laserpoint

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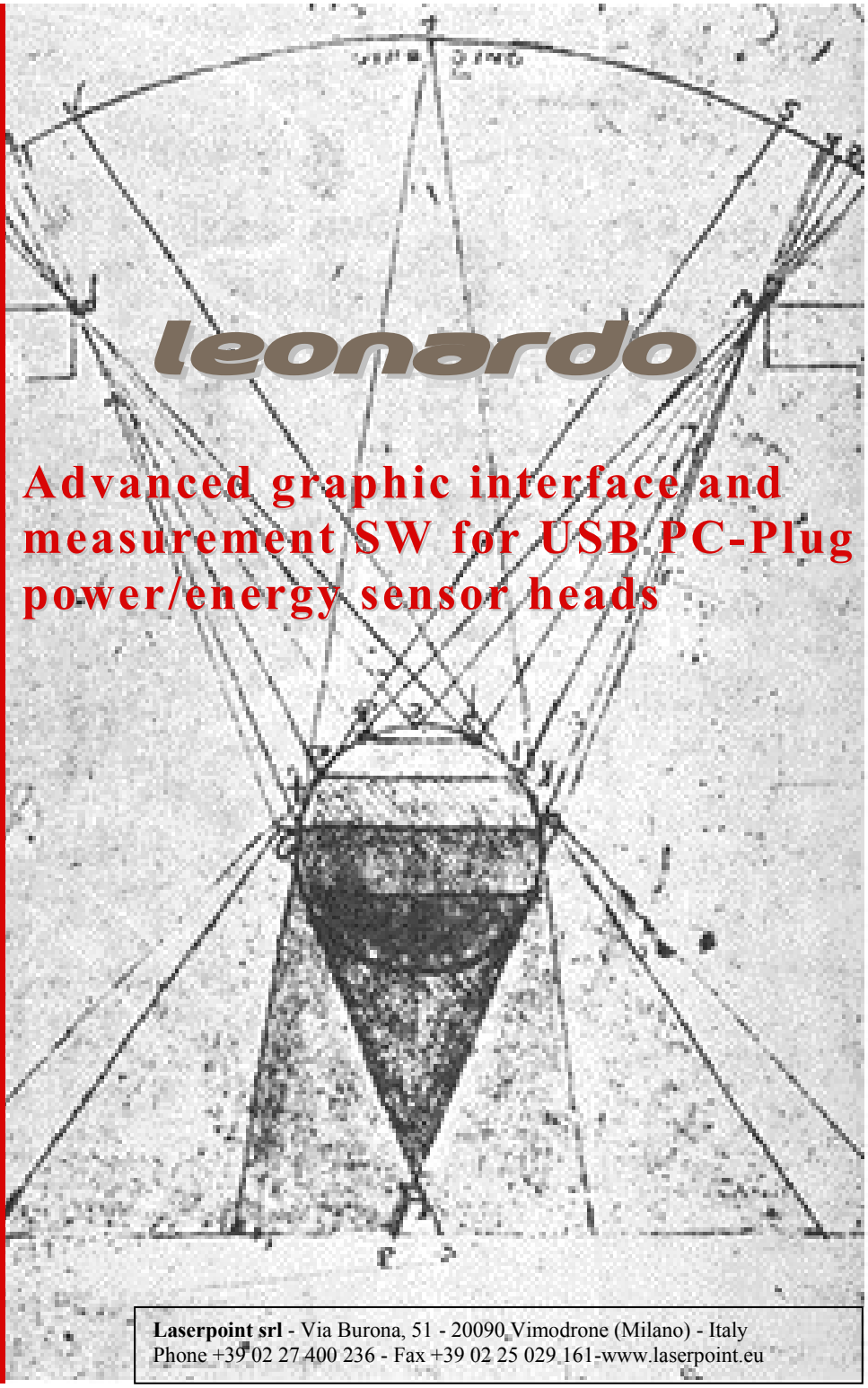
User's Manual



leonardo

Advanced graphic interface and measurement SW for USB PC-Plug power/energy sensor heads

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User's Manual of *leonardo* measurement software and graphic interface for USB PC-Plug power/energy sensor heads

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1. Introduction and software installation

leonardo is an advanced measurement software and graphic interface developed by LaserPoint to make any laptop a true power and energy meter when used to read out, elaborate and manage the data generated by LaserPoint PC-Plug Series sensor heads with USB interface.

Pc-Plug series, are LaserPoint new generation laser power and energy sensor heads with built in metering electronics. This new generation of power & energy sensor heads is available with USB and RS-232 interface and their electronics is contained in a small shell sized like a USB memory stick placed at the end of the sensor head cable.
leonardo software and graphic interface has been developed to provide the user of PC-Plug Series with USB interface with a powerful tool to read, elaborate, represent and store measurement data.

USB PC-Plug Series heads are suitable to be used either in laboratory laser set-ups or easily embedded in laser based systems and as the choice sensor head to match the laptop of every service engineer.

Fig.1 Example of USB PC-Plug Series power/energy sensor head

The PC-Plug Series USB interface built in memory hosts all the relevant data and information pertaining the sensor head like the head model, its identification number, the head full scale, sensitivity spectrum, calibration wavelengths and re-calibration suggested date.
In general, detectors feature different sensitivity values at different wavelengths depending on the detector nature (this is especially important for those based on semiconductor devices), so it is important to account for this when measuring power and energy values. All LaserPoint sensor heads are calibrated up to the rated power/energy head full scale at least at one selected wavelength. PC-Plug sensor heads are also characterised over a broad wavelength range using a low power broadband source and the measured sensitivity spectrum is loaded into the USB interface memory as a table of discrete wavelength dependent data.

All newly released USB PC-Plug sensor heads are designed to be compatible with *leonardo* software and graphic interface; all software content to run *leonardo* is stored in a folder named "***Leonardo***" in the USB key supplied with the PC-Plug sensor head. Two drivers are available to run the software and manage PC-Plug sensor head measurement data:

amd64: suitable for PCs based on 64 bit Operating Systems like Windows 7 and subsequent OS releases.

x86: suitable for PC based on 32 bit Operating Systems like Windows XP or Windows Vista.

After downloading all the USB key content into your PC, install the proper driver by double clicking on ***dpinst_amd64*** or ***dpinst_x86*** application icons stored in the folder named "***Drivers".***
After the driver installation has been completed connect a USB sensor head to a PC port, wait few seconds until the USB sensor head is recognized by the computer and then double click on the icon Leonardo; this makes *leonardo* wizard appear on the PC screen as shown in Fig. 2.
Select USB as "connection mode" and the head model in use as "USB device", then click on "next" and on "finish" as soon as its screen button is highlighted. Few seconds more (10s to 20s depending on the head type) and *leonardo* will be ready for use as soon as its initial page (Fig. 3) appears on the PC screen.

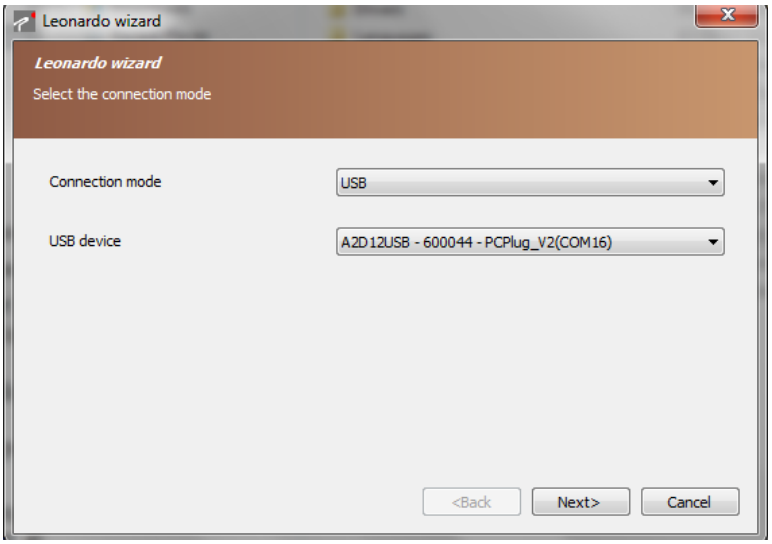

Fig. 2 *leonardo* wizard display

2. Safety notes

Before operating this software and graphic interface to read out and manage the measurement data of a USB PC-Plug sensor head, carefully review the following safety information to avoid personal injury and prevent damage to the sensor in use.

The use of lasers as well as power and energy measurement are potentially dangerous. This application may operate with sensor heads over high laser power/energy ranges and wavelengths including non-visible laser radiations.

Proper operating practice in accordance with laser manufacturer's recommendations is crucial; to ensure correct operating procedures, consult the laser manufacturer and your laser safety officer.

Eyewear and other personal protective equipment must be used in compliance with applicable laws and safety regulations.

3. Introduction to leonardo graphic interface

Upon opening leonardo graphic interface features a large window showing the digital mode measurement screen at its first connection (the last used measurement data representation for all other connections). Beside the measurement data, the window hosts information regarding the head, the screen keys and tools to set up and manage the sensor head before and during the measurement session as well as to set up a representation and the storage of the measurement data in the most appropriate or desired mode.
leonardo window displays nine functional keys needed to plan the measurements and the data representation as well an upper band and a lower line of small boxes showing the relevant information regarding the sensor head type, date /time, head settings and environmental conditions.

At the very left top of leonardo display window there are two accessible commands: **Connect to…** and **Leonardo Options.**
- **Connect to…** can be used to select another head connected to a different USB port or, in the case a USB sensor head was disconnected from the PC, to access leonardo wizard and select the desired USB sensor head to use without launching leonardo again.
- **Leonardo Options** can create a folder to save and store the measurement data; this folder can be freely named according to user's preference. Instructions concerning the saving procedures will be given in Chapter 9 of this manual. This tool is useful to create keyboard command shortcuts too.

Upper band (at the window top): from left to right it shows the sensor head model (e.g. A2D12USB), the head S/N and date / time information.
Lower stripe of rectangular boxes (just above the nine screen keys): from left to right the lower side of the window displays five boxes laid in a row showing information about the data statistics mode, the number of samples taken during the measurement session, Gain and Smoothing values, Offset value and Sensor head temperature value (for thermal sensor heads only).

MAIN KEYS
The five main keys of the interface: (**MENU-MEASURE-SAVE-MODE-ZERO)** offer a quick access to set up and manage the measurement session.

MENU key gives access to the main interface settings:
MENU key opens the *USER INTERFACE* window enabling the selection of the *Language* to interact with the interface and a *Display Colour* (background and main window features colour) among three options.

MEASURE key gives access to measurement settings by means of three sub-keys:
- *MEASUREMENT* enabling to select Power or Energy measurements and to display power data in Watt related units (μW, mW or W) or dBm units by activating the *dBm* function
- *RESOLUTION* enabling to set and display the selected number of digits after the decimal point of the measured value.
- *AREA* enabling to display the measured function value also in terms of function density (power or energy per square cm) by setting the shape and size (area parameters) of the laser beam under test.

SAVE key allows to select the relevant data that will saved, to freeze the selected measured data and save them in a dedicated folder.

MODE key gives access to four different display modes of power measured data, namely:
-Digital mode
-Trend mode

-Analogue/Tuning mode
-Histogram mode

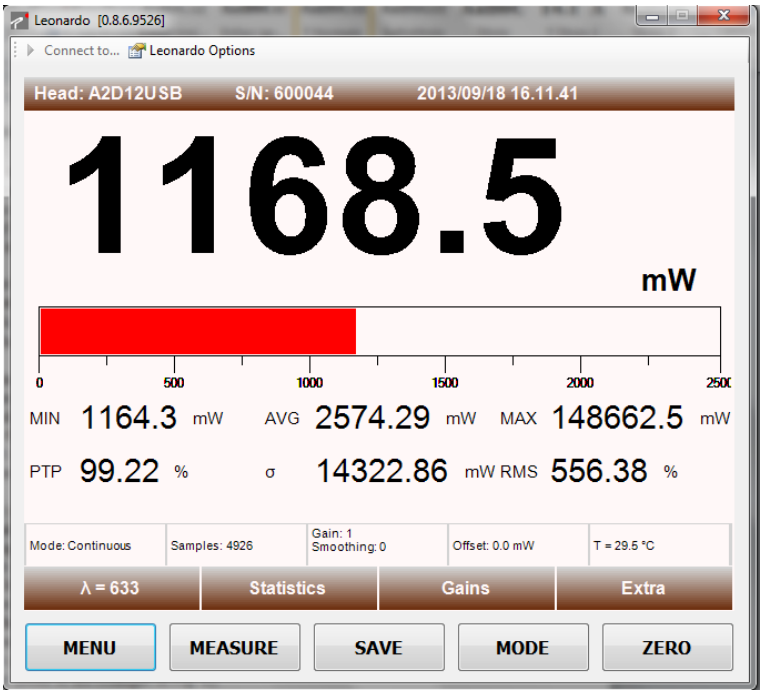

Fig.3 Initial page of *leonardo* graphic interface

ZERO key enables the user to define the optical zero of the sensor head and to reset the ADC of the head electronics.

ADDITIONAL FUNCTIONAL KEYS
Above the five Main Keys there are four additional keys, from left to right side:

- **λ = ….** key: sets and shows the wavelength of the sensor head in use.
- **Statistics** key: defines the statistical setting of measured data collection and elaboration.
- **Gains** key: customizes the read out unit gain and manages the time response of the sensor head through a filter and an acceleration algorithm.
- **Extra** key: allows the factory engineers to update the FW loaded in the sensor head, and check and change its calibration status and the user to access some information concerning the product.

4. Quick start (download SW, connect a sensor head and get started)

To start a measurement in a quick way, simply follow this list of actions

- Download all the content of the USB key supplied with the USB PC-Plug sensor head to your PC, install the proper driver by double clicking on ***dpinst_amd64*** or ***dpinst_x86*** application icons stored in the folder named "***Drivers".***
- After the driver installation has been completed connect a USB sensor head to a PC port, wait few seconds until the USB sensor head is recognized by the PC and then double click on the icon Leonardo; this makes *leonardo* wizard appear on the PC screen as shown in Fig. 2.
- Select USB as "connection mode" and the head model in use as "USB device", then click on "next" and on "finish" as soon as its screen button is highlighted. Few seconds more (10s to 20s depending on the head type) and *leonardo* will be ready for use as soon as its initial page (Fig. 3) appears on the PC screen (at the first head connection the Digital display mode is automatically selected)..

- Start the measurement cycle by placing the active area of the detector head in front of the laser source. Carefully ensure that the active area of the sensor only is hit by the laser beam
- If needed, the measured data display mode can be changed by clicking on "MODE" key; repeat this action until the desired measurement data display mode is shown on the screen (for a more comprehensive description of display mode key operation refer to Chapter 7 of this manual).

5. leonardo Main Menu (MENU key)

MENU key gives access to the main instrument settings.
By clicking on the **MENU** key the *SETTINGS* page appears giving access to the selection of a *Language* to interact with leonardo graphic interface and a display *Colour* theme (background and main screen features colour).

Language selection - To select a Language, just touch the rectangular window with the language of choice. The present release of the software features German, English, Spanish, French and Italian as available languages (Fig 4). The chosen language settings are instantaneosly displayed.

Display colour selection- A proper instrument colour theme selection may be useful to guarantee a correct screen view in different lighting conditions; depending on the available lighting and/or type of laser protection glasses, a specific display colour may offer a better view of the screen relevant information.
To select or change a colour, just click on the rectangular window with the colour of choice that can be chosen among three possible options: Red, Blue and Black and White (Fig 4). Click the "OK" button to return to the measurement display.

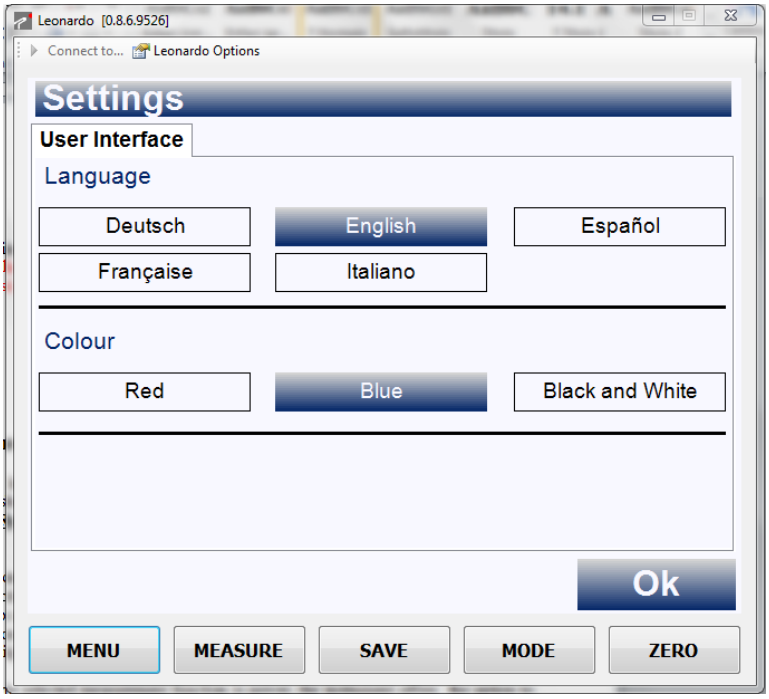

Fig. 4 Settings page of MENU screen key

6. Measurement Menu (MEASURE key)

Clicking on the **MEASURE** key makes the MEASUREMENT page to appear (Fig.5). Normally this page opens showing the **Measurement** sheet that allows the user to select the measurement function between

power and (single shot) energy. The **Resolution** and **Area** sheets can be selected by clicking on the associated button.

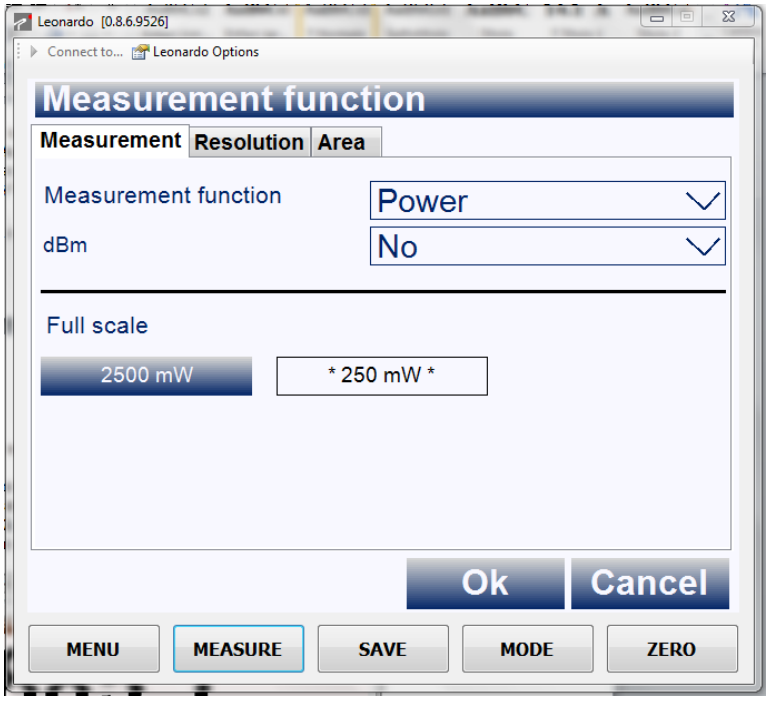

Fig. 5 Measurement setting page

Measurement Function - Some LaserPoint heads can measure both power and single laser pulse energy, so to change measurement function, click on the rectangular window at the right hand side of "*Measurement Function*"; a window pop up appears and, depending on the head type, the measurement of power or single shot energy can be selected out of the pop up dialogue window. Once the selection has been made click on the "OK" button at the low right hand side of the display to enter the changes and exit measurement settings.

Power Measurement – In the case power is the selected measurement function, the instrument offers the option to display the measured data in Watt related units (µW, mW or W) or in dBm units. To do so, just click on the rectangular window at the right hand side of "dBm"; when the dialogue window appears select YES to activate the display of power measured data in dBm units.
The scale upper limit automatically chosen by *leonardo* and dispayed on the screen is the full scale limit of the sensor head as per the information stored in its EEPROM; this parameter is shown in rectangular box placed in the lower left part of the page; the other box at its right hand side is 10% of the full scale value of the sensor head in use and can be optionally set as the upper display scale limit in case of particularly low power or energy beam detection. To select this scale upper limit click on the pertaining rectangular box.
Should the measured function value exceed the set 10% of the rated head detection limit during the measurement session, the displayed scale will automatically return to the head full scale limit. For full scale setting procedures refer to chapter 7 of this manual.

Single shot energy – This measurement function can be selected only when using a thermopile head that has been enabled to measure the energy of a laser single pulse.
If the selected measurement function is single shot energy, upon exiting the Measurement page by clicking on the "OK" button at the right lower hand side of the display, the single shot energy display mode screen appears. This is a histogram-like graph where the energy of each laser pulse is shown as a vertical bar proportional to the pulse energy and the last energy measured value is shown also in digit form at the upper left corner of the display. The measured energy value is expressed in units according to the head energy full scale.

Important: In order to avoid measurement errors or possible misinterpretations of the measured data resetting the head before starting any pulse energy measurement action is mandatory.
For measurement parameters and scale changes refer to paragraph **Single shot energy mode** in Chapter 7 of this manual.
For resetting instructions refer to Chapter 10 of this manual.

Resolution –The resolution sheet allows to select the number of decimal digits after the dot by clicking on the buttons + or – to respectively, increase or decrease the measurement resolution. The number of digits after the decimal dot can be selected for power measurement only and the software will use the same power settings in the case of single shot energy measurements.

Area – The area sheet allows the user to chose whether displaying the values of the measured function in absolute values (e.g in case of power in Watt related units) or in density values (e.g. in case of power density in W/cm^2) by entering the area parameters associated to the laser beam section intercepted by the sensor head. By clicking on the rectangular box at the right hand side of "*Shape"* a dialogue box appears showing three possible choices referred to the laser beam shape: None, Circular, Rectangular.
By choosing None the displayed data show the absolute function value (e.g. power values are displayed in Watt related units), and no further actions are needed; by choosing circular the beam diameter in millimetres must be entered. By clicking on the window at the right hand side of "*Diameter"* the digital keyboard pops up and the actual laser beam diameter in millimetres shall be entered. The software calculates the beam area and displays its value in square centimetres at the right hand side of the notice "Area".
In a similar way the area parameters can be set for a rectangular shaped laser beam.

To enter the changes and exit all pages of **MEASURE** key click on "OK" button at the lower right corner of the display. To exit a page without entering any change click on "Cancel" button at the lower right corner of the display.

7. Display Mode Menu (MODE key)

MODE key allows the user to select one out of four modes to display the measured power data i.e: Digital mode, Trend mode, Analogue/Tuning mode, Histogram mode.
When measuring single shot energy the measured data representation is a Histogram like display mode only.
The mode displayed on the screen at the first head connection to leonardo is the Digital mode as per factory setting; in the case the head has already been connected to leonardo, the displed mode is the one used in the last measurement run.
To change measurement display mode just click on **MODE** key and repeat this action until your desired mode is displayed.
A series of additional functional keys placed just on top of the main five keys: From right to left: **λ=….. (wavelength setting), Statistics, Gains, Extra** complete the functional features of measurement planning, running and managing . The use and setting of these functional keys are described in Chapter 8.

Digital mode –This display mode shows the instantaneous value of the measured power in form of a large sized number shown as per the selected resolution of decimal digits; this display mode features also a coloured bar representing the measured value as a proportional fraction of the sensor head full scale or of the modified scale set by the user (refer to the paragraph **Scale setting** further ahead in this chapter).
Statistical information about all the measured samples is also given in the lower half of the display (an example of digital display mode is given in Fig. 3).

Trend mode – This display mode shows a graph describing the measured values of power (Y axis) as a function of time (X axis) and the instantaneous value of the measured function in form of a number at the upper left hand side of the display.
In this mode, the trace shown on the display starts to scroll when it reaches the X axis full scale limit in the case the set time full scale is lower than or equal to 60 seconds; for full scale settings longer than 60 seconds

the displayed trace does not scroll, and the display content is refreshed when the elapsed time reaches the full scale value. In both cases the data collection goes on and all data are recorded and can be downloaded and saved following the procedures described in Chapter 9 of this manual.
Statistical information concerning all the measured samples is also given in the upper part of the display, just above the graph upper border (refer to the example in Fig. 6).

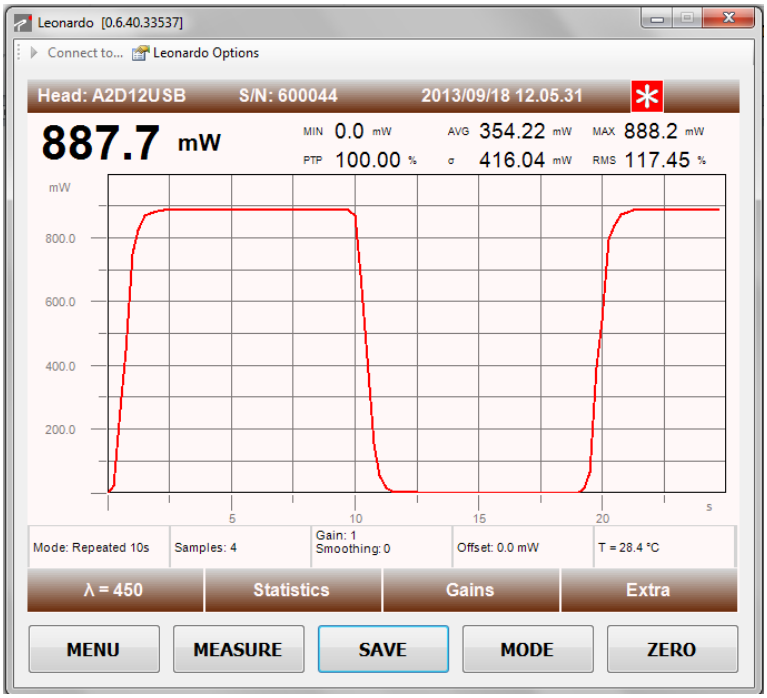

Fig. 6 Trend Display Mode

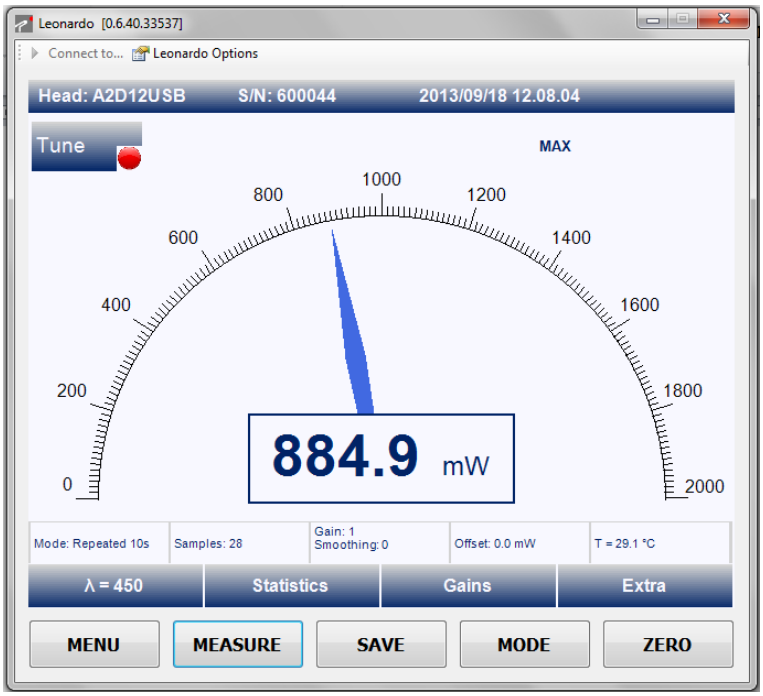

Fig. 7 Analogue Display Mode

Analogue/Tuning mode – This display mode shows the instantaneous value of the measured power indicated by a needle-like representation and in form of a number placed at the rotation centre of the needle. No statistical information is displayed in this mode (Fig. 7).

This measurement data representation mode is generally preferred in complex laser and optical chain alignment, where the alignment optimisation is normally carried out by a technique of active alignment based on many trials. To help the users working in these specific applications, LaserPoint introduced in this mode also a "tuning" option described in the following lines.
By clicking on the **Tune** button placed in the upper left hand side of the display, the analogue representation of the measured power changes into a tuning tool that enhances the needle dynamics and makes it more sensitive to the power value change. The absolute scale converts into a relative scale spanning from -25% to +25% of the (zero) measured value at the time of the tuning function activation. The maximum value achieved during the tuning run, is shown in a small window in the upper right corner of the display. (refer to Fig. 8).
When the display is in tuning mode, the user can update the meter centre value by clicking on the reset button and aligning it to a new (presumably improved) power maximum value and this operation can be repeated many times in order to chase, step by step the optimum alignment conditions.
The small dot at the lower right corner of the tune button is red when the tuning option is off and green when it is on (refer to Fig. 7 and 8).

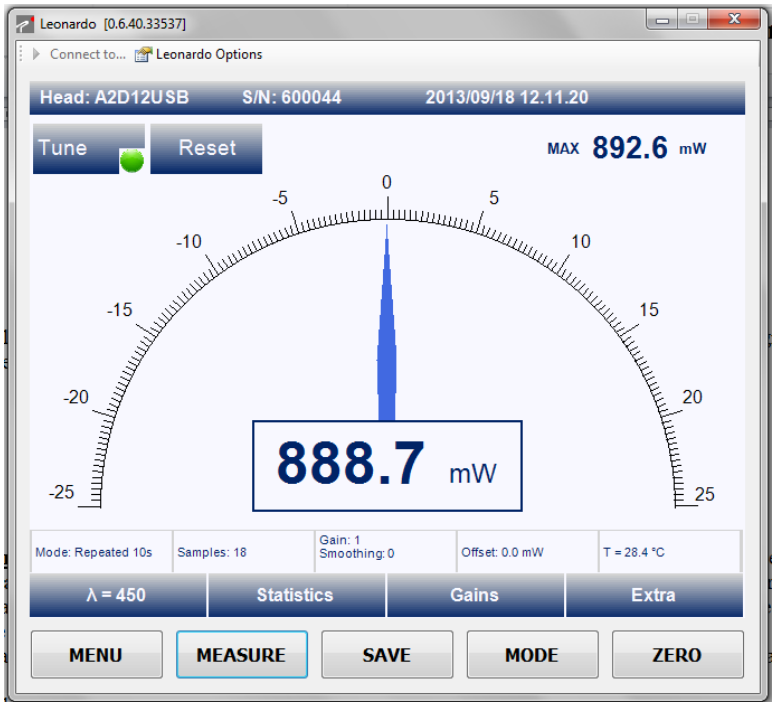

Fig. 8 Tuning Display Mode

Histogram mode – This display mode shows the historical collection of all measured samples represented in a typical histogram format with the measured power values shown in the X axis and the number of counts in the Y axis; the instantaneous value of the measured power in shown in numerical form at the upper left hand side of the display.
As long as the count of samples reaches the upper graph limit the vertical scale is automatically adjusted to allow the display to add more measured data.
Meaningful statistical information about all the measured samples is reported in the upper part of the display (see Fig. 9).

This measurement data display mode is particularly useful to analyse the power stability of a laser beam.

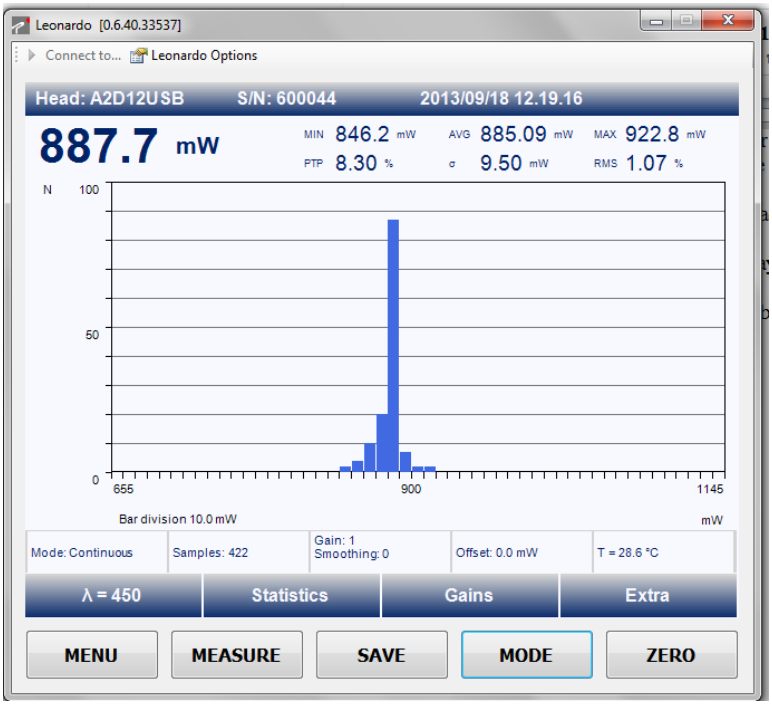

Fig. 9 Histogram Display Mode

Scale setting - The initial scale setting of all display modes is automatic according to the sensor head type full scale or can be set to 10% of full scale as per the option described in Chapter 5.
Custom scale limits may be needed for specific reading or analysis purposes, and this can easily be done by setting the new upper and lower scale limits.

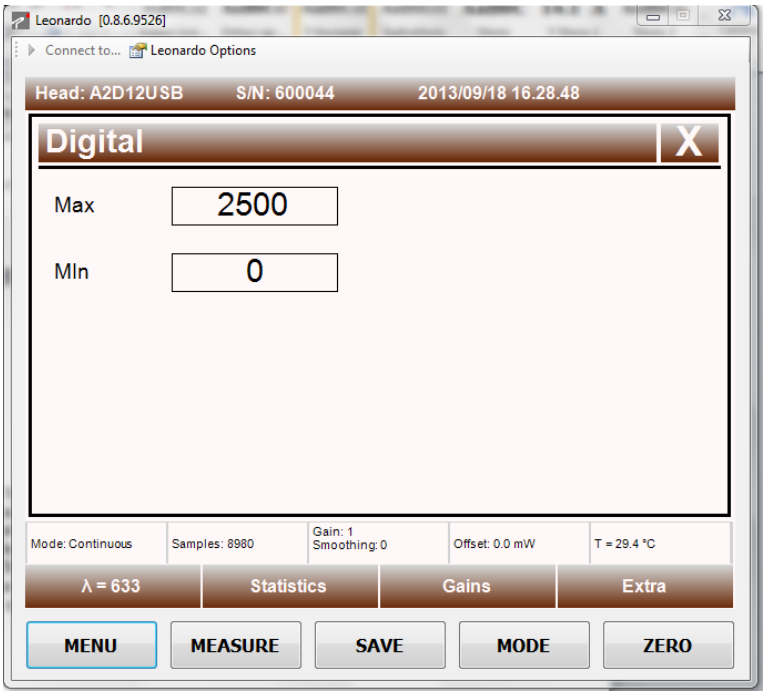

Fig. 10 Scale setting page

Changing the scale values of the chosen display mode can be easily achieved by clicking on any point of the axis whose scale has to be modified; soon the scale setting page appears and two small rectangular boxes show the present lower and upper scale values (Fig. 10). By clicking on one of the two windows, a digital keyboard pops up allowing the user to generate a new value of the chosen limit and to enter it by clicking on the keyboard "OK" button. If needed, this procedure can be repeated to change the value of the other scale limit.
Now the scale setting page shows the newly set value(s) and to return to the data display mode just click on the "X" located at the upper right corner of the page. The selected data display mode shows now the newly set scale value(s).
Histogram, Digital, Single shot energy and Analogue/Tuning display modes have just one scale to set; there is no scale re-setting possibility when the instrument is operated in Tuning mode because its scale has a pre-set range spanning from -25% to +25% of the mean value.

Trend mode features a scale (Fig. 11) with two axis, where Y axis refers to the measured function values and X axis refers to time. In this case both X and Y axis values can be re-set according to the described procedure. The only difference is that by clicking on one of the two scale axis on the trend graph, the scale setting page shows two more windows to enable also the re-setting of time upper limit (minimum time value is always zero) and time measurement units (the choice is among seconds, minutes and hours).

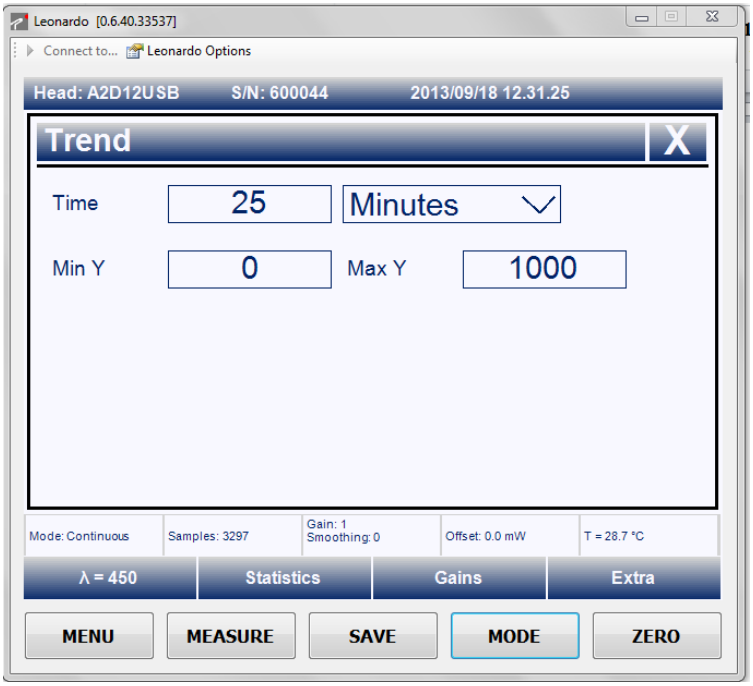

Fig. 11 Scale setting page for Trend display mode

In order to increase the measurement data analysis flexibility and maintain differentiated data representations in different display modes, the newly set scale value(s) in one display mode does not affect the setting of the other display modes, (e.g a full scale view in Trend mode and a narrow window scale view in Histogram mode may be selected to enhance the analysis sensitivity of a laser beam power stability).

Single shot energy mode – This measurement function can only be used with thermal heads enabled to measure the energy of a single laser pulse; the concept of single laser pulse is valid also for repeated pulses with a low enough repetition rate allowing the thermal head to recover its zero state and clearly detect two adjacent pulses without interference between them.

In order to avoid measurement errors or data misinterpretation, resetting the head (for head resetting refer to Chapter 10 of this manual) before starting any pulse energy measurement action is strongly recommended.
After selecting this measurement function as described in Chapter 8, click on "OK" button at the right lower hand side of the display to make the single shot energy display mode screen appear. This page shows a histogram-like graph where the energy of each laser pulse is represented as a vertical bar and the last measured energy value is also shown in digits at the upper left corner of the display. The measured energy value is expressed in units according to the head full scale settings. The statistical information about the measured data is shown in the upper part of the display.
A coloured spot showing three possible head/measurement states is also shown in the upper part of the display placed just at the right hand side of the last energy value; the meaning of these coloured spots are addressed in the following lines of this paragraph.
When the spot is green the head is ready for a new measurement; soon after the sensor is hit by a laser pulse, the spot colour converts to yellow and then to red. The yellow colour indicates the laser pulse has been detected by the head and the software has started the pulse peak search. The red spot indicates the measurement is over. The head is ready for another measurement when the spot goes back to green again.
The energy of a single laser pulse is more complicated to measure than power, so its measurement requires some additional settings like the definition of a signal threshold and a head inhibition time in order to get a meaningful, noise free pulse peak detection. These two parameters are pre-set and their values are stored in the head EEPROM; however, in certain cases, it might be required to change the pre-set values to increase the measurement signal to noise ratio and sensitivity.
The setting of threshold and inhibition time shall be done by expert users only as these parameters can introduce improvements, but also alterations to the measurement results.

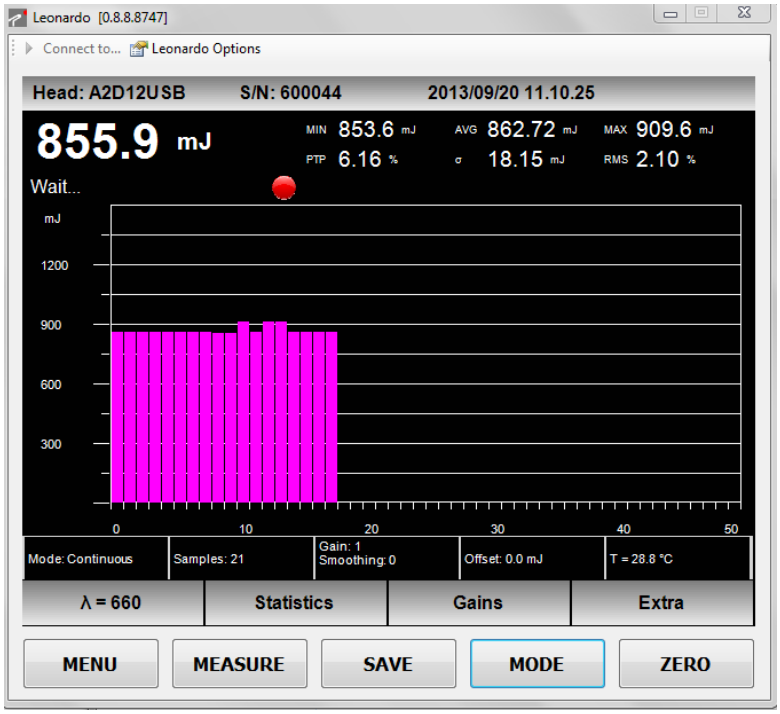

Fig. 12 Display mode of energy measurements of single laser pulses

Threshold and inhibition time setting can be done by entering the scale setting page.
To enter this page click on one of the two axis on the graph shown on the display; when the scale setting page opens, the setting of the scale, threshold and inhibition time can be done in a similar way as previously described in the paragraph **Scale settings** for any other measurement display mode.

8. Additional functions keys

Each representation mode features also a series of additional functional keys placed just on top of the main five keys: From left to right: "λ =……" **(wavelength setting), Statistics, Gains, Extra**. The use and setting of these functions is described in the following lines.

Wavelength setting - "λ =……" This function key is active in all display modes.
In general detectors feature different sensitivity values at different wavelengths depending on the detector nature (this is especially important for those based on semiconductor devices), so it is important to account for the sensor wavelength dependent sensitivity when measuring power and energy values.
The procedure of wavelength setting may differ between thermopile and photodiode sensor heads.

Thermal sensor heads: all LaserPoint sensor thermal heads are calibrated at 50% of its rated power/energy full scale at least at one specified wavelength and can optionally be calibrated up to 16 wavelengths; this information is stored in the EEPROM of the head USB interface. Furthermore LaserPoint thermal heads are characterised also over a broader wavelength range at low optical power; this range spans from 200nm to 2100nm and the measured sensitivity spectrum is loaded too into the head EEPROM as a table of discrete wavelength dependent sensitivity values that are used by *leonardo* software to calculate by interpolation the sensor head sensitivity at any other specific wavelength between 200nm and 2100nm.
Upon clicking on the wavelength selection window placed in the left lower part of the screen in every display mode, the wavelength setting page (shown in Fig. 12) appears on the screen, showing the table of pre-set wavelengths stored in the EEPROM of the sensor head. Any wavelength of the list can be selected by clicking on the rectangular box showing the desired wavelength. Should the sensor head be used at a wavelength of 200-2100nm range that does not appear in the list, *leonardo* software helps computing the sensor sensitivity at the desired wavelength by an interpolation algorithm.

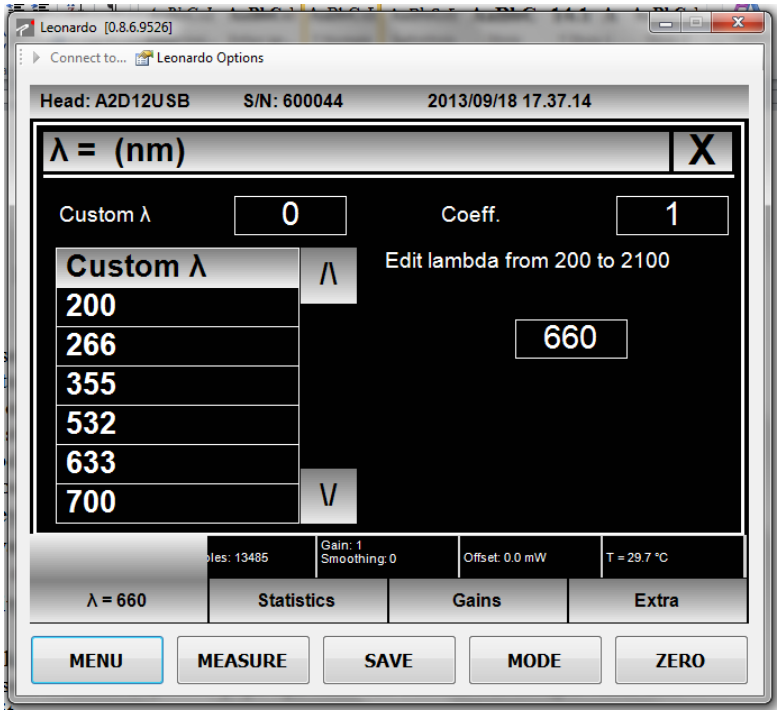

Fig. 12 Wavelength setting page

In such a case click on the small box placed below the notice "Edit lambda from 200 to 2100" and enter the desired wavelength in nanometer units in the box by the digital keyboard that pops up upon clicking on the box. Save the new wavelength setting by clicking on the keyboard "OK" button.
leonardo can take into account also custom wavelengths falling outside the stored wavelength range, however in such a case, the sensitivity coefficient of the sensor at the desired wavelength has to be known; ask LaserPoint for assistance.
To enter a custom wavelength, click first on "Custom λ" box at the top of the pre-set wavelength list that normally contains a 0 (zero); the usual numeric keyboard pops up, write the custom wavelength value and then click the "OK" button to enter it; the newly set wavelength value in nanometer units will be shown in the small box at the right of the notice "Custom λ".
In a similar way the coefficient value that can be provided by LaserPoint upon request, has to be entered in the small rectangular box at the right hand side of "Coeff." that normally contains a 1 (one) as can be seen in Fig. 12.
To exit the Wavelength setting page click on the "X" symbol at the upper right corner of the page.

Photodiode heads: in similar way the wavelength dependent sensitivity of photodiode sensor heads is stored in the sensor head EEPROM in form of a table, and due to the intrinsic characteristics of these sensors, the wavelength dependent sensitivity curve is described by a much higher number of discrete values. Upon opening the wavelength setting page at least one wavelength (in general the wavelength requested by the customer for a specific application) is shown in the top box of left hand side column of rectangular boxes; the specified detector range limits are shown in the notice "Edit from ***A*** to ***Z***" where **A** and ***Z*** are the lower and upper limits of the sensor head operating wavelength range; such wavelength range strongly depends on the photodiode material.
To enter another wavelength within the specified head operating range click on the small box just below the notice "Edit from ***A*** to ***Z***" and enter the desired wavelength value in nanometer units by means of the digital keyboard. Upon clicking "OK" the selected wavelength value is shown in the left hand side column of rectangular boxes, below the already present values; any selected wavelength will be sequentially added in the remaining free boxes up to six different wavelength values. If the number of used wavelengths are more than six, the column of rectangular boxes will show the last six used wavelengths.
The introduction of a custom wavelength outside the specified range can be done with the same procedure described for thermal sensor heads, even though this possibility should be taken into consideration only for wavelength values not too far from the specified wavelength range boundaries due to the relevant sensitivity cut off exhibited by semiconductor devices outside the specified operating range.
To exit the Wavelength setting page click on the "X" symbol at the upper right corner of the page.

Statistics setting - **Statistics** key (the second one from the left hand side) enables the setting of statistical elaboration of the measured data. The statistics page shows two rectangular small windows placed on the right hand side of the main frame; to select the mode of statistical elaboration click on the upper window and click then on the lower one to reset of statistics data. By clicking on the upper small windows, a dialogue box pops up showing four options for the statistical collection mode and elaboration of data (as shown in Fig. 13).
The options are:

- Off: no statistics.
- Continuous: the data elaboration is made on a continuous data collection basis.
- Repeated: the data are repeatedly collected and elaborated within a user's defined time period.
- Single: the data are collected and elaborated once only within a user's defined time period.

When clicking on "Off" or "Continuous" options, the user needs to enter no more instructions; the mode is set upon exiting the page by clicking on the "X" symbol at the upper right corner of the page.
When clicking on "Repeated" or "Single" the user needs to define the time period that limits the statistical data collection and elaboration, so another page opens, showing three small rectangular box alternative options to define a time period measured in hours, in minutes or in seconds (refer to Fig 14). Once a small box for time interval setting has been selected by clicking on it, a numeric keyboard to generate the desired time entity pops up.

To enter the newly generated time entity and start the statistics data collection click on the button “Reset”.

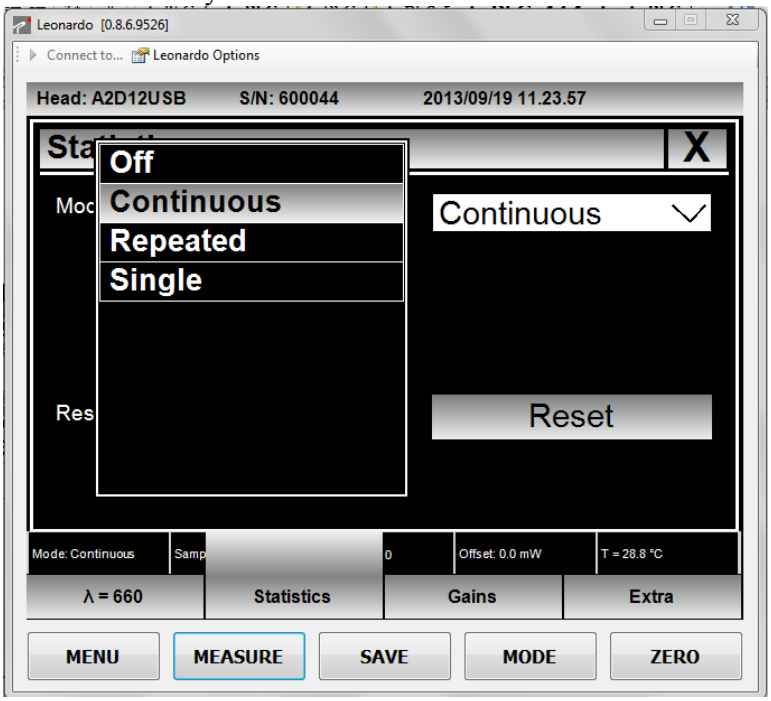

Fig. 13 Statistics page

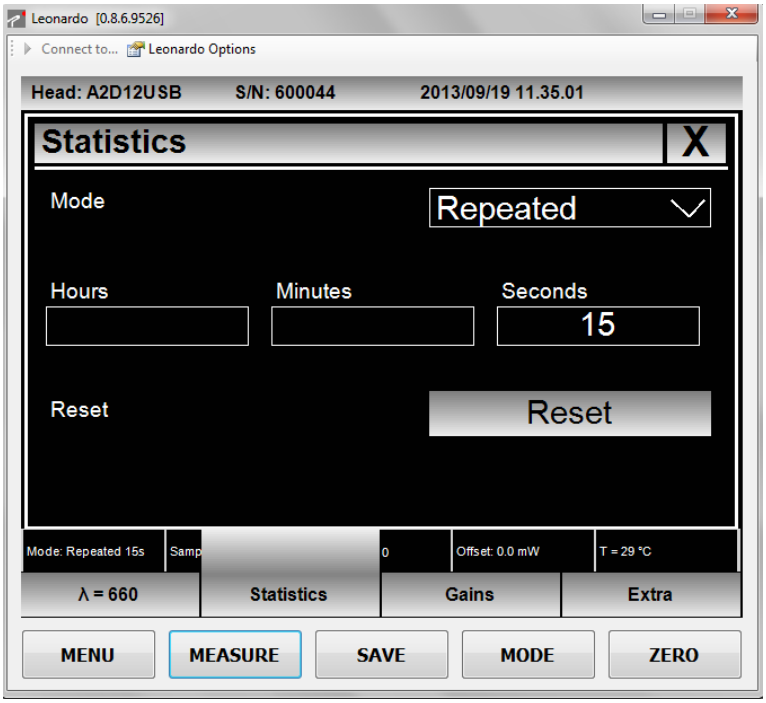

Fig. 14 Statistics page for a single or a repeated period of data collection

Gains settings- **Gains** key, third from the left hand side, enables the change of the head electronics gain (factory setting =1), smoothing and acceleration factors. To open this page (Fig. 15) click on Gains button.

The **Gain** factor is a useful tool especially when measurements are taken in complex optical systems.

Typically this tool is particularly useful when it is desired to normalise a measurement or when the measurement is taken out of a complex optical systems and a beam splitter is used to extract part of the optical signal; in most cases the beam splitter has two output optical ports with significantly different splitting ratios to allow the laser beam to exit the main port of this device almost unaltered and enabling the monitoring of the beam properties by analysing only a small fraction at the output of the monitoring port.
If the power meter is placed on the monitoring port, the user can set a gain factor to take into account the optical splitting ratio of the beam splitter and adjust the Gain parameter to make the PC screen show a power reading as though the sensor head were placed directly at the main output port.

The **Smoothing** parameter is related to the response time change of the head aginst measured power. This function is a low-pass filter that allows to introduce a time constant to the head signal to help smoothing the signal fluctuations in the case the head responds too quickly, thus improving the head signal stability and signal to noise ratio. This function is essentially useful when using thermal heads, that have intrinsic long response times, and are therefore suitable to measure average power levels. In general the optimum smoothing factor has to be determined experimentally.

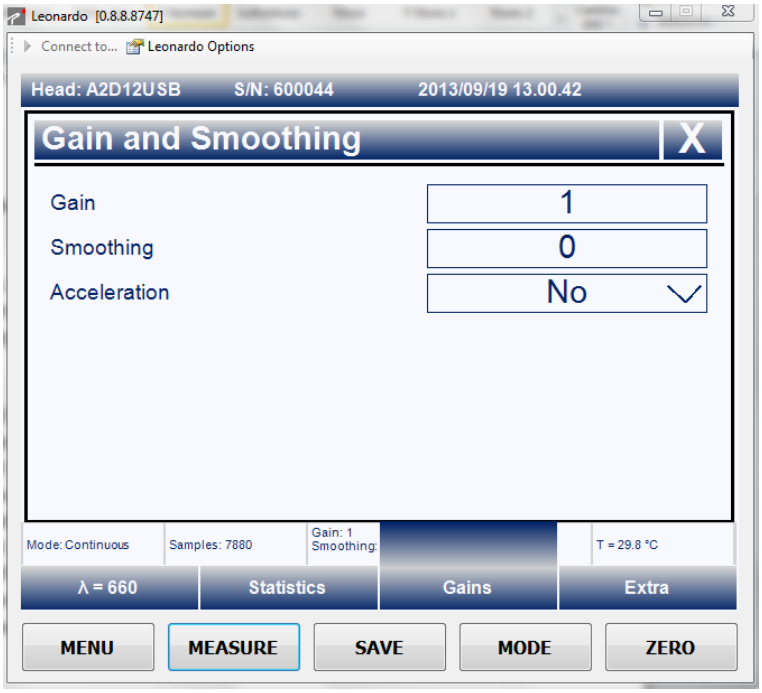

Fig. 16 Gain and Smoothing Page

The **Acceleration** option activate an acceleration algorithm that is particularly useful to speed up the thermopile sensor head measurement response and for this type of heads is normally on. To activate or de-activate this feature, click on the box at the right hand side of the screen and select **Yes** or **No.**

When clicking on the Gains key, the Gain and Smoothing page opens; both Gain and Smoothing small windows activate the usual digital keyboard pop-up to enable the user to enter the new figures. Once the new value has been set, click on the "OK" button to enter it. To exit the Gain and Smoothing page click on the "X" symbol at the upper right corner of the page.

Important notice: It is advisable that Gain, Smoothing functions are used by expert users only as their settings require some experimental skill and the entered values need to be sensibly set, not to alter the measured data.
Extra- The fourth function key, enables the user and LaserPoint service engineer to access information and tools regarding the sensor head electronics.
After clicking on this display key, the Extra page opens providing access to three sheets: Info, Calibration, LaserPoint.

- **Info**: this sheet appears automatically after clicking on the Extra key and provides information about the head HW and FW versions and the suggested next calibration date.
- **Calibration:** this sheet is currently not available to users.
- **LaserPoint**: the access to this sheet is protected by password and is exclusively reserved to LaserPoint engineering.

To exit the Extra page click on the "X" symbol at the upper right corner of the page.

9. Data Saving Function (SAVE key)

This key allows to save the measured data and to define the data logging mode through three available saving mode options: Snapshot, Timed and Quick.

Important notice

First step: generate and name a **main folder** to save and store the measured data and related statistics by means of Leonardo Options (as shown in Chapter 3 of this manual) before using **SAVE** key. The main folder can be freely named according to user's preference.
Second step: select a statistics mode by means of **Statistics** key as already described in Chapter 8 of this manual.

SAVE key has two functions: the first one is the freezing of the display content (display graph and figures) and this is accomplished by clicking on the key once; the second one is the planning the data collection and the saving mode by accessing the **Data Collection** page after clicking on **SAVE** key a second time.

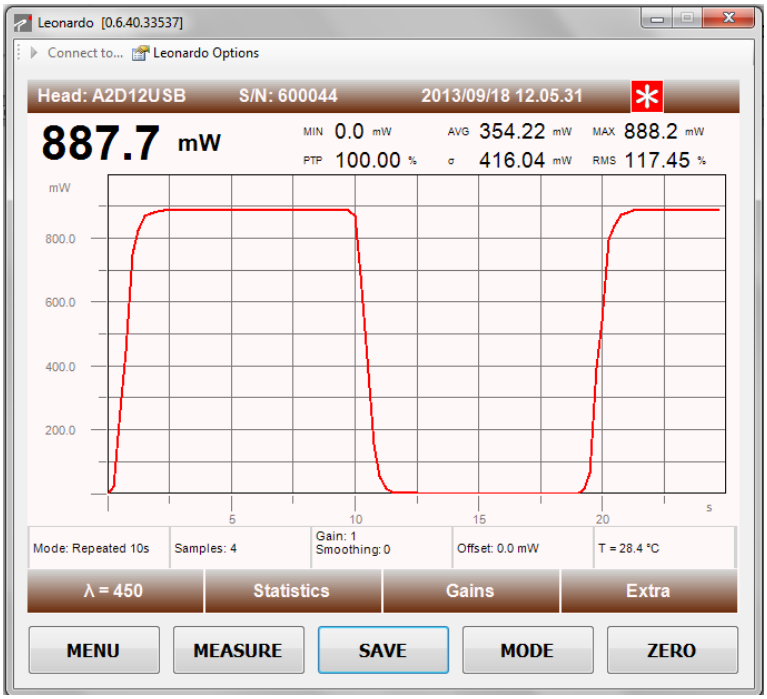

Fig. 17 Frozen measurement display

Snapshot mode - This mode allows to save the screen content, and/or the last value of the measured function and/or the relative statistics collected according to the selected statistics mode (see Statistics Setting paragraph).

Click on **SAVE** key to freeze the screen content (display graph and measurement data); a snow flake icon with a red background appears on the right hand side of the top display bar (see Fig 17) to show the measurement data collection has been stopped. Click a second time on **SAVE** key to access **Data Collection** page (Fig.18); Click on "Snapshot" to select this mode and click on the small rectangular box(es) at the right hand side of the labels "Screen Print" and/or "Current Value" and/or "Current Statistics" to select which of them have to be saved; upon clicking on a box an "OK" appears in the touched box. Once all choices have been entered, click on the lower "OK" screen button to save the selected data and/or screen content; the snow flake icon background is now converted to green.
The data information is saved in a folder hosted in the previously created **main folder** by means of Leonardo Options; this folder may contain up to three different files: one for the screen print and two for the measured and statistics data, depending on which ones were selected.

Folder and files are named according to the following formats:

Folder → year_month_day

Image file → snap_hh_mm_ss. Jpg
Last Value file → snap_data.csv
Statistics file → snap_stats.csv

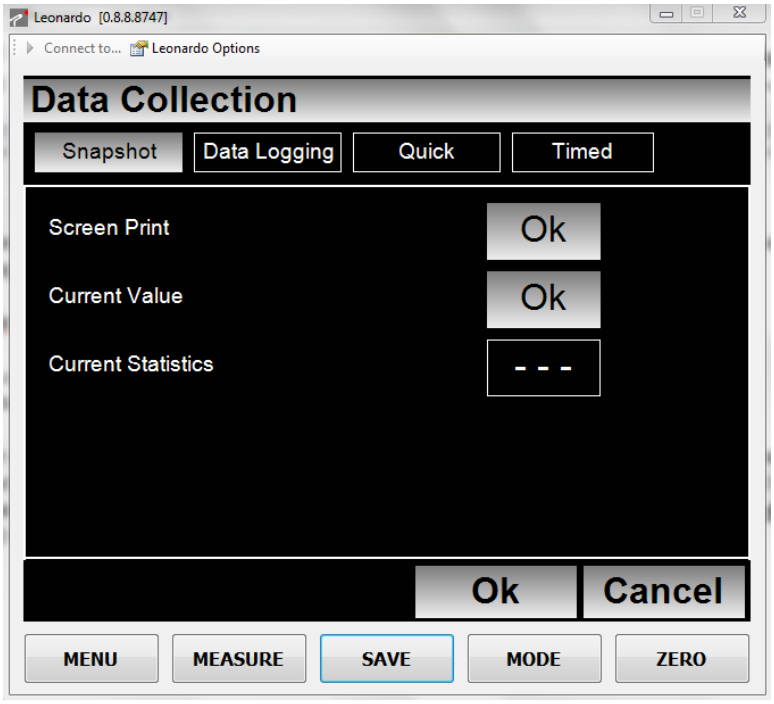

Fig. 18 Snapshot mode data collection and saving page

After completion of each saving sessions, return to measurement display mode by clicking on **MEASURE** key.

All data saved within the same day are loaded into the same folder; each screen print have its individual file. All "Last Values" data are loaded in one single file (snap_data.csv), adding them to the previously loaded data and ordered according to a table whose column headers are shown in Table 1.
Statistics data are also loaded in one single file (snap_stats.csv), as shown in table 2; the headers of both files "snap_data.csv" and "snap_stats.csv" are placed on two different levels to ease the file reading. The upper level reports the data that do not change during the measurementthe data under these headers are

Data and Statistics file formats – All data saved within the same day are loaded into the same folder; each screen print have its individual file. The measurement data are all loaded in one single file (snap_data.csv), adding them to the previously loaded data and ordered according to a table whose column headers are shown in Table 1. Similarly the statistics data are also all loaded in one single file (snap_stats.csv) and ordered according to a table whose column headers are shown in Table 2.
Also the measurement and statistics data saving files pertaining to the other two saving modes, described in the following paragraphs of this chapter, keep this format.

Head	Head S/N	Wavelength (nm)	Gain	Smoothing	Offset	Temperature

Date	Time	Value	M.U.

Table 1. Headers of snap_data.csv file

Head	Head S/N	Wavelength (nm)	Gain	Smoothing	Offset	Statistics mode

Date	Time	MIN	M.U.	MAX	M.U.	AVG	M.U.	PTP	M.U.	STD	M.U.	RMS	M.U.

Table 2. Headers of snap_stats.csv file

Timed mode - This mode allows to save the measured values, and/or the current set statistics values by defining the measurement session time (in hours, minutes and seconds) and the sample rate (in seconds).
Currently the measurement time can be selected between a minimum of 1s and a maximum limit of 23h 59m 59s and the sample rate can be set to any integer value between 1s and 300s.
Similarly to the previously described **Snapshot mode**, also in this mode the user can decide to save the measured values, and/or the planned set statistics values provided the statistics collection mode was previously set (see Statistics Setting paragraph).
Whatever is the measurement display mode in use before **Timed mode** was selected, the measurement display mode is automatically converted into **Trend mode** and the selected measurement time is set as the time axis full scale.

Timed mode setting page is shown in Fig. 19; when one of the small rectangular boxes pertaining to the labels "Hours", "Minutes", "Seconds" and "Sample rate" is clicked, the usual digital keyboard pops up to enable the setting of the desired time figure. Currently in the Hours box time can be set between 0 and 23, in the Minutes and Seconds boxes time can be set between 0 and 59. Sample rate box can be filled with any integer number between 1 and 300.

The selection of the "to be saved" data is achieved by clicking on "Screen print", "Values" and "Current statistics" boxes as previously described for **Snapshot mode**. Upon completion of time settings and data selection, click on the lower "OK" button and the measurement session will start and **Trend mode** will be

shown on the PC screen; the snow flake icon then converts into a floppy disk icon until the planned measurement session is over. At the end of the measurement session the a snow flake icon with a green background appears replacing the floppy disk icon, thus indicating that all data have been transferred to the created folder.

The transferred information is saved in a folder containing two different files. Folder and files are named according to the following formats:

Folder → year_month_day
Image file → snap_hh_mm_ss. Jpg
Value file → log_data.csv
Statistics file → log_stats.csv

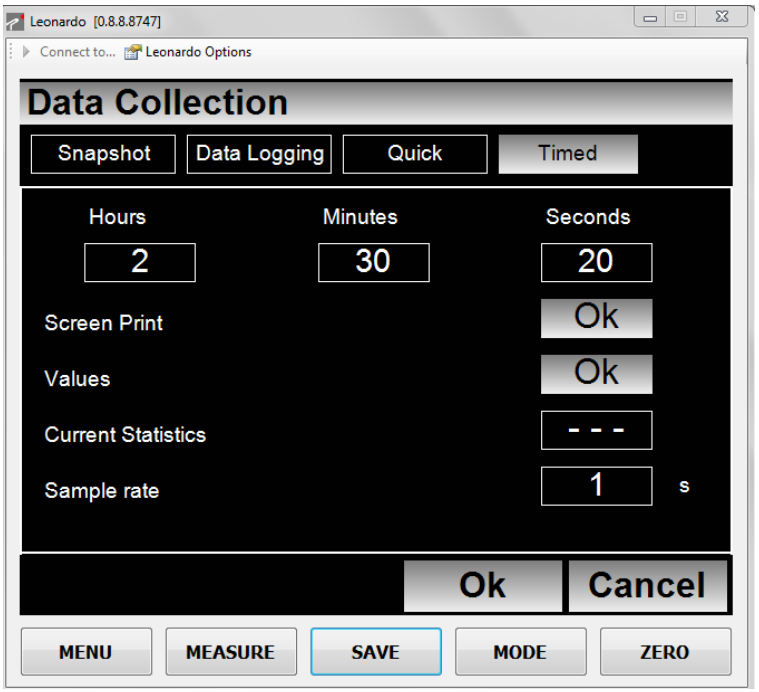

Fig. 19 Timed mode data collection and saving page

All data saved within the same day are loaded into the same folder and all saved values and statistics data are loaded in two files respectively named log_data.csv and log_stats.csv. In both files the data are added to previously loaded data and ordered in tables organised as already described for **Snapshot mode** and shown in table 1 and table 2.

Quick mode - This mode has been provided to help Manufacturing departments to save the testing data of moderately large lots of devices whose characterisation is simple and fast, but still mostly manual. This mode allows to save the measured values, and/or the current set statistics values ordered in a .csv file that can easily be associated to a file containing the S/Ns of the tested devices generated and organised in the same order of testing, to help producing a manufacturing lot test sheet. Before using **Quick** data collection/saving mode, the Continuous statistics collection setting must be selected (see Statistics Setting paragraph).
Similarly to the previous described modes, also in this mode the user can decide to save the measured values, and/or the planned set statistics values. **Quick mode** can be used with all measurement display modes except Tuning mode. **Quick mode** setting page is shown in Fig. 20; after entering this page by double clicking on

SAVE key, simply click on the desired small box placed aside of "Values" and/or "Current statistics" to select the desire data collection and saving, then click on the "OK" button to return to the measurement display mode and an USB key icon with a red background appears on the right hand side of the top display bar to show the measurement set up is ready to collect the measurement data. When the first device under test is ready, click once on **SAVE** key and the selected measurement data are collected and saved. Place another device in the test bench and repeat the measurement data collection by clicking once again on **SAVE** key. After the test of the last device of the lot has been completed, click on MEASURE key to exit **Quick mode.**
The collected information is saved in a folder containing two different files. Folder and files are named according to the following formats:

Folder → year_month_day
Value file → quick_data.csv
Statistics file → quick_stats.csv

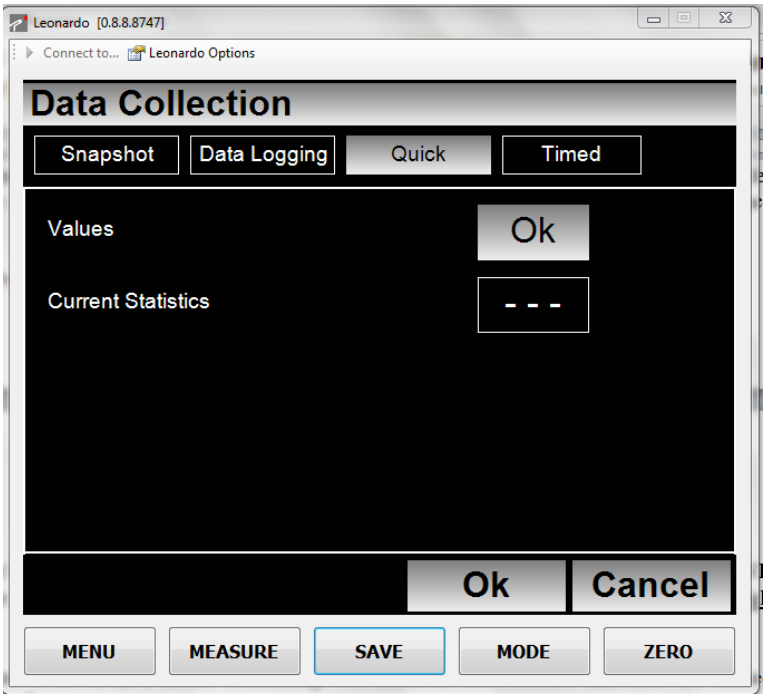

Fig. 19 Quick mode data collection and saving page

All data saved within the same day are loaded into the same folder and all saved values and statistics data are loaded in two files respectively named quick_data.csv and quick_stats.csv. In both files the data are added to previously loaded data and ordered in tables organised with the same format described for **Snapshot mode** and shown in table 1 and table 2. If more than one device lots are tested within the same day, it is advisable to rename each test file upon completion of the lot testing in order to avoid the addition of other lots data to the same day file and consequent possible problems of properly matching device S/Ns with the right device test data.

10. Re-setting Menu (ZERO key)

ZERO key enables to define the optical zero of the sensor head and the electrical zero by resetting the head electronics ADC.

IMPORTANT Before starting both optical and electrical zeroing procedures, take care to ensure the sensor head is properly insulated from any type of radiation in order to avoid introducing any unwanted offset.

Click once on **ZERO** key to define and memorize the head optical zero. If the head is completely blind when the zeroing occurs the offset value equals to zero or is comparable to the head noise level. If intentionally or unintentionally the zeroing of the head has been carried out in presence of an optical signal (e.g. ambient light) the actual offset value is shown in the Offset window on the right lower part of the display (just above the **Gains** key) whatever the measurement display mode is in use.

Clicking on **ZERO** key a second time restores the previous zero conditions.

To electrically reset the head electronics click on and hold **ZERO** key pressed few seconds until the dialogue window with the question "Do you really want to reset ADC?" is displayed. Choose "OK" to start or "Cancel" not to change the current instrument zero conditions. The electrical resetting of the head electronics ADC that takes few seconds.

IMPORTANT Before starting an electrical resetting sequence, ensure the sensor head is in thermal equilibrium with the environment and properly blinded (especially important for high sensitivity heads). Ensure that no laser radiation accidentally hits the sensor not to introduce an unwanted offset level.

11. Alarms

leonardo graphic interface can display three types of alarms: calibration overdue alarm, no head alarm, head excess temperature alarm (only for the thermal heads equipped with a thermistor), measurement overflow alarm. In the two former cases the user is warned by a screen message that fills the display and remains up until the cause of the alarm has been removed. In the latter case a small icon appears in the rectangular window showing the Gain and Smoothing values

Calibration overdue alarm: In the case the head recommended calibration date has been overcome a large calibration reminder appears right in the centre of the window showing the calibration deadline upon *leonardo* loading.

NO head alarm: This alarm appears on the screen when the head is being disconnected after launching *leonardo*.

Temperature Alarm (thermopiles only): This alarm appears when the thermopile sensor head temperature exceeds its specified safety limit (typically 80°C).

Overflow Alarm: This alarm appears when the signal detected by the instrument exceeds the instantaneous maximum power the sensor head can bear.

12. Specifications

■ System Requirements:
- CPU 1.2 GHz (x86 or x64-bit); 10 MB hard-disk space; 1 GB RAM; 1024x600 minimum display resolution
- Operative System: Win XP (service pack 3), Vista or Windows 7

■ Compatible Heads
- All LaserPoint PC-Plug heads with USB-SWL electronics interface

■ Measurement Features & Analysis
- Power Measurement and Display in linear units (W and related units) or logarithmic units (dBm)
- Energy Measurement and Display in linear units (J and fractional related units)
- Measurement resolution: 1/50,000 full scale
- Visual resolution: 3,4 or 5 digits (custom settable)
- Instrument Accuracy: ±1.0%
- Sampling Frequency: 1kHz
- Elaboration frequency: 64Hz
- Power measurement representation Modes: Digital, Trend, Analogue with Tuning Function, Histogram
- Energy measurement representation Mode: Histogram like

■ Statistical Functions
- Full Statistics (Min., Max., Mean, RMS, Std. Dev., Peak-to-Peak).
- Programmable data collection modes

■ Additional Functions and Information
- Wavelength selection with 1nm pitch over 200nm to 2100nm
- Area function for Radiance (W/cm2) and Fluence (J/cm2) measurements
- Gain settable by User to compensate the beam splitting ratio or to normalise the measurement data
- Smoothing Function for head time response optimisation
- Programmable Measurement Data Saving
- Head Temperature indication
- Next Calibration date indication
- Date and time indication