

D-Opto

Dissolved Oxygen Sensor

Operation Manual (Software Version 2.3)



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1 Introduction

The D-Opto is designed to measure dissolved oxygen concentrations in liquids; it uses field-proven solid-state optical sensing technology that is highly stable over long periods of time, even in harsh conditions. The D-Opto has extremely low power requirements, and outputs the data in SDI-12 format making it ideal for incorporation into remote environmental monitoring installations.

1.1 Optical Sensor Technology

Unlike conventional dissolved oxygen sensors, the D-Opto sensing element utilises fluorescence to measure dissolved oxygen. The basic principle involves subjecting a fluorescing compound (ruthenium) to a fixed wavelength of light. When the light source is removed, the compound emits a fluorescence, the intensity of which is dependent on the oxygen levels present in the surrounding water. An extremely stable electronic circuit has been designed to firstly excite the ruthenium, and then measure the intensity of the resulting fluorescence. Therefore using this circuitry, the D-Opto should provide accurate dissolved oxygen measurements over long periods of time (many months) without re-calibration.

Unlike conventional polarographic dissolved oxygen sensors, the optical method does not consume oxygen. Consequently the measurement of dissolved oxygen by the D-Opto is unaffected by water movement. Similarly the D-Opto does not utilise a membrane or any other consumables, thus minimising the servicing requirements.



2 Software

The D-Opto is supplied with the custom designed Windows based communication software program “D-OptoCom”. This program:

- Enables the user to communicate with the D-Opto via a computer;
- Is used to configure and calibrate the D-Opto;
- Has a data logging function that enables data collected by the D-Opto to be logged directly to the computer.

2.1 Installation

The D-Opto is supplied with a software CD that contains the file “Install D-OptoCom.exe”. Double clicking the file from Windows Explorer will initiate installation onto the PC

During installation, the user can select the working path and directory, however it is recommended that the default is used (“c:\Program Files\D-OptoCom”). During installation no files are added or modified on the PC, except in the chosen installation directory. Restarting the computer after installation is not necessary.

2.2 Operation

When D-OptoCom is started, a serial port and SDI-12 address selection window will appear (Figure 1).

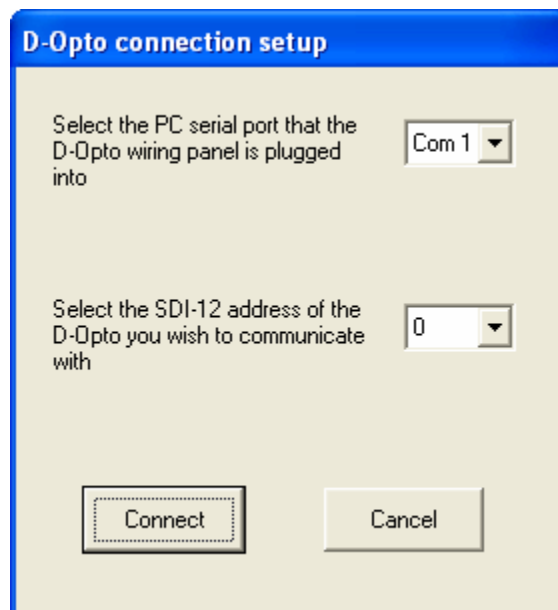


Figure 1: D-OptoCom serial port selection window.

With most computers the D-Opto will be connected to serial com port number 1. However, if the D-Opto is connected to the computer's USB port via a USB to serial converter, the port number will probably be either com port 4 or 5.

Multiple D-Opto sensors can be connected to a single wiring panel. Each D-Opto requires a unique address, and so by selecting the appropriate address in the connection setup window, the PC can communicate with the required D-Opto.

Once the correct port and SDI-12 address has been selected, and the 'OK' button pressed, the computer will start communicating with the D-Opto probe. This may take up to 5 seconds, and when communication has begun, the main window will open (Figure 2).

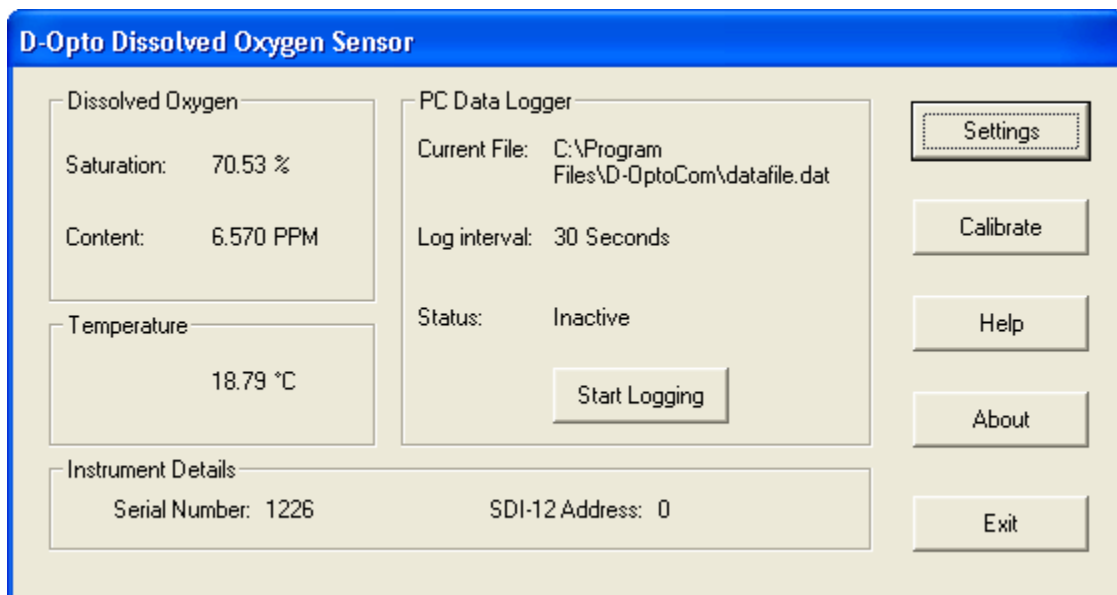


Figure 2: D-OptoCom main window

The main window displays current dissolved oxygen (% saturation and PPM) and temperature (°C) data, and is updated approximately every 5 seconds.

The serial number displayed is factory set and is unique to each D-Opto. It corresponds to the number displayed on the outside of the D-Opto housing.

The SDI-12 address refers to the communication address assigned to the D-Opto. The address can be changed by the user, in the "Settings" window (see below).

The PC data logger section enables data from the D-Opto to be saved directly to the PC. The file that data is currently being saved to, and the log interval can both be changed by the user in the "Settings" window (see below). The status indicates if the PC is logging, or idle. The data file is ASCII (the format is

provided in Appendix 1) which can be opened with most text editors, or imported into Excel.

When using the PC Data Logger function, the D-Opto window should be kept as the active window. When the D-Opto is running as a background application, intermittent communication can occur with some computers, which results in an inconsistent data record.

When the “Settings” button on the main window is pressed, the D-Opto Settings window opens (Figure 3). This window enables the user to change the:

- file that the PC logs the data to;
- PC data log interval;
- SDI-12 address; the address options are 0 through 9, or A through to Z. When changing the PC log interval or SDI-12 address, the update button **MUST** be pressed to transfer the change to the D-Opto. Before the new SDI-12 address is set in the D-Opto, D-Optocom checks to make sure that there are no other D-Opto’s currently connected that have the same address.

The “Calibration” button opens the D-Opto Calibration window (Figure 4). All calibration values are calculated and stored internally by the D-Opto. The “Restore Defaults” button causes the D-Opto to resort back to the original factory calibrations. A full description of the calibration procedure is outlined in the operation section.

The “Altitude Correction” button opens up the Pressure Correction Calculator which provides a tool for pressure correcting the dissolved oxygen saturation content of fully aerated water (Figure 5). It will accept either altitude (m) or barometric pressure (mBar).

By pressing the “Restore defaults” button, the original factory calibration values are reinstated by the D-Opto.

The “Help” button opens the D-Opto manual. The software version is displayed on the front page of the manual.

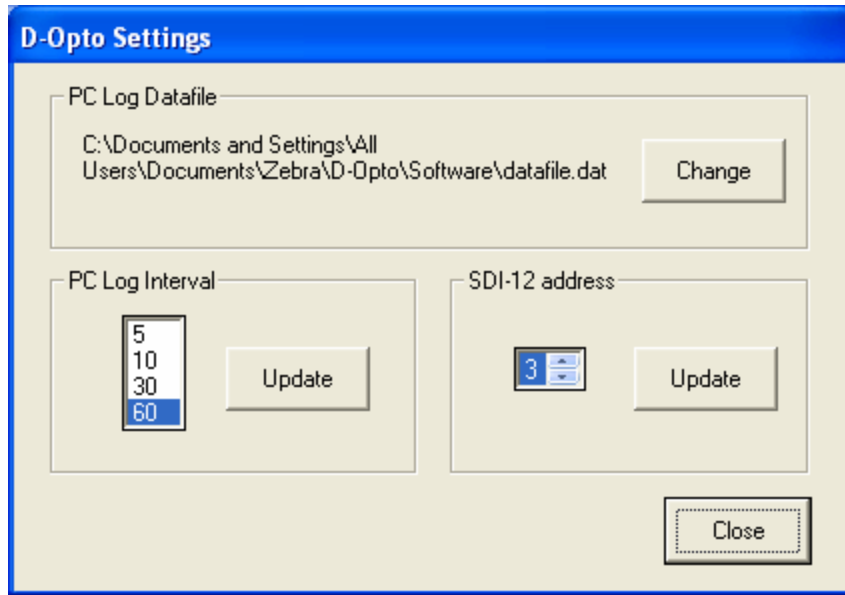


Figure 3: D-Opto Settings window

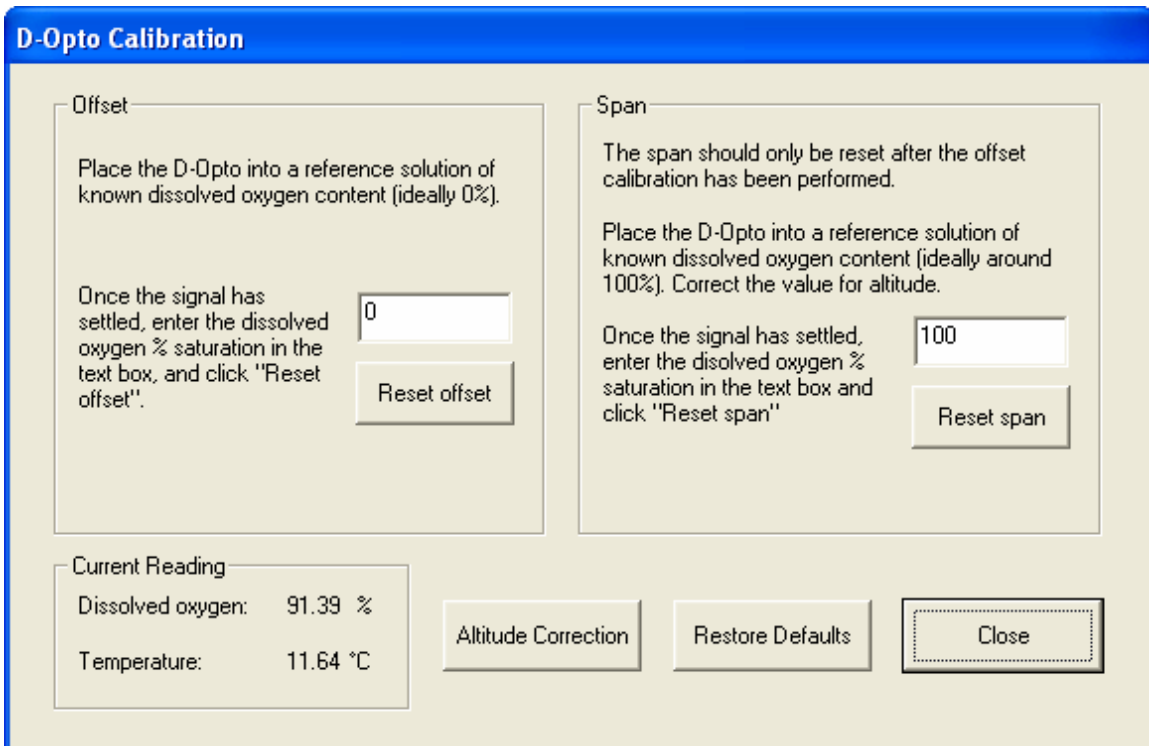


Figure 4: D-Opto Calibration window.

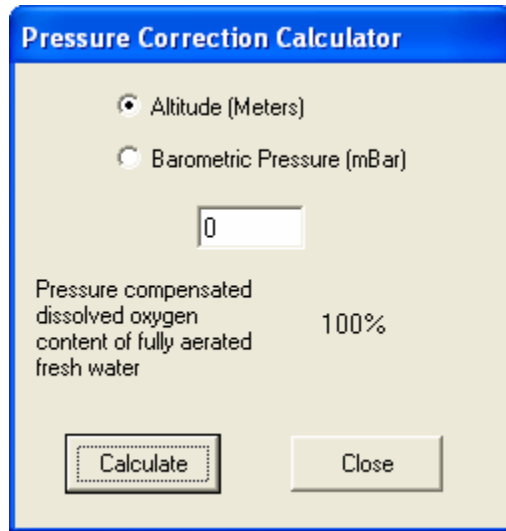


Figure 5: Pressure Correction Calculator

3 Operation

3.1 Installation

The D-Opto can be mounted in any orientation; however it is recommended that the optical window faces away from direct sunlight.

The body can be clamped in position; however avoid using excessive force. The cable should be secured along a solid structure to prevent it trailing in the water.

The D-Opto can be wired directly to the data logger or PC, according to the wiring configuration provided in table 1. Alternatively the wiring interface module supplied as standard with the D-Opto can be used. The interface module simplifies the wiring of the D-Opto and enables a PC to be connected to the D-Opto without having to disconnect the D-Opto from the data logger. Multiple D-Opto's can be wired to a single wiring interface module, **however each D-Opto must have a unique address.**

A standard 9 pin serial extension cable (supplied) can be used to connect the PC to the wiring interface module. **However, whilst the PC is connected to the interface, communications between the logger and the D-Opto are suspended.**



Photo 1: D-Opto wiring interface module

Cable colour	Data logger connection	PC connection
Red	9-15 volts DC power	9-15 volts DC power
Black	Power/Signal ground	Power/Signal ground (PC pin 5)
Green	SDI-12	Tx (PC pin 3)
White	N/C	Rx (PC pin 2)

Table 1: D-Opto wiring configuration

3.2 Communication

SDI-12 (Serial-Digital Interface Standard) is a single wire communication protocol which was developed principally for use in low power micro-processor based sensors, such as those typically used in environmental monitoring. The protocol is widely used, and most data loggers have SDI-12 communication capability.

The SDI-12 protocol provides a simple yet reliable means of transferring data between the data logger and the instrument. Multiple instruments can share a single communication cable though the use of addressing, whereby each sensor is given a unique address, and only responds when its address is associated with a command, therefore ignoring all other commands.

The D-Opto SDI-12 address is set in the settings window in D-OptoCom software.

There are two commands that can be used to request that the D-Opto take a measurement; these are “M!” and “M1!” (see Appendix 2 for examples of how to program a Campbell data logger to interface with the D-Opto).

The M! Command is used where a single measurement is required. When the D-Opto receives the M! Command, the optical circuitry in the D-Opto is powered up and after a stabilisation period of 5 seconds, a measurement is made and the values returned to the data logger; the optical circuitry is then powered down.

The M1! Command is used where a continuous burst measurement is required. When the D-Opto receives the M1! Command, the optical circuitry is powered up. After 5 seconds a measurement is made and the values are returned to the data logger. The optical circuitry remains powered up. Another M1! Command can be issued by the data logger and will be responded to immediately by the D-Opto without a 5 second delay. The maximum sampling rate is approximately one measurement per second. The optical circuitry remains powered up until no relevant commands are received for 6 seconds.

Three data values are returned by the D-Opto, in the following order;

1. Temperature (°C)
2. Dissolved oxygen (% Saturation)
3. Dissolved oxygen (ppm)

3.3 Routine Maintenance

As with all instruments, it is good operating practice to make regular checks on the quality of data being generated by the D-Opto. This can be carried out on site, using one of the following two methods:

1. Place a recently calibrated transportable dissolved oxygen sensor next to the D-Opto and compare the measurements. It is important to allow a sufficient period of time for temperature equilibration to occur.
2. Place the D-Opto in a solution of known dissolved oxygen content. The Zebra-Tech DO Cal-Kit provides a convenient method of generating such reference solutions. If a DO Cal-Kit is not available, a solution of 0% dissolved oxygen saturation can be created by adding a few teaspoons of sodium sulfite to 1 litre of distilled or fresh tap water.

The D-Opto can tolerate some biofouling, however where possible steps should be taken to minimise this; for example covering the D-Opto can reduce the amount of bio-growth by restricting available light. The copper biofouling control ring should reduce bio-growth in the area around the optical window; this ring is sacrificial and may require replacement on an occasional basis. Always use the nylon bolts supplied with the replacement ring to attach the ring to the D-Opto, and avoid over tightening.

3.4 Cleaning

Periodically it may be necessary to clean the D-Opto optical window, to remove bio-growth or other accumulated deposits. **DO NOT** use a brush or any object that may scratch or damage the optical window. Only use the cleaning pads supplied with the D-Opto.

3.5 Calibration

Under normal operating conditions, the D-Opto should only require infrequent calibration.

Calibration of the D-Opto is a simple operation that can be carried out in the field. Due to the measurement principle of the D-Opto, performing air calibrations are not advisable. The Zebra-Tech Do-Cal Kit greatly simplifies the field calibration of the D-Opto.

The offset and gain of the D-Opto are calibrated individually. Normally only the offset will need to be calibrated as the gain is even more stable than the offset over time. The gain should only be calibrated **AFTER** the offset has been calibrated.

- Offset Calibration

A reference solution of 0% dissolved oxygen is required for the offset calibration. This can be created by mixing a couple of teaspoons of sodium sulfite into 1 litre of distilled or fresh tap water.

Procedure:

- 1) Place the D-Opto in the reference solution and allow equilibrating for at least 30 minutes.
- 2) Power up the D-Opto, and start D-OptoCom. Once the measurements have stabilised, press the “Calibrate” button in the main window.
- 3) Enter 0 (zero) in the offset calibration edit box and press the “Reset offset” button.
- 4) The D-Opto performs a calibration routine followed by a self check; this can take up to 30 seconds. Do not remove the D-Opto from the reference solution during this period. The operator will be notified when the process is complete.

- Gain Calibration

A solution of known dissolved oxygen content, other than 0%, should be used for the gain calibration. The most practical method is to create a fully aerated solution. This can be done by bubbling air through a container of distilled or fresh tap water, stirring frequently. After around 30 minutes, the water can be assumed to be fully saturated.

The actual dissolved oxygen saturation can be calculated by correcting for altitude, or preferably, the local barometric pressure if that is known. The “Correction Calculator” can be used to calculate the corrected dissolved oxygen content of the fully aerated reference solution (see page 6). As an example, if the D-Opto is installed at a field site at 435 meters above sea level, and a fully aerated reference solution is prepared on site, the actual dissolved oxygen percent saturation is calculated at 95%.

Procedure:

- 1) Place the D-Opto is placed in the reference solution, and allow it to equilibrate for at least 30 minutes.
- 2) Power up the D-Opto and start D-OptoCom. Once the measurements have stabilised, press the “Calibrate” button in the main window to open the Calibration window.
- 3) Enter the pressure corrected dissolved oxygen percent saturation of the reference solution in the gain calibration edit box and press the “Reset gain” button.
- 4) The D-Opto performs a calibration routine followed by a self check; this can take up to 30 seconds. Do not remove the D-Opto from the reference solution during this period. The operator will be notified when the process is complete.

Appendix 1: PC Data Log File Format

Data Field Number	Description
1	Date DD:MM:YY
2	Time HH:MM:SS
3	Dissolved Oxygen (%)
4	Dissolved Oxygen (ppm)
5	Temperature (Degrees C)

Appendix 2: SDI-12 Commands and D-Opto Responses

The D-Opto probe is SDI-12 version 1.3 compliant, as described in “SDI-12 A Serial-Digital Interface Standard for Microprocessor Based Sensors Version 1.3”*

In accordance with SDI-12 version 1.3, the D-Opto responds to all basic SDI-12 commands. The most relevant commands and responses are provided in Table 1. Extended commands supported by the D-Opto are provided in Table 2.

Name	Command	Response
Active acknowledge	a!	a<CR><LF>
Send Identification	al!	Allccccccmmmmmmvvvxxx...xx<CR><LF>
Address Query	?!	a<CR><LF>
Single measurement	aM!	atttn<CR><LF>
Repeated measurements	aM1!	atttn<CR><LF>
Send Data	aD0!	a<values><CR><LF>

Table 1. Basic SDI-12 commands and D-Opto responses

Name	Command	Response
New Offset	aXDO+<value**>!	a<value><CR><LF>
New Span	aXDS+<value**>!	a<value><CR><LF>
Reset factory defaults	aXLD!	a<CR><LF>

** Format must be xxx.xx

Table 2. Extended SDI-12 commands supported by the D-Opto Probe

* SDI-12 A serial-Digital Interface Standard for Microprocessor Based Sensors Version 1.3 (SDI-12 Support Group, September 17, 2002. <http://www.sdi-12.org>)

Appendix 3: Data logger programming examples

An example of the M! Instruction as used to program a Campbell CR500 data logger and a D-Opto;

```
;Programme for logging data from the D-Opto dissolved oxygen sensor,
;using the SDI-12 recorder instruction (105).
```

```
;The D-Opto can be powered directly from the system battery.
;Current draw is less than 1mA between measurements.
```

```
;The D-Opto SDI-12 cable is connected to the CR500 control port,
;the control port number is specified in the SDI-12 instruction 105.
```

```
;The D-Opto SDI-12 address must correspond to the SDI-12 address
specified in the SDI-12 instruction 105
```

*Table 1 Program

```
01: 30          Execution Interval (seconds)
```

```
1: Batt Voltage (P10)
```

```
1: 1          Loc [ Bat_volts ]
```

```
;Get Temperature(C) DO(%) and DO(ppm) values from sensor with address 0
;It takes about 5 seconds for the measurement to complete
```

```
2: SDI-12 Recorder (P105)
```

```
1: 0          SDI-12 Address
```

```
2: 0          Start Measurement (aM0!)
```

```
3: 1          Port
```

```
4: 2          Loc [ Temp_DegC ]
```

```
5: 1.0        Mult
```

```
6: 0.0        Offset
```

```
;Log Temperature(C), DO(%) and DO(ppm) every 15 minutes in array with
ID 15
```

```
3: If time is (P92)
```

```
1: 0          Minutes (Seconds --) into a
```

```
2: 15         Interval (same units as above)
```

```
3: 10         Set Output Flag High (Flag 0)
```

```
;Set the array ID to 15
```

```
4: Set Active Storage Area (P80)
```

```
1: 1          Final Storage Area
```

```
2: 15         Array ID
```

```
5: Real Time (P77)
```

```
1: 1110      Year,Day,Hour/Minute (midnight = 0000)

6: Sample (P70)
  1: 1      Reps
  2: 2      Loc [ Temp_DegC ]

7: Sample (P70)
  1: 1      Reps
  2: 3      Loc [ DO_Sat   ]

8: Sample (P70)
  1: 1      Reps
  2: 4      Loc [ DO_PPM   ]

9: Do (P86)
  1: 20     Set Output Flag Low (Flag 0)

*Table 2 Program
  02: 0.0000 Execution Interval (seconds)

*Table 3 Subroutines

End Program
```

Appendix 4: Trouble shooting

The D-Opto is not communicating with either a PC or data logger

- Check the power supply is within specifications (Appendix 5).
- Check the wiring is correctly hooked up.
- Check the correct SDI-12 address is set in data logger, or D-OptoCom software

The D-Opto communicates with a PC using D-OptoCom, but not with the data logger

- Check the data logger is wired and programmed correctly.
- Check the D-Opto SDI-12 address is the same as has been programmed into the data logger.

Dissolved oxygen readings are highly erratic, but temperature readings are stable.

The D-Opto incorporates a high gain amplification circuit to measure the fluorescence of the optical window. The instrument has been carefully designed to prevent electrical interference impacting on the operation. Under extreme conditions however, noise may become a problem.

- Track down the source of noise; this could be a nearby pump or other motor.
- Check the data logging system is properly earthed.
- If the D-Opto is being bench tested in a small container of water, noise can be caused by a lack of suitable earthing. Place a grounding wire from the water to the D-Opto power ground.
- The D-Opto is supplied with built in noise rejection specific for the country of supply. If the D-Opto is being used in a country other than the country it was supplied to, contact your supplier.

Appendix 5: Pressure correction chart

Dissolved oxygen % saturation values of air saturated fresh water, corrected for atmospheric pressure.

Altitude (m)	Altitude (feet)	Barometric pressure (mBar)	% Saturation
0	0	1013	100
85	278	1003	99
170	558	993	98
256	841	983	97
343	1126	973	96
431	1413	963	95
519	1703	952	94
608	1995	942	93
698	2290	932	92
789	2587	922	91
880	2887	912	90
972	3190	902	89
1066	3496	899	88
1160	3804	882	87
1254	4115	871	86
1350	4430	861	85
1447	4747	851	84
1544	5067	841	83
1643	5391	831	82
1743	5717	821	81
1843	6047	811	80
1945	6381	800	79
2047	6717	790	78
2151	7058	780	77
2256	7401	770	76
2362	7749	760	75
2469	8100	750	74
2577	8455	740	73
2687	8815	730	72
2797	9178	719	71
2909	9545	709	70
3023	9917	699	69
3137	10293	689	68

Appendix 6: Useful Conversions

Convert from	To	Calculation
kPA	mBar	Multiply by 10
inHg	mBar	Multiply by 33.85
Feet	Meters	Multiply by 0.3048
° Centigrade	Fahrenheit	$(9/5 \text{ } ^\circ\text{C})+32$

Appendix 7: Specifications

Physical Dimensions

48mm diameter x 156.8mm long

Accuracy

Temperature: +/- 0.1 deg C

DO: 1% of reading or 0.02 PPM, which ever is greater

Resolution

Temperature: 00.01 Deg C

DO saturation: 000.01%

PPM: 00.001 ppm

Sensor Drift

< 1% per year

Power supply

8-15 volts DC.

Power consumption

12 mA during measurement, 0.15 mA standby

Depth rating

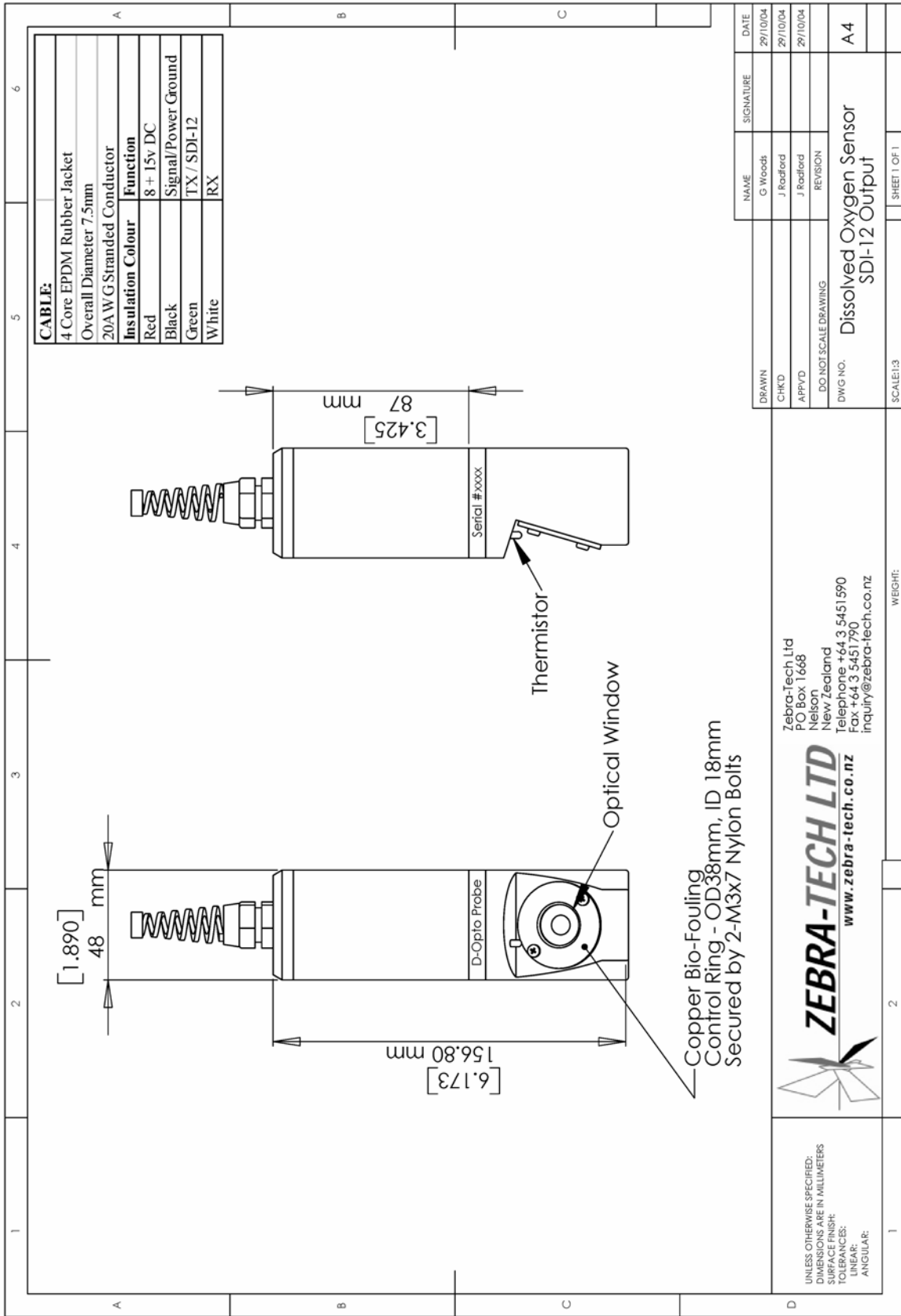
Maximum 30 m water depth

Communications

SDI-12 version 1.3

Cable

4 core, 20 AWG, shielded, EPDM jacket



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