Turbidity Sensor

TS1200

Edition 1.2

User Manual

Greenspan Customer Service
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Technical Support When You Need It

The correct choice of sensor should be supported by professional advice to ensure long term success in the field. **Greenspan Technical Services** is dedicated to customer support and provides assistance in the selection, installation, deployment and commissioning of sensors with a full range of consulting services.

A full technical support and field advice service can be accessed by ringing **Customer Service** on +61 7 4660 1888 between 8am - 6pm, 5 days a week.

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All Warranty service will be completed as soon possible. If delays are unavoidable customers will be contacted immediately.

The sensors should not be dismantled unless under instruction from Greenspan. Incorrect handling will void the warranty.

Contents

1. Introduction to the TS1200 Sensor

1.1 Overview

The Greenspan SDI-12 sensor range has been designed to allow connection to the SDI-12 serial / digital network widely used in the hydrological and field monitoring industry.

SDI-12 allows multiple connection of sensors to a single data-logging recorder, transmitting at 1200 baud over distances up to 60 metres (200 feet) between each sensor and the data logger.

The TS1200 is designed to measure Turbidity and Temperature. It includes complete linearity correction over a wide range, thereby maintaining its factory accurate calibration while in the field. Each sensor is individually calibrated over span and temperature. The TS1200 conforms to SDI-12 version 1.2.

2. Packaging

Media compatibility should be checked before using the sensor and advice sought from Greenspan if any doubt exists. The 316 stainless body can be used in the majority of situations, but care should be taken against possible corrosion in high Chloride or Ferric solutions.

The body should always be totally immersed under the water to ensure the electronic module is at water temperature and also to avoid any possible anodic / cathodic action taking place on the stainless body at the water-air interface due to oxygen differences across the boundary. It has also been noticed at some sites that clamps used to support the sensors made of dissimilar metal to the 316 stainless body have occasionally caused spot corrosion due to electrolysis action.

An optional delrin plastic body is available if there is concern with the suitability of the 316 stainless steel.

3. *Unpacking Your TS1200 Sensor*

Here are the items you should have received.

1. Greenspan TS1200 sensor with polyurethane cable.

2. This User Manual.*

Check the cable is long enough to reach from the depth selected to the data recorder.

* This item can be ordered separately from Greenspan or can be downloaded from http://www.greenspan.com.au.

4. *Checking the Model Number and Range*

Before installing your Greenspan SDI-12 sensor check the information on the label is correct to confirm you have received the instrument you have ordered. The label will look like this.

MODEL	TS1200
RANGE	2000 NTU
OUTPUT	SDI-12
S/N	001243

5. *Testing Your System*

Before installing your Greenspan SDI-12 sensor you may wish to familiarise yourself with its operation. Placing the sensor in a bucket of water and observing your data recorders readings can do this. This has the added advantage of easy access to a telephone if any questions arise.

6. General Methods of Installation

There are many ways of installing sensors in the field in order to ensure the continuous gathering of data and the safety of the device. Consideration needs to be given to the possibility of vandalism, animal damage, theft and extreme weather conditions. Sensor should always be deployed with the stainless steel drop cable, or damage will result.

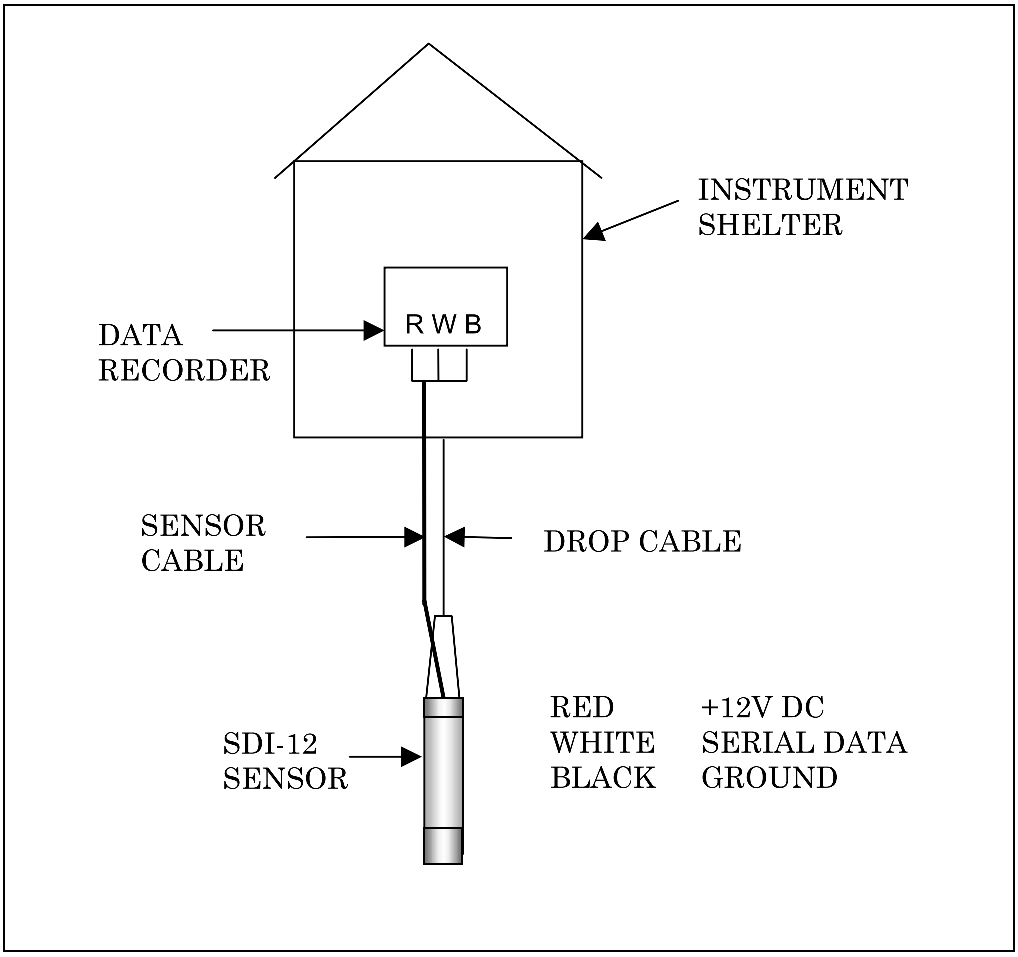


Figure 1. Installation

Note: Additional SDI-12 sensors are wired in parallel to the data recorder.

* Greenspan does not supply the stainless steel drop cable.

Some methods commonly used are:

1. Suspended sensor attached to a guide wire and winch board, which is useful for profiling applications.

2. Fly wire across stream or river, tether the sensor to the fly wire and fully immerse.

3. Installed in PVC conduit with sensor protruding from immersed end.

4. Sealed waterproof, self contained vessel including batteries and continuous logging equipment. Excellent for concealment.

5. Strapped to a pylon or post in areas that become submersed, cabled to bank.

6. Hand operation for spot readings.

6.1 Typical Locations

1. Suspended above bore hole via drop cable

2. Edge of a river, stream or lake embankment.

3. Side of a boat or vessel.

4. Mounted within a stilling well.

5. Mounted within drainage channels or pipes.

6. Suspended from dam walls.

7. Sensor anchored to bed of lake or stream.

6.2 Field Installation Instructions

The Greenspan Range of Pressure Sensors and Water Quality Sensors can be installed into a variety of applications including:

- Rivers, Lakes and streams
- Bore Hole and groundwater wells
- Tanks and Reservoirs
- Wet Wells for Water and Sewer Systems

In all field applications, mechanical, electrical and physical protection of the Sensor, cabling and associated fittings must be provided.

Field Installation must ensure:

- The sensor is anchored or held in position or located so it is not subject to any movement during normal operations.
- Sensor is protected from direct sunlight to avoid high temperature fluctuations
- Sensor is protected against high turbulence and possible debris loading during flow events

6.3 Option 1: Non Turbulent Conditions

Where there is no possibility of the sensor being affected by turbulence it can be suspended into the water body using a stainless steel hanger cable. For example where the sensor is installed into a large water storage tank. The sensor will hang vertically into the tank and not be subject to movement from water movements. The stainless steel wire prevents loading of the sensor cable.

In Sewer Wet Well and Water Tank applications where high turbulence and debris loading may affect the sensor, the following minimum installation standards must be followed:

6.4 Option 2: High Turbulent Conditions

Where turbulence and water movement will act on the sensor it is recommended to mount the sensor in a stilling well or mounting cradle attached to the side of the well. This could simply be a length of PVC pipe bolted to the well wall in which the sensor is located or could be an extension pole with a sensor cradle at the lower end. Potential ragging and debris build up on the sensor & cable should be overcome by extending the stilling well to above the high water level or by cable tying the sensor cable up the cradle mounting arm. The movement of the sensor must be eliminated such that the sensor is not subject to twisting motion from swirling water during pumping, or from sideways movement due to ragging of the sensor.

In all sewer wet well applications regardless of the mounting system used it is recommended to also utilise a stainless steel hanger wire to prevent loading the sensor cable during installation, removal and maintenance. The stainless steel wire must be securely connected to the sensor using the hanger hook and the sensor cable should be cable tied at regular intervals up the stainless wire. An outer sheath of hose or tubing can be fitted over both cables to reduce ragging and debris build up on the cables. At the top of the well the stainless wire can be attached to a bolt or mounting point.

The stainless steel suspension hanger cable can be provided by Greenspan. (Part No 7SK-100)

Warning:
Under no circumstances must the sensor be installed such that it can collide with the sides of the well, or other solid objects within the well. Sensor installation under these circumstances will lead to sensor damage which will not be covered under our normal warranty conditions. In these cases the sensor must be mounted into a cradle or stilling well as per Option 2.

6.5 Other Considerations

Environmental compatibility should be checked before using the sensors and advice sought from Greenspan if any doubt exists. The 316 stainless body can be used in a majority of situations but care should be taken against possible corrosion in high Chloride, Sulphate or Ferric solutions.

The body should always be totally immersed under the water to ensure that the sensor is at water temperature and to also avoid any possible anodic/cathodic action taking place on the stainless body at the water-air interface. At some sites it has also been noticed that clamps used to support the sensor made of a dissimilar metal to the 316 stainless body can cause spot corrosion due to electrolysis.

7. Turbidity Deployment

When installing in shallow water, immerse to at least 250-300mm minimum to prevent infrared radiation from natural sunlight affecting readings. When installing directly into a flowing medium, angle the sensor head to at least 45° to the horizontal, with the lens facing downstream. This will minimise the damage to the lens as a result of impact from travelling particulate matter.

If using the TP100 lens- cleaning pump, it is important to prime the pump prior to positioning sensor at depth. This can be done by placing the unit in water and pressing the test button located inside the Timer Controller unit. This will also check correct pump operation.
When the cleaning pump is activated the force of water creates artificial turbulence, and if left untethered can cause a displacement of sensor position.

Most sediment transport occurs during storm events and flood conditions. Protection from floating debris damage is an important consideration along with adequate tethering of sensors.

8. Turbidity Sensor Cleaning Pump TP100

8.1 Function

To maintain the optical cleanliness of the turbidity sensor by preventing fouling due to algal growth.

A high-pressure jet of filtered water is periodically forced across the lens dislodging any build-up of algae. When used in conjunction with the non-stick polymer an efficient method of cleaning is produced.

This system is particularly suitable for long term unattended data collection situations.

8.2 Overview

The unit conveniently clamps onto the TS-1200 sensor for easy installation and removal. The power cable is strapped to the sensor cable and brought to the surface for connection to the Timer Controller and battery.

The Controller unit can be programmed for various intervals and turn-on durations by settings within the box. Please refer to the table below for settings available.

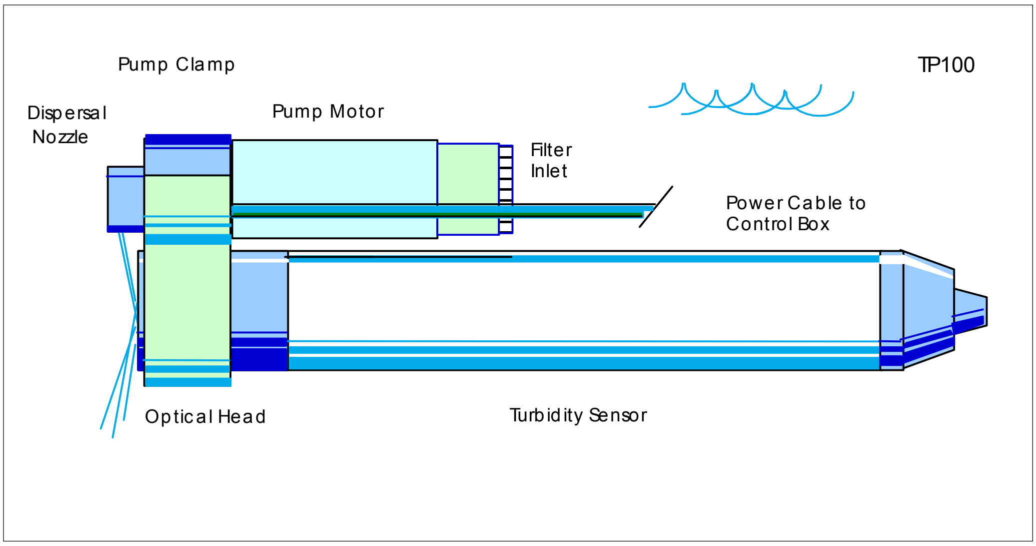
Switch Setting	Interval (Hours)	Duration (Seconds)
0	1	2
1	2	5
2	3	10
3	6	15
4	12	30
5	24	60
6	48	120
7	72	240

The duration chosen can easily be tested by momentarily pressing the test button located internally, this will activate the pump motor.

Greenspan recommends the customer establish a cleaning regime dependent on environmental site conditions. If possible, it is preferable to test the assembled pump mounted on the sensor by immersing near the surface prior to deployment at depth to verify operation and pump priming.

The clamp can be removed from the sensor by undoing the two Allen key bolts and sliding the assembly off the turbidity head. When repositioning, ensure that the dispersal nozzle vent hole is forward of the optical head lens to maintain the water jet across the lens face.

The pump filter cap is a push fit onto the motor body and is easily removed for cleaning.



Note that the pump clamp has been designed to fit the optical head to allow for the differences in outside diameter of the sensor tube depending on whether delrin body or stainless steel is used. When assembling the pump to the optical head, push the sensor all the way to the end stop and tighten the locating screws with a 2mm Allen key.

The power supplied to the Timer Control unit is internally regulated to maintain timing consistency. The pump can be submerged to depths of up to 50m, with cable lengths up to 70m maximum. It is suggested cable ties be used to attach the pump cable to the sensor cable.

It is recommended that a separate battery be used for the pump due to the greater power required and the switching transients that may be present. It is necessary however, to ensure a common ground between the pump power supply and the sensor supply.

9. Operation

The Greenspan TS1200 combines robust, sealed construction with ease of use. Due to its low power consumption it can be operated from remote power sources for extended periods.

The advantage of incorporating a microprocessor is the ability to control both the offset and full scale settings. The main purpose for this is to make fine adjustments when required, as part of regular maintenance. These features are implemented with the extended SDI-12 commands.

10. Extended Commands

10.1 Programmable Gain

The programmable gain command enables re-scaling when calibrating the sensor.

10.2 Programmable Offset

The programmable offset command allows the user to modify the offset of the sensor.

10.3 Programmable Zero Offset

The zero offset command will allow an automatic zero calibration. This command can also be used while the sensor is in place to reference the zero reading to where to sensor is located.

These extended commands are described in “Supported SDI-12 Commands”.

10.4 Reading data from the Greenspan TS1200

Your selected data recorder must be able to read SDI-12 signals. Since data recorders differ widely, you must follow the manufacturers’ instructions when reading data. User requirements also differ, so the data recorders need to be programmed individually.

Detailed operation of the SDI-12 standard can be found in the document “A Serial-Digital Interface Standard for Microprocessor-Based Sensors” version 1.2 at web address.

http://www.sdi-12.org.

11. Supported SDI-12 Commands

This table lists the commands supported by the Greenspan TS1200.

Table 1

Command	Function
a!	Acknowledge active
aI!	Send identification
aAb!	Change address
?!	Address query
aD0!	Send data
aM!	Start measurement
aM1-9!	Additional measurements
aV!	Start verification
aC!	Start concurrent measurement
Extended Commands	
aXU1Wccf !	Gain correction
aXU0Wccf !	Offset correction
aXU1Rcc!	Read gain
aXU0Rcc!	Read offset
aXZcc!	Zero channel
aXRcc!	Read channel
aXPs!	Turn on-off analog circuit power

Where:

a = sensor address (0 - 9), additional addresses (A – Z)

b = new address,

? = any digit or decimal

1-9 = additional sensors on the SDI-12 bus,

! = last character of a command block.

cc = 2 digit channel number (see "Channel Format for Extended Commands).

s = either "1" to turn power on or "0" to turn power off.

f = gain or offset

12. SDI-12 Command and Response Protocol

The Greenspan TS1200 sensor and associated data recorder communicate by an exchange of ASCII characters on the SDI-12 bus. First the data recorder sends a break (this is continuous spacing on the data line for at least 12 milliseconds) which wakes up the sensors on the data line. The sensor, in turn, returns the appropriate response. The first character of each command specifies which sensor the recorder wants to communicate with. All other sensors on the SDI-12 bus ignore the command and return to low power standby mode.

When a start measurement procedure is sent from the data recorder to a sensor, the recorder does not communicate with any other sensor until the data from the first sensor is fully received. Only during a concurrent measurement command can a data recorder communicate with other sensors while one or more sensors are taking measurements.

A typical recorder / sensor sequence is as follows:

1. The data recorder wakes all sensors on the SDI-12 bus with a break.

2. The recorder sends a command to a specific, addressed sensor, instructing it to take a measurement.

3. The addressed sensor responds within 15 milliseconds returning the maximum time in seconds until the measurement data will be ready, and the number of values it will return.

4. If the measurement is immediately available, the recorder transmits a command to the sensor instructing it to return the measurement(s). If the measurement is not ready, the data recorder waits for the sensor to send a request to the recorder, which indicates that the data is ready. The recorder then sends a command to get the data.

5. The sensor responds, returning one or more measurements.

13. Output Channel Format for a Start Measurement Command (aM!)

Table 2: Product TS1200

Output Channel 1	Output Channel 2
Turbidity	Battery Voltage

13.1. Acknowledge active command (a!)

Command	Response
a!	**a<CR><LF>**

a = the sensor address (0-9) (A-Z)

This command is used to ensure that a sensor is responding to a data recorder or other SDI-12 device. The sensor will acknowledge its presence on the SDI-12 bus.

13.2. Send Identification Command (aI!)

Command	Response
aI!	**a11ccccccccmmmmmmvvvxxx…xxx<CR><LF>**

a	= the sensor address (0-9, A-Z)
I	= the send identification command
11	= SDI-12 version number (version 1.2 is indicated as 12)
cccccccc	= 8 character vendor identification number, usually a company name or its abbreviation.
mmmmmm	= 6 characters for sensor model number.
vvv	= 3 characters for sensor version number
xxx…xxx	= optional field with a maximum of 13 characters, used for serial number or other specific sensor information that is not relevant to operation of the data recorder.

This command is used to query sensors for their SDI-12 compatibility level, model number and firmware version.

13.3. Change Address Command (aAb!)

<u>Command</u>	<u>Response</u>
aAb!	**b<CR><LF>**

a = the sensor address (0-9, A-Z)
A = the change address command
b = the new sensor address to be programmed (0-9, A-Z)

The change sensor address command allows the address of the sensor to be changed. The address is stored in a non-volatile EEPROM within the sensor.

13.4. The Address Query Command (?!)

<u>Command</u>	<u>Response</u>
?!	**a<CR><LF>**

? = address character
a = the sensor address (0-9) (A-Z)

This command queries the address of a sensor on the SDI-12 bus. If more than one sensor is on the bus they will all respond, causing bus contention.

13.5. The Start Measurement Command (aM!)

Command	Response
aM!	**atttn<CR><LF>**

a	= the sensor address (0-9) (A-Z)
M	= start measurement
ttt	= the time (in seconds) for the measurement data to be available
n	= the number of measurements the sensor will return

The start measurement command causes a measurement sequence to be performed. Data values will be stored until a “D” command is executed.

13.6. The Send Data Command (aD0!)

Command	Response
aD0! …aD9!	**a<values><CR><LF>**

a	= the sensor address (0-9) (A-Z)
D0	= send data command
D1…D9	= additional send data commands
<values>	= a maximum of 38 characters can be returned with a D command. This is counting <CR><LF>. The aD1…aD9 commands will send additional characters.

The send data command will return data stored in the sensors buffer as a result of a previous “aM” or “aV” command. If the “aD0” command cannot return all the values of the previous “M” or “V” command “aD1…aD2…etc. will return the remaining data.

13.7. Start Verification Command (aV!)

Command	Response
aV!	**atttn<CR><LF>**

a	= the sensor address (0-9) (A-Z)
V	= the verify command
ttt	= the maximum time in seconds for data to be available.
n	= the number of measurements the sensor will return.

The start verification command causes a verify sequence to be performed. This is similar to the "aM!" command, the difference being the start verification command will return diagnostic checksum results and fixed test data. The format of the response is the same as the "D" commands. The return data consists of the following:

axnnnnn

a	= the sensor address (0-9) (A-Z)
x	= +1 or +0 (If +1 factory configuration is okay. If +0 there is a problem. Contact Greenspan)
nnnnn	= checksum of factory configuration file. (Greenspan will use this number for diagnostics).

13.8. The Start Concurrent Measurement Command (aC!)

Command	Response
aC!	**atttnn<CR><LF>**

a	= the sensor address (0-9) (A-Z)
C	= the start concurrent measurement command.
ttt	= the maximum time in seconds for data to be available.
nn	= the number of measurements the sensor will return to one or more "D" commands.

A concurrent measurement is one that can occur while other SDI-12 sensors on the bus are also taking measurements. If successful the addressed sensor will return the maximum time in seconds for the data to be available, and the number of measurements the sensor will return to one or more "D" commands. If the addressed sensor receives a valid command while in the process of a concurrent measurement, it will abort the measurement procedure.

13.9. The User Gain Correction Command. (aXU1Wccf!)

Command	Response
aXU1Wccf!	**atttn<CR><LF>**

a	= the sensor address (0-9) (A-Z)
XU1W	= the gain correction command
cc	= the 2 digit channel number.
ttt	= the maximum time in seconds for data to be available.
n	= 1
f	= the gain expressed as a floating point number.
	ddd.ddd E ± xx
ddd.ddd	= 6 digit number and decimal place. This can be used without the exponential.
E	= exponential
±	= plus or minus
xx	= 2 digit number

The user gain correction command sets the user gain correction for a calibrated channel. Only calibrated channels can be corrected. If successful the gain correction will be copied to the data buffer, which may be retrieved with the "aD0" command. There is a worked example of this command at the end of this chapter.

13.10. The User Offset Correction Command. (aXU0Wccf!)

<u>Command</u>	<u>Response</u>
aXU0Wccf!	**atttn<CR><LF>**

a	= the sensor address (0-9) (A-Z)
XU0W	= the offset correction command
cc	= the 2 digit channel number.
f	= the offset expressed as a floating point number.
ttt	= the maximum time in seconds for data to be available.
n	= 1

The user offset correction command sets the user offset correction for a calibrated channel. Only calibrated channels can be corrected. If successful the offset correction will be copied to the data buffer, which may be retrieved with the "aD0" command.

13.11. The Read Gain Command. (aXU1Rcc!)

<u>Command</u>	<u>Response</u>
aXU1Rcc!	**atttn<CR><LF>**

a	= the sensor address (0-9) (A-Z)
XU1R	= the read gain command
cc	= the 2 digit channel number.
ttt	= the maximum time in seconds for data to be available.
n	= 1

The read gain command allows the user to read the set gain for a calibrated channel. Only calibrated channels can be read. If successful the gain will be copied to the data buffer, which may be retrieved with the "aD0" command.

13.12. The Read Offset Command. (aXU0Rcc!)

Command	Response
aXU0Rcc!	**atttn<CR><LF>**

a	= the sensor address (0-9) (A-Z)
XU0R	= the read offset command
cc	= the 2 digit channel number.
ttt	= the maximum time in seconds for data to be available.
n	= 1

The read offset command allows the user to read the set offset for a calibrated channel. Only calibrated channels can be read. If successful the offset will be copied to the data buffer, which may be retrieved with the "aD0" command.

13.13. The Zero channel Command. (aXZcc!)

Command	Response
aXZcc!	**atttn<CR><LF>**

a	= the sensor address (0-9) (A-Z)
XZ	= the zero channel command
cc	= the 2 digit channel number.
ttt	= the maximum time in seconds for data to be available.
n	= 1

The zero channel command allows the user to zero a calibrated channel. If successful the result will be copied to the data buffer, which may be retrieved with the "aD0" command.

13.14. The Read channel Command. (aXRcc!)

Command	Response
aXRcc!	**atttn<CR><LF>**

a	= the sensor address (0-9) (A-Z)
XR	= the read channel command
cc	= the 2 digit channel number.
ttt	= the maximum time in seconds for data to be available.
n	= 1

The read channel command allows the user to read a calibrated channel. If successful the result will be copied to the data buffer, which may be retrieved with the "aD0" command.

13.15. The Turn Off / on Analog Circuit Power Command. (aXPs!)

Command	Response
aXps!	**atttn<CR><LF>**

a	= the sensor address (0-9) (A-Z)
XP	= the turn channel command
s	= is either "1" to turn power on or "0" to switch off
ttt	= the maximum time in seconds for data to be available.
n	= 1

Once the analog circuit power has been turned on by the command "aXP1" the analog circuit power will remain on until either it is turned off with the command "aXP0" or the SDI-12 power is removed. On SDI-12 power up the analog circuit power will always be turned off. If successful the analog power state will be copied to the data buffer, which may be retrieved with the "aD0" command.

A Worked Example of the User Gain Correction Command (aXU1Wccf!)

To set the user gain correction for the temperature channel proceed as follows:

1. Determine the user gain correction value from Section 16, Calibration.

2. Find the channel number from "Channel Format for Extended Commands" chapter. For temperature this is channel 4.

Command

aXU1Wccf!

a	= the sensor address (0-9) (A-Z)
XU1W	= the gain correction command
cc	= the 2 digit channel number.
f	= the gain expressed as a floating point number.

3. Enter these results into the command line. The sensor address example is 1.

1XU1W040.98

4. This completes gain correction.

14. Channel Format for Extended Commands

Table 3: Product TS1200

Channel 1	**Channel 2**
Turbidity	Battery

Note. These are the channel numbers for the extended commands only, and are not the channel order output for a measurement command.

15. Maintenance

The sensor may be cleaned using a soft cloth and warm water, encrustations or barnacle growth may have to be removed with a scraping action.

Greenspan recommends calibration is checked every six to twelve months. Adjustments can be made using the SDI-12 commands detailed in this manual or returned to Greenspan for re-calibration.

16. Calibration

The following steps are required in calibration of the TS1200: Please refer to **Table 2** for Output Channel assignments during calibration. (Section 13)

One Point (Offset Adjust)

1. Read current User Offset (Uoffset)

2. Place sensor in Formazin Std 1 and read sensor output (measured value)

3. Calculate new User Offset

   New Uoffset = Uoffset + (Std1 – measured value)

4. Write new offset

Two Point (Gain and Offset)

1. Set current user offset, (Uoffset) to 0

2. Set current user gain, (Ugain) to 1

3. Place sensor in Formazin Std 1 and read sensor measurement. (Meas 1)

4. Place sensor in Formazin Std 2 and read sensor measurement. (Meas 2)

5. Calculate new Ugain:

$$\text{Ugain} = \frac{\text{Std 2} - \text{Std 1}}{\text{Meas 2} - \text{Meas 1}}$$

6. Calculate new Uoffset

   Uoffset = Std 2 – Ugain x Meas 2

7. Write Ugain + Uoffset

17. Specification TP100

Specification	Model TP100
Connections	Power Red wire Ground Black wire Trigger Input User option, connections internal Supply line is protected internally with an automatically reset polyfuse.
Dimensions	115 x 90 x 55 (mm)
Power Requirements	12 - 15VDC, typically 2 Amps. Supplies power to both Timer Control unit and pump motor
Cable	Maximum length 70 metres, with 12VDC
Supplied with:	1 x Pump cable 1 x Pump filter cap 1 x Timer Control unit, providing a variable timed pulse to the pump motor as well as an external trigger pulse capability.

18. Specifications TS1200

Specification	Model TS1200
Standard ranges available	0-100 NTU 0-250 NTU 0-500 NTU 0-1000 NTU
Note: Non-standard ranges may have degraded accuracy.	
Operating Temperature	0 to +50°C
Baud Rate	1200 baud
Address Range	00 to 09 A to Z
Linearity	± 2 %
Output	SDI-12
Supply Voltage	9-16VDC
Standby Current Comms Current Measurement Current	<200uA <20mA <120mA
Warm up time to stable reading	16 seconds
Cable	Polyurethane outer-sheath Maximum length 60 metres
Dimensions: Length Diameter	325mm 44mm stainless steel 47mm Delrin
Wetted materials	316 stainless steel and Delrin