

MONITORING-PAM

Multi-Channel Chlorophyll Fluorometer



Long-Term Monitoring of Chlorophyll Fluorescence under Field Conditions

WALZ
Mess- und Regeltechnik

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Multi-Channel Chlorophyll Fluorometer

Measurements of chlorophyll fluorescence give easy and non-invasive access to primary photosynthetic productivity data. In particular, pulse-amplitude modulated (PAM) chlorophyll fluorescence, in combination with saturating pulse analysis of fluorescence quenching, has become a key technique in basic and applied photosynthesis research.

With the introduction of the PAM-101 chlorophyll fluorometer in 1985, by Heinz Walz GmbH, the Walz company has made PAM fluorometry generally available to the scientific community.

While this first system was laboratory-based, further developments resulted in portable above-ground (MINI-PAM, PAM-2000 and its successors PAM-2100/PAM-2500) and underwater fluorometers (DIVING-PAM) which have enabled assessment of photosynthesis in the field.

The launch of the MONITORING-PAM Chlorophyll Fluorometer represents another big step forward in outdoor monitoring of photosynthesis by facilitating, for the first time, long-term multi-site monitoring of PAM-fluorescence under rough environmental conditions.

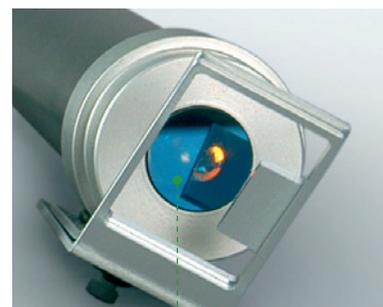
Uniquely, the MONITORING-PAM records, for each measuring site, fluorescence yield and photosynthetically active radiation (PAR), which is essential to evaluate fluorescence parameters in a naturally changing light environment.



Features

- Cylindrical-shaped, robust and weather-resistant measuring heads (MONI-HEAD/485) recording PAM fluorescence, ambient PAR and temperature.
- Pulse-modulated fluorescence measuring light, blue actinic light and blue saturating pulses delivered by a single blue (455 nm) Power LED.

- Operation of up to 4 measuring heads (MONI-HEAD) using a special interface box for computer connection. Alternatively, one can operate up to 7 measuring heads in parallel using the MONITORING-PAM Data Acquisition system (MONI-DA).
- Unattended battery-operated fluorescence monitoring over extended time periods can be achieved using the MONITORING-PAM Data Acquisition system (MONI-DA).

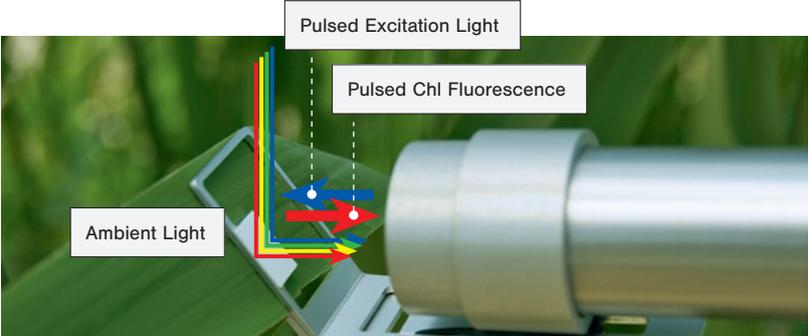


MONI-HEAD/485 (optical window)

System Components & Descriptions

MONI-HEAD/485 Measuring Head

The MONI-HEAD/485 measures both ambient light remitted by a scattering Teflon sheet to a PAR sensor inside the instrument and modulated fluorescence excited by the pulsed measuring light emitted by the measuring head.



MONI-DA Data Acquisition system

The MONI-DA is hermetically sealed. Settings are adjusted using magnetic proximity switches. Data are stored on a 1 GByte memory size microSD flash card.

Front View



Rear View



MONI-IB4/USB PC Interface Box

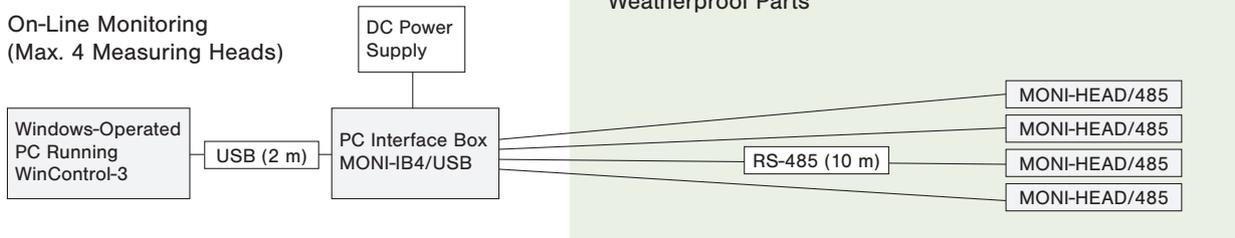
The MONI-IB4/USB PC interface box translates between USB and RS-485 data communication. It also serves as power supply for MONI-HEAD measuring heads and as battery charger for the MONI-DA.



System Configurations

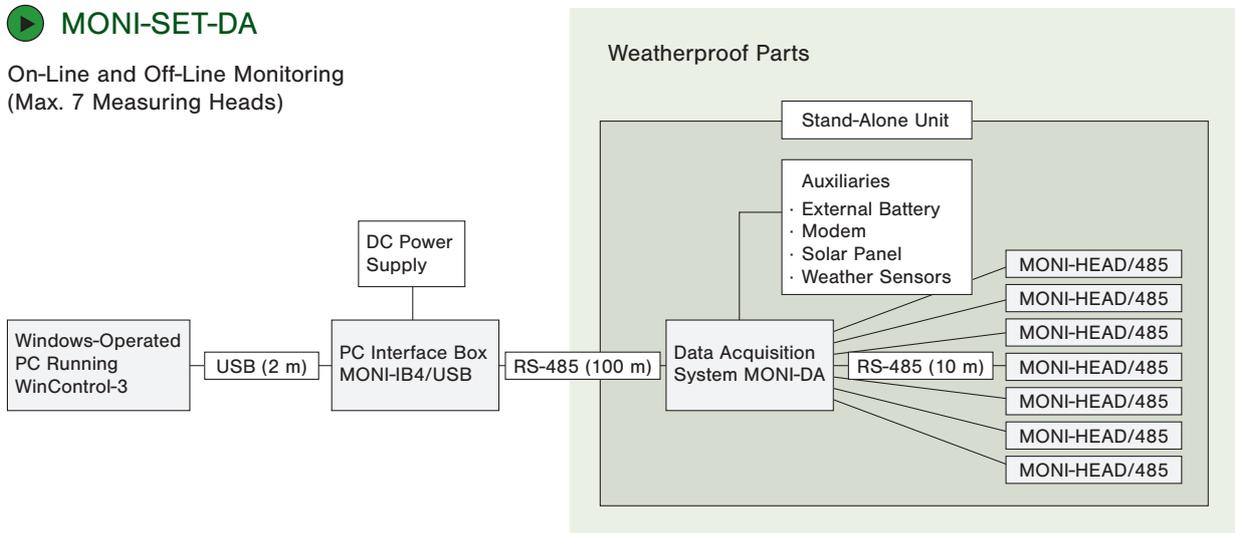
MONI-SET

On-Line Monitoring
(Max. 4 Measuring Heads)



MONI-SET-DA

On-Line and Off-Line Monitoring
(Max. 7 Measuring Heads)



Future Add-Ons

- Solar panel as power supply for Data Acquisition System MONI-DA.
- Radiation, temperature and humidity sensors for the Data Acquisition System MONI-DA.

- Tele Data Concepts.

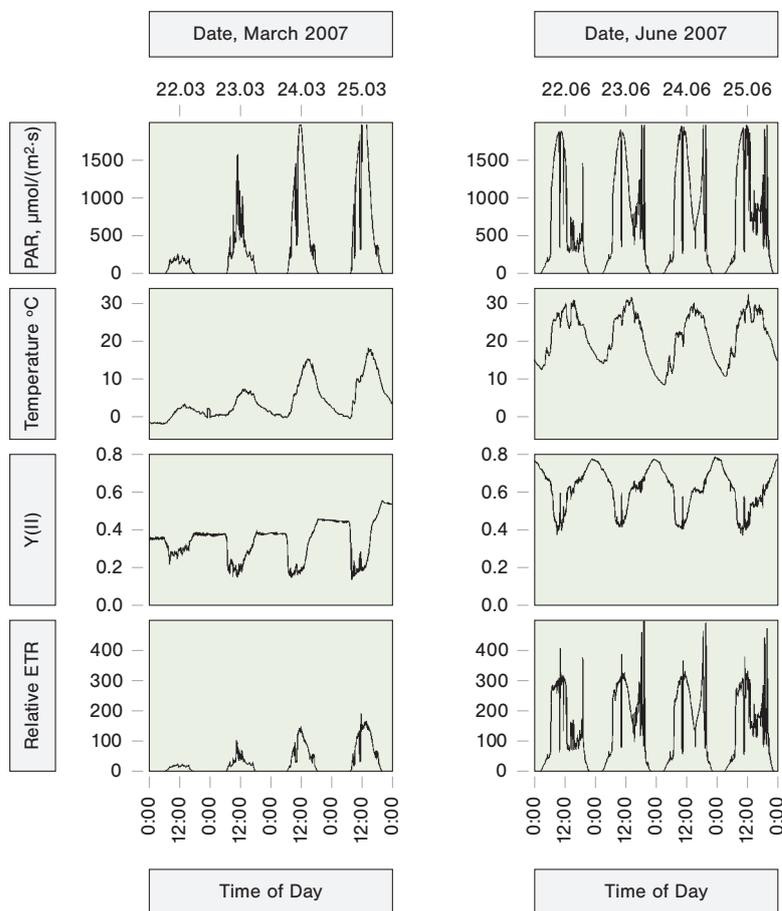
- 1) Data upload to a centralized server via http/https protocol.
- 2) Wireless data upload to a centralized server via telephone modem (GPRS) and smtp protocol. Also, data upload via satellite phone.

- 3) Online view of uploaded data using a web application. Download of WinControl-3 type data from centralized server for evaluation and analysis.

Application

▶ Example of Application

Fluorescence monitoring in the field. Data from Scots pine needles were recorded at the beginning of spring (left-handed panels) and at the beginning of summer in Finland (right-handed panels; data from Porcar-Castell *et al.* (2008) *Photosynth Res* 96, 173-179).



▶ Typical Areas of Applications

- Above-ground and marine eco-physiological research. Crop plant monitoring in precision farming.

- Continuous monitoring and long-term estimation of primary photosynthetic production.
- Detection of sustained non-photochemical energy quenching during long-term stress periods.



WinControl-3 Software

General Features and Graphical User Interface

General Features

The WinControl-3 software represents the latest version of the WinControl software family. Presently, WinControl-3 operates the JUNIOR-PAM and the MONITORING-PAM fluorometers. Different from its predecessors, WinControl-3 handles simultaneously multiple PAM fluorometers and permits very long periods of data acquisition.

Data Evaluation

Saturating pulse analysis with automatic detection and calculation of standard fluorescence parameters including F_o , F_m , F_o' (calculated), F_m' , F_v/F_m , qP , qL , qN , NPQ, $Y(II)$, $Y(NPQ)$, $Y(NO)$, ETR.

Automated Routines

Repetitive triggering of fluorometer functions (e. g., dark-light induction and dark recovery curves) by adjustable clock.

Light Response Curves (Rapid Light Curves)

Automatic execution of light exposure protocols and fitting of two different model functions to data of light response experiments.

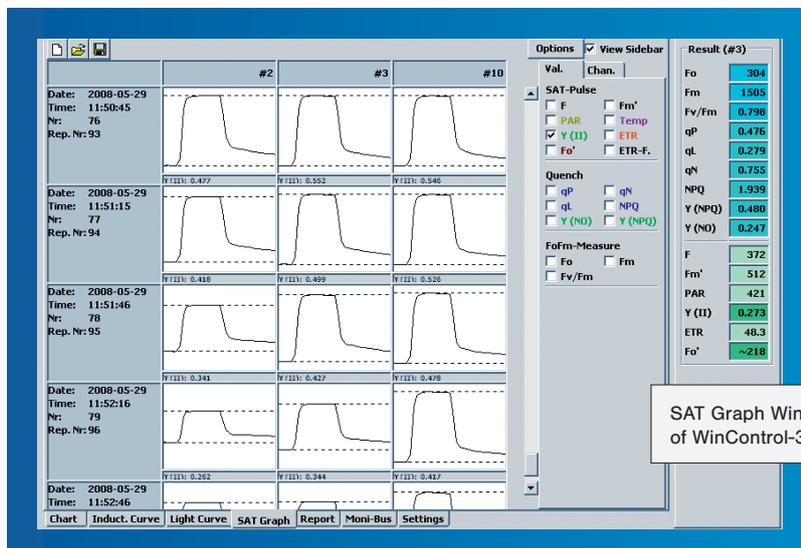
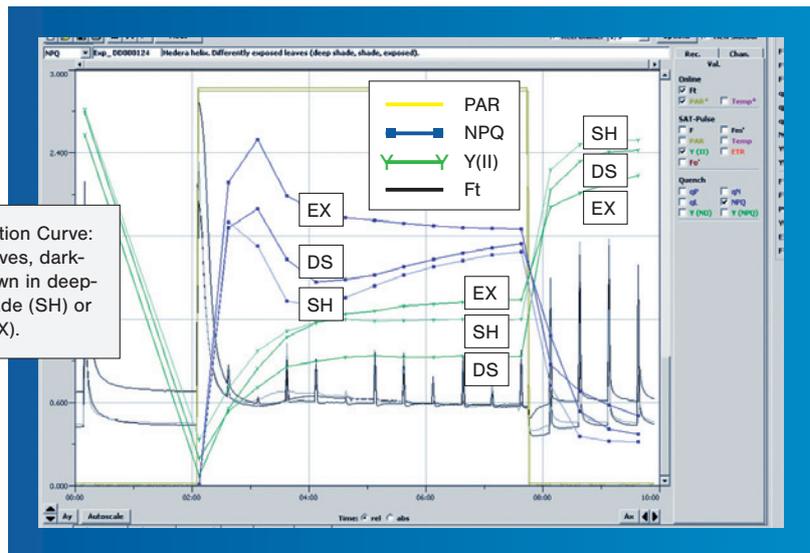
Data Export

Export in CSV (comma-separated values) format of original fluorescence traces, saturating pulse analysis data and parameter estimates of light response curves.

Customer-Defined Measuring Protocols

Execution of customized experimental procedures using easily programmable batch files.

Dark-light Induction Curve: *Hedera helix* leaves, dark-acclimated, grown in deep-shade (DS), shade (SH) or sun-exposed (EX).



Technical Specifications

▶ Measuring Head MONI-HEAD/485

- **Housing:**

Water-tight aluminum cylinder (stainless steel on request) with one end featuring a collimating lens for focusing measuring light, actinic light and saturating pulse light on the sample and collecting fluorescence

- **Sample Clip:**

Consisting of 2 aluminum frames (35 x 25 mm), pressed together by a special O-ring, and mounted at a distance of 25 mm from the MONI-HEAD/485 optical window. Angle between optical axis of the MONI-HEAD/485 and sample clip plane: 120°. Data/power cable: 10 m standard length (MONI-HEAD/485 to MONI-IB4/USB or MONI-HEAD/485 to MONI-DA)

- **Fluorescence Detection:**

PIN-photodiode protected by long-pass filter (50% transmittance at 645 nm). Selective window amplifier to measure pulse-amplitude modulated (PAM) fluorescence

- **Measurement of Photosynthetically Active Radiation:**

Integrated quantum sensor (photodiode protected by near-infrared filters) measuring the radiation reflected by a 13 x 7 mm area of an optically diffuse Teflon sheet, 1 mm thick, mounted at the edge of the leaf clip

- **Temperature Measurement:**

Integrated-circuit temperature sensor on circuit board

- **Measuring Light:**

Blue Power LED (peak wavelength: 455 nm, full width at half maximum is 18 nm). Photosynthetically active radiation of measuring light at level of the sample clip range from 0.1 to 1 $\mu\text{mol}/(\text{m}^2\cdot\text{s})$ at low modulation frequencies (5 to 25 Hz), and from 1 to 15 $\mu\text{mol}/(\text{m}^2\cdot\text{s})$ at high modulation frequencies (100 to 500 Hz)

- **Actinic Light:**

Same Power LED as for measuring light. At the level of the sample clip, maximum photosynthetically active radiation of actinic light and saturating flashes are 1500 and more than 3500 $\mu\text{mol}/(\text{m}^2\cdot\text{s})$, respectively

- **Power Consumption:**

Peak loads during saturating pulses: 7 W. During measuring mode: 0.5 W

- **Physical Properties:**

Dimensions: Cylinder with diameter of 30 mm and length of 280 mm
Weight: 250 g (aluminum), 450 g (stainless steel)
Operating temperature: -5 to +40 °C

▶ PC Interface Box MONI-IB4/USB

- **Housing:**

Aluminum case including one USB-B, four M12 5-pole and one power supply socket

- **Interfacing:**

The interface box connects between computer and maximally four MONI-HEAD/485 or one MONI-DA. RS-485 serial data communication is used between interface box and MONI-HEAD/485 or MONI-DA. USB communication is used between interface box and computer (RS232 and Ethernet communication on request). Standard cable lengths, 2 m to computer, 10 m to MONI-HEAD/485, 100 m to MONI-DA

- **Physical Properties:**

Dimensions: 120 x 93 x 30 mm (L x W x H)
Weight: 350 g
Operating temperature: 0 to +40 °C

- **Power Supply:**

Input: 100 to 240 V AC, 50 to 60 Hz
Output: 19 V DC, 3.7 A
Dimensions: 132 x 58 x 30 mm (L x W x H)
Weight: 310 g

▶ Software, Hardware

- **Fluorometer Software:**

WinControl-3 for PAM fluorometers. Measured and calculated parameters: Fo, Fm, Fm', F, Fo' (calculated), Fv/Fm (max. Yield), $\Delta F/Fm'$ (Yield), qP, qN, qL, NPQ, Y(NPQ), Y(NO), ETR (i.e. PAR x $\Delta F/Fm'$), PAR and °C. Two different fitting routines for ETR versus light intensity curves

- **Computer Operating System:**

Microsoft Windows 2000/XP/Vista

- **Computer Hardware:**

Minimum requirements Processor, 1 GHz. RAM, 256 MB. Hard disc space, 20 MB. Screen resolution: 800 x 600 pixels. Interface, USB 1.1 or USB 2.0

▶ Data Acquisition System MONI-DA

- **Housing:**

Robust water-proof cylinder consisting of a polyvinyl chloride (PVC) tube and Poly-oxy-methylene (POM) endplates. One endplate with 2 male M12 5-pole sockets connected in parallel (MONI-IB4/USB communication, charging voltage), one male M12 5-pole socket for auxiliaries, and 7 female M12 5-pole sockets (MONI-HEAD/485 communication)

- **Communication:**

RS-485 serial data communication

- **Off-line Operation:**

1 GByte memory size on a microSD flash card. Power supply: 7 Ah sealed lead-acid battery. Reduced power consumption by switching into standby mode between measurements

- **Properties:**

Power consumption: 12 mW in standby mode. Operating mode, depends on the number of MONIHEAD/485 connected (see MONI-HEAD/485 power consumption).
Operating temperature: -10 to +40 °C
Dimensions: 160 mm x 240 mm (diameter x length)
Weight: 5.6 kg

Subject to change without prior notice





High Quality Instrumentation for Plant Sciences

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