Stage Discharge Recorder
SDR-0001

Operations & Maintenance Manual

Part No. 8800-1160 Rev. 3.34

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1. Introduction

The Stage-Discharge Recorder (SDR) is an easy to use device programmed to measure and record water levels and flows. The SDR can be completely setup using the front panel keys and display. Once operational, the SDR will record data at a user set interval with sufficient space to store over two four years of data recorded at 15-minute intervals. The display/keys can be used to review any of the logged data as well as real-time operating conditions. The SDR can also be fully programmed and operated by a PC/PDA. Recorded data can be easily transferred to the PC/PDA in spreadsheet-compatible format.

1.1   Models

The SDR is available in the following models:

▶ **SDR-0001-1**   SDR with 400-count optical shaft encoder for measuring water levels (shown above)

▶ **SDR-0001-3**   SDR with analog input for measuring water levels. This SDR can be connected to any analog water level sensor, both submersible and non-contact for measuring the water levels. It also includes options for a 4-20mA output (see Appendix E).

▶ **SDR-0001-4**   This SDR has both the optical shaft encoder and the expanded analog input module (see Appendix E). It has all the features of SDR-0001-1 and SDR-0001-3

▶ **SD Card Option Above** models available with an SD card slot for data retrieval, the part numbers are SDR-0001-1SD, SDR-0001-3SD and SDR-0001-4SD.

1.2 Features

All models have the following standard features:

▶ Measures stage and computes discharge at user set interval.

▶ Measures stage from one or two of the following inputs:

Built in optical shaft encoder
Analog sensor (0-5V, differential, and 4-20mA)
SDI-12 sensor

▶ Computes discharge:

Using standard flume and weir equations.
Using a rating table of up to 50 point pairs
Through a gate when using upstream and downstream sensors

▶ Records/Logs data into ultra-reliable flash memory – no backup batteries needed.

▶ Computes daily values (stage, volume, discharge) and logs them at midnight.

▶ Records/Logs events to keep track of when anyone uses the front panel and/or makes changes to the setup.

▶ Runs for 12 months on standard lantern batteries, available in any hardware store.

▶ All setup can be done from the front panel of the encoder.

▶ Easy to use PC/PDA utilities. Downloads data to PC/PDA as easily read CSV (Comma-separated variable) files that can be opened with any text or spreadsheet program.

▶ SDI-12 interface for connecting the SDR to Sutron's Satlink satellite transmitter or other popular field stations.

▶ RS232 port for connecting the SDR directly to cellular modems for remote access to data.

▶ Ground Water Monitor mode useful for measuring and recording ground water level (Appendix F).

▶ Modbus slave support

1.3 Unpacking

Remove the SDR from the shipping container and visually inspect the unit for signs of damage during shipment. Additionally, rotate the shaft and note any grinding, scraping, or other mechanical problems found. Report any such damage to the factory immediately to ensure a prompt response and resolution. Retain one shipping container in the event a factory return is necessary.

Please note that if a return is required, a return material authorization (RMA) number is required. To get this RMA number, call the Sutron Customer Service Department at 703 406 2800.

Mechanical Features (SDR-0001-1)

Units:Inches

4.9

4.800

2.8

7.490

6.49

4.00   3.00

2.2

Ø.250

X 4
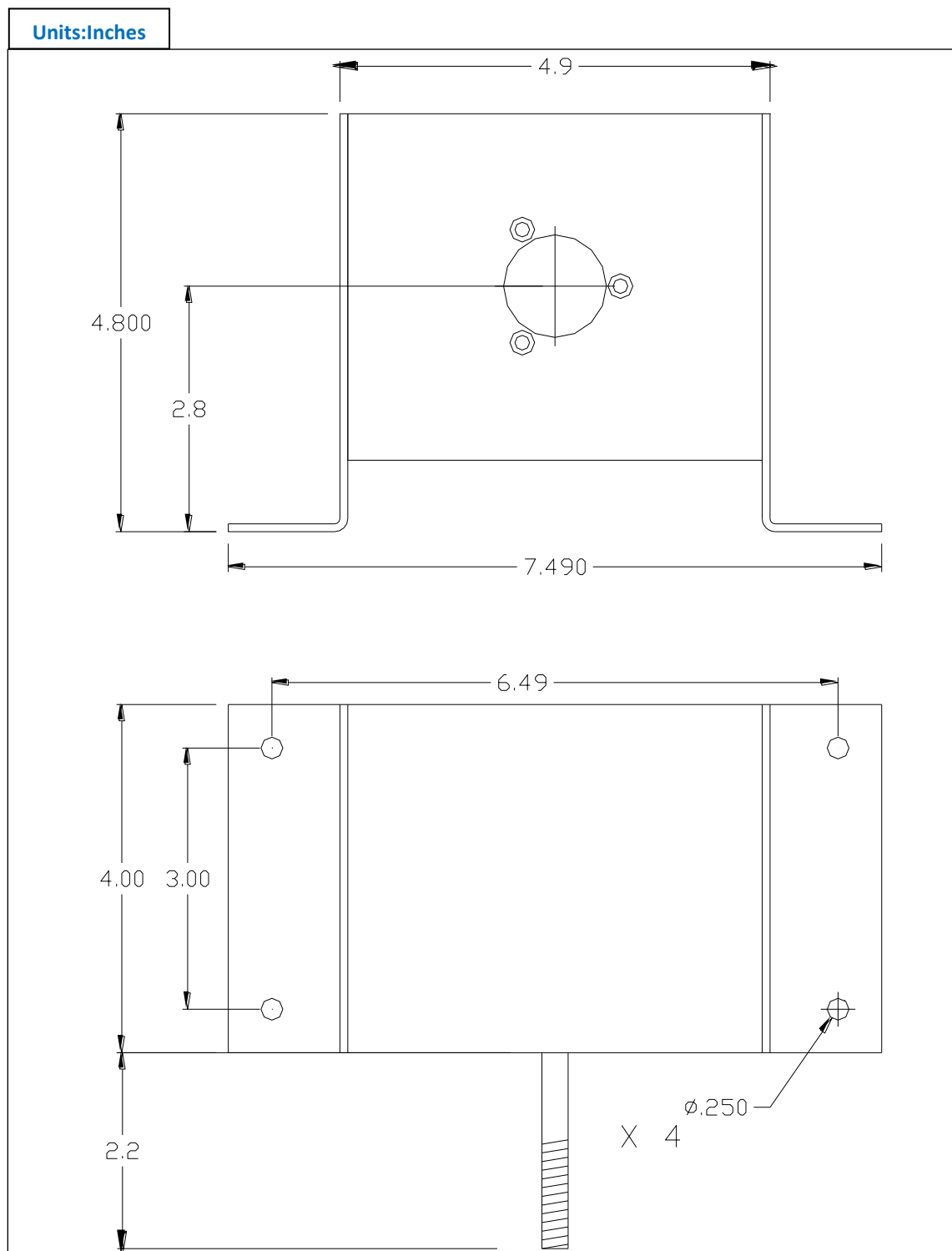
2. Cabling

2.1   Terminal Block Wiring

Terminal Block	Description	Notes
1	BAT G	Battery Ground (-)
2	BAT +	Battery +
3		
4		
5	SDI G	Also can be used for Battery Ground
6	SDI +	Also can be used for Battery +
7	SDI D	
8	Shield	

The SDI G and SDI +, can also be used when changing batteries. Simply connect the new battery to these terminals before disconnecting the old battery, and the SDR will continue operating without interruption.

The SDR is shipped with a cable that can be used for the connection to a battery. The cable is provided with crimp type fasteners for several types of batteries. If you are using 6 volt batteries, be sure to use two batteries in series.

2.2   RS-232 Wiring

The DB9F connector is designed so you can connect a straight serial cable to the SDR from a PC. When using a PDA or when connecting to a modem, you will generally need to use a NULL MODEM. The PC/PDA software used to communicate with the SDR is called "SDRComm", and is available at no charge from Sutron's web site (www.sutron.com and select "downloads/updates").

The following table contains pin descriptions for the DB9F connector on the SDR, with the corresponding RS-232 cable connections to PC.

DB9F Pin	Name	Notes
1	N/C	No Connection
2	RXD	Data from SDR
3	TXD	Data to the SDR
4	DTR	Signal to the SDR
5	Ground	
6	N/C	No Connection
7	RTS	Request to Send, signal to the SDR
8	CTS	Clear to Send, signal from the SDR
9	VOUT	Jumper selectable for 5V or VBAT (100ma max)

3. Setup and Operation

This section gives detailed instructions on the setup and operation of the SDR-0001-1, the model with the built-in shaft encoder.

If you are using the SDR-0001-3 (**analog input**), you should still become familiar with the information in this section, even though some of the information may not be applicable to your specific model. Then refer to Appendix E for the instructions on using the SDR-0001-3 with analog sensors.

If you plan on using the SDR in **Ground Water** mode, you should also first become familiar with the information in this section and then refer to Appendix F for the details on the Groundwater mode.

For those interested in using **two sensors** to measure stage one and stage two, Appendix I has additional information.

3.1   Power Up

1. Connect a battery (5.5 to 16VDC) to the SDR battery terminals. Use either the terminals labeled Bat G and Bat + or use the terminals labeled SDI G and SDI +

2. The SDR will briefly flash the green LED while it is powering up.   After a few seconds, the display will turn on and display a status message. The most common status message you will see at startup is "Stage not Set" because the SDR cannot track changes to the stage when power is off. This is a reminder that you must set the stage for the SDR to be fully

operational. A few seconds later the stage will be displayed. Until you set the stage, the red LED will also flash as a reminder.

3. The SDR will retain the date/time and setup information when the power is off. So, when the SDR is powered on, the SDR will begin to operate exactly as it was configured to do so before it was powered down. A small internal battery keeps the internal clock running.

3.2 Setup – Front Panel

1. The overall menu tree for the SDR is shown on the following page. The arrow keys allow you to navigate the tree to display the desired data or item.

2. To setup the SDR, use the up and down arrow keys until you see the prompt "Station Setup, Right shows details". Press the right arrow and you will see the first of the user setup values "Device type", then press the down arrow to see "Measuring Interval"

3. To change the value press SET. The prompt will change and a flashing cursor will appear. You can then use the arrow keys to select a different value.

4. Once you have the desired value on the display, press SET again to make the change permanent or to cancel a change, press the OFF/CANCEL button.

5. In the case where there are only two possible values for a setting, pressing SET will flip-flop between the values and the change is made immediately.

6. Below is a list of the basic values that can be changed by the user. Additional settings are required to setup analog sensors (see Appendix E) and dual sensor input (see Appendix I).

   * Measuring Interval: 1, 5, 10, 15, 20, 30, 60 minutes
   * Wheel Size: Circumference of 12 inches, 18 inches, 375 mm, Custom inches, or Custom mm
   * Wheel Circumference: xx.xx (visible only if Custom is selected as the Wheel Size)
   * Rotation Direction: Clockwise positive, Counter clockwise positive
   * Units: Feet, Meters
   * Right Digits: (0..7)
   * Averaging Time: (0 to 900 seconds)
   * Discharge: enabled, disabled
   * Discharge Equation: Parshall Flume, Weir (w*Stage^1.5), Generic (A*Stage^B) (note: the appropriate coefficients can be entered once the type of equation has been entered)
   * Gauge Height Shift: xx.xx   (this value is added to the stage prior to its use in the discharge equation).
   * Battery Type: 12V Gell Cell, 12V Alkaline, Other
   * Password Setup
   * Station Name: xxxxxxxxxx
   * Date/Time: yyyy/mm/dd hh:mm:ss
   * WDID: xxxxxxx

- SDI-12 Address: The address the unit responds to when queried by an SDI-12 master (0-9,a-z,A-Z)
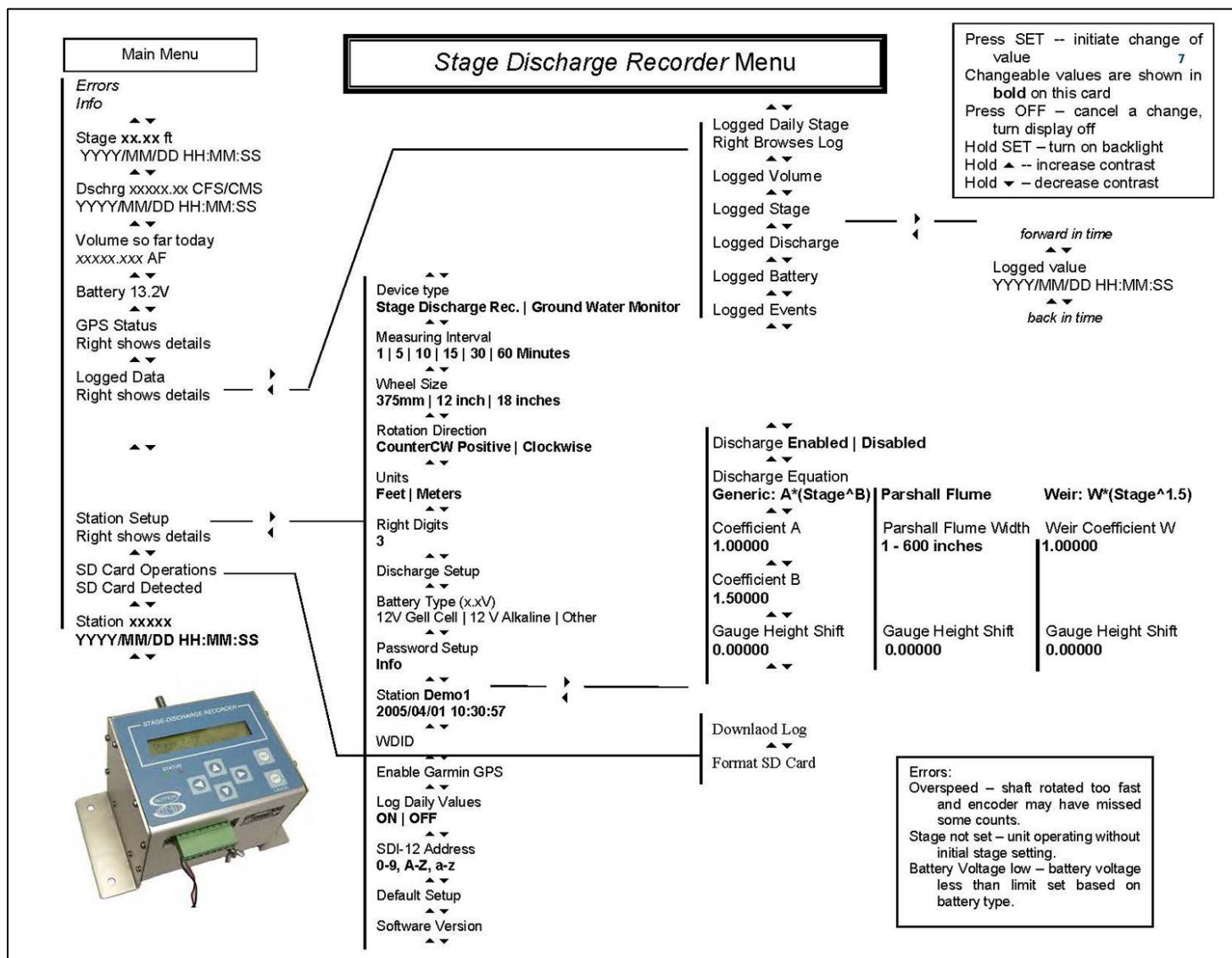
3.3   SDR Operations

Turning On/Off the Display

The SDR will continue to measure and log data as long as a good battery is connected. The display turns off automatically after 5 minutes of inactivity in order to conserve power. The display can be turned on at any time by pressing any key.

To turn off the display, press the OFF/Cancel button. You may need to press it several times to exit out of some menus first.

Holding the OFF/Cancel button in any menu will turn off the display.

Turning on the Backlight

The display is equipped with a backlight to assist in viewing in many different lighting conditions. To turn on the backlight, simply press and hold the SET button until the backlight turns on.

Adjusting the Contrast

If it becomes difficult to read the display, you may need to adjust the contrast. To set the contrast, press and hold the UP or DOWN arrow buttons until you see the CONTRAST prompt and keep holding the button until the display is readable. If the display becomes too dark or too light, press the opposite arrow key to reverse the contrast. Once the display is readable, release the arrow, and this setting will be stored for the next time the display is turned on.

Viewing Current Stage

The *Stage* is the first item displayed when the display is turned on (after any informational messages). The display has the format

Stage x.xx ft

YYYY/MM/DD HH:MM:SS

Where x.xx is the current, live stage along with the time it was measured. The update time will depend on the sensor used and the averaging time setup. A shaft encoder without averaging will update several times per second. If averaging is enabled (see Averaging Time below), the Stage reading will only update as fast as the averaging time. That means that if the averaging time is set to 10 minutes, the display will update only once every 10 minutes!

Remember that a "?" after the units on the top line is a hint that the stage needs to be calibrated. The procedure for calibrating the stage is given in the following section.

Calibrating the Stage

You can calibrate (set) the stage from any of the menus that displays the live stage. Simply press the SET key. The display will change the prompt to "Setting Stage". Use the arrow keys to change any of the digits in the display. When the value is correct, press SET. To discard the entered value, press CANCEL.

If averaging is enabled (see Averaging Time below), you will need to wait an amount of time equal to Averaging Time before you can enter the new stage.

Viewing Discharge

The *Discharge* is immediately below the stage in the main menu. It is available only when the SDR has been setup to compute the discharge. (Refer to Chapter 4 for a complete discussion of how an SDR computes discharge.) Press the down arrow (from Stage) to view it. This value is also a live value, updating several times a second. The Discharge is computed based on the type of calculation selected (Equation or Rating Table) and the corresponding coefficients. The units for the discharge will be CFS (cubic feet per second) if the stage units are in feet and CMS (cubic meters per second) if the stage units are in meters.

Viewing Volume So Far Today

The *Volume so far Today* is immediately below the Discharge. This is the amount of water that has flowed by the SDR since midnight. The units of the volume are Acre Feet (1 Acre Foot = 43,560 cubic feet or 325,828.8 gallons) if the stage units are in feet and TCM (thousand cubic meters) if the stage units are in meters. This value is computed from the data logged by the SDR along with an estimate based on the current discharge and the last logged value. The estimated part of the volume may go up or down as the current discharge changes. At the end of each day, the SDR will make a conclusive calculation on the amount of water that has flowed – see Volume below.

Logged Data

The SDR features a flash log chip on board capable of holding over 300,000 log entries.   Each log entry is self-sufficient, making the log very reliable (there is no log table that can be corrupted). The log cannot be erased. Once the log is full, the oldest entries will be overwritten.

Logging is enabled as soon as the unit is powered on. The unit will log data and events. Data refer to sensor data such as water level and discharge. Events refer to occurrences such as power up, setup change, display on, login fail, hardware errors, etc. Events make it easy to diagnose any issues that may have occurred with the station. The fact that the unit logs as long as it has power makes it reliable and robust.

Measuring stage and discharge every 15 minutes, the unit can store over four years of data in the log!

Measurement Interval

The measurement interval decides how often the SDR should log water level data. This is a user setting that can be changed from the front panel under the *Station Setup->Measurement Setup* menu. This value can be set to 1, 5, 10, 15, 30 or 60 minutes.

The SDR stores the following data in its log:

Item	Interval	Description
Logged Stage	Stage Interval	Instantaneous Stage measured at the specified time.
Logged Discharge	Stage Interval when enabled	Instantaneous Discharge computed at the specified time.
Logged Daily Stage*	23:59:59	Daily average stage computed from instantaneous stage values made during that day.
Logged Volume*	23:59:59	Daily Volume computed from discharge values logged during the day**
Logged Daily Discharge*	23:59:59	Daily Discharge is the average of all the logged discharge readings during the day.
Logged Battery*	23:59:59	Battery voltage measured at the specified time.
Logged Events	As they occur	Events are occurrences such as power on, log download, overspeed, upgrades, and so on.
Logged Volume*	23:59:59	Daily Volume computed from discharge values logged during the day**
Logged Daily Discharge*	23:59:59	Daily Discharge is the average of all the logged discharge readings during the day.
Logged Battery*	23:59:59	Battery voltage measured at the specified time.
Logged Events	As they occur	Events are occurrences such as power on, log download, overspeed, upgrades, and so on.

Log Daily Values*

At the last second of every day (23:59:59), if Log Daily Values is enabled, the SDR will compute and log various measurements. These include daily stage, daily discharge, volume, and battery voltage.

Volume**

At midnight of every day (if Log Daily Values is enabled), the SDR computes Volume. Volume is the amount of water that has flowed by the SDR over the course of one day. The units of the volume are Acre Feet (1 Acre Foot = 43,560 cubic feet or 325,828.8 gallons) if the stage units are in feet and TCM (thousand cubic meters) if the stage units are in meters. Volume can be seen via the front panel as Logged Volume.

These steps are taken to compute Volume

- At midnight, one final discharge reading is made
- All discharge readings for the day are read from the log
- The average of a pair of consecutive discharge readings (CFS) is computed and multiplied by the time amount between the pair (seconds) resulting in a partial volume (CF).
- All the partial volume computations are summed up.
- The sum is converted from CF to AF (or from CM to TCM).

Example (only partial daily data shown):

Time	Discharge CFS	Average Discharge CFS	Time Passed Sec.	Partial Volume PF
06/30/2007 18:00:00	6.6	6.7	3600	24120
06/30/2007 19:00:00	6.8	7.0	3600	25200
06/30/2007 20:00:00	7.2	7.1	3600	25560
06/30/2007 21:00:00	7.0	7.1	3600	25560
06/30/2007 22:00:00	7.2	6.8	3600	24480
06/30/2007 23:00:00	6.4	6.2	3600	22320
07/01/2007 00:00:00	6.0			
			Total Volume CF	147240
			Total Volume AF	3.38

Viewing Logged Data

To view logged data, use the arrows to display the menu:

>   Logged Data

>   RIGHT shows details.

Then press the right arrow to bring up the logged data sub menu. The following menu will be displayed:

>   Logged Daily Stage

>   RIGHT Browses Log/SET Searches by Date

Use the up/down arrow keys to select the desired item (Logged Daily Stage, Logged Volume, Logged Stage, Logged Discharge, Logged Battery, Logged Events, Entire Log) and press either the right arrow or the set key.

If the right arrow is pressed, the last logged value for the item will be displayed along with the date/time, units and possibly the "?" indicator (see below). Press the down arrow to go back in time and the up arrow to go forward. When you reach the end of the log, a message will be displayed. Continuing to press the arrow will wrap to the oldest or most recent values.

If instead of pressing right, set is pressed, a date and time can be entered. Once entered, the log will jump to that date and allow further browsing using the up and down arrows.

Note: when in the log viewing, the contrast adjustment is disabled so you can hold an arrow key to "scroll" up and down through the log.

Understanding the "?" Indicator.

The SDR displays a "?" after a value if there is a question about the quality of the data. This always happens on startup because the user needs to set the stage to the current value. The "?" is a reminder that user action is needed for the station to be operational. The following table gives a description of how "?" is used:

Stage/Logged Stage	Stage not set or overspeed (shaft rotated too fast) or user changed setup without recalibrating or time not set
Discharge/Logged Discharge	Stage used to compute discharge is "?"
Logged Daily Stage	One or more of the stage used in the average is "?"
Logged Volume	One or more of the discharge used in the total is "?"

You can look at the events in the log to determine the exact time of the event that caused the questionable data. This can be used to help reconstruct the data should there be an error.

Logged Events

Events refer to occurrences such as power up and setup change that are recorded in the log. Events make it easy to diagnose any issues that may have occurred with the station.

Event	When is it logged?	What does it signify?
Reset Powerup	Unit is powered on	Unit was powered on or hard reset
Reset Upgrade	Firmware upgrade	Firmware was upgraded
Reset other	Unit rebooted	Software problem caused unit reboot
Time Before Change	System time is changed	The time of the unit before the change
Time After Change	System time is changed	The time of the unit after the change
Before Cal	Measurement calibrated	Sensor reading before calibration
After Cal	Measurement calibrated	Sensor reading after calibration
Log Download	Log is downloaded	Log was download
Setup Change	Setup is changed	Setup was changed
Overspeed	Shaft moved too quickly	Stage may not be correct
Hardware Fail	Hardware error noted	Unit may need to be sent back for repair
Display On	Front panel activated	User is at the site
Display Off	Front panel deactivated	User has left the site
Login Fail	User entered password	Invalid password entered
Login Valid	User entered password	Valid password entered
Password changed	Password protection changed	Password was enabled, disabled or changed
No GPS time fix	GPS time sync	GPS could not acquire satellite fix
GPS Comm problem	Once a day if errors occur	Problem talking to GPS module

Retrieving Data

You will need to use the PC/PDA SDRComm programs provided by Sutron to retrieve data from the SDR. These programs can be downloaded from the Sutron web site (go to www.sutron.com and select "downloads/updates"). Both programs make it easy to download the data as well as view the data and graph it. The download data will reside in a file "*station name YYYY-MM-DD*.CSV" with the actual station name and the date of the download in the name.

Please note that Sutron provides a PC program called Sutron Grapher that can be used to graph SDR log files. The software can be found at www.sutron.com.

Password

The station can be protected with a password. If protection is enabled, no user will be able to make any changes to the station without first entering the password. Data and setup can be viewed but not changed unless the password is first entered.

To enable the password, go to the *Station Setup->Other Setup->Password* menu. Press SET and enter the new password. To disable the password, enter a blank password.

If a station is protected by a password, any attempt to change a setting will result in the 'log in' menu appearing which will provide the user a chance to enter the correct password. A new log entry will be made every time a password is entered. The station will write either 'Login Fail' or 'Login Valid' to the log.

A password is never needed when using the PC/PDA programs. If you forget the password and want to clear it, remove power to the unit and then reapply power while holding the DOWN key. You must keep the button pressed until you see the message "Password Cleared".

Averaging Time

With SDR software version 3.00, an averaging option has been added. SDR does **simple averaging**, meaning that it will collect data the user specified amount of time. Once the time is up, it will sum up all the samples and divide the sum by the number of samples collected.

Averaging Time is expressed in seconds. It can be found under *Station Setup ->Averaging Time*. If that time is zero (which is the default), no averaging is done. If it is not zero, the SDR will collect data for however long the averaging time is setup for. The value can be set anywhere from 0 seconds (no averaging) to 900 seconds (which is equal to 15 minutes).

Please note that the SDR's Stage reading on the front panel will only update as fast as the averaging interval. That means that if the averaging time is set to 10 minutes, the display will update only once every 10 minutes!

The SDR will collect approximately **two samples per second** from the shaft encoder. For example, with a shaft encoder, if averaging is set to 5 seconds, the SDR will collect 10 samples from the encoder, sum them up, and divide the resultant sum by 10. The final result is the stage.

Make sure the averaging time is less than the measurement interval. If the averaging time is close to the measurement interval, the SDR may miss measurements! This means that if the *Measurement Interval* is set to 1 minute, make sure the averaging interval is significantly less than 60 seconds.

3.4   SD Card Interface

The SDR supports SD card usage for downloading logged data and setup changes. An SD card is a portable media storage that is widely available on the commercial market. MMC cards may also be used with the SDR.

SD Card Log Download

To download the log using an SD card, simply plug the card in.

If the front panel is off when the card is plugged in, an automatic log download will start in 10 seconds. The automatic download will download since last download.

If the display is on when the card is plugged in, the download log menu will appear. Navigate the menus and choose the appropriate data format (flat or grup), content (data, events, or both data and events), and the log download times.

There is a red LED that will light up while the SD card is in use. Please do not remove the card when it is in use.

Automatic Log Backup

If an SD card is left plugged in, the unit will perform an automatic backup of the log to the SD card. All the user needs to do is leave the SD card plugged in, and the SDR will periodically download the log and save it to a file on the SD card.

With an SD card left plugged in, four hours after the user stops using the display, and every four hours afterwards, the unit will download the logged data and append it to a file. Once the file exceeds about 2MB, a new file will be started. The backup will work until the SD card gets full, at which point it stops downloading.

When visiting the station for maintenance to retrieve the log, it is only necessary to remove the card that was left plugged in.

3.5   PC/PDA Operation With SDRComm

SDRComm is a program for the PC or PDA that allows you to see current measurements and status, configure the unit, and to download data into both csv files and graphs. SDRComm can also be used to upgrade the SDR firmware. Separate programs exist for the PC and PDAs, SDRCommPC and SDRCommPPC. The PC version runs on any PC running Microsoft Windows 98 or later. The PDA version runs on any Pocket PC compatible PDA (e.g., HP iPaq). These programs can be downloaded from the Sutron web site (go to www.sutron.com and select "downloads/updates"). Please see the downloaded files for installation instructions.

Note: The pictures of SDRComm shown in this manual are of the PC program. However, all of the operational description that follows applies to the PDA program as well, since it has exactly the same menus, buttons, and tabs. Since PDAs do not have a "tab" button, you select a new field by tapping it with the PDA stylus.

Main Tab

The main tab of SDRComm is shown below. This tab displays important status information including calibration status, battery voltage, discharge calculation status, and the current values for stage, discharge and volume.

Pressing "Refresh" causes SDRComm to retrieve updated values from the SDR. Pressing "Set Time" brings up a dialog that allows the time of the SDR to be set. Pressing "Cal…" prompts you for the current stage value in order to calibrate the stage.
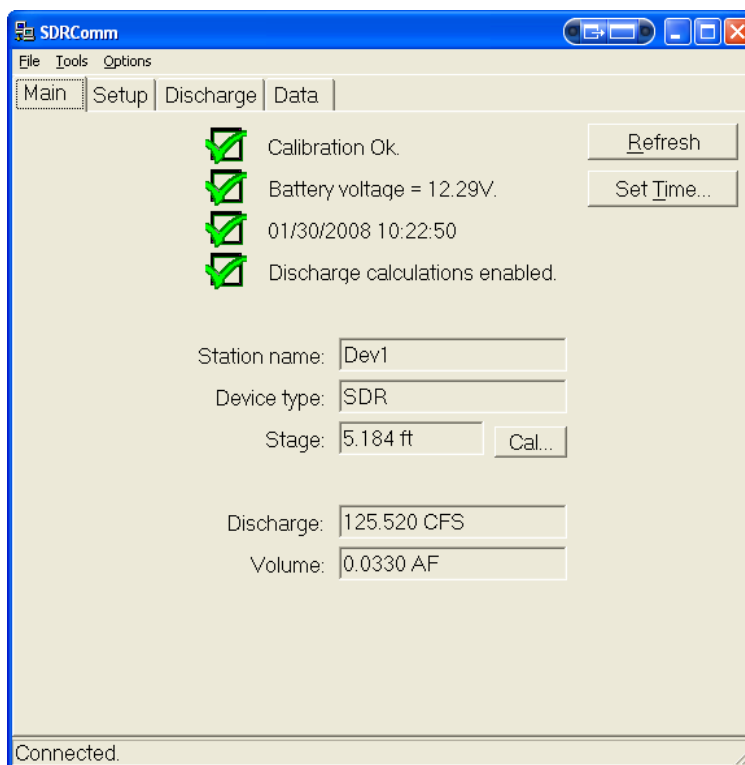
File Menu

The File menu contains an "Exit" item. Use this item to exit the program. Note: On the PDA version of SDRComm, using this menu option is required to fully exit the program and close the serial port. If the small "X" in the upper right corner of the window is clicked instead of "Exit", the PDA program does not fully close, but only minimizes, keeping the serial port open.

Tools Menu

Menu items under 'Tools" can be used to perform several useful functions. "Get SDR version" retrieves the version of the SDR firmware. "Upgrade Firmware" prompts you to select an upgrade file that will upgrade the SDR firmware to a new version (these upgrade files are delivered with the SDRComm installation package).

The "Set setup to default" menu will cause the SDR to reset its configuration to the default . The password can be reset (i.e., to no password) using the "Reset password" menu item.

The "Change device type…" menu item under Tools is used to configure the attached device to be an SDR, a Water Monitor (a variant of the SDR device – see **Appendix** F – Ground Water Monitor Device Type), or to be a DitchMaster (an irrigation control device which has its own manual, available from www.sutron.com). Only change this setting if you are sure you need to. After changing the setting, it is recommended that the unit be rebooted and the setup changed to defaults.
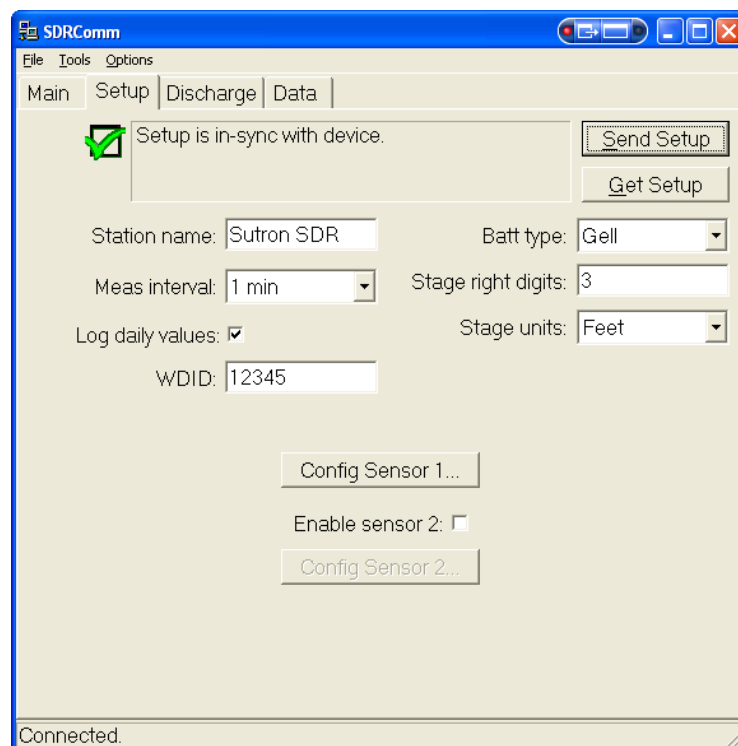
Options Menu

The Options menu "Set Comm Port" item is used to define the PC or PDA communications port to which the SDR is connected (e.g., COM1, COM2, etc.). The "TCP/IP" option is intended for use with Serial IP modems like the Airlink "Raven" cell modem.
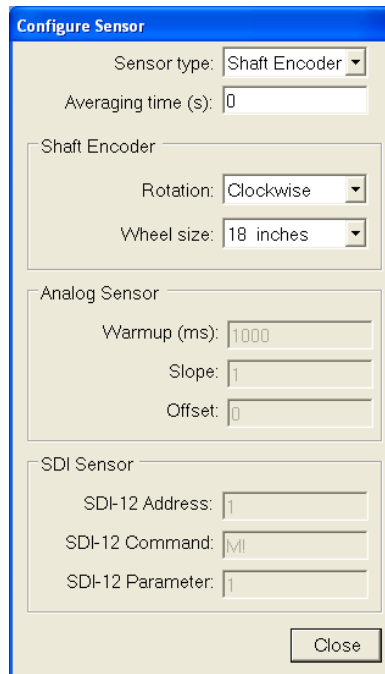
Additionally, the "Update Periodically" feature allows the Main tab to refresh the data it gets from the SDR periodically.

Setup Tab

The Setup tab (shown right) is used to view and define the SDR configuration. When this tab is selected, the current configuration is displayed and SDRComm reports "Setup is in-sync with device" in the status pane at the top of the window. If you make any changes to any of the parameters displayed on this page, the status pane reports that the setup has changed, and reminds you to press "Send Setup" to send the changes to SDR. To restore the changed parameters back to those that are in SDR, simply press "Get Setup".

Press the "Config Sensor" button to bring up the window that gives access to the sensor setup:

Unless the SDR is equipped with the optional analog inputs, that section will not be available for setup. Please refer to the section

Appendix I – Dual Sensor to learn more about configuring dual sensors.

Discharge Tab

Use this screen to enable and setup discharge. Please see the section Practical Applications - Working With Discharge to learn more about properly configuring discharge.

Data Tab

The Data Tab is shown below. This tab is used to view recent data, and to download data into csv files or graphs. When the Data tab is first selected, it automatically downloads the most recent 12 hours of data and displays it in the list box. The list box may be sorted by clicking on one of the column headers. The list will be sorted according to the contents of the column clicked. You can also rearrange columns by clicking and dragging the columns into the desired order.
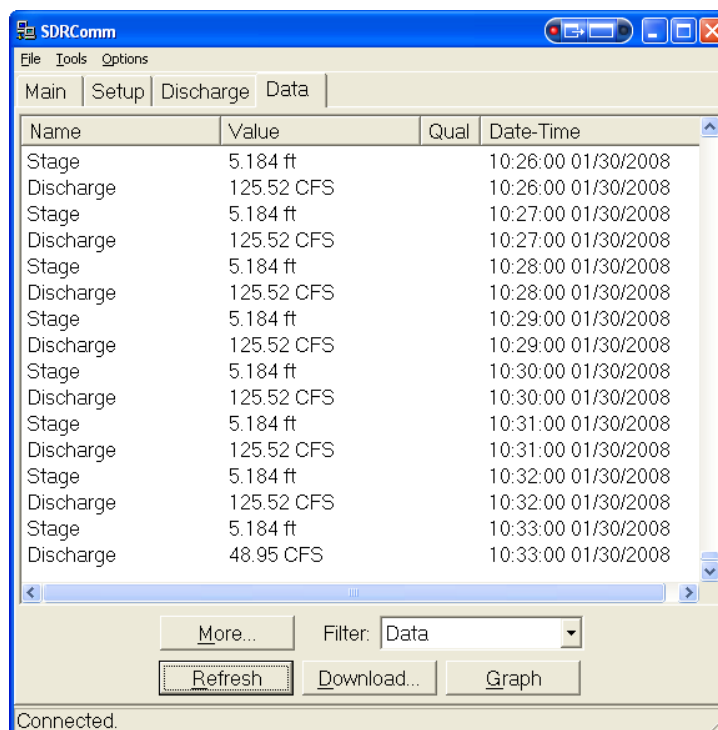
The "Filter" field allows you to narrow the set of data to display. Selecting "Data" displays stage, discharge, volume, and battery voltage, as well as daily values. Selecting "Events" will cause the list to contain only event items, e.g., display on, display off, log download, etc. These events are useful in determining what users have done to the unit since it has been in operation. Other "Filter" possibilities allow you to view only stage, or volume, etc.

To add more data to the list than it currently contains, press the "More" button. You will then be prompted for how much data to add (one day, one week, or one month).

Pressing "Refresh" will cause SDRComm to retrieve the data again, including any data that has been generated since the last download.

To graph the data that is currently in the list, press "Graph". This will bring up a new window containing a graph.

Graphing Data
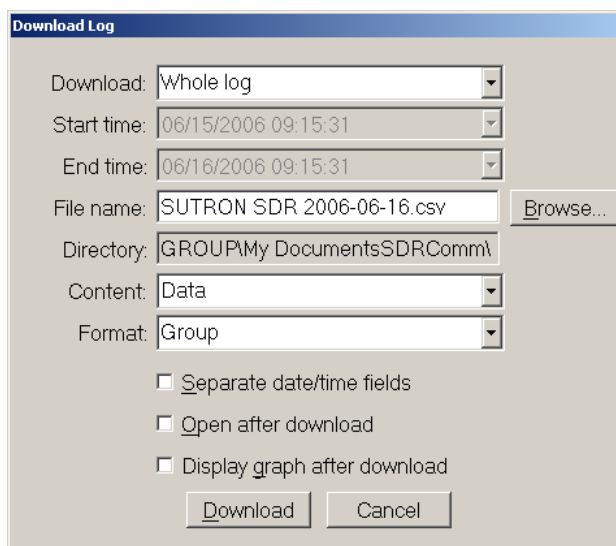
When the graph window is first shown, it defaults to graphing Stage. Other values may be graphed by changing the "Series" field.
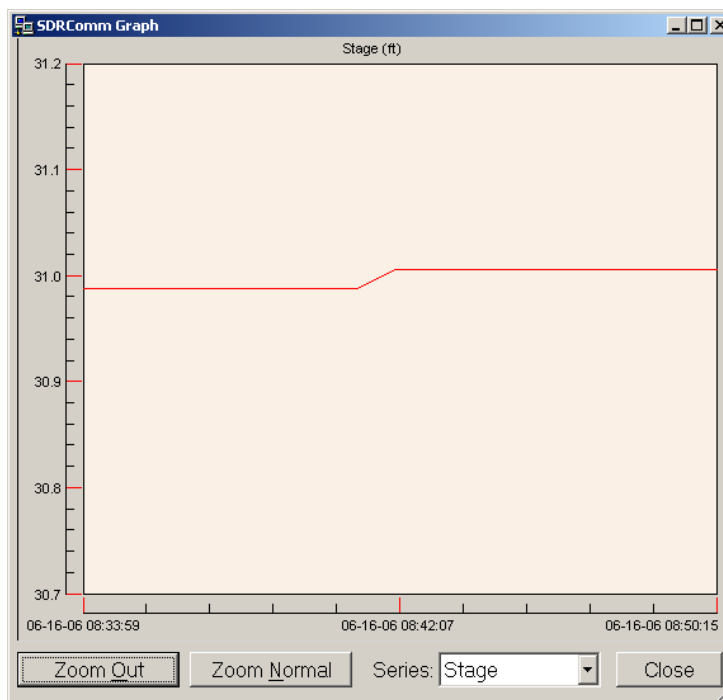
To zoom-in on an area of the graph, click and drag your mouse across that area. To return to the last zoom, press "Zoom Out". To return to the entire span (no zoom), press "Zoom Normal". Pressing "Close" closes the graph dialog.

Downloading Data

To download data, press the "Download" button on the Data tab. This causes the following window to appear.

The "Download" drop-down list allows you to select the span of data to download. You can download the whole log, the last 7 or 30 days, or data that falls within dates you specify in StartTime and End Time. Use the "Browse" button to define where to put the resulting csv file.

The "Content" drop-down list is used to define the content of the downloaded data. The options are "Data", "Events", or "Both".

The "Format" drop-down list is used to select the type of CSV format of the output file. The options are "Group" and "Flat". The "Group" format puts all values having the same date-time on the same line in the file, while the "Flat" format puts every log entry on a separate line. Each format puts text at the beginning of the file that defines the fields in the file.

If "Separate date/time fields" is selected, the output file separates the date and time fields with a comma. Otherwise, date and time are separated with a space, which allows Excel to sort on date-time.

Pressing the "Download" button starts the download.

If "Open after download" is checked, the csv file will be opened in an external viewer, e.g., Microsoft Excel, after it is downloaded (the Pocket Word application is used on Pocket PCs, since Pocket Excel does not support the CSV format). For this to succeed, you must have a program on your PC that has registered itself as a csv viewer. Microsoft Excel does this by default. If you do not have a registered csv viewer, you can still open the downloaded file in a text editor, e.g., notepad, to view its contents.

If "Display graph after download" is selected, the data that is downloaded will be opened in a graph. The window will display a graph of Stage by default, but other values may be selected in the graph window.

3.6   Data Polls Using SDRPoll

SDRPoll is a program for the PC that is used to automatically download log data from the SDR at specified intervals.

SDRPoll Highlights:

- Executes user-defined periodic schedule to download data from an SDR.
- Multiple schedules/stations are possible.
- Schedules can be daily, hourly, every few minutes, etc.
- The downloaded data is appended to a csv file.
- Supports direct, Modbus and ip serial bridge (e.g. Airlink Raven) connections.

Main Window

Here is a picture of the main screen, followed by descriptions of each of the columns:
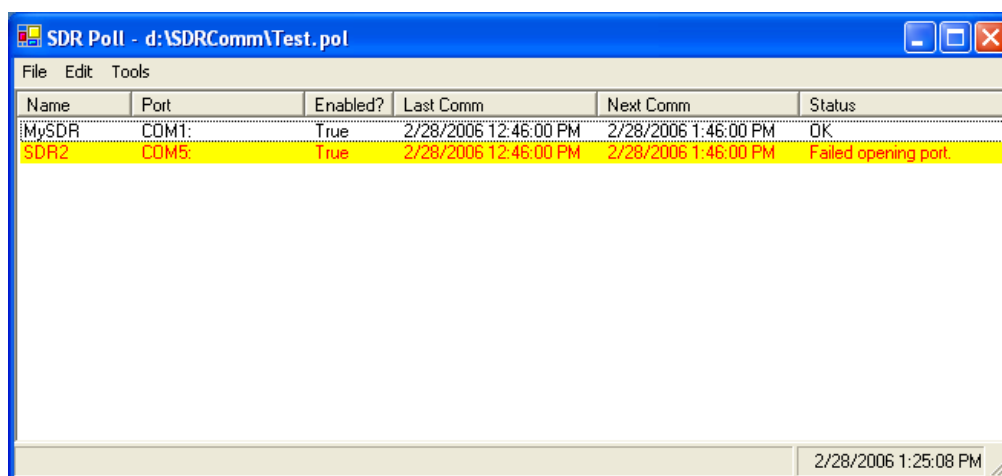
Name	The name of the SDR station.
Port	The com port or ip address of the SDR.
Enabled?	Indicates whether schedule is currently enabled (schedules can be disabled manually by user to support maintenance, etc.).
Last Comm	Date and time of the last successful download.
Next Comm	Date and time of the next scheduled download.
Status	Text that describes either the current operation, or the results of the last operation. When an error occurs, this field explains the nature of the error, and the entire row is highlighted yellow.
Status Bar	Current date and time.

Schedule Details

The following dialog allows the user to create a new poll schedule, or to edit an existing poll schedule. To create a new poll entry, select "New" from the "Edit" menu. To edit an existing poll schedule, highlight the entry in the list and then select "Edit" from the "Edit" menu, or right click on the entry and select "Edit" from the pop-up menu.

Enabled schedule	Indicates whether schedule is currently enabled (schedules can be disabled manually by user to support maintenance, etc.).
Station name	Typically the name of the SDR from which to download.
Device type	Defines the device being connected to, either SDR or Water Monitor. Selection determines the header information placed into the log when downloaded.
Num attempts	This is the total number of times to try for a successful download.
Connection type	This drop down box is used to select the type of connection to the SDR device. You can select from "Direct", "TCP/IP", and "Modbus". To change the parameters for the connection type selected, press the "Connection Settings" button.
Conncection Settings	See below for descriptions of the different connection setting parameters. Adifferent set of settings are shown for each selection made in the Connection type drop down box, described above.
Offset	The schedule offset time.
Interval	The schedule offset interval.
Download type	This defines the span of the data to download. Possible selections: ▶ Since Last: Download all data since last successful download (if no previous download, use schedule interval as download span). ▶ Recent Span: Use "Download span". ▶ Whole Log: Download the entire log.
Download span	Span of data to download when "Recent Span" is selected for download type.
Local time offset	Set this to the difference <u>in minutes</u> between the device's system time and the PC's system time.
Output format	"Flat" format puts one log item on each line of csv output, while "Group" format groups all items with same date-time into a single row, multi-column format. <u>See format section for more details and examples.</u>
Right digits	The number of right digits to use when formatting the downloaded data.
Output file	Path to the csv file in which to store downloaded data.

Connection Settings

Clicking this button brings up the connection properties window. The options available to the user will change depending on the type of connection selected under *Connection Type*.

TCP/IP

If you are using an IP modem to connect to the SDR (e.g., the Airlink "Raven" IP modem that serves as a serial bridge over an IP network), then you will select TCP/IP for the Connection Type. When TCP/IP is selected, the Connection Settings dialog contains the following settings…
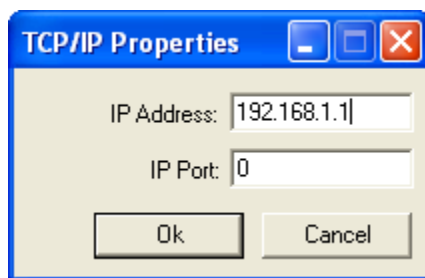
IP address	The IP address of the IP modem that is connected to the SDR device.
IP port	Tthe IP port to which the IP modem responds.

MODBUS

The SDR can do Modbus with only three wires if Pin 6 (DSR) and Pin 7 (RTS) at the SDR are connected together.

Using the MODBUS protocol to poll the SDR is advantageous when you have multiple SDRs connected on the same spread spectrum radio network, and you need a way to uniquely address each of them. When Modbus is selected, the Connection Settings dialog contains the following setting.

Device ID	The address of the sensor to communicate with.
Com Port	The desired port to connect with.
Baud	A drop down list containing the available baud rates the unit can operate at ranging from 1200 to 19200. The default is 19200 and is recommended for all applications.
Parity	A drop down list containing the available parity choices: Odd, Even, None. The default is Even.
Protocol *	A drop down list containing the two Modbus protocols: RTU and ASCII. The default is RTU. *Note:* If using RTU, be sure to setup modems or any other communication equipment to use 8-bit data. If using ASCII, use 7-bit data.
RTS pre-tx delay	The number of ms to assert RTS before transmitting data. This value defaults to 10 and is sufficient for most applications. This setting is typically of concern when RTS is used to "key" the radio, i.e., to push the "button" that tells the radio here is your data to send. Larger values allow the radio to warm-up before data is sent to them for transmission.
RTS post-tx delay	The number of ms to continue asserting RTS after transmitting data. This value defaults to 10 and is sufficient for most applications. This setting is typically of concern when RTS is used to "unkey" the radio, i.e., to release the "button" that tells the radio that no more data will be sent to it for transmission. Larger values allow the radio to complete its current transmission before the "button" is released. This can be important when using radios that go to sleep when RTS drops, regardless of whether the current data transmission is complete.
Wait for DSR	If checked, the pc will wait until the Date-Signal-Ready line is asserted before transmitting data.
Wait for CTS	If checked, the pc will wait for the Clear-To-Send line to assert before transmitting data.
Default slave timeout	The amount of time in milliseconds the software will allow for a reply from the device at the **Device ID** address. The default value is 2000. *Note:* If data being requested is long in the past, a longer timeout may be necessary to allow for the unit to parse its log completely. If this is the case, a timeout of 10,000 should be sufficient.

* Sutron recommends that customers using MDS 9810 spread spectrum radios use the ASCII protocol.

3.7 Log Download Data Formats

Using either SDRComm or the SD card option, when downloading the log, two format options are available: flag and group.

Flat Format

The flat format is an ASCII comma separated value text format in which each line represents one log entry. Each line includes a timestamp, the name of the log entry, optional data value, and optional flags. The flat format uses the Sutron Standard CSV format. It is a format common to current Sutron products.

The general format specification for Sutron Standard CSV format is

mm/dd/yyyy,hh:mm:ss,label,data[,units,qual][,label,data[,units,qual]]

Here is an example of the log download with the flat option:

03/10/2009,15:30:20,Reset Powerup,1
03/10/2009,15:30:32,Setup Change
03/10/2009,15:31:59,Display Off
03/10/2009,15:45:00,Stage,12.87,ft,Good
03/10/2009,16:00:00,Stage,12.82,ft,Good
03/10/2009,16:15:00,Stage,12.77,ft,Good

A flat format log file can be viewed with any text editing program such as MS Notepad. Sutron provides a free program that can do simple graphs of flat format data called Grapher (www.sutron.com).

Group Format

The group format is also a comma separated value ASCII text format. The group format uses a tabular approach, where the rows in the table are timestamps and the columns are data values.

Here is an excerpt from a group format log file:

' date	time	Stage	units	quality	Discharge	units	quality
12/16/2010	11:27:00	1.234	ft	Good	5.51	CFS	Good
12/16/2010	11:28:00	1.234	ft	Good	5.51	CFS	Good
12/16/2010	11:29:00	1.234	ft	Good	5.51	CFS	Good
12/16/2010	18:29:00	1.234	ft	Good	5.51	CFS	Good
12/16/2010	18:30:00	1.234	ft	Good	5.51	CFS	Good
12/16/2010	18:31:00	1.234	ft	Good	5.51	CFS	Good
12/16/2010	18:32:00	1.234	ft	Good	5.51	CFS	Good
12/16/2010	18:33:00	1.234	ft	Good	5.51	CFS	Good
12/16/2010	18:34:00	1.234	ft	Good	5.51	CFS	Good
12/16/2010	18:35:00	1.234	ft	Good	5.51	CFS	Good
12/16/2010	18:36:00	1.234	ft	Good	5.51	CFS	Good
12/16/2010	18:37:00	1.234	ft	Good	5.51	CFS	Good
12/16/2010	18:38:00	1.234	ft	Good	5.51	CFS	Good
12/16/2010	18:39:00	1.234	ft	Good	5.51	CFS	Good

Group format files are best viewed with a spreadsheet program such as MS Excel.

3.8   SDI-12 Sensor Operation

In addition to recording data, the SDR can function as an SDI-12 Sensor. This allows the SDR to connect to another data logger or transmitter to provide the data when requested.   If you are not using the SDR with another data recorder or transmitter, you can skip this section.

The SDR is compliant with SDI-12 Specifications version 1.3. SDI-12 is a standard for interfacing data recorders with microprocessor based sensors. More details on the SDI-12 interface can be found at http://www.sdi-12.org.

All standard SDI-12 1.3 commands are supported. The SDR will respond to the following commands.

A! Change Address Command

The default SDI-12 address is 0. If you are using the SDR connected with other SDI-12 devices, you will need to have a unique address for each sensor. **Note:** If the current address is unknown, make sure the SDR is the only sensor on the SDI-12 bus, then issue an ?! command and the SDR will respond with its current address.

> Send :   **aAb!**
> Response: **b**
>
> Where:
> a is the current address of the SDR
> A is the change address command
> b is the desired new address

I! Identify Command

The identify command will respond immediately (no aD0! needed) with specific information on the SDR about the SDI-12 compliance level, manufacturer, model number and firmware version. This information may be useful when customer service is assisting in troubleshooting a trouble site.

> Send: **aI!**
> Typical Response: **a13 SUTRON SDR001Vx.xx**
>
> Where:
> a is the SDR address
> SUTRON SDR001 is the manufacturer and model number
> Vx.xx is the current firmware version

V! Verify Command

The data value returned is an indication of the error status. If the unit is operating properly, then a 0 is returned. If the unit has any errors, then a 1 is returned. This error status returned follows the status reported on the front panel via the heartbeat LED (e.g. Green LED, no errors and Red LED errors present).

> Send :   **aV!**

Response: a0001

Where:
a is the address of the SDR
000 means data is ready immediately
1 means 1 data item will be returned.

Send: **aD0!**
Response: a+E

Where:
a is the address
E is a 0 or a 1 indicating the error status

Measure Commands

The SDR supports several measurement commands. They can be initiated with Start Measurement (M! or MC!) or Start Concurrent Measurement (C! or CC!) commands, where the extra "C" means add CRC. The continuous measurement commands (R! or RC!) will not return any data.

The SDR will return the data values in whatever measurement units have been configured in the SDR setup (meters or feet). The SDR measurement units cannot be changed or read via any SDI-12 command.

M! Measure Current Stage/Discharge

The SDR will immediately proceed to measure stage and discharge. Three values are returned: stage, discharge and quality. If discharge measurements are disabled, the discharge value returned will be zero. The number of right digits used in the stage measurement is configurable through the front panel or the SDR communicator. The number of right digits in the discharge measurement is not configurable. The quality reading will be 0 if the data is good, 1 if there is an overspeed condition, 2 if stage is not set, or 3 if both stage is not set and an overspeed is present. Also see the M4 command.

Send :   **aM!**
Response: a0005

Where:
a is the address of the SDR
000 means data is ready immediately
5 means 5 data items will be returned.

Send: **aD0!**
Response: a+ss.ss+dd.dd+q+bb.bb+r

Where:
a is the address
ss.ss is the current stage reading
dd.dd is the current discharge
q is the quality of the stage reading flag
bb.bb is the secondary sensor reading (stage2)
r is the quality of the secondary sensor

M2! Get Calculated Stage/Volume from Yesterday

The SDR will return yesterday's calculated daily stage and volume (values calculated at 23:59:59 when viewed in the log). If discharge measurements are disabled, the volume returned will be zero. If the SDR has been reset since yesterday, both readings will return as 0.

Send :   **aM2!**
Response: a0002

Where:
a is the address of the SDR
000 means data is ready immediately
2 means 2 data items will be returned

Send: **aD0!**
Response: a+ss.ss+vv.vv

Where:
a is the address
ss.ss is yesterday's average stage reading
vv.vv is yesterday's daily volume

M3! Measure Battery Voltages

The SDR will return two battery readings. The first is the reading on the BAT connector, the second reading is on the SDI-12 + connector.

Send :   **aM3!**
Response: a0002

Where:
a is the address of the SDR
000 means data is ready immediately
2 means 2 data items will be returned.

Send: **aD0!**
Response: a+bb.bb+vv.vv

Where:

a is the address
bb.bb is the current voltage on the BAT connector
vv.vv is the current voltage on the SDI-12 + connector.

M4! Last Measured Data

The SDR will instantly return sensor readings from a previous measurement. The previous measurement may have occurred due to a scheduled measurement, front panel interaction, or even a different SDI-12 command. In any case, this command will return the result from the last measurement made by the SDR. The formatting is the same as the M! command, the difference being that M! causes a new measurement to be made while M4 returns the last measured data. Use this command to make sure the data in the SDR and in the connected data logger is identical.

Send :   **aM4!**
Response: a0005

Where:
a is the address of the SDR
000 means data is ready immediately
5 means 5 data items will be returned.

Send: **aD0!**
Response: a+ss.ss+dd.dd+q+bb.bb+r

Where:
a is the address
ss.ss is the current stage reading
dd.dd is the current discharge
q is the quality of the stage reading flag
bb.bb is the secondary sensor reading (stage2)
r is the quality of the secondary sensor

C!, MC! and CC! commands

The C command is used to make a concurrent measurement. It operates identical to the M command except that the shaft encoder does not issue a service request when the measurement is complete. This is useful when multiple SDI-12 sensors are being measured, such that all sensors can start measurements at the same time, then the data recorder can get the data back when the sensor with the longest measurement time has completed.

The MC command is identical to the M command except that the shaft encoder adds a CRC to the end of the data. This is useful when the sensor and data recorder are separated by a distance in an electrically noisy environment as it adds extra CRC calculations to ensure the data integrity.

The CC command is identical to the C command except that the shaft encoder adds a CRC to the end of the data. This is useful when multiple sensors and a data recorder are separated by a distance in an electrically noisy environment as it adds extra CRC calculations to ensure the data integrity.

XS! Set Stage Extended Command

This command will set the current stage reading in the units currently configured in the SDR (e.g. If the SDR is reading in feet, then the value entered here must be in feet). It is equivalent to setting the stage via the front panel or using the SDRComm program.

> Send: **aXS±<value>!**
> Response: a
>
> Where:
> a is the address
> XS is the command to set the current stage
> ±<value> is the new stage value. The new stage value must start with a polarity sign (+ or −),
> which must be followed by one to seven digits including an optional decimal point.
>
> Example of the set stage command:
> 0XS+1.234!
> Sets the stage to 1.234

XDT! Set/Read Date and Time Extended Command

Use this command to change the current date and time of the SDR, issuing this command with no data will return the current date and time in the SDR.

To set the date and time:

> Send: **aXDTYYYY/MM/DD HH:MM:SS!**
>
> Where:
> a is address
> XDT is the command to set the date and time
> YYYY is the year
> MM is the month (01 to 12)
> DD is the day of the month (01 to 31)
> HH is the hour (military time 0 to 23)
> MM is the minutes
> SS is the seconds
>
> Example set date time command:
> 0XDT2005/09/01 13:15:00!

Sets the date to the 1st of September2005, and the time to 1:15:00 PM.

To read the current date and time:
Send: **aXDT!**
Response: **aYYYY/MM/DD HH:MM:SS+q+g**

Where the date and time response is the same information as above when setting the date and time.
q is a single digit that indicates the quality of the time. 0 means the time is invalid. 1 can mean that time was set since bootup (if no GPS is present), or that the time has been synced to the GPS in the last 12 hours (if a GPS is present).
g is a single digit that indicates the presence of the GPS. 0 means no GPS is present, 1 means that a GPS is present.

Satlink (versions 6.17 and newer) take advantage of this command and set the SDR clock once a day.

XDR! Rotation Direction Extended Command

This command may be used to read and to write the rotation direction over SDI-12.   SDR software version 3.34 added this command.

To read the direction, issue
Send: **aXDR!**
Response: **a0011**
Indicating that 1 value can be collected after 1 second. Follow up with

Send: **aD0!**
Response: **a+d**

Where **d** is the current direction.
If d is **0**, counter-clockwise is positive.
If d is **1**, clockwise is positive.

To set the direction, issue
Send: **aXDR+d!**

Where **d** is the new direction. SDR will respond the same way it does to the read command.

XWS! Wheel Size Extended Command

This command may be used to read and to write the wheel size and optionally the wheel circumference over SDI-12.   SDR software version 3.34 added this command.

To read the current settings, issue
Send: **aXWS!**
Response: **a0021**
Indicating that 2 values can be collected after 1 second. Follow up with

Send: **aD0!**
Response: **a+f+g**

Where **f** is the current wheel size as per the table below:

f	meaning
0	18"
1	12"
2	375mm
3	custom inches
4	custom millimeters

g is only relevant if **f** is 3 or 4.
g represents the wheel circumference in the respective units.

To set the wheel size, issue
Send: **aXWS+f+g!**

SDR will respond the same way it does to the read command. If **f** is 0,1, or 2, you may omit **g**, in which case the command looks like **aXWS+f!**

4. Practical Applications - Working With Discharge

4.1   What the SDR Can Do For You

The SDR was specifically designed to eliminate most of the labor involved in working up records from a discharge measurement site. Traditionally, the stage values have been recorded as a line on a strip chart. Discharge has been computed by drawing lines to represent the mean daily stage, and then looking up the discharge in a rating table or graph.   The SDR eliminates the need for hand computations and data recording.

The SDR supports real-time calculation of discharge and daily volume for the following:

- Parshall flumes
- Broad-crested weirs
- Any flow measuring device whose rating takes the form Discharge = A * Stage ^ B, where A and B are constants
- Any site where the relationship between discharge and stage can be represented by a graph of 50 or less stage-discharge pairs

You can eliminate the need for after-the-fact hand calculations by:

- Enabling discharge calculations
- Entering the coefficients for your flume or weir, or
- Entering your rating table and selecting the appropriate interpolation technique

4.2   Discharge Setup Sequence

Very little extra effort is required to make an SDR record discharge as well as stage. The steps are as follows:

1. Set up stage recording first

    a)   Select the recording interval, 1, 5, 10, 15, 20, 30, or 60 minutes

    b)   Select the encoder wheel size, 12 inches, 18 inches, or 375 mm circumference

    c)   Set the wheel rotation direction, clockwise positive, or counterclockwise positive

    d)   Select the Stage Units, feet, or meters

2. Calibrate the stage reading so that the SDR stage values match the staff gage for the flume or weir

3. Follow the steps in the next section to enable discharge recording and set up your flow calculation method (equation or table lookup).

4.3   Correctly Recording Discharge

Enabling The Computation

Discharge calculation can be enabled either from the front panel or from the SDR communicator program on your laptop or PDA.

From the front panel, navigate to *Station Setup->Discharge*. Once discharge is enabled, the current discharge setting will appear on the top menu along with volume information

If you are using the SDR Communicator program, select the Setup tab.
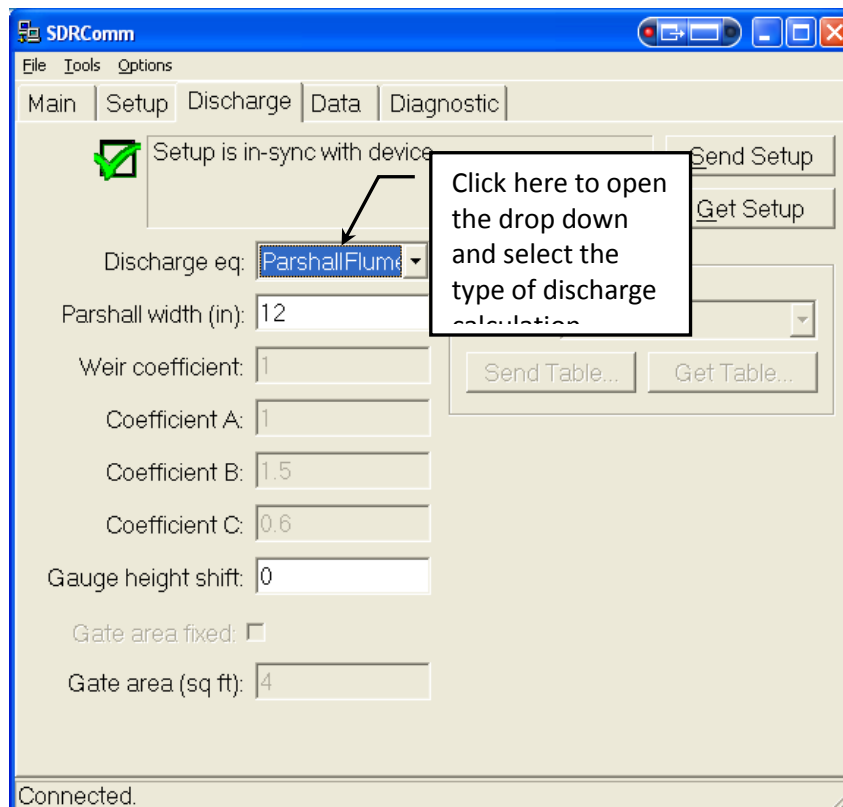
Setup Tab in SDR Communicator

Turn on discharge calculation by clicking on the drop-down arrow in the **Discharge Eq.** box. The choices are:

- Parshall Flume
- Weir
- Generic
- Dual
- Rating Table
- Disabled

Select the type of discharge calculation that you want the SDR to make. Guidance on making the correct selection is provided in the next section.

WORD OF CAUTION

The SDR follows standard computer "execution order" rules when solving the discharge equations. The exponential calculation (Stage ^ B) is made first, followed by the multiplication by the constant A. Rating tables (see next page) are computed this way.

(A * Stage) ^ B is NOT the same as A * (Stage ^ B).   If you are checking values in a table, or creating your own equation by curve fitting values in a table, be sure to do the calculations in the same order as done by the SDR.

Rating Curves and Equations

Every flow measurement site is rated to determine the relationship between the stage at a fixed location (staff gage) and the discharge. The ratings are presented as equations and/or tables that allow the user to determine the discharge. A typical rating table for a weir is illustrated in the figure below.

State of Colorado
Division of Water Resources

Office of State Engineer   Computed by: RVS
Division 1   Checked by: RVS
Rating Table ID: Jumbo Outlet #1 @
JUMBOSCO01   22.8' Weir
Time of Last Edit: 23-Oct-2002

EQ: Q=73.994(GH)^1.8537

GH	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
Feet	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs
0.00										
0.10	1.04	1.24	1.45	1.69	1.93	2.20	2.48	2.77	3.08	3.41
0.20	3.75	4.10	4.47	4.85	5.25	5.66	6.09	6.53	6.99	7.46
0.30	7.94	8.44	8.95	9.48	10.02	10.57	11.14	11.72	12.31	12.92
0.40	13.5	14.2	14.8	15.5	16.2	16.8	17.5	18.3	19.0	19.7
0.50	20.5	21.2	22.0	22.8	23.6	24.4	25.3	26.1	27.0	27.8
0.60	28.7	29.6	30.5	31.4	32.4	33.3	34.3	35.2	36.2	37.2
0.70	38.2	39.2	40.2	41.3	42.3	43.4	44.5	45.6	46.7	47.8
0.80	48.9	50.1	51.2	52.4	53.6	54.7	55.9	57.2	58.4	59.6
0.90	60.9	62.1	63.4	64.7	66.0	67.3	68.6	69.9	71.3	72.6
1.00	74.0	75.4	76.8	78.2	79.6	81.0	82.4	83.9	85.3	86.8
1.10	88.3	89.8	91.3	92.8	94.3	95.9	97.4	99.0	101	102
1.20	104	105	107	109	110	112	114	115	117	119
1.30	120	122	124	126	127	129	131	133	134	136
1.40	138	140	142	144	145	147	149	151	153	155
1.50	157	159	161	163	165	167	169	171	173	175
1.60	177	179	181	183	185	187	189	191	194	196
1.70	198	200	202	204	207	209	211	213	215	218
1.80	220	222	225	227	229	231	234	236	238	241
1.90	243	246	248	250	253	255	258	260	262	265
2.00	267	270	272	275	277	280	282	285	288	290

The figure illustrates a typical rating table as provided by the State of Colorado's Division of Water Resources. Note at the top that the rating is for a weir and that the equation upon which the table is based is provided. The type of device, along with the equation, determine how you should set up the SDR. You may choose to enter an equation, or a rating table.

The SDR is designed to support discharge calculations based on the general formula

Discharge = A * (Stage ^ B)

where A and B are constants and ^ represents the operation of raising a number to a power. The values of A and B are determined by the flow measuring device you are using. Here is how to decide how to set up the SDR.

Are you using a Parshall flume? If so, select Parshall Flume as the discharge calculation type.

Are you using a weir? Examine the coefficient B in the equation. If the coefficient is EXACTLY 1.5 or 3/2, then select Weir as the calculation type.

If you are not using a Parshall Flume or weir, or the B coefficient is NOT 1.5, then select Generic as the calculation type.

In the example table above, the device type is weir, and the equation is:

Q=73.994 * ((GH)^1.8537)

Note that since the B coefficient is 1.8537 the correct calculation type for the SDR will be Generic, and NOT Weir. This is because the B coefficient is NOT 1.5.

The following paragraphs provide additional information on how the SDR computes discharge for the different calculation types.

Parshall Flume

Parshall flumes are one of the most widely used discharge measuring devices in the world. The SDR uses the following equation family to compute the discharge for Parshall flumes:

W, in feet	Discharge equation, Q in CFS
0.25 (3 inches)	Q = 0.992 H ^ 1.547
0.5 (6 inches)	Q = 2.06 H ^ 1.58
0.75 (9 inches)	Q = 3.07 H ^ 1.53
1 to 8	Q = 4W H ^ (1.522 W ^ 0.026)
10 to 50	Q = (3.6875W + 2.5) H ^ 1.6

(Reference: Open Channel Hydraulics, Chow, Ven Tee, McGraw Hill Book Company, New York, 1959)

If you are using a Parshall flume you will only have to enter the throat width, W. The SDR will compute the appropriate values for A and B in the discharge equation. Note that these equations DO NOT account for submerged outlet conditions.

Weir

Weirs are also widely used for discharge measurement, but, unlike Parshall flumes, are not standardized. There is an infinite variety of widths, side shapes, and constructions. In general, the discharge over a weir can be represented by the equation:

$$\text{Discharge = K * L * (Stage ^ (3/2))}$$

where K is a coefficient determined by the rating process, and L is the length of the crest. Examine the rating equation for your weir carefully. Some weirs will provide the coefficient K and some will provide the product K * L. You will need the **PRODUCT,** K * L to enter as W in the SDR. For example, if the weir equation is given as:

$$\text{Q=73.994 * ((GH)^1.5)}$$

then you would enter 73.994 for W in the SDR.

General-Purpose Equation

The general purpose equation should be used for any non-standard flume or weir. As long as the device rating can be expressed in the form:

$$\text{Q=A * ((GH)^B)}$$

then the SDR can be used to compute the discharge. For example, from the rating table presented earlier we were given the discharge equation:

$$\text{Q=73.994 * ((GH)^1.8537)}$$

Enter the value 73.99 for A in the SDR and 1.8537 for B. The procedures for entering coefficients into the SDR are given in the next section.

Entering the Coefficients

The flume and weir constants are entered after you make your selection for the computation type (Parshall Flume, Weir, Generic).

If you are setting your SDR up from the front panel, the coefficient entry is "context sensitive." That is, the SDR will determine what you need to enter.

 If you select Parshall Flume as the device type and scroll down one position you will see the prompt "Parshall Flume Width", followed by a value. Press the SET key to change the width. When you press SET you will see the prompt "Change width", followed by the current value. Use the UP/DOWN arrow keys to scroll through the available widths. (Newer SDRs will allow you to enter non-integer values for the width.)

If you select Weir as the device type and scroll down one position you will see the prompt "Weir Coefficient W". Press the SET key to change the value. Note that W represents the K*L product in the general weir equation. When you press SET you will see the prompt "Change Weir Coefficient W", followed by a value containing a blinking cursor. Use the arrow keys to position

the cursor and to scroll the individual digits. Press SET to make the coefficient permanent after you are done editing.

If you select Generic as the device type and scroll down one position you will see the prompt "Coefficient A", followed by a value. Press SET to change the value. You will see the prompt "Change Coefficient A", followed by a value containing a blinking cursor. Use the arrow keys to position the cursor and to scroll the individual digits. Press SET to make the coefficient permanent after you are done editing. Press the down arrow key after Setting the value of Coefficient A. You will see the prompt "Coefficient B", followed by a value. Press SET to change the value. You will see the prompt "Change Coefficient B", followed by a value containing a blinking cursor. Use the same procedures you used to set and store Coefficient A.

Setting the coefficients with the SDR Communicator program is even easier. The three figures below illustrate the Setup tab and the screen appearance with Parshall Flume, Weir, and Generic selected as the device type. Note in each case that the screen is case sensitive and will only allow you to enter the appropriate coefficients.
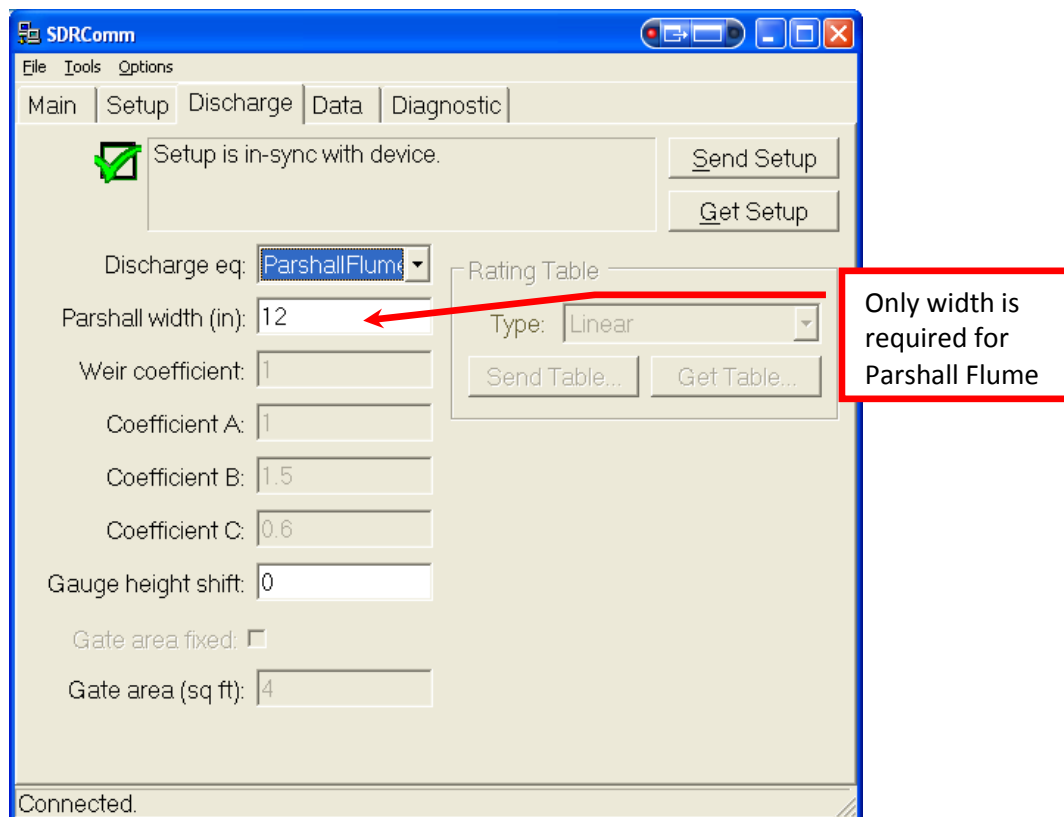
Setup Tab with Parshall Flume Selected

Weir requires entry of W (the K*L product)

Setup Tab with Weir Selected

Generic requires both the A and B coefficients

Setup Tab with Generic Selected

Dual Sensor Discharge Equation

If the secondary sensor is enabled, a new type of discharge equation becomes available. Please see section

Appendix I – Dual Sensor on using dual sensors.   The dual sensor discharge equation uses two sensors to compute the discharge. Stage one is the downstream sensor. Stage two is the upstream sensor. Water flows by the upstream sensor before it flows by the downstream sensor.

Dual sensor (submerged orifice equation) :

$$Q = Cd* A \sqrt{(Hu-Hd)G}$$

Q is the computed discharge.
Cd is the discharge coefficient which can be changed by the user in discharge setup. 0.6 is a generic value for a slide gate.
Hd is the downstream water level (*Stage*)
Hu is the upstream water level (*Stage Two*)
G is 32.175 ft/sec/sec (constant and not changeable)
A is the gate area opening that is setup by the user.
For the SDR, the gate area is fixed and entered by the user in discharge setup.

Rating Table Lookup

Rating table lookups have been added with SDR version 3.03 and higher. The rating table method should be used for natural stream channels, or when the other discharge equations are insufficient. Rating tables are specific to sites and must be developed using standard stream gauging techniques. A rating table contains pairs of entries. A pair consists of the stage and the discharge that corresponds to the stage. Here is an example of a rating table:

Stage	Discharge
0.25	3.66
0.50	4.67
1.25	9.70
1.50	12.38
1.75	15.80
3.50	87.07
4.25	180.92
5.00	375.88

Selecting Rating Table As The Discharge Calculation Method

To choose Rating Table as the discharge calculation method, first make sure discharge calculations are enabled (*Station Setup -> Discharge*). Then choose Rating Table as the discharge equation setting (*Station Setup -> Discharge -> Discharge Equation*).   Rating table options are selected in the Discharge tab of SDRComm, as shown here:
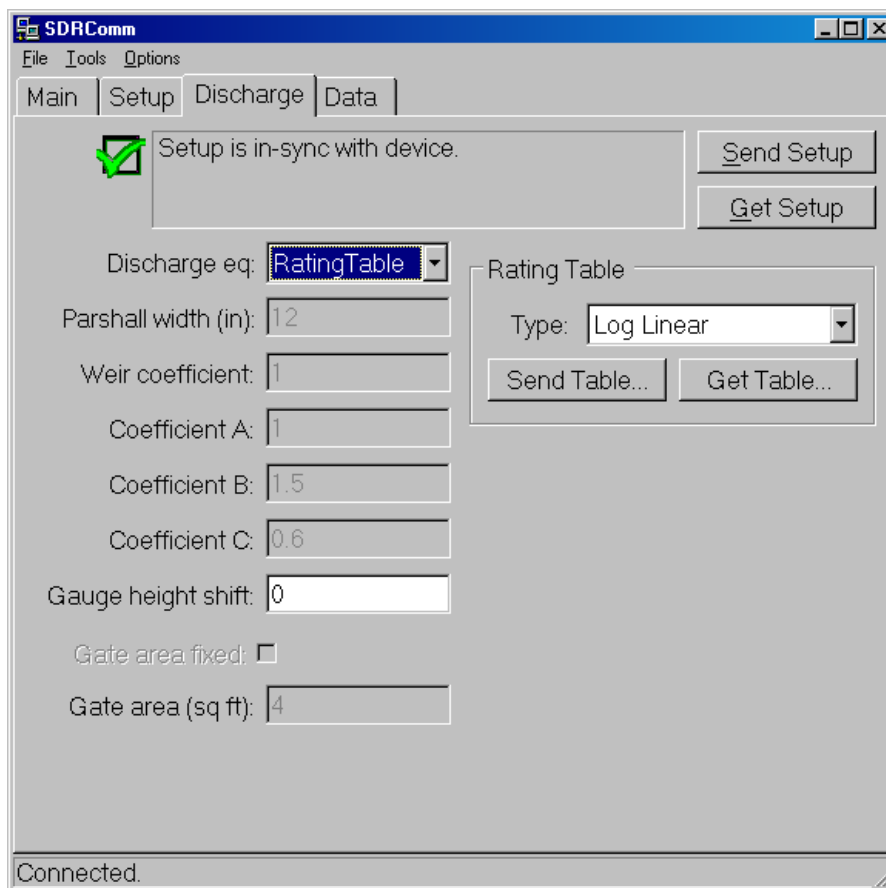
Entering The Rating Table Into The SDR

You may enter tables with up to 50 point pairs into the SDR. You can enter the table from the front panel, or you can enter it using SDRComm. It is much easier to use SDRComm.

First, use NOTEPAD or WORDPAD on your PC or laptop computer to create a .txt file in "comma-separated variable" format. The table above looks like this when entered correctly:

        0.25,3.66
        0.50,4.67
        1.25,9.70
        1.50,12.38
        1.75,15.80
        3.50,87.07
        4.25,180.92
        5.00,375.88

Send the rating table file to the SDR by pressing the Send Table button in the Discharge tab, as illustrated here.
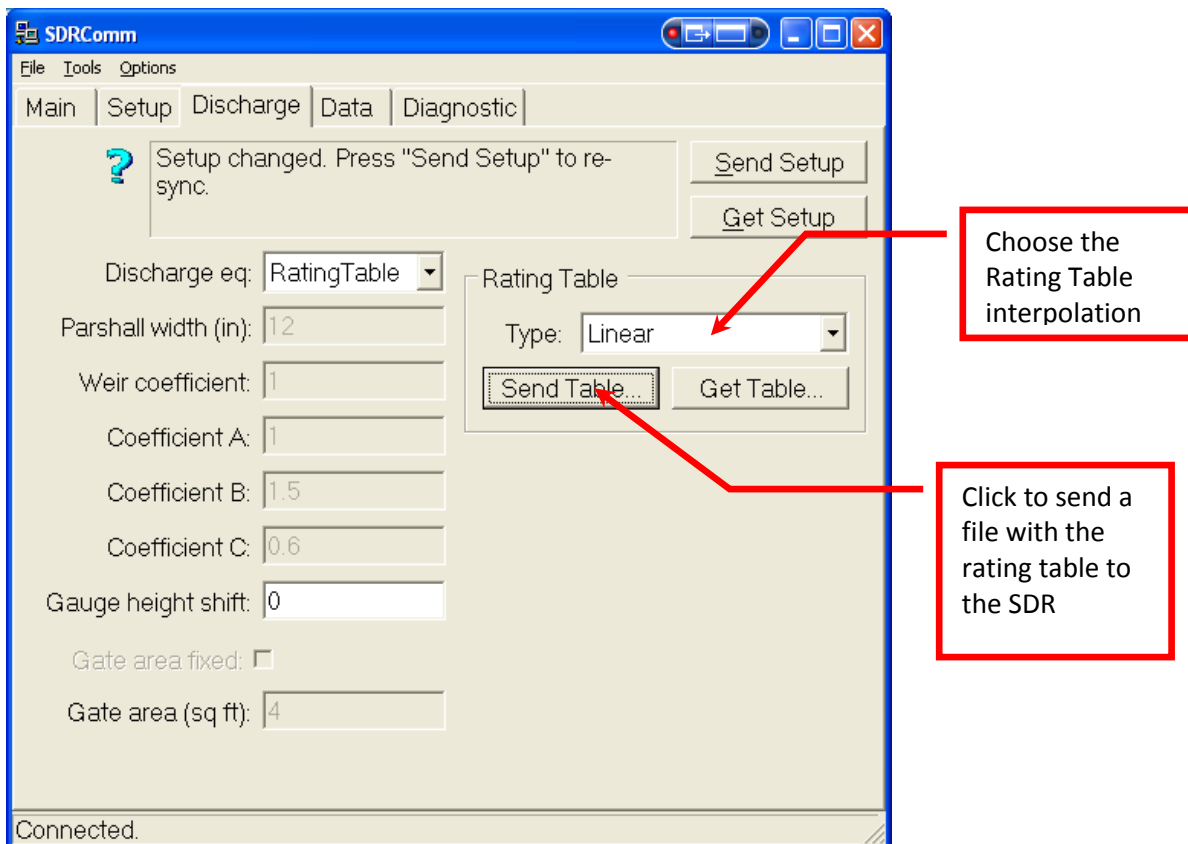
Rating Table Discharge Setup
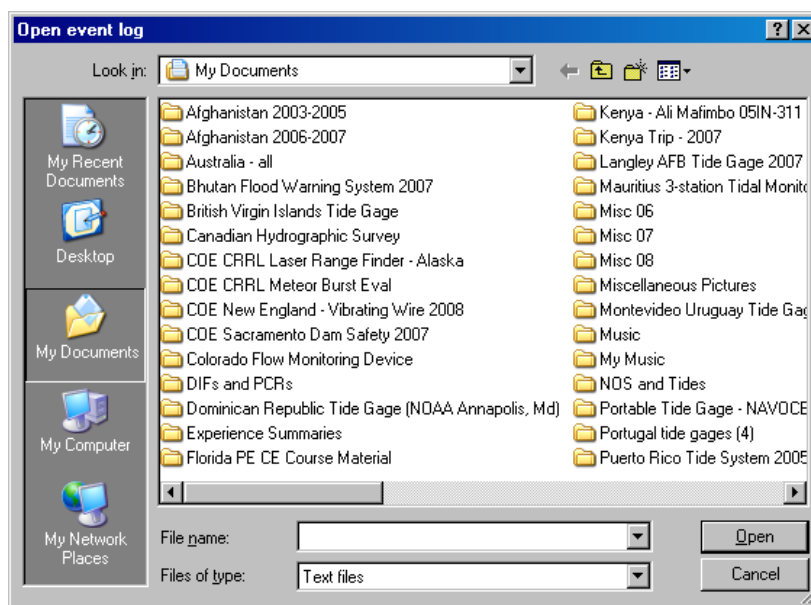
You will see the following Explorer window when you press the Send Table button.

Selecting The Interpolation Method

Most of the time, the stage measured by the SDR will not exactly match a stage in the table. The SDR will interpolate discharge values, based on where the measured stage is in relationship to the stage values in the table.

The SDR offers several interpolation methods, and it is important to select the correct one for your table. The SDR offers several interpolation methods:

- *linear*
- *log–linear* (log stage, linear discharge)
- *linear–log* (linear stage, log discharge)
- *log-log*

The best way to select the interpolation method is to enter your table into Excel and make three graphs. The first graph should be of the stage and discharge, exactly as in the table. The following graph illustrates the data from the example table given earlier.
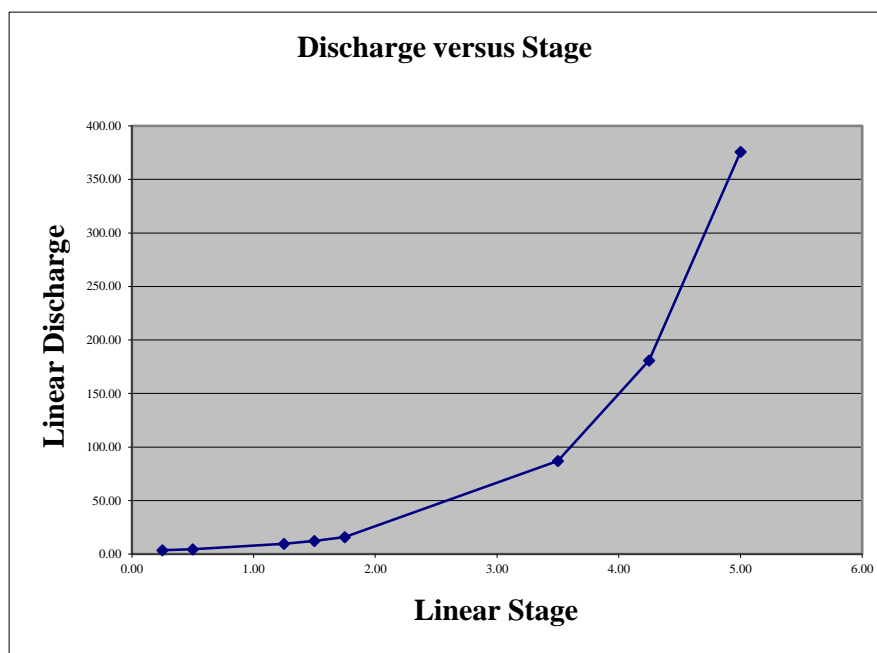
Note that there are wide gaps between the values and that a straight line interpolation would probably give values that are too large – particularly between 1.5 and 3.5 feet of stage.

Next, plot the logarithm of the discharge versus the stage. That looks like this:

Discharge versus Stage

$y = 0.4235x + 0.4576$

Log of Discharge (y-axis)

Linear Stage (x-axis)
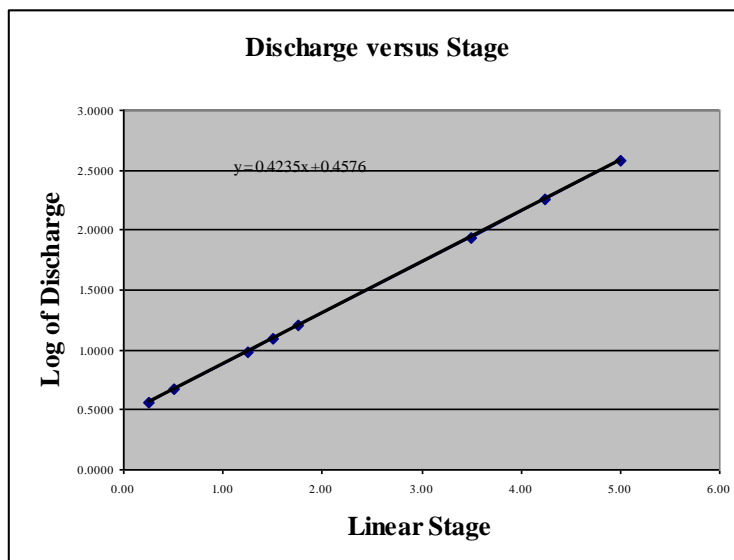
The stage-discharge relationship in the example table is a perfect straight line when plotted this way. As a result, you would select Linear-Log as the interpolation method.

Here is the log of the discharge plotted versus the log of the stage.

Discharge versus Stage

Log of Discharge (y-axis)

Log of Stage (x-axis)
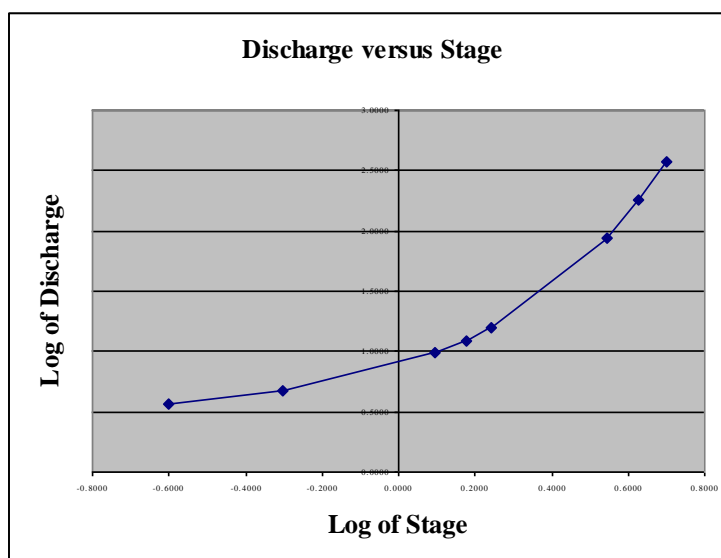
This plot indicates that Log interpolation would be better than Linear interpolation, but not as good as Linear-Log. Had this graph been a straight line, or near straight line, you would chose Log as the interpolation type.

You will almost never use Linear interpolation or Log-Linear in real-world situations. If you have to guess, use Linear-Log or Log. The reason for this is that most real world streams show a large increase in discharge for relatively small increases in stage. The type of interpolation is less critical if your table has a lot of closely spaced points. That being said, you are still always better off to plot the table values and use the best method, as indicated by the shape of the three plots.

5. Installation

5.1 Site Installation

The SDR has been designed to minimize the amount of time needed to set it up. Setup can be done directly from the front panel, or, through the SDR communicator program running on a PC or PDA. Here are some guidelines to follow when installing the SDR:

1. Make sure you have a float, tape or beaded wire, counterweight, and pulley. These items are sold separately by Sutron. The pulley should have an insulating hub or use a plastic/PVC float for maximum lightning protection.

2. The SDR is intended for installation on top of a small stilling well. The minimum well size is 6 inches in diameter. You will also need a small protective cover to protect the SDR from the environment.

3. Secure the SDR to a level base, using the four screw holes in the mounting feet. Use washers as shims, if necessary, to level the SDR. If you are using an 18" float wheel, you may need to cut a slot in the mounting surface to allow the wheel to rotate freely.

4. Connect the SDR to a suitable battery.   Use either a 12V battery or two six-volt batteries in series. Use the crimp type fasteners provided with the SDR or other means to make sure the battery connections are firmly attached to the wire.

5. Ensure the green led is flashing and that the current stage is correct before leaving the site.

6. Configure the SDR for the specific needs of the site, this includes such items as:

    - Station name and desired time.
    - Measurement interval
    - Wheel size (expressed as a circumference)
    - Ensure the direction of rotation is correct
    - Enable/Disable Discharge and, if enabled, discharge calculations (parshall flume, weir, or generic equation)
    - Calibrate the current stage
    - And finally, enter a password if one is needed

Note: If the red led is flashing, it is an indication some user action is needed. The display will indicate the required action when the display is turned on or turned off.

Leveling the SDR

Secure the SDR to a level platform with either four wood screws or the appropriate bolts, nuts, and lock washers. Four #10-32 mounting holes are provided for mounting feet or bolts, if additional leveling is required.

Grounding the SDR

Run a short #12-14 solid copper ground wire between the ground lug on the side of the SDR and an earth ground.

Connecting the Battery

The SDR uses two terminals for power, one labeled Power In, and the other is shared with the SDI-12 connections. This allows replacement of a low battery without interrupting   The SDR is designed to operate from 5.5V to 16VDC using a variety of batteries.   The following table shows the battery life for several common types of batteries.

12V 7 Amp-hr gel cell (NP7-12) -- 4 months @ 20 C, 3 months @ 30 C

12V 12 Amp-hr gel cell (NP12-12) -- 6 months @ 20 C, 5 months @ 30 C

12V 17.2 Amp-hr gel cell (NP18-12B) - 8 months @ 20 C, 7 months @ 30 C

12V 24 Amp-hr gel cell (NP24-12B)- 11 months @ 20 C, 9 months @ 30 C, 7 months @ 40 C

12V Alkaline (two 6V Lantern (Eveready 528 or 529) in series) - 15 months

12V Alkaline (eight D cells (Duracell MN1300) in series) - 9 months

12V Alkaline (eight C cells (Duracell MN1400) in series) - 5 months

7.5V Alkaline (Eveready EN715 industrial battery) - 12 months

Single +12 Volt Connection:
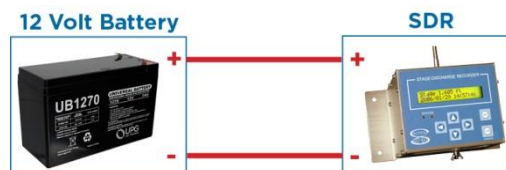
Two +6 Volt Batteries
(Series Connection)
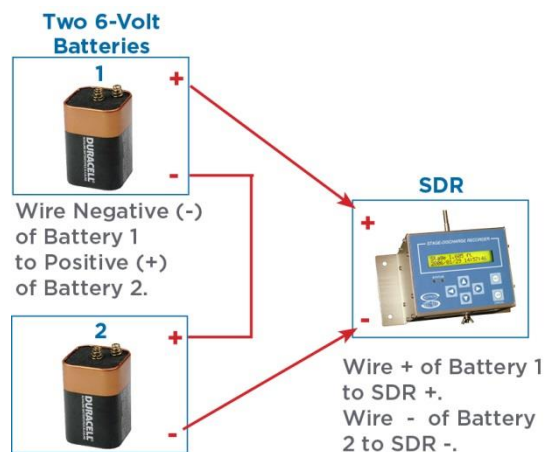
Installing the Float Wheel/Pulley

The SDR is compatible with 5/16" shaft float pulleys/wheels with a circumference of 12 inches, 18 inches or 375 mm. Additionally, a custom circumference may be programmed, expressed in either inches or millimeters.

You may use wheels designed to work with either beaded wire or punched steel tapes. Any wheel used should have an insulating hub in order to protect the unit from lightning. Most wheels attach to the shaft using an Allen screw. Attach the float and counter weight to the tape or beaded wire per the instructions provided. Set both the float and counter weight into the stilling well and mount the tape/beaded wire onto the wheel.

Checking the Direction of Rotation

Rotate the shaft to see if the direction of rotation is set properly (I.E. when float rises, level increases). If the level does not change as desired, either turn the tape around (put the float on the other side of the wheel) or use the setup menus to change the direction of rotation.

Calibrating the Stage Value

Once the unit is secured, and all of the parameters are configured, the stage must be calibrated (set). This is done from the Stage display in the main menu. Simply go to the Stage display and press SET. Use the arrow keys to change the value for the stage and press SET again or CANCEL.

6. Maintenance

The SDR is designed to operate for extended periods with very little or no maintenance required. If a site visit is needed for any reason, it is a good idea to perform a routine maintenance check of the encoder. Some easy to follow guidelines are listed below.

1. Perform a visual inspection of the unit. Note any abnormalities such as external oxidation, rust.

2. Check the wiring to make sure it is not corroded, frayed, or loose.

3. Press any button to turn on the display. Once the stage reading is shown, verify the reading matches the staff gauge installed at the site.

4. Download the data and events. Examine the log for any abnormal readings or events.

6.1   Trouble-Shooting Common Problems

1. **Unit will not power on.**

   Verify power wtih a multimeter directly on the terminal block screws. a common issue is the terminal block has been tightened onto the wire insulation, instead of the conductor.

2. **Display backlight turns on but no menus are visible.**

   Adjust the contrast until the menus are readable.

3. **SDI-12 communications do not work.**

   a) Check wiring to Data Recorder including power connections and SDI-12 Data Line.

   b) Check the SDI-12 address and make sure the Data Recorder is set the same as the Water Monitor.

   c) If multiple SDI-12 sensors are connected, verify each sensor has a unique address.

4. **RS-232 communications do not work with a terminal program.**

   a) Verify the terminal settings (115200, 8, N, 1) and that the terminal program is set to the correct com port of the pc/laptop.

   b) Verify the Water Monitor has not been configured for MODBUS

5. **The Water Monitor does not track the observed readings.**

   a) Check the setup for a wrong wheel size or, if using analog, for wrong slope/offset.

   b) Check the rotation direction for wheel is set correctly.

Appendix A - Specifications for SDR

Input Voltage	5.5 to 16 VDC reverse voltage protected
Power Consumption	< 3.5 mA @ 12 VDC (3mA Typical)
Starting Torque	< 0.25 inch-ounce
Shaft Diameter	5/16 inch with both threads and a flat
Rotation Resolution	400 count per revolution
Range	+/- 80 ft of the set value
Display	2 line, 20 character per line with backlight
Bearing Supports	Double bearing arrangement supports up to 10 lb. shaft load
Supported Wheels	12", 18", 375mm circumference. Any other circumference may be programmed in manually.
Supported Units	Feet, Meters
Maximum Rotation Speed	5.5 rev/s
Log Capacity	Over 300,000 readings
Discharge Calculations	Parshall Flume, Weir (w*Stage^1.5), Generic (A*Stage^B), Dual Sensor, Rating Table

Ordering Information

Part Number	Description
SDR-0001-1	SDR with 400-count optical shaft encoder, no pulley
SDR-0001-3	SDR with expanded analog input options, including 4-20mA output, without a shaft encoder.
SDR-0001-4	SDR with both shaft encoder and expanded analog input options, including 4-20mA output.

Appendix B – Connector Pins

DB9 Connector

The SDR comes with a DB9F connector for connection to RS-232 devices. The DB9F can be connected to the serial port on most PCs using a straight cable. A null modem adapter is needed to connect to most PDAs. The following table shows the pin assignments in the DB9F connector.

DB9F Pin	Name	Notes
1	N/C	No Connection
2	RXD	Data from SDR
3	TXD	Data to the SDR
4	DTR	Signal to the SDR
5	Ground	
6	N/C	No Connection
7	RTS	Request to Send, signal to the SDR
8	CTS	Clear to Send, signal from the SDR
9	VOUT	Jumper selectable for 5V or VBAT (100ma max)

Terminal Block

Terminal Block	Description	Notes
1	BAT G	Battery Ground (-)
2	BAT +	Battery +
3		
4		
5	SDI G	Also can be used for Battery Ground
6	SDI +	Also can be used for Battery +
7	SDI D	
8	Shield	

Appendix C – Sutron Customer Service Policy & Warranty

Customer Service Policy

Dear Customer:

Thank you for making the important decision to purchase Sutron equipment. All Sutron equipment is manufactured and tested to the highest quality standards as set by Sutron's Quality Assurance Department. Our Customer Service Representatives have years of experience with equipment, systems, and services. They are electronic technicians with field and applications experience, not just with a technical background.

CUSTOMER PHONE SUPPORT

Customer Service Representatives routinely handle a wide variety of questions every day. If questions arise, please feel free to contact me or one of the Customer Service Representatives. We are available from 8:00 am to 5:00 pm Monday through Friday and will be happy to take your call.

We can answer most sensor and interface questions on the first call. If we cannot quickly answer a question on an interface, we will work with you until we find a solution.

Sometimes a problem is application related. Although we pride ourselves on handling 95% of application related questions over the phone, we maintain constant contact with our Integrated Systems Division and Engineering Division for additional assistance.

INTRODUCTORY TRAINING

Training is an important part of the Sutron Customer Service philosophy. The Sutron training policy is simple---If you buy Sutron equipment, you get Sutron training! Without the proper training, you cannot take advantage of the benefits and advantages that Sutron equipment provides. We often supply on-site introductory training at your facility for no charge. You provide the classroom, students, equipment, and coffee---we'll provide the instructor.

ON-SITE VISITS

Of course not all problems can be fixed over the phone. Sometimes a customer needs an on-site technician to identify site related problems or troubleshoot a network. Sutron can provide these services at a reasonable cost. Call for details. If you would like to learn more about Sutron products email sales@sutron.com

Thanks again for your order,

Paul Delisi
Customer Service Manager
Sutron Corporation

Commercial Warranty

SUTRON MANUFACTURED EQUIPMENT

THE SUTRON CORPORATION WARRANTS that the equipment manufactured by its Manufacturing Division shall conform to applicable specifications and shall remain free from defects in workmanship and material for a period ending two years from the date of shipment from Sutron's plant.

Sutron's obligation under this Warranty shall be limited to repair at the factory (22400 Davis Drive, Sterling, VA 20164) or, at Sutron's option, replacement of the defective product. In no event shall Sutron be responsible for incidental or consequential damages, whether or not foreseeable or whether or not Sutron has knowledge of the possibility of such damages. This Warranty shall not apply to products that have been damaged through negligence, accident, misuse or acts of nature such as floods, fires, earthquakes, lightning strikes, etc.

Sutron's liability, whether in contract or in tort, arising out of warranties or representations, instructions or defects from any cause, shall be limited exclusively to repair or replacement parts under the aforesaid conditions.

Sutron requires the return of the defective electronic products or parts to the factory to establish claim under this Warranty. The customer shall pre-pay transportation charges to the factory. Sutron shall pay transportation charges for the return of the repaired equipment to the customer when the validity of the damage claim has been established. Otherwise, Sutron will pre-pay shipment and bill the amount to the customer. All shipments shall be accomplished by best-way surface freight.

Sutron shall in no event assume any responsibility for repairs or alterations made other than by Sutron. Any products repaired or replaced under this Warranty will be warranted for the balance of the Warranty period or for a period of 180 days from the repair shipment date, whichever is greater. Products repaired at cost will be warranted for 90 days from the date of shipment.

NON-SUTRON MANUFACTURED EQUIPMENT

The above Warranty applies only to products manufactured by Sutron. Equipment provided, but not manufactured by Sutron, is warranted and will be repaired to the extent of and according to the current terms and conditions of the respective equipment manufacturers.

EXTENDED WARRANTY AND ON-SITE MAINTENANCE

Extended warranty and on-site maintenance contracts are available. Price quotations may be obtained from Sutron Customer Service Representatives.

Appendix D – Analog Option SDR-0001 -3 and -4

The Stage-Discharge Recorder (SDR) model numbers SDR-0001-3 and SDR-0001-4 are modified versions of the standard SDR recorder that include the addition of a special analog input card located on the end panel of the SDR. The main feature of this option is to _allow the SDR to use other various types of sensors._

The SDR-0001-3 has an expanded analog input board that includes an 4-20mA output but does not have the shaft encoder.

The SDR-0001-4 includes expanded analog input board that includes an 4-20mA output and the shaft encoder.

Starting with software version 3.00, SDR can collect data from two stage sensors. Any two inputs may be used. One option is to setup two analog inputs; another is to setup one shaft encoder input and one analog input.
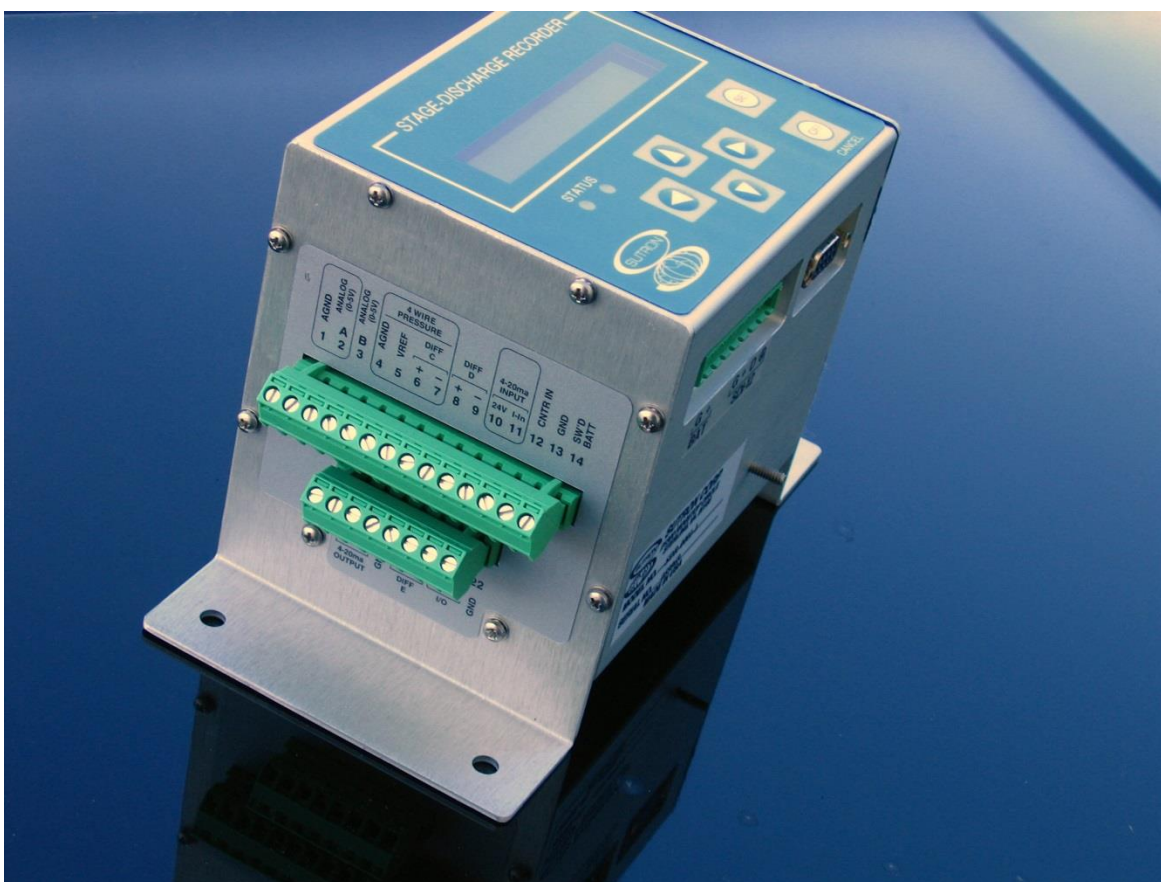
Types Of Sensors Used to Calculate Stage

- Pressure (level) sensors. Pressure sensors have several advantages over shaft encoders in some installations and a pressure sensor, such as a Druck, can be either a 4 wire bridge type or a 4-20ma type.

- Ultrasonic type water level sensors with 4-20ma Output. The SDR supports ultrasonic type such as Flowline ordered with 4-20ma outputs.

- Any other 0-5 Volt analog type sensors, such as a potentiometer, may be used in the general analog input class.

Any of the above mentioned sensors or other analog level sensors may be used with the SDR in order to calculate the stage. The sensor will use a slope and offset to convert the electrical reading into a stage level.

SDR-0001-3 SDR w/Voltage & 4-20ma Input & 4-20ma Output
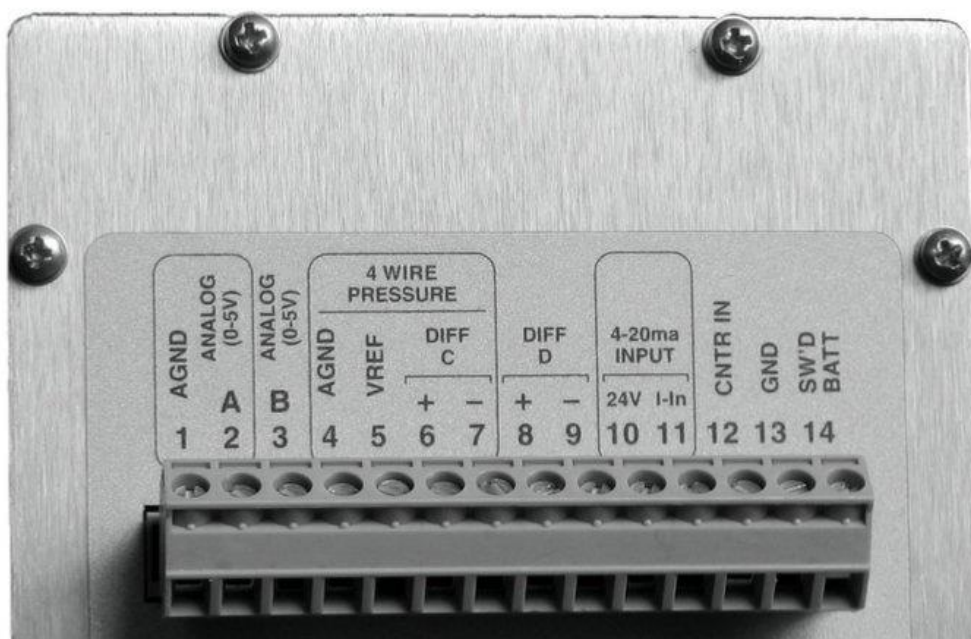
Terminal Block (UPPER)

Note the circled areas. These circled areas assist the user in connecting a sensor to the proper group of wires. The following section will help define the input types.

Terminal Block	Description	Notes
1	AGND	Analog Ground
2	Analog 0-5V 'A'	Voltage input for stage sensors with 0-5V output
3	Analog 0-5V 'B'	Voltage input for stage sensors with 0-5V output
4	AGND	Analog Ground
5	VREF	2.5V output which is turned on during warmup and analog sensor measurement
6	DIFF 'C' (+)	Differential Voltage Input for Bridge type sensors
7	DIFF 'C' (-)	
8	DIFF 'D' (+)	Differential Voltage Input for Bridge type sensors
9	DIFF 'D' (-)	
10	24V (4-20ma)	24 Volt output for 2 wire 4-20ma sensor
11	I-Input (4-20ma)	Current input for 2 wire 4-20ma sensor
12	Counter Input	Future Support
13	Gnd	Digital Ground
14	SW'D Batt	Switched Battery (turned on during warmup and analog sensor measurement)
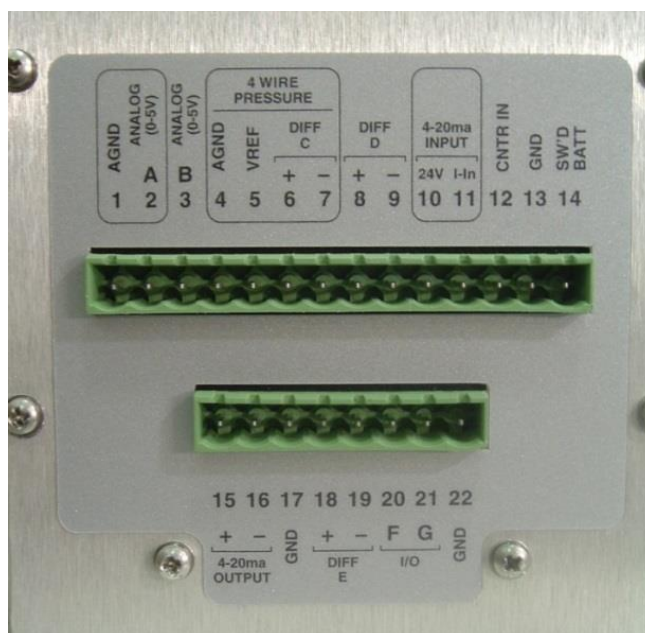
Terminal Block (LOWER)

Note the bracketed areas. These bracketed areas are intended to assist the user in connecting a sensor to the proper group of wires. The section below will help define the input types

Terminal Block	Description	Notes
15	4-20ma Output (+)	Connect 2 wire 'VOLTAGE' wire here (eq. 24 Volts)
16	4-20ma Output (-)	Connect 2 wire '-' terminal here
17	GND	Digital Ground
18	DIFF 'E' (+)	Differential Voltage Input for Bridge type sensors
19	DIFF 'E' (-)	
20	I/O 'A'	Future Support
21	I/O 'B'	Future Support
22	GND	Ground

SDR-0001-4 SDR w/Voltage and 4-20ma Input *and* 4-20ma Output plus Shaft Encoder

This model of the SDR includes both the shaft encoder and the expanded analog board with the 4-20mA output. It's analog inputs are identical to the SDR-0001-3.

Analog Input Types Found on both -3 and -4 Analog Versions

Single Ended Input Voltage (0 to 5 Volts)

This input is designed to be a general purpose 0-5 volt dc input. While sometimes referred to as a single ended input, it is designed to measure voltage with respect to analog GROUND.   This input has a high impedance (>2 Meg Ohms) and will not load down or draw significant current. Two inputs are labeled "Analog 0-5V "on the panel, they are 'A' and 'B', although the current SDR software will only measure and support the Analog "A" input.
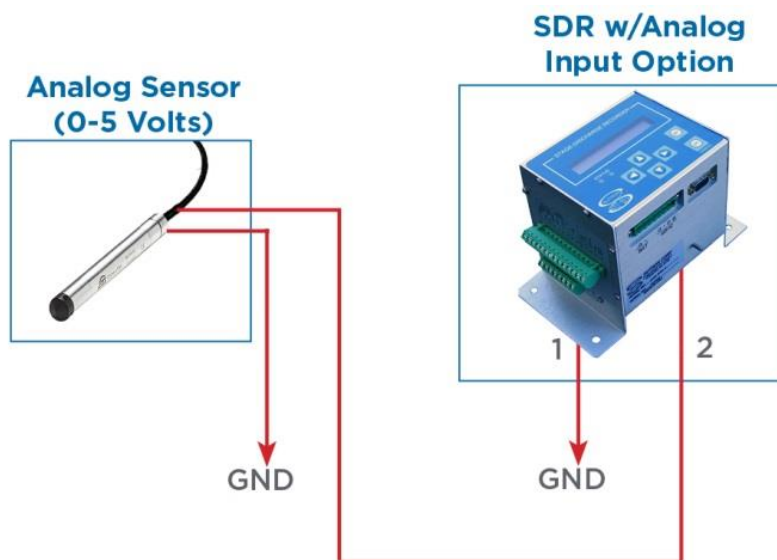
When the measurement type "Analog A 0-5" is selected, the system will make a voltage reading from the sensor connected on the input labeled Analog "A". It will then apply the user entered SLOPE and OFFSET to convert the voltage reading to a stage level by applying the following equation:

Stage = (Voltage * SLOPE) + OFFSET

Differential Input Voltage (+/- 39mV range)

This input is designed to operate with a special type of analog output found on many pressure sensors that use a "bridge" configuration or any sensor that outputs a very small voltage. This input type has a "+" and "-" input that connects to the sensor output. Two inputs are labeled "Diff" on the panel, they are 'C' and 'D', although the current SDR software will only measure and support the Analog Diff "C" input.

Typically in a bridge sensor, the sensor will be powered from the "VREF" output also called Excitation in the pressure sensor manuals, have a "signal +" and "signal -" and the 4th wire for the analog ground. **NOTE:** If after wiring the sensor, it displays a negative reading, you may reverse the "+" and "-" leads coming from the sensor.

**BRIDGE TYPE
SENSOR**
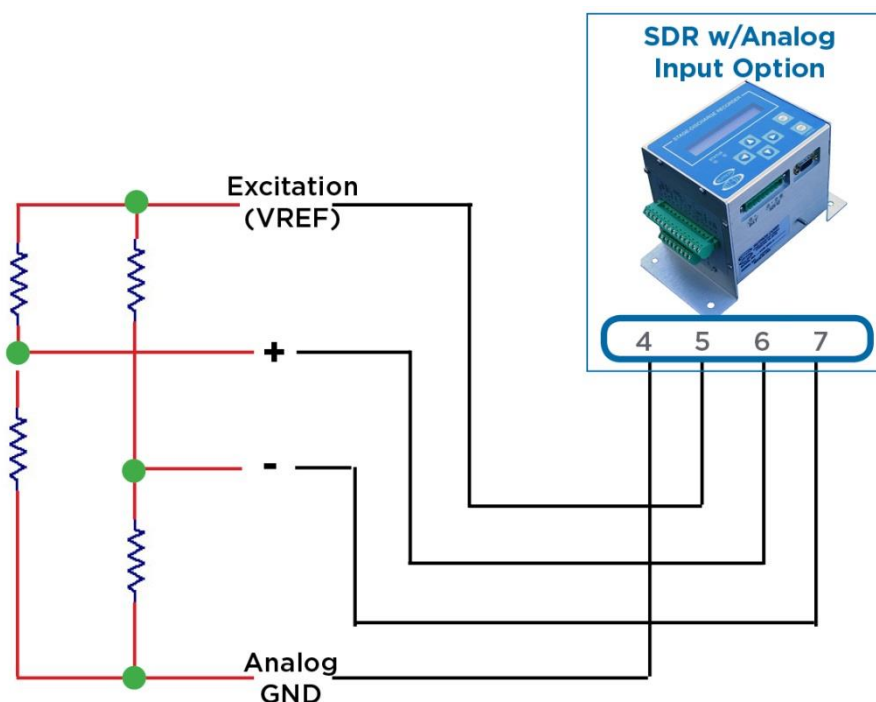
VALID INPUT RANGE +/- 0.0390625 Volts

The returned reading will be in Volts; it ranges from -0.0390625V to +0.0390625V. This applies if the Slope = 1 and the offset = 0.

The system will make a reading of the voltage across the + and – inputs labeled for the "Diff C" input. It will then apply the user entered SLOPE and OFFSET to convert the voltage to a stage level by applying the following equation:

$$Stage = (Voltage* SLOPE) + OFFSET$$

NOTE: The common mode voltage for differential sensors is 0.5V to 3.7V. If the sensor is floating, it should be tied to VREF and not to AGND in order to maintain this common mode voltage.

4 to 20 ma Current Loop Input

This input is designed to function with sensors that have a 4 to 20ma current loop interface. This type of interface is superior to voltage outputs when the cables to the sensors must travel a long distance or when the equipment is located in electrically noisy environments. The current required for the sensor is provided by the 2 wire loop and does not typically require additional connections. The SDR analog card has a 24 Volt supply that is designed just for the 2 wire interface 4-20ma loop.

```
                                            ┌─────────────────────┐
                                            │ SDR with Analog     │
                                            │ Input Option.       │
                                            │                     │
                                            │     10     11       │
                                            │                     │
                                            │    24 v    I-In      │
                                            └─────────────────────┘
       ┌──────────┐
       │  4-20    │
       │  ma      │
       │          │
       └──────────┘

                        ┌────────────────────────────────────────┐
                        │   VALID INPUT RANGE   4 to 20 mA        │
                        └────────────────────────────────────────┘
```
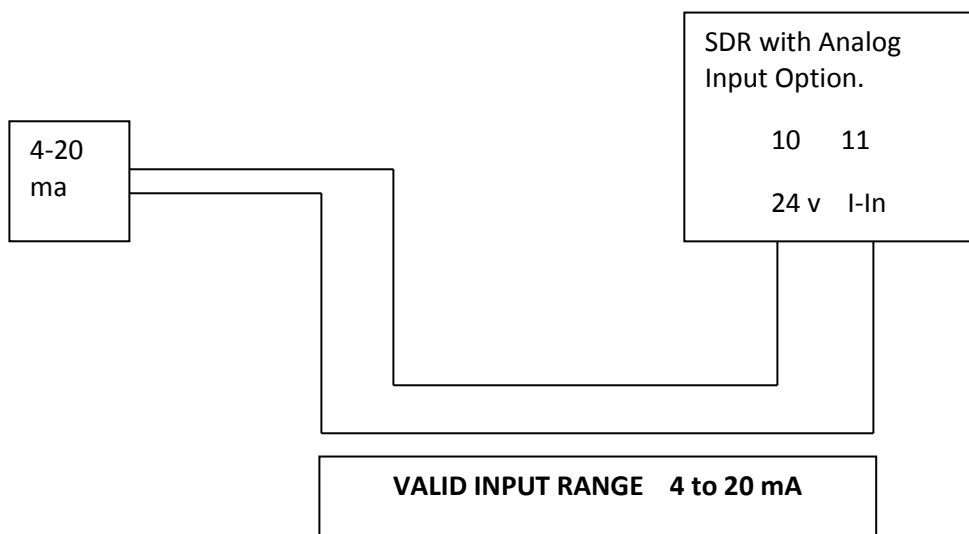
This SDR analog input will measure the current flowing when connected to the '4-20ma Input'. Typical 4-20ma sensors will give a 4 to 20ma current for a 0 and 100% FS. Readings that are greater than 21mA will be considered a fault by the SDR.

 The SDR will convert the 4 to 20ma readings from 'ma' to 'stage' by using the slope and offset fields by applying the following equation:

Stage = (current * SLOPE) + OFFSET

Additional Menu Items to Support Analog Input Sensors

An SDR with an analog expansion board will have a slightly different Station Setup menu structure. It will offer additional options for setting up the analog sensor(s):

> *Station Setup*
> > *Measurement Setup*
> > > *Stage Sensor*
> > > > *Sensor Type*
> > > > *Analog Warmup*
> > > > *Slope*
> > > > *Offset*
> > > > *Averaging Time*
> > > > *Test Sensor*
> > > *Second Sensor*
> > > > *Sensor Type*
> > > > *Analog Warmup*
> > > > *Slope*
> > > > *Offset*
> > > > *Averaging Time*
> > > > *Test Sensor*

Sensor Type

This field will allow the choice of several analog inputs. Please choose the input appropriate for your sensor (see section above). Note that the selection will determine both the input connector and the sensor type. These options are available:

- *Analog A 0-5V*
- *Analog 4-20mA*
- *Analog Diff C*
- *Analog B 0-5V*
- *Analog Diff D*
- *Analog Diff E*

Once an analog the sensor type is selected, proceed to setup the following fields.

Sensor Warmup

This time field will determine how long in advance of the reading the Switched Battery is turned on. This also controls the VREF (2.5 volts) output. Provide enough warmup time to make a good reading from the sensor without wasting too much time and battery power. Warmup time is sensor specific.

Slope

Enter a value for the slope as required to convert volts, milliamps, or ratiometric values into numbers that represent stage in feet or meters. Positive and negative values may be entered. Simply toggle the "+" sign to a "-" sign when entering the value.

Offset

This offset, when combined with the **slope** above, will complete the conversion of physical readings to STAGE level. Positive and negative values may be entered. Simply toggle the "+" sign to a "-" sign when entering the value.

Averaging Time

The SDR can be setup to do **simple averaging**, meaning that it will collect data the user specified amount of time. Once the time is up, it will sum up all the samples and divide the sum by the number of samples collected.   Averaging time should be used for noisy sensors and for choppy water surfaces.

If averaging time is zero (which is the default), no averaging is done. If it is not zero, the unit will collect data for however long the averaging time is setup for. The value can be set anywhere from 0 seconds (no averaging) to 900 seconds (15 minutes).

Please note that the Stage readings on the front panel will only update as fast as the averaging interval. That means that if the averaging time is set to 10 minutes, the display will update only once every 10 minutes!

Additional Setup Comments

▸   When the shaft encoder is installed and selected for operation, the menu fields for the Analog options are not visible. Conversely, if the Analog inputs are selected, the shaft encoder menu fields are not visible.

▸   Slope and Offset values must be entered in the SDR setup fields as they are extremely important in converting the reading into a STAGE value, which is the ultimate goal of the SDR and that is what is logged. Consult the Connecting Sensors to verify that he sensor is connected properly, and equally important, configured properly.

▸   There is a 'Sensor test' menu at the bottom of the Sensor Setup menu. Pressing SET in this menu will cause the SDR to measure the analog sensor and report both the raw voltage provided by the sensor, and the completed measurement result (which is the raw voltage with the slope and offset applied). In addition, the warmup time will be tested to make sure it is adequate (it is tested by first turning off VRef and Switched Battery, waiting a while and then applying power to the sensor for warmup time).

▸   Once the system is properly setup and installed in the field application, the "Calibration" process must be executed as described in page 10 of this manual.

Example Analog Sensor Setups

SENSOR 1:   'DRUCK' Pressure Sensor (10 PSI range)

The DRUCK TM brand of pressure sensors is a common alternative to the shaft encoder type of application. This application note will show operation using the DRUCK model PDCR 1830.

This sensor is a bridge sensor that is designed to be driven by a voltage, VREF in this case, and the output of the bridge is a differential reading that will have a full scale output that is $1/10^{th}$ of the VREF. Since VREF is 2.5 volts, the Full Scale, or FS output of the sensor will be 25 mv. Since the Differential Input Range is 39.0625 mV, then the 25mV FS of the sensor is always within range.

The nature of the bridge sensor will automatically place the differential reading in the allowable common mode range of the Differential input and in this case, in the ballpark of 1.25 volts.

Connect the sensor as follows:
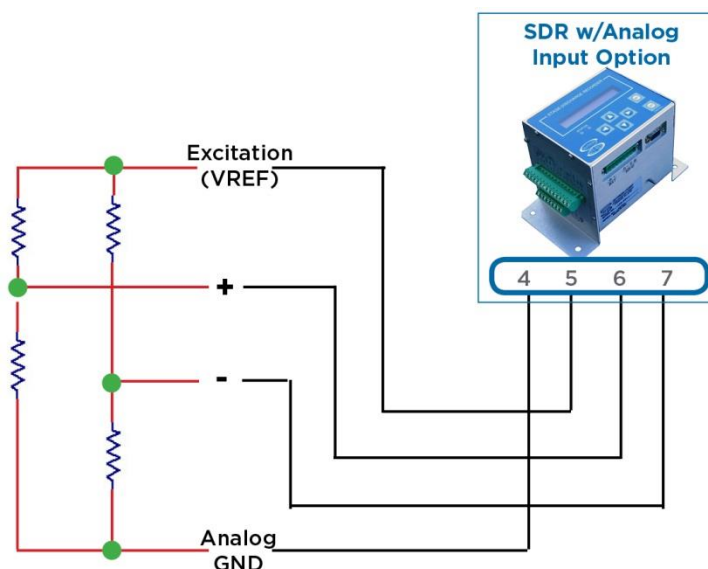
Terminal Block	Description	DRUCK Pin Description	COLOR
3			
4	AGND	Negative Supply	WHITE
5	VREF	Positive Supply	RED
6	DIFF 'C' (+)	Positive Output	YELLOW
7	DIFF 'C' (-)	Negative Output	BLUE
8			

NOTE: Connect the shield wire on the DRUCK to the earth ground on the side of the SDR.

SDR SETUP CONFIGURATION

▶ In the menus, select the "Analog DIFF C" sensor.
▶ Set warmup time to 500 ms.
▶ Set slope to 922.92

▶ Set offset to 0.0
▶ Set units to Feet.

The slope is calculated as follows:

(10 PSI / 25 mV) * (1000 mV / 1 V) * (2.3073 feet / PSI) = 922.92 feet / V

Take measurements and confirm operation. Executing a 'calibration' will allow the level to be adjusted to match a staff gauge if available.

SENSOR 2:   FlowLine Ultrasonic Sensor (4-20ma sensor)

The Flowline brand of ultrasonic sensor is designed to output a 4 to 20 ma current output that is proportional to 0 and Full Scale range of the sensor. This example will be worked with the Flowline Model LA15.

The output range is 3.6 inches to 6 feet (72 inches).
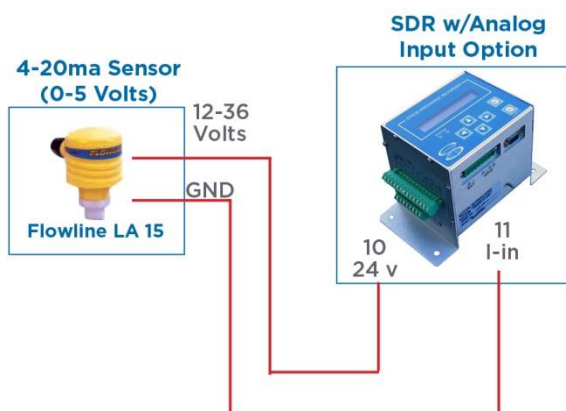
Terminal Block	Description	Flowline Pin Description	COLOR
10	24V (4-20ma)	12-36 Volts DC	na
11	I-Input (4-20ma)	GND	na

SDR SETUP CONFIGURATION for FLOWLINE Type Sensor (for readings in <u>feet</u>)

As this sensor reads distance from sensor to water, using the settings below will reverse that direction providing values that fall when the water level falls. All that is required is to perform a stage calibration following this setup.

▶   In the menus, select the "Analog 4-20ma" sensor.

▶   Set warmup time to 20,000 ms.   (20 Seconds)

▶   Set slope to + 0.35625

▶   Set offset to +0.00

▶ Set Units to Feet

Take measurements and confirm operation. Executing a 'calibration' will allow the level to be adjusted to match a staff gauge if available.

Note that the Flowline sensor takes about 20 or more seconds or so to make a stable reading. This example shows 20 seconds for warmup.

General Transfer Function for Flowline LA15: Note: This is the distance from sensor to water height, so as water falls, the sensor reads higher values.

Transfer Function for Flowline LA 15

$$y = -0.35625x + 7.42500$$
$$R^2 = 1.00000$$

Distance (Feet) vs. Current Loop (ma)
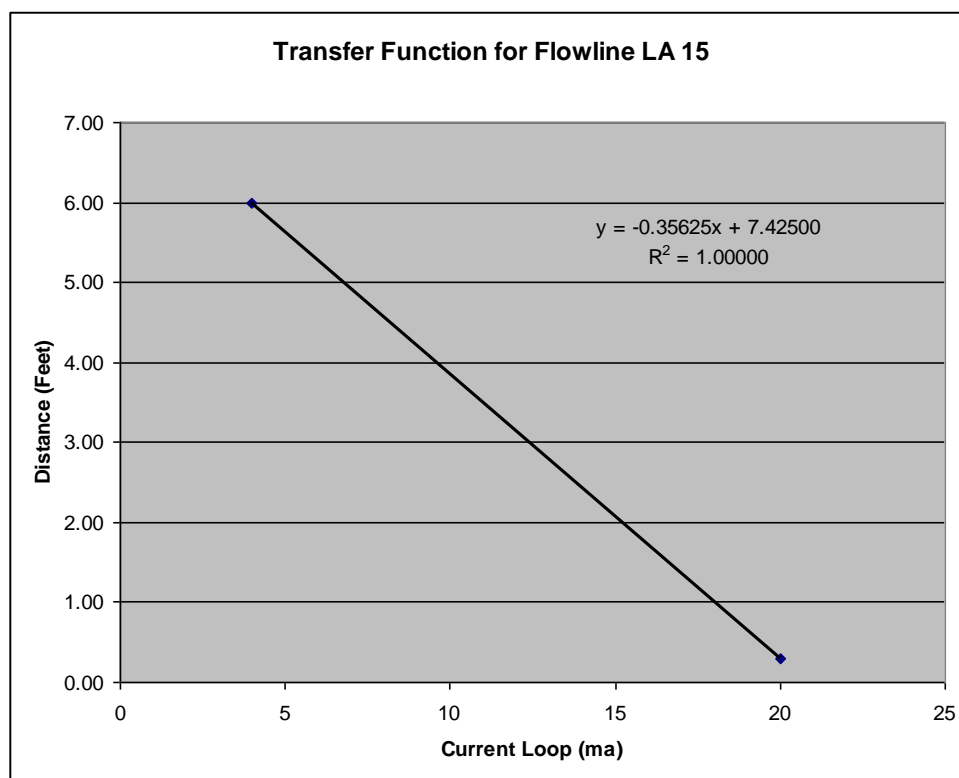
4-20mA Output

SDR-0001-3 and SDR-0001-4 (which feature the expanded analog option board with the 4-20mA output) running software version 3.02 or newer can express the current reading via the 4-20mA output. That means that the SDR will output a current that corresponds to either stage, stage two, discharge, or volume.

An external device needs to be connected to pins labeled '4-20ma output' (pins 15 and 16) of SDR's analog option board. That device will provide power to the SDR (8V to 36V) and read the value output by the SDR. As long as the external device is proving power to the SDR, the SDR will output the proper current on the loop. How often the SDR updates that current to match the stage reading is based on the Update Interval (see below).

Settings that control 4-20mA output behavior can be found via the front panel under:

Station Setup -> Other Setup -> 4-20mA Output

4-20mA output behavior is controlled by these settings:

- ▸ *4-20mA Out Enable* (default disable)
- ▸ *4-20mA Out Source* (default Stage)
- ▸ *EGU Hi* (default 10, 2 right digits)
- ▸ *EGU Lo* (default 00, 2 right digits)
- ▸ *Update interval* (express in seconds, default to 1.0 seconds)

If 4-20mA output is enabled, the SDR will periodically update the current output on the 4-20mA circuit. How often the current is updated to match the stage reading depends on the user setting *Update Interval*. **The device reading the 4-20mA circuit needs to give the SDR an amount of time greater than the *Update Interval* between powering the 4-20mA circuit and reading the 4-20mA current.**

4-20mA Out Source setting determines what value is converted to the 4-20mA output. The choices include stage, stage two, discharge, and volume.

The value of the 4-20mA current output by the SDR will depend on the stage reading and the user set variables *EGU Hi* and *EGU Lo*.

- ▸ *EGU Lo* is the stage reading for which 4mA are output
- ▸ *EGU Hi* is the stage reading for which 20mA are output

E.g. if *EGU Lo* is 0 feet *EGU Hi* is 10 feet, a stage reading of 0ft corresponds to 4mA, 5 feet corresponds to 12mA, and 10 feet to 20mA.

EGU Hi and EGU Lo are expressed in the user chosen units, which can be feet or meters.

When the stage read by the SDR is out of range of *EGU Hi* and *EGU Lo*, the following values are output on the 4-20mA circuit:

- ▸ 3.5mA output if stage is less than EGU Lo
- ▸ 24mA output if stage it is greater than EGU Hi

Using 4-20mA consumes additional power. The shorter the *update interval*, the higher the power consumption.

When wiring the SDR as a 4-20mA output sensor, please follow this diagram:
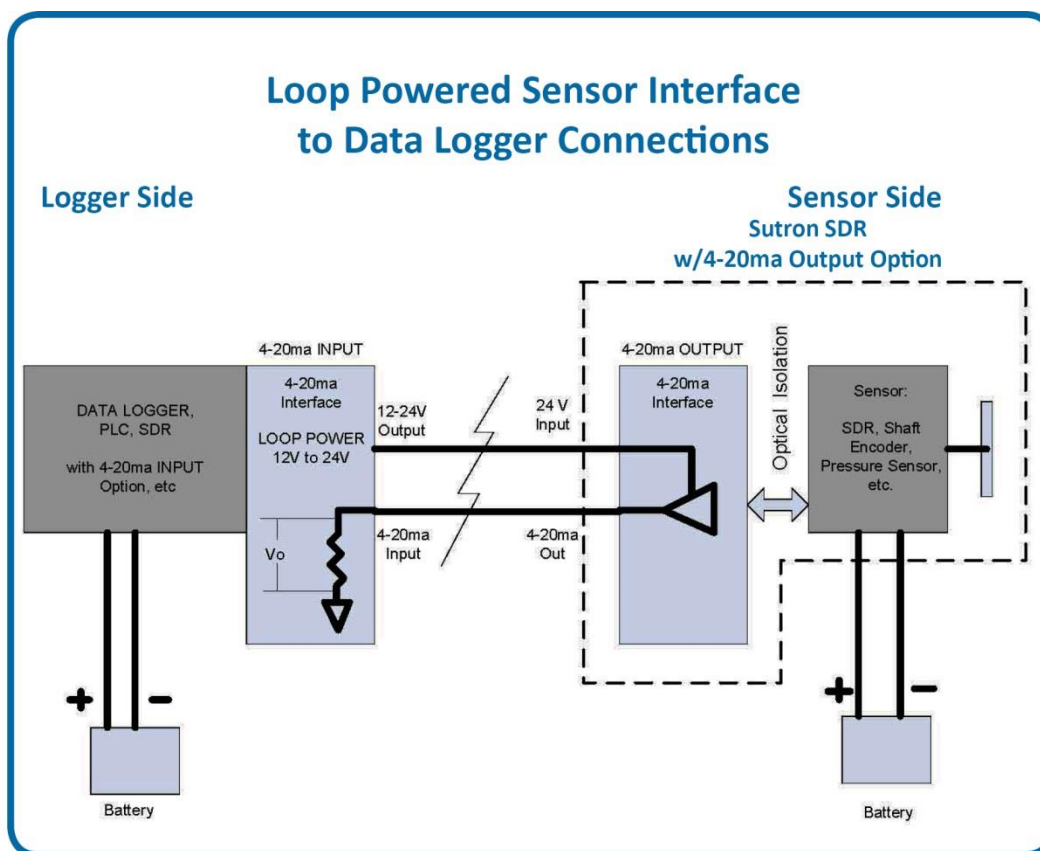
Note: Applications that are located physically close may share the same battery.

If you are setting up on a test on the bench (without a 4-20mA logger), you will need a power supply, a current meter, and an SDR. Please wire:

▸   +12V on the power supply to + of the current meter
▸   Ground of the current meter to 4-20mA output + (pin 15) on the SDR
▸   4-20mA output – (pin 16) on the SDR to ground on the power supply

Setup and turn on SDR's 4-20mA output circuit. Rotate the SDR shaft. Note how the current changes with the SDR's stage. To have the current output match the stage, set *EGU Hi* to 20 and *EGU Lo* to 4 and keep the stage between 4 and 20.

Analog Performance Specifications

Analog Inputs

Number Of Inputs:

- ▶ 2 Single Ended (0 to 5 Volt)
- ▶ 3 Differential ratiometric (common mode 0.05 to 4.5 Volts)
- ▶ 1 4-20mA dedicated input

Resolution:

- ▶ 24 Bit A/D converter, 0.0015% FS resolution.

Accuracy:

- ▶ +/- 0.02% FS @ 25C (5VFS = 100uV)

Temperature Coefficient:

- ▶ +/- 5 ppm/C typical
- ▶ +/- 10 ppm/C maximum

Linearity:

- ▶ +/- 0.005% FS

Reference Output

- ▶ 2.5 Volt, 10 ma max reference output for temperature sensors, bridge references, etc.

4-20 mA Dedicated Input

- ▶ Accuracy 0.02 % FS at room temp
- ▶ Voltage Generation of 18 Volts to source 4-20ma sensor; 50ma capable; *Independently* switched just for 4-20 ma sensors
- ▶ Reverse protected

Switched 'Vbatt' Output: (Controls Power To Sensors)

- ▶ Output current capability: 200 ma nominal.
- ▶ Short circuit protected.

4-20mA Output Specifications:

Accuracy at 25 C	+/- 0.2% FS
Resolution	16 bit over 4 to 20ma range (244nA)
Drift over Temp	+/- 50 ppm/C
Loop Voltage Range	8 to 36 Volts
Reading Refresh Rate	user settable (Update Interval)
Quiescent current consumption (not counting 4 to 20 ma output)	575 uA (typ)
Operating Temp Range	-40C to +60 C

Appendix F – Ground Water Monitor Device Type

The SDR has the capability of operating as a Ground Water Monitor. The Ground Water Monitor device operates very similarly to the standard SDR and shares many of the same features and operative abilities. The Ground Water Monitor is different in that it is meant to calculate and log only the water level, therefore it has no capabilities to calculate stage or discharge. The Ground Water Monitor mode is most commonly used when monitoring the water levels in wells.

Features

▸   Measures water level relative to land surface datum.
▸   Allows entry of measurement and reference points.
▸   Can measure water level via optical shaft encoder or submersible analog sensor.

Changing the Device Type

The device type of the SDR can be set by accessing the "Device type" setting in the "Station Setup" submenu on the front panel display of the SDR. When the display reads "Device type" press SET and use the arrow keys to choose either "Stage Discharge Rec." or "Ground Water Monitor". Press SET again to enable the change. When connected to a PC or PDA, the device type can be changed in SDRComm by selecting "Change device type…" in the "Tools" drop down menu.

Changeable Values

The following is a list of all the values that can be changed by the user:

▸   Measurement Interval: 1, 5, 10, 15, 20, 30, 60 minutes
▸   Wheel Size: 12 inches, 18 inches, 375 mm, Custom circumference
▸   Wheel Circumference: program in the custom circumference in inches or millimeters
▸   Rotation Direction: Clockwise positive, CounterCW Positive
▸   Units: Feet, Meters
▸   Right Digits: (0..7)
▸   Measuring Point: (any distance below or above LSD)
▸   Reference Point: (any distance below or above LSD)
▸   Battery Type: 12V Gell Cell, 12V Alkaline, Other
▸   Password Setup
▸   Station Name: xxxxxxxxxx
▸   Date/Time: yyyy/mm/dd hh:mm:ss

The overall menu tree for the Ground Water Monitor device type is shown on the next page.

Ground Water Monitor Mode Menu

Main Menu

Errors
Info
▲ ▼
Level **xx.xx** ft (Water Level)
 YYYY/MM/DD HH:MM:SS
▲ ▼
Distnc xxxxx.xx ft (Distance to Water)
YYYY/MM/DD HH:MM:SS
▲ ▼
Battery 13.2V
▲ ▼
Logged Data
Right shows details

▲ ▼
Logged Water Level
Right Browses Log
▲ ▼
Logged Daily Level
▲ ▼
Logged Battery
▲ ▼
Logged Events
▲ ▼

forward in time
▲ ▼
Logged value
YYYY/MM/DD HH:MM:SS
▲ ▼
back in time

Device type
Ground Water Monitor | Stage Discharge Rec.
▲ ▼
Measurement Interval
1 | 5 | 10 | 15 | 30 | 60 Minutes
▲ ▼
Wheel Size
375mm | 12 inch | 18 inches
▲ ▼
Rotation Direction
CounterCW Positive | Clockwise
▲ ▼
Units
Feet | Meters
▲ ▼
Right Digits
3
▲ ▼
Measuring Point
0.0 Above/Below LSD
▲ ▼
Reference Point
0.0 Above/Below LSD
▲ ▼
Battery Type (x.xV)
12V Gell Cell | 12 V Alkaline | Other
▲ ▼
Password Setup
Info
▲ ▼
Station **Demo1**
2005/04/01 10:30:57
▲ ▼
Default Setup
▲ ▼
Software Version
▲ ▼

▲ ▼
Station Setup
Right shows details
▲ ▼
Station **xxxxx**
YYYY/MM/DD HH:MM:SS
▲ ▼

Press SET – initiate change of value
Changeable values are shown in **bold** on this card
Press OFF – cancel a change, turn display off
Hold SET – turn on backlight
Hold ▲ -- increase contrast
Hold ▼ – decrease contrast

Errors:
Overspeed – shaft rotated too fast and encoder may have missed some counts.
Level not set – unit operating without initial level setting.
Battery Voltage low – battery voltage less than limit set based on battery type.

Setup and Operation

The Ground Water Monitor device setup and operation is almost identical to that of the standard SDR. It can use either an encoder or a pressure sensor, along with a measuring and reference point set by the user, to calculate the water level. When using an encoder, the formula for water level is:

water level = (distance to water) - measuring point (MP) MP "above" Land Surface Datum (LSD)
water level = (distance to water) + measuring point (MP)MP "below" LSD

When using a pressure sensor the formula is:

water level = offset – depth - measuring point (MP)   MP "above" LSD
water level = offset – depth + measuring point (MP)   MP "below" LSD

See the diagram on the below for reference.

*Note that water levels are positive (+) when they are below the LSD and negative (-) when above the LSD.
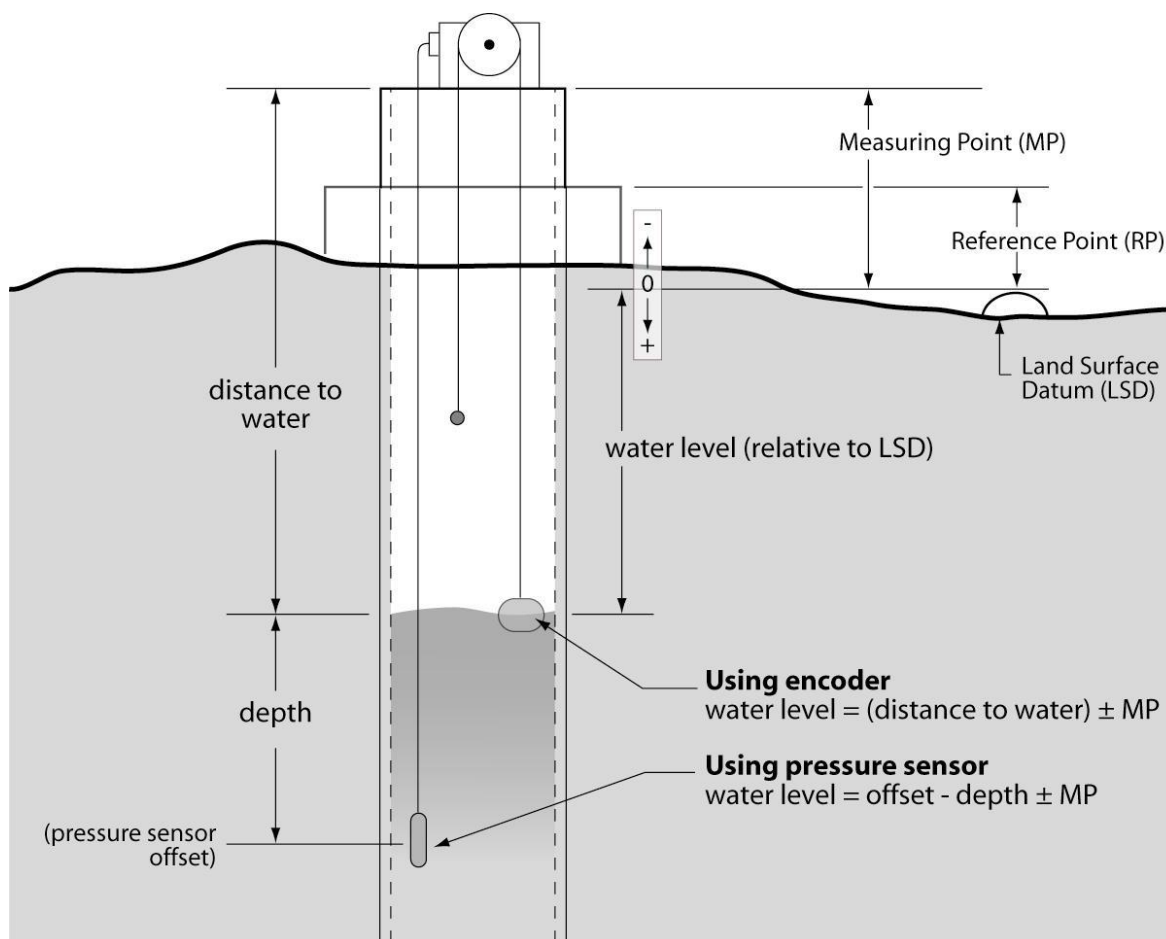
Calibrating the Water Level

You can calibrate (set) the water level from any of the menus that displays the water level or the distance to water. Simply press the SET key. The display will change the prompt to set the distance to water. Use the arrow keys to change any of the digits in the display. When the value is correct, press SET again or press CANCEL.

Please note that you are setting the *distance to water* and not the *water level*.

Setting the Measuring/Reference Point

The Ground Water Monitor allows for a measuring point (MP) and a reference point (RP) to be specified by the user. These values are relative to the LSD (Land Surface Datum) and can be set as "below" or "above" the LSD. You can set the measuring and reference point by entering the

"Station Setup" submenu on the front panel display and pressing the down arrow until the display reads "Measuring Point" or "Reference Point". Press SET once and use the arrow keys to select if the value will be "Above LSD" or "Below LSD". Press SET a second time and use the arrow keys to change the value. Pressing SET third time will set the value.

Appendix G – SDR with GPS

It is possible to use a GPS to provide the SDR with an accurate, self setting clock. SDR can be connected to a Garmin GPS 16HVS. SDR needs to be have software **version 2.20** or newer to support GPS.

Timekeeping

When equipped with a GPS, the SDR will keep UTC time. UTC (Universal Coordinated Time) is an internationally accept time standard. UTC will differ from the local time by a number of hours. Starting with version 3.02, the user can setup the SDR so that it keeps **local time** by changing the setting Local Time Offset. To get EST, set the local time offset to -5 hours.

If a Sutron Satlink (versions 6.17 and newer) is connected to the SDR via SDI-12 (in addition to the Garmin GPS), note that Satlink will set the clock of the SDR once per day. **Please ensure that Satlink's local time offset is equal to the SDR's local time offset.**

An SDR equipped with a GPS will provide a timing accuracy of ± 1 second.

GPS Installation and Setup

When first installing the GPS, make sure the GPS is positioned so that it has a clear view of the sky. Make sure to connect the GPS to the SDR via RS232. Sutron provides a custom RJ45 to RS232 connector for this purpose (the diagram for the connector is on page 83).

After connecting the two devices, go the **Station Setup** menu on the front panel of the SDR. Find the entry called *Garmin GPS* and press set to enable the GPS. Then go back to the top of the menu, and hit the down button until the **GPS status menu** is shown. If SDR is communicating with the GPS, the menu will say

GPS initializing. If the GPS has acquired a time fix, the SDR will show *GPS functioning*.

Pressing right in the GPS status menu will provide more details. If the GPS has locked on satellites and is providing accurate time, the menu will show a message such as

> *GPS has valid time*
> *5 satellites used in time fix*

Pressing down from the detailed status menu will show the **last GPS time sync**. The time show is the time when the GPS last had a time fix. If it has been more than 12 hours since the last valid time fix, the GPS is not working properly and may need to be repositioned (please see page 80).

The next entry in the menu is **local time offset**. The user can setup the SDR so that it keeps local time by changing the variable Local Time Offset. To get EST, set the local time offset to -5 hours.

When installing, it is recommended that the user wait until the GPS has valid time before leaving the station. If the GPS does not acquire the time in ten minutes, the GPS should be repositioned so that it has a better view of the sky.

Keep in mind that whenever the display is turned on, SDR will power up the GPS. This helps with GPS positioning. As long as the display is on, the SDR will provide power the GPS, allowing it to track satellites. When the display is off, the SDR will power the GPS once an hour for up to 15 minutes.

GPS Positioning

If the SDR is reporting that the **GPS cannot get a time fix**, it means that the GPS is unable to get a clear view of the sky. It could also be the case that the GPS is picking up interference. The best solution is to reposition the GPS. The GPS needs to have a **clear view of the sky** in order to properly function.

Place the GPS antenna in the most open space possible. Do not place it directly under anything nor directly beside something. Always attempt to achieve a "full sky" view with the antenna.

Place the GPS antenna high up on a pedestal or in a protected location. Flat surfaces may tend to cover with ice and snow more so than elevated locations. Keep away from areas where birds may nest.   Placement is very important and great care should be taken in selecting the location.

GPS Operation

Once every hour, the SDR will wake up the GPS. Once the GPS has acquired a time fix (should not take more than 40 seconds), the SDR will set its clock and put the GPS in low power mode. Powering the GPS once an hour provides the optimal power consumption.

In addition, whenever the display is turned on, SDR will power up the GPS. This allows the user to see whether the GPS can acquire a time fix and helps in positioning the antenna.

GPS Errors

If the GPS is either not communicating with the SDR or if the GPS cannot acquire a time fix, the SDR will blink the red LED to indicate that there is a problem. In addition, the SDR will show a message describing the problem on the front panel. Once a day, the SDR will write an event to the log indicating that it has GPS problems.

The SDR reporting **"No GPS Detected"** can indicate that the connector between the GPS and SDR is bad (please refer to the section on the connector on page 83) or that the SDR does not have its jumpers set properly (please see the section on page 81 about SDR Jumpers)

If the **GPS cannot get a time fix**, please see the section on GPS Positioning .

If the SDR reports "**GPS Comm Failure",** it means the SDR is detecting data on the RS232 line, but that the data is incomprehensible. It could indicate that the GPS has been improperly configured. If possible, try using a different GPS module.

If a faulty GPS is connect to the SDR, of it the GSP is not connected to the SDR, the SDR will take a full minute before deciding it cannot talk to the GPS. Ensure that the SDR is given enough time to talk to the GPS before leaving the station.

SDR Jumpers

There is a jumper inside the SDR that ensures that the SDR provides 12 Volts on RS232 which the Garmin GPS requires in order to function. **If the SDR is reporting "No GPS Detected"**, it may be the case that the jumper is not properly setup.

Normally, if an SDR is purchased together with a Garmin GPS, Sutron ensures that the jumpers in the SDR jumpers are properly setup. However, if the SDR was purchased at a different time than the GPS, it may be the case that the SDR does not have the jumpers setup properly.

There is a way to determine the jumper setup without opening the SDR. It does require a voltmeter. Firstly, enable the Garmin GPS setting via the front panel. Then, measure the voltage across pins 5 and 9 of the SDR RS232. Those are the two rightmost pins (closest to right side panel). One pin is above the other. If the voltage is NOT 12V, GPS will NOT work. You will then need to open the SDR and set the jumper.
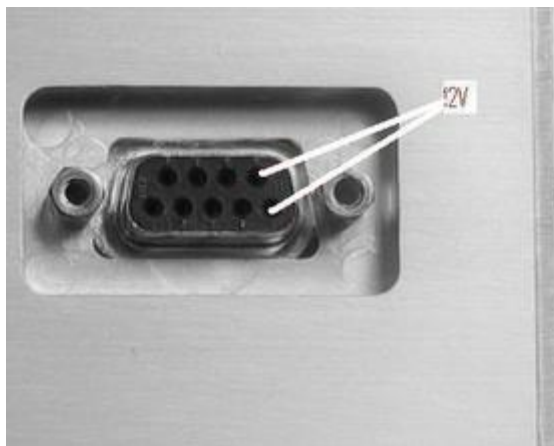
To setup the jumper, the SDR case must be opened. The RIGHT side of the SDR case needs to be opened. First remove all eight screws holding the right side of the case. Then pull hard the right side panel to remove it from the case. There is a gasket that seals the side panel to the case. This gasket can act like a glue, preventing the opening of the side panel. Make sure to pull hard, or insert a screwdriver between the panel and the case to pry the two apart.
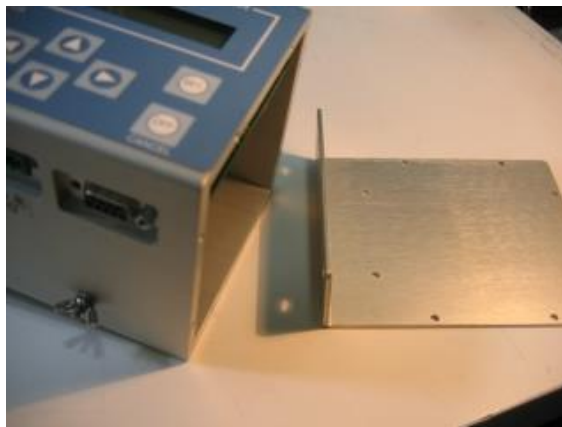
Once the right side panel is removed, the jumper is easily accessible. Place a connector on jumper J8 so that it connects Vbat to the middle pin.
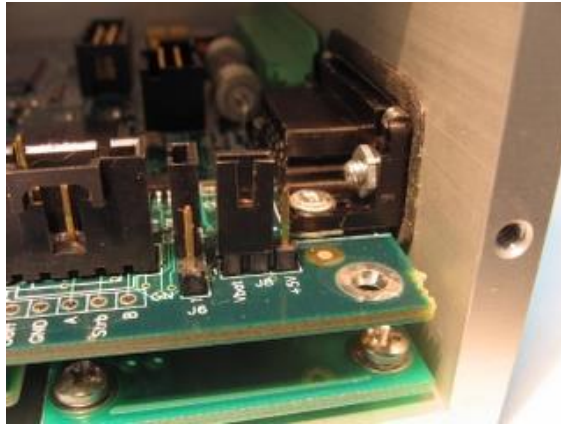
In addition to J8, there is another jumper inside the SDR that needs to be properly configured in order for the SDR to provide power to the GPS. However, this jumper is properly setup at the factory and it is unlikely to be the cause of the problem. The jumper in question is J6 (located next to J8). It should have a connector across pins 2 and 3 or have no connector at all.

Please note that the above instructions do not apply to a SDR prototype. A prototype is labeled as such on the side of the SDR Case. **Prototypes** (also referred to as Rev A) use jumper J7: connect pins 5 and 6 together, and also connect pins 2 and 4 together.

RJ45 to RS232 Connector

A custom connector is required to get the SDR and the Garmin GPS together.   The connector bridges the RJ45 on the Garmin GPS to the RS232 on the SDR. The table below provides the wiring diagram for the connector.

Note: The colors on the Garmin GPS RJ45 **do not match** the colors of the RJ45 to RS232 converter.

RJ45 pin Garmin plug color	RJ45 to Rs232 converter	RS232 on SDR	Function	Comments
1 Red	Blue	9	Power	8 to 40V for 16HVS
2 Black	Orange	5	Ground	
3 Yellow	Black	8 CTS	Remote power on/off	On if <0.3V, Off if open circuit
4 Blue	Red	2	Port 1 Data in	NMEA input to GPS
5 White	Green	3	Port 1 Data out	NMEA output from GPS
6 Gray	Yellow	no connect	PPS	1Hz
7 Green	Brown	no connect	Port 2 Data in	RTCM output
8 Violet	White	no connect	Port 2 Data out	reserved

Appendix H – Modbus on the SDR

The SDR can be configured as a Modbus slave device. In this mode, the unit will respond to properly formed Modbus messages in either RTU (default) or ASCII format. Keep in mind that when Modbus has been enabled, the unit will not be capable of connecting to a PC/PDA to download a log or make setup changes, but SDRPoll can be used to access log data.   Retrieving log data via SDRPoll is discussed in Appendix

To enable Modbus, goto the **Station Setup** menu on the front panel of the SDR and press right when the **Modbus Setup** option is shown. The first option shown is the current status of Modbus, enabled or disabled. Pressing Set will switch between the two options. If Modbus is disabled and it is turned on, a warning message will display showing that GPS and PC communications will cease to work. Hitting Set will enable Modbus.

Modbus Menu Tree

The following menu tree shows where the **Modbus Setup** menus are located within the **Station Setup** menu.
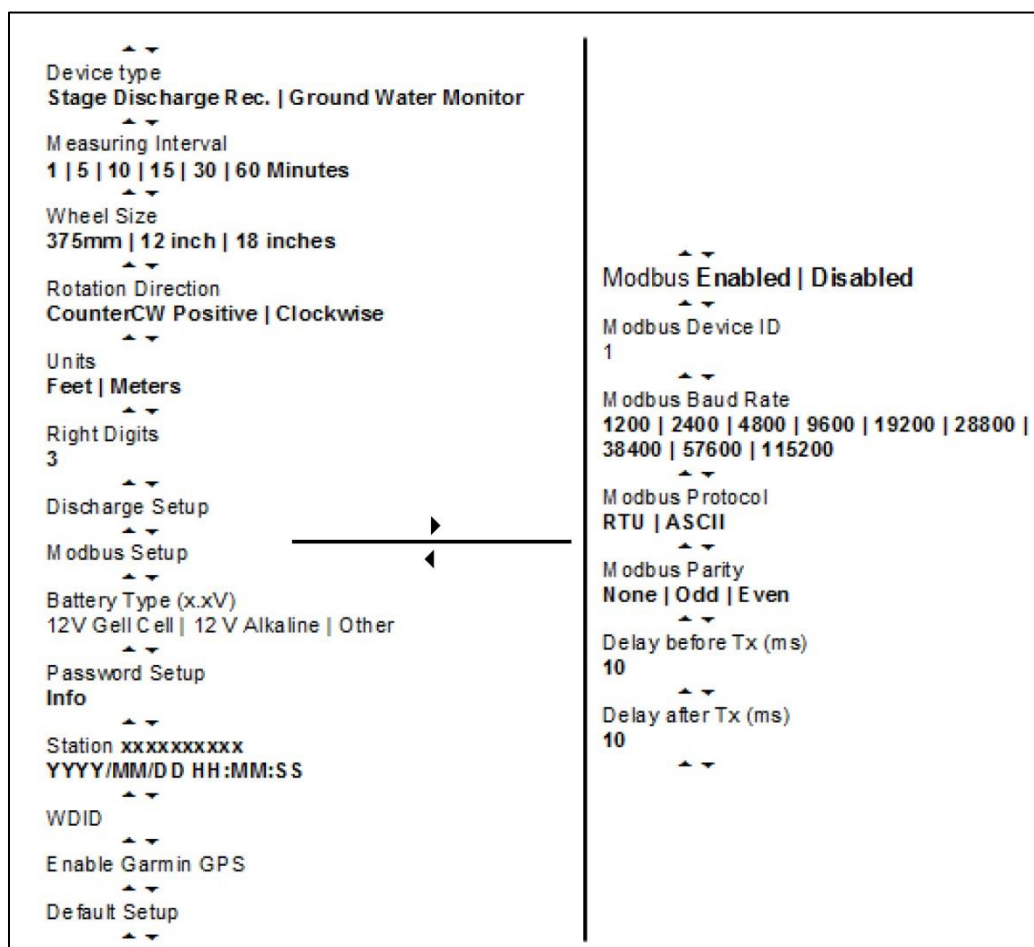
Modbus Menu Options

After enabling Modbus, other setup options become available allowing more customization of the unit. Initially, each of these settings is defaulted to those expected by the Modbus protocol.

Modbus Enabled

Default is DISABLED. Enabling will cause the unit to not communicate properly with any other type of device on the DB9 connector for example a PC/PDA or Garmin GPS unit.

Note: If GPS is enabled and Modbus is turned on, the user will be prompted with '*WARNING! GPS/PC comm. Will no longer work!*' Pressing Set will enable Modbus and disable GPS.

Modbus Device ID

Default is 1. The device ID is the address that is used by the Modbus master to select which device to communicate with. Each slave on the bus must have a unique device ID ranging from 1 – 247. Address '0' is reserved as the broadcast address.

Modbus Baud Rate

Default is 19.2 Kbps. Available communication speeds range from 1200bps – 115 Kbps.

Note: Care must be taken to make sure the selected speed matches that of the master or there will be communication problems.

Modbus Protocol

Default is RTU. There are two protocols available to the user, RTU and ASCII.

In RTU mode a compatible Modbus master device must generate messages, as strict timing is required for a successful communication. This mode allows for better data throughput than ASCII mode for the same baud rate.

When using Modbus over a radio, use ASCII rather than RTU mode. Radios tend to break up Modbus data packets as they are sent over the air. Since RTU does not allow for a timeout between the bytes of the packet, communications errors occur.

In ASCII mode, the user may connect to the device using a serial communication program (ie. Hyperterminal or Procomm) set to 7 data bits and 1 stop bit. Messages can then be sent to the unit by typing the proper command. Each command is prefixed with a ':' and ended with a carriage-return / line-feed (<CR><LF> usually just the 'Enter' key). This mode offers much less throughput than RTU since 2 ASCII characters are required to describe a single binary byte (e.g., the value 0xB5 would be communicated by sending the ASCII characters 'B' and '5'). Since a Cyclic Redundancy Check (CRC) is required on each message, the ability to send the message via Hyperterminal is almost of no use unless the CRC can be generated by the user.

Note: Care must be taken to make sure the selected protocol matches that of the master or there will be communication problems.

Modbus Parity

Default is Even. Available choices include Even, Odd and None.

Note: Care must be taken to make sure the selected parity matches that of the master or there will be communication problems.

Modbus Delay before Tx

Default is 10ms. This identifies the number of milliseconds to wait after asserting CTS before starting data transmission. This is useful if the device is connected to a radio requires keying initialization before data transmission. The possible delay ranges are 10ms – 2000ms.

Modbus Delay after Tx

Default is 10ms. This identifies the number of milliseconds to wait after data transmission is complete before de-asserting CTS. This is useful if the device is connected to a radio that requires a hold-off time after data transmission has completed. The possible delay ranges are 10ms – 2000ms.

Modbus Function Codes

The following table identifies the functions that are supported by the SDR. Each diagnostic counter is cleared when the device is powered up or reset.

Code	Hex	Subcode	Hex
Read Holding Registers	0x03		
Read Input Register	0x04		
Write Single Register	0x06		
Diagnostic	0x08	Return Query Data	0x00
Diagnostic	0x08	Clear Counters	0x0A
Diagnostic	0x08	Return Bus Message Count	0x0B
Diagnostic	0x08	Return Bus Comm Error	0x0C
Diagnostic	0x08	Return Bus Exception Count	0x0D
Diagnostic	0x08	Return Slave Message Count	0x0E
Diagnostic	0x08	Return Slave Broadcast Count	0x0F
Diagnostic	0x08	Return Bus Char Overrun Count	0x12
Write Multiple Registers	0x10		
User Defined Code	0x41	GetLog	GL

Identifying Registers

The SDR has two types of data that can be accessed using the Modbus protocol. These include *Holding* and *Input* registers.

Holding Registers

Holding registers are reserved for the purpose of setting and getting SDR state data such as the date and time and diagnostic counts if the ability to send the above *Diagnostic (0x08)* command is not available. The following table identifies the holding registers and their locations. Each of these registers is an unsigned 16-bit value (if readings registers using an Xpert, set the data type to *ushort*).

Data	Register	Valid Data Values
Hour of current time	1001	0 – 23
Minute of current time	1002	0 – 59
Second of current time	1003	0 – 59
Year of current time	1004	> 2000
Month of current date	1005	1 – 12
Day of current month	1006	1 – 31
Recording status	1007	Always returns 1
Reset Unit	1008	Write 1 to reset
Modbus Protocol	1009	0 – RTU 1 – ASCII
Force Measurement *	1010	1 – force measurement
Bus Message Count	1011	Read Only
Bus Comm Error	1012	Read Only
Slave Exception Count	1013	Read Only
Slave Message Count	1014	Read Only
Broadcast Message Count	1015	Read Only
Char Overrun Count	1016	Read Only

*Note: When forcing a measurement and an analog sensor is being used to take stage measurements, be sure to wait the proper amount of time for a measurement to finish before requesting data.

Input Registers

Input registers return the last measured data from the device including stage, discharge, today and yesterday's volume and battery voltage. Ideally these values should be requested on a schedule slightly lagging the measurement schedule on the SDR. This will ensure data will follow that found in the SDR log. If the last measured data is not acceptable, a live reading can be forced by writing a '1' to the *Force Measurement (1010)* holding register. Care must be taken to allow enough time to pass for taking a measurement before requesting the data, especially if an analog reading is being taken.

Since the SDR works with floating point numbers and Modbus only allows for 16-bit registers, a multiple register read can be used to access the entire reading. The Modbus master device should be configured to treat these reads as a single floating point number. For example, if accessing **Last measured Stage** via an Xpert, read 1 value of type *float* starting at register 1. If the quality is also desired, change the number of values to 2 and choose *ushort* for the second reading type. The complete list of registers and their locations are below.

Data	Register
Last measured Stage (MSW)	1
Last measured Stage (LSW)	2
Stage Quality	3
Last measured Discharge (MSW)	4
Last measured Discharge (LSW)	5
Discharge Quality	6
Volume so far today (MSW)	7
Volume so far today (LSW)	8
Volume Quality	9
Volume yesterday (MSW)	10
Volume yesterday (LSW)	11
Battery Voltage (MSW)	12
Battery Voltage (LSW)	13
Last measured Stage Two (MSW)	14
Last measured Stage Two (LSW)	15
Stage Two Quality	16

In addition to each reading, there may be a quality register that can be read to troubleshoot readings. Any non-zero reading from the quality register means there is something that should be looked into. The following values describe what each quality values means.

Quality Value	Description
1	Overspeed (shaft rotated too fast)
2	The time has not been set in the unit
4	The stage has not been set
8	Not enough readings were available to calculate (usually found in volume calculations)
16	Invalid reading from analog device
32	Battery voltage was too low to make a reading

Get Log Command

The Get Log subcode is used to retrieve log data from the SDR. The format of the command is as follows: *GL,logfilename,datetime,recordID,numbytes*

▶ The logfilename can be used to return log entries of specific types. The available types are *data, events*, and *all*.

▶ The datetime value must be in the following format: MM/DD/YYYY HH:MM:SS.

▶ The numbytes value refers to the number of data bytes from the log entry to include in the response, not the number of bytes to store in the return packet. Since the master station or transport medium may be limited in the number of bytes that can be handled in a single packet, the numbytes value should be sized small enough to allow for header and CRC information, as well as translation to ASCII if that is the selected protocol (the ASCII protocol uses two bytes to represent every data byte).   If numbytes is *, the all log records found will be returned. Regardless of the requested numbytes, only complete log records are returned.

The format of the reply is as follows:

GLR,status,recordID,numbytes,data[numbytes,data]

The value of status can be any of the following values:

Value	Description
0	Ok.
1	File not found.
6	Record not found.
7	Command format error

The datetime value in the response message is the datetime of the returned record and, therefore, may be different from the datetime in the GetLog command statement.

The data to the end of the file can be read by leaving datetime at the desired starting point and incrementing recordID until the status indicates record not found. The [numbytes,data] represents an additional record of data if there is room in the message.

Example:
command: GL,data,02/07/2007 15:50:00,80,0
reply: GLR,0,0,38,02/07/2007,15:51:00,VBAT,13.16,Volts
                   37,10/07/2003,15:51:10,A,10.89,5.2,-25.4

Wrapped for illustration purposes only.

command: GL,data,02/07/2007 15:50:00,80,2
reply: GLR,0,2,37,02/07/2007,15:54:00,C,10.89,5.2,-25.4,0

The GLR response will contain as many log records as can fit into the response. The numbytes value in the GLR response does not include the comma preceding the data, and refers to the number of data bytes from the log that are being returned, not the number of packet bytes used to store the response (which would be twice the data bytes when ASCII protocol is selected).

Appendix I – Dual Sensor

Advanced Menus

SDR software version 3.00 features dual sensor (see below) and SDI-12 master (see below) options. If your SDR comes *without* an analog option, you will not be able to take advantage of the new features until *advanced menus* are enabled. To enable, use the front panel and navigate to **Station Setup -> Other Setup -> Advanced Menus.** If your SDR is equipped with the analog option, the automatic menus are always enabled.

Advanced menus affect measurements. If you are using only one sensor, advanced menus are not appropriate. If, however, you want to setup a dual sensor station, advanced menus are a must. Below are listings of relevant portions of basic and advanced menus.

Basic menus (ideal for a shaft encoder measurement)

> *Station Setup*
> > *Wheel Size*
> > *Direction*
> > *Measurement Interval*
> > *Units*
> > *Right Digits*
> > *Averaging Time*

Advanced menus (required for dual sensors)

> *Station Setup*
> > *Measurement Setup*
> > > *Stage Sensor*
> > > > *Sensor Type*
> > > > *Wheel Size*   *(shaft encoder only)*
> > > > *Direction*   *(shaft encoder only)*
> > > > *Analog Warmup*   *(analog only)*
> > > > *Slope*   *(analog only)*
> > > > *Offset*   *(analog only)*
> > > > *SDI-12 Address*   *(SDI-12 only)*
> > > > *SDI-12 Command*   *(SDI-12 only)*
> > > > *SDI-12 Parameter*   *(SDI-12 only)*
> > > > *Averaging Time*
> > > > *Test Sensor*   *(analog and SDI-12)*
> > > *Second Sensor*
> > > > *Sensor Type*
> > > > *Wheel Size*   *(shaft encoder only)*
> > > > *Direction*   *(shaft encoder only)*
> > > > *Analog Warmup*   *(analog only)*
> > *Slope*   *(analog only)*
> > *Offset*   *(analog only)*

SDI-12 Address   *(SDI-12 only)*
SDI-12 Command   *(SDI-12 only)*
SDI-12 Parameter   *(SDI-12 only)*
Averaging Time
Test Sensor   *(analog and SDI-12)*
Measurement Interval
Units
Right Digits
Send SDI-12 Command (SDI-12 only)

Dual Sensor

With SDR software version 3.00, a second water level sensor has been added. The second sensor is disabled by default and must be enabled through *Setup->Measurement Setup->Secondary sensor setup*.

If your SDR comes *without* an analog option, you will not be able to take advantage of the second sensor until *advanced menus* are enabled. To enable, use the front panel and navigate to **Station Setup -> Other Setup -> Advanced Menus**

The secondary sensor can be setup to be of any type, including shaft encoder, SDI-12, or analog (if the analog option board is installed), just like the primary sensor.

Once enabled, the secondary sensor will be measured and logged at the same time as the primary sensor. If enabled, the secondary sensor will show on the front panel immediately under the primary sensor. For the SDR, the secondary sensor is labeled *Stage Two*.   For the DitchMaster, the sensor is labeled *Canal Level*.

If the secondary sensor is enabled, a the *dual sensor* discharge equation becomes available. The dual sensor equation is the only discharge type that takes both sensor into account. For the dual sensor discharge setup, the primary sensor is considered the downstream sensor, and the secondary sensor the upstream sensor.

Readings made by the secondary sensor are accessible just like the readings made by the primary sensor: via front panel, RS-232, Modbus, and SDI-12.

Both sensors share these settings:
Measurement Interval
Right Digits
Units

Dual Sensor Discharge Equation

If the secondary sensor is enabled, a new type of discharge equation becomes available. Please see section

Appendix I – Dual Sensor on using dual sensors.   The dual sensor discharge equation uses two sensors to compute the discharge. Stage one is the downstream sensor. Stage two is the upstream sensor. Water flows by the upstream sensor before it flows by the downstream sensor.

Dual sensor (submerged orifice equation) :

$$Q = Cd* A \sqrt{(Hu-Hd)}G$$

Q is the computed discharge.

Cd is the discharge coefficient which can be changed by the user in discharge setup. 0.6 is a generic value for a slide gate.

Hd is the downstream water level (*Stage*)

Hu is the upstream water level (*Stage Two*)

G is 32.175 ft/sec/sec (constant and not changeable)

A is the gate area opening that is setup by the user.

SDI-12 Logger

SDI-12 is a standardized three wire digital interface. Many manufacturers provide SDI-12 sensors that measure different environmental effects. SDI-12 sensors provide digital data which improves their reliability and accuracy in terms of logger sensor communications.

SDR software version 3.00 allows the SDR to act as an SDI-12 logger. SDR can be setup to collect data from an SDI-12 compliant sensor. By selecting SDI-12 as the sensor type, the SDR will collect data on the SDI-12 bus.

SDR does not provide power on the SDI-12 + connector. The sensor will have to be powered from a different source. You may use the same power source for both the SDR and the sensor.

If SDR is setup to collect data from an SDI-12 sensor, SDR ceases to be an SDI-12 sensor. This means that data cannot be collected from the SDR via the SDI-12 bus. **The SDR cannot function as both an SDI-12 sensor and a SDI-12 logger.** It can do one or the other but not both.

It is possible to hook up two SDR units using the SDI-12 bus. One SDR would become the logger and collect data form the other SDR. One SDR would collect data not only from its shaft encoder, but also from the other SDR. This setup may be useful if only one modem is available at the site. It may also be useful when computing discharge from an upstream and downstream sensor.

SDI-12 Logger Setup Guide

Before you can use the SDI-12 logger features, advanced menus need to be enabled if your SDR does not have the analog option. To enable, use the front panel and navigate to *Station Setup -> Other Setup -> Advanced Menus.*

One (or even both) of the SDR's dual sensors need to be setup for SDI-12. This guide will provide an example of how to setup the secondary sensor as SDI-12. Use the *Station Setup -> Measurement Setup -> Second Sensor* menus. First turn on the secondary sensor, then set the secondary sensor type as SDI-12.

Once the secondary sensor is enabled and setup as SDI-12, the setup is complete for most situations.   Even thought there are three more settings that control SDI-12 behavior, the default setup is likely sufficient. Use the *Station Setup -> Measurement Setup -> Second Sensor -> Sensor test* menu to see if you get valid results from the SDI-12 sensor. If not, proceed with the rest of the setup.

There are the SDI-12 settings and their default values:

Setting	Default
SDI-12 Address	0
SDI-12 Command	M!
SDI-12 Parameter	1

Setting the *SDI-12 address* of the sensor is a two step process. The sensor has an address and the SDR has the address it will get the data from. Both the SDR and the SDI-12 sensor can change the address. You need to setup both the addresses match.

It is easy to change the address the SDR will get the data from. Simply change the SDR setup field *Station Setup -> Measurement Setup -> Second Sensor -> SDI-12 Address.*

Most sensors default to address 0. To see what address the sensor is at, issue the ?I! command. To change the address of the sensor, you may use the *Diagnostics -> Send SDI-12 Command* menu. To change the sensor from address 0 to address 1, send the 0A1! command.

To get data from the sensor, the SDR needs to send a command to it. That command is usually M!. Please refer to the sensor's guide to find out what command should be issued. Use the menu *Station Setup -> Measurement Setup -> Second Sensor -> SDI-12 Command* to change what command the SDR issues to the sensor.

Some sensors will respond with multiple data values. The *SDI-12 Param* designates which of these data values the user is interested in. The default value of 1 means use the first value reported. Please refer to the sensor's documentation to find out which parameter is appropriate.

Once the SDI-12 setup is complete, use the *Station Setup -> Measurement Setup -> Second Sensor -> Sensor test* menu to see if you get valid results from the SDI-12 sensor. If not, check the cabling and the SDI-12 setup. Additionally, the SDR provides a means of directly issuing SDI-12 commands. That menu is *Diagnostics -> Send SDI-12 Command*. To see if a sensor is responding, issue the ?I! command. If no response is received, the sensor or the wiring is faulty. **Remember that the SDR does not provide power on the SDI-12 + connector.** Use BAT+ instead.

Averaging

With SDR software version 3.00, an averaging option has been added. Under each sensor's setup, there is an averaging time, expressed in seconds. If that time is zero (which is the default), no averaging is done. If it is not zero, the SDR will collect data for however long the averaging time is setup for.

Averaging can be found under *Station Setup ->Averaging* if advanced menus are not enabled. If they are, there is going be an independent averaging setting for each sensor. The stage sensor's averaging can be found in *Station Setup -> Measurement Setup -> Stage Sensor ->Averaging.*

SDR does **simple averaging**, meaning that it will collect data the user specified amount of time. Once the time is up, it will sum up all the samples and divide the sum by the number of samples collected.

Please note that the SDR's Stage reading on the front panel will only update as fast as the averaging interval. That means that if the averaging time is set to 10 minutes, the display will update only once every 10 minutes!

If setup for shaft encoder or analog, the SDR will collect approximately **two samples per second**. SDI-12 sampling speed will depend on the SDI-12 sensor, and will be done as fast as the data becomes available.

For example, with a shaft encoder, if averaging is set to 5 seconds, the SDR will collect 10 samples from the encoder, sum them up, and divide the resultant sum by 10. The final result is the stage.

Make sure the averaging time is less than the measurement interval. If the averaging time is close to the measurement interval, the SDR may miss measurements! This means that if the *Measurement Interval* is set to 1 minute, make sure the averaging interval is significantly less than 60 seconds.