Leica MS60/TS60
User Manual

Nova

Version 2.0
English

- when it has to be **right**

Leica Geosystems

Introduction

Purchase

Congratulations on the purchase of a MS60/TS60 series instrument.

This manual contains important safety directions as well as instructions for setting up the product and operating it. Refer to "1 Safety Directions" for further information. Read carefully through the User Manual before you switch on the product.

Product Identification

The model and serial number of your product are indicated on the type plate. Always refer to this information when you need to contact your agency or Leica Geosystems authorised service workshop.

Trademarks

- Windows is a registered trademark of Microsoft Corporation in the United States and other countries
- *Bluetooth*® is a registered trademark of Bluetooth SIG, Inc.
- SD Logo is a trademark of SD-3C, LLC.

All other trademarks are the property of their respective owners.

Validity of this Manual

This manual applies to all MS60/TS60 instruments. Where there are differences between the various models they are clearly described.

Available Documentation

Name	Description/Format		
MS60/TS60 Quick Guide	Provides an overview of the product together with technical data and safety directions. Intended as a quick reference guide.	✓	✓
MS60/TS60 User Manual	All instructions required in order to operate the product to a basic level are contained in this User Manual. Provides an overview of the system together with technical data and safety directions.	-	✓

Name	Description/Format		
Captivate Technical Reference Manual	Overall comprehensive guide to the product and application functions. Included are detailed descriptions of special software/hardware settings and software/hardware functions intended for technical specialists.	-	✓

Refer to the following resources for all MS60/TS60 documentation/software:

- the Leica USB documentation card
- https://myworld.leica-geosystems.com

Video tutorials are available on:
http://www.leica-geosystems.com/captivate-howto

myWorld@Leica Geosystems (**https://myworld.leica-geosystems.com**) offers a wide range of services, information and training material.
With direct access to myWorld, you are able to access all relevant services whenever it is convenient for you, 24 hours a day, 7 days per week. This increases your efficiency and keeps you and your equipment instantly updated with the latest information from Leica Geosystems.

Service	Description
myProducts	Add all products that you and your company own and explore your world of Leica Geosystems: View detailed information on your products and update your products with the latest software and keep up-to-date with the latest documentation.
myService	View the current service status and full service history of your products in Leica Geosystems service centres. Access detailed information on the services performed and download your latest calibration certificates and service reports.
mySupport	View the current service status and full service history of your products in Leica Geosystems service centres. Access detailed information on the services performed and download your latest calibration certificates and service reports.
myTraining	Enhance your product knowledge with Leica Geosystems Campus - Information, Knowledge, Training. Study the latest online training material on your products and register for seminars or courses in your country.
myTrusted Services	Add your subscriptions and manage users for Leica Geosystems Trusted Services, the secure software services, that assist you to optimise your workflow and increase your efficiency.

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In this manual

1 Safety Directions

1.1 General Introduction

Description

The following directions enable the person responsible for the product, and the person who actually uses the equipment, to anticipate and avoid operational hazards.

The person responsible for the product must ensure that all users understand these directions and adhere to them.

About Warning Messages

Warning messages are an essential part of the safety concept of the instrument. They appear wherever hazards or hazardous situations can occur.

Warning messages...

- make the user alert about direct and indirect hazards concerning the use of the product.
- contain general rules of behaviour.

For the users' safety, all safety instructions and safety messages shall be strictly observed and followed! Therefore, the manual must always be available to all persons performing any tasks described here.

DANGER, **WARNING**, **CAUTION** and **NOTICE** are standardised signal words for identifying levels of hazards and risks related to personal injury and property damage. For your safety, it is important to read and fully understand the following table with the different signal words and their definitions! Supplementary safety information symbols may be placed within a warning message as well as supplementary text.

Type	Description
DANGER	Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.
WARNING	Indicates a potentially hazardous situation or an unintended use which, if not avoided, could result in death or serious injury.
CAUTION	Indicates a potentially hazardous situation or an unintended use which, if not avoided, may result in minor or moderate injury.
NOTICE	Indicates a potentially hazardous situation or an unintended use which, if not avoided, may result in appreciable material, financial and environmental damage.
	Important paragraphs which must be adhered to in practice as they enable the product to be used in a technically correct and efficient manner.

1.2 Definition of Use

Intended Use

- Measuring horizontal and vertical angles.
- Measuring distances.
- Recording measurements.
- Capturing and recording images.
- Automatic target search, recognition and following.
- Visualising the aiming direction and vertical axis.
- Remote control of product.
- Data communication with external appliances.
- Measuring raw data and computing coordinates using carrier phase and code signal from GNSS satellites.
- Recording GNSS and point related data.
- Computing with software.

Reasonably Foreseeable Misuse

- Use of the product without instruction.
- Use outside of the intended use and limits.
- Disabling safety systems.
- Removal of hazard notices.
- Opening the product using tools, for example screwdriver, unless this is permitted for certain functions.
- Modification or conversion of the product.
- Use after misappropriation.
- Use of products with obvious damages or defects.
- Use with accessories from other manufacturers without the prior explicit approval of Leica Geosystems.
- Inadequate safeguards at the working site.
- Aiming directly into the sun.

1.3 Limits of Use

Environment

Suitable for use in an atmosphere appropriate for permanent human habitation: not suitable for use in aggressive or explosive environments.

DANGER

Local safety authorities and safety experts must be contacted before working in hazardous areas, or close to electrical installations or similar situations by the person in charge of the product.

1.4 Responsibilities

Manufacturer of the product

Leica Geosystems AG, CH-9435 Heerbrugg, hereinafter referred to as Leica Geosystems, is responsible for supplying the product, including the user manual and original accessories, in a safe condition.

Person responsible for the product

The person responsible for the product has the following duties:

- To understand the safety instructions on the product and the instructions in the user manual.
- To ensure that it is used in accordance with the instructions.
- To be familiar with local regulations relating to safety and accident prevention.
- To inform Leica Geosystems immediately if the product and the application becomes unsafe.
- To ensure that the national laws, regulations and conditions for the operation of e.g. radio transmitters or lasers are respected.

1.5 Hazards of Use

CAUTION

Watch out for erroneous measurement results if the product has been dropped or has been misused, modified, stored for long periods or transported.

Precautions:

Periodically carry out test measurements and perform the field adjustments indicated in the user manual, particularly after the product has been subjected to abnormal use as well as before and after important measurements.

DANGER

Because of the risk of electrocution, it is dangerous to use poles, levelling staffs and extensions in the vicinity of electrical installations such as power cables or electrical railways.

Precautions:

Keep at a safe distance from electrical installations. If it is essential to work in this environment, first contact the safety authorities responsible for the electrical installations and follow their instructions.

NOTICE

With the remote control of products, it is possible that extraneous targets will be picked out and measured.

Precautions:

When measuring in remote control mode, always check your results for plausibility.

CAUTION

Be careful when pointing the product towards the sun, because the telescope functions as a magnifying glass and can injure your eyes and/or cause damage inside the product.

Precautions:

Do not point the product directly at the sun.

WARNING

During dynamic applications, for example stakeout procedures there is a danger of accidents occurring if the user does not pay attention to the environmental conditions around, for example obstacles, excavations or traffic.

Precautions:

The person responsible for the product must make all users fully aware of the existing dangers.

WARNING

Inadequate securing of the working site can lead to dangerous situations, for example in traffic, on building sites and at industrial installations.

Precautions:

Always ensure that the working site is adequately secured. Adhere to the regulations governing safety, accident prevention and road traffic.

CAUTION

If the accessories used with the product are not properly secured and the product is subjected to mechanical shock, for example blows or falling, the product may be damaged or people can sustain injury.

Precautions:

When setting-up the product, make sure that the accessories are correctly adapted, fitted, secured, and locked in position.

Avoid subjecting the product to mechanical stress.

WARNING

If the product is used with accessories, for example masts, staffs, poles, you may increase the risk of being struck by lightning.

Precautions:

Do not use the product in a thunderstorm.

CAUTION

During the transport, shipping or disposal of batteries it is possible for inappropriate mechanical influences to constitute a fire hazard.

Precautions:

Before shipping the product or disposing of it, discharge the batteries by running the product until they are flat.

When transporting or shipping batteries, the person in charge of the product must ensure that the applicable national and international rules and regulations are observed. Before transportation or shipping contact your local passenger or freight transport company.

WARNING

High mechanical stress, high ambient temperatures or immersion into fluids can cause leakage, fire or explosions of the batteries.

Precautions:

Protect the batteries from mechanical influences and high ambient temperatures. Do not drop or immerse batteries into fluids.

WARNING

If battery terminals are short circuited e.g. by coming in contact with jewellery, keys, metalized paper or other metals, the battery can overheat and cause injury or fire, for example by storing or transporting in pockets.

Precautions:

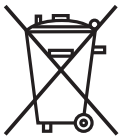
Make sure that the battery terminals do not come into contact with metallic objects.

WARNING

If the product is improperly disposed of, the following can happen:

- If polymer parts are burnt, poisonous gases are produced which may impair health.
- If batteries are damaged or are heated strongly, they can explode and cause poisoning, burning, corrosion or environmental contamination.
- By disposing of the product irresponsibly you may enable unauthorised persons to use it in contravention of the regulations, exposing themselves and third parties to the risk of severe injury and rendering the environment liable to contamination.

Precautions:



The product must not be disposed with household waste.
Dispose of the product appropriately in accordance with the national regulations in force in your country.
Always prevent access to the product by unauthorised personnel.

Product-specific treatment and waste management information can be downloaded from the Leica Geosystems home page at http://www.leica-geosystems.com/treatment or received from your Leica Geosystems distributor.

WARNING

Only Leica Geosystems authorised service workshops are entitled to repair these products.

1.6 Laser Classification

1.6.1 General

General

The following chapters provide instructions and training information about laser safety according to international standard IEC 60825-1 (2014-05) and technical report IEC TR 60825-14 (2004-02). The information enables the person responsible for the product and the person who actually uses the equipment, to anticipate and avoid operational hazards.

☞ According to IEC TR 60825-14 (2004-02), products classified as laser class 1, class 2 and class 3R do not require:

- laser safety officer involvement,
- protective clothes and eyewear,
- special warning signs in the laser working area

if used and operated as defined in this User Manual due to the low eye hazard level.

☞ National laws and local regulations could impose more stringent instructions for the safe use of lasers than IEC 60825-1 (2014-05) and IEC TR 60825-14 (2004-02).

1.6.2 Distancer, Measurements with Reflectors

General

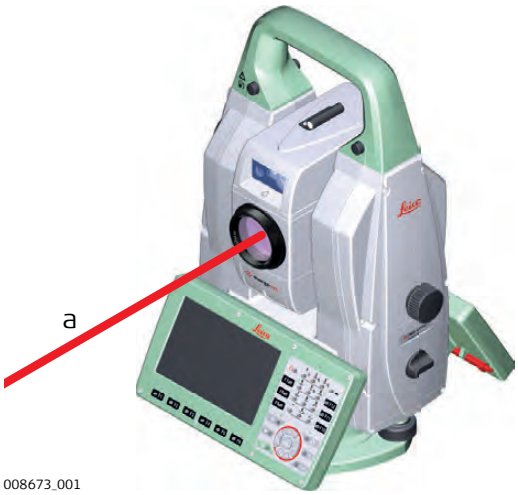
The EDM module built into the product produces a visible laser beam which emerges from the telescope objective.

The product described in this section is classified as laser class 1 in accordance with:

- IEC 60825-1 (2014-05): "Safety of laser products"

These products are safe under reasonably foreseeable conditions of operation and are not harmful to the eyes provided that the products are used and maintained in accordance with this User Manual.

Description	Value	
	TS60	MS60
Wavelength	658 nm	658 nm
Maximum average radiant power	0.33 mW	0.33 mW
Pulse duration	800 ps	700 ps
Pulse repetition frequency (PRF)	100 MHz	1.1 MHz
Beam divergance	1.5 mrad x 3 mrad	1.5 mrad x 3 mrad



a) Laser beam

General

The EDM module built into the product produces a visible laser beam which emerges from the telescope objective.

The laser product described in this section is classified as laser class 3R in accordance with:

- IEC 60825-1 (2014-05): "Safety of laser products"

Direct intrabeam viewing may be hazardous (low eye hazard level), in particular for deliberate ocular exposure. The beam may cause dazzle, flash-blindness and after-images, particularly under low ambient light conditions. The risk of injury for laser class 3R products is limited because of:

a) unintentional exposure would rarely reflect worst case conditions of (e.g.) beam alignment with the pupil, worst case accommodation,
b) inherent safety margin in the maximum permissible exposure to laser radiation (MPE)
c) natural aversion behaviour for exposure to bright light for the case of visible radiation.

Description	Value	
	TS60	MS60
Wavelength	658 nm	658 nm
Maximum average radiant power	4.8 mW	1.7 mW
Pulse duration	800 ps	1.5 ns
Pulse repetition frequency (PRF)	100 MHz	RL continuous, RL-Scan: 2 MHz RL-Pointer: 4 MHz
Beam divergance	0.2 mrad x 0.3 mrad	0.2 mrad x 0.3 mrad
NOHD (Nominal Ocular Hazard Distance) @ 0.25s	44 m / 144 ft	21 m / 69 ft

CAUTION

From a safety perspective, class 3R laser products should be treated as potentially hazardous.

Precautions:

1) Prevent direct eye exposure to the beam.
2) Do not direct the beam at other people.

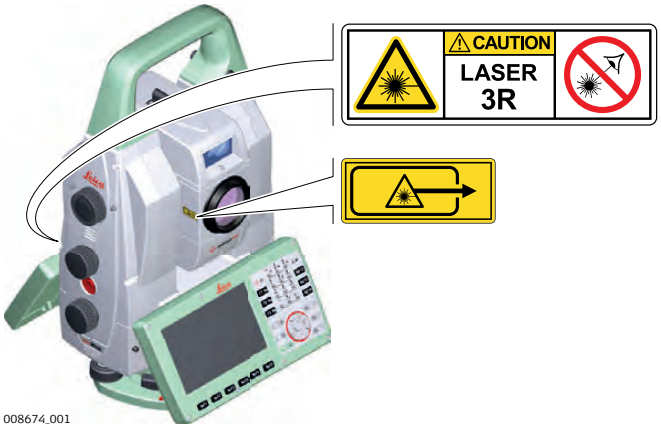
CAUTION

Potential hazards are not only related to direct beams but also to reflected beams aimed at reflecting surfaces such as prisms, windows, mirrors, metallic surfaces, etc.

Precautions:

1) Do not aim at areas that are essentially reflective, such as a mirror, or which could emit unwanted reflections.
2) Do not look through or beside the optical sight at prisms or reflecting objects when the laser is switched on, in laser pointer or distance measurement mode. Aiming at prisms is only permitted when looking through the telescope.

Labelling



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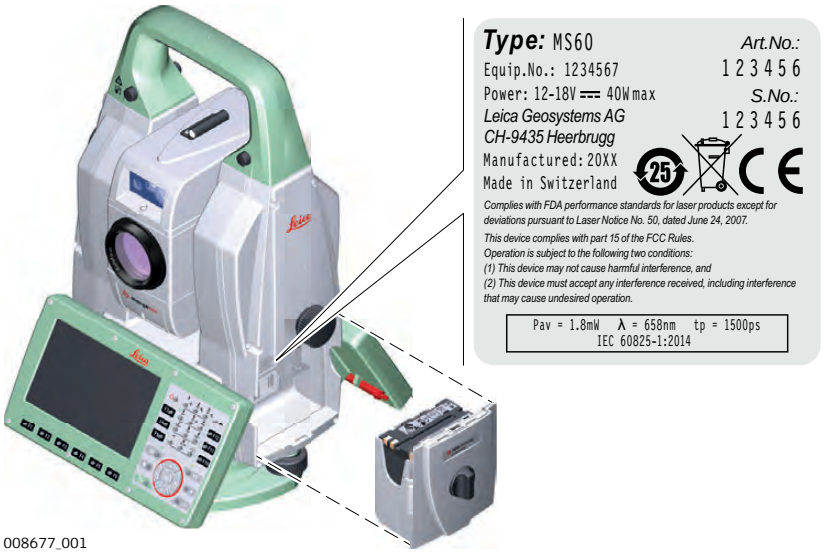

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1.6.4 Red Laser Pointer

General

The laser pointer built into the product produces a visible red laser beam which emerges from the telescope objective.

The laser product described in this section is classified as laser class 3R in accordance with:

- IEC 60825-1 (2014-05): "Safety of laser products"

Direct intrabeam viewing may be hazardous (low eye hazard level), in particular for deliberate ocular exposure. The beam may cause dazzle, flash-blindness and after-images, particularly under low ambient light conditions. The risk of injury for laser class 3R products is limited because of:

a) unintentional exposure would rarely reflect worst case conditions of (e.g.) beam alignment with the pupil, worst case accommodation,
b) inherent safety margin in the maximum permissible exposure to laser radiation (MPE)
c) natural aversion behaviour for exposure to bright light for the case of visible radiation.

Description	Value	
	TS60	MS60
Wavelength	658 nm	658 nm
Maximum average radiant power	4.8 mW	1.7 mW
Pulse duration	800 ps	1.5 ns
Pulse repetition frequency (PRF)	100 MHz	RL continuous, RL-Scan: 2 MHz RL-Pointer: 4 MHz
Beam divergance	0.2 mrad x 0.3 mrad	0.2 mrad x 0.3 mrad
NOHD (Nominal Ocular Hazard Distance) @ 0.25s	44 m / 144 ft	21 m / 69 ft

CAUTION

From a safety perspective, class 3R laser products should be treated as potentially hazardous.

Precautions:

1) Prevent direct eye exposure to the beam.
2) Do not direct the beam at other people.

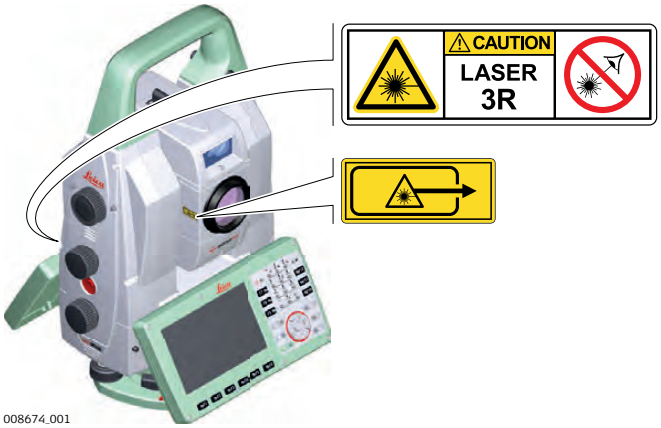
CAUTION

Potential hazards are not only related to direct beams but also to reflected beams aimed at reflecting surfaces such as prisms, windows, mirrors, metallic surfaces, etc.

Precautions:

1) Do not aim at areas that are essentially reflective, such as a mirror, or which could emit unwanted reflections.
2) Do not look through or beside the optical sight at prisms or reflecting objects when the laser is switched on, in laser pointer or distance measurement mode. Aiming at prisms is only permitted when looking through the telescope.

Labelling



1.6.5 Autofocus Capability of Telescope Camera

General

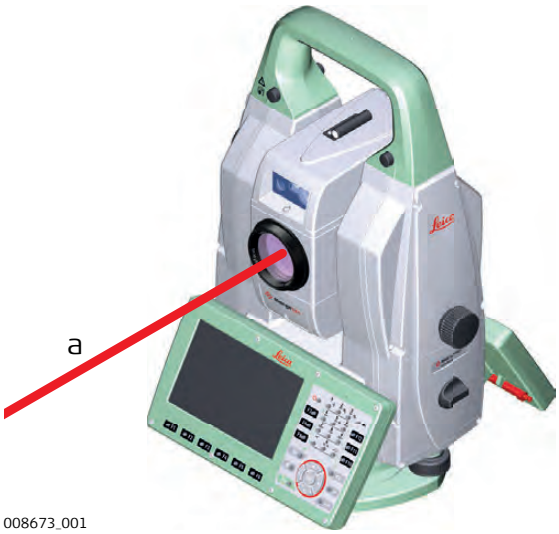
TS60 and MS60 contain a coaxial telescope camera with autofocus capability. When using the auto focus functions a visible laser beam may emerge from the telescope (depending on the focussing mode).

The laser product described in this section is classified as laser class 1 in accordance with:

- IEC 60825-1 (2014-05): "Safety of laser products"

These products are safe under reasonably foreseeable conditions of operation and are not harmful to the eyes provided that the products are used and maintained in accordance with this User Manual.

Description	Value	
	TS60	MS60
Wavelength	658 nm	658 nm
Maximum average radiant power	0.37 mW	0.1 mW
Pulse duration	800 ps	1.5 ns
Pulse repetition frequency (PRF)	100 MHz	Irregular packages max. 670 kHz
Beam divergance	0.2 mrad x 0.3 mrad	0.2 mrad x 0.3 mrad



a) Laser beam

General

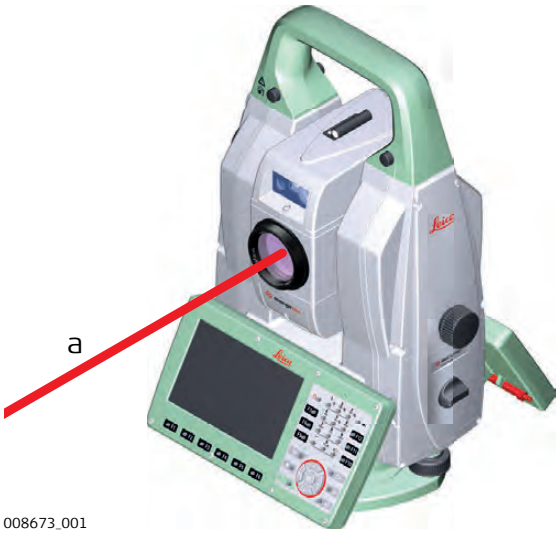
The Automatic Target Aiming built into the product produces an invisible laser beam which emerges from the telescope objective.

The laser product described in this section is classified as laser class 1 in accordance with:

- IEC 60825-1 (2014-05): "Safety of laser products"

These products are safe under reasonably foreseeable conditions of operation and are not harmful to the eyes provided that the products are used and maintained in accordance with this User Manual.

Description	Value	
	TS60	MS60
Wavelength	785 nm	785 nm
Maximum radiant peak power per pulse	10 mW	10 mW
Pulse duration	≤15 ms	≤15 ms
Pulse repetition frequency (PRF)	≤213 Hz	≤213 Hz
Beam divergance	25 mrad	25 mrad



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a) Laser beam

General

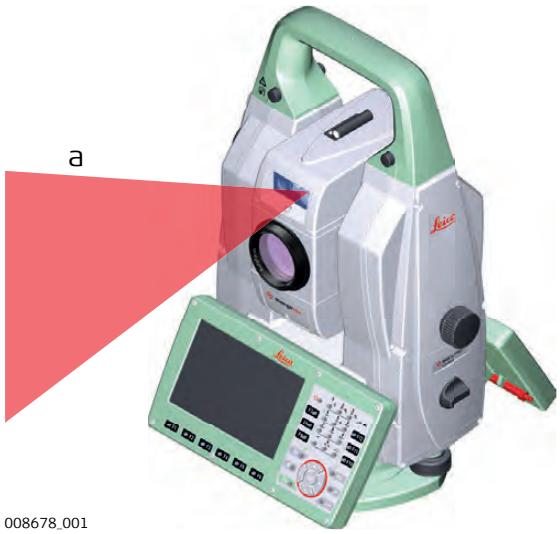
The PowerSearch built into the product produces an invisible laser beam which emerges from the front side of the telescope.

The laser product described in this section is classified as laser class 1 in accordance with:

- IEC 60825-1 (2014-05): "Safety of laser products"

These products are safe under reasonably foreseeable conditions of operation and are not harmful to the eyes provided that the products are used and maintained in accordance with this User Manual.

Description	Value
Wavelength	850 nm
Maximum average radiant power	11 mW
Pulse duration	20 ns, 40 ns
Pulse repetition frequency (PRF)	24.4 kHz
Beam divergance	0.4 mrad x 700 mrad



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a) Laser beam

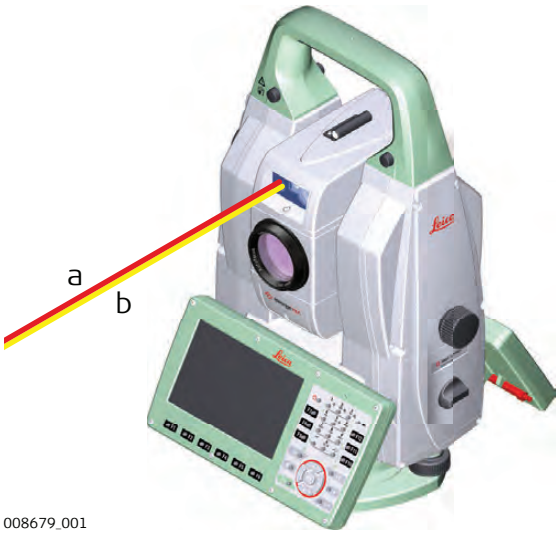
1.6.8 Electronic Guide Light EGL

This is only applicable for MS60 and TS60 I.

General

The Electronic Guide Light built into the product produces a visible LED beam which emerges from the front side of the telescope.

The product described in this section, is excluded from the scope of IEC 60825-1 (2014-05): “Safety of laser products”.
The product described in this section, is classified as exempt group in accordance with IEC 62471 (2006-07) and does not pose any hazard provided that the product is used and maintained in accordance with this user manual.



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a) LED beam red
b) LED beam yellow

1.6.9 Laser Plummet

General

The laser plummet built into the product produces a visible red laser beam which emerges from the bottom of the product.

The laser product described in this section is classified as laser class 2 in accordance with:

- IEC 60825-1 (2014-05): "Safety of laser products"

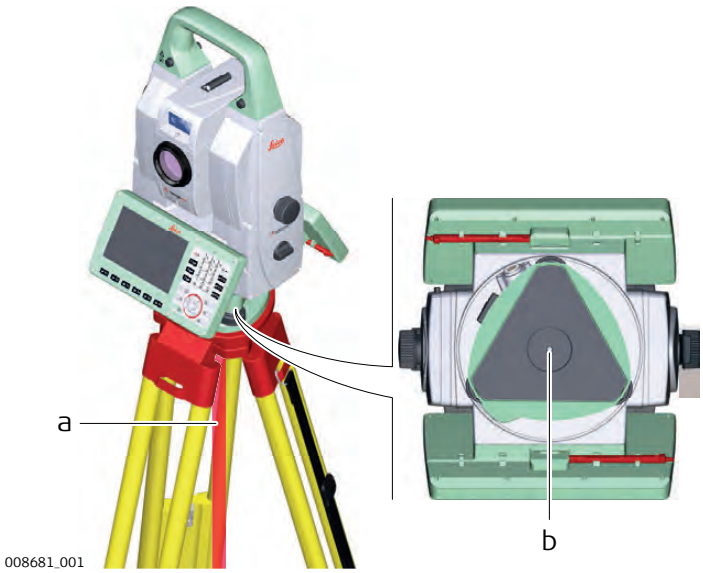
These products are safe for momentary exposures but can be hazardous for deliberate staring into the beam. The beam may cause dazzle, flash-blindness and after-images, particularly under low ambient light conditions.

Description	Value
Wavelength	640 nm
Maximum average radiant power	0.95 mW
Pulse duration	10 ms - cw
Pulse repetition frequency (PRF)	1 kHz
Beam divergance	< 1.5 mrad

CAUTION

From a safety perspective, class 2 laser products are not inherently safe for the eyes.
Precautions:
1) Avoid staring into the beam or viewing it through optical instruments.
2) Avoid pointing the beam at other people or at animals.

Labelling



a) Laser beam
b) Exit for laser beam

1.7 Electromagnetic Compatibility EMC

Description

The term Electromagnetic Compatibility is taken to mean the capability of the product to function smoothly in an environment where electromagnetic radiation and electrostatic discharges are present, and without causing electromagnetic disturbances to other equipment.

WARNING

Electromagnetic radiation can cause disturbances in other equipment.
Although the product meets the strict regulations and standards which are in force in this respect, Leica Geosystems cannot completely exclude the possibility that other equipment may be disturbed.

CAUTION

There is a risk that disturbances may be caused in other equipment if the product is used with accessories from other manufacturers, for example field computers, personal computers or other electronic equipment, non-standard cables or external batteries.
Precautions:
Use only the equipment and accessories recommended by Leica Geosystems. When combined with the product, they meet the strict requirements stipulated by the guidelines and standards. When using computers or other electronic equipment, pay attention to the information about electromagnetic compatibility provided by the manufacturer.

CAUTION

Disturbances caused by electromagnetic radiation can result in erroneous measurements.
Although the product meets the strict regulations and standards which are in force in this respect, Leica Geosystems cannot completely exclude the possibility that the product may be disturbed by intense electromagnetic radiation, for example, near radio transmitters, two-way radios or diesel generators.
Precautions:
Check the plausibility of results obtained under these conditions.

CAUTION

If the product is operated with connecting cables attached at only one of their two ends, for example external supply cables, interface cables, the permitted level of electromagnetic radiation may be exceeded and the correct functioning of other products may be impaired.
Precautions:
While the product is in use, connecting cables, for example product to external battery, product to computer, must be connected at both ends.

Radios or Digital Cellular Phones

Use of product with radio or digital cellular phone devices:

WARNING

Electromagnetic fields can cause disturbances in other equipment, in installations, in medical devices, for example pacemakers or hearing aids and in aircraft. It can also affect humans and animals.
Precautions:
Although the product meets the strict regulations and standards which are in force in this respect, Leica Geosystems cannot completely exclude the possibility that other equipment can be disturbed or that humans or animals can be affected.

- Do not operate the product with radio or digital cellular phone devices in the vicinity of filling stations or chemical installations, or in other areas where an explosion hazard exists.
- Do not operate the product with radio or digital cellular phone devices near to medical equipment.
- Do not operate the product with radio or digital cellular phone devices in aircraft.

1.8 FCC Statement, Applicable in U.S.

The greyed paragraph below is only applicable for products without radio.

WARNING

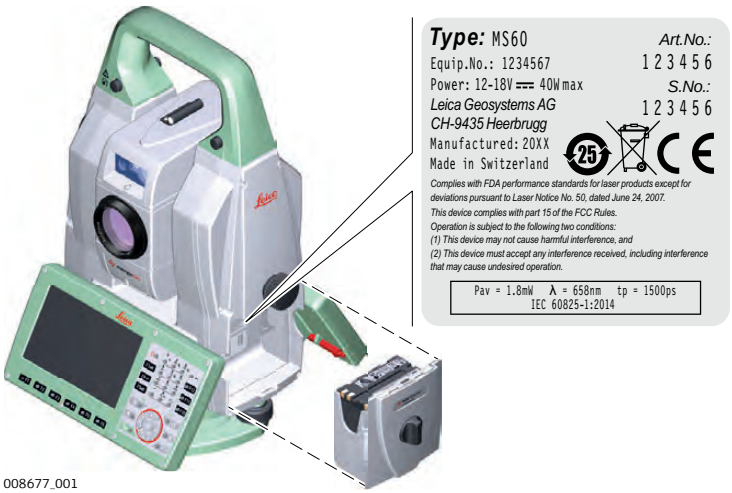
This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC rules.
These limits are designed to provide reasonable protection against harmful interference in a residential installation.
This equipment generates, uses and can radiate 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 the 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.

WARNING

Changes or modifications not expressly approved by Leica Geosystems for compliance could void the user's authority to operate the equipment.

Labelling MS60/TS60



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FCC Labelling GEB242

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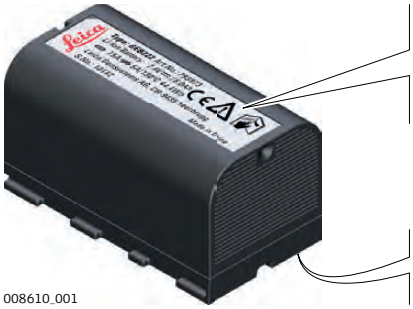
Labelling Internal Battery GEB212, GEB222

008611_001

Type: GEB212 Art.No.: 772806
Li-Ion Battery: 7.4V ⎓ /2.6Ah
10A 5A/130°C 19Wh
Leica Geosystems AG, CH-9435 Heerbrugg
Manufactured: 20XX S.No: 0118 Made in China

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.

c UL us LISTED
ITE Accessory
E179078 . 70YL



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Type: GEB222 Art.No.: 793973
Li-Ion Battery: 7.4V ⎓ /6.0Ah
15A 5A/130°C 44.4Wh
Leica Geosystems AG, CH-9435 Heerbrugg
S.No.: 10142 Made in China

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.

c US
11WE
MH29443

Labelling RadioHandle

RH16

008612_002

Model: RH16
Art.No. : 788853
Power: 7.4V/12.5V⎓ / 0.2A max.
Leica Geosystems AG
CH-9435 Heerbrugg
Manufactured: 20XX
Made in Switzerland
Contains
Transmitter Module:
FCC ID: PHV0939
IC: 5325A-0939
S.No.: 1234567

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.

RH17

008613_002

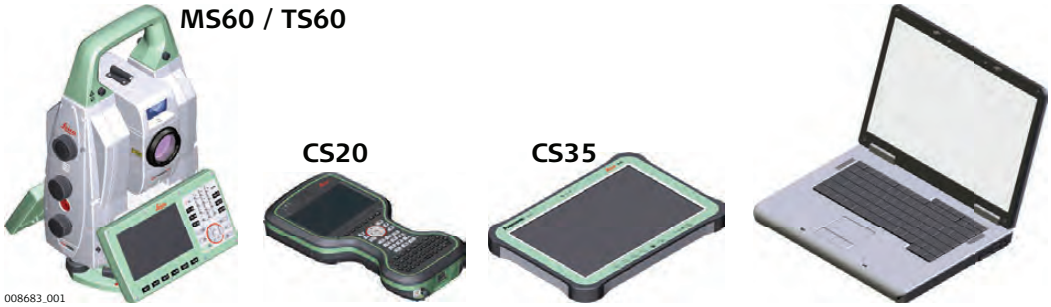
Model: RH17
Art.No. : 818467
Power: 7.4V/12.5V⎓ / 0.2A max.
Leica Geosystems AG
CH-9435 Heerbrugg
Manufactured: 20xx
Made in Switzerland
Contains
Transmitter Module:
FCC ID: PVH0946
IC: 5325A-0946
S.No.: 1234567

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.

2 Description of the System

2.1 System Components

Main Components



Component	Description
MS60/TS60	• an instrument for measuring, calculating and capturing data. • comprised of various models with a range of accuracy classes. • integrated with an add-on GNSS system to form Smart-Station. • combined with a CS20 field controller to conduct remote control surveys. • connected with Infinity to view, exchange and manage data.
CS20 field controller	A multi-purpose field controller allowing the remote control of MS60/TS60.
CS35 tablet	A tablet allowing the remote control of MS60/TS60.
Infinity	An office software consisting of a suite of standard and extended programs for the viewing, exchange and management of data.

Terms and Abbreviations

The following terms and abbreviations can be found in this manual:

Term	Description
Remote Mode	The instrument is remote controlled by the field controller or tablet using radio.
EDM	**E**lectronic **D**istance **M**easurement EDM refers to the laser distancer incorporated into the instrument which enables distance measurement. Two measuring modes are available: • **Prism** mode. This mode refers to the ability to measure distances to prisms. On the TS60, it incorporates the long range mode to measure extended distances to prisms. On the MS60, the standard mode (**Once**) is used for the whole distance range including extended distance prisms. • **Any surface** mode. This mode refers to the ability to measure distances without prisms.
PinPoint	PinPoint refers to the Reflectorless EDM technology which enables an increased measuring range with a smaller laser spot size. Two options are available: R1000 and R2000.

Term	Description
EGL	**E**lectronic **G**uide **L**ight An EGL fitted to an instrument assists with prism targeting. It consists of two differently coloured flashing lights located in the instrument telescope housing. The person holding the prism can align themselves into the line-of-sight of the instrument.
ATRplus	Automatic Target Aiming ATRplus refers to the instrument sensor which enables the automatic aiming and locking.
Autofocus	Instruments equipped with autofocus offer an automatic focussing of the telescope optics.
Automated	Instruments fitted with ATRplus are referred to as Automated. ATRplus refers to the instrument sensor which enables the automatic target aiming to a prism. Three automation modes are available with ATRplus: • Manual: no automation and no lock. • Automatic: automatic target aiming to a prism. • LOCK: an already targeted prism is followed automatically.
Telescope camera	The camera is coaxially located in the instruments telescope using the 30x magnification of the telescope optics.
Overview camera	The overview camera is located in the upper part of the telescope housing and has a fixed focus.
PowerSearch	**P**ower**S**earch refers to the instrument sensor which enables the automatic rapid finding of a prism.
SmartStation	A Leica Nova TS instrument integrated with an add-on GNSS system, comprising hardware and software components, forms a SmartStation. Components of a SmartStation include a SmartAntenna and a SmartAntenna Adapter. A SmartStation provides an additional instrument setup method for determining instrument station coordinates. The GNSS principles and functionality of a SmartStation derive from the principles and functionality of Leica Viva GNSS instruments.
SmartAntenna	SmartAntenna with integrated Bluetooth is a component of a SmartStation. It can also be used independently on a pole with a CS20 field controller. Models compatible with a MS60/TS60 instrument are GS14/GS16/GS15. Where there are differences between the various models they are clearly described.
RadioHandle	A component of remote mode is the RH16/RH17 RadioHandle. It is an instrument carry handle with an integrated radio modem with attached antenna.
Communication side cover	Communication side cover with integrated Bluetooth, SD card slot, USB port, WLAN and RadioHandle hotshoe is standard for a MS60/TS60 instrument and a component of a SmartStation. In combination with the RH16/RH17 RadioHandle, it is also a component of remote mode.

Instrument Models

Model	TS60 I R1000	MS60 R2000
Angle measurement	✓	✓
Distance measurement to prism	✓	✓
Distance measurement to any surface (reflectorless)	✓	✓
Motorised	✓	✓
Automatic Target Aiming	✓	✓
Lock	✓	✓
PowerSearch (PS)	✓	✓
Overview camera	✓	✓
Telescope camera	✓	✓
Scanning	-	✓
RS232 and USB interface	✓	✓
SD card and USB stick as storage device	✓	✓
Bluetooth	✓	✓
WLAN	✓	✓
Internal Flash Memory (2 GB)	✓	✓
Hotshoe interface for RadioHandle	✓	✓
Guide Light (EGL)	✓	✓
Autofocus	✓	✓
Uninterruptible electronic power supply due to internal charging functionality	✓	✓

2.2 System Concept

2.2.1 Software Concept

Description

All instruments use the same software concept.

Software for TS Models

Software type	Description
TS firmware (TS_xxMS60Leica Captivate.fw)	The Leica Captivate software is running on the TS instrument and covers all functions of the instrument. The main applications and languages are integrated into the firmware and cannot be deleted. The languages released with Leica Captivate are included in the firmware file.
Applications (xx.axx)	Many optional survey-specific applications are available for the TS instruments. All applications are included in the Leica Captivate firmware file and can be loaded separately. Some of the applications are activated freely and require no licence key; others require purchasing and are only activated with a licence key. If the licence is not loaded to the instrument, applications requiring a licence key run for a 40 h trial period. For a trial run, the Measure&Stakeout licence must be available on the TS.
Customised applications (xx.axx)	Customised software, specific to user requirements, can be developed using the GeoC++ development kit. Information on the GeoC++ development environment is available on request from a Leica Geosystems representative.

Software Upload

☞ Uploading software can take some time. Ensure that the battery is at least 75% full before you start the upload. Do not remove the battery during the upload process.

Software update instructions for all TS models:

1) Download the most recent firmware file from https://myworld.leica-geosystems.com. Refer to "Introduction".
2) Copy the firmware file into the **System** folder on the Leica SD card.
3) Start the instrument. Select **Settings\Tools\Update software**. Select the firmware file and start the update.
4) When the update is complete, a message appears.

2.2.2 Power Concept

General

Use the batteries, chargers and accessories recommended by Leica Geosystems to ensure the correct functionality of the instrument.

Power Options

Model	Power supply
All instrument types	Internally by GEB242 battery, OR Externally by GEV219 cable and GEB371 battery. If an external power supply is connected and the internal battery is inserted, then the external power is used for the standard setting. It is possible to configure the main power source to either internal battery or external power supply. If both power sources are available the internal battery serves as an uninterruptible electronic power supply due to internal charging functionality of the internal battery.
SmartAntenna	Internally via GEB212 battery fitted into the antenna.

2.2.3 Data Storage Concept

Description

Data is stored on a memory device. The memory device can be an SD card or internal memory. For data transfer an USB stick can also be used.

Memory Device

SD card: All instruments have an SD card slot fitted as standard. An SD card can be inserted and removed.
Available capacity: 1 GB and 8 GB.

USB stick: All instruments have a USB port fitted as standard.

Internal memory: All instruments have an internal memory fitted as standard.
Available capacity: 2 GB.

☞ While other SD cards can be used, Leica Geosystems recommends to only use Leica SD cards and is not responsible for data loss or any other error that can occur while using a non-Leica card.

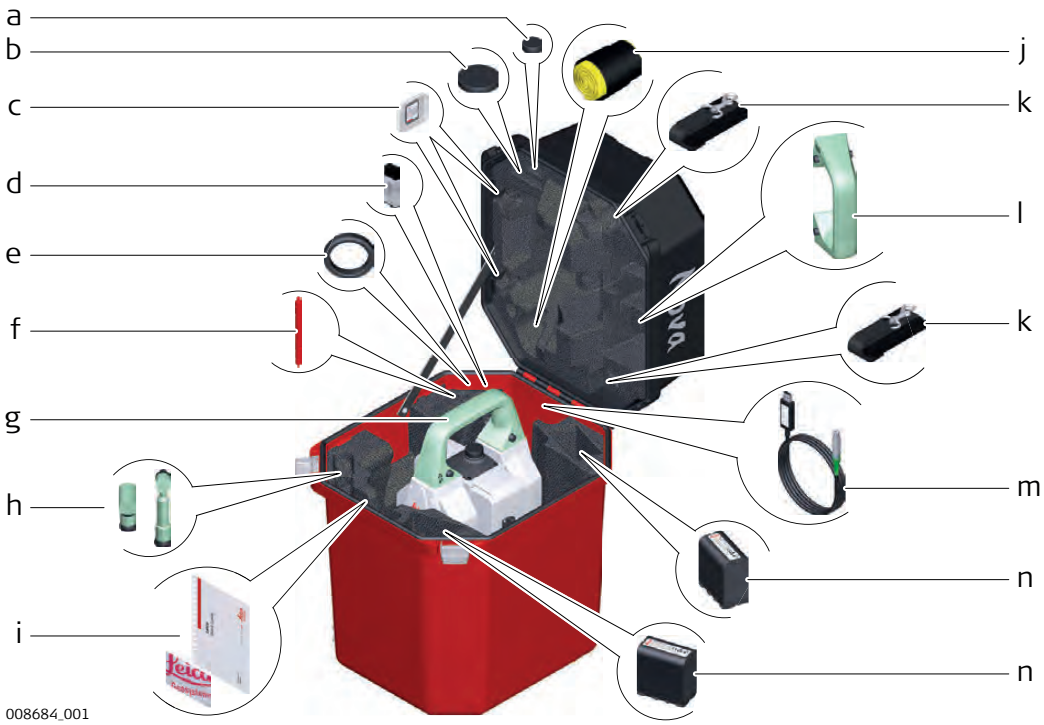
☞ Unplugging connecting cables or removing the SD card or USB stick during the measurement can cause loss of data. Only remove the SD card or USB stick or unplug connecting cables when the TS instrument is switched off.

Transfer Data

Data can be transferred in various ways. Refer to "4.8 Connecting to a Personal Computer".

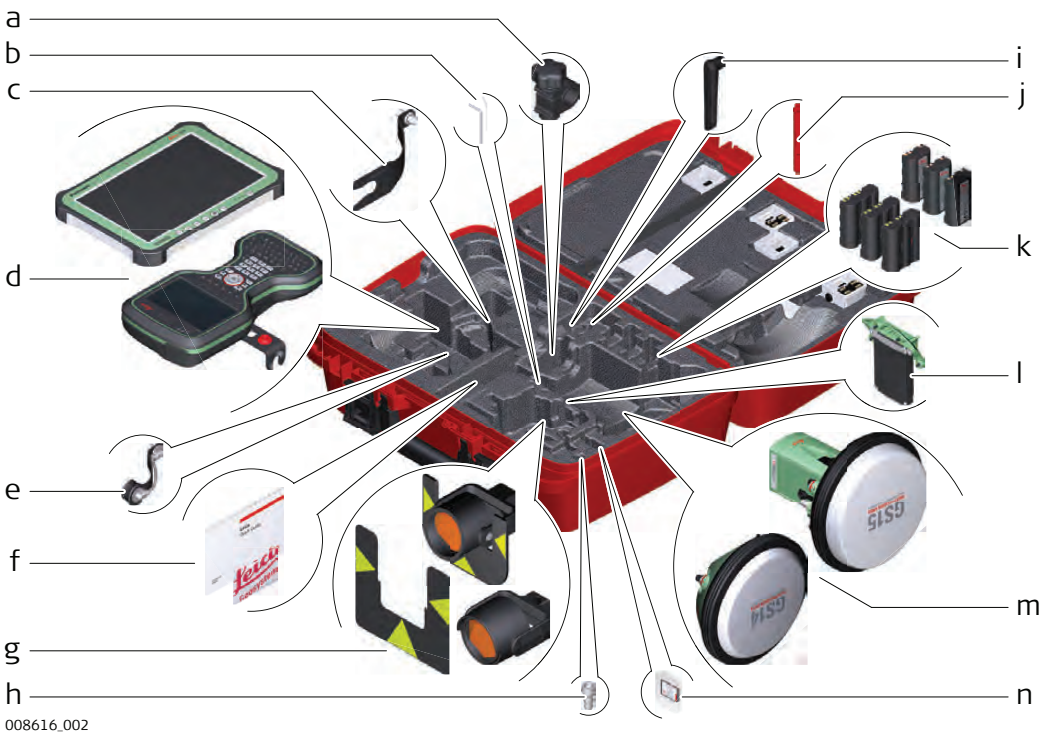
☞ SD cards can directly be used in an OMNI drive as supplied by Leica Geosystems. Other PC card drives can require an adaptor.

Container for MS60/TS60 and Accessories



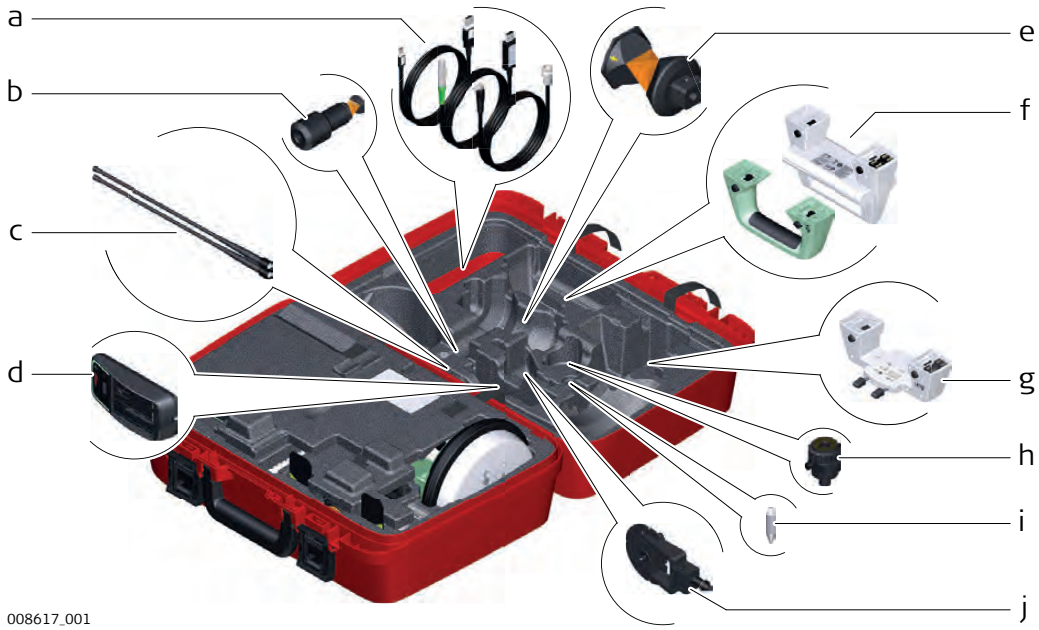
a) Cover for eyepiece
b) Cover for objective
c) SD card and cover
d) MS1 industrial 1 GB USB memory stick
e) Counterweight for diagonal eyepiece
f) Stylus
g) Instrument with tribrach and standard handle or RadioHandle
h) GFZ3 or GOK6 diagonal eyepiece
i) Manuals and USB documentation card
j) Protective cover for instrument, sunshade for objective lens and cleaning cloth
k) Container straps
l) Room for standard handle
m) GEV234 Data transfer cable
n) GEB242 battery

Container for GS14/GS16/GS15 SmartPole/ SmartStation and Accessories - Part 1 of 2



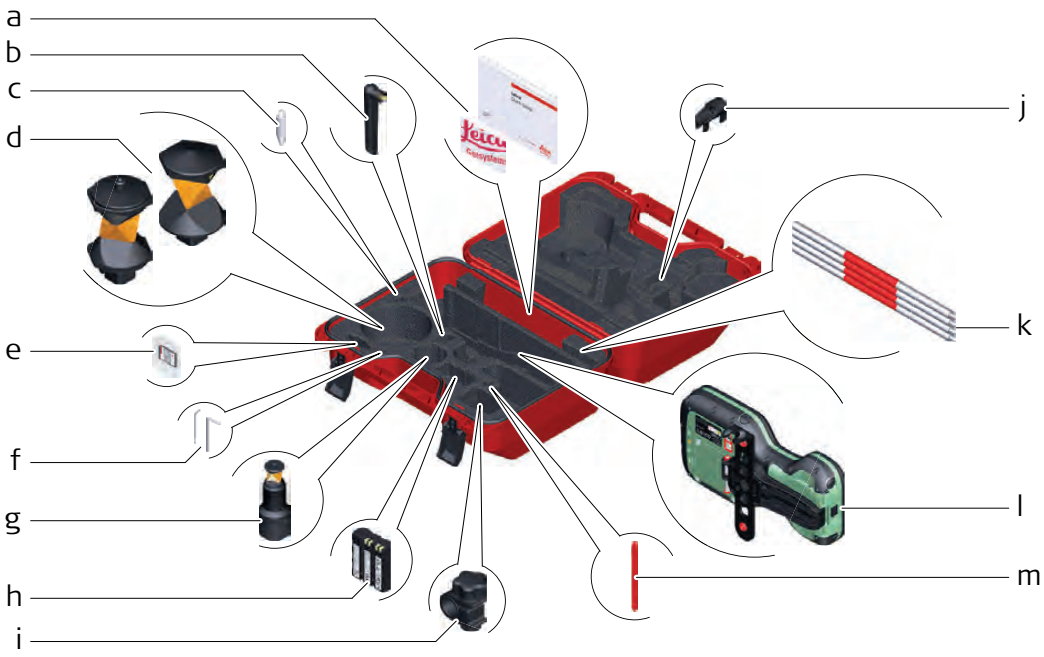
a) GHT63 pole holder clamp
b) Allen key and adjustment tool
c) GAD33 antenna arm
d) CS35 tablet or CS20 field controller with GHT66 holder
e) GAD108 antenna arm
f) Manuals and USB documentation card
g) GPR121 circular prism PRO or GZT4 target plate for GPH1 and GPH1 prism holder with GPR1 circular prism
h) GAD109 QN-TNC Adapter
i) GAT25 radio antenna
j) Stylus
k) GEB212 or GEB331 batteries
l) SLXX RTK modem
m) GS14/GS16 or GS15 antenna
n) SD card and cover

Container for GS14/GS16/GS15 SmartPole/ SmartStation and Accessories - Part 2 of 2



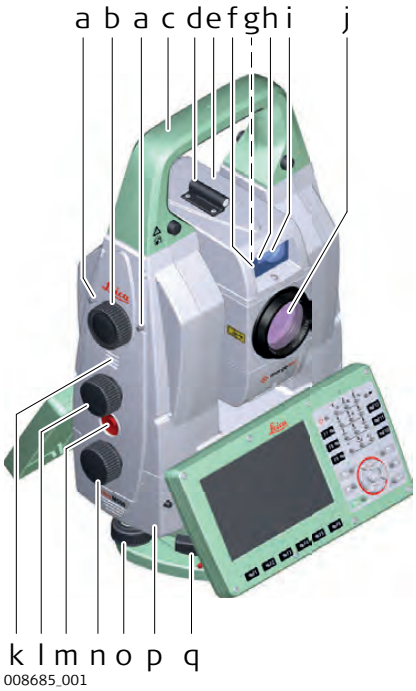
a) Cables
b) GRZ101 mini prism and GAD103 adapter
c) GAT1 or GAT2 radio antennas
d) GKL311 charger
e) GRZ4 or GRZ122 prism
f) Standard handle or RadioHandle
g) GAD110 adapter for GS14/GS16 and GS15 antenna
h) GAD31 screw to stub adapter
i) Mini prism spike
j) GMP101 mini prism

Container for TS Robotic Pole Setup, Small Size



a) Manuals and USB documentation card
b) GAT25 radio antenna
c) Mini prism spike
d) GRZ4 or GRZ122 prism
e) SD card and cover
f) Adjustment tool and allen key
g) GRZ101 mini prism and GAD103 adapter
h) GEB331 battery
i) GHT63 pole holder clamp
j) Tip for mini pole
k) GLI115 clip-on bubble for GLS115 mini prism pole
l) CS20 field controller and GHT66 holder
m) Stylus

Instrument Components Part 1 of 2

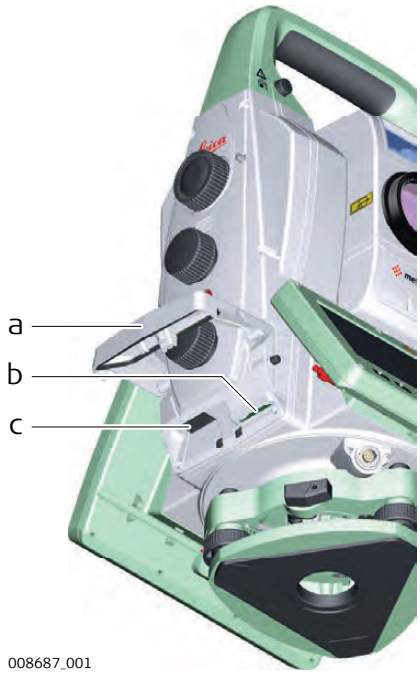


a) Autofocus button
b) Servofocus drive
c) Carry handle
d) Optical sight
e) Telescope with EDM, ATRplus, camera sensors, EGL and PS.
f) EGL
g) Overview camera
h) PowerSearch, transmitter
i) PowerSearch, receiver
j) Coaxial optics for angle and distance measurements, telescope camera and exit port for visible laser beam for distance measurement
k) Loudspeaker
l) Vertical drive
m) User defined SmartKey
n) Horizontal drive
o) Tribrach footscrew
p) SD card and USB stick compartment
q) Tribrach securing screw

Instrument Components Part 2 of 2

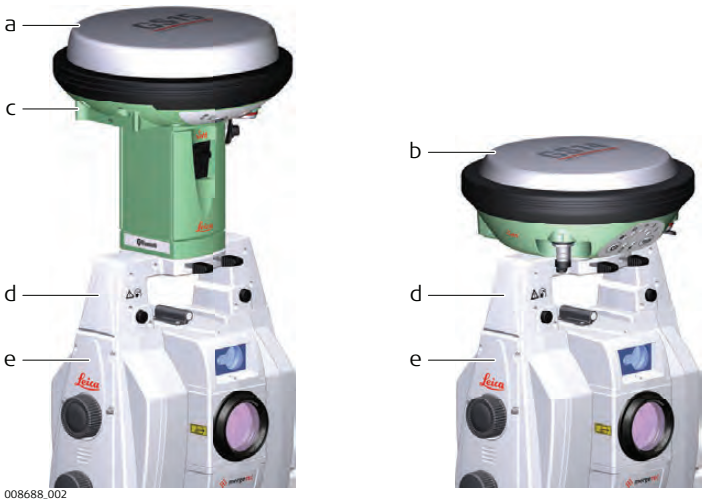
a) Interchangeable eyepiece
b) Circular level
c) Stylus for touch screen
d) Battery compartment
e) Vertical drive
f) Touch screen
g) Keyboard

Communication Side Cover



a) Compartment lid
b) SD card port
c) USB host port for USB stick

Instrument Components for SmartStation



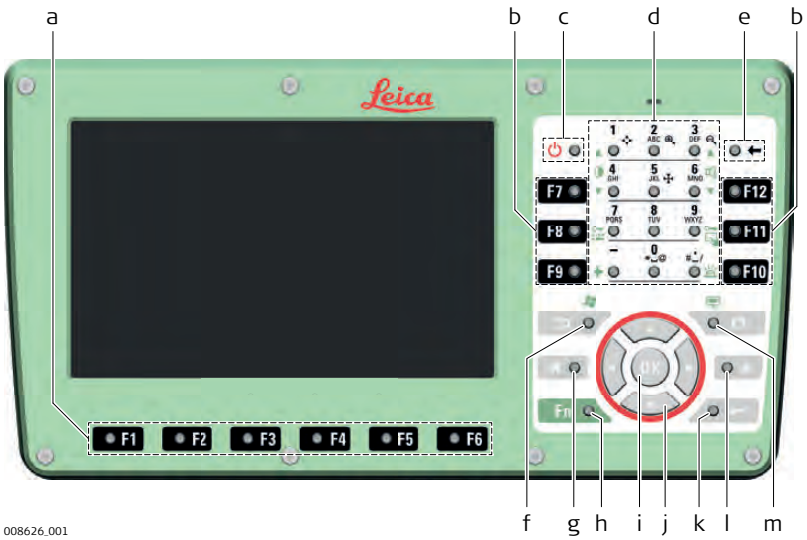
a) GS15 SmartAntenna
b) GS14/GS16 SmartAntenna
c) RTK slot-in device
d) GAD110 SmartAntenna Adapter
e) Communication side cover

a) RadioHandle
b) Communication side cover

3 User Interface

3.1 Keyboard

Keyboard MS60/TS60



a) Function keys F1-F6
b) Function keys F7-F12
c) ON/OFF
d) Alphanumeric keys
e) Backspace
f) Esc
g) Home
h) Fn
i) OK
j) Arrow keys
k) Enter
l) Favourites
m) Camera

Keys

Key	Function
Function keys **F1**-**F6**	Correspond to six softkeys that appear on the bottom of the screen when the screen is activated.
Function keys **F7**-**F12**	User definable keys to execute chosen commands or access chosen screens.
Alphanumeric keys	To type letters and numbers.
Camera	To capture an image with the camera.
Esc	Leaves the current screen without storing any changes.
Fn	Switches between the first and second level of function keys.
Enter	Selects the highlighted line and leads to the next logical menu / dialog. Starts the edit mode for editable fields. Opens a selectable list.
ON/OFF	If the instrument is already off: Turns on the instrument when held for 2 s. If the instrument is already on: Turns to Power Options menu when held for 2 s.
Favourites	Goes to a favourites menu.

Key	Function
Home	Switches to the Home Menu. Switches to the Windows EC7 Start Menu when pressing SHIFT at the same time.
Arrow keys	Move the focus on the screen.
OK	Selects the highlighted line and leads to the next logical menu / dialog. Starts the edit mode for editable fields. Opens a selectable list.

Key Combinations

Key	Function
Fn +	Hold **Fn** while pressing . Switch to Windows.
Fn +	Hold **Fn** while pressing . Take a screenshot of the current screen.
Fn + 1	Hold **Fn** while pressing **1**. Increase the screen brightness.
Fn + 4 GHI	Hold **Fn** while pressing ***4***. Decrease the screen brightness.
Fn + 3 DEF	Hold **Fn** while pressing **3**. Increase the volume for acoustic warning signals, beeps and keypresses on the field controller.
Fn + 6 MNO	Hold **Fn** while pressing **6**. Decrease the volume for acoustic warning signals, beeps and keypresses on the field controller.
Fn + 7 PQRS	Hold **Fn** while pressing **7**. Lock/unlock the keyboard.
Fn + 9 WXYZ	Hold **Fn** while pressing **9**. Lock/unlock the touch screen.
Fn + -	Hold **Fn** while pressing -. Enter a plus sign instead of a minus sign.
Fn + #-/	Hold **Fn** while pressing #-/. Turn the keyboard illumination on/off.

3.2 Operating Principles

Keyboard and Touch Screen

The user interface is operated either by the keyboard or by the touch screen with supplied stylus. The workflow is the same for keyboard and touch screen entry, the only difference lies in the way information is selected and entered.

Operation by keyboard

Information is selected and entered using the keys. Refer to "3.1 Keyboard" for a detailed description of the keys on the keyboard and their function.

Operation by touch screen

Information is selected and entered on the screen using the supplied stylus.

Operation	Description
To select an item	Tap on the item.
To start the edit mode in editable fields	Tap on the editable field.
To highlight an item or parts of it for editing	Drag the supplied stylus from the left to the right.
To accept data entered into an editable field and exit the edit mode	Tap on the screen outside of the editable field.
To open a context-sensitive menu	Tap on the item and hold for 2 s.

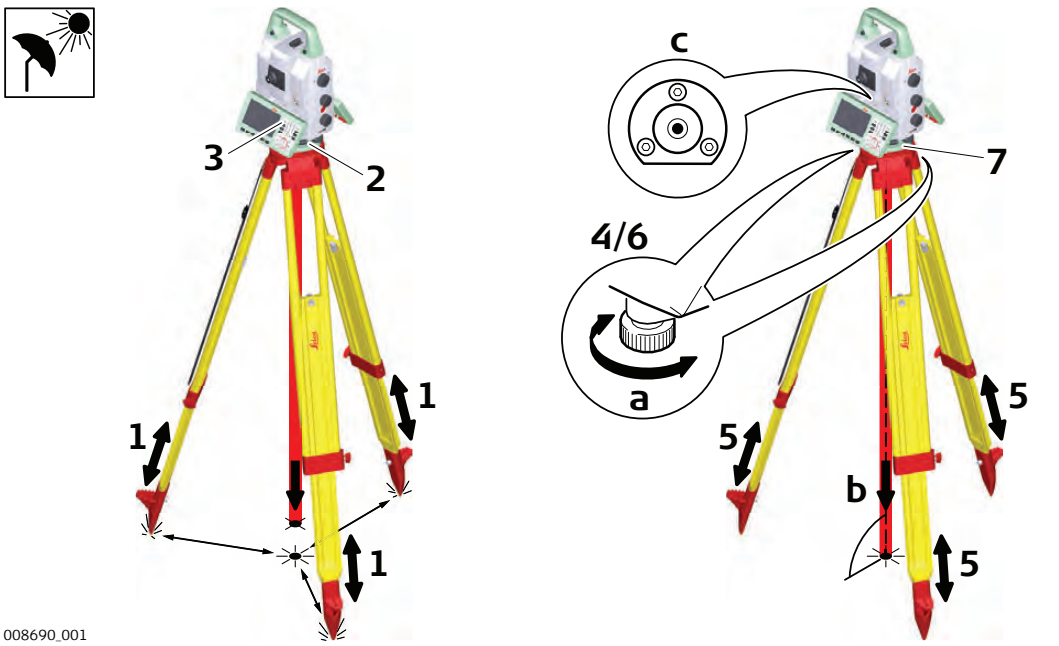
3.3 Autofocus Capability of Telescope Camera

Functionality

The autofocus button is located on the side cover.

Action	Function
Pressing 1x	A single autofocus is executed. The autofocus is related to the selected EDM mode (prism or non-prism measurements).
Pressing 2x	The refocus is executed. Based on the actual focus lense position, a refocus is performed. A refocus does a small movement of the focussing lense to find the best focus position.
Holding for 2 sec	The continuous autofocus is started. By pressing the button again or by turing the servofocus wheel, the continuous autofocus is stopped.

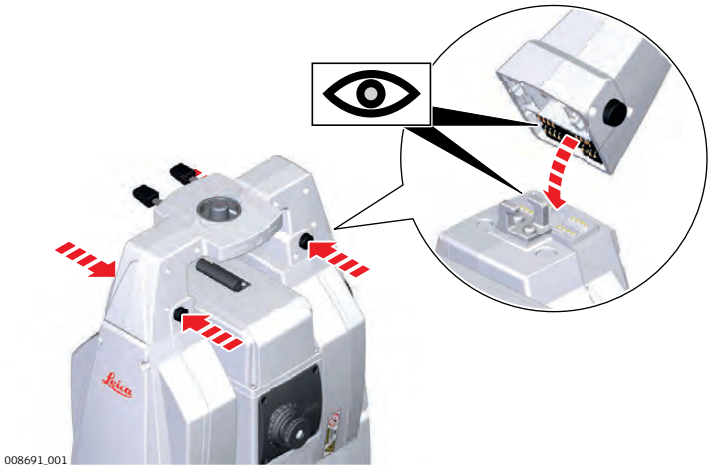
Instrument Setup Step-by-Step



008690_001

Step	Description
☞	Shield the instrument from direct sunlight and avoid uneven temperatures around the instrument.
1.	Extend the tripod legs to allow for a comfortable working posture. Position the tripod above the marked ground point, centring it as good as possible. Ensure that the tripod plate is roughly horizontal.
2.	Fasten the tribrach and instrument onto the tripod.
3.	Turn on the instrument by pressing ⏻ ◎. Select **Settings**/**TS instrument**/**Level & compensator** to activate the laser plummet and electronic level.
4.	Use the tribrach footscrews (a) to centre the plummet (b) above the ground point.
5.	Adjust the tripod legs to level the circular level (c).
6.	By using the electronic level, turn the tribrach footscrews (a) to level the instrument precisely.
7.	Centre the instrument precisely over the ground point (b) by shifting the tribrach on the tripod plate.
8.	Repeat steps 6. and 7. until the required accuracy is achieved.

SmartStation Setup Step-by-Step

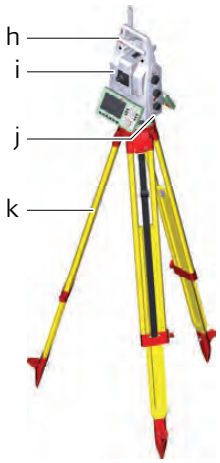


Step	Description
1.	Place the GAD110 adapter for the GS15/GS14/GS16 antenna onto the instrument by simultaneously pressing and holding-in the four push buttons.
☞	Ensure that the interface connection on the underside of the adapter is on the same side as the Communication side cover.

Step	Description
2.	Place the GS15/GS14/GS16 antenna onto the adapter by simultaneously pressing and holding-in the two press clips.

4.3 Setting Up SmartPole

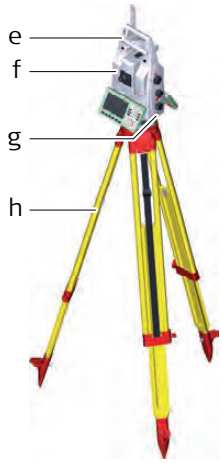
SmartPole Setup using GS15/GS14/GS16



a) GS14/GS16 antenna
b) GS15 antenna
c) RTK slot-in device
d) 360° prism
e) Field controller on GHT66 holder (Alternative, not illustrated: tablet on GHT78 holder)
f) GHT63 clamp
g) GLS31 pole with snap-lock positions
h) RH16/RH17 RadioHandle
i) Instrument
j) Communication side cover, integrated
k) Tripod

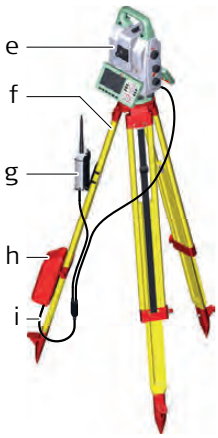
4.4 Setting up for Remote Control (with the RadioHandle)

Setup for Remote Control with RadioHandle



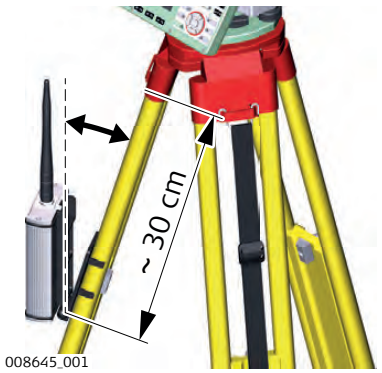
a) 360° prism
b) Prism pole
c) Field controller on GHT66 holder (Alternative, not illustrated: tablet on GHT78 holder)
d) GHT63 clamp
e) RadioHandle
f) Instrument
g) Communication side cover
h) Tripod

Setup for Remote Control with TCPS29/30



a) 360° prism
b) Prism pole
c) Field controller on GHT66 holder (Alternative, not illustrated: tablet on GHT78 holder)
d) GHT63 clamp
e) Instrument
f) Tripod
g) TCPS29/30
h) External battery GEB371
i) Y-cable

Mounting Base Radio to Tripod Step-by-Step

Step	Description
1.	The GHT43 tripod adapter is used to mount the TCPS29/30 to all Leica standard tripods, and to optimise the radio transmission performance. Attach the TCPS29/30 to the adapter and then attach the adapter to the tripod leg.
2.	Adjust the angle of TCPS29/30 until it is vertical.
3.	Adjust the location of the adapter on the tripod leg so that there are no metallic objects in the horizontal plane around the antenna. ☞ Metallic objects near the antenna disturb radio transmissions.
4.	☞ To achieve the best performance from the TCPS29/30, mount it in a vertical position on the tripod leg, approximately 30 cm from the top. ☞ If the adapter is no longer able to retain its angle position, the adjustment bolt at the hinge can be tightened slightly. 

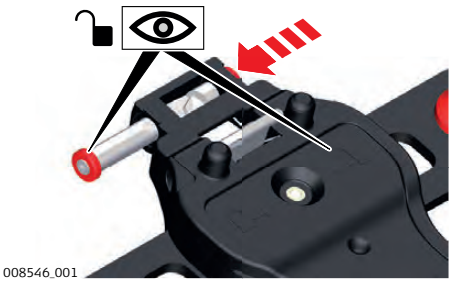
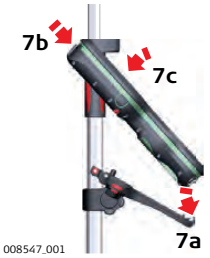
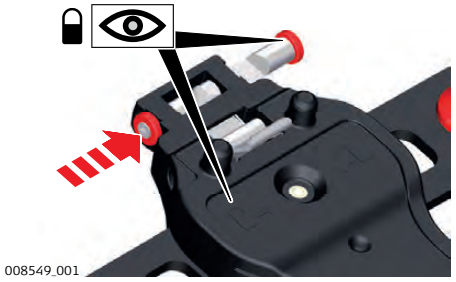
Components of the GHT66 Holder

The GHT66 holder consists of the following components:

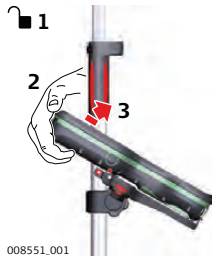
GHT63 clamp
a) Plastic sleeve
b) Pole clamp
c) Clamp bolt

GHT66 holder
d) Locking pin
e) Top clip
f) Mounting plate
g) Bottom clip
h) Tightening screw
i) Mounting arm

Fixing the Field Controller and GHT66 to a Pole Step-by-step

Step	Description
☞	For an aluminium pole, fit the plastic sleeve to the pole clamp.
1.	Insert the pole into the clamp hole.
2.	Attach the holder to the clamp using the clamp bolt.
3.	Adjust the angle and the height of the holder on the pole to a comfortable position.
4.	Tighten the clamp with the clamp bolt.
5.	Before placing the CS field controller onto the mounting plate, ensure that the locking pin is put into the unlocked position. To unlock the locking pin, push the locking pin to the left.  008546_001
6.	Hold the CS field controller above the holder and lower the end of the CS field controller into the mounting plate.
7.	Apply slight pressure in a downward direction and then lower the top part of the CS field controller until the unit is clicked into the holder. The guides of the mounting plate aid in this action. 
8.	After the CS field controller is placed onto the mounting plate, ensure that the locking pin is put into the locked position. To lock the locking pin, push the locking pin to the right.  008549_001

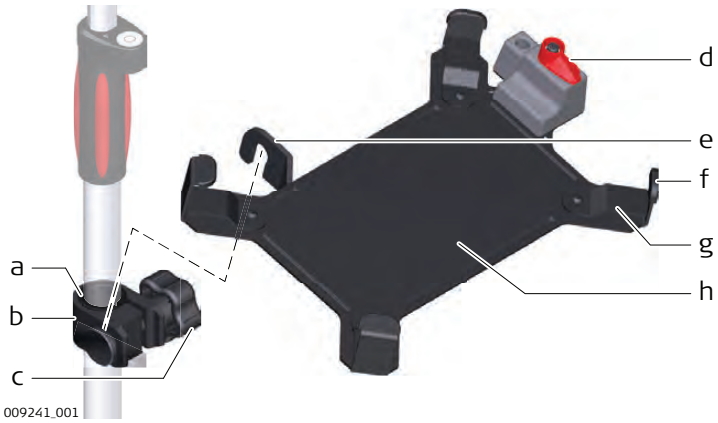
Detaching the Field Controller from a Pole Step-by-step

Step	Description
1.	Unlock the locking pin by pushing the locking pin to the left of the mounting plate.
2.	Place your palm over the top of the field controller.
3.	While in this position, lift the top of the field controller from the holder. 

4.7 Fixing the CS35 Tablet to a Holder and Pole

Components of GHT63 Clamp and GHT78 Holder

For fixing the CS35 tablet to a pole you need the following components:



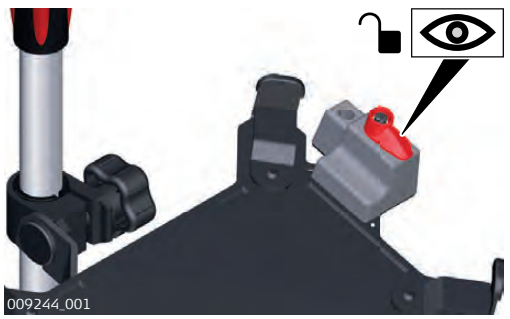
GHT63 clamp

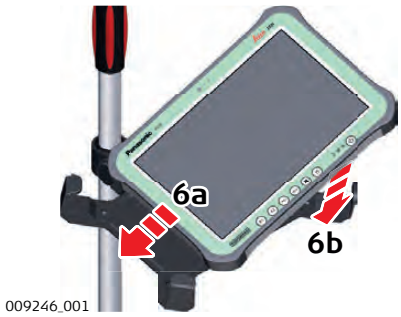
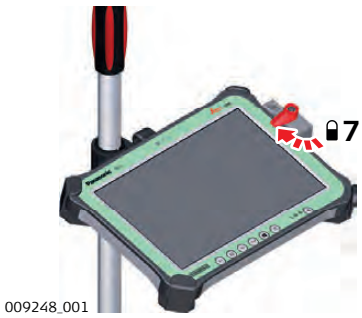
a) Plastic sleeve
b) Pole clamp
c) Clamp bolt

GHT78 holder

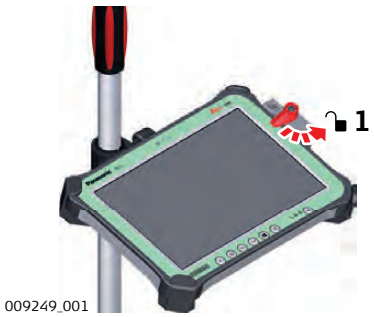
d) Locking lever
e) Mounting arm
f) Mounting brackets
g) Removable inserts
h) Mounting plate

Fixing the CS35 Tablet and GHT78 to a Pole Step-by-Step

Step	Description
☞	For an aluminium pole, fit the plastic sleeve to the pole clamp.
☞	If the 833343 hand strap with high corner guards is attached to the tablet, remove the inserts from the mounting brackets before fixing the tablet to the mounting plate. To untighten the screws of the removable inserts, use a 2.5 mm allen key.
1.	Insert the pole into the clamp hole.
2.	Attach the holder to the clamp using the clamp bolt.
3.	Adjust the angle and the height of the holder on the pole to a comfortable position.
4.	Tighten the clamp with the clamp bolt.
5.	Before placing the CS35 tablet onto the mounting plate, ensure that the locking lever is set to the unlocked position (see illustration). 

Step	Description
6.	Lower the left side of the tablet and slide it from right to left into the mounting brackets of the holder. 
7.	After placing the tablet onto the mounting plate, set the locking lever to the locked position (see illustration). 

Detaching the Tablet from the Holder/Pole Step-by-Step

Step	Description
1.	Set the locking lever of the GHT78 holder to the unlocked position. 
2.	Lift the right side of the tablet and slide the tablet to the right and out of the holder. 

Description

Windows **M**obile **D**evice **C**enter for PCs with Windows 7/Windows 8/Windows 10 operating system is the synchronization software for Windows mobile-based pocket PCs. WMDC enables a PC and a Windows mobile-based pocket PC to communicate.

Leica USB drivers support Windows 7, Windows 8 (8.1) and Windows 10 operating systems.

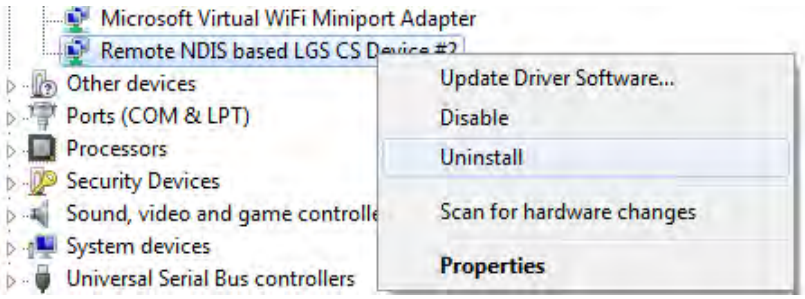
Cables

Leica USB drivers support:

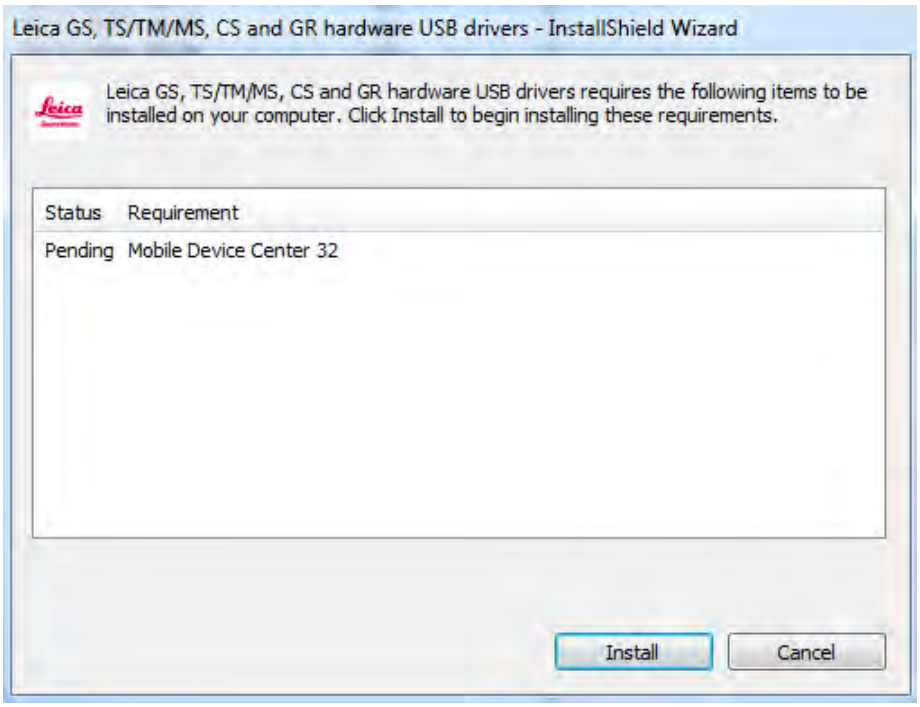
Name	Description
GEV223	USB data cable, 1.8 m, connects instrument to Mini-USB to USB
GEV234	USB data cable, 1.65 m, connects CS to GS or CS to PC (USB)
GEV261	Y-cable, 1.8 m, connects instrument to PC – battery

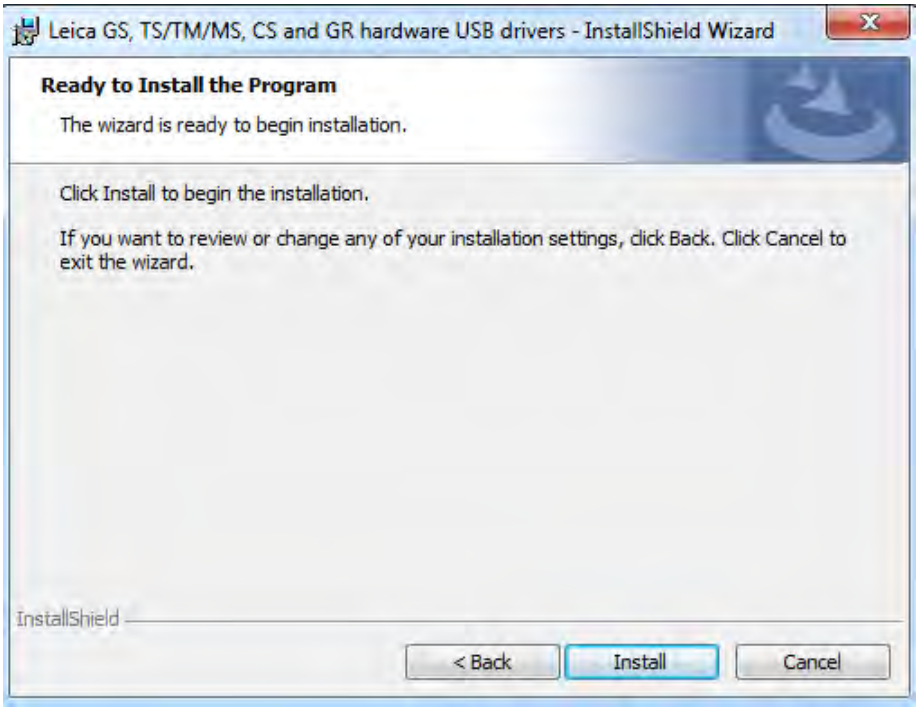
Uninstalling the previous drivers

☞ Skip the following steps if you have never installed Leica USB drivers before. If older drivers were previously installed on the PC, follow the instructions to un-install the drivers prior the installation of the new drivers.

Step	Description
1.	Connect your instrument to the PC via cable.
2.	On your PC, select to **Control Panel** › **Device Manager**.
3.	In **Network Adapters**, right-click on **Remote NDIS based LGS...**.
4.	Click on **Uninstall**. 
5.	Set **Delete the driver...** as checked. Press **OK**. 

Install Leica USB drivers

Step	Description
1.	Start the PC.
2.	Run the **Setup_Leica_USB_XXbit.exe** to install the drivers necessary for Leica devices. Depending on the version (32bit or 64bit) of the operating system on your PC, you have to select between the three setup files following: • Setup_Leica_USB_32bit.exe • Setup_Leica_USB_64bit.exe • Setup_Leica_USB_64bit_itanium.exe ☞ To check the version of your operating system, go to **Control Panel** › **System** › **System type**. ☞ The setup requires administrative privileges. ☞ The setup has to be run only once for all Leicadevices. ☞ For PCs with Windows Vista/Windows 7/Windows 8/Windows 10 operating system: If not already installed, WMDC will be installed additionally otherwise this panel would not appear. Click **Install** to continue or **Cancel** to exit installation. 
3.	The **Welcome to InstallShield Wizard for Leica GS, TS/TM/MS, CS and GR USB drivers** window appears. ☞ Ensure that all Leica devices are disconnected from your PC before you continue!

Step	Description
	
4.	**Next>**.
5.	The **Ready to Install the Program** window appears. 
6.	**Install**. The drivers will be installed on your PC.
7.	The **InstallShield Wizard Completed** window appears.
8.	Click **Finish** to exit the wizard.

Connect to PC via USB cable step-by-step

Step	Description
1.	Start the PC.
2.	Plug the cable into the instrument.
3.	Turn on the instrument.
4.	Plug the cable into the USB port of the PC. ☞ Windows Device Manager cannot be used with CS20/TS16/TS60/MS60.
5.	Press the Windows Start button at the bottom left corner of the screen.
6.	Type the IP address of the device into the search field. • \\192.168.254.1\ for field controller • \\192.168.254.3\ for other instruments
7.	Press **Enter**. A file browser opens. You can now browse within the folders on the instrument.

4.9 Power Functions

Turning the Instrument On

Press and hold power key ( ) for 2 s.

☞ The instrument must have a power supply.

Turning the Instrument Off

Press and hold power key ( ) for 2 s.

☞ The instrument must be on.

☞ For instruments setup in permanent installations with external power sources, for example monitoring, ensure external power remains available until the instrument has successfully completed the power down process.

Power Options Menu

Press and hold power key ( ) for 2 s to open **Power Options** menu.

☞ Instrument must be on.

Option	Description
Turn off	Turn TS instrument off.
Stand-by	Put TS instrument into stand-by mode. ☞ In stand-by mode, the TS instrument shuts down and reduces power consumption. Rebooting from stand-by mode is quicker than a cold start after turning off.
Reset...	Performs one of the following options: • **Restart** (restarts Windows EC7) • **Reset Windows EC7** (resets Windows EC7 and communication settings to factory defaults) • **Reset installed software** (resets settings of all installed software) • **Reset Windows EC7 and installed software** (resets Windows EC7 and settings of all installed software)

4.10 Batteries

4.10.1 Operating Principles

First-time Use/Charging Batteries

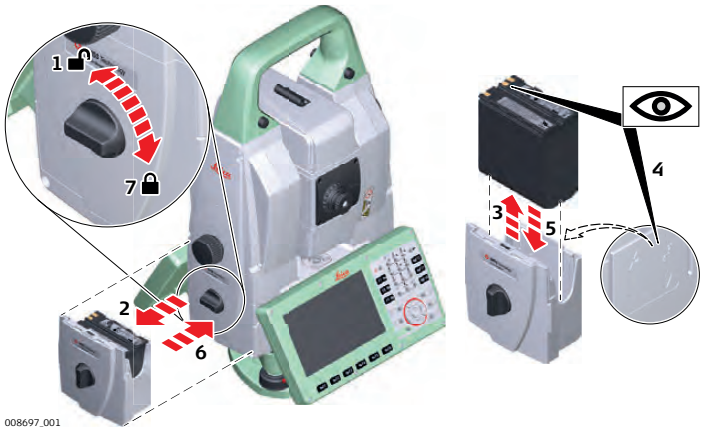
- The battery must be charged before using it for the first time because it is delivered with an energy content as low as possible.
- The permissible temperature range for charging is between 0 °C and +40 °C/+32 °F and +104 °F. For optimal charging, we recommend charging the batteries at a low ambient temperature of +10 °C to +20 °C/+50 °F to +68 °F if possible.
- It is normal for the battery to become warm during charging. Using the chargers recommended by Leica Geosystems, it is not possible to charge the battery once the temperature is too high.
- For new batteries or batteries that have been stored for a long time (› three months), it is effectual to make only one charge/discharge cycle.
- For Li-Ion batteries, a single discharging and charging cycle is sufficient. We recommend carrying out the process when the battery capacity indicated on the charger or on a Leica Geosystems product deviates significantly from the actual battery capacity available.

Operation / Discharging

- The batteries can be operated from • 20 °C to +55 °C/• 4 °F to +131 °F.
- Low operating temperatures reduce the capacity that can be drawn; high operating temperatures reduce the service life of the battery.

4.10.2 Battery for the TS Instrument

Change Battery Step-by-Step

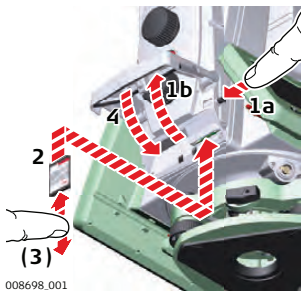


Step	Description
1.	Face the instrument so that the vertical drive screw is on the left. The battery compartment is below the vertical drive. Turn the knob to the vertical position, opening the lid of the battery compartment.
2.	Pull out the battery housing.
3.	Pull the battery from the battery housing.
4.	A pictogram of the battery is displayed inside the battery housing. This pictogram is a visual aid to assist in placing the battery correctly.
5.	Place the battery into the battery housing, ensuring that the contacts are facing outward. Click the battery into position.
6.	Place the battery housing into the battery compartment. Push the battery housing in until it fits completely into the battery compartment.
7.	Turn the knob to lock the battery compartment. Ensure that the knob is returned to its original horizontal position.

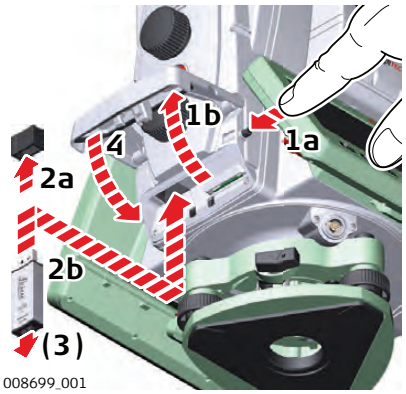
- Keep the card dry.
- Use it only within the specified temperature range.
- Do not bend the card.
- Protect the card from direct impacts.

Failure to follow these instructions could result in data loss and/or permanent damage to the card.

Insert and Remove an SD Card Step-by-Step

Step	Description	
	The SD card is inserted into a slot inside the Communication side cover of the instrument.	
1.	Press the button on the side of the Communication side cover to unlock the communication compartment.	
	The lid opens automatically.	
2.	To insert the SD card, slide it firmly into the SD slot until it clicks into position. The card must be held with the contacts at the top and facing toward the instrument. Do not force the card into the slot.	
3.	To remove the SD card, gently press on the top of the card to release it from the slot.	
4.	Close the lid by pushing the door down. Push the door on the marked part in the middle of the door.	

Insert and Remove a USB Stick Step-by-Step

Step	Description	
	The USB stick is inserted into the USB host port inside the Communication side cover of the instrument.	
1.	Press the button on the side of the Communication side cover to unlock the communication compartment.	
	The lid opens automatically.	
2.	To insert the USB stick, remove the cap of the USB stick. Hold the USB stick with the Leica logo facing you and slide it firmly into the USB host port until it clicks into position.	
	Do not force the USB stick into the port.	
3.	To remove the USB stick, slide the USB stick out of the port.	
4.	Close the lid by pushing the door down. Push the door on the marked part in the middle of the door.	

LED Indicators on RadioHandle

Description

The RadioHandle has **L**ight **E**mitting **D**iode indicators. They indicate the basic RadioHandle status.

Diagram of the LED Indicators

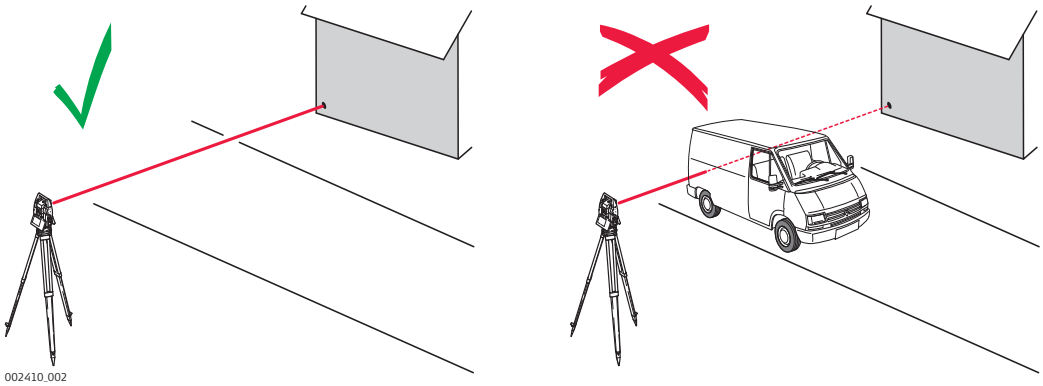
008660_001

a) Power LED
b) Link LED
c) Data Transfer LED
d) Mode LED

Description of the LED Indicators

IF the	is	THEN
Power LED	off	power is off.
	green	power is on.
Link LED	off	no radio link to field controller.
	red	radio link to field controller.
Data Transfer LED	off	no data transfer to/from field controller.
	green or green flashing	data transfer to/from field controller.
Mode LED	off	data mode.
	red	configuration mode.

Distance Measurement



When measurements are being made using the red laser EDM, the results can be influenced by objects passing between the EDM and the intended target surface. This occurs because reflectorless measurements are made to the first surface returning sufficient energy to allow the measurement to take place. For example, if the intended target surface is the surface of a building, but a vehicle passes between the EDM and the target surface as the measurement is triggered, the measurement may be made to the side of the vehicle. The result is the distance to the vehicle, not to the surface of the building.
If using the long range measurement mode (› 1000 m, › 3300 ft, available on TS60) to prisms, and an object passes within 30 m of the EDM as the measurement is triggered, the distance measurement may be similarly effected due to the strength of the laser signal.

☞ Very short distances can also be measured reflectorless in **Prism** mode to well reflecting natural targets. The distances are corrected with the additive constant defined for the active reflector.

⚠ **CAUTION** Due to laser safety regulations and measuring accuracy, using the Long Range Reflectorless EDM is only allowed to prisms that are more than 1000 m (3300 ft) away.

☞ Accurate measurements to prisms should be made in **Prism** mode.

☞ When a distance measurement is triggered, the EDM measures to the object which is in the beam path at that moment. If a temporary obstruction, for example a passing vehicle, heavy rain, fog or snow is between the instrument and the point to be measured, the EDM may measure to the obstruction.

☞ Do not measure with two instruments to the same target simultaneously to avoid getting mixed return signals.

ATRplus/Lock Instruments equipped with an ATRplus sensor permit automatic angle and distance measurements to prisms. The prism is sighted with the optical sight. After initiating a distance measurement, the instrument sights the prism centre automatically. Vertical and horizontal angles and the distance are measured to the centre of the prism. The lock mode enables the instrument to follow a moving prism.

☞ As with all other instrument errors, the collimation error of the automatic aiming must be redetermined periodically. Refer to "5 Check & Adjust" about checking and adjusting instruments.

☞ When a measurement is triggered while the prism is still moving, distance and angle measurements may not be made for the same position and coordinates may vary.

☞ If the prism location is changed too quickly, the target may be lost. Make sure that the speed does not exceed the figure given in the technical data.

Motorised Positioning

Unstable instrument setup conditions or small vibrations of the instrument resulting from heavy traffic or construction activities in the vicinity of the instrument may lead to an abandonment of the instrument's positioning before the final position is reached. Ensure that the instrument setup is stable, especially if steep sightings are necessary. If an incomplete positioning is indicated check the position deviation and repeat the according positioning command.

5 Check & Adjust

5.1 Overview

Description

Leica Geosystems instruments are manufactured, assembled and adjusted to the best possible quality. Quick temperature changes, shock or stress can cause deviations and decrease the instrument accuracy. It is therefore recommended to check and adjust the instrument from time to time. This check and adjust can be done in the field by running through specific measurement procedures. The procedures are guided and must be followed carefully and precisely as described in the following chapters. Some other instrument errors and mechanical parts can be adjusted mechanically.

Electronic Adjustment

The following instrument errors can be checked and adjusted electronically:

l, t	Compensator longitudinal and transversal index errors
i	Vertical index error, related to the standing axis
c	Horizontal collimation error, also called line of sight error
a	Tilting axis error
ATRplus	ATRplus zero point error for Hz and V
Telescope camera	Telescope camera zero point error, relation between principal point of telescope camera and crosshair in telescope in Hz and V - option

If the compensator and the horizontal corrections are activated in the instrument configuration, every angle measured in the daily work is corrected automatically. Check whether the tilt correction and the horizontal correction are turned on.
The results are displayed as errors but used with the opposite sign as corrections when applied to measurements.

Mechanical Adjustment

The following instrument parts can be adjusted mechanically:
- Circular level on instrument and tribrach
- Optical plummet - option on tribrach
- Allen screws on tripod

Precise Measurements

To get precise measurements in the daily work, it is important:
- To check and adjust the instrument from time to time.
- To take high precision measurements during the check and adjust procedures.
- To measure targets in two faces. Some of the instrument errors are eliminated by averaging the angles from both faces.

☞

During the manufacturing process, the instrument errors are carefully determined and set to zero. As mentioned above, these errors can change and it is highly recommended to redetermine them in the following situations:
- Before the first use
- Before every high precision survey
- After rough or long transportation
- After long working periods
- After long storage periods
- If the temperature difference between current environment and the temperature at the last calibration is more than 20°C

Summary of Errors to be Adjusted Electronically

Instrument error	Effects Hz	Effects V	Elimination with two face measurement	Automatically corrected with proper adjustment
c - Line of sight error	✓	-	✓	✓
a - Tilting axis error	✓	-	✓	✓
l - Compensator index error	-	✓	✓	✓
t - Compensator index error	✓	-	✓	✓
i - Vertical index error	-	✓	✓	✓
ATRplus Collimation error	✓	✓	-	✓
Co-axial camera collimation error	✓	✓	✓	✓

5.2 Preparation

Before determining the instrument errors, the instrument has to be levelled using the electronic level.
The tribrach, the tripod and the underground should be stable and secure from vibrations or other disturbances.

The instrument should be protected from direct sunlight to avoid thermal warming.
It is also recommended to avoid strong heat shimmer and air turbulence. The best conditions are early in the morning or with overcast sky.

Before starting to work, the instrument has to become acclimatised to the ambient temperature. Approximately two minutes per °C of temperature difference from storage to working environment, but at least 15 min, should be taken into account.

Even after adjustment of the ATRplus, the crosshairs may not be positioned exactly on the centre of the prism after an ATRplus measurement has been completed. This outcome is a normal effect. To speed up the ATRplus measurement, the telescope is normally not positioned exactly on the centre of the prism. These small deviations/ATRplus offsets, are calculated individually for each measurement and corrected electronically. This means that the horizontal and vertical angles are corrected twice: first by the determined ATRplus errors for Hz and V, and then by the individual small deviations of the current aiming.

Next Step

IF the task is to	THEN
adjust a combination of instrument errors	Refer to "5.3 Combined Adjustment (l, t, i, c, ATRplus and Telescope Camera)".
adjust the tilting axis	Refer to "5.4 Tilting Axis Adjustment (a)".
adjust the circular level	Refer to "5.5 Adjusting the Circular Level of the Instrument and Tribrach".
adjust the laser/optical plummet	Refer to "5.7 Inspecting the Laser Plummet of the Instrument".
adjust the tripod	Refer to "5.8 Servicing the Tripod".

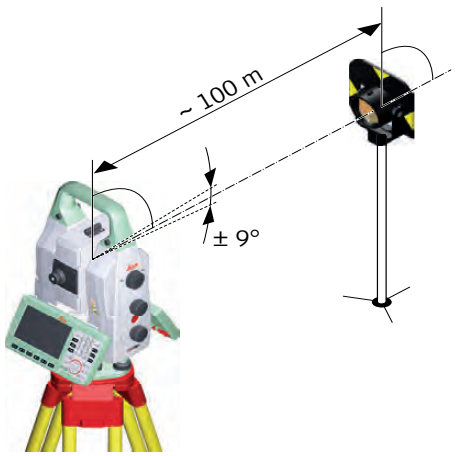
Description

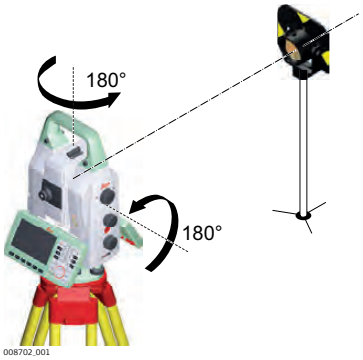
The combined adjustment procedure determines the following instrument errors in one process:

l, t	Compensator longitudinal and transversal index errors
i	Vertical index error, related to the standing axis
c	Horizontal collimation error, also called line of sight error
ATRplus Hz	ATRplus zero point error for horizontal angle
ATRplus V	ATRplus zero point error for vertical angle
Telescope camera Hz	Telescope camera zero point error for horizontal angle - option
Telescope camera V	Telescope camera zero point error for vertical angle - option

Combined Adjustment Procedure Step-by-Step

The following table explains the most common settings.

Step	Description
1.	**Leica Captivate - Home**: **Settings\TS instrument\Check & adjust**
2.	**Check & Adjust** Select the option: **Check & adjust the compensator, index error, line of sight error, automatic target aiming & telescope camera**
3.	**Next**
4.	**Face I measurement** If **Calibrate the automatic target aiming** is checked and an ATRplus is available, the adjustment will include the determination of the ATRplus Hz and V adjustment errors. ☞ Use a clean Leica standard prism as the target. Do not use a 360° prism. If **Calibrate the telescope camera** is checked and a telescope camera is available, the adjustment includes the determination of the telescope camera zero point. ☞ Use a clean Leica standard prism as the target. Do not use a 360° prism.
5.	 Aim the telescope accurately at a target at about 100 m distance. The target must be positioned within ±9°/±10 gon of the horizontal plane. The procedure can be started in any face.

Step	Description
6.	**Measure** to measure and to continue to the next screen.  If **Calibrate the telescope camera** has been checked, aim at the same target accurately with the telescope camera using the view finder and the digital crosshair on the display. **Measure** to measure and to continue to the next screen. ☞ The fine pointing has to be performed manually in both faces.
7.	**Face II measurement** **Measure** to measure the same target in the other face. If **Calibrate the telescope camera** has been checked, aim at the same target accurately with the telescope camera using the view finder and the digital crosshair on the display. **Measure** measure to the target and to calculate the instrument errors.
☞	If one or more errors are bigger than the predefined limits, the procedure must be repeated. All measurements of the current run are rejected and none of them is averaged with the results from previous runs.
8.	Adjustment Status **Number of measurements**: Shows the number of runs completed. One run consists of a measurement in face I and face II. **l Component quality (1 σ)**: and similar lines show the standard deviations of the determined adjustment errors. The standard deviations can be calculated from the second run onwards.
☞	Measure at least two runs.
9.	**Next** to continue with the check & adjust procedure.
10.	Select **Add another calibration loop** if more runs have to be added. **Next** and continue with step 4. OR Select **Finish the calibration & store the results** to finish the calibration process. **Next** to view the adjustment results.
11.	Select **Finish** to accept the results. No more runs can be added later. OR Select **Redo** to decline all measurements and to repeat all calibration runs. OR **Back** returns to the previous screen.

Next Step

IF the results are	THEN
to be stored	If the Use status is set to Yes, **Next** overwrites the old adjustment errors with the new ones.
to be determined again	**Redo** rejects all new determined adjustment errors and repeats the whole procedure. Refer to paragraph "Combined Adjustment Procedure Step-by-Step".

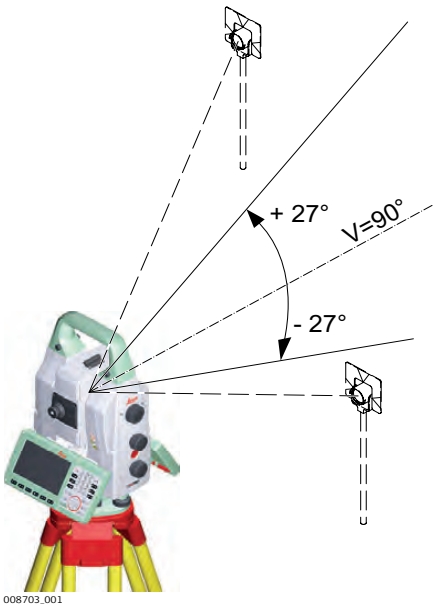
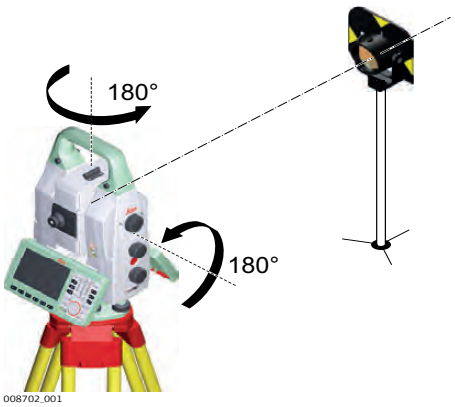
Description

This adjustment procedure determines the following instrument error:

a Tilting axis error

Determination of Tilting Axis Error Step-by-Step

The following table explains the most common settings.

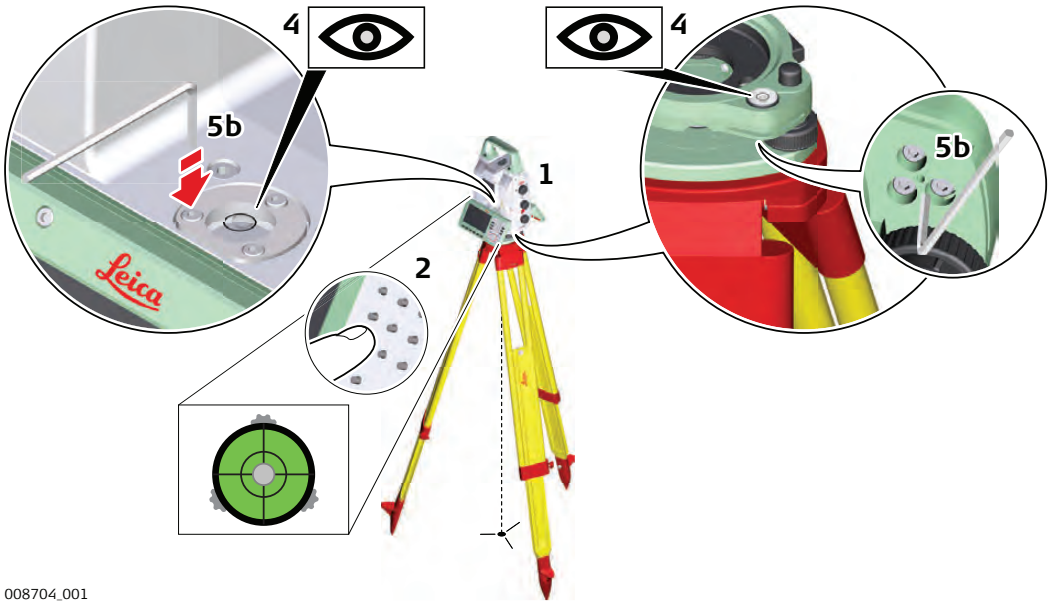
Step	Description
☞	Determine the horizontal collimation error (c) before starting this procedure.
1.	**Leica Captivate - Home**: **Settings\TS instrument\Check & adjust**
2.	**Check & Adjust** Select the option: **Check & adjust the tilting axis**
3.	**Face I measurement**  Aim the telescope accurately at a target at about 100 m distance (or at least 20 m). The target must be positioned at least 27°/30 gon above or beneath the horizontal plane. The procedure can be started in any telescope face.
4.	 **Measure** to measure and to continue to the next screen. ☞ The fine pointing must be performed manually in both faces.
5.	**Face II measurement** **Measure** to measure the same target in the other face and to calculate the tilting axis error.
☞	If the error is bigger than the predefined limit, the procedure must be repeated. The tilting axis measurements of the current run are then rejected and not averaged with the results from previous runs.

Step	Description
6.	Adjustment Status **Number of measurements**: Shows the number of runs completed. One run consists of a measurement in face I and face II. **a T-axis quality (1 σ)**: shows the standard deviation of the determined tilting axis error. The standard deviation can be calculated from the second run onwards.
☞	Measure at least two runs.
7.	**Next** to continue with the check & adjust procedure.
8.	Select **Add another calibration loop** if more runs have to be added. **Next** and continue with step 3. OR Select **Finish the calibration & store the results** to finish the calibration process. No more runs can be added later. **Next** to view the adjustment results.
9.	Select **Finish** to accept the results. No more runs can be added later. OR Select **Redo** to decline all measurements and to repeat all calibration runs.

Next Step

IF the results are	THEN
to be stored	**Next** overwrites the old tilting axis error with the new one.
to be determined again	**Redo** rejects the new determined tilting axis error and repeats the whole procedure. Refer to paragraph "Tilting Axis Adjustment (a)".

Adjusting the Circular Level Step-by-Step

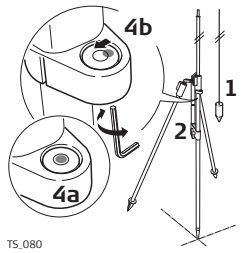


008704_001

Step	Description
1.	Place and secure the instrument into the tribrach and onto a tripod.
2.	Using the tribrach footscrews, level the instrument with the electronic level.
3.	Select **Settings\TS instrument\Level & compensator** to access the **Level & Compensator** screen.
4.	Check the position of the circular level on the instrument and tribrach.
5.	a) If both circular levels are centred, no adjustments are necessary
	b) If one or both circular levels are not centred, adjust as follows:
	Instrument: If it extends beyond the circle, use the supplied allen key to centre it with the adjustment screws. Turn the instrument by 200 gon (180°). Repeat the adjustment procedure if the circular level does not stay centred.
	Tribrach: If it extends beyond the circle, use the supplied allen key to centre it with the adjustment screws.
☞	After the adjustments, all adjusting screws must have the same tightening tension and no adjusting screw should be loose.

5.6 Adjusting the Circular Level of the Prism Pole

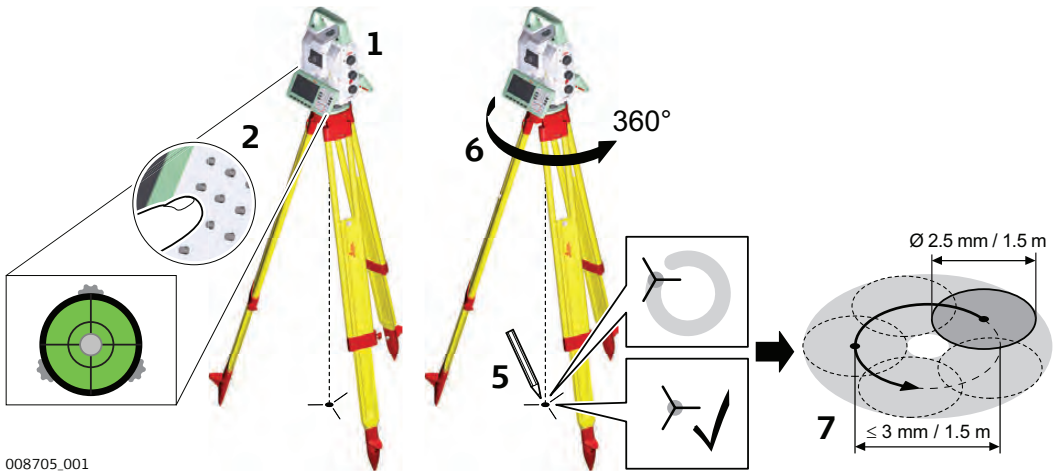
Adjusting the Circular Level Step-by-Step

Step	Description	
1.	Suspend a plumb line.	
2.	Use a pole bipod, to align the prism pole parallel to the plumb line.	
3.	Check the position of the circular level on the prism pole.	
4.	a) If the circular level is centred, no adjustment is necessary. b) If the circular level is not centred, use an allen key to centre it with the adjustment screws.	
☞	After the adjustments, all adjusting screws must have the same tightening tension and no adjusting screw should be loose.	

5.7 Inspecting the Laser Plummet of the Instrument

☞ The laser plummet is located in the vertical axis of the instrument. Under normal conditions of use, the laser plummet does not need adjusting. If an adjustment is necessary due to external influences, return the instrument to any Leica Geosystems authorised service workshop.

Inspecting the Laser Plummet Step-by-Step



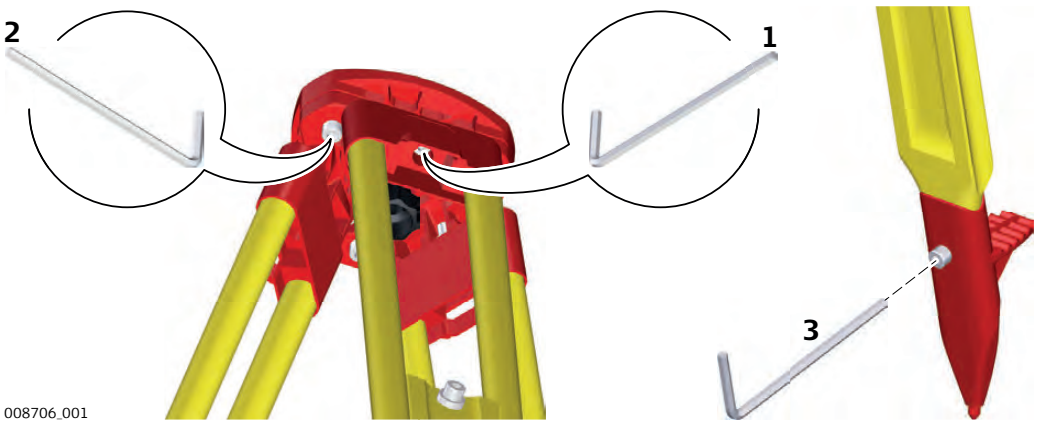
The following table explains the most common settings.

Step	Description
1.	Place and secure the instrument into the tribrach and onto a tripod.
2.	Using the tribrach footscrews, level the instrument with the electronic level.
3.	Select **Settings\TS instrument\Level & compensator** to access the **Level & Compensator** screen.
4.	The laser plummet is switched on when the **Level & Compensator** screen is entered. Adjust the laser plummet intensity. Inspection of the laser plummet should be carried out on a bright, smooth and horizontal surface, like a sheet of paper.
5.	Mark the centre of the red dot on the ground.
6.	Turn the instrument through 360° slowly, carefully observing the movement of the red laser dot.

Step	Description
☞	The maximum diameter of the circular movement described by the centre of the laser point must not exceed 3 mm at a distance of 1.5 m.
7.	If the centre of the laser dot describes a perceptible circular movement, or moves more than 3 mm away from the point which was first marked, an adjustment may be required. Inform your nearest Leica Geosystems authorised service workshop. Depending on brightness and surface, the diameter of the laser dot can vary. At 1.5 m, it is about 2.5 mm.

5.8 Servicing the Tripod

Servicing the Tripod Step-by-Step



The following table explains the most common settings.

Step	Description
☞	The connections between metal and timber components must always be firm and tight.
1.	Tighten the leg cap screws moderately, with the supplied allen key.
2.	Tighten the articulated joints on the tripod head enough to keep the tripod legs open when lifting the tripod off the ground.
3.	Tighten the allen screws of the tripod legs.

6 Care and Transport

6.1 Transport

Transport in the field	When transporting the equipment in the field, always make sure that you • either carry the product in its original transport container, • or carry the tripod with its legs splayed across your shoulder, keeping the attached product upright.
Transport in a road vehicle	Never carry the product loose in a road vehicle, as it can be affected by shock and vibration. Always carry the product in its transport container, original packaging or equivalent and secure it.
Shipping	When transporting the product by rail, air or sea, always use the complete original Leica Geosystems packaging, transport container and cardboard box, or its equivalent, to protect against shock and vibration.
Shipping, transport of batteries	When transporting or shipping batteries, the person responsible for the product must ensure that the applicable national and international rules and regulations are observed. Before transportation or shipping, contact your local passenger or freight transport company.
Field adjustment	Periodically carry out test measurements and perform the field adjustments indicated in the User Manual, particularly after the product has been dropped, stored for long periods or transported.

6.2 Storage

Product	Respect the temperature limits when storing the equipment, particularly in summer if the equipment is inside a vehicle. Refer to "7 Technical Data" for information about temperature limits.
Field adjustment	After long periods of storage inspect the field adjustment parameters given in this user manual before using the product.
Li-Ion batteries	• Refer to "Technical Data" for information about storage temperature range. • Remove batteries from the product and the charger before storing. • After storage recharge batteries before using. • Protect batteries from damp and wetness. Wet or damp batteries must be dried before storing or use. • A storage temperature range of 0 °C to +30 °C / +32 °F to +86 °F in a dry environment is recommended to minimize self-discharging of the battery. • At the recommended storage temperature range, batteries containing a 40% to 50% charge can be stored for up to one year. After this storage period the batteries must be recharged.

6.3 Cleaning and Drying

Product and accessories

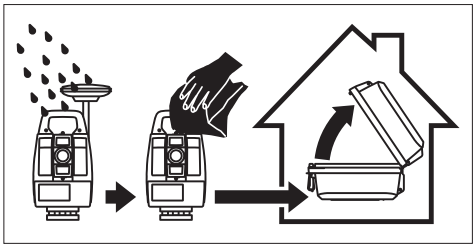
- Blow dust off lenses and prisms.
- Never touch the glass with your fingers.
- Use only a clean, soft, lint-free cloth for cleaning. If necessary, moisten the cloth with water or pure alcohol. Do not use other liquids; these can attack the polymer components.

Fogging of prisms

Prisms that are cooler than the ambient temperature tend to fog. It is not enough simply to wipe them. Keep them for some time inside your jacket or in the vehicle to allow them to adjust to the ambient temperature.

Damp products

Dry the product, the transport container, the foam inserts and the accessories at a temperature not greater than 40°C /104°F and clean them. Remove the battery cover and dry the battery compartment. Do not repack until everything is completely dry. Always close the transport container when using in the field.



Cables and plugs

Keep plugs clean and dry. Blow away any dirt lodged in the plugs of the connecting cables.

6.4 Maintenance

☞ An inspection of the product must be done in a Leica Geosystems authorised service workshop. Leica Geosystems recommends an inspection of the product every 12 months.

As MS60/TS60 instruments are equipped with a self-surveillance system designed for maximum motor performance and long maintenance cycles Leica Geosystems recommends inspection of the product whenever indicated in the message line of the user interface.

7 Technical Data

7.1 Angle Measurement

Accuracy

Type	std. dev. Hz, V, ISO 17123-3		Display least count	
	["]	[mgon]	["]	[mgon]
TS60 R1000	0.5	0.15	0.1	0.01
MS60 R2000	1	0.30	0.1	0.01

Characteristics Absolute, continuous, diametric.

7.2 Distance Measurement with Reflectors

Range

For TS60 - R1000:

Reflector	Range A		Range B		Range C	
	[m]	[ft]	[m]	[ft]	[m]	[ft]
Standard prism (GPR1, GPH1P)	1800	6000	3000	10000	3500	12000
360° prism (GRZ4, GRZ122)	800	2600	1500	5000	2000	7000
360° Mini prism (GRZ101)	450	1500	800	2600	1000	3300
Mini prism (GMP101)	800	2600	1200	4000	2000	7000
Reflector tape (GZM31) 60 mm x 60 mm	150	500	250	800	250	800
Machine Automation power prism (MPR122) ☞ For Machine Control purposes only!	800	2600	1500	5000	2000	7000

Shortest measuring distance: 1.5 m

For MS60 - R2000:

Reflector	Range A		Range B		Range C	
	[m]	[ft]	[m]	[ft]	[m]	[ft]
Standard prism (GPR1, GPH1P)	2200	7300	7500	24600	>10000	>32800
360° prism (GRZ4, GRZ122)	1200	4000	2250	7500	3000	10500
360° Mini prism (GRZ101)	670	2250	1200	3900	1500	5000
Mini prism (GMP101)	1200	4000	1800	6000	3000	10500
Reflector tape (GZM31) 60 mm x 60 mm	220	750	375	1200	370	1200
Machine Automation power prism (MPR122) ☞ For Machine Control purposes only!	1200	4000	2250	7500	3000	10500

Shortest measuring distance: 1.5 m

Atmospheric conditions

Range A: Strong haze, visibility 5 km; or strong sunlight, severe heat shimmer
Range B: Light haze, visibility about 20 km; or moderate sunlight, slight heat shimmer
Range C: Overcast, no haze, visibility about 40 km; no heat shimmer

☞ Measurements can be made to reflector tapes over the entire range without external ancillary optics.

Accuracy

Accuracy refers to measurements to standard prisms.

For TS60 - R1000:

Distance measuring mode	std. dev. ISO 17123-4, standard prism	std. dev. ISO 17123-4, tape**	Measurement time, typical [s]
Precise	0.6 mm + 1 ppm*	1 mm + 1 ppm	7
Standard	1 mm + 1 ppm	1 mm + 1 ppm	2.4
Fast	2 mm + 1 ppm	3 mm + 1 ppm	2.0
Continuously	3 mm + 1 ppm	3 mm + 1 ppm	< 0.15
Averaging	1 mm + 1 ppm	1 mm + 1 ppm	-

Beam interruptions, severe heat shimmer and moving objects within the beam path can result in deviations of the specified accuracy.

* Atmospheric conditions type C, range up to 1000 m, GPH1P reflector
** Target aligned to instrument

For MS60 - R2000:

Distance measuring mode	std. dev. ISO 17123-4, standard prism	std. dev. ISO 17123-4, tape*	Measurement time, typical [s]
Standard	1 mm + 1.5 ppm	1 mm + 1.5 ppm	1.5
Fast	2 mm + 1.5 ppm	3 mm + 1.5 ppm	1.0
Continuously	2 mm + 1.5 ppm	3 mm + 1.5 ppm	>0.05**
Averaging	1 mm + 1.5 ppm	1 mm + 1.5 ppm	-

Beam interruptions, severe heat shimmer and moving objects within the beam path can result in deviations of the specified accuracy.

* Target aligned to instrument
** Auto point application increases the measurement time

Characteristics

Type: Coaxial, visible red laser
Carrier wave: 658 nm
Measuring system: R1000: System Analyzer Basis 100 MHz - 150 MHz
R2000: Wave Form Digitizer

Range

Type	Kodak Gray Card	Range D		Range E		Range F	
		[m]	[ft]	[m]	[ft]	[m]	[ft]
R1000	White side, 90 % reflective	800	2630	1000	3280	>1000	>3280
R1000	Grey side, 18 % reflective	400	1320	500	1640	>500	>1640
R2000	White side, 90 % reflective	1500	4920	2000	6560	>2000	>6560
R2000	Grey side, 18 % reflective	750	2460	1000	3280	>1000	>3280

Range of measurement:

R1000: 1.5 m - 1200 m
R2000: 1.5 m - 2400 m
Distance measurements below 1.5 m are not possible.

Atmospheric conditions

D: Object in strong sunlight, severe heat shimmer
E: Object in shade, sky overcast
F: Underground, night and twilight

Accuracy

For TS60 - R1000:

Standard measuring	std. dev. ISO 17123-4	Measure time, typical [s]	Measure time, maximum [s]
0 m - 500 m	2 mm + 2 ppm	3	12
>500 m	4 mm + 2 ppm	6	12

Object in shade, sky overcast. Beam interruptions, severe heat shimmer and moving objects within the beam path can result in deviations of the specified accuracy. The display resolution is 0.1 mm.

For MS60 - R2000:

Standard measuring	std. dev. ISO 17123-4	Measure time, typical [s]	Measure time, maximum [s]
0 m - 500 m	2 mm + 2 ppm	1.5	14
>500 m	4 mm + 2 ppm	4	14

Object in shade, sky overcast. Beam interruptions, severe heat shimmer and moving objects within the beam path can result in deviations of the specified accuracy. The display resolution is 0.1 mm.

* Auto point application increases the measurement time

Characteristics

Type: Coaxial, visible red laser
Carrier wave: 658 nm
Measuring system: R1000: System Analyzer Basis 100 MHz - 150 MHz
R2000: Wave Form Digitizer

Laser dot size

Distance [m]	Laser dot size, approximately [mm]
at 30	7 x 10
at 50	8 x 20
at 100	16 x 25

7.4 Distance Measurement - Long Range (LO mode)

Availability

Only available for TS60.

Range

Reflector	Range A		Range B		Range C	
	[m]	[ft]	[m]	[ft]	[m]	[ft]
Standard prism (GPR1, GPH1P)	2200	7300	7500	24600	>10000	>32800

Range of measurement: 1000 m to 12000 m
Display unambiguous: up to 12000 m

Atmospheric conditions

Range A: Strong haze, visibility 5 km; or strong sunlight, severe heat shimmer
Range B: Light haze, visibility about 20 km; or moderate sunlight, slight heat shimmer
Range C: Overcast, no haze, visibility about 40 km; no heat shimmer

Accuracy

Standard measuring	std. dev. ISO 17123-4	Measure time, typical [s]	Measure time, maximum [s]
Long Range	3 mm + 1 ppm	2.5	12

Beam interruptions, severe heat shimmer and moving objects within the beam path can result in deviations of the specified accuracy. The display resolution is 0.1 mm.

Characteristics

Principle: Phase measurement
Type: Coaxial, visible red laser
Carrier wave: 658 nm
Measuring system: System analyser basis 100 MHz - 150 MHz

Range of Target Aiming/ Target Locking

For MS60/TS60:

Prism	Range (Target Aiming)		Range (Target Locking)	
	[m]	[ft]	[m]	[ft]
Standard prism (GPR1)	1500	5000	1000	3300
360° prism (GRZ4, GRZ122)	1000	3300	1000	3300
360° Mini prism (GRZ101)	450	1500	250	830
Mini prism (GMP101)	900	3000	600	2000
Reflector tape (GZM31) 60 mm x 60 mm	55	190	not qualified	
Machine Automation power prism (MPR122) ☞ For Machine Control purposes only!	750	2500	650	2200
☞ The maximum range can be restricted by poorer conditions, for example rain.				

Shortest measuring distance: 360° prism (Target aiming): 1.5 m
Shortest measuring distance: 360° prism (Target locking): 5 m

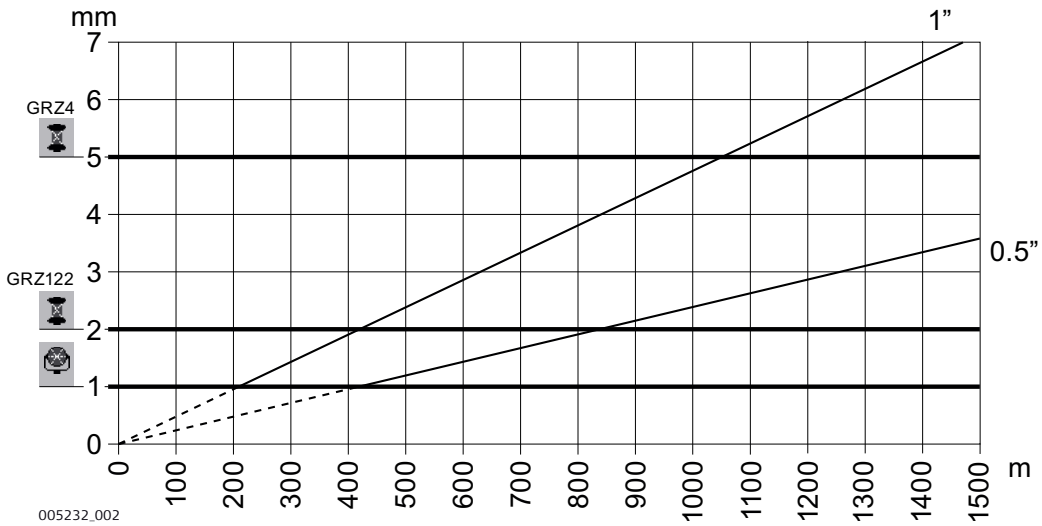
ATRplus Accuracy with the GPR1 Prism

ATRplus angle accuracy Hz, V (std. dev. ISO 17123-3, atmospheric conditions type C):

TS60, 0.5":	0.5 " (0.15 mgon)
MS60, 1":	1 " (0.3 mgon)

Measurement Accuracy with ATRplus

- The accuracy with which the position of a prism can be determined with Automatic Target Aiming (ATRplus) depends on several factors such as internal ATRplus accuracy, instrument angle accuracy, prism type, selected EDM measuring program and the external measuring conditions. The ATRplus has a basic standard deviation level of ±1 mm for 1" instruments and ±0.5 mm for 0.5" instruments.
- The following graph shows the typical ATRplus measurement accuracies based on three different prism types, distances and instrument accuracies.



Leica GRZ4 prism (360°)

Leica GRZ122 prism (360°)

Leica circular prisms and Leica circular Mini prisms

mm ATRplus accuracy [mm]
m Distance measurement [m]
" Instrument angle accuracy ["]

Maximum Speed in Lock Mode

Maximum tangential speed:	9 m/s at 20 m; 45 m/s at 100 m
Maximum radial speed with **Measure distance**: **Continuously**	5 m/s for TS60 14 m/s for MS60

Searching

Typical search time in field of view:	1.5 s
Field of view:	1°25′/1.55 gon
Definable search window:	Yes

Characteristics

Principle:	Digital image processing
Type:	Infrared laser

7.6 Scanning

Availability

Available for MS60 R2000 and on CS when connected to MS60 R2000.

Range

The following ranges refer to optimal measurement conditions (object in shade, sky overcast, static target object).

Mode	Kodak Grey Card (Albedo 90%)	Range, up to	
		[m]	[ft]
1000 Hz	White side, 90% Albedo	300	980
250 Hz		400	1310
62 Hz		500	1640
>1 Hz		1000	3280

Shortest measuring distance: 1.5 m

Accuracy

Range noise* (1 sigma; Kodak Grey Card (Albedo 90%)):

Distance	1000 Hz	250 Hz	62 Hz	1 Hz
10 m	0.6 mm	0.5 mm	0.4 mm	0.4 mm
25 m	0.8 mm	0.6 mm	0.5 mm	0.5 mm
50 m	1.0 mm	0.8 mm	0.6 mm	0.6 mm
100 m	2.0 mm	1.0 mm	0.8 mm	0.8 mm
200 m	6.0 mm	3.0 mm	2.0 mm	1.8 mm

Object in shade, sky overcast. Beam interruptions, severe heat shimmer and moving objects within the beam path can result in deviations of the specified range noise and accuracy.

* Range noise describes the standard deviation of the scan points residuals to the modelled surface:
- Plane surface target
- Perpendicular orientation of the plane target to the measurement direction
- Modelled plane best fitted into the point cloud

The absolute position accuracy of a modelled surface is similar to an RL single measurement:

Standard measuring	std. dev. ISO 17123-4
0 m - 500 m	2 mm + 2 ppm
>500 m	4 mm + 2 ppm

7.7 PowerSearch PS

Range

Reflector	Range PS	
	[m]	[ft]
Standard prism (GPR1)	300	1000
360° prism (GRZ4, GRZ122)	300*	1000*
360° mini prism (GRZ101)	Not recommended	
Mini prism (GMP101)	100	330
Machine Automation power prism (MPR122) ☞ For Machine Control purposes only!	300*	1000*

Measurements at the vertical limits of the fan or under unfavourable atmospheric conditions may reduce the maximum range. (*optimally aligned to the instrument)

Shortest measuring distance: 1.5 m

Searching

Typical search time:	5 - 10 s
Rotating Speed:	up to 100 gon/s
Default search area:	Hz: 400 gon, V: 40 gon
Definable search windows:	Yes

Characteristics

Principle:	Digital signal processing
Type:	Infrared laser

7.8 Overview Camera

Overview camera

Sensor:	5 Mpixel CMOS sensor
Focal length:	21 mm
Field of view:	15.5° x 11.7° (19.4° diagonal)
Frame rate:	≤20 frames per second
Focus:	2 m (6.6 ft) to infinity at zoom level 1 x 7.5 m (24.6 ft) to infinity at zoom level 4 x
Image storage:	JPEG up to 5 Mpixel (2560 x 1920)
Zoom:	4-step (1x, 2x, 4x, 8x)
Whitebalance:	Automatic and user configurable
Brightness:	Automatic and user configurable

7.9 Telescope Camera

Telescope camera

Sensor:	5 Mpixel CMOS sensor
Focal length:	At ∞ 231mm
Field of view:	1.5° diagonal
Frame rate:	≤20 frames per second
Focus:	Servofocus: Manual motorised focus, available for all variants instrument types Autofocus: Automatic focusing, available for instruments with imaging functionality
Time to focus:	Typical 2 s
Focus range:	1.7 m to infinity
Image storage:	JPEG up to 5 Mpixel (2560 x 1920)
Zoom, digital:	4-step (1x, 2x, 4x, 8x)
Whitebalance:	Automatic and user configurable
Brightness:	Automatic and user configurable

7.10 SmartStation

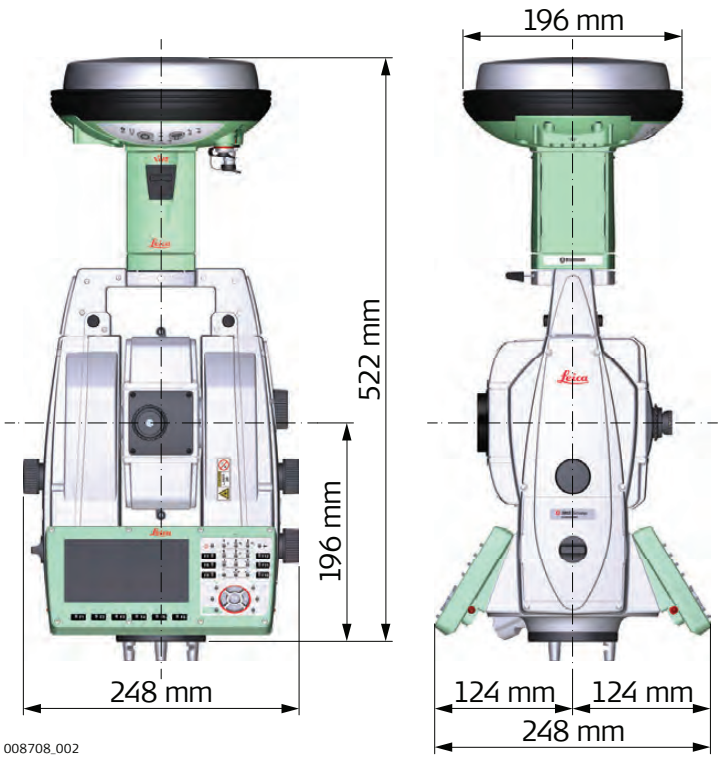
7.10.1 SmartStation Accuracy

☞ Measurement precision and accuracy in position and accuracy in height are dependent upon various factors including the number of satellites tracked, constellation geometry, observation time, ephemeris accuracy, ionospheric disturbance, multipath and resolved ambiguities. Figures quoted assume normal to favourable conditions.
Times required are dependent upon various factors including number of satellites, geometry, ionospheric conditions, multipath and so on. GS and GLONASS can increase performance and accuracy by up to 30 % relative to GS only. A full Galileo and GS L5 constellation will further increase measurement performance and accuracy.

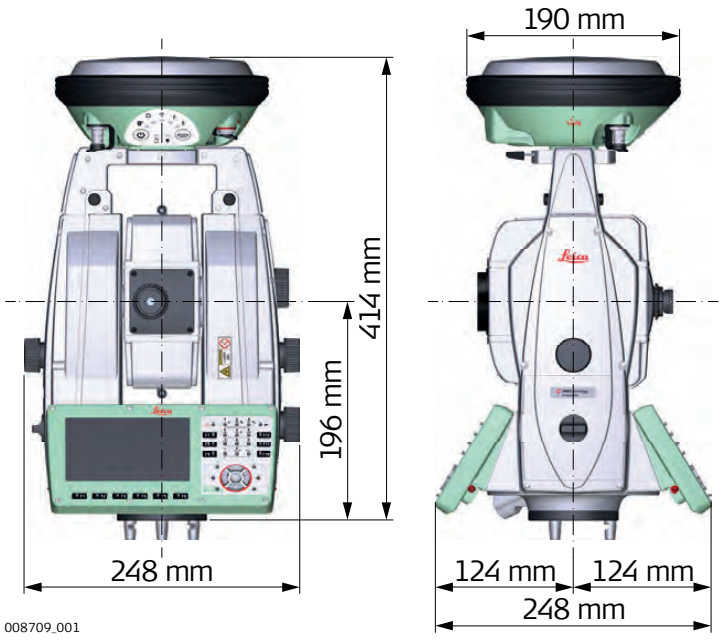
Accuracy	Position accuracy:	Horizontal: 10 mm + 1 ppm Vertical: 20 mm + 1 ppm When used within reference station networks the position accuracy is in accordance with the accuracy specifications provided by the reference station network.
Initialisation	Method:	Real-time (RTK)
	Reliability of initialisation:	Better than 99.99 %
	Time of initialisation:	Typically 8 s, with 5 or more satellites on L1 and L2
	Range:	Up to 50 km, assuming reliable data-link is available
RTK Data Formats	Formats for data reception:	Leica, Leica 4G, CMR, CMR+, RTCM 2.2, 2.3, 3.0, 3.1, 3.2 MSM

SmartStation Dimensions

With GS15



With GS14/GS16



7.11 Conformity to National Regulations

7.11.1 MS60/TS60

Conformity to national regulations

- FCC Part 15 (applicable in US)
- Hereby, Leica Geosystems AG, declares that the product MS60/TS60 is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC and other applicable European Directives. The declaration of conformity may be consulted at http://www.leica-geosystems.com/ce.

  CE Class 1 equipment according European Directive 1999/5/EC (R&TTE) can be placed on the market and be put into service without restrictions in any EU Member state.
- The conformity for countries with other national regulations not covered by the FCC part 15 or European directive 1999/5/EC has to be approved prior to use and operation.
- Japanese Radio Law and Japanese Telecommunications Business Law Compliance.
  - This device is granted pursuant to the Japanese Radio Law and the Japanese Telecommunications Business Law.
  - This device should not be modified (otherwise the granted designation number will become invalid).

Frequency band

Type	Frequency band [MHz]
Bluetooth	2402 - 2480
WLAN	2400 - 2473, channel 1-11

Output Power

Type	Output power [mW]
Bluetooth	< 15
WLAN (802.11b)	100
WLAN (802.11g)	60

Antenna

Type	Antenna	Gain [dBi]	Connector	Frequency band [MHz]
Bluetooth	Integrated antenna	2	-	2400 - 2500
WLAN				

7.11.2 RadioHandle

Conformity to national regulations for RH16

- FCC Part 15 (applicable in US)
- The conformity for countries with other national regulations not covered by the FCC part 15.
- Japanese Radio Law and Japanese Telecommunications Business Law Compliance.
  - This device is granted pursuant to the Japanese Radio Law (電波法) and the Japanese Telecommunications Business Law (電気通信事業法).
  - This device should not be modified (otherwise the granted designation number will become invalid).

Conformity to national regulations for RH17

- FCC Part 15 (applicable in US)
- Hereby, Leica Geosystems AG, declares that the RadioHandle is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC and other applicable European Directives. The declaration of conformity may be consulted at http://www.leica-geosystems.com/ce.

  CE Class 1 equipment according European Directive 1999/5/EC (R&TTE) can be placed on the market and be put into service without restrictions in any EEA Member state.
- The conformity for countries with other national regulations not covered by the FCC part 15 or European directive 1999/5/EC has to be approved prior to use and operation.
- Japanese Radio Law and Japanese Telecommunications Business Law Compliance.
  - This device is granted pursuant to the Japanese Radio Law (電波法) and the Japanese Telecommunications Business Law (電気通信事業法).
  - This device should not be modified (otherwise the granted designation number will become invalid).

Frequency Band

RH16	Limited to 2402 - 2480 MHz
RH17	Limited to 2402 - 2480 MHz

Output power

< 100 mW (e. i. r. p.)

Antenna

Type:	λ/2 dipole antenna
Gain:	2 dBi
Connector:	Special customized SMB

7.11.3 Dangerous Goods Regulations

Dangerous Goods Regulations

The products of Leica Geosystems are powered by Lithium batteries.
Lithium batteries can be dangerous under certain conditions and can pose a safety hazard. In certain conditions, Lithium batteries can overheat and ignite.

☞ When carrying or shipping your Leica product with Lithium batteries onboard a commercial aircraft, you must do so in accordance with the **IATA Dangerous Goods Regulations**.

☞ Leica Geosystems has developed **Guidelines** on "How to carry Leica products" and "How to ship Leica products" with Lithium batteries. Before any transportation of a Leica product, we ask you to consult these guidelines on our web page (http://www.leica-geosystems.com/dgr) to ensure that you are in accordance with the IATA Dangerous Goods Regulations and that the Leica products can be transported correctly.

☞ Damaged or defective batteries are prohibited from being carried or transported onboard any aircraft. Therefore, ensure that the condition of any battery is safe for transportation.

7.12 General Technical Data of the Instrument

Telescope

Magnification:	30 x
Clear objective diameter:	40 mm
Focusing:	1.7 m/5.6 ft to infinity
Field of view:	1°30′/1.66 gon. 2.7 m at 100 m

Compensator

Type	Setting accuracy		Setting range	
	["]	[mgon]	[′]	[gon]
All types	0.5	0.15	4	0.07

Level

Compensation:	Centralised quadruple axis compensation
Circular level sensitivity:	6′/2 mm
Electronic level resolution:	2"

Control Unit

Display:	WVGA (800 x 480 pixels), colour, graphics capable LCD, illumination, touch screen
Keyboard:	37 keys including 12 function keys and 12 alphanumeric keys, illumination
Angle Display:	360°′", 360° decimal, 400 gon, 6400 mil, V %
Distance Display:	m, ft int, ft us, ft int inch, ft us inch
Position:	TS60/MS60 both faces
Touch screen:	Screen protection foil on glass

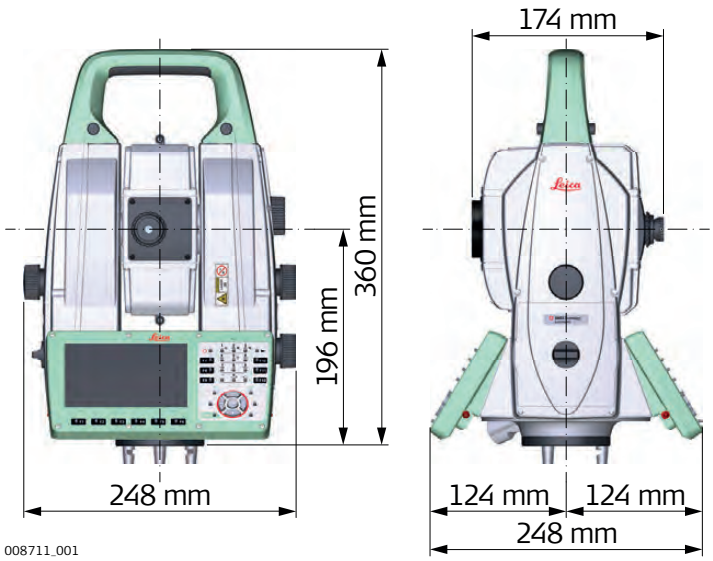
Instrument Ports

Name	Description
Serial/USB	• 8 pin LEMO-1 for power, communication, data transfer. • This port is located at the base of the instrument.
RadioHandle	• Hotshoe connection for RadioHandle with Remote Mode and SmartAntenna Adapter with SmartStation. • This port is located on top of the Communication side cover.
Bluetooth	• Bluetooth module for communication. • This port is housed within the Communication side cover.
WLAN	• WLAN module for communication. • This port is housed within the Communication side cover.
USB host port	• USB memory stick port for data transfer.

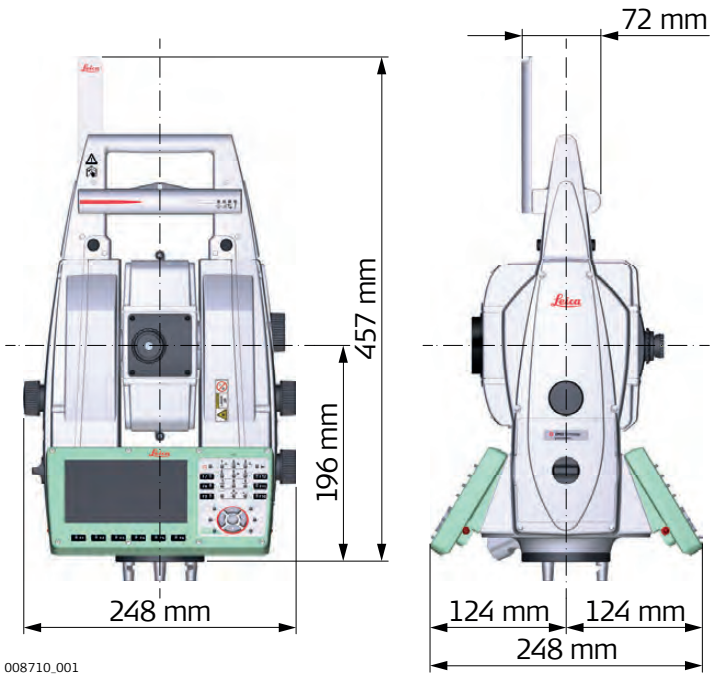
Pin Assignments of the 8 Pin LEMO-1 Port

a) Pin 1: USB data line (In or out)
b) Pin 2: USB data line (In or out)
c) Pin 3: Signal ground
d) Pin 4: RxD (RS232, receive data, In)
e) Pin 5: TxD (RS232, transmit data, Out)
f) Pin 6: Identification pin (In or out)
g) Pin 7: Power input, nominal +12 V (11 V - 16 V, In)
h) Pin 8: Not connected

Instrument Dimensions



With RH16/RH17



Weight

Instrument:	7.27 kg
Tribrach:	0.8 kg
Internal battery:	0.43 kg

Recording

Data can be recorded onto an SD card or into internal memory.

Type	Capacity [MB]	Number of measurements per MB
SD card	• 1024 • 8192	1750
Internal memory	• 2048	1750

Laser Plummet

Type:	Visible red laser class 2
Location:	In standing axis of instrument
Accuracy:	Deviation from plumbline: 1.5 mm at 1.5 m instrument height Diameter of laser point: 2.5 mm at 1.5 m instrument height

Operation

Three endless drives:	For one and two hand manual operation
User defined Smartkey:	Fast precision triggerkey for manual high precision measurements

Motorisation

Maximum acceleration:	400 gon/s^2
Maximum rotating speed:	200 gon/s
Time for change face:	Typically 2.9 s

Power

External supply voltage:	Nominal voltage 12.8 V DC Range 12 V-18 V
Standby power consumption:	Typically 0.3 W
Operating power consumption:	Typically 12 W (max. 40 W)

Internal Battery

GEB242	
Type:	Li-Ion
Voltage:	14.8 V
Capacity:	5.8 Ah

External battery

GEB371	
Type:	Li-Ion
Voltage:	14.8 V
Capacity:	16.8 Ah

Environmental Specifications

Temperature

Type	Operating temperature [°C]	Storage temperature [°C]
All types	-20 to +50	-40 to +70
Leica SD cards, all sizes	-40 to +80	-40 to +80
Battery internal	-20 to +55	-40 to +70

Protection against water, dust and sand

Type	Protection
All types	IP65 (IEC 60529)

Humidity

Type	Protection
All types	Max 95 % non condensing The effects of condensation are to be effectively counteracted by periodically drying out the instrument.

Reflectors

Type	Additive Constant [mm]	ATRplus	PS
Standard prism, GPR1	0.0	yes	yes
Mini prism, GMP101	+17.5	yes	yes
360° prism, GRZ4 / GRZ122	+23.1	yes	yes
360° Mini prism, GRZ101	+30.0	yes	not recommended
Reflector tape S, M, L	+34.4	yes	no
Reflectorless	+34.4	no	no
Machine Automation power prism, MPR122 ☞ For Machine Control purposes only!	+28.1	yes	yes

There are no special prisms required for ATRplus or for PS.

Electronic Guide Light EGL

Working range: 5 m to 150 m (15 ft to 500 ft)
Position accuracy: 5 cm at 100 m (1.97" at 330 ft)

Automatic Corrections

The following automatic corrections are made:

- Line of sight error
- Tilting axis error
- Earth curvature
- Circle eccentricity
- Compensator index error
- Vertical index error
- Standing axis tilt
- Refraction
- ATRplus zero point error
- Telescope camera zero point error

7.13 Scale Correction

Use of scale correction

By entering a scale correction, reductions proportional to distance can be taken into account.

- Atmospheric correction.
- Reduction to mean sea level.
- Projection distortion.

Atmospheric correction ΔD1

The slope distance displayed is correct if the scale correction in ppm, mm/km, which has been entered corresponds to the atmospheric conditions prevailing at the time of the measurement.

The atmospheric correction includes:

- Adjustments for air pressure
- Air temperature
- Relative humidity

For highest precision distance measurements, the atmospheric correction should be determined with an accuracy of 1 ppm. The following parameters must be redetermined:

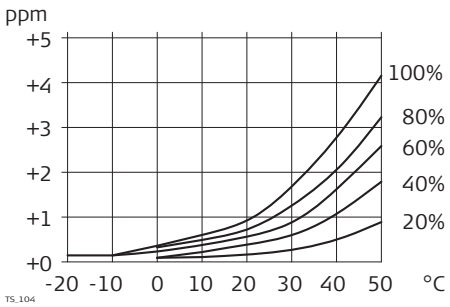
- Air temperature to 1 °C
- Air pressure to 3 mbar
- Relative humidity to 20 %

Air humidity

The air humidity influences the distance measurement if the climate is extremely hot and damp.

For high precision measurements, the relative humidity must be measured and entered along with the air pressure and the temperature.

Air humidity correction



ppmAir humidity correction [mm/km]
% Relative humidity [%]
C° Air temperature [°C]

Index n

Type	Index n	Carrier wave [nm]
MS60 with R2000 (Wave Form Digitizer)	1.0002863	658
TS60 with R1000 Combined EDM (Phase Shift / System Analyzer)		

The index n is calculated from the formula of the IAG Resolutions (1999), and is valid for:

Air pressure p: 1013.25 mbar
Air temperature t: 12 °C
Relative air humidity h: 60 %

Formulas

Formula for visible red laser

$$\Delta D_1 = 286.338 - \left[\frac{0.29535 \cdot p}{(1 + \alpha \cdot t)} - \frac{4.126 \cdot 10^{-4} \cdot h}{(1 + \alpha \cdot t)} \cdot 10^{x} \right]$$

002419_002

ΔD_1 Atmospheric correction [ppm]
p Air pressure [mbar]
t Air temperature [°C]
h Relative humidity [%]
α $\frac{1}{273.15}$
x (7.5 * t/(237.3 + t)) + 0.7857

If the basic value of 60 % relative humidity as used by the EDM is retained, the maximum possible error in the calculated atmospheric correction is 2 ppm, 2 mm/km.

Reduction to mean sea level ΔD_2

The values for ΔD_2 are always negative and are derived from the following formula:

$$\Delta D_2 = - \frac{H}{R} \cdot 10^6$$

TS_106

ΔD_2 Reduction to mean sea level [ppm]
H Height of EDM above sea level [m]
R 6.378 * 10^6 m

Projection distortion ΔD_3

The magnitude of the projection distortion is in accordance with the projection system used in a particular country, for which official tables are generally available. The following formula is valid for cylindrical projections such as that of Gauss-Krüger:

$$\Delta D_3 = \frac{X^2}{2R^2} \cdot 10^6$$

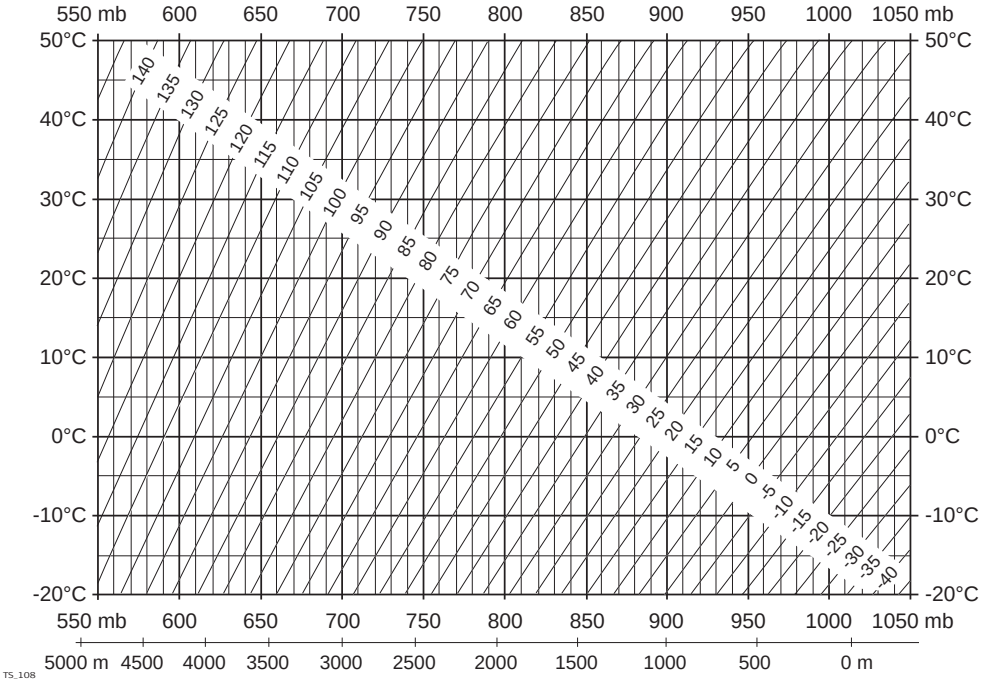
TS_107

ΔD_3 Projection distortion [ppm]
X Easting, distance from projection zero line with the scale factor 1 [km]
R 6.378 * 10^6 m

In countries where the scale factor is not unity, this formula cannot be directly applied.

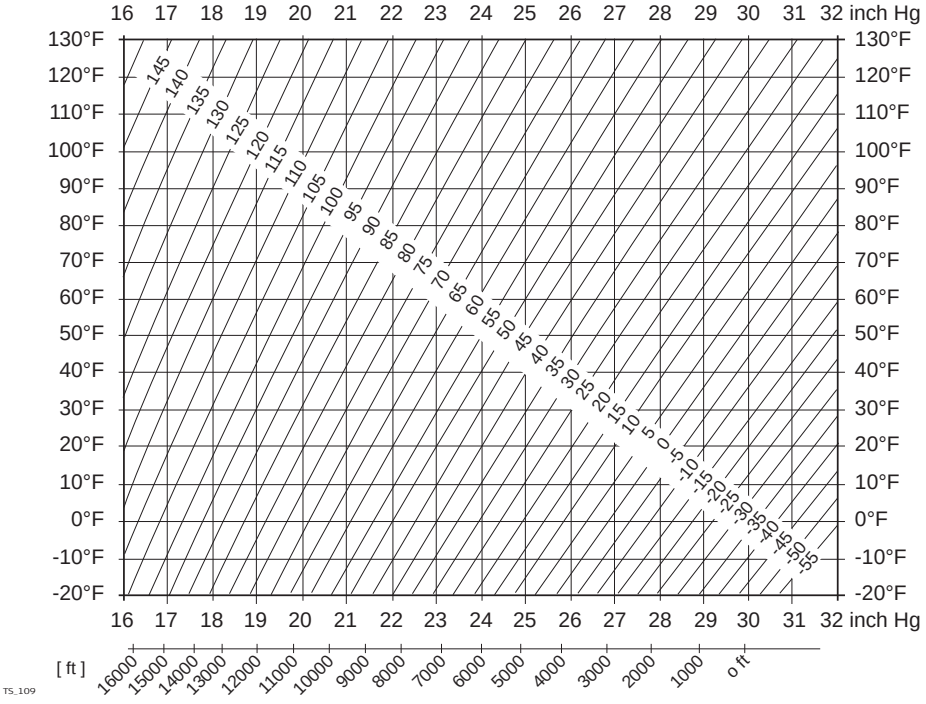
Atmospheric corrections °C

Atmospheric corrections in ppm with temperature [°C], air pressure [mb] and height [m] at 60 % relative humidity.

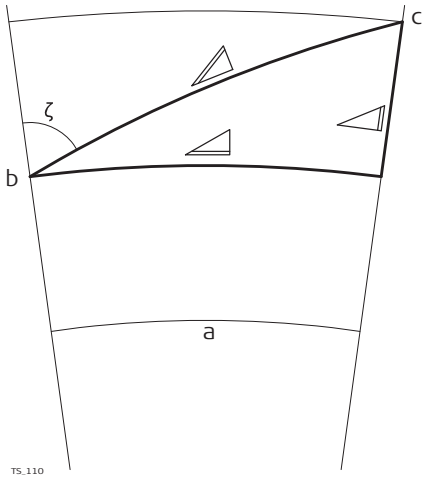


Atmospheric correction °F

Atmospheric corrections in ppm with temperature [°F], air pressure [inch Hg] and height [ft] at 60 % relative humidity.



Measurements



a) Mean Sea Level
b) Instrument
c) Reflector
◿ Slope distance
◿ Horizontal distance
◿ Height difference

Reflector types

The reduction formulas are valid for measurements to all reflector types:
- measurements to prisms, to reflector tape and reflectorless measurements.

Formulas

The instrument calculates the slope distance, horizontal distance, height difference in accordance with the following formulas:

$$\text{◿} = D_0 \cdot (1 + ppm \cdot 10^{-6}) + mm$$
TS_111

◿ Displayed slope distance [m]
D_0 Uncorrected distance [m]
ppm Atmospheric scale correction [mm/km]
mm Additive constant of the reflector [mm]

$$\text{◿} = Y - A \cdot X \cdot Y$$
TS_112

$$\text{◿} = X + B \cdot Y^2$$
TS_113

◿ Horizontal distance [m]
◿ Height difference [m]
Y ◿ * |sinζ|
X ◿ * cosζ
ζ Vertical circle reading
A $(1 - k/2)/R = 1.47 * 10^{-7}$ [m^{-1}]
B $(1 - k)/2R = 6.83 * 10^{-8}$ [m^{-1}]
k 0.13 (mean refraction coefficient)
R $6.378 * 10^6$ m (radius of the earth)

Earth curvature (1/R) and mean refraction coefficient (k) are automatically taken into account when calculating the horizontal distance and height difference. The calculated horizontal distance relates to the station height and not to the reflector height.

Distance measuring program Averaging

In the distance measuring program Averaging, the following values are displayed:

D Slope distance as arithmetic mean of all measurements
s Standard deviation of a single measurement
n Number of measurements

These values are calculated as follows:

$$\bar{D} = \frac{1}{n} \cdot \sum_{i=1}^{n} D_i$$

TS_114

- $\bar{D}$ Slope distance as arithmetic mean of all measurements
- $\sum$ Sum
- D_i Single slope distance measurement
- n Number of measurements

$$s = \sqrt{\frac{\sum_{i=1}^{n} (D_i - \bar{D})^2}{n - 1}} = \sqrt{\frac{\sum_{i=1}^{n} D_i^2 - \frac{1}{n} (\sum_{i=1}^{n} D_i)^2}{n - 1}}$$

TS_115

- s Standard deviation of a single slope distance measurement
- $\sum$ Sum
- $\bar{D}$ Slope distance as arithmetic mean of all measurements
- D_i Single slope distance measurement
- n Number of distance measurements

The standard deviation $s_{\bar{D}}$ of the arithmetic mean of the distance can be calculated as follows:

$$s_{\bar{D}} = \frac{s}{\sqrt{n}}$$

TS_116

- $s_{\bar{D}}$ Standard deviation of the arithmetic mean of the distance
- s Standard deviation of a single measurement
- n Number of measurements

8 Software Licence Agreement

Software Licence Agreement

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