PRIMES

Original Operating Manual

CompactPowerMonitor CPM+ F-10

CompactPowerMonitor CPM+

CPM+ F-1, CPM+ F-10, CPM+ F-30

LaserDiagnosticsSoftware LDS

Revision 00 EN - 03/2025

IMPORTANT!

READ CAREFULLY BEFORE USE.

KEEP FOR FUTURE USE.

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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 58 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!

Do not touch!

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 CompactPowerMonitor CPM+ and how to perform measurements:

- as a stand-alone-device
- using the LaserDiagnosticsSoftware LDS version 4.0 or higher.

The abbreviations CPM+ and LDS are used in this operating manual.

For measurement operation with a PC, the LDS must be installed on the PC. The LDS is 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 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, it is possible that a newer version will be available.

4 Device description

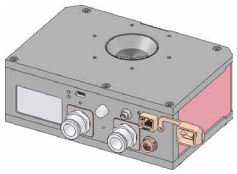
4.1 Type overview

The CPM+ can be equipped with different flow meters:

- Turbine
- Ultrasonic sensors

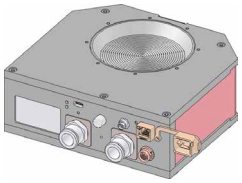
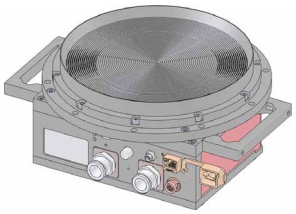
The devices also differ in the size of the entrance aperture, the absorber size and thus in the overall dimensions, the permitted power range and the cooling water flow rate required.

4.1.1 Devices with turbine

Typ		Entrance aperture in mm	Dimensions in mm	Power range in kW	Flow rate (min/max)
CPM+ F-1		45	180x143x71	0.1 – 1.4	0.5 – 2 l/min

Tab. 4.1: Type overview of devices with turbine

4.1.2 Devices with ultrasonic sensors

Typ		Entrance aperture in mm	Dimensions in mm	Power range in kW	Flow rate (min/max)
CPM+ F-10		90	180x182x71	0.5 – 10	4 – 10 l/min
CPM+ F-30		180	260×220x113	2 – 30	9 – 30 l/min

Tab. 4.2: Type overview of devices with ultrasonic sensors

4.2 Functional description

The CPM+ is a measuring device for determining the power of laser beams in the multi-kilowatt range with wavelengths in the NIR and VIS range.

The main application is to monitor the laser power available in the processing area of solid-state lasers or high-power diode lasers.

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

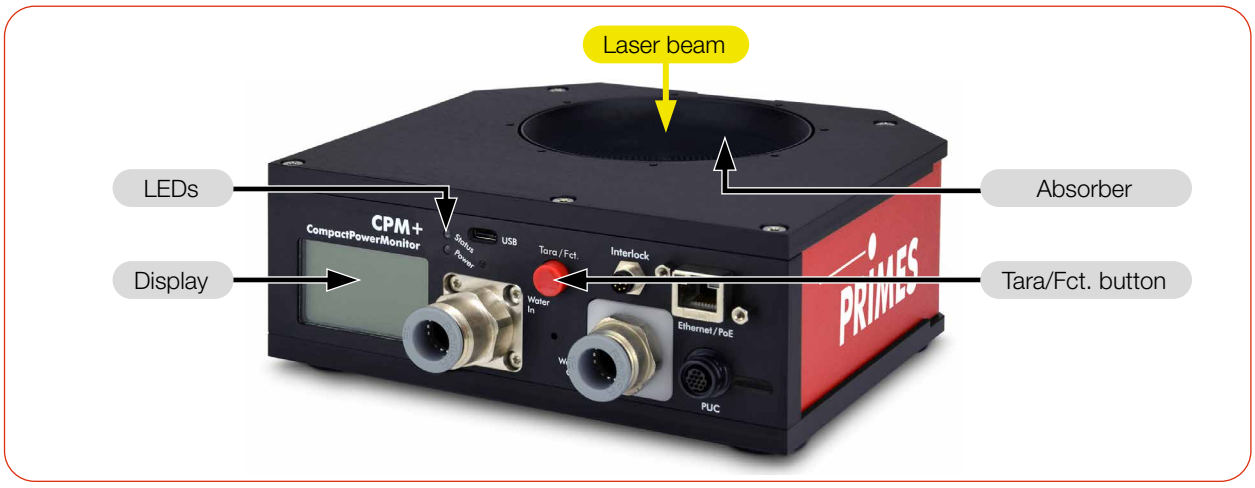


Fig. 4.1: Functional description (using the CPM+ F-10 as example)

4.3 Measuring principle

The CPM+ offers a fast power measurement using the calorimetric measuring principle with active cooling.

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

4.4 Tara/Fct. button

The Tara/Fct. button has two functions:

- Tare function
- Switching between the screens of the display

4.4.1 Tare function

Pressing and holding the Tara/Fct. button (> 0.5 s) applies the currently measured power value as an offset.
The tare screen (without illustration) is displayed for confirmation.

4.4.2 Switching between the screens of the display

Different information can be shown on the display.
Briefly press the Tara/Fct. button to scroll through the different screens.

4.5 Optical displays

4.5.1 LEDs

The LEDs indicate different states of the CPM+.

LED	Color	Meaning
Status	Green	Measurement running without errors.
	Yellow	Warning message (see chapter 10.4.1 on page 52).
	Flashes red	Error message. The safety interlock has been triggered (see chapter 10.4.2 on page 53).
Power	White	Power supply is switched on.

Tab. 4.3: Meaning of the LEDs

4.5.2 Display

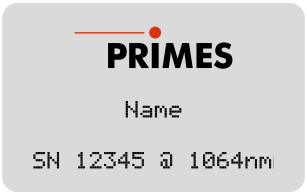
Six different screens can be shown on the display:

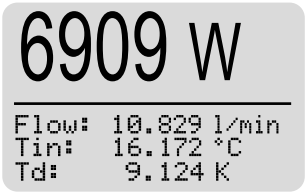
- Start
- Measurement
- Warning
- Status
- Service
- Tare (without illustration)

When the device is powered on, the Start screen is displayed for approx. 1 second.
The measurement screen will subsequently appear.

Briefly pressing the Tara/Fct. button scrolls to the next screen. Four screens can be cycled:
Measurement, Warning, Status and Service.

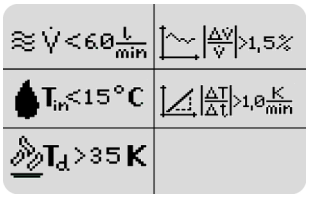
The following information is displayed on the respective screen:

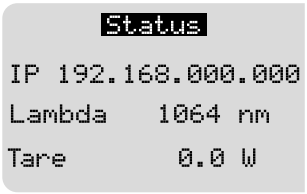
Start	
• the short name of the device • the user-defined device name (this can be entered via the LDS) • the serial number and set calibrated wavelength	

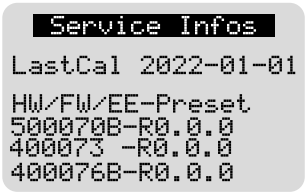
Measurement	
• the currently measured laser power in Watt • the flow rate of the cooling water in l/min (Flow) • the cooling water temperature T_{in} at the water supply (Water In) in °C • the temperature difference T_d between water supply (Water In) and water return (Water Out) in Kelvin	

The CPM+ monitors a wide variety of parameters. In case of deviating parameters, a warning triangle is shown on the display. At the same time, the Status LED lights up yellow or flashes red. For an explanation of the messages, please refer to chapter 10.4 „Warning or error message on the display“ on page 52.

The warning screen displays an icon for the error messages listed below.
Usually, a warning is associated with an increased uncertainty of measurement.

Warning	
• the cooling water flow is too low (depending on device type) • the fluctuations of the flow rate of the cooling water are too high (>1,5 %) • the cooling water temperature at the water supply (Water In) is too low/high (T_{in} < 15 °C / > 40 °C) • the temperature fluctuations at the water supply (Water In) are too high (> 1,0 K/min) • the temperature difference between the water supply (Water In) and the water return (Water Out) is too high (T_d > 35 K) Without error “no warning” is displayed.	

Status	
• IP-address or „USB“ when using USB operation • the set calibrated wavelength • The current tare value (has the value 0 after switching on the device. It remains this way until it is tared using the Tara/Fct. button or set a value in the LDS)	

Service	
• the date of the last calibration • the hardware version • the firmware-version • the preset-version	

4.6 Explanation of the product safety labels and warning labels

Potential hazard areas on the device are labelled with the product safety label “Do not touch” and a warning label. Depending on the device type, the product safety label and the warning label are attached to the top or side of the device:

Product safety label “Do not touch”

Do not touch the absorber. The absorber gets hot during operation. The water cooling prevents the absorber from overheating. However, in the event of an error, strong overheating of the absorber may occur. In this case, touching the absorber can lead to serious burns.

Do not touch the absorber. Touching the absorber can lead to localized absorption of the laser radiation at the points of contact, leading to burn marks and increased scattered radiation.

Only CPM+ F-1 (not illustrated): Warning label “Do not use compressed air” on the top of the device

The CPM+ F-1 uses a turbine for flow measurement. The turbine will be damaged if compressed air is used in the cooling circuit. Do not use compressed air to force drain the cooling water circuit.

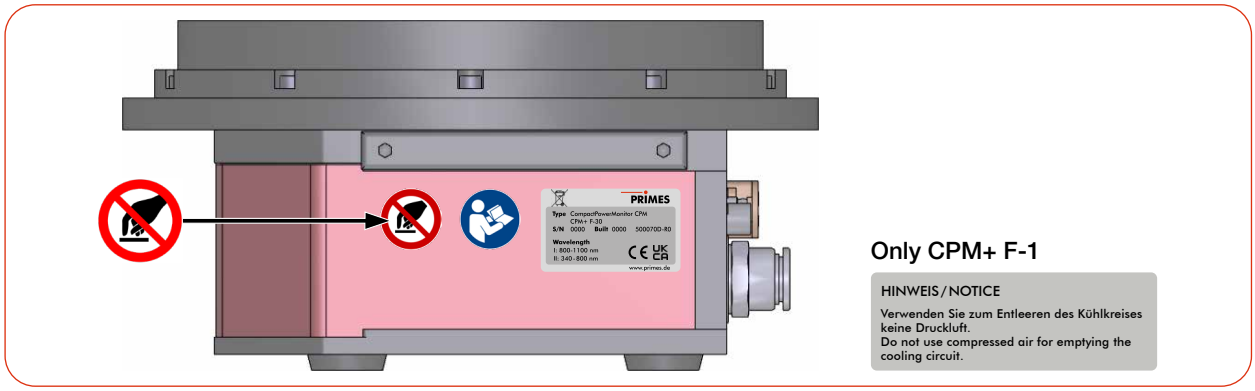


Fig. 4.2: Product safety label „Do not touch“ (using the CPM+ F-30 as example)

4.7 Scope of delivery and optional accessories

The scope of delivery includes:

- CompactPowerMonitor CPM+
- PRIMES USB flash drive
- USB power supply (country-specific)
- USB cable (C to A connector), 2 m
- Ethernet cable, 5 m
- Safety interlock cable, 8-pin, 5 m
- 2 sealing plugs for cooling circuit (installed)
- LaserDiagnosticsSoftware LDS

The following accessories are optional:

- Transport and storage case
- Fiber adapter and domes for CPM+ F1 and CPM+ F-10 (see appendix C on page 65)

5 Transport and storage

NOTICE

Damage/Destruction of the device

Hard hits or falls may damage the device.

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

- ▶ Do not touch the absorber.
- ▶ 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.

- ▶ Drain the cooling circuit lines by tilting the device. To drain the cooling circuit completely, follow the instructions in chapter 7.7.4 on page 36.
- ▶ 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 (only CPM+ F-1)

The CPM+ F-1 uses a turbine for flow measurement.
The turbine will be damaged if compressed air is used in the cooling circuit.

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

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 connection cables and hoses.

6.2.2 Possible mounting positions

CPM+ F-1 with turbine

The device can be mounted in the mounting positions shown in Fig. 6.1 on page 17:

- Text on connector side the right way up, beam incidence from above
- Text on connector side upside down, beam incidence from below
- Text of the connection side rotated by 90°, beam incidence from the left
- Text of the connection side rotated by 90°, beam incidence from the right

The device must not be installed with the connection side facing up or down.

CPM+ F-10 and CPM+ F-30 with ultrasonic sensors

The devices can be installed in any mounting position.

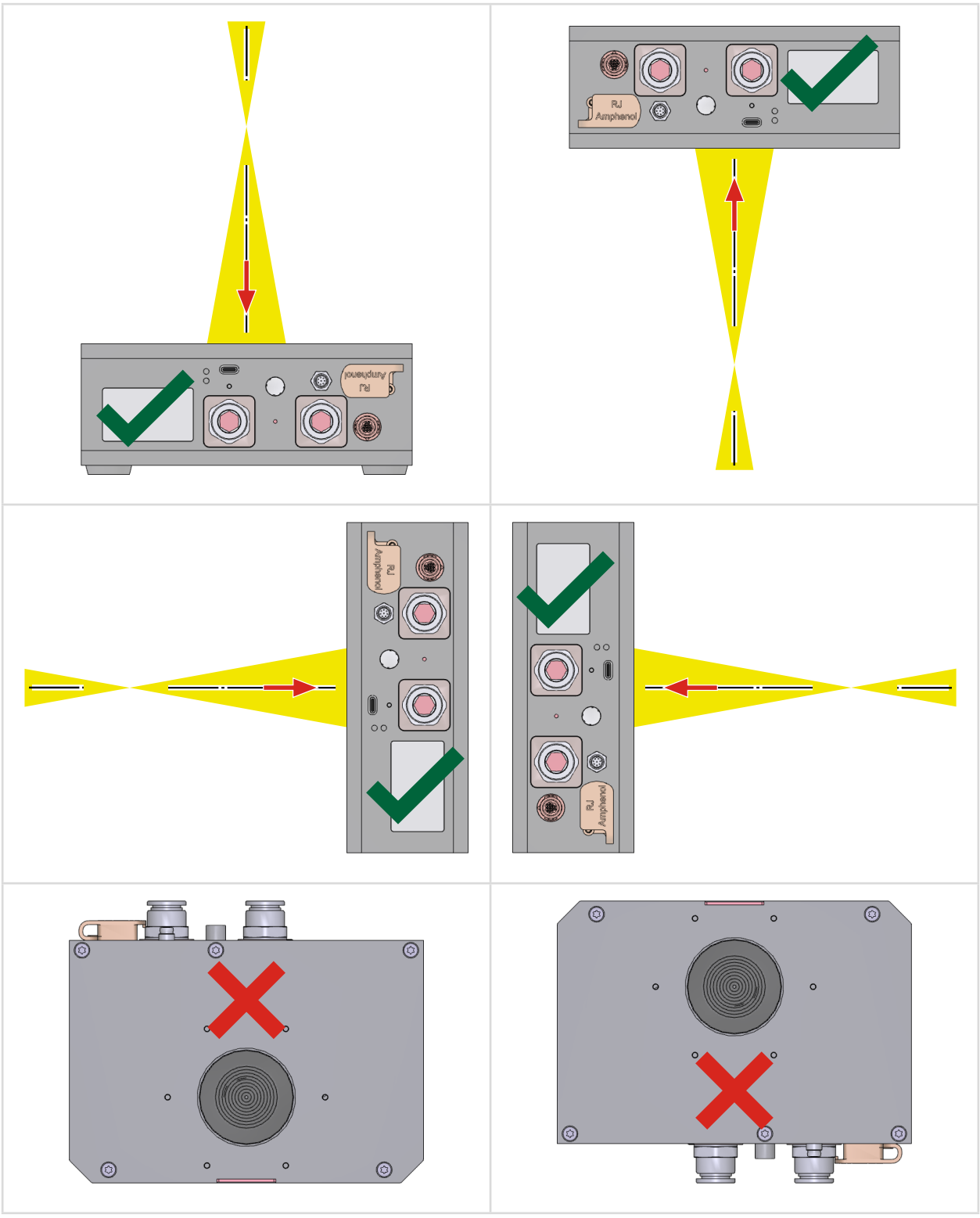


Fig. 6.1: Mounting positions of the CPM+ F-1

6.2.3 Align the device

The device must be aligned to the laser beam. The laser beam must hit the entrance aperture within the specified limit values according to chapter 14 „Technical data“ on page 58.

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 absorber is not exceeded.

Depending on the device type, observe the following (see chapter 14 „Technical data“ on page 58):

- the max. laser power as a function of the beam diameter according to appendix A on page 63
- the max. beam diameter on the absorber
- the max. power density of 1 kW/cm² on the absorber
- the max. tolerance to the centered beam incidence
- the max. angle of incidence perpendicular to the entrance aperture of ± 10°

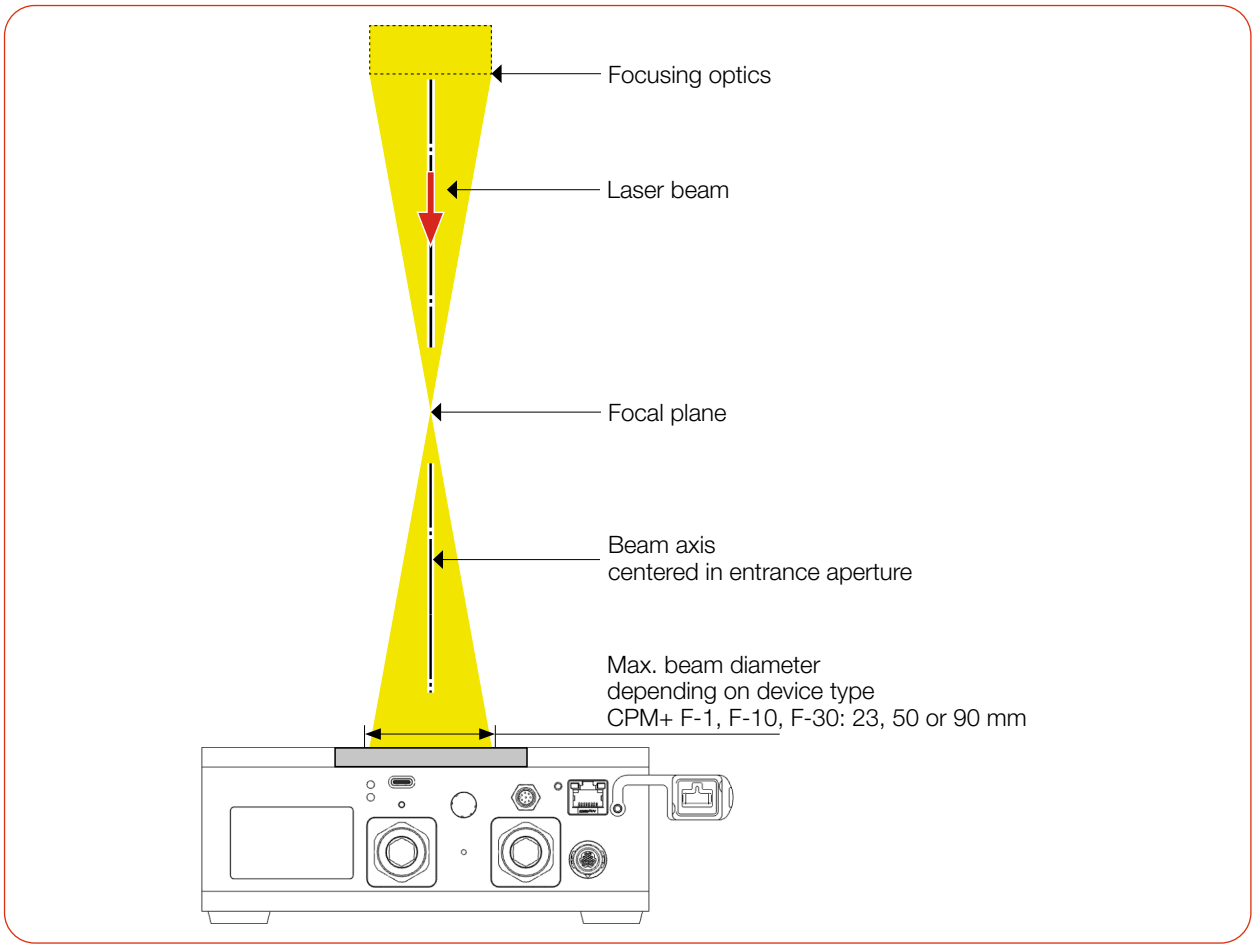


Fig. 6.2: Alignment of the CPM+ to the laser beam using the CPM+ F-10 as example (schematic)

6.2.4 Mount the device

DANGER

Serious 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.

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.

NOTICE

Damage/Destruction of the device

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

- ▶ Do not touch the absorber.

NOTICE

Damage/Destruction of the device

Fastening screws which are too long can damage internal components in the device.

- ▶ Do not use screws that protrude more than 8 mm into the housing.

The baseplate has M4 and M6 threaded holes to mount the device on a customer specific mount.

▶ If necessary, remove the device feet. Mount the device in the threaded holes.
The fastening screws must not protrude into the housing by more than 8 mm.

CPM+ F-1

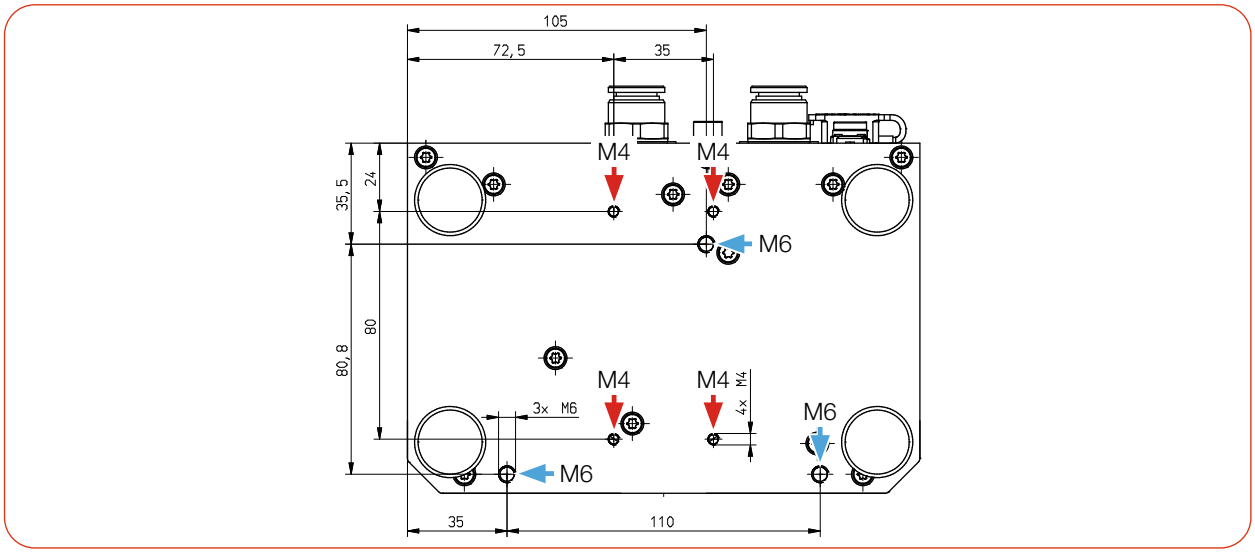


Fig. 6.3: Mounting threads M4 and M6 in the bottom of the housing of the CPM+ F-1 (dimensions in mm)

CPM+ F-10

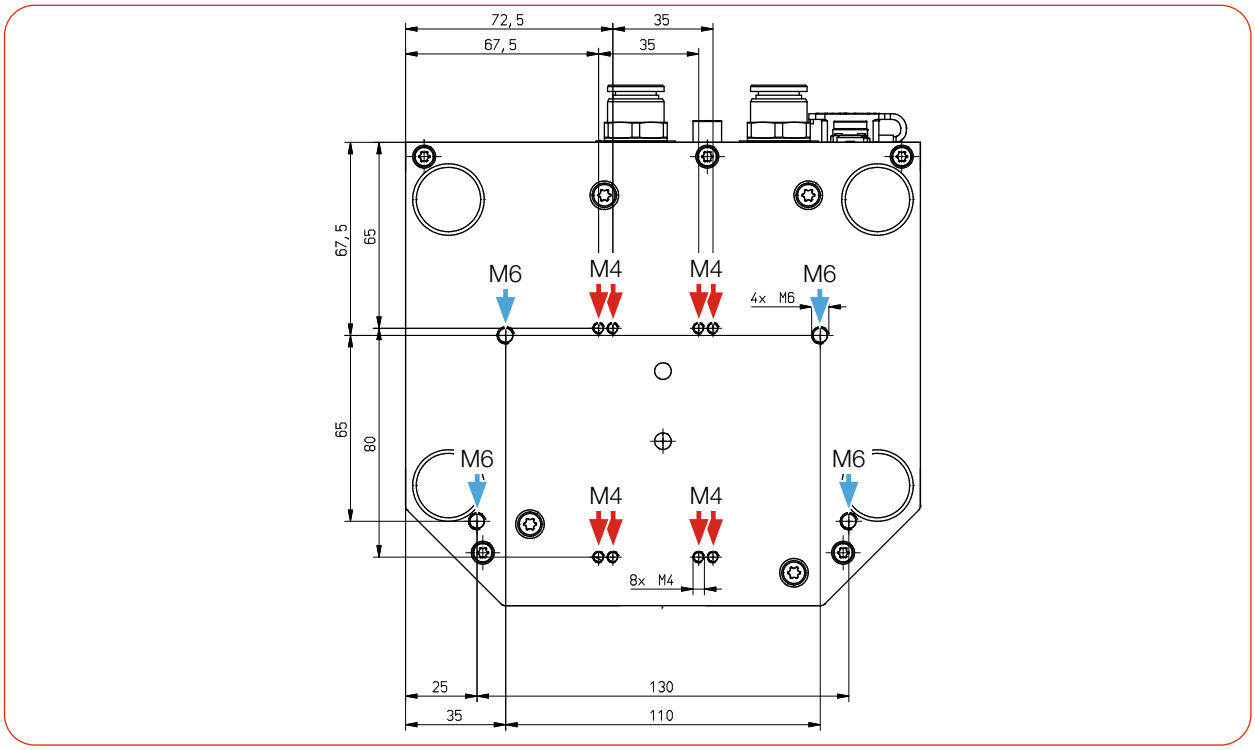


Fig. 6.4: Mounting threads M4 and M6 in the bottom of the housing of the CPM+ F-10 (dimensions in mm)

CPM+ F-30

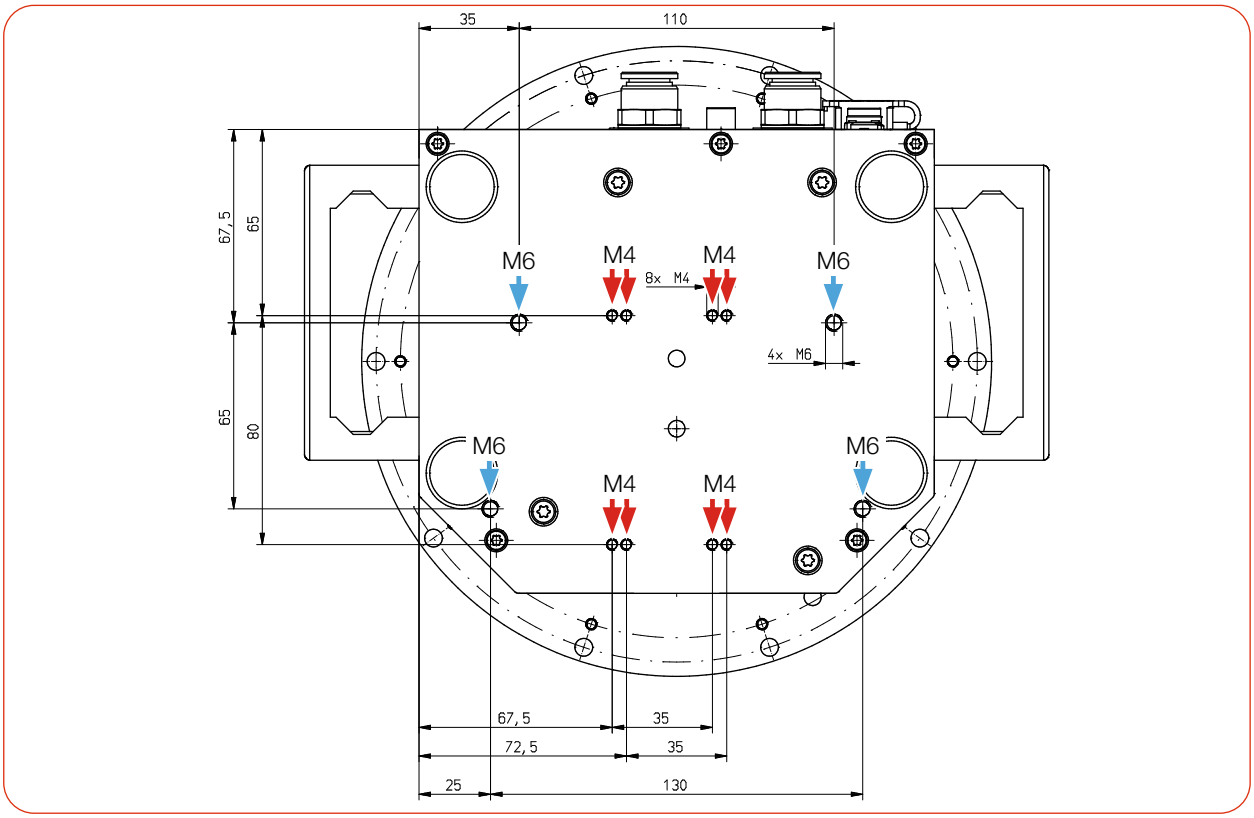


Fig. 6.5: Mounting threads M4 and M6 in the bottom of the housing of the CPM+ F-30 (dimensions in mm)

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 (only CPM+ F-1)

The CPM+ F-1 uses a turbine for flow measurement.
The turbine will be damaged if compressed air is used 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. Switch off the power supply.
4. Turn off the water supply.
5. Push down the release ring of the water connector with two fingers of one hand and pull out the cooling water hose with the other hand.
6. Disconnect all connections.
7. Unscrew the fastening screws.
8. Remove the device from the laser system.
9. Drain the cooling circuit lines by tilting the device. To drain the cooling circuit completely, follow the instructions in chapter 7.7.4 on page 36.
10. Seal the connectors with the supplied sealing plugs.

7 Connectors

7.1 Overview of connectors

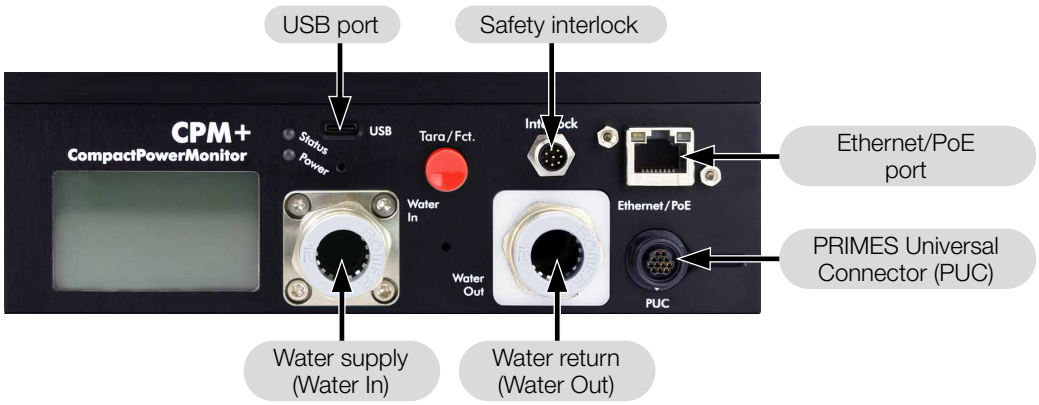


Fig. 7.1: Connectors on the CPM+

7.2 Power supply

The following ports can be used for the power supply of the device:

- USB (with USB-C power supply)
- USB (with cable to PC)
- PoE (Power over Ethernet)

The device starts automatically after connecting the power supply. When starting for the first time, initialization of the device takes about 1 minute. Do not remove cables during this time.

If the LaserDiagnosticsSoftware LDS 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:

- Ethernet
- USB

Connection options:

Power supply	Data transmission	Chapter
USB-C power supply	As stand-alone device (display on the device)	7.2.1 on page 26
USB	USB	7.2.2 on page 27
USB	Ethernet	7.2.3 on page 28
Power over Ethernet (PoE)	Ethernet	7.2.4 on page 29
USB-C power supply	Ethernet	7.2.5 on page 30

Tab. 7.1: Connection options

Combination of PoE for power supply and USB for data transmission not possible

Using PoE for power supply and USB for data transmission cannot be implemented in practice, since Ethernet has priority over USB. The data would be sent via Ethernet, not USB.

UPS (uninterruptible power supply) is not possible with dual power supply

Power supplies can be connected in parallel. However, the second power supply can not be used as a UPS (uninterruptible power supply).
If the supply cable of the active power supply is removed, the data connection will be disconnected and the interlock will be triggered. The device must be restarted.

7.2.1 Power supply via USB-C power supply when used as a stand-alone device

- Power is supplied via the USB-C power supply.
- The measured values are shown on the display of the device.

Required components (included in the scope of delivery)

- USB-C power supply

Connecting the CPM+

▶ Connect the USB-C power supply according to Fig. 7.2 on page 26.

Fig. 7.2: Power supply via USB-C power supply, display of the measured values on the device

7.2.2 Power supply via USB and communication with the PC via USB

Only use the provided USB connection cable.

- Power is supplied via the USB cable on the PC.
  If further USB devices are connected to the PC, it may be necessary to connect the power supply via Power over Ethernet (PoE) (see chapter 7.2.4 on page 29).
- Data is transferred via USB cable.

Required components (included in the scope of delivery)

- USB cable (C to A connector)

Connecting the CPM+ to a PC

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

Fig. 7.3: Power supply via USB, data transfer via USB

7.2.3 Power supply via USB and communication with the PC via Ethernet

Only use the provided connection cables.

- Power is supplied via the USB cable on the PC.
  If further USB devices are connected to the PC, it may be necessary to connect the power supply via Power over Ethernet (PoE) (see chapter 7.2.4 on page 29).
- Data is transferred via Ethernet cable.

Required components (included in the scope of delivery)

- USB cable (C to A connector)
- Ethernet cable

Connecting the CPM+ to a PC

▶ Connect the cables according to Fig. 7.4 on page 28 an.

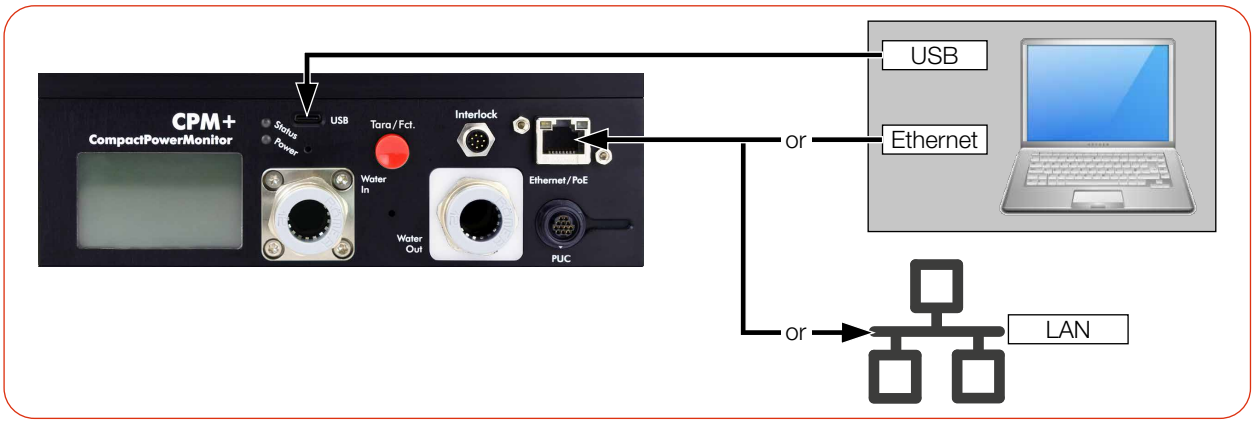


Fig. 7.4: Power supply via USB, data transfer via Ethernet

7.2.4 Power supply via Power over Ethernet (PoE) and communication with the PC via Ethernet

With the PoE port, the power supply can be set up in 2 ways:

- with a PoE injector (midspan device)
- with a PoE capable Ethernet port e.g. on a switch (endspan device)

Data is transferred via Ethernet cable.

Required components

Included in the scope of delivery:

- Ethernet cable

Not included in the scope of delivery:

- PoE Injector (Midspan Device)
- Second Ethernet cable on PoE injector

Connecting the CPM+ to a PC

▶ Connect the cables according to Fig. 7.5 on page 29.

The device will not start if the two plugs on the PoE injector are reversed.

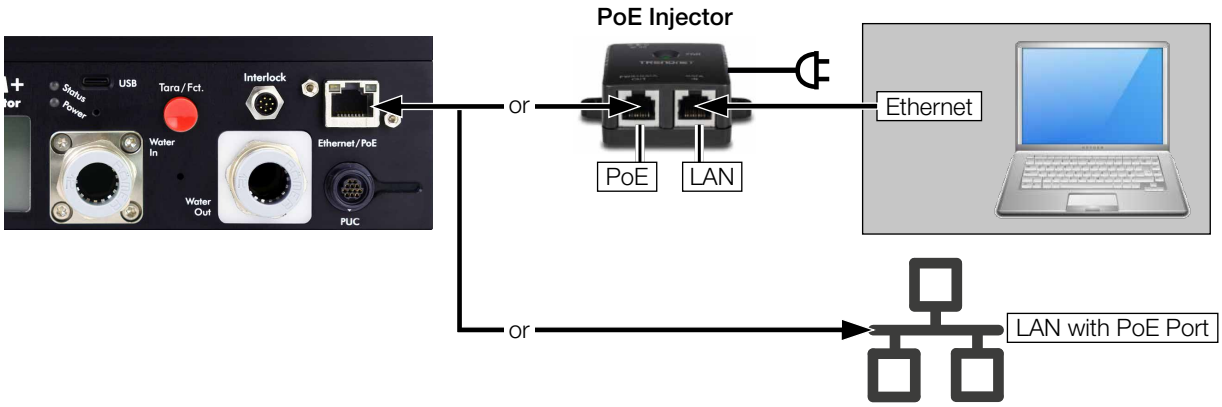


Fig. 7.5: Power supply and data transfer via Power over Ethernet (PoE)

7.2.5 Power supply via USB-C power supply and communication with the PC via Ethernet

- Power is supplied via the USB-C power supply.
- Data is transferred via Ethernet cable.

Required components (included in the scope of delivery)

- Ethernet cable
- USB-C power supply

Connecting the CPM+ to a PC

▶ Connect the power supply according to Fig. 7.6 on page 30.

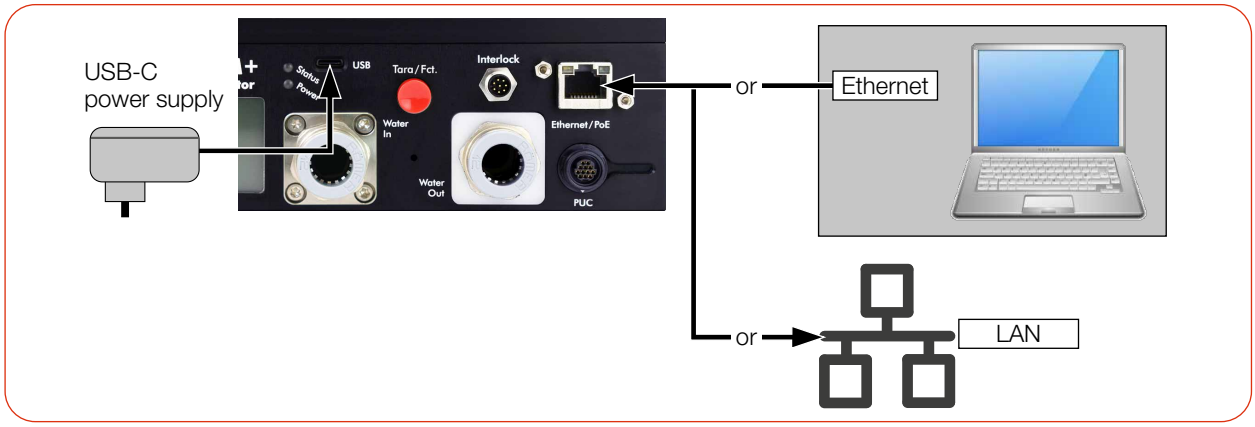


Fig. 7.6: Power supply via USB-C power supply, data transmission via Ethernet

7.3 Ethernet/PoE

The PoE port is specified according to PoE standard IEEE 802.3af (802.3at Type1) Power Class 3.

This port can be used as an Ethernet or as a Power over Ethernet port:

- Ethernet port: The port can only be used for data transmission.
- PoE port: The port can be used for power supply and data transmission via Power over Ethernet.

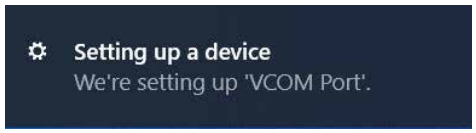
7.4 USB

USB port: connection type USB-C.

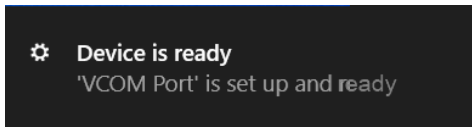
Note that a USB interface without additional interference suppression measures is not EMC-compliant. Therefore, in industrial environments with strong sources of interference, connection interruptions and data transmission disturbances may occur.

The Windows driver usbser.sys is used. It is part of the driver packages included in Windows.

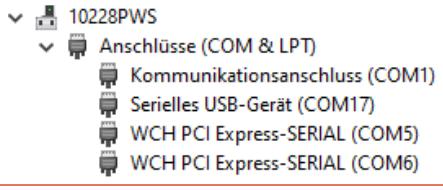
If a CPM+ is connected to a PC for the first time, this driver is automatically activated and the following message appears:



Next:



From then on, every time such a device is connected, it will appear in the Device Manager as „USB Serial Device (COMxx)“.



The driver is set up for the device as soon as the USB connector is used, even if this is only for the purpose of supplying power.

7.5 PRIMES Universal Connector (PUC)

The port serves as a PRIMES service interface.

7.6 Safety interlock (Interlock)

The device has two redundant safety circuits internally.

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

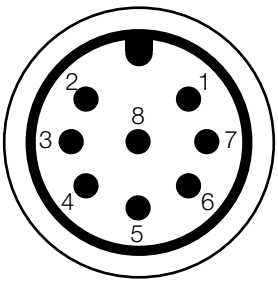
The safety interlock protects the device by switching off the laser beam in the following cases:

- the cooling water flow is too low (depending on device type)
- the cooling water temperature at the water supply (Water In) is too high (T_{in} > 50 °C)
- the temperature difference between water supply (Water In) and water return (Water Out) is too large (T_d > 40 K)
- the permitted temperature at the absorber is exceeded. The maximum permitted temperature depends on the device type:

CPM+ F-1	CPM+ F-10	CPM+ F-30
60 °C	70 °C	70 °C

Tab. 7.2: Permitted temperature of the absorber by device types

Pin assignment M8 connector 8-pin (Pin assignment: view to plug on device; Color: wire colors of cable)



Pin	Color	Function
1	White	COM 1
2	Brown	NC: Connected with pin 1 in faulty operating conditions.
3	Green	NO: Connected with pin 1 when ready for operation.
4	Yellow	COM 2
5	Grey	NC: Connected with pin 4 in faulty operating conditions.
6	Pink	NO: Connected with pin 4 when ready for operation.
7	Blue	Not connected
8	Red	Not connected

Tab. 7.3: Pin assignment of the safety interlock connector

In faulty operating conditions, pin 1 and pin 2, as well as pin 4 and pin 5 are connected.

If the values correspond to the operating conditions, pin 1 and pin 3, as well as pin 4 and pin 6 are connected.

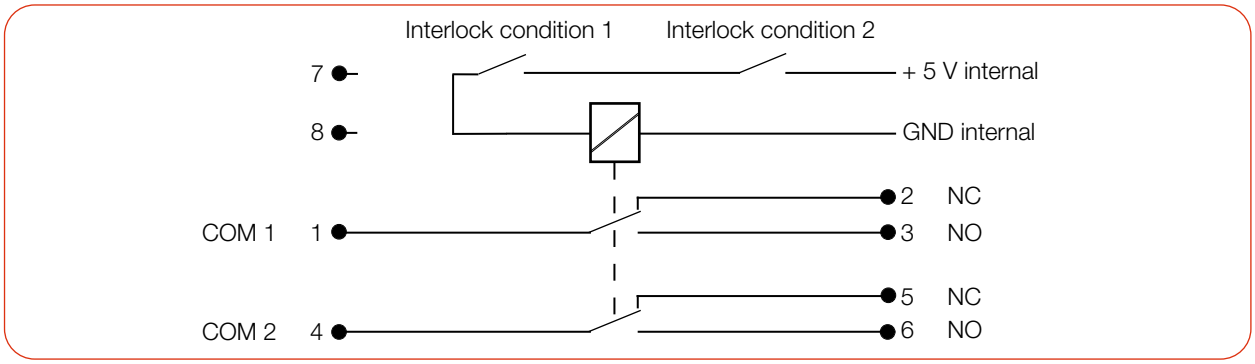


Fig. 7.7: Circuit diagram: Monitored operating conditions (Interlock conditions)
Device not ready for operation, Laser is off

Required component

A suitable connection cable with a device plug and bare ends is included in the scope of 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 connections 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. 7.8: Connect/remove cooling water hoses

7.7.2 Damage to the device

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.

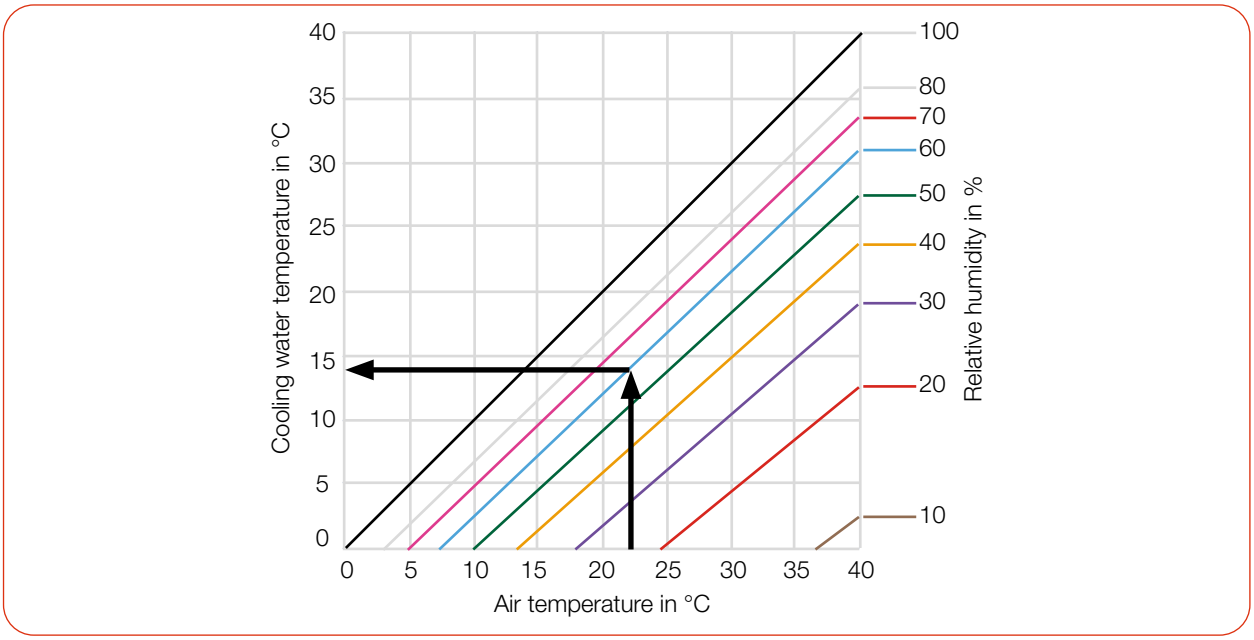
Large dirt particles or fibrous sealants may block internal cooling circuits. Therefore, please rinse the system thoroughly before connecting it.

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. 7.4: 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 of the flow meter

The device uses a Turbine (CPM+ F-1) or 2 ultrasonic sensors (CPM+ F-10 and F-30) for flow measurement. This can be damaged by improper handling.

▶ Observe the following requirements.

Observe mounting position

CPM+ F-1 only:
Observe the mounting position according to chapter 6.2.2 „Possible mounting positions“ on page 16.

Observe flow direction

If the flow direction is reversed, the display of the device shows a negative flow. If the LDS software is used, the displayed laser power has a negative prefix.

CPM+ F-1 only:
Reversing the flow direction will damage/destroy the turbine during longer operation.

CPM+ F-10 and CPM+ F-30 only:
To clean the internal water filter, the flow direction can be reversed for a short period of time.

Do not use compressed air

CPM+ F-1 only:
The turbine will be damaged if compressed air is used in the cooling circuit. Do not use compressed air to force drain the cooling water circuit.

Use compressed air

CPM+ F-10 and CPM+ F-30 only:
To drain the cooling circuit, compressed air can be used for a short period of time in the water return connector (Water Out).

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. This can lead to a build-up of debris and thus to measurement inaccuracies.

7.7.5 Parameters of cooling water connection

Supply data	CPM+ F-1	CPM+ F-10	CPM+ F-30
Hose diameter	12 mm	12 mm	16 mm
Water flow warning (warning threshold)	0.9 l/min	6 l/min	10 l/min
Min. cooling water flow (interlock threshold)	0.5 l/min	4 l/min	9 l/min
Max. cooling water flow	2 l/min	10 l/min	30 l/min
Recommended cooling water flow	1 – 2 l/min	7 – 10 l/min	20 – 30 l/min
Min. cooling water pressure	2 bar		
Max. cooling water pressure	4 bar		
Cooling water temperature T_{in}	Dew point temperature < T_{in} < 30 °C		
Stability of the cooling water temperature	< 1.0 K per minute or 0.08 K per 5 seconds		

Tab. 7.5: Parameters of cooling water connection by device types

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. 7.5!

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.

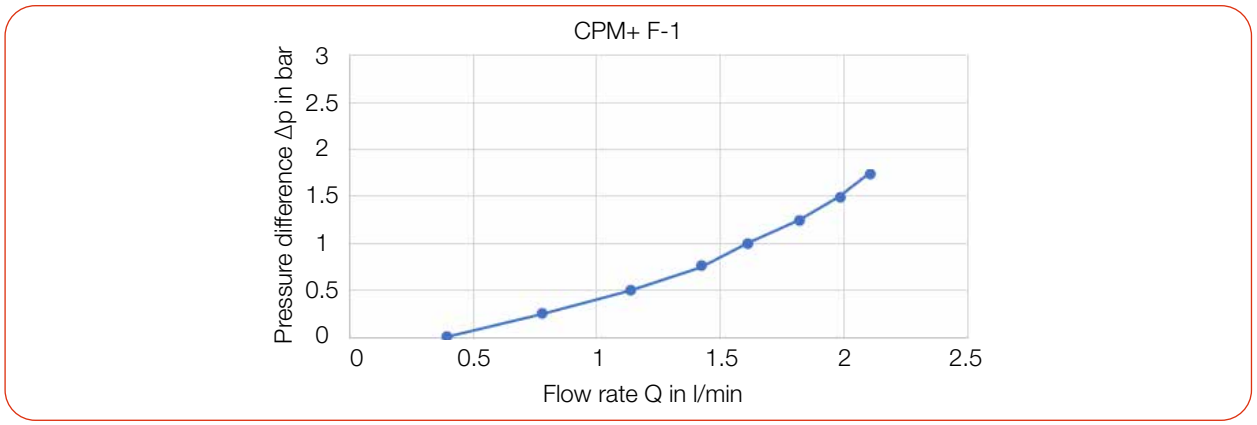


Fig. 7.9: Pressure loss diagram CPM+ F-1

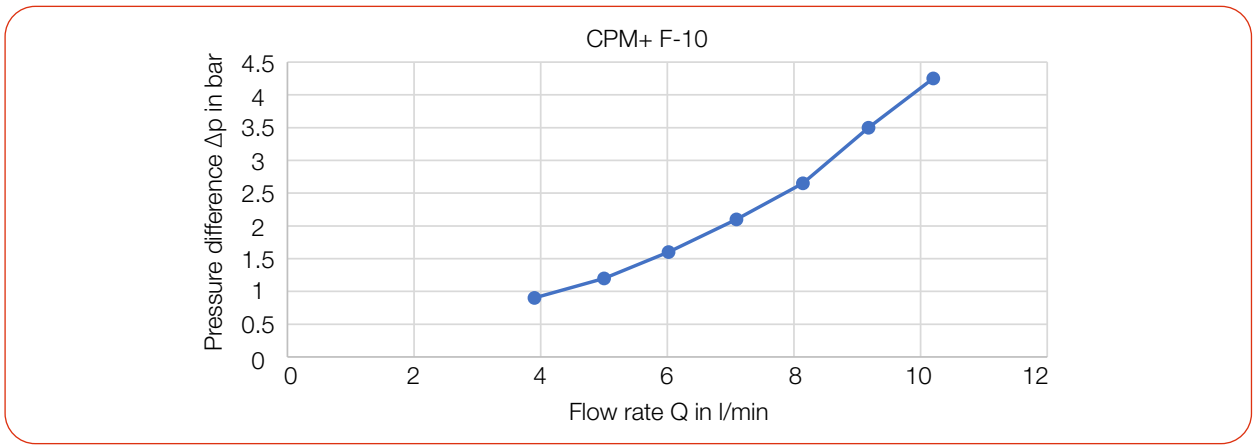


Fig. 7.10: Pressure loss diagram CPM+ F-10

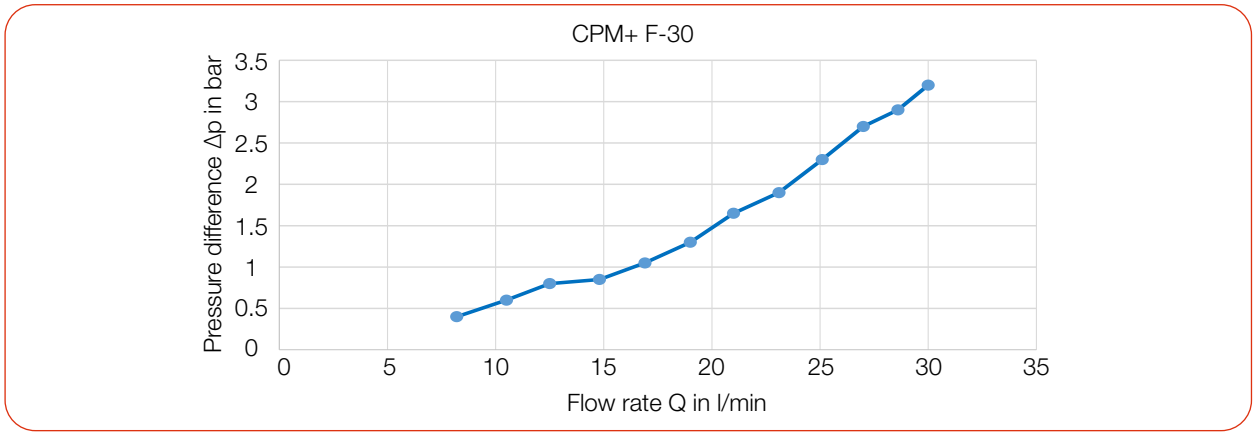


Fig. 7.11: Pressure loss diagram CPM+ F-30

8 Software installation

8.1 Install LaserDiagnosticsSoftware LDS

The LDS is included in the scope of 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 in 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 port type A or Ethernet port for connecting the measuring device

8.2 Connect PRIMES device to a PC

Choose one of the following options to establish a connection between the PRIMES device and the PC.

The IP address of the PRIMES device can only be changed once this connection has been established (see section „Change IP address of a connected device“ on page 43).

8.2.1 Integration of a PRIMES device into a network

Within the PRIMES device, the option DHCP (Dynamic Host Configuration Protocol) is activated by default.

- The PRIMES device is assigned an IP address by a DHCP server.
- The device communicates via the IPv4 internet protocol.
  The internet protocol IPv6 is not supported.

8.2.2 Direct connection of a PRIMES device to a PC

Administrator rights are necessary in order to set the IP address.

1. In ***Windows > Control panel > Network and Sharing Center***, assign an IP address to your PC that is within the same address range as the static IP address of your PRIMES device (e.g. 192.168.116.xyz).

- The static IP address of your PRIMES device is located on the identification plate or is shown on the display (status page).
- The first 3 number blocks must be identical, the last number block (0-255) can be freely selected.
- The static IP address of the PRIMES device on the identification plate must not be used for the PC.

2. The subnet mask is to be set to 255.255.255.0.

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).

For example, 10 kW of laser power can generate several 100 W of scattered radiation.

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

- ▶ 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).

- ▶ When mounting the device, ensure that it cannot be moved, neither due to an unintended push nor 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.

WARNING

Burn hazard; Eye or skin injury due to increased scattered radiation

The absorber gets hot during operation. The water cooling prevents the absorber from overheating. However, in the event of an error, strong overheating of the absorber may occur. In this case, touching the absorber can lead to serious burns.

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

- ▶ Do not touch the absorber.

9.2 Preparing measurement readiness

1. Observe the warning messages according to chapter 9.1 on page 40.
2. Connect the safety interlock of the laser control to the device.
3. Connect the device to the power supply.

👁 The green Power LED must light up.

👁 Wait until the display lights up.

👁 The Status LED flashes red after a short time.

4. Turn on the water cooling.

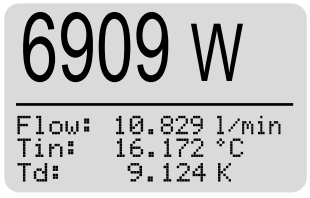
👁 After a few seconds, the red Status LED must turn off.

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

➔ The CPM+ is ready for measurement.

9.3 Measuring with the CPM+ as a stand-alone device

The CPM+ 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	
W	Laser power in W	
Flow	Flow rate of the cooling water in l/min	
T_{in}	Cooling water temperature at the water supply (Water In) in °C	
T_d	Temperature difference between water supply (Water In) and water return (Water Out) in Kelvin	

Tab. 9.1: Abbreviations on the display

Get ready for measurement

1. Prepare the device according to chapter 9.2.

Determine zero level

The Tara/Fct. button can be used to reset the measured value of the power display to zero. PRIMES recommends the following procedure before each measurement:

2. Press the Tara/Fct. button (> 0.5 s) to reset the power display to zero.

Start measurement

3. Observe the max. laser power as a function of the beam diameter according to appendix A on page 63.
4. Switch on the laser.

➔ The measured laser power is displayed after about 2 seconds.
CPM+ F-1, F-10: After about 10 seconds the display reaches about 99 % of the final value.
CPM+ F-30: After about 15 seconds the display reaches about 99 % of the final value.

5. Switch off the laser.

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”.

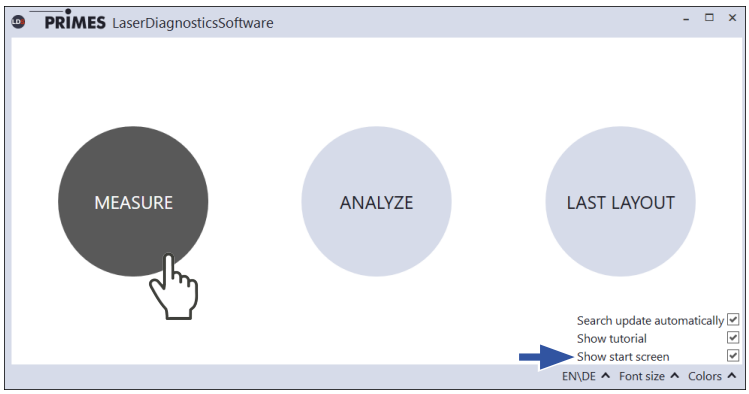
9.4.1 Connect/disconnect the device with the LDS

Switch on the device and connect it to the LDS

1. Prepare the device according to chapter 9.2 „Preparing measurement readiness“ on page 41.
2. Start the LDS by double-clicking on the program icon LDS in the start menu group or on the desktop icon.

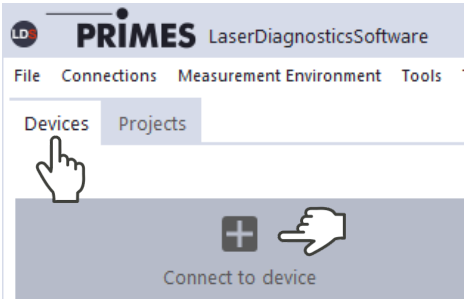
The start screen appears.

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.

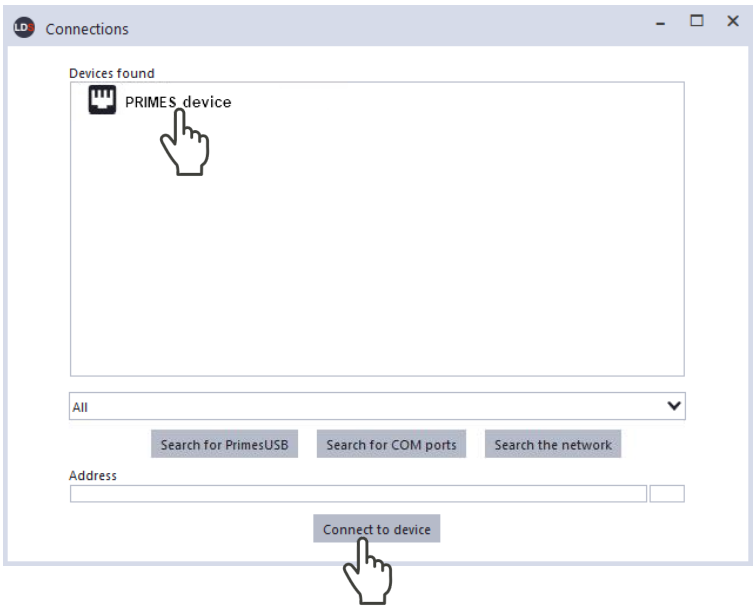
If the device does not appear when connected to USB:

▶ Click the ***Search for PRIMES USB*** button.

If the device does not appear when connected to Ethernet:

▶ Click the ***Search the network*** button.

If the device still does not appear in the ***Connections*** window, see chapter 10.2 „Connection errors whit the LDS“ on page 51.



Change IP address of a connected device

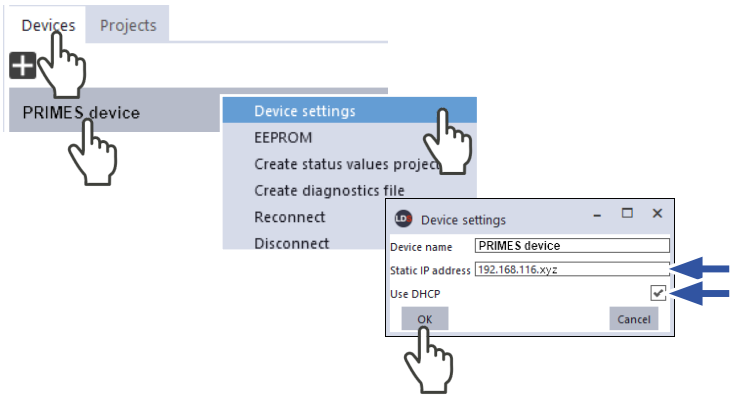
A static IP address is stored within the device and the function ***Use DHCP*** is activated. When establishing a connection, the device will first wait to be assigned a suitable IP address via DHCP. If this proves unsuccessful, it will revert to the factory static IP address.

If ***Use DHCP*** is disabled, the device will directly use the static IP address. As a result, the connection can be established faster.

For a connected device, both the IP address and the activation of DHCP can be changed.

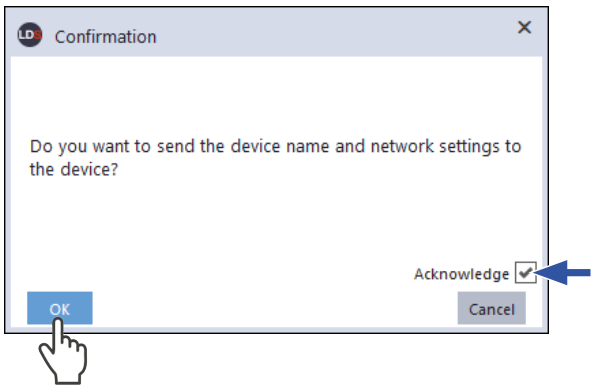
Change the IP address of a device as follows:

1. Click the ***Devices*** tab.
2. Right-click on the device and select the ***Device settings*** menu point.
3. Enter the desired IP address in the ***Static IP address*** input field.
4. Deactivate ***Use DHCP***.
5. Confirm the entry with ***OK***.



The ***Confirmation*** window appears.

6. In the ***Confirmation*** window, place a check mark at ***Acknowledge*** and click ***OK***.
7. Switch the device off and on again.



If the PRIMES device is connected directly to a PC (without network), the IP address of the PRIMES device and the PC must be within the same address range.

If a static IP address is selected that is outside the address range of the PC and DHCP is also deactivated, the device can no longer be addressed.

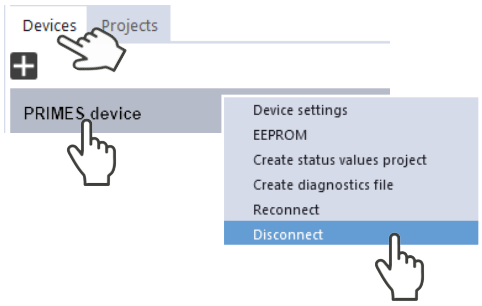
To reconnect the PRIMES device, the IP address of the PC has to be changed (see chapter 8.2.2 „Direct connection of a PRIMES device to a PC“ on page 39).

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 by disconnecting the cable.
4. If applicable, disconnect the electrical connections.

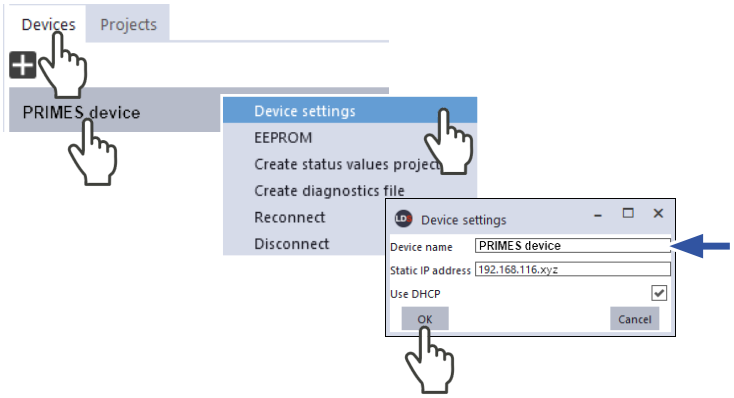


9.4.2 General information about working with the LDS

Enter user-defined device name

If you want to assign a user-defined device name to a device, proceed as follows:

1. Click the ***Devices*** tab.
2. Right-click on the device and select the ***Device settings*** menu point.
3. Enter the desired device name in the ***Device name*** input field (max. 18 characters).
4. In the ***Device settings*** window, confirm the entry with ***OK***.

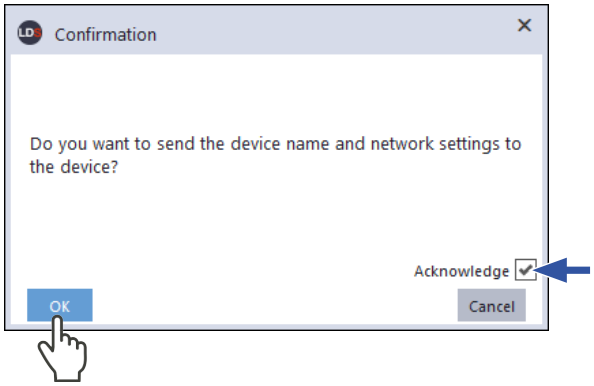


👁 The ***Confirmation*** window appears.

5. Place a check mark at ***Acknowledge*** and click ***OK***.
6. Switch the device off and on again.

➔ The device name is displayed in the ***Connections*** window.

➔ After connecting, the device name is displayed in the ***Devices*** tab.



Enter parameters and activate

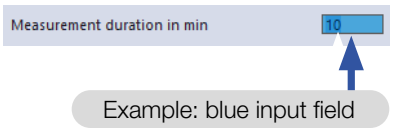
Confirm an entered parameter value by pressing the Enter key.

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.



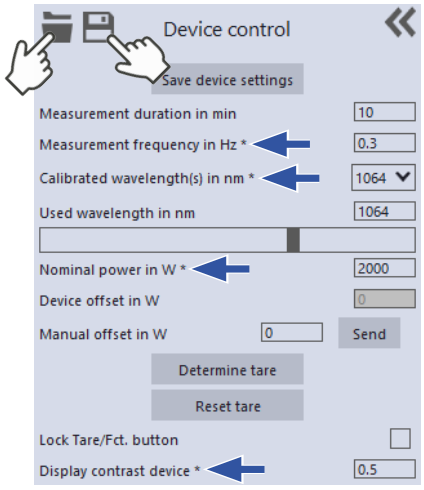
Saving options

The LDS offers 2 different options for saving. They differ by the storage location.

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 the icon 💾.
- ▶ To load a configuration, click the icon 📂.

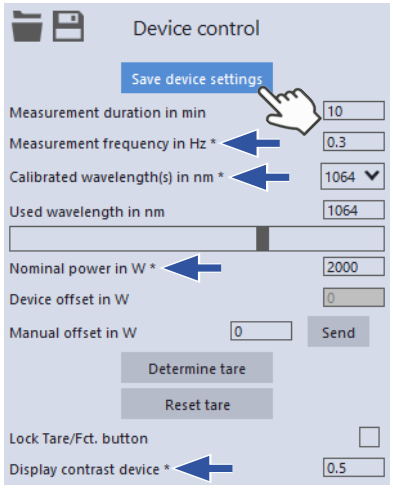


Save data with an asterisk (*) in the EEPROM of the device.

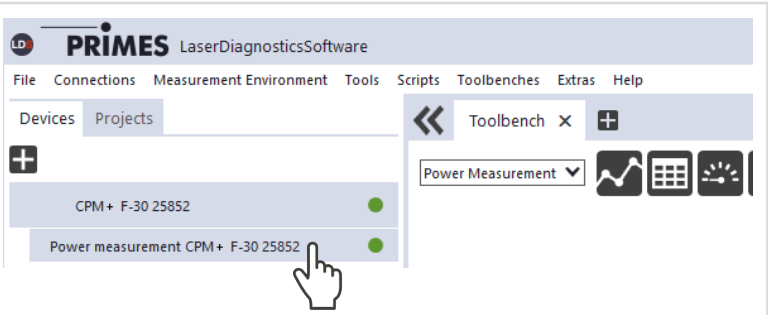
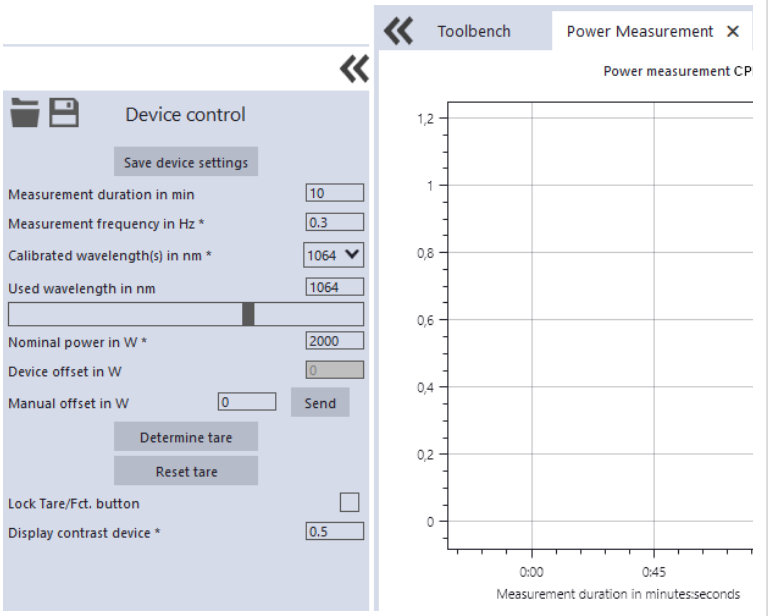
All options marked with an asterisk in the ***Device control*** menu can be saved in the EEPROM in the device.

In this case, the settings will be retained even if the device is switched off or disconnected from the power supply.

- ▶ Click the ***Save device settings*** button.



9.4.3 Open power measurement mode

👁 The CPM+ 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.
Measurement frequency in Hz	▶ Enter a value in the input field. The value must be between ≥ 0.1 Hz and ≤ 3 Hz.

Tab. 9.2: Settings in the device control

Option	Explanation
Calibrated wavelength(s) in nm	The CPM+ can measure the laser power of lasers with the following wavelength ranges: 340 – 800 nm, 800 – 1 100 nm. The calibrated wavelengths of 1 064 nm (included in the scope of delivery) or 515 nm (optional) can be selected. 1. Select the ***Calibrated wavelength(s) in nm*** from the drop-down list. 2. Click the ***Save device settings*** button. The absorption behavior of the absorber is wavelength-dependent. By selecting the appropriate calibrated wavelength, the measurement accuracy is improved.
Used wavelength in nm	The entry is only for documentation purposes. Use one of the following options: ▶ Enter a value in the input field. ▶ Use the slider below the input field.
Nominal power in W	The entry is only for documentation purposes. ▶ Enter a value in the input field.
Device offset in W	The offset value (tare) shown on the display of the device is displayed.
Manual offset in W	▶ Enter a value in the input field. The offset value must be between > (–300 W) and < (+1 000 W). The offset value is only taken into account in the LDS. ▶ Click ***Send***. The entered manual offset value is added to the offset value stored in the device.
Determine tare	▶ Click ***Determine tare***. The offset value is determined and set in the LDS. ▶ Click ***Send***. The offset value stored in the device is overwritten.
Reset tare	The offset value is reset in the LDS and on the device.
Lock Tara/Fct. button	▶ Activate the check mark. The Tara/Fct. button on the device can no longer be used for taring. It is still possible to switch cyclically through the screens of the display.
Display contrast device	1. Enter a value in the input field. The value must be between > 0 and < 1. 2. Click the ***Save device settings*** button. The value remains even after restarting the device or without using the LDS.

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 turned off, click ***Start***.
3. Click ***Determine tare***.

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

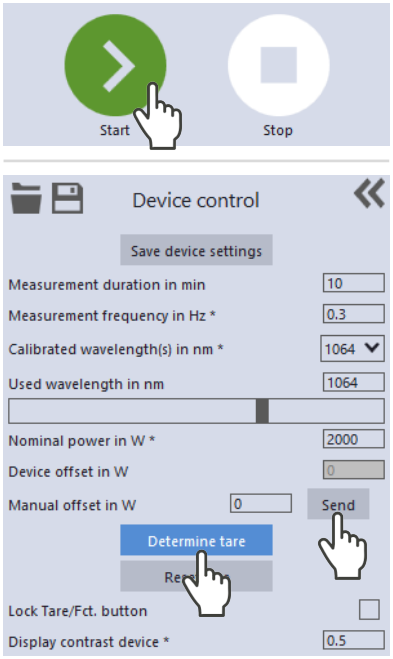
👁 The display of the laser power is automatically corrected with the stored offset value.

4. Click ***Send***.

➔ The offset value stored in the device is overwritten.

Alternatively, the device offset can also be reset directly on the device by pressing the Tara/Fct. button (> 0.5 s).
The ***Lock Tare/Fct. button*** option must not be activated for this.

5. Start a measurement.



Start measurement

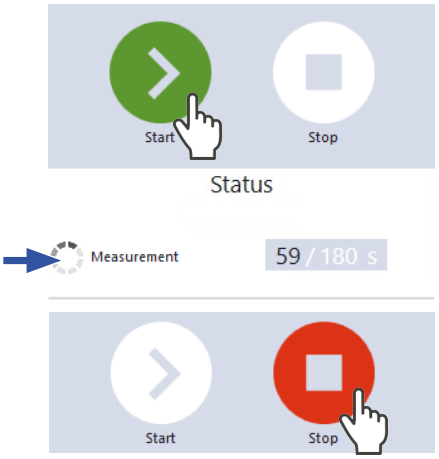
1. Observe the max. laser power as a function of the beam diameter according to appendix A on page 63.
2. Switch on the laser.
3. Click the ***Start*** button.

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

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

➔ The measurement is finished.

5. Switch off the laser.

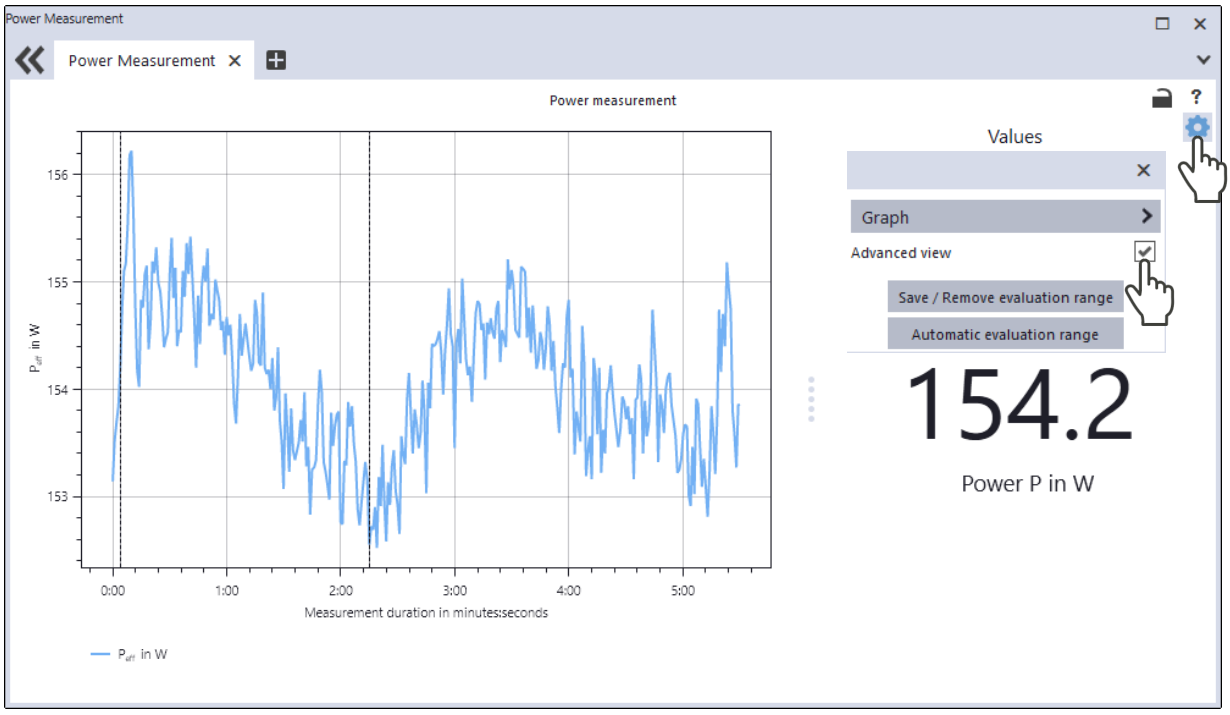


9.4.5 Measurement results display

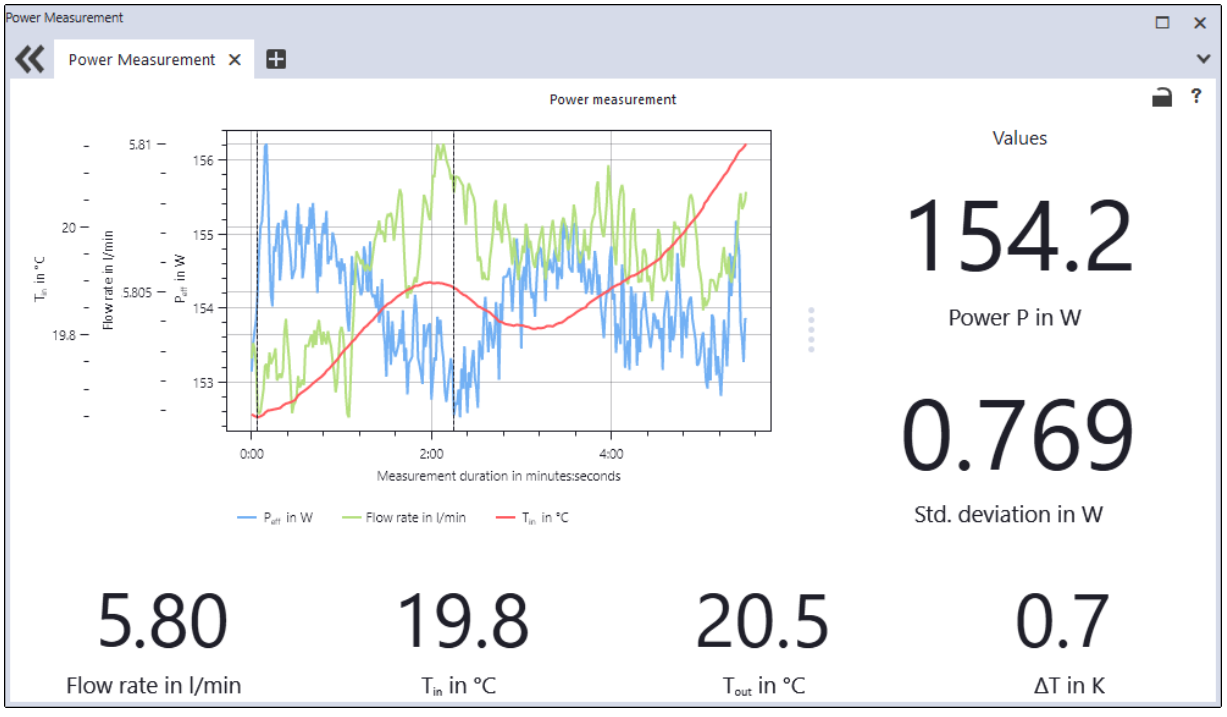
The measurement results are shown during the measurement in the opened ***Power Measurement*** tool.

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



10 Troubleshooting

10.1 Messages in the LDS during measurement

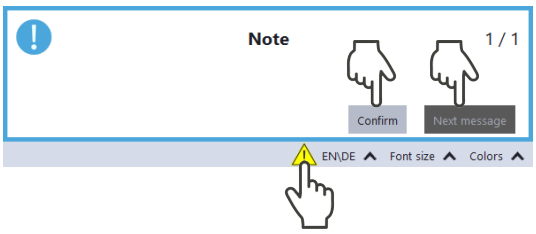
If problems occur during a measurement, the LDS displays them in different categories and different colors.

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.

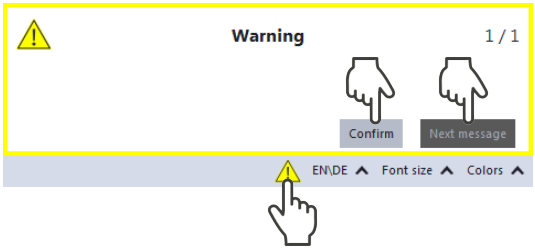


Warning

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

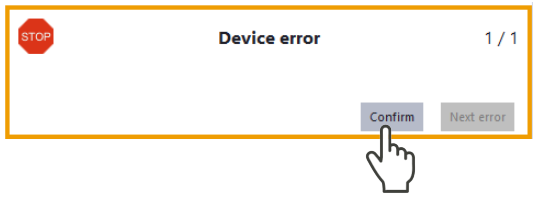
Device errors that can result in damage of the device are displayed in an orange window.

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

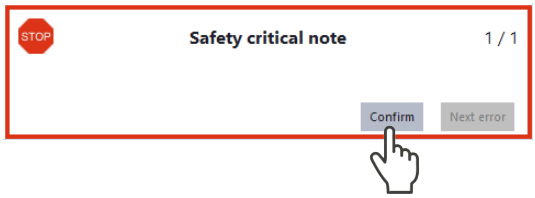
Safety-critical problems that can result in damage/destruction of the device are displayed in a red window.

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 whit the LDS

10.2.1 Ethernet connection errors

Error	Possible cause	Solution
The Ethernet connection between the device and the LDS cannot be established.	The firewall may block the connection between the device and the LDS.	The UDP port should be enabled by a system administrator. ▶ In ***Windows > Control panel > Firewall***, enable the UDP port 20034.
	The IP address of the PC is not within the range of the device.	Administrator rights are necessary in order to set the IP address. ▶ Set the IP address according to chapter 8.2.2 „Direct connection of a PRIMES device to a PC“ on page 39.
	If several network cards or a USB3-to-Ethernet card are installed in the PC, the connection between device and LDS may be blocked by the selection of the wrong network card.	1. Select the appropriate network card in the ***Connections > All*** window. The device is displayed in the ***Connections*** window 2. Click on the device. 3. Click the ***Connect to device*** button.

Tab. 10.1: Ethernet connection errors

10.2.2 USB connection errors

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 device does not turn on when connected to the PC via USB.	The USB interface on the PC cannot supply the CPM+ with sufficient power.	▶ Connect the USB-C power supply according to chapter 7.2.1 on page 26.

Tab. 10.2: USB connection errors

10.3 Red flashing Status LED without an error message on the display

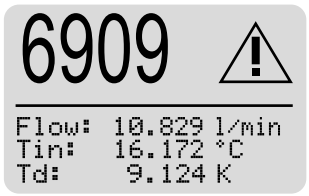
If the Status LED flashes red and no warning triangle is shown on the display, then the permitted temperature at the absorber is exceeded. The safety interlock has been triggered.

The maximum permitted temperature depends on the device type:

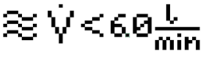
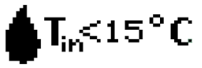
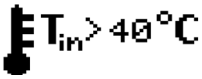
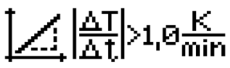
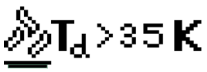
CPM+ F-1	CPM+ F-10	CPM+ F-30
60 °C	70 °C	70 °C

Tab. 10.3: Permitted temperature of the absorber by device types

10.4 Warning or error message on the display

Display of a warning or error message	
A warning triangle is shown on the display. At the same time, the Status LED lights up/flashes. The potential cause is shown in the warning screen (change screen by briefly pressing the Tara/Fct. button). **Warning message** The Status LED lights up yellow. **Error message** The safety interlock has been triggered. The Status LED flashes red.	

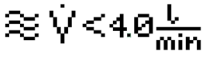
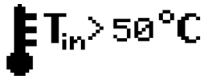
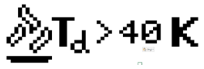
10.4.1 Warning message (Status LED lights up yellow)

Display	Possible cause	Solution
	The cooling water flow is too low (depending on the device type).	Increase the flow rate. There is a risk of the device overheating.
	The fluctuations of the flow rate of the cooling water are too high (> 1,5 %).	Read the power value when the fluctuations have decreased. Check the pump. There should be no air bubbles in the cooling water.
 or	The cooling water temperature at the water supply (Water In) is too low (T_{in} < 15 °C).	Increase the temperature of the cooling water or use a different cooling system. There is a risk that the device will be damaged by condensation water.
	The cooling water temperature at the water supply (Water in) is too high (T_{in} > 40 °C).	Check the cooling system. There is a risk of the device overheating.
	The temperature fluctuations at the water supply (Water In) are too high (> 1,0 K/min).	High temperature fluctuations increase the measurement uncertainty of the device. Read the power value when the temperature fluctuations have decreased. In general, a large volume of water in the cooling circuit provides a small gradient (increase water tank volume).
	The temperature difference between the water supply (Water In) and the water return (Water Out) is too high (T_d > 35 K).	Increase the flow rate or reduce laser power. There is a risk of the absorber overheating.
Without error “no warning” is displayed.		

Tab. 10.4: Warning messages (Status LED lights up yellow)

10.4.2 Error message (Status LED flashes red)

The safety interlock has been triggered.

Display	Possible cause	Solution
	The cooling water flow is too low (depending on the device type).	Check the cooling circuit and the direction of the water flow through the device. Increase the flow rate. There is a risk of damage to the device.
	The cooling water temperature at the water supply (Water In) is too high (T_{in} > 50 °C).	Check the cooling system. There is a risk of the device overheating.
	The temperature difference between water supply (Water In) and water return (Water Out) is too high T_d > 40 K).	Check the laser power. Reduce the power or increase the flow rate. There is a risk of damage to the device.
Without error “no warning” is displayed.		

Tab. 10.5: Error messages (Status LED flashes red)

10.5 Other errors

Error	Possible cause	Solution
The displayed laser power on the display or the LDS has a negative prefix.	The flow direction has been reversed.	▶ Connect the water supply (Water In) and the water return (Water out) according to the markings on the device.

Tab. 10.6: Other errors

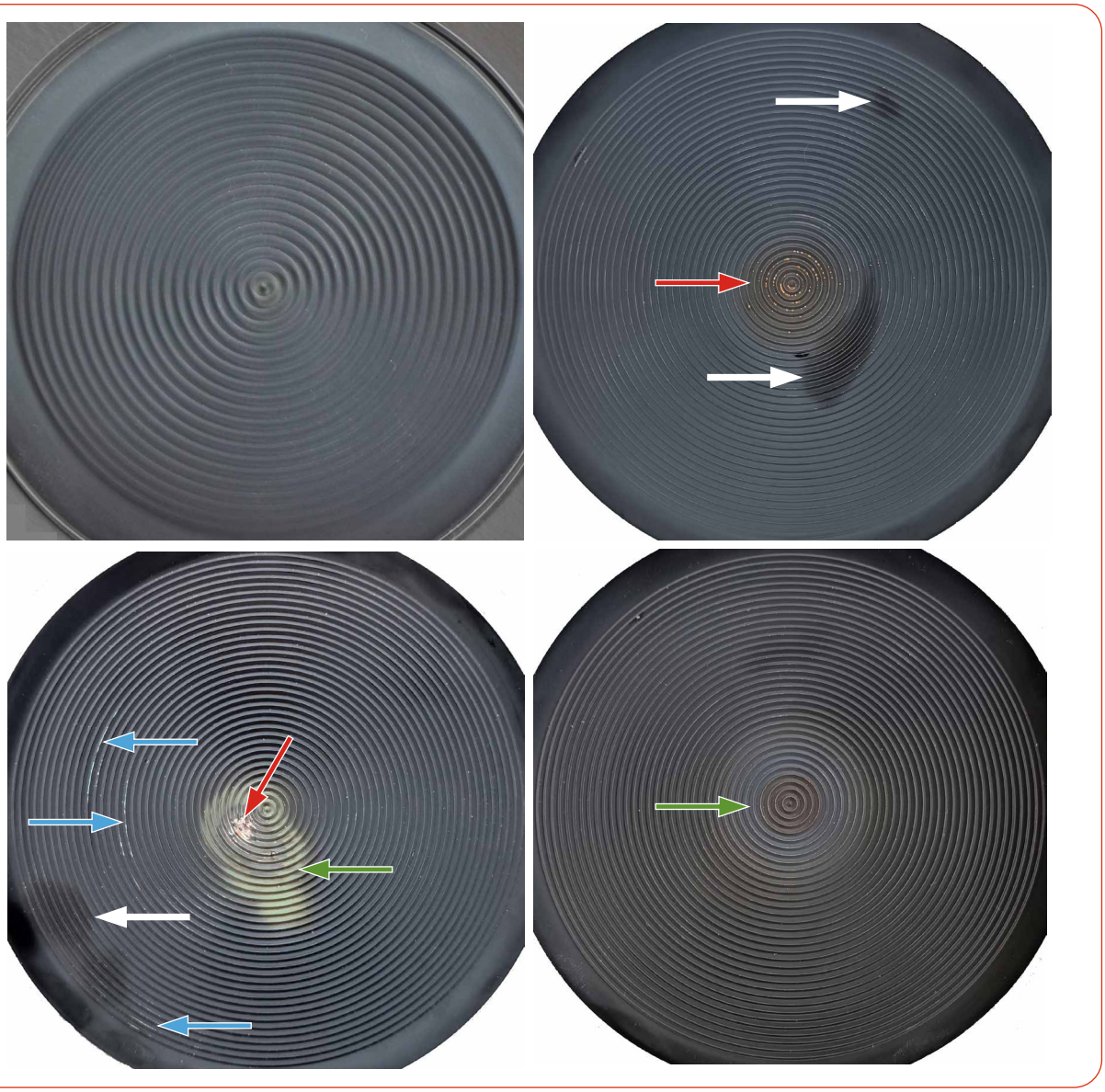
10.6 Damages to the absorber

The first picture shows a new absorber.

The arrows show damage to the absorber and have the following meaning:

- White: surface appears shiny, first sign of overheating
- Green: the absorber is clearly discolored; clear sign of overheating
- Red: the coating is missing or there is a hole in the absorber, burn-in caused by overheating
- Blue: the coating is missing, caused by mechanical damage

The damages shown result in reduced absorption and thus inaccurate power measurement. The absorbers must be replaced.

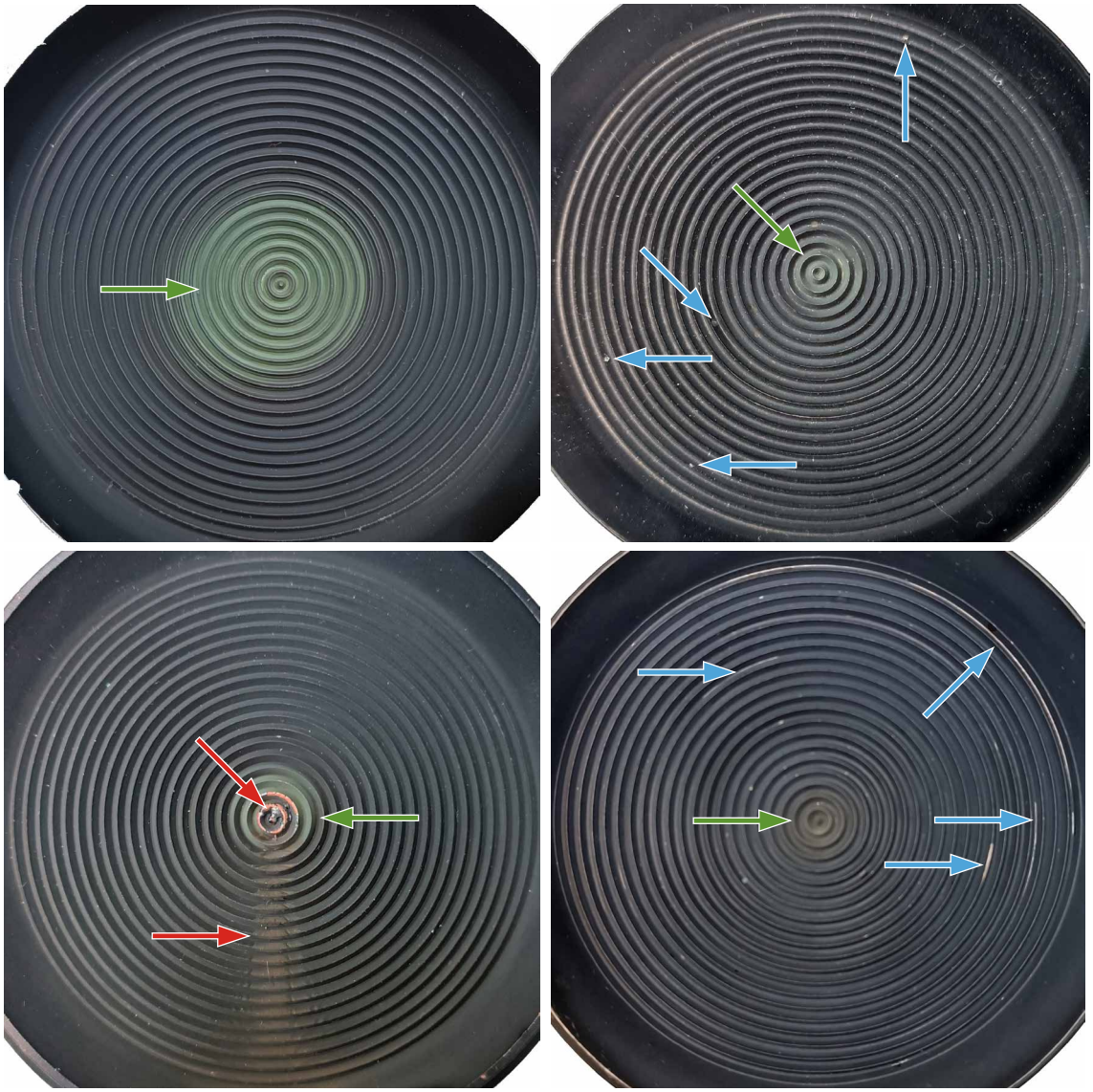


Continued on the following page.

The arrows show damage to the absorber and have the following meaning:

- Green: the absorber is clearly discolored; clear sign of overheating
- Red: the coating is missing or there is a hole in the absorber, burn-in caused by overheating
- Blue: the coating is missing, caused by mechanical damage

The damages shown result in reduced absorption and thus inaccurate power measurement. The absorbers must be replaced.



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.

11.3 Cleaning the internal water filter (only CPM+ F-10 and CPM+ F-30):

▶ Swap the flow direction of the cooling water for a short time.

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.

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:

CompactPowerMonitor (CPM)

Types: CPM C-9; CPM F-1; CPM F-10; CPM F-20; CPM F-30
CPM+ C-9; CPM+ F-1; CPM+ F-10; CPM+ F-20; CPM+ F-30

is in conformity with the following relevant EC Directives:

- 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
- Radio Equipment Directive 2014/53/EU

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, July 19, 2021

Dr. Reinhard Kramer, CEO

14 Technical data

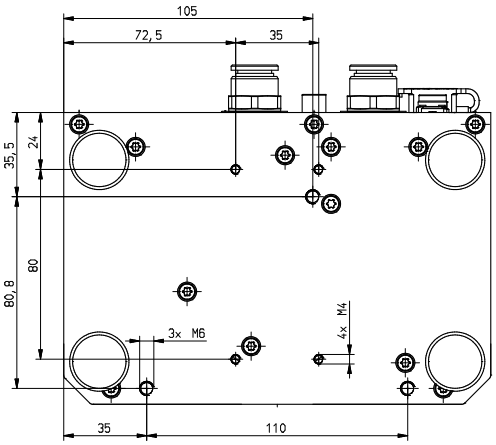
Measurement parameters		CPM+ F-1	CPM+ F-10	CPM+ F-30
Power range		0.1 – 1.4 kW	0.5 – 10 kW	2 – 30 kW
Irradiation time		Continuous (cw)		
Wavelength range (see identification plate)		340 – 800 nm [1], 800 – 1 100 nm		
Max. power density		1 kW/cm²		
Average power density		0.5 kW/cm²		
[1] Due to technical limitations and the lack of national high-performance standards in the wavelength range of 340 – 800 nm, only verifications at the wavelength of 515 nm are optionally available. However, we have provided evidence that measurements can be made in this range. For this demonstration, we used low power absorption spectra and a wavelength transfer process. The latter requires the use of a PRIMES EC-PM with a wavelength-independent absorber. For practical purposes, add 2 % to the device accuracy value (± 5 % instead of ± 3 %).				
Device parameters				
Entrance aperture		45 mm	90 mm	180 mm
Max. beam diameter		23 mm	50 mm	90 mm
Max. centered tolerance [2]		± 3 mm	± 5 mm	
Max. angle of incidence perpendicular to inlet aperture		± 10°		
Accuracy (NIR)		± 3 %		
Reproducibility (NIR)		± 1.5 %		
Time constant (up to 99 % of final value)		10 s		15 s
Flow meter		Turbine	Ultrasonic sensors	
[2] The values apply to the max. beam diameter. For smaller beam diameters, the deviation can be selected correspondingly larger.				
Supply data				
Power supply, DC	Power over Ethernet (PoE)	Standard IEEE 802.3af (802.3at Type1), Power class 3		
	USB-C	USB-C connection to PC		
		USB-C power supply		
Cooling water	Hose diameter	12 mm		16 mm
	Min. cooling water flow (interlock threshold)	0.5 l/min	4 l/min	9 l/min
	Max. cooling water flow	2 l/min	10 l/min	30 l/min
	Min. cooling water pressure	2 bar		
	Max. cooling water pressure	4 bar		
	Cooling water temperature T_{in}	Dew point temperature < T_{in} < 30 °C		
	Stability of the cooling water temperature	< 1.0 K per minute or 0.08 K per 5 seconds		
Communication				
Interfaces		Ethernet/PoE, USB-C, Interlock, PUC		

Dimensions and Weights	CPM+ F-1	CPM+ F-10	CPM+ F-30
Dimensions CPM+ with turbine in mm (L x W x H) with connectors and device feet	180 x 143 x 71	180 x 182 x 71	260 × 220 x 113
Weight CPM+ (approx.)	2.2 kg	3.25 kg	5.62 kg
Environmental conditions			
Operating temperature range	15 – 40 °C		
Storage temperature range	5 – 50 °C		
Reference temperature	22 °C		
Permissible relative humidity (non-condensating)	10 – 80 %		
PRIMES is committed to a continuous product improvement strategy, which can lead to specifications being optimized without any prior announcement.			

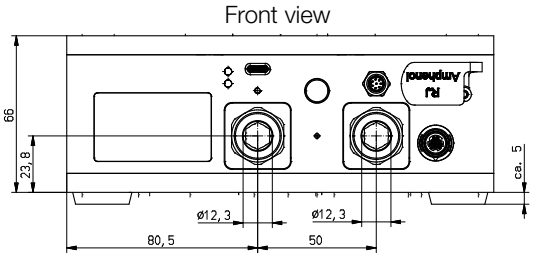
15 Dimensions

15.1 CPM+ F-1

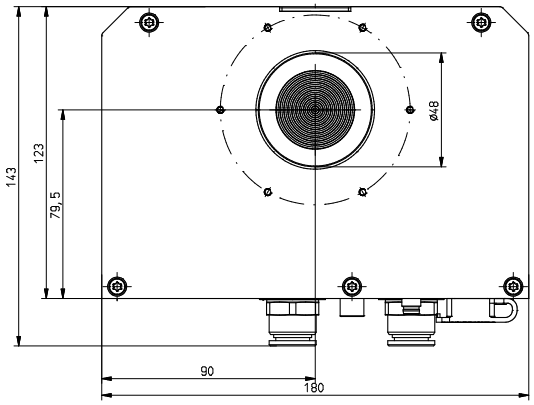
Bottom view



Front view



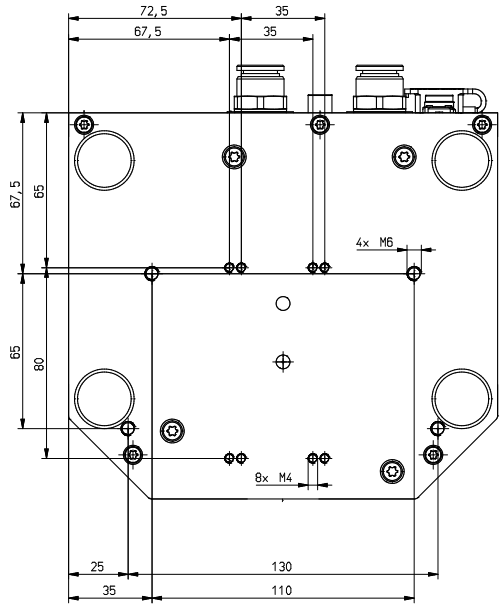
Top view



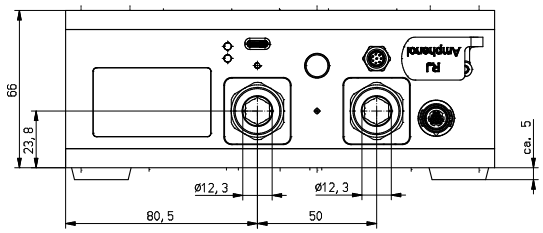
Dimensions in mm

15.2 CPM+ F-10

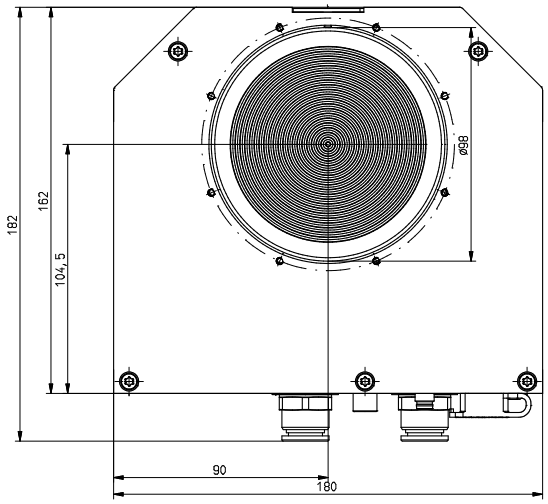
Bottom view



Front view



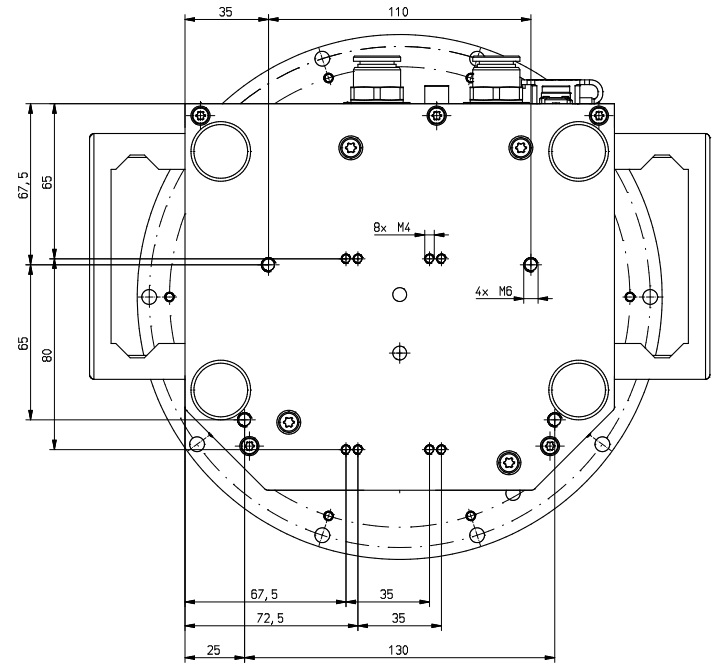
Top view



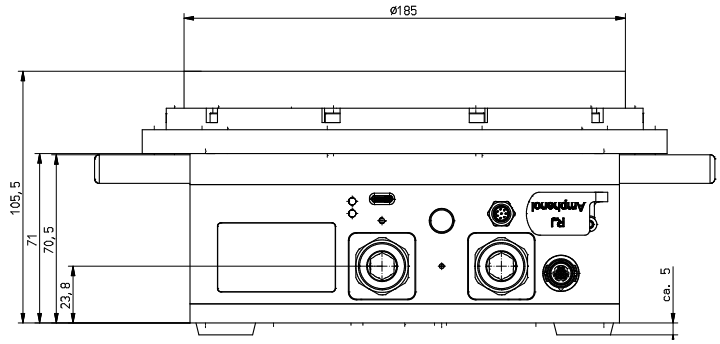
Dimensions in mm

15.3 CPM+ F-30

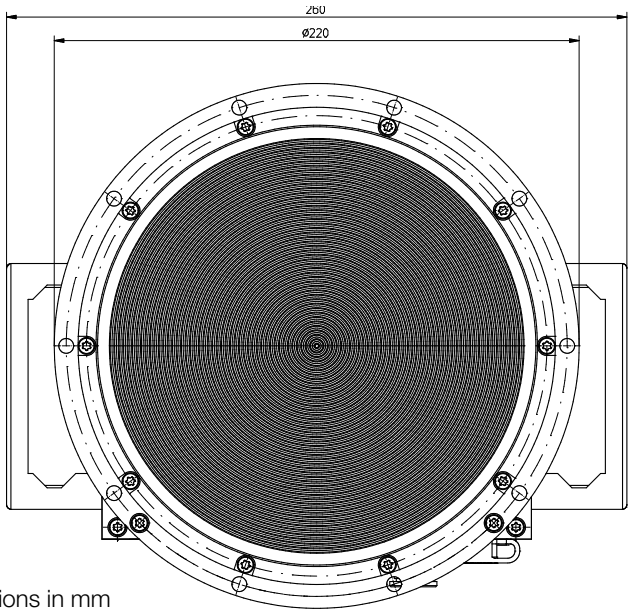
Bottom view



Front view



Top view

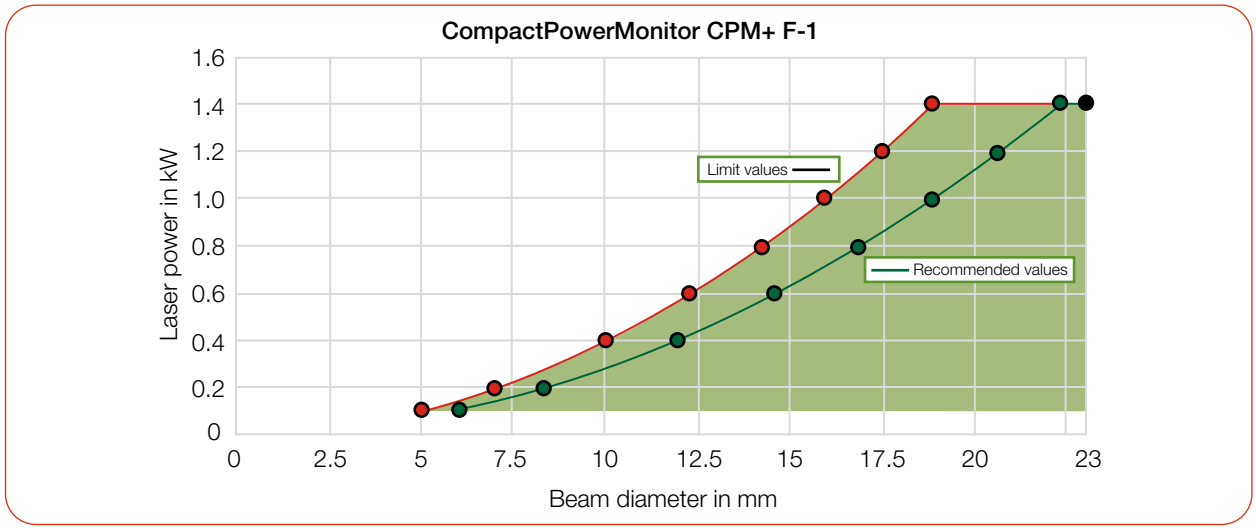


Dimensions in mm

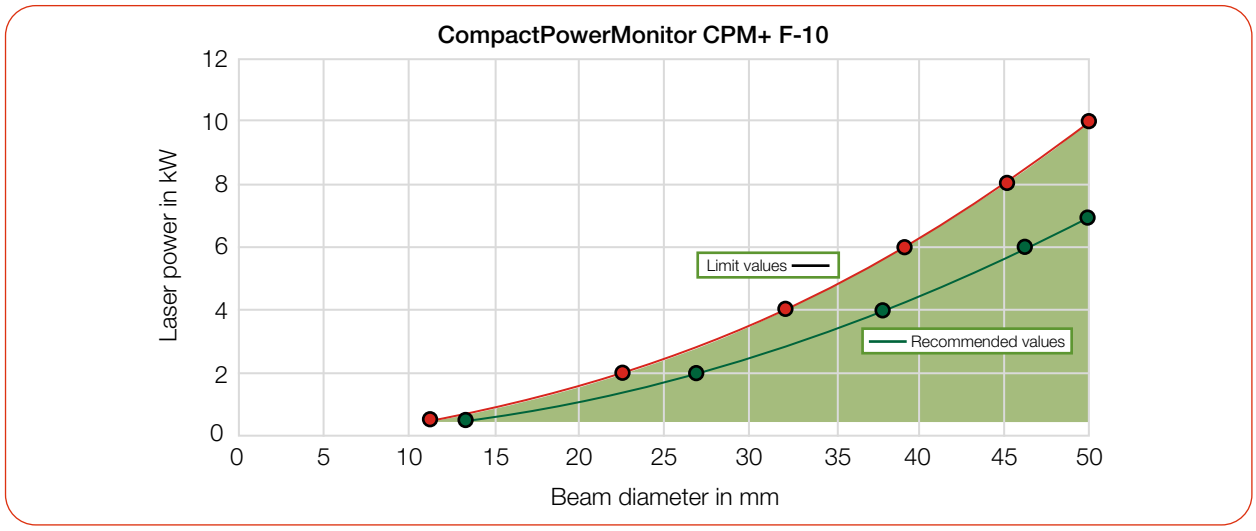
16 Appendix

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

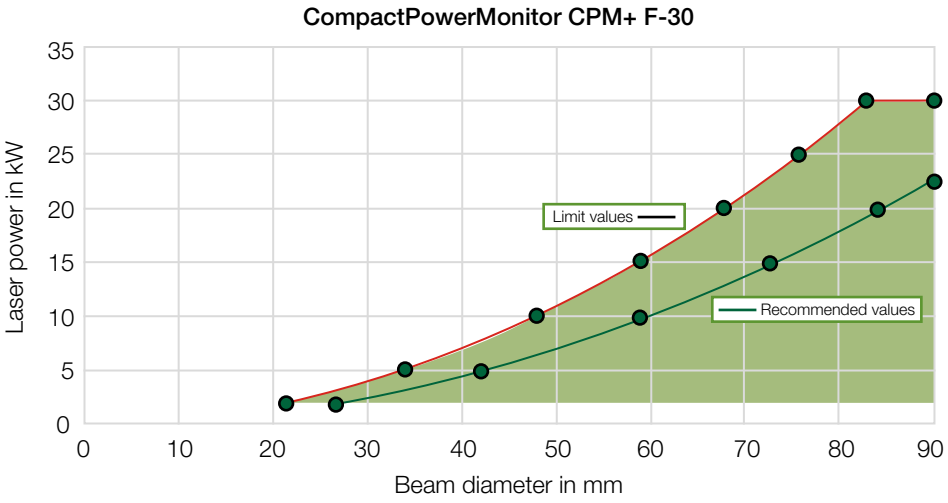
A.1 CompactPowerMonitor CPM+ F-1



A.2 CompactPowerMonitor CPM+ F-10



A.3 CompactPowerMonitor CPM+ F-30



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- https://www.gnu.org/licenses/old-licenses/gpl-2.0.en.html
- https://www.gnu.org/licenses/licenses.en.html

C Fiber adapters and domes

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

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

C.1 CPM+ F-1

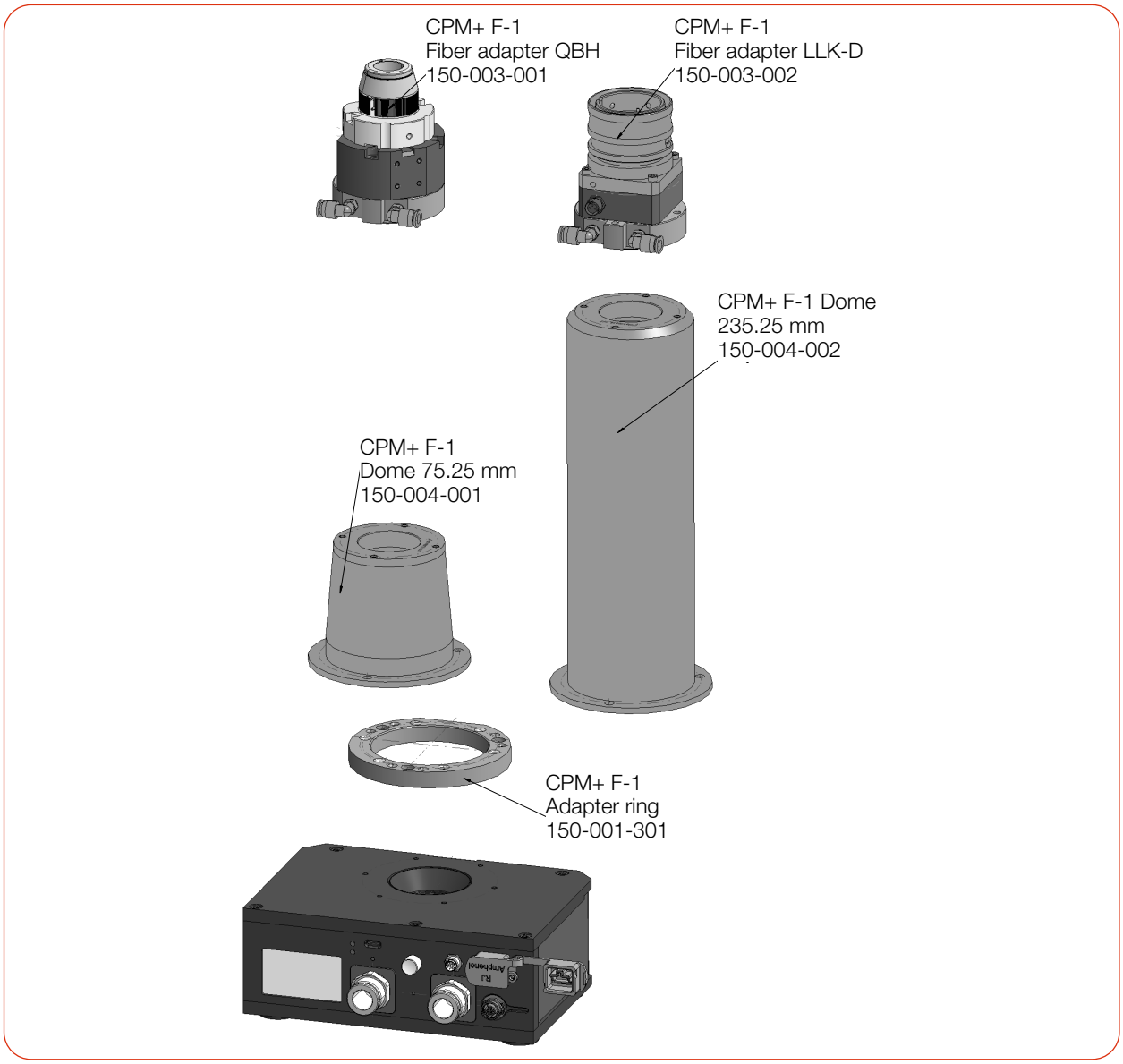

Fig. C.1: Fiber adapters and domes of CPM+ F-1

C.2 CPM+ F-10

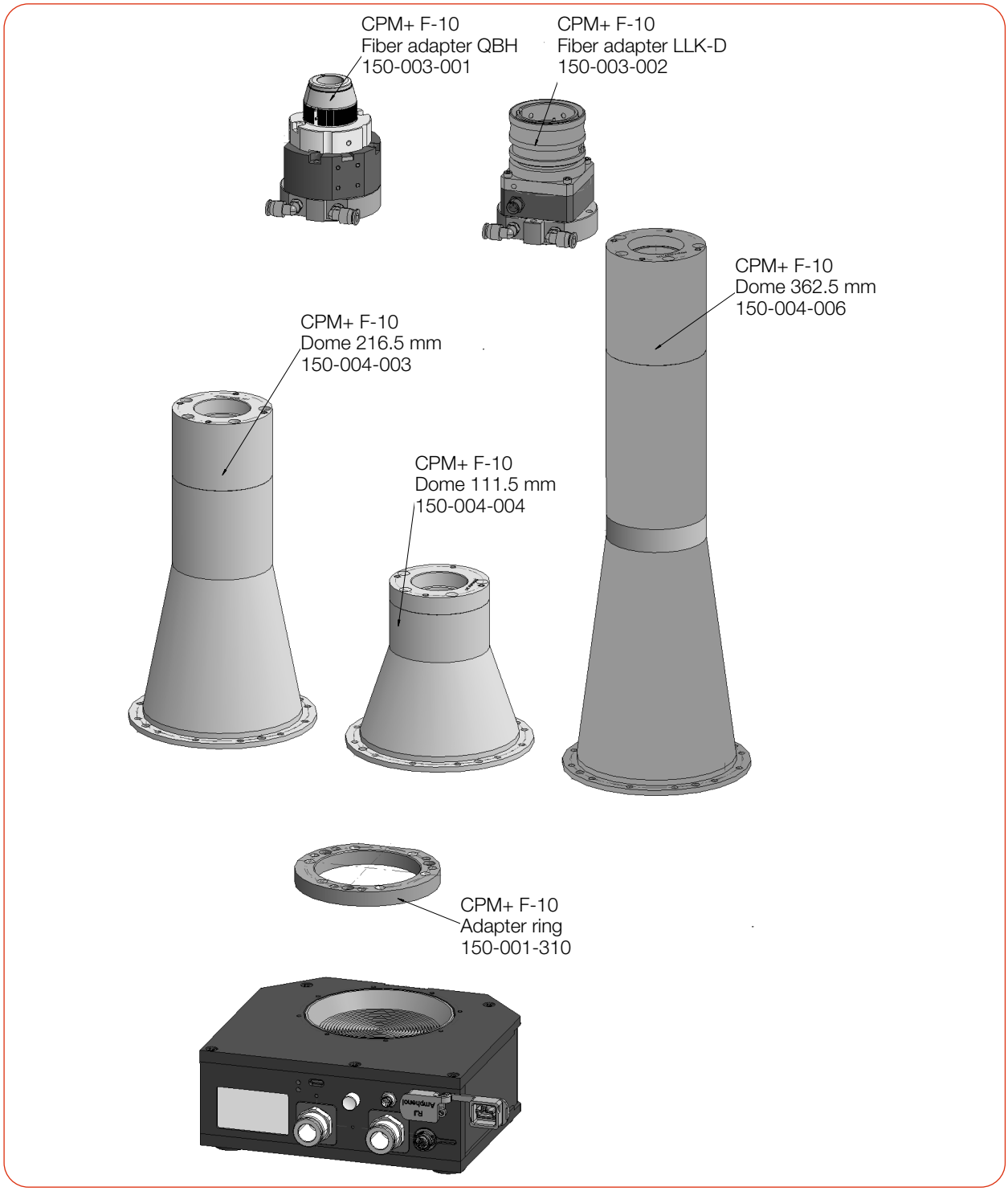

Fig. C.2: Fiber adapters and domes of CPM+ F-10

D Parallel operation of the CPM+ with a FocusMonitor FM+

1. Connect the FM+ to the PC via Ethernet.
2. Connect the CPM+ to the PC via Ethernet/PoE or via the USB-C interface to the PC.
3. Connect the PRIMES power supply to the FM+

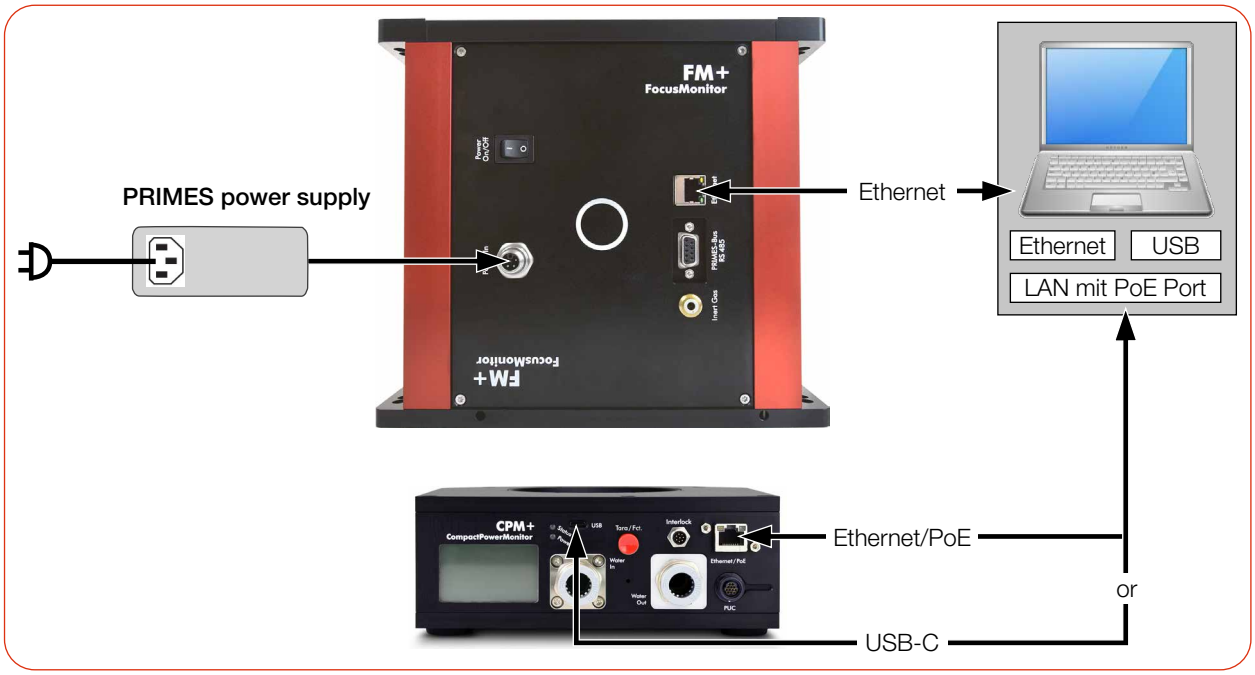

Fig. D.1: Connecting the FocusMonitor FM+ to the CPM+ (using the CPM+ F-10 as example)