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USER MANUAL
ITEM# 45-0068
REVISION L

SonTek-IQ Series

VELOCITY AND LEVEL IN OPEN CHANNELS AND PIPES

SonTek
a xylem brand

SonTek – a Xylem brand
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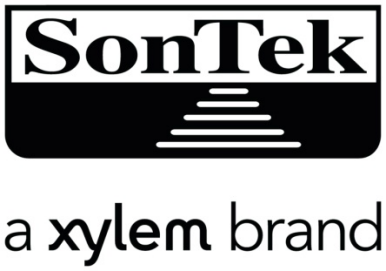


SonTek-IQ® Series
Intelligent Flow
Featuring
SmartPulse^{HD}
User's Manual

Firmware Version 3.0
Software Version 3.0

SonTek – a Xylem brand

WARRANTY, TERMS, AND CONDITIONS

Thank you for purchasing the SonTek-IQ 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
September 15, 2011	45-0068 Rev A	Original Engineering Release
November 4, 2011	45-0068 Rev B	Additions and updates
January 31, 2012	45-0068 Rev C	Additions for IQ Flow Display, System Status, CE Certification, Assorted Editing.
October 02, 2012	45-0068 Rev D	Pre-release
October 03, 2012	45-0068 Rev E	Addition of IQ-Pipe system to SonTek-IQ Series
June 24, 2013	45-0068 Rev F	Software/Firmware v1.60 Release
April 15, 2015	45-0068 Rev G	All stainless steel hardware and non-ATEX/IS
July 1, 2015	45-0068 Rev H	Software/Firmware v2.00 Release
August 20, 2016	45-0068 Rev J	Software/Firmware v2.1 Release
October 15, 2017	45-0068 Rev K	RoHS compliance on P/N's: IQX3000-I-3 or higher and IQ3000-I-5 and higher
July 15, 2020	45-0068 Rev L	Software/Firmware v3.0 Release

CE

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-IQ

Product Names: SonTek-IQ, SonTek-IQ Plus, SonTek-IQ Pipe

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: 2006

CISPR 11: 2009, Class "A"

IEC 61000-3-2: 2005/A1:2008/A2:2009

IEC 61000-3-3: 2008

IEC 61000-4-2: 2008

IEC 61000-4-3: 2006

IEC 61000-4-4: 2004

IEC 61000-4-5: 2005

IEC 61000-4-6: 2008

IEC 61000-4-8: 2009

IEC 61000-4-11: 2004

RoHS 2 DIRECTIVE 2011/65/EU

Per the current RoHS Directive, the SonTek-IQ 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-IQ Series product. This instrument is an Intelligent Flow 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 IQ or installing it in the field. We hope you enjoy many years of high quality data from your new IQ.

1.1. System Components

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

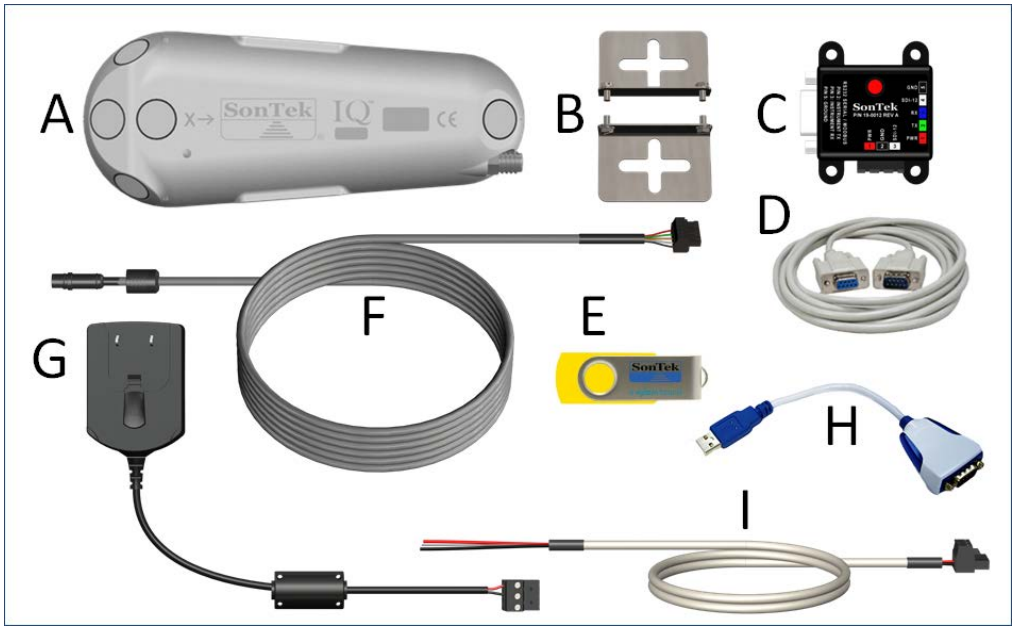


Figure 1. IQ shipping Box and Contents

There are three SonTek-IQ products available: The **IQ Standard,** the **IQ Plus**, and the **IQ Pipe.** Both the Standard and Plus models are physically identical and are shipped with the same components. The difference between versions is in the number of measurement options and data parameters available. The IQ Standard is more economical, while the IQ Plus provides a greater level of detail in the flow and velocity measurements. The **SonTek-IQ Pipe** is slightly different in shape from the SonTek-IQ Standard and SonTek-IQ Plus, as it is slightly taller and narrower than the SonTek-IQ. In either case, Item A represents the flow meter shipped from the factory. All other standard items shipped are the same. The SonTek-IQ Pipe has an option for a ring mount for when other mounting options are not available. This does not apply to the SonTek-IQ or IQ Plus. In addition, the SonTek-IQ and SonTek-IQ Plus have an option for a riser mount that does not apply to the SonTek-IQ Pipe.

Itemized list of IQ components

Item	Item
A	SonTek-IQ or SonTek-IQ Pipe
B	Mounting Brackets (2) with screws
C	Cable adaptor
D	RS232 cable (6-ft/1.8-m)
E	IQ USB Thumb Drive
F	IQ Power/Communications Cable
G	AC Power Supply
H	USB to Serial adaptor
I	Battery hookup cable

Item A: SonTek-IQ – A multi-beam acoustic flow meter with five 3.0 MHz transducers (Figure 2). 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 in the bottom of a channel or culvert for the SonTek-IQ and SonTek-IQ Plus. For pipes and closed conduits the SonTek-IQ Pipe should be used (Figure 3). All three instruments measure 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.

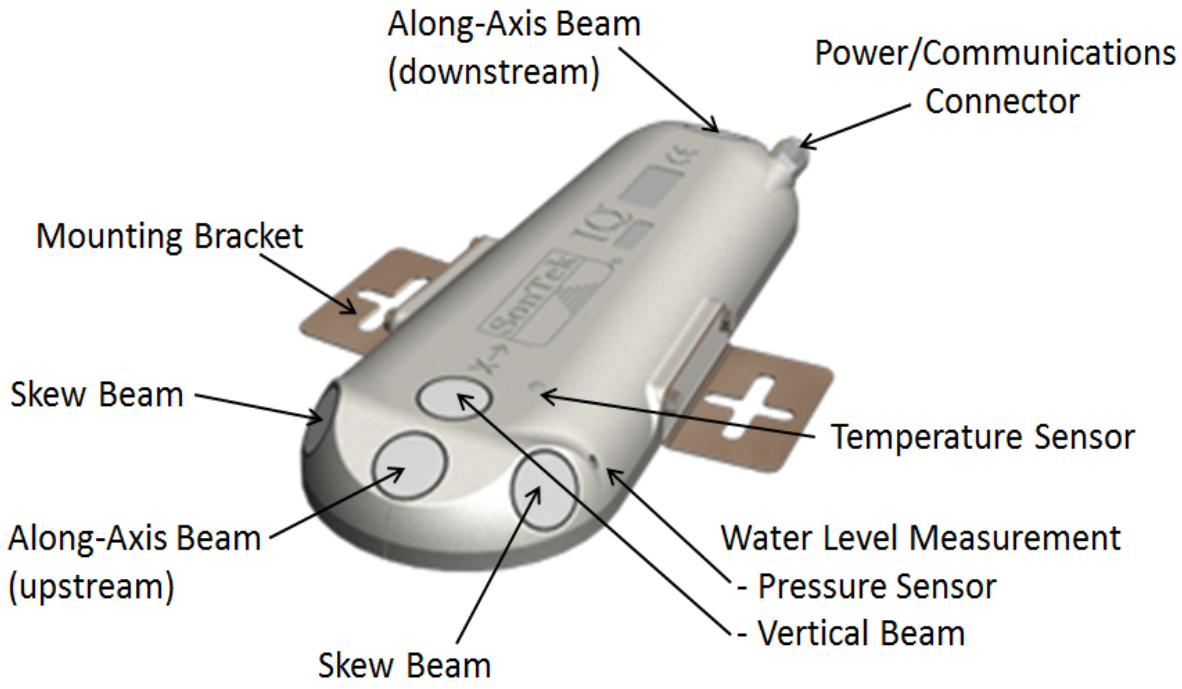


Figure 2. SonTek-IQ Standard and IQ Plus Attributes

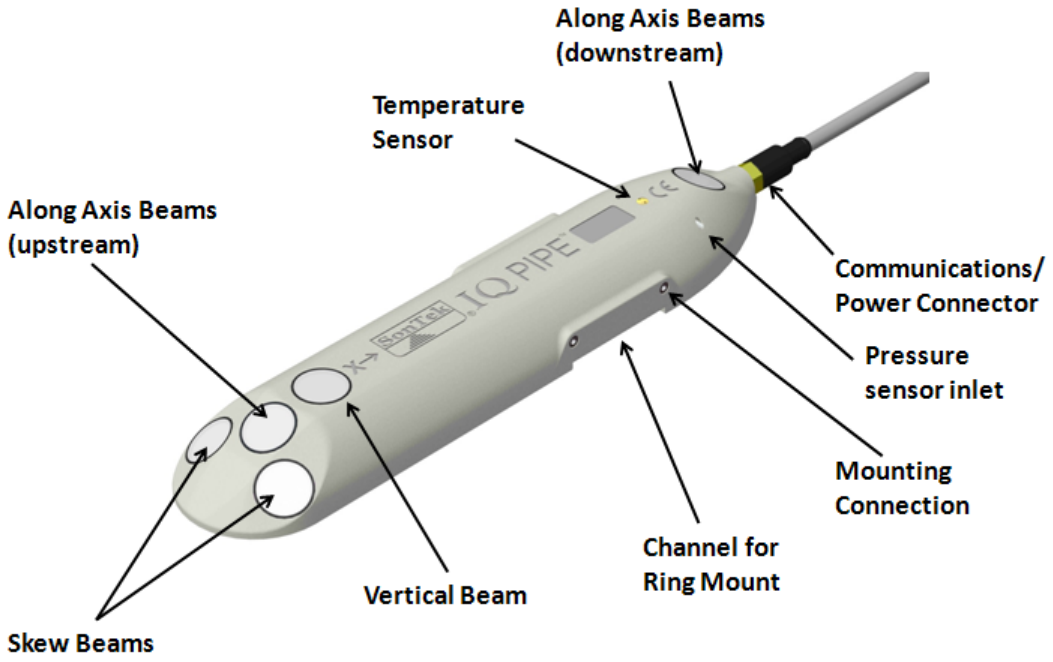


Figure 3. SonTek-IQ Pipe Attributes

Item B: Mounting brackets – Attach the mounting brackets to the side of the SonTek-IQ or SonTek-IQ Pipe with four mounting screws (flat-head screwdriver or 1/4" socket driver) for easy installation in the bottom of a channel. Mounting bracket slots are 12.7 cm (5 in.) apart. These slots allow for orienting the x-axis of the IQ parallel to the flow. In Figure 4, the flow would be moving from left to right.

Figure 4. IQ Mounting Brackets

***Note:** The same mounting brackets are used on the SonTek-IQ as the SonTek-IQ Pipe. Only use the mounting bracket inserts on the sides of the IQ. DO NOT MOUNT USING THE INSERTS ON THE BOTTOM OF THE IQ.

Item C: IQ Cable Adaptor – Provides easy and convenient input for a 10-15 VDC power source and system communications. **RS-232**, **Modbus**, and **SDI-12** connections provide a simple solution for integrating an IQ with a data logger, 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).

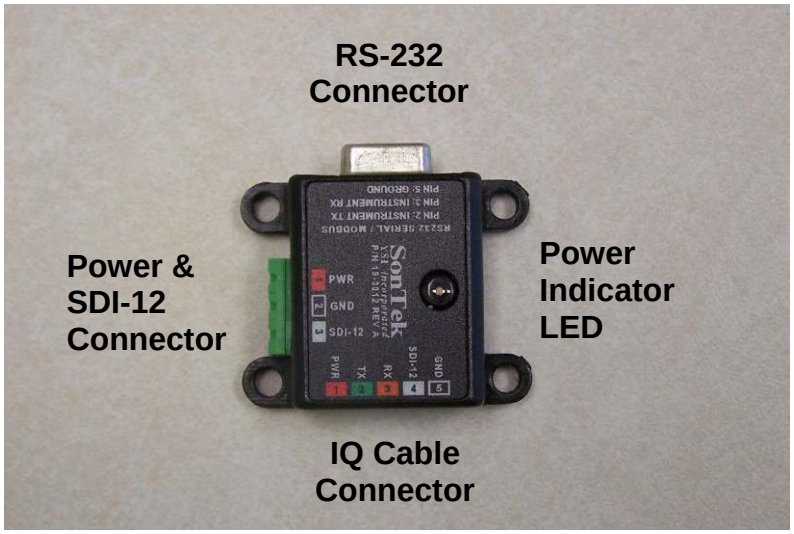


Figure 5. IQ Cable Adaptor

Item D: RS232 cable – Connects the IQ cable adaptor with a computer, laptop, data logger, RTU, or PLC.

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

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

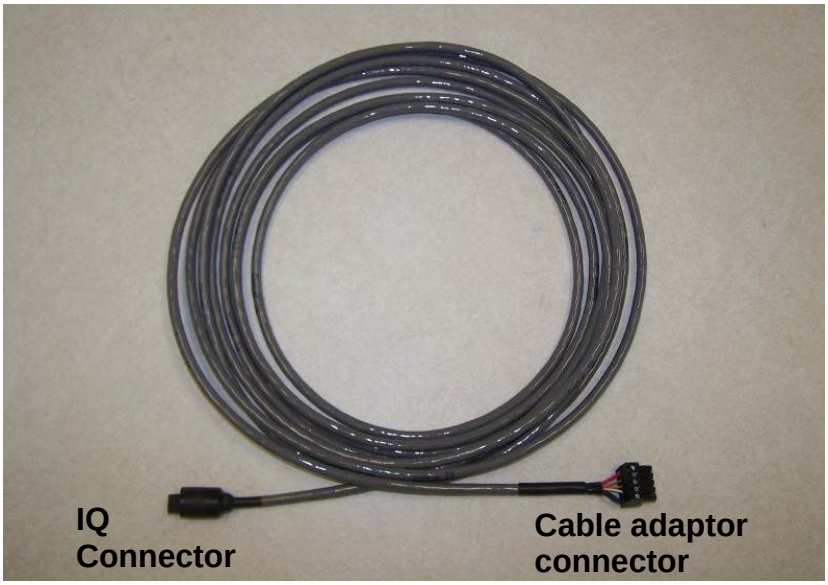


Figure 6. IQ Power and Communication Cable

Important note: The IQ 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 IQ connector to the IQ 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 IQ 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 IQ. Simply plug the 3-pin connector into the IQ 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. IQ Power Supply with International Adaptors

Item H: SonTek supplied USB to Serial adapter (Shown in Figure 18) **–** 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 IQ cable adaptor (Figure 5). Input voltage levels are 10-15 VDC. Power (red) and ground (black) wires are provided with a third pin available to bring in SDI-12 communications.

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

Optional Item: IQ Flow Display – Allows users to view data collected by the SonTek-IQ 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, IQ, Modbus communications and errors.

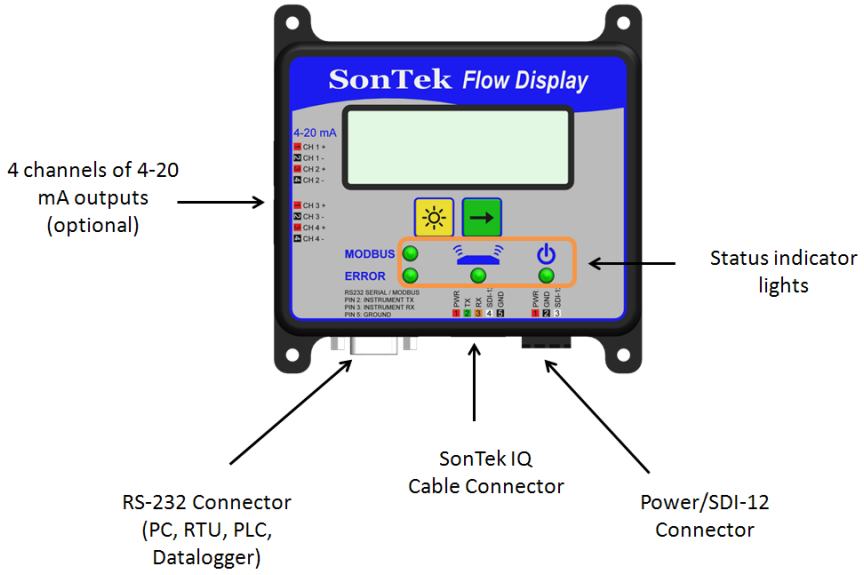


Figure 8. Optional SonTek Flow Display

Optional Item: IQ Riser Mount – Users who will be installing the IQ in soft bed channels or canals with sand or mud sediments should consider ordering the optional IQ Riser Mount to prevent burial. The riser mount elevates the IQ by one inch (2.5 cm) and allows material to pass underneath. It has the same slot pattern and spacing as the standard mounting brackets (Figure 9).

***Note: DO NOT MOUNT USING THE INSERTS ON THE BOTTOM OF THE IQ**

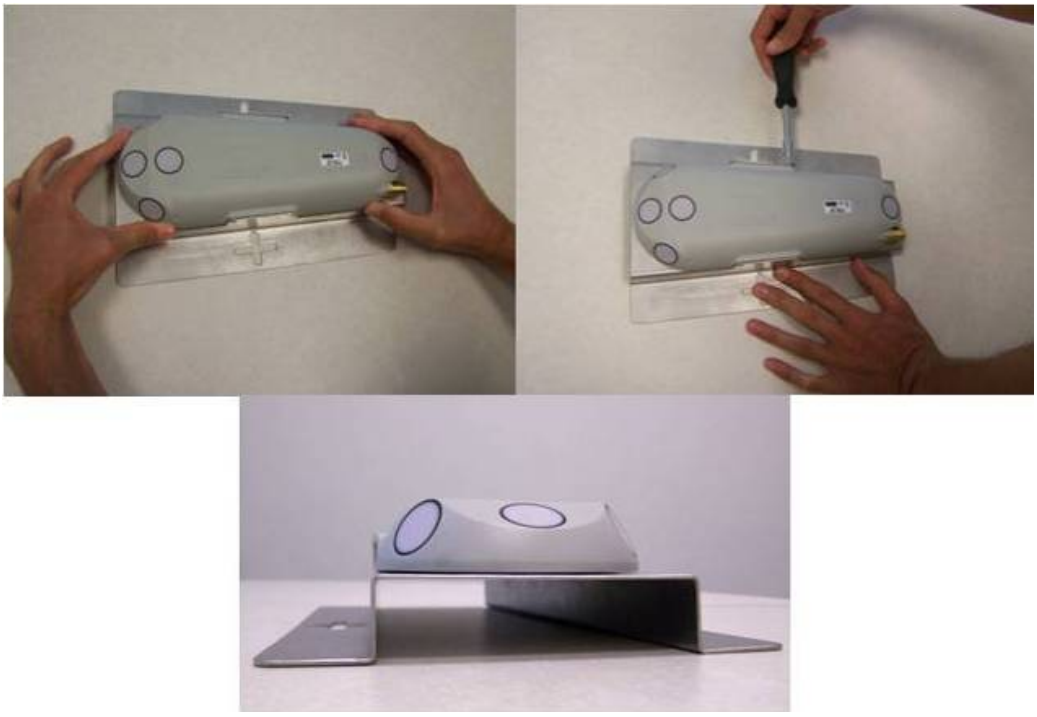


Figure 9. Optional IQ Riser Mount

Optional Item: SonTek-IQ Pipe Ring Mount – For the SonTek-IQ Pipe only, SonTek offers a Pipe Ring that can be used to mount systems inside of a pipe. The Ring consists of a metal band and a "Scissor Jack" that stretches the ring, and locks it in place inside the pipe. To use the Pipe Ring:

- Start by removing the two nuts and screws from the Scissor Jack to release the two arms (Figure 10).

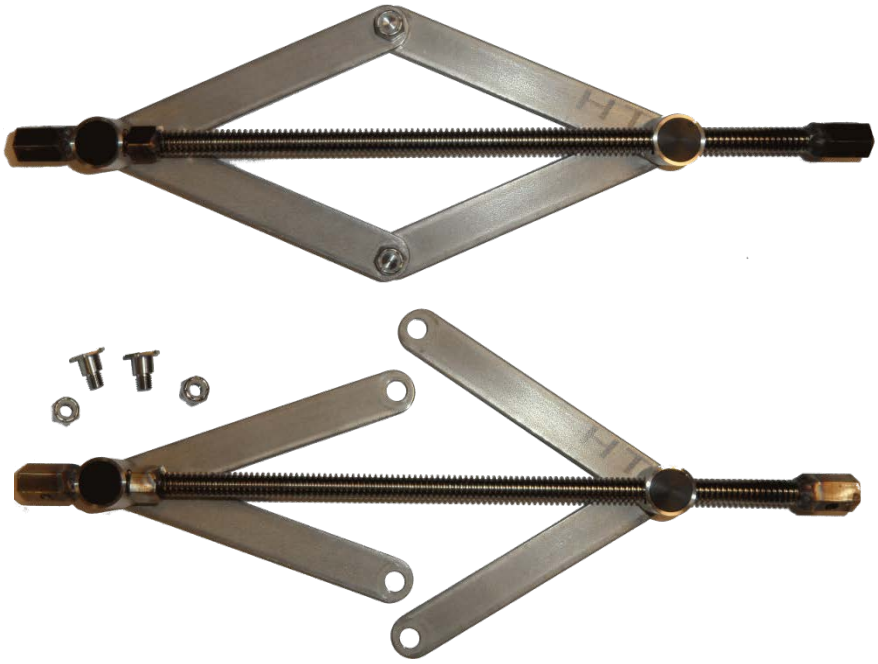


Figure 10. Opening the Scissor Jack

- Attach one side of the Scissor Jack arms through the hole at the end of the Pipe Ring with the double slots (Figure 11).

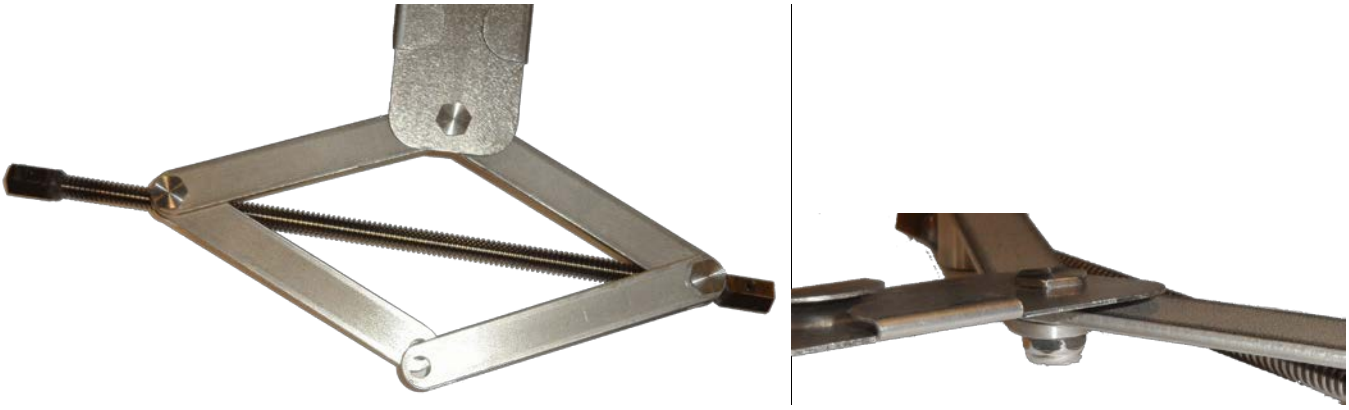


Figure 11. Attaching the Scissor Jack to the Pipe Ring

- Insert the opposite side of the Pipe Ring through the double slots. Align the hole of the desired pipe diameter (see printed on the ring) with the Scissor Jack arms, and secure the Scissor Jack arms to the Pipe Ring with the remaining nut and screw (Figure 12).

Figure 12 . Pipe Ring with Scissor Jack

- Using the two mounting brackets attached to the Pipe Ring, attach the SonTek-IQ Pipe using the provided screws (Figure 13).

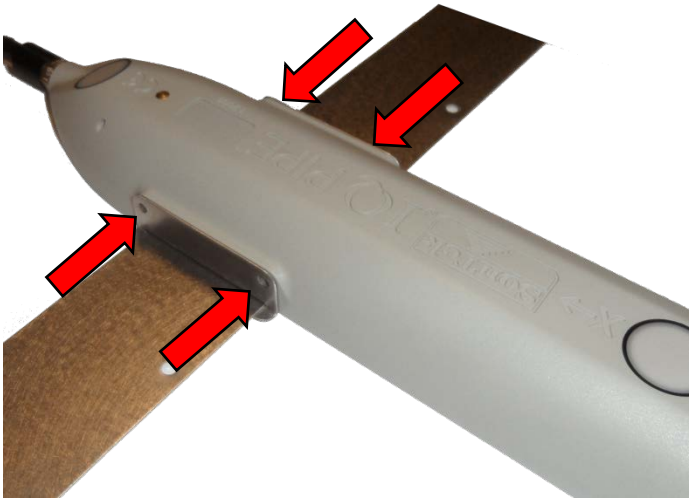


Figure 13. Slide and Attach the Brackets

- Once assembled, slide the Pipe Ring inside of the pipe and rotate the Scissor Jack to expand the ring so that it is tight inside the pipe. The Pipe Ring must not move or vibrate when properly tightened (Figure 14).

Figure 14 . SonTek-IQ Pipe Installed with SonTek Pipe Ring

IMPORTANT:

1. For FULL pipe applications, the scissor jack must NOT be installed directly opposite of the IQ Pipe; otherwise, the jack will interfere with the acoustic vertical beam.
2. The system is typically installed with the cable pointed downstream. An arrow indicating positive (downstream) flow direction is printed on the top to the instrument. See Section 5.3.4 for details. It can be installed with the cable upstream, provided that you check the box next to Reverse Flow in the software.

1.2. Interconnecting the System

Connect the cable to the IQ while in the air.

- Insert the keyed cable connector into the underwater connector on the downstream end of the IQ (this must be done in a dry environment) as seen in Figure 15.
- Tighten the locking sleeve on the cable connector by rotating clockwise until finger tight.

Figure 15. Connecting IQ to Power and Communications Cable

***Note:** The same procedure and hardware are used to fix the brackets on the SonTek-IQ Pipe for mounting directly to a closed conduit or pipe.

Next, connect the five-pin terminal connector to the cable adaptor (Figure 16). Be sure that all wires are tightly connected to the five pin terminal connector to ensure proper communication with the IQ. 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.

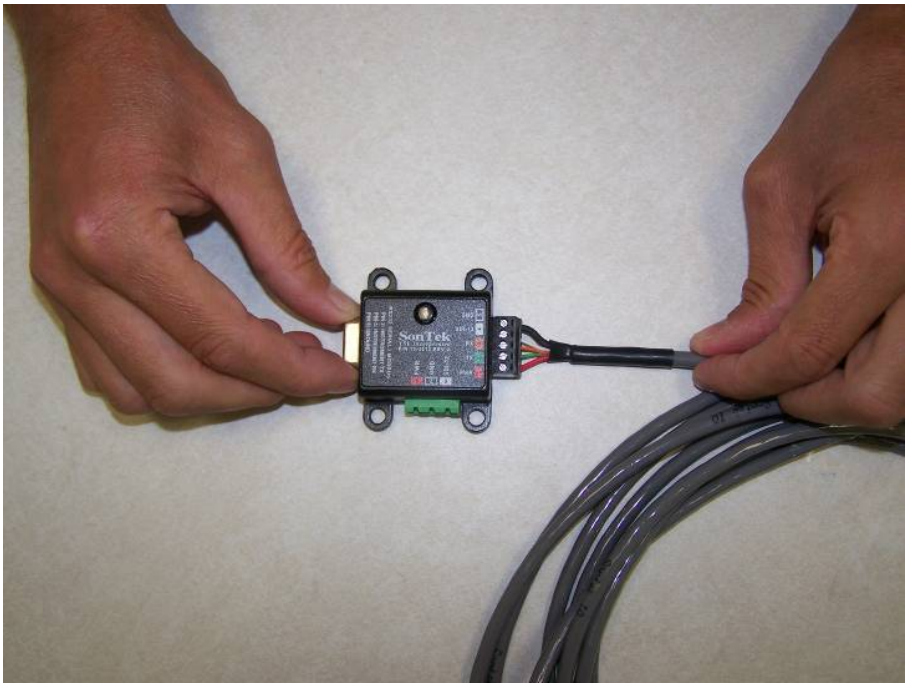


Figure 16. Connecting the IQ Cable Adaptor

Connect the three-pin power connector from the power supply to the cable adaptor (Figure 17).

- 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 17. Connecting the Power Supply to 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 IQ. We recommend using the USB to serial converter included with the system (Figure 18).

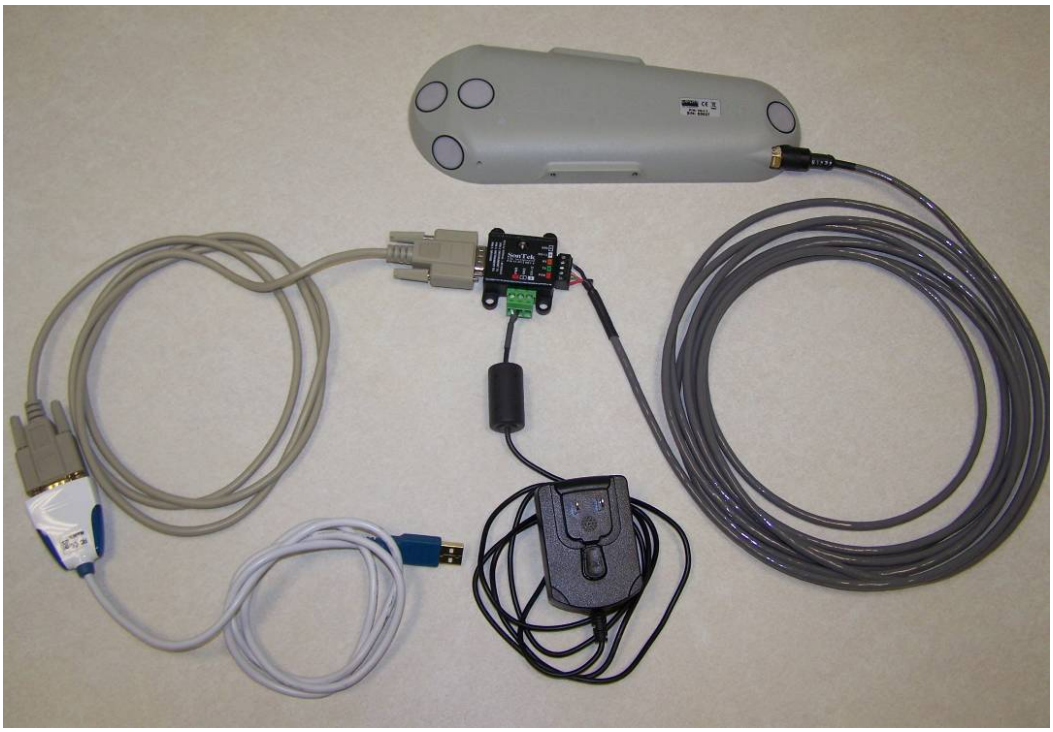


Figure 18. Connecting the USB-Serial Adaptor to Cable Adaptor

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

In cases where the Flow Display is used in place of the cable adaptor, the connections should be as presented below (Figure 19).

Figure 19. Flow Display Connections

1.3. Installing the IQ Software

The IQ software is provided on the USB memory stick. The minimum Windows PC system requirements are below:

Microsoft Windows 7 and 10
- 700-MHz processor or better (1 GHz recommended)
- 128 MB memory (256 MB recommended)
- 200 MB available disk space (500 MB recommended)
- Monitor capable of 1024x768 resolution, 16-bit color, or better

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 20).

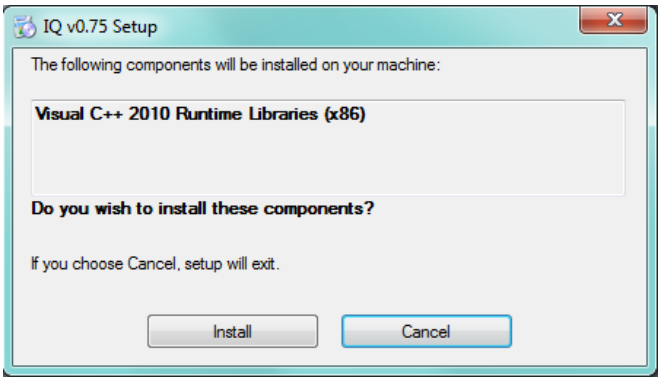


Figure 20. IQ Software Setup

Select the “Install” button to continue.

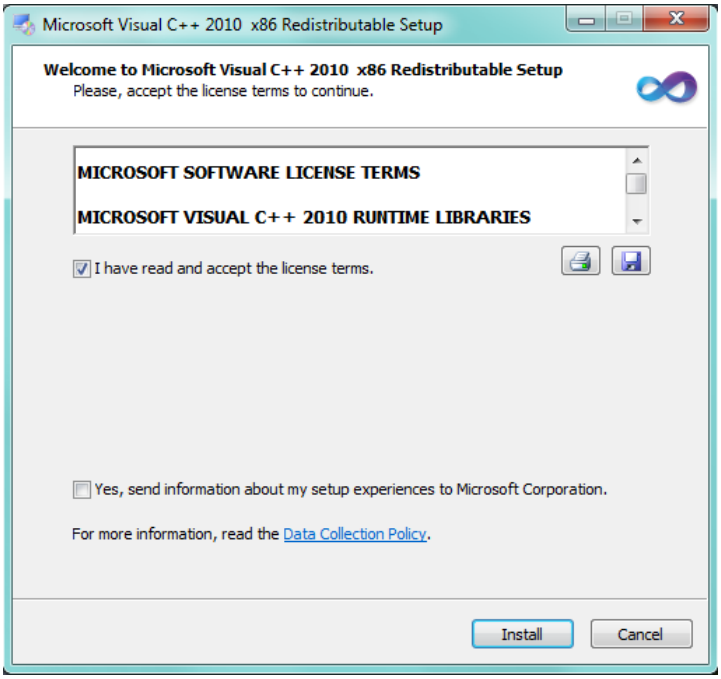


Figure 21. IQ Software License Agreement

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 21). After the Visual C++ Runtime libraries are installed, select the “Finish” button to continue (Figure 22).

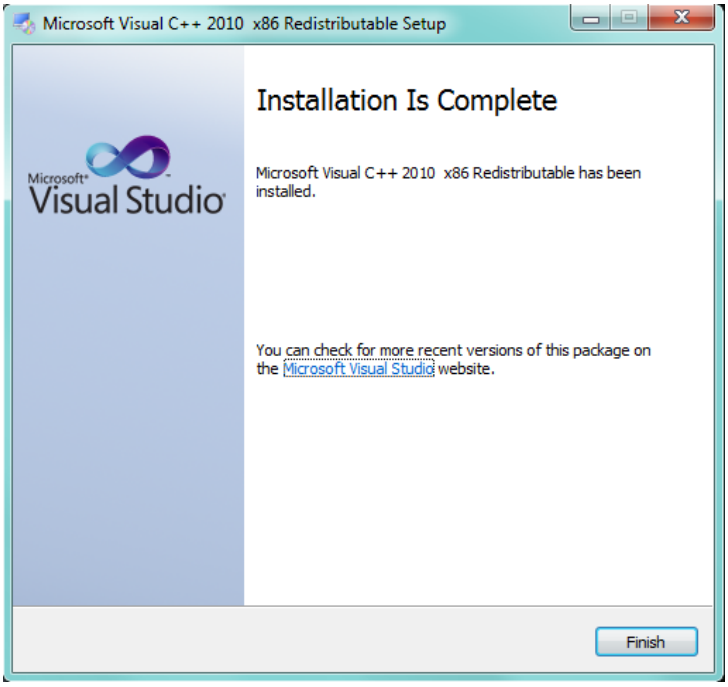


Figure 22. IQ Software Installation Complete

Select the “Next” button to continue with the IQ software installation (Figure 23).

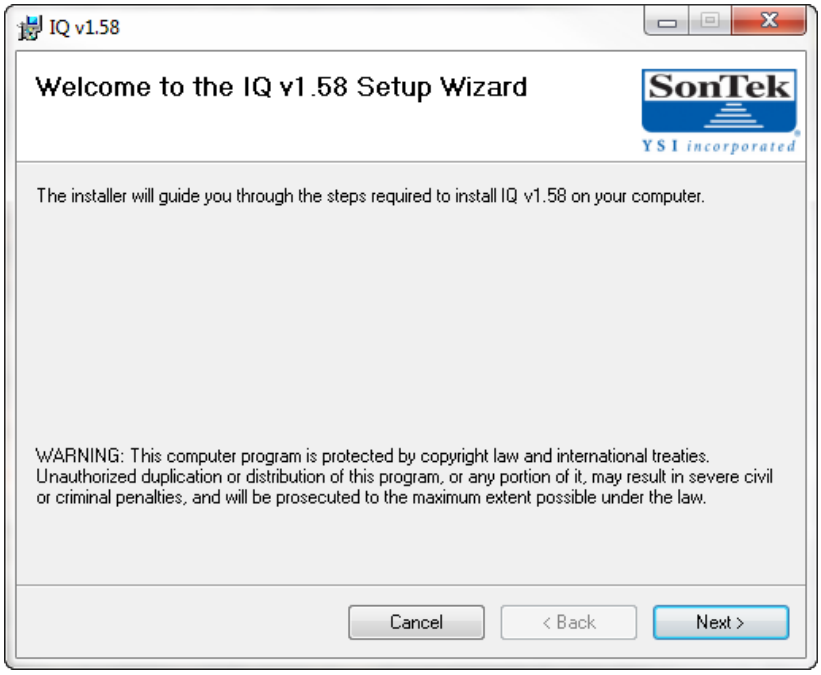


Figure 23. IQ Software Setup Wizard

We recommend using the default folder as the installation directory in this window (Figure 24). Also, if more than one user account will need access to the IQ software, please select the **Everyone** option. Select the **Next** button to continue.

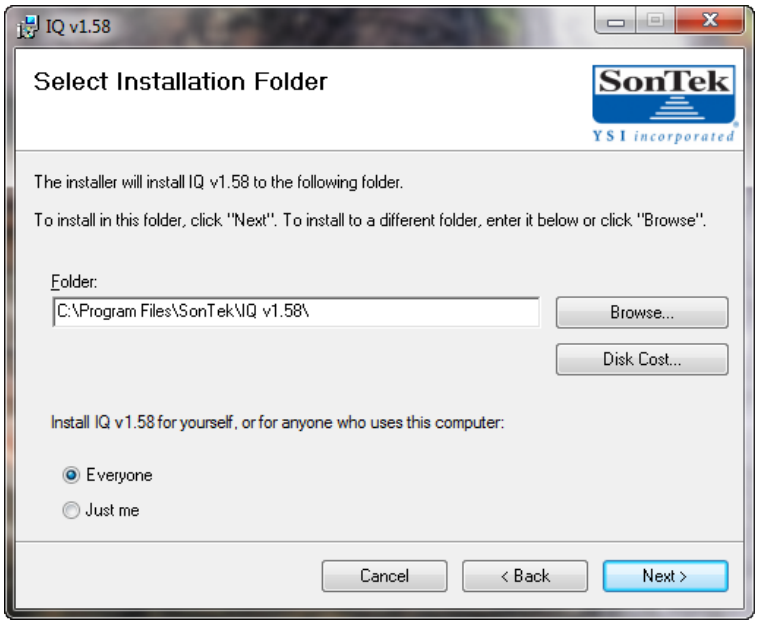


Figure 24. IQ Software Setup – Data Folder

After a successful installation, **Close** the dialog window and use Windows Update to check for new Microsoft updates that may be required by the IQ software (Figure 25).

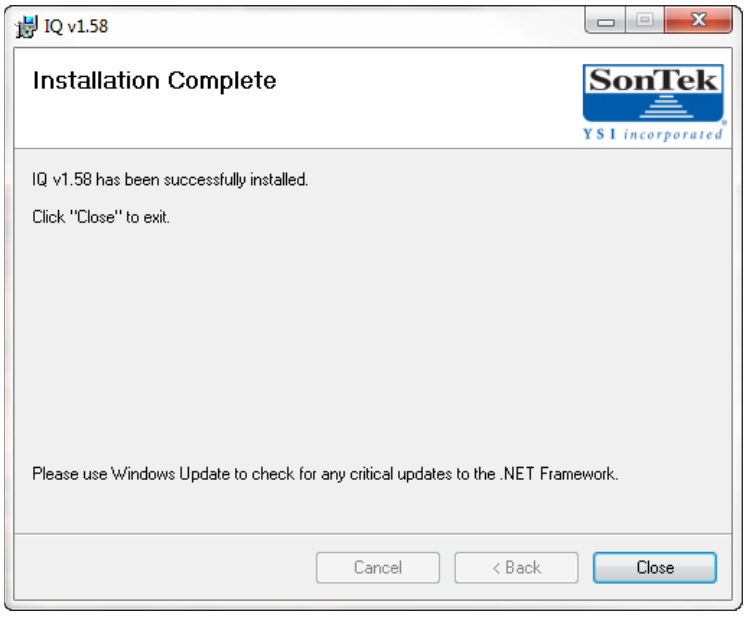


Figure 25. IQ Software Setup – Installation Complete

A desktop shortcut icon will appear on your computer when installation is complete. Double-click this icon with the mouse to begin using the IQ software (Figure 26).

Figure 26. IQ Software Desktop Shortcut

Once the IQ software starts, you can connect to an IQ, plan a deployment, view data, or perform one of many functions discussed in the following sections (Figure 27).

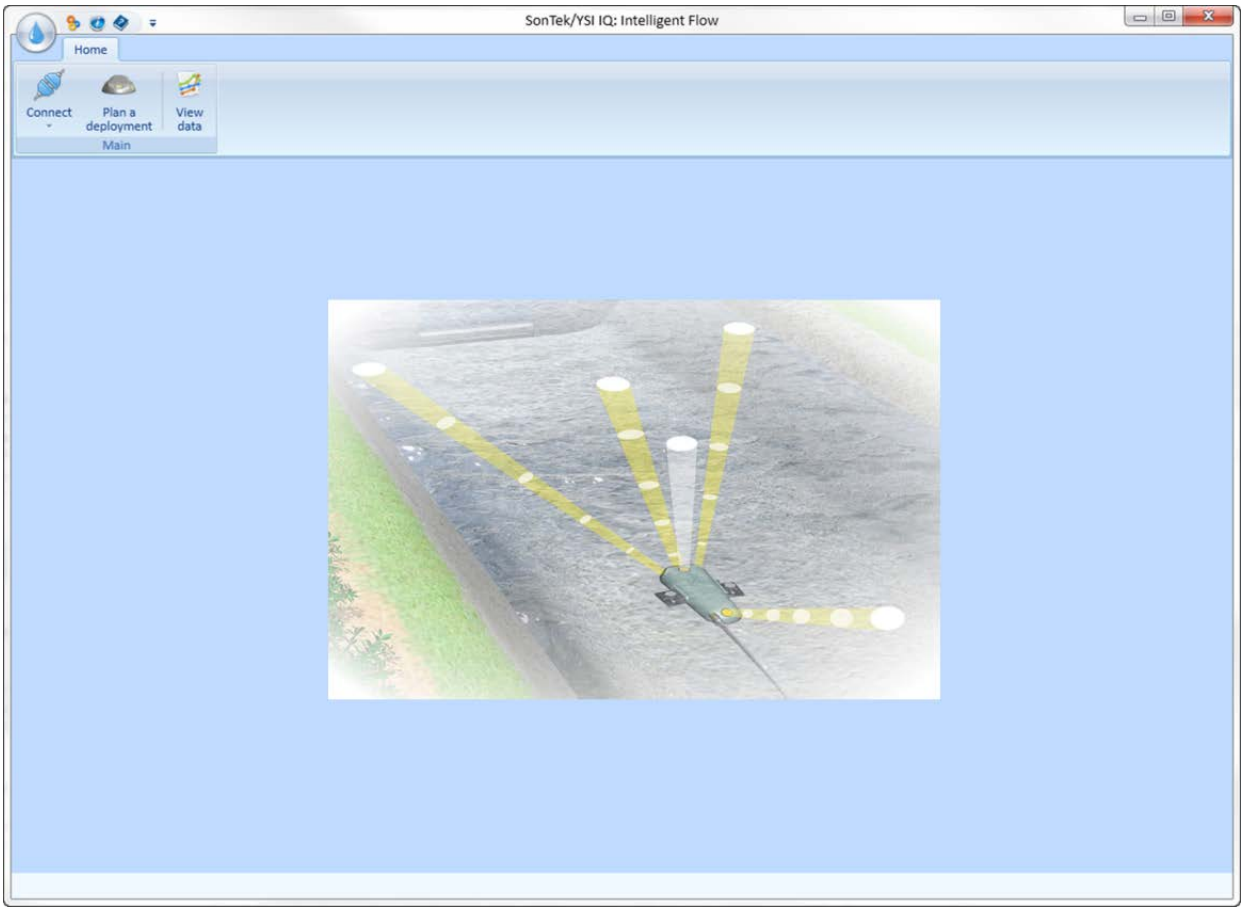


Figure 27. IQ Software Main Window

Section 2. IQ Software Overview

This section is designed as an overview of the features and functions of the IQ software. This software is primarily used to configure the IQ 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 IQ in the field.

2.1. Using the IQ Software

The IQ 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. To display the help hyperlink, left-click on the text as shown in Figure 28 below.

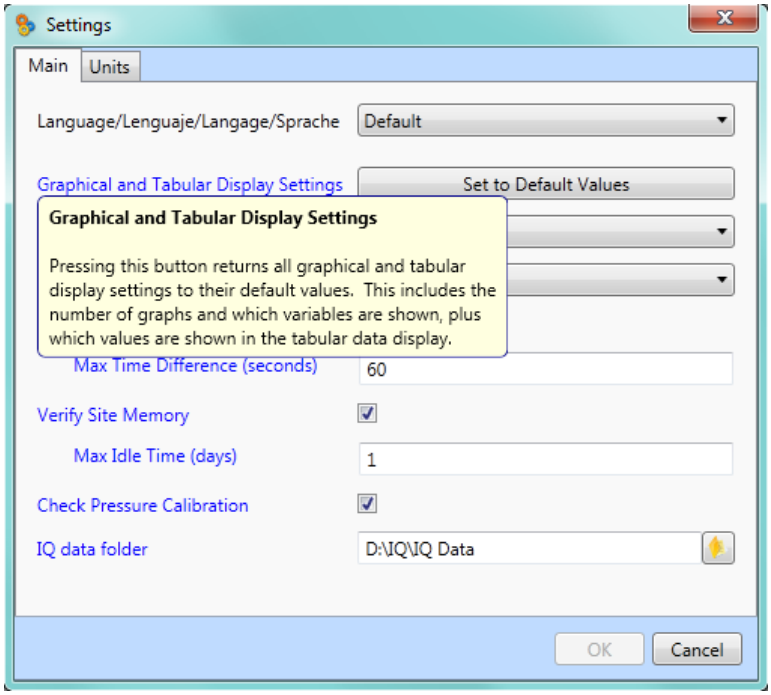


Figure 28. Help Hyperlink

Some of the icons in the software will automatically open a small help pop-up window when the mouse hovers over them (Figure 29).

Figure 29. Help Pop-Up Windows

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

2.2. IQ Software 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 30). We will first discuss the functions of the title bar icons before moving on to the details of the Main Ribbon.

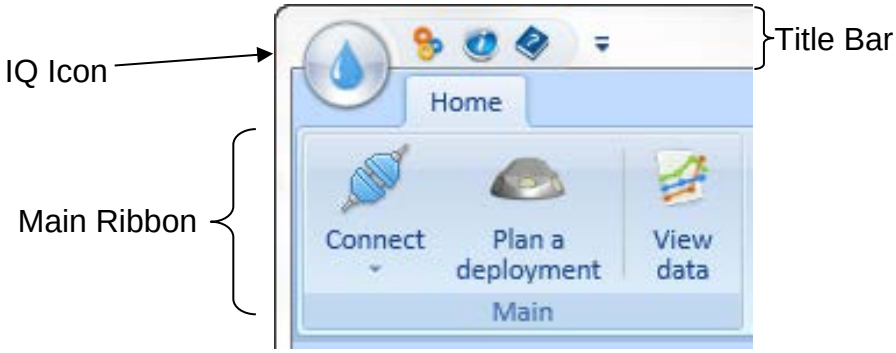


Figure 30. Title Bar and Main Ribbon Locations

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 IQ software settings, version information, and documentation found in the title bar (Figure 31).

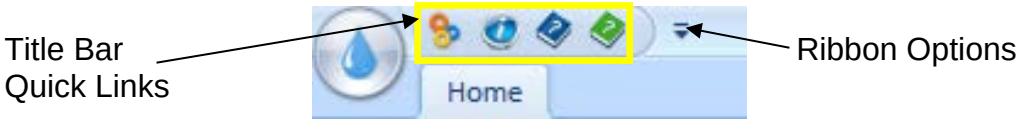


Figure 31. Quick Links to Settings, Information and Documentation

Settings – provides a link to the IQ Software Settings window.

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

Documentation – provides a link to the SonTek-IQ User's Manual in PDF format

Documentation – provides a link to the SonTek-IQ Software Release Notes 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. IQ Software General Settings

To view the IQ software **Settings**, select the settings quick link icon or navigate to the settings menu from the IQ Icon. The IQ software settings window has two navigation tabs at the top of the window as seen in Figure 32. 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.

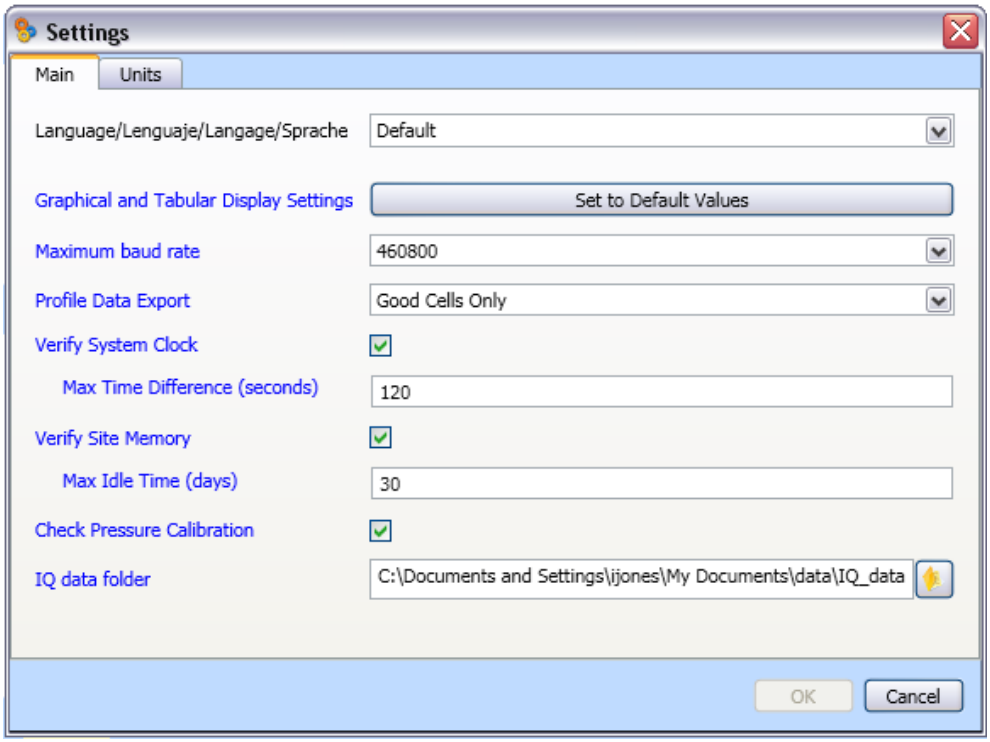


Figure 32. IQ Software Main Settings

IQ Settings – Main Tab

Language: The IQ supports multiple languages. The language displayed in the IQ 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 IQ. This setting does not affect Modbus communications; it affects only communications between the IQ and the IQ software.

Profile Data Export: The range of the IQ is predefined at the factory. If the IQ is deployed at a water depth that is less than the system range, some of the measured velocity cells will be located above the existing water surface or past the sides of the channel. To export only those cells located below the water surface and 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 IQ software to compare the IQ clock to the PC clock upon each connection.

Max Time Difference (seconds): This field allows you to define the maximum difference between the IQ clock and the PC clock. If the period is greater than the user-defined interval, you will be prompted to reset the IQ 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 IQ determines that flow in the channel has changed significantly based on the recent Site Memory.

Max Idle Time (days): If the IQ 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 IQ is established. Because the IQ 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.

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

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

IQ Settings – Units Tab

The **Units** tab, presented in Figure 33, allows users to customize the displayed dimensions or units for each measured parameter. Units defined here are only used in the IQ software for graphical and tabular data. These settings are **NOT** applied to the RS-232 Serial/Modbus data output by the IQ. Units for the output data sent to the serial port must be specified in the Output Settings section on the IQ 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.

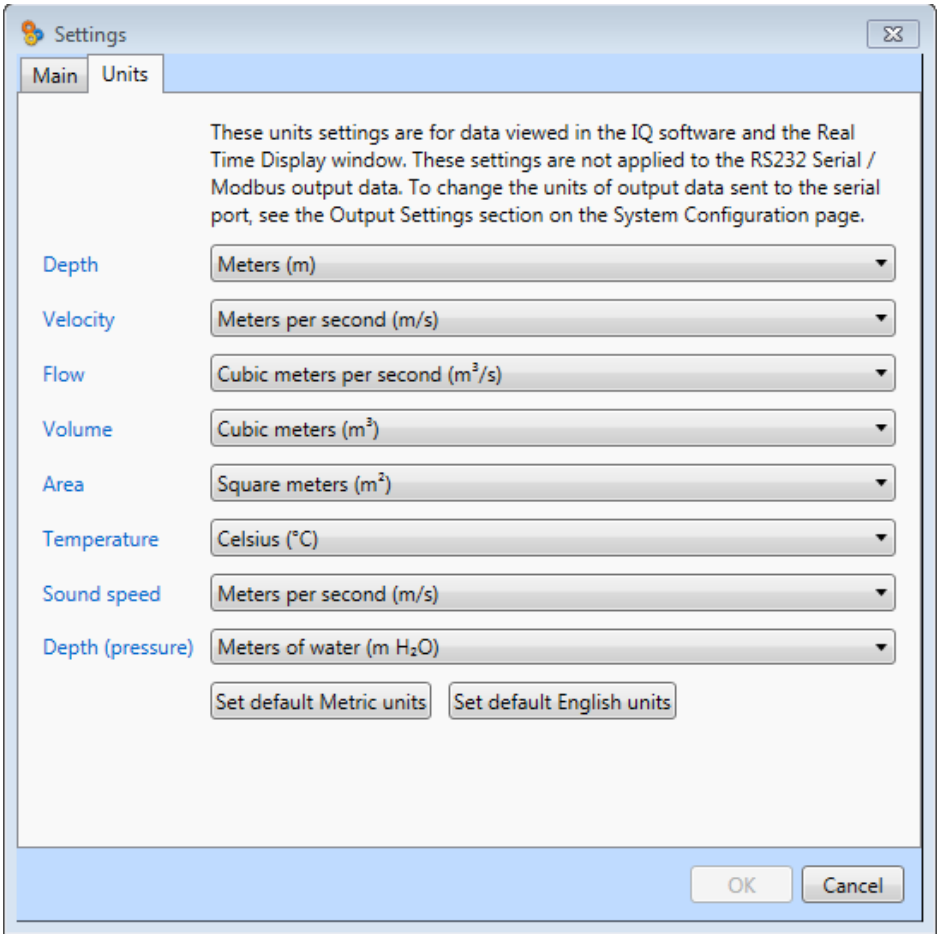


Figure 33. IQ Software Units Settings

Users can also access several functions by clicking on the IQ Icon in the software title bar (Figure 34).

Figure 34. IQ Icon

2.4. IQ Software Recover Instrument and Maintenance Functions

Users can access the Recover Instrument and Maintenance functions by clicking on the IQ icon in the upper left corner of the main window (Figure 35).

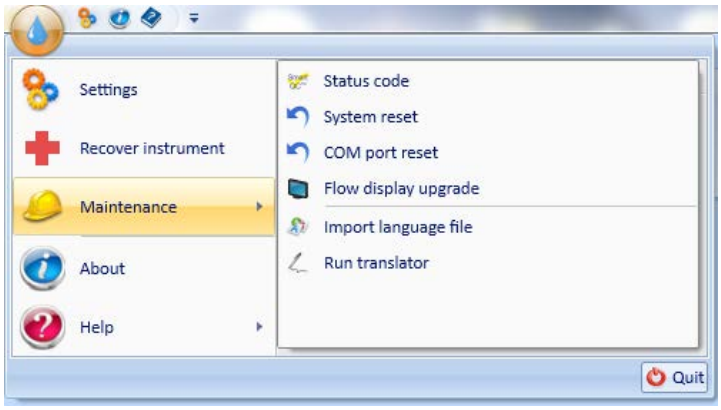


Figure 35. IQ Icon Menu and Software Maintenance Menu

- The Recover Instrument function will guide the user through several steps to reestablish IQ communications.
- The *Status code* and *System reset* functions are found in multiple locations in the IQ 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.

IQ Maintenance – Status Code

The SonTek-IQ has several SmartQC™ functions designed to warn you of potential problems at a measurement site (Section 7.1). The Status Code lookup is provided for easy interpretation of any Status Code reported by the IQ, an example is provided in Figure 36.

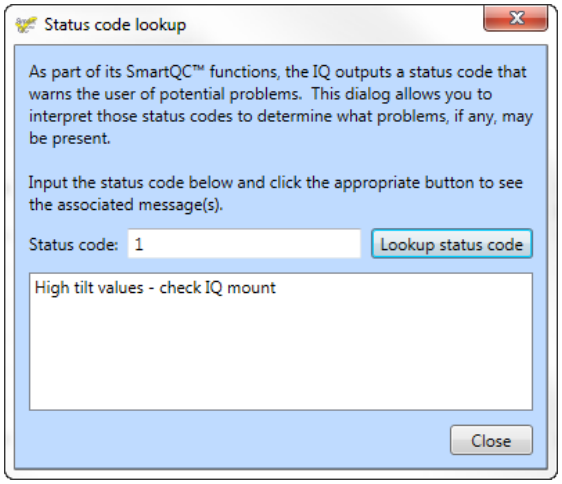
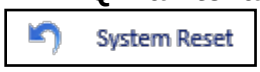


Figure 36. Status Code Lookup

IQ Maintenance – System Reset



The system reset function can be used if communication with the IQ cannot be established or if the system stops responding. This function forces the IQ baud rate to the default setting and interrupts data sampling. If the IQ 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).

IQ Maintenance – COM Port Reset

This option is available for users to specify a COM port by number. This function will attempt a System Reset and connect to the specified COM port. The COM port number can be confirmed in the Device Manager from the PC Control Panel. This function is accessed through the main IQ Icon at the top left corner of the software window. Select “Maintenance” and then “COM port reset”. This will activate a small window to enter the COM port number. The software will attempt to connect and report whether the connection was successful.

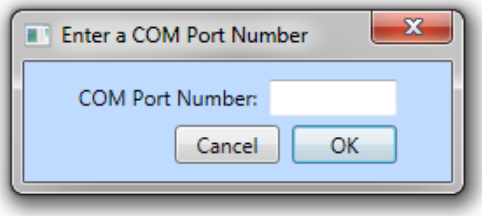


Figure 37. Enter a COM Port Number

IQ Maintenance – Flow Display Upgrade

This menu item is only available when **not** connected to an IQ Product. Periodically, upgrades may be available for the firmware inside the IQ 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 IQ 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.

IQ Maintenance – Import Language File

The IQ 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.

IQ Maintenance – Run Translator

Run the IQ software translator to create your own custom translations (Figure 38). This function opens a separate window with a spreadsheet containing all of the text displayed in the IQ software. The IQ 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.

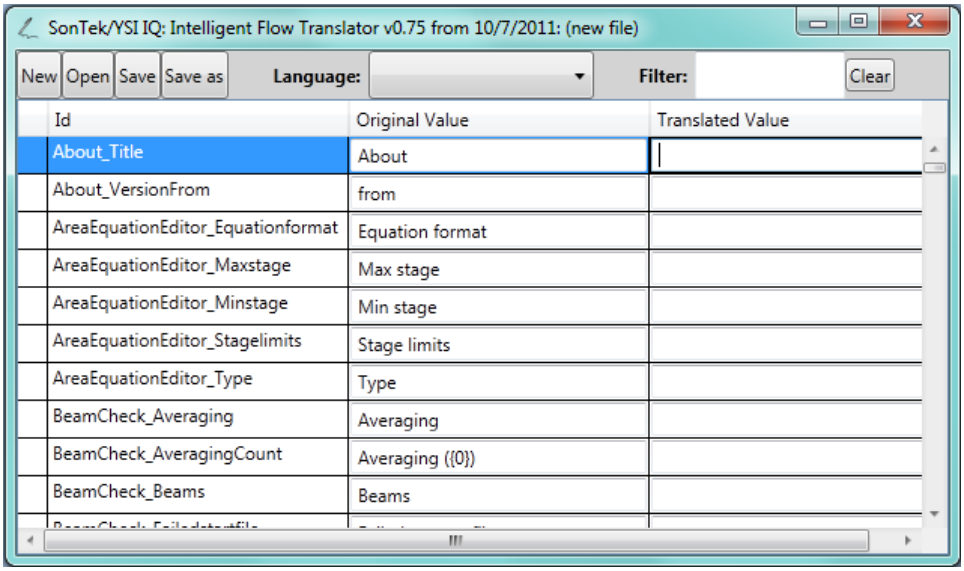


Figure 38. Language Translator

About IQ Provides information about the software version as well as contact information for SonTek Support (Figure 39).

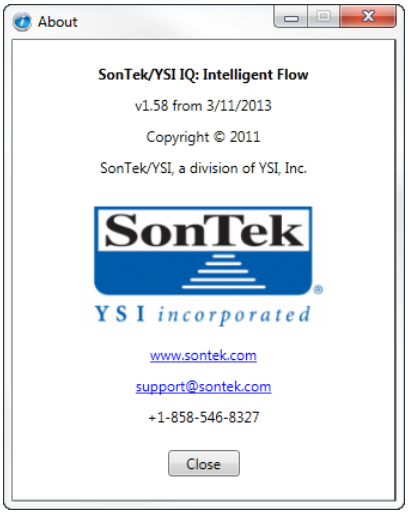


Figure 39. IQ About Window

Help – Documentation

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

2.5. IQ Software Main Ribbon

The IQ 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 IQ, 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.

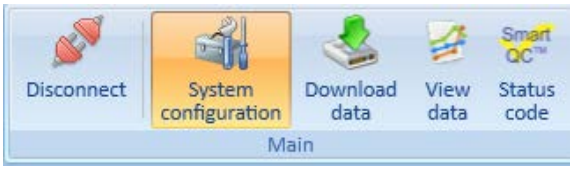
2.5.1. Main Ribbon – Not connected

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

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 6.

2.5.2. Main Ribbon – Connected



Disconnect: Disconnects the computer's communication port from the IQ. If the IQ 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 IQ without interrupting measurements.

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

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.

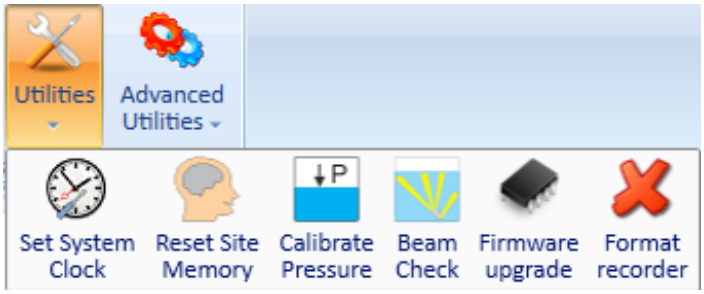
Status code: The IQ automatically performs many functions to identify potential problems at a deployment site (Section 7.1). If a status code is reported, select this icon to decode the status code number.

2.5.3. Main Ribbon – Connected – System configuration – Operations

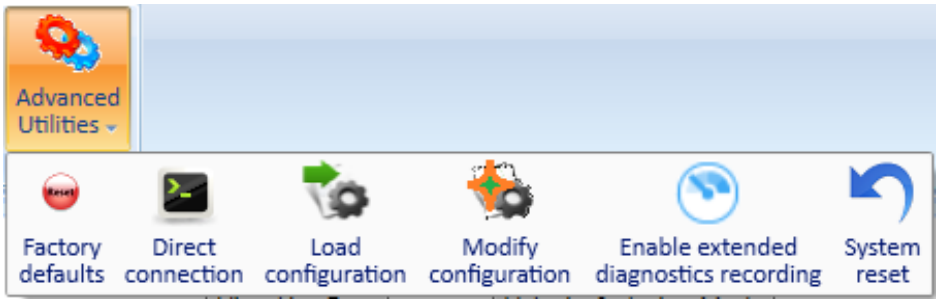
Load Settings: Used in conjunction with deployment planning, users can select a previously saved setup file to load on an IQ. This file will have the extension **.sontek_system_config**.

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 IQ. Files saved will have the extension **.sontek_system_config**.

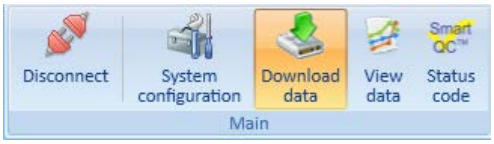
Utilities: Opens a mini-ribbon with the following common utility functions: set system clock, reset site memory, calibrate pressure, Beam Check, firmware upgrade, and format recorder.



Advanced Utilities: 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.



2.5.4. 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.

2.5.5. Main Ribbon – Connected – View Data

The “View Data” function on the main ribbon opens the data visualization window in the IQ software. Clicking on the bottom half drops down two options to open files. They are labeled “Open database” and “Selected files”. Opening and processing data files is explained further in Section 6.

2.5.6. Main Ribbon – Not Connected – View Data

You do not have to be connected to an IQ to view a data file. When not connected, the disconnect, system configuration, and download data functions will be hidden.

Section 3. Planning a Deployment – IQ Smart Page

There are two methods for setting up a SonTek-IQ before a deployment: (1) connect to the IQ and enter the appropriate settings while connected or (2) plan a deployment before connecting and upload the settings when convenient. Both methods will begin the IQ setup process by displaying the IQ Smart Page.

- IQ configuration files can be downloaded and saved from the IQ while connected.
- IQ 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 IQ Smart Page

Start by opening the IQ software. To view the IQ 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 40). 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 40). If more than one IQ is connected to your computer, you will be asked to choose a COM port. If there is only one IQ, the software will automatically connect to the system.

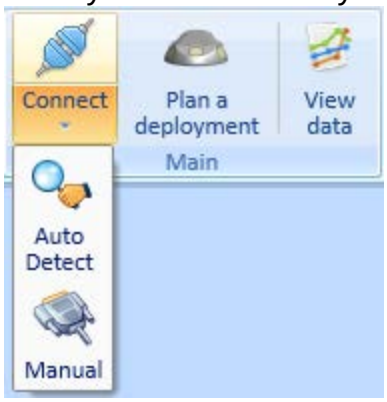


Figure 40. Auto Connect IQ Search

If you choose **Manual**, the software will ask you to choose a COM port (Figure 41).

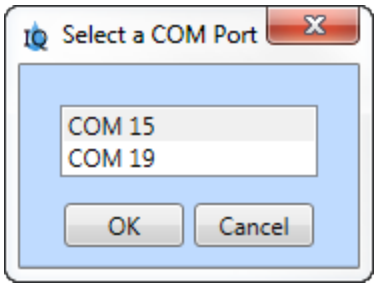


Figure 41. Manually Select a COM Port

If you select **Plan a deployment**, you will be asked to identify the IQ model type to plan a new deployment or you can open an existing configuration file for editing (Figure 42). After choosing an option, you will be taken to the IQ Smart Page.

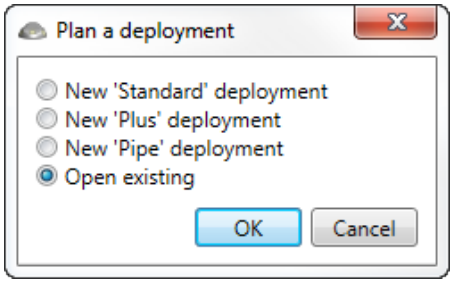


Figure 42. Plan a Deployment

The IQ 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 IQ Smart Page (Figure 43) provides feedback during the setup procedure to indicate completed steps and settings that still need to be checked. The IQ Smart Page is a complete overview of the IQ's current configuration including potential problems with the setup options.

- The IQ Smart Page has six sections
  - System Information
  - Site Details
  - Data Collection Schedule
  - Velocity Configuration
  - Flow Configuration
  - Output Settings

- IQ 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 are not connected to an IQ, the System information section will only display the IQ model (Standard, Plus or Pipe) and the **Start Data Collection** button will be hidden.

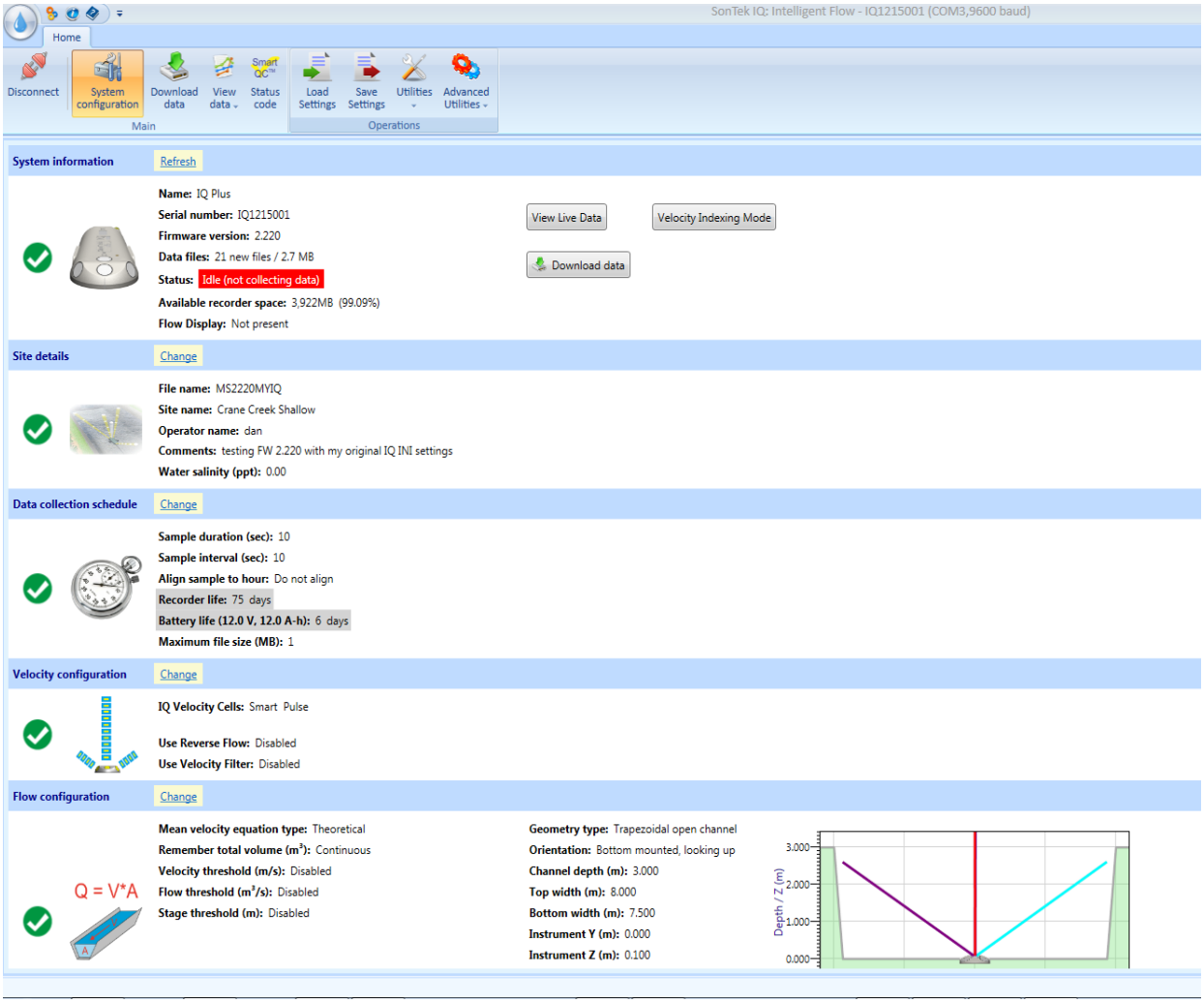


Figure 43. IQ Smart Page – Connected to an IQ

If this is the first time you are connecting to your IQ, you may be prompted to calibrate the pressure sensor (Figure 44). Because atmospheric pressure changes continually, the amount of pressure from the atmosphere must be removed or calibrated out of the raw pressure measurement. The IQ will perform this calibration on a regular basis while measuring. Select either button to continue to the IQ Smart Page.

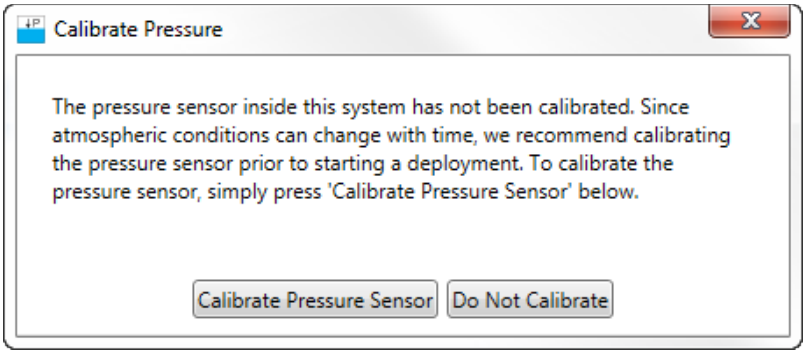
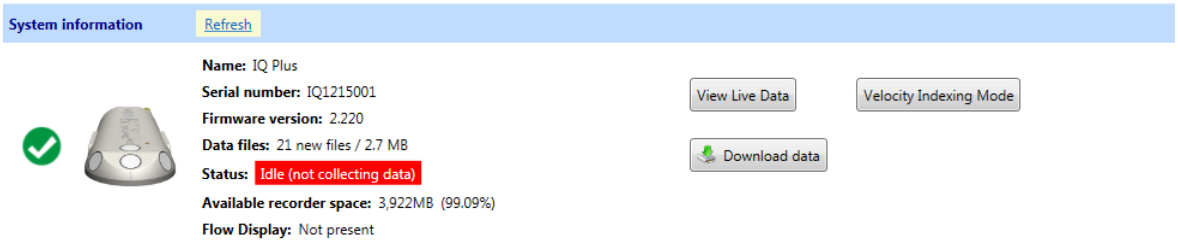


Figure 44. Calibrate Pressure Sensor

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

3.1.1. IQ Smart Page – System Information



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

Name: Defines the type of IQ system: IQ Standard (Std) or IQ Plus or IQ Pipe

Serial Number: Every IQ 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).

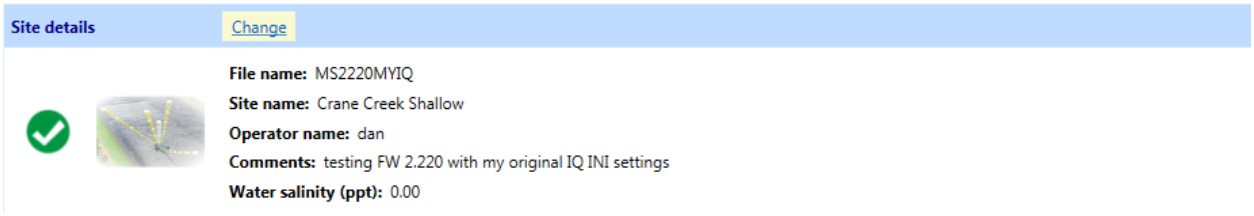
Flow Display: Indicates if a flow display is currently being used. Three different cases can be seen here: No display connected, standard display present, and display with 4-20 mA present.

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: A sampling mode where the sample interval and sample duration are automatically set to 60 seconds and data is collected for one hour. The IQ will revert to the original data collection settings at the end of the hour. See Section 3.3 for details.

3.1.2. IQ Smart Page – Site Details



The IQ Smart Page Site Details section is where users can view and change input details about the deployment site. Selecting the **Change** button will open a dialog where you can change or enter values for each field.

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 IQ 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.IQ*. 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 IQ 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 IQ, 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.

3.1.3. IQ Smart Page – Data Collection Schedule

The **Data Collection Schedule** (Figure 48) allows users to setup the IQ sampling scheme and the timing of the first sample. The external battery life can also be estimated.

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 10 and maximum is 3600 seconds.

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 IQ will start the first sample at the time that ensures that a sample will align with the top of the next hour. The IQ 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.
- Deployment Starts at a Specific Date/Time means data collection will begin at the programmed date/time in the future. After the date and time are set and the dialog is closed, the user settings will be displayed on the Smart Page in the Data Collection Schedule section. To begin the deployment you will still need to press the “Start data collection” button at the bottom of the system configuration page. The deployment will begin immediately after pressing the button, but the first sample will not be collected until the start date and time are reached. A summary dialog will be displayed after the system is started.

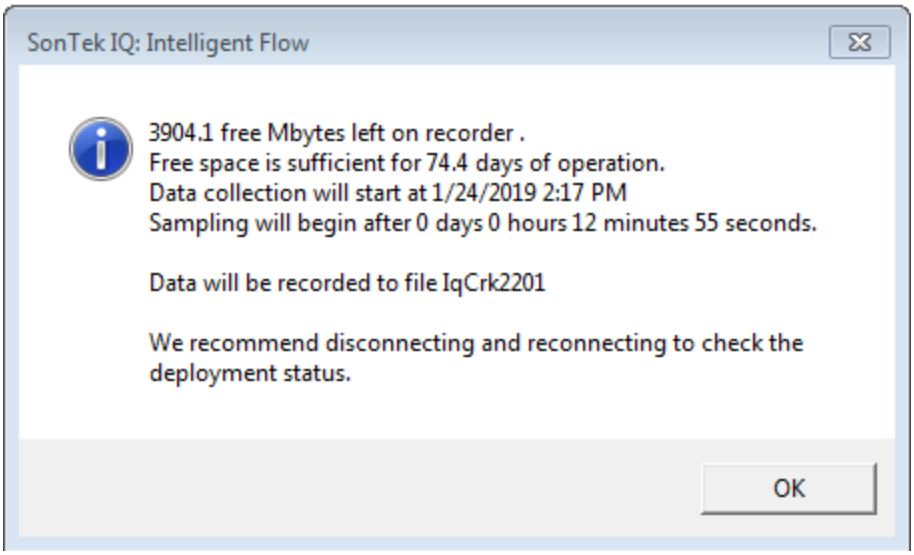
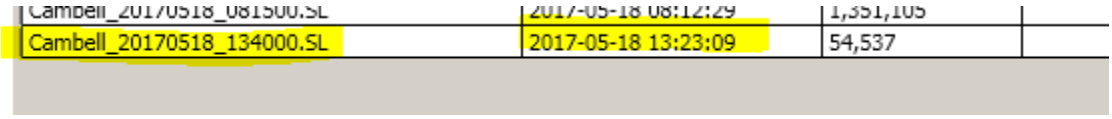


Figure 45. Deployment Summary

<u>It is highly recommended to disconnect and reconnect to confirm that the deployment has begun. Reconnecting will re-check the instrument settings including the start time.</u>

After clicking the “Start data collection” button, a file will immediately be created on the recorder. This filename will include the user defined start date and time, but it will have a file creation time equal to the time the “Start data collection” button was pressed.
For example, the user setting for a start time of 5/18/2017 1:40PM is included in the file name as the equivalent 24-hour time of 13:40, but the file time on the right is 13:23 when the “Start data collection” button was clicked.



When the data collection is stopped, the IQ will automatically return to the default setting for “Align sample to hour” which is “Do not align”. If the user wishes to start another deployment at a specific time they will have to change the settings again. This is to help prevent mistakes when the start button is clicked.

The start date and time are checked before starting. If the start time has already passed the deployment will begin immediately and a warning message will be displayed.

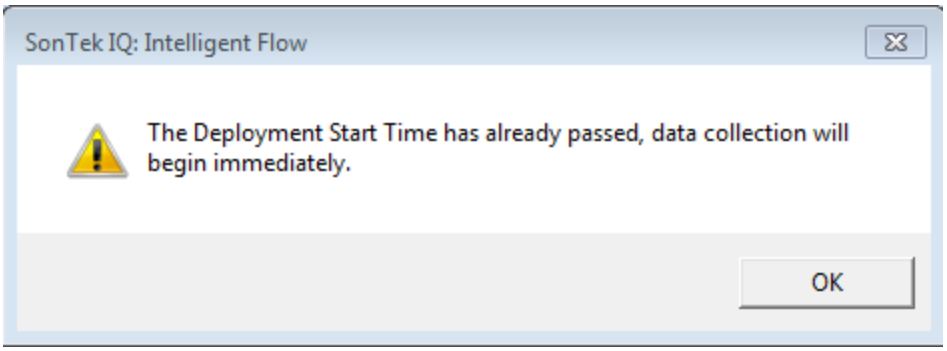


Figure 46. Deployment Start Time Passed

The software will not let the user set the start date more than 1 year in the future.

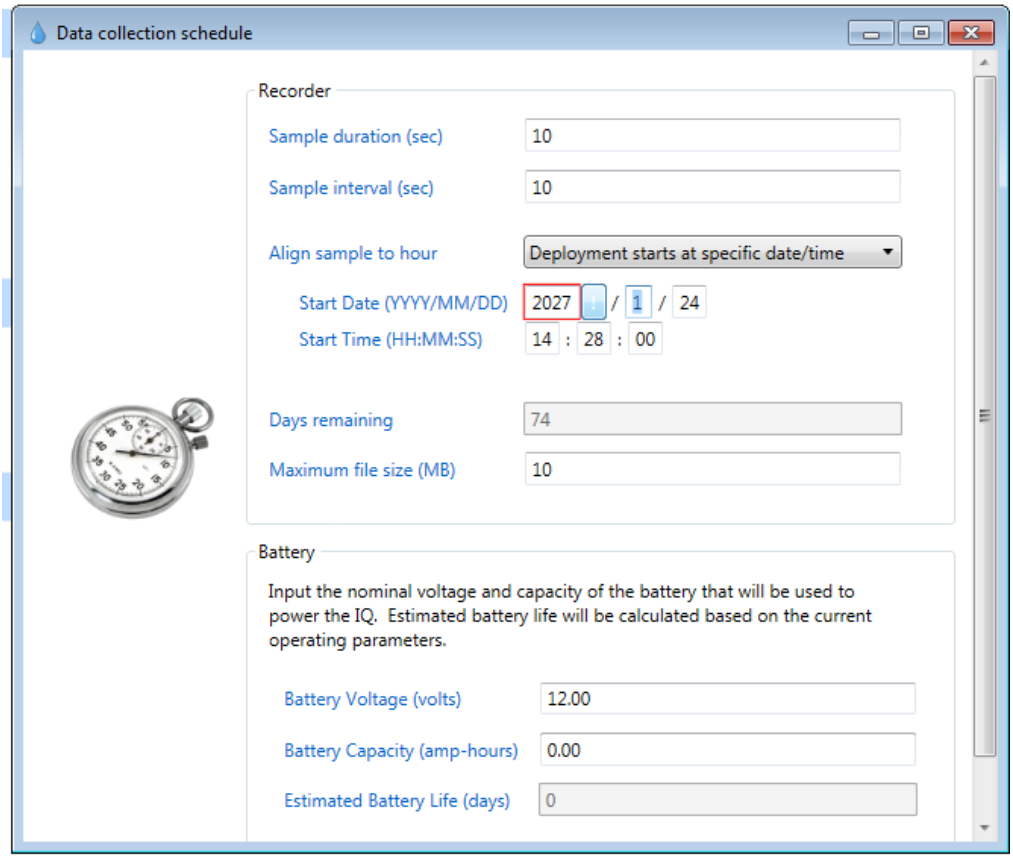


Figure 47. Deployment Date Limit

In the event of power loss before the start date and time are reached, the system will restart when power is reapplied and it will continue to wait for the start date and time. A new file will be created after each power failure with the seconds in the time stamp incrementing by one. In the example below, the data collection was scheduled to start at 14:30 (2:30 pm), but power was lost 2 times before then. Note the increase in the time stamp seconds for each new file. The file creation time stamps indicate when power was restored.

IqCrk2201_20190124_143000.IQ	2019-01-24 14:14:57	39,413	
IqCrk2201_20190124_143001.IQ	2019-01-24 14:16:21	39,413	
IqCrk2201_20190124_143002.IQ	2019-01-24 14:16:59	39,413	

Maximum file size (MB): This setting will determine the maximum size of files on the recorder. During data collection, the current data file will be closed once this limit is reached and a new file will be started. The sample numbers will maintain continuity from file to file meaning that if one file ends at sample 500, the next file will start with sample number 501. Sample numbers will restart at 1 only after stopping and restarting the instrument.
File sizes will be approximate (not exactly 1MB) because the size of the file is not monitored in real-time. It is estimated from the sample settings and then closed at a particular sample number.

Battery Life: Input the nominal voltage and capacity of the battery that is used to power the IQ. 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 10 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% for 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

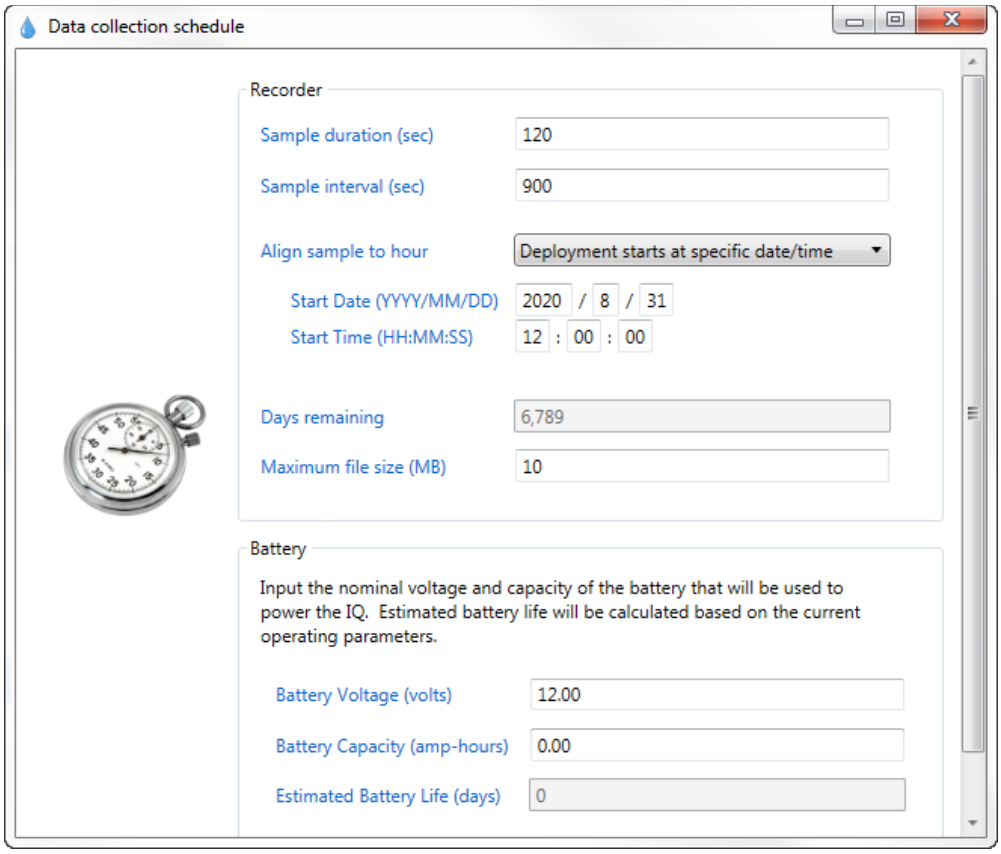


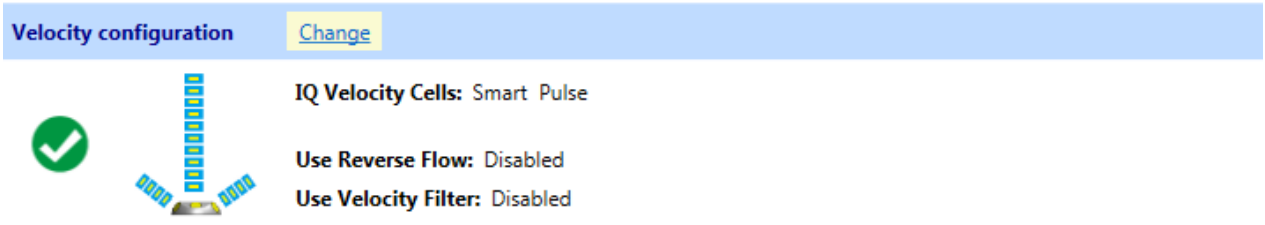
Figure 48. IQ Data Collection Schedule

While entering values for settings, it is possible to enter values that are incorrect (Figure 49). If the IQ software detects an incorrect value, it will highlight the value and associated fields in red.

To get help with the error, hover over the red box next to the incorrect field.

Figure 49. IQ Software Help with Incorrect Settings

3.1.4. IQ Smart Page – Velocity Configuration



The Velocity Configuration section can be used to manually configure the velocity settings and multi-cell settings instead of Smart Pulse. The manual mode (Figure 50) should only be used by

experienced users. The Reverse Flow feature can be enabled if the IQ is installed with the connector pointing upstream instead of downsteam.

IQ Velocity Cells: The velocity cell measurements can be automatically configured using Smart Pulse (default) or set manually. The Manual setting disables Smart Pulse to allow the user to set the cell size, number of cells and blanking distance for the center and skew beams independently. Cells programmed beyond the water surface will not be used in the velocity measurement. However, care must be taken by the user to set up the skew beams so that they do not hit the walls of the channel, otherwise those data will be contaminated. The Manual setting is subject to these parameters:

- The IQ only pings in IC (incoherent) mode.
- The minimum cell size and blanking distance are 4cm.
- The minimum operational depth for manual mode with 5 or more cells is 12cm. For 4 or less cells, it is 10cm.

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.

Reverse flow direction: Use the check box to enable this feature, which allows you to reverse the sign (+/-) on measured velocities and flow direction. This option should be selected when the system is pointing downstream (cable is pointing upstream).

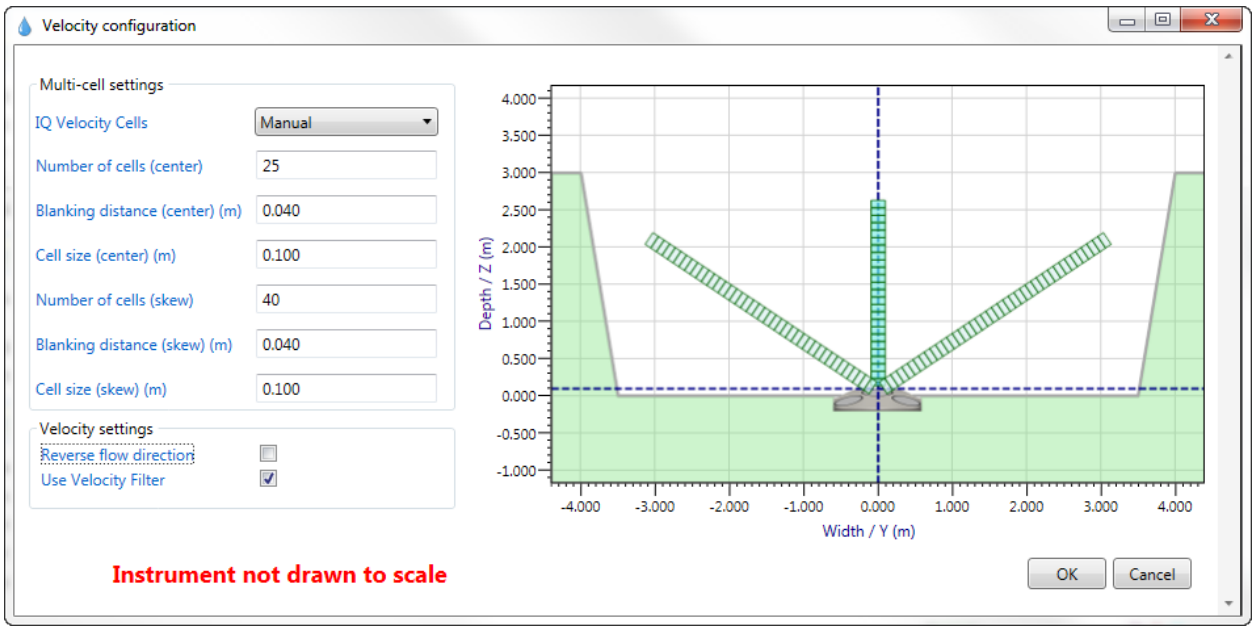
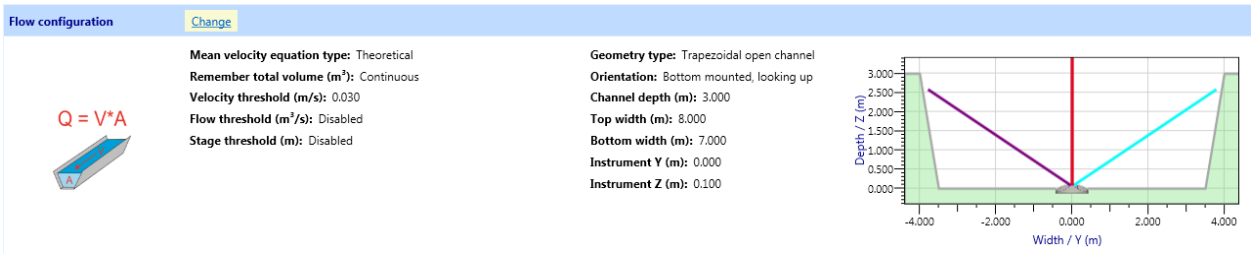


Figure 50. Velocity Configuration Manual Multi-Cell Settings

3.1.5.IQ Smart Page – Flow Configuration



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 IQ measures water velocity and depth to combine with the channel dimensions to calculate flow. This section allows users to configure the flow calculation settings and to set threshold limits on the Velocity, Flow, and Stage.

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 IQ 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.

IQ Velocity Cells: The velocity cell measurements can be automatically configured using Smart Pulse (default) or set manually. The Manual setting disables Smart Pulse to allow the user to set the cell size, number of cells and blanking distance for the center and skew beams independently. Cells programmed beyond the water surface will not be used in the velocity measurement. However, care must be taken by the user to set up the skew beams so that they do not hit the walls of the channel, otherwise those data will be contaminated. The Manual setting is subject to these parameters:

- The IQ only pings in IC (incoherent) mode.
- The minimum cell size and blanking distance are 4cm.
- The minimum operational depth for manual mode with 5 or more cells is 12cm. For 4 or less cells, it is 10cm.

Channel 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.

Elliptical Pipe: A regular closed conduit or pipe defined by the width and height.

Round Pipe: A regular closed conduit or pipe that is defined by the diameter.

Irregular Pipe: A closed conduit of any shape defined by up to 200 user defined supplied survey points.

Stage / area equation: (IQ Plus and IQ Pipe only) 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: Flow will not be calculated. For velocity data only.

Survey origin: The origin of the horizontal distances as measured from either 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

IQ Orientation (only for closed channels or pipes) – Normal operation is for the system to be bottom mounted (up-looking); however, in pipe applications that are always full the system can be installed at the top of the pipe looking down (example provided in Figure 51). **This option is only available in the IQ Plus and IQ Pipe.**

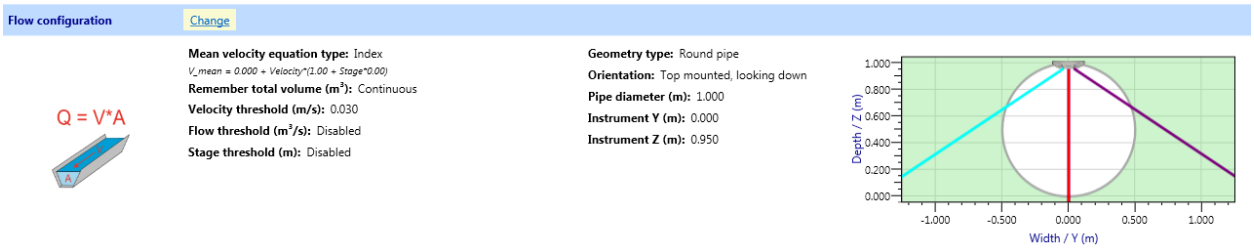


Figure 51. IQ Inverted Orientation in a Closed Channel

It is important to note that the locations of where the beams are profiling are mapped on the Channel Shape diagram (via dark blue, light blue, red and green lines). This feature is applied for all IQ products. In addition, it is important to note beams will stop profiling based on the entered geometry – this helps prevent side lobe interference and makes for a better measurement.

Pipe Diameter: The IQ Pipe algorithms are based on a pipe diameter ranging from 0.46m (18”) to 1.83m (72”). Diameter settings outside of this range may not generate accurate theoretical flows. A velocity index may be necessary for accurate flow calculations. IQ status code 2048 is used to warn users that settings are outside of recommended theoretical range. All samples that meet the above criteria are flagged with this code.

Instrument Y: The horizontal location of the IQ in the channel. This distance is measured from the origin. For trapezoidal shapes, the origin is in the middle of the channel. For irregular channels, the origin is located on the side of the channel.

Instrument Z: The vertical location of the IQ in the channel. This distance is measured from the origin. For trapezoidal shapes, the origin is in the middle of the channel. For irregular channels, the origin is located on the side of the channel.

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.

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. This option is only available on the IQ Plus.

Theoretical (Center Beams Only): Theoretical flow will be computed using the velocity profiles from the center beams only. The same algorithm is used to compute theoretical flow. This algorithm integrates over the entire channel using the center beam velocity profile for the vertical and horizontal distribution of velocity. This function can be used if installation sites are causing interference with the skew beams or if the instrument is installed in a narrow channel. This option is available when using the Recalculate Flow feature in post-processing.

Theoretical (Beam 1 Only): Theoretical flow will be computed like the 'Center Beams Only' option described above, but using the velocity profiles from beam 1 only. This function can be used if something is causing interference affecting beam 2.

Theoretical (Beam 2 Only): Theoretical flow will be computed like the 'Center Beams Only' option described above, but using the velocity profiles from beam 2 only. This function can be used if something is causing interference affecting beam 1.

Flow algorithms are dependent on instrument type. The table below describes the flow algorithms based on instrument type.

Flow Algorithm	IQ Standard	IQ Plus	IQ Pipe
Open Channel All		T/R	R
Closed Conduits All		R	T/R
Open Channel Trapezoid	T	T/R	R
Open Channel Irregular	T	T/R	R

T = Theoretical Flow Algorithm
R = Index Velocity Rating

It is important to note that although both the IQ Plus and IQ Pipe can be installed in either open channels or closed conduits, the theoretical pipe flow algorithms only exist in the IQ Pipe system and theoretical open channel flow algorithms only exist in the IQ Plus (and IQ Standard). If an IQ Pipe is installed in an open channel, or an IQ Plus is installed inside a pipe, flow (volumetric discharge) must be computed outside of the system using the index velocity (rating) method.

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 IQ 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 IQ was not collecting data. Based on previous measurements, the total volume is adjusted to include the volume of water that flowed while the IQ 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 IQ 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.

Note: In the event of a power loss, the total volume will be saved to begin accumulating again when power is restored. The amount of time that the volume will carry over to the next file can be changed in Advanced Utilities > Modify Configuration > Maximum number of minutes continuous volume is valid. The default setting is 60 minutes.

Use velocity threshold: 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.

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.

Use stage threshold: 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.

Figure 52 shows an example of the Flow Configuration setup window.

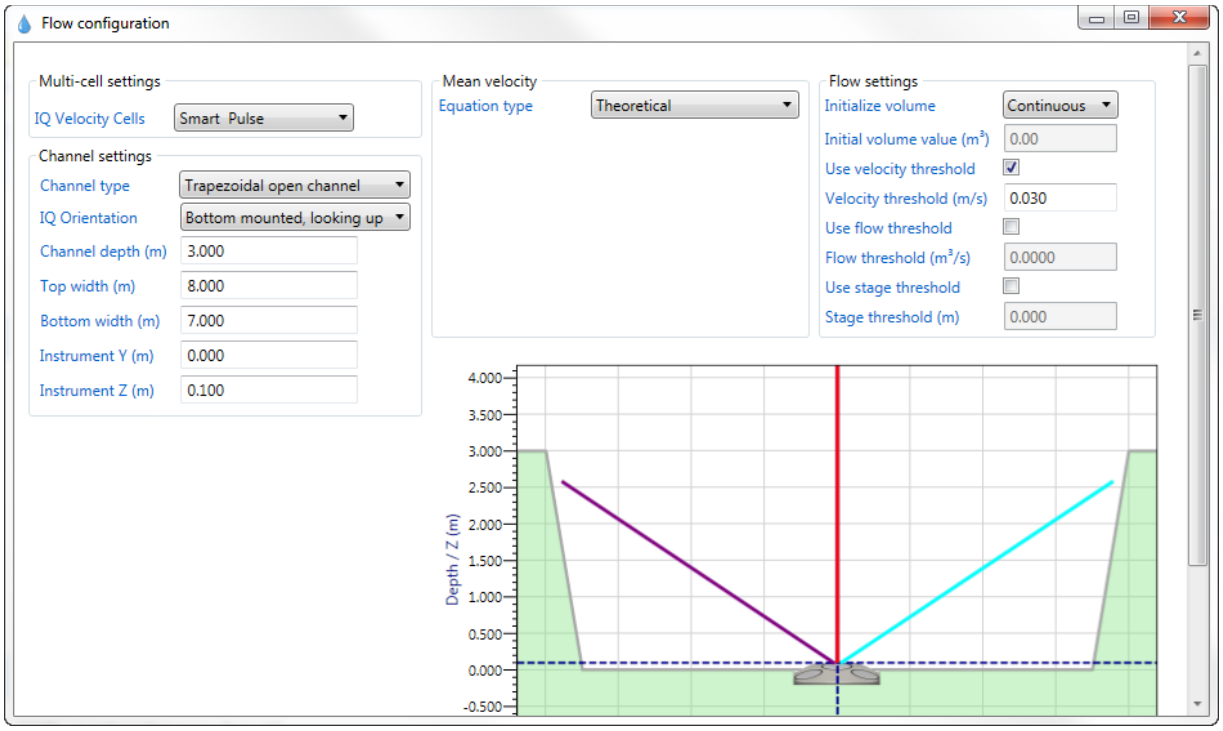


Figure 52. Flow Configuration Setup

The Channel settings provide a quick and easy way to enter the channel dimensions at the measurement site. The options in this area will change depending on the type of channel selected.

- The channel dimensions can be entered manually in the spreadsheet (for Irregular Open Channel and Irregular Pipe).
    - 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 IQ 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 IQ 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 53).

- 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

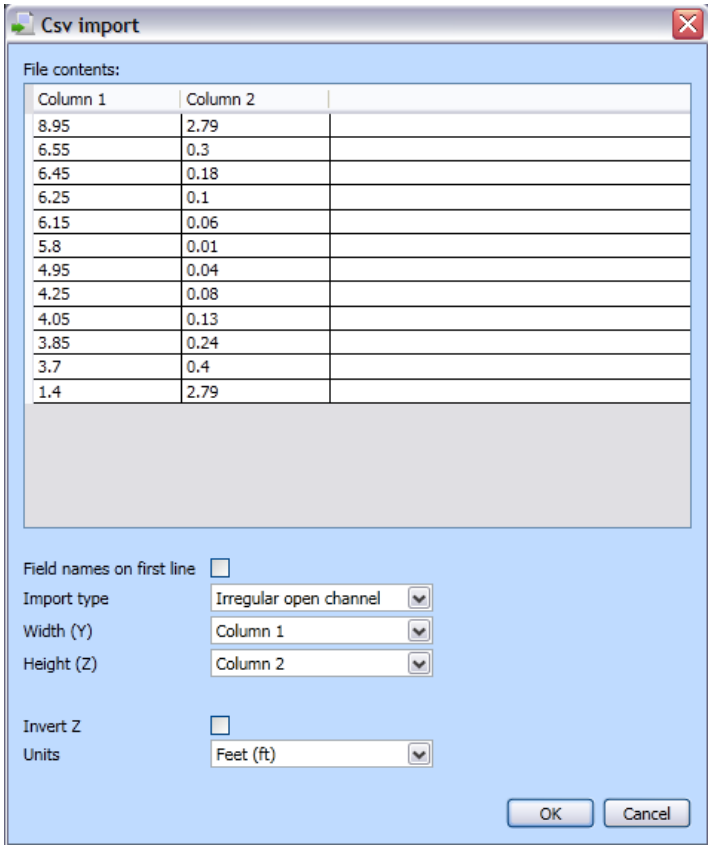


Figure 53. CSV Import Window

3.1.6.IQ Smart Page – Output Settings

The SonTek-IQ is capable of outputting data in a variety of usable formats. Output data formats are compatible with many data loggers, PLCs, and RTUs. The IQ 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 54).

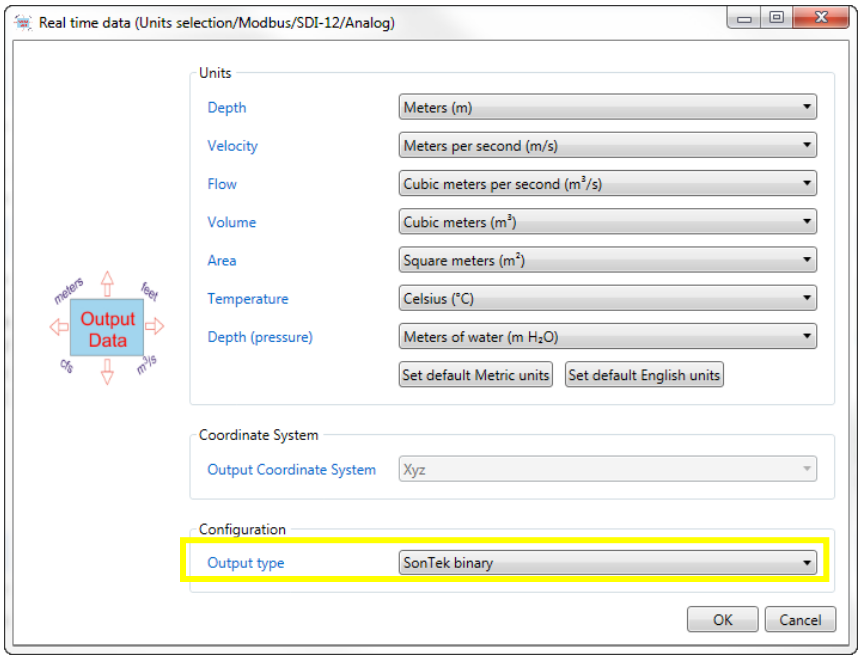


Figure 54. Configuring Output Data Settings

- Units for each type of output variable are set in the Output settings dialog
- Buttons for default metric and default English units are provided
- The **Output Coordinate System** only applies to the ream time ASCII and SDI-12 output for the IQ Plus and IQ Pipe. The velocities will be output in the selected coordinate system (XYZ or Beam).
- To use the **View live data** function in the IQ 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 IQ 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 data loggers 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 IQ to control up to four analog signals generated by the IQ 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 IQ. For example, if the data variable on channel 1 is Flow and the Min value setting is zero, the IQ will output a 4 mA signal on channel 1 when the calculated Flow is zero (Figure 55). 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.

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.

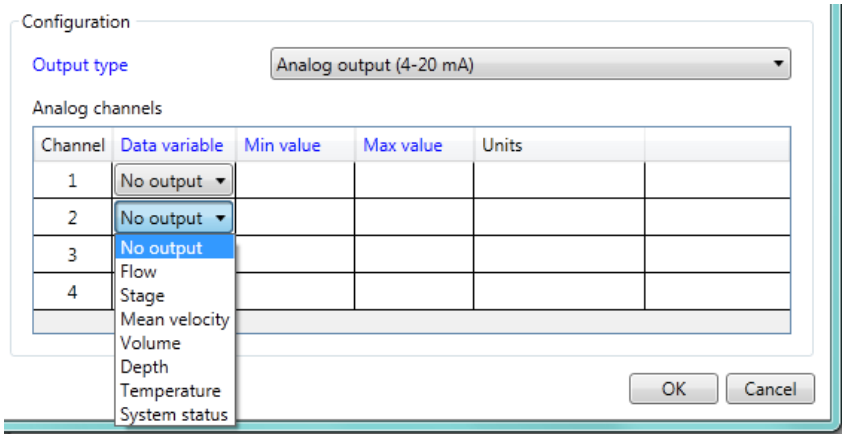


Figure 55. Analog Output Configuration

SDI-12 output: Select this option to interface the SonTek-IQ with an SDI-12 data logger 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 56 presents the SDI-12 Configuration dialog.

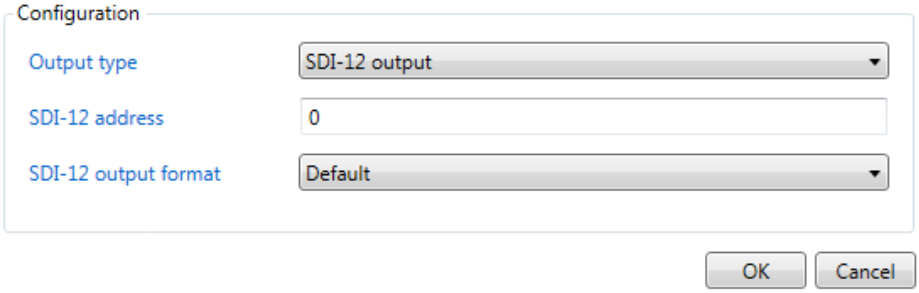


Figure 56. SDI-12 Default Output

The Default SDI-12 output format is covered in Section 7.5.2. There is also a Profile format covered at the end of the same section that contains velocity data from the first 10 multi-cells of the center beams.

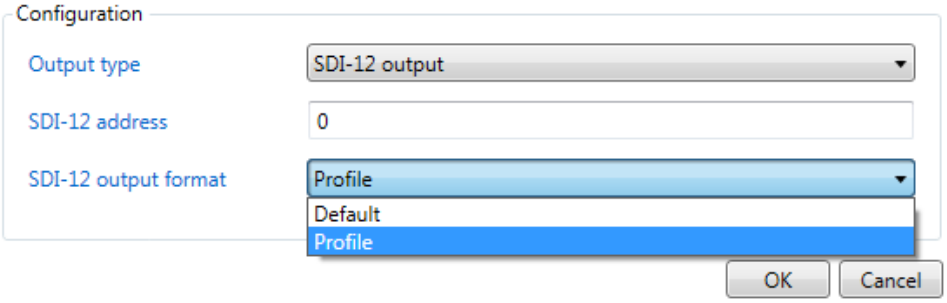


Figure 57. SDI-12 Profile Output

Modbus output: The SonTek-IQ 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 58 presents the Modbus Configuration dialog.

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

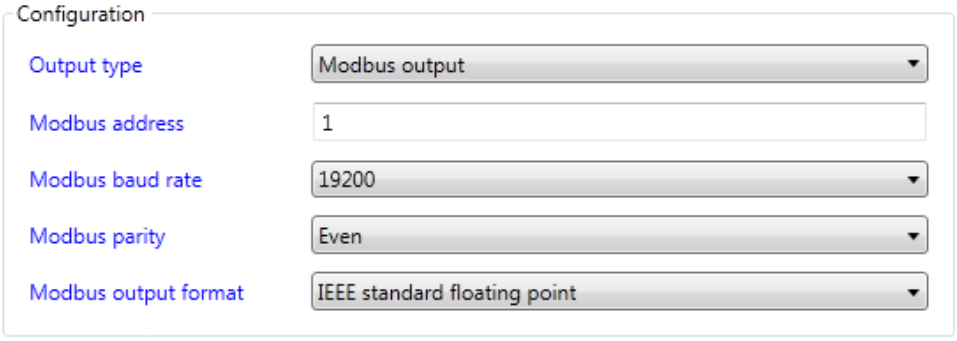
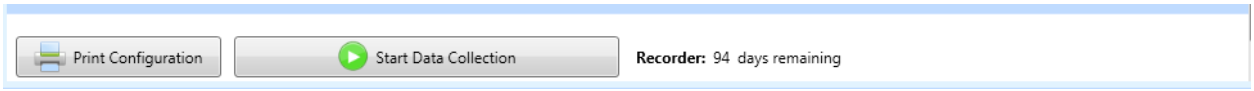


Figure 58. Modbus Output Configuration

3.1.7. IQ Smart page – Print Configuration and Start Data Collection



Two buttons at the bottom of the IQ Smart Page are used to **Print Configuration** and **Start Data Collection**. After configuring all of the options on the IQ 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 IQ 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 IQ Smart Page that can be used for record keeping with all of the IQ 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 IQ, 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 IQ cable adaptor and open the software. Click on connect and the IQ Smart Page will open. Data can be downloaded in two ways (Figure 59):

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

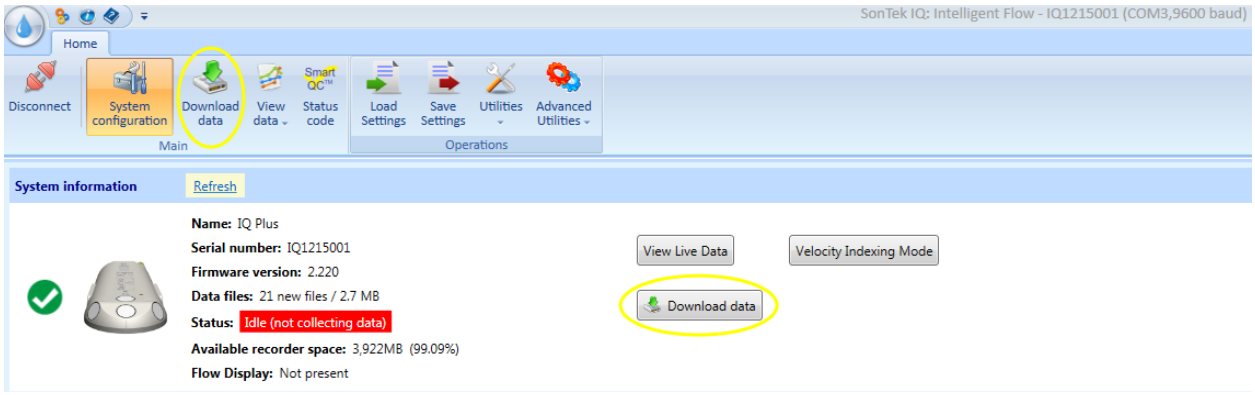


Figure 59. Download Data Buttons on the IQ Smart Page

Both options will take you to the Download data window (Figure 60). Once the Download data window is open, you will see a list of new files currently stored onboard the IQ. 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 IQ Data directory. This directory is defined in the IQ 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.

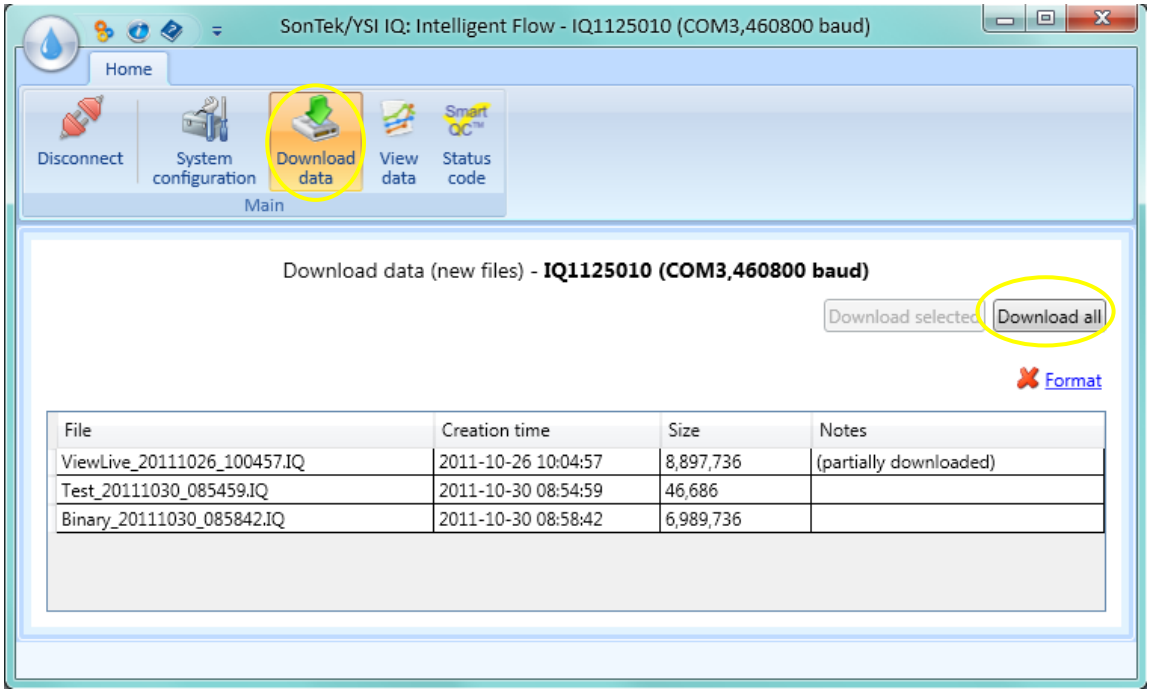


Figure 60. Download Data Window

- The IQ serial number, COM port, and baud rate are displayed at the top of the page.
- The maximum baud rate can be changed in the IQ 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 → IQ 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. IQ 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 IQ 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:

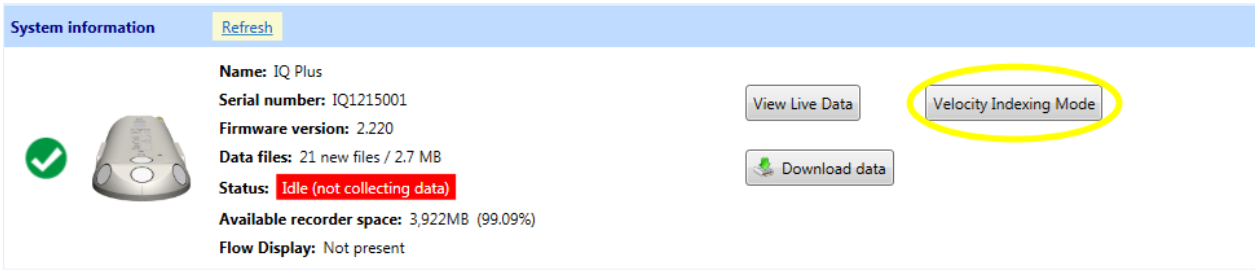
- If a folder containing IQ data does not exist in one directory – copy the entire folder (and its contents) from one local drive to the other local drive.
- When copying files from one folder to another – make sure folder names are exactly the same.
- The software will create supplementary hidden files in the same folder that your data files are located. They will have ".fastdat" or ".wsp" extensions. The ".wsp" files hold the settings used for recalculating data, if this file is deleted the original data will be loaded when the file is selected. The ".fastdat" file is a compressed version of the raw data that is generated when the file is first opened for viewing in the software. Subsequent views of the file should load faster. Deleting the *.fastdat file will not affect any settings, but could cause the file to load slower the next time it is opened. Because this is a compressed file, occasional errors can be introduced when loading the compressed data. If you should see something odd in the software, like one of the velocity profiles is missing or looks like a flat horizontal line instead of a vertical profile., deleting the *.fastdat file can sometimes fix these problems.

3.3. System Configuration – Velocity Indexing Mode

Velocity Indexing Mode is a sampling mode where the Sample Interval and Sample Duration are automatically set to 60 seconds and data is collected for one hour. Users can modify these settings, but by default it is designed for users to activate VI mode and disconnect the computer. The IQ then collects this indexing data and returns to the original data collection settings after the hour has passed.

VI mode is available in the IQ Software and by using the "ViStart" ASCII command. See the ASCII commands that start with "Vi" for details on changing the VI mode settings from the command line.

The Velocity Indexing Mode is activated by clicking on the button in the System Information section of the Smart Page.



If the system is currently collecting data, the following warning dialog will appear:

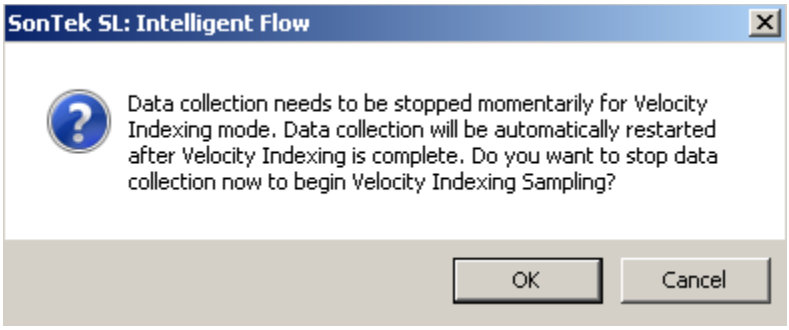


Figure 61. Velocity Indexing Confirmation

Once the main Velocity Indexing window opens, you will see buttons for starting and stopping the index measurement along with several status boxes and a real time chart. The user can change the duration of the index by entering the number of minutes in the Index Duration text box. The default duration is 60 minutes.

The Instrument Status box will keep a scrolling log of the instrument status while changing settings, starting the system, stopping the system, and reconfiguring the system after the indexing is finished. There is a check box below the Start and Stop buttons to close the window automatically. By default the window will close automatically when the indexing duration has expired.

Figure 62 shows the Velocity Indexing Mode window when the Output Type is set to SDI-12, ASCII, Modbus or Analog. When the Output Type is set to SonTek Binary, the window looks like Figure 63.

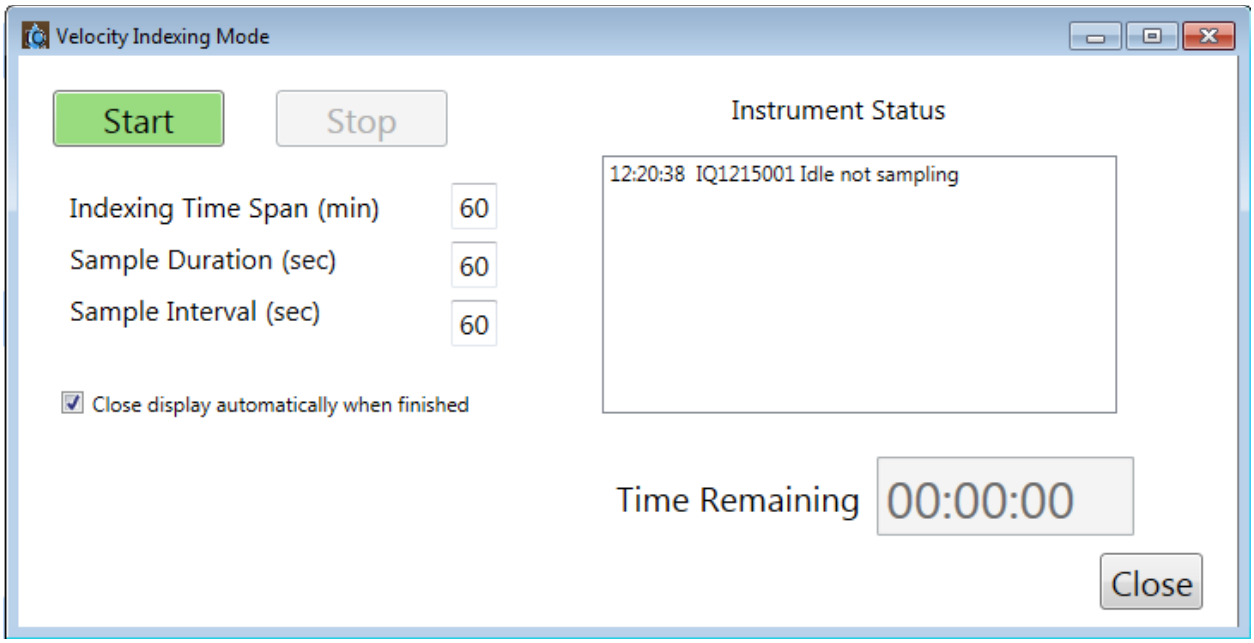


Figure 62. Velocity Indexing with SDI-12/ASCII/Modbus/Analog

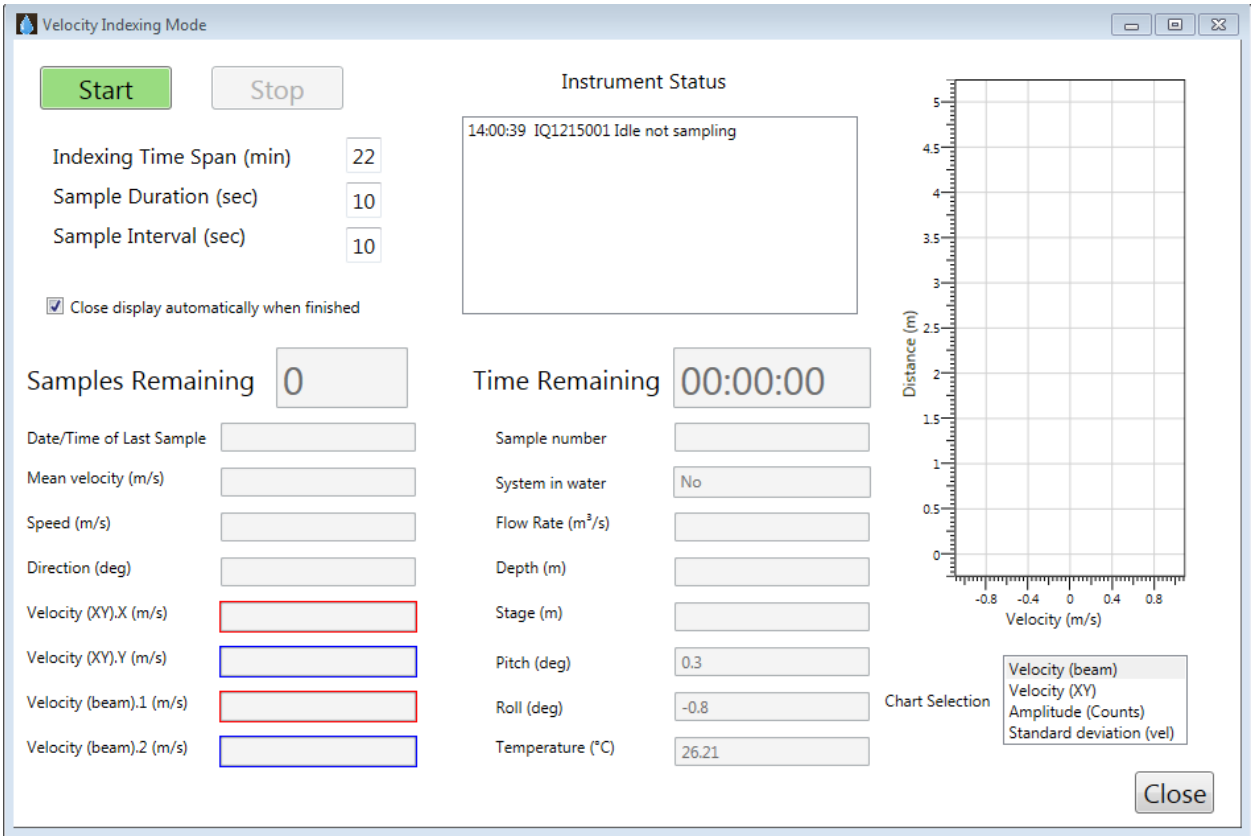
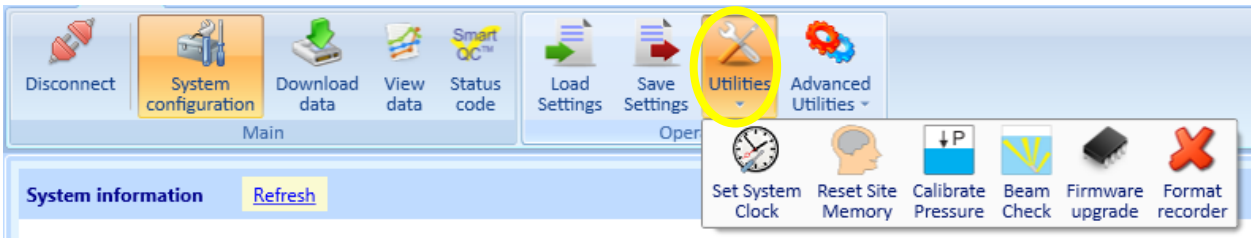


Figure 63. Velocity Indexing with SonTek Binary

3.4. System Configuration – Utilities



There are several common utility functions accessible from the main ribbon when viewing the IQ Smart Page. The IQ 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 IQ clock to the PC clock or input another reference date and time (Figure 64). The **System Date Time** is the current time onboard the IQ. If the **Verify system clock** option is enabled in the software settings, the IQ will automatically prompt you to correct the time if it differs from the PC time upon connection.

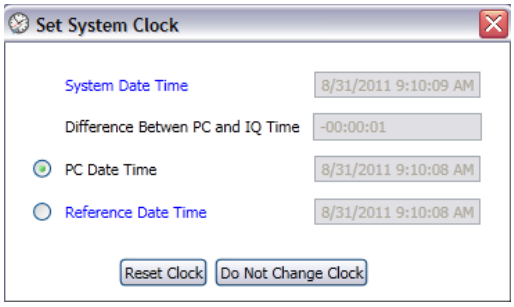


Figure 64. Set Sytem Clock window

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 IQ 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 IQ is submerged in water at a depth greater than 0.1 meter (0.3 ft).
- The IQ can calibrate the pressure sensor while underwater if the surface conditions are stable (smooth water surface).
- The IQ 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 IQ will automatically prompt you for a pressure calibration when the last calibration is no longer valid.
- While sampling, the IQ will calibrate the pressure sensor on a regular basis if conditions are acceptable.
- While idle, the IQ 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 IQ users. You may receive IQ firmware from SonTek support personnel or the SonTek 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 been saved correctly before formatting the recorder.

3.4.1. 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 hide data from that beam.
- To view a previously recorded Beam Check file, select stop to end sampling and then select **Open Beam Check File** to view data (Figure 65).

Figure 65. 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 66 presents the Beam Check window.
  - The vertical dashed lines on the Amplitude chart are the noise levels for each beam.
  - Noise and Amplitude are both displayed as “counts”.
  - The noise levels are also displayed in the text boxes to the left of the charts.
  - Noise levels are not displayed on the SNR chart because noise is included in the SNR decibel calculation.

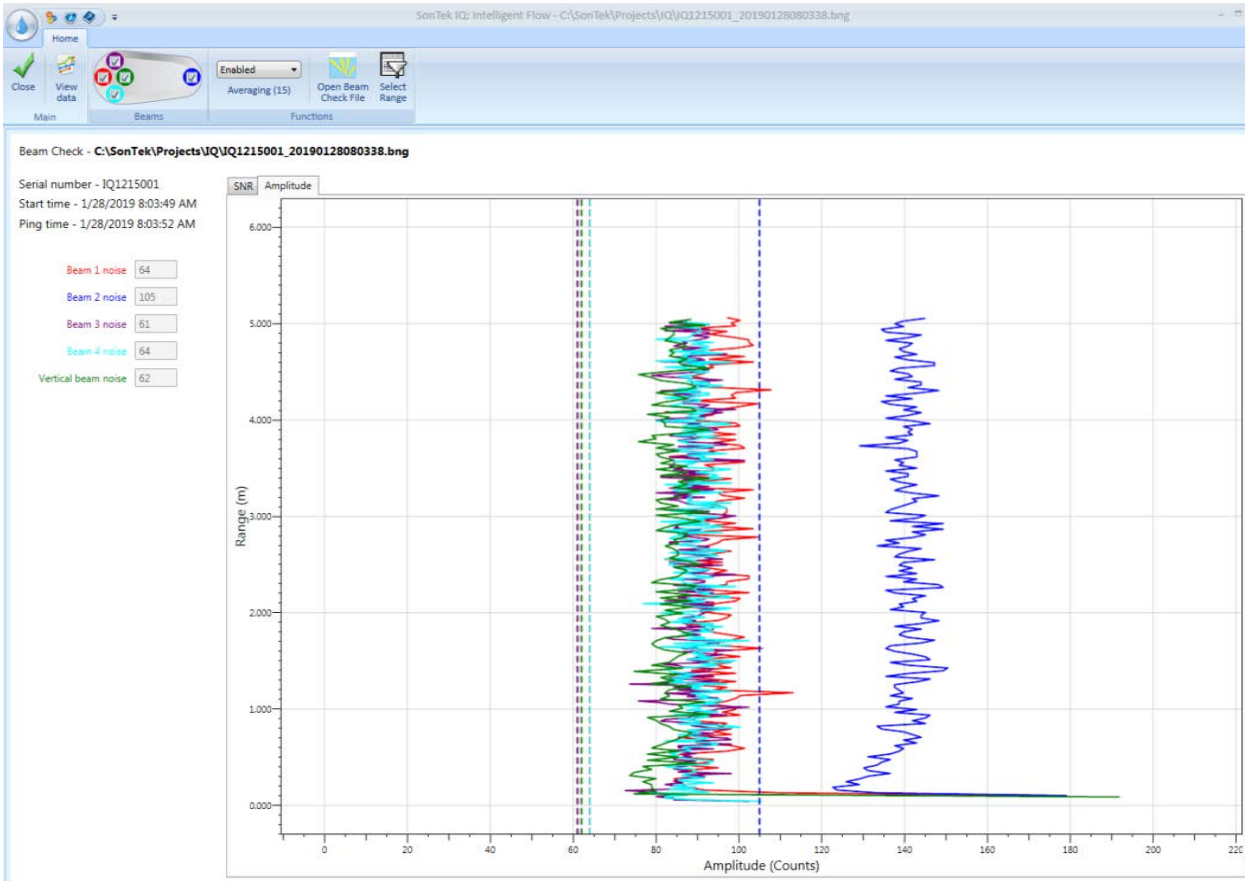


Figure 66. IQ Software Beam Check Window

3.5. System Configuration – Advanced Utilities

The Advanced Utilities section is used for less common functions by experienced users or with the assistance of SonTek Support personnel.

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

Direct connection: A command line terminal window for direct communication.

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.

Modify configuration: This is an advanced configuration menu that should be used with caution as some of the system settings will affect the IQ operation and could result in data loss. The Temperature mode can be set to user if there is a problem with the temperature sensor or a fixed temperature value is required. The sound speed can also be set to a fixed value here. There are check boxes at the bottom to enable ice detection and disable the recorder. Disabling the recorder means no *.IQ files will be recorded for post-processing or potential troubleshooting purposes. The last check box will disable the skew beams. Flow is still computed if skew beams are disabled. Disabling the skew beams means that the skew beams do not ping and do not record velocity data. SNR data for the skew beams will still be displayed in the software, but it will be incorrect because it is based purely on the noise ping which is a “listening” ping. The velocity correlation filter threshold can be adjusted here.

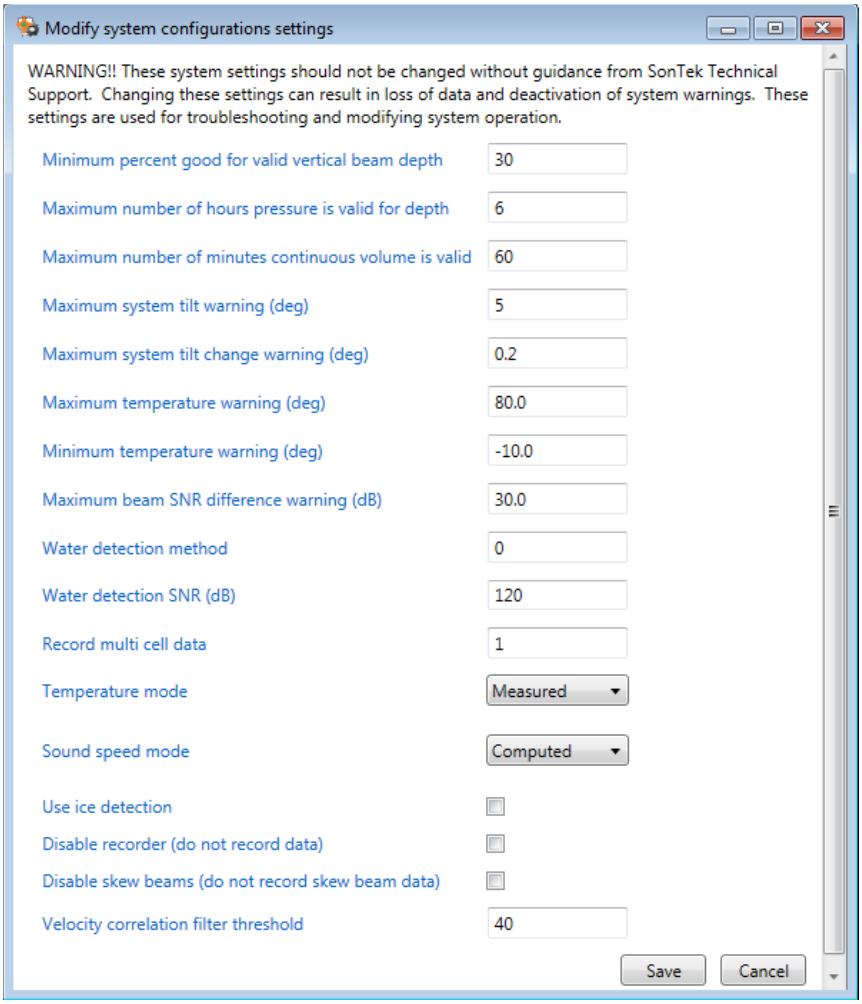


Figure 67. Modify System Configuration

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 IQ, use this function to restart the IQ 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 IQ to the flow display and then to a PC. Run the IQ software and select **Advanced Utilities – 4-20 mA Calibration**. Figure 68 shows the display screen.

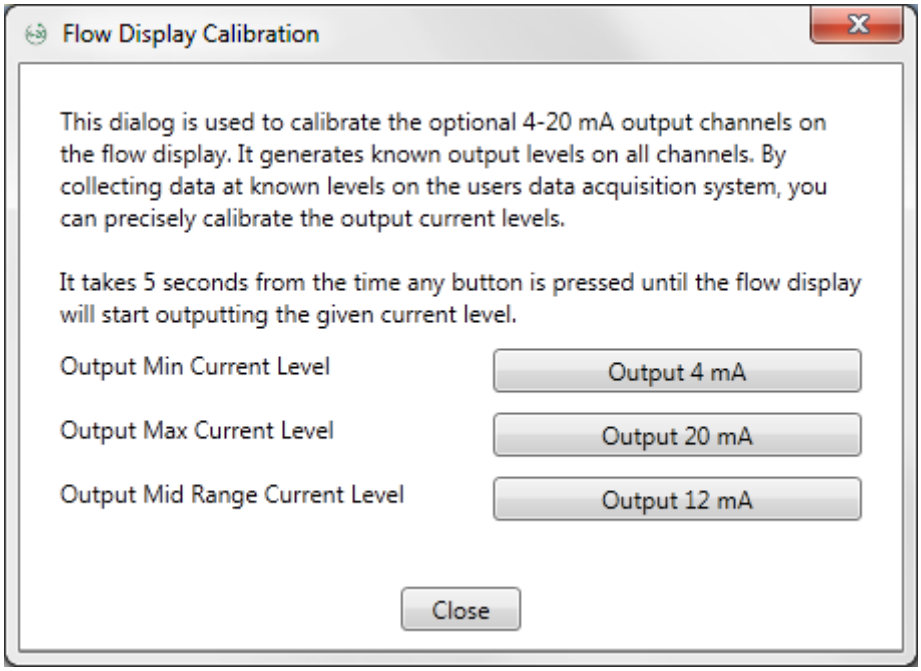


Figure 68. Flow Display Calibration

- 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 IQ value for any given **MeasuredAmp**.

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

- 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.

Section 4. Installing the IQ in a Channel

The previous sections described most of the IQ software operations and settings involved in configuring a system for deployment. Now it is time to install your IQ in a channel and begin collecting some flow data – in most cases the SonTek-IQ and IQ Plus are the most appropriate systems to use in an open channel. The low profile design and acoustic range of the IQ make it suitable for almost any channel. Proper site selection and mounting will be key factors in getting the best possible data from your IQ.

The minimum input voltage to the IQ system is 10 VDC. 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 10 VDC minimum. Longer cables will require a higher minimum input voltage to compensate for the larger voltage loss.

Note for wastewater applications: The SonTek-IQ is not certified ATEX or Intrinsically Safe. Do not use in areas where there is risk of flammability or explosion.

4.1. SonTek-IQ 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-IQ 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 IQ.
- SonTek highly recommends installing the SonTek-IQ at least ten channel widths downstream or upstream of control points (gates) and flow disturbances.
- Figure 69 and Figure 70 present examples of SonTek-IQ site selection.

Figure 69. Poor Installtion Site:
Control Gate Upstream and Turbulent Flow Downstream

Figure 70. Good Installation Site: Long Straight Unobstructed Flow

4.2. Mounting the SonTek-IQ Standard and IQ Plus

Whenever possible, we recommend using stainless steel fasteners and hardware with the mounting brackets to avoid problems with corrosion. The SonTek-IQ comes with standard L-shaped mounting brackets to secure the system to the bottom of the channel. In addition to the standard brackets, you can purchase a riser mount. The riser mount should be used in locations where sedimentation or burial of the instrument could occur. The riser mount elevates the SonTek-IQ approximately 1” or 2.5 cm off the bottom of the channel (Figure 71). This added elevation will help to prevent sediment from accumulating around the transducers.

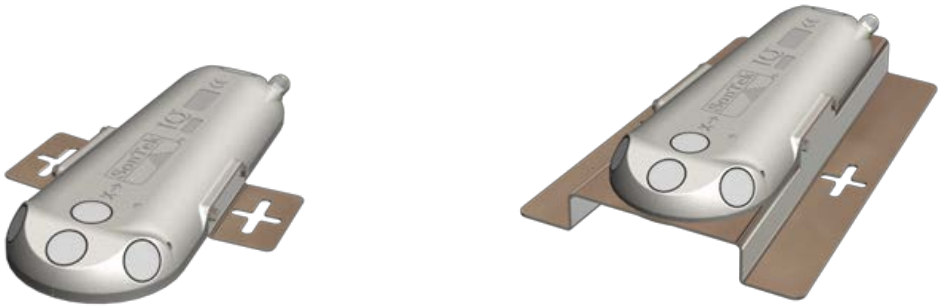


Figure 71. Standard Mounting Option (left) and Optional Riser Mount (right)

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

- Mount the IQ in the center of the channel at the bottom.
- Certify that the longitudinal axis (X-direction) is aligned with the axis of the channel.
- Secure the IQ cable to the bottom and side of the channel; when possible, protect the cable by routing it through conduit.
    - AVOID bending the cable as it comes out of the IQ as debris can be caught on the bend and damage the cable.
    - If a cable needs to be bent near the IQ, keep a bend radius no smaller than 4 inches (10 cm). See Figure 72.

Figure 72. Cable Bend Radius

- Mount the IQ so that it is level. Pitch and roll should be less than 5 degrees. You can check pitch and roll from the IQ Smart Page using “View Live Data”.
- Use non-corrosive (preferably 316 stainless steel) 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 a conduit to protect the IQ cable from vibration or floating debris (Figure 73).

Figure 73. IQ Mounted with Cable Conduit

When positioning the IQ, 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 IQ. If you decide to use a custom mount, be sure that it is a smooth hydrodynamic shape. If the IQ will be mounted some distance above the bottom (to prevent burial or allow easy removal), it is best if the mount allows the flow to continue underneath it– so that water can flow above and below the instrument to minimize the flow disturbance.

IMPORTANT: Do NOT use the screw inserts on the underside to mount the SonTek-IQ. Only use the screw inserts on the side of the SonTek-IQ, when mounting the system.

Appendix C provides a technical drawing of the IQ 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 74). 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 IQ 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.

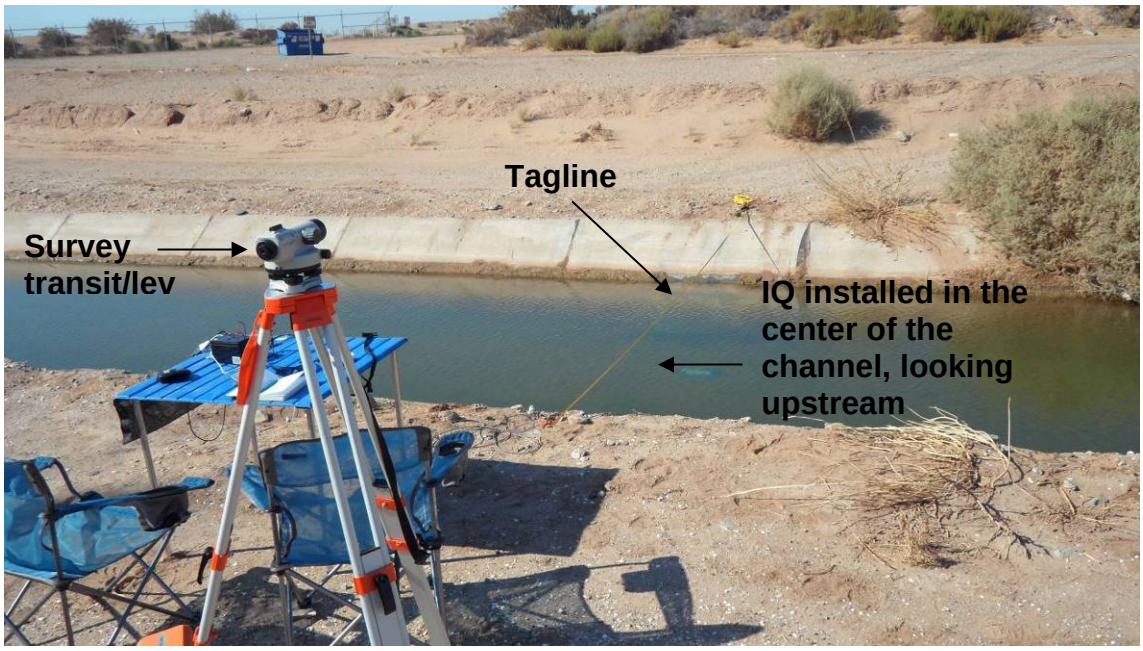


Figure 74. Site Survey of Cross-Sectional Area

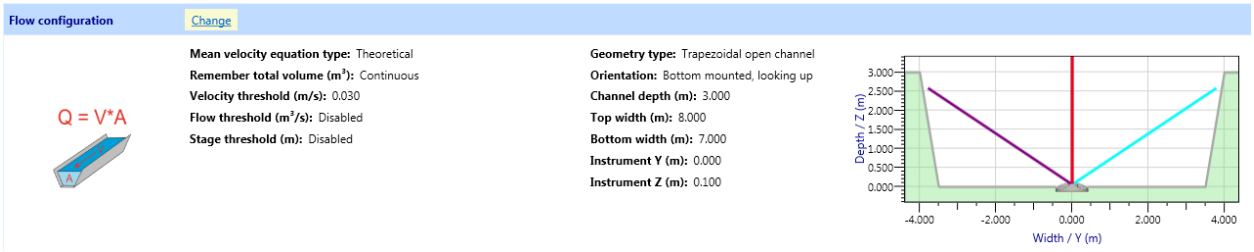
After a site has been selected, SonTek highly recommends completing a cross-section survey of the site. Below is a basic channel cross-section survey procedure:

1) Setup a survey transit/level at the site – be sure to use 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 is allowed for an open channel. The maximum for a pipe is 100 survey points.
6) Accurately survey 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 IQ flow and volume data as the cross-sectional area will be changing.

4.4. Entering Channel Settings

The survey data or channel dimensions are the most important settings on the IQ Smart Page. Accurate flow calculations implicitly rely on an accurate cross-sectional area. See Section 3.1.4 for instructions on entering the survey data. You can quickly navigate to the Channel Settings by selecting the **Change** button in the Flow Configuration section of the IQ 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 75).

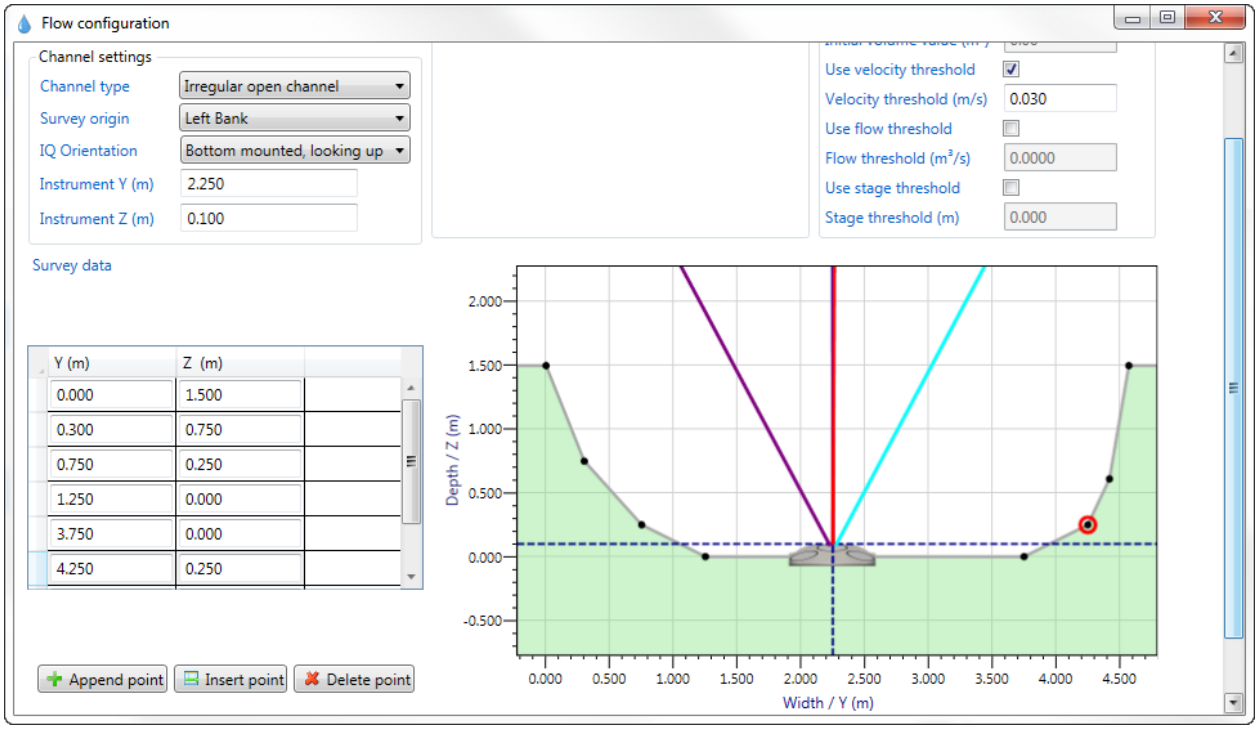


Figure 75. Irregular Open Channel Input Settings

If you are installing the IQ in a Trapezoidal channel, you only need to fill in the channel dimensions (Figure 76)

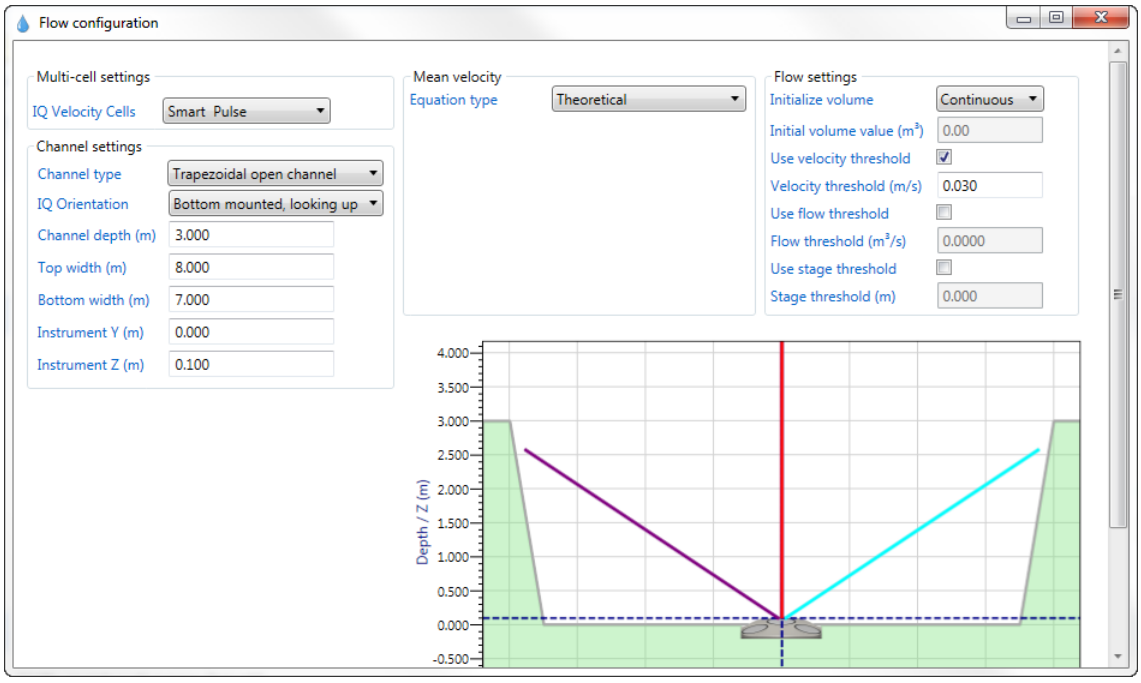


Figure 76. Trapezoidal Channel Input Settings

Section 5. Installing the IQ in a Closed Conduit

5.1. Site Selection

Both the SonTek-IQ Plus and IQ Pipe utilize four acoustic beams to measure the water velocity distributed inside of the pipe. From these data, the volumetric discharge (flow) can be computed based on a custom algorithm. With very rare exceptions, the SonTek-IQ Pipe is the most appropriate instrument for closed conduits. If a SonTek-IQ Plus system is installed inside of a pipe, no theoretical flow algorithms are available for direct (internal) flow computations and therefore flow can only be computed through a velocity index method outside of the system (using the index velocity provided by the SonTek-IQ Plus system).

The minimum input voltage to the IQ system is 10 VDC. 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 10 VDC minimum. Longer cables will require a higher minimum input voltage to compensate for the larger voltage loss.

Note for wastewater applications: The SonTek-IQ is not certified ATEX or Intrinsically Safe. Do not use in areas where there is risk of flammability or explosion.

Care must be taken to ensure the system is installed in a section of the pipe where the flow regime will be as uniform as possible.

- The SonTek-IQ Pipe should be installed in a region of the pipe that is free from flow disturbances and excessive turbulence, such as intersections, abrupt changes in pipe diameter, or the presence of obstructions inside the pipe.
- The system should be installed in a straight section of the pipe, away from any bends or turns both upstream and downstream.
- It is recommended that the installation location be at least 10 pipe diameters in either direction from an obstruction or flow diversion (for example, in a 1-ft diameter pipe, the section should be straight for a total of 20 ft, with the instrument mounted in the middle of this section).
- Sections of the pipe where significant aeration occurs should be avoided, as the presence of bubbles could affect the velocity measurement.
- The instrument must be firmly attached to the inside of the pipe. It should not move or vibrate during the measurement.
- The instrument must be kept free from debris and sedimentation, as it will not be able to measure flow if it is obstructed by debris or buried by sediment.

5.2. Evaluating the Closed Conduit Cross-Section

Cross-section area is one of the most important parameters when configuring the instrument for data collection. Experience has detailed that errors in channel geometry create the largest errors when collecting flow data; therefore, for best possible data quality care should be taken when entering channel geometry. The diameter and shape of the closed conduit should always be

evaluated or inspected. Environmental conditions over time and these conditions can have an impact on shape and diameter.

- For concrete pipes or culverts, erosion over time can change the inner shape of the closed channel.
- Load from weight bearing culverts can change the shape of the closed conduit, this can also be a factor for the structural integrity of the closed channel.
- Take care in estimating channel dimensions (i.e., inner diameter and outer diameter).
- Be sure to have accurate measurements for where the system is located in the channel (Instrument Y and Instrument Z).

5.3. Mounting the IQ Pipe

When mounting the system inside of a pipe, the following important observations must be made. Failure to follow the instructions in this section can result in invalid data being collected:

5.3.1. General Installation Instructions

- The SonTek-IQ Pipe is normally installed on the bottom of the pipe, with the transducers pointing upwards.
    - In pipes and culverts that are *always* full, the IQ Pipe (and IQ Plus) can be installed at the top looking down. This may provide for a more secure installation site, with reduced risks of the system being buried by sediment. Care must be taken to ensure the pipe is ALWAYS full.
- The longitudinal axis (X-direction) SonTek-IQ Pipe must be aligned with the axis of the pipe.
- The SonTek-IQ Pipe must be installed as level as possible. The forward portion of the instrument should not be higher than the back, or vice-versa.
- The instrument comes with two mounting brackets to facilitate installation. It can also be installed using an expansion ring secured to the inside of the pipe (see Pipe Ring section below).
- The instrument's height is 29 mm (1.15 in). Measure the SonTek-IQ Pipe elevation after installation. System elevation is measured from the top of the SonTek-IQ Pipe, at the horizontal transducer and is defined as the height of the top of the system relative to the bottom of the pipe (the inside wall). If mounted directly to the bottom, the Instrument Z would be entered as 0.29 m (0.096 ft).
- Secure the deployment site as needed to protect cables and connectors from damage (from debris and animals) and vandalism.

5.3.2. Alignment

- A critical part of the installation inside of a pipe is the alignment with the center of the pipe. If the system is off to the side (left or right) of the center of the pipe, the flow can be affected as the theoretical flow algorithms assume the system is centered in the middle of the pipe.
- This is not always an easy task to perform, especially for larger pipes, but a critical step and care should be taken to properly measure the pipe's diameter and identify its center.

5.3.3. Location Inside the Pipe

- **Pipe Entrance:** SonTek recommends that the installation location be at least 10 pipe diameters from the entrance of a pipe. In some rare cases, it may be possible to shorten this to 5 pipe diameters, AS LONG AS the flow conditions at the system are steady!
- **Pipe Exit:** The IQ Pipe can be mounted closer to a pipe's exit than its entrance (typically less than 10 pipe diameters). The advantages are that installation and maintenance is significantly easier because of access. Also, the flow is fairly well developed by this point.
- **Partially submerged pipe:** In this case, it is best to mount the system close to the pipe's exit IF the flow conditions are stable at the exit. It should be noted that at times the pipe exit will act as a weir and the flow will start to draw down (transition) inside the pipe to a critical flow point (possibly right at the exit). If this is the case for your pipe, make sure the IQ Pipe is away from the drawdown section.
- **Pipe transitions:** In some pipe sections the pipe diameter will change abruptly. Usually it is only a few inches but this can cause the flow conditions to change inside the pipe in proximity to it. These should be treated similar to a pipe entrance condition so the IQ Pipe should be mounted at least 5 to 10 pipe diameters away in either direction.

5.3.4. Cable Installation Instructions

- The system should be installed with the cable pointed downstream. An arrow indicating positive (downstream) flow direction is printed on the top to the instrument. If the system can only be installed with the cable pointing upstream, make sure to check the box next to **reverse flow direction** in the flow settings.
- For the sections of the cable that are inside the pipe, the cable needs to be anchored to the inside pipe wall at no more than 5-ft between anchors points.
- SonTek recommends that the cable be mounted straight downstream of the system. If the cable needs to be bent, make sure the bend radius is not smaller than 4 inches (10 cm) as shown in Figure 72.
- For larger pipe diameters, it may be possible to install the cable inside a conduit. Care should be taken for smaller pipe diameters as conduit can cause flow disturbances.
- If the pipe is partially submerged, it is best if the cable is run to the top of the pipe (or above the water line) and then inside a conduit to the pipe's exit. This minimizes the potential for cable snags and offers the best protection to the cable.
- Once outside the pipe, the cable must be protected inside of a conduit.

5.3.5. SonTek Pipe Ring Installation

- SonTek supplies a Pipe Ring that can be used to mount systems inside of a pipe.
- For details of how to use the Pipe Ring, please see Section 1.1.

5.4. Entering the channel shape

The survey data or channel dimensions are the most important settings on the IQ Smart Page. Accurate flow calculations implicitly rely on an accurate cross-sectional area. See Section 3.1.4 for instructions on entering the survey data. You can quickly navigate to the Channel Settingd by selecting the **Change** button in the Flow Configuraiton section of the IQ Smart Page.

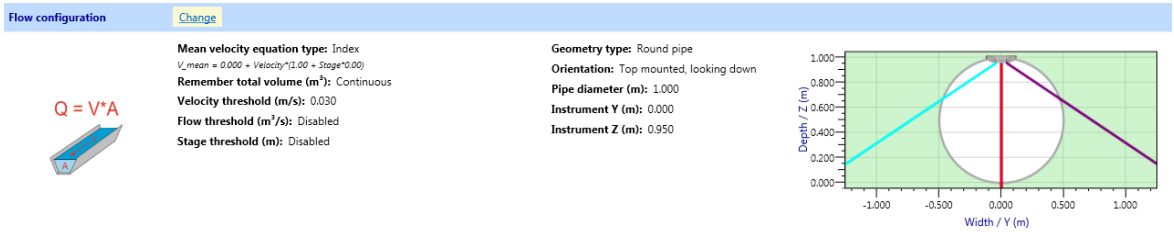
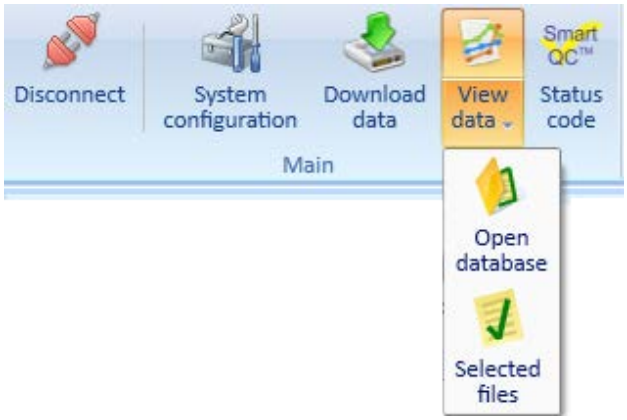


Figure 77. Channel Dimensions and Instrument Position

Once the Flow Configuration window is opened, use the same protocol outlined in Section 0.

Section 6. Data Analysis and Visualization – View Data

The SonTek-IQ 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** function on the main ribbon opens the data visualization window in the IQ software. Clicking on the bottom-half drops down two options to open files. They are labeled **Open database** and **Selected files**. The data window displays all of the files you have collected or opened and provides a suite of plotting functions to examine and compare flow conditions at all of your measurement sites.



The **View data** window is available with or without a connection to the IQ. 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 IQ software includes a sample data file that you can use to explore the ViewData functions before your own data are available.

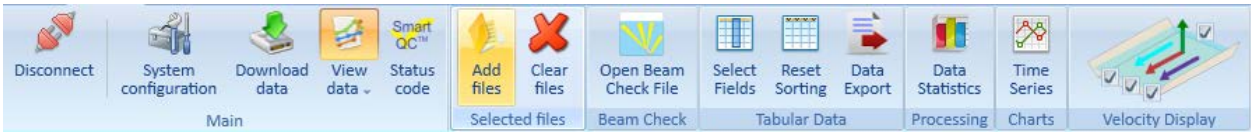
- The file name is **SampleData**.
- If you are organizing data by site name, look for **Sample Data Site Name**.
- /The sample data file is available only with software versions 1.10 and higher
    - It will be copied to your PC only for new software installations; it is copied when you select the IQ 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 IQ software.
- If you are using an older version of the IQ software and want access to the sample data file, do the following
    - Un-install your existing version of the IQ software.
    - Install the latest IQ software (version 1.10 or higher).

- Select your desired IQ data directory from the software settings menu (see Section 2.3). This can be the same directory used for the older version of the IQ software. Any existing data files will automatically be available. The sample data file will be added to this directory.

There are two ways to open data files. The first is by clicking the top half of the **View data** button or the pull-down **Open database** button. That will take the user to the original data view page which shows all files located in the data folder (database) specified in the Settings>Main dialog. The IQ stores and accesses all downloaded data from that folder.

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

The second way to open files is by clicking on the bottom half of the **View data** button and **Selected files**. That will initially take the user to an empty data view page to add single or multiple files from an open file dialog using the **Add files** button.



In the open file dialog, users can select one or more files with a left click and drag of the mouse. Selected files will be automatically loaded.

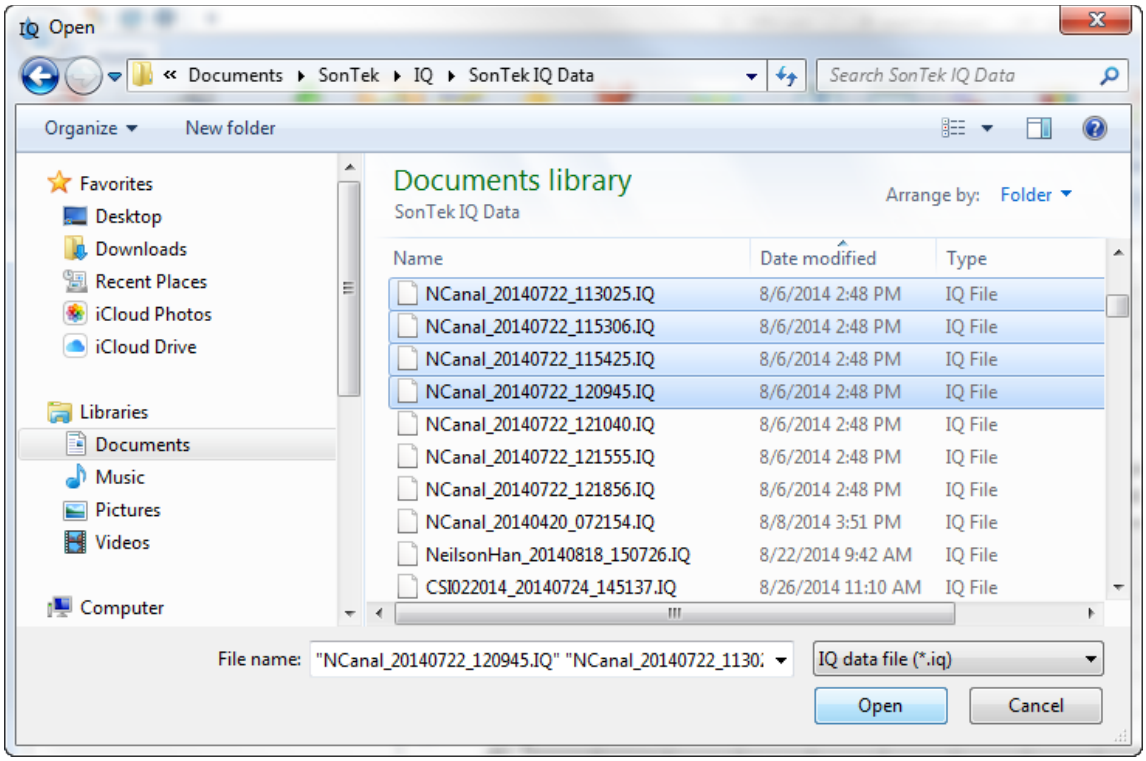


Figure 78. Open Selected Files

To remove all the open files click the **Clear files** button next to the **Add files** button. This will remove all the files and folders in the tree view. These files are not deleted; they are simply removed from the data viewing page.

To remove a single file, right-click on the file and select **Remove file** from the menu.

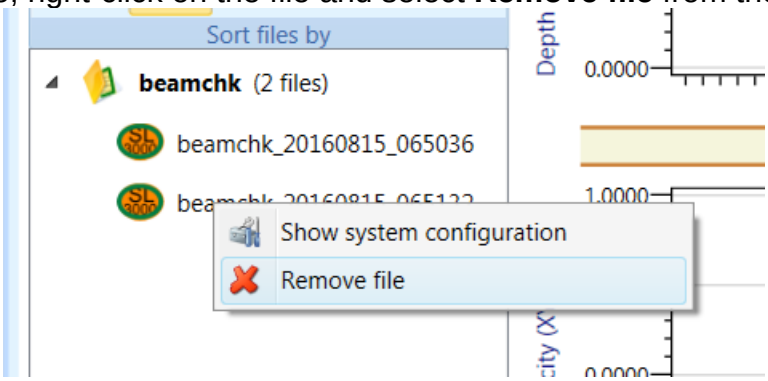


Figure 79. Remove Single File

Users can switch back and forth between the database view and the selected files view by clicking the buttons at any time. The software will remember the selected files until a new selection is made. For example, if the user selects the above two files, switches to the database view and then switches back to the selected files view these two files will load again. However, if the user had opened any files in the database view and then returned to the selected files view, the two files would not load. One exception is if the files exist in both the database view and the selected

files view. In this case, the files will load in both views until they are unselected or the data view page is closed.

If the user opens a beam check file, the software will remember the files and the view (database or selected) that are currently open and will re-open them when the user returns to the data view page. The software will also reload the previous data file after viewing the diagnostic data.

Please note that downloaded files still go to the folder specified in the settings menu.

6.1. 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 80).

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 IQ 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 IQ 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 (IQ Plus and IQ Pipe only). 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 80. View Data Window

6.2. 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 IQ 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 IQ flow data.

6.2.1. Organizing your data files

As you begin using your SonTek-IQ, 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 IQ 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 IQ 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 IQ 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 81). The sorting options are enabled by clicking on the appropriate button at the top of the data files section in the View data window.

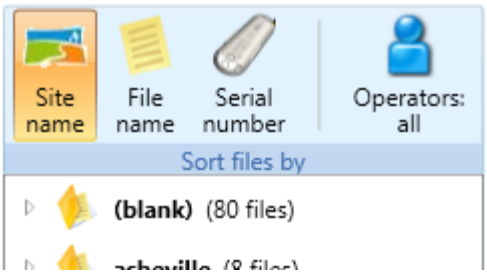


Figure 81. Sorting Data Files

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

6.2.2. 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 IQ icon next to the file name. A single click with the mouse loads the data for viewing (Figure 82). A second click will remove the data from the charts and table.

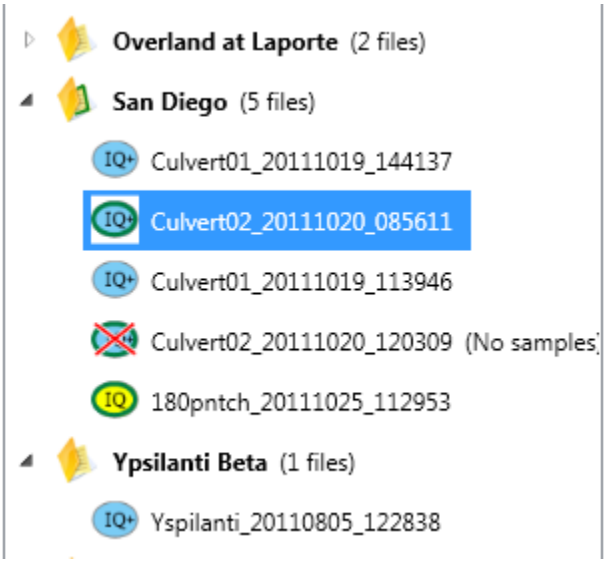


Figure 82. Loading a Data File

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 IQ icon and the containing folder will be outlined in green
- Select multiple files to display with a single click on the IQ icon or the folder name, click again to remove data from charts and table.

- indicates the file was collected with an IQ Plus
- indicates the file was collected with an IQ Standard
- indicates the file was collected by an IQ Pipe
- 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 83)

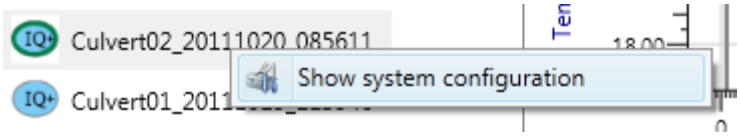


Figure 83. Right-Click on File Name to See IQ Settings

6.3. 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 IQ 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 84).

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 84. 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

6.3.1. 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 85).

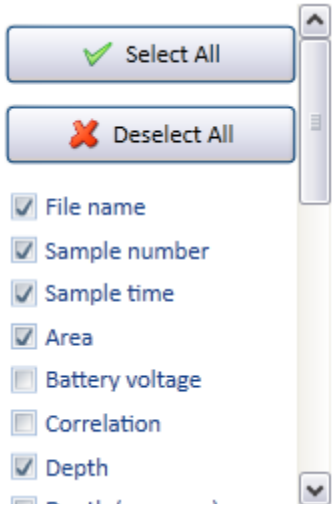
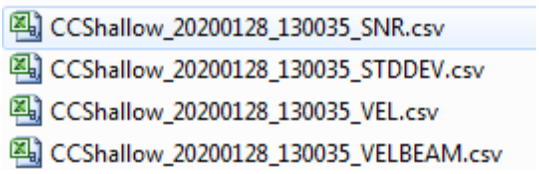


Figure 85. Selecting Data Fields for Tabular Data Output.

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 IQ 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 (IQ Plus and IQ Pipe only): If you are using an IQ Plus, you have access to a vast amount of data. The IQ Plus 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 as shown below:

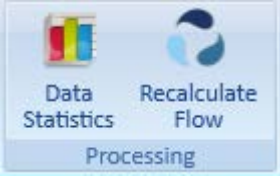


MATLAB Export (IQ Plus and IQ Pipe only): This function exports data collected by the IQ Plus in a MATLAB file (.mat file). The file will be saved in the IQ data folder named after the File name. You can import the .mat file into MATLAB using the load command. IQ fields and settings are organized in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

6.4. Processing Data

In general, most data processing is performed onboard the IQ. The IQ 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 IQ Plus, 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.

6.4.1. 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 86).

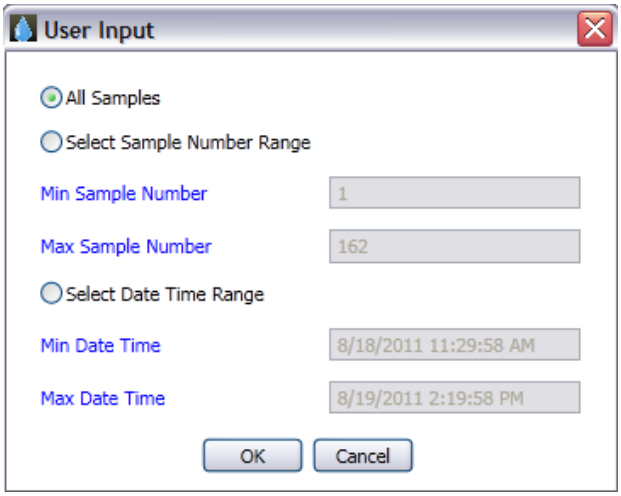
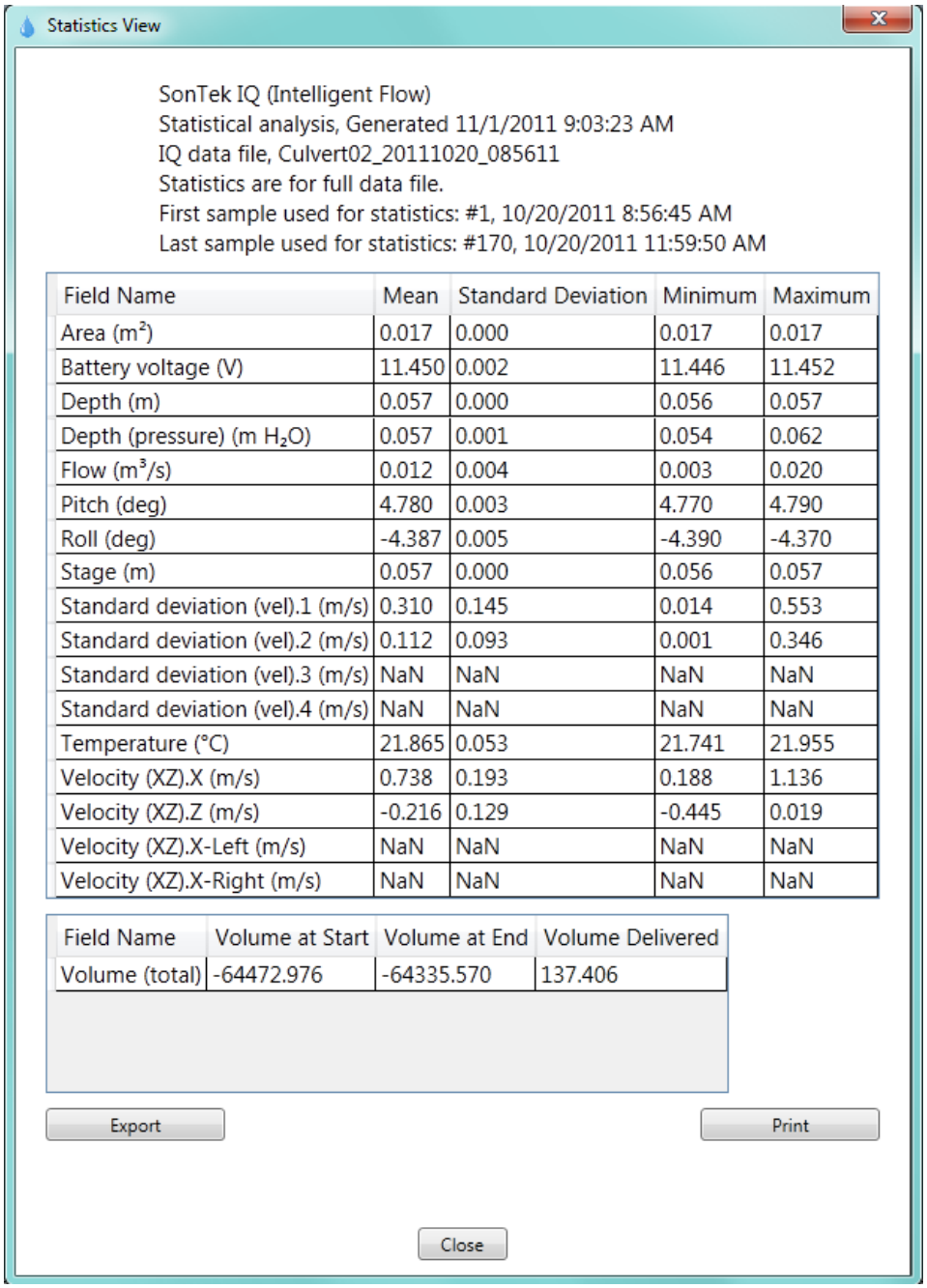


Figure 86. Selecting Data Statistical Analysis

Once the desired sample range is selected, a new window with a table of statistics for each field is displayed (Figure 87).

- 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)	0.017	0.000	0.017	0.017
Battery voltage (V)	11.450	0.002	11.446	11.452
Depth (m)	0.057	0.000	0.056	0.057
Depth (pressure) (m H_2O)	0.057	0.001	0.054	0.062
Flow (m^3/s)	0.012	0.004	0.003	0.020
Pitch (deg)	4.780	0.003	4.770	4.790
Roll (deg)	-4.387	0.005	-4.390	-4.370
Stage (m)	0.057	0.000	0.056	0.057
Standard deviation (vel).1 (m/s)	0.310	0.145	0.014	0.553
Standard deviation (vel).2 (m/s)	0.112	0.093	0.001	0.346
Standard deviation (vel).3 (m/s)	NaN	NaN	NaN	NaN
Standard deviation (vel).4 (m/s)	NaN	NaN	NaN	NaN
Temperature (°C)	21.865	0.053	21.741	21.955
Velocity (XZ).X (m/s)	0.738	0.193	0.188	1.136
Velocity (XZ).Z (m/s)	-0.216	0.129	-0.445	0.019
Velocity (XZ).X-Left (m/s)	NaN	NaN	NaN	NaN
Velocity (XZ).X-Right (m/s)	NaN	NaN	NaN	NaN

Field Name	Volume at Start	Volume at End	Volume Delivered
Volume (total)	-64472.976	-64335.570	137.406

Figure 87. Data Statistics Window

sRecalculate Flow (IQ Plus and IQ Pipe only): A post-processing function that allows users to recalculate flow by changing velocity, channel geometry, flow, temperature, salinity and sound speed settings. Changes to these parameters can affect the vertical beam range, velocity and flow. Selecting this function will open a limited version of the IQ Smart Page showing the IQ configuration for the data file. You can edit each section as you would if you were configuring a system for deployment (Figure 89).

- To change the velocity, flow and other settings, click on the **Change** button in the appropriate section.
- The Velocity Configuration section allows users to enable or disable Reverse Flow and Velocity Filtering. The velocity correlation filter threshold can be changed here too. The Flow Configuration settings can be changed to reprocess data using a velocity index as well applying new thresholds to data for volume calculations.
- The temperature, sound speed and salinity can be changed in the last section. There is also a check box to enable ice detection on any old or new file to compute an *ice score*. Values greater than 100 indicate possible surface ice.

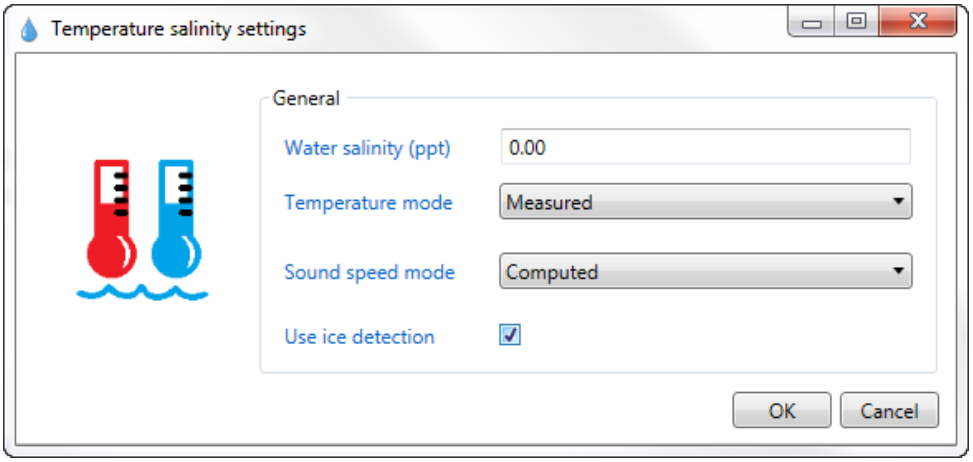


Figure 88. Use Ice Detection

- 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 “Record multi-cell data” is set to 1 in the Modify Configuration window under the Advanced Utilities men.
- 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.

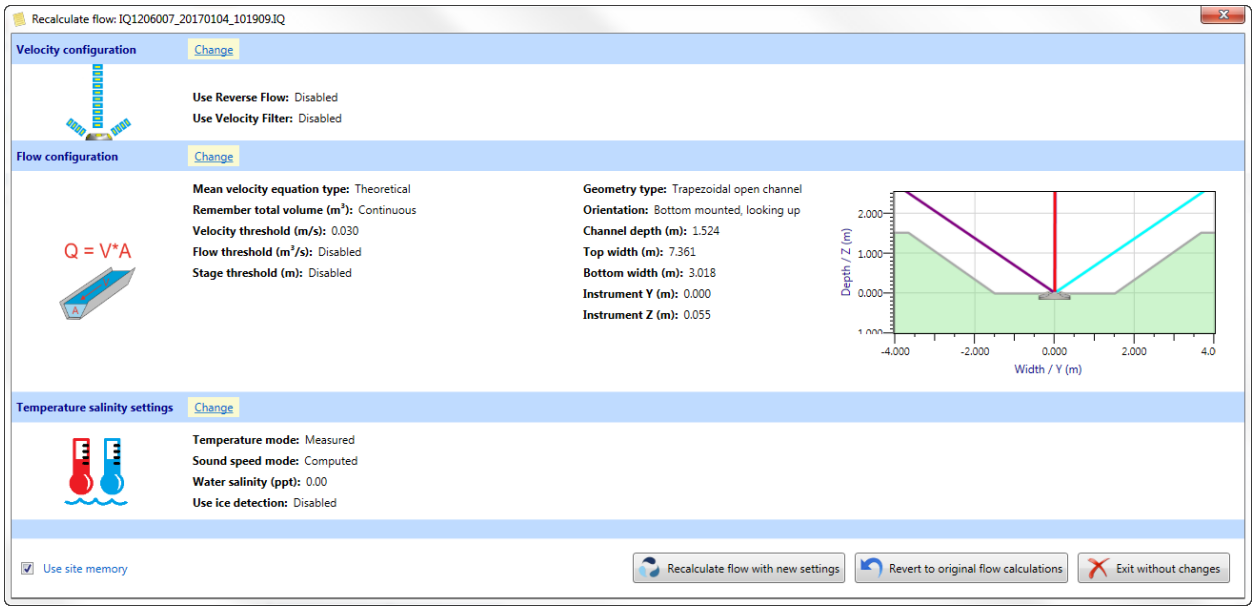


Figure 89. Recalculate Flow (IQ Plus and Pipe only)

6.5. Working with Charts

There are two types of charts displayed in the IQ 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 90).

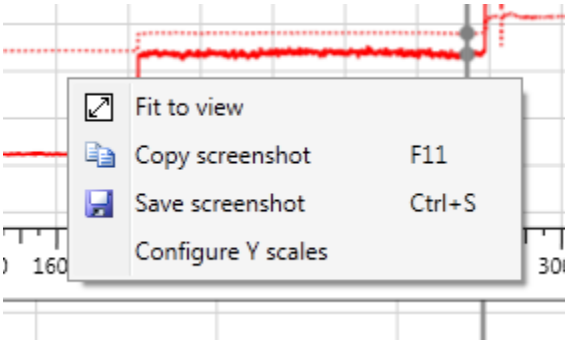


Figure 90. Left Click Chart Options

- 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.

6.5.1. 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 91).

- 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 IQ Standard.

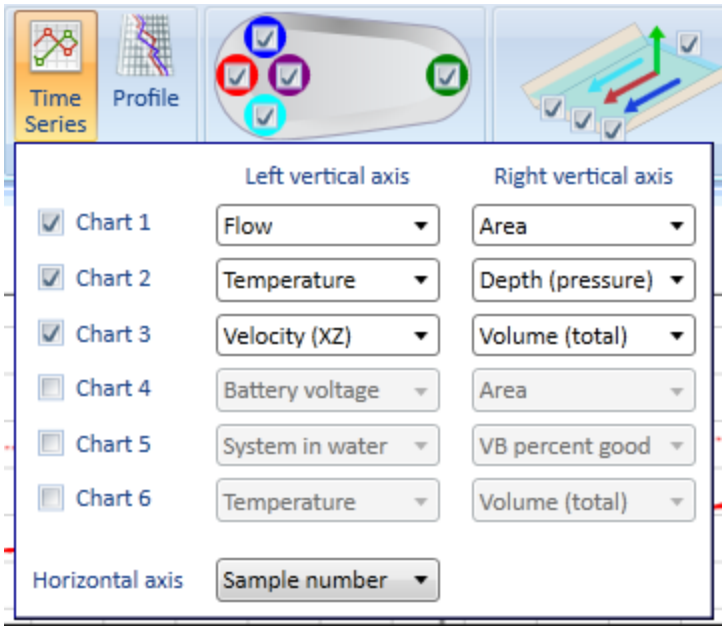


Figure 91. Time Series Chart Field Selection

Profile (IQ Plus and IQ Pipe only): 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 92).

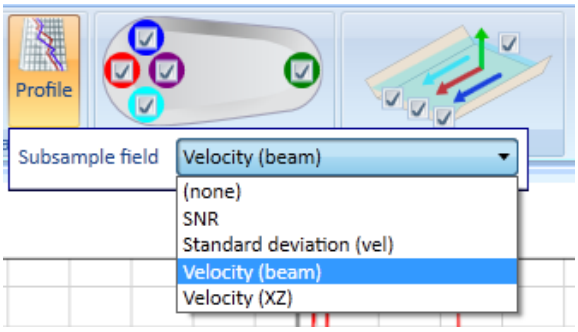


Figure 92. Profile Chart Subsample Field Selection

- 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 93 presents velocity profile data.

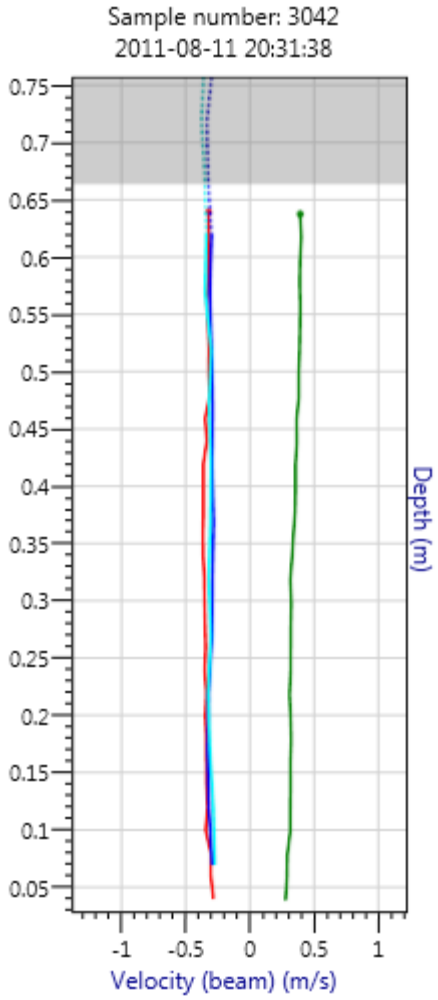


Figure 93. Profile Chart

6.5.2. 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 and Velocity data can be plotted in Time series charts along with SNR. 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 7. Output Data Settings

The SonTek-IQ 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 IQ. It is included in the output type dropdown as a convenience (Figure 94). You can select an output type from the IQ Smart Page while configuring a system for deployment. Instructions for configuring the options for each output data type are presented in Section 3.1.6. This section provides complete definitions for each output type and the data fields available.

- The type of data output used by the SonTek-IQ must be selected when configuring the system with the IQ 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 IQ software.

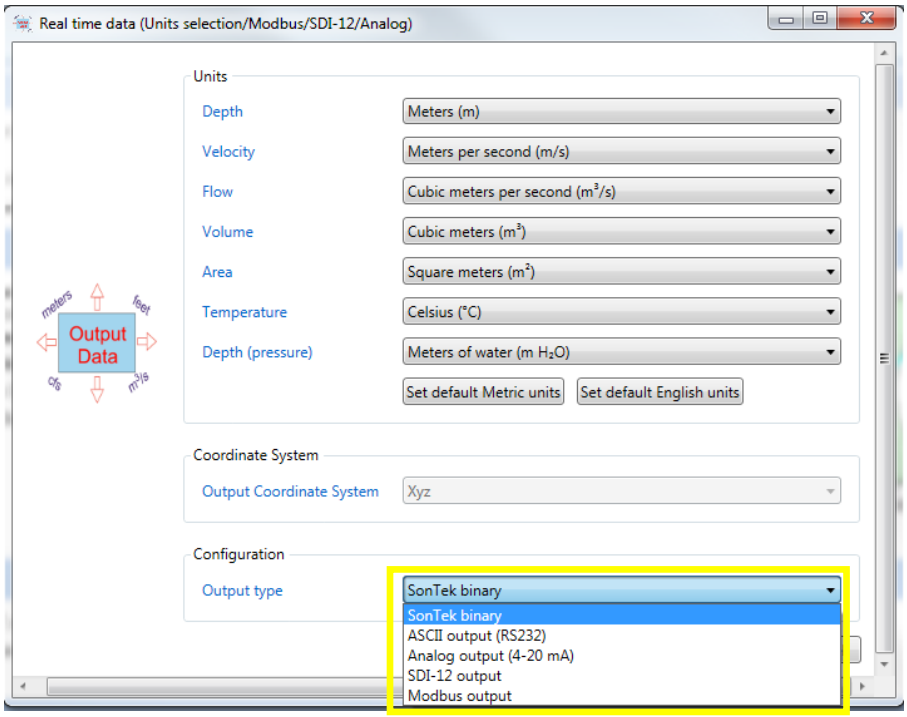


Figure 94. SonTek-IQ Data Output Types

7.1. IQ System Status

The IQ 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, and the IQ can be said to be “All Clear”.
- If **System Status** has any value other than zero, the IQ 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 IQ analyzes all data to look for potential problems. If any problems are found, the IQ sets a flag within the **System Status** value.

- A technique called bitwise encoding is used so that multiple flags are incorporated within this single value.
- In bitwise encoding, a different number (each of which is a power of 2) is used 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 IQ software includes a utility to interpret the status value.
  - This utility can be accessed from several locations (see Section 2.4 and Section 2.5.2).
- With the IQ Flow Display, any **System Status** messages are available in real time from the LCD display (see Section D-4.).

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 IQ mount	One or more tilt values are greater than 5º; this may affect data quality. Inspect the IQ mount.
2	Tilt values have changed; IQ may have moved	One or more tilt values have changed significantly since the start of data collection. This may indicate the IQ has moved. Inspect the IQ 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 10.0 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 IQ. 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 IQ 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; IQ may need repair	The temperature sensor may have failed, which will affect the quality of data. The IQ 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.
2048	Pipe Size Warning	Dimensions are outside of recommended range
4096	Vertical beam range exceeded	Pressure depth is greater than maximum vertical beam range.
8192	Poor depth warning	No good vertical beam measurements for more than 6 hours (or whatever is set in the Modify Configuration window). The depth will be based only on the pressure sensor and the pressure sensor has not been calibrated by the vertical beam in over 6 hours. Atmospheric pressure changes could result in less accurate depth and flow data.

7.2. 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. A proprietary communication protocol allows users to view live data. Users who do not need to use real-time data (i.e. not connected to a data logger or a Modbus network) or users who will only communicate with the IQ using the IQ software should use this output data type. Data is recorded and stored on the IQ in a proprietary file format. The IQ 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 IQ software. Selecting **View Live Data** (Figure 95) on the IQ 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 IQ during the installation process.

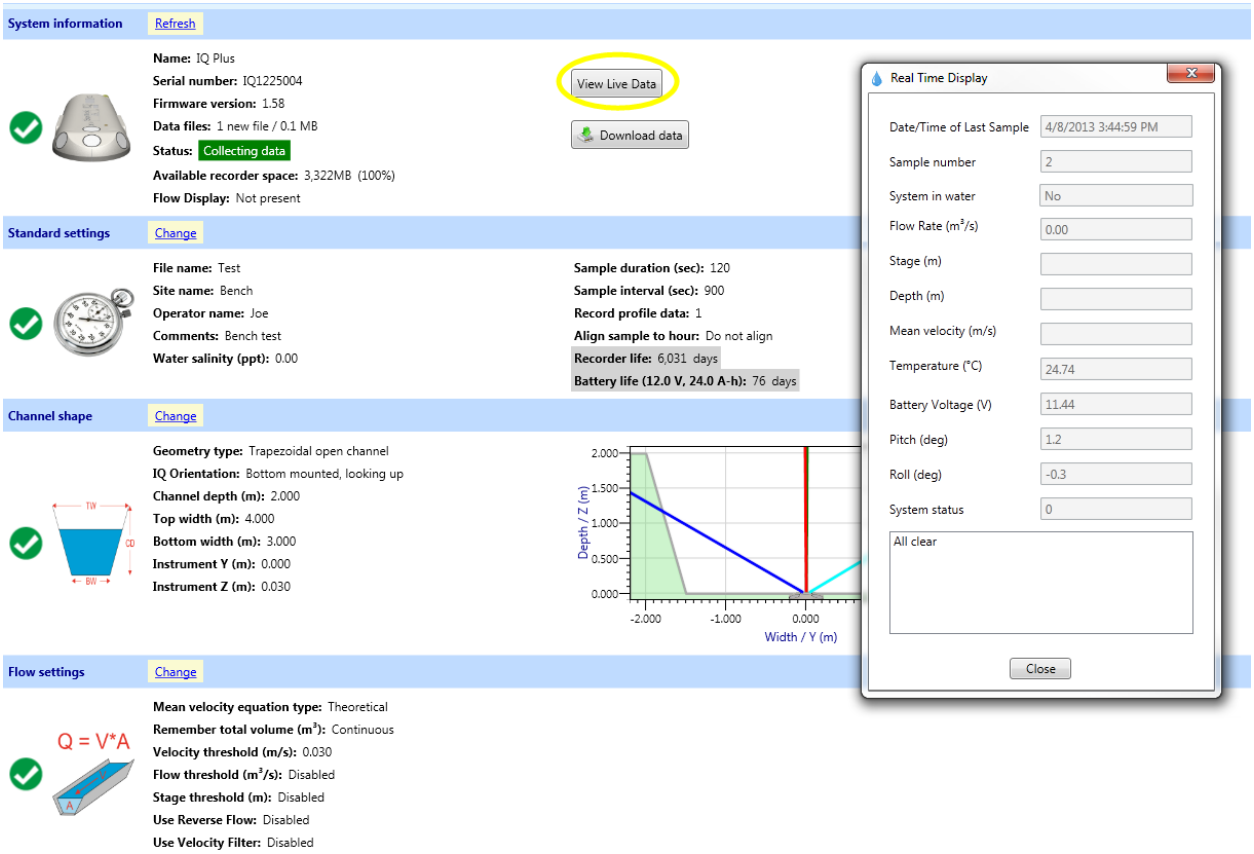


Figure 95. View Live Data

7.3. ASCII Output (RS232)

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

- The IQ 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 space delimited parameters. The number and the order of parameters differs for the IQ Standard and IQ Plus systems.
- RS232 serial parameters are fixed at:
    - 9600 baud
    - 8 data bits
    - 1 stop bit
    - No parity

7.3.1. IQ Standard ASCII Output Values

Example of output from an IQ Standard (Table 2):

1125010 1 2011 10 31 12 19 28 -0.0429 -0.937 -0.643 290.7893 0.042 -0.735 0.066 20.55 0 -0.735 -0.016 -0.670 -0.728 11.45 3.9 -3.6 100 0

1125010 2 2011 10 31 12 19 40 -0.0369 -0.937 -0.553 290.3402 0.042 -0.632 0.066 20.56 0 -0.632 0.042 -0.692 -0.821 11.46 3.9 -3.6 100 0

Table 2. IQ Standard – Output Field Definitions

Parameter	Contents	Notes
1	SonTek-IQ ID	System serial number
2	Sample number	Sequential sample number
3	Year	Year of sample start
4	Month	Month of sample start
5	Day	Day of sample start
6	Hour	Hour of sample start
7	Minute	Minute of sample start
8	Second	Second of sample start
9	Flow rate	Flow rate (using defined channel geometry)
10	Stage	Stage (water depth of the user-defined channel)
11	Mean velocity	Mean velocity
12	Volume (Total)	Total water volume (based on all measured flow)
13	Depth	Depth (relative to the top of the instrument)
14	Velocity Index	Downstream velocity in center of channel
15	Area	Cross-sectional area of user-defined channel
16	Temperature	Water temperature
17	System Status	System status (Section 7.1)
18	X Velocity, Center Beams	Center X velocity (downstream velocity in center of channel)
19	Z Velocity, Center Beams	Center Z velocity (vertical velocity in center of channel)
20	X Velocity, Left Beam	Left X velocity (downstream velocity along the left bank)
21	X Velocity, Right Beam	Right X velocity (downstream velocity along the right bank)
22	Battery	Battery voltage
23	Pitch	Pitch angle in degrees
24	Roll	Roll angle in degrees
25	System in water	Percentage of sample during which instrument was submerged (100% means it was submerged for entire sample)
26	Ice score	Values greater than 100 indicate possible surface ice

7.3.2. IQ Plus and IQ Pipe ASCII Output Values

The IQ Plus and the IQ Pipe includes the velocity profile

- If the velocity cell setting is “Manual”, the profile will include the number of cells specified by the user up to a maximum of 30 cells.
- If the velocity cell setting is “Smart Pulse”, the profile will include 30 cells
- Smart Pulse cells beyond the water surface will be zeroed
- In the example below, the water depth is very shallow (~ 8 cm)
- The velocity parameters (fields 18,19,20,21) will change based on the following user settings
    - If the Real-time output coordinate system is “XYZ” (as shown in the table below)
        - Field 18 is the center X velocity
        - Field 19 is the center Z velocity
        - Field 20 is the left X velocity
        - Field 21 is the right X velocity
        - Profile cells are center Vx and center Vz
    - If the real-time output coordinate system is “Beam”
        - Field 18 is the beam 1 velocity
        - Field 19 is the beam 2 velocity
        - Field 20 is the beam 3 velocity
        - Field 21 is the beam 4 velocity
        - Profile cells are beam 1 velocity and beam 2 velocity
    - If the Real-time output coordinate system is “XYZ” AND the Mean Velocity Equation Type is “Index” AND the Mean Velocity Type is “Velocity (beam).1” OR “Velocity (beam).2” OR “Velocity (beam).3” OR “Velocity (beam).4”
        - Field 18 is the beam 1 velocity
        - Field 19 is the beam 2 velocity
        - Field 20 is the beam 3 velocity
        - Field 21 is the beam 4 velocity
        - Profile cells are center Vx and center Vz
    - If the Real-time output coordinate system is “XYZ” AND the Mean Velocity Equation Type is “Theoretical (Beam 1 Only)” OR “Theoretical (Beam 2 Only)
        - Field 18 is the center X velocity Beam 1 Only (One beam solution)
        - Field 19 is the center X velocity Beam 2 Only (One beam solution)
        - Field 20 is the left X velocity
        - Field 21 is the right X velocity
        - Profile cells are center Vx and center Vz
    - If the Real-time output coordinate system is “XYZ” AND the Mean Velocity Equation Type is “Index” AND the Mean Velocity Type is “Velocity (XZ).X-Center (Beam 1 Only)” OR “Velocity (XZ).X-Center (Beam 2 Only)”
        - Field 18 is the center X velocity Beam 1 Only (One beam solution)
        - Field 19 is the center X velocity Beam 2 Only (One beam solution)
        - Field 20 is the left X velocity

- Field 21 is the right X velocity
- Profile cells are center Vx and center Vz

Example of ASCII output from an IQ Plus and IQ Pipe (Table 3):

1125010 8 2011 10 31 12 17 03 0.0000 -0.937 0.000 293.2300 0.042 -0.574 0.066 20.54 0 -0.574 -0.196 -0.670 -1.800 11.44 3.9 -3.6 100 0.042 0.041 965.8429 -752.6129 0.138 69.1 76.8 48.0 51.3 0

1125010 9 2011 10 31 12 17 15 0.0000 -0.937 0.000 293.2300 0.042 -0.573 0.066 20.54 0 -0.573 -0.201 -0.681 -2.090 11.44 3.9 -3.6 100 0.042 0.039 965.8429 -752.6129 0.138 69.2 76.9 48.0 48.2 0

Table 3. IQ Plus – Output Field Definitions

Parameter	Contents	Notes (Units based on User Setup)
1	SonTek-IQ ID	System serial number
2	Sample number	Sequential sample number
3	Year	Year of sample start
4	Month	Month of sample start
5	Day	Day of sample start
6	Hour	Hour of sample start
7	Minute	Minute of sample start
8	Second	Second of sample start
9	Flow rate	Flow rate (using defined channel geometry)
10	Stage	Stage (water depth of the user-defined channel)
11	Mean velocity	Mean velocity
12	Volume (Total)	Total water volume (based on all measured flow)
13	Depth	Depth (relative to the top of the instrument)
14	Velocity Index	Downstream velocity in center of channel
15	Area	Cross-sectional area of user-defined channel
16	Temperature	Water temperature
17	System Status	System status (Section 7.1)
18	X Velocity, Center Beams	Center X velocity (downstream velocity in center of channel)
19	Z Velocity, Center Beams	Center Z velocity (vertical velocity in center of channel)
20	X Velocity, Left Beam	Left X velocity (downstream velocity along the left bank)
21	X Velocity, Right Beam	Right X velocity (downstream velocity along the right bank)
22	Battery	Battery voltage
23	Pitch	Pitch angle in degrees
24	Roll	Roll angle in degrees
25	System in water	Percentage of sample during which instrument was submerged (100% means it was submerged for entire sample)
26	Range	Acoustically measured distance to water surface
27	Adjusted Pressure	Measurement with atmospheric pressure removed
28	Positive Volume	Total volume of water in the positive downstream direction
29	Negative Volume	Total volume of water in the negative upstream direction
30	Cell End	Distance to the farthest measurement cell
31	SNR (Beam 1)	SNR for beam 1 (acoustic signal strength in dB)
32	SNR (Beam 2)	SNR for beam 2 (acoustic signal strength in dB)
33	SNR (Beam 3)	SNR for beam 3 (acoustic signal strength in dB)
34	SNR (Beam 4)	SNR for beam 4 (acoustic signal strength in dB)
35	Ice score	Values greater than 100 indicate possible surface ice

Followed by up to 30 velocity profile cells with the format:

Cell #	Center X velocity	Center Z velocity	Vel STD Beam 1	Vel STD Beam 2	Sig Amp Beam 1	Sig Amp Beam 2

If the real-time output is in beam coordinates, the profile cells have the following format:

Cell #	Velocity Beam 1	Velocity Beam 2	Vel STD Beam 1	Vel STD Beam 2	Sig Amp Beam 1	Sig Amp Beam 2

7.4. Analog Output

Optional analog outputs are available via the SonTek-IQ flow display (Figure 96).

- The flow display supports four channels of 4-20 mA outputs.
- The analog output connectors have terminals (+ and -) for each analog channel (see Appendix D-2.).
- Each channel generates an analog signal proportional to one value measured by the IQ; the exact configuration of channels is selected by the user.
- Analog outputs are not a preferred method of collecting data from the IQ; a lot of resolution and information is lost when converting IQ 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 IQ software provides a function for outputting calibration values (see Section 3.3).
- Using the analog outputs will significantly increase power consumption – the IQ 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 3.1.6).
- 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 7.1). We strongly encourage monitoring this value; any value other than zero indicates that the IQ site should be inspected.
  - Min value: this should normally be zero.
  - Max value: this should normally be 512.
  - The IQ software provides a utility to interpret the system status variable in order to understand what different values mean (see Section 7.1).

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.

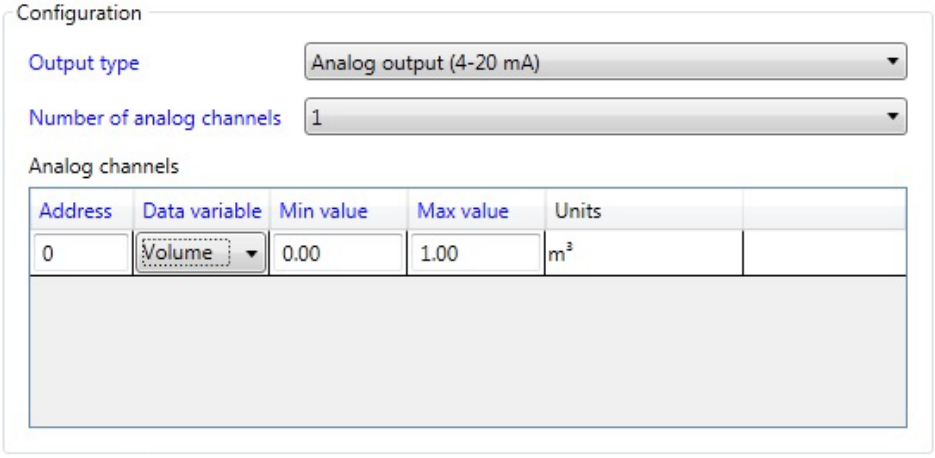


Figure 96. Analog Output Configuration

7.5. SDI-12 Output

SDI-12 is a standardized ASCII based serial communication protocol. The SonTek-IQ is capable of communicating with a data logger 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 data logger and NOT by the SonTek-IQ. The IQ will wait for commands from the data logger 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 IQ at the same time. The IQ cable adaptor supports both types of connections independently. However, this is **NOT recommended during the initial setup** of the IQ. Since the instrument is controlled by the data logger, it is important that the SonTek-IQ is NOT connected to the data logger during instrument setup to avoid possible configuration errors.

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

- Configure the SonTek-IQ with the IQ software prior to connecting to the SDI-12 network
- All measurements are controlled by the data logger. If the data logger never sends any commands, the IQ will never collect any data!
- You do **NOT** have to start the data collection using the **Start Data Collection** button. The IQ starts when it receives a valid measurement command from the data logger.
- Each instrument on the SDI-12 network must have a unique address
- Certain settings in the IQ software will have no effect when using SDI-12.
  - **Align sample to hour** is not used because samples are initiated by the data logger.
  - **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-IQ while it is connected to a data logger
- After configuring/checking the IQ Smart Page settings disconnect and exit the program.

7.5.1. SDI-12 Setup

See Figure 97 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 data logger.

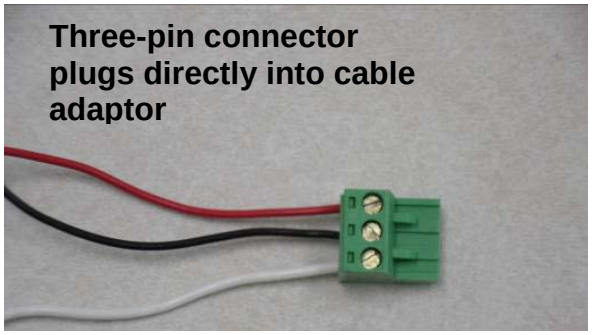


Figure 97. SDI-12 Wire Connection

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 and SDI-12 output format (Figure 98). When setting up an SDI-12 network, each instrument on the network must have a unique address.

- The SonTek-IQ SDI-12 default address is zero.
- SonTek-IQ 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.

The **Default** SDI-12 output format is covered at the beginning of Section 7.5.2. The **Profile** option includes data from the first 10 multi-cells from the center beams. After the SDI-12 address is entered, be sure to confirm all settings on the IQ Smart Page including the channel dimensions. **If the channel dimensions are not defined, the IQ will be unable to calculate and report flow conditions.** Once the IQ Smart Page settings are complete, you can connect the SonTek-IQ to the data logger or SDI-12 network. Please refer to the documentation included with your data logger to complete the SDI-12 setup procedures.

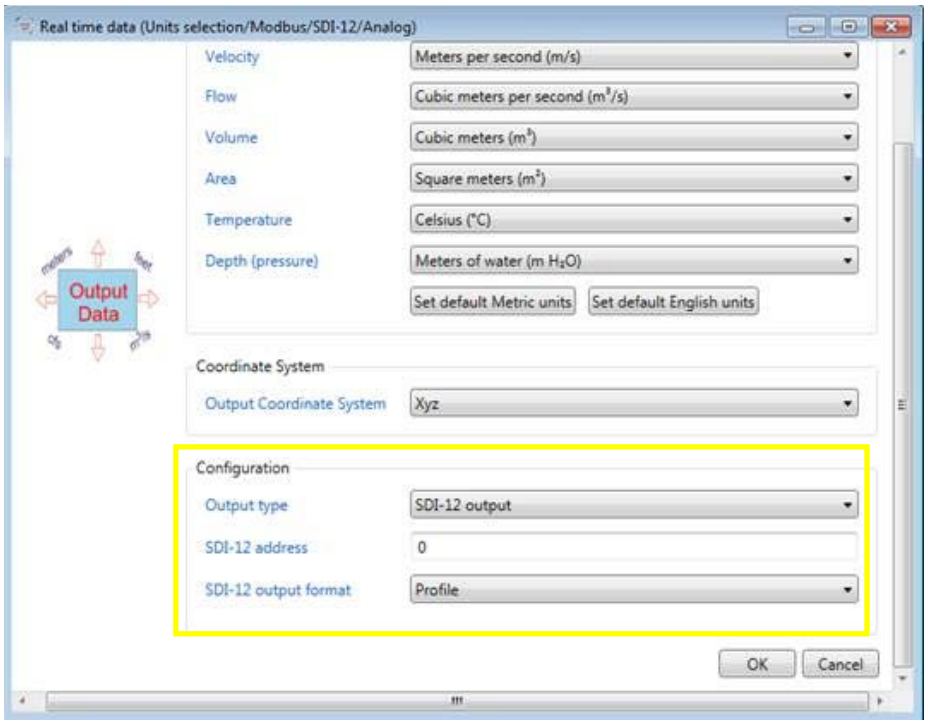


Figure 98. SDI-12 Settings

7.5.2. SDI-12 Commands

The IQ Plus and IQ Pipe have a user selectable option to output the Default or velocity Profile parameters in the SDI-12 format. The Profile output format can return up to 10 profile cells. The IQ Standard will only output the Default SDI-12 format.

The SonTek-IQ 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.

IMPORTANT: Be sure the data logger allows sufficient time between samples for both the sample duration and overhead time.

The SDI-12 commands and responses are shown below:

- **Identify Command - I command:** Returns the IQ firmware version and serial number.
  Command: **aI!**
  Response: **a13SonTek IQ 160IQ1215001**

  where:

  a is the sensor address assigned by the user. The default is 0, but this could be 0-9 or any upper or lower case letter (a-z and A-Z).

  13SonTek IQ is a signature string that is always returned

  160 is the firmware version onboard the responding IQ (v1.60)

  IQ1215001 is the IQ serial number

- **Measure Command - M command:** Initiates a new measurement sequence. Data values generated in response to this command are stored in the IQ's buffer for subsequent retrieval using D commands. Data will remain in the buffer until another M, C or V command is executed. An example is provided below:

  Command: **aMc!**
  Response: **atttn**

  where:

  a is the sensor address assigned by the user. The default is 0, but this could be 0-9 or any upper or lower case letter (a-z and 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.

  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 the IQ to write data to the buffer. 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.

The **Default** output is shown below:

Table 4. SDI-12 M Parameters

Number	Parameter name
1	Flow rate (using the user-defined channel geometry)
2	Stage (water depth relative to the user-defined channel)
3	Mean velocity (throughout the channel cross section)
4	Total volume (based on all measured flow)
5	Water depth (best available data from either the VB or the adjusted pressure*)
6*	Index velocity (provides the user 11 options, Main Vx, Main Vz, Vx Beam 3, Vx Beam 4, Average of all Vx, Beams 1-4 velocity, Vx Beam 1 One beam solution, Vx Beam 2 One beam solution)
7	Cross-sectional area of channel
8	Water temperature
9	System Status (Section 7.1)

***** This will usually be the VB depth, but in the case where the VB % good is too low, this will be adjusted pressure.

Use "0D0!" to retrieve parameters 1-4
Use "0D1!" to retrieve parameters 5-8
Use "0D2!" to retrieve parameter 9

Note: In all practical cases, either Main Vx and Average of All Vx will be the best data to use. Main Vx will be the historic data parameter to use, while Average of all Vx is a new parameter that averages out all of the Vx data from the four beams, potentially eliminating noise in the data.

M1 and **M2** commands report additional parameters from the previous measurement (these commands do not initiate a new measurement). The M1 command (Table 5) outputs an extended list of parameters to be returned following an M command. This command does not initiate a new measurement.

Table 5. SDI-12 M1 Parameters

Number	Parameter name
1	Center X velocity (downstream velocity in the center of the channel)
2	Center Z velocity (vertical velocity in the center of the channel)
3	Left X velocity (downstream velocity along the left bank)
4	Right X velocity (downstream velocity along the right bank)
5	Battery voltage
6	Pitch angle in degrees
7	Roll angle in degrees
8	Percentage of the sample during which the instrument was submerged (100% means the IQ was submerged for the entire sample)
9	Ice Score >100 indicates possible surface ice

Use “0D0!” to retrieve parameters 1-4

Use “0D1!” to retrieve parameters 5-8
Use “0D2!” to retrieve parameter 9

The M1 parameters 1 & 2 change depending on the user selected velocity output.

If the Mean Velocity Equation Type is “Index” (IQ Plus and IQ Pipe Only)

- If the Velocity Type is “Velocity (beam).1”
  - M1 parameter 1 is Beam 1 Velocity
  - M1 parameter 2 is zero
- If the Velocity Type is “Velocity (beam).2”
  - M1 parameter 1 is Beam 2 Velocity
  - M1 parameter 2 is zero
- If the Velocity Type is “Velocity (beam).3”
  - M1 parameter 1 is Beam 3 Velocity
  - M1 parameter 2 is zero
- If the Velocity Type is “Velocity (beam).4”
  - M1 parameter 1 is Beam 4 Velocity
  - M1 parameter 2 is zero
- If the Velocity Type is “Velocity (XZ).X (Beam 1 Only)”
  - M1 parameter 1 is X Velocity from Beam 1 one beam solution
  - M1 parameter 2 is zero
- If the Velocity Type is “Velocity (XZ).X (Beam 2 Only)”
  - M1 parameter 1 is X Velocity from Beam 2 one beam solution
  - M1 parameter 2 is zero

If the Mean Velocity Equation Type is “Theoretical (Beam 1 Only)”

- M1 parameter 1 is X Velocity from Beam 1 one beam solution
- M1 parameter 2 is zero

If the Mean Velocity Equation Type is “Theoretical (Beam 2 Only)”

- M1 parameter 1 is X Velocity from Beam 2 one beam solution
- M1 parameter 2 is zero

If the Real time Output Coordinate System is “BEAM” (IQ Plus and IQ Pipe)

- M1 parameter 1 is Beam 1 Velocity
- M1 parameter 2 is Beam 2 Velocity
- M1 parameter 3 is Beam 3 Velocity
- M1 parameter 4 is Beam 4 Velocity

The M2 command (Table 6) outputs an extended list of parameters to be returned following an M command. This command does not initiate a new measurement.

Table 6. SDI-12 M2 Parameters

Number	Parameter name
1	Range to water surface from vertical beam
2	Water depth (from pressure adjusted for atmospheric pressure)
3	Total volume (based only on positive measured flow)
4	Total volume (based only on negative measured flow)
5	End Cell (distance to farthest good measurement cell)
6	SNR for beam 1 (acoustic signal strength in dB)
7	SNR for beam 2 (acoustic signal strength in dB)
8	SNR for beam 3 (acoustic signal strength in dB)
9	SNR for beam 4 (acoustic signal strength in dB)

Use “0D0!” to retrieve parameters 1-4
Use “0D1!” to retrieve parameters 5-8
Use “0D2!” to retrieve parameter 9

- **Concurrent Measurement Command - C command:** Initiates a new measurement; reports all measured and calculated parameters. 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. Data will remain in the buffer until another M, C, or V command is executed.

  Command: **aC!**
  Response: **atttnn**

  where:

  a is the sensor address assigned by the user. The default is 0, but this could be 0-9 or any upper or lower case letter (a-z and 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, in seconds, the sensor will take to complete the command and have measurement data available in its buffer.

  n is a two 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.

Table 7. SDI-12 C Parameters

Number	Parameter name
1	Flow rate (using the user-defined channel geometry)
2	Stage (water depth relative to the user-defined channel)
3	Mean velocity (throughout the channel cross section)
4	Total volume (based on all measured flow)
5	Water depth (best available data from either the VB or the adjusted pressure*)
6	Index velocity (downstream velocity in the center of the channel)
7	Cross-sectional area of channel
8	Water temperature
9	System Status (Section 7.1)
10	Center X velocity (downstream velocity in the center of the channel)
11	Center Z velocity (vertical velocity in the center of the channel)
12	Left X velocity (downstream velocity along the left bank)
13	Right X velocity (downstream velocity along the right bank)
14	Battery voltage
15	Pitch angle in degrees
16	Roll angle in degrees
17	Percentage of the sample during which the instrument was submerged (100% means the IQ was submerged for the entire sample)
18	Range to water surface from vertical beam
19	Water depth (from pressure adjusted for atmospheric pressure)
20	Total volume (based only on positive measured flow)
21	Total volume (based only on negative measured flow)
22	End Cell (distance to farthest good measurement cell)
23	SNR for beam 1 (acoustic signal strength in dB)
24	SNR for beam 2 (acoustic signal strength in dB)
25	SNR for beam 3 (acoustic signal strength in dB)
26	SNR for beam 4 (acoustic signal strength in dB)

*This will usually be the VB depth, but in the case where the VB % good is too low, this will be adjusted pressure

- **Send Data Command - D command:** Return data parameters from a measurement. Typically, you would initiate a measurement with the **M** command, retrieving the main parameters from that measurement using **D** commands. After the **M** command, you can send the **M1** and **M2** commands to move additional parameters to the data registers. Alternatively, you can issue the **C** command to retrieve all of the data at once.

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: **aD0! through aD9!**
Response: **a±d.d…±d.d**

where:

a is the sensor address assigned by the user. The default is 0, but this could be 0-9 or any upper or lower case letter (a-z and 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 (data values). 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.

If one or more values were specified, and an aD0! returns no data, it means that the measurement was aborted, and a new M, C, or V command must be sent. The exact response to a D command depends on the type of SDI-12 data collection being used. The outputs of the M and C commands are shown above.

- **Continuous Measurements Command– R Command:** The Continuous Measurement command (R) was added to the Version 1.2 SDI-12 Specification. Sensors that are able to monitor continuously 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.

  Command: **aR!** or **aR0!**
  Response: **a+0** or **a+1**

  where:

  a is the sensor address assigned by the user. The default is 0, but this could be 0-9 or any upper or lower case letter (a-z and A-Z).

  R or R0 are the upper case ASCII characters representing the Continuous Measurements command.

- **Verify Command – V Command:** 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. Data generated in response to this command are placed in the sensor's buffer for subsequent collection using **D** commands. Data are stored in the buffer until another **M**, **C**, or **V** command is executed.

  Command: **aV!**
  Response: **atttn**

  where:

  a is the sensor address assigned by the user. The default is 0, but this could be 0-9 or any upper or lower case letter (a-z and A-Z).

  V is the upper case ASCII character representing the Verify command.

  ttt is a 3-digit integer (always 000) 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 (always 3) specifying the number of values that will be placed in the data buffer. Issuing a '0V0!' command to get the values will return '0+123+456-789'.

- **Send Acknowledge Command – A 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: **a!**
  Response: **a**

  where:

  a is the sensor address (0-9)

If the SDI-12 **Profile** output is selected (IQ Plus and IQ Pipe only), the output is in the format below depending on the output coordinate system.

Command	Response	SDI-12 M Command Output Output Coordinate System = "XYZ"							
		1	2	3	4	5	6	7	8
0M!	0D0!	Mean Temp	Adjusted Pressure	Stage	Cell end				
	0D1!	Vx*	Vz*	Vel XZ Mag	Avg SNR beams 1&2	flow			
0M1!	0D0!	Vx1	Vz1	Vx2	Vz2	Vx3	Vz3		
0M2!	0D0!	AvgAmp 1	AvgAmp2	AvgAmp3	AvgSnr1	AvgSnr2	AvgSnr3		
0M3!	0D0!	Vx4	Vz4	Vx5	Vz5	Vx6	Vz6		
0M4!	0D0!	AvgAmp 4	AvgAmp5	AvgAmp6	AvgSnr4	AvgSnr5	AvgSnr6		
0M5!	0D0!	Vx7	Vz7	Vx8	Vz8	Vx9	Vz9		
0M6!	0D0!	AvgAmp 7	AvgAmp8	AvgAmp9	AvgSnr7	AvgSnr8	AvgSnr9		
0M7!	0D0!	Vx10	Vz10	AvgAmp10	AvgSnr10				
0M8!	0D0!	Battery V	MB free	Flow	Total volume	Ice score			

*If one beam solutions are selected Vx is from the selected beam one-beam solution and Vz is zero. One beam solutions are selected if Mean Velocity Equation is Theoretical (beam 1 only), Theoretical (beam2 only), Index Equation (Velocity (XZ).X (Beam 1 Only)), or Index Equation (Velocity (XZ).X (Beam 2 Only))

Command	Response	SDI-12 M Command Output Output Coordinate System = "BEAM"							
		1	2	3	4	5	6	7	8
0M!	0D0!	Mean Temp	Adjusted Pressure	Stage	Cell end				
	0D1!	V Beam 1	V Beam 2	Vel B1 & B2 Mag	Avg SNR beams 1&2	Flow			
0M1!	0D0!	Vb1c1	Vb2c1	Vb1c2	Vb2c2	Vb1c3	Vb2c3		
0M2!	0D0!	AvgAmp1	AvgAmp2	AvgAmp3	AvgSnr1	AvgSnr2	AvgSnr3		
0M3!	0D0!	Vb1c4	Vb2c4	Vb1c5	Vb2c5	Vb1c6	Vb2c6		
0M4!	0D0!	AvgAmp4	AvgAmp5	AvgAmp6	AvgSnr4	AvgSnr5	AvgSnr6		
0M5!	0D0!	Vb1c7	Vb2c7	Vb1c8	Vb2c8	Vb1c9	Vb2c9		
0M6!	0D0!	AvgAmp7	AvgAmp8	AvgAmp9	AvgSnr7	AvgSnr8	AvgSnr9		
0M7!	0D0!	Vb1c10	Vb2c10	AvgAmp10	AvgSnr10				
0M8!	0D0!	Battery V	MB free	Flow	Total volume	Ice score			

Command	Response	SDI-12 C Command Output Output Coordinate System = “XYZ”							
		1	2	3	4	5	6	7	8
0C!	0D0!	Mean Temp	Adjusted Pressure	Stage	Cell end				
	0D1!	Vx*	Vz*	Vel XZ Mag	Avg SNR beams 1&2	Flow			
	0D2!	Vx1	Vz1	Vx2	Vz2	Amp c1b1	Amp c1b2	Amp c2b2	Amp c2b2
	0D3!	Vx3	Vz3	Vx4	Vz4	Amp C3b1	Amp C3b2	Amp C4b2	Amp C4b2
	0D4!	Vx5	Vz5	Vx6	Vz6	Amp C4b1	Amp C5b2	Amp C6b2	Amp C6b2
	0D5!	Vx7	Vz7	Vx8	Vz8	Amp C7b1	Amp C7b2	Amp C8b2	Amp C8b2
	0D6!	Vx9	Vz9	Vx10	Vz10	Amp C9b1	Amp C9b2	Amp C10b2	Amp C10b2
	0D7!	Battery V	Noise B1	Noise B2	NoiseB3	NoiseB4	Noise B5	Ice score	

*If one beam solutions are selected Vx is from the selected beam one-beam solution and Vz is zero. One beam solutions are selected if Mean Velocity Equation is Theoretical (beam 1 only), Theoretical (beam2 only), Index Equation (Velocity (XZ).X (Beam 1 Only)), or Index Equation (Velocity (XZ).X (Beam 2 Only))

Command	Response	SDI-12 C Command Output Output Coordinate System = “BEAM”							
		1	2	3	4	5	6	7	8
0C!	0D0!	Mean Temp	Adjusted Pressure	Stage	Cell end				
	0D1!	V Beam 1	V Beam 2	Vel B1 & B2 Mag	Avg SNR beams 1&2	flow			
	0D2!	Vb1c1	Vb2c1	Vb1c2	Vb2c2	Amp c1b1	Amp c1b2	Amp c2b2	Amp c2b2
	0D3!	Vb1c3	Vb2c3	Vb1c4	Vb2c4	Amp C3b1	Amp C3b2	Amp C4b2	Amp C4b2
	0D4!	Vb1c5	Vb2c5	Vb1c6	Vb2c6	Amp C4b1	Amp C5b2	Amp C6b2	Amp C6b2
	0D5!	Vb1c7	Vb2c7	Vb1c8	Vb2c8	Amp C7b1	Amp C7b2	Amp C8b2	Amp C8b2
	0D6!	Vb1c9	Vb2c9	Vb1c10	Vb2c10	Amp C9b1	Amp C9b2	Amp C10b2	Amp C10b2
	0D7!	Battery V	Noise B1	Noise B2	NoiseB3	NoiseB4	Noise B5	Ice score	

7.6. Modbus

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

- No additional modules or converters are necessary for connecting the SonTek-IQ to a Modbus network.
- To connect to a Modbus network, first configure the SonTek-IQ for Modbus data output using the IQ Software.
- The RS232 serial port on the cable adaptor or flow display is used for both RS232 and Modbus communications.
- Unlike SDI-12, the IQ will sample continuously based on its settings and will output the latest measurement when polled by the Modbus network controller.
- Using Modbus output, the system will have slightly higher power consumption and decreased battery life – the IQ software will include these types of settings into its battery life calculations.

7.6.1. IQ Software Configuration for Modbus

In order for the SonTek-IQ 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
- No flow control
- The SonTek-IQ operates in RTU (Remote Terminal Unit) mode.
- Modbus output format default is IEEE standard floating point (Inverted floating point is also offered)
- Figure 99 presents an example Modbus configuration.

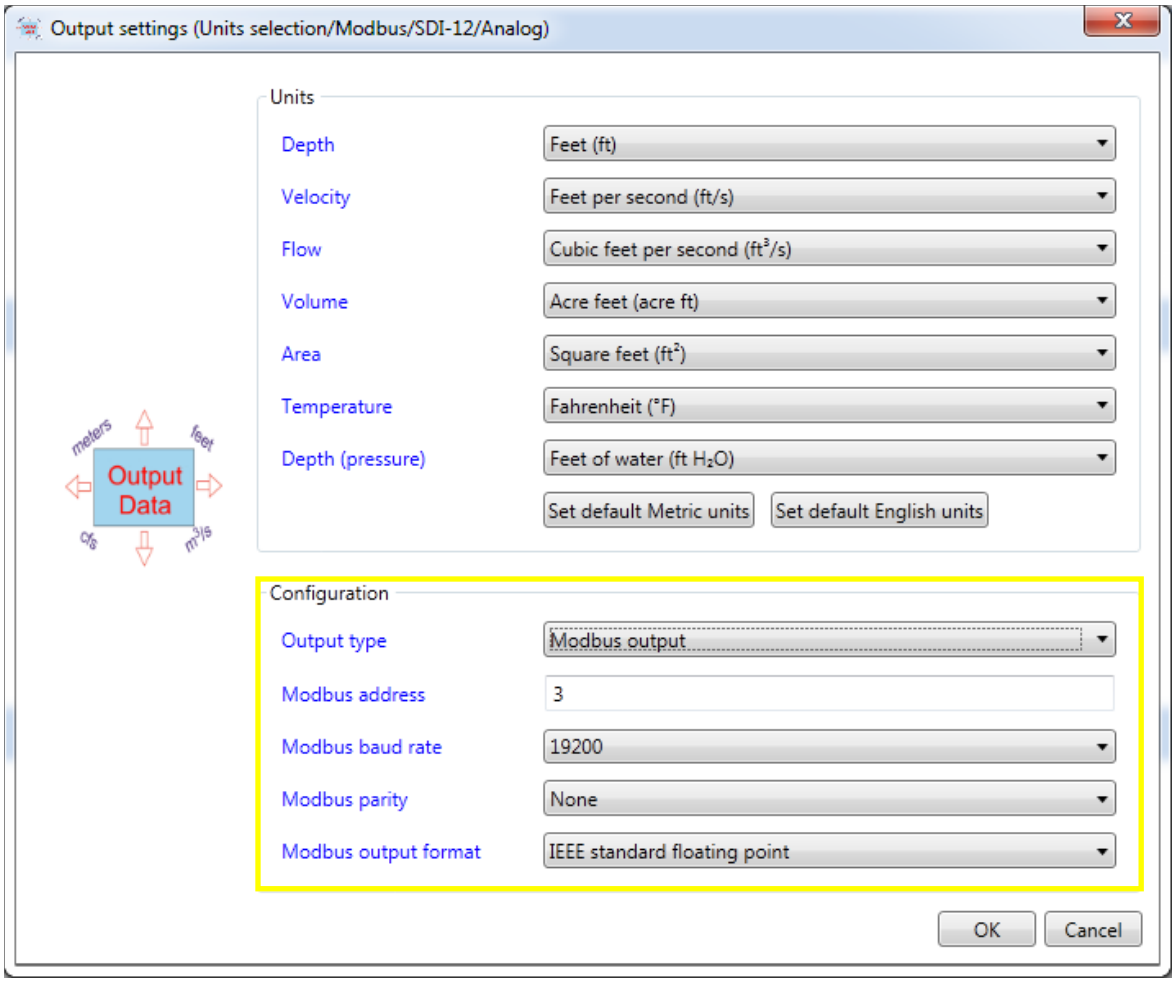


Figure 99. Modbus Configuration Using the IQ Software

7.6.2. Modbus Hardware Setup

Use the IQ software to configure the system. When all status icons on the IQ Smart Page are green, start the data collection, disconnect, and exit the IQ software. Connect the SonTek-IQ to the Modbus network using the RS232 cable (Figure 100).

Figure 100. Modbus Connection with RS232 Cable

7.6.3. Modbus Data Output

Modbus data from the IQ 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 53 input registers used to report the 27 sample parameters (addresses 100-152) defined in Table 8.
- The units of the output data (meters, feet, etc.) are set in the IQ Software by the user in the Output settings window.

Table 8. Modbus Register Addresses and Parameter Descriptions

Address	Parameter name
0	IQ serial number
2	IQ sequential sample number
4	Year – start time of current IQ sample
6	Month – start time of current IQ sample
8	Day – start time of current IQ sample
10	Hour – start time of current IQ sample
12	Minute – start time of current IQ sample
14	Second – start time of current IQ sample
100	Flow rate (using the user-defined channel geometry)
102	Stage (water depth relative to the user-defined channel)
104	Mean velocity (throughout the channel cross section)
106	Total volume (based on all measured flow)
108	Water depth (amount of water above instrument from pressure)
110	Index velocity (user-specified if using the Index Velocity method, or same as Velocity (XZ).X if none specified)
112	Cross-sectional area of channel
114	Water temperature
116	System Status (Section 7.1)
118	Velocity (XZ).X-Center (downstream velocity in the center of the channel)
120	Velocity (XZ).Z-Center (vertical velocity in the center of the channel)
122	Velocity (XZ).X-Left (downstream velocity along the left bank)
124	Velocity (XZ).X-Right (downstream velocity along the right bank)
126	Battery voltage
128	Pitch angle in degrees
130	Roll angle in degrees
132	Percentage of instrument submerged (100% is fully submerged)
134	Range to water surface from vertical beam
136	Water depth (from pressure adjusted for atmospheric pressure)
138	Total volume (based only on positive measured flow)
140	Total volume (based only on negative measured flow)
142	End Cell (distance to farthest good measurement cell)
144	SNR for beam 1 (acoustic signal strength in dB)
146	SNR for beam 2 (acoustic signal strength in dB)
148	SNR for beam 3 (acoustic signal strength in dB)
150	SNR for beam 4 (acoustic signal strength in dB)
152	Ice Score > 100 indicates possible surface ice

Section 8. Troubleshooting

8.1. Cannot Establish Communications with the SonTek-IQ

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

- Connect the cable from the IQ 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 IQ 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.

8.1.1. Verify All Connections

- Make sure that the connectors (five-pin IQ 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 IQ 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 IQ cable is correctly connected to the SonTek-IQ
  - 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-IQ is connected to a power source
  - The SonTek-IQ requires 10-15VDC, 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.
  - We have tested this converter and it is more reliable and faster than many other USB-Serial products (including built in serial ports).

8.1.2. Use the System and COM Port Reset Functions

If the IQ software cannot connect to the IQ, 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 IQ icon in the upper left corner of the software (Figure 101).
- 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.

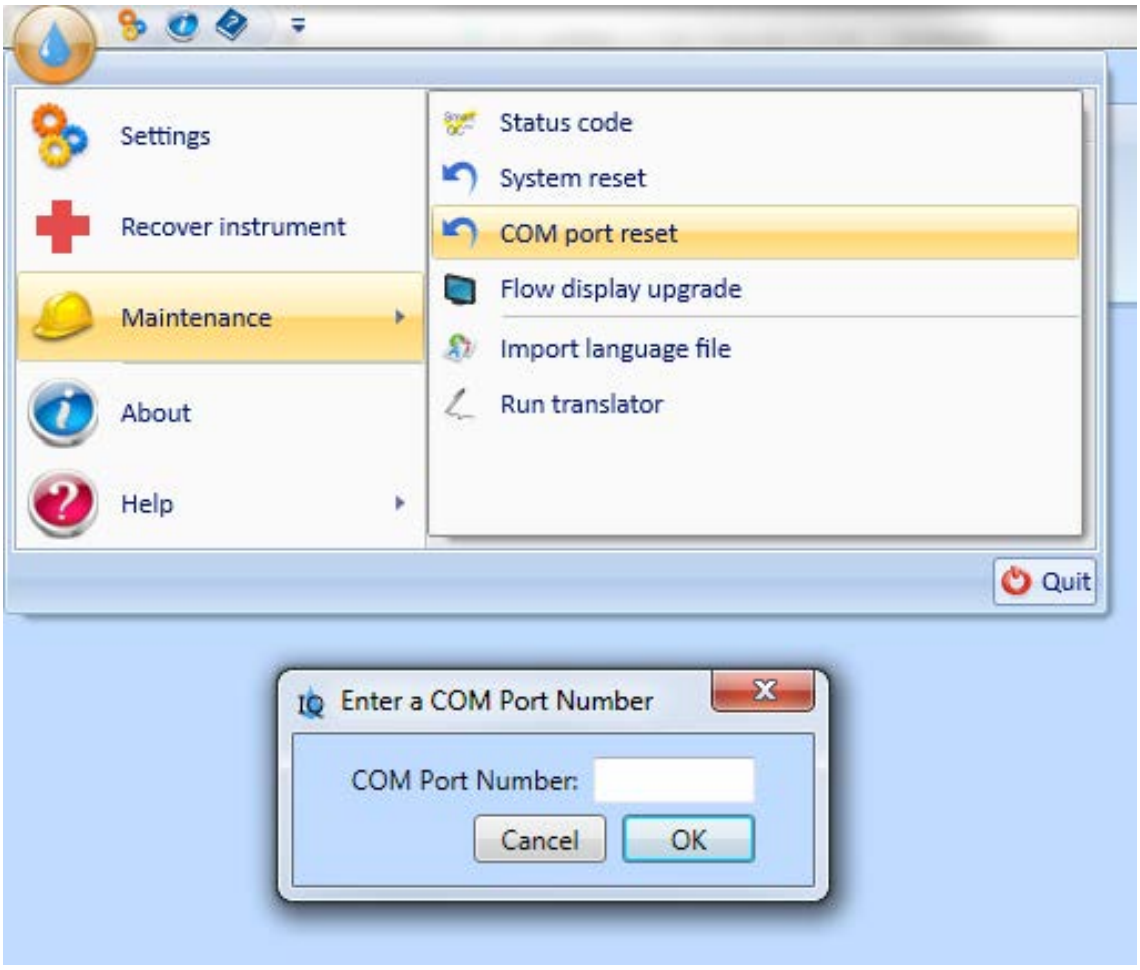


Figure 101. IQ System and COM Port Reset Function

8.1.3. Cycle Power

If you are still not able to establish communication with the IQ, 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

8.1.4. Recover Instrument

Clicking on the IQ icon in the upper left corner of the software leads to the Recover Instrument function. This will guide the user through a series of timed steps to cycle power and re-establish communications.

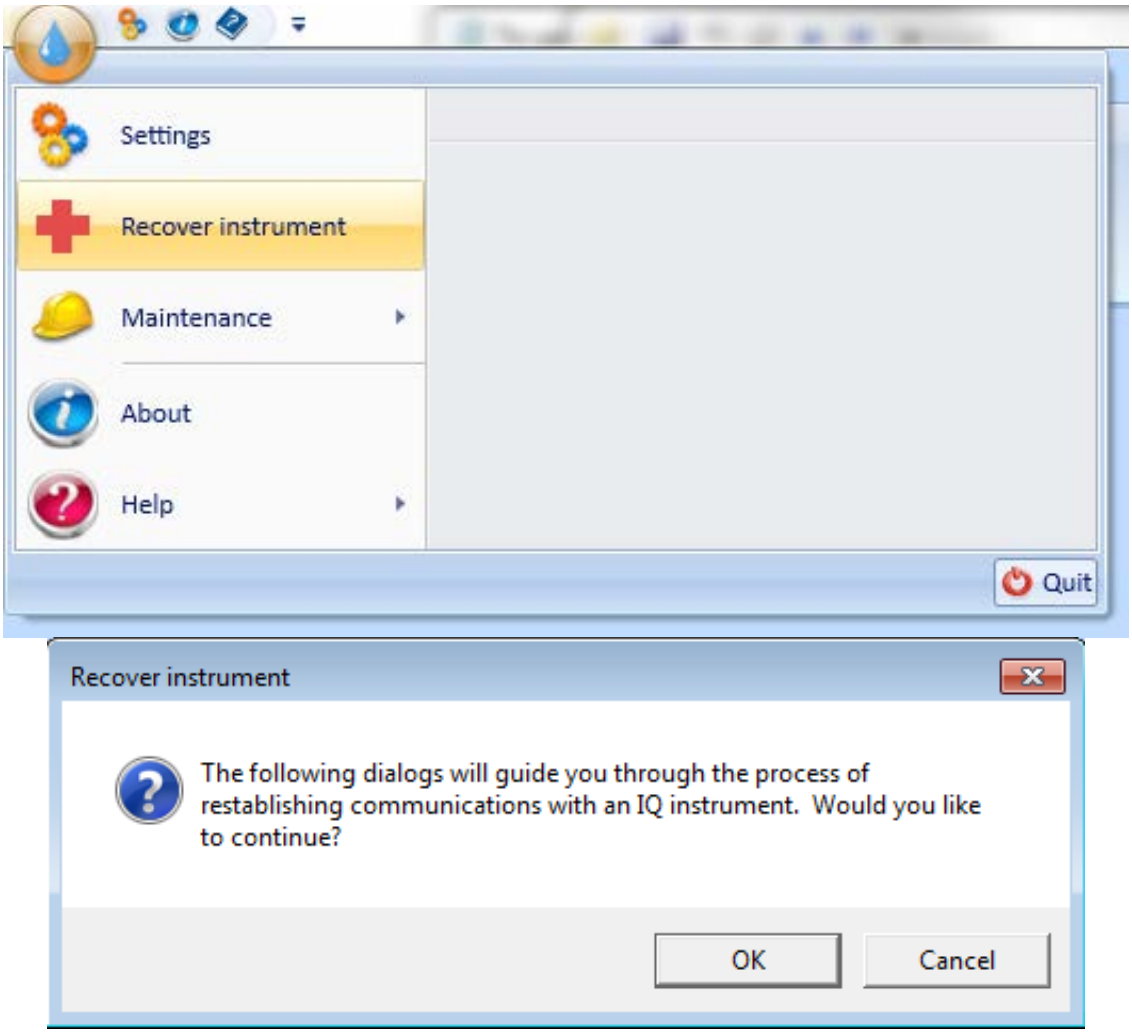


Figure 102. Recover Instrument

8.1.5. Lower Maximum Baud Rate

If communications is still unsuccessful or intermittent, lower the Maximum Baud Rate in the software Settings. See Figure 103.

A maximum baud rate lower than 19200 is not recommend . If you think the baud rate is a causing a problem, try lowering the maximum baud rate setting one step down at a time so that the final selected baud rate is as high as possible. During normal operation, the software tests the communication speed and negotiates the fastest baud rate the system can handle. Lowering the maximum baud rate will cause an increase in the file download times and could slow down the software response time.

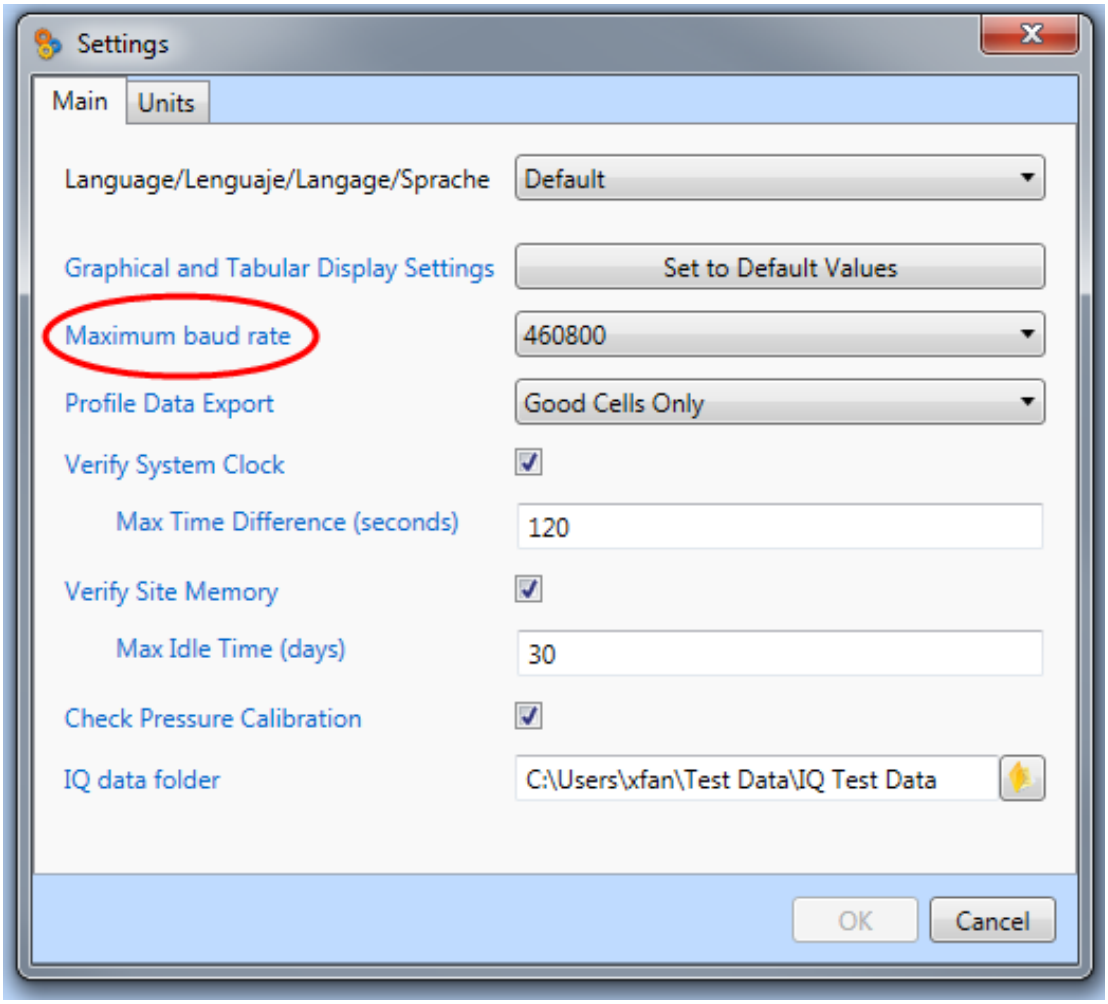


Figure 103. Maximum Baud Rate

8.2. Beam Check

- Beam Checks are performed 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 104.
- There are tabs to display SNR or Signal Amplitude.

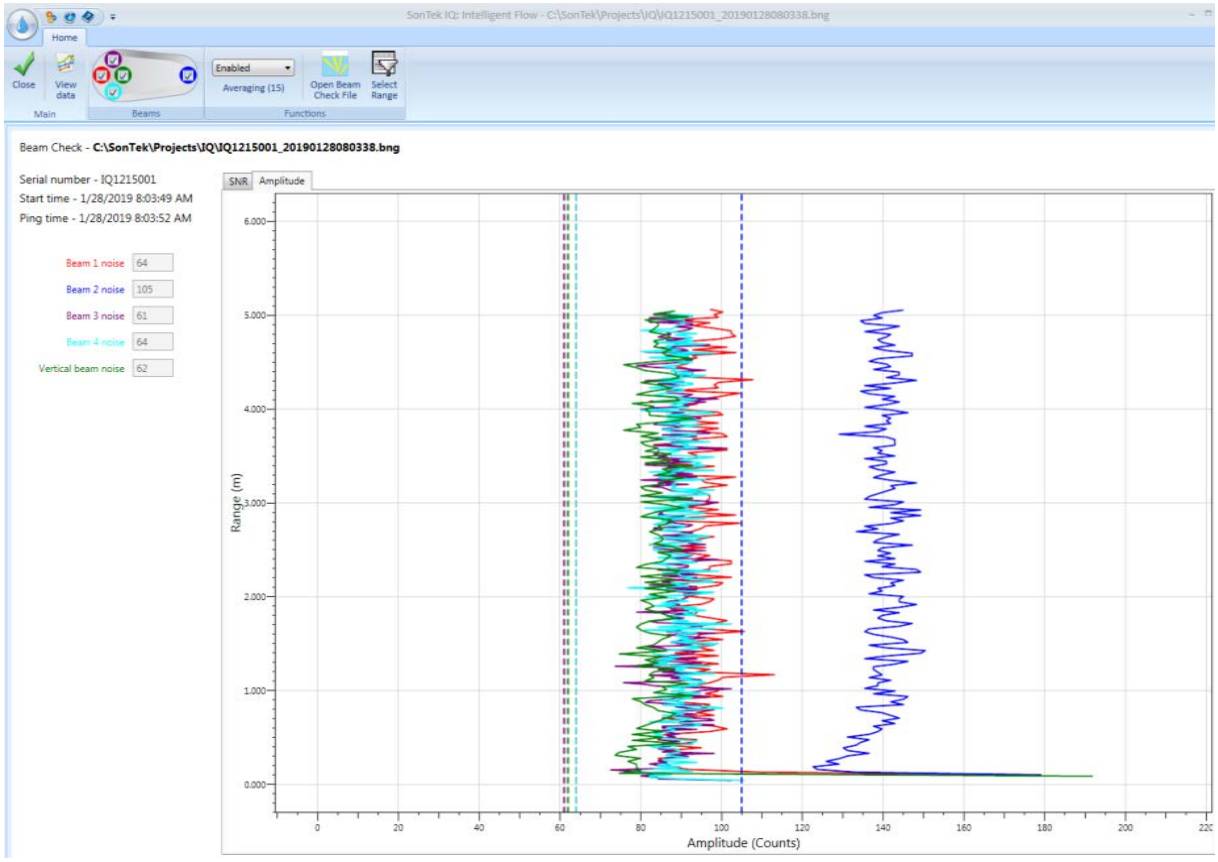


Figure 104. Beam Check Amplitude Display

- The solid lines represent the Signal Amplitude, effectively the strength of the signal received from the instrument, for each beam versus the vertical distance from from the instrument.
- The dashed vertical lines represent the beam noise levels
- In ideal conditions, the along axis beams, beams 1 and 2 (red and blue respectively) and the skew beams 3 and 4 (light blue and purple) should display similar plots, however older IQ systems can have higher Signal Amplitude and noise level in beam 2. In those cases, the SNR will remain unaffected.
  - If any 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 green 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.

8.3. Cannot Retrieve Data from the Internal Recorder

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

- The SonTek-IQ software retrieves data from the internal recorder using a higher baud rate to speed up the download process.
- When you connect with the IQ, 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 IQ.
  - If problem persists, try using another computer.

8.4. 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 IQ product as well as the flow display
  - Firmware versions are indicated in the System Information of the IQ 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.

8.5. Missing Data from a Deployment

The SonTek-IQ 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 the recorded data, look at the measured battery voltage. 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-IQ

8.6. Cannot Communicate with an External Device

If you cannot establish communications between the SonTek-IQ 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-IQ in the appropriate output mode (Section 3)?
- The IQ software must first be programmed using the RS-232 serial interface.
- Disconnect the IQ and exit the program before connecting other networks or data loggers.
- Do you have the correct address specified?
- Do you have the correct Baud rate?
- Do you have the correct output format?

8.7. Unreasonable Data

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

Evaluate the deployment site

- Is the IQ in an area with stable flow conditions?
- Is the IQ oriented correctly with respect to the direction of flow?
- Is the SonTek-IQ 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-IQ Standard 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 (more than 3 inches or 8 cm)?

Check temperature sensor and battery voltage data

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

8.8. Protection from Biological Fouling

The SonTek-IQ 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 IQ.
- 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.

8.9. 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-IQ.

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.

Deployment Starts at a Specific Date/Time means data collection will begin at the programmed date/time in the future. The deployment will begin immediately after pressing the "Start data collection" button, but the first sample will not be collected until the start date and time are reached.

Analog Data Variable: Each external analog channel generates a signal proportional to an IQ 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 IQ flow display) that generate up to four analog signals (4-20 mA) each proportional to a single IQ 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 IQ RS232 serial port (9600 8-N-1) using standard ASCII characters.

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

Battery capacity: This is the expected capacity, in amp-hours, of the battery that will be used to power the IQ 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)

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 Type: Several channel types are supported for flow calculations (Irregular Open Channel, Trapezoidal Open Channel, Trapezoidal Culvert, and Stage/Area Equations). All calculations are supported by the IQ Plus and IQ Pipe, while the IQ Standard only allows for the Trapezoidal Channel and Irregular Open Channel.

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.
Round Pipe is a regular closed conduit or pipe that is defined by the diameter.
Elliptical Pipe is a regular closed conduit or pipe defined by the pipe width and pipe height.
Irregular Pipe can be a closed conduit of any shape defined by up to 100 user defined supplied survey points.
Stage/Area Equation (IQ Plus and IQ Pipe Only) is a set of one or more user supplied equations that relates the measured stage to the cross sectional flow area.
None is for no flow calculation. For velocity data only.

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 IQ 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.

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.

IQ Orientation: In a closed conduit, the IQ can either be installed on the bottom looking up or on the top looking down. Naturally, installation on the top will only work if the channel is always completely full. 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 (IQ Plus and IQ Pipe only): 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. In the event of a power loss, the total volume will be saved to begin accumulating again when power is restored.

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 IQ 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).

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

IQ Data Folder: The IQ 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 IQ 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 IQ software to control automatically the data file organization.

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 IQ. 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 IQ, 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 IQ 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 Calculation Method: This parameter is required for internal flow.

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.

Number of Analog Channels: The IQ 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 IQ.

Operator Name: This is usually the name of the person configuring the IQ 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 IQ 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 IQ. Each analog signal (4-20 mA) is proportional to a single IQ 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.

Pressure: Specifies the units used for the measured water pressure.

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 Multi-Cell Data (IQ Plus and IQ Pipe Only): Setting determines the interval at which detailed multi-cell data are recorded. Depending on the system configuration, this may include SNR and/or velocity data. A value of 1 indicates multi-cell data are recorded with each sample. A value of N indicates multi-cell data are recorded with every N samples (i.e. every 100 samples). A value of 0 indicates multi-cell data are not recorded. The recording of multi-cell data has a significant impact on file size and recorder life, and this impact should be considered when setting this parameter. If you would like to be able to reprocess your data for changes in channel shape, temperature, salinity, etc., this must be set to “1” to record all of the necessary data for recalculating.

Reference Date and Time: 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 IQ clock.

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

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 data logger.

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.

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.

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

Stage/Area Equation (IQ Plus and IQ Pipe Only): 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.

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: The reading of the IQ clock at the time the dialog was opened.

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: 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.

Flow Threshold 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 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.

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

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 IQ 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 IQ 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-IQ products (SonTek-IQ, SonTek-IQ Plus and SonTek-IQ Pipe) 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-IQ products operation. To learn more about specific SonTek-IQ applications, please refer to other sections of the *SonTek-IQ User's Manual* or contact SonTek Support.

B-1. Overview

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

- Horizontally and vertically integrated velocity measurement (using along axis and skew beams)
- 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

The SonTek-IQ product line combines horizontally and vertically integrated velocity data with precise stage measurements to determine real-time flow data. A variety of real-time flow calculations are supported and are presented below:

- Natural streams
- Regular (trapezoidal) channels (typically concrete lined)
- Irregular channels (typically, not lined or earthen channels)
- Pipes and closed conduits (SonTek-IQ Pipe)
- Theoretical flow calculations
- Full support for index velocity sites (SonTek-IQ Plus)
- Calculation of total water volume for water deliveries

B-2. The Doppler Shift

The SonTek-IQ products measures the velocity of water 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:

$$F_d = (2 F_0 V/C)$$

Where:

F_d = Change in received frequency (Doppler shift)

F_0 = Frequency of transmitted sound

V = Represents the relative velocity between source and receiver (i.e., motion that changes the distance between the two); positive V indicates that the distance from source to receiver is increasing

C = Speed of sound

The SonTek-IQ products are a *monostatic* Doppler current meter. Figure B1 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 IQ 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.

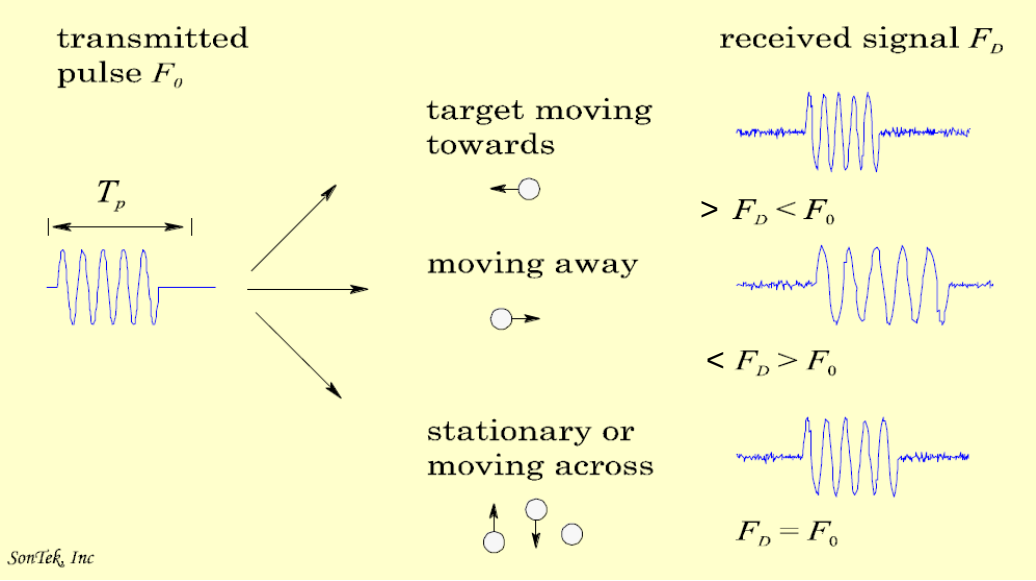


Figure B1. Monostatic Doppler Shift

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 SonTek-IQ measures the water velocity at different distances from the transducer.
- It is important to note that SonTek-IQ products measure 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. So much so that SonTek and many other companies have built their business upon this assumption.
- If there is no particulate matter in the water, the IQ is unable to measure velocity. In general, the practical limitation of clear water is not whether the IQ can make velocity measurements, but what is the maximum range (distance from the system) at which the IQ 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 IQ software can be used to make an on-site field determination of range.

B-3. Beam Geometry

The SonTek-IQ product line is a class of flowmeter that is typically mounted in the bottom of open channels or pipes. In cases where a closed conduit is known to always be full flowing, the instrument can be mounted to the top of the conduit looking down. Regardless of being mounted at the bottom or top of the channel, the SonTek-IQ products measure velocity along the axis of flow as well as horizontally using the along-axis beams skew beams respectively.

- The IQ is mounted such that the along axis transducer are aligned with the center of the channel (Figure B2).

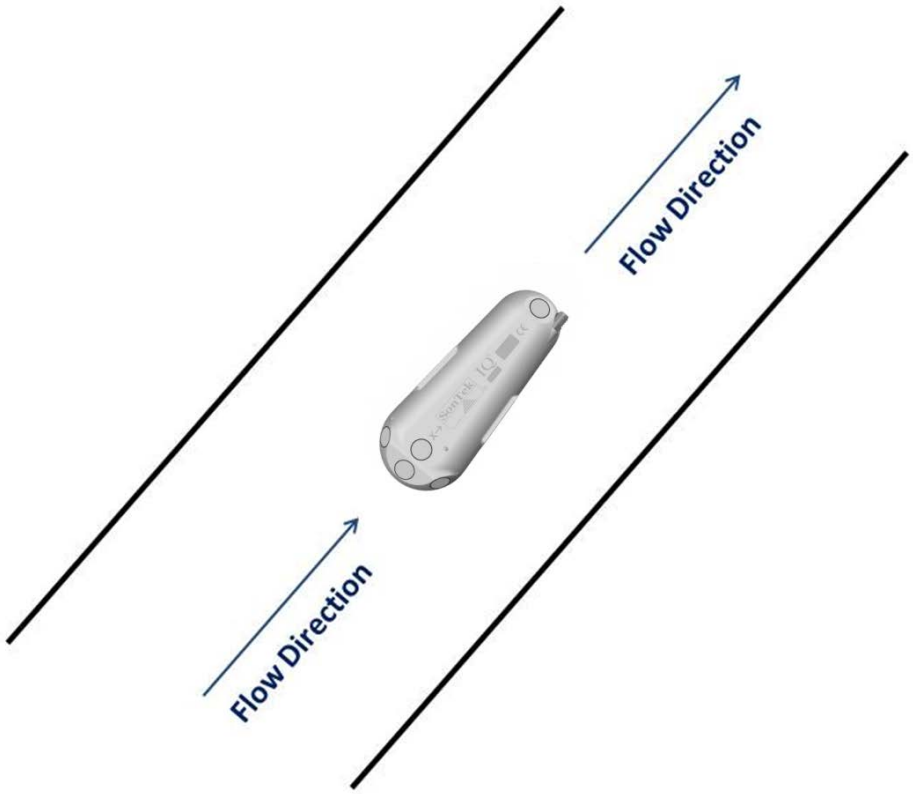


Figure B2. IQ Orientation Relative to Flow

Note: SonTek-IQ and IQ Plus are represented in the Figure above – the same instructions apply for the SonTek-IQ Pipe.

- The IQ uses four transducers to measure velocity — two along-axis beams and two skew beams. This beam geometry optimizes the balance between total measurement range and performance in shallow water.
    - Along axis beams are 25° off the vertical axis
    - Skew beams are 60° off the vertical axis and 60° of the center axis of channel

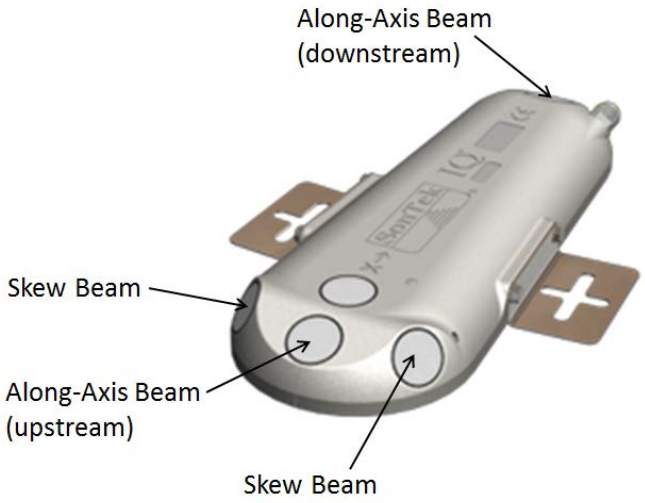


Figure B3. SonTek-IQ Velocity Beams

- The SonTek-IQ Pipe uses four transducers to measure velocity — two along-axis beams and two skew beams. This beam geometry optimizes the balance between total measurement range and performance in shallow water (Figure B2).
    - Along axis beams are 25° off the vertical axis
    - Skew beams are 37° off the vertical axis and 45° of the center axis of channel

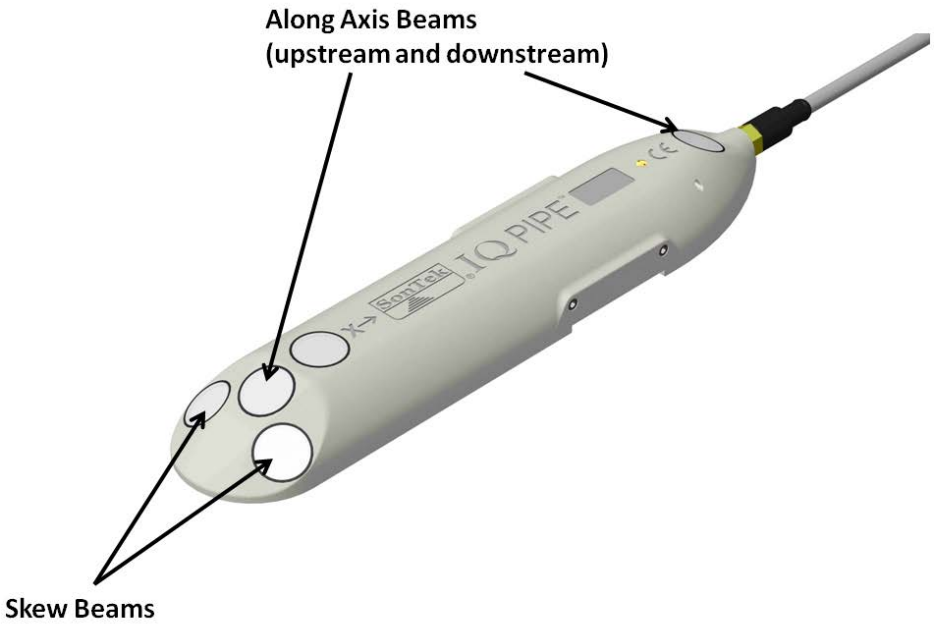


Figure B4. SonTek-IQ Pipe Velocity Beams

- The IQ products use the relative orientation of the transducers to calculate the 3D water velocity.
- The velocity measured by one transducer is the projection of the 2D water velocity onto the axis of the acoustic beam, and is referred to as the beam velocity.
- Beam velocities are converted to XY (Cartesian) velocities using the beam geometry.
- The X velocity for the IQ is the along-channel water velocity; the Z velocity is the vertical water velocity (typically very small).
- The IQ typically measures as much of the water column as possible — from a short distance above the transducer head all the way to the water surface.
- The starting point of the velocity measurement is 0.02 m above the transducer. This distance (called the *blanking distance*) is required for the transducers to recover after transmitting the acoustic pulse.
- The IQ dynamically adjusts the ending point of the velocity measurement based on the measured *water level* from the vertical acoustic beam. This lets the IQ automatically optimize operation with changing water level.

B-4. Water Level Measurement

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

- The vertical beam sends a short sound pulse and listens for the reflection from the surface.
- The surface reflection is very strong and clearly defined, allowing SonTek-IQ products to precisely measure the time at which the return reflection is received.
- To convert the reflection time to surface range, SonTek-IQ products needs to know the speed of sound in the water at the site, which is primarily a function of temperature and salinity.

  - SonTek-IQ products 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 (i.e., SonTek-IQ products do not automatically adjust for salinity variations).
- The vertical beam can operate with water depths from 0.08 to 1.5 m (from the base) for the SonTek-IQ, and 0.08 to 5 m for the SonTek-IQ Plus and IQ Pipe.
- Both the vertical beam and pressure measurements can be used for water depth. The IQ firmware has a set of algorithms to determine which measurement is best for water depth in real time. These water depth algorithms were modified in firmware version 2.00 to provide water depth estimates even when conditions are not ideal. These water depth estimates will be accompanied by two new status codes to identify poor conditions. Previous firmware versions including 1.60 would stop reporting water depth if vertical beam measurements and/or pressure sensor calibrations were poor.
- When submerged measurement conditions are good, the vertical beam measurement is used to calibrate the pressure sensor in real time for up-looking instrument orientations. This calibration removes fluctuations in pressure due to changes in atmospheric conditions. If atmospheric pressure variation is not removed (by vertical beam calibration) this can lead to inaccurate water depths and consequently inaccurate flow computations when using the pressure sensor for water depth.
- For up or down orientations with the system in air, the pressure sensor is zeroed during each sample if the standard deviation of the subsample pressure measurements is low. This is basically a pressure spike filter.
- For down-looking systems when submerged:
  - The pressure sensor is not calibrated with the vertical beam.
  - If the IQ detects water, the vertical beam is used for water depth when vertical beam percent good is equal to or greater than 30%.
  - If the vertical beam percent good is below 30%, the vertical dimension of the channel/pipe is used as the water depth.
- For up-looking systems when submerged:
  - 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.
- For pressurized pipes, note the pressure sensor range, as well as the IQ's (all models) housing rating is 30 m of water (or 42 psi).

B-5. Flow Calculations

One of the primary functions of the SonTek-IQ products is to provide real-time flow data and total volume data for water deliveries. SonTek-IQ products combine water velocity data and level data with user-supplied channel geometry information about the installation site to calculate flow and volume. SonTek-IQ 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 (SonTek-IQ Plus)
- Any channel that can be represented with a stage/area equation (SonTek-IQ Plus)
- Pipes and other closed conduits (SonTek-IQ Pipe)
  - **It is important to note that although both the IQ Plus and IQ Pipe can be installed in either open channels or closed conduits, pipe flow algorithms only exist in the IQ Pipe system and open channel flow algorithms only exist in the IQ Plus (and IQ Standard).**
  - **If an IQ Pipe is installed in an open channel, or an IQ Plus is installed inside a pipe, flow (volumetric discharge) must be computed outside of the system using the index velocity. For best results, SonTek strongly recommends that the SonTek-IQ Plus be used in open channels and the SonTek-IQ Pipe be used in closed conduits.**

SonTek-IQ 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-IQ products and the mean channel velocity can be determined two ways.

- Theoretical flow calculations
- Index velocity calibration

SonTek-IQ 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.

B-5-1. 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 SonTek-IQ products are utilized. For theoretical flow calculations SonTek-IQ products make use of the following information.

- The largest variations of velocity occur with changing depth

- SonTek-IQ products measure a vertically integrated velocity over the largest possible portion of the water column, including information about the variation of vertical velocity
    - The SonTek-IQ outputs average velocity data from 0.08 – 1.5 m
    - The SonTek-IQ Plus and IQ Pipe outputs velocity profile data from 0.08 – 5.0 m
- A power-law velocity profile model is used, assuming a 1/6 power-law coefficient for open channels and pipes.
- The theoretical flow model accounts for the portion of the vertical velocity profile measured by the SonTek-IQ product. It determines the relationship between the mean velocities measured in this portion of the water column with the mean velocity through the vertical profile.
- The model provides a velocity scaling factor that relates the SonTek-IQ product measured velocity to the mean channel velocity.
- The flow model is customized based on specified channel type — open channel, round pipe (full/partially full), elliptical pipe (full/partially full), or closed culvert (full/partially full).

B-6-1 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.
- IQ 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 IQ measured velocity and the mean channel velocity. This empirical relationship is then input into the IQ, 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} = IQ 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 IQ 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.

B-6. SonTek-IQ Data

Below are details on collecting data with the SonTek-IQ product line.

B-6.1 Sampling Strategy

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

- The IQ samples velocity (via ping) each second. The type of velocity pings depends upon flow conditions.
- The IQ 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 IQ's internal recorder, and can also be reported to an external data logger.
- The IQ 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.

B-6.2 Velocity Data

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

- The IQ can measure water velocities from ±0.001 to 5 m/s.
- The IQ also measures flow direction and will accurately report reversing flow.
    - The standard IQ outputs average velocity
    - The IQ Plus outputs velocity profiles
- Data are output in Cartesian coordinates (XY) relative to system orientation.
- If one transducer is buried or blocked, the IQ may switch to a one-beam solution for velocity.
- Velocity data are accurate to 1% of the measured velocity (after accounting for random noise).
- The IQ provides diagnostic parameters with each sample to verify the quality and accuracy of these data.
- The IQ calibration will not change with time; the system never requires re-calibration.

B-6.3 Accuracy of Velocity data

The IQ is well suited to low-flow applications to less than 0.01 m/s. When discussing the accuracy of the IQ 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 IQ 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 IQ 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.

B-6.4 Signal-to-Noise Ratio

The IQ 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 IQ.
- 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 IQ requires a minimum SNR (≈3 dB) to make accurate velocity measurements.

For the IQ, the location and size of the measurement volume is variable over a range up to 1.5 m for the standard IQ and up to 5.0 m from the IQ Plus.

- 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.

The IQ will continuously change vertical extent of the measurement based on water depth.

- In most conditions, the IQ is able to measure to the specified maximum range of 5 m for the IQ Plus and 1.5 m for the standard IQ.
- If at any point the signal strength is too low for reliable velocity measurements, the IQ 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.

B-7. Flow Data

With each sample, the IQ 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 IQ 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 that has passed the IQ.
- 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 are 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.

B-8. Data Output

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

- Only one output type (RS232, RS422, 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 IQ 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 IQ is programmed using the RS-232 serial bus, and then Connected to an SDI-12 data logger.
  - The IQ'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 IQ's data collection.
  - Sample duration must be configured for the IQ 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 IQ can optionally be set up to generate analog output signals.
  - The IQ 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 IQ 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.

B-9. Speed of Sound Calculations

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

- Since the IQ 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%).

IQ 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 IQ.

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

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 IQ measurement volume, although these errors are generally very small. To calculate the correct location of the IQ 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. Specifications and Technical Drawings

C-1 Specifications

Parameter	SonTek-IQ Plus & IQ Pipe*	SonTek-IQ Standard
Minimum Operating Depth	0.08 m / 0.3 ft	0.08 / 0.3 ft
Maximum Operating Depth	5.0 m / 16.5 ft	1.5 m / 5.0 ft
Horizontal and vertical beam width	1.4°	1.4°
Side Lobe Suppression	>60 dB	>60 dB
True Compass Tilt Accuracy	±1°	±1°
Water Level Range (Vertical Beam)	0.05 – 5 m	0.05 – 1.5 m
Water Level Accuracy	0.1% of measured depth or ±0.003 m (0.01 ft) whichever is greater	0.1% of measured depth or ±0.003 m (0.01 ft) whichever is greater
Pressure Sensor Range	30 m	30 m
Pressure Sensor Accuracy	0.1% of full scale	0.1% of scale
Power Input	10 – 15 VDC	10 – 15 VDC
Power Consumption (data collection)	0.5 – 1.0 W	0.5 – 1.0 W
Power Consumption (idle)	< 0.03 W	< 0.03 W
Pressure Rating	20 m	20 m
Communications	RS232, SDI-12, ModBus	RS232, SDI-12, ModBus
Velocity Range	±5 m/s	±5 m/s
Resolution	0.001 m/s (0.003ft/s)	0.001 m/s (0.003ft/s)
Velocity Accuracy	±1% of measured velocity, ±0.5 cm/s (0.015 ft/s)	±1% of measured velocity, ±0.5 cm/s (0.015 ft/s)
Temperature Sensor Resolution/ Accuracy	±0.01°C /±0.1°C	±0.01°C /±0.1°C
Smart Pulse enabled	Profiling, 100 cell maximum output	Average velocity output
Operating and Storage Temperature	-5 to 60° C	-5 to 60° C
Velocity Indexing	Enabled	Disabled
Memory	4 GB	4 GB
Data	Reprocessing, Diagnostics, Display and Export	Display and Export

C-2 Technical Drawing

- If the SonTek-IQ or IQ Plus is installed directly on the bottom of the channel, the system elevation is 1.125 inch (0.029 m).
    - System Elevation is defined as the distance from the bottom of the instrument/channel to the top of the vertical beam (assuming the bottom of the channel is referenced to 0.00.
- However, if the system is installed with a riser mount or other custom option, this elevation is best determined using survey equipment.
- A technical drawing of the IQ highlighting the dimensions of the instrument is presented below. English units in inches are presented, with metric units in brackets [cm].

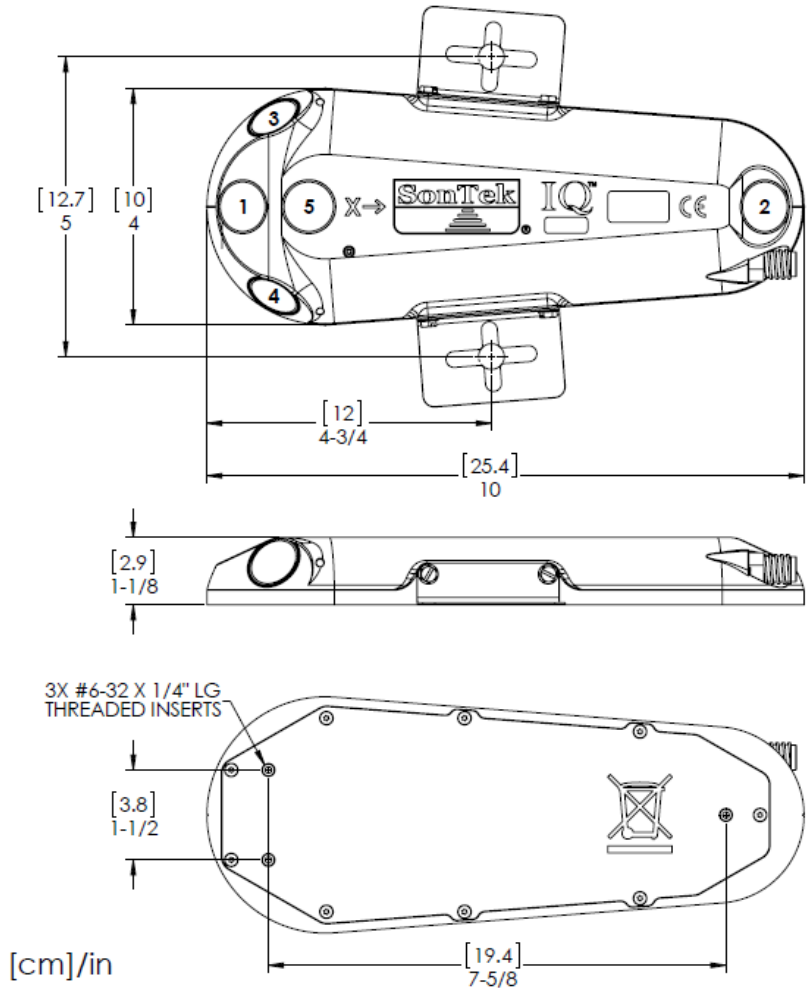


Figure C1. Technical Drawing of the SonTek-IQ and IQ Plus with Mounting Options

- If the SonTek-IQ Pipe is installed directly on the bottom of the channel, the system elevation is 1.15 inches (0.029 m).
    - System Elevation is defined as the distance from the bottom of the instrument/channel to the top of the vertical beam (assuming the bottom of the channel is referenced to 0.00.

- However, if the system is installed inverted at the top of a closed conduit, the system elevation will be equal to the maximum depth of the closed conduit minus the system elevation.
- A technical drawing of the IQ Pipe highlighting the dimensions of the instrument is presented below. English units in inches are presented, with metric units in brackets [cm].

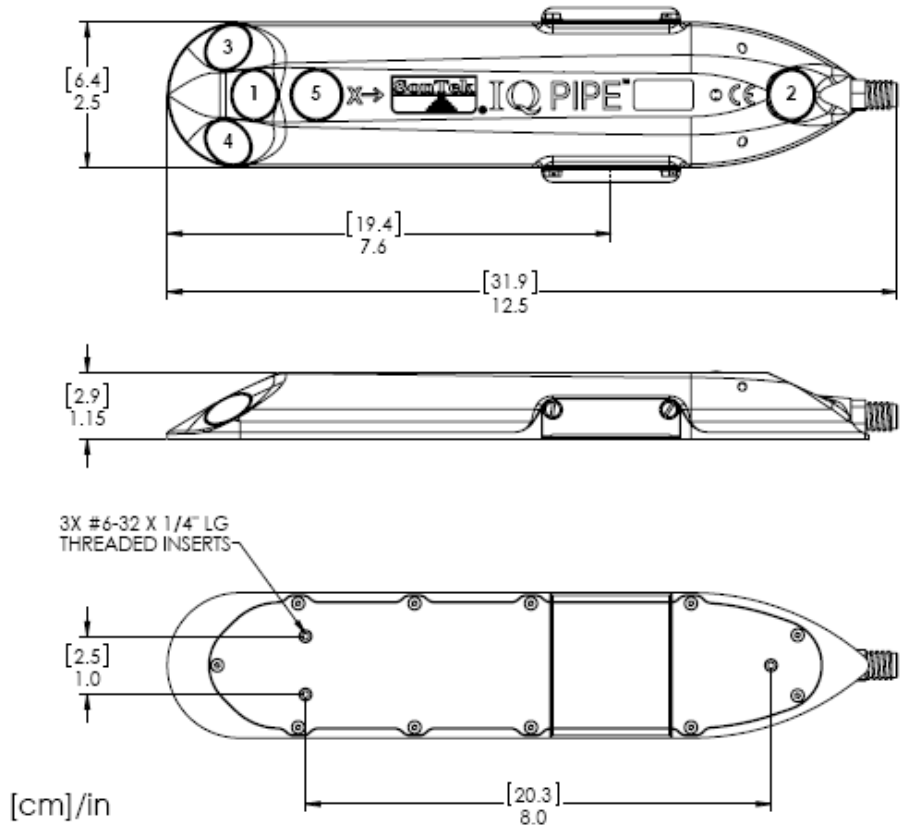


Figure C2. SonTek-IQ Pipe Technical Drawing

Appendix D. SonTek Flow Display

The SonTek Flow Display is an LCD display that can be connected to the SonTek-IQ. 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-IQ. 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-IQ for downloading and interfacing with a data logger.
- The display has four LED status lights showing system power, if an IQ 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.

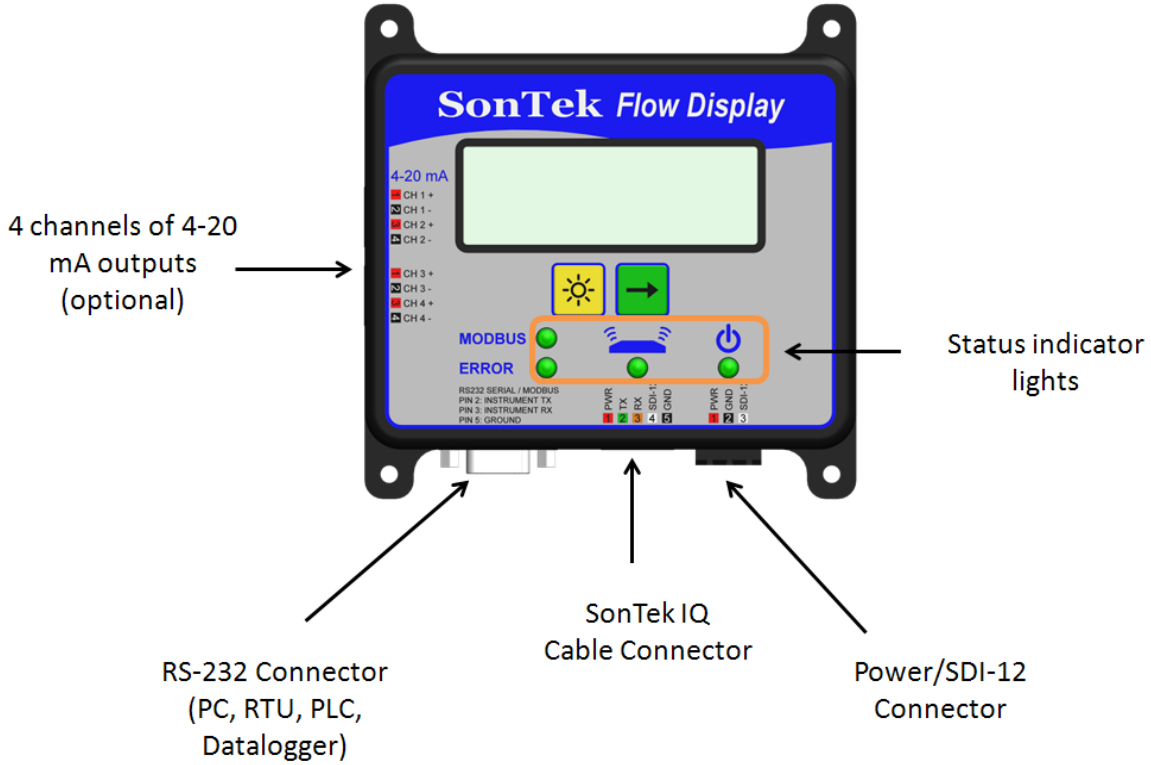


Figure D1. SonTek-IQ Flow Display with Analog Outputs

D-1. Firmware and Software Requirements

The SonTek Flow Display was released in February 2012.

- The SonTek-IQ must be running firmware version 1.1 or higher.
- For full support, you should install IQ software version 1.10 or higher.

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

- When connected to the IQ, 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 IQ software (see Section 3.1.6).
- 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 3.1.6.

D-2. 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 IQ 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-IQ via laptop, RTU, PLC, or data logger.
- The IQ 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.

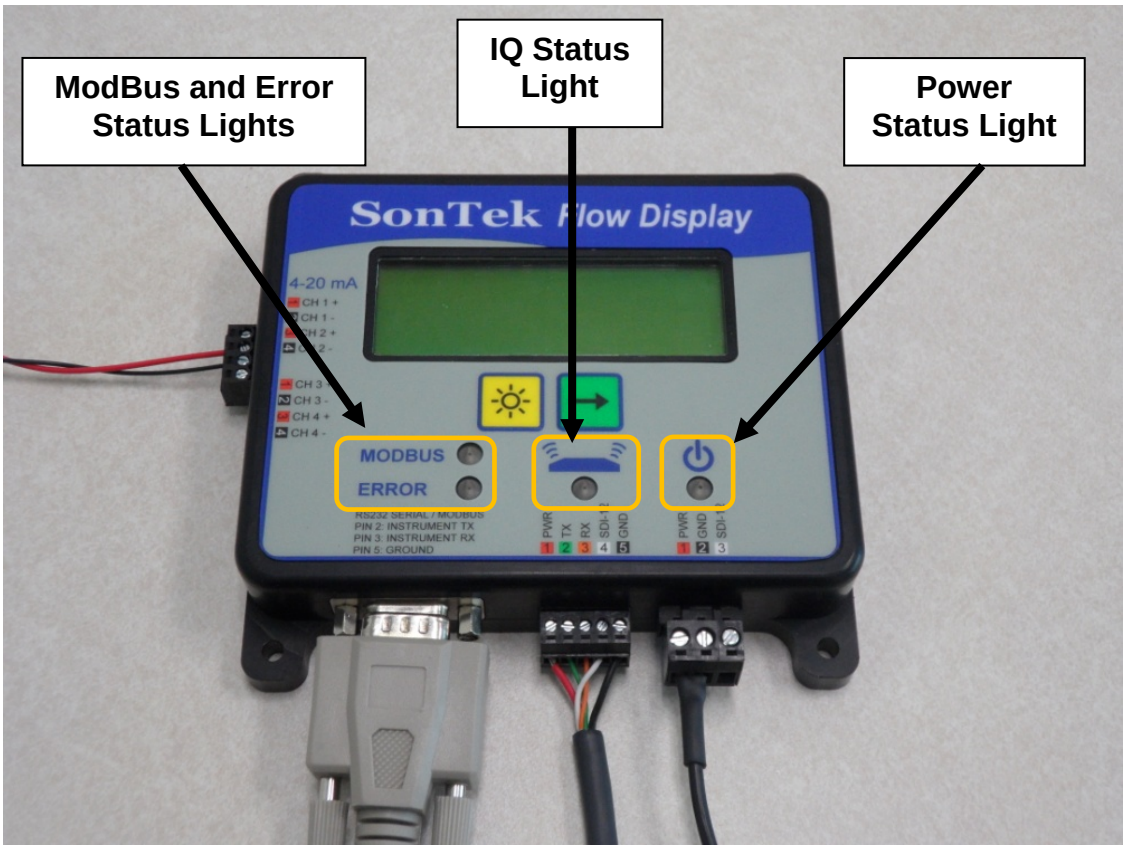


Figure D2. SonTek-IQ Flow Display Status Lights

D-3. 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 IQ status light (middle LED, green) indicates when communication is successfully established between the IQ 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 3.1.6).
- 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 IQ Modbus address.

- If the IQ **System Status** value indicates there is a potential problem with the IQ data, the Error LED will turn on.
  - The IQ **System Status** value is described in detail in Section 7.1.
  - If system status is 0, this means “All Clear” – no potential problems with the IQ 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.

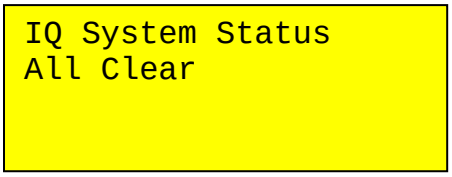
D-4. Using the Flow Display

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 IQ (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.

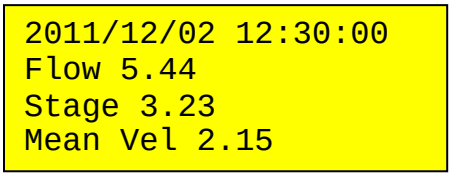


The following are possible status messages based on the data collected. Status messages are designed to prompt you for action (Section 7.1).

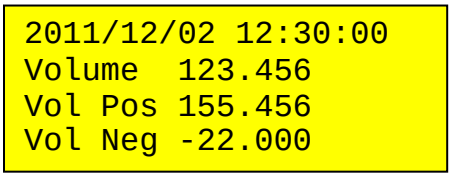
- **All Clear** – No potential problems have been detected.
- **High Tilt Values** – One or more tilt values is greater than 5º; this may affect data quality.
- **IQ may have moved** – One or more tilt values have changed significantly since the start of the deployment; this may indicate the IQ has moved.
- **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 10.0 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 IQ 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 IQ should be inspected and may need to be returned for service.
- **Low SNR warning** – The SNR is less than 10 dB
- **Velocity sample filtered - turbulent or low flow detected** – When velocity filtering is enabled, velocity spikes are removed and the flow becomes zero.
- **Pipe Size Warning** – Dimensions are outside the recommended range.
- **Vertical beam range exceeded** – Pressure depth is greater than maximum vertical beam range.
- **Poor depth warning** – No good vertical beam measurements for more than 6 hours (or whatever is set in the Modify Configuration window). The depth will be based only on the pressure sensor and the pressure sensor has not been calibrated by the vertical beam in over 6 hours. Atmospheric pressure changes could result in less accurate depth and flow data.

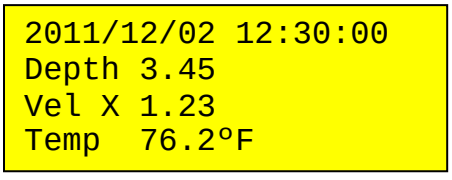
The **Flow/Stage/Mean Velocity Screen** shows flow, stage and mean velocity as well as the time of the last sample.



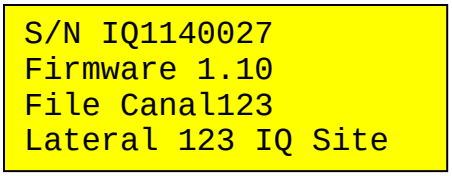
The **Volume Screen** shows total volume (sum of the positive and negative accumulated volume), positive volume (accumulated from positive velocity data) and negative volume (accumulated from negative velocity data).



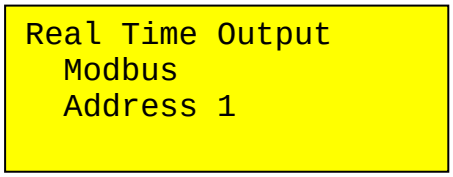
The **Velocity / Depth / Temperature Screen** presents water depth, velocity in the X direction and temperature data.

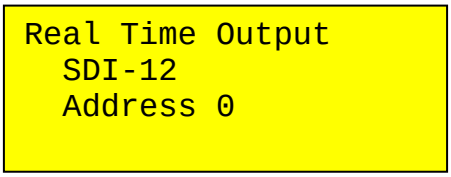


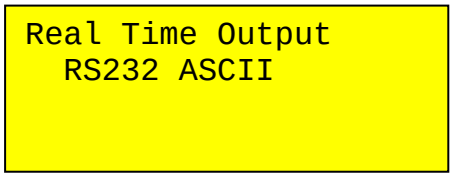
The **System Info Screen** presents serial number, firmware version, file name, and site name.

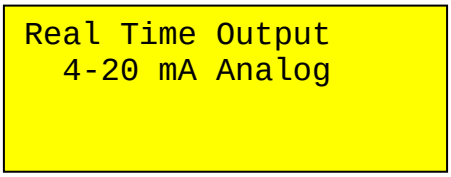


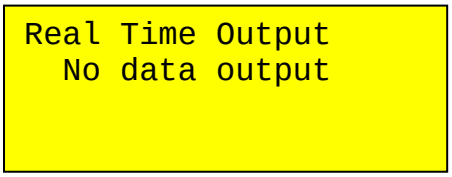
The **Output Type Screen** presents the type of data output the user has specified. If appropriate, the instrument address will be shown.



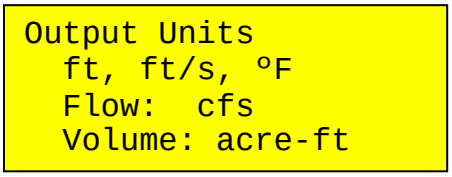








The **Units Screen** presents the units for which data are displayed. The selection of units is done within the IQ software (see Section 3.1.6) and cannot be modified using the Flow Display.



D-5. Power Consumption

- Since the Flow Display and IQ use the same power source, overall battery life will be determined by the sum of the two.
- The IQ 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.

D-6. Limitations

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

D-7. Technical Specifications

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

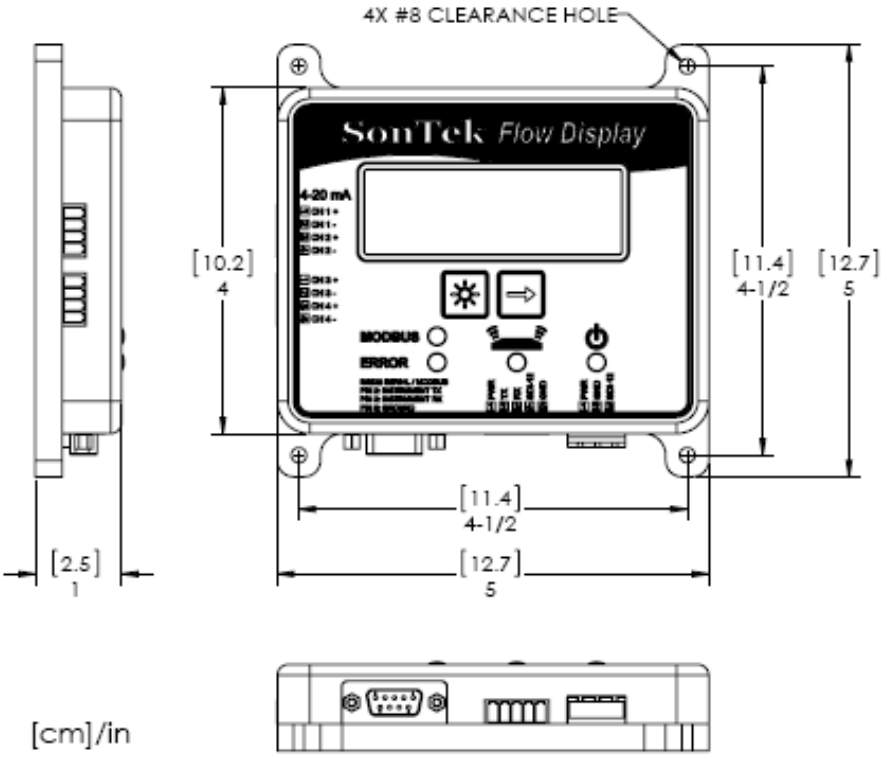


Figure D3. SonTek-IQ Flow Display Technical Drawing

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.

D-8. 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).

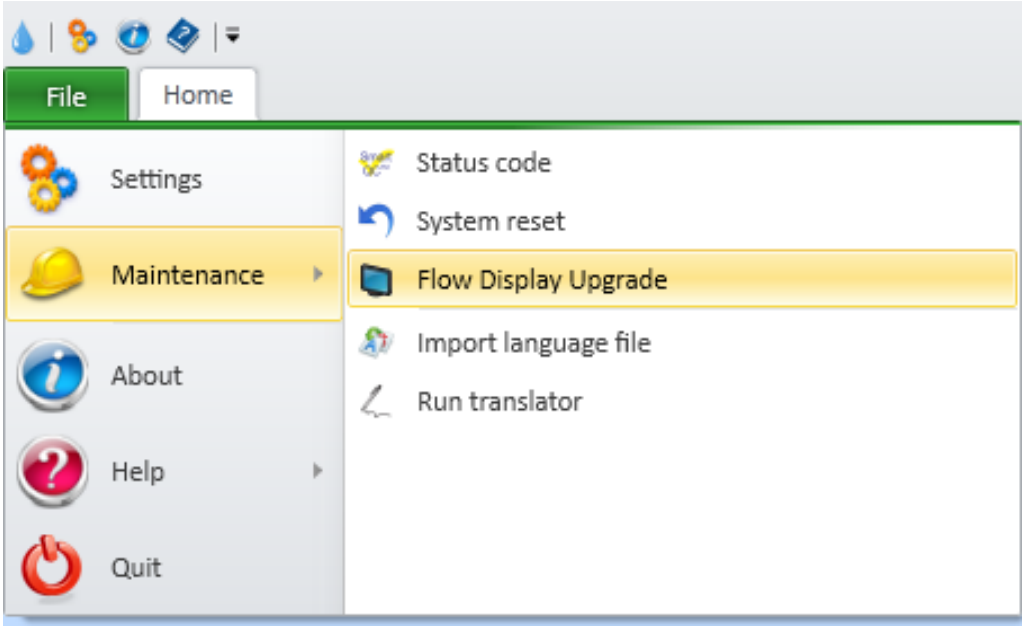


Figure D4. Flow Display Firmware Upgrade

This menu item is only available when **not** connected to an IQ Product. Periodically, upgrades may be available for the firmware inside the IQ 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 IQ 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 E. ASCII Command Interface

This section describes the details of all ASCII commands available to the user. Differences with Argonaut commands will be noted where applicable.

In general, all ASCII commands 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 can be capital or lower case letters, it doesn't matter.
- Text commands sent by themselves will return the current setting
- Text commands followed by values (numbers or characters) will save the new setting value to the IQ and respond with an "OK"
- All new setting values are immediately saved if the system is not sampling
    - Argonauts required the "SaveSetup" command before powering down to save changes to the EEPROM memory
- If the IQ 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 sampling, this will not interrupt the measurements. Settings cannot be changed while collecting data.

+++

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.

A (time to next sample)

The "A" command is an Argonaut command that returns the time in seconds until the next sample. If the A command is issued when the IQ is not sampling, it returns nothing.

If the A command is sent to the IQ while it is sampling, the number of seconds until the next sample is returned.

If the A command is sent after the IQ has been deployed but the start time has not occurred yet, the A command will return a negative number indicating the number of seconds until the first sample begins.

```
deploy
Checking Setup Paramters...
3934.00 free Mbytes left in recorder.
Free space is sufficient for 75.01 days of operation.
Data collection will start on: 2019/01/23 at 13:55:00
In 0 days, 0 hours, 2 minutes and 55 seconds from now.
Data will be recorded to file Cabazon
OK
A
-172
A
-168
```

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.

```
Failed to start sampling
```

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
```

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.
```

The IQ blanking distance must be between 0.004 and 4.996 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.

```
bd 0
Blanking distance must be >= 0.004 m.
bd 27
Blanking distance must be <= 4.996 m.
```

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

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

BlankDistanceSkew or BDSK

This command sets the blanking distance on the skew beams. This command behaves the same as the BlankDistance command in the previous section except that it applies to the skew beams instead of the center beams.

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+
13:49:40
```

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

```
C-
13:50:48
```

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.

```
cs
Current cell size is 0.300 m.
cellsize
Current cell size is 0.300 m.
```

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

```
cellsize 0.5
OK
```

The IQ can have cell sizes between 0.004 and 5.0 meters.

```
cs 0
Cell size must be >= 0.004 m.
cs 27
Cell size must be <= 5.000 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
```

CellSizeSkew or CSSK

This command sets the size of the skew beam multi-cells. This command behaves the same as the CellSize command in the previous section except that it applies to the skew beams instead of the center beams.

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 IQ only expects one continuous line of text.

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

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

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
```

Date

The Date command will display or set the current date on the system clock.

```
Date
2017/02/14
```

When setting the date, the IQ 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 IQ 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.

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
```

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 IQ 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 system is sampling, the system will return the following error message.

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

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.

```
ld
Cabazon_20190123_143812.IQ 2019/01/23 14:38:12  0.045
Cabazon_20190123_143730.IQ 2019/01/23 14:37:30  0.041
Cabazon_20190123_143716.IQ 2019/01/23 14:37:16  0.038
Cabazon_20190123_141714.IQ 2019/01/23 14:17:14  0.091
Cabazon_20190123_141652.IQ 2019/01/23 14:16:52  0.041
Cabazon_20190123_135501.IQ 2019/01/23 13:52:05  0.043
Cabazon_20190123_135500.IQ 2019/01/23 00:09:46  0.038
Cabazon_20190124_000611.IQ 2019/01/24 00:06:11  0.043
Cabazon_20190123_133808.IQ 2019/01/23 13:38:08  0.038
Cabazon_20190123_082150.IQ 2019/01/23 08:21:50  0.041
Cabazon_20190123_081129.IQ 2019/01/23 08:11:29  0.038
Cabazon_20190123_081029.IQ 2019/01/23 08:10:29  0.041
Cabazon_20190122_103157.IQ 2019/01/22 10:31:57  0.038
CabazonQm_20190121_094635.IQ 2019/01/21 09:46:35  0.052
Cabazon_20190121_094354.IQ 2019/01/21 09:43:54  0.045
Cabazon_20190117_141429.IQ 2019/01/17 14:14:29  0.060
SDI29_20190117_091007.IQ 2019/01/17 09:10:07  0.055
IqPlus_20190108_083959.IQ 2019/01/08 08:39:59  0.037
IqPlusQm_20190108_083849.IQ 2019/01/08 08:38:49  0.066
IqPlus_20190108_083818.IQ 2019/01/08 08:38:18  0.037
Cabazon_20190104_113558.IQ 2019/01/04 11:35:58  0.043
Cabazon_20190104_113521.IQ 2019/01/04 11:35:21  0.043
Cabazon_20190104_113056.IQ 2019/01/04 11:30:57  0.042
Cabazon_20190104_104600.IQ 2019/01/04 10:46:00  0.048
Cabazon_20190104_104447.IQ 2019/01/04 10:44:47  0.043
Cabazon_20190104_104405.IQ 2019/01/04 10:44:06  0.037
IQ1447004_20190103_132123.IQ 2019/01/03 13:21:23  0.037
NEWSDI12_20190103_075434.IQ 2019/01/03 07:54:34  0.043
NEWSDI12_20190103_075252.IQ 2019/01/03 07:52:52  0.037
29 files, 1.300 Mbytes
```

At the end of the list a summary of the number of files and the total used space is displayed.

FirmwareDateTime

This command returns information about the currently installed IQ firmware.

```
firmwaredatetime
Firmware version 2.205, Jan 17 2019 08:58:43
OK
```

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.

MultiCellBegin or MCB

This command by itself will display the location of the beginning of the first multi-cell in the velocity profile.

```
MultiCellBegin
Current multi-cell begin distance is 0.500 m.
mcb
Current multi-cell begin distance is 0.500 m.
```

If this command is followed by a number, the location of the beginning of the first multi-cell will be changed. This command will adjust the blanking distance automatically to achieve the desired location of the multi-cell start location.

In the following series of commands, note how the blanking distance is modified automatically.

The location of the beginning of the first multi-cell is computed as follows:

MultiCellBegin = blanking distance + cell size = blanking distance + (0.5*pulse length)

```
bd
Current blanking distance is 0.450 m.
mcb
Current multi-cell begin distance is 0.500 m.
cs
Current cell size is 0.050 m.
mcb 1
OK
mcb
Current multi-cell begin distance is 1.000 m.
bd
Current blanking distance is 0.950 m.
```

The location of the multi-cells will also change automatically if we change the cell size. Increasing the cell size from 0.05m to 0.1m caused the multi-cell location to change from 1.0m to 1.05 m.

The blanking distance remains unchanged but the change in the cell size has cause the location of the multi-cells to move farther from the transducers.

```
cs
Current cell size is 0.050 m.
cs 0.1
OK
mcb
Current multi-cell begin distance is 1.050 m.
bd
Current blanking distance is 0.950 m.
```

MultiCellBeginSkew or MCBSK

This command sets the begin location of the skew beam multi-cells. This command behaves the same as the MultiCellBegin command in the previous section except that it applies to the skew beams instead of the center beams.

MultiCellEnd or MCE

This command does not change any of the multi-cell settings. It only displays the end location of the last multi-cell.

```
multicellend
Current multi-cell end distance is 2.050 m.
mce
Current multi-cell end distance is 2.050 m.
```

MultiCellEndSkew or MCESK

This command does not change any settings. It only displays the end location of the last skew beam multi-cell. This command behaves the same as the MultiCellEnd command in the previous section except that it applies to the skew beams instead of the center beams.

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.
```

NcellsSkew or NCSK

This command sets the number of cells in the skew beams. The IQ has 2 skew beams that measure the velocity distribution across the channel. This command behaves the same as the Ncells command in the previous section except that it applies to the skew beams instead of the center beams.

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 IQ 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.

```
1447004,2,2019,01,23,14,38,22,0.0000,0.000,0.000,0.0000,0.000,0.000,0.000,25.27,1,0.000,0.000,0.000,0.000,11.
48,179.3,-176.1,0,0.000,0.000,0.0000,0.0000,0.000,0.0,0.0,0.0,0.0
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
2019 01 23 14 38 22 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0 0 0 0  0 00.00 179.3 -176.1 0.00 0.00 0
.00 25.27 -1.711 0.000 11.48 51 117 44 0 00.0000 0.000 0.0000
```

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 IQ 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 IQ 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 IQ 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 IQ always display the configuration parameters in meters for the “Show” commands. Because none of the limited set of the “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
```

RecorderStatus

The “RecorderStatus” 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
```

Argonaut Difference: On the Argonaut, the command is “RecStatus”. This abbreviation has not been implemented in the IQ.

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.

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 IQ 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
```

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
```

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.

SaveSetup or SSU

The “SaveSetup” command or the abbreviation “SSU” will check that the current system settings are ok. On the IQ, this command does not actually save the settings because they are saved whenever a command is issued. 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 IQ 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.

To disable SDI-12, use the “OutFormat” or “OF” command to change the output format (e.g. “OF BINARY” will change the output to binary).

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 follows 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
```

Sensors

The “Sensors” 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.

```
sensors
#,T(C),P(dBar),B(V),E(V),Pitch(deg),Roll(deg)
1,26.079,9.964,11.490,1.115,0.26,-0.84
OK
```

To display a continuous stream of measurements, send “Sensors cont”. To interrupt the stream of measurements, hit enter or return key.

```
sensors cont
#,T(C),P(dBar),B(V),E(V),Pitch(deg),Roll(deg)
1,26.074,9.964,11.491,1.095,0.33,-0.84
2,26.084,9.938,11.488,1.112,0.33,-0.98
3,26.074,9.941,11.488,1.101,0.33,-0.84
4,26.070,9.926,11.484,1.098,0.33,-0.84
5,26.074,9.934,11.488,1.098,0.25,-0.98
6,26.084,9.930,11.487,1.098,0.26,-0.84
7,26.074,9.926,11.485,1.098,0.33,-0.84
```

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 or S

The Show command displays a help screen with all of the Show command options.

```
Show

COMMANDS TO DISPLAY SYSTEM CONFIGURATION
----------------------------------------
Show Conf   - Display hardware configuration parameters
Show System - Display system parameters
Show Setup  - Display data sampling parameters
Show Deploy - Display deployment parameters
Show Sdi12  - Display SDI-12 settings
```

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 IQ output.

The “Show Conf” command displays the current hardware configuration.

```
s conf

HARDWARE CONFIGURATION PARAMETERS
---------------------------------
System Type---------------------- IQ Std
Sensor serial # ---------------- IQ1447004
Sensor frequency - (kHz)-------- 3000
Number of beams----------------- 4
Beam Geometry------------------- 2+1+1_BEAMS
Vertical beam ------------------ YES
System Orientation--------------- UP
Compass installed---------------- NO
Recorder installed--------------- YES
Temperature sensor--------------- YES
Pressure    sensor--------------- YES
Ctd         sensor--------------- NO
PressOffset  - (dbar)----------- -8.390797
PressScale  -- (dbar/count)----- 0.003832
PressScale_2 - (pdbar/count^2) - 0.000000
```

Show Sdi12 or S Sdi12

The “Show Sdi12” or “S Sdi12” commands will display the current SDI-12 settings. The IQ 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 IQ.

```
SDI-12 PARAMETERS
-----------------
Sdi12Address --------- a
Sdi12 Multi-Address - NO
```

Show System or S System

The “Show System” command displays the current system parameters.

```
s system

CURRENT SYSTEM PARAMETERS
-------------------------
CPU Ver --- IQ
DSP Ver --- 0
BoardRev -- 0
Date ------ 2019/01/23
Time ------ 13:20:58
OutFormat - SDI12
Recorder -- ON
```

Show Setup or S Setup

The “Show Setup” command will display the current setup parameters. The “Profiling Mode” will display “MANUAL” when the velocity cells are set by the user. When the IQ is in Manual mode, the cell settings will also be displayed.

```
show setup

CURRENT SETUP PARAMETERS
------------------------
Temp ------------ 20.00 deg C
Sal ------------- 0.00 ppt
TempMode -------- MEASURED
Sound Speed ----- 0.00 m/s
AvgInterval ----- 10 s
SampleInterval - 10 s
CoordSystem ----- XYZ
RevXVelocity ---- NO
ProfilingMode -- MANUAL
Ncells ---------- 100
CellSize -------- 0.100 m
BlankDistance -- 0.950 m
NcellsSkew ---------- 10
CellSizeSkew -------- 0.300 m
BlankDistanceSkew -- 0.040 m
```

When the IQ is using smart pulse, the cell settings are not shown.

```
s setup

CURRENT SETUP PARAMETERS
------------------------
Temp ------------ 20.00 deg C
Sal ------------- 0.00 ppt
TempMode -------- MEASURED
Sound Speed ----- 0.00 m/s
AvgInterval ----- 10 s
SampleInterval - 10 s
CoordSystem ----- XYZ
RevXVelocity ---- NO
ProfilingMode -- SMART PULSE
```

Show Deploy or S Deploy

The “Show Deploy” command will display the current deployment parameters.

Argonaut difference: The comments section in the IQ 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.

The start date and time in this example have not been set.

```
show deploy

CURRENT DEPLOYMENT PARAMETERS
-----------------------------
Deployment ------ Cabazon
StartDate -------- 2000/01/01
StartTime -------- 00:00:00
AvgInterval ------ 10 s
SampleInterval -- 10 s
Comments:
install
```

SoundSpeed

This is a new IQ command that will rarely be used, but it provides a short cut for 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
```

Start

The start command will initiate a measurement. Before the IQ begins sampling, the configuration settings are verified.

There are two conditions that will prohibit the IQ from collecting data after receiving a start command:

- If the sample duration is longer than the sample interval
- If the output format type is SDI-12

The IQ will not start if either of the above conditions is true.

If the sample duration is longer than the sample interval, the user will see the following message.

```
start
Failed to start sampling
```

If the start command is issued while the IQ is configured for SDI-12 output, the user will see the following message.

```
start
Start command disabled when output type is SDI-12. Data collection will begin when SDI-12 commands are received.
```

If the above settings are ok, the IQ will begin sampling.

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
```

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 IQ will respond with the sample number of the sample that was interrupted.

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). The “T” command does not set the time, it only displays the current time. Use the “Time” command to set the time.

```
T
13:48:13
```

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 IQ 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
```

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 IQ 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 IQ will display the current user-defined temperature setting. If you are setting the mode to MEASURED, the SL responds with an “OK”

ViAvgInterval or VIAI

The ViAvgInterval command operates almost exactly like the ViSampleInterval command. It can be used to display the current setting or to change the velocity indexing averaging interval.

```
viavginterval
Current velocity indexing averaging interval (sample duration) is 12 seconds
viavginterval 15
OK
viai
Current velocity indexing averaging interval (sample duration) is 15 seconds
```

The velocity indexing averaging interval must be greater than or equal to 10 seconds and less than or equal to 3600 seconds.

```
viai 0
Velocity indexing averaging interval (sample duration) must be >= 10 seconds.
problem setting velocity indexing averaging interval
viai 10000
Velocity indexing averaging interval (sample duration) must be <= 3600 seconds.
problem setting velocity indexing averaging interval
```

If the velocity indexing averaging interval is less than the velocity indexing sample interval, velocity indexing will not start.

```
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 10 seconds.
Velocity Indexing data will be recorded to file: CabazonQm
Velocity Indexing Mode will be active for the next 22 minutes.
Failed to start Velocity Indexing
```

ViSampleInterval or VISI

The velocity indexing mode operates much like a normal measurement, but it has its own sample interval and averaging interval. The ViSampleInterval command can be used to display the current setting and to set the sample interval for Velocity Indexing.

```
visampleinterval
Current velocity indexing sample interval is 12 seconds
visampleinterval 20
OK
visi
Current velocity indexing sample interval is 20 seconds
```

The velocity indexing sample interval must be greater than or equal to 10 seconds and less than or equal to 3600 seconds.

```
visi 0
Velocity indexing sample interval must be >= 10 seconds.
problem setting velocity indexing sample interval
visi 8000
Velocity indexing sample interval must be <= 3600 seconds.
problem setting velocity indexing sample interval
```

ViStart

The “ViStart” command initiates the velocity indexing mode. When VI mode is started, the current configuration settings are saved and the velocity indexing settings are applied.

```
vistart
Saving current setup...
Configuring sytem for Velocity Indexing...
Checking Setup Paramters...
Velocity Indexing sample duration is 12 seconds.
Velocity Indexing averaging interval (sample interval) is 12 seconds.
Velocity Indexing data will be recorded to file: CabazonQm
Velocity Indexing Mode will be active for the next 60 minutes.
```

After the velocity indexing time is over, the system reverts back to its original settings and sampling restarts as indicated by the message.

```
1447004,1,2019,01,23,15,01,12,0.0000,0.000,0.000,0.0000,0.000,0.006,0.000,25.51,1,0.000,0.000,0.000,0.000,11.
48,179.2,-176.0,0,0.000,0.000,0.0000,0.0000,0.000,0.0,0.0,0.0,0.0
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
[E:DaqEngine] Velocity Indexing time has expired, restarting normal data collection.
```

However, if velocity indexing is interrupted with a “Stop” command the original settings will be restored, but the sampling will not restart automatically as indicated by the warning message.

```
stop
[W:UswApp] Skipping flowSample 2
・ca: Velocity Indexing interrupted by STOP command, data collection will not restart automatically.ﾌﾒ･OK
```

ViTimeSpan or VITS

This command sets the time span of Velocity Indexing in minutes. Sending this command by itself will return the current time span setting.

```
vitimespan
Current velocity indexing time span is 60 minutes
vits
Current velocity indexing time span is 60 minutes
```

Sending this command followed by a number will change the velocity indexing time span setting. The IQ will respond with “OK” if the setting is successfully changed. All numbers are truncated to the integer value.

```
vits 22.9
OK
vits
Current velocity indexing time span is 22 minutes
```

The ViTimeSpan must be greater than or equal to 1 minute and less than or equal to 65535 minutes.

```
vits 100000000
Velocity indexing time span must be <= 65535 minutes.
problem setting velocity indexing time span
vits 0
Velocity indexing time span must be >= 1 minutes.
problem setting velocity indexing time span
```

Appendix F. Software Changes

Version 1.52

- Support for the SonTek-IQ Pipe and firmware v1.52

Version 1.60

- Manually select a COM port to bypass the automatic Connect feature
- New vertical beam settings to improve measurements in very shallow water
- Low level (raw data) incoherent velocity measurement filtering enabled
- User option for high level velocity filtering
- User option to reverse the flow for IQs installed looking downstream instead of upstream
- New error code warning (code 512) for low SNR
- New error code warning (code 1024) for turbulent or low flow conditions
- New error code warning (code 2048) for pipe diameter settings outside of recommended range

Version 2.00

- New option for resetting a specific COM port by number
- SNR time series plot now available for IQ Standard systems
- Maximum file size option in Standard settings
- Disable the skew beam for Theoretical flow calculations
- Reset total volume after user specified number of samples
- Modify configuration option added to Advanced Utilities

Version 2.1

- Modbus data from the IQ are reported on both input and holding registers
- Minimum voltage changed from 10V to 9V
- Sampling Duration minimum lowered from 10 seconds to 1 second
- IQ velocity cell measurements can be manually configured in the Channel Shape dialog
- COM Port Reset function added to the Maintenance menu
- Maximum baud rate feature added to the Settings menu

Version 3.0

- Faster data download speeds
- Velocity indexing mode
- The SDI12 Profile output format can return up to 10 profile cells (formerly 5 cells). SDI-12 output now has two formats available, the original format and a new profile format that has data from the first 10 multi cells.
- Recorder can be disabled
- Open data files from any file location, in addition to the existing IQ file folder structure
- ASCII command interface
- More cells added to serial RS-232 output—now up to 30 cells
- One-beam solutions available in post-processing
- Ice detection function available

- Recovery mode—interactive troubleshooting guide; use when having difficulty communicating with the IQ
- More intuitive “smart page” setup screen
- Deployment mode (user-input sampling start date and time)
- “Record Profile Data” option was renamed to “Record Multi Cell Data”. This option was relocated from the system configuration page to the Advanced Utilities>Modify configuration dialog. The default setting is “1” to record all profiles.
- Temperature, salinity, and sound speed post-processing now available in "recalculate flow" section of the software
- Disable skew beams function
- Velocity correlation filter threshold

SonTek, founded in 1992 and advancing environmental science in over 100 countries, manufactures affordable, reliable acoustic Doppler instrumentation for water velocity measurement in oceans, rivers, lakes, harbors, estuaries, and laboratories. Simply put, our instruments use sound waves to tell you how fast water is moving, where it is moving, and even if it is not moving at all. Our customers are scientists, engineers, hydrologists, research associates, water resource planners and anyone that needs to collect velocity (speed) data in every kind of body of water imaginable. SonTek is located in San Diego, California and is a brand of Xylem Inc. Learn more at sontek.com.

Xylem |'zīləm|

1) The tissue in plants that brings water upward from the roots;
2) a leading global water technology company.

We're a global team unified in a common purpose: creating advanced technology solutions to the world's water challenges. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. Our products and services move, treat, analyze, monitor and return water to the environment, in public utility, industrial, residential and commercial building services settings. Xylem also provides a leading portfolio of smart metering, network technologies and advanced analytics solutions for water, electric and gas utilities. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise with a strong focus on developing comprehensive, sustainable solutions.

For more information on how Xylem can help you, go to www.xylem.com

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