RAYTEC SYSTEMS

GEPARD™-M4

Laser geometrical measuring and alignment system

Operating instructions

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GEPARD-M4™ LASER GEOMETRICAL MEASURING AND ALIGNMENT SYSTEM

With the ***RAY****TEC GEPARD-M4™* you have acquired an instrument of the highest technical quality.

The ***RAY****TEC GEPARD-M4™* is a laser measuring instrument equipped with the latest optical and electronic components for very precise measuring of straightness, flatness, parallelism, perpendicularity, alignment and much more.

Your measuring instrument consists of a highly stable laser transmitter which, in the cubic casing version, has an integral micro-adjustment for fine alignment of the laser beam, or in the cylindrical casing version, features an exactly aligned optical/mechanical axis, a high-precision location-sensing receiver with full evaluation electronics and a display device which can be a commercially available notebook PC or a desktop PC. The ***RAY****TEC GEPARD™* software supports you as user while performing comprehensive geometric measurements and their subsequent logging.

These operating instructions explain how to set up the measuring instrument for the first time and offer help in answering any questions you may have about taking measurements using a laser measuring device. You will find additional information on the *GEPARD-M4™* CD ROM (or USB memory stick) which is included in the scope of the delivery, and in the operating instructions for your WIN-GEPARD software.

SCOPE OF DELIVERY

Packaging contents

The toolbox contains a laser transmitter, laser receiver and the following accessories:

- High-Energy NiMH batteries (6 pcs.).
- Battery charger with mains adapter (100-230V / 50–60 Hz).
- Bluetooth-adapter to USB for PC (2.4GHZ / 100m).
- Fiber optics-adapter to USB for PC with fiber optics 10m (optional).
- Allen key / battery lid key.
- Pentagonal prism (optional).
- CD-ROM or USB-Stick with GEPARD processing software.

BATTERY CHARGING

The batteries are not completely charged when they are delivered.

- Insert the connector into the back of the battery charger.
- Plug the battery charger into a electrical socket (115-230V / 50-60Hz).
- Place the battery in the charger taking care that the contact surfaces are at the back during insertion.
- The battery charger may only be used with the original mains adapter.
- Only use rechargeable batteries of the same type (AA or AAA) and the same storage capacity (e.g. the supplied rechargeable battery with 2500mAh) !

Charging time

- Charge new batteries overnight.
- Afterwards, only 3 to 5 hours will be enough to fully recharge the batteries again.
- It is normal that batteries become slightly warm while they are being charged.

Operating state	LED indicator
Power on	Blue
Batteries are being charged	Flashing green
Batteries are charged	Constant green light
Wrong battery inserted or bad battery contacts	Red

NOTE :

☞ *The working life of the batteries can be extended by avoiding unnecessarily long charging times.*

RAYTEC GEPARD-M4™ LASER TRANSMITTER (cylindrical design)

The ***RAY**TEC GEPARD-M4™* laser transmitter is a highly stable semiconductor laser which uses fibre coupling and precision optics to emit a homogenous and stable measuring reference. Modern semiconductor technology makes low-current circuits possible, whereby direct connection to a mains supply is no longer necessary. Power is supplied by a rechargeable NiMH battery which has a long service life when correctly maintained. Using a battery with optimum charge, the laser transmitter delivers an operating time of more than 24 hours.

The new cylindrical GEPARD laser transmitter is distinguished by the high-precision alignment of its optical-mechanical longitudinal axis. This alignment allows precise absolute value measurements in relation to the laser focal point - for example, the alignment of rotation systems or the machining axes of milling cutters, lathes, boring machines etc. Using suitable mountings (square supports), these cylindrical transmitters can also be used for measurement and alignment work on flat test objects.

The use of the extremely durable stainless steel INOX (1.4305) as the material for the casing permits the manufacture of a very exact, dimensionally stable component. This also affects the temperature coefficient, which is extremely small for this material. These properties and the scratch and rust proof surface of the device casing contribute in addition to a very precise device and account for the enduring value of the GEPARD laser transmitter.

SAFETY INSTRUCTIONS

☞ ***The GEPARD-M4™ laser is assigned to laser protection class 2 according to the internationally binding standard EN 60825-1:2008: semiconductor laser, wavelength 630-670nm, $Pout_{peak} \leq$ 1mW. This means that the laser may be activated without any special protective measures being taken.***
Even so, the following safety precautions must be taken by the operator of the laser and maintained at all times:

- ***Do not look into the beam.***
- ***Do not direct the beam deliberately at people.***
- ***The laser must only be used for the intended purpose, that is for measurement tasks in combination with the GEPARD-M4™ receiver.***
- ***Only use qualified and trained staff.***

SAFETY INSTRUCTIONS FOR LASERS WITH ADJUSTABLE LASER POWER

☞ ***When using an AF-transmitter with variable laser power (Poutvar ≤ 5mW in the visible range) the laser protection class is 3R and the following additional security precautions must be taken when operating the laser:***

- ***Only use qualified and trained staff.***
- ***Set up a warning signs.***
- ***Avoid direct exposure of the eyes, i.e. do not allow the beam to travel at eye level, for both standing and seated persons.***
- ***Remove reflective objects from the radiated area or cover them.***
- ***Delimit the beam at the end of the intended path if possible (e.g. erect a screen).***
- ***Ensure that any lasers not in use are secured against access by unauthorised persons.***

BEGINNING OPERATION

To begin operation, lay the supplied rechargeable battery with the positive terminal (button) forward in the laser transmitter. To give the contact springs inside the device the longest possible service life, the rechargeable battery should always be slid into the device horizontally (do not let it drop in vertically!).

The battery cover is equipped with a bayonet fastener and it must be gently pressed in and turned clockwise through about 10° to lock it. When inserting the battery cover, pay careful attention to the pin position!

When changing the rechargeable battery, gently press the battery cover inwards and turn it anti-clockwise through about 10°. The spring inside the device then presses the cover outwards and the battery can be removed.

The laser is switched on by briefly pressing the yellow push-button on the rear panel of the device. When the LED flashes regularly, the laser is in the operating state.

☞ **Please make absolutely certain that no eye contact with the laser beam can occur while switching on the device (see illustration).**

Fig. 1: GEPARD-M4™ laser transmitter - front view

OPERATING STATE INDICATOR - LED

Fig. 2: GEPARD-M4 ™ laser transmitter - rear view

The operating state is shown by the bicolour LED near the on/off button switch. The following states are indicated:

Operating state	LED indicator
PSU off line, battery fully charged	Flashing green
PSU off line, battery adequately charged	Flashing orange
PSU off line, battery almost fully discharged	Flashing red
PSU on line, battery fully charged (trickle charging)	Green
PSU on line, battery being charged	Orange
PSU on line, no battery present	Red

If the status indicator is flashing red, it is vital to replace the discharged battery with a charged one or connect the PSU (Power Supply Unit)! Otherwise there will be loss of power at the laser with decreased intensity, which could lead to incorrect measurements!

ADJUSTING LASER POWER (ONLY LASER WITH PVAR)

When operating a GEPARD AF laser with adjustable laser power, several specific points are to be observed:

The laser has a maximum power output of <5mW$_{AVG}$ and falls therefore into laser safety class 3R (for further information, see the safety instructions above).

In measurement mode the laser power must always be adjusted so that it operates within an optimal intensity range. The optimal intensity, to which the measuring instrument is calibrated in the factory, is 70% (see intensity display on the evaluation unit).

If the intensity is much too low (<35%), measurements are likely to be incorrect.

Similarly, if the laser power is much too high (>90%), measurements are likely to be incorrect.

If the intensity is too low (<10%) or the intensity is too high (>95%), the measurement becomes invalid and the X/Y measured value display is set to --.-- (flashes).
The power of the laser is adjusted using the rotary knob on the back of the device (see figure below).

Figure 3: Back view of GEPARD-M4 Laser Var-Power

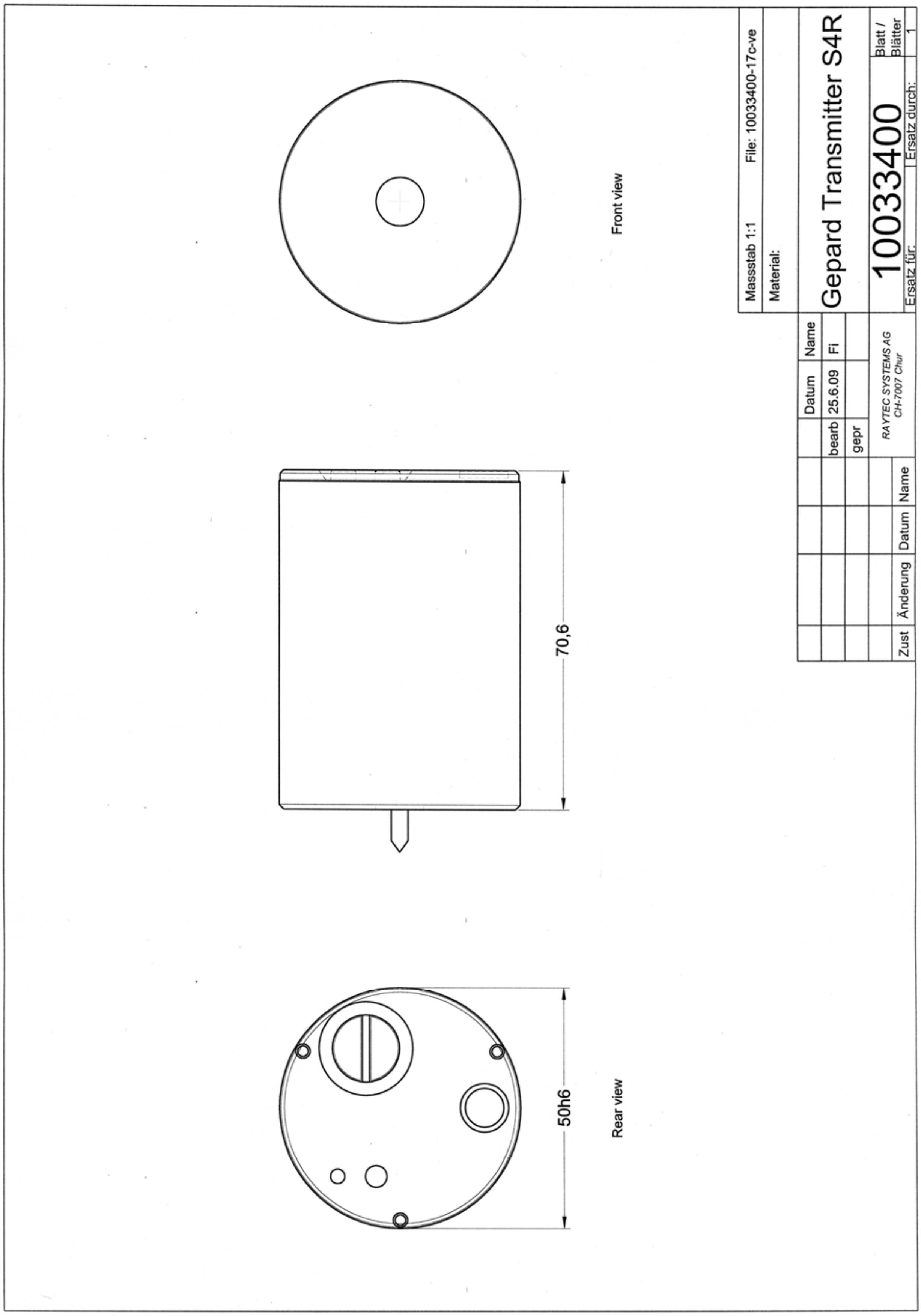
NOTE:

- ***This transmitter provides you with an ultra-stable laser. However, to reach the optimum stability, it always needs a warm-up time of about 20 to 30 minutes. We therefore recommend that the transmitter should be switched on some time before setting up the measuring equipment. The transmitter should also not be switched off if measurements are to be interrupted for one or two hours. This is because, as well as low-current technology, high-power rechargeable batteries are used in these devices and such operating conditions pose no limitation when working with the devices.***

- ***The optical/mechanical longitudinal axis is very precisely aligned (< 0.1mrad). In order to ensure that these mechanical settings can be maintained, the device must never be subjected to high acceleration (impacts/vibrations).***
  If the beam position needs to be checked, this can be done on an exact turning device. While turning through 360°, the laser dot should not "wander".

- ***If you need further information about this, please contact Raytec Systems AG.***

GEPARD-M4™ LASER TRANSMITTER INSTALLATION DIMENSIONS (cylindrical)



RAYTEC GEPARD-M4™ LASER TRANSMITTER (CUBIC DESIGN)

The ***RAY****TEC GEPARD-M4™* laser transmitter is a highly stable semiconductor laser which uses fibre coupling and precision optics to emit a homogenous and stable measuring reference. Modern semiconductor technology makes low-current circuits possible, whereby direct connection to a mains supply is no longer necessary. Power is supplied by a rechargeable NiMH battery which has a long service life when correctly maintained. Using a battery with optimum charge, the laser transmitter delivers an operating time of more than 24 hours.

The cubic GEPARD laser transmitter is distinguished by its ingenious calibration mechanism which permits fast and precise direction of the laser beam onto the test object. This transmitter is therefore particularly suitable for very exact relative measurements on flat test objects.

SAFETY INSTRUCTIONS

☞ ***The GEPARD-M4™ laser is assigned to laser protection class 2 according to the internationally binding standard EN 60825-1:2001: semiconductor laser, wavelength 630-670nm, Pout$_{peak}$ ≤ 1mW. This means that the laser may be activated without any special protective measures being taken.***
Even so, the following safety precautions must be taken by the operator of the laser and maintained at all times:

- ***Do not look into the beam.***
- ***Do not direct the beam deliberately at people.***
- ***The laser must only be used for the intended purpose, that is for measurement tasks in combination with the GEPARD-M4™ receiver.***

BEGINNING OPERATION

To begin operation, lay two of the supplied rechargeable batteries in opposite directions (one with the positive terminal pointing forwards and one with it pointing towards the rear) in the laser transmitter. A suitable polarity guard is provided in the battery cover. To give the contact springs inside the device the longest possible service life, the rechargeable batteries should always be slid into the device horizontally (do not let them drop in vertically!).

To close the battery compartment, the cover must be pressed in gently; a quarter turn of the screw closure then makes the cover secure.

To change the batteries, return the screw closure to the home position, the contact springs on the inside of the casing then push the cover outwards to open it slightly, after which the batteries can be removed.

The laser is switched on by briefly (< 1 second) pressing the yellow push-button on the rear panel of the device. When the LED flashes regularly, the laser is in the operating state.

☞ **Please make absolutely certain that no eye contact with the laser beam can occur while switching on the device (see illustration).**

Fig. 3: GEPARD-M4™ laser transmitter - front view

OPERATING STATE INDICATOR - LED

Fig. 4: GEPARD-M4™ laser transmitter - rear view

The operating state is shown by the bicolour LED near the on/off button switch. The following states are indicated:

Operating state	LED indicator
PSU off line, battery fully charged	Flashing green
PSU off line, battery adequately charged	Flashing orange
PSU off line, battery almost fully discharged	Flashing red
PSU on line, battery fully charged (trickle charging)	Green
PSU on line, battery being charged	Orange
PSU on line, no battery present	Red

If the status indicator is flashing red, it is vital to replace the discharged battery with a charged one or connect the PSU (Power Supply Unit)! Otherwise there will be loss of power at the laser with decreased intensity, which could lead to incorrect measurements!

NOTE:

☞ ***This transmitter provides you with an ultra-stable laser. However, to reach the optimum stability, it always needs a warm-up time of about 20 to 30 minutes. We therefore recommend that the transmitter should be switched on some time before setting up the measuring equipment. The transmitter should also not be switched off if measurements are to be interrupted for one or two hours. This is because, as well as low-current technology, high-power rechargeable batteries are used in these devices and such operating conditions pose no limitation when working with the devices.***

LASER BEAM ALIGNMENT (only cubic casing version)

Two Allen key screws are countersunk into the rear of the casing (see fig. 5 below) and these are used to exactly align the laser beam.

Fig. 5: GEPARD-M4 ™ laser transmitter - rear view

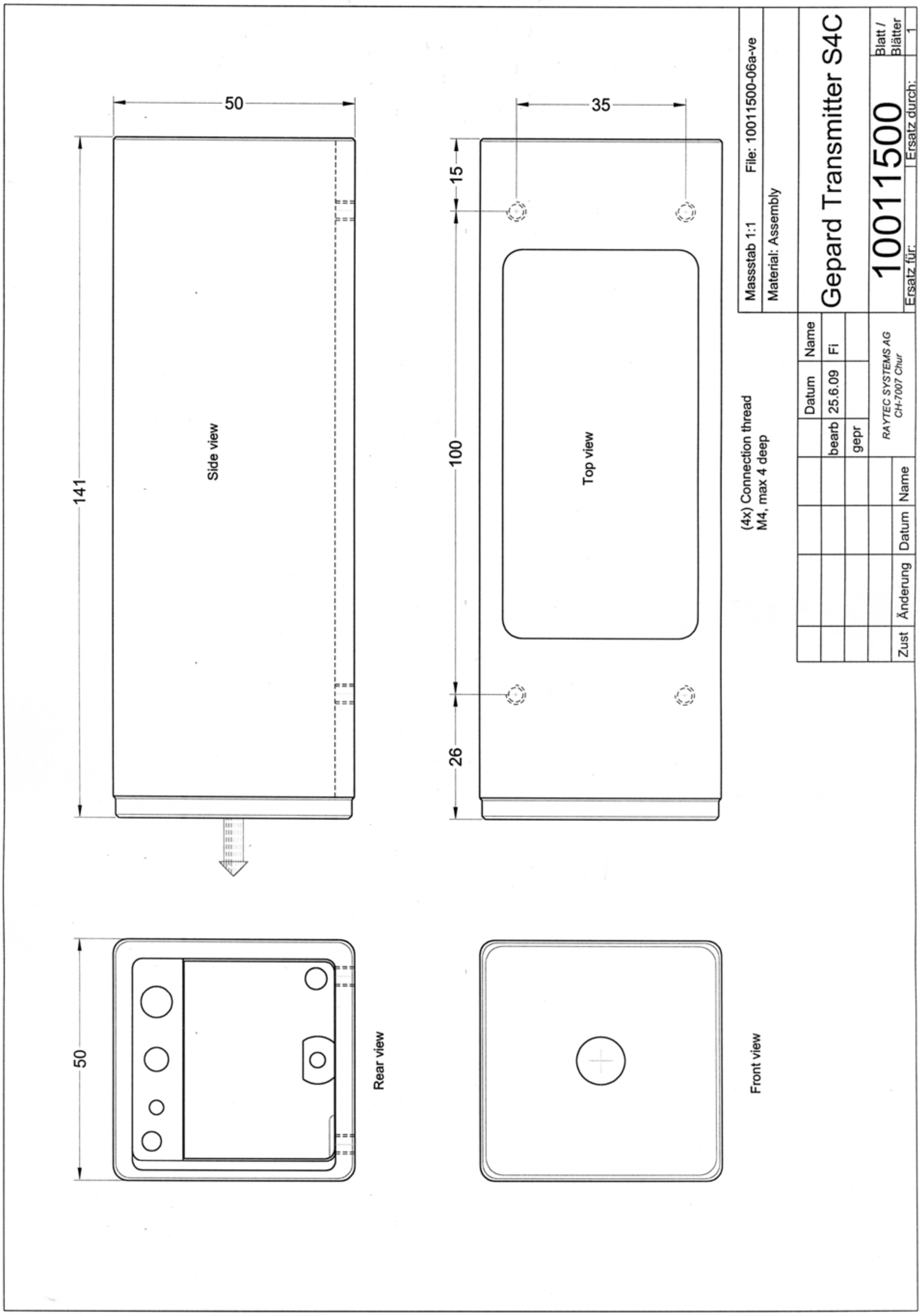
By turning the adjusting screws (see illustration) using the supplied Allen key driver, the laser can be displaced by ±1.5 degrees in the X or Y axis, allowing the alignment of the optical/mechanical axis to be optimally set.

The precision mechanisms inside the device allow this especially fine and exact levelling of the laser.

NOTE:

- ☞ ***Please note that when the screws are turned in or out when they are towards the end of their adjustment travel, a mechanical stop comes into operation; this must not be overcome with excessive force, otherwise the mechanism (precision thread) may be damaged.***
- ☞ ***After the laser transmitter has been adjusted you should wait for about 2 to 3 minutes before taking any measurements in order to achieve optimum stability of the measured values (settling phase).***

GEPARD-M4™ LASER TRANSMITTER INSTALLATION DIMENSIONS (cubic)



RAYTEC GEPARD-M4™ LASER RECEIVER (CYLINDRICAL DESIGN)

The ***RAY****TEC GEPARD-M4™* laser receiver is a high-precision optoelectronic position sensor which, together with the *GEPARD-M4™* laser transmitter, forms a very exact geometry measuring system.

The cylindrical GEPARD receiver is distinguished by the high-precision alignment of its optical-mechanical axis. This alignment allows precise absolute value measurements in relation to the laser focal point - for example, the alignment of rotation systems or the machining axes of milling cutters, lathes, boring machines etc. Using suitable mountings (square supports), these cylindrical receivers can also be used for measurement and alignment work on flat test objects.

The use of the extremely durable stainless steel INOX (1.4305) as the material for the casing permits the manufacture of a very exact, dimensionally stable component. This also affects the temperature coefficient, which is extremely small for this material. These properties and the scratch and rust proof surface of the device casing contribute in addition to a very precise device and account for the enduring value of the GEPARD measuring instrument.

The *GEPARD-M4™* laser receiver comprises a 10x10mm (or 20x20mm) PSD (Position Sensitive Detector) and comprehensive amplification and evaluation electronics, at the heart of which lies a DSP (Digital Signal Processor). Using the supplied programs, this DSP performs signal evaluation, filtering and linearisation of the measurement values - further program functions are needed by the DSP to control and monitor the sensor and for data communication to the higher evaluation unit. An internal calibration table is used for linearisation of the position detector and thus ensures the excellent linearity of this measuring instrument.

The measuring instrument is equipped with wireless data transmission for communication with the evaluation unit. This communication is performed using bidirectional serial transmission (SPP) of ASCII data. A special transmission protocol ensures that the data arrives at the receiver with no errors.
Bluetooth technology is used for the data transmission. With the long-range components this makes a range of up to 100m possible (in open spaces/sites). Bluetooth is a world standard for radio transmission and in the meantime a great number of devices and components have been equipped with it as standard - for instance, new notebook PCs are also preconfigured by the manufacturer with a Bluetooth interface.

Modern semiconductor technology makes low-current circuits possible, whereby connection to a mains supply is no longer necessary. This laser receiver is powered by standard rechargeable NiMH batteries which have a long service life when suitably maintained. In continuous operation (alignment) the laser receiver achieves an operating time of up to 12 hours with an optimally charged battery. Using the supplied replacement battery, continuous operation for up to 24 hours is possible.

BEGINNING OPERATION

To begin operation, lay two of the supplied rechargeable batteries in opposite directions (one with the positive terminal pointing forwards and one with it pointing towards the rear) in the receiver. A suitable polarity guard is provided in the battery cover. To give the contact springs inside the device the longest possible service life, the rechargeable batteries should always be slid into the device horizontally (do not let them drop in vertically!).

To close the battery compartment, the cover must be pressed in gently; a quarter turn of the screw closure then makes the cover secure.

To change the batteries, return the screw closure to the home position, the contact springs on the inside of the casing then push the cover outwards to open it slightly, after which the batteries can be removed.

The measuring instrument is switched on by briefly (< 1 second) pressing the yellow on/off push-button on the rear panel of the device. The LED should show a constant green light, indicating that the operating state is correct. If the button is briefly pressed once more, the device is switched off again.

Depending on the desired operating mode for data transmission between the *GEPARD-M4™* receiver and the evaluation unit, either the antenna or the fibre optic cable should be connected to the socket provided for it.

NOTE:

☞ *The antenna (wireless data transmission using Bluetooth) or the fibre optic cable must always be installed* ***before switching on*** *the receiver. Only one mode of data transmission should ever be connected at any one time.*

Fig. 6: GEPARD-M4 ™ laser receiver - rear view

The measuring instrument is switched on by briefly (< 1 second) pressing the yellow on/off push-button on the rear panel of the device. The LED should show a constant green light, indicating that the operating state is correct. If the button is briefly pressed once more, the device is switched off again.

OPERATING STATE INDICATOR

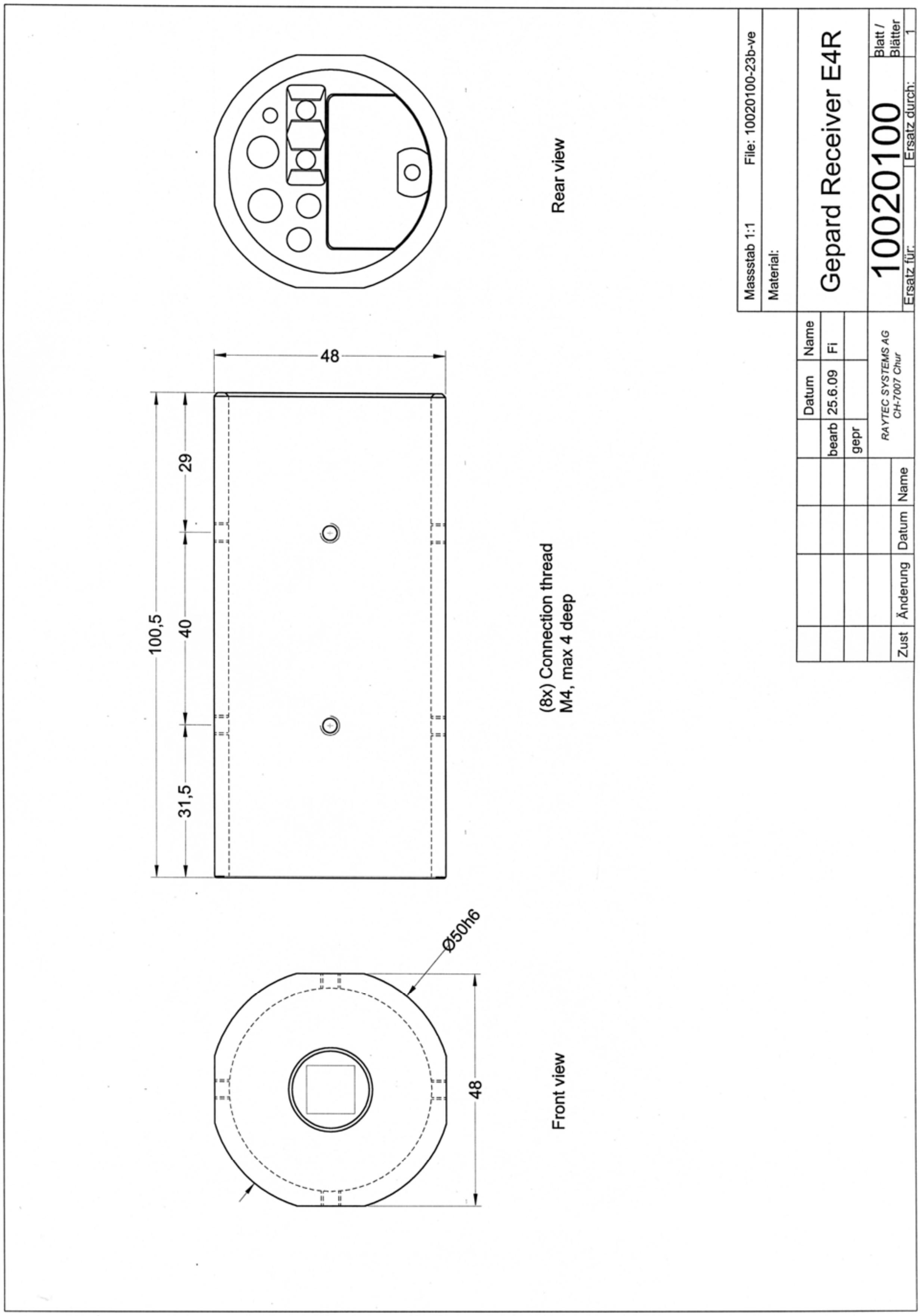
The operating state of the *GEPARD-M4 ™* receiver is indicated by the bicolour LED on the rear of the device.

ACTION	LED STATE	GEPARD operating state
Push-button on	Continuously lit green	Ready for operation with fully charged batteries.
	Continuously lit orange	Ready for operation with partly discharged batteries.
	Continuously lit red	Ready for operation with almost fully discharged batteries.
	Not lit	Battery fully discharged or fatal hardware fault.
Command activation	Light off	Command was recognised and is being processed directly.
	Continuously lit (see above for colour)	Command processed.
Aligning	Flashes in time with the transmission of the measurement values (see above for colour)	The GEPARD continuously sends the current measurement values.

NOTE:

- ☞ ***The GEPARD-M4™ receiver is an ultra-precise measuring instrument for taking measurements in the micrometer range. This device was specially developed and manufactured for everyday use in the industrial environment - it is therefore quite robust.***
However, please note that excessive loads caused by heat and mechanical shock may have a lasting adverse effect on the high precision of the instrument.
- ☞ ***The optical/mechanical axis is very precisely aligned ($\leq$ 1 μm). In order to ensure that these mechanical settings can be maintained, the device must never be subjected to high acceleration (impacts/vibrations).***
If the zero position needs to be checked, this can be done on an exact turning device. During uniform rotation through 360° the average values of X and Y should come to lie exactly at the zero point in the four quadrant representation of the position measurement module (WIN-GEPARD).
- ☞ ***If you need further information about this, please contact Raytec Systems AG.***

GEPARD-M4™ LASER RECEIVER INSTALLATION DIMENSIONS (CYLINDRICAL)



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The *GEPARD-M4™* laser receiver comprises a 10x10mm (or 20x20mm) PSD (Position Sensitive Detector) and comprehensive amplification and evaluation electronics, at the heart of which lies a DSP (Digital Signal Processor). Using the supplied programs, this DSP performs signal evaluation, filtering and linearisation of the measurement values - further program functions are needed by the DSP to control and monitor the sensor and for data communication to the higher evaluation unit. An internal calibration table is used for linearisation of the position detector and thus ensures the excellent linearity of this measuring instrument.

The measuring instrument is equipped with wireless data transmission for communication with the evaluation unit. This communication is performed using bidirectional serial transmission (SPP) of ASCII data. A special transmission protocol ensures that the data arrives at the receiver with no errors.
Bluetooth technology is used for the data transmission. With the long-range components this makes a range of up to 100m possible (in open spaces/sites). Bluetooth is a world standard for radio transmission and in the meantime a great number of devices and components have been equipped with it as standard - for instance, new notebook PCs are also preconfigured by the manufacturer with a Bluetooth interface.

Modern semiconductor technology makes low-current circuits possible, whereby connection to a mains supply is no longer necessary. This laser receiver is powered by standard rechargeable NiMH batteries which have a long service life when suitably maintained. In continuous operation (alignment) the laser receiver achieves an operating time of up to 12 hours with an optimally charged battery. Using the supplied replacement battery, continuous operation for up to 24 hours is possible.

BEGINNING OPERATION

To begin operation, lay two of the supplied rechargeable batteries in opposite directions (one with the positive terminal pointing forwards and one with it pointing towards the rear) in the receiver. A suitable polarity guard is provided in the battery cover. To give the contact springs inside the device the longest possible service life, the rechargeable batteries should always be slid into the device horizontally (do not let them drop in vertically!).

To close the battery compartment, the cover must be pressed in gently; a quarter turn of the screw closure then makes the cover secure.

To change the batteries, return the screw closure to the home position, the contact springs on the inside of the casing then push the cover outwards to open it slightly, after which the batteries can be removed.

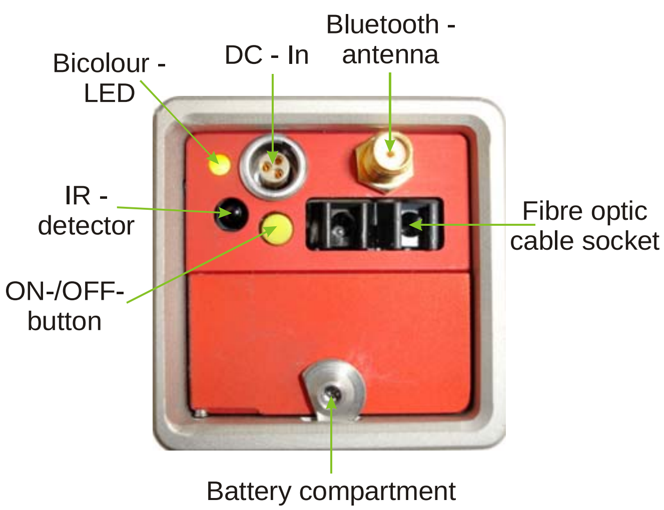
The measuring instrument is switched on by briefly (< 1 second) pressing the yellow on/off push-button on the rear panel of the device. The LED should show a constant green light, indicating that the operating state is correct. If the button is briefly pressed once more, the device is switched off again.

Depending on the desired operating mode for data transmission between the *GEPARD-M4* ™ receiver and the evaluation unit, either the antenna or the fibre optic cable should be connected to the socket provided for it.

NOTE:

☞ *The antenna (wireless data transmission using Bluetooth) or the fibre optic cable must always be installed* ***before switching on*** *the receiver. Only one mode of data transmission should ever be connected at any one time.*

Fig. 7: GEPARD-M4 ™ *laser receiver - rear view*



The measuring instrument is switched on by briefly (< 1 second) pressing the yellow on/off push-button on the rear panel of the device. The LED should show a constant green light, indicating that the operating state is correct. If the button is briefly pressed once more, the device is switched off again.

OPERATING STATE INDICATOR

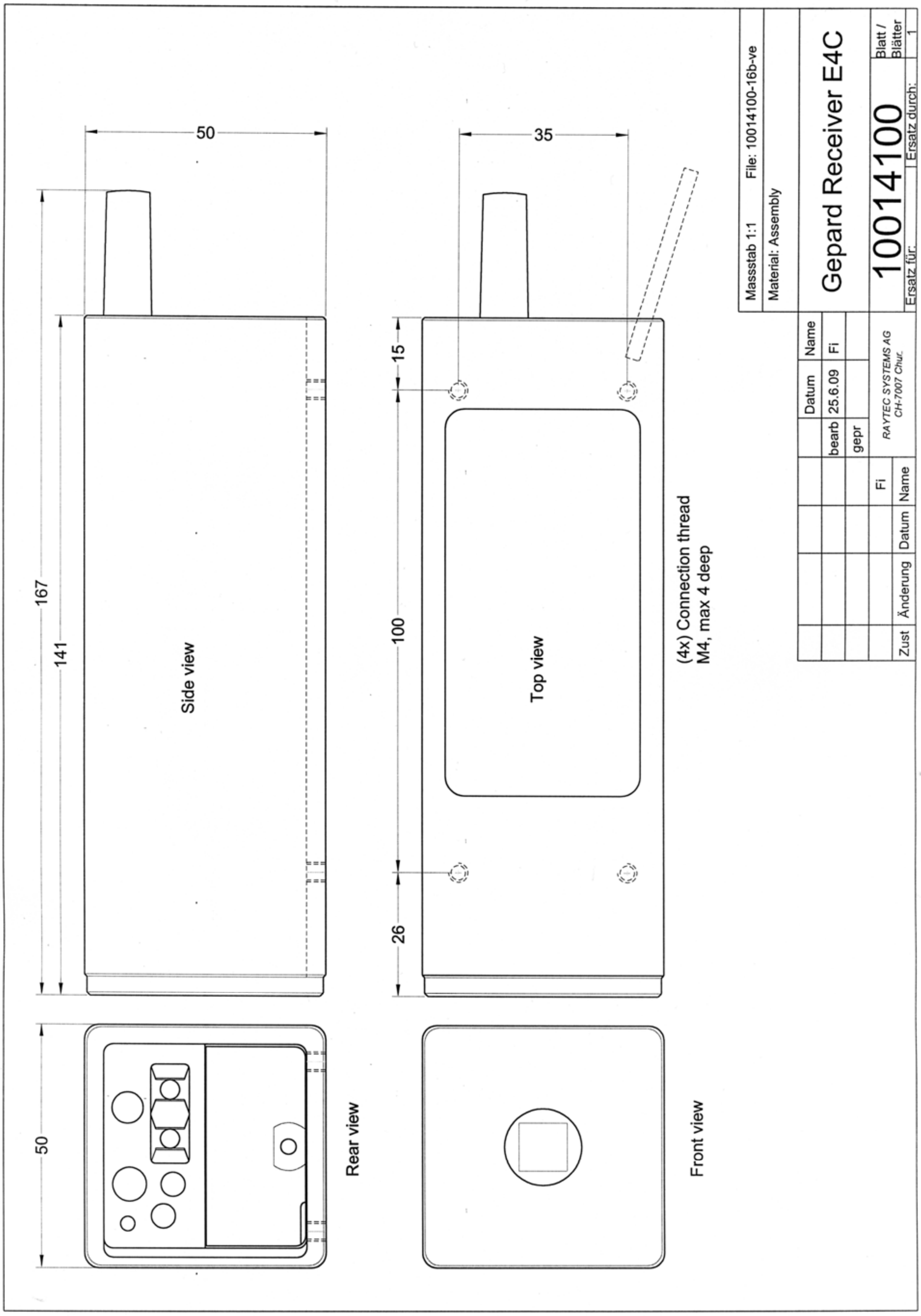
The operating state of the *GEPARD-M4™* receiver is indicated by the bicolour LED on the rear of the device.

ACTION	LED STATE	GEPARD operating state
Push-button on	Continuously lit green	Ready for operation with fully charged batteries.
	Continuously lit orange	Ready for operation with partly discharged batteries.
	Continuously lit red	Ready for operation with almost fully discharged batteries.
	Not lit	Battery fully discharged or fatal hardware fault.
Command activation	Light off	Command was recognised and is being processed directly.
	Continuously lit (see above for colour)	Command processed.
Aligning	Flashes in time with the transmission of the measurement values (see above for colour)	The GEPARD continuously sends the current measurement values.

NOTE:

☞ ***The GEPARD-M4™ receiver is an ultra-precise measuring instrument for taking measurements in the micrometer range. This device was specially developed and manufactured for everyday use in the industrial environment - it is therefore quite robust.***
However, please note that excessive loads caused by heat and mechanical shock may have a lasting adverse effect on the high precision of the instrument.

GEPARD-M4™ LASER RECEIVER INSTALLATION DIMENSIONS (cubic)



RAYTEC GEPARD-M4™ IR-remote control

The infra-red (IR) remote control unit offers optimal support for measuring and alignment work as the different functions of the measuring instrument can be controlled from any position.

Remote control key commands are carried out by the ***RAY****TEC GEPARD-M4™* receiver:

Fig. 4: View of IR remote control unit

To carry out one of these commands, the IR remote control unit should be pointed towards the back of the ***RAY****TEC GEPARD-M4™* receiver and the corresponding button pushed briefly. - the green LED on the remote control unit will also light up briefly.

The IR remote control contains a high-capacity lithium battery with a very long life expectancy (approx. 5 - 7 years).

RAYTEC GEPARD-M4™ PC INTERFACE

Data transfer between the ***RAY****TEC GEPARD-M4™* receiver and the data processing unit (personal computer) is carried out over a standard serial interface (COM port). This means that a USB connection is necessary on the PC used and that this is configured as a serial COM port in the operating system (WINDOWS).
The data carrier is either bi-directional wireless transfer using Bluetooth wireless technology or via a dual-pole optical fibre waveguide (optional).
A corresponding carrier adapter for the PC USB connection converter is contained in the standard scope of delivery. This allows the signals to be exchanged with the *GEPARD-M4™* to be converted for the USB interface.

USE AND HANDLING

In order to install the Bluetooth Wireless data transfer, a PC with an already installed Bluetooth interface or the Bluetooth to USB stick included in the delivery package, are required.
Should you use the Bluetooth to USB stick (see pictures below), you must follow exactly the installation instructions provided in the WIN-GEPARD-M4 manual where the installation steps are described in detail. If LWL to USB is used follow the WINDOWS installation instructions. The appropriate SW-drivers are located on the WIN-GEPARD CD-Rom!

Fig. 5: Bluetooth to USB-Stick / LWL to USB Converter

- ☞ ***Check the set up of the Com-Port in the basic settings the WIN-GEPARD software (see also "WIN-GEPARD manual"). This set up must coincide with the COM-port used for the Bluetooth installation on the PC (e.g. ComPort#9)! You can now activate the data transfer in the Bluetooth manager (double click on the GEPARD symbol in the BT manager window).***
- ☞ ***From WIN-GEPARD version 5.50, it is no longer necessary to manually set the parameters of the serial interface. During startup of WIN-GEPARD, the software itself checks whether a GEPARD receiver is connected to a COM port and is switched on. If no device is connected or the receiver is switched off, an error message is issued.***

☞ ***While Bluetooth data transmission is being used, it is vital that the fibre optic sockets on the GEPARD receiver are covered with the plastic plugs supplied at delivery (see illustration below). If the fibre optic sockets are not covered, the GEPARD receiver may malfunction!***

Fig. 9.2: Plastic plugs for fibre optic sockets

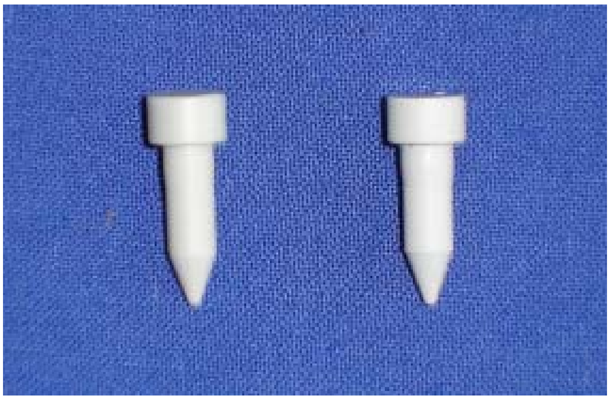


Fig. 9.3: Fibre optic sockets on the GEPARD, with plastic plugs

INSTALLATION / BEGINNING OPERATION, FIBRE OPTIC TO USB

The USB driver software supplied with WIN-GEPARD must be installed so that the fibre optic to USB converter can be used (follow the instructions of your WINDOWS operating system).

1. Connect the fibre optic/USB adapter to your computer.
2. Install the USB driver following the WINDOWS instructions. You will find this driver on the WIN-GEPARD data medium provided. ***(E:\GEPARD CD v5.54\USB to LWL Software\CDM 2.04.16 WHQL Certified\i386).***
3. Then search for the device manager in WINDOWS system control and open "(COM and LPT) connections" by clicking on it. Here you should find an entry *USB serial Port (COM n)* (e.g. n=3).
   Make a note of this COM port number for the setting in the WIN-GEPARD software (see below).

☞ ***Check the COM port setting in the standard settings of the WIN-GEPARD software (also see the WIN-GEPARD manual). This setting must match the "USB serial Port (COM n)" entry above in WINDOWS system control (e.g. COM port: #3)!***

Fig. 10: Fibre optic to USB converter

Depending on the preferred operating mode for data transmission between the *GEPARD-M4™* receiver and the evaluation unit, either the antenna or the fibre optic cable should be connected to the socket provided for it on the *GEPARD-M4™* receiver.

☞ ***From WIN-GEPARD version 5.50, it is no longer necessary to manually set the parameters of the serial interface. During startup of WIN-GEPARD, the software itself checks whether a GEPARD receiver is connected to a COM port and is switched on. If no device is connected or the receiver is switched off, an error message is issued.***

EXTERNAL DATA TRANSFER

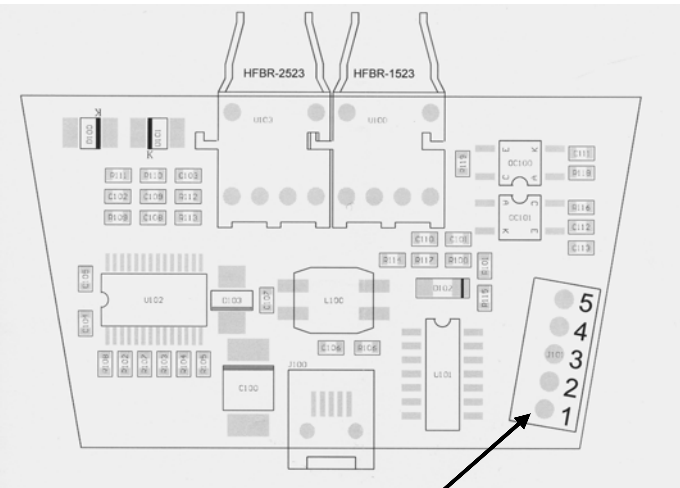
If the ***RAY****TEC GEPARD-M4™* is used for measuring with an electromechanical system with a drive unit, data transfer can also initiated by this drive unit. For this purpose, a trigger input port is available on the PC data module. This input port is designated "Single measurements "***M***" to PC" (refer also to IR remote control unit and WIN-GEPARD software).

Pin layout SPS-Trigger on the USB-Converter

Fig. 6: View to USB-Converter without protection cover

For cable inlet: remove protection cover beside

Fig. 7: Pin layout



SPS-Trigger („Automated start measuring"):

Pin 1 : +VDC external data transfer initiation (+5VDC to +24VDC)
Pin 2 : GND for external data transfer initiation

Feedback („Measuring done"):

Pin 3 : Power supply voltage (+5VDC to +24VDC)
Pin 4 : Output "Confirmation measurement data" (+5VDC to +24VDC)
Pin 5 : Power supply voltage (GND)

RAYTEC GEPARD-M4™ PENTAGONAL PRISMA

An accurate pentagonal prism (3") can be used when measuring parallelism or perpendicularity with the ***RAYTEC GEPARD-M4™***. The use of this pentagonal prism enables accurate reproduction of the deflection of the laser beam (by exactly 90°). This right-angle remains even when the prism is offset or turned.

Fig. 7: View of the pentaprism and the prism with adjustment stage

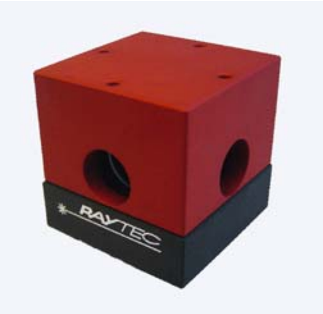
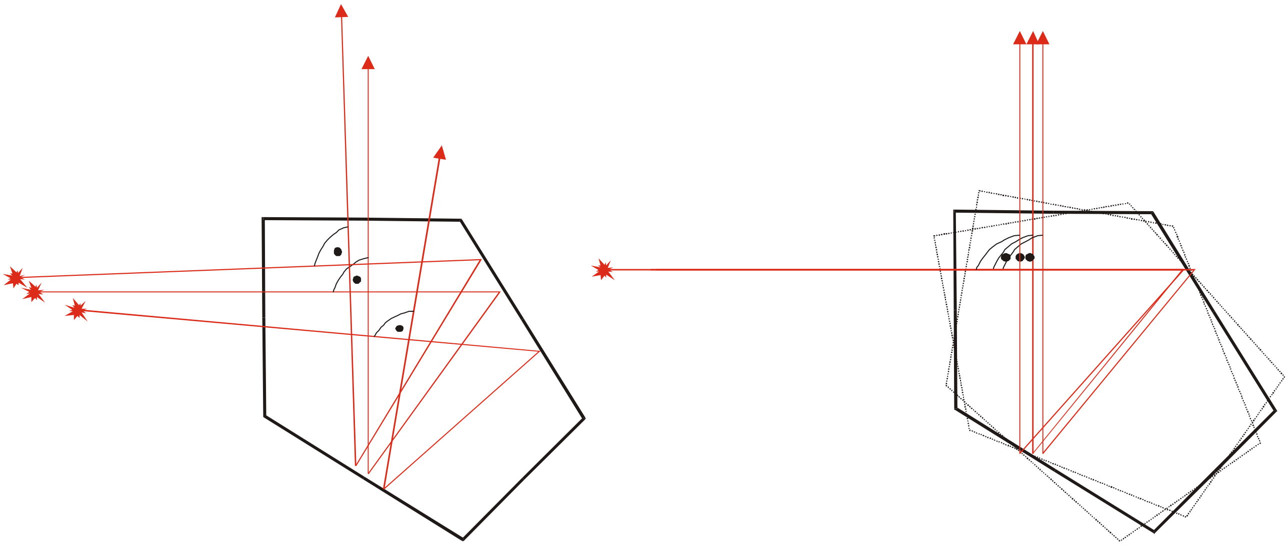


Fig. 8: Working principle of the pentagonal prism



Action of the pentaprism with different angles of incidence of the laser beam.

Effect on the laser beam when the pentaprism is turned

NOTE :

☞ *The pentaprism only guarantees the exact reproducible 90°-deflection in one dimension - e.g. in X-direction. When the prism is tilted, the beam is redirected, in this case, for example, in Y-direction. (Note. if it is also intended to measure the Y-direction, the laser beam and pentaprism must be positioned exactly, i.e. the measuring object, the laser beam and the pentaprism must be levelled).*

PENTAPRISMS, REQUIREMENTS OF THE MEASURING SET-UP

Principal:
A pentaprism deflects an arriving (laser)beam onto the X/Z plane *(fig. 9)* by exactly 90 degrees. This deflection depends on the location of the prism in relation to its rotation around the Y-axis.

GEPARD-M4™ **application:**
For every application of the 2-dimensional "GEPARD" measuring system, the limitation applies, that the Y-axis is only given by the spatial position of the prism when this prism is put in the path of the laser beam in order to deflect it. The ***RAY****TEC GEPARD-M4™* measuring system uses the co-ordinates X (horizontal) and Y (vertical).

Set-up for measuring up rectangularity / parallelism with the *GEPARD-M4™* measuring system:

- Adjust the laser beam in relation to the reference and measuring plane *(fig. 10)*
- Recording of the reference line, receiver at Pos E1 (MP 1), then Pos E2 (MP 2)
- Recording of the measuring line, receiver at Pos E3, then Pos E4.

Introduction of the prism means that the WIN-GEPARD evaluation software virtually creates two parallel lines, the angular error of which to each other, can be calculated or shown.

Definition of the co-ordinate systems used:

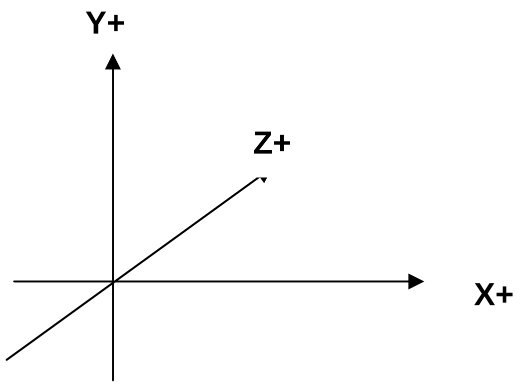


Fig. 9: Prism plane

Special requirements regarding the position of the prism:
In order for the pentaprism to also achieve the given beam deflection of 90 degrees with approx. 3 sec. accuracy during measuring, it is **absolutely necessary** that both the planes are determined by:

- laser beam plane (*fig. 10*, plane 1) and
- pentaprism plane (base of the prism), (*fig. 10*, plane 2),

are very exactly positioned, i.e. that they are parallel. This is ensured if the beam hits the receiving area of the prism in the Y-axis at a right-angle. Every deviation from this results in an increase in size of the 90-degree angle (in the X direction). The resulting X-error is dependent on the Y-angle deviation at entry of the beam in the prism (an exact right-angle is necessary) and the dimensions of the prism.

RAYTEC X-/Y- fine adjustment unit (no. 10000840):

Exact positioning of plane 1 (laser beam) and plane 2 (prism receiving area) in relation to each other can be carried out most efficiently using our mechanical fine adjustment unit.

Method of adjustment:

1. *Bring the prism into the beam using the adjustment unit.*
2. *The prism is adjusted to be orthogonal to plane 1 by tilting the Y-axis (turning the knurled screw on the adjustment unit). The laser beam reflected by the prism must arrive back at the* ***RAY****TEC GEPARD-M4™ transmitter at exactly the same height as the outgoing beam.*
3. *It is absolutely necessary to ensure that the reflecting light at the* ***RAY****TEC GEPARD-M4™ transmitter remains approx. 5 mm horizontally from the centre of the outgoing laser beam.*
4. *This ensures that the prism lane is parallel to the reference line (fig. 11). Fig. 12 shows the incorrect placement of these planes.*
5. *The second knurled screw on the fine adjustment unit can be used to adjust the measuring line optimally in relation to the* ***RAY****TEC GEPARD-M4™ receiver (e.g. centre measuring range).*

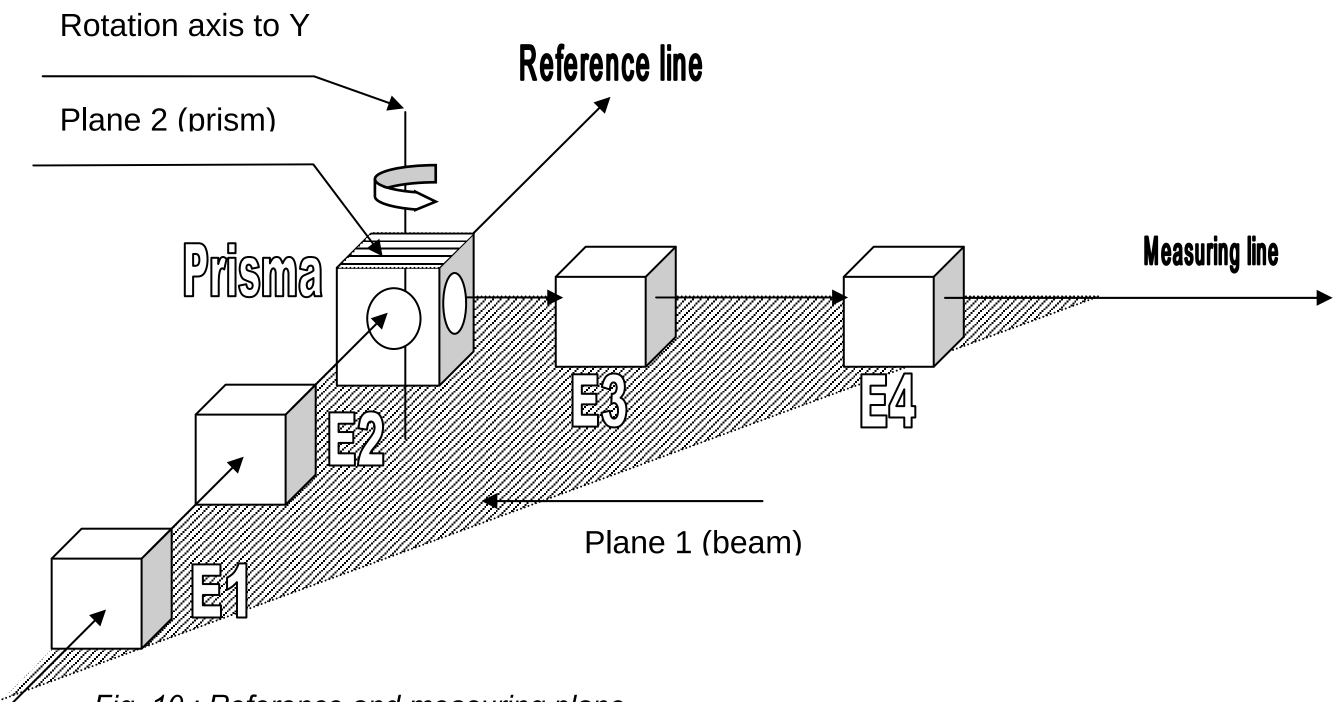


Fig. 10 : Reference and measuring plane

Side view:
This shows the reference plane: in *Fig. 11* the reference and prism planes correspond (they are parallel).

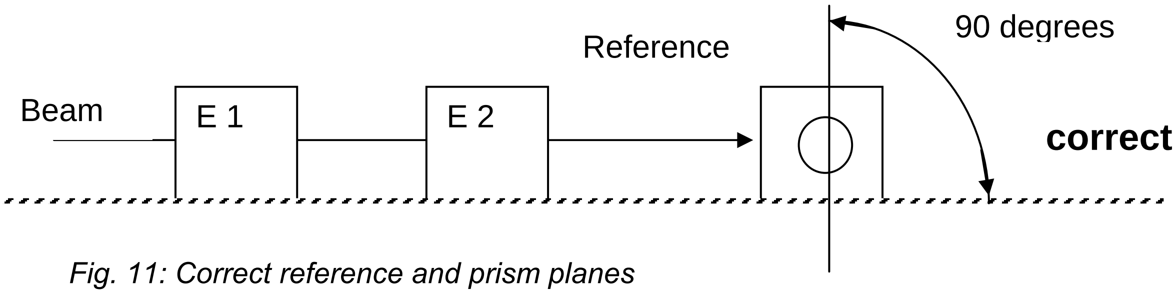


Fig. 11: Correct reference and prism planes

A measuring set-up according to *fig. 12* results in the above-mentioned angular error of the 90° angle.

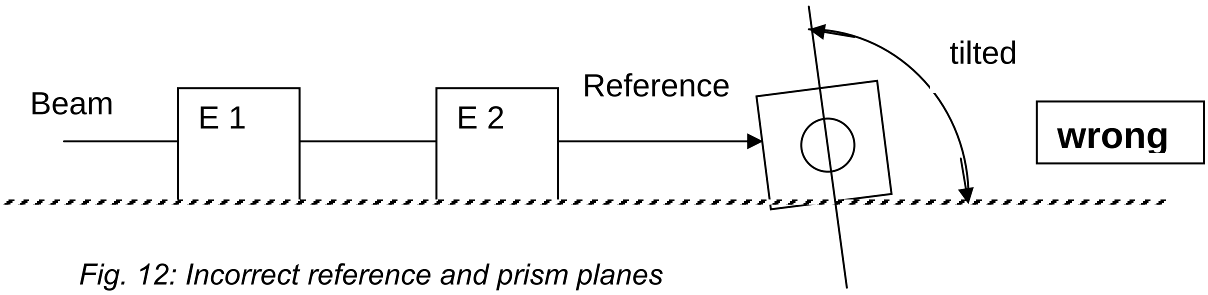
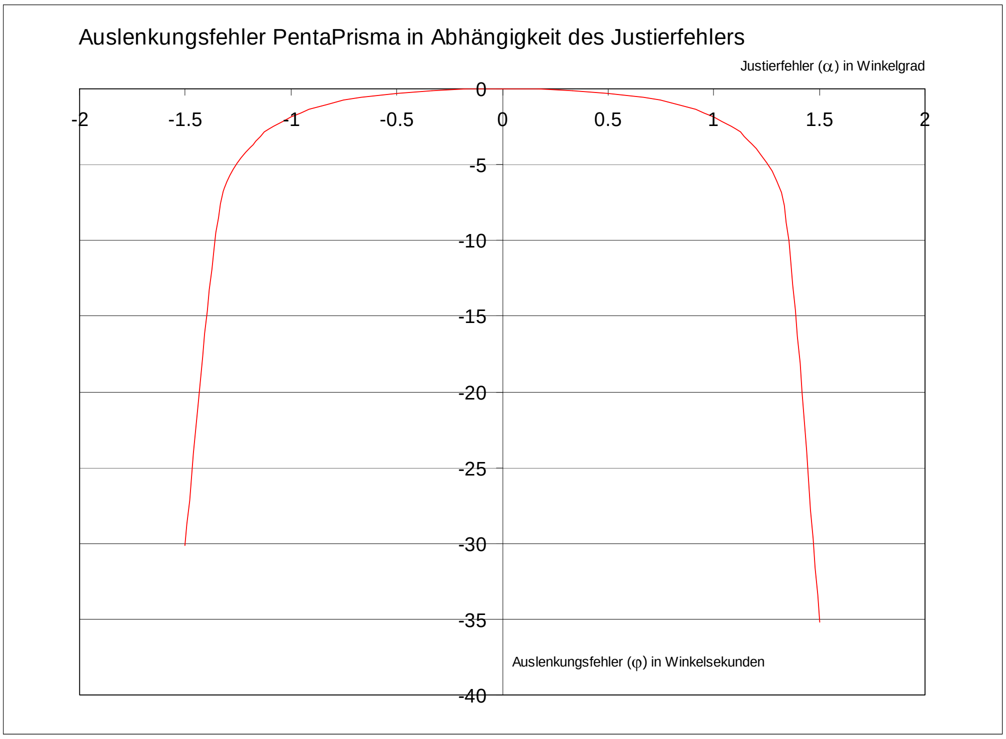


Fig. 12: Incorrect reference and prism planes

Angular-error versus positioning-error



Final comment:

☞ *When using the pentaprism, accurate measurements can only be obtained if attention is paid to the exact positioning.*

PentaPrisms in the WIN-GEPARD software

When using a Pentaprism (PP) for perpendicularity (RA) and parallelism measurements (PA) with the ***RAY**TEC* WIN-GEPARD software, certain conditions must be observed so that the measurement results can be correctly interpreted.

1. Assignment of the PP measuring plane:

Since GEPARD provides a two-dimensional measurement (X/Y) – but the pentaprism only exactly reproduces the 90° angle on one plane – it is important to know and/or select in the WIN-GEPARD software in which of the two measuring planes the PP is used. For this purpose WIN-GEPARD provides this option when choosing the settings for the RW/PA measurements. With just one click on the relevant (X/Y) box, either the horizontal (X) plane or the vertical (Y) plane can be selected (see also fig. 15).

2. Assignment of the measurement set-up and measuring procedure:

In order to correctly calculate internally the individual measured values in the WIN-GEPARD software (RW or PA module) when using a PP, it is essential to define the measurement set-up and the procedure.

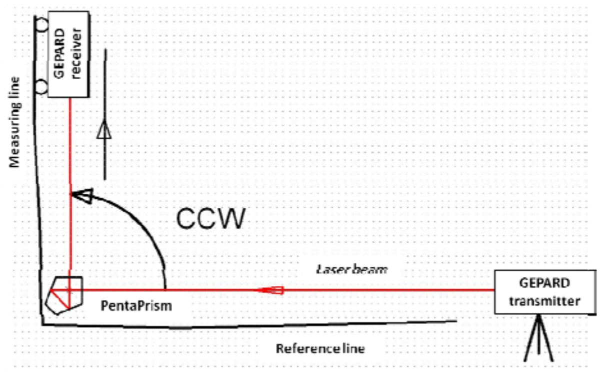
By default, the angle calculation assumes that the measuring device layout, the PP set-up and the measuring procedure are set as counter clockwise (CCW), as this is the mathematical standard for angle calculation and the angle can be displayed as "positive" in the counter clockwise direction. In the clockwise (CW) direction the angle is displayed accordingly as negative.

For possible configurations see the table below (fig. 20). Every possible set-up is covered with these four illustrations – for one's own use scenario the set-up must be checked precisely and then the CCW/CW assignment must be set in the software!

☞ *The position of the PP and the opening angle side – i.e. the measuring line in relation to the reference line – are crucial in this respect.*

To this end WIN-GEPARD provides the CCW and CW options for the settings for the RW/PA measurements. With just one click on the relevant (CCW/CW) box, the relevant sign setting can be selected.

PentaPrism measurement set-up / measuring procedure (fig. 20)

<table>
<tr><th>CCW</th><th>CW</th></tr>
<tr>
<td>
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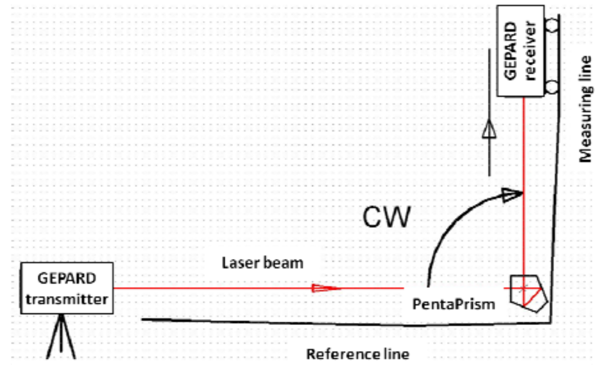
<td>
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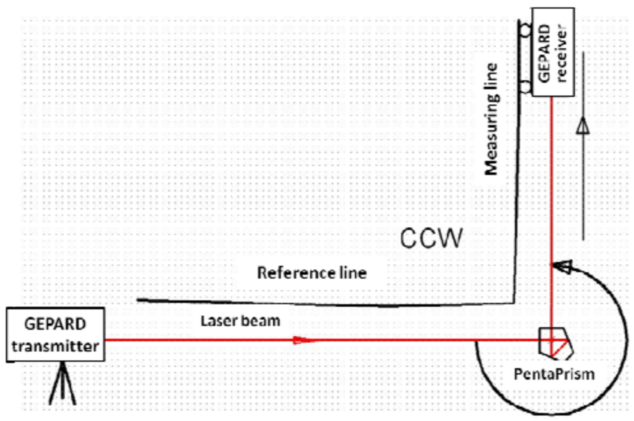
<td>
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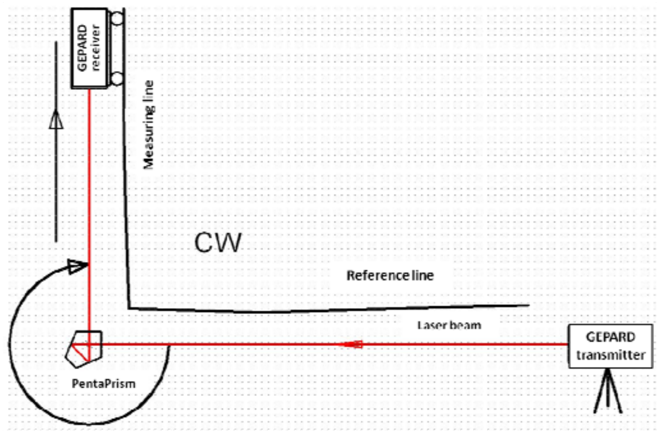
<td>
</td>
</tr>
</table>

GENERAL NOTES

CALIBRATION THE MEASURING INSTRUMENT

In order to keep this precision instrument well maintained, it is recommended that our customer service is allowed to test and calibrate it once a year. We can then issue you with a testing certificate and you can be certain that your ***RAY****TEC GEPARD-M4™* measures accurately.

CARE OF THE LASER TRANSMITTER

Clean the laser transmitter by wiping it with a damp cloth. If the exit of the laser beam is dirty it should be cleaned with a conventional, mild, anti-static optical cleaning agent.

Laser transmitter and battery should not be exposed to extreme temperatures (above 60°C) such as a can be experienced, for example, behind glass in direct sunlight.

CARE OF THE LASER RECEIVER

Clean the laser receiver by wiping it with a damp cloth. If the entry of the laser beam is dirty it should be cleaned with a conventional, mild, anti-static optical cleaning agent. The sensitive sensor surface is protected by a glass cover.

Laser receiver and battery should not be exposed to extreme temperatures (above 60°C) such as a can be experienced, for example, behind glass in direct sunlight.

CARE OF THE BATTERIES

- In order to increase the life expectancy of the batteries they should not be kept on charge longer than necessary (3 - 5 hours).
- Only use the original battery charger supplied with the corresponding mains adapter.
- Care should be taken that the contacts do not touch metal or oily parts.
- Batteries must not be opened, placed in water or thrown into an open fire.
- Used batteries must not be thrown away in household waste. They must be disposed of in the proper way.
- Attention must be paid that only original batteries are used.
- Use of other types of battery or non-chargeable batteries may cause malfunctioning or even damage to the instrument.
- The manufacturer will accept no liability in such a case.

REMARKS REGARDING USE OF THE RADIO-DATA-LINK

The following conditions must be taken into consideration when using cordless data transfer:

- The ***RAY****TEC GEPARD-M4™* data transfer is equipped with Bluetooth wireless technology. Bluetooth uses an adaptive frequency jump process and works with a transmission frequency of 2.4GHz with a transmission performance of >10mW.
- This frequency band (2.4GHz) is a globally free frequency range when the transmission performance is <100mW.
- Successful use of the Bluetooth wireless technology with an adaptive frequency jump process for data transfer from the *GEPARD-M4™* receiver to the PC is ensured by "pairing" of the equipment. Disturbance of the data transfer is practically impossible.
- In some cases, machinery which generates a strong electro-magnetic field (e.g. frequency controlled high-performance motors, electrical welding equipment etc.), can affect the data transfer.
- In addition, the environment may also affect the range of the wireless data transfer (e.g. concrete walls, steel scaffolding etc.).
- Under optimal conditions, normal wireless range within a building is max. 100m (range of visibility); this should be more than sufficient for operation and data transfer with the *GEPARD-M4™*.
- The data transfer of the *GEPARD-M4™* is controlled by different measures. If external influences disturb the wireless connection, this control ensures that no wrong values are shown.
- Short-term disturbances are not noticed by the operator as *GEPARD-M4™* software requests additional sending of any missing data.
- Massive disturbances are shown by a red "lightening" symbol at bottom left of the screen. If the source of this disturbance cannot be determined and removed, data transfer should be carried out via an optical fiber waveguide which is included as an optional extra to the *GEPARD-M4™* . This kind of connection guarantees undisturbed transfer of data in any situation.
- If the connection between the *GEPARD-M4™* and the evaluation unit is interrupted, WIN-GEPARD requires maximum 60s to automatically renew the connection.
- Using the Bluetooth long-range modules (range up to 100m) with a small distance (<2m) between the evaluation unit and *GEPARD-M4™*, it is possible that the extremely strong signal can lead to "crosstalk" of the signals. This makes data transmission between the equipment impossible. This problem can be easily solved by moving the equipment farther apart.

TECHNICAL DATA

Transmitter	GEPARD5 S4$_K$	GEPARD5 S4$_R$
Laser power	≤ 1 mW	≤ 1 mW
Laser class	2	2
Laser wave length	approx. 650 nm (red)	approx. 650 nm (red)
Laser beam profile	circular optimised Gaussian distribution	circular optimised Gaussian distribution
Laser beam dia. in 20 m	approx. 6 mm	approx. 6 mm
Power supply	NiMH rechargeable battery 1.5 V type AA	NiMH rechargeable battery 1.5 V type AA
Dimensions L x H x W	141 x 50 x 50 mm	ø 50 mm, L: 70 mm
Weight	650 g incl. rechargeable battery	500 g incl. rechargeable battery
Micro-fine adjustment	yes	–
Optical-mechanical alignment	–	yes

Receiver	GEPARD5 E4$_K$	GEPARD15 E4$_K$	GEPARD5 E4$_R$	GEPARD15 E4$_R$
Measuring range (x/y)	5 x 5 mm	15 x 15 mm	5 x 5 mm	15 x 15 mm
Measuring range resolution	0.1 µm	0,5 µm	0,1 µm	0,5 µm
Linearity [1] [2]	0.4 ‰	0,5 ‰	0,4 ‰	0,5 ‰
Reproducibility [1] [2]	± 0.25 µm	± 0,5 µm	± 0,25 µm	± 0,5 µm
Power supply 3)	NiMH 1.5 V type AA	NiMH 1,5 V type AA	NiMH 1,5 V type AA	NiMH 1,5 V type AA
Radio data transmission range	up to 100 m	up to 100 m	up to 100 m	up to 100 m
Dimensions L x W x H	141 x 50 x 50 mm	141 x 50 x 50 mm	ø 50 mm, L: 70 mm	ø 50 mm, L: 70 mm
Weight	570 g incl. rechargeable battery		500 g incl. rechargeable battery	
Measuring distance	0–15 m	0–30 m	0–15 m	0–30 m
Optical-mechanical alignment	–	–	yes	yes

Evaluation	
Software	RAYTEC WIN-GEPARD with unique adaptive measuring. Measurement of straightness, parallelism, perpendicularity, position, alignment
System requirements	Windows, current PC generation (Windows XP, Vista)

RAYTEC WIN-GEPARD™ SOFTWARE

The WIN-GEPARD software has been developed according to the latest ergonomic aspects and provides support for the operator during measuring (straightness, perpendicularity, parallelism, etc.) in that the complete operation is limited to a few keystrokes. Necessary measuring parameters can be defined and saved before actual measuring is carried out.

Measurements are shown very clearly either numerically and/or graphically. Comprehensive functions for tolerance range, statistics and different methods of evaluation are available as standard.

Due to the unique "**adjustment mode**", the operator can accurately adjust the measuring object "**online**" at any given time.

After measuring of the measuring object has been carried out a quality protocol according to current standards can be printed.
The effort of writing the measuring results and, therefore, the possibility of making mistakes, is eliminated completely.

The measuring values are available in ASCII format for further specific processing (table calculations or database).

Detailed instructions for use are given in the WIN-GEPARD software manual included on the data carrier in the delivery package.

RAYTEC GEPARD-M4™ DESCRIPTION OF USE

Using the measurement of straightness for a precision guide in mechanical engineering, the simple steps of setting up and using the ***RAY**TEC GEPARD-M4™* will be described.

A measurement of straightness was chosen because this is the basis for all further measurements (parallelism/rectangularity etc.).

For the measuring of this guide, a ***RAY**TEC GEPARD-M4™* laser transmitter, a ***RAY**TEC GEPARD-M4™* laser receiver and a processing unit (PC Notebook or laptop/printer) are necessary. Naturally, mechanical adapters are also necessary in order to fix the ***RAY**TEC GEPARD-M4™* transmitter and receiver. The laser transmitter can be mounted on a stable tripod, the receiver can be fastened to a sliding carriage and thus, slid along the guide.

NOTE:

☞ *In order to make complete use of this very accurate measuring instrument, a few marginal conditions for the mechanical adaptation of the measuring object must be fulfilled. If it is aimed to obtain measurements accurate to a micrometer, the adapters for the measuring instrument must be correspondingly robust and the reproducibility of the mechanical positioning must also fulfil these conditions. Ideally, it should be attempted to create a mechanically coupled system between **RAY**TEC GEPARD-M4™ transmitter and **RAY**TEC GEPARD-M4™ receiver. This can eliminate possible differences in vibration between the machine and the building which may lead to faulty measurement readings.*
*If the **RAY**TEC GEPARD-M4™ transmitter is fitted separately to a tripod, the two **RAY**TEC GEPARD-M4™ components may be subjected to different movements, also resulting in faulty measurement readings.*

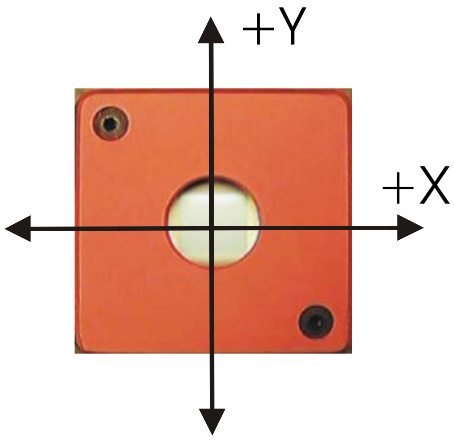
DEFINITION AND ALLOCATION OF THE X- / Y- CO-ORDINATES

As the instrument makes it possible to measure two dimensions simultaneously, corresponding interpretation and allocation of the evaluation values in a co-ordinate system is necessary.

Definition of the co-ordinate system for measuring of positions:

In this application, a two-dimensional co-ordinate cross is laid across the sensor. The abscissa corresponds to the X-value and the ordinate corresponds to the Y-value of the ***RAY****TEC GEPARD-M4™* system. If the laser point is moved in a horizontal direction to the right, a positive change in the display of the X-value results; movement to the left gives a corresponding negative change to the X-value.
If the laser point is moved vertically upwards, a positive change in the display of the Y-value occurs; movement downwards results in a corresponding negative change of the Y-value.

Fig. 13: X-/Y- co-ordinate allocation when measuring positions:



Definition of the co-ordinate system for measurements of straightness:

When measuring straightness (and parallelism or rectangularity) the shape of the measuring object is portrayed accurately as a 2-D graph. This means the following, for example, for the vertical axis: if a cambered measuring object is seen, the measuring graph on the monitor and in the protocol (see fig. 14) shows a corresponding height increase i.e. positive Y-values. If a depression is measured, correspondingly negative Y-values are shown.

In the horizontal direction, positive and negative X-values are displayed so that an accurate picture of the measuring object is given, whereby the beam trajectory of the laser transmitter must correspond in the graph to the direction MP1 to MPx.

Fig. 14: Y- co-ordinate allocation when measuring straightness:

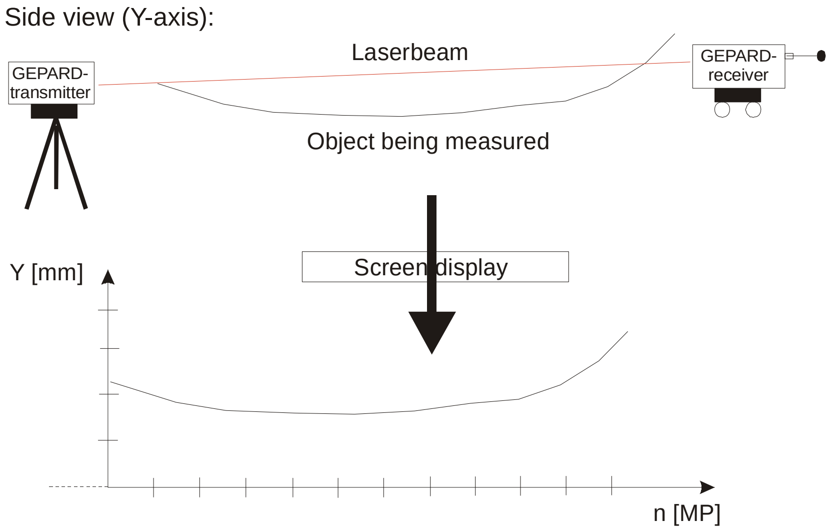
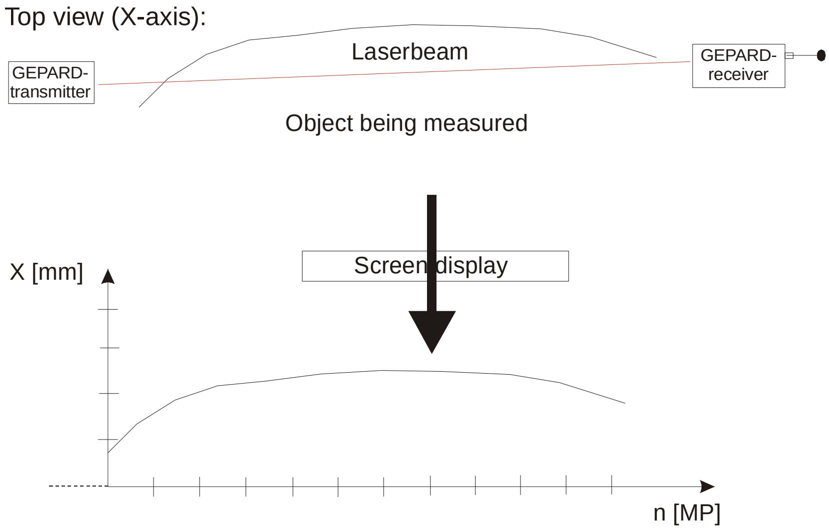


Fig. 15: X- co-ordinate allocation when measuring straightness:



SETTING UP THE MEASURING SYSTEM

Before measuring can begin, the laser transmitter should be adjusted so that every measuring point is within the measuring range. This means that the laser beam must be able to hit the PSD over the complete measuring distance.

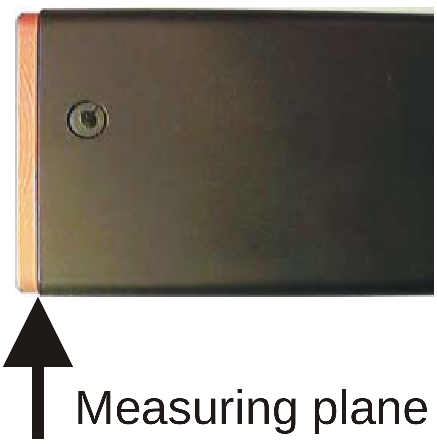
The WIN-GEPARD software can also help with setting up. By starting the function "Position measurement" the position of the beam is shown both graphically and numerically on the PC monitor (refer to the WIN-GEPARD manual for operating instructions).

An exact alignment of the laser beam (more accurate than ± 0.5 mm) is not necessary, the offset beam is compensated automatically.

☞ *For very accurate measurements however, it is absolutely necessary that the laser is set as close to the centre of the PSD (X=0mm and Y=0mm) as possible. This means that the linearity faults of the* ***RAY****TEC GEPARD-M4™ receiver are negligible.*

In addition, all measuring positions (MPx) of the measured object which are to be measured, must be designated. Generally, these are the positions which can be aligned during assembly. Ideally, these positions should be aligned as accurately as possible with the physical measuring plane of the ***RAY****TEC GEPARD-M4™* receiver (refer to fig. 17), i.e. the receiver must be placed as close to this position as possible.

Fig. 16: Measuring plane of GEPARD-M4™ receiver:



This concludes the setting-up phase, a process which usually takes no more than 5 - 10 minutes.

☞ *From this point on, it must be ensured that the reference position - the position of the laser transmitter - is not changed.*

An interruption of the laser beam, on the other hand, has no effect. Measurements can continue to be made as soon as the beam hits the receiver again.

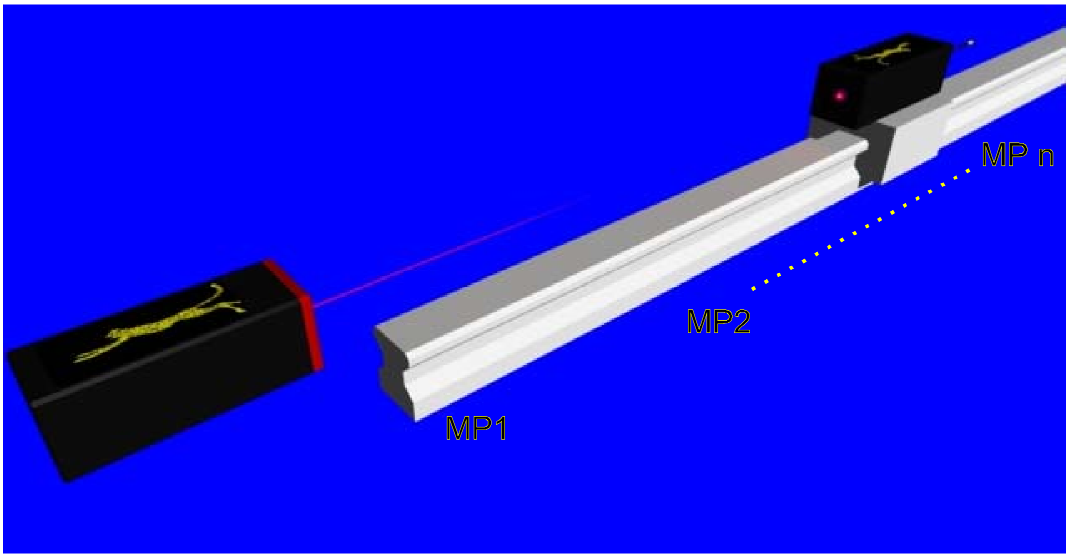
By clicking on the symbol, the function of measuring straightness is started. The operator can call up the measuring parameters and may adapt these to his measuring job or simply confirm the given parameters. The most important parameters are the measuring length (ML) of the object to be measured, the number of measuring points (MP) and the measuring tolerance (T). These parameters are required for on-line drawing of the graphs on screen and the quality protocols.

Registration of the measuring data can now begin. The laser receiver is positioned on the marked point ***MP1***. By pushing the buttons (on the IR remote control unit), the actual measured X / Y values of the guide are noted. The laser receiver can then be repositioned straight away at MP2 - after processing of a pair of measuring points, the indicator of the processing unit jumps automatically to the next MP - so that the measuring point can be noted immediately after positioning of the receiver at this position. This process is repeated until all MP's have been noted.

IMPORTANT:

☞ ***It is absolutely necessary that the first measuring point (MP1) is defined in the processing software on the Z-axis as length 0.0 mm and, therefore, is the point nearest to the laser sender.***

Fig. 17: Configuration "Measurement of straightness"“



The user sees his measurements on the monitor of the processing unit, for example, as follows (in this case, only X-values presented graphically and numerically).

Fig. 18: Presentation of "Measurement of straightness"

Summary: With a minimal amount of setting-up, pushing some keys to register the measuring points and a few minutes for the actual measurements, the graph shown here, giving a great deal of information, can be obtained:

It can be seen *straight away*, both qualitatively and quantitatively, how the guide is placed in the X-direction (horizontal). This allows corrective measures to be undertaken e.g. correction of extreme values by use of washers etc. The measuring system offers support in that the change in value at the points to be corrected is shown online.

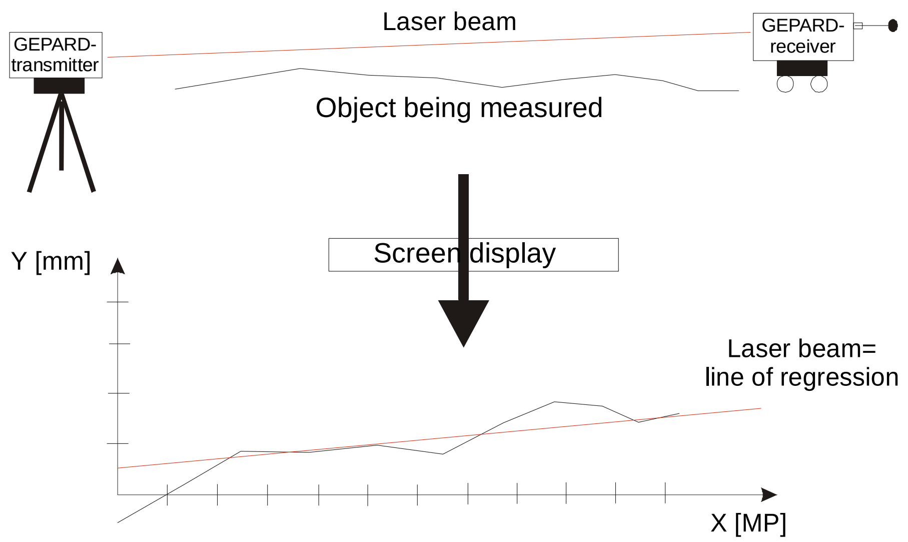
This simple operation of the measuring system is made possible by the software (WIN-GEPARD), which can be used with any WINDOWS operating system on standard personal computers. This software has been developed in co-operation with customers according to industrial standards.

METHODOLOGY OF MEASUREMENT OF STRAIGHTNESS

What actually takes place while straightness is being measured?

Presentation of a selected number of „discrete“ measuring points, as is created during processing with the ***RAY****TEC GEPARD-M4™* receiver, is shown in the graph as a series of single points.
WIN-GEPARD automatically joins these points with a line. In this way, a curve showing the processed "rough values" can be shown from point to point immediately during measuring using the measured points connected by the line.
At this point the values are still subject to inaccuracies due to the adjustment of the laser equipment and further variations stemming from the system (e.g. misalignment of the optical / mechanical axes). For this reason, no completely accurate statements about the measured object are available to the user at this point.

Fig. 19: Representation of "rough values"



Using the measuring points recorded, (MP1 to MPn), the WIN-GEPARD software lays down a line of regression according to the method of the “least squares”. This line of regression is nothing more than a mathematical representation of the laser beam.

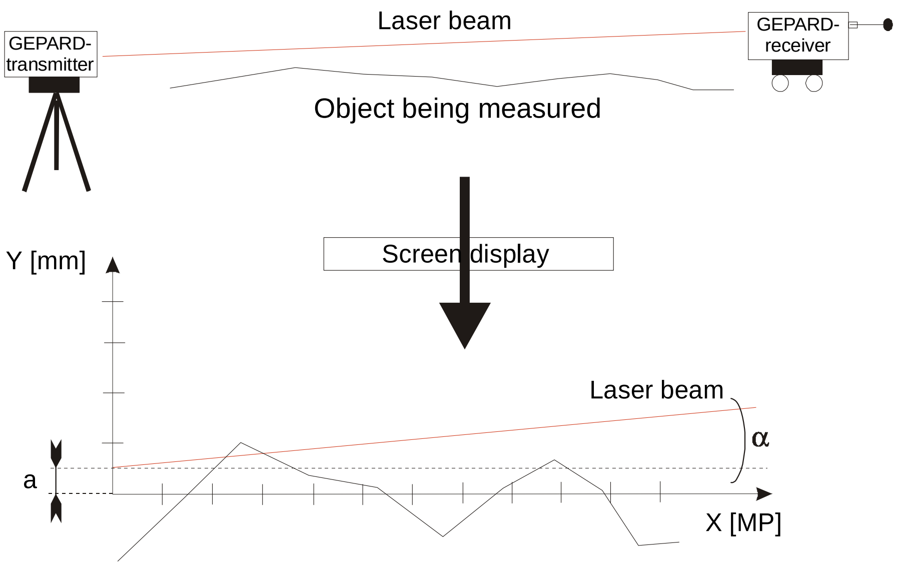
By using the two analytical methods "ISO" and "REF", the evaluation software WIN-GEPARD allows the measured object to be evaluated. Using these two methods the user is provided with clear statements regarding the quality of straightness, evenness etc. of the object measured. The procedures involved to achieve this are given in the following pages.

In order to show the user the exact deviation of longitudinal measurements to a zero or reference line, the single measured values must be mathematically adjusted in order compensate for misalignment (a) and the angle of gradient (α). In this way, the line of regression becomes the "zero line" of the graph.

The calculated line is a line of regression which contains the same number (weighting) of positive and negative values, i.e. the average of all measured points is exactly 0.0mm.

Evaluation of the measurement of straightness using the ISO method is shown on the screen display as follows:

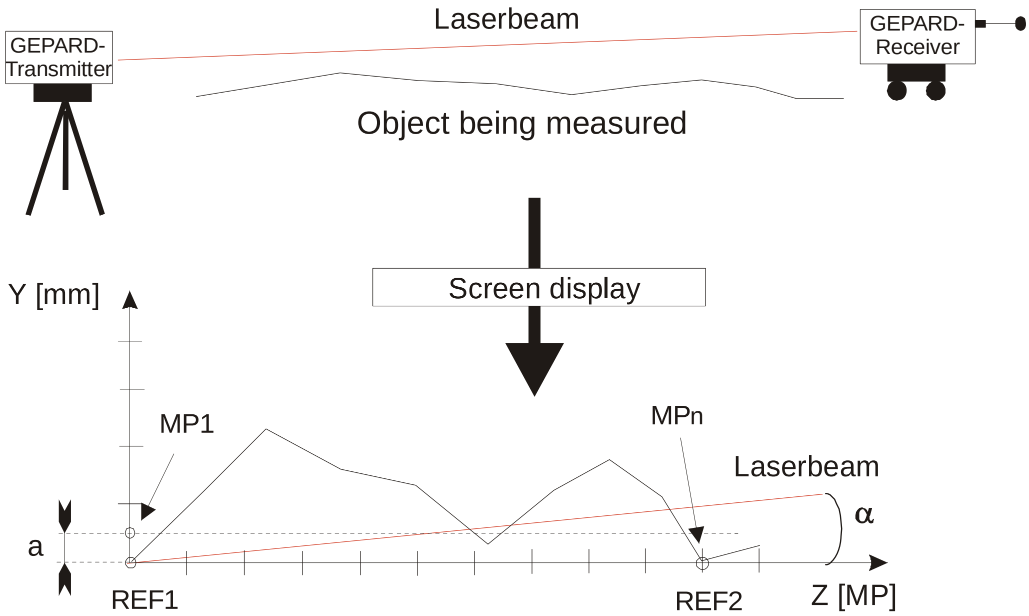
Fig. 20: Representation of "ISO line"



Reading the graph is now very simple: at each measuring point the deviation from the X-axis (zero line) is visible. Time-consuming conversion of angle of gradient and off-set become completely unnecessary.

A further possibility for evaluation of the measurement of straightness is to select any two measuring points in the series of measurements and define these as reference points (an explanation of how to do this is given in the WIN-GEPARD software).
The value axes (the abscissa, in the following example the Y axis) is then drawn through these selected points and defined as the zero or reference line:
REF1 = REF2 = 0mm.
All further measured values are then plotted in relation to the reference points using a linear equation.
In this way, a measuring result is obtained which is comparable to the creation of a guideline between REF1 and REF2 and following processing of all values in between.

Fig. 21: Presentation: "Straight line through two reference points"



Recording of protocol

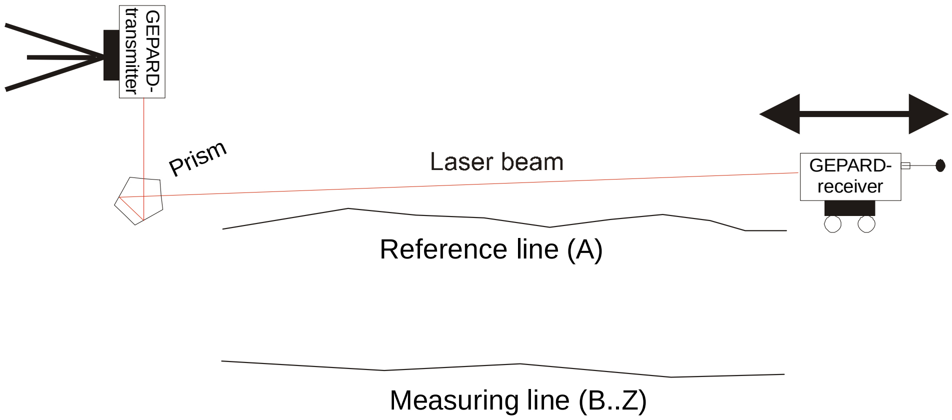
The protocol was designed with the help of the Swiss federal weights and measures authority (Eidg. Amtes für Messwesen). Abbreviations and symbols used have been taken from the relevant ISO standards. Measurement, calculation and display of straightness, parallelism and perpendicularity originate from the corresponding ISO standards (refer also to protocol).

METHODOLOGY OF MEASUREMENT OF PARALLELISM AND PERPENDICULARITY

Set up for measuring parallelism

The set-up here is different in that the laser transmitter is set at right angles to the object to be measured and the pentaprism deflects the beam at exactly 90° to the object being measured. During setting up care should be taken that in the interplay of laser and prism a good laser alignment to the object being measured, is attained. The reference line is recorded as in the measurement of straightness.

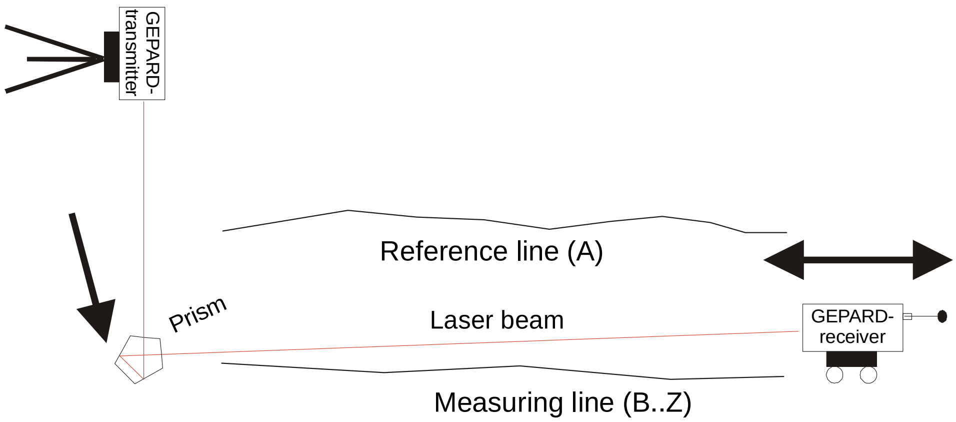
Fig. 22: Recording the reference line



☞ *The measuring reference consists of laser transmitter and pentaprism*

The measuring line(s) are measured by repositioning the pentaprism to the measuring line. As the laser transmitter is the reference position, it remains where it is.
The prism must be positioned on the measuring line so that the laser beam hits the receiver over the complete length of the measuring line. This is carried out by horizontal repositioning of the prism - the measuring points are then recorded analogue to the measurement of straightness.

Fig. 23: Recording of the measuring line(s)



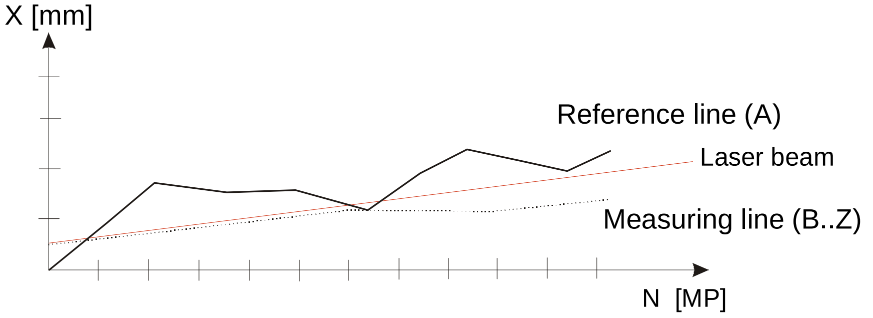
- *The pentaprism allows an accurate 90° deflection of the beam in one dimension (refer to the description of the pentaprism given above).*
- *As the measurement of parallelism is a relative measurement of two lines - the ISO lines of the lines are compared - the absolute accuracy of angle of the pentaprism per se is not important. The reproducibility of the angle is important here.*

Calculation of parallelism and angle of parallelism (w)

When considering the parallelism, WIN-GEPARD shows the deviation of each single measuring point (MP) with regard to the ISO lines of the reference lines.

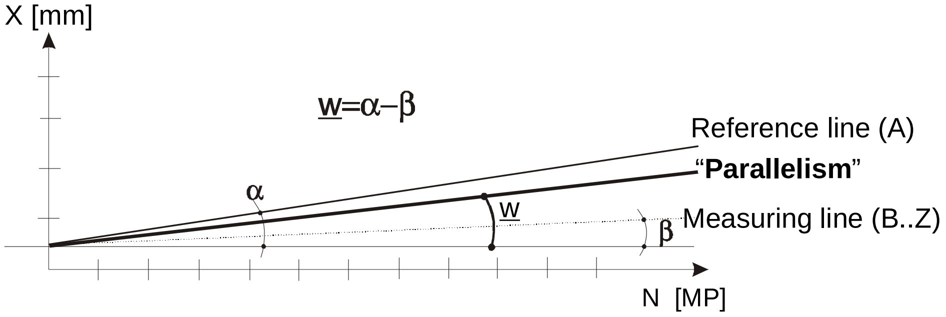
The angle of parallelism, **w,** is created by the difference in angle of the ISO lines of the reference line (line of regression through all the measuring points) and the ISO line of the measuring line. The reference for the calculation of the angle is given by the zero line of the X / MP graph).

Fig. 24: Presentation of reference line and measuring line



Reduction of the measured lines to their ISO straight lines and calculation of the parallelism as the difference between these two lines.

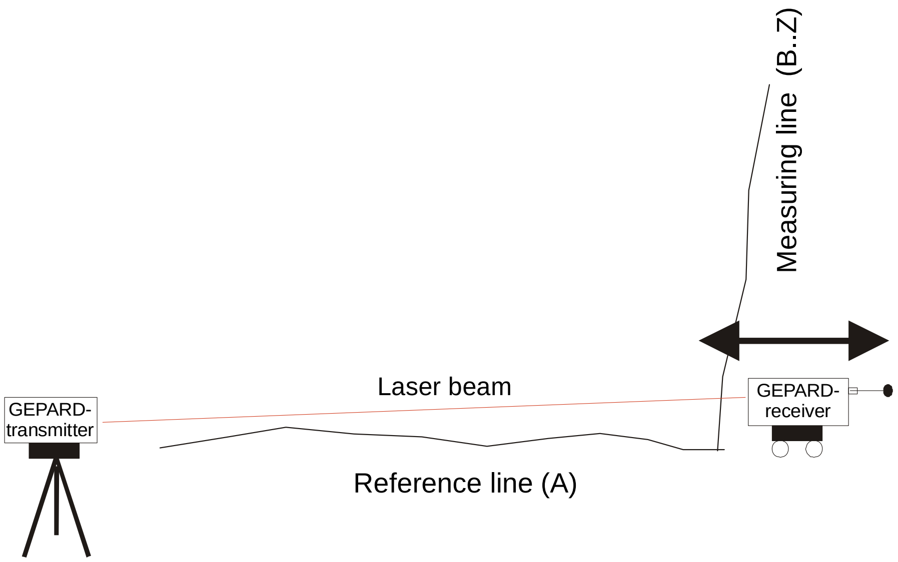
Fig. 25: Presentation of parallelism



Set up for measuring perpendicularity

The reference line can be set up and measured as for a measurement of straightness.

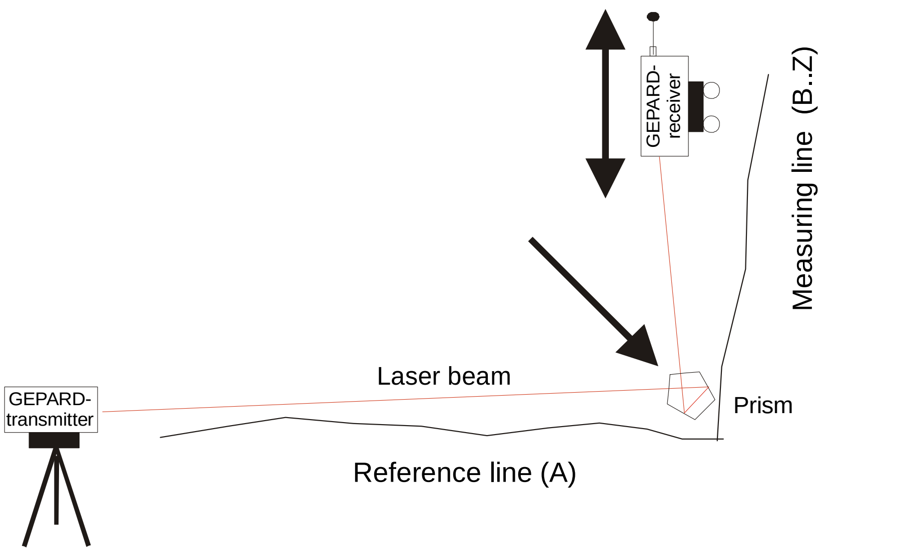
Fig. 26: Determination of the reference line



Determination of the measuring line(s)

The measuring line(s) are measured by positioning the pentaprism on the measuring line. As the laser transmitter forms the reference position, it must remain in its position. The prism must be positioned so that the laser beam hits the laser receiver over the whole length of the measuring line. This is ensured by horizontal repositioning of the prism.

Fig. 27: Determination of measuring line(s)



- ☞ *The pentaprism allows an accurate 90° deflection of the beam in one dimension (refer to the description of the pentaprism given above).*

- ☞ *As the measurement of perpendicularity is an absolute measurement of angles of two lines - and he pentaprism is included in the measurement as a 90° reference - the absolute accuracy of angle of the pentaprism is also decisive for the measurement inaccuracy (1" deviation gives a measurement inaccuracy 5µm/m).*

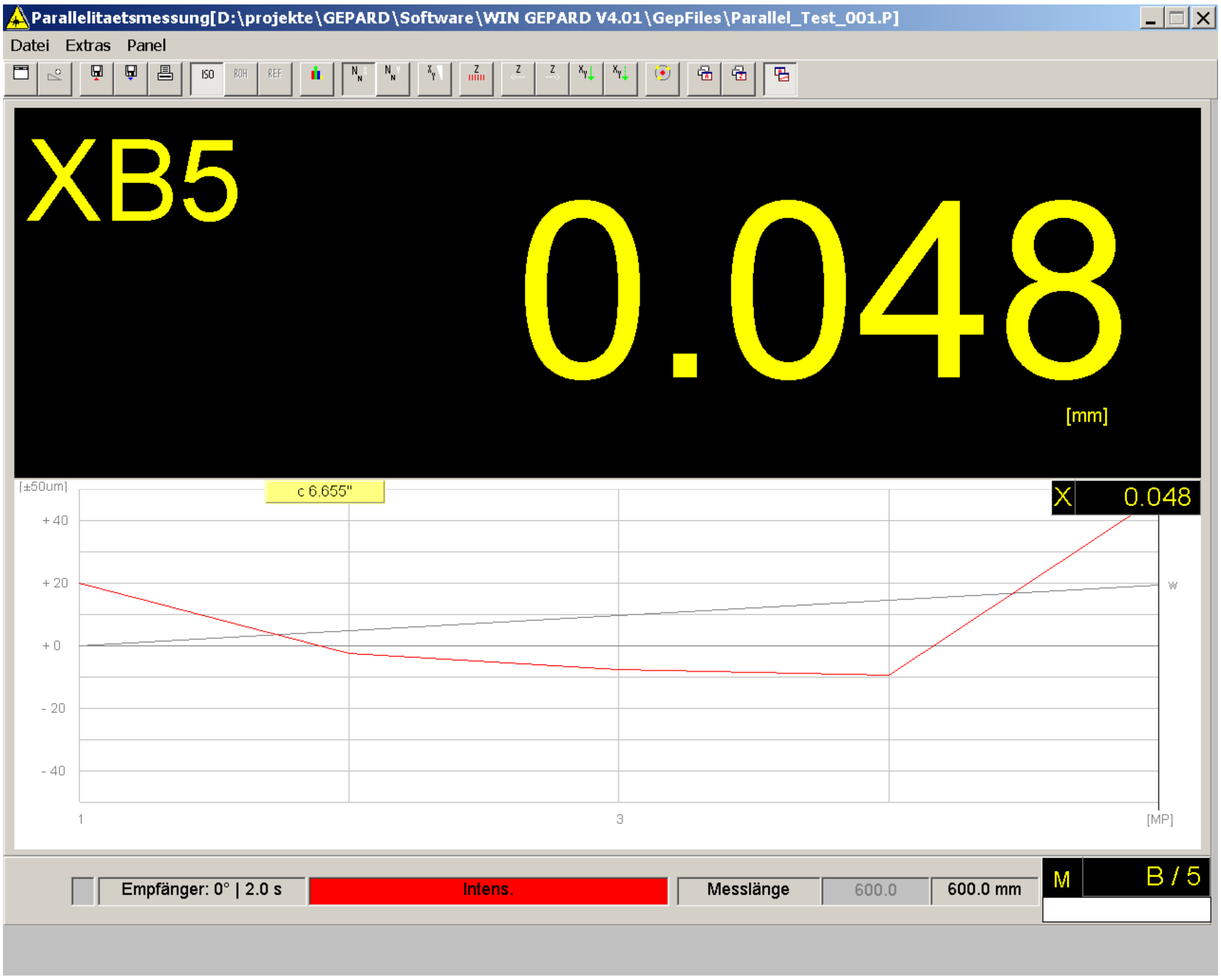
Calculation of perpendicularity (w)

Reference line (A)
Calculation of the perpendicularity is analogue the calculation of parallelism given above with the difference that the 90° interrelation of the pentaprism must be taken into consideration. The calculated difference in angle (plus the 90° angle of the pentaprism) gives the resulting perpendicularity.
For these calculations the ISO lines of reference straight line and measuring straight line(s) were included.

This is not shown in graph form as the derivation is completely the same as for the measurement of parallelism.

WIN-GEPARD enables a measurement of straightness of reference lines and measured lines at any time in the SW modules parallelism and perpendicularity. In addition, however, it is now possible to achieve representation of the parallelism or perpendicularity in relation to the reference line, as shown in the following screen shot.

Fig. 29: Representation: Measurement of parallelism and perpendicularity"



In this graph, the additional line („w"), which represents the angle of variation to the ideal parallelism or perpendicularity can be clearly seen. The corresponding numerical value designated by c = n.nnn'', is displayed in the yellow window within the line diagram. A positive angle "w" (or c +n.nn'') indicates an opening system (parallel angle >180° or right angle >90°).

This representation also provides support for the user in the on-line adjustment of parallelism / perpendicularity as the measured values are continually processed and the graphic can be completed at any time by corresponding manual adjustment of the measured object.

Please contact your supplier or the manufacturer for further details regarding use of the pentaprism, drawing up of reference and measuring lines and the effects on the screen display.

PROCESSING GEPARD-M4 MEASURING DATA

The data processing of a measuring instrument is decisive for quality of the measured results. An ingenious distribution of tasks between the firmware in the ***RAY****TEC GEPARD-M4™* receiver and the evaluation software WIN-GEPARD ensures optimisation of the throughput of measured data and achievable measurement inaccuracy. Depending on the measuring task, the user can set the measuring instrument to the optimum adjustment speed or maximum measuring accuracy.

☞ *It must be mentioned again that a corresponding environment and suitable measuring times are absolutely necessary for precision measurements in µm range!*

Measuring methods available using the ***RAY****TEC GEPARD-M4™* measuring system:

Single-point measurements

Single-point measurements which are suitable - under good environmental conditions - for very precise measuring tasks while taking straightness, parallelism, perpendicularity or position measurements.

In this method, a single measuring value is transmitted from the ***RAY****TEC GEPARD-M4™* receiver to the evaluating computer by pushing a button, and is then displayed immediately graphically and numerically. The previously adjusted measuring time (e.g. 2sec.) determines the length of time of measuring until display on the evaluating computer.

One characteristic of this measuring method is that the measuring system (the ***RAY****TEC GEPARD-M4™* receiver) records a filter algorithm with around 5,000 single measuring values for each second of measuring time and calculates an ("averaged") measuring value from these single values using a median algorithm. This averaged value is than transmitted to the evaluating computer.
The measuring inaccuracy is higher for shorter measuring times, i.e. long measuring times are necessary for very precise measurements. The measuring time can be adjusted between 0.5sec and 10sec.

Single point measurements with the "adaptive measuring method"

Single-point measurements which are suitable for very precise measuring tasks - even under rough environmental conditions - within a measurement of straightness, parallelism, perpendicularity or positions measurements.

This measuring method enables the system to adjust the measuring time adaptively (automatically) according to the actual environmental conditions.
The user has the possibility of defining a maximum allowable measuring inaccuracy and a maximum measuring time (as termination criteria) (see also the WIN-GEPARD manual). The evaluation software then requests measured values from the ***RAY****TEC*

GEPARD-M4™ receiver until the defined criteria have been reached. In some cases this may take a very long time (max. 100sec.), above all when very narrow tolerances are defined and poor environmental conditions exist. It should further be noted that with increasing distance between the ***RAY**TEC GEPARD-M4™* laser transmitter and the ***RAY**TEC GEPARD-M4™* receiver, the environmental conditions have a stronger influence on the measurements, i.e. the measuring inaccuracy increases correspondingly to the measuring distance.

As a characteristic of this measuring method, the measuring system (the ***RAY**TEC GEPARD-M4™* receiver) uses a low-pass filter with a ***large*** time constant – this means that very rapid changes (disturbances etc.) can be greatly reduced. In addition, the measuring values are further calculated by the evaluating computer using a statistical computation of error based on a normal (Gaussian) distribution. Using this normal distribution, it is assumed that the measuring values converge towards the mean value.
When the required measuring accuracy is achieved this calculated mean value is displayed as an actual measured value.
This process guarantees a substantial increase in stability of the measured values and measuring inaccuracy of static measurements even under the worst imaginable environmental conditions.

☞ *In comparison to the standard method "Single-point measuring", an improvement of measuring accuracy by a factor of 2 - 3 can be achieved using the adaptive measuring method.*

Online measuring with "Quick adjustments"

Continuous measurements which are suitable for very rapid measuring tasks, for example, pre-settings or adjustments which require less precision.

Using these measuring methods the measuring values are transmitted rapidly and continually from the ***RAY**TEC GEPARD-M4™* receiver to the evaluating computer and are displayed immediately. The pre-set measuring time (e.g. 2sec.) determines the measuring rate and the refresh cycle on the evaluating computer. As a rule, approx. 10 measured values are shown for each set measuring time - in this case, therefore, at 0.2sec. intervals. A short measuring time gives a large number of measuring values for each time unit and vice versa.

A characteristic of this measuring method is that the measuring system (the ***RAY**TEC GEPARD-M4™* receiver) uses a low-pass filter with a very ***small*** time constant. This allows the receiver to react very sensitively and rapidly to changes in position. A disadvantage however, could be than disturbances from the environment are also reacted to just as sensitively.

Online measuring with "precision adjustments"

Continuous measurements which are suitable for very precise measuring tasks such as follow-up adjustments or setting work for mechanical systems where high accuracy is required.

With this measuring method, the measured values are transmitted very rapidly and continually from the ***RAY**TEC GEPARD-M4 ™* receiver to the evaluating computer and are displayed immediately. The pre-set measuring time (e.g. 2sec.) determines the measuring rate and the refresh cycle on the evaluating computer. As a rule, approx. 10 measured values are shown for each set measuring time - in this case, therefore, at 0.2sec. intervals. A short measuring time gives a large number of measuring values for each time unit and vice versa.

As a characteristic of this measuring method, the measuring system (the ***RAY**TEC GEPARD-M4 ™* receiver) uses a low-pass filter with a ***large*** time constant – this means that very rapid changes (disturbances etc.) can be greatly reduced. This process guarantees a substantial increase in stability of the measured values and measuring inaccuracy of static measurements. Changes in the position of the receiver are however, followed only relatively slowly (Caution: dragging of measured values!).

Multi-point measuring "Environmental analysis"

The environmental analysis is used in critical measuring situations to automatically generate the measuring parameters for the "adaptive measuring method".

The purpose of the environmental analysis is to obtain a statement regarding measuring inaccuracy with the actual configuration and the current environmental situation. To achieve this, the ***RAY**TEC GEPARD-M4 ™* transmitter and ***RAY**TEC GEPARD-M4 ™* receiver must be placed on the measuring object in the way in which any later measurements are to be taken.

☞ *The **maximum** measuring distance between the **RAY**TEC GEPARD-M4 ™ transmitter and the **RAY**TEC GEPARD-M4 ™ receiver must be set, as this is the only way of recording all possible disturbance variables from external influences on measuring.*

Following the completed environmental analysis (approx. 30sec) the dependency of measuring inaccuracy in relation to the measuring time (for the actual configuration) can be visualised using a sliding controller. Using this sliding controller, while the measuring time is changed the resulting measuring inaccuracy in X and Y direction can be seen.

In general: higher accuracy requires a longer measuring time, this interrelation can be seen directly using the sliding controller.

A further very useful aid when measuring straightness (and parallel/perpendicularity), is that the required parameters (measuring time / expected accuracy) can be taken directly – with a simple mouse click - into the basic settings for the adaptive measuring method.

INFLUENCES ON THE MEASUREMENT ACCURACY

Influence of the measuring time

Measuring inaccuracy of results achieved with the ***RAY**TEC GEPARD-M4™* measuring device is dependent on a series of difference influences: these are, on the one hand, the technical data specific to the instrument (with GEPARD5, measuring inaccuracy is ±1µm) and, on the other hand, the ambient conditions.
In order for these ambient conditions not to influence each single measuring result, the measuring values are averaged from many single recorded measurements. The high internal processing speed of the ***RAY**TEC GEPARD-M4™* receiver allows each measuring point to be calculated from a large number (>500) of single values.
Accurate measurements in "rough" conditions, require a correspondingly large number of single measurements. This is then synonymous with an increase in the measuring time.

The user is able to set the required measuring time of the ***RAY**TEC GEPARD-M4™* in the following intervals: 0.5s, 1.0s, 2.0s, 5.0s, 10.0s.
As a rule, very good measuring results can be obtained with a measuring time of 1.0s or 2.0s. A standard setting of 2.0s is suitable.
Further information on this topic can be found under “Processing ***RAY**TEC GEPARD-M4™* measuring data”.

☞ *A measuring time of 2.0 s is suitable as a standard setting.*

Influence of the measuring equipment set up and the surroundings

It should be noted that the surrounding conditions can have a massive influence on the measuring results of your precision instrument.

We recommend that the measuring instrument should be set up as a mechanical closed system with the object to be measured wherever this is possible. This means that the ***RAY**TEC GEPARD-M4™* transmitter and the ***RAY**TEC GEPARD-M4™* receiver should be mounted on the same unit (e.g. machine body, carriage guide etc.). Assembly components should be stable enough so that the measuring position can be accurately reproduced at any time.

The composition of the surrounding atmosphere can have an effect on the laser beam and, therefore, on the measuring results. Care should be taken that no solvents are used in the direct vicinity of the measuring area and no extreme differences in temperature, e.g. through cold draughts of air, exist (air turbulence).

☞ *For this reason, when carrying out precision measurements, it should always be ensured that no solvents are in use in the immediate vicinity of the area where measurements are being taken and that no extreme differences in temperature or draughts – air turbulence - occur. Smoke (cigarettes etc.) may also have an effect on the laser beam.*

Influence of positioning accuracy in the Z-direction

The positioning of the ***RAY**TEC GEPARD-M4™* receivers in the Z-axis (traverse e.g. on a guide), is usually carried out manually by the user.
The position of the single measuring points is determined by WIN-GEPARD according to the total measuring length and the number of measuring points (entered by the user). The single distances are then automatically determined equidistant the software.
It is also possible, however, that the user can determine the distance(s) between the measuring points individually (refer to WIN-GEPARD manual).

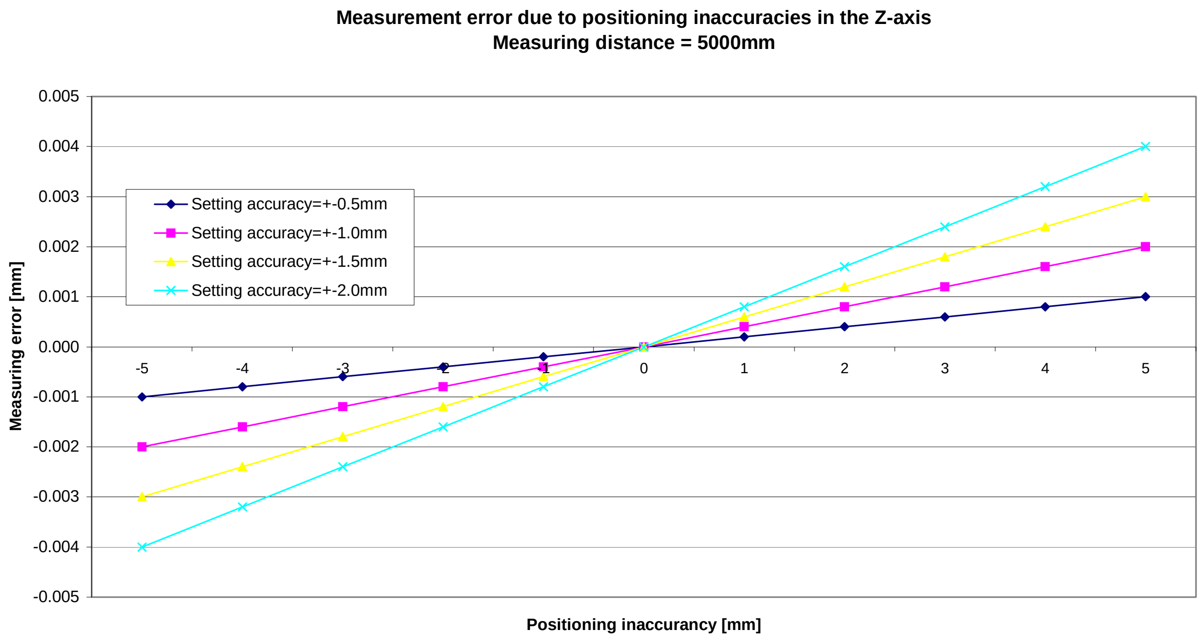
If the positions of the single measuring points are not exactly located with the ***RAY**TEC GEPARD-M4™* receiver - according to the calculated positions shown on the display - corresponding measurement errors are caused. This measurement error is defined as follows:

$$\underline{\Delta X = X * \Delta Z / Z}$$

where:

ΔX : measurement error
X : setting up accuracy at Z
Z : total measuring length
ΔZ : positioning inaccuracy

The results in the following graph:



Note:
The errors shown here only occur in this way during the measurement of rough data.

If the regression line is laid through the single points of the measurement of straightness which is calculated and evaluated according to ISO methods, these errors, due to the smoothing effect of the ISO methods, are reduced from 1 : 2 to 1 : 4.

In addition, with improved setting accuracy (levelling error < 1mm), this influence can be kept very low.

☞ *If the influence of the positioning should be kept as low as possible, either the laser beam should be set up in alignment or the Z-positions must be accurately kept to.*

Influence of the impact angle of the laser beam on the PSD

If the laser beam hits the sensor at an angle due to tilting of the laser transmitter or the laser receiver, a tilt error occurs in the measuring results. This measuring error is defined as follows:

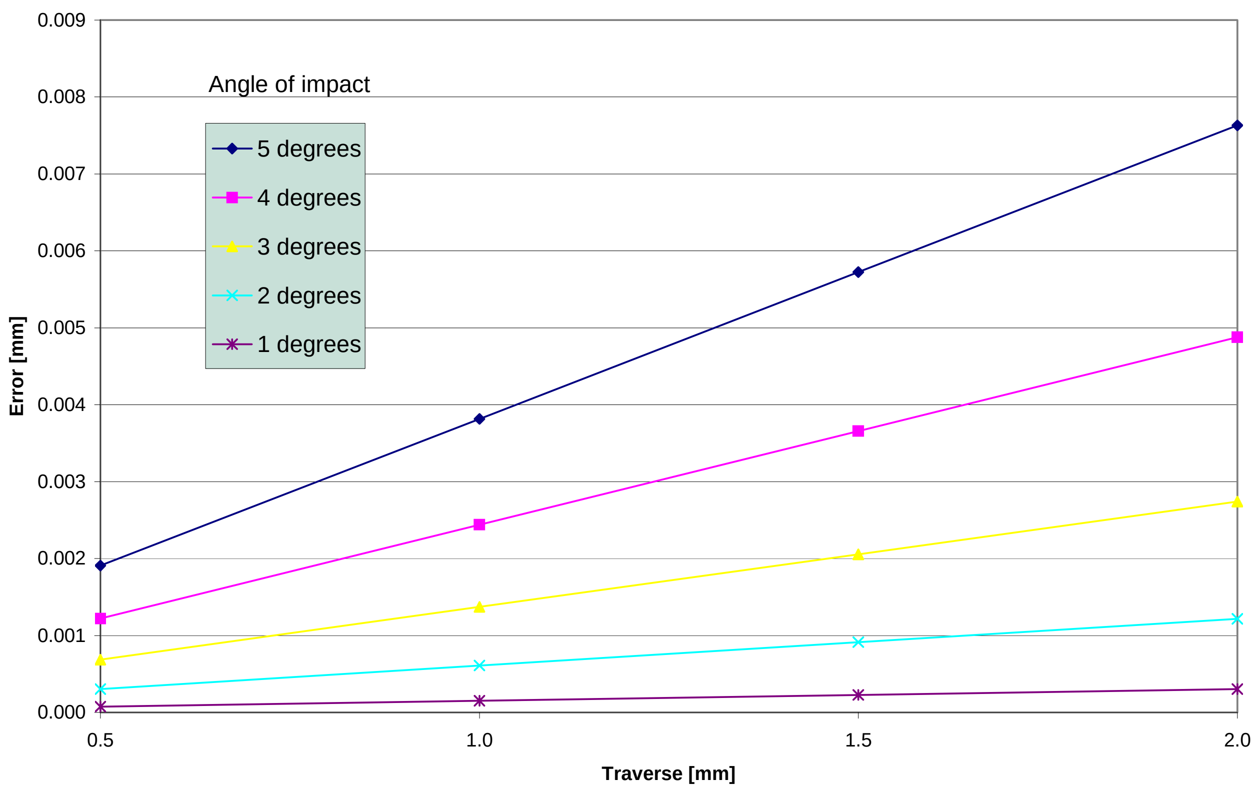
$$\Delta X = X/\cos(\alpha) - X$$

where:

X : measuring range used (in X or Y direction)
α : angle of tilt (transmitter / receiver)
ΔX : measuring error

This results in the following graph:

Influence of angle of impact, laser - PSD



Note :

The errors shown here only occur in this way during the measurement of rough data.

☞ *This error does not have any bearing on measurements of straightness, when the ISO / reference methods are used, as long as the angle of impact remains* ***unchanged****. When the regression line is determined the angle of impact is reduced out of the formula for the straight line and, therefore, has no effect on he measuring accuracy.*

USES / APPLICATIONS

The measuring system is suitable for both static measurements (straightness, parallelism, etc.) and for dynamic measurements up to frequency limits of 1 kHz, whereby these applications require different firmware.

Some application examples (without claiming to be complete) for the various uses of the universal laser geometrical measuring and alignment system ***RAY**TEC GEPARD-M4 ™* are given below:

- measuring straightness and adjusting guides, machine beds, guide rulers ...
- aligning steel and frame constructions ...
- levelling measurements for foundations and level surfaces ...
- parallelism measurements and adjustment of tracks, guides, rollers, shafts ...
- alignment and adjustment of bearing seats and bores ...
- all kinds of perpendicularity measurements and adjustments
- positioning of work pieces, machines, units ...
- long-term control of deformation, deflection, movement ...

***RAY**TEC GEPARD-M4 ™* has been developed for daily industrial use and offers economical solutions in the field of production, quality assurance, assembly and maintenance because:

- alignment and measuring work can be carried out simply and extremely quickly.
- extensive auxiliary constructions for production and assembly, required with conventional measuring methods are, to a great degree, not necessary when using ***RAY**TEC GEPARD-M4 ™*
- simple, rapid and error-free recording of the measuring task can be carried out.

FIELDS OF USE

- mechanical engineering, tooling machines and the metal industry
- railway industry (construction, operation, maintenance)
- automotive industry
- aircraft construction
- paper and printing industry
- and many more.

DECLARATION OF CONFORMITY

CE KONFORMITÄTSERKLÄRUNG
DECLARATION OF CONFORMITY

Hersteller / *Manufacturer's Name*:	Raytec Systems AG
Adresse / *Manufacturer's Address*:	Triststrasse 8 CH-7007 Chur Switzerland

erklärt, dass das Produkt
declares, that the product

Bezeichnung / *Product Name*:	GEPARD-M4 Geometrievermessungs- und Richtsystem. *GEPARD-M4 Measuring and Alignment System.*
Typ / *Model*:	GEPARD-M4 Sender und Empfänger. *GEPARD-M4 Transmitter and Receiver.*
Optionen / *Product Options*:	Diese Erklärung umfasst alle Produkteoptionen. *This declaration covers all options of the product.*

mit den folgenden Normen übereinstimmt:
is in conformity with the following standards:

EN 60825-1, 2007:	Laser Class 2
EN 55022, 2006	EN 300328-1, 2001
EN 60950-1, 2006	EN 301489-1, 2005
	EN 301489-17, 2008

gemäss den Bestimmungen der Richtlinie(n):
following the provisions of directive(s):

EMC Directive	2004/108/EC
R&TTE Directive	1999/5/EC

CH-7007 Chur, 18. 02. 2010

E. Fischer

E. Fischer, QS

BLUETOOTH EQUIPMENT

***RAY**TEC GEPARD-M4™* instruments are equipped with OEM serial port adapter 331x with Bluetooth® wireless technology:

Manufacturer:	connectBlue AB Norra Vallgatan 64 3V SE-211 22 Malmö, Sweden
Productname:	cB-OBS 421x-04 (external Antenna)
Bluetooth Qualification:	Single mode classic Bluetooth (v 2.1 /EDR)
RF output power:	Class 1, max. 16.9dBm (49mW)

FCC COMPLIANCE

FCC Statement for cB-0946

This device contains
FCC ID: PVH0946
IC: 5325A-0946

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected

Consult the dealer or an experienced radio/TV technician for help

COUNTRY SPECIFIC INFORMATION FOR BLUETOOTH RADIO LINK (>10MW RF-POWER)

GENERAL	Hereby, RAYTEC SYSTEMS AG, CH-7000 Chur, declares that “GEPARD-M4” and its components (2.400 - 2.4835 GHz) are in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.
CH	Hiermit erklärt RAYTEC SYSTEMS AG, CH-7000 Chur, dass sich „GEPARD-M4“ und seine Geräte (2.400 - 2.4835 GHz) in Übereinstimmung mit den grundlegenden Anforderungen und den anderen relevanten Vorschriften der Richtlinie 1999/5/EC befinden.
CZ	Tímto firma RAYTEC SYSTEMS AG, CH-7000 Chur, deklaruje, ze " GEPARD-M4" a jeho soucásti, jsou v souladu s nezbytnými pozadavky a s ostatními príslusnými podmínkami smernice 1999/5/EC
DE	Hiermit erklärt RAYTEC SYSTEMS AG, CH-7000 Chur, dass sich „GEPARD-M4“ und seine Geräte (2.400 - 2.4835 GHz) in Übereinstimmung mit den grundlegenden Anforderungen und den anderen relevanten Vorschriften der Richtlinie 1999/5/EC befinden.
NL	Hierbij verklaart RAYTEC SYSTEMS AG, CH-7000 Chur dat “GEPARD-M4” en zijn componenten (2.400 - 2.4835 GHz) in overeenstemming zijn met de essentiële eisen en de andere relevante bepalingen van richtlijn 1999/5/EC.
NO	Herved erklærer RAYTEC SYSTEMS AG, CH-7000 Chur, at „GEPARD-M4“ og deres komponenter (2.400 - 2.4835 GHz) stemmer overens med de vesentlige egenskapskrav og øvrige relevante bestemmelser som fremgår av direktiv 1999/5/EC.
SE	Härmed intygar RAYTEC SYSTEMS AG, CH-7000 Chur att “GEPARD-M4” och deras komponenter (2.400 - 2.4835 GHz) stämmer överens med de väsentliga egenskapskrav och övriga relevanta bestämmelser som framgår av direktiv 1999/5/EC.
UK	Hereby, RAYTEC SYSTEMS AG, CH-7000 Chur, declares that “GEPARD-M4” and its components (2.400 - 2.4835 GHz) are in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.

List of European countries with notification, with restrictions :

FR	Par la présente RAYTEC SYSTEMS AG, CH-7000 Chur déclare que les instruments„GEPARD-M4“ et ses composants (2.400 - 2.4835 GHz) sont conforme aux exigencies essentielles et aux autres dispositions pertinentes de la directive 1999/5/EC. Attention: En France (06/2006) les contraintes géographiques sont a respecter : L’utilisation de l’equipment bluetooth (>10mW) à l’extérieur des bâtiments sur le domaine public n’est pas possible. Attention: In France (06/2006) the geographic restrictions must be respected. The use of Bluetooth™ equipment (>10 mW) outside of buildings in the public domain is not possible.
IT	Con la presente RAYTEC SYSTEMS AG, CH-7000 Chur dichiara che questo instrumenti „GEPARD-M4“ (2.400 - 2.4835 GHz) sono conforme ai requisiti essenziali ed alle altre disposizioni pertinenti stabilite dalla direttiva 1999/5/EC. Attenzione: In Italia (06/2006) vanno osservate le limitazioni geografiche : L’equipaggiamento deve essere utilizzato solo all’interno dell’edificio / dell’area aziendale. Attention: In Italy (06/2006) the geographic restrictions must be respected. Bluetooth™ equipment must be used inside of buildings / factory areas only.

List of countries with pending notification:

- Russia
- China
- Taiwan
- South Korea
- India
- Thailand
- Australia / NZ

COMPLIANCE WITH ROHS DIRECTIVE

All parts based on the ***RAY****TEC GEPARD-M4*™ are produced according to the RoHS (Restriction of the use of certain Hazardous Substances in electrical and electronic equipment) directive and complies with the directive.

GUIDELINES FOR EFFICIENT AND SAFE USE

GENERAL

Read this information before using your GEPARD Laser measuring instrument with Bluetooth Serial Port Adapter.
For any exceptions, due to national requirements or limitations, when using your OEM Serial Port Adapter, please visit www.bluetooth.org.

Note:

☞ *Changes or modifications to the product not expressly approved by* ***RAY****TEC SYSTEMS AG will void the user's authority to operate the equipment.*

PRODUCT CARE

- Do not expose your product to liquid or moisture.
- Do not expose you product to extreme hot or cold temperature (see section Environmental for further information).
- Do not expose your product to lit candles, cigarettes, cigars, open flames, etc.
- Do not drop, throw or try to bend your product since rough treatment could damage your product.
- Do not attempt to disassemble your product. Doing so will void warranty. The product does not contain consumer serviceable or replaceable components. Service should only be performed by ***RAY****TEC SYSTEMS AG*.
- Do not paint your product as the paint could prevent normal use.
- If you will not be using your product for a while, store it in a place that is dry, free from damp, dust and extreme heat and cold.

RADIO FREQUENCY EXPOSURE

The GEPARD receiver contains a small radio transmitter and receiver. During communication with other Bluetooth products the GEPARD Serial Port Adapter receives and transmits radio frequency (RF) electromagnetic fields (microwaves) in the frequency range 2400 to 2500 MHz. The output power of the radio transmitter is very low.
When using the Bluetooth Serial Port Adapter, you will be exposed to some of the transmitted RF energy. This exposure is well below the prescribed limits in all national and international RF safety standards and regulations.

ELECTRONIC EQUIPMENT

Most modern electronic equipment, for example, in hospitals and cars, is shielded from RF energy. However, certain electronic equipment is not. Therefore:

Note:

☞ *This equipment emits RF energy in the ISM (Industrial, Scientific, Medical) band. Please insure that all medical devices used in proximity to this device meet appropriate susceptibility specifications for this type of RF energy.*