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But you don't have to take our word for it – review the literature to see why the LI-6400/LI-6400XT is the most referenced photosynthesis system in scientific publications, talk to other scientists who have used one, or talk to one of our knowledgeable Application Scientists to see for yourself why the LI-6400XT is the undisputed market leader.

- Proven technology that places the gas analyzers in the sensor head, to provide rapid response and eliminate time delays.
- An open system design that allows complete control over environmental variables of interest.
- A flexible, open source software language in the LI-6400XT console that can be modified to write your own equations or AutoPrograms, providing an unprecedented level of automation.
- Powerful networking capability via Ethernet connectivity, providing a world of data output, file-sharing, and training possibilities.
- A variety of leaf chambers and light sources, a leaf chamber fluorometer, and soil CO₂ flux chamber that are interchangeable with the same LI-6400XT sensor head.
- Worldwide service, support, and training that ensures your purchase of the LI-6400XT remains a smart investment for years to come.



Proven Technology

Analyzers in the Sensor Head

The LI-6400XT has two absolute CO₂ and two absolute H₂O non-dispersive infrared analyzers in the sensor head. Mounting the analyzers in the sensor head provides a number of advantages over systems which place the analyzers in the console:

1. Changes in the leaf dynamics are measured in real time. Because there is no tubing between the leaf chamber and the console, there are no time delays confounding effects of changes in environmental driving variables such as light, CO₂ mole fraction, etc.
2. CO₂ and H₂O concentrations are controlled at the leaf surface, because the fast response IRGAs are built into the mixing volume of the leaf curvette. This is important because, for example, it allows you to easily make photosynthesis comparisons across treatments with widely differing rates, at a constant CO₂ concentration, thus avoiding biases in your conclusions.
3. CO₂ and H₂O concentrations are continuously measured at both reference and sample cells, eliminating flow swapping, which provides fast response times, minimizes noise and drift, and gives more accurate photosynthesis measurements.
4. Rapid, automatic control of chamber humidity is possible, even when the transpiration rate is changing.
5. Absence of tubing between the chamber and the analyzers eliminates equilibration times due to water vapor sorption on the tubing walls.

Analyzer Operation

Infrared radiation from the sample analyzer source passes into the leaf chamber mixing volume and is twice reflected 90° by gold mirrors. The mirrors are gold plated to enhance IR reflection and provide long-term stability.

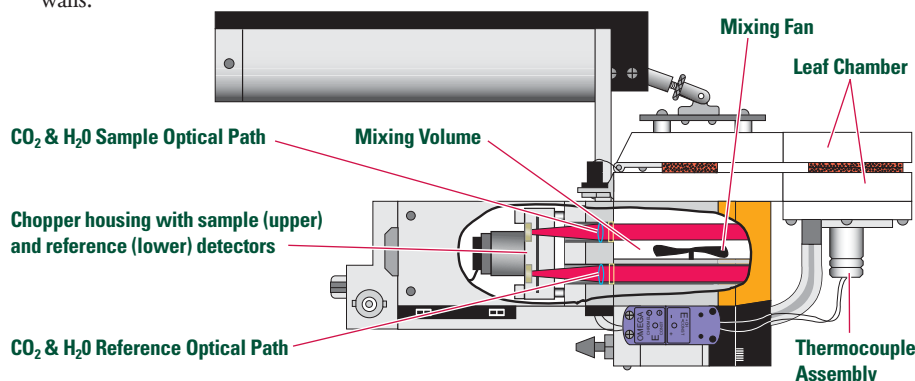
After being reflected through the leaf chamber mixing volume where IR absorption occurs, infrared radiation passes through a chopping filter wheel and into the sample analyzer detector.

The chopping filter wheel has four filters that pass light in absorption and optical reference wavelengths for CO₂ and H₂O. These filters provide excellent rejection of IR radiation outside the wavelengths of interest, eliminating the effects of other IR absorbing gases.

The reference analyzer measures incoming gas concentrations and is located directly below the sample analyzer. The sample and reference analyzers can be matched at any time, either manually or automatically, without altering conditions in the leaf chamber.

The sample analyzer detector, reference analyzer detector, and chopping filter wheel are sealed in a housing that is continuously purged of CO₂ and water vapor to prevent interference.

Through years of experience, the LI-6400XT analyzer and sensor head have proven to be robust and reliable, even in the most rigorous field conditions.



LI-6400XT Console

The LI-6400XT system console combines a data acquisition system with a high-speed computer for dedicated data logging and computations. High speed analog-to-digital converters support fast response applications.

The backlit 8 x 40-character graphical display allows any 12 experimental variables to be displayed at once. All computed variables are calculated and displayed in real time. The full keyboard is membrane sealed and designed to be used under harsh field conditions.



Powering the LI-6400XT

The LI-6400XT system is powered by 12VDC batteries stored in the console. Four batteries and a battery charger are included with the system, providing 4-8 hours of operation. The optional 6400-70 AC Adapter fits in one of the battery compartments.

Controlling the Environment

The LI-6400XT open system design allows automatic, independent control of leaf chamber CO_2 , H_2O , temperature, and light.

CO_2 Control (optional)

The 6400-01 CO_2 Injector System consists of an electronic controller, a CO_2 Source Assembly that uses readily-available cartridges for portable operation, and a CO_2 tank fitting for greenhouse or laboratory operation. All parts integrate directly into the standard console with no external batteries or control modules.

The CO_2 Injector System provides a constant CO_2 input from 50 to 2000 $\mu\text{mol mol}^{-1}$. CO_2 is controlled by delivering a precisely controlled pure CO_2 stream into air that is CO_2 -free. The CO_2 concentration can be controlled at the incoming air stream or at the leaf surface to within 1 ppm of a target value.

The 6400-01 facilitates measurements at elevated CO_2 concentrations and easy generation of CO_2 response curves. The CO_2 injector is under complete software control, allowing you to manually set CO_2 levels from



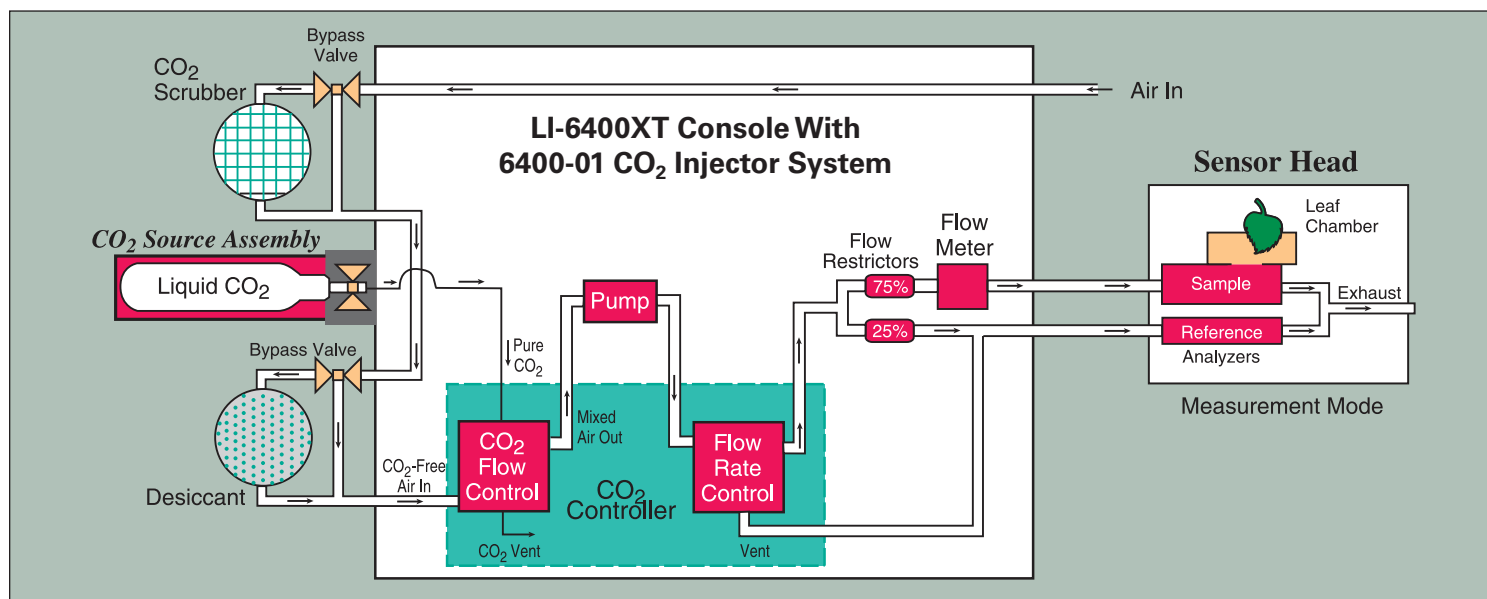
the console, or use AutoPrograms to make measurements at a series of concentrations.

12g cartridges provide up to 8 hours of operation. The cartridges are accessible outside the instrument, making them easy to change.

H_2O Control

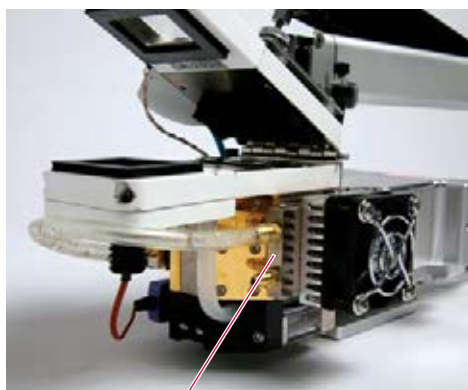
The LI-6400XT controls chamber humidity by automatically varying the flow rate to null-balance at the chamber humidity level you specify in software; the input flow rate can also be held constant. Flow rate is controlled by pump speed in the standard system. With the 6400-01 CO_2 Injector System, pump speed is constant and flow rate to the chamber is controlled by redirecting excess flow. This “shunt regulation” allows flow to be controlled smoothly and quickly across a broad range.

Whether the controller in the 6400-01 is used or not, air supplied to the chamber may be dry or moist. Supplying the chamber with moist air allows higher flow rates to be used to balance low transpiration rates, which provides more stable control and more accurate measurements. Inaccuracies and time delays due to water sorption on the air lines between the console and the sensor head are eliminated by measuring the reference and sample water vapor concentrations in the sensor head.



Temperature Control

Integrated Peltier coolers control temperature based on either leaf temperature or chamber block temperature (software selectable). Chamber block temperature can be set to any value within $\pm 6^\circ\text{C}$ of ambient temperature. Temperature control is a standard feature of the LI-6400XT; no bulky external power supplies or accessories are required. An optional Expanded Temperature Control Kit is available (p/n 6400-88) that can increase the range of temperature control of the sensor head block.



6400-88 Water Jacket

Light Control

The 6400-02B LED Light Source, 6400-18 RGB (Red, Green, Blue) Light Source, and 6400-40 Leaf Chamber Fluorometer (all optional accessories) are integrated with the hardware and software of the LI-6400XT System.

The use of LEDs makes them practical light sources because of their small size and low power consumption. LEDs also minimize the influence of the light source on the leaf temperature and are easily computer controlled.

Light Source and Fluorometer light output is continuously variable over the entire measurement range, so you can specify any light level without needing to make adjustments or change filters. Light curves can be generated automatically using AutoPrograms and user-selectable light set points.

The Light Sources are easily installed in the field. Careful placement of the LEDs also ensures uniform light distribution at the leaf surface.

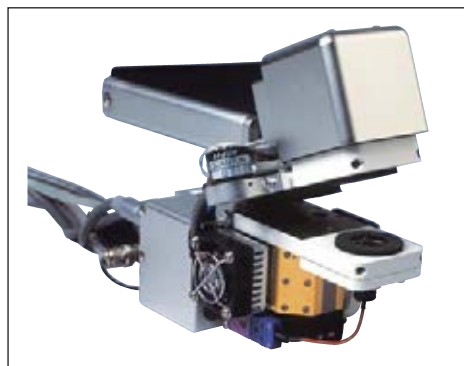
Accuracy during operation is assured by a feedback photodiode that adjusts the light source to maintain the target value.



The 6400-02B Red/Blue LED Light Source.



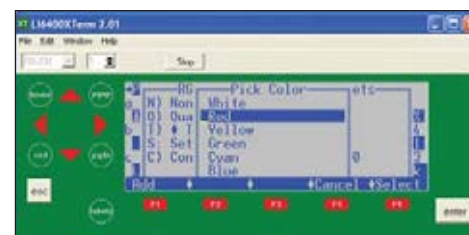
The 6400-18 RGB Light Source.



The 6400-40 Leaf Chamber Fluorometer.



The 6400-18 RGB Light Source is designed to be used with the 6400-17 Whole Plant Arabidopsis Chamber; the package is available under part number 6400-17L.



Using the 6400-18, you can choose from a variety of colors, or define your own custom blended color.

Data Output and Networking



When you're ready to output your data, the LI-6400XT provides a variety of output options to suit your particular needs. Use the standard 9-pin RS-232 port on the console to connect to your computer and output real-time or logged data. If you're away from your computer, simply log your data to the removeable Compact Flash card, and transfer the files without moving the instrument. Compact Flash cards also make it easy to transfer files to other LI-6400XTs.

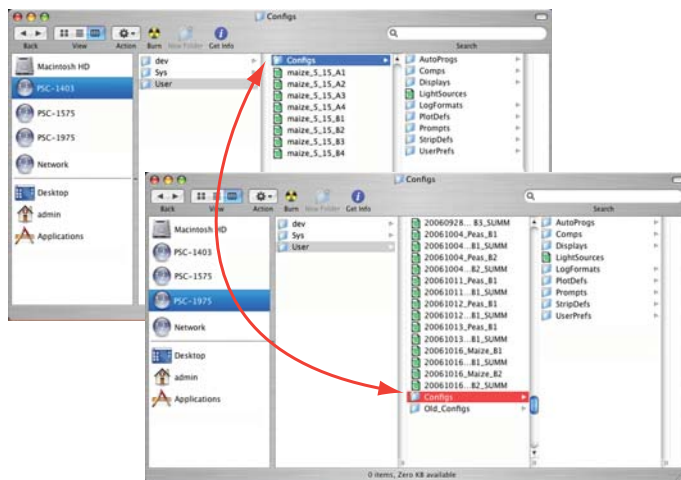
To skip the file transfer process completely and open data files directly on the computer, your instrument can be connected to an existing Local Area Network (LAN), making the LI-6400XT a powerful networkable device. No special configuration is needed; plug the Ethernet adapter card into the expansion slot on the back of the instrument case, plug the other end into your computer or LAN, and you're ready to share files across your network.



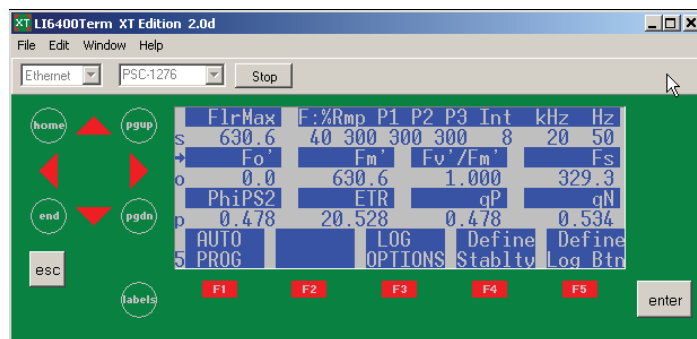
Ethernet connectivity

Ethernet connectivity is a powerful tool for performing various networking operations, including:

1. Dragging and dropping files between instruments, computers, or networked printers.
2. Configuring multiple LI-6400XTs in the same way by moving configuration files.

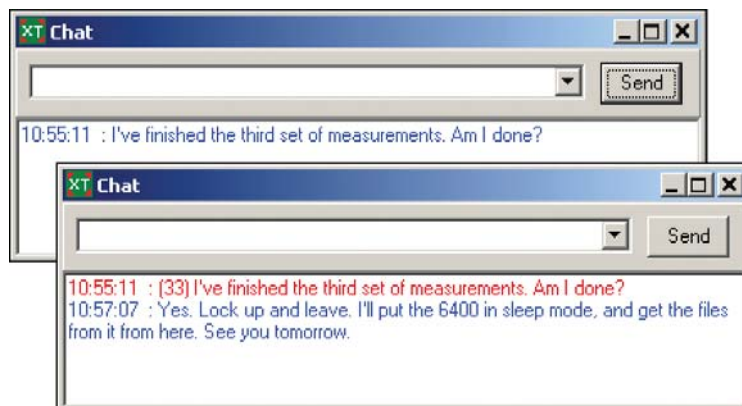


3. Connecting multiple clients simultaneously to a single LI-6400XT.
4. Controlling the instrument remotely.
5. Displaying a simulated keyboard so training participants can "see" the keys being pressed on the client keyboard.



After connection, the display will show exactly what's on the instrument's display. The buttons around the simulated display behave the same as those on the instrument.

6. Opening chat windows between connected clients so that a technician, for example, can be using the LI-6400XT while a supervisor watches from a remote location.



Flexible Software

OPEN Instrument Software

The software application used by the LI-6400XT to make measurements is called OPEN, due to the source code transparency that allows it to be modified according to each user's unique needs. Programs and data are stored in simple ASCII format, allowing the on-board editor or other external word processors to open existing computation lists, for example, modify them, and save under a new name. Novice users can use the simple software defaults to make measurements using pre-defined AutoPrograms; more experienced users may choose to modify the software using the included Programming Guide to unlock the potential of the open source application.

OPEN uses the console display to show any of the experimental variable in text or graphical modes. This allows you to examine the approach to steady state for any of the variables of interest with as many as 3 plots per graph set.

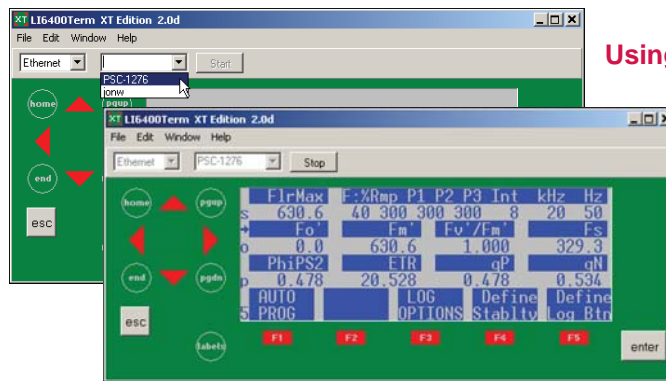
A variety of built-in AutoPrograms allow you to choose setpoints for desired chamber environmental conditions. After the system stabilizes, data are logged, and the cycle repeats for the next set point. All other environmental controls maintain their setpoints, providing stable conditions for your experiment. AutoPrograms can be modified, stored, or created using your own combination of setpoints and desired environmental conditions.

Simulator Software

The included Simulator software allows you to completely simulate your LI-6400XT on your computer screen. This is a convenient way to write and test your own equations or AutoPrograms, train yourself or others, and manage your data.

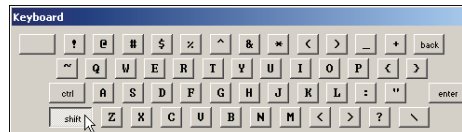
Remote Control Capability - Great for Teaching

LI6400XTerm software is also included, which is designed to be used as a terminal program to remotely control the LI-6400XT and display real-time data on your computer, while the LI-6400XT continues to function normally. This can be an invaluable tool for teaching others how to use the LI-6400XT in classroom or seminar presentations; simply implement the terminal program, connect your computer to a projector, and demonstrate to a roomful of students how the LI-6400XT works.

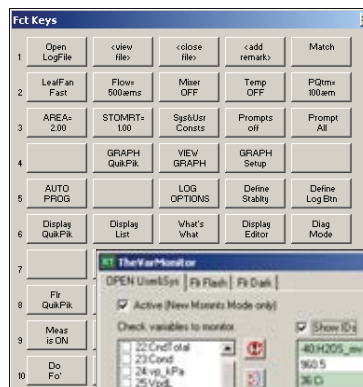


Using LI6400XTerm, you can:

A. Connect to your LI-6400XT via Ethernet or RS-232 to show what is on the instrument display.

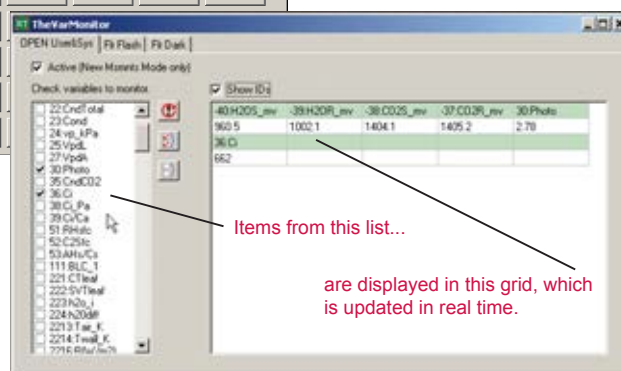


B. Display a simulated keyboard so class participants can see what keys are being pressed.



C. Display all available function keys as active buttons.

D. Display a variables monitor window, where you can view any variable, without it having to be on the instrument's display.



Leaf Chambers and Accessories

A variety of interchangeable leaf chambers are available for use with the LI-6400XT. Each chamber is designed for simple operation. Internal surfaces are coated to minimize water sorption, and external surfaces minimize radiation absorbance and maximize emissivity. Replaceable gaskets are nearly impermeable to CO₂ and water vapor, and seal tightly.

Leaf temperatures are measured directly using a thermocouple, or estimated using energy balance in the 6400-05 Conifer, 6400-07 Needle, and 6400-15 Extended Reach 1 cm Chambers.

A bracket is provided on the LI-6400XT sensor head, or on the chamber itself, to hold a LI-COR Quantum Sensor for measuring ambient photosynthetically active radiation (PAR). Other chambers measure PAR in the chamber using a small GaAsP sensor.



Standard 2 x 3 cm Chamber

Coniferous Plants



6400-05 Conifer Chamber

Features a 7.5 cm diameter that accommodates short-needed conifers with needles up to 3.5 cm long. The 6400-05 replaces the typical upper and lower leaf chambers, and mounts directly to the sample cell of the CO₂ and H₂O IRGAs. The Conifer Chamber is constructed of acrylic for durability and lined with teflon to minimize water sorption.



6400-07 Needle Chamber

For measuring long-needed conifers, specially designed foam pads hold up to 5 needles in the 2 x 6 cm chamber. The 6400-07 allows each needle to be pressed into place in the chamber, where it is held securely in the channels of the foam mounting pad. The 6400-07 top and bottom have clear windows for excellent light transmittance. A quantum sensor in the chamber provides light measurement at the plane of the needles.

Broadleaf Plants

The standard leaf chamber included with the LI-6400XT is suitable for a variety of deciduous leaf sizes, has a 2 x 3 cm clear top, and an opaque bottom.



6400-08 Clear Chamber Bottom

Illuminating the bottom of a leaf is useful for survey measurements and erect foliage. The Clear Chamber Bottom has a Propafilm® window similar to the standard chamber top. The Clear Chamber Bottom is designed to be used with any 2 x 3 cm chamber top.



6400-11 Narrow Leaf Chamber

Ideal for foliage with narrow bladed leaves, the 6400-11 has a 2 x 6 cm aperture, and measures PAR inside the chamber at the leaf plane.

Specialized Applications



6400-15 Extended Reach 1 cm Chamber

The 6400-15 Extended Reach 1 cm Chamber was designed for measurement of small leaves of rosette plants, which are difficult to clamp with conventional chambers. The 6400-15 has clear apertures for natural illumination of the top and bottom of the leaf. The aperture is 1.0 cm in diameter and is positioned 8.5 cm away from the main body of the IRGA. This chamber is designed to be used with CO₂ concentrations near ambient.



6400-17 Whole Plant Arabidopsis Chamber

The 6400-17 provides a much larger aperture (7 cm diameter) for measurements of entire Arabidopsis rosettes, rather than just the leaves.

Chamber air temperature is measured by a thermocouple in the air return path, preventing radiant effects from the light source. This thermocouple plugs into the existing thermocouple block on the LI-6400/6400XT sensor head.

The leaf temperature is computed in software using an energy balance approximation. An O-ring sealed top plate with a Propafilm covering is placed over the chamber when making measurements. The O-ring provides a tight seal that eliminates the need for traditional foam gaskets.

Because soils or artificial media are present within the chamber volume, CO₂ fluxes from the soil can be introduced into the whole plant measurement. A standard peat media mix capped with a heavy clay layer on top suppresses soil respiration. An exhaust tube fitting is also provided that can be used to apply a slight over-pressure within the chamber, which also suppresses CO₂ fluxes from the soil.



Interchangeable chamber bottom plates are provided for use with readily available 2.5 in. (65 mm) pots or 1.5 in. (38 mm) Cone-tainers.

Soil CO₂ Flux Measurements



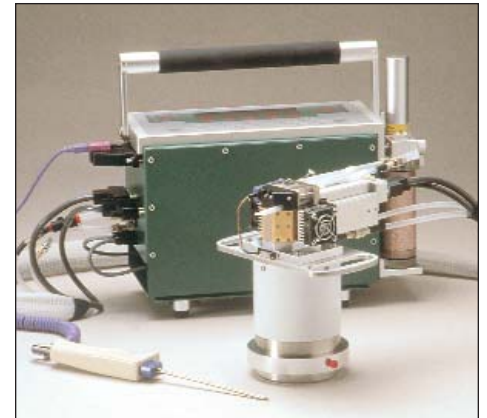
6400-09 Soil CO₂ Flux Chamber

The LI-6400XT and 6400-09 address the many challenges of making soil CO₂ flux measurements in a variety of ways, including:

- The chamber concentration is automatically scrubbed to just below an ambient target, and then measured as it rises to slightly above ambient. This maintains the CO₂ concentration gradient to within a few ppm of the natural, undisturbed value. The flux is computed according to the rate

of change of CO₂ concentration with time. Automated cycling ensures that CO₂ flux measurements are accurate and repeatable.

- A pressure equilibration tube is used to eliminate pressure differentials and avoid chamber leaks.
- Air inside the 6400-09 is thoroughly mixed while maintaining a constant pressure; this, along with a water vapor dilution correction, results in consistently accurate data.



Calibration of H₂O Gas Analyzers



LI-610 Portable Dew Point Generator

The LI-610 is a rugged, portable instrument that provides a stream of gas with a precisely controlled dew point. High accuracy and stability make the LI-610 an ideal water vapor source for calibrating the H₂O gas analyzers in the LI-6400XT sensor head.

- NIST (National Institute of Science and Technology) certified
- Generates stable dew points from 0 to 50 °C
- Accuracy of ± 0.2 °C dew point
- Completely portable and self-contained (battery or AC operated)
- No need for gas tanks and mixing systems
- Millivolt output of dew point temperature for data acquisition
- External control via 0-5 V input signal



Light Sources



6400-02B Red/Blue LED Light Source

The 6400-02B is completely integrated with the hardware and software of the LI-6400/6400XT Portable Photosynthesis System, providing maximum ease-of-use and application flexibility. The LED Light Source can produce any light intensity from 0 to 2000 $\mu\text{mol m}^{-2} \text{s}^{-1}$. The use of LEDs with low power consumption makes the 6400-02B a practical light source because of its small size and its ability to operate from the LI-6400XT batteries. LEDs also minimize the influence of the light

source on the leaf environment because they have low heat generation compared to other light sources.

The 6400-02B Light Source red LEDs are used to provide radiant output at 665 nm (nominal), while blue LEDs provide output at 470 nm. The output of the blue LEDs is crucial for studying stomatal kinetics.

The 6400-02B replaces the upper half of the standard leaf chamber, and mates with the standard 2 x 3 cm chamber bottom.



6400-18 RGB Light Source

The 6400-18 is designed to be interfaced with the 6400-17 Whole Plant Arabidopsis Chamber and other specialized chambers, including custom chambers. This 7 cm diameter light source features LEDs with independent control of the intensity and percent of red, green, and blue light. White light can be achieved by using equal proportions of red, green, and blue. Select any intensity of a pre-defined color, or define your own blended color by selecting

the proportion of red, green, and/or blue light to be applied to the sample. The 6400-18 can be easily configured to emulate the output of the 6400-02B Red/Blue LED Light Source for comparison studies.

The light source intensity can be changed for light response curves, set to match external PAR sensor readings, or held constant while other environmental conditions are altered. Light and CO₂ response curve AutoPrograms are built into OPEN software that can be used to automatically control and collect data for unattended curves.

The 6400-18 mounts easily to the 6400-17; the propafilm-covered plate used with the Whole Plant Arabidopsis Chamber attaches directly to the Light Source. This method of attachment ensures that the geometry between the plant sample and the light source is repeatable for every measurement.



Accessories

6400-70 AC Adapter

Replaces one of the 6400-03 Rechargeable Batteries in the LI-6400XT console to provide for an AC power supply.

6400-19 Custom Chamber Kit

Contains sample cell optical path mounting plate and accessories for mounting custom chambers to the LI-6400XT sensor head.

6400-88 Expanded Temperature Control Kit

For increasing the range of temperature control of the sensor head block.

6400-89 Insect Respiration Kit

The 6400-89 Insect Respiration Kit is for LI-6400XT users interested in measuring the respiration rate of insects, small mammals, small fruits, nuts, etc.

9964-053 Sample Cell Outlet Manifold

The Sample Cell Outlet Manifold replaces the bottom leaf chamber and isolates the sample cell from the leaf chamber so the LI-6400XT can be used as a stand-alone gas analyzer.

9964-098 Leg Extensions

Raises the LI-6400XT console an additional 12 inches. Set of four.

Fluorescence Adapter Chambers

Simultaneous measurements of chlorophyll fluorescence and gas exchange can be made with fluorometer adapter chamber tops, in conjunction with fiber optic probes from other manufacturers. The chamber tops are designed to hold 2 mm, 8 mm, or 10 mm fiber optic probes at a 60° angle from the leaf plane.

Leaf Chamber Fluorometer

Measure Fluorescence and Gas Exchange Simultaneously

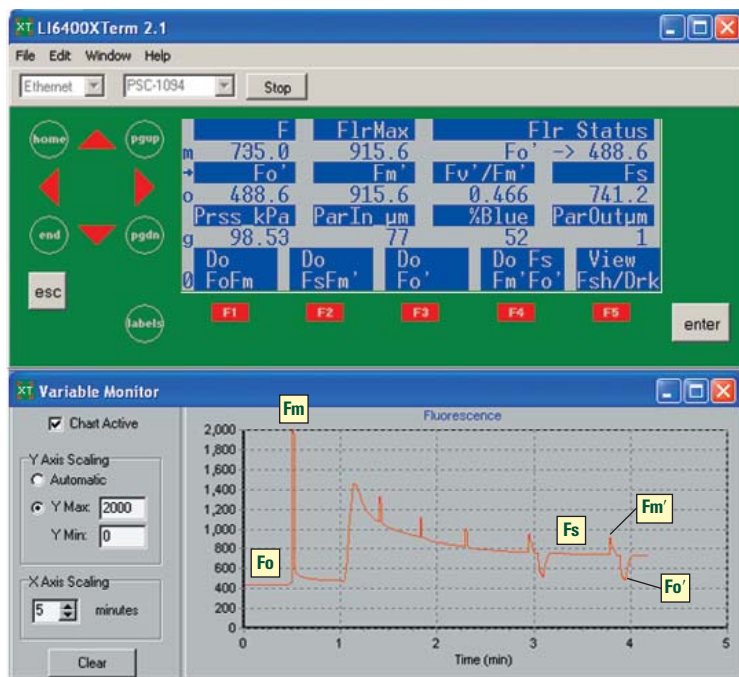


The 6400-40 Leaf Chamber Fluorometer attaches to the LI-6400XT sensor head to form an integrated, powerful Portable Fluorescence and Gas Exchange System. Using the 6400-40, you can:

1. Make simultaneous measurements of fluorescence and gas exchange over the same area of the leaf.
2. Combine fluorescence and gas exchange data into a single data set for maximum correlation.
3. Create user-defined manual or automatic measurement protocols.
4. View real-time numeric and graphic data on the LI-6400XT console and/or your computer.

The Leaf Chamber Fluorometer is a pulse-amplitude modulated (PAM) fluorometer that can be used to take measurements on both dark- and light-adapted samples. Measured parameters include F_o , F_m , F , F_m' , and F_o' , and calculated parameters include F_v , F_v/F_m , F_v'/F_m' , Φ_{PSII} , qP , qN , NPQ, and ETR. The 6400-40 provides complete control over the actinic and saturation (independently controlled red 630 nm and blue 470 nm LEDs), measuring (red 630 nm LEDs, modulated from 0.25 to 20 kHz), and far-red (740 nm LED for PSI excitation) light.

The unique design of the 6400-40 Leaf Chamber Fluorometer eliminates the need for fragile, awkward fiber optic light guides. The lightweight design and low power consumption of the 6400-40 make it possible for one person to gather data quickly and easily. Calibration information for the Leaf Chamber Fluorometer is stored onboard, making it easy to move between different LI-6400XT consoles.

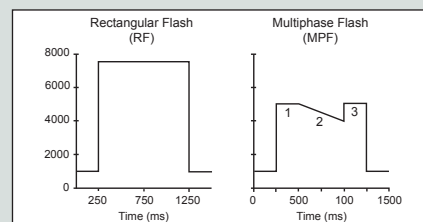


Multiphase Flash™ Fluorescence

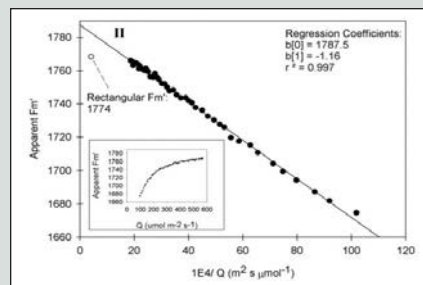
F_m' (maximal fluorescence) is usually measured using a single saturating 'multiturnover', or 'rectangular' flash (RF) to reduce the QA-PQ pool. Multiturnover means that the primary acceptor of Photosystem II, QA, is reduced and oxidized multiple times, until the transport chain of QA to PQ is in a reduced state.

In some cases, however, as with high-light adapted field plants, it is difficult to achieve full reduction of the QA-PQ pool with the RF method. Multiphase Flash™ fluorescence, developed by LI-COR scientists, can be used under these conditions to derive true estimates of F_m' , Φ_{PSII} , and ETR within about one second. This is included in the LI-6400XT OPEN software, and can be performed with the Fluorometer. Learn more:

Loriaux, S. D., T. J. Avenson, J. M. Welles, D. K. McDermitt, R. D. Eckles, B. Riensche, and B. Genty. 2013. Closing in on maximum yield of chlorophyll fluorescence using a single multiphase flash of sub-saturating intensity. *Plant, Cell & Environment*. doi: 10.1111/pce.12115



Rectangular flash (RF) method: a saturating multiturnover flash (Q) of 400 to 1200 ms duration. **Multiphase flash (MPF) method:** (1) high, nearly saturating Q for approximately 250 ms to reduce QA-PQ pool; (2) ramp of declining Q for about 500 ms; (3) return to the initial high Q for approximately 250 ms to check for flash-induced non-photochemical quenching (qN).



F_m' values from phase 2 of the MPF method are regressed against $1E4/Q$ and extrapolated to estimate the maximal fluorescence at infinite flash intensity.

LI-6400XT System

Photosynthesis, Fluorescence, Respiration



LI-COR®



Measuring Canopy Gas Exchange with the LI-6400 Portable Photosynthesis System

APPLICATION NOTE

LI-6400 Portable Photosynthesis System

Introduction

Canopy gas exchange systems are useful for quantifying the effects of environmental changes on the instantaneous productivity of a plant community. Measuring the gas exchange of the entire canopy with a chamber system obviates difficulties encountered when extrapolating leaf measurements to the canopy scale such as accurately modeling the distribution of absorbed radiation. Canopy gas exchange systems, if properly designed and operated, can provide a measure of CO₂ flux that closely approximates natural conditions. However, it is important to consider how the chamber may alter, among other factors, the canopy temperature, wind speed (and therefore boundary layer conductance), and radiation balance of the plant community. When possible, canopy chamber results should be compared to micrometeorological flux measurements, since they do not disturb the environment around the canopy (Baldocchi et. al., 1988).

Oftentimes the focus of a study is an individual species of a plant community, or field plots are too small to make use of micrometeorological techniques. In these cases enclosure methods are the only methods available to determine instantaneous canopy CO₂ flux.

Many types of chambers and systems have been designed and will not be reviewed here. Garcia et. al. (1990) summarize some of the advantages and disadvantages of open and closed canopy chamber systems.

This application note will be concerned with the design and implementation of a simple continuous flow "open" canopy chamber system based around the LI-6400 Portable Photosynthesis System. This system allows steady-state canopy fluxes to be measured over a period of several hours or days, and is less susceptible to errors introduced by leaks and water sorption than a closed system. (Water sorption can have a significant effect on transpiration estimates until equilibrium conditions are reached.) Nonetheless, depending on plant material and experimental design, a closed system may be more suitable. In that case, the LI-6200 Portable Photosynthesis System may be readily adapted for closed system canopy measurements (Vourlitis et. al., 1993). For soil respiration measurements, the LI-6200 with the 6000-09 Soil Respiration Chamber has been thoroughly tested (Norman et. al., 1992) and is recommended.



Canopy gas exchange system installed in August, 1995, in Lincoln, Nebraska.

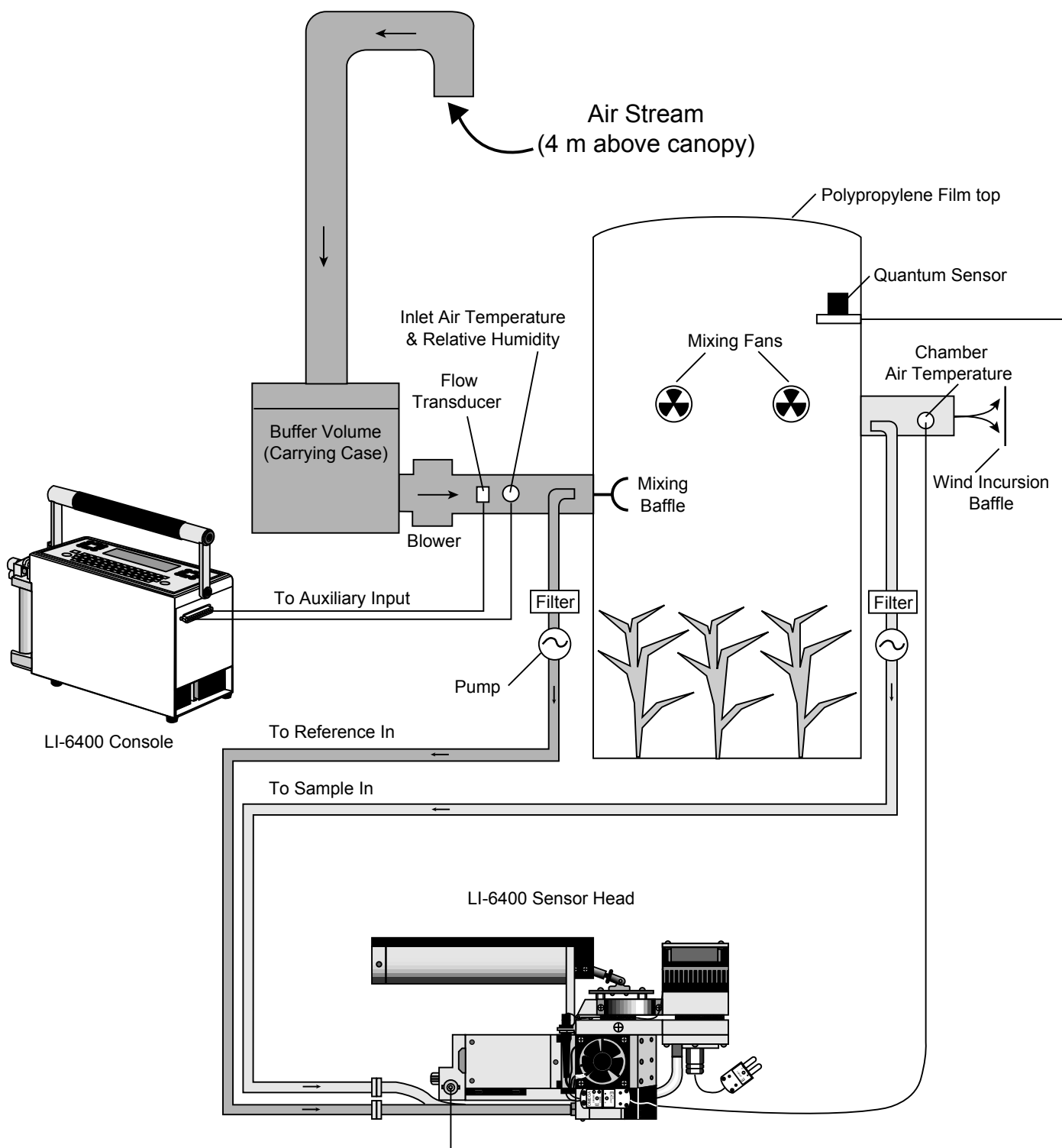


Figure 1. A flow-through canopy chamber system configured to operate with the LI-6400 Portable Photosynthesis System.

LI-8100A Automated Soil CO₂ Flux System

Survey, Long-Term, and Multiplexed Measurements

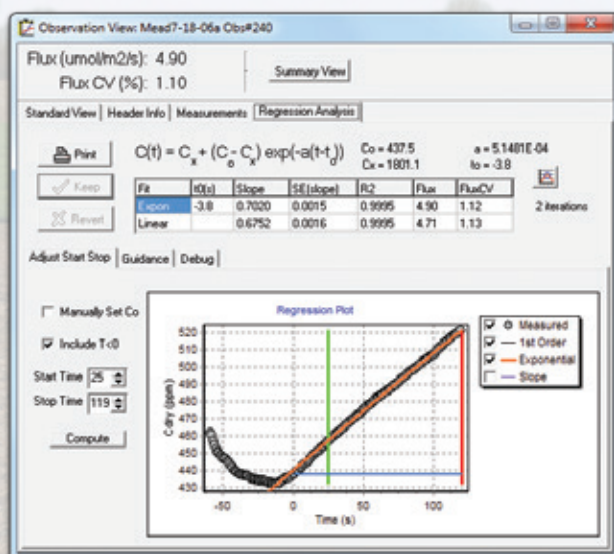


LI-COR[®]

System Features

Integrated, simple to use, and modular by design, the LI-8100A Automated Soil CO₂ Flux System allows researchers to design a setup from a variety of components, customized for their application and research needs. The new LI-8100A builds upon the proven LI-8100 with features that include:

- **Extended CO₂ measurement range** of up to 20,000 ppm, allowing you to make soil CO₂ flux measurements in high CO₂ environments.
- **Ethernet connectivity** with standard TCP/IP networking protocols facilitates two-way communication with networked computers at any remote location. Setup, data collection, and diagnostics can be performed remotely by simply logging on to any LI-8100A connected to your local network.
- **The new LI-8100APP** for iOS allows for wireless remote control of the LI-8100A for long-term or survey measurements. You can perform any action from your iPhone®, iPad® or iPod® Touch that is available from the LI-8100A Windows® Application Software.
- **Novel pressure vent** minimizes pressure pulses at chamber closing, and allows chamber pressure to track the ambient pressure under calm and windy conditions, minimizing pressure pulses at chamber closing.
- **CO₂ flux rate is calculated at the CO₂ concentration of the surrounding ambient air.** This minimizes effects resulting from the necessary increase in chamber CO₂ concentration during a measurement.
- **Data Analysis software** allows convenient ways to view selected summaries of data files and observations logged by the LI-8100A. Plotting, editing, recomputing, and viewing of flux measurements calculated with a variety of regression fits is also available.



LI-8100A File Viewer

Choose Your Configuration...

The LI-8100A System's modular design allows you to build a custom system that fits your particular research needs. All systems start with the LI-8100A, which is the weather tight enclosure that houses system components for gas analysis, chamber control, data storage, and data communications. Next, choose from a variety of soil chambers to attach to the LI-8100A, including survey and long-term chambers. Long-term measurements can be multiplexed to measure up to 16 chambers to address both spatial and temporal variability.



Single Chamber Survey System

- 10 or 20 cm chamber options (8100-102 and 8100-103, respectively)
- Quickly conduct measurements over a number of locations
- Assess spatial variability in soil CO₂ flux



Single Chamber Long-Term System

- Fully automated long-term measurements (8100-104 and 8100-104C)
- Allows assessment of CO₂ flux patterns for weeks or months at a time
- Careful design minimizes perturbations to the soil environment around the chamber



Multiplexed Long-Term System

- Includes LI-8150 Multiplexer to multiplex up to 16 long-term chambers (30m diameter coverage)
- Can combine both clear and opaque chambers in one multiplexed system
- Allows assessment of both spatial and temporal variability

Application Flexibility

Soil CO₂ Flux

The LI-8100A was designed primarily to measure soil CO₂ flux temporally and spatially over the variety of environmental conditions that influence soil CO₂ flux.

Soil CO₂ production is heavily influenced by environmental factors (soil temperature, soil moisture, organic content, etc.) and biological factors (above ground can-



opy size, growth activity, etc.). Soil CO₂ efflux is a physical process driven primarily by the CO₂ concentration diffusion gradient between the upper soil layers and the atmosphere near the soil surface. The challenge of accurate soil CO₂ flux measurements is that the deployment of chambers must cause minimal disturbance to environmental conditions that have an impact on CO₂ production and transport inside the soil profile.

LI-8100A chambers are designed to minimize perturbations to the surrounding environmental conditions and measurement artifacts that can affect the natural soil CO₂ production and diffusion processes. Both survey and long-term chambers close automatically, eliminating variations caused by manual chamber placement, providing accurate, repeatable data.

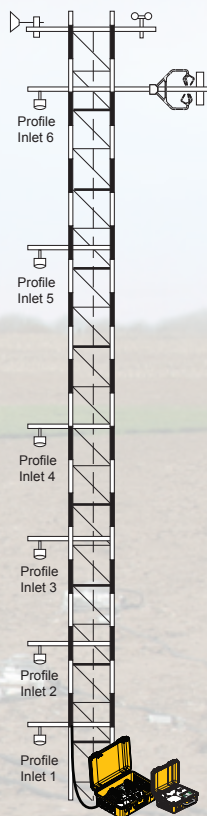
Net Carbon Exchange

A new clear chamber (8100-104C) allows measurements of Net Carbon CO₂ Exchange (NCE), which is the difference between the photosynthetic uptake of CO₂ by foliage and the emission of CO₂ through soil respiration. The clear chamber bowl can be installed on existing 8100-104 opaque chambers, with a simple field upgrade kit.

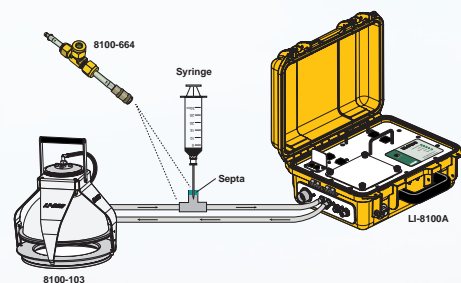


Atmospheric CO₂ Profiling

With a multiplexed system, atmospheric CO₂ profile measurements can be performed at the same time as soil CO₂ flux measurements, by simply adding the atmospheric profiling kit (part #8150-662). Each profiling kit converts 4 of the multiplexer ports to sample air from inlet ports mounted at various heights on a tower or other mounting fixture. The LI-8150 supports tubing lengths of up to 45m for profiling measurements.



Trace Gas Analysis



Air samples can be collected from the same air stream used to measure soil CO₂ flux using the Trace Gas Sampling Kit (part #8100-664). Estimates of the flux rate of trace gases such as methane (CH₄), ammonia (NH₃), nitrous oxide (N₂O), isotopic species, etc. can be made based on the rate of change of the gas species concentration inside the chamber. The sampling kit can be used with any LI-8100A chamber, without any modification to the chamber.

Flask Measurements



By adding either the 8150-670-8 or 8150-670-16 Flask Sampling Kit to the LI-8150 Multiplexer, the system can be modified to explore CO₂ fluxes from discrete samples enclosed in custom chambers, or flasks. The installation includes simple plumbing changes and the addition of an auxiliary pump inside the LI-8150 Multiplexer. The pump serves to continuously flush chambers with ambient or conditioned

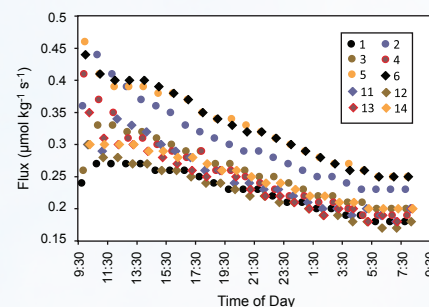


air between measurements. This effectively maintains the chamber atmosphere at or near ambient between measurements

and allows samples to be left in the chamber for extended periods of time, making this system well suited to explore temporal variation in CO₂ flux. These modifications are easily reversible and with the auxiliary pump unpowered the instrument operates as normal.

Flask measurement applications are varied; similar measurement approaches have been applied in entomological studies to

evaluate insect respiration, in studies of postharvest and developmental fruit biology, and for measurement of soil CO₂ flux from isolates soil samples or cores. The multiplexed nature of the LI-8100A system makes it particularly well suited for applications where high throughput is required, due to statistical or sample availability limitations.



Surface Monitoring for Geologic Carbon Sequestration



With the increased concern of global greenhouse gas emissions, scientists are researching ways to limit the amount of CO₂ entering

the atmosphere in an effort to mitigate the atmospheric CO₂ concentration increase. Currently there is a global push to limit CO₂ emissions through Carbon Capture and Storage (CCS) technologies.

One of the biggest concerns with CCS is whether or not the CO₂ remains within the geologic formation into which it was injected. A well organized surface monitoring campaign should include a pre-injection background study to better

understand the natural variation in soil CO₂ flux over the surface of the injection area. By establishing baseline CO₂ fluxes, the researcher can say with confidence that routine post-injection monitoring is effective and can provide quantitative data to prove a leak has not taken place. An active surface monitoring campaign that includes Monitoring, Verification, and Accounting (MVA) can also be used to ease public perception of any potential leak concerns. Even though the risk of a leak in most cases is very low, using surface monitoring techniques is a valid way to convince the public that the CO₂ has not escaped to the surface.

The LI-8100A and LI-8150 are in use for surface monitoring at a number of active and proposed geologic carbon sequestration sites around the world.

Flux Measurements In Areas With High CO₂ Concentrations

The LI-8100A features an extended CO₂ measurement range of 0-20,000 ppm, making it ideal for use in difficult areas like volcanoes. Large reservoirs of gases can be present deep below the surface, from which the gases escape along fissures to the surface. In other extreme environments, CO₂ can build up beneath the snowpack; the LI-8100A is rugged enough to be used in any of these extremes.



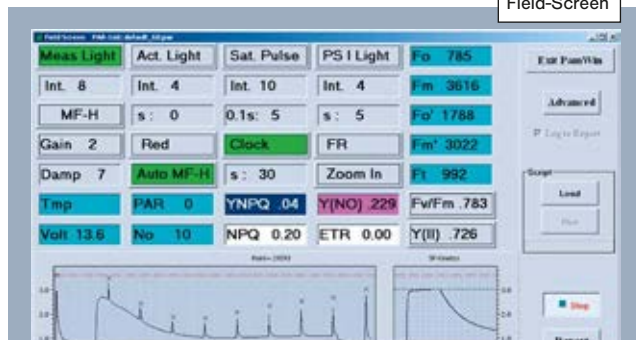
PamWin-3 Software

• Different levels of graphical user interface

Two different user interfaces are provided by the PamWin-3 software: the Field Screen serves mainly for outdoor operation where ease and simplicity of instrument control is important.

The Advanced Level offers a multitude of fluorescence analyses ranging from measurements of Kautsky induction kinetics to polyphasic rise kinetics, and fast fluorescence decay curves.

Field-Screen



• Script files

The PAM-2500 Fluorometer can be operated automatically by employing the Script File feature of the PamWin-3 software. Script Files easily perform complex test protocols, which otherwise would require many manually entered commands.



Script Programming Window

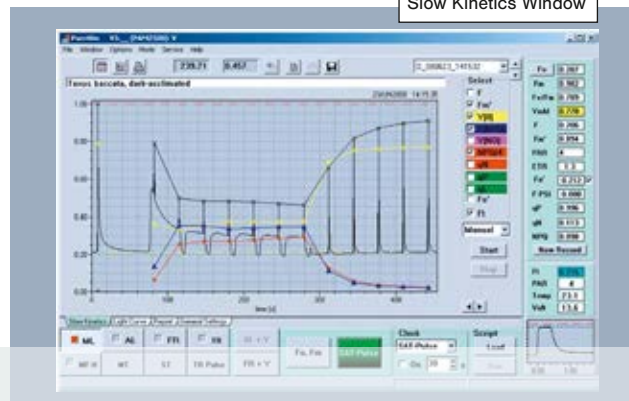
In this way, sophisticated measurements can be carried out reliably and reproducibly even by inexperienced users.

• Advanced level windows

The advanced level of the PamWin-3 software includes Saturation Pulse analysis, recording of fluorescence kinetics (ranging from fast changes in the μ sec domain to slow changes over many seconds, minutes or even hours), and a wide range of graphical and analytical features.

The instrument parameters of fluorescence Induction Curves and Light Curves can be easily programmed on the Settings window. The reproducible recording of Fast Kinetics can be designed using a special graphical user interface (Fast Trigger Settings).

Slow Kinetics Window



• Accessories

- Ultra-mobile touchscreen computer
- Leaf-Clip Holder 2030-B
- Arabidopsis Leaf Clip 2060-B
- Micro Quantum/Temperature-Sensor 2060-M
- Suspension Cuvette KS-2500

Please visit www.walz.com for further informations, detailed technical specifications and updated software versions.

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Continuing the
PAM-2000/2100 tradition with
state-of-the-art technology

PAM-2500

Portable Chlorophyll Fluorometer



For basic/applied research and plant screening

WALZ
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PAM-2500

Portable Chlorophyll Fluorometer

- For basic/applied research and plant screening
- Powerful illumination system featuring red, blue, far-red light and single/multiple turn-over flashes
- Fully computer controlled; optional ultra-mobile PC for touch screen operation
- User-friendly and versatile PamWin-3 software for quenching analysis, slow/fast kinetic recordings, and Light Curves
- Optional accessories for algae and cyanobacteria



- The **PAM-2500** Portable Chlorophyll Fluorometer is the successor of the well-known PAM-2000/2100 instruments which were introduced in the 1990s as the first portable PAM fluorometers. Since then they have been successfully applied worldwide by numerous scientists. In the development of the PAM-2500, particular care was taken to maintain all properties appreciated by PAM-2000/2100 users and, at the same time, to integrate state-of-the-art technology.

Essentially, the hardware and optical system are thoroughly modernized. Also, while continuing basic elements of the graphical user interface, instrument operation is based on the newly-developed PamWin-3 software. The program permits operation under Windows operating systems on normal personal computers, but also on ultra mobile touch screen computers (UMPC).

System Description

The PAM-2500 is an extremely compact and powerful system with all optical and electronic components contained in a 23 cm x 10.5 cm x 10.5 cm housing. The Measuring Light is generated by a 630 nm LED in the form of 1 μ s pulses at frequencies ranging from 10 to 200,000 Hz.



Actinic Light sources are 455 nm blue, 630 nm red and 750 nm far-red LEDs.

A special fiberoptics links the fluorometer control unit to a leaf or to an optional special cuvette for measurements with suspensions of isolated chloroplasts, algae or cyanobacteria.

Measuring principle and quenching analysis

The PAM-2500 Chlorophyll Fluorometer employs pulse modulated (PAM) Measuring Light to excite chlorophyll fluorescence. The resulting pulse modulated chlorophyll fluorescence is detected with high sensitivity and selectivity, but the fluorometer is virtually insensitive to even strong unmodulated light like full sunlight or Saturation Pulses at up to 25,000 μ mol quanta/(m²·s).

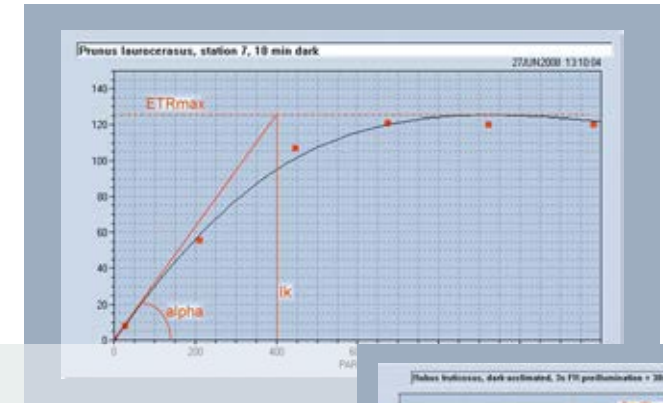
The intensity of the Measuring Light can be sufficiently low for monitoring fluorescence yield without any change in the state of photosynthesis. In addition to the current fluorescence yield (Ft, in continuous light) and the maximum yield (Fm or Fm', during Saturation Pulses) it is also possible to determine the minimum yield Fo (after dark-acclimation) or Fo' (in the illuminated state).

Application

Light saturation curves

A major application of the PAM-2500 Fluorometer in eco-physiology consists in the fast and reliable analysis of the photosynthetic performance of plants. Two important parameters for characterizing photosynthesis are the maximum quantum yield for whole chain

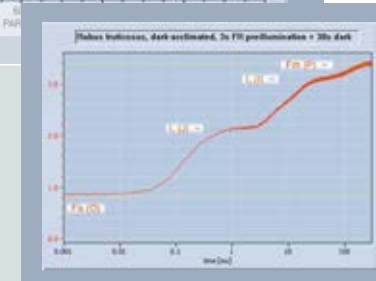
electron transport ("alpha", at low light intensities) and the maximum electron transport capacity ("ETRmax", at light saturation). The PamWin-3 software derives these parameters from the dependence of the electron transport rates on actinic light using a curve fitting procedure.



Polyphasic fluorescence rise upon onset of saturating light

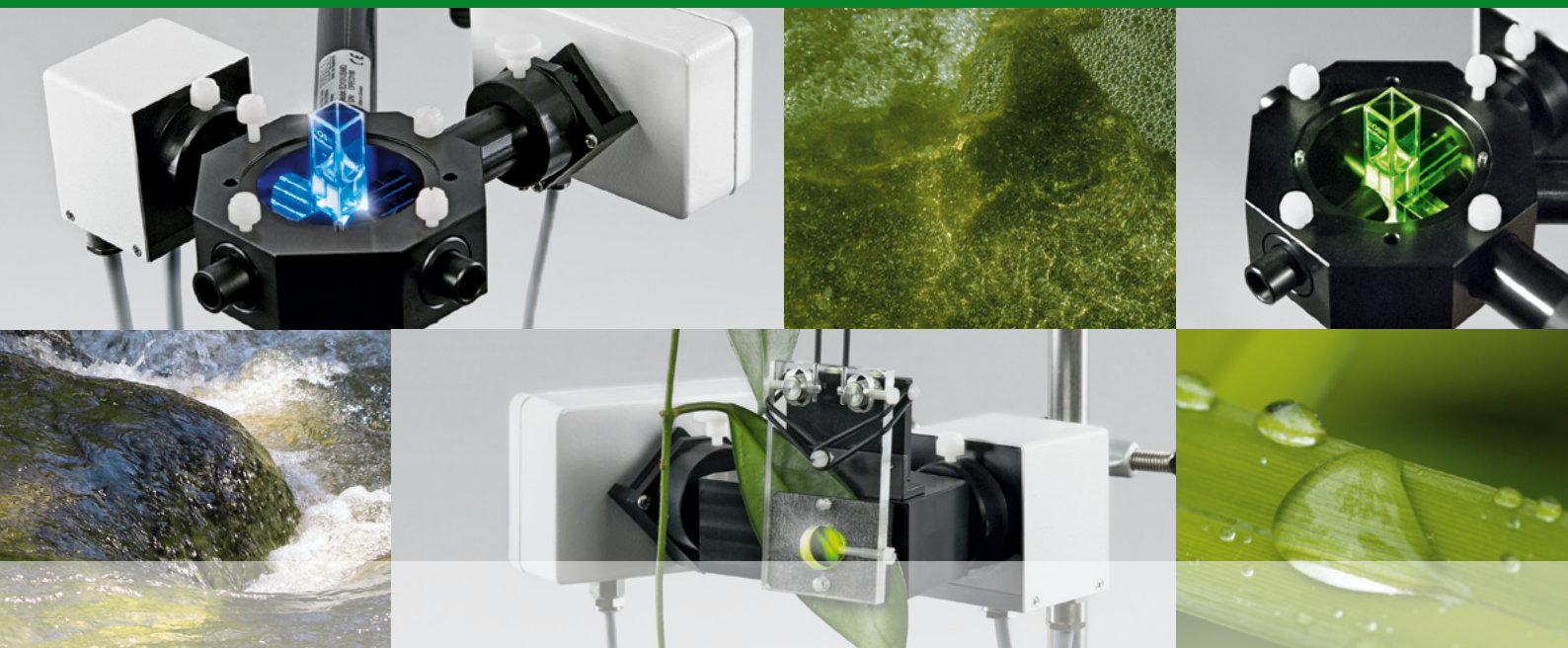
The Fast Acquisition mode of the PAM-2500 enables recordings of rapid fluorescence kinetics with 10 μ s time resolution. It may be emphasized that this high time resolution is achieved with pulse modulated signals.

This means that the fast kinetics of fluorescence yield is measured and, consequently, that signal amplitudes from different experiments can be directly compared irrespective of light intensity and sample geometry.



MULTI-COLOR-PAM

Multiple Excitation Wavelength
Chlorophyll Fluorescence Analyzer



Pinpointing Light Color Effects on Photosynthesis

WALZ
Mess- und Regeltechnik

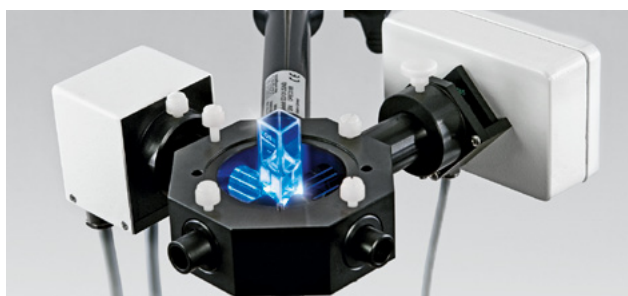
MULTI-COLOR-PAM

Multiple Excitation Wavelength Chlorophyll Fluorescence Analyzer.
Eliciting pulse-amplitude-modulated (PAM) fluorescence by six different light colors.
Driving photosynthesis by five different light colors or white light.

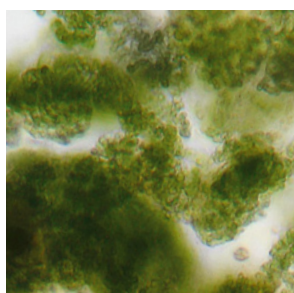
The MULTI-COLOR-PAM fluorometer provides an extraordinary color range of measuring and actinic light including white and far-red light sources. The various colors enable researchers to tailor conditions of fluorescence measurements exactly to the spectral properties of their sample. The outstanding variety of light colors of the MULTI-COLOR-PAM opens the way to

study many wavelength-dependent aspects of photosynthesis that so far have not been commonly accessible.

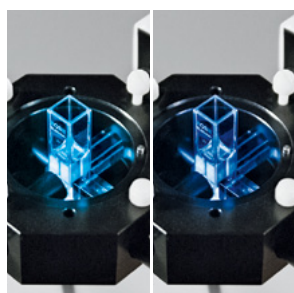
The MULTI-COLOR-PAM is optimized for highly sensitive assessment of photosynthesis in dilute suspensions of cyanobacteria, algae and chloroplasts. In addition, the measuring system can be configured to study leaf photosynthesis and epidermal UV-A screening.



Optical Unit for Suspensions



Photosynthesis in Suspensions



AL/ML 480 nm

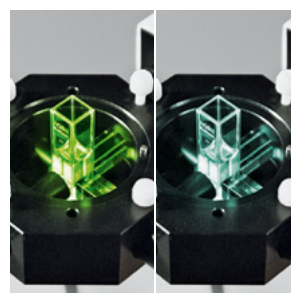
AL/ML 440 nm



Optical Unit for Leaves



Leaf Photosynthesis, UV-A Screening



AL/ML 540 nm

AL White

► FEATURES

- The MULTI-COLOR-PAM provides six colors of pulse-modulated measuring light (400, 440, 480, 540, 590 and 625 nm) and five colors of actinic light (440, 480, 540, 590, 625). In addition, white (420-640 nm) and far-red light (730 nm) light sources are built in.

- By employing state-of-the-art LED light sources in combination with elaborated chip-on-board technology, strong actinic photon fluxes are achieved while keeping the emitter unit highly compact. Each measuring light color can be freely combined with one of the available actinic light sources.

- The MULTI-COLOR-PAM measures fluorescence by a highly sensitive photodiode attached to either an optical unit for suspensions or for leaves. A spherical or flat cosine-corrected sensor feeds its

signal directly to the control unit so that accurate PAR measurements can be obtained in suspension or at leaf surfaces. A special routine is provided to measure PAR-lists for all colors automatically.

- The MULTI-COLOR-PAM determines the effective PS II quantum yield, $Y(II)$, with outstanding accuracy and, thus, enables highly reliable calculations of relative electron transport rates (rel. ETR) even with extremely stressed samples.

MAIN COMPONENTS

The main components of the MULTI-COLOR-PAM form the working system for fluorescence measurements of suspensions. Various accessories are provided to optimize this basic system for different suspensions and to extend its capacity to measure leaves.

► POWER-AND-CONTROL-UNIT MCP-C

The central unit controls the emitter head MCP-E and the photodiode detector MCP-D of the fluorometer. Additionally, it provides connections for a Walz PAR sensor, a stirrer for the optical unit ED-101US/MD, an auxiliary device and 5 V TTL trigger in/out signals. Another socket permits connection of an additional actinic light source. The central unit is connected to a Windows computer via USB.

► EMITTER HEAD MCP-E

The light sources within the emitter head MCP-E are light emitting diodes (LED) which are densely arranged on a 10 x 10 mm area. In total, the MCP-E head provides 6 differently-colored measuring lights, and 5 spectrally different actinic light sources; the latter are complemented by white and far red LEDs.

► DETECTOR HEAD MCP-D

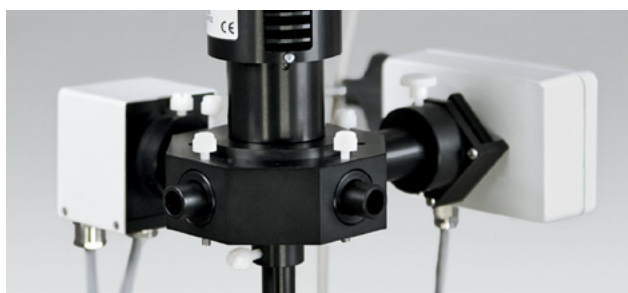
The MCP-D head detects fluorescence by a highly sensitive PIN photodiode with with maximum time resolution of 10 μ s. The photodiode is protected from modulated excitation light by a RG 665 long pass filter. Due to the open design of the filter holder, filters can easily changed to vary the spectral range of fluorescence detection.



Measuring Setup



Power-and-Control-Unit

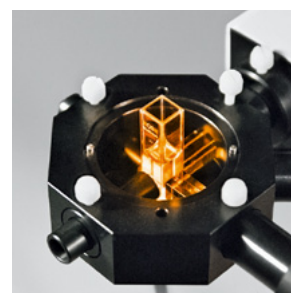


Emitter Head (left), Optical Unit for Suspensions (center), Detector Head (right)



AL/ML 625 nm

ML 400 nm



AL/ML 590 nm

► OPTICAL UNIT FOR SUSPENSIONS ED-101US/MD

The optical unit ED-101US/MD consists of a centrally located place for a 10 x 10 mm cuvette and peripherally positioned ports for the emitter and detector heads of the MULTI-COLOR-PAM.

Perspex rods efficiently guide light from emitters to the sample, and from the sample to the detector.

Two plugs are provided to close ports not occupied by emitter or detector heads. These plugs possess a light reflecting and a light trapping end. The reflecting end may be positioned opposite to the fluorescence detector to enhance the fluorescence signal, the light-trapping part can be positioned opposite to the emitter to reduce effects of strayed light on the signal.

The cover of the unit has a pinhole through which chemicals can be added using a syringe. A port at the bottom of the ED-101US/MD unit holds the optional PHYTO-MS Magnetic Stirrer.

ACCESSORIES

► TEMPERATURE CONTROL UNIT US-T

The US-T unit consists of a heat-transfer head with a cooling/heating Peltier element, and a separate power-and-control unit. The heat-transfer head is mounted on top of a Walz optical unit ED-101US-type so that the dip of the rod is in touch with the suspension investigated. The achievable temperature spread in suspensions is about 30 K; absolute temperatures depend on ambient temperature.



Temperature Control Unit and Heat-Transfer Head

► TEMPERATURE CONTROL BLOCK ED-101US/T

For measurements under defined temperatures, the temperature control block ED-101US/T can be mounted on the optical unit ED-101US/MD. The block consists of an inner flow-through metal part which is slightly pressed on the sample cuvette by a spring mechanism, and an external foam part for temperature insulation. Temperature control is achieved by an external flow-through water bath (not included) connected to the temperature block.



Temperature Control Block Mounted on Optical Unit for Suspension

► MINIATURE MAGNETIC STIRRER PHYTO-MS

Settling of particles is prevented by using a miniature magnetic stirrer US-MS. The stirrer is mounted directly beneath the sample cuvette. A rotating magnetic field created by the stirrer tip moves a miniature magnetic stir bar in the cuvette. The stirrer is connected to the control unit MCP-C. Stirring can be switched on and off by the PamWin-3 software.



Miniature Magnetic Stirrer

► SPHERICAL MICRO QUANTUM SENSOR US-SQS/WB

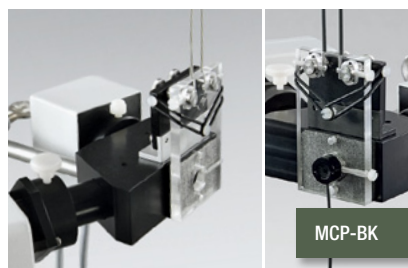
Exact light measurements in suspensions (but also in air) can be carried out by the spherical micro quantum sensor US-SQS/WB. The sensor has a 3.7 mm diameter sphere as the entrance optics. When the sensor is connected to the control unit MCP-C, data will be acquired and processed by the PamWin-3 software.



Spherical Micro Quantum Sensor and Preamplifier

► OPTICAL UNIT FOR LEAVES MCP-BK

This optical unit is designed for measurements of leaves or flat photosynthetic surfaces. The unit features a clip to position leaves optimally for fluorescence measurements. The clip has a port for a Mini Quantum Sensor US-MQS/WB.



Optical Unit for Leaves with Mini Quantum Sensor

► MINI QUANTUM SENSOR US-MQS/WB

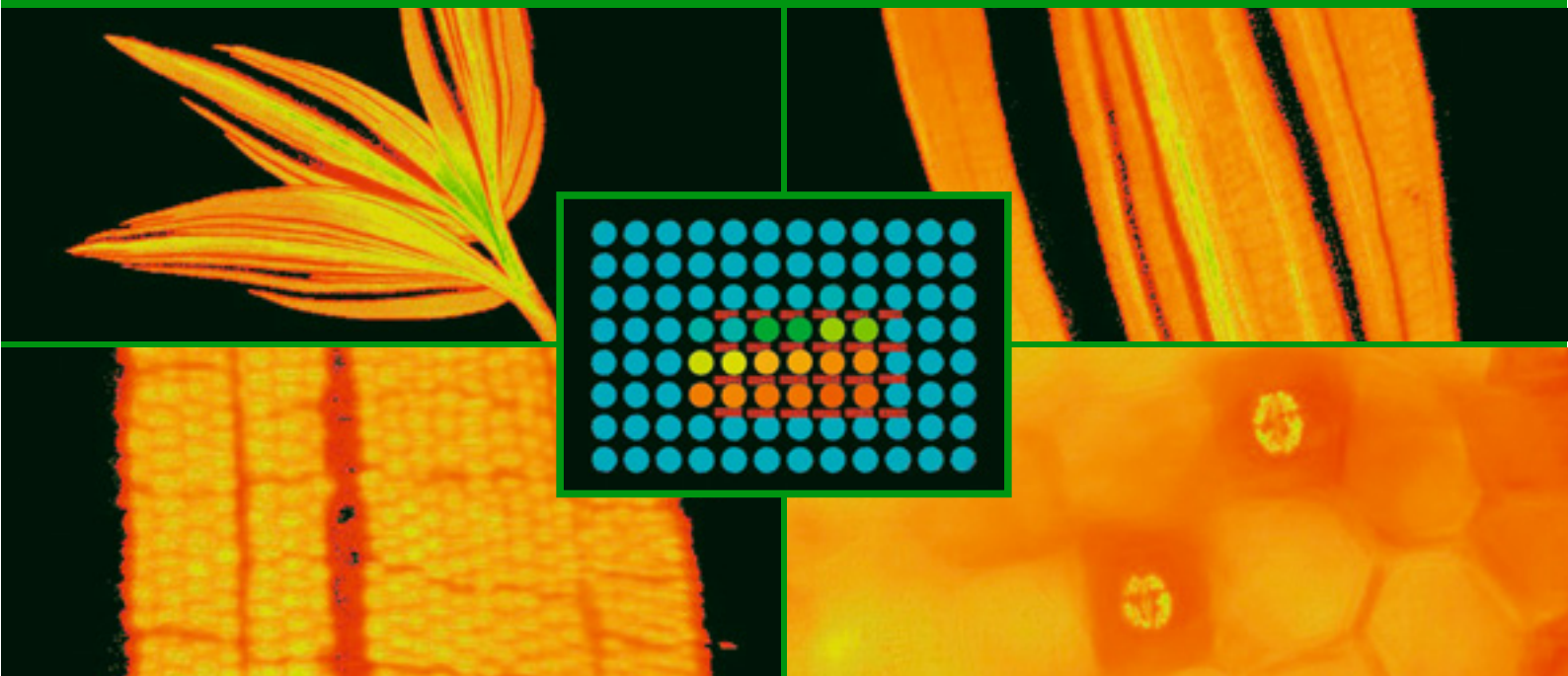
A cosine-corrected mini quantum sensor measures light intensities which are relevant for plant leaves or flat surfaces. When the sensor is connected to the control unit MCP-C, data will be acquired and processed by the PamWin-3 software.



Mini Quantum Sensor and Preamplifier

IMAGING-PAM **M**-Series

Chlorophyll Fluorescence System

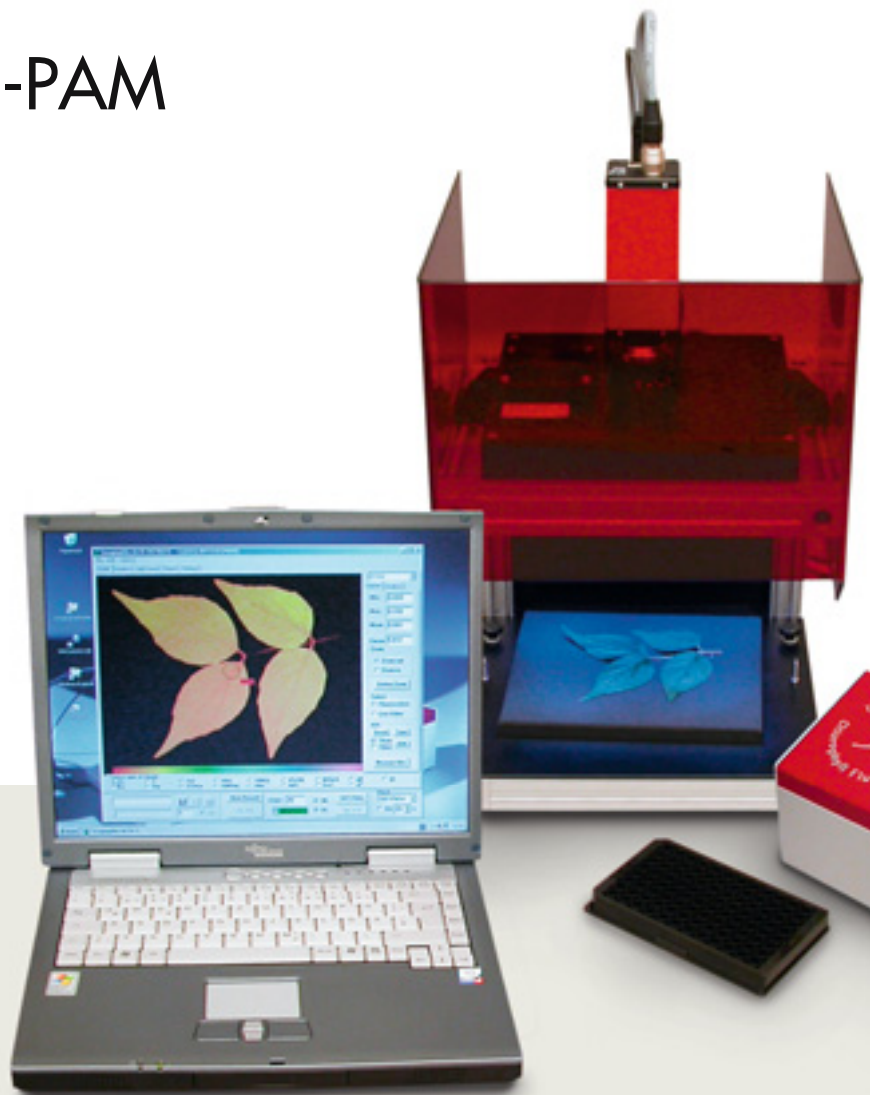
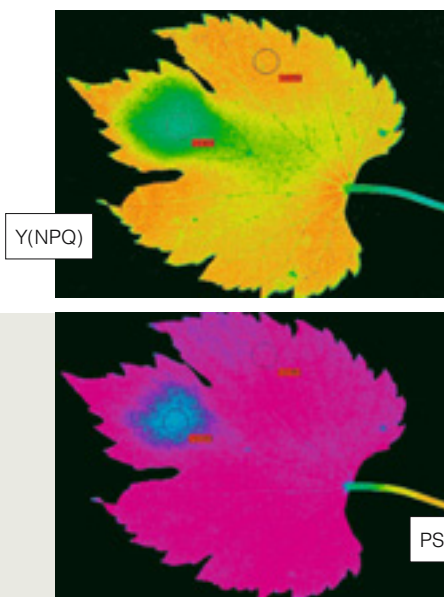


... for a wide range of chlorophyll fluorescence imaging applications

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MAXI-Version of the IMAGING-PAM

- ▶ for imaging large areas
up to 10x13 cm



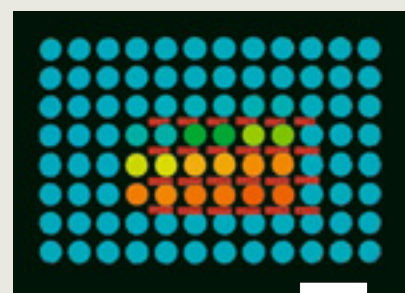
- ▶ The **MAXI-Version** of the IMAGING-PAM employs a very compact and powerful **300 W LED-Array** for homogeneous illumination of up to **10x13 cm** areas with pulse-modulated excitation, actinic and Saturation Pulse light. A special **Mounting Stand with Eye Protection** is provided, which features a red perspex hood, through which the red fluorescence can be viewed.

On the bottom of this stand an x-y stage for variable sample positioning or a **multi well plate** can be placed at defined working distance of 18.5 cm. The bottom can be removed and the whole stand jacked up for imaging of plants growing on trays or in pots.

- ▶ Two different CCD-cameras are available. For **high sensitivity** applications the IMAG-MAX/K (2/3" chip, 1392x1040 pixel with **4-pixel-binning**) is recommended. For standard applications the IMAG-MAX/K2 (1/2" chip, 640x480 pixel) is available, which can be used in conjunction with the powerful IMAG-MAX/K2Z **zoom objective** (F1.0/f=8-48mm).



Images of the various fluorescence parameters are depicted in false colors coding from 0.0 (black) to 1.0 (purple)



Different Configurations of the **MAXI**-Version

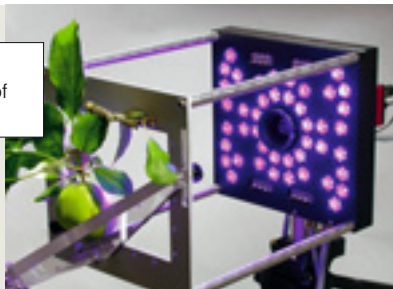
Measuring Head (LED-Array plus camera) mounted on separate stand with leaf holder providing fixed working distance



With Mounting Stand being jacked up for studying potted plants

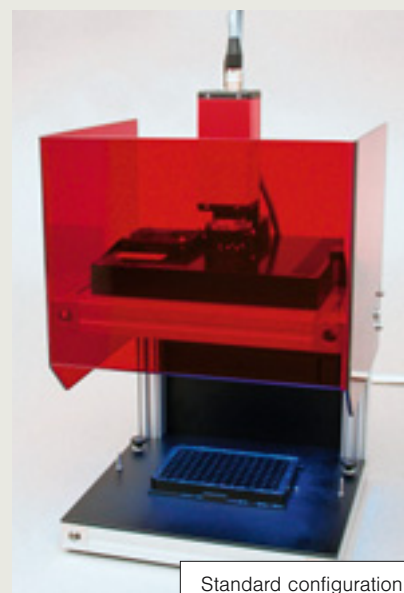


Special head mounted on tripod for assessment of fruit in the field



▶ The **MAXI-Version** of the IMAGING-PAM can be used in a variety of different configurations for a wide field of applications in the laboratory and under field conditions. Due to the very powerful **LED-Array Illumination Unit**, in all applications steps must be taken to avoid looking directly into the LED-Array.

For laboratory applications, the **Mounting Stand with Eye Protection** is ideally suited, as it not only protects the eyes, but also allows to view directly the red chlorophyll fluorescence via the red perspex hood.



Standard configuration with 96-well microtiter plate

Standard configuration with LED-Array and camera fixed on Mounting Stand with Eye Protection

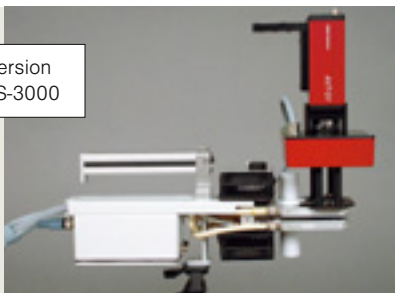


MINI-Version of the IMAGING-PAM

- ▶ for imaging 24x32 mm areas
(6x magnification)



MINI-Version
on GFS-3000



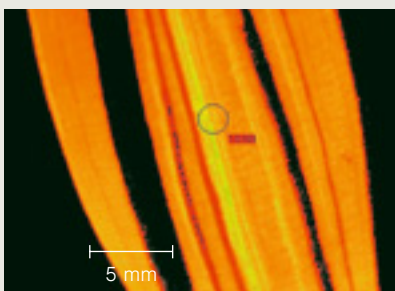
- ▶ The 24x32 mm area imaged by the **MINI-Version** is illuminated by a very powerful Luxeon LED array consisting of 4 groups of 3 LEDs equipped with 4 individual short-pass filters. Red (650 nm) and NIR (780 nm) LEDs (8 each) serve for assessment of **PAR-Absorptivity images**.

Three different versions are available:

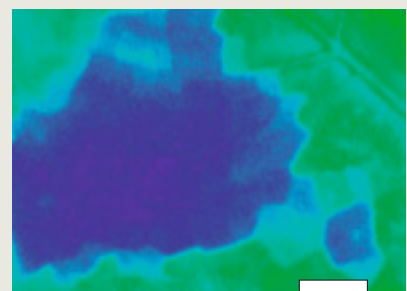
IMAG-MIN/B (blue, 450 nm, standard leaf applications;
IMAG-MIN/R (red, 620 nm, for cyanobacteria);
IMAG-MIN/GFP (blue, 480 nm, GFP imaging).

- ▶ Due to the compact design, the MINI-Version is well suited for field applications. As the imaged area is much smaller than that of the MAXI-Version (factor of 16), maximal intensities are higher, whereas power consumption is lower. It can be mounted on the Standard measuring Head 3010-S of the Portable Gas Exchange Fluorescence System **GFS-3000**.

The MINI-Version employs a **1/3" CCD camera (640x480 pixel)** with a F1.2/f=12mm objective lense. It is designed for measurements at fixed working distance.



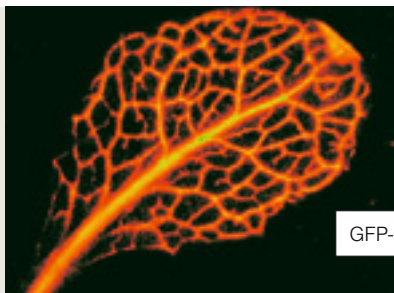
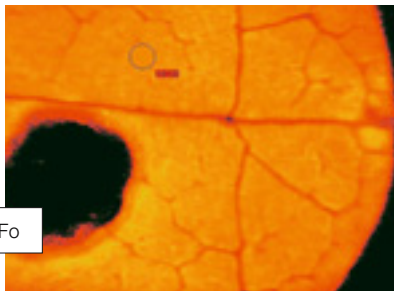
Fm



qN

MICRO-Version of the IMAGING-PAM

- ▶ for imaging 3.5x4.5 mm areas (45x magnification)



- ▶ The **MICRO-Version** of the IMAGING-PAM features an extremely compact Measuring Head with integrated Cosmical-Pentax CCTV objective lens (F1.4/f=16mm). It is directly mounted on the CCD camera (1/3" chip with 640x480 pixel).

A single high power Luxeon LED (blue, 450 nm) in conjunction with a special **dichroic beam splitter** is employed, similarly as in an epifluorescence microscope.

- ▶ With an imaged area of 3.5x4.5 mm (**45x magnification**) the resulting high spatial resolution allows imaging heterogeneities at the level of the **minor veins** of leaves. A special version for **GFP imaging** is available.

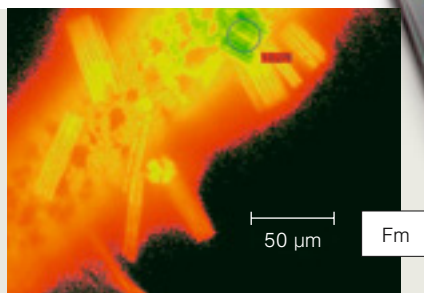
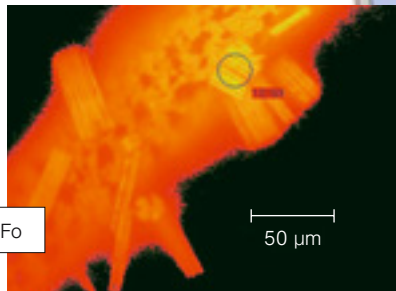
The MICRO Measuring Head can be also connected to the original Standard IMAGING-PAM with the IMAG-C Control Unit. It features a miniature x-y stage and is designed for fixed working distance.

Compact Measuring Head with integrated Cosmical-Pentax CCTV objective lens, directly mounted on CCD camera



MICROSCOPY-Version of the IMAGING-PAM

- ▶ for imaging areas down to $130 \times 150 \mu\text{m}$ (130–1300x magnification)



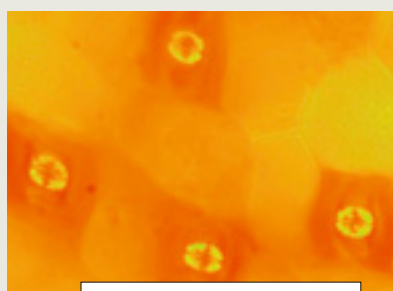
- ▶ The **MICROSCOPY-Version** of the IMAGING-PAM operates in conjunction with special **Epifluorescence Microscopes** that are adapted for optimal excitation intensity and fluorescence collection.

For this purpose, relatively simple microscopes with short optical pathlengths, as **Axiostar** (Zeiss, Göttingen) and **H600AFL** (Hund, Wetzlar), are best suited, which are available with appropriately adapted components.

The IMAG-MAX/K CCD Camera (1392×1040 pixel with 4-pixel-binning) provides high sensitivity.

- ▶ For standard applications a single high power **Luxeon LED** (450–480 nm) is provided for excitation, actinic illumination and Saturation Pulses. Alternatively a sophisticated **Red-Green-Blue-White LED Lamp** with separate drivers soon will become available. This lamp is controlled via the RGB-output of the IMAG-CM. RGB fluorescence excitation allows to differentiate between various types of algae and cyanobacteria in biofilms, in analogy to the PHYTO-PAM.

An extended ImagingWin software takes account of the particular needs of microscopy applications. A **Life Video image** of the object can be obtained using the standard through-light condenser-illuminator of the microscope. A **special saturation pulse routine** is provided for optimal assessment of F_o , F_m and F_v/F_m at low levels of excitation intensity.



Zebrina – green tissue / F_o



Zebrina – white tissue / F_o

Product Catalog

2013

ap  *gee*

New Products

The SF-110 Radiation Frost Detector is a two sensor combination ideal for warning of frost on leaves.



See page 18

Infrared Radiometer

Measure the surface temperature of

- **plant canopies**
- **soil**
- **snow**
- **roads**
- **water**

An infrared radiometer measures surface temperatures without contact. Apogee SI series sensors are sensitive to radiation in the 8-14 μm waveband, thereby minimizing water vapor and carbon dioxide absorption/emission effects. Sensors include an internal thermistor to measure sensor temperature. This internal temperature is used to correct the target temperature and provide accurate measurements over a wide range of temperatures (-40 to 70 C).

The sensors are available in either standard, narrow or ultra-narrow field of view (see Figure 1). The area that the sensor actually measures is dependent on field of view and sensor mounting geometry. The standard field of view radiometer measures an area of approximately 2.1 m^2 (a circle with a diameter of 1.6 m) when it is mounted two meters above the target surface and pointed straight down.

These sensors were designed to interface with Campbell Scientific dataloggers capable of making high



accuracy voltage measurements in the sub- μV range.

Applications include monitoring:

- plant canopy temperature for water stress detection
- soil surface temperature in land surface energy balance studies
- water surface temperature for use in weather forecasting
- snow surface temperature to aid in avalanche prediction
- road surface temperature for determination of icing conditions



Infrared Radiometer

Measure the surface temperature of

- plant canopies
- soil
- snow
- roads
- water



MI series infrared radiometer meters provide rapid, mobile measurements of surface temperature and have datalogging capability using our SI series infrared radiometer sensors.

Two meter versions are available, one with a standard field-of-view sensor (MI-210) and one with a narrow field-of-view sensor (MI-220). Both meters have the sensor connected to the handheld meter via two meters of cable.

Viewable on meter display & downloadable to a PC:

- (SMPL) 99 Sample Measurements
- (LOG) 99 Log Measurements

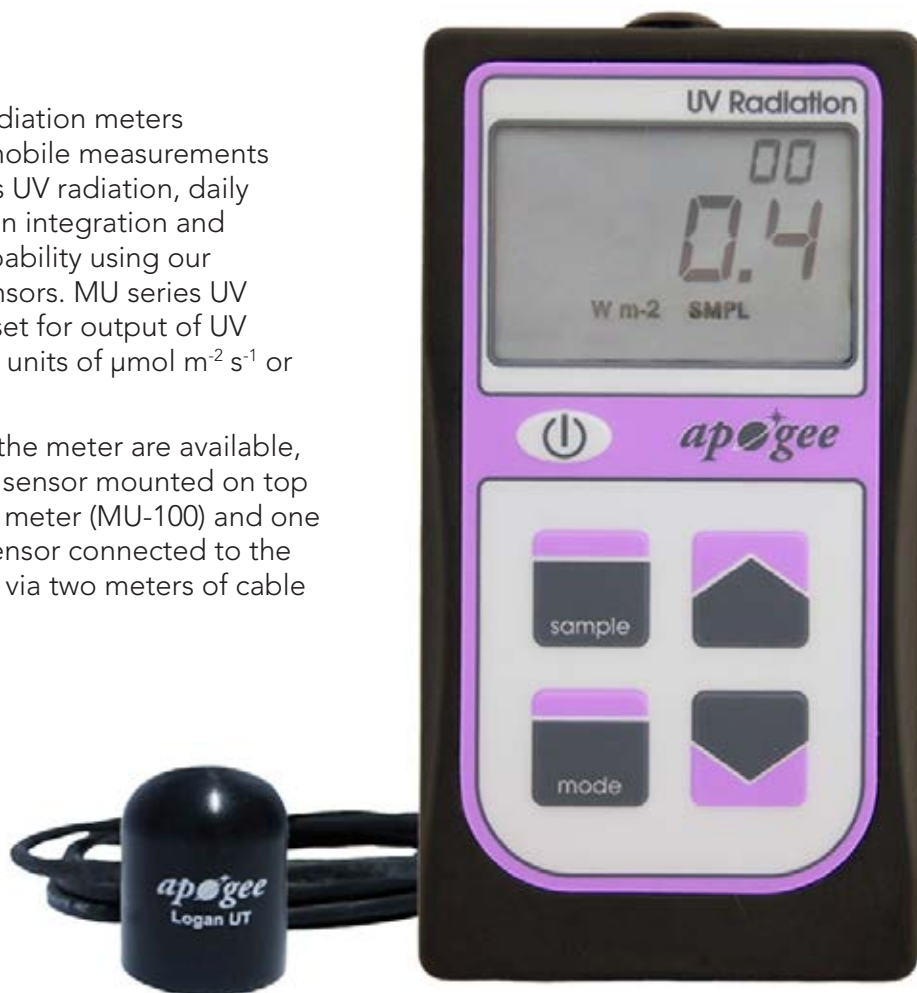
Downloadable only:

- (LOG) 99 Daily Average Measurements

Measure ultraviolet radiation

MU series UV radiation meters provide rapid, mobile measurements of instantaneous UV radiation, daily total UV radiation integration and datalogging capability using our SU series UV sensors. MU series UV meters may be set for output of UV measurement in units of $\mu\text{mol m}^{-2} \text{s}^{-1}$ or W m^{-2} .

Two versions of the meter are available, one with a fixed sensor mounted on top of the handheld meter (MU-100) and one with a remote sensor connected to the handheld meter via two meters of cable (MU-200).



MU-200 with remote sensor

Viewable on meter display & downloadable to a PC:

- (SMPL) 99 Sample Measurements
- (LOG) 99 Log Measurements

Downloadable only:

- (LOG) 99 Daily Total Measurements

This sensor is particularly useful for determining the UV filtering capacity of transparent plastic and glass barriers commonly used below electric lamps.

Measure oxygen gas concentration

MO series oxygen meters provide rapid, mobile measurements of instantaneous oxygen mole fraction, daily average oxygen mole fraction and datalogging capability using the fast response oxygen sensor.

Being a galvanic cell type sensor, a small amount of oxygen is consumed in the reaction in order to produce the current flow and subsequent mV output. The oxygen consumption was measured to be 2.2 micromoles (μmol) O_2 per day when the O_2 concentration was 20.95% (3240 mmol) at 23 degrees Celsius.



Each meter can store up to 99 manually recorded measurements. In automatic mode, measurements are made every 30 seconds and averages are stored every 30 minutes. Daily averages are also calculated and the past 99 days are recorded. The AC-100 communication cable must be purchased to download data to a PC.

Viewable on meter display & downloadable:

- (SMPL) 99 Sample Measurements
- (LOG) 99 Log Measurements

Downloadable only:

- (LOG) 99 Daily Total Measurements

This meter is useful for

- **monitoring soil respiration**
- **soil aeration**
- **gaseous O_2 levels in the field or laboratory**

Take non-destructive measurements of relative chlorophyll concentration

The CCM-200 (manufactured by Opti-Sciences, Inc., Hudson, New Hampshire, USA) indicates the relative chlorophyll content of leaves by measuring the chlorophyll content index (CCI). See Figure 1 for more detail.

The CCM-200 integrates a large leaf area in order to provide a representative spatial average of leaf CCI. It also includes datalogging capability and GPS synchronization.

Applications include:

- relative chlorophyll content comparison within and between plant species
- chlorophyll content estimation based on published equations relating CCI to chlorophyll content



Related Product



The spectroradiometer measures reflectance and transmission.

Measure photon flux and energy flux with half nanometer bandwidth resolution



A spectroradiometer measures the spectral (wavelength-dependent) intensity of radiation within a specific wavelength range. PS series spectroradiometers (manufactured by StellarNet, Inc.) measure ultraviolet, visible and near-infrared wavelengths. Three models are available for different wavelength ranges. PS series calibrations are traceable to an NIST-traceable calibration lamp.

Detectors for PS series spectroradiometers are built by Apogee and feature a cosine-corrected castle design to accurately measure radiation at all incidence angles.

PS series spectroradiometers come complete with all required components for portable use, including a carrying case.

A computer is required to interface with PS series spectroradiometers in order to view measurements, download data and power the instrument. Required software is included.

Applications include:

- irradiance

- luminance
- transmission
- absorption
- detailed analysis of radiation sources and barriers





Pressure Chamber Instruments

[MODEL 1000](#)

[MODEL 1505D](#)

[MODEL 1505D-EXP](#)

[MODEL 1515D](#)

[MODEL 600](#)

[MODEL 610](#)

[MODEL 615](#)

[MODEL 615D](#)

[MODEL 670](#)

[PUMP-UP CHAMBER](#)

Specialty Chambers

[DIGITAL CAVITATION
CHAMBER INSTRUMENT](#)

[SUPER CHAMBER](#)

Accessories

[COMPRESSION GLAND
GASKETS AND INSERTS](#)

[EYE LENS WITH LANYARD](#)

Digital Cavitation Chamber Instrument

This instrument is used to simulate cavitation of xylem vessels in plants under stress. A plant stem, limb or root is introduced into the Cavitation Chamber and a head of water is connected to the sample to measure water conductivity. The chamber is then pressurized to “seed” air into the xylem. It can be used to establish vulnerability curves in plants or to continue [research](#) in the area of xylem cavitation.



GRASS
COMPRESSION GLAND

INSTRUMENT MOUNTED
EYE LENS

LIGHTED HAND LENS
(10X) LED

PORTABLE TANK

STEM WATER
POTENTIAL BAGS

VOLUME REDUCER

Sealing Gaskets

INSERTION TOOLS

STANDARD INSERTS

STANDARD RUBBER
SEALING GASKETS

Standard

COMPRESSION
GLAND COVER

Used Instruments



The chamber is in the center and is 3.20 inches long.



The rubber gaskets slide down the sample and seat inside the chamber.

The metal “inserts” slide down behind the gaskets to help them seal.



Pressure Chamber Instruments

MODEL 1000

MODEL 1505D

MODEL 1505D-EXP

MODEL 1515D

MODEL 600

MODEL 610

MODEL 615

MODEL 615D

MODEL 670

PUMP-UP CHAMBER

Specialty Chambers

DIGITAL CAVITATION
CHAMBER INSTRUMENT

SUPER CHAMBER

Accessories

COMPRESSION GLAND
GASKETS AND INSERTS

EYE LENS WITH LANYARD

Super Chamber

For years we have received requests for large custom sized chambers. We are now offering 6 sizes of “Super Chambers”. We can also make a custom sized chamber to fit your needs.



GRASS
COMPRESSION GLAND

INSTRUMENT MOUNTED
EYE LENS

LIGHTED HAND LENS
(10X) LED

PORTABLE TANK

STEM WATER
POTENTIAL BAGS

VOLUME REDUCER

Sealing Gaskets

INSERTION TOOLS

STANDARD INSERTS

STANDARD RUBBER
SEALING GASKETS

Standard

COMPRESSION
GLAND COVER

Used Instruments



Left is a 24 inch deep chamber that is 4.0 inch inside diameter set in a 15 Degree Stand.

Right is a 12 inch deep chamber that is 2.5 inch inside diameter set in a 15 Degree Stand.

Both chambers are fit with our [Compression Gland Sealing System](#).



The Vertical Stand – simply hold the chamber vertical for normal PMS readings.

The above stand is a powder-coated stand for the 4.0 Inch Chamber.

The Super Chamber is a custom made chamber made to fit your needs. You choose from the options below

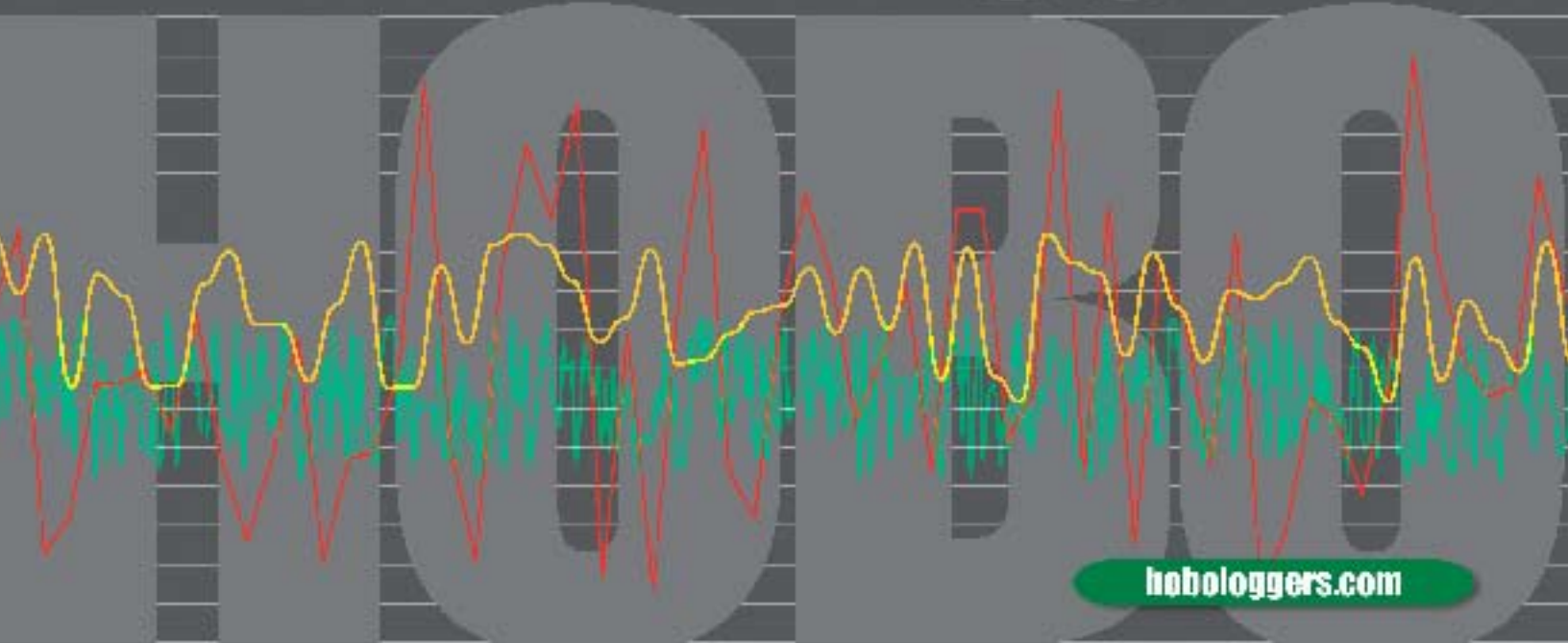
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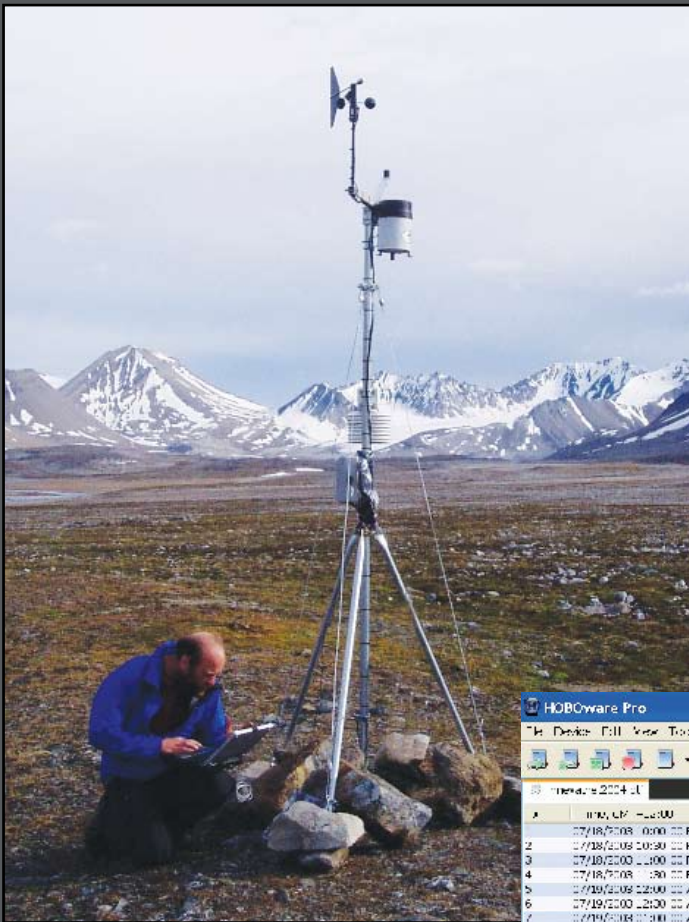
temperature
RH
rainfall
soil moisture
wind speed & direction
leaf wetness
barometric pressure
PAR
solar radiation
water level
light intensity
event
pulse input
voltage input
4-20mA input
motion in 3-axes

Outdoor Monitoring 2007

Data Loggers



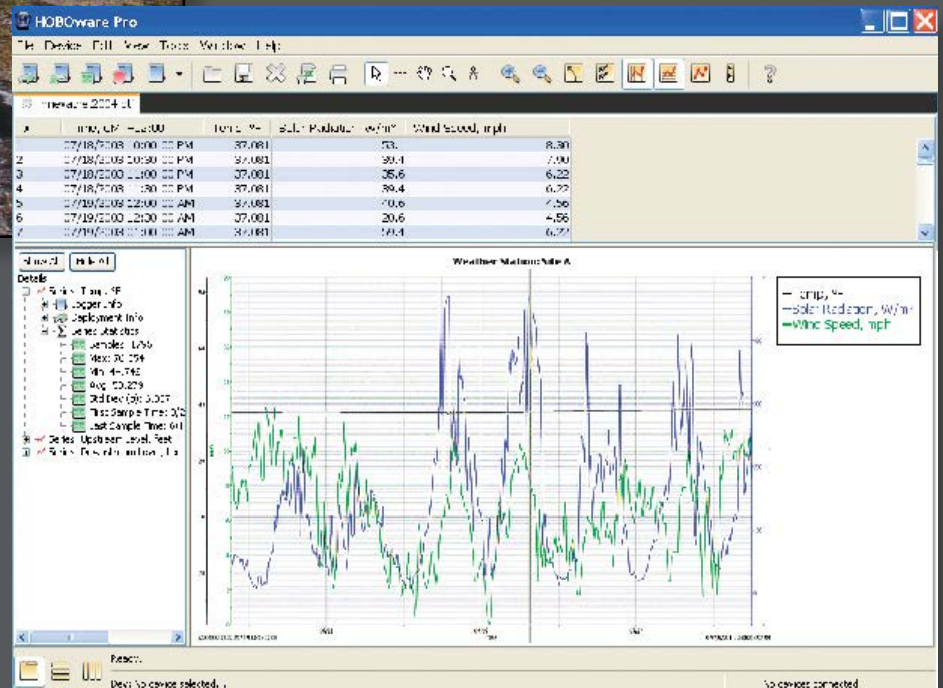
hobologgers.com



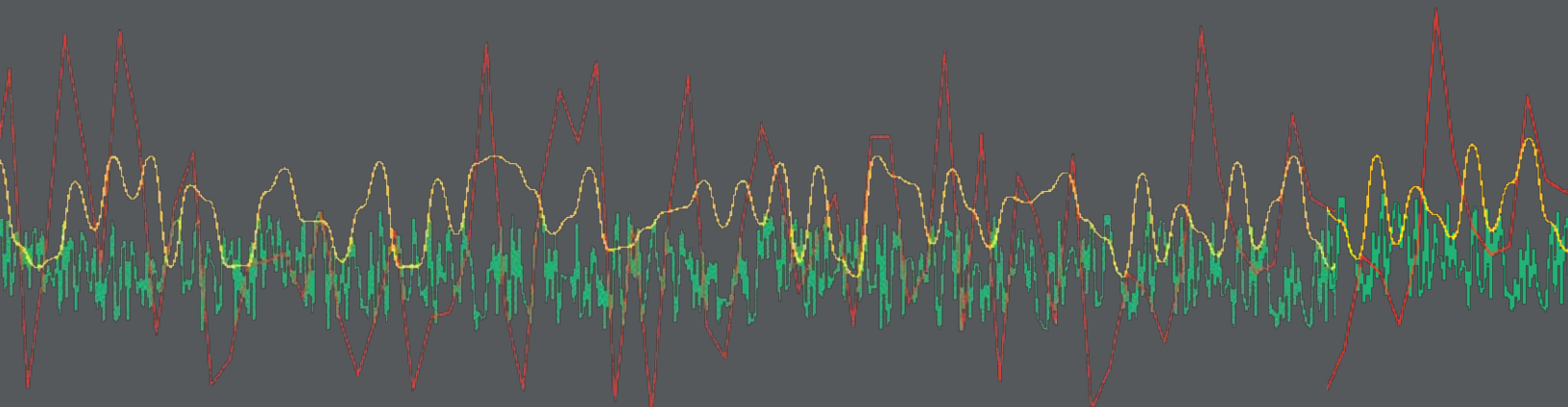
About Onset®

Onset Computer Corporation designs and manufactures data loggers and weather stations. Onset introduced its first data logger more than 25 years ago and revolutionized the portable data logging industry with the first temperature logger under \$100 — the original HOBO® data logger.

Today, more than one million HOBO data loggers are in use around the globe in a broad range of environments, from glaciers in Patagonia to vineyards in Mexico.



HOBO data loggers and HOBOWare® software make it easy to track changing environmental conditions.



- Accept Onset's wide range of plug-in smart sensors
- Optional analog and pulse inputs for 3rd-party sensors
- Battery-powered for up to a year — no solar panels required
- Wireless remote communication options



HOB0 Weather Station

#H21-001

\$399

Size/Weight:
18 x 23 x 10 cm
(7 x 9 x 4 in)
0.9 kg (2 lbs)

Memory:
Logging interval:
Battery life:
Operating range
and battery type:

Sensor network
cable length:



Common Specifications

512K non-volatile data storage
1 second to 18 hours, user-selectable
1 year (typical) — up to 10 sensors with 10-min or longer logging interval
-20° to 50°C (-4° to 122°F) 4-AA alkaline batteries — standard
-40° to 70°C (-40° to 158°F) 4-AA lithium batteries — optional
100 m (328 ft) maximum

HOB0 Weather Station

Up to 15 inputs for maximum system flexibility
10 sensor inputs, expandable to 15 with optional
1-to-2 sensor adapters
Up to 10 voltage or 4-20mA input adapters
Built-in weatherproof communication port for use with remote
communication accessories
Mast mounting brackets included

*HOB0 Weather Station Data Logger and Smart Sensor Kit is available
See page 5*



HOB0 Micro Station

#H21-002

\$199

Size/Weight:
8.9 x 11.4 x 5.4 cm
(3.5 x 4.5 x 2.125 in)
0.5 kg (1 lb)

HOB0 Micro Station

Compact and low-cost
4 sensor inputs
Up to 2 voltage or 4-20mA input adapters
Optional Adapter Cable (CABLE-HWS-F) required for connection
to Onset approved remote communications accessories
Mount on 3.5 in. wide post; use optional mast mounting kit (M-MKA) for tripod



Temperature/RH

#S-THA-M0xx

\$135-\$155

2 m, 6 m, 17 m (6.5 ft, 20 ft, 56 ft)
cable lengths available



Ranges: -40° to 75°C (-40° to 167°F); 0 to 100% RH from 0° to 50°C (32° to 122°F)
Accuracy: ± 0.7° @ 25°C (±1.3° @ 77°F); 3% RH over the range of 0° to 50°C (32° to 122°F); ± 4% in condensing environments 0° to 30°C (32° to 86°F)
Resolution: 0.4° @ 25°C (0.7° @ 77°F); 0.5% RH @ 25°C (77°F)
Response time: Temp: 8 minutes, RH: 10 minutes (to 90% in airflow of 1 m/s)
Data channels: 2

Check website for latest options

8-bit Temperature

#S-TMA-M0xx

\$75-\$95

2 m, 6 m, 17 m (6.5 ft, 20 ft, 56 ft)
cable lengths available



Range: -40° to 100°C (-40° to 212°F)
Accuracy: ± 0.7° @ 25°C (±1.3° @ 77°F)
Resolution: 0.4° @ 25°C (0.7° @ 77°F)
Environment: Sensor tip and cable rated for 1 year immersion in fresh water ≤50°C (122°F)
Response time: < 3 minutes (to 90% in airflow of 1 m/s)

12-bit Temperature

#S-TMB-M0xx

\$90-\$110

2 m, 6 m, 17 m (6.5 ft, 20 ft, 56 ft)
cable lengths available



Range: -40° to 75°C (-40° to 167°F)
Accuracy: ± 0.2° from 0° to 50°C (±0.36° from 32° to 122°F)
Resolution: 0.03° from 0° to 50°C (0.054° from 32° to 122°F)
Environment: Sensor tip and cable rated for 1-year immersion in fresh water ≤ 50°C (122°F)
Response time: < 3 minutes (to 90% in airflow of 1 m/s)

Rainfall

0.2 mm: #S-RGB-M00x,

0.01 in: #S-RGA-M00x

\$389-\$399

2 m, 6 m (6.5 ft, 20 ft)
cable lengths available



Mechanism: Tipping bucket, with 154 mm (6.06 in) receiving orifice
Range: Up to 12.7 cm/hr or 5 in/h, maximum 4000 tips per interval
Resolution: 0.2 mm (S-RGB) and 0.01 in. (S-RGA)
Calibration accuracy: ±1.0% at up to 20 mm/hour or up to 1 in/hour

Comes with side bracket for post or tripod mount and feet for surface mount

Leaf Wetness

#S-LWA-M003

\$99

Sensor Plate 4.7 x 5.1 cm (1.8 x 2.0 in)
Tube 12.2 cm x 1.8 cm diameter
(4.8 x 0.7 in)
Cable 3 m (9.8 ft)



Range: 0 (dry) to 100% (wet)
Sensor Type: Capacitive Grid
Repeatability: ± 5%
Resolution: 0.59%

Includes mounting bracket

Soil Moisture

#S-SMA-M005

\$139

254 x 32 x 1.0 mm (10 x 1.25 x 0.04 in)
Cable 5 m (16 ft) (all #S-SMx-005)



Range: 0 to 0.405 m³/m³ volumetric water content (0 to 40.5%)
Accuracy: Typical: ±0.041 m³/m³ (±4%) for most soils, ±0.20 m³/m³ (±2%) with soil specific calibration
Resolution: ±0.0004 m³/m³ (±0.04%)

#S-SMB-M005

\$139

152 x 32 x 1.0 mm (6 x 1.25 x 0.04 in)
Cable 5 m (16 ft) (all #S-SMx-005)



Range: 0 to 0.450 m³/m³ volumetric water content (0 to 45%)
Accuracy: Typical: ±0.041 m³/m³ (±4%) for most soils, ±0.20 m³/m³ (±2%) with soil specific calibration
Resolution: ±0.0006 m³/m³ (±0.06%)

#S-SMC-M005

\$139

89 x 15 x 1.5 mm (3.5 x 1.25 x 0.06 in)
Cable 5 m (16 ft) (all #S-SMx-005)



Range: 0 to 0.550 m³/m³ volumetric water content (0 to 55%)
Accuracy: Typical: ±0.031 m³/m³ (±3%) up to 8 ds/m, ±0.20 m³/m³ (±2%) with soil specific calibration
Resolution: ±0.0007 m³/m³ (±0.07%)

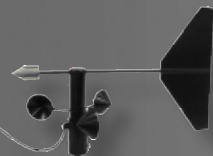
NIST-traceable temperature accuracy certification service available for all temperature sensors

Wind Speed & Direction

#S-WCA-M003

\$499

3 m (9.8 ft) Cable



Range:
Accuracy:
Resolution:
Starting threshold:
Data channels:

Speed

0 to 44 m/s (0 to 99 mph)
Greater of ± 0.5 m/s (1.1 mph)
or $\pm 4\%$ of reading

Direction

0-358°, 2° dead band
 $\pm 5^\circ$

0.19 m/s
 ≤ 0.5 m/s, (1.1 mph)
3 (average wind speed, direction, and highest 3-sec gust)
Survival to 54 m/sec (120 mph). Cross arm recommended for mounting

Wind Speed

#S-WSA-M003

\$199

3 m (9.8 ft) Cable



Range:
Accuracy:
Resolution:
Starting threshold:
Data channels:

0 to 45 m/s (0 to 100 mph)
 ± 1.1 m/s (2.4 mph) or $\pm 4\%$ of reading, whichever is greater
0.38 m/s
 ≤ 1 m/s (2.2 mph)
2 (average wind speed and highest 2 sec gust)
*Survival to 54 m/sec (120 mi/hr)
Cross arm or pole mount recommended (2x hose clamps required for pole mount)*

Barometric Pressure

#S-BPA-CM10

\$119

10 cm (4 in) Cable



Range:
Accuracy:
Resolution:

660 mb to 1070 mb (19.47 to 31.55 in. Hg)
 ± 1.5 mbar (0.044 in. Hg) over full pressure range at 25°C (77°F)
Additional temperature induced error of ± 2.5 mbar (0.074 in. Hg)
0.1 mbar (0.003 in. Hg)
Use inside logger enclosure to protect from direct exposure to the weather

**Photosynthetically
Active Radiation (PAR)**

#S-LIA-M003

\$210

3 m (9.8 ft) Cable



Range:
Spectral range:
Accuracy:
Resolution:

0 to 2500 $\mu\text{mol}/\text{m}^2/\text{sec}$
400 to 700 nm
 ± 5 $\mu\text{mol}/\text{m}^2/\text{sec}$ or $\pm 5\%$, whichever is greater in sunlight,
Cosine corrected 0 to 80 degrees
2.5 $\mu\text{mol}/\text{m}^2/\text{sec}$
Light sensor bracket (M-LBA) and light sensor level (M-LLA) recommended

Silicon Pyranometer

#S-LIB-M003

\$199

3 m (9.8 ft) Cable



Range:
Spectral range:
Accuracy:
Resolution:

0 to 1280 W/m^2
300 to 1100 nm
 ± 10 W/m^2 or $\pm 5\%$, whichever is greater in sunlight,
Cosine corrected 0 to 80 degrees
1.25 W/m^2
Light sensor bracket (M-LBA) and light sensor level (M-LLA) recommended

12-bit 4-20mA Input Adapter

#S-CIA-CM14

\$79



Range:
Accuracy:
Resolution:
Sensor trigger:

0-20mA
 ± 0.1 mA
 ± 4.93 μA
Choice of non-switched or switched input to save external battery power
2.5 V

12-bit Voltage Input Adapter

#S-VIA-CM14

\$69



Range:
Accuracy:
Resolution:
Sensor trigger:

0-5 V DC
 ± 0.025 V
1.221 millivolts
Open collector or 2.5 V

Pulse Input Adapters

Electronic Switch Version
(#S-UCA-M006)

\$69

6.5 m (21 ft) Cable



Range:
User connection:

0-4093 counts per logging interval

2-wire input (24 AWG wire; 2 wire nuts included)

Compatibility:
Maximum input
frequency:
Preferred pulse
polarity:

Electronic switch closures (FET or open-collector outputs, or CMOS-level logic)

120 Hz (120 pulses per second)

Active low

Contact Closure Version
(#S-UCB-M006)

\$69

6.5 m (21 ft) Cable

Compatibility:
Maximum input
frequency:

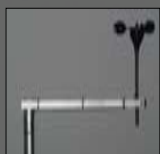
Contact closures (tipping-bucket rain gauges or reed switches)

2 Hz (2 pulses per second)

Preferred switch type: Normally-open

All smart sensors are CE compliant when used with H21-00x loggers

- Tripods and masts provide convenient system deployment
- Sensor mounting accessories provide proper spacing for accurate measurements
- Kits available for ordering convenience

**Cross Arm****Half #M-CAB****Full #M-CAA****\$40-\$50**

Half cross arm (49 cm or 19.2 in)

Full cross arm (91 cm or 36 in)

**Solar Radiation Shield****#M-RSA****\$90****Light Sensor Bracket****#M-LBA****\$20**

Includes levelling screws

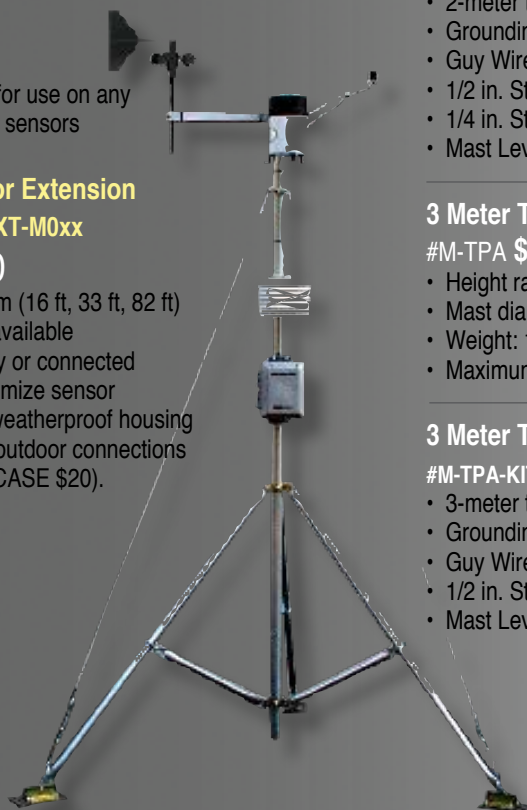
**Light Sensor Level****#M-LLA****\$30**

Purchase one for use on any number of light sensors

**Smart Sensor Extension****Cables #S-EXT-M0xx****\$25-\$40**

5 m, 10 m, 25 m (16 ft, 33 ft, 82 ft) cable lengths available

Use individually or connected together to optimize sensor placement. A weatherproof housing is required for outdoor connections (Part# S-EXT-CASE \$20).

**HOBO® Weather Station Data Logger & Smart Sensor Kit****#H21-SYS-A \$1159**

Includes:

- HOBO Weather Station Data Logger (H21-001)
- Temperature/RH (S-THA-M002)
- Wind Speed and Direction sensors (S-WCA-M003)
- Half Cross Arm (M-CAB) for mounting the Wind sensor
- Solar Radiation Shield (M-RSA) for the Temperature/RH sensor
- Additional smart sensors can be added
- Software sold separately

2 Meter Tripod**#M-TPB \$50**

- Height range: 1.72 to 2.13 m (5.6 to 7 ft)
- Mast diameter: 4.1 cm (1.63 in)
- Weight: 5.8 kg (12.8 lbs)

2 Meter Tripod Kit**#M-TPB-KIT \$165**

- 2-meter tripod (M-TPB)
- Grounding Kit (M-GKA)
- Guy Wire Kit (M-GWA)
- 1/2 in. Stake Kit (M-SKA) for guy wires
- 1/4 in. Stake Kit for tripod (M-SKB)
- Mast Level (M-MLA)

3 Meter Tripod**#M-TPA \$140**

- Height range: 2.74 to 3.20 m (9 to 10.5 ft)
- Mast diameter: 4.1 cm (1.63 in)
- Weight: 12.7 kg (28 lbs)
- Maximum slope: 13 degrees for installation on moderately uneven ground

3 Meter Tripod Kit**#M-TPA-KIT \$245**

- 3-meter tripod (M-TPA)
- Grounding Kit (M-GKA)
- Guy Wire Kit (M-GWA)
- 1/2 in. Stake Kit (M-SKA) for guy wires
- Mast Level (M-MLA)

Weather/Micro Station Remote Communications

onset



Radio Modem and Base Station

#C-002

\$599

#C-003

\$250

Size/Weight: 14.6 x 22.2 x 5.7 cm
(5.7 x 8.7 x 2.2 in)
2.1 kg (4.6 lbs)
including D-cell batteries

SOLARSTREAM™ Pager-Based Wireless System

\$579



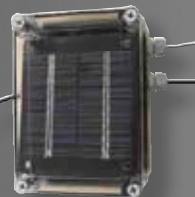
- Wireless launch and offload at distances up to 7 km (5 miles) with optional Yagi Antenna; distances up to 5 km (3 miles) with included whip antenna
- Software running on PC can automatically forward data to other locations over the Internet by FTP or email



- Available from *Upward Innovations* (upwardinnovations.com)
- Automatically transmits data to a secure Internet server
- Provides access to current and historical data from any Internet browser
- Can be configured to send alert messages via cell-phone text messages or email
- Service options start at \$10 per month

SOLARSTREAM Satellite Wireless System

\$979 - \$1179



- Available from *Upward Innovations*, (upwardinnovations.com)
- Provides world-wide coverage via the ORBCOMM or IRIDIUM global satellite networks
- Automatically transmits data to a secure Internet server
- Provides access to current and historical data from any Internet browser
- Can be configured to send alert messages via cell-phone text messages or email
- Service options start at \$20 per month

Remote Modem #C-001

\$599

includes RSM software

Size/Weight: 18 x 23 x 10 cm
(7 x 9 x 4 in)
2.4 kg (5.3 lbs)
including D-cell batteries



- Launch and offload over standard telephone lines
- Battery-powered
- On-demand or automatic offloads
- Software running on PC can automatically forward data to other locations over the Internet by FTP or email

Communication Cables (optional) 2 m Cable: #CABLE-HWS2

\$25

17 m Cable: #CABLE-HWS17

\$50

- Weatherproof cables allow communication to the logger while the logger box is closed
- Connects to weatherproof communication port on Weather Station or Micro Station Adapter Cable (CABLE-HWS-F)
- Opposite end connects to Serial Interface Cable (CABLE-PC-3.5) or HOBO U-Shuttle serial cable

* Micro Station Adapter Cable: #CABLE-HWS-F

\$39

- **Required** for connection of SolarStream, Radio Modem, Remote Modem or 2 m or 17 m Communication Cables with the H21-002 HOBO Micro Station
- Adapter Cable includes grounding wire

HOBO® Pro v2 Loggers

onset



HOB0 Pro v2 Internal Temp/RH #U23-001 \$139



Size/Weight:
10.2 x 3.8 cm
(4.0 x 1.5 in)
U23-001 57 g (1.5 oz)
U23-002 118 g (3.1 oz)
U23-003 138 g (3.7 oz)
U23-004 102 g (2.7 oz)

HOB0 Pro v2 External Temp/RH #U23-002 \$179



1 cm (0.38 in) diameter probe
on 1.8 m (6 ft) cable

HOB0 Pro v2 2x Ext Temp #U23-003 \$149



Two 0.5 cm (0.2 in) diameter
probes on 1.8 m (6 ft) cables

HOB0 Pro v2 Temp/Ext & Temp/Internal #U23-004 \$129



0.5 cm (0.2 in) diameter probe
on 1.8 m (6 ft) cable

- User-replaceable RH sensor provides improved performance in humid environments
- External probe versions
- Data readout in less than 30 seconds via fast, direct USB interface

Memory: 42,000 measurements
Sample rate: 1 second to 18 hours, fixed rate or multiple logging intervals
Battery life: 3 years (typical)—user-replaceable



Internal Temperature

Measurement range: -40° to 70°C (-40° to 158°F)
Accuracy: ±0.18°@ 25°C (±0.32°@ 77°F)
Resolution (12-bit): 0.02°@ 25°C (0.04°@ 77°F)
Response time: 40 minutes (to 90% in airflow of 1 m/s)

External Temperature

Measurement range: U23-002: -40° to 70°C (-40° to 158°F)
U23-003 & 004: -40° to 100°C (-40° to 212°F); sensor tip and cable immersion in fresh water up to 50°C (122°F) for one year
Accuracy: ±0.18°@ 25°C (±0.32°@ 77°F)
Resolution (12-bit): 0.02°@ 25°C (0.04°@ 77°F)
Response time: U23-002: 5 minutes (to 90% in airflow of 1 m/s)
U23-003 & U23-004: 3 minutes (to 90% in airflow of 1 m/s)
30 seconds (to 90% in water)

Relative Humidity

Measurement range: 0 to 100% RH
Accuracy: ±2.5% RH from 10% to 90%
Resolution (12-bit): 0.03% RH
Response time: U23-001: 10 minutes (to 90% in airflow of 1 m/s; RH change only)
U23-002: 4 minutes (to 90% in airflow of 1 m/s; RH change only)

NIST-traceable temperature accuracy certification service available

Complete system requires logger, software, and base station

HOB0 Pro v2 Ordering Information

Description	Part No.	Price
HOB0 Pro v2 Temp/RH**	U23-001	\$139
HOB0 Pro v2 Ext Temp/RH**	U23-002	\$179
HOB0 Pro v2 2x Ext Temp**	U23-003	\$149
HOB0 Pro v2 Temp/Ext Temp**	U23-004	\$129

Software and Communications

HOB0ware® Pro Software (Windows®)	BHW-PC	\$99
HOB0ware Pro Software (Mac)	BHW-MAC	\$99
Optic USB Base Station* with Couplers	BASE-U-4	\$110

Optional Communications and Accessories

HOB0 Waterproof Shuttle with Couplers	U-DTW-1	\$219
HOB0 U-Shuttle (requires Base Station)	U-DT-1	\$249
Solar Radiation Shield***	RS1	\$65
Mounting Clamp	U23-RS-CLAMPKIT	\$5
(for mounting U23-001 or -004 in RS1 or M-RSA)		

* HOB0 Waterproof Shuttle can also be used as a Base Station

** Also compatible with HOB0ware Lite, see page 21

*** Accurate temperature measurements in sun require a radiation shield

Patented technology (U.S. Patent 6,826,664)

HOBO® Data Logging Rain Gauge

onset

- Self-contained rainfall logger includes a HOBO Pendant™ Event data logger with a high quality tipping-bucket rain gauge
- Time and date stamp is stored for each tip — provides detail needed to determine rainfall rates and duration
- Reliable, field-proven rain gauge
- Also records temperature when used with an optional radiation shield

Data Logging Rain Gauge

0.2 mm: #RG3-M

0.01 in: #RG3

\$399

Size/Weight:

15.24 cm diameter x
25.7 cm high
(6 x 10 in)
1.2 kg (2.5 lbs)



Memory:

- Constructed from field-proven corrosion-resistant components: aluminum housing and collector ring; stainless steel shaft and brass bearings; tipping bucket is high-precision, injection-molded, high-impact ABS plastic
- Three mounting feet to use on flat, level surfaces (three screws included)
- Side bracket for mast mounting (hose clamps included)
- 15.4 cm (6.06 in.) collector ring
- Self-emptying for continuous rainfall logging

Battery life:

64K; number of data points depends on rainfall rate
16K to 23K tips when recording rainfall only
25K to 30K tips and temperature measurements when recording both
1 year (typical)— user-replaceable

Rainfall

Range: Up to 320 cm (RG3-M), up to 16 in. (RG3)

Resolution: 0.2 mm (RG3-M), 0.01 in. (RG3)

Time stamp resolution: 1 second

Calibration accuracy: ±1.0% (up to 20 mm/hr [RG3-M], 1 in/hr [RG3])

Temperature

Range: -20° to 70°C (-4° to 158°F)

Accuracy: ±0.47° @ 25°C (±0.85° @ 77°F); a solar radiation shield is required for temperature measurements

Resolution: 0.10° @ 25°C (0.18° @ 77°F)

Response time: 15 minutes (to 90% in airflow of 1 m/s)

Sample rate: 1 second to 18 hours, user-selectable

Optional NIST-traceable certification available (temperature only)



Complete system requires logger, software, and base station

Data Logging Rain Gauge Ordering Information

Description	Part No.	Price
Data Logging Rain Gauge:**		
0.2 mm	RG3-M	\$399
0.01 in.	RG3	\$399

Software and Communications

HOBOWare® Pro Software (Windows®)	BHW-PC	\$99
HOBOWare Pro Software (Mac)	BHW-MAC	\$99
Pendant Base Station*	BASE-U-1	\$59

Optional Communications and Accessories

HOBO Waterproof Shuttle with Couplers	U-DTW-1	\$219
HOBO U-Shuttle (requires Base Station)	U-DT-1	\$249
Solar Radiation Shield (unassembled)	RS1	\$65

* HOBO Waterproof Shuttle or Optic USB Base Station (BASE-U-4) can be used instead of the Pendant Base Station

** Also compatible with HOBOWare Lite, see page 21

Patented technology (U.S. Patent 6,826,664)