THE ZEISS ELTA 2 ELTA 4

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References- Leitz, H., Dr.
Ten Years of Electronic Tacheometry,
Carl Zeiss, Oberkochen, West Germany

Introduction

When presenting the first Total Station in 1968, nobody could foresee the profound effect this instrument would have on measurement and data-collection techniques. This instrument was the ZEISS RegELTA 14.

With the new generation of equipment, the ELTA 2 and ELTA 4, it becomes obvious that the concept of that first instrument - namely integration of an electronic theodolite and an electronic-optical rangefinder, automatic recording of measurement data and connection to an on-line computer - is still fully valid today.

Compared with the first generation RegELTA 14 and SM 11, the following requirements were incorporated into the new line of instruments: reduced volume and weight, increased accuracy and greater versatility. Since the efficiency-to-price ratio is of decisive importance for the success of a new instrument, two different versions were developed, as it was found that no one instrument would fully satisfy all the requirements. The two new instruments are: the Self-Reducing Electronic Engineers' Tacheometer ELTA 4 (Fig. 3) and the Self-Reducing Second Reading Electronic Tacheometer ELTA 2 that can easily be expanded by the user into a recording computer tacheometer (Fig.1).

The two instruments differ in size, weight, accuracy and price. Common features are the electro-optical rangefinder - an improved version of the time-tried ELDI-microprocessor control of measurement and transformation of measurement data by microcomputer. The following description is subdivided into mechanical and optical assemblies on the one hand and electronics on the other.

It should be noted, incidentally, that these days the theodolite of an electronic tacheometer is likewise electronic. Still, a preferable term would undoubtedly be "theodolite with electronic circle reading",

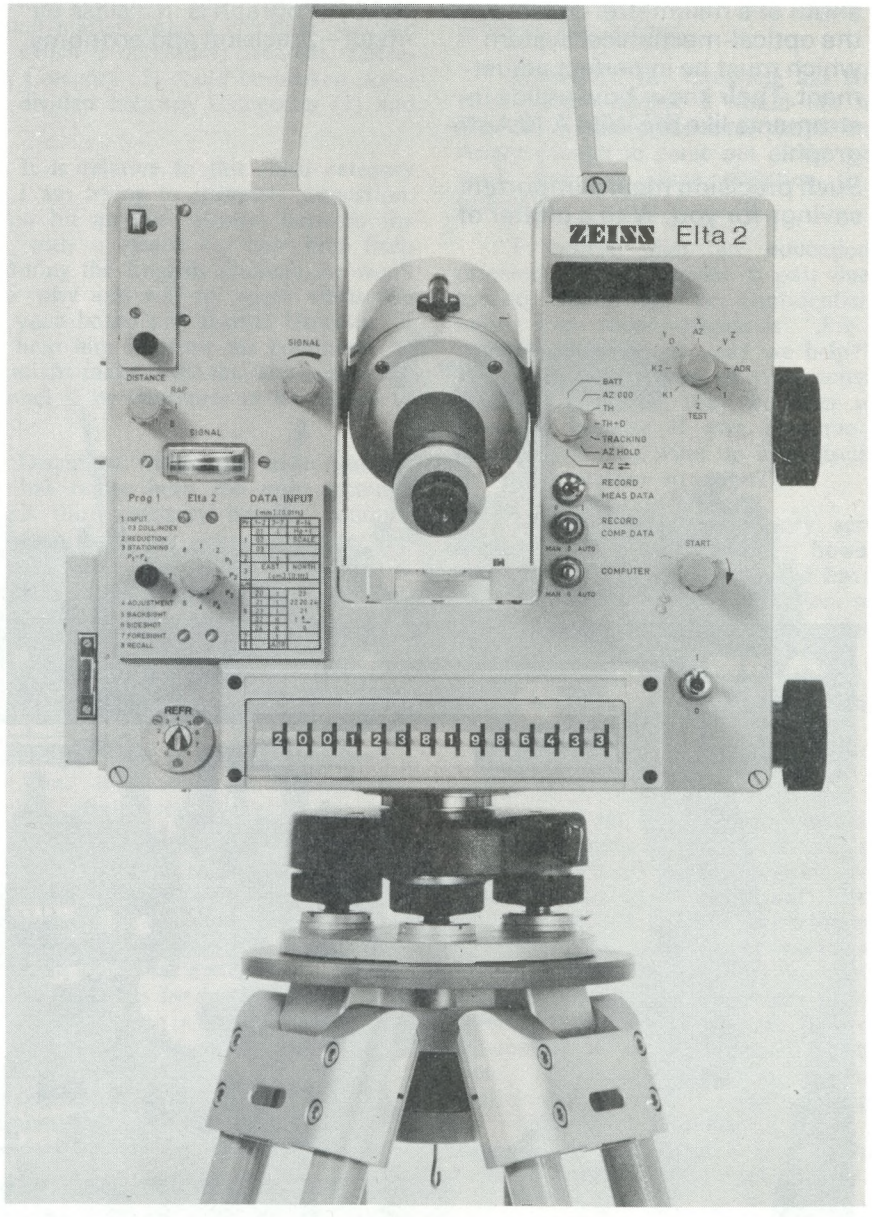

FIGURE 1 — ZEISS ELTA 2
Self-Reducing, Second Reading Tacheometer

since essential components such as uprights, telescope, axes, clamp, motions and even optical imaging of the circle on the electronic detector are, of course, largely identical with those of an optical theodolite.

ELTA 2 Self-Reducing, Second-Reading Tacheometer

In accordance with the aspect outlined in the introduction, the ELTA 2 was developed as an equipment system designed for maximum flexibility.

The ELTA 2 is an electronic tacheometer. Its angle measuring accuracy makes it a **second-reading electronic tacheometer.** Reduction of slope distance to horizontal distance and difference in elevation makes it a **self-reducing, second-reading electronic tacheometer.** Finally, the possibility of using recording memories and slide-in program units for computations make it a recording computer tacheometer. As a result, the ELTA 2 truly deserves to be called a universal instrument (total, total station).

Theodolite of ELTA 2

This is the first ZEISS theodolite made of steel, following a new design which guarantees both high accuracy and high stability of adjustment. A steel upright - a new type of absolutely play-free vertical axis not heretofore used in surveying instruments - special tilting-axis steel bearings and a solid main telescope body of steel with the tilting axis form the framework of this precision theodolite. The horizontal and vertical circles are identical, divided at intervals of 0.5 grad over a diameter of 98 mm. Unlike the figures used for optical circle reading, the circles have vacuum-deposited code tracks. The opposite diametrical projection of the interior graduation onto the exterior one eliminates circle eccentricity and halves the graduation interval to 0.25 grad.

A rotating parallel-plate micrometer keeps shifting the graduation image until symmetrical coincidence with the diametrical graduation is obtained. A second optical system transmits the image of the interior graduation and the coded graduation to the reading coincidence electronic system. When coincidence occurs - without actual stopping, since the micrometer keeps turning continuously - the coded figures are read, the position of the plane-parallel plate and the micrometer reading are recorded and added up to the final circle reading by the microprocessor.

Basically, this is the same principle that is used in conventional second-reading theodolites with double imaging of circles, the only difference being that the visual coincidence setting is here electronically automated and thus made with much greater speed and accuracy. If the micrometer is allowed to rotate continuously in the "tracking" mode, the frequency of two measurements per second permits continuous reading as the instrument is turned. The same micrometer is used simultaneously for the horizontal and vertical circles, while the light path projecting the vertical-circle onto the reading and coincidence matrix passes through a vertical index compensator in order to eliminate the residual inclination of the vertical axis affecting zenith angles. The resolution of the micrometer of 1250 intervals gives a least unit of measurement in elevation and azimuth of 0.0002 grad (2cc or 0.648″). The accuracy of the theodolite, defined by a direction (or zenith angle) measured with the telescope direct and reversed, is the same as the resolution, namely +- 0.002 grad or +-0.6″.

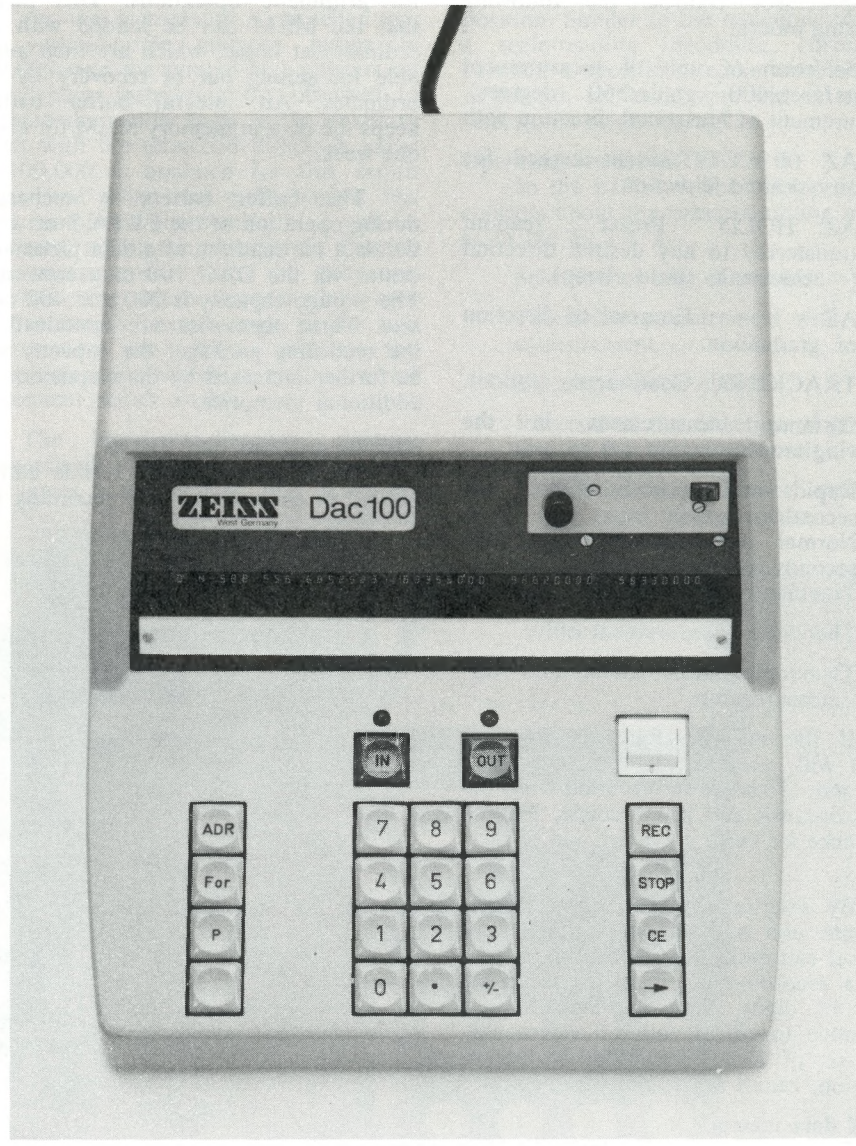

FIGURE 2 — ZEISS DAC 100
Data Converter

Electro-optical rangefinder of ELTA 2

This rangefinder is based on the ZEISS ELDI 2, of which large quantities have been produced. The introduction of an additional coarse frequency has extended the unambiguous measuring range to five kilometers. Here also, the distance is, of course, reduced in accordance with the meteorological data present on a special control. In keeping with the design principle originally introduced in the RegELTA 14, the collimation axes of theodolite and rangefinder are identical, since the telescope objective is at the same time used for transmitting and receiving.

Even in the basic instrument, the

microprocessor controls the following operating modes:

Selection of unit of measurement (meters/feet/400 grads/360 degrees). Measurement of horizontal direction with

AZ 00 Readout zeroed for any desired direction.

AZ HOLD Preset readout transferred to any desired direction (= electronic circle clamp).

AZ Reversal of direction of graduation.

TRACKING Continuous readout.

Distance measurement in the following modes:

Rapid measurement within one second.
Normal measurement within five seconds in range I or II.
Tracking (continuous measurement).

Theodolite measurement only.

Theodolite measurement and distance measurement.

If the microcomputer is switched on, it will calculate the horizontal distance and difference in elevation from the slope distance and zenith angle, making allowance for earth curvature and refraction.

By inserting a data input, PROG program unit and MEM memory unit, the user can easily expand the instrument into a recording computer tacheometer. With 14 digits, the data input makes allowance for the length of a measurement set of 7 digits each for horizontal direction, zenith angle and distance.

MEM data memory

The storage medium for ELTA is an electronic solid-state memory. A stored data set consisting of 14 code figures and the 7-digit measurement data for horizontal direction, zenith angle and slope distance or the reduced measurement data for horizontal direction, horizontal distance and difference in elevation or, on the other hand, the X-coordinate, Y-coordinate, elevation above sea level, setting out parameters, fiducial distances, etc., for computation is automatically addressed starting with 001.

Example:

187	2014127	1000356
236.7852	90.3964	4041.94
Address Code figure	Az	V D

Either measurement and/or calculation data can be recorded. The microprocessor allows two-track interaction with MEM so that it is not only possible to read out recorded data by presetting the desired address on the data input, but also to recall data from the memory for arithmetic operations. This means that the MEM can be loaded with coordinates at home, which are then available for setting out or recovery by coordinates. An integral buffer battery keeps the data in memory MEM for about one week.

The buffer battery is recharged during operation of the ELTA 2 or when the data are read out at a data processing center via the DAC 100 data converter. The storage capacity is 200 and 400 data sets. Three memories are contained in the recording package; the capacity can be further increased by the acquisition of additional memories.

Slide-in program unit PROG

The standard PROG 1 slide unit is needed in conjunction with recording for recalling previously recorded data sets.

In addition, the following computer programs are available.

Free stationing with a maximum of four control points, with or without adjustments (Helmert transformation). Setting out by coordinates with correction readout, either polar (r, q) or rectangular (l, q).

Additional slide-in program units provide the following:

Computation of fiducial distances.

Allowance for axial errors of the theodolite during measurement with the telescope only in the direct position.

Traverse program.

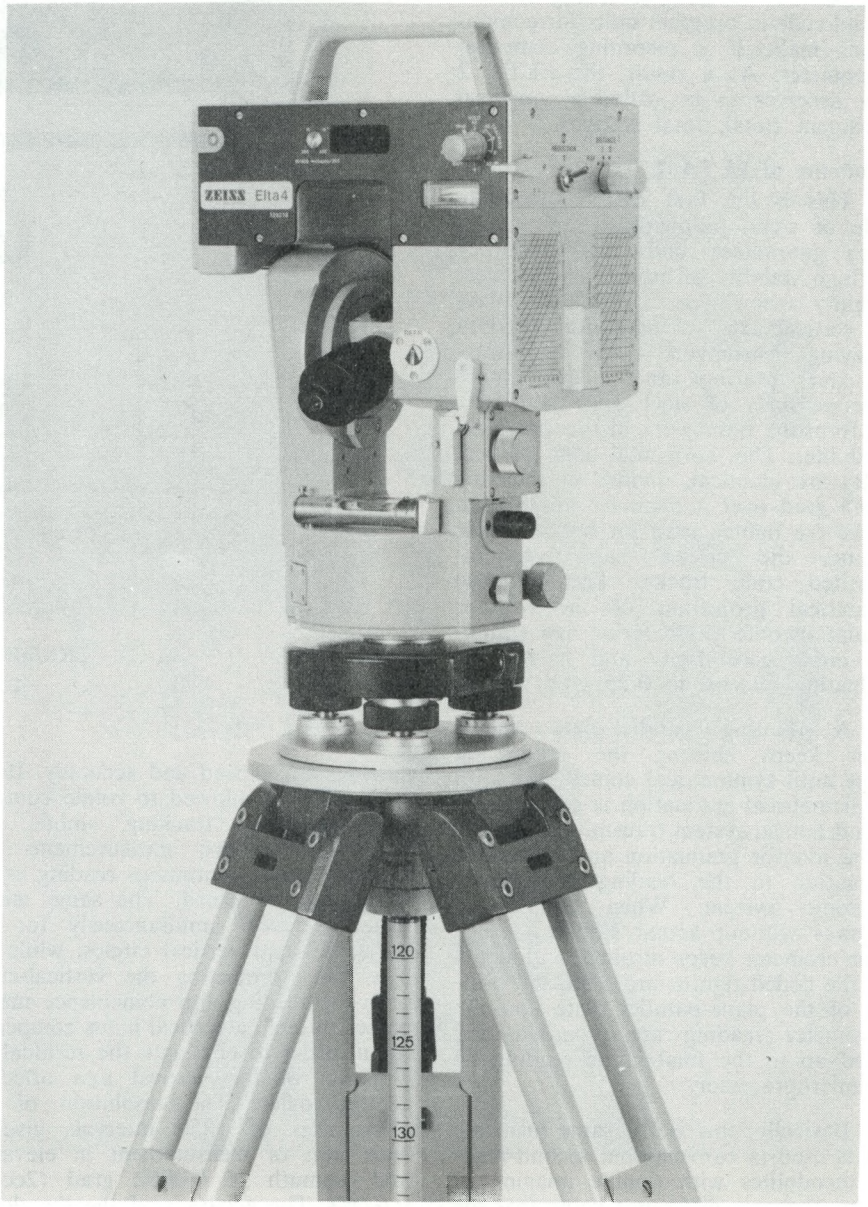

FIGURE 3 — ZEISS ELTA 4
Self-Reducing Engineers' Tacheometer

Determination of coordinates of new points in state or local systems.

DAC 100 data converter

The DAC-100 data converter is the link between the ELTA 2/MEM and the data processing center. It transmits the data stored in MEM via a standard output or a user specific output to the data processing center. In addition, the data can be read out by lines on a 38-digit display, printed in clear text on a printer, transmitted to a permanent recording medium or processed directly in an on-line desk calculator or microcomputer. Data coding is programmed in the data converter (Fig. 2).

In the reverse direction, the data converter is used to read coordinates into the data memory, either manually through the built-in keyboard or directly from an on-line computer.

ELTA 4 Self-Reducing Engineers' Tacheometer

Unlike the universal and highly precise Second-Reading ELTA 2 Tacheometer, the ELTA 4 Engineers' Tacheometer (Fig. 3) has been conceived as a self-reducing instrument, without the possibility of connecting recorders or computers. Its advantages are reduced size, weight and price.

The electro-optical rangefinder is identical to the one used in the ELTA 2, however its range is less, due to the smaller telescope aperture. Here also, measurement is controlled by a microcomputer which reduces the slope distance to horizontal distance and difference in elevation and allows selection of meters, feet, 400 grads or 360 degrees as a unit of measurement. The upright, telescope, clamps and tangent screws of the instrument are identical to those of the mass-produced opto-electronic SM 4 Tacheometer, while the vertical axis is designed as a highly precise ball-bearing axis basically identical to that of the ELTA 2.

Angle measurement in the ELTA 4

The graduated circles are scanned in increments, that is, the circles carry an unfigured grating which during rotation of the instrument generates pulses in increments of 2 milligrads (6.48″) that are counted and displayed. The lack of figures has the following consequences for measurement of zenith angles: with out figures, the vertical circle is not oriented so that the vertical index has to be set by measuring the zenith angle with the telescope direct and reversed by using an auxiliary target. The sequence of measurements is controlled by the microprocessor which automatically locks the measurement system if this order of operations is changed, thus preventing erroneous measurement.

As the instrument is switched on, the vertical-circle memory jumps to 100,000, and the symbol V 1 appears on the display, instructing the observer to measure the zenith angle to the auxiliary target with the telescope direct. A value of 100,000 is assumed for this zenith angle, and when the measurement has been completed, the symbol V 2 will be displayed, telling the observer to proceed with measurement with the telescope reversed. The microcomputer then uses the "erroneous" zenith angle in the two measurement positions to calculate the index correction which is applied to all subsequent zenith angles.

The horizontal-direction memory automatically jumps to 0,000 as the instrument is switched on, and directions are referred to this more or less accidental position. Similar to the technique used in a scale-reading theodolite, correlation between a specific direction and a given target can be found with the aid of the "electronic circle clamp".

Operating modes of ELTA 4

In the ELTA 4, the microprocessor controls about the same operating modes as in the ELTA 2.

Selection of unit of measure.

Theodolite measurement with index measurement.

Electronic circle clamp.

Reversal of the direction of graduation of the horizontal circle.

Theodolite and distance measurements with rapid measurements.

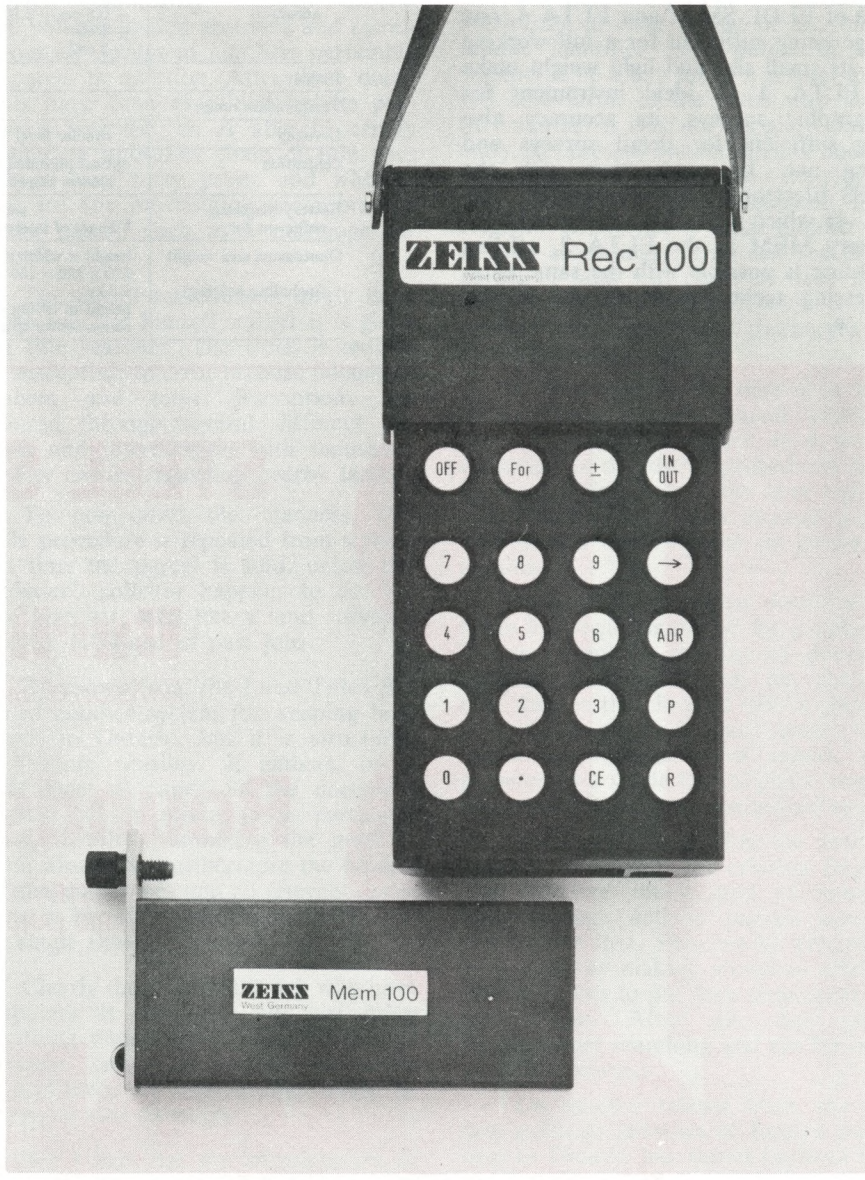

FIGURE 4 — ZEISS REC 100

Electronic Fieldbook with MEM 100 Solid State Data Memory

Normal measurement in range I or II.
Tracking.

In all these modes, either the slope distance or the horizontal distance and the difference in elevation can be displayed.

The data corresponding to the horizontal direction, zenith angle and slope distance or horizontal direction, horizontal distance and level difference are displayed by the brief depression of a button, each value being identified by a suitable code letter. Since the display consumes more power than any other component of the instrument, it is automatically switched off after about 15 seconds, but can be reactivated at any time by slightly pressing the display selector button. A battery magazine with six type E93NiCd cells is identical to those of ELDI, SM 4, and ELTA 4, one charge being sufficient for a full working day. Its small size and light weight make the ELTA 4 an ideal instrument for topographic surveys, its accuracy also being sufficient for detail surveys and setting out. In conjunction with the ZEISS Electronic Field Book REC 100 (Fig. 4) which uses the same solid-state memory MEM as the ELTA 2, off-line recording is possible with the same data-processing technique as in the ELTA 2. ●

Technical Data

Instrument type	Elta-4, Engineers' Tacheometer	Elta-2, Second-Reading Tacheometer
Telescope	erect image; telescope plunging through objective end	
Aperture/magnification	40 mm/25 ×	60 mm/30 ×
Focusing range	3 m to ∞	2.5 m to ∞
Angle measurement	electronic, incremental	electronic, absolute
Graduated circles	glass, grating graduation	glass, coded linear graduation
Least unit	2 milligrads/6″	0.2 milligrads/0.6″
Index compensator	—	range 0.05 grad, accuracy 0.1 milligrad
Accuracy	± 1 milligrad/3″	± 0.2 milligrad/0.6″
Distance measurement	electro-optical, with modulated infrared light ($\lambda = 910$ nm)	
Modulation frequency	30 kHz, 300 kHz, 15 MHz	
Transmitter/receiver	GaAs LED/avalanche photodiode	
Optical system	coaxial transmitting and receiving optical systems, integrated in theodolite telescope	
Unambiguous measuring range	5 km	5 km
Range	dependent on number of reflector prisms and atmospheric conditions	
3 prisms, range I	1.2 km	1.6 km
range II	1.6 km	2.0 km
9 prisms, max.	3 km	4 km
Measurement time	1 second for rapid measurement and tracking, 5 seconds for normal measurement	
Accuracy	± 0.5 cm + $2.10^{-6} \cdot D$ in range I ± 1 cm in range II ± 2 cm with rapid measurement and tracking	
Display	seven digits, switchable	
Temperature range	− 20 °C to + 60 °C	
Leveling	circular level 10′ per 2 mm	tubular level 15″ per 2 mm
Centration	optical plummet in vertical axis, centering rod, positive centering system as per DIN 18719	
Battery magazine sufficient for	six type E93 NiCd cells, rechargeable 8 hours of intermittent operation	approx. 500 measurements
Dimensions and weight	height × width × depth 370 × 220 × 150 mm; 6.5 kg	380 × 320 × 190 mm; 12 kg
(including battery)	height of tilting axis above center spigot 158 mm	181 mm