PhenoMaster / LabMaster – Phenotyping Research Platform

SOFTWARE Operating Instructions® – Calibration

Description of Standard Components
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Further examples of these operating instructions are available and can be ordered from us; a charge will be made for these extra copies.
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1. General

NOTE – General information
See manual *PM/LM Software Operating Instructions — Basic Modules*, section General.

NOTE – Setup installation
See manual *PM/LM Software Operating Instructions — Basic Modules*, section General, Setup installation.

2. Overview of menu items

NOTE – General information
See manual *PM/LM Software Operating Instructions — Basic Modules*, section Overview of menu items.

NOTE – PhenoMaster/LabMaster modules
See manual *PM/LM Software Operating Instructions — Basic Modules*, section Overview of menu items, PhenoMaster/LabMaster modules.

3. File menu

NOTE
See manual *PM/LM Software Operating Instructions — Basic Modules*, section File menu.

4. Status menu

NOTE – General information
See manual *PM/LM Software Operating Instructions — Basic Modules*, section Status menu.

NOTE – File info
See manual *PM/LM Software Operating Instructions — Basic Modules*, section Status menu, File info.
5. Measurement

NOTE
See manual PM/LM Software Operating Instructions — Basic Modules, section Measurement.

6. Setup

NOTE – General information
See manual PM/LM Software Operating Instructions — Basic Modules, section Setup.

NOTE – Experiment
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NOTE – Boxes
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7. View menu

NOTE – View
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NOTE – Decimal places
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8. Table menu

NOTE
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9. Graph menu

NOTE – General information
See manual PM/LM Software Operating Instructions — Basic Modules, section Graph menu.
NOTE – Graph display pop-up menu
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10. Event menu

NOTE
See manual PM/LM Software Operating Instructions — Basic Modules, section Event menu.

11. Printing

NOTE
See manual PM/LM Software Operating Instructions — Basic Modules, section Printing.

12. Selective storage of measuring data

NOTE
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13. Data export

NOTE – General information
See manual PM/LM Software Operating Instructions — Basic Modules, section Data export.

NOTE – Export table
See manual PM/LM Software Operating Instructions — Basic Modules, section Data Export, Export table.

NOTE – Export events
See manual PM/LM Software Operating Instructions — Basic Modules, section Data Export, Export events.
14. Terminating the program

NOTE

See manual *PM/LM Software Operating Instructions — Basic Modules*, section Terminating the program.
15. Calibration

The Calibration menu can be used for calibrating the system sensors. These depend on the system configuration and could be CO₂, O₂, temperature sensors and drinking & feeding sensors.

Fig. 1 Calibration menu

The program stores the complete calibration together with all other program settings in the file LabMaster.SET on the hard disk. For security purposes the program writes an ASCII-file when the calibration window is closed; this contains all the values under the name LabMaster.CAL in readable text form on the hard disk.

The system is delivered pre-calibrated for first tests after installation of the system. A new calibration should be carried out before a series of measurements is to be made.

Before starting a measurement please take a look at the measured values in the Status/.../Current Values menu in order to check that the sensors are showing values in the correct range (e.g. for room temperature). This procedure is only recommended for a quick check. If totally incorrect values are shown, e.g. for an obviously incorrect room temperature, then the hardware must be checked (e.g. the sensor connections). 0°C is frequently shown if no calibration has been carried out.

Fig. 2 Calibration main menu (example temperature sensor calibration)

Buttons:
Channel
Selects the required calibration channel.
+,- selects a sensor channel higher or lower in the sequence;
<< and >> for jumping to the individual sensor groups
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**Measure**
A single calibration value is measured (graphical display: blue bar – ADC Excitation) when the button is activated. This button is disabled when the “Auto“ function has been selected.

**Auto**
The calibration value is measured automatically – a value is determined five times per second.

**Calculate**
A1 and A0 are calculated from the calibration values.

**Save**
A1 and A0 and are stored. This function is also activated automatically on a channel change.

**Copy**
Only for service purposes – copies a “calibration value”.

**Load**
A saved calibration file (.CAL), e.g. a backup file can be loaded

**ADC Excitation**
The ADC value is entered in the column “Calc. Values“

**Clear ADC**
Deletes an entered ADC value – can be used only if the Auto checkbox is not activated

**Calorimetry:**
- **Flow DAC**
- **Span**
  Value in volt/l/min of the mass flow controller (Flow Dac)
- **Offset**
  Offset in volt of the mass flow controller (Flow Dac)

The following functions can only be seen if the **Auto** checkbox is activated.

**Smoothing**
Time (sec) for which the measured values are to be averaged

**Buffer usage (%)**
Shows the percentage of the data buffer to be filled *

**CLR**
Deletes the measured values in the buffer

**Curr. Delta (ADC)**
Difference between lowest and highest measured ADC value in the buffer

**Curr. Drift**
In order to determine the Curr. Drift [ADC] the buffer is divided into two sections with the same length. The mean of the ADC values will be calculated for each of these sections and the difference between these two mean values will be shown as the Curr. Drift [ADC].

*By using the buffer usage display you can see when the selected smoothing time has elapsed, i.e. the display then shows 100%.

**NOTE – Smoothing**
With the smoothing entry you can define the time for which the measured values are to be averaged – we recommend 30-60 seconds. The **Curr. Delta** value (in ADC) then shows the difference between the lowest and highest value measured in this time interval. For low ADC values the **Curr. Delta** should not be higher than 10; for high values not above 20. Only then will the measured value have stabilized sufficiently for the calibration procedure to be continued.

**Calorimetry:**
If a calibration flowmeter is supplied it can be used for checking the flow. It should be included between the control unit and the corresponding cage. The flow shown by the flowmeter and the value shown in the Status/Calo/Current Value menu should be the same. If the flows differ greatly from each other please contact the TSE Service.
NOTE – Calibration of mass flow controllers
These parameters are set prior to delivery and should only be changed after consulting the TSE service department!
The calibration menus for the individual sensors are available in the following sequence: O₂, CO₂ sensors, mass flow controllers, temperature sensors, drinking and feeding sensors – the calibration menu only shows the sensors that have been installed.

15.1. General description of the calibration routine

NOTE – Calibration procedure
Calibration can only be carried out in the STOP mode. Before a further calibration is carried out you should make a safety copy of the LabMaster.SET file and LabMaster.CAL, so that after an incorrect calibration you can still access the last calibration data used or the factory default settings.

The general calibration routine is described below; any special information about the procedure for the particular sensors is given in the following sections. The “…All” channel is reserved for our service technicians

15.1.1. Preparatory work

- 120 minutes before the start of the calibration of the O₂ and CO₂ sensor switch on the calorimetry control unit and start the program.
- Prepare the calibration standards (gases, weights, etc.).
- The following preparation procedures must be carried out for the particular sensors:
  - O₂ and CO₂ sensor: connect the calibration gas and purge the sensor with the calibration gas for at least 30 minutes.
  - Temperature sensors: bring the thermostatting device to the required temperature.
  - Drinking and feeding sensors: weigh out the calibration weights to two decimal placed.

NOTE – Preparation of drinking and feeding sensors
Before being used for the first time or after a long storage period without attached containers the drinking and feeding sensors must be loaded for 24 hours before the calibration with approximately half-full drinking/food containers in order to obtain correct measurements. Appropriate weights can also be used instead of the half-full containers.
15.1.2. Calibration routine

Calibration is carried out by means of linear regression. At least two measurements must be carried out (minimum/maximum value). It takes approximately one day to calibrate the calorimetry sensors and one day to calibrate the Drinking and Feeding sensors.

NOTE – 2-point calibration!
For a calibration using only two calibration standards (e.g. two gases, two weights) the coefficient of the linear regression will always be shown as 1.00000. This means that calibration errors cannot be recognized. Variations will also have a greater effect on the accuracy than in a multipoint calibration. The more calibration standards you use, the more accurate the measurement.

A maximum of eight calibration values can be defined. The highest calibration value cannot exceed the upper ADC limit. We recommend using more calibration points for very precise measurements.

1. Open the calibration window with the Calibrate command from the main menu.

2. Select the required sensor channel using the +/- keys; the green status display shows the type of sensor allocated to that channel.

3. Enter the first calibration value (the minimum value) in the first left-hand input field Cal. Values. The calibration values should be entered in increasing order.

4. Then activate the Auto checkbox and select the required smoothing value.

The blue ADC bar (ADC Excitation) shows the modulation of the analog-digital converter.

NOTE – Checking the stability
Check whether the ADC value has stabilized. If the value no longer rises or falls steadily, but varies around a particular value – can be followed by observing the Curr. DELTA (ADC) values –, then the calibration can be carried out with this value.

After activating the CLR function it is very easy to see whether the ADC value has stabilized by observing the filling of the buffer (the Curr. Delta value remains the same) or whether the value drifts (the Curr. Delta value changes continually).

5. When the buffer has filled and the ADC value has stabilized uncheck the Auto checkbox. The ADC value will be halted and can then no longer be altered, e.g. by removing the calibration standard.

6. Press the Apply ADC button, the ADC value will be accepted and appears to the right of the Cal. Values input field.
Calibration Modules

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If the value of the calibration standard is above or below the measuring range of the sensor then the error message “Sensor may be over/underloaded continue?” appears. In this case a different calibration standard must be used that is appropriate for the measuring range of the sensor.

7. Click in the next left-hand input field **Cal. Values**, as otherwise the ADC value that has already been measured will be overwritten, and enter the next value.

8. Connect the next calibration standard to the sensor.

9. Activate the **Auto** checkbox and wait until the buffer has filled and the ADC value has stabilized.

10. Uncheck the Auto checkbox.

11. Press the **Apply ADC** button, the ADC value will be accepted.

12. Proceed as described above with all the other calibration standards.

13. After measuring the last calibration value uncheck the **Auto** checkbox and press **Calculate** and **Save** your values.

The first hardware channel, e.g. Drink1 or Temp1 is calibrated. The other channels, e.g. Drink2, Drink3, etc. must also be calibrated as described above. Further information about the calibration of the individual sensors is given in the following sections.

⚠️ **NOTE – Calibration coefficient**

With more than two calibration values the **Coefficient** indicates the quality of the calibration. The value should be as close as possible to 1.0.

Internal calculation: value = measured value (= ADC value) * A1 + A0.

After calibration – e.g. with a weight for Drinking and Feeding experiments – you can check whether the weight of a weight attached to the sensor is shown correctly after calibration in the **Status** menu under **Drink/Feed**. Only slight variations should occur, otherwise a new calibration must be carried out.

After a new calibration the calibration data should be saved in a Backup directory.
15.2. Calibration of the O\textsubscript{2} and CO\textsubscript{2} sensor

Calibration can be carried out using two different methods:

- Calibration of the O\textsubscript{2}, CO\textsubscript{2} sensors using calibration gases.
- Calibration of the O\textsubscript{2}, CO\textsubscript{2} sensors using “fresh air”.
  1-point calibration of the O\textsubscript{2} sensor using a predefined factory calibration factor and “fresh air”.
  The calibration of the CO\textsubscript{2} sensor using “fresh air” and only 1 calibration gas.

\textbf{NOTE – Calibration gases}
You should ensure that only calibration gases whose O\textsubscript{2} and CO\textsubscript{2} concentrations are accurately known are used. Only use certified calibration gases. \textbf{We recommend the use of TSE calibration gases. Please contact our technical service to obtain the exact specifications of the calibration gases.}

15.2.1. Some important hints

For 1-point calibration TSE Service has provided the file \texttt{O2Zero.cal} in the program directory and on the Setup diskette.

The system is delivered pre-calibrated. A new calibration should be carried out each time that a series of measurements is to be made.

\textbf{Requirements for correct calibration:}
- The accuracy of the calibration depends, among other factors, on the quality of the calibration gas. Only gases whose O\textsubscript{2} and CO\textsubscript{2} content is known exactly will provide a correct calibration. Only certified gases should be used.
Before each calibration process there must be a continuous flow of gas through the sensor unit for at least 120 minutes – with switched-on control unit and started software.

A system with rat cages requires a flow of approx. 0.2l/min; one with mouse cages a flow of approx. 0.15l/min at the flowmeter of the control unit. After a calibration the setting must not be altered as otherwise the calibration will no longer be accurate and a new calibration procedure must be carried out. If you have any questions please contact TSE Service.

- The calibration must be carried out with the same flow as used during an experiment in order that the measured values are correct.
- The supply of calibration gas to the Sample In inlet of the control unit should only take place via the reference input of the sample switch unit and the downstream air drying unit so that the conditions are the same as those for a normal measurement.
- The calibration should always be carried out under the same and constant laboratory conditions, i.e. the temperature, humidity and pressure should be the same as those during an experiment.
- In the menu “Status/Current Values” the Ref input can be selected in order to be able to follow the currently measured values.

15.2.2. Reset button for CO₂ sensor zero-point setting

<table>
<thead>
<tr>
<th>!</th>
<th>CAUTION – Measuring Errors!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressing the CO₂ zero-point reset button can cause wrong measurement values. Operating of CO₂ zero-point reset button is reserved for TSE Service only.</td>
<td></td>
</tr>
<tr>
<td>• Do not operate red CO₂ zero-point reset button on rear panel of CaloSys control unit without prior consulting TSE Service.</td>
<td></td>
</tr>
</tbody>
</table>

In addition to calibration with the calibration gases and the software calibration routine, the CO₂ sensor can be calibrated via a hardware calibration routine. On the rear panel of the master control a red reset button is provided for this purpose. The red reset button should only light up when the sensor zero-point is being set, not during normal operation, e.g. before and during a measurement.

This type of calibration must be carried out
- before test series
- when the ADC value for CO₂ continuously decreases to lower values.

After the zero-point setting has been carried out the calibration with the software calibration menu must be carried out.
### Zero point setting

<table>
<thead>
<tr>
<th>![WARNING]</th>
<th>CAUTION – Measuring Errors!</th>
</tr>
</thead>
<tbody>
<tr>
<td>![WARNING]</td>
<td>If the CO₂ zero-point reset button is pressed when the sensor is not surrounded by sufficient nitrogen then an incorrect zero-point will be set.</td>
</tr>
<tr>
<td>![WARNING]</td>
<td>• Purge the sensor tubing with an adequate supply of nitrogen.</td>
</tr>
<tr>
<td>![WARNING]</td>
<td>• Never operate the zero-point reset button during a measurement.</td>
</tr>
</tbody>
</table>

- Purge the sensor tubing with nitrogen for approx. 20 minutes.
- Lift up the protective cover of the reset button on the rear panel of the master control unit, press down the reset button and wait for approx. 1 minute – **the button lights up** – then press the reset button again.
- Lower the protective cover of the reset button.
- Carry out a calibration using the software calibration menu.

#### 15.2.3. Calibration with calibration gases

Examples of calibration gases that can be used for calibration:
- 19.00% and 21.00% oxygen or
- 0.01% and 0.50% … 0.90% carbon dioxide

As the sensors must be thoroughly purged with the calibration gas this means that large capacity gas cylinders must be used.

An optimal size of the gas bottles would be 10l per bottle. A 10l bottle commonly contains 1500l of gas (compression of 150bar). In addition, two pressure reduction valves will be needed which should fit onto the gas bulbs. On the outlet of these valves a female thread will be needed G ¼” straight.

**NOTE – Calibration value**
The calibration value to be entered is the **exact** concentration value of the gas as marked on the calibration gas cylinder.

Calibration should never be carried out at the measuring limits of the sensor as this could result in calibration errors.

<table>
<thead>
<tr>
<th>![WARNING]</th>
<th>CAUTION – Instrument damage!</th>
</tr>
</thead>
<tbody>
<tr>
<td>![WARNING]</td>
<td>Excessively high pressure will damage the internal sensor.</td>
</tr>
<tr>
<td>![WARNING]</td>
<td>• Never connect a gas bottle directly to an inlet connector without using a pressure reducing valve set to 0.2-0.3bar above atmospheric pressure and an additional calibration flowmeter set to approx. 0.2l/min (not that on the control unit).</td>
</tr>
</tbody>
</table>
1. Connect the gas mixture of the calibration gas to the REF IN connector on the rear panel of the sample switch unit. The outlet of the sample switch unit is connected to Sample In connector on the rear panel of the control unit via the air drying unit – for detailed information about the connections please refer to the hardware description of the PhenoMaster/LabMaster system.

2. Purge the sensor with the calibration gas for at least 60 minutes – with switched-on control unit and started software.

3. Open the calibration window with the Calibrate command from the main menu.

4. Select the O₂ channel using the +/- keys; the green status display shows the type of sensor allocated to that channel, in this case the oxygen sensor (O₂).

5. Enter the first calibration value (the minimum value) in the first left-hand input field Cal. Values. The minimum value for the oxygen sensor should not be less than 19%.

6. Then activate the Auto checkbox and select the required smoothing value.

7. To ensure the stability of the ADC value wait at least until the smoothing buffer has been filled.

8. When the buffer has filled and the ADC value has stabilized uncheck the Auto checkbox.

9. Press the Apply ADC button, the ADC value will be accepted.

10. Connect the appropriate gas for the second measurement – purge the sensor with the calibration gas for at least 60 minutes.
11. Enter the second calibration value in the second left-hand input field **Cal. Values** for the O₂ sensor.

12. Then activate the **Auto** checkbox.

13. Wait to ensure the stability of the ADC value – check the **Curr. Delta** value.

14. Uncheck the **Auto** checkbox.

15. Press the **Apply ADC** button, the ADC value will be accepted.

If this is your last calibration point, press **Calculate** and **Save**. Otherwise continue with the next O₂ calibration gas as described above.

16. After measuring the last calibration value uncheck the **Auto** checkbox.

17. Then press **Calculate** and **Save** your values.

The program now calculates the parameters **A1**, **A0** and the **Coefficient**. These parameters are then used to calculate the ADC-values of any gas concentration in terms of percentage.
18. Using the +/- keys and select the CO₂ sensor for calibration.

**Before calibrating the CO₂ sensor with the software you should first carry out the hardware zero point setting routine for the CO₂ sensor, see section 15.2.2.**

19. Connect the appropriate gas (as described under item 1) with the lowest CO₂ concentration for this measurement – purge the sensor with the calibration gas for at least 60 minutes.

20. Enter the first value in the first calibration box **Cal. Values**. Then activate the **Auto** checkbox.

21. Wait at least 10 minutes for the ADC value to stabilize – check the **Curr. Delta** value.

22. Uncheck the **Auto** checkbox.

23. Press the **Apply ADC** button, the ADC value will be accepted.

24. Attach the second calibration gas of appropriate concentration – purge the sensor with the calibration gas for at least 60 minutes.

25. Enter the second calibration value for the CO₂ sensor in the left-hand input field **Cal. Values**. Then activate the **Auto** checkbox.

26. Wait at least 10 minutes until the ADC value is stable – check the **Curr. Delta** value.

27. Uncheck the **Auto** checkbox.

28. Press the **Apply ADC** button, the ADC value will be accepted.

   If this is your last calibration point press **Calculate** and **Save**. Otherwise continue with the next CO₂ calibration gas as described above.

29. After measuring the last calibration value uncheck the **Auto** checkbox.

30. Then press **Calculate** and **Save** your values.
15.2.4. Calibration with “fresh air”

15.2.4.1. 1-point calibration of the O\textsubscript{2} sensor

\textbf{NOTE – File O2Zero.cal}

The file “O2Zero.cal” is required for the 1-point calibration of the O\textsubscript{2} sensor. During the installation of the system by TSE Service it is stored in the program directory and should, like all the other calibration data, be saved again on a backup diskette.

In this case calibration is carried out with only two values – the zero point value and the value of the oxygen content of “fresh air”.

\textbf{NOTE – Calibration with ambient air}

The oxygen content of fresh air is exactly 20.95%; however, the laboratory must be well aired, e.g. by an air-conditioning unit, or outside air must be led in.

The calibration procedure corresponds to that described in the previous section with the exception that instead of the first value (min. value) “0” is entered as Calc. Value and calibration is carried out with “fresh air” as the second value (max. value).

When calibrating with “fresh air” it is also important that the air exchange at the sensor is carried out to completion, i.e. no correct calibration can be carried out until the ADC value has stabilized.

1. Enter “0” as the first value and press \textbf{Measure}. An ADC value of approx. -16500 should appear.

\textbf{NOTE – Calibration with 0% O\textsubscript{2}}

Calibration with a gas with 0% oxygen cannot be carried out as this is outside the measuring range of the sensor.
2. Purge the sensor with an adequate supply of “fresh air” – depending on the previous measurements this may take a long time.

3. Enter “20.95” as the second value and activate the Auto checkbox; Wait at least 10 minutes to ensure the stability of the ADC value – check the Curr. Delta value.

4. Uncheck the Auto checkbox.

5. Press the Apply ADC button, the ADC value will be accepted.

6. Press Calculate and then save the calibration with Save.

15.2.4.2. Calibrating the CO\textsubscript{2} sensor with fresh air

The calibration of the CO\textsubscript{2} sensor can be carried out with two calibration gases as described previously. However, if you uncertain about the quality of your calibration gases you can carry out a calibration with “fresh air” (0.03% CO\textsubscript{2}) as one “calibration gas”.

During the calibration of the CO\textsubscript{2} sensor it is also very important that the air exchange at the sensor is carried out to completion, i.e. the fresh air as well as the calibration gas should flow past the sensor for at least 60 minutes.

15.3. Calibration of the temperature sensors

In order to calibrate the temperature sensors they have to be placed in a chamber where two (or more) different temperatures can be generated (e.g. a heating box). TSE recommends to calibrate the temperature sensors in the range of the required test conditions (e.g. 25 °C to 36 °C)

The following description explains the calibration procedure irrespective of the actual temperature values.

1. Open the calibration window with the Calibrate command from the main menu.

2. Set the temperature channel using the +/- keys; the green status display shows the type of sensor allocated to that channel, e.g. the temperature sensor for box1 (Temp-1).

3. Place the sensor in a heating box with the first calibration temperature.

\textbf{NOTE – Temperature equilibration}

The temperature sensor should be allowed to stand for at least 15min for temperature equilibration.
4. Enter the first calibration value (the minimum value) in the first left-hand input field **Cal. Values**, and activate the **Auto** checkbox.

5. Wait at least 10 minutes for the ADC value to stabilize – check the **Curr. Delta** value.

6. Uncheck the **Auto** checkbox.

7. Press the **Apply ADC** button, the ADC value will be accepted.

8. Place the sensor in a heating box with the second calibration temperature. Wait least 15min for temperature equilibration.

9. Enter the next calibration value in the second left-hand input field **Cal. Values**. Activate the **Auto** checkbox.

10. Wait at least 10 minutes for the ADC value to stabilize – check the **Curr. Delta** value.

11. Uncheck the **Auto** checkbox.

12. Press the **Apply ADC** button, the ADC value will be accepted.

13. If this is your last calibration point press **Calculate** and **Save**. Otherwise continue with the next temperature value as described above.

14. Finally uncheck the **Auto** checkbox and press **Calculate**. The program now calculates the parameters **A1**, **A0** and the **Coefficient**.

---

**Fig. 8** Temperature calibration with two measurements (demo values)
Fig. 9  Temperature calibration calculation (demo values)

15. Press **Save** to store the settings.

16. Select the next temperature channel (Temp-2). Proceed as described above for all temperature sensors.

**15.4. Calibration of the drinking and feeding sensors**

Before being used for the first time or after a long storage period without attached containers the drinking/feeding sensors must be loaded for 24 hours before the calibration with approximately half-full drinking/food containers in order to obtain correct measurements.

Appropriate weights can also be used instead of the half-full containers. For calibration the weights must be weighed out accurately to at least two decimal places and the corresponding number of decimal places should also be entered in the “Cal. Values” input field, as otherwise the measured values recorded will be inaccurate.

During the calibration process make sure that no shocks or vibrations, e.g. those caused by people moving about, can cause the sensor units to oscillate as otherwise the calibration will be inaccurate and therefore inaccurate measured values will be recorded.

**NOTE – Measurement error**

It is imperative that each sensor be calibrated with the drinking bottle and food container to be used on that sensor.
The measuring range of the sensor is given on the type plate (in grams), i.e. the maximum possible weight refers to the weight of the drinking/food container plus the calibration weight or contents.

**NOTE – First calibration value**
The first calibration value is taken using the empty container with all its components (chain, cover, etc). In the calibration this weight corresponds to the zero point and therefore 0.0g is entered as the first weight value. A small variation of the ADC value should be observed.

**Important NOTE – Correct ADC for calibration**
The calibration should cover the whole measuring range of the sensor. This means that calibration should be carried out at approx. 10% and approx. 90% of the nominal value of the sensor. With an ADC range of values for the drinking & feeding sensors of 65000 this means that the following calibrations should be carried out:

10% → approx. 4000 to 7000 ADC counts for the first calibration value and 90% → approx. 50000 to 60000 ADC counts for the second calibration value.

If calibration is carried out with more than two values then all the calibration points should be within this range.

### 15.4.1. General description

1. Select the channel to be calibrated.

2. Connect the container to the sensor and **enter the weight 0.0** in the first left-hand input field “Cal. Values”.

![Fig. 10 Calibration step 1](image-url)
3. Activate the **Auto** checkbox and wait until the buffer is filled (100%) and the ADC value is stable; the variation should be less than 10 ADC values – check the **Curr. Delta** value.

![Calibration step 2](image)

**Fig. 11 Calibration step 2**

This ADC value represents your "zero" value for the sensor.

4. Uncheck the **Auto** checkbox

![Calibration step 3](image)

**Fig. 12 Calibration step 3**

5. Press the **Apply ADC** button, the ADC value will be accepted.
6. Next, add the calibration weight with the smallest weight to the container. Enter the calibration value for this weight in the second left-hand input field Cal. Values.

7. Activate the Auto checkbox and wait until the buffer is filled (100%) and the ADC value is stable – check the Curr. Delta value.
8. Uncheck the **Auto** checkbox.

9. Press the **Apply ADC** button, the ADC value will be accepted.
10. Next, add the calibration weight with the second smallest weight to the container. Enter the calibration value in the third left-hand input field **Cal. Values**.

11. Then activate the **Auto** checkbox and wait until the buffer is filled (100%) and the ADC value is stable – check the **Curr. Delta** value.
Fig. 19 Calibration step 10

12. Uncheck the **Auto** checkbox.

Fig. 20 Calibration step 11

13. Press the **Apply ADC** button, the ADC value will be accepted.
14. If this is your last calibration point press **Calculate** and **Save**. Otherwise continue with the next calibration weights as described above.

15. After the last calibration point, uncheck the **Auto** checkbox.

16. Press the **Apply ADC** button, the ADC value will be accepted.
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Fig. 23 Calibration step 13

17. Press the **Calculate** button, and the software will calculate \( A_1 \), \( A_0 \), and the **Coefficient** values.

Fig. 24 Calibration step 14

18. Press the **Save** button to save the calibration values.

You can check whether the weight of a weight attached to the sensor is shown correctly after calibration in the **Status** menu under **Drink/Feed**. If the calibration has been carried out correctly then the weight will be shown correctly in the Status menu (see below illustration).
19. Proceed as described above for each sensor.

15.4.2. Calibration of the drinking sensors

1. Select the first drinking channel (Drink-1).

2. Connect the drinking bottle to the sensor and enter the **weight 0.0** in the first left-hand input field “Cal. Values”.

3. Activate the **Auto** checkbox and wait until the buffer is filled and the ADC value is stable; the variation should be less than 10 ADC values – check the **Curr. Delta** value.

   This ADC value represents your ”zero” value for drink sensor No. 1.

4. Uncheck the **Auto** checkbox

5. Press the **Apply ADC** button, the ADC value will be accepted.

6. Next, add the calibration weight with the smallest weight to the bottle. Enter the calibration value for this weight in the second left-hand input field **Cal. Values**.

7. Activate the **Auto** checkbox and wait until the buffer is filled and the ADC value is stable – check the **Curr. Delta** value.

8. Uncheck the **Auto** checkbox.

9. Press the **Apply ADC** button, the ADC value will be accepted.

10. Next, add the calibration weight with the second smallest weight to the bottle. Enter the calibration value in the third left-hand input field **Cal. Values**.
11. Then activate the **Auto** checkbox and wait until the buffer is filled and the ADC value is stable – check the **Curr. Delta** value.

12. Uncheck the **Auto** checkbox.

13. Press the **Apply ADC** button, the ADC value will be accepted.

14. If this is your last calibration point press **Calculate** and **Save**. Otherwise continue with the next calibration weights as described above.

15. After the last calibration point, uncheck the **Auto** checkbox and press the **Apply ADC** button, the ADC value will be accepted

16. Press the **Calculate** button, and the software will calculate \( A_1 \), \( A_0 \), and the **Coefficient** values.

17. Press the **Save** button to save the calibration values.

18. Continue as described above for each drink sensor.

### 15.4.3. Calibration of the feeding sensors

1. Select the first feeding channel (Feed-1).

2. Connect the food container to the sensor and **enter the weight 0.0** in the first left-hand input field **Cal. Values**.

3. Activate the **Auto** checkbox and wait until the buffer is filled (100%) and the ADC value is stable – check the **Curr. Delta** value.

   This ADC value represents your "zero" value for drink sensor No. 1.

4. Uncheck the **Auto** checkbox.

5. Press the **Apply ADC** button, the ADC value will be accepted.

6. Next add the calibration weight with the smallest weight to the container. Enter the calibration value for this weight in the second left-hand input field **Cal. Values**.

7. Activate the **Auto** checkbox and wait until the buffer is filled and the ADC value is stable – check the **Curr. Delta** value.

8. Uncheck the **Auto** checkbox.

9. Press the **Apply ADC** button, the ADC value will be accepted.

10. Next, add the calibration weight with the second smallest weight to the container. Enter the next calibration value in the third left-hand input field **Cal. Values**.
11. Then activate the **Auto** checkbox and wait until the buffer is filled and the ADC value is stable – check the **Curr. Delta** value.

12. Uncheck the **Auto** checkbox.

13. Press the **Apply ADC** button, the ADC value will be accepted.

14. If this is your last calibration point press **Calculate** and **Save**. Otherwise continue with the next calibration weights as described above.

15. After the last calibration point uncheck the **Auto** checkbox and press the **Apply ADC** button, the ADC value will be accepted.

16. Press the **Calculate** button, and the software will calculate $A_1$, $A_0$, and the **Coefficient** values.

17. Press the **Save** button.

18. Continue as described above for each feeding sensor.

15.4.4. Attaching drinking and feeding sensors after cleaning

The calibration menu has a tare function so that the drinking and food containers do not have to be reattached to exactly the same sensor. In this way it is possible to compensate for the differences in weight between the individual drinking and food containers. However, the software always differentiates between drinking and food containers. This means that it is **not possible to suspend a drinking container from a feeding sensor and vice versa**. The containers are reattached as follows.

1. Open the calibration menu.

2. Select a drink or feed channel.
3. Suspend the empty container from the sensor.

4. Activate the AUTO checkbox.

5. Wait until “ADC Excitation” shows 100%. The Tare button above the A0 (+) display field is then enabled.

**NOTE – Current values**
As in the calibration you should make sure that the value for Curr. Delta is small and that the value for Curr. Drift is almost zero.
6. If all the values are within the required range then click on the Tare button.

7. You will then be asked to check the container.

8. After confirmation of the message you will be asked to change the offset value.

9. After confirmation of this query the Save button in the calibration menu must be pressed to save the new offset value. The ADC value measured at this moment will be used as the basis for the new offset calculation.

10. The calibration window can then be exited with Close. If the Save button has not been pressed then a query will appear: Calibration values not saved, save now?

11. When the offset value has been successfully altered an empty container should now be shown with a weight of zero or virtually zero in the Drink/Feed Status menu.

15.5. Batch calibration

Allows a time-saving handling of larger set-ups. Several calibration weights are recorded simultaneously.

- A single set of calibration weights is required. Values of weights must clearly differ from each other.
- Each weight is attached once in succession to each of the sensors to be calibrated.
- Each of these sensors must record each of these weights once.

NOTE – Number of sensors to be calibrated
We recommend to calibrate ≤8-16 sensors at a time.
NOTE – Calibration weights
Calibration weights are to be attached to every sensor to be calibrated except that you want to include a zero value (calibration weight: 0g, empty container).

15.5.1. Calibration of the drinking / feeding sensors

1. Open Calibrate menu, Batch Calibrate.

2. Press Weights.
3. Enter your Calibration Weights.
4. Select the **Task Calibration**.
5. **Select Sensors**, e.g. **Drink**.

**NOTE – Sensor channel**

We recommend to select a single sensor at a time.

6. **Select Boxes** with drinking sensors /feeding sensors to be calibrated.
7. Attach the drinking bottles/food containers to the sensors.
8. Click **Calibration** tab.
9. Attach the calibration weights to the bottles/containers, e.g. sensors **Drink**
Fig. 33  Drinking bottle with attached calibration weight

Example

<table>
<thead>
<tr>
<th>Box No.</th>
<th>Calibration Weight [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.84</td>
</tr>
<tr>
<td>2</td>
<td>0*</td>
</tr>
<tr>
<td>3</td>
<td>0*</td>
</tr>
</tbody>
</table>

*empty bottle

10. Press **Clear Buffer** and wait until the buffer is filled (**Buffer: 100%**) and the ADC value shown below each sensor bar is stable. The drift should be ≤3
ADC values – check the **Drift** value, the variance should be ≤10 ADC values – check the **Variance** value.

**NOTE – Sensor color**
As soon as the drift value is ≤**Max. Drift** and the variance value is ≤**Max. Variance** the sensor bar changes from red to green.

**Fig. 34** Calibration tab, Box1, Box3: Drift, Variance
11. Press **Catch**.

**Fig. 35** Calibration tab, 1st **Catch** (configuration example)

**NOTE** – Number of recorded calibration weights
The number of recorded calibration weights can be seen from the number in the center of a sensor.

**Fig. 36** Number of recorded calibration weights, e.g. 1
12. Rearrange and attach the calibration weights to the bottles/containers, e.g. sensors Drink:

**Example**

<table>
<thead>
<tr>
<th>Box No.</th>
<th>Calibration Weight [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0*</td>
</tr>
<tr>
<td>2</td>
<td>9.84</td>
</tr>
<tr>
<td>3</td>
<td>0*</td>
</tr>
</tbody>
</table>

*empty bottle

13. Press Clear Buffer and wait until the buffer is filled (Buffer: 100%) and the ADC value shown below each sensor bar is stable. The drift should be ≤3 ADC values – check the Drift value, the variance should be ≤10 ADC values – check the Variance value.


15. Rearrange and attach the calibration weights to the bottles/containers, e.g. sensors Drink:

**Example**

<table>
<thead>
<tr>
<th>Box No.</th>
<th>Calibration Weight [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0*</td>
</tr>
<tr>
<td>2</td>
<td>0*</td>
</tr>
<tr>
<td>3</td>
<td>9.84</td>
</tr>
</tbody>
</table>

*empty bottle

16. Press Clear Buffer and wait until the buffer is filled (Buffer: 100%) and the ADC value shown below each sensor bar is stable. The drift should be ≤3 ADC values – check the Drift value, the variance should be ≤10 ADC values – check the Variance value.

17. Press Catch.

**NOTE – Red ticks**

The red ticks will be shown when exactly the same number of ADC values is present as the number of entered calibration weights.

![Fig. 37 Red tick](image-url)
NOTE – Assigning calibration weights — ADC values
Assignment of the ADC values to the calibration weights can only take place when exactly the same number of ADC values is present as the number of entered calibration weights. The program arranges the values according to size and it is assumed that the smallest ADC value corresponds to the smallest weight, etc.

18. Press **Calculate**.

**Fig. 38** Calculation of A0, A1 and coefficient value

19. Press **Save**.

NOTE – Show ADC values
The recorded ADC values can be shown on the **Calibration** tab with a tool tip on the sensor bar.
**NOTE – Verification of calibration**

You can check whether the weights of the weights attached to the sensors are shown correctly after calibration in the **Status** menu under **Drink/Feed**.

**Fig. 39** ADC values, Box1

**Fig. 40** Status menu, Drink/Feed

**15.5.1.1. AutoCatch of drinking / feeding sensors**

Allows recording ADC values automatically.

1. Open **Calibrate** menu, **Batch Calibrate**.
2. Press **Weights**.
3. Enter your **Calibration Weights**.
4. Select the Task Calibration.
5. Select Sensors, e.g. Drink.

**NOTE – Sensor channel**
We recommend to select a single sensor at a time.

6. Select Boxes with drinking sensors/feeding sensors to be calibrated.
7. Attach the drinking bottles/food container to the sensors.
8. Click Calibration tab.
9. Select AutoCatch
10. Attach the calibration weights to the bottles/containers, e.g. sensors Drink

**Example**

<table>
<thead>
<tr>
<th>Box No.</th>
<th>Calibration Weight [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.84</td>
</tr>
<tr>
<td>2</td>
<td>0*</td>
</tr>
<tr>
<td>3</td>
<td>0*</td>
</tr>
</tbody>
</table>

*empty bottle

When the buffer is filled (Buffer: 100%) and the ADC value shown below each sensor bar is stable, ADC values are automatically recorded. The drift should be ≤3 ADC values – check the Drift value, the variance should be ≤10 ADC values – check the Variance value.
**NOTE – Acoustic signal**
In addition to the graphical display the catching of an ADC value will be signalized via a beep.

11. Rearrange and attach the calibration weights to the bottles/containers, e.g. sensors **Drink**:

**Example**

<table>
<thead>
<tr>
<th>Box No.</th>
<th>Calibration Weight [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0*</td>
</tr>
<tr>
<td>2</td>
<td>9.84</td>
</tr>
<tr>
<td>3</td>
<td>0*</td>
</tr>
</tbody>
</table>

*empty bottle

12. Rearrange and attach the calibration weights to the bottles, e.g. sensors **Drink**:
Example

<table>
<thead>
<tr>
<th>Box No.</th>
<th>Calibration Weight [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0*</td>
</tr>
<tr>
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<td>0*</td>
</tr>
<tr>
<td>3</td>
<td>9.84</td>
</tr>
</tbody>
</table>

*empty bottle

13. Rearrange and attach the calibration weights to the bottles/containers, e.g. sensors Drink:

Example

<table>
<thead>
<tr>
<th>Box No.</th>
<th>Calibration Weight [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39.58</td>
</tr>
<tr>
<td>2</td>
<td>0*</td>
</tr>
<tr>
<td>3</td>
<td>0*</td>
</tr>
</tbody>
</table>

*empty bottle

Fig. 43 Calibration, 4th Catch (configuration example)

14. Rearrange and attach the calibration weights to the bottles/containers, e.g. sensors Drink:
**Example**

<table>
<thead>
<tr>
<th>Box No.</th>
<th>Calibration Weight [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0*</td>
</tr>
<tr>
<td>2</td>
<td>39.58</td>
</tr>
<tr>
<td>3</td>
<td>0*</td>
</tr>
</tbody>
</table>

*empty bottle

15. Rearrange and attach the calibration weights to the bottles/containers, e.g. sensors **Drink**:

**Example**

<table>
<thead>
<tr>
<th>Box No.</th>
<th>Calibration Weight [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0*</td>
</tr>
<tr>
<td>2</td>
<td>0*</td>
</tr>
<tr>
<td>3</td>
<td>39.58</td>
</tr>
</tbody>
</table>

*empty bottle

---

**Fig. 44** ADC values, Box3

20. Press **Calculate**.

**NOTE – Assigning calibration weights — ADC values**

Assignment of the ADC values to the calibration weights can only take place when exactly the same number of ADC values is present as the number of entered
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calibration weights. The program arranges the values according to size and it is assumed that the smallest ADC value corresponds to the smallest weight, etc.

21. Press Save.

NOTE – Verification of calibration
You can check whether the weights of the weights attached to the sensors are shown correctly after calibration in the Status menu under Drink/Feed.

15.5.1.2. Adding a new calibration weight

Enables you to add a new calibration weight when Presets have been configured and you are working with the Calibration tab.

1. Press Weights to open the Calibration Weights window.

Fig. 45 Calibration Weights dialog

2. Enter a new calibration weight in a new entry field

NOTE – Other Entries
Do not overwrite an existing value!

Fig. 46 New entry

3. Press Ok.

4. Attach the calibration weights to the bottles/containers — including the new calibration weight — and proceed as described in section 15.5.1, steps 7-19.
15.5.1.3. Deleting a calibration weight

Recommended only for experienced users. Enables you to delete a calibration weight when Presets have been configured and you are working with the Calibration tab.

⚠️ NOTE – Protocol

We recommend to write a calibration protocol to facilitate the assignment of calibration weights to ADC values.

1. Press Weights to open the Calibration Weights window.
2. Delete the calibration weight.
3. Press Ok.
4. With the right-hand mouse key click in sensor bar of the first box to open the context menu.
5. Delete the corresponding ADC value of the deleted calibration weight.

![Batch Calibration]

Fig. 47 Deleting an ADC value (example)

6. Repeat steps 4-5 with other boxes.
7. Attach the calibration weights to the bottles/containers — excluding the deleted calibration weight — and proceed as described in section 15.5.1 steps 7-19.
NOTE – Deleting ADC values
Steps 4-6 can be omitted if the corresponding calibration weight has not yet been recorded.

NOTE – Assigning calibration weights – ADC values
Assignment of the ADC values to the calibration weights can only take place when exactly the same number of ADC values is present as the number of entered calibration weights. The program arrange the values according to size and it is assumed that the smallest ADC value corresponds to the smallest weight, etc.

15.5.2. Attaching drinking bottles / food containers after cleaning
The Batch Calibration menu has a tare function so that the drinking bottles/food containers do not have to be reattached to exactly the same sensor. In this way it is possible to compensate for the differences in weight between the individual drinking and food containers.

1. Open Calibration, Batch Calibration menu.
2. Select the Task Tare.
3. Select Sensors, e.g. Drink.
4. Select Boxes.
5. Attach the empty drinking bottles/food containers to the sensors.
6. Click Tare tab.
7. Press Clear Buffer and wait until the buffer is filled (Buffer: 100%) and the ADC value shown below each sensor bar is stable. The drift should be \( \leq 3 \).
ADC values – check the Drift value, the variance should be ≤10 ADC values – check the Variance value.

8. Press Catch.
10. Press Save.

NOTE – Verification of tare
You can check whether the weights of the containers attached to the sensors are shown correctly after tare in the Status menu under Drink/Feed.

Fig. 49 Status menu, Drink/Feed

15.6. Adoption of calibration values

15.6.1. Weight sensors (drinking, feeding, feces, urine, body weight)

The differential use of the same sensor hardware (e.g. 2x drink, 1x feed vs. 1x drink, 1x feed, 1x body weight) allows the adoption of the corresponding calibration values.

Apart from the channel name the *.cal-file records adapter code and hardware input (if applicable).

<table>
<thead>
<tr>
<th>Drink/Feed Current Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

*Fig. 49 Status menu, Drink/Feed

15.6. Adoption of calibration values

15.6.1. Weight sensors (drinking, feeding, feces, urine, body weight)

The differential use of the same sensor hardware (e.g. 2x drink, 1x feed vs. 1x drink, 1x feed, 1x body weight) allows the adoption of the corresponding calibration values.

Apart from the channel name the *.cal-file records adapter code and hardware input (if applicable).

<table>
<thead>
<tr>
<th>TSE LabMaster V2.8.3 (3903) Calibration values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel</td>
</tr>
<tr>
<td>DrinkAll</td>
</tr>
<tr>
<td>Drink1-1</td>
</tr>
<tr>
<td>Drink1-2</td>
</tr>
<tr>
<td>Drink2-1</td>
</tr>
<tr>
<td>Drink2-2</td>
</tr>
<tr>
<td>Drink3-1</td>
</tr>
<tr>
<td>Drink3-2</td>
</tr>
</tbody>
</table>

*.cal (example)

During the reading of the *.cal-file the PM/LM software checks whether there is a match with the adapter code and the hardware input of the connected hardware. If needed you can confirm the adoption of the calibration values.
Fig. 50  Adoption of calibration values via adapter code resp. hardware input dialog (example)

15.6.2. Other sensors

Adoption of calibration values possible if sensor hardware was recognized via the channel name.

Fig. 51  Adoption of calibration values via channel name dialog (example)
16. Analysis menu

NOTE – General information
See manual PM/LM Software Operating Instructions — Basic Modules, section Analysis menu.

16.1. Global analysis

NOTE – Parameter selection
See manual PM/LM Software Operating Instructions — Basic Modules, section Global analysis, Parameter selection.

NOTE – Animal groups
See manual PM/LM Software Operating Instructions — Basic Modules, section Global analysis, Animal groups.

NOTE – Analysis parameters
See manual PM/LM Software Operating Instructions — Basic Modules, section Global analysis, Animal parameters.

NOTE – Actogram
See manual PM/LM Software Operating Instructions — Basic Modules, section Global analysis, Actogram.
Appendix

PhenoMaster/LabMaster settings and results files

⚠️ NOTE
See manual PM/LM Software Operating Instructions — Basic Modules, Appendix.
TSE Systems is a leading supplier of sophisticated research instrumentation in the global life science market. Our focus is on providing the total customer solution, with modular designs of integrated hardware and software platforms for neuroscience, metabolic and behavioral phenotyping, drug screening and toxicology. It is our corporate goal to become the number one manufacturer of highly sophisticated products in each market we serve.

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Fax: +1-866-467-8873

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Phone: +91-11-2646-9031
Fax: +91-11-2648-1469
E-mail: harish@axiombiotek.com

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