Dissolved Oxygen Sensor

DO1200

Edition 1.4

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.

All requests for information will be serviced within 24 hours.

All Greenspan products are designed, developed and manufactured in Australia and can be supplied at short notice.

Warranty Details

Greenspan warrants all new Greenspan products against defects in materials and workmanship for **12 months** from the date of invoice. During the warranty period, we will repair or, at our option, replace at no charge a product that proves to be defective provided that it is returned, shipping prepaid, to Greenspan Technology Pty Ltd.

Greenspan's liability and obligations in connection with any defects in materials and workmanship are expressly limited to repair or replacement, and the sole and exclusive remedy in the event of such defects shall be repair or replacement. Greenspan's obligations under this warranty are conditional upon it receiving prompt written notice of claimed defects within the warranty period and its obligations are expressly limited to repair or replacement.

This warranty does not apply to products or parts thereof which have been altered or repaired outside of the Greenspan factory or other authorised service centre, or products damaged by improper installation or application, or subjected to misuse, abuse neglect or accident. This warranty also excludes items such as reference electrodes and Dissolved Oxygen membranes that may degrade during normal use.

Greenspan Technology Pty Ltd will not be liable for any incidental or consequential damage or expense incurred by the user due to partial or incomplete inoperability of it's products for any reason whatsoever or due to inaccurate information generated by its products.

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.

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1. Introduction to the DO1200 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 DO1200 is designed to measure Dissolved Oxygen and Temperature. It includes complete linearity correction and temperature 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 DO1200 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 DO1200 Sensor

Here are the items you should have received.

1. Greenspan DO1200 sensor with polyurethane cable.

2. This User Manual*

3. SDI-12 Command Calibration Reference *

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/ manuals.htm

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 similar to this:

MODEL DO1200

RANGE 0-20 ppm/0-50°C

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.

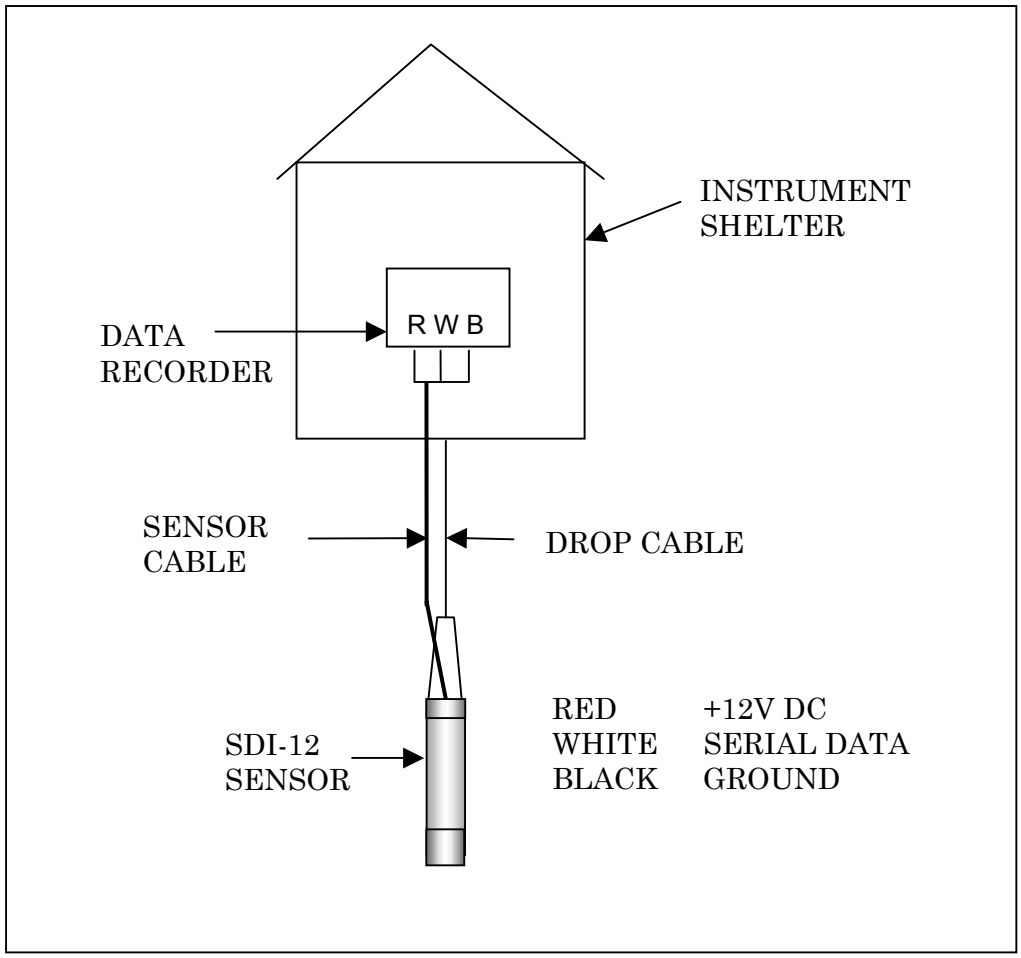

Figure 1. Installation

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.

6.6 Unit Range

Your Greenspan DO sensor has been designed to operate to a maximum of 20 ppm.

7. Sensor Maintenance

7.1 DO Rod

The DO sensor membrane is subject to fouling, but this generally has little effect on readings. However it may be cleaned using warm water.
It may be necessary to remove the membrane assembly from the bulkhead for easier cleaning.
Cleaning is advised if output readings indicate any drift or marked change.
Generally the sensor should be checked for both fouling and calibration every 3-6 months in reasonable conditions.
The effect of algal growth can also block transmission of oxygen through the membrane. Gentle cleaning under tap water will remove this build-up. If this is not successful, replacement membrane assemblies are available from Greenspan.
It is not necessary to re-calibrate the sensor if the membrane assembly is replaced.

8. Operation

The Greenspan DO1200 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 DO1200 outputs DO in ppm. Temperature output selection can be in degrees Fahrenheit or Celsius.

The DO1200 contains a microprocessor to provide temperature and linearity compensation, and to control both the offset and full scale settings. This allows for fine adjustments if and when required, as part of regular maintenance. These features are implemented with the extended SDI-12 commands.

Note. Output units for temperature must be specified on order.

9. Extended Commands

Please refer to the SDI-12 Command Calibration Reference for further information on the following commands.

9.1 User Gain

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

9.2 User Offset

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

9.3 Zero Channel

The zero channel 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.

9.4 Reading data from the Greenspan DO1200

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.

10.4 Dissolved Oxygen Channel Calibration

The following two methods describe the calibration of the DO. Refer to **Table 1** in Appendix of SDI-12 Command Calibration Reference for channel value.

10.4.1 Quick Air Calibration Method

10.4.1.1 PPM Calibration

This procedure uses the User Gain adjustment. Do not use offset adjustment or errors will result.

1. Clean the diffusion rod of the sensor with a jet of mild detergent solution from a laboratory wash bottle. Leave to dry.

2. Allow temperature and oxygen concentration to stabilise in air for two hours minimum.

3. Calculate the local atmospheric pressure using the following formula:

$$\text{Atmospheric Pressure Factor} = \frac{\text{Local Atmospheric Pressure (mb)}}{1013\text{mb}}$$

For example if local pressure is 960mb then:

$$= \frac{960}{1013}$$
$$= \mathbf{0.947}$$

4. Obtain the temperature using the *Start Measurement* command, *eg: 0M!* Wait for time out, then use the *Send Data* command *0D0!* to display reading.

5. From temperature to ppm table, (Table 2) determine the corresponding oxygen concentration for that temperature. (ppm value)

6. Note ppm reading of sensor (measured value). This is obtained through the datalogger with the *Start Measurement* command (eg: 0M!) Wait for time out, then use the *Send Data* command *0D0!* to display reading.

7. Read current user gain (old *Ugain eg 0XU1R03!).* Refer to Table 1 in Appendix of SDI-12 Command Manual for channel value.

8. Calculate:
$$\text{new Ugain} = \text{old Ugain} \times \frac{\text{ppm value} \times \text{Atmospheric Pressure Factor}}{\text{measured value}}$$

For example, if old gain is 2, ppm value @25°C from Table 2 is 8.26ppm, measured value is 8.23ppm and pressure is 0.947

$$\text{New gain} = \frac{2 \times 8.23 \times 0.947}{8.26}$$
$$= \mathbf{1.88}$$

9. Enter new Ugain value into sensor with *Gain Correction* command, *eg:0XU1W031.88!*. Refer to Table 1 in Appendix of SDI-12 Command Manual for channel value.

10. The DO ppm channel is now calibrated and ready for use.

10.4.2 Water Bath Calibration Method

10.4.2.1 PPM Calibration

This procedure uses the User Gain adjustment. Do not use offset adjustment or errors will result.

1. Prepare calibration bath of de-ionised water, bath should be deep enough to allow full immersion of the sensor.

2. Bubble air from aquarium pump into bath.
3. Place sensor in bath and allow to stabilise overnight or for a minimum of two hours.

4. Determine oxygen concentration in bath. This can be done by:
   - Calibrated DO meter
   - Winkler Titration
   - Theory- for complete method see; 'Standard Methods', Edition19, 1995, p4-99 (1). See step 5 below if this method is selected.

5. The Dissolved Oxygen concentration may be determined by the abbreviated theoretical method given here. To determine bath concentration measure bath temperature and use the formula below to calculate concentration:

$$C = 14.612 - t \times 0.408 + t^2 \times 8.606 \times 10^{-3} - t^3 \times 1.148 \times 10^{-4} + t^4 \times 6.572 \times 10^{-7} \quad (1)$$

Where: C = calculated bath DO concentration in ppm at standard atmosphere (1013 hPa)
t = bath temp in degrees C.

To compensate for non standard atmospheric pressures use the following formula.

$$\text{Calculated Conc.} = C \times \frac{\text{atmospheric pressure (hPa)}}{1013}$$

Note: Atmospheric pressure should be not be normalised to sea level.

6. Note ppm reading of sensor (measured value). This is obtained through the datalogger with the *Start Measurement* command (eg: 0M!) Wait for time out, then use the *Send Data* command *0D0!* to display reading.

7. Read current user gain (old *Ugain eg 0XU1R03!).* Refer to Table 1 in Appendix of SDI-12 Command Manual for channel value.

Calculate: new Ugain = old Ugain x $\frac{\text{(Bath Conc)}}{\text{measured value}}$

Where:

Bath Conc = either the measured or calculated DO concentration of the bath.

measured value = ppm reading of sensor.

For example, if old gain is 2 and Bath Conc is 8.23 and measured value is 8.26ppm

$$\text{New gain} = \frac{2 \times 8.23}{8.26} = \mathbf{1.99}$$

8. Enter new Ugain value into sensor with *Gain Correction* command, *eg:0XU1W031.99!.* Refer to Table 1 in Appendix of SDI-12 Command Manual for channel value.

9. The DO ppm channel is now calibrated and ready for use.

10.4.2.2 % Saturation Calibration

The % saturation channel is calculated from the ppm reading by the following formula.

$$\%\,\text{Sat} = \frac{Conc_{measured}}{Conc_{Theoretical}}.100$$

Where $Conc_{measured}$ = DO ppm channel reading

$Conc_{Theoretical}$ = Theoretical Concentration determined by formula 1.

This means that to calibrate the % sat reading, all that has to be done is to re-calibrate the ppm channel using either the air cal or bath cal methods previously described for ppm.

As the theoretical concentration is determined at a standard atmosphere of 101.3kPa, the user gain for the % sat channel is used to calibrate for non standard atmospheric pressures.

To Re-Calibrate % sat channel:

1. Calibrate ppm channel as per above
2. Read % Sat old user gain (old gain). *(eg: 0XU1R05!)*
3. Calculate new User Gain for 100% sat, use the following formula:

$$\text{Ugain} = \text{old gain} \times \frac{100\%}{\text{Measured Value}}$$

Where Measured Value is the % sat

For example: if old gain is 2 and measured value is 97% sat

$$\text{Ugain} = 2 \times \frac{100}{97}$$
$$= \mathbf{2.06}$$

4. Write new % sat channel user gain using *Gain Correction* command *eg: 0XU1W052.06!*

5. The %Sat channel is now re-calibrated and ready for use.

It is recommended calibration is checked every six months.

10.4.2.3 Table 2. DO Temperature to PPM Table @ 101.3kPa

Temp ºC	ppm	Temp ºC	ppm	Temp ºC	ppm
0	14.62	17	9.66	34	7.06
1	14.22	18	9.47	35	6.95
2	13.83	19	9.28	36	6.84
3	13.46	20	9.09	37	6.73
4	13.11	21	8.91	38	6.62
5	12.77	22	8.74	39	6.51
6	12.45	23	8.58	40	6.41
7	12.14	24	8.42	41	6.31
8	11.84	25	8.26	42	6.21
9	11.56	26	8.11	43	6.12
10	11.29	27	7.97	44	6.02
11	11.03	28	7.83	45	5.93
12	10.78	29	7.69	46	5.83
13	10.54	30	7.56	47	5.74
14	10.31	31	7.43	48	5.65
15	10.08	32	7.30	49	5.56
16	9.87	33	7.18	50	5.47

10.5 Temperature Calibration

The temperature calibration is factory set, it is strongly recommend this channel is not re-calibrated by the customer due to difficulties involved in setting up accurate, stable temperature standards.
The method presented here is included for completeness and assumes an accurate temp reference bath.

1. Ensure sensor is connected to power and computer.

2. Set up a low temperature stable bath (0-10°C)

3. Immerse the sensor in the bath (sensor should be completely covered) and allow two hours for sensor to stabilise to bath temperature.

4. Temperature calibration requires a 2 point Gain and Offset Calibration.

5. Set current *User Offset Correction* to 0 *eg: 0XU0W040!* (Uoffset). Refer to Table 1 in Appendix of SDI-12 Command Manual for channel value.

6. Set current *User Gain Correction* to 1 *eg: 0XU1W041!* (Ugain). Refer to Table 1 in Appendix of SDI-12 Command Manual for channel value.

7. Obtain the low point using *Start Measurement* command for temperature. *eg: 0M!* (Meas1). Wait for time out, then use the *Send Data* command *0D0!* to display reading.

8. Immerse the temp sensor in the hot water bath, (approx. 40- 50°C). Allow two hours for temperature to stabilise. Most sensors have the temperature reference device mounted internally and therefore require the airspace around them to equilibrate to case temperature.

9. Obtain the high point using *Start Measurement* command for temperature. *eg: 0M!* (Meas2) Wait for time out, then use the *Send Data* command *0D0!* to display reading.

10. To re-calibrate the sensor, calculate the new user gain:

$$\text{Ugain} = \frac{\text{Full Scale}}{\text{Meas2} - \text{Meas1}}$$

where: Full Scale = 50°C

for example:
If measured temperature (Meas2) is 45°C and measured low value (Meas1) is 5°C

$$\text{new Ugain} = \frac{50}{45 - 5}$$
$$= \mathbf{1.25}$$

11. Calculate new *User Offset Correction*:

    new Uoffset = Full Scale - (Ugain x Meas2)

    for example:
    If Full Scale is 50°C and measured temperature is 45°C

    new Uoffset = 50 - (1.25 x 45)
    = **-6.25**

12. Write new *User Offset Correction, eg: 0XU0W04-6.25!*. Refer to Table 1 in Appendix of SDI-12 Command Manual for channel value.

13. Write new *User Gain Correction, eg: 0XU1W041.25!*. Refer to Table 1 in Appendix of SDI-12 Command Manual for channel value.

14. The Temperature channel is now re-calibrated and ready for use.

It is recommended calibration is checked every six months.

11. Specifications

Specification	Model DO1200
Standard ranges available	0-20 ppm 0 –200%
Operating Temperature	0 to +50°C
Baud Rate	1200 baud
Address Range	00 to 09 A to Z
Dissolved Oxygen Accuracy	±0.3ppm for temperature range 5-35°C ±2% FS Saturation (0-50°C)
Temperature Accuracy	±1°C
Output	SDI-12
Supply Voltage	9-16VDC
Standby Current Comms Current Measurement Current	<200uA <15mA <50mA
Warm up time to stable reading	2 seconds
Cable	Polyurethane outer-sheath Maximum length 60 metres
Dimensions: Length: Diameter:	473mm 44mm Stainless Steel 47mm Delrin
Weight:	701g Delrin (potted) 803g Stainless Steel (potted)
Wetted materials	316 Stainless Steel and Delrin