D-Opto

Dissolved Oxygen Sensor

Operation Manual

Software version 2.6

Contents

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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.

Optical Sensor Technology

Unlike conventional dissolved oxygen sensors, the D-Opto sensing element utilizes 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. Using this circuitry, the D-Opto should provide accurate dissolved oxygen measurements over 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. Also the D-Opto does not utilize a membrane or any other consumables, thus minimizing servicing requirements.

Features

Your D-Opto offers the following features:

- **Accurate dissolved oxygen measurements over long periods without re-calibration**

- **Low power consumption**

- **Windows based communication software**

- **Minimal servicing requirements**

2. D-Opto Specifications

Specifications

Physical Dimensions		48mm diameter x 160mm long
Accuracy	Temperature:	+/- 0.1 degrees C
	DO:	1% of reading or 0.02 PPM, whichever is greater
Resolution	Temperature:	00.01 degrees C
	DO saturation:	000.01%
	PPM	00.001 PPM
Sensor Drift		<1% per year (provided measurement interval ≥10 minutes)
Power Supply		8-24 volts DC
Power Consumption		At 12 volts: 12 mA during measurement, 0.02 mA standby
Depth Rating		Maximum 30m water depth
Cable		4 core, 20 AWG, shielded, EPDM jacket

TABLE 1: D-OPTO SPECIFICATIONS

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3. Software

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

- 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

Installation

The D-Opto software CD contains the file 'Install D-OptoComX.exe' (X = version number). Double clicking the file from Windows Explorer will initiate installation onto the PC.

The default installation destination is C:\Program Files\D-Opto. It is recommended that this destination is accepted. This will result in the correct installation into the appropriate folders for either XP or Vista operating systems.
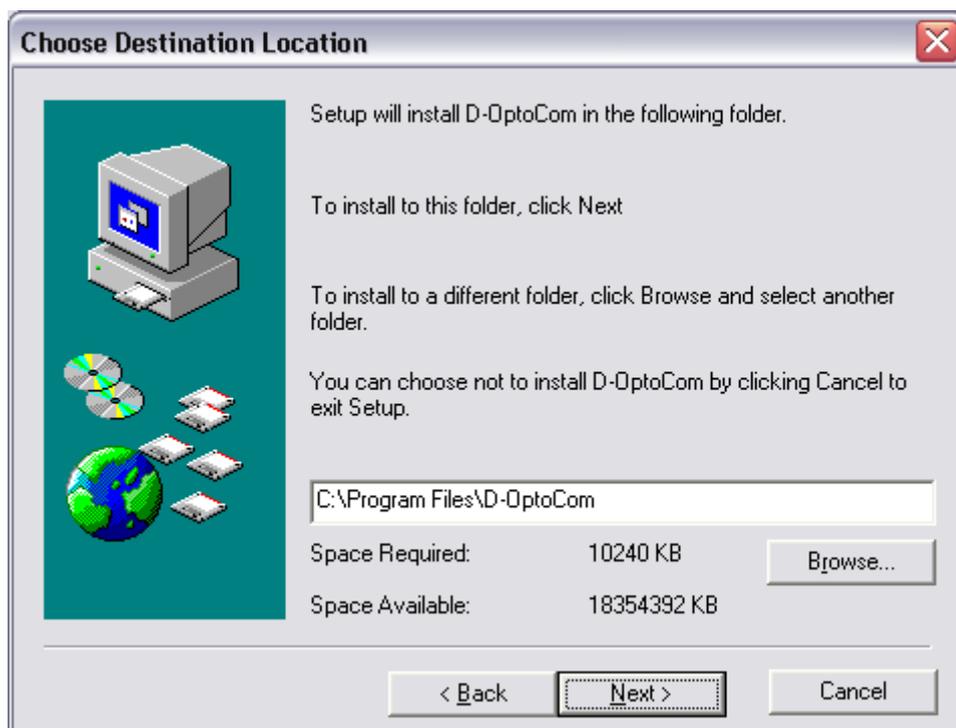

FIGURE 1: SOFTWARE INSTALLATION

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Operation

The D-Opto is supplied with a communication cable. This cable has a 9-pin female plug on one end and a 9-pin male plug on the other end.

The female plug is connected to the serial port on the PC. If the PC does not have a serial port, a USB to serial adaptor can be used. This adaptor plugs into the USB port on the PC and has a serial port that the communication cable can be plugged into.

The male end of the communication cable is connected to the 9-pin socket on the white interface panel.

Once D-OptoCom software is started, the communication window opens (Figure 2). The connection window allows the communication port number to be set.
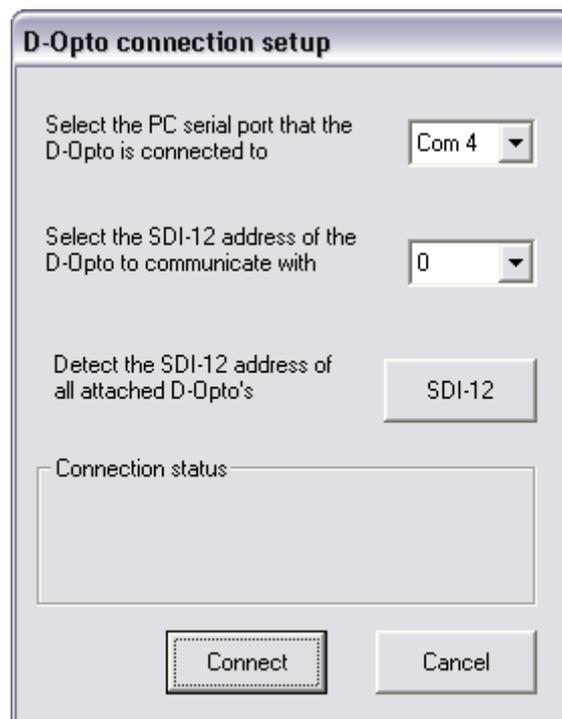

FIGURE 2: D-OPTOCOM SERIAL PORT SELECTION WINDOW

If the computer has a hardware serial port, it will typically be 'Com 1'. If a USB to serial converter is being used, the com port number will most probably be another number. To determine the correct com port number when using a USB to serial converter, it is necessary to open the Device Manager.

In Vista, the Device Manager can be opened directly from the Control Panel. In XP, first open 'Control Panel', then open the 'System' folder, click on the 'Hardware' tab, and then click on the 'Device Manager' button. Once you have opened the Device Manager, click on 'Ports (COM & LPT)' to extend the tree. The com port number for the USB to serial converter will be displayed.

Control Panel → System → Hardware → Device Manager → Ports (COM & LPT)

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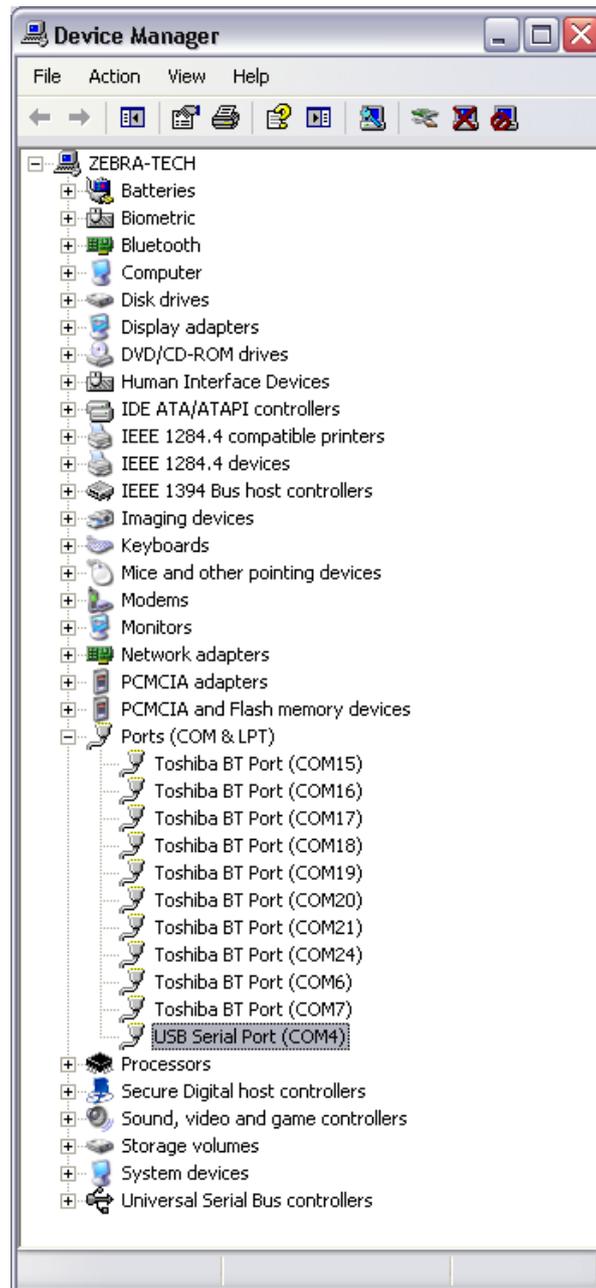www.zebra-tech.co.nz

In the example in Figure 3, the com port is 'Com 4'.

FIGURE 3: DEVICE MANAGER

💡	NOTE! The com port number assigned to the USB serial converter may change between computer re-starts.

The connection window also enables the SDI-12 address to be set. This must be set to the same address as the D-Opto. If you are unsure what the address of the attached D-Opto is, then click on the 'SDI-12' button. This will result in a scan being evoked of the SDI-12 addresses 0-9.

FIGURE 4: SDI-12 ADDRESS SCAN RESULT WINDOW

Once the correct port and SDI-12 addresses have been selected and the 'OK' button pressed, the computer will start communicating with the D-Opto. This may take up to 8 seconds.
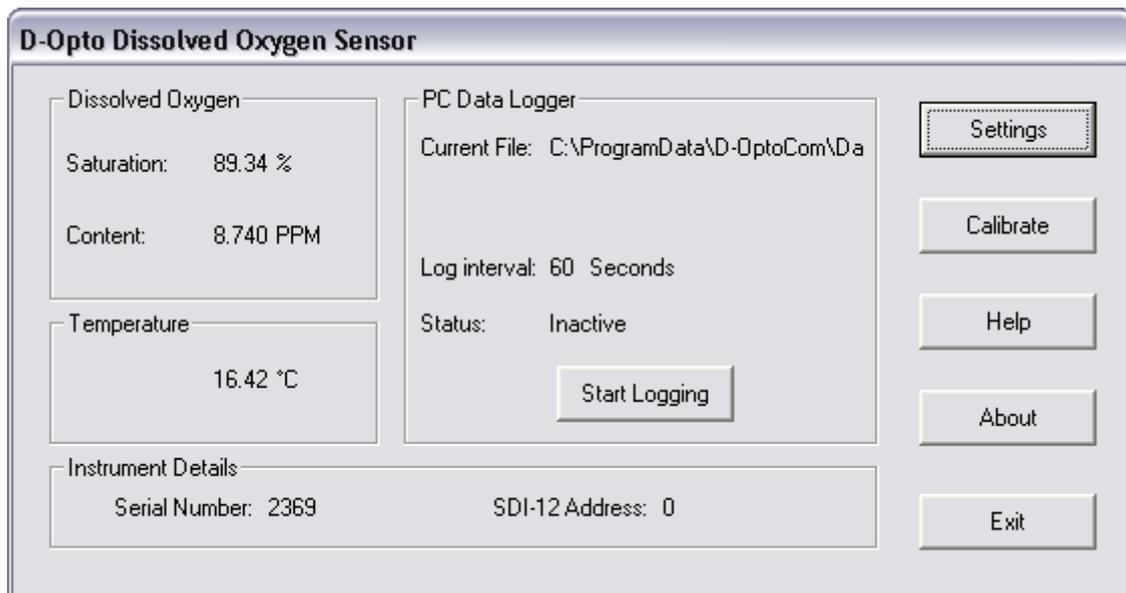
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FIGURE 5: D-OPTOCOM MAIN WINDOW

The main window displays current dissolved oxygen (% saturation and PPM) and temperature (˚C) data, and is updated approximately every 2 seconds.

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

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. Both the file that data is currently being saved to, and the log interval can 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 (see Table 2), which can be opened with most text editors or imported into Excel.

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)

TABLE 2: PC DATA LOG FILE FORMAT

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 6). 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.

> **NOTE!**
>
> When changing the PC log interval or SDI-12 address, the 'Update' button **MUST** be pressed to transfer the change to the D-Opto.
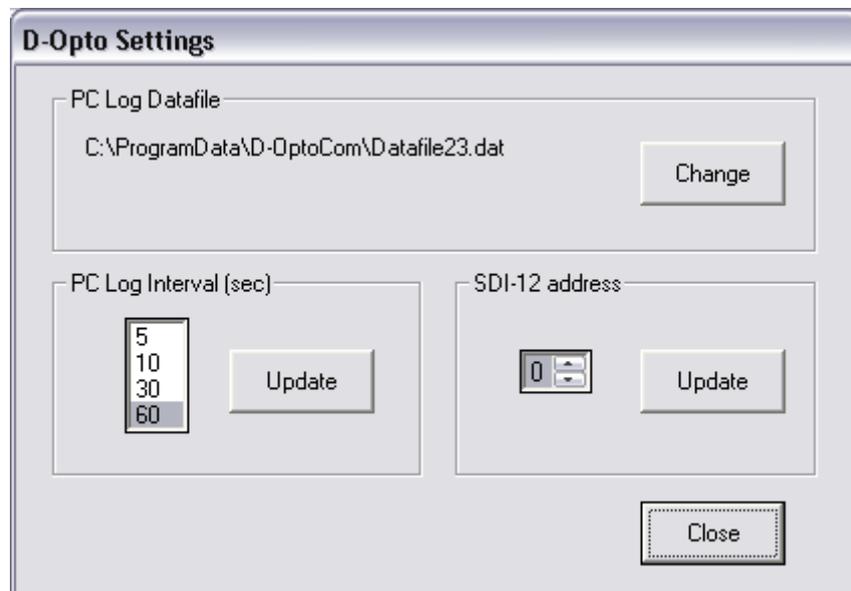

FIGURE 6: D-OPTOCOM SETTINGS WINDOW

The 'Calibration' button opens the D-Opto Calibration window (Figure 7). 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.
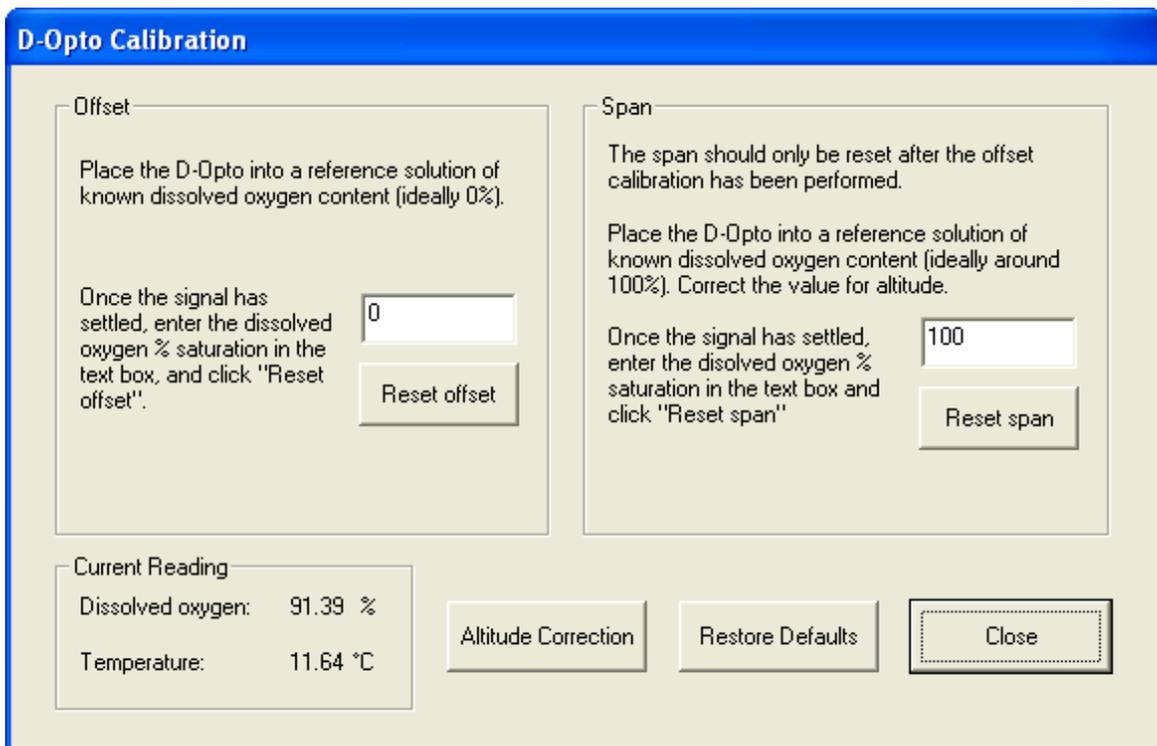
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FIGURE 7: D-OPTO CALIBRATION WINDOW

By pressing the 'Restore Defaults' button, the original factory calibration values are reinstated by the D-Opto.

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 8). It will accept either altitude (m) or barometric pressure (mBar).
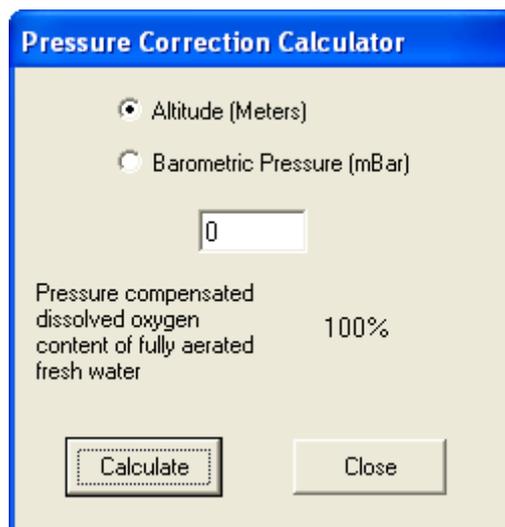

FIGURE 8: PRESSURE CORRECTION CALCULATOR

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4. Operating the D-Opto

Installation

The D-Opto can be mounted in any orientation; however it is recommended that the optical window be faced away from direct sunlight. The body can be clamped in position; 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 2. Alternatively use the interface module supplied as standard with the D-Opto. 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 data logger. However, while the PC is connected to the interface, communications between the data logger and the D-Opto are suspended.
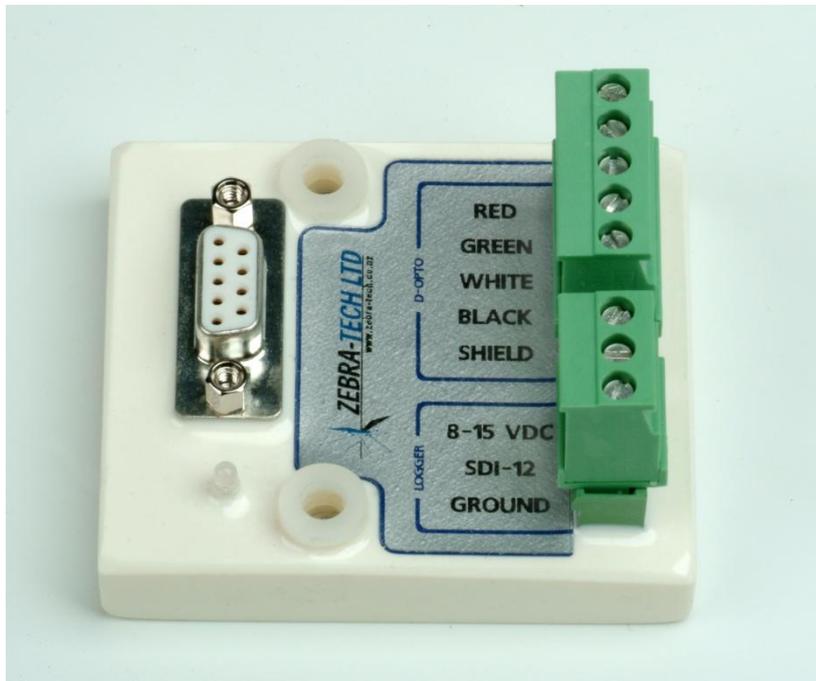
PHOTO 1: D-OPTO INTERFACE PANEL

Cable colour	Data logger connection	PC connection
Red	8-24 volts DC power	8-24 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 2: D-OPTO WIRING CONFIGURATION

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Communication

The 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 through 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:

M!   The M! Command is used when 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 stabilization period of 5 seconds, a measurement is made and the values returned to the data logger. The optical circuitry is then powered down.

M1!   The M1! Command is used when 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. When no relevant commands are received within 6 seconds, the optical circuitry is powered down.

Three data values are returned by the D-Opto, in the following order:
1) Temperature (˚C)
2) Dissolved oxygen (% Saturation)
3) Dissolved oxygen (PPM)

Calibration

Under normal operating conditions the D-Opto should require only infrequent calibration. The main reason to calibrate is to compensate for the gradual deterioration in the fluorescent properties of the optical window which occurs as a result of exposure to the excitation wave length during the measurement cycle. This deterioration is very slow. Typically a small but just noticeable offset change will occur after the equivalent of 500 hours of continuous excitation of the optical window. Under normal operating conditions, the D-Opto is used to make single measurements with a time

interval of many minutes. Excitation of the optical window lasts for around 5 seconds per measurement. Therefore, as an example, if a measurement was made once every 5 minutes, the D-Opto would require recalibration after 3 years of operation.

> **NOTE!**
> When the D-Opto is communicating with a PC, the optical window is being continuously excited. This should be considered when using the PC Data Logger function of the D-OptoCom software.

Calibration of the D-Opto is a simple operation that can be performed in the field. Due to the measurement principle of the D-Opto, performing air calibrations is 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 more stable than the offset over time.

> **NOTE!**
> The gain should be calibrated only **AFTER** the offset has been calibrated.

FIGURE 9: D-OPTO CALIBRATION WINDOW

▪ **Offset Calibration**

A reference solution containing 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 it to equilibrate for at least 30 minutes.
2) Power up the D-Opto and start D-OptoCom. Once the measurements have stabilized, 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. 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%. (See Appendix 3)

Procedure:
1) Place the D-Opto 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 stabilized, 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 span' 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.

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5. 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 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 equilibrium 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 steps should be taken to minimize this where possible. 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.

Periodically it may be necessary to clean the D-Opto optical window to remove bio-growth or other accumulated deposits. Use warm soapy water to clean the D-Opto.

> NOTE!
> DO NOT use a hard object to clean the optical window as this may scratch or damage it.
> Only use the cleaning pads supplied with the D-Opto.

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6. Troubleshooting

Loss of communication

If the D-Opto is not communicating with either the PC or the data logger:
- Check the power supply is within specifications (see Specifications, page 2).
- Check the wiring is correctly hooked up.

If 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 that programmed into the data logger.

Erratic dissolved oxygen readings

You may encounter occasions when the dissolved oxygen readings are highly erratic, but the 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 or Zebra-Tech.

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7.   Appendices

Appendix 1: 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	C) +32

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Appendix 2: 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

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8. Further Assistance

For further assistance with this or any other **Zebra-Tech** product, please contact:

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For up to date information about the D-Opto and other Zebra-Tech products, please visit the **Zebra-Tech Ltd** website at:
http://www.zebra-tech.co.nz

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