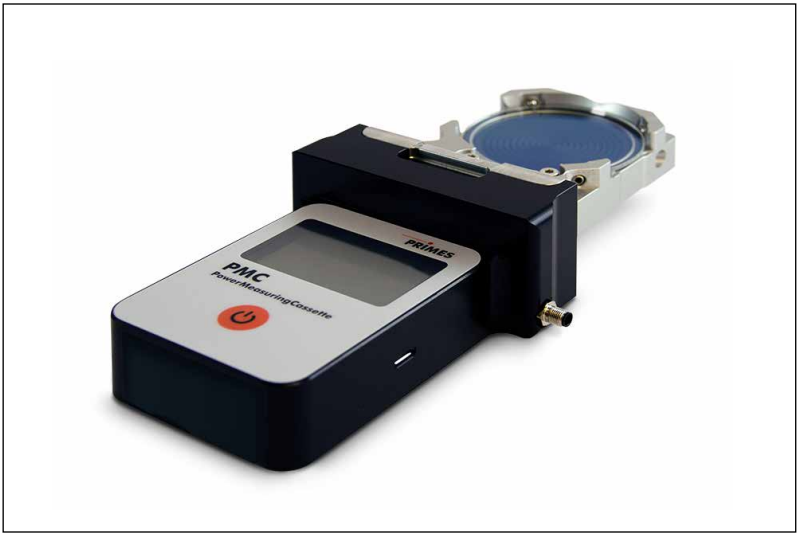
PRIMES

Original Instructions



PowerMeasuringCassette PMC

PMC-LSK

LaserDiagnosticsSoftware LDS

Revision 00 EN - 12/2021

IMPORTANT!

READ CAREFULLY BEFORE USE.

KEEP FOR FUTURE USE.

Table of contents

PRIMES - The Company

PRIMES manufactures measuring devices used to analyze laser beams. These devices are employed for the diagnostics of high-power lasers ranging from CO_2 lasers and solid-state lasers to diode lasers. A wavelength range from infrared through to near UV is covered, offering a wide variety of measuring devices to determine the following beam parameters:

- Laser power
- Beam dimensions and position of an unfocused beam
- Beam dimensions and position of a focused beam
- Beam quality factor M^2

Development, production and calibration of the measuring devices is performed at PRIMES. This guarantees optimum quality, excellent service, and a short reaction time, providing the basis for us to meet all of our customers' requirements quickly and reliably.

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1 Basic safety notes

Intended use

The PowerMeasuringCassette PMC-LSK has been designed exclusively for measurements of high-power lasers. The PMC-LSK is used to measure power of lasers directly within the laser processing head. Alternatively, the PMC-LSK can also be operated outside the laser processing head as a „Stand-Alone“ device.

Use for any other purpose is considered as not intended and is strictly prohibited. Furthermore, intended use requires that you observe all information, instructions, safety notes and warning messages in this operating manual. The specifications given in chapter 13 „Technical data“ on page 54 apply. Any given limit values must be complied with.

If not used as intended, the device or the system in which the device is installed can be damaged or destroyed. In addition, there is an increased risk to health and life. Only use the device in such a way that there is no risk of injury.

This operating manual is an integral part of the device and must be kept in the immediate vicinity of the place of use, accessible to personnel at all times.
Every person who is responsible for the installation, start-up or operation of the device must have read and understood the operating manual and, in particular, the safety instructions.
If you still have questions after reading this operating manual, please contact PRIMES or your supplier for your own safety.

Observing applicable safety regulations

Observe the safety-relevant laws, guidelines, standards and regulations in the current editions published by the state, standardization organizations, professional associations, etc. In particular, observe the regulations on laser safety and comply with their requirements.

Necessary safety measures

The device measures direct laser radiation, but does not emit any radiation itself. However, during the measurement the laser beam is directed at the device. This produces scattered or directed reflection of the laser beam in “Stand-Alone” operation (laser class 4). The reflected beam is usually not visible.

Protect yourself from direct and reflected laser radiation while working with the device by taking the following measures:

- If the device is moved from its aligned position in “Stand-Alone” operation, increased scattered or directed reflection of the laser beam occurs during measuring operation. Mount the device in such a way that it cannot be moved by unintentional bumping or pulling on the cables.
- Connect the laser control’s safety interlock to the device. Check that the safety interlock will switch off the laser properly in case of error.
- Install safety switches or emergency safety mechanisms that allow the laser to be switched off immediately.
- Use suitable beam guidance and beam absorber elements which do not emit any hazardous substances when irradiated.
- Wear **safety goggles** adapted to the power, power density, laser wavelength and operating mode of the laser beam source in use.
- Wear suitable **protective clothing** or **protective gloves** if necessary.
- If possible, also protect yourself from direct laser radiation and scattered radiation by using separating protective devices that block or attenuate the radiation.

Employing qualified personnel

The device may only be operated by qualified personnel. The qualified personnel must have been instructed in the installation and operation of the device and must have a basic understanding of working with high-power lasers, beam guiding systems and focusing units.

Conversions and modifications

The device may not be modified in terms of design or safety without the explicit consent of the manufacturer. The same applies to unauthorised opening, dismantling and repair. The removal of covers is only permitted within the scope of the intended use.

Liability disclaimer

Manufacturer and distributor exclude any liability for damages and injuries which are direct or indirect consequences of using the device not as intended or modifying the device or the associated software without authorization.

2 Symbols and conventions

Warning messages

The following symbols and signal words indicate possible residual risks in the form of warnings:

DANGER

Means that death or serious physical injuries **will** occur if necessary safety precautions are not taken.

WARNING

Means that death or serious physical injuries **can** occur if necessary safety precautions are not taken.

CAUTION

Means that a slight physical injury **can** occur if necessary safety precautions are not taken.

NOTICE

Means that property damages **can** occur if necessary safety precautions are not taken.

Product safety labels

The following symbols are used on the device itself to indicate imperatives and possible dangers:

Read and understand the operating manual before using the device!

Further symbols and conventions in this operating manual

Here you can find useful information and helpful tips.

▶ Indicates a single instruction.
If several such instructions appear one below the other, then the order of their execution is irrelevant or they are alternative procedures.

1. A numbered list identifies a sequence of instructions that must be executed
2. in the specified order.
...

→ Indicates the result of an action to explain processes that take place in the background.

Indicates an observation prompt to draw attention to visible feedback from the device or the software.
Observation prompts make it easier to check whether an instruction was executed successfully. Often they also guide to the next instruction.

Points to a control element that is to be pressed / clicked.

Points to an element described in the text (for example an input field).

3 About this operating manual

This manual describes the installation and operation of the PowerMeasuringCassette PMC-LSK and how to perform measurements with the optional LaserDiagnosticsSoftware LDS 1.1.2.

The software description includes a brief introduction on using the device for measurements. For a detailed description of the software installation, file management and evaluation of the measurement data, please refer to the separate instructions for the LaserDiagnosticsSoftware LDS.

This operating manual describes the software version valid at the time of printing. Since the operating software is subject to continuous further development, it is possible that a higher version will be available.

If you have questions, please let us know the software version you are using. The software version can be found under the following menu item: ***Help > About LaserDiagnosticsSoftware***.

4 Device description

4.1 Functional description

The PMC-LSK is used for power measurement of lasers directly within the laser processing head. Alternatively, the PMC-LSK can also be operated outside the laser processing head as a „Stand-Alone“ device. As a “Stand-Alone” device, the PMC-LSK is positioned below the beam focus in the beam path. If this is not possible, the PMC-LSK can also be positioned above the focus.
The laser beam passes through the protective window and hits the absorber. The display shows the measured laser power and further information on the status of the device.

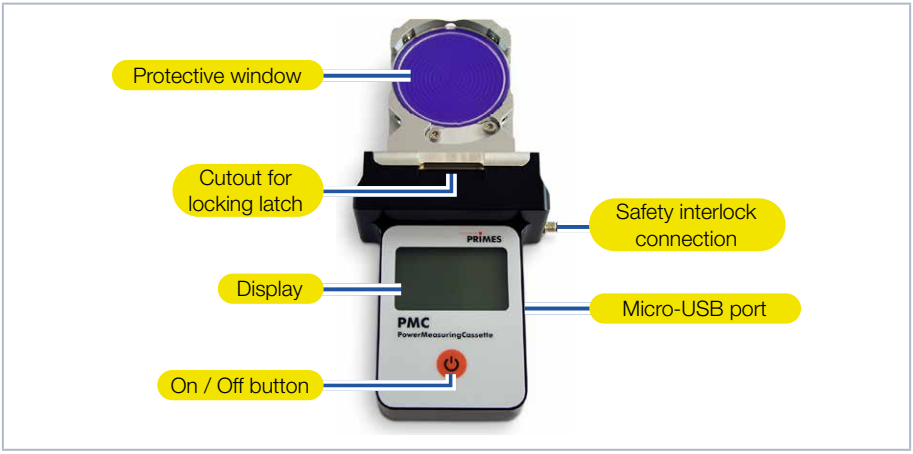


Fig. 4.1: Device description

4.2 Measuring principle

The device measures the laser power according to the calorimetric principle. The absorber of the device is irradiated with the laser for a short period of time. The temperature of the absorber is measured at the beginning and end of the irradiation. Based on the temperature rise, the irradiation time and the thermal properties of the absorber, the microprocessor-based electronics are able to calculate the laser power with high accuracy.

4.3 Scope of delivery and accessories

The following parts are included in the scope of delivery of the PowerMeasuringCasette PMC-LSK:

- PowerMeasuringCasette PMC-LSK
- Cable USB 2.0, 1.8 m
- Safety interlock cable with connector on one side M5, 2 m
- Operating manual PowerMeasuringCasette PMC-LSK
- Transport and storage case

The following accessories are available for the PowerMeasuringCasette PMC-LSK:

- LaserDiagnosticsSoftware LDS
- Operating manual LaserDiagnosticsSoftware LDS

4.4 Functions of the On / Off button

The on / off button has several functions:

	Keystroke	Function
⏻	Short press	Turn on
	5 seconds	Turn off
	2 seconds	Show measuring values
	Press again for 2 seconds	Turn over measuring value display

Tab. 4.1: Functions of the On / Off button

4.5 Displays on the device

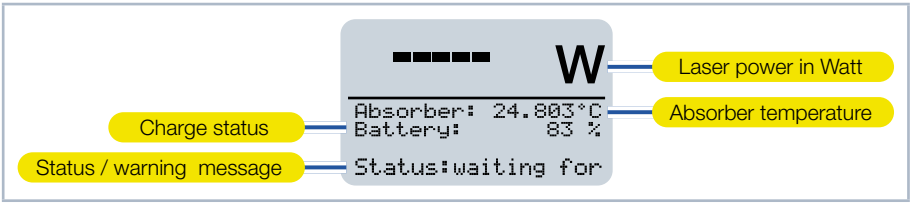


Fig. 4.2: Displays on the device

4.5.1 Status messages

Status message	Meaning
Waiting for laser beam	The device is ready for operation, the laser can be turned on.
Check temp.	The temperature gradient (change in the absorber temperature / time) is checked. Please wait until the message disappears.
Thermalize	The thermalization time allows for a uniform temperature distribution in the absorber. Afterwards, the temperature is measured.
Finished	The measurement is completed.

Tab. 4.2: Status messages

4.5.2 Warning message

Warning message	Reason
Safety interlock open	The absorber temperature has exceeded 100 °C. In order to protect the device, the safety Interlock is switched to the impermissible operating status.

Tab. 4.3: Warning message

This warning message does not imply an error. The message is automatically reset as soon as the absorber temperature falls below 100 °C. The safety interlock is then also automatically switched back to the permissible operating status.

4.6 Important notes on the lithium-ion battery

The device is equipped with a permanently installed rechargeable battery. Be aware that this battery may ignite at high temperatures. For operation, storage and shipping, refer to the information according to chapter 13 „Technical data“ on page 54.

4.6.1 Charging the lithium-ion battery

Fully charge the battery on the PC before using it for the first time. The first complete charge on the PC requires approx. 3 hours. Only use the supplied USB cable to charge the battery. Recharge the battery when the charge level reaches 20 percent. Do not

charge the rechargeable battery unattended, e.g. overnight. Do not expose the device to direct sunlight.

4.6.2 Storing the device with a permanently installed lithium-ion battery

Store the device in a cool, dry place. Keep a minimum distance of 3 m from combustible materials. Do not expose the device to direct sunlight. Please charge the battery at least every three months.

4.6.3 Dangers to health and the environment in the event of damage to the lithium-ion battery

In general, contact with leaking battery components may pose a hazard to health and the environment. Do not open the device to replace or dismantle the battery:

- When the battery is damaged, fluids (electrolytes) may leak out. These are flammable, contact with the eyes or skin may cause irritation.
- Vapors may irritate the eyes, respiratory organs, and skin.
- Fire or intense heat may cause violent bursting. Heating or fire may release toxic gases. Burning produces irritating smoke.

4.6.4 Charge status of the lithium-ion battery

The charge status of the battery is displayed in percent. The accuracy of this display depends on various factors (e.g. temperature, age of the battery, etc.). Recharge the battery when the charge level reaches 20 percent.
The battery has a capacity of 1 400 mAh. The charging time of the battery on the PC via USB connection with a charging current of 500 mA is approx. 3 hours.
At 100 % charge status, the possible operating time is approx. 8 hours (equivalent to approx. 100 measurements). When using all power saving functions (see chapter 9.2.3 on page 40) approx. 20 hours.

5 Transport and storage

5.1 Warning messages

NOTICE

Damaging / Destruction of the device

The device optical components may be damaged if the device is subjected to hard shocks or is allowed to fall.

- **Handle the device carefully when transporting or installing it.**
- **To avoid contamination, cover the inlet aperture with a suitable protective film.**

5.2 Shipping the device with battery

The device with a permanently built-in battery is a dangerous good in case of shipment and is classified as “lithium ion batteries contained in equipment”.
Particularly in case of a damaged battery, special regulations must be observed.
A damaged battery can cause fire! This battery must be sorted out, checked and, if necessary, repacked by qualified personal! Please observe the requirements for shipping according to the valid regulations.

Battery details for shipping
Cell / battery typ: Lithium Ion
Cell or battery: Cell
LC or Wh rating: 5.2 Wh
Cell / battery weight: 25 g
UN-Classification: UN 3481: Lithium ion batteries contained in equipment

6 Mounting

6.1 Conditions at the installation site

- The device must not be operated in a condensing atmosphere.
- The ambient air must be free of organic gases.
- Protect the device from splashes of water and dust.
- Operate the device in closed rooms only.

In industrial environments, strong electromagnetic fields can possibly trigger faulty measurements. In this case we recommend EMC compliant shielding of the safety interlock cable.

6.2 Use within the laser processing head

6.2.1 Installation into the laser processing head

1. Turn off the laser source.
2. Ensure that moving parts, e.g. robot arms, etc. are at a standstill and that they cannot be set in motion unintentionally.
3. Remove the protective glass cassette (part of the laser system) from the laser processing head.

- Protect the protective glass of the protective glass cassette from contamination.

NOTICE

Damaging / Destruction of the device or the laser system

Contamination and fingerprints on the protective window can lead to damage or shattering or splintering of the protective window during measuring operation.
Parts of the protective window can get into the laser system and damage it.

- ▶ **Do not touch the protective window.**
- ▶ **Only operate the device with a clean protective window.**

4. Remove the protective film from the protective window of the device.
5. Push the device into the slot of the laser processing head until the locking latch locks into the cutout (see Fig. 4.1 on page 13).

6. Ensure a secure fit of the device within the laser processing head:
- The device must be fully seated within the laser processing head until the locking latch engages in the cutout.
7. Connect the safety interlock connection cable.

6.2.2 Possible mounting positions

Insert the PowerMeasuringCassette PMC-LSK into the laser processing head so that the laser beam hits the protective window.

6.2.3 Removal from the laser processing head

DANGER

Serious eye or skin injury due to laser radiation

If the device is pulled out of the laser processing head during the measurement, scattered or directed reflection of the laser beam will occur.

▶ **First turn the laser source off and then remove the device from the laser processing head.**

1. Turn off the laser source.
2. Ensure that moving parts, e.g. robot arms, etc. are at a standstill and that they cannot be set in motion unintentionally.
3. Remove the safety interlock connection cable, press the locking latch and remove the device from the laser processing head.
4. Apply a suitable protective film to prevent contamination of the protective window.
5. Insert the protective glass cassette (part of the laser system) back into the laser processing head.

6.3 Use as „Stand-Alone“ device

6.3.1 Prepare mounting

1. Turn off the laser source.
2. Ensure that moving parts, e.g. robot arms, etc. are at a standstill and that they cannot be set in motion unintentionally.

DANGER

Severe eye or skin injury due to laser radiation

If the stability of the device is not ensured or the inlet aperture is not centered and mounted perpendicular to the laser beam, increased scattered or directed reflection of the laser beam will occur.

- **Align the device as described in chapter 6.3.3 on page 20.**
- **Install the device according to chapter 6.3.4 on page 22 in a way that ensures, that the device can not shift or fall.**

NOTICE

Damaging / Destruction of the device

Contamination and fingerprints on the protective window can lead to damage or shattering or splintering of the protective window during measuring operation.

- **Do not touch the protective window.**
- **Only operate the device with a clean protective window.**

6.3.2 Possible mounting positions

When used as a “Stand-Alone” device, the device can be mounted vertically or horizontally.

6.3.3 Align the device

The device must be aligned to the laser beam. The laser beam must hit the inlet aperture in the middle and perpendicular. Please mind and adhere to the specifications and limit values given in chapter 13 „Technical data“ on page 54.

Normally, the device is positioned underneath the focus position of the beam path for power measurement (divergent laser radiation). If this is not possible, the device can be positioned above the focus.
If the device is mounted above the focus, be aware that the laser radiation is convergent and that the maximum permissible power density on the absorber is not exceeded. The absorber position is approx. 2 mm under the protective window.

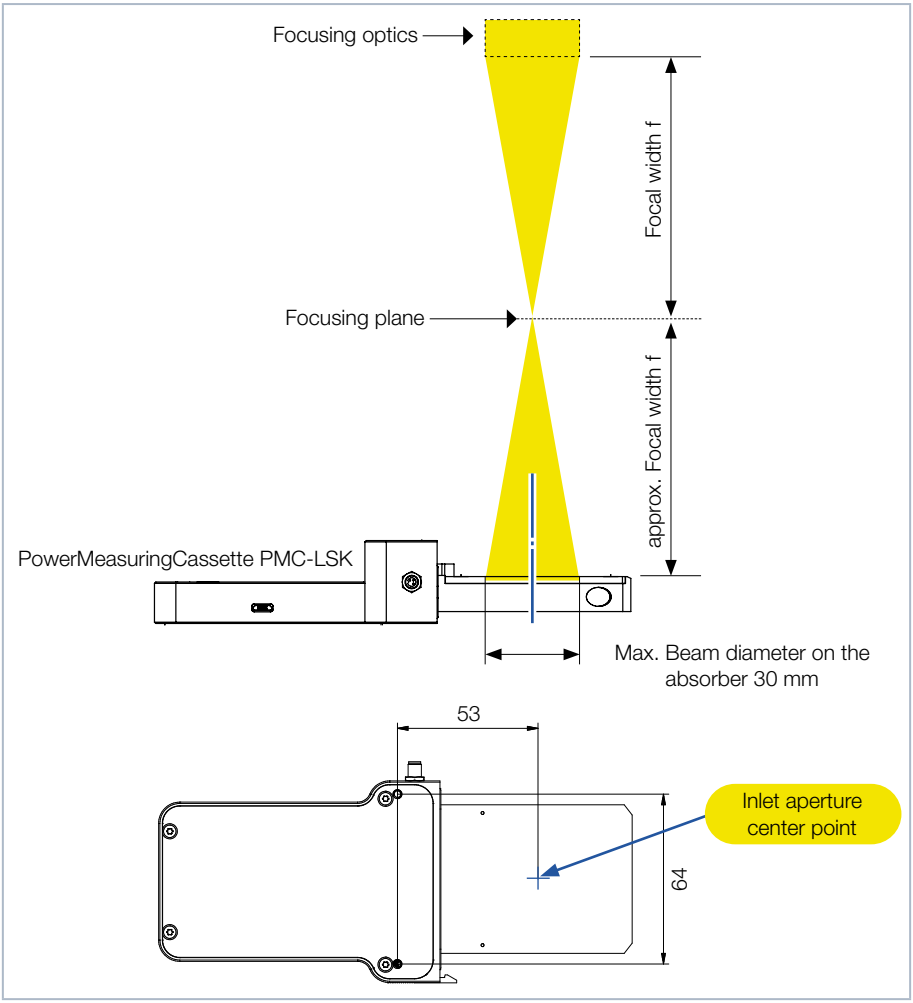


Fig. 6.1: Alignment to the laser beam (schematic) (dimensions in mm)

6.3.4 Mount the device

1. Align the device towards the laser beam as described in chapter 6.3.3 on page 20 and Fig. 6.1 on page 21.
2. Install the device with the mounting threads M3 at the bottom of the device (see Fig. 6.2 on page 22).
- Observe the maximum screw-in depth of 5 mm.
3. Ensure a stable installation of the device:
- It must no longer be possible to move the device.
4. Connect the safety interlock connection cable.
5. Remove the protective film from the protective window of the device.

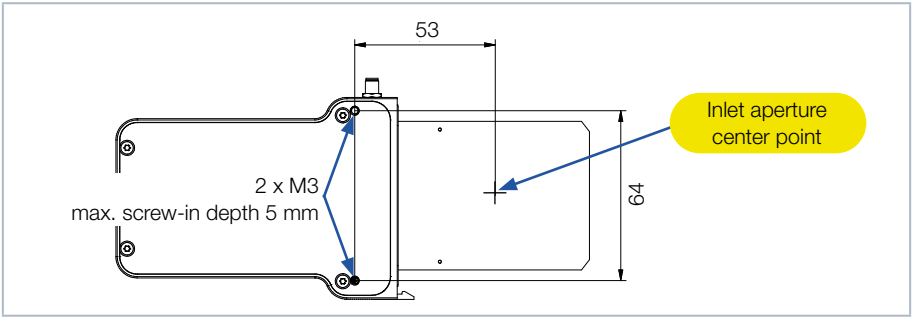


Fig. 6.2: Mounting threads in the housing (dimensions in mm)

6.3.5 Remove the device

1. Turn off the laser source.
2. Ensure that moving parts, e.g. robot arms, etc. are at a standstill and that they cannot be set in motion unintentionally.
3. Unscrew two screws from the mounting threads M3 on the underside of the device (see Fig. 6.2 on page 22).
4. Remove the safety interlock connection cable and remove the device from the laser system.
5. Apply a suitable protective film to prevent contamination of the protective window.

7 Connections

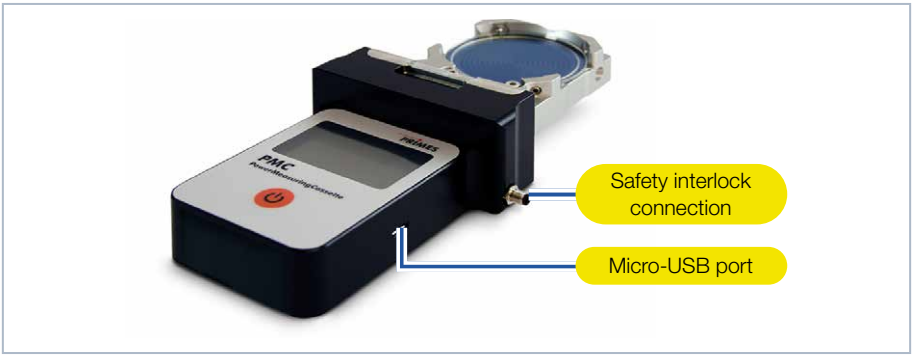


Fig. 7.1: Connections

7.1 Safety interlock

The use of the safety interlock protects the device from damage in many situations. Nevertheless, depending on the parameters of the laser beam to be measured, damage to the absorber may occur. Please observe the specifications and limit values given in chapter 13 „Technical data“ on page 54.

During irradiation, the temperature of the absorber can rise significantly above 100 °C for a short time because the heat has not yet been distributed evenly in the absorber. To avoid triggering the safety interlock during irradiation in this case, the safety interlock is only triggered at a temperature above 200 °C when irradiation is in progress.

Therefore, when a running irradiation is detected, the interlock threshold is temporarily increased from 100 °C to 200 °C. After the end of the irradiation, the interlock threshold is reduced again to 100 °C.
If the temperature of the absorber is above 100 °C after the measurement is completed, the safety interlock is triggered to protect the absorber. This prevents the device from being irradiated again.

Pin 3 and pin 4 are connected when a safety interlock is triggered. After the absorber has cooled down, pin 1 and pin 4 of the safety interlock are connected.
Please observe the information on minimum and maximum energy input per measurement according to chapter 8.2.3 on page 31.

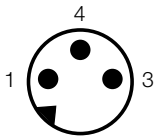
A suitable 2 m long connection cable is included.

NOTICE

Damaging / Destruction of the device

If the safety interlock is not connected, the device can be damaged or destroyed due to overheating.

▶ **When connecting the laser control, please ensure that the laser is turned off in case of an interruption of the connection.**

Pin diagram safety Interlock plug (view connector side)	Pin	Wire color	Function
	4	Black	Mutual pin
	1	Brown	Connected with pin 4 when ready for operation
	3	Blue	Connected with pin 4, when in safety interlock mode (absorber too hot)

Tab. 7.1: Pin assignment of the safety interlock plug

7.2 Micro-USB port

The Micro-USB port can be used to charge the device's battery on a PC or a compatible power supply unit. Only use the supplied USB cable to charge the battery.
When using the optional LaserDiagnosticsSoftware LDS (not included in delivery), the device communicates with the LDS via the Micro-USB port. For this purpose, the PRIMES USB driver must be installed on the PC.

Install the USB driver manually

The USB-driver can be found on the PRIMES website at: https://www.primes.de/en/support/downloads/software.html.

The driver installation requires administrator rights.

1. Download the USB driver from the PRIMES website.
2. Save the driver to a data carrier.
3. Connect the data carrier to a PC.
4. Double-click to start the driver installation software.
5. Follow the instructions on the screen.

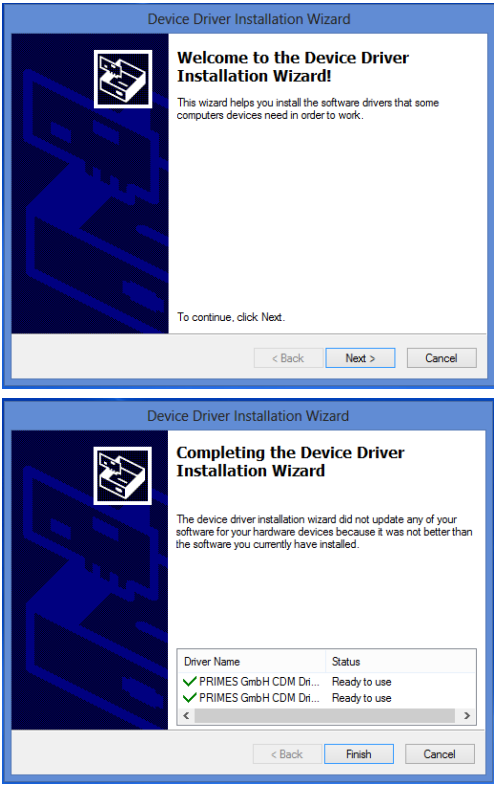


Fig. 7.2: Windows® menu for USB driver installation

6. Click ***Finish*** to complete the installation.

8 Important information for measuring with the PMC-LSK

8.1 Warning messages

DANGER

Severe eye or skin injury due to laser radiation
(when used as „Stand-Alone“ device)

If the stability of the device is not ensured or the inlet aperture is not centered and mounted perpendicular to the laser beam, increased scattered or directed reflection of the laser beam will occur.

- ▶ Install the device according to chapter 6.3.4 on page 22 in a way that ensures, that the device can not shift or fall.

DANGER

Severe eye or skin injury due to laser radiation
(when used as „Stand-Alone“ device)

During the measurement the laser beam is guided on the device, which causes scattered or directed reflection of the laser beam (laser class 4). The reflected beam is usually not visible.

- ▶ Please wear safety goggles adapted to the power, power density, laser wave length and operating mode of the laser beam source in use.
- ▶ Wear suitable protective clothing and protective gloves.
- ▶ Protect yourself from laser radiation by separating protective devices (e.g. by using appropriate shielding).

DANGER

Serious eye or skin injury due to laser radiation

If the device is pulled out of the laser processing head during the measurement, scattered or directed reflection of the laser beam will occur.

- ▶ First turn the laser source off and then remove the device from the laser processing head.

NOTICE

Damaging / Destruction of the device

The maximum permissible energy per laser pulse depends on various variables, including the absorber temperature.

- Please observe the limit values and dependencies specified in chapter 13 „Technical data“ on page 54 and chapter 15 „Appendix“ on page 57 before the measurement.

NOTICE

Damaging the device when using a ring-mode laser

If center beam and ring beam are measured simultaneously, the combined laser power (see chapter 8.2.2 on page 29) must not exceed the maximum permissible power density as given in chapter 13 „Technical data“ on page 54.

- If necessary, measure the center and ring beam separately.

NOTICE

Damaging / Destruction of the device or the laser system

Contamination and fingerprints on the protective window can lead to damage or shattering or splintering of the protective window during measuring operation.
When using the device within the laser processing head, parts of the protective window can get into the laser system and damage it.

- Do not touch the protective window.
- Regularly check the condition of the protective window and exchange it in case of pollution (see chapter 10.3 „Exchanging the protective window on the device“ on page 48).
- Only operate the device with a clean protective window.

8.2 Laser parameter setting

8.2.1 Setting the laser rise time

The applicable measurement time is between 0.1 s and 2.0 s, which has to be transferred to the laser controller as pulse length. The maximum laser rise time for measuring the power cannot exceed 100 µs. This limit has to be adhered to in order to avoid incorrect results of the power measurement.
Some laser beam sources are factory set with power ramps of up to a few 100 ms to switch on the laser beam. To achieve a high measuring accuracy the shortest possible rise time has to be set.

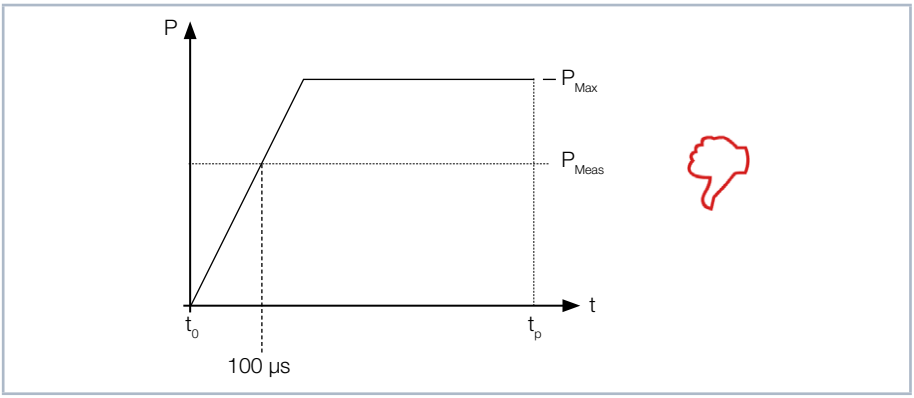


Fig. 8.1: Laser rise time > 100 µs

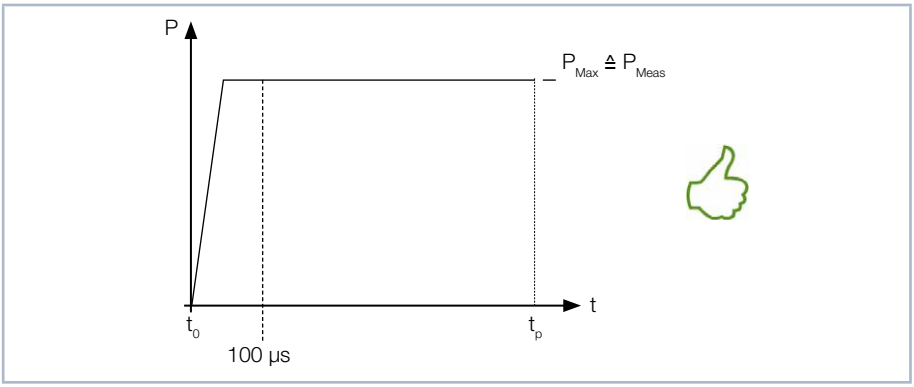


Fig. 8.2: Laser rise time < 100 µs

8.2.2 Maximum permissible power

To avoid damage to the absorber, the maximum permissible power density at the absorber must not be exceeded. The permissible power densities vary depending on the beam diameter. A list of the permitted power densities is given in chapter 13 „Technical data“ on page 54.

The power density in kW/cm² is calculated according to the formula:

$$Power\ density = \frac{P_{\ Laser\ power\ in\ kW}}{\pi \cdot r^2_{\ Beam\ radius\ in\ cm}}$$

Formula 1: Calculation of the power density

To determine the maximum laser power, the result is weighted with a safety factor of 2. The safety factor compensates the ratio of maximum to average power density of a gaussian beam (far field). The maximum permissible laser power in kW depending on the beam radius is calculated according to the formula:

$$P_{\ Laser\ power\ in\ kW} = max.\ Power\ density\ \frac{kW}{cm^2} \cdot \pi \cdot r^2_{\ Beam\ radius\ in\ cm} \cdot 0{,}5$$

Formula 2: Calculation of the permissible laser power depending on the beam diameter

Example: Using a ring-mode laser with a center beam diameter of 15 mm. As specified in chapter 13 „Technical data“ on page 54, the maximum permissible power density for a beam diameter > 10 mm is 4 kW/cm². The maximum laser power is calculated as follows:

P in kW = 4 kW/cm² · π · 0.75 cm · 0.75 cm · 0.5 = 3.5 kW

Fig. 8.3: Example calculation

Please note:
The example calculation assumes a slightly larger divergence of the ring beam compared to the center beam. As the resulting ring beam is bigger than 15 mm, a measurement up to 4 kW is possible.

Conclusion:
With the parameters given in the example calculation, the center beam can be measured up to a laser power of 3.5 kW, and the ring beam up to 4 kW.

NOTICE

Damaging the device when using a ring-mode laser

If center beam and ring beam are measured simultaneously, the combined laser power must not exceed the maximum permissible power density as given in chapter 13 „Technical data“ on page 54.

▶ **If necessary, measure the center and ring beam separately.**

When using a different laser, a different fiber optic cable or a change in the distances, the maximum permissible power must be calculated with the changed parameters.

For a quick determination of the maximum permissible laser power as a function of the beam diameter, a diagram is given in chapter 15 „Appendix“ on page 57.

8.2.3 Minimum and maximum energy input per measurement

The measured temperature rise in the absorber is decisive for an accurate and reproducible measurement. Regardless of the starting temperature, we recommend an energy input of approx. 300 J per measurement.

Example: At 1 kW laser power the recommended pulse length is 300 ms.

$E = P \cdot t = 1\,000\ W \cdot 0.3\ s = 300\ J$

Fig. 8.4 on page 31 shows information for selecting the energy permissible for a measurement in conjunction with the absorber temperature.

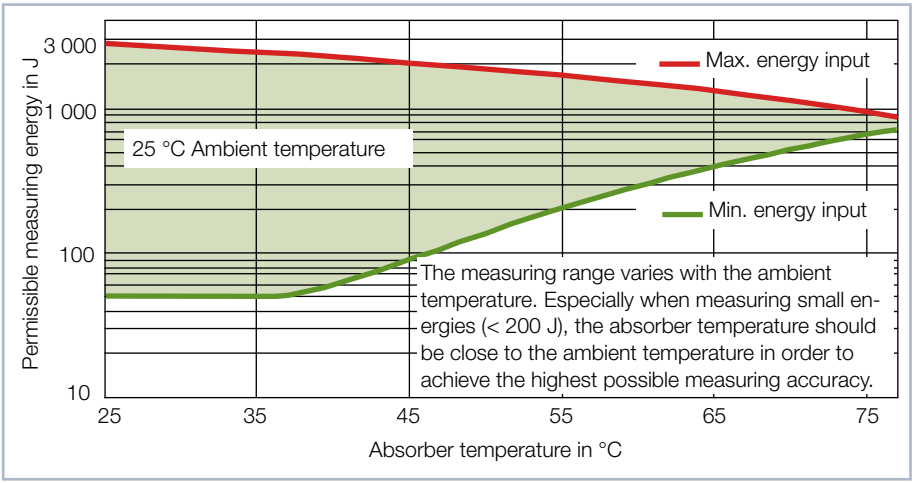


Fig. 8.4: Measuring range as a function of the absorber temperature

The minimum energy input indicates the lower limit values with which measurements can still be performed within the specified accuracy. The maximum energy application value specifies the limit at which the absorber reaches its permissible limit temperature. The energy, e.g. for multiple measurements (series measurements) can be distributed across the range shown in green.
If the absorber temperature is greater than 70 °C, it won't be possible to take any further measurements. In this case, please wait until the absorber temperature has fallen below 50 °C (depending on the selected energy input). Please take the limit values from Fig. 8.4 on page 31 and Tab. 8.1 on page 32.

Absorber temperature in °C	Min. energy input in J	Max. energy input in J
20	50	3 000
25	50	2 800
30	50	2 600
35	50	2 400
40	60	2 200
45	90	2 100
50	140	1 900
55	200	1 700
60	290	1 500
65	390	1 300
70	520	1 100

Tab. 8.1: Absorber temperature with the recommended minimum and permissible maximum energy input (ambient temperature 20 °C)

8.3 Waiting times until the next measurement in a measurement series

Please note that at high measuring frequencies the measuring accuracy may be limited. For serial measurements within the specified accuracy, we recommend the following waiting times until the next measurement.

Energy input in J	Minimum waiting time in s	Optimal waiting time in s
50	12	40
100	23	50
200	50	60
1 000	250	250

Tab. 8.2: Waiting times until the next measurement in series measurements

8.4 Measurement with pulsed lasers

When using pulsed laser radiation a correct exposure time measurement is possible up to a pulse frequency of 10 kHz and a duty cycle of 50 %. In case of on / off times shorter than 50 µs a correct exposure time measurement is not possible.

With pulsed lasers, the device recognizes the number of pulses n and the number of pulse pauses n-1. The last pulse pause t_{off} is not measured for physical reasons. This leads to an increased display of the average power with a low number of pulses. The average power is corrected on the basis of the corrected burst duration (see Fig. 8.5 on page 33).
For cw lasers and lasers with one pulse, the average power corresponds to the maximum power of one pulse.

Measurements with pulsed lasers, which have an oscillating switch-on and switch-off behavior outside the specifications according to chapter 13 „Technical data“ on page 54, can cause incorrect results for the number of recorded pulses. However, this has no effect on the calculated average laser power and energy.

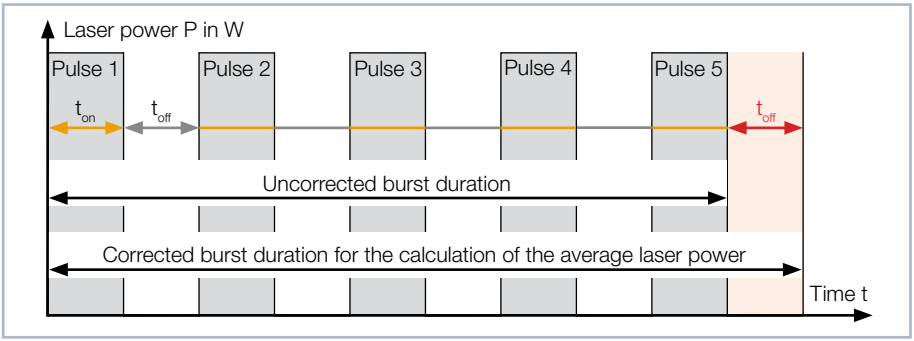


Fig. 8.5: Uncorrected and corrected burst duration with pulsed lasers

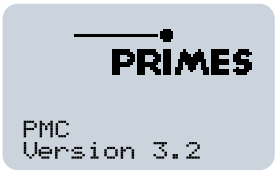
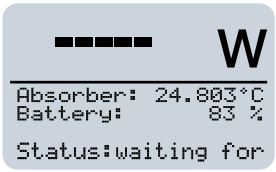
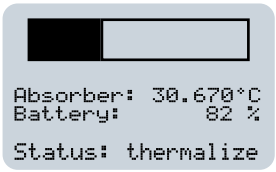
9 Measuring

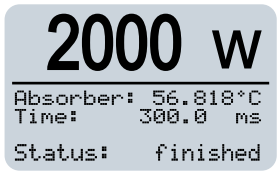
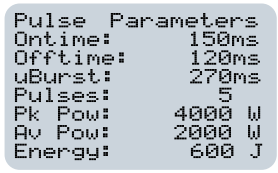
9.1 Measuring with the PowerMeasuringCassette PMC-LSK

Please read chapter 8 „Important information for measuring with the PMC-LSK“ on page 26 first.

9.1.1 Start measurement

Measurements with the PMC-LSK should be performed exclusively with a static (motionless) laser beam.

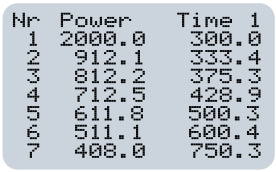
1. Observe the warning messages in chapter 8.1 on page 26.	
2. Press the on / off button.	
The start menu appears.	
After approx. 5 seconds, the device is ready for operation.	
3. Turn on the laser. ➔ The measurement with the PMC-LSK is started automatically when the the laser is switched on.	For a high measurement accuracy, we recommend an energy input of 300 J per measurement (see chapter 8.2.3 on page 31).
The thermalization is displayed by means of a progress bar (duration approx. 10 seconds). A measuring cycle (measure, thermalize, send data) takes approx. 15 seconds. The device is then ready for a new measurement.	

The window displays the following measurement values: • Laser power in W [1)] • Absorber temperature in °C • Corrected burst duration in ms (Time) **[1)] The average power over the entire irradiation time is displayed in W.**	
4. To access the following window, press the on / off button for approx. 2 seconds.	
For a pulsed laser the measured values of the pulse parameters are displayed: • Total pulse duration in ms (Ontime) • Total pulse pause in ms (Offtime) • Uncorrected burst duration in ms (uBurst) • Number of pulses (Pulses) • Max. Power of a pulse in W (Pk Pow) • Average power in W (Av Pow) • Energy in J Further information on measuring with pulsed lasers can be found in chapter 8.4 on page 33.	

In the delivery state, the device turns off automatically after approx. 10 minutes.
The power-off time of the device can be set via the LaserDiagnosticsSoftware LDS (see chapter 9.2.3 on page 40).
You can also turn off the device manually by keeping the on / off button pressed for approx. 5 seconds.

9.1.2 Measuring results display

The last 14 measured values can be read on the display of the PowerMeasuringCassette PMC-LSK. The latest measurement is always displayed with the counter “Nr. 1”. Using the optional LDS, the last 30 measured values can be read out.

1. Press the on / off button for approx. 2 seconds.	
The measured average laser power (Power) and pulse duration [1] (Time) are displayed. 2. Press the on / off button again for 2 seconds to have the remaining measuring values (no. 8-14) displayed. **[1] For cw lasers, the total irradiation time is displayed. For pulsed lasers, the corrected burst duration is displayed in ms (Time).**	

9.2 Measuring with the optional LaserDiagnosticsSoftware LDS

This chapter describes measurements with the optional LaserDiagnosticsSoftware LDS. For a detailed description of the software installation, file management and evaluation of the measured data, please refer to the separate operating manual LaserDiagnosticsSoftware LDS.

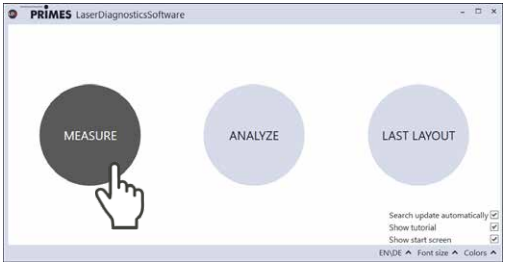
Please read chapter 8 „Important information for measuring with the PMC-LSK“ on page 26 first.

9.2.1 Switch on the device and connect it to the LDS

1. Observe the warning messages in chapter 8.1 on page 26.
2. Connect the USB cable to the Micro-USB port on the device and with the PC (see Fig. 7.1 on page 23).
3. Press the on / off button on the device.
4. Start the LDS by double-clicking on the program icon in the start menu group or on the desktop icon.

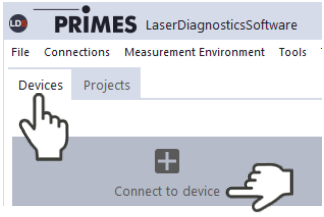
The start screen appears.

5. Select the operating mode ***Measure***.



Only if the *Show start screen* option is disabled:

▶ Click on the ***Devices*** tab and then on the ***+ Connect to device*** button.



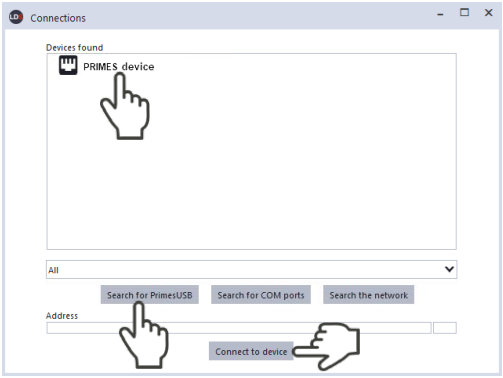
The ***Connections*** window appears.

6. Click on the desired device.

7. Click on the ***Connect to device*** button.

If the device does not appear:

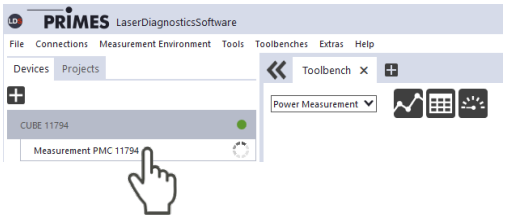
1. Click on the ***Search for Primes USB*** button.
2. If the device still does not appear in the Connections window, install the USB driver according to chapter 7.2 on page 24.



9.2.2 Open toolbench

The PMC-LSK is established as a connected device.

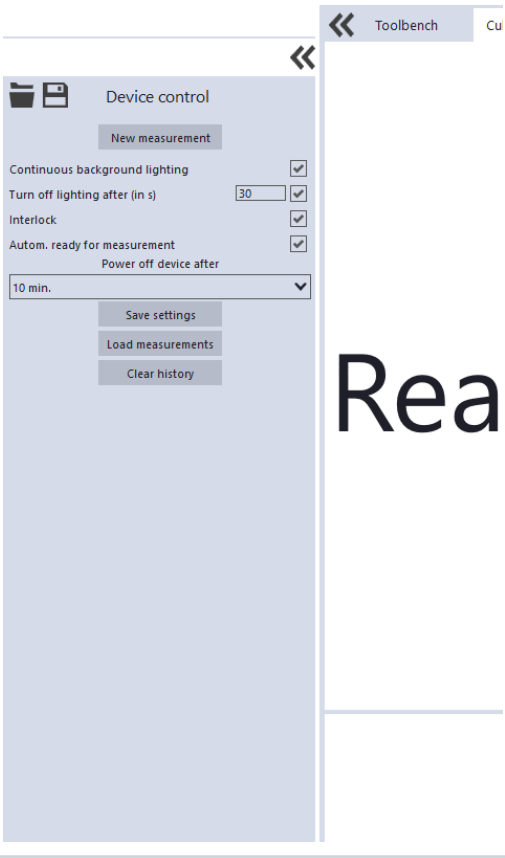
1. Click on the connected device.



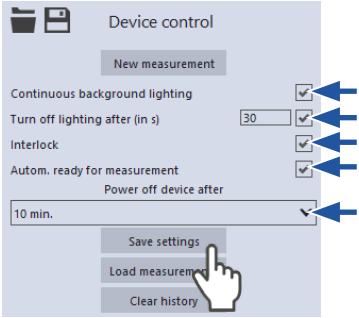
The corresponding ***Device control*** opens.

The toolbench ***Cube Measurement*** is opened.

If the toolbenches have previously been closed, click the ***Open measurement toolbench*** button to open it again.



9.2.3 Settings for power saving functions and automatic measurement readiness

In the LaserDiagnosticsSoftware LDS you can make additional settings for power saving functions and the automatic measurement readiness. 1. Enter the desired settings in the ***Device control***. 2. Click on the ***Save settings*** button.	
Autom. ready for measurement	By default, the device automatically returns to measurement readiness after each measurement. If you uncheck the box, you will need to reset the unit after each measurement by briefly pressing the on / of button.
Power Saving Function	Switch permanent background lighting on / off
	Turn off lighting after (in s). The set time only applies if the permanent backlight is switched off.
	Switch the safety interlock on / off. For safety reasons switching off the safety interlock is not recommended.
	Switch off the device after a set time. When a charging cable is connected, the device does not switch off automatically. The device is then permanently ready for measurement.

9.2.4 Start measurement

Measurements with the PMC-LSK should be performed exclusively with a static (motionless) laser beam.

The measurement is started automatically when the laser is switched on. The display field ***Start*** is therefore not active.
A measuring cycle (measure, thermalize, send data) takes approx. 15 seconds. The device is then ready for a new measurement.

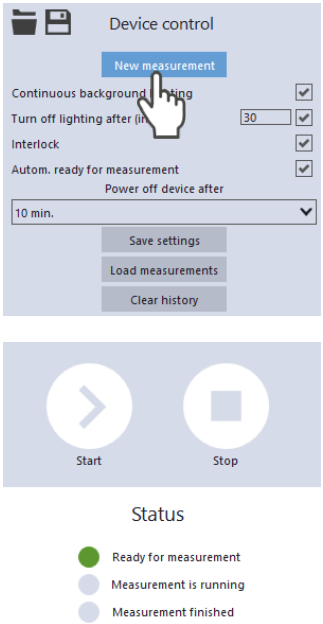
If a measurement was previously displayed in the workbench, press the ***New measurement*** button.

If the setting ***Autom. ready for measurement*** (see chapter 9.2.3 on page 40) is deactivated, briefly press the on / off button on the device.

1. Observe the warning messages in chapter 8.1 on page 26.
2. Turn on the laser.

The progress of the measurement is indicated in the ***Measurement is running*** and then ***Measurement is finished*** displays.

3. Turn off the laser.

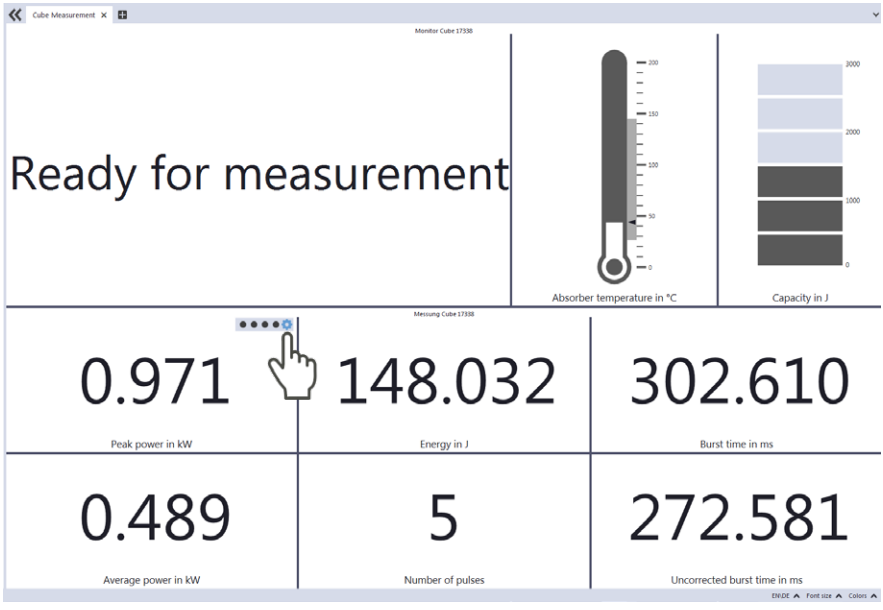


9.2.5 Measuring results display

Display the current measurement in the toolbench Cube measurement

The measurement results are displayed in the open toolbench after the measurement is finished (see below).

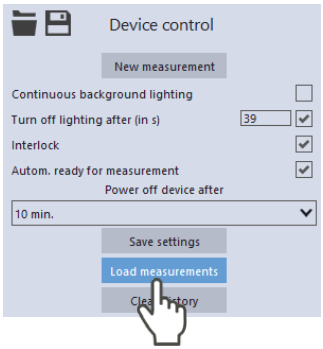
By clicking on the gear symbol you can adjust the displayed parameters.



Display of the measurements stored in the PMC-LSK

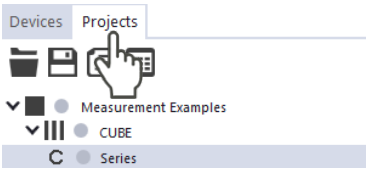
1. Press the ***Load measurements*** button

➔ The last 30 measured values stored in the device are read out of the memory of the PMC-LSK.



2. Switch to the ***Projects*** tab.

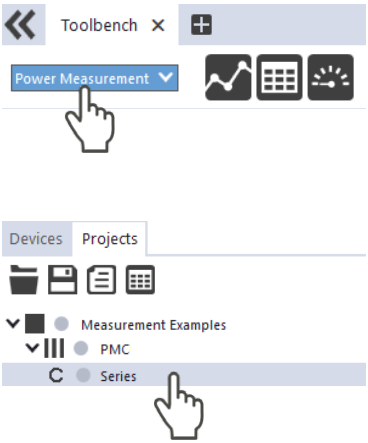
👁 In the project tree the read out measured values are displayed.



3. Click on the ***Power Measurement*** selection in the drop-down list below the Toolbench.

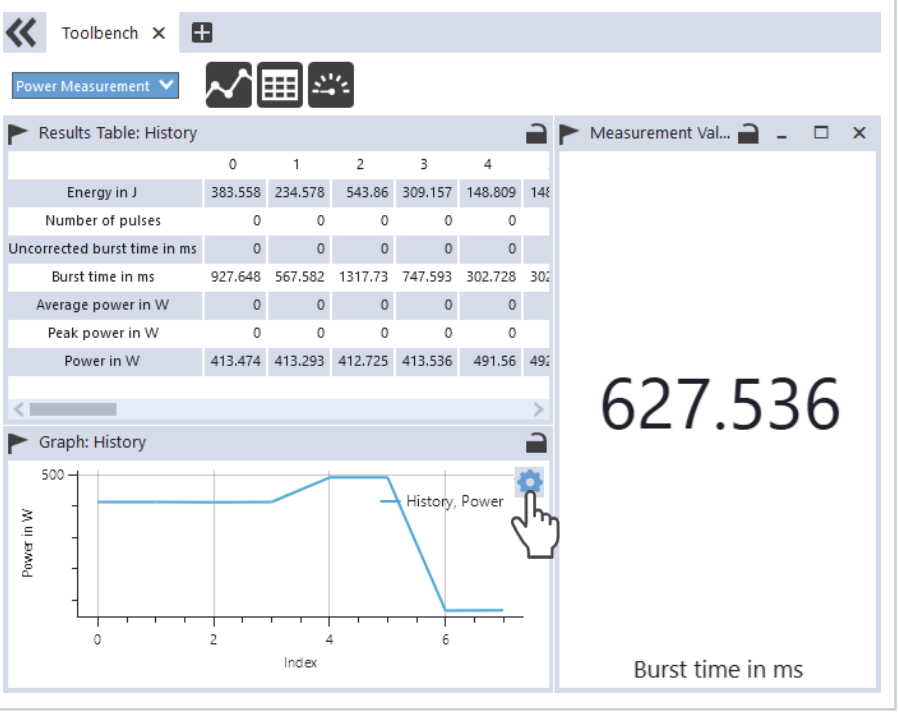
👁 The tools ***Graph***, ***Results Table*** and ***Measurement Value Display*** are displayed.

4. Open the desired tool and drag and drop the measured values from the project tree into the opened tool.



By clicking on the gear symbol you can adjust the displayed parameters.

Please note:
The latest measurement is always displayed with the counter “0”.

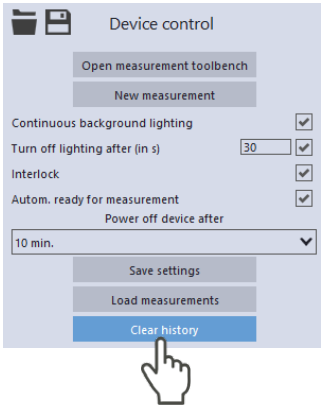


9.2.6 Delete measured values from the memory of the PMC-LSK

The PMC-LSK stores the measured values in an internal memory. The measured values can be deleted with the LaserDiagnosticsSoftware LDS.

1. Click on the ***Clear history*** button.

➔ The measured values in the PMC-LSK are deleted.

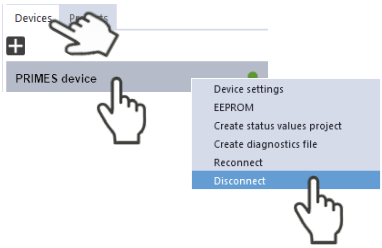


9.2.7 Disconnect and switch off the device

1. Click on the ***Devices*** tab.
2. Right-click on the device and select the ***Disconnect*** menu point.

➔ The device is no longer connected to the LDS.

3. Switch off the device by pressing the on / off button for 5 seconds.
4. Only then disconnect other electrical connections.



9.2.8 Messages in the LaserDiagnosticsSoftware LDS during measurement

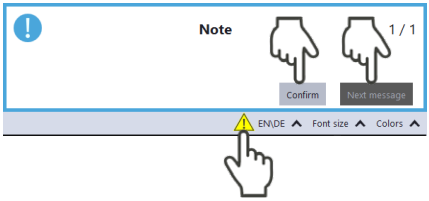
If problems occur during a measurement, the LaserDiagnosticsSoftware LDS displays them in different categories and different colors.

Notes

Notes provide assistance in interpreting the measurement results and are displayed in a blue window.

Use one of the following options:

- ▶ Click on the warning triangle in the footer to display / hide the window.
- ▶ If applicable, click the ***Next message*** button to display more messages of the same category.
- ▶ Click the ***Confirm*** button to remove the displayed message.

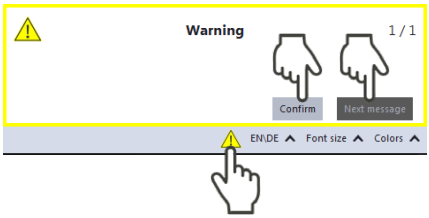


Warnings

Non-safety-critical problems that influence the quality of the measurement results, for example, are displayed in a yellow window.

Use one of the following options:

- ▶ Click on the warning triangle in the footer to display / hide the window.
- ▶ If applicable, click the ***Next message*** button to display more messages of the same category.
- ▶ Click the ***Confirm*** button to remove the displayed message.



Safety critical device errors

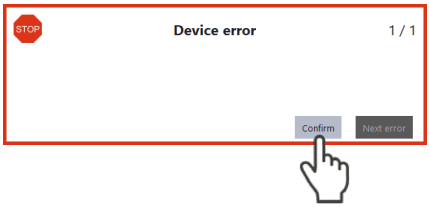
Safety-critical problems that can result in damage / destruction of the device are displayed in a red window.

In this case, proceed as follows:

1. Fix the problem immediately.
2. Click the ***Confirm*** button to remove the message.

The message disappears. If the problem is not fixed, then the message appears again shortly afterwards.

3. Do not proceed with the measurement until the problem is fixed.



10 Maintenance and service

10.1 Maintenance intervals

The operator is responsible for determining the maintenance intervals for the measuring device.
PRIMES recommends a maintenance interval of 12 months for inspection and calibration. If the device is used only sporadically, the maintenance interval can also be extended up to 24 months.
Please note that the safety and warning functions of the device must be checked regularly.

10.2 Cleaning

Let the device cool down for an adequate period of time.

10.2.1 Cleaning the device surfaces

1. Close all device openings.
2. First clean the device surfaces with cleaned, oil-free compressed air.
3. For further cleaning, use a mixture of distilled water and isopropanol in a ratio of approx. 5:1.
   Use lint-free cleaning wipes that do not cause scratches. This can be e.g. microfiber wipes or paper towels from the cosmetics sector.
4. If these steps are not sufficient, please contact PRIMES or your PRIMES distributor.

10.2.2 Cleaning the protective window

1. Dismount the protective window according to chapter 10.3.2 on page 50.
2. First clean the protective window with cleaned, oil-free compressed air.
3. For further cleaning, use isopropanol (observe the manufacturer‘s safety instructions).
   The coating of the protective window is particularly sensitive to scratches. Use wipes suitable for cleaning protective windows.
4. Replace the protective window with a new one if the contamination cannot be removed or if it is damaged.

10.3 Exchanging the protective window on the device

The protective window in the beam entrance is a wearing part and can be replaced if necessary.

The protective window is coated with an anti-reflective coating and has low reflectance values of less than 1 %. To avoid increased reflection, use only original PRIMES protective windows.

PMC-LSK

Protective window diameter	55 mm
Glass thickness	1.0 mm
Order number	410-030-004 (1 piece); 410-030-005 (10 pieces)

10.3.1 Warning messages

DANGER

Severe eye or skin injury due to laser radiation

If the protective window is not positioned correctly, reflections can cause directional laser radiation.

- ▶ Make sure that the new protective window lies flat underneath the four ball heads.

CAUTION

Burns due to hot components

After a measurement the absorber below the protective window is hot! Unintentional contact during the protective window exchange could lead to burns.

- ▶ Do not clean or replace the protective window directly after a measurement.
- ▶ Let the device cool down for an adequate period of time.

NOTICE

Damaging / Destruction of the device or the laser system

Contamination and fingerprints on the protective window can lead to damage or shattering or splintering of the protective window during measuring operation.
When using the device within the laser processing head, parts of the protective window can get into the laser system and damage it.

- ▶ Only replace the protective window in a dust-free environment.
- ▶ Do not touch the protective window or the absorber.
- ▶ When exchanging the protective window wear suitable gloves.

10.3.2 Exchanging the protective window of the PMC-LSK

1. Observe the warning messages in chapter 10.3.1 on page 49.
2. Place the device as shown in Fig. 10.1 on page 50.
3. Put on suitable gloves.
4. Carefully pull the protective window upwards in the direction of the arrows over the four spring-actuated ball heads.
   Make sure that the inserted O-ring does not fall out of the device.
5. Dispose of the old protective window.
6. Check the new protective window for contamination.
7. Insert the new protective window into the device from above.
   Ensure that the inserted O-ring is not out of place.
8. Carefully press the protective window over the four spring-actuated ball heads.
9. Check that the protective window is securely seated:
   The protective window must lie flat in the device underneath the four ball heads.

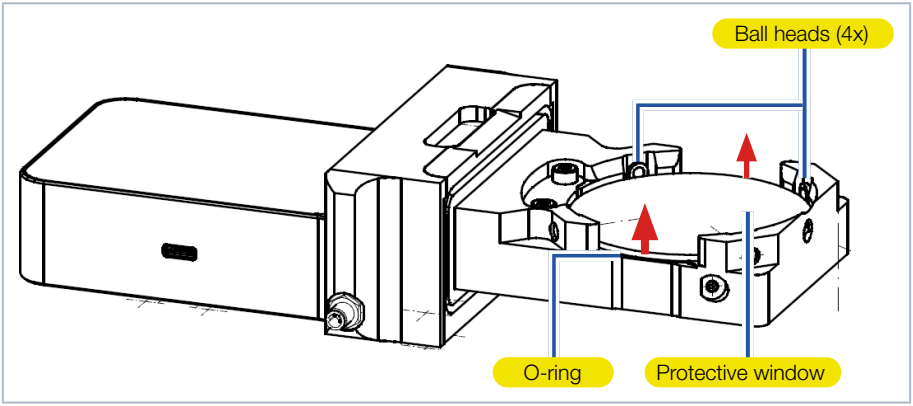


Fig. 10.1: Exchanging the protective window

11 Measures for the product disposal

PRIMES gives you the opportunity to return your PRIMES measuring device for free disposal within the scope of the Waste of Electrical and Electronic Equipment (WEEE Directive). This service does not include shipping costs. You can send PRIMES measuring devices to be disposed of within the EU to our address:

PRIMES GmbH
Max-Planck-Str. 2
64319 Pfungstadt
Germany

If you are located outside the EU, please contact your local PRIMES distributor to discuss the disposal procedure for your PRIMES measuring device.

PRIMES is a registered manufacturer in the German “Used Appliances Register“ stiftung elektro-altgeräte register (stiftung ear). Our number is: WEEE-reg.-no. DE65549202.

Please note that there is a permanently installed lithium-ion battery in the device.
This must be disposed of in accordance with the applicable national and international laws if the device is not returned to PRIMES.

12 Declaration of conformity

Original EG Declaration of Conformity

The manufacturer: PRIMES GmbH, Max-Planck-Straße 2, 64319 Pfungstadt, Germany,

hereby declares that the device with the designation:

PowerMeasuringCassette (PMC)

Types: PMC-C; PMC-BEO; PMC-YW; PMC-ALO; PMC-LSK

is in conformity with the following relevant EC Directives:

- EMC Directive EMC 2014/30/EU
- Radio Equipment Directive 2014/53/EU (PMC-C only)
- Directive 2011/65/EC on the restriction of the use of certain hazardous substances (RoHS) in electrical and electronic equipment

Authorized for the documentation:
PRIMES GmbH, Max-Planck-Straße 2, 64319 Pfungstadt, Germany

The manufacturer obligates himself to provide the national authority in charge with technical documents in response to a duly substantiated request within an adequate period of time.

Pfungstadt, June 15, 2021

Dr. Reinhard Kramer, CEO

UKCA Declaration of Conformity

The manufacturer: PRIMES GmbH, Max-Planck-Straße 2, 64319 Pfungstadt, Germany,

hereby declares that the device with the designation:

PowerMeasuringCassette (PMC)

Types: PMC-C; PMC-BEO; PMC-YW; PMC-ALO; PMC-LSK

is in conformity with the following relevant EC Directives:

- Electromagnetic Compatibility Regulations 2016
- Radio Equipment Regulations 2017 (PMC-C only)
- The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012

Authorized for the documentation:
PRIMES GmbH, Max-Planck-Straße 2, 64319 Pfungstadt, Germany

The manufacturer obligates himself to provide the national authority in charge with technical documents in response to a duly substantiated request within an adequate period of time.

Pfungstadt, June 15, 2021

Dr. Reinhard Kramer, CEO

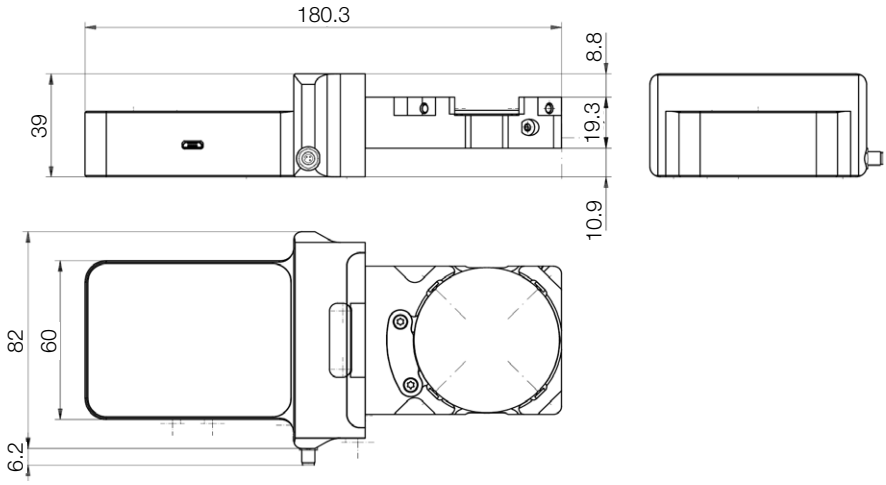
13 Technical data

Measurement parameters		
Power range		400 – 12 000 W [1]
Wavelength range		900 – 1 090 nm
Max. beam diameter on the absorber		30 mm
Max. power density (peak) on the absorber (approx. 2 mm underneath the protective window) at beam diameters	> 10 mm	4 kW/cm²
	10 – 3 mm	5 kW/cm²
	3 – 1.5 mm	10 kW/cm²
	< 1.5 mm	12 kW/cm²
Irradiation time		0.1 – 1 s [1] (depending on laser power)
Min. on / off times (duty cycle) for pulsed lasers		50 µs (e.g. max. 10 kHz at 50 % duty cycle)
Max. laser rise time		100 µs
Energy per measurement		50 – 3 000 J
Recommended energy per measurement		300 – 500 J
Total duration until measurement value output		< 15 s
Nominal measurement frequency		300 J: 1 cycle/min 3 000 J: 1 cycle/15 min
Device parameters		
Max. absorber temperature		120 °C
Max. angle of incidence perpendicular to inlet aperture		± 5 °
Max. centered tolerance		± 2.0 mm
Measuring accuracy at angles of incidence up to 5 °		± 3 %
Reproducibility		± 1 %

[1] The stated limit values are to be understood in correlation with the permitted maximum energy (E = P · t).

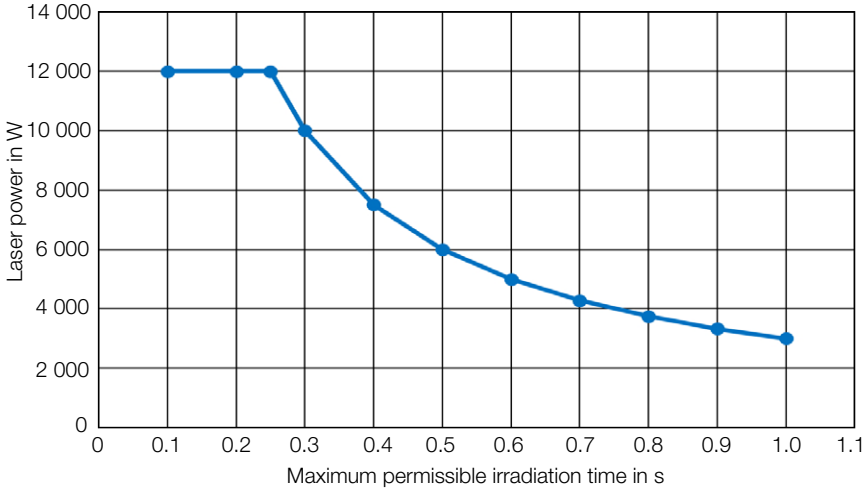
Supply Data	
Power supply	Built-in lithium-ion battery
Voltage	3.7 V
Capacity	1 400 mAh
Energy	5.2 Wh
Weight of the battery	25 g
Shipment classification	Lithium ion batteries contained in equipment
Temperature range for charging the lithium-Ion battery	0 – 45 °C
Communication	
Interfaces	USB
Dimensions and Weight	
Dimensions (LxWxH)	180.3 x 88.2 x 39 mm
Weight (approx.)	ca. 924 g
Environmental Conditions	
Operating temperature range	15 – 40 °C
Storage temperature range	5 – 50 °C
Reference temperature	22 °C
Permissible relative humidity (non-condensing)	10 – 80 %

14 Dimensions

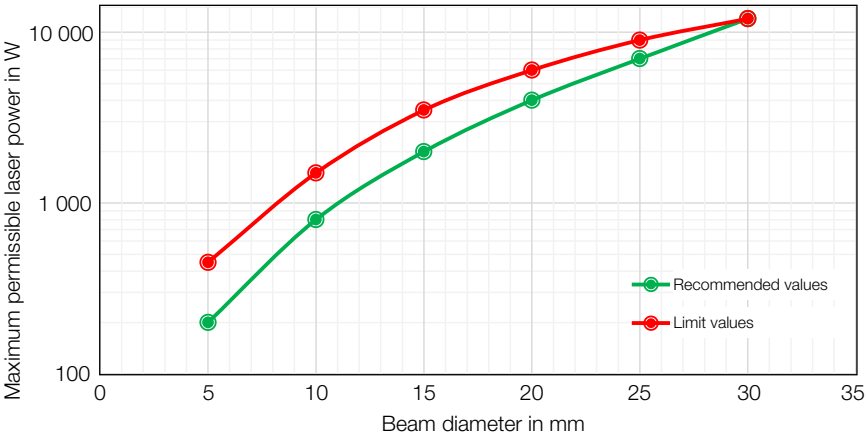


15 Appendix

15.1 Max. laser power depending on the irradiation time



15.2 Max. laser power depending on the beam diameter



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