

FluorPen FP 100

Series

Operation Manual

*For: FluorPen FP 100
FluorPen FP 100-MAX
PAR-FluorPen FP 100-MAX-LM
FluorPen FP 100-B
FluorPen FP 100-U
FluorPen or PAR-FluorPen
with detachable leafclips*



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1. Technical Specification

Measured and Calculated Parameters:

Fo, Ft, Fm, Fm', QY, NPQ 1*, NPQ 2*, OJIP*, LC 1*, LC 2*, PAR**

Cosine Correction**:

Cosine corrected up to 80° angle of incidence

Linearity**:

Maximum deviation of 1 % up to per 10,000 $\mu\text{mol s}^{-1} \text{m}^{-2}$

Saturating Light:

Adjustable from 0 to 3,000 $\mu\text{mol}(\text{photons})/\text{m}^2.\text{s}$ (0 to 100 %)

Actinic Light:

Adjustable from 0 to 1,000 $\mu\text{mol}(\text{photons})/\text{m}^2.\text{s}$ (0 to 100 %)

Measuring Light:

Adjustable from 0 to 3,000 $\mu\text{mol}(\text{photons})/\text{m}^2.\text{s}$ (0 to 100 %)

Detector Wavelength Range:

PIN photodiode with 697 to 750 nm bandpass filters

Communication:

Bluetooth, USB, or serial (not included in the FluorPen FP 100)

FluorPen 1.0 Software:

Windows 2000, XP, or higher compatible***

Memory Capacity:

Up to 4 Mb

Internal Data Logging:

Up to 100,000 data points

Display:

2 x 8 characters LC display

Keypad:

Sealed, 2-key tactile response

Keypad Escape Time:

Turns off after 3 minutes of no use

Power Supply:

4 AAA alkaline batteries (single use or rechargeable)

Battery Life:

48 hours typical with full operation

Low Battery Detection:

Low battery indication displayed

Size:

120 mm x 57 mm x 30 mm

4.7" x 2.2" x 1.2"

Weight:

180 g, 6.5 oz

Sample Holder:

Mechanical leaf clip (non-destructive for plants, effective for sample pre-darkening)

Operating Conditions:

Temperature: 0 to 55 °C; 32 to 130 °F Relative humidity: 0 to 95 % (non-condensing)

Storage Conditions:

Temperature: -10 to +60 °C; 14 to 140 °F Relative humidity: 0 to 95 % (non-condensing)

Warranty:

1 year parts and labor (see the last page of this Operation Manual for precise conditions)

* Only in the FluorPen FP 100-MAX or PAR-FluorPen FP100-MAX-LM.

** Only in the PAR-FluorPen FP100-MAX-LM.

*** Windows is a registered trademark of Microsoft Corporation.

The Bluetoothmodule BlueNiceCom III is endowed with a declaration of conformity with the following norms:

EN 300 328 V1.6.1 (2004-11)

EN 301 489-1, -3 V1.5.1 (2003-12)

EN 50371 December 2002

EN60650

FCC Part 15.247

FCC Grantee Code: R7T

Bluetooth Qualified Product Notice:

GRA_013_04

Bluetooth Listing Identifier: B01572

2. General Information

FluorPen is a portable, battery-powered fluorometer that enables quick and precise measurement of chlorophyll fluorescence parameters in the laboratory, greenhouse, or in the field. It can be effectively used for studying photosynthetic activity, stress detection, herbicide testing, or mutant screening. Affordable price and straight-forward two-button operation makes the FluorPen a perfect tool for teaching photosynthesis. Because of its rapid measurement capability and large internal memory, the FluorPen is also an invaluable tool for large plant-screening programs.

PAR-FluorPen FP 100-MAX-LM includes all features of the FluorPen FP 100-MAX, i.e., it measures chlorophyll fluorescence parameters Ft, QY, NPQ, OJIP, and Light Curve (QY).

Besides that, the PAR-FluorPen incorporates an integrated **Light Meter** for direct digital readouts of Photosynthetically Active Radiation (PAR) in the range from 400 to 700 nm, the span in which plants use energy during photosynthesis. PAR is measured as Photosynthetic Photon Flux Density (PPFD), which is indicated by units of quanta (photons) per unit time per unit surface area. The sensor has a uniform response to photons withing the 400-700 nm waveband. Instant readouts are provided as average values of 20 measurements.

Measured data are sequentially stored in the internal FluorPen or PAR-FluorPen memory. Data transfer to a PC is via USB or Bluetooth communication. Comprehensive FluorPen 1.0 software provides data transfer routines and many additional features for data presentation in tables and graphs.

FluorPen versions:

FluorPen FP 100-MAX

Includes one of the communication modules (Bluetooth, USB, or serial), FluorPen 1.0 software, protocol update, user's guide. Measures Ft, QY, NPQ, OJIP, and Light Curve. Equipped with a standard leaf-clip.

FluorPen FP 100-MAX-D

Includes one of the communication modules (Bluetooth, USB, or serial), FluorPen 1.0 software, protocol update, user's guide. Measures Ft, QY, NPQ, OJIP, and Light Curve. Adapted for use with detachable leaf-clips; leaf clips sold separately.

FluorPen FP 100-MAX-W

This version of the FluorPen FP 100-MAX is equipped with a special open leaf-clip that enables measurements in ambient light. The open leaf-clip may is supplied with a cover for short term dark adaptation of measured samples.

FluorPen FP 100

Standard FluorPen version with no PC communication. Data are saved to the device internal memory only.

FluorPen FP 100-B

Standard FluorPen version supplemented with Bluetooth communication module and FluorPen 1.0 software for data transfer to a PC.

FluorPen FP100-U

Standard FluorPen version supplemented with USB communication module and FluorPen 1.0 software for data transfer to a PC.

PAR-FluorPen FP 100-MAX-LM

Includes an integrated Light Meter, one of the communication modules (Bluetooth, USB, or serial), FluorPen 1.0 software, protocol update, and user's guide. Measures Ft, QY, NPQ, OJIP, Light Curve, and Photosynthetically Active Radiation (PAR) in the range from 400 to 700 nm. Equipped with a standard leaf-clip.



PAR-FluorPen FP 100-MAX-LM-D

Includes an integrated Light Meter, one of the communication modules (Bluetooth, USB, or serial), FluorPen 1.0 software, protocol update, user's guide. Measures Ft, QY, NPQ, OJIP, Light Curve and Photosynthetically Active Radiation (PAR) in the range from 400 to 700 nm. Adapted for use with detachable leaf-clips; leaf clips sold separately.



FluorPen measures the following parameters:

Ft - Instantaneous Chlorophyll Fluorescence

Ft is equivalent to Fo if the leaf sample is dark-adapted.

QY - Quantum Yield

QY is a measure of the Photosystem II efficiency. In a dark-adapted leaf this is equivalent to Fv/Fm. In a light-adapted leaf it is equivalent to Fv'/Fm'.

NPQ* - Non-Photochemical Quenching

The NPQ protocol is the most typically used measuring approach to quantify photochemical and non-photochemical quenching. The measurement should be performed with a dark-adapted sample (see more in Chapter 8.E. of this Manual).

OJIP* - Chlorophyll Fluorescence Induction Kinetics

The OJIP curves enable observing major changes that occur during exposure of plants to high irradiance (see more in Chapter 8.D. of this Manual).

Light Curve*

The LC 1 and LC 2 protocols serve to describe adaptation of Quantum Yield to six or five different light levels (see more in Chapter 8.F. of this Manual).

PAR - Photosynthetically Active Radiation**

Photosynthetically Active Radiation measured as Photosynthetic Photon Flux Density (PPFD).

** Only in the FluorPen FP 100-MAX, PAR-FluorPen FP100-MAX-LM or in the FluorPen models including the protocol update (FluorPen FP 100-B, FP 100-U).*

*** Only in the PAR-FluorPen FP100-MAX-LM.*

3. List of Equipment

Carefully unpack the carton. You should have received the following items:

- **FluorPen**
- **4 AAA Alkaline Batteries**
- **Carrying Case**
- **Textile Strap for Comfortable Wearing**
- **Self-Adhesive Rubber Pads for Optics Protection** (*FP 100, FP 100-B, FP 100-U, FP 100-MAX or FP 100-MAX-W only*)
- **FluorPen Quick Guide**
- **This Owner's Manual** (*on a USB flash disc*)
- **Install USB flash disc with FluorPen software** (*FluorPens with communication only*)
- **Bluetooth Communication Module** (*FluorPen FP 100-B or FP 100-MAX* only*)
- **USB Communication Module** (*FluorPen FP 100-U or FP 100-MAX* only*)
- **Other Accessories or Optional Features** (*according to your specific order*)

* *FluorPen FP 100-MAX includes **only one** communication module (Bluetooth or USB).*

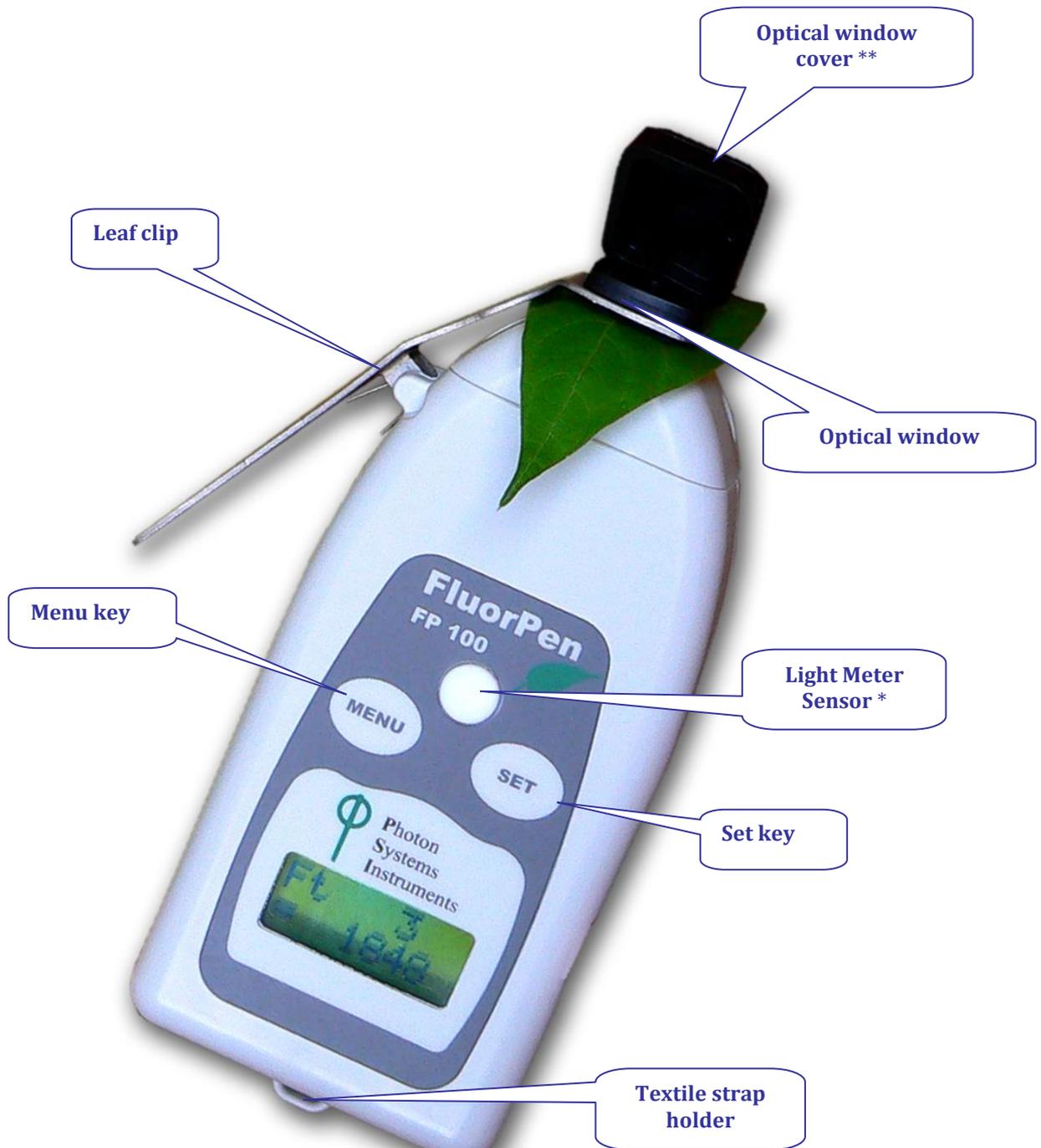


Note:

If any item is missing, please, contact PSI. Also check the carton for any visible external damage. If you find any damage, notify the carrier and PSI immediately. The carton and all packing materials should be retained for inspection by the carrier or insurer.

For customer support, please write to: support@psi.cz

4. Physical Features



* Only in the PAR-FluorPen FP 100-MAX-LM

** Only in the FluorPen FP 100-MAX-W (supplied with a special "open-window" leaf clip).

5. Accessories

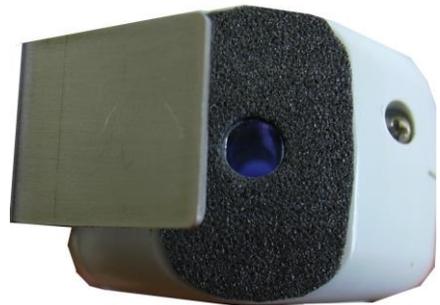
Carrying Case

The FluorPen is supplied with a carrying case which is padded to protect the instrument during transportation. You can either carry the FluorPen case over the shoulder or hang it on your belt.



Protective Rubber Pad

The optical part of the FluorPen is covered with a self-adhesive rubber pad that protects the optics from dirt or moisture. The damaged or dirty pad can be easily removed by tearing it off from the surface. To affix a new one, just remove the sheeting and stick the pad on cleaned and dried surface. Be sure that you placed the pad properly and that you did not cover the optical window.



Batteries

The FluorPen operates from four AAA single-use or rechargeable batteries. They may be easily replaced by unscrewing the cover of the battery holder on the rear of the instrument. Battery life is approximately 48 hours when the FluorPen is operated continuously.



Detachable leaf-clip

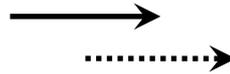
Supplementary detachable leaf-clips for use with the FluorPen FP 100-MAX-D and PAR-FluorPen FP 100-MAX-LM-D. Sample holder is a clip for gentle fixing of a leaf sample and its short duration dark adaptation. "D" version of the PAR-FluorPen with detachable leaf-clips is suitable for experiments where long term dark adaptation is needed.



6. Operation Instructions

The next six pages explain the structure of the Main Menu and three Sub-Menus with all their options.

- The blue color represents the Main Menu and its Options.
- The yellow color represents the first-level Sub-Menus and their Options.
- The green color represents the second-level Sub-Menus and their Options.
- Full-line arrows are used for the **SET** key.
- Dashed-line arrows are used for the **MENU** key.

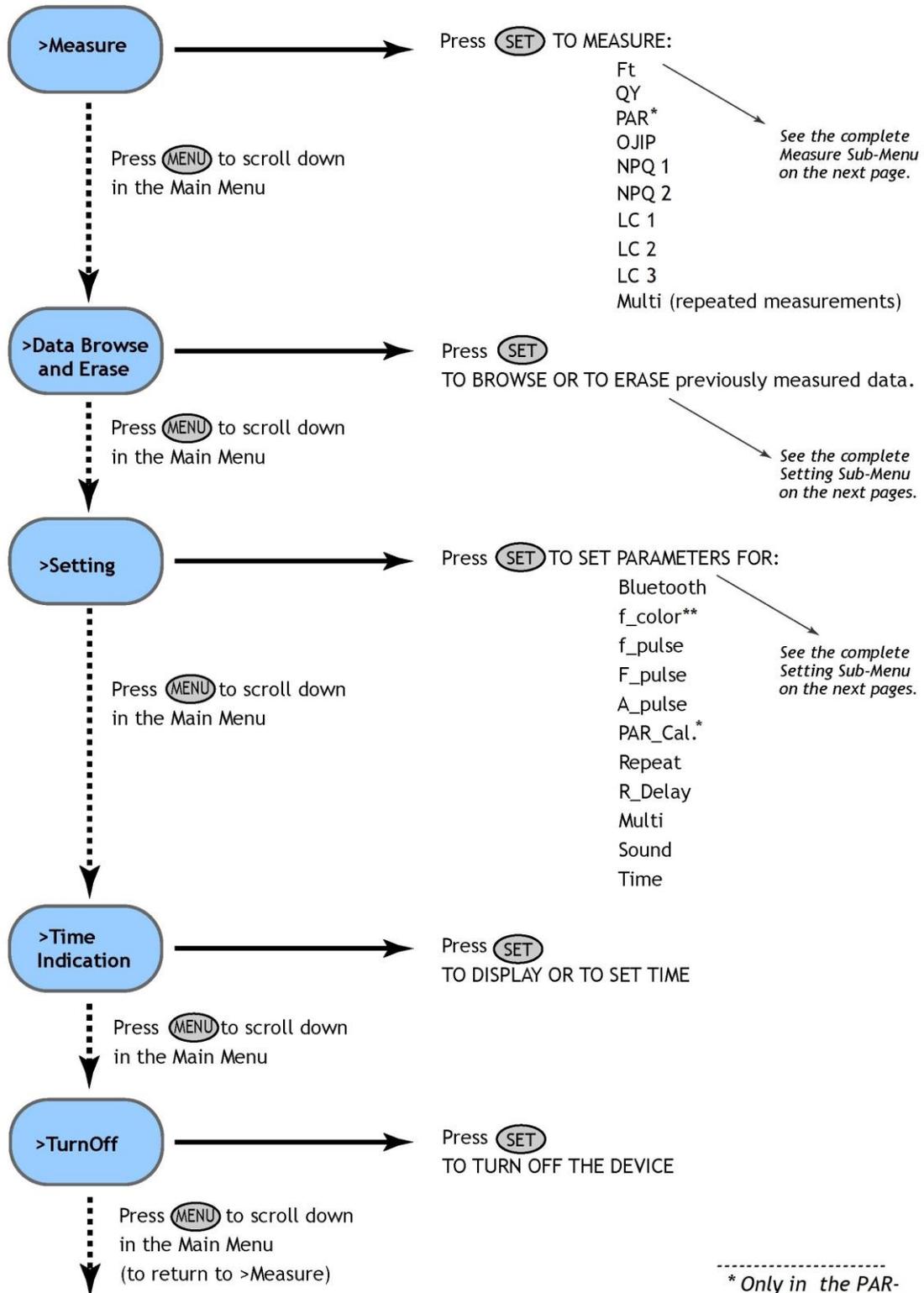


In general:

- Use the **MENU** key to scroll through sequential menu options on the digital display.
- Use the **SET** key to select a menu option based on cursor (>) position.

Main Menu

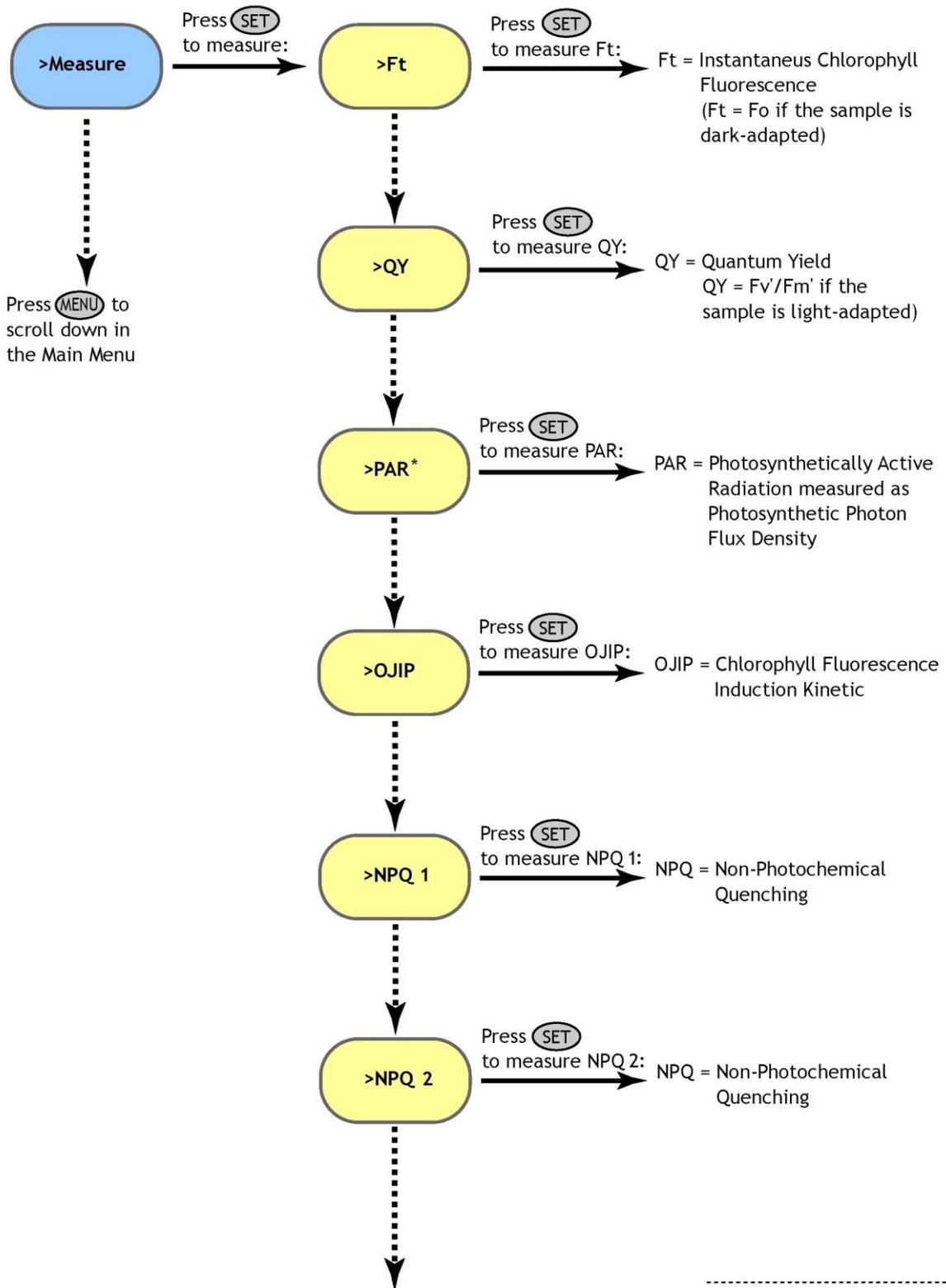
To start hold the SET key for 1 second.



 * Only in the PAR-FluorPen FP100-MAX-LM
 ** Not active.

Measure Sub-Menu - Part 1

Use the Measure Sub-Menu when measuring selected parameters.

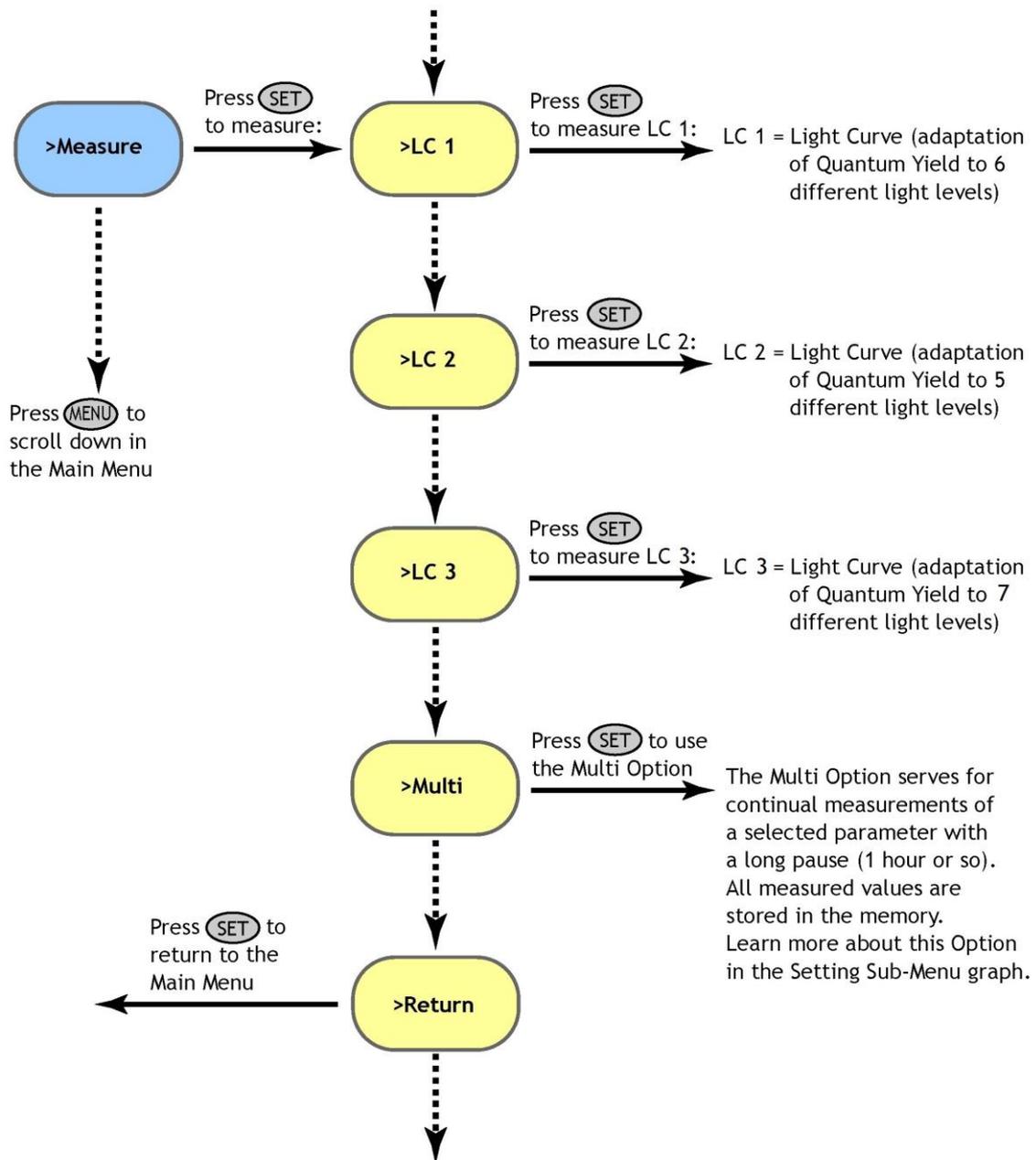


To be continued on the next page

* Only in the PAR-FluorPen FP100-MAX-LM

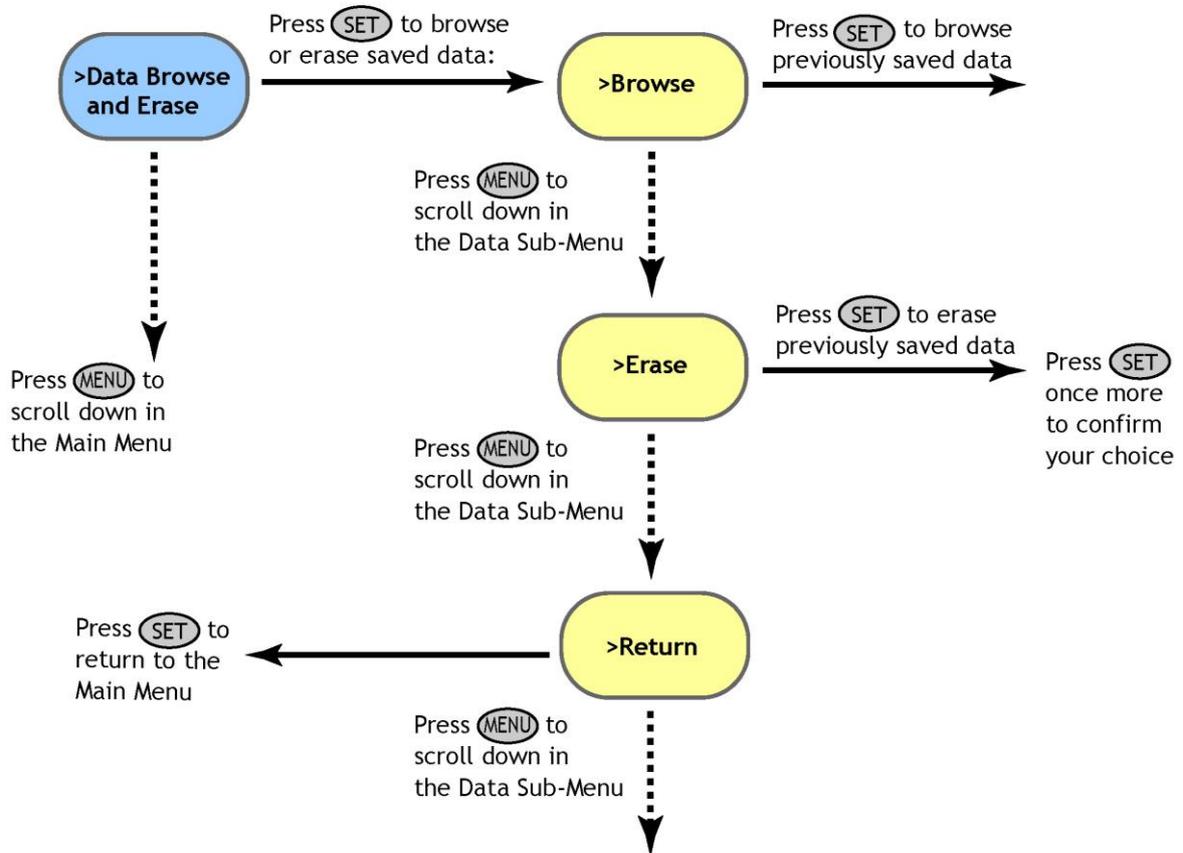
Measure Sub-Menu - Part 2

Use the Measure Sub-Menu when measuring selected parameters.



Data Sub-Menu

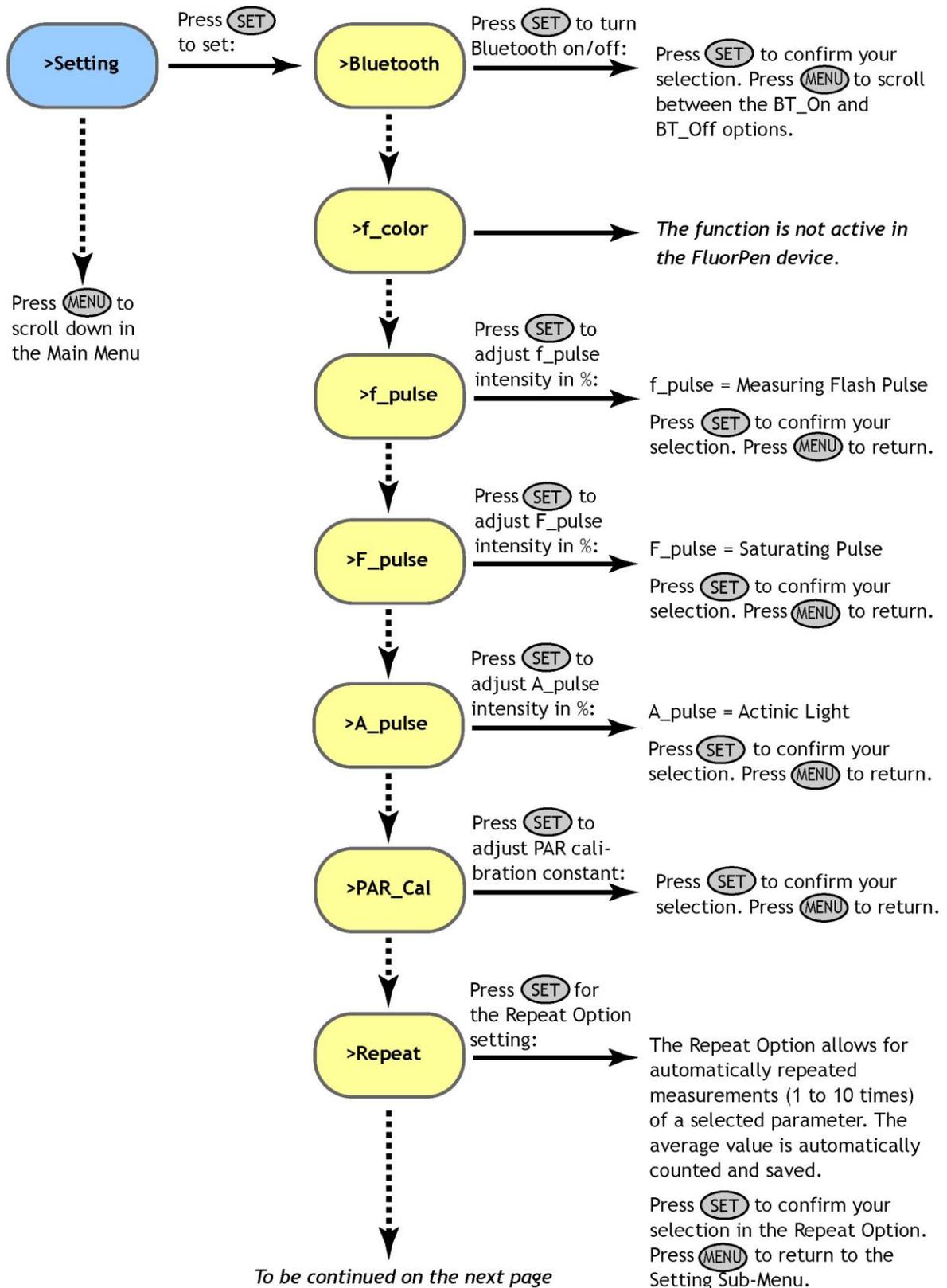
Use the Data Sub-Menu when browsing or erasing previously measured data.



IMPORTANT NOTE: Be aware that it is not possible to erase single data.
All stored data are erased!

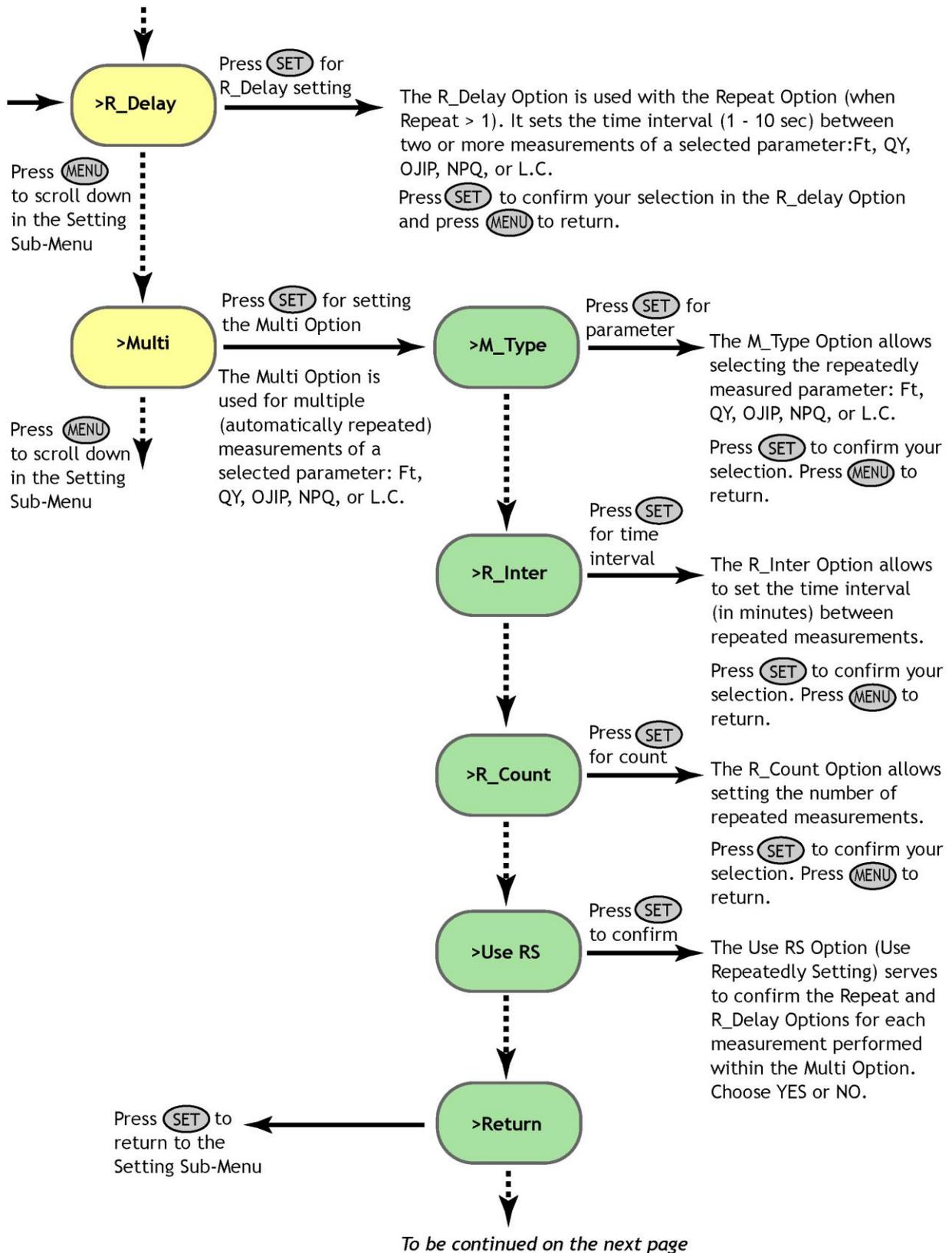
Setting Sub-Menu - Part 1

Use the Setting Sub-Menu to set the light color, light intensity, number and frequency of measurements, date, time, or the sound mode.



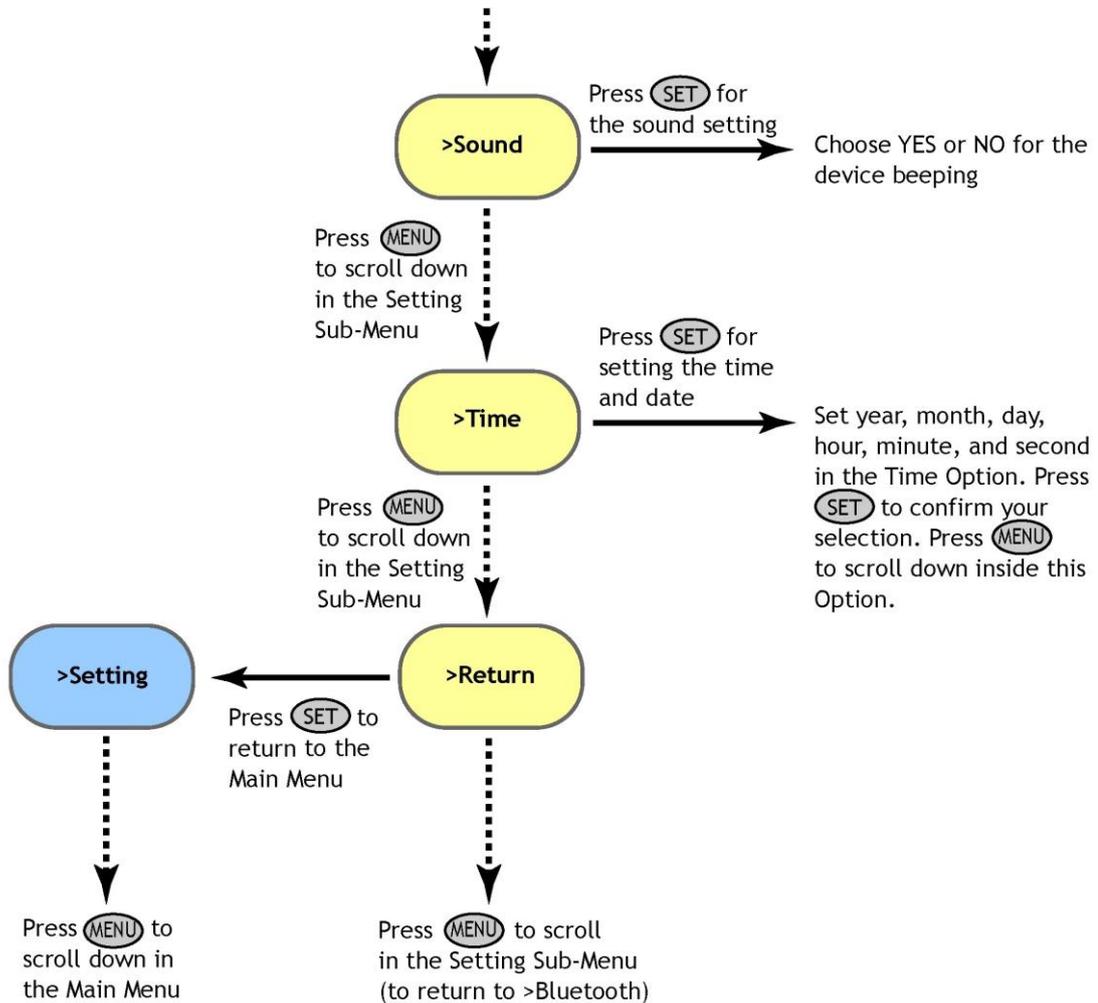
Setting Sub-Menu - Part 2

Use the Setting Sub-Menu to set the light color, light intensity, number and frequency of measurements, date, time, or the sound mode.



Setting Sub-Menu - Part 3

Use the Setting Sub-Menu to set the light color, light intensity, number and frequency of measurements, date, time, or the sound mode.



IMPORTANT NOTES: Standard setting for light intensity:

f_pulse: 30%
F_pulse: 70%
A_pulse: 30%

7. Bluetooth Pairing and Connecting

This Chapter applies to users of the **FluorPens with an incorporated Bluetooth** communication module.

7.A. General Information

What you will need first:

Before you set up the Bluetooth connection between the FluorPen and PC, make sure you have these components:

1. Bluetooth enabled FluorPen

FluorPen FP 100-MAX and **FluorPen FP 100-B** include built-in Bluetooth capabilities.

2. Bluetooth enabled PC

The PC with which you connect must have Bluetooth wireless technology, either built-in or through a Bluetooth card. Make sure that the PC's Bluetooth setting is "discoverable" (meaning that it shows up when other devices search for nearby Bluetooth connections). Consult the user guide for your PC or Bluetooth card to learn how to do this.

3. Bluetooth configuration software properly set up on PC

Before you can exchange files with your PC, you will need to set up the Bluetooth software that came with your PC, or your PC's Bluetooth card. This software varies by manufacturer. Please consult your PC's Bluetooth documentation for more information.

4. Bluetooth must be switched on visible on both devices

To pair the FluorPen with another Bluetooth device, such as a computer, you will need to ensure that Bluetooth is switched on visible on both devices.

7.B. Bluetooth Pairing

Step 1: Enabling Bluetooth in the FluorPen

Switch on the FluorPen (press and hold the SET key).

Scroll to the “Setting” menu (press the MENU key twice, then press the SET key once).

Select “BT_On” to enable Bluetooth (press the SET key).

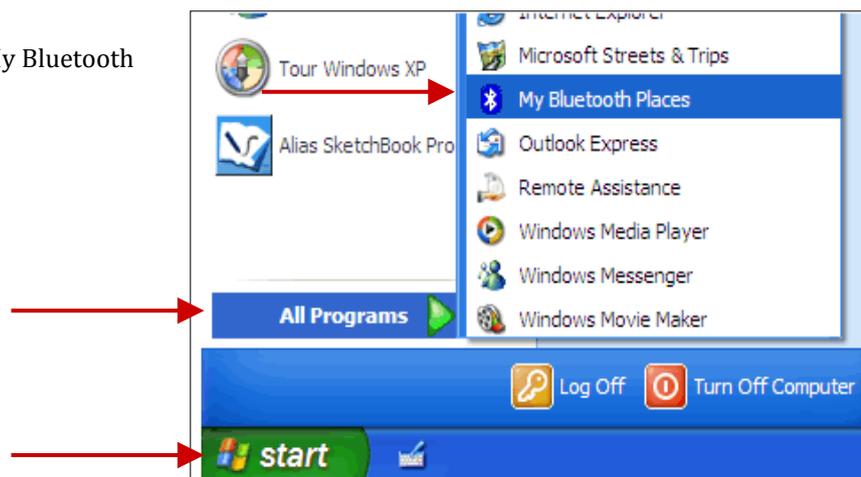
** Keep in mind that the FluorPen turns off automatically after about 3 minutes of no action. Turning off the FluorPen always turns off Bluetooth.*



Step 2: Starting the Bluetooth Application on Your PC

Be aware that this description is a general example; some of the steps may be different on your PC.

Select: Start>All Programs>My Bluetooth Places.



You may also start your Bluetooth application via the Control Panel:

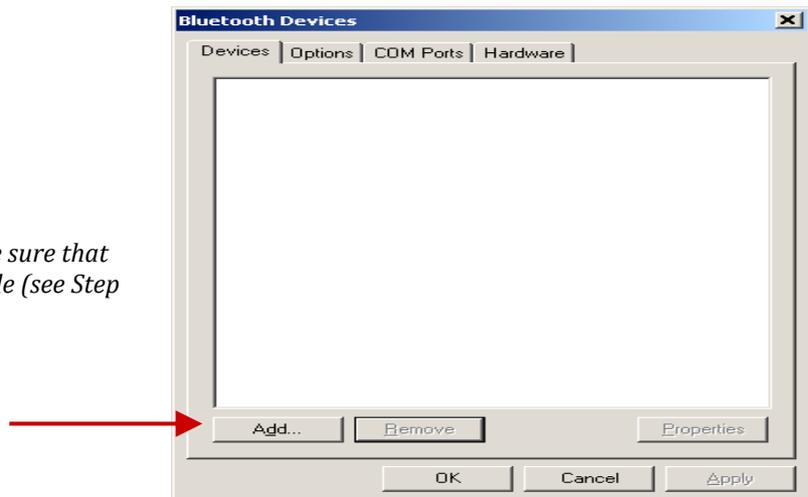
Select: Start>Settings>Control Panel>Bluetooth Devices.



Step 3: Opening the Add Bluetooth Device Wizard

Select: "Add" to start the wizard.*

* Before starting to use the wizard, be sure that the FluorPen is in discoverable mode (see Step 1).



Step 4: Searching for a New Bluetooth Device

Mark the following box: "My device is set up and ready to be found".

Select: Next.

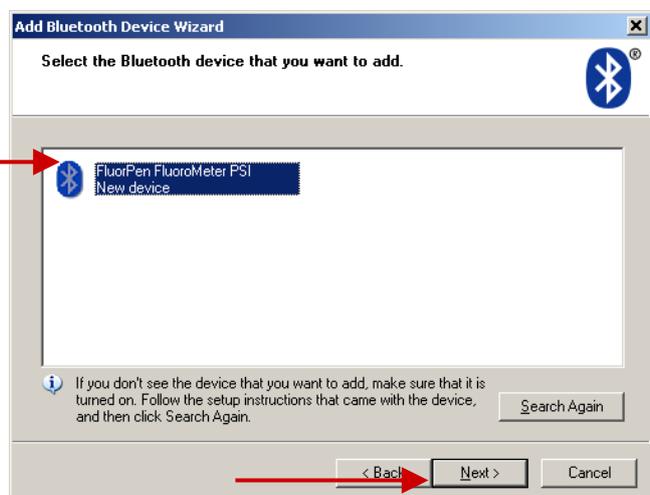


Step 5: Selecting the FluorPen

Select: Bluetooth FluorPen icon (FluorPen FluoroMeter PSI).*

Select: Next.

* Your display may show more Bluetooth Device icons.



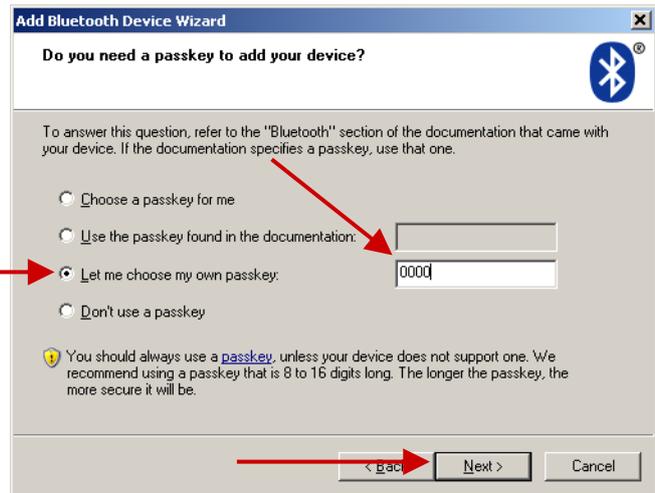
Step 6: Starting the Pairing Process

Your Bluetooth Pairing Passkey is:
0000

Select: "Let me choose my own passkey."

Enter: 0000 (four digits).

Select: Next.



Step 7: Completing the FluorPen Pairing

Select: Finish.



7.C. Bluetooth Connection

Step 1: Installing the FluorPen Software

Install the FluorPen software to your PC. Use the **CD** that came **enclosed** with your FluorPen.*

** See Chapter 8 of this Operation Manual for complete information on FluorPen software.*

Step 2: Enabling Bluetooth in the FluorPen

Switch on the FluorPen (press and hold the SET key).

Scroll to the “Setting menu” (press the MENU key twice, then press the SET key once).

Select “BT_On” to enable Bluetooth (press the SET key).*

** Keep in mind that the FluorPen turns off automatically after about 3 minutes of no action. Turning off the FluorPen always turns off Bluetooth.*

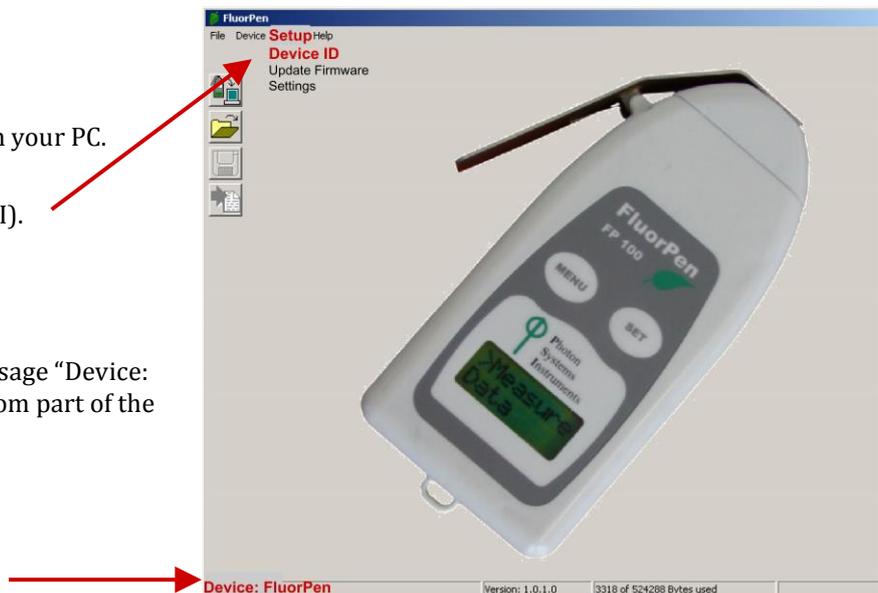


Step 3: Starting Connection

Start the FluorPen software on your PC.

Select: Setup>Device ID (Ctrl+I).

If properly connected, the message “Device: FluorPen” appears on the bottom part of the screen.

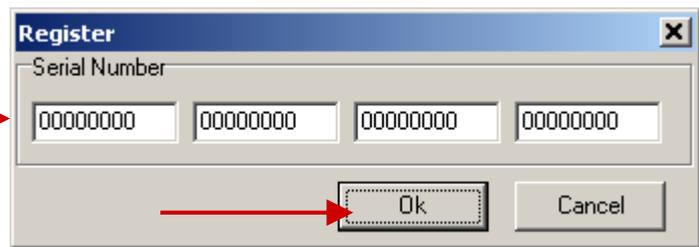


Step 4: Registering the FluorPen Software

Select: Help>Register.

Enter your serial (registration) number.*

Select: OK.



** You will find your serial (registration) number in the file **SN.txt** on the enclosed CD.*

Important Note: How to Reconnect Bluetooth

Disconnection can occur, either when the Bluetooth feature has been turned off in one or both of the devices, or when the units move outside their operating range.

If the devices have been turned off, simply turn them on and enable Bluetooth in the FluorPen again.

If the FluorPen has been moved outside the Bluetooth operational range, bringing it back into range within 90 seconds will allow it to reconnect automatically. If more time elapses, simply turn the FluorPen on and enable Bluetooth again.

8. USB pairing and connecting

8.A. General Information

What you will need first:

Before you set up the USB connection between the FluorPen and PC, make sure you have these components:

1. USB enabled FluorPen

FluorPen FP 100-MAX and FluorPen FP 100-U include connector for communication by USB cable.

2. USB cable



8.B. USB Pairing

Connect the USB cable to a computer and FluorPen as shown below. Then **Switch on** the FluorPen (press and hold the SET key). On computer run the program Fluorpen 1.0. Then follow chapter 9. – FluorPen software.



9. FluorPen Software

This Chapter applies to users of the **FluorPen FP 100-MAX, PAR-FluorPen FP 100-MAX-LM** and to users of the **FluorPen FP 100-B and FP 100-U**.

9.A. Starting up

Starting up:

1. Switch on the computer.
2. Switch on the FluorPen and enable Bluetooth.*
3. Make sure that your PC and the FluorPen are properly paired.*
4. For FluorPens supplied with the USB communication module, use provided USB cable to connect your device to a PC. Please note that FluorPens battery is automatically re-charged when connected to the PC.
5. Start the FluorPen program.

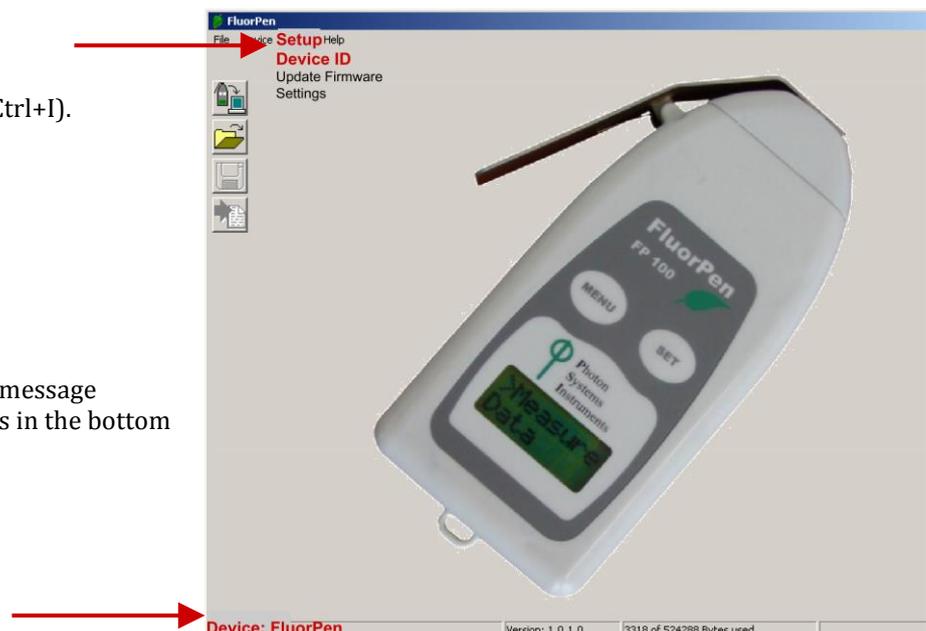
Please note that the device always comes with just one communication module - either USB or Bluetooth. For USB connection you need to have the USB driver installed in your PC. You find the driver on the installation disk (USB driver folder). If you check the Device Manager in Windows you should see the USB serial port in the device tree. In case of missing driver you may download it from the following link: http://www.psi.cz/ftp/FluorPen/USB_Driver_Setup.exe. When the driver is installed correctly you should be able to connect to the device in the FluorPen software menu Setup->Device ID.

** Points 2 and 3 apply only to users of the FluorPen FP 100-MAX and FluorPen FP 100-B. See Chapter 7 of this Operation Manual for complete information on Bluetooth pairing and connecting.*

Connecting:

Select: Setup>Device ID (Ctrl+I).

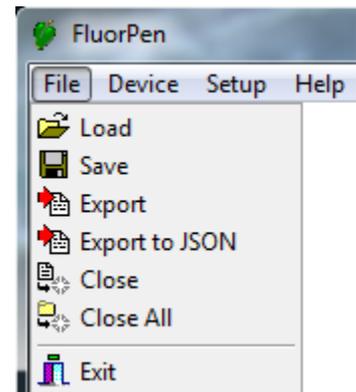
If properly connected, the message "Device: FluorPen" appears in the bottom part of the screen.



9.B. Menu and Icon Explanation

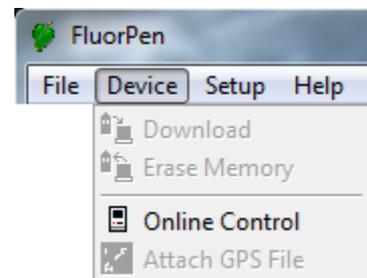
Menu: File

| | |
|-----------------------|---|
| Load | Loads previously saved data files. |
| Save | Saves data to hard disc. |
| Export | Exports data in .txt format. |
| Export to JSON | Exports data in JavaScript Object Notation. |
| Close | Closes the current experiment. |
| Close All | Closes all running experiments. |
| Exit | Exits the program. |



Menu: Device

| | |
|------------------------|--|
| Download | Downloads data from the FluorPen to your PC. |
| Erase Memory | Erases data from the FluorPen memory. |
| Online Control | Settings sound and time. |
| Attach GPS File | Used for download data from GPS module. |



Menu: Setup

| | |
|------------------------|--|
| Device ID | Detects the Bluetooth connected device. |
| Update Firmware | Used for software updates.* |
| Settings | Used for modification of the program settings.** |

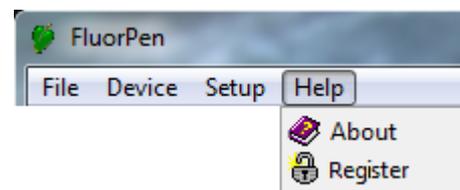


* For more information on software updating, see Chapter 9G of this Operation Manual.

** See more information on the next page.

Menu: Help

| | |
|-----------------|---|
| About | Offers basic information about the program. |
| Register | Used for the FluorPen software registration.* |



* See Chapter 7C of this Operation Manual for more information on FluorPen software registration.

Menu: Settings

After Download - Memory Erase

If the box is checked, the FluorPen memory is erased after each data download.

Data - Inverted

If the box is checked, the polarity of data is inverted, e.g., multiplied by -1.*

Data - Add to Opened

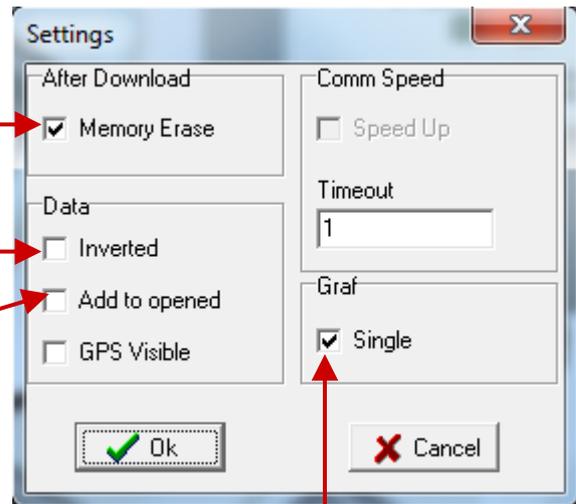
If the box is checked, the downloaded data are added to that of the current opened experiment.

Graf - Single

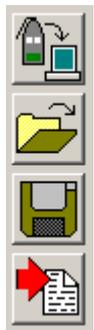
If the box is checked, all measured data are visualized in one graph, i.e., the value of each new measurement is added to the currently used graph window.

If the box is not checked, a new graph is opened for every new measurement.

** This feature can be helpful for a certain type of experiment when the measured data are undesirably interpreted as negative values.*



Icon Explanation:



Download

Downloads data from the FluorPen to PC.

Load

Loads (opens) previously saved data files.

Save

Saves data to hard disc.

Export

Exports data in .txt format.

9.C. Example of Data Transfer and Visualization

Step 1: Do a measurement with your FluorPen.

(Here, we did an OJIP measurement.)

Step 2: Click the “Download” icon or select Device>Download.

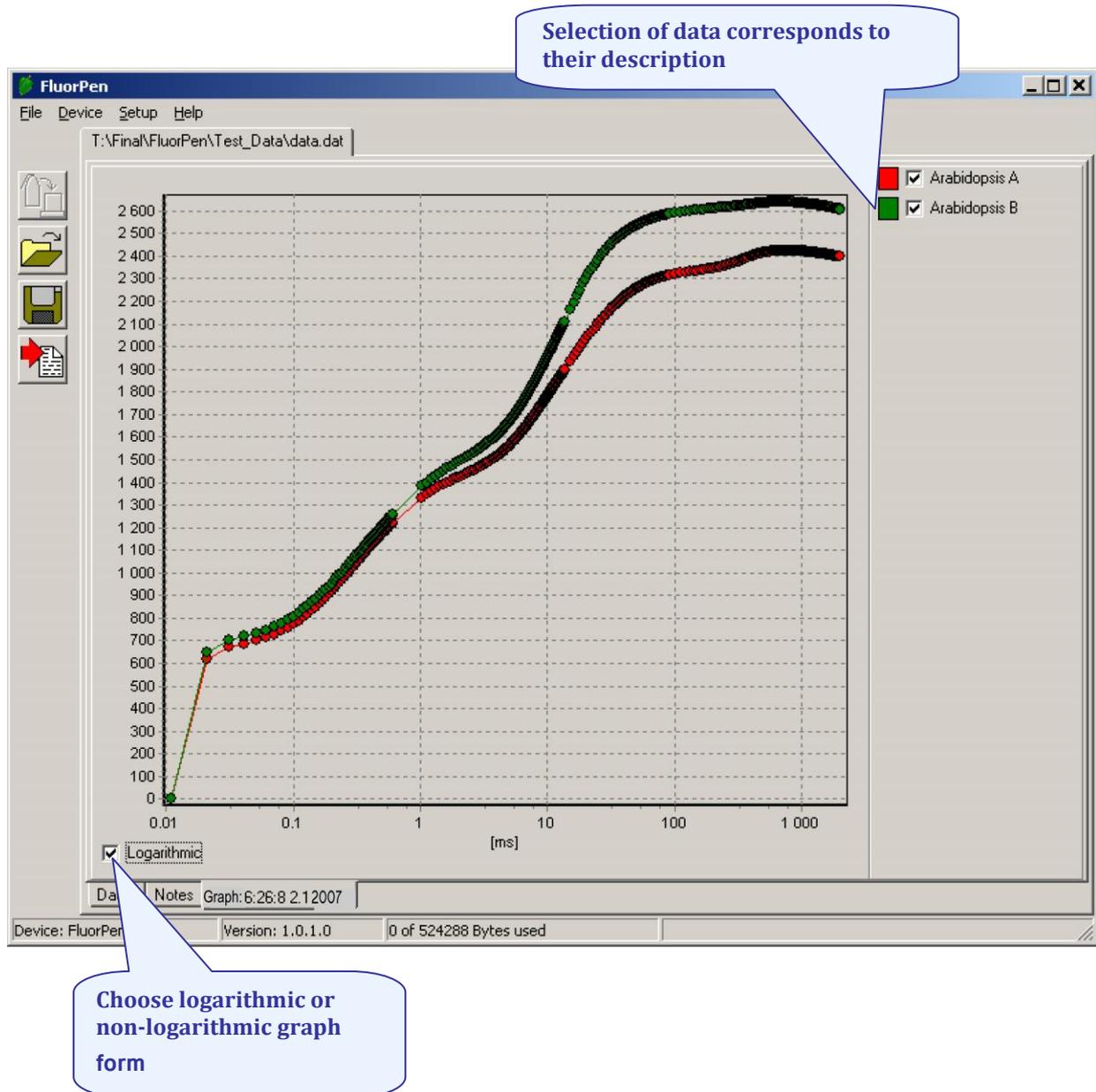
Step 3: The Data table appears.

The screenshot shows the FluorPen software interface with a data table. The table has columns for Time, ID, and Measured parameter. The data is organized into five columns representing different time points: 6:26:3 2.1 2007, 6:26:8 2.1 2007, 6:26:32 2.1 2007, 6:27:25 2.1 2007, and 6:4 19 2.1 2007. The measured parameters are QY, OJIP, Ft, QY, and OJIP. The table contains various measured and calculated values, including Fo, Fv, Fm, Vi, Vj, Fm/Fo, Fv/Fo, Fv/Fm, Mo, Area, Sm, Ss, N, Phi_Po, Psi_Lo, Phi_Eo, Phi_Do, Phi_Pav, ABS/RC, TRo/RC, ETo/RC, and DIo/RC. The table also includes a Description column with entries for Arabidopsis A and Arabidopsis B. The interface includes a menu bar (File, Device, Setup, Help), a toolbar with icons for file operations, and a status bar at the bottom showing the device name (FluorPen), version (1.0.1.0), and memory usage (0 of 524288 Bytes used). Callouts point to various features: 'File name' points to the file path; 'Time of experiment' points to the time columns; 'Measured parameter' points to the parameter columns; 'Save experiment' points to the save icon; 'Measured and calculated values' points to the data cells; 'Space for written notes' points to the 'Notes' tab; 'Switch to graphic visualization of the experiment' points to the 'Graph' tab; and 'Experiment description' points to the 'Description' column.

| Time | 6:26:3 2.1 2007 | 6:26:8 2.1 2007 | 6:26:32 2.1 2007 | 6:27:25 2.1 2007 | 6:4 19 2.1 2007 |
|-------------|-----------------|------------------|------------------|------------------|------------------|
| ID | QY | OJIP | Ft | QY | OJIP |
| | 0.64 | | 355 | 0.71 | |
| Fo Backgr | 1 | Fo 618 | Backgr 1 | Fo Backgr 1 | Fo 646 |
| Fo Flash | 351 | Fi 1422 | Flash 356 | Fo Flash 275 | Fi 1491 |
| Fm Backgr | 1 | Fi 2149 | | Fm Backgr 1 | Fi 2438 |
| Fm Flash | 964 | Fm 2423 | | Fm Flash 942 | Fm 2639 |
| | | Fv 1805 | | | Fv 1993 |
| | | Vj 0.445 | | | Vj 0.424 |
| | | Vi 0.848 | | | Vi 0.899 |
| | | Fm/Fo 3.921 | | | Fm/Fo 4.085 |
| | | Fv/Fo 2.921 | | | Fv/Fo 3.085 |
| | | Fv/Fm 0.745 | | | Fv/Fm 0.755 |
| | | Mo 0.911 | | | Mo 0.831 |
| | | Area 4786890 | | | Area 5229888 |
| | | Sm 2652.017 | | | Sm 2624.129 |
| | | Ss 0.489 | | | Ss 0.510 |
| | | N 5422.780 | | | N 5142.671 |
| | | Phi_Po 0.745 | | | Phi_Po 0.755 |
| | | Psi_Lo 0.555 | | | Psi_Lo 0.576 |
| | | Phi_Eo 0.413 | | | Phi_Eo 0.435 |
| | | Phi_Do 0.255 | | | Phi_Do 0.245 |
| | | Phi_Pav 2857.311 | | | Phi_Pav 2908.289 |
| | | ABS/RC 2.745 | | | ABS/RC 2.595 |
| | | TRo/RC 2.045 | | | TRo/RC 1.960 |
| | | ETo/RC 1.134 | | | ETo/RC 1.129 |
| | | DIo/RC 0.700 | | | DIo/RC 0.635 |
| Description | | Arabidopsis A | | | Arabidopsis B |

Step 4: To visualize measurement in the graphic mode, click the “Graph” field in the bottom bar.

Step 5: The colored Graph of measured data appears.



Step 6: For **export** press File>Export or “Export” icon, select what you want to export (Ft, QY, Measuring by protocol...). Measuring by protocol export all protocols at once (OJIP, NPQ, LC...).

Selected only - exports only one measurement that is selected by mouse, otherwise it will export everything.

Source data - exports raw data, in case of OJIP: points of the curve

Computed values - export calculated data, in case of OJIP: Fo, Fi, Fj...

Description - exports the data description if any

FluorPen

File Device Setup Help

W:\Laborka\DATA-LAB\@DOKUMENTY\Manualy\AP, FP\DATA-FP.dat

| Index | 1 | 2 | 3 | 4 | 5 | 6 | |
|-------------|--|--|---|--|--|----------|--|
| Time | 21:04:12 19.2.2000 | 19:31:57 12.3.2000 | 19:32:15 12.3.2000 | 19:35:16 12.3.2000 | 19:41:37 12.3.2000 | 19:47:58 | |
| GPS | | | | | | | |
| ID | OJIP-455 | | | | LC1-455 | LC1- | |
| Value | Bckg 8 Fo 200 Fj 199 Fi 197 Fm 196 Fv -4 Vj 0.250 Vi 0.750 Fm/Fo 0.980 Fv/Fo -0.020 Fv/Fm -0.020 Mo -0.000 Area 37335 Fix Area 192308 HACH Area-7684 Sm -9333.82 Ss 0.000 N 0.000 Phi_Po -0.020 Psi_o 0.750 | N 540.326 Phi_Po 0.657 Psi_o 0.453 | N 1899.346 Phi_Po 0.606 Psi_o 0.516 | Qp_Lss 0.45 Rfd 1.22 Fm_D1 12322 | Fo 5364 Fm 18954 Fm_L1 19116 Fm_L2 17588 Fm_L3 15865 Fm_L4 12192 Fm_L5 10371 Fm_L6 10078 Ft_L1 7087 Ft_L2 7900 Ft_L3 7738 Ft_L4 7933 Ft_L5 9428 Ft_L6 9753 QY_max 0.72 QY_L1 0.63 QY_L2 0.55 QY_L3 0.51 QY_L4 0.35 QY_L5 0.09 | | |
| Description | OJIP | OJIP | OJIP | NPQ1 | LC1 | LC | |

Export

How

Selected Only Description

Source Data

Computed Values

What

Ft OD

Qy N

Measuring By Protocol PAR

NDVI ALAI

PRI BWI

MURPI PAR-ID

Ok Cancel

Device: Not Connected

9.D. Explanation of OJIP Parameters

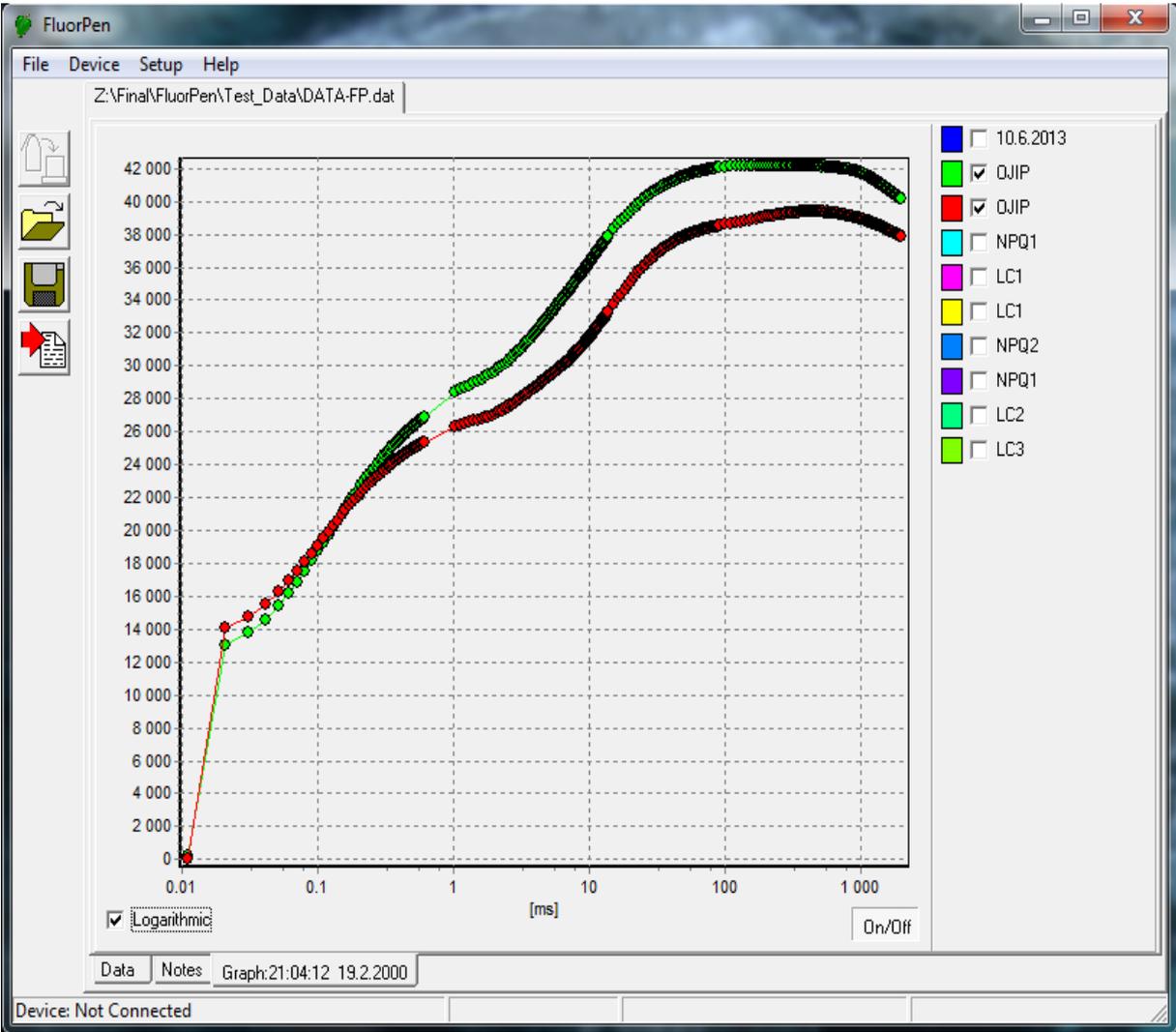
The FluorPen also offers the possibility to capture rapid fluorescence transient – OJIP, which occurs during exposure of plants to high irradiance. The FluorPen software enables data downloading to a personal computer and subsequent OJIP analysis. The OJIP protocol includes the following extracted and technical parameters*:

| Formula Abbreviation | Formula Explanation |
|-------------------------------|---|
| Bckg | Background |
| F_0 | $F_0 = F_{50\mu s}$, fluorescence intensity at 50 μs |
| F_j | F_j = fluorescence intensity at J-step (at 2 ms) |
| F_i | F_i = fluorescence intensity at i-step (at 60 ms) |
| F_M | F_M = maximal fluorescence intensity |
| F_V | $F_V = F_M - F_0$ (maximal variable fluorescence) |
| V_j | $V_j = (F_j - F_0) / (F_M - F_0)$ |
| V_i | $V_i = (F_i - F_0) / (F_M - F_0)$ |
| F_M / F_0 | |
| F_V / F_0 | |
| F_V / F_M | |
| M_0 or (dV/dt) ₀ | $M_0 = TR_0 / RC - ET_0 / RC = 4 (F_{300} - F_0) / (F_M - F_0)$ |
| Area | Area between fluorescence curve and F_M (background subtracted) |
| Fix Area | Area below the fluorescence curve between $F_{40\mu s}$ and F_{1s} (background subtracted) |
| S_M | $S_M = \text{Area} / (F_M - F_0)$ (multiple turn-over) |
| S_S | S_S = the smallest S_M turn-over (single turn-over) |
| N | $N = S_M \cdot M_0 \cdot (1 / V_j)$ turn-over number Q_A |
| Φ_{P_0} | $\Phi_{P_0} = 1 - (F_0 / F_M)$ (or F_V / F_M) |
| Ψ_{i_0} | $\Psi_{i_0} = 1 - V_j$ |
| Φ_{E_0} | $\Phi_{E_0} = (1 - (F_0 / F_M)) \cdot \Psi_{i_0}$ |
| Φ_{D_0} | $\Phi_{D_0} = 1 - \Phi_{P_0} - (F_0 / F_M)$ |
| $\Phi_{P_{av}}$ | $\Phi_{P_{av}} = \Phi_{P_0} (S_M / t_{FM})$ t_{FM} = time to reach F_M (in ms) |
| ABS / RC | $ABS / RC = M_0 \cdot (1 / V_j) \cdot (1 / \Phi_{P_0})$ |
| TR_0 / RC | $TR_0 / RC = M_0 \cdot (1 / V_j)$ |
| ET_0 / RC | $ET_0 / RC = M_0 \cdot (1 / V_j) \cdot \Psi_{i_0}$ |
| DI_0 / RC | $DI_0 / RC = (ABS / RC) - (TR_0 / RC)$ |

* Formulas Derived From:

R.J. Strasser, A. Srivastava and M. Tsimilli-Michael (2000): The fluorescence transient as a tool to characterize and screen photosynthetic samples. In: Probing Photosynthesis: Mechanism, Regulation and Adaptation (M. Yunus, U. Pathre and P. Mohanty, eds.), Taylor and Francis, UK, Chapter 25, pp 445-483.

Example of OJIP protocol



9.E. Non-Photochemical Quenching (NPQ) Protocol

The NPQ protocol is the most typically used measuring approach to quantify photochemical and non-photochemical quenching. The measurement should be performed with a dark-adapted sample. Thereby, it may not be appropriate under field conditions.

The NPQ protocol starts by giving a measuring light to acquire minimal level of fluorescence F_o . A short saturating flash of light is then applied to reduce the plastoquinone pool and measure maximum fluorescence in the dark adapted state, F_m . After a short dark relaxation, the sample is exposed to actinic irradiance for tens to hundreds of seconds to elicit a transient of the Kautsky effect. Moreover, a sequence of saturating flashes is applied on top of the actinic light to probe the non-photochemical quenching NPQ and effective quantum yield of photosynthesis QY in light adapted state. After exposure to continuous illumination, the relaxation of non-photochemical quenching is determined by means of saturating pulses applied in dark.

Two NPQ protocols, NPQ1 and NPQ2 are predefined. The protocols differ in the duration of the light exposure and the dark recovery phase, in the number and interval between pulses. See table below.

| | Phase | Duration | # of pulses | 1st pulse | Pulse interval |
|------|---------------|----------|-------------|-----------|----------------|
| NPQ1 | Light | 60s | 5 | 7s | 12s |
| | Dark recovery | 88s | 3 | 11s | 26s |
| NPQ2 | Light | 200s | 10 | 10s | 20s |
| | Dark recovery | 390s | 7 | 20s | 60s |

| Abbreviation | Explanation |
|---|--|
| F_o | minimum fluorescence in dark-adapted state |
| F_m | maximum fluorescence in dark-adapted state, measured during the first saturation flash after dark adaptation |
| F_p | fluorescence in the peak of fast Kautsky induction |
| F_{m_L}, L_{ss}, D, D_{ss}¹ | maximum fluorescence |
| QY_{max}² | maximum quantum yield of PSII in dark-adapted state - F_v/F_m |
| QY_L, L_{ss}, D, D_{ss}^{1,3} | effective quantum yield of PSII |
| NPQ_L, L_{ss}, D, D_{ss}^{1,4} | non-photochemical chlorophyll fluorescence quenching |
| Q_p_L, L_{ss}, D, D_{ss}^{1,5} | coefficient of photochemical quenching, an estimate of open PSII reaction centers |

¹ *L* - indicates light adapted parameters; *D* - refers to dark recovery phase after switching of the actinic illumination; *n* - represents a sequential number of light phase; *ss* - steady state

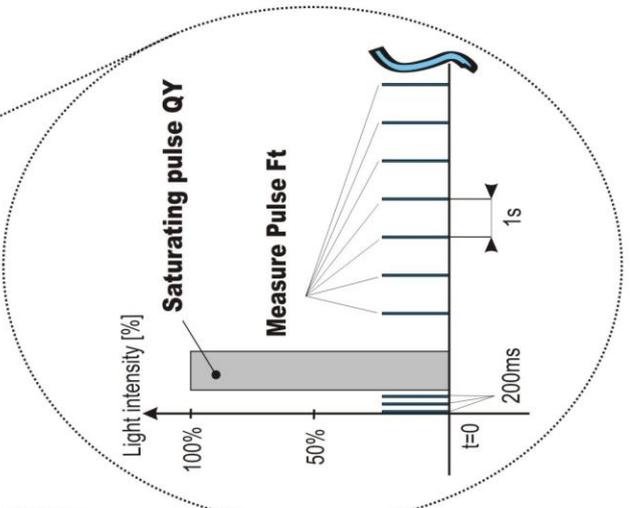
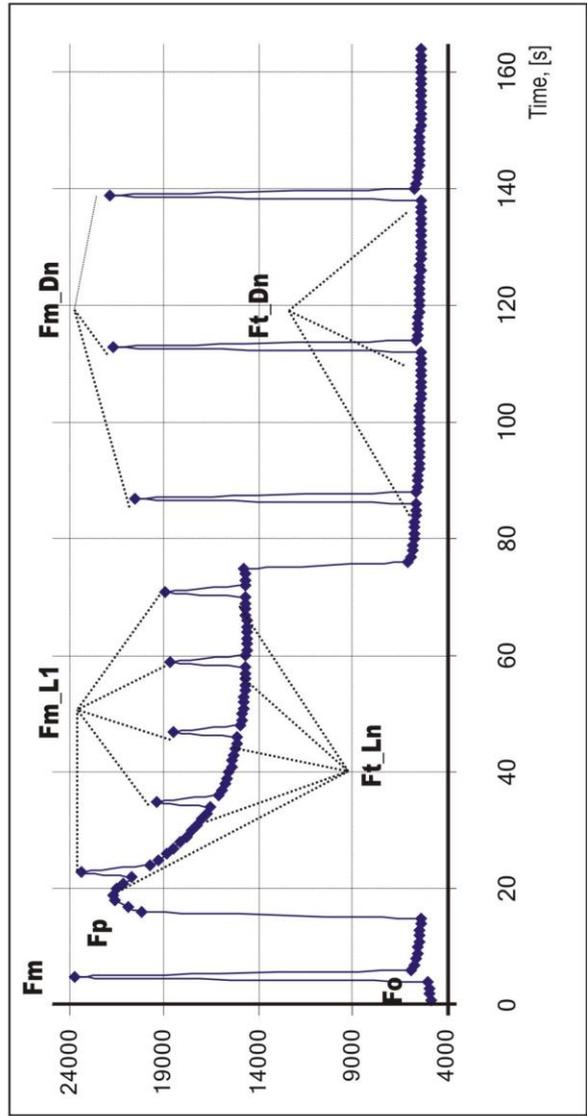
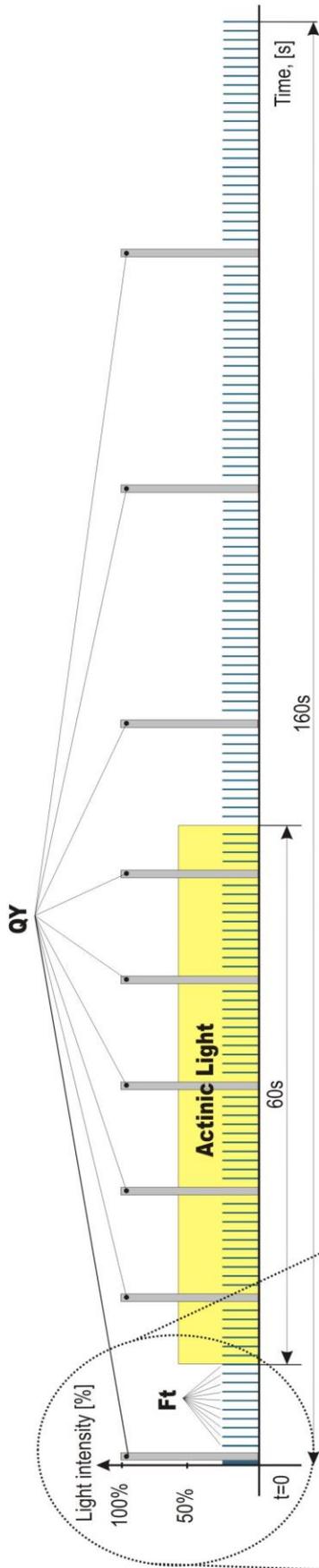
² Calculated as $(F_m - F_o) / F_m$

³ Calculated as $(F_{m_{Ln}} - F_{t_{Ln}}) / F_{m_{Ln}}$ or of corresponding steady state or dark recovery parameters

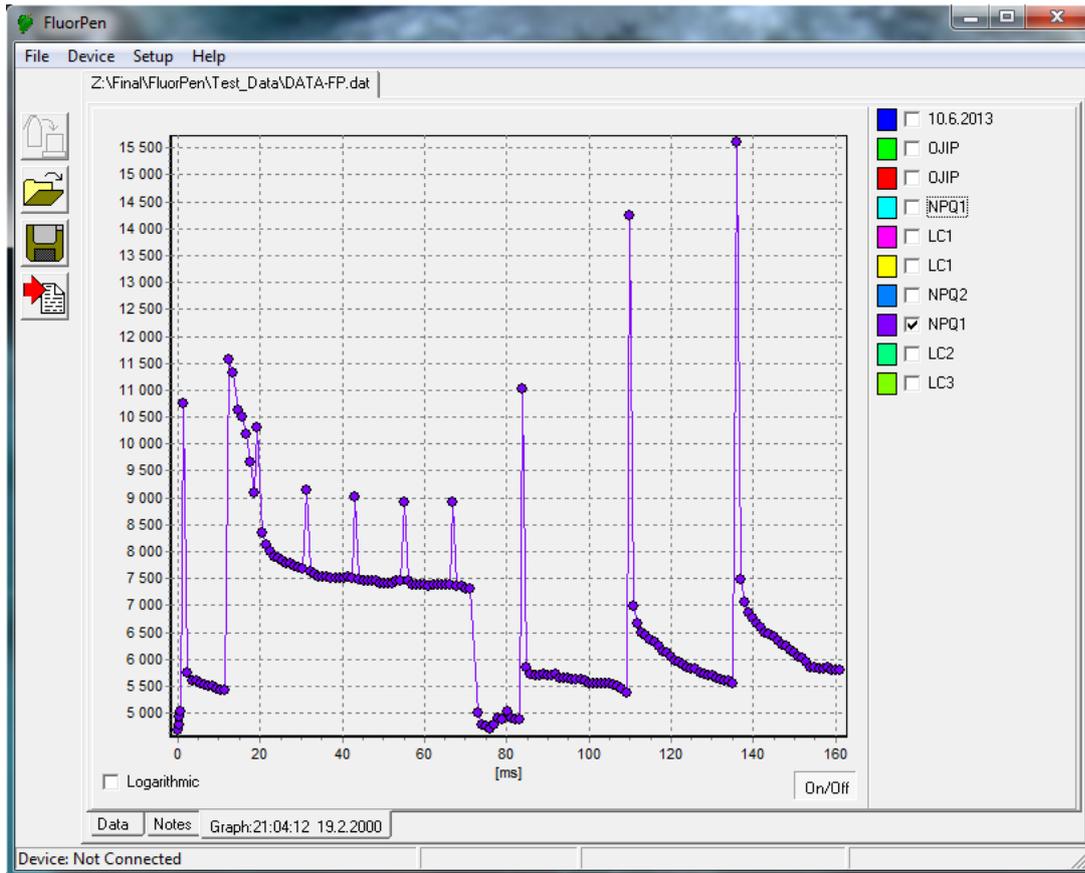
⁴ Calculated as $(F_m - F_{m_{Ln}}) / F_{m_{Ln}}$ or of corresponding *ss*, *D_n* or *D_{ss}* parameters

⁵ Calculated as $(F_{m_{Ln}} - F_{t_{Ln}}) / (F_{m_{Ln}} - F_{o_{Ln}})$ or of corresponding *ss*, *D_n* or *D_{ss}* parameters

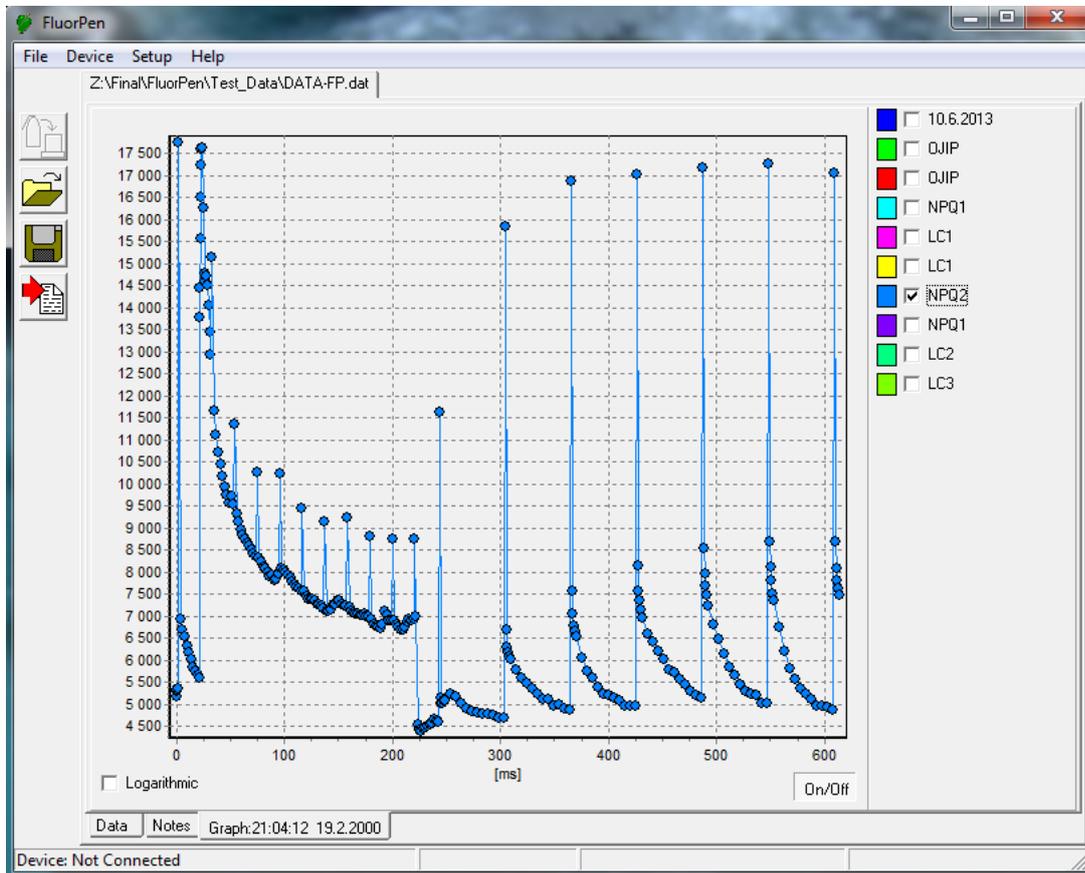
NPQ Protocol



Example of NPQ1 protocol



Example of NPQ2 protocol



9.F. Light Curve (LC) Protocol

The protocol called Light Curve (LC) was designed to acquire parameters for construction of Light Response Curve relating the rate of photosynthesis to photon flux density. The method is based on successive measurements of the sample exposed to a stepwise increase of light intensity. The effective quantum yields of photosynthesis are determined under various light intensities of continuous illumination. Measurement is based on pulse modulated fluorometry (PAM).

Several LC protocols are predefined in FP. These differ in number and duration of individual light phases and light intensities.

| | # of phases | Phase duration | Light intensities, [$\mu\text{mol m}^{-2} \text{s}^{-1}$] |
|------------|-------------|----------------|---|
| LC1 | 6 | 60s | 10; 20; 50; 100; 300; 500 |
| LC2 | 5 | 30s | 100; 200; 300; 500; 1000 |
| LC3 | 7 | 60s | 10; 20; 50; 100; 300; 500; 1000 |

The protocol includes following measured and calculated parameters:

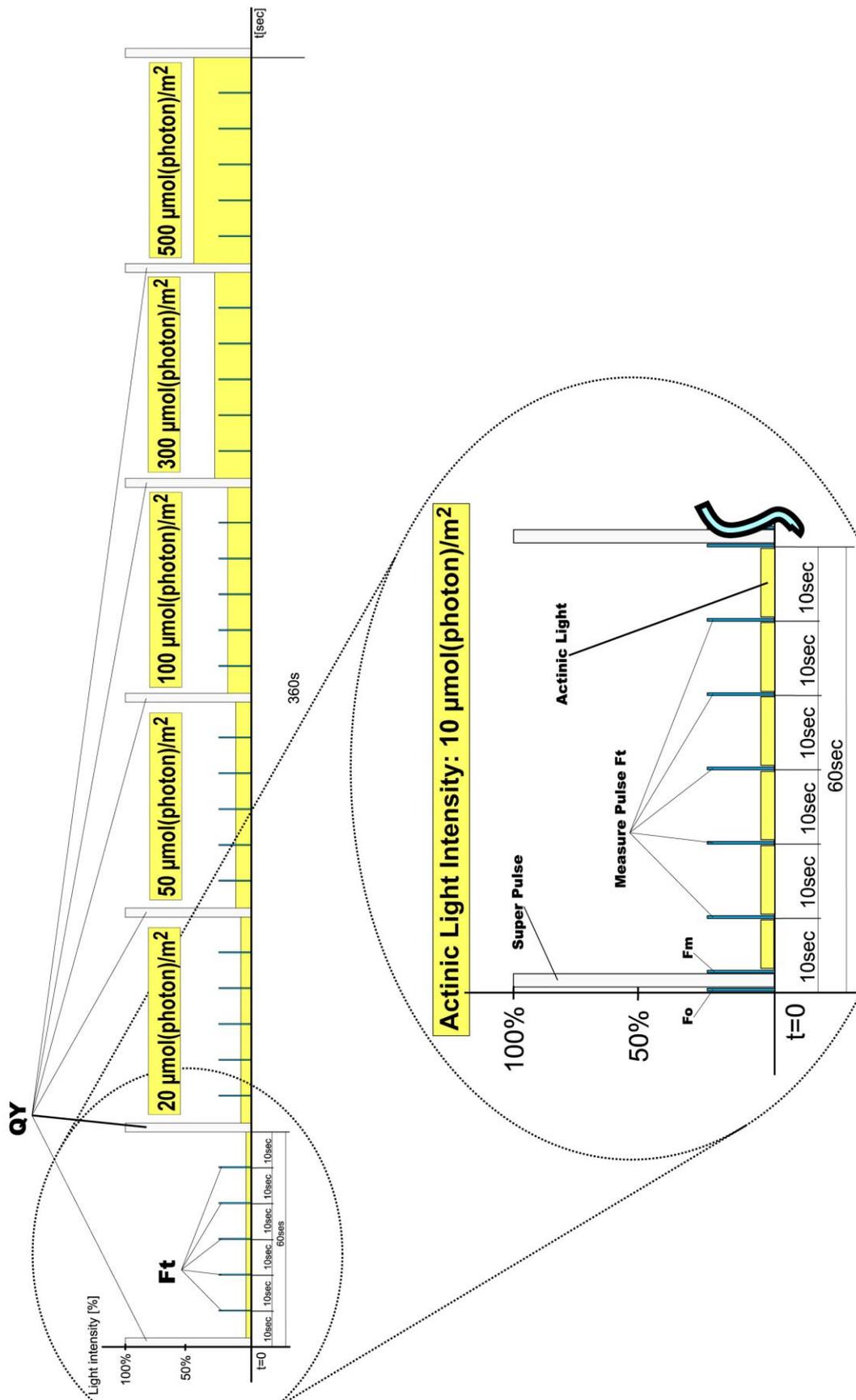
| Abbreviation | Explanation |
|--|---|
| F_o | minimum fluorescence in dark-adapted state |
| F_m | maximum fluorescence in dark-adapted state |
| F_m_L_n[‡] | maximum fluorescence in light adaptation state |
| F_t_L_n[‡] | instantaneous fluorescence during light adaptation |
| QY_{max}* | maximum quantum yield of PSII in dark-adapted state - F_v/F_m |
| QY_L_n^{‡**} | instantaneous PSII quantum yield induced in light |

[‡] n represents a sequential number of light phase

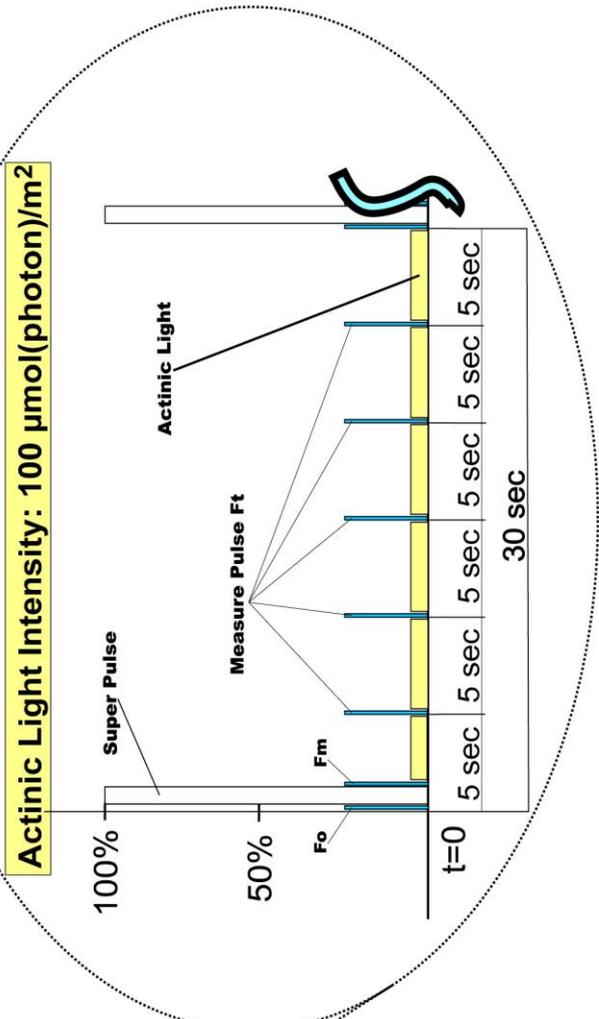
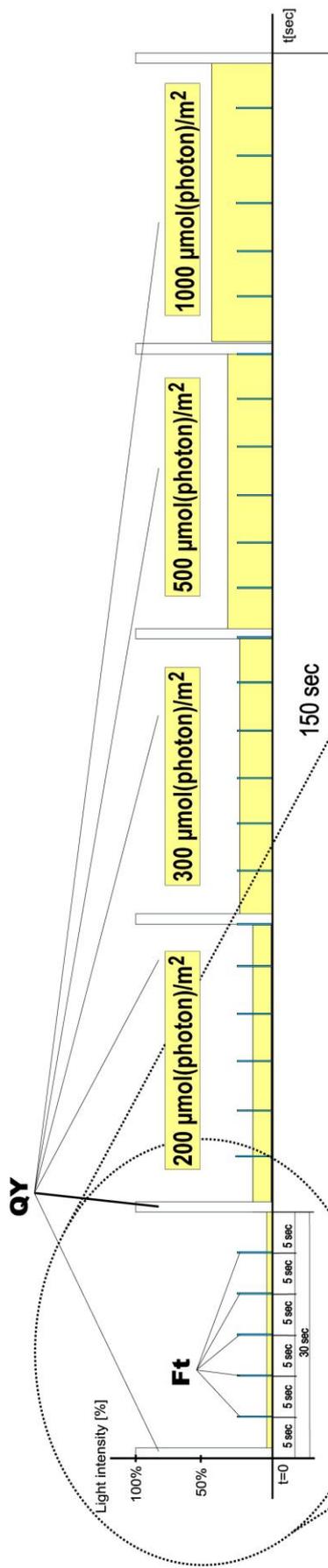
* Calculated as $(F_m - F_o) / F_m$

** Calculated as $(F_{m_L_x} - F_{t_L_x}) / F_{m_L_x}$

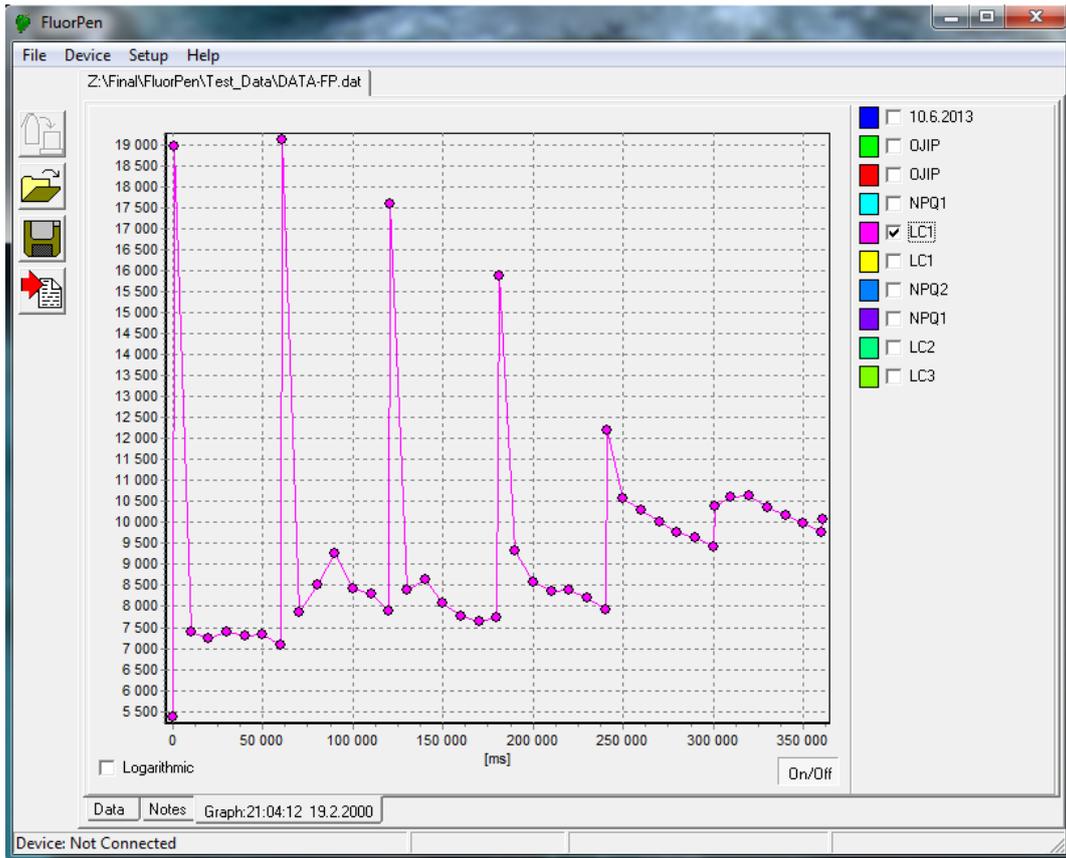
Light Curve 1 Protocol



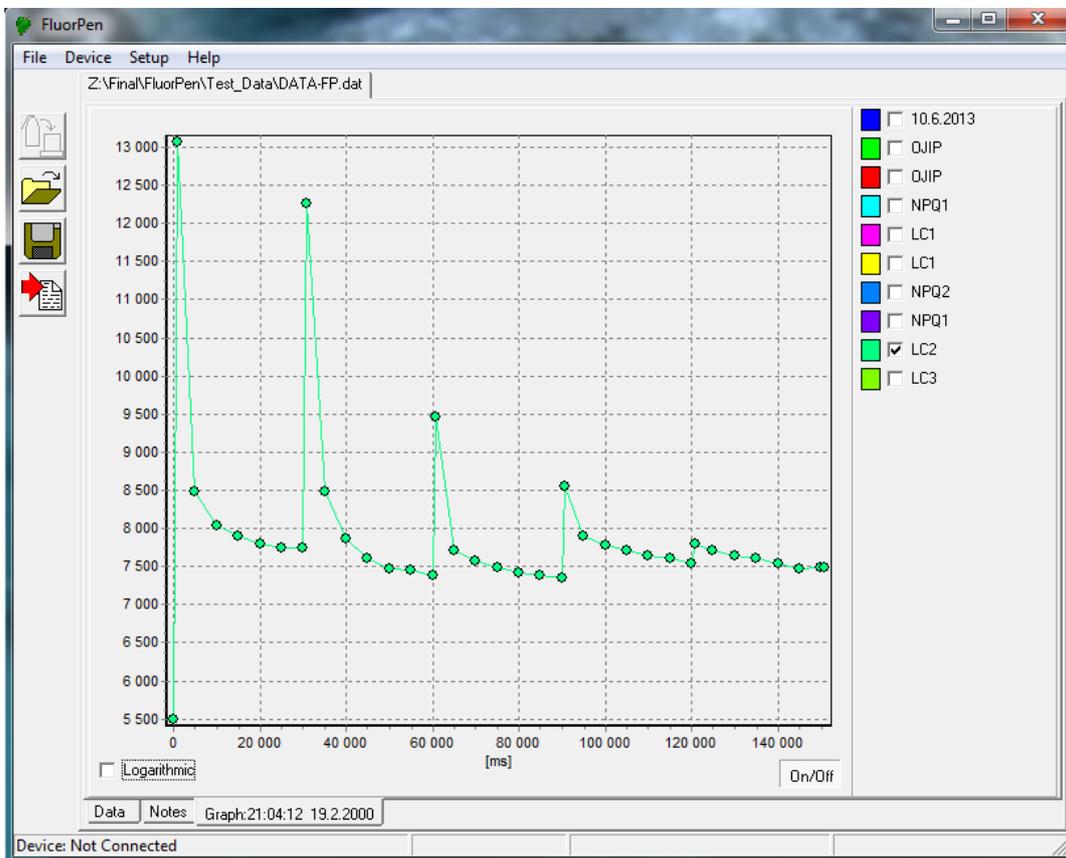
Light Curve 2 Protocol



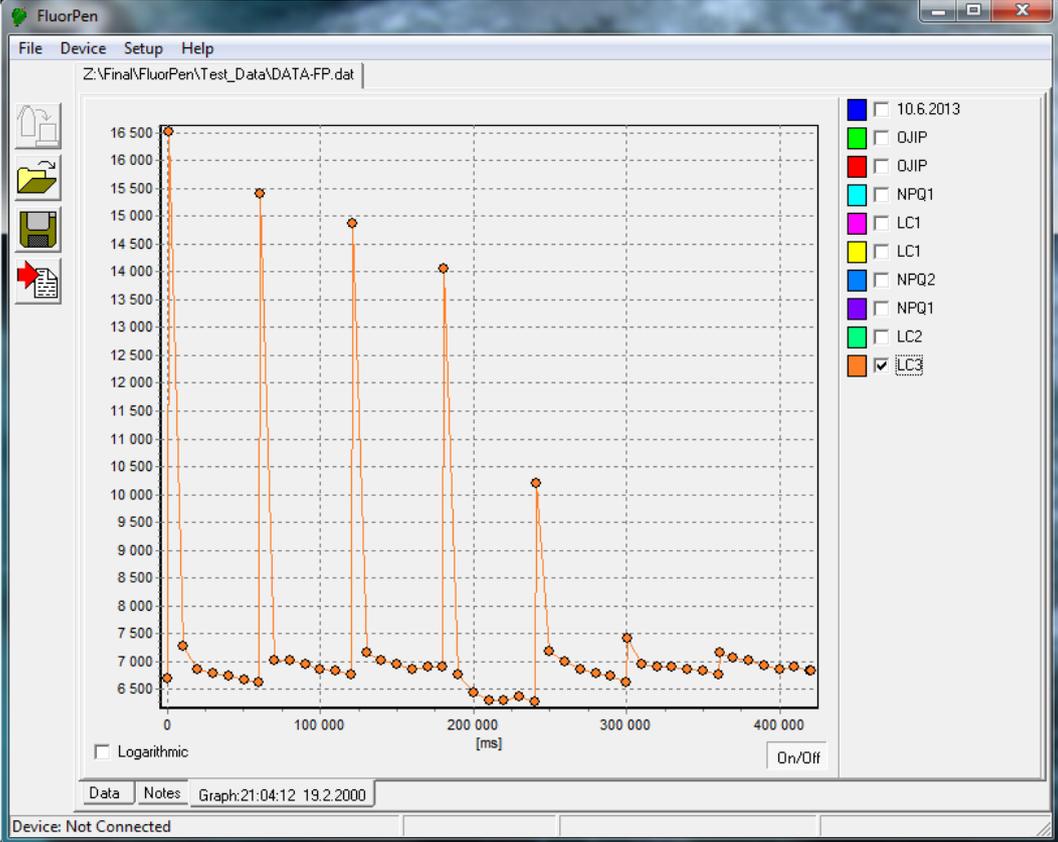
Example of LC1 protocol



Example of LC2 protocol



Example of LC3 protocol



9.G. Software Update

Very important!

The FluorPen memory is erased during the software update!

Before starting any software update, export all your data from the FluorPen memory into your computer!

Step 1: Starting Update

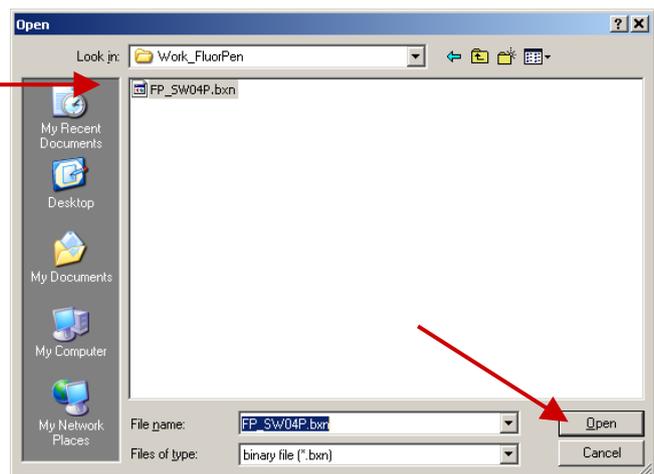
Select: Setup>Update Firmware



Step 2: Selecting .bxn File

Find: Binary file (with the extension .bxn)

Select: Open



Step 3: Finishing Upload

Select: "OK" to start uploading of the update.



The bottom bar indicates the upload progress.



Press: "OK" to finish upload.



10. GPS Module

For all devices in FluorPen Series GMS module might be connected to the device.

IMPORTANT INFORMATION:

For proper GPS reading, the **time in your FluorPen and in your computer must be synchronized!** Pre-set time and time zone must correspond to GPS time (time zone) in your location.

10.A. GPS Module Description

Device Overview



| | |
|---|-----------------|
| ① | Zoom keys |
| ② | Back key |
| ③ | Thumb Stick™ |
| ④ | Menu key |
| ⑤ | ⏻/Backlight key |



| | |
|---|-----------------------------------|
| ⑥ | Mini-USB port (under weather cap) |
| ⑦ | Battery cover |
| ⑧ | Battery cover locking ring |
| ⑨ | Mounting spine |

1. Installing AA Batteries

The device operates on two AA batteries. You can use alkaline, NiMH or lithium batteries. Use NiMH or lithium batteries for best results.

1. Turn the D-ring counter clockwise and pull up to remove the cover.
2. Insert the batteries, observing polarity.
3. Replace the battery cover and turn the D-ring clockwise.
4. Hold 
5. Select **Setup->System->Battery Type**
6. Select **Alkaline, Lithium or Rechargeable NiMH**

2. Device settings

1. Hold 
2. After the device is on, it begins acquiring satellite signals. The device may need a clear view of the sky to acquire satellite signals.
3. You can check current position and accuracy in **Satellite Page**
4. For better precision you can enable **GPS+GLONASS** mode in **Setup->System->Satellite System->GPS+GLONASS** and turn **WAAS/EGNOS On**.
5. Make sure that **USB Mode** is set to **Mass Storage** (Setup->System->USB Mode)

For more information please check Garmin eTrex manual.

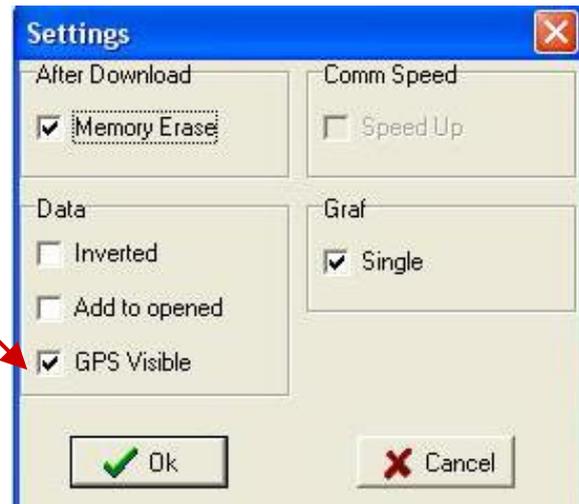
10.B. First Time Installation of the GPS Module

Step 1: Enabling GPS Module in the FluorPen Software

Select: Setup>Settings



Select: Settings>GPS visible



Step 2: Accepting GPS Setting

Close and restart the FluorPen program to accept GPS setting.

10.C. GPS / FluorPen Operation

Step 1: Time Synchronization

Synchronize the FluorPen time with the time of your PC. Time must be set correctly with respect to your time zone.

Step 2: GPS Positioning

Switch the GPS module on and wait until the GPS position is fixed (GPS green LED indicator flashes 1s ON and 2s OFF while tracking the position).

Step 3: Operation

Be aware that while performing field experiments, the FluorPen and the GPS module must be kept close to each other.

10.D. Data Download

Step 1: Enabling Communication

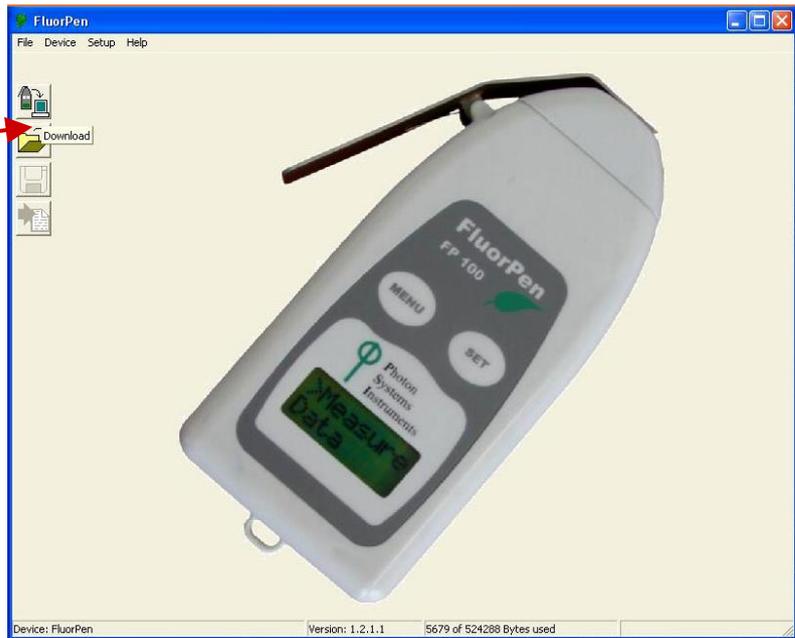
Switch on the computer, FluorPen, and GPS module and set your computer to FluorPen communication (enable Bluetooth or connect to serial or USB port).

Step 2: Downloading FluorPen Data

Start: FluorPen program.

Connect: FluorPen device.

Download: Measured data from the FluorPen to your PC.



Be aware that no GPS coordinates are visible at this moment.

The screenshot shows the FluorPen software window displaying a data table. The title bar reads 'FluorPen'. The menu bar includes 'File', 'Device', 'Setup', and 'Help'. The window title is 'Untitled - 1'. The table has three columns for data points. The 'GPS' row is empty, indicating no coordinates are visible. The 'Value' row contains various parameters for each data point. The status bar at the bottom shows 'Device: FluorPen', 'Version: 1.2.1.1', and '0 of 524288 Bytes used'.

| Index | 1 | 2 | 3 |
|-------------|--|---|---|
| Time | 16:13:03 13.5.2009 | 16:13:40 13.5.2009 | 16:14:47 13.5.2009 |
| GPS | | | |
| ID | OJIP | OJIP | OJIP |
| Value | Bckg 59 Fo 3370 Fi 5135 Fi 5972 Fm 6212 Fv 2842 Vi 0.621 Vi 0.916 Fm/Fo 1.843 Fv/Fo 0.843 Fv/Fm 0.458 Mo 0.926 Area 2646077 Fix Area 6177313 Sm 931.062 Ss 0.671 N 1388.416 Phi_Po 0.458 Psi_o 0.379 Phi_Eo 0.173 Phi_Do 0.542 | Bckg 97 Fo 10956 Fi 19897 Fi 22985 Fm 23928 Fv 12972 Vi 0.689 Vi 0.927 Fm/Fo 2.184 Fv/Fo 1.184 Fv/Fm 0.542 Mo 1.454 Area 4942979 Fix Area 23695322 Sm 381.050 Ss 0.474 N 803.610 Phi_Po 0.542 Psi_o 0.311 Phi_Eo 0.168 Phi_Do 0.458 | Bckg 99 Fo 3201 Fi 4576 Fi 5254 Fm 5544 Fv 2343 Vi 0.587 Vi 0.876 Fm/Fo 1.732 Fv/Fo 0.732 Fv/Fm 0.423 Mo 0.799 Area 1580145 Fix Area 5467296 Sm 674.411 Ss 0.795 N 918.180 Phi_Po 0.423 Psi_o 0.413 Phi_Eo 0.175 Phi_Do 0.577 |
| Description | | | |

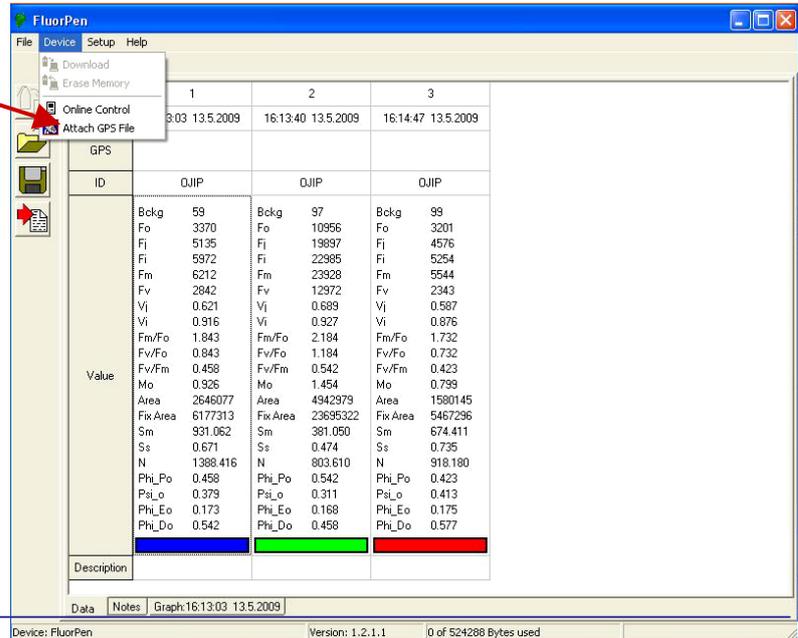
Step 3: Connecting GPS Module

Connect the GPS Module to your PC. Communication is set properly if the hardware is recognized by your PC.

Step 4: Downloading GPS Data

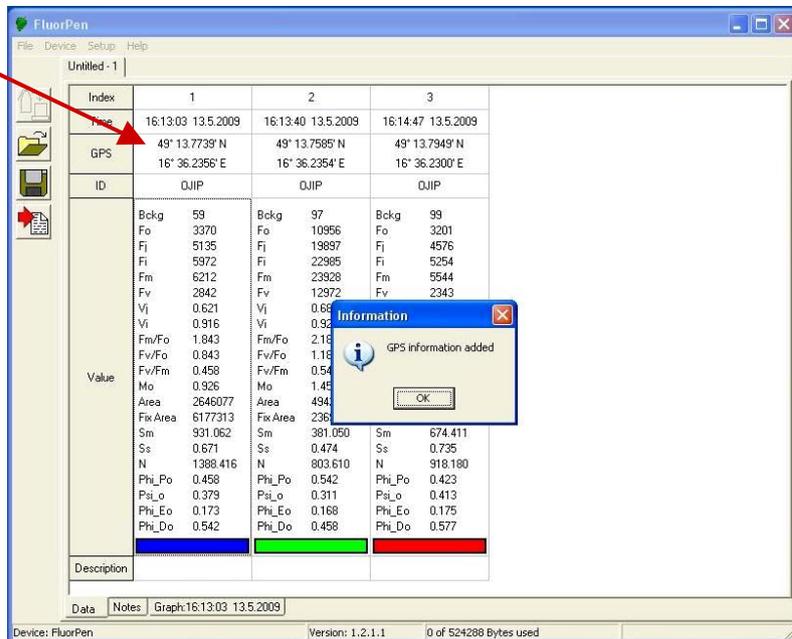
Select:

Device>Attach GPS file
to download data from the GPS
module.



Step 5: Completing the Download

Successfully downloaded GPS
coordinates paired with FluorPen
data.



11. Statement of Limited Warranty

- This Limited Warranty applies only to the FluorPen and its accessories (excluding any batteries). It is valid one year from the date of shipment.
- If at any time within this warranty period the instrument does not function as warranted, return it and PSI will repair or replace it at no charge. The customer is responsible for shipping and insurance charges (for the full product value) to PSI. PSI is responsible for shipping and insurance on return of the instrument to the customer.
- No warranty will apply to any instrument that has been (i) modified, altered, or repaired by persons unauthorized by PSI; (ii) subjected to misuse, negligence, or accident; (iii) connected, installed, adjusted, or used otherwise than in accordance with the instructions supplied by PSI.
- The warranty is return-to-base only, and does not include on-site repair charges such as labor, travel, or other expenses associated with the repair or installation of replacement parts at the customer's site.
- PSI repairs or replaces faulty instruments as quickly as possible; the maximum time is one month.
- PSI will keep spare parts or their adequate substitutes for a period of at least five years.
- Returned instruments must be packaged sufficiently so as not to assume any transit damage. If damage is caused due to insufficient packaging, the instrument will be treated as an out-of-warranty repair and charged as such.
- PSI also offers out-of-warranty repairs. These are usually returned to the customer on a cash-on-delivery basis.
- *Wear & Tear Items* (such as sealing, tubing, padding, etc.) are excluded from this warranty. The term *Wear & Tear* denotes the damage that naturally and inevitably occurs as a result of normal use or aging even when an item is used competently and with care and proper maintenance.

For customer support, please write to: support@psi.cz

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