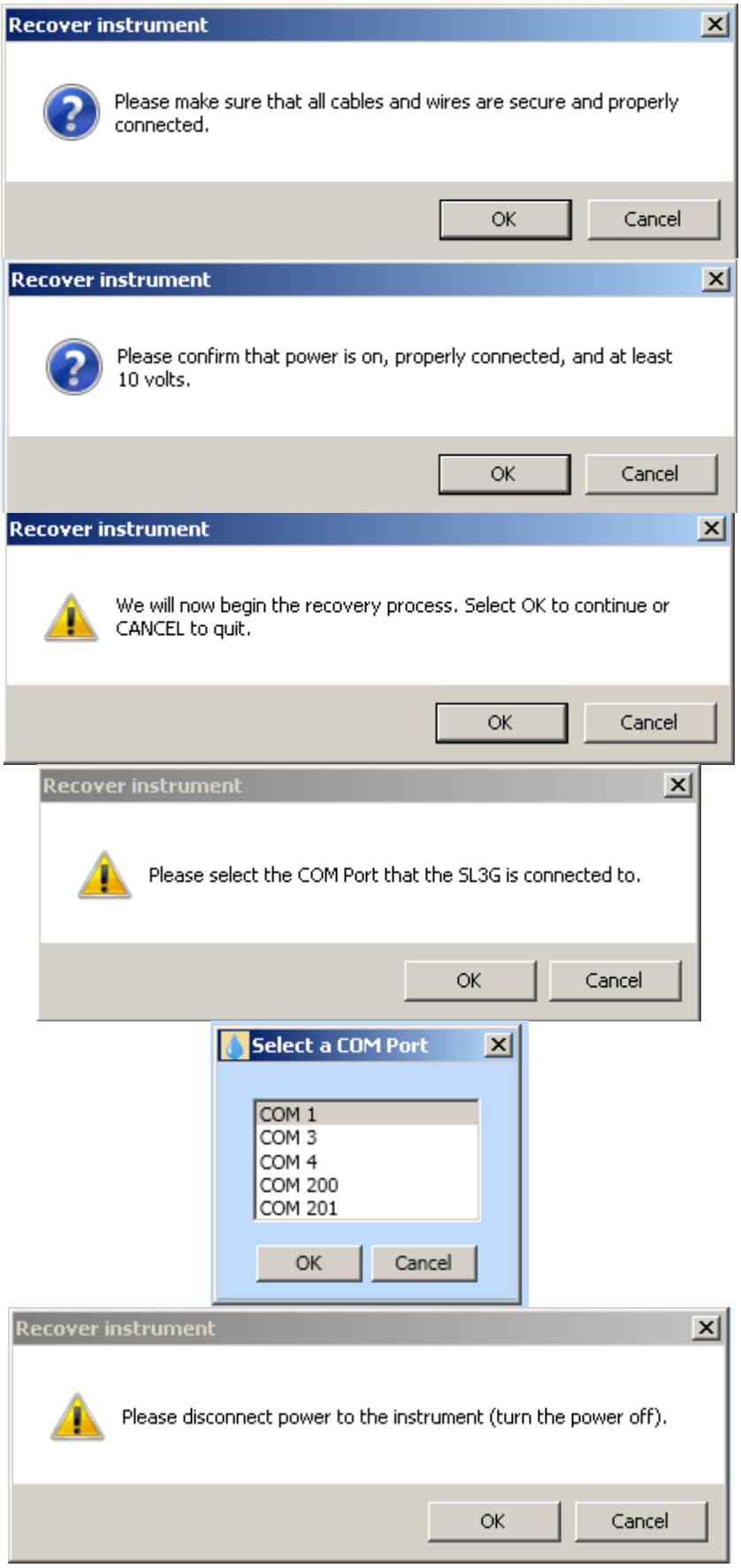
A series of dialogs will step the user through the recovery process. This is basically a hard reboot of the instrument. If a system should "lose" its firmware or not respond in a way that the software can recognize the reboot will allow the user to reconnect and reload firmware or it will simply restart the system. It is a fairly simple process, but the dialogs provide the user with the timing and pace for the process so that the system has enough time to reboot and recover.

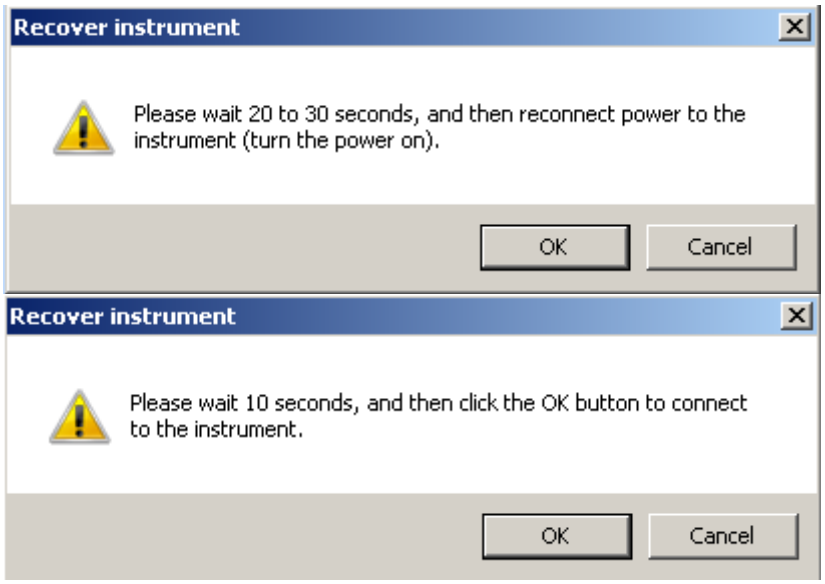


If an SL is already connected and appears to be communicating correctly, the following dialog will be displayed.

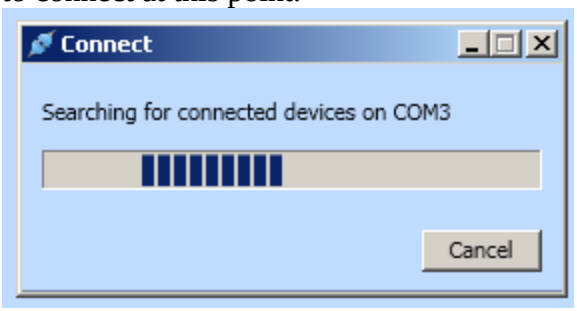


If a system is not currently connected the recovery process will commence. The user can cancel the process at any time using the cancel button.

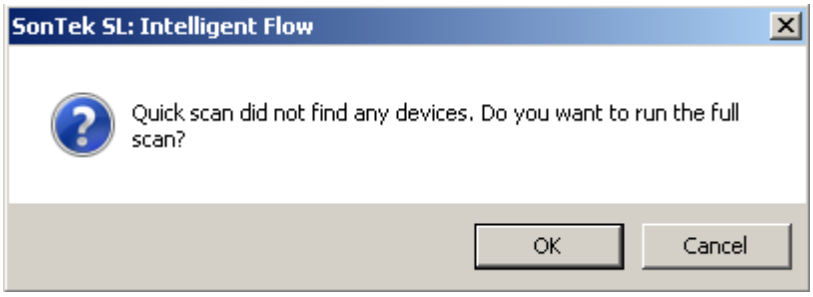

Recover instrument
Please make sure that all cables and wires are secure and properly connected.
OK
Cancel
Recover instrument
Please confirm that power is on, properly connected, and at least 10 volts.
OK
Cancel
Recover instrument
We will now begin the recovery process. Select OK to continue or CANCEL to quit.
OK
Cancel
Recover instrument
Please select the COM Port that the SL3G is connected to.
OK
Cancel
Select a COM Port
COM 1
COM 3
COM 4
COM 200
COM 201
OK
Cancel
Recover instrument
Please disconnect power to the instrument (turn the power off).
OK
Cancel



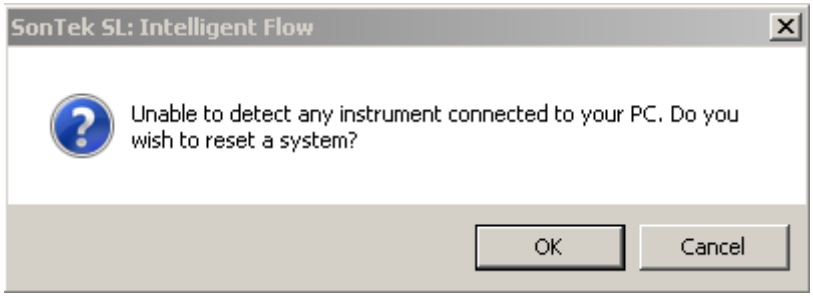
The software will attempt to connect at this point.

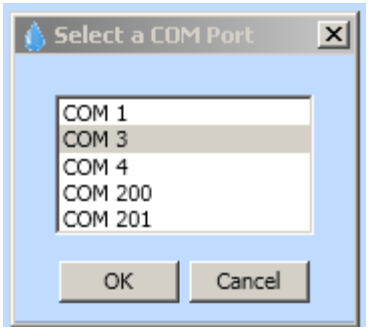


If a connection is successful the system configuration page will appear as it normally does.
If the connection fails, the user will step through the reset process.

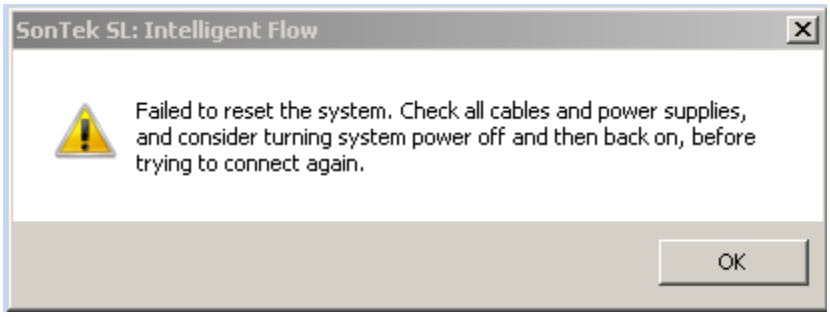


After about 20 seconds a new dialog will appear.





If the reset fails the user is prompted to check the cables and connections.



This ends the recovery process.

2.5. Maintenance Functions

Users can access the maintenance functions by clicking on the SL icon in the upper left corner of the main window and then selecting “Maintenance” (Figure 30).

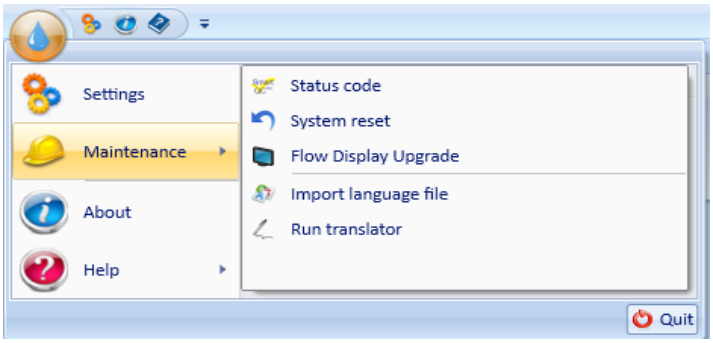


Figure 30. SL Icon Menu and Software Maintenance Menu

- The SL Icon menu has all of the same quick links as the title bar plus a new menu item for maintenance functions.
- The *Status code* and *System reset* functions are found in multiple locations in the SL software.
- The *Flow Display Upgrade* is found in the maintenance menu and is used for upgrading the firmware of the Flow Display.
- The *Import language file* and *Run translator* functions are only found in the software maintenance menu.

Maintenance – Status Code

The SonTek-SL has several SmartQC™ functions designed to warn you of potential problems at a measurement site (Section 6.1). The Status Code lookup is provided for easy interpretation of any Status Code reported by the SL, an example is provided in Figure 31.

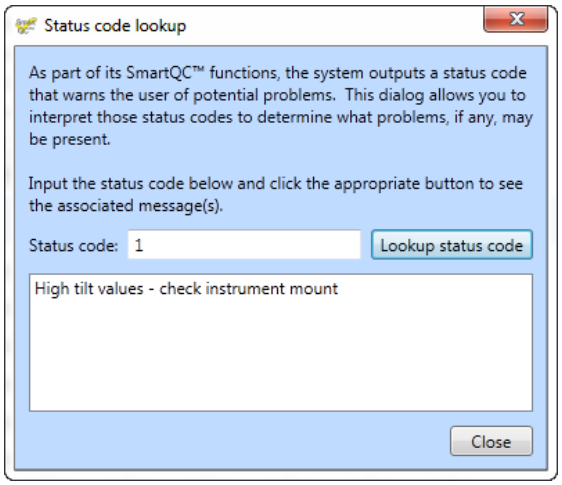


Figure 31. Status Code Lookup

Maintenance – System Reset

The system reset function can be used if communication with the SL cannot be established or if the system stops responding. This function forces the SL baud rate to the default setting and interrupts data sampling. If the SL still does not respond after a system reset, check all cable connections and make sure that the system is getting power (red LED on cable adapter is on).

Maintenance – Flow Display Upgrade

This menu item is only available when **not** connected to an SL Product. Periodically, upgrades may be available for the firmware inside the SonTek Flow Display. This option allows users to upgrade the flow display firmware. The software provides detailed on-screen instructions for the upgrade; a brief summary is below.

- Save the new flow display firmware file, provided by SonTek, to your PC.
- From the maintenance menu, select the **Flow Display Upgrade** option.
- Disconnect the SL from the flow display; connect the flow display to your PC. Disconnect power to the flow display and wait 5 seconds.
- While holding both flow display keys down, connect power to the display – this places the display in upgrade mode. Click OK on your PC to start the upgrade.
- Follow on-screen instructions once the upgrade is complete.

Maintenance – Import Language File

The SL software was designed to support multiple languages. Language files can be edited and distributed by users. If you receive a language file from SonTek support or from a known and trusted source, use this function to import the file. Once the file is imported, navigate to Settings> Main>Language, to select the new language file from the Language Menu.

Maintenance – Run Translator

Run the SL software translator to create your own custom translations (Figure 32). This function opens a separate window with a spreadsheet containing all of the text displayed in the SL software. The SL software variable or “Id” is in the left column. The word or phrase that you will see displayed in the software is shown in center column. Users can enter their own translated phrase in the right hand column in any language. Saved files become available as a language option in the Settings> Main> Language menu. You are not required to translate all of the text; the original text (center column) will be used wherever the translated value is left blank.

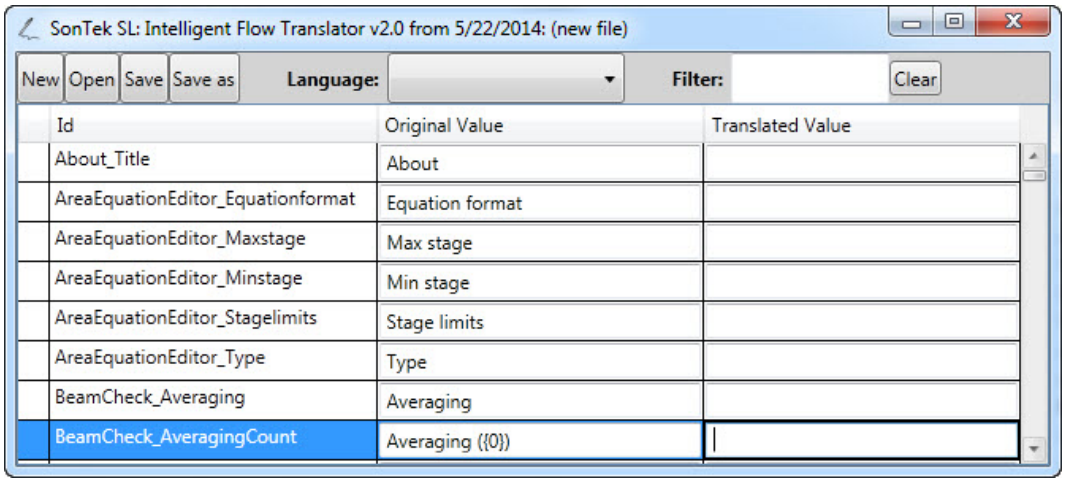


Figure 32. Language Translator

About – provides information about the software version as well as contact information for SonTek Support (Figure 33).

Figure 33. About window

Help – Documentation

The Help menu provides links to the SL User's Manual. These are PDF files that can be saved and copied to a convenient location.

2.6. SL Software Main Ribbon

The SL software has a series of icons located in the Main Ribbon at the top of the window. The number of icons and associated functions shown here depends on the current software operation. For example, after connecting to an SL, more icons will appear in the Main Ribbon. However, once connected, the main section of the ribbon will always display the same five functions. After selecting one of these main functions, more ribbon functions will appear to the right of the main ribbon section.

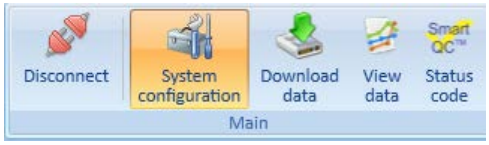
2.6.1. Main Ribbon – Not connected

Connect: Allows users to connect or open communications to the SL.

Plan a deployment: Allows you to prepare for a future deployment by setting parameters for data collection.

View data: Opens the View data window where users can open files and visualize collected data. Details are presented in Section 5.

2.6.2. Main Ribbon – Connected



Disconnect: Disconnects the computer's communication port from the SL. If the SL is collecting data – disconnect does **not** stop the system from collecting data. Once data collection begins, you can connect, disconnect, and download data from the SL without interrupting measurements.

System configuration: This icon brings you to the main page for configuring the SL for a deployment or data collection. This configuration page is also known as the SmartPage.

Download data: Takes you to a new window to download data. Users can download single files, multiple files, or all files during data collection or when idle. Even the current data file can be downloading data without interrupting the current measurement.

View data: Brings you to a new window to visualize collected data in graphs and tables. Data from single files or multiple files can be displayed for analysis.

Status code: The SL automatically performs many functions to identify potential problems at a deployment site (Section 6.1). If a status code is reported, select this icon to decode the status code number.

2.6.3. Main Ribbon – Connected – System configuration – Operations

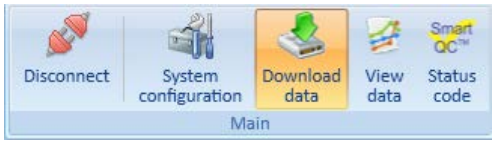
Load Settings: Used in conjunction with deployment planning, users can select a previously saved setup file to load on an SL. This file will have the extension **.sontek_system_config**.

Save Settings: Used to save current configuration and deployment settings to a file that can be loaded again in the future or loaded on a different SL. Files saved will have the extension **.sontek_system_config**.

Utilities: This icon opens a mini-ribbon with the following common utility functions: set system clock, reset site memory, calibrate pressure, Beam Check, firmware upgrade, and format recorder.

Advanced Utilities: This icon opens a mini-ribbon with several advanced functions that are typically only used when working with SonTek Support: factory defaults, direct connection, load configuration, and system reset.

2.6.4. Main Ribbon – Connected – Download data



Selecting the "Download data" function from the main ribbon will open a new window for selecting files to be downloaded. There are no other ribbon icons in this window.

2.6.5. Main Ribbon – Connected – View Data

The "View Data" function on the main ribbon opens the data visualization window in the SL software. There are many functions for viewing, analyzing, and exporting data. These functions will be described in later sections. One of the new features of the SL is that you can view recently collected data even while the SL is still sampling. The SL has a powerful onboard processor that can handle many operations simultaneously.

2.6.6. Main Ribbon – Not Connected – View Data

You do not have to be connected to an SL to view a data file. However, when not connected, the disconnect, system configuration, and download data functions will be hidden. Section 2.5 is intended to familiarize you with different ribbon displays that you will frequently see when using the SL software. See Section 3 for planning a deployment, Section 4 for downloading data, and Section 5 for data analysis.

Section 3. Planning a Deployment – Smart Page

There are two methods for setting up an SL before a deployment: (1) connect to the SL and enter the appropriate settings while connected or (2) plan a deployment before connecting and upload the settings when convenient. Both methods begin on the Smart Page.

- SL configuration files can be downloaded and saved from the SL while connected.
- SL configuration files can be created and saved from a deployment planning session.
- By planning deployments and saving configuration files, you can easily distribute the same settings to several instruments.

3.1. Accessing the Smart Page

Start by opening the SL software. To view the Smart Page, select either the **Connect** or **Plan a deployment** function from the main ribbon area. The **Connect** button provides two options: Auto Detect or Manual (Figure 39). If you select **Auto Detect**, the software will automatically scan all the COM ports on the computer and present the available ports for connection (Figure 34). If more than one SL is connected to your computer, you will be asked to choose a COM port. If there is only one SL, the software will automatically connect to the system.

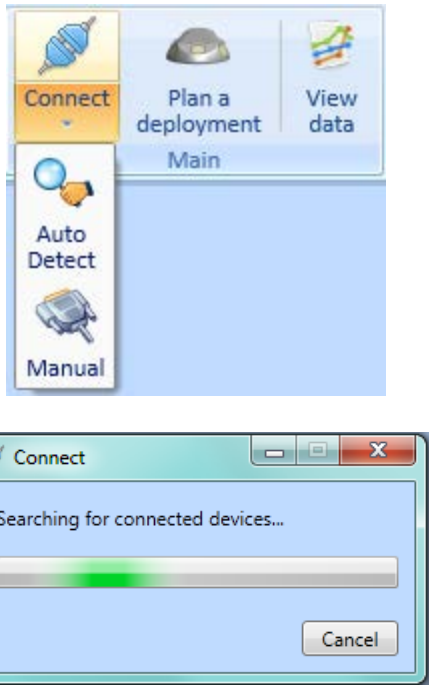


Figure 34. SL Software searching for devices

If you choose **Manual**, the software will ask you to choose a COM port (Figure 40).

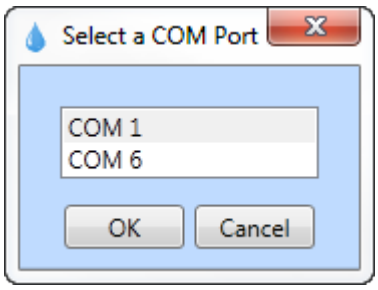


Figure 35. Manually connect by choosing a COM port

If you select **Plan a deployment**, you will be asked to identify the SL model type to plan a new deployment or you can open an existing configuration file for editing (Figure 36). After choosing an option, you will be taken to the Smart Page.

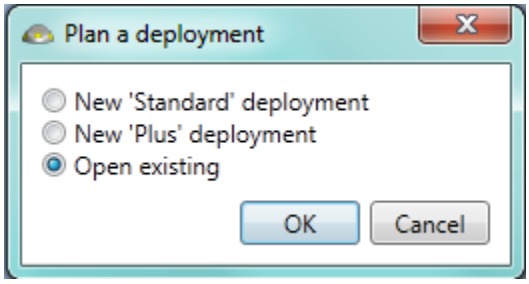


Figure 36. Plan a deployment dialog

The Smart Page is designed to provide a quick and easy method for you to configure your system for collecting data. Several settings are required. The Smart Page (Figure 37) provides feedback during the setup procedure to indicate completed steps and settings that still need to be checked. The Smart Page is a complete overview of the SL's current configuration including potential problems with the setup options.

- The Smart Page has five sections
  - System information
  - Standard settings
  - Channel shape
  - Flow settings
  - Output settings

- Smart Page section status indicators

  – Section recently updated, ready for deployment

  – Section not updated recently, settings are ok for deployment

  – Section not updated recently, user should verify settings before deployment

- There is a text button to “Refresh” or “Change” the settings in each section.
- Each section shows a brief summary of the important settings for that section.

If you are planning a deployment, and not connected to an SL, the System information section will only display the SL model and the **Start Data Collection** button will be hidden.

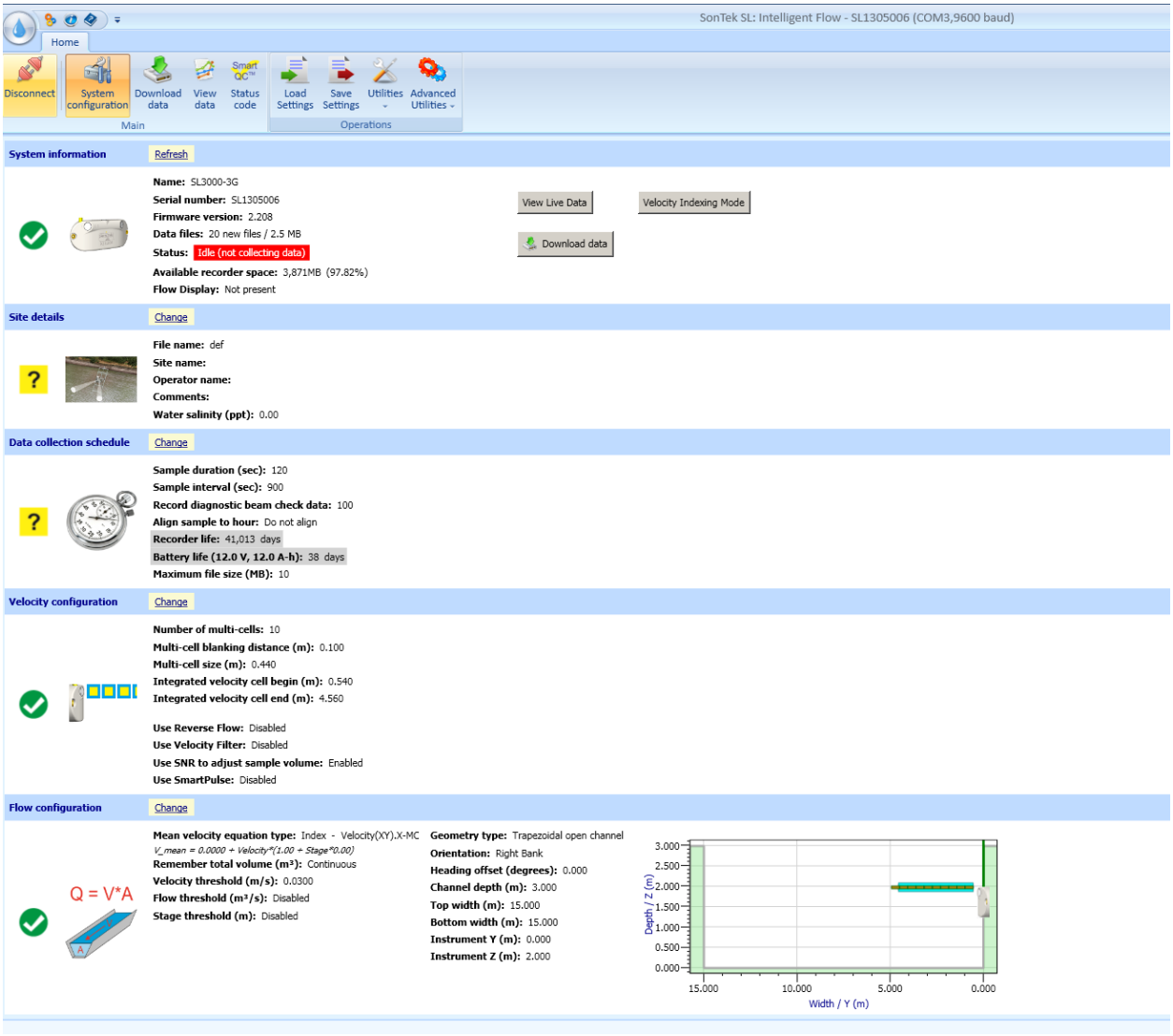


Figure 37. Smart Page – Connected to an SL

If this is the first time you are connecting to your SL, you may be prompted to calibrate the pressure sensor (Figure 38). Because atmospheric pressure changes continually, the amount of pressure from the atmosphere must be removed or calibrated out of the raw pressure measurement. The SL will perform this calibration on a regular basis while measuring. Select either button to continue to the Smart Page.

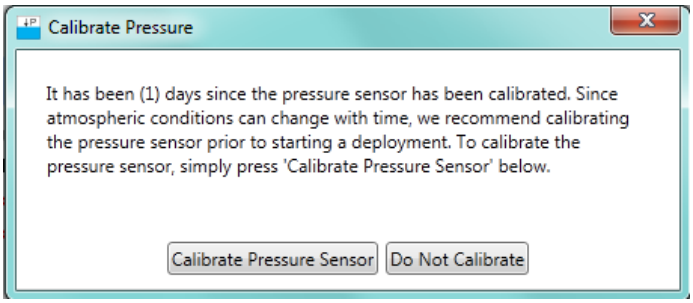
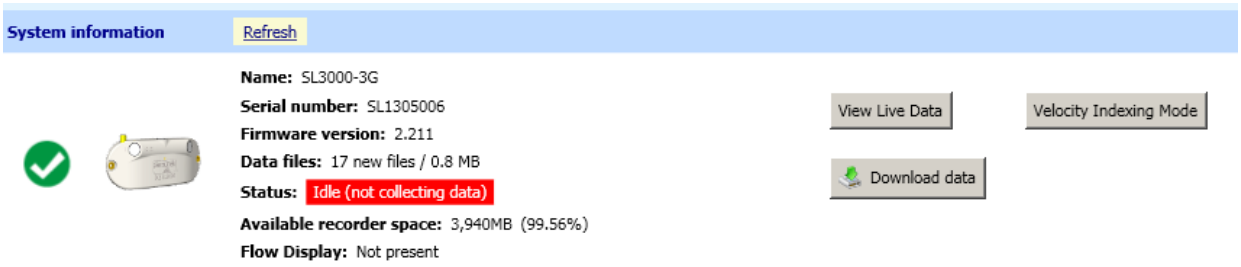


Figure 38. Calibrate Pressure dialog

The following Smart Page descriptions will assume that you have connected to an SL and are configuring the system manually.

3.1.1. Smart Page – System Information



The System Information section on the Smart Page provides general information about the SL, the sampling status, and the available recorder space. Use the "Refresh" button to update the information here when connected to an SL.

Name: Defines the type of SL system: SL3000 or SL1500

Serial Number: Every SL has a unique serial number.

Firmware version: The firmware version used by the instrument.

Data Files: The number of new data files available and the amount of space occupied by these files on the recorder.

Status: Indicates the system sampling status: RED-Idle (not collecting data) or GREEN-Active (collecting data).

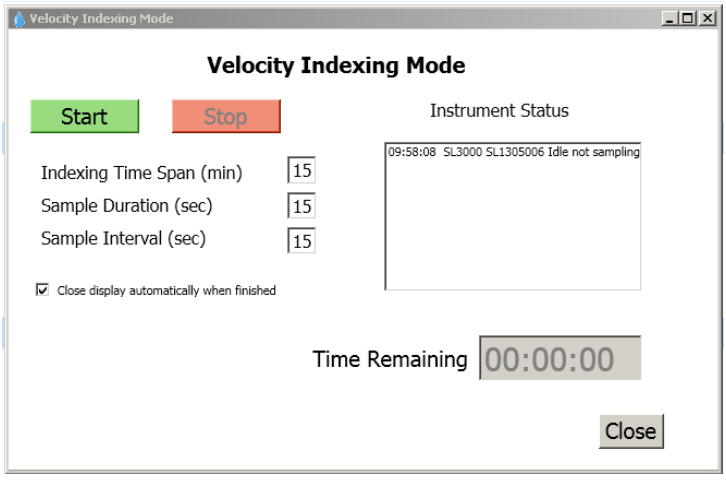
Flow Display: Indicates if a flow display is currently being used. Three different cases can be seen here: No display connected, standard display present, and display with 4-20 mA present.

Available recorder space: Shows how many megabytes of space are available on the recorder and the percentage of free space.

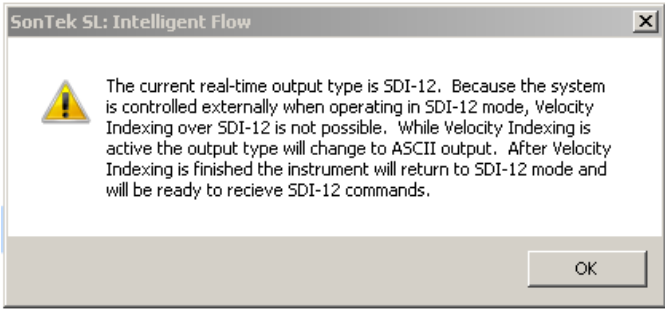
View Live Data: Presents a table with the most recent data collected by the instrument. View live data can be used when the system is idle or when collecting data if the output type is SonTek binary. SonTek Binary is the only output type that will allow you to view live data.

Download data: Allows users to download data from the system. This is the same function as Download data in the ribbon.

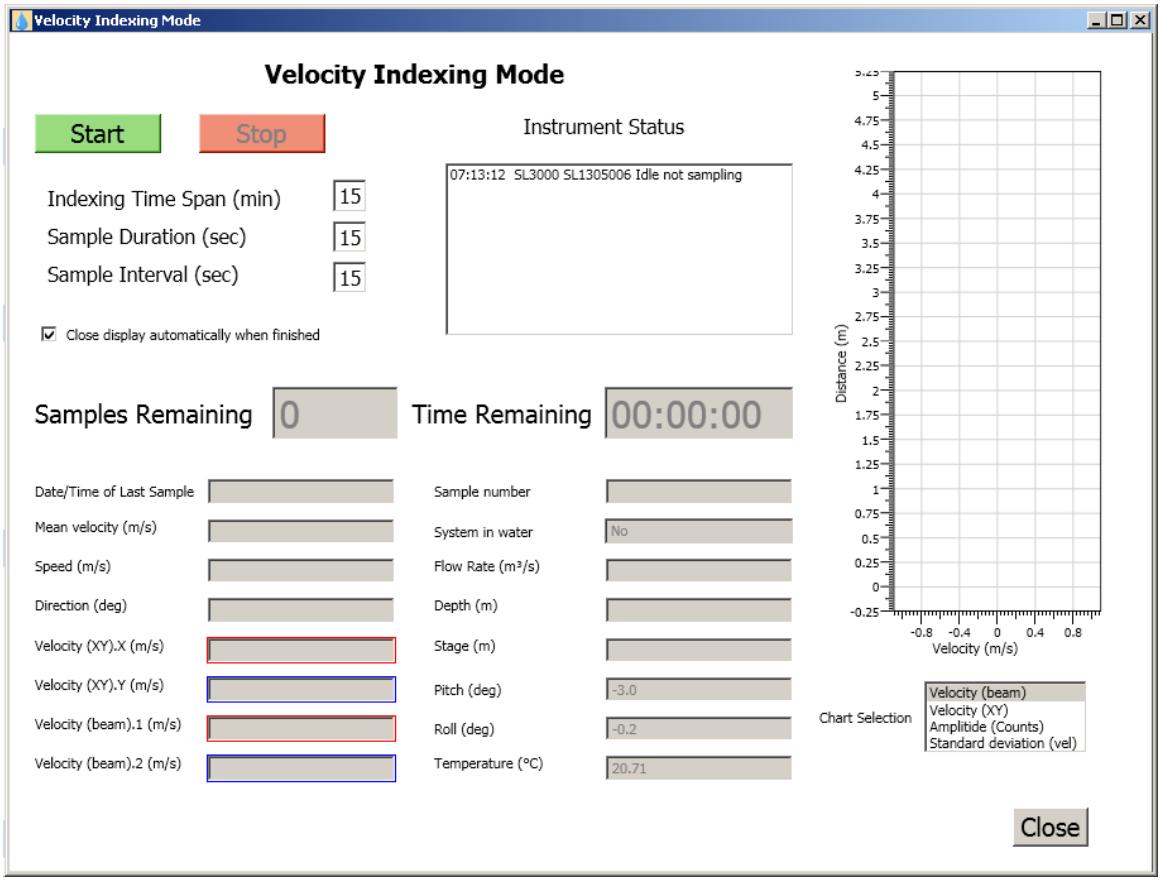
Velocity Indexing Mode: Clicking the "Velocity Indexing Mode" button will open one of two dialogs. If the real-time output setting is ASCII, Modbus, SDI-12, or Analog the following dialog will appear.



If VI mode is started while the real-time output setting is SDI-12, the following message will appear.



If the user opens the VI mode while the system is configured for Binary output, the following dialog will appear. When outputting Binary data, the real-time data is available during VI mode. In this dialog, the user can view Velocity, Amplitude, and standard deviation profiles in real-time. This dialog is updated every 5 seconds and the user can select the different profiles using the "Chart Selection" box in the lower right hand corner.



Both versions of this dialog will display the last VI settings applied to the instrument. These settings are saved inside the instrument, not the software. Switching connections from one instrument to another will not transfer the VI settings; the settings can be unique to each instrument. The default settings are for a 60 minute time span and 60 second duration/interval. If the "Factory defaults" button is clicked, the default settings will be stored on the instrument.

To begin Velocity Indexing, click the green "Start"button. Starting VI mode will transfer the VI settings from the dialog to the instrument and will create a new data file with "_VI" appended to the file name. For example, if the file name in the Site Details section is "Creek", the new VI mode data file will be "Creek_VI_201710031224.SL". The "_VI" is appended to the file name and then the time stamp is added as normal. After VI mode, the data file name will return to "Creek_201710031324.SL", assuming VI mode was active for one hour (time stamp has increased by one hour).

Click the red "Stop" button to interrupt or cancel VI mode.

- The "Stop" button only becomes active after the system has started.
- The "Stop" button can be clicked any time after starting VI mode.
- If VI mode is stopped in this dialog using the STOP button, the system will restore the original user settings and start sampling.
- NOTE: If VI mode is stopped with an ASCII command or immediately after reconnecting, the system will restore the original user settings but it ***does not*** restart sampling.

The "Close" button and the default dialog close "X" button will close the dialog but will not interrupt VI mode if it is active. It is important to understand the difference between the "Stop" button and the "Close" button.

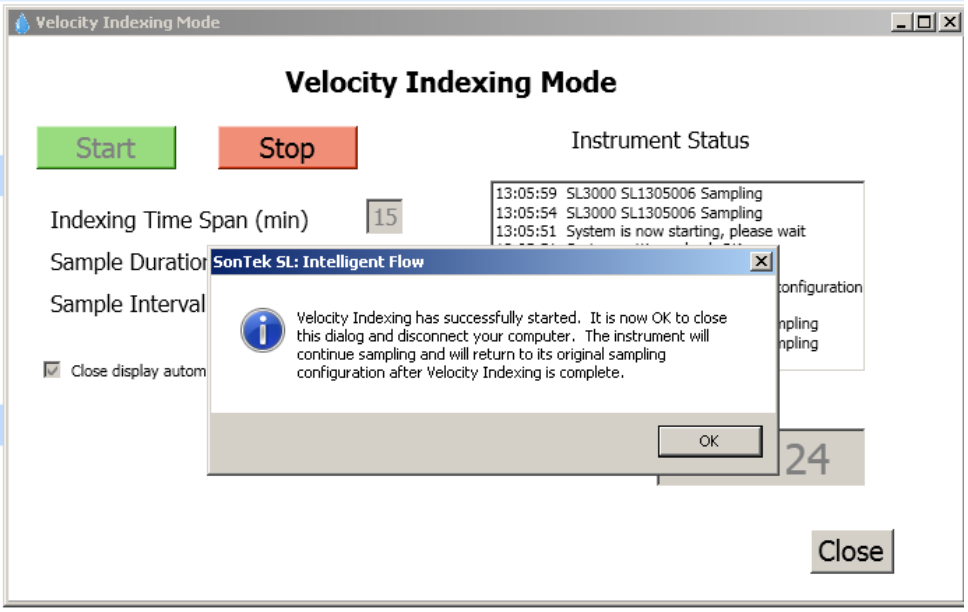
In this dialog, the VI mode settings can be changed by the user.

- The “Indexing Time Span” text box defines the number of minutes that VI mode will be active.
- The “Sample Duration” text box defines the length of the sample duration in seconds. This is also known as the averaging interval.
- The “Sample Interval” text box defines the length of time between averaged samples in seconds.
- The checkbox labeled “Close display automatically when finished” controls the behavior of the dialog after VI mode time has expired. If this box is checked, the dialog will close after VI mode. If this box is not checked, the dialog will remain open.

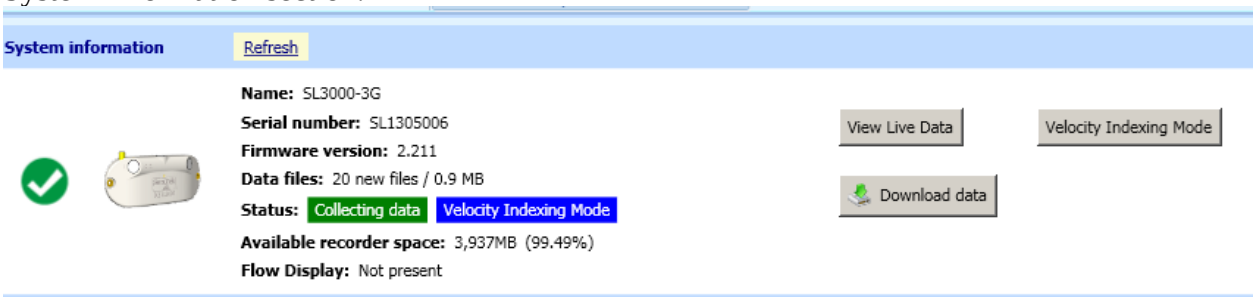
There are two boxes for displaying VI mode information in both dialog versions.

- The “Time Remaining” box is not editable. It will show a countdown timer with hours, minutes, and seconds until VI mode is finished.
- The “Instrument Status” list box will show status messages from the instrument before, during, and after VI mode. These messages will indicate if the instrument is sampling, being configured, starting, or stopping. Error messages will also appear here.

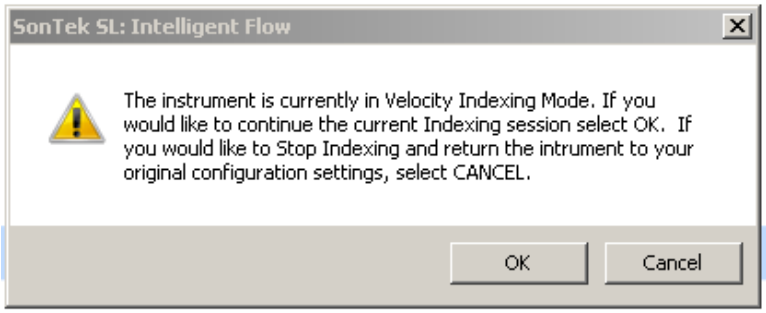
In the extended version for Binary output, the real-time data is displayed (similar to the “View Live Data” dialog)
After clicking the “Start” button, the following message will appear, instructing the user that it is ok to disconnect from the system.



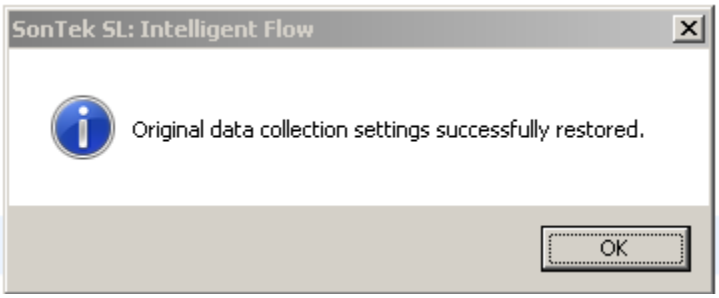
Closing the message dialog and then the VI dialog (using the CLOSE button) will return the user to the System Configuration page. While VI mode is active, a blue icon will be displayed in the System Information section.



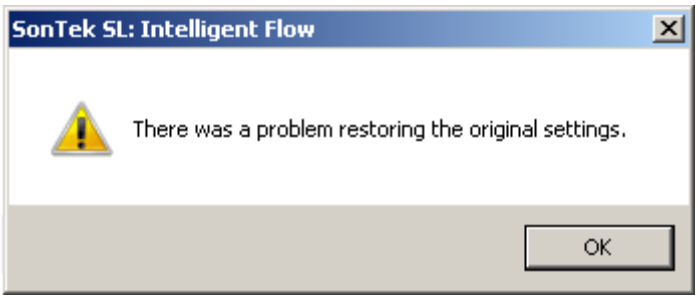
If the user disconnects the software from the system, the following dialog will appear if the user reconnects while VI mode is still active.



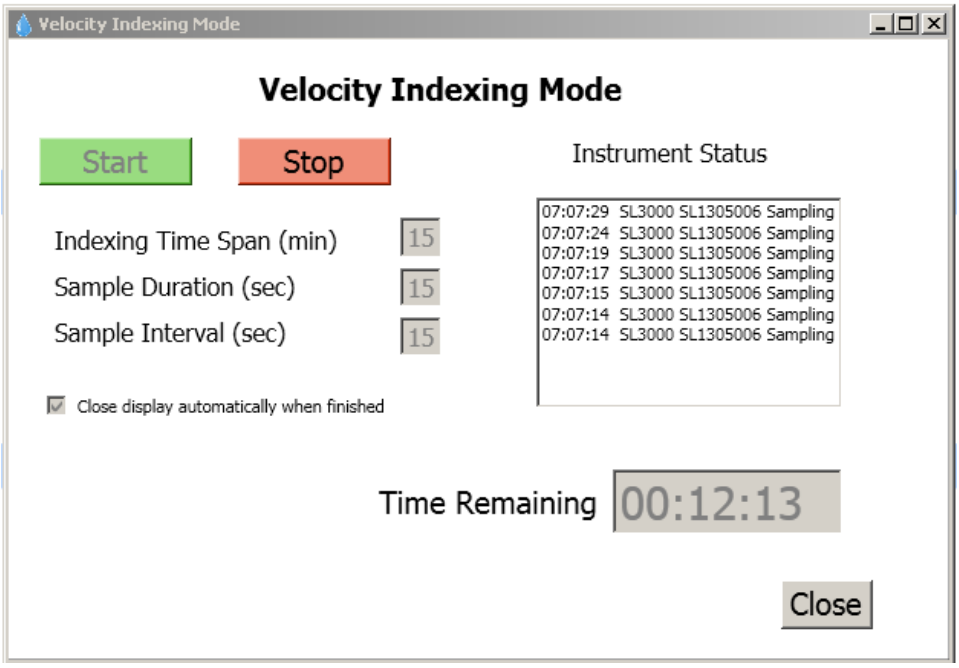
If the user selects CANCEL after reconnecting, the original settings will be restored and the system will enter an idle (not sampling) state. The original settings are checked and a success or failure message will appear.



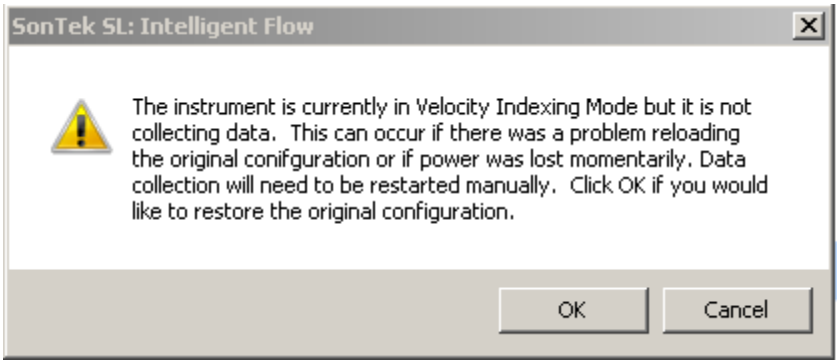
or



If the user selects OK after reconnecting, the VI mode dialog will reopen. The short dialog is shown below, but If the real-time output is Binary the extend version of this dialog will appear.



In the rare instance of a power failure during Velocity Indexing or if there was a problem loading the original configuration; VI sampling will end and will not restart. In this case the user will see the following warning dialog when reconnecting.



3.1.2. Smart Page – Standard Settings

The Smart Page Standard settings section is where users can view and change input details about the deployment site and the sampling scheme. Selecting the **Change** button will open a dialog where you can change or enter values for each field (Figure 39).

File Name: Is the file name under which data are recorded to the internal recorder. You can enter up to 10 letters or numbers. Symbols and spaces are not allowed. The SL automatically appends a time stamp to avoid duplicate file names. For example, if you enter "Test", on the recorder the data file name will be *Test_20111028_134109.SL*. The time stamp format is YYYYMMDD_HHMMSS (Year, Month, Day, Hour, Minute, Second). If this field is left empty, the default file name is the SL serial number.

Site Name: Allows for a short description of the site, up to 32 characters.

Operator Name: The name of the person configuring or deploying the SL, up to 32 characters.

Comments: Users can enter up to 120 characters and spaces to describe the site or the deployment conditions.

Water Salinity (ppt): User input salinity in parts per thousand. An appropriate salinity value is necessary for accurate calculations. Most fresh water can be considered 0 ppt while typical salinity values for seawater are between 30 and 35 ppt.

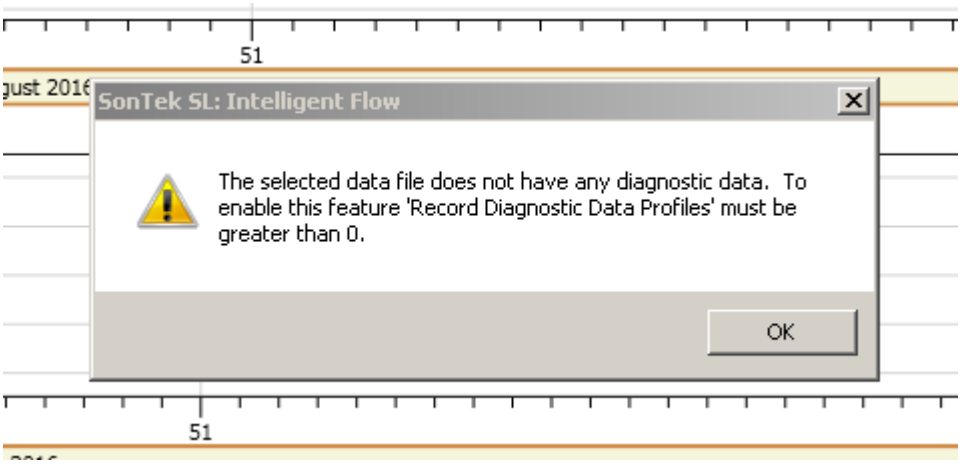
Sample duration (sec): Determines the period of time (in seconds) that the system averages data for each sample. Typically, sample durations are 2-5 minutes (120 – 600 seconds), but these values depend on field conditions – default setting is 120 seconds. For turbulent channels, longer durations may provide more consistent flow rates. The minimum is 1 and the maximum is 3600 seconds. *Note: Sample durations less than 10 seconds should be used for laboratory testing only; flow will not be calculated.*

Sample interval (sec): The period (in seconds) from the start of one sample to the start of the next, typical values are 5-15 minutes (300 – 900 seconds); default value is 900 seconds. The minimum is 1 and the maximum is 3600 seconds.

Record profile data: Determines the interval at which detailed profile data are recorded. Profile data includes measured velocity profiles (a velocity from each cell) and Signal to Noise (SNR) ratios. A value of "1" here will record a profile with each sample while a "0" turns off profile recording. If you would like to have the option to recalculate flow during post-processing, this parameter must be set to "1". Recording profiles can significantly increase file size and shorten the length of time that data can be recorder.

Record diagnostic beam check data: Determines the interval at which diagnostic beam check data are recorded. The default setting is every 100 samples. The minimum standard setting is two. In certain cases, it can be set to zero. However, that can only be done from the Direct Connection terminal window from the Advanced Utilities menu by sending the command: iqsetup.basicsetup.beamcheckinterval=0

If you try to view the diagnostic data in a file with beamcheckinteval=0 you will get the following warning:



Align sample to hour: This setting determines how the timing of data is related to the start of each hour; users can align samples to start or end at the top of the hour.

- Do Not Align means that data collection is started immediately upon your request, and is not specifically aligned to the start of each hour.
- Sample Starts at the Top of the Hour means that the timing of samples is set so that samples will align with the top the hour (i.e. 9:00:00). Based on the sample interval and duration, the SL will start the first sample at the time that ensures that a sample will align with the top of the next hour. The SL will not wait for the top of the hour to begin, but will begin when it can align the timing correctly.
- Sample Ends at the Top of the Hour means that the timing of samples is set so that a sample will end at the top of the next hour (i.e. 9:00:00). Based on the sample interval and duration, it starts the first sample at the first time that ensures that a sample will end at the top of the next hour.

Battery Life: Input the nominal voltage and capacity of the battery that is used to power the SL. Estimated battery life is based on the operating parameters and whether a flow display is being used. If the flow display is being used it is important to note that calculations on deployment determined by the software will be accurate as long as the flow display is connected when the calculations are done.

- Battery Voltage (volts): voltage for battery used during the deployment. Operating range is 9 to 15 VDC.
- Battery Capacity (amp-hours): the expected capacity (in amp-hours) of the battery used for the deployment
- Estimated Battery Life (days): calculated based on user supplied battery information and instrument configuration. Site conditions may influence this estimate – this value is only an estimate.

Details of the battery life calculations are shown below.

- BattV = battery voltage (user supplied, volts)
- BattC = battery capacity (user supplied, amp-hours)
- SD = sample duration (seconds)
- SI = sample interval (seconds)
- ActiveP = power consumption when active (W) = see table below

- IdleP = power consumption when system idle (W) = see table below
- 0.8 = SonTek recommends a safety margin of 20% applied to battery life calculations

Flow Display	Output Format	ActiveP (W)	IdleP (W)
No	Modbus	0.75	0.15
No	Any other	0.75	0.03
Standard Display	Any	0.85	0.11
Display w/ 4-20 mA	4-20 mA analog	2.00	1.50
Display w/ 4-20 mA	Any other	0.90	0.17

Two equations are used to calculate the battery life.

$$MeanPower(W) = \frac{(SD * ActiveP) + \big((SI - SD) * IdleP\big)}{SI}$$

$$BatteryLife(days) = \frac{0.8 * BattV * BattC}{24 * MeanPower}$$

Example:

- BattV=12 V, BattC=30 A-h, SD=120 s, SI=900 s, standard flow display, Modbus output
- MeanP = 0.330 W
- Battery life = 36.4 days

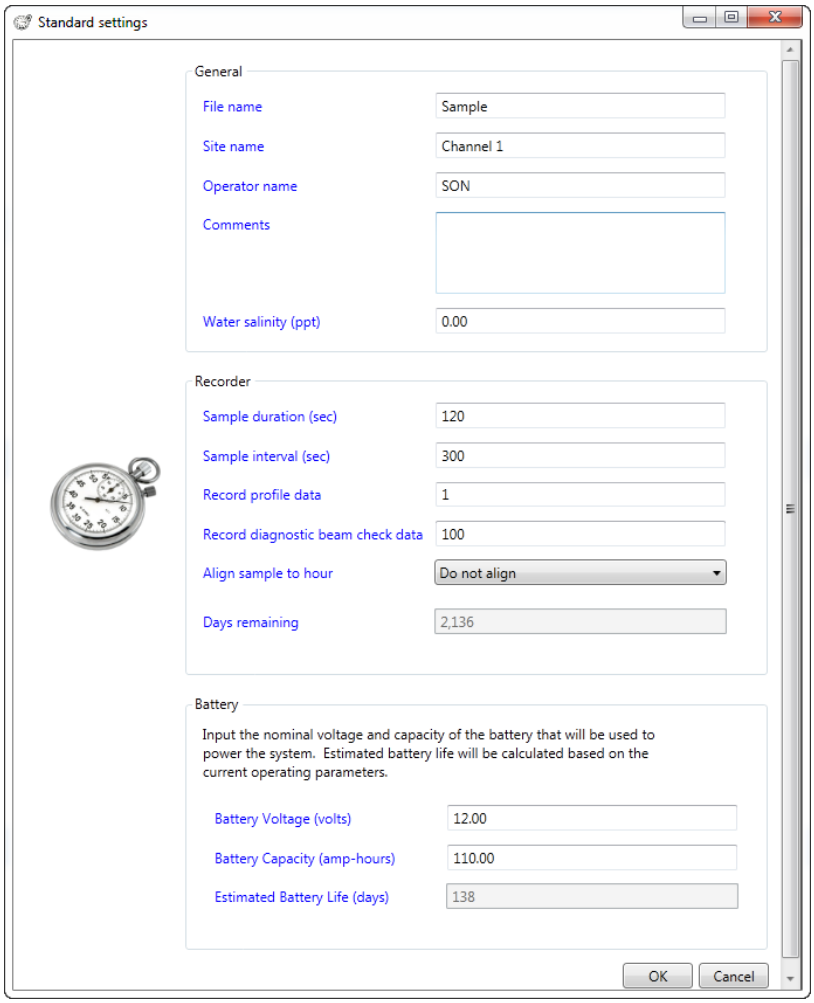


Figure 39. Standard Settings dialog

While entering values for settings, it is possible to enter values that are incorrect (Figure 40). If the SL software detects an incorrect value, it will highlight the value and associated fields in red.

To get help with the error, click on the red box next to the incorrect field  .

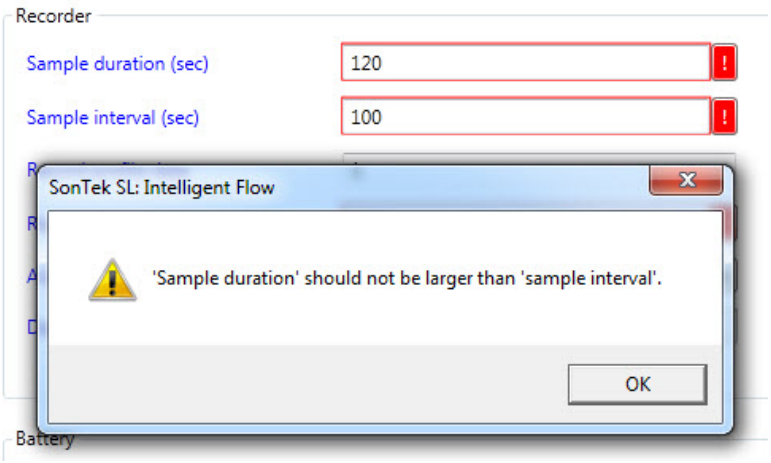
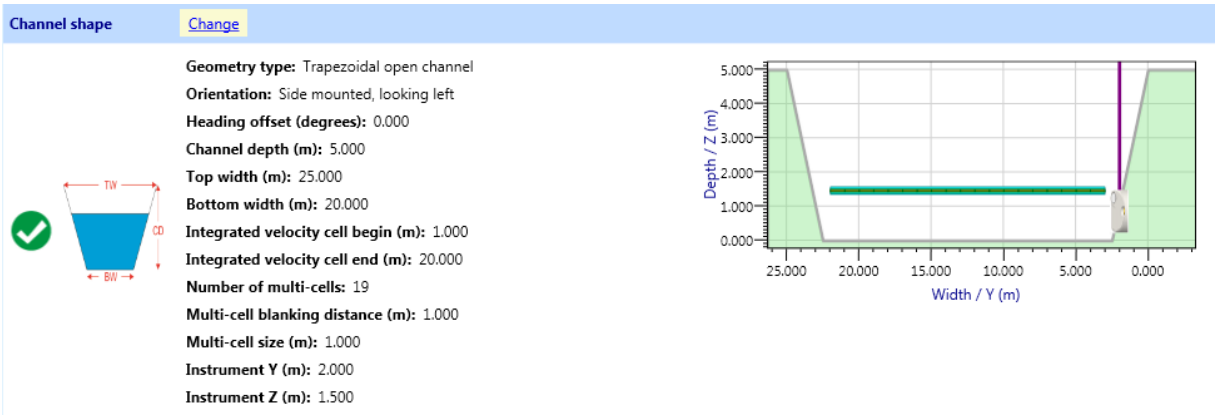


Figure 40. SL Software help with incorrect settings

3.1.3. Smart Page – Channel Shape



In order to calculate flow correctly, the channel shape needs to be well defined.
This section provides a simple method for entering a wide variety of channel types.:

- To update the information in this section, select the **Change** button.
- Enter the dimensions of the channel where the SL will be installed.
- Channel dimensions should be as accurate as possible.
- Use built-in templates for common cross-sections, or enter survey points from a cross-sectional survey to define an irregular channel.
- Note the warning icon on the left side of the section summary indicating that you must complete this section before beginning data collection.

Figure 41 shows the channel shape section of the Smart Page setup.

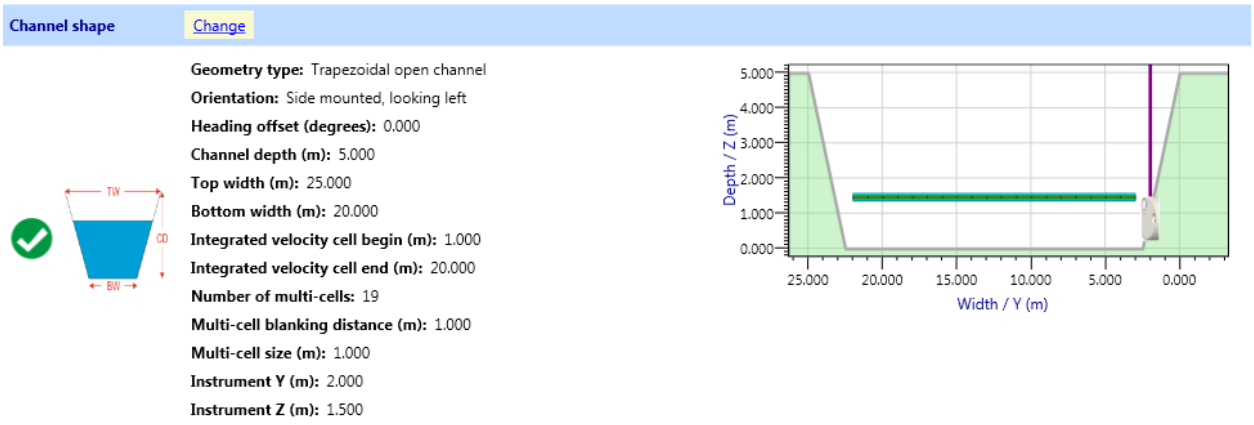


Figure 41. Smart Page channel shapes

Geometry type: Specifies the shape of the Channel.

Irregular Open Channel: An open channel of any shape defined by up to 200 user supplied survey points.
Trapezoidal Open Channel: A regular open channel defined by three parameters: bottom width, top width, and channel depth, typically used on known cross-sections that are completely clean.

Trapezoidal Culvert: The same as Trapezoidal Open Channel, except that the channel is closed at the top, the channel is defined by width at the bottom, width at the top, and channel depth.

Stage / area equation: A set of equations that relates the cross-sectional area of the channel to the measured stage level. Users can enter multiple equations to define complex channel geometries and flow conditions.

None: This is for recording velocity data only, typically when a Velocity Index Rating has been established for the site. Flow calculations are disabled. The Equation Type in the Flow Settings section must be set to Index when this Geometry Type is used.

Orientation: The origin of the horizontal distances as measured from the right or left bank.

- The right bank is the right side of the channel when facing downstream
- The left bank is the left side of the channel when facing downstream

Heading Offset: This setting will rotate the velocity vector direction. Positive values rotate the velocity vector counter clockwise and negative values rotate the vector clockwise.

Integrated Velocity Cell Begin: This value is the start location of the cell or the distance between the cell and the instrument. Velocity will be integrated over the width of the cell. The integrated velocity from this cell will be available in the data view table and charts.

Integrated Velocity Cell End: This value is the end location of the cell or the distance between the end of the cell and the instrument. Velocity will be integrated over the width of the cell. The integrated velocity from this cell will be available in the data view table and charts.

Number of Multi-Cells: From 1 to 128 individual velocity cells defined by the user.

Multi-Cell Blanking Distance: This value is the horizontal distance from the instrument to the start of the first "Multi-Cell" in the velocity profile.

Multi-Cell Size: This value is the horizontal distance from the start of one cell to the start of the next cell.

Instrument Y: This specifies the horizontal location of the SL in the channel. The instrument location is always specified as the top of the vertical beam.

Instrument Z: This specifies the vertical location of the SL in the channel. The instrument location is always specified as the top of the vertical beam.

Figure 42 presents the general Channel shape dialog.

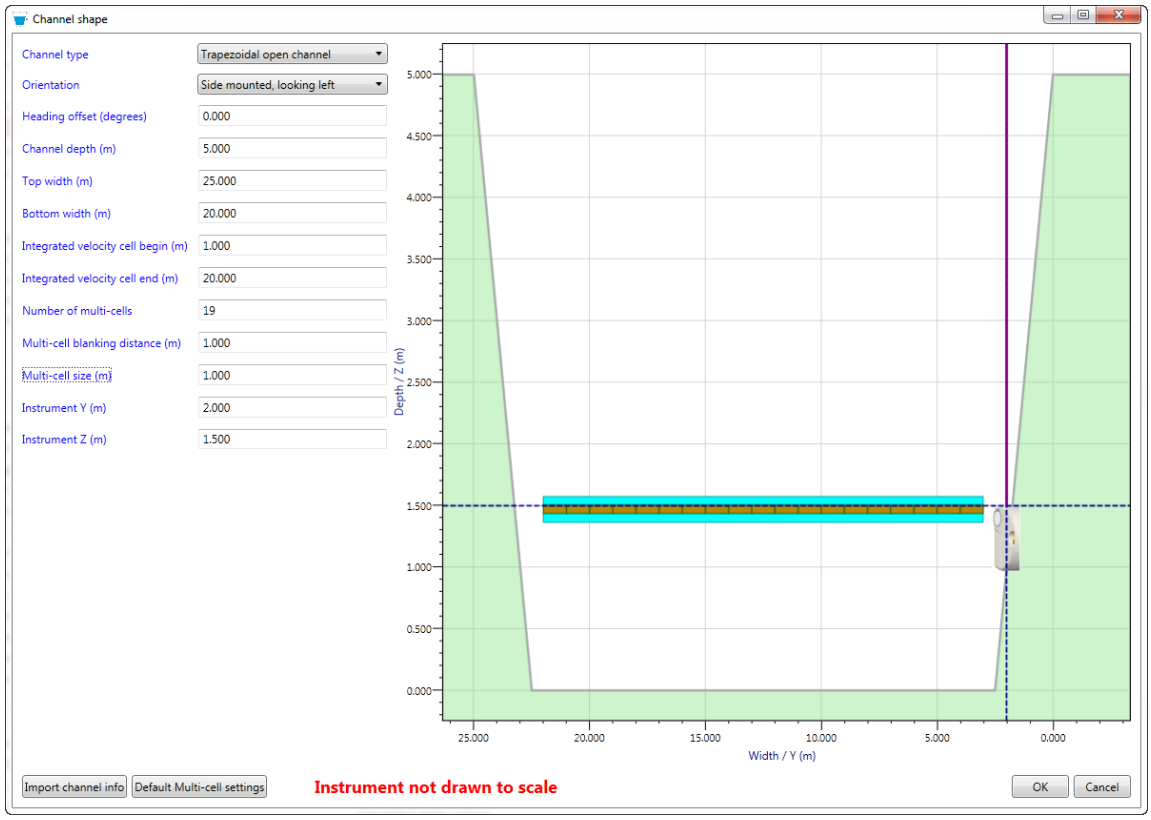


Figure 42. Channel shape dialog

The Channel shape dialog provides a quick and easy way to enter the channel dimensions at the measurement site. The options in this window will change depending on the type of channel selected.

- For an Irregular Open Channel, the channel dimensions can be entered manually in the spreadsheet.
  - Use **Append survey point** to add a new row to the end of the columns.
  - Use **Insert survey point** to insert a row above the currently selected row.
  - Use **Delete survey point** to remove the currently selected row.
- Select the spreadsheet cell with the mouse to update the value.
- Selecting a point on the figure will outline the point in red and highlight the location of the point in the spreadsheet.
- The channel and the SL in the figure appear as if you are standing in the channel looking downstream. The right bank is on the right side of the figure and the left bank is on the left. The water in this channel would be flowing into the figure.
- The **Import channel info** button can be used to import data from an SL configuration file (*.sontek_system_config) or a Comma Separated Values file (CSV).

After selecting the “Import channel info” button, if you choose to import a CSV file, a new window will appear for defining the columns of the CSV file (Figure 43).

- Users can indicate if field descriptors are on the first line of data with the checkbox
- A drop down menu allows for identification of channel type
- Width and height drop down menus are used to identify appropriate data columns

- The Invert Z check box is used for raw survey data – data that has not been referenced to a bench mark
- The Units drop down menu allows users to select the unit for length

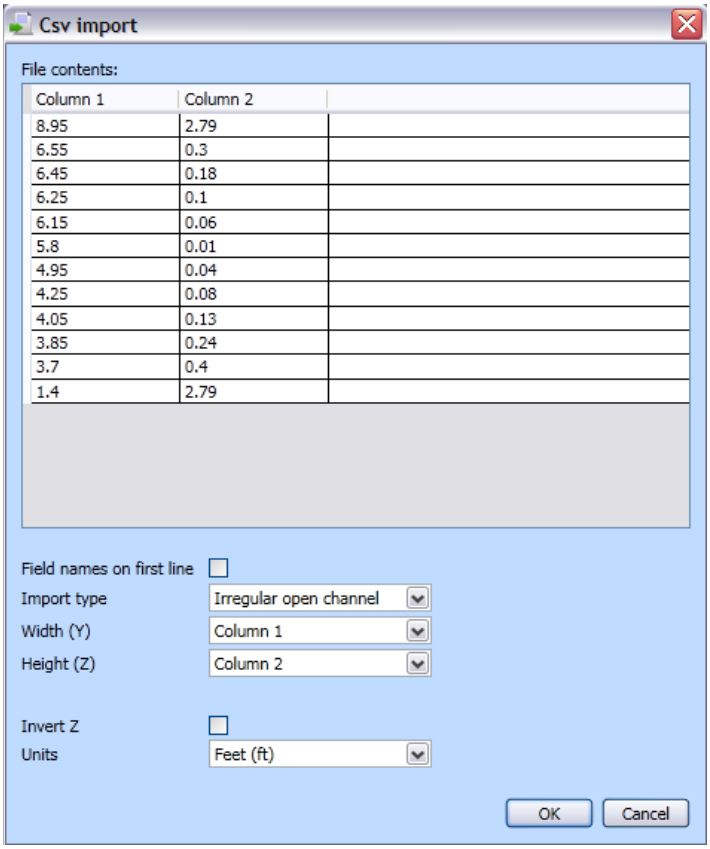
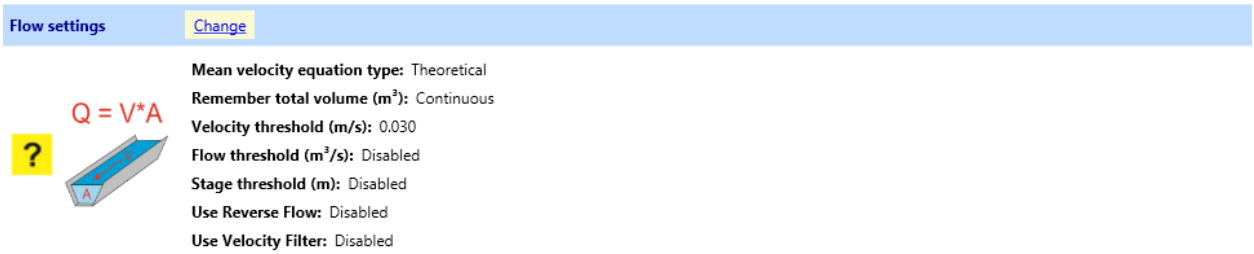


Figure 43. CSV import window

3.1.4. Smart Page – Flow Settings



Flow is the mean water velocity multiplied by the cross-sectional area of the channel. Flow is a volume of water that moves through a channel in a specific amount of time. The SL measures the water velocity profile and uses the channel dimensions to calculate the most accurate flow measurement possible. This section allows users to configure the flow calculation settings and to set threshold limits on the Velocity, Flow, and Stage. Figure 44 presents the Flow Settings Window.

Select the **Change** button to edit the Flow settings. A new window will appear with a variety of options to consider.

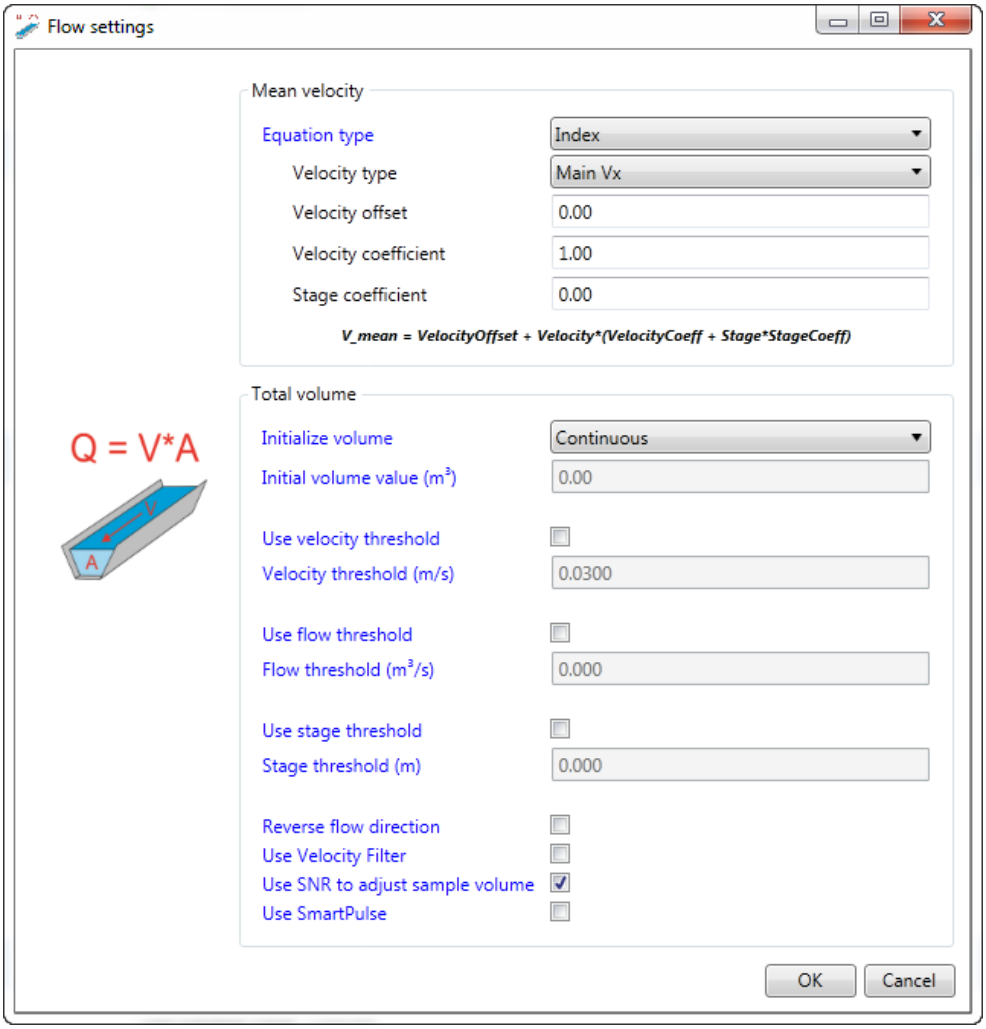


Figure 44. Configuring Flow Settings

Equation type: The equation type defines the relationship between the measured velocity and the mean velocity in the channel.

Theoretical: A theoretical model of velocity distribution that uses the location and magnitude of velocity measurements to calculate flow. This equation is based on years of scientific research and field measurements.

Velocity Index: Is an empirical relationship between a measured velocity and the channel mean velocity. A Velocity index is calculated with a series of measurements over time for different flow rates. The velocity type, velocity offset, velocity coefficient, and stage coefficient are determined experimentally at a site.

Total volume: The total volume delivered through the channel based on measured flow rate multiplied by time.

Initialize volume: This setting determines the starting value for total volume calculations each time data collection is started. There are three options for initializing the volume calculation

Continuous: The default setting for which volume continues to accumulate from the last measured value after the SL has been stopped and re-started. It is important to note that the continuous setting will include an estimate of water volume for the period that the SL was

not collecting data. Based on previous measurements, the total volume is adjusted to include the volume of water that flowed while the SL was not sampling.
Initialize: If you would like to begin measurements with a nonzero starting volume, use this setting and enter the **Initial volume value**. After data collection starts, the Initialize volume setting will automatically switch to the Continuous setting so that the volume will continue to accumulate whenever data collection stops and starts. When installing an SL at a new site, the system would typically use this setting with an Initial volume value of zero so that only data from the new site is included in the Total Volume measurement.
Reset: Use this setting if you would like the total volume to start at zero each time data collection is started.

Use velocity threshold: Use the check box to enable this feature, which allows you to filter velocity data based on the entered value. When this option is selected, flow rate and total volume data are only accumulated when the magnitude of the mean velocity exceeds the velocity threshold value. Note that the SL uses the magnitude of this value, or the absolute value. For example, if the velocity threshold value is 2.0, then measured mean velocities of 2.1 and -2.1 both exceed the threshold.

Use stage threshold: Use the check box to enable this feature and accumulate volume only when the stage is above the entered value. The entered value is considered the minimum stage value. For stages below this value, volume is not accumulated and flow is not computed. For stage levels above this value, flow rate is calculated and total volume is accumulated.

Reverse flow direction: Use the check box to enable this feature, which allows you to reverse the sign (+/-) on measured velocities and flow direction.

Use Velocity Filter: Use the check box to enable this feature, which allows you to filter out poor quality velocity and flow data. This option is recommended for turbulent flow.

Use SNR to Adjust Sample Volume: Use the check box to automatically decrease the horizontal profiling range when the SNR drops below 2.5 dB. The previous generation Argonaut-SLs used this feature by default. Enabling this setting is recommended to avoid including questionable velocities at the end of the integrated velocity cell that might bias the averaged velocities low. However, unlike SL-SLs, this setting will screen and remove low SNR "Multi-cells" from computed averages. Adjusted sample volumes will be recorded as changes in the Cell End.

Use SmartPulse: Use the check box to enable SmartPulse. SmartPulse is a self-adjusting sampling method that uses the best velocity measurement technique for changing conditions. For very slow moving water, SmartPulse will switch to a velocity method that greatly reduces the standard deviation of individual samples. For intermediate to fast moving water, SmartPulse will switch to the best method for the maximum measured velocity. User's employing velocity indexing methods may want to disable SmartPulse to keep a consistent velocity sampling method.

3.1.5. Smart Page – Output Settings

The SonTek-SL is capable of outputting data in a variety of usable formats. Output data formats are compatible with many dataloggers, PLCs, and RTUs. The Smart Page Output settings section displays the current settings for the output format and the units of the output variables. Select the ***Change*** button to edit the Output Settings (Figure 45).

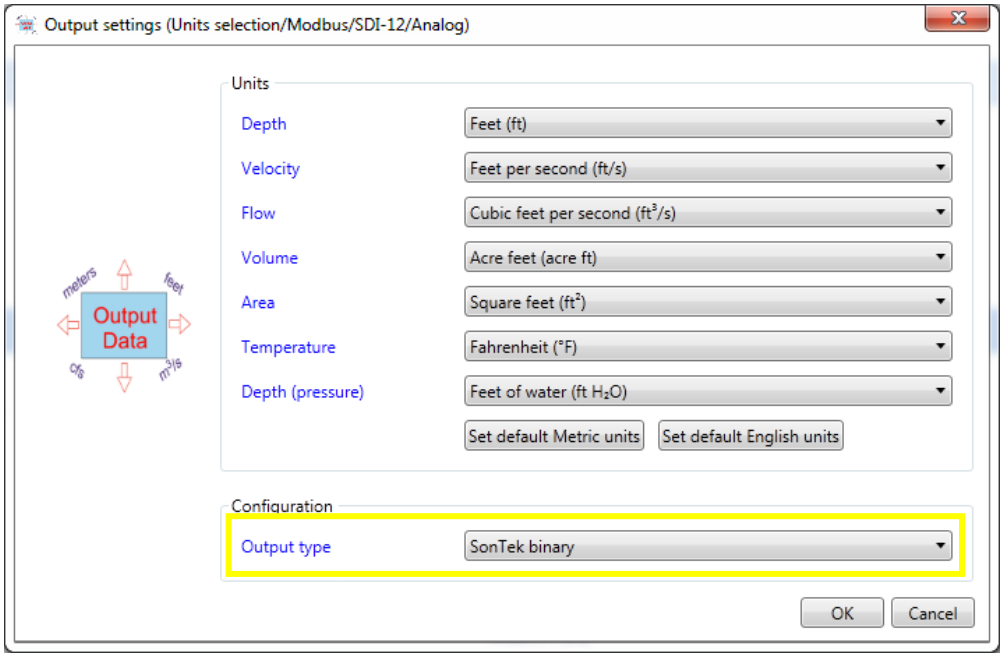


Figure 45. Configuring Output Settings

- Units for each type of output variable are set in the Output settings dialog
- Buttons for default metric and default English units are provided
- To use the **View live data** function in the Smart Page System information section, the output type must be set to SonTek Binary. This is the default setting. SonTek Binary is a communication protocol that allows you to view the live data. The SL does not output in a SonTek Binary format.
- Additional output options in the "Output type" pull-down menu are :
    - ASCII output (RS232)
    - Analog output (4-20 mA)
    - SDI-12
    - Modbus

ASCII output (RS232): Use this output type to communicate with dataloggers and computers through a serial COM port. Port settings are 9600 baud, no parity, and 1 stop bit. No additional settings are required.

Analog output (4-20 mA): Analog output (4-20 mA) configures the SL to control up to four analog signals generated by the SonTek Flow display. Use the pull down menu next to each of the four channels in the configuration dialog to set the output data variable. Once the variable is selected, enter a minimum and maximum value. The Min and Max values specify the range of the analog signal generated by the Flow Display. For example, if the data variable on channel 1 is Flow and the Min value setting is zero, the Flow Display will output a 4 mA signal on channel 1 when the calculated Flow is zero (Figure 46). After selecting the data variable, the units column will display the current units of the variable. To change the units, use the Units drop-down menus in the Output settings window.

The analog output signals should be calibrated on the data collection system that will be used. That is done from the Advanced Utilities menu as shown in Figure 54.

Important note: Using analog outputs will significantly increase power consumption and decrease battery life. The exact impact on power consumption and battery life cannot be reliably predicted. If you are using analog outputs, it is best to have access to a constant power source (i.e. AC main supply). If you are running from a battery (with or without solar panel), you should budget for up to 2.0 W of continuous power consumption when using the analog outputs.

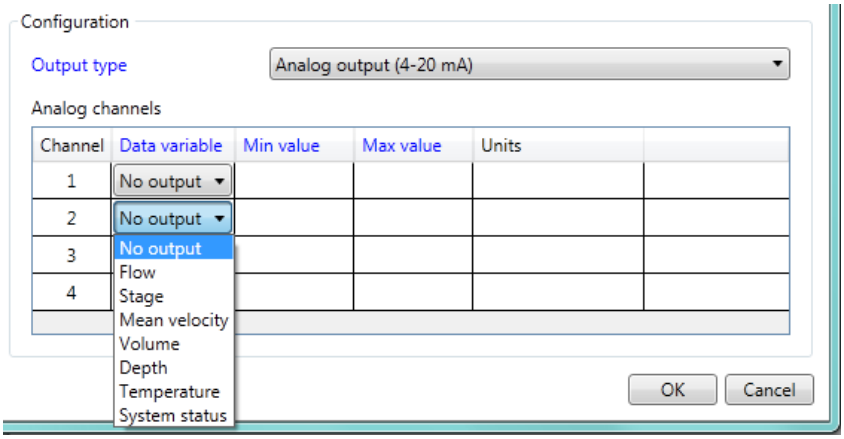


Figure 46. Configuring Analog output in the Output settings dialog

SDI-12 output: Select this option to interface the SonTek-SL with an SDI-12 datalogger or network. The SDI-12 connection on the cable adaptor is used to access these data with this setting. The SDI-12 default network address is 0. Each instrument in a SDI-12 data collection network must have a unique address; values from **0-9**, lower case **a-z**, and upper case **A-Z** are allowed, Figure 47 presents the SDI-12 Configuration dialog.

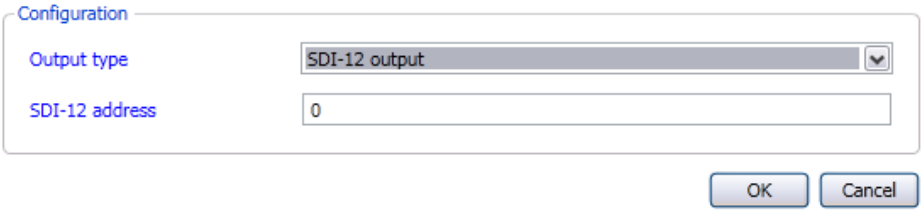


Figure 47. Configuring SDI-12 output in the Output settings dialog

Modbus output: The SonTek-SL can act as a Modbus slave device over the RS232 port on the cable adaptor. Devices on a Modbus network must have a unique address number between 1 and 247. The default baud rate is 19200, but values from 300 to 115000 are supported. Longer cable runs may require lower baud rates for error-free communications. The default parity is even with options for odd and none. The output format on most Modbus data collection networks is IEEE standard floating point. An option for Inverse floating point is also included. Figure 48 presents the Modbus Configuration dialog.

Important Note: Using Modbus output will increase power consumption, when using this option the SL software will incorporate this factor when making battery life calculations.

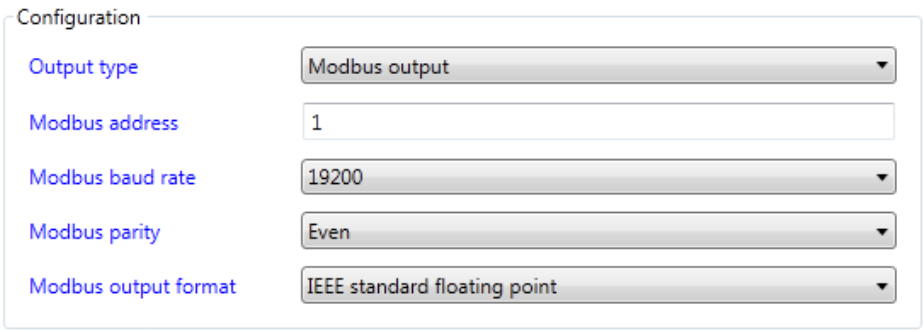
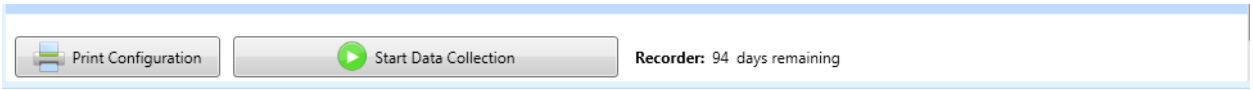


Figure 48. Configuring Modbus output in the Outputs settings dialog

3.1.6. Smart page – Print Configuration and Start Data Collection



Two buttons at the bottom of the Smart Page are used to **Print Configuration** and **Start Data Collection**. After configuring all of the options on the Smart Page, you should see a  next to each section. If all sections are green, you are ready to begin collecting data. Be sure to check the settings in any section with  or  next to it.

- If an SL is deployed and collecting data, the Smart Page will have a Stop Data Collection button in place of the Start Data Collection button.
- The number of days available for data collection is next to the start button.
- **Print Configuration** generates a printer friendly SL Smart Page that can be used for record keeping with all of the SL configuration information.
- Once the system is configured, simply click **Start Data Collection** at the bottom of the Smart Page to deploy the instrument.
- While collecting data you can stay connected or disconnect from the SL, it will continue sampling until you select the **Stop Data Collection** button.

3.2. System Configuration – Download data

To download data, connect the USB-Serial adaptor to the SL cable adaptor and open the software. Click on connect and the Smart Page will open. Data can be downloaded in two ways (Figure 49):

- Select the download data button in the main ribbon
- Select the download data button in the Smart Page System information section

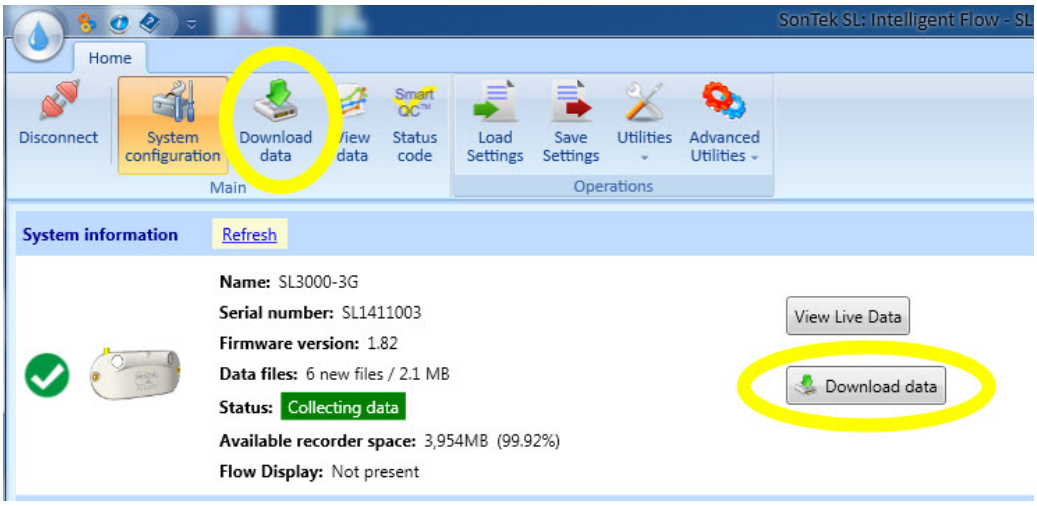


Figure 49. Download data buttons on the Smart Page

Both options will take you to the Download data window (Figure 50). Once the Download data window is open, you will see a list of new files currently stored onboard the SL. All data files always remain on the recorder until it is formatted. Only new files are shown in the list until they are downloaded and saved to the SL Data directory. This directory is defined in the Software Settings. If there are no new files on the recorder, the Download data buttons will be disabled until a new file is available for download.

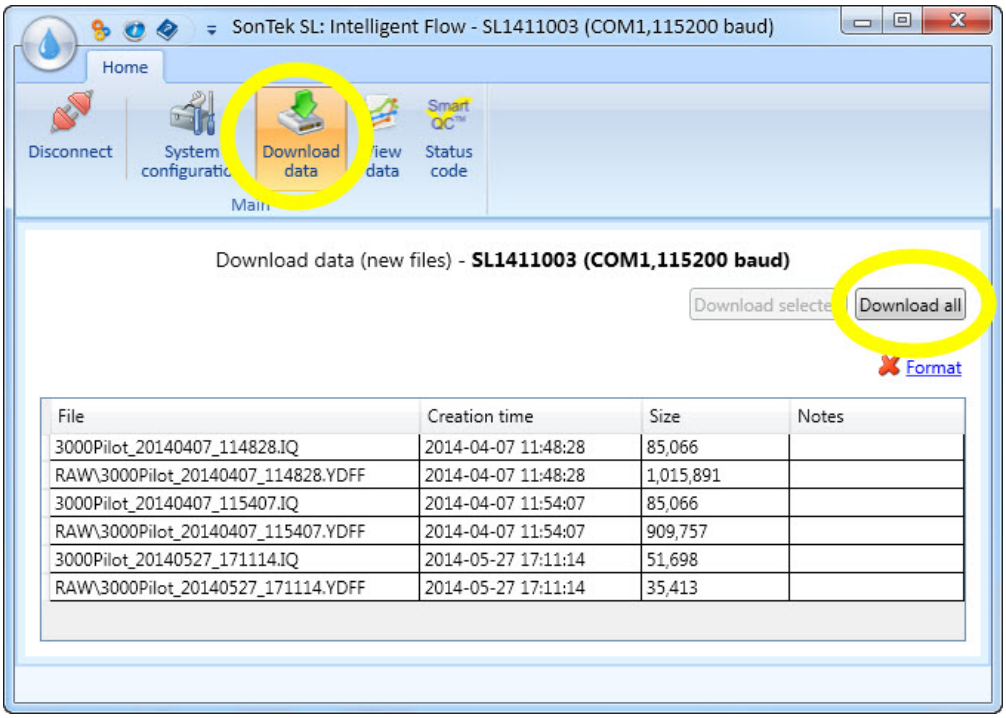


Figure 50. Download data window

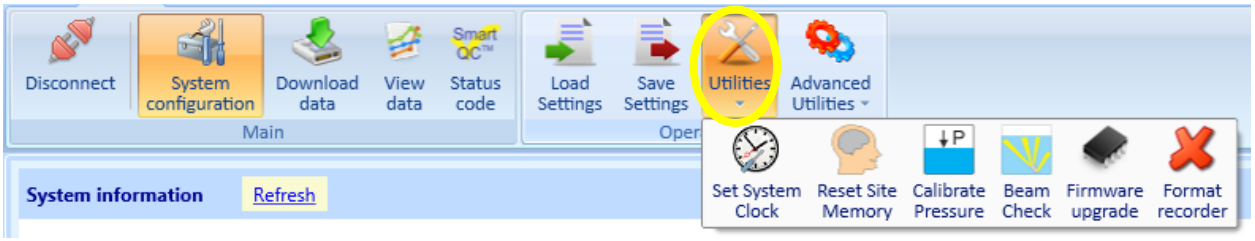
- The SL serial number, COM port, and baud rate are displayed at the top of the page.
- The maximum baud rate can be changed in the SL Software settings using the title bar quick-link .
- Users can select individual files from the list or multiple files by holding "Shift" and clicking on several file names. Use the **Download Selected** button to retrieve one or more files.
- Use the **Download all** button to retrieve all of the listed files.
- Use the **Format** button to delete all data on the recorder.
- Double-click on a file to download that file.
- All files are downloaded to the user-defined directory in the Settings → SL data folder and are organized into sub-folders based on site name.
- The Notes section will display "(partially downloaded)" if data has been added to a file since the last download. SL data files are continuous and data will be appended to the current file until the data collection is manually stopped or there has been a change to the system configuration.

The SL software is designed with a database structure. Users must indicate where data will be stored using the Settings button. The software is not designed for multiple user access to files. As such it is recommended that files are stored in a local drive. Sub folders are named according to file name (done in the instrument deployment phase).

If files need to be transferred between computers, it is highly recommended to do the following:

- If a folder containing SL data does not exist in one directory – copy the entire folder (and its contents) from one local drive to the other local drive.
- When copying files from one folder to another – make sure folder names are exactly the same.
- The software will create supplementary hidden files in the same folder that your data files are located. They will have ".fastdat" or ".wsp" extensions. Deleting these files may cause a loss of software settings (including flow that is "Recalculated") and is thus not recommended.

3.3. System Configuration – Utilities



There are several common utility functions accessible from the main ribbon when viewing the Smart Page. The SL will perform some of these functions automatically based on the options selected in software Settings, but you can access them anytime from here.

Set System Clock: Allows users to synchronize the SL clock to the PC clock or input another reference date and time (Figure 51). The **System Date Time** is the current time onboard the SL. If the **Verify system clock** option is enabled in the software settings, the SL will automatically prompt you to correct the time if it differs from the PC time upon connection.

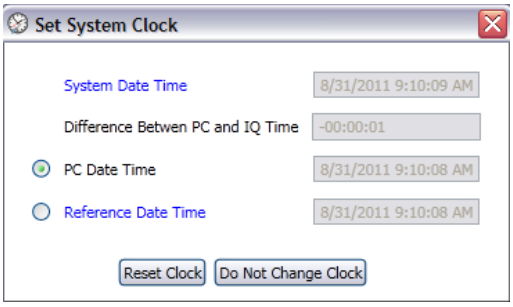


Figure 51. Set Sytem Clock window

Reset Site Memory: This function clears all memory related to the flow conditions at the site. This includes total volume parameters relating to flow conditions in the channel.

- Use **Reset Site Memory** to clear total volume parameters and start accumulating new data from zero.
- **Important:** this function should be used whenever a system is installed at a new site or site conditions have changed.
- If the **Verify site memory** option is enabled in the software settings, the SL will automatically prompt you to reset the site memory if it detects significant changes in channel flow conditions.

Calibrate Pressure: This function adjusts the pressure sensor for changes in atmospheric pressure.

- The pressure sensor calibration can be performed when the system is in the air or if the SL is submerged in water at a depth greater than 0.1 meter (0.3 ft).
- The SL can calibrate the pressure sensor while underwater if the surface conditions are stable (smooth water surface).
- The SL will evaluate the surface conditions and inform you if an underwater calibration is possible.
- If the **Check pressure calibration** option is enabled in the software settings, the SL will automatically prompt you for a pressure calibration when the last calibration is no longer valid.
- While sampling, the SL will calibrate the pressure sensor on a regular basis if conditions are acceptable.
- While idle, the SL will prompt you to calibrate the sensor if no recent measurements have been collected.

Beam Check: Provides real-time information about the status of the acoustic beams. This function can be used to troubleshoot measurement problems and help to identify buried beams. See the next section for a complete description of this function.

Firmware Upgrade: Used to upload new firmware to the instrument. On occasion, new firmware will be made available to SL users. You may receive SL firmware from SonTek support personnel or it may be posted on SonTek's website. Do not accept or load firmware from any other source. To load firmware, select the **Firmware upgrade** button and navigate to the firmware file location. All firmware files will have a .yfw extension.

Format Recorder: Deletes all data from the recorder. After selecting this button, you will be given one chance to cancel the operation. Once the recorder is formatted, data files will no longer be available for download. Please be sure to download and verify that all data has saved correctly before formatting the recorder.

3.3.1. Utilities-Beam Check

After selecting the Beam Check button, the main ribbon will add a "Beams" section and a "Functions" section.

- Use the color-coded check boxes on each beam to turn transducers on and off.
- To view a previously recorded Beam Check file, select stop to end sampling and then select **Open Beam Check File** to view data (Figure 52).

Figure 52. Opening a Beam Check File

- Use **Start** to begin sampling again.
- Beams are color-coded to match the SNR data graphed on the plot.
- Use **Disabled** to view each sample independently or use **Enabled** to accumulate Beam Check samples for averaging.
- You can record Beam Check data to a file, pause sampling, and stop sampling.
- Figure 53 presents the Beam Check window.

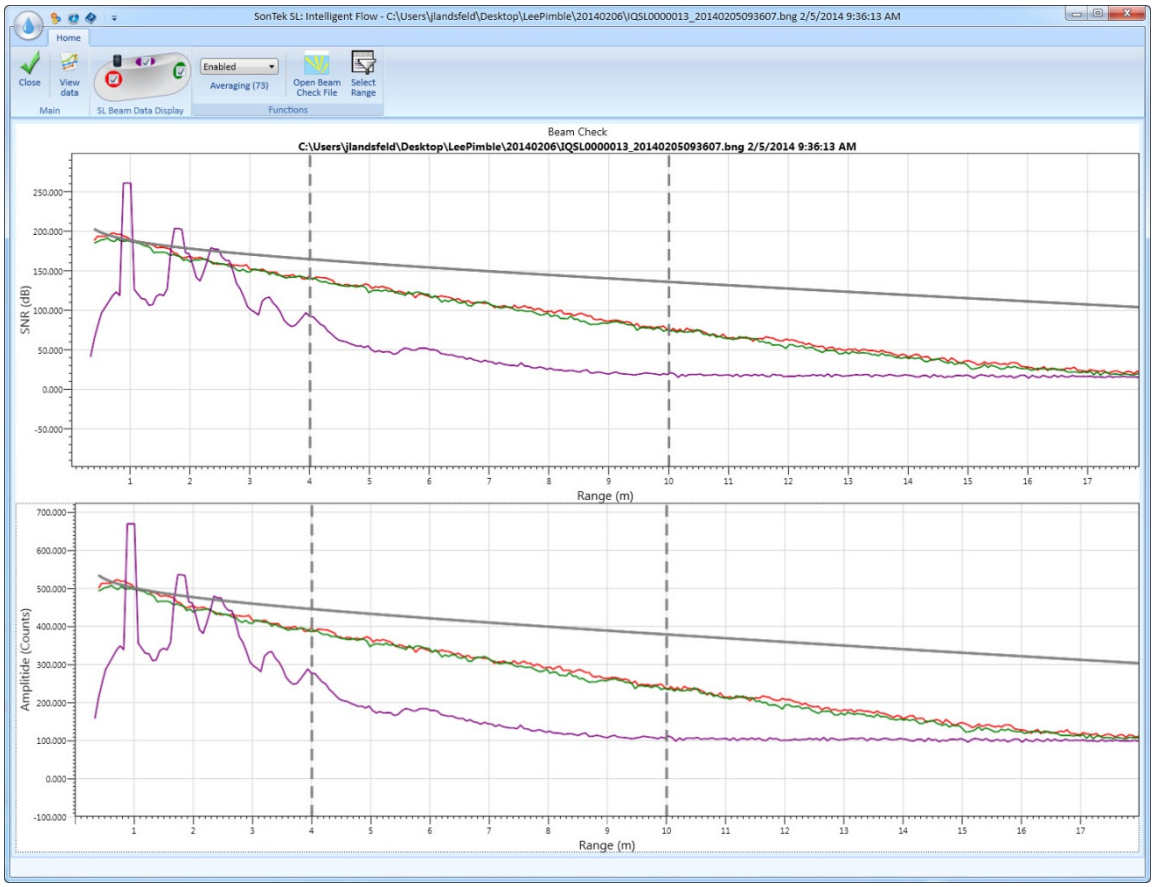
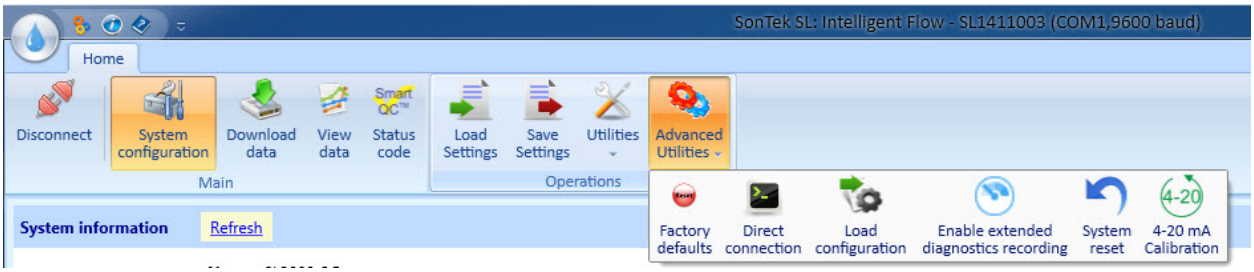


Figure 53. SL Software Beam Check window

3.4. System Configuration – Advanced Utilities



Advanced Utilities are used for less common functions, and are commonly used when working with SonTek Support personnel.

Factory defaults: Resets the instrument to the configuration as shipped from the factory.

Direct connection: A command line window or terminal that provides direct communication with the system.

Load configuration: A configuration file is different from a setup file created using "Save settings". Configuration files contain calibration data specific to each instrument and are only available from the manufacturer. These files will have .ini as the file name extension.

System Reset: This is a full system reset typically used when troubleshooting; this is effectively a system reboot. If you are having trouble communicating with an SL, use this function to restart the SL and re-establish communications.

4-20 mA Calibration: When using the flow display with optional 4-20 mA analog outputs, the outputs should be calibrated on the data collection system that will be used.

- Connect all channels of the 4-20 mA analog outputs on the flow display to the data collection system that will be used.
- Connect the SL to the flow display and then to a PC. Run the SL software and select **Advanced Utilities – 4-20 mA Calibration**. Figure 54 shows the display screen.

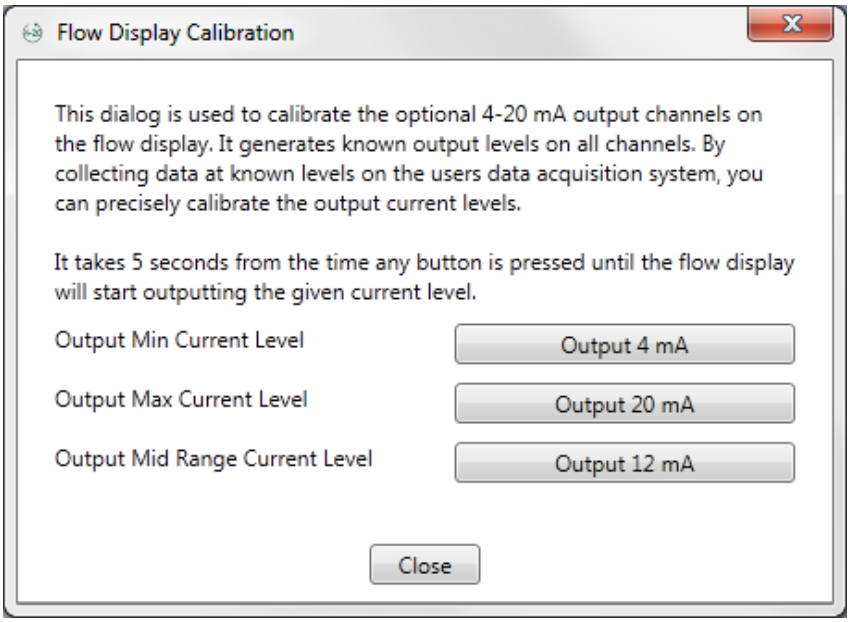


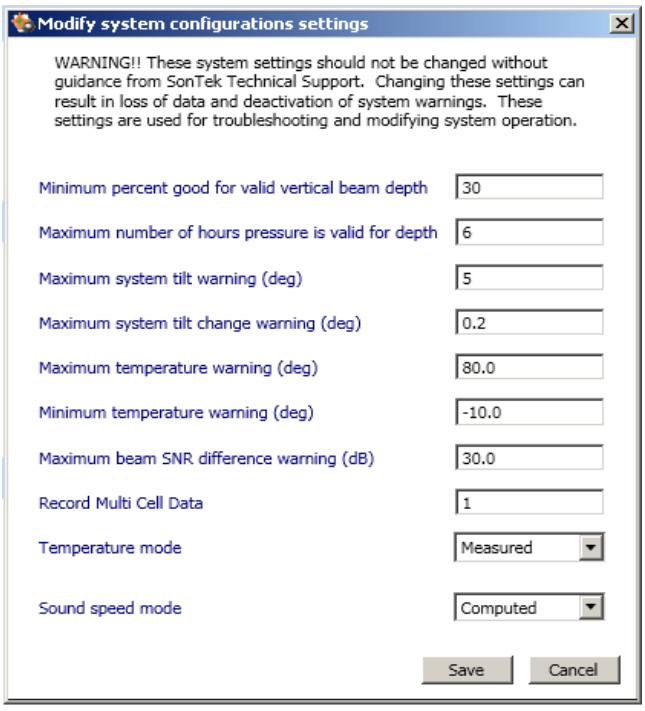
Figure 54. Flow Display Calibration

- Click the **Output 4 mA** button; wait 5 seconds for the value to be set. Verify the current output on each channel of your analog data collection system. This current will correspond to the programmed minimum value for that channel.
- Click the **Output 20 mA** button; wait 5 seconds for the value to be set. Verify the current output on each channel of your analog data collection system. This current will correspond to the programmed maximum value for that channel.
- A third option, **Output 12 mA**, can be used to verify the calibration with one point exactly in the middle.
- **MinAmp** is the value measured for **Output 4 mA**, and **MaxAmp** is the value measured for Output 20 mA, and **MinValue**/**MaxValue** are the user-specified min and max ranges for that channel, then the formula below gives the SL value for any given **MeasuredAmp**.

$$\text{MeasuredAmp}=\text{MinValue}+\left(\frac{(\text{MeasuredAmp-MinAmp})}{(\text{MaxAmp-MinAmp})}*(\text{MaxValue-MinValue})\right)$$

- Example:
  - Analog channel 1 is programmed to output flow, with a min value setting of 0 cfs (cubic feet per second) and a max value setting of 40 cfs.
  - During calibration, 3.97 mA was measured for **Output 4 mA**.
  - During calibration, 19.93 mA was measured for **Output 20 mA**.
  - The system should measure close to 11.95 mA for **Output 12 mA** to verify operation.
  - A measured value of 10.50 mA would yield a flow of 16.37 cfs.

Modify System Configuration Settings: These system settings should not be changed without guidance from SonTek Technical Support.



Section 4. Installing the SL in a Channel

The previous sections described most of the SL software operations and settings involved in configuring a system for deployment. Now it is time to install your SL in a channel and begin collecting some flow data. The low profile design and acoustic range of the SL make it suitable for almost any channel. Proper site selection and mounting are key factors in getting the best possible data from your SL.

NOTE: The minimum input voltage to the SonTek-SL system is 9VDC. Due to the resistance in the wires, there will be a voltage drop over the length of the power & communications cable when the system is actively pinging and drawing current. Therefore, it is important that the user supply an appropriate level supply voltage at the 'dry' end of the cable to insure that the supply voltage to the instrument will exceed the 9VDC minimum. Longer cables will require a higher minimum input voltage to compensate for the larger voltage loss.

4.1. SonTek-SL Site Selection

Site selection is one of the most important factors in data quality. For the best possible data, use the following guidelines:

- The SonTek-SL should be installed in a straight section of channel, avoiding any curves and abrupt changes in elevation.
- Try to find an area with uniform flow conditions and low turbulence.
- Look for a clean and consistent cross-section, with minimal chance of sedimentation that could change the cross sectional area or potentially bury the SL.
- SonTek highly recommends installing the SonTek-SL at least ten channel widths downstream or upstream of control points (gates) and flow disturbances.
- Figure 55 and Figure 56 present examples of SonTek-SL site selection.

Figure 55. Example of a poor installtion site:
upstream is a contol gate; downstream is a drop in elevation with turbulent flow

Figure 56. Example of a good installation site (long straight section of channel)

4.2. Mounting the SonTek-SL3000 and SL1500

Whenever possible, we recommend using the hardware that came in the SL toolkit to avoid problems with corrosion. The SonTek-SL comes with a mounting plate to secure the system to the side of the channel (Figure 57).

Figure 57. SL Mounting Plate and Hardware

Every installation will be slightly different, but you should ALWAYS:

- Mount the SL on the side of the channel at an elevation below the lowest water level.
- Certify that the longitudinal axis (X-direction) is aligned with the axis of the channel.
- Secure the SL cable to the side of the channel; when possible, protect the cable by routing it through a conduit.
    - SonTek recommends AVOIDING bending the cable as it comes out of the SL as debris can be caught on the bend and damage the cable
    - If a cable needs to be bent near the SL, keep a bend radius no smaller than 4 inches (10 cm). See Figure 58.

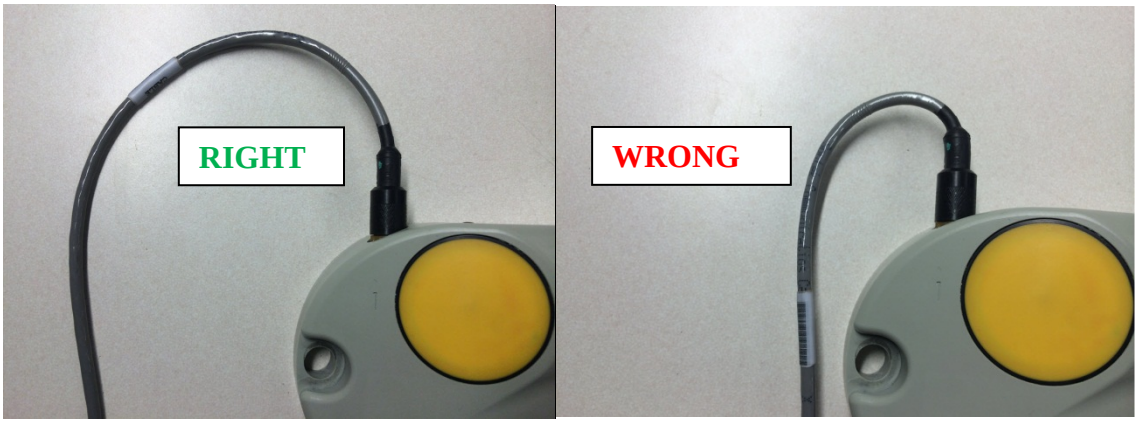


Figure 58. When installing an SL, it is always best to keep the cable STRAIGHT as it comes out the back of the instrument to keep debris from snaging on the cable. However, if the cable needs to be bent, keep the bend radius at 4 in (10 cm) or larger to avoid stress on the cable over time.

- Mount the SL so that it is level. Pitch and roll should be less than 5 degrees. You can check pitch and roll from the SL Smart Page using "View Live Data".
- To assist in leveling the instrument while mounting, a bubble level is also provided in the toolkit and fits inside a groove in the housing, for this purpose as shown in Figure 58.
- Use non-corrosive hardware.

When installing a monitoring station, it is important to secure the deployment site to protect cables, batteries, and connectors from weather and vandalism. It may also be necessary to install conduit to protect the SL cable from high flows or floating debris. The SL1500 connector port is equipped with 1/2-14 NPT threads to adapt directly to conduit. This will protect both the cable and connector during deployment. Plastic conduit is recommended to avoid stripping the SL threads.

SonTek provides and recommends plastic conduit fitting (McMaster-Carr P/N 3185K64) and 3ft snap in flexible conduit (McMaster-Carr P/N 3146K24) as shown in Figure 59 and Figure 60.

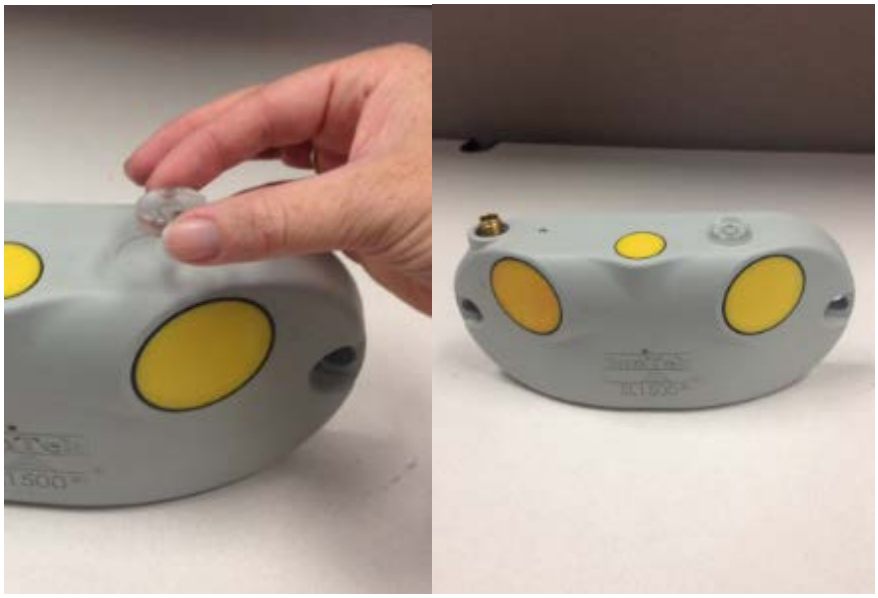


Figure 58. The bubble level provided in the SL toolkit fits into a groove in the housing.

Figure 59. SL1500 cable conduit and fitting

Figure 60. Threads on the cable conduit fitting will screw into threads on the SL1500 housing around the cable connector.

When positioning the SL, it is important to understand that the mount can create flow disturbances. To minimize turbulence around the instrument, everything should be secured and mounted downstream of the SL.

Appendix D provides technical drawings of the SL3000 and SL1500 for designing custom mounting options.

4.3. Cross-sectional Survey Procedure

Prior to any installation activities, the cross-sectional area of the installation site should be surveyed or measured as accurately as possible (Figure 61). If the channel has a solid bottom with a uniform shape (such as a uniform concrete trapezoid) a survey may not be necessary. Accurate measurement of the channel dimensions is critical; if there is any question, we strongly recommend that you perform a detailed channel survey to verify the shape of the cross section.

The accuracy of the SL volume and flow calculations is highly dependent on the cross-sectional area of the site. Periodic verification of the cross-sectional area is recommended as conditions at the site could change over time. If possible, use local benchmarks during the channel survey.

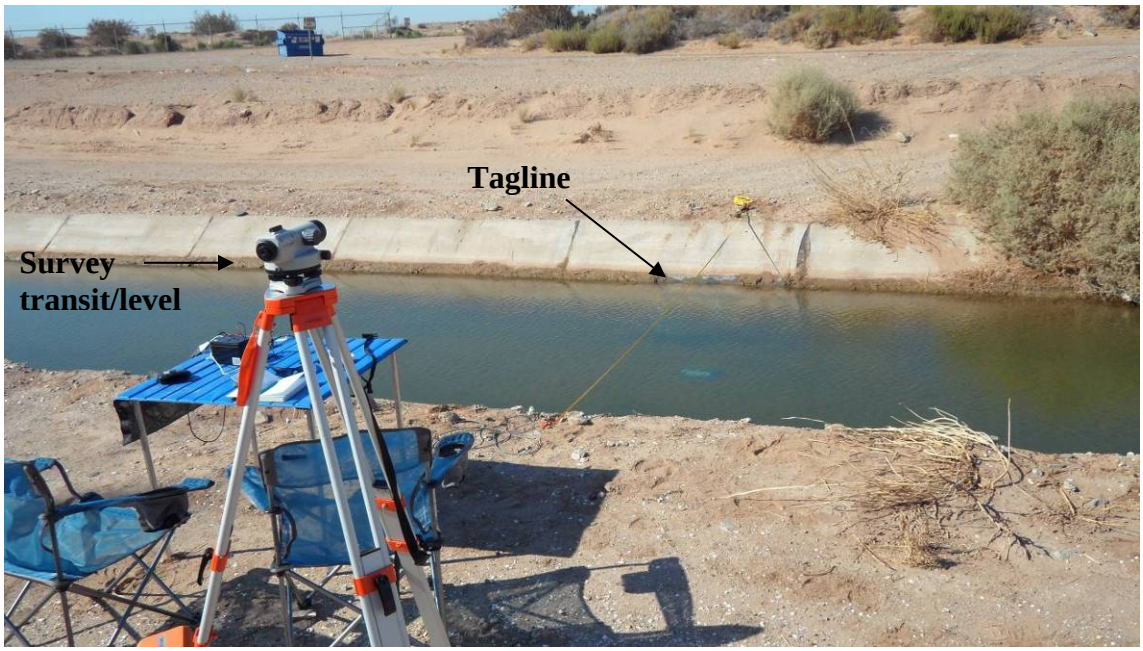


Figure 61. Survey of cross-sectional area of the flow-monitoring site

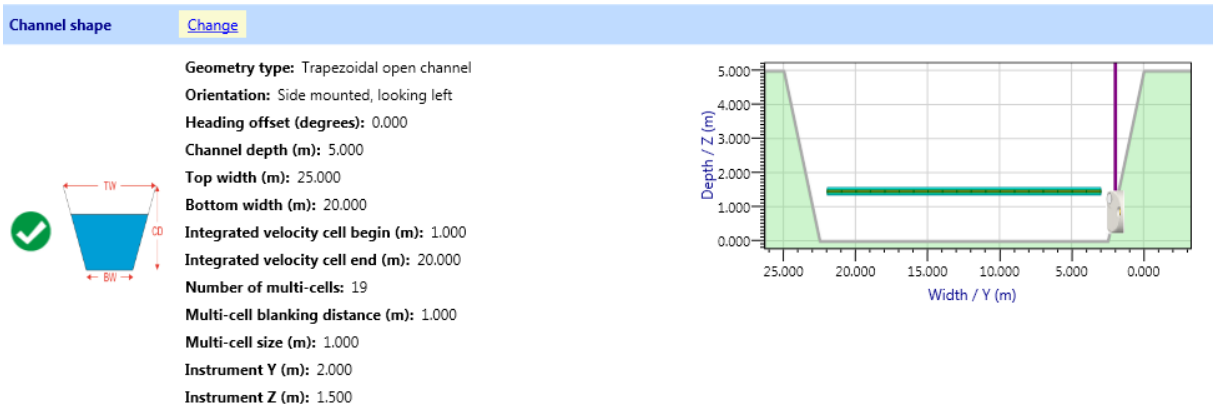
After a site has been selected, SonTek highly recommends completing a cross-section survey of the site. Below is a basic channel cross-section survey procedure:

1) Setup a survey transit/level at the site – make sure that it is level using the bubble level on the transit.
2) Install a tagline across the channel making sure that the tagline is perpendicular to flow.
3) The survey should include points that are higher than the highest water level expected for the site.
4) Collect tagline or station information (Y-data) and corresponding elevation (Z-data). Elevation data are collected using the survey rod and transit.
5) Approximately 10-40 survey points should be taken across the width of the channel. The appropriate number of points will depend on channel size and uniformity. It is important to accurately characterize and define the channel, especially any inflection/transition points. A maximum of 200 points are allowed.
6) Accurately survey in the instrument location and elevation after it is installed.
7) When possible, SonTek recommends using permanent benchmarks near monitoring sites in order to track changes at the site

   Important note: If sedimentation is likely– this will have a direct impact on the accuracy of the SL flow and volume data as the cross-sectional area will be changing.

4.4. Entering Channel Shape Data

The survey data or channel dimensions are the most important settings on the SL Smart Page. Accurate flow calculations implicitly rely on an accurate cross-sectional area. See Section 3.1.3 for instructions on entering the survey data. You can quickly navigate to the Channel Shape dialog by selecting the **Change** button in the Channel shape section of the SL Smart Page.



Once the channel shape dialog is open, for an Irregular open channel, complete the table with the survey data you previously collected (Figure 62).

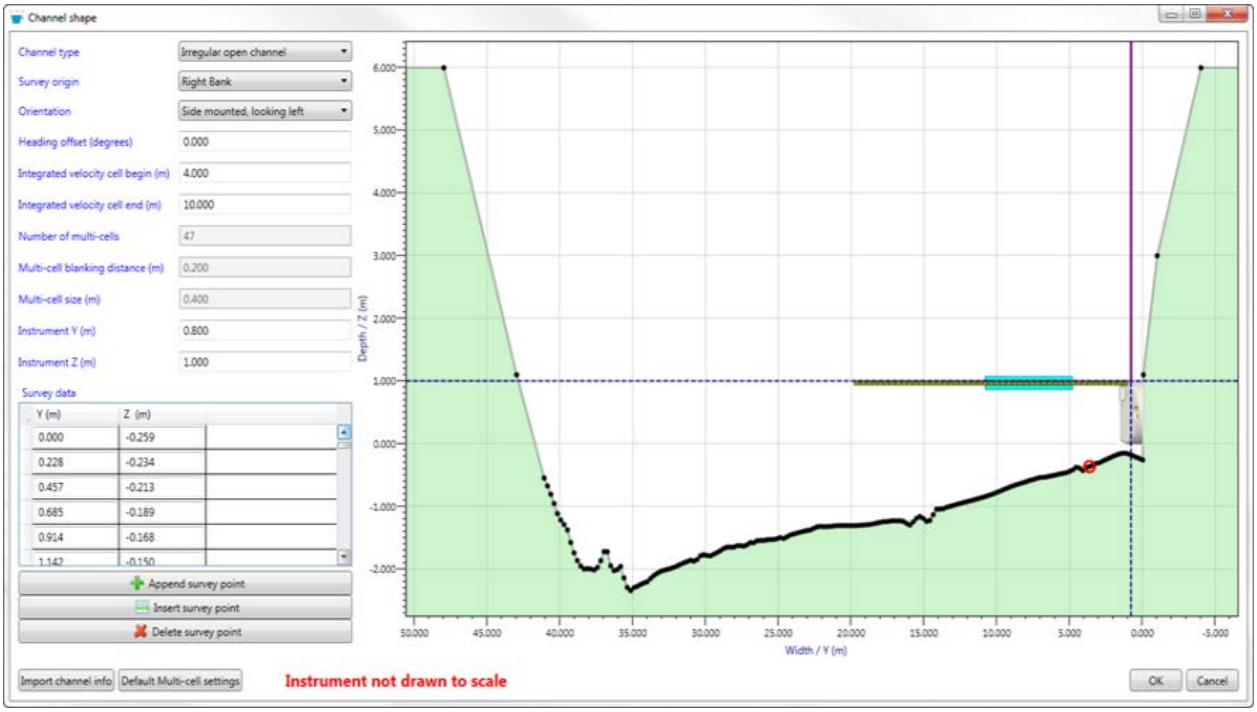


Figure 62. Inputting survey data for an Irregular open channel

If you are installing the SL in a Trapezoidal channel, you only need to fill in the channel dimensions (Figure 63)

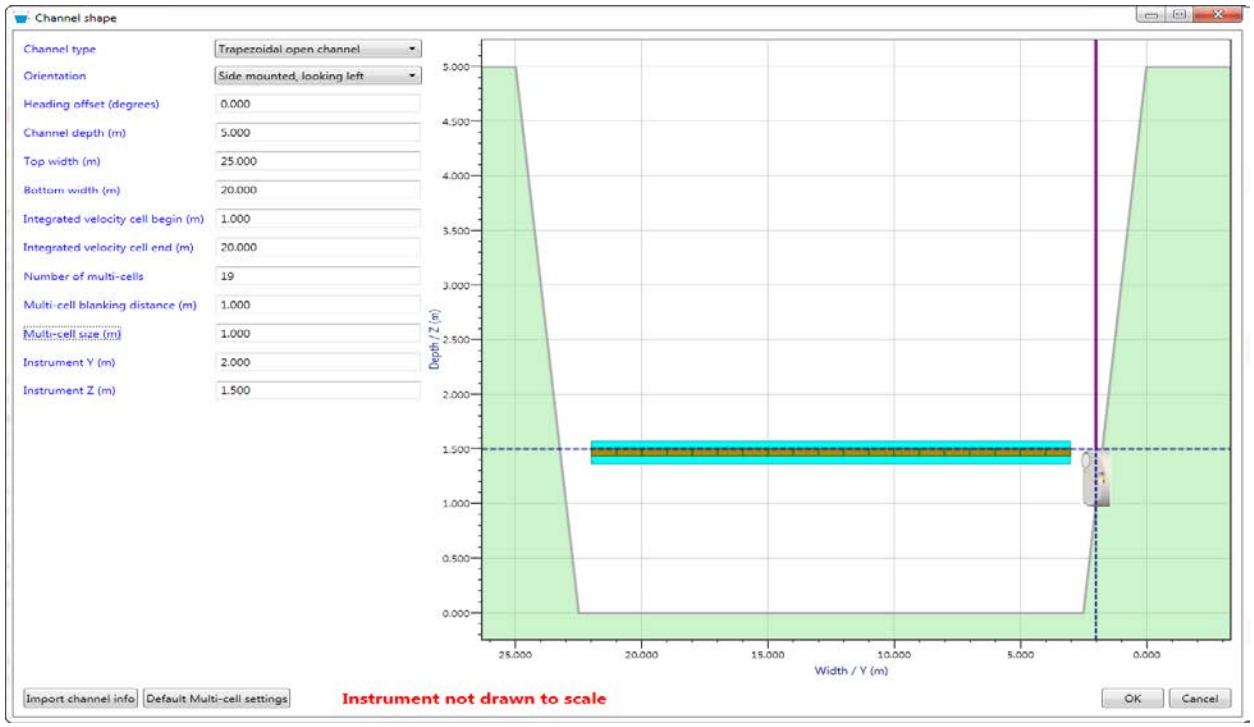


Figure 63. Inputting dimensions for a Trapezoidal channel

Section 5. Data Analysis and Visualization – View Data

The SonTek-SL software includes several tools and functions for visualizing and analyzing all data collected. The software organizes and saves all downloaded data to a simple database structure on your computer. The **View data** window displays all of the data you have collected and provides a suite of plotting functions to examine and compare flow conditions at all of your measurement sites. To access the visualization and analysis tools, select the "View data" button in the main ribbon after starting the SL software.

The **View data** window is available with or without a connection to the SL. If you are connected to a system, you can view data as soon as the download is complete. This provides a quick and convenient way to evaluate the data you have just collected at a site.

The SL software includes a sample data file that you can use to explore the ViewData functions before your own data are available.

- The file name is **SampleData**.
- If you are organizing data by site name, look for **Sample Data Site Name**.
- The sample data file is available only with software versions 1.10 and higher
    - It will be copied to your PC only for new software installations; it is copied when you select the SL data directory (the first time you use the **View Data** function).
    - It will not be copied if you are upgrading an older version of the SL software.
- If you are using an older version of the SL software and want access to the sample data file, do the following
    - Un-install your existing version of the SL software.
    - Install the latest SL software (version 1.10 or higher).
    - Select your desired SL data directory from the software settings menu (see Section 2.3). This can be the same directory used for the older version of the SL software. Any existing data files will automatically be available. The sample data file will be added to this directory.

The SL stores and accesses all downloaded data from a common folder. This setting specifies the data folder location and name.

- If you are manually transferring SL data files into the SL data folder, place the files into a subdirectory matching the SL file name.
- Example: Suppose the SL data folder is **C:\SLData**, and you manually want to transfer a data file named **SampleData_20110805_120000.SL** into your SL data directory.
    - Create a folder **C:\SLData\SampleData**.
    - Move the data file into that folder.
    - Close and re-open the SL software. You will now be able to view the data file from the **View Data** menu.

5.1. Tour of the View data window

The View data window is packed full of features and functions. Once you are familiar with the layout and operation of this window, it will be a valuable tool for analyzing your flow data. There are four main sections in the View data window: the data files, the data table, charts, and ribbon functions (Figure 64).

Data files: The data files are displayed along the left side of the window. This section can be organized by site name, file name, system serial number, or operator. All SL files on your local computer will be displayed here. To view a data file, use the small triangle icon to expand a folder and select one or more files. Selected files and folders will be outlined in green. To deselect a file, simply click on the SL icon next to the file name.

Data Table: The data table is located along the bottom on the View data window. This table lists the sample variables. The data columns can be moved horizontally by dragging them with the mouse and sorted vertically by selecting the column header. Clicking on a row of data will highlight the corresponding sample in the data figures.

Charts: The charts fill most of the View data window's main area. The charts are very configurable and can be ordered and organized in a number of ways. The time series charts are in the middle of the window and the profile chart is oriented vertically along the right side of the window. You can have up to six individual time series charts and the profile chart can display SNR and velocity profile data.

Ribbon functions: The ribbon is located at the top of the View data window. All of the data processing and plotting functions are here. Use these buttons to select which variables to display in the table, export data, calculate statistics, and show or hide plotted lines.

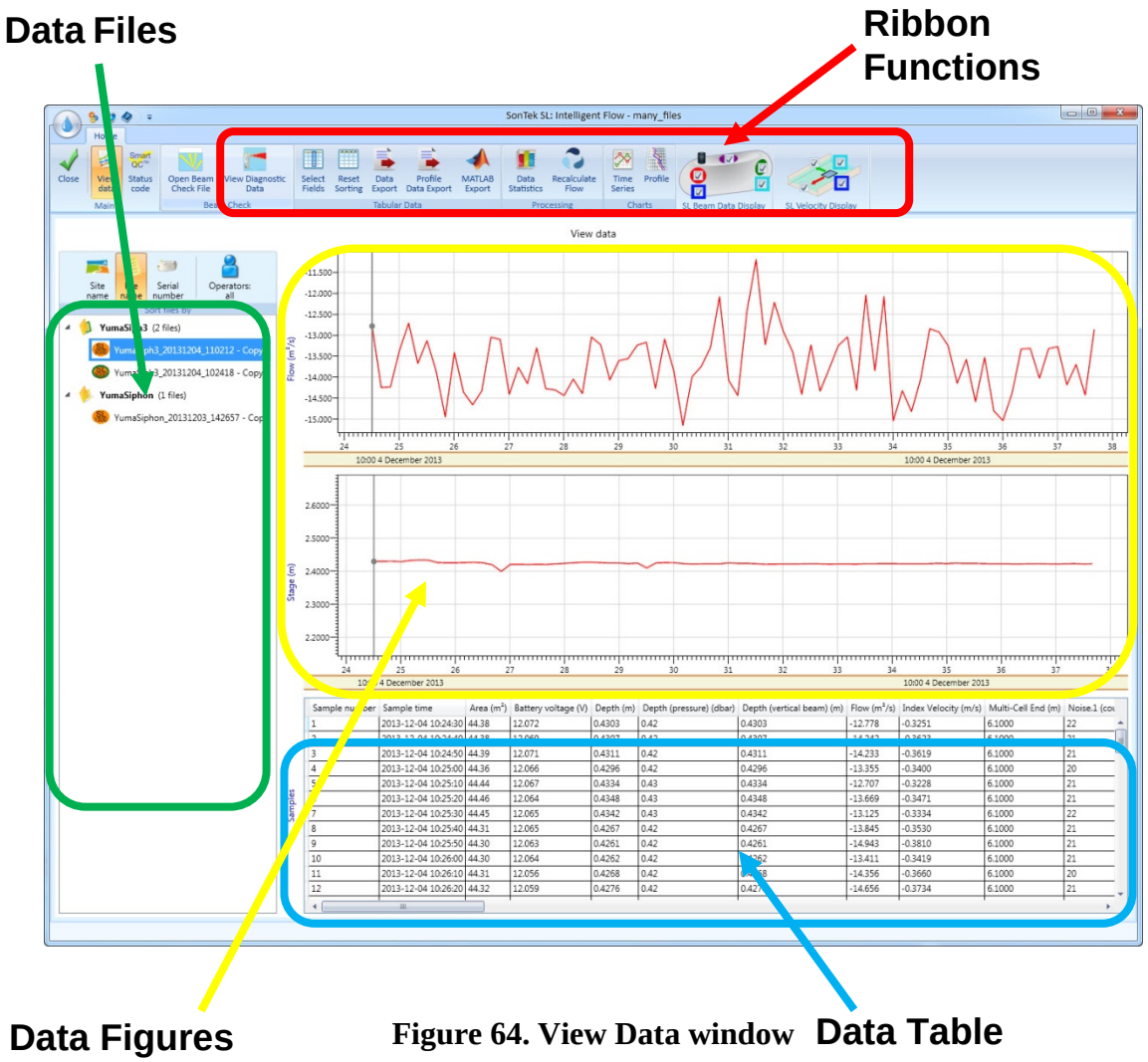


Figure 64. View Data window

5.2. Using View Data

The easiest way to learn how to use the many functions on the View data window is to try them and see what happens. The original SL data files are never changed or modified. None of the functions in this window will harm your data in anyway. Each function provides a simple and meaningful way to look at and organize SL flow data.

5.2.1. Organizing your data files

As you begin using your SonTek-SL, you will undoubtedly start to accumulate a large number of data files. Each downloaded file is stored on your computer in the folder or directory specified in the Software Settings page (see Section 2.3). The SL software will create a new folder in the database for each new file name. It is always a good practice to enter a File name and a Site name in the SL Smart Page when configuring a system for deployment. This will help to keep your data organized and accessible.

We do not recommend moving files within the directory structure created for the SL database. Moving files from one folder to another could make it difficult to find that file in the future.

The View data window can automatically sort your data files by **Site Name**, **File Name**, **Serial Number**, and **Operator Name** (Figure 65). The sorting options are enabled by clicking on the appropriate button at the top of the data files section in the View data window.

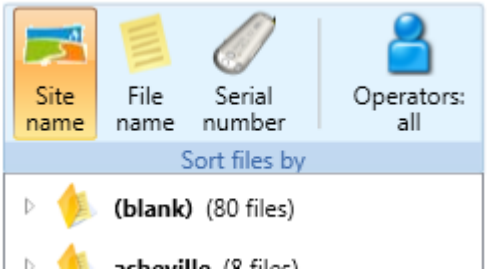


Figure 65. Sorting data files

If you do not include a **Site name** or **Operator name** when configuring your SL for deployment, the files will be sorted under the **(blank)** heading at the top of the list.

5.2.2. Loading a Data file

To begin visualizing a data file, click on the small white triangle next to a data folder in the data file section of the View data window. This will open the folder and list all of the sorted files. To load a file and begin viewing the data, select the file name or the SL icon next to the file name. A single click with the mouse loads the data for viewing (Figure 66). A second click will remove the data from the charts and table.

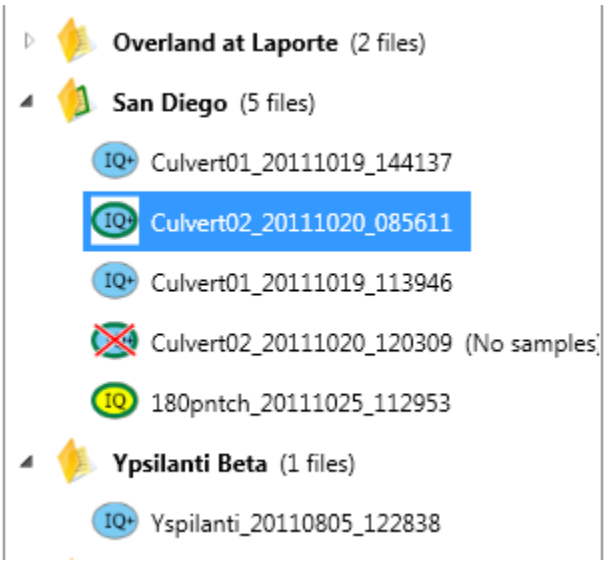


Figure 66. Loading a data file

For convenience and quick navigation, there are several visual indicators used in the data file section to show the status of each file.

- After selecting a file, the SL icon and the containing folder will be outlined in green
- Select multiple files to display with a single click on the SL icon or the folder name, click again to remove data from charts and table.
- SL3000 indicates an SL3000 file
- SL1500 indicates an SL1500 file
- If a data file is empty, the icon next to the folder will display a red "X" when selected.
- Right click on the file name to view the settings used to collect the data (Figure 67)

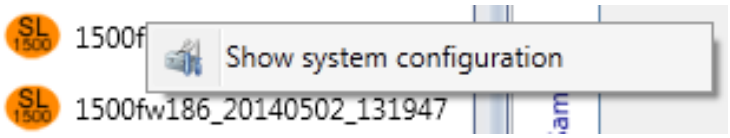


Figure 67. Right click on file name to see SL settings

5.3. The Data Table

The Tabular Data in the View data window is a list of all the samples for each selected field or variable. The SL software will remember which fields are selected and it will display the same fields in the table the next time the software is started. After loading a data file, you will see data displayed in the data table (Figure 68).

Samples

Sample number	Sample time	Area (m^2)	Battery voltage (V)	Depth (m)	Flow (m^3/s)	Pitch (deg)	Roll (deg)	Stage (m)	Velocity (mean) (m/s)
1	10/20/2011 8:56:45 AM	0.02	11.452	0.057	0.0033	4.78	-4.39	0.057	0.193
2	10/20/2011 8:57:50 AM	0.02	11.452	0.057	0.0030	4.78	-4.39	0.057	0.176
3	10/20/2011 8:58:55 AM	0.02	11.452	0.057	0.0052	4.78	-4.38	0.057	0.303
4	10/20/2011 9:00:00 AM	0.02	11.452	0.057	0.0046	4.78	-4.39	0.057	0.271
5	10/20/2011 9:01:05 AM	0.02	11.452	0.057	0.0068	4.78	-4.39	0.057	0.398
6	10/20/2011 9:02:10 AM	0.02	11.452	0.057	0.0051	4.78	-4.38	0.057	0.298
7	10/20/2011 9:03:15 AM	0.02	11.452	0.057	0.0083	4.78	-4.38	0.057	0.488

Figure 68. The Data table

- Use the scroll bars along the bottom and right side of the table to move to any row or column in the table.
- Clicking on the column header will sort the entire data set by the ascending or descending order of data in the selected column.
- Organize and order the columns by clicking on the column header and dragging the column to a new location in the table.
- Selecting a row or cell will locate the data point in all of the time series charts with a vertical gray line and an icon at the point

5.3.1. Tabular Data Functions

The Tabular Data functions located in the main ribbon of the View Data window are used to select which fields are displayed in the table, to reset the row sorting, and to export data. Activate these functions by clicking on the button.

Select Fields: Opens a small window with a list of check boxes to select which fields are shown in the data table. Simply click the checkbox to include the data field in the table at the bottom of the screen. You can also use the **Select All** and **Deselect All** buttons for activating and deactivating data fields (Figure 69).

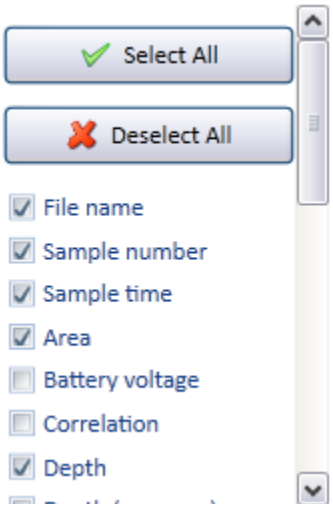


Figure 69. Selecting data fields for tabular data output.

Reset Sorting: Tabular data can be sorted by clicking on the column header of the data table. To remove the column sorting, use the Reset Sorting function to reorganize the rows by Sample number.

Data Export: Export selected files to a user-defined location such as a .csv file (Comma Separate Variable). The default location is the SL Data folder that has the same name as the first selected file. If multiple files are selected – all files will be exported as one CSV file with the first file name in the group of files. Only the fields or variables currently displayed in the data table will be exported.

Profile Data Export: The SL can store information about each velocity profile sample. Each profile sample includes data from each beam for the Signal to Noise Ratio (SNR), the Standard Deviation, the Channel Velocities, and Beam Velocities. A CSV file for each of these fields will be created with different file extensions (.SNR, .STDDEV, .VEL, and .VELBEAM respectively).

MATLAB Export: This function exports data collected by the SL in a MATLAB file (.mat file). The file will be saved in the SL data folder named after the File name. You can import the .mat file into MATLAB using the load command. SL fields and settings are organized in data structures as shown in Appendix F.

5.4. Processing Data

In general, most data processing is performed onboard the SL. The SL has many built-in intelligent features to provide the best possible flow data as conditions at your measurement site evolve over time. If you have an SL, significant changes in a channel may prompt you to reprocess your flow data with a new channel shape or new flow conditions. The View data window provides a way for you to reprocess flow data and to calculate statistics on specific fields. These processing functions do not change the raw data files. Any processing that you apply can be undone later.

5.4.1. Processing Data Functions

Two processing functions are available in the View data window to help you to evaluate your data statistically and to recalculate flow if conditions in the channel should change.

Data Statistics: Use this function to calculate statistics on the fields displayed in the Data table. Add or remove fields with the Select Fields function in the Tabular Data section of the ribbon. To begin the statistical analysis, select the desired time span based upon Sample Number or Time (Figure 70).

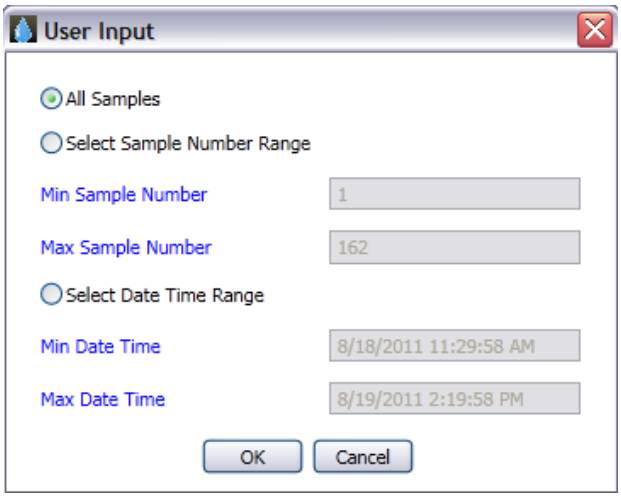
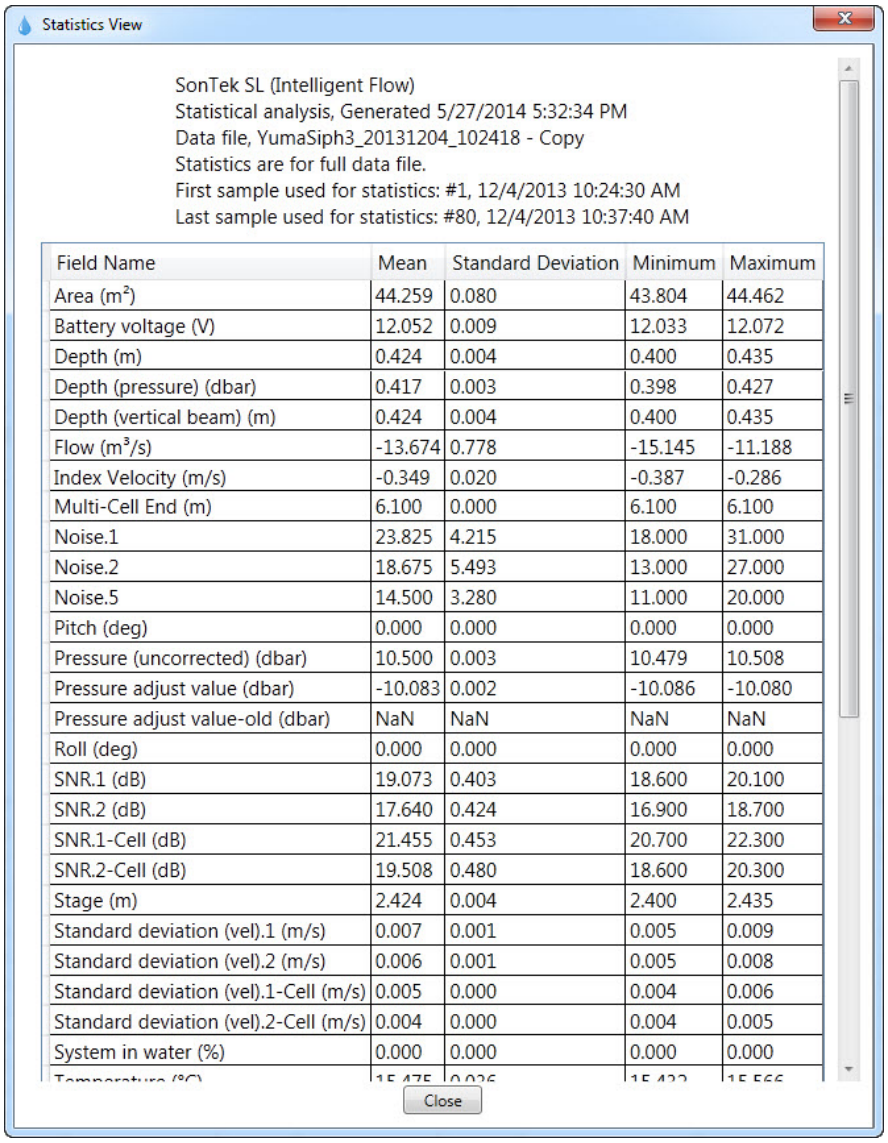


Figure 70. Selecting data statistical analysis

Once the desired sample range is selected, a new window with a table of statistics for each field is displayed (Figure 71).

- A general summary appears above the table
- Each row of the table has the Field name, Mean, Standard Deviation, Minimum, and Maximum values.
- Fields that have errors or fields that are unavailable will have a “NaN” value in the cell.
- A scroll bar may appear on the right side of the window if there are a large number of fields
- You can export the table as a CSV file or print the statistical data in window.



Field Name	Mean	Standard Deviation	Minimum	Maximum
Area (m^2)	44.259	0.080	43.804	44.462
Battery voltage (V)	12.052	0.009	12.033	12.072
Depth (m)	0.424	0.004	0.400	0.435
Depth (pressure) (dbar)	0.417	0.003	0.398	0.427
Depth (vertical beam) (m)	0.424	0.004	0.400	0.435
Flow (m^3/s)	-13.674	0.778	-15.145	-11.188
Index Velocity (m/s)	-0.349	0.020	-0.387	-0.286
Multi-Cell End (m)	6.100	0.000	6.100	6.100
Noise.1	23.825	4.215	18.000	31.000
Noise.2	18.675	5.493	13.000	27.000
Noise.5	14.500	3.280	11.000	20.000
Pitch (deg)	0.000	0.000	0.000	0.000
Pressure (uncorrected) (dbar)	10.500	0.003	10.479	10.508
Pressure adjust value (dbar)	-10.083	0.002	-10.086	-10.080
Pressure adjust value-old (dbar)	NaN	NaN	NaN	NaN
Roll (deg)	0.000	0.000	0.000	0.000
SNR.1 (dB)	19.073	0.403	18.600	20.100
SNR.2 (dB)	17.640	0.424	16.900	18.700
SNR.1-Cell (dB)	21.455	0.453	20.700	22.300
SNR.2-Cell (dB)	19.508	0.480	18.600	20.300
Stage (m)	2.424	0.004	2.400	2.435
Standard deviation (vel).1 (m/s)	0.007	0.001	0.005	0.009
Standard deviation (vel).2 (m/s)	0.006	0.001	0.005	0.008
Standard deviation (vel).1-Cell (m/s)	0.005	0.000	0.004	0.006
Standard deviation (vel).2-Cell (m/s)	0.004	0.000	0.004	0.005
System in water (%)	0.000	0.000	0.000	0.000
Temperature (°C)	15.475	0.026	15.422	15.566

Figure 71. Data statistics window

Recalculate Flow: A post-processing function that allows users to recalculate flow by changing channel geometry or flow settings. Selecting this function will open a limited version of the SL Smart Page showing the SL configuration for the data file. You can edit each section as you would if you were configuring a system for deployment (Figure 72).

- To change channel shape or flow settings, click on the **Change** button in the appropriate section.
- Flow settings can be changed to reprocess data using a velocity index as well applying new thresholds to data for volume calculations. You can also enable and disable Reverse Flow and Velocity Filtering.
- When finished, click **Recalculate flow with new settings**, and your data will be reprocessed using the new settings. Only the last recalculated flow will be saved. **Note**: You cannot recalculate flow unless you have set Log Profile Data to "1" under Standard Settings on the SmartPage .

- If you want to undo the new settings, click **Revert to original flow calculations**, and your original data will be restored.
- The original field data files are never changed and can always be recovered. Any modified flow calculations are stored in a separate file.

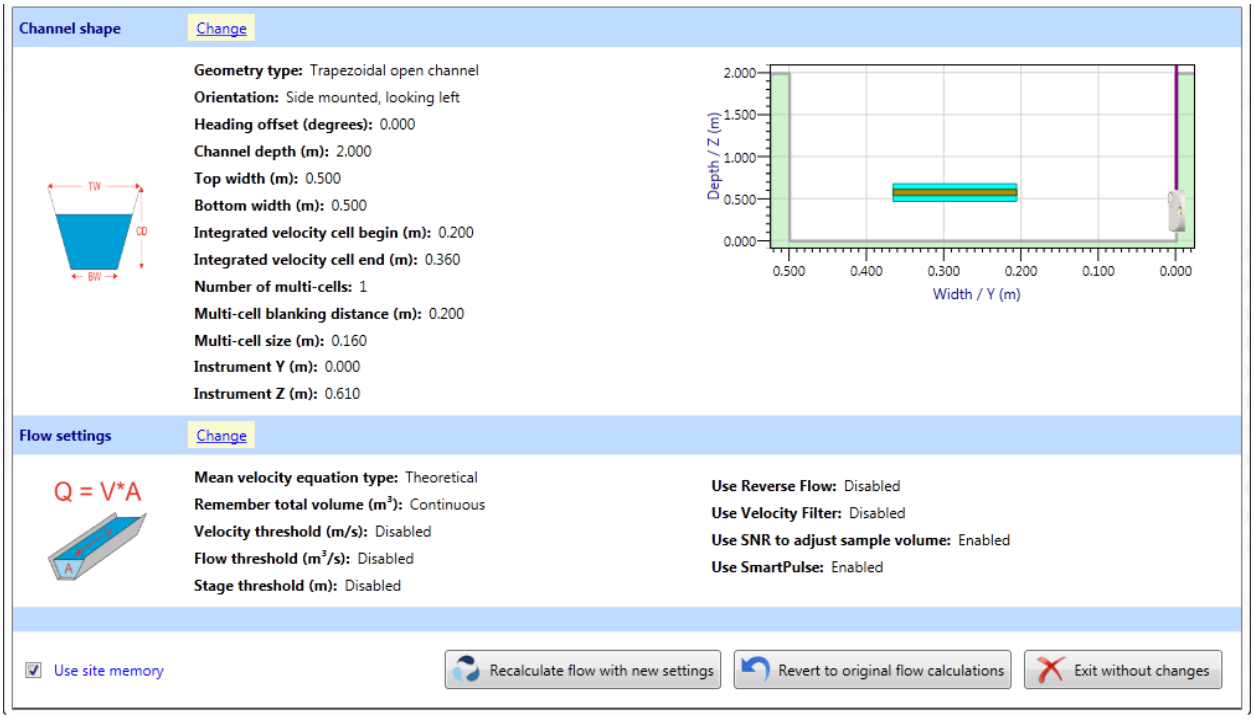


Figure 72. Recalculate Flow

5.5. Working with Charts

There are two types of charts displayed in the SL software View data window: Time series and Profile. The Time series charts are the horizontally oriented charts in the center of the View data window and the Profile chart is the vertical chart located along the right side of the window. These charts share several common navigation features.

- Left click inside the chart area and hold the mouse button to drag the data view.
- To zoom: Hold the Alt key, left click and hold mouse button while dragging a zoom window inside a chart.
- Right click in the chart to see more chart options (Figure 73).

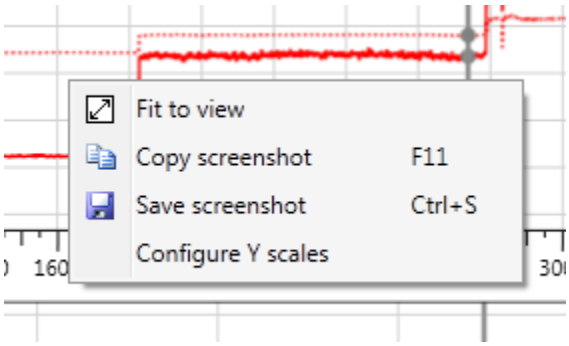


Figure 73. Left mouse button chart options

- Use **Fit to view** to return to the original zoom level.
- Use **Configure Y scales** to manually set the vertical axes on the Time Series charts.
- To scroll the chart view only in the vertical or horizontal direction, left-click on the vertical or horizontal axis holding the mouse button and dragging the axis.
- To zoom the chart view only in the vertical or horizontal direction, right-click an axis and drag along the axis direction to increase or decrease the axis range.

5.5.1. Chart Functions

Use the chart functions located in the main ribbon of the View data window to add or remove fields from the Time Series and Profile charts.

Time Series: Time series charts can be configured in a number of ways. Select the **Time Series** function to open a small window to add charts to the View data window and to add fields to the individual charts (Figure 74).

- Users can select data fields for both the Left and Right vertical axes.
- Data plotted versus the Left axis will be a solid line
- Data plotted against the Right axis will be a dotted line.
- Time series fields with multiple variables will be color coded to match either the Beam Data Display or the Velocity Display check boxes.
- Time series can be plotted with the horizontal axis as sample number or sample time.
- Not all fields are available for the SL3000.

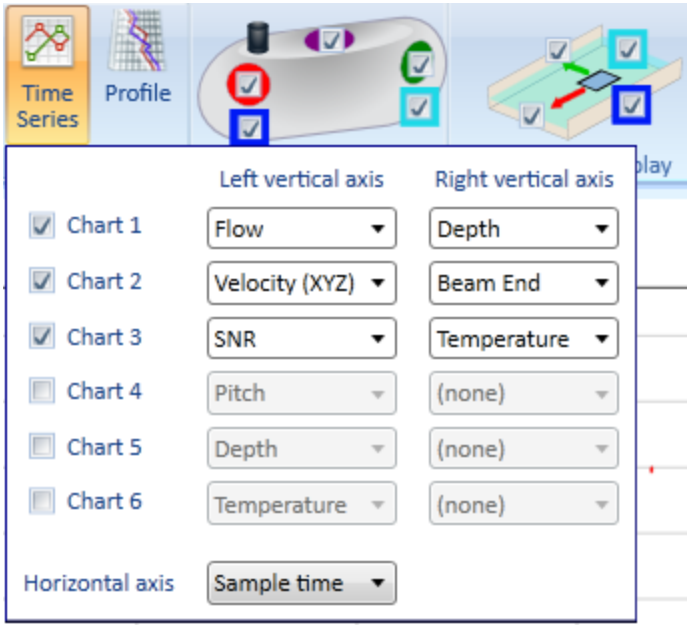


Figure 74. Time Series chart field selection dialog

Profile: Use the Profile function in the main ribbon to select the field to display in the Profile chart located along the right side of the View data window (Figure 75).

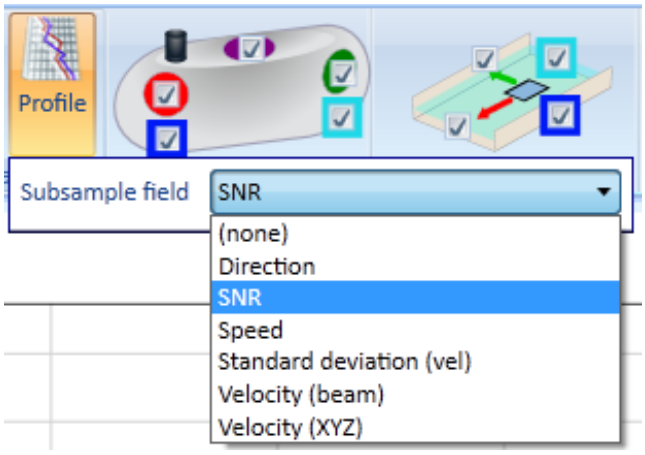


Figure 75. Profile chart Subsample field selection dialog

- Select **(none)** to remove the Profile chart from the View data window
- Selecting any other field will plot multiple color-coded lines in the Profile chart.
- Colors in the Profile chart correspond to individual Beams or measured water Velocities.
- The Profile chart will include a gray shaded area to indicate the region above the current water level.
- Figure 76 presents velocity profile data.

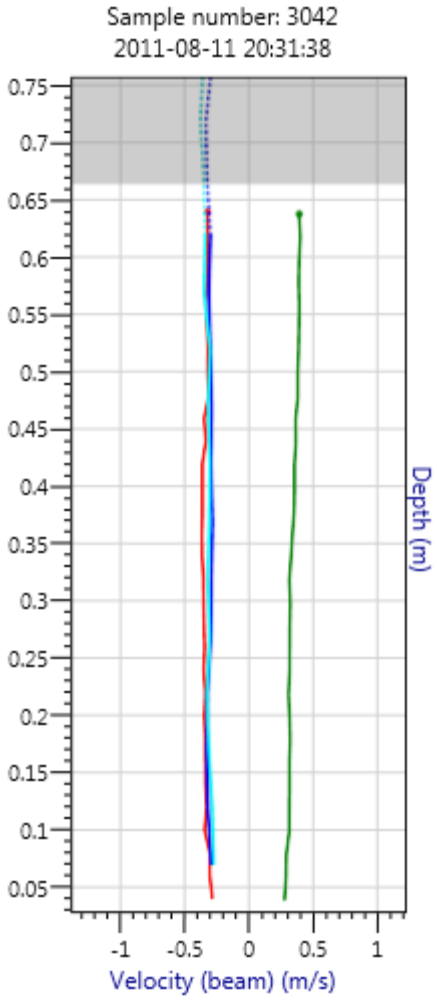


Figure 76. Profile chart

5.5.2. Display Functions

The **Beam Data Display** and **Velocity Display** functions in the View data window are provided as a quick method to enable or disable lines in charts. Beam data and Velocity data can be plotted in Time series charts while velocity and SNR profile data are plotted in the Profile chart. Beam data, as the name implies, are raw data collected from a single transducer or beam. Velocity data are processed or calculated from these raw beam data and are a combination of data collected from all the beams.

- Activate or deactivate a Beam or Velocity graph series (line) by toggling its check box.
- The color surrounding the Beam corresponds to the color of the line on the chart
- The color of the Velocity arrow corresponds to the color of the line on the chart

Section 6. Output Data Settings

The SonTek-SL supports four different output data types. These are listed, along with SonTek Binary,under the output type dropdown. However, SonTek Binary is not an output format, rather a communication protocol used by SonTek to display the live data from the SL. It is included in the output type dropdown as a convenience (Figure 77). You can select an output type from the Smart Page while configuring a system for deployment. Instructions for configuring the options for each output data type are presented in Section 3.1.5. This section provides complete definitions for each output type and the data fields available.

- The type of data output used by the SonTek-SL must be selected when configuring the system with the SL Software. The default is SonTek binary.
- The output units are selected in the same menu. Note that the output units may be different from the units displayed when viewing live data in the SL software.

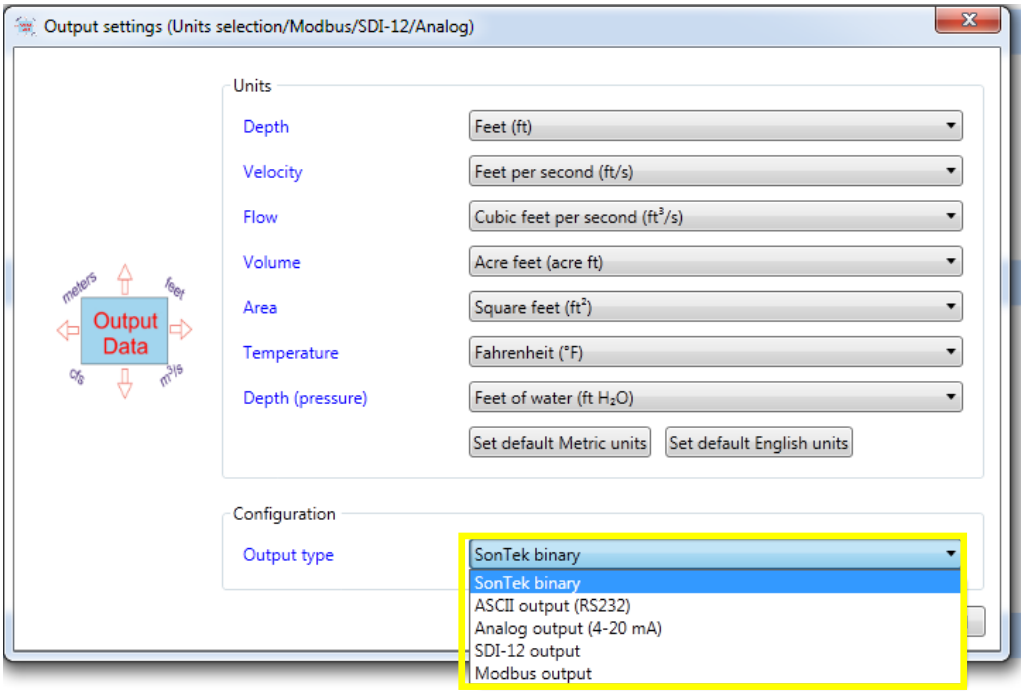


Figure 77. SonTek-SL data output types

6.1. SL System Status

The SL output data includes a valuable diagnostic and monitoring value called **System Status**.

- If **System Status** has a value of zero, no potential problems have been detected. The SL can be said to be "All Clear".
- If **System Status** has any value other than zero, the SL has detected some sort of problem that may affect data quality. You should evaluate the issue as soon as possible, and clear up the potential problem if possible.
- **System Status** is available in all output data output formats.
  - We strongly encourage users to monitor this value to help determine when a site visit may be needed.

When calculating this value, the SL analyzes all data to look for potential problems. If any problems are found, the SL sets a flag within the **System Status** value.

- We use a technique called bitwise encoding so that multiple flags are incorporated within this single value.
- In bitwise encoding, we use a different number (each of which is a power of 2) for each flag. The value 1 indicates one flag, 2 is second flag, 4 is a third, and so on.
- If multiple flags are set, the values add together. For example, a value of 5 indicates the flags for 1 and 4 are both set.
- With bitwise encoding, each value of **System Status** corresponds to a unique combination of flag(s) that are currently set.

To make it easy to interpret the **System Status** value:

- The SL software includes a utility to interpret the status value.
  - This utility can be accessed from several locations (see Section 2.4 and Section 2.6.2).
- With the SL Flow Display, any **System Status** messages are available in real time from the LCD display (see Section 0).

Table 1 lists all System Status flags, the message that is associated with them, and a brief description of the potential problem.

Table 1. System Status Flags

Flag Value	Message	Description
0	All clear	No potential problems have been detected.
1	High tilt values – check instrument mount	One or more tilt values are greater than 5º; this may affect data quality. Inspect the SL mount.
2	Tilt values have changed; instrument may have moved	One or more tilt values have changed significantly since the start of data collection. This may indicate the SL has moved. Inspect the SL mount.
4	Recorder space low – less than 14 days remaining	Less than 2 weeks of recording time remain on the internal recorder. Data should be downloaded and the recorder formatted as soon as possible.
8	No valid depth data; check for debris or burial	The instrument is in the water but no valid depth data is available. There are several possible causes that may include debris, burial, highly uneven water surface, or too much air in the water.
16	One or more beams may be buried	One or more of the profiling transducers may be coverer or buried, potentially affecting data quality.
32	Low battery voltage	Battery voltage is less than 9.0 V. Check the power supply – replace or charge as appropriate.
64	Internal recorder is full	No internal recording space is remaining, so data is no longer being recorded by the SL. Data should be downloaded immediately and the recorder formatted.
128	Stage is outside defined channel; no flow data will be reported	The depth measured by the SL is beyond the defined limits of the channel. No flow calculations are possible (flow data is reported as 0). This may indicate a problem with the depth data, or an error in the definition of channel geometry.
256	Invalid temperature data; instrument may need repair	The temperature sensor may have failed, which will affect the quality of data. The SL should be inspected and may need to be returned for service.
512	Low SNR warning	The SNR is less than 10 dB.
1024	Velocity sample filtered - turbulent or low flow detected	When velocity filtering is enabled, velocity spikes are removed and the flow becomes zero.

6.2. SonTek Binary

The SonTek Binary option is the default output data type. However, it should be understood that SonTek Binary is not an actual output format. It is a proprietary communication protocol that allows users to view live data. Users who do not need to use real-time data (i.e. not connected to a datalogger or a Modbus network) or users who will only communicate with the SL using the SL software should use this output data type. Data is recorded and stored on the SL in a proprietary file format. The SL software uses this format to manage the data. To output the data to an external device or database, one of the four supported format outputs need to be selected.

- The SonTek binary output format type must be selected to use **View Live Data** from the SL software. Selecting **View Live Data** (Figure 78) on the SL Smart Page shows a summary of the last measurement from the system. This function can be useful to view the latest data, or to check the orientation (pitch and roll) of the SL during the installation process.

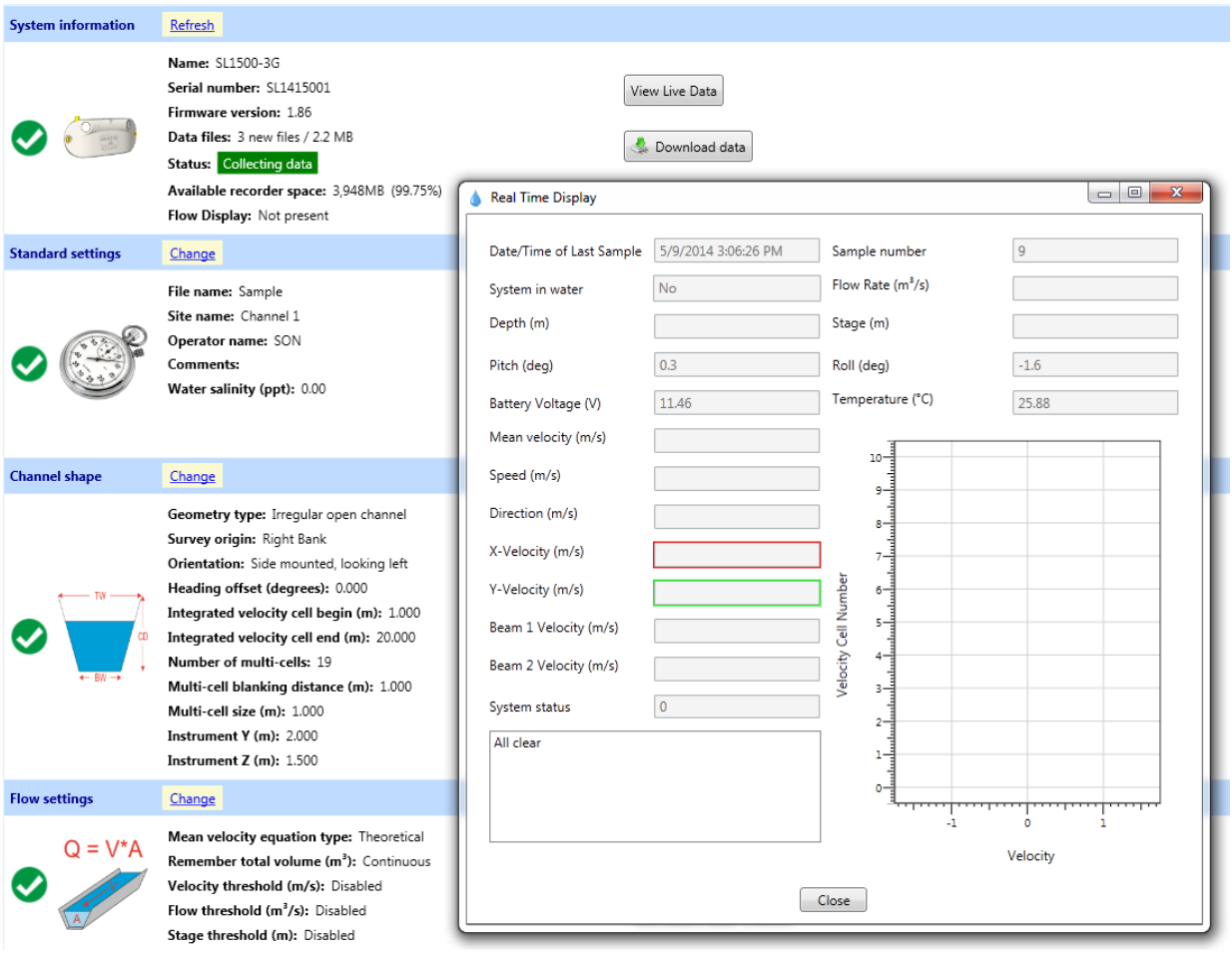


Figure 78. View live data window

6.3. ASCII Output (RS232)

The RS232 ASCII Output setting lets you connect to the SonTek-SL using any device that can accept and interpret ASCII characters over an RS232 serial line. This could be a datalogger or other recording equipment. The SL is configured and data collection is started using the SL software. To select RS232 ASCII output, select **ASCII Output (RS232)** from the **Output Settings** menu. All data collected are stored onboard the SL and is available for download using the SL software. While sampling, the SL outputs ASCII data to the RS232 COM port.

- The SL outputs one text line of data for each sample collected.
- These data are output at the end of each sampling interval.
- The units for all output data are specified in the **Output Settings** configuration menu.
- Each sample includes several data parameters separated by commas. The output format is the same for the SL3000 and SL1500 systems.
- RS232 serial parameters are fixed at:
    - 9600 baud
    - 8 data bits
    - 1 stop bit
    - No parity

6.3.1. SL3000 and SL1500 ASCII Output Values

ASCII output column headers from an SL3000 and SL1500 (Table 2):

Table 2. ASCII Output Field Definitions

#	Contents	Notes (Units based on User Setup unless noted below)
1	Year	Year of sample start
2	Month	Month of sample start
3	Day	Day of sample start
4	Hour	Hour of sample start
5	Minute	Minute of sample start
6	Second	Second of sample start
7	Velocity (XY).X-IVC	Integrated Velocity Cell Velocity X
8	Velocity (XY).Y-IVC	Integrated Velocity Cell Velocity Y
9	VB Range	Vertical Beam Range
10	Vel STD (XY).X-IVC	Integrated Velocity Cell Std. Dev. of Velocity X
11	Vel STD (XY).Y-IVC	Integrated Velocity Cell Std. Dev. of Velocity Y
12	Vel STD (XY).X	Average of Multi-Cell Std. Dev. of Velocity X
13	Signal Amp Beam 1	Beam 1 Signal Strength (counts)
14	Signal Amp Beam 2	Beam 2 Signal Strength (counts)
15	Signal Amp VB	Vertical Beam signal strength (counts)
16	VB percent good	Percent of good Vertical Beam pings
17	Heading offset	User input value (deg)
18	Pitch	Rotation about the Y-axis (deg)
19	Roll	Rotation about the X-axis (deg)
20	STD Heading	Std. Dev. of Heading (not reported or calculated)
21	STD Pitch	Std. Dev. of Pitch (not reported or calculated)
22	STD Roll	Std. Dev. of Roll (not reported or calculated)
23	Temperature	Water temperature
24	Pressure	Raw pressure measurement
25	Adjusted pressure	Adjusted for atmospheric pressure
26	Battery Voltage	Voltage powering the SL
27	IVC Cell Begin	Distance from SL to the start of the Integrated Velocity Cell
28	IVC Cell End	Distance from SL to the end of the Integrated Velocity Cell
29	Noise beam 1	Beam 1 noise (counts)
30	Noise beam 2	Beam 2 noise (counts)
31	Noise VB	Vertical Beam noise (counts)
32	Flow Rate	Volumetric discharge
33	Flow Area	Calculated cross section area of the channel
34	Total Volume	Cumulative sum of the flow rate

Followed by multi-cell data columns (up to 32 cells):

Cell #	Vx	Vy	Vel STD Beam 1	Vel STD Beam 2	Sig Amp Beam 1	Sig Amp Beam 2

6.4. Analog Output

Optional analog outputs are available via the SonTek-SL flow display (Figure 79).

- The flow display supports four channels of 4-20 mA outputs.
- The analog output connectors have terminals (+ and -) for each analog channel (see Appendix 0).
- Each channel generates an analog signal proportional to one value measured by the SL; the exact configuration of channels is selected by the user.
- Analog outputs are not a preferred method of collecting data from the SL; a lot of resolution and information is lost when converting SL data to analog signals. However when they are needed, the analog outputs do provide an easy way to integrate with established data acquisition systems.
- When using the analog outputs, we strongly recommend that you calibrate the output of each channel with your data acquisition system. The SL software provides a function for outputting calibration values (see Section 3.3).
- Using the analog outputs will significantly increase power consumption – the SL Software will provide calculations. However, it is highly dependent on instrument configuration, number of channels used, and level of interfacing with the flow display.

How the analog outputs are configured depends on your goals. Here is a suggested configuration.

- The units used for all variables when configuring the analog outputs will match all other output units as specified by the user (see Section 3.1.5).
- Channel 1: Flow
  - Min Value: this should match the minimum flow value expected in the channel (commonly 0). If the channel has bi-directional flow, minimum value may be a negative number.
  - Max Value: this should match the maximum flow expected in the channel. If the flow exceeds this value, the output will stay at the maximum value of 20 mA.
  - Example: min value 0 cfs, max value 40 cfs
    - 0 cfs will output 4 mA
    - 20 cfs will output 12 mA
    - 40 cfs will output 20 mA
    - 45 cfs will output 20 mA
- Channel 2: Stage
  - Min Value: this should match the minimum stage expected in the channel. This may be 0 or may be the survey elevation corresponding to the bottom of the channel.
  - Max Value: this should match the maximum stage expected in the channel, which will typically be the top of the defined channel.
- Channel 3: Mean Velocity
  - Min Value: this should match the minimum velocity expected in the channel (commonly 0). If the channel has bi-directional flow, the minimum value may be a negative number.
  - Max Value: this should match the maximum velocity expected in the channel, which can vary widely depending on the type of channel.
- Channel 4: System Status
  - This variable indicates if there are any potential problems with the system (see Section 6.1). We strongly encourage monitoring this value; any value other than 0 indicates that the SL site should be inspected.
  - Min value: this would normally be 0.
  - Max value: this would normally be 511 (this is the maximum value for system status).

- The SL software provides a utility to interpret the system status variable in order to understand what different values mean (see Section 6.1).

General instructions for configuring the analog outputs are below.

- Select the data variable of interest using the drop-down box for each channel.
- Use the Min/Max value boxes to scale the analog outputs. Min/Max should be scaled based on the range of values expected in the field.

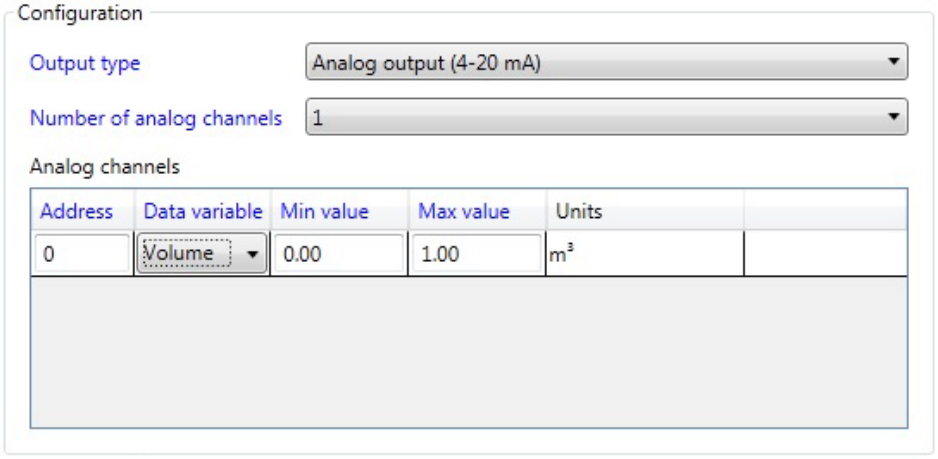


Figure 79. Analog outputs configure window

6.5. SDI-12 Output

SDI-12 is a standardized ASCII based serial communication protocol. The SonTek-SL is capable of communicating with a datalogger over an SDI-12 network. The terminal connection for SDI-12 is located on the cable adaptor next to the ground terminal connection. In SDI-12 mode, data collection is controlled by the datalogger and NOT by the SonTek-SL. The SL will wait for commands from the datalogger to begin a measurement and to transfer the data collected.

It is possible to have an SDI-12 and a serial port (RS232) connected to the SL at the same time. The SL cable adaptor supports both types of connections independently. However, this is **NOT recommended during the initial setup** of the SL. Since the instrument is controlled by the datalogger, it is important that the SonTek-SL is NOT connected to the datalogger during instrument setup to avoid possible configuration errors.

The following are some important notes about the SDI-12/SonTek-SL interface.

- Configure the SonTek-SL with the SL software prior to connecting to the SDI-12 network
- All measurements are controlled by the datalogger. If the datalogger never sends any commands, the SL will never collect any data!
- You do **NOT** have to start the data collection using the **Start Data Collection** button. The SL starts when it receives a valid measurement command from the datalogger.
- Each instrument on the SDI-12 network must have a unique address
- Certain settings in the SL software will have no effect when using SDI-12.
  - **Align sample to hour** is not used because samples are initiated by the datalogger.
  - **Sample interval** is not used with SDI-12. However, this parameter should still be set by the user to allow for accurate recorder and battery life calculations.
- Users must configure the “Sample duration”

- To output flow data, a channel geometry must be input
- You can download data from the SonTek-SL while it is connected to a datalogger
- After configuring/checking the SL Smart Page settings, disconnect and exit the program.

6.5.1. SDI-12 hardware setup

See Figure 80 for connecting your SDI-12 wire (shown in white) to the 3-pin power connector. This connector is used with the cable adaptor shown in Figure 5. Once the wires are connected to the 3-pin connector, simply insert the 3-pin connector into the cable adaptor and attach the other end of the SDI-12 line (white wire) to the correct terminal on the datalogger.

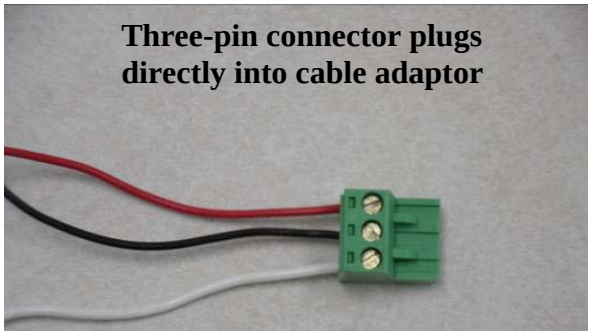


Figure 80. Connecting the SDI-12 communications line

After selecting the SDI-12 output type, the configuration area of the Output settings window will display an input text box for an SDI-12 address. When setting up an SDI-12 network, each instrument on the network must have a unique address (Figure 81).

- The SonTek-SL SDI-12 default address is 0.
- SonTek-SL SDI-12 addresses can be single digit numbers **0-9**, lower case letters **a-z**, and upper case letters **A-Z** for a total of 62 unique addresses on a local network.

After the SDI-12 address is entered, be sure to confirm all settings on the SL Smart Page including the channel dimensions. **If the channel dimensions are not defined, the SL will be unable to calculate and report flow conditions.** Once the SL Smart Page settings are complete, you can connect the SonTek-SL to the datalogger or SDI-12 network. Please refer to the documentation included with your datalogger to complete the SDI-12 setup procedures.

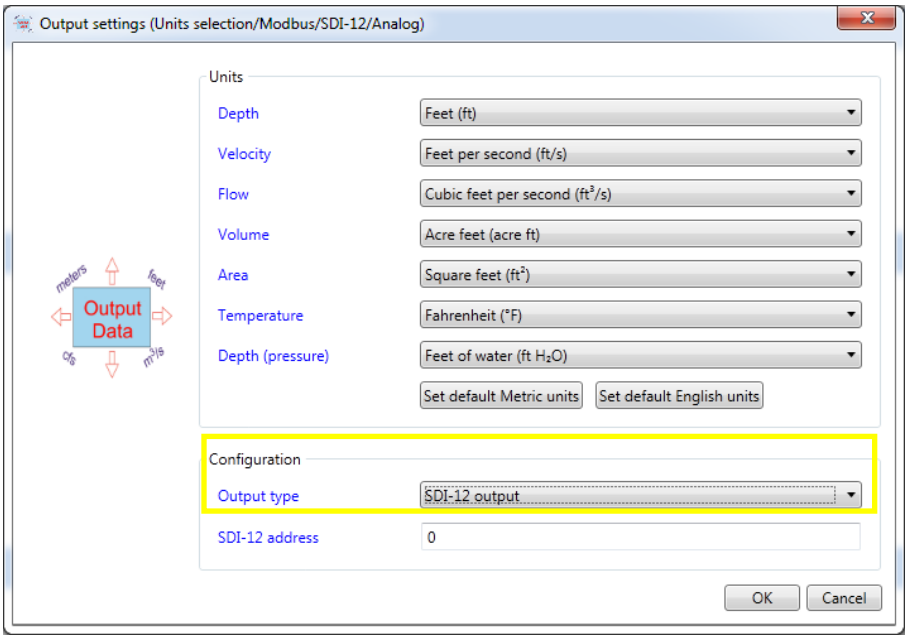


Figure 81. SDI-12 configuartion in SL software

6.5.2. SDI-12 Command and Response Protocol

IMPORTANT: ***The SonTek-SL requires a 2 second overhead time to complete all calculations. As such, the sample will be ready after a period no more than 2 seconds longer than the specified sample duration. Be sure the data logger allows sufficient time between samples for both the sample duration and overhead time.***

This is a brief description of the SDI-12 "command and response" protocol used by the SL. For detailed information about the SDI-12 protocol itself, refer to the most recent version of *A Serial Digital Interface Standard for Hydrologic and Environmental Sensors*, coordinated by the SDI-12 Support Group, 135 East Center, Logan, Utah (http://www.sdi-12.org/).

During normal communication, the data recorder sends an address together with a "command" to the SL. The SL replies with a "response". In the following descriptions, SDI-12 commands and responses are in **`bold`**. The SDI-12 address and the command/response terminators are defined as follows:

a is the sensor address. The following ASCII characters are valid addresses: "0-9", "A-Z", "a-z", "*", "?". Sensors will be initially programmed at the factory with the address of "1" for use in single sensor systems. Addresses "0", "2-9", "A-Z", and "a-z" can be used for additional sensors connected to the same SDI-12 bus. Addresses "*" and "?" are wild card addresses that select any sensor, regardless of its actual address.

! is the last character of a command block.

<cr><lf> are carriage return (0D) hex and line feed (0A) hex characters. They are the last two characters of a response block.

Notes:

*All commands/responses are upper case, printable ASCII characters.

*Commands to the SDI-12 device (i.e., SL) must be terminated with a "**!**" character.

*Responses from the SDI-12 device are terminated with **<cr><lf>** characters.

*The command string must be transmitted in a contiguous block with no gaps of more than 1.66 milliseconds between characters.

- ***Measure Command "M"***

The Measure command (**M**) initiates a measurement sequence. Data values generated in response to this command are stored in the sensor's buffer for subsequent retrieval using **D** commands. The data will be retained in the sensor until another **M**, **C**, or **V** command is executed.

Command	Response	Description
aMc!	**atttn<cr><lf>**	Initiate measurement
	a<cr><lf>	Sent when measurement complete and data is available.

Where:

a is the sensor address ("0-9", "A-Z", "a-z", "*", "?").

M is the upper case ASCII character representing the Measure command.

c is the data line to be retrieved. Depending on system configuration, **c** can be a value from 0 through 7, where a value of 1-7 represents an additional data line to be retrieved, and a value of 0 (or null) represents the main data lines from the single integrated velocity cell. Note that only the last **aM!** or **aM0!** command actually initiates a measurement; the other commands simply report the specified data from the most recent measurement.

ttt is a 3-digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to complete the command and have measurement data available in its buffer. When making a new measurement, this value is equal to the Sample Duration + 2 seconds. This provides extra time for system overhead in taking a velocity sample. When reporting additional data lines from a previous measurement (using a **c** value from 1-7), this value will be 000.

n is a single-digit integer (0-9) specifying the number of values that will be placed in the data buffer. If "n" is zero (0), no data will be available using subsequent "**D**" commands.

Upon completion of the measurement, a service request "**a<cr><lf>**" is sent to the data recorder indicating the sensor data is ready. The recorder may wake the sensor with an SDI-12 **BREAK** (continuous spacing by the data recorder on the data line for at least 12 ms) and collect the data any time after the service request is received, or when the specified processing time has elapsed.

Table 3 shows all of the available data from the M command.

- ***Concurrent Measurement Command***

The Concurrent Measurement command (**C**) was added to the Version 1.2 SDI-12 Specification. A concurrent measurement is one that occurs while other SDI-12 sensors on the bus are also taking measurements. This command is similar to the **aM!** command; however, the **nn** field has an extra digit (allowing additional output parameters), and the sensor does not issue a service request when it has completed the measurement. Communicating with other sensors will not abort a concurrent measurement. Data values generated in response to this command are stored in the sensor's buffer for subsequent collection using **D** commands. The data will be retained in the sensor until another **M**, **C**, or **V** command is executed.

Command	Response	Description
aC!	**atttnn<cr><lf>**	Initiate measurement

Where:

a is the sensor address ("0-9", "A-Z", "a-z", "*", "?").

C is the upper case ASCII character representing the Concurrent Measurement command.

ttt is a 3-digit integer (000-999) specifying the maximum time (Sample Duration+2), in seconds, the sensor will take to complete the command and have measurement data available in its buffer.

nn is a 2-digit integer (00-99) specifying the number of values that will be placed in the data buffer. If "**nn**" is zero (0), no data will be available using subsequent "**D**" commands.

The data recorder may wake the sensor with an SDI-12 **BREAK** and collect the data any time after the specified processing time has elapsed.

Table 4 shows all of the available data from the C command.

- ***Send Data Command "D"***

The Send Data Command (**D**) returns sensor data generated as the result of previous **aMc!**, **aC!**, or **aV!** commands. Values returned will contain 33 characters or less. The sensor's data buffer will not be altered by this command.

Command	Response
aD0! through **aD9!**	**a±d.d…±d.d<cr><lf>**

Where:

a is the sensor address ("0-9", "A-Z", "a-z", "*", "?").

D0…D9 are the upper case ASCII characters representing the Send Data command.

± is a polarity sign (+ or -).

d.d represents numeric digits before and/or after the decimal. A decimal may be used in any position in the value after the polarity sign. If a decimal is not used, it will be assumed to be after the last digit.

Example: 1+3.29+23.5-25.45+300

If one or more values were specified, and an **aD0!** returns no data (**a<cr><lf>** only), it means that the measurement was aborted, and a new **M**, **C**, or **V** command must be sent.

All possible responses to the **D** command are shown below.

Table 3. SDI-12 M Command Output

Address	Command	Response	Output								
			1	2	3	4	5	6	7	8	9
0 – 9 (0 used as example)	0M!	0D0!	Mean Temp	Mean Press (Adj.)	Stage	Multi-Cell End					
		0D1!	IVC X	IVC Y	Vel Mag (Speed)	IVC Mean SNR	Flow				
	0M1!	0D0!	Vx1	Vy1	Vx2	Vy2	Vx3	Vy3			
	0M2!	0D0!	AvgAmp1	AvgAmp2	AvgAmp3	AvgSnr1	AvgSnr2	AvgSnr3			
	0M3!	0D0!	Vx4	Vy4	Vx5	Vy5	Vx6	Vy6			
	0M4!	0D0!	AvgAmp4	AvgAmp5	AvgAmp6	AvgSnr4	AvgSnr5	AvgSnr6			
	0M5!	0D0!	Vx7	Vy7	Vx8	Vy8	Vx9	Vy9			
	0M6!	0D0!	AvgAmp7	AvgAmp8	AvgAmp9	AvgSnr7	AvgSnr8	AvgSnr9			
	0M7!	0D0!	Vx10	Vy10	AvgAmp10	AvgSnr10					
	0M8!	0D0!	BatteryV	RecorderFreeSpaceMB	Flow	TotalVolume					

Table 4. SDI-12 C Command Output

Address	Cmd	Response	Output								
			1	2	3	4	5	6	7	8	9
0 – 9	0C!	0D0!	Mean Temp	Mean Press (Adj.)	Stage	Multi-Cell End					
		0D1!	IVC X	IVC Y	Vel Mag (Speed)	Mean SNR	Flow				
		0D2!	V1x	V1y	V2x	V2y	AmpCell1 Beam1	AmpCell1 Beam2	AmpCell2 Beam1	AmpCell2 Beam2	
		0D3!	V3x	V3y	V4x	V4y	AmpCell3 Beam1	AmpCell3 Beam2	AmpCell4 Beam1	AmpCell4 Beam2	
		0D4!	V5x	V5y	V6x	V6y	AmpCell5 Beam1	AmpCell5 Beam2	AmpCell6 Beam1	AmpCell6 Beam2	
		0D5!	V7x	V7y	V8x	V8y	AmpCell7 Beam1	AmpCell7 Beam2	AmpCell8 Beam1	AmpCell8 Beam2	
		0D6!	V9x	V9y	V10x	V10y	AmpCell9 Beam1	AmpCell9 Beam2	AmpCell10 Beam1	AmpCell10 Beam2	
		0D7!	BatteryV	NoiseBeam1	NoiseBeam2						

For less than 10 cells the last line will move to a lower register. For example, for 5 cells the M and C command responses will have the following format. Note that cell 6 values will be reported as zeros to maintain the output structure.

Table 5. Shortened M Command Output

Address	Command	Response	Output								
			1	2	3	4	5	6	7	8	9
0 – 9 (0 used as example)	0M!	0D0!	Mean Temp	Mean Press (Adj.)	Stage	Multi-Cell End					
		0D1!	IVC X	IVC X	Vel Mag (Speed)	IVC Mean SNR	Flow				
	0M1!	0D0!	Vx1	Vy1	Vx2	Vy2	Vx3	Vy3			
	0M2!	0D0!	AvgAmp1	AvgAmp2	AvgAmp3	AvgSnr1	AvgSnr2	AvgSnr3			
	0M3!	0D0!	Vx4	Vy4	Vx5	Vy5	Vx6	Vy6			
	0M4!	0D0!	AvgAmp4	AvgAmp5	AvgAmp6	AvgSnr4	AvgSnr5	AvgSnr6			
	0M5!	0D0!	BatteryV	RecorderFreeSpaceMB	Flow	TotalVolume					

Table 6. Shortened C Command Output

Address	Cmd	Response	Output								
			1	2	3	4	5	6	7	8	9
0 – 9	0C!	0D0!	Mean Temp	Mean Press (Adj.)	Stage	Multi-Cell End					
		0D1!	IVC X	IVC X	Vel Mag (Speed)	IVC Mean SNR	Flow				
		0D2!	V1x	V1y	V2x	V2y	AmpCell1 Beam1	AmpCell1 Beam2	AmpCell2 Beam1	AmpCell2 Beam2	
		0D3!	V3x	V3y	V4x	V4y	AmpCell3 Beam1	AmpCell3 Beam2	AmpCell4 Beam1	AmpCell4 Beam2	
		0D4!	V5x	V5y	V6x	V6y	AmpCell5 Beam1	AmpCell5 Beam2	AmpCell6 Beam1	AmpCell6 Beam2	
		0D5!	BatteryV	NoiseBeam1	NoiseBeam2						

- ***Continuous Measurements "R"***

The Continuous Measurement command (**R**) was added to the Version 1.2 SDI-12 Specification. Sensors that are able to continuously monitor the phenomena to be measured, such as a shaft encoder, do not require a start measurement command. They can be read directly with the **R** commands (**R0!…R9!**). The **R** commands work exactly like the **D** (**D0!…D9!**) commands. The only difference is that the **R** commands do not need to be preceded with an **M** command.

While the original definition of the **R** commands does not apply to the SL, we have adapted one of the **R** commands to a special function not available with other SDI-12 commands.

Command	Response
aR! or **aR0!**	**a+0<cr><lf>** or **a+1<cr><lf>**

Where:

a	is the sensor address ("0-9", "A-Z", "a-z", "*", "?").
R or R0	are the upper case ASCII characters representing the Continuous Measurements command.
±	is a polarity sign (+ or -).

The function of this command is to reset the total volume calculations to zero. When this command is received, and if total volume calculations are enabled, the SL will reset the computed total volume to zero and respond with **a+1**. If total volume calculations are not enabled, the SL will respond with **a+0**. When total volume is reset, this affects both real-time output data and values recorded in the data file.

- ***Initiate Verify Command "V"***

The Verify Command (**V!**) causes a verify sequence to be performed. The result of this command is similar to the **aM!** command except that the values generated are fixed test data and the results of diagnostic checksum tests. The data generated in response to this command is placed in the sensor's buffer for subsequent collection using **D** commands. The data are retained in the sensor until another **M**, **C**, or **V** command is executed.

Command	Response	Description
aV!	**atttn<cr><lf>**	Initiate verify sequence

Where:

a	is the sensor address ("0-9", "A-Z", "a-z", "*", "?").
V	is the upper case ASCII character representing the Verify command.
ttt	is a 3-digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to complete the command and have data available in its buffer.
n	is a single-digit integer (0-9) specifying the number of values that will be placed in the data buffer. If "n" is zero (0), no data will be available using subsequent "D" commands.

Example of an SL **aV!** command:

Command	Response	Time	Values	Description
aV!	**a0013<cr><lf>**	1 s	3	Return fixed data and diagnostic data for testing purposes.

Subsequent Command	Response
aD0	**a+123.456+78.9+y<cr><lf>**

Key	Description	Value
+123.456	Fixed test data	
+78.9	Fixed test data	
y	ROM checksum test	0=Failed, 1 = Passed

- ***Send Acknowledge Command***

The Send Acknowledge Command returns a simple status response that includes the address of the sensor. Any measurement data in the sensor's buffer is not disturbed.

Command	Response
a!	**a<cr><lf>** Where: **a** is the sensor address ("0-9", "A-Z", "a-z", "*", "?").

- ***Send Identification Command "I"***

The Send Identification Command (**I**) responds with sensor vendor, model, and version data. Any measurement data in the sensor's buffer is not disturbed.

Command	Response
aI!	**allcccccccccmmmmmmvvvxx…xx<cr><lf>**

Where:

a is the sensor address ("0-9", "A-Z", "a-z", "*", "?").

ll is the SDI-12 version compatibility level (e.g., version 1.2 is represented as "12").

cccccccc is an 8-character vendor identification to be specified by the vendor and usually in the form of a company name or its abbreviation.

mmmmmm is a 6-character field specifying the sensor model number.

vvv is a 3-character field specifying the sensor version number.

xx…xx is an optional field of up to a maximum of 13 characters to be used for serial number or other specific sensor information not relevant to operation of the data recorder.

Example of an SL **aI!** command:

a12 SonTek SW 93 T18<cr><lf>

- ***Change Sensor Address***

The Change Sensor Address Command (**A**) allows the sensor address to be changed. The address is stored in non-volatile EEPROM within the sensor. The SL will not respond if the command is invalid, the address is out of range, or the EEPROM programming operation fails.

Command	Response	Description
aAn!	**n<cr><lf>**	Change sensor address

Where:

a is the current (old) sensor address ("0-9", "A-Z", "a-z", "*", "?"). An ASCII "*" may be used as a "wild card" address if the current address is unknown and only one sensor is connected to the bus.

A is an upper case ASCII character.

n is the new sensor address to be programmed ("0-9", "A-Z", "a-z", "*", "?"). Note: To verify the new address, use the "Identify Command".

Example of a "Change Sensor Address" command:

Command	Response	Description
aA2!	**2<cr><lf>**	Change sensor address from "**a**" to "**2**".

6.6. Modbus

The SonTek-SL is capable of serial communication using the Modbus protocol.

• No additional modules or converters are necessary for connecting the SonTek-SL to a Modbus network.

• To connect to a Modbus network, first configure the SonTek-SL for Modbus data output using the SL Software.

• The RS232 serial port on the cable adaptor or the flow display is used for both RS232 and Mod-bus communications.

• Unlike SDI-12, the SL will sample autonomously based on its settings and will output the latest measurement when polled by the Modbus network controller.

• Using Modbus output, the SL will have slightly higher power consumption and decreased battery life. The SL software will compensate of that in its battery life calculations.

6.6.1. SL Software configuration for Modbus

In order for the SonTek-SL to collect data properly using Modbus output, the instrument must be configured to collect data (i.e. sampling interval and duration, channel geometry, etc) and sampling must be started.

- The instrument collects data and is polled as a slave on the Modbus network
- Address range is 1-247
- Default baud rate is 19200 (and can go as high as 115200)
- Default Modbus parity is Even (options for None and Odd)
- For even parity, there is one stop bit
- The SonTek-SL operates in RTU (Remote Terminal Unit) mode.
- Modbus output format default is IEEE standard floating point (Inverted floating point is also offered)
- Figure 82 presents an example Modbus configuration.

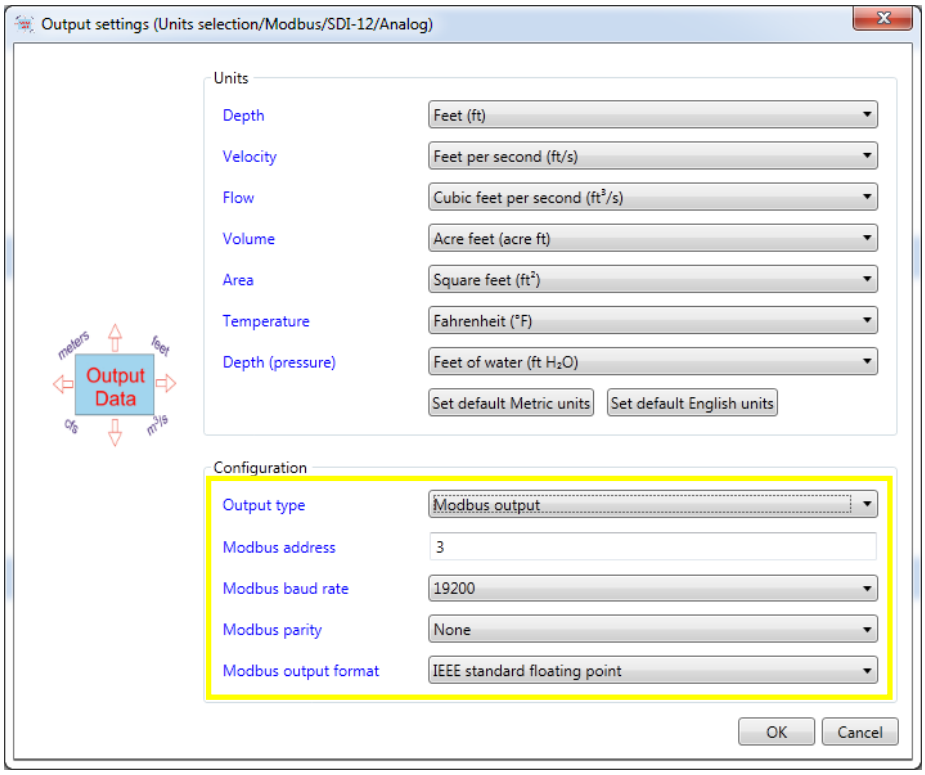


Figure 82. Modbus configuration using the SL software

6.6.2. Modbus hardware setup

Use the SL software to configure the system. When all status icons on the SL Smart Page are green, start the data collection, disconnect, and exit the SL software. Connect the SonTek-SL to the Modbus network (Figure 83).

RS232 connector plugs directly into Modbus device (PLC, RTU, etc.)

Figure 83. Connect to Modbus network using the RS232 cable

6.6.3. Modbus Data Output

Modbus data from the SL are reported on both input and holding registers.

- Use the Modbus "read input registers" command (function code 04 or 4x) to read the sample header and the sample. Sometimes these are referred to as the "30,000" analog input registers.
- Use the Modbus "read holding registers" command (function code 03 or 3x) to read the sample header and the sample. Sometimes these are referred to as the "40,000" analog output holding registers.
- Each parameter is output as a floating-point number in two adjacent registers.
- The first header value is stored at register address 0. There are 8 header values.
- The first sample value is stored at register address 100.
- There are 52 input registers used to report the 26 sample parameters (addresses 100-150) defined in table below.
- The units of the output data (meters, feet, etc.) are set in the SL Software by the user in the Output settings window.

Table 7. Modbus Register Addresses and Parameter Descriptions

Address	Parameter name
0 , 1	SL serial number
2 , 3	SL sequential sample number
4 , 5	Year – start time of current IQ sample
6 , 7	Month – start time of current IQ sample
8 , 9	Day – start time of current IQ sample
10 ,11	Hour – start time of current IQ sample
12 ,13	Minute – start time of current IQ sample
14 ,15	Second – start time of current IQ sample
100 ,101	Flow rate (using the user-defined channel geometry)
102 ,103	Stage (water depth relative to the user-defined channel)
104 ,105	Mean velocity (throughout the channel cross section)
106 ,107	Total volume (based on all measured flow)
108 ,109	Water depth (amount of water above instrument from pressure)
110 ,111	Index velocity (user-specified if using the Index Velocity method, or same as Velocity (XZ).X if none specified)
112 ,113	Cross-sectional area of channel
114 ,115	Water temperature
116 ,117	System Status (Section 7.1)
118 ,119	Multi-Cell Velocity X
120 ,121	Multi-Cell Velocity Y
122 ,123	IVC Velocity X
124 ,125	IVC Velocity Y
126 ,127	Battery voltage
128 ,129	Pitch angle in degrees
130 ,131	Roll angle in degrees
132 ,133	Percentage of instrument submerged (100% is fully submerged)
134 ,135	Range to water surface from vertical beam
136 ,137	Water depth (from pressure adjusted for atmospheric pressure)
138 ,139	Total volume (based only on positive measured flow)

140 ,141	Total volume (based only on negative measured flow)
142 ,143	End Cell (distance to farthest good measurement cell)
144 ,145	SNR MC beam 1 (acoustic signal strength in dB)
146 ,147	SNR MC beam 2 (acoustic signal strength in dB)
148 ,149	SNR IVC beam 1 (acoustic signal strength in dB)
150 ,151	SNR IVC beam 2 (acoustic signal strength in dB)

Section 7. Troubleshooting

7.1. Cannot Establish Communications with the SonTek-SL

Establishing communication between your PC and the SL will normally be a simple process.

- Connect the cable from the SL to the cable adaptor, from the cable adaptor to the power supply, and from the cable adaptor through the USB to RS232 converter and into your PC.
- Turn the power supply on.
- Open the SL software and click the **Connect** button.

If you are not able to establish communication, the steps outlined in the following sections will usually locate the problem.

7.1.1. Verify All Connections

- Make sure that the connectors (five-pin SL connector and three-pin power connector) are attached firmly to the cable adapter or flow display.
- Make sure that the wires are firmly attached to the connectors that plug into the cable adaptor or flow display.
  - Check 5-pin connector wiring from the SL communication cable into the cable adaptor/flow display. The colors of the wires should match the labels on the adaptor/display.
- Make sure that the SL cable is correctly connected to the SonTek-SL
  - If the system is in the water, do NOT disconnect the system and reconnect.
  - This connector should only be disconnected and reconnected in a dry environment.
- Make sure that the SonTek-SL is connected to a power source
  - The SonTek-SL requires 9-15VDC, if the system is receiving power, the LED on the cable adaptor/flow display should be illuminated bright red
  - Use a voltmeter to verify the power supply is providing sufficient voltage.
- Make sure that the cable adaptor/flow display is connected securely to the PC/laptop.
  - SonTek highly recommends using the USB-Serial adaptor provided with the system.
    - The latest driver is available as a Setup Executable from the Comments section here: http://www.ftdichip.com/Drivers/D2XX.htm

7.1.2. Use the System and COM Port Reset Functions

If the SL software cannot connect to the SL, it will prompt you to send a reset to the system.

- The System Reset function can also be found in the Maintenance menu accessed from the SL icon in the upper left corner of the software (Figure 84).
- Select System Reset and provide the correct serial COM port number when prompted. In many cases, this will successfully establish communication with the system.
- If it still will not connect, select COM Port Reset and enter the appropriate number before trying to connect again.

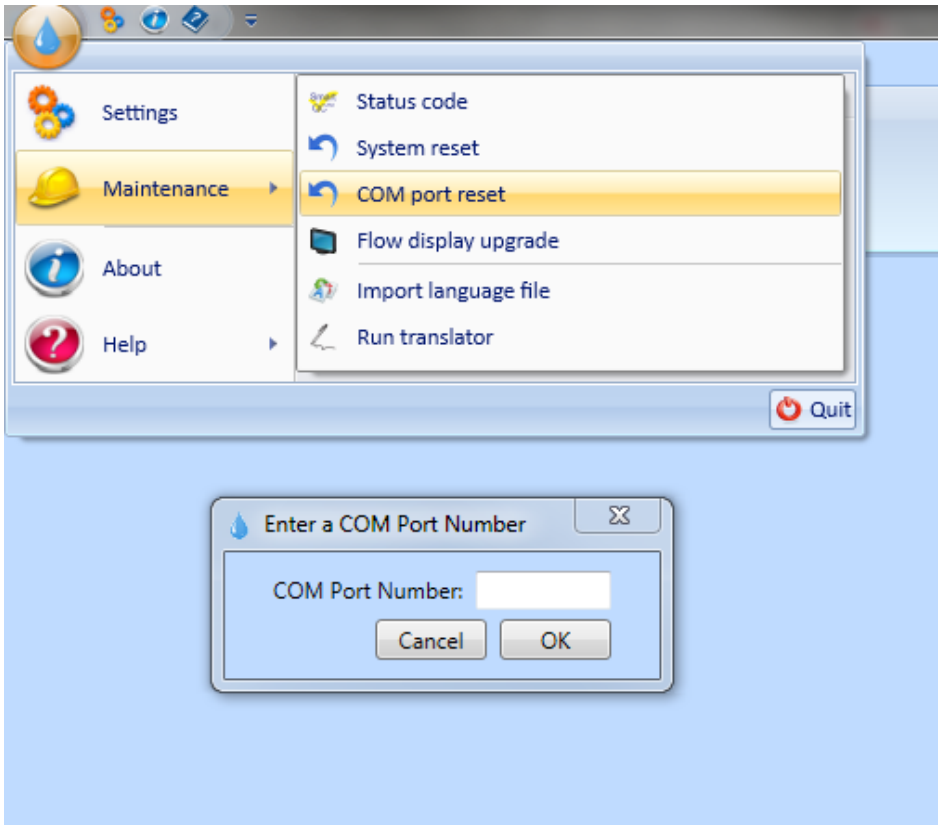


Figure 84. SL Software reset function

7.1.3. Cycle Power

If you are still not able to establish communication with the SL, cycle the power supply in order to complete a full reset of the system

- Disconnect the system from the power source (the wall outlet or battery) or disconnect the power connector from the cable adaptor.
- After disconnecting, wait 30 seconds and then reconnect power to the system.

7.1.4. Lower Maxiumum Baud Rate

If communications is still unsuccessful or intermittent, lower the Maximum Baud Rate in the software Settings.

See Figure 85:

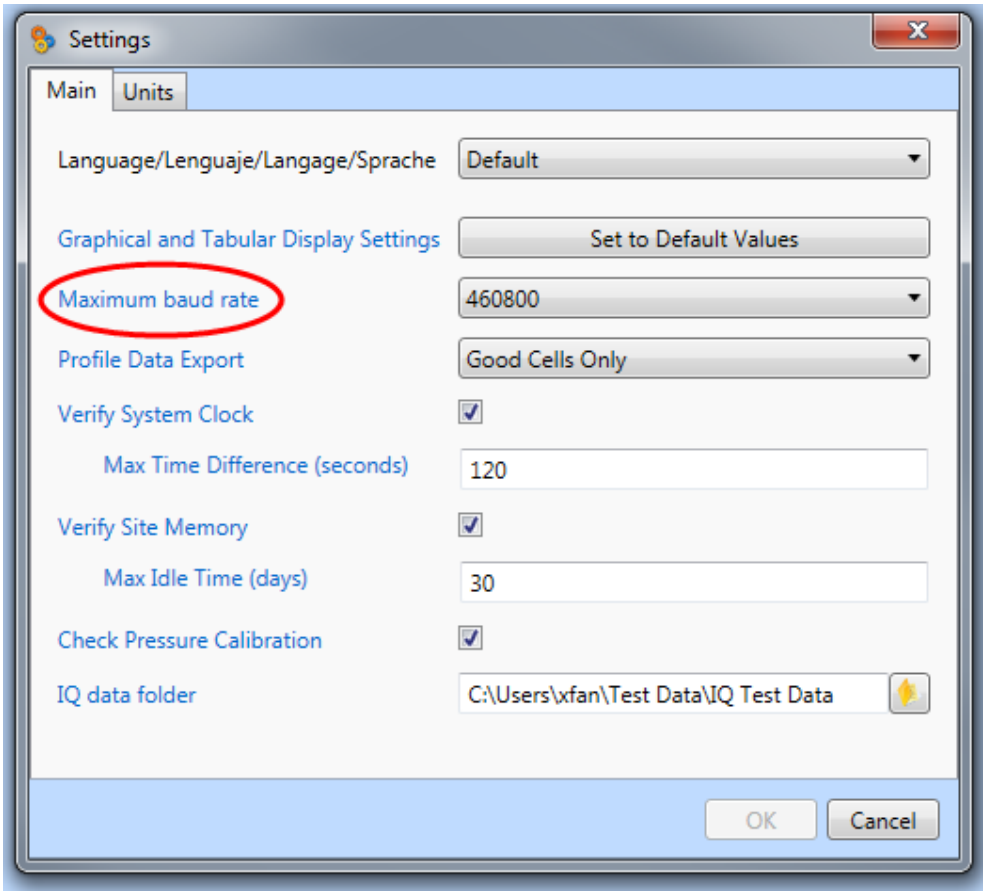


Figure 85. Maximum Baud Rate

7.2. Beam Check

- Beam Checks are preformed to ensure that the acoustic beams are functioning correctly
- When deployed in the field a Beam Check can be used to verify that the transducers or beams are not obstructed
- Beam Check is found under Utilities → Beam Check. Once opened, a graphic will be displayed as in Figure 86.

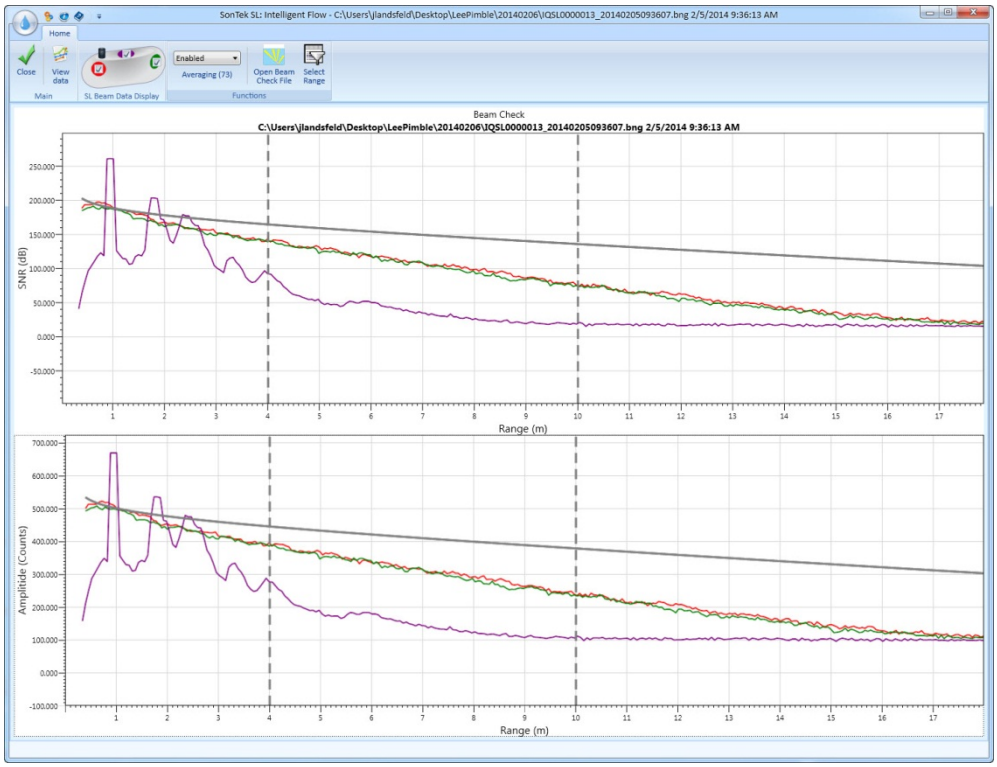


Figure 86. Beam Check window in SonTek-SL software

- The plot presents signal to noise ratio (SNR), effectively the strength of the signal received from the instrument (horizontal axis) versus range from the instrument on the vertical axis
- In most cases, the along axis beams, beams 1 and 2 (red and green respectively) and the skew beams 3 and 4 (light blue and dark blue) should present similar data
  - If along axis beams or the skew beams do not have similar plots it is possible that the there is an obstruction in the channel cross-section
- The purple line is the vertical beam – the first major peak moving up from the bottom of the figure should correspond to the local water depth
  - In the field, this trace will have multiple reflections, which correspond to the vertical beam rebounding off the surface and channel bottom.

7.3. Cannot retrieve data from the internal recorder

If you have trouble retrieving data from the internal recorder, review the following items.

- The SonTek-SL software retrieves data from the internal recorder using a higher baud rate to speed up the download process.
- When you connect with the SL, the software runs a series of tests to determine the highest possible baud rates. For most situations, this provides fast and reliable communication.
- The maximum reliable baud rate is a function of the length and quality of the communication cable, the computer, and the operating environment (for external sources of noise). In some cases, a lower baud rate may be needed.
- If you are having problems with data download, you may try reducing the maximum baud rate that can be used from the software settings menu. See Section 2.3 for details.
- Some computers have poor quality serial ports and are unable to receive large amounts of data at high baud rates.

  - We do not recommend using the built in serial ports in a PC. Many of these ports cannot reliably run the high baud rates used for data download.
  - We always recommend using the USB to serial converter included with the SL.
  - If problem persists, try using another computer.

7.4. Software Version and Firmware Version

- For best results please use the most recent version of firmware and software, which can be found at the SonTek website (www.sontek.com/software.php)
  - Be sure to check for the most recent version of firmware for the SL product as well as the flow display
  - Firmware versions are indicated in the System Information of the SL Software Smart Page
- Once at the website follow the instructions to update the software and firmware
- In order to download files from the website, you will have to login by providing a user name and password. New users will be required to create an account.

7.5. Missing data from a deployment

The SonTek-SL internal recorder was designed for high reliability; recorder failures are extremely rare.

- Missing data is most commonly traced to problems with the power supply
- When analyzing recorded data, look at the measured battery voltage as this provides information on the condition of the power supply.
- Check that sufficient recorder space remained for data collection
- If any real-time data logging is available (typically SDI-12 or the analog output modules), compare data from these systems for that period.
- If the system was connected to an SDI-12 data logger, that data logger is required to initiate each velocity sample. Check data logger operation and cable continuity to ensure that data collection commands were reaching the SonTek-SL

7.6. Cannot communicate with an external device

If you cannot establish communications between the SonTek-SL and an external real-time device (SDI-12 data logger or Modbus unit for example), review the following items.

- Have you completed all steps required to place the SonTek-SL in the appropriate output mode (Section 3)?
- The SL software must first be programmed using the RS-232 serial interface.
- Disconnect the SL and exit the program before connecting other networks or dataloggers.
- Do you have the correct address specified?
- Do you have the correct Baud rate?
- Do you have the correct output format?

7.7. Unreasonable Data

If data from the SonTek-SL does not appear reasonable, review the following list.

Evaluate the deployment site

- Is the SL in an area with stable flow conditions?
- Is the SL oriented correctly with respect to the direction of flow?
- Is the SonTek-SL mounted level?
- Are there any underwater objects that could cause interference?
- Do all beams have a clear, unobstructed path?
- Is there any debris caught on the system that could be influencing data collection?
- Is the system buried or partially buried by sediment?

Consider the SonTek-SL Settings

- Is the value of the Sample Duration long enough to eliminate instrument noise and real variations in flow?
- We do not recommend using a Sample Duration settings less than 30 seconds; settings from 120 to 900 seconds are more common

Look at signal-to-noise ratio data (SNR)

- SNR should be greater than 3 dB
- Evaluate signal strength and noise data for potential problems

Check water level data

- Was the system able to measure water level accurately?
- Was water depth sufficient for reliable operation (specifications in Appendix D)?

Check temperature sensor and battery voltage data

- Is temperature data reasonable for the deployment environment?
- Is the power supply sufficient and reliable?

7.8. Protection from Biological Fouling

The SonTek-SL has excellent resistance to biological fouling and can operate reliably even with biological growth on the transducers.

- Biological growth may cause a loss in signal strength, but it does not affect the water velocity measurements.
- Both the transducers and the underwater housing can be coated with commercial anti-fouling paints to prevent biological growth.

  - Anti-fouling paint is typically only required in warm environments where algae and similar biological growth is common.

- Thick layers of anti-fouling paint on the transducers will cause a decrease in acoustic signal strength and will reduce the effective measurement range of the SL.
- For most applications, the loss of signal strength caused by anti-fouling paint does not have a significant effect on instrument performance.

Within the United States, SonTek recommends using an anti-fouling paint called Interlux Tri-Lux. This paint contains a biocide (a copper derivative) that allows its use on all metals. For information on Interlux paints, see http://www.yachtpaint.com/usa/.

Normal anti-fouling paints, which use cuprous oxide based biocides, cannot be used on some metals as they cause galvanic corrosion.

- Outside the United States, anti-fouling paints containing TBT can be used on metal systems with a suitable primer.
- On plastic systems, any type of anti-fouling paint can be used.
- Our experience with the above paint (Interlux Tri-Lux) on SonTek systems causes us to recommend its use for all systems.

When applying the anti-fouling paint:

- Follow the instructions provided with the paint on all areas except the transducers.
- When painting the transducers, apply only one coat. Make the paint as smooth and uniform as possible, and avoid trapping any air bubbles on the transducer face.
- If anti-fouling protection is desired for some portion of the cable, the paint can be applied directly to the polyurethane jacket

7.9. SonTek Support Information

Any questions, concerns, or suggestions can be directed to SonTek by telephone, fax, or email. Office hours are 7:30 a.m. to 4:30 p.m., Pacific Time, Monday through Friday. After-hours Technical Support is available for emergencies in the field at the phone number below.

Phone: (858) 546-8327
Fax: (858) 546-8150
Web: http://www.sontek.com

inquiry@sontek.com (General information)
sales@sontek.com (Sales information)
support@sontek.com (Support information)

Appendix A. Field Descriptions

This appendix provides a description of the major terms and abbreviations used in discussing the SonTek-SL.

Align Sample To Hour: This setting determines how the timing of data is related to the start of each hour.

> ***Do Not Align*** means that data collection is started immediately upon the user request, and is not specifically aligned to the start of each hour.
>
> ***Sample Ends at the Top of the Hour*** means that the timing of samples is set so that a sample will end at the top of the next hour (i.e. 9:00:00). Based on the sample interval and duration, it starts the first sample at the first time that ensures that a sample will end at the top of the next hour.
>
> ***Sample Starts at the Top of the Hour*** means that the timing of samples is set so that a sample will start at the top of the next hour (i.e. 9:00:00). Based on the sample interval and duration, it starts the first sample at the first time that ensures that a sample will start at the top of the next hour.

Analog Data Variable: Each external analog channel generates a signal proportional to an SL data value; this variable specifies what data value is used to scale the signal.

Analog Min and Max Value: The minimum and maximum values used to specify the range of the analog signal. For 4-20 mA converters, the min value will generate an output of 4 mA while the max value will generate an output of 20 mA.

Analog output (4-20 mA): Configures the system to control external converters (an optional part of the SonTek flow display) that generate up to four analog signals (4-20 mA) each proportional to a single SL data variable.

Area: The calculated cross sectional area of the channel, based on water depth and the user-supplied channel shape.

ASCII output (RS232): Outputs data over the SL RS232 serial port (9600 8-N-1) using standard ASCII characters.

Battery Voltage: This is the voltage powering the SL during data collection.

Battery capacity: This is the expected capacity, in amp-hours, of the battery that will be used to power the SL during data collection. Battery life calculations assume the battery has a full charge. If the battery has not been fully charged, the battery life will be reduced.

Bottom Width: Bottom width of a trapezoidal channel (in units of m, ft, etc).

Cell End: The location of the end of the measurement volume.

Channel Depth: The vertical depth of an open channel (in units of m, ft, etc) from the bottom to the top of the channel bank.

Channel Depth Estimate: The average depth of the channel. This setting is used to determine if velocity measurement cells are located within the channel.

Channel Type: Several channel types are supported for flow calculations (Irregular Open Channel, Trapezoidal Open Channel, Trapezoidal Culvert, and Stage/Area Equations).

Irregular Open Channel can be an open channel of any shape defined by up to 200 user supplied survey points.

Trapezoidal Open Channel is a regularly shaped open channel defined by three parameters: width at the bottom of the channel, width at the top of the channel, and channel depth.
Trapezoidal Culvert is the same as Trapezoidal Open Channel, except that the channel is closed with a solid top.

Stage/Area Equation is a set of one or more user supplied equations that relates the measured stage to the cross sectional flow area.
None is set to disable flow calculations.

Check Pressure Calibration: If this option is selected, the software will automatically check the pressure sensor to be sure it has been reliably calibrated for changing atmospheric conditions. If it is not enabled, and if the pressure sensor has not been calibrated for more than 1 day, you will be prompted to perform the pressure sensor calibration when connecting to the system.

Comments: Up to 120 characters are allowed. This is typically a short description of the details of the deployment.

Data Statistics: Key statistical values can be calculated for a range of SL data. Max sample number represents the last sample number to be used in this range of data.

Depth: This specifies the units used for any length or distance variable, including water depth and channel dimensions.

Depth (pressure): Height of the water above the top of the instrument measured by the pressure sensor.

Depth (vertical beam): Height of the water above the top of the instrument measured by the vertical beam.

Estimated battery life: Battery life is calculated based on the user-supplied battery voltage and capacity, and the conditions at the site. This value is an estimate only, and actual results may vary. A number of factors, including the level of charge in the battery and cold weather, may significantly decrease battery life below the expected values shown here. Battery life will also be affected by the presence of the flow display; if the flow display is connected, this is taken into account in battery life calculations.

File Name: This determines the file name under which data is stored to the internal recorder. You can select up to 10 letters or numbers; spaces or symbols are not allowed. The system automatically adds a date and time stamp to the file name, to avoid duplicate file names. For example, if you set file name TEST, the data file names will look like TEST_YYYYMMDD_HHMMSS (for year, month, day, hour, minute, second).

Flow: This specifies the units used for the computed flow rate value.

Flow Threshold: This specifies the minimum flow rate threshold used when the "Use Flow Threshold" option is enabled.

IEEE Standard Floating Point: A format specified by the IEEE standard; this is the default setting for most Modbus data collection platforms.

SL Orientation: The SL can either be installed on the right bank, looking left, or on the left bank, looking right. This setting tells the instrument how it is installed and is critical for accurate data collection and analysis. The location/orientation of the instrument will be shown accordingly, so be sure to check that you have the correct setting.

Index: An empirically determined, user-supplied index relationship can be used to relate system velocity to mean velocity in the channel. This requires three index coefficients to define the relationship between measured and mean velocity.

Initialize: With this setting in total volume calculations, the user provides an initial volume amount (the Initial Volume Value) and the instrument accumulates volume from that point. After starting data collection, the instrument automatically switches to the Continuous setting, so that volume will continue to accumulate whenever data collection is stopped and started. When installing the instrument at a new site, the system would typically be set for Initialize with an Initial Volume Value of 0, so that the accumulated volume represents only data from the new site.

Initialize Volume: This setting determines the starting value for total volume calculations each time data collection is started.

> ***Continuous:*** This is the default setting. With this setting, volume continues to accumulate from the last measured value when data collection is stopped and re-started; this includes an estimate of the volume of water for the period that was not measured.
>
> ***Initialize:*** With this setting, the user provides an initial volume amount (the Initial Volume Value) and the instrument accumulates volume from that point. After starting data collection, the instrument automatically switches to the Continuous setting, so that volume will continue to accumulate whenever data collection is stopped and started. When installing the instrument at a new site, the system would typically be set for Initialize with an Initial Volume Value of 0, so that the accumulated volume represents only data from the new site.

Initial Volume Value: When using the Initialize setting above, this specifies the starting value for total volume calculations. The units match the total volume output units setting.

Instrument Y/Z: This specifies the location of the instrument within the channel. Y is the horizontal location across the width of the channel and Z is the vertical location. The instrument location is always specified as the top of the instrument's vertical beam. For an irregular open channel, instrument location is relative to the same Y/Z origin as all other survey data. For a trapezoidal open channel or a trapezoidal culvert, the bottom center of the channel is defined as location Y=0, Z=0. Negative Y values are moving towards the left bank, and positive Y values are moving towards the right bank when looking downstream.

Instrument Z: This specifies the height of the instrument within the channel. Instrument height is always measured from the top of the instrument's vertical beam. The SL measures water depth above the vertical beam. Stage is computed as this water depth plus Instrument Z. This computed Stage value is used in the Stage/Area equation(s).

Integrated Velocity Cell: For a side-looking instrument, an integrated velocity cell can be defined by the user. Velocity will be integrated over the width of the cell.

> **Integrated Velocity Cell Begin:** This value is the start location of the cell or the distance between the cell and the instrument.
>
> **Integrated Velocity Cell End:** This value is the end location of the cell or the distance between the end of the cell and the instrument.

Inverse Floating Point: Uses an alternative format that is needed for some Modbus system configurations.

Irregular Open Channel: Can be an open channel of any shape defined by up to 200 user supplied survey points.

Maximum Baud Rate: This setting determines the maximum baud rate at which the software will communicate and download data from the SL. When connecting to the system, the software runs tests to determine the maximum effective baud rate that can be achieved. In most cases, the maximum baud rate can be left at the default value of 460800, and the software will automatically determine the best baud rate to use. If you are experiencing communication problems with the SL, particularly when using a long cable (30 m/100 ft or more), you can try to set a lower maximum baud rate to see if this helps. In general, settings of 57600 / 38400 / 19200 may be good values to try. Note that a lower maximum baud rate will significantly increase the time required to download data files.

Maximum Idle Time: One thing that may indicate the site memory needs to be reset is if the system has been idle for an extended period. This parameter specifies what that period is; the default value is 30 days. If the SL has not collected data for a period greater than this value, the software will ask you if you wish to reset the site memory. If channel conditions have changed during that period, you should reset the site memory. If channel conditions have not changed significantly, you should not reset the site memory.

Mean-Velocity Equation Type: This parameter is required for internal flow. The relationship between velocity as measured by the system and mean velocity in the channel can be determined two ways (Theoretical or Index).

Modbus: Configures the system to act as a Modbus slave device over the RS232 serial port.

Modbus Address: Each instrument in a Modbus data collection network must have a unique address from 1 to 247.

Modbus Baud Rate: This specifies the baud rate for serial communication used when collecting data in a Modbus data collection network. The default value for Modbus is 19200; values from 300 to 115200 are supported. For longer cable runs (greater than 15 m / 50 feet), be sure to use a low enough baud rate for reliable communications.

Modbus Output Format: All Modbus data are output as floating point numbers; this setting determines how data inside the floating-point numbers are formatted.

Modbus Parity: Specifies the parity for serial communication used when collecting data in a Modbus data collection network. The default setting is EVEN; settings of EVEN, ODD and NONE are supported.

Multi-cell Profiler Parameters: the SL can profile multiple cells and calculate SNR and velocity values for each individual cell.

Number of multi-cells: 1 to 128 individual velocity cells can be defined by the user.

Multi-cell blanking distance: Refers to the region in front of the transducers where no measurements are made. It is the distance from the instrument transducers to the start of the first cell in the multi-cell velocity profile.

Multi-cell size: The horizontal distance from the start of one cell to the start of the next cell.

Noise: the measured acoustic return when no acoustic pulse has been transmitted, representing the ambient electronic noise level.

Noise.1: Ambient electronic noise level for beam 1.

Noise.2: Ambient electronic noise level for beam 2.

Noise.3: Ambient electronic noise level for beam 3.

Number of Analog Channels: The SL can control from 1 to 4 external analog output devices. Each channel generates an analog signal (4-20 mA) proportional to a data variable from the SL.

Operator Name: This is usually the name of the person configuring the SL and setting up the site. Up to 32 characters are allowed. If an operator name is provided, data files can be organized and viewed based upon the operator name.

Output Type: The SL supports a number of different methods of data output types for integration with an external data logger or network.

SonTek Binary is a proprietary protocol used only to communicate with SonTek software.

ASCII output (RS232) outputs data over the RS232 serial port (9600 baud, 8 data bits, 1 stop bit, no parity) using standard ASCII characters.

Analog output (4-20 mA) configures the system to control up to four analog signals generated by the SL. Each analog signal (4-20 mA) is proportional to a single SL data variable.

SDI-12 configures the system to interface to an SDI-12 data logger.

Modbus configures the system to act as a Modbus slave device over the RS232 serial port.

Pitch: Rotation about the Y-axis. Positive values indicate Beam 2 is higher than Beam 1. Negative values mean Beam 1 is higher than Beam 2.

Pressure: Used for redundant water level measurements. The pressure sensor is used as a secondary measurement in case there is no valid data from the vertical beam.

Pressure (uncorrected): The raw pressure measurement, which includes atmospheric pressure.

Pressure adjusted value: Measurement with atmospheric pressure removed.

Profile Export Data: This option determines how much data are included when exporting profile data.

Good Cells Only exports only data for those cells determined to be valid. This is determined by the measured depth and the shape of the channel.

All Cells exports all profile data that were recorded. Many of these cells may be past the surface or the walls of the channel and may not represent valid data.

Recorder Days Remaining: Based on current instrument settings and the amount of free space on the recorder, this displays how long the system can run before the recorder runs out of free space. When the recorder is full, data collection will continue and output data (i.e. via an external data logger) will still be available, but data will no longer be stored to the instrument recorder. The system will give a warning if you restart data collection when the recorder is full.

Record Profile Data: Setting determines the interval at which detailed profile data are recorded. Depending on the system configuration, this may include SNR and/or velocity data. A value of 1 indicates profile data are recorded with each sample. A value of N indicates profile data are recorded with every N samples (i.e. every 100 samples). A value of 0 indicates profile data are not recorded. The recording of profile data has a significant impact on file size and recorder life, and this impact should be considered when setting this parameter.

Reference Date and Time: Is initially set to the PC clock time when the dialog was opened. If you un-select Use PC Time, you can manually enter a date and time to be sent to the SL clock.

Reset: With this setting in total volume calculations, the volume value starts at 0 each time data collection is stopped and re-started.

Reverse Flow Direction: Select this option to reverse the sign (+/-) on measured velocities and the direction of flow. This option should be selected when the X → is facing upstream.
Roll: Rotation about the X-axis. Positive values mean the velocity beams are pointed towards the water surface. Negative values indicate the velocity beams are pointed towards the bottom.

Sample Duration (seconds): Determines the period of time (in seconds) that the system averages data for each sample. Settings as short as 10 seconds are allowed; however, we do not recommend settings less than 30 seconds. We suggest using the largest value possible based on the required data output rate and power limitations. Settings of 60 to 900 seconds (1 to 15 minutes) are common. Longer averaging times will reduce the amount of variability (noise) in flow data.

Sample Interval (seconds): This determines the period (in seconds) from the start of one sample to the start of the next; it must be greater than or equal to the sample duration. Setting this value greater than the sample duration will reduce total power consumption, as the system enters a low power state between samples. When interfacing with an external data logger using SDI-12, the data logger will control the exact timing between samples, and the setting of this sample interval is ignored. For proper recorder life calculations, sample interval should match the time between samples as programmed into the data logger.

SDI-12: Configures the system to interface to an SDI-12 datalogger.

SDI-12 Address: Each instrument in a SDI-12 data collection network must have a unique address. Address values from **0-9**, lower case **a-z**, and upper case **A-Z** are allowed.

Signal-to-Noise Ratio (SNR): The magnitude of the received signal to the ambient electronics noise level. SNR are calculated by subtracting noise level from measured signal strength.

SNR.1: Signal-to-noise ratio for beam 1

SNR.2: Signal-to-noise ratio for beam 2

Site Name: Normally a short description of installation site. Up to 32 characters are allowed. If a site name is provided, data files can be organized and viewed based upon the site name.

SL Data Folder: The SL software stores and accesses all downloaded data from a common data folder. This setting specifies that data folder location and name. Within this folder, the SL software follows a specific structure for how files from different systems and sites are stored. We recommend that you do not manually move any files into or within this folder, but instead allow the SL software to control automatically the data file organization.

SonTek Binary: A proprietary output data format used only with the SonTek-SL software.

Stage: Computed as water depth plus Instrument Z.

Stage/Area Equation: Set of one or more equations defining the mathematical relationship between stage and area. Two equation formats, Quadratic and Power, are supported. Min and max stage values must be defined for each equation.

Standard deviation (vel): The statistical calculation of deviation (or variation) from the central (mean) velocity value.

Survey Data: An irregular open channel must be defined by user supplied survey points. A minimum of 3 and a maximum of 200 survey points are allowed. Y is the horizontal location across the width of the channel and Z is the vertical location. The setting of survey origin determines whether lower Y values are near the left or right bank of the channel (when looking downstream).

Survey Origin: When providing channel survey data for an irregular open channel, this specifies the origin of the horizontal (Y) survey data. Left Bank indicates that smaller Y values are towards the left side of the channel when looking downstream. Right Bank indicates that smaller Y values are towards the right side of the channel when looking downstream.

System Date and Time: Is the reading of the SL clock at the time the dialog was opened.

System in Water: Percentage of sample during which the instrument was submerged. A value of 100 indicates the unit was submerged for the entire sample.

System Status: A valuable diagnostic and monitoring tool.

Temperature: Specifies the units used for water temperature.

Theoretical: A power law based theory, using the location of the measured velocity data within the overall channel geometry, to determine the relationship between measured velocity and mean channel velocity.

Top Width: Defines the width of a trapezoidal channel (in units of m, ft, etc.) at the top of the channel bank.

Trapezoidal Culvert: Is the same as Trapezoidal Open Channel, except that the channel is closed with a solid top. The most common example of this is a rectangular culvert that might pass under a road or bridge.

Trapezoidal Open Channel: A regularly shaped open channel defined by three parameters: width at the bottom of the channel, width at the top of the channel, and channel depth.

Use Flow Threshold: When this option is selected, total volume data are only accumulated when the magnitude of the measured flow rate exceeds the flow threshold. Note that we use magnitude, or absolute value, for this comparison. As such, the magnitude of a flow rate of -2.1 m^3/s would exceed a flow threshold of 2.0 m^3/s, and that datum would be accumulated for total volume calculations.

> ***Flow Threshold:*** This specifies the minimum flow rate threshold used when Use Flow Threshold is enabled.

Use Stage Threshold: When this option is selected, total volume data are only accumulated when the measured stage exceeds the stage threshold.

Stage Threshold: This specifies the minimum stage threshold used when Use Stage Threshold is enabled.

Use Velocity Threshold: When this option is selected, total volume data are only accumulated when the magnitude of the mean velocity exceeds the velocity threshold. Note that we use magnitude, or absolute value, for this comparison. Therefore, the magnitude of a velocity of -2.1 m/s would exceed a velocity threshold of 2.0 m/s, and that datum would be accumulated for total volume calculations.

***Velocity Threshold*:** This specifies the minimum velocity threshold used when Use Velocity Threshold is enabled.

VB Percent Good: A percentage of the vertical beam pings that meet the criteria needed to be considered "good".

Velocity: Measurement of the speed of the water for a given direction.

Verify System Clock: If this option is selected, the software will automatically compare the system clock to the PC clock each time you connect to the system. If the time difference between the two clocks is greater than the value specified by Maximum Time Difference, the software will notify you of the difference in time and will allow you to reset the clock if desired.

Maximum Time Difference: If Verify System Clock is set to Yes, the system clock is compared to the PC clock each time you connect to the system. If the time difference between the two clocks is greater than the value specified by Maximum Time Difference, the software will notify you of the difference in time and will allow you to reset the clock if desired.

Verify Site Memory: The SL maintains a record of the flow conditions for the current measurement site. This record includes the total volume of water delivered and details about the vertical and horizontal distribution of velocity within the canal. These parameters help the system perform the most accurate flow calculations possible. When an instrument is first installed at a new site, it takes the system a short period (~5-30 minutes) to "learn" the conditions at the new site—this assumes that the site is under regular flow conditions. If the SL is moved to a new site, or if the conditions at a given site change (perhaps due to cleaning of the channel, or a long time span when the canal is not used), the site memory should be reset to allow the system to quickly adapt to the new conditions. This parameter enables/disables several features that attempt to determine automatically if the site memory should be reset. If this parameter is enabled, the software will ask if you wish to reset the site memory if anything occurs that would suggest site memory might need to be reset.

Volume: Specifies the units used for the computed total water volume.

Water salinity: User input salinity is used to calculate sound speed, which is required for system operation. Salinity should be input with the best possible accuracy (ideally within 1 ppt) to ensure accurate sound speed data. Freshwater can be considered 0 ppt. Typical values for seawater are 30-35 ppt.

Appendix B. Principles of Operation

This document introduces the operating principles of the SonTek-SL Doppler current meters. It does not attempt to provide a detailed discussion of all technical issues, nor does it provide a detailed description of SonTek-SL products operation. To learn more about specific SonTek-SL applications, please refer to other sections of the *SonTek-SL User's Manual* or contact SonTek Support.

Overview

SonTek-SL products are Doppler current meters designed for water velocity, level, and flow measurements in the field. The SonTek-SL product line provides the technological advantages of complex/expensive current profilers, but in a simple, inexpensive, and easy to use package. SonTek-SL products attributes include:

- Horizontally integrated velocity measurement
- Measurements to the maximum possible extent of the water column
- Invariant factory calibration — no periodic recalibration required
- Simple operation (very few user entries needed)
- Excellent performance for low and high flows
- Accuracy — 1% of measured velocity
- Water level measured by vertical beam and pressure sensor
- Built-in temperature sensor

Typical applications for the SL include:

- River discharge monitoring
- Velocity indexing
- Irrigation
- Flood alert systems
- Water supply
- Environmental monitoring
- Vessel traffic
- Offshore platforms
- Ship berthing

The Doppler Shift

The SL measures water velocity using a physical principle called the Doppler shift. This principle states that 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. For a Doppler current meter, this can be expressed as:

$$F_d = -2F_0 \frac{V}{C}$$

where

F_d = Change in received frequency (Doppler shift)
F_0 = Frequency of transmitted sound
V = Represents relative velocity between source and receiver (i.e., motion that changes the distance between the two); +V means the distance from source to receiver is increasing.
C = Speed of sound

The SL is a *monostatic* Doppler current meter. Figure 87 illustrates the operation of a monostatic Doppler current meter.

- Monostatic means the same transducer is used as transmitter and receiver.
- The transducer generates a short pulse of sound at a known frequency (F_0), which then propagates through the water.
- The transducer is constructed to generate a narrow beam of sound where the majority of energy is concentrated in a cone a few degrees wide.
- As the sound travels through the water, it is reflected in all directions by particulate matter (i.e., sediment, biological matter, bubbles).
- Some of the reflected energy travels back along the transducer axis, where the transducer receives it.
- The SL electronics measure the change in frequency of the received signal.
- The Doppler shift measured by a single transducer relates to the velocity of the water along the axis of the acoustic beam of that transducer.
- If the distance between the transducer and the target is decreasing, frequency (F_D) increases; if the distance is increasing, frequency (F_D) decreases. Motion perpendicular to the line-connecting source and receiver has no effect on the frequency of received sound.

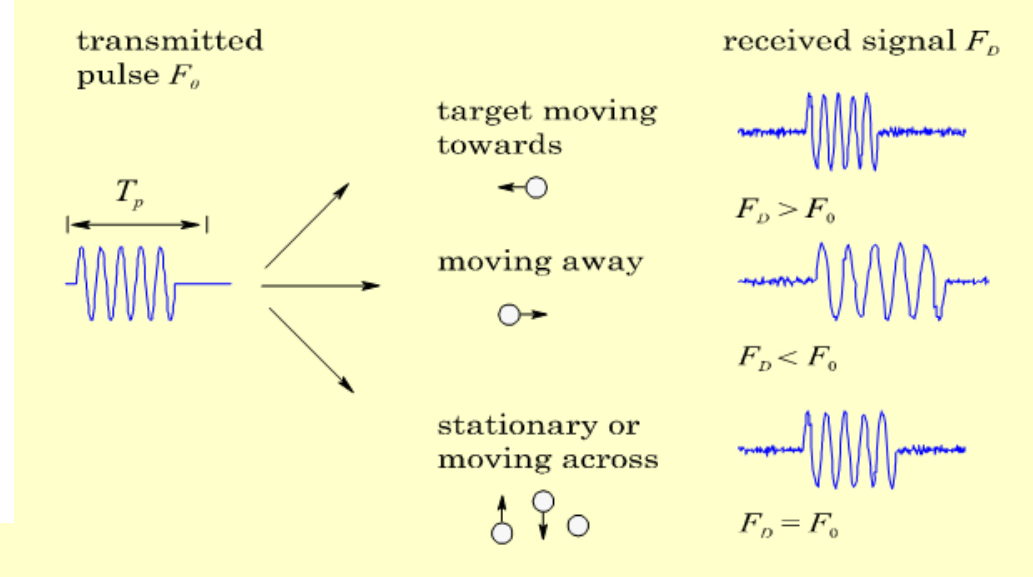


Figure 87. Measuring target velocity with a monostatic Doppler system

The location of measurements made by a monostatic Doppler current meter is a function of the time at which the return signal is sampled.

- The time since the pulse was transmitted determines how far the pulse has propagated, and thus specifies the location of the particles that are the source of the reflected signal.
- By measuring the return signal at different times following the transmit pulse (T_P), the SL measures the water velocity at different distances from the transducer.
- It is important to note that the SL measures the velocity of particles in the water, and not the velocity of the water itself.
- The velocity of particles in the water is assumed to match the velocity of the water. This assumption has been tested extensively and found to be highly reliable.
- If there is no particulate matter in the water, the SL is unable to measure velocity. In general, the practical limitation of clear water is not whether the SL can make velocity meas-

urements, but what is the maximum range (distance from the system) at which the SL can measure velocity. In clear water, the maximum measurement range may be reduced.

Important Note: *Clear water* is a relative term; visual inspection is not a good way to determine particulate matter concentration. Beam Check, in the Utilities Tab of the SL software can be used to make an on-site field determination of range.

Beam Geometry

The SL is designed for horizontal operation from underwater structures such as bridge pilings and channel walls.

- The system measures velocity in a horizontal layer (parallel to the water surface) away from the flow interference generated by the structure.
- The system uses two acoustic velocity beams in a single plane, each slanted 25° off the instrument axis. This beam geometry is designed for side-looking applications, giving the optimal balance between 2D velocity response and total measurement range (Figure 88).
- The velocity measured by each beam is referred to as the *along-beam velocity*.
- Beam velocities are converted to XY (Cartesian) velocities using the beam geometry.
- In most applications, the orientation of the SL is known and XY velocities are used directly.
  - XY velocities are reported relative to the orientation of the SL; if the SL is looking across a stream, X is parallel to the direction of flow and Y is across the stream.
- SL systems include a vertical beam to measure the distance from the top of the system to the water surface.

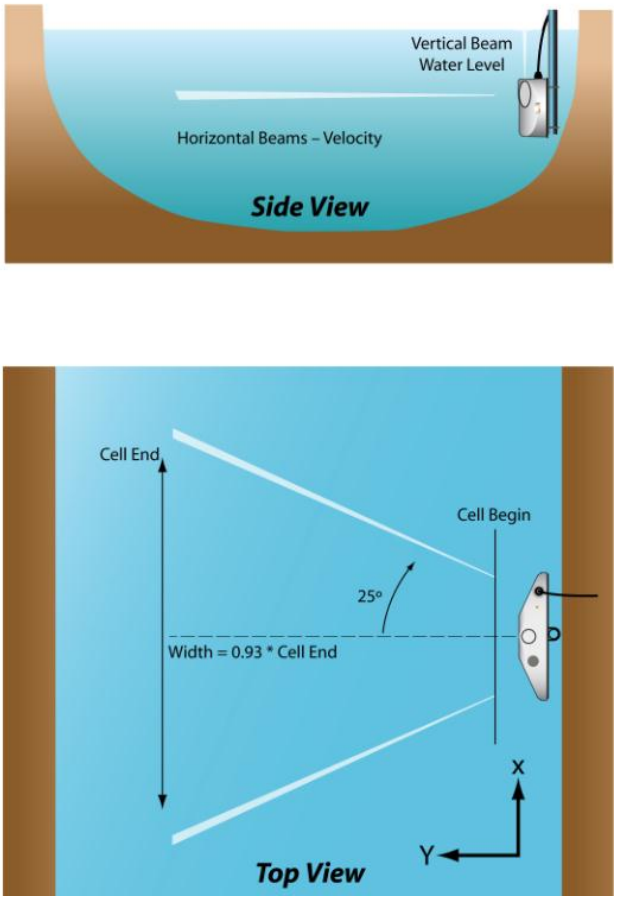


Figure 88. SL Beam Geometry

Water Level Measurement

Water level (Stage) is determined by using a vertical beam and integrated pressure sensor.

- The vertical beam sends a short pulse and listens for the reflection from the surface.
- The surface reflection is very strong and clearly defined, allowing SonTek-SL products to precisely measure the time at which the return reflection is received.
- To convert the reflection time to surface range, SonTek-SL products needs to know the speed of sound in the water at the site, which is primarily a function of temperature and salinity.
  - Th SLs have an internal temperature sensor that automatically compensates for changing conditions by continually updating the sound speed used for surface range calculations.
  - Salinity is user defined. SonTek-SL products do not automatically adjust for salinity variations.
- The vertical beam operating range depends on the SL system frequency. The range specifications can be found in Appendix D.
- The vertical beam works in conjunction with the integrated pressure sensor to determine water level
  - The vertical beam is the principle measurement
  - The pressure sensor is used as a secondary measurement in the case that there is no valid data from the vertical beam
- The pressure sensor is not vented to the atmosphere, therefore it must be calibrated for changes in atmospheric conditions.
  - The pressure sensor is calibrated during the deployment using data from the vertical beam. Thus both sensors can provide reliable and accurate water level data.
  - If vertical beam percent good is greater than 30% use vertical beam for water depth and calibrate pressure sensor
  - If vertical beam percent good is below 30% use pressure for water depth if calibration has occurred within the last 6 hours
  - If vertical beam percent good is below 30% and pressure has not been calibrated for more than 6 hours, use pressure for water depth subject to the following conditions and status codes:
    - If pressure depth is less than 0.04 m, do not report water depth or flow
    - If pressure depth is greater than 0.04 m and less than instrument maximum vertical beam range, use pressure for water depth and activate status code 8192, “Poor depth warning”. Water depth and flow will still be reported but should be used with caution.
    - If pressure depth is greater than maximum beam range, use pressure for depth and activate status code 4096, “Vertical beam range exceeded”. Water depth and flow will still be reported but should be used with caution.
  - If an over pressure condition exists (pipe or closed channel), use vertical beam for water depth when vertical beam percent good is equal to or greater than 30% otherwise use channel vertical dimension.
- Water level data are used to modify the measurement volume location in real-time, optimizing performance with changing water level.

Flow Calculations

One of the primary functions of the SonTek-SL products is to provide real-time flow data and total volume data for water deliveries. SonTek-SL products combine water velocity data and level data with user-supplied channel geometry information about the installation site to calculate flow and volume. SonTek-SL products support flow calculations for a variety of environments:

- Natural streams (defined by a series of survey points)
- Regular and irregular (trapezoidal) channels (typically concrete lined)
- Regular (trapezoidal) culverts with a closed top
- Any channel that can be represented with a stage/area equation

SonTek-SL products combine channel geometry with stage to calculate the cross-sectional area. The area is then multiplied by the mean channel velocity to determine flow. The relationship between the velocity measured by SonTek-SL products and the mean channel velocity can be determined two ways:

- Theoretical flow calculations
- Index velocity calibration

SonTek-SL products can use the measured flow rate to compute the total volume. Total volume is the cumulative sum of flow rate multiplied by time. An example of this type of data is total irrigation volume. This the amount of water delivered through an irrigation channel over a given time span. Total volume is available both in real-time display and output, as well as in the recorded data.

Theoretical Flow Calculations

Theoretical flow calculations are used when no reference flow data are available; that is, only channel geometry and data measured directly by the SL are available. For theoretical flow calculations, the SL makes use of the following information.

- The largest variations of velocity occur with changing depth within the channel.
- Based on the supplied channel geometry, the SL can determine the vertical location of the velocity measurement within the water column. The system assumes the river follows a power-law velocity profile model with a 1/6 power-law coefficient.
- Using this model, combined with the location of the SL velocity measurement, the SL estimates a relationship between the measured velocity and the mean channel velocity.
- The relationship between measured and mean channel velocity will change as water depth changes, since the location of the SL measurements within the water column is also changing.
- The theoretical velocity calculation of the SL should provide good results for regular, concrete lined channels (typically rectangular or trapezoidal in shape) where the SL is installed near the midpoint of the water depth.
- For natural streams or sites with large variations in water depth, SonTek recommends developing an index velocity calibration to provide accurate flow data specific to that site.

Index Velocity Calibration

An index velocity calibration is a popular technique for monitoring discharge when reference discharge measurements are available.

- Discharge measurements are made at a variety of water levels and flow conditions.
- SL water velocity data and stage data are collected at the same time as reference discharge measurements.
- These data are analyzed to determine an empirical relationship between the SL measured velocity and the mean channel velocity. This empirical relationship is then input into the SL, which outputs calibrated flow data in real time.
- The empirical index relationship uses the following form:

$$V_{mean} = V_{intercept} + V_{meas} * (V_{slope} + (StageCoef * Stage))$$

where:

V_{mean} = mean velocity in the channel
$V_{intercept}$ = user-supplied* velocity offset (cm/s or ft/s)
V_{meas} = SL measured velocity
V_{slope} = user-supplied* velocity scale factor (no units)
StageCoef = user-supplied* water depth coefficient (1/s)
Stage = measured stage (total water depth) (m or ft)

***Important**: These constants are empirically derived coefficients based on several user-made, independent discharge measurements. These coefficients relate SL product measured velocity to mean channel velocity as determined by the independent measurements. The details of how these constants are derived are beyond the scope of this appendix. For more information, contact SonTek.

An index velocity calibration will usually supply more accurate flow data than a theoretical flow calculation. However, an index calibration requires extensive reference data and data analysis expertise to construct — for many applications, this is not practical. In these situations, the theoretical flow calculations can provide good quality flow data.

SonTek-SL Data

Sampling Strategy

The SonTek-SL products average data for a fixed interval for each reported water velocity sample.

- The SL samples velocity (via ping) each second. The type of velocity pings depends upon flow conditions.
- The SL pings the vertical beam once per second to measure stage data.
- Pings are accumulated over a user-specified sample duration (typically 1 to 15 minutes) and average values for velocity, stage, and a variety of diagnostic data are reported.
- The sampled data are normally recorded to the SL's internal recorder, and can also be reported to an external data logger.
- The SL can operate continuously (i.e., start the next sample immediately after completing a sample), or it can enter a low power (i.e., sleep) state between samples to conserve power.

Velocity Data
The SL velocity data are determined using three types of acoustic pulses. The SL automatically determines the best pulse scheme to provide the best possible velocity data.

- The SL can measure water velocities from ±0.001 to 7 m/s.
- The SL also measures flow direction and will accurately report reversing flow.
- Data are output in Cartesian coordinates (XY) relative to system orientation.
- Velocity data are accurate to 1% of the measured velocity (after accounting for random noise).
- The SL provides diagnostic parameters with each sample to verify the quality and accuracy of these data.
- The SL calibration will not change with time; the system never requires re-calibration.

Accuracy of Velocity data
The SL is well suited to low-flow applications to less than 0.01 m/s. When discussing the accuracy of the SL water velocity data, we are referring to the presence of any bias in mean velocity measurements. Velocity data may have random short-term variations (noise) that do not reflect a bias to velocity data. Two factors influence the accuracy of SL velocity data: sound speed and beam geometry.

- With properly specified salinity data, sound speed errors are negligible (less than 0.25%).
- Beam geometry is fixed during system construction and will not change with time (unless there is catastrophic physical damage to the system).
- The SL calibration is specified to 1.0% of the measured velocity.
- There is no potential for zero offset or drift in velocity measurements and no inherent minimum measurable velocity.

Signal-to-Noise Ratio
The SL measures velocity by looking at the reflections of an acoustic pulse from particles in the water.

- The magnitude of the reflection is called signal strength. It varies with the amount and type of suspended material, and with the distance from the transducers.
- Signal strength decreases with distance from the transducer due to geometric spreading and sound absorption.
- The distance at which signal strength approaches the electronics noise level determines the maximum measurement range of the SL.
- Signal strength is commonly used as the signal-to-noise ratio (SNR), which compares the magnitude of the received signal to the ambient electronics noise level.
- SNR is reported in logarithmic scale.
- Signal strength data are measured and recorded in internal logarithmic units called counts.
  - Signal strength and noise level are recorded in counts; one count equals 0.43 dB.
  - Signal strength is converted to SNR by subtracting the noise level and converting to dB.
- The SL requires a minimum SNR (≈3 dB) to make accurate velocity measurements.

- Signal strength and SNR reported are the mean value over the measurement volume.

- Signal strength decreases with range from the transducers and will vary with conditions in the water. For good operating conditions, SNR should be greater than 3 dB.

When SmartPulse is enabled, the SL will automatically change the horizontal range of the measurement based on water depth.

- In most conditions, the SL is able to measure to the specified maximum range of 5 m for the SL3000 and 20 m for the SL1500.

- If at any point the signal strength is too low for reliable velocity measurements, the SL will end the measurement volume at that range. In this situation, the system will automatically cut off the measurement volume at the maximum effective range. The exact limits of the measurement volume are recorded with each sample.

Signal strength is primarily a function of the amount and type of particulate matter in the water. While signal strength cannot be immediately converted to sediment concentration, it provides an excellent qualitative picture of sediment fluctuations and, with proper calibration, can be used to estimate sediment concentration.

Flow Data

With each sample, the SL records cross-sectional area and flow.

- Cross-sectional area depends on the user-supplied channel geometry and water level determined by the vertical beam and pressure sensor.
- Typically, the accuracy of area data is most strongly influenced by the accuracy of channel geometry, rather than uncertainty in stage data.

The SL can also be programmed to calculate total volume in addition to flow rate.

- Total volume is the cumulative sum of flow rate multiplied by elapsed time, and represents the total volume of water than has passed the SL.
- Total volume can be accumulated continuously between files (when data collection is interrupted and restarted) or reset with each data file. Several methods are also provided to reset total volume (restart the accumulation at zero) within a data file, if required.
- Total volume can be output in a variety of different units as required by the user.

The accuracy of flow data depends on a few factors.

- Accuracy of cross-sectional area
- Accuracy of velocity data
- Method used to relate measured velocity to mean channel velocity

In general, the largest factor in determining the accuracy of flow data is the method used to relate measured velocity to mean velocity. Some guidelines are presented below:

- A well-established index calibration can give real-time flow accuracy of about 2-3% of the measured flow.
- Theoretical flow calculations in a regular channel (i.e., trapezoidal, concrete lined) may give accuracy of about 3-5%. This can be strongly affected by nearby intake or outlet structures or by nearby changes in channel geometry (including bends in the channel).

- Theoretical flow calculations in natural streams can be difficult. They can provide reasonable results in streams with a simple, uniform cross section, but are notably limited in wide, shallow streams where velocity can vary dramatically across the width of the stream.

Data Output

The SL offers several options for data output, including SDI-12, Modbus, RS232 ASCII and 4-20 mA outputs.

- Only one output type (RS232, SDI-12, Modbus, analog outputs) can be used at a time.
- The SDI-12 serial bus can be used to output a portion of the SL sample data, including velocity and limited diagnostic data. Multi-cell velocity data can also be output in real-time using SDI-12.
  - For SDI-12 operation, the SL is programmed using the RS-232 serial bus, and then Connected to an SDI-12 datalogger.
  - The SL's SDI-12 interface is compatible with SDI-12 revisions 1.0, 1.1, 1.2, and 1.3. Options are provided to allow integration with a variety of data logger types.
  - When using SDI-12, the external data logger controls the timing of SL's data collection.
  - Sample duration must be configured for the SL to provide accurate battery life calculations when using SDI-12.
- The Modbus protocol provides a standardized means to acquire reliable digital data from a variety of sensors.
- The SL can optionally be set up to generate analog output signals.
  - The SL can generate up to four analog output signals at the same time.
  - Analog outputs can be either 4-20 mA or 0-5 VDC (only one analog output type can be used on a single system at any given time).
  - An external analog converter and special software are required to generate the analog output signals.
  - Each analog output signal can represent one variable.
  - The user specifies the range of values represented by the analog output signal, customizing the output range to the particular environment.

The SL can record data to the internal recorder at the same time as any of the above data outputs are being used. SonTek encourages users to always record (and regularly download and archive) data on the internal recorder to ensure full access to diagnostic data.

Speed of Sound Calculations

The SL uses sound speed to convert Doppler shift to water velocity. This section describes how to correct SL velocity data for errors in the sound speed used for data collection.

- Since the SL uses an internal temperature sensor for automatic sound speed compensation, user corrections are rarely needed.
- The only time sound speed corrections are normally required is if salinity has been incorrectly specified.

In shallow water, speed of sound is a function of temperature and salinity. Generally, a temperature change of 5^{o}C or a salinity change of 12 parts per thousand (ppt) results in a change in sound

speed of one percent. The full range of typical temperature and salinity levels (from -5 to 60^{o}C and 0-60 ppt) gives a sound speed range of 1375-1600 m/s (total change of 14%).

SL velocities scale directly with sound speed; that is, a 1% error in sound speed results in a 1% error in velocity measurements. The following formula is used for post-processing corrections and can be directly applied to the output velocity data of the SL.

$$V_{true} = V_{orig} (C_{true} / C_{orig})$$

where:

V_{true} = Corrected velocity measurements
V_{orig} = Uncorrected (original) velocity measurements
C_{true} = True speed of sound
C_{orig} = Speed of sound used in original calculations

Errors in sound speed also affect the physical location of the SL measurement volume, although these errors are generally very small. To calculate the correct location of the SL measurement volume, use the following formula.

$$Z_{true} = Z_{orig} (C_{true} / C_{orig})$$

where:

Z_{true} = Corrected measurement volume location
Z_{orig} = Uncorrected (original) measurement volume location
C_{true} = True speed of sound
C_{orig} = Speed of sound used in original calculations

Appendix C. SmartPulseHD®

SonTek's third generation of side-looking acoustic Doppler profilers-the SonTek-SL (3G)—now features SonTek's exclusive SmartPulseHD®* feature for dynamic selection and optimization of the acoustic pulsing scheme. The feature was first introduced in 2010 with the RiverSurveyor ADCP in down-looking configuration for instantaneous discharge measurements on moving platforms. In 2012, the feature was adapted and transferred to the SonTek-IQ series of velocity and flow meters for continuous measurements in vertical, fixed-mounted configurations in rivers, canals, and pipes. Continuing this trend, SmartPulseHD® now benefits side-looking fixed-mounted systems for use in rivers, canals, and ports/harbors. Because the RiverSurveyor, SonTek- IQ, and SonTek-SL (3G) are each mounted, configured, and operated differently, SmartPulseHD® will work differently in each instrument type.

SmartPulseHD® in the SonTek-SL (3G) works as follows:

The system continuously tracks water velocity and profiling range, depth, turbulence factors, and signal-to-noise-ratio (SNR). Based upon these values, it selects the optimum processing configuration.

At any given time, the system is sending multiple ping types at one acoustic frequency, using different processing techniques to achieve the optimum system performance.

For the SonTek-SL (3G), the acoustic frequency will be either 3000 or 1500 kHz.

Multiple different ping types and processing techniques are utilized: water level detection and water velocity detection; and pulse-coherent, pulse-incoherent, and broadband. The exact technique being used will depend upon operating conditions and may change as conditions change.

The system tracks velocity and depth on a second-by-second basis, and updates the processing technique accordingly.

The best processing technique permitted by conditions will be used. While the selection criteria also depend on horizontal profiling range (frequency-specific criteria—see next section), the velocity criteria used are:

- Pulse-coherent up to 0.7 m/s
- Broadband up to 1.7 m/s
- Pulse-incoherent up to 7 m/s

Specific to side-looking configurations, the system accounts for changing water level and beam spreading effects, and adjusts the horizontal profile to avoid side-lobe contamination. Unlike RiverSurveyor or SonTek-IQ systems, the cell size and number of cells reported in the horizontal profile are user-programmable parameters.

For the SonTek-SL3000(3G)

When the water is sufficiently slow, the system can report data from pulse-coherent pings. If it can be used, pulse-coherent pings generally will offer the lowest standard deviations for a given condition. Maximum horizontal profiling range for pulse-coherent pings is 1.5 m.

If conditions do not permit pulse-coherent pings, the system will select (using SmartPulseHD® algorithms) either broadband or pulse-incoherent pings, within a horizontal profiling range up to 5 m.

Cell sizes are user-defined from 0.04 to 0.5 m.

For the SonTek-SL1500(3G)

When the water is sufficiently slow, the system can report data from pulse-coherent pings. If it can be used, pulse-coherent pings generally will offer the lowest standard deviations for a given condition. Maximum horizontal profiling range for pulse-coherent pings is 5.0 m.

If conditions do not permit pulse-coherent pings, the system will select (using SmartPulseHD® algorithms) either broadband or pulse-incoherent pings, within a horizontal profiling range up to 20 m.

Cell sizes are user-defined from 0.16 to 2 m.

The SonTek-SL (3G) SmartPulseHD® feature utilizes the system's powerful CPU with multi-thread parallel processing routines; some key advantages are listed below.

The parallel processing capabilities allow the system to collect new acoustic pings while at the same time analyze data from the last set of pings. This continuous evaluation of the data allows the system to modify operation, on a second by second basis, to ensure it always uses the best ping types for the conditions at that moment.

The high speed of the CPU means that the SonTek-SL (3G) has no limits in the type of pinging, processing or analysis that can be done. The final performance of the SonTek-SL (3G) is limited only by the physics of underwater sound.

SmartPulseHD® processing should be able to adapt automatically to any operating condition without any user input. Despite this, the SonTek-SL (3G) software (called the "SonTek-SL: Intelligent Flow" software) includes an option to disable SmartPulseHD® processing.

When SmartPulseHD® is disabled, the system will use pulse-incoherent pings only, exactly as done with previous-generation Argonaut-SL Doppler profilers, with the exception that the SonTek-SL (3G) will ping four times faster, even in pulse-incoherent mode.

It is conceivable that users who use velocity data for velocity indexing purposes might want to control the system operation in order to control the variables that may affect a pre-existing velocity index.

*Patent pending

Appendix D. Specifications and Technical Drawings

D-1 Specifications

	SL3000 (3G)	SL1500 (3G)	SL500
Sampling Range[1]	0.1 to 5m (0.3 to 17 ft)	0.2 to 20m (0.7 to 66 ft)	1.5 to 120m (5 to 400 ft)
Minimum Channel Width	0.5m (1.6 ft)	1.0m (3.3 ft)	6.5m (21 ft)
Acoustics -Horizontal Beam Width[2]	1.4°	1.4°	1.4°
-Vertical Beam Width[2]	1.4°	2.9°	3.8°
-Side Lobe Suppression[3]	>60dB	>60dB	>60dB
Multi-cell Velocity Profiling	Up to 128 cells	Up to 128 cells	Up to 10 cells
SmartPulseHD®	Yes	Yes	n/a
SonTek Compass/Tilt	Tilt	Tilt	Compass/Tilt
Internal Nonvolatile Memory	4GB	4GB	4MB
Water Velocity -Range	±7 m/s (23 ft/s)	±7 m/s (23 ft/s)	±6 m/s (20 ft/s)
-Resolution	0.0001 m/s (0.0003 ft/s)	0.0001 m/s (0.0003 ft/s)	0.001 m/s (0.003 ft/s)
-Accuracy	±1% of measured velocity; ±0.005 m/s (0.015 ft/s)	±1% of measured velocity; ±0.005 m/s (0.015 ft/s)	±1% of measured velocity; ±0.005 m/s (0.015 ft/s)
Water Level -Vertical Beam Range	0.1 to 5.0 m (0.3 to 17 ft)	0.15 to 10 m (0.5 to 33 ft)	0.2 to 18.0 m (0.7 to 59 ft)
-Vertical Beam Accuracy	(depth < 3 m): ±0.3 cm (0.01 ft) (depth ≥ 3 m): ± 0.1%	(depth < 3 m): ±0.3 cm (0.01 ft) (depth ≥ 3 m): ±0.1%	(depth < 6 m): ±0.6 cm (0.02 ft) (depth ≥ 6 m): ±0.1%
-Pressure Sensor Range	30 m	30 m	20 m
-Pressure Sensor Accuracy (FS)	0.10% FS	0.10% FS	0.25% FS
-Wave Height Spectra	Optional	Optional	Optional
Power -Input	9-15 VDC	9-15 VDC	7-15 VDC
-Consumption[4]	0.8	1.0 W	0.7 – 1.0 W
Physical -Weight in Air	0.45 kg (1.0 lb)	0.90 kg (2.0 lb)	6 kg (13.2 lb)
-Weight in Water	0.15 kg (0.3 lb)	0.20 kg (0.5 lb)	1.1 kg (2.5 lb)
-Pressure Rating (Max Depth)	30 m (98 ft)	30 m (98 ft)	30 m (98 ft)
-Mounting Plate Dimensions	25 x 17 x 1 cm (10" x 6.7" x 0.4")	25 x 17 x 1 cm (10" x 6.7" x 0.4")	35.5 x 22.9 x 1.5 cm (14" x 9" x 0.6")
-Operating Temperature	-5° to 60°C (23°F to 140°F)	-5° to 60°C (23°F to 140°F)	-5° to 60°C (23°F to 140°F)
-Storage Temperature	-10° to 70°C (14°F to 148°F)	-10° to 70°C (14°F to 148°F)	-10° to 70°C (14°F to 148°F)
Communications -Standard Protocols	RS232/SDI-12/Modbus	RS232/SDI-12/Modbus	RS232/SDI-12
-Software	SonTek-SL: Intelligent Flow	SonTek-SL: Intelligent Flow	ViewArgonaut
-Modbus Interface Module	n/a	n/a	Required for Modbus
-Analog Output Option	Integrated on Flow Display	Integrated on Flow Display	Separate AO module
-Flow Display Type	SonTek Flow Display	SonTek Flow Display	Argonaut®
Temperature Sensor -Resolution	±0.01° C	±0.01° C	±0.01° C
-Accuracy	±0.2° C	±0.2° C	±0.1° C

D-2 Technical Drawings

- English units in inches are presented with metric units in brackets [cm].

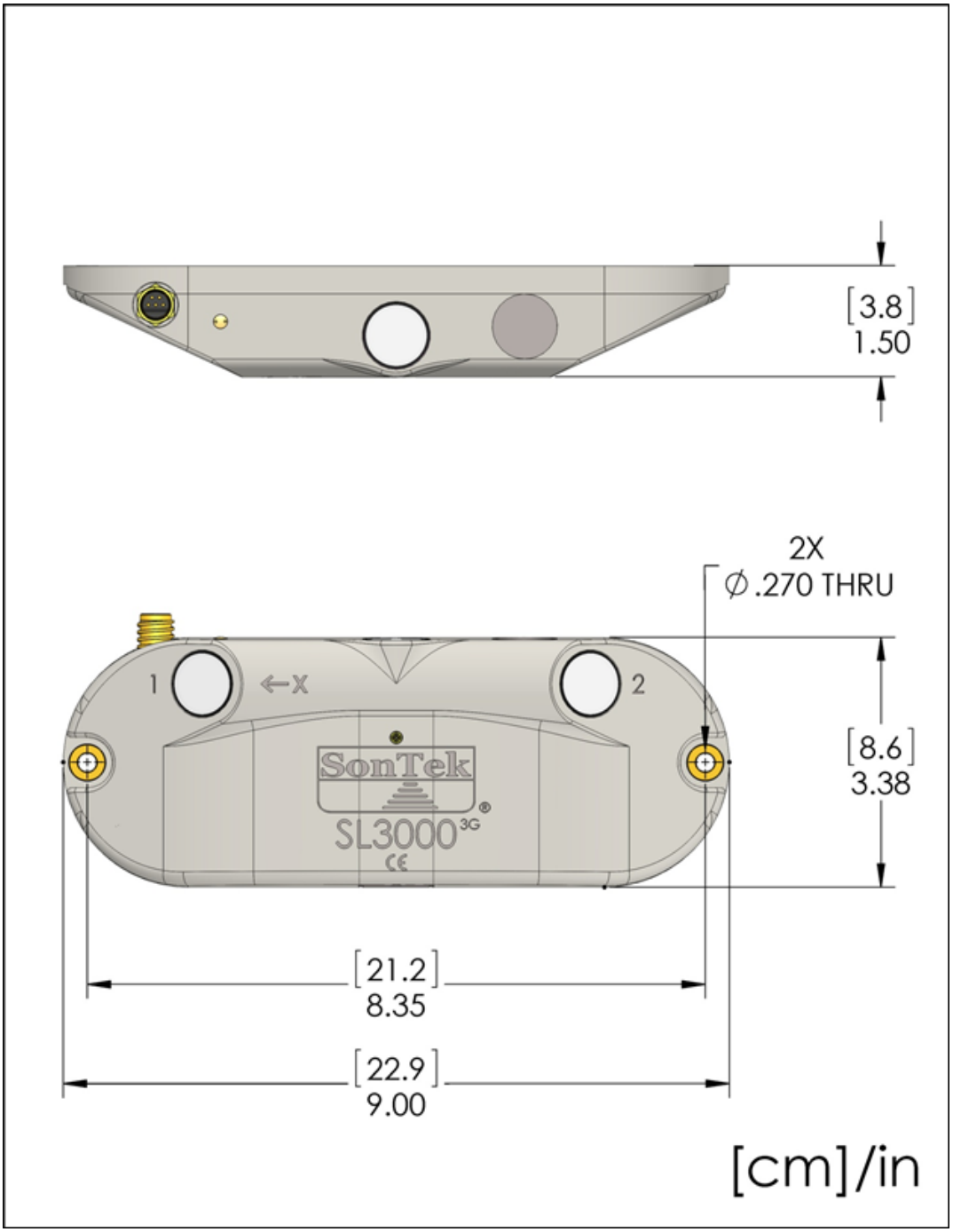


Figure C1. Technical drawing of the SL3000

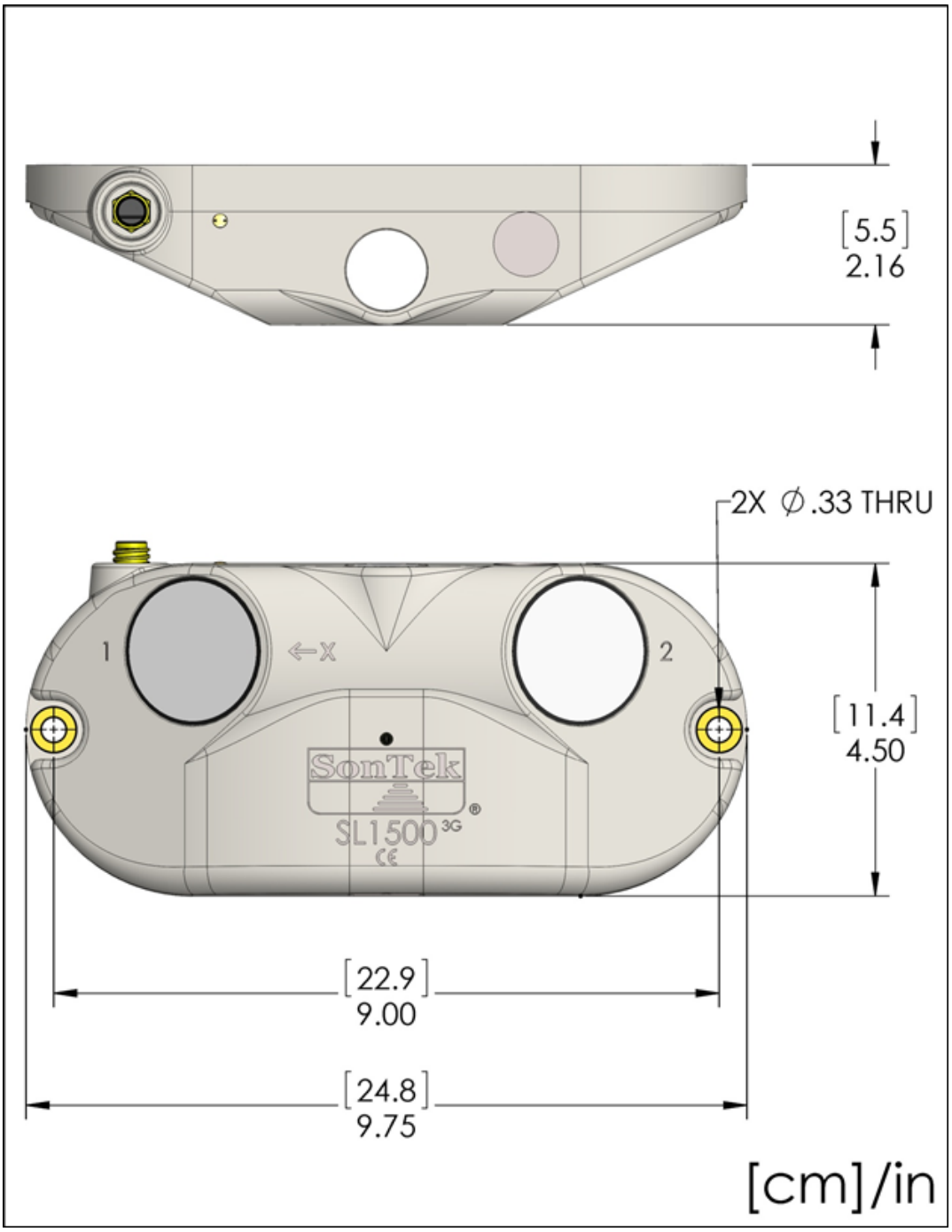


Figure C2. Technical drawing of the SL1500

Appendix E. SonTek Flow Display

The SL Flow Display is an LCD display that can be connected to the SonTek-SL. The Flow Display allows you to view data without the need to connect to a laptop. The Flow Display is operated from the same power supply as the SonTek-SL. Below is a list of features:

- There are two versions of the Flow Display.
  - The standard display with LCD only.
  - The analog output display that includes four channels of 4-20 mA output (Figure D1).
- The display allows pass through communications to the SonTek-SL for downloading and interfacing with a data logger.
- The display has four LED status lights showing system power, if an SL is connected, when Modbus communication is active, and if there are any errors.
- The display includes a backlight for easier viewing.
- An arrow key allows users to scroll through multiple screens of data.

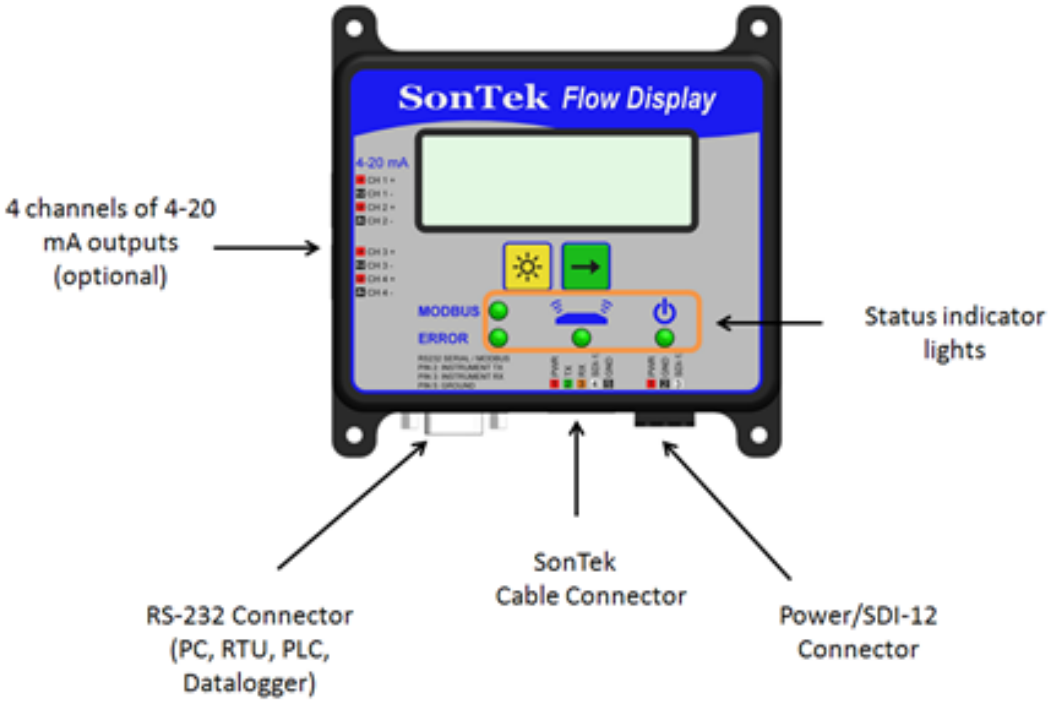


Figure D1. SonTek-SL Flow Display with analog outputs

In most cases, no specific software actions are required to configure the flow display.

- When connected to the SL, the System Information portion of the screen (see Section 3.1.1) indicates the following.
  - If there is a flow display present.
  - If present, whether it is a standard flow display or a flow display with the 4-20 mA analog outputs.

  - What display firmware version is installed.

- The output units used by the flow display are the same as for any other data output, and are set in the SL software (see Section 3.1.5).
- If you have a flow display with the optional 4-20 mA outputs, and you are using these outputs to integrate with an external data logger, these outputs must be specifically configured.
- Guidelines for configuring the analog outputs are given in Section 3.1.5.

Interconnection and Operation

The connection of the Flow Display follows the same procedure as the cable adaptor (Section 1.2).

- When using the Flow Display, the cable adaptor is not needed.
- Figure D2 shows the connection of the SL to the Flow Display.
- It is important to note that there are two options for the Flow Display – a standard version and one with four channels of analog outputs (Figure D2).
- The RS232 connector (bottom left) allows for direct communication with SonTek-SL via laptop, RTU, PLC, or data logger.
- The SL connects to the 5-pin connector (bottom middle).
- Power and SDI-12 connectors use the 3-pin connector (bottom right).
- When present, the upper left of the Flow Display has two 4-pin connectors for the four 4-20 mA output channels.
- The exact pin-outs and standard wire colors for each connector are labeled on the Flow Display.

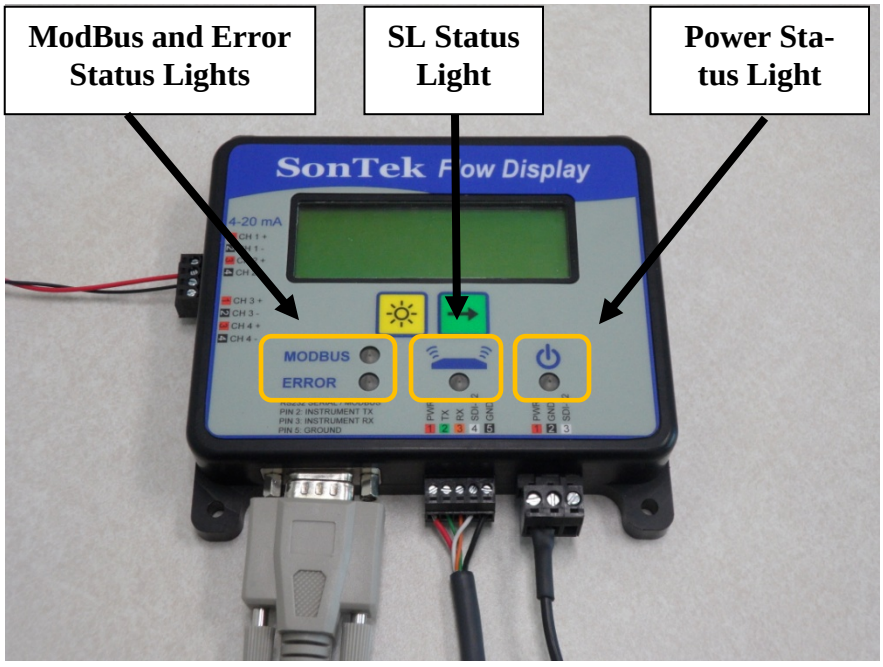


Figure D2. SonTek-SL Flow Display with analog outputs

Status Lights

The Flow Display includes four status LEDs (see figure above).

- The power status light (right side LED, green) indicates when a DC power supply is connected to the flow display.
- The SL status light (middle LED, green) indicates when communication is successfully established between the SL and Flow Display.
- The Modbus status light (left side, upper LED, yellow) will light for 1 second each time a Modbus communication packet is received.
  - Any Modbus communication must match all parameters (baud rate, parity, data bits, stop bits) that have been selected for Modbus communication (see Section 3.1.5).
- The Error status light (left side, lower LED, red) is used for two purposes.
  - It indicates that an invalid Modbus packet was received.
    - Serial communication was received at parameters (baud rate, parity, data bits, stop bits) matching those selected for Modbus communications, but the communication was not a valid Modbus packet.
    - In this case, the Error LED will remain on until a valid Modbus packet is received.
    - The error light does NOT come on if a valid Modbus packet is received, but that packet is not addressed to the specified SL Modbus address.
  - If the SL **System Status** value indicates there is a potential problem with the SL data, the Error LED will turn on.
    - The SL **System Status** value is described in detail in section 6.1.
    - If system status is 0, this means "All Clear" – no potential problems with the SL data have been detected.
    - If system status is greater than 0, one or more potential problems have been detected. The exact value of **System Status** indicates what the potential problem is.
    - Whenever **System Status** is not 0, the Error LED will turn on and remain on until **System Status** returns to 0. A description of the potential problem will be shown on the Flow Display LCD screen.
    - Whenever system status indicates a potential problem, we recommend that you evaluate the site to determine the nature of the problem and resolve it if possible.

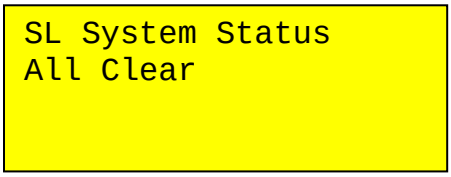
Using the Flow Display

The Flow Display provides two keys for interfacing with the instrument.

 Illuminates the LCD screen for 15 seconds

 Cycles through different screens of data from the SL (effectively a "Next" button). The user can cycle through eight screens using the arrow key. Each screen presents four lines of 20 characters of data.

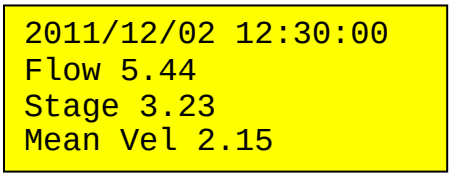
The **Status Screen** indicates any possible errors with the deployment.



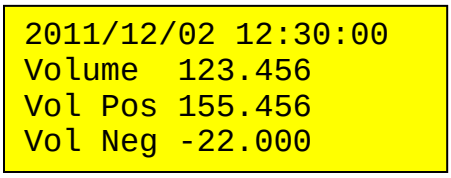
The following are possible status messages based on the data collected. Status messages are designed to prompt you for action (section 6.1).

- **All Clear** – No potential problems have been detected.
- **High Tilt Values** – One or more tilt values is greater than 5º; this may affect data quality.
- **SL may have moved** – One or more tilt values have changed significantly since the start of the deployment; this may indicate the SL has moved.
- **Recorder space low** – Less than 2 weeks of recording time remain on the recorder; data should be downloaded and the recorder formatted as soon as possible.
- **No depth data** – There are a variety of possible causes that may include debris, burial, highly uneven water surface, or too much air in the water.
- **Beam(s) are buried** – One or more of the profiling transducers may be coverer or buried, potentially affecting data quality.
- **Low battery voltage** – Battery voltage is less than 9.0 V; the power supply should be checked and replaced or charged as appropriate.
- **Recorder is full** – No internal recording space is remaining; data should be downloaded immediately and the recorder formatted.
- **Stage too high** – The depth measured by the SL is beyond the defined limits of the channel; no flow calculations are possible (flow will be reported as 0). This may indicate a problem with depth data, or an error in the definition of channel geometry.
- **Bad temperature data** – The temperature sensor may have failed, which will affect the quality of data. The SL should be inspected and may need to be returned for service.

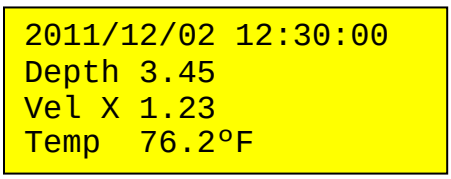
The **Flow/Stage/Mean Velocity Screen** shows flow, stage and mean velocity as well as the time of the last sample.



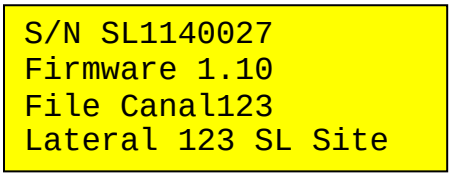
The **Volume Screen** shows total volume (sum of the positive and negative accumulated volume), positive volume (accumulated from positive velocity data) and negative volume (accumulated from negative velocity data).



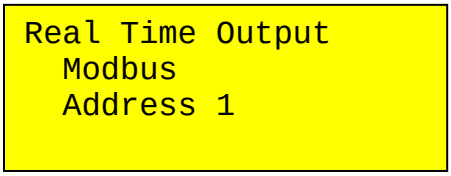
The **Velocity / Depth / Temperature Screen** presents water depth, velocity in the X direction and temperature data.

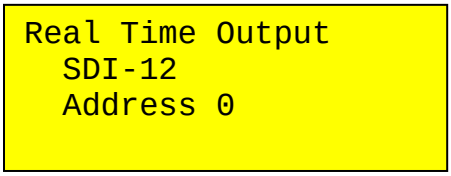


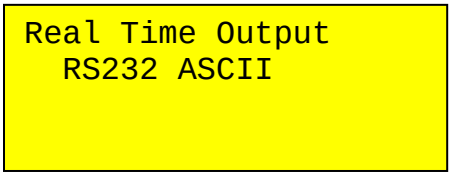
The **System Info Screen** presents serial number, firmware version, file name, and site name.

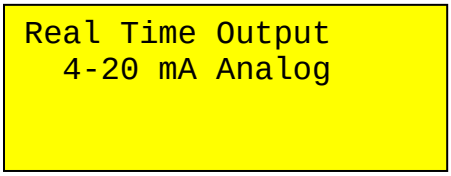


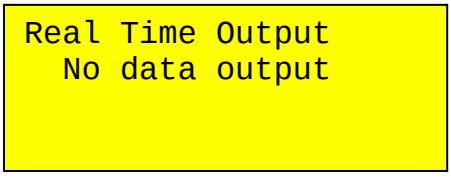
The **Output Type Screen** presents the type of data output the user has specified. If appropriate, the instrument address will be shown.











The **Units Screen** presents the units for which data are displayed. The selection of units is done within the SL software (see Section 3.1.5) and cannot be modified using the Flow Display.

```
Output Units
  ft, ft/s, ºF
  Flow:  cfs
  Volume: acre-ft
```

Power Consumption

- Since the Flow Display and SL use the same power source, overall battery life will be determined by the sum of the two.
- The SL software detects if a flow display is present, and includes that in the battery life calculations (see Section 3.1.2).
  - When doing battery life calculations, you should use the system as it will be used in the field (i.e. if using a flow display, make sure this flow display is connected when you do battery life calculations).
  - If using the "Plan a Deployment" feature, the software assumes that a flow display is not present for all battery life calculations.
- Some typical power consumption values are below.
  - The standard Flow Display consumes approximately 0.10 W of power.
  - The Flow Display with analog outputs, when not using the outputs, consumes approximately 0.20 W.
  - When using the analog outputs, it consumes between 0.5 -3.0 W depending on configuration, number of channels in use, and the data values being output.
  - There is no reliable way to estimate battery life when using the 4-20 mA analog output signals.
  - Use of the backlight increases the power consumption of the Flow Display.
  - Since the backlight only remains on for 15 seconds at a time, it will generally not have a significant impact on battery life.

Limitations

The Flow Display is limited for use with the SonTek-SL and SonTek-SL family of products. It cannot be used with the Argonaut family of products (SW, SL, and XR).

Technical Specifications

A technical drawing of the Flow Display is shown in Figure D3. Dimensions are given in centimeters in brackets [ ], and inches.

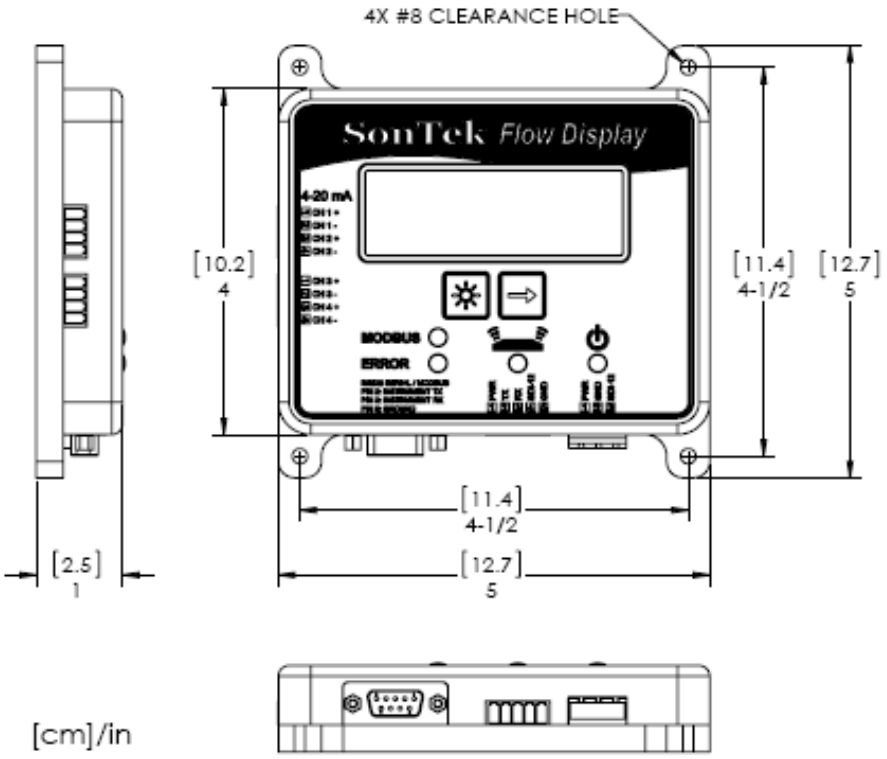


Figure D3. SonTek Flow Display technical drawing

Technical specifications for the optional 4-20 mA analog outputs:

- The maximum drive voltage for the outputs is approximately 29 V. This means the total load on each channel should be no more than about 1400 ohms.
- The 4-20 mA analog outputs use a 16-bit digital-to-analog converter to generate the output current.

Upgrading the firmware for the Flow Display

To upgrade the firmware of the flow display, click on the **File** tab at the top of the screen. Hover over the Maintenance option and then select Flow Display Upgrade (Figure D4).

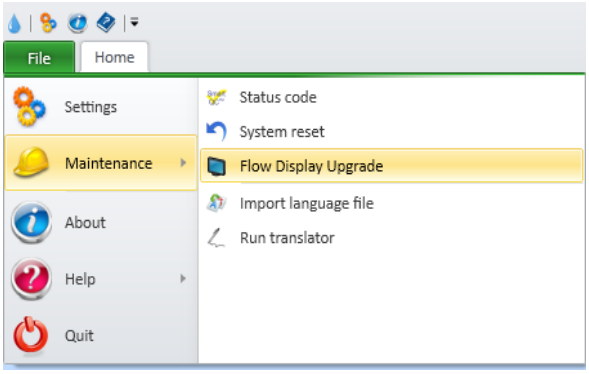


Figure D4. Menu option to upgrade the firmware of the flow display

This menu item is only available when **not** connected to an SL Product. Periodically, upgrades may be available for the firmware inside the SL Flow Display. This option allows users to upgrade the flow display firmware. The software provides detailed on-screen instructions for the upgrade; a brief summary is below.

- Save the new flow display firmware file, provided by SonTek, to your PC.
- From the maintenance menu, select the **Flow Display Upgrade** option.
- Disconnect the SL from the flow display; connect the flow display to your PC. Disconnect power to the flow display and wait 5 seconds.
- While holding both flow display keys down, connect power to the display – this places the display in upgrade mode. Click OK on your PC to start the upgrade.

Follow on-screen instructions once the upgrade is complete.

Appendix F. MATLAB Export

Table 8. MATLAB Flow Data (Time Series Data)

NS = number of samples	Size	
NB = number of profiling beams		
NT = number of transducers		
FlowData Variables		FlowData variables are averaged over the sample duration. Typically, 1 second subsamples are collected and these individual subsample measurements are averaged to get the FlowData variables. The individual subsamples are not available in the Matlab Export. The units for each of the FlowData variables are described in the Data Units Structure.
FlowData_AdjustedPressure	NSx1	Pressure measurement with atmospheric pressure removed.
FlowData_Area	NSx1	Cross-sectional area of water inside the user defined channel. This computed using water depth and instrument location.
FlowData_Batt	NSx1	Battery voltage
FlowData_Depth	NSx1	Water depth above instrument. This is the best depth available from either the vertical beam or the pressure.
FlowData_Flow	NSx1	Computed flow based on the theoretical calculation or index equation.
FlowData_HorizontalSkew	NSx1	Internal system variable tracking the horizontal distribution of velocity in the channel
FlowData_NoiseLevel	NSxNT	Noise level measured by each transducer
FlowData_Pitch	NSx1	Instrument pitch (elevation of the x -axis)
FlowData_PressOffsetAdjust	NSx1	Value used to compute the adjusted pressure. This value can change over time because vertical beam measurements are used to adjust the pressure sensor in real time.

FlowData_Pressure	NSx1	Raw pressure measurement
FlowData_Range	NSx1	Range or distance to the water surface measured by the vertical beam
FlowData_Roll	NSx1	Instrument roll (rotation about the x-axis)
FlowData_SNR	NSxNB	The average signal to noise ratio for each beam
FlowData_SampleNumber	NSx1	Sample number
FlowData_SampleTime	NSx1	Sample time is recorded as the number of microseconds since January 1, 2000 at 00:00:00 AM
FlowData_Stage	NSx1	Water level relative to the channel origin
FlowData_SystemInWater	NSx1	Percent of the time during a sample that the instrument is submerged
FlowData_Temp	NSx1	Water temperature
FlowData_VbPercentGood	NSx1	Percentage of good vertical beam measurements during a sample
FlowData_Vel	NSxNB	Beam average velocity for each profiling beam
FlowData_VelStd	NSxNB	Beam average standard deviation of velocity during the sample for each profiling beam
FlowData_VelXYZ	NSxNB	Depending on which instrument, these are the channel velocities. For SL and SL Pipe, [1] is the depth averaged X channel velocity, [2] is the depth averaged Z channel velocity, [3] is the depth averaged X-channel velocity measured by beam 3, [4] is the depth averaged X-channel velocity measured by beam 4. For side looking systems, [1] is the horizontally averaged X channel velocity, [2] is the horizontally averaged Y channel velocity, [3] is the horizontally averaged X channel velocity within the integrated velocity cell, and [4] is the horizontally averaged Y channel velocity within the user defined integrated velocity cell
FlowData_Vel_Mean	NSx1	The computed flow divided by the cross sectional area of water in the channel

FlowData_Volume_Negative	NSx1	Cumulative volume of water flowing in the negative X direction
FlowData_Volume_Positive	NSx1	Cumulative volume of water flowing in the positive X direction
FlowData_Volume_Total	NSx1	Cumulative volume of water flowing in both positive and negative X directions
FlowSubData_AdpSamplesInWater	NSx1	Number of subsamples recorded within the sample duration. This is typically the sample duration minus 2.
FlowSubData_FirstAdpSampleTime	NSx1	Sample time is recorded as the number of microseconds since January 1, 2000 at 00:00:00 AM
FlowSubData_PrfHeader_0_BlankingDistance	NSx1	Blanking distance setting for beam 1. Distance to beginning of first velocity cell.
FlowSubData_PrfHeader_0_CellSize	NSx1	Velocity cell size setting for beam 1.
FlowSubData_PrfHeader_0_PingMethod	NSx1	Ping method used for each sample collected by beam 1. (0 = Incoherent, 1 = Pulse Coherent, 2 = Broadband, 3 = Diagnostic)
FlowSubData_PrfHeader_0_PulseLength	NSx1	Pulse length setting for beam 1.
FlowSubData_PrfHeader_1_BlankingDistance	NSx1	Blanking distance setting for beam 2. Distance to beginning of first velocity cell.
FlowSubData_PrfHeader_1_CellSize	NSx1	Velocity cell size setting for beam2.
FlowSubData_PrfHeader_1_PingMethod	NSx1	Ping method used for each sample collected by beam 2. (0 = Incoherent, 1 = Pulse Coherent, 2 = Broadband, 3 = Diagnostic)
FlowSubData_PrfHeader_1_PulseLength	NSx1	Pulse length setting for beam 2.
FlowSubData_PrfHeader_2_BlankingDistance	NSx1	Blanking distance setting for beam 3. Distance to beginning of first velocity cell.
FlowSubData_PrfHeader_2_CellSize	NSx1	Velocity cell size setting for beam 3.
FlowSubData_PrfHeader_2_PingMethod	NSx1	Ping method used for each sample collected by beam 3. (0 = Incoherent, 1 = Pulse Coherent, 2 = Broadband, 3 = Diagnostic)
FlowSubData_PrfHeader_2_PulseLength	NSx1	Pulse length setting for beam 3.

FlowSubData_PrfHeader_3_BlankingDistance	NSx1	Blanking distance setting for beam 4. Distance to beginning of first velocity cell.
FlowSubData_PrfHeader_3_CellSize	NSx1	Velocity cell size setting for beam 4.
FlowSubData_PrfHeader_3_PingMethod	NSx1	Ping method used for each sample collected by beam 4. (0 = Incoherent, 1 = Pulse Coherent, 2 = Broadband, 3 = Diagnostic)
FlowSubData_PrfHeader_3_PulseLength	NSx1	Pulse length setting for beam 4.
FlowSubData_SampleNumber	NSx1	
Profile_0_Amp	NS x NC	Beam 1 amplitude measured in each profiling cell
Profile_0_Vel	NS x NC	Beam 1 velocity measured in each profiling cell
Profile_0_VelStd	NS x NC	Beam 1 standard deviation of velocity in each profiling cell
Profile_1_Amp	NS x NC	Beam 2 amplitude measured in each profiling cell
Profile_1_Vel	NS x NC	Beam 2 velocity measured in each profiling cell
Profile_1_VelStd	NS x NC	Beam 2 standard deviation of velocity in each profiling cell
Profile_2_Amp	NS x NC	Beam 3 amplitude measured in each profiling cell
Profile_2_Vel	NS x NC	Beam 3 velocity measured in each profiling cell
Profile_2_VelStd	NS x NC	Beam 3 standard deviation of velocity in each profiling cell
Profile_3_Amp	NS x NC	Beam 4 amplitude measured in each profiling cell
Profile_3_Vel	NS x NC	Beam 4 velocity measured in each profiling cell
Profile_3_VelStd	NS x NC	Beam 4 standard deviation of velocity in each profiling cell

Table 9. MATLAB Data Units Structure

Data_Units	Data units with "<1x1 char>" have no associated units (blanks). These are the default units. These units cannot be changed in the software.
Data_Units.FlowData_SampleNumber	<1x1 char>
Data_Units.FlowData_SampleTime	<1x1 char>

Data_Units.FlowData_Depth	'm'
Data_Units.FlowData_Stage	'm'
Data_Units.FlowData_Area	'm2'
Data_Units.FlowData_Flow	'm3/s'
Data_Units.FlowData_Vel_Mean	'mm/s'
Data_Units.FlowData_Volume_Total	'm3'
Data_Units.FlowData_Volume_Positive	'm3'
Data_Units.FlowData_Volume_Negative	'm3'
Data_Units.FlowData_Vel	'mm/s'
Data_Units.FlowData_VelXYZ	'mm/s'
Data_Units.FlowData_VelStd	'mm/s'
Data_Units.FlowData_SNR	'dB'
Data_Units.FlowData_NoiseLevel	'counts'
Data_Units.FlowData_Range	'm'
Data_Units.FlowData_Temp	'C'
Data_Units.FlowData_Pressure	'dBar'
Data_Units.FlowData_PressOffsetAdjust	'dBar'
Data_Units.FlowData_AdjustedPressure	'dBar'
Data_Units.FlowData_Batt	'V'
Data_Units.FlowData_Pitch	'deg'
Data_Units.FlowData_Roll	'deg'
Data_Units.FlowData_VbPercentGood	'%'
Data_Units.FlowData_HorizontalSkew	<1x1 char>
Data_Units.FlowData_SystemInWater	'%'
Data_Units.FlowSubData_SampleNumber	<1x1 char>
Data_Units.FlowSubData_FirstAdpSampleTime	<1x1 char>
Data_Units.FlowSubData_AdpSamplesInWater	<1x1 char>
Data_Units.FlowSubData_PrfHeader_0_PingMet	<1x1 char>
Data_Units.FlowSubData_PrfHeader_0_Blankin	'mm'
Data_Units.FlowSubData_PrfHeader_0_PulseLe	'mm'
Data_Units.FlowSubData_PrfHeader_0_CellSiz	'mm'
Data_Units.FlowSubData_PrfHeader_1_PingMet	<1x1 char>
Data_Units.FlowSubData_PrfHeader_1_Blankin	'mm'
Data_Units.FlowSubData_PrfHeader_1_PulseLe	'mm'
Data_Units.FlowSubData_PrfHeader_1_CellSiz	'mm'
Data_Units.FlowSubData_PrfHeader_2_PingMet	<1x1 char>
Data_Units.FlowSubData_PrfHeader_2_Blankin	'mm'
Data_Units.FlowSubData_PrfHeader_2_PulseLe	'mm'
Data_Units.FlowSubData_PrfHeader_2_CellSiz	'mm'
Data_Units.FlowSubData_PrfHeader_3_PingMet	<1x1 char>
Data_Units.FlowSubData_PrfHeader_3_Blankin	'mm'
Data_Units.FlowSubData_PrfHeader_3_PulseLe	'mm'
Data_Units.FlowSubData_PrfHeader_3_CellSiz	'mm'

Data_Units.Profile_0_Amp	<1x1 char>
Data_Units.Profile_0_VelStd	'mm/s'
Data_Units.Profile_0_Vel	'mm/s'
Data_Units.Profile_1_Amp	<1x1 char>
Data_Units.Profile_1_VelStd	'mm/s'
Data_Units.Profile_1_Vel	'mm/s'
Data_Units.Profile_2_Amp	<1x1 char>
Data_Units.Profile_2_VelStd	'mm/s'
Data_Units.Profile_2_Vel	'mm/s'
Data_Units.Profile_3_Amp	<1x1 char>
Data_Units.Profile_3_VelStd	'mm/s'
Data_Units.Profile_3_Vel	'mm/s'

Table 10. MATLAB System_IqSetup Structure

System_IqSetup	This structure contains several substructures related to different configuration settings within the system. Not all of these settings are available or settable in the software.
System_IqSetup.basicSetup	The basicSetup structure stores most of the basic user settings, file name, site location, and comments
System_IqSetup.basicSetup.fileName	File name
System_IqSetup.basicSetup.siteName	Site name
System_IqSetup.basicSetup.userComments	User comments
System_IqSetup.basicSetup.operatorName	Operator name
System_IqSetup.basicSetup.flowSampleDuration	Flow sample duration in seconds
System_IqSetup.basicSetup.flowSampleInterval	Flow sample interval in seconds
System_IqSetup.basicSetup.waveSampleInterval	Wave sample interval in seconds
System_IqSetup.basicSetup.currentsSampleInterval	Currents sample interval in seconds
System_IqSetup.basicSetup.userSalinity	User salinity setting
System_IqSetup.basicSetup.outputFormat	Output format. 0 = Sontek Binary, 1 = RS232 ASCII, 2 = Analog, 3 = SDI-12, 4 = Modbus
System_IqSetup.basicSetup.outputMode	Output mode, not used
System_IqSetup.basicSetup.alignFlowSampleToHour	Setting for time of first sample aligning with clock time. 0 = do not align, 1 = sample starts at top of the hour, 2 = sample ends at

	top of the hour
System_IqSetup.basicSetup.standardSettingsChanged	Standard settings changed indicator
System_IqSetup.basicSetup.realTimeSettingsChanged	Real time settings changed indicator
System_IqSetup.basicSetup.spare1	not used
System_IqSetup.basicSetup.batteryVoltage	Battery voltage
System_IqSetup.basicSetup.batteryCapacity	Battery capacity
System_IqSetup.basicSetup.spare	not used
System_IqSetup.advancedSetup	The advancedSetup structure contains a variety of user settings and internal configuration settings.
System_IqSetup.advancedSetup.recorderEnabled	System setting for installed recorder
System_IqSetup.advancedSetup.recordAdpFile	Internal setting to record diagnotic data file (YDFF) file
System_IqSetup.advancedSetup.recordSubSampleProfiles	Number of subsamples to record.
System_IqSetup.advancedSetup.useMeasuredTemperature	System setting for installed temperature sensor
System_IqSetup.advancedSetup.userTemperature	Temperature overide setting
System_IqSetup.advancedSetup.fixedSoundSpeed	Sound speed setting overide
System_IqSetup.advancedSetup.flowSubSampleDuration	Subsample duration in seconds
System_IqSetup.advancedSetup.flowSubSampleInterval	Subsample interval in seconds
System_IqSetup.advancedSetup.adpSampleDuration	not used
System_IqSetup.advancedSetup.adpSampleInterval	not used
System_IqSetup.advancedSetup.pingInterval	Internal system setting
System_IqSetup.advancedSetup.enableAdvancedTiming	Internal system setting
System_IqSetup.advancedSetup.minimumVbPercentGood	Minimum percentage value setting for adjusting pressure using vertical beam measurement
System_IqSetup.advancedSetup.PcOnDepth	Internal system setting
System_IqSetup.advancedSetup.PcOffDepth	Internal system setting
System_IqSetup.advancedSetup.BbOnDepth	Internal system setting
System_IqSetup.advancedSetup.BbOffDepth	Internal system setting
System_IqSetup.advancedSetup.enableDummyOutputData	Internal system setting
System_IqSetup.advancedSetup.maxHoursNoPressureAdjust	Internal system setting
System_IqSetup.advancedSetup.batteryWarningVoltage	Voltage at which warning will appear in software
System_IqSetup.advancedSetup.recorderLifeWarning	Number of days remaining on recorder when warning appears in software

System_IqSetup.advancedSetup.snrDifferenceWarning	Minimum SNR value for software warning
System_IqSetup.advancedSetup.maxTiltWarning	Maximum tilt value for warning (degrees)
System_IqSetup.advancedSetup.minTemperatureWarning	Minimum temperature warning value in degrees Celcius
System_IqSetup.advancedSetup.maxTemperatureWarning	Maximum temperature warning value in degrees Celcius
System_IqSetup.advancedSetup.maxTiltChangeDeg01	Maximum allowed system tilt before software warning
System_IqSetup.advancedSetup.SLcellCount	Number of profiling cells for side-looking system
System_IqSetup.advancedSetup.SLblankingDistance	Blanking distance for side-looking system (mm)
System_IqSetup.advancedSetup.SLcellSize	Cell size for side-looking system (mm)
System_IqSetup.advancedSetup.SLminCellSize	Minimum cell size for side-looking system (mm)
System_IqSetup.advancedSetup.SLmaxCellSize	Maximum cell size for side-looking system (mm)
System_IqSetup.advancedSetup.SLminBlankingDistance	Minimum blanking distance for side-looking system (mm)
System_IqSetup.advancedSetup.maxRange	Maximum profiling range for side-looking system (m)
System_IqSetup.flowSetup	
System_IqSetup.flowSetup.channelType	User setting for type of channel (0 = Irregular open channel, 1 = Trapezoidal open channel, 2 = Trapezoidal culvert, 3 = Round pipe, 4 = Elliptical pipe, 5 = Irregular pipe, 6 = Index equation, 7 = none)
System_IqSetup.flowSetup.equationType	User setting for type of equation (0 = quadratic, 1 = power)
System_IqSetup.flowSetup.surveyOrigin	Location of survey origin (0 = left edge, 1 = right edge)
System_IqSetup.flowSetup.surveyPointCount	Number of points in channel survey
System_IqSetup.flowSetup.instrument_Y	Horizontal location of instrument in channel
System_IqSetup.flowSetup.instrument_Z	Vertical location of instrument in channel
System_IqSetup.flowSetup.channel_Y	Horizontal coordinate of survey points (up to 200)
System_IqSetup.flowSetup.channel_Z	Vertical coordinate of survey

	points (up to 200)
System_IqSetup.flowSetup.bottomWidth	Bottom width of trapezoidal channel
System_IqSetup.flowSetup.topWidth	Top width of trapezoidal channel
System_IqSetup.flowSetup.channelDepth	Depth of trapezodial channel
System_IqSetup.flowSetup.pipeDiameter	Pipe diameter
System_IqSetup.flowSetup.pipeHeight	Pipe ellipse height
System_IqSetup.flowSetup.pipeWidth	Pipe ellipse width
System_IqSetup.flowSetup.areaEquation	Structure with equation coefficients and constants
System_IqSetup.flowSetup.velocityOffset	Velocity equation offset
System_IqSetup.flowSetup.velocityCoeff	Velocity equation coefficient
System_IqSetup.flowSetup.stageCoeff	Stage equation coefficient
System_IqSetup.flowSetup.velocityStartRange	Velocity equation starting range
System_IqSetup.flowSetup.velocityEndRange	Velocity equation ending range
System_IqSetup.flowSetup.velocityType	Indicates which velocity to use in the index equation
System_IqSetup.flowSetup.velocitySource	Not used
System_IqSetup.flowSetup.velocityFirstCell	Not used
System_IqSetup.flowSetup.velocityLastCell	Not used
System_IqSetup.flowSetup.initializeVolume	Initialize volume setting (0 = continuous, 1 = initialize, 2 = reset)
System_IqSetup.flowSetup.useFlowThreshold	Use flow threshold indicator (0 = no, 1 = yes)
System_IqSetup.flowSetup.useVelocityThreshold	Use velocity threshold indicator (0 = no, 1 = yes)
System_IqSetup.flowSetup.boundaryRangeCalculation	Not used
System_IqSetup.flowSetup.initialVolumeValue	Volume setting when initialize volume = 1
System_IqSetup.flowSetup.flowThreshold	Flow threshold
System_IqSetup.flowSetup.velocityThreshold	Velocity threshold
System_IqSetup.flowSetup.validFlowSetup	Indicator for valid setup conditions
System_IqSetup.flowSetup.channelShapeChanged	Channel shape settings changed indicator
System_IqSetup.flowSetup.flowSettingsChanged	Flow settings changed indicator
System_IqSetup.flowSetup.minCellsPowerFit	Minimum number of cells to use for velocity profile curve fitting
System_IqSetup.flowSetup.minDepthPowerFit	Minimum depth for velocity profile curve fitting
System_IqSetup.flowSetup.minVelPowerFit	Minimum power coefficient value
System_IqSetup.flowSetup.useStageThreshold	Use stage threshold indicator (0 = no, 1 = yes)

System_IqSetup.flowSetup.iqOrientation	System orientation (0 = up looking, 1 = down looking, 2 = side looking right, 3 = side looking left)
System_IqSetup.flowSetup.spare1	Not used
System_IqSetup.flowSetup.stageThreshold	Stage threshold
System_IqSetup.flowSetup.maxChannelZ	Maximum channel height
System_IqSetup.flowSetup.sideLookingCellBegin	Beginning of integrated velocity cell for side-looking instrument
System_IqSetup.flowSetup.sideLookingCellEnd	End of integrated velocity cell for side-looking instrument
System_IqSetup.flowSetup.useReverseFlow	Use reverse flow indicator (0 = no, 1 = yes)
System_IqSetup.flowSetup.useVelocityFilter	Use velocity filter indicator (0 = no, 1 = yes)
System_IqSetup.flowSetup.useSnrFilter	Use SNR filter indicator (0 = no, 1 = yes)
System_IqSetup.flowSetup.spare2	Not used
System_IqSetup.unitsSetup	
System_IqSetup.unitsSetup.depthUnits	Units for real time data output
System_IqSetup.unitsSetup.velocityUnits	Units for real time data output
System_IqSetup.unitsSetup.flowUnits	Units for real time data output
System_IqSetup.unitsSetup.volumeUnits	Units for real time data output
System_IqSetup.unitsSetup.areaUnits	Units for real time data output
System_IqSetup.unitsSetup.temperatureUnits	Units for real time data output
System_IqSetup.unitsSetup.pressureUnits	Units for real time data output
System_IqSetup.unitsSetup.spare1	Not used
System_IqSetup.unitsSetup.spare	Not used
System_IqSetup.modbusSetup	
System_IqSetup.modbusSetup.address	Modbus address
System_IqSetup.modbusSetup.baudRate	Modbus baud rate
System_IqSetup.modbusSetup.parity	Modbus parity
System_IqSetup.modbusSetup.inverseFloat	Modbus inverse float
System_IqSetup.modbusSetup.spare	Not used
System_IqSetup.sdi12Setup	
System_IqSetup.sdi12Setup.address	SDI-12 address
System_IqSetup.sdi12Setup.spare	Not used

System_IqSetup.aoSetup	
System_IqSetup.aoSetup.aoType	Type of analog data (0 = current, 1 = voltage)
System_IqSetup.aoSetup.spare	not used
System_IqSetup.aoSetup.address	Analog address
System_IqSetup.aoSetup.dataVariable	Variable selected
System_IqSetup.aoSetup.minValue	Minimum variable value
System_IqSetup.aoSetup.maxValue	Maximum variable vale
System_IqSetup.aoSetup.spare2	not used
System_IqSetup.smartPageStatus	
System_IqSetup.smartPageStatus.systemInfo	Idicator for system status in software
System_IqSetup.smartPageStatus.standardSettings	Idicator for system status in software
System_IqSetup.smartPageStatus.channelShape	Idicator for system status in software
System_IqSetup.smartPageStatus.flowParameters	Idicator for system status in software
System_IqSetup.smartPageStatus.realTimeOutput	Idicator for system status in software
System_IqSetup.smartPageStatus.spare1	Not used
System_IqSetup.smartPageStatus.spare	Not used

Table 11. MATLAB System_IqState Structure

System_IqState	The System_IqState structure is a snapshot of the system on a sample by sample basis. This structure holds the last updated system snapshot.
System_IqState.flowSampleNumber	Last full sample number
System_IqState.flowSampleTime	Time of last sample
System_IqState.flowSampleDuration	Sample duration setting in seconds. This is the length of the sample.
System_IqState.flowSampleInterval	Sample interval setting in seconds. This is the time between samples.
System_IqState.flow	Last computed flow value.
System_IqState.volumeTotal	Last computed total volume
System_IqState.volumePositive	Last computed positive volume
System_IqState.volumeNegative	Last computed negative volume
System_IqState.bestFilteredM	Last computed M coefficient. Used in theoretical flow computations.

System_IqState.pressOffsetAdjust	Last adjusted pressure measurement.
System_IqState.horizFitCoeffFilt[0]	Last computed horizontal fitting coefficient [0]. Used in theoretical flow computations.
System_IqState.horizFitCoeffFilt[1]	Last computed horizontal fitting coefficient [1]. Used in theoretical flow computations.
System_IqState.horizFitCoeffFilt[2]	Last computed horizontal fitting coefficient [2]. Used in theoretical flow computations.
System_IqState.lastPressAdjust	Last computed pressure adjustment value.
System_IqState.skewAdjustFilt[0]	Last computed velocity skew coefficient [0]. Used in theoretical flow computations.
System_IqState.skewAdjustFilt[1]	Last computed velocity skew coefficient [1]. Used in theoretical flow computations.
System_IqState.iqBoxVersion	Flow display firmware version
System_IqState.iqBoxFlags	Interal messages for the Flow display operating system
System_IqState.overPressureState	State variable, if 0 then a pressurized pipe is not detected, if 1 then pressurized conditions detected
System_IqState.spare1[0] to [2]	Spare storage locations not currently used
System_IqState.spare2[0] to [27]	Spare storage locations not currently used

Table 12. MATLAB System_Id Structure

System_Id	Typical values	
System_Id.InstrumentType	'SL'	String describing the type of instrument
System_Id.InstrumentVersion	200	Firmware version number (172 is version 1.72)
System_Id.SerialNumber	'SL0000013'	System serial number
System_Id.InstrumentSubType	<1x1 char>	usually blank
System_Id.InstrumentFamily	'SonTek'	Instrument manufacturer
System_Id.InstrumentFriendlyName	'SL'	Instrument string

Appendix G. ASCII Command Interface

ASCII Command Requirements

This section will describe the details of the ASCII commands available in Firmware v2.2. In general, all ASCII commands for the SL3G require the following:

- All commands must be followed by a carriage return (hit Enter to send)
- If a command has an abbreviation, it can be used interchangeably with the full command,
- Commands are not case sensitive.
- Text commands, by themselves, will return the current setting.
- Text commands followed by values (numbers or characters), will save the new setting value to the SL3G and respond with an "OK".
- New setting values are immediately saved to the SL3G if it is not sampling.
- If the SL3G is sampling, the settings cannot be changed, but the current settings can be viewed
- An error message will occur if you attempt to change any settings while the SL3G is sampling. This will not interrupt the measurements. Settings cannot be changed while collecting data.

ASCII Command Details

+++

This command followed by a carriage return will interrupt the current sample.

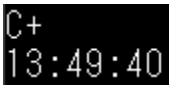
Argonaut Difference: On the Argonaut, after connecting to the serial port, pressing multiple "+" keys on the keyboard would wake the instrument from sleep or interrupt the sample. The user did not have to hit enter or carriage return to issue this command

T

This command followed by a carriage return will respond with the current system clock time in twenty-four hour time format (13:48 is 1:38 pm).

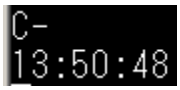
C+

This command followed by a carriage return will increase the system clock time by 1 second. It will respond with the new clock time



C-

This command followed by a carriage return will decrease the system clock time by 1 second. It will respond with the new clock time



Deployment

This command followed by a carriage return will display the current setting for the file name. The Argonaut referred to this as the deployment name and used it as the file prefix. The SL3G also uses this as the prefix for the filenames. Files saved to the recorder will have this prefix followed by a time stamp.

```
Deployment
Current deployment name is: Ascii.
```

This command followed by some text and a carriage return will change the filename to the text value.

```
Deployment AscTest
OK
```

If the above command is issued while the SL3G is sampling, the system will return the following error message.

```
deployment AscNow
FAIL: DAQ in progress.
deployment name was not saved
```

Comments

This command followed by a carriage return will display the comments currently stored in the system.

```
Comments
Current deployment comments are: Ascii command testing.
```

This command followed by up to 120 characters and a carriage return will save the new text to the standard settings comments and return an OK if successful.

```
Comments New comments for Ascii testing
OK
```

Argonaut Difference: On the Argonaut, the user was expected to enter up to three lines of text each with a maximum of 60 characters. The SL3G only expects one continuous line of text.

If this command is sent while the SL3G is sampling, you will see the following error message.

```
FAIL: DAQ in progress.
comment was not saved
```

AvgInterval or AI

This command followed by a carriage return will display the current averaging interval setting.

```
AvgInterval
Current averaging interval is 12 s.
```

```
AI
Current averaging interval is 10 s.
```

To set the averaging interval, send the command followed by an integer. Decimals will be truncated and ignored. If you were to send 15.9, the averaging interval will be set to 15 seconds.

```
AvgInterval 12
OK
```

```
AI 15.9
OK
AI
Current averaging interval is 15 s.
```

The averaging interval must be an integer between 10 and 3600 seconds.

```
AvgInterval 2
Averaging interval must be greater than 10 seconds.
AvgInterval 4800
Averaging interval must be less than 3600 seconds.
```

If your settings are such that the averaging interval is greater than the sample interval you will see the following error after sending the start command.

```
start
Configuration errors: Flow Sample Duration (AvgInterval) must be less than or equal to Flow Sample Interval (
SampleInterval).
```

If you try to send the "AvgInterval" command with a parameter while the system is sampling, you will see the following message and the new value will not be saved.

```
avginterval 14
FAIL: DAQ in progress.
averaging interval was not saved
```

SampleInterval or SI

This command is nearly identical to the "AvgInterval" command above except that it sets the flow sample interval. Please refer to the AvgInterval section above for a description of this command.

CellBegin or CB

This command sets the distance between the instrument and the beginning of the Integrated Velocity Cell (IVC) in meters. Sending this command by itself will return the current system setting in meters. The units will always be meters for this command.

```
CellBegin
Current cell begin is 0.20 m.
```

```
CB
Current cell begin is 0.10 m.
```

Sending the "CellBegin" command followed by a decimal value in meters will change the cell begin setting. The system will respond with "OK" to acknowledge the setting has been changed.

```
CellBegin 0.5
OK
```

The firmware will check to make sure the cell begin value is valid. The limits shown below are for an SL3G 1500. The SL3G 3000 cell begin must be >= 0.04m and <= 5 m.

```
CellBegin 0.01
Cell begin must be >= 0.20 m.
CellBegin 24
Cell begin must be <= 20.00 m.
```

If the IVC settings are not valid, the instrument will still start sampling, but flow data will be disabled. For example, if the blanking distance is greater than the distance to the beginning of the IVC, you will see the following warning before starting measurements.

```
start
[W:UswApp] The integrated velocity cell end is beyond the extent of the velocity cells
[W:UswApp] Invalid flow setup. Flow data will not be available.
OK
```

If you send this command with no parameter while sampling, the instrument will respond with the current setting. If you try to change the setting while sampling you will see a warning message.

```
cellbegin
Current cell begin is 0.50 m.
cellbegin 4
FAIL: DAQ in progress.
cell begin was not saved
```

During the writing of this document a SW/FW bug was found for incorrect IVC settings. It is currently possible to set the cell end closer than the cell beginning. Neither the software nor the firmware accurately checks for this mistake. This will be addressed in the next beta version.

CellEnd or CE

The “CellEnd” or “CE” command is identical in operation to the “CellBegin” command. Please refer to the above section for details on this command.

Ncells or NC

This command sets the number of cells in the velocity profile. Sending this command followed by a carriage return will show the current number of cells in the profile. As a reminder, capitalization is not necessary, only the correct spelling of commands is required.

```
ncells
Current number of cells is 5.
```

```
NC
Current number of cells is 10.
```

Sending this command with an integer will change the number of cells. Decimals are truncated and only the integer number of cells will be set. The instrument will respond with “OK” to acknowledge the setting change.

```
ncells 8
OK
```

As with other commands, you cannot change the number of cells once sampling has begun.

```
ncells 9
FAIL: DAQ in progress.
number of cells was not saved
```

The number of cells must be greater than zero and less than or equal to 128.

```
ncells 140
Number of cells must be <= 128.
ncells 0
Number of cells must be greater than 0.
```

CellSize or CS

This command sets the size of the velocity cells in the velocity profile in meters. Sending this command followed by a carriage return will display the current cell size setting.

```
cellsize
Current cell size is 2.00 m.
```

```
CS
Current cell size is 0.20 m.
```

Sending the CellSize command followed by a decimal number will update the cell size setting. The SL will respond with "OK" once the cell size is changed.

```
cellsize 0.5
OK
```

There are different minimum and maximum values for the cell size settings depending on the instrument frequency. The SL3G 1500, shown below, can have cell sizes between 0.16 and 2.0 meters. The SL3G 3000 has cell sizes between 0.04 and 0.5 meters.

```
cellsize 3
Cell size must be <= 2.00 m.
cellsize 0.04
Cell size must be >= 0.16 m.
```

As with other ASCII commands, the cell size cannot be changed while the SL is sampling.

```
cellsize 5
FAIL: DAQ in progress.
cell size was not saved
```

It is possible to configure the cell size and number of cells so that the maximum range of the SL is exceeded. The firmware will not prevent you from doing this, but the SL will not start sampling when configuration errors are found. After the "start" command is sent, the firmware checks the range of the velocity cell settings.

```
cellsize 2
OK
ncells 120
OK
start
Configuration errors: Profile settings exceed maximum range
```

BlankDistance or BD

The BlankDistance command sets the blanking distance between the transducers and the first velocity cell. Sending this command by itself will return the current setting.

```
BlankDistance
Current blanking distance is 1.00 m.
```

Sending this command followed by a decimal value changes the blanking distance setting.

```
BlankDistance 0.2
OK
```

```
BD
Current blanking distance is 0.10 m.
```

There are different minimum and maximum values depending on the system transmit frequency. The SL3G 1500 blanking distance must be between 0.16 and 19.84 meters. The SL3G 3000 blanking distance must be between 0.1 and 4.96 meters. The minimum blanking distance value is determined by transducer ringing. All transducers have a ringing effect that inhibits signal reception near the transducer. The maximum blanking distance value is the maximum instrument range minus one cell of the minimum size. All velocity profiles must have at least one cell.

```
BlankDistance 0.05
Blanking distance must be >= 0.16 m.
BlankDistance 21.1
Blanking distance must be <= 19.84 m.
```

The blanking distance cannot be changed while the SL is collecting data.

```
BlankDistance 0.5
FAIL: DAQ in progress.
blanking distance was not saved
```

Show Conf or S Conf

The ASCII “Show” commands do not change any of the system settings. These commands are only used to display the configuration settings. The “Show” commands can be sent while the system is idle or while sampling. The text and spacing of these commands was copied from the Argonaut manual, but not all of the Argonaut parameters are included in the SL3G output.

Product management will need to compare the SL3G “Show” command output with the Argonaut output and decide which parameters to keep or delete. During firmware development, several parameters were removed because they were irrelevant to SL3G operation. However, these tables can be easily modified to display any or all of the Argonaut parameters.

In the following descriptions, the parameters that are hard coded in the firmware will be noted. If a parameter is not “hard coded” it is an active parameter that is stored in the SL3G data structures.

The “Show Conf” command displays the current hardware configuration. The following parameters in this table are hard coded in the firmware: Number of beams, Beam Geometry, Slant angle, System Orientation, Compass installed, and Recorder installed.

```
show conf

HARDWARE CONFIGURATION PARAMETERS
---------------------------------
System Type---------------------- SL1500-3G
Sensor serial # ----------------- 9999
Sensor frequency - (kHz)-------- 1500
Number of beams----------------- 2
Beam Geometry-------------------- 2_BEAMS
Vertical beam ------------------- YES
Slant angle - (deg)------------- 25.0
System Orientation--------------- SIDE
Compass installed---------------- NO
Recorder installed--------------- YES
Temperature sensor--------------- YES
Pressure    sensor--------------- YES
Ctd         sensor--------------- NO
PressOffset  - (dbar)----------- 0.000000
PressScale  -- (dbar/count)----- 0.003200
PressScale 2 - (pdbar/count^2) - 0.000000
```

Show System or S System

The “Show System” command displays the current system parameters. This list was copied from the Argonaut manual, but some of these parameters are not available in the SLs. The “CPU Ver” is hard coded in the firmware because the SL3G uses the IQ platform. The “DSP Ver” and “BoardRev” are available parameters from the SL configuration structures, but these are not currently filled with relevant values during the instrument build.

```
CURRENT SYSTEM PARAMETERS
-------------------------
CPU Ver --- IQ
DSP Ver --- 0
BoardRev -- 0
Date ------ 2017/02/14
Time ------ 07:44:04
OutFormat - ASCII
Recorder -- ON
```

Show Setup or S Setup

The “Show Setup” command will display the current setup parameters. The “CoordSystem” and “Profiling Mode” are hard coded in the SL3G firmware. The SL3G does not have a compass; it can only operate in “XYZ” mode. The SL3G is always in profiling mode recording at least the first 10 cells of data even if the velocity profiles are not being saved to the recorder.

All other parameters display the current user configuration settings.

```
Show Setup

CURRENT SETUP PARAMETERS
------------------------
Temp ----------- 20.00 deg C
Sal ------------ 25.00 ppt
TempMode ------- MEASURED
Sound Speed ---- 0.00 m/s
AvgInterval ---- 12 s
SampleInterval - 12 s
CellBegin ------ 0.50 m
CellEnd -------- 15.00 m
CoordSystem ---- XYZ
RevXVelocity --- YES
ProfilingMode -- YES
Ncells --------- 10
CellSize ------- 2.00 m
BlankDistance -- 0.20 m
```

Show Deploy or S Deploy

The “Show Deploy” command will display the current deployment parameters. This table is significantly shorter than its Argonaut equivalent. Because the SL3G does not support the Argonaut “Deploy” command (starting at a future date and time), the “StartDate” and “StartTime” were removed from this table. The Burst mode, Burst Interval, and Samples Per Burst were also removed.

Argonaut difference: The comments section in the SL3G will be displayed as one line of text up to 120 characters. The Argonaut displays up to 3 lines of text up to 60 characters each.

These differences are not expected to affect operation with USGS data loggers, but any of the “Show” tables can be modified to meet any USGS specifications.

```
CURRENT DEPLOYMENT PARAMETERS
-----------------------------
Deployment ------ AscTest
AvgInterval ----- 12 s
SampleInterval -- 12 s
Comments:
New comments for Ascii testing
```

Start

The start command will initiate a measurement. Before the SL3G begins sampling, the configuration settings are verified.

There are three conditions that will prohibit the SL3G from collecting data after receiving a start command:

- If the velocity cells are beyond the range of the instrument
- If the sample duration is longer than the sample interval
- If the output format type is SDI-12

The SL3G will not start if any of the above conditions are true.

```
start
Configuration errors: Profile settings exceed maximum range
```

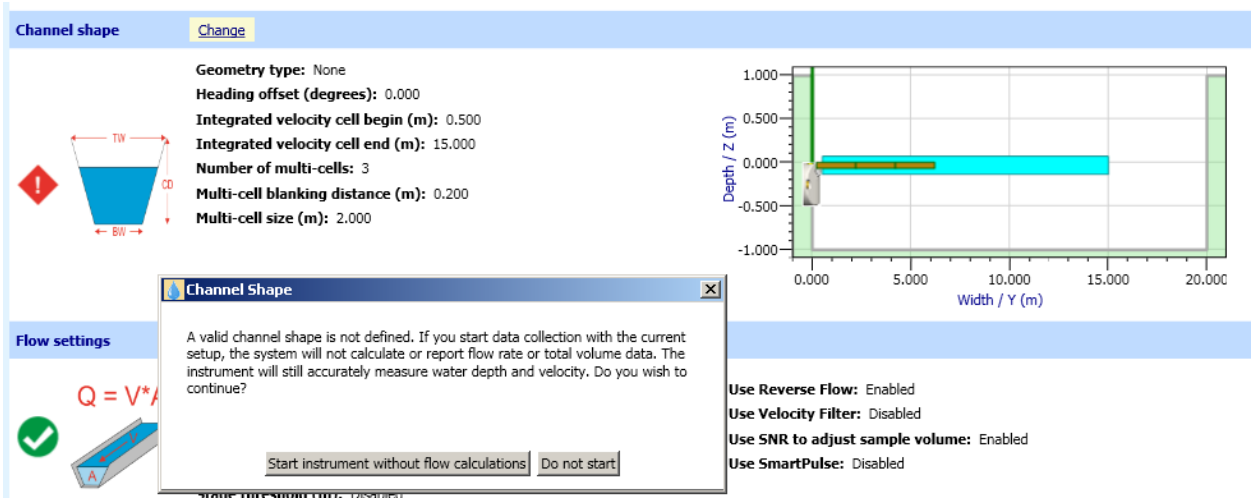
```
start
Configuration errors: Flow Sample Duration (AvgInterval) must be less than or equal to Flow Sample Interval (
SampleInterval).
```

```
start
Start command disabled when output type is SDI-12.
```

If the above settings are ok, the SL3G will begin sampling even if other configuration problems are detected.

For example, if the channel settings are incompatible with flow computations the SL3G will start collecting depth and velocity data only (no flow data). This behavior is slightly different when using the SL3G software to begin measurements.

The SL3G software will attempt to prevent the user from starting a measurement with incompatible channel settings. The user will see a dialog stating the flow data will not be saved and they can decide to continue with the data collection or not.



If the "Start" command is sent from a terminal program, the firmware will simply warn the user and begin measurements.

```
start
[W:UswApp] The integrated velocity cell end is beyond the extent of the velocity cells
[W:UswApp] Invalid flow setup. Flow data will not be available.
OK
```

Stop

This command is not available in the Argonauts. The "Stop" command was added to simplify the syntax of the start/stop functions. The "Stop" command will interrupt sampling just like the "+++" command.

To stop sampling enter the "Stop" command followed by a carriage return.

```
stop
[W:UswApp] Skipping flowSample 2
OK
```

The SL3G will respond with the sample number of the sample that was interrupted.

SerNum

This command shows the serial number of the SL3G.

```
sernum
SL1305006
```

Date

The Date command will display or set the current date on the system clock.

```
Date
2017/02/14
```

When setting the date, the SL3G will respond with the new date and time.

```
Date 2017/02/16
OK:2017/02/16 08:40:43.589
```

If the format of the new date is incorrect; the SL3G will respond with a warning.

```
Date 2017
Date format should be YYYY/M/D
date was not set
```

Some incorrect dates will be accepted. For example, February 31st will be correctly set as March 3rd.

```
Date 2017/02/31
OK:2017/03/03 08:41:23.839
```

But trying to set the 13th month will result in a clock reset.

```
Date 2017/13/02
OK:2000/01/01 00:00:00.001
```

If the date parameter format is readable but erroneous, the default date and time will be set to January 1st 2000 00:00:00.

Time

The Time command will display the current system clock time or set the system clock time. The system clock is displayed in the 24 hour time format.

```
Time
00:06:35
```

When setting the time, the SL3G will respond with the new system clock time.

```
Time 08:50
OK:2017/02/14 08:50:00.001
```

The time parameter must be in the 24 hour format.

```
Time 8:50
Time is 24 hour time and format should be HH:MM:SS
time was not set
```

Certain format errors will result in the clock returning to the default time.

```
Time 0850:27
OK:2000/01/01 00:00:00.001
```

You can only set the clock to the nearest second.

```
Time 09:10:42
OK:2017/02/14 09:10:42.001
```

Decimal seconds are ignored.

```
time 09:10:25.35
OK:2017/02/14 09:10:25.001
```

OutFormat or OF

This is a multi-purpose command. The "OutFormat" command can set both the type of data output (ASCII, Binary, Modbus, SDI-12, Analog, None) and the output units (Metric, English).

Sending the command by itself will display the current output format setting.

```
OutFormat
OutFormat BINARY
```

```
OF
OutFormat SDI12
```

Sending the command with one of the parameters will update the output format setting. If the output format is successfully changed, the SL3G will respond with "OK".

```
OutFormat SDI12
OK
```

If there is a problem setting the output format type you will see a warning message.

```
OutFormat SDI!@
output format was not set
```

IMPORTANT NOTE, the SL3G will continue to communicate and respond to ASCII commands when the output format is not “ASCII”. The output format only controls the type of output data, not the serial port communications.

You can also use the “OutFormat” command to change the output data units to Metric or English units. The SL3G will respond with an “OK” if the change is successful.

```
Outformat METRIC
OK
```

OutFormat Units or OF Units

A new command, not available on the Argonauts, was added for displaying the output units. The Argonaut and the SL3G always display the configuration parameters in meters for the “Show” commands. Because none of the limited set of the SL3G “Show” commands will display the output units, the new command option “OutFormat Units” was added.

The response to “OutFormat units” will be Metric, English, or Custom. The “Custom” response indicates that a mix of different output units was configured using the software.

```
OutFormat units
METRIC
```

```
OF units
METRIC
```

Temp

The Temp command changes or displays the user defined temperature setting. This temperature is used to override the measured temperature when the temperature mode is set to “USER”. The temperature, whether it is measured or user-defined, is used to compute the speed of sound in water. The speed of sound is used to compute velocity from the measured Doppler shift of the received acoustic pings, and the range of the vertical beam pings. The speed of sound is more sensitive to temperature than salinity, but both of these parameters are included in the sound speed equations.

To see the current temperature setting, send the temp command by itself.

```
temp
Current User temperature is 20.20 deg C
```

To change the user temperature, send the command with an integer or decimal value. The SL3G will respond with “OK” after changing the temperature setting.

```
temp 20.45
OK
```

Warning messages are displayed if the temperature parameter is out of range. The acceptable range for the temperature setting is -10 to 80 degrees Celsius.

```
temp 100
User temperature must be <= 80.00 deg C.
user temperature was not set
temp -20
User temperature must be >= -10.00 deg C.
user temperature was not set
```

The temperature setting is only applied if the TempMode is set to USER.

TempMode or TM

This command controls the temperature mode of sound speed calculation. There are two modes: USER and MEASURED. The default setting is MEASURED. The default setting is almost always used, but if a system should have a faulty temperatures sensor, this command can be used to correct the velocity and range data.

Send the command by itself to see the current temperature mode setting.

```
TempMode
Current temperature mode is MEASURED
```

```
TM
Current temperature mode is MEASURED
```

Send the command with either MEASURED or USER to change the mode. Capitalization is not required.

```
TempMode User
OK
Current User temperature is 12.00 deg C
TempMode Measured
OK
```

If you are setting the mode to USER, the SL will display the current user-defined temperature setting. If you are setting the mode to MEASURED, the SL responds with an "OK"

Sal

This command sets or displays the user-defined salinity in parts per thousand (ppt). The salinity value is used in computing velocity and range.

To see the current salinity setting, send the "Sal" command with no parameter.

```
Sal
Current salinty is 0.00 ppt
```

To change the salinity, send a decimal value along with the command.

```
Sal 20.2
OK
```

The salinity setting must be greater than or equal to 0.00 ppt and less than or equal to 300.00 ppt. Settings outside of this range will produce warning messages.

```
Sal -40
Salinty must be >= 0.00 ppt.
salinity was not set
Sal 500
Salinty must be <= 300.00 ppt.
salinity was not set
```

SoundSpeed

This is a new SL3G command that will rarely be used, but it provides a short cut to setting a specific sound speed to use for velocity and range calculations. The same result can be achieved with the appropriate user-defined temperature and salinity settings which match the desired sound speed.

The default "SoundSpeed" setting is zero, to deactivate. When "SoundSpeed" is zero, the temperature and salinity settings are used. If the "SoundSpeed" setting is some value other than zero, this setting is used to compute range and velocity. Typical values are between 1400 and 1600 meters per second.

To see the current sound speed setting, send the "SoundSpeed" command with a carriage return.

```
soundspeed
Current sound speed is 0 m/s
Zero value indicates sound speed is computed using temperature and salinity settings
```

To change the sound speed, send an integer value. Decimal values are ignored.

```
SoundSpeed 1487
OK
```

Sound speed cannot be greater than 1800 m/s or less than zero.

```
soundspeed 1900
Sound speed must be <= 1800 m/s.
Sound speed was not set
soundspeed -3
Sound speed must be >= 0 m/s.
Sound speed was not set
```

See the last section "A note about sound speed" for details on the firmware sound speed computation.

ReverseXVelocity or RXV

This command will multiply the channel x-direction velocity by a negative one (-1), effectively reversing the velocity direction. This command is mainly for convenience to match the velocity convention a user is expecting to see regardless of the alignment of the instrument (right or left side of channel).

To see the current setting for "ReverseXVelocity" send the command followed by a carriage return.

```
ReverseXVelocity
ReverseXVelocity setting is NO
```

You can also send the abbreviated command "RXV"

```
RXV
ReverseXVelocity setting is NO
```

To change the setting, send “Yes” or “No” following the command. The SL3G will send “OK” to confirm the setting has been changed.

```
ReverseXVelocity YES
OK
```

Leading spaces are ignored between the command and the parameter.

```
ReverseXVelocity    No
OK
```

An incorrect parameter will return a warning message.

```
ReverseXVelocity Sometimes
ReverseXVelocity was not set
```

Dir or LD

The “DIR” command will list all the files currently stored on the data recorder. You can also send “LD” to display the file list. For each file, the file name, the date the file was started, the time the file was started, and the size of the file in Megabytes (MB) are displayed in a list.

```
DIR
Crane2202_20170331_143909.SL 2017/03/31 14:39:09  0.062
Crane2202_20170331_143208.SL 2017/03/31 14:32:08  0.206
Crane2202_20170331_140535.SL 2017/03/31 14:05:35  0.636
Crane2202_20170331_134926.SL 2017/03/31 13:49:26  0.090
Crane2202_20170331_125145.SL 2017/03/31 12:51:45  1.369
Crane2202_20170331_124508.SL 2017/03/31 12:45:08  0.062
Crane2202_20170331_124002.SL 2017/03/31 12:40:02  0.098
Crane2202_20170331_123418.SL 2017/03/31 12:34:18  0.098
Profiles_20170330_133026.SL 2017/03/30 13:30:26  0.052
```

At the end of the list a summary of the number of files and the total used space is displayed.

```
Profiles_20170327_094309.SL 2017/03/27 09:43:09  0.061
Profiles_20170327_092803.SL 2017/03/27 09:28:03  0.059
Profiles_20170327_092711.SL 2017/03/27 09:27:11  0.058
136 files, 58.063 Mbytes
```

Format

The format command will erase all files from the recorder. This command will be followed by a question prompt to ensure that you wish to continue with the format procedure. Files cannot be recovered after the recorder has been formatted.

```
format
Are you sure? YES/NO
n
Cancel format
OK
```

You can enter “n” or “no” to cancel, or “y” or “yes” to continue.

If you enter the format command and do not respond within 5 seconds, the command will automatically cancel.

```
format
Are you sure? YES/NO
Cancel format
OK
```

You can send the “Format Now” command to format the recorder immediately. You will not be prompted with an “Are you sure?” for this command, the formatting will begin immediately.

O (send last sample)

The “O” command, the letter “o” not zero, will re-send the data from the last sample in the ASCII output format. In the example below with the SL3G out of the water, the sampling was started and the “O” command was sent after the first sample was completed. You can see that the sample time and sample data are identical because the previous sample was re-sent to the terminal window.

```
start
OK
2017 05 01 13 58 47 0.000 0.000 0.000 0.000 0.000 0.000 0 0 0 0 0.00 -2.8 -1.2 0.00 0.00 0.00 23.08 9.177 -0.
000 11.47 0.11 0.000 28 23 24 0.0000 0.000 0.0000
1 0.000 0.000 0.000 0.000 0 0
2 0.000 0.000 0.000 0.000 0 0
3 0.000 0.000 0.000 0.000 0 0
4 0.000 0.000 0.000 0.000 0 0
5 0.000 0.000 0.000 0.000 0 0
6 0.000 0.000 0.000 0.000 0 0
7 0.000 0.000 0.000 0.000 0 0
8 0.000 0.000 0.000 0.000 0 0
9 0.000 0.000 0.000 0.000 0 0
10 0.000 0.000 0.000 0.000 0 0
o
2017 05 01 13 58 47 0.000 0.000 0.000 0.000 0.000 0.000 0 0 0 0 0.00 -2.9 -1.3 0.00 0.00 0.00 23.08 9.178 -0.
001 11.48 0.110 0.000 28 23 24 0.0000 0.000 0.0000
1 0.000 0.000 0.000 0.000 0 0
2 0.000 0.000 0.000 0.000 0 0
3 0.000 0.000 0.000 0.000 0 0
4 0.000 0.000 0.000 0.000 0 0
5 0.000 0.000 0.000 0.000 0 0
6 0.000 0.000 0.000 0.000 0 0
7 0.000 0.000 0.000 0.000 0 0
8 0.000 0.000 0.000 0.000 0 0
9 0.000 0.000 0.000 0.000 0 0
10 0.000 0.000 0.000 0.000 0 0
```

Compass

The “Compass” command can be issued by itself to receive one pitch and roll sensor sample or with “Compass Cont” to receive a continuous stream of samples. To interrupt the continuous samples hit “enter” or “return”. The SLG does not have a compass so no direction parameter is available. This is an original Argonaut command. It was possible to equip an Argonaut with a compass, but there are no plans to add compasses to the SL3Gs.

```
compass
#,Pitch(deg),Roll(deg)
1,-2.90,-1.28
OK
compass cont
#,Pitch(deg),Roll(deg)
1,-2.90,-1.22
2,-2.83,-1.29
3,-2.90,-1.21
4,-2.90,-1.21
5,-2.90,-1.28
6,-2.82,-1.28
7,-2.90,-1.28
8,-2.90,-1.28

OK
```

CoordSystem or CY

The "CoordSystem" or the abbreviated "CY" command by itself will display the current coordinate system setting. Sending either "CoordSystem XYZ" or "CoordSystem BEAM" will change the velocity output to the XYZ or BEAM coordinate systems respectively. This will change the velocity output for output types (ASCII, MODBUS, SDI-12). Binary output has both XYZ and Beam velocity output types. Analog output is configured manually and does not include the XYZ or Beam velocities as output options.

In the example below the coordinate system is queried using the full command. The coordinate system is changed to Beam coordinates using the abbreviated command "CY Beam". The current setting is then checked using both the abbreviation and the full command.

```
CoordSystem
Output coordinate system is XYZ
CY Beam
OK
CY
Output coordinate system is BEAM
CoordSystem
Output coordinate system is BEAM
```

Deploy

The "Deploy" command will start an autonomous deployment at a specific date and time specified by the "StartDate" and "StartTime" settings. This command will check the current system settings and provide warnings if any settings are incorrect. If the system settings check is ok, the deployment will begin at the scheduled time.

```
deploy
Checking Setup Paramters...
3821.00 free Mbytes left in recorder.
Free space is sufficient for 68.86 days of operation.
Data collection will start on: 2017/05/02 at 07:45:00
In 0 days, 0 hours, 1 minutes and 31 seconds from now.
Data will be recorded to file Crane2202
OK
```

If configuration errors are found, the appropriate error message will be displayed.

```
deploy
Checking Setup Paramters...
Configuration errors: The beginning distance of the Integrated Velocity cell must be less than the end distance.
```

If the scheduled deployment time has already passed, the deployment will begin immediately.

```
deploy
Checking Setup Paramters...
3820.00 free Mbytes left in recorder.
Free space is sufficient for 68.84 days of operation.
Data collection will start on: 2017/05/02 at 07:45:00
The Start Time has already passed, data collection will begin immediately.
Data will be recorded to file Crane2202
OK
```

Level

The “Level” ASCII command will display the range to the surface measured by the vertical beam. The range is measured in millimeters. In the following example, the instrument is in the air which results in a zero mm measurement

```
level
#,VbRange(mm)
1,0
OK
```

You can send “Level cont” to get a series of range measurements every 0.5 seconds. To end the output hit enter or return. In the following example, the enter key was pressed after the fourth sample.

```
level cont
#,VbRange(mm)
1,0
2,0
3,0
4,0

OK
```

RecStatus

The “RecStatus” command will display the current recorder status with details on the amount of total memory space available and an approximate number of days available for the current system settings. This command, like all ASCII commands, is not case sensitive.

```
Total Recorder Space: 3961.9 MB
Free  Recorder Space: 3819.9 MB
Recorder Life:        68.8 days
```

SaveSetup or SSU

The “SaveSetup” command or the abbreviation “SSU” will check that the current system settings are compatible with the channel and flow settings. On the SL3G, this command does not actually save the settings because they are saved whenever a command is issued.

In the example below, the “SaveSetup” command is sent from the terminal window and a configuration error is displayed. The setup below is for an SL3G-3000 which has a maximum range of 5 meters. Because the current configuration has 100 cells, the maximum range of the instrument is exceeded.

```
CURRENT SETUP PARAMETERS
------------------------
Temp ------------ 0.00 deg C
Sal ------------- 0.00 ppt
TempMode -------- MEASURED
Sound Speed ----- 0.00 m/s
AvgInterval ----- 10 s
SampleInterval - 10 s
CellBegin ------- 0.10 m
CellEnd --------- 0.50 m
CoordSystem ----- BEAM
RevXVelocity ---- NO
ProfilingMode --- YES
Ncells ---------- 100
CellSize -------- 0.20 m
BlankDistance --- 0.10 m
savesetup
Configuration errors: Profile settings exceed maximum range
```

It is not necessary to send the “SaveSetup” command to save all settings to the SL3G. All settings are saved when ASCII commands are sent to the system. If a command is not properly saved, you will see an error message indicating that there was a problem immediately after sending a command.

The “SaveSetup” command is useful for checking the setup for configurations errors, but the “Start” command and the “Deploy” command also perform the same system checks.

The Argonaut systems required the “SaveSetup” command to save the settings to the system because it needed to physically write the settings to a specific area of memory. The SL3G does this automatically whenever an ASCII command is sent to the system.

Sdi12

The “Sdi12” command by itself will indicate if the current communication setting is configured for SDI-12 output and the current SDI-12 address.

```
sdi12
SDI-12 is currently OFF
SDI-12 address is: 0
```

Sending the ASCII command “Sdi12 on” will put the instrument in SDI-12 communication mode. This command will also check the system configuration for errors.

```
sdi12 on
Checking Setup Paramters...
3819.00 free Mbytes left in recorder.
Free space is sufficient for 68.82 days of operation.
Switching to SDI-12 mode
SDI-12 address is: 0
OK
```

As a reminder, the “start” command and “deploy” commands are disabled when the instrument is communicating via SDI-12. Data collection and transmission will only occur when the system receives valid SDI-12 commands.

```
start
Start command disabled when output type is SDI-12. Data collection will begin when SDI-12 commands are received.
deploy
Deploy command disabled when output type is SDI-12. Data collection will begin when SDI-12 commands are received.
```

The “OutFormat SDI12” command can also be used to put the system in SDI-12 mode. However, the “OutFormat” command does not perform the system settings check.

Sdi12Address

The “Sdi12Address” command by itself will return the current SDI-12 address. If the command is followed by a single digit number 0-9 or a single lowercase or uppercase letter a-z, the SDI-12 address will be changed. In the example below, the SDI-12 address is first queried and then changed.

```
Sdi12address
SDI-12 address is: 0
sdi12address 1
OK
sdi12address
SDI-12 address is: 1
```

If more than one digit or more than one letter follow the “Sdi12Address” command, only the first number or letter will be used for the address setting. For example, if “Sdi12Address 27” is sent from the terminal window, this will not produce an error. If we query the system setting, we see that the address is set to “2” not “27”.

```
sdi12address 27
OK
sdi12address
SDI-12 address is: 2
```

Sensor

The “Sensor” command displays the most recent measurements of temperature, pressure, battery voltage, external measured voltage, pitch and roll. A header is also displayed to define each value.

```
sensor
#,T(C),P(dBar),B(V),E(V),Pitch(deg),Roll(deg)
1,23.048,0.001,11.474,1.143,-2.90,-1.21
OK
```

To display a continuous stream of measurements, send “Sensor cont”. To interrupt the stream of measurements, hit enter or return key.

```
sensor cont
#,T(C),P(dBar),B(V),E(V),Pitch(deg),Roll(deg)
1,23.044,0.001,11.474,1.144,-2.90,-1.28
2,23.025,0.005,11.475,1.100,-2.97,-1.28
3,23.034,0.005,11.465,1.092,-2.90,-1.21
4,23.034,0.005,11.477,1.091,-2.90,-1.28
5,23.034,0.001,11.478,1.090,-2.90,-1.28
6,23.034,0.005,11.471,1.090,-2.90,-1.28
```

SensorsVb

“SensorsVb” is a diagnostic command similar to “Sensor”. This command will display the most recent measurements of temperature, pressure, battery voltage, external measured voltage, pitch, roll, vertical beam range to surface in meters, in-water indicator, and sound speed. The “in-water” indicator is zero if the system is in air and one if the system is submerged. The sound speed is either the user defined sound speed or it is computed from the sound speed equation using the measured temperature and user defined salinity. To get a single measurement send “SensorsVb”. To receive multiple measurements you can add a number following the command, “SensorsVb 5”.

```
sensorsvb
OK:1,23.0823,0.00698566,11.4176,1.13303,-2.93324,-1.31715,-nan,0,1490.82
sensorsvb 5
OK:5
OK:1,23.0846,0.00698566,11.4183,1.13197,-2.89649,-1.28298,-nan,0,1490.83
OK:2,23.095,0.000861168,11.4311,1.11873,-2.86188,-1.28386,-nan,0,1490.86
OK:3,23.0959,-0.00118065,11.4304,1.11306,-2.86188,-1.28386,-nan,0,1490.86
OK:4,23.0967,-0.00158882,11.4307,1.11122,-2.82726,-1.28473,-nan,0,1490.86
OK:5,23.0969,-0.00179195,11.4316,1.11085,-2.89793,-1.24949,-nan,0,1490.86
OK:5
```

Show Sdi12 or S Sdi12

The “Show Sdi12” or “S Sdi12” commands will display the current SDI-12 settings. The SL3G does not support the Argonaut Multi-Address function. This function was designed to circumvent the limited amount of data that could be accessed for SDI-12 v1.0. Because most data loggers no longer use SDI-12 v1.0 and because subsequent versions of SDI-12 don’t have the same limitation, it was not necessary to support the Multi-Address option on the SL3G.

```
SDI-12 PARAMETERS
-----------------
Sdi12Address --------- a
Sdi12 Multi-Address - NO
```

StartDate or SD

The "StartDate" or "SD" command can be used to set the starting date of the autonomous deployment. The start date must be entered in the year-month-day format YYYY/MM/DD. The month and day can be single digits or the leading zeros can be included. Basic error checking on the format and the dates is performed. If there is a problem, a warning message will be displayed.

In the example below, the first date "sd 2017/05/32" generates an error message because the "day" value is never greater than 31 for any given month. The same error will occur if the month field is greater than 12. The error message does not indicate an out of range field, but this is the actual problem here. The second attempt below, "sd 2017/4/31" was successful even though this date does not exist, April only has 30 days. Here we see that April 31st is translated as May 1st.

```
sd 2017/05/32
Date format should be YYYY/M/D
StartDate was not set
sd 2017/4/31
OK: Start Date = 2017/05/01
```

When a successful data is entered, the system will respond with "OK: Start Date = " followed by the saved date.

StartTime or ST

The "StartTime" or "ST" command can be used to set the starting date of the autonomous deployment. The starting time must be entered as hour:minute:second (hh:mm:ss) in the 24-hour format. For example 13:37:20 is 1:37 PM and 20 seconds. The seconds do not have to be entered, they will be assumed zero if they are missing. Leading zeros must be included.

For example, the first attempt fails because the leading zeros were missing. The second attempt was successful despite missing the seconds. When the start time is successfully set, the instrument will respond with "OK: Start Time = " followed by the starting time.

```
st 6:45
Time is 24 hour time and format should be HH:MM:SS
StartTime was not set
st 06:45
OK: Start Time = 06:45:00
```

MultiCellBegin or MCB

"MultiCellBegin" or "MCB" sets the start location of the first multi-cell without having to specify blanking distance. Send this command by itself will display the current setting.

```
mcb
Current multi-cell begin distance is 0.50 m.
multicellbegin
Current multi-cell begin distance is 0.50 m.
```

Sending this command followed by a distance in meters will change the MCB setting. When the setting is changed, it is checked to see if it is within the acceptable range.

```
multicellbegin 0.2
Based on current cell size, multi-cell begin distance must be >= 0.60 m.
```

If the setting is acceptable the system will respond with OK.

```
multicellbegin 0.6
OK
```

Users can also still use the “BlankingDistance” or “BD” command. This will change the MCB value as well. In the example below, the MCB is set to 0.6 meters. Because the cell size is 0.5 meters, the blanking distance becomes 0.1m. Then the blanking distance is changed to 0.2m. This results in an MCB setting of 0.7m = 0.2(blank) + 0.5(cell size).

```
mcb 0.6
OK
bd
Current blanking distance is 0.10 m.
mcb
Current multi-cell begin distance is 0.60 m.
bd 0.2
OK
mcb
Current multi-cell begin distance is 0.70 m.
```

MultiCellEnd or MCE

The "MultiCellEnd" or "MCE" can be used to display the distance to the end of the multi-cell.s

Resetcfg

The “Resetcfg” command is an ASCII command that will reset the system to the factory default settings. The software sends this command to the SL when the user clicks the “Factory Defaults” button.

Velocity Indexing ASCII Commands

Four new ASCII commands were added to the firmware to facilitate remote VI mode control. These commands can be used to initiate VI mode as well as change the time interval settings.

ViStart

The “ViStart” command is used to start Velocity Indexing mode over an ASCII connection. The command is not case sensitive; “vistart” will work just as well. Once the “ViStart” command is issued, the system will perform a configuration check to make sure the VI settings are correct. If the VI settings are not correct you will see an error and VI mode will not begin.
If VI mode settings are not correct, you will see an error.

```
vistart
Saving current setup...
Configuring sytem for Velocity Indexing...
Checking Setup Paramters...
Configuration errors: Flow Sample Duration (AvgInterval) must be less than or equal to Flow Sample Interval (
SampleInterval).
```

If all VI settings are correct, you will see a summary of the settings and VI mode will begin.

```
vistart
Saving current setup...
Configuring sytem for Velocity Indexing...
Checking Setup Paramters...
Velocity Indexing sample duration is 15 seconds.
Velocity Indexing averaging interval (sample interval) is 15 seconds.
Velocity Indexing data will be recorded to file: defd_VI
Velocity Indexing Mode will be active for the next 1 minutes.
OK
```

If VI mode is allowed to run to completion, you will see a message indicating VI mode is ending and the system is returning to its original configuration.

```
[E:DaqEngine] Velocity Indexing time has expired, restarting normal data collection.
2017 10 03 09 19 29 0.000 0.000 0.000 0.000 0.000 0.000 0 0 0 0 0.00 -3.0 -0.1 0.00 0.00 0.00 19.87 9.244 0.001 11.48 1.83 0.000 7
5 72 72 0.0000 0.000 0.0000
1 0.000 0.000 0.000 0.000 0 0
2 0.000 0.000 0.000 0.000 0 0
3 0.000 0.000 0.000 0.000 0 0
```

If VI mode is interrupted by a "stop" or "+++" command, the original configuration will be restored but sampling will not restart automatically.

```
stop
[W:UswApp] Skipping flowSample 1
・ca: Velocity Indexing interrupted by STOP command, data collection will not restart automatically.ｽﾍ･OK
```

ViSampleInterval

The command to set the VI mode sample interval is "ViSampleInterval" or "Visi" followed by an integer value of seconds. The system will respond with "OK" if the setting is updated.

```
ViSampleInterval 15
OK
```

To see the current setting, send the command without the parameter.

```
visampleinterval
Current velocity indexing sample interval is 15 seconds
visi
Current velocity indexing sample interval is 15 seconds
```

ViAvgInterval

The command to set the VI mode averaging interval is "ViAvgInterval" or "Viai" followed by an integer value of seconds. The system will respond with "OK" if the setting is updated.

```
ViAvgInterval 15
OK
```

To see the current setting, send the command without the parameter.

```
viai
Current velocity indexing averaging interval (sample duration) is 15 seconds
```

ViTimeSpan

The "ViTimeSpan" or "Vits" command can be used to change or set the length of time that Velocity Indexing mode is active. To set the Vi mode time span, send the command followed by an integer value of minutes. The instrument will respond with "OK" if the time span setting is changed.

```
ViTimeSpan 15
OK
```

To see the current time span setting, send the command without the parameter.

```
vits
Current velocity indexing time span is 15 minutes
```

Appendix H. Software Changes

Version 2.00

- Initial release for SonTek-SL firmware v2.00

Version 2.1

- Modbus data from the SL are reported on both input and holding registers
- SDI-12 M and C command output changed
- Minimum voltage changed from 10V to 9V
- Vertical beam and pressure sensor interaction improved. See the Water Level Measurement section of Appendix B for details.
- Sampling Duration minimum lowered from 10 seconds to 1 second
- Velocity labels updated
- Beam velocity colors changed to be consistent with Argonaut-SL systems (red is beam 1, blue is beam 2).
- COM Port Reset function added to the Maintenance menu
- CE Certificate updated in the manual
- Maximum baud rate feature added to the Settings menu

Version 2.2

- Released with firmware v2.2 in support of hardware changes that do not affect user operation and/or data collection.

Version 3.0

- Faster download speeds
- ASCII and run-time commands for dataloggers and direct interface
- ASCII output reports up to 32 cells of data in real-time (used to be 10 cells)
- Velocity indexing mode for during gagings
- One-beam solution for velocity data
- Improved Smart Page and beam check
- Autonomous deployment commands
- Temp/salinity/sound speed made editable in post-processing
- Improved vertical beam/pressure sensor interaction