Total Precip Gauge (TPG)
TPG-0001-1
TPG-0003-1

Operations & Maintenance Manual

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Introduction

The TPG-0001-1 and TPG-0003-1 are precision instruments intended to measure total precipitation using a mechanism to collect and weigh the precipitation.

The log inside TPG is capable of holding more than 300,000 readings, and allows the recording of status and precipitation data. TPG has an SDI-12 interface as well as RS232 so it can provide data to data loggers or communications equipment.

The RS232 port 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 TPG Recorder to a modem or radio.

Features

- Precision temperature compensated load cell.
- Low power consumption (<1ma quiescent, <20ma measuring @ 12V) for long battery life.
- High precision featuring 0.001" precision.
- Two built-in calibration routines for simple recalibration.
- High accuracy: <0.1" -40C to +60C
- Automatically saves data in permanent log
- User-settable measurement, logging, and averaging (filtering)
- 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
- Front panel allows full access to setup, status and data
- Provides redundant data storage when connected to a logger
- Optional tipping bucket output
- Optional heater
- Optional autodrain mechanism

Unpacking

Remove TPG Recorder and associated parts 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.

A complete parts list for the kit is given in Appendix D.

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

SDI-12 Connections

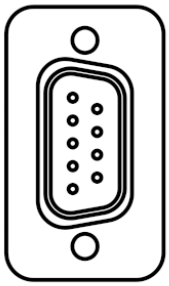
The TPG has and SDI-12 interface with only 3 connections – GND, +12V and Data. To connect a data recorder to the Precip regorder, remove the cover of the Integrated Measurement Unit (IMU) and connect the 3 SDI-12 wires to the corresponding terminals on a data recorder. The TPG is shipped to respond to SDI-12 address 0. The address can be changed via the SDI-12 A command. See the section titled SDI-12 Sensor Operation on page 25 for more details.

DB9 Connector

TPG 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.

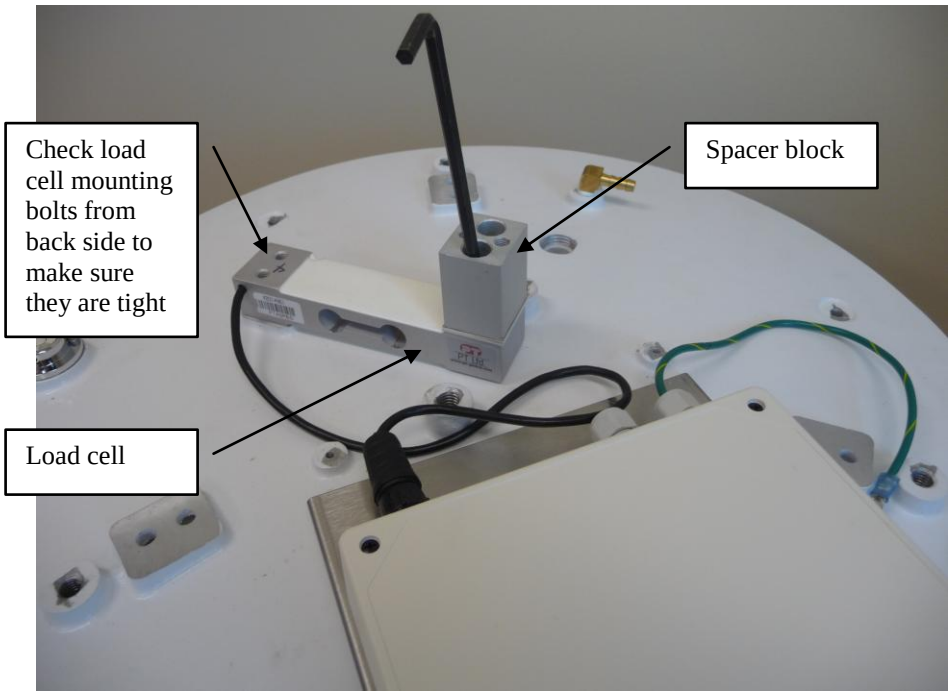
DB9F Pin	Name	Notes
1	N/C	No Connection
2	RXD	Data from TPG
3	TXD	Data to TPG
4	DTR	Signal to TPG
5	Ground	
6	N/C	No Connection
7	RTS	Request to Send, signal to TPG
8	CTS	Clear to Send, signal from TPG
9	VOUT	Jumper selectable for 5V or VBAT (100ma max)



Installation

1. Mount the TPG base on 4.5" OD pipe. Using the built-in level, tighten the 6 bolts on the base, keeping the bubble in the target of the level. Use the nuts to lock the bolts in place.

2. Using the Allen wrench check load cell mounting bolts to make sure they are tight.



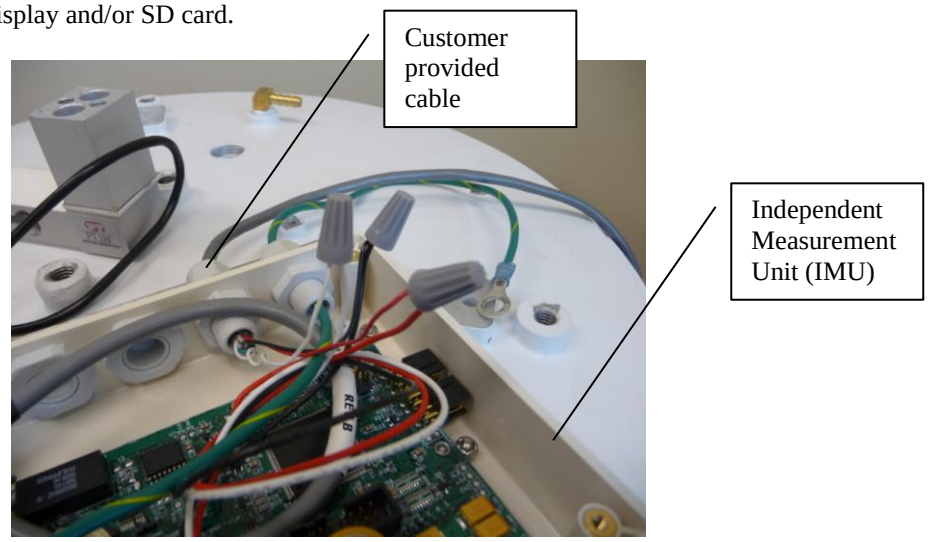
3. Remove cover to Independent Measurement Unit (IMU). Connect customer provided cable to the SDI connections as follows:

   Black – GND
   Red -- +12VDC
   White – SDI-12 Data

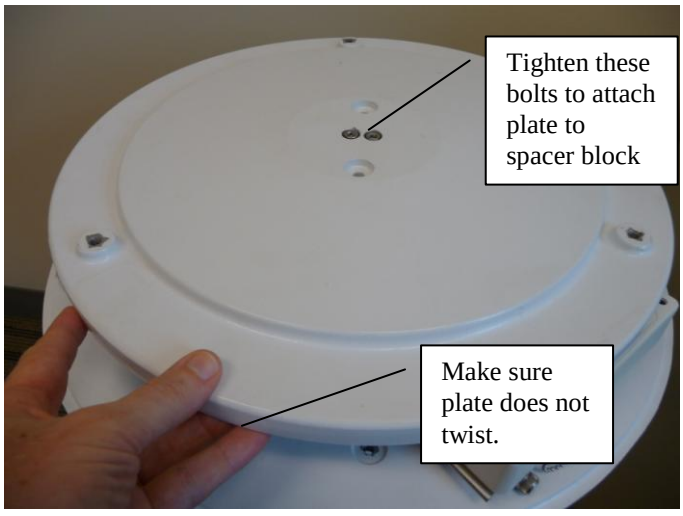
   Use the wire nuts and or electrical tape to make the connections secure. Replace the cover. Test the TPG by sending the SDI-12 commands to the TPG. Use the 0Xa command if you need to change the SDI-12 address. Issue the M command to cause a measurement. Issue a D command to see the data. The format of the data is:

   Precip,Temp,BattV,Amt Drained,validity

   You can also connect to the DB9 serial connection and verify operation with a PC (baud rate is 115,200). Issue a "status" command or "meas" command and view the results. Note: ignore errors that deal with the display and/or SD card.



4. Install the bucket plate on the spacer block. Tighten the plate to the block using the bolts provided. Make sure the connections are tight enough that the plate does not twist



5. Place bucket on the plate. Be sure the bucket sits flat on the plate and not on the alignment bumps.

6. Line up the notch on the cover with the groove on the base and place cover over the bucket. Use the clips to fix the cover in place.

Calibration

The TPG has been calibrated at the factory. To check the calibration, you must have an accurate set of weights or known volumes of water. 1" = 0.8236kg = 1.8157 lbs. Given this relationship we can create the following table:

		Precipitation		
Weight	Units	Inches	cm	mm
1	KG	1.214	3.08	30.8
5	KG	6.071	15.42	154.2
10	KG	12.142	30.84	308.4
19	KG	23.069	58.60	586.0
1	lb	0.551	1.40	14.0
5	lb	2.754	6.99	69.9
10	lb	5.507	13.99	139.9
20	lb	11.015	27.98	279.8
1	liter water	1.214	3.08	30.8
1	gallon water	4.596	11.67	116.7

Calibration Check

Before beginning calibration check, make sure that the TPG is level by checking the bubble level and making adjustments if necessary. At any point during the calibration, you can abort the process by pressing Escape if you are using a serial port, or pressing CANCEL if you are using the TPG display.

Use the command PRECIP = 0 or precip = xx.xxx to set the precip to a known value (SDI XS command). Then add weights/water from the table above and note the change in precip. The change in value should

agree with the values from the table within 0.1% if you are using accurate weights. If you do not get good agreement or want to recalibrate the sensor, follow the procedures below.

Field Offset Calibration

Via the front panel, when viewing the current precipitation reading (the first menu that shows up when the unit is turned on if no errors are present), press SET. Enter the correct reading. The unit will adjust the *offset* so that the current reading corresponds to the user entered correct reading. Additionally, use the SDI-12 interface's XS command or the command line PRECIP = xx.xxx to calibrate the precipitation reading. Normally you will want to do this after adding antifreeze and oil to the bucket (or emptying the bucket) to initialize it to the desired correct accumulated precip.

Calibrating the One Sensor TPG

Note: do this only if the station fails the calibration check.

1. Make sure the sensor is level and stable. It should not rock or shift when pushed with body weight.
2. To begin the calibration process, issue the CAL command over a serial port or from the TPG main menu go to Diagnostic > Two Point Cal, and press SET. Follow the instructions sent over the serial port or displayed on the TPG screen.
3. Select the unit (in, cm, or mm) that you want to measure precipitation in by sending the number corresponding to that unit over the serial port, or by pressing DOWN on the TPG until the desired unit is displayed, then pressing SET.
4. Enter the bucket capacity of the TPG bucket. This number will be used for the TPG's AutoDrain feature. (capacity is 37", 94cm or 940mm)
5. Follow the prompts to place the empty, dry bucket on the TPG's weight sensor. The system will measure the empty, dry weight.
6. The system will then prompt for your calibration weight. For this step you will need an accurate weight or known volume of water. Using the conversion factor or table given at the beginning of the Calibration section, enter its weight in the units you specified in step 2. For example, if you had a 5 kg weight, and you wanted the TPG to report precipitation in inches, you would enter 6.071 (because the table says that 5 kg of water in the bucket corresponds to 6.071 inches of precipitation).
7. Follow the prompts to put the weight in the bucket and proceed with the calibration.
8. After the calibration measurement is complete, you will be given a slope and offset calculated by the TPG. These values convert the raw data received from the weight sensor to units of precipitation you specified. The expected value of slope is as follows:
    a. Units mm slope: 98 to 118 offset: -170 to -220
    b. Units cm slope: 9.8 to 11.8 offset -17.0 to -22.0
    c. Units inches slope: 3.8 to 4.6 offset: -6.5 to -8.7

    To accept the values displayed press Enter or SET. To retry steps 6 and 7 press R or any of the arrow keys on the TPG. Write the values down for your records. For more information on slope and offset, consult the section on Measurement Processes, in Principles of Measurement.
9. Calibration is now complete. At this time you may vary the weight in the bucket to make sure it reads properly the precipitation. Use the meas command or front panel display of precip to see the results.

Calibrating the Three Sensor TPG

Note: do this only if the station fails the calibration check.

1. Make sure the sensor is level and stable. It should not rock or shift when pushed with body weight.
2. To begin the tri sensor calibration process, issue the CAL command over a serial port or from the TPG main menu go to Diagnostic > Two Point Cal, and press SET. Follow the instructions sent over the serial port or displayed on the TPG screen.

3. Select the unit (in, cm, or mm) that you want to measure precipitation in by sending the number corresponding to that unit over the serial port, or by pressing DOWN on the TPG until the desired unit is displayed, then pressing SET.
4. Enter the bucket capacity of the TPG bucket. This number will be used for the TPG's AutoDrain feature. (capacity is 37", 94cm or 940mm)
5. As prompted by the software, remove the bucket and plate from the TPG. The software will make a measurement of the sensor 0.
6. For the next three steps you will need an accurate weight. Using the conversion factor or table given at the beginning of the Calibration section, enter its weight in the unit you specified in step 2. For example, if you had a 5 kg weight, and you wanted the TPG to report precipitation in inches, you would enter 6.071 (because the table says that 5 kg of water in the bucket corresponds to 6.071 inches of precipitation).
7. Follow the prompts to put the weight on Sensor 1 to calibrate it. Be sure to place the weight on the load end of the sensor (end opposite the cable with the clamp on it). The weight should rest only on the clamp. After each calibration, the system will display a slope and offset for the sensor. The values for the slope and offset will depend on you're the capacity of the load cells used and the units you have selected for the calibration.

   15KG sensor

   a. Units mm slope: 42 to 50 offset: TBD
   b. Units cm slope: 4.2 to 5.2 offset: TBD
   c. Units inches slope: 1.6 to 2.0 offset: TBD

   20KG sensors

   d. Units mm slope: 55 to 67 offset: TBD
   e. Units cm slope: 5.5 to 6.7 offset: TBD
   f. Units inches slope: 2.7 to 2.1 offset: TBD
8. Follow the prompts to calibrate sensors 2 and 3.
9. Follow the prompts to put the plate and empty, dry bucket onto the sensors.
10. The system will then measure the distribution of the weight on the three sensors. If the weight is not equally distributed on the sensors, the software will prompt you to adjust the bucket plate posts. Turn the screws that connect the plate to the sensor to adjust the load distribution so that each L value is close to 1. Doing this will make the TPG perform better in both normal use and if a sensor fails.
11. Repeat the test of the weight distribution until the system no longer recommends adjustment. If repeated attempts to adjust the distribution fail, you may need to re-level the gauge and or readjust the alignment of the sensors on the base. (see troubleshooting section).

    Note: a gauge without a successful distribution will operate properly as long as all three sensors are operational.

    Note: at any time you want you can repeat the distribution part of these tests by pressing CANCEL or ESC during steps 3, 4 or 5 and selecting SKIP
12. Calibration is now complete.

Preventing Evaporation

Evaporation can cause a loss of precipitation from the gauge of as much as an inch a day. To minimize the effects of evaporation on the TPG, add ½ inch of mineral oil to the bucket (2 litre). The oil will prevent the water from evaporating.

Operation in cold temperatures

If the TPG is operated at cold temperatures, add an environmentally friendly anti-freeze to the bucket. The anti-freeze will help melt any solid precipitation that lands in the bucket to keep the bucket from filling prematurely. The following tables show the change in freezing point based on the amount of propylene glycol antifreeze added and the amount of precipitation received. For example, if you had 1 Gallon antifreeze in the bucket and received 12 inches precipitation, the freezing point of the mixture would be -22 C. With 23 inches precip, the freezing point of the mixture would be -8C.

	Freezing Point (Celsius)					
	-3C	-8C	-14C	-22C	-34C	-48C
Antifreeze	Amount Precip (inches)					
2Gal	92	46	31	23	18	15
1Gal	46	23	15	12	9	8

	Freezing Point (Celsius)					
	-3C	-8C	-14C	-22C	-34C	-48C
Antifreeze	Amount Precip (mm)					
2Gal	2340	1170	780	585	468	390
1Gal	1170	585	390	293	234	195

All types of antifreeze are harmful to the environment including those that are branded "environmentally friendly". A common antifreeze used is Industrial grade propylene glycol. Another antifreeze commonly used in precip gauges is a 1:1 mixture of propylene glycol and ethanol (often referred to as PGE). However, PGE should be avoided as the ethanol in it will evaporate more readily than the propylene glycol. Antifreeze should be disposed of properly and should never be dumped in the environment.

An optional heater is available for the TPG. The heater is designed to heat the rim to prevent an ice or snow cap from blocking the opening. Details on the heater can be found in the Heater section of this document.

Standalone Operation

TPG starts measuring and collecting data as soon as it is powered up. By default, the sensor will measure and log precipitation and temperature 15 minutes; each reading is averaged for the amount of time specified by *Station Setup, Measurement Setup, Averaging Time*. All of these settings and more can be changed – please refer to page 16 to learn more about how the sensor measures.

Operation with a Logger

The TPG can be connected to other devices via either SDI-12 or RS232.

- For SDI-12 operation, connect the three wire interface to the properly labeled pins on the terminal strip and setup the logger to periodically collect data from the sensor. The first parameter of the M! command will provide the precipitation. For more details on SDI-12, please refer to the SDI-12 Sensor Operation section on page 25.
- If connecting using the RS232 port, the data can be polled from the sensor, or it can be automatically output by TPG. 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 precipitation.
- To capture data, setup TPG for *auto output* via the front panel Setup > Other Settings > Auto Output. Once setup, TPG will periodically output measured data in ASCII.

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

Redundant Data Collection

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

Setup and Operation

Overview

TPG 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 TPG to provide the data to another logger. For full details on SDI-12, please refer to the section on page 25.

TPG can be attached to a telemetry device, such as a modem, via its RS232 port. TPG 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 21 for details.

Principles of Measurement

What is a Measurement?

The act of collecting and processing sensor data is referred to as a measurement. Each measurement will be the result of multiple samples, where each sample is one discrete reading of the sensor. Measurement results will include a precipitation reading in addition to a timestamp and a data quality. In addition, measurement details such as minimum, maximum, standard deviation, and number of samples can be provided.

Measurements are made based on the *automeasure time* and *automeasure interval* settings in *Measurement Setup*. Measurements made because of automeasure are logged when they are made. Turning on the front panel will cause a live measurement that is displayed but not logged. Additionally, SDI-12 and RS-232 interfaces allow other machines to invoke a measurement by issuing the appropriate commands.

Sharing Measurement Results

If the system is setup to automeasure at the top of hour, and a measurement command is received via SDI-12 one second before the hour, the system will make only one measurement and use that result for both the SDI-12 reply and the automeasure log.

Measurement Process

TPG uses the following process to make a measurement. Note that any field in italics can be set by the user.

1. Warmup for *sensor warmup* time by turning on power to the sensor and delaying.
2. Collect multiple samples:
    a. Make read the precipitation sensor
    b. If the reading is valid, multiply it by *slope* and add *offset;* add that result to the sum
    c. Wait *sampling interval*
    d. Check timer:
        i. If data has been collected for *averaging interval* time period or longer, move to computing results.
        ii. If not, go back and collect another sample.
3. Compute average of samples: divide the sum of the samples by the number of samples collected

The first step of the measurement is to turn on and warm up the sensor. The length of time spent warming up is determined by the user setting *sensor warmup.* Please note that this is a **minimal** warmup, not an exact one. If another measurement had been made immediately prior to the current measurement, the sensor will already be warmed up.

A measurement consists of multiple samples. Each sample is measured in millivolts. The millivolts are converted to precipitation units by multiplying the voltage by the user set *slope* and adding the user set *offset*.

Precip = millivolts * slope + offset + field_calibration_offset

> Warning: The values for slope and offset are set automatically by the Precip Recorder during the calibration process. You should not manually edit the values for slope or offset.

If *log every sample* is enabled, then every precipitation sample collected will be stored in the log. Minimum and maximum readings are tracked during sample collection. If the user setting *log precip details* is enabled, minimum (*Min)* and maximum (*Max)* will be logged with each measurement.

The system waits *sampling interval* time between each sample.

How long samples are collected for is determined by the user setting *averaging time*. Warmup is **not** included in *averaging time*. The timer is started immediately before collecting the first sample and checked right after collected each sample. Once the timer has expired, the samples are averaged and recorded as the precipitation reading. The averaged reading in volts can also be recorded for diagnostic purposes (enable *log precip details*).

The total number of samples (*Total)* will be reported with each measurement. In addition, the number of good samples (*Good*) is provided, allowing for diagnostics of sensor operation. Normally, the number of total and good samples will match. Additionally, the standard deviation (*Std Dev)* of all the samples is reported with each measurement.

Do not forget to turn on *log precip details* if you would like to see measurement details logged. The diagnostic front panel menu will provide the details of the last measurement regardless of whether the setting is enabled. The command line interface will provide details only if *log precip details* is enabled.

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

Measurement Setup

Automeasure

Automeasure refers to the unit's ability to automatically measure and log sensor data. The user can determine when this will occur by changing the settings Automeasure Time and Automeasure Interval. Automeasure cannot be turned off.

Automeasure time and interval determine when TPG 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 17.

Averaging Time

Every time TPG measures it will collect samples for a user defined period (Station Setup > Measurement Setup > Averaging Time) in order to produce a precipitation reading. The setting *averaging time* determines how long to collect samples for. Averaging time can be changed via SDI-12 XT, and via AVERAGING TIME command line.

Adding all the (good) samples and dividing the sum by the number of (good) samples will provide the precipitation measurement.

Sampling Interval

In addition to the averaging time, the *sampling interval* can be adjusted, allowing for control of the time waited between samples.

Sensor Warmup

This user setting determines how long (in milliseconds) the sensor should be powered on before sensor measurements are made. This number is the minimal warmup provided to the sensor. The actual amount of time the sensor has been turned on may be longer. A certain minimal warmup is required before the sensor provides accurate reading. This value will depend on the sensor used. If another measurement had been made immediately prior to the current measurement, the sensor will already be warmed up and the sampling will start immediately.

Precip Right Digits

For every precipitation measurement, the number of digits shown after the decimal place is referred to as the Right Digits. If you would like the see 10.12 rather than 10.12345, set the right digits to 2.

Log Precip Details

Each precipitation measurement is computed as the average of numerous samples. During this measurement, other values are calculated:

- *Precip mV*: analog reading in millivolts (precipitation before *slope* and *offset* are applied)
- *StdDev*: standard deviation computed on all the good samples
- *Min*: the minimum, which is the lowest reading of all the good samples
- *Max*: maximum, which is the highest readings of all the good samples
- *Good*: the number of valid samples
- *Total*: total number of samples

These details can be viewed by pressing right when viewing the precipitation via front panel. The SDI-12 M2 command will provide measurement details. Via the command line, MEAS and LAST, will provide details only if *log precip details* is enabled. In order to log these details, make sure to enable the measurement setup field *log precip details.*

Log Daily Values

The daily values are internal temperature, battery voltage, heater on time. When Log Daily Values is enabled, these values will be logged at midnight.

Log Health

The health values are the internal temperature and battery voltage. When Log Health is enabled, these values will be logged each time the precip is automeasured.

Last Automeasured

Precipitation measurements made by TPG are not instantaneous; how long they take depends on the setup. For details check averaging time and sensor warmup. When a logger is communicating with TPG, it can ask TPG to make a new measurement. However, the logger then has to wait for TPG to complete the measurement.

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

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

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

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

Tipping Bucket Output

The Sutron TPG provides support for tipping bucket output, which can be enabled in Station Setup > Tipping Output Setup. (A special cable, ordered separately, is also required for the tipping bucket output.) Once enabled, you can adjust the various settings related to tipping output.

- *Resolution:* The amount of precipitation change that each pulse represents.
- *Threshold:* The minimum amount of change in precipitation that must occur before pulses are sent. Setting a threshold higher than the resolution reduces errors in readings due to temperature variations.
- *Tipping Output Rate:* The rate at which pulses will be outputted.
- *Tipping K:* A dampening constant between 0 and 1, which improves performance in situations where evaporation occurs (decrease in accumulation). With K=0, any decrease in accumulation is ignored and new precipitation must exceed the prior accumulated amount for the output to resume. With K=1, decreases are immediately accounted for and any increase is considered new precipitation.

AutoDrain

The AutoDrain uses an electronically controlled valve at the bottom of the bucket to drain the contents of the bucket once they have reached 75% of the bucket capacity. Because the bucket may contain hazardous additives such as antifreeze and oil, the precipitation bucket cannot just be drained out into the environment, so it is instead drained into a drain container.

AutoDrain can be enabled or disabled in the Station Setup -> Measurement Setup menu.

AutoDrain Total

This main menu item displays the total amount of precipitation that has been drained. Press SET to reset this number back to zero.

Last AutoDrain

This main menu item displays the amount of precipitation that was drained in the last AutoDrain. Press SET to start an AutoDrain right now.

Heater

An optional heater is available for the TPG. The heater is designed to maintain the rim of the TPG above freezing so that an ice bridge will not form to cover the opening. The heater does not attempt to keep the accumulated precipitation from freezing.

The heater is designed to operate from a separate power supply with voltages of 24 V or greater. The heating power depends on the voltage. The following table may be of use to understand the relationship of the heater voltage to its ability to heat the rim.

The software supports the following user settings:

User Setting	Description
Heater Enable	Default: disabled. Controls whether the system runs the heater software or not
Heater On Temp	Default: 34C. Turn the heater on if the temperature drops below this temperature
Heater Too Cold	Default: 24C. Don't operate the heater if the rim is below this temperature
Heater Precip Threshold	Default: The heater only starts and operates during times the precipitation rate exceeds the threshold.
Heater Max Timeout	Default: 00:20:00. Allow this much time for the heater to reach the target temperature. If it doesn't, timeout and wait Heater Dead Time before trying again.
Heater Maintain Time	Default: 00:20:00. Continue to operate the heater to maintain the rim temperature for this long after precipitation ends.
Heater Dead Time	Default: 01:00:00. Wait this amount of time before trying to operate the heater again. Used to prevent a 100% duty cycle when the heater can't heat the rim to the desired temperature.

The software is designed to operate the heater as follows:

1. With each automeasure, check to see if it is precipitating (rate greater than Heater Precip Threshold) and if the rim temperature is in range (less than Heater On Temp and greater than Heater Too Cold
2. If condition 1 is met, start a heating cycle
3. In the heating cycle, track the performance of the heater.
    a. Turn it off if the rim doesn't reach Heater On Temp+2C within the time Heater Max Timeout. Wait Heater Dead Time before trying again.
    b. If it does reach the desired temperature, cycle the heater on and off to maintain the temperature for at least Heater_Maintain_time after precipitation stops.
4. Support a test mode (Heater Override in Heater Diagnostics) where the user can enter their own target temperature to test heater operation. This allows operation of the heater at ambient temperatures when it is not precipitating.

5. Provide the use status of the heater with details on the last heater cycle, heater runtime, etc.

Heater Diagnostics

Heater diagnostics include the heater status (standby or active) and information about the current cycle or last cycle. When the heater cycle is currently not active, the software will show the user when the heater was last turned off (which is not necessary when the last cycle was run - consider the case when the user overrides the heater). If the last heater cycle ran to its completion, no further note will be posted. The phrase *heater standby* is used instead of *heater off* to differentiate the cases of *heater being enabled but currently inactive* and *heater being completely disabled*.

However, if there was an issue, then it will be shown the user:

Too warm to heat	The temperature is too high to use the heater.
Too dry to heat	There is not enough precipitation to use the heater.
Too cold to heat	The temperature was too low to attempt to heat the bucket rim.
Heater max timeout	Heater failed to achieve target rim temperature in *Heater Max Time*.

If the status reports *Heater active*, it means that either a heater cycle is currently in progress or that the user has turned the heater on. During a heater cycle, the heater itself may be switched on or off.

Heater user override	Heater is always on
Heater cycle	Heater may be on or off, depending on the rim temperature. If the temperature is in range, heater will be off.

Battery Voltage

TPG can be powered via either the SDI-12 connector or the battery connector. The two are internally connected, so power will flow from one to the other.

TPG will report and recorder the battery voltage. Battery voltage can be read from the front panel, SDI-12 M1 command, or BATT command. If *log daily values* is enabled, battery voltage will be logged at the end of each day.

Logging

A secure flash chip in TPG 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. Logging cannot be disabled.

Each log entry consists of

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

Here are several examples of log entries:

- Reset Powerup,09/20/2007,10:12:54,2
- Setup Change, 09/20/2007,10:12:59,
- Precip,09/20/2007,10:13:00,14.99,
- Air Temp,09/20/2007,10:13:00,41.7,

Logging Measurements

Every time automeasure occurs, a precipitation and an air temperature will be logged. The user can decide how often to log precipitation (via automeasure settings see page 16). In addition the user can chose to *log precip details* (via front panel, access Station Setup>Measurement Setup>Log Precip Details).

Please note that the measurements are logged only for automeasure. Turning on the front panel will not cause sensor data to be logged. However, there is an exception. If the setting *log every sample* is enabled, than individual samples will be logged no matter the source of the measurement. Please note that this applies only to individual samples, and not to processed measurement data such as precipitation.

Log Every Sample

Log every sample is a diagnostic setting. If enabled, every sample collected from the analog sensor will be recorded in the log. **This setting should not be turned on in the field.** If left on, it can fill up the log in a matter of days.

Events

Occasionally, TPG will log events. Events are used to help troubleshoot the data.
The following actions will cause TPG 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 precipitation)
- 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 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.**

Setup

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

Setting the setup to defaults (Station Setup > Other Settings > Default Setup) will reset all the settings to factory defaults. Note, you must recalibrate the system if you set TPG back to defaults.

The following sections detail some commonly modified settings.

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 TPG.

System Time

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

TPG sports an RTC (real time clock) backed by an internal battery. The RTC keep ticking even if the main battery to TPG 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.

Sensor Serial Number

Every weight sensor has a unique serial number on an attached label. This number can be entered into the Sensor Serial Num field. This value is reported at the start of a log downloaded from TPG.

Starting TPG

TPG starts operating as soon as power is applied. While TPG is operating, the green LED will flash occasionally to let you know that TPG is operational. TPG cannot be stopped from measuring without removing power from it.

- **Green LED** flashes every several seconds to indicate TPG is operating normally
- **Red LED** flashes if TPG has encountered a problem

When TPG first starts, it may display the message "Calculating…" on the front panel display. This means that TPG 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 TPG was unable to get valid signals from the weight sensor.

Connecting TPG to a Logger

TPG 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, TPG will keep collecting data.

The digital SDI-12 interface allows for a standardized connection to a logger. SDI-12 also provides power to TPG. For full details on SDI-12, please refer to the section on page 25.

The recorder can be attached to a telemetry device, such as a modem, via its RS232 port. TPG 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 TPG and the attached logger match (as far as precipitation goes), make sure that the automeasure time and interval of TPG are the same as the measurement time and interval of the logger. To set TPG's time and interval, use the Station Setup > Measurement Setup > Automeasure Time and Automeasure Interval menus.

Ensure that the time of TPG and logger match by changing the time of either one (page 21).

Satlink and TPG

When connecting TPG 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 TPG's automeasure time and interval (Station Setup > Measurement Setup > Automeasure Time and Automeasure Interval).

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

Automatic Log Backup

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

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

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

Front Panel Menu Tree

- Errors (only show if errors are present)
  - Hardware error details
- Precipitation (live) and time of reading -- Press set to calibrate offset
  - Precipitation details
- AutoDrain Total
- Last AutoDrain
- Battery Voltage
- Logged Data
  - Precipitation
  - Logged Events
  - All Logged Data
- Station Setup
  - Measurement Setup
    - Automeasure Interval
    - Automeasure Time
    - Averaging Time
    - Sampling Interval
    - Precip Right Digits
    - Sensor Warmup
    - Field Cal Offset
    - Autodrain Enable
    - Log Precip Details
    - Log Every Sample
  - Tipping Output Setup
    - Tipping Bucket Out
    - Tipping Resolution
    - Tipping Threshold
    - Tipping Output Rate
    - Tipping K
  - Heater Setup
    - Heater Enable
    - Heater On Temp
    - Heater Precip Threshold
    - Heater Voltage
    - Heater Power
  - Advanced Setup
    - Precip Units
    - Bucket Capacity
    - Slope Precip ST
    - Offset Precip OT
    - Sensor Serial Num
  - Other Settings
    - Station Name
    - Password
    - Log Health
    - Log Daily Values
    - Auto Output
    - RS232 Baud Rate
    - SDI-12 Address
    - Default Setup
- SD Card Operations
  - Download Log
  - Write Setup to SD Card
  - Read Setup From SD Card
  - Format SD Card
- Diagnostic
  - Two Point Cal
  - Precip in Bucket
  - Empty Bucket
  - Field Cal Offset

Precip Rate
Temp In Box
Precip Details
Heater Diagnostics
Software Version
Station Name And Time

Troubleshooting

LAST Command

Use the Last command to display the last value measured by the TPG. The results will include the Precip measured, the amount in the bucket (in case some has been drained off), the field calibration offset, computed precip rate (computed from the last 2 measurements) and the box temperature. If there are any errors in the reading, an additional error message will be displayed.

Last Reading
Precip 0.3272 in

Precip in bucket 0.3235 in
Field Cal Offset 0.0036504 , Precip Rate 0.0076 in/hour

Temp In Box 5.95 C

Possible error messages are:

- Error in Reading, Sensor n in Discord Discord can come from a sensor failing the range check or the sensor being out of tolerance as described in the tri cell sensor check below
- Hardware Fail 700x, Load cell x range Note: the range check is described below

With the error message, the sensor value may also be set to -999.9 if the TPG was unable to provide a valid reading.

Range Check

The TPG automatically does a range check on each measurement. The measurement is flagged if it is either to low or too high based on the capacity entered at the time of calibration (typically 36", xx mm, or xx cm).

- Lower limit: -capacity*0.1
- Upper limit: capacity*1.1

Triple Cell Sensor check

- The purpose of the triple cell sensor check is to use the sensors to check each other in order to eliminate from the measurement a sensor that may not be working properly.
- The system checks the cells by using the principle of "loading", the distribution of the weight on the three load cells.
- Loading is first determined during calibration and the adjustment of the leveling screws leaves the loading at a value of 1.0+/-0.01 indicating that weight is equally distributed on each load cell.
- The software compares the Current loading vs. loading at time of calibration
- If loading changes more than 0.15 (Tri Threshold user setting), that sensor is considered in "discord" and is not used in the calculation of the precip.
- This can happen if the sensor fails or if the TPG is tilted from its calibrated position of if the sensor or its measurement failed.
- Making Tri Threshold larger allows a wider range of motion in the sensor without triggering the discord.
- If all sensors are in "discord", the system uses sensor 1 for its calculation.

DIAG Command

The Diag Command provides important information to help diagnose problems in the TPG.

```
Resets total 0000
        0000 powerup, 0000 monitor
        0000 illegal,  0000 watchdog
        0000 unimplem, 0000 upgrade
        0000 unknown,  0000 soft

Sensor:  1       2       3
Precip:  3.2823  3.2395  3.2435
Min:     3.2727  3.2352  3.2317
Max:     3.2950  3.2438  3.2536
StdDev:  0.0098  0.0029  0.0082
Good:    6       6       6
Total:   6       6       6
mV:      1.5195  1.4930  1.6241
Load:1.0084      0.9952  0.9964
  Type "DIAG 0" to clear counts
```

CERT Command

The CERT command gives important calibration information as shown below:

```
> CERT
Calibration Certificate

Station Name            = ROOFTRIPLE

Cal date              = 2011/03/22 10:25:10
Cal weight             = 6.07

Precip Units           = in
Bucket Capacity          = 36.000
Slope S1              = 2.307819
Offset O1              = -0.224490
Slope S2              = 2.377203
Offset S2             = -0.309542
Slope S3              = 2.350943
Offset S3             = -0.574602
LoadCal1               = 1.005103
LoadCal2               = 0.995023
LoadCal3               = 0.999874
Bucket Weight            = 9.4418
Sensor Serial Num 1        = 0000001
Sensor Serial Num 2        = 0000002
Sensor Serial Num 3        = 0000003
```

SDI-12 Sensor Operation

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

For details on SDI-12 wiring, please refer to page 6.

The most common SDI-12 command used with TPG is the "M" measure command followed by the "D0" command. The "M" command requests TPG 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: TPG '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 TPG. 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

TPG 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. TPG 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

	Description	Command(s)	Response	Example/Notes
	Acknowledge Active	a!	A	
I	Send Identification	aI!	A13 SUTRON Where is the software revision	
A	Change Address	aAb!	B	
?	Address Query	?!	A	
M MC C CC	Measure Precipitation	aM! aD0!	Atttn a +Precip +Temp +BattV +Amt Drained +validity	Measures and returns precipitation, temperature, battery voltage, and validity. The validity can be 0-valid, 1-sensor failure, 2-data old, 3-system not configured properly

	Description	Command(s)	Response	Example/Notes
M1 MC1 C1 CC1	Last precipitation. This command does not cause a measurement to be made.	aM1! aD0!	Atttn a +Precip +Temp +BattV +Amt Drained +validity	This command does not cause a measurement to be made. It returns the measurement details information for the last measurement.
M2 MC2 C2 CC2	Measure Precip Details	aM1! aD0!	Atttn a +Precip +Precip mV +StdDev +Min +Max +Outliers (Bad Count) +Total Count +validity	Measures and returns precipitation details. Tri sensor version will return data for only LS1

	Description	Command(s)	Response	Example/Notes
M3 MC3 C3 CC3	Last measurement precipitation details. This command does not cause a measurement to be made.	aM3! aD0!	Atttn a +Precip +Precip mV +StdDev +Min +Max +Outliers (Bad Count) +Total Count +validity	This command does not cause a measurement to be made. It returns the measurement details information for the last measurement. Tri sensor version will return data for only LS1
M4 MC4 C4 CC4	Last precip rate. Returns last precip rate computed at last automeasure	aM4! aD0!	Atttn a +PrecipRate	This command does not cause a measurement to be made. It returns the precip rate computed from the last automeasure.
M5 MC5 C5 CC5	Measure TRI sensor details. Causes measurement.	aM5! aD0!	Atttn a +Precip +P1 +P2 +P3 +L1 +L2 +L3 +validity	Validity: same validity as for M but add 4 for sensor 1 discord, 8 for sensor 2 discord, 16 for sensor 3 discord.
M6 MC6 C6 CC6	Last Tri sensor details Same as M5 except it returns last measured value	aM6! aD0!	Atttn a +Precip +P1 +P2 +P3 +L1 +L2 +L3 +validity	Validity: same validity as for M but add 4 for sensor 1 discord, 8 for sensor 2 discord, 16 for sensor 3 discord.
C8	Measure TRI sensor full details. Causes measurement	aC8! aD0!	Atttn A +Precip +P1 +P1mv +P1std +P2 +P2mv +P2std +P3 +P3mv +P3std +Validity	Causes measurement, use for tri sensor version only, too many parameters for M command. Same validity as M6
C9	Last TRI sensor full details.	aC9! aD0!	Atttn A +Precip +P1	Use for tri sensor version only, too many parameters for M command. Same

	Description	Command(s)	Response	Example/Notes
			+P1mv +P1std +P2 +P2mv +P2std +P3 +P3mv +P3std +Validity	validity as M6
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 TPG 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.
XDRN	Causes DrainNow	aXDRN!		Causes DrainNow
XE	Set Offset (see Calibration)	aXE+d! d is the new offset.	attt1	0XE+12.0 set the Field Calibration Offset to 12.0. This will change the current Precip reading (Precip = Precip + FieldCalOffset. Note: XS command allows the system to compute the field calibration offset for you. Use it instead of XE. **Note:** a D0 command issued after XE is complete will display the new Measuring Point in the current units.
XH	Sets Heater control	aXH+d d=0 for disable d=1 for enable	A +status +rimtemp	If caller provides no value, heater is not affected. If user provides the value 1, heater is turned on. If user provides the value 0, heater is turned off. Heater status and rim temperature are always returned.
XS	Set Precip (see Offset Calibration)	aXS+d! d is the desired reading for the	attt1	Example: 0XS+7.87 (Precip should read 7.87, adjust Offset to

	Name	Command(s)	Response	Example/Notes
		sensor. The sensor will adjust the Field Calibration Offset to ensure the reading matches the value entered.		ensure this reading)
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.
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.
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 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	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 32 for details		

XXS Generic Change TPG 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 list.

1. Station Name
2. Automeasure Interval
3. Automeasure Time
4. Averaging Time
5. Sampling Interval
6. Precip Right Digits
7. Field Cal Offset
8. Sensor Warmup
9. Autodrain Enable
10. Log Every Sample
11. Log Precip Details
12. Log Daily Values
13. Log Health
14. Tipping Bucket Out
15. Tipping Resolution
16. Tipping Threshold
17. Tipping Output Rate
18. Tipping K
19. Heater Enable
20. Heater On Temp
21. Heater Precip Thresh
22. Heater Voltage
23. Heater Power
24. SDI-12 Address
25. Garmin GPS
26. GPS Local Time Offset
27. Modbus Enable
28. Modbus Device ID
29. Modbus Protocol
30. Modbus Parity
31. Delay before Tx
32. Delay after Tx
33. Modbus Baudrate
34. Auto Output
35. RS232 Wakeup
36. Hardware Flow Ctrl

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

XXS+1+5+5

You can also change right digits to 6 and precipitation 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 TPG to PCs, modems and other communications devices. Details on the DB9 connector are on page 6.

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. Handshaking is recommended. The RTS line (pin 7 RS232) must be asserted for communication to work. Asserting RTS wakes up TPG. Please allow at least half a second between asserting RTS and starting communication (automatically done by HyperTerminal).

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. TPG will respond with a prompt >

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

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". The default baud rate is 115200.

Machine to Machine Communication

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.

Viewing Data

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

Precip
Precip 15.01
Air Temp 27.3

If log precip details is enabled, additional information will appear:

Precip mV 2.33
StdDev 0.00
Min 15.00
Max 15.01
Good 8, Total 8
Temp R 9239.1
Temp V 2.32

For details on what each of the measurements means, please refer to Precip Details on page 16.

For a concise version, try !LAST or !MEAS;

15.01,27.3

Downloading the Log

TPG will save the data 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"
"LOG HELP" Shows details on how to use the download command.

Auto Output

When TPG 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 precipitation. 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
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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**
Precip
Precip 15.01
Air Temp 27.3

"!MEAS" will show
15.01, 27.3

List of commands

BATT +
Shows the current battery reading.

CERT

Displays detailed calibration information

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 NY – NY stands for no Ymodem. Download the data without using Y modem protocol
"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	Sensor Serial Num	Model and Version	Slope	Offset	Averaging Time	Sampling Interval
Sutron	6061049	FpRain 1.23	-6.3267507	0.0754818	2.000 sec	0 ms

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

The following are examples of the logged data :

Display On, 09/20/2007,10:12:54,
Precip,09/20/2007,10:13:00,14.99,
Air Temp,09/20/2007,10:13:00,21.2,
Precip,09/20/2007,10:14:00,14.99,
Air Temp,09/20/2007,10:14:00,21.2,
Precip,09/20/2007,10:15:00,15.00,
Air Temp,09/20/2007,10:15:00,21.2,

LOG HELP

Shows details on how to use the download command.

PRECIP= 14.5

Changes the current precipitation to 14.5 (of whatever units are currently chosen). User can choose any number, not just 14.5. Please see the section Setting Precip 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 TPG measurements, current onboard sensor readings, and any hardware errors that may exist. If followed by 0, it clears the hardware errors.

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".

```
Station Name
Automeasure Interval (time)
Automeasure Time (time)
Averaging Time
Sampling Interval
Precip Right Digits
Field Cal Offset
Sensor Warmup
AutoDrain Enable
Log Every Sample
Log Precip Details
Log Daily Values
Log Health
Tipping Bucket Out
      Tipping Resolution
      Tipping Threshold
      Tipping Output Rate
      Tipping K
Heater Enable
      Heater On Temp
      Heater Precip Thresh
      Heater Voltage
      Heater Power
SDI12 Address
Garmin GPS
      GPS Local Time Offset
Modbus Enable
```

```
        Modbus Device ID
        Modbus Protocol
        Modbus Parity
        Delay before Tx
        Delay after Tx
        Modbus BaudRate
Auto Output
RS232 Wakeup
Hardware FLow Ctrl
```

List of calibration setup variables

SETUP CAL
Tri sensor enable = 0 for single cell models
Tri sensor enable = 1 for triple cell models
Tri Threshold = .15 for triple cell models, this defines the loading error allowed during calibration. 0.15 means we'll allow loads of 0.85 to 1.15 (with 1 being a perfect load).

SETUP ADVANCED

Connecting a Modem

It is possible to connect a modem to TPG, 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 TPG.

The modem will need to be configured before it can be used. Please make sure to test out the modem-TPG 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 TPG awake, increasing power consumption)
- **Command echo: disable** (otherwise the modem and TPG 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 – TPG 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 TPG (TPG 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 TPG. When connecting this modem, make sure to set the modem's internal jumper for external power AND for either 5V or 12V depending on which you provide. A null modem is needed between TPG and the modem. 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 TPG 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 TPG.

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

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.

FIRMWARE Upgrade (Operating system)

TPG 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 TPG unit.

Methods for upgrade:

There are serveral possible methods to use to upgrade the software in TPG unit. The first step in all three methods is to download from the Sutron web site the program upgrade file, such as 'v1_12mainRLR1260.upg', found at http://www.sutron.com/downloads/software.htm. Select TPG 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 TPG 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 TPG unit powered DOWN.
- Open the serial port with hyperterm.
- Power up TPG 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.

Appendix A – Specifications

Electrical	
Power Required	8-16VDC
Average current (10 Sec Average, Measuring every 15 minutes, display on 2 minutes/day)	< 2mA @ 12V
Quiescent current	<1 mA @ 12V
Outputs	SDI-12 V1.3, RS232
Accuracy	
Resolution	< 0.001ft
Mechanical	
Enclosure	
Dimensions	
Weight	
Mechanical	
Enclosure	
Dimensions	
Weight	
Environmental	
Temperature	-40°C to +60°C
Humidity	0-95% Non-condensing
Log	Flash memory, 300,000 readings >20 years data retention

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 – Parts List

TPG-0001-1

1	PR-0002-1	1	ea	TPG, SINGLE CELL
2	2251-1833-1	1	ea	TPG BASE
3	2251-1834-1	1	ea	TPG BUCKET PLATE
4	2251-1835-1	1	ea	TPG BUCKET
5	2251-1836-1	1	ea	TPG DOME
6	2251-1837-1	1	ea	TPG INLET
8	2251-1840-1	1	ea	TPG SPACER BLOCK
9	3911-1102-3T	1	ea	LOAD CELL, 35KG, TESTED
10	2281-1130	1	ea	CIRCULAR LEVEL, 1.25" DIA
14	2141-1425	2	ea	SCREW,SOC,CAP,SS,M6x25
15	2141-1426	2	ea	SCREW,SOC,CAP,SS,M6x16
16	2141-1419	3	ea	SCREW, 4-40X1/4, SOCKET CAP,SS
17	2141-1427	6	ea	SCREW,HEX,CAP,SS,3/8-16x1.5
18	2131-1021	6	ea	NUT, HEX, 3/8-16, SS
19	2911-1273	1	ea	1/8", PLUG,MED PRES
21	2251-1887-1	1	ea	TPG Enclosure Bracket
23	2141-1206	1	ea	GROUND LUG 4-14 AWG
26	2141-1428	3	ea	SCREW,HEX,CAP,SS,5/16-18x2.5
27	2131-1075	3	ea	NUT, HEX, SS, 5/16-18
28	2141-1054	2	ea	SCREW,#6-32X.25,PH,CR,SS
30	2141-1092	12	ea	SCREW,#6-32X.50,PH,CR,SS
31	2131-1025	12	ea	HEX NUT,SELF-LOCK,#6-32
32	2911-1330	3	ea	Latch, Wire Link
33	2221-1061	1	ea	CABLE GLAND, 1/2 NPT, SMALL
40	2911-1312	1	ea	ALLEN WRENCH, 5MM

TPG-0003-1

Item	Part Number	Qty		Description
1	PR-0002-3	1	ea	TPG, TRIPLE CELL
2	2251-1833-1	1	ea	TPG BASE
3	2251-1834-1	1	ea	TPG BUCKET PLATE
4	2251-1835-1	1	ea	TPG BUCKET
5	2251-1836-1	1	ea	TPG DOME
6	2251-1837-1	1	ea	TPG INLET
9	3911-1102-2T	3	ea	LOAD CELL, 15KG, TESTED
10	2281-1130	1	ea	CIRCULAR LEVEL, 1.25" DIA
11	2141-1432	1	ea	BOLT,HEX,1/4-20X.38,SS
12	2251-1839-1	3	ea	TPG LOAD POST

13	2131-1017	3	ea	NUT, HEX, 1/4-28, SS
14	2141-1425	6	ea	SCREW,SOC,CAP,SS,M6x25
16	2141-1419	3	Ea	SCREW, 4-40X1/4, SOCKET CAP,SS
17	2141-1427	6	ea	SCREW,HEX,CAP,SS,3/8-16x1.5
18	2131-1021	6	ea	NUT, HEX, 3/8-16, SS
19	2911-1273	1	ea	1/8", PLUG,MED PRES
20	2141-1433	3	ea	SCREW,CAP,5/16-18x.5,SS
21	2251-1887-1	1	ea	TPG Enclosure Bracket
23	2141-1206	1	ea	GROUND LUG 4-14 AWG
28	2141-1054	2	ea	SCREW,#6-32X.25,PH,CR,SS
30	2141-1092	12	ea	SCREW,#6-32X.50,PH,CR,SS
31	2131-1025	12	ea	HEX NUT,SELF-LOCK,#6-32
32	2911-1330	3	ea	Latch, Wire Link
33	2221-1061	1	ea	CABLE GLAND, 1/2 NPT, SMALL
45	2251-1897-1	3	ea	TPG, LOADCELL CLAMP

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