

# MULTI-COLOR-PAM

Multiple Excitation Wavelength Chlorophyll Fluorometer



6 colors of pulse-modulated measuring light, 5 colors of actinic light plus white, and far-red light.

Highly sensitive analysis of very dilute suspensions, allowing light gradient-free measurements.

Accessory for leaf studies available.

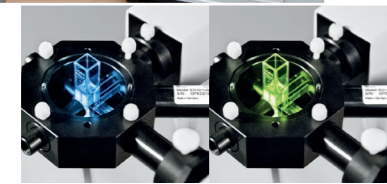
Saturation Pulse analysis and fast kinetics recordings with 10  $\mu$ s time resolution.

Highly accurate determination of effective PS II quantum yield even with extremely small variable fluorescence.

Determination of functional PS II absorption cross-section and PS II turnover rates.



The MULTI-COLOR-PAM provides six colors of pulse-modulated measuring light (365 or 400, 440, 480, 540, 590 and 625 nm) and five colors of actinic light (440, 480, 540, 590, 625) plus white (420-640 nm) and far-red light (730 nm).

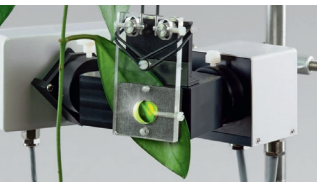


### Optical unit for suspensions

sample and to study wavelength-dependent aspects of photosynthesis.

Spherical and flat cosine-corrected sensors are available for accurate PAR-measurements in suspension or at leaf surface, respectively. A special routine is provided for measuring PAR-lists of all colors.

### Optical unit for leaf measurements



# PHYTO-PAM-II

Multiple Excitation Wavelength Phytoplankton & Photosynthesis Analyzer

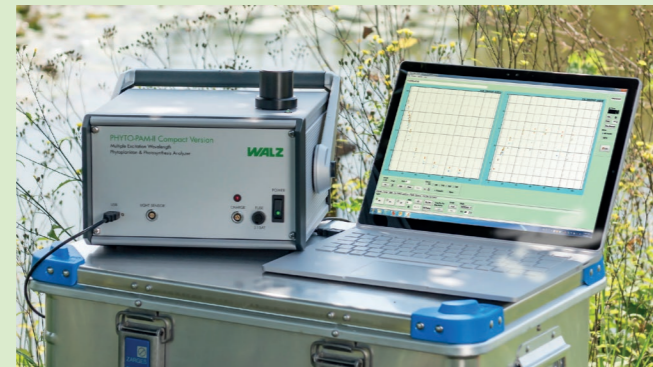


Live determination of four algal types in suspension in a mixed sample; e.g. green algae, cyanobacteria, diatoms/dinoflagellates, and phycoerythrin-containing algae.

The COMPACT version is highly portable due to integration of light sources, fluorescence detection, and signal processing in the same housing.

The MODULAR version provides two extra optical ports, the option of changing detector filters, software-triggered stirring and temperature control.

The COMPACT version can be equipped with the Flow-Through Cuvette and a 0-10 V pump control to automate sampling processes.



Both PHYTO-PAM-II versions provide five measuring light wavelengths, six actinic light colors, the full range of saturation pulse analysis, assessment of chlorophyll a content, fast kinetics, determination of the functional antenna size of PS II, automated recording, and script file operation.



### Modular Version

The photomultiplier detector provides the high sensitivity required to analyze even extremely dilute cell suspensions such as natural water samples.

Reference spectra of algae can be transferred between different PHYTO-PAM-II units.

An exchange data base of reference spectra is available on the Walz website.

### Flow-Through Cuvette



# MICRO-PAM

Small PAM Sensor for MONITORING-PAM Systems



Small and lightweight measuring heads for long-term monitoring of photosynthesis in the field.

Dimensions 13.5 x 4.0 x 3.5 cm, weight 100 g.

Weather-proof design. High power blue LED employed for measuring light, actinic illumination, and saturation pulses.

### Measuring heads



MICRO-PAM systems are controlled by the WinControl-3 software running on Windows PCs.

At remote places, the MONI-DA Data Acquisition System operates the MICRO-PAM system. An optional WiFi or a satellite modem transfers data from the MONI-DA to the lab.

Batch file operation permits to automatically control sampling frequency depending on light conditions.

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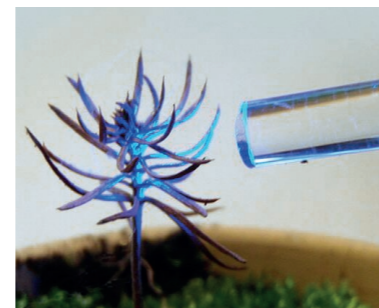
A light guide directs chlorophyll fluorescence from the sample to the detector. An external cosine-response sensor measures PAR. A thermocouple records leaf temperature. An internal sensor reports air humidity.

Automatic evaluation of PS II photochemical yield ( $\Phi_{II}$ ), quenching parameters, and electron transport rate, ETR.

Long-term power supply by solar panels.

Up to 16 MICRO-PAM measuring heads can be connected to a MONI-DA.

### Light guide



# MINI-PAM-II

Photosynthesis Yield Analyzer



Ultra-mobile, compact and reliable PAM fluorometer for field use.

Easy operation via touch-screen interface.

Versions available with blue or red light. Strong far-red light source for PS I excitation.



Unique expandability by add-ons like a high-power RGBW lamp, compact spectrometer (for light, fluorescence and reflectance spectra), or oxygen package for suspensions.

### Oxygen Package for Suspensions



Leaf clip with improved sensor for photosynthetically active radiation (PAR).

Energy efficient LED sources and easy to replace off-the-shelf batteries guarantee long field sessions and low maintenance costs. High-performance rechargeable batteries are included.



### External LED Light Source

All common fluorescence parameters are automatically calculated. Photosynthetic electron transport under field conditions can be derived from PAR measurements by the leaf and PAM fluorescence. When actinic light of internal light source drives photosynthesis, an internal sensor measures PAR. The MINI-PAM-II can be operated by Windows computers using WinControl-3 software.

# DIVING-PAM-II

Underwater Fluorometer with Miniature Spectrometer



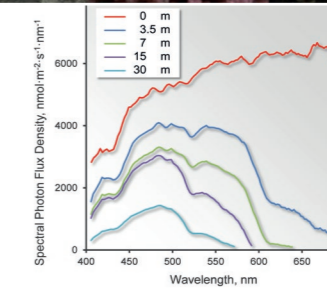
The well-known PAM fluorometer for aquatic research down to diving depths of 50 m.

Available with blue and red light (DIVING-PAM-II/B and DIVING-PAM-II/R, respectively). Both versions possess a far-red light source to evaluate  $F_o'$  fluorescence levels.

With sun-readable LCD display and WiFi communication.

The system includes the submersible miniature spectrometer MINI-SPEC to measure spectra of sunlight and total PAR, as well as fluorescence emission and reflectance spectra of samples.

Upgradeable with the Underwater Oxygen Sensor DIVING-PAM-II/O<sub>2</sub> and various sample holders.



### Underwater light spectra

High-capacity battery for more than 2,000 PS II yield measurements. Flash memory for more than 27,000 saturation pulse analyses.

Evaluation of photosynthetic quantum yield and quenching parameters. Automatic execution of induction and light curves. Fully programmable.

Compatible with MINI-PAM-II accessories.

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# PRODUCT HIGHLIGHTS

NEW:  
WATER-PAM-II  
HEXAGON-  
IMAGING-PAM



High Quality Instrumentation for Plant Sciences



# HEXAGON-IMAGING-PAM

Chlorophyll Fluorometer for Large Sampling Areas



Visualization and analysis of the photosynthetic activity of samples on 20 x 24 cm in high resolution. The HEXAGON-IMAGING-PAM employs a powerful LED array for the homogeneous illumination of the sample area. Blue high-power LEDs are used for saturation pulse analysis of the PS II. Two additional types of far-red LEDs can be used for Fo' measurements and other applications.

For convenient use, we have combined various measurement setups in one device. It is ideal for leaves or other plant parts, algae, lichens, mosses and small whole plants – from detached leaves and multiwell applications to trays of potted plants. The position of the base plate can be adjusted in height or equipped with special pot-holders. Samples can be inserted through the front sliding doors or the tray-slot at the side.



The software shows parallel the sample image and numerical or graphical analyses of selected areas of interest. The photosynthesis analysis parameters include inhibition analyses and offers photochemical and non-photochemical quenching parameters.

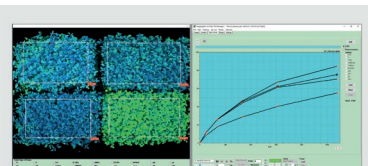


## Accessory: IMAG-HEX/PC

For automation, the device can be fully remote controlled.

Recommended accessory is the IMAG-HEX/PC, an Intel NUC Mini-PC with Win 10 OS.

## Data Analysis



# DUAL-PAM-100

P700 & Chlorophyll Fluorescence System



The standard system for measuring simultaneously PS I and PS II.

The basic MODULAR version combines a PAM fluorometer and a two-wavelength absorption spectrometer. PAM chlorophyll fluorescence is used to analyze PS II. Minute absorption changes in the near infrared region tell the redox state of PS I.

The FIBER version DUAL-PAM/F records the absorption changes of PS I as variations in the reflection signal.

MODULAR and FIBER versions have blue, red, and far-red actinic light. Measuring light is red or blue in case of the MODULAR version, the FIBER version is available only with red measuring light.

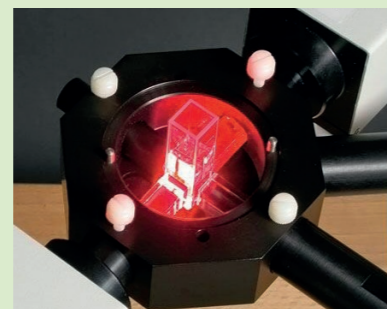


The MODULAR version can easily be modified: An optional photodiode or photomultiplier enhances sensitivity of fluorescence detection. Special configurations permit measurements of  $\Delta A_{515}$ ,  $\Delta A_{535}$ , NADPH, and the pH-sensitive dyes acridine orange, acridine yellow, and 9-aminoacridine. Another setting can detect simultaneously fluorescence of two different spectral windows.

Special features are the P700 flux mode to measure the electron flux through PS I, a method for PQ pool size determination, a macro recorder to create experimental routines, and the script file programming option.

## ED-101US / MD Optical Unit

The DUAL-PAM Gas-Exchange Cuvette 3010-DUAL connects the MODULAR version to the GFS-3000 to simultaneously evaluate PS I and PS II photochemistry, and CO<sub>2</sub> fixation. The highly versatile DualPAM software controls the DUAL-PAM systems.



# PAM-2500

Portable Chlorophyll Fluorometer



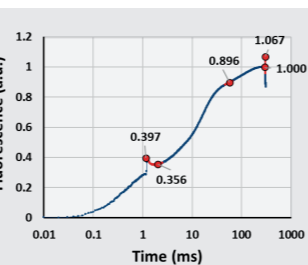
Instrument to probe both the electron transport chain (O<sub>1</sub>-I<sub>2</sub>-P transients, 10  $\mu$ s time resolution) and activity/the steady state (Light Curves and Induction-Recovery measurements).

A PAM fluorometer that offers the user a complete overview of the light reactions both in the field and in the lab.



Powerful LEDs providing single turnover flashes for one complete PS II excitation and multiple turnover pulses for O<sub>1</sub>-I<sub>2</sub>-P determinations and the standard saturation pulse method.

## Macro for analysis O<sub>1</sub>-I<sub>2</sub>-P transients



## PAM-2500 with Leaf Clip 2030-B in lab environment

Free Walz macro provided to evaluate levels, halfrise times, and areas from O<sub>1</sub>-I<sub>2</sub>-P (OJIP) transients.

Optional accessories include an ultra-mobile tablet PC for touch-screen operation and a special optical cuvette for the study of microalgae and cyanobacteria.

# WATER-PAM-II

Chlorophyll Fluorometer for Phytoplankton



The new WATER-PAM-II is our most sensitive instrument for the analysis of phytoplankton in aqueous samples. LEDs for both blue and red excitation of the samples and multiwavelength detection of different algal groups greatly extend the range of applications. The instrument offers answers to three questions: how much, what, and how active.

Analysis of the photosynthetic activity of phytoplankton samples can be determined by single measurements or with easy-to-use analysis protocols such as induction curves and light curves. The differential analysis of algal content provides a tool to determine the composition of algae populations with respect to three algae groups, based on differences in their antenna properties.



The very compact and lightweight instrument is ideal for field applications. Common, easily replaceable, off-the-shelf (rechargeable) batteries provide power for more than 30 h continuous operation.

WATER-PAM-II can be used as a stand-alone instrument or connected to an external computer on which WinControl-3 software is run.

## Flow-Through Cuvette



## Numerical and graphical display

The integrated sunlight readable touchscreen enables easy operation and gives numerical and graphical display of the measurements.

The versatile accessories include a Flow-Through Cuvette for high throughput measurements.

# GFS-3000

Portable Gas Exchange & Fluorescence System



High precision gas exchange and chlorophyll fluorescence system. Simultaneous measurement of CO<sub>2</sub> assimilation and saturation pulse analysis of PS II.

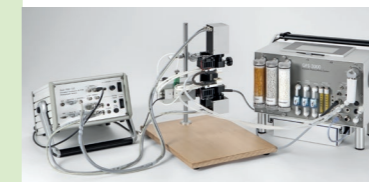
Full control of CO<sub>2</sub> and H<sub>2</sub>O concentrations, cuvette or leaf temperature, ventilation and illumination.



Extensive options for data acquisition by combination with other Walz systems (IMAGING-PAM, DUAL-PAM-100, or DUAL-KLAS-NIR).

Many cuvette configurations including Gas-Exchange Chamber 3010-GWK1 for medium sized samples.

## DUAL-PAM-100 and GFS-3000



Control ranges: CO<sub>2</sub>: 0 to 2000 ppm, H<sub>2</sub>O: 0 to nearly 100% rh  
Temperature: 10 K below ambient to 60°C.

Intuitive software. Color touchscreen. Easy programming of automated experiments.

Employing eSMART batteries.



## 3041-L and 3057-FL

LED Array 3041 L: homogeneous warm white illumination: 1 to 3000  $\mu$ mol m<sup>-2</sup> s<sup>-1</sup> PAR on up to 10 cm<sup>2</sup>

LED Array/PAM Fluorometer 3057-FL: outstandingly homogeneous red and/or blue illumination on up to 8 cm<sup>2</sup> in combination with chlorophyll fluorescence measurements.

# DUAL-KLAS-NIR

Measuring System for P700, Plastocyanin, Ferredoxin & Chlorophyll Fluorescence



Simultaneous determination of the redox states of plastocyanin (PC), PS I reaction center (P700) and ferredoxin (Fd) with four pairs of measuring beams at near infrared wavelengths.

Blue- and green-excited chlorophyll fluorescence can be measured concurrently.

## System overview



On-board blue, red and far-red actinic light. Red multiple turnover pulses and red single turnover flashes.

Configurations for both leaves and suspensions available. Includes positioning system for emitter and detector units.

Software structure similar to DUAL-PAM-100 software; streamlined to operate the six-channel DUAL-KLAS-NIR as easy as the two-channel device DUAL-PAM-100.

Assessment of quantum yields and effective antenna sizes of PS I and PS II, control of linear electron transport by lumen pH, as well as ratios of PC:P700 and P700:Fd.

Ideal for studying function, stoichiometry and regulation of the photosynthetic electron transport chain.

Including many standard measuring protocols. With templates for automated experiments. Signal deconvolution based on pioneering approach of Differential Model Plots (DMPs).

## Polyphasic fluorescence rise and redox changes of Fd, P700, and PC

