TD 290 Operating Manual for Oxygen Sensor 4500

AANDERAA DATA INSTRUMENTS

AADI, an ITT Analytics company

1st Edition	15 January 2010	
2nd Edition	29. January 2010	correction: output settings 4 -20mA sensor, ref Table 3-3
3rd Edition	30. June 2010	correction: new range from Software Version 3B23
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Introduction

Purpose and scope

This document describes the Oxygen Sensor 4500. It is intended to give the reader knowledge of how to operate and maintain the sensor and to give insight in how the sensor works.

Since oxygen is involved in most biological and chemical processes in aquatic environments, it is the single most important parameter needing to be measured. Oxygen can also be used as a tracer in oceanographic studies.

For many reasons it can be critical to monitor oxygen in areas where the supply of oxygen is limited compared to demand e.g.:

- Inside fish cages located in sea and on shore
- In tanks and closed areas

Document overview

The document starts by giving a short description of the Oxygen Sensor 4500.

Subsequently operating instructions, communication with the sensor, oxygen calculations and maintenance issues are presented.

The Appendix includes the principle behind the oxygen optodes, electronic and mechanical design, specifications, calibration procedures, illustrations, and finally a chapter on Frequently Asked Questions.

Applicable documents

- Form 621 Calibration Certificate, O2 Sensing Foil 3853
- Form 622 Calibration Certificate, Oxygen Sensor 4500
- Data sheet D380, Oxygen Optode 4500
- AADI Oxygen Optode FAQ, refer our web site.

References

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Abreviations

O2	Oxygen molecule
LED	Light Emitting Diode
ADC	Analogue to Digital Converter
DSP	Digital Signal Processor
EPROM	Erasable Programmable Read Only Memory
ASCII	American Standard Code for Information Interchange
MSB	Most significant bit
UART	Universal Asynchronous Transmitter and Receiver
RTC	Real Time Clock

Product description

Oxygen Optode 4500 is available in several versions:

4500A: 0 – 5V output format

4500B: 0 – 10V output format

4500C: 4 – 20mA output format

4500D: RS232 output format

Cable length:

10m

20m

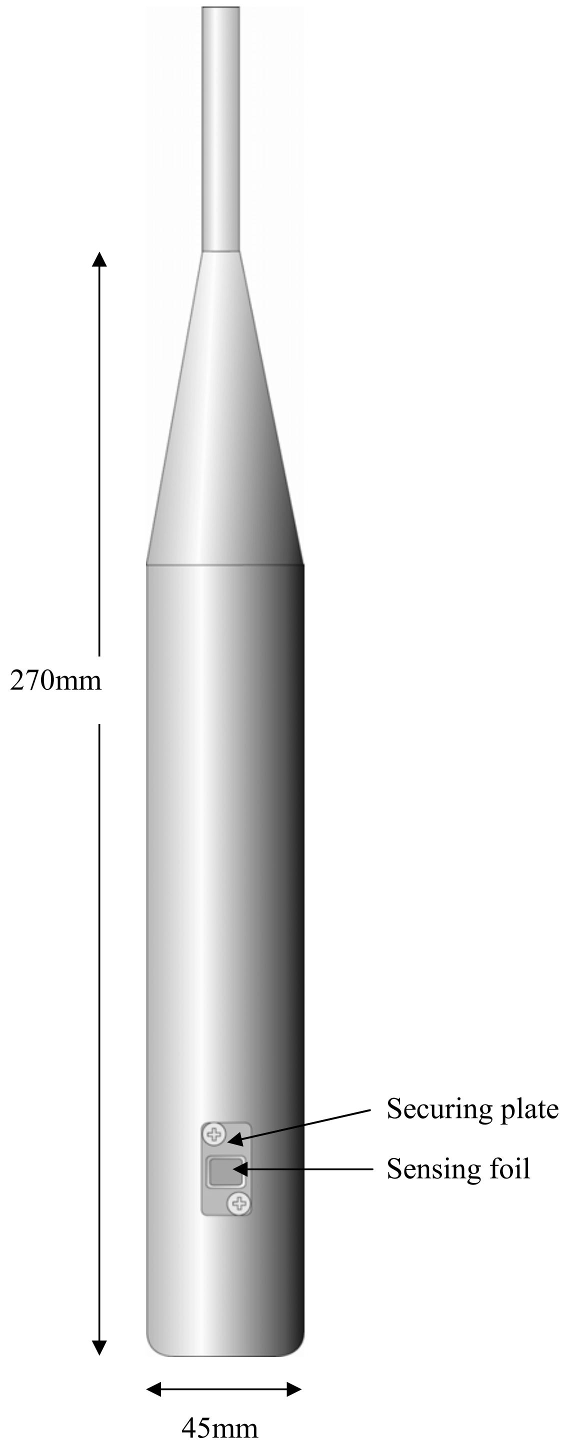
50m

Connection plug:

9 pin D-sub

Amphenol C16 Part nr: C016 30H006 110 12

Note! The sensor version, cable length and type of connection plug must be specified when ordering your sensor.



Cable specifications:

Outer diamter: 9.9mm ± 0.4mm

Minimum bending radius: 155mm

Figure I 1 Illustration of the Oxygen Sensor 4500.

CHAPTER 1 Short description

Oxygen Sensor 4500 is depth rated to 50meters. The sensor is designed for use in the process industry.

AADI Oxygen Sensors are based on the ability of selected substances to act as dynamic fluorescence quenchers.

The fluorescent indicator is a special platinum porphyrin complex embedded in a gas permeable foil that is exposed to the surrounding water. A black optical isolation coating protects the complex from direct incoming sunlight and fluorescent particles in the water.

The sensing foil is attached to a window by a screw mounted securing plate, providing optical access to the measuring system from inside a watertight housing.

The foil is excited by modulated blue light, and the phase of a returned red light is measured, ref Appendix 4. By linearizing and temperature compensating, with an incorporated temperature sensor, the absolute O_2- concentration can be determined.

The lifetime-based luminescence quenching principle, as used in AADI Oxygen Sensors, offers the following advantages over electrochemical sensors:

- Not stirring sensitive (it consumes no oxygen).
- Measures absolute oxygen concentrations without repeated calibrations.
- Better long-term stability
- Not affected by pressure.
- Less affected by fouling
- Faster response time.

The sensor can be logged directly by a PC (via the RS232 interface) and by most custom made dataloggers and systems.

Oxygen Sensor 4500 output data as either RS232, 0 - 5V, 4 - 20mA, or 0 - 10V signals. The sensor outputs both oxygen and temperature data. The analog output can be configured to output oxygen data as either % air saturation (default) or oxygen concentration in µM or mg/l. The measured temperature is available at an additional analog output. At the RS232, both the air saturation and oxygen concentration (µM) as well as raw data readings are presented.

The current drain is independent of the battery voltage (due to use of a linear regulator).

Aanderaa Data Instruments have proven reliability. With over 30 years of producing instruments for the scientific community around the world, you can count on our reputation for designing some of the most reliable products available.

We are guided by three underlying principles: quality, service, and commitment. We take these principles seriously, for they form the foundation upon which we provide lasting value to our customers.

Our quality is based on a relentless program of continuous monitoring to maintain the highest standards of reliability.

1.1 Illustration of sensor

Figure 1-1 Illustration of the Oxygen Sensor 4500 using the Amphenol plug.

CHAPTER 2 Sensor output specifications

Table 2-1 gives the calibrated range, the accuracy and resolution of the Oxygen Sensor 4500:

Table 2-1 Output specifications.

Parameter	Output	Operating Range	Calibrated Range	Accuracy	Resolution
Oxygen Concentration	0 - 5V	0 to 800µM	0 to 500µM	<8µM or 5% whichever is greater	< 1µM
	4 - 20mA	0 to 800µM	0 to 500µM	<9µM or 5.2% whichever is greater	< 1µM
	0 – 10V	0 to 800µM	0 to 500µM	<8µM or 5% whichever is greater	< 1µM
Oxygen Saturation	0 - 5V	0 – 200%	0 - 120% [1)]	<5 %	<0.4%
	4 - 20mA	0 – 200%	0 - 120% [1)]	<5.2 %	<0.4%
	0 – 10V	0 – 200%	0 - 120% [1)]	<5 %	<0.4%
Temperature	0 - 5V	-5 to + 35°C	0 - 36°C [2)]	±0.1°C	±0.01°C
	4 - 20mA	-5 to + 35°C	0 - 36°C [2)]	±0.15°C	±0.02°C
	0 – 10V	-5 to + 35°C	0 - 36°C [2)]	±0.1°C	±0.01°C

[1)] The full saturation range of the analog output is 0 to 200%; however the accuracy above 120% may be reduced compared to the specified accuracy.

[2)] The full temperature range of the analog output is -5 to 35°C; however the accuracy outside the 0 to 36°C range may be reduced compared to the specified accuracy.

2.1 Calculating engineering data from analog signals

When converting raw data sensor readings to engineering units, remember to use the full operating range of the sensor, not the calibrated range, refer Table 2-1.

Equations for calculating the engineering values from the raw data readings are given below, together with a few examples.

From voltage (V_{out}) to temperature (°C): .... $$T = \frac{V_{out} \cdot 40}{V_{max}} - 5$$

From voltage (V_{out}) to Air Saturation (%): .... $$AirSat = \frac{V_{out}}{V_{max}} \cdot 200$$

From voltage (V_{out}) to Oxygen Concentration (µM): .... $$Cons = \frac{V_{out}}{V_{max}} \cdot 800$$

From current (I_{out}) to temperature (°C): .... $T = \frac{(I_{out} - 4)\cdot 40^*}{16} - 5$

From current (I_{out}) to Air Saturation (%): .... $AirSat = \frac{I_{out} - 4}{16}\cdot 200$

From current (I_{out}) to Oxygen Concentration (μM): .... $Cons = \frac{I_{out} - 4}{16}\cdot 800$

Examples for 0 – 5V sensor, refer equations above using V_{max} = 5:

Raw data reading, **Vout**	Temperature, **T**	Oxygen Air saturation, **AirSat**	Oxygen concentration, **Cons**
0V	-5°C	0%	0μM
2V	$\frac{2\cdot 40}{5} - 5 = 11\,°C$	$\frac{2}{5}\cdot 200 = 80\,\%$	$\frac{2}{5}\cdot 800 = 320\,\mu M$
5V	35°C	200%	800μM

Examples for 4 – 20mA sensor, refer equations above:

Raw data reading, **Vout**	Temperature, **T**	Oxygen Air saturation, **AirSat**	Oxygen concentration, **Cons**
4mA	-5°C	0%	0μM
15mA	$\frac{(15-4)\cdot 40^*}{16} - 5 = 22.5\,°C$	$\frac{15-4}{16}\cdot 200 = 137.5\,\%$	$\frac{15-4}{16}\cdot 800 = 550\ \mu M$
20mA	35°C	200%	800μM

Examples for 0 – 10V sensor, refer equations above using V_{max} = 10:

Raw data reading, **Vout**	Temperature, **T**	Oxygen Air saturation, **AirSat**	Oxygen concentration, **Cons**
0V	-5°C	0%	0μM
5V	$\frac{5\cdot 40}{10} - 5 = 15\,°C$	$\frac{5}{10}\cdot 200 = 100\,\%$	$\frac{5}{10}\cdot 800 = 400\,\mu M$
10V	35°C	200%	800μM

2.2 Default sensor settings

The default sensor setting is O_2 air saturation in %, refer Table 3-3.

The default salinity value is 0. The setting can be changed according to the salinity conditions on site.

Refer Appendix 1 for user accessible sensor properties.

2.3 Oxygen concentration

The O_2 concentration is presented in µM = µmol/l. To obtain the concentration in mg/l, divide by 31.25.

CHAPTER 3 Communication with the sensor

For communication with the sensor we recommend you to use OxyView software, which is available for a nominal license fee. The software is user friendly and provides graphic and tabular display for set-up, calibration, and logging. These functions are easily accessed without deeper knowledge about the sensor. Read more about OxyView on page 17.

As an alternative you can also communicate with the sensor using any standard Terminal communication program (such as HyperTerminal included in Windows or Tera Terminal). Read the guidelines carefully and type in every command separately. Refer chapter 3.2 for guidelines.

Note! We recommend that you write standard lines in a text document and copy the text lines into the terminal program, refer page 27. You can also copy lines from a text editor and paste into the terminal program.

3.1 Sensor integrated software

The sensor integrated software's main tasks are to control the transmitter, sample the returned signal, extract the phase of this signal, and convert it into oxygen concentration and/or Air Saturation.

All properties that can be changed for each individual sensor, i.e. calibration coefficients, are called sensor properties.

The Oxygen Sensor 4500 will perform an oxygen sample and present the result within the first 1.5 seconds after the sensor has been powered up.

The input buffer is checked for 100 milliseconds after each sample (including the first sample).

If the buffer contains any characters the timeout is increased to 1 second and the software starts interpreting the input.

If the input buffer is empty the sensor will continue to sample and present data according to the setting of the *Interval* property.

If the *Interval* is set to zero the user can initiate a new sample by use of a *Do Sample* command. Table 3-1 illustrates the operation sequence.

After approximately 20 seconds without valid command inputs the sensor enters sleep mode until the next interval starts.

In sleep mode the sensor will not respond to input commands. If the time interval is long, the best way to start communication with the sensor is to first disconnect and then reconnect the power to the sensor.

However, before entering sleep mode the sensor stops the host's transmission by sending out a *XOFF* handshake-control character.

After waking up and finishing the next sample, the host transmission is switched back on.

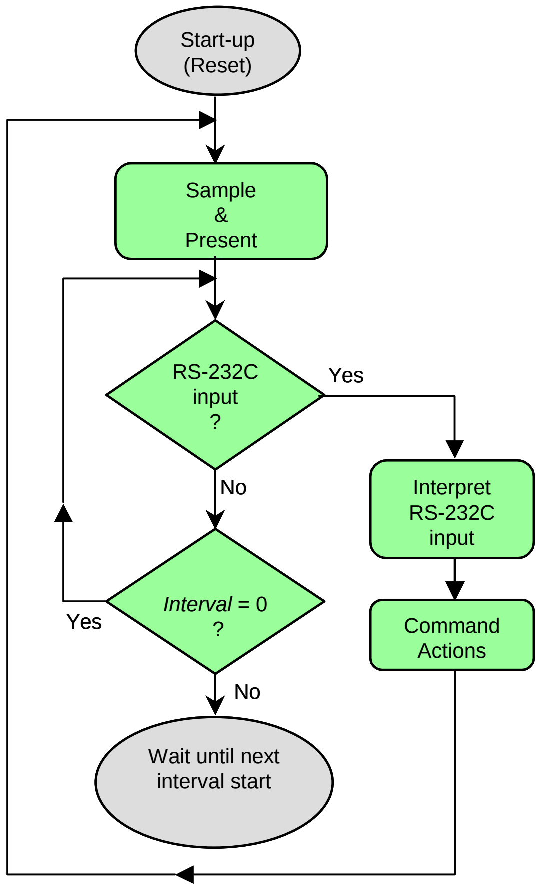


Figure 3-1Operational Sequence of the internal Software

When the handshake method is used the host's output will be buffered until the sensor is ready to receive.

This relieves the host from the need to synchronize the communication with the sensors sampling interval.

3.2 Communication setup

The RS232 protocol describes how to communicate with the sensor. All inputs to the sensor are given as commands; a list of main commands is given in Table 3-1 (next page).

All commands described in this chapter are available by single mouse clicks in OxyView Software. Communication setup:

9600 Baud

8 Data bits

1 Stop bit

No parity

Xon/Xoff Handshake

Note! Select the options 'Sent line ends with line feeds' and 'Echo line ends with line feeds' in the Hyper Terminal.

After approximately 1 minute without any RS232 input the sensor will enter sleep mode in-between samples. This is indicated by a % character at the output. In order exit sleep mode any character can be used (provided that XON/XOFF handshake is used), however the sensor will not respond until the next sampling is executed. If the *Interval* property is set to 0 the sensor will not enter the sleep mode (polled mode).

3.3 Available commands

Available commands and properties for the sensors are given in Table 3-1 and Table A 1 respectively. Available subcommands for the Oxygen Sensor 4500 are given in Table 3-2.

Table 3-1 Main RS232 commands available for the Oxygen Sensor 4500.

Command	Description
Do *Subcmd*	Execute Subcmd (refer Table 3-2)
Get *Property*	Output Property value (refer Table A 1)
Get All	Output all property values
Set *Property(Value,… Value)*	Set Property to Value,… Value
Save	Store current settings
Load	Load stored settings
Help	Print help information

Table 3-2 Available Subcommands for the Oxygen Sensor 4500

Subcommand	Description	Write Protection
Sample	Execute an oxygen measurement and presents the result	No
Calibrate	Execute calibration function	Yes
CalAir	Collect calibration data in air	Yes
CalZero	Collect calibration data in zero solution	Yes
Test	Execute a test function and present the result	No

A property may contain one or more equal elements of the type Character, Integer or Float. The Character type is stored as an 8-bit bit word and may be signed (value –128 to 127) or unsigned (0-256).

The Integer type is stored as a 16-bit word and may be signed (value –32768 to 32767) and unsigned (0 to 65535).

The Float consists of 32-bit and has a range from 1.19209290e–38 to 3.4028235e+38.

3.4 Output settings –presentation of data

Table 3-3 Output settings for Oxygen Sensor 4500.

Sensor version	Default setting	Other output settings & description
0 – 5V	-102	The default output setting gives the O_2 air saturation -101 gives the O_2 concentration
4 - 20mA	-122	The default output setting gives the O_2 air saturation -121 gives the O_2 concentration
0 – 10V	-122	The default output setting gives the O_2 air saturation -121 gives the O_2 concentration

3.5 OxyView

OxyView is a Windows application designed for use with the Oxygen Sensor 4500 in real time situations. The program is intuitive, and will allow display of Oxygen Concentration, Oxygen Saturation and Temperature in table and graphical form.

Included in the software is a Calibration Wizard to help calibrate Oxygen Sensors.

3.5.1 System requirements

- 233 MHz or faster Pentium or compatible
- 1MB of free hard disk space
- Microsoft Windows 98, 2000, XP or 7
- 64MB of RAM
- SVGA (640x480) colour display
- Local CD-ROM Drive
- Internet Explorer (4.0 or later)

3.5.2 Installation of the software

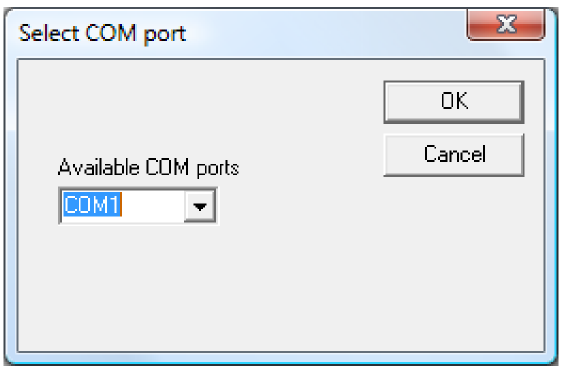
To install OxyView, run *OxyView setup.exe* found on the product CD. This will install OxyView in a program folder on your machine. In the same folder, a help file and an operating manual can be found.

To uninstall OxyView, run *unwize.exe* found in the same folder as *OxyView.exe*.

If you have an old version of OxyView uninstall this one before installing the latest version (run *unwize.exe*).

3.5.3 OxyView start-up

When you run OxyView, you must set which of the PC COM port the sensor is connected to. Select the proper COM port from the drop down list, and press OK.



OxyView will now try to establish a connection with the Oxygen Sensor by sending *Get Interval* commands, refer Figure 3-2. If the sensor is in sleep mode it will not respond to RS232 commands before the sampling interval elapses.

If the interval is greater than about 60 seconds, OxyView will not be able to get information regarding the sampling interval and will then create a graph assuming that the time between ticks is 2 seconds.

To force the sensor out of sleep mode, disconnect and reconnect the power to the sensor (normally the USB plug on your PC will supply 5V).

Note!

Losing power during the flashing process can cause corruption of vital settings, such as coefficients, serial number, model number etc. If losing power, contact Aanderaa Data Instruments for new setting file for the specific sensor with further instructions.

Flashing is carried out when running the Do CalAir, DO CalZero, Do Calibrate and Save commands.

Graph window:

The Graph Window displays plot lines for Oxygen Concentration, Oxygen Saturation and temperature with separate y-axis scales to the right of the graph.

Input pane:

Text strings (raw data) from the Oxygen Sensor are presented in this pane.

Output pane:

Text strings sent from OxyView to the Oxygen Sensor are presented in this pane. The sensors internal software calculates engineering values (calibrated oxygen concentrations) based on the sampled raw-data and a set of stored ('flashed') coefficients.

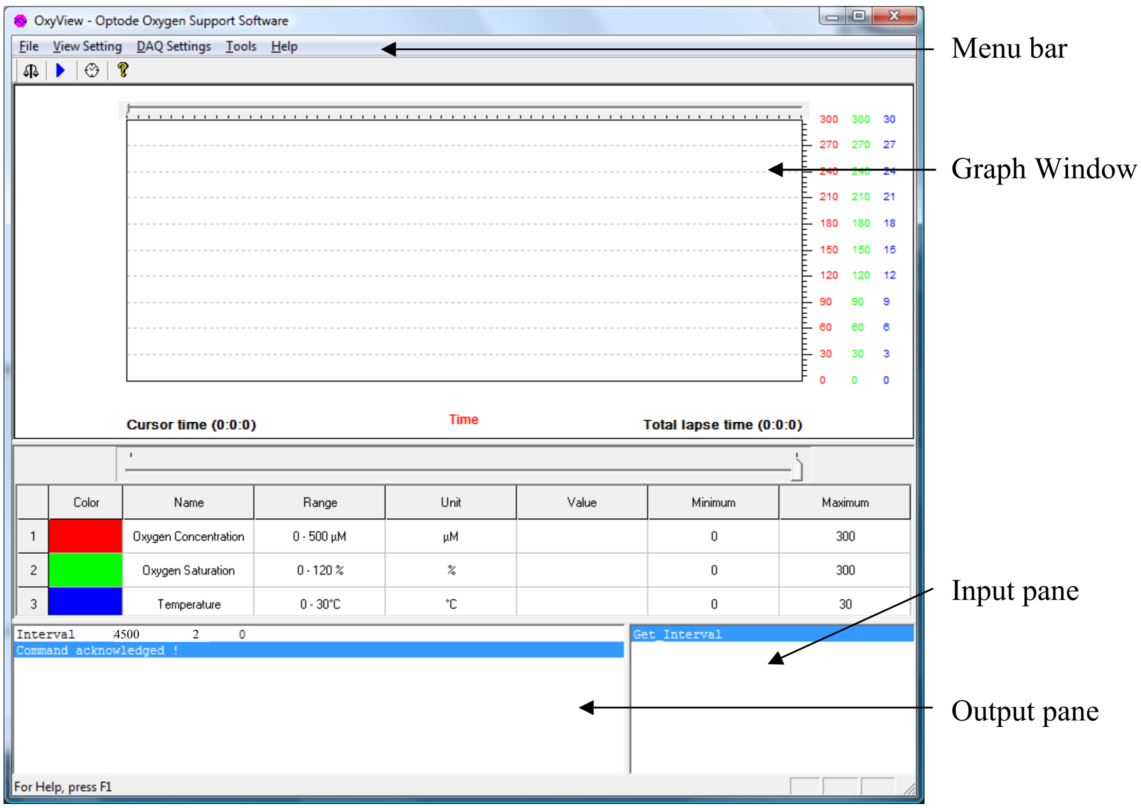
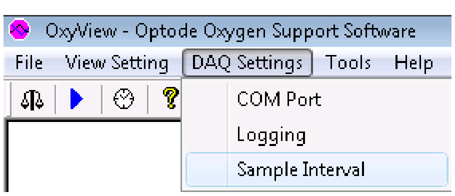


Figure 3-2 Starting OxyView.

3.5.4 Change sensor sampling interval

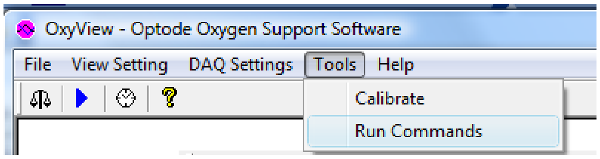


If you are to change the sensor sampling interval, you can easily do this from the DAQ Settings menu.

Select Sample Interval, and set the sampling interval in seconds, minutes and hours. Press OK to complete the settings.

3.5.5 Change sensor settings

You can communicate commands to the sensor from the Tools menu, click the Run Command option to open a Command dialog, refer Figure 3-3.



By use of the Command Dialog, the user can run all command supported by the Oxygen Sensor 4500.

- Select a command from the drop-down list; the command function is fully explained in a dialogue box in the lower part of the window.
- Select a sub command.
- Give the property element.
- Click Send to send the command to the sensor.
- Click Close Dialog when you are done changing sensor settings.

For more detailed information about the commands, refer chapter 3.3.

The input pane will show the commands that you send to the sensor, and the output pane will show that the sensor receives to the commands.

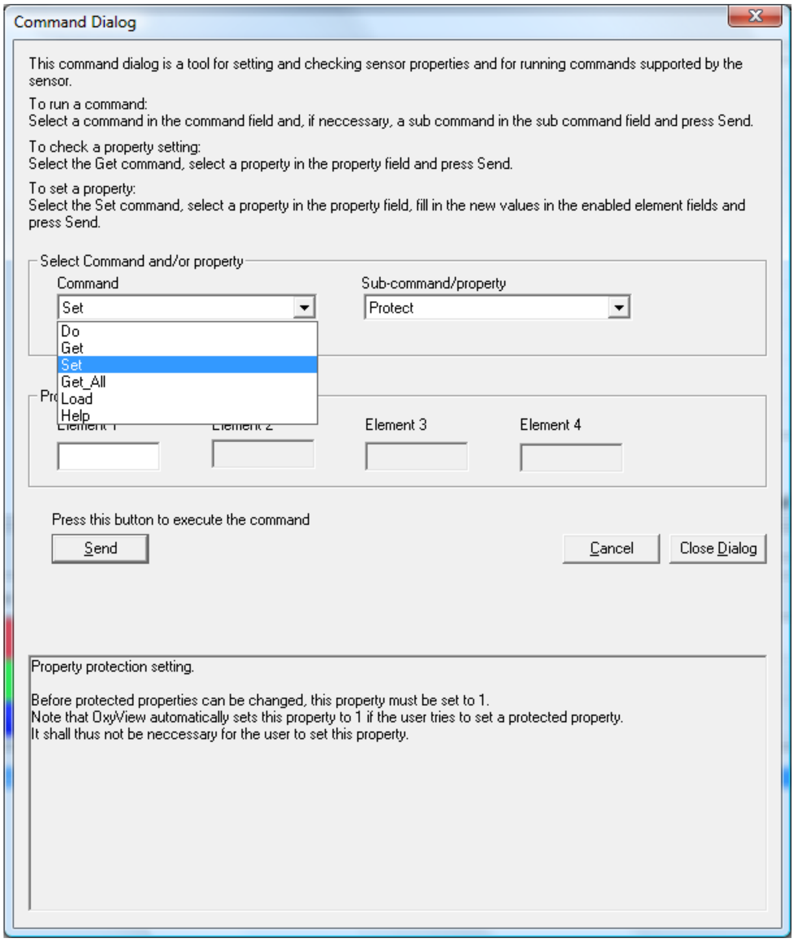
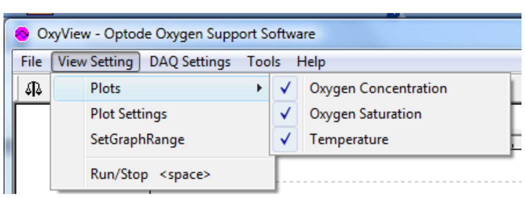


Figure 3-3 OxyView command dialog.

3.5.6 Change graph presentation

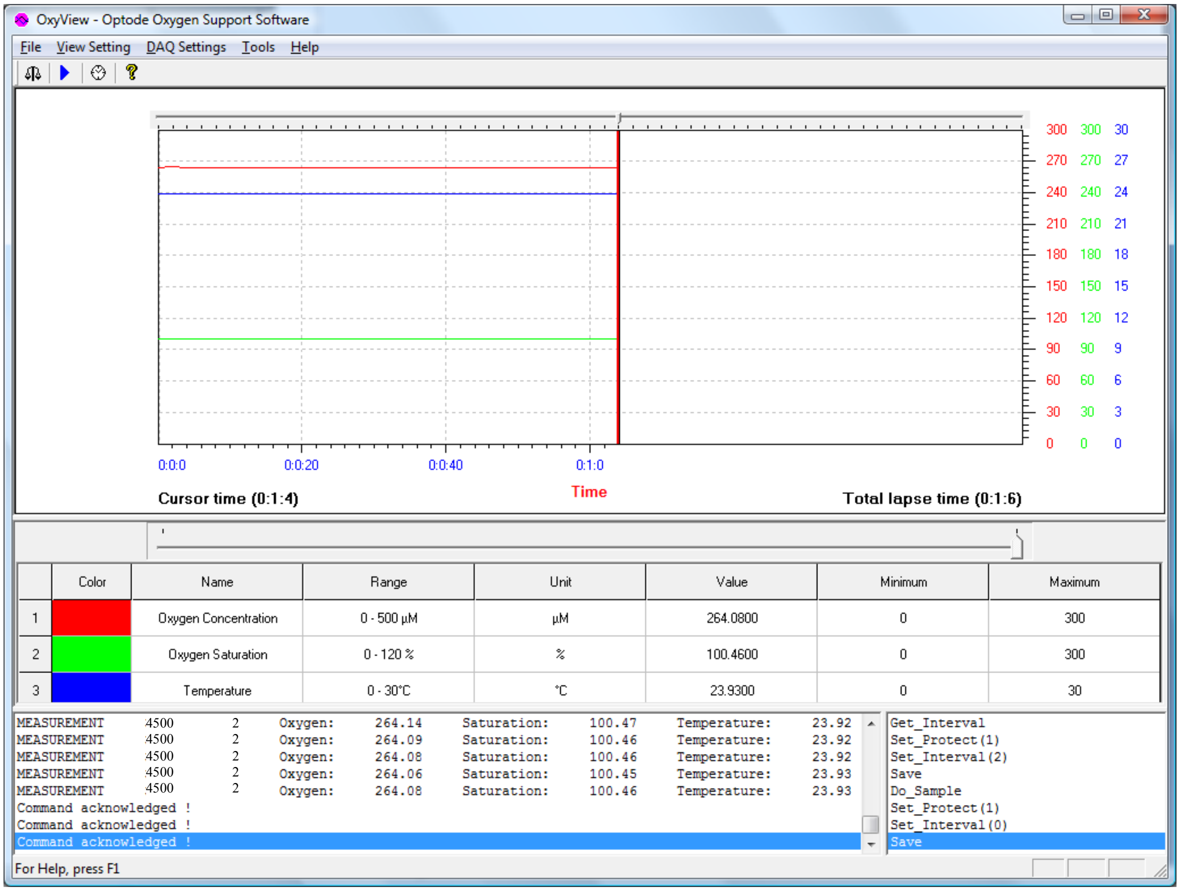


Click *View Settings* to change presentation of data according to the description given in Table 3-4.

Generally, you can change a setting from a drop-down list, by typing a value in an input-field, or click a colour-field.

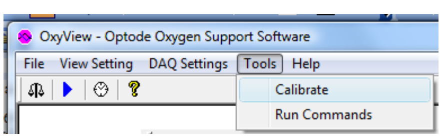
Table 3-4 Commands available in the View settings Menu.

Commands	Description
Plots	By default, OxyView display three graphs, • Oxygen Concentration • Oxygen Saturation • Temperature Use the *Plot* command to add or remove plots. A check mark to the left of a plot name indicates that the plot line is displayed. Click on the plot name to add or hide the plot line.
Plot Settings	Use the *Plot Settings* command to bring up a dialog that enables the user to modify the color, style or the y-axis scale for the individual plot lines.
SetGraphRange	Use the *SetGraphRange* command to bring up a dialog that enables the user to modify the range of the time axis.
Run/Stop	Use the *Run/Stop* command to start or stop sampling. *Shortcut key: SPACE*



3.5.7 Calibrate the Oxygen Sensor 4500

You can calibrate the Oxygen Sensor 4500 from the Calibration Wizard in the Tools menu.



Follow the instructions on the screen to perform a one or two point calibration of the sensor.

Shortcut: Press the weight symbol on the short cut toolbar.

You can also activate the calibration wizard from the command dialog, setting Do Calibrate.

3.5.8 DAQ settings

The *DAQ settings* menu enables users to set sample interval, to start logging of data to file and to change COM port, refer Table 3-5.

Table 3-5 Commands available in the DAQ settings menu.

Commands	Description
COM port	Use the *COM port* command to select another serial port.
Logging	Use the *Logging* command to enable logging of data and to specify the path to and the name of the data file (text file with tab delimiter).
Sample Interval	Use the *Sample Interval* command to bring up a Set Sampling Interval dialog. Note that clicking on the watch symbol at the short cut toolbar brings up the same dialog.

3.6 RS232 protocol

All communication is ASCII coded with the following rules:

All inputs to the sensor are given as commands with the following format:

- *MainCmd_SubCmd* or *MainCmd_Property(Value.., Value)*
- The main command, *MainCmd_SubCmd* is followed by an optional subcommand (*SubCmd*) or sensor property (*Property*).
- The *MainCmd* and the *SubCmd*/*Property* must be separated with the underscore character '_' or a space ' ' character.
- When entering new settings the *Property* is followed by a parentheses containing comma-separated values.
- The command string must be terminated by a Line Feed character (ASCII code 10). Termination with Carriage Return followed by Line Feed is also allowed.
- The command string is not case sensitive (UPPER/lower-case).
- A valid command string is acknowledged with the character '#' while character '*' indicates an error. Both are followed by Carriage Return/ Line Feed (CRLF).

For most errors a short error message is also given subsequent to the error indicator.

Note!

Losing power during the flashing process can cause corruption of vital settings, such as coefficients, serial number, model number etc. If losing power, contact AADI for new setting file for the specific sensor with further instructions.

Flashing is carried out when running the Do CalAir, Do CalZero, Do Calibrate and Save commands.

3.6.1 Terminal communication program

The sensor will send a start-up string when connected to the terminal communication program. This string presents the analog output and scaling coefficients.

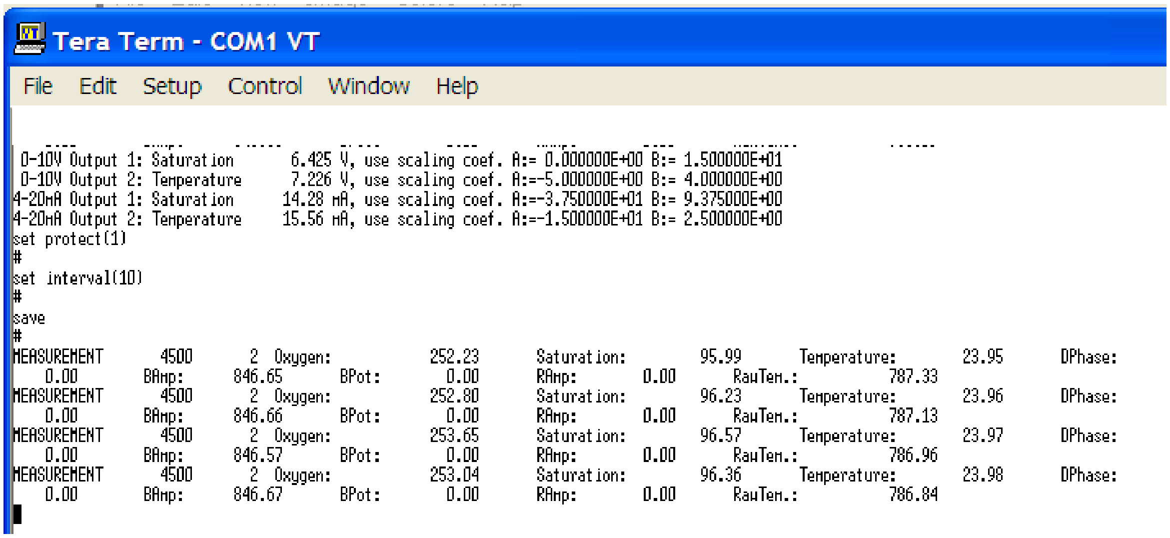


Figure 3-4 Sensor start up. Note! The view has been cropped. Some data are missing from the true display.

Note! All measurements are presented at the RS232 port.

3.6.2 The Get command

The *Get* command is used for reading the value/values of a property.

The command name Get, is followed by *Property* and returns a string on following format:

Property ProductNo SerialNo Value, ..Value

The string starts with the name of the property (*Property*), continues with the product number and serial number of the sensor, and finally the value or values of the property.

All names and numbers are separated by tabulator spacing (ASCII code 9).

The string is terminated by Carriage Return and Line Feed (ASCII code 13 & 10). This is indicated by the ↵ symbol in this manual.

Example:

//read the salinity setting (fixed)

Get Salinity ↵ //wait for ack #

#

Salinity 4500 2 0

#

A special version, Get All, reads out all available properties in the sensor.

3.6.3 The Set command

The Set command is used for changing a property. The corresponding *Get* command can be used to verify the new setting. Use the *Save* command to permanently store the new property value.

Example 1:

//set new fixed value, 35, for the salinity

Set Salinity(35) ↵

#

Example 2:

//set new values for TempCoeff

Set TempCoef(-124,1.6644E-4, 3.3456E-12,0) ↵

#

Float values may be entered on normal decimal form or exponential form, either with ‘e’ or ‘E’ leading the exponent. Extra ‘Space’ characters in front or after a value are allowed.

When one or more properties are changed, the sensor will start using the new properties.

When using the *Load* command, the previous stored setting will be reloaded.

3.6.4 Output control

The *Do Sample* command or an interval initiated measurement result in one output string containing the obtained data.

A property called *Output* controls the presentation of the measured data. When the *Output* value is set to the default value for your sensor, refer Table 3-3, the comprehensive RS-232 string is presented:

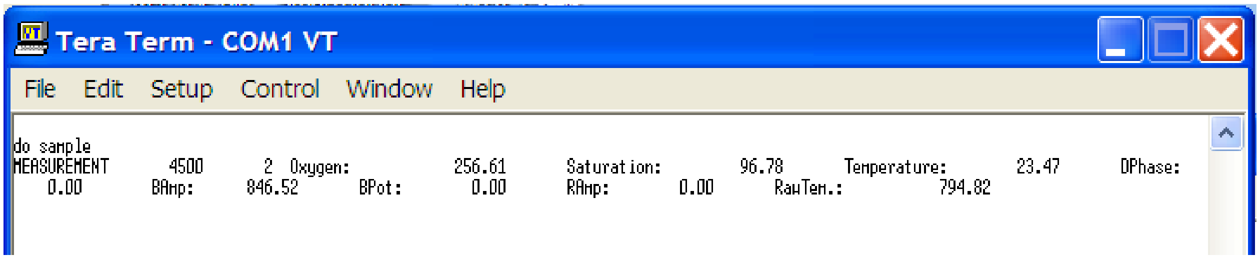


Figure 3-5 Presentation of data.

3.6.5 Passkey for write protection

To avoid accidental change, most properties are write-protected, refer Table A 1. The property called *Protect* must be set to 1 before changing the value of these properties.

Note! the passkey is 1 for changing a write-protected property.

Example:

// changing the sensor output

// Set Output to -101. Valid for a 0 – 5V and 4 – 20mA sensor

Set Interval(0) ↵ // Stop current measurement. Wait for ack #. Repeat if necessary.
Set Protect(1) ↵ //wait for ack #
Set Output(-101) ↵ //wait for ack #
Save ↵ //wait for ack #

The *Protect* property always returns to zero after power up or execution of the *Load* or *Save* command.

3.6.6 Save

When the required properties are set, you should send a *Save* command to make sure that the new configuration is saved internally in the flash memory. The sensor always reads the configuration from the internal flash memory after reset and power up. The *Save* command takes about 20 seconds to complete (indicated with the character '#').

If the *Save* command is executed the new setting will be stored in the internal Flash memory. Property changes will be lost when the sensor is reset or looses power unless you type the *Save* command.

3.6.7 Scripting -sending a string of commands

Often it may be usefully to collect more than one command in a text file. For example the instructions below can be written in an ordinary text editor and saved as a text file, which can be sent to the sensor. In the HyperTerminal click *send text file* in the *Transfer* menu, and select the correct file.

Example of text file:

```
// Set sampling interval to 30 seconds
Set Protect(1) ↵
Set Interval(30) ↵
Save ↵
Get All ↵
```

Note! The last line, Get All, reads out available properties for the sensor.

The first line is a comment line that is disregarded by the sensor. Strings starting with either '//' or ';' are ignored by the software, and do not produce errors or acknowledgements.

CHAPTER 4 Maintenance

The Oxygen Sensor 4500 requires very little maintenance. When the membranes on traditional oxygen consuming sensors (based on electrochemical principles), often called Clark sensors, are fouled the water mixing in front of the sensor membrane becomes poorer, which influences the measurement directly.

Since the sensor consumes no oxygen, the ability to diffuse gas has no influence on the measurement accuracy.

However, if the fouling is in the form of algae that produce or consume oxygen, the measurement might not reflect the oxygen concentration in the surrounding water correctly. Also the response time of the measurements might increase if the sensing foil is heavily fouled.

Therefore, the sensor should be cleaned at regular intervals from 1 month to a year depending on the required accuracy and the fouling condition at the site.

The sensor housing can be cleaned using a brush and clean water. Carefully, use a wet cloth to clean the sensing foil.

Note! Never use sharp object when cleaning the sensor as this may harm the sensor.

Fouling consisting of calcareous organisms (e.g. barnacles), can be dissolved by dipping the sensor/instrument in a weak acid solution (e.g. 7% Vinegar).

If the sensing foil is scratched or if the protective black layer on the foil is removed the sensor will still work as long as there is enough Fluorophore on the foil.

If severely damaged (so that the sensor gives unrealistic readings) the sensing foil should be replaced (Sensing Foil Kit 3853) and the sensor recalibrated.

Note! Enter new calibration coefficients when changing the sensor foil.

Due to the measurement technology, the sensor do not drift over time (within the given specifications).

It is recommended that the sensor is recalibrated annually (refer next section), although feedback tells us that the sensors are stable over a longer time period.

4.1 Sensing foil kit

If the sensing foil gets damaged and has to be changed you need the Sensor foil Kit 3853. The content of Kit 3853 is given in Table 4-1, and a procedure for changing the foil is given below the table.

Note! If you use a foil from a different batch, new calibration coefficients must be entered. If not, the sensor will be inaccurate and there is no way of post compensating your data.

Table 4-1 Contents of sensor foil kit 3853.

Part no.	Pieces	Description
962203	2	Sensing Foil packed in aluminium foil
1642222	2	M2, 5x6mm screw TorxA4 DIN 965A
1913032	1	Torx-Key No. 8
Form No. 621	Calibration Sheet for Sensing Foil (each batch of foils is calibrated)	

Procedure for changing the sensor foil:

- The Sensor Foil is changed by unscrewing the 2 Torx screws in the securing plate, refer Figure A 1. Remove the securing plate and the old foil.
- Clean the window and place the new foil with the black side outwards.
- Square the foil in the window and remount the securing plate.
- Control and if necessary update the sensing foil coefficients according to the foil certificate, refer next chapter or Technical Note TN 275.
- Recalibrate the sensor.

4.2 Calibration

If the sensor foil has not been removed or changed recalibration is normally not necessary. Feedback from our users shows that the sensors (and foils) are stable for one to several years.

The easiest and fastest way for a user to calibrate the Oxygen Sensor is to use OxyView Software, refer page 17. OxyView is a Windows based software containing a wizard, which guides the user step by step trough the calibration procedure.

The present chapter describes how to perform the calibration procedure without using OxyView.

Note!

Please contact factory before you calibrate the sensor.

Losing power during the flashing process can cause corruption of vital settings, such as coefficients, serial number, model number etc. If losing power, contact Aanderaa Data Instruments for new setting file for the specific sensor with further instructions.

Flashing is carried out when running the Do_CalAir, Do_CalZero, Do_Calibrate and Save commands.

4.2.1 Calibration procedure using a terminal program

1. Prepare a suitable container with fresh water. Aerate (apply bubbling) the water using an ordinary aquarium pump together with an airstone, and let the temperature stabilize (might take hours).

2. Prepare a zero oxygen solution by dissolving 5 grams of sodium sulfite (Na2SO3) in 500 ml of water. Other substances that removes oxygen can also be used.

   Note! Stripping of the oxygen with e.g. N2 gas is also possible, but not recommended, since it is uncertain when an absolute zero Oxygen level is reached using this method.

3. Connect the sensor to a PC. Start a terminal program, i.e. the HyperTerminal by Hilgraeve Inc (included in Microsoft operating systems), refer chapter 3.2 for communication set-up.

   Note! Select one of the options 'Sent line ends with line feeds' or 'Echo line ends with line feeds' in the Hyper Terminal.

   Control, and if necessary update, the C_0Coef, C_1Coef, C_2Coef, C_3Coef and C_4Coef properties accordingly to the Calibration Certificate for the sensing foil in use (refer chapter 3.2 for communication with the sensor).

   Example of changing foil coefficients:

   Set Protect(1) ↵

   Set FoilNo(1403) ↵

   Set C0Coef(3.95439E+03,-1.38606E+02,2.98835E+00,-2.73775E-02) ↵

   Set C1Coef(-2.46937E+02,7.58489E+00,-1.62433E-01,1.50790E-03) ↵

   Set C2Coef(6.32108E+00,-1.67391E-01,3.64539E-03,-3.50274E-05) ↵

   Set C3Coef(-7.61504E-02,1.72586E-03,-3.95623E-05,4.02602E-07) ↵

   Set C4Coef(3.52769E-04,-6.78062E-06,1.70524E-07,-1.86920E-09) ↵

   Save ↵

   Type *Get All* ↵ to verify the new coefficients.

4. Submerge the sensor into the aerated water. Set the *Interval* property to e.g. 30 seconds. Enter the *Save* command and wait until both the temperature and the phase measurements have stabilized:

   Set Protect(1) ↵

   Set Interval(30) ↵

   Save ↵

5. Store calibration values by typing:

   Set Protect(1) ↵

   Do CalAir ↵

   The *save* command is automatically performed when you type *Do CalAir*.

6. Set the *CalAirPressure* property to the actual air pressure in hPa at the site.

   Set Protect(1) ↵

   Set CalAirPressure(..)↵

   Save ↵

   Note! For maximum accuracy do not compensate the air pressure for height above sea level.

7. Submerge the sensor in the zero solution. Make sure that the sensing foil is free from air bubbles. Wait until both the temperature and the phase measurements have stabilized.

8. Enter the *Do CalZero* command to store calibration values. The *save* command is automatically performed.

   Set Protect(1) ↵

   Do CalZero ↵

9. Enter the *Do Calibrate* command to effectuate the new calibration. The *save* command is automatically performed.

   Set Protect(1) ↵

   Do Calibrate ↵

10. Check that the sensor is working properly by taking it up into the air and rinse off. In dry air, the sensor should show close to 100% oxygen saturation at sea level. Put the sensor back into the anoxic water; the reading should drop to zero.

Appendix 1 User accessible sensor properties

All settings and configurations that determine the behaviour of the sensor are called properties and are stored in a persistent memory block (flash). One property can contain several data elements of equal type (Boolean, character, integer etc.). The different properties also have different access levels.

Table A 1 lists all user accessible properties for the Oxygen Sensor 4500.

Table A 1 Available Properties for the Oxygen Optode; NA = Not Applicable

Properties	Type	No. of elements	Use	Write protection	Default setting
Protect	Int	1	Protection of property read and write access	No	0
PhaseCoef	Float	4	Curve fitting coefficients for phase measurements	Yes	NA
TempCoef	Float	4	Curve fitting coefficients for temperature measurement	Yes	NA
FoilNo	Int	1	Foil batch number	Yes	NA
C0Coef	Float	4	Temperature Coefficients in the [O_2] phase	Yes	NA
C1Coef	Float	4		Yes	NA
C2Coef	Float	4		Yes	NA
C3Coef	Float	4		Yes	NA
C4Coef	Float	4		Yes	NA
Salinity	Float	1	Salinity setting	No	0
CalAirPhase	Float	1	Calibration data in air, phase	Yes	NA
CalAirTemp	Float	1	Calibration data in air, temperature	Yes	NA
CalAirPressure	Float	1	Calibration data in air, pressure	Yes	NA
CalZeroPhase	Float	1	Calibration data in zero solution, phase	Yes	NA
CalZeroTemp	Float	1	Calibration data in zero solution, temperature	Yes	NA
Interval	Int	1	Sample Interval in seconds.	No	30
AnCoef	Float	2	Offset and slope correction coefficients for I2C output to Analogue Adaptor	Yes	0,1
Output	Char	1	Output setting	Yes	-102/-122

Appendix 2 Salinity compensations

The O_2-concentration sensed by the sensor is the partial pressure of the dissolved oxygen.

Since the foil is only permeable to gas and not water, the sensor can not sense the effect of salt dissolved in the water, hence the osensor always measures as if immersed in fresh water.

If the salinity variation on site is minor (less than ±1ppt), the O_2-concentration can be corrected by setting the internal property *Salinity* to the average salinity at the measuring site.

However, if the salinity varies significantly and a measured salinity is available a more accurate correction may be applied by a post compensation of the data.

The O_2-concentration, μM, should then be multiplied by the following factor:

$$O_{2C} = [O_2] \cdot e^{S\left(B_0 + B_1 T_S + B_2 T_S^2 + B_3 T_S^3\right) + C_0 S^2}$$

where:

S = salinity in ppt

T_s = scaled temperature

$$= \ln\left[\frac{298.15 - t}{273.15 + t}\right]$$

t = temperature, °C

B_0 = -6.24097e-3 C_0 = -3.11680e-7

B_1 = -6.93498e-3

B_2 = -6.90358e-3

B_3 = -4.29155e-3

If the Salinity setting in the sensor is set to other than zero (zero is the default value), the equation becomes:

$$O_{2C} = [O_2] \cdot e^{(S - S_0)\left(B_0 + B_1 T_S + B_2 T_S^2 + B_3 T_S^3\right) + C_0 (S^2 - S_0^2)}$$

Where S_0 is the internal salinity setting.

Appendix 3 Theory of operation

The Oxygen Sensor 4500 is based on a principle called dynamic luminescence quenching.

This phenomenon is the ability of certain molecules to influence the fluorescence of other molecules. Fluorescence is the ability of a molecule to absorb light of a certain energy and later emit light with lower energy (longer wave length). Such a molecule, called a luminophore, will after absorbing a photon with high enough energy, enter an exited state.

After a while the luminophore will emit a photon of lower energy and return to its initial state. Some types of luminophores might also return to the initial state when colliding with certain other molecules.

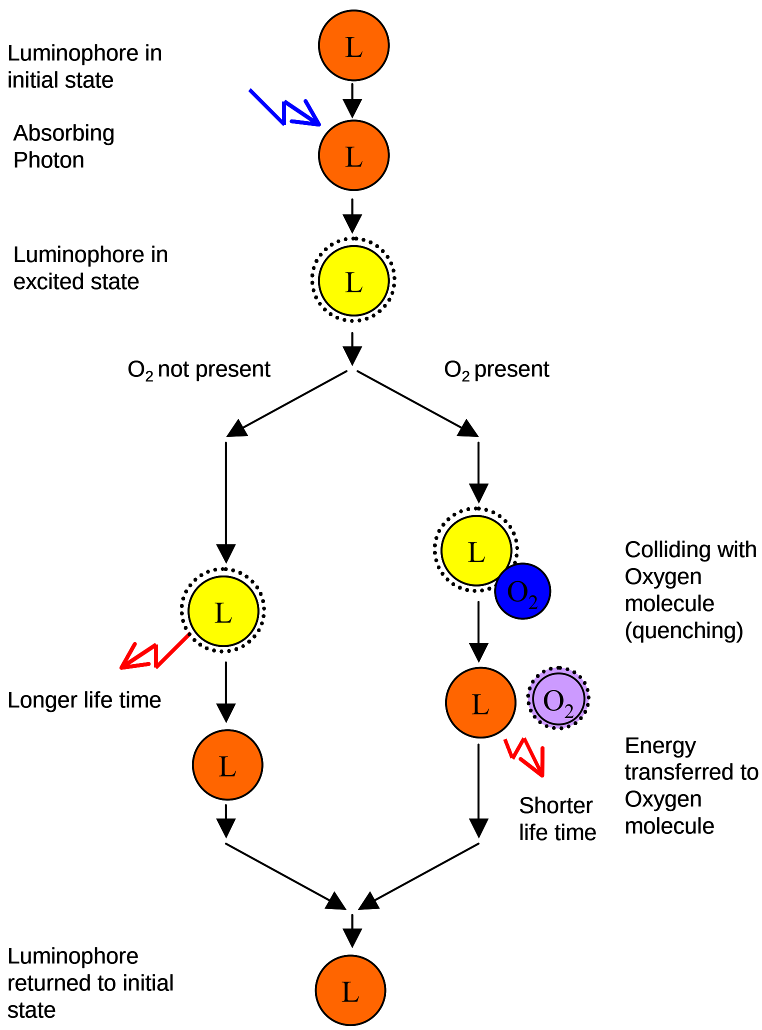


Figure A 1 Dynamic Luminescence Quenching.

The luminophore will then transfer parts of its excitation energy to the colliding molecule, with the result that less photons (giving a shorter life time) are emitted from the luminophore. This effect is called dynamic luminescence quenching, and in the Oxygen Sensor the colliding molecules are O_2.

The luminophore used in the Oxygen Sensor is a special molecule called platinum porphyrine. These luminophores are embedded in a polymer layer, called the indicator layer (coated on a thin film of polyester support).

To avoid potential influence from fluorescent material surrounding the sensor or direct incoming sunlight when measuring in the photic zone, the foil is also equipped with gas permeable coating.

The coating gives optical isolation between the indicator layer and the surroundings.

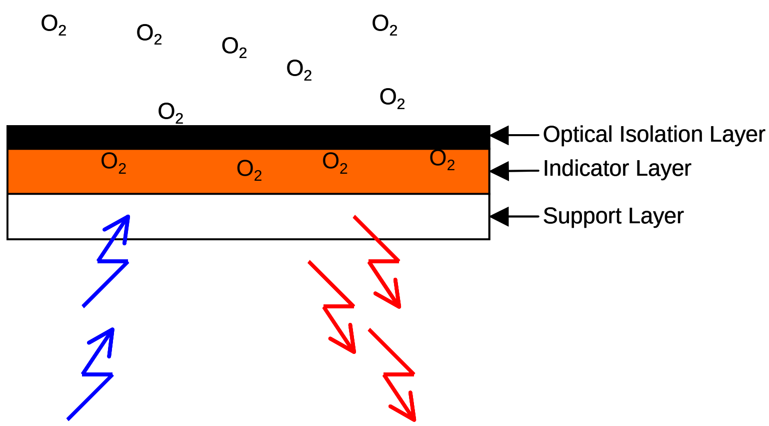


Figure A 2 Sensing Foil.

Appendix 4 The optical design

An illustration of the optical design is given in Figure A 3.

The sensing foil is mounted outside the optical window and is exposed to the surrounding water. The foil is held in place by a screw fixed PVC plate.

A light emitting diode (LEDs) and one photodiode is placed on the inside of the window. A blue-green LED is used for excitation of the foil. The photodiode is used for sensing the fluorescent light.

Even thought the sensing foil is highly fluorescent part of the light will be directly reflected.

The photo diode is equipped with a colour filter that stops light with short wavelengths to minimize the influence of the reflected light. Further, the blue-green LED is equipped with a filter that stops light with long wavelengths.

The spectral response of the LEDs and the filter are illustrated in Figure A 4.

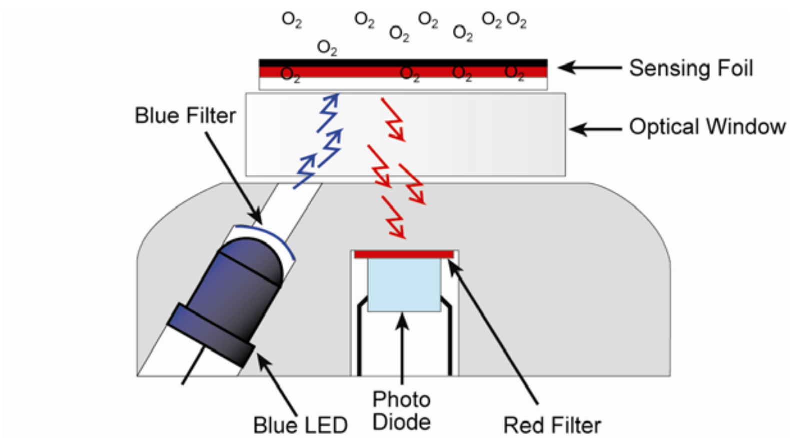


Figure A 3 The optical design.

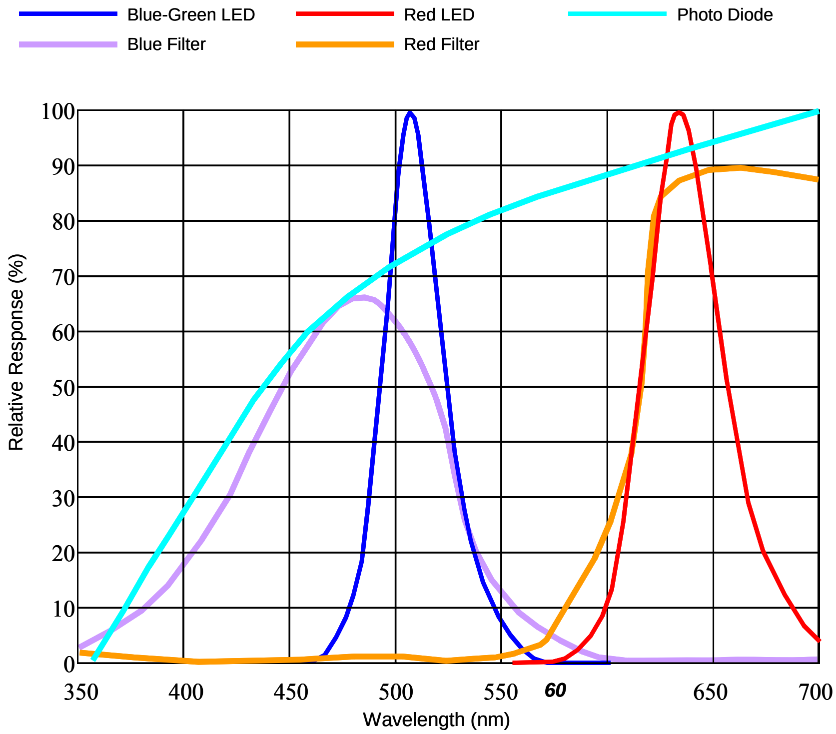


Figure A 4 An example of spectral response, Oxygen Sensor 4500 comes without the red reference LED.

Appendix 5 Electronic design

Figure A 5 illustrates the main functions of the electronics.

To obtain good oxygen measurements the electronic circuit must be able to measure the phase between the excitation signal and the received signal accurately and with good resolution.

The received signal is sampled with a frequency of four times the excitation frequency. Two signal components with a phase difference of 90 degrees are extracted from these samples and is used for calculations of the phase of the received signal. The O2-concentration is calculated after linearizing and temperature compensating the phase measurements. A thermistor thermally connected to the sensor body, provides the temperature measurement.

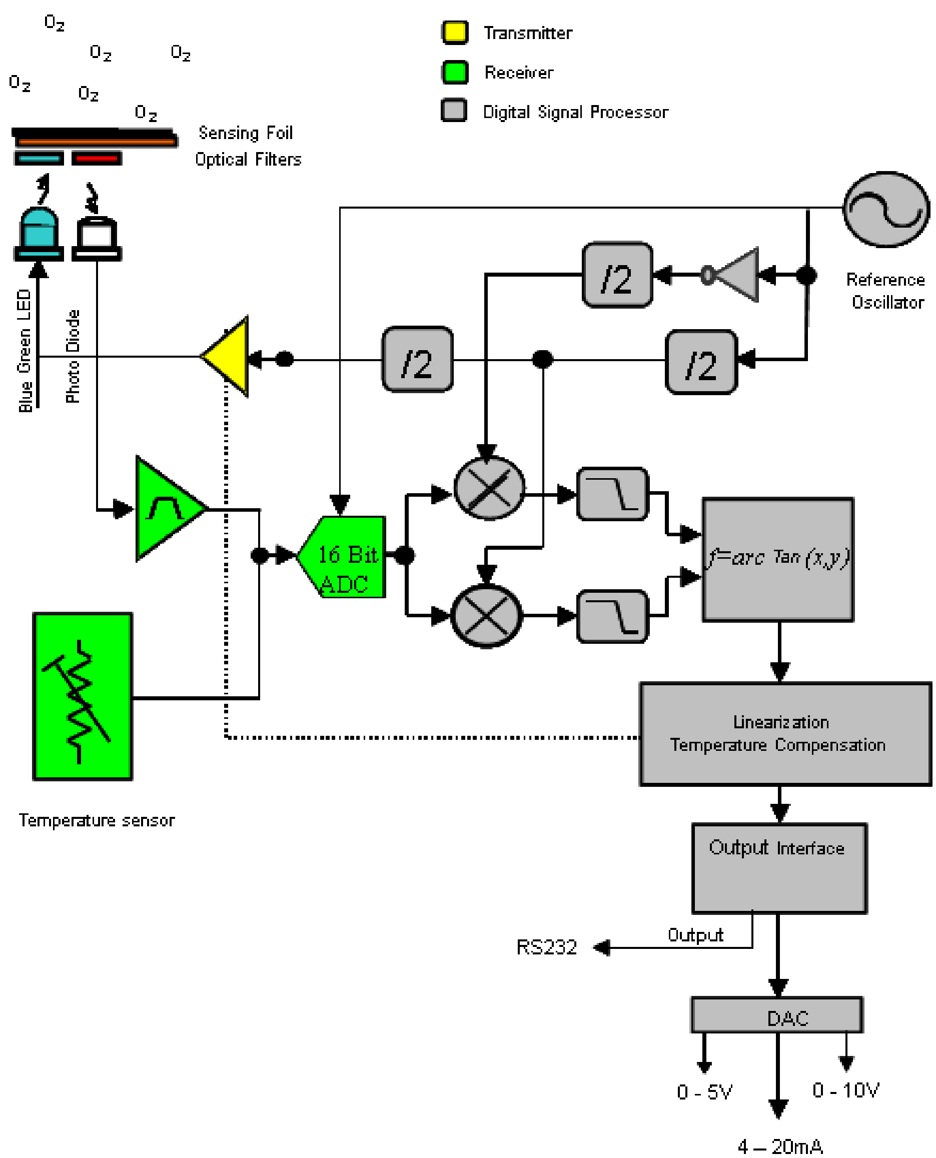


Figure A 5 Functional diagram.

Appendix 6 Wiring diagram

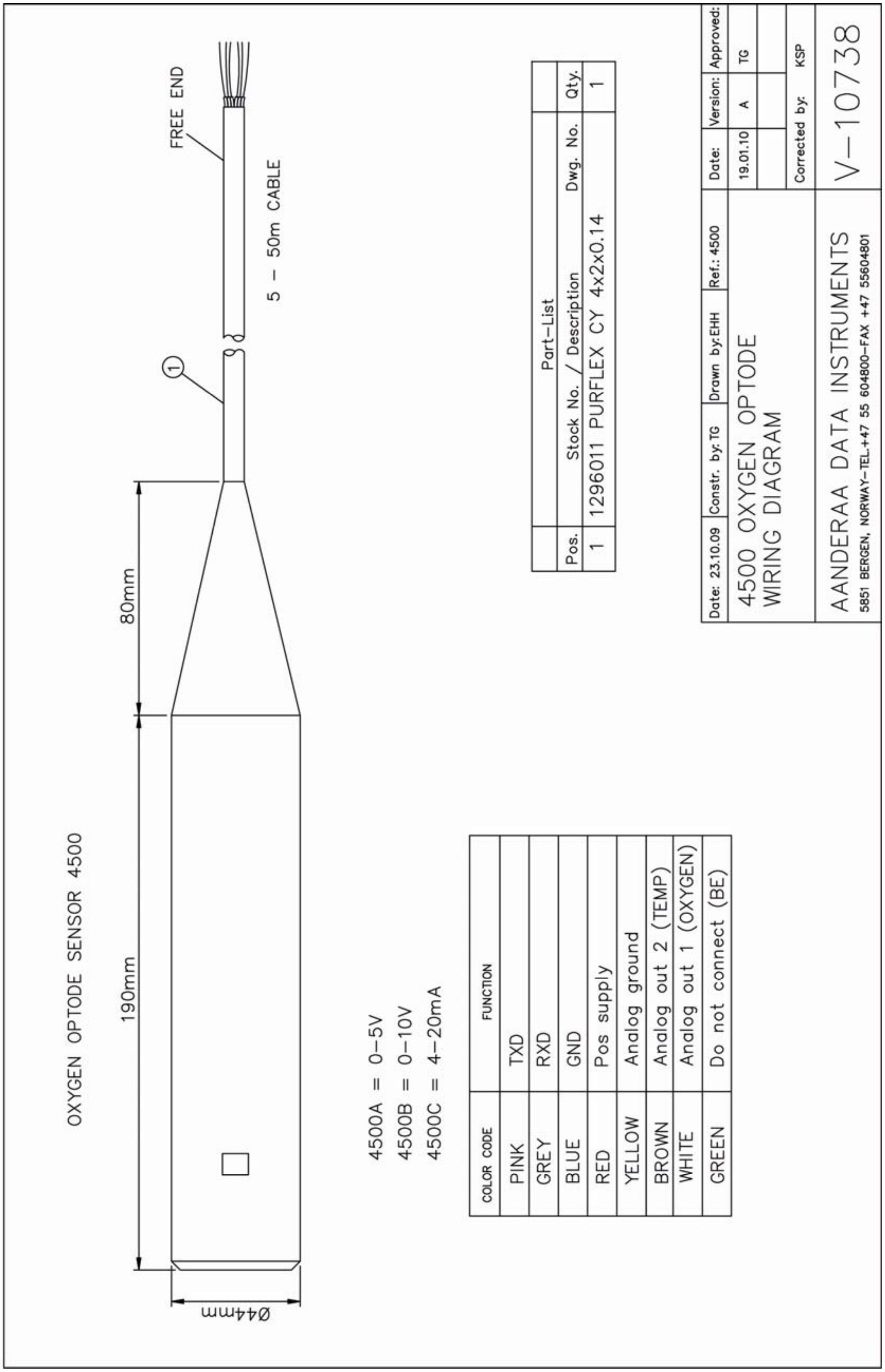
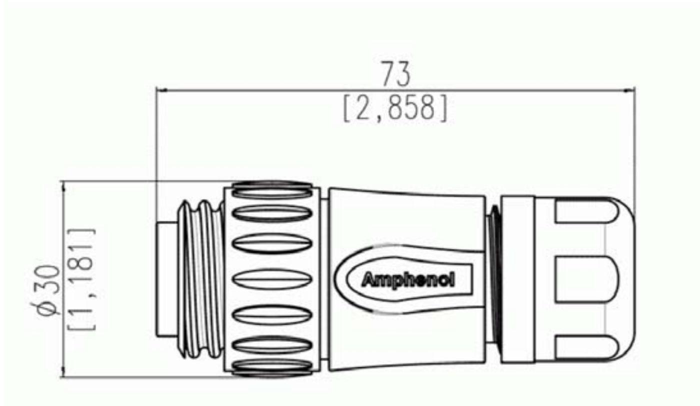


Figure A 6 Oxygen Sensor 4500 wiring diagram.



		Amphenol Plug	
Color code	**Function**	**4500A/4500C/4500D**	**4500B**
Pink	TXD	3	3
Grey	RXD	4	4
Blue	GND	GND	GND
Red	Pos supply	1	1
Yellow	Analog ground	6	GND
Brown	Analog out 2 (TEMP)	5	
White	Analog out 1 (OXYGEN)	2	2
Green	Do not connect		

Figure A 7 Oxygen Sensor 4500 wiring diagram Amphenol Plug

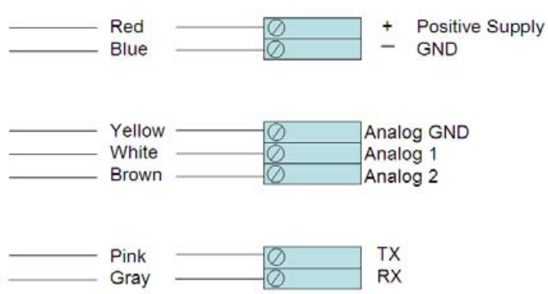


Figure A 8 Oxygen Sensor 4500 wiring diagram with free end.