Laser-Interferometric Gauging Probe

Series LM 20/50

User's Guide

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1 Basic Information

1.1 Notes on user documentation

IMPORTANT
Users should read this documentation carefully before starting to use the device. Failure to heed the notices in this documentation can endanger those around the device as well as cause damage to the device itself!

The purpose of this user documentation is to provide information on the structure and function of the LM series laser-interferometric gauging probes and to give qualified operators the necessary knowledge to safely handle the devices and its components. The user documentation also offers tips on care and maintenance of the devices as well as on the causes and solutions to possible disruptions which may occur.

Terms and Conventions Used

Handling instructions with a specific order are numbered and grouped together as an instruction unit, with the appropriate results listed.

Itemized lists without an order are indicated using bullets, with dashes being used to represent sub-points.

Safety tips are marked with a symbol and a keyword (see the chapter entitled ‘Safety Tips’ for the meaning of the symbols used). The type, source and consequences of the dangers are given as well as methods for dealing with them should they arise. The safety tips are always given **before** the corresponding action.

1.2 Purpose

LM series laser-interferometric gauging probes are precision measuring devices for length measurement. These interferometers allow users to carry out tactile length measurements in the ranges of 20mm and 50mm with nanometer accuracy.

Through the compact design and the integrated fibre coupling, they can be used in many different application fields and can be employed for example in the following areas:

- ❏ Precision length gauging probes for tactile measurement of optical and mechanical parts
- ❏ Gauging probe for gauge block calibration systems
- ❏ Calibration of gauging probes, plug gauges, measuring rules, dial gauges and other measuring standards
- ❏ Thickness measurement (e.g., film thickness measurement)
- ❏ Hardness indentation depth measurement
- ❏ Surface measurements (contacting)

- ❏ Deformation measurement
- ❏ Precision measuring instrument for research and development to standard characteristics

Users are required to only operate the device in accordance with the information contained in this documentation. The use of the device is limited by the functional capabilities of the software and firmware as well as by the equipment as delivered.

1.3 Intended Use

The **intended use** of the laser-interferometric gauging probe consists of:

- ❏ Operation by qualified and trained personnel
- ❏ Compliance with the operating conditioned as laid out in this user documentation and compliance with the methods and procedures described here
- ❏ Observing all requirements in this user documentation with regard to putting into service and general operation as well as care and maintenance of the device
- ❏ Compliance with all safety regulations

All other use is considered against these directives! Damage caused by use outside of these parameters voids all warranties and becomes the sole responsibility of the operator.

Improper use includes, in particular:

- ❏ Operation of the device in medical laboratories
- ❏ Operation in explosive atmospheres
- ❏ Exposing the device to conditions listed in Chapter 1.4 which lead to loss of warranty and liability

IMPORTANT

Improper use of the laser-interferometric gauging probe will result in the loss of all warranty, and the exclusion of liability on the part of SIOS Meßtechnik GmbH for material damage and personal injuries.

1.4 Warranty and Liability

The duration of warranty and liability protection are consistent with legal regulations and the general terms and conditions for SIOS Meßtechnik GmbH as well as special conditions as applicable.

Warranty protection is limited to the repair of the device and its individual components as well as the replacement of damaged parts and specifically excludes consequential damages.

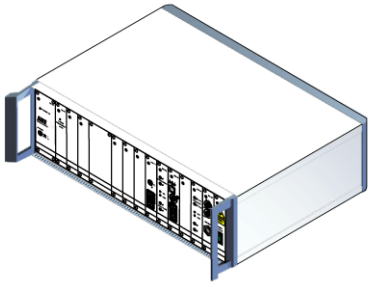
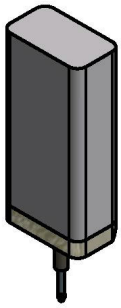
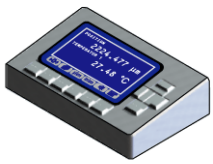
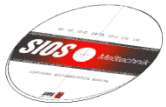
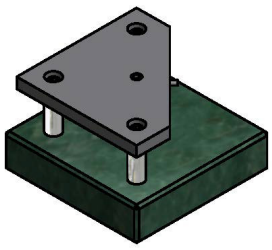
Deviations from the directives specified in this user documentation (including operating conditions and procedures) will result in limitations of warranty and liability in case of damage.

Warranty and liability claims due to damage to persons or property are precluded if they are based on one or more of the following causes:

- ❏ Non-compliance with this user documentation
- ❏ Improper use of the laser-interferometric gauging probe or its individual components
- ❏ Improper operation, handling or repair of the device
- ❏ Unauthorized opening of the device
- ❏ Alterations to the device without prior permission from SIOS Meßtechnik GmbH
- ❏ Manipulation of or damage to the software or its configuration
- ❏ Operation of the device with defective safety and protective features or while these features are missing or improperly applied
- ❏ Use of accessories or spare parts which are not listed in this user documentation or are not supplied or recommended by SIOS Meßtechnik GmbH
- ❏ Carrying out of servicing and repairs as well as bringing the device into operation by unauthorized service personnel

1.5 Scope of Delivery

The scope of delivery of the laser-interferometric gauging probe includes the following components:

Standard supply list	
Supply and evaluation unit (SEU)	
Sensor head (gauging probe)	
Power cable	
Data cable to connect the SEU with the input and display unit or with a computer	RS 232  USB 
Options	
Input and display unit	
INFAS NTC measurement and control program	
BNC connector cable (2x)	
Measuring portal	

2 Technical Data

General Characteristics	LM 20	LM 50
Measuring range	0...20 mm	0...50 mm
Resolution	0.1 nm	
Force exerted by probe shaft (permanently factory set)	0.5...1.5 N	
Laser	HeNe laser*	
Wavelength	632.8nm	
Frequency stability of the laser after warm-up time	$\leq 3 \cdot 10^{-7}$	
Laser warm-up time	1min	
Laser protection class - according EN 60825-1: 2007 - according ANSI Z136.1 (CDRH)	2M* II	
Maximum positioning speed	20 mm/s	
Beam transmission to the interferometer	Single-mode fiber optic cable	
Operational Data and Standards	**LM 20**	**LM 50**
Supply voltage	100...240 V AC, 47...60 Hz	
Power consumption	$\leq$ 65 W	
Device fuse (2x)	Fine-wire fuse 2A (T)	
Protection class	IP 20	
Noise emissions	EN 61326-1: 2006 (EMV requirements) EN 61000-3-2:2006 (supply feedback)	
Interference immunity	EN 61000-6-2: 2005	
Laser safety	EN 60825-1: 2007 ANSI Z136.1 (CDRH)	
General safety considerations	EN 61010-1:2001	

* see page 12

Interfaces	**LM 20**	**LM 50**
Standard	RS 232C, USB	
Options	- 32-Bit Evaluation Card DP-02 (see page 87) - Digital interface module IP-02 (TTL level, see page 91) - Voltage Converter Card IS-01 (±1 V_{pp}, see page 95) - Vibration measuring module SM-05 (see page 96)	
Cable length between the sensor head and the SEU	3m, optionally up to 25m	
Oscilloscope connection	BNC connector, R_i = 75Ω (2 items) Standard output level: 3 V_{ss}	
Dimensions and Mass	**LM 20**	**LM 50**
Gauging probe (height x width x depth)	[170 x 60 x 36] mm	[220 x 60 x 36] mm
Probe casing (height x width x depth)	[137 x 60 x 36] mm	[170 x 60 x 36] mm
Gauging probe weight	approx. 370 g	approx. 420 g
Supply and evaluation unit (SEU) " Height x width x depth " Weight	[150 x 450 x 400] mm approx. 9,500 g	
Input and display unit " Height x width x depth " Weight	[48 x 190 x 138] mm approx. 630 g	
Clamp shank diameter	8h6 mm	
Storage and Operating Conditions	**LM 20**	**LM 50**
Storage and transport: " Allowable ambient temperature " Allowable relative humidity	-10...+50 °C ≤ 85 % (at 30 °C)	
Operation: " Allowable ambient temperature " Allowable relative humidity	15...30 °C < 70 % (at 23 °C), without condensation	

3 Safety Tips

3.1 Fundamentals

IMPORTANT

Read this chapter carefully for your own safety before the device is brought into operation and to ensure uninterrupted and safe operation of the laser-interferometric gauging probe!

All safety tips found in this user documentation before the corresponding action should be heeded as well as all messages and tips displayed on the input and display unit or indicated on the monitor by the control and evaluation software.

Safety tips serve to protect the users during operation and prevent accidents, thus they must be followed at all times! Users are advised to maintain constant awareness of their surroundings and to bear in mind that most dangers are not easily recognized.

In addition to the tips found in this documentation, general regulations found in individual countries must be followed with regard to safety and accident prevention. The operator is required to determine the current state of these laws and regulations.

In order to guarantee safe operation, operators must assure themselves that those operating the gauging probe have been informed of the possible dangers associated with the utilisation of laser beams. It is recommended for the operator to receive written acknowledgement from the personnel using the device that they have read and understood the contents of this user documentation as well as the pertinent accident prevention regulations. In the end, the owner of the Laser-interferometric gauging probe or qualified personnel authorized by the owner will be responsible for accident-free operation of the device.

The user documentation must be made available to the operating and maintenance personnel at any time. The working area in which the gauging probe has been set up must be labelled in accordance with legal regulations in order to prevent accidental damage through third parties.

3.2 Standards and Guidelines

The laser-interferometric gauging probe has been designed in accordance with current technological rules and recognized safety regulations.

Basic health and safety requirements from the appropriate laws, standards and guidelines were applied in the design of the device and its components.

All safety information is based on the current provisions of the European Union. In other countries the appropriate laws and provisions must be followed.

General rules on accident prevention and provisions for industrial safety must be adhered to in addition to the safety tips found in this documentation and the local safety regulations appropriate for the operation of this device.

Tips regarding possible dangers do not replace valid industrial safety provisions and practices.

3.3 Symbols and Signal Words

This user documentation uses the following symbols and signal words to denote dangers or tips. The safety tips can be found before the corresponding response or action.

DANGER

Describes an immediate threat or danger.
If this aspect is not avoided, serious injury or death will most likely result.

WARNING

Indicates a potentially dangerous situation.
If this aspect is not avoided, serious injury or death could result.

CAUTION

Indicates a potentially dangerous situation.
If this aspect is not avoided, light or minor injuries as well as damage to property could result.

IMPORTANT

Describes application tips and other especially useful information, in which no dangerous or damaging situations can arise.

ENVIRONMENT PROTECTION

Describes application tips and information which can assist in the proper disposal or handling of the used materials and components.

3.4 Safety Markings on the Device

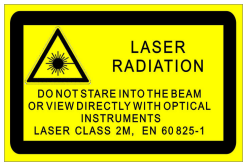
IMPORTANT

The warnings and safety symbols placed on the device are an important component and must be heeded!

Before operating the device, please assure the warning labels and safety symbols are complete and intact. The device should not be used with incomplete, missing or damaged warning labels or safety symbols!

Damaged or missing warning labels or safety symbols could lead to improper handling resulting in damage to persons or property! The warning notes and safety signs must never be removed! Replace damaged warning notes and safety symbols without delay.

The following safety symbols are located on the device:

Safety symbol	Meaning	Comments
	Warning about laser radiation	Laser radiation can lead to major damage to the eyes including blindness! Do not look directly into the laser beam!
	Warning about dangerous electric potential	The laser operates with high voltage! This represents a danger to life! The power cable must be removed before opening the back panel of the supply and evaluation unit!
Warning Label	Meaning	Comments
	Warning about laser radiation from a class 2M laser in accordance with EN 60825-1:2007	Laser radiation can lead to major damage to the eyes including blindness! Do not look directly into the laser beam!
	Warning about laser radiation from a class II laser in accordance with ANSI Z136.1 (CDRH)	Laser radiation can lead to major damage to the eyes including blindness! Do not look directly into the laser beam!
	Warning about dangerous electric potential	Remove the power cable **before** opening the device!

3.5 State of the Art

The laser-interferometric gauging probe is designed and built in accordance with current technological design principles. Unauthorized alterations, especially those affecting personal safety or environmental protection, are generally prohibited.

Note the following general safety instructions:

- ❏ Any manipulation of the safety features is prohibited!
  Manipulations to the safety features are considered gross negligence in the case of an accident!
- ❏ Only operate the gauging probe when it is in a fully functional, reliable state. The reliable functioning of all safety features must especially be checked.
- ❏ The gauging probe should only be connected to properly tested supply lines specifically designed for the device.

3.6 Requirement for Operators

The laser-interferometric gauging probe may only be operated by qualified personnel who have been specifically instructed in the use of the device. Proper instruction includes the information contained in this user documentation and the contents of manuals for other system components or accessories as applicable.

Dangers can arise from the gauging probe if it is used by unqualified personnel or utilized improperly or not in accordance with these directives. Therefore, each person authorized to operate the gauging probe must have read and understood this user documentation before carrying out the corresponding work. This also applies if the persons in question have already worked with these types of devices or have received training.

Note the following general safety instructions:

- ❏ Only trained and qualified personnel instructed in appropriate safety measures are allowed to start up, operate or repair the laser-interferometric gauging probe.
- ❏ Minors or persons under the influence of alcohol, drugs or other medicine are prohibited from operating and repairing the gauging probe.
- ❏ Operating personnel must be made aware of the dangers stemming from the device, especially from the laser. Protective goggles should be worn as necessary in accordance with appropriate regulations.
- ❏ Do not eat, drink, smoke or have open flame in the area where the gauging probe is installed!

3.7 Safety Tips for Transport and Installation

Installation and start-up of the gauging probe may only be carried out by qualified and authorized personnel in accordance with the directives found in Chapter 6, starting on page 48. Assembly and installation work by unauthorized personnel is prohibited. Significant dangers could arise through improper installation!

Note the following general safety instructions:

- ❏ Danger of injury or damage to the device can arise through improperly secured parts! Device components must be securely packed prior to transport in accordance with the directions in this user documentation (see page 40).
- ❏ The prescribed ambient conditions must be maintained during transport of the gauging probe. Do not leave the gauging probe in the open.
- ❏ Users must not attempt assembly and installation of the gauging probe if they are not authorized or do not possess the requisite qualifications.

3.8 Safety Tips for Operation

3.8.1 General

The operator of the laser-interferometric gauging probe must ensure that it and its components, including the safety features, are in good working condition each time before starting up. This is especially true after any alterations or additions are made or after the device has been repaired.

Note the following general safety instructions:

- ❏ The gauging probe should only be operated when all safety features (e.g. panels and other protective covers) are in correctly in place and fully functional.
- ❏ Proper condition of the safety and security features must be regularly checked. Defective or missing elements must be corrected immediately upon discovery.
- ❏ Safety and security features must never be removed, altered or shut down while the device is in operation.
- ❏ Easy access to the main switch as well as any emergency shut-off switched must always be guaranteed during operation.
- ❏ Users must ensure that existing vents and other cooling apparatus are functional and unblocked. Covering up the venting grates, slots etc. can lead to operational interruptions as well as damage to the device.
- ❏ The device must be immediately switched off when a malfunction or other fault arises!

3.8.2 Safety Tips for Laser Handling

DANGER

Danger to life from high voltage and possible danger from main voltage !

A HeNe laser is integrated into the supply and evaluation unit, which operates with high voltage! Residual charge can remain even after the SEU has been switched off!

Switch off the SEU and remove the power cable from the socket before opening the back panel or adding or removing modules! Wait a **minimum of one hour** before opening the SEU! Do not touch the anode of the laser after the opening!

WARNING

Hazard due to class 2M laser light!

The He-Ne laser, built in the supply and evaluation unit, is assigned to the Laser Class 3R because of its power. But the direct laser radiation of the He-Ne laser can not penetrate to the outside through the incorporation into the closed case of SEU. By coupling into the unit's internal fiber optic cable, the laser radiation of the laser is reduced so that the fiber optic coupling E 2000 or at the sensor head only the Laser class 2M laser radiation is emitted.

The laser radiation is transmitted from the supply and evaluation unit to the laser via fiber optic cable. The measuring beam of the laser emerging from the sensor head represents a serious health hazard for the eyes which can even lead to blindness!

Do not look directly into the laser beam! If the laser radiation reaches the eyes, immediately close them or immediately turn away!

Do not intentionally point the laser beam at people! Do not allow loose mirrors or other optical components to come into contact with the beam as this could cause dangerous random reflections and focused rays!

Note the following general safety instructions:

- ❏ While the laser is in operation, safety regulations found in DINEN60825-1 (VDE0837Part1):2007 must be observed! The appropriate specifications regarding design and features for the laser apparatus have been implemented in this device.
- ❏ In countries other than Germany, regulations corresponding to the German directives on accident prevention and other standards must be observed. For example, the respective regulations in the United States are ANSI Z136.1 Standard for the safe use of lasers and IEC 825-1 Safety of Laser Products - Part 1: Equipment classification, requirements and user' s guide.
- ❏ The safety symbols and warning labels must remain on the device at any time! The safety measures necessary for this laser class must be observed at all times in accordance with the regulations for accident prevention and other standards.
- ❏ Opening the supply and evaluation unit or the interferometer head is prohibited for anyone not specifically instructed by SIOS Meßtechnik GmbH.
- ❏ Elements carrying high or mains voltage can become exposed when the rear panel of the supply and evaluation unit is open or all modules are removed. This

represents a danger to life! Therefore, the power cable must be removed from the socket before modules are taken out or the back panel is opened!

- ❏ High operating temperatures affect the electronics. The prescribed ambient conditions must be maintained. Ensure that the cooling vents of the SEU are kept free!

3.8.3 Safety Tips for Explosion and Fire Protection

The laser-interferometric gauging probe must not be operated in areas with a danger of explosion. Smoking or open flames are prohibited near the device!

Flammable materials are to be kept away from the device. Personnel using the miniature interferometer must be aware of the location of the nearest fire extinguishing systems or apparatus as well as how to operate them.

3.8.4 Electrical Safety Tips

Work on the electrical and electronic parts of the device and its components may only be carried out by qualified personnel schooled in these areas in accordance with current electrical engineering regulations.

Note the following general safety instructions:

- ❏ Do not operate the device with damaged cables (e.g. cut, rubbed-off or otherwise open insulation). Defective cables must be renewed by an electrician.
- ❏ The electrical components must be regularly inspected by qualified technicians. Any deficiencies, such as loose connections and defective or damaged cables) must be immediately corrected.
- ❏ Immediately switch off the gauging probe if disruptions or malfunctions occur in the electric components and remove the power cable from the socket.
- ❏ The gauging probe should only be operated with a mains voltage and frequency within the ranges specified on the type plate. Voltage levels and frequencies outside of these ranges can lead to the destruction of the device!
- ❏ The power cable of the device is fitted with an earthing contact and may only by inserted into a socket with a corresponding contact. The earthed conductor must not be disconnected (e.g. through the use of an adjustable voltage transformer). Do not use extension cables without an earthed conductor!
- ❏ The power cable must not be stretched or kinked.
- ❏ Only pull on the plug when removing the cable from the socket. Do not touch the plug with wet hands!
- ❏ Never remove the casings or other protective features of the device! Removing the casings represents a threat to life from electric current!
- ❏ Do not introduce foreign objects into device openings and keep liquids from going into openings and joints in the device components.
- ❏ The device fuses help avoid danger of fire from electrical overload. Do not short-circuit the fuses. Only replace defective fuses with fuses of the same strength and type (see page 82).

3.8.5 Safety Tips for Repair and Maintenance

Maintenance of the laser-interferometric gauging probe may only be carried out by qualified personnel authorized and instructed by SIOS Meßtechnik GmbH.
We recommend a service contract (annual maintenance) to provide appropriate, regular maintenance of the gauging probe.

Unauthorized maintenance work can lead to damage to the device or components. Therefore, users are only allowed to carry out the actions listed in the chapter “Care and Maintenance“.

Note the following general safety instructions:

- ❏ All cleaning and maintenance work of the gauging probe may only be carried out when the device is powered down. Remove the power cable from the socket before completing any cleaning or repair work. Only a soft dry towel should be used to clean the outside of the device.
- ❏ Only use original accessories and replacement parts or those recommend by SIOS Meßtechnik GmbH (see the chapter “Accessories and Spare Parts“). Observe the tips listed in the chapter “Care and Maintenance“.
- ❏ All safety features must be immediately reinstalled after repair and maintenance work has been completed. The complete and proper functioning of these features must then be immediately checked before any further operation of the device!

3.9 Action in an Emergency

If a dangerous situation does arise or in case of accidents, immediately switch off the gauging probe or remove the power cable from the mains socket.

Because quick reactions save lives, the following must be guaranteed at all times:

- ❏ Operating personnel must know where to locate safety features, accident and danger alarms as well as first aid and lifesaving equipment and they must be familiar with their use. The operating agency is responsible for appropriate instruction of the users.
- ❏ All first aid equipment (first aid box, eye-wash bottles, stretchers, etc.) as well as fire-fighting equipment (fire extinguishers) must be kept close at hand and be easily accessible at all times. All equipment must be fully functional and have received regular inspections.

4 Technical Description

4.1 System Design

4.1.1 One-Axis Measuring System

The LM series gauging probe shown in Fig. 2 consists of three basic components:

- ❏ Sensor head (gauging probe)
- ❏ Supply and evaluation unit with 19-inch rack mount
- ❏ PC with optional control software or input and display unit

The sensor head contains a miniature interferometer, which transforms the motion of the motor-driven measuring sleeve into an optical signal. This quantized optical measurement signal is transmitted to the supply and evaluation unit over a fiber optic cable, processed and output as the measurement result.

The purposeful separation of the sensor head (gauging probe) and the electronics unit through the fibre optic connection virtually eliminates a significant disturbing factor in the measurement environment brought about by waste heat. Through the use of fiber optic technology, the sensor head can also be used in environments with strong electromagnetic fields because the generation and transmission of the measurement signals is exclusively carried out optically.

The basis for the excellent linearity and measurement accuracy is achieved using a HeNe laser, which is extremely stabile with respect to wavelength and the radiation from which is transmitted to the miniature interferometer in the sensor head through fiber-optic cables, and through the correction of environmental factors (air temperature, air pressure) which influence the wavelength value.

Operation of the gauging probe may be carried out using the delivered control software running on a personal computer or the input and display unit (see Fig. 1 and Fig. 2). Both a serial interface (RS-232C) and a USB interface are available for data transfer.

Fig. 1: Laser-interferometric gauging probe with personal computer (laptop)

1 Measuring portal
2 Sensor head (gauging probe)
3 Personal computer (laptop)
4 Supply and evaluation unit (SEU)

Fig. 2: Laser-interferometric gauging probe with optional input and display unit

1 Input and display unit
2 Measuring portal
3 Sensor head (gauging probe)
4 Supply and evaluation unit (SEU)

4.1.2 Two-axis measuring system

The two-axis gauging probe consists principally of two individual LM series systems, in which the modules of the supply and evaluation unit are integrated in one rack mount.

The following modifications apply to the two-axis system of the supply and evaluation unit (SEU) (also see Fig. 6 on page 22):

- ❏ Rack mount with extended depth for supply and evaluation unit (19 inch rack; H x W x DT: (150 x 450 x 460) mm)
- ❏ Implementation using two HeNe lasers in the supply and evaluation unit.
- ❏ Additional power supply module in the back area of the supply and evaluation unit to power the HeNe lasers.
- ❏ Arrangement of two identical signal processing units (with the exception of the environment measuring module, see next bullet). The arrangement of the modules for each unit corresponds to that for one-axis devices. However, the laser output module LA-04 is only found once and contains the fibre optic connectors for both axes.
- ❏ The environment module UW-27 evaluates the temperatures of both gauging probes.

All other parameters correspond to those of the one-axis measuring system. See see chapter 4.2 for a description of the individual modules.

The measurement values and parameters of each axis can be transmitted separately to and from the supply and evaluation unit over the serial interface belonging to the axis or over the optional interfaces.

Because the modules are individually adjusted for each axis, they may not be switched with each other. Doing so will yield errors in the measurement results.

4.1.3 Control unit

The control of the laser-interferometric gauging probe is carried out using the software INFAS NTC installed on an external computer or via the input and display unit (see page 37). INFAS NTC allows the user to operate and control the components of the gauging probe using a graphical user interface. To use the software INFAS NTC see “software documentation INFAS NTC“.

4.2 Description of the Components

4.2.1 Sensor head (gauging probe)

Structure and function

The LM series sensor head of the laser-interferometric gauging probe shown in Fig. 3 contains all of the optical and mechanical elements of a modified Michelson interferometer which has a moving reflector equipped with a ball-guided measuring sleeve. In addition the sensor head contains the electromechanical components to modulate the interference signal and a fiber optic sensor to sample the interference structure. The interferometer output signal represents a direct reference from the measured change in displacement to the highly accurate, stable laser frequency of the HeNe laser.

The sensor head is connected to the supply and evaluation unit with a single-mode fibre optic cable and a metal-encased hybrid cable containing another optical fibre and electrical conductors. The fiber optic cable supplies the interferometer with the HeNe laser radiation. The shielded hybrid cable carries the interferometer signals to the supply and evaluation unit along the optical fibre and transmits control signals from the unit to the sensor head.

The gauging probe has a Pt-100 temperature sensor to correct the environment influences. The air pressure sensor is located in the environment module UW-25 of the supply and evaluation unit (see page 32).

Fig. 3: LM series sensor head (in connection with the optional measuring portal)

The interferometer uses a motor-driven measuring sleeve which allows the installation of various gauge inserts. The traversing rate of the measuring sleeve is factory-programmed in both directions of movement. A cut-off mechanism with a pressure spring is used to switch off the extending measuring sleeve when a defined measuring force is reached. This measuring force has a permanent factory setting and is 0.8 N when delivered (default value, other values are available upon request).

IMPORTANT

The value of the measuring force refers to a perpendicular mounting position with the measuring sleeve pointing downwards. Although admissible, another mounting position would reduce the measuring force to a smaller value.

CAUTION

Possible damage to interferometer or measuring sleeve

The measuring sleeve must not be moved manually or by any outside action. The measuring sleeve must not be moved unless by the motor-driven control system (for the exception see chapter 7.6 on page 73)!

To ensure reproducible measurements, we recommend to use the measuring portal shown in Fig. 4 on page 20 to fasten the sensor head. The gauging probe may also be inserted in all commercially available clamp shanks with a diameter of 8h6. To allow this, the clamping mechanism must be designed as a circumferential clamp. Any further mechanical load on the gauging probe must be excluded.

Measuring inserts

Various gauge inserts with an M2.5 thread may be screwed into the measuring sleeve. The following gauge inserts are available on an optional basis (for dimensional drawings see the appendix on page 86):

- ❏ Ruby sphere R = 1.5 mm (standard measuring insert)
- ❏ Spherical gauge insert for gauge block calibration system
- ❏ Gauge insert with a big radius for film thickness measurement

IMPORTANT

The replacement of the measuring inserts is described on page 72. Please be sure to observe the corresponding safety instructions.

Measuring portal (optional)

The setup of the measuring portal is shown in Fig. 4. A flat aluminium plate with the clamp for the gauging probe is located above the lapped granite base plate. The distance between base plate and aluminium plate is adjusted according to the measuring range of the corresponding gauging probe.

To reduce exposure to changes in ambient temperature, the three spacing columns are made of Invar (a metal alloy having a low coefficient of thermal expansion). A mechanism with a clamping screw is used to fasten the gauging probe (finger-tighten by applying a moderate torque). When secured, a small gap (0.5 to 1 mm) should remain between the aluminium plate and the probe casing.

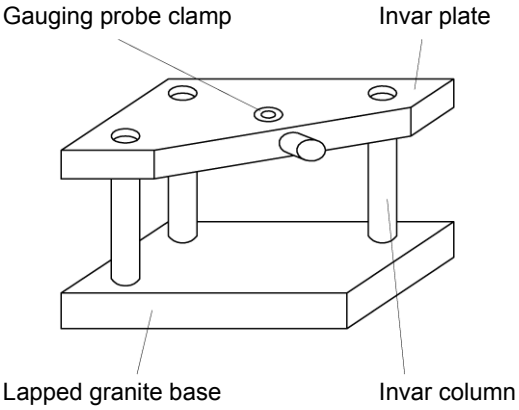


Fig. 4: Measuring portal

IMPORTANT

Even though the measuring gantry has been manufactured to extremely small tolerances, users should be aware that the guide direction of the gauging probe may not be absolutely orthogonal to the lapped granite base. So-called cosine errors will occur in this case (see page 58).

The entire measuring setup has to be calibrated using high-precision gauge blocks and known nominal dimensions. The probe itself has been adjusted to minimum length errors in the factory. A double-probe arrangement is recommended for precision measurement.

4.2.2 Supply and evaluation unit (SEU)

General

The supply and evaluation unit contains the electronic components for signal conditioning and processing and realizes the calculation of the measurement results, the environment correction and the transfer of data. Further, the HeNe laser with the optical fibre input coupling is implemented as a light source in the rear part of the housing.

The supply and evaluation unit is designed to be modular and to fit in a 19 rack mount. The following modules can be found in the unit starting sequentially at the left (one-axis measuring system, see Fig. 5; two-axis measuring system, see Fig. 6):

- ❏ Power supply module NT-04
- ❏ Open slots
- ❏ Environment module UW-25
- ❏ Motor control module MS-02
- ❏ Environment module UW-26
- ❏ Data processing module RE-06
- ❏ Digital controller module RG-10
- ❏ Analog input module EM-11
- ❏ Laser output module with E2000 coupling LA-02

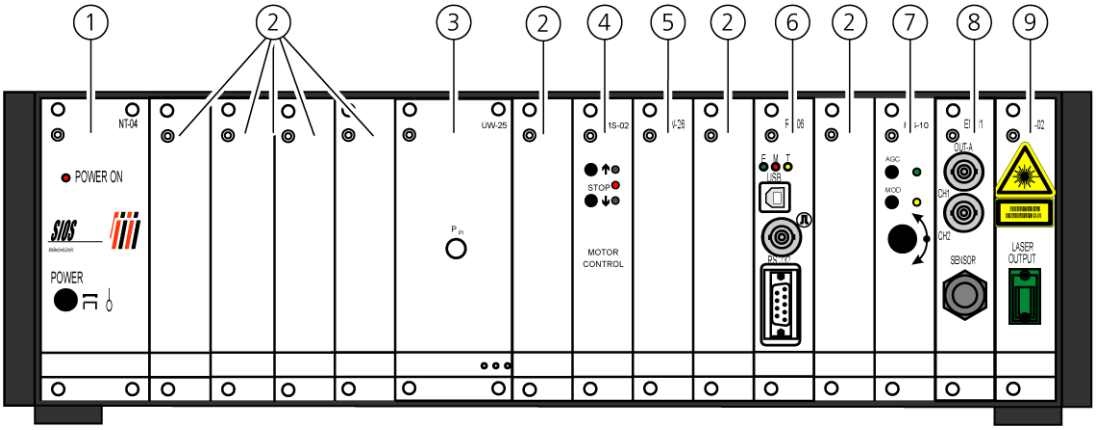


Fig. 5: Supply and evaluation unit, one-axis measuring system (front view)

1 Power supply module NT-04
2 Open slots
3 Environment module UW-25
4 Motor control module MS-02
5 Environment module UW-26
6 Data processing module RE-06
7 Digital controller module RG-10
8 Input module EM-11
9 Laser output module LA-02

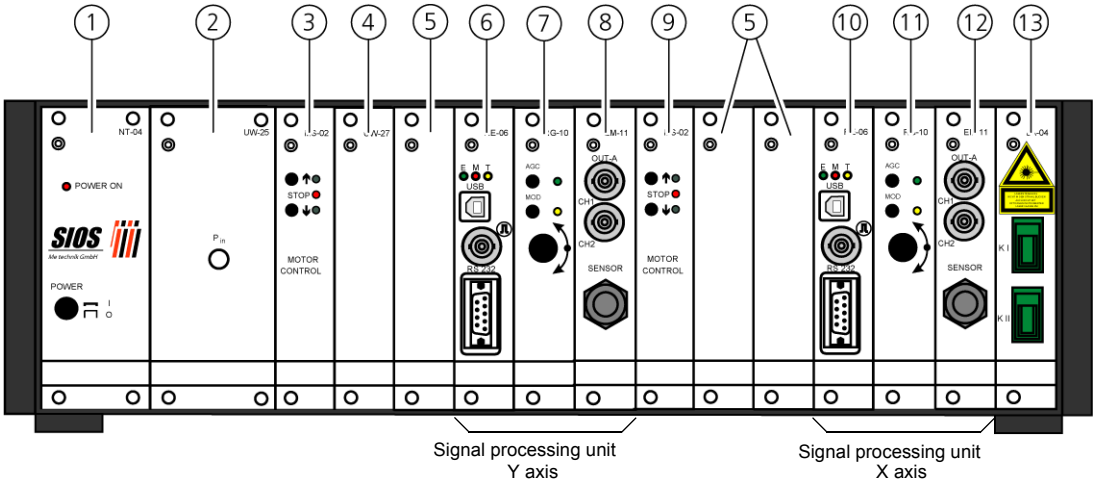


Fig. 6: Supply and evaluation unit, two-axis measuring system (front view)

1 Power supply module NT-04
2 Environment module UW-25
3 Motor control module MS-02 (Y axis)
4 Environment module UW-27
5 Open slots
6 Data processing module RE-06 (Y axis)
7 Digital controller module RG-10 (Y axis)
8 Input module EM-11 (Y axis)
9 Motor control module MS-02 (X axis)
10 Data processing module RE-06 (X axis)
11 Digital controller module RG-10 (X axis)
12 Input module EM-11 (X axis)
13 Laser output module LA-04

The electronic assemblies of the supply and evaluation unit can be pulled out after the screws are released from the front panel. However, this does not apply to the power supply module NT-04!

Laser output module LA-02

On its front plate the laser output module LA-02 (see Fig. 7) contains a separable coupling (E2000) between the HeNe laser integrated into the supply and evaluation unit and the supply optical fibre for the sensor head.

This coupling allows the fibre optic cable to be removed from the housing if necessary. For this the fibre connector contains a snap-fit rocker. The connector can be unlocked by applying slight pressure. A beam cover prevents laser light from escaping after the fibre optic cable has been removed in order to eliminate danger from the laser beam to the eyes.

IMPORTANT

Dust penetrating into the optical fiber cable coupling can cause increased attenuation in the coupling. In order to prevent dust entering, insert the protective cap into the optical fiber cable coupling immediately after removing the fiber optic cable.

Connecting the optical fibre to the fibre coupling is accomplished with axial pressure in the direction of the coupling until the rocker has audibly snapped in.

IMPORTANT

Frequent removal of the fiber connector can lead to increased wear, which can cause higher attenuation in the coupling. Only remove the fiber optic cable if it is absolutely necessary!

Fig. 7: Front view of the laser output module

1 E2000 fiber connector (with protective cap inserted)
2 Warning label regarding laser radiation

IMPORTANT

The warning label regarding laser radiation may not be removed under any circumstances! A damaged or missing warning label must be replaced immediate or remove the gauging probe from service until the label has been replaced!

The safety measures necessary for the respective laser class must always be observed (see the appropriate directives for accident prevention and other standards)!

Optoelectronic Input Module EM-11

The optoelectronic input module EM-11 (see Fig. 8) establishes all electrical connections (oscillator, laser power monitoring) between the internal device wiring and the hybrid cable of the sensor head and conditions the two interferometer signals, which are phase-offset by 90° (sine and cosine signals), into normalized electric signals to be fed into the analogue-digital converters of the data processing module RE-06. Both circuit channels are designed identically.

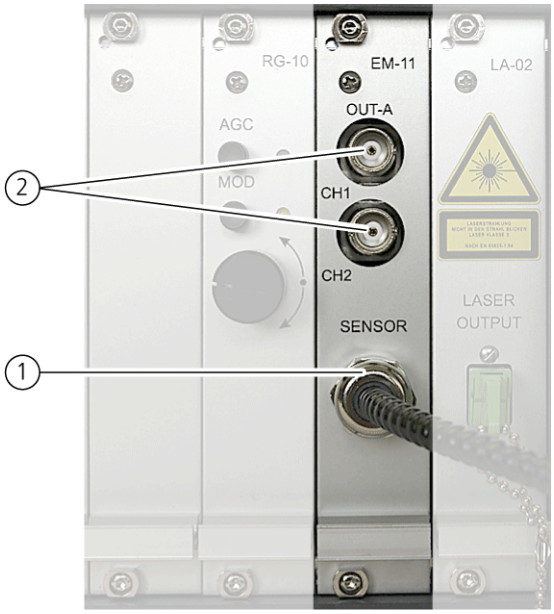


Fig. 8: Front view of the optoelectronic input module EM-11

1 Hybrid cable lead-through and clamping
2 Analogue control outputs (BNC sockets)

The fundamental circuitry components of the amplifier unit are shown in the block diagram in Fig. 9. Photodiodes placed directly on the control amplifier boards are used to transform the optical information into electrical signals. The two fibre optic cables in the hybrid cable assembly carry the optical interference signal from the sensor head to the photo detectors with minimal loss. The electrical signals are conditioned using transimpedence amplifier stages to drive the control amplifiers.

In conjunction with the digital controller module RG-10, the control amplifiers realize the necessary automatic signal gain or attenuation and offset control. The control amplifiers are driven by the digital control module, which continuously monitors the analogue output signals of the input module.

The regulated analogue signals (sin/cos signal, $3V_{SS}$) are fed internally into the data processing module RE-06 and can also be tapped using the two BNC sockets on the input module (see Fig. 8). Both analogue signals can be used to generate a Lissajous figure on an oscilloscope in x-y-mode, which is a great aid in the alignment of the sensor head and to confirm the condition of that alignment. An oscilloscope is connected to these sockets by two BNC cables.

In addition to the BNC sockets, the front plate of the module also contains a mechanical lead-through and clamping for the hybrid cable (black metal tube), which is not detachable from the module.

For ease of handling the sensor head, the module can be removed from the supply and evaluation unit by releasing the holding screws and pulling the card out.

IMPORTANT

The process of removing the module from the supply and evaluation unit is described on page 81. The safety tips listed there must be absolutely observed! Special attention must be paid to prevent the fiber optic cable lying loosely within the module from being kinked or pinched!

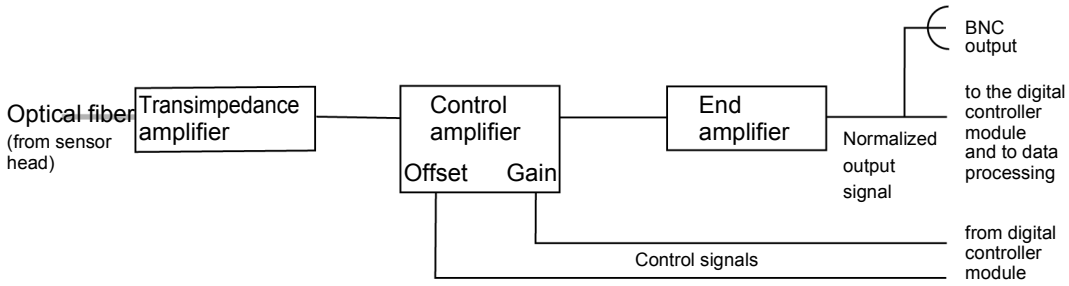


Fig. 9: Block diagram of the optoelectronic amplifier units in the input module (only one channel shown; second channel is identical)

Digital controller module RG-10

The digital controller module RG-10 contains a microprocessor, which uses the analogue output signals from the input module EM-11 to calculate the gain and offset parameters necessary to control the control amplifiers. Figure 10 gives a schematic diagram of the RG-10, including its various interfaces.

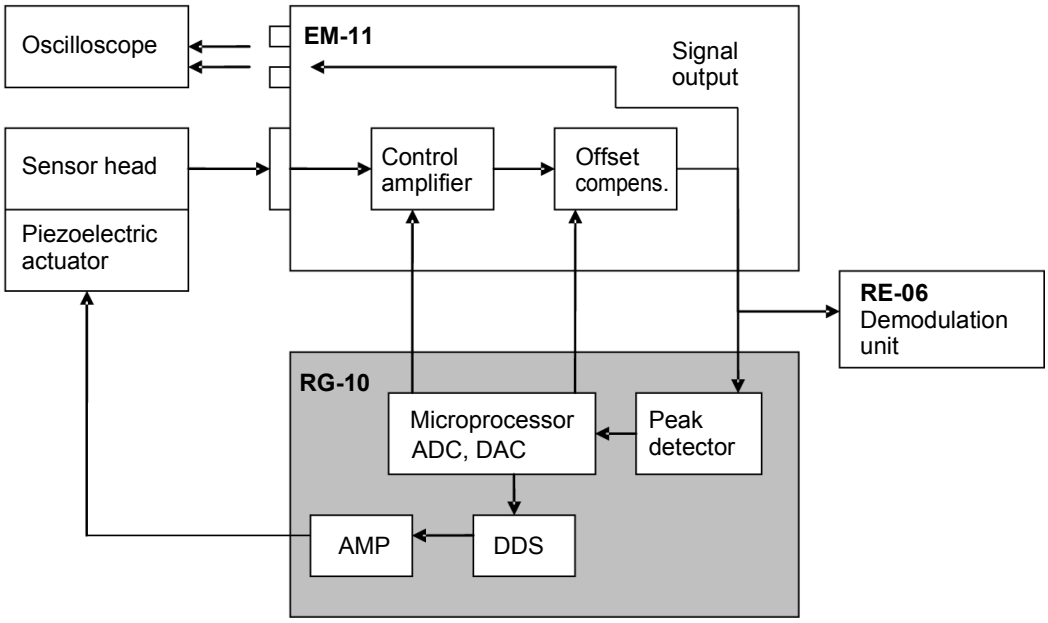


Fig. 10: Schematic diagram of the RG-10 with interfaces

During normal operation the module runs in the automatic control mode (the green LED is illuminated) without user intervention. In some applications it can be advantageous to deactivate automatic amplifier control or to switch on an oscillator, for example when performing optical interferometer alignment. Two buttons T1 and T2 and a pressable knob T3 are located on the front panel to select a control mode and to change other settings and two LEDs 1 and 2 indicate the current status of the module (see Fig. 11).

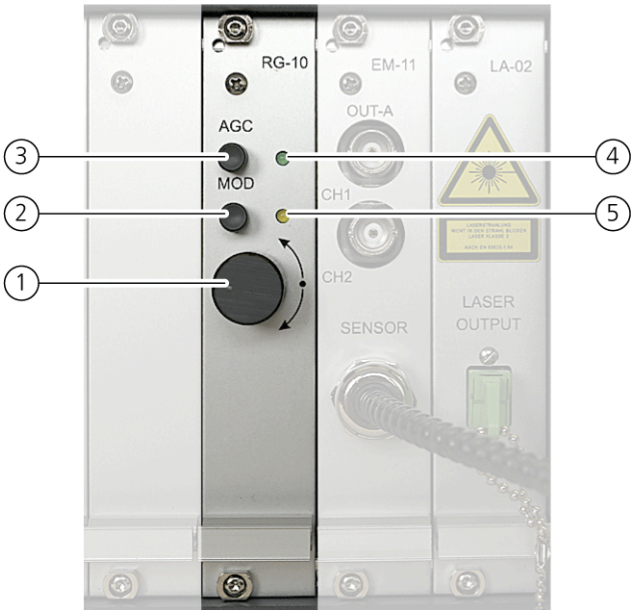


Fig. 11: Front view of the digital controller module

1 Pressable knob (T3)
2 Modulation button MOD (T2)
3 Automatic Gain Control button AGC (T1)
4 LED1 (green)
5 LED2 (yellow)

Data Processing Module RE-06

The data processing module RE-06 is used for oscillation and dynamic length measurement. The electronic components are placed on an Euro-format circuit board (160 mm x 100 mm). The card is assigned to a fixed slot in the supply and evaluation unit, which supplies the module with the necessary voltage and the analogue incremental signals to be processed.

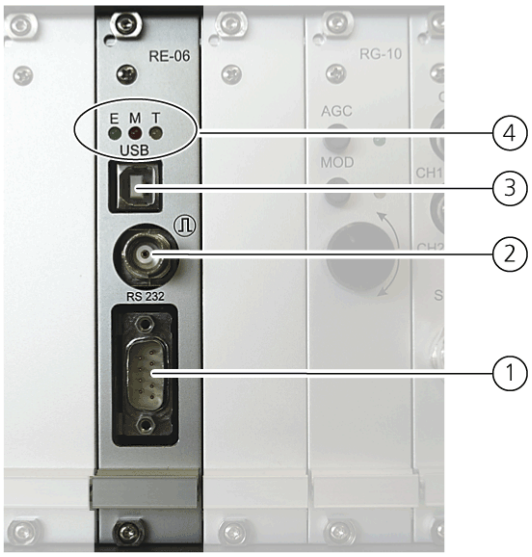


Fig. 12: Front view of the data processing module RE-06 with connectors

1 RS-232C interface
2 Trigger input
3 USB interface
4 LED:
E (green) – „Environment“: (LED toggled after each environment measurement)
M (red) – „Measurement“: (measurement value is ready)
T (yellow) – „Transmit“: (data transmission over the USB interface)

On the input side the output module of the analogue path information has two 8 bit flash A/D converters to digitalize the normalized quadrature signals from the input module EM-11. The quadrant angle is determined from this 16-bit-wide word in the arctangent unit and from that the length information. If the object to be measured moves at speed v along the measuring axis of the interferometer, the maximum order frequency f_O of the measurement signal can be calculated using the doppler effect as

$$f_O = \frac{2 \cdot v}{\lambda}$$

where: v is the object speed and

λ is the wavelength of light (HeNe laser: approx. 632.8 nm).

Because the procedure is absolute within one interferometer period and relative beyond one period, the sampling frequency used in the electronics must be four times the order frequency so that no measurement errors arise; put another way, each quadrant must at least be sampled once.

The countable range of the card is sufficient for object displacements up to ±10 m. The microprocessor on the RE-06 card is responsible for the necessary signal processing and ensures the following functionality:

- ❏ Initialization and interrupt-triggered acquisition of the counter values
- ❏ Recording of the current environment temperature and pressure
- ❏ Supply of counting pulses, temperature values and pressure values
- ❏ Output of the processed data using a proprietary ASCII protocol
- ❏ Administration of the USB interface

Triggering

The evaluation card is capable of the following triggering modes:

- ❏ External triggering of primary values
- ❏ External triggering when measurement values are finished being processed

Setting the trigger source and flank can be done in software. The protocol of the data processing module RE-06 has been expanded with respect to previous versions to include new trigger settings and transfer speeds.

The block diagram for the triggering sub-system is shown in Fig. 13. The difference can be seen there between the trigger for processed measurement values and the trigger for raw values.

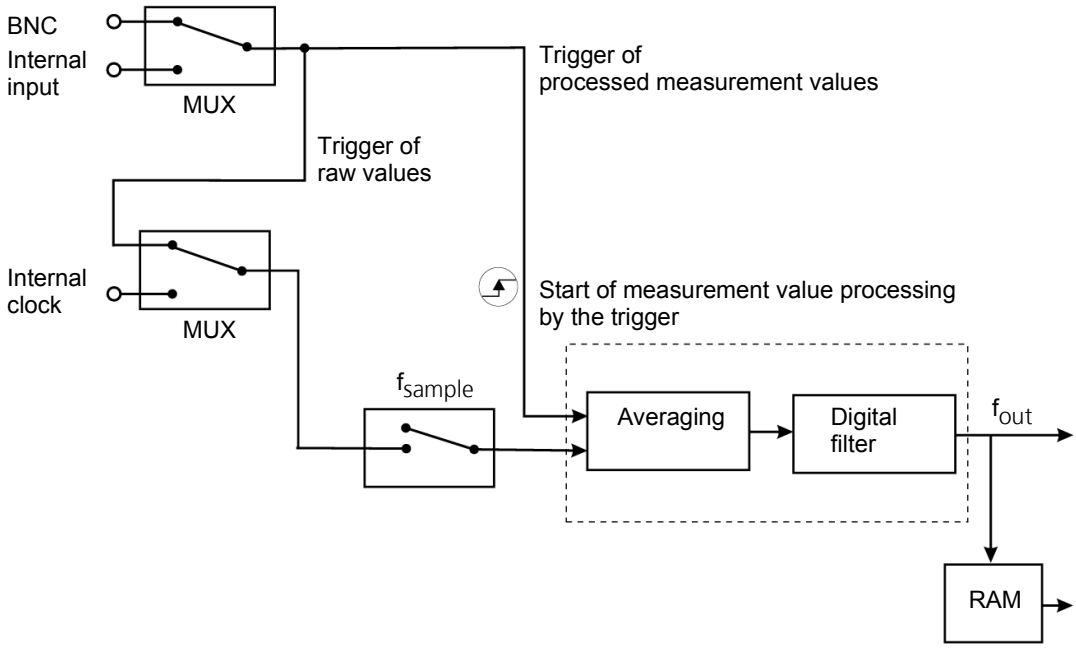


Fig. 13: Block diagram of the triggering

Triggering the processed measurement values

The trigger pulse is written to the status register and simultaneously fires an interrupt in the microprocessor. Upon receiving the interrupt the microprocessor begins processing measurement values until a value can be offered up. After that, the microprocessor either sends the value over the serial interface or, in the case of a USB connection, writes the value to an internal FIFO buffer, which can hold up to 40 measurement values. Therefore, data cannot be fed out faster than the frequency at which the measurement values are measured.

Example:

The current measurement settings are:

- ❏ Sampling frequency F_{sample} = 10,000 Hz
- ❏ Length of the moving weighted average MWA = 4096;

The output frequency then is F = F_{sample} / MWA is 2.44 Hz.

If the trigger frequency exceeds this value, it cannot be guaranteed that a measurement value will be ready after every trigger pulse.

When using the USB interface, the host software on the computer must ensure that the measurement values are retrieved from the FIFO buffer of the module RE-06 or the values will be overwritten as newer values are acquired.

Initialization of multiple measuring channels is done asynchronously. This can arise in the case of multiple serial interfaces because commands to individual channels are sent successively. It is therefore recommended to send a zeroing command after all channels have been initialized. All internal buffers are cleared upon receiving this command, thus ensuring that no delays are present in the measurement values.

Triggering the raw values

The trigger pulse is fed directly into the counter of interference orders. The current counter value is acquired and sent to the microprocessor. In this case triggering delays are only on the order of nanoseconds. The trigger pulse replaces the sampling frequency from the RE-06 module.

It is not recommended to activate the averaging of measured values while using this triggering mode because the starting times for the averaging channels are not synchronized. For high trigger frequencies it is recommended to utilize the available temporary buffering of the values in RAM (fast mode). This ensures that no measurement values are lost during data transfer or are not retrieved because the computer reaction time for the USB interface is too low.

In fast mode a set of primary data values is recorded into internal memory using the selected sampling frequency; this set may have a freely selectable length from 256 to 16,384 values (RS-232 interface) or up to 131,072 values (USB interface). The data set may be transferred to the computer and saved after acquisition has been completed.

Example:

The active interface is USB. A triggering of the unprocessed measuring values (raw values) is set. The trigger frequence is 500 Hz. This frequency is too high to guarantee that all measurement values can be sent to the computer without loss. In fast mode using USB transfer, the card can handle up to 131,072 measurement values in internal memory. This represents a measurement time of up to four minutes!

Summary of the Technical Properties

Maximum displacement resolution	0.1 nm
Maximum object speed	0.8 m/s
Length measurement:	
Sampling frequency	100 Hz - 16 kHz
Length of the averaging	256 - 32,768
FIR filter	1 - 7
Fast mode:	
Sampling frequency	Current output frequency
Data set length	256 - 16,384 (RS-232)
	256 - 131,072 (USB)
Superfast mode:	
Sampling frequency	900 Hz - 1 MHz
Data set length	256 - 32,768

Additional functions:

- ❏ Querying the controller parameters
- ❏ Environment value recording
- ❏ Software-controlled triggering of the acquisition of measurement values

The communication interfaces (USB interface and RS 232 interface) use a protocol open to all users. A detailed description of the interfaces can be found in separate documentations.

The measurement and evaluation program INFAS NTC is offered as an option and described in a separate documentation.

Environment module UW-xx

Precise measurement of the environment parameters is an important prerequisite for correcting the laser wavelength in air using the algorithm from Edlen (also see page 62).

The environment modules UW-26 and UW-25 measures the air temperature and the current air pressure in order to correct the index of refraction in the data processing module RE-06. The pressure transducer is located in the environment module UW-25 and is internally connected to the environment module UW-26. The covered opening P_{in} on the front panel is used for calibrating the pressure sensor (see arrow in Fig. 14).

The measuring sensor for temperature is located inside the sensor head (gauging probe). The temperature probe used is a precise Pt 100 resistance thermometer which is connected to the UW-26 environment module via a four-wire circuit. The lines are integrated in the hybrid cable (black flexible metal tube) and connected to the environment module via the EM-11 input module and via the internal wiring of the appliance.

Fig. 14: Front view showing the UW-26 (left-hand) and UW-25 (right-hand) environment modules

The following environment modules are used depending on the application:

Environment module	Capability
UW-26 (standard)	Environment: 1 x internal air pressure, 1 x internal temperature
UW-25	internal air pressure sensor
UW-27	Environment: 1 x internal air pressure, 2 x internal temperature

The sensors have the following measurement ranges:

	Temperature sensor	Air pressure sensor	Relative humidity sensor
Measuring range	+4...+75 °C	800...1150 hPa	1...99 %
Uncertainty	± 0.1 K	± 50 Pa	± 3 %

The electronic components in the environment module power the sensors, digitalize the measurement signals and form the coded digital signal proportional to the measurement value, which is then fed into the data processing module.

Identical circuits are used for the temperature and pressure measurements on the bases of high-resolution A/D converters.

The circuits are extremely stabile over the long-term; the basic configuration allows a measurement resolution of 0.001K for temperature and 1Pa for pressure. The data processing module reads previously processed environment values from the environment module over an I^2C interface. Wavelength correction is done in the data processing module in approx. 4 secs intervals. An optional extension with a digital measuring sensor allows to determine the air humidity.

The sensors are calibrated at the manufacturer. A recalibration of the gain and offset of all sensors is possible using a software tool.

An environment card is expandable to four temperature channels. The combination of multiple environment cards is also possible. If additional environment dimensions are required, customers may contact the SIOS Meßtechnik GmbH for more information.

The sensors are assigned a sensor number in the data processing modules. More information on this can be found in the INFAS NTC software documentation.

Motor control module MS-02

The motor control module MS-02 supplies the required operating voltage to control the motor drive unit. It ensures the directional speed control of the drive motor in the sensor head and provides for constant and smooth motor operation (single line diagram, see Fig. 16).

The different speeds for the upward and downward movements of the measuring sleeve are factory-programmed. If another speed is needed, please contact the service of SIOS Meßtechnik GmbH (support@sios.de).

The two pushbuttons are used to lift or lower the measuring sleeve regardless whether an input and display unit or a personal computer is connected or not (see Fig. 15).

IMPORTANT

The “Stop“ control command must be sent after the upward or downward control of the measuring sleeve by the PC or by the connected input and display unit. The pushbuttons for manual control will have no effect otherwise.

Fig. 15: Front view of the motor control module MS-02

1 Pushbutton to lower the measuring sleeve
2 Pushbutton to lift the measuring sleeve

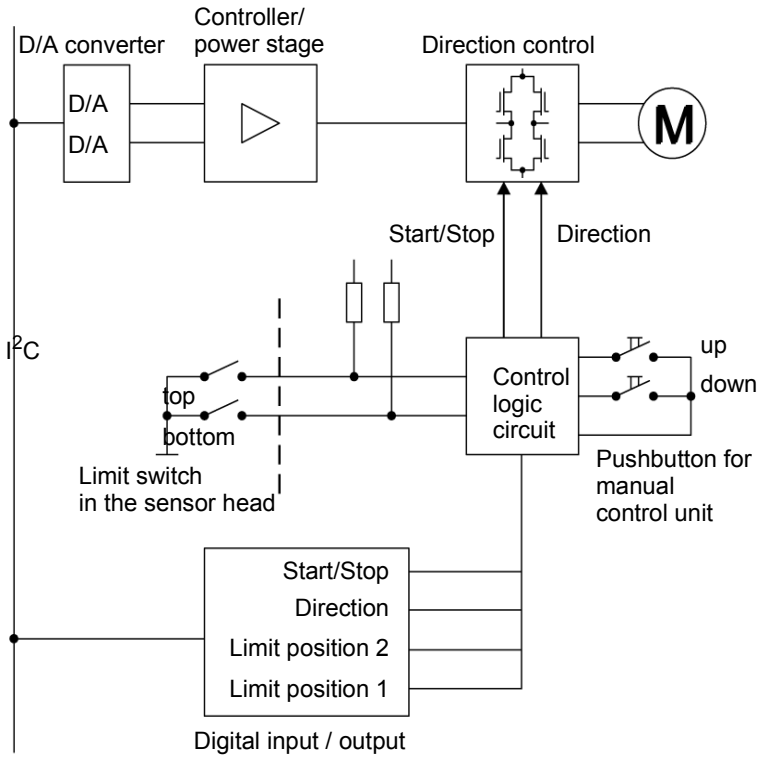


Fig. 16: Motor control module MS-02 (schematic diagram)

Power supply module NT-04

The power supply module NT-04 (see Fig. 17) establishes the mains connection for the system. It contains the two-pole power switch and three maintenance-free fixed-voltage modules in the form of switchable power supplies which provide the operating voltages of +5VDC [4A], -5VDC [2.5A] and +12VDC [4A]. These supply voltages are then provided to the other device components, such as the HeNe laser, using the internal wiring and through connectors.

The power from the low-voltage sources is dimensioned such that, when fully equipped, a reserve is available for other elements (e.g. an input and display unit).

The mains input is set up for a large range ([100-240]VAC, [50-60]Hz). Power consumption is approx. 50 W. A peak current of about 1.5 A arises when the device is switched on.

The mains connection is placed on the back panel of the supply and evaluation unit using a standard power cable and is outfitted with a power filter. This contains two fine-wire fuses 2A (T), which are externally accessible (see Fig. 18). The replacement of the fuses is described on page 82.

The power supply module is fixed to the case and can only be removed from the supply and evaluation unit after consulting the service personnel of the SIOS Meßtechnik GmbH.

Fig. 17: Front view of the power supply module with switch and indicators

1 Power switch
2 Power indicator LED

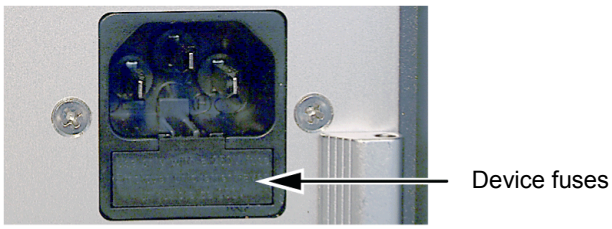


Fig. 18: Position of the device fuses

Input and display unit (optional)

The input and display unit (see Fig. 19) is connected to the supply and evaluation unit over a serial cable.

The measurement values are displayed in the same format as they are sent over the serial interface. The measurement values cannot be reconditioned using the keyboard. The resolution of the display is 1nm.

Furthermore the user can change all basic settings of the device through a menu-driven interface. It must be noted that an output rate which is too high will lead to a buffer overrun and therefore to disturbance of the display. Optimum value display is always guaranteed immediately after the device has been switched on.

See for information on using the input and display unit as well as on the function of the keys, see page 65.

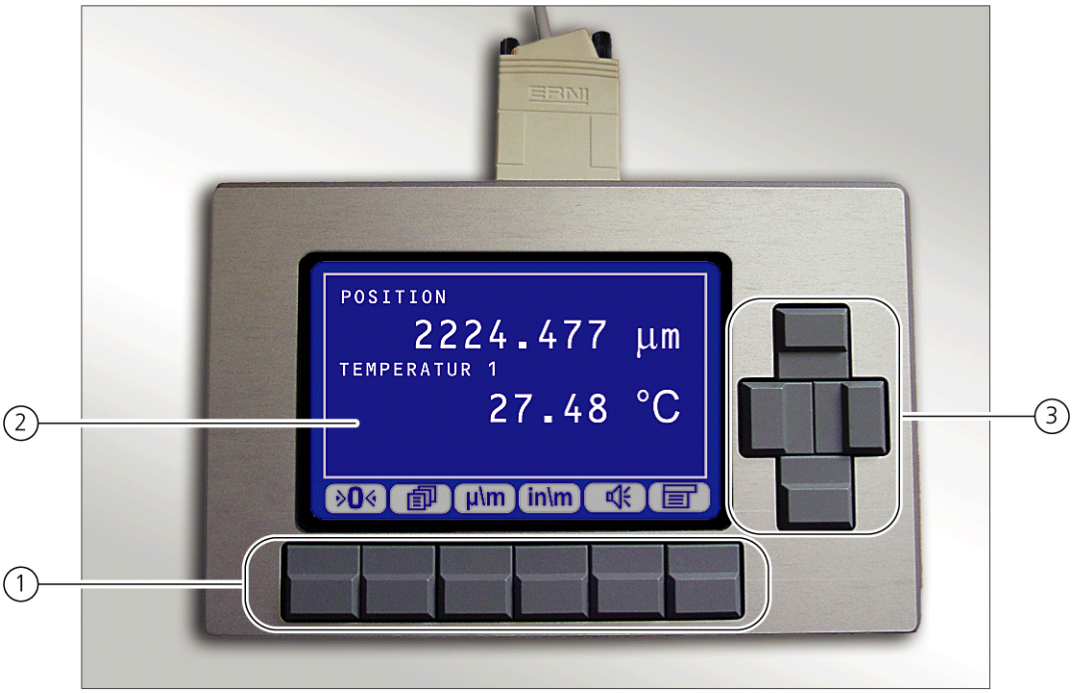


Fig. 19: Input and display unit DU-03

1 Function keys
2 Display
3 Cursor keys

4.3 Functional principle

The LM series laser-interferometric gauging probes are integrated measuring devices for precision length metrology. In addition the very compact design and the spatial separation of the gauging head and the evaluation electronics (including HeNe laser) are well-suited for length calibration tasks. The three-part basic system concept is shown in Fig. 20.

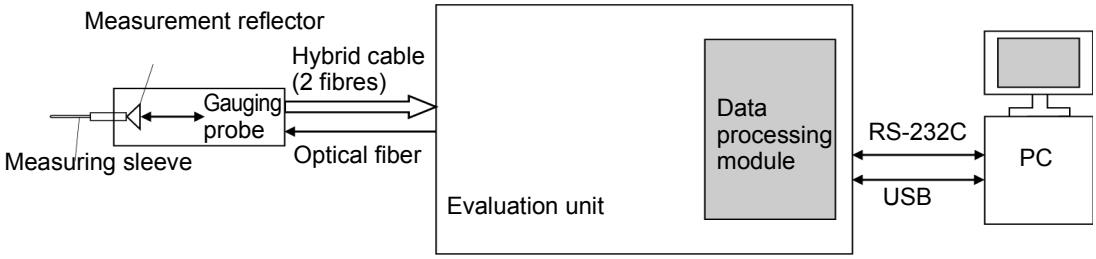


Fig. 20: Basic concept of the LM series interferometric measuring system

The working principle of the interferometer measuring system is based on the application of a Michelson interferometer with retroreflectors utilizing the interference effect. The scale is based on the extremely exact vacuum wavelength of an HeNe laser.

The measurement reflector is firmly connected to the movable measuring sleeve. All optical parts of the interferometer are located within the sensor head (gauging probe) and balanced. The gauging probe is ready for measurement without adjustment steps. The alignment of the reference axis to the object to be measured (see chapter 6.5.2) is recommended in order to minimize the measuring deviations.

A basic prerequisite for the compact design is the use of optical fibres. Here one fibre serves as the supply line for the HeNe laser output to the interferometer. Two other fibre-optic cables transfer the optical interference signals to the supply and evaluation unit. There a transformation is done from two optical analogue incremental signals (sine and cosine) into electrical signals normalized with respect to amplitude and offset.

The data processing module completes the analogue-digital conversion and post-processing (counting and interpolation) of the digital signals using logic circuits and a microprocessor. Length measurement values coherent with the metre unit are output using the counter values and the interpolation values, taken into account the vacuum wavelength and the optionally recorded environment parameters (temperature, pressure, humidity). Two interfaces are available for this by default: a serial RS-232C interface and a serial USB connection.

Input and display capabilities are realized either using a PC software or an input and display unit. The modular concept for the evaluation electronics allows other interfaces to be used as well. Of note are a module to output analogue position information (SM-05), a 32-bit interface (DP-02) and analogue (IS-01) and digital (IP-02) incremental signal modules.

The modular design also allows for a multitude of device configurations, for example multi-axis set-ups. Depending on equipment and configuration of the measuring system, it is also possible to carry out highly accurate thickness measurements (e.g. wafers, lenses).

The power supply for the evaluation unit is provided by a large-range voltage input accepting mains power between 90 and 240VAC with frequencies from50 to 60Hz. This allows the device to be connected to all available power networks worldwide.

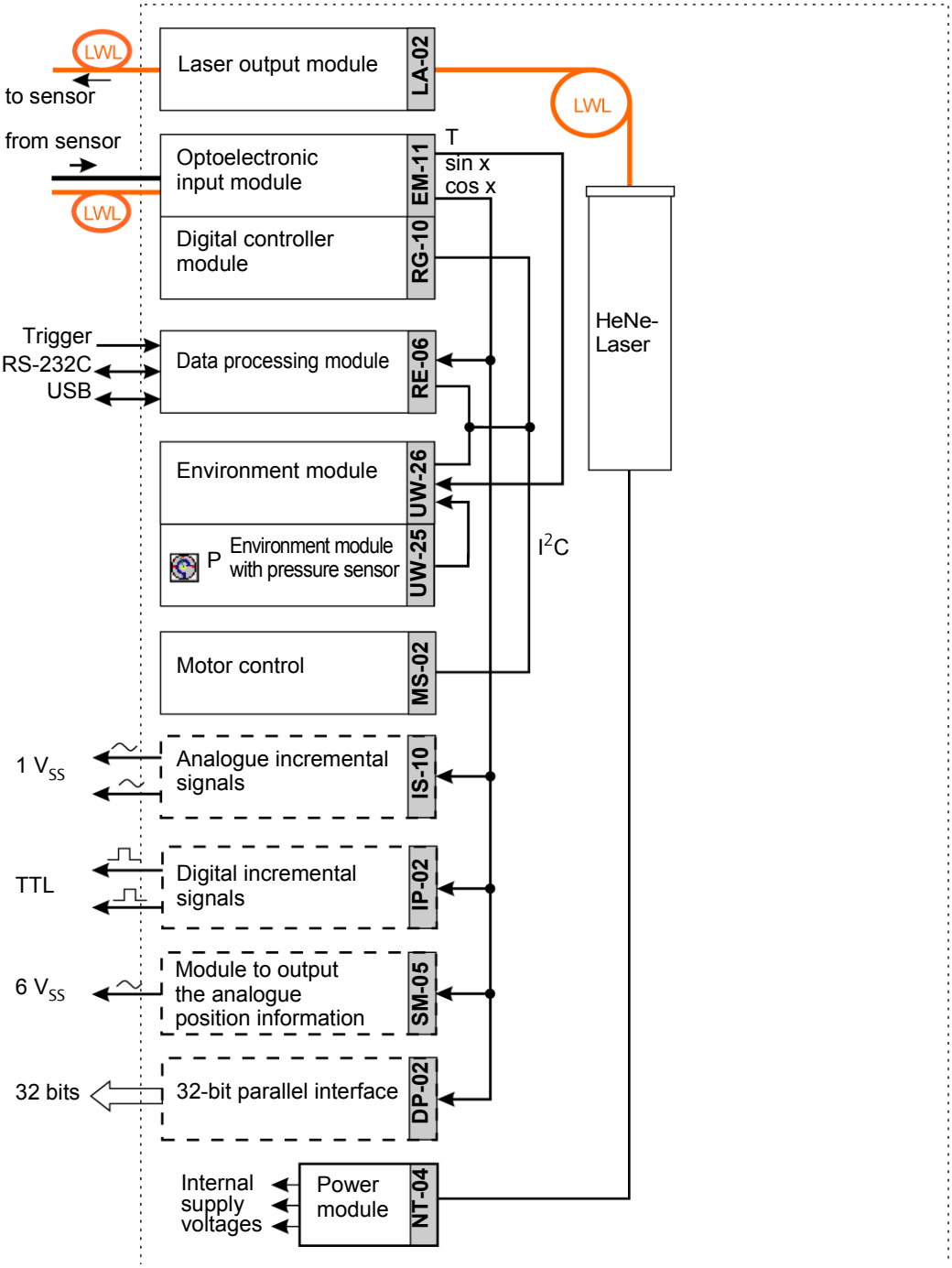


Fig. 21: Diagram of overall data flow

5 Transport and Storage

5.1 Transport

5.1.1 General Tips

CAUTION

Environmental influences, jolts and build-up of condensation can lead to the destruction of individual device components!

Protect all components of the gauging probe during transport using appropriate measures against the aforementioned factors! Temporarily storing the device or its component in the open is prohibited!

CAUTION

Damage possible from improper packing!

Do not pack or transport the sensor head (gauging probe) unless after having **retracted** the measuring sleeve!

Only transport the components of the gauging probe in their original packaging! Secure all moving parts with cable ties and cushion the packaging with appropriate materials!

The following conditions must be maintained during transport of the gauging probe:

- ❏ Temperature range: -10...+50 °C
- ❏ Allowable relative humidity: < 85% at 30 °C, no condensation
- ❏ Allowable pressure range: 100...1150 kPa

When transporting the gauging probe, only use the original packaging or the optionally available transport case (see Fig. 22). The gauging probe must be transported extremely carefully in order to prevent damage from impacts or careless loading and unloading. Jolts and vibrations as well as condensation build-up due to large temperature changes should be avoided during transport.

Fig. 22: Original packaging (1) and transport case (2)

CAUTION

Careless packing can lead to functional limitations or even destruction of individual components!

Laser-interferometric gauging probes are optical precision length measuring systems. The components should be packed with the utmost care. Never pull on, jerk or bend connecting cables when packing individual components. When carrying out the steps listed below, ensure that the hybrid cable and the lone fibre optic cable are not kinked or stretched because the optical fibres could be destroyed!

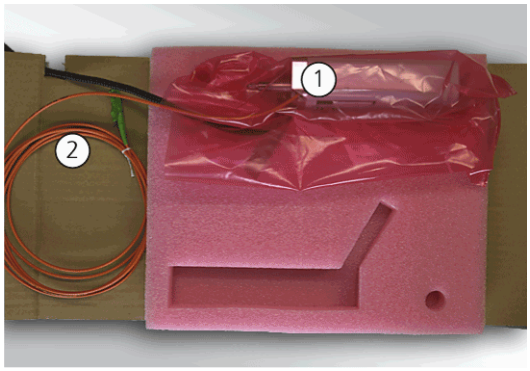
Completely shut down the gauging probe and remove all connecting cables from the SEU. Secure all moveable parts with cable ties.

5.1.2 Packing in original box

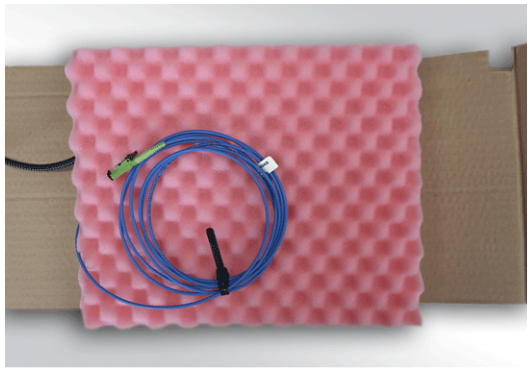
Pack the device components in the original packaging as follows:

CAUTION
Check that the measuring sleeve has been retracted.

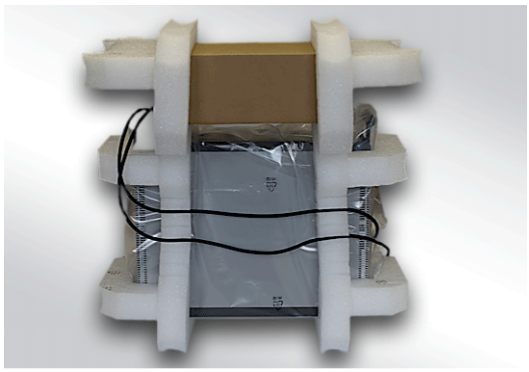
1. Pack the gauging probe (1) in an antistatic protective bag.
2. Wind the fibre optic cable (2) into large loops and secure it with cable ties.
3. Lay the gauging probe into the appropriate cutouts in the hard foam padding.

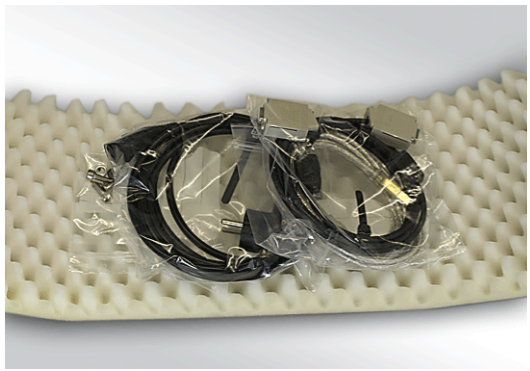
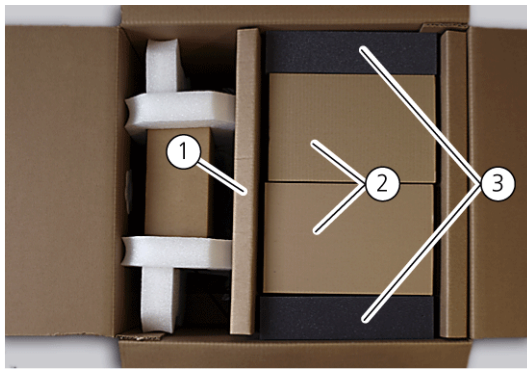


4. Cover the hard foam padding with a soft foam pad and lay the fiber on the soft foam.



5. Cover the fiber optic cable with the second foam pad.
6. Guide the hybrid cable along the cutout cable guideway in the folding box (see arrow.

7. Close the folding box.	
8. Pack the SEU into a clear plastic bag (with the opening of the bag toward the front side of the unit).	
9. Pack the SEU into the hard foam frame pieces. The grips on the SEU housing should remain in the direction of the cutouts for the sensor head box. 10. Place the sensor head box into the appropriate cutout section in the hard foam and secure the hybrid cable in the slots in the hard foam as shown in the image.	
11. Place the fully packed unit into the transport box. <u>Tip:</u> Add an appropriate desiccant (e.g. silica gel) into the package if necessary.	

12. Pack the accessories in the corresponding foam pads and folding boxes.	 
13. Lay the corrugated cardboard (1), the full folding boxes (2) and the anthracite-coloured cushioning (3) into the transport box.	
14. Lay the foam cover on top and close the entire box using strong packing tape. ✔ **The gauging probe has now been securely packed and can be transported.**	

5.1.3 Packing in carrying case

DANGER

Danger to life from high voltage and possible danger from main voltage and class 2M laser light!

The HeNe laser installed in the supply and evaluation unit is operated with high voltage! Residual charge can remain even after the SEU has been switched off!

Switch the SEU off (power switch to position “0“, cable removed from wall socket) before removing the input module EM-11!
Ensure the device cannot be inadvertently switched back on!

Pack the device components in the carrying case as follows:

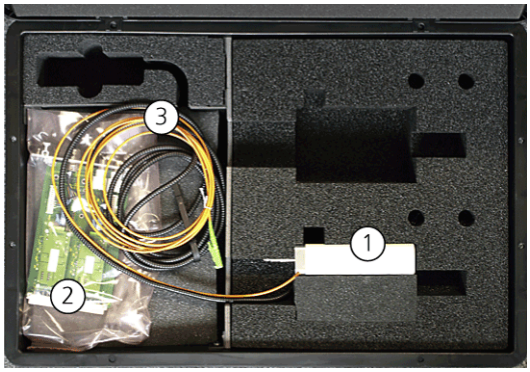
CAUTION
Check that the measuring sleeve has been retracted.

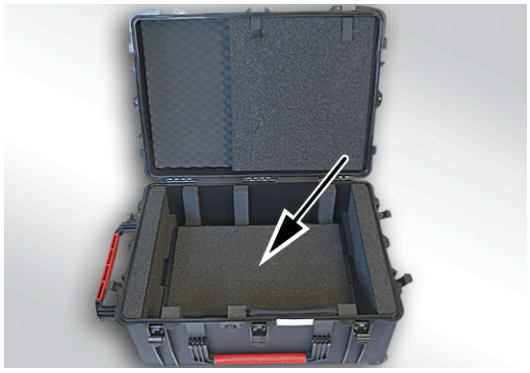
1. Remove the large and small transport containers from the transport case (see arrows).

Be sure to observe the above safety notice.

2. Remove the input module EM-11 from the SEU. For this purpose, loosen the two screws of the module and carefully pull the card out. **Do not touch the circuit board itself!**

3. Pack the gauging probe and the input module EM-11 in the large transport container:
   " Pack the input module EM-11 (2) in an antistatic protective bag and place it in the compartment provided. **Do not touch the circuit board itself!**
   " Wind the hybrid cable and the fiber optic cable (3) into large loops and secure it with cable ties.
   " Carefully press the gauging probe (1) into the corresponding recess in the foamed plastic, and place the cable (3) with care. In particular, ensure that the fiber optic cable is not pinched by the edge.
   " Use suitable material to pad the compartment containing the input module and the cables so as to prevent the input module from slipping.
4. Close the transport container, and place it in the transport case (see arrow).





5. Pack the accessories in the small transport container.

6. Close the small transport container, and place it in the transport case (see arrow).

7. Place the SEU in the transport case (see arrow).	
8. Open the two Velcro fastenings in the lid, and fold the flap down. 9. Place the user documentation and any other documentation in the corresponding pockets, close the flap in the lid, and close the Velcro fastenings.	
10. Close the lid, and lock the locks on all three sides. Tip: There are two rollers on the bottom of the case which make it easy to transport.	

5.2 Storage

If the gauging probe is not going to be installed soon after delivery or if it is not needed for a longer duration, it should be stored in an appropriate manner in its original packaging. Add an appropriate desiccant to avoid damage due to humidity.

The following conditions must be maintained within the area in which the device is being stored:

- ❏ Temperature range: -10...+50 °C
- ❏ Allowable relative humidity: < 85% at 30 °C, no condensation

6 Installation and Start-Up

6.1 Location Requirements

6.1.1 Installation Conditions

The operational space of the LM series gauging probe must fulfil the following environment requirements:

- ❏ Temperature range: 15...30 °C
- ❏ Allowable relative humidity: < 70 % at 23 °C, no condensation
- ❏ Allowable pressure range: 800...1150 kPa

The accuracy of the length measurement is highly dependent on the conditions around the sensor head installation and the proper functioning of the electronic components. Electrostatic charges and strong air circulation should be avoided in the operation space. Protect the measurement path from air motion using appropriate measures as necessary.

The atmosphere of the operational space should be as dust-free as possible as well as free of draughts and corrosive vapours. Please comply with the following instructions for locating the device:

- ❏ The floor must be stabile, level and free of vibrations.
- ❏ Do not install the gauging probe directly near doors or windows or place the supply and evaluation unit near sources of electromagnetic disturbance.
- ❏ Avoid the direct radiation of heat onto the sensor head, e.g. through sunlight, light sources or heaters. Ensure adequate climate control if necessary.
- ❏ The air humidity in the measuring room should be between 40% and 70% relative humidity. Keep relative humidity of the operational space as constant as possible during measurements.
- ❏ Continuous access to the device must be guaranteed and the venting grates must be kept clear of other devices and set-ups.
- ❏ Avoid increased environment temperatures (trapped heat) arising from installation of the gauging probe in higher-level systems (racks). When installing the gauging probe in a rack, ensure sufficient circulation of the system in order to avoid trapped heat.

6.1.2 Space Requirements

Space requirements are determined by the arrangement of all components of the gauging probe. Sufficient space must also be available for the computer, monitor and other accessories.

6.2 Unpacking

CAUTION

Careless unpacking can lead to limitations in functionality or destruction of individual components!

Laser-interferometric gauging probes are optical precision length measuring systems. Therefore, the utmost care should be exercised when unpacking the components. When unpacking individual components, do not pull on, stretch or bend connecting cables! Pay special attention to the hybrid cable and the fibre optical cable so that they especially remain free of kinks, which would almost certainly destroy them!

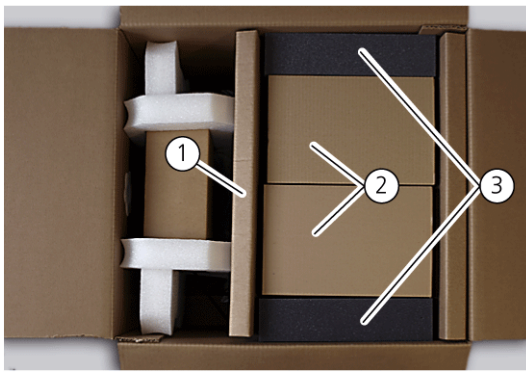
CAUTION

The formation of condensation due to temperature differences can lead to damage to the electronic parts!

Let the system acclimatize for one hour after being unpacked or moved so that the system can adapt to the temperature conditions at the new location. Only start up the laser-interferometric gauging probe after the temperature of the sensor head and the entire set-up has been fully equalized!

6.2.1 Unpacking from the transport box

Unpack the components of the gauging probe from the transport box as follows:

1. Open the transport box and remove the foam cover.	
2. Remove the following components from the box: – Corrugated cardboard insert (1) – Anthracite-coloured cushioning (3) – Folding box with accessories (2)	

CAUTION
When completing the following steps, the hybrid cable assembly and the fibre optic cable must not be kinked or stretched!

3. Remove the hard foam packing frame together with the sensor head box and the SEU.

4. Carefully pull out the hybrid cable from the hard foam frame, remove the sensor head box from the frame and place it carefully next to it.
5. Carefully remove the SEU from the frame and place it on the table. Keep in mind that the hybrid cable is attached to the sensor head and the SEU.

6. Place the SEU together with the sensor head box near the installation site and open the box. Carefully remove the sensor head and the rolled-up optical fibre from the foam padding and place the sensor head on the table.
7. Unpack the remaining parts from the folding boxes.

✔ **The laser-interferometric gauging probe is completely unpacked from the transport box now.**

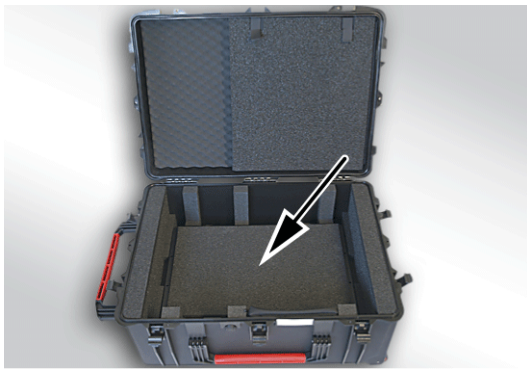
IMPORTANT

Safe transport of the gauging probe components is only possible using the original packaging!

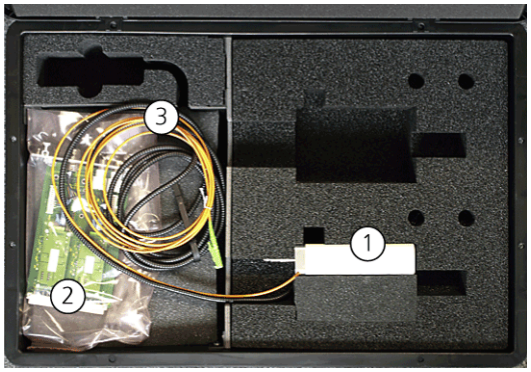
The original packaging should therefore be stored for later transport purposes, such as returning the unit for servicing!

6.2.2 Unpacking from the transport case

Unpack the components of the gauging probe from the transport case as follows:

1. Open the transport case and remove the SEU (see arrow) with caution.	
2. Take the small transport container (see arrow) out of the transport case, and remove the accessories.	 
3. Take the large transport container (see arrow) out of the transport case.	

4. Carefully remove the sensor head (1), the input module EM-11 (2) as well as the hybrid cable and the fiber optic cable (3) from the transport container. Keep in mind that the hybrid cable is attached to the input module and the hybrid cable and the fiber optic cable to the sensor head.



CAUTION
Especially ensure that the fiber optic cable must not be kinked or stretched!

5. Close the two transport containers, and replace them in the transport case (see arrows).
6. Close the transport case.

✔ **The laserinterferometric gauging probe is completely unpacked from the carrying case now.**

6.2.3 Installing input module EM-11 in the SEU

DANGER

Danger to life from high voltage and possible danger from main voltage and class 2M laser light!

Before installing the EM-11 input module, make certain that the appliance switch at the SEU is in the “0“ position and the power plug is not plugged into any mains outlet.

Install the input module EM-11 as follows into the SEU:

1. Remove the antistatic protective bag from the input module EM-11. **Do not touch the circuit board itself!**
2. Reinsert the card carefully into the SEU slot. **Do not touch the circuit board itself!**
3. Tighten the two screws.

✔ **The input module EM-11 has now been successfully reinserted.**

6.3 Connecting the Device

6.3.1 Installation instructions

CAUTION

Danger of injury and possible device damage can arise through the connection of cables carrying voltages!

Only connect cables to system components when the device is powered off and free of voltage!

CAUTION

Large tension and bending forces on the connecting cables can lead to severe damage and reduced functionality of the sensor head!

Proceed with extreme care when complete the following steps! Special attention should be paid when placing the cables that they are loose and not kinked! The cables may not be placed on the floor!

To avoid subjecting the sensor head to any unwanted tensile force, it is recommended to secure the connecting cables in a suitable way **before** the sensor head. Ensure that the single-mode fibre-optic cable is not pinched or acutely bent under any circumstance.

IMPORTANT

After its setup or after changing its location, the system needs some time to adapt to the prevailing temperature conditions. The temperature balance inside the sensor head must be established before making any high-precision measurement.

The dimensions or mounting dimensions of the sensor head are indicated in the appendix (see page 85).

The higher-level mechanical system must ensure the restraint-free installation of the sensor head. Particular caution is needed when clamping the precision ball guide. Select a clamping force which ensures that the deformation of the guide sleeve caused by this does not obstruct the free movement of the measuring sleeve.

But the firm fit of the sensor head must still be guaranteed. When clamping the sensor head, leave a gap between the bottom surface of the sensor head and the measuring fixture. This ensures that the alignment of the sensor head will be determined almost exclusively by the guide direction and avoids measuring errors caused by an uneven support or by constraint.

IMPORTANT

Before inserting the sensor head, the measuring sleeve must be moved into the measuring fixture.

6.3.2 Connecting the Fiber Optic Cable

CAUTION

Tension and bending forces on the fiber optic cable can lead to its destruction!

The fiber optic cable should be placed loosely and without kinks! The cable may not be placed on the floor!

Never pull directly on the fibre optic cable; only disconnect the cable by removing the E2000 plug!

Connect the fiber optic cable to the laser output module as follows:

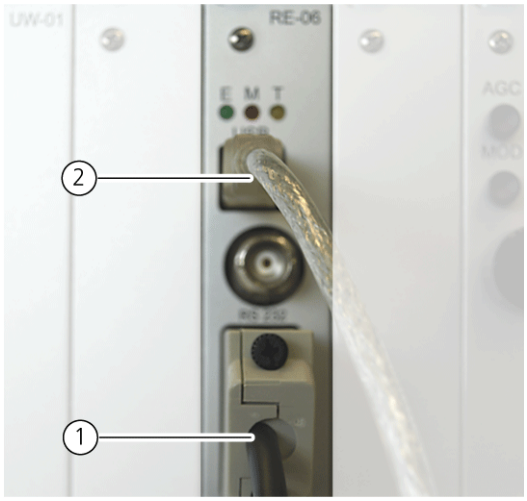
1. Remove the protective cap from the laser output. Tip: The protective cap is connected to the handle of the SEU by a chain to prevent losing it.	
2. **Immediately** after removing the protective cap, insert the E2000 plug at the end of the fiber optic cable with the snap-in rocker pointed up. Be sure that the snap-in rocker locks into place. Important: To prevent dust from entering, the laser output must never remain open for a long time.	

6.3.3 Connecting the Data Interface

Connection between the supply and evaluation unit and the computer or the input and display unit is realized using a connector cable (USB cable or RS-232C cable with RxD and TxD crossed) including as part of the standard delivery contents.

The communications interface is connected as follows:

1. Connect the RS-232 cable (1) or the USB cable (2) to the corresponding port on the data processing module RE-06.



2. Connect the other end of the cable to the computer s serial or USB interface.
   Tip:
   When connecting the cable to the serial port, ensure the cable shielding and the D-sub socket housing are connected with low impedance (large area). Not doing so could reduce the system s immunity to interference and therefore its stability.

   ✔ **The connection between the SEU and the computer or the input and display unit has now been established.**

6.3.4 Connecting the Power Cable

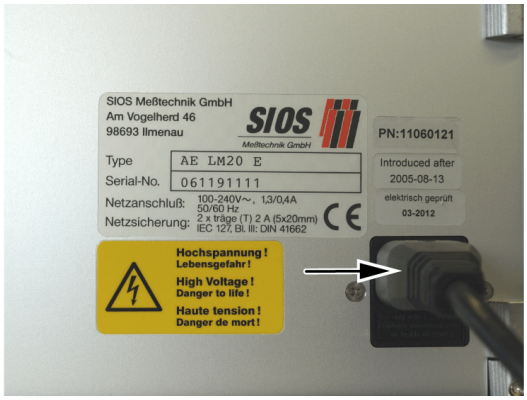
WARNING

Danger to life due to electric shock in case of breakage in the earthing conductor!

Only plug in the supply and evaluation unit to a mains socket with an earthing contact! Ensure that the safety function is not interrupted by extension leads without an earthing conductor or through the use of a power converter!

The laser-interferometric gauging probe operates using single phase AC mains power. The power connection is done using the cable included with delivery. The mains connection is done as follows:

1. Connect the power cable to the socket on the back of the SEU.

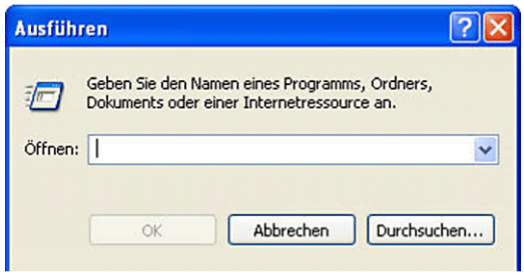
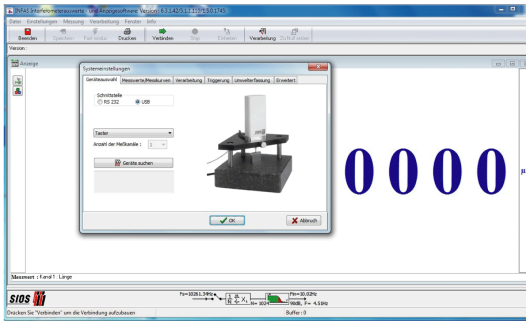


2. Connect the other end of the power cable to a properly functioning mains socket (100-240VAC, 47-60Hz) with an protective earth (PE) conductor.
   Tip:
   The sensor itself operates with a small voltage (<12V) supplied across the sensor cable. The sensor housing is connected to the device earth and respectively the protective earth conductor.

   ✔ **The power supply has now been established.**

6.4 Basic Configuration

After all system connections have been established, the interfaces must be defined in the INFAS NTC control and analysis software and the addresses assigned. This is done as follows:

1. Switch on the SEU by pushing the power button on the supply module.	
2. Switch on the computer and wait for Windows to boot up. Insert the installation CD into the CD drive and follow the installation steps on the screen. Tip: If the CD does not automatically start, click “Run“ under the Windows start menu. Run the file setup.exe found on the installation CD	
3. The interfaces to be used and the appropriate addresses must be set in the INFAS NTC software (see the INFAS NTC software documentation). Tip: When the USB interface is connected for the first time, the computer will require the USB driver to be installed. To ensure reproducible measurements, we recommend to use the measuring gantry shown in Fig. 4 on page 20 to fasten the sensor head. This is located on the installation CD. In the case of multi-channel devices, each USB card must be installed separately. Each card has its own USB number, and is regarded as a separate device by Windows. Please follow the installation steps on the screen.	

6.5 Set-up and Alignment

6.5.1 Mounting the Sensor Head

For reproducible measurements we recommend the use of measuring portal shown in Fig. 4 at page 20 to mount the sensor head.

The gauging probe may also be inserted in all commercially available clamp shanks with a diameter of 8h6. To allow this, the clamping mechanism must be designed as a circumferential clamp. Any further mechanical load on the gauging probe must be excluded.

IMPORTANT

When fastened, a small gap must remain between the casing of the sensor head and the mounting plate into which the clamping mechanism is integrated.

6.5.2 Calculating systematic errors of measurement

Measuring errors caused by the angular misalignment of the measurement axis to the device under test

In order to best utilize the high accuracy of the laser-interferometric gauging probe, the sensor head be aligned as carefully and accurately as possible to the object to be measured. Cosine errors are caused when the gauging probe hits the device under test in an oblique direction at an angle α (see Fig. 23). These are always positive, i.e., the length values measured are always bigger than the true value *l*. To obtain the true value, the measuring error needs to be subtracted.

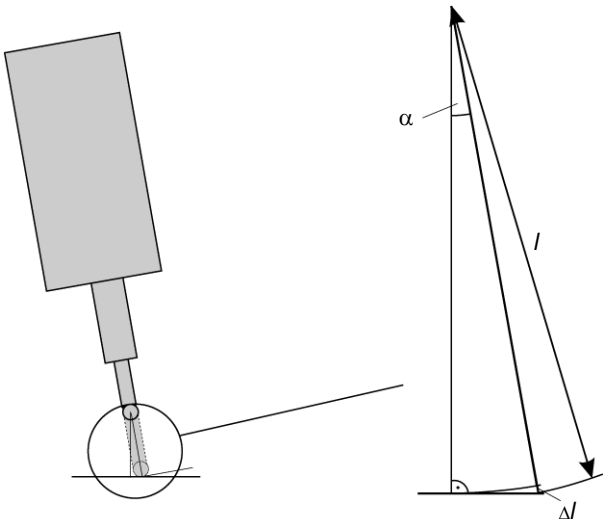


Fig. 23: Measuring error caused by the angular misalignment of the measurement axis to the device under test

To calculate the measuring error Δl, proceed as follows:

$$\Delta l = l \cdot (1 - \cos(\alpha))$$

with: α – Angle between the direction of the measured variable of the tested device, gauging probe
l – measured path

A measuring path of 20 mm and an angular misalignment by an angle of 5 arcmin yields a systematic error of dimension of + 21 nm.

Flattening error

Another systematic measuring error should be taken into account when scanning devices under test which consist of different materials. The elastic deformation, which occurs at the surface of the device under test and of the gauge insert due to the measuring force exerted, is referred to as Hertzian flattening.

The resulting length measuring error depends on the geometry of the measuring surface and on the geometry of the gauging probe (radius) as well as on material and measuring force. This error is always negative, i.e., the length measuring values are always smaller than their true values.

For example, a ruby sphere with a radius of 1.5 mm (standard measuring insert) pressed against a flat steel surface by applying a 0.8 N measuring force leads to flattening and thus to a measuring error of - 245 nm (additive correction).

When comparing devices under test which consist of the same material, this error is constant and does not need to be taken into account.

6.5.3 Adjustment of the Piezoelectric Oscillator

The LM series measuring system is delivered in a fully adjusted and aligned state and is immediately ready to run when unpacked. However due to natural wear and aging of parts, deviations from the normal operational parameters can arise, which require a renewed compensation procedure for the piezoelectric oscillator in the sensor head.

CAUTION

Changes in the settings of the electronic assemblies can lead to functional errors in the system!

Do not carry out unauthorized changes to the settings in the electronics assemblies! Necessary changes to these settings may only be done after having contact SIOS Meßtechnik GmbH by qualified, instructed personnel. If necessary send the device back to SIOS Meßtechnik GmbH for readjustment of the parameters.

In order to set up the interferometer, the optical phase difference must be modulated using the piezoelectric oscillator in such a way that at least one minimum and one maximum from the interferometer signal (closed circle of the Lissajous curve when displayed on an oscilloscope in x-y-format) with an order frequency above 400Hz. With the oscillation amplitude of at least ± 0.5 interference orders, the input module EM-11 can adjust itself to the currently available amplitude and offset values and deliver the corrected output signals as desired. This adjustment completes approximately 10s after the device is switched on.

The piezoelectric oscillator can be switched on and off when the digital controller module RG-10 is in automatic control mode by pressing the MOD button (button 1) (see page 69).

For automatic gain control (the green LED on the RG-10 module is on) the signal amplitude measurable with an oscilloscope is approx. $3V_{SS}$. Large deviations from this amplitude value indicate a change in the beam power of the laser, a misalignment of the optical system or malfunction of the supply and evaluation unit.

Setting the modulation stroke is done on the digital controller module RG-10 that the Lissajous curve shown in Fig. 24 is achieved on the oscilloscope display (90° phase offset between the channels, closed circle). To set the modulation stroke, see page 69 sqq.

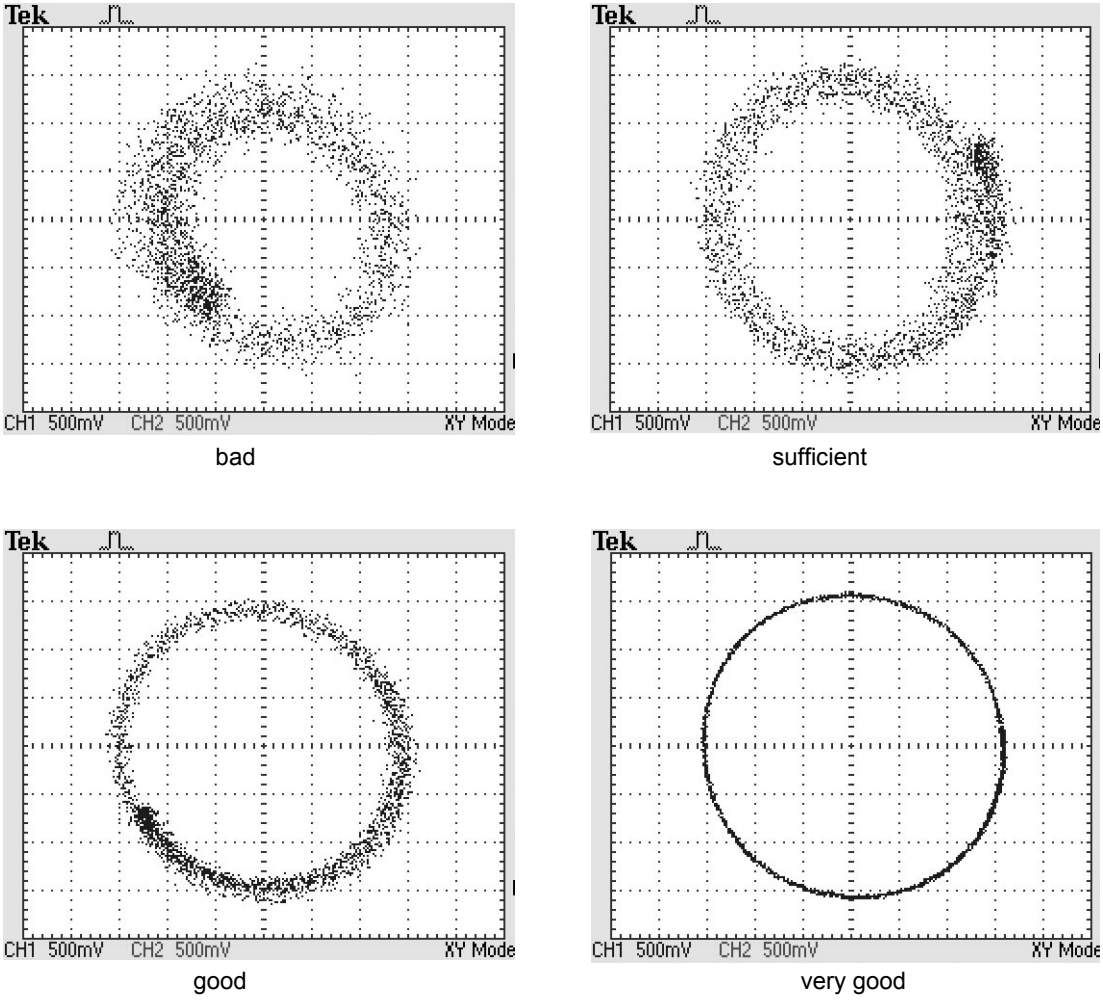


Fig. 24: Analogue signals from the output of the input module after optimum alignment and automatic gain control (CH1 and CH2); oscilloscope in X-Y display (0.5V/div.)

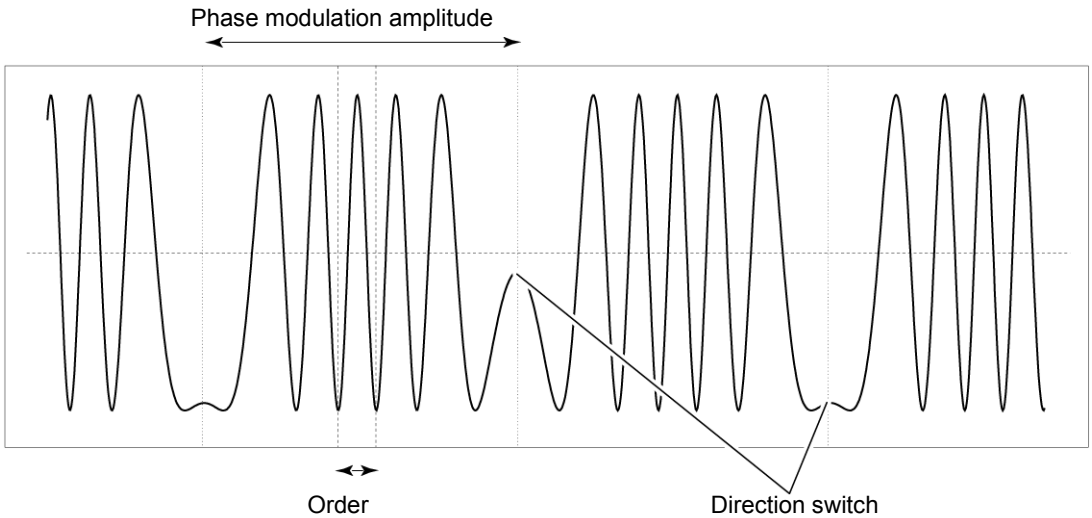


Fig. 25: Time-dependent analogue signal at the oscilloscope input (CH1 or CH2)

6.5.4 Environment Influences

The correction of the laser wavelength in air is an important component contributing to precise length measurements with a LM series gauging probe. The laser wavelength in air changes depending on the index of refraction, which is in turn chiefly determined by the environment parameters temperature, pressure and humidity. The analytical relationship between the air parameters and the index of refraction is described using formula originally developed by Edlen. The following table lists the relative deviations of the length measurements caused by the environment parameters

Accuracy of the Parameter Measurement	**Relative Error for λ**	**Valid Range of the Parameter Measurement**
Temperature: <0.1 K	$\pm 2{,}8 \cdot 10^{-7}$	10...35 °C
Pressure: ±50 Pa	$\pm 1{,}4 \cdot 10^{-7}$	900...1100 hPa
Relative humidity: ±5 % (when using the optional humidity measurement)	$\pm 0{,}3 \cdot 10^{-7}$	10...90 %

In general the larger the measurement path in the air is, the greater the absolute influence brought about by the environment parameters. In the standard configuration of the supply and evaluation unit, temperature measurements are done using a Pt-100 temperature sensor in the sensor head and the air pressure measurement takes place using an absolute pressure sensor located in the environment module UW-25. The optional humidity sensor can be included as well for smaller, better measurement uncertainties.

7 Operation

7.1 General

Keep in mind the following tips to ensure proper, undisturbed operation of the laser-interferometric gauging probe and for maintaining metrological properties specified in the technical characteristics:

- ❏ The laser-interferometric gauging probe of the LM series is a precision measuring instrument! Be sure to avoid exposing the sensor head to any mechanical shock or tensile force and avoid any transverse force on the measuring sleeve.
- ❏ Ensure that the single-mode fiber optic cable is not pinched, stretched or acutely bent under any circumstances.
- ❏ Never open the sensor head! Any internal alignment work may only be carried out by service personnel from SIOS Meßtechnik GmbH!
- ❏ We recommend switching off the device when not in use for an extended period because the service life of the laser is limited.

7.2 Switching the Device On

WARNING

Injury and possible device damage can result from incorrect connections!

Before switching on the device, ensure that all components are connected together, the mains connection is properly in place and the cables are undamaged. During operation, no electrical connected may be detached or reattached!

Switch on the entire system by pressing the appropriate button on the power supply module NT-04 in the supply and evaluation unit (see Fig. 26). The powered state of the Laser-interferometric gauging probe is indicated by the red LED.

Fig. 26: Switching on gauging probe

7.3 Warm-Up Times for the Electrical Components

The LM20 and LM50 measuring systems are equipped with an unstabilized HeNe laser. In principle these measuring systems are ready for use as soon as they are switched on. However the HeNe laser does require some thermal warm-up time in order to reach the stability necessary to fulfil the measurement principle.

In the given application temperature range of 23 °C (±7 K), this process is completed in approx. 1minute. Measurements should not be started until after this warm-up phase is finished in order to be able to fully utilize the capabilities of the system.

7.4 Performing Measurements

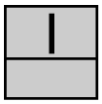
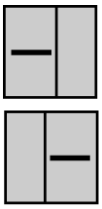
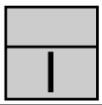
7.4.1 General

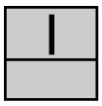
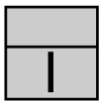
For precision measurements temperature equalization processes should be allowed to proceed for some time after performing work on the sensor head. These equalization processes can last several hours. A good criterion for when to start measuring is to observe the behaviour of the measured value indication of the gauging probe.

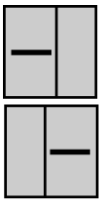
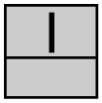
Operation of the gauging probe can be done using either the input and display unit (see chapter 7.4.2), the software INFAS NTC running on a computer (see “Software documentation INFAS NTC“) or a supervising system running proprietary software.

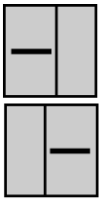
7.4.2 Operating the Gauging probe via Input and Display Unit

The laser-interferometric gauging probe can be operated using the optionally available input and display unit. The key and function assignments are as follows:

Menu	Key Assignment	
Main Menu		Set to zero
		Change environment parameter representation
		Switch units (nm, µm, mm)
		Switch unit systems (inches or metres)
		Toggle sound on/off
		Next menu
		Lift motor
		Stop motor
		Lower motor
Menu 2		Data rate
		Expert mode
		Default settings
		Dead path settings
		Version information
		Back to the previous menu

Menu	Key Assignment	
Data rate		Select a value
		
		Cancel and go back
		Save value and go back
Expert mode		Raw values
		Mean values
		Filtered values
		Signal monitor
		Settings
		Back to the previous menu
Raw values		Back to the previous menu
Mean values		Back to the previous menu
Filtered values		Back to the previous menu
Signal monitor		Extended signal monitor
		Back to the previous menu
Extended monitor		Back to the previous menu

Menu	Key Assignment	
Settings	F1	Sampling frequency
	F2	Moving weighted average
	F3	Filter number
	F4	Toggle modulator on/off
	F5	Motor control
		Back to the previous menu
Sampling frequency		Change cursor position
		Increment/decrement
		Cancel
		Save value and go back
Moving weighted average		Select a value
		Cancel and go back
		Save value and go back
Filter number		Back to the previous menu
Modulator		Toggle on/off
		Back to the previous menu

Menu	Key Assignment	
Motor control		Select speed
		Cancel and go back
		Save value and go back
Dead path settings		Change cursor position
		Increment/decrement
		Cancel and go back
		Save value and go back

7.4.3 Operation the Gauging Probe using Software INFAS NTC

The laser-interferometric gauging probe can be operated using the optionally available control and evaluation software INFAS NTC. Refer to the software manual for further information on the available functions and operation of the software INFAS NTC.

The software can be started as follows:

1. Check that the gauging probe is switched on and properly connected to the computer.
2. Switch on the computer.
3. Start the INFAS NTC program by double-clicking on the appropriate desktop icon.

   ✔ **The INFAS NTC program begins by showing the starting screen.**

7.4.4 Switching the Controller and Oscillator on and off

Algorithm for Setting Values

The settings described below are represented as a flow chart in Fig. 27. Refer to see Fig. 11 on page26 for the position of the buttons on the front panel.

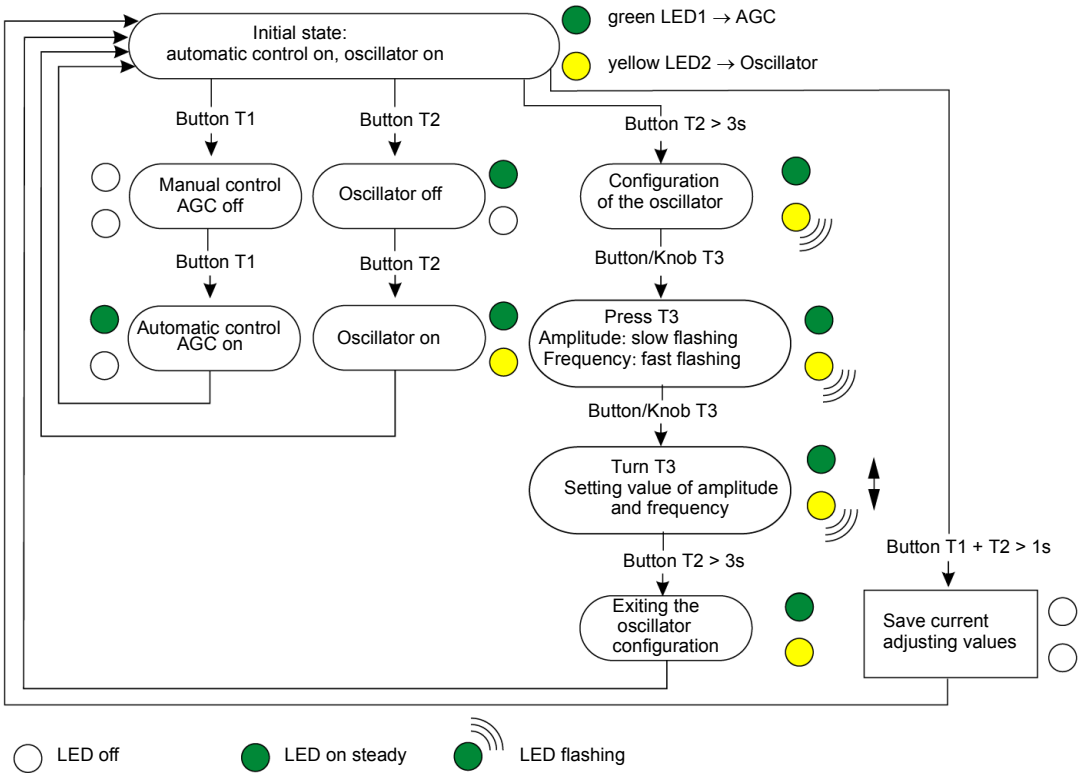


Fig. 27: Setting algorithm for the digital controller module RG-10

Control AGC

When the supply and evaluation unit is switched on, the automatic gain control (AGC) begins running, which constantly monitors and controls the signal gain and offset. The green LED1 is illuminated.

Activity of the controller can be toggled by pressing button T1.

If the controller is switched off, LED1 ceases to illuminate; no signal adaptation (gain or offset) is done. If button T1 is pressed again, AGC is reactivated and LED1 again lights up.

Oscillator MOD

Activity of the oscillator can be toggled by pressing button T2. If the oscillator is active, the yellow LED2 lights up. The yellow LED goes out when the oscillator is powered down.

When the oscillator is switched on or off, the controller is also switched on or off accordingly with a slight delay in order to minimize noise from the amplifiers. In systems without an oscillator, button T2 is not present.

Configuring the Oscillator

To configure the oscillator, button T2 must be pressed and held for longer than 3s. The yellow LED then begins to flash.

Switching between setting the amplitude and the frequency is done by pressing the button/knob T3:

- ❏ Setting frequency yellow LED flashes quickly
- ❏ Setting amplitude yellow LED flashes slowly

The selected parameter can be increased or decreased by turning button T3.

When aligning the interferometer, the user can monitor the analogue signals using a connected oscilloscope.

When setting up the oscillator, it is sensible to choose the amplitude such that the Lissajous curve appears to be an open circle and then find the correct frequency which closes the circle. When the frequency has been found at which the circle is close furthest (forming multiple circles), then the circle can be completely closed by setting the amplitude. The recommended amplitude is about 2 circles.

In order to exit the oscillator configuration, press the T2 button for longer than three seconds until the yellow LED stops flashing. The controller card begins operating with the new oscillator settings. This sets the same operating mode as was active before the oscillator was configured.

Saving the Configuration

After successful configuration, the settings should be saved if they are to be retained after a restart.

Buttons T1 and T2 are both pressed a minimum of 1s. Both LEDs switch off. The settings are written to the EEPROM and will be active the next time the device is activated. Here the current operational state (controller on/off, oscillator on/off) is also saved.

For systems without an oscillator, saving the configuration can only be tripped by the computer (INFAS signal monitor).

Connection to the PC

The controller module is connected to the data processing module RE-06 over a digital interface, which allows it to monitor and set the controller parameters and other operational states with the PC over the USB interface of the RE-06. All settings and operational modes of the RG-10 can be set using the computer and also saved if necessary. This means that the oscillator and controller can be switched on and off from the computer.

Signal Monitoring Function

The controller module RG-10 is equipped with a signal monitoring function, which on the one hand allows users to monitor the quality of the interference signals and on the other hand the laser power. If the limits are exceeded, the controller module delivers a signal internally to the data processing module. It generates an error code in the communications protocol, which generates an error message in the display unit. The indication on the display of the input and display unit is: “Beam interruption“. Customer service should be contacted if this error appears without any obvious cause.

7.5 Changing Gauge Inserts

CAUTION

Possible damage to the sensor head or to the gauging probe.

Be sure to avoid exposing the sensor head to any mechanical shock or tensile force, and avoid any transverse force acting on the measuring sleeve.

The measuring sleeve must not be moved manually or by any outside action. The measuring sleeve must not be moved unless by the motor-driven control system (for the exception see chapter 7.6 on page73)!

Do not open the sensor head. Adjusting work must not be performed and the measuring force must not be adjusted unless by service personnel of SIOS Meßtechnik GmbH.

For mounting commercially available gauge inserts, the measuring sleeve is provided with a standardised M2.5 female thread. To change the gauge insert, proceed as follows:

1. Carefully loosen the installed gauge by hand and unscrew it from the measuring sleeve. When unscrewing, be sure to apply only a minimal axial force and transverse force on the measuring sleeve.
2. Carefully screw in the gauge insert to be replaced until reaching the stop.
3. Hand-tighten the gauge insert to a moderate degree only without exerting any transverse forces on the measuring sleeve.

   ✔ **The replacement of the gauge insert is complete now.**

IMPORTANT

The joining system used does not guarantee that the contact point of a spherical gauge insert will be in alignment with the guide axis after replacement. This must be considered especially when measuring any spherical device under test (e.g., an optical lens).

7.6 Displacement of the Bottom End Stop

A movement of the ball cage may be observed in the precision ball guides used in the LM 50 gauging probe after a certain number of strokes. Depending on the number and distance of strokes, symptoms appear, including the gradual reduction of the lower traversing range and creepage in the readings displayed when approaching the bottom end stop. This creates the impression that the bottom touchdown point is displaced towards the probe casing. This effect is no malfunction but rather a particular mechanical characteristic which is related to the internal setup of the guide system.

To allow the full use of the measuring range, enable downward motor travel and carefully pull the sleeve of the guide with your hand in axial direction to the bottom limit of travel until reaching it. Then, perform several movements between the two limits of travel (see Fig. 28). Remove the gauging probe beforehand if necessary.

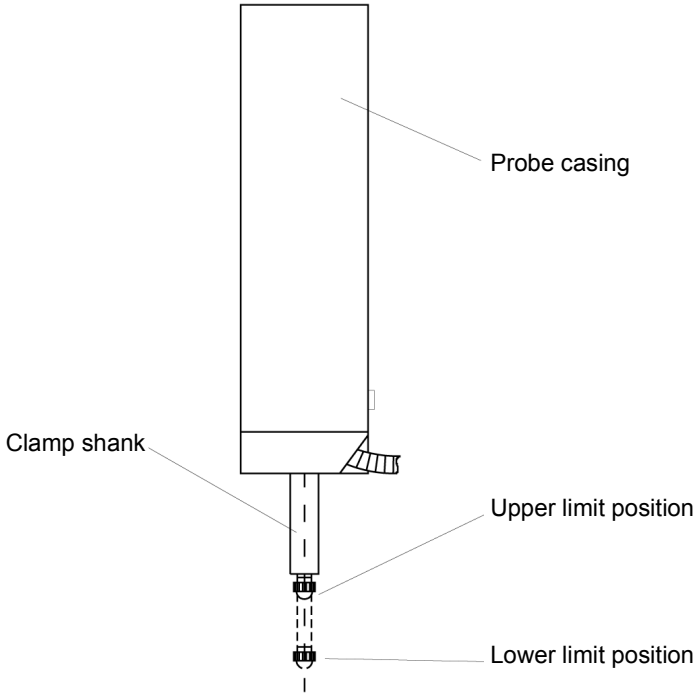


Fig. 28: Limit positions of the gauging probe

IMPORTANT

Due to the procedure described, measurement may not be started unless after balancing the temperature gradients which have been caused by your warm hand.

To ensure this, observe the temperature signal and/or length signal. Measurement may start when these signals are sufficiently stable.

7.7 Switching off Gauging Probe

Switch off the entire system by pressing the power switch on the power supply module NT-04 in the supply and evaluation unit (see Fig. 29). The red LED switches off.

Fig. 29: Switching off gauging probe

8 Troubleshooting

WARNING

Touching live wires or cables can lead to serious injury or death!

Switch off the device switch and pull the power plug out of the power socket before troubleshooting or rectifying faults.

While troubleshooting, secure the gauging probe against being switched on again accidentally!

CAUTION

Possible injury and device damage from the unauthorized opening of components!

Opening the components in case of error or for maintenance or repair is only allowed by service personnel from SIOS Me technik GmbH or other authorized personnel.

Any functional disturbances that occur are displayed by the device or the software. If the problem is obviously caused by the user, the work may be continued after troubleshooting.

Some common issues and tips are given in the following table. If the steps do not lead to clearing the problem or if disruptions occur which are not listed here, contact SIOS GmbH customer service (support@sios.de) or an authorized service partner.

The following problems might arise during operation:

Error/Error Code	Cause	Remedy
No reaction when the device is switched on	Power cable not connected	Connect the power cable (see page 56)
	Defective power cable	Replace the power cable
	Blown fuse	Replace fuse
	No current from the wall socket	Reset main circuit breaker; Have socket inspected by a qualified electrician if necessary
Insufficient signal quality	Optical fiber connector dirty	Carefully clean the optical fiber connector (see page 79)
	Optical setup out of adjustment	Contact support service of SIOS Meßtechnik GmbH (support@sios.de)
Insufficient signal quality	Oscillator off	Switch on oscillator
	Laser power too low	Contact support service of SIOS Meßtechnik GmbH (support@sios.de)

Error/Error Code	Cause	Remedy
Problems with the software installation		see page 57 and the software manual
No connection to the measuring device	Device not switched on	Connect power cable, switch device on (see page 56 and page57)
	Connector cable not or not correctly connected or defective	Check connector cable (USB, RS-232C) (see page 55)
	Wrong interface or wrong interface parameters selected	Check the interface connection based on the corresponding documentation
	Driver not or incorrectly installed	Check whether the interface requires a driver and reinstall it if necessary
Measurement value display not stable	Unprocessed (unfiltered) length measurement values (raw values) displayed with active oscillator	Switch on appropriate measurement value processing or switch off oscillator Tip: The selection of the method is dependent on the task at hand.
	Loose gauge insert	Fasten the gauge insert (see page 72)
	Displaced ball cage, displacement of the bottom end stop	Carefully pull out the sleeve, following the instructions (see page 73)
	Probe not clamped tightly enough	Clamp the probe tightly (see page 20)
	Device under test not standing firmly enough	Fasten the device under test
	Excessive tensile forces on the cables	Relieve the strain from the cables
	Insufficient mechanical decoupling of the sensor connector cables	Route the cable in a suitable form so as to avoid any strain, secure the cables before reaching the sensor head if necessary CAUTION: Do not damage the cables!

Error/Error Code	Cause	Remedy
Measurement value display not stable	External influences (dirt, air circulation, temperature changes)	Minimize the influences using appropriate measures (e.g. shielding of the measuring beam, see page 48)
	Electromagnetic disturbances	Check the measurement environment for potential disturbance sources, switch off sources if practical, check measurement value display (see page 48)
Permanent indication of beam interruption	Improper alignment of the system	Contact support service of SIOS Meßtechnik GmbH (support@sios.de)
	Laser power too low	Contact support service of SIOS Meßtechnik GmbH (support@sios.de)
	Oscillator not operational	Acoustic check of the oscillator in power-on state, if necessary inspection based on the Lissajous curve (see page 60 and page69)
Missing or incorrect environment values displayed	No environmental measuring card available	Check device configuration
	Environment sensor or card defective	Check the plausibility of the displayed value, if necessary contact support service of SIOS Meßtechnik GmbH (support@sios.de)
	Operation outside of the permissible measurement ranges	Operate the device within the allowable measurement ranges for the environment sensors (see page 62)
	Incorrect configuration of the measurement software	Check the assignment and location of the environment measurement channels and the allocation of environment sensors to interferometer channels
	Incorrect environment measurement display due to disturbance (heat source, fan etc.)	Keep disturbances away from the environment sensors, position the environment sensors near the measuring beam

Error/Error Code	Cause	Remedy
Problems with the external trigger	No external trigger pulse	Check external hardware
	Wrong trigger level	Check trigger level with an oscilloscope
	Trigger cable defective	Check trigger cable, replace if necessary
	Incorrect trigger input selected	Check trigger input settings according to the description (see page 28 sqq.)
	Multiple measurement values acquired at one trigger pulse	Reduce trigger frequency, apply a no-bounce trigger signal
	Trigger frequency too high or trigger pulse too narrow	Check trigger pulse according to the specifications (see page 28 sqq.)

9 Care and Maintenance

9.1 General Care and Maintenance Tips

WARNING

Touching live wires or cables can lead to serious injury or death!

The supply and evaluation unit must be switched off and the power cable removed from the socket before repair or maintenance work is performed, especially when modules are added or removed from the unit! Ensure the device cannot be inadvertently switched back on!

It is prohibited for the operator to carry out repair or maintenance when the device can potentially receive power! Maintenance, repair and alignment work on devices under power may only be carried out by qualified electricians or electronics technicians!

CAUTION

The fiber optic cables lying loose in the supply and evaluation unit must not be bent or pinched as this will almost certainly lead to significant damage!

Care should also be taken when switching out modules in the supply and evaluation unit so as not to damage the loose fiber optic cables inside the unit. It is especially important to prevent the fiber optics from being kinked or pinched when removing or inserting the input module in the supply and evaluation unit!

CAUTION

Danger of damage to electrical and electronic components if liquids leak in!

When performing maintenance and care, ensure that no liquids can get into the device! Only use dry towels or rags when cleaning the components.

Maintenance and repair of the gauging probe and its components should only be done by service personnel from SIOS Meßtechnik GmbH or other qualified personnel authorized and instructed by them. We recommend a service contract (annual maintenance) to provide appropriate, regular maintenance of the gauging probe.

Unauthorized maintenance and repair work can lead to damage to the device. The operator may only carry out maintenance and repair work explicitly listed in this chapter and for which he or she is authorized.

Comply with the following instructions during all care and maintenance work:

- ❏ Regularly clean the device components with a soft, dry towel.
- ❏ Never use cleaning powder, paint thinner or solvents such as petrol or acetone to clean the device components! These substances will corrode the surfaces of the housing.
- ❏ Ensure that no liquids enter the device components.

9.2 Overview of Maintenance and Care Work

For proper operation and long service life, the gauging probe should receive regular preventative maintenance and care. Maintenance work is covered by the service contract with SIOS GmbH. Contact the service personnel for appointments and further details.

The following table lists the maintenance and care tasks to be carried out as well as the duration between occurrences of the tasks.

Maintenance/Care Measure	Interval	Comments
Clean the outside of the device with a dry towel	as needed	done by user
Check that all cable connections are still fully in place	before starting up	done by user
Check that all screws and clamps are seated firmly	before starting up	done by user
Inspect the electrical components and cables, including protective earth	semi-annually	done by qualified electrical technician
Check functionality of sensor	annually	done by SIOS service
Check functionality of the laser	annually	done by SIOS service

9.3 Exchanging Modules in the SEU

Changing out modules in the supply and evaluation unit may only be done by service personnel from SIOS Meßtechnik GmbH or qualified personnel authorized and instructed by them.

An exception is the removal and insertion of the input unit EM-11. This can become necessary if the sensor head is to be installed at another location than the SEU.

DANGER

Danger to life from high voltage and possible danger from main voltage and class 2M laser light!

The HeNe laser installed in the supply and evaluation unit is operated with high voltage! Residual charge can remain even after the SEU has been switched off!

Switch the SEU off (power switch to position “0“, cable removed from wall socket) before removing or reinserting the input module EM-11! Ensure the device cannot be inadvertently switched back on!

Wait **at least one hour** before opening the back panel of the SEU!
Do not touch the anode of the laser after the opening!

To remove or reinsert the input module EM-11, proceed as follows:

1. Switch the power switch of the supply and evaluation unit to position “0“ and remove the mains cable from the wall socket.
2. Loosen the two screws of the module and carefully pull the card out. **Do not touch the circuit board itself!**
3. Install the sensor head at the intended location.
4. Reinsert the card carefully into its slot. **Do not touch the circuit board itself!**
5. Tighten the two screws.

   ✔ **The input module EM-11 has now been successfully removed and reinserted.**

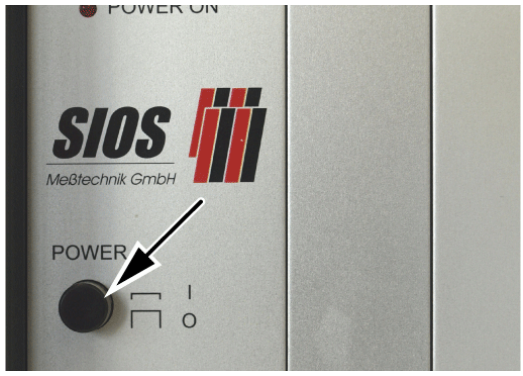
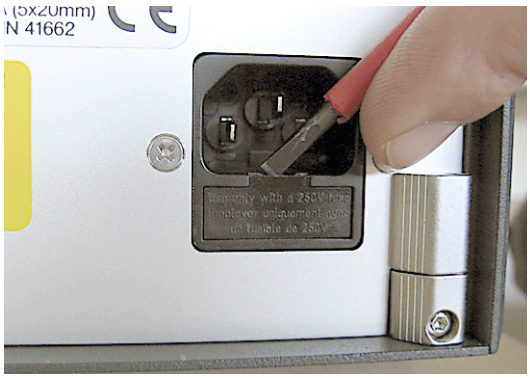
9.4 Replacing Fuses

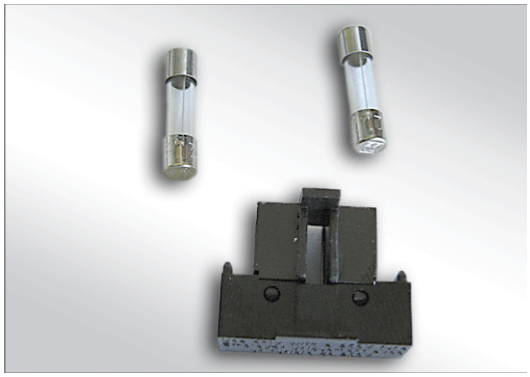
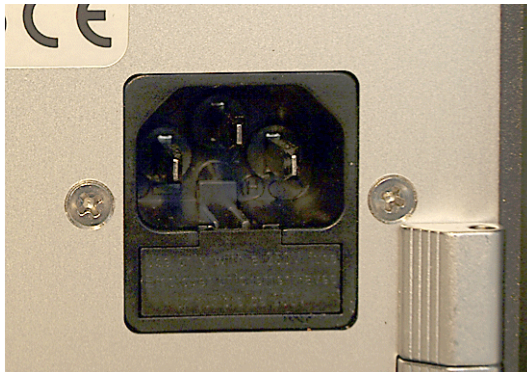
CAUTION

Danger of malfunction or possible damage if fuses are shorted or if incorrect fuses are used!

The device fuses help avoid danger of fire from electrical overload. Do not short-circuit the fuses. Only replace defective fuses with fuses of the same strength and type (fine-wire fuse 2A (T)).

If the device fuses are defective, they can be changed out as follows:

1. Turn off the SEU using the power switch and remove the power cable from the wall socket.	
2. Use a screwdriver to remove the fuse cover under the mains socket of the SEU.	
3. Remove the fuse compartment from the mains socket.	

4. Remove the two fine-wire fuses and inspect them. 5. If the fuses are defective, replace them with fuses of the same strength and type (fine-wire fuse 2A (T)) and place them in the fuse compartment.	
6. Place the fuse compartment back into the mains socket until it snaps into place.	

10 Shutting Down

WARNING

Removal of live wires or cables can lead to serious injury or death!

The gauging probe must be switched off using the power switch on the supply and evaluation unit before cables are removed! The power cable may then be removed from the mains socket!

If the gauging probe is not required for an extended period of time, the devicet should be shut down as follows:

1. Power down the gauging probe by actuating the switch on the power module (switch it to position “0“).
2. Remove the power cable from the mains socket.
3. Cover all components to protect them from dust.

   ✔ **The gauging probe is thus out of operation.**

11 Disposal

ENVIRONMENT PROTECTION

Do not dispose of the gauging probe with domestic refuse.

The gauging probe can be returned to SIOS Meßtechnik GmbH for disposal. Please contact the responsible Customer Service for disposal of the device or SIOS Meßtechnik GmbH.

Contact information:

SIOS Meßtechnik GmbH

Am Vogelherd 46

98693 Ilmenau, Germany

Phone: +49-3677-6447-0

Fax: +49-3677-6447-8

e-mail: info@sios.de

Internet: http://www.sios.de

Appendix

A 1 Dimensional Drawings

The installation dimensions of the sensor head of the laser-interferometric gauging probes LM 20 or LM 50 are shown in the figure 30. Fig. 31 contains the dimensions of the measuring inserts.

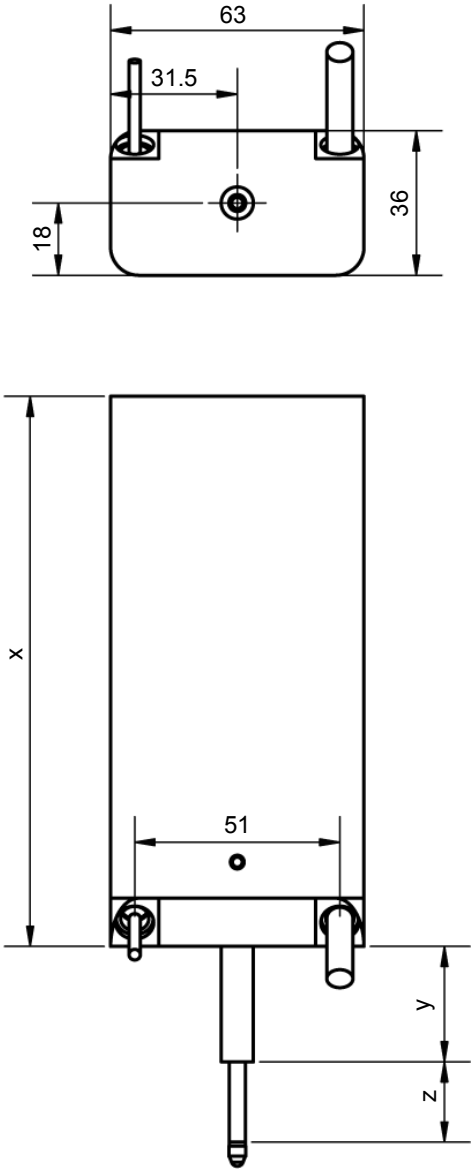


Fig. 30: Dimensional drawing of the sensor head (gauging probe)

Sensor head	x	y	z
LM 20	137 mm	29 mm	approx. 20 mm
LM 50	170 mm	45 mm	approx. 50 mm

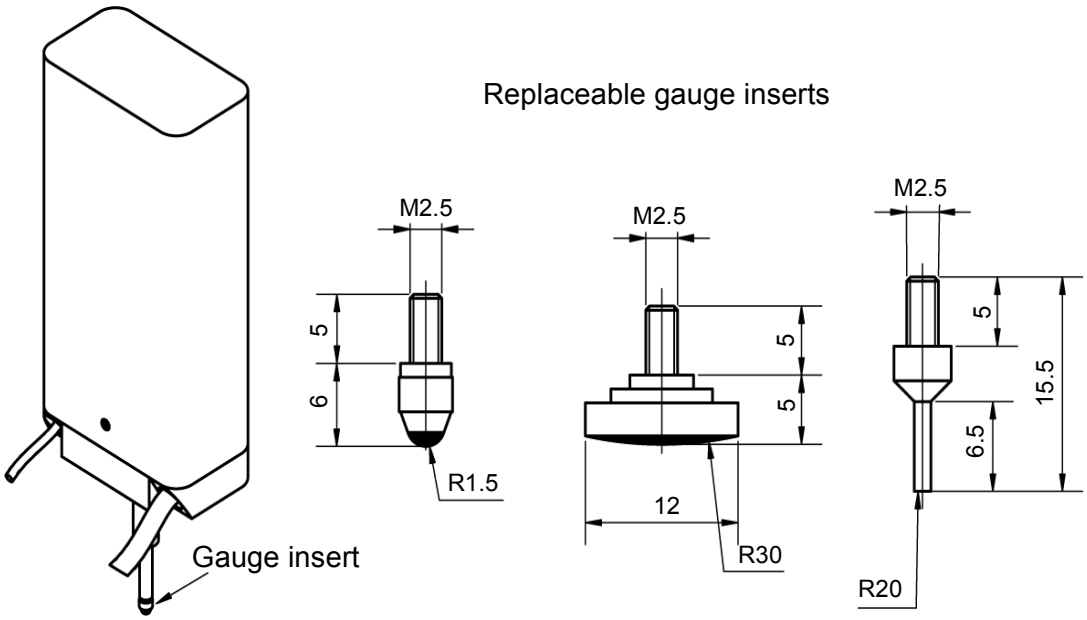


Fig. 31: Dimensional drawing of the replaceable gauge inserts

from left to right:

1 Ruby sphere (standard measuring insert)
2 Gauge insert with a large radius (e.g., for film thickness measurement)
3 Spherical gauge insert for gauge block calibration system

A 2 SEU – Optional Modules

A 2.1 32-Bit Evaluation Card DP-02

Description of Function

The DP-02 module is an evaluation card which makes demodulated interferometer measurement values available for further processing. The electronic components are placed on an Euro-format (160x100 mm) circuit board. The card is assigned to a fixed slot within the supply and evaluation unit, which provides the card with the necessary supply voltages and the analogue incremental signals to be processed. The DP-02 works independently of all other evaluation cards within the device and only requires the aforementioned power supply and the sine and cosine signals.

The card possesses a 32-bit output, which must be queried by external hardware. Using the clock frequency of the card, it is possible to synchronize multiple cards with low jitter. This means that the DP-02 card is suitable for fast control tasks in which an interferometer is operated in a closed feedback control loop.

A block diagram of the DP-02 is show in figure 1.

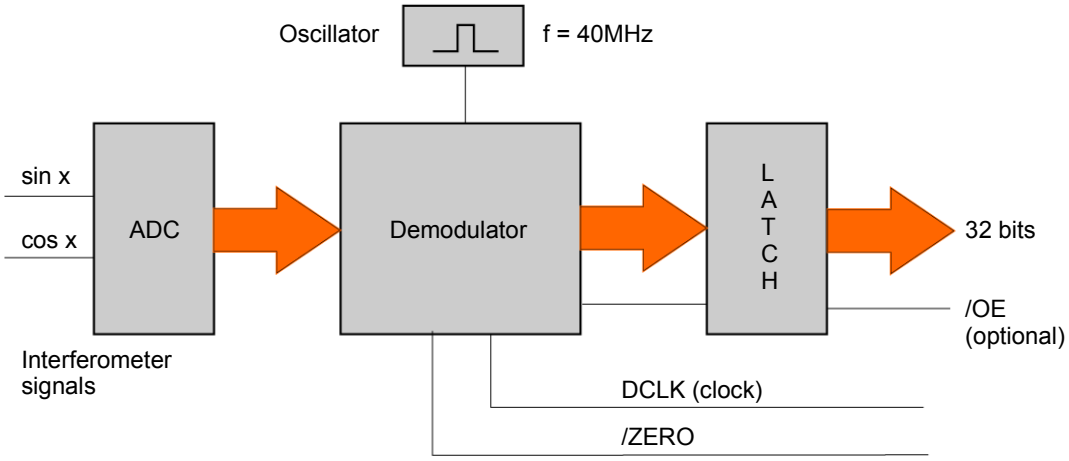


Fig. 32: DP-02 – Block diagram

Control

The DP-02 card uses 32 data output lines and three input control signals. The values are saved in a register at the rising clock (DCLK) edge and can be collected by connected hardware. The time delay is 220 ± 20 ns.

Only positive measurement values are sent. For this reason the counter value is set to a fixed offset value of 0x80000000 (hexadecimal) when the demodulation logic is reset.

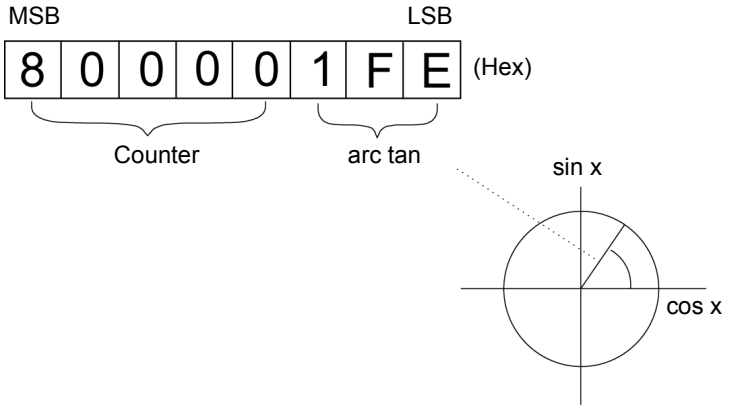


Fig. 33: DP-02 – Counter value after reset

The last 12 bit (LSB) represents the position of the pointer along the Lissajous curve, which is determined from the sine and cosine signals. Therefore an offset value always remains after a reset, which must be taken into account in subsequent calculations. The conversion of the values into units of length must be done in the external evaluation electronics using the following equation:

$$L = \frac{N \cdot \lambda}{8192}$$

where N is the value read and λ the laser wavelength in air. From this the resolution of the card can be determined to be approx. 0.08nm.

The laser wavelength represents the scale for the length measurement. Changes in the index of refraction alter the laser wavelength as such:

$$\lambda = \frac{\lambda_0}{n}$$

The vacuum wavelength λ_0 is set during manufacturing and is given to the customer by SIOS upon delivery. The influence of the parameters temperature, pressure and humidity on the index of refraction can be taken into account with the necessary correction algorithm.

Changes to the index of refraction in air amount to:

$$\Delta n / n = -0{,}929 \cdot 10^{-6} K^{-1} \cdot \Delta\delta$$

$$\Delta n / n = +2{,}682 \cdot 10^{-9} Pa^{-1} \cdot \Delta p$$

$$\Delta n / n = -3{,}84 \cdot 10^{-10} Pa^{-1} \cdot \Delta p_F$$

where: n – index of refraction
$\Delta\delta$ – change in air temperature
Δp – change in air pressure
$\Delta\delta$ – change in water vapour pressure in the air

The corrected wavelength in air can either be requested from the device or calculated by the user on the basis of the optimized EDLEN formula.

Changes in wavelength are generally the products of a slow process. Therefore recording of the environment parameters is only carried out in intervals of 1-2 s in SIOS devices.

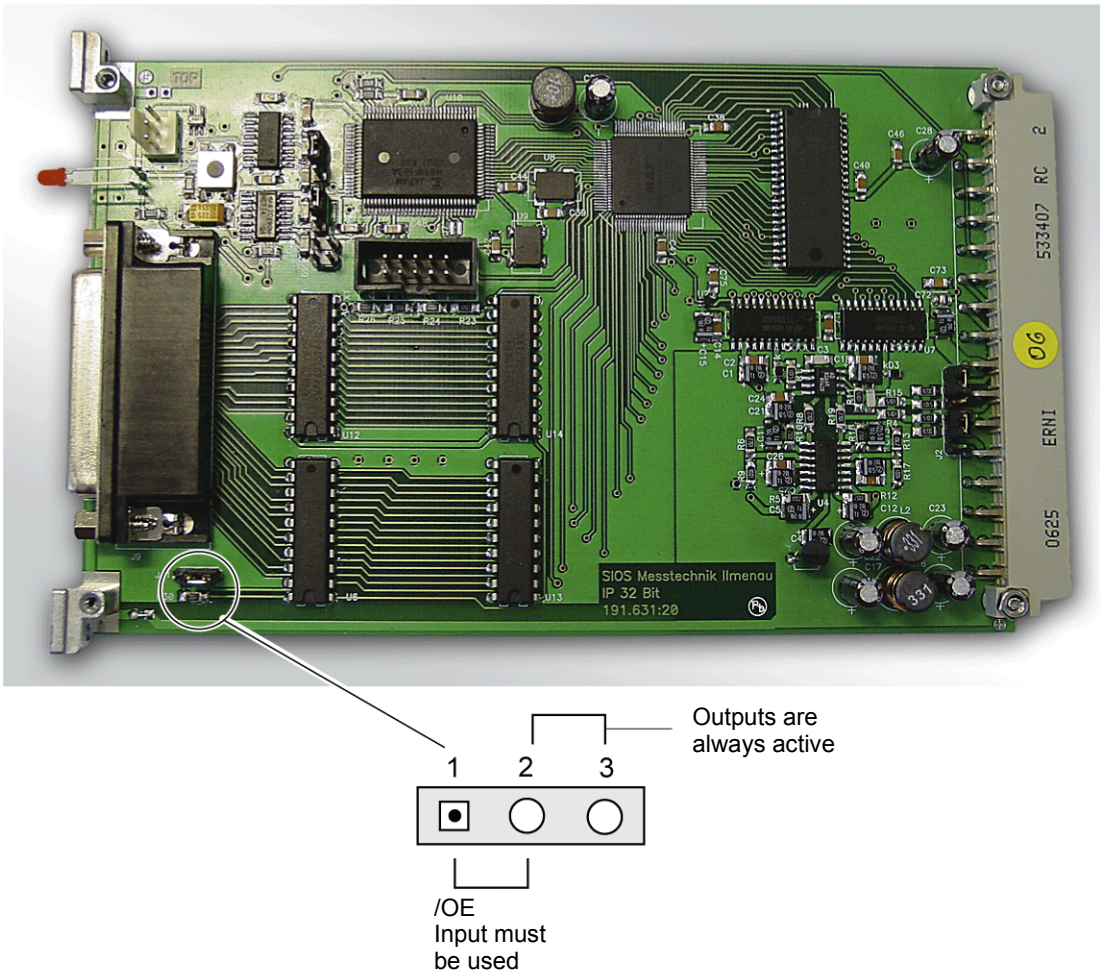


Fig. 34: DP-02 with jumper 11

The data outputs can be placed into a tri-state condition to allow a bus-type connection between multiple cards. To accomplish this, jumper 11 (see Fig. 34) must be set to condition 1-2. The factory setting for the device is to have the jumper in position 2-3, in which the outputs are always active and the input /OE is not required.

The data connection is established using a high-density 44-pin D-sub connector. The pin assignments are shown in the following table. The cable connector can be purchased from Harting Stecker-Express GmbH, Fischer elektronik GmbH and JIT electronic GmbH, among others.

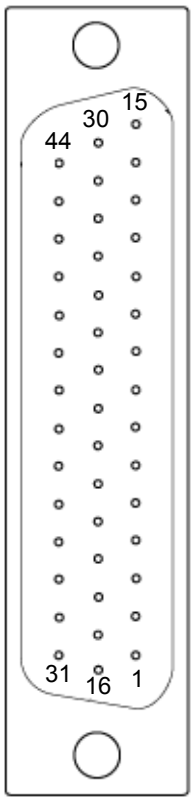
Pin	Label	Description	Graphic
1	D1	Data output	
2	D18	Data output	
3	D19	Data output	
4	D5	Data output	
5	D22	Data output	
6	D23	Data output	
7	D9	Data output	
8	D26	Data output	
9	D27	Data output	
10	D28	Data output	
11	D29	Data output	
12	D30	Data output	
13	D31	Data output	
14	GND	Ground	
15	GND	Ground	
16	D16	Data output	
17	D17	Data output	
18	D3	Data output	
19	D20	Data output	
20	D21	Data output	
21	D7	Data output	
22	D24	Data output	
23	D25	Data output	
24	D11	Data output	
25	D12	Data output	
26	D13	Data output	
27	D14	Data output	
28	D15	Data output	
29	GND	Ground	
30	GND	Ground	
31	OE	Optional control of the tri-state condition (high-impedance) for the outputs D0 ... D31 (low active)	
32	D0	Data output	
33	D2	Data output	
34	D4	Data output	
35	D6	Data output	
36	GND	Ground	
37	D8	Data output	
38	D10	Data output	
39	GND	Ground	
40	GND	Ground	
41	GND	Ground	
42	GND	Ground	
43	DCLK	External synchronization signal to request data (active on the rising edge)	
44	/ZERO	Reset counter – default value 0x80000000 (hex) (low-active)	

Table 1: DP-02 – Pin assignments for the D-sub socket (44-pin)

A 2.2 Digital Interface Module IP-02

The digital interface module IP-02 provides an option for outputting digitalized increment signals. In connection with the interpolator on board the module and a λ/2 interferometer (series MI, SP or LM), the module IP-02 is capable of outputting pulse sequences with an interpolation factor up to n=64. This means that with this module a maximum positioning resolution of approx. 10nm can be realized along the entire interpolation chain (interferometer=2, fourfold evaluation=4 and interpolator=1, 2, 4 and 8).

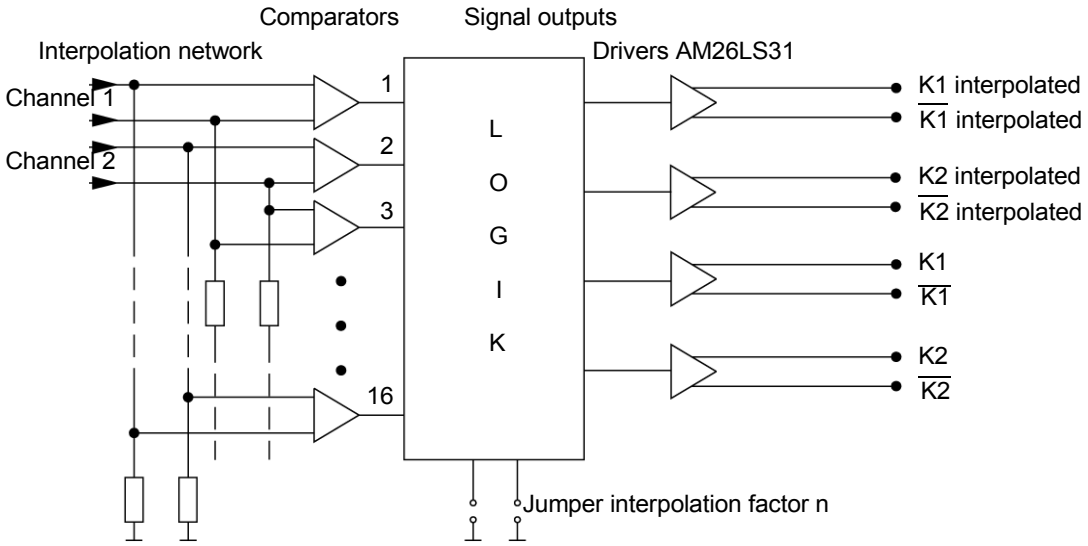


Fig. 35: IP-02 – Block diagram

The four analogue output signals (quadrature signals: sin, -sin, cos, -cos) formed in both channels of the receiver module together represent the input signals for the input module. The block diagram is shown in Fig. 35.

First the quadrature signals are fed into comparators, which switch states at the quadrant crossings to produce square-wave signal sequences for the fourfold evaluation at 0 , 90 , 180 and 270 of a signal period or interference order. Signal processing is done here such that the addition theorem

$$\sin(x) + \cos(x+j) = A[\sin(x + j/2 + 45°)] \text{ and}$$

$$\sin(x) - \cos(x+j) = B[\sin(x + j/2 - 45°)]$$

is fulfilled. This allows the card to compensate for deviationsj from the prescribed 90 phase angle between channels.

The additional increases in resolution are accomplished by evaluating the signals using voltage dividers and linking them with comparators, giving rise to square-wave signals which are offset from each other with respect to phase. The comparator outputs are connected with logic circuits to create pulse sequences with an increased frequency by a factor equivalent to the interpolation factor. The circuit operates with 16 comparators. Two signal groups are available at the output of the 9-pin D-sub, each with four outputs; the pin assignments are given in table 2. Two square-wave signals with 90° phase difference are output for each group. For the purposes of noise suppression, the negated signals are also output to provide the symmetrical signal transmission required by the RS-422A standard. An AM26LS31 circuit is used as the output driver.

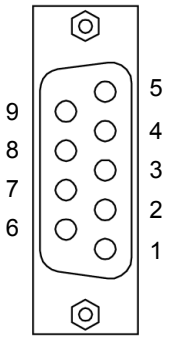
Pin	Label	Description	Graphic
1	Channel 1	interpolated [sin(n/8.x)]	
2	Channel 1	interpolated, negated [-sin(n/8.x)]	
3	Ground	Data output	
4	Channel 2	interpolated, negated [-cos(n/8.x)]	
5	Channel 2	interpolated [cos(n/8.x)]	
6	Channel 2	[cos(x)]	
7	Channel 2	negated [-cos(x)]	
8	Channel 1	[sin(x)]	
9	Channel 1	negated [-sin(x)]	

Table 2: IP-02 – Pin assignments for the D-sub socket (9-pin)

The output signals of the first group correspond to the triggered analog signals with a period length of λ/2 and are square-wave signal sequences from the fourfold evaluation with switching points at 0°, 90°, 180° and 270° of a signal period, which yields a resolution of approx. 80nm. The second group delivers the interpolated signals as square-wave signal sequences with an n/8-factor higher frequency with respect to the first group. The factor n can be set by jumper to 8, 16, 32 or 64. The factor 64 then generates switching point distances of 11.25° of a signal period. The configuration with the highest interpolation may only be used for slow displacement speeds and an excellent signal-to-noise ratio. Otherwise significant disturbances will most likely arise during signal post-processing.

This module is assigned to the slot between the data processing module RE-10 and the controller module RG-10 and only functions at that location.

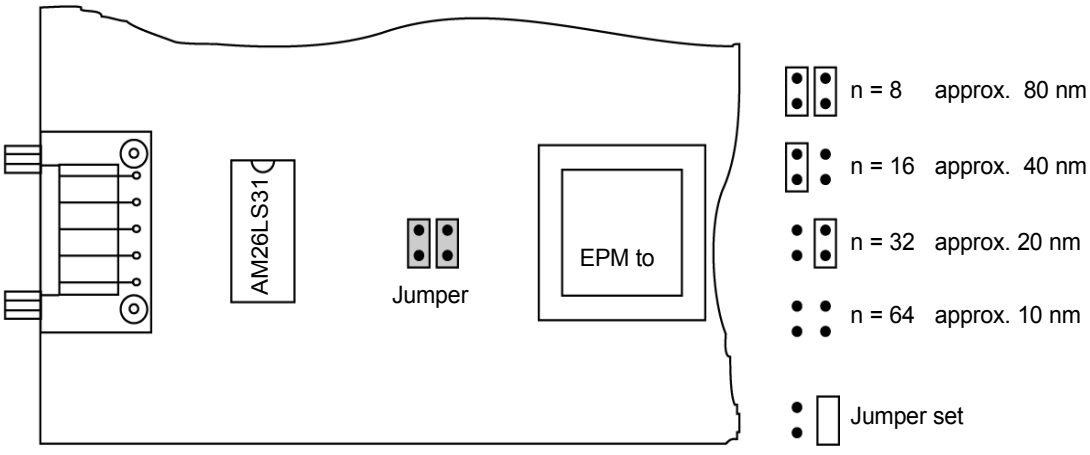


Fig. 36: IP-02 – Jumper settings for interpolation factor n

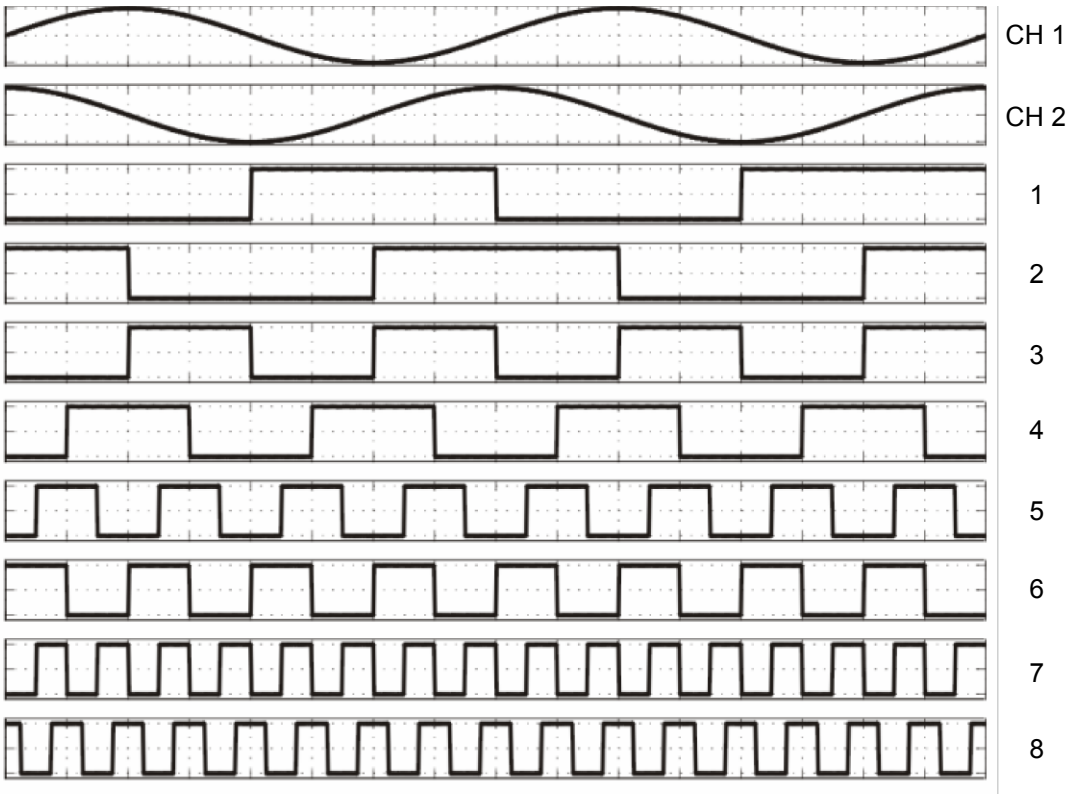


Fig. 37: IP-02 – Signal pattern
(Tip: The negated signals required by the RS-422-A standard are not shown here!)

The analog and digital output signals and their phase relationships are shown in Fig. 37. The following assignment applies:

CH 1	Analogue output signal for increment channel 1 from the input module EM (BNC socket CH1)
CH 2	Analogue output signal for increment channel 2 from the input module EM (BNC socket CH2)
1	Digital output signal of increment channel 1 on the D-sub connector of the IP-02 (channel 1/sin(x)) and digital output signal of increment channel 1 on the D-sub connector of the IP-02 (channel 1/sin(n/8 · x)) when the jumper is set for n=8; the period length is approx. 320 nm and the edge spacing 160 nm.
2	Digital output signal of increment channel 2 on the D-sub connector of the IP-02 (channel 1/cos(x)) and digital output signal of increment channel 2 on the D-sub connector of the IP-02 (channel 2/cos(n/8 · x)) when the jumper is set for n=8; the period length is approx. 320nm and the edge spacing 160 nm.
3	Digital output signal of increment channel 1 on the D-sub connector of the IP-02 (channel 1/sin(n/8 · x)) when the jumper is set for n=16; the period length is approx. 160 nm and the edge spacing 80 nm.
4	Digital output signal of increment channel 2 on the D-sub connector of the IP-02 (channel 2/sin(n/8 · x)) when the jumper is set for n=16; the period length is approx. 160 nm and the edge spacing 80 nm.

5 Digital output signal of increment channel 1 on the D-sub connector of the IP-02 (channel 1/sin(n/8 · x)) when the jumper is set for n=32;
the period length is approx. 80nm and the edge spacing 40nm.

6 Digital output signal of increment channel 2 on the D-sub connector of the IP-02 (channel 2/sin(n/8 · x)) when the jumper is set for n=32;
the period length is approx. 80 nm and the edge spacing 40 nm.

7 Digital output signal of increment channel 1 on the D-sub connector of the IP-02 (channel 1/sin(n/8 · x)) when the jumper is set for n=64;
the period length is approx. 40 nm and the edge spacing 20 nm.

8 Digital output signal of increment channel 2 on the D-sub connector of the IP-02 (channel 2/sin(n/8 · x)) when the jumper is set for n=64;
the period length is approx. 40 nm and the edge spacing 20 nm.

The indicated length measurement resolutions are valid for the edge distance between digital increment signals when both channels are used.

The following limits are in place with respect to the allowable order frequency (frequency of the analogue increment channels) and the maximum positioning speed of the measurement reflector derived from it. Operation outside of this specification automatically leads to measurement errors during signal evaluation.

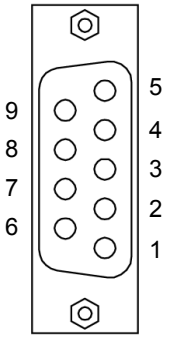
Interpolation factor	Maximum order frequency	Maximum positioning speed
64	500 kHz	156.25 mm/s
32	1 MHz	312.50 mm/s
16	2 MHz	625.00 mm/s
8	2.5 MHz	781.25mm/s

Table 3: IP-02 – limits

A 2.3 Voltage Converter Card IS-10

The voltage converter card IS-10 allows the output of the analogue quadrature signals in accordance with the Heidenhain specification 1 Vss.

The pin assignment of the voltage converter board IS-10 SIOS Heidenhain is shown below.

Pin	Description	Graphic
1	+sin (1 V_{ss})	
2	+cos (1 V_{ss})	
3	GND	
4	n. c.	
5	GND	
6	-sin (1 V_{ss})	
7	-cos (1 V_{ss})	
8	GND	
9	n. c.	

IS-10 – Pin assignments for the D-sub socket (9-pin)

Deactivate the piezo-oscillator at the supply and evaluation unit when using the analogue quadrature signals. The analogue interferometer signals are uncorrected with respect to the environment parameters!

The factory-set voltage converter board IS-10 allows the adjustment of the offset voltage values of the output signals in the range from -2.5 V to +2.5 V (default value: offset voltage +2.5 V, see Fig. 38). Other levels on request.

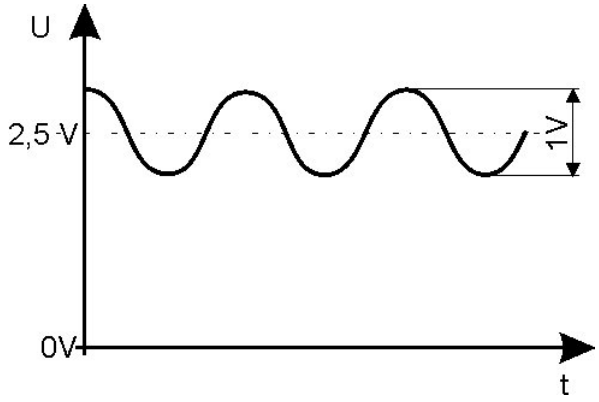


Fig. 38: Output signal of the voltage converter board IS-10

A 2.4 Output Module of the Analogue Position Information and Oscillation Measurement SM-05

SIOS Meßtechnik GmbH offers a output module of the analogue position information suitable for the modular concept of the evaluation electronics. The electronic components are placed on an Euro-format (160x100 mm) circuit board. This card is assigned a fixed slot within the supply and evaluation unit. It is supplied with power and the appropriate input signals (oscillation signals) over the internal device wiring.

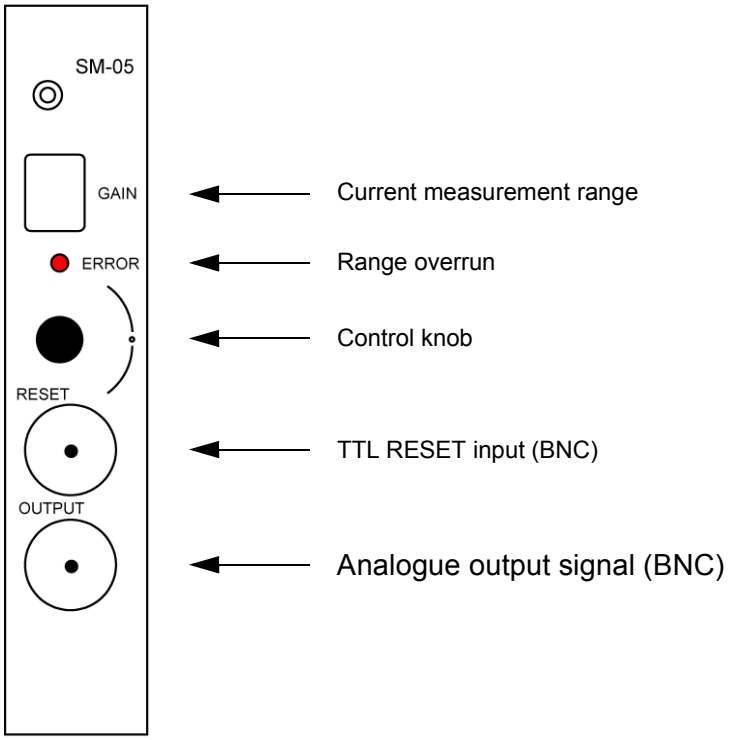


Fig. 39: SM-05 - Front side of the output module of the analogue path information

Functional principle

On the input side the output module of the analogue path information has two 8 bit flash A/D converters to digitalize the normalized quadrature signals from the input module EM. The quadrant angle is determined from this 16-bit-wide word in the arctangent unit and from that the length information. If the object under test moves at speed v along the measuring axis of the interferometer, the maximum order frequency f_0 of the measurement signal can be computed using the doppler effect as:

$$f_0 = \frac{2 \cdot v}{\lambda}$$

where : v is the object speed and

λ is the wavelength of light (HeNe laser: = 632.8nm).

Because the procedure is absolute within one interferometer period and relative beyond one period, the sampling frequency used in the electronics must be four times the order frequency so that no measurement errors arise; put another way, each quadrant must at least be sampled once.

The sampling frequency of the flash A/D converters is 20 MHz. This means that input signal frequencies up to 5MHz can be processed. The maximum allowable object speed is approx. 1.5m/s in this case (see equation on page 96). This bandwidth can only be achieved with correspondingly conditioned analogue signals (through the input module EM). The optical input stages and the control amplifiers must be adapted to this bandwidth.

In practice knowledge of the parameter limits (amplitude and object frequency) play a decisive role. These limits are shown in the diagram in figure 45. The bounded area represents the allowable operational range. Operating outside of these limits will generally lead to misleading and incorrect data. The relationship between amplitude A and object frequency f can be modelled as:

$$A = \frac{f_0 \cdot \lambda}{4 \cdot \pi \cdot f}$$

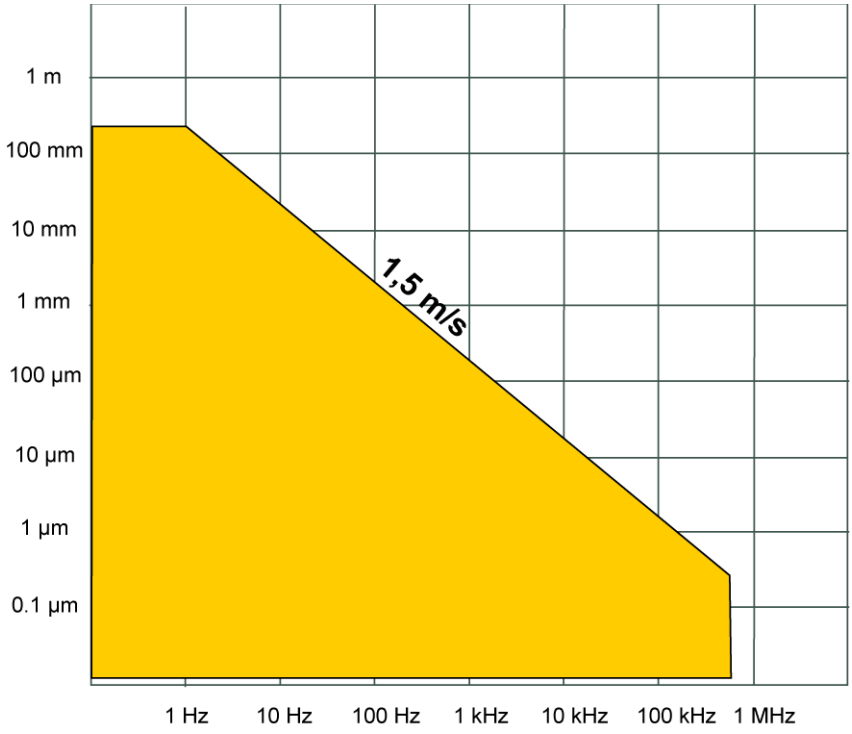


Fig. 40: SM-05 - Allowable dynamic range for the output of analogue path information

The evaluation card possesses seven measurement ranges, which can be selected with the help of the control element on the front panel.

Zeroing the interference fringe counter is done by pressing the control knob for a few moments or by setting the voltage on the RESET input to 0 V.

After the device has been switched on, the maximum measurement range is automatically selected. The selected range should be zeroed before beginning measurements.

This home position is assigned to the current measuring value present on the sensor head. After that more sensitive ranges can be selected by turning the knob, which

can be done as long as the signal remains within the range of the measuring card output (avoiding overmodulation). This limit is recognizable on a connected oscilloscope as a horizontal line at the end values of the range (±3V). Furthermore a signal is given using the red LED on the front panel of the module. In the case of overmodulation the level should be switched back down to a less sensitive range. If the signal only reaches one end of the range, the user can try to use an offset adjustment to bring the signal into range. This can be done through a further reset of by repositioning the object under test relative to the sensor head.

The following table contains the measurement range factors and the maximum measurement ranges:

Measuring range no.	Range factor K in µm/V	Maximum measuring range in µm
0	0.24	0.63
1	0.97	2.50
2	3.87	10.10
3	15.48	40.30
4	61.90	161.20
5	247.61	644.90
6	990.44	2579.50

Table 4: Measurement ranges of the output module of analogue path information

The current measurement range is indicated by a 7-segment display. The output signal of the module for the output of the analogue path information is a position-proportional analogue signal, which can be read using the front-side BNC socket. Here display devices such as oscilloscopes or an A/D converter card can be connected for further processing. The maximum signal amplitude is 3Vss.

If a voltage of 0V is placed on the RESET input, the internal counter stops and switches back to 0. The input is protected from overvoltage.

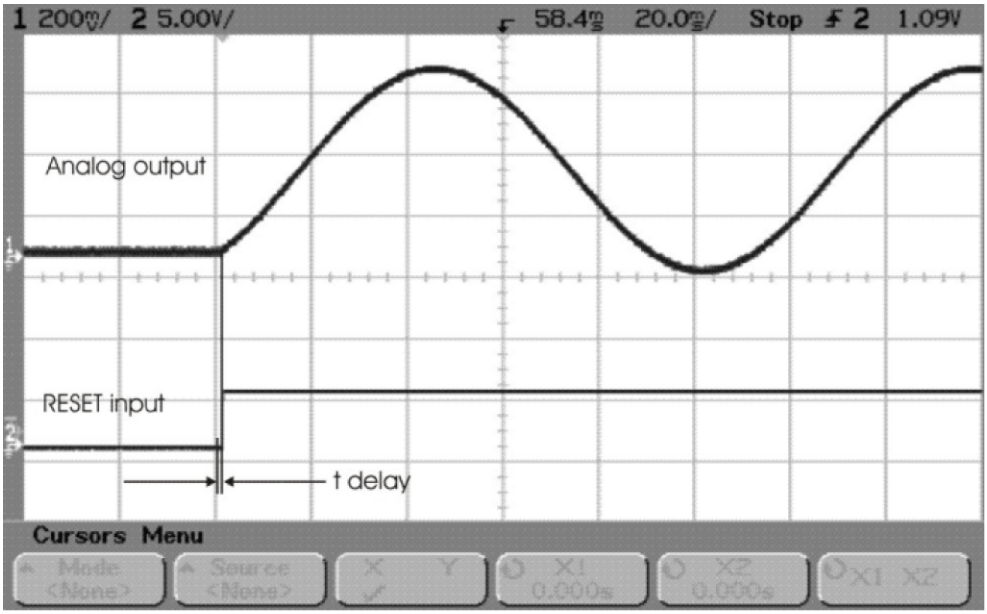


Fig. 41: SM-05 – Time diagram of the RESET input

The delay between the LOW-HIGH edge of the RESET voltage and the analogue output of the module is approx. 380 ns.

I²C Interface

The SM-05 card can be configured using the internal I²C interface. The standard I²C address of the SM-05 is 0x80. The interface emulates the behaviour of the PCF8570 I²C RAM. The following table gives an overview of the parameters stored in the RAM of the SM-05 and an overview of the technical parameters of the I²C interface.

Address	Value, read access	Value, write access
0x00	current range 0 to 6	range to use allowable values: 0 to 6
0x01	Reset timer counter	Reset 0 – no reset 1 – reset card
0x02	Overflow bit 0 – overflow 1 – normal status	unused
0x03	unused	unused

Table 5: Parameters in SM-05 RAM

Parameter	Value
Supply voltage:	± 5 VDC
Maximum output voltage:	± 3 V
Clock frequency of the D/A converter:	10MHz
Maximum oscillation amplitude:	± 2.5 mm
Maximum resolution:	approx. 0.3 nm
Maximum object frequency:	500 kHz

Table 6: Technical parameters of the I^2C interface

SIOS Meßtechnik GmbH

EC Declaration of Conformity

CE marking.

Per	EU-Guideline 2006/95/EC regarding low-voltage devices
and	EU-Guideline 2004/108/EC regarding electromagnetic compatibility

we herewith certify that the design and construction of the products listed below and the form in which they have been brought into commercial traffic are in compliance with applicable basic safety and health provisions of said EU guidelines.

Product group: **LM series laser-interferometric gauging probe**

Applicable standards

Safety:

EN 60825-1: 2007	Safety of laser products
EN 61010-1: 2001	Safety requirements for electrical equipment for measurement, control and laboratory use

Emission:

EN 61326-1:2006	Electrical equipment for measurement, control and laboratory use - EMC requirements
EN 61000-3-2: 2006	Harmonic current environments

Immunity:

EN 61000-6-2: 2005	Immunity for industrial environments

Manufacturer: SIOS Meßtechnik GmbH
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Ilmenau, 02 November 2009

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