

# SDI-TB

## SDI-12 Tipping Bucket Interface with Smart Compensation



# Operations & Maintenance Manual



Part No. 8800-1205

Revision 1.1

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## 1. Introduction

The SDI-TB is an ultra low power, compact and rugged SDI-12 rain gauge sensor. It can be configured to work with most tipping bucket sizes and configurations and supports a correction polynomial for high rainfall rate compensation. The SDI-TB also has numerous built in features like programmable daily rainfall reset time, programmable yearly reset. The SDI-TB sensor has a backup power source that permits un-interrupted operation for up to 10 hours in case SDI-12 power is lost.

## 2. Quick Start

### 2.1 Unpacking

Remove SDI-TB sensor 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.

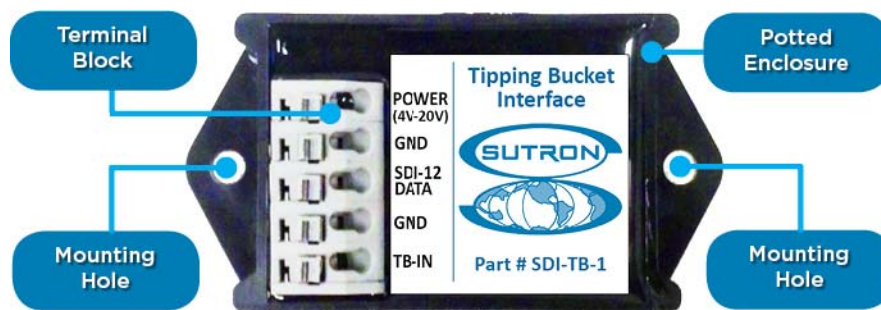
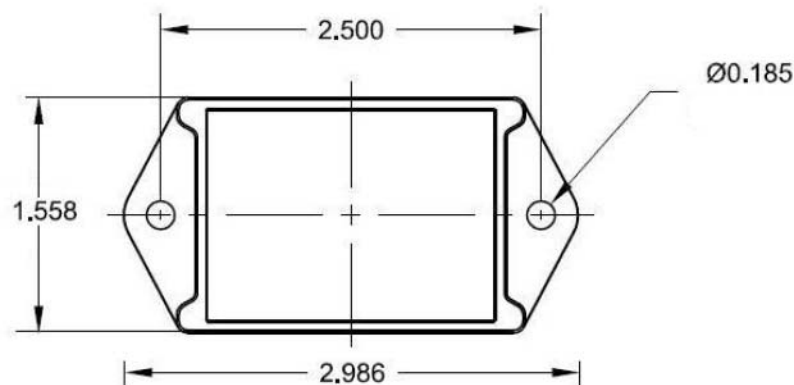


Figure 1 - SDI-TB



## 2.2 Operation

**IMPORTANT:** On powering up the SDI-TB for the first time, the SDI-TB requires about 2minutes for the internal capacitor to charge up and the supply voltage to get up to the minimum voltage threshold required for the module to be operational. The capacitor typically takes about 10 hours to discharge once completely charged

Reading any of these registers will initiate a new measurement and the measured value will be returned.

The SDI-TB provides a standard 3-wire SDI-12 bus to interface with any SDI-12 v1.3 compliant logger and a 2-wire interface for connection to standard Tipping buckets.

Most Tipping buckets consist of a bucket attached to a simple switch. The switch makes a brief contact between the two wires as the bucket tips. The SDI-TB increments the cumulative total and daily rainfall and raw tip count for each tip it records. The SDI-TB can be configured to record a tip on a falling edge or rising edge. A pull-up or pull-down resistor is automatically active depending on whether a falling edge or rising edge respectively has been configured.

A user programmable debouncing duration can be configured to filter out noise during the voltage transitions as the switch makes/breaks contact.

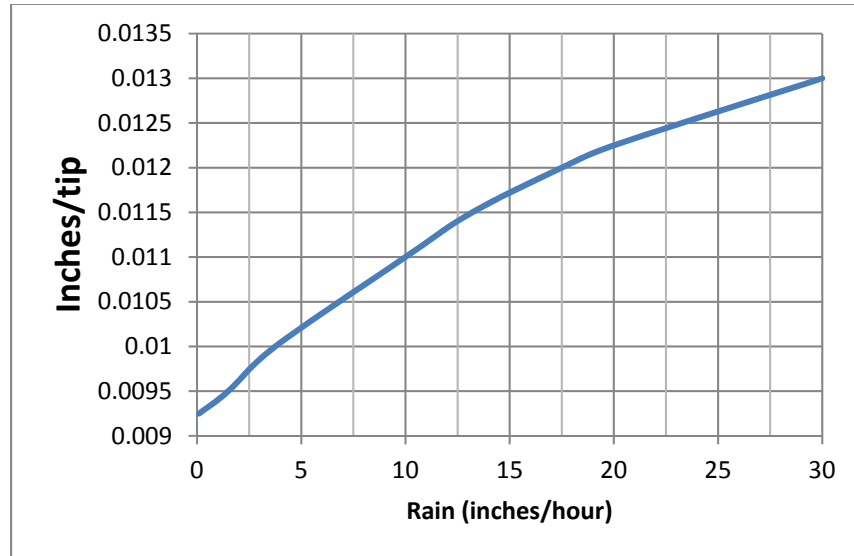
The SDI-TB uses a configurable 'Bucket size' or a third order compensation polynomial to convert tips into rainfall. The bucket size indicates the amount of rainfall that corresponds to a single tip of the bucket. By default (if no compensation has been programmed) the SDI-TB increments the total accumulation after each valid tip. The new accumulations is calculated using the formula

$$\text{New Accumulation} = \text{Current Accumulation} + \text{Bucket Size}$$

Since the bucket takes a finite amount of time to tip over and start filling again, some rain will be lost before the bucket is in position to collect rain again. This amount of rainfall lost will become more significant as the rainfall rate increases. To compensate for such heavy rainfall rates, the SDI-TB supports a third order polynomial with user configurable coefficients. The polynomial is used to compute the rainfall for each tip based on how frequently the bucket tips. The polynomial is of the form

$$\text{Rain/per tip} = kx^3 + k_2x^2 + k_1x^1 + k_0$$

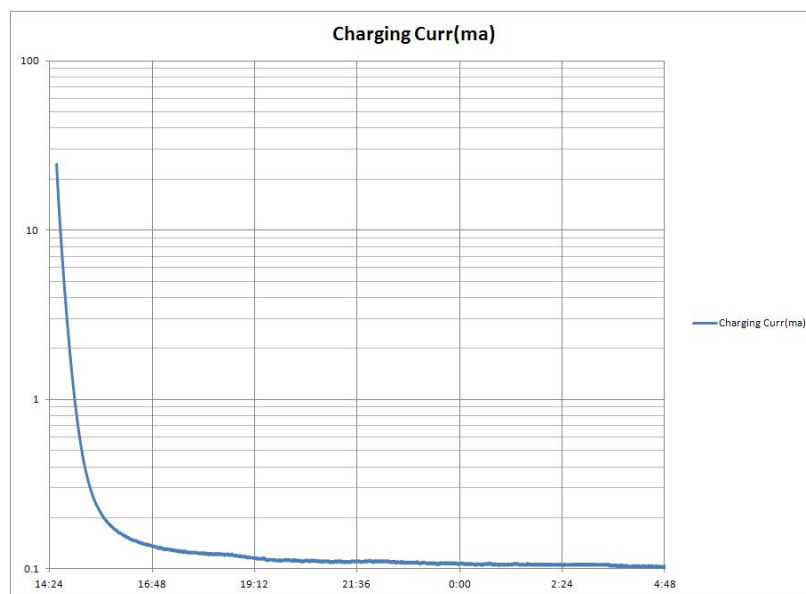
The coefficients can be obtained by plotting the rainfall in inches/hour on the x-axis and the compensated rain (inches/tip) on the Y-axis and fitting the resultant curve to a third order polynomial. The following plot shows the curve for a 0.01 inch bucket.



The SDI-TB measures the time between the current tip and the previous tip and uses the bucket size to compute the equivalent rainfall in inches/hour. The polynomial is then used to convert the resultant rainfall in inches/hour to rainfall per tip. If the coefficients have not been configured, the bucket size is used.

The SDI-TB has an internal Real Time Clock (RTC) that is used to keep time and can be programmed to perform daily and annual rainfall resets.

The SDI-TB has a built in rechargeable backup power source that is used to power the module for upto 10 hours of uninterrupted operation in case SDI-12 power is lost. The current draw will be higher during the charging phase and reduce over time, till the backup power source is completely charged.



*Fig: Charging current vs Time*

The internal RTC and Tipping bucket interfaces are fully functional while running off the backup power source. However, the SDI-12 interface is disabled while running off backup power. The SDI-12 interface functionality is automatically restored when SDI-12 power is restored.

The SDI-TB is fully compliant with the SDI protocol v1.3 The 'D0' command issued after an 'M' command returns various accumulations and counter values.

For eg

Command = aM!

Response = a0005

Command = aD0

Response = a+<acc\_last>+<raw\_tip\_year>+<acc\_year>+<acc\_daily>+<acc\_yest>

<acc\_last> = total accumulations since the last M command was issued. Every time an M command is issued, this parameter will be reset.

<raw\_tip\_year> = The SDI-TB can be programmed to reset its annual counters/accumulation at the start of a rain year. This parameter returns the total raw tip counts for the current *rain-year*.

<acc\_year> = This parameter returns the total rainfall for the current *rain-year*.

<acc\_daily> = The SDI-TB can be programmed to reset the daily rainfall value once every day. This parameter returns the total rainfall today.

<acc\_yest> = This parameter returns the total accumulation yesterday. Each time the daily accumulation is reset by the daily timer, the total accumulation today is saved as yesterday's accumulation.

## 2.3 Connections

The SDI-TB sensor is very simple to connect and get working. The unit has a 5 position push header for interfacing with an SDI logger and a standard 2-wire Tipping bucket.

Pin Label	Description
TB-IN	Connect to the reed switch terminal of the tipping bucket.
GND	Ground connection for the Tipping bucket
SDI-12 Data	Bidirectional SDI data bus
GND	SDI-12 interface Ground connection
Power (4v-20v	SDI-12 power from the logger/SDI-12 master

## 2.4 Sensor Configuration

The SDI-TB sensors are configured at the factory to the default SDI address 0. If other SDI12 sensors are present on the SDI 12 bus, the address must be changed using the standard 'address change' command. Refer to the SDI-12 command table below for instructions on how to change the address if needed.

The SDI-TB has a default debouncing of 15ms. If the bucket has a switch close time other than 15ms, the appropriate debounce duration can be set using the XDBNC command.

If the tipping Bucket being used has a capacity other than the default size (0.01"), the bucket size must be set using the XBKTSZ command.

If the tipping bucket being used does not have a siphon or the user wishes to compensate for heavy rainfall rates, the XCOMP command must be used to set the polynomial coefficients.

The SDI-TB sensor is SDI-12 compliant and will respond to all SDI-12 commands according to version 1.3 of the standard. To use the SDI-12 commands you must have a data logger or interface that supports the SDI-12 standard. 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.

It is expected that the user is familiar with the SDI-12 protocol and this section is written accordingly.

### 3. Command Reference

#### 3.1 Standard SDI-12 commands

Command	Name	Command	Response	Notes
?	Query SDI Address	?!	A where a= address	Only one SDI-12 device should be connected to the bus since all will respond.
	Acknowledge Active	a!	A	
I	Send Identification	a!	For a master the expected response is a13 SUTRON SDI-TB ssssss vx.xx a 13 SUTRON = manufacturer SDI-TB = model number ssssss = Serial number x.xx = software revision number	Identification string for SDI-TB sensor.
A	Change Address	aAb!  Example: 0A5!	b Indicating new address example 5	

Command	Name	Command	Response	Notes
M MC C CC	Get accumulation and raw tip values	aM! (or MC, C, CC) Ex : 8M! <hr/> aD0! Ex: 0D0!	a0005 5 values available in 0 seconds. Use D0 to retrieve data. a+<acc_last>+<raw tip_years> +<acc_year>+<acc_daily>+<acc_yest> t> where: a = Sensor address <acc_last>=Rainfall since last measurement <raw_tip_years>=Total raw tips this year <acc_year>= Total accumulation this year <acc_daily>=Total accumulation today <acc_yest>= Total accumulation Yesterday Ex: 0+0.01+12+0.12+0.03+0.02	Returns the current accumulation values and resets the accumulated rainfall since last measurement.
M1 MC1 C1 CC1	Get rainfall in last 'x' minutes.	aM1! (or MC1, C1, CC1) Ex : 0M1! <hr/> aD0! Ex: 0D0!	a0002 2 values available in 0 seconds. Use D0 to retrieve data.  a+<acc_x_minutes><x>  where: a =address <acc_x_minutes>= rainfall <x> = duration for which rainfall is reported  Ex: 0+0.03+15	Returns the ainfall in the last 'x' minutes, where x can be set using the extended command 'XIDUR' described the 'Extended SDI-12 commands' table.



### 3.2 Extended SDI-12 commands

Command	Name	Command	Response	Notes
XDT	Read/Write current system time	aXDT! or aXDT+yyyy/mm/dd hh:mm:ss!  Ex: 0XDT+! or 0XDT+2015/04/24 17:45:31 Sets time to April 24, 2015 5:45.31 pm.	a+yyyy/mm/dd hh:mm:ss  Ex: 0+2015/04/24 17:45:31	Command to set the system time on the SDI12-TB module. This will be used to perform the daily and Yearly rainfall resets. If the XDT command is issued without any arguments (eg. aXDT!), the current time is returned without modifying the existing time. Default = 2012/01/01 00:00.0 hrs
XDR	Read/Write <i>daily rainfall</i> reset time	aXDR! or aXDR+hh:mm:ss!  Ex: 0XDR+! or 0XDR+09:30:15  Reset <i>daily rainfall</i> at 09:30.15 hrs every day.	a+hh:mm:ss  Ex: 0+09:30:15	Command to configure the daily reset time. Default = 00:00.0 hrs
XYR	Read/Write <i>Yearly rainfall</i> reset time	aXYR! or aXYR+mm/dd hh:mm:ss!  Ex: 0XYR+! or 0XYR+05/24 09:30:15 Reset <i>Yearly rainfall</i> on May 24 at 09:30.15 hrs every year.	a+mm/dd hh:mm:ss  Ex: 0+05/24 09:30:15	Command to configure the yearly reset time. Default = 01/01 00:00.0 hrs

Command	Name	Command	Response	Notes
XBKTSZ	Read/Write tipping bucket size	<p>aXBKTSZ! or aXBKTSZ+&lt;bucket size&gt;!</p> <p>Ex: 0XBKTSZ! or 0XBKTSZ+0.01!</p> <p>Set the bucket size to compute 0.01 inches of rainfall for every tip.</p>	<p>a+&lt;bucket size&gt;</p> <p>where: &lt;bucket size&gt; = Bucket size</p> <p>Ex: 0+0.01</p>	<p>Command to configure the bucket size.</p> <p>The bucket size is used to convert bucket tips into rainfall. If the compensation coefficients (<i>XCOMP</i>) are not provided, then each tip is equal to <i>bucket size</i>. If coefficients are provided, then a 3<sup>rd</sup> order polynomial is used to convert tips into rainfall. Default value = 0.01</p>
XEDGE	Read/Write edge	<p>aXEDGE! or aXEDGE+&lt;edge&gt;!</p> <p>Where &lt;edge&gt; = 1 (rising edge) = 0 (falling edge)</p> <p>Ex: 0XEDGE! or 0XEDGE+1!</p> <p>Configures the Tipping Bucket input to register a tip on the rising edge.</p>	<p>a+&lt;edge&gt;</p> <p>where: &lt;edge&gt; = new edge</p> <p>Ex: 0+1</p>	<p>Command to configure the tipping bucket input edge. If a falling edge is configured then the internal pull up resistor is automatically active, else pull-down resistor is activated.</p> <p>Default value = 0 (pull-up)</p>

Command	Name	Command	Response	Notes
XDBNC	Read/Write debouncing duration	<p>aXDBNC! or aXDBNC+&lt;debounce_duration&gt;! Where &lt;debounce_duration&gt; = new debounce duration <math>0 \leq \text{debounce\_duration} \leq 255\text{ms}</math> Ex: 0XDBNC! or 0XDBNC+30! Configures the Tipping Bucket to only register a tip if the TB-IN line is held in the active state for at least 30ms.</p>	<p>a+&lt;debounce_duration&gt;  Ex: 0+30</p>	<p>Command to configure the debounce duration in milliseconds.  This is used to filter out noisy tipping bucket outputs, so that the switching noise is not counted as a tip.  The TB-IN input must be held in the active state for atleast <i>debounce_duration</i> ms.  Default value = 15ms</p>
XIDUR	Read/Write Rain sample duration	<p>aXIDUR! or aXIDUR+&lt;duration_minutes&gt;! Ex: 0XIDUR! or 0XIDUR+15! Will return the total rainfall in the last 15 minutes</p>	<p>A+&lt;duration_minutes&gt;  Ex: 0+15</p>	<p>A moving window keeps track of the total rainfall in the last <i>duration_minutes</i> minutes.  Max = 20 minutes.  Default = 15 mintes.</p>
XRBOOT	Reboot the system	aXRBOOT+SDITB!	<p>a+OK or 0+ERR</p>	Reboots the module after 8 secs. All internal counter / accumulation values will be lost.

Command	Name	Command	Response	Notes
XCOMP	Read/write compensation polynomial coefficients.	<p>aXCOMP !</p> <p>or</p> <p>aXCOMP+&lt;k3&gt;+&lt;k2&gt;+&lt;k1&gt;+&lt;k0&gt;</p> <p>where:</p> <p>k3,k2,k1,k0 are coefficients for a third order compensation polynomial</p> <p>Ex:</p> <p>0XCOMP!</p> <p>or</p> <p>0XCOMP+0.00000002-0.000003+0.0002+0.0092</p>	<p>a+&lt;k3&gt;+&lt;k2&gt;+&lt;k1&gt;+&lt;k0&gt;</p>	<p>The SDI-TB implements a 3<sup>rd</sup> order polynomial to compensate for heavy rainfall rates.</p> <p>If no coefficients are provided, each tip = &lt;bucket_size&gt;.</p> <p>The polynomial is of the form</p> $Rain/per\ tip = kx^3 + k_2x^2 + k_1x^1 + k_0$ <p>Where <math>x</math> = inches of rain per hour.</p>
XYA	Read/Write Yearly accumulation.	<p>aXYA!</p> <p>or</p> <p>aXYA+&lt;yearly_acc&gt;!</p> <p>&lt;yearly_acc&gt; = New accumulation this year</p> <p>Ex:</p> <p>0XYA</p> <p>or</p> <p>0XYA+2.1!</p>	<p>a+&lt;yearly_acc&gt;</p> <p>Ex:</p> <p>0+1.2</p>	<p>Command to read/write the total accumulation for this rain year. This command will reset the daily accumulation, total raw tip count, accumulation since last measurement and yesterday's accumulation.</p>

## Appendix A: Specifications & Ordering Information

MECHANICAL /ENVIRONMENTAL	
<b>Enclosure</b>	Potted enclosure for humid environments
<b>Dimensions</b>	3 x 1.5 x 1.5 inches
<b>Weight</b>	~60gms
<b>Temperature</b>	-40C to +60C
<b>Connector</b>	5 pin screw less connector

POWER	
<b>Input Voltage</b>	DC 4v-20v
<b>Initial (capacitor discharged) Power up delay</b>	~2 minutes
<b>Internal backup power run time</b>	~10 hours
<b>Internal backup power charge time</b>	~18 hours
<b>Internal backup power charging current</b>	25mA (fully discharged) to 100uA (fully charged)
<b>Quiescent Current</b>	< 100 uA @12v (once fully charged)

COMMUNICAION	
<b>Protocol</b>	SDI-12 v1.3 (SDI communication will be disabled when running off internal backup power)

### ORDERING INFORMATION

SDI-TB	SDI-12 tipping bucket interface with internal backup power.
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## Appendix B: 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](mailto: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 (22400 Davis Drive, Sterling, VA 20164) or, at Sutron's option, replacement of the defective product. In no event shall Sutron be responsible for incidental or consequential damages, whether or not foreseeable or whether or not Sutron has knowledge of the possibility of such damages. This Warranty shall not apply to products that have been damaged through negligence, accident, misuse or acts of nature such as floods, fires, earthquakes, lightning strikes, etc.

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

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

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

### NON-SUTRON MANUFACTURED EQUIPMENT

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

### EXTENDED WARRANTY AND ON-SITE MAINTENANCE

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

