



miniDOT® Clear Logger Field Calibration Adjustment

How To Guide



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Introduction

Optical sensors inherently lose their initial factory calibration and become less accurate over time. The miniDOT® Clear Logger, an optical sensor, is a long lasting and reliable sensor but as time passes it will record oxygen concentrations slightly less than the actual amount that are present because of this change in calibration. The “calibration drift” of the miniDOT® Clear is typically in the range of negative few percent per year.

An important aspect of miniDOT® Clear calibration drift is that over much of the temperature and oxygen range of measurement, the calibration drift can be approximately described by a single factor. For example, if at a certain temperature and oxygen concentration a given ratio of measured oxygen to actual oxygen is observed, then approximately this same ratio will be observed at most other temperature and oxygen concentrations. This is important because it allows an entire miniDOT® Clear calibration to be adjusted based on a single calibration measurement point. That calibration measurement is obtained by performing the bucket experiment described in the [Verifying Calibration](#) section of the miniDOT® Clear Manual.

The [miniDOTAdjustCalibration.jar](#) software implements the miniDOT® Clear field calibration adjustment. It determines the adjustment factor by dividing the observed saturation in the experiment by the actual saturation of the water. The program then reads the connected miniDOT® Clear calibration and saves it in a calibration folder. Next, it applies the adjustment factor to the calibration and returns it to the connected miniDOT® Clear. At that point, the miniDOT® Clear records adjusted oxygen values.

The software also allows restoration of calibrations by reading the saved original calibration.

The idea that miniDOT® Clear calibration drift can be described by a single factor is useful but not exact. A single factor roughly describes the calibration drift of most miniDOT® Clear Loggers. In reality, each miniDOT® Clear is on its own journey. The factor idea applies to a greater or lesser degree individually. However, since most miniDOT® Clear drift only a few percent yearly, small errors in the factor are made even smaller since the overall correction is only a few percent. This means a field calibration adjustment can improve the calibration of miniDOT® Clear Loggers that exhibit small yearly drift.

Notably, the single factor idea fails for oxygen measurements close to zero. Here, a small factor adjustment is incorrect, but the error in absolute terms is insignificant compared to miniDOT® Clear Loggers' calibration accuracy.

The net result is that for miniDOT® Clear Loggers with a negative calibration drift of 10% or less, a field calibration adjustment will bring the measurement accuracy back within the original accuracy of $\pm 5\%$ or $\pm 10 \mu\text{mol/L}$, whichever is greater. It's reasonable to expect $\pm 3\%$ for most loggers.

The following sections provide detailed information about each step in the calibration adjustment process. The field calibration adjustment is applicable to loggers purchased August 2019 and beyond.



Field Calibration Experiment

For step by step instructions [click here to jump to Appendix A](#).

The bucket calibration experiment exposes the miniDOT® Clear to a known environment of 100% DO saturated freshwater. This is accomplished by performing the experiment described in the miniDOT® Clear operator's manual, in the [Verifying Calibration](#) section.

Note: If a miniDOT® Clear has been previously adjusted, it is best practice to restore the original calibration before performing another adjustment. This needs to be done before the calibration experiment is performed. This way, the user may determine how much the miniDOT® Clear has drifted relative to the original calibration and whether the unit needs to be recalibrated at PME rather than adjusted. See section [Restoration of a miniDOT® Clear Calibration](#) for more details and instructions.

The calibration experiment must be performed well for the field calibration adjustment to be effective. Multiple miniDOT® Clear Loggers can undergo the same experiment at once. The zero oxygen baker's yeast experiment described in the manual is not necessary for the field calibration adjustment.

The barometric pressure present during the experiment must be accurately determined. There are many inexpensive barometers available that will greatly improve the accuracy of the field calibration adjustment. To determine an average pressure for the experiment period, take a pressure measurement at the start, middle and end of the experiment.

Performing the experiment outside in a shaded area is best. This will ensure the climate control of a building does not create more variance in the pressure throughout the experiment. It is also strongly recommended that a black bucket be used and covered with a black lid during the experiment to prevent light from promoting algal growth (which would consume oxygen).



Note: In the photo above, the white bucket is only used for demonstrative purposes. In practice, use a black bucket.

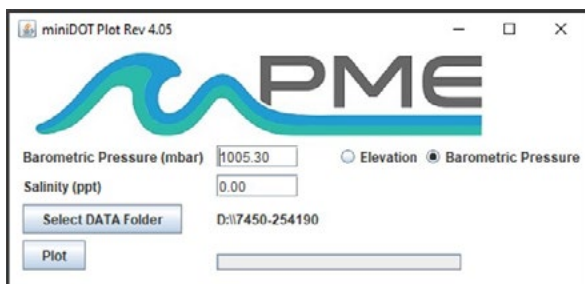
An air-stone is used in the experiment to achieve 100% saturation. The water must be continuously mixed by the air-stone or an aquarium water pump. This will ensure oxygen stratification does not occur during the experiment.

Arrange the experiment so that temperature is stable or changes only slowly (less than 0.5°C per hour). An experiment of at least 1 hour is recommended to ensure that the temperature of the miniDOT® Clear becomes equal to water temperature. Longer experiments give more opportunities to find points where temperature is stable.

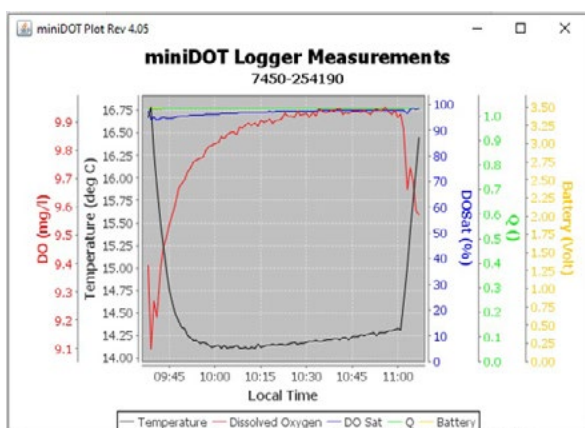
The miniDOT® Clear Loggers must be positioned with their sensing faces pointed up, as shown by the picture above. This will mitigate bubbles accumulating on the sensing spot which can compromise the accuracy of oxygen measurements. miniDOT® Clear Loggers will naturally float with their sensor faces pointed down, so they must be restrained in some way to prevent this.

Field Calibration Experiment Analysis

The goal of calibration experiment analysis is to determine the oxygen saturation percentage measured by the miniDOT® Clear at the time that the oxygen concentration of the water in the bucket was 100% saturated. This involves good judgment on the part of the experimenter. Water temperature must have stabilized (usually after an hour). Significant bubbling must have occurred continuously throughout the experiment to ensure the water was fully saturated.

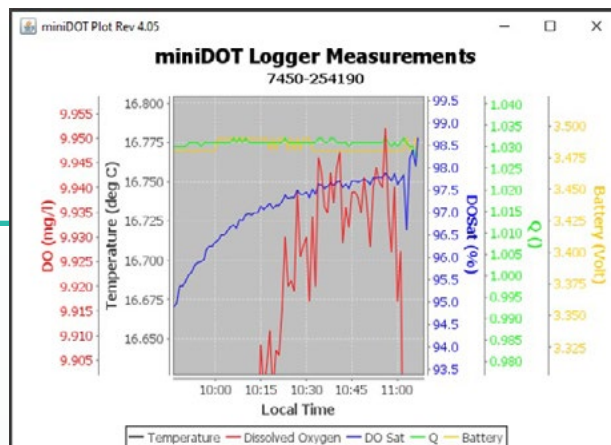
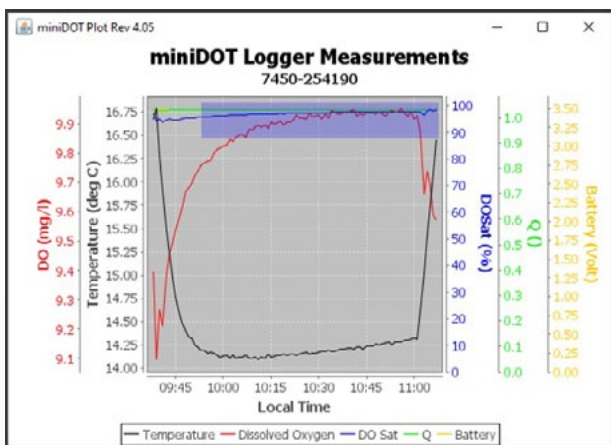


Upon completion of the experiment, plot the miniDOT® Clear measurements using **miniDOTPlot**, inputting the average measured barometric pressure during the experiment. Do not use elevation to approximate pressure.



The measured oxygen saturation should be identified in the plot over a period when the water is at 100% saturation and its temperature is changing slowly (less than 0.5°C per hour). See an example plot to the left showing the measured oxygen saturation calculated from the pressure (blue line).

A magnified view of the plotted data can be seen by clicking and dragging to the right on the plot. Reset the view by clicking and dragging to the left. See an example of this below.



In the example plot above, a reasonable estimation of the measured saturation value would be identified as 97.75% as that is the saturation value it appears to be settling at once the water reached saturation after a little over an hour. This measured saturation is the result of the calibration experiment that is used in the field calibration adjustment software.



Alternatively, the experimental data can instead be concatenated using the [miniDOTConcatenate.jar](#) program along with the pressure measurement to obtain a CAT file with calculated saturation data. This saturation data can be averaged over the selected period where the temperature is changing slowly.

MiniDOT Logger Concatenated Data File
 Sensor: 7450-001623
 Concatenation Date: 2024May16 13:50:49 PDT

DO concentration compensated for salinity: 0.0 (ppt)
 Saturation computed at pressure: 1015.24 (mbar)

Unix Timestamp, (Second),	UTC Date & Time, (none),	Pacific Standard Time, (none),	Battery, (Volt),	Temperature, (deg C),	Dissolved Oxygen, (mg/l),	Dissolved Oxygen Saturation, (%),	Q (none)
1682037480,	2023-04-21 00:38:00,	2023-04-20 17:38:00,	3.480000,	21.569000,	8.825000,	99.780551,	0.970000
1682038080,	2023-04-21 00:48:00,	2023-04-20 17:48:00,	3.480000,	21.568000,	8.806000,	99.679708,	0.970000
1682038680,	2023-04-21 00:58:00,	2023-04-20 17:58:00,	3.480000,	21.635000,	8.777000,	99.480485,	0.970000
1682039280,	2023-04-21 01:08:00,	2023-04-20 18:08:00,	3.480000,	21.718000,	8.763000,	99.481436,	0.970000
1682039880,	2023-04-21 01:18:00,	2023-04-20 18:18:00,	3.480000,	21.777000,	8.743000,	99.367669,	0.970000
1682040480,	2023-04-21 01:28:00,	2023-04-20 18:28:00,	3.480000,	21.835000,	8.735000,	99.388009,	0.970000
1682041080,	2023-04-21 01:38:00,	2023-04-20 18:38:00,	3.480000,	21.886000,	8.726000,	99.383362,	0.970000
1682041680,	2023-04-21 01:48:00,	2023-04-20 18:48:00,	3.480000,	21.953000,	8.716000,	99.397775,	0.970000
1682042280,	2023-04-21 01:58:00,	2023-04-20 18:58:00,	3.480000,	22.003000,	8.699000,	99.299493,	0.970000
1682042880,	2023-04-21 02:08:00,	2023-04-20 19:08:00,	3.480000,	22.062000,	8.690000,	99.307547,	0.970000
1682043480,	2023-04-21 02:18:00,	2023-04-20 19:18:00,	3.480000,	22.095000,	8.690000,	99.372504,	0.970000
1682044080,	2023-04-21 02:28:00,	2023-04-20 19:28:00,	3.480000,	22.145000,	8.687000,	99.433706,	0.970000
1682044680,	2023-04-21 02:38:00,	2023-04-20 19:38:00,	3.480000,	22.195000,	8.668000,	99.331545,	0.971000
1682045280,	2023-04-21 02:48:00,	2023-04-20 19:48:00,	3.480000,	22.245000,	8.662000,	99.338873,	0.972000
1682045880,	2023-04-21 02:58:00,	2023-04-20 19:58:00,	3.480000,	22.273000,	8.663000,	99.399095,	0.972000
1682046480,	2023-04-21 03:08:00,	2023-04-20 20:08:00,	3.490000,	22.304000,	8.651000,	99.324223,	0.971000
1682047080,	2023-04-21 03:18:00,	2023-04-20 20:18:00,	3.490000,	22.346000,	8.647000,	99.358220,	0.971000
1682047680,	2023-04-21 03:28:00,	2023-04-20 20:28:00,	3.490000,	22.379000,	8.637000,	99.306048,	0.971000
1682048280,	2023-04-21 03:38:00,	2023-04-20 20:38:00,	3.490000,	22.404000,	8.636000,	99.342075,	0.971000
1682048880,	2023-04-21 03:48:00,	2023-04-20 20:48:00,	3.490000,	22.429000,	8.629000,	99.309043,	0.971000

Field Calibration Adjustment

Note: If the adjustment program freezes and must be closed during an adjustment, restore the original calibration before attempting to adjust the calibration again. A successful adjustment is marked by a pop up message that states "miniDOT® calibration adjusted from (entered saturation) to 100%" along with a green check mark.

ATTENTION: When performing a field calibration adjustment using the [miniDOTAdjustCalibration.jar](#) program, a calibration file is generated with the date and calibration settings (both previous and current). It is good practice to save a copy of this file in a separate location for safekeeping and to keep track of the original calibration.



Adjustment of miniDOT® Clear calibration is accomplished by running the [miniDOTAdjustCalibration.jar](#) program shown below. Ensure the miniDOT® Clear being adjusted is connected to the computer running the adjustment program.

Click the '**Connect**' button and enter the measured saturation that was determined in the calibration experiment analysis. In the example, this is 97.75%. Click '**Adjust Calibration to Give 100%**'.

THE PROGRAM WILL DISPLAY A MESSAGE BASED ON THE ENTERED VALUE:

- **"Unreasonable saturation value"** (Measured saturation > 105%). The program will not provide an option to continue for values in this range.
- **"Measured saturations greater than 100% are unusual"** (105% > Measured saturation > 100%). The miniDOT® Clear calibration typically drifts to lower values, not higher. However, the program will provide an option to continue.
- **"After a year or two saturation measurements in the 100% to 95% range are normal"** (100% > Measured saturation > 95%). Values in this range are normal for one or two years without a field calibration adjustment. The program will provide an option to continue. This miniDOT® Clear calibration can likely be successfully adjusted.
- **"Measured saturations less than 95% are unusual"** (95% > Measured saturation > 90%). The miniDOT® Clear calibration has drifted lower by a substantial amount, possibly too much for a simple adjustment. However, the program will provide an option to continue.
- **"Unreasonable saturation value"** (90% > Measured saturation). The program will not provide an option to continue for values in this range.

We recommend returning any miniDOT® Clear to PME with a measured saturation value outside the 100% to 95% range for a full re-calibration and evaluation.

UPON CONFIRMATION OF THE ENTERED SATURATION VALUE, THE SOFTWARE WILL DO THE FOLLOWING:

- Read the connected miniDOT® Clear Logger's calibration.
- Store this calibration on the miniDOT® Clear in a calibrations folder.

Note: Be sure to keep track of the original calibration file. This will be used to restore the original calibration before subsequent adjustments.

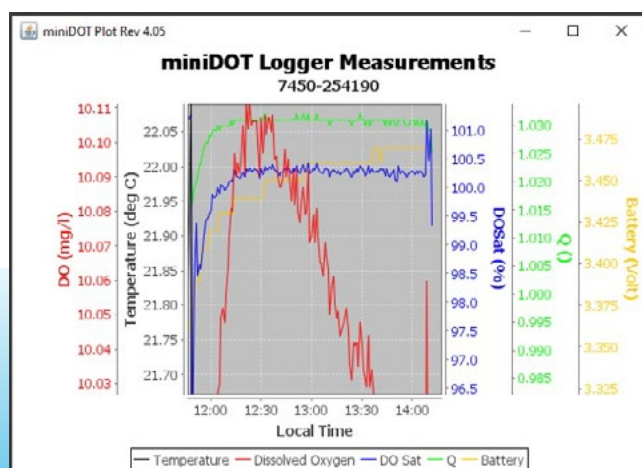
- Apply the adjustment factor to this calibration.
- Return the adjusted calibration onto miniDOT® Clear.
- Change the miniDOT® Clear Logger's 'Sensor Calibration Date' to the current date.

Thereafter **miniDOTControl** will display the adjustment date as the calibration date. Future measurements made by the miniDOT® Clear will have the adjustment date in the header of each measurement file.

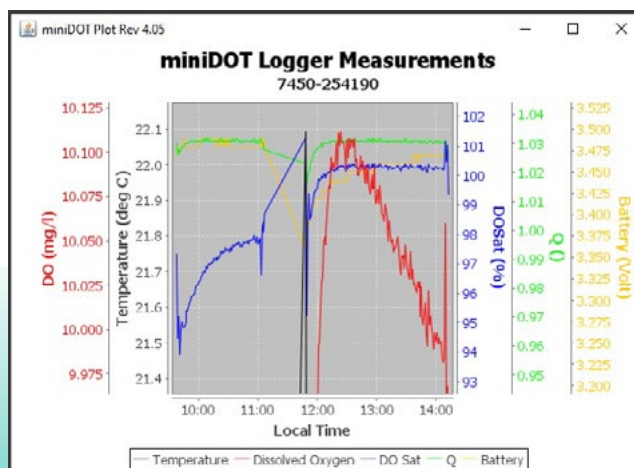
Verification of Field Calibration Adjustment

Note: Ensure the quality (Q) value measured by the miniDOT® Clear does not shift by more than 0.1, as it should remain consistent before and after the adjustment process. If the Q value shifts by a large amount as a result of the adjustment, restore the original calibration and perform the calibration adjustment again.

PME recommends that a second calibration experiment be performed to verify that the adjustment was applied correctly and that the measured saturation during the initial experiment was accurate. The same procedure should be followed as before, only the measured saturation should be much closer to the expected 100% and typically well within $\pm 3\%$ of that value.

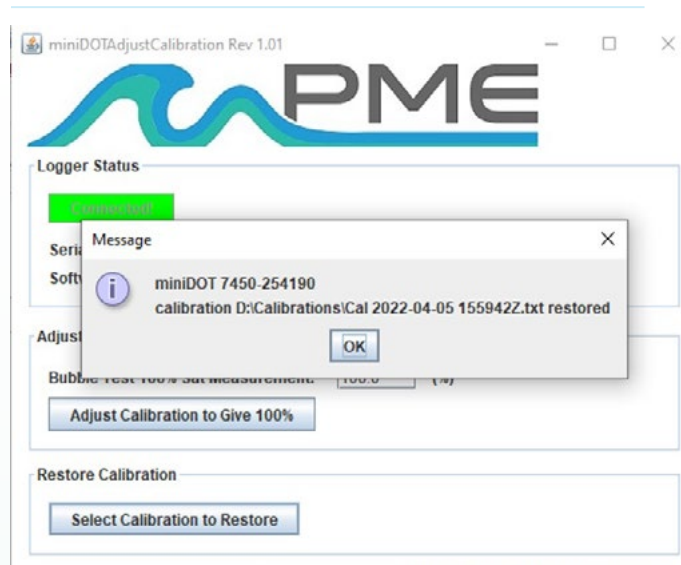


The plot above shows the results of a verification experiment that was performed immediately after the adjustment was made. It shows the saturation at only 0.5% higher than the expected 100%.



The above plot shows the first and second calibration verification experiments and highlights the improvement in accuracy post adjustment.

Restoration of Field Calibration



To revert to the original or a previous calibration, click 'Select Calibration to Restore'. The program will present the files located in the miniDOT® Clear Logger's calibration folder. Calibration files are named according to the date the contained calibration was performed. The calibration in the selected file is read and then returned to the connected miniDOT® Clear along with the date of that calibration. A popup window will show which calibration was restored.

APPENDIX A:

Steps for miniDOT® Clear Field Calibration Adjustment

PREFACE:

This appendix is a step-by-step guide through a manual calibration adjustment of miniDOT® Clear sensors. Supplementary information is provided in the main body of this document. Follow guidelines closely to ensure an accurate field calibration adjustment.

MATERIALS:

Ensure you have the following materials before proceeding with the field calibration adjustment:

- Air-stone
- Aquarium water pump
- Barometer
- Computer with Java 1.7 or higher
- miniDOT® Clear Java programs:
 - miniDOT® Plot
 - miniDOTConcatenate (optional)
 - miniDOTAdjustCalibration
- USB to micro-USB cable to connect to the computer
- Black, opaque 5-gallon bucket and lid
- Fresh water supply

Site Name:	Date Performed:
Sensor Serial Numbers:	Personnel Involved:



PROCEDURE:

Experiment

ATTENTION: Restore loggers to original calibration at this point.

For details on this process, reference the [Restoration of Field Calibration](#) section on page 7.

For more details regarding the following steps, reference the [Field Calibration Experiment](#) section on page 3.

1. Take barometric pressure measurements and estimate the average value during the experiment.
Average absolute barometric pressure: _____mbar
2. Fill the black bucket with enough fresh water to submerge miniDOT® Clear Loggers.
3. Set up the air-stone and water pump to oxygenate and mix the water.
4. Place all the miniDOT® Clear Loggers into the bucket and ensure they are restrained with their sensing faces pointing up.
5. Allow all miniDOT® Clear Loggers to record for a minimum 1 hour to ensure equilibrium is reached.
6. Retrieve the miniDOT® Clear from the bucket and dry the exterior of the unit (use caution and do not dry the actual sensor, to avoid scratching it).

Analysis

For more detail regarding the following steps, reference the [Field Calibration Experiment Analysis](#) section on page 4

For each miniDOT® Clear:

1. Connect the miniDOT® Clear to a computer with a USB cable.
2. Using the plot program with the measured barometric pressure entered, identify a period of the experiment where the temperature was changing slowly and the water was fully saturated.
3. Estimate the measured saturation percentage visually in the plot or by concatenating the data with the pressure measurement entered and average the saturation values recorded over the identified period.

Calibration Adjustment

For more details regarding the following steps, reference the [Field Calibration Adjustment](#) section on page 5.

1. Ensure the miniDOT® Clear being adjusted is connected to the computer.
2. Run the miniDOTAdjustCalibration.jar program and click the "Connect" button.
3. Enter the saturation percentage the miniDOT® Clear measured.
4. Click "Adjust Calibration to Give 100%" and follow the prompts that appear.
5. Save a copy of the original calibration file recorded in the calibration folder so it can be restored later.

Verification

For more details regarding the following steps, reference the [Verification of Field Calibration Adjustment](#) section on page 7.

1. Repeat the 'Experiment' section with the newly adjusted loggers.
Note: Do not restore the original calibration for this verification experiment.
2. Repeat the 'Analysis' section. The new readings should be within $\pm 3\%$ of 100% DO.

Contact PME with any questions or issues.