FluoMini Pro Optical Photosynthesis Efficiency + PAR Sensor

User manual

Contents

1. General

1.1. Product

Product	FluoMini Pro Optical Photosynthesis Efficiency + Photosynthetically Active Radiation (Eff% + PAR) Sensor
Version	1
Software	2.21
Firmware	200501

1.1.1. Scope of delivery

- FluoMini Pro Optical Eff% + PAR Sensor (handhold, analog or digital)

- Leaf clip incl. 2 optical fibers (1,0 m)

- USB cable (1.0 m)

- Analog cable (1.0 m, for analog sensor only)

- Digital cable (1.0 m, for digital sensor only)

- Leaf clip mount incl. 2 qlipr clips

- Test target

- Fiber Distance Tool

1.1.2. Technical specifications

Specifications	Values
Photosynthesis efficiency range	10 – 90 %
PAR range	0 – 2000 µmol/m^{2}s (± 10 %)
Saturation Pulse	±1000 – 3000 µmol/m^{2}s
Temperature range	+ 5 to + 45 °C
Sample Time	≥ 3 sec

Connectivity	Handheld: USB serial interface
	Digital: USB serial interface
	        digital output / TTL serial port
	Analog: USB serial interface
	        4 – 20 mA output (4 wires)

	12 – 24 V AC/DC
Output signal	USB serial interface port
Dimensions (l x w x h in mm)	169 x 62 x 25
Weight (g)	235
Housing material	Aluminium, with ABS covers
Electrical connections	Handheld: 1 x M5 4 pole male Digital: 2 x M5 4 pole male Analog: 1 x M5 4 pole male 1 x M5 4 pole female
Probe material	Leaf clip with 2 optical fiber
Protection level	IP53
Power supply	Handheld/digital: USB port (5V, < 200 mA) Analog:12-24 V
Battery lifetime (handheld/digital)	48 h at 5 sec interval 2 weeks at 60 sec interval

1.2. Important user instructions

This sensor is developed to be used for the measurement of photosynthesis efficiency on leaves of living plants. Too short measurement intervals can cause damage to the photosynthetic apparatus of the leaf and cause erroneous readings. Weak leaves could also be mechanically damaged due to the weight of the probe. In this case, the leaf clip support should be used.

1.3. Warranty

This product has a warranty of two years on the mechanics and electronics (excl. battery).

1.4. Transport, storage and disposal

This product is subject to the "GENERAL RESEARCH, ADVICE, SALES, DELIVERY AND PAYMENT CONDITIONS OF SENDOT RESEARCH BV (deposited with no. 62488295 bij KvK Haaglanden)". It can be downloaded from www.sendot.nl.

2. Installation

2.1. Unpacking and setup

The sensor will be delivered fully calibrated, ready to be used. Before first use, the sensor might need to be charged using the included USB cable. The display is protected with a plastic film that can be removed. Both fibers need to be screwed on the two SMA ports on the top of the sensor. On the fibers and the SMA ports labels are applied for orientation.

For the installation of a digital or analog sensor, please read the corresponding manual.

2.2. Type probe

Leaf clip

The FluoMini Pro Optical Eff% + PAR Sensor is provided with a leaf clip for the measurements on leaves of living plants.

2.3. Connections

2.3.1. Handheld sensor

The sensor can be connected to a Windows or Android system by means of a USB cable. Charging is possible via the USB port. A battery is included, so the sensor does not necessarily need to be attached to a power source for use.

2.3.2. Digital sensor

The sensor can be connected to a Windows system by means of a USB cable. Charging is possible via the USB port. A battery is embedded, so the sensor does not necessarily need to

be attached to a power source for use. Additionally, a digital input/output can be used to attach the sensor to an external control device, e.g. a wireless transmitter.

2.3.3. Analog sensor

The sensor can be connected to a Windows system by means of a USB cable. A battery is not included, so the sensor must be attached to a power source via the USB port for use. Additionally, an analog output can be used to attach the sensor to an external control device, e.g. a climate computer.

2.4. Display and buttons

In the picture below the basic sensor screen is shown, as well as the buttons with their names as being used in this manual.
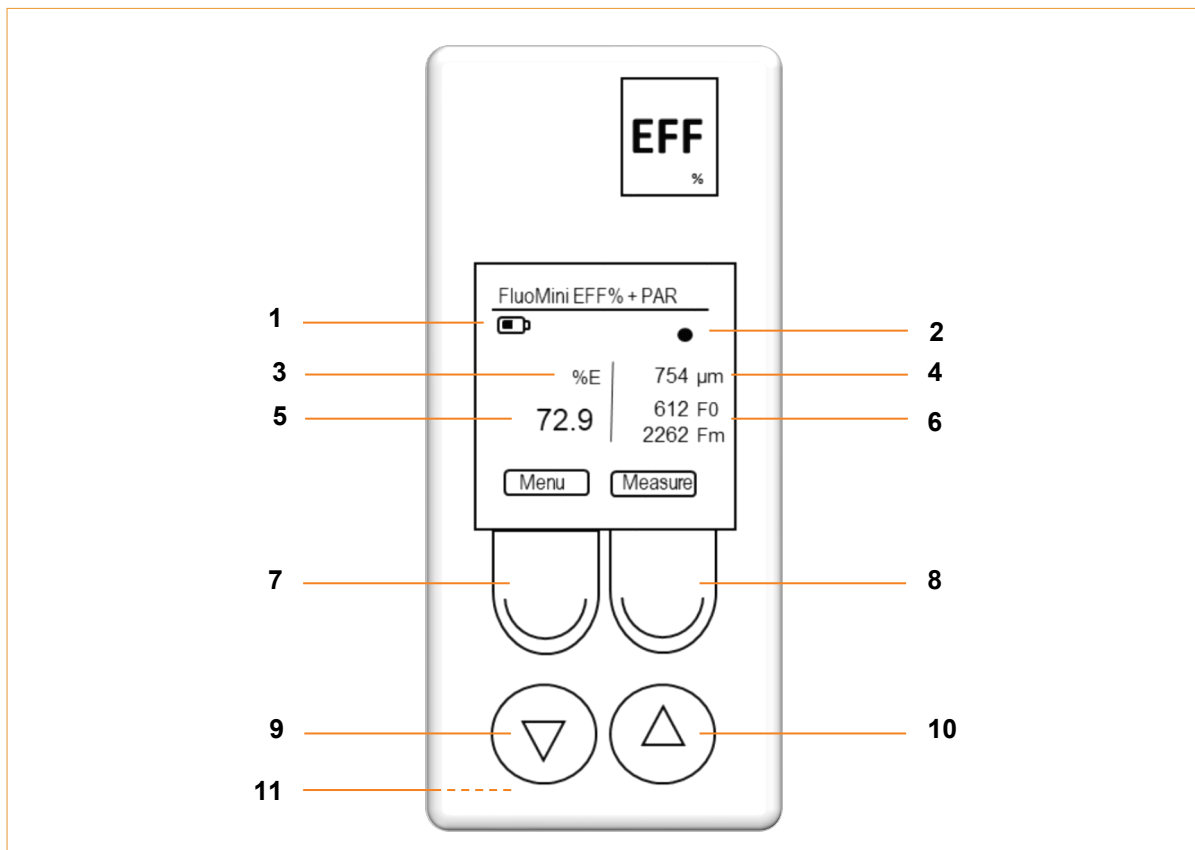
1	Battery indicator
2	Measurement indicator
3	Photosynthesis efficiency measurement unit
4	Measured photosynthetically active radiation (PAR)
5	Measured photosynthesis efficiency (Eff%)
6	Measured fluorescence intensities (F_0 & F_m)

7	**Menu/Exit button** With this button the main menu can be entered, and every menu can be quit. The feature of this button is always visible on the display (bottom left).
8	**Measure/Enter button** This button is used to end the standby mode. This and additional features of this button are always visible on the display (bottom right). This button has several features, but for simplicity, it is named Measure/Enter button throughout this manual.
9	**Down button**
10	**Up button**
11	**Reset button** This button is located on the back of the sensor and resets the sensor to factory settings. It is protected by a white plastic screw which needs to be unscrewed to reach the reset button with a thin device.

3. Measuring with the FluoMini Pro Optical Eff% + PAR Sensor

3.1. Measurement principle

The FluoMini Optical Eff% + PAR Sensor is based on the measurement of the so-called F_0 and F_{max} (F_m) of the chlorophyll fluorescence induction when a saturation light pulse is administered to a plant. F_0 is measured just before administering the saturating light pulse and F_m is determined during the saturating light pulse. The saturating light pulse directly affects the photosynthetic apparatus. This becomes apparent when measurements are done and saturating light pulses are administered too short after each other, the photosynthetic apparatus responds to the raised averaged. It is therefore required when the sensor has to function as logger or monitoring instrument to specially pay attention to measurement interval, mode and saturation pulse height. With the photosynthesis efficiency and the PAR level, an indication can be obtained about the captured CO2. Some precautions are necessary amongst which are photorespiration. When conditions are not extreme however this indication can be very representative for CO2 capturing

3.2. Ending the standby mode

3.2.1. Handheld sensor

To save energy the sensor display automatically turns off after 30 seconds. During battery operation, the sensor will automatically go into standby mode after 1 min. The sensor will wake up again when the Measure/Enter button is pressed. When the sensor is attached to a computer or external power source, it will not turn into standby mode, only the display will turn off. If the sensor is in logging mode, the sensor turns off after each measurement.

3.2.2. Digital sensor

When the sensor is connected to an external control device (e.g. a computer) through the USB port, it will wake up when the Measure/Enter button is pressed. From that moment on, it will respond like a regular handheld sensor. When the sensor is connected through the serial digital port it will operate in a special mode. For more information about running the sensor through the digital port please contact Sendot Research *via* phone (+31 (0)30-636-8477) or e-mail (info@sendot.nl).

3.2.3. Analog sensor

This sensor has no battery why it always must be attached to a power source to operate. The sensor display automatically turns off after 30 seconds. When the sensor is connected to an external control device (e.g. a computer) through the USB port, it will operate as a regular handheld sensor. When it is connected *via* the analog port it will also never turn into standby mode. As soon as the sensor is coupled to an external control device it will start measuring with the interval specified in the sensor and output the analog value through the port.

3.3. Measurement

Apply the leaf clip to a leaf without burdening the leaf. The leaf surface should be put in the desired position, if a leaf is too weak to support the leaf-clip please use the leaf-clip support to keep the leaf in the desired position, (Remark: leaves in the top of the plant best exposed to light show the highest photosynthetic activity)

3.3.1. Single measurement

1. Press the Measure/Enter button to activate the sensor.

2. Press the Measure/Enter button again to start a single measurement.

> **Tip:** The sensor will store single measurements not automatically. This can be changed. For further information see chapter 4.2.3.

3.3.2. Continuous measurements

In continuous measurement mode the sensor will perform a measurement every 2 seconds (see also paragraph 3.1). To activate this mode:

1. Press the Measure/Enter button to activate the sensor.

2. Press the Measure/Enter button for 2 seconds to start continuous measurements.

3. Press the Measure/Enter button for 2 seconds to stop continuous measurements.

(Remark: Operating the sensor in this mode will certainly affect the measured photosynthetic efficiency and should only be used when measurement results are not relevant)

> **Tip:** The sensor will store measurements not automatically. This can be changed. For further information see chapter 4.2.3 and 4.3.

3.4. Logger and transmitter function

With this sensor it is possible to measure continuously. In case of a handhold and digital sensor, the data is stored on the internal memory (for further information on this function see chapter 4.3). In case of an analog sensor, the data is send to an external device, e.g. a computer (for further information on this function see chapter 4.4). Both in logger mode as well as in analog mode setting of day/night measurement interval should be paid attention to.

4. Settings

4.1. Main menu

The main menu can be entered by pressing the Menu/Exit button. The screen with the different setting options will be opened.

The main menu consists of four submenus: <General settings>, <Logger settings>, <Sensor settings>, and <System info>. To navigate towards any menu, use the Up and Down buttons and enter a submenu with the Measure/Enter button.
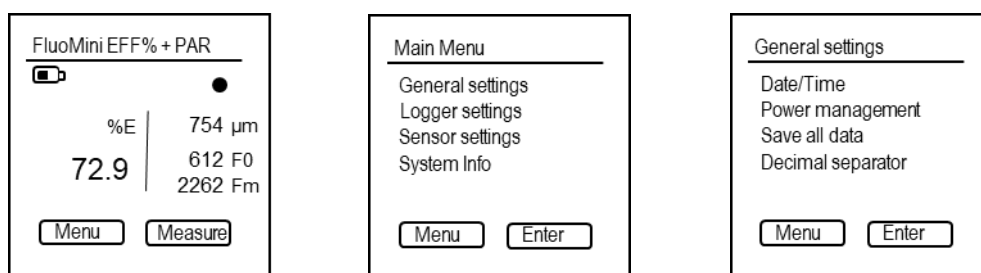

4.2. General settings

The menu <General settings> contains submenus to set date and time, control power management, save data and change the decimal separator. Use the Up and Down buttons to navigate to the desired submenu. To enter a submenu, press the Measure/Enter button.

4.2.1. Date/Time

In this menu, date and time can be set manually. Alternatively, date and time can be synchronized with the current date and time on the computer using the FluoMini Sensor Software Suite (for further information see manual for FluoMini Sensor Software Suite). Default, date and time are set to 0:00:00, 01/01/1999 and must be set after a restart due to an empty battery or a hard reset (pressing Menu/Exit button and Measure/Enter button parallel for 30 sec).

1. Open the menu <General settings>.

2. Open the menu <Date/Time>.

3. Use the Up and Down buttons to set date and time.

4. Use the Measure/Enter button (Next) to navigate to the next position in date and time.

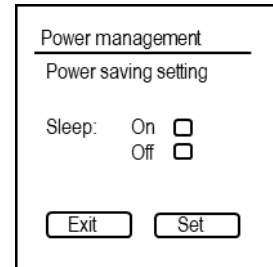5. Confirm settings and close menu with the Measure/Enter button.
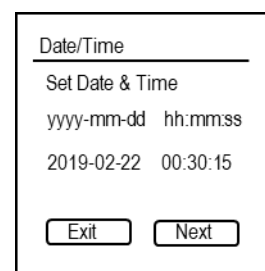
4.2.2. Power management

I In this menu, the standby mode can be turned on and off. Default, this function is turned on, so the sensor will turn into standby mode after 30 sec.

1. Open the menu <General settings>.

2. Open the menu <Power management>.

3. Use the Up and Down buttons to choose the desired setting.

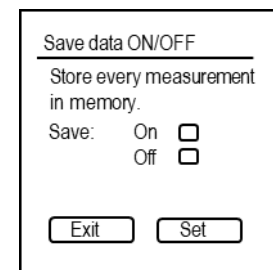4. Confirm setting and close menu with the Measure/Enter button (Set).

```
Power management
Power saving setting

Sleep:     On   ☐
           Off  ☐

[ Exit ]     [ Set ]
```

4.2.3. Save data

In this menu, automatic storage of every measurement can be turned on and off. Default, this function is turned off.

1. Open the menu <General settings>.

2. Open the menu <Save all data>.

3. Use the Up and Down buttons to choose the desired setting.
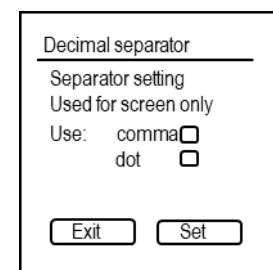
4. Close menu with the Measure/Enter button (Set).

```
Save data ON/OFF
Store every measurement
in memory.
Save:      On   ☐
           Off  ☐

[ Exit ]     [ Set ]
```

4.2.4. Decimal separator

In this menu, the decimal separator for values shown on the screen can be changed.
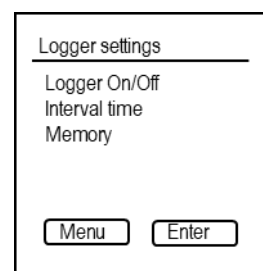
1. Open the menu <General settings>.

2. Open the menu <Decimal separator>.

3. Use the Up and Down buttons to choose the desired setting.

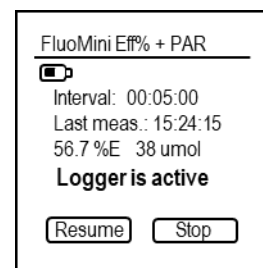4. Confirm setting and close menu with the Measure/Enter button (Set).

```
Decimal separator
Separator setting
Used for screen only
Use:     comma ☐
         dot   ☐

[ Exit ]     [ Set ]
```

4.3. Logger settings (handheld/digital)

With the logger function continuous measurements are performed and stored internally. Within the menu <Logger settings> the logger function can be turned on and off, the interval time of the measurements can be set, or the stored data erased. Use the Up and Down buttons to navigate to the desired submenu. To enter a submenu, press the Measure/Enter button.

Remark: If the sensor is in logging mode, it is not possible to communicate with the sensor through an external device, e.g. a computer. Logging must be stopped first to communicate with the sensor. Nevertheless, by pressing the Measure/Enter button the last measured value will be visible on the display.

4.3.1. Logger On/Off

In this menu, the logger function can be turn on and off.

1. Open the menu <Logger settings>.

2. Open the menu <Logger On/Off>.

3. Use the Up and Down buttons to choose the desired setting.

4. Confirm the setting with the Measure/Enter button (Set).

5. Exit menu with the Menu/Exit button. Logging will start automatically.
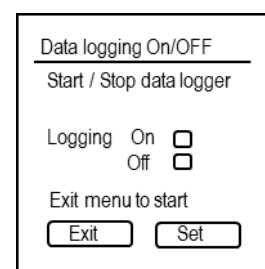
If date and time have not been set in advance, the sensor will show an error (Date & Time not set.). In this case, the logger function can still be started, if wanted. To start the logger function, press the Measure/Enter button (Ignore) or wait for 5 sec. The start date and time will be set to 00:00, 01/01/1999. Another option is to cancel the logger function by pressing the Menu/Exit button (Cancel). Now, date and time can be set before the logging function is started again (see chapter 4.2.1).

4.3.2. Interval time

In this menu, the time interval between the measurements during logging can be changed. It is possible to set the interval separately for a day and night mode. By measuring the PAR, the

FluoMini Pro Eff% + PAR Sensor will automatically recognize if it is day or night (PAR level = 0) and switch between these two intervals. Default, the interval time is set to 15 min during the day and 1 h during the night. For most applications, these interval times are sufficient, shorter intervals could cause damage to the leaf. The interval time should be set before the first use of the sensor.

1. Open the menu <Logger settings>.

2. Open the menu <Interval time>.

3. Use the Up and Down buttons to change the value.

4. Use the Measure/Enter button (Next) to navigate to the next position in time (hh:mm:ss) for both the day and the night interval.

5. Confirm the setting and close menu with the Measure/Enter button.
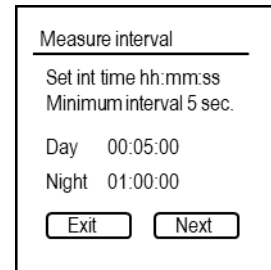
Remark: The interval time for the <u>digital</u> FluoMini Pro Eff% + PAR Sensor can be controlled through an external device. In this case, the interval times set within this menu are not valid. When the sensor is hooked up to a SenBox the day/night interval is controlled by the SenBox

4.3.3. Memory

In this menu, the storage volume in total as well as used by stored data can be read. The stored data can be deleted.

1. Open the menu <Logger settings>.

2. Open the menu <Memory>.

3. Use the Up and Down buttons to choose the desired setting.

4. Confirm the setting and close menu with the Measure/Enter button (Set).
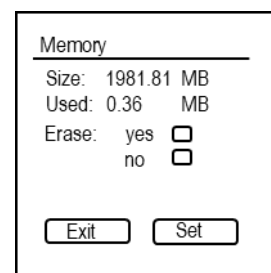
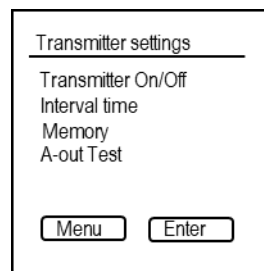It is advisable to use the FluoMini Sensor Software Suite to store the data on a computer before the data is deleted from the sensor's memory.

4.4. Transmitter settings (analog)

With the transmitter function continuous measurements are performed and send to an external device, e.g. computer. Within the menu <Transmitter settings> the transmitter function can be turned on and off, the interval time of the measurements can be set, stored data erased and the analog output being tested. Use the Up and Down buttons to navigate to the desired submenu. To enter a submenu, press the Measure/Enter button.

```
┌─────────────────────────────┐
│ Transmitter settings        │
│ ─────────────────────────   │
│ Transmitter On/Off          │
│ Interval time               │
│ Memory                      │
│ A-out Test                  │
│                             │
│                             │
│   ┌────────┐  ┌────────┐    │
│   │ Menu   │  │ Enter  │    │
│   └────────┘  └────────┘    │
└─────────────────────────────┘
```

4.4.1. Transmitter On/Off

In this menu, the transmitter function can be turn on and off.

1. Open the menu <Transmitter settings>.

2. Open the menu <Transmitter On/Off>.

3. Use the Up and Down buttons to choose the desired setting.

4. Confirm the setting with the Measure/Enter button (Set).

```
┌──────────────────────────┐
│ Transmitter On/OFF        │
│ ──────────────────────    │
│ Start / Stop transmitter  │
│                           │
│ Transmit  On  ☐           │
│           Off ☐           │
│ Exit menu to start        │
│ ┌──────┐   ┌──────┐       │
│ │ Exit │   │ Set  │       │
│ └──────┘   └──────┘       │
└──────────────────────────┘
```

5. Exit menu with the Menu/Exit button. Transmitting will start automatically.
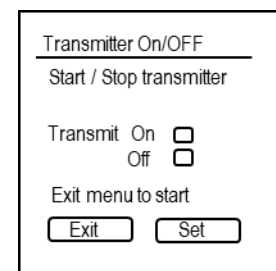
If date and time have not been set in advance, the sensor will show an error (Date & Time not set.). In this case, the transmitter function can still be started, if wanted. To start the transmitter function, press the Measure/Enter button (Ignore) or wait for 5 sec. The start date and time will be set to 00:00, 27/01/2000. Another option is to cancel the transmitter function by pressing the Menu/Exit button (Cancel). Now, date and time can be set before the logging function is started again (see chapter 4.2.1).

4.4.2. Interval time

In this menu, the time interval between the measurements transmitted can be changed. It is possible to set the interval separately for a day and night mode. By measuring the PAR, the FluoMini Pro Eff% + PAR Sensor will automatically recognize if it is day or night and switch

between these two intervals. Default, the interval time is set to 5 min during the day and 1 h during the night. For the most applications, these interval times are sufficient and lower shorter intervals could cause damage to the plant. The interval time should be set before the first use of the sensor.

1. Open the menu <Transmitter settings>.

2. Open the menu <Interval settings>.

3. Open the menu <Interval time>.

4. Use the Up and Down buttons to change value.

5. Use the Measure/Enter button (Next) to navigate to the next position in time (hh:mm:ss) for both the day and the night interval.

6. Confirm the setting and close menu with the Measure/Enter button.
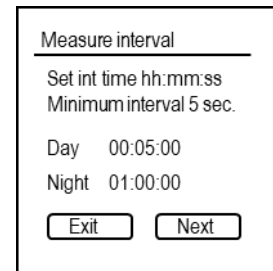
4.4.3. A-out Test

This function only applicable for analog sensors and is to test the analog output signal send to an external device, e.g. computer.

1. Open the menu <Transmitter settings>.

2. Open the menu <A-out Test>.

3. Use the Up and Down buttons to set a value.

4. Confirm the value with the Measure/Enter button (Set). A signal will be sent to the external device, which is translating it into Eff%.

5. Compare this value with the Eff% on the external device. Here, 4 – 20 mA are translated to 0 – 100 % for photosynthesis efficiency and 0 – 2500 µmol/s for PAR. Therefore, a change of 1 mA relates to a change of 6.25 % for photosynthesis efficiency and 156.25 µmol/s for PAR.
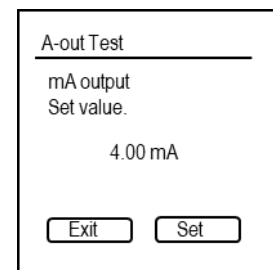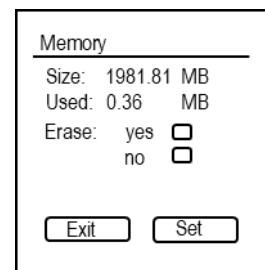
4.4.4. Memory

In this menu, the storage volume in total as well as used by stored data can be read. The stored data can be deleted as followed:

1. Open the menu <Transmitter settings>.

2. Open the menu <Memory>.

3. Use the Up and Down buttons to choose the desired setting.

4. Confirm setting and close menu with the Measure/Enter button (Set).

```
Memory
 Size:  1981.81 MB
 Used:  0.36    MB
 Erase:   yes  ☐
          no   ☐

 [ Exit ]    [ Set ]
```
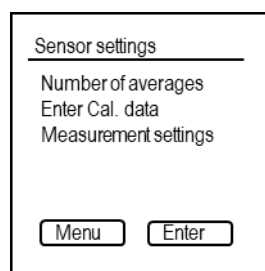
Remark: It is advisable to use the FluoMini Sensor Software Suite to store the data on a computer before the data is deleted from the sensor's memory.

4.5. Sensor settings

Within this menu, the sensor PAR calibration can be set manually.

```
Sensor settings
 Number of averages
 Enter Cal. data
 Measurement settings



 [ Menu ]   [ Enter ]
```

4.5.1. Number of averages

It is possible to change the amount of LED pulses which are averaged for the measurements of F_0 and F_m by changing the number of averages. On the one hand, a higher number leads to less noise and therefore, a smoother graph. On the other hand, this number should not be too high, because this can influence the measured Eff%. Numbers higher than 8 (default setting) are might lead to such an influence. Averaging can be especially useful when measuring under dimmable/pulsed LED-lamps. The steep edges of these illumination pulses cause a high variation in the measurement which can be averaged out with this option.

1. Open the menu <Sensor settings>.

2. Open the menu <Number of averages>.

3. Use the Up and Down buttons to adjust the number of averages.

4. Confirm the setting with the Measure/Enter button (Set).

```
Measurement settings
Number of averages

     [ 8 ]

[ Exit ]   [ Set ]
```

4.5.2. Enter Cal. data

In this menu, you can add an offset and slope to the measured PAR. Therefore, a reference PAR sensor is necessary. The slope is adjusted until the measurement value matches the measured reference value (± 20 µmol). An offset is for this sensor not necessary.

> **Remark:** It is possible to calibrate the PAR sensor for a specific lighting environment. This makes it necessary to compare the PAR level of a light source measured with a suitable detector next to the read-out of the FluoMini Eff% + PAR sensor. Take care to position the Eff% + PAR probe like the reference sensor with respect to angle, height.

1. Open the menu <Sensor settings>.

2. Open the menu <Enter Cal. data>.

3. Use the Up and Down buttons to adjust slope (offset is for this sensor not necessary).

4. Use the Measure/Enter button (Next) to navigate to the next position.

5. Confirm settings and close the menu with the Measure/Enter button.

6. Exit the menu completely with the Menu/Exit button.

7. Make a measurement using the Measure/Enter button. If the PAR value deviates more than 20 µmol from the measured value of the reference PAR sensor, repeat step 1 – 6 until the values match.

```
Enter cal data
Set Slope & Offset
            Slope   Offset
PAR :        76       0

[ Exit ]    [ Next ]
```

4.5.3. Measurement settings

In this menu, you can adjust the intensity of the saturating pulse and the number of samples taken to determine F_m (sample mode).

1. Open the menu <Sensor settings>.

2. Open the menu <Measurement settings>.

3. Use the Up and Down buttons to adjust the measurement light.

4. Confirm the setting with the Measure/Enter button (Set).

5. Use the Up and Down button to choose a sample mode. 0 is auto (here the internal software determines every 100 ms if the measured fluorescence is still rising, it will stop the measurement after a decrease in measured fluorescence is detected. The maximum number of measurements is 10. If a number is chosen here, the sensor measures F0 and consecutively takes between 1 (minimum) and 10 (maximum) samples separated 100 ms during the saturation puls.

6. Confirm settings and exit the menu with the Measure/Enter button (Set).
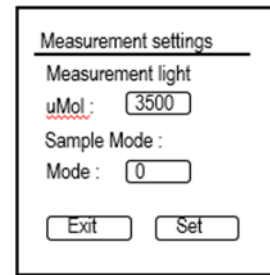
4.6. System info

The menu System info contains information about the FluoMini type, the installed firmware, the battery voltage and the baud rate necessary to communicate with the sensor. Additionally, the sensor can be named using the FluoMini Software Suite (for further info see manual for FluoMini Software Suite). In this menu, the given name is visible.
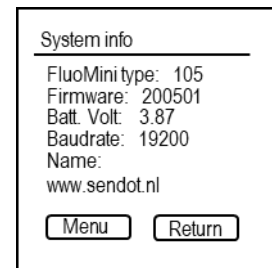
4.7. Test target

To check the functioning of the photosynthesis measurement part of the sensor the accompanied test target can be used. Place the test target in leaf-clip and do a measurement. The resulting F0 and Fm visible in the display should lie between 300 and 600 when the saturation pulse setting is on 2500 umol/m2.s. If this is not the case check the fiber distance and/or clean the fiber tips carefully with a soft moist cloth.

4.8. Fiber Distance tool

In case the leaf clip has to be removed, the distance of the fiber to the targets can be set by using the Fiber distance tool.

1. Unscrew the fibers and retract them slightly.

2. Place the fiber distance tool.

3. Push the fibers such that they touch the surface of the tool

4. Tighten the screws

5. Troubleshooting

The display stays black and the sensor is not reacting anymore.

1. Recharge the sensor using the included USB cable. The battery might be empty.

2. If the sensor is still not responding, reset the sensor by pressing the Up and Down button at the same time for 2 sec.

3. If the sensor still not reacts, the sensor can be reset to factory settings by pressing the Up and Down button at the same time for 30 sec.

4. If the sensor still not reacts, press the reset button on the back of the sensor. Therefore, screw of the white plastic screw on the back of the sensor. Use a thin plastic or metal device, e.g. an open paper clip, to carefully press the button. Close the hole with the screw again.

5. If there is still no response, please contact Sendot Research *via* phone (+31 (0)30-636-8477) or e-mail ((info@sendot.nl).

The following errors can be visible on the display:

Low signal & measured value is written in red

1. Check, if the leaf clip is still attached to a leaf.

2. Check, if the leaf clip is attached to a dead part of the leaf.

3. Check, if the fibers are properly attached to the sensor and not switched.

4. If this message is still shown, one of the fibers might be broken. In this case the fiber needs to be exchanged. Therefore, please contact Sendot Research *via* phone (+31 (0)30-636-8477) or e-mail (info@sendot.nl).

Error opening logfile

1. Check if the sensor is properly attached to the computer. Reattach the sensor and press refresh in the menu Sensors in the FluoMini Software Suite.

2. If date & time of the logging strongly changes, reading the logfile might not be possible. This can happen, if the time has been changed between two log sessions or if the sensor logged once without a set time & date, followed by logging with set time & date.

It is advisable to set time & date before the first log. If the time changes (e.g. different time zone), the memory should be emptied in between.

No SD card

1. The communication between the sensor and the internal memory is interrupted. Please contact Sendot Research *via* phone (+31 (0)30-636-8477) or e-mail ((info@sendot.nl).

Red battery icon

This icon is showing that the battery is empty. In this case the sensor needs to be recharged with the included USB cable.