PSP32 - *Automated* plant stress measuring system

Automatically monitors <u>all types of plant stress</u> on up to 32 separate plants over long periods of time.

Automated *daylight dark adaption* for **chlorophyll fluorescence**

Standard **chlorophyll fluorescence** probe

Automated **chlorophyll content** probe for *nutrient plant stress*

NDVI, NDRE, PPR & CCCI automated probe for *drought & nitrogen stress*

PSP32 - *Automated* plant stress measuring system

Standard Versions

"Daylight-Dark-Adaption" Versions

Standard version

Available with:

- Blue or Red modulated light
- Measures Y(II) & ETR in day
- Measures F_V/F_M at night
- Computes Lake and Puddle Model Quenching parameters from pre-Dawn F_V/F_M and day time Y(II) parameters
- Automated modulated light intensity setup
- Either 10,000 μmol square top saturation flash or F_M' correction for Y(II) and ETR measurements
- Measures PAR and leaf Temp.
- Can integrate with soil moisture sensors & weather stations
- Can provide measurement output to drive external functions such as control of actinic light intensity or nutrient supply.
- *Custom protocol capability*

Daylight-Dark-Adaption version

Available with:

- **Everything in the standard version and more...**
- Can measure *Quenching Relaxation* parameters at different times of day Including:
  The photo-protective xanthophyll cycle q_E
  Photoinhibition q_I
  Chloroplast migration q_M
  State transitions q_T
  Ruban & Murchie's photo-protective pNPQ & qP_d with color graphing.
- Can measure F_V/F_M at different times of day
- Can measure light saturation characteristics with Rapid Light Curves ETR_{MAX}, I_M, I_K, & α
- *Custom protocol capability*

PSP32 - *Automated* plant stress measuring system

Chlorophyll Content Probe using ratio-fluorescence

NDVI, NDRE, PPR Probe independent of actinic light

The Chlorophyll Content probe allows measurement in mg m^{-2} and will measure reliably from 41 mg m^{-2} up to 675 mg m^{-2}. It uses the Gittleson ratio fluorescence method that is independent of leaf size. It can measure at distances up to 1.2 meters with a field of view up to 1.2 meters. It also uses a modulated light that provides measurements that are independent of actinic light values. It is ideal for nutrient plant stress applications but may also be used for other types of plant stress.

The NDVI, NDRE, PPR & CCCI probe allows sensing of larger areas with a field of view up to 1.2 meters & up to a distance of 1.2 meters. This weather proof instrument allows measurement of drought stress in C_3, C_4 or CAM plants as well as nitrogen stress.

Like the Chlorophyll Content probe, this probe fits on a standard 1/4 in. /20 tripod mount. The probe works with the PSP32 system or it can work separately with an independent data logger.

Remote control & Data collection with webpage interface design

Control, programming, and data retrieval, are possible *remotely ...* by cell phone, lap top, or desktop computer. This makes the system *ideal for growth chamber work*, **and** *remote field work.* It also means that no additional special software is necessary and software updates are not a requirement when computer operating systems change or update.

Warnings of measurement errors can be sent to cell phones or computers to minimize data loss.

While the system comes standard with WiFi, Ethernet, and USB capability, options include a cell phone modem, radio point to point and a satellite phone modem for more remote situations.

Some control & data screens as they appear on cell phones or computers

< WiFi antenna
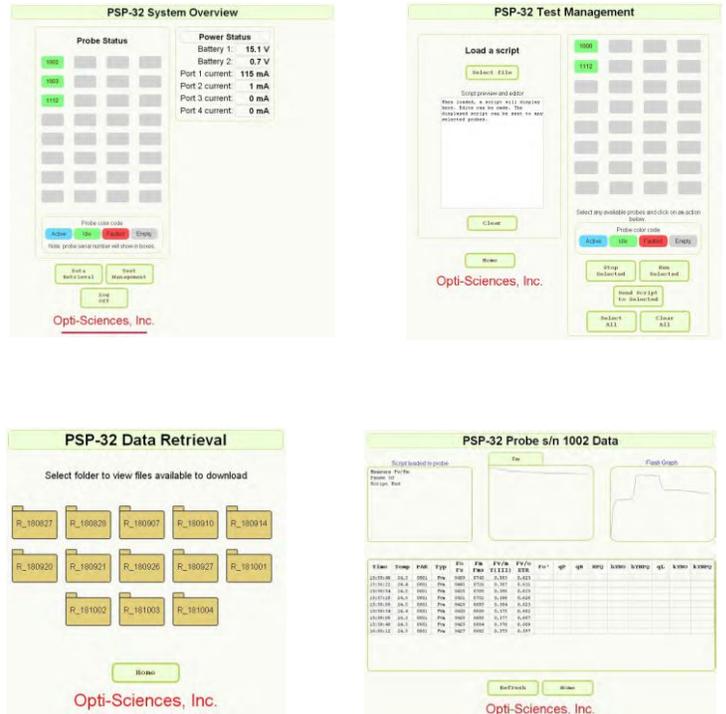
Some controller screens

Options for plant variations

Moss and small plant mount

Ground stake with articulation arm

Large tripod with articulating arm

Scissors stand with articulating arm

Standard leaf holder

More Options

Solar kit

Heavy duty FL-Arm table top mount recommended for systems with dark hoods.

Probe link cables lengths of:
- 10 meters
- 20 meters
- 45 meters
- 60 meters

4 probe junction box

8 probe junction box

Cell phone modem - optional

More Options

Allows measurement output to external controls & instruments

PSP-4IB PSP32 Four channel signal output box

This accessory allows up to four separate control signals from a PSP32 measuring probe to communicate with other separate independent systems. Applications may include using measurement values to control growth chamber temperature or lighting. This allows PSP32 events or measurements to direct external functions of other systems.

Options include:
1. Up to 4 voltage outputs,
2. 4 current loop outputs,
3. or 4 N.O/N.C relay contact sets.
4. Any combination of these options may be chosen at time of order to create a custom configuration having a mix of output styles.
5. Up to 4 of these devices can be installed in a PSP32 system.

The PSP32 offers a text-based scripting capability. Special calculation scripts allow scaling of measurements or calculations to the output signal range. For example: Fv/Fm ranges from zero to 0.83 and scaling scripts allow the output to range from zero to 5 volts. Relays can be controlled by data variable levels or timed events.

Allows input of data from external weather stations

PSP-WS PSP32 Weather station input box.
Allows collection of weather station data at the same time as PSP32 measurement data in the same measuring file.

It may also be connected to an external CO_2 sensor.

The weather station input box has a standard PSP32 probe connection port on one side and an RS-232 data connection and status LED on the other. The RS-232 connector is a water resistant DB9 male connector with standard pin out. The data led flashes with the receipt of data to aid in connection troubleshooting.

Specifications:
Data Rate: 300Baud – 115.2KBaud
Parity: Even, Odd, None
Data Bits: 8 Bits
Handshaking: Hardware, None
Items Included: 1 PSP-SB, 1 3m PSP link cable (custom length cables available)

More Options

Allows soil moisture probe and soil temperature probe input

Allows the PSP32 to control liquid nutrient and water distribution

PSP32 PSP-PIB - 8 analog input channels

Each channel also supplies power for sensors. Up to 4 of these devices can be installed in a PSP32 system.

While this accessory allow soil temperature and soil moisture probes to connect to the PSP32, it is also possible to connect leaf wetness sensors, salinity sensors or other analog sensors to the system.

The device is controlled by a text script. The script is managed from the PSP32 like probe scripts. Each input can have data range scaling values, units conversion calculations and sampling interval functions set independently.

Specifications:

Channel Count: 8 channels.

Input Range: (Script selectable per channel) +-2.5V, +-5.0V, +-10V

Input connection: A 4 pin water resistant connector

Excitation Voltage Output: 5.0VDC max load 30mA per sensor.

PSP32 PSP-PP Peristaltic Pump Box

The PSP-PP provides a way for the PSP32 system to add the dimension of chemical solution additives to a test protocol. Up to 4 of these devices can be installed in a PSP32 system.

The device is meant to allow the PSP32 to add solutions to plants during a test run. The pumping action may be controlled by timed events of by inputs from other sensors. For example, A soil moisture sensors input can be used to meter out a watering solution based on sensor readings.

The pump action is configured by a text script. The script is managed from the PSP32 like probe scripts. This allows for configuring such settings as flow rate, duration, or dosing event triggering.

Specifications:

Flow Rate: 0 – 120mL/Min

Tubing Connection: 1/8 I.D. Silicone

Items Included: 1 PSP-PP, 1 3m PSP link cable (custom length cables available)

Automated Monitor Fluorometer

PSP32 - Protocols and Parameters:

Light adapted -

Y(II): Quantum Yield of PSII
(or) $\Delta F/F_M'$
ETR: Electron transport rate
PAR: Photosynthetically Active Radiation
T: Leaf temperature
F_M' (or F_{MS}): Maximum fluorescence of a light adapted sample using a saturation pulse
F (of F_S): Fluorescence under light adapted conditions.

Either 10,000 µmols m^{-2} s^{-1} square topped saturation flash or **F_M' correction according to Loriaux 2013**

Dark adapted -

F_V/F_M: Maximum photochemical efficiency of PSII
F_V/F_O: A more sensitive plant stress detector ratio.
F_O: Minimum fluorescence
F_M: Maximum fluorescence
F_V: Variable fluorescence
F_O': Minimum fluorescence after exposure to far red light.

With red light measuring probe only - Kramer fast quenching parameters NPQ(T), q_E(T) & q_I(T)

Quenching -

Hendrickson Quenching equations with NPQ, Y(NPQ), Y(NO), Y(II), & F_V/F_M

Kramer Quenching equations with q_L, Y(NPQ), Y(NO), Y(II), F_V/F_M

Baker Puddle Model Quenching equations with NPQ, q_N, q_P, Y(II), F_V/F_M

The following measuring parameters require Daylight Dark adaption module

Quenching relaxation parameters with q_E, q_T, q_M, q_Z, & q_I

Ruban and Murchie's Quenching relaxation equations with pNPQ & qP_d

Rapid Light Curves

ETR_{MAX}, I_M, I_K, α

Other Specifications:

Light Sources:
Blue Saturation flash blue probe:
> 7,000 µmols m^{-2} s^{-1} with F_M' correction
> 10,000 µmols m^{-2} s^{-1} square topped flash

Red Saturation flash red probe
> 7,000 µmols m^{-2} s^{-1} with F_M' correction
> 10,000 µmols m^{-2} s^{-1} square topped flash

Modulated light
> Blue 455 nm with a half bandwidth of 21 nm
> Red 640 nm with a half bandwidth of 17 nm

Actinic light source
> Blue - up to 5,000 µmols m^{-2} s^{-1}
> Red - up to 5,000 µmols m^{-2} s^{-1}

Far Red light
> Available with the Daylight-Dark-Adaption module to measure F_O' and to pre-illuminate samples before F_V/F_M measurement.

Detection method - pulse modulated

Detector and Filters - Pin photodiode with a 700 nm to 750 nm bandpass filter

Sampling rate - from 1 to 10,000 points per second depending on test and phase of test

F_M' Correction according to Loriaux 2013 for all light adapted modes, used during daylight hours.

Test Duration: Will measure samples 24 hours a day, 7 days a week, for months at a time. Runs on solar power, battery power or mains current.

Storage Capacity: 2 Gb. of non-volitile memory supporting almost unlimited data sets and traces or more than 500,000 data sets.

Special Algorithms: 8 point rolling 25 ms average to determine F_M, F_M', F_O & F_S. It eliminates saturation pulse NPQ and electronic noise as issues.

Output: Comma delineated files may be opened in Excel. Data may be retrieved by WiFi, Eithernet, USB stick or optional methods that include radio point to point, cell phone, or satellite phone.

User Interface: Color touch screen, or webpage remote control and data collection by computer or cell phone.

Accessory Specifications:

Chlorophyll content probe:

Y(II): Quantum Yield of PSII

Measured Parameters: CFR or Chlorophyll Fluorescence
Ratio - fluorescence emission ratio of intensity at 735nm / 700nm readout to 0.01, or relative chlorophyll content in mg/m^{-2}

Measurement Area: From about 10 cm to about 1.2 meters in diameter.

Source: LEDs 460 nm blue diode half band width 15 nm.

Detector: Two solid state, high sensitivity detectors. Band
limiting filter sets provided. Dual wavelength detection at
the same time. 700nn to 710nm, and 730 nm to 740 nm.

Storage Capacity: Up to 2 gigabytes of non-volatile flash

Modes: Single measurement or averaging of measurements

User Interface: Color touch screen

Output: USB 1.1, WiFi, & Eithernet are Standard

Temperature Range: 0-50 Deg C

Power Source: Mains power, Solar and battery option

Repeatability: is dependent on signal strength. For samples with low signal strength, averaging of multiple measurements is recommended. for samples with good signal strength, ratio values of +- 0.03 or better, are common

Accessory Specifications:

NDVI, NDRE, PPR & CCCI probe:

Measured Parameters: NDVI, NDRE, PPR, CCCI

Measurement Area: From about 10 cm to about 1.2 meters in diameter.

Modulated light design: Prevents actinic light intensity differences from being an issue.

NDVI is Normalized Difference Vegetation Index
NDVI - ratio of (r800-r670)/(r800+r670),
Range 0-1.00

NDRE is Normalized Difference Red Edge
NDRE- ratio of (r800-r730)/(r800+r730),
Range 0-1.00

PPR is Plant Pigment Ratio
PPR - ratio of (r540-r450)/(r540+r450),
Range 0-1.00

CCCI is Canopy Chlorophyll Content Index
CCCI - NDRE/ NDVI
Range 0-1.00

Storage capacity: 2 gigabytes of non-volitile flash memory.

User interface: Color touch screen, webpage based remote control or data logger with cell phone or computer control.

Mount: Standard 1/4 in. / 20 tripod mount