25 Years + ANNIVERSARY

OPTI-SCIENCES, INC.

OS1p +
Research Chlorophyll Fluorometer

Offers a wide range of measuring protocols including:

F_V/F_M & F_V/F_O

$\Delta F/F_M'$ or Y(II), PAR, I_{temp}

Quenching:
Kramer lake model
Hendrickson lake model
Puddle model
Ruban & Murchie $_p$NPQ
Quenching relaxation

Option for barcode reader

White Actinic light source

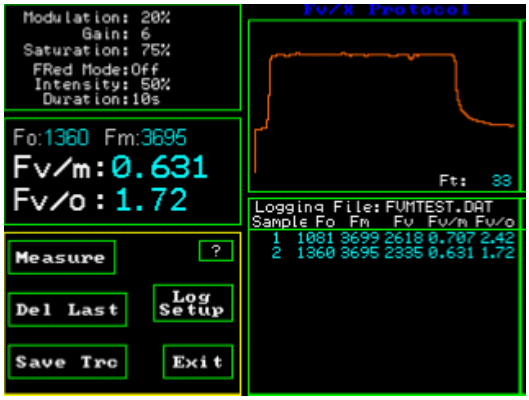
Light response curves:
Slow, fast &
Rapid light curves

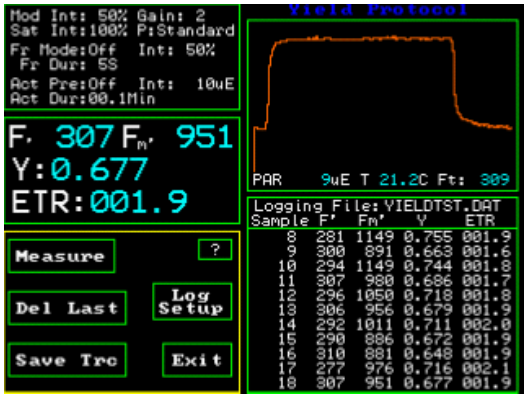
Tel: (603) 883-4400 Fax: (603) 883-4410 Web: www.optisci.com Email:sales@optisci.com

The OS1p provides a wide range of measuring protocol types with superior functionality.

The Most Popular Tests:

Fv/Fm: Maximum quantum yield - Photochemical efficiency of PSII **(Affordable dark clips)**
Fv/Fo: A more sensitive stress detector than Fv/Fm.
Y: or ΔF/Fm' or (Y(II)) quantum photosynthetic yield of PSII (light adapted)
ETR: Electron Transport Rate (with standard PAR clip included)
PAR: Photosynthetically Active Radiation value
(with standard PAR clip included)





Advanced Protocols:

Quenching tests – The widest range available. Uses a stable internal actinic illuminator:

Ruban & Murchie photoprotective NPQ protocol for measurement of pNPQ qPd & qI
Hendrickson lake model protocol parameters with NPQ, resurrected from the puddle model by Klughammer,
Kramer lake model protocol parameters,
Puddle model protocol parameters
Quenching relaxation protocol with q_E, q_T, q_Z and q_I

Fm' correction for light adapted high actinic light level use according to Loriaux (2013) The method is available on all light adapted protocols including quenching and light curves

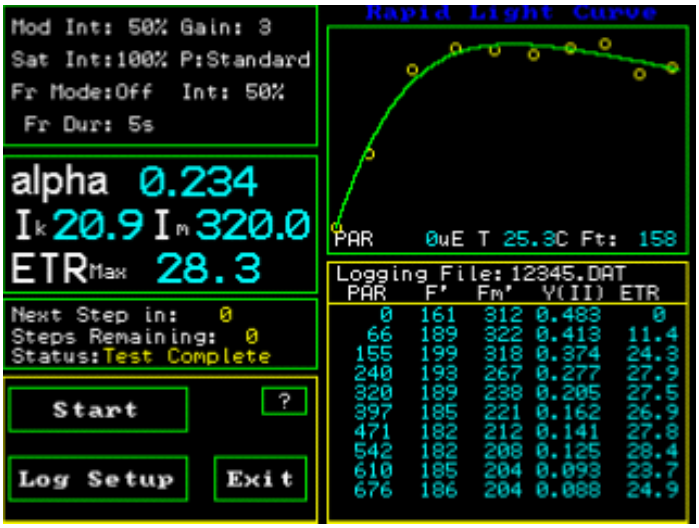
Light response curves - Slow and fast

RLC- rapid light curves to study the light saturation characteristics of samples. Ideal for under canopy work & aquatic work where actinic light level changes constantly. Under rapidly changing actinic light conditions, Y(II) overestimates photosynthesis and RLCs provide more reliable results. **ETR_{MAX}, Ik Im,** and **α.**

Stable actinic light source - light output stays the same as the instrument heats up. Ideal for light curves, quenching protocols and even steady state Y(II) measurements.

Rapid light Curves

Y(II) and ETR were designed to be used at steady state photosynthetic lighting conditions It takes between 15 to 30 minutes at a specific actinic light intensity to reach steady state conditions. Under variable lighting conditions, Y(II) and ETR overstate the real condition. Rapid light Curves provide a more realistic estimate of rubisco activity under variable light conditions. Variable light conditions include under canopy plants, plants under windy conditions, aquatic plants with wavy conditions, and light fleck conditions of all types. For more information, contact Opti-Sciences for the RLC application note.



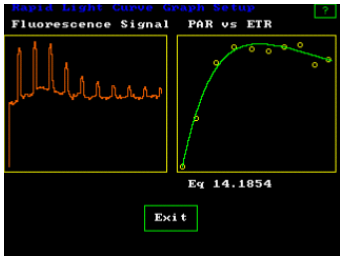
RLC cardinal points & fitted curve for ETR vs. PAR light intensity

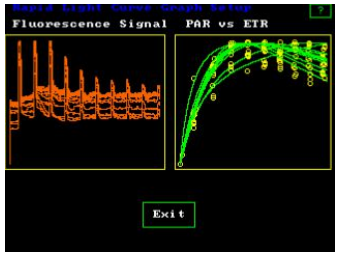
RLC

By touching the graphic display a secondary screen appear that shows the actual fluorescence trace side by side with the resulting RLC curve fitting ETR vs intensity graph.

The lower screen shows multiple RLCs taken at different times of day. Light history changes many of the RLC parameters but ETR_{MAX} usually changes very little.

The time duration for actinic light steps is adjustable from 5 seconds to more than 90 seconds.
seconds.





The system uses Eilers & Peeters curve fitting formulas

Quenching measurements

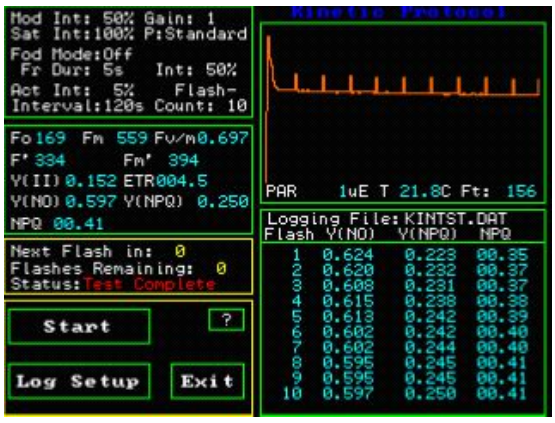
The OS5p+ includes the widest range of quenching protocols available. All measuring protocols use the stable internal actinic light source for the most reliable measurements. Furthermore, researchers can choose between using F_M' correction or square top saturation flash technology.

Hendrickson lake model parameters with NPQ resurrected by Klughammer from the puddle model (2008)

Y(II) Quantum photosynthetic yield of PSII
Y(NPQ) Photoprotective non-photochemical quenching
Y(NO) All other non-photo-protective non-photochemical quenching
NPQ: Non-photochemical quenching NPQ=Y(NPQ)/Y(NO)

Kramer lake model quenching parameters (2004)

Y(II) Quantum photosynthetic yield
q_L Photochemical quenching
Y(NPQ) Photoprotective non-photochemical quenching
Y(NO) All other non-photo-protective non-photochemical quenching



Puddle model quenching

Y(II) Quantum photosynthetic yield
q_P: Photochemical quenching
q_N: Non-photochemical quenching
NPQ: Non-photochemical quenching

Quenching relaxation - for measuring the xanthophyll cycle, state transitions, and photoinhibition.

q_E Fast acting photoprotective mechanism non-photochemical quenching,
q_T The portion of NPQ related to state transitions,
q_Z The portion of NPQ related a slower photoprotective zeaxanthin mechanism.
q_I The portion of NPQ due to photo-inhibition and photodamage.

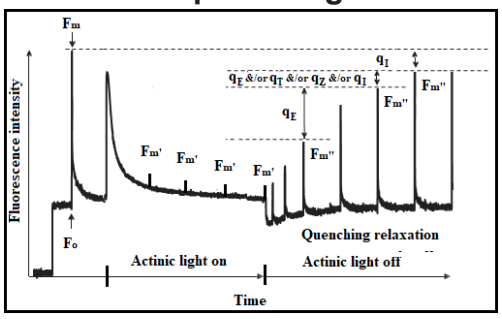
Ruban & Murchie's photoprotective NPQ protocol – Measuring pNPQ, qP_d & q_I

A more reliable way to measure photoprotective NPQ and Photodamage.
For many years, researchers have been trying to measure various Photosystem II plant protective mechanisms using a technique involving chlorophyll fluorescence quenching relaxation. In the technique, one dark adapts to the equivalent of overnight pre-dawn levels, and measures Fv/Fm that serves as a measuring standard for all subsequent values. Then, one illuminates a leaf or plant, at a specific actinic light intensity, until it reaches steady state photosynthesis, after about 15 to 30 minutes. At that point, the actinic light turns off and intense saturation flashes occur at interval spacings in the dark. Over time, the saturation flashes get taller to measure plant mechanisms as they relax in the dark.

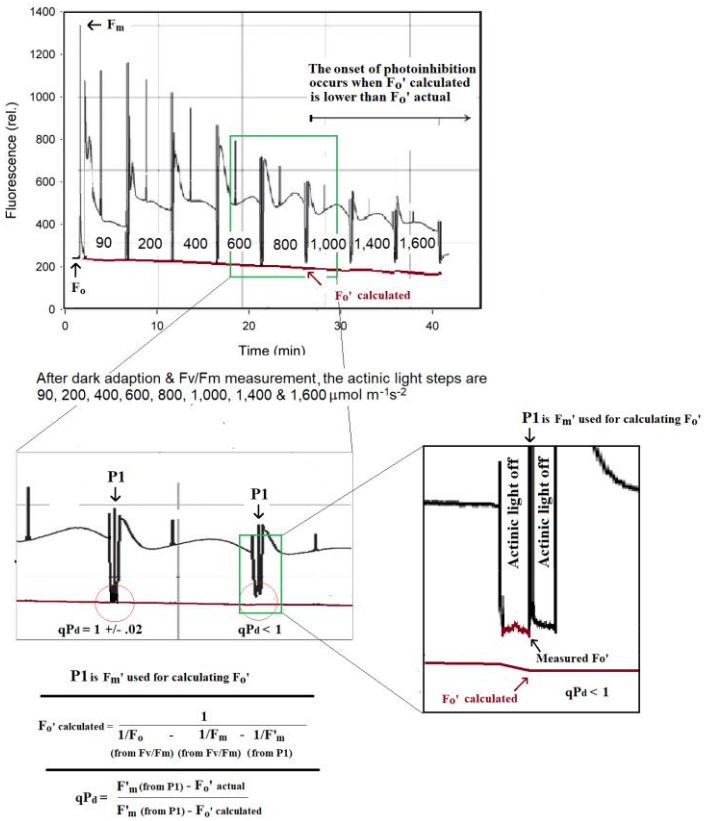
Years of research find, that after the initial fast photosystem II photoprotective mechanism, q_E, adjusts, there are multiple plant mechanisms that adjust over time. A longer lasting photoprotective mechanism called q_Z has been proposed (Nilkens 2010) that took between 10 to 30 minutes to adjust and relax. However, Ruban & Murchie (2012) suggested that the multiple plant mechanisms, involving zeaxanthin, state transitions and acute photoinhibition relaxation times, overlapped during "time-based measurements", and made them somewhat ambiguous.

For this reason, Ruban & Murchie developed a method for differentiating between photoprotective plant mechanisms and photodamage, that was not "relaxation time" dependent and not ambiguous. *In general terms*, they develops a method that was similar to a light curve using 8 actinic light steps of 5 minutes duration for each step, going from low to high actinic light levels. After each step, they measure Fo' & then Fm' in the dark with a saturation flash. Then, they "calculate" Fo' according to the Oxborough – Baker method (1997). The research shows that when the "*measurement of Fo'* " is higher than the "*calculation of Fo'* ", by more than .02 (possible measurement error level), photodamage starts. This method allows distinct separation of photoprotective NPQ from photoindamage. the parameter, **pNPQ, is photoprotective NPQ**. Another parameter in the protocol is **qP_d or photochemical quenching in the dark**. It allows measurement of the difference between "the measurement of Fo' " and "the calculation Fo' ". As a result, it determines the onset and increase of photodamage.

Time based quenching relaxation



Ruban & Murchie pNPQ protocol



From this information, one can determine clear evidence of how photoprotective mechanisms compare in different plants, determine the actinic light intensity where photodamage starts to occur and the maximum light intensity where there is no photodamage. Other calculations are also possible such as the light intensity tolerated by 50% of all leaves, the light intensity tolerated by all leaves and the minimum light intensity to create photodamage. Therefore, one can find plants with the best pNPQ, determine the optimal actinic light intensities for growing conditions and prevent wasted light energy.

F_M' correction – attention to detail

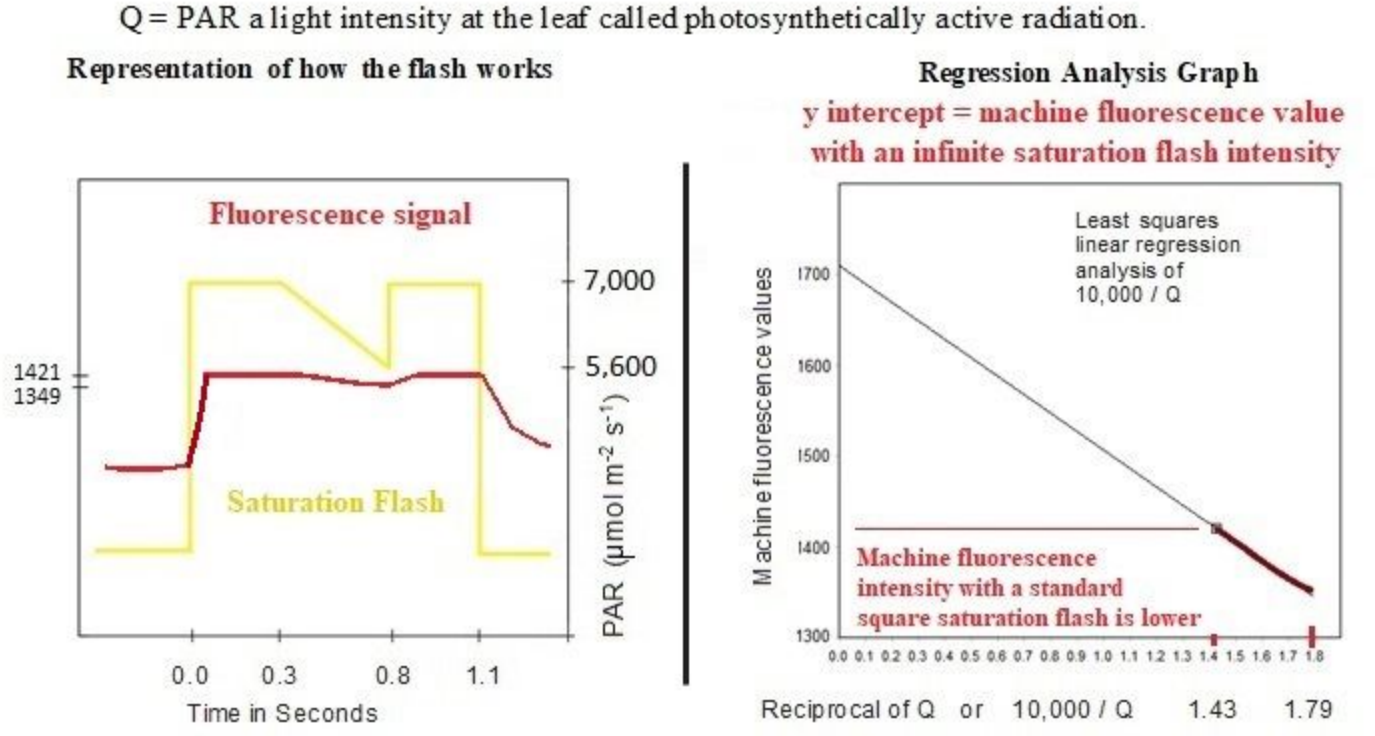
Loriaux, Avenson, Welles, McDermitt, Eckles, Riensche, & Genty (2013) Closing in on maximum yield of chlorophyll fluorescence using a single multiphase flash of sub-saturating intensity Plant, Cell and Environment (2013) 36, 1755–1770

Saturation flashes, from modulated chlorophyll fluorometers, have to close all PSII reaction centers for reliable measurement. If not, measurement error exists.

However, plants under near saturating actinic light conditions are a special case. It has been known, for a number of years, that closing all PSII reaction centers in plants, under near saturating actinic light conditions, was impossible, even with the most intense saturating light intensity. The resulting error in Y(II) measurement can be up to 22% and the error in ETR can be up to 41%. It is thought that fast turnover of the plastoquinone pools, under these conditions, prevent complete reduction of QA. (Margraph 1990, (Earl 2004) Loriaux 2006, Loriaux 2013)

The solution, was created by some top researchers, that included Bernard Genty, the developer of quantum yield of PSII (or $\Delta F / F_M'$) protocol. It involves a multiple phased saturation flash at different intensities and measuring the fluorescence results. While the range of intensities for this method are adjustable, the original research uses a 7:000 μmol m^{-2} s^{-1} for the first 0.5 seconds and then reduces the saturation intensity down 20% to 5,600 μmols m^{-2} s^{-1} over the next 0.3 seconds, using a ramping rate of less than 0.01 mols m^{-2} s^{-1}. Over the next 0.3 seconds, the saturation intensity returns to 7,000 μmol m^{-2} s^{-1} to test for saturation pulse NPQ. After the saturation flash is complete, the method uses least squares linear regression analysis of 10,000 / PAR, to determine what the intensity of F_M' fluorescence level with an infinitely intense saturation flash.

This standard option is available in all measuring protocols, and it can be turned off or on. The standard square flash may also be used. The instrument uses the method from **Loriaux, Avenson, Welles, McDermitt, Eckles, Riensche, & Genty (2013)**

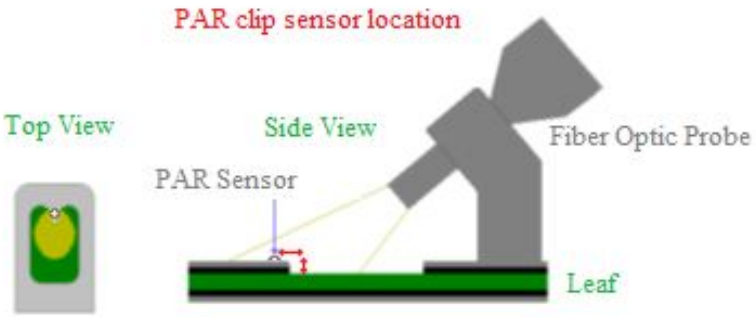


Attention to detail

Unique - Stable light source

When used with the PAR Clip, the OS5p+ maintains a stable actinic light intensity to +- 2 % during all tests.This is unique. With non-stabilized light sources, the light intensity drops significantly for longer tests due to heat, and can be a source of significant error. Accurate quenching measurements, light response curves, rapid light curves, pre-illuminated Y(II) and ETR tests require a stable light source to maintain steady state photosynthesis.

Light intensity output changes with lamp temperature and instrument temperature. Normally, the longer that an instrument is on, the greater the heat, and the lower the actinic light intensity. When the OS5p+ is used with the PAR clip, the PAR clip monitors PAR level and maintains that level for the length of the test. This ensures that samples are at steady state photosynthesis, a process that takes between 15 to 30 minutes for a specific light level. There is sufficient reserve light intensity to maintain an actinic intensity of greater than 2,000 μmols m^{-2} s^{-1} for extended periods of time.



Innovative PAR Clip

The Opti-Science PAR Clip was created to improve upon previous industry designs. By developing a *bottom opening* PAR Clip, this model prevents inappropriate opening when measuring leaves above the operators head, or when mounted on a tripod that occurs with some industry designs. As a result, the Opti-Science PAR Clip allows one handed operation. This PAR light sensor allows measurement of ambient PAR as well as PAR from internal actinic light sources. A solid state thermistor allows reliable leaf temperature measurement to +/- 0.5°C over the instrument operating range for all measuring protocol conditions. New thermistors provide improved measuring accuracy over older thermocouple designs and they don't drift over long periods of time like older thermocouple technology. In addition, they rarely have to be replaced and they do not damage leaf samples.

Cosine correction: When measuring PAR in ambient light or with internal illumination, one must not change the orientation of the leaf to make a measurement. Reliable Y(II) measurements require steady state photosynthesis, so, a change in orientation to a light source will end steady state conditions & cause a significant error. Cosign correction insures that leaves that are oriented at different angles to actinic light sources will be measured reliably.

Sensor Location error: In 2000, a researcher found that having a PAR sensor at a different plane from the leaf plane, and that is also laterally displaced from the center of measuring field, can produce an error in PAR measurement of up to 10%. Opti-Sciences corrects for this error.

Attention to detail

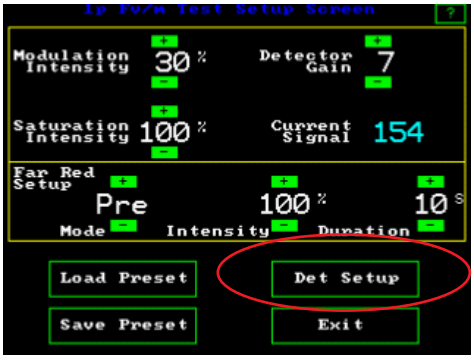
Optional BARCODE reader

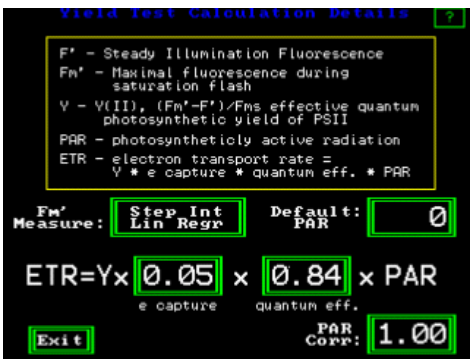
One can use any commercially available barcode reader, with a USB connection, to record plant identification information before measurement. This is ideal for measuring larger plant populations in the field, in green house settings, & other indoor settings. When reading a barcode, the OS5p+ will beep and it will flash on the measuring screen. The measurement that follows will appear with the barcode information in the measuring file.

It is necessary to buy a barcode reader with a USB A connection and a USB mini type B adapter.
Barcode readers are relatively inexpensive. If they fail, they are not repaired, but replaced.

Automated modulated light intensity adjustment option- Use "Det Setup" The OS5p+ provides an automated method to set the modulated light intensity correctly. It starts low and adjusts the light intensity and the detector gain control until the fluorescence signal is high enough for detection, but low enough so that there is no QA being reduced. While one can still adjust the modulated light intensity manually, the automated method saves time and helps prevent mistakes.

Input of actual leaf absorptance & PSII / PSI ratio values - The average values for leaf absorptance, 0.84, and the ratio of PSII reaction centers to PSI reaction centers, 0.5 are shown as the default values used to determine electron transport rate. The window on the left allows input of actual measured values for a more accurate electron transport rate. It also allow input of PAR measurement by other means when the PAR clip is not used.





Attention to detail

Data Management

The OS5p+ provides 2 gigabyte of non-volatile flash memory designed to prevent data loss due to power interruption.

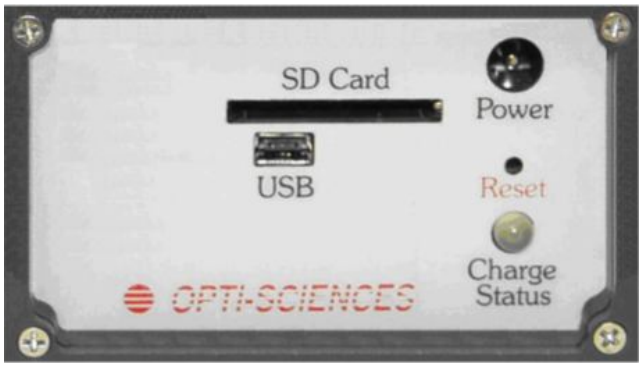
Data Card
The built-in MMC/SD data card system can be used with an unlimited number of fluorometer users to store individual measuring routines and individual data records. The data cards are very inexpensive and can store up to an additional 2 gigabytes of information. Instrument settings, and experimental results can be automatically, and instantaneously set by each researcher, by loading the stored file from the data card.

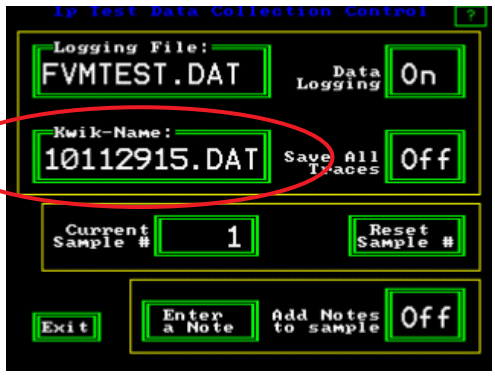
USB
A small USB mini B port is on the side of the OS5p+. When connected to a PC, the OS5p+ becomes a hard drive for a computer, allowing the transfer of data, measuring files, and allows software upgrades. There is no requirement for special software. Just open Excel® and click on the new drive that appears on your computer when you attach the OS5p+ by USB cable. Files may be opened with Excel, or any other program that takes comma delineated information.

Kwik Name - To create a new file name with existing settings, Kwik Name allows rapid naming convenience with the touch of a button. It uses today's date and time to create a unique name. of course more descriptive names may also be entered.

Notes - Notes that include up to 35 alpha-numeric characters may be created for each measurement. The note is transferred to the comma delineated data file for future reference.

Touch Screen Menu Driven Software
To ensure that the OS5p+ is easy to use in the field, a high degree of automation, a touch sensitive screen, and menu driven software are provided. Even custom measuring routine functions are easily changed.





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Soil pH Fv/Fm

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OS1p+ Parameters Measured and Protocols included:

$\Delta F/F_M'$ protocol

Y(II): Quantum Yield of PSII or ΔF/Fm'
ETR: Electron transport rate
PAR: Photosynthetically Active Radiation value
T: Leaf temperature (with optional PAR clip)
F_{MS} (or F_M'): Maximal fluorescence with actinic illumination at steady state fluorescence.
Fs or F': Fluorescence under steady state conditions (prior to saturation pulse)

F_V/F_M protocol

Fv/FM: Maximum Photochemical efficiency of PSII
Fv/Fo: A more sensitive detector of stress than **Fv/Fm**, but it does not correlate with gas exchange
Fo: Minimum fluorescence
FM: Maximal fluorescence
Fv: Variable fluorescence

Light response curves Slow and fast

RLC: Rapid light curves.

ETR_{MAX} - a measure of a leaf's photosynthetic capacity or maximum electron transport rate

α is the initial slope of line at low PAR values created by relating ETR to PAR. It provides a measure of quantum efficiency

I_k = ETR_{MAX}/α is a measurement of the light intensity where light saturation dominates, or the minimum saturation level
I_M = PAR light intensity at $ETR_{m\ MAX}$

Quenching protocols:

Ruban & Murchie pNPQ, qPd, ql, Fo', Fo'_{calc}, Y(II), Fv/FM

Hendrickson Quenching with NPQ
Y(NPQ), Y(NO), Y(II), NPQ, Fv/FM

Kramer Quenching (standard)
q_L , Y(NPQ), Y(NO), Y(II), Fv/FM

Puddle model parameters
NPQ, q_P , q_N , Y(II), Fv/FM

Quenching relaxation protocol
q_E, q_T, q_Z, & q_I along with either puddle model or Hendrickson parameters. Adjustable times

Technical Specifications

Light Sources:
Saturation pulse White LED with 690 nm short pass filter. 12,000 μmols m^{-2} s^{-1}
Modulated light
Red: 660 nm LED with 690 nm short pass filter
Optional at time of purchase: Blue: 450 nm LED.
Actinic light source: White LED source to 3000 μmols m^{-2} s^{-1}
Far red light: above 740 nm
Detection method: Pulse modulation method.
Detector & Filters: A PIN photodiode with a 700 ~ 750 nm bandpass filter.

Sampling Rate:
Test Duration: Adjustable from 0.1 seconds to 12 hours.
Storage Capacity: 2 Gigabyte of non-volatile flash memory. supporting almost unlimited data sets and traces.
Digital Output: USB, SD/MMC 2 gigabyte data cards. Data in comma delineated format.
User Interface:
Display: Graphic color touch screen
Menu driven touch screen.
Power Supply: Internal 12V, rechargeable nickel metal hydride battery.
Battery Life: 8 to 12 hours of continuous operation. The spec drops with high temperatures.
Dimensions: 7 in x 5.5 in x 3.25 in. or 17.8 cm, x 14 cm, 8.3 cm.
Weight: with fiber optic probe - 3 lbs or 1.36 kgs. with fiber optic probe and PAR Clip- 3.6 lbs or 1.62 kg

Automated routine to optimally set the modulated light intensity. The modulated light may also be set manually.
F_M' correction for all light adapted protocols. It may be turned on or off.

Optional barcode reader- The system will work with any barcode reader with a USB A connection. The barcode reader requires a USB mini B connection to plug into the OS1p system or an adapter.

Accessories

Standard Storage Shipping and Transport Case.

This durable abrasion resistant water tight plastic case allows storage of the OS5p+ with the fiber optic sensor PAR clip, charger and dark clips. Airline approved for carry-on luggage.

Accessories included:

- 1 Open Body Actinic Light Leaf Cuvette –light adapted work
  PAR clip with PAR sensor and leaf temperature thermistor
- 10 Dark Adaption Clips
- Fiber Optic Probe
- Battery Charger
- USB Cable
- Carrying bag with shoulder strap
- Data Card Reader and 2 GByte Data Card
  USB to Data Card adapter
- Storage and Transport Case
-

Optional features & accessories:

- ***Comming soon- PAR clip that also measures chlorophyl content***

Barcode reader
Algae Cuvette
- 70 hour battery belt (specification at 20°C value falls at higher or lower temps.)
- Tripods
  Package of 50 dark clips

25 Years ANNIVERSARY

OPTI-SCIENCES

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