ADC BioScientific Ltd.

iFL

Integrated fluorometer and gas exchange system

The most automated and accurate combined photosynthesis system for advanced plant physiology research

Photosynthetic parameters include:

- **A**: Photosynthesis rate
- **E**: Transpiration rate
- **Ci**: Substomatal CO_2
- G_s: Stomatal conductance
- **Q**: PAR
- **A/Ci** curve
- **A/Q** curve
- Γ^*: CO_2 compensation point
- R_d: CO_2 respiration in the light (by Laisk, Kok or Yin protocols)
- Flexas chamber leakage protocol
- Leaf absorptance/ transmittance
- g_m: Mesophyll conductance
- C_c: CO_2 at site of carboxylation
- A/C_c curves
- ***J***: Electron transport rate
- Fluorescence stress tests including: Fv/Fm, Yield Y(II) with Fm' multiflash, quenching tests and Rapid light curves

- **Complete and full automation**
  The **first** gas exchange system to conduct fully automated Laisk protocols and subsequent post processing without interruption

- **Accurate and reliable data**
  The **first** gas exchange system to:
  - Measure leaf absorptance/transmittance
  - Measure chamber leakage
  - Ensure chloroplast migration

- **Truly field portable**

- **Large touch screen, colour, graphic display**

- **Use as:**
  - **Automated combined system**
  - **Advanced gas exchange system**
  - **Powerful chlorophyll fluorometer**

New gas exchange developments

ADC BioScientific Ltd: world leading innovators in gas exchange instrumentation, introduces the new iFL Integrated fluorometer and gas exchange system. Featuring many new technological developments, the iFL is designed to provide plant physiologists with the most advanced, accurate and reliable experimental capabilities.

The iFL features a highly accurate, miniaturised infra red gas analyser (IRGA), housed directly inside the leaf chamber head, with a fully integrated pulse modulated chlorophyll fluorometer. Thus providing researchers with measurements of an expanded range of photosynthetic parameters.

Additional photosynthetic parameters

These photosynthetic parameters include Γ^* and R_d, which can be used in subsequent automated experiments to measure g_m, ***J***, and C_c. So providing researchers with more detailed diagnostic information on the photosynthesis process and its adaption to different environmental conditions and stresses.

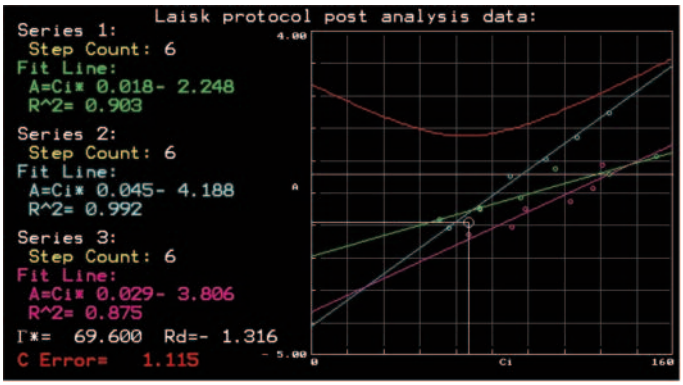
These long-term experiments, such as Laisk protocols, are conducted without any interruption for cell matching or battery change.

Full automation - without interruption

The unique differential in time design of the ADC IRGA, with automatic zeroing, ensures that there is no calibration drift. This means that long experiments such as entire Laisk protocols may be performed, fully automatically, without any interruption for cell “matching” or any other intervention. Simply set up an experiment, walk away and return when the experiment has finished.

Several hours of automated experimentation can be initiated with one touch of the iFL screen. For example a complete Laisk may be performed together with post processing, directly followed by automated experiments to measure g_m, ***J*** and C_c including A/C_c curves.

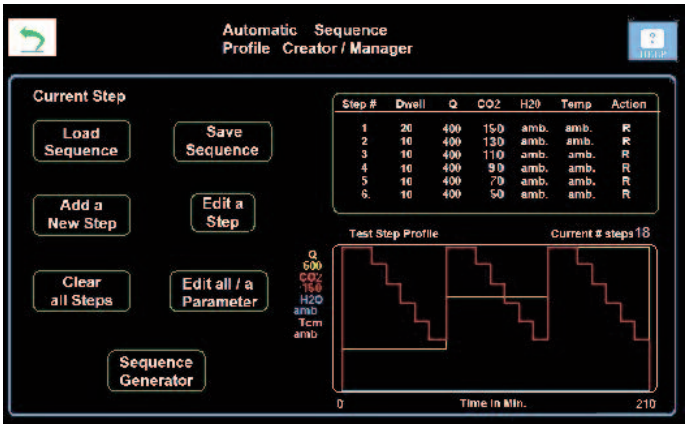
Some Laisk protocols alone can take more than 4 hours to perform. The iFL can operate continuously for up to 8 hours from a single charge ensuring that long experiments can be completed without the need to change batteries.



Pre-programmed experimental protocols

Setting up long and detailed experiments is easy, whether loading or editing an existing protocol or building a brand new protocol. A number of factory preprogrammed protocols are supplied as standard which may also be modified by the user. These include Laisk with van Caemmerer correction, Yin, Kok, g_m and C_c and A/C_c protocols.

Up to 8 protocols may be linked together to run consecutively. New or modified protocols can be saved and recalled for future use.



The most accurate and reliable data

- **Measures leaf absorptance/transmittance**
- **Measures chamber leakage**
- **Uses white light to allow chloroplast migration**
- **Measures leaf temperature by IR sensor**

The iFL features a number of new technological developments to provide the most highly accurate and reliable photosynthesis data.

Measures leaf absorptance/transmittance

The iFL is the **first** plant physiology system to measure leaf absorptance/transmittance and chamber leakage (Flexas protocol) and thus removes any errors that these variable factors could introduce.

Leaf absorptance, in particular can vary with plant stress, by species, leaf age, chlorophyll content and with light intensity. It is therefore now widely recommended that leaf absorptance should be measured to avoid potentially significant errors in ***j,*** **g**m and **C**c and **A/Q** curves. The iFL uses RGB sensors above and below the leaf to measure leaf absorptance and transmittance.

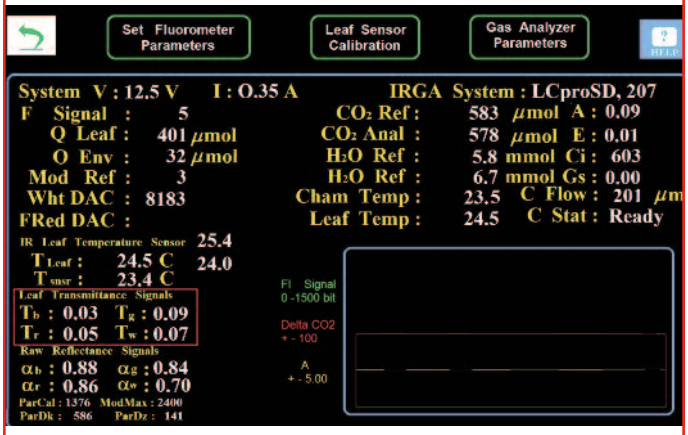
Enables chloroplast migration

The iFL is the **first** plant physiology system to feature a white actinic light with an intense blue spectrum to ensure that chloroplast migration occurs as in nature. This prevents potentially significant errors in quenching protocols and in some gas exchange experiments.

Leaf temperature is measured by a new miniaturised IR sensor positioned directly inside the leaf chamber.

One PAR sensor is positioned inside the leaf chamber to monitor the constant actinic light source during routines. A second PAR sensor positioned on top of the fluorometer allows ambient light to be measured and if required automatically matched inside the chamber.

Optional averaging of CO_2 data points can reduce measurement variability. Whilst the integrated fluorometer design ensures an even illumination across the whole gas exchange chamber area.



The iFL can be used in three modes

- **Automated combined system**
- **Advanced gas exchange system**
- **Powerful chlorophyll fluorometer**

Automated combined fluorescence and gas exchange system

The iFL provides preprogrammed, fully automated routines of the Laisk, Kok and Yin protocols for the determination of Γ^* and $\mathbf{R_d}$ including all post processing. These determinations may then be automatically transferred to subsequent experimentation for measuring $\mathbf{g_m}$, ***J*** and $\mathbf{C_c}$ including A/$\mathbf{C_c}$ curves.

Whilst the Laisk protocol is the most frequently used protocol for determining Γ^* and $\mathbf{R_d}$, Kok is sometimes preferred for determining $\mathbf{R_d}$ in C_4 plants. The more recent Yin protocol offers some potential advantages of being able to work at higher light levels and higher CO_2 concentrations.

Flexas chamber leakage protocol

When measuring the very small gas exchanges involved with measuring Γ^*, $\mathbf{R_d}$, $\mathbf{g_m}$ and $\mathbf{C_c}$ chamber leakage and dark respiration underneath the chamber gaskets can become important. The iFL features the Flexas chamber leakage protocol, that allows the researcher to test specific plant material in the chamber and automatically apply these results to following experiments.

Advanced gas exchange system

The iFL can operate as an advanced stand alone gas exchange system, providing all the portability and versatility of the LC*pro-SD* (Intelligent portable photosynthesis system) combined with the powerful graphing user interface of the iFL.

Researchers can conduct standard gas exchange experiments under ambient or controlled conditions. **A**/**Q** and **A**/**C**i protocols are supplied as standard.

When using the LC*pro-SD* independently of the iFL, the LC*pro-SD* gas exchange system can be used with a wide variety of chamber heads including: broad, narrow, conifer, small leaf, canopy, fruit and soil.

Powerful chlorophyll fluorometer

A variety of highly accurate fluorescence plant stress tests can be performed including:

- Fv/Fm
- Yield (Y)II with Multiflash-Fm' correction
- Rapid light curves
- Quenching protocols
  - Hendrickson model
  - Kramer lake model
  - Puddle model

Multiflash-Fm' correction ensures the closure of all PSII reaction centres at high light intensities, so preventing potential significant errors in ***J***. The iFL employs the latest multiple phase, optimal 7,000µmols m^{-2} s^{-1} saturation flash technique.

Automated modulated light adjustment ensures optimal intensities are used in fluorescence experiments. Thus eliminating potential errors and reducing set up time.

Rapid light curves enable the determination of leaf saturation characteristics, required for setting up Laisk protocols and A/Ci curves.

iFL Rapid light curve

Truly portable for field research

Weighing only 5.2kg (including battery) the iFL is a truly portable and versatile instrument for field plant physiology research.

The highly power efficient iFL operates continuously from a single battery charge for up to 8 hours.

Colour touch screen display

The large, colour, touch screen display provides a state of the art user interface making the iFL both interactive and simple to use.

Real time data, experimental status, calculations and graphs with auto-curve fitting software are clearly presented on screen. Sub screens can be enlarged to full screen size for even easier viewing.

Gas exchange measurements can be presented in either ppm/mbar or µmol mol^{-1}/mmol mol^{-1}.

Data, protocols and graphs can be stored on the internal 2Gb flash memory or on SD cards. The user may select to store to card or in the internal memory.

Downloading of data is either directly from the SD cards or via USB. For class or group presentations the iFL features a high quality video HDMI output.

ADC: Never compromise on quality

"Quality of product and quality of service."

From design to delivery ensuring optimal performance and reliability is of paramount importance to our team of experienced engineers. Once in the field you are supported by our network of over 40 customer support centres worldwide.

iFL provisional specification

Gas exchange provisional specification

Measurement range, technique and control:

CO_2: 0-3,000ppm, 1ppm resolution Infrared gas analyser. Differential, open system with auto zero. Programmed control 0-2000ppm

H_2O: 0-75mbar, 0.1mbar resolution dual laser trimmed, fast response sensors. Programmed control above and below ambient dependent on ambient conditions

PAR: External 0-3,000µmols m^{-2} s^{-1} Silicon photocell. Programmed control 0-7,500µmols m^{-2} s^{-1}
Internal leaf chamber PAR sensor 0-7,500µmols m^{-2} s^{-1}

Temperature:

Leaf: -5°C to 50°C IR sensor

Chamber: -5°C to 50°C precision thermistor
Programmed control typically +/- 14°C from ambient

Flow rate: 100-500ml min^{-1}

Warm up: 5 minutes@20°C

Fluorometer provisional specification

Excitation sources:

Saturation pulse: White LED with 690nm filter. 0-7,000 µmols m^{-2} s^{-1}

Modulating light: 660nm LED with 690nm short pass filter

Actinic light: White LED 0-2,000µmols m^{-2} s^{-1}

Far red: 740nm LED

Blue/red/green absorptance sensors

Detection method: Pulse modulation

Automated setting of modulated light intensity: Adjustable On/Off

Automated Multi-Flash Fm' correction for all light adapted protocols: Adjustable On/Off

Detector: PIN photodiode with 700-750nm filter

Sampling rate: 10 to 10,000 points per second, dependent on phase of test

Test duration: Adjustable 20 seconds - 4,000 hours

System provisional specification

Data storage: 2Gb internal memory for thousands of data sets and traces. Removable SD cards

Digital output: SD cards, USB and HDMI

User interface: Large, colour, menu driven, graphic touch screen display (14.5cm x 8.5cm)

Battery: 7.0Ah 12 V lead acid battery. Up to 8 hours of battery life as iFL system

Total console dimensions: 31cm x 11cm x 24cm

Total leaf chamber dimensions: 30cm x 8cm x 16cm

Total console weight: 5.2kg (including battery)

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