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Unique. Accurate. Simple.

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- Leica Geosystems understands construction and provides levels for all needs
- Protected shape for increased ergonomic handling while ensuring the highest quality results
- Simple handling for quick and accurate measurements

KEY BENEFITS

- Quick and easy measurements
- Unique design and highest quality of results for levelling needs
- Manufactured for the most rugged sites and the harshest conditions
- Expert knowledge of Leica Geosystems with more than 270 service centres worldwide
- Unbeaten service offering

PART OF HEXAGON

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Leica Geosystems

Leica NA300 Series

Leica NA320

Leica NA324

Leica NA332

TECHNICAL DATA			
Standard deviation for 1 km double levelling (ISO17123-2)	2.5 mm	2.0 mm	1.8 mm
TELESCOPE			
Telescope image		Upright	
Magnification	20 x	24 x	32 x
Objective aperture		36 mm	
Shortest target distance from instr. axis		< 1.0 m	
Field of view at 100 m		< 2.1 m	
Multiplication factor		100	
Additive constant		0	
COMPENSATOR			
Working range		± 15'	
Setting accuracy (standard deviation)		< 0.5''	
Sensitivity		8'/2 mm	
HORIZONTAL CIRCLE			
Graduation		360°	
Graduation interval		1°	
Weight (net)		1.5 kg	
Operating temperature range		–20° C to +40° C	

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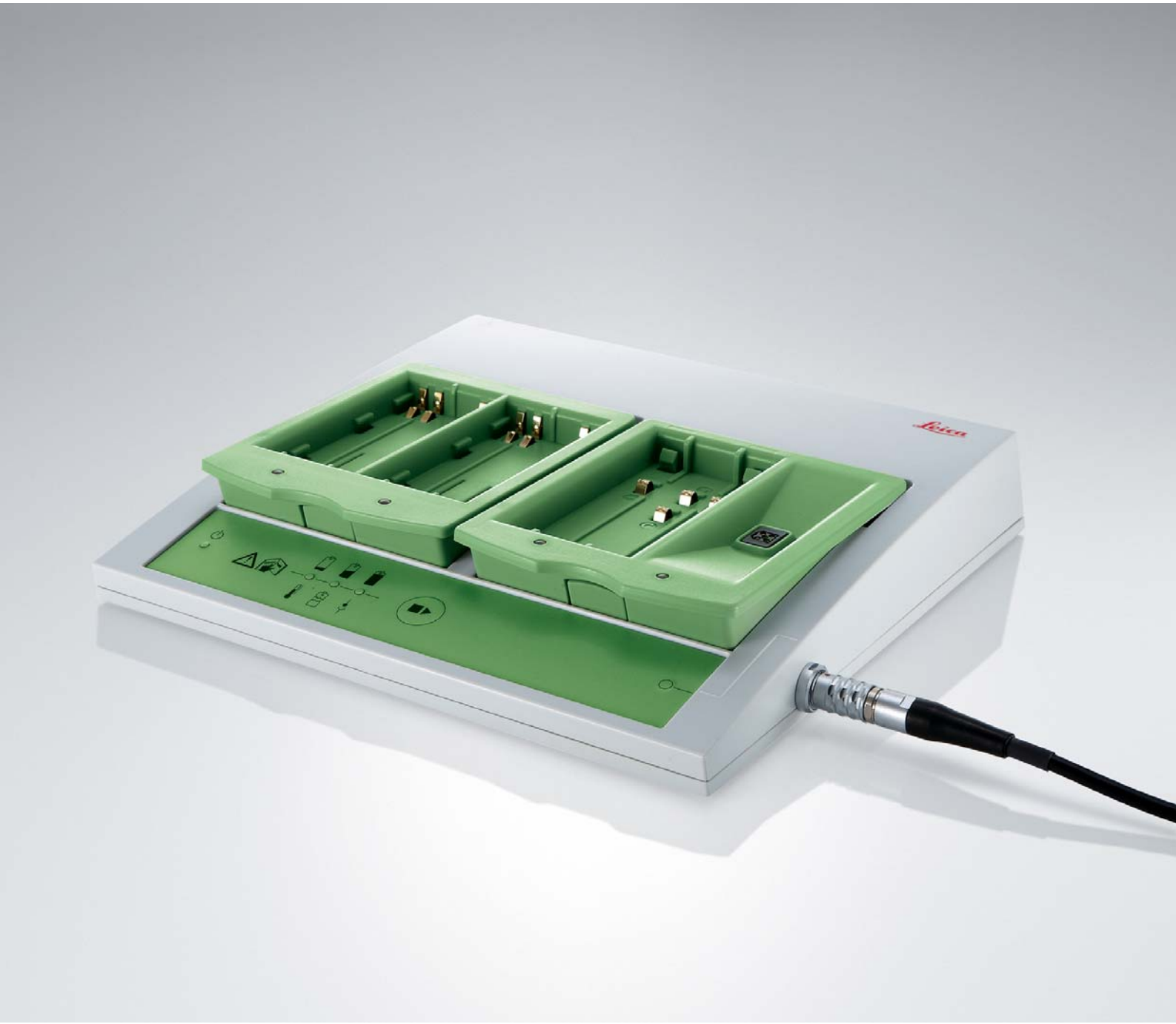
Leica Geosystems

Batteries and Chargers - White Paper

Technical Specifications and Characteristics



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Leica Geosystems

May 2010

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Technical Specifications and Characteristics of Leica Geosystems Batteries and Chargers

Gerhard Soenser

Abstract

This paper presents an overview of the different factors regarding batteries and card-readers that should be considered by the surveyor in order to ensure the highest quality and best system performance.

It describes the regulations and guidelines that batteries and chargers must fulfill in order to comply with the requirements for being an approved Leica Geosystems Product.

Introduction

The reliable supply of power to surveying equipment forms one of the most important preconditions for all surveying tasks in the field. It is a basic precondition for the operation of the equipment and an important factor for the equipment to function faultlessly and reliably in all environmental conditions.
For batteries to have a long service life, achieve their optimum performance and function faultlessly, they must be correctly maintained, stored, charged and discharged. Incorrect handling of batteries and chargers may lead to battery malfunction and premature loss of capacity.
This product information summarises the most important and useful information on the chargers and batteries manufactured by Leica Geosystems for surveying instruments and systems.

Charging technology

Leica Geosystems currently provides quick chargers as a matter of preference (accelerated charging).
These charge the batteries in a shorter time. They ensure, thanks to the latest charging technology, appropriate charging and therefore, the long life of the batteries. The chargers are temperature-monitored so that, for example, at low temperatures the batteries are charged more gently.

Leica Geosystems chargers are divided into two product lines: Professional 5000 charging stations for the highest demands and functionality and Professional 3000 chargers as the simple, low-cost alternative.
For batteries with 5-pin charging sockets, a simple, low-cost normal charger with reduced functionality is still available.

Professional 5000 charging station GKL221

The GKL221 is an intelligent charging station with advanced charging technology. It is suitable for charging the Leica Geosystems batteries listed below and ensures the optimal battery operation with your Leica Geosystems device.

Power supply

The GKL221 can be connected to a mains electricity supply with an input voltage range from 100 to 240 V AC by means of the country-specific power cable. With the optional GDC221 car adapter, the charging station can be connected to the battery circuit of a vehicle.

Battery identification

The microprocessor-controlled charging station recognizes the type of battery connected and derives the necessary charging parameters such as time and current. The batteries are optimally and appropriately charged. This ensures the maximum possible service life. The charging station can recognise Li-Ion, NiCd and NiMH cells. Up to five batteries can be connected

to the charger simultaneously. In this situation, two batteries are charged at the same time and the rest are charged in the order that they were connected to the charging station.

The following batteries can be charged with the GKL221 charging station

Version	Name	Cell type	Nominal capacity (mAh)	Typical charging time
Leica Geosystems Li-Ion batteries	GEB90	Li-Ion	2000	2.5 h
	GEB221	Li-Ion	4400	3.0 h
	GEB211	Li-Ion	2200	2.5 h
	GEB212	Li-Ion	2600	2.7 h
	GEB241	Li-Ion	4800	3.5 h
Leica Geosystems camcorder type batteries	GEB121	NiMH	4200	2.5 h
	GEB111	NiMH	2100	2.0 h
Leica Geosystems batteries with 5-pin sockets	GEB70	NiCd	2200	1.5 h
	GEB77	NiCd	600	1.0 h
	GEB79	NiCd	600	1.0 h
	GEB87	NiCd	1100	1.0 h
	GEB187	NiMH	2100	1.5 h
	GEB171	NiMH	8000	5.0 h

Charging times

The charging time depends primarily on the maximum charging current, the battery capacity and the charge state of the batteries when connected. Charging time of discharged batteries at +20 °C (+68 °F):

At ambient temperatures above +20 °C (+68 °F), the battery charging time can increase by up to 1 hour. (For the recommended charging temperature range see the section on "Charging temperature"). As the temperature of the battery increases towards the end of charging, the efficiency of the storage of the charge drops. Taking the GEB121 as an example, in the first 90 minutes the battery is charged to approximately 80% of its full capacity but a further 60 minutes is required for the remaining 20%.

The GKL221 charging station has a temperature-control mode. This temperature-control mode is activated as soon as the battery becomes warm. In temperature-control mode, the charging current is switched off until the temperature of the battery has dropped back to a specific value. Charging is then continued at a reduced charging current. The user does not notice the charging current being switched on and off in temperature-control mode because the indicator remains green (charging). The temperature-control mode is also activated if the ambient temperature is too high.

Trickle charging

If fully charged batteries remain connected to the charging station, trickle charging is performed automatically.
This compensates for the self-discharge of the batteries that occurs for technical reasons. The batteries are always fully charged and ready for use.
The trickle-charging feature only activates for NiCd and NiMH batteries, as Li-Ion batteries undergo a very small self-discharge when not in use.

Refresh function

If the capacity of a NiCd or NiMH battery drops noticeably, it should be "refreshed" 2 to 3 times. When a battery is refreshed, it is completely discharged and then subject to a quick charge. Further information about the refresh function can be found in the GKL221 user manual.

Battery adapter

The GKL221 charger is supplied with two battery adapters. Using the charger in combination with the battery adapters allows the following batteries to be connected to the charger:

Battery adapter	Rechargeable batteries
GKL221 with two GDI221	Up to four Li-Ion batteries and one battery with 5 pole socket.
GKL221 with one GDI221 & one GDI222	Up to two Li-Ion batteries, one camcorder type battery and two batteries with 5 pole sockets.
GKL221 with two GDI222	Up to two camcorder type batteries and three batteries with 5 pole sockets.

Professional 3000 charger GKL211

The GKL211 is a simple, low-cost quick charger (accelerated charging) for charging Li-Ion batteries. Only Leica Geosystems Li-Ion batteries GEB90, GEB211, GEB212 and GEB221 can be charged with this charger.

Power supply

The GKL211 can be connected to the mains electricity supply or to the battery circuit of a vehicle.

A country-specific AC/DC adapter and a car adapter cable are included with the charger.

Battery identification

An identification chip recognises the type of battery connected and derives the necessary charging parameters such as time and current. The batteries are optimally and appropriately charged to ensure the maximum possible service life.

Charging times

The charging times for batteries charged with the GKL211 charger are longer than those experienced with the GKL221 charging station.

Trickle charging and refresh function

This charger has no trickle charge or battery refresh function.

Professional 3000 charger GKL112

The GKL112 is a simple, low-cost quick charger for charging NiCd and NiMH batteries.It is used for charging Leica Geosystems GEB111 and GEB121 batteries.
The specifications are similar to the GKL211 charger.

Trickle charging

The charger has a trickle charge function.
This ensures that the battery is always fully charged and ready for use.

Professional 3000 charger GKL22

The GKL22 is a simple, low-cost standard charger (14-hour charger) for charging NiCd and NiMH batteries. It is available in GKL22 (EU) and GKL22-1 (US) versions for connection to different mains supplies.

Battery identification

The GKL22 has no facility for recognising the battery type and charges all batteries with the same charging current. It can charge all Leica Geosystems batteries with a 5-pin charging socket except the GEB171.

Charging time

The charging time is 14 hours at a current of 200mA.

Trickle charging and refresh function

This charger has no trickle charge or battery refresh function.

Batteries

Cell types

Leica Geosystems currently uses lithium ion (Li-Ion) and nickel-metal hydride (NiMH) cells. The cell type is marked on the battery.

Intelligent batteries

All batteries have an integrated intelligent battery monitoring chip. This chip calculates the charge state of the battery and the most favorable charging cycle from the data it collects, such as temperature and current. This ensures that the battery can achieve its maximum service life and that the customer always knows the actual available remaining capacity of the instrument in use.

Li-Ion

Li-Ion cells have a high energy density. This minimizes battery size and weight.
Li-Ion batteries are low maintenance and exhibit no memory effect. They do not require regular charge/discharge cycles to prolong battery life.
Li-Ion batteries supplied by Leica Geosystems have a protection circuit to maintain safe operation, limit the peak voltage of each cell during charge and prevent the battery voltage from dropping too low on discharge. In addition, the cell temperature is monitored to prevent temperature extremes.

NiMH cells

NiMH cells have a higher internal resistance than NiCd cells and are therefore not suitable for as high charging and discharging currents, or low temperatures as NiCd cells. This higher internal resistance causes the voltage of NiMH batteries to collapse rapidly at minus temperatures and under high current loading. This can result in the activation of the deep discharge protection fitted in all Leica Geosystems batteries. This means that the full capacity of these NiMH batteries cannot be drawn at low temperatures. Leica Geosystems uses only NiMH cells that provide problem-free operation when supplying the current drawn by all Leica equipment, even at –20 °C (–4 °F).

Condition when delivered

Li-Ion

For safety, storage and shipment reasons, when the batteries leave the factory they contain an optimally low quantity of charge.

NiMH

For safety, storage and shipment reasons, when the batteries leave the factory they contain the lowest possible quantity of charge. NiMH batteries must not be stored in a discharged state. The batteries should therefore be fully charged as soon as possible following receipt.

Charging the batteries
New and stored batteries

New NiCd and NiMH batteries reach their maximum capacity only after a number of charging and discharging cycles.
The batteries should be fully discharged and charged three to five times. NiMH batteries that have been stored and not used for an extended period (more than a month) should be refreshed similarly. For Li-Ion batteries that have been stored for longer than one year, a single discharging and charging cycle is sufficient.
The easiest way to perform this cycling is by using the GKL221 charging station, which has a discharge function.

For this conditioning to work reliably, only almost empty batteries should be discharged in the GKL221. Therefore before cycling, the batteries should be

used operate an instrument until it automatically switches off.

Batteries in regular use

After use, a battery in regular use can be placed in the charger until fully charged (the green light flashes). The charging time depends on the battery capacity and temperature. An indication of typical charging times is shown on page 4.

Charging temperature

The charging temperature (ambient temperature) has a significant impact on the life of the batteries. Charging at high temperature can cause loss of capacity. These losses in capacity are irreversible. Even with several charging and discharging cycles, the original capacity can no longer be obtained.
For optimal charging, we recommend that the batteries are charged at ambient temperatures that are as cool as possible (+10 °C to +20 °C / +50 °F to +68 °F). The permitted temperature range in which charging can still be performed is between 0 °C and +35 °C (+32 °F and +95 °F). A temperature-control mode built into the GKL221, GKL211 and GKL112 prevents batteries from being charged at temperatures that may damage them.

Useful capacity

The temperature has a particularly significant effect on the useful capacity of a battery. The batteries can be operated from –20 °C to +55 °C (–4 °F to +131 °F) in accordance with the operating range of the surveying instrument. The useful capacity drops rapidly with reducing temperature. Continuous use in the upper temperature range (> +45 °C / +131 °F) shortens the life of the battery.

Storage

Leica Geosystems batteries can be stored at –40 °C to +55 °C (–40 °F to +131 °F). Do not store batteries inside the surveying instrument. After a long period in storage, batteries should be fully recharged before use.

Li-Ion

Li-Ion batteries start to deteriorate from the date of manufacture. To minimise the aging effect, store the battery in a cool place in a 10%–50% state of charge. Li-Ion batteries do not require regular charging while in storage.

NiMH

NiMH batteries must always be stored fully charged and recharged after 180 days at the latest. High temperatures and high atmospheric humidity accelerate the self-discharging effect. We recommend storage in the range 0 °C to +20 °C (+32 °F to +68 °F) in a dry environment. Irreversible damage can be caused to NiMH batteries if they are stored in the discharged state for an extended period.

Shipment

To prevent hazardous conditions or physical damage (fire, chemical or toxic hazards), batteries must be shipped in the discharged state.
The regulations relating to the shipment of batteries must be observed.

Memory effect

The "memory effect" occurs if the same charging and discharging (partial discharge) conditions are continuously applied to a battery. The battery then no longer provides its full capacity. The operating time per battery charge reduces. If the capacity of the battery drops noticeably, it should be "refreshed" 2 or 3 times (see above).
The memory effect occurs with NiMH and NiCd batteries. Li-Ion batteries are not influenced by the memory effect.

Battery refresh function

If the capacity of a NiCd or NiMH battery drops noticeably, the battery can be refreshed using one to three full charge and discharge cycles. The GKL221 charging station has a discharging and charging function for refreshing batteries.
The GKL112 and GKL211 chargers do not have a discharge function. Therefore the batteries must be discharged in the instrument (i.e. operate until the instrument switches off).

Defective batteries

Even if handled correctly, statistics show that a small number of batteries can still be expected to fail prematurely. Never replace a suspected defective cell in a battery pack.The cells in a battery pack are all from the same manufacturing batch and thus have the same manufacturing tolerances.If new and old cells are mixed, the weaker (old) cells in the battery pack are more heavily loaded and further failures are inevitable. For this reason, the entire battery pack is always replaced in Leica Geosystems service centres. The Li-Ion and camcorder type batteries are in sealed housing and the cells cannot be replaced.

Life

The life of batteries is primarily defined by the following
factors:

- Electrical loading
- Charging method
- Temperatures on charging, discharging and storage
- Quality of the cells

Losses in capacity caused by incorrect charging are practically excluded with the Leica Geosystems chargers that have special switch-off criteria to protect the battery. Reduction in battery capacity is normally due to age. However it can also be the result of storage at excessively low or high temperatures.
The suppliers who provide batteries to Leica Geosystems are among the leading manufacturers of batteries and guarantee good quality.

Protecting the environment / disposal

For reasons of environmental protection and safety, used or defective batteries must not be thrown away. They must be correctly disposed of in a discharged state. Follow the applicable national regulations on disposal.

Supply from other 12 V DC sources
GEV71 cable

For the supply of power to Leica Geosystems equipment from external 12 V DC networks (i.e. vehicle electrical systems) the GEV71 car battery connecting cable must be used. This is connected to the standard battery cable used for Leica Geosystems external batteries.

Protection

The GEV71 cable protects the instrument from damage due to pole reversal, voltage spikes occurring over a limited period and electrostatic discharges. The cable also provides deep discharge protection to the connected battery.

Malfunctions

A "basic suppressor" is integrated into the adapter to prevent malfunctions. Large interference spikes may arise in vehicle electrical systems when the engine is running or when other loads are switched on (e.g. electric windows). These spikes often cannot be sufficiently attenuated by the basic suppressor. If vehicle electrical systems are used to supply power, it is imperative that the engine and other loads are switched off to prevent malfunctions.

Mains supply

If a 12 V DC source supplied from the mains is used, the relevant information and advice from the manufacturer on proper use and safety must be observed.

Customer benefits from the use of Leica Geosystems accessories

The batteries available from Leica Geosystems are of the highest quality in respect of temperature tolerance, recharging capability, operating time and cycle behaviour.
By using Leica Geosystems chargers and observing the recommendations contained in this document, the user can benefit from the following significant advantages:

- Long battery life
- Reliable supply of power in the field
- Batteries and chargers compatibly matched
- Quick charging of batteries
- Prevention of battery memory effect
- Trickle charging after completion of charging
- Microprocessor-controlled and -monitored charging
- Discharging with regeneration charging of the batteries using the GKL221 charging station

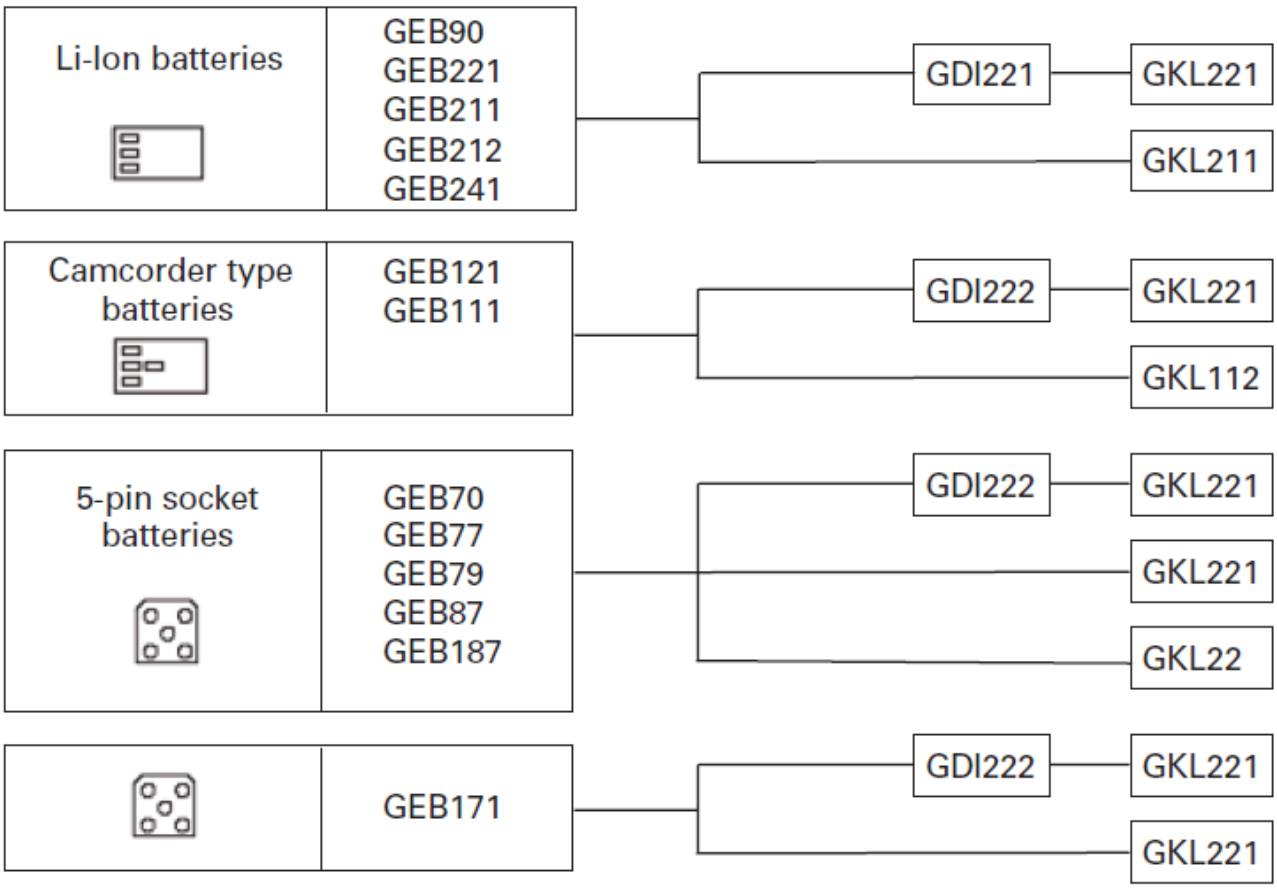
Genuine Leica vs. Leica Copies

The sections above described several factors contributing to the high quality of original Leica Geosystems batteries and chargers. Because of their well known quality these Leica Geosystems products are often perceived as quality-defining references on the market.

Hence Leica batteries and reflectors are often used as a model for copying. Subsequently several manufacturers have started to make business by flooding the market with cheap battery copies without having a warranted quality standard ensured. The right column shows the necessary steps to make a genuine Leica Geosystems battery or charger. Most of the steps are invisible to the customer, but in compliance with our strong quality management, we guarantee to supply the best products for our customers.

What you get is a „Black-Box" purchase. Something that looks similar as a genuine Leica accessory but ultimately you just don't know what you have got ...	Original Accessories
	Supplier qualification for a sustainable product quality
	Material and process qualification
	Reliability and quality checked electronic components
	Controlled brand cells
	Verifying quality of plastic and metall parts
	Maximum lifetime of battery
	maximum recharging cycles possible
	Batteries and chargers compatibly matched
	multiple electronic secuity built into batteries and chargers
	Monitor assembly process
	Fulfill national testings and regulations
	Requalification of technical specification in certain intervals
	Finetuning of batteries and chargers to the Instruments for maximum output and lifetime.

Appendix
System overview



Whether you want to monitor a bridge or a volcano, survey a skyscraper or a tunnel, stake out a construction site or perform control measurements – you need reliable equipment. With Leica Geosystems original accessories, you can tackle demanding tasks. Our accessories ensure that the specifications of the Leica Geosystems instruments are met. Therefore you can rely on their accuracy, quality and long life. They ensure precise and reliable measurements and that you get the most from your Leica Geosystems instrument.

When it has to be right.

Leica Geosystems AG
Heerbrugg, Switzerland

www.leica-geosystems.com

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Leica Geosystems

Cables -
White Paper
Technical Specifications and Characteristics

- when it has to be **right**

Leica Geosystems

March 2010

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Technical Specifications and Characteristics of Leica Geosystems Cables

Gerhard Soenser

Abstract

This paper presents an overview of the different factors regarding cables that should be considered by the surveyor in order to ensure the highest quality and best system performance.

This document describes the materials used to manufacture a cable, the criteria by which the materials were selected and the regulations and guidelines that a cable must fulfill in order to comply with the requirements for being an approved Leica Geosystems cable.

Introduction

Cables – in particular data transfer cables - are an important and yet often overlooked component of a complex measuring system.

During product development, the selection of the right cable, outer jacket and plug is crucial to achieving the desired overall performance.

The Leica Geosystems range of cables consists of three basic types.

- Data transfer cables
- Power supply cables
- High-frequency antenna cables

Data transfer cables may be classified as serial (RS232) or USB data transfer cables. Each of these may be further classified as low, full or high-speed cables, depending on their data transfer rate.

Almost all of these cables are also available in the form of Y-cables.

Anatomy of a cable

Plug-in connectors

All Leica data and power supply cables for use in an outdoor environment are fitted with LEMO® plugs.

LEMO® is a respected market leader in the design and manufacture of custom-made solutions for precision plug-in connections. These high-quality push-pull connectors find use in a large number of areas of application that call for the highest quality requirements.
LEMO® connectors are deployed in orbit 36,000 km above the earth and 600 m below sea level as well as in temperatures of +500°C and -200°. The largest fields of application are testing and metrology, biomedical engineering, radio/television and communications

Cable outer jacket

The second most important component of a cable is the outer jacket. Of course the insulation must protect the cable and the user from electric shocks and short-circuits. These are functions that every user knows.
But very few users know that all Leica cables have been designed and tested to ensure that they continue to fulfill their functions under the most unfavorable conditions. At Leica all cables are tested at regular intervals to ensure that they can withstand storage temperatures of -40°C to +70°C. The cables have to function within an operating temperature range of -40°C to +65°C.

Cable strands

The most fundamental factor in the design of a cable is the choice of the right cable type and material.

A cable for transmitting signals may have five to eight conductors, depending on its purpose. Each conductor consists of up to 44 individual strands of copper wire. The strands may be arranged in different ways to make up the conductor. Signal cable conductors are often wrapped in a shield, either in pairs and/or all together.

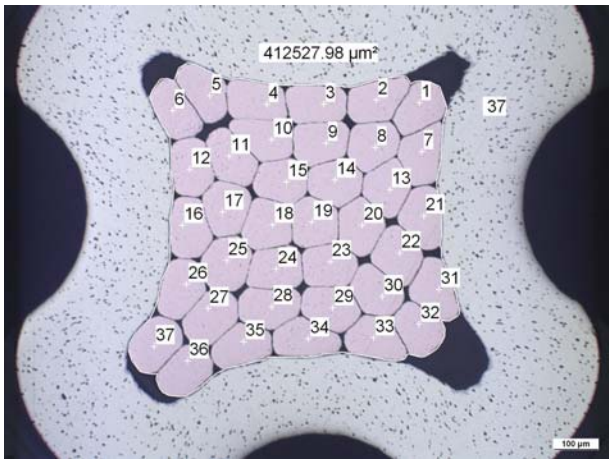


Figure 1 – cross section view of a cable crimped in connector

Data transfer rate

An important aspect of a cable is its data transfer rate. The data transfer rate depends on the quality and design of the cable.
Cables are designed to achieve the data transfer rates required for the intended purpose and field of application so that the user does not lose time as a result of slow data transfer.

Geschwindigkeit	Toleranz USB 3.0	Toleranz USB 2.0	Toleranz USB 1.0/1.1
Low-Speed (1,5 Mbit/s)	–	± 0,75 kbit/s	± 22,5 kbit/s
Full-Speed (12 Mbit/s)	–	± 6 kbit/s	± 30 kbit/s
High-Speed (480 Mbit/s)	–	± 240 kbit/s	–
Super-Speed (5 Gbit/s)	–	–	–

Figure 2 – table showing different speeds USB connections

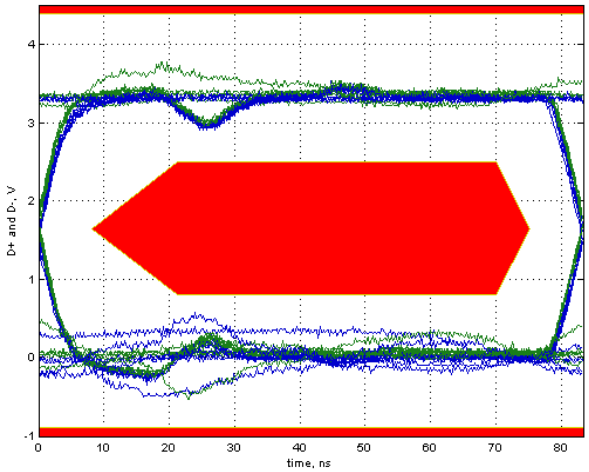


Figure 3 - The figure shows a typical eye diagram used to assess whether the desired data transfer rate has been achieved.

Environmental specifications and fields of use

The cables undergo special tests during the design phase and regularly afterwards in order to ensure that they can meet the high demands placed upon them. For example, they are tested to see whether antikink protection and flexibility is retained at very low temperatures and that fracture or embrittlement does not occur. All Leica cables are tested for the protection they provide against splash water, high humidity and condensation. The materials must be able to resist UV light for many years and withstand extreme temperature shocks, survive vibrations and drop tests, and be resistant to lime, sand and cleaning agents. High barometric pressures, such as at depths of -1000 m or at an altitude of 8500 m, have no effects on original Leica accessories.

Regulations and guidelines

Leica Geosystems would like to set the standard and an example for the future by having its cables fulfill all applicable and recommended regulations.
The following rules, regulations and directives are currently considered in the design of Leica Geosystems cables.

PAH – polycyclic aromatic hydrocarbons

Only very few people are aware that the German Federal Institute for Risk Assessment (BfR) issued a new guidance document in 2008 that limits an article's percentage content of polycyclic aromatic hydrocarbons. Many PAH compounds used in the plastic used to make the outer jacket of cables are proven carcinogens.

Some PAH compounds have been clearly shown to be carcinogenic to humans (e.g. causing cancer of the lungs, larynx, skin, stomach, intestines, and bladder). They are also associated with birth defects and reduced reproductive capacity.

These compounds can be absorbed by skin contact, for example through the hands.

The guidance document sets out the permitted limit for the amount of PAH absorbed through the skin over a specific period of time.

Most of Leica Geosystems cables have been checked and comply with this guidance document.

Parameter	Category1	Category2	Category3
	Material that can be inserted into mouth, or material for toys for children <36 month and skincontact	Material, not in category 1, with skincontact longer than 30 seconds	Material, not in category 1 or 2,with skincontact up to 30 seconds
Benzopyren mg/kg	not detectable (<0,2)	1	20
Sum 16 PAH (EPA) mg/kg	not detectable (<0,2)	10	200

Figure 4 – allowed highest PAH concentration for materials on handles or touched surfaces.

RoHS

European Union Directive 2002/95/EC restricting the use of specific hazardous substances in electrical and electronic equipment governs the use of hazardous substances in equipment and components.

In the face of the massive spread of disposable electronic goods, the object of the directive is to prohibit the most troublesome constituent substances from the products. These prohibitions include the ban on toxic flame retardants in the manufacture of cables. The directive also seeks to increase the use of appropriate substitute products and lead-free soldering.

The toxic substances currently used in electronics are rated as highly hazardous to the environment. These substances sometimes leak out of landfill into the environment. They do not readily decompose easily and can therefore enter nature's environmental cycles. The RoHS regulations are designed to ban the use of these substances in products. The substances affected are

- Lead
- Mercury
- Cadmium
- Hexavalent chromium
- Polybrominated biphenyl (PBB)
- Polybrominated diphenylether (PBDE)

All Leica Geosystems cables meet this standard.

WEEE

The WEEE Directive (Waste Electrical and Electronic Equipment) is the EU Directive 2002/96/EC for reducing the growing quantity of electro-scrap arising from discarded electrical and electronic equipment. The objective is the avoidance, reduction and environmentally compatible disposal of the rising quantities of electronic scrap through extending the responsibilities of the manufacturers.
The EU directive came into effect in January 2003. The EU member states had until 13th August 2005 to incorporate the directive into their national legislation and put in place a national e-waste return system. From December 2006, at least 4 kg electronic scrap per person per year must be recycled. The Electrical and Electronic Equipment Act (ElectroG) came into force in Germany on 16th March 2005 and joined the WEEE and RoHS directive (Restriction of Hazardous Substances in electrical and electronic equipment) as part of German law.

EMC

Compliance with regulations is controlled on the international stage by standards and directives on electromagnetic compatibility. National legislation also demands that Leica systems can operate perfectly in an interference-laden environment and do not cause interference with other devices and systems. Cables play an important role to play in this. Within European Union member states, EU Directive 2004/108/EC on electromagnetic compatibility defines the limits for transmitted electromagnetic interference and resistance to it

Summary

Cables – data transfer cables in particular – are an important accessory for achieving a proper set up of an instrument. Anyone not working as a cable specialist would never think that a cable has to fulfil so many requirements and specifications before it can be called a "Leica-approved cable".
But all these criteria have to be fulfilled in order to provide a specific minimum standard and ensure the best possible performance under the most unfavorable conditions.

Usually a great deal of importance is attached to the surveying instrument and the influence of each accessory on the accuracy of the system is often overlooked.

All Leica Geosystems cables and accessories are based on these important factors.
These cables are manufactured under technically exacting conditions of production and strict production and quality control mechanisms.
Leica Geosystems cables of the very highest quality.

Genuine Leica vs. Leica Copies

The preceding sections describe the individual factors that have to be considered in designing a cable to meet all Leica requirements.

Solidly based on these high requirements, Leica Geosystems accessories are defining the standards and leading the way ahead for the surveying market.

While most of this development, testing and regulation remains invisible to the end user, Leica Geosystems works accordance with its specifications and guidance documents to achieve the highest standards for its customers.

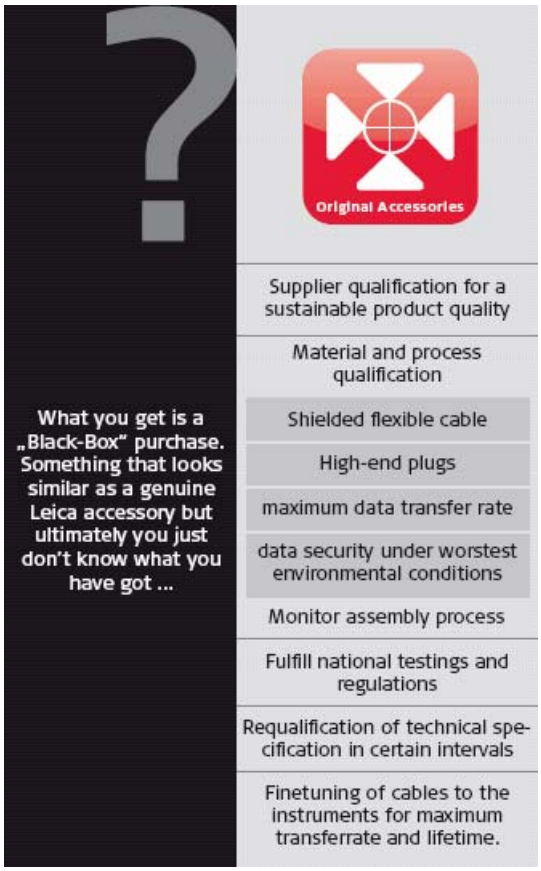


Figure 5 – Manufacturing process of Leica Geosystems' Originals vs. Leica copies

Copies of Leica cables appear sporadically on the market. They are usually USB download cables.

If these counterfeits are used, it cannot be guaranteed that the instrument or even the computer connected by its USB port by this cable will not be damaged.

In times of high copper prices, cheaper aluminium has been used instead of copper in the strands. This is never apparent from the outside to the customer, but it can lead to severe reductions in performance and transmission errors during data transfer.

Recommendations

The objective of this white paper is to provide the surveyor and user with a brief overview of the guidance documents and requirements to which a Leica cable is designed, developed, manufactured and tested.
A customer will never look closely at a cable, analyse or take it apart, as long as that cable presents no problems and continues to function in a satisfactory manner.
Leica ensures that an accessory belonging to a Leica instrument is precisely matched to the requirements of that instrument. Whether it is a TPS or GPS instrument.

The benefits of using Leica Geosystems accessories are long service life, highest accuracy and highest reliability. Leica Geosystems accessories are designed to be a perfect match for Leica Geosystems instruments, so that we can guarantee you the best performance and measurement quality.

The entire surveying chain is only as strong as its weakest link.

Whether you want to monitor a bridge or a volcano, survey a skyscraper or a tunnel, stake out a construction site or perform control measurements – you need reliable equipment. With Leica Geosystems original accessories, you can tackle demanding tasks. Our accessories ensure that the specifications of the Leica Geosystems instruments are met. Therefore you can rely on their accuracy, quality and long life. They ensure precise and reliable measurements and that you get the most from your Leica Geosystems instrument.

When it has to be right.

VII.10

Leica Geosystems AG
Heerbrugg, Switzerland

www.leica-geosystems.com

- when it has to be **right**

Leica Geosystems

3D Disto

Measure Once, Cut Once

Explore >

3D measuring just became easy with the automated and motorized 3D Disto. The integrated camera relays images of the points being measured to the wireless touchscreen tablet and the laser captures the distance remotely. From one stationary point, you can measure everything, including complete rooms, walls, staircases, windows and structural elements at +/- 1/16” accuracy at 33 feet. Data is captured and displayed on your tablet screen and can be exported into packages such as CAD for further processing. Applications include

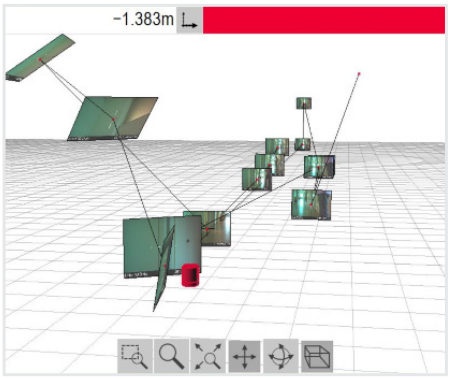
- Creating CAD templates
- 3D visualizations
- Capturing As-Built measurements
- Building Information Modeling (BIM)
- Highly accurate measurements for custom fabrications

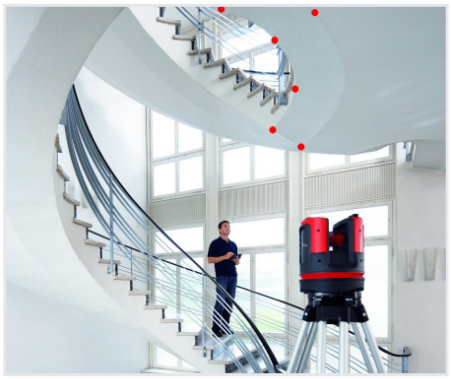
LEARN MORE >

PART OF HEXAGON

Leica Geosystems

3D Disto





Measure

Easy to setup: self-leveling, quick to plumb, sharp, bright, visible lines. Easy to use: Call out photos can be added to clarify measurement points

View Video Here >

Document

The remote control's 98' wireless range and 164' wifi range provides for fewer moves and less trips up the steps, ladder or scaffolding

View Video Here >

Communicate

Prepares 2D and 3D DXF and DWG so design work can be started immediately in precise digital as-built model

View Video Here >

Features

- Digital measurements with immediate results
- Digital Pointfinder
- Camera provides photo backup for position changes
- 2D & 3D graphic display
- Cable free operation
- 3D visualizations, navigation – wire frame modeling
- Captures as-built measurements in 3D or 2D
- Creates CAD templates for fabrication & shop drawings

See Full Specs >

Advanced Functions

No matter what you are doing with a 3D Disto, accuracy is paramount. Since form follows function, the 3D Disto a cross between a surveyor's robotic total station and a hand-held Disto

- Measure to +/-1/16" accuracy at 33'
- Produce precise measurements indoors or outdoors
- Intuitive and easy to learn
- Small size
- Universally compatible file format that works with any CAD program
- The 3D Disto measures horizontal angle, vertical angle and slope distance with angle sensors borrowed from our total stations
- New 20 layer functionality view video here link


3D Disto


S910


D810 Touch


E7500i


X4


X3


D2


E7100i


D1

DISTO Plan

PART OF HEXAGON

Leica Geosystems

Leica DISTO™ D510

The original laser distance meter

Precise targeting and reliable outdoor measurement!

The new Leica DISTO™ D510 stands for easy and effortless outdoor distance measurement. The unique combination of digital Pointfinder and 360° tilt sensor allows measurements which are not possible with conventional distance meters. In addition, with Bluetooth® Smart and attractive free apps, you are prepared for the future.

Featured with:

- Pointfinder with 4x zoom
- IP65 water jet protection and dust-tight
- 360° tilt sensor
- Smart Horizontal Mode™
- Height tracking
- Bluetooth® Smart
- Free App – Leica DISTO™ sketch

Available on the App Store

- when it has to be right

Leica Geosystems

Simple and precise targeting

With the Pointfinder with 4x zoom, the Leica DISTO™ D510 takes measurements with perfect accuracy and in unfavorable light conditions. This is a decisive advantage when working outside in sunny weather. Even if the red laser point is no longer visible, the target can be seen exactly on the display.

Tough and easy to clean

The housing and keypad are specially sealed against water and dust. Cleaning under running water is also no problem. Furthermore the laser distance meter can be used in all weather conditions, being dustproof and water jet protected (IP65).

Unlimited measuring options

The Leica DISTO™ D510 is equipped with a 360° tilt sensor. This means that it is not only possible to measure angles, but horizontal distances too! Combined with the Pointfinder, amazing indirect measurement options are provided. Hence, measurements are possible where no reflective target point is available.

Bluetooth® Smart with app

Measurement data can be transferred using the Bluetooth® Smart Technology. The free app Leica DISTO™ sketch supports the creation of ground plans or tables on iPhone or iPad. Dimensions can even be entered onto photographs.

Available on the App Store

Leica DISTO™ D510

Art.No. 792290

- Leica DISTO™ D510 laser distance meter
- Holster
- Hand loop
- Batteries

Technical Data

Accuracy, typ.	± 1 mm
Range	0.05 – 200 m
Measuring units	m, ft, in
Tilt sensor	360°
Color display with Pointfinder	4x zoom
Data interface*	Bluetooth® Smart
Free App*	Leica DISTO™ sketch
Batteries	2 x AA
Dimensions	143 × 58 × 29 mm
Memory	30 Displays
Multifunctional end-piece	automatic recognition
Personalized Favorites	•

Functions

Distance measurement	Inclination tracking
Min/max measurement	Area/volume
Smart Horizontal Mode	Addition/subtraction
Height tracking	Pythagoras
Height profile	Stake-out
Sloped objects	Trapezium
Long Range Mode	Calculator

*) System requirements & details at www.disto.com

Leica Geosystems AG
Heerbrugg, Switzerland
www.leica-geosystems.com

Laser class 2
in accordance with
IEC 60825-1

PROTECT by Leica Geosystems Swiss Technology

Register your device within 8 weeks of purchase at www.leica-geosystems.com/registration and extend your no cost period to 3 years.

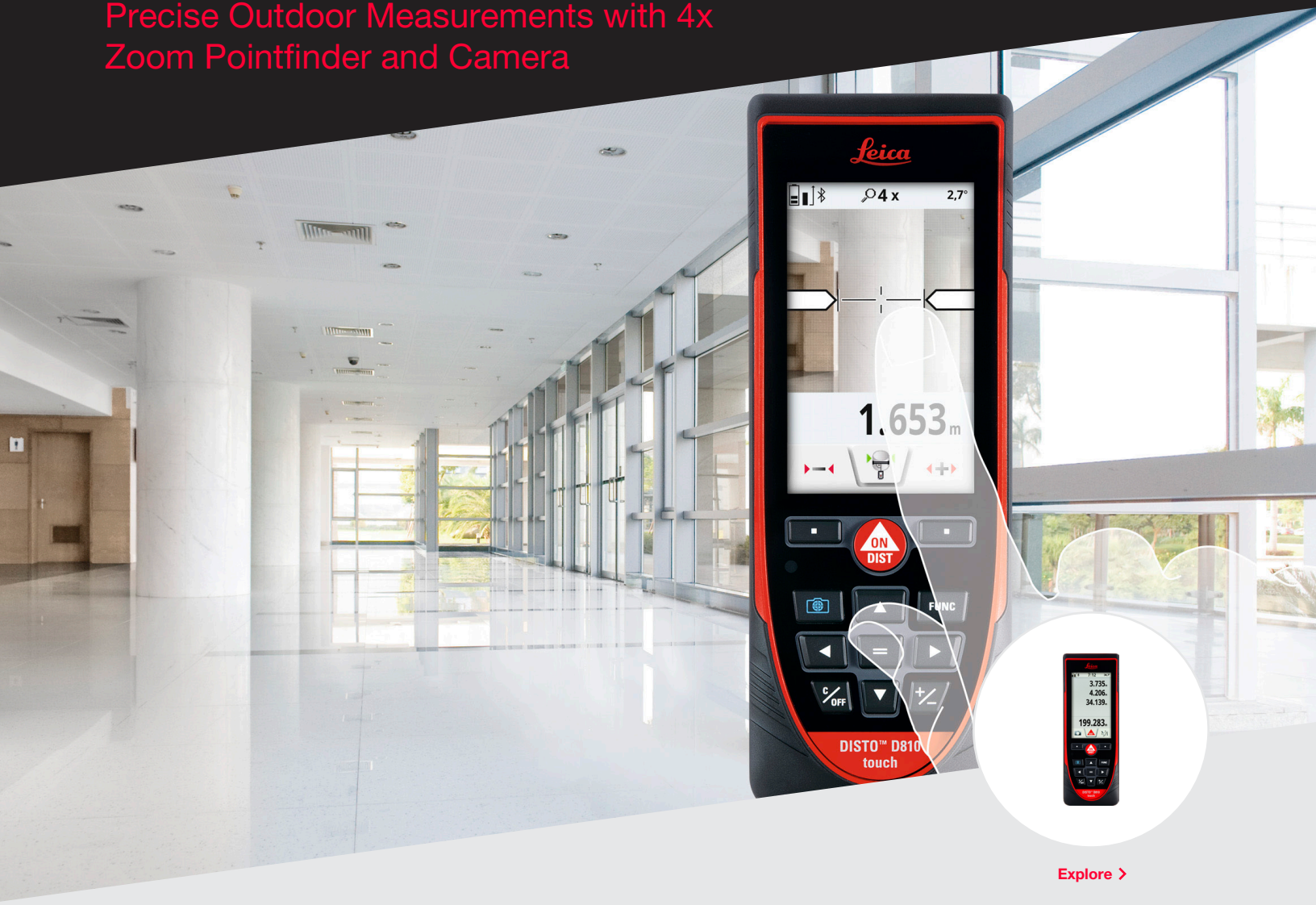
Dealer Stamp

- when it has to be right

Leica Geosystems

DISTO D810

Precise Outdoor Measurements with 4x Zoom Pointfinder and Camera



Explore >

Simply navigate through the familiar 3.2" touch screen zoom features to determine, width, height, surface area or diameter. Then document the measurements using photos from the built-in camera. Indirect measuring is incredibly precise with built-in tilt sensors with additional accuracy provided by the FTA 360 tripod adoptor

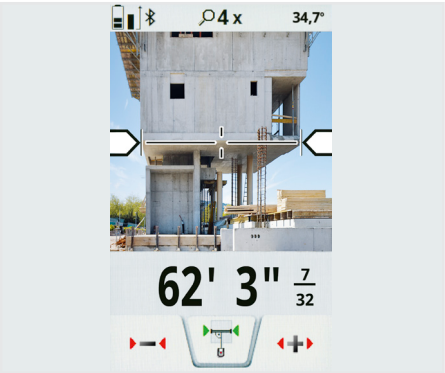
- Digital Pointfinder with 4X zoom identifies long distance targets in bright sunlight
- Easy JPEG data transfer to your PC with Bluetooth® and USB
- Indirect height/width measurements of inaccessible targets
- Range: 2" - 820'

PART OF HEXAGON

LEARN MORE >

Leica Geosystems

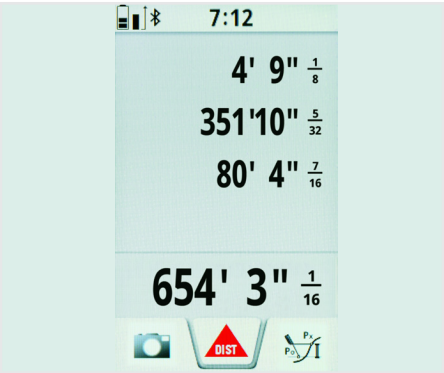
DISTO D810



Measure

Long distances in seconds, without help from another person

View Video Here >



Document

Precise laser technology always produces reliable measurements in the format you want

View Video Here >

Communicate

USB & Bluetooth® Smart readily connects to DISTO Plan and you to the rest of the world

View Video Here >

Features

- Pointfinder camera measuring
- Measure in picture
- Photo gallery documentation
- Indirect smart horizontal distance
- Height tracking
- Long range mode
- 3.2" color touch screen
- Min / max tracking
- Rechargeable Li-Ion Batteries
- Surface area
- Room volume
- Auto end-piece
- Bluetooth® Smart
- Free DISTO Plan app

See Full Specs >

Advanced Functions (* Requires FTA 360 Tripod adapter)

- **Measure with a picture:** Only one measurement at the correct angle is needed. Once taken, simply align the 2 arrows on your screen to the required points in your measurement picture and the results will show- distance, width, area, diameter*
- **Document using pictures:** The onboard camera provides color photos that can be downloaded with the USB interface to your computer – no details about the measured target need to be lost View Video Here >
- **Indirect measuring function:** The pointfinder, tilt sensor and laser generate precise dimensions and when combined with the FTA 360 tripod adaptor exact targeting can be achieved


3D Disto


S910


D810 Touch


E7500i


X4


X3


D2


E7100i


D1

DISTO Plan

PART OF HEXAGON

Leica Geosystems

Leica TS01
Data sheet

LEICA TS01: THE ENTRY TO LEICA GEOSYSTEMS' TOTAL STATIONS

- **A smart decision:** Leica TS01 represents a business-smart entry into the Leica Geosystems world. You and your surveying crew members will be ready for new projects in no time.
- **Powerful distance measurement:** Enjoy the benefits of a 500 m non-prism range and 3,000 m prism range, always combined with accuracy and measurement speed.
- **Fast setup and measurements:** increase your productivity with built-in sensors like an electronic dual axis compensator, a laser plummet, intuitive field software and short keys for quick menu access.
- **Your all-in-one package:** The TS01 comes with Leica Geosystems accessories, such as a long-operating battery, a charger and a tribrach tested to perform best – when every detail counts.
- **Benefit from Leica Geosystems service and support:** Make use of the well-established Leica Geosystems' service and support network.

Leica TS01 empowers you to carry out measurement tasks with ease and simplicity. The TS01 is an entry-level manual total station, created to help you master surveying, layout and mapping projects. It will prove itself in the field and immediately become a valuable member of your team.

Leica TS01

Leica TS01

ANGULAR MEASUREMENT		
Accuracy Hz and V	Absolute, continuous	5''
	■ Display resolution: 1'' (0.1 mgon) ■ Dual axis compensation with Hz collimation and V index correction ■ Compensator range: +/- 8' ■ Longitudinal level sensitivity: 2'/2 mm	✔
DISTANCE MEASUREMENT		
Range[1]	■ Prism (GPR1): 3,000 m ■ Non-Prism: up to 500 m[2]	✔
Accuracy	■ Single prism: 2 mm + 2 ppm ■ Non-Prism: 3 mm + 2 ppm[3]	✔
Measurement time	Prism mode ■ Standard: 1.5 s ■ Quick: 1.1 s ■ Tracking: 0.15 s	✔
	Non-prism mode ■ Standard: 1.4 s ■ Quick: 1.1 s	✔
	Display resolution: 0.1 mm	✔
Laser dot size	■ At 50 m: 12 mm × 24 mm	✔
Telescope	■ Magnification: 28x ■ Focusing range: 1.5 m / 4.92 ft to infinity ■ Field of view: 1°30' / 1.66 gon ■ Field width at 100 m: 2.8 m ■ Adjustable reticule illumination	✔
GENERAL		
Display and keyboard		240×128 px, grayscale, 28 keys display background light, face 1
Operation	■ Coarse and fine drive for HZ & V ■ operating system: Free RT/OS ■ Shortcut keys	✔
Power management	Exchangeable Lithium-Ion battery ■ Operating time with GEB264	up to 24 h
Data storage	■ Internal memory: 50,000 points ■ USB memory device for data transfer	✔
Interfaces	USB	✔
Laser plummet (Laserclass 2)	Accuracy ■ Plumb line deviation: 1.5 mm at 1.5 m instrument height ■ Diameter of laser point: 2.5 mm at 1.5 m instrument height	✔
Weight	With battery and tribrach	5.9 kg
Environmental specifications	■ Working temperature range: –20°C to +60°C ■ Dust / Water (IEC 60529) / IP55 ■ Storage temperature range: –30°C to +60°C	✔

Legend:
1. Overcast, no haze, visibility about 40 km, no heat shimmer
2. Object in shade, sky overcast, Kodak Gray Card white side (90% reflective)
3. Up to 200 m. Above 200 m: 5 mm + 3 ppm

✔ = Included

Laser radiation, avoid direct eye exposure.
Class 3R laser product in accordance with IEC 60825-1:2014.

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- when it has to be **right**

Leica Geosystems

Leica FlexLine TS03/TS07 Manual Total Stations

FlexLine

LEICA FLEXLINE TS03/TS07 MANUAL TOTAL STATIONS

- **Work faster**: measure more points per day due to faster measurement and stakeout procedures (endless drives, trigger key, drives on both sides, pinpoint EDM and more), supported by our comprehensive and user-friendly Leica FlexField software.
- **Use it trouble-free**: increase productivity and minimise downtime by relying on instruments that simply work and come with a global service and support network.
- **Choose products that are built to last**: FlexLine operates with the same high level of quality even after years of use under harsh conditions (like mud, dust, blowing rain, extreme heat and cold).
- **Control your investment**: reliability, speed and accuracy ensure a lower investment over the product lifetime and a higher resell value.
- **Save time with AutoHeight:** measure, read and set the instrument height automatically with this revolutionary feature in the FlexLine TS07 (optional). Errors are minimised and the setup process onsite is faster.

The Leica FlexLine TS03 and TS07 high-quality, manual total stations are based on a proven product concept that has been revolutionising the world of measurement and survey for nearly 200 years. The instruments are equipped with a comprehensive application-based software package - Leica FlexField software - that enables most survey and stakeout tasks to be carried out easily and efficiently. The new FlexLine manual total stations work reliably and deliver accurate results even in harsh environments.

Leica FlexLine TS03/TS07

Leica FlexLine TS03

Leica FlexLine TS07

ANGULAR MEASUREMENT			
Accuracy Hz and V	Absolute, continuous, diametrical[1] ■ Display resolution: 0.1'' (0.1 mgon) ■ Quadruple axis compensation ■ Compensator setting accuracy[2]: 0.5'' / 1''/ 1.5'' / 2'' ■ Compensator range: +/- 4' ■ Electronic level resolution: 2'' ■ Circular level sensitivity: 6` / 2 mm	2'' / 3'' / 5'' ✔	1'' / 2'' / 3'' / 5'' / 7'' ✔
DISTANCE MEASUREMENT			
Range	■ Prism (GPR1, GPH1P): 0.9 m to 3,500 m ■ Prism GPR1 (Long Range mode) › 10,000 m	✔	✔
	Non-Prism / Any surface ■ R500[3] ■ R1000[4]	✔ ✗	✔ •
Accuracy / Measurement time	Single prism ■ Precise+ / Once: 1 mm + 1.5 ppm (typical 2.4 s) ■ Precise&Fast / Once&Fast: 2 mm + 1.5 ppm (typical 2 s) ■ Tracking / Continously: 3 mm + 1.5 ppm (typical ‹ 0.15 s) ■ Averaging: 1 mm + 1.5 ppm ■ Long Range mode / › 4 km: 5 mm + 2 ppm (typical 2.5 s)	✔	✔
	Non-Prism / Any surface ■ 0 m - 500 m: 2 mm + 2 ppm (typical 2.4 s[5]) ■ › 500 m: 4 mm + 2 ppm	✔	✔
Laser dot size	■ At 30 m: 7 mm x 10 mm ■ At 50 m: 8 mm x 20 mm ■ At 100 m: 16 mm x 25 mm	✔	✔
Telescope	■ Magnification: 30x ■ Resolving power: 3'' ■ Focusing range: 1.55 m / 5.08 ft to infinity ■ Field of view: 1°30' / 1.66 gon / 2.7 m at 100 m	✔	✔
GENERAL			
Display and keyboard		3.5'' (inch), 320 x 240 px QVGA, grayscale, 28 keys[6a]	3.5'' (inch), 320 x 240 px QVGA, colour, touch, 28 keys[6b]
	2nd keyboard	✗	•
	Key illumination	✗	✔
Operation	■ Endless drives for HZ & V ■ Trigger-Key: user definable with 2 functions	✔	✔
Power management	Exchangeable Lithium-Ion battery[7] ■ Operating time with GEB364 ■ Operating time with GEB334	 up to 32 h up to 16 h	 up to 32 h up to 16 h
	Battery charging time with ■ GKL341 charger for GEB364 / GEB334 ■ GKL311 charger for GEB364 / GEB334	 3 h 30 min / 3 h 6 h 30 min / 3 h 30 min	 3 h 30 min / 3 h 6 h 30 min / 3 h 30 min
	External supply voltage ■ Nominal voltage 13.0 V DC & 16 W max	✔	✔
Data storage	■ Internal memory: 4 GB Flash ■ Memory card: SD card 1 GB or 8 GB ■ USB memory stick: 1 GB	✔	✔
Processor	■ TI OMAP4430 1GHz Dual-core ARM® Cortex™ A9 MPCore™ ■ Operating system – Windows EC7	✔	✔
Interfaces	RS232[8], USB device	✔	✔
	Bluetooth®[9], WLAN[10]	✗	✔
	Mobile Data sidecover: LTE-Modem for internet access	✗	•
Guide Light (EGL)	■ Working range: 5 m to 150 m ■ Position accuracy: 5 cm at 100 m ■ Wavelength red /orange: 617 nm / 593 nm	✗	✔ (R1000)
Laser plummet (Laserclass 2)	Accuracy ■ Plumb line deviation: 1.5 mm at 1.5 m instrument height ■ Diameter of laser point: 2.5 mm at 1.5 m instrument height	✔	✔
AutoHeight module for automatic instrument height measurement (Laserclass 2)	Accuracy ■ Distance accuracy: 1.0 mm (1 Sigma) ■ Distance range: 0.7 m to 2.7 m	✗	•
Weight		4.3 kg	4.3 - 4.5 kg
Environmental specifications	■ Working temperature range: –20°C to +50°C[11] ■ Arctic version: –35°C to +50°C ■ Dust / Water (IEC 60529) / Humidity: IP66 / 95%, non-condensing ■ Military Standard 810G, Method 506.5	✔ ✗ ✔ ✔	✔ • ✔ ✔
LOC8	Tracking and theft deterrence device	•	•

Legend:

1. 1'' (0.3 mgon), 2'' (0.6 mgon), 3'' (1 mgon), 5'' (1.5 mgon), 7'' (2 mgon)
2. Angular accuracy / Compensator setting accuracy: 1'' /0.5'' (0.2 mgon), 2''/0.5'' (0.2 mgon), 3''/1.0'' (0.3 mgon), 5''/1.5'' (0.5 mgon), 7''/2.0'' (0.7 mgon)
3. R500: Kodak gray 90% reflective (0.9 m to ›500 m), Kodak gray 18% reflective (0.9 m to ›200 m)
4. R1000: Kodak gray 90% reflective (0.9 m to ›1000 m), Kodak gray 18% reflective (0.9 m to ›500 m)
5. Up to 50 m, max. measurement time 15 s
6. (a) Face I standard, (b) Face I standard, face II optional
7. Continuous angle measurement, new battery
8. 5 PIN Lemo-0 for power, communication and data transfer
9. For communication and data transfer
10. For internet access, communication and data transfer, WLAN range up to 200 m
11. Storage temperature: –40°C to +70°C

✔ = Included • = Optional ✗ = Not available

Laser radiation, avoid direct eye exposure.
Class 3R laser product in accordance with IEC 60825-1:2014.

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- when it has to be **right**

Leica Geosystems

Leica FlexLine TS03/TS07/TS10 Manual Total Stations

FlexLine

The new Leica FlexLine TS03, TS07 and TS10 high-quality, manual total stations are based on a proven product concept that has been revolutionising the world of measurement and survey for nearly 200 years. The easy-to-use and familiar Leica FlexField software (TS03/TS07) helps you to easily and efficiently carry out surveying and stakeout tasks. The FlexLine TS10 is equipped with Leica Captivate field software, enabling you to tie into the modern 3D dataflow – including enhanced linework and coding. The new Leica FlexLine manual total stations work reliably and deliver accurate results even in harsh environments.

LEICA FLEXLINE TS03/TS07/TS10 MANUAL TOTAL STATIONS

- **Work faster**: measure more points per day due to faster measurement and stakeout procedures (new endless drives, trigger key, drives on both sides and more), supported by our easy-to-use and familiar Leica Geosystems software.
- **Use it trouble-free**: increase productivity and minimise downtime by relying on instruments that simply work and come with a global service and support network.
- **Choose products that are built to last**: even after years of use under harsh conditions (like mud, dust, blowing rain, extreme heat and cold), FlexLine total stations still operate with the same high level of accuracy and reliability.
- **Save time with AutoHeight:** this revolutionary feature enables the manual total stations to automatically measure, read and set your instrument's height. This way errors are minimised and the setup process onsite is faster.
- **Control your investment**: reliability, speed and durability ensure a lower investment over the product lifetime.

Leica FlexLine TS03/TS07/TS10


Leica FlexLine TS03


Leica FlexLine TS07


Leica FlexLine TS10

ANGULAR MEASUREMENT				
Accuracy Hz and V	Absolute, continuous, diametrical[1]	2'' / 3'' / 5''	1'' / 2'' / 3'' / 5'' / 7''	1'' / 2'' / 3'' / 5''
	■ Display resolution: 0.1'' (0.1 mgon) ■ Quadruple axis compensation ■ Compensator setting accuracy[2]: 0.5'' / 1''/ 1.5'' / 2'' ■ Compensator range: +/- 4' ■ Electronic level resolution: 2'' ■ Circular level sensitivity: 6` / 2 mm	✔	✔	✔
DISTANCE MEASUREMENT				
Range	■ Prism (GPR1, GPH1P): 0.9 m to 3,500 m ■ Prism GPR1 (Long Range mode) › 10,000 m	✔	✔	✔
	Non-Prism / Any surface ■ R500[3] ■ R1000[4]	✔ ✗	✔ •	✔ •
Accuracy / Measurement time	Single prism ■ Precise+ / Once: 1 mm + 1.5 ppm (typical 2.4 s) ■ Precise&Fast / Once&Fast: 2 mm + 1.5 ppm (typical 2 s) ■ Tracking / Continously: 3 mm + 1.5 ppm (typical ‹ 0.15 s) ■ Averaging: 1 mm + 1.5 ppm ■ Long Range mode / › 4 km: 5 mm + 2 ppm (typical 2.5 s)	✔	✔	✔
	Non-Prism / Any surface ■ 0 m - 500 m: 2 mm + 2 ppm (typical 2.4 s[5]) ■ › 500 m: 4 mm + 2 ppm	✔	✔	✔
Laser dot size	■ At 30 m: 7 mm x 10 mm ■ At 50 m: 8 mm x 20 mm ■ At 100 m: 16 mm x 25 mm	✔	✔	✔
Telescope	■ Magnification: 30x ■ Resolving power: 3'' ■ Focusing range: 1.55 m / 5.08 ft to infinity ■ Field of view: 1°30' / 1.66 gon / 2.7 m at 100 m	✔	✔	✔
GENERAL				
Display and keyboard		3.5" (inch), 320 x 240 px QVGA, grayscale, 28 keys[6a]	3.5" (inch), 320 x 240 px QVGA, colour, touch, 28 keys[6b]	5" (inch), 800 x 480 pixels WVGA, colour, touch, 25 keys[6b], (optional[6c]: 37 keys with function keys)
	2nd keyboard	✗	•	•
	Key illumination	✗	✔	✔
Operation	■ Endless drives for HZ & V ■ Trigger-Key: user definable with 2 functions	✔	✔	✔
Power management	Exchangeable Lithium-Ion battery[7] ■ Operating time with GEB364 ■ Operating time with GEB334	 up to 32 h up to 16 h	 up to 32 h up to 16 h	 up to 26 h up to 13 h
	Battery charging time with ■ GKL341 charger for GEB364 / GEB334 ■ GKL311 charger for GEB364 / GEB334	 3 h 30 min / 3 h 6 h 30 min / 3 h 30 min	 3 h 30 min / 3 h 6 h 30 min / 3 h 30 min	 3 h 30 min / 3 h 6 h 30 min / 3 h 30 min
	External supply voltage ■ Nominal voltage 13.0 V DC & 16 W max	✔	✔	✔
Data storage	■ Internal memory: 4 GB Flash ■ Memory card: SD card 1 GB or 8 GB ■ USB memory stick: 1 GB	✔	✔	✔
Processor	■ TI OMAP4430 1GHz Dual-core ARM® Cortex™ A9 MPCore™ ■ Operating system – Windows EC7	✔	✔	✔
Interfaces	RS232[8], USB device	✔	✔	✔
	Bluetooth®[9], WLAN[10]	✗	✔	✔
	Mobile Data sidecover: LTE-Modem for internet access	✗	•	•
Guide Light (EGL)	■ Working range: 5 m to 150 m ■ Position accuracy: 5 cm at 100 m ■ Wavelength red /orange: 617 nm / 593 nm	✗	✔ (R1000)	✔ (R1000)
Laser plummet (Laserclass 2)	Accuracy ■ Plumb line deviation: 1.5 mm at 1.5 m instrument height ■ Diameter of laser point: 2.5 mm at 1.5 m instrument height	✔	✔	✔
AutoHeight module for automatic instrument height measurement (Laserclass 2)	Accuracy ■ Distance accuracy: 1.0 mm (1 Sigma) ■ Distance range: 0.7 m to 2.7 m	✗	•	✔
Weight		4.3 kg	4.3 - 4.5 kg	4.4 - 4.9 kg
Environmental specifications	■ Working temperature range: –20°C to +50°C[11] ■ Arctic version: –35°C to +50°C ■ Dust / Water (IEC 60529) / Humidity: IP66 / 95%, non-condensing ■ Military Standard 810G, Method 506.5	✔ ✗ ✔ ✔	✔ • ✔ ✔	✔ • ✔ ✔
Imaging	■ 5 megapixel CMOS sensor ■ Overview camera with field of view 19.4°	✗	✗	•
LOC8	Tracking and theft deterrence device	•	•	•

Legend:

1. 1'' (0.3 mgon), 2'' (0.6 mgon), 3'' (1 mgon), 5'' (1.5 mgon), 7'' (2 mgon)
2. Angular accuracy / Compensator setting accuracy: 1'' /0.5'' (0.2 mgon), 2''/0.5'' (0.2 mgon), 3''/1.0'' (0.3 mgon), 5''/1.5'' (0.5 mgon), 7''/2.0'' (0.7 mgon)
3. R500: Kodak gray 90% reflective (0.9 m to ›500 m), Kodak gray 18% reflective (0.9 m to ›200 m)
4. R1000: Kodak gray 90% reflective (0.9 m to ›1000 m), Kodak gray 18% reflective (0.9 m to ›500 m)
5. Up to 50m, max. measurement time 15s
6. (a) Face I standard, (b) Face I standard, face II optional, (c) face I optional, face II optional
7. Continuous angle measurement, new battery
8. 5 PIN Lemo-0 for power, communication and data transfer
9. For communication and data transfer
10. For internet access, communication and data transfer, WLAN range up to 200 m
11. Storage temperature: –40°C to +70°C

✔ = Included • = Optional ✗ = Not available

Laser radiation, avoid direct eye exposure.
Class 3R laser product in accordance with IEC 60825-1:2014.

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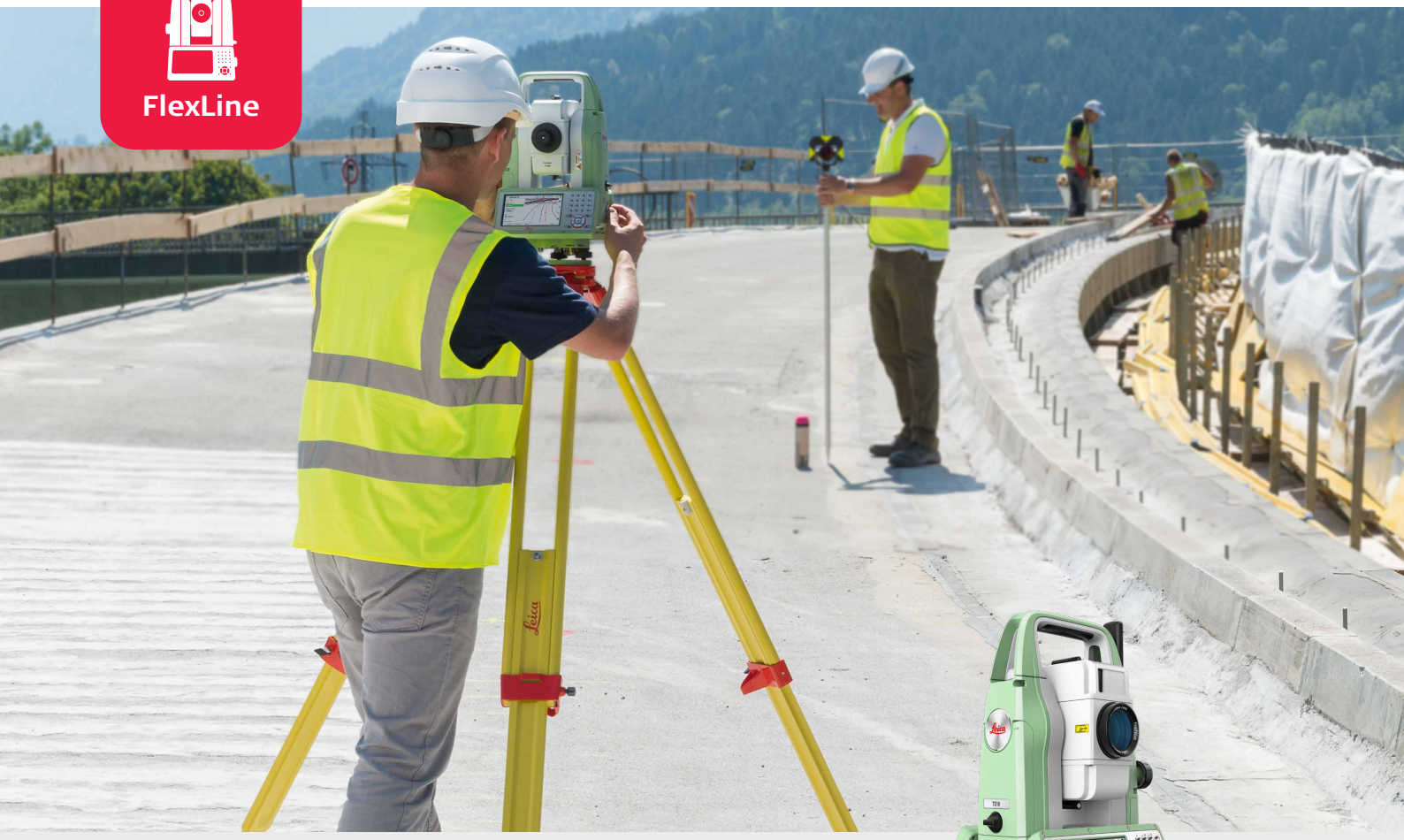
Leica Geosystems

Leica FlexLine TS10
Manual Total Station

FlexLine



LEICA FLEXLINE TS10 MANUAL TOTAL STATION

- **Work faster**: measure more points per day due to faster measurements and stakeout procedures, supported by the revolutionary Leica Captivate field software. The software is made to make your work easier and more enjoyable.
- **Use it trouble-free**: increase productivity and minimise downtime by relying on instruments that simply work and come with a global service and support network.
- **Choose products that are built to last**: even after years of use under harsh conditions (like mud, dust, blowing rain, extreme heat and cold), FlexLine still operates with the same high level of quality.
- **Control your investment**: reliability, speed and accuracy ensure a lower investment over the product lifetime and a higher resell value.
- **Save time with AutoHeight:** this revolutionary feature enables the FlexLine TS10 manual total station to automatically measure, read and set the instrument height. Errors are minimised and the setup process onsite is faster.

The Leica FlexLine TS10 manual total station combines user-friendly, ergonomic design with high-end reliability under harsh conditions. It enables you to tie into the modern 3D dataflow, including enhanced linework and coding. The TS10 offers mobile data device integration as an option. The larger, highly visible colour- and touchscreen helps you to complete your surveying tasks with the highest speed and accuracy. The new FlexLine generation of manual total stations relies on a proven product concept that has been revolutionising the world of measurement and survey for nearly 200 years.

Leica FlexLine TS10

Leica FlexLine TS10

ANGULAR MEASUREMENT		
Accuracy Hz and V	Absolute, continuous, diametrical[1]	1'' / 2'' / 3'' / 5''
	■ Display resolution: 0.1'' (0.1 mgon) ■ Quadruple Dual axis compensation with Hz collimation and V index correction ■ Compensator setting accuracy[2]: 0.5'' / 1''/ 1.5'' ■ Compensator range: +/- 4' ■ Electronic level resolution: 2'' ■ Circular level sensitivity: 6` / 2 mm	✔
DISTANCE MEASUREMENT		
Range	■ Prism (GPR1, GPH1P): 0.9 m to 3,500 m ■ Prism GPR1 (Long Range mode) › 10,000 m	✔
	Non-Prism / Any surface ■ R500[3] ■ R1000[4]	✔ •
Accuracy / Measurement time	Single prism ■ 1 mm + 1.5 ppm (typical 1 - 2 s)	✔
	Non-Prism / Any surface ■ 0 m - 500 m: 2 mm + 2 ppm (typical 2.4 s[5]) ■ › 500 m: 4 mm + 2 ppm	✔
	Display resolution: 0.1 mm	✔
Laser dot size	■ At 30 m: 7 mm x 10 mm ■ At 50 m: 8 mm x 20 mm ■ At 100 m: 16 mm x 25 mm	✔
Telescope	■ Magnification: 30x ■ Resolving power: 3'' ■ Focusing range: 1.5 m / 4.92 ft to infinity ■ Field of view: 1°30' / 1.66 gon / 2.7 m at 100 m	✔
GENERAL		
Display and keyboard	5'' (inch), 800 x 480 pixels WVGA, colour and touch ■ 25 keys[6a] ■ 37 keys with function keys[6b]	✔ •
	2nd keyboard	•
	Key illumination	✔
Operation	■ Endless drives for HZ & V ■ Trigger-Key: user definable with 2 functions	✔
Power management	Exchangeable Lithium-Ion battery[7] ■ Operating time with GEB361 ■ Operating time with GEB331	 up to 19 h up to 9 h
	External supply voltage ■ Nominal voltage 13.0 V DC & 16 W max	✔
Data storage	■ Internal memory: 2 GB Flash / 4 GB Flash ■ Memory card: SD card 1 GB or 8 GB ■ USB memory stick: 1 GB	✔ / • ✔ ✔
Processor	■ TI OMAP4430 1GHz Dual-core ARM® Cortex™ A9 MPCore™ ■ Operating system – Windows EC7	✔
Interfaces	RS232[8], USB device	✔
	Bluetooth®[9], WLAN[10]	✔
	Mobile Data sidecover: LTE-Modem for internet access	•
Guide Light (EGL)	■ Working range: 5 m to 150 m ■ Position accuracy: 5 cm at 100 m ■ Wavelength red /orange: 617 nm / 593 nm	✔ (R1000)
Laser plummet (Laserclass 2)	Accuracy ■ Plumb line deviation: 1.5 mm at 1.5 m instrument height ■ Diameter of laser point: 2.5 mm at 1.5 m instrument height	✔
AutoHeight module for automatic instrument height measurement (Laserclass 2)	Accuracy ■ Distance accuracy: 1.0 mm (1 Sigma) ■ Distance range: 0.7 m to 2.7 m	✔
Weight		4.4 - 4.9 kg
Environmental specifications[11]	■ Working temperature range: –20°C to +50°C ■ Arctic version: –35°C to +50°C ■ Dust / Water (IEC 60529) / Humidity: IP66 / 95%, non-condensing ■ Military Standard 810G, Method 506.5	✔ • ✔ ✔
Imaging	■ 5 megapixel CMOS sensor ■ Overview camera with field of view 19.4°	•
LOC8	Tracking and theft deterrence device	•

Legend:

1. 1'' (0.3 mgon), 2'' (0.6 mgon), 3'' (1 mgon), 5'' (1.5 mgon)
2. Angular accuracy / Compensator setting accuracy: 1'' /0.5'' (0.2 mgon), 2''/0.5'' (0.2 mgon), 3''/1.0'' (0.3 mgon), 5''/1.5'' (0.5 mgon)
3. R500: Kodak gray 90% reflective (1.5 m to ›500 m), Kodak gray 18% reflective (1.5 m to ›200 m)
4. R1000: Kodak gray 90% reflective (1.5 m to ›1000 m), Kodak gray 18% reflective (1.5 m to ›500 m)
5. Up to 50 m, max. measurement time 15 s
6. (a) Face I standard, face II optional, (b) face I optional, face II optional
7. Distance/angle measurement every 30 seconds
8. 5 PIN Lemo-0 for power, communication and data transfer
9. For communication and data transfer
10. For internet access, communication and data transfer, WLAN range up to 200 m
11. Storage temperature: –40°C to +70°C

✔ = Included • = Optional

Laser radiation, avoid direct eye exposure.
Class 3R laser product in accordance with IEC 60825-1:2014.

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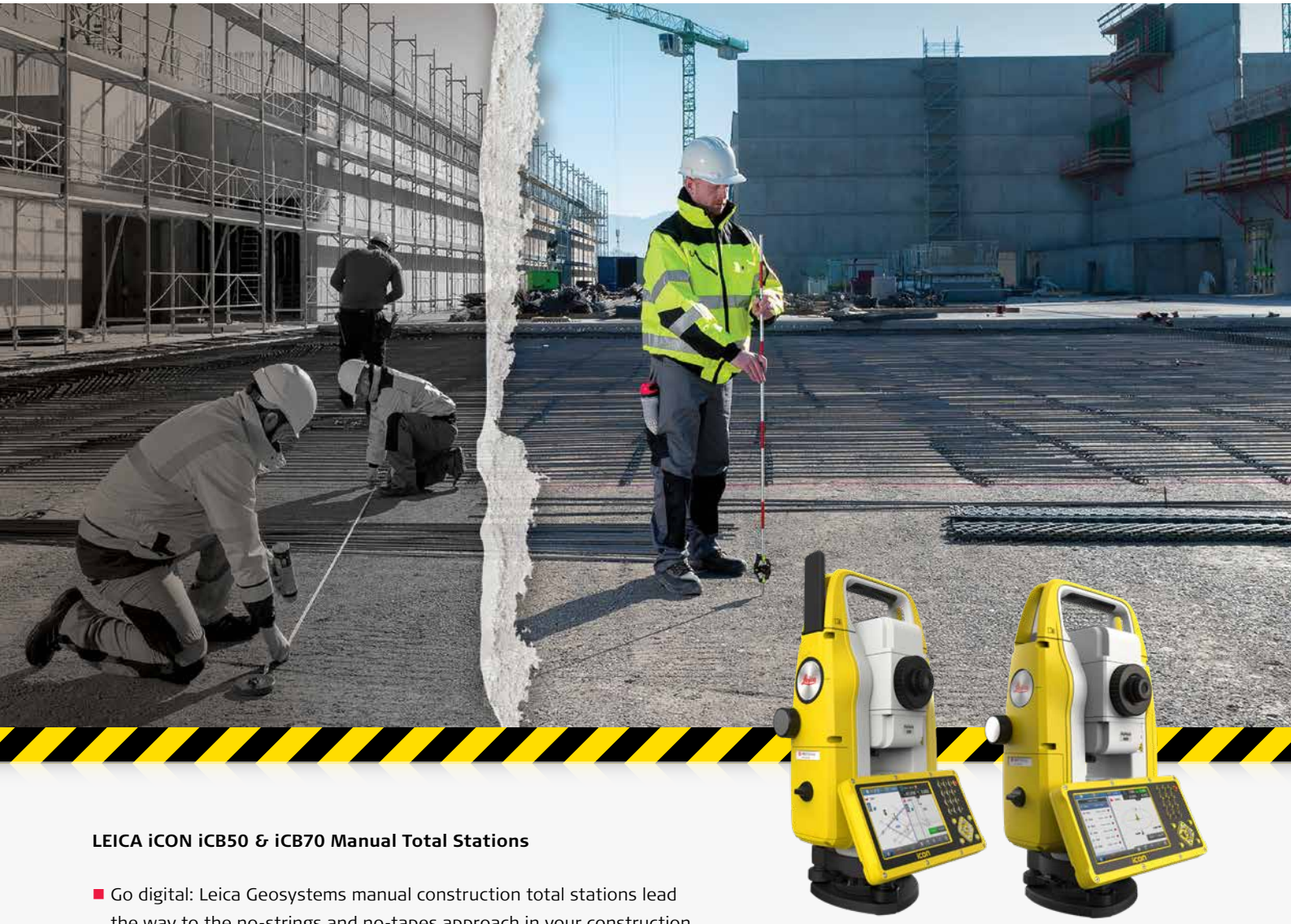
Leica Geosystems

Leica iCON iCB50 & iCB70

Manual total stations for construction



LEICA iCON iCB50 & iCB70 Manual Total Stations

- Go digital: Leica Geosystems manual construction total stations lead the way to the no-strings and no-tapes approach in your construction project
- Ease of use: simple to learn and easy to master, the Leica iCB50 and iCB70 help you to complete projects more efficiently with minimal training
- Understanding Construction: Leica Geosystems iCON portfolio offers software and hardware solutions specifically designed for any task in the Building and Heavy Construction segment
- Mobile data: featuring an integrated 4G modem, the iCB70 allows mobile data transfer directly between the design office and the instrument on site.

The new generation of Leica Geosystems' manual construction total stations facilitate your move from conventional analogue layout methods to modern digital workflows. Layout more points per day on your construction project and achieve the productivity and accuracies demanded by the building construction industry. Work with digital design data directly on the instrument, including fully rendered models in IFC file format.

Leica iCON iCB50 & iCB70

iCB50

iCB70

		iCB50	iCB70
ANGULAR MEASUREMENT			
Accuracy Hz and V	Absolute, continuous, diametrical[1]	2'' / 5''	1'' / 2'' / 5''
	■ Display resolution: 0.1'' (0.1 mgon) ■ Quadruple axis compensation ■ Compensator setting accuracy[2]: 0.5'' / 1.5'' ■ Compensator range: +/- 4' (+/- 0.07 gon) ■ Electronic level resolution: 2'' ■ Circular level sensitivity: 6` / 2 mm	✔	✔
DISTANCE MEASUREMENT			
Range	■ Prism (GPR1, GPH1P): 1.5 m to 3.500 m ■ Reflective Tape 60 mm x 60 mm › 250 m	✗	✔
	Non-Prism / Any surface ■ R500[3]	✔	✔[4]
Accuracy / Measurement time	Single prism ■ Single: 1 mm + 1.5 ppm (typical 2.4 s) ■ Continuous: 3 mm + 1.5 ppm (typical ‹ 0.15 s) Reflective tape 60 mm x 60 mm ■ Single mode: 3 mm + 2 ppm (typical ‹ 2 s)	✗	✔
	Non-Prism / Any surface ■ 0 m - 500 m: 2 mm + 2 ppm (typical 3 - 6 s)	✔	✔[4]
Laser dot size	■ At 30 m: 7 mm x 10 mm ■ At 50 m: 8 mm x 20 mm ■ At 100 m: 16 mm x 25 mm	✔	✔[4]
Telescope	■ Magnification: 30x ■ Resolving power: 3'' ■ Focusing range: 1.55 m / 5.08 ft to infinity ■ Field of view: 1°30' / 1.66 gon / 2.7 m at 100 m	✔	✔
GENERAL			
Display and keyboard		5" (inch), 800 x 480 px WVGA, colour, touch, 22 keys	5" (inch), 800 x 480 px WVGA, colour, touch, 22 keys
	2nd keyboard	•	•
	Key illumination	✔	✔
Operation	■ Endless drives for HZ & V ■ Trigger-Key: user definable with 2 functions	✔	✔
Power management	Exchangeable Lithium-Ion battery[5] ■ Operating time with GEB361 ■ Operating time with GEB331	 up to 18 h up to 9 h	 up to 18 h up to 9 h
	Battery charging time with ■ GKL341 charger for GEB361 / GEB331 ■ GKL311 charger for GEB361 / GEB331	 3 h 30 min / 3 h 6 h 30 min / 3 h 30 min	 3 h 30 min / 3 h 6 h 30 min / 3 h 30 min
	External supply voltage ■ Nominal voltage 13.0 V DC & 16 W max	✔	✔
Data storage	■ Internal memory: 2 GB Flash ■ Memory card: SD card 1 GB ■ USB memory stick: 1 GB	✔	✔
Interfaces	■ RS232[6], USB device ■ Bluetooth®[7] ■ WLAN[8] ■ Mobile Data sidecover: LTE-Modem for internet access	✔ ✔ ✗ ✗	✔ ✔ ✔ •
Laser plummet (Laserclass 2)	Accuracy ■ Plumb line deviation: 1.5 mm at 1.5 m instrument height ■ Diameter of laser point: 2.5 mm at 1.5 m instrument height	✔	✔
Field software	iCON build field software	iCON build (incl. Sketching, Layout Points, Layout Lines, Checks, As-built)	iCON build plus (incl. Sketching, Layout Points, Layout Lines, Checks, As-built, Volumes, Cut/Fill, Slopes, Stakeout)
	■ Software options	iCON build plus (Volumes, Cut/Fill, Slopes, Stakeout), Layout Objects, Hidden Point, Tilted Plane, 2Face and Set, Roading, Drill Pattern, MC Calibration	Autodesk BIM360, Leica ConX, Layout Objects, Hidden Point, Tilted Plane, 2Face and Set, Roading, Drill Pattern, MC Calibration
Weight		4.5 kg	4.5 kg
Environmental specifications[9]	■ Working temperature range: –20°C to +50°C ■ Dust / Water (IEC 60529) / Humidity: IP66 / 95%, non-condensing ■ Military Standard 810G	✔ ✔ ✔	✔ ✔ ✔

✔ = Included • = Optional ✗ = Not available

Legend:
1. 1'' (0.3 mgon), 2'' (0.6 mgon), 5'' (1.5 mgon)
2. Angular accuracy / Compensator setting accuracy: 1'' /0.5'' (0.2 mgon), 2''/0.5'' (0.2 mgon), 5''/1.5'' (0.5 mgon)
3. R500: Kodak gray 90% reflective (1.5 m to ›500 m), Kodak gray 18% reflective (1.5 m to ›200 m)
4. iCB70 Laserclass 2 model is Prism mode only, without reflectorless measurement and laser pointer
5. Distance/angle measurement every 30 seconds
6. 5 PIN Lemo-0 for power, communication and data transfer
7. For communication and data transfer
8. For internet access, communication and data transfer, WLAN range up to 200 m
9. Storage temperature: –40°C to +70°C

Laser radiation, avoid direct eye exposure.
Class 3R laser product in accordance with IEC 60825-1:2014.

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Surveying Tribrachs - White Paper

Characteristics and Influences

- when it has to be **right**

Leica Geosystems

March 2010

Daniel Nindl
Heerbrugg, Switzerland

Surveying tribrachs – Characteristics and Influences

Daniel Nindl

Abstract

This paper presents an overview of different factors and properties regarding surveying tribrachs. It should provide comprehensive information for the surveyor to further ensure highest quality surveys. Secondly the influences that a tribrach could be subjected to are summarized. After reading, it should be clear what the important points to think about are. Four main functions can be assigned to a tribrach:

1. connect instrument with area of support (tripod, pillars, etc.)
2. secure your instrument in the tribrach (via clamp mechanism)
3. enable the possibility to level your instrument within a certain range
4. provide a stable orientation over time

These functions are furthermore explained with detailed information.

Introduction

As a major quality measurement the meaning of hysteresis, often misunderstood, is explained and its bandwidth applied to different tribrach models. Discrete measurements confirm certain quality levels. Further aspects like special tuning of the pair instrument ‹ › tribrach are explained as well as geometrical aspects, mechanical principles and standardized test procedures.

For genuine Leica Geosystems accessories a clear commitment to quality standards is given and Leica customers shall be sufficiently equipped with information and specifications regarding their Leica products.

Surveying tribrachs are important accessories for various applications in surveying. Widely accepted as a reliable accessory, surveyors normally do not consider the influence which its link to the ground (tribrachs & support) might have on measurements. However, obtaining a certain level of accuracy and reliability requires the consideration of all possible effects on the measurements. A high emphasis is usually put on specifications and accuracy of the total station or other instruments. However, too often the role of accessories is not given enough thought towards the intended application and the subsequent results. Various applications require 3D coordinate qualities only in the range of centimeters. But other tasks demand much higher accuracies. For such tasks, an in-depth analysis of the influence and treatment of potential error sources is mandatory.

This paper summarizes the key factors relative to surveying tribrachs that can influence the measurements – primarily angular measurements. Centring accuracy and the tribrachs orientation in coincidence with the instruments orientation over time are two examples that may have a crucial effect on the survey results. Ignoring these key factors normally leads to a decrease of the measurement quality. All Leica Geosystems tribrachs consider these important factors. Based on sophisticated production techniques, strict assembly and quality control, Leica Geosystems ensures that Leica tribrachs are of the highest quality.

The following structure is applied to the overall document:

- Components
- Mode of operation
- Quality criteria
- User recommendations

Components & general characteristics

In general a tribrach consists of a base plate and an upper plate connected via three thread studs (cf. figure 1).

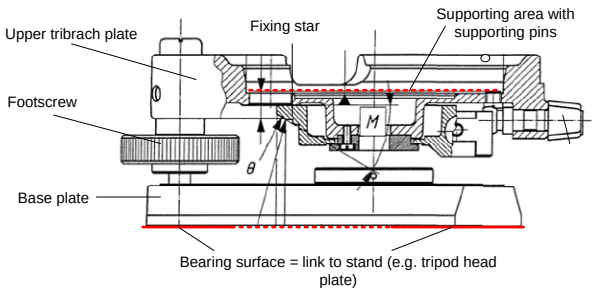

Figure 1 - Cross section of a Leica GDF121 tribrach

By turning the footscrews the upper tribrach plate can be moved in relation to the base plate. By turning the footscrews differently the upper tribrach plate can achieve an angle tilt (compared to the base plate) of about 10°.

A major requirement to ultimately achieve a leveled horizon for your instrument or your accessory is a horizontal plane projected through the supporting pins on the upper tribrach plate (cf. red arrows in figure 2). Ideally being parallel to the reference plane for your bubble. At least within the tolerance of the bubble specification of the circular level (e.g. Leica Geosystems' GDF121 circular bubble is specified with 8', cf. figure 4). The red lines in figure 1 indicate the upper and the lower planes on one hand providing the reference plane to the instrument, on the other hand providing the link to the supporting area of the tripod head or the measurement pillar, etc. Its planarity is an important and necessary geometrical feature to ensure the perpendicularity of the standing axis of your instrument relative to the horizon.

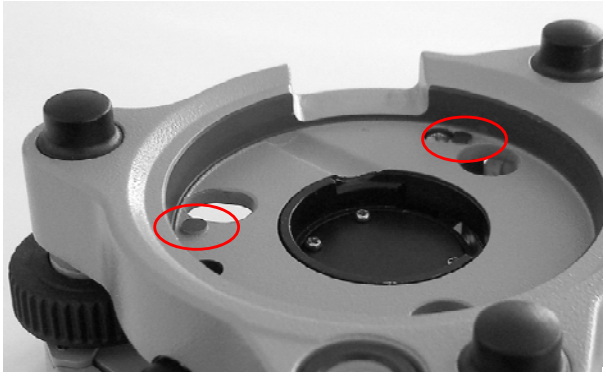

Figure 2 - Leica GDF121 tribrach showing supporting pins on upper tribrach plate

Optical Plummet

Leica Geosystems tribrach optics follow the strict Leica standards to provide a perfect, erect, crisp image, assured being distortion free.

Figure 3 - Detail view of the GDF121 optical plummet

The adjustment of the plummet ocular guarantees uniform, smooth movement and no backlash. Further characteristics are:

- **Magnification** 2x
- **Field of view** 6° +-1°
- **Eyepiece Adjustment range**: ±5 dioptres
- **Centring Accuracy** ±0.5mm@1.5m
- **Focus Range** 0.35m to infinity
- **Centring Image** 2 concentric circles
- **Image Adjustment** adjustable

The design offers full operating ergonomics to the user to provide a convenient and fast focusing process when centering to your surveying mark. However, certain surveying tasks don't require an optical plummet, others use the instruments laser plummet, but a forced centered traverse – for instance – is hardly ever done without tribrachs having optical plummets.

Leica Geoystems accessories/tribrach portfolio offers the right model for the particular task...

Circular Level

Circular levels of Leica Geosystems tribrachs are specified with 8'/2mm (that means a tilt of the level plane of 8' moves the bubble for 2mm). The bubble is adjustable with 3 allen screws providing the possibility to make sure that the bubble remains well calibrated referring to the centrally printed circle on the bubble glass. As a reference for e.g. a tube bubble (e.g. Leica's GZR2 reflector holder) or the total station itself can be used: (1) Make sure that your instrument is calibrated, (2) use the digital bubble to level the total station – turn the instrument 180° to ensure that the digital (or analog) bubble is centered. (3) adjust the circular level of the tribrach using adjusting pin (provided either in the total station container or with the tribrach).

Figure 4 - Detail view of the GDF121 circular bubble

Supporting Areas / Supporting Pins

The mechanical design and the treatment (especially hardened) of the surfaces of the supporting areas is also a fundamental characteristic to create a solid,

anti-slippery connection to the tripod head plate (cf. figure 2 and figure 5).

Figure 5 - Bottom side of the base plate of a Leica GDF121 tribrach – shown is one of three supporting areas (points)

Historical Design Aspects

In figure 6 a former Leica (Wild) tribrach model is shown – the GDF6 (not available any more), used as standard tribrach for various instruments (e.g. Wild T16). The cut (1) in figure 6 was used to fix the instrument permanently in the same position in the tribrachs (older instruments had a compatible nose) to avoid centring errors for special applications. The hole (2) was made for the light channel for the horizontal circle reading. Today's models do not provide the hole (2) any more because it's simply outdated. There are no devices relying on it any more. However, the cut (1) is still necessary for some instruments (e.g. Leica TDA5100).
Soon after market introduction first sub-standard copies appeared and various manufacturers still produce models having these holes without knowing why...

Leica Geosystems' tribrachs remain compatible in order to provide a flexible and efficient use of your equipment.

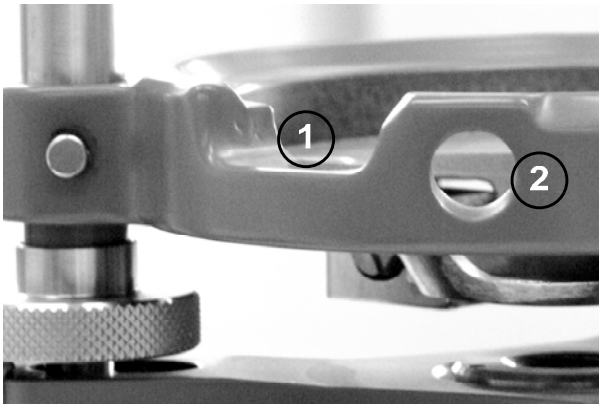

Figure 6 - Detail view of WILD GDF6 tribrach

Mode of Operation

Even tough a tribrach appears to be a simple connecting device between the instrument and its support, the mechanics behind have to be designed sophisticatedly in order to guarantee smooth operation over its entire lifecycle. To secure your instrument in the tribrach is one of its four major tasks. Therefore the clamping arm (G) is turned (close/open) to press the clamping flange of the lock assembly (E) into the instruments holding studs (A).

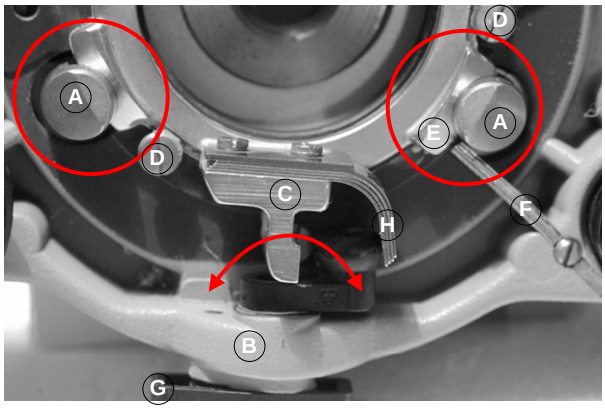

Figure 7 - Detail view (from below) of the upper tribrach plate showing the instrument secured

A	instrument studs
B	upper tribrach plate
C	lock assembly – spring holder
D	holding screws for lock assembly – in other models also realized through an insert ring
E	lock assembly – clamping flange
F	orientation spring
G	tribrach clamping arm
H	lock assembly - spring

Before the clamping mechanism can work, the instrument needs to be placed in the tribrach. Sounds easy, but the initial position of the instrument studs – cf. figure 8 is arbitrary. If the clamp is released, the orientation spring is loose.

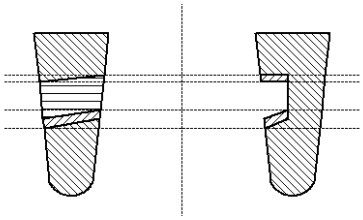

Figure 8 - Cross section of instrument studs

When tightening the clamp, the stud in hole 1 (cf. figure 9) is pressed to its edge via the orientation

spring. Further the lock assembly ring is turned slightly eccentric because of non-concentric position of the clamping arm.

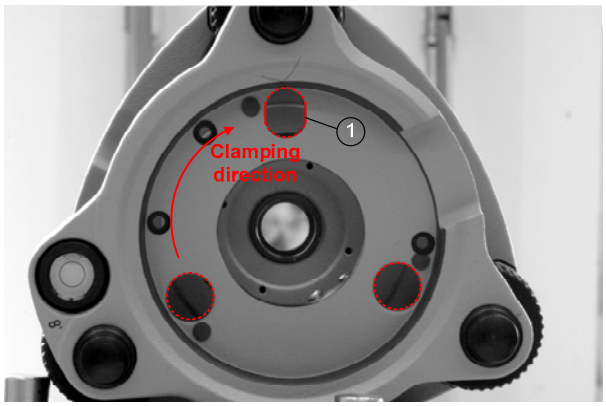

Figure 9 - View of the upper tribrach plate showing the holes for the instrument studs and indicating the clamping direction

Based on the special design of the clamping flanges E (cf. figure 10b) together with the tilted cut of the instrument studs a buildup of pressure occurs when closing the clamp. Subsequently the lock assembly (fixing star) presses the instrument studs against the upper tribrach plate. Now the instrument is secure.

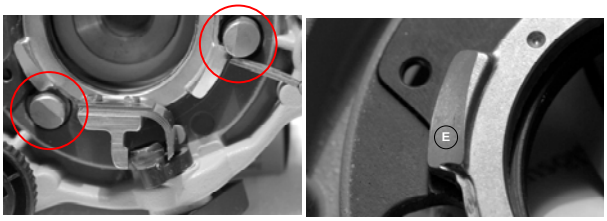

Figure 10a+b - Detail view (from below) of the upper tribrach plate showing the instrument released (a); Detail view of a clamping flange (b)

Especially the clamping flange E (cf. figure 10b) is a very sensitive part in order to guarantee a perfect clamping function.

For Leica Geosystems tribrachs, the design, the manufacturing process and the quality control of the lock assembly ring follows traditional high standards in order to guarantee smooth operation and long lifetime.

Quality Criteria

Certain tribrach features are defined with an ISO standard to establish general standards for different manufacturers. Furthermore interchangeability between instruments shall be garanteed. Beside mechanical design elements, one of the major accuracy measurements (= torsional rigidity) is defined in the following standard:

ISO Standard 12858-3

Torsional Rigidity (Hystersis)

"The tribrach shall be capable of absorbing, without lasting deformation, the torsion which occurs when the instrument is used." [ISO12858-3]

The statement above refers to the second main function: secure your instrument in the tribrach – over the entire measuring process! It's important to rely on the initial orientation of the tribrach to achieve accurate horizontal (and vertical) angle measurements to subsequently guarantee the instruments overall orientation.

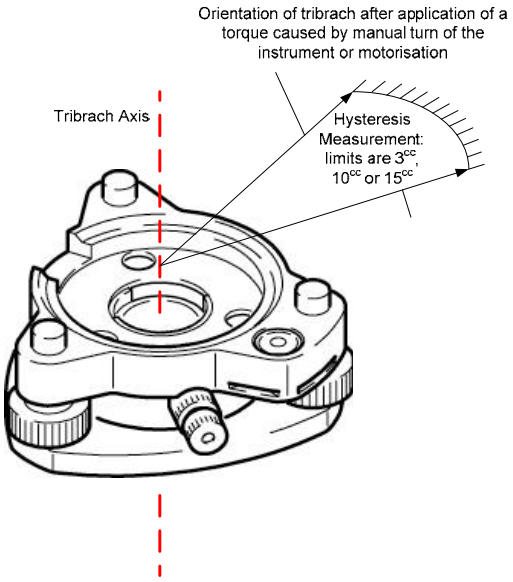

Figure 11 - Illustration of the meaning of hysteresis

In both cases, when using a motorized or a manual instrument, certain torques are applied from the instrument to the tribrach, then furthermore to the tripod (or any other support) and subsequently to the ground.

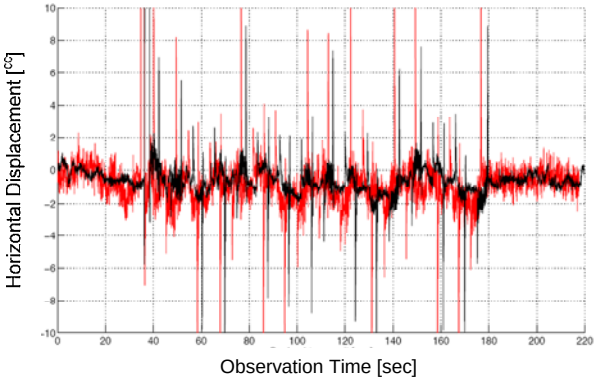

Figure 12 - Effect of applied torques to tribrach and tripods

Figure 12 shows a synchronized measurement of torsional rigidity of a tribrach (red line). The damping (partly absorption of applied torque) shall be indicated; compared to the black line (measurement at tripod head) the red line shows continuously higher amplitudes – this is a clear evidence for the absorption characteristics of tripods. The measurement series shown in figure 2 was performed with a Leica TCA2003 (7.5 kg) executing an automated measurement sequence to 2 prisms in two faces during a measurement time of ca. 4min. During these face changes high torque-peaks are created (up to 20^{cc}=7″). This is acceptable as long as the deformation is elastic and the initial orientation is held within a certain level (compare average deformation level within measurements 0-20 and 200-220). The according hysteresis is less than 1^{cc}=0.3″. Further information regarding hysteresis measurements is shown in Kusber, 2007.

The according ISO standard doesn't define any limits regarding torsional rigidity, derived from hysteresis measurements it is just mentioned that: *"It shall be the responsibility of the user to ensure that the tribrach has sufficient torsional rigidity to be compatible with the accuracy of the instrument" [ISO12858-3]*

Subsequently the orientation of the instrument in Leica Geosystems tribrachs during and after use refers to certain limits. Leica Geosystems' tribrachs portfolio offers 3 main series:

- Professional 1000: < 15^{cc} (5″)
- Professional 3000: < 10^{cc} (3″)
- Professional 5000: < 3^{cc} (1″)

These values are under continuous quality control within Leica Geosystems quality management. Thereby total compliance of technical specification is ensured. Operators can fully trust Leica Geosystems! And with a broad product portfolio, a tribrach can be found for all applications.

Life Time Tests

Every instrument setup must undergo a leveling process in order to guarantee the operation of your compensator and to refer your measurement to the horizon respectively. The remaining tilt after your tripod setup is usually compensated via your tribrach footscrews. Leica Geosystems tribrachs are tested with 3000 turns on each screw over the entire length of the thread.

Over 3000 turns for each screw Leica Geosystems ensures

- a smooth and friction-free movement
- without any backlash and
- no grating.

In figure 13 a detail of Leica Geosystems lifetime test machine is shown.

Figure 13 - Tribrach lifetime test setup

User Recommendations

Almost every total station, GNSS antenna, laser scanner or laser plummet is mounted and secured with a tribrach (some examples are shown in figure 14); through the forced centring system the setup of the particular device over a given control point becomes possible. Tribrachs are an integral part of surveying procedures, and careful selection is critical to ensure the required accuracy is achieved.

Devices on the Tribrach

Figure 14 - Different devices requiring a tribrach in order to be used at all

Special applications like forced traverses cannot be performed without using a forced centring system provided by tribrachs. Other applications based on

pillar setups are not possible without using tribrachs either...

Within Leica Geosystems entire instrument portfolio it is warranted that all tribrach models are designed to fit to particular instruments and devices. The mechanical design, the environmental standards and the accuracy specifications are aligned to enable a maximum of flexibility within your Leica hardware.

Genuine Leica vs. Leica Copies

Various tribrachs copies are available on the market. To rigorously compare genuine Leica tribrachs with products cheaply copied is not easy. The devil is in the detail. An objective measurement is certainly a determination of the torsional rigidity via hysteresis measurements, but this takes time and is most likely not easily possible for most users. A low quality copy may look the same, but will certainly not satisfy surveyors expectations. However, over time the threadwear and the loose of clamping mechanism will be certainly noticeable whereas the genuine Leica tribrachs guarantee continued quality.

Turning the screws, turning the focus ring of the optical plummet, closing the clamp: a genuine Leica product guarantees smooth operation – the operator certainly feels the difference! Along the same side a smooth functioning is the basis for a long life of your product.

Figure 15 - Quality management steps within Leica Geosystems' tribrachs assembly

Figure 15 represents the necessary steps to manufacture a genuine Leica Geosystems tribrach. Most of the steps are invisible to the customers, but in compliance with our strong quality we guarantee to supply the best products for our customers.

Best Practice

The goal of this paper is to provide surveyors with basic knowledge of the less thought about details which a measurement-setup consists of – in particular the role of the tribrachs. And for the surveyors who strive for the most precise measurement, this paper provides a strong summary for both the magnitude and effects of the chosen target components that influence the measurements:

To achieve highest measurement accuracy

- Use tribrachs with adequate specifications in order to fulfill required measurement accuracy
- Use a tribrach model providing required features (e.g. optical plummet)
- Ensure periodic maintenance

Table 1 shows a summary of different tribrach models, currently offered within Leica Geosystems accessories portfolio.

Model	Torsional Rigidity	Optical Plummet	Operating life	Weight	Colour
GDF121	3cc	NO	3000	780g	GREEN
GDF122	3cc	YES	3000	860g	GREEN
GDF111-1	10cc	NO	3000	780g	GREEN
GDF112	10cc	YES	3000	860	GREEN/ RED
GDF101	15cc	NO	1000	780g	BLACK
GDF102	15cc	YES	1000	860g	BLACK

Table 1 - Different tribrachs models with its main characteristics

The benefits when using Leica Geosystems surveying tribrachs are long lifetime, highest accuracy and highest reliability. Leica Geosystems accessories are adjusted together with Leica Geosystems instruments. Thus we can guarantee best performance and quality of your measurements.

References

[ISO1723-3]

ISO 12858-3:2005(E) – INTERNATIONAL STANDARD „Optics and optical instruments – Ancillary devices for geodetic instruments – Part 3: Tribrachs, ISO 2005", www.iso.org

[DIN2277]

DIN 2277 – DEUTSCHE NORMEN „Dosenlibellen – Begriffe und Ausführungen" , 1961

[Kusber07]

KUSBER, Danuta: Accuracy Analysis of a 0.5" Totalstation in Relation to the Centre of Gravity Offset and Tribrach Deformations – Diploma Thesis, University of Applied Sciences Mainz

Whether you want to monitor a bridge or a volcano, survey a sky-scraper or a tunnel, stake out a construction site or perform control measurements – you need reliable equipment. With Leica Geosystems original accessories, you can tackle demanding tasks. Our accessories ensure that the specifications of the Leica Geosystems instruments are met. Therefore you can rely on their accuracy, quality and long life. They ensure precise and reliable measurements and that you get the most from your Leica Geosystems instrument.

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Surveying Tripods – White Paper

Characteristics and Influences

- when it has to be **right**

Leica Geosystems

March 2010

Daniel Nindl, Mirko Wiebking
Heerbrugg, Switzerland

Surveying tripods – characteristics and influences

Daniel Nindl, Mirko Wiebking

Abstract

In the daily work of a surveyor, he often doesn't think about the influence of accessories on accuracy. However, with precision surveys and measurements over long periods, the influence of accessories becomes significant. Therefore it is necessary to have some knowledge about this influence.

In this paper, the effect of tripods on instrument accuracy is evaluated. The tripod requirements are defined by the International Standard (ISO 12858-2) in terms of height stability under load and torsional rigidity. In addition to these requirements, Leica Geosystems also evaluates the horizontal drift. For this paper, these three properties were tested on a range of tripods. Using the results, recommendations are made for which tripod to use depending on the instrument and the application.

The tests were all performed in stable laboratory conditions to achieve the best possible comparisons. The influence of temperature und humidity was not considered. To obtain comparable results, all tripod clamps were tightened with the same force using a torque wrench.
Two tripods of each Leica Geosystems type were evaluated. In order to achieve comparable results for a fibreglass tripod, two Trimax tripods from Crane Enterprises were included in all the tests. The results of the tests were similar for Tripod A and Tripod B of each type (model). Therefore only the graphs for Tripod A are shown in this paper.
Following structure is applied to the overall document:

- Quality criteria – describes the relevant test-parameters
- Test results – summarizes and evaluates test results
- User recommendations

Quality Criteria – Standardized Quality Measurements according to ISO-Standard 12858-2

According to the ISO standard 12858-2, tripods can be classified as either heavy- or light-weight. A heavy tripod is required to have a mass of more than 5.5kg. This tripod type can support instruments up to 15kg. Lighter tripods are suitable only for instruments weighing less than 5kg. For Leica Geosystems instruments this includes only the Builder TPS, GPS antennas and prisms.

Height Stability

The ISO standard defines that the position of the tripod head may not vertically shift by more than 0,05 mm when subject to double the maximum instrument weight. Therefore the heavy duty GST120-9, GST101 and Trimax require testing with 30kg. The GST05, GST05L and GST103 are defined for light duty and were tested with 10kg.

Figure 1: Quality management steps within Leica Geosystems' tribrachs assembly

The defined vertical deformation of 0.05 mm is of such a small amount that the effect is insignificant on TPS angular accuracy. However, for precision leveling applications, the tripod height stability should be considered.

By considering measurement accuracy and automatic capability, a Leica DNA03 Digital Level was used to measure the deformations. Measurements were made to a GWCL60 invar scale, attached to the fixing screw of the tripod (cf. figure 1). 100 measurements were first made without load on the tripod. Using a pulley system, a weight was gently lowered onto the

tripod plate. After another 400 measurements, the weight was removed.

Torsional Rigidity

When an instrument rotates, the forces effect a horizontal rotation of the tripod head plate. The torsional rigidity is a characteristic of the tripod to absorb this horizontal rotation by returning to its original position when the instrument is stationary. The precision to which the tripod orientation returns to the original position is known as hysteresis.

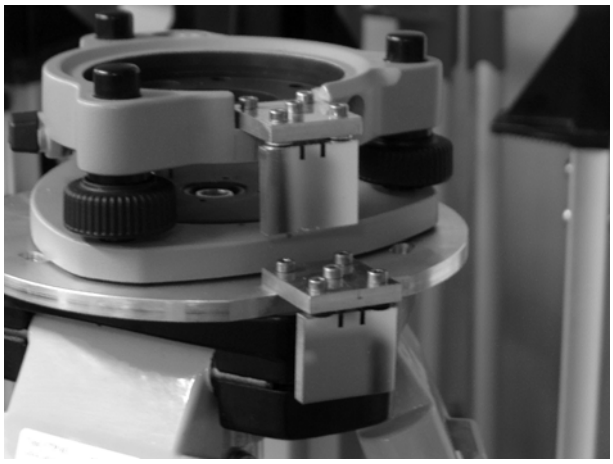

Figure 2 - Autocollimation mirrors mounted on tripod and tribrach to detect rotational deformations

In accordance with ISO standard, if the tripod plate is rotated by 200 cc (ca. 70"), the maximum allowable hysteresis for heavy tripods is 10cc (3") and for light tripods is 30cc (10"). To obtain more practical results, the effect of a rotating motorized instrument was tested. A TPS1200 was used which exerts a horizontal torque of 56Ncm while accelerating and braking. Using the application "Sets of Angles", observations were automatically made on two prisms alternatively. This provided a rotation in both directions continuously during the observation time. Measurements were recorded for at least 200 seconds. To measure the torsional rigidity, an electronic collimator was used to monitor the deformations through the principle of autocollimation. An output frequency of 16 Hz ensured rapid tracking of the deformations. A specially made plate was mounted between the tripod head and the tribrach. Measurements were made to a mirror mounted on the plate. In the picture above, a second mirror can be seen mounted on the tribrach. This allowed additional measurements to be made that took in the combined effect of the tripod and tribrach on the instrument.

Horizontal Drift

The horizontal drift of a tripod is the measurement of how its orientation changes over time. This is not an ISO requirement, but Leica Geosystems checks their tripods for this drift for the sake of quality assurance. A similar measurement method as for torsional rigidity was used, but with the measurement period extended to a minimum of 3 hours. To reduce the amount data, the frequency of the collimator was reduced to 0.5Hz.

The TPS1200 was again mounted in the tribrach. However, during the measurement period, the instrument remained stationary.

Model Name	GST120-9	GST101	Trimax	GST05	GST05L	GST103
						
Material	Beech wood	Pine wood	Fibreglass	Pine wood	Aluminium	Aluminium
Surface treatment	Oil & Paint	Paint	Non	PVC coating	Non	Non
Leg clamp	Side screw	Side screw	Quick-clamp	Central screw	Central screw	Side screw
Country of origin	Hungary	China	USA	Hungary	Hungary	China
Weight	6.4 kg	5.7 kg	7.4 kg	5.6 kg	4.6 kg	4.5 kg
Maximum Height	180 cm	166 cm	175 cm	176 cm	176 cm	167 cm
ISO Classification	Heavy	Heavy	Heavy	Light	Light	Light

Table 1 - Tested tripod model

Therefore the instrument exerts no rotational force on the tripod. The movement of the tripod is only due to the instrument load. Table 1 shows a summary of different properties of the tripod models used for the particular tests.

Test Results – Height Stability

The GST120-9 provides the best results with a height stability of 0.02mm.

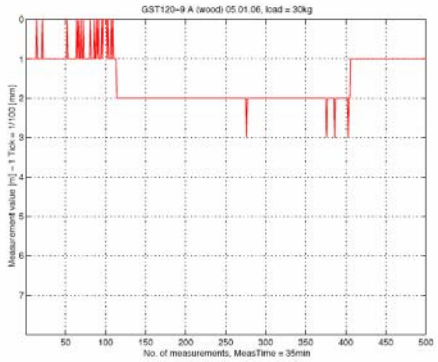

Figure 3a - Leica GST120-9 tripod

The GST101 has 14cm shorter legs than the GST120-9, which assists in making this a more stable tripod.

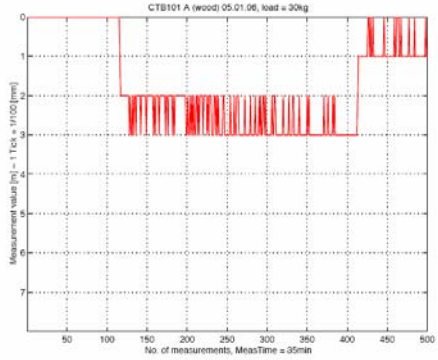

Figure 3b - Leica GST101 tripod

The Trimax has a maximum distortion of 0.05mm. This value is at the limit of the ISO requirement. The tested tripod had quick-clamps, in comparison to all Leica Geosystems tripods that use screw clamps. The clamps might be the cause for the poor height stability.

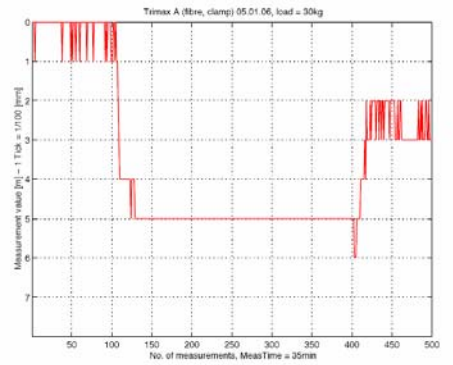

Figure 3c - Crain Trimax fiberglass tripod

Light Tripods

The GST05 shows the best performance for the light tripods. After a load of 10kg, the tripod deforms by a maximum of only 0.02mm.

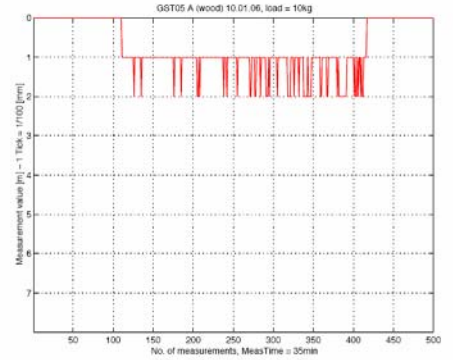

Figure 4a - Leica GST05 tripod

The GST05L has a slightly higher vertical deformation of 0.03mm in comparison to the wooden GST05.

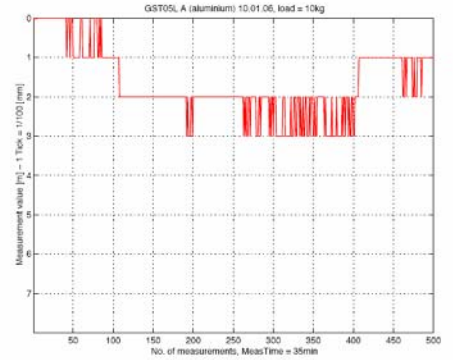

Figure 4b - Leica GST05L tripod

The GST103 performs similarly to the GST05L with a maximum vertical movement of 0.03mm. Although this is also a low-cost product recommended for lower accuracy instruments, the ISO criteria are still fulfilled.

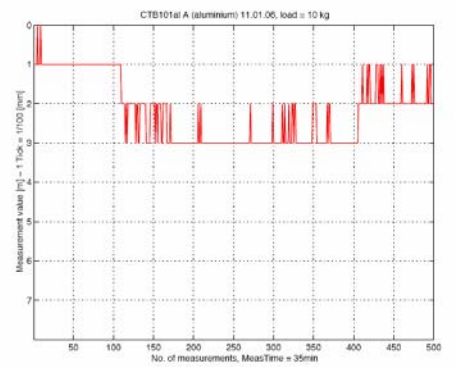

Figure 4c - Leica GST103 alu tripod

Test Results – Torsional Rigidity

The large amplitude spikes occur during the acceleration and deceleration of the rotating instrument. Since no angular values can be recorded on the instrument during this time, these influences may be ignored. The hysteresis value is determined by examining the maximum amplitude of the graph when the spikes are disregarded.

The results clearly show the difference in stability between the heavy and light tripods. The light tripods show up to several times the distortion. In addition, the fiberglass and aluminium tripods experience an overall linear trend. This means that the instrument constantly looses orientation over time.

Heavy Tripods

Of all the tripods tested, the GST120-9 has the lowest hysteresis of 2^{cc} (0.7"). During the entire measurement process the tripod head plate remains extremely stable.

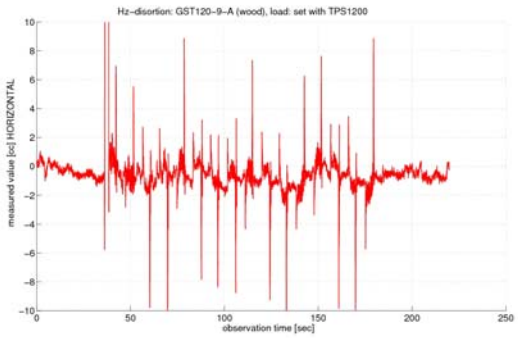

Figure 5a - Leica GST120-9 tripod

The GST101 results have similarly low amplitude of 3^{cc} (1"). The Trimax shows an amplitude twice that of the other heavy tripods, of 6^{cc} (2"). The overall linear trend indicates that the hysteresis constantly increases during the set-up time.

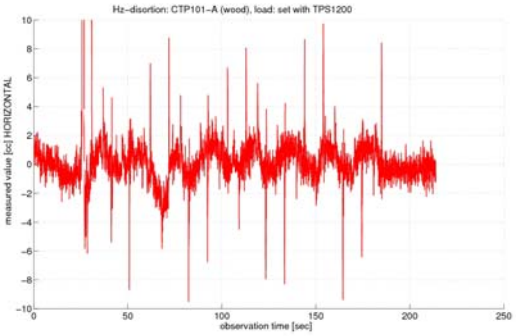

Figure 5b - Leica GST101 wood tripod

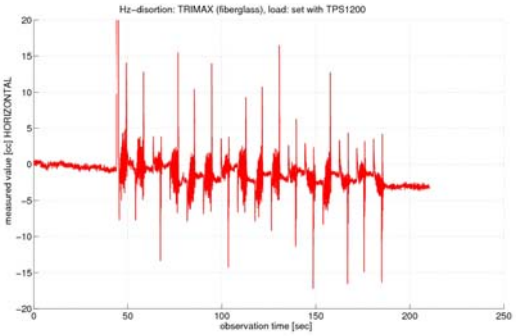

Figure 5c – Crain Trimax fiberglass tripod

Light Tripods

For the light tripods, the wooden GST05 proves to be the most stable with a hysteresis of 8^{cc} (2.7"). Both the aluminium tripods have a large rotational deviation over time. After 200 seconds, the GST05L has a hysteresis of 11^{cc} (3.7") and the GST103 reaches 30^{cc} (10"). The value of 30^{cc} (10") is at the limit of the ISO standard for a light tripod.

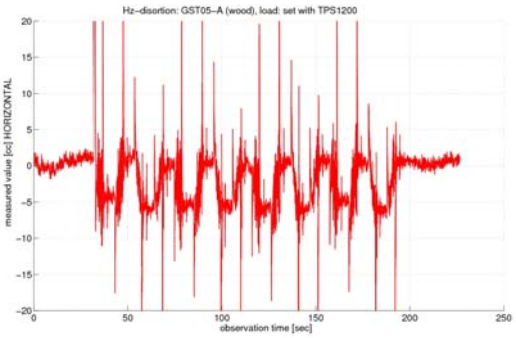

Figure 6a - Leica GST05 tripod

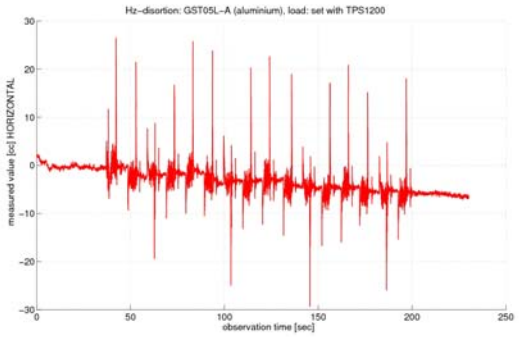

Figure 6b - Leica GST05L tripod

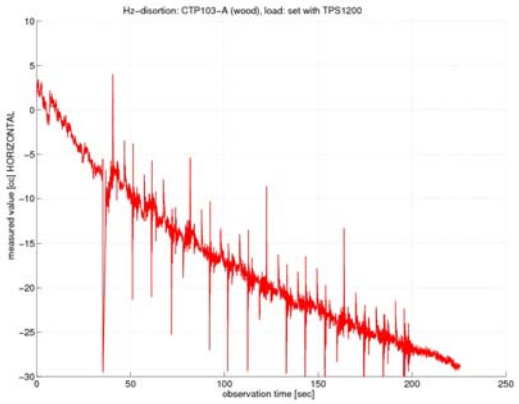

Figure 6c - Leica GST103 tripod

Test Results – Horizontal Drift

Similarly to the torsional rigidity test, the fiberglass and aluminium tripods loose orientation over time. This continues for approximately the first 1200 sec. After this time, the fiberglass Trimax becomes stable. The aluminium tripods continue to rotate, but at a slower rate.

Heavy Tripods

For the GST120-9, a constant linear change occurs throughout the measurement period. However, the drift remains small at 7^{cc} (2.3") after 3 hours.

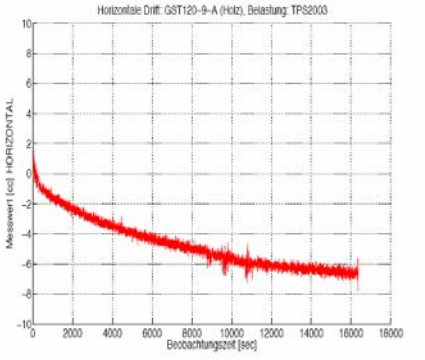

Figure 7a - Leica GST120-9 tripod

The CTP101 experiences the least drift, to a maximum of 4^{cc} (1.3").

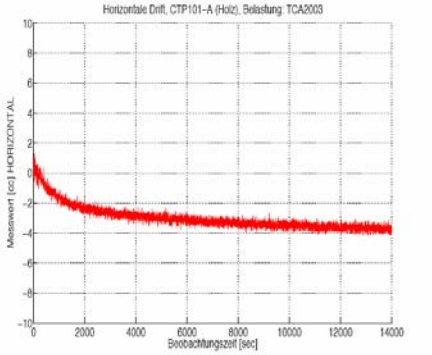

Figure 7b - Leica GST101 tripod

The Trimax drifts rapidly after set-up, by as much as 12^{cc} (4") during the first 600 sec. However, after approximately 20 minutes the Trimax remains stable at 14^{cc} (4,7").

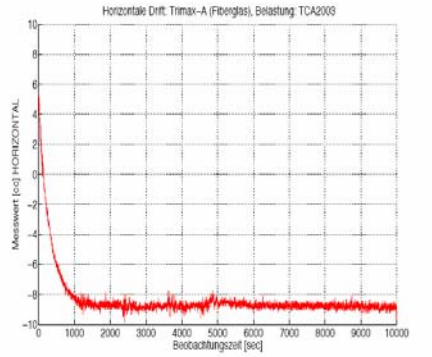

Figure 7c - Crain Trimax tripod

Light Tripods

The GST05 shows to be the most stable tripod of all those tested, with a drift of less than 3^{cc} (1"). The aluminium tripods continue to deform for the entire measurement time. After the 3 hours, the GST05L has drifted by 23^{cc} (7,7") and the GST103 by 9^{cc} (3").

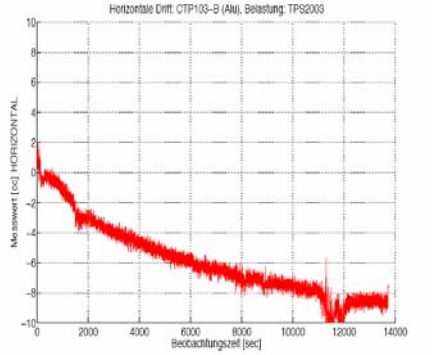

Figure 8a - Leica GST103 tripod

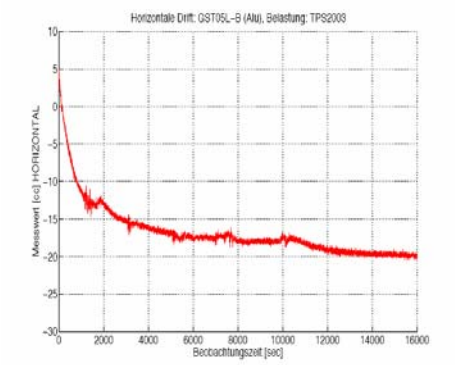

Figure 8b - Leica GST05L tripod

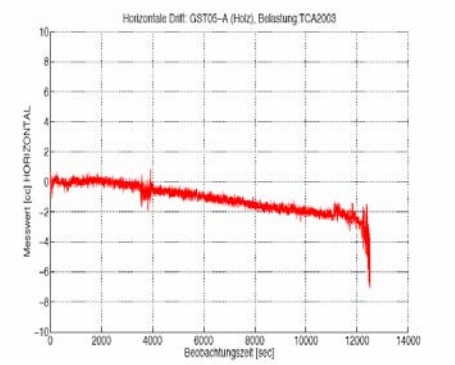

Figure 8c - Leica GST05 tripod

Genuine Leica vs. Leica Copies

Various tripod copies are available on the market. Because of their well known quality Leica Geosystems tripods are often perceived as quality-defining references.

What you get is a „Black-Box" purchase. Something that looks similar as a genuine Leica accessory but ultimately you just don't know what you have got ...	Original Accessories
	Supplier qualification for a sustainable product quality
	Material and process qualification
	Tripod wood or
	Tripod aluminium
	Surface structure of tripod head plate
	Tripod tips - special steel
	Torsional Rigidity
	Height Stability
	Horizontal Drift
	Monitor assembly process
	Fulfill national testings and regulations
	Requalification of technical specification in certain intervals
	Finetuning of tripods to the instruments for maximum stability and lifetime.

Table 1 - Quality management steps within Leica Geosystems' tripod assembly

Hence Leica tripods are often used as a model for copying. Subsequently several manufacturers have started to make business by flooding the market with cheap tripod copies without having a warranted quality standard ensured. The right column in table 2 shows the necessary steps to make a genuine Leica Geosystems tripod. Most of the steps are invisible to the customer, but in compliance with our strong quality management, we guarantee to supply the best products for our customers.

Usage recommendations

Table 2 summarizes the results of the all the measurements taken during this project. The values shown are the maximum error occurred during the measurement time. To determine the total effect on TPS accuracy, the hysteresis value of the tribrach is also included in the table. Leica Geosystems recommends the GDF121 (1″) with heavy tripods and the GDF111-1 (3″) with light tripods. From the total possible influence, it is clear that the tripod and tribrach have a significant effect on TPS angular accuracy. As a material, wood has been proven to provide the most stable tripod. The GST120-9 has the best results for height stability and torsional rigidity and therefore suitable for all Leica TPS instruments. The horizontal drift results show that the wooden GST05 has the least distortion over an extended time. This makes the tripod ideal for GPS antennas and prism targets, which are usually set-up for long periods.

Aluminium tripods provide good height stability, but poor horizontal orientation. Therefore they should be avoided for use with angular measuring instruments. Since aluminium tripods are cheaper than wooden ones, light-weight and long lasting, they are recommended for leveling applications.

As shown by the horizontal drift graphs, aluminium and fiberglass experiences large distortions during the first 20 minutes of set-up. To obtain reliable results, it should be considered to allow this period to pass before starting observations. In addition, the orientation should be regularly checked during the measurement process.
The tripod analysis tests were all made under laboratory conditions. However, under normal field conditions, further effects such as temperature, humidity, ground type, wind, etc. additionally affect stability. As tripods age, it can also be expected that their stability would decrease. Therefore the influence of the tripod and tribrach must always be considered when determining the angular accuracy that can be achieved.

Using the values in the table the most suitable tripod can be chosen for the required surveying application. For precision surveys over long periods, it is recommended to use a concrete pillar. Alternatively, a sophisticated measurement process should be used which compen sates for these errors.

Model Name	GST120-9	GST101	Trimax	GST05	GST05L	GST103
Leica product for which suitable	All TPS	All TPS	TPS >5″	GPS antenna Prisms	Prisms Levels	Prisms Levels
Material	Beech wood	Pine wood	Fibreglass	Pine wood	Aluminium	Aluminium
ISO Classification	Heavy	Heavy	Heavy	Light	Light	Light
Height stability	0.02 mm	0.03 mm	0.05 mm	0.02 mm	0.03 mm	0.03 mm
Tripod hysteresis	1″ (2^{cc})	1″ (3^{cc})	2″ (6^{cc})	3″ (8^{cc})	4″ (11^{cc})	10″ (30^{cc})
Tribrach hysteresis	1″ (3^{cc})	1″ (3^{cc})	1″ (3^{cc})	3″ (10^{cc})	3″ (10^{cc})	3″ (10^{cc})
Max. possible influence	**2″ (5^{cc})**	**2″ (6^{cc})**	**3″ (9^{cc})**	**6″ (18^{cc})**	**7″ (21^{cc})**	**13″ (40^{cc})**
Hz Drift after 3 hours	2″ (7^{cc})	1″ (4^{cc})	5″ (14^{cc})	1″ (3^{cc})	8″ (23^{cc})	3″ (9^{cc})

Table 2 - Summary of results and recommendations

Source

This document is a summary and translation of the Thesis named *Genauigkeitsanalyse von Vermessungsstativen und Dreifüssen unter der Belastung verschiedener Instrumente*. The Thesis was conducted during 2006 by Daniel Nindl of the Department Geodesy Engineering, Technical University of Vienna, under guidance of Mirko Wiebking of Leica Geosystems AG, Heerbrugg. The purpose of the thesis study was to analyses the effect of tripods and tribrachs on instrument accuracy. The analysis of tribrachs is not included within this document, but there is an additional white paper available, called: "Surveying Tribrachs – Characteristics and Influences".

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Leica Geosystems

Leica TS13
Data sheet

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The TS13 works with the revolutionary Leica Captivate field software, turning complex data into the most realistic and workable 3D models. It spans industries and applications with little more than a simple swipe, regardless of whether you work with GNSS, total stations or both. A smooth data transfer ensures the project stays on track. Captivate and Leica Infinity office software work in conjunction to join previous survey data and edit projects faster and more efficiently.

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Through Active Customer Care (ACC), a global network of experienced professionals is only a click away to expertly guide you through any problem. Eliminate delays with superior technical service, finish jobs faster with excellent consultancy support, and avoid costly site revisits with online service to send and receive data directly from the field. Control your costs with a tailored Customer Care Package, giving you peace of mind, you're covered anywhere, anytime.

Leica TS13 Total Station

Basic variant

ANGULAR MEASUREMENT		
Accuracy [1] Hz and V	Absolute, continuous, diametrical	1'' (0.3 mgon), 2'' (0.6 mgon) 3'' (1 mgon), 5'' (1.5 mgon)
DISTANCE MEASUREMENT		
Range [2]	Prism (GPR1, GPH1P) [3] Non-Prism / Any surface [4]	1.5 m to 3500 m R500: 1.5 m to >500 m, R1000: 1.5 m to >1000 m
Accuracy / Measurement time	Single (prism) [2,5] Single (any surface) [2,4,5,6]	1 mm + 1.5 ppm / Typically 2.4 s 2 mm + 2 ppm / Typically 3 s
Laser dot size	At 50 m	8 mm x 20 mm
Measurement technology	System analyser	Coaxial, visible red laser
AUTOMATIC AIMING - ATR		
Target aiming range[2]	Circular prism (GPR1, GPH1P) 360° prism (GRZ4, GRZ122)	1000 m 800 m
Accuracy [1,2] / Measurement time	ATR angle accuracy Hz, V	1'' (0.3 mgon), 2'' (0.6 mgon), 3'' (1 mgon), 5'' (1.5 mgon) / Typically 3-4 s
GUIDE LIGHT (EGL)		
Working range / Accuracy		5 - 150 m / Typically 5 cm @ 100 m
GENERAL		
Processor	TI OMAP4430 1GHz Dual-core ARM® Cortex™ A9 MPCore™	Operating system – Windows® EC7
Power management	Exchangeable Lithium-Ion battery	Operating time 8 - 10 h
Field software	Leica Captivate incl. apps	Running on field controller (Leica CS20)
Data storage	Internal memory 2 GB SD card 1 GB or 8 GB	On field controller (Leica CS20)
Interfaces	RS232, USB, Bluetooth®, WLAN	
Weight	Total station including battery	5.0 kg
Environmental specifications	Working temperature range Dust / Water (IEC 60529) / Humidity	–20°C to +50°C IP55 / 95%, non-condensing
Keyboard	Face I standard	4 button keyboard with status LEDs

Upgrades[7]

KEYBOARD DISPLAY UNIT (Optional)		
Keyboard with display	Face I and face II optional	5'' (inch), WVGA, colour, touch 25 keys, illumination
Power management	Exchangeable Lithium-Ion battery	Operating time 6 - 8 h
Field software	Leica Captivate including apps	Running on TS13 instrument
Data storage	Internal memory 2 GB SD card 1 GB or 8 GB	On TS13 instrument
Weight	Total station including battery	5.3 kg
TARGET LOCK (Optional)		
Target locking range[2]	Circular prism (GPR1, GPH1P) 360° prism (GRZ4, GRZ122)	800 m 600 m
ROBOTIC SURVEYING including PRISM FAST SEARCH (Optional)		
SpeedSearch range / Search time	360° prism (GRZ4, GRZ122)	300 m / Typically 7 s
Robotic range with long-range Bluetooth® [8]	To CS20 internal long-range Bluetooth® To CTR20 expansion pack	500 m 1000 m

[1] Standard deviation ISO 17123-3
[2] Overcast, no haze, visibility about 40 km, no heat shimmer
[3] 1.5 m to 2000 m for 360° prisms (GRZ4, GRZ122)
[4] Object in shade, sky overcast, Kodak Gray Card (90% reflective)
[5] Standard deviation ISO 17123-4
[6] Distance > 500 m: Accuracy 4 mm + 2 ppm, Measurement time typically 6 s
[7] Initial or after sales, independent from each other
[8] Under good radio conditions

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- when it has to be **right**

Leica Geosystems

Leica TS16
Data sheet

Leica TS16 robotic total station is a self-learning hard worker, just like yourself. It combines the engaging **Leica Captivate field software**, **ATRplus** for a robust targeting performance, **PowerSearch** for prism fast search, a **camera** for image-assisted surveying and documentation. You can keep your instrument safe by adding **LOC8**, our theft deterrence and location solution. **AutoHeight** and the optional **DynamicLock** feature can make your work even more efficient. The TS16 is the key to absolute control over any surveying situation or environmental condition.

LEICA TS16 ROBOTIC TOTAL STATION: SURVEY IT.

- **Best-in-class automated total station for the widest variety of measurement tasks and applications:** including one-person or two-person instrument operation for surveying and stakeout.
- **Topographic surveying to create digital reality for mapping:** control point measurements, adjustments, computations, and data collection with powerful coding and line work routines.
- **Highest efficiency and productivity for stakeout and construction measurements:** stakeout design data, as-built checks, BIM and clearance checks.
- **Site preparation and machine guidance in heavy construction projects:** site control, surveying, layout of design data, as-built checks, machine guidance, and road, rail and tunnel focused workflows.
- **Quick and reliable monitoring of locations, buildings, and objects in real-time in any environment:** perfect for campaign monitoring and scaling up to an automated monitoring solution.

Leica TS16 Total Station

ANGLE MEASUREMENT		
Accuracy [1] Hz and V	■ Absolute, continuous, diametrical	1'' (0.3 mgon), 2'' (0.6 mgon), 3'' (1 mgon), 5'' (1.5 mgon)
DISTANCE MEASUREMENT		
Range [2]	■ Prism (GPR1, GPH1P) [3] ■ Non-Prism / Any surface [4,9]	0.9 m to 3,500 m R500: 0.9 m to >500 m R1000: 0.9 m to >1,000 m
Accuracy / Measurement time	■ Single (prism) [2,5] ■ Single (prism fast) [2,5] ■ Single (any surface) [2,4,5,6]	1 mm + 1.5 ppm / typically 2.4 s 2 mm + 1.5 ppm / typically 1.5 s [11] 2 mm + 2 ppm / typically 2 s [7]
Laser dot size	At 50 m	8 mm x 20 mm
Measurement technology	System analyser	Coaxial, visible red laser
IMAGING		
Overview camera	■ Sensor ■ Field of view ■ Frame rate	5 megapixel CMOS sensor 19.4° Up to 20 frames per second
AUTOMATIC AIMING - ATRplus		
Target aiming range[2] / Target locking range[2]	■ Circular prism (GPR1, GPH1P) ■ 360° prism (GRZ4, GRZ122)	■ 1,500 m / 1,000 m ■ 1,000 m / 1,000 m
Accuracy [1,2] / Measurement time	ATRplus angle accuracy Hz, V	1'' (0.3 mgon), 2'' (0.6 mgon), 3'' (1 mgon), 5'' (1.5 mgon) / typically 3-4 s
LASER GUIDE		
Spot Size[8] / Range	■ Daylight: 30 mm @250 m ■ Darkness: 65 mm @300 m	250 m 500 m
POWERSEARCH		
Range / Search time	360° prism (GRZ4, GRZ122)	300 m / typically 5 s
GUIDE LIGHT (EGL)		
Working range / Accuracy		5 - 150 m / typically 5 cm @ 100 m
GENERAL		
Operating System / Field Software	Windows EC7 / Leica Captivate with apps	
Processor	TI OMAP4430 1GHz Dual-core ARM® Cortex™- A9 MPCore™	
AutoHeight module for automatic instrument height measurement	■ Distance accuracy ■ Distance range	1.0 mm (1 Sigma) 0.7 m to 2.7 m
Display and keyboard	5'' (inch), WVGA, colour, touch, face I standard / face II optional	37 keys, illumination
Power management	Exchangeable Lithium-Ion battery	Operating time up to 8 h
Data storage	Internal memory / Memory card	2 GB / SD card 1 GB or 8 GB
Interfaces	RS232, USB, Bluetooth®, WLAN	
Weight	Total station including battery	5.1 - 5.8 kg
Environmental specifications	■ Working temperature range ■ Dust & Water (IEC 60529) / Humidity	–20°C to +50°C IP55 / 95%, non-condensing

LEICA TS16 TOTAL STATIONS	TS16 M	TS16 A	TS16 G[10]	TS16 P	TS16 I
Angular measurement	✔	✔	✔	✔	✔
Distance measurement to prism	✔	✔	✔	✔	✔
Distance measurement to any surface	✔	✔	✔	✔	✔
Automatic target aiming (ATRplus)	✗	✔	✔	✔	✔
Laser Guide	✗	✗	✔	✗	✗
PowerSearch (PS)	✗	✗	✗	✔	✔
Overview camera	✗	✗	✗	✗	✔
Guide Light (EGL)	✔	✔	✗	✔	✔

[1] Standard deviation ISO 17123-3
[2] Overcast, no haze, visibility about 40 km, no heat shimmer
[3] 0.9 m to 2,000 m for 360° prisms (GRZ4, GRZ122)
[4] Object in shade, sky overcast, Kodak Gray Card (90% reflective)
[5] Standard deviation ISO 17123-4
[6] Distance > 500m: Accuracy 4mm+2ppm, Measurement time typ. 6s
[7] Up to 50m; max. measurement time 15 s for full range.
[8] Typical laser beam diameter on white, smooth surfaces with intensity 100%
[9] TS16G R30: 0.9 m to 30 m
[10] Angle accuracies 1" to 3", PinPoint R30 & R1000 variants available
[11] Initial measurement time typically 2 s

Laser radiation, avoid direct eye exposure.
Class 3R laser product in accordance with IEC 60825-1:2014.

Integrate with LOC8 – Lock & Locate
For more information visit: **leica-geosystems.com/LOC8**

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