PRIMES

Original Operating Manual

PowerMonitor EC-PM

LaserDiagnosticsSoftware LDS

PowerMonitorSoftware PMS

Revision 02 EN - 10/2024

IMPORTANT!

READ CAREFULLY BEFORE USE.

KEEP FOR FUTURE USE.

Table of contents

PRIMES - the company

PRIMES is a manufacturer of measuring devices for the analysis of laser beams. These devices are used for the diagnostics of high-power lasers. This ranges from CO_2 lasers to solid-state and fiber lasers to diode lasers and the wavelength ranges from IR to near UV. A wide range of measuring devices is available 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 device has been designed exclusively for measurements in the beam of high-power lasers.

Use for any other purpose is considered as not intended and is strictly prohibited. Furthermore, intended use requires that all information, instructions, safety notes and warning messages in this operating manual are observed. The specifications given in chapter 14 „Technical data“ on page 66 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 (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:

- Never leave the device unattended when taking measurements.
- 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.
- If the device is moved from its aligned position, 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 unintentionally, i.e. by bumping or pulling 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.

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 unauthorized 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 Icons and conventions

Warning messages

The following icons 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 **may** occur if necessary safety precautions are not taken.

CAUTION

Means that minor physical injury **may** occur if necessary safety precautions are not taken.

NOTICE

Means that property damage **may** occur if necessary safety precautions are not taken.

Product safety labels

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

Read and understand the operating manual before using the device!

Electrical voltage warning!

Do not reach inside!

Labeling according to WEEE directive:

The device must not be disposed of with household waste, but in a separate WEEE collection in an environmentally friendly way.

Further icons and conventions in this operating manual

Here you will find useful information and helpful tips.

▶ Indicates a single instruction.

If several of these instructions appear one below the other, the order in which they are executed is irrelevant or they represent alternative courses of action.

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

→ 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 PowerMonitor EC-PM (Electronically Calibrated) and how to perform measurements:

- as a stand-alone-device
- with the LaserDiagnosticsSoftware LDS version 3.0 or higher
- with the PowerMonitorSoftware PMS

In this operating manual, the abbreviations EC-PM, LDS and PMS are used.

For measurement operation with a PC, the LDS or the PMS must be installed on the PC. The LDS and PMS are included in the scope of delivery. PRIMES will also be happy to provide you with a current download link.

For this purpose, contact your sales partner or send an e-mail to: ***support@primes.de***

The compatibility of your EC-PM with the LDS is indicated by the LDS symbol on the identification plate. If the identification plate does not bear the LDS symbol, the device is not compatible with the current LDS Version. Please use the PMS instead.

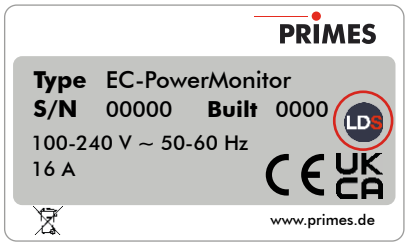


Fig. 3.1: Identification plate with LDS symbol

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 LDS.

This operating manual describes the software version valid at the time of printing. Since the LDS is subject to continuous development, the supplied data medium may have a newer version number.

4 Device description

4.1 Type overview

The EC-PM can be equipped with different power supplies:

- 100-240 V
- 100-120 V

The specific power supply for the device is marked on the identification plate.
The 100-120 V device type is additionally marked with a warning label:

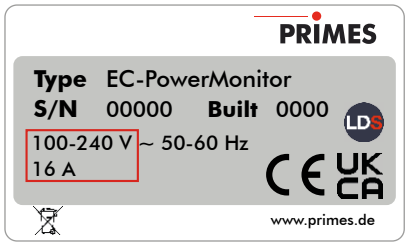
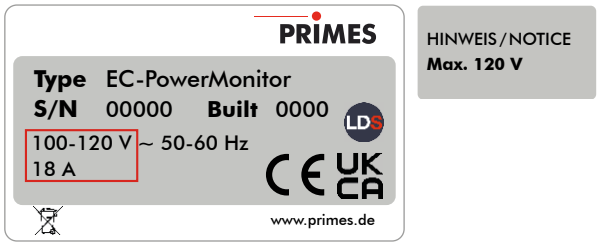
EC-PM with 100-240 V power supply	EC-PM with 100-120 V power supply
	

Fig. 4.1: Identification of the power supply

4.2 Functional description

The EC-PM is a measuring device for determining the power of laser beams in the multi-kilowatt range with wavelengths in the CO_2, NIR and VIS range.

The main application is to monitor the laser power available in the processing area of CO_2, solid-state lasers or high-power diode lasers. With its integrated self-test function, the EC-PM can also be used as a factory standard for other calorimeters for calibration purposes.

The device is suitable for measuring collimated laser beams as well as divergent and convergent laser beams.

Fig. 4.2: Functional description

4.3 Measuring principle

The EC-PM offers a fast power measurement using the calorimetric measuring principle with active cooling.

The laser beam hits a deflection mirror in the device. This deflects the beam through an aperture and expands it so that it irradiates as much absorber surface as possible.

The total irradiated laser power is absorbed by a water-cooled absorber in the device. The absorbed power is determined by measuring the cooling water flow rate and the temperature difference between water supply and water return.

Based on the temperature rise and thermal properties of the absorber, the microprocessor-based electronics are able to calculate the laser power with a high degree of accuracy.

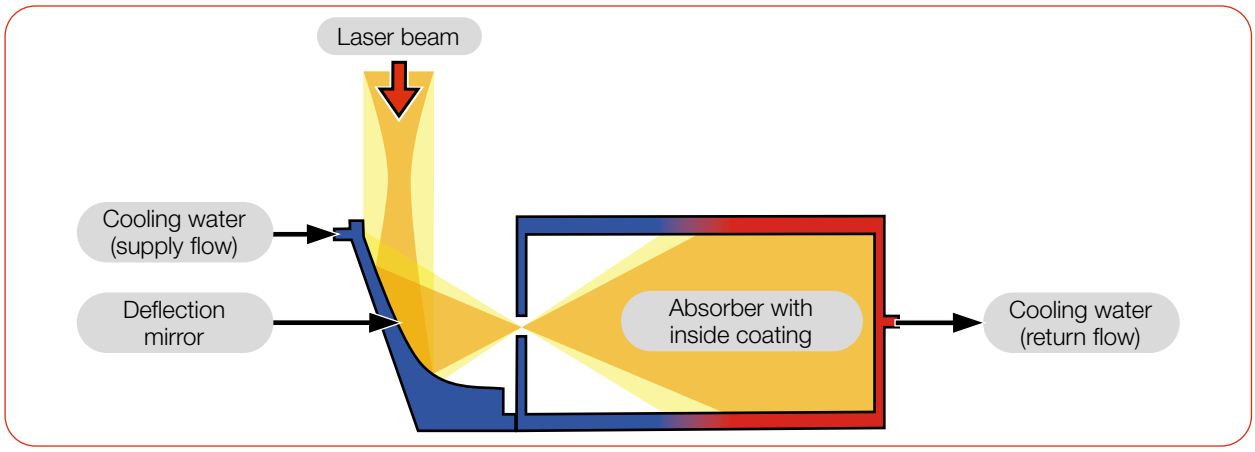


Fig. 4.3: Measuring principle (schematic)

4.4 Electronic calibration

With the integrated self-test function, the measuring accuracy of the device can be checked at any time.

A heating cartridge heats the cooling water and the electrical heat output is determined calorimetrically. This value is compared with the electrical power consumed by the heating cartridge.

For this purpose, the EC-PM has high-precision measuring systems for current consumption and operating voltage of the heating cartridge.

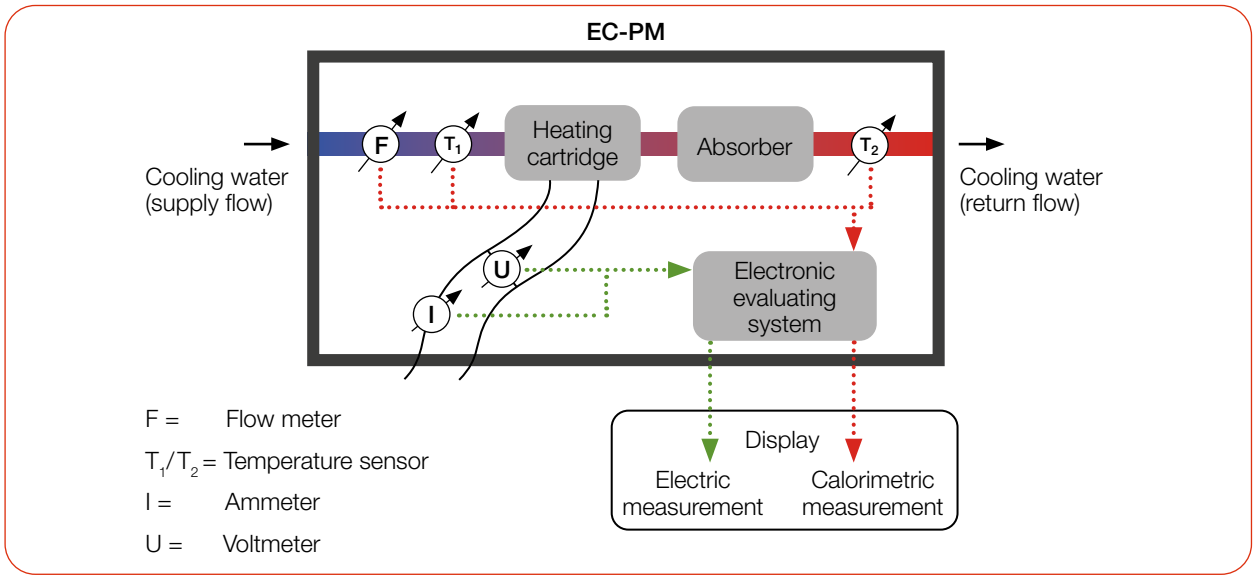


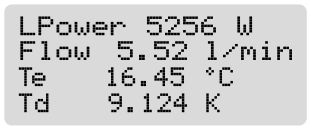
Fig. 4.4: Measuring principle of electronic calibration (schematic)

4.5 Optical displays and acoustic signal

4.5.1 Display

The display shows the following measured values:

Display	Meaning
LPower	Laser power in W
Flow	Flow rate of the cooling water in l/min
Te	Cooling water temperature at the water supply (Water In) in °C
Td	Temperature difference between water supply (Water In) and water return (Water Out) in Kelvin



Tab. 4.1: Meaning of the abbreviations on the display

4.5.2 LEDs

The LEDs indicate different states of the EC-PM.

LED	Color	Meaning
Power	Green	Power supply is switched on.
Error	Red	The safety interlock was triggered by at least one of the following conditions: • the cooling water flow is too low (Flow < 4 l/min) • the cooling water temperature at the water supply (Water In) is too high (Te > 70 °C) • the temperature difference between water supply (Water In) and water return (Water Out) is too large (Td > 50 K) • the shutter is not (completely) open

Tab. 4.2: Meaning of the LEDs

4.5.3 Acoustic warning signal

If the permitted temperature of the absorber of 60 °C is exceeded, a warning signal will sound:

▶ Switch off the laser immediately.

The further troubleshooting procedure is described in chapter 10.3 „Acoustic warning signal“ on page 61.

4.6 Explanation of the product safety labels and warning labels

Potential hazard areas are marked on the device with product safety labels and warning labels:

Warning label „Hinweis/Notice Max. 120 V“ (only 100-120 V type)

Connecting the 100-120 V device type to a 230 V power supply will damage the device. Before start-up, make sure that the provided mains voltage corresponds to the nominal voltage on the identification plate.

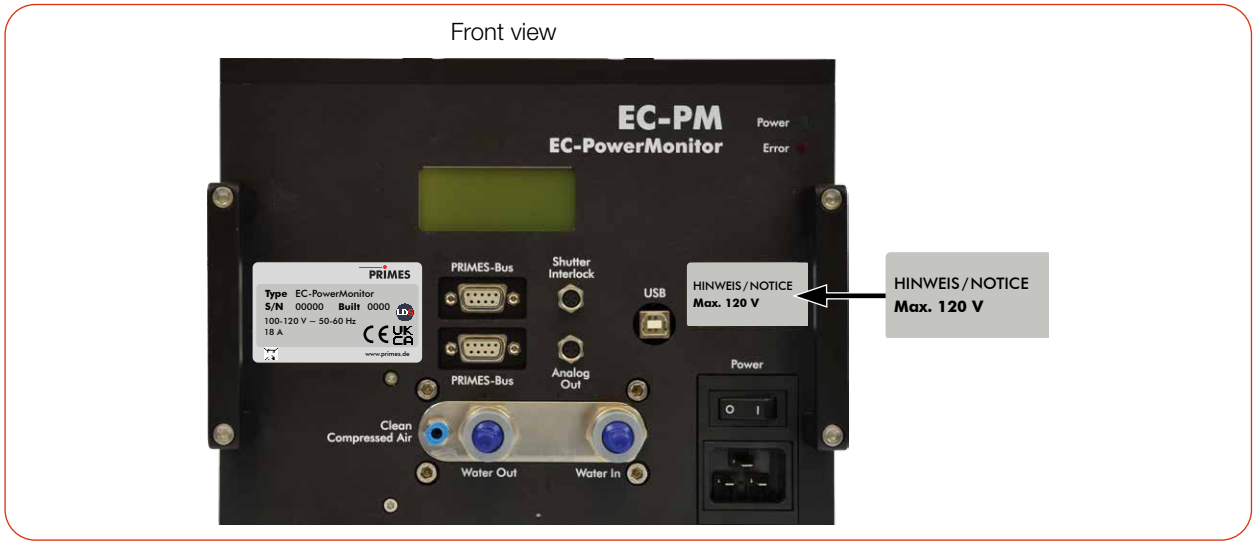


Fig. 4.5: Warning label „Notice max. 120 V“

Product safety label “Electrical voltage warning – Disconnect mains before opening”

To mount the device on a customer specific mount, the sheet metal housing must be removed. Pull the mains plug before opening the device. There are live parts under the sheet metal housing that cause an electric shock if touched. Do not loosen the screw of the grounding cable ⏚ on the sheet metal housing.

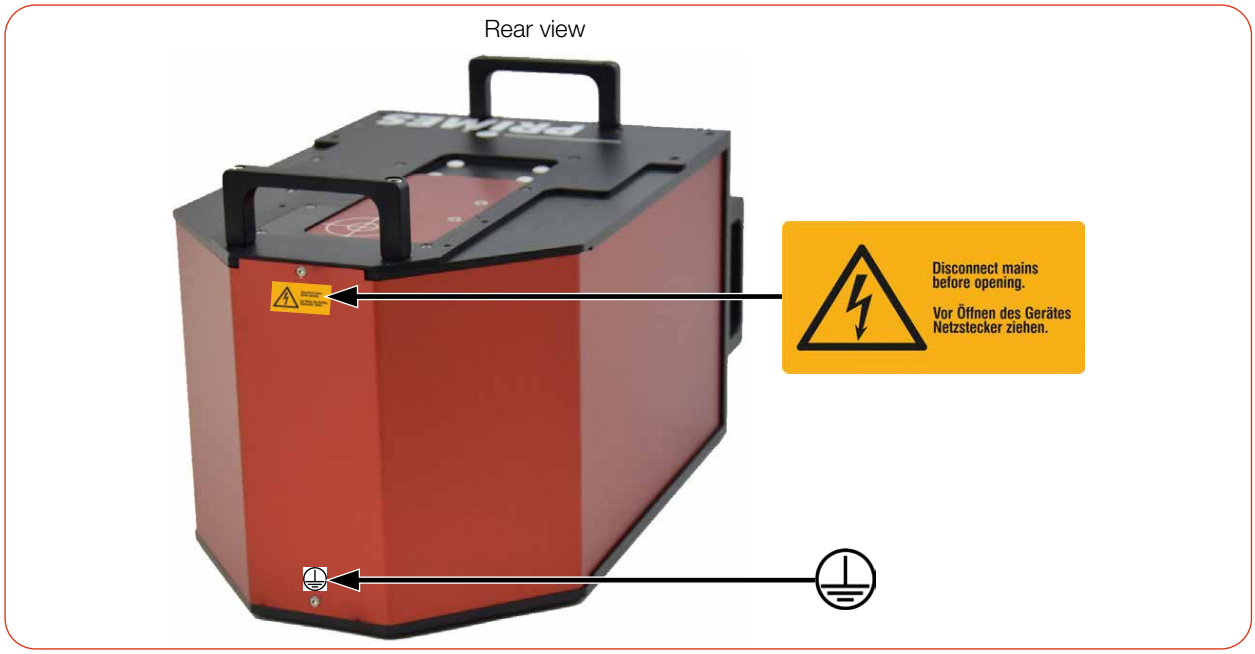


Fig. 4.6: Product safety label “Electrical voltage warning” and position of the grounding cable

Product safety label “Do not reach inside”

Do not reach into the entrance aperture. Touching the deflection mirror underneath the shutter can lead to localized absorption of the laser radiation at the points of contact, leading to burn marks and increased scattered radiation.

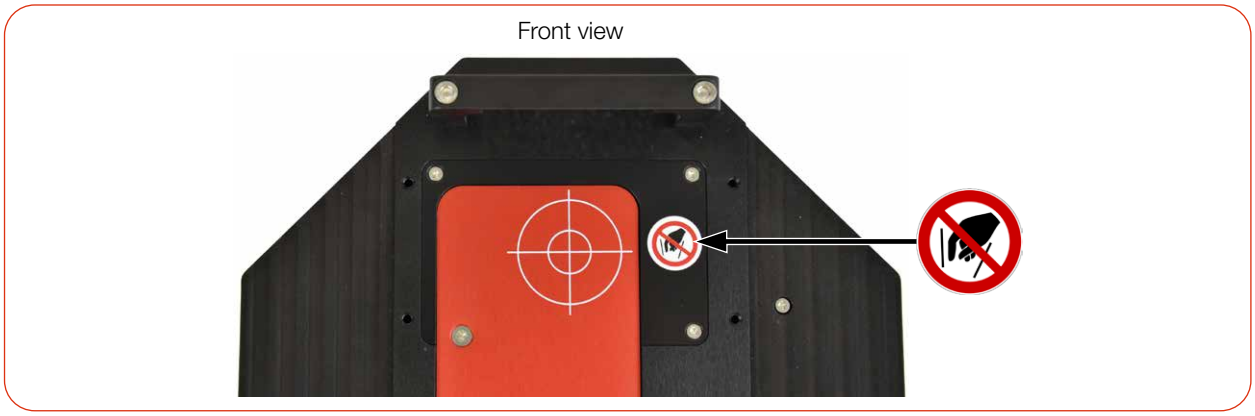


Fig. 4.7: Product safety label “Do not reach inside”

Warning label “Do not use compressed air”

The flow meter is damaged by the use of compressed air in the cooling circuit. Do not use compressed air for emptying the cooling circuit.

Fig. 4.8: Warning label „Do not use compressed air“

4.7 Scope of delivery and optional accessories

The scope of delivery includes:

- PowerMonitor EC-PM with oval wheel meter
- PRIMES USB flash drive
- Operating manual
- Country specific PRIMES power cable
- USB cable (B to A connector), 5 m
- PRIMES RS485/RS232 converter:
  - 2 D-Sub cable, 1.8 m
  - Extension cable, 10 m
  - USB-serial converter, 0.1 m
- Analog out cable, 5 m
- Safety interlock cable, 5 m
- 2 sealing plugs for cooling circuit (installed)

The following accessories are optional:

- Transport and storage case
- PRIMES PanelDisplay
  external display with up to 20 m distance to EC-PM
  (see appendix C on page 71)
- Fiber adapter for EC-PM
  (see appendix D on page 73)
- Spacers EC-PM for FocusMonitor FM+
  (see appendix E on page 74)

5 Transport and storage

5.1 Warning messages

NOTICE

Damage/Destruction of the device

Hard hits or falls may damage the device.

Touching the deflection mirror underneath the shutter can lead to localized absorption of the laser radiation at the points of contact, leading to burn marks and increased scattered radiation.

- ▶ Do not reach into the entrance aperture.
- ▶ Handle the device carefully when transporting it.

NOTICE

Damage/Destruction of the device caused by leaking or freezing cooling water

Leaking cooling water can damage the device. Transporting and storing the device at temperatures near or below freezing and without emptying the cooling circuit completely can damage the device.

- ▶ Empty the lines of the cooling circuit completely.
- ▶ Even when the lines of the cooling circuit have been emptied, a small amount of residual water will remain in the device at all times. This may leak out and end up inside the device. Close the connectors of the cooling circuit with the included sealing plugs.

NOTICE

Damage/Destruction of the flow meter

The flow meter is damaged by the use of compressed air in the cooling circuit.

- ▶ Do not use compressed air for emptying the cooling circuit.

5.2 Shipping the device with permanently installed lithium metal batteries

The device is equipped with 2 permanently installed lithium metal cells (hereinafter referred to as battery). A removal of the battery by the end user is not intended for this product.

In case of shipment, the device is to be considered as hazardous good. Because of the permanently installed battery, it is classified as “batteries contained in equipment”.

▶ Please observe the requirements for shipping according to the valid regulations.

Particularly in case of a damaged battery, special regulations must be observed:

Damaged batteries can cause fire! These batteries must be sorted out, checked and, if necessary, repacked by qualified personnel!

Battery details for shipping:

Cell/battery type: Lithium metal

Cell or battery: Cell

LC or Wh rating: 0.7 g

Cell/battery weight: 16 g

UN-Classification: UN 3091: Lithium metal batteries contained in equipment

6 Mounting

6.1 Conditions at the installation site

- The device must not be operated in a condensating atmosphere.
- The ambient air must be free of gases and aerosols that interfere with the laser radiation (e.g. organic solvents, cigarette smoke, sulfur hexafluoride).
- Protect the device from spray water and dust.
- Operate the device in closed rooms only.

6.2 Installation in the laser system

6.2.1 Prepare mounting

1. Switch off the laser beam.
2. Ensure that moving parts, e.g. robot arms, etc. are at a standstill and that they cannot be set in motion unintentionally.
3. Check the space available before installing the device, especially the required space for the cables and -hoses.

6.2.2 Possible mounting positions

The EC-PM can be mounted in the installation positions shown in Fig. 6.1.

The EC-PM must not be installed with the connection side facing upwards or downwards.

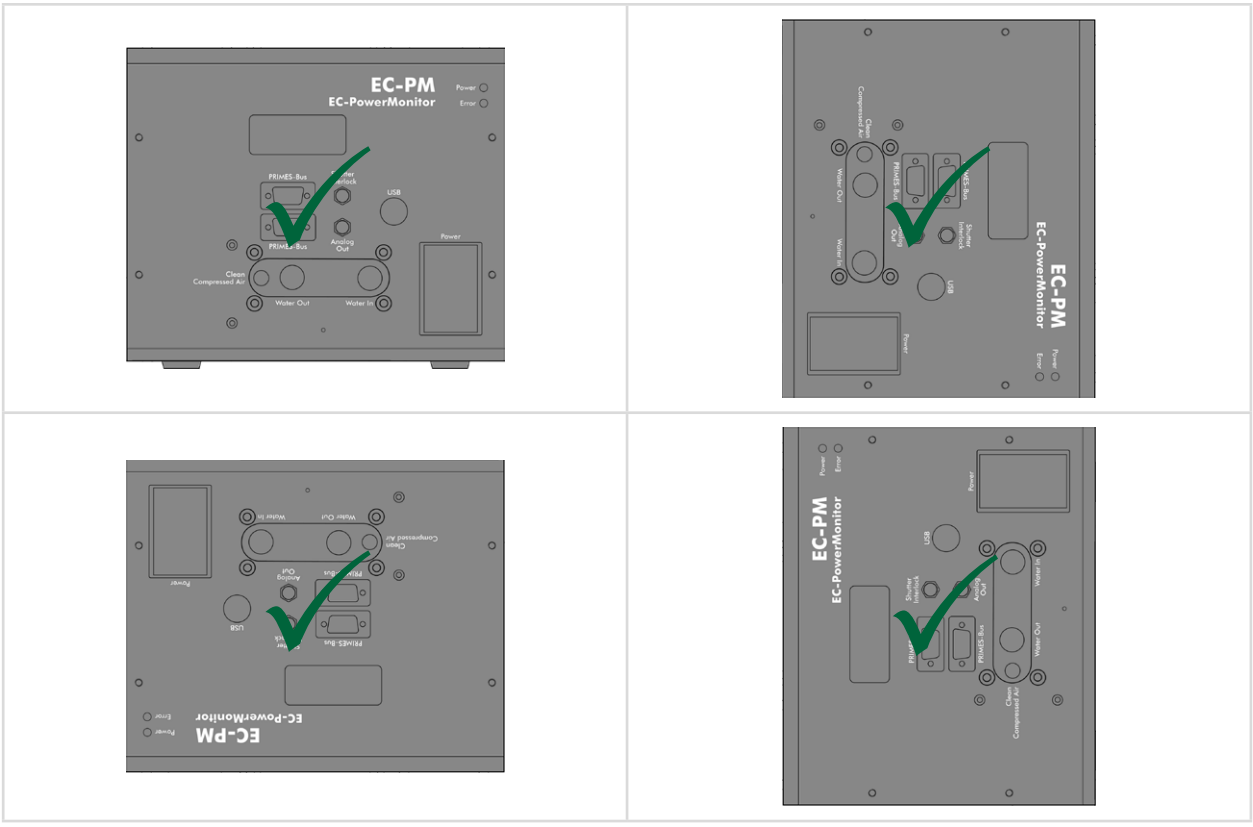


Fig. 6.1: Possible mounting positions

For a short period of time (a few hours per year) the EC-PM can be operated in the “incorrect“ installation position without immediately causing damages to the device.
Longer operation periods, however, may cause accelerated wear.

6.2.3 Align the device

NOTICE

Damage/Destruction of the device

The deflection mirror can be damaged if the power density is too high.

- ▶ Make sure the focal plane is not located on the deflection mirror.
- ▶ Make sure that the permitted power density on the deflecting mirror is not exceeded.

The device must be aligned to the laser beam. The laser beam must hit the entrance aperture centrally and perpendicular. The specifications given in chapter 14 „Technical data“ on page 66 must be observed.

The reticle printed on the shutter can be used to center the device under the laser. Align the device using the pilot beam with the shutter closed.

Use of the device with divergent laser radiation

Normally, the device is positioned underneath the focal plane of the beam path for power measurement.

Use of the device with convergent laser radiation

If this is not possible, the device can be positioned above the focal plane.

In this case, observe that the laser radiation is convergent and that the permitted power density on the deflection mirror is not exceeded.

Observe the following (see chapter 14 „Technical data“ on page 66):

- **the max. laser power as a function of the beam diameter according to appendix A on page 70**
- **the max. beam diameter at the entrance aperture of 24 mm**
- **the max. tolerance to the centered beam incidence of ± 3 mm**
- **the min. divergence full angle (convergent) of – 50 mrad /**
  the max. divergence full angle (divergent) of + 160 mrad
- **the max. angle of incidence perpendicular to the entrance aperture of ± 5°**

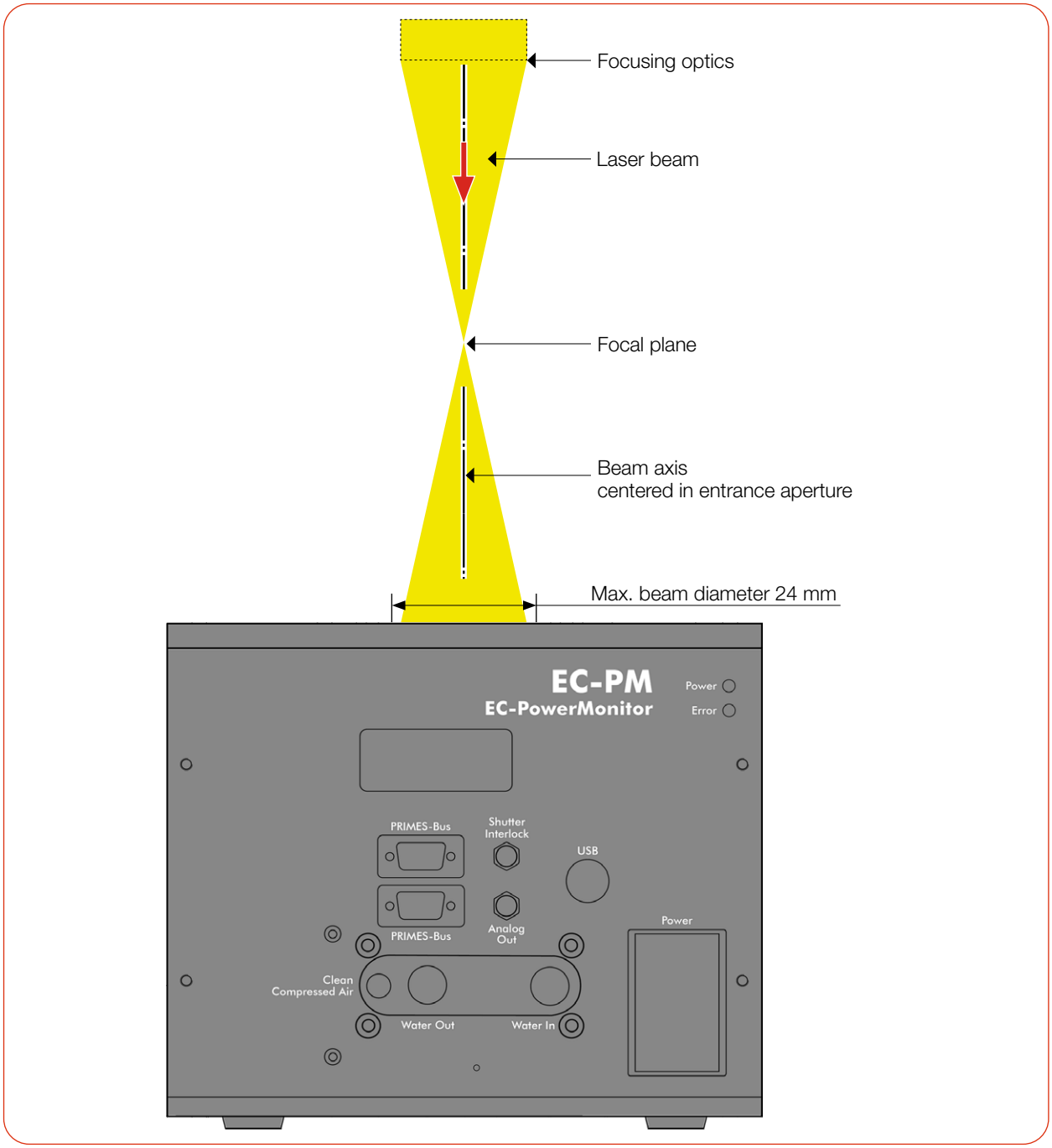


Fig. 6.2: Alignment of the EC-PM to the laser beam (schematic)

6.2.4 Mount the device

DANGER

Electrical voltage warning – Disconnect mains plug before opening!

There are live parts under the sheet metal housing that cause an electric shock if touched.

▶ Disconnect the mains plug before opening the device.

DANGER

Serious eye or skin injury due to laser radiation

If the device is moved from its aligned position, increased scattered or directed reflection of the laser beam occurs during measuring operation (laser class 4).

▶ Mount the device so that it cannot be moved by an unintended push or a pull on the cables or hoses.

WARNING

Injuries if the device falls down

If the device is not fastened securely, it may fall down.

▶ The secure fastening of the device according to the selected mounting position and the selection of the screws with appropriate tightening torque must be carried out by the customer.

1. Switch off the power supply at the on/off switch Power and pull the mains plug.
2. Unscrew the countersunk screw M3 (Torx 10).
3. Do not loosen the screw of the grounding cable ⏚.
4. Carefully slide the sheet metal housing in the guide rails in the direction of the blue arrow.
   Make sure that the mounted grounding cable ⏚ on the sheet metal housing is not torn off.

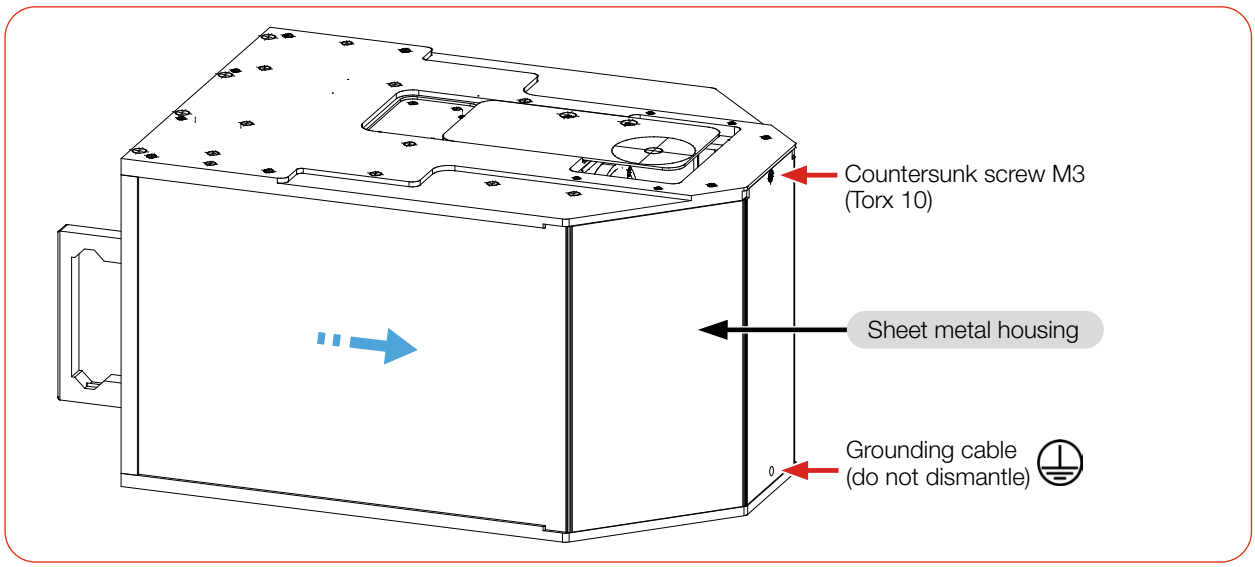


Fig. 6.3: Removing the sheet metal housing

5. The baseplate has 2 through holes Ø 6.6 mm for mounting the device on a customer specific mount. As a positioning aid, 2 slip fit bores Ø 6 mm H7 are provided.
   If necessary, remove the device feet. Mount the device through the through holes.

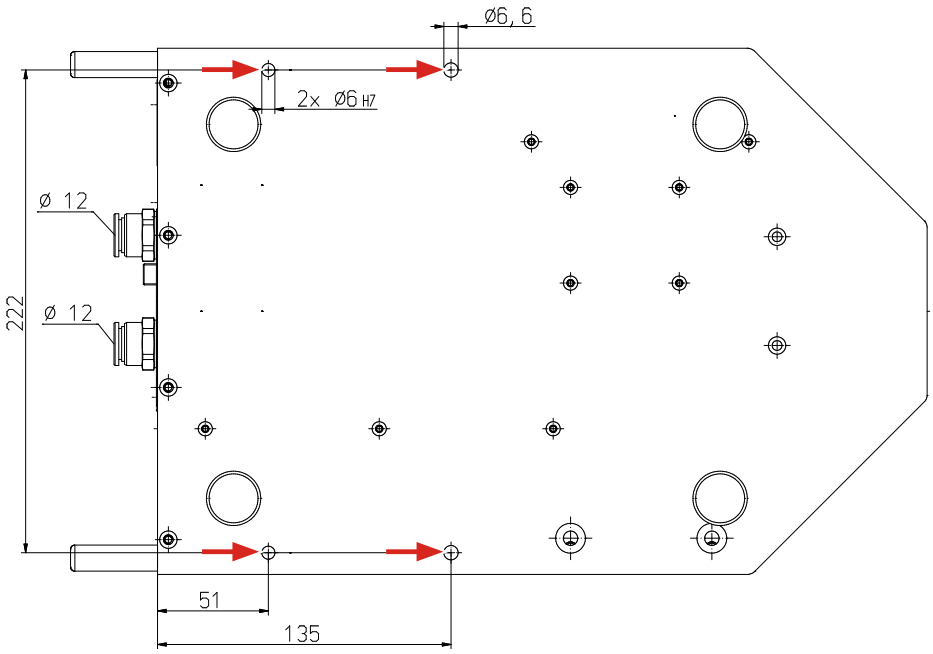


Fig. 6.4: Slip fit bores and mounting holes, bottom view

6. Place the sheet metal housing in the guide rails and push it back into the housing as far as it will go.
7. Screw in the countersunk screw M3 (Torx 10) and tighten it hand tight.

6.3 Removal from the laser system

CAUTION

Eye and skin damage

If the cooling water hoses are disconnected while the water supply is on, high-pressure water may spray into the eyes.

▶ Turn off the water supply before disconnecting the cooling water hoses.

NOTICE

Damage/Destruction of the flow meter

The flow meter is damaged by the use of compressed air in the cooling circuit.

▶ Do not use compressed air to force drain the cooling water circuit.

1. Switch off the laser beam.
2. Ensure that moving parts, e.g. robot arms, etc. are at a standstill and that they cannot be set in motion unintentionally.
3. Close the shutter.
4. Switch off the power supply at the on/off switch Power and pull the mains plug.
5. Turn off the water supply.
6. Turn off the compressed air supply.
7. Push down the release ring of the compressed air connector with two fingers of one hand and pull out the hose with the other hand.
8. Push down the release ring of the hose connector with two fingers of one hand and pull out the cooling water hose with the other hand.
9. Disconnect all connections.
10. Unscrew the fastening screws.
11. Remove the device from the laser system.
12. Drain the cooling circuit lines completely by tilting the device.
13. Seal the connectors with the supplied sealing plugs.

7 Connectors

7.1 Overview of connectors

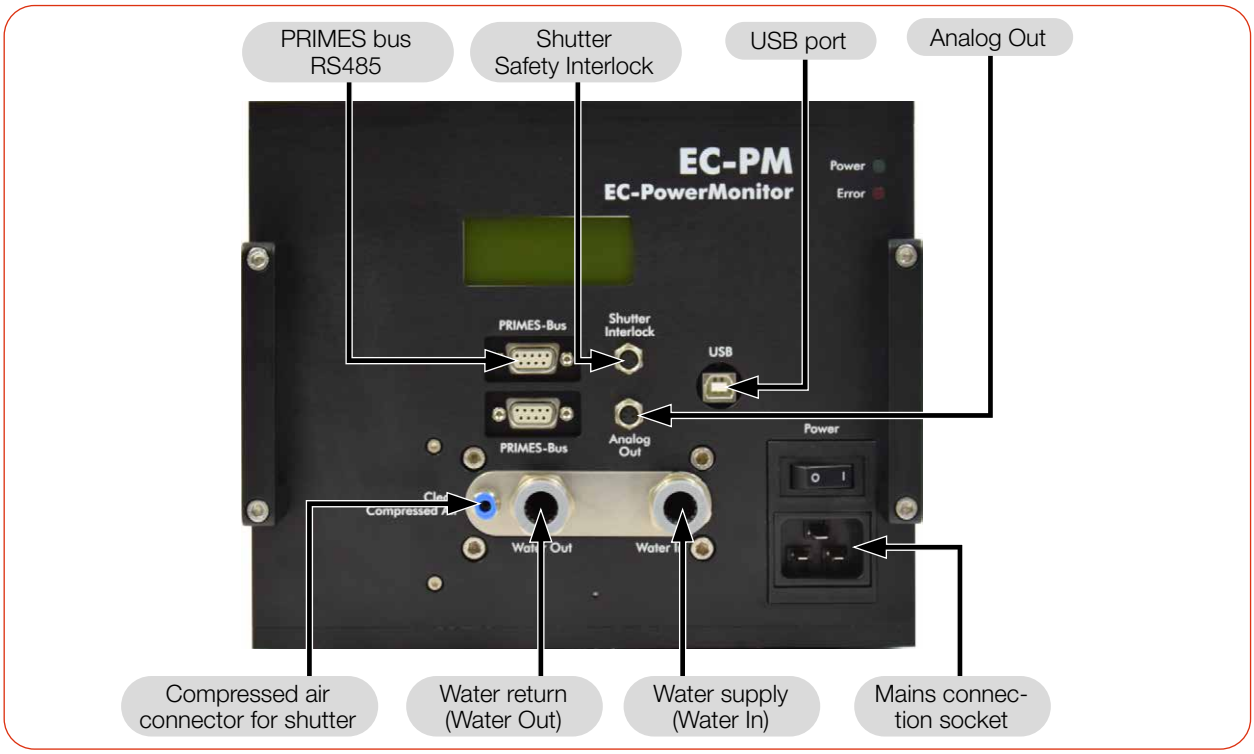


Fig. 7.1: Connectors on the EC-PM

7.2 Power supply (Power)

Power is supplied via the country-specific PRIMES power cable in the mains connection socket.

The device requires a power supply of:

- 100-240 V, 50/60 Hz, 16 A
- 100-120 V, 50/60 Hz, 18 A

Connecting the 100-120 V device type to a 230 V power supply will damage the device.

▶ Before start-up, make sure that the provided mains voltage corresponds to the nominal voltage on the identification plate.

Observe that the mains connection socket used:

- is fused with at least 16 A (100-240 V) / 18 A (100-120 V)
- has a proper grounding

The device starts after being switched on at the on/off switch Power. When starting for the first time, initialization of the device takes about 1 minute. Do not remove cables during this time.

If the LDS or PMS software is to be used for the measurement, a data connection to the PC/network must be set up. One of the following connections can be used for data transmission:

- USB connection to PC
- PRIMES converter with RS232 connection to PC or USB-A connection to PC

Connection options:

Power supply	Data transmission	Chapter
PRIMES power cable	As stand-alone device (display on the device)	7.2.1 on page 27
	USB connection to PC	7.2.2 on page 28
	PRIMES converter with RS232 connection to PC or D-Sub cable with USB-serial converter to PC	7.2.3 on page 29

Tab. 7.1: Connection options

7.2.1 Power supply via PRIMES power cable when used as a stand-alone device

Only use the provided PRIMES power cable.

- Power is supplied via the PRIMES power cable in the mains connection socket.
- The measured values are shown on the display of the device.

Required components (included in delivery)

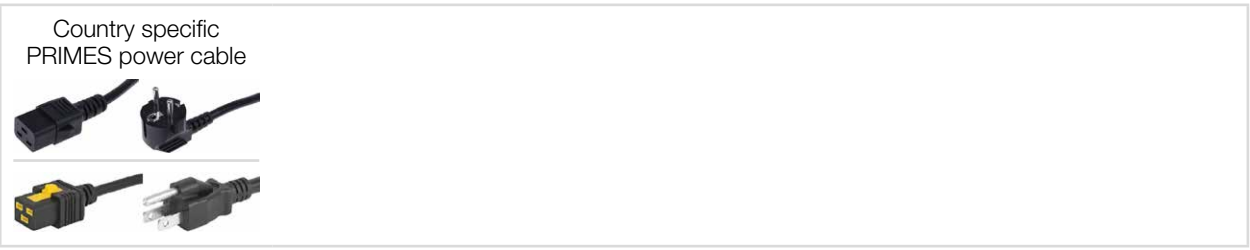


Fig. 7.2: Required component

Connecting the EC-PM

▶ Connect the PRIMES power cable according to Fig. 7.3 on page 27.

Fig. 7.3: Power supply via PRIMES power cable, display of the measured values on the device

7.2.2 Power supply via PRIMES power cable and communication with the PC via USB

Only use the PRIMES power cable and the provided USB cable.

- Power is supplied via the PRIMES power cable in the mains connection socket.
- Data is transferred via USB cable.

Required components (included in delivery)

Fig. 7.4: Required components

Connecting the EC-PM to a PC

When using the USB port, note the following:

- If the PC is connected to the internet, the USB driver will be installed automatically.
- If the PC is not connected to the internet, the USB driver must be installed manually before connecting the device (see chapter 7.4.2 on page 32).

▶ Connect the cables according to Fig. 7.5 on page 28.

Fig. 7.5: Power supply via PRIMES power cable, data transfer via USB

7.2.3 Power supply via PRIMES power cable and communication with the PC via PRIMES converter

Only use the PRIMES power cable and the provided connection cables.

- Power is supplied via the PRIMES power cable in the mains connection socket.
- Data is transferred via the PRIMES converter with RS232 connection to the PC or D-Sub cable with USB-serial converter to the PC.

Required components (included in delivery)

Fig. 7.6: Required components

Connecting the EC-PM to a PC

NOTICE

Damage/Destruction of the device

Connecting or disconnecting the bus cables when the power supply is on, can lead to voltage peaks that may destroy the communication modules of the device.

▶ Ensure all connections are made only when the power supply is turned off.

NOTICE

Damage/Destruction of the PC

A voltage of 24 V is present in the RS485-based PRIMES bus of the EC-PM.
If the PC is directly connected to the PRIMES bus of the EC-PM, the PC may be damaged.

▶ Only connect the PC to the EC-PM via the PRIMES RS485/RS232 converter (to PC) (see Fig. 7.7 on page 30).

When using the USB-serial converter, note the following:

- The converter's USB driver must be installed before connecting the device (this can be found on the CD included in the package).

Continued on the following page.

▶ Connect the cables according to Fig. 7.7 on page 30.

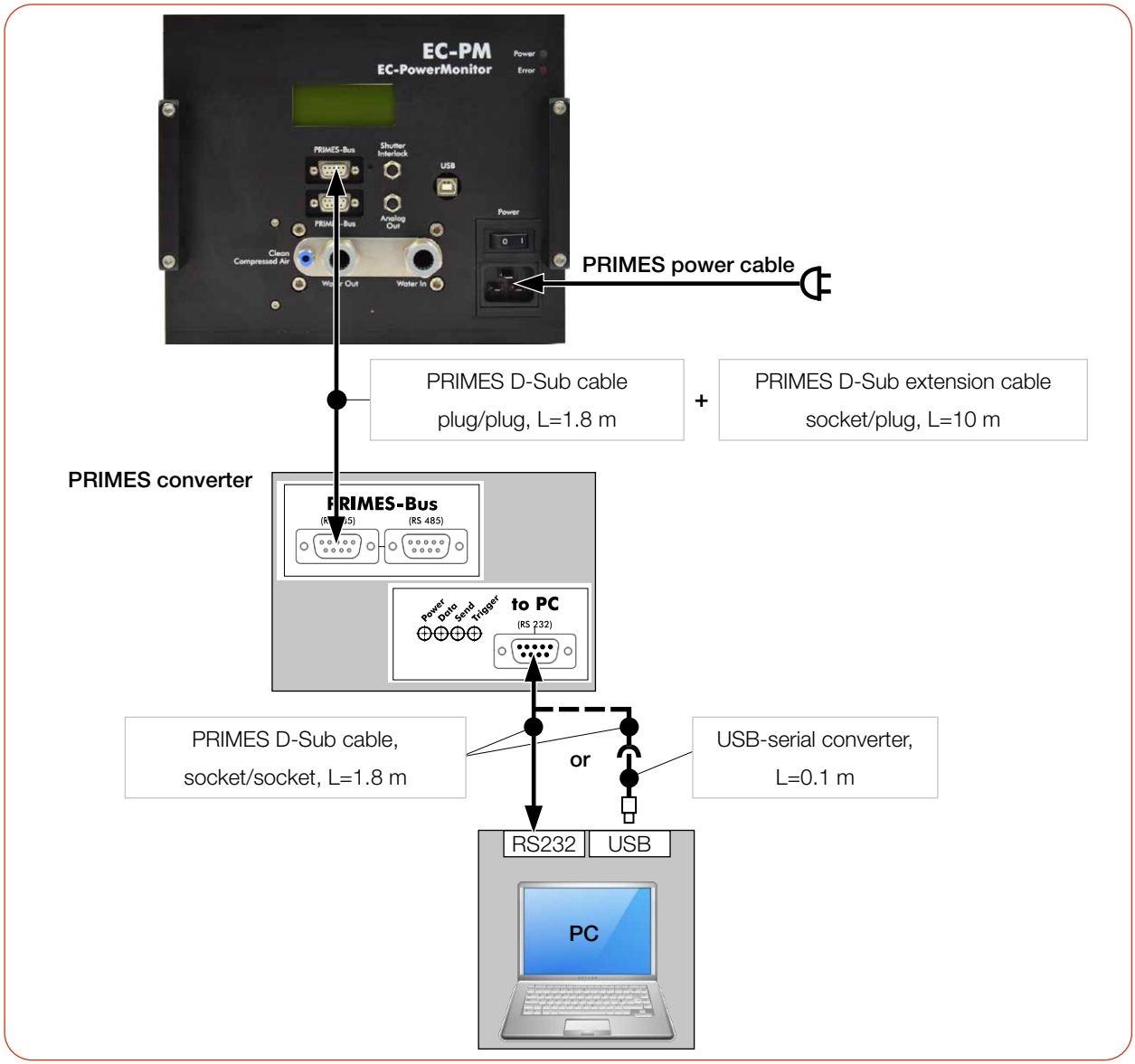


Fig. 7.7: Power supply via PRIMES power cable, data transfer via D-Sub cable or USB-serial converter

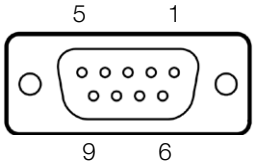
7.3 PRIMES bus RS485

The PRIMES bus is an RS485 interface with 9 pin D-Sub socket. Via the PRIMES bus a PC can be connected for communication.

Use the PRIMES RS485/RS232 converter for this purpose (see chapter 7.2.3 on page 29)

Pin assignment

Pin assignment (view to socket on device)



Pin	Function
1	Ground
2	RS485 (+)
3	+24 V
4	Not assigned
5	Not assigned
6	Ground
7	RS485 (–)
8	+24 V
9	Not assigned

Tab. 7.2: Pin assignment PRIMES bus

7.4 USB

7.4.1 Specification

USB port: USB-B connector type; USB 2.0 version.

Note that a USB interface without additional interference suppression measures is not EMC-compliant. Therefore, in industrial environments with strong sources of interference, connection interruptions and data transmission disturbances may occur.

When using the USB port, note the following:

- If the PC is connected to the internet, the USB driver will be installed automatically.
- If the PC is not connected to the internet, the USB driver must be installed manually before connecting the device (see chapter 7.4.2 on page 32).

7.4.2 Installing the USB driver manually

The PRIMES USB driver for all USB-enabled devices can be found on the enclosed PRIMES USB flash drive or on the PRIMES website at: ***https://www.primes.de/en/support/downloads/software.html***

The USB driver can be installed from the supplied USB flash drive for 32-bit and 64-bit Windows® operating systems:

- Driver installation software ***dpinst_x64.exe*** for Windows® 7/8/10 (64 bit)
- Driver installation software ***dpinst_x86.exe*** for Windows® 7 (32 bit)

Administrator rights are necessary in order to install the USB driver.

1. Connect the supplied PRIMES USB flash drive to your PC.
2. Open the ***USBdriver*** folder.
3. Double-click the desired USB driver software (32- or 64 bit) to start the installation.
4. Follow the instructions on the screen.

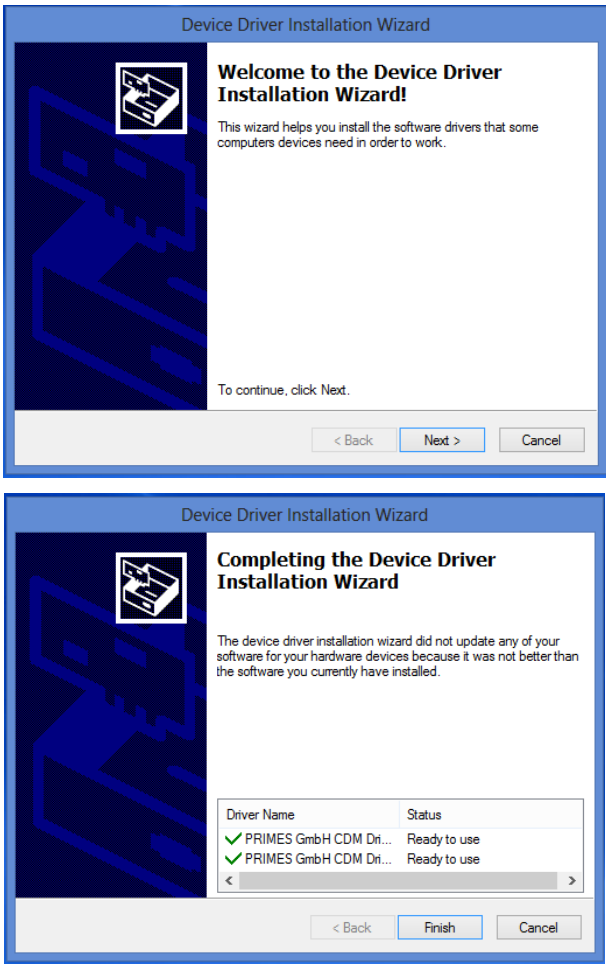


Fig. 7.8: Windows® menu for USB driver installation

5. Click ***Finish*** in order to complete the installation.

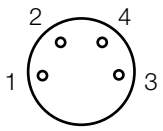
7.5 Analog Out

The EC-PM has an analog voltage output (Analog Out) that emits a voltage value proportional to the measured laser power. The analog signal is transmitted to a 4-pin M8 connector.

In addition, the EC-PM can be supplied with power via pin 1 and 2.
To use the integrated self-test function, the PRIMES power cable must be connected.

Pin assignment

Pin assignment (Pin: view to socket on device; color: wire colors of the cable)



Pin	Wire color	Function
1	Brown	24 V (input power supply)
2	White	Ground for the power supply
3	Blue	Ground for the analog signal
4	Black	Analog signal 0 – 10 V (output)

Tab. 7.3: Pin assignment analog output

Required components

A suitable cable is included in the delivery.

Output voltage and laser power

The maximum output voltage is 10 V. The output voltage of 10 V is scaled to the maximum output value of the connected device (see Tab. 7.4 on page 33).

The load resistance at the analog output should not be smaller than 100 kOhm.

Device type	EC-PM
An output voltage of 1 V equals approx.	1 000 W

Tab. 7.4: Output voltage relative to the laser power

7.6 Safety interlock (Shutter Interlock)

DANGER

Fire hazard; Damage/Destruction of the device

The safety interlock monitors the operating conditions of the device. The safety interlock offers potential-free switch contacts for integrating the device into an existing safety circuit.

- ▶ Connect the safety interlock of the laser control unit in such a way, that in the event of faulty operating conditions, the laser is switched off.
- ▶ Check that the safety interlock will switch off the laser properly in case of error.

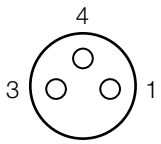
Monitored operating conditions

The safety interlock protects the device by switching off the laser beam in the following cases:

- the cooling water flow is too low (Flow < 4 l/min)
- the cooling water temperature at the water supply (Water In) is too high (Te > 70 °C)
- the temperature difference between water supply (Water In) and water return (Water Out) is too large (Td > 50 K)
- the shutter is not (completely) open

Pin assignment

Pin assignment (Pin: view to socket on device; Color: wire colors of the cable)



Pin	Color	Function
1	Brown	Common pin
3	Blue	Connected with Pin 1 when ready for operation
4	Black	Connected with Pin 1 when in safety interlock mode

Suitable connector: Binder 79-340-55-03

Tab. 7.5: Pin assignment of the safety interlock connector

When the safety interlock is triggered, pin 1 and pin 4 are connected.

If the values correspond to the operating conditions, pin 1 and pin 3 are connected.

Safety interlock specifications

- Switching voltage: 125 V AC/60 V (DC)
- Switching capacity: 62.5 VA/30 W
- Max. switching current: 1 A

Required components

A suitable connection cable with a device plug and bare ends is included in the delivery.

7.7 Cooling circuit (Water In/Water Out)

DANGER

Fire hazard due to overheating of the device

If there is no water cooling or insufficient water flow, the device will heat up and may catch fire.

▶ Operate the device only with a connected water cooling system and a sufficient flow rate.

CAUTION

Eye and skin damage

If the cooling water hoses are disconnected while the water supply is on, high-pressure water may spray into the eyes.

▶ Turn off the water supply before disconnecting the cooling water hoses.

7.7.1 Connect/remove cooling water hoses

The water connectors are sealed with plugs to prevent residual water leakage.

1. Push down the release ring of the hose connector with two fingers of one hand and pull out the sealing plug with the other hand.
2. Keep the sealing plugs for closing the water connectors at a later stage.

Connect cooling water hoses

1. Connect the supply hose (Water in) and the return hose (Water out) by pushing the cooling water hoses into the hose connectors as far as they will go (approx. 2 cm).
2. Check whether the hose connections are tight.

Remove cooling water hoses

▶ Push down the release ring of the hose connector with two fingers of one hand and pull out the cooling water hose with the other hand.

Fig. 7.9: Connect/Remove cooling water hoses

7.7.2 Damage to the device

NOTICE

Damage/Destruction of the device

If the following requirements for the cooling circuit are not observed, the measuring device may be damaged.

▶ Observe the following requirements.

Water quality

The device can be operated with tap water as well as demineralized water.

An operation with strongly deionized water (DI-water, conductivity < 30 µS/cm) is only possible with appropriate connection parts (stainless steel) – we will be glad to advise you as necessary.

No dirt particles/fibrous sealants

When sealing the external thread with fibrous sealant (e.g. hemp or teflon tape, make sure that no sealant residue gets into the flow.

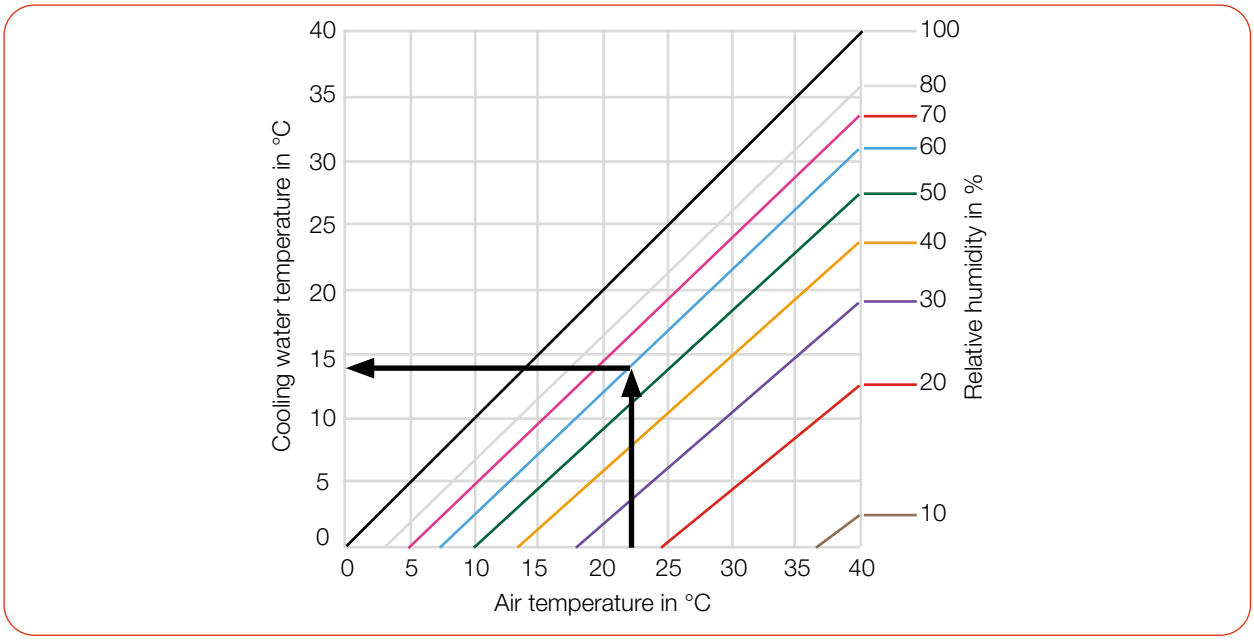
Large dirt particles or fibrous sealants may block internal cooling circuits. Therefore, please rinse the system thoroughly before connecting it.

Aluminum components

Do not operate the device on a cooling circuit in which aluminum components are installed. Otherwise, corrosion in the cooling circuit can occur, particularly when operating at high powers and power densities. In the long term, this will reduce the efficiency of the cooling circuit.

Condensates within the device

The device must not be operated in a condensating atmosphere. Check the environmental humidity levels to prevent condensates within and outside the device.



Tab. 7.6: Dew point diagram: The temperature of the cooling water must not be lower than the dew point

Example:

Air temperature: 22 °C

Relative humidity: 60 %

The cooling water temperature must not fall below 14 °C.

7.7.3 Avoid measurement inaccuracies

Antifreeze and additives

The heat capacity is one of the key parameters that is used in order to calculate the laser power. Therefore, do not operate the unit in a cooling circuit that contains antifreeze (or only after consultation with PRIMES).

Other additives - such as biocides and corrosion inhibitors - may be added to the cooling water up to a maximum concentration of 1 %.

Temperature fluctuations of the cooling water

It is important that the temperature of the inflowing water remains constant. The fluctuation of the temperature should not exceed 1 K per minute or 0.08 K per 5 seconds.

Observe the temperature display for the incoming water.

Alternatively, the power display can be observed for approx. 1 minute without the laser being switched on. The fluctuations give a first indication of the influence of the temperature fluctuations due to the chiller.

Gas bubbles in the cooling water

Gas bubbles in the cooling water can lead to measurement inaccuracies.

7.7.4 Damage to the flow meter

NOTICE

Damage/Destruction to the flow meter

The device uses an oval wheel meter for flow measurement. This can be damaged by improper handling.

▶ Observe the following requirements.

Observe mounting position

The oval wheel axes of the oval wheel meter must be horizontal. Observe the mounting position according to chapter 6.2.2 „Possible mounting positions“ on page 19.

Observe flow direction

Reversing the flow direction will damage/destroy the flow meter during longer operation. If the flow direction is reversed, the device does not display any flow or the laser power shown on the display, the LDS or PMS has a negative prefix.

Do not use compressed air

The flow meter is damaged by the use of compressed air in the cooling circuit. Do not use compressed air to force drain the cooling water circuit.

Prevent freezing

Freezing of the cooling water must be prevented at any time by suitable precautions.

Limit cooling time

Only cool the device during measurements. PRIMES recommends starting the cooling approx. 2 minutes before the measurement and ending it approx. 1 minute after the measurement. The operating time has an influence on the service life of the flow meter.

No metal shavings/rust particles

There must not be any metal shavings/rust particles in the cooling water. The flow meter installed in the device is magnetic and attracts the metal shavings. This can lead to a build-up of debris and thus to measurement inaccuracies up to destruction of the flow meter.

7.7.5 Parameters of cooling water connection

Supply data	EC-PM
Hose diameter	12 mm
Water flow warning (warning threshold)	4 l/min
Min. cooling water flow (interlock threshold)	4 l/min
Max. cooling water flow	12 l/min
Recommended cooling water flow	8 – 11 l/min
Min. cooling water pressure	2 bar
Max. cooling water pressure	6 bar
Cooling water temperature Te	Dew point temperature < Te < 30 °C
Stability of the cooling water temperature	< 1.0 K per minute or 0.08 K per 5 seconds

Tab. 7.7: Parameters of cooling water connection

Recommended flow rate (rule of thumb)

The following rule of thumb can be used to determine the cooling water flow rate:

Per 1 kW laser power, a flow rate of approx. 1 l/min cooling water is recommended.

Example:

At 7 kW laser power, this corresponds to a flow rate of 7 l/min.

Observe that the cooling water flow must not be below the warning threshold according to Tab. 7.7!

Temperature increase of the cooling water

The temperature increase of the cooling water as a function of the laser power and the flow rate is calculated as follows:

Temperature increase: Δ T [K]

Laser power used: P [kW]

Flow rate: Q [l/min]

$$\Delta T\,(K) = 14.3\,\frac{l \cdot K}{kJ} \cdot \frac{P\,(kW)}{Q\,\left(\frac{l}{min}\right)}$$

Formula 7.1: Calculation of the temperature increase of the cooling water as a function of the laser power and the flow rate

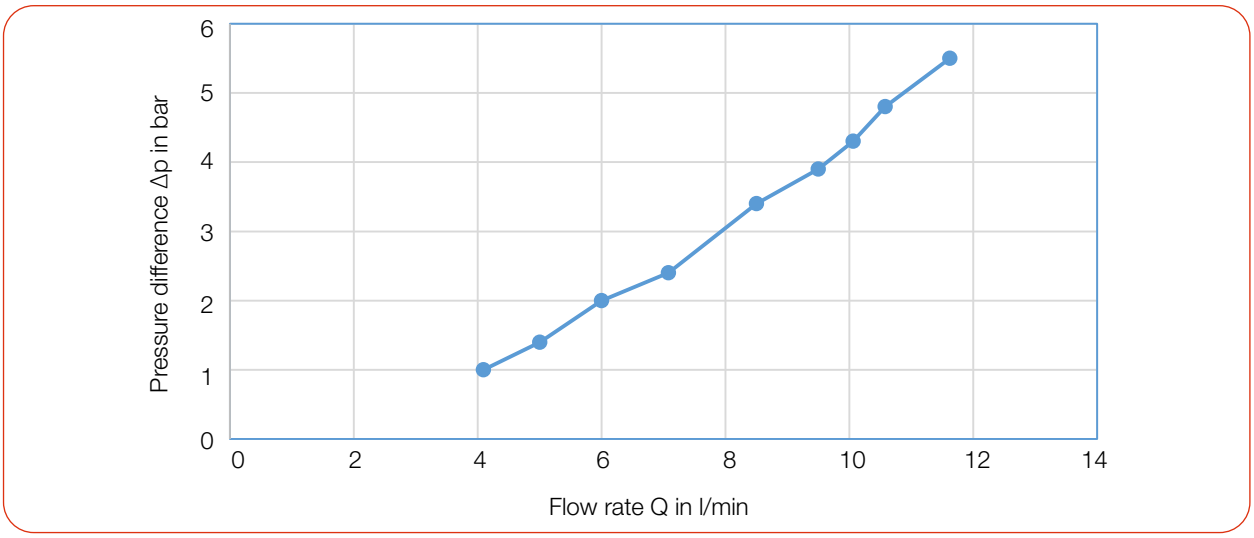
Example:

At 7 kW laser power and a flow rate of 9.5 l/min, the temperature of the cooling water increases by 10.5 °C.

7.7.6 Pressure loss

Usually, a primary pressure of 2 bar at the water supply (Water In) of the device (with unpressurised outlet) is sufficient to ensure the necessary flow rate.

With the following diagram, the minimum pressure required at the cooling water supply (Water In) of the unit can be determined.



Tab. 7.8: Pressure loss diagram EC-PM with oval wheel meter

7.8 Compressed air

The compressed air connector is provided for automatic operation of the shutter.

Only use cleaned, oil- and water-free compressed air for the compressed air connection.

Supply data	EC-PM
Hose diameter	4 mm
Min. air pressure	2 bar
Max. air pressure	4 bar
Purity class	ISO 8573-1:2010 [7:4:4]

Tab. 7.9: Parameters of compressed air connection

Connect compressed air hose

▶ Push the hose into the plug-in connector as far as possible.

Disconnect compressed air hose

1. Turn off the compressed air supply.
2. Push down the release ring of the connector with two fingers of one hand and pull out the hose with the other hand.

Fig. 7.10: Compressed air connector

8 Software installation

The following software can be used to operate the PM with a PC:

- LaserDiagnosticsSoftware LDS
- PowerMonitorSoftware PMS

8.1 Install LaserDiagnosticsSoftware LDS

The LDS is included in delivery. PRIMES will also be happy to provide you with a link to download the current version. Please contact your sales partner or contact us by e-mail: ***support@primes.de***

1. Please ensure:
- System requirements are met.
- You have administrator rights.
2. Close all programs on your PC.
3. Insert the PRIMES USB flash drive into your PC and open the directory.
In the standard configuration, Windows automatically opens the removable storage device.
4. Double-click the LDS_Setup exe file to start the installation.
5. Follow the instructions on the screen.

➔ If no other location is specified, then the main program ***LDS.exe*** will be copied into the directory ***C:\Programs\Primes\LaserDiagnostics-Software***.

System requirements:

- Intel Pentium Core i3 or better
- Windows 10 (64-bit version)
- At least 4 GB RAM; 8 GB RAM recommended
- Display resolution: Full HD (1 920 x 1 080) at 100 % scaling
- A USB interface type A or RS232 interface for the connection of the measuring device

8.2 Install PowerMonitorSoftware PMS

The PMS in version 2.57 is included in delivery.

1. Please ensure:
- System requirements are met.
- You have administrator rights.
2. Close all programs on your PC.
3. Insert the PRIMES USB flash drive into your PC and open the directory.
In the standard configuration, Windows automatically opens the removable storage device.
4. Double-click the PMS_Setup exe file to start the installation.
5. Follow the instructions on the screen.

➔ If no other location is specified, then the main program ***PMS.exe*** will be copied into the directory ***C:\Programs\Primes\PowerMonitorSoftware***.

System requirements:

- Intel Pentium or better
- Windows 10 (32-bit version)
- At least 2 GB RAM; 4 GB RAM recommended
- Display resolution: XGA (1 024 x 768) at 100 % scaling
- A USB interface type A or RS232 interface for the connection of the measuring device

9 Measuring

9.1 Warning messages

DANGER

Serious eye or skin injury due to laser radiation

During the measurement, the laser beam is guided on the device. This causes scattered or directed reflection of the laser beam (laser class 4).

The device must not be operated without taking the following precautions:

- ▶ Before switching on the laser, open the shutter of the device.
- ▶ 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** 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 moved from its aligned position, increased scattered or directed reflection of the laser beam occurs during measuring operation (laser class 4).

- ▶ Mount the device so that it cannot be moved by an unintended push or a pull on the cables or hoses.

DANGER

Fire hazard; Damage/Destruction of the device

The safety interlock monitors the operating conditions of the device. The safety interlock offers potential-free switch contacts for integrating the device into an existing safety circuit.

- ▶ Connect the safety interlock of the laser control unit in such a way, that in the event of faulty operating conditions, the laser is switched off.
- ▶ Check that the safety interlock will switch off the laser properly in case of error.

NOTICE

Damage/Destruction of the device

The deflection mirror can be damaged if the power density is too high.

- ▶ Make sure the focal plane is not located on the deflection mirror.
- ▶ Make sure that the permitted power density on the deflecting mirror is not exceeded.

9.2 Preparing measurement readiness

1. Observe the warning messages according to chapter 9.1 on page 42.
2. Connect the safety interlock of the laser control to the device.
3. Connect the device to the power supply.
4. Switch on the device at the on/off switch Power.

👁 The green Power LED must light up.

👁 Wait until the display lights up.

👁 The Error LED lights red after a short time.

5. Turn on the water cooling.

👁 After a few seconds, the red Error LED must turn off.

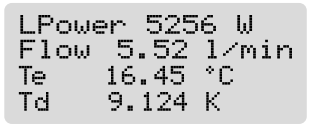
After approx. 2 minutes, the device temperature and the temperature of the cooling water are in equilibrium.

6. The EC-PM is ready for measurement.

9.3 Measuring with the EC-PM as a stand-alone device

The EC-PM can also be used to measure without a PC. The measured values are shown on the display of the device. The display shows the following measured values:

Display	Meaning
LPower	Laser power in W
Flow	Flow rate of the cooling water in l/min
Te	Cooling water temperature at the water supply (Water In) in °C
Td	Temperature difference between water supply (Water In) and water return (Water Out) in Kelvin



Tab. 9.1: Meaning of the abbreviations on the display

Get ready for measurement

1. Prepare the device according to chapter 9.2.

Determine zero level

2. Read the displayed value. The value must later be subtracted as zero level from the displayed laser power.

Start measurement

3. Observe the max. laser power as a function of the beam diameter according to appendix A on page 70.
4. Open the shutter completely.
5. Switch on the laser.

➔ The measured laser power is displayed after about 2 seconds.
After about 15 seconds the display reaches about 99 % of the final value.

6. Switch off the laser.
7. Subtract the previously recorded zero level from the displayed laser power.
8. Close the shutter completely.

9.4 Measuring with the LaserDiagnosticsSoftware LDS

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

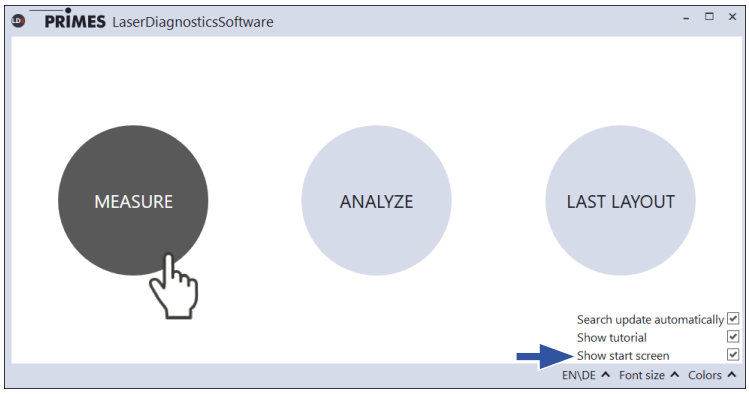
9.4.1 Connect/disconnect the device with the LDS

Switch on the device and connect it to the LDS

1. Prepare the device according to chapter 9.2 „Preparing measurement readiness“ on page 43.
2. Start the LDS by double-clicking on the program icon LDS in the start menu group or on the desktop icon.

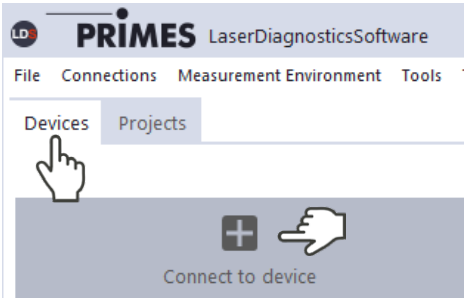
👁 The start screen appears.

3. Select the operating mode ***Measure***.



If the ***Show start screen*** option is disabled or the window ***Connections*** is closed:

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

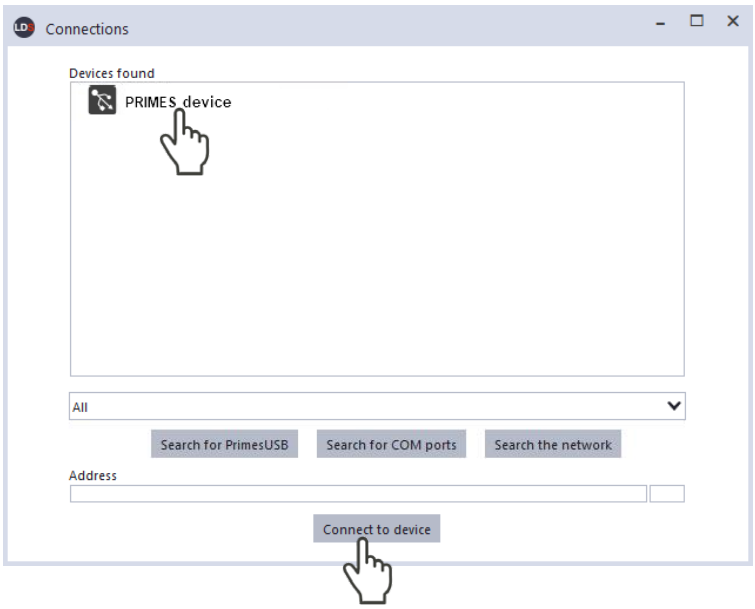


👁 The ***Connections*** window appears.

4. Click on the desired device.
5. Click the ***Connect to device*** button.

If the device does not appear

See chapter 10.2 „Connection errors with the LDS“ on page 61.

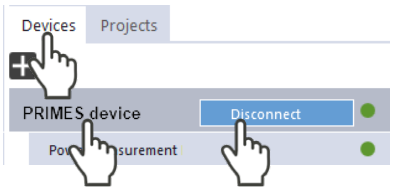


Disconnect from the LDS and switch off the device

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

➔ The device is disconnected from the LDS.

3. Switch off the power supply at the on/ off switch Power.
4. If applicable, disconnect the electrical connections.



9.4.2 General information about working with the LDS

Enter parameters and activate

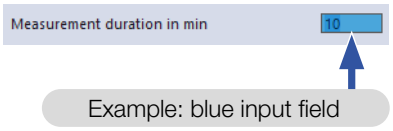
Transfer an entered parameter value with the Enter key:

1. Enter the desired value in the input field.

👁 The background color of the input field changes to blue.

2. Confirm the entry by pressing the Enter key.

👁 The field returns to its original background color.



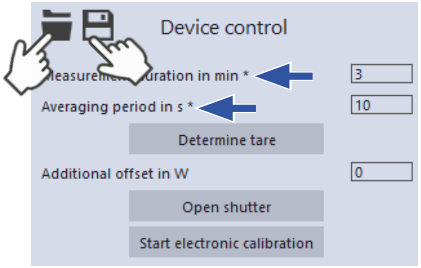
Saving options

Save data with asterisk (*) to a file / load from a file:

All data marked with an asterisk in the ***Device control*** menu can be saved to a preset file with the extension ***.pre*** on the PC.

▶ To save a configuration, click on the icon 💾.

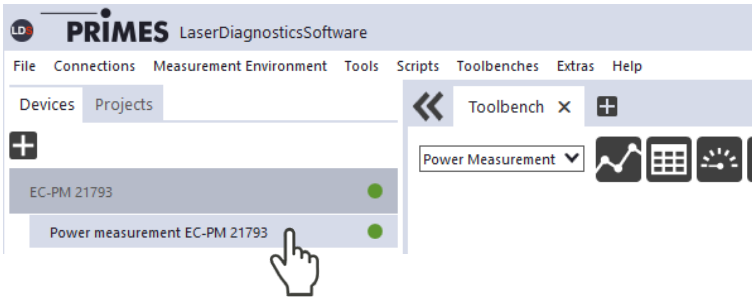
▶ To load a configuration click on the icon 📂.



9.4.3 Open power measurement mode

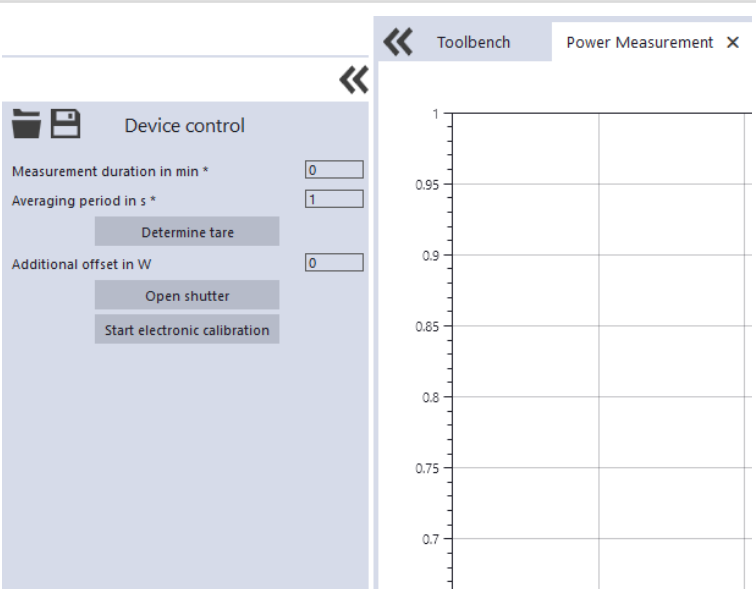
👁 The EC-PM is displayed as a connected device.

▶ Click on the connected device.



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

👁 The ***Power Measurement*** toolbench opens.



9.4.4 Perform power measurement

Settings in the device control

Option	Explanation
Measurement duration in min	▶ Enter a value in the input field. Without input, the power is measured permanently.
Averaging period in s	▶ Enter a value in the input field. The measured values are averaged over the entered time
Determine tare	▶ Click this button to adjust the value for the offset in the LDS.
Additional offset in W	▶ Enter a value that will be subtracted from the measured laser power.
Open shutter/Close shutter	▶ Click on the button: • With the compressed air supply connected, the shutter is automatically opened/closed. • Without compressed air supply, the shutter must be opened/closed manually.
Start electronic calibration	▶ Click this button to start the electronic calibration.

Tab. 9.2: Settings in the device control

Determine device offset (Tare)

To determine the device offset, the device must go through a thermalization time.

1. Run the cooling water for approx. 2 minutes.

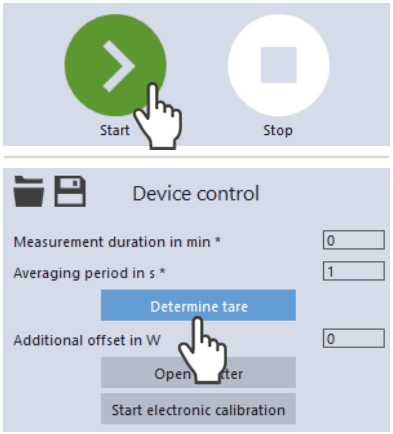
➔ After approx. 2 minutes, the device temperature and the temperature of the cooling water are in equilibrium.

2. With the laser switched off, click ***Start***.
3. Click ***Determine tare***.

➔ The offset value is determined and stored in the LDS.

👁 The display of the laser power is automatically corrected with the stored offset value.

4. Start an electronic calibration or a measurement.



Start electronic calibration

1. Run the cooling water for approx. 2 minutes.

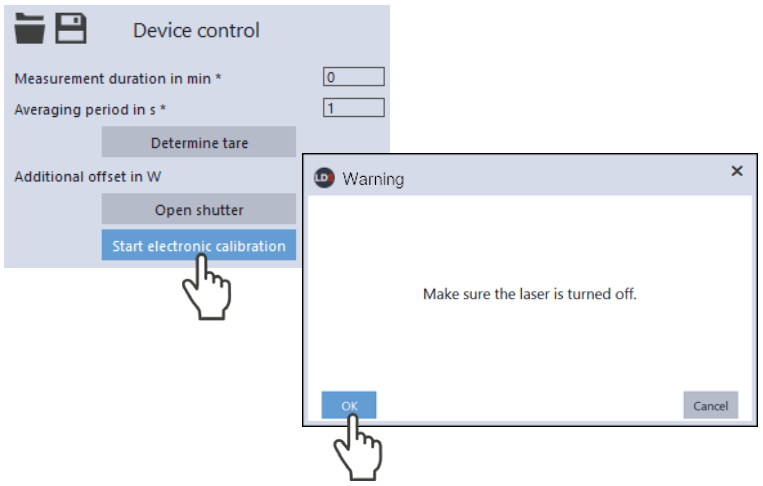
➔ After approx. 2 minutes, the device temperature and the temperature of the cooling water are in equilibrium.

2. Click the ***Start electronic calibration*** button.

👁 The ***Warning*** window appears.

3. Make sure that the Laser is turned off.
4. Click ***OK***.

➔ The calibration is started (duration approx. 90 seconds).

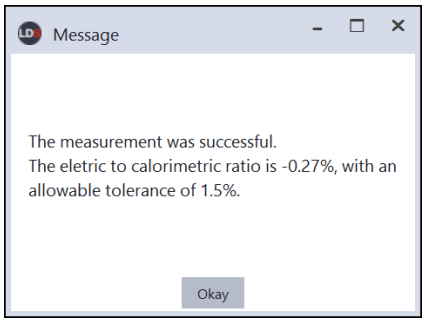


➔ The measured calorimetric and electronic power is displayed in W.

👁 The ***Message*** window appears.

➔ If the permissible deviation of 1.5% is exceeded, send the device to PRIMES for calibration.

5. Click ***Okay***.



Start measurement

1. Observe the max. laser power as a function of the beam diameter according to appendix A on page 70.
2. Click the ***Open shutter*** button:

- With the compressed air supply connected, the shutter is opened automatically.
- Without a compressed air connection, the shutter must be opened manually as far as it will go.

3. Switch on the laser.
4. Click the ***Start*** button.

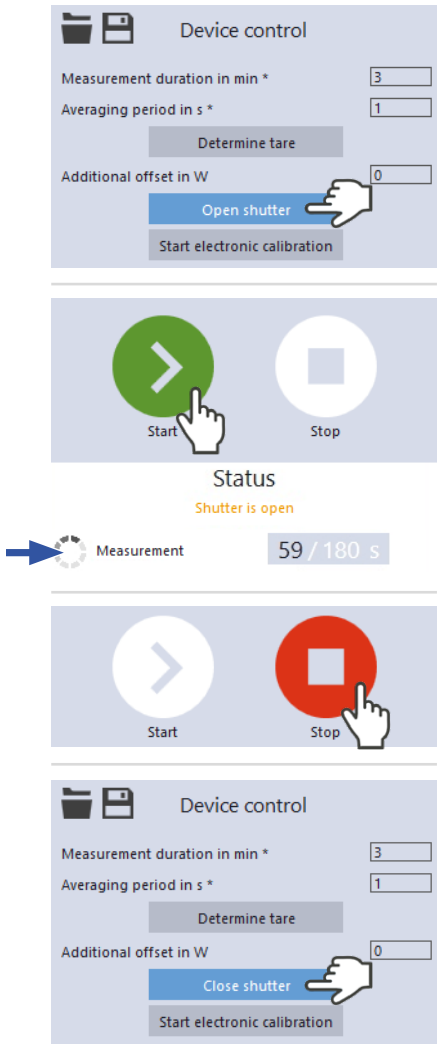
👁 The progress of the measurement is displayed in the ***Status***.

5. If you have not entered a measuring duration, click the ***Stop*** button.

➔ The measurement is finished.

6. Switch off the laser.
7. Click the ***Close shutter*** button:

- The shutter on the device is closed automatically
- Without a compressed air connection, the shutter must be closed manually as far as it will go.

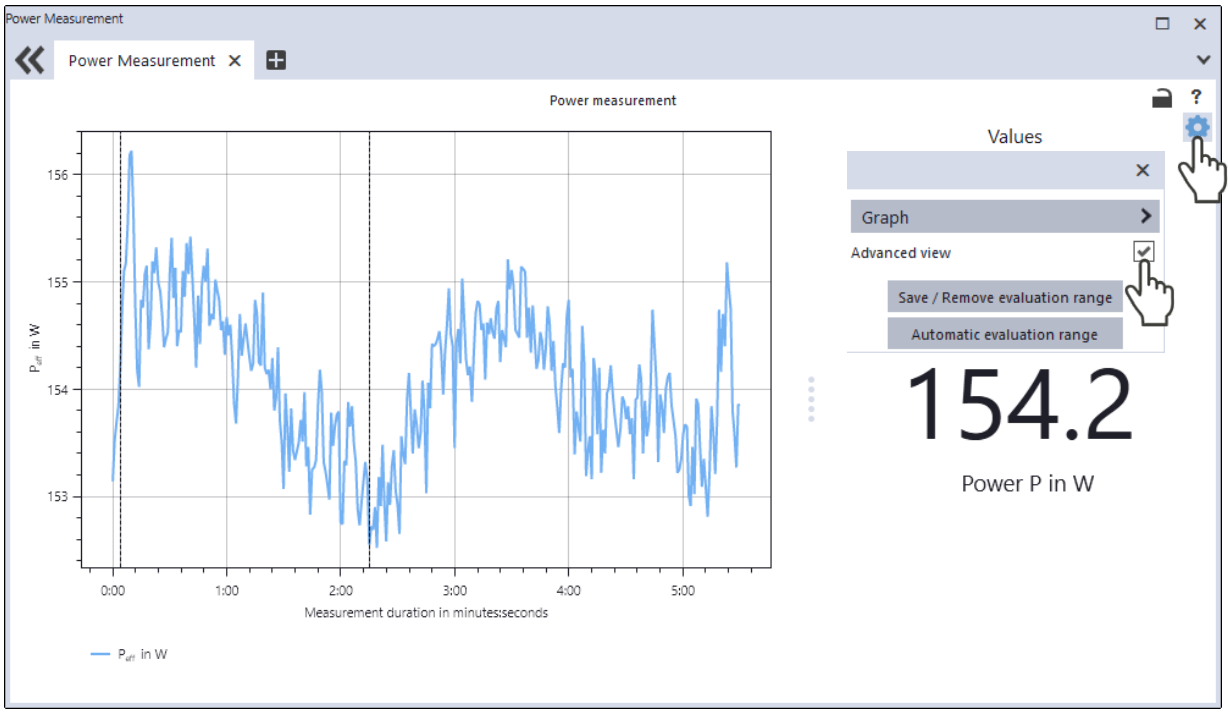


9.4.5 Measurement results display

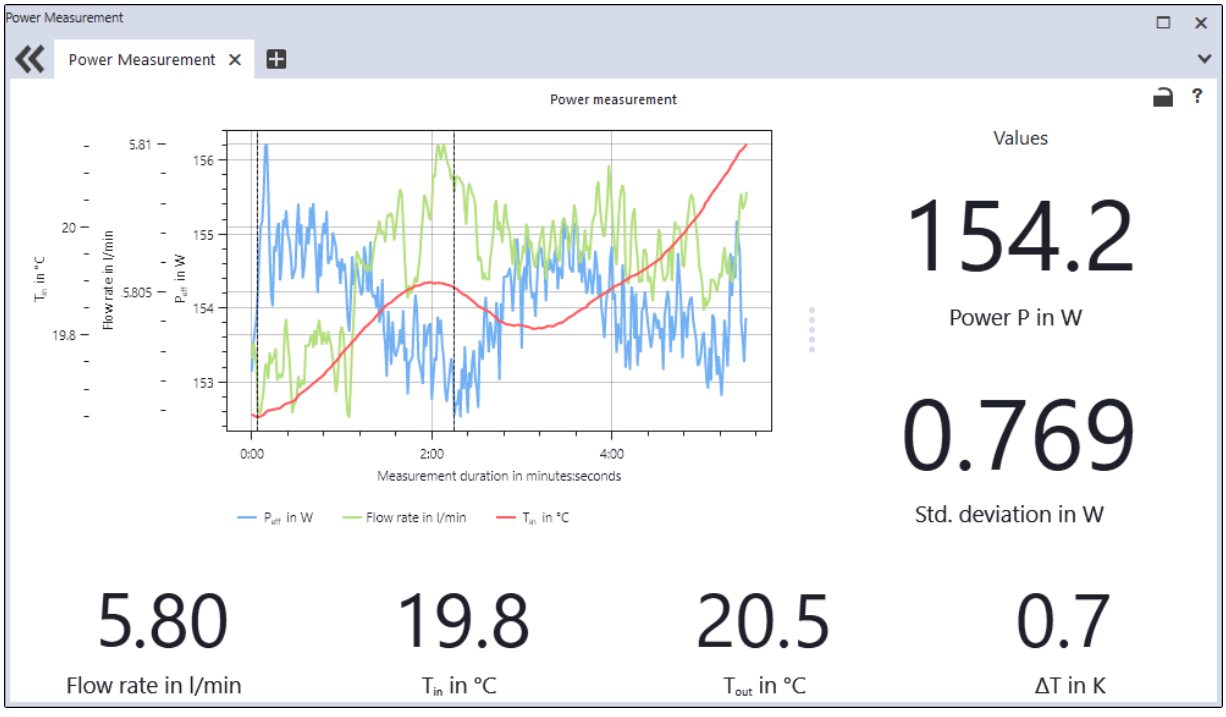
The measurement results are shown during the measurement in the opened ***Power Measurement*** tool.

The displayed parameters can be adjusted by clicking the gear icon . For example, ***Advanced view***.
The view changes to an extended display of the measured parameters.

A detailed description of the tools and the assessment of the measuring results can be found in the separate operating manual for the LDS.



Advanced view



9.5 Measuring with the PowerMonitorSoftware PMS

9.5.1 Switch on device and start PMS

1. Prepare the device according to chapter 9.2 „Preparing measurement readiness“ on page 43.
2. Start the PMS by double-clicking on the program icon in the start menu group or on the desktop icon.

Various dialogue windows can be called up via the menu bar.

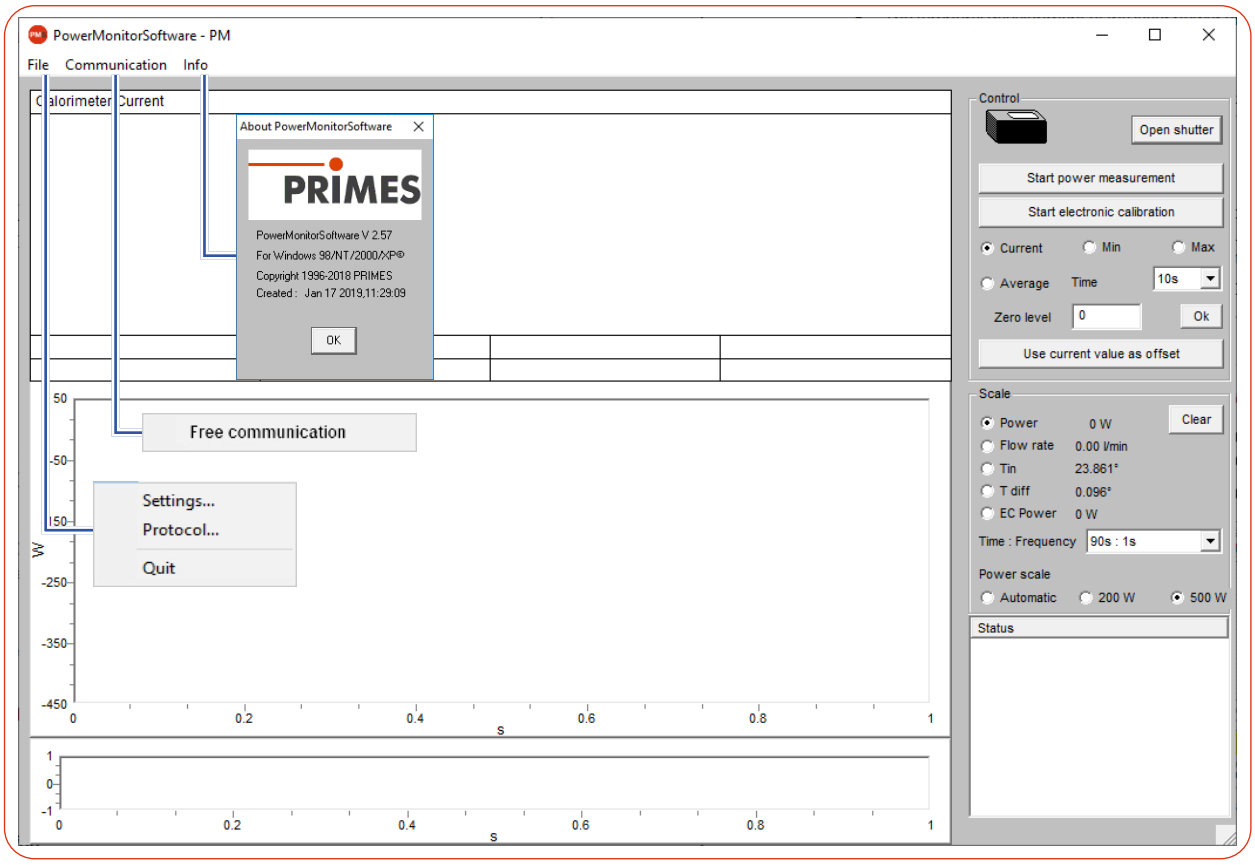


Fig. 9.1: Menu Selection in the menu bar

File > Settings

A different device address can be entered here. The preset deviation limit (EC) of the electronic calibration of 1.50% is displayed (see also chapter 9.5.6 on page 56).

File > Protocol

The determined measurement results can be stored in a tab-separated text file:

1. Activate the check box ***Write*** and type in a file name or choose a file.
2. Click ***OK***.

File > Quit

Terminates the software.

Communication > Free communication

Opens the dialogue window for the communication.

Info

Provides information regarding the software.

9.5.2 Connect device with the PMS

▶ Open the ***Communication > Free Communication*** menu.

For connection via the RS232 and PRIMES converter

See chapter 7.2.3 on page 29.

After the start-up, the software tries to establish a connection with the serial interface “COM2”. If “COM1” is the only available serial interface, “COM1”has to be explicitly selected in ***Com port*** in the menu ***Communication > Free Communication***.

When using the USB-serial converter, please choose the operating mode ***USB2Serial***.

For connection via the USB interface

See chapter 7.2.2 on page 28.

If the device was connected via USB, the operating mode ***USB*** has to be selected in the menu ***Communication > Free Communication***.

Then press the ***Scan*** button.

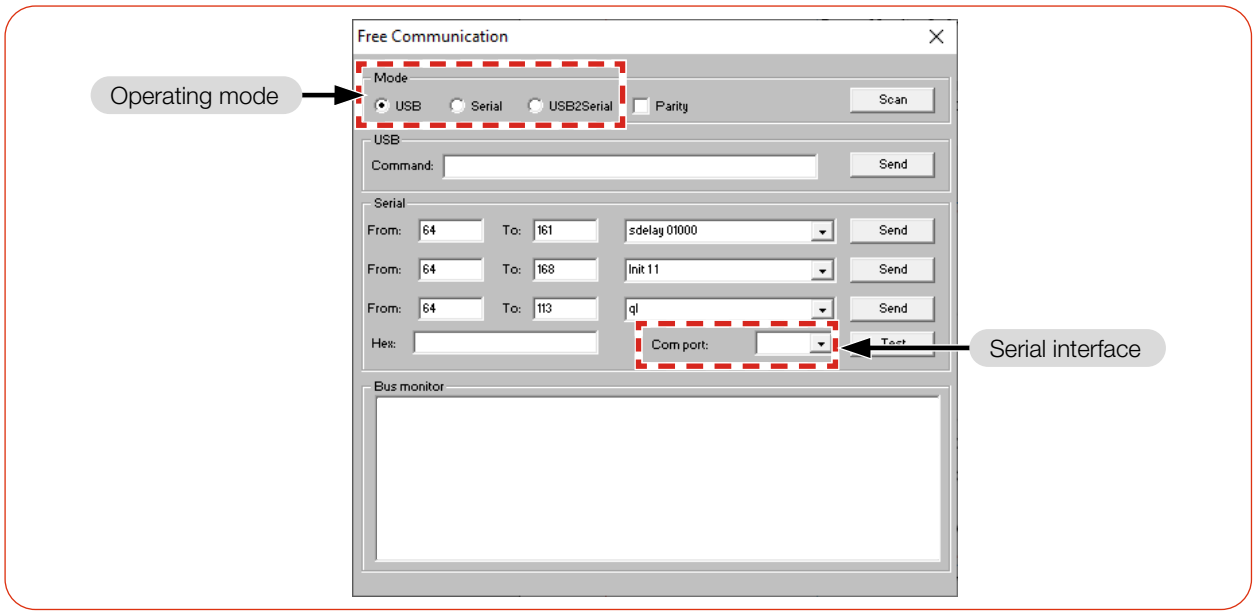


Fig. 9.2: Menu Free Communication

If no communication is established, press the ***Start power measurement / Stop power measurement*** button in the upper right hand corner a couple of times (see Fig. 9.1 on page 51).

If communication is still not possible, test the interfaces according to chapter 9.5.3 on page 53.

9.5.3 Testing the interface

After connecting the devices, the communication between PC and device can be checked in the menu ***Communication > Free Communication***.

First of all, the interface is checked by starting the software on the PC.

Possible error message:

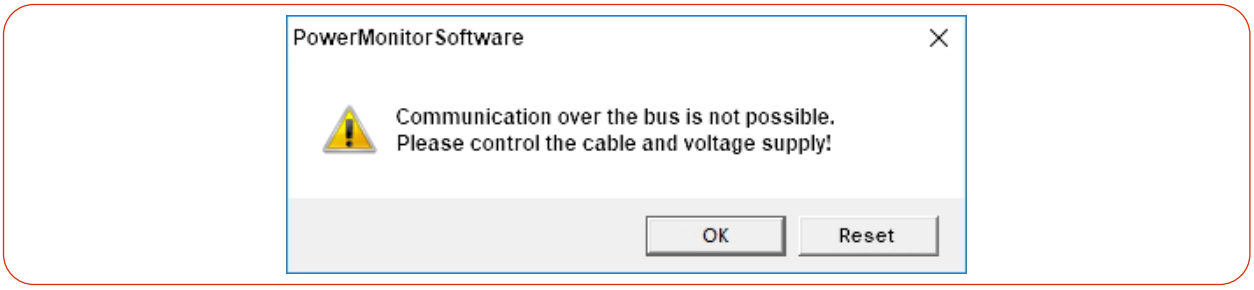


Fig. 9.3: Possible error message

Reason:

- The communication via the bus system is not possible.

Remedy:

1. Check the cabling of the devices.
2. Ensure that the power supply is connected and switched on (the communication is only possible if the PRIMES bus is supplied with 24 V direct current voltage).
3. Switch off the power supply and switch it on again.

Possible error message (only when operated with the PRIMES converter):

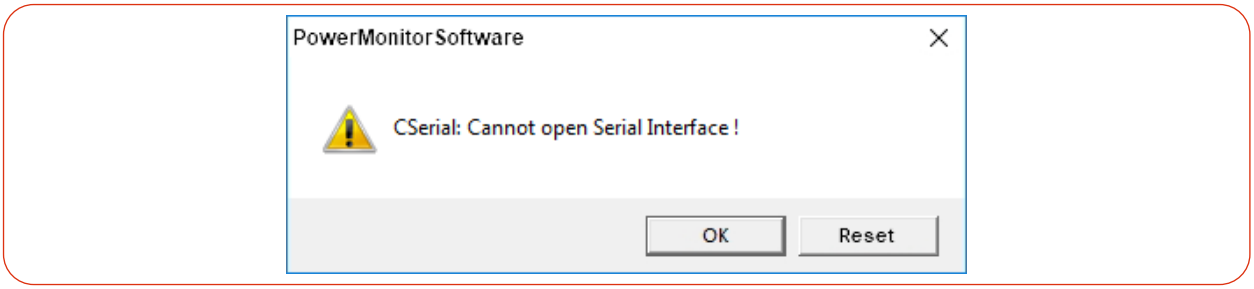


Fig. 9.4: Possible error message

Reason:

- The software cannot open the preset interface.

Remedy:

1. Check whether another software, e.g. a fax software or a parallel running LDS, is just using the interface. A serial port can only be used by one software at a time.
2. Check whether the software opens the correct port. After starting the software, the used interface can be changed in the menu ***Free Communication***. All interfaces available for the software are initially displayed here (drop down list ***Com port***).

9.5.4 Testing the communication of multiple devices

The communication is checked via the PC by means of the PMS. For this purpose, a certain command is sent to each device. If a device replies as stated in Tab. 9.3 on page 54 the communication works without any problems.

1. Select ***Communication > Free communication***.
   In the appearing window the address of the sender (PC) has to be entered in the field ***From***, the address of the recipient has to be entered in the field ***To*** (PRIMES device) and the command is entered in the text field on the right.
2. The command is confirmed by clicking the button ***Send***.
   The reply of the device appears below in the bus monitor.

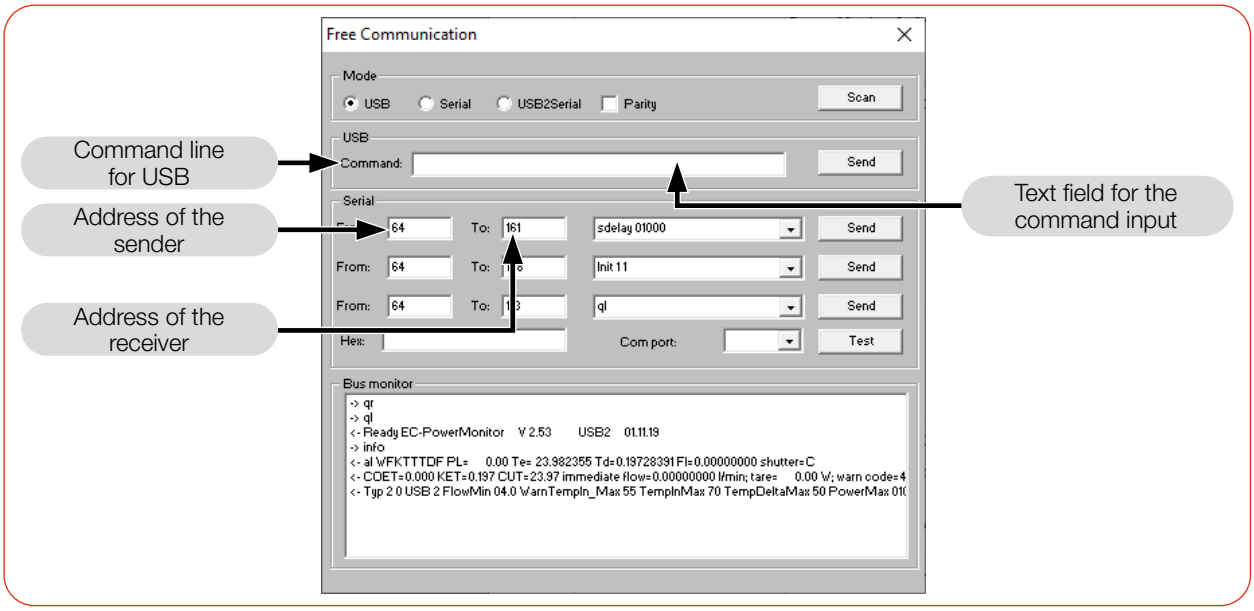


Fig. 9.5: Menu Free Communication

Device	From (PC)	To (Device)	Command	Reply
FocusMonitor FM	64	161	qr	aID FocusMonitor
BeamMonitor BM	64	144	qr	aID BeamMonitor
PowerMonitor	64	113	qr	ready PowerMonitor

Tab. 9.3: Table for the function control

The command for a query request is ***qr***.

If no reply is received from a device:

1. Switch off the power supply and switch it on again. Send the command again.
2. Check the wiring of the unit and whether all plugs are connected.
3. A device blocks the PRIMES bus. Switch off the power supply and take the corresponding device off the bus. Put the the system back into operation.
4. The PC blocks the PRIMES bus: The red LED “Send“ at the PRIMES converter glows permanently. Start the PC again.

9.5.5 Determine device offset

To determine the device offset, the device must go through a thermalization time.

1. Run the cooling water for approx. 2 minutes.

➔ After approx. 2 minutes, the device temperature and the temperature of the cooling water are in equilibrium.

2. With the laser switched off, click ***Start power measurement***.
3. Click ***Use current value as offset***.

➔ The offset value is determined and stored in the PMS.

👁 The display of the laser power is automatically corrected with the stored offset value.

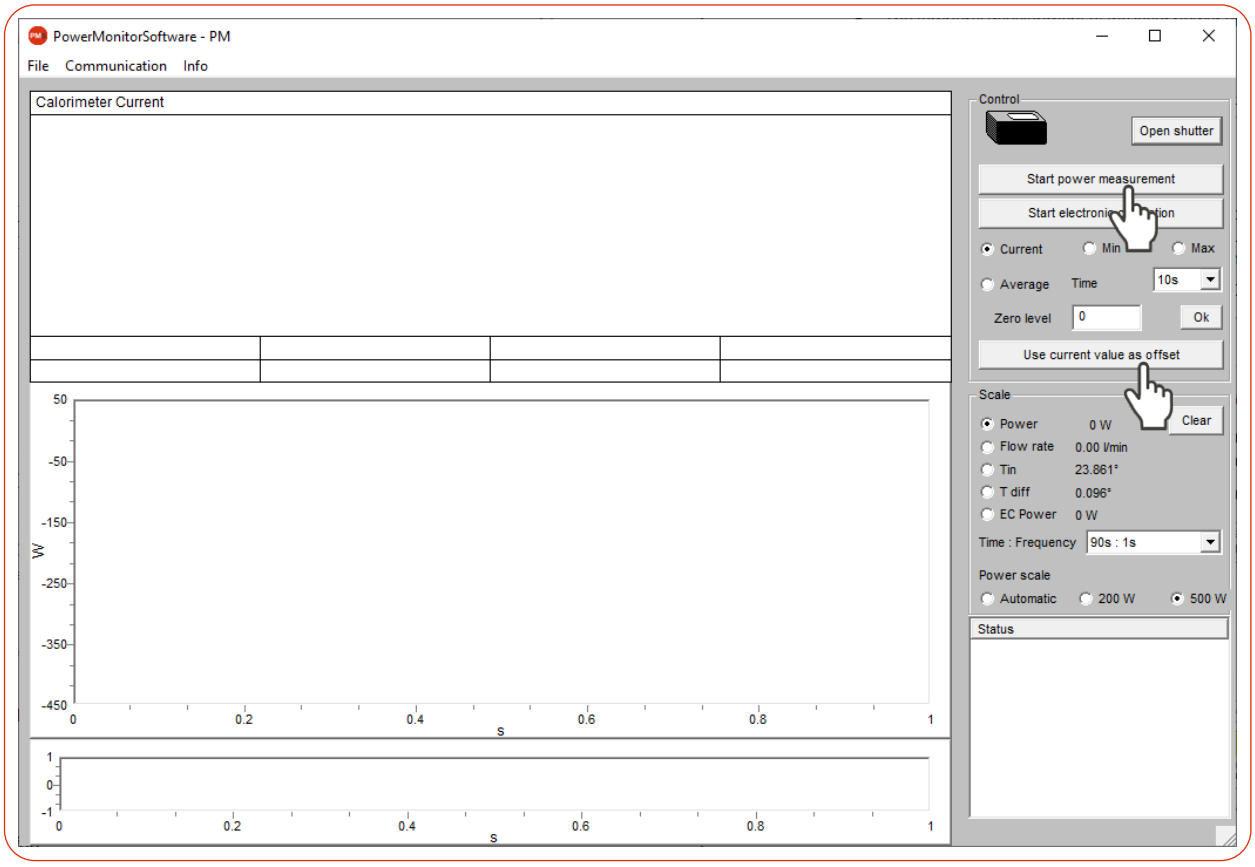


Fig. 9.6: Determine device offset

9.5.6 Start electronic calibration

1. Run the cooling water for approx. 2 minutes.

➔ After approx. 2 minutes, the device temperature and the temperature of the cooling water are in equilibrium.

2. Click the ***Start electronic calibration*** button.

👁 The ***Shutdown laser*** window appears.

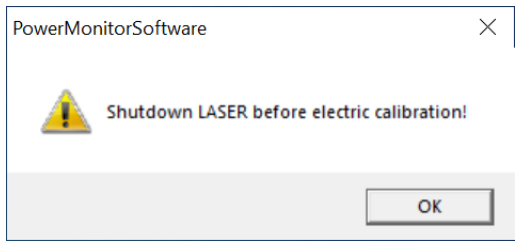


Fig. 9.7: Shutdown laser

3. Make sure that the Laser is switched off.
4. Click ***OK***.

➔ The calibration is started (duration approx. 90 seconds).

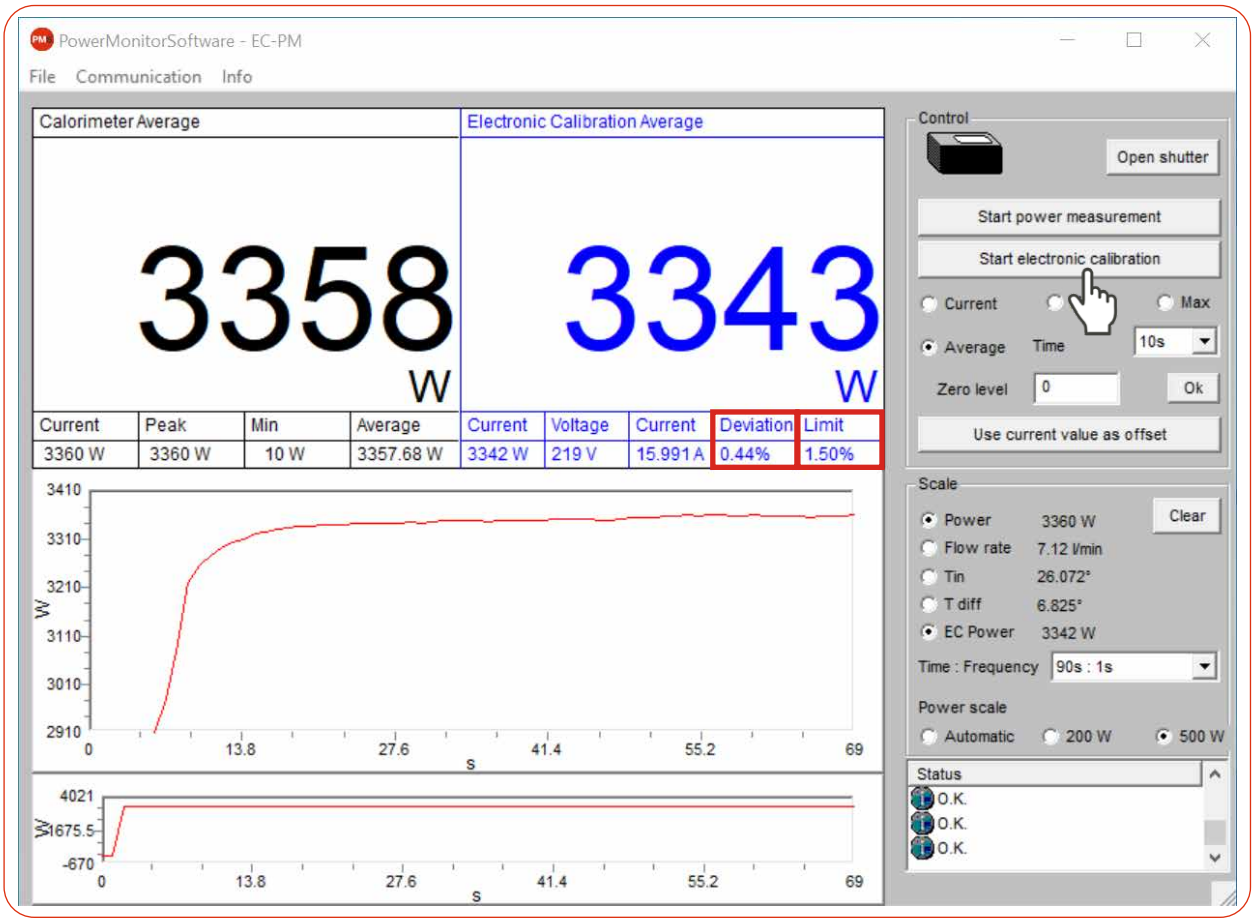


Fig. 9.8: Electronic calibration display

➔ The measured calorimetric and electronic power is displayed in W. The deviation is displayed in percent in the ***Deviation*** field. The limit is displayed in the ***Limit*** field as ***1.50 %***. The limit setting is preset to ***1.50 %*** in the ***File > Settings*** menu in the ***Deviation limit (EC)*** input field. If the permitted deviation of 1.5 % is exceeded, send the device to PRIMES for calibration.

9.5.7 Perform power measurement

1. Observe the max. laser power as a function of the beam diameter according to appendix A on page 70.
2. Click the ***Open shutter*** button.

- With the compressed air supply connected, the shutter is opened automatically.
- Without a compressed air connection, the shutter must be opened manually as far as it will go.

If the position of the shutter is unknown or an ***Open shutter*** command has not been executed correctly, a question mark will appear on the PowerMonitor icon.

3. Switch on the laser.
4. Click the button ***Start***.

➔ The measured laser power is displayed after about 2 seconds.
After about 15 seconds the display reaches about 99 % of the final value.

5. If no measurement duration has been entered in the drop down list ***Time : Frequency***, click the ***Stop*** button.

➔ The measurement is finished.

6. Switch off the laser.
7. Click the ***Close shutter*** button.

- The shutter on the device is closed automatically
- Without a compressed air connection, the shutter must be closed manually as far as it will go.

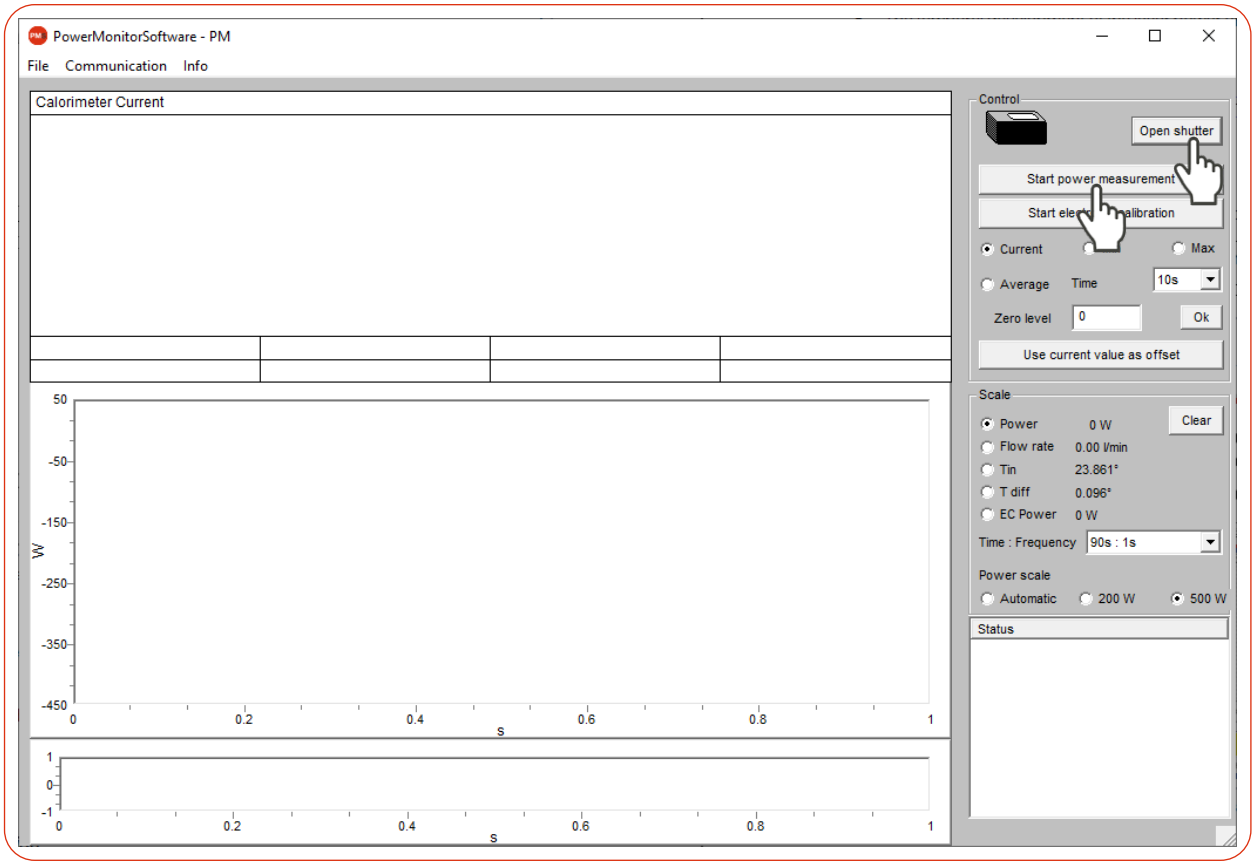


Fig. 9.9: Perform power measurement

9.5.8 Measuring value display

The graphical user interface is divided into three display parts (see Fig. 9.10 on page 58):

- The numerical display of the current measuring values (window A)
- The temporal development of the laser power or the flow rate or of the cooling water temperature (window B)
- Status window

Window A (Numerical display)

In window A below the large display in Fig. 9.10 on page 58: 969 W the following measured values are displayed:

- The current measuring value
- The minimum value and the maximum value
- The average value (button ***Average***) of the chosen time interval (drop down list ***Time***)

With the averaging of the power measuring values (***Time*** 10 s, 20 s, 30 s, 50 s, max = 90 s) a noise can be reduced, which enables very accurate measurements.

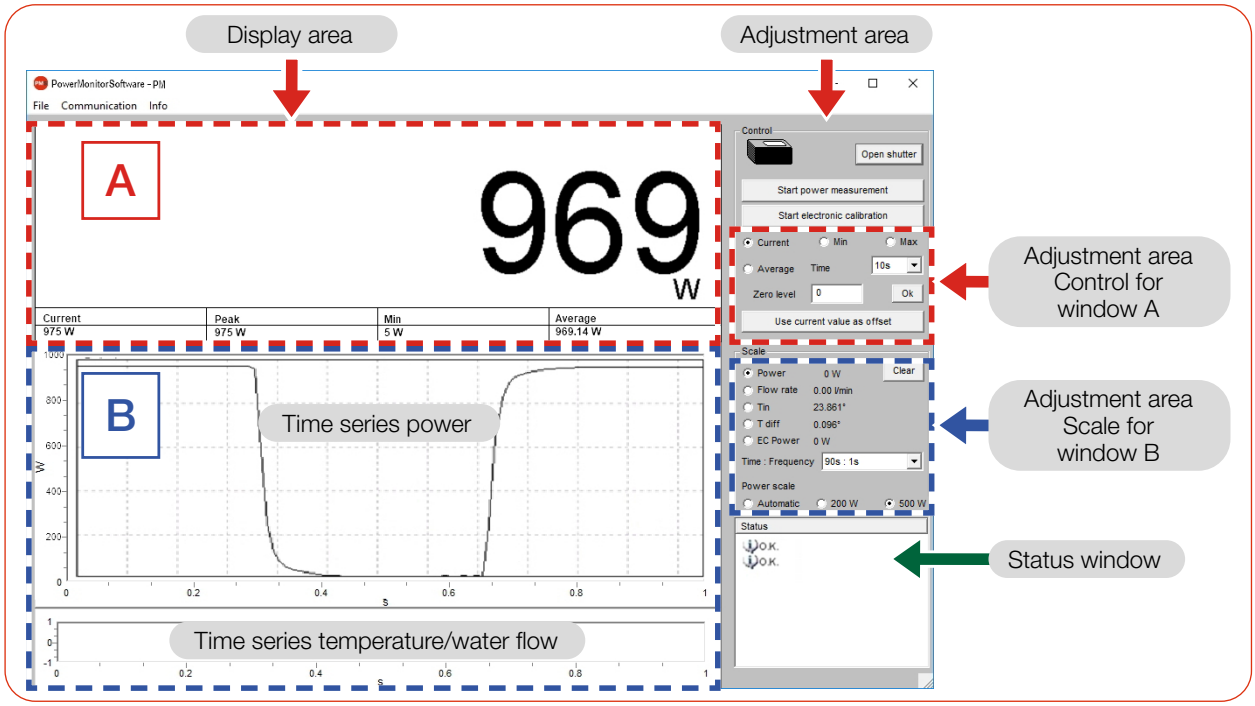


Fig. 9.10: The graphical user interface during a measurement

The option switches ***Current***, ***Min***, ***Max***, ***Average*** in the configuration range ***Control*** set which measured value is shown in large digits (see Tab. 9.4 on page 58).

Selection	Display
Current	Display of the current power
Min	Display of the minimum power measured
Max	Display of the maximum power measured
Average	Display of the average value within the chosen measurement duration

Tab. 9.4: Selection for large display of the measured value

Settings

The maximum duration (Max) for the averaging is 90 seconds.

A possible zero offset can be compensated with the button ***Use current value as offset*** or numerically via the input field ***Zero level***.

Window B (Graphical display)

In window B two time series are displayed:

Time series power

The y-axis (power) of the window can be scaled automatically or with fixed values (200 W or 500 W). In the setting ***Automatic*** the y-axis is scaled with the difference of the measured minimum and maximum value.

Time series temperature/Flow rate

The cooling water flow rate or the input temperature (T_{in}) or the difference temperature (T_{diff}) between the water supply (Water In) and the water return (Water Out) or the EC power can be controlled here. The selection is made via the option switches within the adjustment area ***Scale***.

- ***Flow rate***
- T_{in}
- T_{diff}
- ***EC Power***

Push button clear

Deletes all numerical and graphical displays in the windows.

Select list Time: Frequency

In this drop down list the duration of the measurement as well as the measurement rate (number of measurements per time unit) can be chosen. Possible settings:

Measurement duration	Measurement rate	
90 s	1 s	≙ 1 Hz
10 min	2 s	≙ 0,5 Hz
30 min	2 s	≙ 0,5 Hz
2 h	5 s	≙ 0,2 Hz
10 h	5 s	≙ 0,2 Hz
50 h	10 s	≙ 0,1 Hz

Tab. 9.5: Setting Time: Frequency

Status window

In the bottom right window ***Status*** of the user interface (see Fig. 9.10 on page 58) error messages can appear in red font. These errors have to be remedied before a measurement.

10 Troubleshooting

10.1 Messages in the LDS during measurement

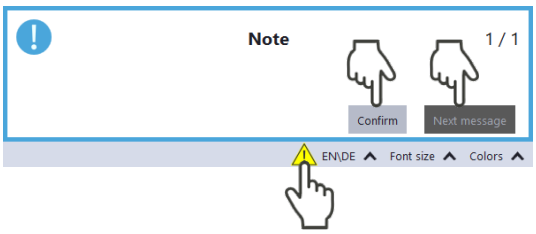
If problems occur during a measurement, the LDS displays them in different categories and different colors.

Note

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.

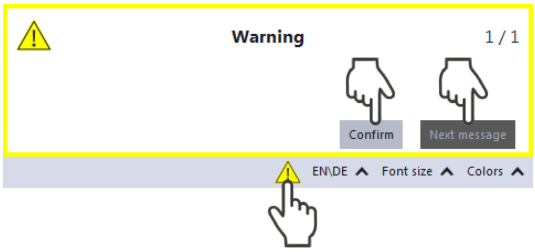


Warning

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.



Device error

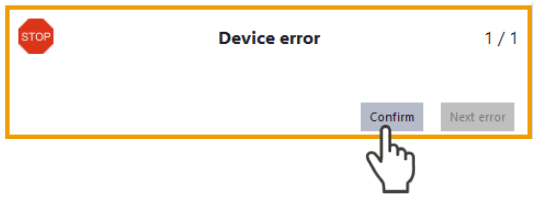
Device errors that can result in damage of the device are displayed in an orange window.

In this case, proceed as follows:

1. Fix the problem.
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 solved.



Safety critical note

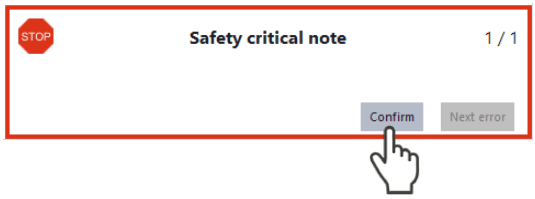
Safety-critical problems that can result in damage/destruction of the device are displayed in a red window.

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 solved.



10.2 Connection errors with the LDS

Error	Possible cause	Solution
The USB connection between the device and the LDS cannot be established.	No USB connection has been established.	▶ Connect the USB port on the device and on the PC with the USB cable.
	The PRIMES USB driver has not been installed.	A driver is required for a USB connection. ▶ Install the USB driver according to chapter 7.4.2 on page 32.

Tab. 10.1: Connection errors when using the LDS

10.3 Acoustic warning signal

If the permitted temperature of the absorber of 60 °C is exceeded, a warning signal will sound:

1. Switch off the laser immediately.

If water leaks out of the device after the warning signal has sounded, the device may be damaged by overheating and cease to be operable.

The overpressure caused in the standing cooling water can also cause leaks in the hoses and connectors.

2. Check the device for leaks. In the event of a leak, please send the device to PRIMES for inspection.

If no leakage can be detected:

1. Check the flow and the correct flow rate.
2. Check the proper shutdown of the laser in the event of a fault by the safety interlock.
   To do this, reduce the flow rate.
3. If the device stops working properly, please send the device to PRIMES for inspection.

10.4 Safety interlock was triggered

The safety interlock is triggered when a safety-critical error occurs. There is a risk that the device will be damaged due to insufficient cooling.

The measurement can only be continued after the cause of the error has been resolved.

Possible error causes:

- The cooling water flow is too low (Flow < 4 l/min). Increase the flow rate.
- The cooling water temperature at the water supply (Water In) is too high (Te > 70 °C). Check the cooling system.
- The temperature difference between water supply (Water In) and water return (Water out) is too large (Td > 50 K). Reduce the power or increase the flow rate.
- The shutter is not (completely) open.

The cause of the error is displayed in the LaserDiagnosticsSoftware LDS.

When measuring without the LDS, check the values on the display against the given setpoints.

10.5 Other errors

Error	Possible cause	Solution
The device shows no flow. The shown laser power on the display, the LDS or PMS has a negative prefix.	The flow direction has been reversed.	Reversing the direction of flow will damage/destroy the flow meter during longer operation. ▶ Connect the water supply (Water In) and the water return (Water out) according to the markings on the device.

Tab. 10.2: Other errors

11 Maintenance and service

11.1 Maintenance intervals

The operator is responsible for determining the maintenance intervals of the measuring device.

PRIMES recommends a maintenance interval of 12 months after initial operation for inspection and calibration.

If the device is used sporadically (less than once a day), the maintenance interval can be extended up to 24 months.

Please note that the safety and warning functions of the device must be checked regularly.

11.2 Cleaning the device surface

1. After a measurement let the device cool down for an adequate period of time.
2. Clean the device surface with clean and oil-free compressed air.
3. Close all device openings.
4. For further cleaning, use a mixture of distilled water and isopropanol in a ratio of approx. 5:1.
   Use lint-free cleaning cloths that do not cause scratches.
5. If these steps are not sufficient, please contact PRIMES or your PRIMES distributor.

12 Measures for the product disposal

As a B2B device, this PRIMES measuring device is subject to the European Waste Electrical and Electronic Equipment (WEEE) Directive and the corresponding national laws. The WEEE directive obliges the operating company to dispose of the device in an environmentally sound manner, not with household waste, but in a separate WEEE collection.

PRIMES gives the opportunity to return PRIMES measuring devices for free disposal within the scope of the Waste of Electrical and Electronic Equipment (WEEE Directive). This service does not include shipping costs. 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 registered at the german „joint body“ for producers „Stiftung Elektro-Altgeräte Register“ (Stiftung EAR). Our number is: WEEE-reg.-no. DE65549202.

Caution batteries included!

Please note that there are 2 permanently installed lithium metal cells in the device.

These must be disposed of in accordance with applicable national and international laws if the device is not returned to PRIMES.

13 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:

EC-PowerMonitor (ECPM)

Types: ECPM

is in conformity with the following relevant EC Directives:

- Machinery Directive 2006/42/EC
- EMC Directive EMC 2014/30/EU
- Low voltage Directive 2014/35/EU
- 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, April 26, 2017

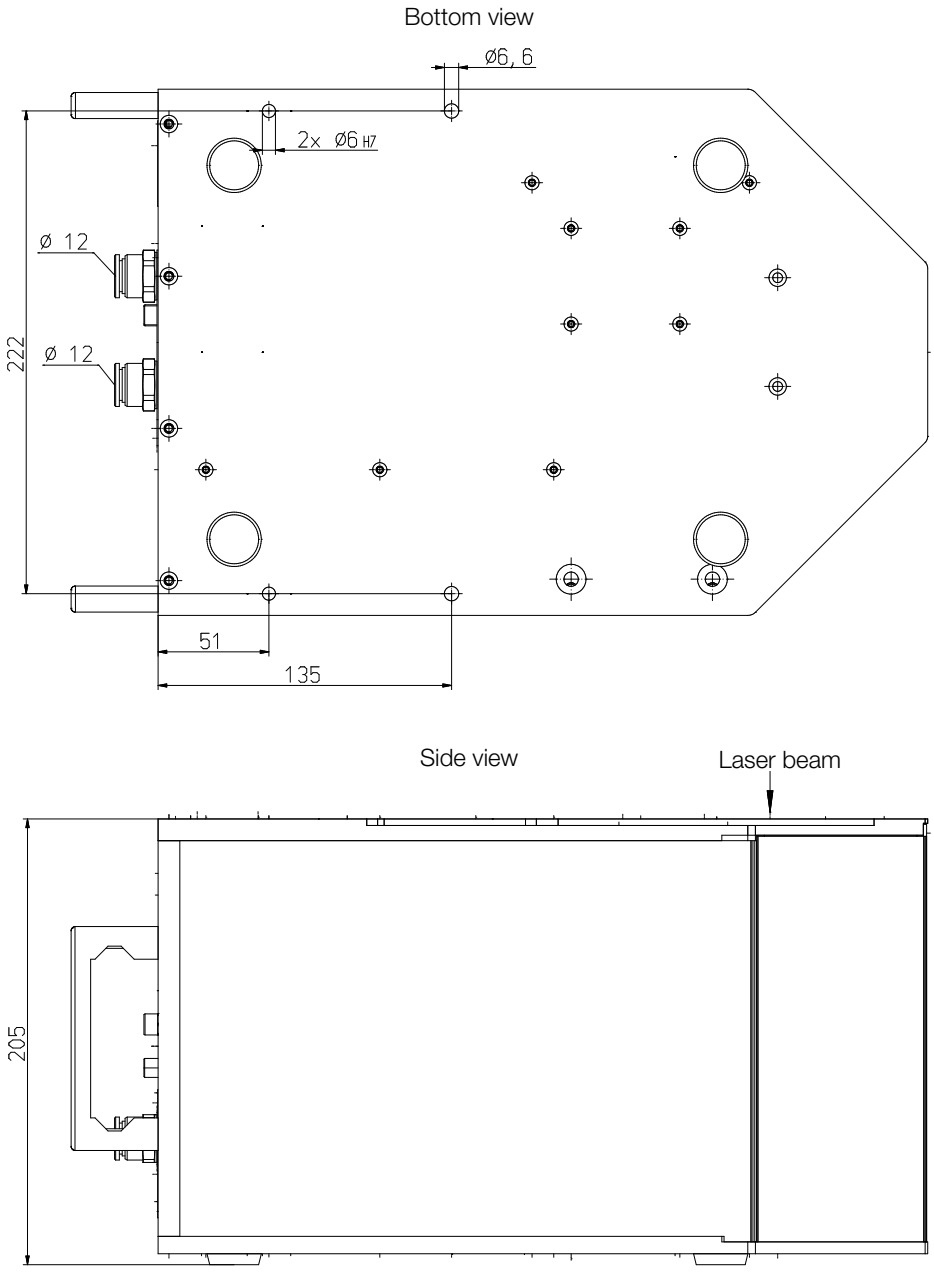
Dr. Reinhard Kramer, CEO

14 Technical data

Measurement parameters		EC-PM
Power range		0.2 – 10 kW
Irradiation time		Continuous (cw)
Wavelength range		450 nm, 515 – 532 nm, 800 – 1 100 nm, 10 600 nm
Max. power density at wavelength	450 nm, 515 – 532 nm	10 kW/cm²
	800 – 1 100 nm, 10 600 nm	15 kW/cm²
Device parameter		
Entrance aperture		48 mm
Min./max. beam diameter [1]		14/24 mm
Max. centered tolerance [1]		± 3 mm
Min. divergence full angle (convergent) Max. divergence full angle (divergent) [1]		– 50 mrad + 160 mrad
Max. angle of incidence perpendicular to entrance aperture [1]		± 5°
Measurement accuracy at wavelength	450 nm, 515 – 532 nm	± 2.5 %
	800 – 1 100 nm, 10 600 nm	± 2 %
Measuring accuracy of electronic calibration		< 0,5 %
Reproducibility		± 1 %
Time constant		15 s up to 99 % of final value
[1] All specifications apply to the respective maximum values.		
Supply data		
Power supply, AC	Country specific PRIMES power cable	100-240 V, 50/60 Hz, 16 A 100-120 V, 50/60 Hz, 18 A
Cooling water	Hose diameter	12 mm
	Min. cooling water flow (interlock threshold)	4 l/min
	Max. cooling water flow	12 l/min
	Min. cooling water pressure	2 bar
	Max. cooling water pressure	6 bar
	Cooling water temperature Te	Dew point temperature < Te < 30 °C
	Stability of the cooling water temperature	< 1.0 K per minute or 0.08 K per 5 seconds
Compressed air for automatic opening of the shutter	Hose diameter	4 mm
	Min. air pressure	2 bar
	Max. air pressure	4 bar
	Purity class	ISO 8573-1:2010 [7:4:4]

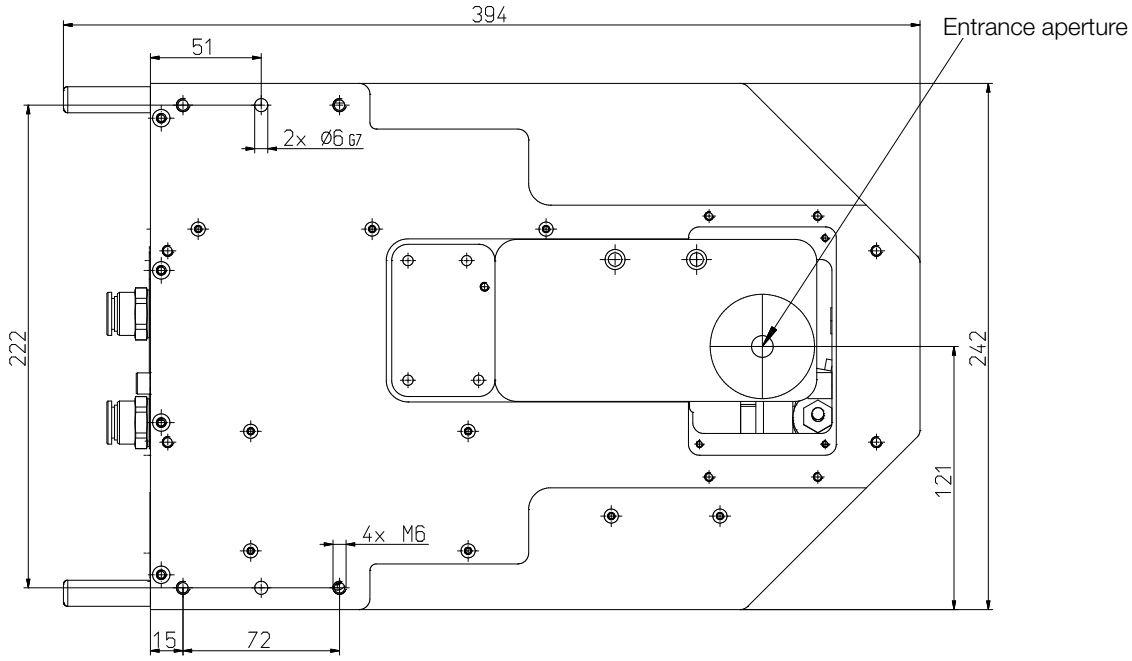
Communication	EC-PM
Interfaces	RS485/USB/Interlock/Analog out
Dimensions and Weights	
Dimensions (L x W x H) with handles and device feet	394 x 242 x 205 mm
Weight (ca.)	16 kg
Environmental conditions	
Operating temperature range	15 – 40 °C
Storage temperature range	5 – 50 °C
Reference temperature	22 °C
Permissible relative humidity (non-condensing)	10 – 80 %
PRIMES is committed to a continuous product improvement strategy, which can lead to specifications being optimized without any prior announcement.	

15 Dimensions

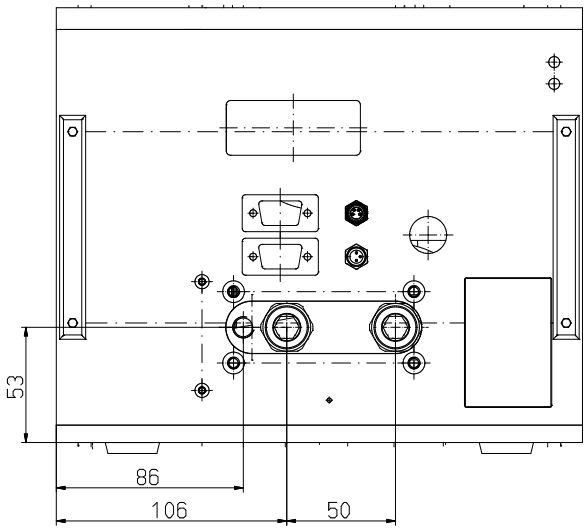


Dimensions in mm

Top view



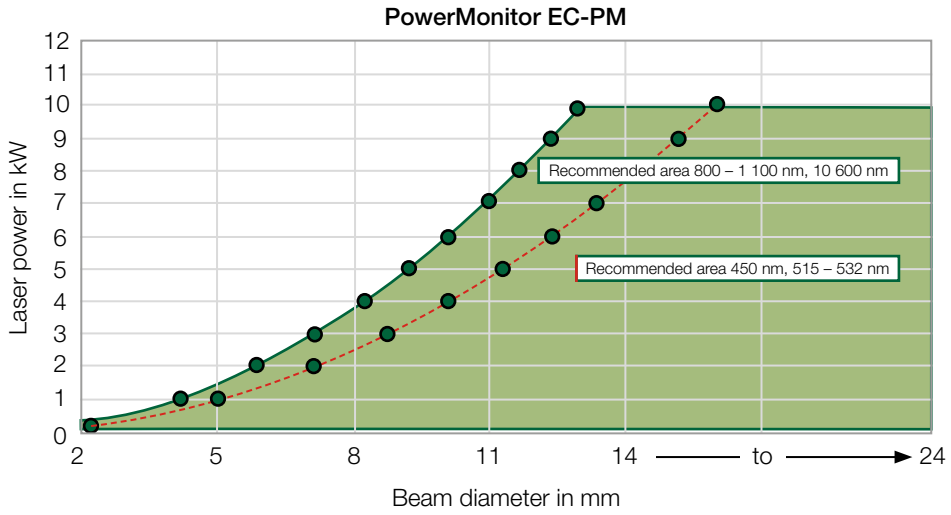
Front view



Dimensions in mm

16 Appendix

A Diagram of the max. laser power as a function of the beam diameter



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C Operation of the EC-PM with a PRIMES PanelDisplay

The optional display (PRIMES PanelDisplay, order no. 130-005-003) enables the measured power to be displayed without a PC at a distance up to 20 m from the EC-PM. A D-Sub cable with a length of 1.8 m is included in delivery.

The PanelDisplay is supplied with power via the PRIMES bus on the EC-PM.

1. Connect the PanelDisplay (front or rear) to the EC-PM using the 9-pin D-Sub cable.
2. Connect the PRIMES power cable to the EC-PM.

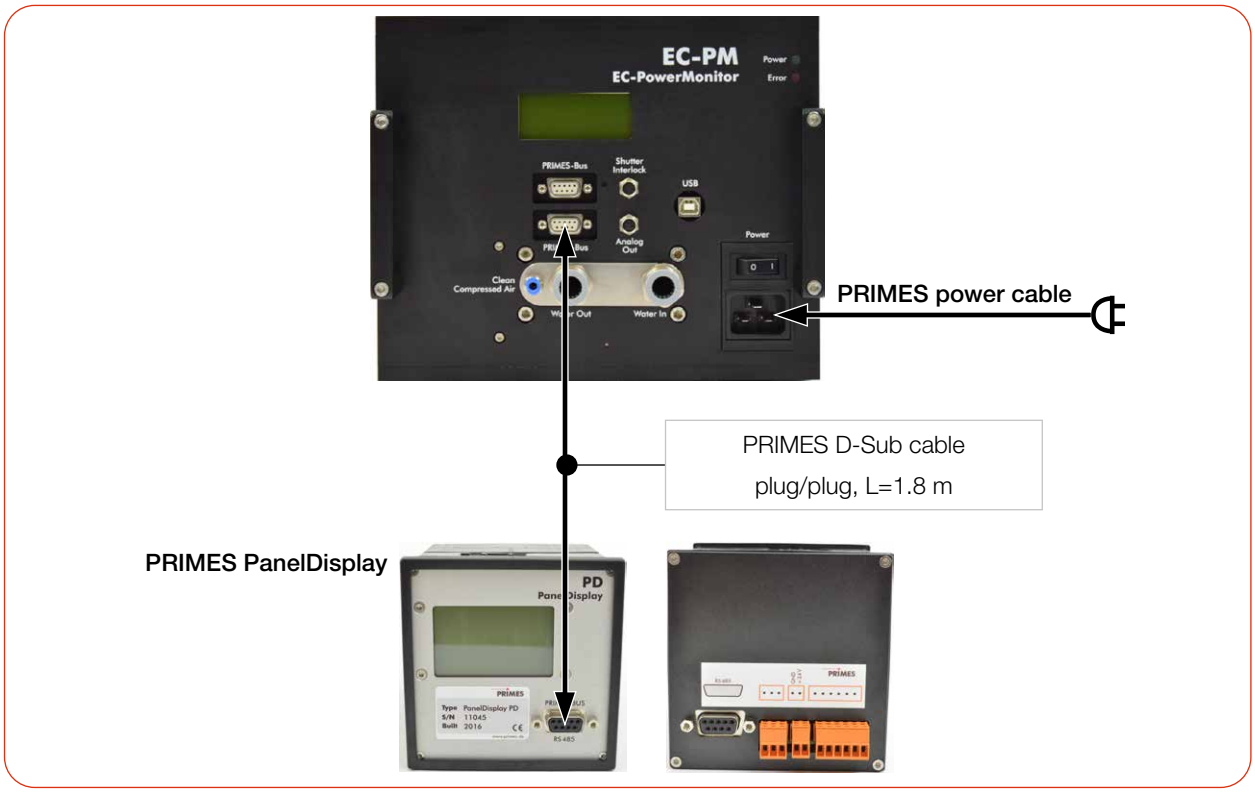
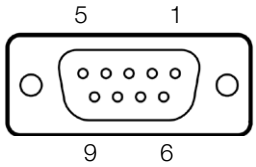


Fig. C.1: Connecting the EC-PM to the PRIMES PanelDisplay

C.1 Pin assignment

Pin assignment (view to socket on device)



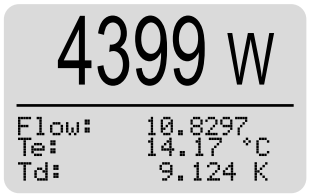
Pin	Function
1	Ground
2	RS485 (+)
3	+24 V
4	Not assigned
5	Not assigned
6	Ground
7	RS485 (–)
8	+24 V
9	Not assigned

Tab. C.1: Pin assignment D-Sub socket on the PRIMES PanelDisplay

C.2 Display

The PRIMES PanelDisplay reflects the display of the EC-PM and shows the following measurement values:

Display	Meaning
W	Laser power in W
Flow	Flow rate of the cooling water in l/min
Te	Cooling water temperature at the water supply (Water In) in °C
Td	Temperature difference between water supply (Water In) and water return (Water Out) in Kelvin



Tab. C.2: Meaning of the abbreviations in the PRIMES PanelDisplay

For the operation of the PowerMonitorSoftware PMS via PC, you have to change the operating mode of the display from “Active” to “Passive”. Further information can be found in the operating manual „Panel Display“, chapter „Operating Mode“.

D Fiber adapter

For detailed information on the available fiber adapters, please contact PRIMES or your PRIMES distributor.

The fiber adapter connects the EC-PM to a fiber, so that power measurements at the fiber end are possible. The following fiber adapters are available:

Device type	Fiber adapter type	Order number
EC-PM	Fiber adapter for LLK-B	130-006-006
	Fiber adapter for LLK-D	130-006-007
	Fiber adapter for QBH	130-006-009

Tab. D.1: Fiber adapter types

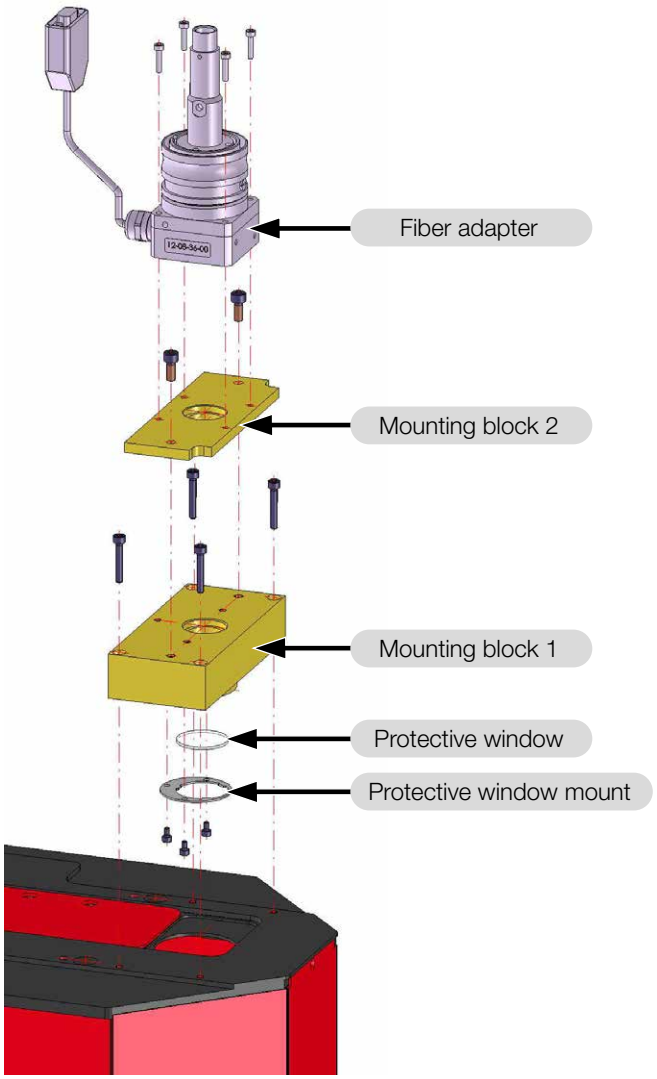


Fig. D.1: Fiber adapter (using the fiber adapter LLK-D as example)

E Parallel operation of EC-PM with a FocusMonitor FM+

E.1 Spacers for EC-PM operation with FocusMonitor FM+

Various spacers are available for mounting the FM+ on the EC-PM.

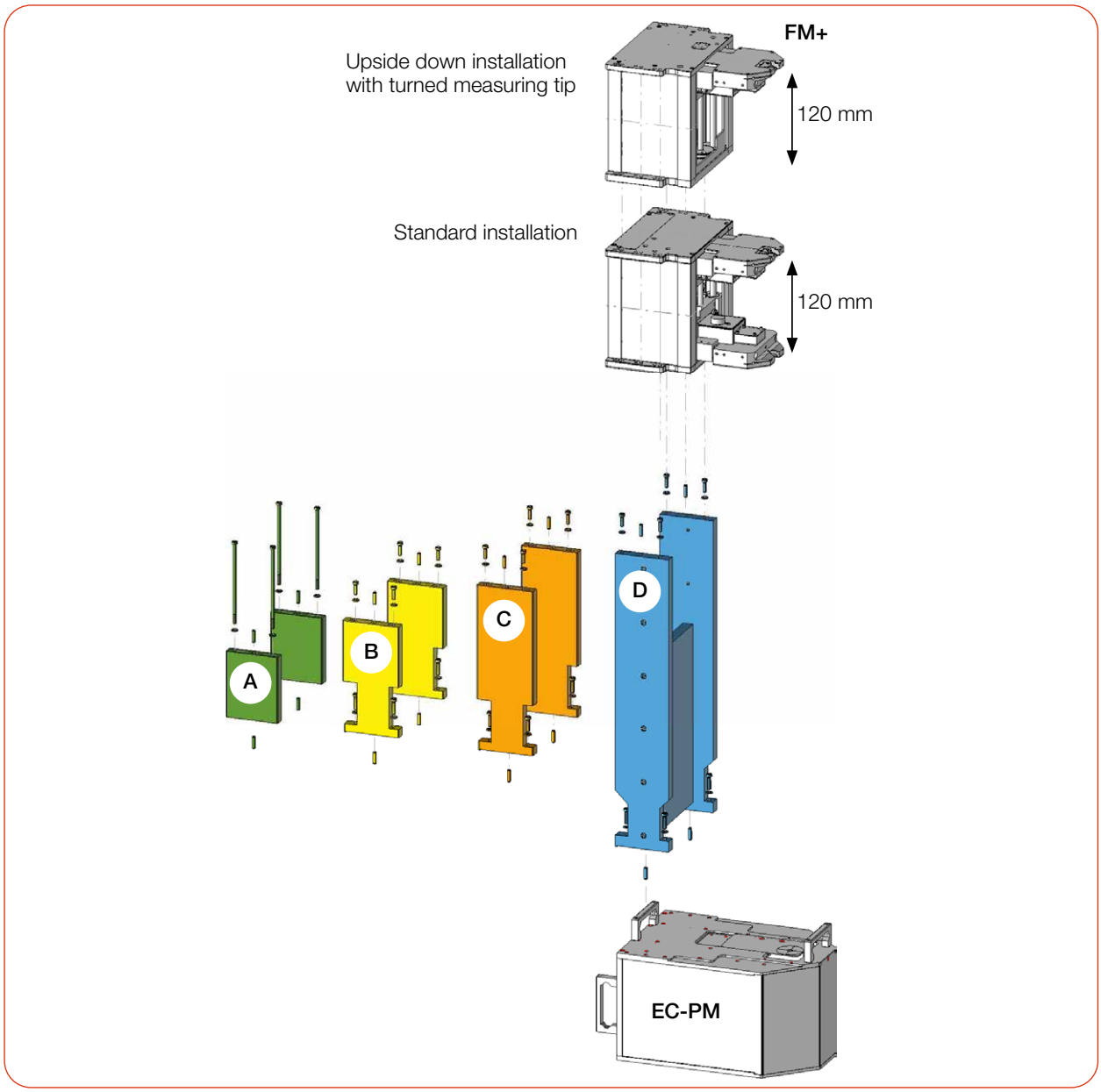
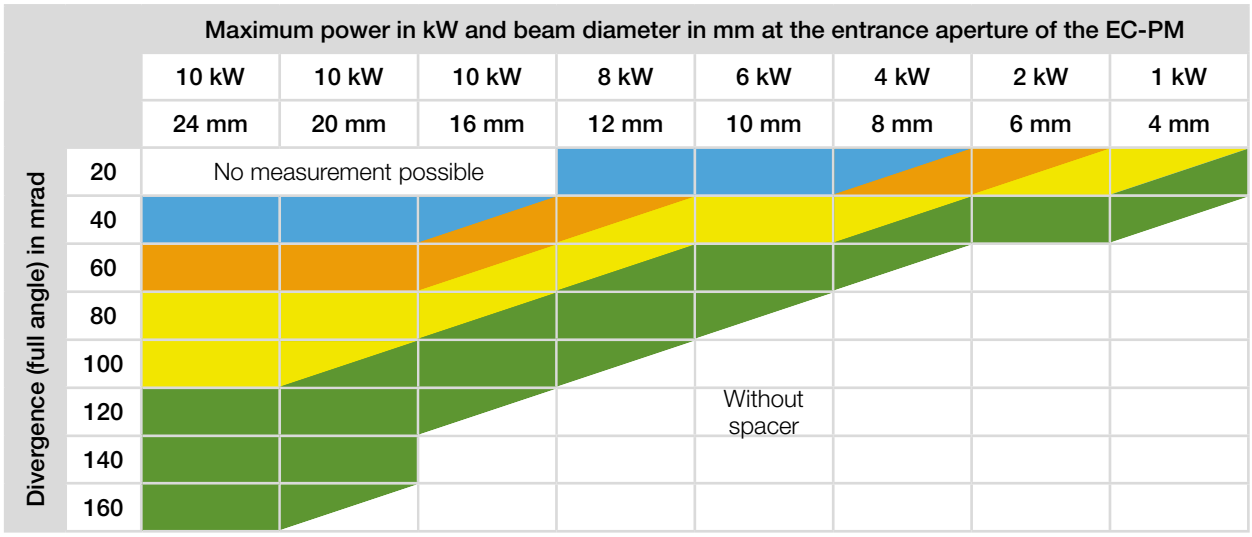


Fig. E.1: Spacer types

Spacers	Height in mm	Order-No.
A	123	130-006-001
B	208	130-006-003
C	308	130-006-015
D	548	130-006-010

Tab. E.1: Dimensions and order numbers of the spacers

E.2 Selecting spacers for the PowerMonitor EC-PM



In the fields with diagonally separated colors, both spacers can be used depending on the beam parameters at the entrance aperture of the EC-PM.

Without	Spacer A	Spacer B	Spacer C	Spacer D

Tab. E.2: Selecting spacers for the EC-PM

E.3 Overview of the overall height

The spacers can be used for the EC-PM

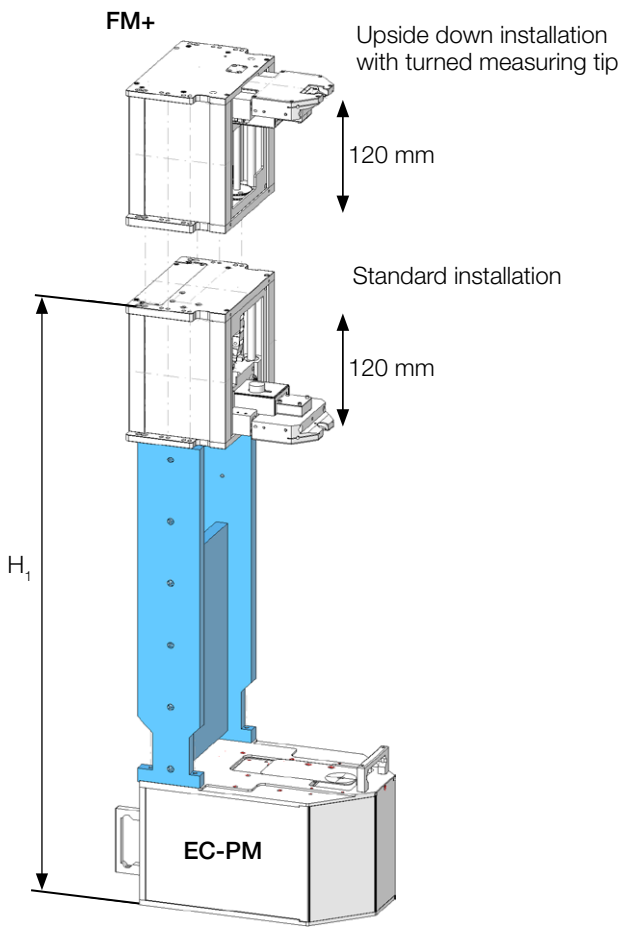


Fig. E.2: Overview of the total height

	EC-PM with FocusMonitor FM+
Spacers	**H_1 in mm**
A	541
B	626
C	726
D	966

Tab. E.3: Mounting heights of the FocusMonitor FM+ with different spacers on the EC-PM

The total height includes the removable device feet of the EC-PM (device feet height = 5 mm).

E.4 Connect devices

NOTICE

Damage/Destruction of the device

Connecting or disconnecting the bus cables when the power supply is applied leads to voltage peaks that may destroy the communication modules of the device.

▶ Only establish all connections when the power supply is switched off.

1. Connect the FM+ to the PC via Ethernet.
2. Connect the EC-PM to the FM+ via the RS485 interfaces (PRIMES bus).
   The signal of the EC-PM is forwarded by the FM+ via its Ethernet interface to the PC.
3. Connect the PRIMES Power supply to the FM+.
4. Connect the PRIMES power cable to the EC-PM.

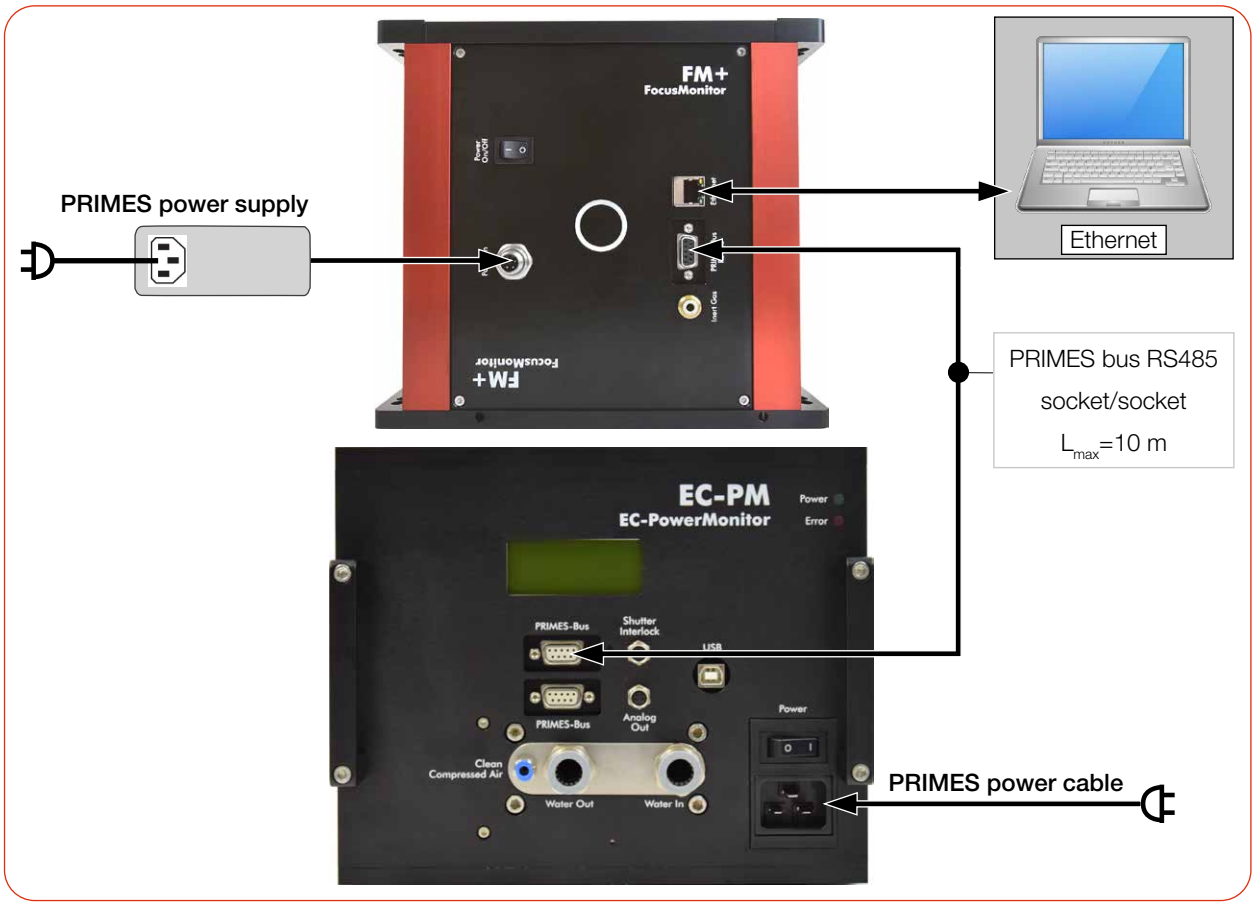


Fig. E.3: Connecting the FocusMonitor FM+ to the EC-PM