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Operation Manual

Thorlabs Instrumentation

Optical Power and Energy Meter

PM100D



2011

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We aim to develop and produce the best solution for your application in the field of optical measurement technique. To help us to live up to your expectations and develop our products permanently we need your ideas and suggestions. Therefore, please let us know about possible criticism or ideas. We and our international partners are looking forward to hearing from you.

Thorlabs

This part of the instruction manual contains every specific information on the PM100D handheld optical power and energy meter. A general description is followed by explanations of how to operate the unit manually. You will also find information about a simple remote control of the unit.

☝Attention☝

This manual contains 'WARNINGS" and 'ATTENTION" labels in this form, to indicate danger for persons or possible damage to equipment.

Please read these advises carefully!

NOTE

This manual also contains 'NOTES" and 'HINTS" written in this form.

1 General Information

The PM100D Handheld Optical Power and Energy Meter is designed to measure the optical power of laser light or other monochromatic or near monochromatic light sources and the energy of pulsed light sources.
The space-saving, battery powered design and compatibility to all Thorlabs “C-Type” Photodiode, Thermal, Pyroelectric sensors, and custom Photodiode, Thermal and Pyroelectric detectors, combined with a fast USB device interface open a wide range of applications in Manufacturing, Quality Control, Quality Assurance, and R&D for stationary and field use.
The provided software, including drivers and applications for LabVIEW and C makes it easy to integrate the instrument in test and measurement systems.
A rechargeable lithium polymer battery allows long intervals between the charging cycles. The unit can be recharged with the supplied AC adapter or via USB connection to a PC or laptop.

1.1 Safety

☝ Attention ☝

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly.

The power meter PM100D must not be operated in explosion endangered environments!

Sensor, photodiode and control inputs and outputs must only be connected with duly shielded connection cables.

Only with written consent from Thorlabs may changes to single components be carried out or components not supplied by Thorlabs be used.

Do not remove covers!

Refer servicing to qualified personal!

☝ Attention ☝

Mobile telephones, cellular phones or other radio transmitters are not to be used within the range of three meters of this unit since the electromagnetic field intensity may then exceed the maximum allowed disturbance values according to IEC 61326-1.

This product has been tested and found to comply with the limits according to IEC 61326-1 for using connection cables shorter than 3 meters (9.8 feet).

☝ Attention ☝

The following statement applies to the products covered in this manual, unless otherwise specified herein. The statement for other products will appear in the accompanying documentation.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules and meets all requirements of the Canadian Interference-Causing Equipment Standard ICES-003 for digital apparatus. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- **Reorient or relocate the receiving antenna.**
- **Increase the separation between the equipment and receiver.**
- **Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.**
- **Consult the dealer or an experienced radio/T.V. technician for help.**

Thorlabs GmbH is not responsible for any radio television interference caused by modifications of this equipment or the substitution or attachment of connecting cables and equipment other than those specified by Thorlabs GmbH. The correction of interference caused by such unauthorized modification, substitution or attachment will be the responsibility of the user.

The use of shielded I/O cables is required when connecting this equipment to any and all optional peripheral or host devices. Failure to do so may violate FCC and ICES rules.

1.2 Ordering Codes and Accessories

Order Code	Description
PM100D	Handheld Power/Energy Meter Console

Photodiode Power Sensors:

Order Code	Type	Detector	Aperture mm	Wavelength nm	Power W
S120C	Compact Sensor	Si	∅ 9.5	400 - 1100	50n - 50m
S120VC	Compact Sensor	UV-Si	∅ 9.5	200 - 1100	50n - 50m
S121C	Compact Sensor	Si	∅ 9.5	400 - 1100	500n - 500m
S122C	Compact Sensor	Ge	∅ 9.5	700 - 1800	50n - 40m
S130C	Slim Sensor Dual Range	Si	∅ 9.5	400 - 1100	5n - 5m 500n - 500m
S130VC	Slim Sensor Dual Range	UV-Si	∅ 9.5	200 - 1100	5n - 5m 50n - 50m
S132C	Slim Sensor Dual Range	Ge	∅ 9.5	700 - 1800 1200 - 1800	5n - 5m 500n - 500m
S140C	Integr. Sphere (1”)	Si	∅ 5.0	350 - 1100	1µ - 500m
S144C	Integr. Sphere (1”)	InGaAs	∅ 5.0	800 - 1700	1µ - 500m
S142C	Integr. Sphere (2”)	Si	∅ 12	350 - 1100	10µ - 20
S145C	Integr. Sphere (2”)	InGaAs	∅ 12	800 - 1700	1µ - 3
S145C	Integr. Sphere (2”)	InGaAs	∅ 12	800 - 1700	10µ - 20
S150C	Fiber Head	Si	3.6 x 3.6	350 - 1100	100p - 5m
S151C	Fiber Head	Si	3.6 x 3.6	400 - 1100	1n - 20m
S154C	Fiber Head	InGaAs	∅ 2.0	700 - 1700	100p - 5m
S155C	Fiber Head	InGaAs	∅ 2.0	700 - 1700	1n – 20m

Thermal Power Sensors:

Order Code	Type	Aperture mm	Wavelength nm	Power W
S302C	Thermally Stabilized Thermal Absorber	∅ 12	190 - 25000	100µ - 2
S310C	Thermal Surface Absorber	∅ 20	190 - 25000	10m - 10
S314C	Thermal Surface Absorber	∅ 25	190 - 10600	10m - 60
S322C	Thermal Surface Absorber	∅ 25	190 - 10600	100m - 250
S350C	Thermal Surface Absorber Excimer Coating	∅ 40	190 - 1100 and 10600	10m - 60
S370C	Thermal Volume Absorber for high peak power lasers	∅ 25	400 - 5200	10m - 15

Pyroelectric Energy Sensors:

Order Code	**Type**	**Aperture** mm	**Wavelength** nm	**Energy** J
ES111C	Pyroelectric Sensor with broadband coating	∅ 11	185 - 25000	10µ - 150m
ES120C	Pyroelectric Sensor with broadband coating	∅ 20	185 - 25000	100µ - 500m
ES145C	Pyroelectric Sensor with broadband coating	∅ 45	185 - 25000	500µ - 2
ES220C	Pyroelectric Sensor with ceramic coating	∅ 20	185 - 25000	500µ - 3
ES245C	Pyroelectric Sensor with ceramic coating	∅ 45	185 - 25000	1m -15

Please visit our homepage http://www.thorlabs.com for various accessories like fiber adapters, posts and post-holders, data sheets and further information.

2 Getting Started

3 Unpacking

Inspect the shipping container for damage.

If the shipping container seems to be damaged, keep it until you have inspected the contents and you have inspected the PM100D mechanically and electrically.

Verify that you have received the following items within the hard-case:

1. PM100D power/energy meter console
2. 1GB SD memory card – installed in PM100D
3. Plug-In power supply with Interchangeable primary plug for USA, UK, Europe, and Australia
4. USB cable, type ‘A’ to ‘mini-B’
5. Quick-start guide
6. USB memory stick with instrument drivers, user application and operation manual
7. Certificate of Calibration

3.1 Preparation

Configure the plug-in power supply with the primary plug for your local power supply.

Connect a suitable power or energy sensor. The sensors have a self-fixing mechanism. To plug or unplug a sensor slightly press from both sides on the pins in the connector housing.
Turn the unit on by pressing the power button in the side panel.
After switching on the unit, the graphics display will show the device status and then jump to the last measurement screen before power down.
The PM100D is immediately ready to use after turning on.

3.2 Physical Overview

3.2.1 Front Panel



Navigation Keys ▼▲◀▶

Enter/Edit Key **OK**

Wavelength Key **λ**

Relative Meas. Key **Δ**

Backlight Key ☼

Figure 1 Physical Overview Front Panel

3.2.2 Side Panel

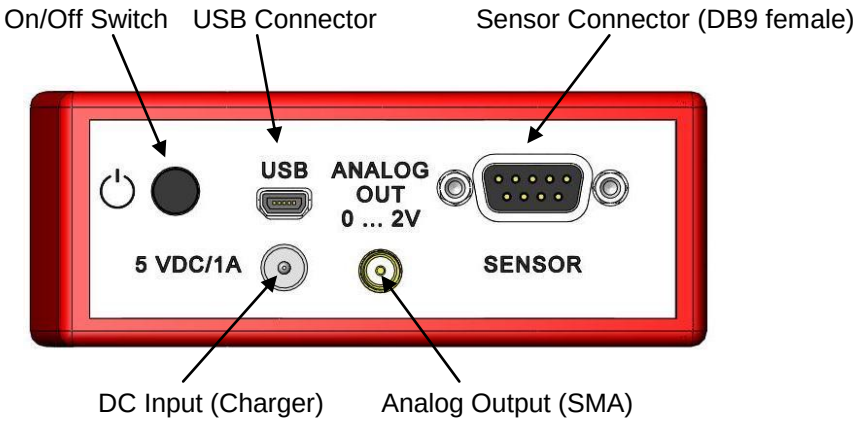


Figure 2 Physical Overview Side Panel

3.2.3 Bottom



Figure 3 Physical Overview Bottom View

3.2.4 Rear Panel

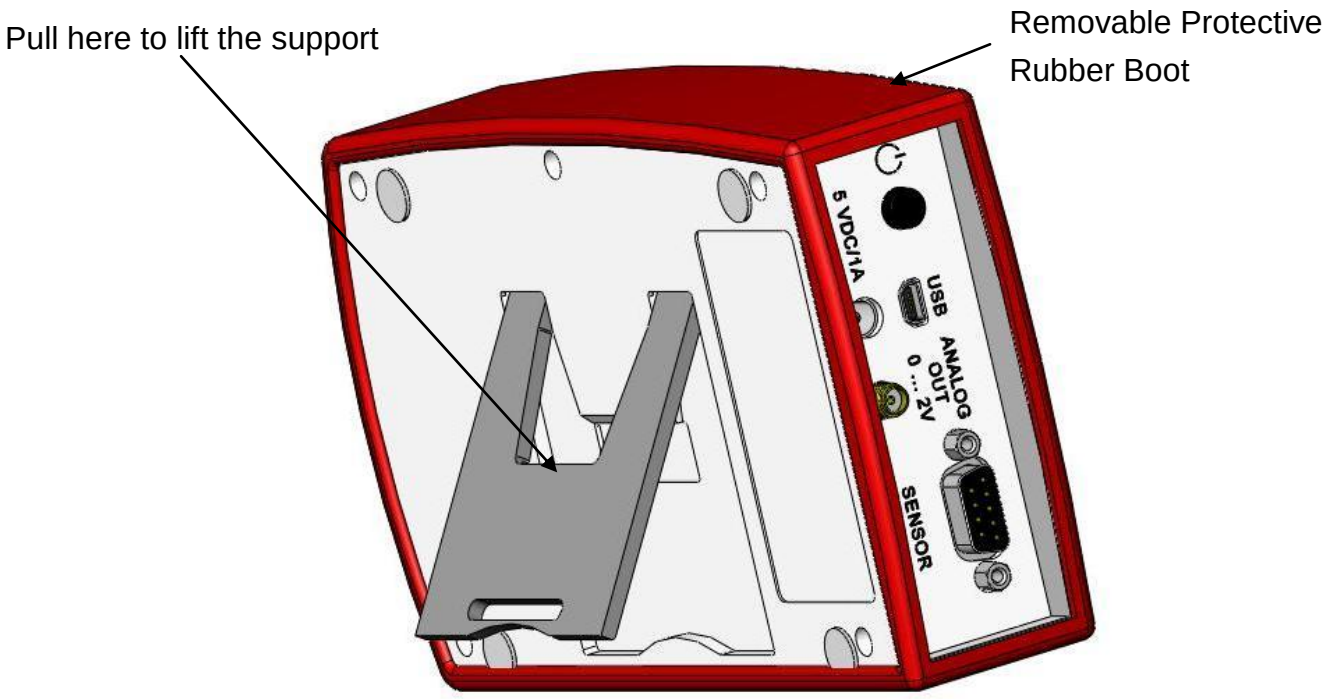


Figure 4 Rear View

3.2.5 Display Options

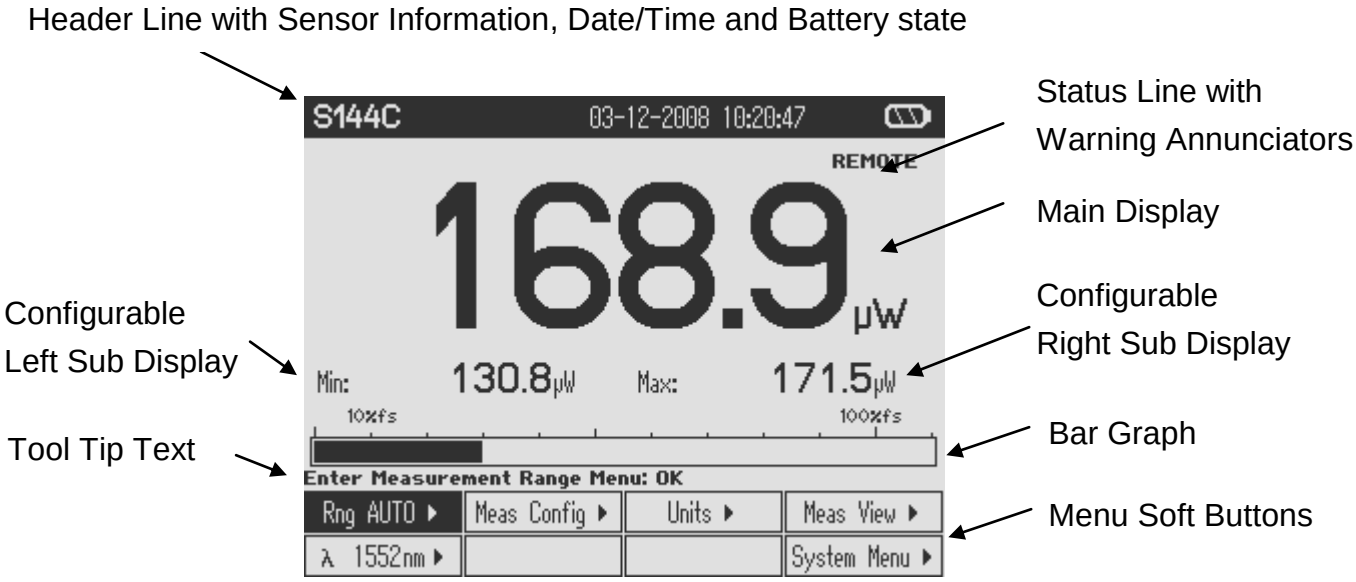


Figure 5 Numeric Screen (Power and Energy Mode)

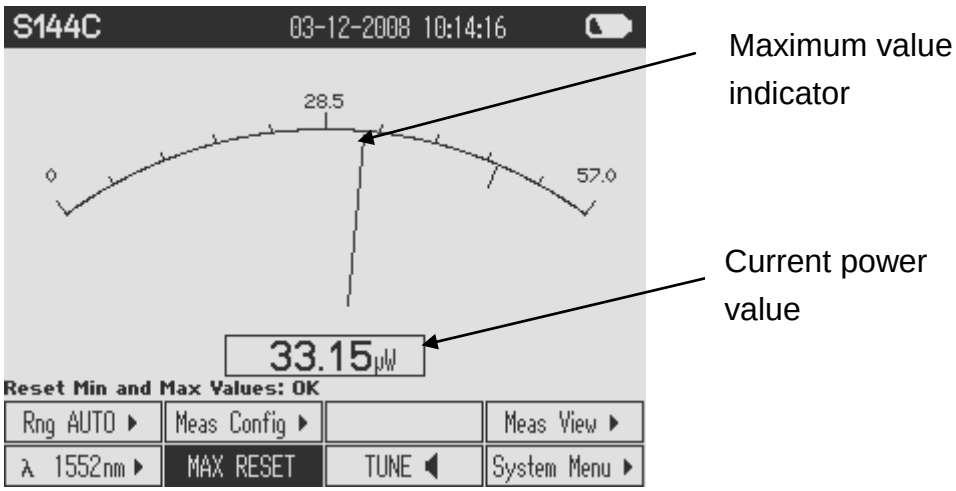


Figure 6 Needle Tuning (Power Mode)

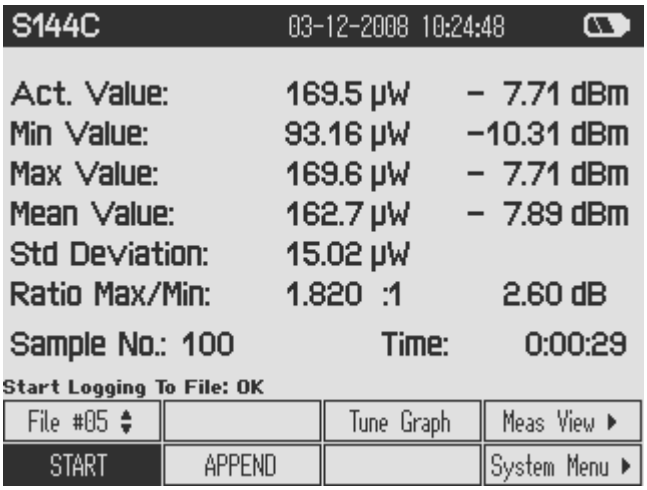


Figure 7 Statistics Screen (Power Mode)

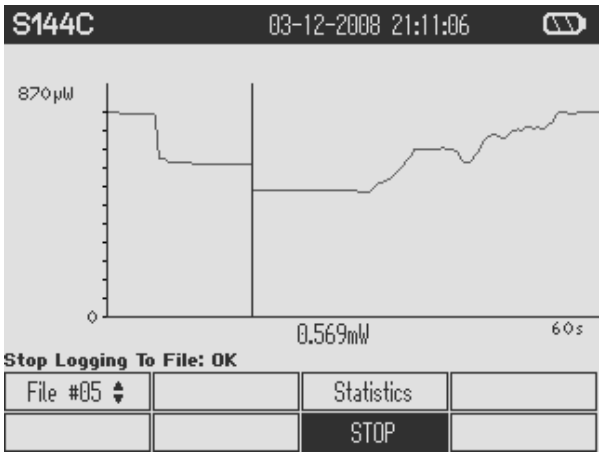


Figure 8 Trend Graph (Power Mode)

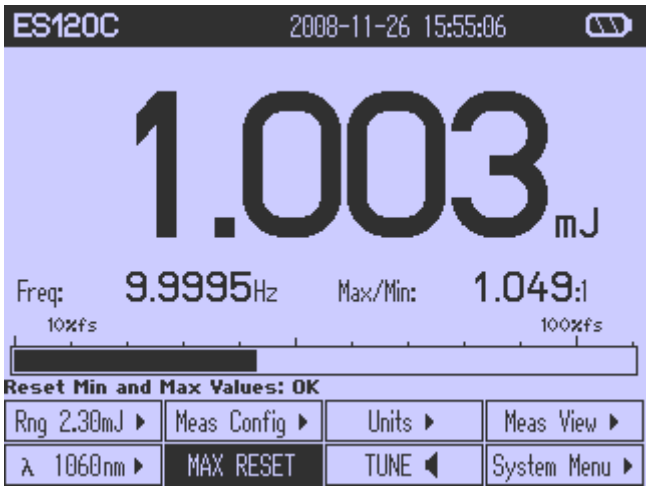


Figure 9 Numeric Screen (Energy Mode)

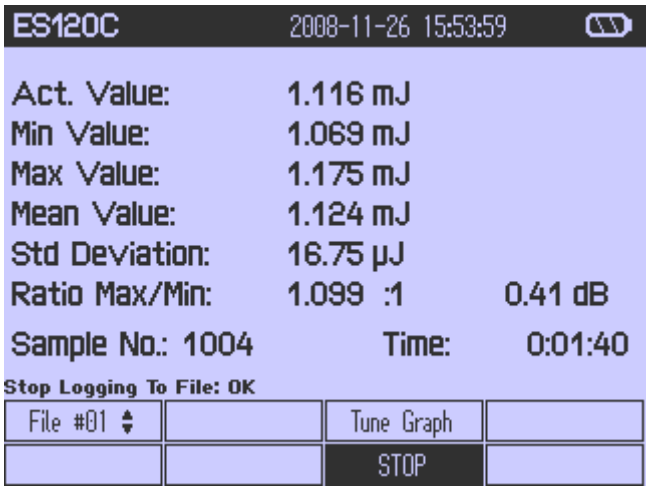


Figure 10 Statistics Screen (Energy Mode)

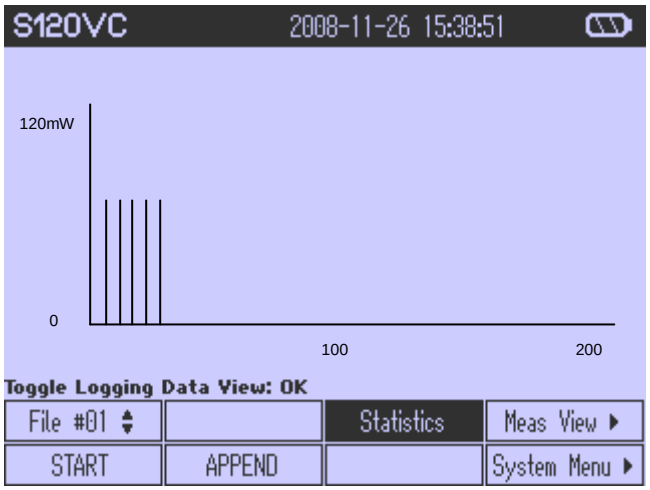


Figure 11 Pulse Chart (Energy Mode)

4 Operating the PM100D

4.1 Connecting a Power or Energy Sensor

The PM100D supports all Thorlabs 'C-Series' photodiode, thermal and pyroelectric sensors. These can easily identified against older versions of Thorlabs power or energy sensors by their red connector housing. The console will not recognize sensors from the 'A' and 'B' series. Please contact Thorlabs for upgrading of old sensors with 'C-Series' connectors.
To plug or remove a sensor slightly press the two bolts in the connector housing. Sensors can be 'hot-swapped' to the console, after recognizing a new valid sensor the type and calibration data will be downloaded to the console in less than 2 seconds and the unit is ready to operate with the new sensor.
The PM100D also supports custom detectors, please refer to chapter 4.2.2 for the console measurement settings and chapter 8.4 for the connector pin-out.

4.2 Controlling the PM100D

4.2.1 Navigating the Menus

Each measurement screen contains eight soft buttons arranged in 2 rows at the bottom of the graphics display. These can be controlled by the four navigation (▲▼◀▶), and the enter/edit (**OK**) key. An interactive help text above shortly describes shortly the function of each selected button.
The soft buttons may be configured with the following functions:

Type	**Indicator**	**Function when pressing 'OK'**	**Example**
Menu	▶	Shows a sub menu, by rearranging the soft button labels	Meas Config ▶
Ring Control	▲▼	Scrolls up and down the ring with the up and down navigation buttons. The changes are valid immediately. A blinking button frame indicates that the control is active. Confirm with 'OK'	Range ▲▼
Function key	Label in capitals	Proceeds the described function	RESET

Radio button	✓	Selects the function of the pressed key. The active key gets the 'checked' mark (✓)	✓ W
Numeric	Key label contains a number	The button goes in the 'edit' mode. This is indicated by a blinking frame and one digit with a blinking underline. With the ◀▶ buttons navigate the digit to change; with the ▲▼ keys increment or decrement the digit. Confirm with 'OK'	1.550µm

Button Appearance

Focus: Text Negative

Edit Mode: Blinking frame

All sub menus can be left by navigating to the EXIT button at the down right soft button location or to any empty button, and pressing the **OK** key.

4.2.2 System Settings

To enter the system settings press the System Menu ▶ button that is located at the low right soft button position in the top level measurement screens. The following sub menus will appear:

- Measurement Settings
  - Remote state — PM100D can be switched back to local mode
  - Line filter — Sets the unit to the local line frequency 50Hz/60Hz to avoid aliasing effects
  - Default sensor — Sets the PM100D in a mode to measure photo current, thermal voltage with custom detectors, or the peak voltage from a custom pyroelectric detector. See chapter 8.4 about connecting custom detectors.
- Console Settings
  - Language — User interface language setting
  - Backlight — Switches the LCD and key backlight on and off

(Same function as the ☼ key)

- Brightness — Sets the brightness of the LCD and key backlight. The setting range is 0 – 100% in 1% increments
- LCD Contrast — Adjusts the LCD contrast. The setting range is 0 – 100% in 1% increments
- Sound — Switches on and off the key and warning sounds
- Shutdown — The unit automatically powers off in battery operation after a certain time without user action. This feature can be set to 10 minutes, 1 hour or switched off; and is not active when an external power supply (AC adapter or USB) is connected.
- Firmware Upload — Needs to be 'enabled' before uploading a new firmware version. The function will automatically re-set to 'disabled' when powering down.

- File Explorer — Administrates the log files on the SD memory card.
- Date and Time — Enters a submenu to set date and time. It is possible to chose various date and time formats.
- Console Info — Shows the console related information.
- Sensor Info — Shows the related information of the currently connected power or energy sensor.

4.2.3 Power and Energy Measurement in the Numeric Display

The numeric display contains a large configurable measurement value, two small sub displays for additional measurement information, and a bar-graph that shows the saturation degree of the chosen measurement range.
To control and configure the numeric display the soft buttons in the top level are arranged as following:

Range Control	Measurement Configuration	Readout Configuration	Measurement Representation
Wavelength Correction	Min/Max Monitor Reset	Tuning Sound	System Menu

4.2.3.1 Range Control

The PM100D provides six decades of power corresponding current and four decades of power corresponding voltage ranges. The ranges are displayed in the respectively applicable unit, depending on sensor and chosen unit. (Exception: When displaying

the power in dBm, the ranges will still display in Watts) Combined with a 16 bit linear A/D converter and a 4 digit numeric display the meter allows very precise measurements with a dynamic range of over 100 dB with one photodiode power sensor. For laser energy measurements four decades energy corresponding voltage ranges are available.
Each current or voltage range measures precisely from -10% up to 110% of the nominal range limits. At the low end this is helpful to identify badly zeroed detectors by a negative power display; at the high end it adds more dynamic when switching to a less sensitive range.
For power measurements an auto-ranging function is available. This is very convenient for measuring an unknown steady CW power level, or when using the logarithmic representation of the power reading ('dBm' units). Switching to auto-range can be done by entering the range menu [Rng 123.4 W▶] (upper left soft button), navigating to the [AUTO OFF] button and confirming with the **OK** key.
For tasks like laser tuning or measuring pulsed laser sources manual ranging is often the better choice. To switch back to manual mode enter the range menu with the **OK** key and use the ▲ or ▼ keys to select a manual range or confirm the [AUTO ON] button. The bar-graph in the numeric display gives a good visualization of the saturation level in the selected range.
In the energy measurement mode only manual ranging is available.

4.2.3.2 Wavelength Correction

Most power and energy sensors show a dependent behaviour in their spectral response. For accurate measurements it is important to set the PM100D to the wavelength of the light to measure.
To quickly change an operating wavelength the PM100D offers eight user adaptable soft buttons in the wavelength menu. Therefore press the wavelength key **λ** or navigate to, and enter the [λ 12345 nm ▶] button in the menu located at the left side on the lower row. The menu will change and it is possible to chose out of the eight wavelengths by navigating and confirming with **OK**.
If the wavelength of a button should be changed it can be edited by pressing the **OK** key for longer than 2 seconds. After then the appearance of the button will change to edit mode and the wavelength can be adjusted by the navigation keys ▲▼◀▶.
When a custom sensor is connected that doesn't have an EEPROM with calibration data (adapter mode), the user can set a calibration value in A/W for photodiode detectors, or V/W for thermal or pyroelectric detectors. The control therefore replaces the wavelength button in the main menu. It can be edited by pressing the **OK** key and adjusted by the navigation keys ▲▼◀▶.

4.2.3.3 Readout Configuration

The numeric display can be configured in terms of units of measure and also by selecting additional functions for the two small sub displays.
To enter the readout configuration menu press the Units ▶ button. A menu will appear where the large measurement value for power sensors can be displayed in linear (W) or logarithmic (dBm) representation; further in its direct sensor response in Amperes for photodiode sensors and Volts for thermal sensors. For energy sensors the large display can be configured to Joules and Volts to measure the energy or Watts to measure the average power.
The min-max monitor and manual range setting automatically switches to the same unit that is selected for the main display; exception is the average power measurement for energy sensors, the ranges will stay in Joules.

The left sub display Sub Left ▶ can be configured to measure the minimum value, frequency / repetition rate, sensor temperature or hiding the display.

For the right display Sub Right ▶ following functions are available: Maximum value, ratio max/min, power density, energy density, alternate unit of main display and hidden display.

4.2.3.4 Zeroing

The zeroing function can be accessed in the Meas Config ▶ measurement configuration menu. To perform a zero adjustment it is important to properly cover the power sensor with a light-tight shield and after then pressing the ZERO button. The zero adjustment will fail and show a warning, when the detected zero value is too large for the connected sensor; e.g. when accidentally hitting the zero button under light exposure to the sensor.

> Do not hold a sensor in the hand, especially a thermal sensor, when performing a zero adjustment. Temperature effects will influence the quality of the zeroing result!

When measuring very small power levels dark current of photodiode sensors or zero voltage on thermal sensors will have an influence on the measurement result and must be compensated by the zero adjustment. An indicator that a sensor needs to be zeroed is when with covered sensor either a negative power reading or a reading

much greater than zero is displayed. At negative power readings additionally a 'ZERO!' warning appears in the status display.
After performing a zero adjustment, the detected zero value will be included in all power readings in Watts or dBm. The basic units (A, V) will still measure the absolute values without zero correction. The detected zero value may influence the wavelength corrected calculated full scale power range values in the lower power ranges; there will also be a zero shift in the bar graph representation.
In logarithmic (dBm) representation the unit cannot display negative values. In this case the display will '---'.
Photodiode sensors emit small current levels, even when no photons hit the active area – the so called dark current, that is temperature dependent and in the region of some nA for silicon and InGaAs sensors and up to some µA for germanium sensors.
Thermopile sensors need to be zeroed when thermal differences between active area (thermal disk) and the sensor heat sink appear when no light hits the active area or when the heat sink gets hot under light exposure. The zero value will be negative when the heat sink is hotter than the active area and positive, when the active area is hotter than the heat sink. When both heat sink and active area are at room temperature a zero voltage of some µV is normal.

4.2.3.5 Setting an Attenuation / Gain Factor

To set an attenuation or gain factor that will be taken into account when calculating the displayed power or energy enter the Meas Config ▶ measurement configuration menu and navigate to Att 0.00 dB button. When confirming this button with the **OK** key an attenuation or gain factor from 60dB to -60dB can be entered. A positive value will set an attenuation factor.
This feature can be used to display the origin laser or probe power, with having a filter or beam splitter in the system; or to enlarge the measurement range of a power or energy sensor with a calibrated filter.

4.2.3.6 Light Intensity Measurements

To display the power or energy density or the light intensity value in W/cm² or J/cm² in the right sub display it is necessary to enter the diameter of the incident beam or at an overfilled sensor the diameter of the sensor aperture.
After entering the Meas Config ▶ measurement configuration menu the beam diameter can be set in millimeters from 10µm up to the diameter of the sensor aperture of the connected sensor in the ∅ 1.23 mm button.
Round beam shapes: enter the 1/e² beam diameter

Square beams with the edge length (*a*): the input diameter calculates to 1.128 x *a*.
Rectangular beams with edge lengths (*a, b*): the input value calculates to 1.128 x $\sqrt{(a \times b)}$.
To show the intensity value navigate: Units ▶ / Sub Disp 2 ▶ / ✓ Area

4.2.3.7 Min / Max Monitor

The sub displays can be configured to display a minimum and a maximum value or a ratio out of both values. See chapter 4.2.3.3 to configure the numeric display. These values will update permanently. The MAX RESET button will reset the displays to zero and restart the measurement sampling.

The ratio value will show '**---**' when a negative reading occurs.

4.2.3.8 Relative Power / Energy Measurements

This feature can be used to observe power drifts, adjust power to a certain level, or quickly subtract ambient light. To switch to the relative mode press the **Δ** key. The main display will set to zero, the offset and the absolute power or energy value will be displayed in the sub displays. The bar graph will change to a measurement range from -10% to +10% of the set range.
The power / energy display then will show negative values for levels smaller than the offset value. In logarithmic representation the power difference to the offset value is displayed in dB.

4.2.3.9 Sensor Temperature Measurements

Most Thorlabs photodiode and thermal sensors are equipped with a NTC Thermistor to control the temperature of the sensor head. To show the sensor temperature in the left sub display navigate : Units ▶ / Sub Left ▶ / ✓ Temperature
In addition to this feature the PM100D will give a warning when a sensor surface gets hotter than approximately 60° C to prevent from injury when touching the sensor housing, or damaging the sensor.

4.2.3.10 Frequency Measurements

The PM100D can measure and display frequencies of pulsed, modulated or chopped light sources up to 100kHz. The maximum measurable frequency is depending on the sensor type and instrument settings.
To show the frequency value in the left sub display navigate:
Units ▶ / Sub Left ▶ / ✓ Frequency

4.2.4 Sensor Dependent Functions

4.2.4.1 Photodiode Sensors

The PM100D works with all Thorlabs S100C series photodiode power sensors. The sensor is ready to operate few seconds after plugging to the DB9 connector.

☝ Attention ☝

Refer to the sensor data sheet and pay attention to the optical damage threshold!

Exceeding these values will permanently destroy the sensor!

For the measurement of power levels from nano-watts up to 20 W Thorlabs offers photodiode sensors that show big advantages in sensitivity, stability and drift against thermal sensors. The sensors are built up in a combination of a photodiode and a neutral density filter or a photodiode in combination with an integrating sphere. They provide linearity over several decades and show a very good sensitivity at smallest power levels down to the pW range. Handling fairly small power levels the sensor size can be held small, further the response time of such sensors is very fast down to the sub-microsecond range.
Photodiodes, neutral density filters and also integrating sphere materials show a wavelength dependent behaviour and therefore each sensor is individually calibrated over the whole spectral working range in 5 or 10nm steps. Thereby the sensors spectral response data gets stored in a non-volatile memory inside the DB-9 sensor connector and downloaded to the PM100D when plugged to the unit. To perform an accurate measurement it is necessary to enter the operating wavelength of the light to measure so that the PM100D can calculate the laser power from the measured photo current and the right response value from the wavelength calibration table.

4.2.4.1.1 Bandwidth Setting (Signal Filtering)

The analogue bandwidth setting influences the power reading and the analogue output. The bandwidth can be selected in the Meas Config ▶ measurement configuration menu to 'HI' (range dependent bandwidth up to 100kHz) or 'LO' (15 Hz bandwidth) by toggling the BW HI/LOW button.
For measuring CW or average power from pulsed sources the bandwidth should be set to 'LO'. When using the analogue output to control external equipment or

measuring peak power levels the ‘HI’ setting is required so that the meter can follow the signal.

4.2.4.1.2 Power Measurements with Photodiodes

Common photodiodes can be used for power measurements with the PM100D. Therefore the PM100D needs to be set to the ‘Photodiode’ default setting in the ‘System Menu \ Measurement Settings’. A photodiode and an interlock must be connected to the sensor input (see chapter 8.4 for the connector pin out); it is important to attend to the right polarity (the cathode needs to be connected to ground).

The operation is similar to photodiode power sensors with the exception that at the soft button position of the wavelength menu a response value in A/W for one wavelength can be set.

4.2.4.2 Thermal Power Sensors

The PM100D is compatible to the Thorlabs S300C series thermal power sensors. The sensor will be ready to operate few seconds after plugging to the DB9 connector.

☝ Attention ☝

Refer to the sensor data sheet and pay attention to the optical damage threshold!

Exceeding these values will permanently destroy the sensor!

Thermal sensors absorb the incident laser power, whereby the developing heat gets turned into a small voltage caused by heat flow through thermocouple elements between absorbing area and sensor heat sink. Thorlabs offers with its S3xxC series thermal sensors that cover a wide range of applications. The sensors are available with different coatings. Black broad band coating as absorber does not need a wavelength correction because the response is nearly flat from the UV to the mid-IR. Special hard coatings can withstand high power levels and show also a good spectral flatness. Further Thorlabs offers special heads for Excimer lasers with large beam diameters and short pulse lasers with coatings for very high peak power levels. The output voltage of a thermal sensor is linear to the incident laser power, as long the thermal system is properly zeroed. The main application area for thermal sensors is the measurement of high power levels from 100mW. Thorlabs offers also a special thermally isolated thermal head with flat response and on power levels starting in the µW range.

4.2.4.2.1 Readout acceleration

Thermal sensors show a fairly slow response. When laser power hits the active area it takes, depending on the sensor type, from some 1 up to 20 seconds until the system has settled and the power reading shows the right value.
Through special circuitry this time can be shortened to approximately 1-3 seconds by 'predicting' the final power value. The PM100D automatically uses the right adjustment of the electronics to the time constant of the thermal sensor. Nevertheless this circuitry has the disadvantage of inducing some noise to the measurement value. Therefore the acceleration circuit can be disabled / enabled in the Meas Config ▶ measurement configuration menu by the Acc *AUTO/ON/OFF* button.

In ‘AUTO’ mode the accelerator will switch on when a power change larger than 5% of the measurement range is detected and switch off after 5 times of the time constant of the sensor. This feature provides a fast response and keeps the noise level to a minimum on constant power levels.

4.2.4.2.2 Custom Thermal Elements

Custom thermal elements can be used for power measurements with the PM100D. Therefore the PM100D needs to be set to the ‘Thermopile’ default setting in the ‘System Menu \ Measurement Settings’. A thermal element and an interlock must be connected to the sensor input (see chapter 8.4 for the connector pin out). The operation is similar to thermal power sensors with two exceptions:

- The soft button position of the wavelength menu is replaced by a button to enter a response value for one wavelength in V/W.
- In the [Meas Config ▶] measurement configuration menu a button [Tau XX.Xs] to enter a thermal time constant is available. This time constant adjusts the acceleration circuit for the measurement prediction.

4.2.4.3 Pyroelectric Energy Sensors

With pyroelectric sensors the PM100D measures laser pulse energy of single and continuously repeating laser pulses (short pulse). Pyroelectric sensors of the Thorlabs ES100C and ES200C series can work with the PM100D console. The sensor will be ready to operate few seconds after plugging.

☝ Attention ☝

Refer to the sensor data sheet and pay attention to the optical damage threshold!

Exceeding these values will permanently destroy the sensor!

A pyroelectric sensor permits widely independent of the incident radiation wavelength, the direct transformation of a radiation energy pulse into a voltage pulse. The height of this voltage pulse that is proportional to the laser pulse energy is measured by a peak detector circuit.

When a pyroelectric sensor is connected the PM100D cannot be switched in auto-range mode. The measurement value will be updated with each incoming pulse. When no pulses appear the measurement display will be held on the last measured value until the [Reset] button in the [Meas Config ▶] menu will be pressed.

4.2.4.3.1 Trigger Level

The trigger level can be set in the [Meas Config ▶] menu with the [Trig XXX%] button.

When an incoming pulse exceeds the set trigger level, the peak detector circuit gets armed and is waiting until the pulse peak is reached. After finding the maximum voltage the level is kept and the microprocessor reads the AD converted voltage for displaying the pulse energy. Finally the peak detector circuit gets a reset and is ready for the next pulse.

The trigger level can be adjusted between 1% and 70% of each selected energy range. Only pulses that are higher than the adjusted trigger level are recognized by the PM100D. The trigger level should be set between the noise level and the expected pulse height.

4.2.4.3.2 Average Power Measurement

With continuously repeating pulses the PM100D calculates the average power from the pulse energy and the repetition rate. For displaying the average power enter Units ▶ / ✓ Watt .

4.2.4.3.3 Repetition Rate

The pulse repetition rate in Hz can be displayed in the left sub display.
Navigate: Units ▶ / Sub Left ▶ / ✓ Rep Rate

4.2.4.3.4 Area Calculation

When the right beam diameter of the incident beam is entered, this function returns either the average power density in W/cm² or the energy density in J/cm².
Navigate: Units ▶ / Sub Right ▶ / ✓ Area P or ✓ Area E

4.2.4.3.5 Custom Pyroelectric Sensors

Custom pyro detectors can be used for energy measurements with the PM100D. Therefore the PM100D needs to be set to the 'Pyro Electric' default setting in the 'System Menu \ Measurement Settings'. A pyro detector and an interlock must be connected to the sensor input (see chapter 8.4 for the connector pin out). The pyro detector must provide a positive signal. The operation is similar to pyro-electric energy sensors with exception that at the soft button position of the wavelength menu a response value in V/J for one wavelength can be set.

4.2.5 Display Options

The PM100D offers several options like graphics or statistics for the measurement value representation in the Meas View ▶ menu

Power Sensors:

Numeric Display	Tune Graph Display	Statistics Display	Needle Display

Energy Sensors:

Numeric Display	Pulse Graph Display	Statistics Display	

To select a display navigate to the desired option and click the **OK** key. Depending on the display type measurement range, wavelength and measurement configuration can be set. Further each graphical and statistical display has a Setup ▶ button for the function configuration.

4.2.6 Statistics Display

The statistics function can be accessed by navigating to the Meas View ▶ and then choosing the Statistics button. The sampling will start and stop manually after pressing the START button. The values will be stored to the SD memory card on the chosen file number.

The display contains at a glance actual, minimum, maximum and mean value in linear (power & energy) and logarithmic (power) representation, further the standard deviation, the max/min ratio, the number of samples and the elapsed time.

The statistics function supports auto-ranging in power mode. Measurement data during ranging will be suppressed in the log data.

4.2.7 Needle Display

This display for power measurement simulates an analogue needle and is designed to support laser tuning tasks. The exact power value can be read on a small numerical display within this screen; a special feature is a resettable max hold indicator and the shiftable tuning sound.

The power is always displayed in Watts.

4.2.8 Tune Graph and Pulse Graph Display

The graph functions can be accessed by navigating to the Meas View ▶ and then choosing the Statistics button. The sampling will start and stop manually after pressing the START button. The values will be stored to the SD memory card on the chosen file number.
The power graph function supports auto-ranging. Measurement data during ranging will be suppressed in the log data.

4.3 Analog Output

The analog output provides the amplified photo-diode current or the amplified thermal or pyroelectric sensor voltage.
With thermal sensors the analog output shows the direct amplified and accelerated voltage response from the sensor. With pyroelectric sensors the signal from the analog output is the pulse response from the sensor prior to the peak detection circuit.
The signals from the analog outputs are not wavelength and zero corrected.
The analog output voltage is range dependent and can be calculated to:
$U_{Analog\ Out}$ [V] = 2V / full scale range value [V, A] x measurement value [V, A]
The analog output voltage can go from -0.3V to +2.3V.

4.4 Tuning Sound

For power measurements in the numeric and needle display a sound support can be added to adjust to the maximum power level without the need of watching the display. The tone will increase its repetition frequency with the height of the power level until a local maximum is reached.
To switch on the tuning sound navigate and confirm the TUNE ◀ button. The sound shuts off by pressing any of the keys.

4.5 SD Memory Card

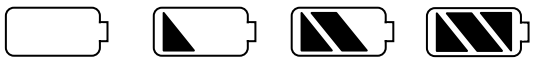
Measurement data can be stored on a SD memory card. The memory card is located in the instrument bottom and can be removed / inserted with a push pull mechanism.
The data logging function is available in the statistics and graphical screen. Up to 99 files can be selected to store data, old data in the selected file will be overwritten. When a statistics or a graph is running, the data automatically will be written to the

selected file. Each log file contains a header with sensor information, start time stamp and the unit of measure (Watts or Joules). The data itself are tab-stop separated and contain the measurement value in engineering notation with '.' decimal separator and the elapsed time in milliseconds since start time. To load the log data to a computer, the card currently must be removed from the PM100D and read by an external card reader. The files can easily be edit with text pad or imported to an Excel spreadsheet (chose tab stop separator and, when necessary the right decimal separator).
The system is tested with the SD card type and memory size that came with the instrument, though it should work with most available SD cards, Thorlabs does not guarantee proper function with other SD cards. In any case the SD card has to be formatted to 'FAT32' file system.

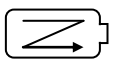
4.6 Battery Charging

The PM100D is powered by a 1 cell $LiPo^+$ battery that needs to be recharged intermittently by plugging the AC adapter or plugging the USB cable to a computer. To fully charge the battery it takes approximately 3-4 hours. A built in charging circuit automatically regulates and terminates the charging.

Following battery icons in the display header show the charging state from empty to full battery



The empty battery symbol starts blinking for one minute until the unit shuts off.
When an external power supply is plugged the symbols above change sequent until the battery is fully charged.
The following icon will appear when the battery gets not fully loaded after a given time of approximately four hours. This can happen when the unit is switched on, the charging is done via USB link and the computer cannot supply sufficient charging current. The symbol will disappear after 2 seconds when disconnecting the external power supply and show the actual battery charging state.



Should the 'arrow icon' permanently remain there may be a malfunction either in the battery itself or in the charging circuitry, please refer to chapter 0 for maintenance and repair.

The AC adapter for charging the system battery that comes with the PM100D provides a wide range power input from 100VAC to 240VAC and an output voltage from 5VDC. The mains connectors for US, Europe, UK and Australia can be switched by pressing the lever and pulling off; the new connector easily clicks into the socket.

Do not use other than the provided power supply at the DC input. Higher input voltages may damage the unit.

When charging the battery via USB link it will take longer until the battery is fully charged or it never gets completely fully charged. It depends on the connected computer what charging current can be supplied. The maximum current that can be drained via USB is limited to 500mA. Some laptop computers just can drive 100mA via USB interface.

5 Measurement Considerations

5.1 Choosing the right Sensor

The question of the right sensor depends on many factors starting with the light source to measure and the application. No sensor can cover all applications; the following table shows the main pros and contras of the different power sensor types. Of course this can only be a rough guide because within each sensor group there are special models best suitable for specific applications.

Power Sensors:

	Photodiode			Thermal		
Light Source	**Si**	**Ge**	**InGaAs**	**BB**	**HTC**	**Volume**
Diode UV - NIR	+++	+	-	++	-	-
Diode NIR	-	+	+++	++	-	-
High Power Fiber Lasers	-	-	++	++	++	-
ASE sources	-	-	++	++	-	-
fs Laser	-	+	++	++	+	-
Gas Laser	++	-	-	++	+	-
Excimer	-	-	-	-	+++	+
YAG	-	-	-	-	+	+++
LED	+	-	-	+++	+	-

5.2 Reducing Noise for High Accuracy Measurements

Main disturbing influence on each measurement is noise from grounding, the cable capacitance, temperature effects, stray and ambient light and detector noise.

- The housing of power sensors are connected to the digital ground of the meter and should be linked to earth ground (e.g. via a post); energy sensors should be mounted isolated, because the housing is connected to the meter analog ground.
- The sensor cable must handle very small current or voltage signals. Moving the cable will induce disturbances given through the cable capacitance. For measuring small power or energy levels the cable should be fixed in position.
- With photodiode sensors the bandwidth should be set to ‘LOW’ setting; with thermal sensors the acceleration circuit should be shut off or set to ‘AUTO’.

- The detector noise is lowest with silicon or InGaAs sensors.
- For long term measurements in free space applications it is necessary to provide constant ambient light conditions, or shielding the beam.
- The temperature should be stable over the time of the measurement.

5.3 Power Measurement of Pulsed Signals

The PM100D will read the average value of a pulsed signal when the following conditions apply: For a thermal sensor pulse length, repetition rate and peak power is uncritical as long as the peak power is lower than the damage threshold of the sensor. A thermal sensor reacts very slow and will integrate the power incident on the active area of the sensor.
With a photodiode sensor that can follow short pulses in the ns range it is important that the pulse peak power is within the maximum power range of the sensor. It is also important that the power range is set that accordingly the peak power is within this range, otherwise the reading will clip at the range end and lead to a wrong average value. Further it is important to use a power range in manual mode that can measure the peak value, therefore the Min-Max function is very helpful. Depending on the pulse length and repetition rate the bandwidth setting will influence the power reading. It is recommended to use the low bandwidth setting for a stable display; when the pulse should be monitored via the analog output, the bandwidth should be set to ‘HI’.

5.4 Line width of Light Sources

The line width of light sources can be neglected only when using a broadband thermal or pyro-electric sensor. Photodiode sensors show a strong dependency of the operating wavelength so if the line width of light sources is greater than 10nm (e.g. LED) there may be an influence on the displayed power. To achieve the best result for broadband light sources with a photodiode sensor it is necessary that the response curve is nearly linear over the line width. When entering the center wavelength of the light source as operation wavelength the PM100D will nearly show the right optical power for a symmetrical spectral response shape.

5.5 Temperature Effects on Thermal Sensors

Thermal sensors react on any temperature differences that occur between thermal disc and heat sink. Influence to the measurement result can be caused by airflow

disturbances or by heating up the heat sink through long enough exposure of the laser beam to the thermal disc.
To avoid disturbances it is recommended to shield the sensor as good as possible from airflow and to zero it properly in the operating condition. That means for short term measurements zero the cold sensor, for long term measurements zero the sensor when it is in a state of thermal stability (e.g. after 10 minutes light exposure).

5.6 Ambient and Stray Light

Ambient or stray light can strongly affect the measurement accuracy in free-space applications. A permanent background light level can be subtracted by conducting a zero adjustment. More complicated is varying ambient light like daylight or turning on/off room light. In such cases the only solution is a proper light shielding of the sensor.

5.7 Back Reflection

Photodiodes, ND filters and even black coatings of thermal sensors show a certain kind of back reflection of the incoming light. Back reflection for example to a diode or HeNe laser can distort the power stability of the laser, therefore it is recommended to slightly tilt the power meter sensor in the laser beam.
When back reflection must be avoided it is advised to use an integrating sphere based S14xC series sensor where the incoming light gets nearly completely absorbed in the sensor.

5.8 Beam Diameter vs. Active Sensor Area

Most sensors are not completely uniform in their response over the active area; except are sensors that are using an integrating sphere as filter and diffuser.
To overcome uniformity issues the incident beam should have a diameter larger than 10% sensor area.
A second topic to follow are the maximum allowed power and energy densities of the sensor. The maximum ratings are given in the sensor spec-sheet. The PM100D can display the actual power or energy density for a known beam diameter. For high power or high energy beams a good efficiency can be reached to chose a detector that is about 20% - 30% larger than the beam diameter.

5.9 Fiber Based Measurements

Laser light emits from an optical fiber in a conical shape, with an angle twice the acceptance angle of the fiber. The acceptance angle is calculated by the numerical aperture of the fiber and is defined as the inverse sine of the numerical aperture.
Fore typical single mode fibers the total angle of the emitted light is between 15° and 25°, for an angled connector (APC) the cone shifts by approximately 4° from the fiber axis.
This expansion of the beam has to be considered to avoid overfilling the detector and getting wrong results. On the other hand for measurements with high power fiber lasers a certain gap between fiber tip and detector surface has to be kept to decrease the power density.
Thorlabs offers fiber adapters with the most common connectors that are verified with the S12xC series optical sensors and with most thermal sensors.
For large divergence angles or fiber measurements that are critical to back-reflections it is recommended to use an integrating sphere based sensor from the S14xC series.
Another good choice for fiber based measurements are the new ‘Fiber-Heads’ of the S15xC series. They plug directly to the meter and go without a disturbing cable between sensor and console.

5.10 Energy Measurement with Pyroelectric Sensors

The application depending best suitable pyroelectric energy sensor must be chosen with respect to the following parameters:

- Energy to Measure
  The maximum load allowed is determined from the absorption layer (too high load causes mechanical damages on the layer); and also by the sensor material, that must remain in a certain temperature level. It is important to pay attention to the maximum power density during a pulse, the maximum energy density and the average power.
  The detection limit on the low side is given by the resolution and the minimum settable trigger level of the display unit, as well as the noise level. To minimize the noise level and ground loops it is advisable to mount the detectors isolated with the supplied isolation adapters.
- Beam Diameter
  The active area of the detector should be chosen that it has a slightly larger cross section than the beam diameter. It is not a must that the beam should

cover most of the sensor area, but it has to be considered the maximum allowed energy density.

- Repetition Rate

  The maximum pulse repetition rate depends on the combination of the internal capacitance of the detector and the load resistor. The display unit has an input resistor of 1MΩ (like the typical input resistor of an Oscilloscope).

- Pulse Length

  Thorlabs energy sensors detect and measure pulses from sub nano-seconds up to approximately 2 ms.

  The pyroelectric effect allows generally just the measurement of a temperature change given by radiation pulses or modulated radiation. In regards to shorter impulses there are no restrictions, as the energy of the shortest impulse is converted into heat flow in the absorption layer. The maximum impulse duration possible is influenced from the size of the R-C constant, given by the detector capacity and the load resistance, as well as the precondition that the thermal time constant of the detector must have no influence up to the point of the measurement evaluation.

- Wavelength

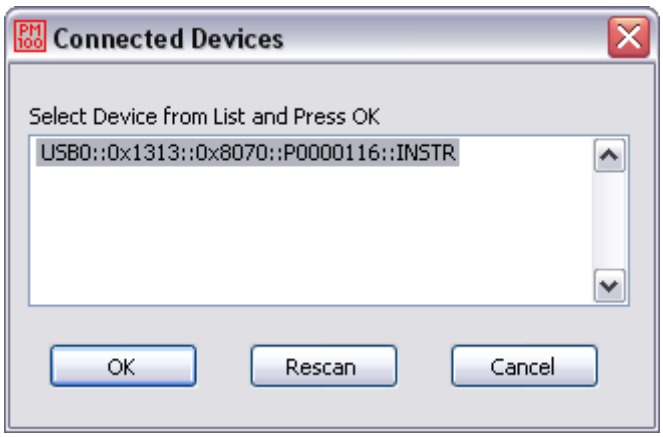
  The sensors are typically calibrated at one wavelength, for other wavelengths a sensor specific correction curve is stored in the memory in the sensor connector. The black coating is nearly linear flat over a wavelength range from 185nm to > 25µm; the ceramic coating is also suitable for this wavelength range, but is not spectrally linear.

6 Computer Interface

The PM100D optical power meter has a USB 2.0 interface that allows to send commands from a host computer to the instrument. The connection between PC and PM100D is accomplished by a USB cable with a male type 'A' connector at the PC side and a type 'Mini B' connector on the instrument side.
When connecting the PM100D to the PC first time, a new hardware will be found. For proper installing the PM100D it requires a NI-VISA runtime version on the PC (available on the National Instruments website www.ni.com or from the data carrier that comes with the instrument. Allow installing and follow the dialog instructions.

6.1 PM100D Utility Software

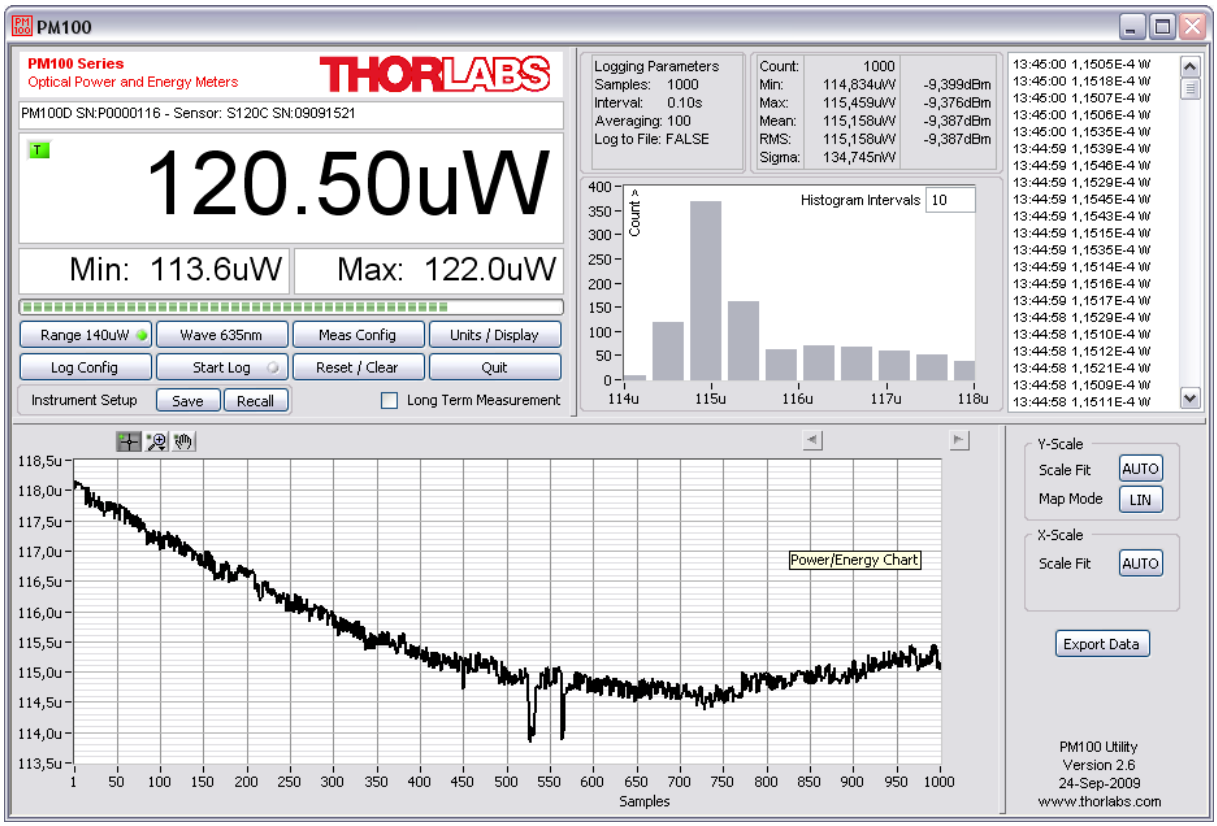
The PM100D comes with a utility software that easily enables remotely operating the PM100D and visualizing and logging measurement data. The software is written in LabVIEW 8.5.1 and can either be installed from the data carrier as executable where LabVIEW isn't required on the PC; or can be run with LabVIEW 8.5.1 or higher.
The source code of the application is included on the data carrier and can be used to build own applications or to modify the utility program to specific requirements.
The PM100D utility software does **not** require the installation of the instrument drivers that are described under 6.3.
After launching the PM100D utility program it will automatically screen for connected PM100D series devices. Select the desired device and press o.k. In case that the connected PM100D is not yet recognized, press Rescan to perform a new search for connected PM100D devices.



The identification string contains the following items:

USB Port number
Thorlabs Vendor ID = 0x1313
Product ID = 0x8070 = PM100D
Instrument serial number
Measurement instrument device

6.1.1 Front Panel



6.1.2 Description of the Front Panel Elements:

Header
This indicator shows the device setup:
- console type (PM100D)
- serial number of the console
- sensor type
- sensor serial number

Main Display
The display has a configurable display resolution. Independent from the measurement range the display always has the full number of the selected digits.
To achieve best AD converter resolution it is necessary to set the measurement range according to the signal to measure.
A trigger indicator shows whether the unit is sampling data ‘A’ indicator or a new

measurement value gets displayed ‘T’ indicator and green light.

Left Sub Display
The display has the following configurable items:
- no display
- maximum value - sampling until reset
- ratio max/min value - sampling until reset
- power or energy density
- alternate unit depending on connected sensor
the possible choices depend on the connected sensor

Right Sub Display
The display has the following configurable items, the possible choices depend on the connected sensor::
- no display
- minimum value - sampling until reset
- frequency or repetition rate
- temperature
- resistance of temperature sensor

Bargraph indicator
The bargraph indicator shows the incidence or the used measurement range.

Statistics screen
Statistical values in linear and logarithmic representation

Data logging screen
Shows the logging history data

Histogram Power / Energy histogram
- displays histogram data

Chart display
Power/Energy Chart

Range button
Press to open a dialog box for setting the measurement range
The indicator in the button shows the currently used measurement range in the chosen unit. A green light indicates 'auto-ranging'
Shortcut: [Shift + F1]

Wavelength / Response button
Press this button to open a dialog box for setting the correction wavelength, or in adapter mode to enter the responsivity value in A/W or V/W.
The currently used parameter is indicated in the button label.
Shortcut: [Shift + F2]

Measurement configuration button
Depending on the connected sensor the following parameters can be set in the dialog box:
- display resolution - set number of digits

- averaging rate, a rate of 3000 averages the incoming measurement values for approx. 1 second
- photodiode bandwidth HI and LO
- acceleration circuit for thermal sensors ON, AUTO and OFF
- trigger level for pyroelectric sensors
- Zeroing for photodiode and thermal sensors

Shortcut: [Shift + F3]

Units / Display button

A dialog box with the following items appears:

- configure unit of measure, depending on the connected sensor in W, J, dBm, V and A
- configure the left sub display
- configure the right sub display

Shortcut: [Shift + F4]

Logging configuration button

Open dialog box to:

- set averaging rate for logging
- set interval between samples
- set number of samples
- configure logging into data file

Shortcut: Shift + F5

Start/Stop log button

- start and stop data logging

Shortcut: [Shift + F6]

Reset / Clear button

- reset min/max monitor
- clear power / energy graph
- clear power / energy histogram
- clear power / energy statistics
- clear log screen

Shortcut: [Shift + F7]

Quit button

- stops the PM100D application
- to restart press the white arrow in the tool bar

Shortcut: [Shift + F8]

Instrument Setup Save / Recall

- save / recall remote control specific parameters

Shortcut: [Shift + F9]

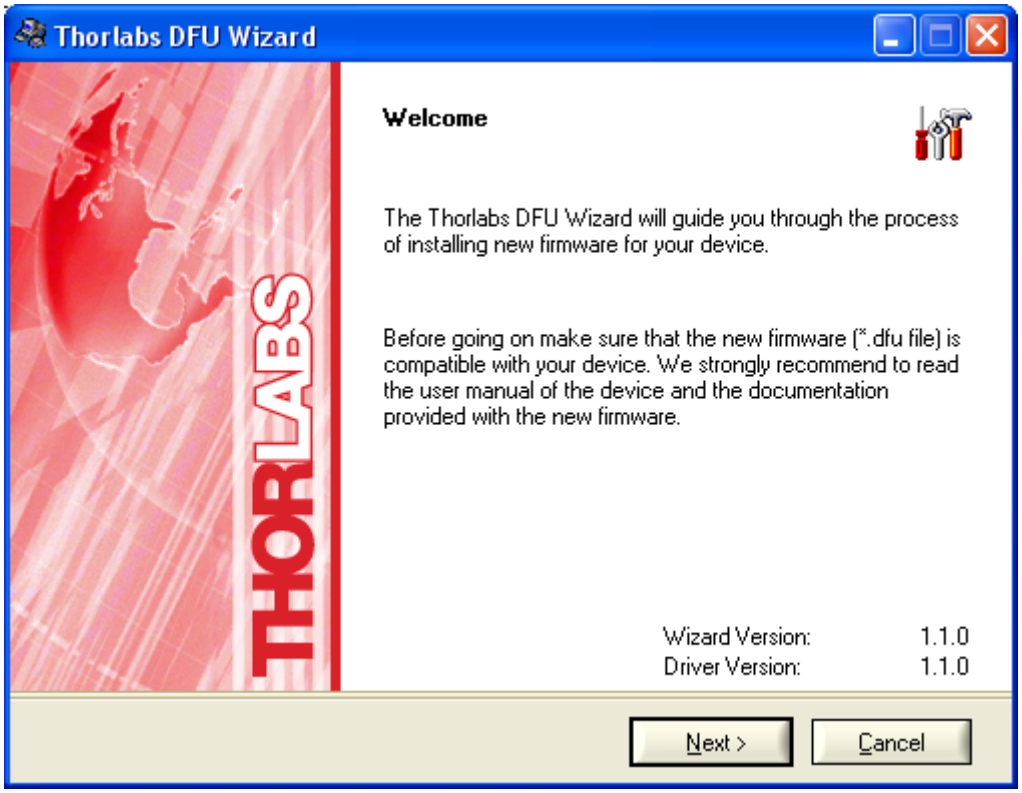
Long Term Measurement

- sets the device to local mode between the measurement intervals

Shortcut: [Shift + F10]

6.2 Firmware Update

Firmware upgrades can be done by the user via the USB interface. Therefore install the DFU (device firmware upgrade) wizard from the distribution data carrier.
Switch on the PM100D and enable the firmware download in the system menu:
System Menu ▶ \ Console Settings \ Firmware Upload \ Enabled
(This setting will be reset to 'Disabled' when the unit was shut off.)
Connect the PM100D to an USB port of your PC, the PC will find a DFU device; when proceeding the DFU wizard the first time a new DFU device will be recognized, please allow installing.
After then launch the DFU wizard from the start bar. Follow the wizard instructions.



Please refer to www.thorlabs.com for the latest PM100D firmware version that can be downloaded as a *.dfu file.

Do not switch off the PM100D or disconnect the USB cable while the firmware is downloading!

6.3 Using the Instrument Drivers

6.3.1 Instrument Driver Installation

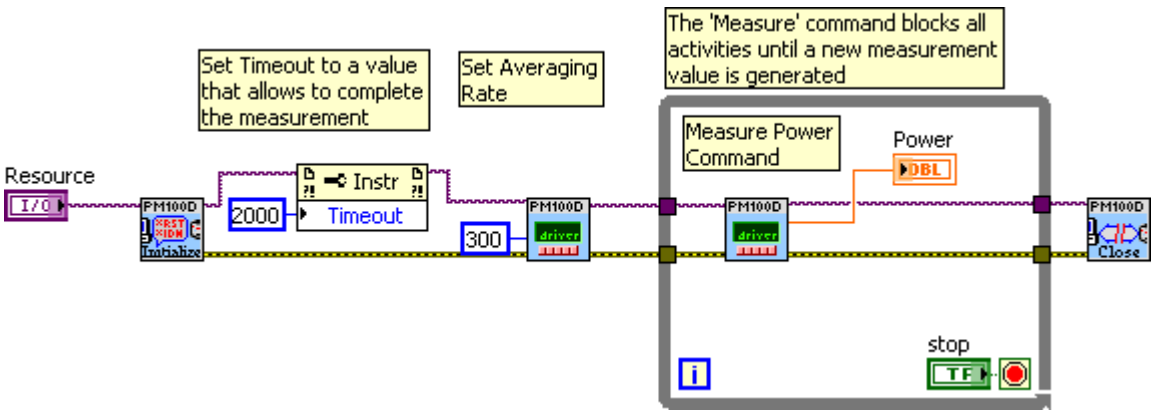
The PM100D software package contains a set of instrument drivers that allow conveniently remote controlling the instrument in most common programming languages. The instrument drivers must be installed, please follow the setup dialog instructions.

To successfully complete the install of the PM100D USB driver you must have Administrator privileges on the PC which you are performing the install.

Prior to connecting the PM100D with a PC, please check if NI-VISA is installed on the PC, otherwise install NI-VISA that is available for free from the National Instruments website www.ni.com of from the data carrier that came with the instrument.
After successfully installing the drivers connect the PM100D to a USB port of your PC. The PC will find a PM100D test and measurement device. Please follow the instructions of the dialog screens and allow the installing.

6.3.2 Instrument Driver Example

The following LabVIEW example demonstrates how to use the instrument drivers for measurement tasks. The example is included on the data carrier that came with the instrument.



6.4 PM100D SCPI Commands

6.4.1 An Introduction to the SCPI language

The PM100D interface commands use the SCPI (*Standard Commands for Programmable Instruments*), ASCII-based command language that was designed for test and measurement instruments.
SCPI commands are based on a hierarchical structure, also known as a *tree system*. In this system, associated commands are grouped together under a common node or root, thus forming *subsystems*. A portion of the `SENSE` subsystem is shown below to illustrate the tree system.

```
[SENSe:]
  CORRection
       :COLLect
          :ZERO
             [:INITiate]
             :ABORt
             :STATe?
             :MAGNitude?
       :BEAMdiameter {MINimum|MAXimum|DEFault|<numeric_value>[mm]}
       :BEAMdiameter? [{MINimum|MAXimum|DEFault}]
       :WAVelength {MINimum|MAXimum|<numeric_value>[nm]}
       :WAVelength? [{MINimum|MAXimum}]
       :POWer
           [:PDIode]
              [:RESPonse] MINimum|MAXimum|DEFault|<numeric_value>[A]}
              [:RESPonse]? [{MINimum|MAXimum|DEFault}]
           :THERmopile
              [:RESPonse] {MINimum|MAXimum|DEFault|<numeric_value>[V]}
              [:RESPonse]? [{MINimum|MAXimum|DEFault}]
```

`SENSe` is the root keyword of the command, `CORRection` is the second-level keyword, and `COLLect` and `BEAMdiameter` are third-level keywords, and so on.
A *colon* (**:**) separates a command keyword from a lower-level keyword.

Command Format
The format used to show commands in this manual is shown below:
`CURRent[:DC]:RANGe {MINimum|MAXimum|<numeric_value>[A]}`
`CORRection:BEAMdiameter {MINi-`
`mum|MAXimum|DEFault|<numeric_value>[mm]}`
The command syntax shows most commands (and some parameters) as a mixture of upper- and lower-case letters. The upper-case letters indicate the abbreviated spelling for the command. For shorter program lines, send the abbreviated form. For better program readability, send the long form.
For example, in the above syntax statement, `CURR` and `CURRENT` are both acceptable forms. You can use upper- or lower-case letters. Therefore, `CURRENT`, `current`, and `Current` are all acceptable. Other forms, such as `CUR` and `CURREN`, will generate an error.

Braces (**{ }**) enclose the parameter choices for a given command string. The braces are not sent with the command string. A *vertical bar* (**|**) separates multiple parameter choices for a given command string.
Triangle brackets (**< >**) indicate that you must specify a value for the enclosed parameter. For example, the above syntax statement shows the *range* parameter enclosed in triangle brackets. The brackets are not sent with the command string. You must specify a value for the parameter (such as "CURR:DC:RANG 50E-6").
Some parameters are enclosed in *square brackets* (**[ ]**). The brackets indicate that the parameter is optional and can be omitted. The brackets are not sent with the command string. In this example [:DC] can be omitted, so the command string can be shortened to "CURR:RANG 50E-6". If you do not specify a value for an optional parameter, the power/energy meter chooses a default value.

Command Separators
A *colon* (**:**) is used to separate a command keyword from a lower-level keyword. You must insert a *blank space* to separate a parameter from a command keyword. If a command requires more than one parameter, you must separate adjacent parameters using a *comma* as shown below:
"SYST:TIME 10, 34, 48"
A *semicolon* (**;**) is used to separate commands within the *same* subsystem, and can also minimize typing. For example, sending the following command string:
"CORR:BEAM 1; WAVE 1310"
... is the same as sending the following two commands:
"CORR:BEAM 1"
"CORR:WAVE 10"
Use a colon *and* a semicolon to link commands from *different* subsystems. For example, in the following command string, an error is generated if you do not use both the colon *and* semicolon:
"CORR:BEAM 1;:AVER 300"

Using the *MIN* and *MAX* Parameters
You can substitute MINimum or MAXimum in place of a parameter for many commands. For example, consider the following command:
CURRent[:DC]:RANGe {MINimum|MAXimum|<numeric_value>[A]}
Instead of selecting a specific current range, you can substitute MIN to set the range to its minimum value or MAX to set the range to its maximum value.
Querying Parameter Settings
You can query the current value of most parameters by adding a *question mark* (**?**) to the command. For example, the following command sets the operating wavelength to 1550 nm: "CORR:WAVE 1550"
You can query the operating wavelength by executing: "CORR:WAVE?"
You can also query the minimum or maximum operating wavelength allowed as follows:
"CORR:WAVE? MIN"
"CORR:WAVE? MAX"
Caution *If you send two query commands without reading the response from the first, and then attempt to read the second response, you may receive some data*

from the first response followed by the complete second response. To avoid this, do not send a query command without reading the response. When you cannot avoid this situation, send a device clear before sending the second query command.

SCPI Command Terminators

A command string sent to the power/energy meter *must* terminate with a <*new line*> character. The IEEE-488 *EOI* (end-or-identify) message is interpreted as a <*new line*> character and can be used to terminate a command string in place of a <*new line*> character. A <*carriage return*>
followed by a <*new line*> is also accepted. Command string termination will *always* reset the current SCPI command path to the root level.

IEEE-488.2 Common Commands

The IEEE-488.2 standard defines a set of *common commands* that perform functions like reset, self-test, and status operations. Common commands always begin with an asterisk (*****), are four to five characters in length, and may include one or more parameters. The command keyword is separated from the first parameter by a *blank space*. Use a *semicolon* (**;**) to separate multiple commands as shown below:

```
"*RST; *CLS; *ESE 32; *OPC?"
```

SCPI Parameter Types

The SCPI language defines several different data formats to be used in program messages and response messages.

Numeric Parameters Commands that require numeric parameters will accept all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation.

Special values for numeric parameters like `MINimum`, `MAXimum`, and `DEFault` are also accepted. You can also send engineering unit suffixes with numeric parameters (e.g., `M`, `K`, or `u`). If only specific numeric values are accepted, the power/energy meter will automatically round the input numeric parameters. The following command uses a numeric parameter:

```
POWer:REFerence {MINimum|MAXimum|DEFault|<numeric_value>[W]}
```

Discrete Parameters Discrete parameters are used to program settings that have a limited number of values (like `W`, `DBM`). They can have a short form and a long form just like command keywords. You can mix upper- and lower-case letters. Query responses will *always* return the short form in all upper-case letters. The following command uses discrete parameters:

```
POW:UNIT {W|DBM}
```

Boolean Parameters Boolean parameters represent a single binary condition that is either true or false. For a false condition, the power/energy meter will accept "`OFF`" or "`0`". For a true condition, the meter will accept "`ON`" or "`1`". When you query a boolean setting, the instrument will *always* return "`0`" or "`1`". The following command uses a boolean parameter:

```
CURRent:RANGe:AUTO {OFF|0|ON|1}
```

String Parameters String parameters can contain virtually any set of ASCII characters. A string *must* begin and end with matching quotes; either with a single quote or with a double quote. You can include the quote delimiter as part of the string by typing it twice without any characters in between. The following command uses a string parameter:

```
DIAG:CALString <quoted string>
```

6.4.2 IEEE488.2 Common Commands

Common commands are device commands that are common to all devices according to the IEEE488.2 standard. These commands are designed and defined by this standard. Most of the commands are described in detail in this section. The following common commands associated with the status structure are covered in the "Status Structure" section: *CLS, *ESE, *ESE?, *ESR?, *SRE, *SRE?, *STB?

6.4.2.1 Command summary

Mnemonic	Name	Description
***CLS**	Clear status	Clears all event registers and Error Queue
***ESE <NRf>**	Event enable command	Program the Standard Event Enable Register
***ESE?**	Event enable query	Read the Standard Event Enable Register
***ESR?**	Event status register query	Read and clear the Standard Event Register
***IDN?**	Identification query	Read the unit's identification string
***OPC**	Operation complete command	Set the Operation Complete bit in the Standard Event Register
***OPC?**	Operation complete query	Places a "1" into the output queue when all device operations have been completed
***RST**	Reset command	Returns the unit to the *RST default condition
***SRE <NRf>**	Service request enable command	Programs the Service Request Enable Register
***SRE?**	Service request enable query	Reads the Service Request Enable Register
***STB?**	Status byte query	Reads the Status Byte Register
***TST?**	Self-test query	Performs the unit's self-test and returns the result.
***WAI**	Wait-to-continue command	Wait until all previous commands are executed

6.4.2.2 Command reference

6.4.2.2.1 *IDN? – identification query - read identification code

The identification code includes the manufacturer, model code, serial number, and firmware revision levels and is sent in the following format: THORLABS,MMM,SSS,X.X.X

Where: MMM is the model code
SSS is the serial number
X.X.X is the instrument firmware revision level

6.4.2.2.2 *OPC – operation complete - set OPC bit

6.4.2.2.3 *OPC? – operation complete query – places a “1” in output queue

When *OPC is sent, the OPC bit in the Standard Event Register will set after all pending command operations are complete. When *OPC? is sent, an ASCII “1” is placed in the Output Queue after all pending command operations are complete.

Typically, either one of these commands is sent after the INITiate command. The INITiate command is used to take the instrument out of idle in order to perform measurements. While operating within the trigger model layers, many sent commands will not execute. After all programmed operations are completed, the instrument returns to the idle state at which time all pending commands (including *OPC and/or *OPC?) are executed. After the last pending command is executed, the OPC bit and/or an ASCII “1” is placed in the Output Queue.
When *OPC is sent, the OPC bit in the Standard Event Register will set after all pending command operations are complete. When *OPC? is sent, an ASCII “1” is placed in the Output Queue after all pending command operations are complete.

6.4.2.2.4 *RST – reset – return instrument to defaults

When the *RST command is sent, the instrument performs the following operations:

- Returns the instrument to the default conditions
- Cancels all pending commands.
- Cancels response to any previously received *OPC and *OPC? commands.

6.4.2.2.5 *TST? – self-test query – run self test and read result

Use this query command to perform the instrument self-test routine. The command places the coded result in the Output Queue. A returned value of zero (0) indicates that the test passed, other values indicate that the test failed.

6.4.2.2.6 *WAI – wait-to-continue – wait until previous commands are completed

The *WAI command is a no operation command for the instrument and thus, does not need to be used. It is there for conformance to IEEE488.2.

6.4.2.3 PM100D specific SCPI Command Reference

See also SCPI Specification, Version 1999.0, May, 1999, http://www.scpiconsortium.org . All commands with a 'SCPI' checkmark are described in the SCPI specification.

All described commands work also with the PM100A and PM100USB instruments. (With some limitations due to the hardware capabilities)

6.4.2.3.1 SYSTem subsystem commands

Command	Description
SYSTem	Path to SYSTem subsystem. (SCPI Vol.2 §21)
:BEEPer	
[:IMMediate]	Issue an audible signal. (SCPI Vol.2 §21.2.2)
:STATe {ON|1|OFF|0}	Activate/deactivate the beeper. (SCPI Vol.2 §21.2.3)
:STATe?	Return the state of the the beeper (SCPI Vol.2 §21.2.3)
:ERRor	
[:NEXT]?	Returns the latest <error code, "message">. (SCPI Vol.2 §21.8.8)
:VERSion?	Query level of SCPI standard (1999.0) . (SCPI Vol.2 §21.21)
:DATE <year>,<month>,<day>	Sets the instrument's calendar. (SCPI Vol.2 §21.7)
:DATE?	Query the instrument's calendar. (SCPI Vol.2 §21.7)
:TIME <hour>,<min>,<sec>	Sets the instrument's clock. (SCPI Vol.2 §21.19)
:TIME?	Query the instrument's clock. (SCPI Vol.2 §21.19)
:LFRequency <numeric value>	Sets the instrument's line frequency setting to 50 or 60Hz. (SCPI Vol.2 §21.13)
:LFRequency?	Query the instrument's line frequency setting. (SCPI Vol.2 §21.13)

:SENSor	
:IDN?	Query information about the connected sensor. This is a query only command. The resopnse consists of the following fields: `<name>,<sn>,<cal_msg>,<type>, <subtype>,<flags>` `<name>`: Sensor name in string response format `<sn>`: Sensor serial number in string response format `<cal_msg>`: calibration message in string response format `<type>`: Sensor type in NR1 format `<subtype>`: Sensor subtype in NR1 format `<flags>`: Sensor flags as bitmap in NR1 format. Flag: — Dec.value: Is power sensor — 1 Is energy sensor — 2 Response settable — 16 Wavelength settable — 32 Tau settable — 64 Has temperature sensor — 256

6.4.2.3.2 STATus subsystem commands

Command	Description
STATus	Path to STATus subsystem. (SCPI Vol.2 §20)
:MEASurement	Path to control measurement event registers
[:EVENt]?	Read the event register
:CONDition?	Read the condition register
:PTRansition <value>	Program the positive transition filter
:PTRansition?	Read the positive transition filter
:NTRansition <value>	Program the negative transition filter
:NTRansition?	Read the negative transition filter
:ENABle <value>	Program the enable register
:ENABle?	Read the enable register
:AUXillary	Path to control measurement event registers
[:EVENt]?	Read the event register
:CONDition?	Read the condition register
:PTRansition <value>	Program the positive transition filter
:PTRansition?	Read the positive transition filter
:NTRansition <value>	Program the negative transition filter
:NTRansition?	Read the negative transition filter
:ENABle <value>	Program the enable register
:ENABle?	Read the enable register
:OPERation	Path to control operation event registers
[:EVENt]?	Read the event register
:CONDition?	Read the condition register
:PTRansition <value>	Program the positive transition filter
:PTRansition?	Read the positive transition filter
:NTRansition <value>	Program the negative transition filter
:NTRansition?	Read the negative transition filter
:ENABle <value>	Program the enable register
:ENABle?	Read the enable register

:QUEStionable	Path to control questionable event registers
[:EVENt]?	Read the event register
:CONDition?	Read the condition register
:PTRansition <value>	Program the positive transition filter
:PTRansition?	Read the positive transition filter
:NTRansition <value>	Program the negative transition filter
:NTRansition?	Read the negative transition filter
:ENABle <value>	Program the enable register
:ENABle?	Read the enable register
:PRESet	Return status registers to default states.

6.4.2.3.3 DISPlay subsystem commands

Command	Description
DISPlay	Path to DISPlay subsystem. (SCPI Vol.2 §8)
:BRIGhtness <value>	Set the display birghtness. (SCPI Vol.2 §8.2)
:BRIGhtness?	Return the display birghtness value. (SCPI Vol.2 §8.2)
:CONTrast <value>	Set the display contrast. (SCPI Vol.2 §8.4)
:CONTrast?	Return the display conrast value. (SCPI Vol.2 §8.4)

6.4.2.3.4 CALibration subsystem commands

Command	Description
CALibration	Path to CALibration subsystem. (SCPI Vol.2 §5)
:STRing?	Returns a human readable calibration string. This is a query only command. The response is formatted as string response data.

6.4.2.3.5 SENSe subsystem commands

Command	Description
[SENSe]	Path to SENSe subsystem. (SCPI Vol.2 §18)
AVERage	
[:COUNt] <value	Sets the averaging rate (1 sample takes approx. 3ms)
[:COUNt]?	Queries the averaging rate
CORRection	
[:LOSS[:INPut[:MAGNitude]]] {MINimum|MAXimum|DEFault| <numeric_value>}	Sets a user attenuation factor in dB
[:LOSS[:INPut[:MAGNitude]]]? [{MINimum|MAXimum|DEFault}]	Queries the user attenuation factor
COLLect	
ZERO	
[:INITiate]	Performs zero adjustment routine
ABORt	Aborts zero adjustment routine
STATe?	Queries the zero adjustment routine state
MAGNitude?	Queries the zero value
BEAMdiameter {MINimum| MAXimum|DEFault| <numeric_value>[mm]}	Sets the beam diameter in mm
BEAMdiameter? [{MINimum| MAXimum|DEFault}]	Queries the beam diameter
WAVelength {MINimum| MAXimum| <numeric_value>[nm]}	Sets the operation wavelength in nm
WAVelength? [{MINimum| MAXimum}]	Queries the operation wavelength

POWer	
[:PDIOde]	Sets the photodiode response value in A/W
[:RESPonse] {MINimum|MAXimum|DEFault|<numeric_value>[A]}	
[:RESPonse]? [{MINimum|MAXimum|DEFault}]	Queries the photodiode response value
:THERmopile	
[:RESPonse] {MINimum|MAXimum|DEFault|<numeric_value>[V]}	Sets the thermopile response value in V/W
[:RESPonse]? [{MINimum|MAXimum|DEFault}]	Queries the thermopile response value
ENERgy	
[:PYRO]	
[:RESPonse] {MINimum|MAXimum|DEFault|<numeric_value>[V]}	Sets the pyro-detector response value in V/J
[:RESPonse]? [{MINimum|MAXimum|DEFault}]	Queries the pyro-detectro response value
CURRent[:DC]	
RANGe	
AUTO {OFF|0|ON|1}	Switches the auto-ranging function on and off
AUTO?	Queries the auto-ranging function state
[:UPPer] {MINmum|MAXimum|<numeric_valuje>[A]}	Sets the current range in A
[:UPPer]? [{MINimum|MAXimum}]	Queries the current range
REFerence {MINimum|MAXimum|DEFault|<numeric_value>[A]}	Sets a delta reference value in A

REFerence? [{MINimum|MAXimum|DEFault}]	Queries the delta reference value
STATe {OFF|0|ON|1}	Switches to delta mode
STATe?	Queries the delta mode state
ENERgy	
RANGe	
[:UPPer] {MINmum|MAXimum|<numeric_valuje>[J]}	Sets the energy range in J
[:UPPer]? [{MINimum|MAXimum}]	Queries the energy range
REFerence {MINimum|MAXimum|DEFault|<numeric_value>[J]}	Sets a delta reference value in J
REFerence? [{MINimum|MAXimum|DEFault}]	Queries the delta reference value
STATe {OFF|0|ON|1}	Switches to delta mode
STATe?	Queries the delta mode state
FREQuency	
Range	
[UPPer]?	Queries the frequency range
LOWer?	
POWer[:DC]	
RANGe	
AUTO {OFF|0|ON|1}	Switches the auto-ranging function on and off
AUTO?	Queries the auto-ranging function state
[:UPPer] {MINmum|MAXimum|<numeric_valuje>[W]}	Sets the current range in W
[:UPPer]? [{MINimum|MAXimum}]	Queries the current range
REFerence {MINimum|MAXimum|DEFault|<numeric_value>[W]}	Sets a delta reference value in W
REFerence? [{MINimum|MAXimum|DEFault}]	Queries the delta reference value
STATe {OFF|0|ON|1}	Switches to delta mode

STATe?	Queries the delta mode state
UNIT {W|DBM}	Sets the power unit W or dBm
UNIT?	Queries the power unit
VOLTage[:DC]	
RANGe	
AUTO {OFF|0|ON|1}	Switches the auto-ranging function on and off
AUTO?	Queries the auto-ranging function state
[:UPPer] {MINmum|MAXimum|<numeric_valuje>[V]}	Sets the current range in V
[:UPPer]? [{MINimum|MAXimum}]	Queries the current range
REFerence {MINimum|MAXimum|DEFault|<numeric_value>[V]}	Sets a delta reference value in V
REFerence? [{MINimum|MAXimum|DEFault}]	Queries the delta reference value
STATe {OFF|0|ON|1}	Switches to delta mode
STATe?	Queries the delta mode state
PEAKdetector	
[:THReshold] {MINimum|MAXimum|DEFault|<numeric_value>	Sets the trigger level in % for the energy mode
[:THReshold]? [{MINimum|MAXimum|DEFault}	Queries the trigger level setting

6.4.2.3.6 INPut subsystem commands

Command	Description
INPut	
[:PDIode]	
:FILTer	
[:LPASs]	
[STATe] {OFF|0|ON|1}	Sets the bandwidth of the photodiode input stage
[STATe]?	Queries the bandwidth of the photodiode inut stage
:THERmopile	
:ACCelerator	
[STATe] {OFF|0|ON|1}	Sets the thermopile accelerator state
[STATe]?	Queries the thermopile accelerator state
:AUTO {OFF|0|ON|1}	Sets the thermopile accelerator to auto mode
?	Queries thermopile accelerator auto mode
:TAU {MINimum| MAXimum|DEFault| <numeric_value>[s]}	Sets thermopile time constant 0-63% in s
:TAU? [{MINimum| MAXimum|DEFault}]	Queries the thermopile time constant in s
:ADAPter	
[:TYPE] {PHOTodiode| THERmal|PYRo}	Sets default sensor adapter type
[:TYPE]?	Queries default sensor adapter type

6.4.2.3.7 Measurement commands

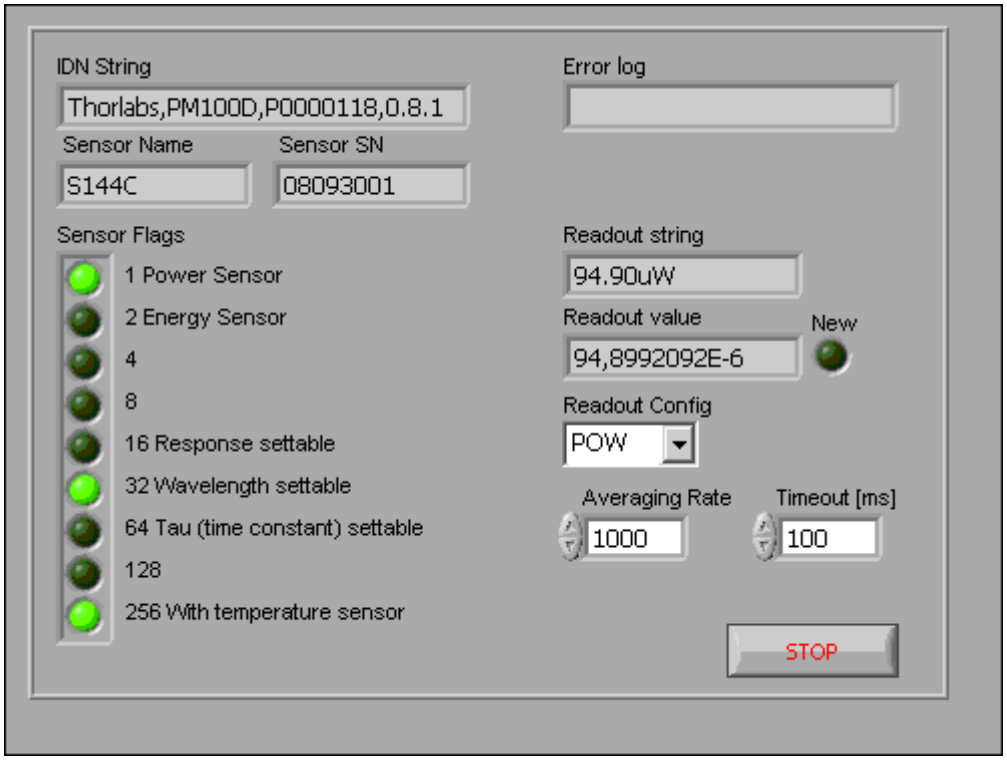
Command	Description
INITiate[:IMMediate]	Start measurement
ABORt	Abort measurement
CONFigure[:SCALar]	
[:POWer]	Configure for power measurement
:CURRent[:DC]	Configure for current measurement
:VOLTage[:DC]	Configure for voltage measurement
:ENERgy	Configure for energy measurement
:FREQuency	Configure for frequency measurement
:PDENsity	Configure for power density measurement
:EDENsity	Configure for energy density measurement
:RESistance	Configure for sensor presence resistance measurement
:TEMPerature	Configure for sensor temperature measurement
MEASure[:SCALar]	
[:POWer]	Performs a power measurement
:CURRent[:DC]	Performs a current measurement
:VOLTage[:DC]	Performs a voltage measurement
:ENERgy	Performs a energy measurement
:FREQuency	Performs a frequency measurement
:PDENsity	Performs a power density measurement
:EDENsity	Performs a energy density measurement
:RESistance	Performs a sensor presence resistance measurement
:TEMPerature	Performs a sensor temperature measurement
FETCh?	Read last measurement data (SCPI Vol.2 §3.2)
READ?	Start new measurement and read data (SCPI Vol.2 §3.3)
CONFigure?	Query the current measurement configuration.

6.4.3 Simple LabVIEW Example using SCPI Commands

PM100D Simple Example.vi

This VI shows how to communicate with a PM100D optical power/energy meter with SCPI commands. The following steps are demonstrated within this application:

- Initializing the instrument
- Getting system info
- Setting parameters
- Measurement configuration
- Measuring queue
- Fetching and displaying a measurement value
- Closing the application



Averaging Rate

Sets the averaging rate - 3000 averages take approximately 1s for performing a new measurement value

Readout Config

Selects the measurement parameter

- POW power measurement in W
- CURR current measurement in A
- VOLT voltage measuremetn in V
- ENER energy measurement in J
- FREQ frequency / repetition rate measurement in Hz
- PDEN power density measurement in W/cm²
- EDEN energy density measurement in J/cm²
- RES thermistor resistance measurement in Ohm
- TEMP temperature measurement in °C

Stop
Stops application

Timeout [ms]
Sets a timeout value in ms that allows the instrument to sample.
The timeout must be longer than it takes to perform a new measurement.
This has especially to be considered when performing single shot energy measurements.

Error log
Error indicator, 'no error' is suppressed

Readout string
Formatted measurement value
- limitation to 4 significant digits
- SI notation
- '.' decimal separator
- appended unit according readout configuration

New
Indicator lights up, when a new measurement value is processed

Sensor Flags

Sensor flag bitmap:
1 Is power sensor
2 Is energy sensor
16 Response settable
32 Wavelength settable
64 Tau settable
256 Has temperature sensor

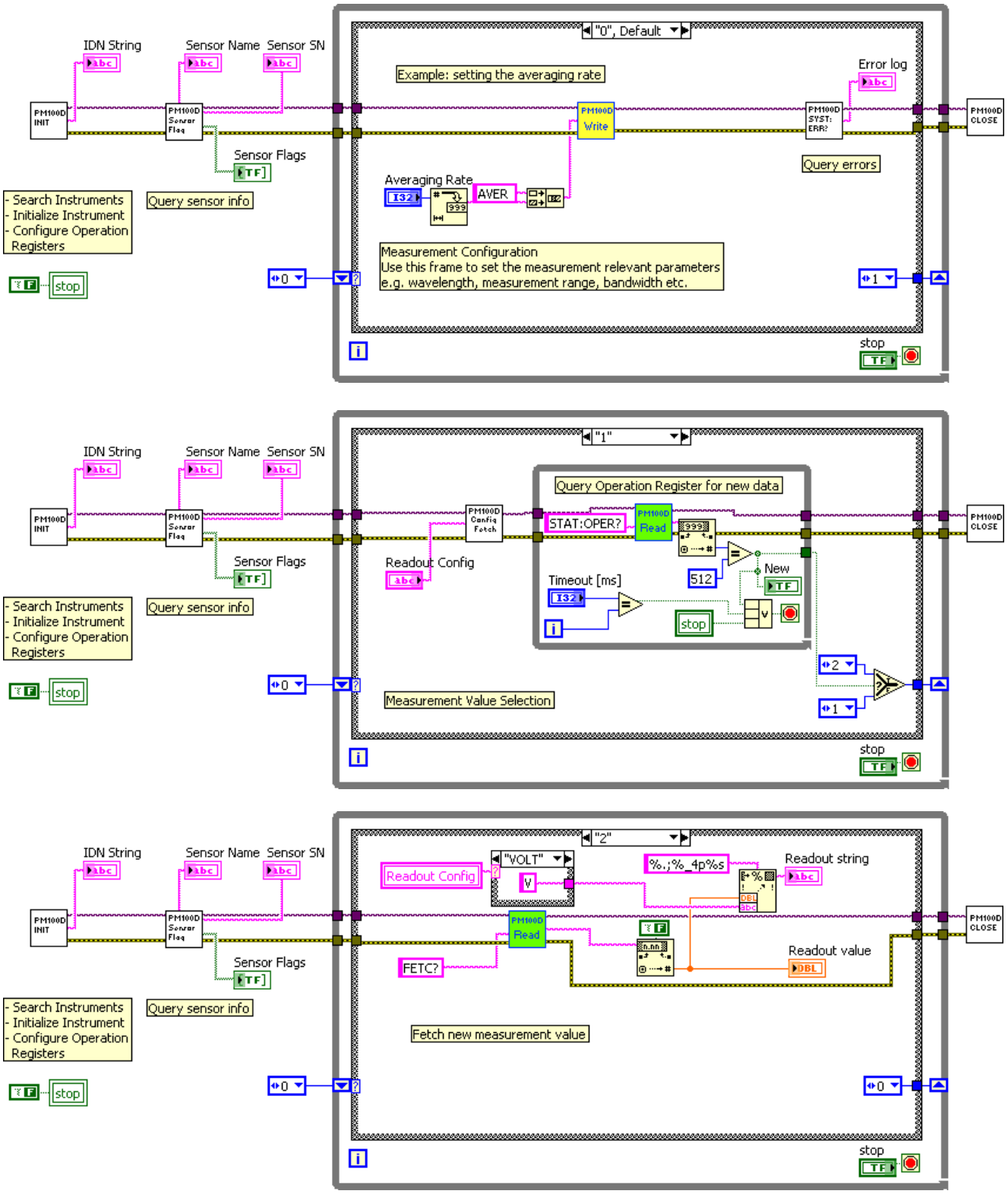
Sensor Name
Name of connected power/energy sensor

Sensor SN
Serial number of connected power/energy sensor

IDN String
Answer from instrument on *idn? command:
- manufacturer
- model number
- serial number
- firmware version

Readout value
Plain readout value in full resolution

Block diagram





PM100D_Initialize.vi
This VI scans for connected devices, that can be selected in a dialog box.
Next steps
- setting timeout
- performing identification query
- configuring the operation register to '512'; flag gets to HI when a new measurement
value is ready to fetch
- clear operation register



PM100D_Write.vi
Writes a SCPI command to the connected instrument



PM100D_Read.vi
Reads data from the connected instrument. All query commands according the SCPI command table are terminated by a question mark (?)



PM100D_SensorFlag.vi
This VI queries all relevant sensor info with SYST:SENS:IDN?
- sensor name
- sensor serial number
- calibration message
- sensor type
- sensor sub-type
- sensor flags



PM100D_ConfMeas.vi
- CONFigure measurement; CONF:<parameter> (POW, ENER, etc.)
- ABORt measurement
- Clear operation register with STAT:OPER?
- INITiate measurement



PM100D_SYST-ERR.vi
This VI lists all errors coming from the instrument with the command SYST:ERR?
'no error' is suppressed



PM100D_Close.vi
Closes the VISA session
Sets the connected instrument in local mode (default option)

7 Maintenance and Repair

7.1 Maintenance

Protect the PM100D from adverse weather conditions. The PM100D is not water resistant.

☝ Attention ☝

To avoid damage to the PM100D, do not expose it to spray, liquids or solvents!

The unit does not need a regular maintenance by the user.

If necessary the unit and the display can be cleaned with a cloth dampened with water.

The PM100D does not contain any modules that could be repaired by the user himself. If a malfunction occurs, the whole unit has to be sent back to *Thorlabs*. Do not remove covers!

To guarantee the specifications given in chapter 0 over a long period it is recommended to have the unit calibrated by *Thorlabs* every year.

7.2 Troubleshooting

In case that your PM100D shows malfunction please check the following items:

- Unit does not work at all (no display at the front):
  - PM100D turned on?
    - Press On switch in the left side panel.
  - PM100D battery discharged / defect
    - Plug in AC Adapter
- Unit automatically switches off
  - Check auto-shutoff setting
  - Check battery charging symbol
  - Plug in AC Adapter
- Display gets or remains blank while or after connecting a new sensor
  - Power down and up the unit with the On switch in the left side panel
- Power or Energy reading is negative
  - A photodiode or thermal sensor is connected
    - Check if the unit is in relative measurement mode
    - Conduct the dark current adjustment procedure
  - A photodiode is connected
    - Check the polarity of the connected photodiode
  - A thermal element is connected
    - Check the polarity of the connected thermal element
  - A pyro-electric element is connected
    - Check the polarity of the connected pyro element
- Pulse energy measurement cannot be measured or is measured wrongly
  - Check for the right trigger level between noise level and expected pulse height
  - Check if energy sensor can handle the laser pulse repetition rate
- Data logging to SD card doesn't work
  - Check for inserted SD card
  - Check write protection switch on SD card
  - Check for enough free memory

If you don't find the error source by means of the trouble shooting list please first contact the *Thorlabs-Hotline (europe@thorlabs.com)* before sending the PM100D for checkup and repair to *Thorlabs* - Germany.

➔ (refer to section 8.7, 'Addresses" on page 73)

8 Appendix

8.1 Warranty

Thorlabs warrants material and production of the PM100D for a period of 24 months starting with the date of shipment. During this warranty period *Thorlabs* will see to defaults by repair or by exchange if these are entitled to warranty.
For warranty repairs or service the unit must be sent back to *Thorlabs* or to a place determined by *Thorlabs*. The customer will carry the shipping costs to *Thorlabs*, in case of warranty repairs *Thorlabs* will carry the shipping costs back to the customer.
If no warranty repair is applicable the customer also has to carry the costs for back shipment.
In case of shipment from outside EU duties, taxes etc. which should arise have to be carried by the customer.

Thorlabs warrants the hard- and software determined by *Thorlabs* for this unit to operate fault-free provided that they are handled according to our requirements. However, *Thorlabs* does not warrant a fault free and uninterrupted operation of the unit, of the soft- or firmware for special applications nor this instruction manual to be error free. *Thorlabs* is not liable for consequential damages.

Restriction of warranty

The warranty mentioned before does not cover errors and defects being the result of improper treatment, software or interface not supplied by us, modification, misuse or operation outside the defined ambient stated by us or unauthorized maintenance.

Further claims will not be consented to and will not be acknowledged. *Thorlabs* does explicitly not warrant the usability or the economical use for certain cases of application.

Thorlabs reserves the right to change this instruction manual or the technical data of the described unit without notice.

8.2 Certifications and compliances

Certifications and compliances

Category	Standards or description	
EC Declaration of Conformity – EMC	Meets intent of Directive 2004/108/EEC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:	
	EN 61326:2006	Electrical equipment for measurement, control and laboratory use – EMC requirements: Immunity: complies with immunity test requirements for equipment intended for use in industrial locations [1]. Emission: complies with EN 55011 Class B Limits [1,3], IEC 610003-2 and IEC 61000-3-3.
	IEC 61000-4-2	Electrostatic Discharge Immunity (Performance criterion A)
	IEC 61000-4-3	Radiated RF Electromagnetic Field Immunity (Performance Criterion A) [5]
	IEC 61000-4-4	Electrical Fast Transient / Burst Immunity (Perf. Criterion A)
	IEC 61000-4-5	Power Line Surge Immunity (Performance Criterion B)
	IEC 61000-4-6	Conducted RF Immunity (Performance Criterion A)
	IEC 61000-4-11	Voltage Dips, Short Interruptions and Voltage Variations Immunity (Performance Criterion A / C [6])
	IEC 61000-3-2	AC Power Line Harmonic Emissions
	IEC 61000-3-3	Voltage Fluctuations and Flicker
FCC EMC Compliance	Emissions comply with the Class B Limits of FCC Code of Federal Regulations 47, Part 15, Subpart B [1,3].	
EC Declaration of Conformity - Low Voltage	Compliance was demonstrated to the following specification as listed in the Official Journal of the European Communities: Low Voltage Directive 2006/95/EEC	
	EN 61010-1:2001	Safety requirements for electrical equipment for measurement, control and laboratory use.
Additional Compliance	IEC 61010-1:2001	Safety requirements for electrical equipment for measurement, control, and laboratory use.
Equipment Type	Test and measuring	
Safety Class	Class I equipment (as defined in IEC 60950-1:2001)	

[1] Compliance demonstrated using high-quality shielded interface cables shorter than 3 meters.

[3] Emissions, which exceed the levels required by these standards, may occur when this equipment is connected to a test object.

[5] MOD IN port capped at IEC 61000-4-3 test.

[6] Performance Criterion C was reached at additional test levels according to EN 61326-1:2006 table 2

8.3 Technical data

General Data	
Detector Compatibility	Photodiode Sensors S100C Series Thermal Sensors S300C Series Pyroelectric Sensors ES100C/ES200C Series Photodiodes (max. 5.5mA) Thermopiles (max. 1.1V) Pyros (max. 110V)
Display Type	4“ Graphical LCD 320 x 240 pixels
Viewing Area	81,4 x 61,0 mm
Display Update Rate (max)	20 Hz
Display Format	Numerical, Bargraph, Trendgraph, Histogram, Statistics, Simulated Analog Needle
Backlight Display and Keypad	LED
Dimensions (H x W x D) Overall	183 x 109 x 40 mm³ with rubber boot
Options	Kickstand; 1/4“-20 Post thread
Weight	< 0.5 kg
Operating Temperature	0°C - +40°C
Storage Temperature	-40°C - +70°C
Relative Humidity	Max. 80% up to 31 °C, decreasing to 50% at 40 °C
Operation Altitude	< 3000 m
Current Input (Photodiode Sensors)	
Connector	DB9F, left side
Units	W, dBm, W/cm², A
Measurement Ranges	6 decades; 50 nA … 5 mA Ranges selectable in W or A, sensor depending
Display Resolution	1 pA / responsivity value (A/W)
AD Converter	16 bit
Accuracy	+/- 0.2% f.s. (5 µA – 5 mA) +/- 0.5% f.s. (50nA)
Bandwidth	DC – 100 kHz, depending on sensor and settings
Photodiode Polarity	Cathode ground
Max. Photodiode Impedance	10 nF
Input Resistance	0 Ω (virtual ground)
Wavelength Correction	nm (A/W)
Beam Diameter Setting	1/e²
Voltage Input (Thermopile Sensors)	
Connector	DB9F, left side
Units	W, dBm, W/cm², V
Measurement Ranges	4 decades; 1 mV … 1V Ranges selectable in W or V, sensor depending
Display Resolution	1 µV / responsivity value (V/W)
AD Converter	16 bit
Accuracy	+/- 0.5% f.s.
Bandwidth	DC - 10Hz, depending on sensor and settings
Input Impedance	1 MΩ
Time Constant Correction Range	1 s – 30 s
Wavelength Correction	Sensor depending; nm, (V/W)
Beam Diameter Setting	1/e²

Voltage Input (Pyro Sensors)	
Connector	DB9F, left side
Units	J, J/cm², W, W/cm², V
Measurement Ranges	4 decades; 100mV … 100V Ranges selectable in J or V, sensor depending
Display Resolution	100µV / responsitivity value (V/J)
AD Converter	16 bit
Accuracy	+/- 0.5% f.s.
Trigger Threshold	0.1% - 99.9% f.s.
max. Repetition Rate	3 kHz
Input Impedance	1 MΩ
Wavelength Correction	Sensor depending; nm, (V/J)
Beam Diameter Setting	1/e²
Analog Outputs	
Connector	SMA, left side
Signal	amplified input signal
Voltage Range	0 .. 2 V
Bandwidth	up to 100 kHz, depending on sensor and settings
Sensor Temperature Control	
Supported temperature sensor	Thermistor
Temperature measurement range	-10 °C .. +80 °C
Sound	
Type	Speaker 300 Hz – 5 kHz
Function	Laser tuning support, console function support
Memory	
Type	SD Card
Size	2 GB
Interface	
Type	USB2.0
Connector	Mini USB, left side
Power Management	
Battery	LiPo 3.7 V 1300 mAh
External power supply DC Input	5 VDC
AC adapter input	100 V – 240 V; 50 Hz – 60 Hz
Accessories	
AC Adapter	X
Hardcase	X
Instrument Drivers on USB Stick	X
Application Software on USB Stick	X
User Manual	X
SD Memory Card 1GB	X

Current Input Phtodiode Sensors

Current Range	Display Resolution	Measurement Accuracy	Analog Output Gain	Analog Output Bandwidth
5 mA	1 µA	+/- 0.2% f.s.	4×10^{2} V/A	100 kHz / 25 Hz
500 µA	100 nA	+/- 0.2% f.s.	4×10^{3} V/A	100 kHz / 25 Hz
50 µA	10 nA	+/- 0.2% f.s.	4×10^{4} V/A	100 kHz / 25 Hz
5 µA	1 nA	+/- 0.2% f.s.	4×10^{5} V/A	100 kHz / 25 Hz
500 nA	100 pA	+/- 0.2% f.s.	4×10^{6} V/A	10 kHz / 25 Hz
50 nA	10 pA	+/- 0.5% f.s.	4×10^{7} V/A	1 kHz / 25 Hz

Voltage Input Thermal Sensors

Voltage Range	Display Resolution	Measurement Accuracy	Analog Output Gain	Analog Output Bandwidth
1 V	100 µV	+/- 0.5% f.s.	2×10^{0}	10 Hz
100 mV	10 µV	+/- 0.5% f.s.	2×10^{1}	10 Hz
10 mV	1 µV	+/- 0.5% f.s.	2×10^{2}	7 Hz
1 mV	0.1 µV	+/- 1.0% f.s.	2×10^{3}	0.7 Hz

Voltage Input Pyroelectrical Sensors

Voltage Range	Display Resolution	Measurement Accuracy	Analog Output Gain	Analog Output Bandwidth
100 V	100 mV	+/- 0.5% f.s.	2×10^{-2}	50 kHz
10 V	10 mV	+/- 0.5% f.s.	2×10^{-1}	50 kHz
1 V	1 mVV	+/- 0.5% f.s.	2×10^{0}	50 kHz
0.1V	100µV	+/- 0.5% f.s.	2×10^{1}	50 kHz

8.4 Pin Assignment of the Sensor Connector

The PM100D is capable to support custom made detectors. Please read carefully the following instruction prior to connecting a self made sensor.

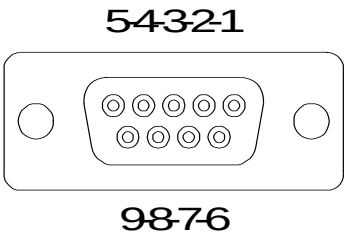


Figure 12 Pin assignment of the sensor connector jack(s) (female)

pin	connection	
3	photodiode ground (anode), thermal and pyro sensor ground, analog ground	
4	photodiode cathode	
5	pyro-electric sensor +	
8	thermal sensor +	
7	PRESENT	connect this pin via a 1kΩ – 10kΩ resistor to Pin 3 (AGND)
1	+5V	drive max. 50mA from this pin
6	DGND	
9	n.c.	

The following described pin is uniquely used for the memory in the sensor head and may not be used. Connecting this pin may cause malfunction of the PM100D.

2 EEPROM Digital I/O

8.5 Thorlabs 'End of Life' policy (WEEE)

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return 'end of life" units without incurring disposal charges.

This offer is valid for Thorlabs electrical and electronic equipment

- sold after August 13th 2005
- marked correspondingly with the crossed out 'wheelie bin" logo (see Figure 13)
- sold to a company or institute within the EC
- currently owned by a company or institute within the EC
- still complete, not disassembled and not contaminated

As the WEEE directive applies to self contained operational electrical and electronic products, this 'end of life" take back service does not refer to other Thorlabs products, such as

- pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
- components
- mechanics and optics
- left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

8.5.1 Waste treatment on your own responsibility

If you do not return an 'end of life" unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

8.5.2 Ecological background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.
The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of live products will thereby avoid negative impacts on the environment.

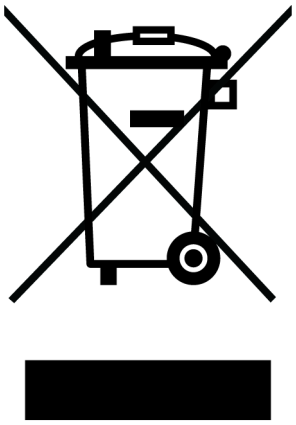


Figure 13 Crossed out 'wheelie bin" symbol

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8.7 Addresses

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