Original Instructions

PowerMeasuringModule PMM

Hardware- und Software Interfaces

PROFINET® | PROFIBUS® | Parallel | DeviceNet™ | EtherNet/IP™ | EtherCAT®

IMPORTANT!

READ CAREFULLY BEFORE USE.

KEEP FOR FUTURE USE.

Table of contents

PRIMES - the company

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

- Laser power
- Beam dimensions and position of an unfocused beam
- Beam dimensions and position of a focused beam
- Beam quality factor M²

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 you observe all information, instructions, safety notes and warning messages in this operating manual. The specifications given in chapter 17 „Technical data" on page 88 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 as well as machine safety and comply with their requirements.

Before commissioning, it must be ensured that the entire machine in which the device is installed meets these safety requirements. Otherwise the commissioning of the device is prohibited.

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:

- 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
- 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 Symbols and conventions

Warning messages

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

⚠ **DANGER**

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

⚠ **WARNING**

Means that death or serious physical injuries **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 symbols are used on the device itself to indicate imperatives and possible dangers:

Read and understand the operating manual before using the device!

Do not grab inside!

General warning sign

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 symbols and conventions in this operating manual

	Here you can 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 operating manual describes the installation of the PowerMeasuringModule PMM and the integration of the device into the laser system via the respective fieldbus system.

In these operating manual, the abbreviated designation PMM is used.

4 Device description

4.1 Type overview

The PowerMeasuringModule PMM is available with a screwed protective window or with an integrated exchangeable cassette.

In the PMM with exchangeable cassette, the protective window is enclosed in a cassette that can be quickly exchanged without tools (see chapter 15.4 on page 85).

PMM with screwed protective window	PMM with exchangeable cassette
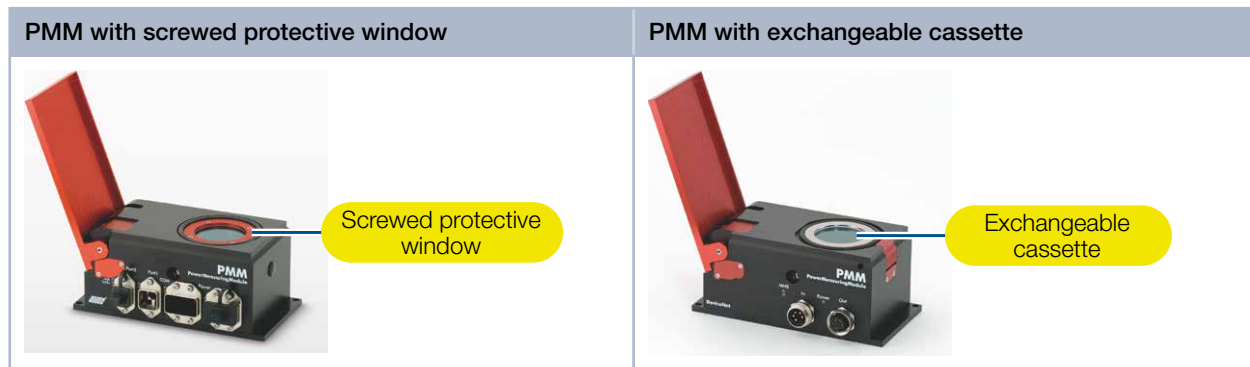
Fig. 4.1:   PMM and PMM with exchangeable cassette

The different PMM types can be found in the information on the identification plate.

The devices differ by the interface, the absorber type (standard or advanced absorber), the possibility to measure pulsed lasers, the reduced thermalization time and the measurable wavelength range.

In addition, devices with UL marking are available.

4.1.1 Distinction by interface and absorber type

Interface	Standard absorber without mark "A"	Advanced absorber with mark "A"
PROFINET® PROFIBUS® Parallel DeviceNet™ EtherNet/IP™ EtherCAT®	PRIMES **Type** PowerMeasuringModule PMM PROFINET® **S/N** 0000 **Built** 0000 000000X 532 nm CE UK CA www.primes.de	PRIMES **Type** PowerMeasuringModule PMM PROFINET® A **S/N** 0000 **Built** 0000 000000X 532 nm CE UK CA www.primes.de

Tab. 4.1:   Distinction by interface and absorber type
              using the PMM PROFINET® as an example

4.1.2 Distinction by the interface, the possibility to measure pulsed lasers and a reduced thermalization time

Interface	Advanced absorber With the AP3s marking, pulsed lasers can also be measured and the device is designed for a reduced thermalization time.
PROFINET® PROFIBUS® DeviceNet™ EtherCAT® Further interfaces on request	

Tab. 4.2: Distinction through the interface, the possibility to measure pulsed lasers and a reduced thermalization time using the PMM PROFINET® as an example

4.1.3 Distinction by the interface and the measurable wavelength range

Interface	Advanced Absorber With the "BG" mark, the device is suitable for measuring blue/green wavelengths. Without "BG" mark, the device is suitable for measuring NIR wavelengths. The measurable wavelengths are marked on the lower edge of the identification plate.
PROFINET® PROFIBUS® Parallel DeviceNet™ EtherNet/IP™ EtherCAT®	

Tab. 4.3: Distinction by the interface and the measurable wavelength range using the PMM PROFINET® as an example

4.1.4 Devices with UL marking

Interface	Standard absorber The type of absorber is indicated on the identification plate.	Advanced absorber The type of absorber is indicated on the identification plate.
PROFINET® LWL (Fiber optics)		

Tab. 4.4: Distinction by the interface and the absorber type on the PROFINET® LWL (Fiber optics) with UL marking.

4.2 Functional description

The PMM is used to measure laser power. After opening the shutter, the laser beam hits the absorber and scattering light is registered by a photodiode. The absorber and the photodiode are protected from contamination by the protective window. The shutter and the caps on the ports protect the PMM from contamination. Thus, the PMM can be used directly in the production environment in the process zone.

The PMM operates without cooling water and compressed air. The absorber cools off only through thermal conduction to the ambient air.

Thanks to the availability of various fieldbus interfaces, the PMM can be integrated in nearly every existing machine. The measurement results are transferred directly to the PLC.
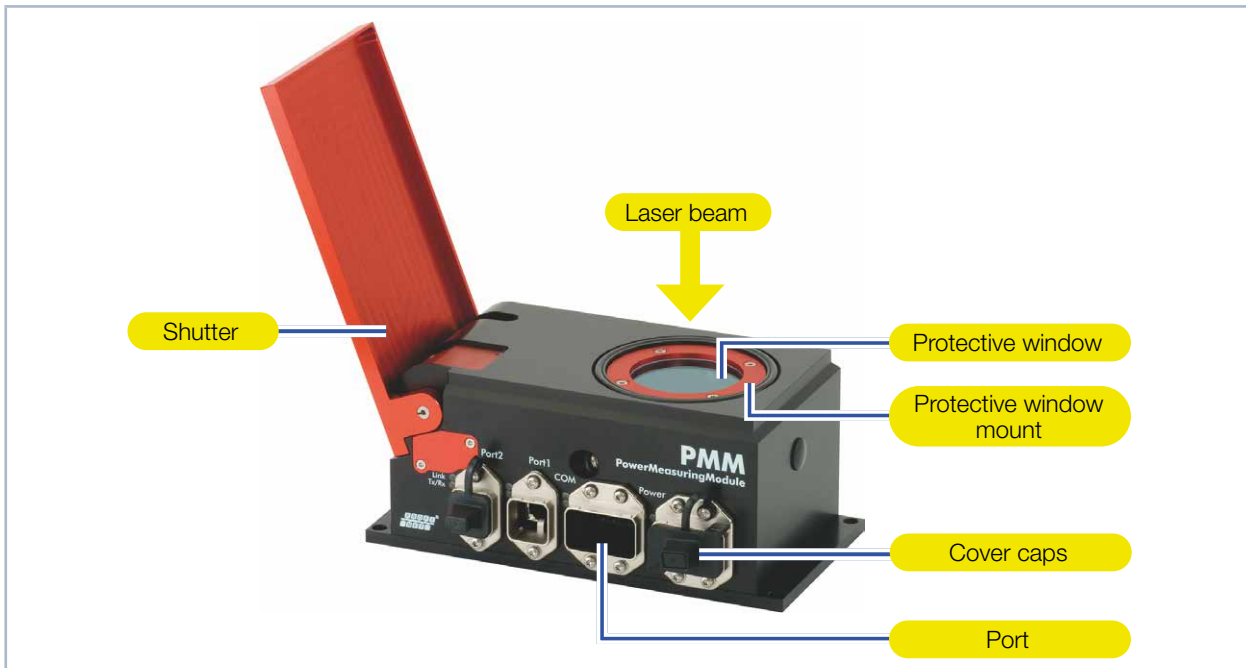
Fig. 4.2: PMM with open shutter using the example of PMM PROFINET®

4.3 Measuring principle

The PMM offers a fast, passively cooled power measurement according to the calorimetric measuring principle. The absorber of the measuring device is briefly irradiated with the laser beam. The irradiated energy is determined by the temperature rise of the absorber.

The photodiode simultaneously determines the laser ontime. The high-frequency sampling rate of the photodiode enables single pulse detection for pulses not shorter than 50 µs.

Thus, in addition to the average power, the peak power can also be calculated. In the second step, the actual laser power is calculated from the absorbed energy divided by the laser ontime.

4.4 Explanation of the product safety labels

Potential hazard areas are marked on the device with the symbols „Do not grab inside" and „General warning sign".

4.4.1 Warning of hand injuries/damage to the device

Do not grab inside
Under the protective window is an opening with the absorber. Touching the hot absorber can cause serious burns. Touching the absorber can lead to burn-in by the laser radiation at the points of contact. Burn-in causes damage to the absorber and increases the scattered radiation. Do not grab inside the opening.

General warning sign
The protective window is hot after a measurement! Do not replace the protective window directly after a measurement. Let the device cool down for an adequate period of time.
Contamination and fingerprints on the protective window can lead to damage or destruction of the protective window during measuring operation. When exchanging the protective window wear suitable gloves.
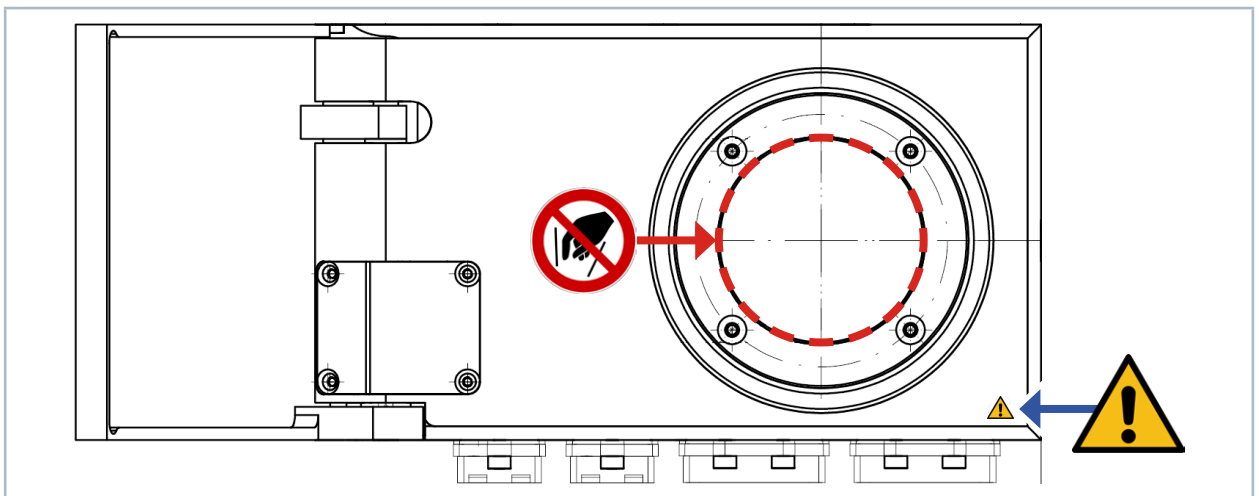
Fig. 4.3: Product safety labels „Do not grab inside" and „General warning sign"

4.4.2 Warning of internally connected power ports

The product safety label „General warning sign" indicates that the power connections are internally connected 1: 1. Please refer to the information on the pin assignment of these two user interfaces in chapter 7 „Connections" on page 21.
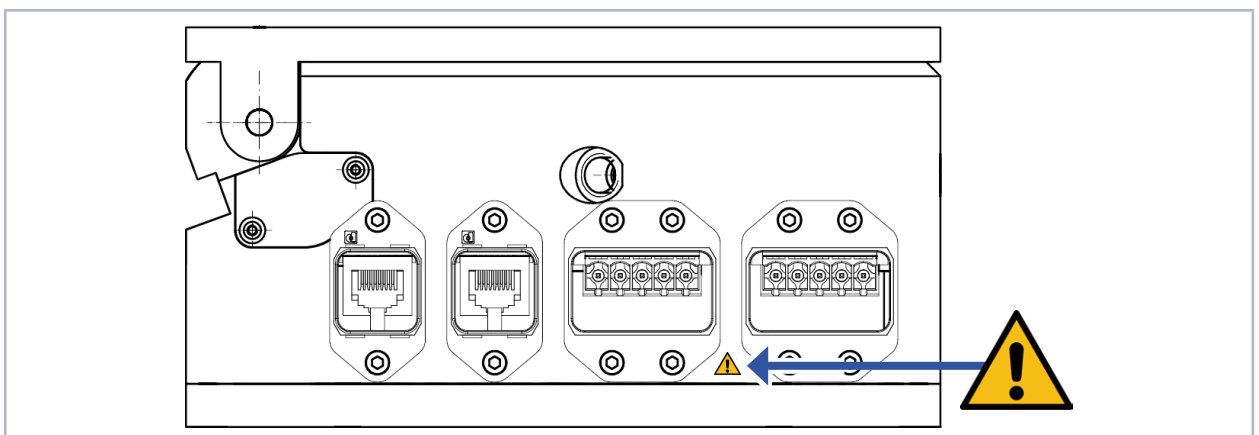
Fig. 4.4: Product safety label „General warning sign"

4.5 Scope of delivery and optional accessories

The scope of delivery includes:
- PowerMeasuringModule PMM
- USB stick (PDF of operating manuals, software, Embedding files *.gsd and *.gsdml, etc.)
- Operating manual

The following accessories are optional:
- Replacement protective windows (see chapter 15.3 on page 82)
- Replacement exchangeable cassette incl. protective window (see chapter 15.4 on page 85)

5 Transport and storage

NOTICE

Damage/Destruction of the device

Hard shocks can damage the absorber in the device.

▶ Handle the device carefully when transporting or installing it.

▶ Insert the transport lock into the device (see transport lock supplement).

▶ To avoid contamination, pack the device in a suitable plastic film or bag for shipping.

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6 Mounting

6.1 Conditions at the installation site

- The device must not be operated in a condensing atmosphere.
- The ambient air must be free of gases and aerosols that interfere with the laser radiation (e.g. organic solvents, cigarette smoke, sulfurhexafluoride).
- Protect the device from splashes of 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.

> ### NOTICE
>
> **Damage/Destruction of the device**
>
> During operation, the shutter of the device is fully opened. Obstacles in the traveling path of the shutter can damage the device.
>
> ▶ Before installing the device, check that a collision of the shutter with the laser system is not possible. A dimensioned view of the swivel range can be found in chapter 18 „Dimensions" on page 91.

3. Check the space available before installing the device, especially the required space for the connection cables and shutter.

6.2.2 Possible mounting positions

The PMM can be mounted either horizontally or vertically. Due to the risk of contamination, vertical mounting as shown in Fig. 6.1 on page 17 is recommended. Close unused ports with the cover caps.
An "upside down" installation position should be avoided as the general risk of contamination is higher.
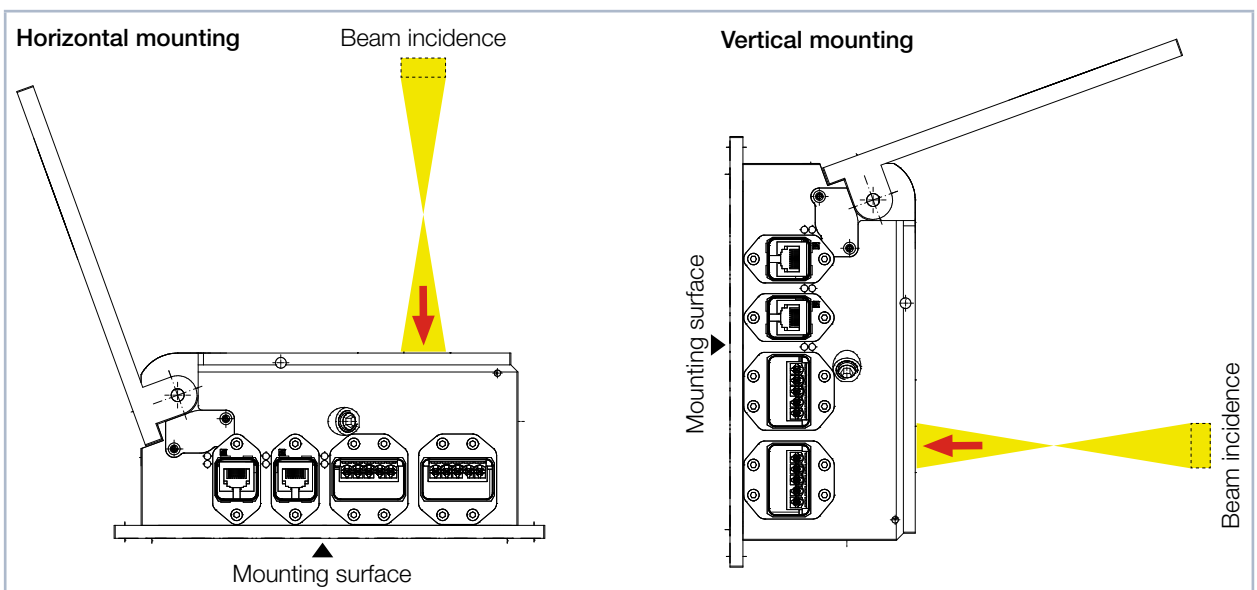
Fig. 6.1:   Possible mounting positions of the device

6.2.3 Align the device

The device must be aligned to the laser beam. The laser beam must hit the centre of the inlet aperture. Please mind and adhere to the specifications and limit values given in chapter 17 „Technical data" on page 88.

Usually, the device is positioned underneath the focusing plane in the beam path (divergent laser radiation). If this is not feasible, the device can be positioned above the focusing plane.

If the device is mounted above the focusing plane, be aware that the laser radiation is convergent and make sure that the maximum power density on the absorber will not be exceeded. The absorber is located approx. 25 mm below the top edge of the unit when the shutter is open.

The device is aligned with a pilot laser and the reticle on the shutter.
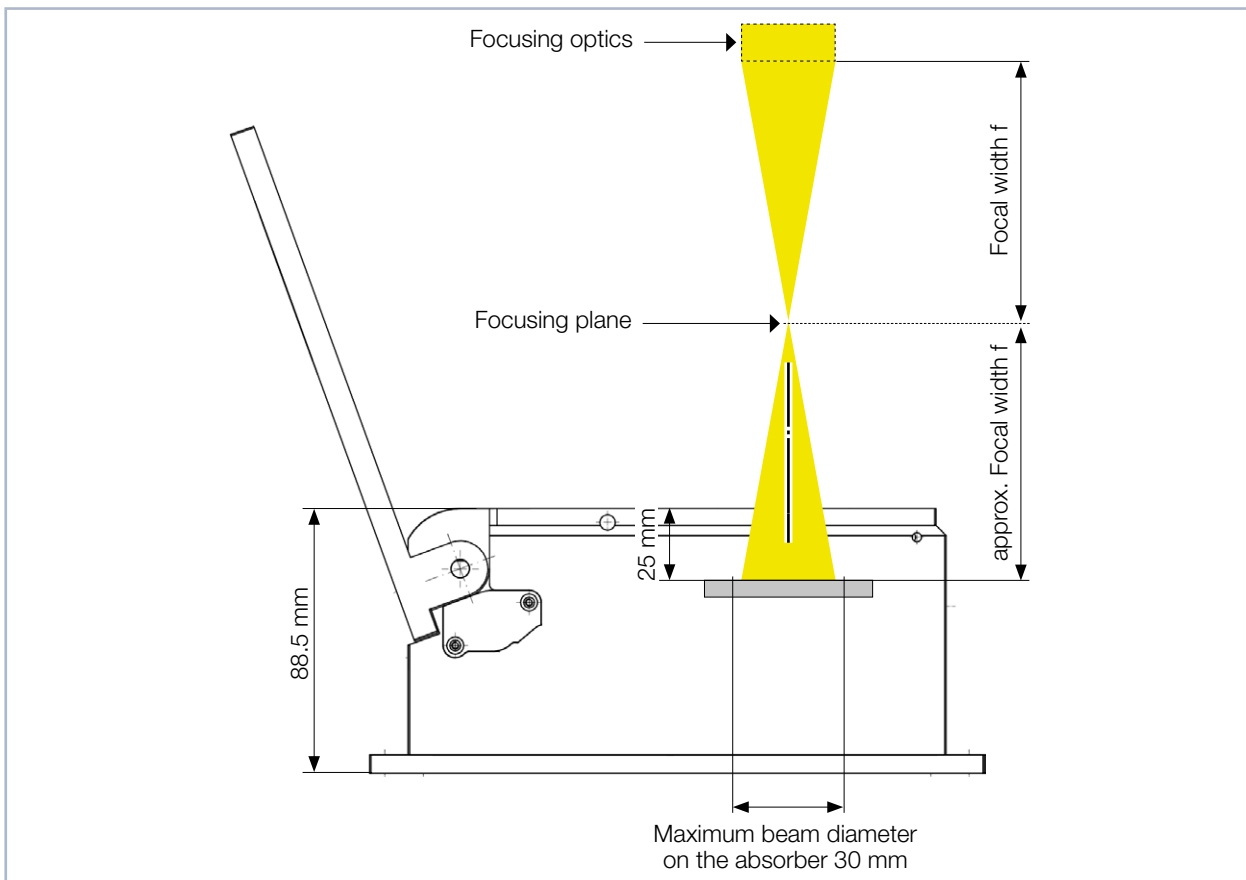
Fig. 6.2:   Alignment to the laser beam (schematic)

6.2.4 Mount the device

In the bottom of the housing there are four holes Ø 6.6 mm for mounting on a customer-side bracket.

> ℹ️ Ensure a good thermal conductivity of the mounting surface, especially for measurement procedures with a high repetition rate (see chapter 8.4 on page 40), in order to ensure a fast heat dissipation.

1. Mount the PMM according to Fig. 6.3 on page 19 with 4 screws M6.
   The total length of the screws depends on the dimensions of the customer's bracket.
   Screws of strength class 8.8 and a tightening torque of 35 N·m are recommended.

> ⚠ **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 in such a way that it cannot be moved by an unintended push or a pull on the lines.

> *NOTICE*
>
> **Damage/Destruction of the device**
>
> Contamination and fingerprints on the protective window can lead to damage or destruction of the protective window during measuring operation.
>
> ▶ Do not touch the protective window.
>
> ▶ Regularly check the condition of the protective window. The protective window can be cleaned or replaced in case of heavy, non-removable contamination (see chapter 15 „Maintenance and service" on page 82).
>
> ▶ Only operate the device with a clean protective window.

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2. Ensure a stable installation of the device. The device must not be able to move.
3. After mounting the device, check that a collision of the shutter with the laser system is excluded. A dimensioned view of the swivel range can be found in chapter 18 „Dimensions" on page 91.
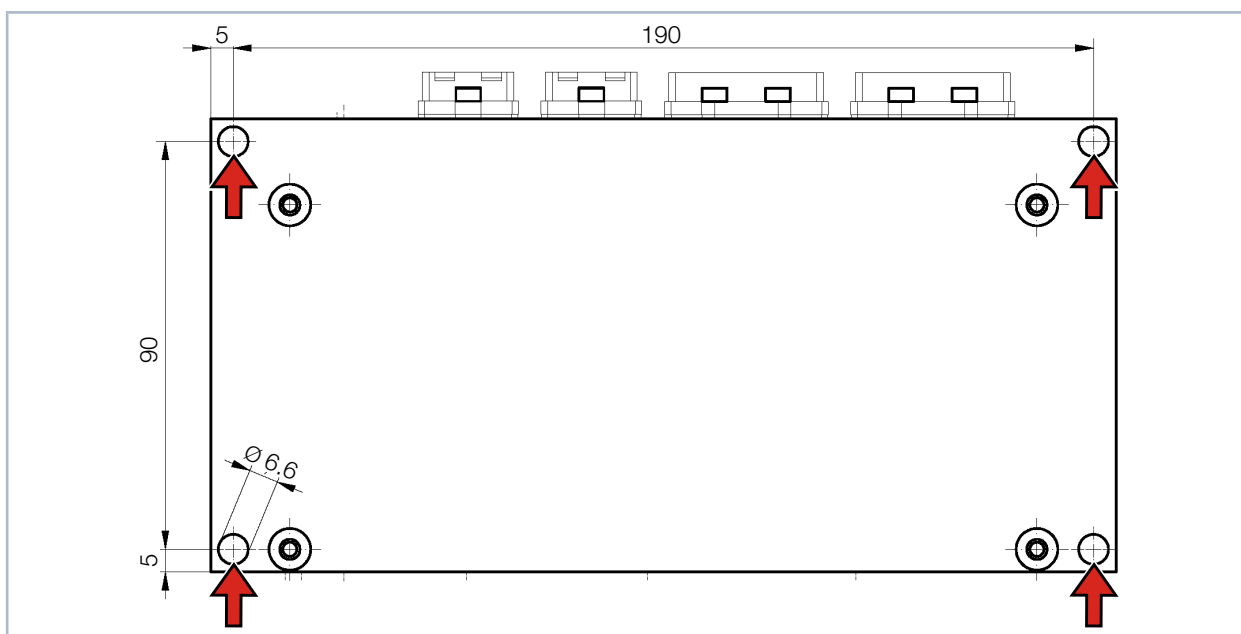
Fig. 6.3:   Mounting holes, view underside (Dimensions in mm)

6.3 Removal from the laser system

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.
5. Unscrew the mounting screws.
6. Disconnect the electrical connections.
7. Remove the device from the laser system.
8. Insert the transport lock into the device (see transport lock supplement).
9. To avoid contamination, pack the device in a suitable plastic film or bag.

7 Connections

7.1 Interface overview

Interface	Number of interfaces	
	Data	Power supply 24 V; max. 1 A power input
PROFINET®	2	2
PROFINET® LWL (Fiber optics)	2	2
PROFIBUS®	2	2
Parallel	2	1
DeviceNet™	1	1
EtherNet/IP™	2	2
EtherCAT®	2	2
Only PROFINET®, PROFINET® LWL (Fiber optics), PROFIBUS®, EtherNet/IP™ and EtherCAT® interface The bus interface and the power supply are duplicated so that the PMM can be inserted into a serial structure.		

Tab. 7.1: Interface overview

7.2 PROFINET®/PROFINET® LWL (Fiber optics)

Fig. 7.1:   PMM PROFINET®

To integrate the PMM into a serial bus system, the bus interface and the voltage supply are implemented twice.

7.2.1 Connectors

PROFINET®

Mounting frame / connectors	Designation
Mounting frame for RJ45 connectors	PHOENIX CONTACT VS-PPC-F1-RJ45-MNNA-1R-PHA – 1608029
Suitable RJ45 connector	e.g.: PHOENIX CONTACT VS-PPC-C1-RJ45-MNNA-PG9-8Q5 – 1608016
Mounting frame for MSTB connectors	PHOENIX CONTACT VS-PPC-F2-MSTB-MNNA-1R-P – 1608087
Suitable power connector	PHOENIX CONTACT CUC-PPC-C2ZNI-SX/24FKP5:FC – 1425514

Tab. 7.2:   PROFINET® – Mounting frames and connectors

PROFINET® LWL (Fiber optics)

Mounting frame / connectors	Designation
Transceiver for SC-RJ fiber optic cable	AVAGO TECHNOLOGIES QFBR-5978Z - TRANSCEIVER 10/100 - SC-RJ
Mounting frame for SCRJ connectors	PHOENIX CONTACT VS-PPC-F1-SCRJ-MNNA-1RP – 1608061
Suitable fiber optic connector for POF*	PHOENIX CONTACT VS-PPC-C1-SCRJ-MNNA-PG9-A4D-C – 1608032
Mounting frame for MSTB connectors	PHOENIX CONTACT VS-PPC-F2-MSTB-MNNA-1R-P – 1608087
Suitable power connector	PHOENIX CONTACT CUC-PPC-C2ZNI-SX/24FKP5:FC – 1425514
* POF = Plastic Optical Fibre. This optical subassembly couples the optical power efficiently from POF or HCS fiber to the receiving PIN. Compatible with electrical and optical performance of the POFAC recommendations for the Fast Ethernet over Plastic Optical Fiber (POF).	

Tab. 7.3:   PROFINET® LWL (Fiber optics) – Mounting frames and connectors

7.2.2 Pin assignment data connector XF1/XF2

The PMM has two PROFINET® interfaces that are connected via an integrated switch. These interfaces are routed to AIDA-compatible installation sockets with suitable mounting frames.
XF1 is the input (In) and XF2 is the output (Out).
The PMM is connected via Ethernet patch cables of CAT5e quality or higher.
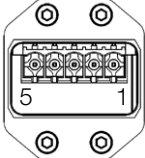
Pin	Color coding Europe T568A	Color coding Outside Europe T568B	Function
1	Green/White	Orange/White	TX+
2	Green	Orange	TX-
3	Orange/White	Green/White	RX+
6	Orange	Green	RX-

Tab. 7.4:   Pin assignment data connector XF1/XF2

7.2.3 Pin assignment power supply XD1/XD2

The power consumption of the PMM is below 250 mA, which is provided by the sensor supply.
Both connectors are internally connected 1:1.

Pin assignment XD1/XD2 (view on connection on the device)	Pin	Function
	1	Sensor power supply 24 V
	2	GND Sensor power supply
	3	Actor power supply 24 V
	4	GND Actor power supply
	5	FE (functional earth)

Tab. 7.5:   Pin assignment power supply XD1/XD2

7.2.4 Status LEDs

LED	Color	Mode	Meaning
Power	Green	On	Supply voltage is connected.
COM	Green	On	Watchdog time-out or „channel, generic or extended diagnostics present" or system error.
	Green	Flashing	DCP signal service is triggered via the bus.
	Red	On	No configuration or slow physical connection or no physical connection.
	Red	Flashing	No data exchange.
Link [1]	Green	On	The device has a connection to the Ethernet (XF1 / XF2).
Tx/Rx [1]	Yellow	Flicker-ing	The device sends / receives Ethernet frames (XF1 / XF2).
[1] without function in the PROFINET® fiber optic version			

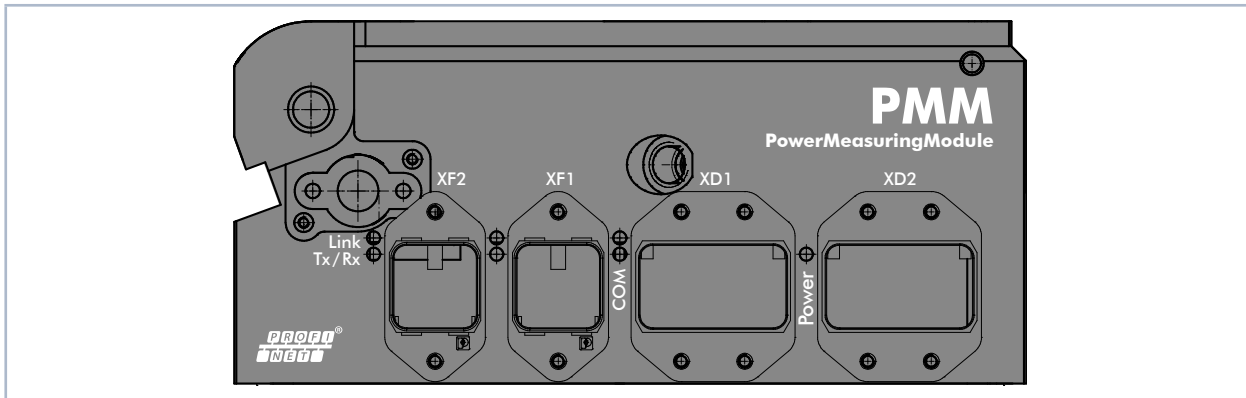Tab. 7.6:   Status LEDs

7.3 PROFIBUS®
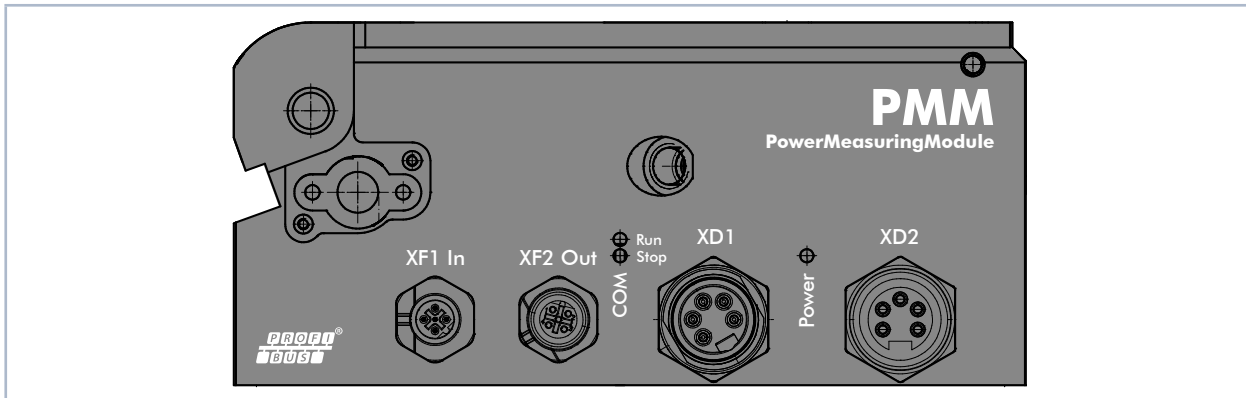
Fig. 7.2:   PMM PROFIBUS®

To integrate the PMM into a serial bus system, the bus interface and the voltage supply are implemented twice.

7.3.1 Connectors
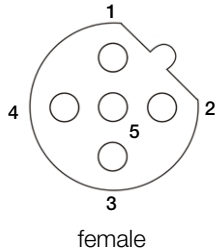
Connectors	Designation
Power supply connector	5 pin, 7/8" (plug/socket)
Matching socket (female)	PHOENIX CONTACT SACC-MINFS-5CON-PG 9 – 1521384
Matching plug (male)	PHOENIX CONTACT SACC-MINMS-5CON-PG 9 – 1521668
Data connector	5 pin, B-coded M12 (plug/socket)
Matching socket (female)	PHOENIX CONTACT SACC-M12FSB-5PL SH – 1424664
Matching plug (male)	PHOENIX CONTACT SACC-M12MSB-5PL SH – 1424662

Tab. 7.7:   PROFIBUS® – Connectors

7.3.2 Pin assignment data connector XF1 In/XF2 Out

The PMM has two PROFIBUS® interfaces. The M12 panel jack serves as an interface for further bus users or for the power supply of the termination resistors.
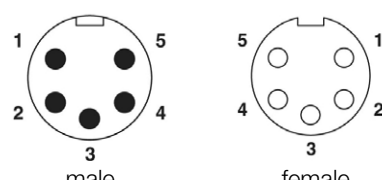
Pin assignment XF1 In (view on connection on the device)	Pin	Function
	1	Not connected
	2	Signal A
	3	Not connected
	4	Signal B
	5	Not connected

Pin assignment XF2 Out (view on connection on the device)	Pin	Function
	1	5 V
	2	Signal A
	3	ISOGND
	4	Signal B
	5	Not connected

Tab. 7.8:   Pin assignment data connector XF1 In/XF2 Out

7.3.3   Pin assignment power supply XD1/XD2

The power consumption of the PMM is below 250 mA, which is provided by the sensor supply. Both connectors are internally connected 1:1.

Pin assignment XD1/XD2 (view on connection on the device)	Pin	Function
	1	GND Actor
	2	GND Sensor
	3	FE (functional earth)
	4	Sensor supply 24 V
	5	Actor supply 24 V

Tab. 7.9:   Pin assignment power supply XD1/XD2

7.3.4   Status LEDs

LED	Color	Mode	Meaning
Power	Green	On	Supply voltage is connected.
Run	Green	On	Communication with the bus.
Stop	Yellow	Flashing	Device has no physical connection to the bus.
	Yellow	On	A connection exists, but no data will be exchanged.

Tab. 7.10:   Status LEDs

7.4   Parallel
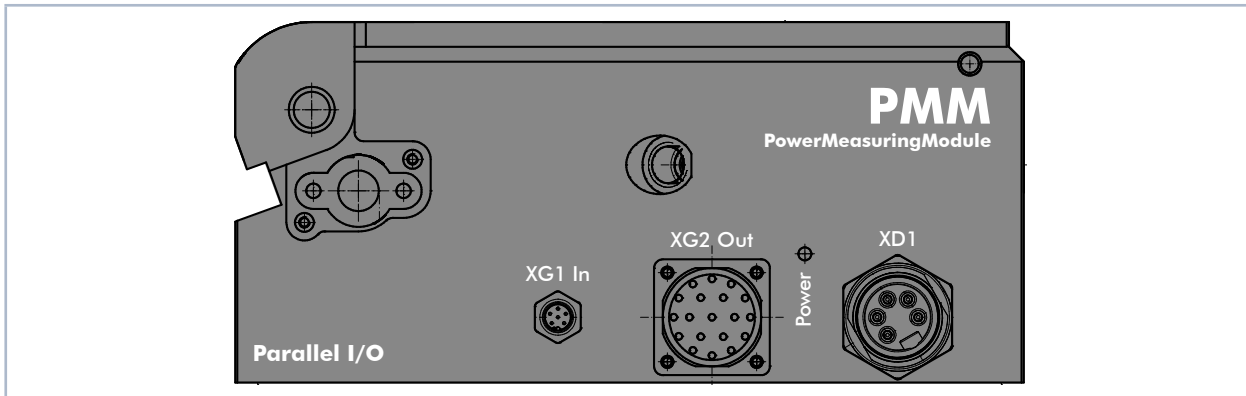
Fig. 7.3:   PMM Parallel
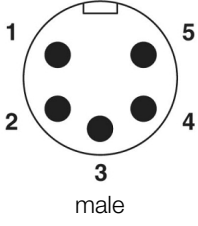
The PMM Parallel has an interface with four inputs and 16 outputs.

7.4.1   Connectors

Connectors	Designation
Power supply connector	5 pin, 7/8" (plug)
Matching socket (female)	PHOENIX CONTACT SACC-MINFS-5CON-PG 9 – 1521384
Output connector	16-channel
Matching socket	LQ-Mechatronik, plug M23 Sig-A, 16+3-E STI-CR9,0-13,2
Input connector	4-channel
Suitable cable with socket (female)	Binder M8 cable socket, 6 pin, series 718; Binder order number: 77 3406 0000 50006-0200; (alternative order number : 79 3464 52 06)
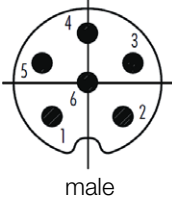
Tab. 7.11:   Parallel – Connectors

7.4.2 Pin assignment power supply XD1

Pin assignment XD1 (view on connection on the device)	Pin	Function
male	1	0 V
	2	Not connected
	3	Not connected
	4	Sensor supply 24 V; 0.5 A
	5	Actor supply, not connected

Tab. 7.12: Pin assignment power supply XD1

7.4.3 Pin assignment input, 4-Channel XG1 In

Pin assignment XG1 In (view on connection on the device)	Pin	Name	Function
male	1	Bit 0	Shutter opening
	2	Bit 1	Shutter closing
	3	Bit 2	Start measurement
	4	Bit 3	Reset
	5		Not connected
	6		Ground

Tab. 7.13: Pin assignment input, 4-channel XG1 In

The inputs are electrically isolated by means of an opto coupler.
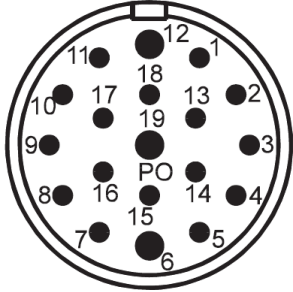
7.4.4   Pin assignment output, 16-Channel XG2 Out

The outputs 1 to 17 have two functions, depending on the setting of bit 15:
- In case of bit 15=1 (measurement finished) the 14 lines below are used for displaying the laser power (Watt) as binary code.
- In case of bit 15=0 those lines provide status information.

> **i** After a change of edge of bit 15, the measured value bits should be taken over a few milliseconds later to avoid runtime problems of the individual bits.

Pin assignment XG2 Out (view on connection on the device)	Pin	Name	Function	
			Bit15=0	Bit 15=1
male	1	Bit 0	Shutter is open	Power Bit 0
	2	Bit 1	Shutter is closed	Power Bit 1
	3	Bit 2	Shutter is moving	Power Bit 2
	4	Bit 3	Shutter time error	Power Bit 3
	5	Bit 4	Irradiation time 100 ms	Power Bit 4
	6	-	GND [1]	
	7	Bit 5	Irradiation time 200 ms	Power Bit 5
	8	Bit 6	Irradiation time 400 ms	Power Bit 6
	9	Bit 7	Irradiation time 800 ms	Power Bit 7
	10	Bit 8	Irradiation time 1,600 ms	Power Bit 8
	11	Bit 9	Confirmation command closing	Power Bit 9
	12	-	GND	
	13	Bit 10	Confirmation start measurement	Power Bit 10
	14	Bit 11	Absorber too warm	Power Bit 11
	15	Bit 12	System not in operation	Power Bit 12
	16	Bit 13	Measurement in process, Pulse received	Power Bit 13
	17	Bit 14	System waiting for pulse	Power Bit 14
	18	Bit 15	Measurement finished	
	19	-	Supply voltage output driver (24 VDC)	
[1] Is connected with pin 1 in the power supply (see Tab. 7.12 on page 27).				

Tab. 7.14:   Pin assignment output, 16 channel XG2 Out

The output driver is supplied with 24 V via Pin 19. The maximum current load of all outputs is 2 Amperes. A single output can have a load of 500 mA. The outputs are not electrically isolated.

7.4.5 Status LED

LED	Color	Mode	Meaning
Power	Green	On	Supply voltage is connected.

Tab. 7.15:   Status LED

7.5 DeviceNet™
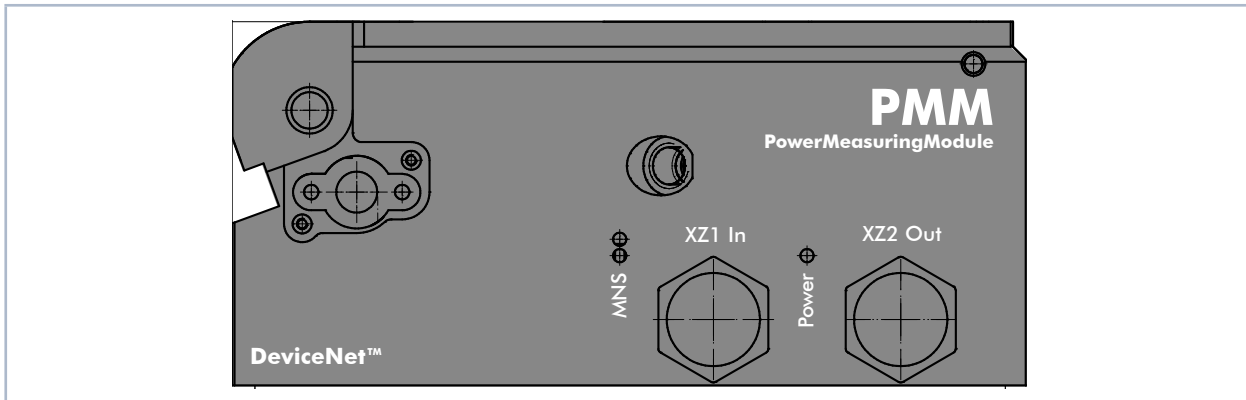
Fig. 7.4: PMM DeviceNet™

The PMM has two DeviceNet™ interfaces, which also provide the voltage.

7.5.1 Connectors

Connectors	Designation
Power supply connector	5 pin, 7/8" (plug/socket)
Matching socket (female)	PHOENIX CONTACT SACC-MINFS-5CON-PG 9 – 1521384
Matching plug (male)	PHOENIX CONTACT SACC-MINMS-5CON-PG 9 – 1521668

Tab. 7.16: PMM DeviceNet™ – Connectors

7.5.2 Pin assignment connectors XZ1 In/XZ2 Out

Pin assignment XZ1 In (view on connection on the device)	Pin	Function
	1	Drain
	2	V+ (24 V)
male	3	V– (GND)
	4	CAN_H
	5	CAN_L
Pin assignment XZ2 Out (view on connection on the device)	Pin	Function
	1	Drain
	2	V+ (24 V)
female	3	V– (GND)
	4	CAN_H
	5	CAN_L

Tab. 7.17: Pin assignment connectors XZ1 In/XZ2 Out

7.5.3 Status LEDs

LED	Color	Mode	Meaning
Power	Green	On	Supply voltage is connected.
MNS	Green	On	A device is online and has established one or more connections.
	Green	Flashing	Device is online and has not established a connection.
	Red	On	Critical connection error; Device has detected a network error: double MAC-ID or severe error in CAN-network (CAN-Bus-Off).
	Red	Flashing	Connection monitoring time has expired.
	Green / Red	Green/Red/Off	Start-up self-test: green on for 0.25 s, then red on for 0.25 s, then off.
	—	Off	After start-up of the device and during the check for a double MAC-ID.

Tab. 7.18:   Status LEDs

7.6 EtherNet/IP™
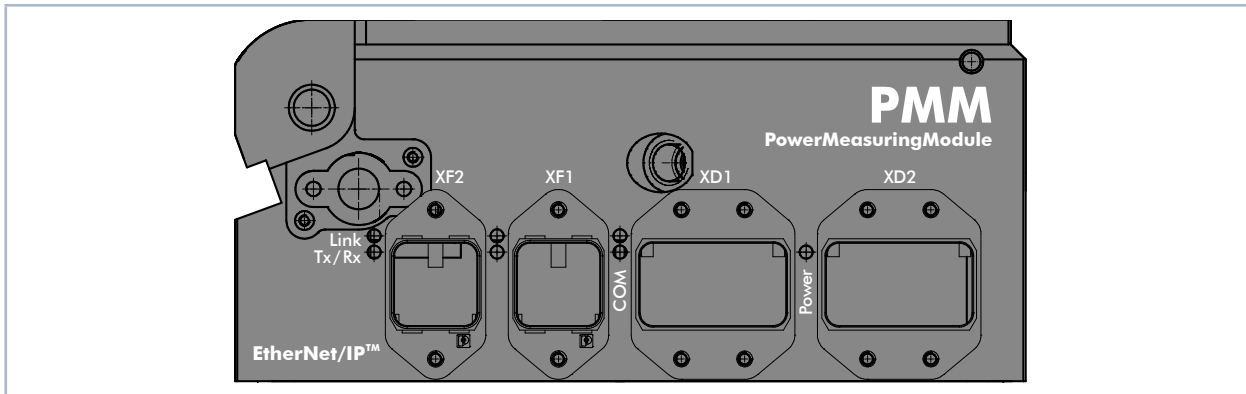
Fig. 7.5: PMM EtherNet/IP™

To integrate the PMM into a serial bus system, the bus interface and the voltage supply are implemented twice.

7.6.1 Connectors

Mounting frame / connectors	Designation
Mounting frame for RJ45 connectors	PHOENIX CONTACT VS-PPC-F1-RJ45-MNNA-1R-PHA – 1608029
Suitable RJ45 connector	e.g.: PHOENIX CONTACT VS-PPC-C1-RJ45-MNNA-PG9-8Q5 – 1608016
Mounting frame for MSTB connectors	PHOENIX CONTACT VS-PPC-F2-MSTB-MNNA-1R-P – 1608087
Suitable power connector	PHOENIX CONTACT CUC-PPC-C2ZNI-SX/24FKP5:FC – 1425514

Tab. 7.19: EtherNet/IP™ – Mounting frames and connectors

7.6.2 Pin assignment data connector XF1/XF2

The PMM has two EtherNet/IP interfaces that are connected via an integrated switch. These interfaces are routed to AIDA-compatible installation sockets with suitable mounting frames.
XF1 is the input (In) and XF2 is the output (Out).
The PMM is connected via Ethernet patch cables of CAT5e quality or higher.

Pin	Color coding Europe T568A	Color coding Outside Europe T568B	Function
1	Green/White	Orange/White	TX+
2	Green	Orange	TX-
3	Orange/White	Green/White	RX+
6	Orange	Green	RX-

Tab. 7.20: Pin assignment data connector XF1/XF2

7.6.3 Pin assignment power supply XD1/XD2

The power consumption of the PMM is below 250 mA, which is provided by the sensor supply.
Both connectors are internally connected 1:1.

Pin assignment XD1/XD2 (view on connection on the device)	Pin	Function
	1	Sensor power supply 24 V
	2	GND Sensor power supply
	3	Actor power supply 24 V
	4	GND Actor power supply
	5	FE (functional earth)

Tab. 7.21: Pin assignment power supply XD1/XD2

7.6.4 Status LEDs

| LED	Color	Mode	Meaning
Power	Green	On	Supply voltage is connected.
Link	Green	On	Connection established with Ethernet.
		Off	No connection established with Ethernet.
Tx/Rx	Yellow	Flashing	The device sends/receives Ethernet Frames.
COM	Green	On	**PMM, PMM A only – Connected:** If the device has at least one connection (including the message router).
	—	Off	**PMM AP3s only – Connected:** If the device has at least one connection (including the message router).
	Green	Flashing	**No connections**: If the device has no existing connections but has received an IP address, the network status display flashes green.
	Red	On	**Double IP**: If the device realizes that an IP address is already in use, the network status display glows red.
	Red	Flashing	**Time out of the connection:** If one or more connections with the device have reached the time out, the network status display flashes red. This status will not terminate until all connections, that have timed-out, have been restored or until the device has been reset.
	Red / Green	Flashing	**Self-test**: When the device is carrying out a self-test, the network status display flashes green/red.
	—	Off	**Not turned on, no IP address:** If the device does not have an IP address (or is turned off), the network status display is off.

Tab. 7.22: Status LEDs

7.7 EtherCAT®
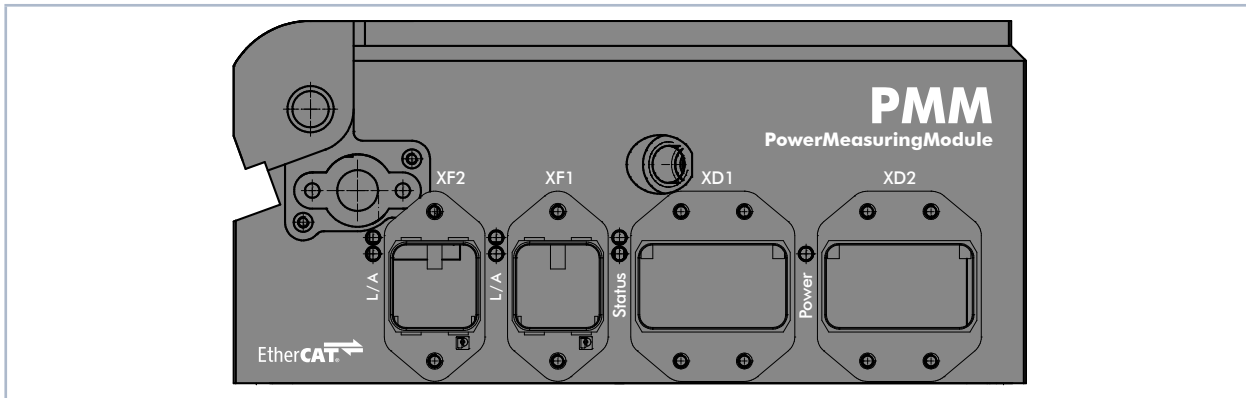
Fig. 7.6:   PMM EtherCAT®

To integrate the PMM into a serial bus system, the bus interface and the voltage supply are implemented twice.

7.7.1 Connectors

Mounting frame / connectors	Designation
Mounting frame for RJ45 connectors	PHOENIX CONTACT VS-PPC-F1-RJ45-MNNA-1R-PHA – 1608029
Suitable RJ45 connector	e.g.: PHOENIX CONTACT VS-PPC-C1-RJ45-MNNA-PG9-8Q5 – 1608016
Mounting frame for MSTB connectors	PHOENIX CONTACT VS-PPC-F2-MSTB-MNNA-1R-P – 1608087
Suitable power connector	PHOENIX CONTACT CUC-PPC-C2ZNI-SX/24FKP5:FC – 1425514

Tab. 7.23:   EtherCAT® – Mounting frames and connectors

7.7.2 Pin assignment data connector XF1/XF2

The PMM has two EtherCAT® interfaces that are connected via an integrated switch. These interfaces are routed to AIDA-compatible installation sockets with suitable mounting frames.
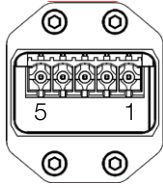XF1 is the input (In) and XF2 is the output (Out).
The PMM is connected via Ethernet patch cables of CAT5e quality or higher.

Pin	Color coding Europe T568A	Color coding Outside Europe T568B	Function
1	Green/White	Orange/White	TX+
2	Green	Orange	TX-
3	Orange/White	Green/White	RX+
6	Orange	Green	RX-

Tab. 7.24:   Pin assignment data connector XF1/XF2

7.7.3 Pin assignment power supply XD1/XD2

The power consumption of the PMM is below 100 mA, which is provided by the sensor supply.
Both connectors are connected internally 1:1.

Pin assignment XD1/XD2 (view on connection on the device)	Pin	Function
	1	Sensor power supply 24 V
	2	GND Sensor power supply
	3	Actor power supply 24 V
	4	GND Actor power supply
	5	FE (functional earth)

Tab. 7.25: Pin assignment power supply XD1/XD2

7.7.4 Status LEDs

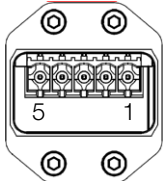| LED	Color	Mode	Meaning
Power	Green	On	The supply voltage is applied.
L/A	Green	On	There is a connection to the EtherCAT®.
	Green	Flashing	The device sends/receives Ethernet frames.
	Green	Off	The device has no connection to the EtherCAT®.
Status	Green	On	The device is in OPERATIONAL mode.[1]
	Green	Flashing	The device is in PRE-OPERATIONAL mode.[2]
	Green	Simple flash	The device is in SAFEOPERATIONAL mode.[3]
	Green	Off	The device is in INIT mode.[4]
	Red	Flashing	Invalid configuration: General configuration error: Possible cause: A status change specified by the master isn't possible, because of the register or object settings.
	Red	Simple flash	Local error: The slave device application has an EtherCATStats Changed autonomously. Possible cause 1: A host watchdog time-out has occurred. Possible cause 2: Synchronization error, the device switches automatically after safe operational.
	Red	Double flash	Process data watchdog time-out: A process data watchdog time-out has occurred. Possible cause: Sync manager watchdog time-out.

Tab. 7.26: Status LEDs

[1] Inputs and outputs are valid and the final mode has been achieved.

[2] Communication with the application layer already runs through the mailbox, but the process data still isn't being communicated. Additional parameters now need to be configured. This includes the mapping of process data and the setup of the SyncManager and FMMU. The safe operational state can then be queried.

[3] Communication of process data will start, but only the input values are valid at the start. Outputs are left in a so-called safe state. This will change as soon as the master sends valid output values and requests operational state.

[4] There is no communication on the application layer, but the master has already accessed the DL information register. Here the master at least has to configure the DL address register and channels for the mailbox of the SyncManager.

LED states	Description
On	The indication is steadily lit up.
Off	The indication is not lit up.
Flashing	The indication is turned on or off in phases, with a frequency of 2.5 Hz: On for 200 ms, followed by off for 200 ms.
Simple flash	The indication shows a short flash (200 ms), followed by a long off phase (1 000 ms).
Double flash	The indication shows a series of two short flashes (200 ms each), punctuated by a brief off phase (200 ms). The series ends with a long off phase (1 000 ms).

Tab. 7.27: LED states

8   Laser parameter setting

For correct measurements and to protect the device from damage, the following parameters must be observed and adhered to.

8.1   Setting the laser rise time

The applicable irradiation time is between 0.1 – 2.0 s resp. 0.1 – 1.0 s for PMM type AP3s, which has to be transferred to the laser controller as pulse duration/burst duration.

For high measurement accuracy, make sure that the rise time of the laser does not exceed 1 % of the irradiation time (in some cases, even 2 % may be acceptable).

Example: If an irradiation time of 500 ms is selected, the rise time of the laser must be < 5 ms. Many industrial lasers have a rise time < 0.1 ms, so this point can be ignored in most cases.
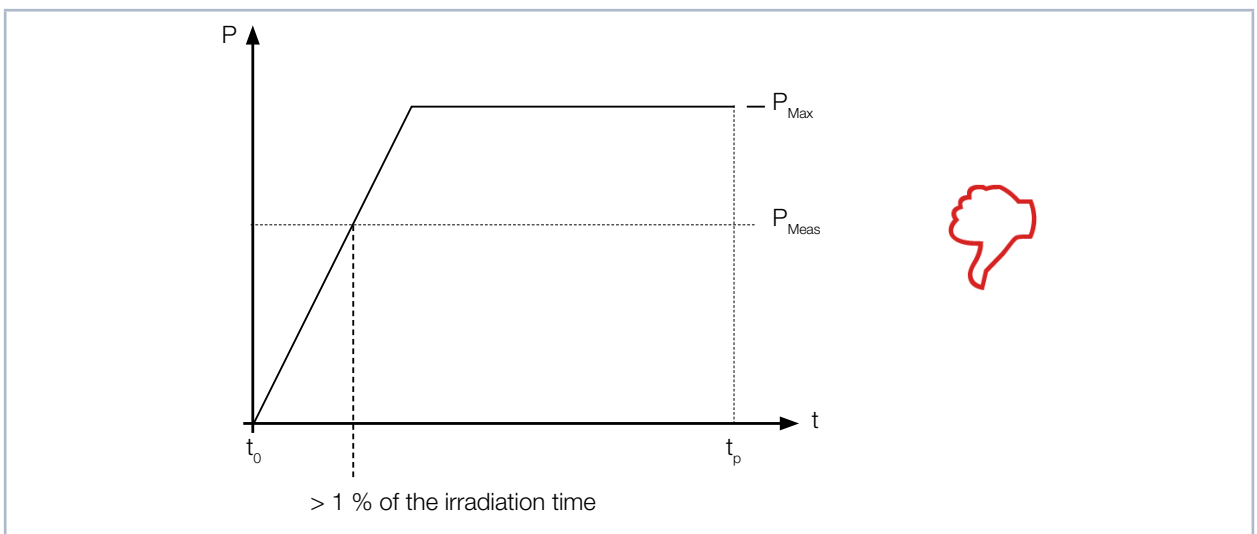

Fig. 8.1:   Laser rise time > 1 % of the irradiation time (schematic)
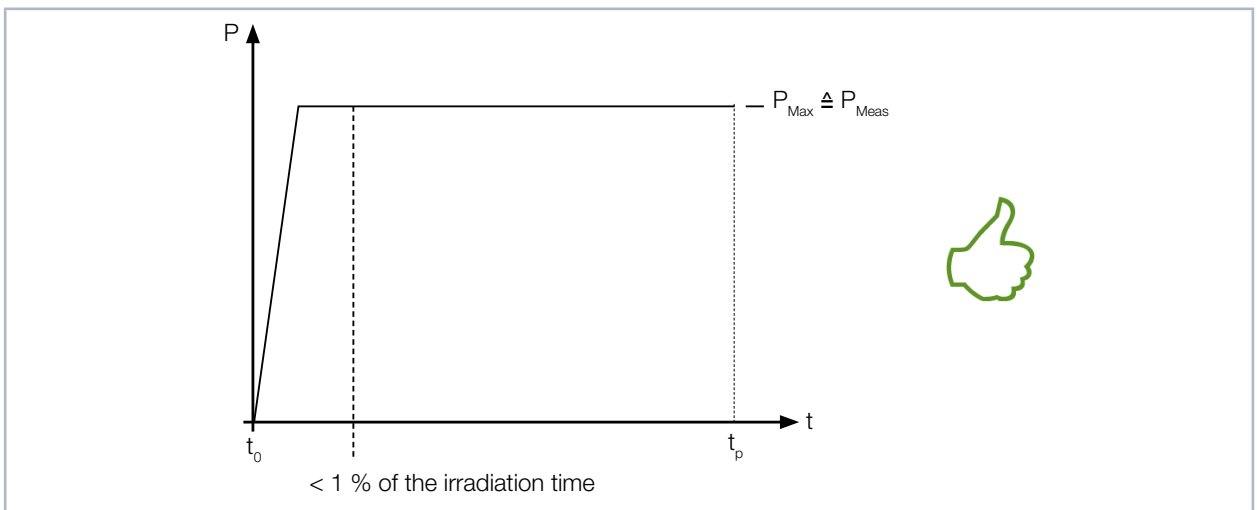

Fig. 8.2:   Laser rise time < 1 % of the irradiation time (schematic)

8.2 Maximum power density

To avoid damage to the absorber, the maximum power density at the absorber must not be exceeded. The permissible power densities vary depending on the beam diameter and the type of absorber installed. A list of the permitted power densities is given in chapter 17 „Technical data" on page 88.

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

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

Formula 1: Calculation of the power density

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

$$P_{\ Laser\ power\ in\ kW} = max.\ Power\ density\ \frac{kW}{cm^2} \cdot \pi \cdot r^2_{\ Beam\ radius\ in\ cm} \cdot \frac{1}{2}$$

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

Example 1: In case of a beam diameter of 1.5 – 3 mm, a device with advanced absorber can absorb a maximum power density of 10 kW/cm². For a beam diameter of 3 mm (beam radius 0.15 cm), the maximum laser power is calculated as follows:

P in kW = 10 kW/cm² · π · 0.15 cm · 0.15 cm · $\frac{1}{2}$ = 0.353 kW = 353 W

Fig. 8.3: Example calculation 1

Example 2: In case of a beam diameter of > 10 mm, a device with advanced absorber can absorb a maximum power density of 4 kW/cm². For a beam diameter of 10 mm (beam radius 0.5 cm), the maximum laser power is calculated as follows:

P in kW = 4 kW/cm² · π · 0.5 cm · 0.5 cm · $\frac{1}{2}$ = 1.571 kW = 1 571 W

Fig. 8.4: Example calculation 2

For quick determination of the maximum laser power as a function of the irradiation time or the beam diameter, you will find two diagrams in chapter 21 „Appendix" on page 95.

8.3　Minimum and maximum energy input per measurement

The measured temperature rise in the absorber is decisive for an accurate and reproducible measurement. Regardless of the starting temperature, an energy input of approximately 400 J to 1 000 J per measurement is recommended.

Example: At 1 kW laser power the recommended pulse length is 400 ms.

$E = P \cdot t = 1\,000\ W \cdot 0.4\ s = 400\ J$

Fig. 8.5 on page 39 shows the permissible energy input for a measurement as a function of the absorber temperature.
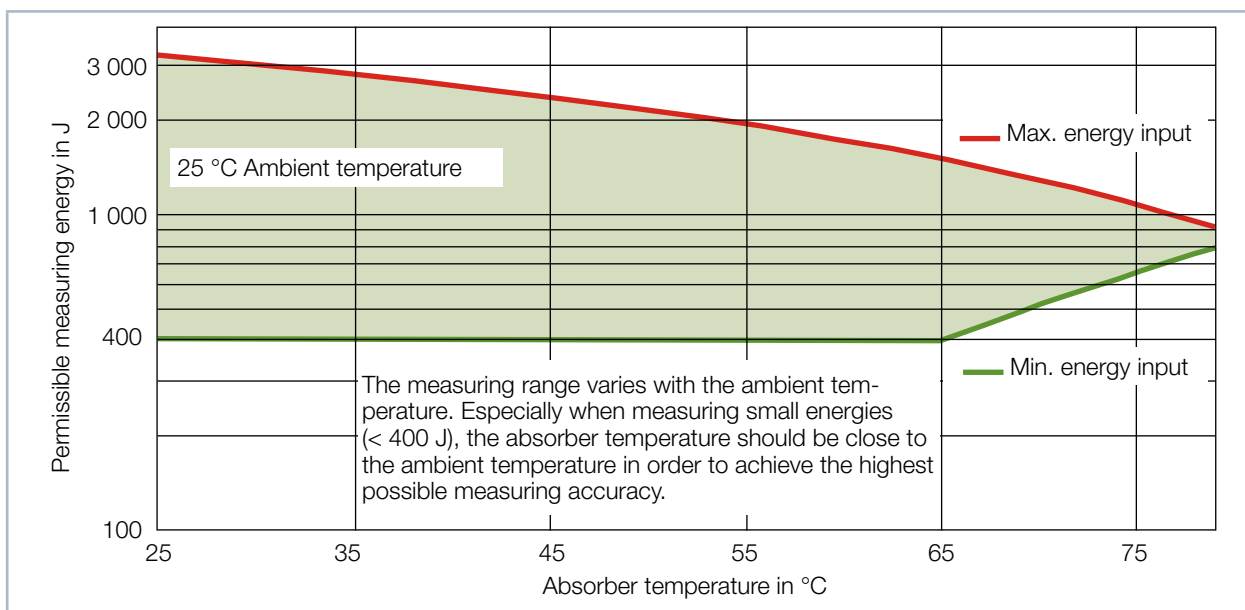
Fig. 8.5:　　Measuring range as a function of the absorber temperature

The minimum energy input indicates the lower limit values with which measurements can still be performed within the specified accuracy. The maximum energy application value specifies the limit at which the absorber reaches its permissible limit temperature. The energy, e.g. for multiple measurements (repetitive measurements) can be distributed across the range shown in green.

If the absorber temperature is higher than 80 °C, it won't be possible to take any further measurements. In this case, please wait until the absorber temperature has fallen below 50 °C (depending on the selected energy input).
If a high repetition rate is prioritized over the uncertainty of measurement, a lower energy per measurement may be used, e.g. down to 200 J.

Please take the thresholds from Fig. 8.5 on page 39, Tab. 8.1 on page 40 and Tab. 8.3 on page 41.

Absorber temperature in °C	Min. energy input in J	Max. energy input in J
20	400	3500
25	400	3320
30	400	3100
35	400	2880
40	400	2660
45	400	2440
50	400	2210
55	400	1990
60	400	1770
65	400	1550
70	520	1330

Tab. 8.1: Absorber temperature with the recommended minimum and maximum energy input (ambient temperature 22 °C)

8.4 Number of measuring cycles (repetitive measurements)

With a start temperature of 20 °C, the absorber can accomodate a heat quantity (= energy) of approx. 3 500 J. PRIMES recommends an energy input of approx. 400 J to 1 000 J per measurement in order to achieve the highest possible measurement accuracy.

Measurements can be repeated in rapid succession until the absorber reaches 80 °C. Then, a cooling cycle in the range of 1-2 minutes is required until further measurements are possible. For repetitive measurements, see chapter 8.5 on page 41.

> **NOTICE**
>
> **Damage/Destruction of the device**
>
> The maximum absorber temperature of 80 °C must not be exceeded.
>
> ▶ Note the possible number of measurements according to Tab. 8.2 on page 40.

With an assumed laser power of 8 kW and 4 kW, the following numbers of measurements are possible:

Laser power in Watt	Exposure time in ms	Energy input in J	Possible number of measurements
8 000	100	800	4
	200	1 600	2
	400	3 200	1
4 000	100	400	8
	200	800	4
	400	1 600	2

Tab. 8.2: Possible number of measurements

The absorber cools itself down by releasing heat into the environment.

8.5 Waiting times until the next measurement in repepetive measurements

With high measuring frequencies, the measuring accuracy can be limited. For repetitive measurements within the specified accuracy, the following waiting times prior to the next measurement are recommended.

Energy input in J	Waiting time in s
200	50
400	100
600	150
800	200
1 000	250

Tab. 8.3:   Waiting time until the next measurement in repepetive measurements

8.6 Calculation of the irradiation time

The selection of a certain irradiation time is based on three different criteria:

1. The minimum irradiated energy should amount to at least 10 % of the total capacity of the absorber (Variable: "Max. Capacity"). This requirement ensures best measurement accuracy (5 % may be acceptable if the repetition rate is a priority). See also point 2.
2. In case of a repeated power measurement within a short period of time, a maximum of 50 % of the residual absorber capacity of the test piece must be used. (Variable: "Remaining Capacity")
3. The irradiated energy may not exceed the "Remaining capacity", otherwise the absorber may be overheated during the measurement.

With the following formula the irradiation time can be determinated:

Δt = Remaining capacity / Laser power

Δ t	=	Irradiation time
Remaining capacity	=	Remaining capacity after a measurement
Laser power	=	Total power of the laser beam

> ℹ️ A constant irradiation time ensures a best possible performance and repeatability.

> ℹ️ Even with absorbers at room temperature the remaining capacity does not reach the "Maximum capacity". This is due the fact that the "Maximum capacity" refers to an absorber temperature of 0 °C.

Example

- MaxCapacity   =   4 000 J
- Remaining capacity =   3 000 J
- Minimum energy   =   400 J
- Laser power   =   8 000 W

▶ selected: 100 milliseconds

The irradiation time of 100 ms leads to an irradiation of 800 J. This means, the minimum amount of energy of 400 J is clearly exceeded. Furthermore, this irradiation time enables two more power measurements, that can be carried out immediately.

8.7 Measurement with pulsed lasers (only PMM type AP3s)

When measuring pulsed lasers, the technical specification according to chapter 17 „Technical data" on page 88 must be observed.

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

Measurements outside the specification may result in an incorrect calculation of the number of pulses. This affects the calculated average power. But not on the measured energy.

> **i** When measuring pulsed lasers, as of firmware version 3.2, the power (measured power) is calculated with a corrected burst duration (see Fig. 8.6 on page 42).
> For devices with former firmware versions, the power (measured power) is calculated with the uncorrected burst duration. This leads to an increased value of the average power.

With pulsed lasers, the device detects the number of pulses n and the number of pulse pauses n-1 (the last pulse pause t_{off} is not measured, for physical reasons).

The burst duration here is $(t_{on} + t_{off}) \cdot n - t_{off}$. This leads to a significantly increased value of the power (measured power) for a low number of pulses.

The power is therefore calculated for devices with firmware version 3.2 and higher on the basis of a corrected burst duration: $(t_{on} + t_{off}) \cdot n$ (see Fig. 8.6 on page 42).
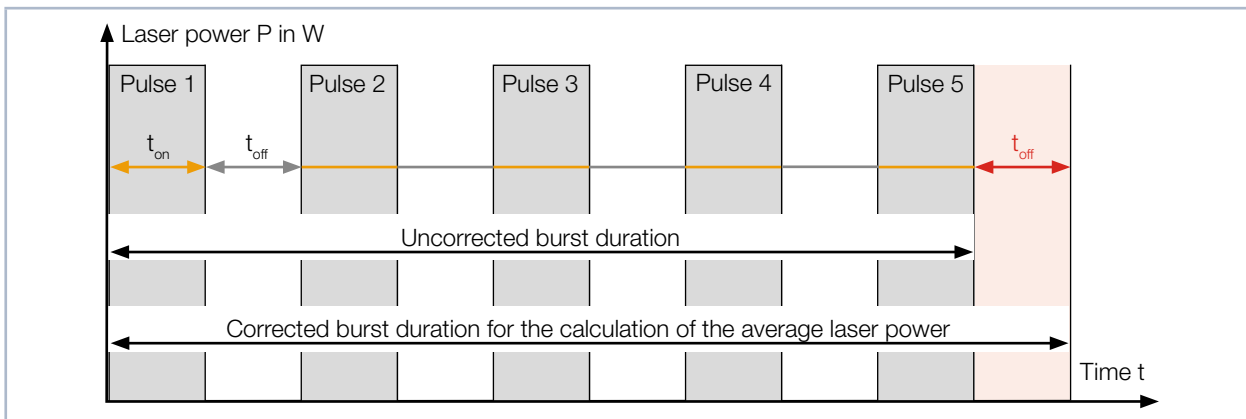
Fig. 8.6: Uncorrected and corrected burst duration with pulsed lasers

The deviation of the laser power is the ratio of corrected to uncorrected burst duration:

$$\text{Deviation} = \frac{(t_{on} + t_{off}) \cdot n}{(t_{on} + t_{off}) \cdot n - t_{off}}$$

The values for t_{on} and t_{off} illustrated in Fig. 8.6 do not correspond to the values for „Ontime" and „Offtime" in the registry settings: Ontime = $t_{on} \cdot n$ and Offtime = $t_{off} \cdot (n-1)$.

For cw lasers respectively one pulse, the average power corresponds to the maximum power of one pulse.

i	The firmware version used in the device is shown on the identification plate or, in the case of older devices, on a label inside the device. The label in the device can be found after disassembling the base plate.

Fig. 8.7:   Four fastening screws on the base plate, view from below

9 Measuring

9.1 Warning messages

⚠ **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 can occur during measuring operation (laser class 4).

▶ Mount the device in such a way that it cannot be moved by an unintended push or a pull on the lines.

⚠ **DANGER**
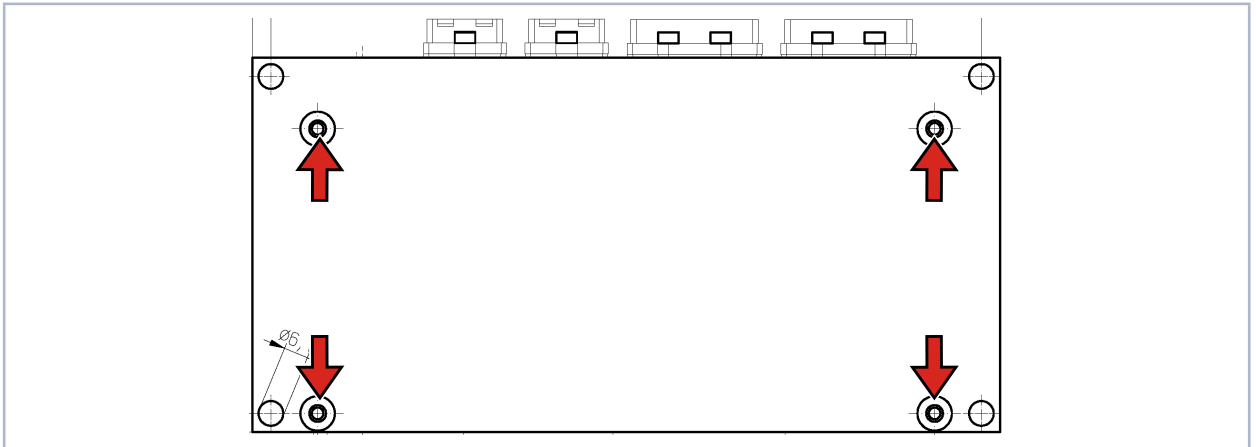
Serious eye or skin injury due to laser radiation

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

▶ Wear safety goggles adapted to the power, power density, laser wave length and operating mode of the laser beam source in use.

▶ Wear suitable protective clothing and protective gloves.

▶ Protect yourself from laser radiation by separating protective devices (e.g. by using appropriate shielding).

NOTICE

Damage/Destruction of the device

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

▶ Observe the limit values and dependencies specified in chapter 17 „Technical data" on page 88 and chapter 21 „Appendix" on page 95 before the measurement.

NOTICE

Damage/Destruction of the device

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

▶ Do not touch the protective window.

▶ Regularly check the condition of the protective window. The protective window can be cleaned or replaced in case of heavy, non-removable contamination (see chapter 15 „Maintenance and service" on page 82).

▶ Only operate the device with a clean protective window.

9.2   General flow diagram of a PMM measurement

```
            ┌─────────────────────────┐
            │  Start PMM Measurement  │
            └─────────────────────────┘
                        │
                   ◇ Excess temperature
                      flag?  ─────────────────────────────────┐
                        │                                       │
                   ◇ PMM idle?  ───────→ [ Command do_reset = 1 ]
                        │                         │
                        │                    ◇ PMM idle? ──┐
                        │                         │         │
                        │                [ Command do_reset = 0 ]
                        │←────────────────────────┘
                        │
                   ◇ Shutter open = 1? ──→ [ Command do open shutter = 1 ]
                        │                         │
            [ Set "Start measurement" = 1 ]  ◇ Shutter Acknowledge? ──┐
                        │                         │
                   ◇ Start Acknowledge = 1?  [ Command do open shutter = 0 ]
                        │                         │
            [ Reset "Start measurement" = 0 ]  ◇ Status Shutter is open = 1?
                        │                         │
                   ◇ PMM ready = 1?          ◇ Status Shutter error = 1? ──┐
                        │                         │
                       (A)                       (B)
```
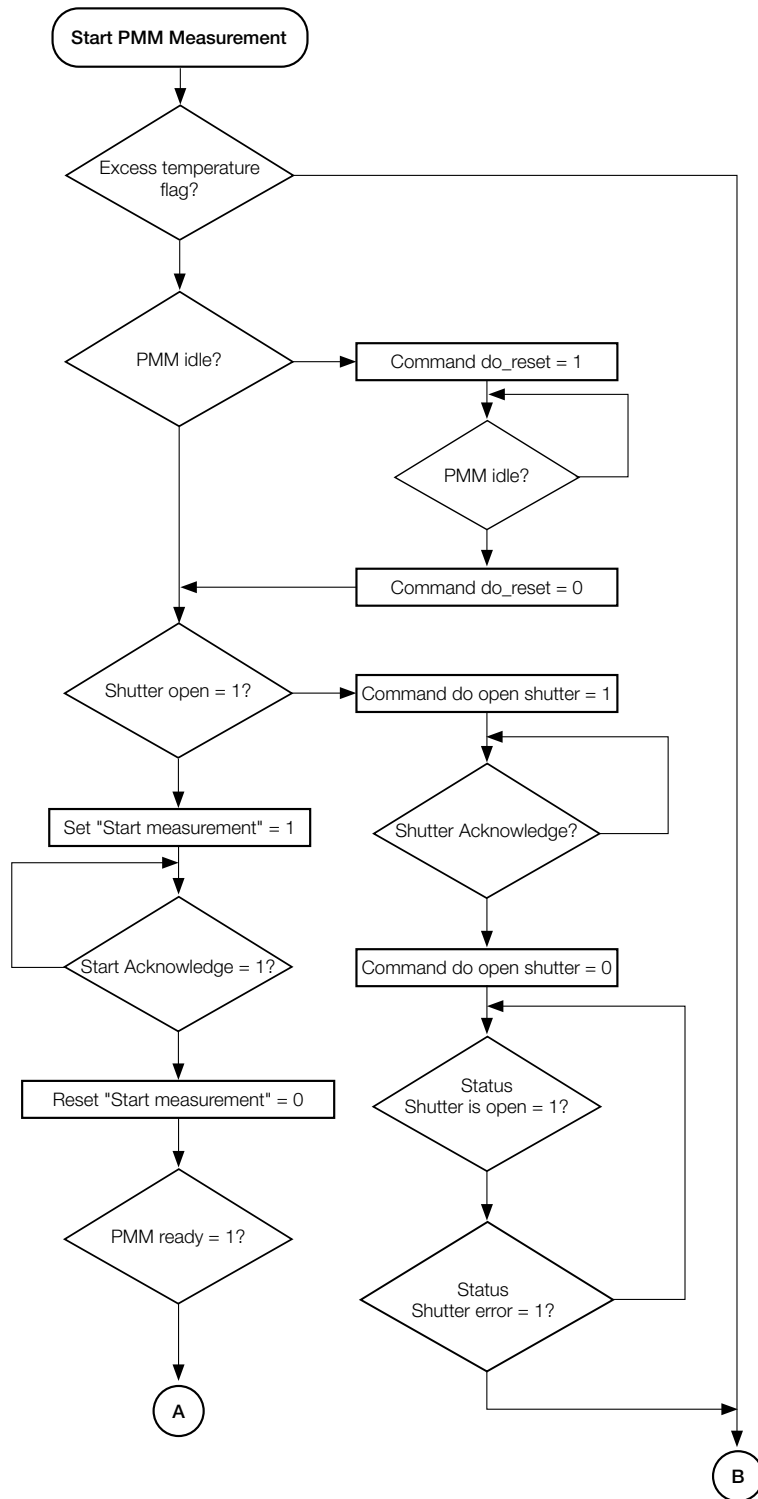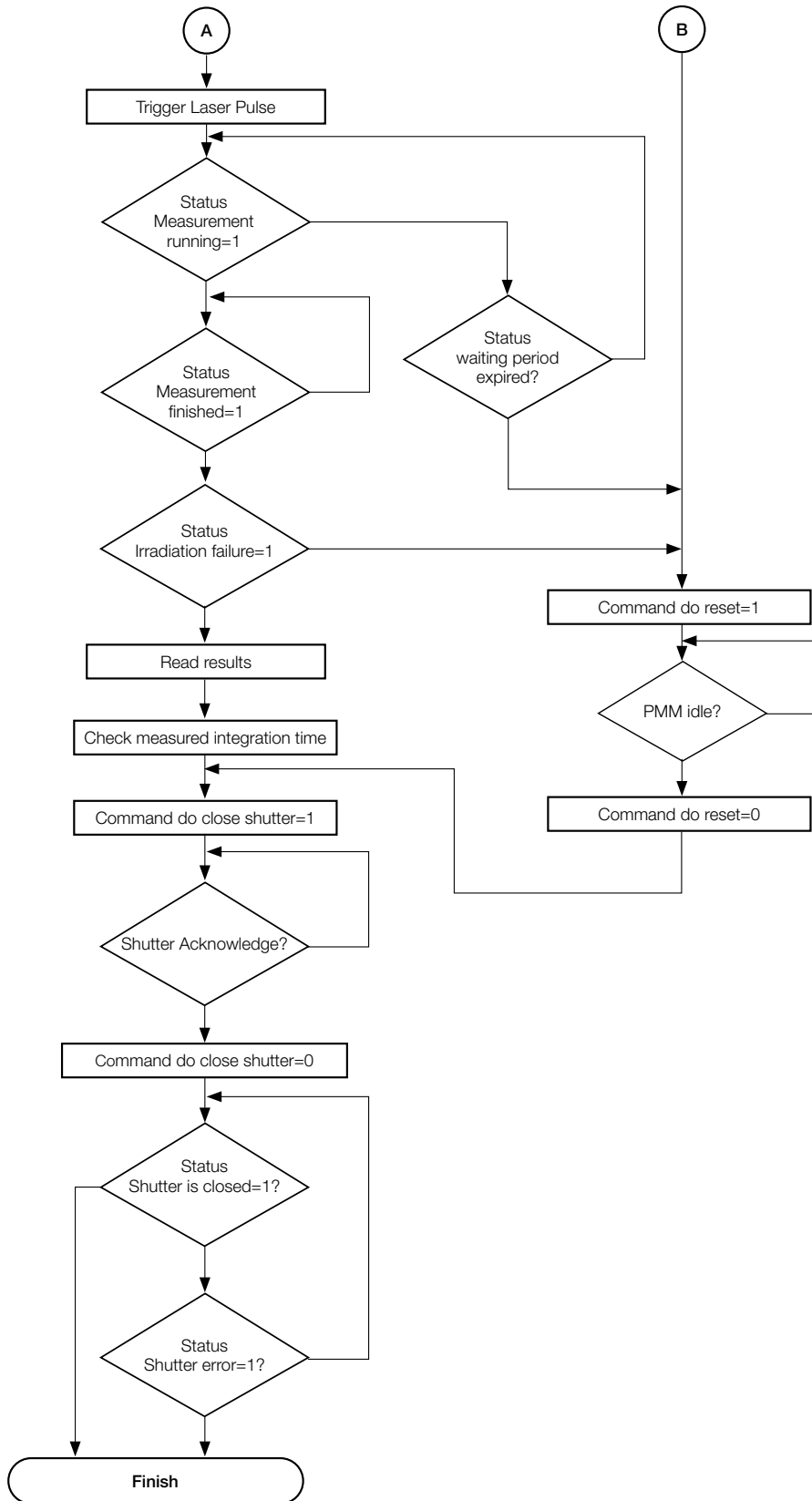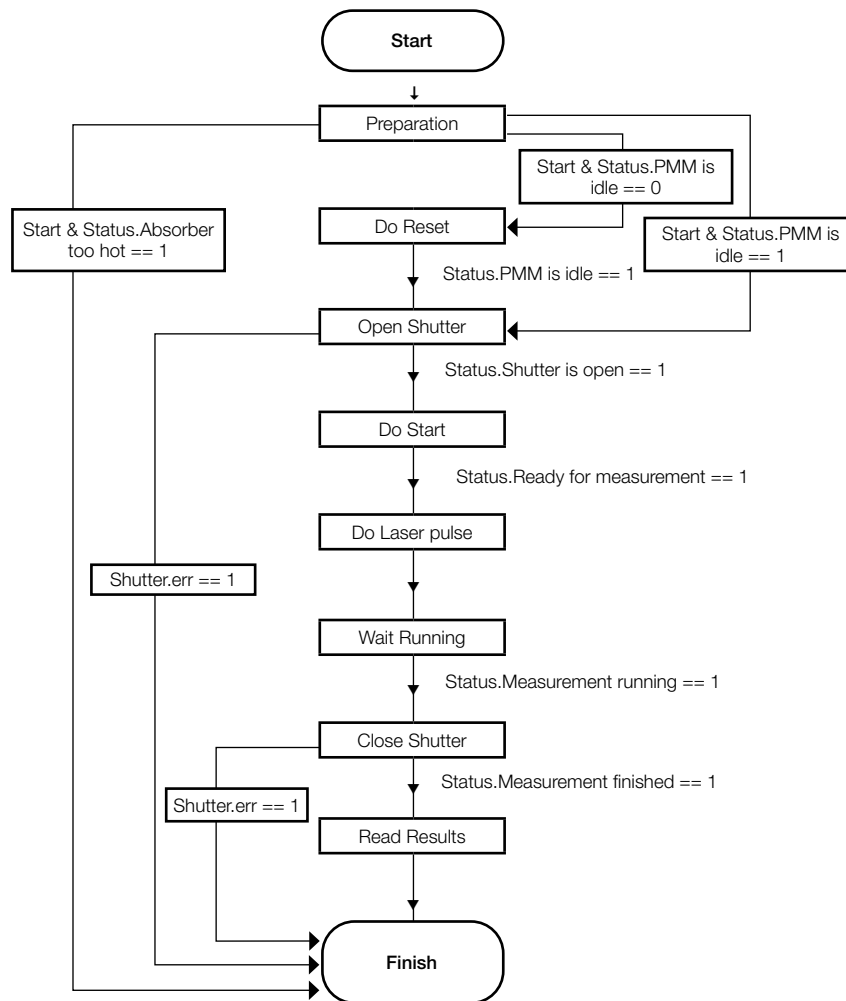
9.3 PLC Control program sequence of the PMM

```
                            ┌──────────┐
                            │  Start   │
                            └──────────┘
                                  ↓
                            ┌──────────────┐
                            │ Preparation  │
                            └──────────────┘
                                          Start & Status.PMM is
                                          idle == 0
  Start & Status.Absorber   ┌──────────┐   Start & Status.PMM is
  too hot == 1              │ Do Reset │   idle == 1
                            └──────────┘
                              Status.PMM is idle == 1
                            ┌──────────────┐
                            │ Open Shutter │
                            └──────────────┘
                              Status.Shutter is open == 1
                            ┌──────────┐
                            │ Do Start │
                            └──────────┘
                              Status.Ready for measurement == 1
                            ┌───────────────┐
                            │ Do Laser pulse│
                            └───────────────┘
  Shutter.err == 1
                            ┌───────────────┐
                            │ Wait Running  │
                            └───────────────┘
                              Status.Measurement running == 1
                            ┌───────────────┐
                            │ Close Shutter │
                            └───────────────┘
                              Status.Measurement finished == 1
  Shutter.err == 1          ┌───────────────┐
                            │ Read Results  │
                            └───────────────┘
                            ┌──────────┐
                            │  Finish  │
                            └──────────┘
```

9.4 Internal conditions

```
                    ┌──────────────┐
              ┌────▶│  PMM is idle │────┐
              │     └──────────────┘    │ Command "Start
  Command     │                         │ Measurement"
  "do_reset"  │                         │ &
              │     ┌─────────────────────┐ Statusbit Shutter is open == 1
              └─────│ Ready for Measurement│◀──┐
                    └─────────────────────┘    │
  Automatically                                │
  Statusbit Measurement            ┌────────────┐
  finished == 1                    │ Laser pulse│
                                   └────────────┘
                    ┌──────────────┐          │
                    │ Calculate Power│◀────────┘
                    └──────────────┘
```

9.5 Shutter conditions

```
          ┌─────────────────────────┐
          │  ((Statusbit  idle==1) or │
          │   (Statusbit running == 1)) │
          │  and Command "open Shutter"│
          └─────────────────────────┘

┌──────────────────┐              ┌──────────────────┐
│ Shutter is closed │              │ Shutter is opened │
└──────────────────┘              └──────────────────┘

          ┌─────────────────────────┐
          │  ((Statusbit  idle==1) or │
          │   (Statusbit running == 1)) │
          │  and Command "close Shutter"│
          └─────────────────────────┘
```

10 Measurement cycle details

The power measurement cycle includes three steps:

1. Preparing the measurement
2. Executing the power measurement
3. Evaluating the power measurement

The details of these steps are discussed below:

10.1 Preparing the measurement

The readiness of the device is subject to three conditions:

1. The shutter is open.
2. The absorber still has the capacity to absorb the energy of a measurement
3. No other measurement cycle is activated

10.1.1 Opening the shutter

The shutter is opened by a gear motor with a friction clutch. The bit "open shutter" in the command byte issues the command to open the shutter. The gear motor requires less than 5 seconds to open the shutter completely.

As soon as the shutter has reached the open position the "shutter open"- bit changes to the value 1 in the "Status 1" byte. The command bit "open shutter" can then be deactivated. Closing the shutter is done in the same way.
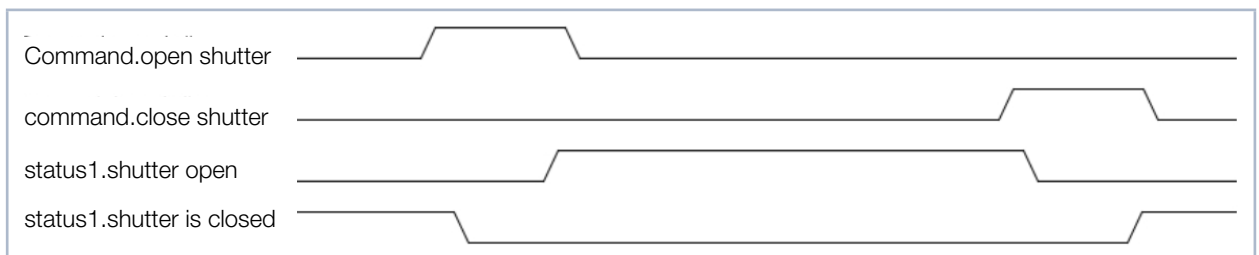
Fig. 10.1: Shutter control timing diagram

Step 2 according to chapter 10.1 requires a delay time. The waiting time allows the absorber to cool down so that a new measurement is possible. The waiting times can be found in chapter 8.5 on page 41.

At step 3 according to chapter 10.1 the measuring readiness is automatically established again after the end of the current measuring cycle.

10.1.2 Determination of the irradiation time

The irradiation time is to be determined according to the regulations stated in chapter 8.6 „Calculation of the irradiation time" on page 41.

10.2 Execution of the power measurement

The PMM is ready for measurement when the "Ready for Measurement" status bit is set (shutter is open, temperature is OK).

To initialize the PMM for the measurement the external control system must set the "start" bit in the "Command" byte (please see Fig. 10.2 on page 50).
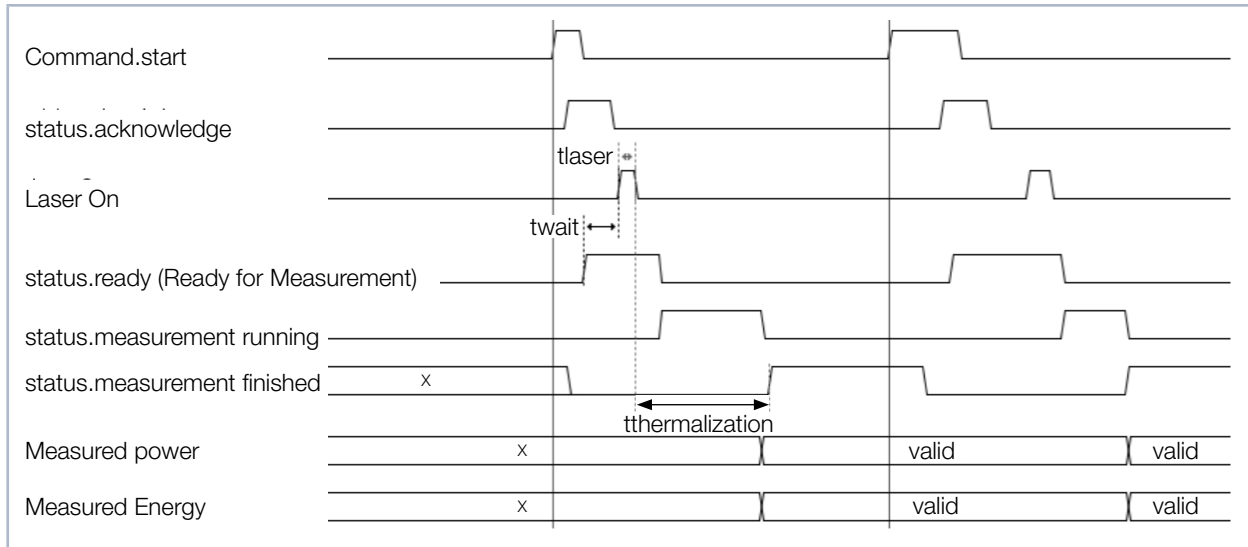
Fig. 10.2:   Timing diagram of the measurement cycle

The PMM answers the starting command with an "acknowledge" in status byte1.
As soon as the PMM is ready for measurement the "ready" bit is set in the status byte1.

Before starting the laser pulse, check that status Byte1 Bit0 is set to 1.

From this point on, the laser can irradiate the absorber using the calculated irradiation time (see chapter 8.6 „Calculation of the irradiation time" on page 41.
If the shutter is not in the open position or a laser pulse is detected, the "ready" status is deleted.

After the laser pulse, the PMM can identify the laser pulse due to the temperature rise of the absorber and the signal from the internal photodiode. The following thermalization period of the absorber is indicated by the bit "running" in the status byte.

At the end of the thermalization phase (approx. 10 seconds for standard devices and 3 seconds for devices with reduced thermalization time - PMM type AP3s), the measurement result is calculated and the "measurement finished" bit is set. The results of the measurement can be displayed now.

> ℹ️ If the measuring procedure is supposed to be aborted without a measurement and the shutter is supposed to be closed again, a reset has to be carried out (Do_reset; set bit 7 in the command byte, see Tab. 11.2 on page 54).

10.3 Evaluate measurement

The data generated during the measurement is stored within the variables. The measured values within the variables can be found in chapter 11.3 „Variables" on page 55.

10.4 Time-optimized measuring procedure

To optimize the measurement time, the robot downtime can be reduced to the irradiation time.

Measuring procedure

1. Robot moves towards the measuring device, at the same time the shutter opens.
2. The shutter is open, start measurement.
3. Robot has reached the right position, check "Ready for Measurement".
4. Laser pulse is activated.
5. Laser pulse is finished.
6. Robot can move away again.
7. Wait for the signal "Measurement completed".
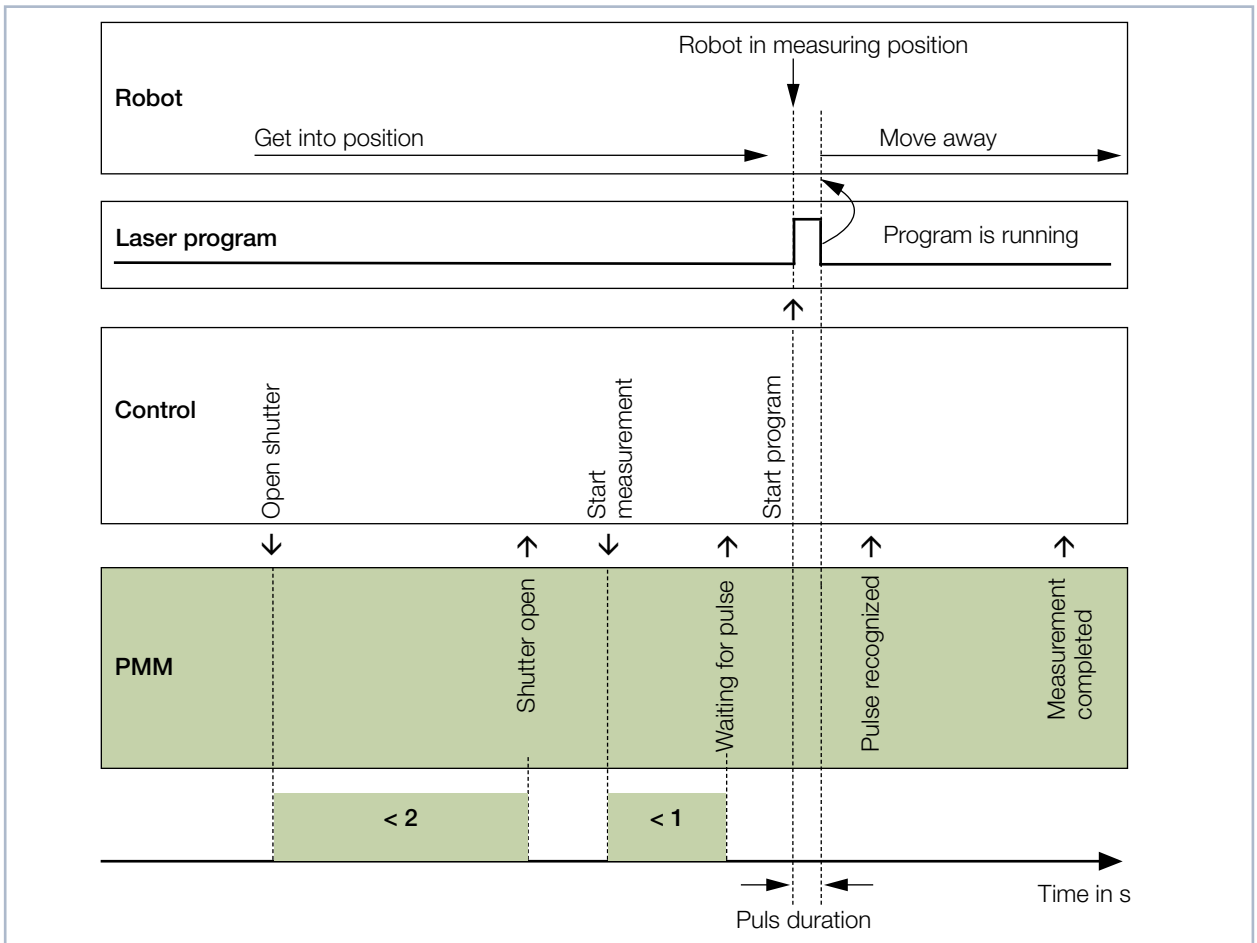
Fig. 10.3: Time-optimized measuring procedure

10.5 Measuring procedure parallel-interface

The measuring procedure of the PMM Parallel is identical to the procedures of the PMM PROFINET®/ PROFIBUS®. Due to a limited range of information, only the status bits as well as the result of the measurement are transmitted via the interfaces.

The status bits for input "XG1 In" can be found in Tab. 7.13 on page 27, for output "XG2 Out" in Tab. 7.14 on page 28.

Resetting the device

1. Check at output XG2 that „Measurement finished" bit 15 is set to 1.
2. Apply a signal with a duration of min. 200 ms to input XG1, bit 3 „Reset".
➥ After the reset „Measurement finished" bit 15 is set to 0.
➥ The status of the PMM can then be read at the output lines.

Opening the shutter

3. Apply a signal to input XG1, bit 0 „Shutter opening".
   This signal has to be reset to 0 again after the signal at output XG2, bit 9 "Confirmation command closing" is set.
➥ The open shutter is indicated at output XG2, bit 0 „Shutter is open".

Checking the temperature of the absorber

If the temperature of the absorber is too high, output XG2 bit 11 "Absorber to warm" is set to 1.
This bit is only set if the max. absorber capacity has been reached. This bit is reset due to thermal conduction.

Starting the measurement

A measurement may only be performed with the shutter open and sufficient absorber capacity.

NOTICE

Damage/Destruction of the device

The permissible temperature of the absorber must not be exceeded.

▶ **When programming the laser system, please ensure that no measurement can be started, as long as the absorber is too warm (bit 11 = 1, see section "Checking the temperature of the absorber").**

---

4. Apply a signal to input XG1, bit 2 "Start measurement".
   This signal has to be reset to 0 again after the signal at output XG2, bit 10 "Confirmation start measurement" is set.
➥ With the signal at output XG2, bit 14 „System waiting for pulse", the PMM indicates readiness for measurement.

5. **Activating the laser pulse**
The absorber capacity of the PMM is max. 3 500 J. The pulse should contain at least 400 J.
Example: For a laser power of 4 000 W, the pulse length should be at least 400 : 4 000 = 0.1 s.
The irradiation time does not have to be communicated to the system because the PMM measures it itself.
➥ After the laser pulse has been triggered, after a few 100 ms, output XG2, bit 13 „Measurement in process, Pulse received" is set to 1.

Waiting for the measurement result

Ten seconds after activating the signal at output XG2, bit 13 "Measurement in process, Pulse received"", the bit is reset and bit 15 "Measurement finished" is set to 1.
Simultaneously, the bits 0 to 14 show the measurement result in binary form.

11 Programming model

The data, exchanged by the PMM via the upstream PLC field bus can be split into four parts:

1. Configuration data (read only, byte 12-35)
2. Variable (read only, byte 40-77)
3. Status (read only, byte 10-11)
4. Command (write only, byte 11)

In the registers, the data is available in the following format:

Field bus	Format
PROFINET®, PROFIBUS®	Motorola-Format, Big Endian
Devicenet™, Ethernet/IP™	Intel-Format, Little Endian
EtherCAT®	Little Endian

Tab. 11.1: Formats

11.1 Registry settings

Fixed value (ReadOnly)			Unit	Length	Type		Address
	MaxCapacity	4.000.000	1/1000 Joule	4 byte	dword		2 (MSB) - 5 (LSB)
	Minimum energy	400.000	1/1000 Joule	4 byte	dword		6-9
	Minimum irradiation time	1	ms	2 byte	word		10-11
	Maximum irradiation time	1000	ms	2 byte	word		12-13
	Maximum power	8000	Watt	2 byte	word		14-15
	Minimum absorber temperature	0	°C	2 byte	word		16-17
	Maximum absorber temperature	80	°C	2 byte	word		18-19
	Pulse duration Measurement avail.	0 / 1		2 byte	word		Byte 21:Bit 0
	Typ		-	2 byte	word		22-23
	Release		-	2 byte	word		24-25
Variable (read only)						Actualisation rate	
	Remaining capacity		1/1000 Joule	4 byte	dword	> 5 Hz	26 (MSB)-29 (LSB)
	Absorber temperature		1/1000 °C	4 byte	dword	> 5 Hz	30-33
	Housing 1 temperature		1/1000 °C	4 byte	dword	per measuring cycle	34-37
	Housing 2 temperature		1/1000 °C	4 byte	dword	per measuring cycle	38-41
	Housing 3 temperature		1/1000 °C	4 byte	dword	per measuring cycle	42-45
	Measured Energy		1/1000 Joule	4 byte	dword	per measuring cycle	46-49
	Measured Power		1/1000 Watt	4 byte	dword	per measuring cycle	50-53
	Measured irradiation time		Mikrosecond	4 byte	dword	per measuring cycle	54-57
Gap due to bus system							58-65
Only for devices with AP3s marking on the identification plate	Ontime		Mikrosecond	4 byte	dword	per measuring cycle	66-69 [1]
	Offtime		Mikrosecond	4 byte	dword	per measuring cycle	70-73
	Count of pulses		-	4 byte	dword	per measuring cycle	74-77
Status	Statusbyte (read only)			2 byte			
	Ready for Measurement		statusbyte1.Bit 0		Bool	> 5 Hz	Byte 0: Bit 0
	Measurement running		statusbyte1.Bit 1		Bool	> 5 Hz	0:1

Fixed value (ReadOnly)			Unit	Length	Type		Address
	Measurement finished		statusbyte1.Bit 2		Bool	> 5 Hz	0:2
	Absorber too hot		statusbyte1.Bit 3		Bool	> 5 Hz	0:3
	PMM is idle		statusbyte1.Bit 4		Bool	> 5 Hz	0:4
	Irradiation failure		statusbyte1.Bit 5		Bool	> 5 Hz	0:5
	Start acknowledged		statusbyte1.Bit 6		Bool	> 5 Hz	0:6
	Shutter acknowledged		statusbyte1.Bit 7		Bool	> 5 Hz	0:7
	Shutter is open		statusbyte2.Bit 0		Bool	> 5 Hz	Byte 1:0
	Shutter is closed		statusbyte2.Bit 1		Bool	> 5 Hz	1:1
	Shutter is moving		statusbyte2.Bit 2		Bool	> 5 Hz	1:2
	Shutter time-out		statusbyte2.Bit 3		Bool	> 5 Hz	1:3
	Shutter error angle sensor		statusbyte2.Bit 4		Bool	> 5 Hz	1:4
							1:5
Command							
	Commandbyte (write only)			1 byte		Set to default	
	Start measurement		Commandbyte Bit 0		Bool		0:0
	do open shutter		Commandbyte Bit 1		Bool		0:1
	do close shutter		Commandbyte Bit 2		Bool		0:2
	do_reset		Commandbyte Bit 7		Bool		0:7

Tab. 11.2: Registry settings overview

11.2 Configuration data

The configuration data includes all parameters that are factory set and that inform about the possibilities the device offers.

MaxCapacity	Max. energy (= thermal capacity) the absorber can absorb starting with 20 °C up to the max. temperature. This value is given for information only and is not needed for any calculations.
Minimum irradiation time	Is given for information only and is not needed for any calculations.
Maximum irradiation time	Should not be exceeded, as the determination of the energy content of the absorber would then show inaccuracies.
Maximum power	Shows the max. laser beam power, the absorber can be irradiated with. In case the power is exceeded, the absorber can be damaged.
Minimum energy	The laser has to generate a sufficient increase in temperature for a measurement with the desired accuracy. To achieve this, a minimum amount of energy is needed. This value is given by the formula: $t_{Irradiation} >$ **Minimum energy / P_{Laser}**
Minimum absorber temperature	The minimum temperature of the absorber currently has no importance for this measurement system.
Maximum absorber temperature	No measurements can be carried out if the absorber temperature lies above the "max. absorber temp." as the absorber would overheat otherwise.
Pulse duration Measurement avail.	This constant shows whether the integrated pulse duration measurement is available. Only for devices with AP3s marking on the identification plate.

Tab. 11.3: Overview configuration data

11.3 Variables

The data generated during the measurement is stored in the variables. The measured temperatures are updated faster than 1 Hz and the measured energy, power and irradiation time are updated once in every measurement cycle.

Remaining capacity	Shows the remaining thermal capacity of the absorber. Do not use more energy for the next measurement than specified in this variable. When exceeding the amount of energy, the absorber is overheated. (Starting at 80 °C absorber temperature: remaining capacity = 0)
Absorber temperature	The current temperature of the absorber. This value is for information only.
Housing 1 temperature	The current temperature of the housing. This value is for information only.
Housing 2 temperature	The current temperature of the housing. This value is for information only.
Housing 3 temperature	The current temperature of the housing. This value is for information only.
Measured Energy	Display of the measured energy of the last measurement.
Measured Power	Display of the calculated laser power of the last measurement. The laser power is calculated from the irradiation time and the measured energy.
Measured irradiation time	Display of the irradiation time of the last measurement.
Only for devices with AP3s marking on the identification plate:	
Measured Ontime	Display of the measured laser ontime of the last measurement.
Measured Offtime	Display of the measured laser offtime of the last measurement.
Measured Count of pulses	Number of measured pulses of the last measurement.

Tab. 11.4: Overview variables

11.4 Status information

The current status is shown in the status bits. The status bits are organized in 2 status bytes:

Ready for Measurement	The PMM is ready for measurement.
Measurement running	The laser has emitted a pulse onto the PMM. The PMM is evaluating the measurement.
Measurement finished	The measurement cycle is finished, the measurement results are provided in the corresponding registers.
Absorber too hot	The absorber is too hot for a further measurement. It has to cool down until the temperature is below the maximum absorber temperature. **Hint:** The bit indicating an excess temperature only displays that no further measurements are possible at this moment. An active bit after the measurement does not display an error and is reset within a minute.
PMM is idle	The PMM is in its initial state and is waiting for instructions.
Irradiation failure	The measurement of the irradiation time has detected an interruption of the laser power during the laser pulse. This bit is for information only.
Start acknowledge	The "start measurement" signal has been identified and can now be deactivated. The measurement standby is activated.
Shutter acknowledge	The "open shutter" and "close shutter" signal is identified and can now be deactivated.
Shutter is open	The shutter of the PMM is open.

Tab. 11.5: Overview status

Shutter is closed	The shutter of the PMM is closed.
Shutter is moving	The shutter of the PMM is moving.
Shutter time-out	The shutter has moved but has not reached the desired position within 5 seconds. This flag is deleted with the "Reset" command as well as a new "Open/Close"-shutter command.
Shutter error angle sensor	The angle sensor to determine the angle of the shutter is defective.

Tab. 11.5:   Overview status

11.5   Commands

Commands are sent to the device via four command bits. However, only one bit may be activated and transferred at a time.

Start measurement	The start measurement bit launches the new measurement cycle. The start command is only issued if all status requirements are met. The instrument shows the incoming command via the „acknowledge-bit" as the current status. Then, the „start-measurement-bit" can be deactivated again.
Do open shutter	Activating the „open-shutter-bit" leads to the opening of the shutter. This function can be observed via the status bits. As soon as the shutter is open, the bit can be deactivated again.
Do close shutter	Activating the „close-shutter-bit" leads to the closure of the shutter. This function can be observed via the status bits. As soon as the shutter is closed, the bit can be deactivated again.
Do_reset	Activating this bit will set the PMM to the initial state. The "idle-bit" is activated.

Tab. 11.6:   Overview commands

12   PROFINET® or PROFIBUS® connection

12.1   GSDML file (PROFINET®)

The registration of any PMM with the bus master occurs by means of the GSDML file. Within the GSDML file all parameters and variables are summarized in blocks (e.g. status, results). The contents of the single blocks are specified in the Tab. 11.2 on page 54.

The GSDML-file for the PMM can be found on the supplied PRIMES data medium or contact PRIMES or your PRIMES distributor.

The software also includes a PMM image as a bitmap in the format 70 x 40 pixel (PMM icon).
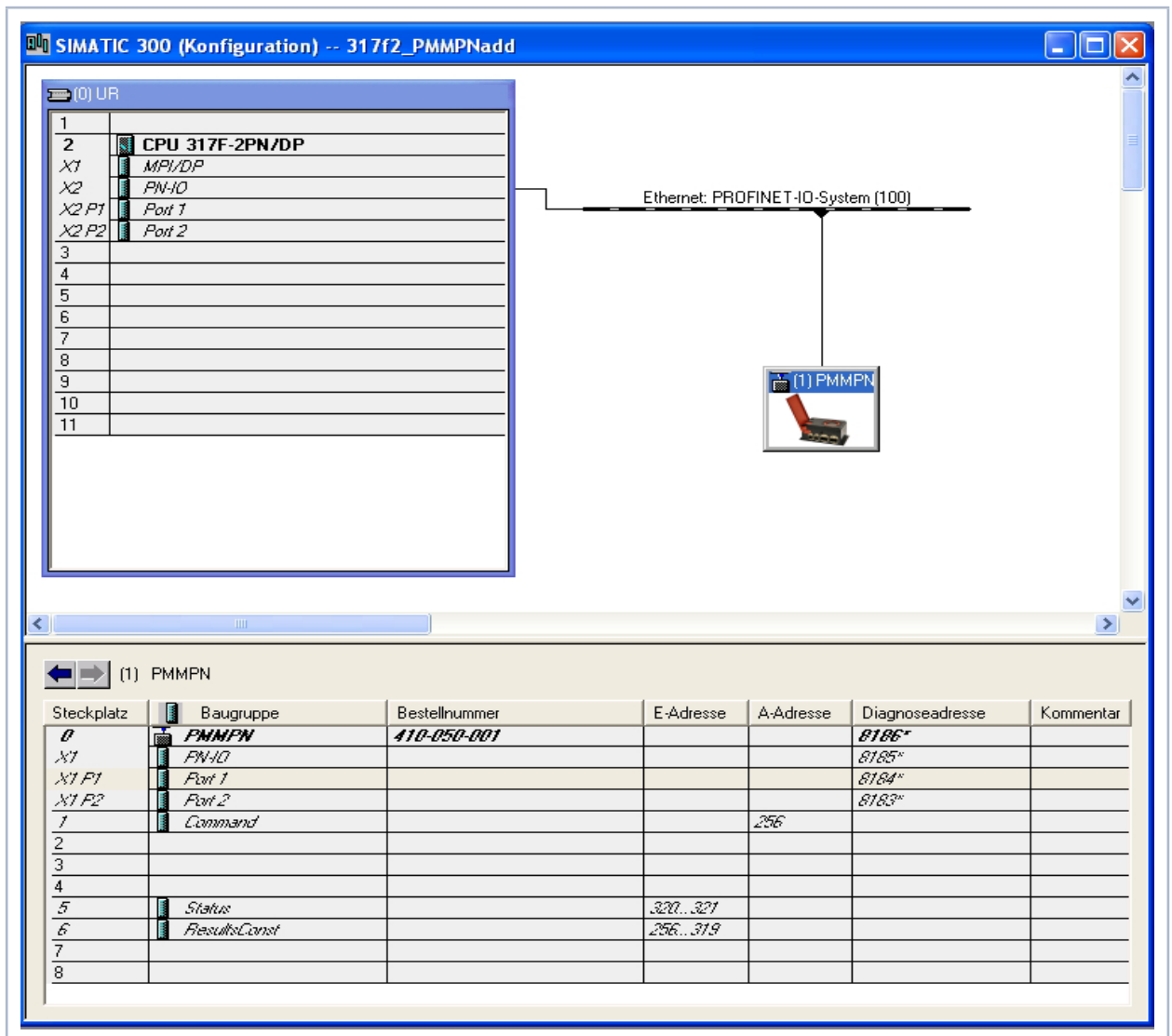
Fig. 12.1:   Installed GSDML file

12.2　GSD file (PROFIBUS®)

The GSD-file for the PMM can be found on the supplied PRIMES data medium. The address is factory set to 3.
For devices delivered from 03.2012 onwards, the PROFIBUS® address is adjustable from 1 to 99.

Setting the PROFIBUS® address

1. Please remove the base plate of the device (four hexagon socket screws a. f. 2.5 mm).

2. Please set the desired bus address by means of the rotary switches A and B. The arrow head of the rotary switch has to point to the respective figure.

The address consists of two digits. Use switch A to set the first digit (tens), and switch B to set the second digit (units).

Example
The bus address is supposed to be 3.

Setting switch A=0
Setting switch B=3
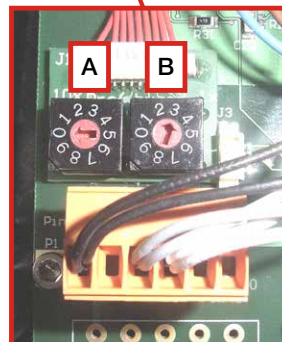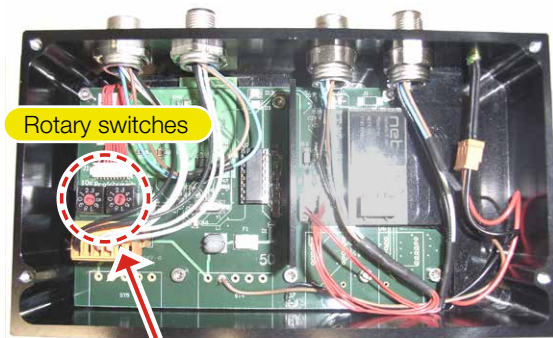
The following screenshot shows the integration of the GSD file under SIMATIC STEP 7.
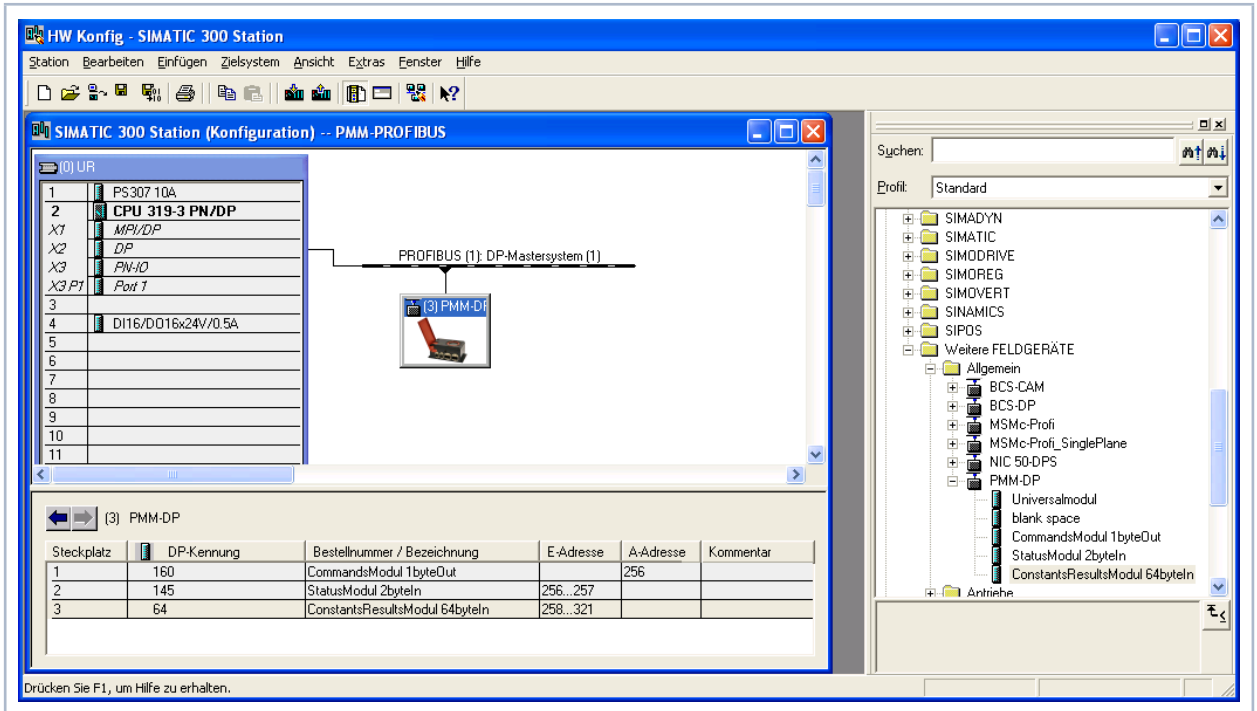
Fig. 12.2:   GSD file under SIMATIC STEP 7

The correct order of the input and output modules in the configuration table must be observed.
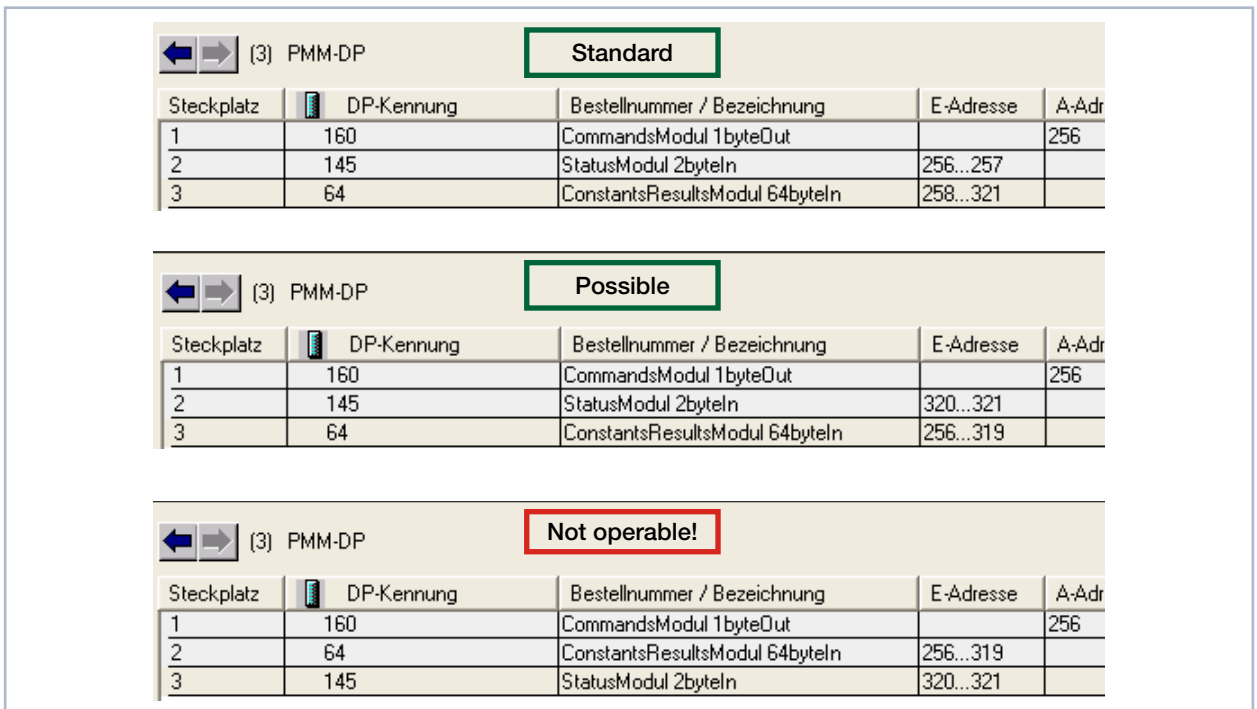
Fig. 12.3:   Order of the input and output modules in the configuration table

13 DeviceNet™ or EtherNet/IP™ connection

DeviceNet™ was developed by Rockwell Automation and the user organization ODVATM (OpenDeviceNet™ Vendor Association) as an open field bus standard, based on the CAN protocol. DeviceNet™ is in accordance with the European standard EN 50325.

Just like ControlNet™ and EtherNet/IP™, DeviceNet™ is part of the family of CIP™-based networks. CIP™ (Common Industrial Protocol) forms the common application layer of these three industrial networks. DeviceNet™ is an object-oriented bus system which works according to the producer/consumer procedure. DeviceNet™-devices can be client (master) or server (slave) or both. Clients and server can be producer, consumer or both.

Based on DeviceNet™ the field bus EtherNet/IP™ was developed, which integrates the devices networked via EtherNet/IP™ seamlessly – automatically via mapping in the I/O tree of the RSLogix programming tools. As an option, the configuration software tool (RSNetWorx), known from DeviceNet™, can be used for the integration of further field devices into the network.

13.1 Hardware/Software

The descriptions in this manual refer to the application of the following hardware- and software components:

13.1.1 Hardware

- Allen-Bradley Control, type 1769-L24ER-QB1B CompactLogix
- DeviceNet™ Scanner, type 1769-SDN/B

| Allen-Bradley Control | DeviceNet™ Scanner |

Fig. 13.1: Hardware

13.1.2 Software

- Rockwell Software RSLogix 5000 (for the control programming and configuration of EtherNet/IP™)
- Rockwell Software RSNetWorx (for the network configuration)
- Rockwell Software RSLinx

Detailed information regarding the used hardware can be found on the manufacturer's homepage:

http://www.rockwellautomation.com/literature/

13.2 Data model

For the communication of the PMM with the field bus, a specific internal field bus module is used. The PMM is controlled by a command-byte, which encodes four commands. The PMM data are stored in an "Array of Byte", which contains 66 elements. In the table of variables only entries up to byte 56 can be found. The remaining bytes contain information which is used for the calibration of the device and is not handled by a user.
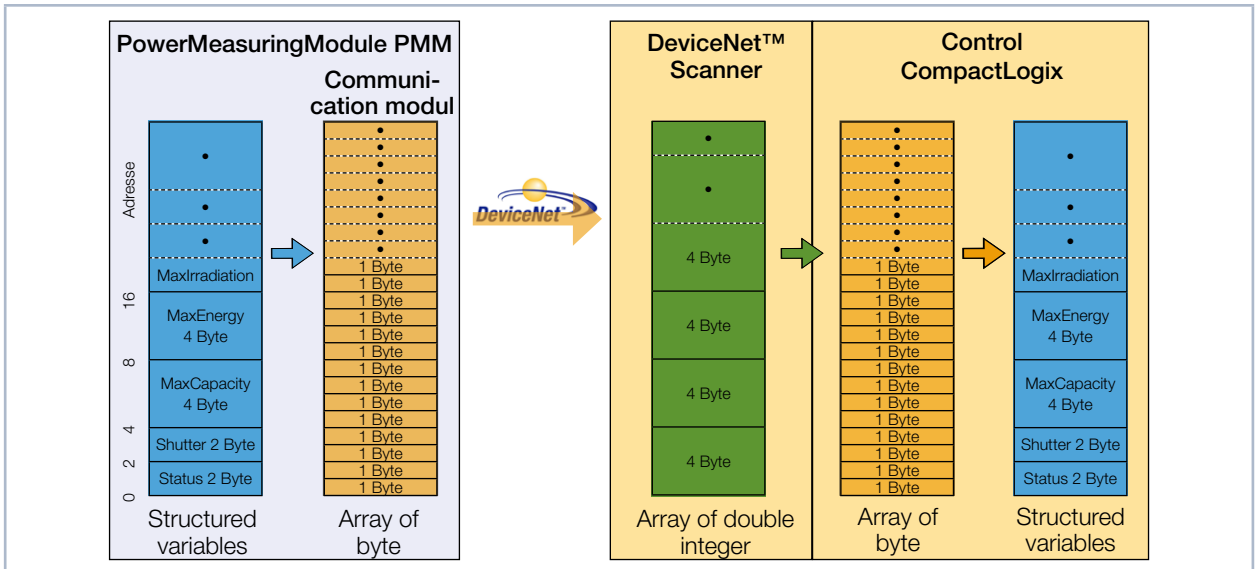
Fig. 13.2:   Data structure between PMM and control

The PMM stores the data in the format 2 byte Integer and 4 byte Integer. With EtherNet/IP™ and DeviceNet™, the data is arranged in the "Little-Endian" format.
The field bus module used in the PMM generally only supports the "Array of bytes" and no tags, as defined by the CIP™ (Common Industrial Protocol). The variables of the PMM can therefore not be read directly from the bus.

13.3 PMM with DeviceNet™

With DeviceNet™, the data is transferred to the control via a scanner module. As an example, the data transfer of a CompactLogix 1769 by Allen Bradley is displayed here.
The measuring data of the PMM is written into the integrated communication module in the form of 2 byte Integer and 4 byte Integer. The communication module transfers this data as "Array of Byte" to the bus. Other data types are not supported.
The scanning module 1769-SDN stores the data as "Array of DINT" (4 byte Integer) in the area "local" of the control. The control does not contain direct commands which can carry out a type conversion. Therefore, the data is copied to the target variable in a two-step procedure.

1. Step:
   The data range of the type "Array of DINT" is copied to a variable range "Array of Byte" (see Fig. 13.3 on page 62, copy command A). By means of this copying process, data cannot only be copied with the start addresses modulo 4 (i.e. 0, 4, 8, 12, 16, 20 …), but every start address is possible.

2. Step:
   The data is copied to the user-defined data types (see Fig. 13.3 on page 62, copy command B). The data is then available within the control.

The copying process is done with an add-on instruction (AOI) of the control software:
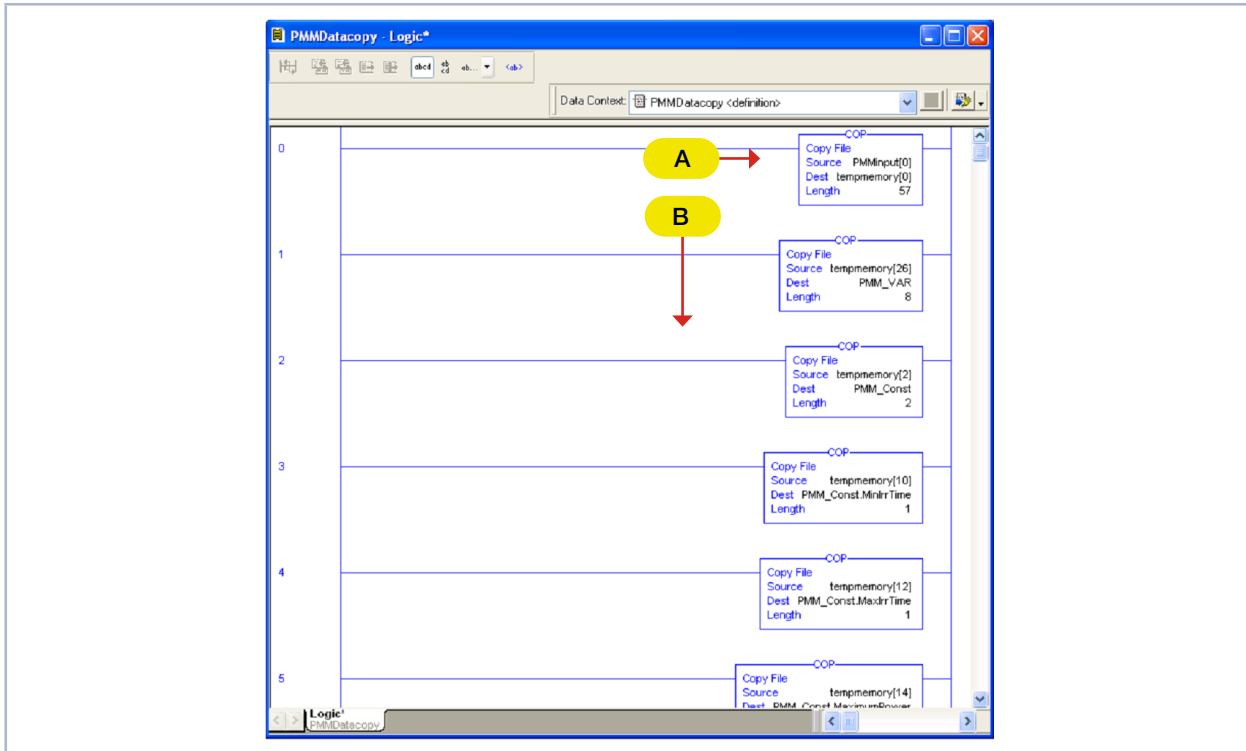
Fig. 13.3:   Copy command in the contact plan logic routine

The entire copy instructions can be found in chapter 21.5 „Add-On Instruction of the RSLogix 5000 Control Software" on page 97. The call up is displayed in Fig. 13.4 on page 62.
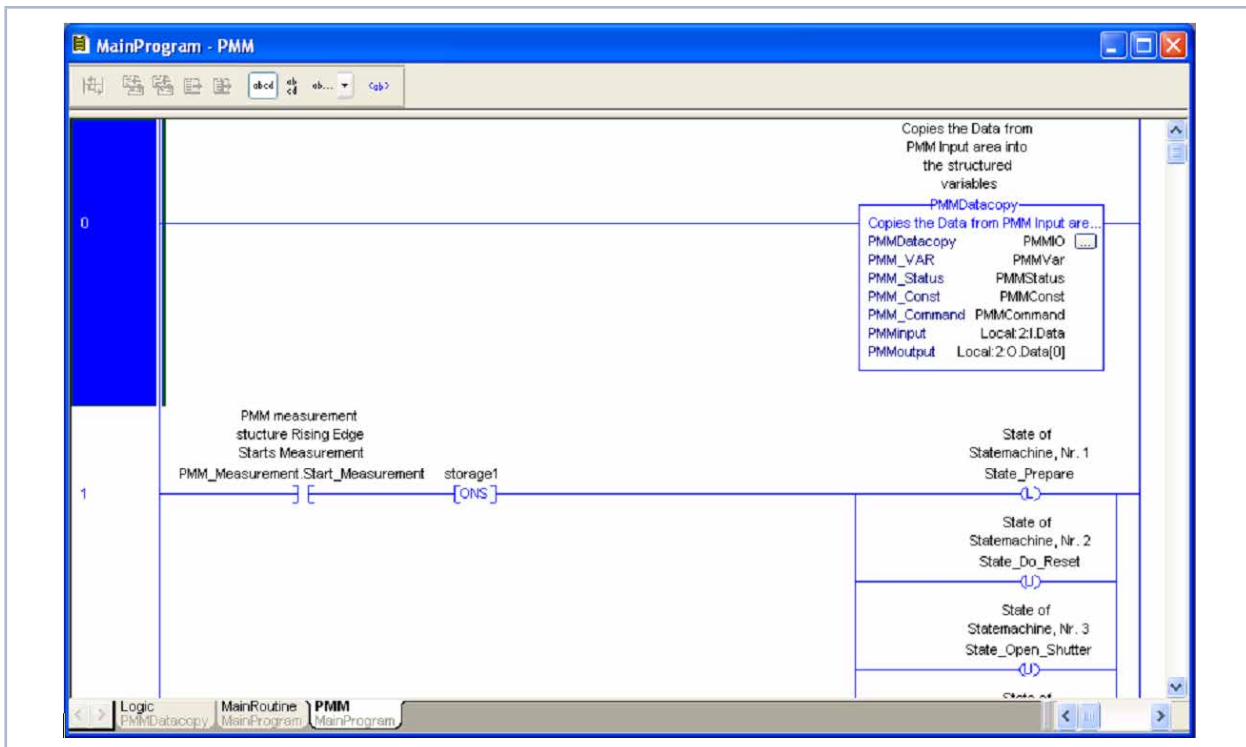
Fig. 13.4:   Call up of the add on instruction "PMMDataCopy"

13.3.1 Setting the DeviceNet™ address and the baud rate

1. Remove the base plate of the device (four hexagon socket screws a. f. 2.5 mm).
2. Set the desired bus address by means of the rotary switches SW2 and SW1. The arrow head of the rotary switch has to point to the respective figure.

The address consists of two digits. Use switch SW2 to set the first digit (tens), and switch SW1 to set the second digit (units).

Example
The bus address is supposed to be 14.

Setting switch SW2=1
Setting switch SW1=4
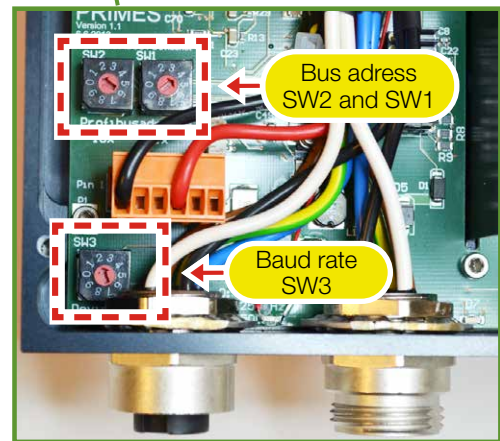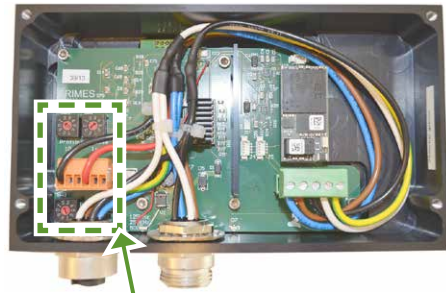
3. Set the desired baud rate by means of the rotary switch SW3 (factory settings 2 ≙ 500 kHz).
4. Mount the base plate of the device again.

Switch position SW3	Baud rate in kHz
0	125
1	250
2	500

13.3.2 Integrating DeviceNet™ scanner into DeviceNet™

1. Click "I/O Configuration" in the directory tree of the hardware window and choose *New Module…* by clicking the right button.
2. Choose your scanner from the type list (here "1769-SDN/B Scanner DeviceNet™) and confirm by clicking *OK*.
3. Enter as an input parameter:
- PMM A:
  17 double words; corresponding to 68 bytes
- PMM AP3s:
  21 double words; corresponding to 84 bytes
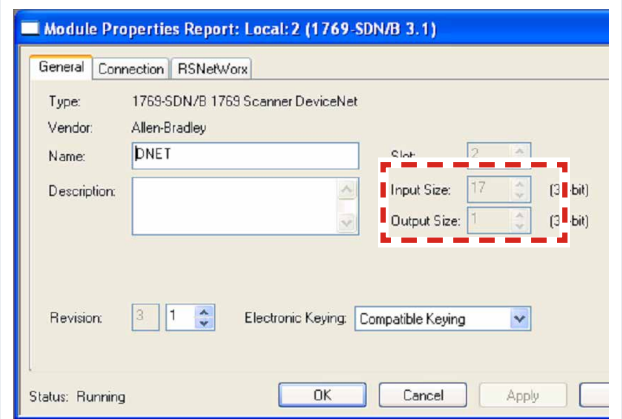
13.3.3 Importing EDS file

1. Insert the PRIMES data medium into the drive of your computer.
2. Start the program RSNetWorx.

1. Start the EDS-Wizard: 2. Choose the menu **Tools --> EDS Wizard**. 3. Choose the option **Register an EDS File**. 4. Click **Weiter (Next)**.	**Rockwell Software's EDS Wizard** **Options** What task do you want to complete? • Register an EDS file(s). This option will add a device(s) to our database. Unregister a device. This option will remove a device that has been registered by an EDS file from our database. Change a device's graphic image. This option allows you to replace the graphic image (icon file) associated with a device. Create an EDS file. This option creates a new EDS file that allows our software to recognize your device. Upload EDS file(s) from the device. This option uploads and registers the EDS file(s) stored in the device. < Zurück Weiter > Abbrechen
5. Choose the option **Register a single file**. 6. Choose the corresponding EDS file on the PRIMES data medium via **Browse…** : • PMM A: PMM_DNS-V2.1-20150413.EDS • PMM AP3s: PMMP_DNS-V3.1-20221111.EDS 7. Click **Weiter (Next)**. 8. Confirm all upcoming dialogue windows by clicking **Next** or **Complete**.	**Rockwell Software's EDS Wizard** **Registration** Electronic Data Sheet file(s) will be added to your system for use in Rockwell Software applications. • Register a single file Register a directory of EDS files □ Look in subfolders In folder: _____ Browse... ⓘ * If there is an icon file (.ico) with the same name as the file(s) you are registering then this image will be associated with the device. To perform an installation test on the file(s), click Next < Zurück Weiter > Abbrechen

13.3.4 Bus configuration with RSNetWorx

1. Start the program RSNetWorx. 2. Set the bus address and the baud rate in **Tools --> Node Commissioning**.	
3. Open the network (menu **Network --> Online**). 👁 The search process on the bus starts automatically. The found bus components are displayed. 4. Double-click the scanner symbol.	
👁 The characteristics dialogue of the DeviceNet™ scanner appears. 5. Switch to the tab **Scanlist**.	
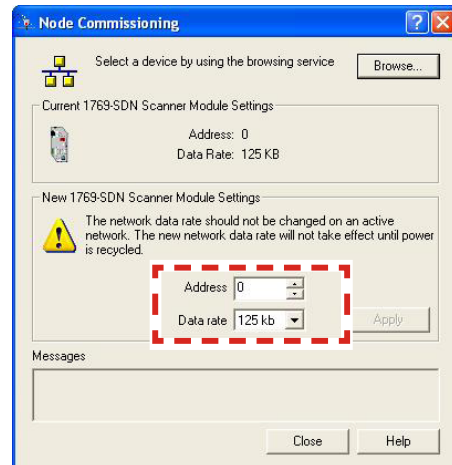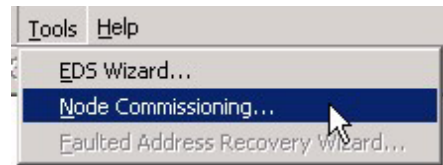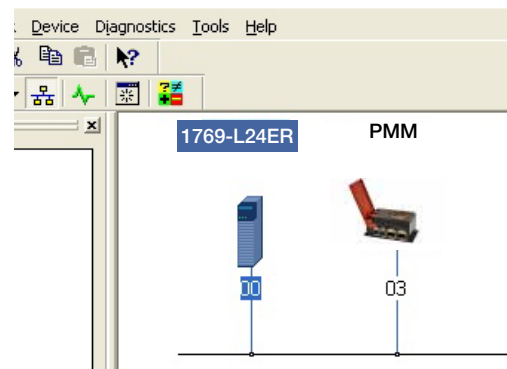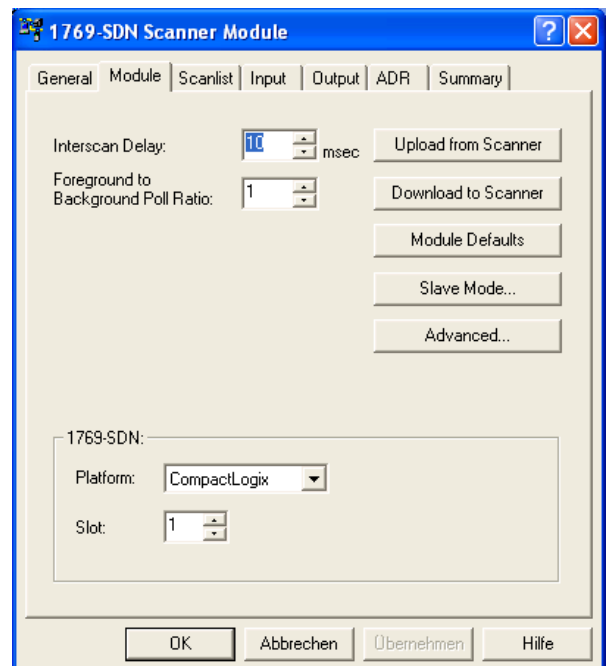
The list of the nodes configured at the scanner appears.

6. Move the PMM to the scan list on the right, using the button ⟩ .
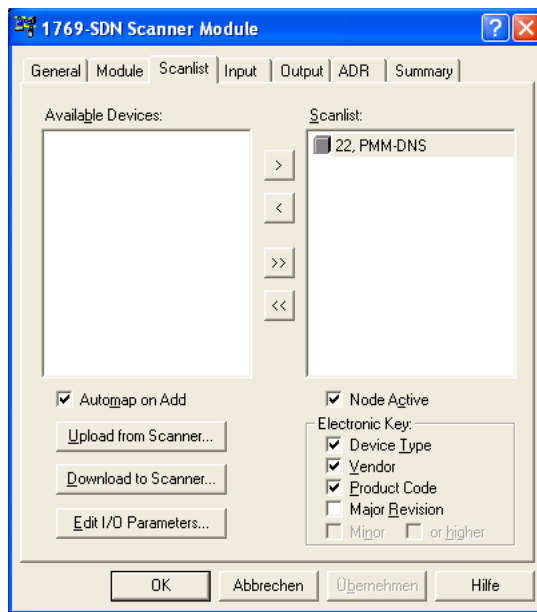
The process data are mapped automatically by RSNetWorx. The addresses can be checked in the tabs input or output.
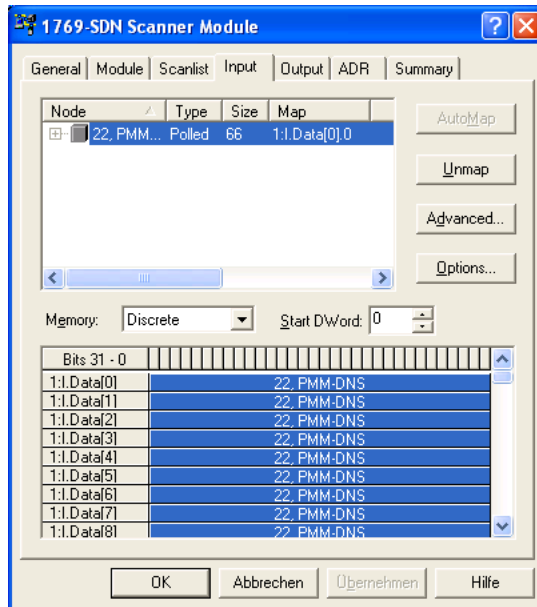
7. Click the button **Advanced**.	
⊙ It is essential that the command byte is mapped correctly (8 Bit).	
8. Activate the devices via the menu **Network ---> Online**. 9. Load the configuration via **Download to Network** into the scanner and the PMM.	
10. Open the menu **View --> Diagnostics** ⊙ In this dialogue window the network condition is displayed. If all components are provided with a green tick, the field bus is ready for operation.	
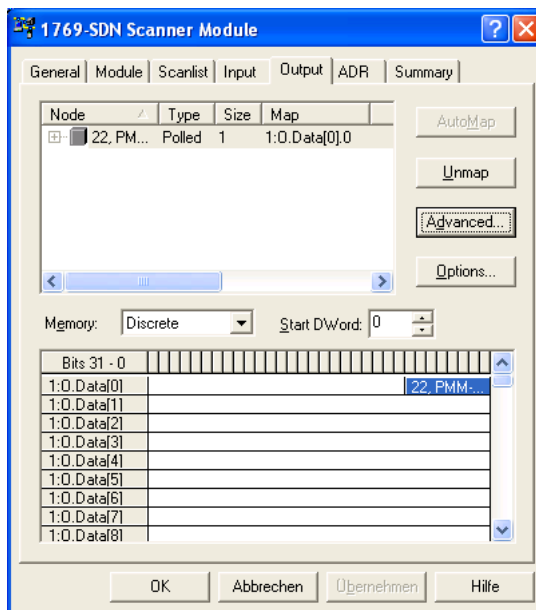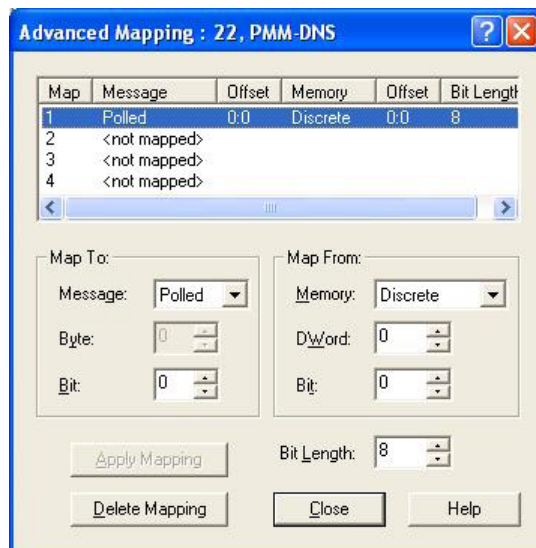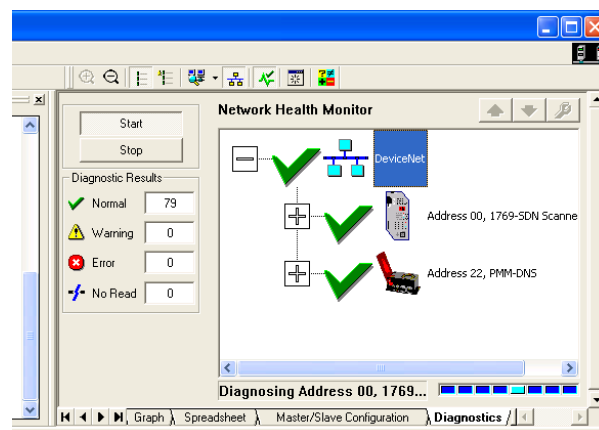
13.3.5 Debugging

After the configuration you can switch the system to the "Run Mode". Select "Go Online" first. The software is then programmed into the system via "download" and then the "Run Mode" is set.

1. Select the control symbol and click **Go Online**.	
⊙ The dialogue window **Connect to Go Online** is opened. 2. Click the button **Download**.	
3. Start the **Run Mode**.	
⊙ The check boxes „Run Mode", „Controller OK" and „I/O OK" have to be highlighted in green.	
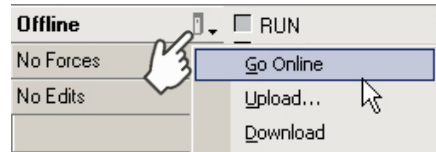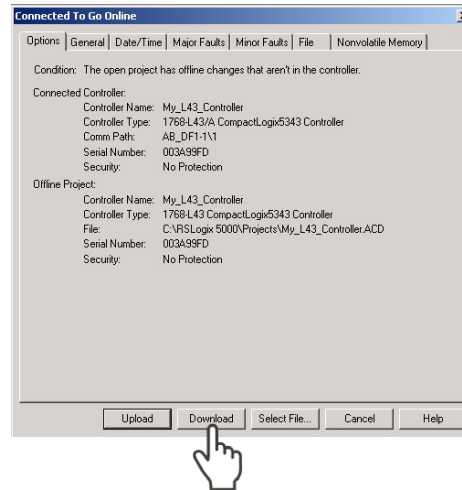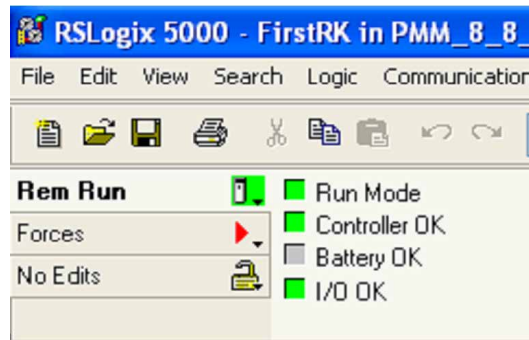
After the integration of the DeviceNet™ scanner and the PMM into the system, the data of the PMM are displayed in the data range of the scanner first (see Fig. 13.5 on page 69):
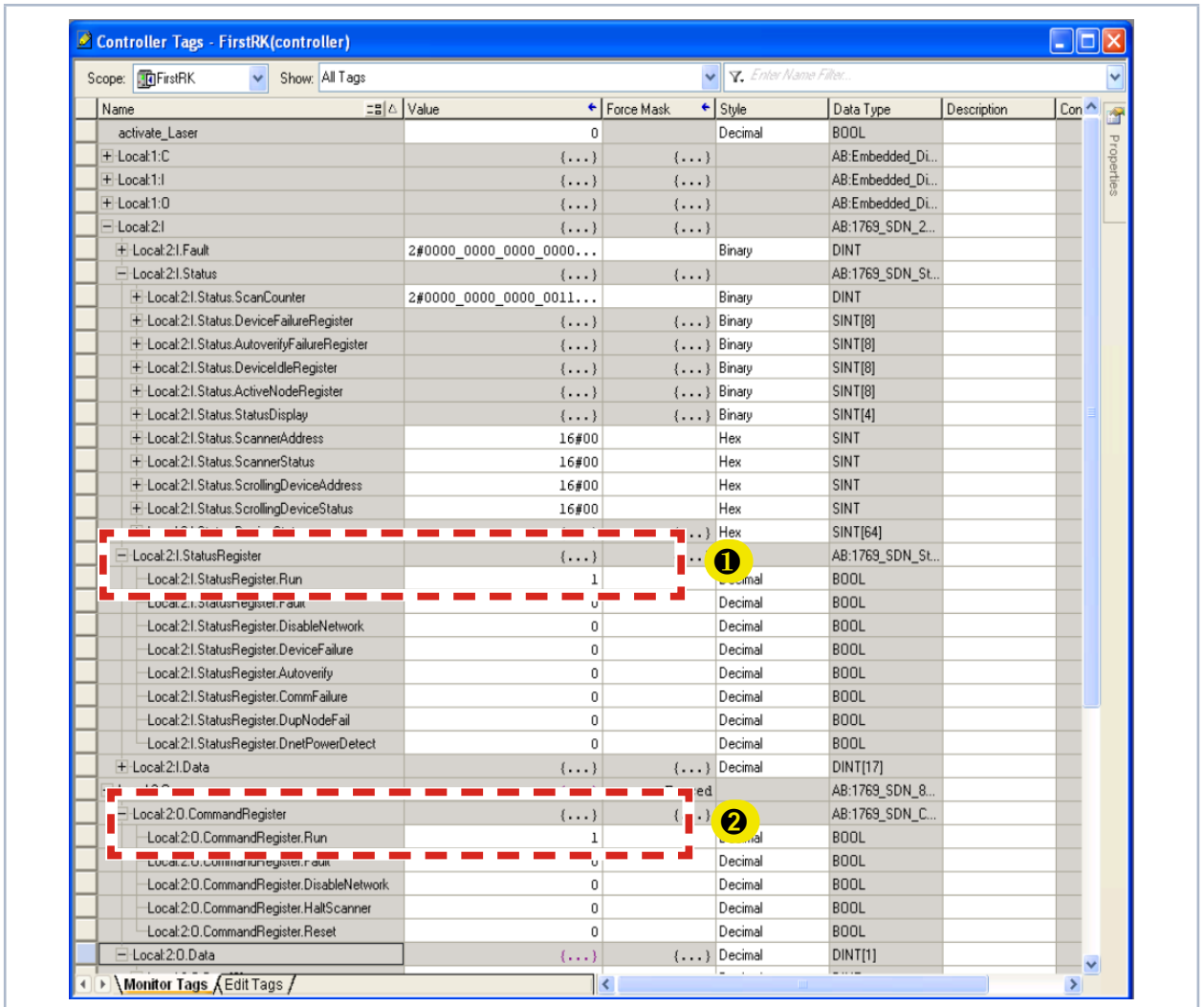
Fig. 13.5: Data range of the scanner

The entry „Local:2:O.CommandRegister.Run = 1" in Fig. 13.5 on page 69 --> ❷ sets the scanner into the RUN-Mode. Only then data will be transferred from the scanner to the PMM.
The RUN-Mode of the scanner can be checked by means of the status register in Fig. 13.5 on page 69 --> ❶„Local:2:I.StatusRegister.Run = 1".

⊙ The two-digit segment display of the scanner bears the bus address of the scanner. If the bus address is 0, the display will depict "00".
If run = 0, the bus address and the error code are displayed alternately. The error codes are listed in the manual of the scanner by Rockwell.
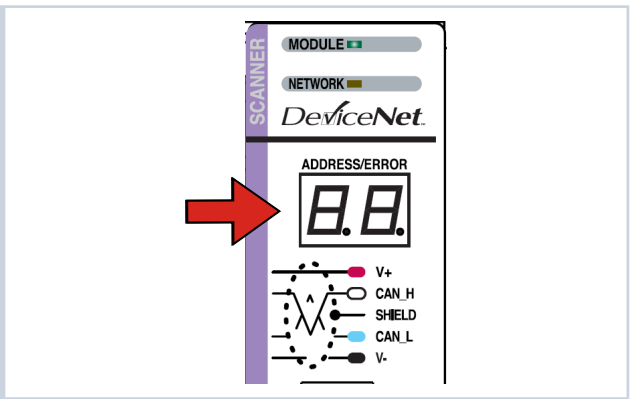
The display of the scanner must not show any error codes when in the "RUN-Mode". During the communication with the PMM the values in the entry "Local:2:I.Data[7]" should change (absorber temperature). When opening and closing the shutter of the PMM manually, the bits in Local:2:I.Data[0] should change (see Fig. 13.6 on page 70).

Fig. 13.6:   Values for absorber temperature and shutter movement

As soon as the add-on command for copying of the data is carried out, the absorber temperature can be read out directly in the variable „PMMVar.AbsorberTemperature" in a thousandth degree Celsius (see Fig. 13.7 on page 70).

Fig. 13.7:   Variable „Absorber temperature"

13.4 PMM with EtherNet/IP™

The PMM is put into operation with EtherNet/IP™ according to the following scheme:

- Address assignment (automatically via DHCP or manually)
- Installation of the EDS-file
- Transfer of the data to the control unit

The EDS-file contains all identification- and communication parameters of the device. After the integration of the EDS-file (PRIMES data medium path: Tools/EDS Hardware Installation Tool) the PMM can be added as a new module.

13.4.1 Module configuration

Insert the PMM module by clicking the right button on **Ethernet --> New Module**. Enter a device name.
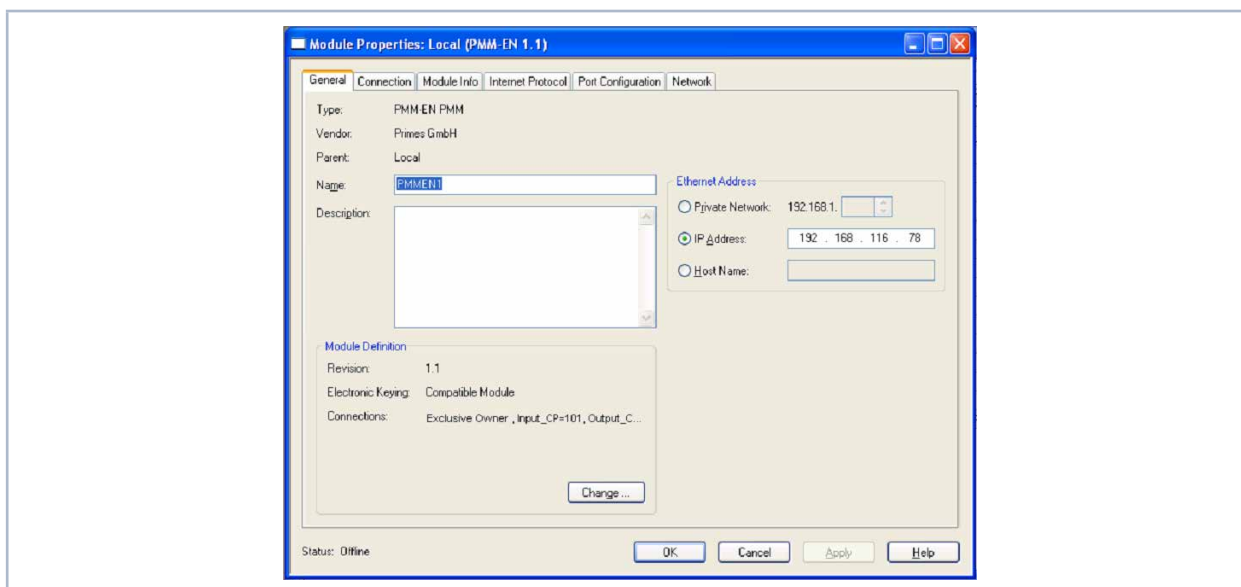
Fig. 13.8:   Entering device name and IP-address

13.4.2 Setting the IP address

The IP address is set by means of two hexadecimal coding switches inside the device.

1. Remove the base plate of the device (four hexagon socket screws a. f. 2.5 mm).
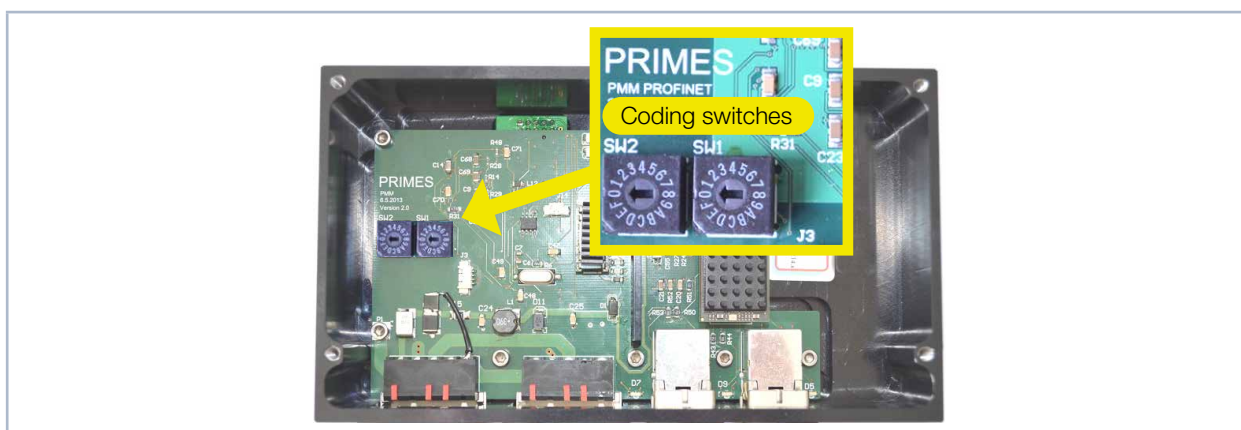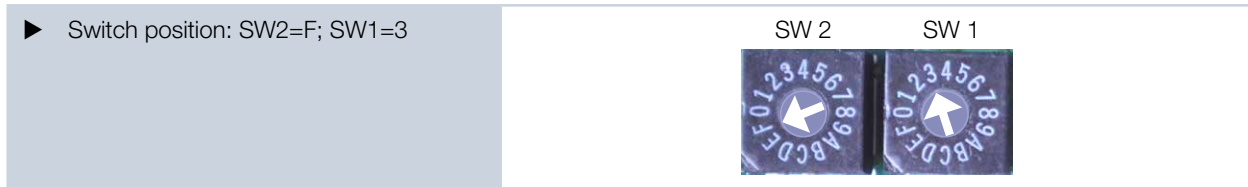

Fig. 13.9:   Rotary switches for setting the IP address

2. Set the desired IP address by means of the rotary switches SW2 and SW1:
- If both rotary switches are set to 0, the address is assigned by DHCP.
- In case of addresses in the range of 1-254 (hexadecimal 0x01 to 0xFE), the address is set by means of the network segment 192.168.1.xxx. "xxx" stands for the preset number of the rotary switches.
- If you set the rotary switch to 0xFF = 255, the programmed IP address is completely accepted.

Example:
The address 192.168.1.243 should be set. 243 (decimal) ≙ F3 (hexadecimal)

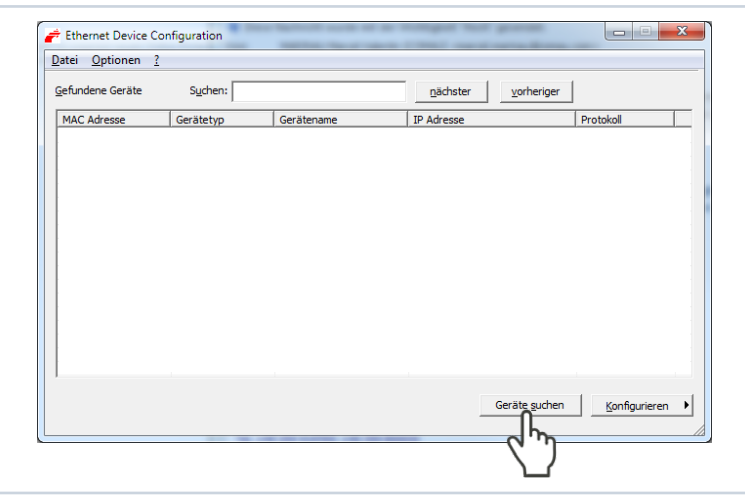|	
▶ Switch position: SW2=F; SW1=3	

3. Remount the base plate of the device.

### 13.4.3 Setting the IP address via a web browser

The first three bytes of the IP address can be set by means of your web browser via a web interface.
The fourth (last) byte is set via the internal rotary switches and as described in chapter 13.4.2 on page 71.
In order to read out the current IP address of the PMM in the network, the program "EthernetDeviceConfiguration" is required. It can be found on the PRIMES data medium.

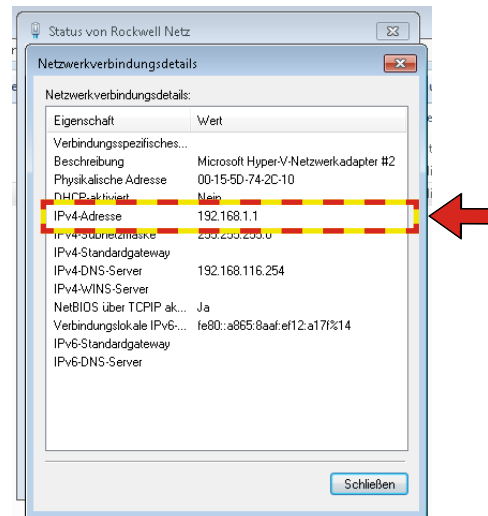|	
The PMM has to be turned on. 1. Start the program "EthernetDeviceConfiguration". 2. Click the **Geräte suchen** (Search Device) button.	
◉ The dialogue window is opened and the found devices are listed. The IP address of the PMM can be found in the line of the device type "**netIC**".	
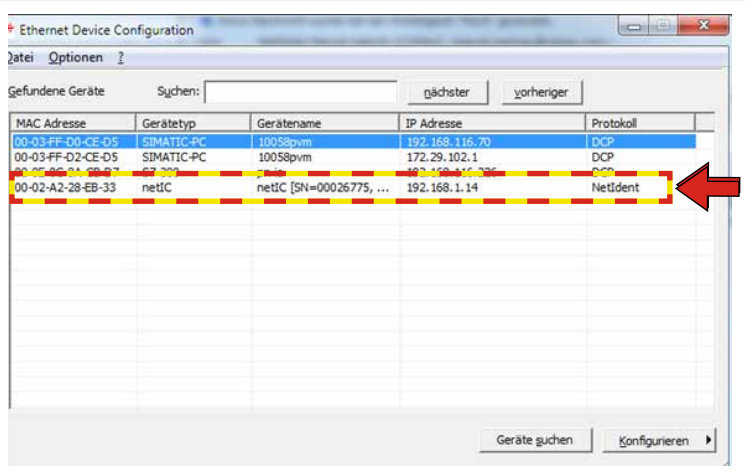
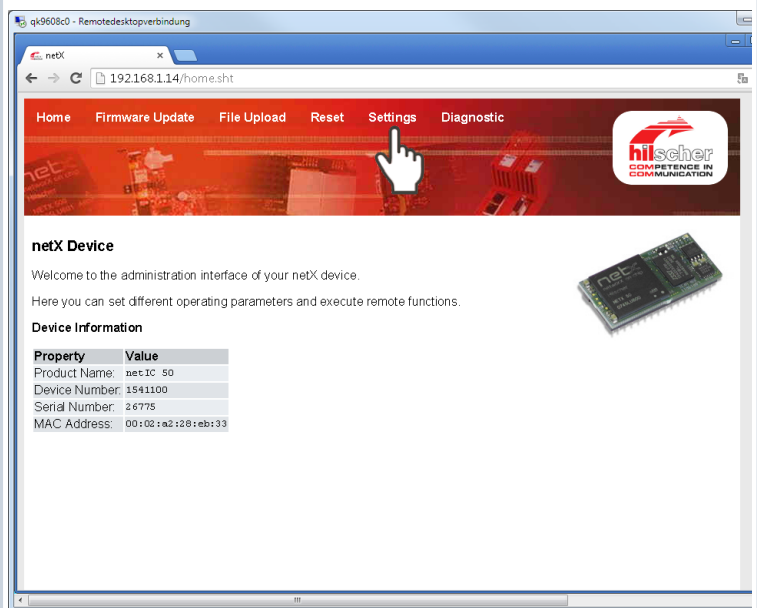|	
Please mind for the next steps, that the IP address of the network interface card of your PC has to be within the address range of the PMM.	
3. Start your web browser. 4. Enter the IP address of the PMM in the address line.	If no connection can be established, this can have the following reason: The communication software „EthernetDeviceConfiguration" of the PMM is not up-to-date (version 1.5 is required).
◉ The dialogue window of the web browser interface is opened. 5. Click **Settings**.	
◉ The registration window is opened. Please mind the correct use of capital and small initial letters. 6. Enter the user name (Nutzername) **User**. 7. Enter the password (Passwort) **User**. 8. Click the **Register** (Anmelden) button.	
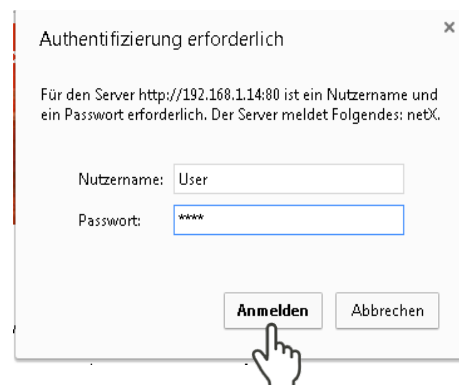
◉ The current IP address of the PMM is displayed.
9. Change the address according to your wishes.

Notice:
The **Mode** selection field must always be left **static**!
Switching to **dhcp** or **bootp** leads to a loss of communication with the PMM.

10. Click the Submit button.
➜ The device address is transferred.
11. Please mind that the last byte of the IP address of the PMM is set by means of two rotary switches (see chapter 13.4.2 on page 71).
➜ The PMM is now reprogrammed.

12. Switch off the PMM and turn it on again so that the new address is implemented.
13. Reset the network interface card of your computer to the new address as well.
14. Check the communication with the PMM.

13.4.4   Module definition

With regard to the module definition, the name "Exclusive Owner" is selected in the drop-down box (see Fig. 13.10 on page 74). The automatically entered data sizes of 66 for input and 1 for output are kept.
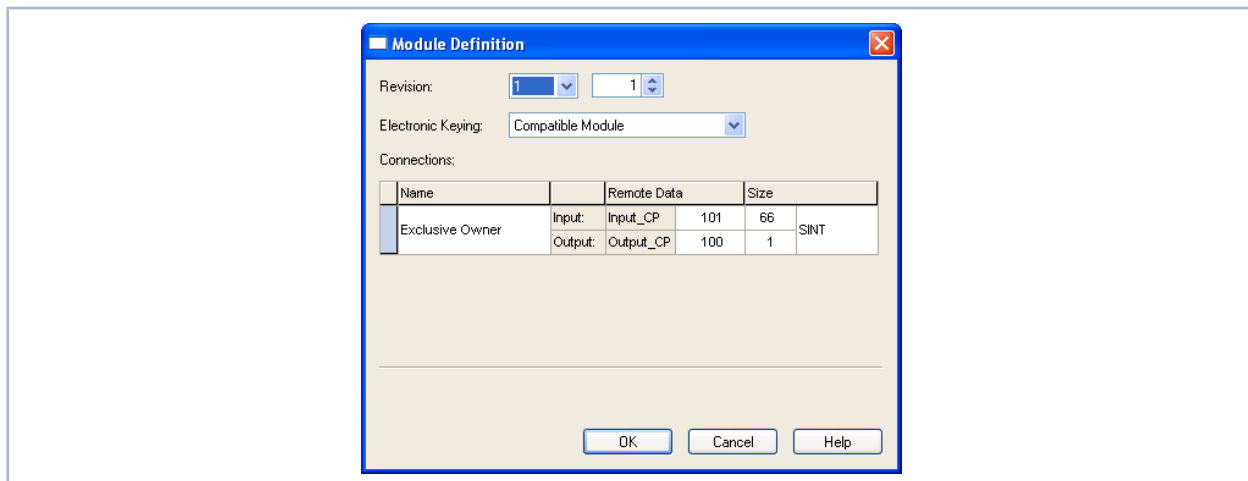

Fig. 13.10:   Module Definition

After the confirmation of all entries, the module is created and appears in the list of Ethernet devices (see Fig. 13.11 on page 75).

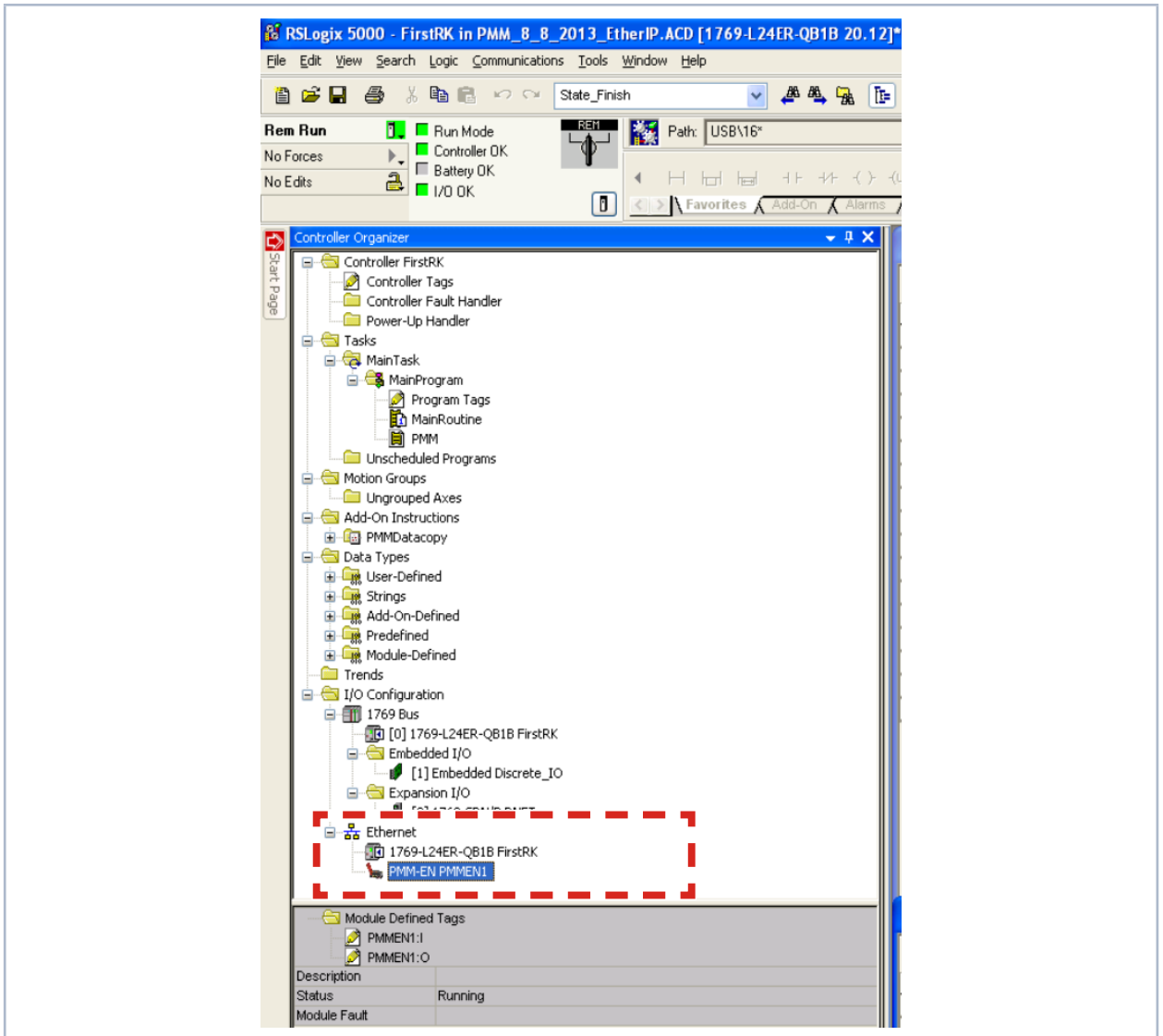Fig. 13.11:   Device list in the directory tree

As far as the controller tags are concerned, the PMM now has an entry in its I/O range. These data have the format Array of SINT, which means that a conversion of the data into the structural variables of the PMM has to be done (same procedure as for DeviceNet™). As soon as the control is in RUN Mode, the variables are constantly updated.
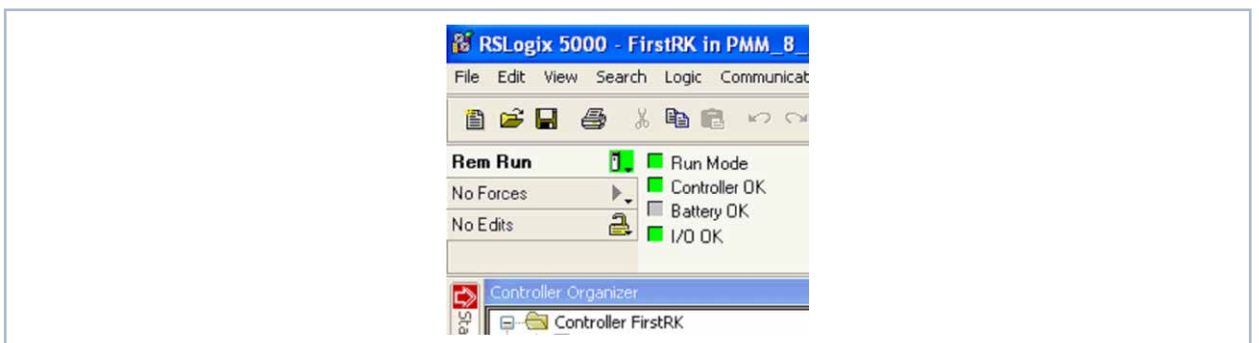
Fig. 13.12:   RUN-Mode

The status of the shutter can be found in the variable: PMMEN1:I.Data[1] under "Value" (see Fig. 13.13 on page 76). A "2" stands for a closed shutter. As soon as the shutter is opened manually, the value changes to "1". This is a simple procedure in order to check the communication.

Fig. 13.13: Status of the shutter

As soon as the add-on instruction "PMMDataCopy" is included in the program, the PMM variables can be monitored directly (see Fig. 13.14 on page 76).

Fig. 13.14: PMM variables

14 EtherCAT® connection

EtherCAT® stands for Ethernet for Control Automation Technology and is an Ethernet-based field bus. EtherCAT® is optimized for the recognized bus or line structures of field buses. Withi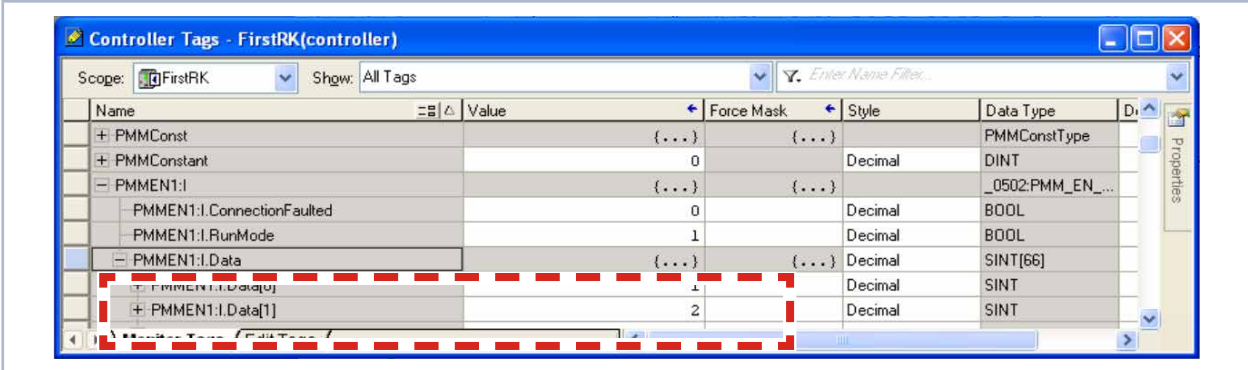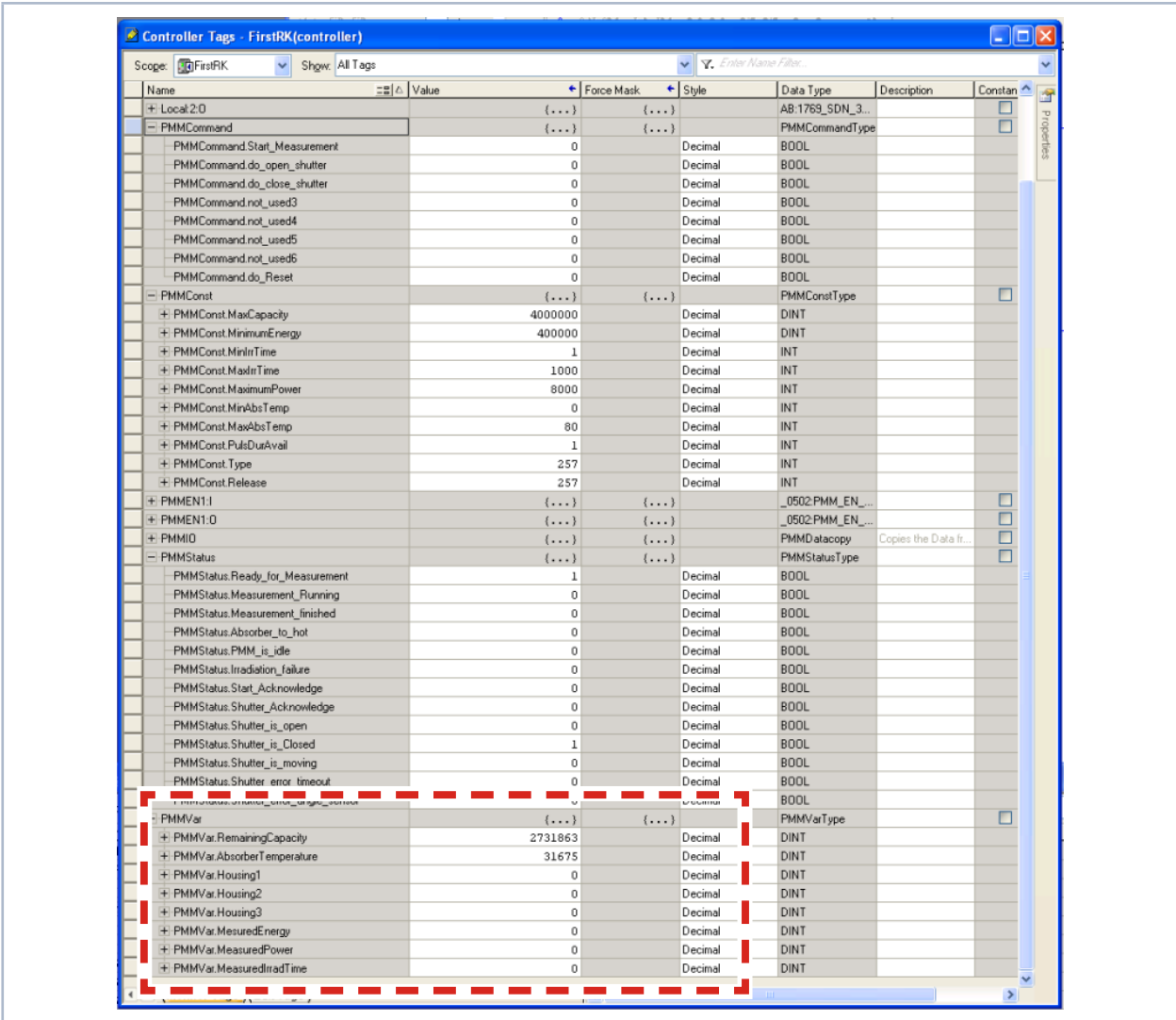n this topology, the EtherCAT® slave participants are connected in a series. To make this possible, each EtherCAT® slave participant has an incoming and a continuing Ethernet connection.

The EtherCAT® network is configured in Windows® with the TwinCAT® automation software. The electronic data sheets of the connected EtherCAT® devices, the so-called ESI files (EtherCAT® Slave Information) are required for configuration. Each EtherCAT® device needs an individual ESI file made available by the respective device manufacturer.

TwinCAT® 3 contains all languages in accordance with IEC-61131-3. The program for the PMM is written in ST (Structured Text).

Requirements for connecting via EtherCAT®:

- The TwinCAT® software is installed on the PC
  (detailed installation instructions can be found on the website of the manufacturer Beckhoff).
- The ESI file **PRIMES PMM ECS Vx.x.xml** is copied in the TwinCAT directory (usually in the folder **c:\TwinCAT\3.x\Config\Io\EtherCAT**).
  The ESI file **PRIMES PMM ECS Vx.x.xml** is located on the supplied PRIMES data medium.
- The PMM is connected via Ethernet patch cables of CAT5e quality or higher.

> ℹ️ The following descriptions relate to the TwinCAT® Version 3.1. The TwinCAT® displays shown can be changed in keeping with the build version.

14.1 Connect the PMM to the device tree

1. Start the TwinCAT system manager.
2. Mark the project tree **I/O --> Devices** the device icon**Device (EtherCAT)** and click on **Scan** in the context menu.
   👁 The PMM icon appears in the device tree.
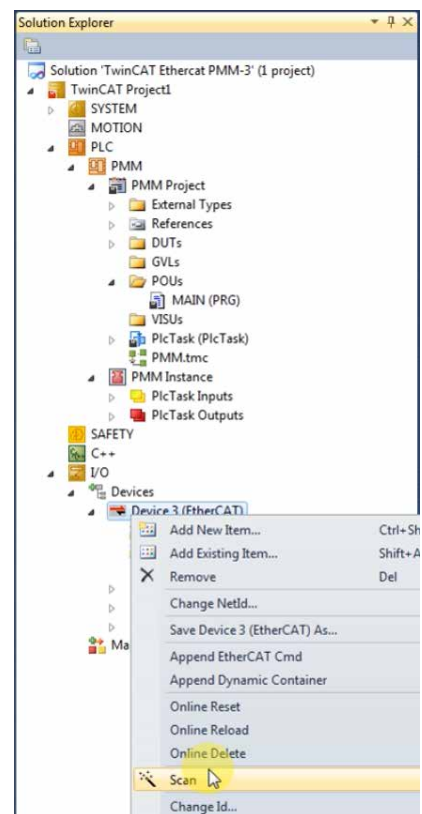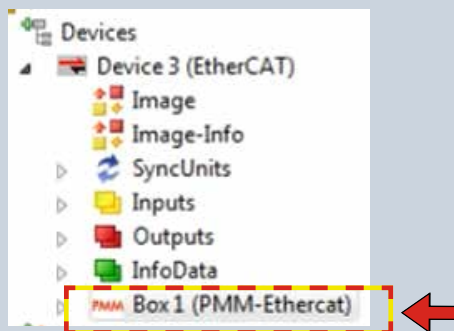
14.2   Process data mapping

1. Open the **PMM Ethercat box**. 2. Open the subdirectory for the input data **TxPDO**.	
3. Mark the first two bytes (status bytes) in the project window and click on **Change Multi Link...** in the context menu.	
4. Mark the input **Status byte** and click on **OK**.	
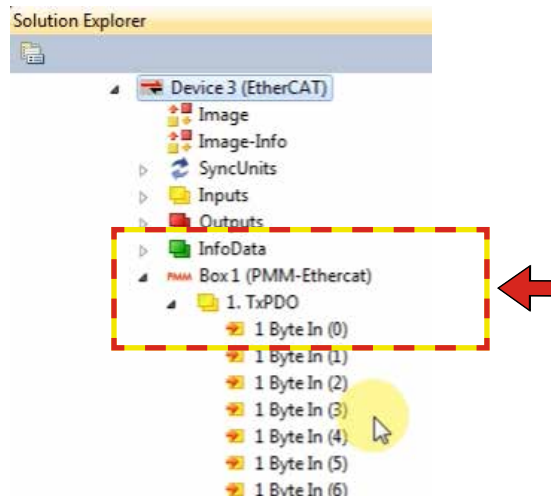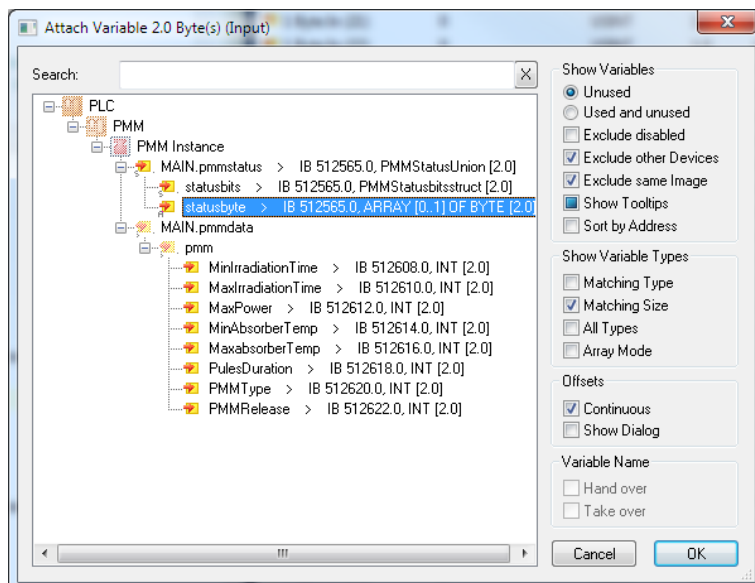
5. Mark all remaining bytes in the project window and click on *Change Multi Link...* In the context menu.	
6. Mark the input *inbytes* and click on *OK*.	
7. Open the subdirectory for the output data *RxPDO*.	
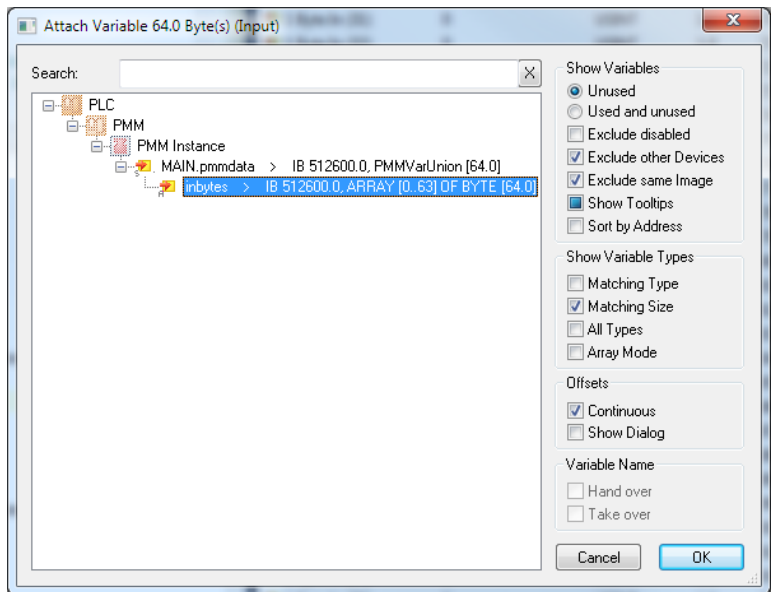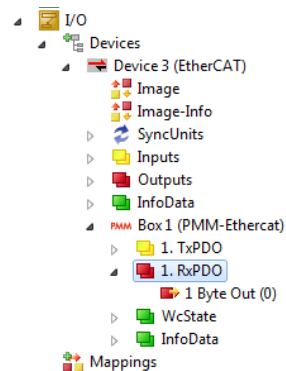
8. Mark the command byte in the project window and click on *Change Link...* in the context menu.
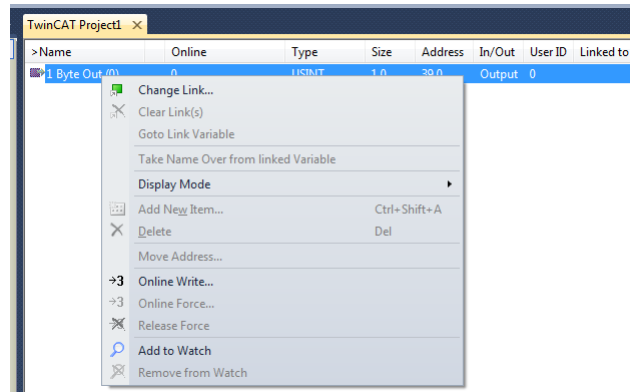
9. Mark the output *Out bytes* and click on *OK*.
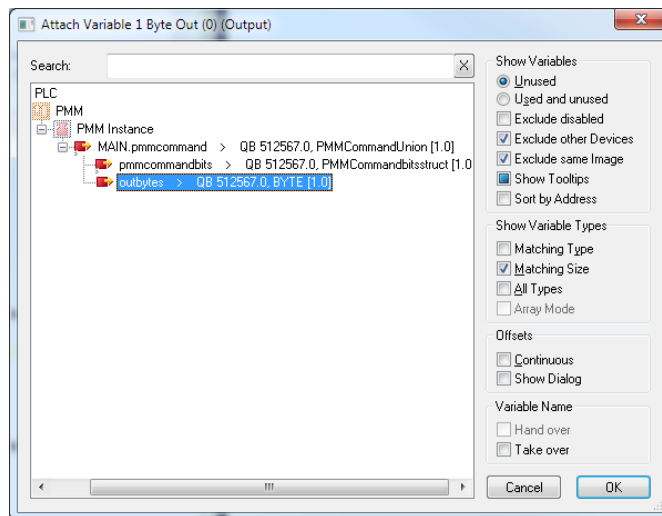
Once mapping has been completed, the variable groups and their current states can be displayed in the program window (main [online]).
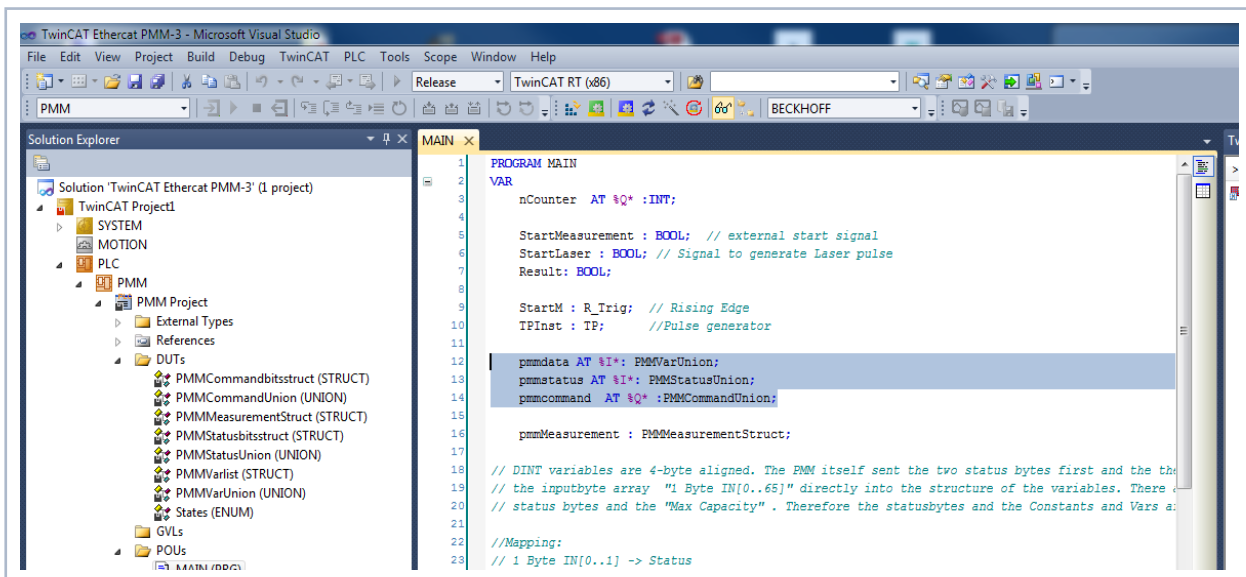
Fig. 14.1:   Indication of the variable groups and their current states

Example: States of the status bits
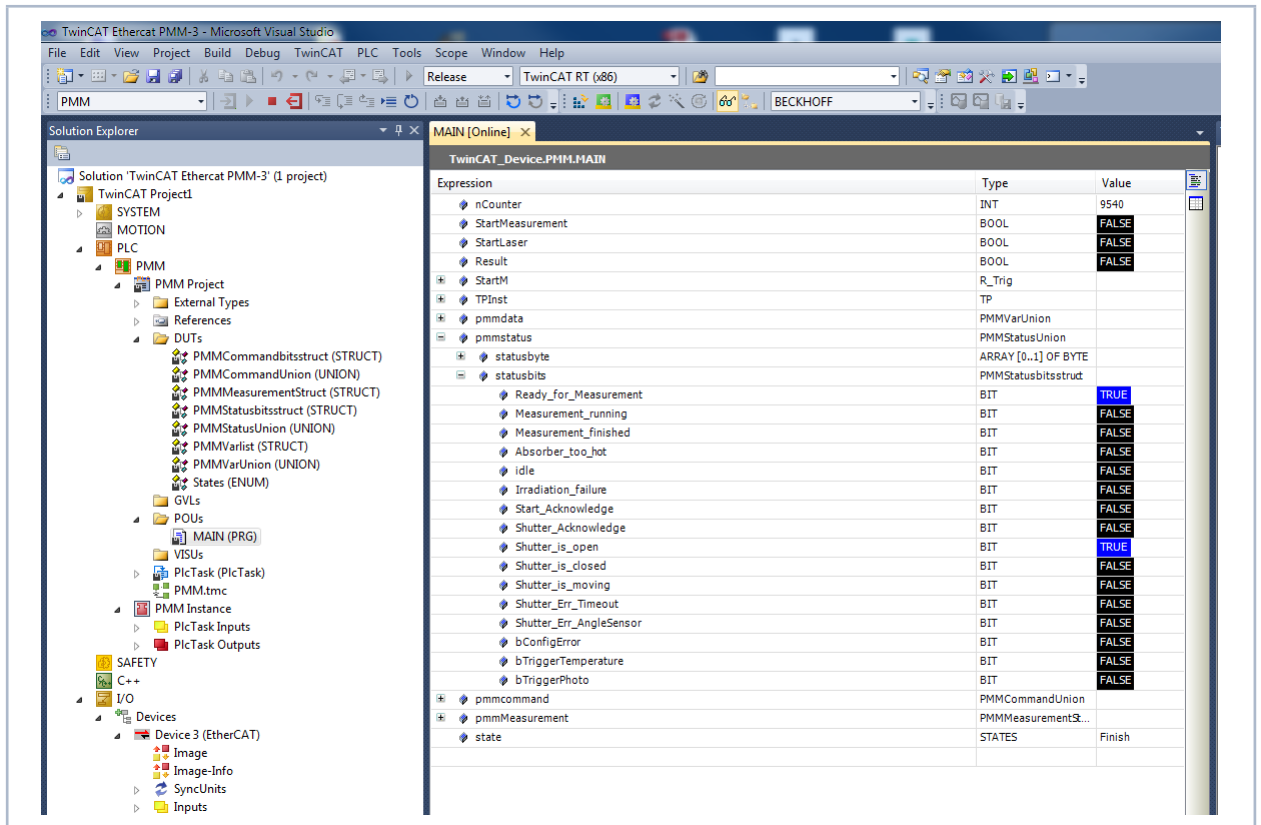
Fig. 14.2:   States of the status bits

15 Maintenance and service

15.1 Maintenance intervals

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

15.2 Cleaning

15.2.1 Cleaning the device surfaces

1. After a measurement, let the device cool down for an adequate period of time.
2. Close all device openings.
3. First clean the device surfaces with cleaned, oil-free compressed air.
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. This can be e.g. microfiber cloths or paper towels from the cosmetics sector.
5. If these steps are not sufficient, please contact PRIMES or your PRIMES distributor.

15.2.2 Cleaning the protective window

1. After a measurement, let the device cool down for an adequate period of time.
2. Dismount the protective window according to chapter 15.3.2 on page 84.
3. First clean the protective window with cleaned, oil-free compressed air.
4. For further cleaning, use isopropanol (observe the manufacturer's safety instructions).
   The coating of the protective window is particularly sensitive to scratches. Use cloths suitable for cleaning protective glasses.
5. Replace the protective window with a new one if the contamination cannot be removed or if it is damaged.

15.3 Exchanging the protective window

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

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

Protective window diameter	55 mm
Glass thickness	1,5 mm
Order number	PMM without exchangeable cassette
	NIR: 410-070-021 (1 piece) 410-070-030 (10 pieces)
	BG: 410-070-024 (1 piece) 410-070-033 (10 pieces)
	PMM with exchangeable cassette
	NIR: 410-070-021 (1 piece) 410-070-031 (10 pieces)
	BG: 410-070-024 (1 piece) 410-070-033 (10 pieces)

15.3.1   Warning messages

⚠ **DANGER**

Serious eye or skin injury due to laser radiation

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

▶ Ensure that the new protective window is positioned evenly in the indentation of the device/exchangeable cassette.

⚠ **CAUTION**

Burns due to hot surface

After a measurement the absorber below the protective window/exchangeable cassette is hot. Under the protective window/exchangeable cassette is an opening with the absorber. Touching the hot absorber can cause serious burns.

▶ Do not clean or exchange the protective window directly after a measurement.

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

▶ Do not grab inside the opening under the protective window/exchangeable cassette.

NOTICE

Damage/Destruction of the device

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

▶ Only clean or exchange the protective window in a dust-free environment.

▶ Do not touch the protective window with bare hands.

▶ When exchanging the protective window wear suitable gloves.

15.3.2   Exchanging the protective window of the PMM

1. Observe the warning messages in chapter 15.3.1 on page 83.
2. Switch off the laser source.
3. Ensure that moving parts, e.g. robot arms, etc. are at a standstill and that they cannot be set in motion unintentionally.
4. Let the device cool down for an adequate period of time.
5. Open the shutter.
6. Put on suitable gloves.
7. Unscrew the four screws (Torx TX 10) on the protective window mount.
   Hexagon AF 2.0 for older versions.
8. Carefully remove the protective window mount upwards.
9. Press down the edge of the protective window with a blunt object, grasp it by the circumference and lift it out.
   If the O-ring sticks to the protective window, remove it and reinsert it into the inlet aperture.
10. Check the cleaned or a new protective window for contamination.
11. Insert the new protective window into the device.
12. Place the teflon disc on the protective window.
13. Tighten the protective window mount evenly with four screws.
14. Check that the protective window mount is securely seated.
    The protective window mount must rest flat against the device.
15. Close the shutter.
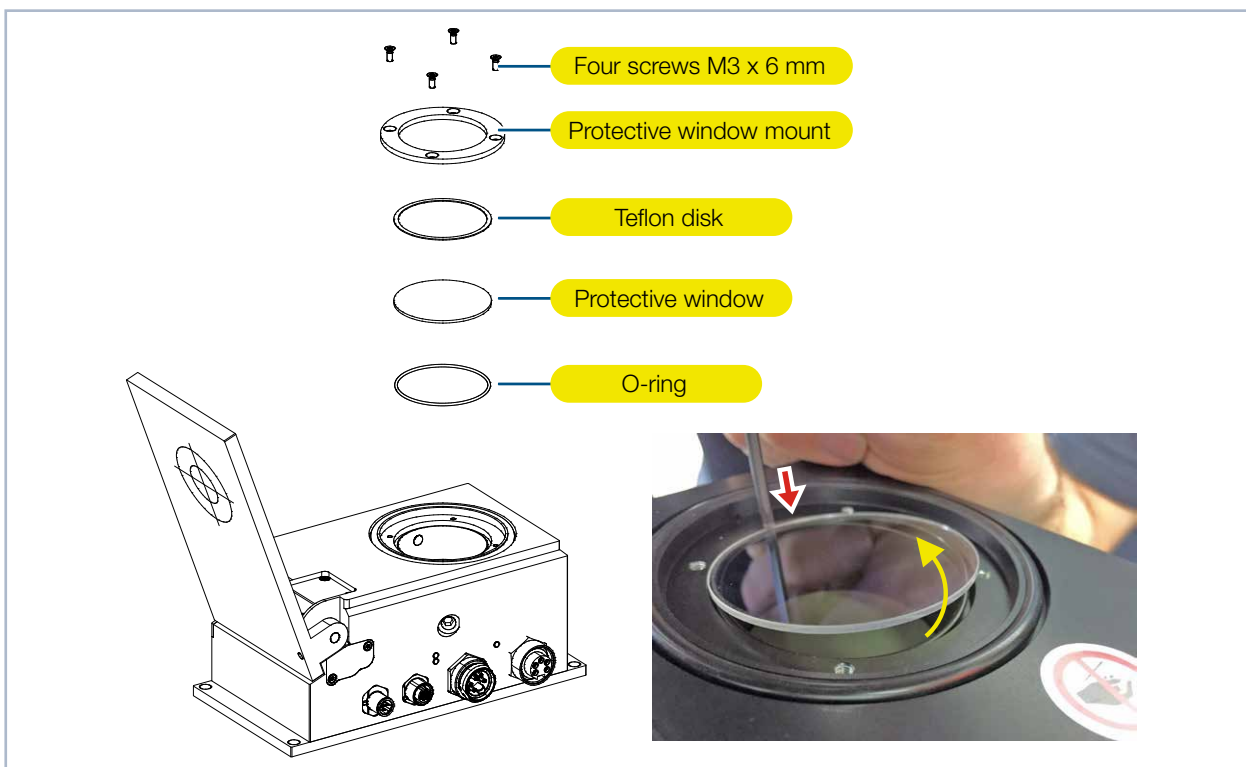
Fig. 15.1:   Exchanging the protective window of the PMM

15.4 Exchangeable cassette

In the PMM with exchangeable cassette, the protective window is enclosed in a cassette that can be quickly exchanged without tools.

Replacement exchangeable cassette incl. protective window
Order number: NIR: 410-070-020, BG: 410-070-025

15.4.1 Replacing the exchangeable cassette

1. Observe the warning messages in chapter 15.3.1 on page 83.
2. Switch off the laser source.
3. Ensure that moving parts, e.g. robot arms, etc. are at a standstill and that they cannot be set in motion unintentionally.
4. Let the device cool down for an adequate period of time.
5. Open the shutter.
6. Put on suitable gloves.
7. Push the cassette lock button.
➡ The exchangeable cassette is automatically lifted by an ejector.
8. Pull the exchangeable cassette out of the housing.
9. Insert the new exchangeable cassette (with the O-ring pointing upwards) at an angle into the cutout in the housing.
10. Press and hold the cassette lock button.
11. Press the exchangeable cassette into the housing and release the button.
➡ The exchange cassette is now locked.
12. Close the shutter.
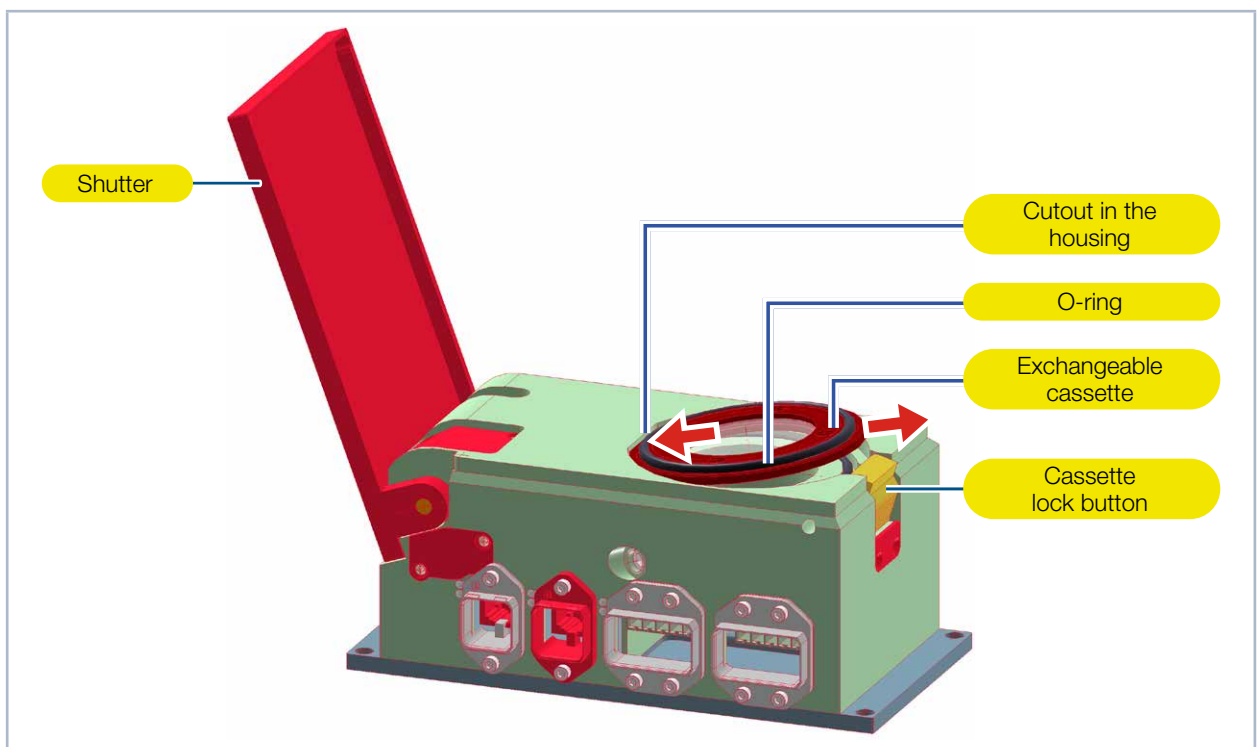
Fig. 15.2:   Replacing the exchangeable cassette

15.4.2   Replacing the protective window of the exchangeable cassette

1. Insert a blunt tool into the Ø 3 mm bore.
2. Push the retaining ring with Teflon disk out of the exchangeable cassette, grasp it by the circumference and lift it out.
   The retaining ring is held magnetically in the exchangeable cassette.
3. Carefully push the protective window out of the exchangeable cassette from below.
   If the inner O-ring sticks to the protective window, remove it and reinsert it into the exchange cassette.
4. Put on suitable gloves.
5. Check the cleaned or a new protective window for contamination.
6. Insert the new protective window into the exchangeable cassette.
7. Place the Teflon disk under the magnetic retaining ring and place it on the protective window.
8. Check that the protective window mount is securely seated.
   The retaining ring with Teflon disc and protective window must rest flat inside the exchangeable cassette.
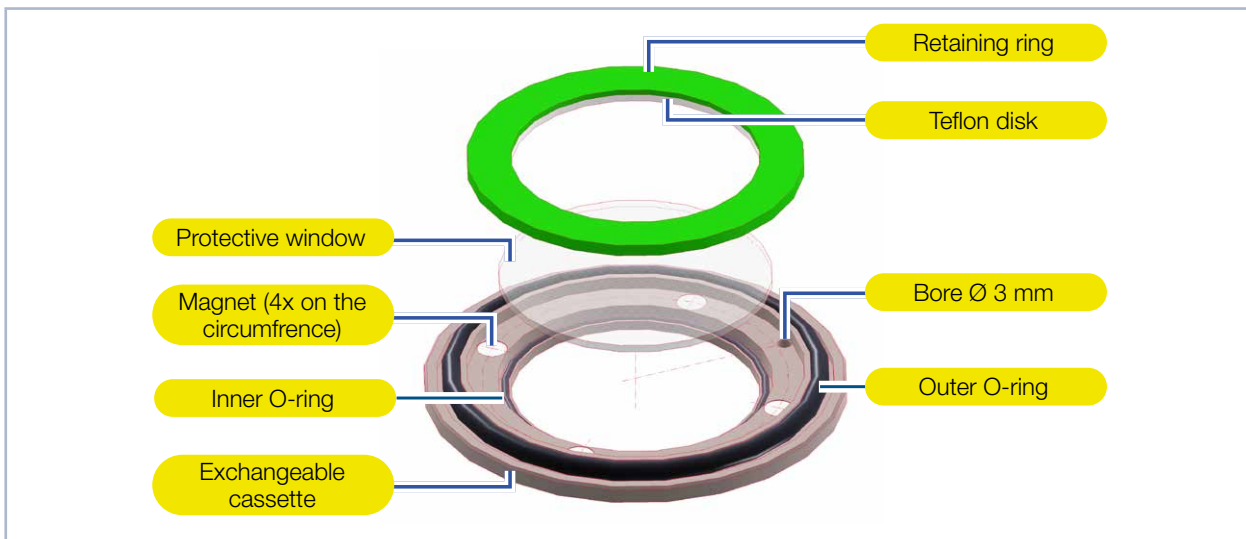
Fig. 15.3:   Replacing the protective window of the exchangeable cassette

16   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.

17 Technical data

Measurement parameters		Standard absorber [1]	Advanced absorber [1]
Power range		400 – 6 000 W [2]	400 – 12 000 W [2]
Wavelength range	BG	440 – 460 nm / 510 – 540 nm	
	NIR	800 – 1 100 nm	
Max. beam diameter		30 mm	
Max. power density on the absorber (approx. 25 mm below the top edge of the device when the shutter is open) at beam diameters	> 10 mm	1.5 kW/cm²	4 kW/cm²
	10 – 3 mm	2.5 kW/cm²	5 kW/cm²
	3 – 1.5 mm	5 kW/cm²	10 kW/cm²
	< 1.5 mm	6 kW/cm²	12 kW/cm²
Irradiation time [2]		0.1 – 2.0 s (depending on laser power) 0.1 – 1.0 s (Type AP3s)	
Min. ontime/offtime (duty cycle) for pulsed lasers		50 µs (e.g. max. 10 kHz at 50 % duty cycle)	
Max. laser rise time		< 1 % of irradiation time	
Energy per measurement		400 – 3 500 J	
Recommended energy per measurement		400 – 1 000 J	
Total duration until measurement value output		< 15 s	
Total duration until measured value output for devices with reduced thermalization time (type AP3s)		< 5 s	
Nominal measurement frequency		500 J: 1 cycle / 2 min 1 000 J: 1 cycle / 4 min	

[1] **Please read the information on the identification plate to determine if your device is equipped with a standard or advanced absorber.**

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

Device parameters	Standard absorber [1]	Advanced absorber [1]
Max. absorber temperature	120 °C	
Max. angle of incidence perpendicular to inlet aperture	± 10°	
Max. center tolerance	± 2.0 mm	
Measuring accuracy at angles of incidence up to 10°	± 3 %	
Reproducibility	± 1 %	

1) Please read the information on the identification plate to determine if your device is equipped with a standard or an advanced absorber.
The identification plate shows as an example the PowerMeasuringModule PMM PROFINET®.
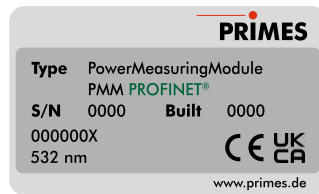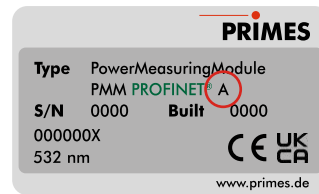
Standard absorber (without mark "A")	Advanced absorber (with mark "A")

The configuration of your device with the possibility to measure pulsed lasers and a reduced thermalization time can be found on the identification plate.
The identification plate shows as an example the PowerMeasuringModule PMM PROFINET®.
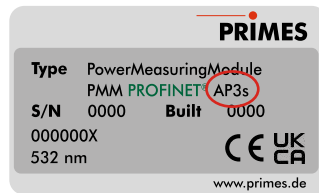
With the AP3s marking, pulsed lasers can also be measured and the device is designed for a reduced thermalization time. The device is equipped with an advanced absorber.

1) Please read the information on the identification plate to determine if your
PMM PROFINET® LWL (Fiber optics) with UL marking is equipped with a standard or advanced absorber.
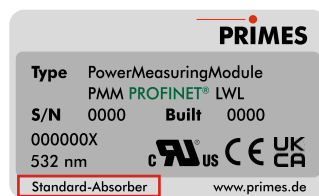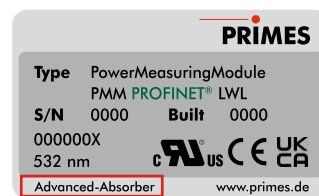
The type of absorber is indicated on the identification plate.	The type of absorber is indicated on the identification plate.

The configuration of your device with the possibility to measure certain wavelengths can be found on the identification plate.
The identification plate shows as an example the PowerMeasuringModule PMM PROFINET®.
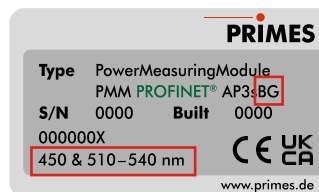
A "BG" mark indicates that the device is suitable for measuring blue/green wavelengths.
Without the "BG" mark, the device is suitable for measuring NIR wavelengths.
The measurable wavelengths are marked on the lower edge of the identification plate.

Supply data	
Power Supply, Limited energy, SELV 　　DC IN 　　DC OUT	24 V DC ⎓ +25 % / -20 %; 250 mA 24 V DC ⎓ Bypass on DC IN; the current between DC IN and DC OUT is max. 5 A.
For devices with the device part numbers listed below, the current between DC IN and DC OUT is max. 16 A. The device part number can be found on the identification plate. **The identification plate shows as an example the PowerMeasuringModule PMM PROFINET®.**	
Power Supply, Limited energy, SELV 　　DC IN 　　DC OUT 500030X 500031X 500032X 500033X 500034X 500035X	24 V DC ⎓ +25 % / -20 %; 250 mA 24 V DC ⎓ Bypass on DC IN; the current between DC IN and DC OUT is max. 16 A.
X = all letters and revision numbers following the 6-digit number	
Communication	
Interface (selectively)	PROFINET®/ PROFINET® LWL (Fiber optics) PROFIBUS® Parallel DeviceNet™ EtherNet/IP™ EtherCAT®
Dimensions and weight	
Dimensions (LxWxH) •　closed •　open	200 x 100 x 89 mm 246 x 100 x 227 mm
Weight (approx.)	2.2 kg
Environmental conditions	
Operating temperature range	15 – 40 °C
Storage temperature range	5 – 50 °C
Reference temperature	22 °C
Relative humidity (non-condensing)	10 – 80 %
Pollution degree	3 (industrial environment)
Max. altitude of operation	3 000 m
Max. nonoperating altitude	12 000 m
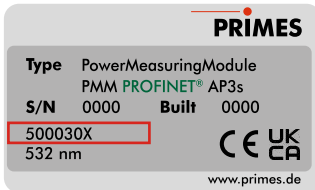
18   Dimensions

View X
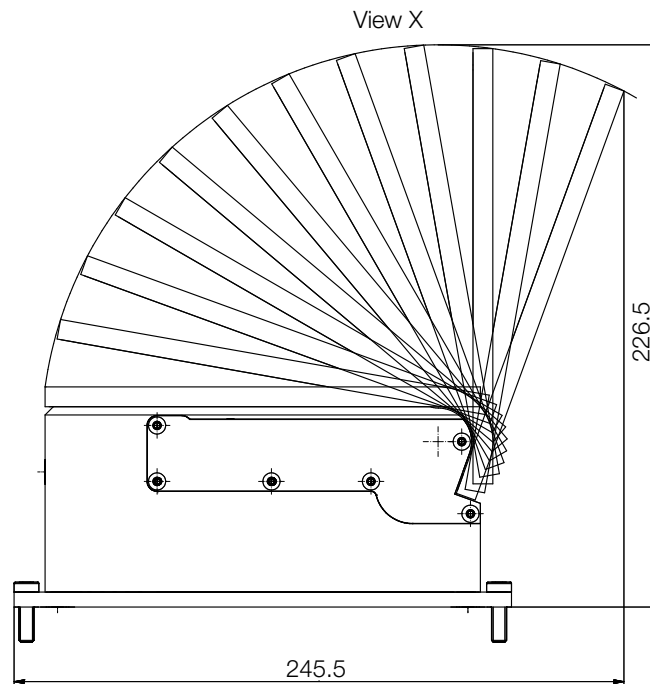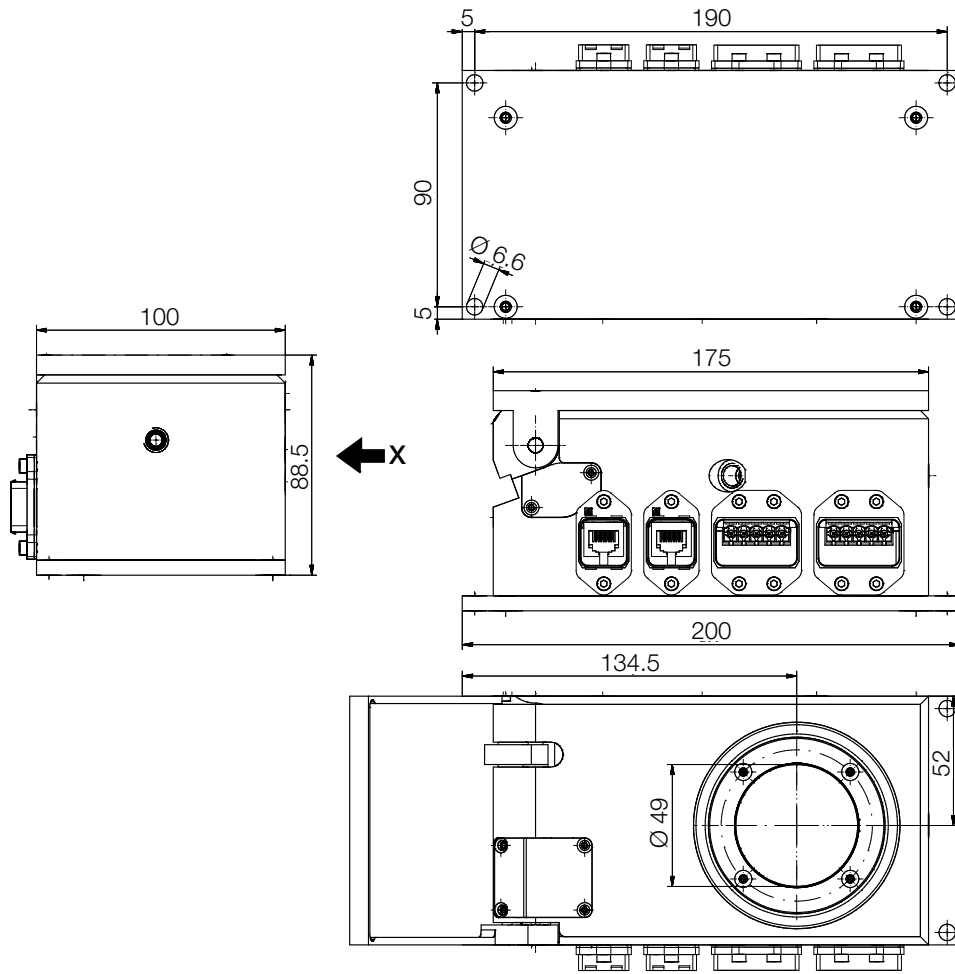
Dimensions in mm

19 Declaration of Incorporation of Partly Completed Machinery

Original Declaration of Incorporation of Partly Completed Machinery

according to the Machinery Directive 2006/42/EC, Annex II B

The manufacturer: PRIMES GmbH, Max-Planck-Straße 2, 64319 Pfungstadt, Germany
hereby declares, that the partly completed machine with the designation:

PowerMeasuringModule (PMM)

Types: PMM

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-Str. 2, 64319 Pfungstadt, Germany

The technical documentation according to Annex VII Part B of the Machinery Directive which belongs to the partly completed machinery was drawn up. 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.

This partly completed machinery is intended for the integration into a laser system. An initial operation is strictly prohibited until it was ensured that the complete machine, into which the partly completed machinery was integrated, is in compliance with the requirements of the EC-Directive 2006/42/EC as well as the Laser Safety, e.g. the DIN EN ISO 12254, the DIN EN 60825 and TROS.

Pfungstadt, August 11, 2021

Dr. Reinhard Kramer, CEO

Declaration of Incorporation

according to the Supply of Machinery (Safety) Regulations 2008

The manufacturer: PRIMES GmbH, Max-Planck-Straße 2, 64319 Pfungstadt, Germany
hereby declares, that the partly completed machine with the designation:

PowerMeasuringModule (PMM)

Types: PMM

is in conformity with the following relevant UK Regulations:

- Supply of Machinery (Safety) Regulations 2008
- Electromagnetic Compatibility Regulations 2016
- Electrical Equipment (Safety) Regulations 2016
- The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic
Equipment Regulations 2012

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

The technical documentation according to Annex VII Part B of the Machinery Directive which
belongs to the partly completed machinery was drawn up. The manufacturer obligates himself to
provide the national authority in charge with technical documents in response to a duly substantia-
ted request within an adequate period of time.

This partly completed machinery is intended for the integration into a laser system. An initial
operation is strictly prohibited until it was ensured that the complete machine, into which the partly
completed machinery was integrated, is in compliance with the requirements of the EC-Directive
2006/42/EC as well as the Laser Safety, e.g. the DIN EN ISO 12254, the DIN EN 60825 and TROS.

Pfungstadt, August 11, 2021

Dr. Reinhard Kramer, CEO

20 Manufacturer's Declaration

We, the PRIMES GmbH, declare under our sole responsibility that the device variant

PowerMeasuringModule PMM PROFINET LWL (Fiber optics)

meets the following requirements and standards:
- Guideline „Profinet Cabling and Interconnection Technology", Version 2.00 March 2007
- PI-specification „Physical Layer Medium Dependent Sublayer on 650 nm Fiber Optics" version 1.0 January 2008.
- IEC 61158-6-10/CD: 2010 Industrial Communication Networks – Fieldbus specification, Part 6-10: Application layer protocol specification – Type 10 elements (PROFINET).

21 Appendix

21.1 Max. laser power depending on the irradiation time for devices with standard absorber

Maximum permissible irradiation time in s
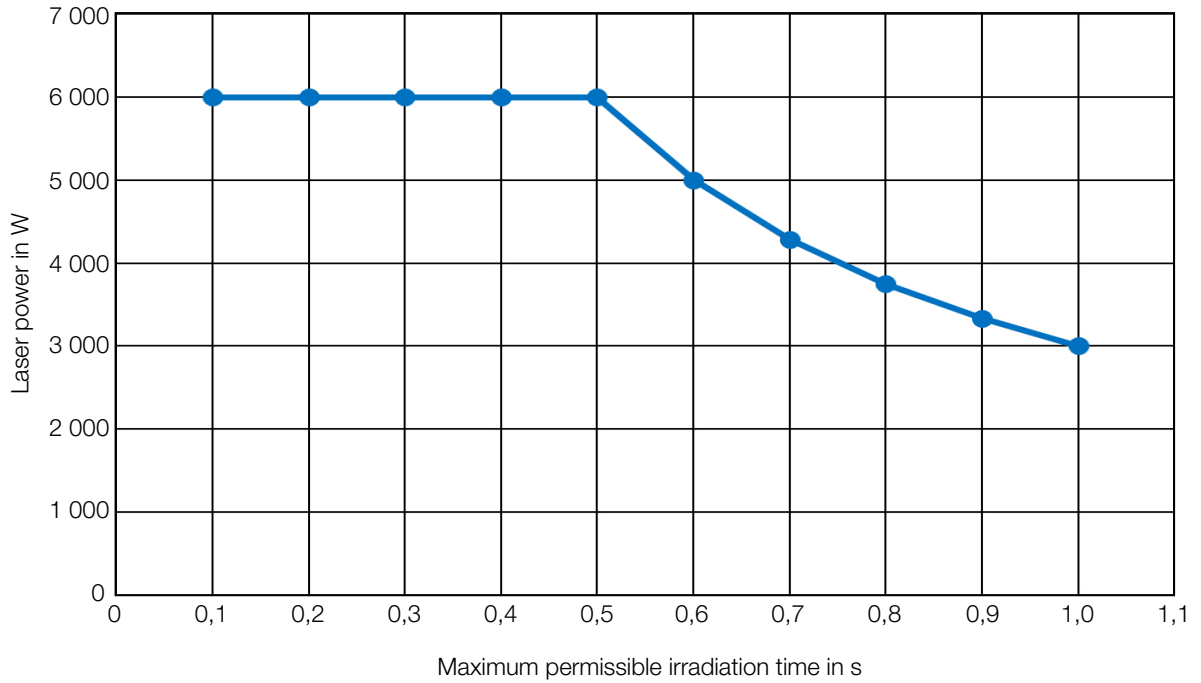
21.2 Max. laser power depending on the beam diameter for devices with standard absorber
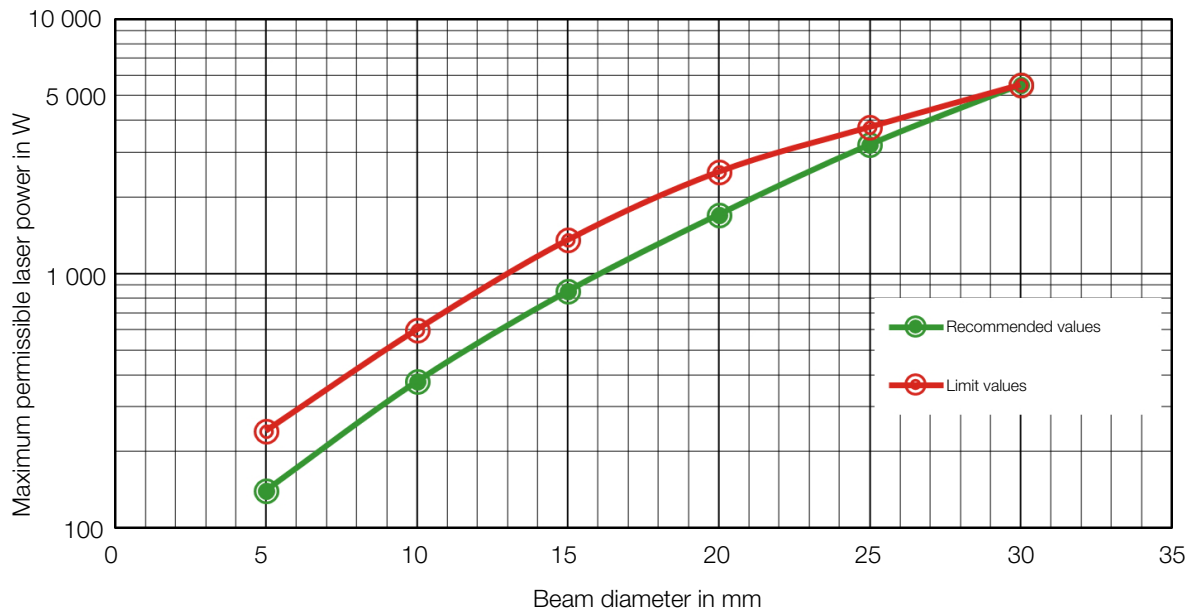
Beam diameter in mm

21.3 Max. laser power depending on the irradiation time for devices with advanced absorber
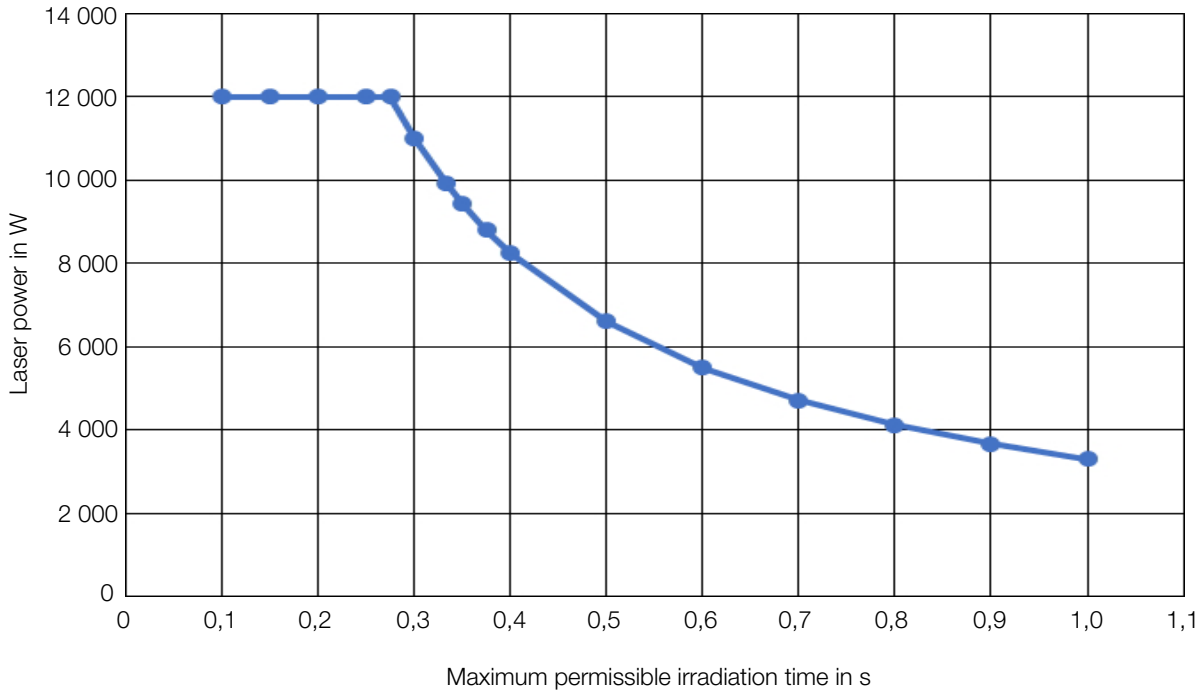
21.4 Max. laser power depending on the beam diameter for devices with advanced absorber

21.5 Add-On Instruction of the RSLogix 5000 Control Software

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