OptiSense

EN Version 4.2

Operating instructions

PaintChecker Industrial

PaintChecker Industrial Multi

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1. Introduction

1.1 Brief description

The PaintChecker Industrial systems are photothermal measuring systems in accordance with DIN EN 15042-2:2006 and the DIN EN ISO 2808:2019 standard. They are used for non-contact and non-destructive coating thickness measurement.

They are suitable for wet and dry coatings, e.. solvent-based and water-soluble paints and varnishes, powder paints and varnishes on various substrates such as metals, extruded rubber and ceramics.

A PaintChecker Industrial measuring system consists of a controller and sensor(s). Depending on the controller, it can be equipped with up to eight sensors. The sensors are connected to the controller via cables. These in turn can be connected to a higher-level sequence controller via various interfaces. The device must be installed in accordance with the national regulations for the installation of electrical systems.

Figure 1: PaintChecker Industrial Multi with various laser and LED sensors

The OS Manager software supplied can be used to carry out measurements and statistically evaluate the measured values.

1.2 Scope of delivery

The scope of delivery of the measuring system is specified in the documents *Data Sheet Controller Industrial* and *Data Sheet Sensors Industrial* (see https://optisense.com).

1.3 General information on the operating instructions

These operating instructions enable the safe and efficient use of the measuring system. The instructions are part of the delivery and must be kept in the vicinity of the measuring system at all times and be accessible to employees.

Personnel must have carefully read and understood these instructions before using the system. A basic prerequisite for working safely with the measuring system is compliance with all safety instructions and work instructions specified in these operating instructions.

Only accessories that comply with the OptiSense specifications may be used for the PaintChecker. In addition, the local safety requirements and the general safety regulations for the area of application of the measuring system also apply. Illustrations in these operating instructions are for general understanding only and may differ from the actual design.

1.4 Copyright

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1.5 Customer service

OptiSense customer service is available for technical questions:

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2. Safety instructions

2.1 Explanation of symbols for pictograms and signal words

Safety instructions are indicated in these operating instructions by hazard pictograms. These pictograms provide information about the type of danger. The signal words indicate the extent of the danger. A distinction is made between two levels of danger: Danger is the signal word for the serious hazard categories and Caution is the signal word for the less serious hazard categories.

DANGER!

The combination of symbol and signal word indicates a serious hazard category. The symbol indicates the danger of laser radiation.

DANGER!

The combination of symbol and signal word indicates a serious hazard category. This symbol indicates a fire hazard.

DANGER!

The combination of symbol and signal word indicates a serious hazard category. The symbol stands for risks caused by electricity.

ATTENTION!

The combination of symbol and signal word indicates a less serious hazard category. The symbol shows an exclamation mark.

TIPS AND RECOMMENDATIONS

This symbol highlights tips and recommendations as well as information for efficient and error-free operation.

2.2 Correct application

The PaintChecker Industrial photothermal measuring system is used to determine the thickness of wet or dry coatings in quality assurance or production-related testing. Correct use includes observing all the information contained in these operating instructions. Any use outside or beyond the correct use is considered incorrect use.

Danger if used incorrectly

Danger!

Incorrect use of the Paint-Checker Industrial system can lead to dangerous situations.

- The sensor's light beam must never be directed at highly flammable materials.
- The sensor and controller must never be used in potentially explosive atmospheres.
- The sensor must never be used to illuminate, heat or dry other objects.
- The sensor must never be used for medical purposes.
- The sensor must never be immersed in liquids.
- The sensor's light beam must never be directed at people.
- Incorrect measurement parameters can lead to damage to the measurement object.

2.3 Safety markings

2.3.1 Safety labeling in the work area

The following symbols and signs are located in the work area. They refer to the immediate surroundings in which they are located.

Attention!

Danger if signs are illegible!

Over time, stickers and signs can become dirty or otherwise unrecognizable so that hazards cannot be identified and necessary operating instructions cannot be followed. This poses a risk of injury.

- All safety, warning and operating instructions must be kept in a legible condition at all times.
- Damaged signs or stickers must be replaced immediately.

2.3.2 Safety marking on the measuring system

Warning sign 1

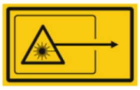
Position: Near the light source (lens of the sensor)

Warning sign 2

Position: Near the light source (lens of the sensor)

Warning sign 3

Position: Near the light source (lens of the sensor)



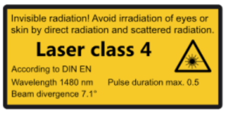
Warning sign 4

Position: Near the light source (lens of the sensor)

Warning sign 5

Laser class 1

Position: via status LEDs of the controller



Warning sign 6

Laser class 4

Position: via status LEDs of the controller

Warning sign 7

Hazard group 3 | IR

Position: via status LEDs of the controller

Warning sign 8

Hazard group 3 | UV

Position: via status LEDs of the controller

The laser safety class varies depending on the type and amperage of the laser power supply used and the working distance of the sensor.

2.4 Risks caused by electricity

Danger to life due to electric current

Danger!

There is an immediate danger to life from electric shock when touching live parts. Damage to the insulation or individual components can be life-threatening.

Type plate

Position: On top of the controller housing

- Work on the electronics of the measuring system may only be carried out by OptiSense or by personnel trained by OptiSense.
- If the insulation is damaged, the power supply must be switched off immediately and a repair arranged.
- Fuses must never be bypassed or deactivated. When replacing a fuse, the correct rating must be ensured.
- Live parts must be protected from moisture. Otherwise a short circuit may occur.
- Do not open the protective covers yourself, otherwise the warranty will be invalidated.
- The main plug must be disconnected before cleaning or maintenance work or when troubleshooting.
- The supply voltage cable must be laid in such a way that it cannot be driven over, kinked or pinched, come into contact with liquids, heat or the laser itself or be damaged in any other way.
- The supply voltage cable socket must always be easily accessible.
- The PaintChecker is intended for indoor use.
- Altitudes of up to 2000 m are intended for installation.
- Technical requirements:
  - Fluctuations in mains voltages: maximum ±10%
  - Overvoltage category II
  - Pollution degree II
  - Protection class I, the appliance must be connected to protective earthing

2.5 Dangers due to invisible light radiation from the sensor

Attention!

The accident prevention regulations of DGUV Regulation 11 and the regulations of the Occupational Health and Safety Ordinance on Artificial Optical Radiation (OStrV) must be observed.

The description of the dangers of the radiation used here is device-dependent.

The risk class applicable to the PaintChecker is indicated on the warning label of the controller. The specified exposure time limits have been determined as part of an optical test of the systems and are not generally applicable to devices of this safety class.

Incoherent radiation of risk group 3 (RG3) | IR

Radiation in the IR-A range. There is a low risk here. Damage to the retina can be largely ruled out. Even prolonged but temporary exposure to the light source does not cause any damage.

Irradiation of the skin near the exit opening on the measuring head can lead to skin damage in the focus. The optical radiation itself is not visible.

Source: LED (Cube LED-R)
Operating mode: clocked
λ: 950 nm +- 19 nm
E_e: 20.1 kW/m²

Incoherent radiation of risk group 3 (RG3) | UV

Radiation in the UV-B range. Represents a risk with brief exposure within the safety distance. Protective measures are essential here. If an individual threshold dose (minimum erythema dose) is exceeded, so-called sunburn (UV erythema) occurs. The maximum permissible irradiation of the skin is 64 seconds per day.

If the cornea is irradiated for more than 120 seconds within 1000 seconds, impairment according to the criteria of the EN 62471:2008 standard is to be expected.

Source: LED (Cube LED-B)
Operating mode: clocked
λ: 365 nm +- 9 nm
E_e: 5.4 kW/m²

LARES

A health hazard due to invisible class 1 light radiation is excluded if used correctly (see LARES®). The radiation in this system is accessible, but so weak that any damage can be ruled out. The radiation in this system is so weak that damage to the eye can be ruled out at a distance of more than 10 cm from the light source. This is important as the light radiation is in the non-visible wavelength range.

Class 1 coherent radiation

Radiation in the IR-B spectrum. Radiation in this class can be dangerous if an optical instrument (magnifying glass, microscope, etc.) is in front of the eye. Glasses are not an optical instrument in this case.

Irradiation of the skin near the exit opening on the measuring head can cause burns in the focus. The laser radiation itself is not visible.

Source: Laser diode (Tube LP, Angle LP, Line LP)
Operating mode: clocked
λ: 1480 nm
Pmax: < 5 mW (laser 16 mm)
Pmax: < 7 mW (laser 35 mm)

Class 4 coherent radiation

Radiation in the IR-B spectrum. Radiation of this class can be dangerous to the eye when looking directly into the laser beam. Therefore, direct and indirect irradiation of the eye should be avoided. The risk of injury increases with the duration of exposure.

Class 4 lasers should only be used if a direct view into the beam is unlikely.

Danger!

Irradiation of the skin near the exit opening on the measuring head can cause burns in the focus. The laser radiation itself is not visible

- The laser beam must never be directed at the eyes or skin.
- The light beam must never be viewed with optical instruments such as magnifying glasses or microscopes.
- The system may only be switched on after the light beam exit opening of the measuring head has been checked for external damage.
- The system must be switched off again immediately after the measurement and secured against being switched on again.
- If the sensor is damaged, the measuring system may no longer be used. The sensor must be returned to OptiSense GmbH & Co KG for repair.
- The maximum energy of 1.3J with a maximum duration of 1s can be emitted. The beam divergence refers to the angle to the surface normal. The total angle would then be twice as large, i.e. 14.2°.

For divergent lasers, NOHD (Nominal Ocular Hazard Distance) refers to the distance at which the measured value is equal to the exposure limit value. This distance indicates the danger zone within which there is a risk of damage to the eyes when looking directly into the laser beam. The NOHD for the laser class 4 sensor is 80 cm.

If it is necessary to work in the area of the NOHD and it cannot be ensured that the laser is inactive, appropriate personal protective equipment must be worn. This includes safety goggles that comply with the DIN EN 207 standard and are approved for lasers of operating modes D and I and for the data specified on the warning notice.

2.6 Fire hazards

Danger!

The light beam can set flammable materials, liquids or gases on fire and cause serious or even fatal injuries.

- The sensor and controller must not be used in a potentially explosive atmosphere.
- The light beam of the sensor must not be directed at highly flammable materials.
- Suitable extinguishing equipment (fire blanket, fire extinguisher) must be kept ready.
- In the event of a fire, work with the system must be stopped immediately. Leave the danger zone until the all-clear has been given and alert the fire department.

2.7 Responsibility of the operator

The operator is the person who operates the measuring system for commercial or business purposes or who allows a third party to use the system and who assumes legal responsibility for the product and the protection of users, personnel or third parties.

The system is used for commercial purposes. The operator of the system is therefore subject to the legal requirements for occupational health and safety.

In addition to the safety instructions in these operating instructions, the regulations for health and safety at work and for environmental protection that apply to the area in which the system is used must be observed. The following applies in particular:

- The operator must inform himself about the applicable occupational safety regulations and carry out a risk analysis in order to identify additional risks arising from the particular working conditions at the place of use of the measuring system. These must be implemented in the form of work instructions for the users of the measuring system.
- During the entire period in which the measuring system is used, the operator must check that his work instructions are up to date with the current uniform regulations and must adapt them if necessary.
- The operator must clearly regulate and specify who is responsible for commissioning, operation and cleaning.
- The operator must ensure that all employees who work with the measuring system have read and understood these operating instructions.
- The PaintChecker is a protection class I device and must be connected to the protective earth.
- A switch must be provided in the building installation, be easily accessible by the user and be installed near the PaintChecker. The switch must be labeled as a disconnecting device for the device (emergency stop). OptiSense recommends the Enable Box (C24-0500) for this purpose.
- The security of the system into which the PaintChecker is integrated is the responsibility of the manufacturer of the system.
- If the PaintChecker is not used as intended, the protection provided by the PaintChecker may be impaired.
- The detachable supply voltage cable must not be replaced by an inadequately dimensioned mains cable. The power supply cable must be an H05VSS / IEC53 cable with a cross-section of at least 3 x 1 mm².
- All devices connected to the PaintChecker must have safety extra-low voltage and be energy-limited circuits (fuse).
- The PaintChecker is suitable for installation in a system or a larger housing. When installing in a system or housing, ensure sufficient distance from the housing walls and adequate ventilation so that the ambient temperature does not exceed 40 °C.

The operator remains responsible for ensuring that the measuring system is free of technical faults at all times. The operator must have all safety equipment checked regularly for functionality and completeness.

2.8 Requirements for personnel

Danger!

If unqualified personnel carry out work with the measuring system or are in the danger zone of the measuring system, risks arise that can lead to serious injuries and considerable material damage.

- There is a risk of injury if personnel are not sufficiently qualified.
- Have all tasks carried out by qualified personnel only.
- Keep unqualified personnel away from the danger zone.
- Safety goggles must be worn when working with lasers. These safety goggles must be approved for the 1480 nm wavelength range and a class 4 laser as described in section 2.6.

3. Product description

3.1 The functional principle of photothermal coating thickness measurement

Non-contact, fast and efficient: photothermal coating thickness measurement is a non-contact process for paints, powder coatings and glazes on metallic and non-metallic substrates. The different thermal properties of the coating and substrate are used to determine the coating thickness.

The surface of the coating is heated up by a few degrees with a short, intense light pulse and then cools down again by dissipating the heat into deeper areas. The thinner the coating, the faster the temperature drops. The temperature curve over time is recorded with a highly sensitive infrared sensor and converted into the coating thickness.

The light pulse can be generated in various ways. Compared to xenon flash lamps, LEDs and diode lasers offer all the advantages of semiconductor technology, such as a long service life, high efficiency and absolute vibration resistance.

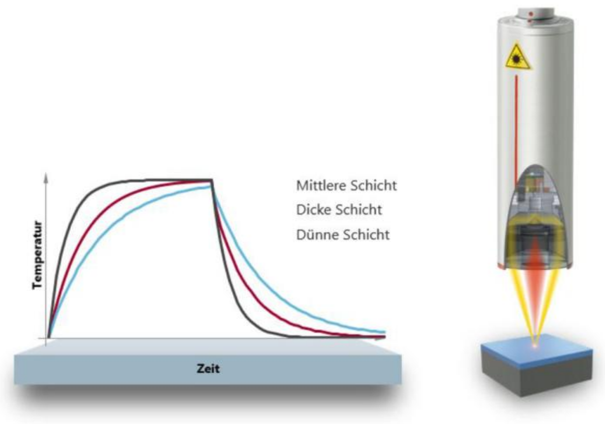


Figure 2: The functional principle of photothermal coating thickness measurement

Thanks to the exact measuring point, the method is also suitable for the smallest components. The coating thickness can even be determined on bending edges, corners and curved surfaces, where conventional measurement technology reaches its limits. Disturbances caused by rough surfaces or material grains are compensated for by optical averaging, so that even pastes and powders can be tested before baking.

The measurement is contactless and takes place from a distance of several centimeters. This means that wet and sticky coatings can be measured just as easily as soft and sensitive surfaces. Contamination of the component or carry-over of coating material is ruled out in principle.

3.2 LARES® - safety redefined

LARES® stands for safe LAser Radiation Eye Safety technology and is the intelligent answer to the continuously increasing requirements in the area of personal and eye protection. Especially when working directly with lasers, these safety requirements always have the highest priority. By using the new LARES® technology in the manufacturing and process industries, people, machines and the environment are reliably protected. The handling and use of the devices can be carried out without the need for user training and instruction requiring documentation. Thanks to LARES® technology, the devices can be used directly and without any restrictions in almost all areas of application.

Thanks to the LARES® logo on the corresponding OptiSense products, the safe laser technology is immediately recognizable. All sensors with the LARES® logo are safe for the eye and can be operated without technical protective measures. The radiation in these systems is so weak that damage to the eye at a distance of more than 10 cm from the light source can be ruled out.

3.3 Features and area of application

The PaintChecker Industrial is a photothermal coating thickness measurement system for automated use in production. It combines OptiSense's many years of experience in the manufacture of reliable and durable coating thickness measurement systems for production-related component monitoring and the production of small and therefore flexible sensors.

The underlying photothermal measuring method is standardized according to DIN EN 15042-2 and is suitable for testing moist, powdery and dry coatings on various substrates such as metal, rubber and ceramics.

The PaintChecker Industrial measuring system is designed for customer integration into automatic coating systems and consists of the following components:

- 1-8 sensors (depending on controller variant)
- Controller

The PaintChecker Industrial systems can be flexibly integrated into the production line. They detect process deviations immediately after coating and thus help to avoid returns and unnecessary material waste. Measurements can be taken both in stop-and-go mode on stationary objects and directly on moving objects using active motion compensation.

OptiSense offers measuring systems with different optics for different measuring field sizes and distances, adapted to the specific tasks. Rough surfaces, for example, can be inspected with a large measuring field, while a correspondingly smaller measuring field is suitable for small structures.

With the PaintChecker Industrial systems, a wide variety of coatings can be measured non-destructively in a wet or dry state, regardless of their geometry. Examples of coating combinations include rubber coatings wet/dry, powder coatings on metal, coated glass and coated ceramics. Further combinations can be found in the respective data sheets for the industrial sensors (see www.optisense.com).

3.4 Model overview sensors

The sensor is the heart of the measuring system. It contains the high-performance diode with folding optics and the fast infrared detector with data acquisition controller and communication interface to the controller. The geometry of the sensor as well as the measuring distance and spot size vary according to the respective measurement requirements.

The special feature of all PaintChecker Industrial systems are the extremely lightweight sensors, which weigh just 150, 280 or 330 grams, depending on the version.

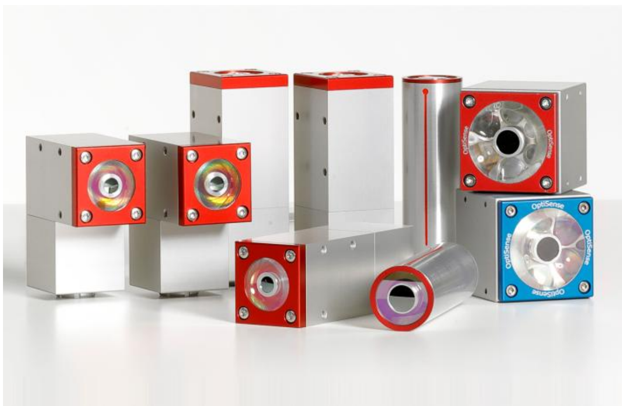


Figure 3: Model overview sensors

3.4.1 PaintChecker Industrial laser sensors Line, Angle and Tube

The OptiSense laser sensors use a diode laser as a light source - with all the advantages of semiconductor technology, such as long service life, high efficiency and absolute vibration resistance. There are versions with a tiny measuring point for micromechanical applications and special angle sensors with a folded geometry and particularly small measuring distance, which can be used even in the tightest of spaces.

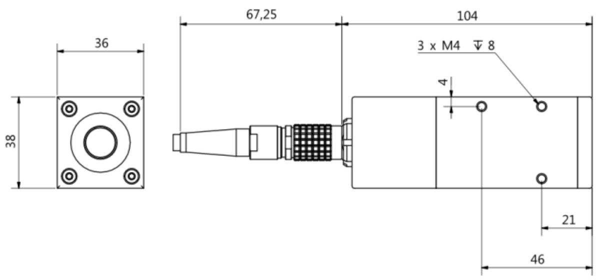


Figure 4: PaintChecker Laser Line

PaintChecker Laser Line is the new generation of OptiSense laser sensors. Thanks to the robust industrial housing, it can withstand even the harshest environments.

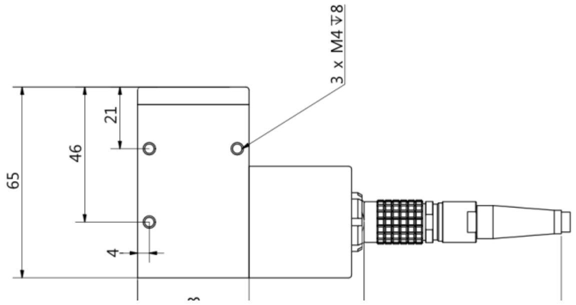


Figure 5: PaintChecker Laser Angle

PaintChecker Industrial Angle is an angle sensor equipped with special optics. This results in a particularly compact design that allows it to be used even in the tightest of spaces. The featherweight is just 77 mm long.

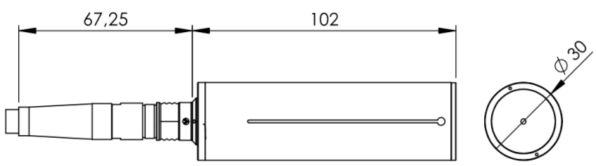


Figure 6: PaintChecker Laser Tube

PaintChecker Laser Tube is integrated into the respective coating system as a cylindrical laser sensor with a holder.

Detailed technical information can be found in the respective data sheets for the industrial sensors.

3.4.2 PaintChecker Industrial LED sensors Cube

The LED sensors called Cube have a larger measuring field than the laser versions and are particularly suitable for rough and grainy surfaces of powders and pastes. Depending on the coating material, you can choose between models with infrared and UV excitation. Of course, measurements on non-metallic surfaces are also possible. The compact sensors in the cube-shaped housing can be mounted particularly flexibly thanks to the freely selectable alignment of the cable connection and their large contact surface ensures optimum heat dissipation.

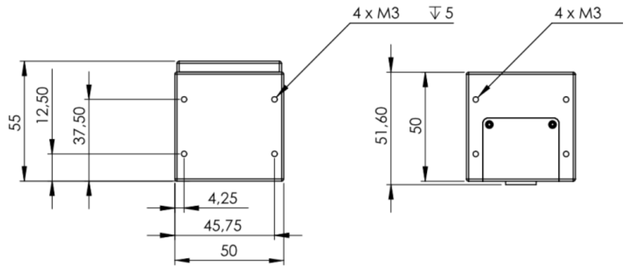


Figure 7: Dimensioned drawing Sensors Industrial Cube LED-B, LED-R

3.4.3 PaintChecker Industrial high-power variants of the sensors

Photothermal measurements on thick layers with a high glass or metal content require a higher light output. In addition, the power requirement increases with the distance between the sensor and the component. For these applications, sensors with the same external dimensions are available as a high-power version with higher output power. The 10.0 version also has a larger measuring distance and a higher energy density, so that in many cases there is no need for precision positioning of the component for the measurement.

3.5 Controller model overview

The controller is the central element of the measuring system. On the one hand, it generates the electrical energy required for the optical pulse (laser, UV or IR light) of the measurement sensor, but it also processes the signals, saves the measurement configuration and controls the data flow to the system controller.

There are three different versions of the controller:

3.5.1 PaintChecker Industrial

The PaintChecker Industrial Controller is the basic version for measurements with one sensor. The controller in a robust, dust-protected aluminum housing is available in different versions for laser and LED sensors. It is connected to the sensor via a flexible cable and can also be mounted remotely. A serial interface and a Profinet IO connection are integrated for communication with the PC and system PLC.

3.5.2 PaintChecker Industrial Multi

The PaintChecker Industrial Multi models support multi-point measurements with up to 8 sensors. They record all measuring points simultaneously and evaluate them at the same time. Measurements on several components or different component positions are carried out in a fraction of the time without cost-intensive automatic movement machines. Combined with easy integration, this results in significantly shorter throughput times.

Further advantages: improved data quality and quality control, a reduction in cost-intensive motion machines and increased efficiency. All sensors from the laser, LED or high-power series can be combined with the respective PaintChecker Industrial Multi model

3.5.3 PaintChecker Highpower models

The otherwise functionally identical high-power controllers from OptiSense have an amplified power supply unit. In addition to the higher excitation power, the associated high-power sensors have a larger measuring distance and a higher energy density, making it easier to position the component during measurement.

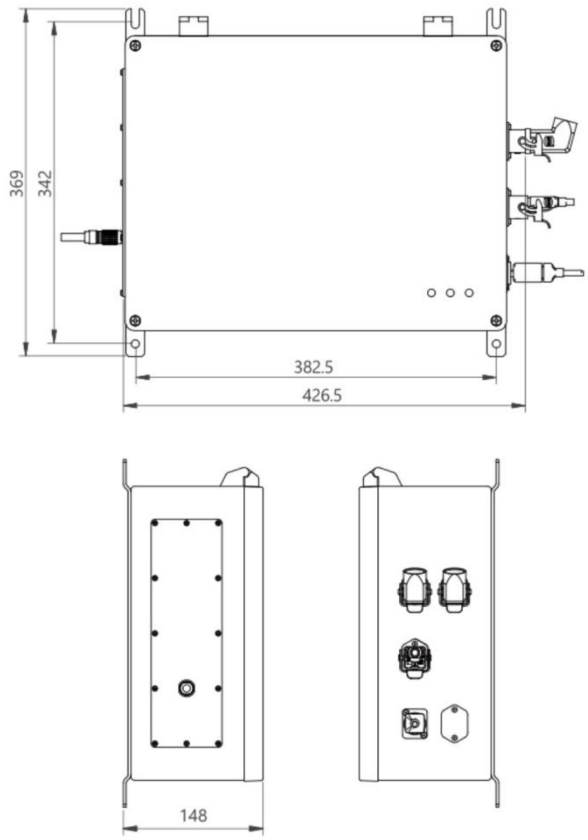


Figure 8: Dimensioned drawing | Controller industrial

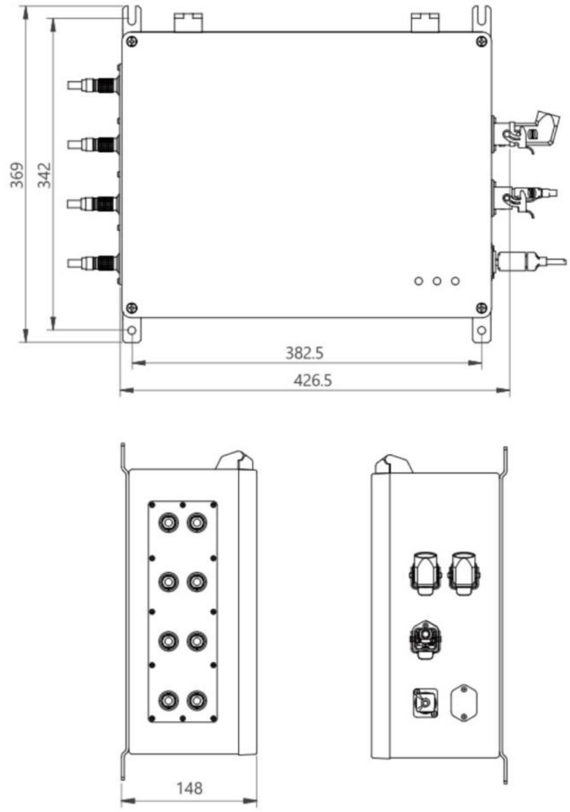


Figure 9: Controller Industrial Multi

3.6 Controller connections

For information on the terminal assignment of the control and supply cables, see chapter Pin assignments.

RJ45 network connection
Connection to external network-based communication software

Supply U~= 100-240 V
Power supply for the entire measuring system

USB B 2.0
Service interface for maintenance and calibration based on the internal OptiSense protocol (using the OS Manager)

Safety circuit
Connection to laser release (2x2 line channels) and reset control (2 lines)

Power indicator light (yellow)
Power supply U~= 100-240 V switched on

Indicator light safe (green)
The laser is disconnected by the relay contact and the system is "safe". Measurements are not possible

Laser active indicator light (red)
Indicates the pulsing of the laser or an error in the measurement process if the LED is permanently lit. When the LED is active, the sensor is actively activated and the optical power specified on the warning label is emitted.

3.7 Communication interfaces

The PaintChecker Industrial models have various communication interfaces and protocols for system control, depending on the equipment:

Each PaintChecker controller is equipped with a USB interface. The controller can be addressed via this interface using the OS Manager software or alternatively addressed and controlled using the ASCII commands described in the Input signals table.

Baud rate: 115200
Data bits: 8
Stop bits: 1
Parity: None

In addition, each PaintChecker is supplied with a further interface. This must be specified when ordering. The corresponding connection is located on connector X14. If no interface is specified by the customer, the controller is equipped with Profinet IO as standard.

Alternatively, the following interfaces can be ordered:

- Profinet IO
- DeviceNet
- EthernetIP

Other interfaces are possible by arrangement.

The PaintChecker is always controlled via input and output registers, the structure of which is described in the Input signals and output signals table. A Gdsml file and a TIA V14/V15 module can be requested from OptiSense for the Profinet IO connection.

3.8 Accessories

The optional accessories for the measuring system are listed in the *Controller Industrial data sheet* and in the data sheets for the respective *Industrial sensors.*

4. Installation

4.1 General information on installing and setting up the system

The measuring system, including the pre-assembled sensor cables, consists of two components:

- Sensor(s)
- Controller

Only cables and connections that comply with local safety regulations may be used.

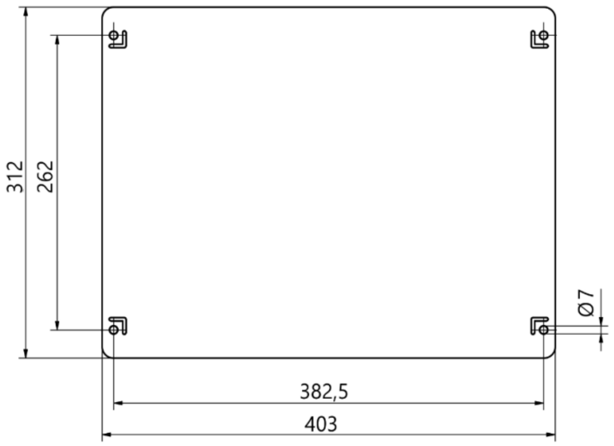


Figure 10: Controller installation dimensions

4.2 Mounting the controller

The location of the controller must be selected so that it is within reach of the supply lines of the sensors to be connected. Easy and safe access for maintenance work must be possible. Power is supplied via connector X16 on the controller.

The housing can be easily attached when closed using the wall mounting rails attached to the underside. The assembly:

- Drill hole according to Fig. 21
- Attach the bottom two screws so that they protrude from the wall at least the thickness of the tabs.
- Insert the controller using the tabs and press the controller firmly against the wall
- A second person tightens the top two screws. Then tighten the bottom two screws

Connect the controller to :

- the safety circuit and the reset lines to the Harting connector (X15)
- the Ethernet RJ45 connection (X14)/ Profinet IO or the alternative interface
- the power connection Harting plug (X16)

4.2.1 Connection of the controller to the safety circuit

If the control signals (see pin assignment X15) are disconnected, the laser control is stopped by immediately switching off the power supply. The green laser safety LED switches on. After the control signals have been closed to enable the laser, the two reset lines must be short-circuited to enable the laser energy again. If the reset line is closed while the control signals are closed, the safety circuit goes into a fault and can only be activated again after the controller has been de-energized.

Danger due to uncontrolled restart

Uncontrolled restarting of the system can lead to serious injuries.

Danger!

- Before the system is switched on again, it must be ensured that the cause of the emergency shutdown has been rectified and that all safety devices are in place and functional.
- If there is no longer any danger, the control signals can be unlocked and operation can be resumed with the reset lines.

4.2.2 Connection of the communication module

Depending on the version, the PaintChecker Industrial system is equipped with one or more communication interfaces via which the controller can be connected to a higher-level control unit.

The interface is provided via an internal module, the so-called Anybus converter. Depending on the interface, this module can be set via the corresponding connector X14 using a PC and the IPConfig software from HMS.

For other interfaces, it may be necessary to make the settings directly on the Anybus module. To do this, the PaintChecker Con troller must be opened and the settings made mechanically on the Anybus.

The measuring system is connected to the designated control unit via the respective interface using a suitable cable.

4.3 Mounting the sensor

The sensors of the Tube type should be mounted with a metal clamp of Ø = 30 mm to ensure optimum heat conduction to the rest of the mounting mechanism. This is particularly necessary for applications with high duty cycles.

The Line, Angel and Cube sensors should be attached via the screw connection in such a way that a maximum contact surface to a heat sink is ensured. The mounting plate of the sensors is usually sufficient here.

The sensor is attached at a suitable point in the production line or on the movement unit. It must be ensured that the sensor reliably maintains the intended measuring distance from the workpiece.

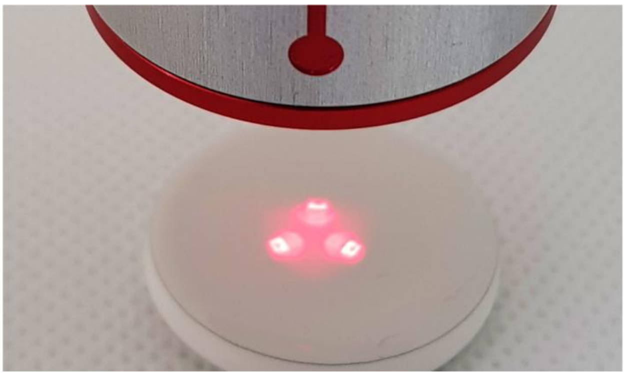


Figure 11: Incorrect distance to the measurement object

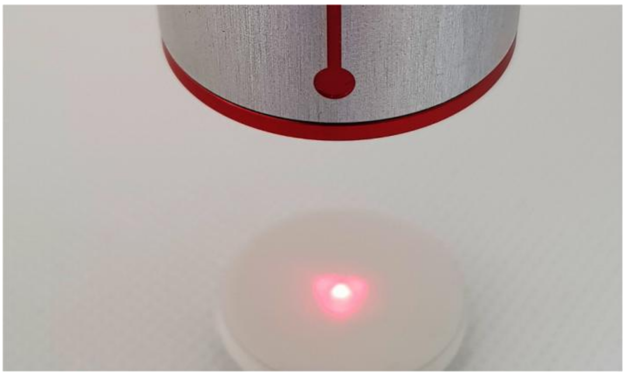


Figure 12: Correct distance to the measurement object

When mounting the sensor, it must be installed in such a way that it cannot slip or be damaged by movement.

The sensor cable is connected to the controller. The cable must not exert tensile stress on the sensor at any time. This applies in particular to moving sensors.

Minimum bending radius for fixed installation: 45 mm
Minimum bending radius freely movable: 80 mm

The order in which the sensors are connected should be noted so that the sensors can be assigned later.

Heat dissipation must be ensured!

When measuring in rooms with a high ambient temperature and when measuring with short cycle times, the sensor may overheat as excess heat cannot be dissipated (sensor temperature >40°C).

Water or other liquids must never be used to cool the sensor!

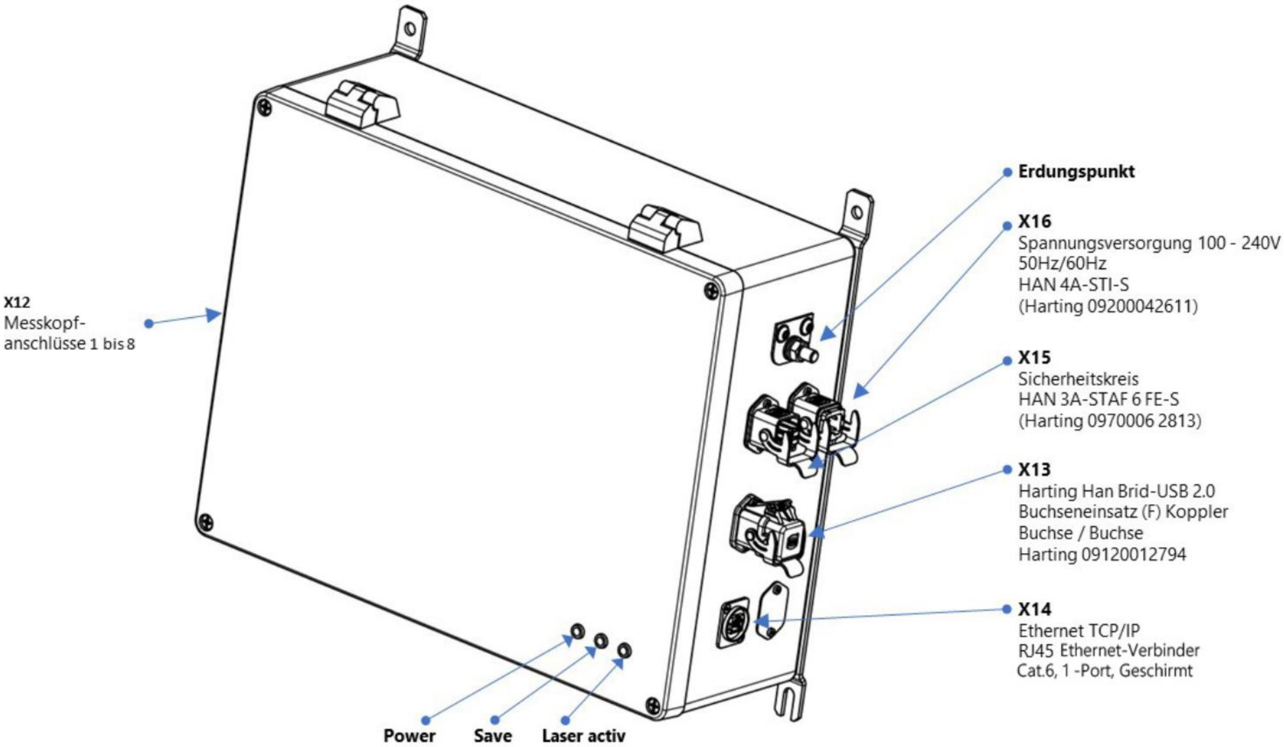


Figure 13: Pin assignment

5. Commissioning

5.1 General information on commissioning

Danger! If a PaintChecker Industrial system is operated with the housing open, live parts are accessible. Electric, magnetic and electromagnetic fields emanating from live parts can have a disruptive effect on the environment.

- The PaintChecker Industrial Controller may only be operated with the housing closed!
- The PaintChecker Industrial system can only be operated when the safety circuit is closed.
- It must be ensured that the safety circuit functions properly and is closed!

5.2 Switch on the measuring system

5.2.1 Prerequisites

- The general instructions for commissioning have been read and understood.
- The PaintChecker Industrial system has been installed correctly.

The PaintChecker Industrial measuring system performs the following when it is switched on:

- Load the last measurement settings used.
- Activate the installed communication interfaces.
- Establishing communication with the sensor connected to port 1.

The X16 plug of the PaintChecker Industrial system is connected to the power supply.

5.3 Aligning the sensor

Depending on the sensor model, the distance and permitted deviation from the measurement object vary. In order to precisely maintain the working distance to the measurement object, it makes sense to design the mounting of the sensors so that they always maintain the same distance - even if the mounting or the measurement object is shaken.

If the distance is set on the measurement object, the position LEDs built into the sensor can be used to determine the correct working distance . The correct working distance is reached when the three light points on the measurement object merge into one point. There must be no objects in the beam path of the sensor. The beam path runs conically from the lens to the measuring spot.

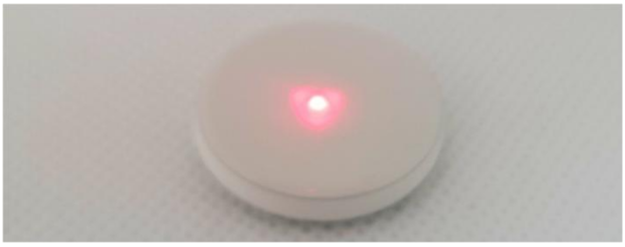


Figure 14: Correct distance to the measurement object

5.4 Establish communication

5.4.1 Prerequisites

- The general instructions for commissioning have been read and understood.
- The PaintChecker Industrial Controller is switched on and is connected to the higher-level control unit via a suitable interface.
- The higher-level control unit is set up for operation with the PaintChecker Industrial system.

5.4.2 Profinet and Devicenet (user-defined interfaces)

To connect the communication module, see pin assignments. The measuring system has the slave address "1". The Lifebit register (Output signals table, 0.0) changes its value between 0 and 1 every second. Cyclical reading can be used to determine whether the measuring system is properly registered in the network.

5.4.3 OptiSense ASCII protocol

The measuring system provides a serial interface (COM port), which is listed in the system settings of the operating system. Commands can be sent to the measuring system via the interface. A terminal program (e.g. TeraTerm) should be used to establish communication with the measuring system. The following parameters must be used for the serial interface:

Baud rate: 115200
Data bits: 8
Stop bits: 1
Parity: None

To check whether the measuring system is properly registered in the network, an s command should be sent cyclically to the system and the response string checked for the Lifebit abbreviation (Output signals table, 0.0). Its value changes between 0 and 1 every second.

6. Calibration

6.1 Introduction

The PaintChecker coating thickness gauges use the photothermal measuring method to determine the thickness of coatings on a wide variety of substrates. This non-contact, non-destructive method is ideal for measuring paints, powder coatings and glazes on metallic and non-metallic substrates.

This means that the measuring device does not measure coating thickness values directly, but that these are derived indirectly from the evaluation of the photothermal measurement signal. The individual thermal properties of the coating material and substrate must be taken into account.

Thick, heavy layers require more energy to heat up and cool down more slowly than thin, light layers. During the measuring process, it is therefore important, as in photography, to adjust the strength of the light source and the measuring time optimally to the respective situation in order to obtain accurate and reproducible measurement results.

In the case of powder coatings and paints, the user often does not want to know the thickness of the powder or wet film that has just been applied, but rather the final thickness after curing or drying. For this purpose, the device includes the expected shrinkage of the coating material during curing in the measurement.

This requires the measuring system to be calibrated against reference coating thickness values using samples. The applications contain information about the correct laser power, measurement duration, evaluation models and calibration coefficients for the specific material system. These calibrations can usually be used directly for measurements on the produced parts.

6.2 Applications provided

OptiSense applications specifically relevant to the customer are stored on each device. The scope of delivery can include applications for standard situations that already cover a large proportion of typical applications. In addition, each customer receives an application specifically tailored to their application, which is created by OptiSense using the coating samples provided. Additional applications can be obtained from OptiSense as part of an order calibration and permanently stored in the device.

The respective applications can be activated via a higher-level control system. The layer thickness is then calculated on the basis of the currently active application.

TIP!

Calibration is carried out using the OS Manager software from OptiSense. All details on the various calibration options can be found in the associated OS Manager software operating instructions.

6.3 Reference samples and reference masters

6.3.1 Reference samples

As the measuring system reacts to the thermal properties of the coating of the sample, it is necessary that the reference sample has the same material properties as the objects to be measured later. In addition, it is important that the coating thicknesses of the reference samples are distributed as evenly as possible over the coating thickness range to be measured in the application. Coating thicknesses outside the calibrated measuring range can deviate significantly from the actual thicknesses under certain circumstances.

6.3.2 Reference master

For all users who require a particularly high level of safety, accuracy and reliability when it comes to coating thickness measurement, the reference masters from OptiSense, which have been checked by a DAkkS laboratory, are the ideal solution. The reference masters are used for regular inspection of the measuring system and calibration. Reference masters are not part of the measuring system, but can be ordered as an option. Reference masters are paint samples with a defined coating thickness that are attached to a test specimen. They are custom-made products that are provided with the exact coating that will later be used in production. The reference master is therefore often produced directly from an original component.

Figure 15: The reference master

Our reference masters, which are checked by a DAkkS laboratory, are regarded as a high standard in terms of accuracy and traceability of a measurement.

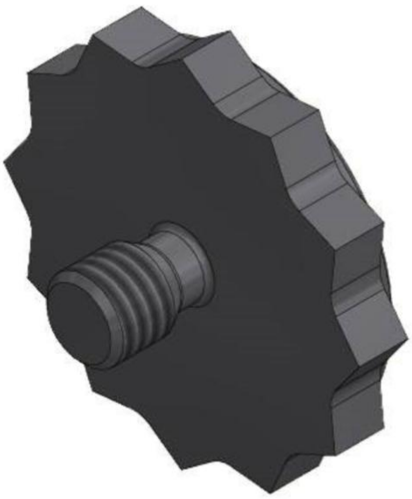


Figure 16: 3D view reference point

In addition to the standard M3 thread, other sizes are also available.

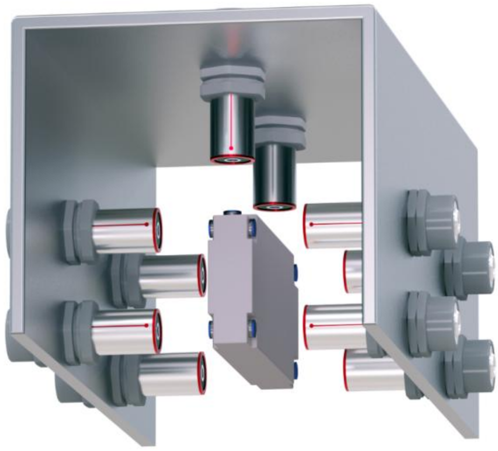


Figure 17: Measurement example reference master

7. Operation

7.1 Measuring procedure

7.1.1 Prerequisites

- The general instructions for commissioning have been read and understood by the user.
- The sensors are properly connected.
- The PaintChecker Industrial Controller is switched on.
- The PaintChecker Industrial Controller is connected to the higher-level control unit via a suitable interface.
- The higher-level control unit is set up for operation with the PaintChecker Industrial system.
- Communication between the control unit and the measuring system is established.

7.1.2 Implementation

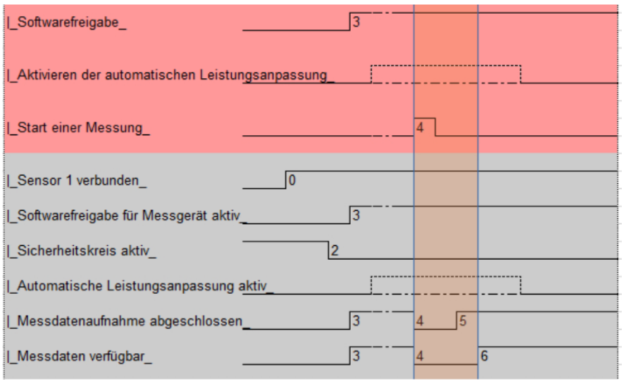


Figure 18: Typical measurement process

The illustration shows the typical measuring sequence of an automated coating thickness measurement. The fields shown in red correspond to the inputs of the higher-level control system. The fields highlighted in gray represent the feedback from the measuring system.

The following steps are required to carry out a coating thickness measurement:

1. With the PaintChecker Industrial, the sensors to be used must be activated via control channels 1.0 - 1.7. The connection status is displayed on the output channels 21.0 - 21.7.
2. A suitable calibration must then be loaded via the input signals bits 0.8 to 0.11 (Input signals table). The active calibration is displayed on output channel 10.
3. Now ensure that the safety circuit is closed. A measurement is only possible when the green LED on the controller goes out by activating the safety circuit. This is indicated via output channel 0.4 (Output signals table).
4. The software release (Input signals table, 0.0) must be granted. The successful release is displayed on the Software release active flag (Output signals table, 0.3). It is recommended that the software enable remains active until the safety circuit is switched. In addition, the signals Measurement data recording completed (table Output signals, 0.1) and Measurement data available (table Output signals, 0.5) are activated. Sensors must be connected to all activated ports in order to activate the software release.
5. If the measurement object is positioned correctly, the measurement (Input signals table, 0.4) is triggered. The *Measurement data recording completed* and *Measurement data available* signals are then deactivated. It must be ensured that the sensors are not moved during measurement data recording.
6. Once all the measurement data has been recorded, the *Measurement data recording complete* signal is activated. The sensors can now be moved to the next measuring point.
7. Once the measurement data has been fully processed, the *Measurement data available* signal is activated. The measured values can now be called up.
8. The measurement is complete.

The PaintChecker Industrial Controller features automatic power adjustment, which is activated via table input signals, 0.7. The excitation power of the light source is regulated in such a way that optimum measurement results can be achieved. However, this is sometimes associated with a longer measurement time, as the power of individual sensors is adjusted during the measurement.

It is recommended to use this function, if required, only at the beginning for the first point of a measurement series. This bit is only used for special applications in consultation with OptiSense.

Further measurements are then carried out with the power settings determined at the first point. The status of the automatic power adjustment can be read out in table Output signals 0.6.

7.2 Self-test

As described in the photothermal standard DIN EN 15042-2:2006, the basic functional test of the measuring system should be carried out using an optically impermeable homogeneous test specimen with good long-term stability. This check serves to ensure proper operation and should be repeated at regular intervals.

A reference glass (NG1) with defined optical and thermal properties, available from OptiSense as an accessory, is used as the test specimen. During the test, this plate should be positioned exactly at the working distance (see technical data).

After mounting the reference sample, the measuring system can be set to self-test mode with the help of input signal 0.12. The necessary measurement settings are transferred to all activated sensors. The necessary measurement settings are transferred to all activated sensors.

The reference measurements can then be carried out as described in the Measurement sequence chapter. The measured time signal for each sensor is now output on the channels for the coating thickness. The strength of the photothermal signal can be read out on the channels for the photothermal amplitude. The values indicate the percentage deviation from the target values stored in the respective sensor.

If one of the above values is outside the permitted specifications, this is displayed as an error message on the error channel of the respective sensor.

8. Communication protocols

8.1 Introduction

Various communication interfaces are available to control the PaintChecker Industrial system, depending on the configuration. The most common interfaces Profinet IO, Modbus RTU, DeviceNet and NativeIP can be accessed via the RJ45 connection. The OptiSense ASCII protocol can be accessed via the USB interface. The protocols are described in the tables below.

The control commands are described in the Input signals table in the *measuring system control protocol*. The output parameters can be found in the Output signals table in the measuring system control protocol.

8.2 Modbus RTU

To control the measuring system via Modbus RTU, the register entries in the *Modbus RTU register* column specified in the Input signals table and Output signals table must be used. The measuring system can be accessed as a Modbus slave via address "1".

The serial interface of the control unit must first be set to the following parameters:

Baud rate:	57600
Data bits:	8
Stop bits:	1
Parity:	None

The registers of the control commands (Input signals table) can be sent completely with the function code *Write multiple coils* (0x0f) and individually with the code *Write single coil* (0x05).

The register structure of the output signals (Output signals table) can be read out using the *Read Input Register* (0x04) function code. The cycle time is 50 ms.

8.3 Profinet

The Profinet interface is implemented via a protocol converter that is connected to the Modbus RTU slave interface as a master. The 16-bit values are output in little-endian notation.

To connect the higher-level control system to the measuring system, the corresponding configuration file (GDSML) of the converter must first be integrated into the control system (see control system manual).

The register addresses specified in the Input signals table and Output signals table can then be written or read. The cycle time here is 20 ms. New commands are transmitted when the signal changes (update-on-change).

8.4 OptiSense ASCII protocol

The PaintChecker Industrial Controller is controlled using ASCII commands via the serial interface of the measuring system.

The serial interface of the control unit must first be set to the following parameters:

Baud rate:	115200
Data bits:	8
Stop bits:	1
Parity:	None

The character strings listed in the ASCII command column (see chapter 10.2 Measuring system control protocol) must be used for this purpose.

Feedback is provided via the specified entries. If several values are output at the same time, they are separated by a semicolon.

In addition to the messages from the measuring system relating to command inputs, the current measurement data status and the current system status can be queried using the s command.

8.5 Error codes

In the event of measurement errors, the error messages for the controller and each sensor are output separately (Output signals table) The error messages are bit-coded so that several error messages can be output simultaneously on one channel. These can then be broken down using the *Error bits* table.

Example:

Error code 134 is output. This corresponds to error bits 1, 2 and 7, as 21 + 22 + 27 = 134

Error bit	Error description	Instruction for action
0	Measurement was triggered, but software release is not activated	Activate software release
1	Measurement was triggered, but safety circuit is not activated	Close the safety circuit and reset the safety switch
2	Warning of increased sensor temperature	• Reduce measuring frequency if possible • Mount the sensor in a heat-dissipating holder
3	Sensor overheated	• Reduce measuring frequency if possible • Mount the sensor in a heat-dissipating holder
4	Laser power too low	Please contact OptiSense Service
5	Photothermal signal too weak	Use a measurement setting with higher laser power
6	Photothermal signal too high	Use a measurement setting with lower laser power
7	Component temperature too low (< 0° C)	Heat the component to room temperature
8	Error in the laser supply	Please contact OptiSense Service
9	Amplitude signal of the reference measurement outside the specifications	• Make sure that the reference surface is clean and free of scratches. • Check the correct positioning of the reference sample in relation to the sensor • If the error persists, please contact OptiSense Service
10	Time signal of the reference measurement outside the specifications	• Make sure that the reference surface is clean and free of scratches. • Check the correct positioning of the reference sample in relation to the sensor • If the error persists, please contact OptiSense Service
11	Layer thickness above calibration limit	Use a calibration with a higher boundary layer thickness
12	Layer thickness below calibration limit	Use a calibration with a lower boundary layer thickness
13	Photothermal signal below calibration limit	Use a calibration with a lower limit for the photothermal signal
14	Sensor not connected	Make sure that the sensor is connected to the activated port of the sensor

Table 1: Error bits

9. Maintenance

9.1 Spare parts

TIP!

An annual inspection and maintenance of the measuring system by OptiSense or by personnel instructed by OptiSense is recommended.

The following spare parts are available from OptiSense GmbH & Co:

- Sensor
- Sensor cable
- Controller
- Harting connector set (power supply, network and safety circuit)

Spare parts suitable for the measuring system are available from OptiSense, stating the serial number of the controller and the systems.

E-Mail: info@optisense.com
Phone +49 23 64 50 882-0

9.2 Replacing the sensor cable

To replace a defective cable, first make sure that the power supply to the controller is disconnected. If this is not possible due to the higher-level control system, plug X16 should be removed. All controller LEDs must be inactive (off).

The plugs of the defective cable must now be disconnected on the controller and sensor side. Remove the cable and insert the new cable into the cable guide (red side on the sensor and black side on the controller). Turn the plugs so that the red dots on the plug and socket are opposite each other. Then insert the plug until it clicks into place.

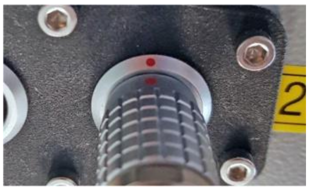
Plug	
Controller	**Sensor**
	
	

Table 2: Sensor cable plug

9.3 Controller replacement

If a replacement controller has been ordered for a specific system, it is already set up so that it can be used with the existing sensors for the respective measuring task. However, the specific network parameters for your system must be entered.

First remove all plugs from the defective controller and mark each sensor cable so that it is clear which socket it was plugged into. The defective controller is then removed from the system.

After installing the new controller, all plugs are reconnected to the corresponding sockets. Cable X16 must be plugged in last so that the power supply is not connected before the sensor cables are plugged in.

A PC on which the IPConfig software from HMS is installed is required for the network settings of the new controller. This is available free of charge at the following link:

https://www.anybus.com/technical-support/pages/files-and-documentation/?ordercode=AB7013

First establish a network connection between the PC and controller (either via the associated switch or directly via connector X14) and then start the IPConfig software.

The corresponding Anybus (default setting on delivery Name: PaintChecker DHCP: ON) is selected via the *Refresh button* in the top left-hand corner (see Fig. 20).

You can now enter the appropriate network setting for the system on the right-hand side of the window and apply it by clicking *Apply*. The settings are active as soon as the controller has been de-energized.

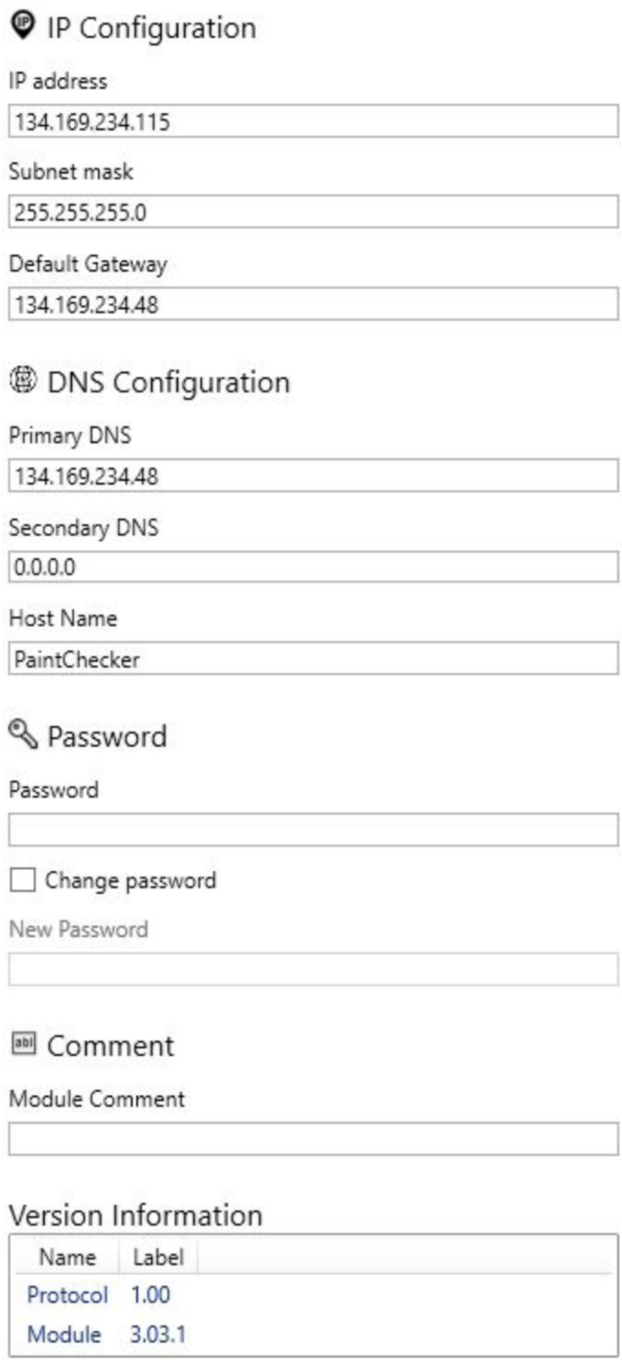


Figure 19: System configuration

9.4 Sensor replacement

To replace a sensor, the power supply to the controller must be disconnected. If this is not possible due to the higher-level control system, plug X16 must be removed. All controller LEDs must be inactive (off). Then remove the red end of the cable from the sensor if necessary.

The replacement sensor is turned so that the red dot on the cable and sensor are aligned. The plug is inserted until it clicks into place.

Once the power supply to the controller has been restored, the LEDs on the sensor will first flash and then light up permanently as soon as the software has been enabled by the higher-level control system. The sensor is now operational.

To adjust the distance between the sensor and the target, align the sensor so that the three LED dots of the illuminated sight converge at one point. For optimum adjustment, several measurements should be carried out with slightly varying distances. The sensor is set correctly when the *Photothermal Amplitude* value displayed is maximum.

9.5 Transportation and storage

Improper storage can lead to material damage to the measuring system. Controller and sensor...

- Do not store outdoors
- Store in a dry and dust-free place
- Do not expose to aggressive substances
- Protect from sunlight
- Avoid mechanical shocks

9.6 Cleaning and care

All maintenance work must be carried out exclusively by OptiSense GmbH & Co KG. In particular, the controller must never be opened by unqualified personnel and the front ring of the sensor must never be unscrewed.

Attention! The use of corrosive, abrasive and scratching cleaning agents can cause considerable material damage to the sensor.

Never use solvents for cleaning Please only use lens cleaning cloths for lens cleaning. In case of heavy soiling, wipe the controller and sensor with a damp, soft cloth.

9.7 Waste disposal

The symbol "crossed-out waste garbage can" indicates that this appliance may only be disposed of separately from other types of waste and not with household waste. We will always repair defective appliances . Please contact us at Service@optisense.com. This saves resources and protects the environment.

The PaintChecker Industrial also contains a lithium buffer battery. This must not be disposed of with household waste. There is a legal obligation to return used batteries to the appropriate collection points. Used batteries may contain harmful substances that can damage the environment or your health if they are not stored or disposed of properly. There is a legal obligation to return used batteries to the appropriate collection points. You can either send the batteries back to us after use or return them free of charge, e.g. to a retailer or municipal collection point.

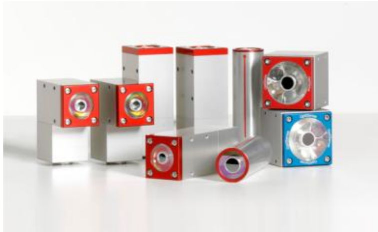
10. Technical data

10.1 System specifications

10.1.1 Types

The aluminum sensors are designed for mounting on fixed mounts.

The pre-assembled cable between the sensor and controller is 3 m long, but is also available in a 5 m version.



Technical data | Laser sensors Industrial						
Model	**Laser Angle LP**	**Laser Angle HP**	**Laser Tube LP**	**Laser Tube HP**	**Laser Line LP**	**Laser Line HP**
Design	Angle		Cylinder		Mini Tower	
Measuring range	1 - 1000 µm					
Measuring rate	max. 2.5 Hz					
Measuring time	125 - 1000 ms; laser pulse: maximum 500ms					
Operating mode	Pulse operation					
Resolution	1 % of the measured value					
Accuracy	3 % of the measured value					
Measuring distance from the lens	35 mm	100 mm	35 mm	100 mm	35 mm	100 mm
Distance tolerance	± 2.5 mm	± 5 mm	± 2.5 mm	± 5 mm	± 2.5 mm	± 5 mm
Angular tolerance to the surface of the measurement object	± 15 °					
Measuring field size	0.3 mm	0.5 mm	0.3 mm	0.5 mm	0.3 mm	0.5 mm
Max. Pulse energy	650 mJ	1250 mJ	650 mJ	1250 mJ	650 mJ	1250 mJ
Wavelength	1480 nm					
Beam divergence	20,3°	7,1°	20,3°	7,1°	20,3°	7,1°
Eye-safe	Yes	no	Yes	no	Yes	no
Dimensions (L x W x H)	87 x 28 x 41 mm		Ø 30 x 102 mm		38 x 36 x 104 mm	
Weight	330 g		150 g		330 g	
Laser class	1	4	1	4	1	4

Table 3: Laser sensor specifications

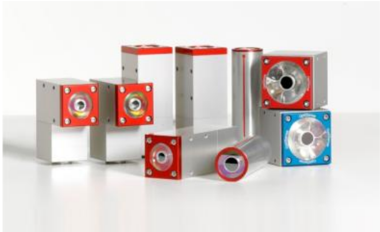
Technical data | LED sensors Industrial		
Model	**Cube LED-R**	**Cube LED-B**
Design	Cube	
Measuring range	1 - 1000 µm	
Measuring rate	max. 2.5 Hz	
Measuring time	125 - 1000 ms	
Operating mode	Pulse operation	
Resolution	1 % of the measured value	
Accuracy	3 % of the measured value	
Measuring distance from the lens	33 mm	
Distance tolerance	± 3 mm	
Angle tolerance	± 45 °	
Measuring field size	1 mm	
Max. Pulse energy	1700 mJ	850 mJ
Wavelength	980 nm	360 nm
Risk group	Risk 1	Risk 3
Eye-safe	Yes	
Dimensions (L x W x H)	50 x 51.6 x 55 mm	
Weight	280 g	
Protection class	IP 50	

Table 4: Specifications LED sensors

10.1.2 Controller

The aluminum sensors are designed for mounting on fixed mounts.

The pre-assembled cable between the sensor and controller is 3 m long, but is also available in a 5 m version.



Technical data | Controller Industrial						
Model	**LP**	**LED**	**HP**	**Multi LP**	**Multi LED**	**Multi HP**
Sensor outputs	1	1	1	8	8	8
Sensor type	Laser	LED	High-power laser	Laser	LED	High-power laser
Protection class	IP50					
Power supply	$U_{\sim}$ = 100-240 V; $f_{\sim}$ =50/60 Hz					
Power consumption	400 W					
Standardization	DIN EN 15042-2					
Dimensions (L x W x H)	369 x 426.5 x 148 mm					
Weight	13.5 kg					
Interfaces	Profinet IO / deviceNet / NativeIP: RJ45 USB					
Air humidity	0 - 90 %, non-condensing					
Operating temperature	10 - 40 °C					
Storage temperature	0 - 50 °C					

Table 5: Controller specifications

10.1.3 Block diagram

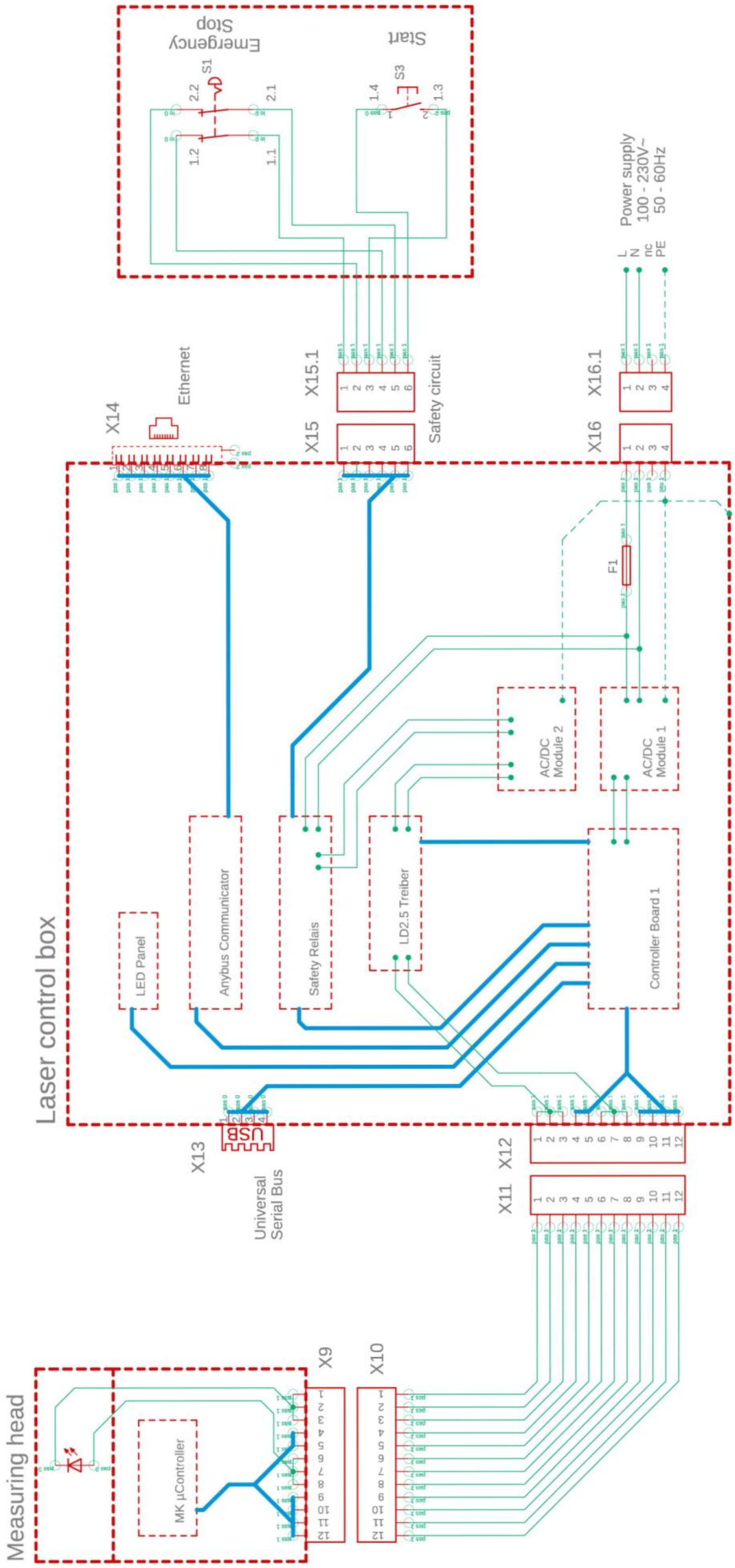


Figure 20: Block diagram

10.1.4 Unlocking process

The light source/laser is activated in a coupled manner via two separate µC systems. The central µC is located in the industrial controller. The controller board communicates with up to 8 sensors.

a. When "Enable" is activated via software, a relay connected in series on controller board 1 is activated by both the measuring head and the controller board (see -> block diagram).

b. Only when an enable signal is received from the µC on the controller board 1 and a request is made by the µC in the measuring head is a PWM signal generated by the controller's measuring head sent to the laser driver's power output stage via the two relays connected in series.

c. Each sensor has its own power output stage, which is additionally switched via an enable bus line controlled by the controller board 1.

The power output stages of all sensors are connected to a separate AC/DC module 2 power supply unit whose input power is protected by a safety relay (PNOZ). The sensor contact of this safety relay can be read out potential-free in Controller Board 1. However, the safety relay itself cannot be controlled by the µC. For this purpose, the completely galvanically isolated lines to the safety circuit (emergency stop, 2-stage) and for resetting the safety relay are routed to the outside. The safety relay does not activate automatically after a fault.

10.1.5 Security concept

a. In the industrial controller: Each sensor ends the measurement and thus the PWM signal independently. A maximum measuring time of 1 second can be set in the sensor software with a maximum duty cycle of 50 %.

b. In one of the sensors: The µC on controller board 1 configures the sensors via software and therefore "knows" the expected measurement time of each sensor. As the sensors are queried individually for data at the end of the measurement time, the "Enable" relay of all sensors is switched off by the controller after a response timeout of approx. 500 ms after the expected end of the measurement time, thus interrupting any static PWM signal that may still be present from a defective sensor. Accordingly, the corresponding laser is switched off after approx. 2.5 seconds at the maximum measuring time of 2 seconds.

10.1.6 Pin assignments

X14: TCP/IP connection controller (cable length max. 35 m)				
Function	**Harting RJ Industrial IP67Data3A**	**Cable number**	**RJ45 female/male Control**	**RJ45 pin number**
Tx+	1	1	Tx+	1
Tx-	7	2	Tx-	2
Rx+	3	3	Rx+	3
Rx-	9	4	Rx-	6

Table 6: Pin assignment X14

X15 / X15.1: Safety circuits controller (max. cable length see below 1*)			
Function	**Harting housing Plug/socket** Han 4A-STI-S	**Cable number**	**Switch connections**
START (laser enable) EMERGENCY OFF 1	X15.3 X15.6	1 2	S3 / 1.3 S3 / 1.4
EMERGENCY OFF 2 START (laser enable)	X15.1 X15.4	3 4	S1 / 1.1 S1 / 1.2
EMERGENCY OFF 1	X15.5 X15.2	5 6	S1 / 2.1 S1 / 2.2

1* Calculation of the max. cable length lmax in the input circuit: lmax = Rlmax/(Rl/km)
with Rlmax = max. total cable resistance and Rl/km = cable resistance/km

Table 7: Pin assignment X15 / X15.1

X16 / X16.1: Power supply U~= 100-240 V; f~=50/60 Hz (cable length max. 35 m)				
Function	**Harting connector** Han 3A-STAF 6 FE -S	**Harting socket** Han 3A-STAF 6	**Cable number**	**Power supply 240V~/50Hz**
L	X16.1	X16.1.1	1	~ L
N	X16.2	X16.1.2	2	~ N
Reserve	X16.3	X16.1.3	3	Reserve
PE	X16.4	X16.1.4	PE	PE

Table 8: Pin assignment X16 / X16.1

X17: Anybus PC connection (cable length max. 35 m)			
Anybus Function	**Anybus** PC connection	**Sub-D** Function	**LTW socket** DB-09PFFS-SL7001
GND	1	GND	X17.5
GND	2	GND	X17.5
RS232 Rx	3	RS232 Tx	X17.3
RS232 Tx	4	RS232 Rx	X17.2

Table 9: Pin assignment X17

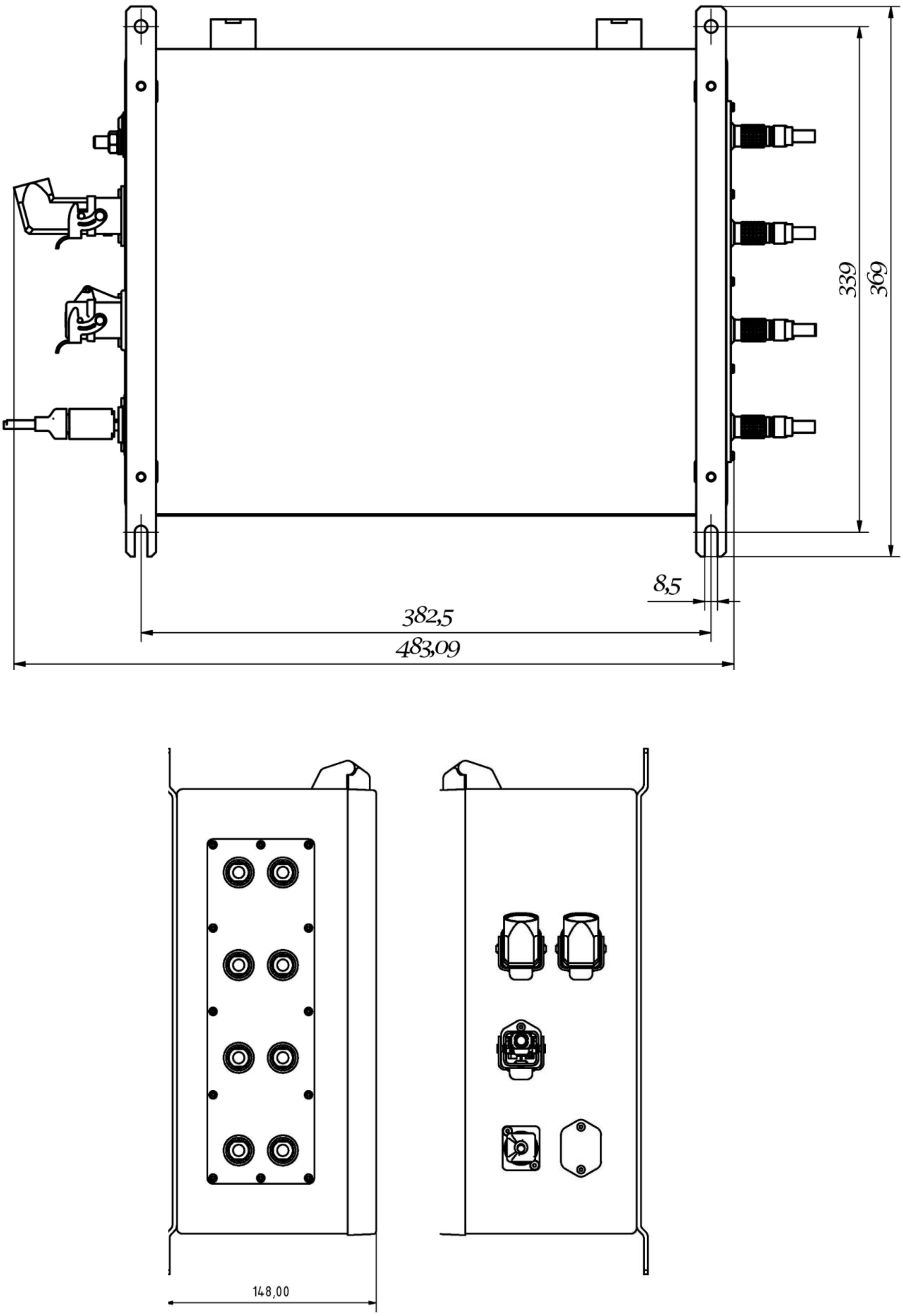


Figure 21: Plug positions

10.2 Measuring system control protocol

10.2.1 Control commands

				Modbus RTU Register		ASCII		Profi-Net IO
#	Designation	Unit	Size	Byte	Bit	Command	Abbreviation	Range
0	Digital input register 1		2 byte	0				0 - 15
0.0	Software release	#	1 bit	0	0	fe,<#>	mse	0
0.1	Not documented	#	1 bit	0	1			1
0.2	Not documented	#	1 bit	0	2			2
0.3	Not documented	#	1 bit	0	3			3
0.4	Start a measurement	#	1 bit	0	4	tt	cth	4
0.5	Not documented	#	1 bit	0	5			5
0.6	Resetting the error counter	#	1 bit	0	6	r	ecc	6
0.7	Activating the automatic power adjustment	#	1 bit	0	7	fa,<#>	aas	7
0.8	Selection of the measurement settings Bit 0	1-16	1 bit	0	8	cla,<#>	acg	8
0.9	Bit 1	1-16	1 bit	0	9			9
0.10	Bit 2	1-16	1 bit	0	10			10
0.11	Bit 3	1-16	1 bit	0	11			11
0.12	Activation of the self-test with gray glass sample	#	1 bit	0	12	fs,<#>	sts	12
1	Digital input register 2		2 byte	1				16 - 31
1.0	Activation of sensor 1	#	1 bit	1	0	oca,1,<#>	con1	16
1.1	Activation of sensor 2	#	1 bit	1	1	oca,2,<#>	con2	17
1.2	Activation of sensor 3	#	1 bit	1	2	oca,3,<#>	con3	18
1.3	Activation of sensor 4	#	1 bit	1	3	oca,4,<#>	con4	19
1.4	Activation of sensor 5	#	1 bit	1	4	oca,5,<#>	con5	20
1.5	Activation of sensor 6	#	1 bit	1	5	oca,6,<#>	con6	21
1.6	Activation of sensor 7	#	1 bit	1	6	oca,7,<#>	con7	22
1.7	Activation of sensor 8	#	1 bit	1	7	oca,8,<#>	con8	23

Table 10: Input signals

10.2.2 Output signals

				Modbus RTU register		ASCII		Profi-Net IO
#	**Designation**	**Unit**	**Size**	**Byte**	**Bit**	**Command**	**Abbreviation**	**Range**
0	Digital output register	#	2 byte	0			DIO	0 - 15
0.0	Lifebit of the measuring controller	#	1 bit	0	0	s	l	0
0.1	Measurement data recording completed	#	1 bit	0	1	s	m	1
0.2	Layer thickness calculation completed	#	1 bit	0	2	s	c	2
0.3	Software release for measur-ing device active	#	1 bit	0	3	s	m	3
0.4	Safety circuit active	#	1 bit	0	4	s	s	4
0.5	Measurement data available	#	1 bit	0	5	s	u	5
0.6	Automatic power adjustment status	#	1 bit	0	6	s	A	6
0.7	Laser driver status (High Power Controller only)	#	1 bit	0	7	s	L	7
0.8	Status self-test with gray glass	#	1 bit	0	8	s	S	8
1	Layer thickness (at sensor 1)	0.1 µm	2 byte	1		sr	RCT	16 - 31
2	Not documented	0,01 W	2 byte	2		sr		32 - 47
3	Temperature of the meas-ured object (at sensor 1)	0,01 °C	2 byte	3		sr	BGT	48 - 63
4	Temperature of the sensor (at sensor 1)	0,01 °C	2 byte	4		sr	DET	64 - 79
5	Number of measurements (High-Word)	#	2 byte	5		sr	DNH	80 - 95
6	Number of measurements (low-word)	#	2 byte	6		sr	DNL	96 - 111
7	Runtime (High-Word)	ms	2 byte	7		sr	DTH	112 - 127
8	Runtime (Low-Word)	ms	2 byte	8		sr		128 - 143
9	Photothermal amplitude (at sensor 1)	0,01 °C	2 byte	9		sr	AMP <0,1,2>	144 - 159
10	Number of the current measurement setting	#	2 byte	10		s	#callND	160 - 175
11	Not documented	0	2 byte	11		sr	0	176 - 191
12	Not documented	0	2 byte	12		sr	0	192 - 207

				Modbus RTU register		ASCII		Profi-Net IO
#	**Designation**	**Unit**	**Size**	**Byte**	**Bit**	**Command**	**Abbreviation**	**Range**
13	Not documented	0	2 byte	13		sr	0	208 - 223
14	Not documented	0	2 byte	14		sr	0	224 - 239
15	Not documented	0	2 byte	15		sr	0	240 - 255
16	Not documented	0	2 byte	16		sr	0	256 - 271
17	Not documented	0	2 byte	17		sr	0	272 - 287
18	Numbers for error messages	#	2 byte	18		sr	ECC	288 - 303
19	Error code for sensor 1	#	2 byte	19		sr	ERS	304 - 319
20	Error code for measuring controller	#	2 byte	20		sr	ERC	320 - 335
21	Connection status sensors tab	#	2 byte	21		s	CON	336 - 351
21.0	Sensor 1 connected	#	1 bit	21	0	s	1	336
21.1	Sensor 2 connected	#	1 bit	21	1	s	2	337
21.2	Sensor 3 connected	#	1 bit	21	2	s	3	338
21.3	Sensor 4 connected	#	1 bit	21	3	s	4	339
21.4	Sensor 5 connected	#	1 bit	21	4	s	5	340
21.5	Sensor 6 connected	#	1 bit	21	5	s	6	341
21.6	Sensor 7 connected	#	1 bit	21	6	s	7	342
21.7	Sensor 8 connected	#	1 bit	21	7	s	8	343
22	Layer thickness at sensor 2	#	2 byte	22		sr	RCT (per line)	352 - 367
23	Layer thickness at sensor 3	#	2 byte	23		sr	RCT (per line)	368 - 383
24	Layer thickness at sensor 4	#	2 byte	24		sr	RCT (per line)	384 - 399
25	Layer thickness at sensor 5	#	2 byte	25		sr	RCT (per line)	400 - 415
26	Layer thickness at sensor 6	#	2 byte	26		sr	RCT (per line)	416 - 431
27	Layer thickness at sensor 7	#	2 byte	27		sr	RCT (per line)	432 - 447
28	Layer thickness at sensor 8	#	2 byte	28		sr	RCT (per line)	448 - 463
36	Temperature of the measured object at sensor 2	#	2 byte	36		sr	BGT (per line)	576 - 591
37	Temperature of the measured object at sensor 3	#	2 byte	37		sr	BGT (per line)	592 - 607
38	Temperature of the measured object at sensor 4	#	2 byte	38		sr	BGT (per line)	608 - 623
39	Temperature of the measured object at sensor 5	#	2 byte	39		sr	BGT (per line)	624 - 639

				Modbus RTU register		ASCII		Profi-Net IO
#	**Designation**	**Unit**	**Size**	**Byte**	**Bit**	**Command**	**Abbreviation**	**Range**
40	Temperature of the meas-ured object at sensor 6	#	2 byte	40		sr	BGT (per line)	640 - 655
41	Temperature of the meas-ured object at sensor 7	#	2 byte	41		sr	BGT (per line)	656 - 671
42	Temperature of the meas-ured object at sensor 8	#	2 byte	42		sr	BGT (per line)	672 - 687
43	Temperature from sensor 2	#	2 byte	43		sr	DET (per line)	688 - 703
44	Temperature from sensor 3	#	2 byte	44		sr	DET (per line)	704 - 719
45	Temperature from sensor 4	#	2 byte	45		sr	DET (per line)	720 - 735
46	Temperature from sensor 5	#	2 byte	46		sr	DET (per line)	736 - 751
47	Temperature from sensor 6	#	2 byte	47		sr	DET (per line)	752 - 767
48	Temperature from sensor 7	#	2 byte	48		sr	DET (per line)	768 - 783
49	Temperature from sensor 8	#	2 byte	49		sr	DET (per line)	784 - 799
50	Photothermal amplitude at sensor 2	#	2 byte	50		sr	PHA <0.1.2> (per line)	800 - 815
51	Photothermal amplitude at sensor 3	#	2 byte	51		sr	PHA <0.1.2> (per line)	816 - 831
52	Photothermal amplitude at sensor 4	#	2 byte	52		sr	PHA <0.1.2> (per line)	832 - 847
53	Photothermal amplitude at sensor 5	#	2 byte	53		sr	PHA <0.1.2> (per line)	848 - 863
54	Photothermal amplitude at sensor 6	#	2 byte	54		sr	PHA <0.1.2> (per line)	864 - 879
55	Photothermal amplitude at sensor 7	#	2 byte	55		sr	PHA <0.1.2> (per line)	880 - 895
56	Photothermal amplitude at sensor 8	#	2 byte	56		sr	PHA <0.1.2> (per line)	896 - 911
57	Error code for sensor 2	#	2 byte	57		sr	ERS (per line)	912 - 927
58	Error code for sensor 3	#	2 byte	58		sr	ERS (per line)	928 - 943
59	Error code for sensor 4	#	2 byte	59		sr	ERS (per line)	944 - 959
60	Error code for sensor 5	#	2 byte	60		sr	ERS (per line)	960 - 975
61	Error code for sensor 6	#	2 byte	61		sr	ERS (per line)	976 - 991
62	Error code for sensor 7	#	2 byte	62		sr	ERS (per line)	992 - 1007
63	Error code for sensor 8	#	2 byte	63		sr	ERS (per line)	1008-1023

Table 11: Output signals

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