Radar Level Recorder

RLR-0001-1

RLR-0003-1

Operations & Maintenance Manual

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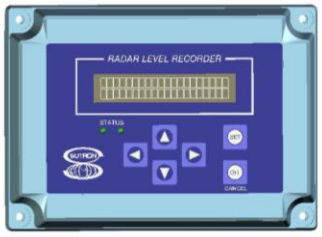
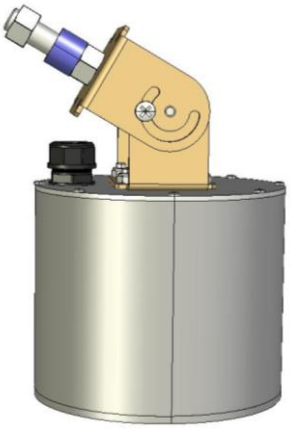
Introduction

Sutron's Radar Level Gauge/Recorders are self-contained, precision devices for measuring stages (water level) without direct contact with the water surface. The Radar comes in three different models. The RLR-0001-1 combines into a single package radar, antenna, keypad, display, permanent log, SDI-12 interface, RS232 interface. The RLR-0001-1 is packaged in sealed enclosure; however, the enclosure is not rugged enough to be installed outdoors without additional protection.



RLR-0001-1



RLR-0003-1

The RLR-0003-1 is an integrated unit without display. The enclosure is rugged and can be installed outdoors without additional protection. All the electronics for the radar are housed in the antenna enclosure. A 25 foot long cable provides both RS232 and SDI-12 interfaces to the radar.

The Radar Level Recorder is ideally suited for making stage (stage) measurements in rivers, streams, reservoirs, tidal, oceans and industrial areas where the sensor can be located above the water surface. Using a special pulse-echo measurement technique, the radar has a range of 60 ft.

The radars that have a front panel that allow a user to setup the operating parameters, monitor performance and perform tests via the front panel.

The radar is both a sensor and a logger, allowing for stand-alone and integrated applications. The log inside radar is capable of holding more than 300 000 readings, and allows the recording of status and stage (stage) data. The radar has an SDI-12 interface as well as RS232 so it can provide data to data loggers or communications equipment.

All radars provide an RS232 port that supports a simple command line mode compatible with HyperTerminal and other communications programs to display data from the log and perform some essential operating functions. It is possible to connect the radar to a modem or radio.

Features

- Non-contact measurement of stage (water level).
- Low power consumption (<1ma quiescent, <20ma measuring @ 12V) for long battery life.
- High precision featuring 0.001 ft resolution a range of 60ft.
- High accuracy 0.01ft 5- 20ft, 0.05% reading 20-60ft.
- Powerful and configurable processing filters out waves (Averaging and DQAP)
- Automatically saves data in permanent log
- User-settable measurement, logging, and averaging
- Built-in flash log for 300,000 readings safeguards your data even if power is lost
- Stand-alone operation or operation with other loggers/communications via SDI-12 and RS232
- Automatically computes discharge
- Front panel allows full access to setup, status and data
- Provides redundant data storage when connected to a logger

Unpacking

Remove the Radar from the shipping container and visually inspect the unit for signs of damage during shipment. 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.

Cabling

RLR-0003-1

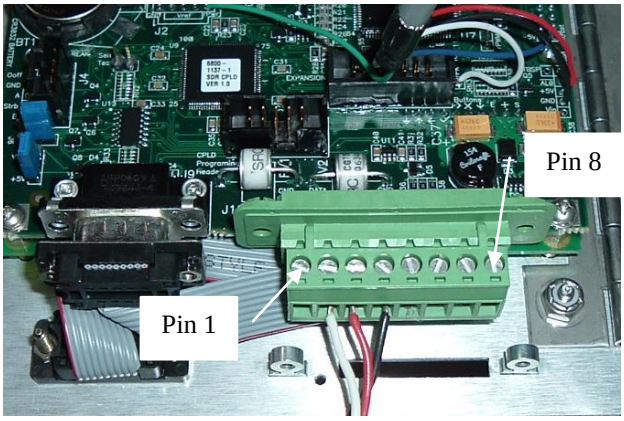
The RLR-0003-1 comes with the interface cable already connected. The interface cable provides both SDI-12 and RS232 communications. DO NOT open the radar enclosure during the course of installation or maintenance as the water tight seal may be broken. The DB9 is wired as described on the following page. The SDI and power wiring is as follows:

Color	Description	Notes
GREEN	Earth	Earth ground for protection
WHITE	SDI Data	To Data Logger SDI-12 Data
RED	SDI +12V	To Data Logger SDI-12 Power
BLACK	SDI GND	To Data Logger SDI-12 Ground
RED /w Black Stripe	Backup Battery +12	Optional backup battery connection
BLUE /w WHITE STRIPE	Backup Battery GND(-)	Optional backup battery connection

Terminal Block – RLR-0001-1

The following table contains the pin descriptions for the terminal block. You must open the radar enclosure to access this terminal block:

Terminal Block	Description	Notes
1	Earth	Earth
2	Data	SDI-12
3	+12V	SDI-12
4	GND	SDI-12
5		
6		
7	Battery +12V	Battery power -- Not needed when powered via SDI-12
8	Battery GND	Battery power -- Not needed when powered via SDI-12



Power Connections

The radar requires external +12V power to operate. Power may be given via the battery connector (pins 7 and 8), and /or via the SDI-12 connector (pins 3 and 4). **When both sets of connections are used, the radar will operate off either power source. This allows a redundant power source for the radar.** The two sets of power connections are separate – current will not flow from one to the other.

Use wire that is at least 24 gauge.

When using the radar with a Satlink or other logger, you may use the SDI-12 power connection with or without the battery connection.

Please note that the radar battery voltage (page 20) measurement will measure the higher of the two voltages (battery and SDI-12) that can be supplied to it.

SDI-12 Connections

The SDI-12 interface has only 3 connections – GND, +12V and Data. The connections are made to the terminal block as given in the table above and as shown in the above picture. Wire all three connections directly to the SDI-12 connections on a compatible data logger. The sensor is shipped to respond to SDI-12 address 0 (the address can be changed via the front panel). See the section titled SDI-12 Sensor Operation on page 28 for more details.

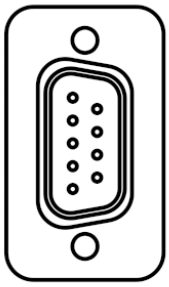
Note that if operating without a logger, nothing need be connected to the SDI-12 pins.

DB9 Connector

The radar 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 and modems. This connector allows for access to the command line interface (see page 34) using a terminal program. Some modems (see page 38) and radios can be connected to this port. A logger can be programmed to use this port.

The following table shows the pin assignments of the DB9F connector.

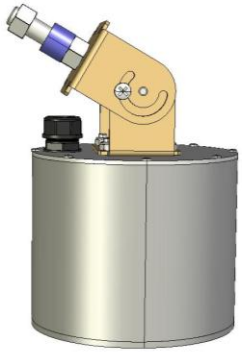
DB9F Pin	Name	Notes
1	N/C	No Connection
2	RXD	Data from Radar
3	TXD	Data to the radar
4	DTR	Signal to the radar
5	Ground	
6	DSR	Signal from unit, asserted as long as unit has power
7	RTS	Request to Send, signal to the radar
8	CTS	Clear to Send, signal from the radar
9	VOUT	Jumper J8 selectable for 5V (default) or VBAT (100ma max) - this line is usually NOT passed by a null modem



Quick Install

It is very important to properly install the radar sensor. The RLR-0001-1 radar is designed to mount with the front panel display facing up. In this orientation, the radar antenna points down to the water surface. You may switch the orientation of the antenna by opening the enclosure and changing the mounting plate so the antenna points to the side of the enclosure. Do not install the RLR-0001-1 outdoors without an additional protective enclosure.

The RLR-0003-1 is designed with a 5/8" bolt for connection to a mounting arm. The bolt and the swivel bracket can be adjusted to allow the radar to point directly to the water surface no matter what the angle is of the mounting arm. The adjustments are made by loosening the two screws in the sides of the swivel bracket and also rotating the bracket relative to the bolt.



Mount the radar directly above the water surface, such that the radar beam is perpendicular to the water. The radar will not operate well if the beam strikes the water at an angle or if there objects other than the water that will reflect the signals from the radar. A circular level is provided to simplify the process of pointing the antenna at the water surface. For more details on the antenna beamwidth see Targeting the Radar on page 46. Keep in mind that the range of the sensor is up to 60 feet with a minimum of 5 feet.

After setting up the radar above the water's surface and providing power to the unit, use the front panel to bring up the Diagnostic > Signal Quality menu (press the up arrow several times until "Diagnostic" is displayed, then press right). Adjust the antenna pointing to the water surface for a peak signal. Additionally, you may find the command line TARGET mode useful for setting up the Radar.

Once the radar is properly mounted and indicates a good signal strength, set the stage. The stage is the first item shown on the front panel after power-up. Once the stage is shown, press set, enter the new stage, and press set again. After a few seconds, the radar will show the entered stage. Ensure that ? is not shown. If ? is shown, it means the radar does not have a good signal. Please see page 14 for more details on setting the stage.

Standalone Quick Install

The radar starts measuring and collecting data as soon as it is powered up. By default, the radar will measure and log stage every 15 minutes; each reading is averaged for 10 seconds. All of these settings and more can be changed – please refer to page 16 to learn more about how the radar measures.

Quick Install with a Logger

Radar can be connected to other devices via either SDI-12 and RS232.

- For SDI-12 operation, connect the three wire interface to the properly labeled pins on the radar and setup the logger to periodically collect data from the sensor. The first parameter of the M! command

will provide the stage. For more details on SDI-12, please refer to the SDI-12 Sensor Operation section on page 28.

- If connecting using the RS232 port, the data can be polled from the radar, or it can be automatically output by the radar. Setup the connected device (which may be a logger, a modem, or even a direct connection to a PC running HyperTerminal) for 115200 baud, 8 data bits, no parity (the baud rate can be changed via the front panel Setup > Other Settings > Baud Rate).
  - To poll for data, have the connected device issue a carriage return, wait for prompt, issue the ASCII command "!MEAS" followed by a carriage return, and capture the returned data. The first data item returned is the stage.
  - To capture data, setup the radar for *auto output* via the front panel Setup > Other Settings > Auto Output. Once setup, the radar will periodically output the stage in ASCII.

  Please refer to the section RS232 Command Line Interface on page 34 for more details.

Redundant Data Collection

- Connect the radar via SDI-12 to a logger and setup the logger to get data from the radar.
- Provide a redundant power supply to the radar (via the Battery connector).
- With this setup, if the logger malfunctions, the radar will keep on collecting data.

Setup and Operation

Overview

Radar operates as both a sensor and a logger. As a sensor, it is capable of performing stage measurements. As a logger, it is capable of recording those stage measurements.

Radar will measure and log data as long as it has power, regardless of whether it is connected to a logger. This ensures that data is not lost if the logger malfunctions.

The digital SDI-12 interface allows for a standardized connection to a logger. SDI-12 also provides power to the radar. For full details on SDI-12, please refer to the section on page 28.

The radar can be attached to a telemetry device, such as a modem, via its RS232 port. Radar allows full access to status, setup and data via the RS232 port, using the command line interface (detailed on page 34). Loggers that do not support SDI-12 should interface via the RS232 port.

The front panel offers a means of viewing data, status, and configuring the unit. Please see page 24 for details. The RLR-0003-1 without a front panel can be setup and operated via the RS232 and/or SDI-12 interfaces.

Starting the radar

The radar starts operating as soon as power is applied. On models with displays, the green LED will flash occasionally to let you know that the radar is operational. The Radar cannot be stopped from measuring without removing power from it.

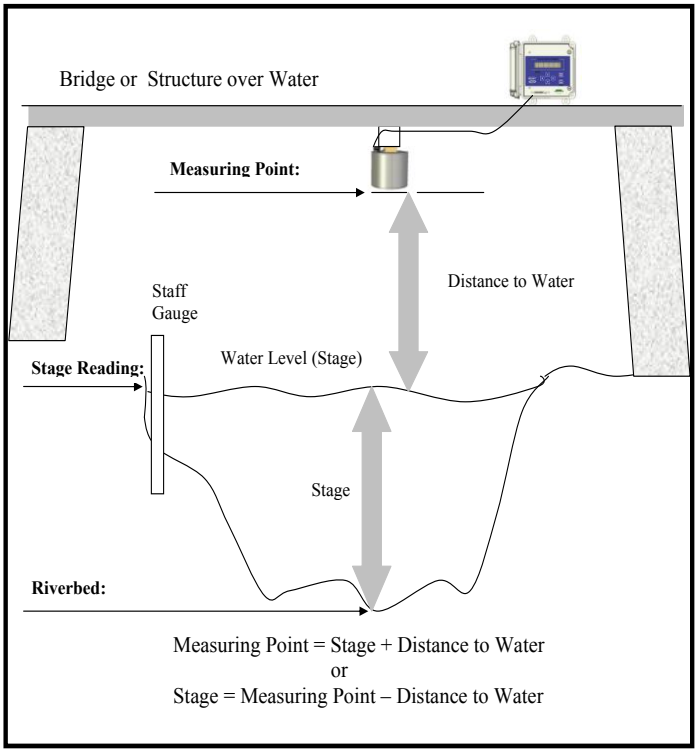
Green LED	flashes every several seconds to indicate the radar is operating normally
Red LED	flashes if the radar has encountered a problem

When the radar first starts, it may display the message "Calculating…" on the LCD. This means that the radar is in the process of taking a measurement. This message will be displayed for as long as it takes to make one measurement (see Averaging Time). The message "Error in Reading" means that the radar was unable to get valid signals from the radar.

Stage, Distance to Water, and Measurement Point

Ultimately, the job the radar is to compute a stage measurement. However, the direct measurement made by the radar is distance to water.

- Distance to water is the length between the radar and the water surface.
- Stage is the depth of water; for a river it is distance between the water surface and the riverbed.
- **Stage = Measurement point – Distance to water**
- Measurement point is the length between the radar and the riverbed (or ocean floor or well bottom). **(NOTE: Calibration of the radar unit has been made with respect to the front cover of the antenna unit.)**



Stage is displayed on the first menu shown on the front panel. Via command line, use the "MEAS" command or the "LAST" command. Via SDI-12, use the M command.

Measurement point can be accessed via the front panel Station setup > Measurement Setup > Measurement point, via SDI-12 using the XE command, and the command line MEASURING POINT.

Setting Stage

When the radar is installed, you will typically read the current stage off a staff gauge and then set this new stage into the radar.

To set the stage via front panel, power up the radar, wait for it to show a stage reading (which will be negative until the stage is set), and the press SET. Enter the correct stage and press set again. *Don't forget to change the sign of the stage to* "+". It is also possible to use SDI-12 XS command and command line STAGE to set the stage.

The radar compares this user entered value with its own reading and uses it to set the Measuring Point. From then on, the radar will report the stage relative to this Measuring Point – so it will match the staff gauge.

Alternatively, if you know the exact elevation of the radar, you can enter this elevation as the Measuring Point and the radar will automatically display the stage relative to this elevation.

Measuring Stage

The radar takes multiple samples and computes a stage from them. Each sample is itself the average of millions of radar pulses to the water surface and as such has a quality reading and signal strength associated with it. If the radar is not getting a good reflection from the water surface, the quality of the sample will be bad. If less than half of the samples were good, the quality will be set to bad. The user controls when the samples are collected and how the average is computed through the Measurement Setup settings. Please see sections on Operating Modes, Averaging and Sample Form Period for further details.

A bad quality is indicated with a "?" after the reading if using the front panel. The command line interface will say 'error', and SDI-12 will indicate an invalid reading. In addition, the red LED will flash and the front panel will show 'Error in reading' if the last reading was invalid. Logged data will be marked as invalid..

To see the stage, use the first menu shown on the front panel. Via command line, use the "MEAS" command. Via SDI-12, use the M command.

Signal Strength

The radar gives a signal strength expressed as a percentage 0 to 100%. The higher the number, the better the signal. Signal strength can be viewed via the front panel Diagnostic > Signal Strength.

Stage Details

In addition to providing a stage, the radar sensor can provide additional details:

- average signal strength
- standard deviation (of good samples)
- number of good samples
- total number of samples

These details can be viewed by pressing right when viewing the stage via front panel. Also, command lines MEAS and LAST, and SDI-12 M2 will reveal stage details.

In order to log all these details, make sure to enable the measurement setup field Station Setup > Measurement Setup > Log Stage Details.

Stage Units

Radar can report stage readings in feet, meters, centimeters or millimeters. Please use Station Setup > Measurement Setup > Stage units to change the units. Units are logged along with stage. They are also shown on the front panel and reported with the results of SDI-12 and command line measurements.

Right Digits

The number of digits shown after the decimal place is referred to as the Right Digits. If you would like the stage to read 10.12 rather than 10.12345, set the right digits to 2.

Automeasure

Automeasure refers to the radar's ability to automatically measure and log stage data. The user can determine when this will occur by changing Station Setup > Measurement Setup > Automeasure Interval and Offset settings. Automeasure cannot be turned off.

Automeasure time and interval determine when the radar measures and logs data.

- *E.g. Automeasure time 00:00:00 interval 00:10:00*
  - 00:10:00 data measured and logged
  - 00:20:00 data measured and logged
  - 00:30:00 data measured and logged
  - and every ten minutes afterwards…
- *E.g. Automeasure time 00:00:30 interval 00:05:00*
  - 00:00:30 data measured and logged
  - 00:05:30 data measured and logged
  - 00:10:30 data measured and logged
  - and every five minutes afterwards...

The last automeasured data can be accessed via SDI-12 and command line – please see page 18.

Operating Modes

There are two operating modes: normal and continuous:

- In **normal mode**, radar spends its time in low power mode until it is time to measure or a measurement is requested via the front panel, RS232 or SDI-12. Once the measurement is complete, radar goes back to low power mode. This is the most commonly used mode and is recommended unless the radar will be measuring very frequently.
- In the **continuous mode**, radar is constantly collecting data. When it is time to measure, radar will use the previously collected data to instantly come up with a stage reading. The radar does not go into low power in continuous mode. The continuous mode adds about 10 mA to the quiescent power consumption compared with 0.25mA in the normal mode. **Please note that Radar can hold only 180 samples** in continuous mode. If the averaging time and the sample form period are such that more than 180 samples are collected, the system will only use the last 180 samples. For example, if the averaging time is 10 minutes, and the sample form period is one second, the radar compute the r based on three *and not ten* minutes worth of data. Normal mode is unaffected by this limitation.

These examples illustrate the difference between continuous and normal modes:

Normal mode with 10 second averaging:

1. 12:00:00 measure command is received (via SDI-12, front panel, RS232, or automeasure)
2. 12:00:00 sensors are powered on and measurement starts
3. 12:00:11 measurement completes with data collected between 12:00:00 and 12:00:10
4. 12:00:11 sensors are powered down

Continuous mode with 10 second averaging (sensors are powered on all the time):

1. 12:00:00 measure command is received (via SDI-12, front panel, RS232, or automeasure)
2. 12:00:00 measurement completes with data collected from 11:59:50 to 12:00:00

Desired Effect	Appropriate Mode
Low power consumption	Normal mode
Low power consumption and immediately ready data	Normal mode, use last measured readings (page 18)
Immediately ready and current data	Continuous mode
Very frequent measurements (every 15 seconds or less)	Continuous mode
More than 180 samples	Normal mode

Operating mode can be changed via front panel Station Setup > Measurement Setup > Operating Mode, via SDI-12 XOM and via OPERATING MODE command line

Averaging Time

Every time the radar measures it will collect samples for a user defined period (Station Setup > Measurement Setup > Averaging Time) in order to produce a stage reading. The setting *avg time* determines how long to collect samples for. Averaging time can be changed via SDI-12 XT, and via AVG TIME command line.
In addition to the averaging time, the sample form period can be adjusted, allowing for control of the number of samples collected. The sample form period determines how often each sample is collected.

Two methods are offered for computing a stage from multiple samples: averaging and DQAP.

Averaging

Adding all the (good) samples and dividing the sum by the number of (good) samples will provide the average distance to water. In addition to the averaged distance to water, radar will also provide the average signal strength, the standard deviation of the good samples, the total number of samples and the number of good samples. Finally, the quality of the stage will be set to good if at least half of the samples were good. In order to log all these details, make sure to enable the measurement setup field log water details. They can also be accessed via command line or SDI-12.
Averaging is enabled by default. **If DQAP is disabled, averaging is enabled** (Station Setup > Measurement Setup > DQAP Enable).

DQAP

DQAP is a method defined by the NOS (National Ocean Service) of computing the stage that is designed to eliminate erroneous values from the calculation. With DQAP, the distance to water is calculated using two computations:

For the first computation, the average and standard deviation of all the samples are calculated. Then, two limits are figured: the average plus/minus three times the computed standard deviation. Each sample is then compared against the two limits. If the sample is outside the limits, it will not be used in the final computation.

In the final computation, the average and standard deviation are recomputed from all the samples remaining from the first calculation. The quality of the stage reading will be set to good if at least half of the samples were selected for the secondary computation; it will be set to bad otherwise. The good sample count of the stage reading will be set to the number of samples selected for the secondary computation.

To enable DQAP, use the Station Setup > Measurement Setup > DQAP Enable menu. If DQAP is enabled, averaging is disabled.

Sample Form Period

As mentioned in measuring stage, each sample of the stage is actually the average of millions or radar pulses to the water. The sample form period value controls how much raw radar data to include in each sample. The default value for sample form period is 1.0 second. Do not change this value without consulting with the factory. The quality of the sample depends on the number of good subsamples collected. If there are not enough good subsamples, the quality is set to bad.

The details of each sample can be viewed in the diagnostic menu. The details consist of distance to water, standard deviation, number of good and number of total subsamples, sample validity, signal strength, minimum and maximum. Each sample may be logged by activating *log every sample* setting.

Log entry	Description
Sample Min	The minimum distance to water
Sample Max	The maximum distance to water
Sample Avg	The average distance to water
Sample StdDev	The standard deviation of all the subsamples
Sample Good Subs	The number of valid subsamples included in the average
Sample Total Subs	The total number of subsamples collected (only the good subsamples are included in computation)

Last Automeasured

Stage measurements made by the radar are not instantaneous; how long they take depends on averaging time (page 17). When a logger is communicating with the radar, it can ask the radar to make a new measurement. However, the logger then has to wait for the radar to complete the measurement.

If the user desires data that is instantly available, the radar can provide the last measured data. The radar automatically measures based on the automeasure interval (see page 16) . That data can be retrieved as the last measured data.

For example, if radar is setup to automeasure every 10 minutes, with an averaging time of 10 seconds:

12:00:00 to 12:00:10 radar measures stage
12:01:00 logger asks for last measured data; radar immediately returns 12:00:10 data
12:10:00 to 12:10:10 radar measures stage
12:11:00 logger asks for last measured data; radar immediately returns 12:10:10 data

If the user desires data that is both immediately available and current, continuous mode (page 16) is the way to go.

Last measured data can be accessed via SDI-12 M3 and via LAST command.

Discharge

Discharge is a measurement of water volume flowing over time. Please refer to the discharge section on page 41 for complete details.

Logging

A secure flash chip in the radar provides a logging capacity of more than 300,000 entries. Data will *not* be lost if power is removed. There is not a means of erasing data from the log. Once the log is full, the oldest data will be overwritten.

Each log entry consists of

- date and time (with a second resolution)
- name of the logged entry
- measurement reading (optional)
- measurement quality and units (optional)

The format of logged data is the Sutron Standard CSV format which was introduced in the Summer of 2009. 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 are several examples of log entries:

- 01/19/2010,09:21:49,Reset Powerup,1
- 01/19/2010,09:30:00,Stage,1.25,feet
- 01/19/2010,09:45:00,Stage,1.27,feet
- 01/19/2010,09:50:27,Setup Change

Minimally, radar will log stage and various events. The user can decide how often to log stage (via automeasure settings see page 15), and the user can chose to log **stage details** (via front panel, access Station

Setup>Measurement Setup>Log Stage Details), which consist of signal strength, standard deviation of samples, number of good and total samples.

Events

Occasionally, the radar will log events. Events are used to help troubleshoot the data.
The following actions will cause the radar to log an event:

- Setup change (whenever any setting is changed)
- Log download (whenever the log is downloaded)
- Display On and Display off (whenever the user wakes the unit up by pressing a button)
- Command line enter (whenever the user connects via the RS232 port)
- Reset (log contains reset type and count)
- Errors (such as low battery and sensor failure)
- Before cal and after cal (logged whenever the user sets the stage to record the stage before and after the calibration)
- Log in events (if password is enabled), including failure to log in.

The log can be examined via the front panel (the Logged Data menu), or downloaded via command line (using the LOG command). SDI-12 does not provide access to the log.

Logged Measurement Time

Measurements are not instant. Once initiated, a radar measurement will take the user defined averaging time plus some overhead to complete. For example, a measurement that starts at 12:00:00, with an averaging time of 10 seconds will complete at about 12:00:11. That measurement will be logged with 12:00:00 as the timestamp. **The timestamp of the logged measurement is the time the measurement was started.**

Log Daily Values

The Radar log the battery voltage into at 23:59:59 each day. Whether it does is controlled by the log daily values setting (Station Setup > Other Setup > Log Daily Values).

Setup

The radar's setup is stored in secure memory, meaning it will not be lost if power is removed (for any time period). The setup of the radar is broken into sections: Measurement Setup, Discharge Setup, and Other Setup. All setup can be changed through any interface: SDI-12, front panel or RS232 command line.

Setting the setup to defaults (Station Setup > Other Setup > Default Setup) will reset all the settings to factory defaults.

Connecting Radar to a Logger

The radar will measure on its own schedule regardless of whether it is connected to another logger. This ensures redundancy of logged data. If the connected logger malfunctions, the radar will keep collecting data.

The digital SDI-12 interface allows for a standardized connection to a logger. SDI-12 also provides power to the radar. For full details on SDI-12, please refer to the section on page 28.

The radar can be attached to a telemetry device, such as a modem, via its RS232 port. Radar allows full access to status, setup and data via the RS232 port, using the command line interface (detailed on page 34). Loggers that do not support SDI-12 should interface via the RS232 port.

To ensure that the logs of the radar and the attached logger match (as far as stage goes), make sure that the automeasure time and interval of the radar are the same as the measurement time and interval of the logger.

To set the radar's time and interval, use the Station Setup > Measurement Setup > Automeasure Time and Automeasure Interval menus.

Ensure that the time of the radar and logger match by changing the time of either one (page 20).

Satlink and Radar

When connecting a radar to a Satlink, use the SDI-12 connection. Setup Satlink for an SDI-12 measurement (please see the Satlink manual for details). Make sure that Satlink measurement time and interval match the radar's automeasure time and interval (Station Setup > Measurement Setup > Automeasure Time and Automeasure Interval).

Satlink will automatically synchronize the radar's clock via SDI-12. This will happen as soon as Satlink is started; Satlink will then periodically ensure that radar and Satlink clocks are in sync.

Station Name

The station name can be viewed and set via the front panel Station Name and Time or by using the STATION NAME command. The name is used to name the file when data is downloaded from the Radar.

Radar Time

Radar time can be viewed and set via the front panel Station Name and Time, via the front panel Station Name, via the SDI-12 XDT command, or by using the TIME command line.

Radar sports an RTC (real time clock) backed by an internal battery. The RTC keep ticking even if the main battery to the radar is removed. The RTC will, at worst case drift ±2 minutes per month (0 to +50C). The lifetime of the RTC battery is about 5 years.

WDID

The WDID is a 7 character code given to stations. The code is included in ???

Battery Voltage

Radar can be powered via either the SDI-12 connector, the battery connector, or via both for redundant power (see page 9 for connection details). The two power connections are separate – current will not flow from one to the other.

When reporting battery voltage, radar will report the higher of the two voltages (battery and SDI-12) that can be supplied to it. Battery voltage can be read from the front panel, SDI-12 M1 command, or BATT command.

Password

You can enable password protection by configuring a password. If password protection is enabled, the user is allowed view setup and data. However, no changes to setup will be allowed until a password is entered. A password prompt will automatically appear whenever a setup change is attempted.

Via front panel, go to Station Setup > Other Setup > Password. Press set and enter a password. Press set again and the password will be enabled.
Using the command line, type "PASSWORD = XXX" to set password to XXX. Type "PASSWORD =" to disable password usage.

To disable the password, enter a blank password.

Logging out is accomplished by turning off the display, by typing EXIT in the command line, or by powering down the unit.

SDI-12 is unaffected by password protection.

If you forget the password and want to clear it, reset the unit and press and hold the DOWN key. You must keep the key pressed until you see the message "Password Cleared" appear on the front panel.

Diagnostics

This section provides details about how Sutron's Radar Level Recorder computes stage based upon radar sensor data.

The purpose of the radar level sensor is to produce a stage measurement. The measurement cycle consists of different processes. At the lowest level, raw signal data is acquired the radar sensor. That data is converted into a subsample. As multiple subsamples are collected, their data is analyzed and processed into a sample. Numerous samples are finally converted into a stage reading.

Raw Radar Sensor Data

Two measurements come from the radar sensor hardware: distance to water and signal strength. The distance to water signal coming from the radar sensor is a PWM signal, provided as a percentage. It is computed into distance to water in feet by multiplying it with the *PWM Slope* and adding the *Factory Offset* to it. The signal strength is expressed as a percent, and is recorded along with stage data.

The diagnostic menu will show the raw PWM signal (expressed as a percentage) along with the signal strength.

Subsamples

Based upon raw sensor data and the history of previous sensor data, the radar will form a subsample. The subsamples are coming in at a rate of about 10 per second.

Every new subsample gets checked to see if it is valid. The distance reading of every new subsample (in percent) is compared to *PWM minimum* (in percent) and *PWM maximum* (in percent). We will also compare the new subsample to the last good subsample and make sure the difference does not exceed the *PWM Delta*.

The subsample diagnostic menu will show subsample details, including distance to water in PWM, signal strength, the state of the lock/unlock engine, along with a quality rating.

Lock/Unlock Quality Engine

In addition to checking each new subsample for quality, radar will monitor a brief history of the subsamples in order to determine the overall quality of the sensor signal. The term 'unlock' is used to mean that there is

inadequate sensor signal quality to make stage readings, and the term 'lock' means that there is good sensor signal quality. If, at the time when sample is created, the state is unlocked, that sample becomes invalid.

The lock/unlock quality is dependent on these settings:
Signal Lock Count: number of good subsamples required to change state to locked.
Signal CBad Count: number of consecutive bad subsamples required to change the state to unlocked
Signal Unlock Count: number of bad samples required to reset the quality engine a when unlocked

The subsample diagnostic menu shows the state of the lock/unlock engine. Subsamples may be logged by activating *log every subsample* setting. Please note that since about 10 subsamples are created every second, the log will fill up in a matter of hours if this setting is enabled. When *log every subsample* is enabled, the log entry "Sub Duty" will record the PWM signal as a percentage. The log entry "Sub SigStr" will represent the signal strength (also a percentage). Additionally, the lock/unlock engine will report any changes with the log entry "Lock". If the value logged with "Lock" is 1 it means the signal locked, a value of 0 means the signal unlocked, and a value of -1 means the engine restarted.

Default, Max, Min Settings

The table below indicates the default settings and the maximum and minimum ranges it may be set to.

Parameter	Default Setting	Minimum	Maximum	Comment
Automeasure Interval	00:15:00	00:00:01	01:00:00	
Automeasure Time	00:00:00	00:00:00	23:59:59	
Operating Mode	Normal	0 = Normal	1 = Continuous	
Avg Time	10.000 sec	0	900	seconds
Right Digits	2	0	7	
Stage Units	Feet	0	3	0=feet,1=m, 2=cm, 3=mm
Measuring Point	1.00000 feet	-1000000.00499	1000000.00499	Indirectly set when user sets stage.
DQAP	Disabled	0=Disabled	1=Enabled	
Discharge	Disabled	0=Disabled	1=Enabled	
Discharge Equation	Parshall Flume	0=Disabled	1=Enabled	
Parshall Flume Width	12 inches	1	600	inches
Coefficient A	1.0000000	-1000000.0049999	1000000.0049999	
Coefficient B	1.5000000	-1000000.0049999	1000000.0049999	
Gauge Height Shift	0.0000000	-1000000.0049999	1000000.0049999	
Weir Coefficient W	1.0000000	-1000000.0049999	1000000.0049999	
Station Name	Sutron Radar	1 Char ASCII	24 char ASCII	Numbers included
WDID				
Auto Output	Disabled	0=Disabled	1=Enabled	
Log Every Subsample	Disabled	0=Disabled	1=Enabled	
Log Every Sample	Disabled	0=Disabled	1=Enabled	
Log Level Details	Disabled	0=Disabled	1=Enabled	
Log Daily Values	Disabled	0=Disabled	1=Enabled	
Sample Form Period	1.0 sec	0.1	10000.0	Seconds
PWM slope	0.755105			Contact Customer
Factory Offset	-1.2			Service for further information on
SigStrCal	3.300			these items.

Front Panel Interface

The radar features a two line LCD interface, six buttons and two LEDs. The front panel interface can be used to setup the radar, examine its status, view the current stage readings, and view logged data.

Navigating the Menus

The menu has a tree structure, like directories in an operating system.

1. The radar menu tree (page 24) can be navigated with the arrow keys. Press ▲ (up) and ▼ (down) to browse the menu items that are on the same level. On certain menus, press ► (right) to enter a sub menu, and ◄ (left) to go up to the parent menu.
2. Some menu items offer a means to change setup. To change a 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.
3. 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.
4. 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.

Front panel key functions

- RIGHT will navigate to a sub-menu (assuming there is one).
- LEFT will go back to the parent menu.
- UP and DOWN will navigate among the menus on the same level.
- SET starts a change or confirms an action.
- CANCEL cancels a change or action. The CANCEL key is also labeled OFF.
- CANCEL also goes back levels.
- Hold CANCEL to go to the top of the menu.
- Hold UP or DOWN to change contrast setting.

Turning Display On/Off

The radar 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.

Backlight

The display is equipped with a backlight to assist in viewing in many different lighting conditions. The backlight will automatically turn on whenever the display is turned on.

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 Data

When the display is turned on, the last measured stage will display. The radar will then initiate a new measurement and display the results as soon as the measurement completes (which is based on averaging time).

Understanding the "?" indicator.

The radar displays a "?" after a value if there is a question about the quality of the data. This is most likely due to poor targeting of the radar (see Targeting the Radar on page 46). The "?" is a reminder that user action is needed for the station to be operational.
If you are viewing the live stage, you may press right to see the details of the measurement. Details like signal strength and number of good samples may provide clues as to why the reading is bad.
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.

Viewing Logged Data

The radar will save the stage in its flash memory each time a measurement is made. To view logged data, use the down arrow to display the menu Logged Data. The press right, and press up/down to select the desired item (Logged Events, Entire Log) and press the right arrow. The last logged value for the item will be displayed along with the date/time, and units. 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.

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

Front Panel Menu Tree

- Errors (only show if errors are present)
  - Hardware error details
- Stage (live) and time of reading -- Press set to calibrate
  - Stage Details
- Distance to Water and signal strength (live)
- Discharge * (when discharge is enabled)
- Battery Voltage
- GPS* (when Garmin GPS is enabled)
  - GPS Status
  - GPS Time of Last Sync
  - Local Time Offset
- Logged Data
  - Stage
  - Discharge * (when discharge is enabled)
  - Logged Events
  - All Logged Data
- Station Setup
  - Measurement Setup
    - Automeasure Interval
    - Automeasure Time
    - Operating Mode (Single | Continuous)
    - Averaging Time
    - Stage Units (feet | cm | m | mm)
    - Right Digits
    - Measurement Point
    - DQAP Enable
    - Log Stage Details
    - Sample Form Period
  - Discharge Setup
    - Discharge Enable
    - Discharge Equation (Parshall | Weir | Generic)*
    - Parshall Flume Width (Pequation only)*
    - Weir Coefficient (weir equation only)*
    - Coefficient A (generic equation only)*
    - Coefficient B (generic equation only)*
    - Gauge Height Shift*
  - Modbus Settings
    - Modbus Enable
    - Modbus Device ID
    - Modbus Protocol
    - Modbus Parity
    - Delay before Tx
    - Delay after Tx
    - Modbus BaudRate
  - Other Setup
    - Station Name
    - WDID
    - Garmin GPS
    - Password
    - Default Setup
    - RS232 Baud Rate
    - RS232 Wakeup
    - Hardware Flow Ctrl
    - Auto Output
    - SDI-12 Address

- Log Daily Values
- Diagnostics
  - Signal Strength
  - Raw Sensor Data
  - Subsample
  - Sample
    - Distance
    - Quality
    - Min/Max
  - Log Every Subsample
  - Log Every Sample
  - Software Version
- Station Name and Time

SDI-12 Sensor Operation

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

For details on SDI-12 wiring, please refer to page 10.

The most common SDI-12 command used with the radar is the "M" measure command followed by the "D0" command. The "M" command requests the radar to make a measurement and the "D0" command gets the data. While there are a lot of other commands available, most users will simply use the M, D0 commands.

Note: The radar 'Mode' of operation, ie Normal vs. Continuous Mode, will have an impact on the communication delays experienced with the SDI-12 operation. See section Operating Modes for more details on operation.

The remainder of this section documents all the SDI-12 commands supported by the radar. Note that most any setting that can be changed from the front panel, can also be changed via SDI-12.

Changing the SDI-12 address can be accomplished via the front panel (Station Setup > Other Setup > SDI-12 Address).

SDI-12 Reference

The radar will respond to all standard SDI-12 commands. To use the SDI-12 commands you must have a data logger or interface that supports the SDI-12 standard. The radar is compliant with SDI-12 Specifications version 1.3. More details on the SDI-12 interface can be found at http://www.sdi-12.org.

The general form of an SDI-12 command is:

aC!<CR><LF>

where a is the sensor address 0-9,A-Z,a-z,*, ?. (Addresses * and ? will address any sensor, regardless of its address.)
C is the command and ! is the last character of the command.

The standard SDI commands are as follows

	Name	Command(s)	Response	Example/Notes
	Acknowledge Active	a!	a	
I	Send Identification	aI!	A13 SUTRON 1.0 RLRXXXV1.21 Where 1.0 is the board revision, V1.21 is the software revision	
A	Change Address	aAb!	b	
?	Address Query	?!	a	
M MC C CC	Measure Stage and discharge	aM! aD0!	atttn a +stage +discharge +units +distance +validity	Returns stage in user set units, discharge (0 if disabled), units indicator, and validity. The validity can be 0-valid, 1-sensor failure, 2-data old, 3-system not configured properly

	Name	Command(s)	Response	Example/Notes
M1 MC1 C1 CC1	Measure Distance to Water and Battery	aM1! aD0!	atttn a +distance +battery	Returns distance to water in **feet** and battery voltage.
M2 MC2 C2 CC2	Measure Stage, Return stage details	aM2! aD0!	atttn a +stage +deviation +outliers +total count +signal strength +validity	
M3 MC3 C3 CC3	Returns last automeasured stage and Related stage details. This command does not cause a measurement to be made.	aM3! aD0!	atttn a +stage +deviation +outliers +total count +signal strength +validity +age	This command does not cause a measurement to be made. It returns the extended information for the last measurement. Age is the number of seconds since the measurement was made.
M4 MC4 C4 CC4	Return raw radar sensor readings	aM4! aD0!	atttn a +duty cycle +signal strength	**Diagnostic** command, not intended for field use.
M5 MC5 C5 CC5	Measures and returns radar subsample data.	aM5! aD0!	atttn a +duty cycle +signal strength + quality (0=not graded, 1=good, 2=out of range, 3=delta error, 4=sensor failure) +lock/unlock (1=locked)	**Diagnostic** command, not intended for field use. May return more data than allowed by SDI-12 specification.
M6 MC6 C6 CC6	Measures and returns radar sample data.	aM6! aD0!	atttn a +distance +standard deviation +minimum +maximum +signal strength +good count +total count +quality (0=bad, 1=good)	**Diagnostic** command, not intended for field use. May return more data than allowed by SDI-12 specification.
M7 MC7 C7 CC7	Return automeasured stage and discharge. This command does not cause a measurement to be made	aM7! aD0!	atttn a +stage +discharge +units +distance +validity +age	Age is the number of seconds since the measurement was made

	Name	Command(s)	Response	Example/Notes
M8 MC8 C8 CC8	Returns last measured radar sample data (same as M6, but no new measurement is initiated)	aM8! aD0!	atttn a +distance +standard deviation +minimum +maximum +signal strength +good count +total count +quality (0=bad, 1=good)	**Diagnostic** command, not intended for field use. May return more data than allowed by SDI-12 specification.
V	Verification	aV!	Errcount+resets	

	Name	Command(s)	Response	Example/Notes
X?	Request unknown address	*X?!	a Address of the sensor	This command causes the Bubble to identify itself.
XAD	Set SDI-12 address	aXADnAn! n the new SDI-12 address, repeated twice	a0011 no response if the addresses do not match	**Note:** a D0 command issued after will return the new address.
XE	Set Measuring Point	aXE+d+u! d is the Measuring Point in the units indicated by u.	attt1	0XE+0+0 (set the Measuring Point to 0 causing all stages to be inverse of the distance to water.) 0XE+15.25+0 (set the Measuring Point to 15.25ft) **Note:** a D0 command issued after XE is complete will display the new Measuring Point in the current units (as set by the XUP command).
XS	Set Stage	aXS+d+u! d is the desired reading for the sensor and in the units indicated by u. The sensor will adjust the Measuring Point to ensure the reading matches the value entered.	attt1	Example: 0XS+7.87+0 (sensor is at 7.87 feet, adjust Measuring Point to ensure this reading) **Note:** a D0 command issued after XS is complete will display the Measuring Point in the current units (as set by the XUP command).
XOM	Set/display operating mode	aXOM+m! m is optional. Omit m to read the current mode, include it to change the mode.	attt1	Example: 0XOM+0! (puts device into single mode) **Note:** a D0 command issued after XS is

	Name	Command(s)	Response	Example/Notes
		m = 0, single mode, measure only when data is requested m = 1, continuous mode, measure continuously and provide data when requested.		complete will display the operating mode.
XT	Set/display averaging time	aXT+t! t is optional. Omit t to read the current value, include it to change. t = averaging time in seconds (0 to 900 seconds)	attt1	Example: 0XT+10! (sets the averaging time to 10 seconds) **Note:** A D0 command issued after will return the averaging time.
XUP	Set/display stage units & number of right digits	aXUP+n+d! Both n and d are optional. Include them if you want to change the values. n = 0 feet water n = 1 m water n = 2 cm of water n = 3 mm water d = number of places right of the decimal	attt2	Example: 0XUP+1+2! select m with 2 right digits **Note:** a D0 command issued after the XUP will return the value of the units that are selected and the number of digits right of the decimal point.
XFD	Set factory defaults	aXFD!	a0011	**Note:** a D0 command issued after the XFD command will return the operating mode.
XOP	Set/display auto serial output	aXOP+a! a is optional. Include it to change the value. a = 0 disable output a = 1 enable output	a0011	**Note:** a D0 command issued after command will return the auto serial output.

	Name	Command(s)	Response	Example/Notes
XDT	Set/display date and time	aXDT! this command reads the current time aXDTYYYY/MM/DD HH:MM:SS! 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	aYYYY/MM/DD HH:MM:SS+q+g a is address 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 **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.	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.
XXS	Generic setup command	See page 33 for details		

XXS Generic Change Radar Setup Command

This command is used to view and change all setup data in the unit. It is used in the following manner:

XXS+s+n+v1+v2+v3+…+vx where

s is the setup identifier and must be equal to 1
n is the setup variable to start making changes at.
v1 is the new value to write for the first variable
v2 is the value to write for the next variable

The setup variables are accessed using their order in the software meta variable map as seen in the following table. The values than can be used for any of the variables can be seen in the radar Settings and Radar Settings sections.

1. Automeasure Interval
2. Automeasure Time
3. Operating Mode
4. Avg Time
5. Right Digits
6. Stage Units
7. Measuring Point
8. DQAP Enable
9. Discharge Enable
10. Discharge Equation
11. Parshall Width
12. Coefficient A
13. Coefficient B
14. Gauge Height Shift
15. Weir Coefficient W
16. Station Name
17. WDID
18. Auto Output
19. Log Every Subsample
20. Log Every Sample
21. Log Stage Details
22. Log Daily Values
23. Sample Form Period
24. Garmin GPS Enable
25. GPS Local Time Offset

An example command to change the right digits to 5 is:

XXS+1+5+5

You can also change right digits to 6 and stage units to 2 together in the same command by typing:
XXS+1+5+5+2

To read a setup value, issue command XXS+1+n!, where n is the setup variable whose value you are interested in. For example, to read the current right digits, issue command XXS+1+5! and follow it up with a D0! command. The reply to D0 will have the right digits.

Any settings that allow for a negative value can be set using a '-' as a delimiter.

Changing the station name can use either a '+' or '-' delimiter and may contain spaces:
XXS+1+16+New Name would change the station name to "New Name".

RS232 Command Line Interface

The RS232 interface provides a simple way to connect the radar to PCs, modems and other communications devices. Details on the DB9 connector are on page 10.

Microsoft Windows usually comes with a program called HyperTerminal. It can be found by going to the Windows start menu, Programs, Accessories, Communications.

By default the RS232 interface operates at 115200 Baud, no parity, 8 data bits, 1 stop bit. Changing the baud rate can be done via the front panel: Station Setup > Other Settings > Baud Rate, or via the command line by typing "BAUD RATE".

If connecting to a PC, use a standard DB9 serial cable. If connecting to a modem or a logger, you are likely to need a null modem adapter.

To start command line mode, send carriage return or line feed (or both). If using HyperTerminal or a similar program, simply press ENTER. Radar will respond with a prompt >

Once in command line mode, type "HELP" to get a list of supported commands.

RS232 Setup

The setting *RS232 Wakeup* controls what is required to wake the unit up via the RS232 connection. The options are:

Wake on RTS (default)
Wake on DTR
Wake on either RTS or DTR
Always on

If setup to wake on *RTS*, *DTR*, and *RTS or DTR*, the connected device must assert said line for communication to work. At least half a second needs to occur between the assertion of the correct control line and the start of communication (automatically done by HyperTerminal). The unit can also be setup to be always on, which increases power consumption but requires neither RTS nor DTR to establish RS232 communication. If setting up the unit with a modem, it is likely that *Wake on DTR* would be the correct option that results in lowest power consumption. However, it will depend on the modem. Access this setting via the front panel: Station Setup > Other Settings, or via the command line.

Please note that the unit will always assert DSR (as long as it has power).

Hardware flow control via lines RTS and CTS (a.k.a. hardware handshaking) can be enabled via the *Hardware Flow Ctrl* setting. Enabling the setting can improve communication, especially if using a modem. When handshaking is on, the receiver is able to pause the data flow from the transmitter. Access this setting via the front panel: Station Setup > Other Settings, or via the command line.

Please note that if *RS232 Wakeup* is set to wake on RTS, it is not possible to use *Hardware Flow Ctrl.*

Machine to Machine Communication

All commands may be preceded with an !. If they are, there is no echo, and a concise reply meant for machine to machine interaction is returned. Commands would be preceded by an ! if they were sent by an Xpert or some such computer.

Viewing Stage

To initiate a new stage measurement, type MEAS. To see the last automeasured stage, including details, type LAST. The output by the radar will look like this:

Radar Reading
Stage 7.01 feet

Discharge 52.21 CFS
Distance 23.38 feet
Good Samples 2
Total Samples 2
Standard Deviation 0.00
Signal Strength 59.7%

For details on what each of the measurements means, please refer to Stage Details on page 15.

For a concise version, try !LAST or !MEAS;
7.01,23.38,53.21,
2,2,0.01,59.7

Downloading the Log

The radar will save the stage in its flash memory each time a measurement is made. This data is then available to download to via the RS232 port. The command "LOG" command will start a Y-Modem transfer of the log to the connected device. There are optional parameters that alter what data is downloaded as follows:

"LOG" with no parameters will download since last.
"LOG ALL" gets whole log.
"LOG X" gets X last days ("LOG 3" gets last 3 days worth of data)
"LOG timeStart" gets data since provided date
"LOG timeStart timeEnd" gets data between provided dates
time can be YYYY/MM/DD HH:MM:SS or YYYY/MM/DD or HH:MM:SS
e.g. "LOG 12:00:00 13:00:00"
e.g. "LOG 2006/01/20 12:00:00 2006/01/21 12:00:00"
Appending NH will omit the header : « LOG ALL NH »
"LOG HELP" Shows details on how to use the download command.

Auto Output

When the radar has *auto output* mode enabled (via front panel, Station Setup>Other Settings>Auto Output, command line AUTO OUTPUT), it will automatically send data out on the RS232 port. The data will come out at whatever *baud rate* is setup (via front panel, Station Setup>Other Settings>Baud Rate, command line BAUD RATE). If connected via HyperTerminal, and if command line mode is active, type EXIT to leave command line mode and to capture the auto output.

The data auto output is the stage. It is output as fast as it is measured (which depends on user settings), once a second at most. The data is ASCII. This is an example of the output:

46.3
46.3
46.4
46.4

Target Mode

In order to help setup the Radar so that its antenna correctly points at the water's surface, the TARGET command may be issued. Once issued, the Radar will continuously output distance to water and signal strength. readings. The readings are output once a second. To ensure fresh data is output, make sure that the *sample form period* is one second or less (which it is at default).

RS232 Command Reference

Documentation Legend:

+ If any command **is followed by +**, it means that as long as the command starts with the indicated word, it will be accepted.
E.g. MEAS + means that typing "MEAS", "MEASURE", or "MEASXXX" will all have the same effect.

0 **If a 0 follows** a listed command, it means that the command can optionally be followed by the character 0.
E.g. "DIAG" will show the system diagnostic status. "DIAG 0" will first show current status and then clear the status.

! NOTE:

All commands may be preceded with an !. If they are, a concise reply meant for machine to machine interaction is returned. Commands would be preceded by an ! if they were sent by an Xpert or some such computer.

E.g. **"MEAS" will show**

Radar Reading
Stage 23.04 feet
Distance 23.30 feet
Good Samples 2
Total Samples 2
Standard Deviation 0.01
Signal Strength 63.5%

"!MEAS" will show

23.05,23.29,0.00,
2,2,0.00,63.0

List of commands

BATT +
Shows the current battery reading.

DIAG + 0
Shows system diagnostics, including system resets. If followed by 0, it will clear system resets.

DOWNLOAD
See LOG

EXIT
Quits command line.

HELP
Brings up the end user help (lists commands).

HI
System replies with "Hello"

LAST +
Shows the last automeasured reading.

LOG
This command is used to download the log. It can be followed by optional parameters indicating what part of the log to download.
LOG with no parameters will download since last.
"LOG ALL" gets whole log.
"LOG X" gets X last days ("LOG 3" gets last 3 days worth of data)
"LOG timeStart" gets data since provided date
"LOG timeStart timeEnd" gets data between provided dates
time can be YYYY/MM/DD HH:MM:SS or YYYY/MM/DD or HH:MM:SS
e.g. "LOG 12:00:00 13:00:00"
e.g. "LOG 2006/01/20 12:00:00 2006/01/21 12:00:00"

The file name for the downloaded log has the format
Stationname_log_YYYYMMDD.csv where YYYYMMDD is the date of the first data in the log file

The data in the log file consists of some header lines to document important station information followed by data. The following are examples of the header lines :

Station Name, WDID, model and version, Measuring Point, Operating Mode, Avg Time, DQAP, Sample Form Period
Sutron Radar, 20003, RDR ver 1.11, 48.24659 feet, Normal, 10.000 sec, Disabled, 1.0 sec
PWM Slope, Factory Offset, SigStrCal
0.75743, -2.216, 3.195
Discharge, Equation, Parshall Flume Width, Weir Coefficient W, Coefficient A, Coefficient B, Gauge Height Shift Enabled, Generic: A*(Stage^B), 12 inches, 1, 1, 1.5, 0.1

The header lines are followed by data in the following format :
Name, Date, Time, Value, Units, Quality

The following are examples of logged data :
04/13/2009,10:51:25,Stage,-3.91,feet,
04/13/2009,10:51:25,Distance,3.91,feet,
04/13/2009,10:51:25,Standard Deviation,0.00,,
04/13/2009,10:51:25,Signal Strength,101.0,,
04/13/2009,10:51:25,Good Samples,5,,
04/13/2009,10:51:25,Total Samples,5,,

LOG HELP
Shows details on how to use the download command.

STAGE = 14.5
Changes the current stage to 14.5 (of whatever units are currently chosen). User can choose any number, not just 14.5. Please see the section Setting Stage on page 14.

MEAS +
Initiates, waits for, and shows the results of sensor measurements.

REBOOT
Does a software resets of the system.

RESETS + 0
Shows system diagnostics, including system resets. If followed by 0, it will clear system diagnostic status.

SETUP
If provided without any other parameters, it lists all setup details. That includes each setup variable and its current value.
Can be followed by a setup variable name and a new value for that variable.
E.g. "CHANGE STATION NAME = SUTRON"
If SETUP DEFAULT is issued, it will reset the entire setup to defaults.

STATUS 0
Shows system status including time, boot time, battery readings, last Radar measurements, current onboard sensor readings, and any hardware errors that may exist. If followed by 0, it clears the hardware errors.

TARGET
Continuously measures and outputs sample data, including distance to water and signal strength.

TIME
Shows the current system date and time. If followed by a new time, it changes the system time.

UPG +
Initiates a system software upgrade. It needs to be followed by the YModem transfer of an .upg file specific to the product. Both the main application and the bootloader are upgraded this way (but each needs its own .upg file).

VER +
Shows the current software version, including build date and time and the bootloader version.

List of setup variables

Type SETUP to get a list of the whole setup. Every setup variable can be viewed by typing its name.
E.g. "STATION NAME" will show the current station name.
Every setup variable can be changed by typing its name = new value.
E.g. "STATION NAME = SUTRON" will set the station name to "SUTRON".

AUTO OUTPUT
AUTOMEASURE INTERVAL
AUTOMEASURE TIME
AVG TIME
COEFFICIENT A
COEFFICIENT B
DISCHARGE ENABLE
DISCHARGE EQUATION
DQAP ENABLE
GAUGE HEIGHT SHIFT
HARDWARE FLOW CTRL
STAGE UNITS
LOG STAGE DETAILS
LOG DAILY VALUES
MEASURING POINT
OPERATING MODE
PARSHALL WIDTH
RIGHT DIGITS
RS232 BAUD RATE
RS232 WAKEUP
STATION NAME
WDID
WEIR COEFFICIENT W

List of calibration setup variables

These settings are set at the factory for optimum operation and should not be changed. If they are, radar may stop functioning, **Note:** Consult Sutron Customer Service for further information regarding factory calibration.

Setup Transfer via Hyperterminal

It is possible to capture a Radar's setup and save it to file. Using HyperTerminal, establish RS232 connection first. Once you are able to talk to the Radar, use HyperTerminal's Transfer menu and select Capture Text. Then type !SETUP on the command line. The Radar will stream out it's entire setup and it will be saved in the file selected. Make sure to tell HyperTerminal to stop text capture after getting the setup in the file.

Once the setup is saved to file, feel free to edit the file, changing any of the settings. To send a setup file to the Radar, HyperTerminal will need to be properly configured to delay after sending every line. To do so, user HyperTerminal's **File**, **Properties** menu. Click on the **Settings** tab and click the **ASCII Setup** button. Change the **Line delay to 1000 milliseconds** and change the C**haracter delay to 5 milliseconds**. If these changes are not made, HyperTerminal will send the file too fast for the Radar to capture any but the first few settings. Once the changes are made, choose HyperTerminal's Transfer menu and click **Send Text File.** Select the file with the saved setup. You will see the transfer take place on HyperTerminal's main window. Radar will report which settings have been changed.

Connecting a Modem

It is possible to connect a modem to the Radar, allowing for remote access to the station. Use the RS232 port to connect the modem. Most modems will need a null modem adapter between the modem and the Radar.

The modem will need to be configured before it can be used. Please make sure to test out the modem-Radar connection before deploying them in the field. The following modem settings must be configured:

- **Autoanswer: enable** (otherwise a connection will never be established)
- **Connect timeout: enable** (otherwise the modem will keep the Radar awake, increasing power consumption)
- **Command echo: disable** (otherwise the modem and the Radar will forever talk to each other, preventing further connections and increasing power consumption)
- **Telnet mode: enable** (this is required only if using a modem over TCP/IP – if not enabled, log downloads may fail, especially if using HyperTerminal)
- **RTS: enable** (this is likely on by default – unless the setting *RS232 Wakeup* is changed, the Radar will not notice the modem unless RTS is on)
- **Carrier Detect: always on** (also know as LSD Action, DCD, and CD)
- **Baud rate, parity, etc:** set this up to match the settings of the Radar (Radar defaults are 115200 Baud, no parity, 8 data bits, 1 stop bit)

Xpert-Xlite Modem 8080-0005

Sutron manufactures a modem (Xpert-Xlite Modem part number 8080-0005) that is suitable for use with the Radar. On the Radar, setup *RS232 Wakeup* to wake on RTS (it is that way by default).

A null modem cable is needed between the device and the modem since they are both configured as DCE devices. If the null modem cable routes pin 9 through from end to end, you can power the modem from the device, but most null modem adapters leave pin 9 disconnected. In that case, just connect the power (5V-16V DC) to the power connector. Note: this can be done even if the cable routes power through pin 9. The modem will utilize which ever is providing the higher voltage. The modem also must be configured to power up on RTS instead of DTR and to output CD on the DSR pin.

Set J4 to pins 1-2 to have the modem wake up on RTS
Set J5 to pins 1-2 to route CD out the DSR pin

The default settings from Sutron for the modem will work. If the settings have been changed, issue these commands to the modem:

AT&F
ATS0=1
ATE0Q1&D0&W

This is what the commands mean:

AT&F set to factory defaults
S0=1 answer on first ring
E0 don't echo characters
Q1 don't send result codes
&D0 ignore DTR
&W save settings into profile.

Raven Modem

A Raven modem allows you to access the Radar through the Internet. The Raven should be ordered with a fixed IP address. Using that IP address, you will be able to use HyperTerminal or other TCP/IP aware communications programs to use the command line interface of the Radar.

Make sure to place a null modem adapter between the Raven and the Radar.

The Raven modem must be configured as follows:

Device Port	3001
Configure Serial Port	115200,8N1
Command Echo	0

TCP Auto Answer	2
TCP Connect Timeout	30
TCP Idle Timeout	2
Telnet Echo Mode	0
UDP Auto Answer	2

You can connect the Raven to the same battery powering the Raven; however, remember that it will increase the power consumption (both when the modem is idle and when it is connected). As a result, you will need to make sure your battery is large enough to provide the power needed by the station.

Discharge

What the Radar Can Do For You

The radar 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 radar eliminates the need for hand computations and data recording.

The radar supports real-time calculation of discharge 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

You can eliminate the need for after-the-fact hand calculations by enabling discharge calculation and entering the coefficients for your flume or weir.

Discharge Setup Sequence

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

1. Set up stage (see Setting Stage on page 14)
2. Follow the steps in the next section to enable discharge recording and enter the correct coefficients for your flume or weir

Correctly Recording Discharge

Enabling The Computation

Discharge calculation can be enabled either from the front panel or via the command line interface. Via the front panel, go to Station Setup > Discharge Setup > Discharge Enable and press set to enable discharge.

Once discharge is enabled, press down to choose the discharge equation: The choices are:

- Parshall Flume
- Weir
- Generic

WORD OF CAUTION

The radar 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 RADAR.

Selecting the Calculation Type

Rating Curves and Equations

Every flow measurement device 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 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 @ 22.8'
JUMBOSCO01 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 radar.

Base your radar setup **primarily on the equation**, if one is given.

The radar 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.

1. Are you using a Parshall flume? If so, select Parshall Flume as the discharge calculation type.
2. 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.
3. 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 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 radar computes discharge for the three calculation types.

Parshall Flume

Parshall flumes are one of the most widely used discharge measuring devices in the world. The following equation family is used 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 radar 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:

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 setup. For example, if the weir equation is given as:

Q=73.994 * ((GH)^1.5)

then you would enter 73.994 for W in the setup.

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:

Q=A * ((GH)^B)

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

Q=73.994 * ((GH)^1.8537)

Enter the value 73.99 for A in the setup and 1.8537 for B. The procedures for entering coefficients 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 radar up from the front panel, the coefficient entry is "context sensitive." That is, the radar 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.

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.

Installation

Electrical Connections:

Refer to the Cabling section on page 9 for a description of the electrical connections.

Mount the Radar

Be sure to pick a location for the radar where it has a clear, unobstructed view of the water below it. The minimum distance for the sensor is 5 feet so make sure that the sensor is at least 5 feet above the highest stage that can be measured. The maximum distance from the sensor to the water is 60ft. Read the next section titled "Targeting the Radar" for additional before mounting the radar.

The RLR-0001-1 radar is designed to mount with the front panel display facing up. In this orientation, the radar antenna points down to the water surface. You may switch the orientation of the antenna by opening the enclosure and changing the mounting plate so the antenna points to the side of the enclosure. Do not install the RLR-0001-1 outdoors without an additional protective enclosure. The radar mounts to a panel or surface through four holes that are accessible in the corners of the enclosure

The RLR-0003-1 antenna enclosure is designed with a 5/8" bolt for connection to a mounting arm. The bolt and the swivel bracket can be adjusted to allow the radar to point directly to the water surface no matter what the angle is of the mounting arm. The adjustments are made by loosening the two screws in the sides of the swivel bracket and also rotating the bracket relative to the bolt.

Targeting the Radar

The radar sensor operates by emitting a pulse and capturing its reflection. The pulse is meant to be reflected on the surface of water. To operate properly, the antenna emitting the pulse must be carefully pointed at the water surface.

For best results, **mount the radar directly above the water surface, such that the radar beam is perpendicular to the water**. The radar will not operate well if the beam strikes the water at an angle**.**

The Half-power beamwidth of the radar is 32 degrees -- +/-16 degrees off a center line). The radar can get a reflection off anything that is within the area of the beamwidth. The following table shows the width of the beam at different distances from the water. Make sure that this area is free from obstructions.

Distance to Water	Beamwidth (radius in feet)
10	3
20	6
30	9
40	12
50	15
60	18

When installing the radar, please use the front panel diagnostic feature (Diagnostic > Signal Quality**)**. The radar gives a signal strength expressed as a percentage 0 to 100%. Before mounting the enclosure move the enclosure a small amount in each direction and note the change in the signal strength. When you have found the maximum signal strength, mount the radar in the same orientation. You may also use the circular level to point the antenna at the water surface.

If using the front panel is not convenient, try the command line TARGET mode. It will continuously output Radar readings on the RS232 port which may a useful aid during installation.

Please see the section Quick Install for more installation tips.

FIRMWARE Upgrade

The radar level recorder has been designed using the most modern techniques such that at any time the system firmware may be upgraded while it is in the field preventing the need to ever return a unit to the factory for firmware upgrades. The factory may offer new features or bug fixes that may only be accessed through firmware upgrades. The techniques below will illustrate how to install the upgraded firmware into the radar unit.

Methods for upgrade:

There are several possible methods to use to upgrade the software in the radar unit. The first step in all three methods is to download from the Sutron web site the program upgrade file, such as 'v1_24mainRLR1260.upg', found at http://www.sutron.com/downloads/software.htm. Select the radar and download the UPG file to a temporary folder or desktop location where it may be accessed at a later time.

Method 1: Using 'UPGRADE' command using Hyperterm:

Open and run Hyperterm on a PC. Set the properties to:

Baud Rate: 115200
Bits: 8
Parity: None
Stop Bits: 1

- Start with the radar unit powered up and running.
- Connect DB-9 serial cable and establish communications by typing 'enter'. (connect port)
- Once the prompt is found, type 'UPGRADE" or 'UPG'.
- Now the system is waiting for Hyperterm to send the file.
- An upper case "C" will repeat every 2 seconds or so over the serial port. Select 'Send File" and choose 'Y-Modem' and then select the upgrade file name previously stored on the computer.
- Once the download is completed, the system will reboot.
- Type the command 'Ver' to confirm that the upgrade was successful

Method 2: Using Hyperterm and 'Escape' key:

Open and run Hyperterm on a PC. Set the properties to:

Baud Rate: 115200
Bits: 8
Parity: None
Stop Bits: 1

- Start with the radar unit powered DOWN.
- Open the serial port with hyperterm.
- Power up the radar unit simultaneously while holding the 'Escape' key on the keyboard of the computer running Hyperterm. Release the escape key once the unit has powered up.
- An upper case "C" will repeat every 2 seconds or so over the serial port. At this time, use 'Send File' and choose 'Y-Modem' and then select the upgrade file name previously stored on the computer.
- Once the download is completed, the system will reboot.
- Type the command 'Ver' to confirm that the upgrade was successful.

GPS

It is possible to use a GPS to provide the RLR with an accurate, self setting clock. RLR can be connected to a Garmin GPS 16HVS. RLR needs to be have software **version 1.15** or newer to support GPS.

Timekeeping

When equipped with a GPS, the RLR 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. The user can setup the RLR so that it keeps local time by changing the variable 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 RLR via SDI-12 (in addition to the Garmin GPS), note that Satlink will set the clock of the RLR once per day. **Please ensure that Satlink's local time offset is equal to that of the RLR.**

An RLR 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 RLR via RS232. Sutron provides a custom RJ45 to RS232 connector for this purpose (the diagram for the connector is on page 51).

After connecting the two devices, go the **Station Setup** menu on the front panel of the RLR. 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 RLR is communicating with the GPS, the menu will say *GPS initializing*. If the GPS has acquired a time fix, the RLR 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 49).

The next entry in the menu is **local time offset**. The user can setup the RLR 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, RLR will power up the GPS. This helps with GPS positioning. As long as the display is on, the RLR will provide power the GPS, allowing it to track satellites. When the display is off, the RLR will power the GPS once an hour for up to 15 minutes.

GPS Positioning

If the RLR 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 RLR will wake up the GPS. Once the GPS has acquired a time fix (should not take more than 40 seconds), the RLR 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, RLR 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 RLR or if the GPS cannot acquire a time fix, the RLR will blink the red LED to indicate that there is a problem. In addition, the RLR will show a message describing the problem on the front panel. Once a day, the RLR will write an event to the log indicating that it has GPS problems.

The RLR reporting **"No GPS Detected"** can indicate that the connector between the GPS and RLR is bad (please refer to the section on the connector on page 51) or that the RLR does not have its jumpers set properly (please see the section on page 50 about Jumpers)

If the **GPS cannot get a time fix**, please see the section on GPS Positioning on page 49.

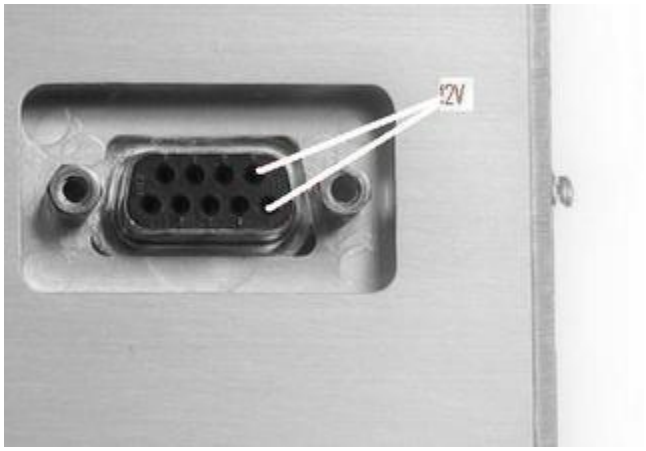
If the RLR reports "**GPS Comm Failure",** it means the RLR is detecting data on the RS232 line, but that the data is incomprehensible. It could indicate that the GPS has been improperly configured. If possible, try using a different GPS module.

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

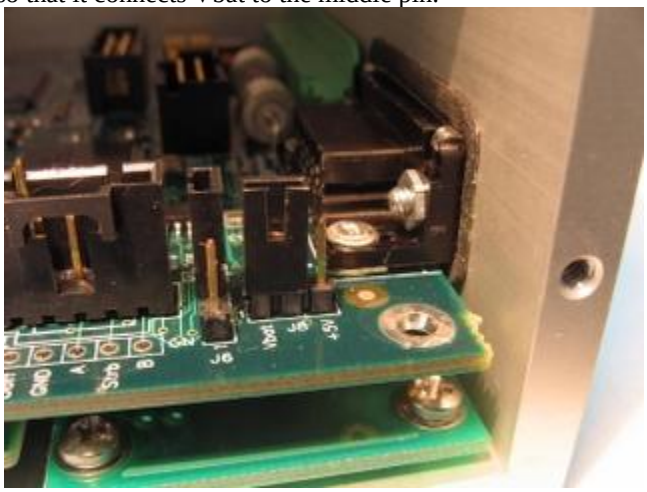
Jumpers

There is a jumper inside the RLR that ensures that the RLR provides 12 Volts on RS232 which the Garmin GPS requires in order to function. Normally, Sutron sets this jumper so that the unit can work with a GPS. However, **if the RLR is reporting "No GPS Detected"**, it may be the case that the jumper is not properly setup.

There is a way to determine the jumper setup without opening the unit. 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 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 unit and set the jumper.



To setup the jumper, the case must be opened. Once the case is open, 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 needs to be properly configured in order for the unit 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.

RJ45 to RS232 Connector

A custom connector is required to get the Sutron and the Garmin GPS together. The connector bridges the RJ45 on the Garmin GPS to the RS232 on the Sutron unit. 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 Sutron unit	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 if <0.3V, Off if open

			on/off	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

Modbus

RLR 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 AutoPoll can be used to access log data. For more information on AutoPoll, please visit www.sutron.com

To enable Modbus, go to the **Station Setup** menu on the front panel 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 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.

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 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 (i.e. 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 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 Function Codes

The following table identifies the functions that are supported. 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

There are 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 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	1 means running 0 means stopped
Reset Unit	1008	Write 1 to reset
Modbus Protocol	1009	0 – RTU 1 – ASCII
Force Measurement *	1010	0 – force all active measurements 1-16 force that measurement only
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
Modbus Enable	1022	Read/Write 0=OFF 1=ON

**Note: When forcing a measurement, 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 RLR. This will ensure data will follow that found in the RLR 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 unit 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
Quality (see below)*	3
Last measured Discharge (MSW)	4
Last measured Discharge (LSW)	5
Last measured Distance to Water (MSW)	6
Last measured Distance to Water(LSW)	7
Last measured Signal Strength (MSW)	8
Last measured Signal Strength (LSW)	9
Last measured Standard Deviation (MSW)	10
Last measured Standard Deviation (LSW)	11
Battery Voltage (MSW)	12
Battery Voltage (LSW)	13

*Quality – the quality register will hold the value 1 if the reading is valid, and the value 0 if an error occurred during the reading. Quality relates to Stage, Discharge, Distance to Water, Signal Strength, and Standard Deviation.

Get Log Command

The Get Log subcode is used to retrieve log data from the unit. 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,G
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 A – Specifications for the radar

Electrical	
Power Required	8-16VDC
Current (during measure)	< 30mA @ 12V
Quiescent current	< 1 mA @ 12V
Outputs	SDI-12 V1.3, RS232
Radar	6.2 GHz 32° Half power beamwidth
Accuracy	0.01 ft up to 20 ft, 0.05% reading 20 to 60ft
Range	60ft
Resolution	< 0.001ft
Mechanical	RLR-0001-1
Enclosure	NEMA-4 Plastic
Dimensions	5.2”x7.1”x5.75”
Weight	2 lbs.
Mechanical	RLR-0003-1
Enclosure	NEMA-4 ABS plastic
Dimensions	
Weight	5.6 lbs.
Environmental	
Temperature	-40°C to +60°C
Humidity	0-95% Non-condensing
Log	Flash memory, 300,000 readings >20 years data retention
Keypad/Display	2x20 character LCD 6 button keypad 2 status LED
Operating Modes	Standalone or SDI-12/RS232 Discharge/Volume calculations Average/DQAP calculations

Ordering Information

Part Number	Description
RLR-0001-1	Radar Level Sensor with built-in antenna
RLR-0003-1	Radar Level Sensor with built-in antenna

Appendix B – Sutron Customer Service Policy

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

Appendix C – 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 (21300 Ridgetop Circle, Sterling, VA 20166), or at its option, replacement of 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 prepay transportation charges to the factory. Sutron shall pay transportation for the return of the repaired equipment to the customer when the validity of the damage claim has been established. Otherwise, Sutron will prepay shipment and bill 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 90 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.

REPAIR AND RETURN POLICY

Sutron maintains a repair department at the factory, 21300 Ridgetop Circle, Sterling, VA 20166. Turn around time normally ranges from 10-30 days after Sutron receives equipment for repair. **Call Customer Service at (703) 406-2800 for a Return Material Authorization (RMA) number.** Return the defective equipment to the factory, transportation charges paid.

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 – FCC Information

The Sutron Radar model RLR-0003-1 has been designed and tested to comply with the FCC Code of Federal Regulations Title 47 Part 15 rules for intentional and unintentional radiating devices. Under no circumstance shall the user open and modify/change in any way the hardware or software content of the product. Opening of the product (thereby breaking the tamper seals) and/or any of its sub modules for any reason not expressly approved by the manufacturer will violate any warranty and risk generating illegal emissions that may cause interference with other equipment. This is a direct violation of the FCC rules.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined buy turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

--Reorient or relocate the receiving antenna.
--Increase the separation between the equipment and receiver.
--Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
--Consult the dealer or an experienced radio/TV technician for help.

Additional Compliance Information:

1) Sutron Water Level Sensor Model Number ' RLR-0003-1'.

2) This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

3) Contact Information:

Sutron Corporation
22400 Davis Drive
Sterling, VA 20164-4444

Phone: 703-406-2800
Fax: 703-406-2801
Web: www.Sutron.com

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