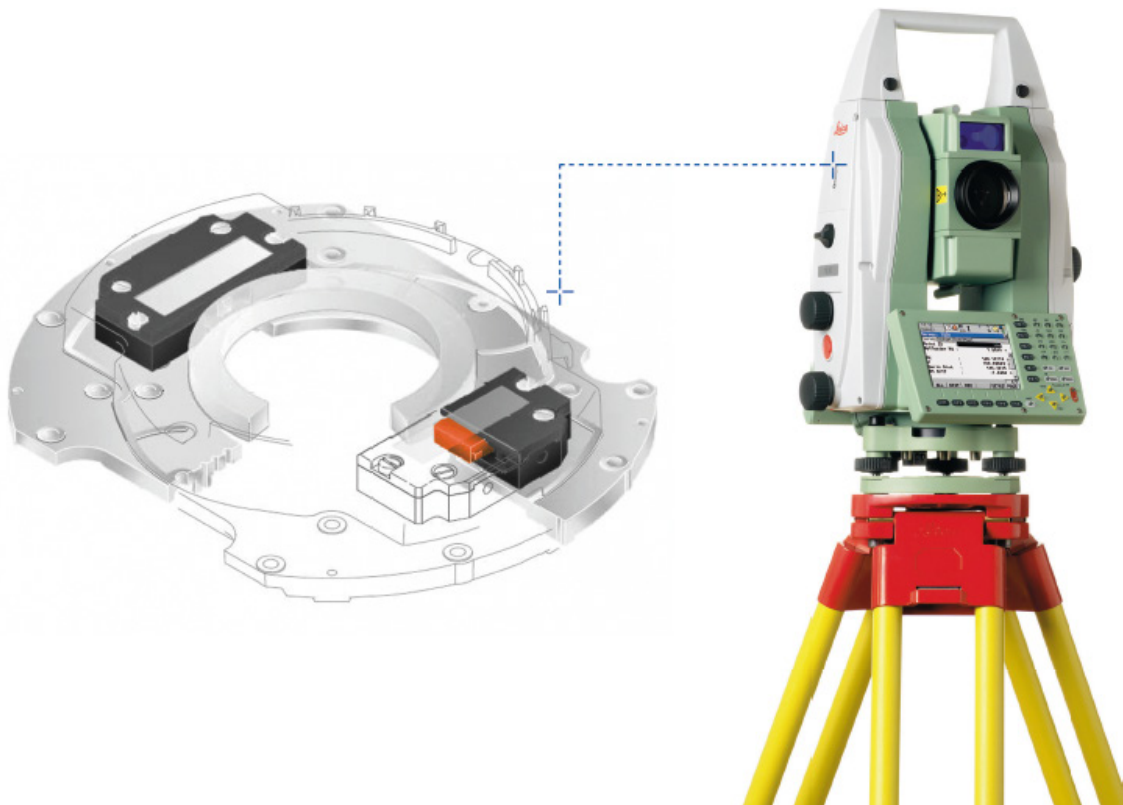


## Technical Progress with Ultrasonic Piezomotors

Precise, Fast, Energy-Saving and Compact



Choosing the right drive system can be a decisive criterion in differentiating oneself from competitors. Numerous factors influence the choice: The installation space available, the speeds and accelerations required as well as the necessary positioning accuracy, the energy consumption and not least the reliability of the motor selected. If the requirements increase, ultrasonic piezomotors can now be used as practical alternatives to classic DC stepper motor combinations. The application described below provides a typical example of this. Ultrasonic piezomotors provide an as yet unrivaled speed and acceleration for the latest total stations used in geodesy at high resolution and low power consumption.



*Fig. 1 The new Leica TS30 total station sets new standards for precision and reliability in angle and distance measurement. The drive solution also plays its part here (Image: Leica Geosystems AG, Switzerland)*

Total stations are the most frequently used surveying instruments for angle and distance measurement in geodesy. One of the world's leading manufacturers of such precision instruments is Leica Geosystems AG with headquarters in Heerbrugg in Eastern Switzerland and German sales offices in Munich, Berlin, Karlsruhe and Düsseldorf. The company has almost 200 years of experience in the field of geodetic measuring instruments and continues to impress with its innovations. Even today – several instrument generations after the introduction of the first high-precision WILD T3 theodolite more than 75 years ago – precision and reliability are the most important characteristics of the company's products. The Swiss specialists are also demonstrating this with their most recent development, the Leica TS30 total station (Fig. 1), which sets new standards of precision and reliability in angle and distance measurement.

## Geodetic Total Station Belongs to a New Generation

The angular measuring accuracy of the new Leica TS30 total station is 0.5" (according to ISO 17123-3) and the distance measuring accuracy is 0.6 mm + 1 ppm (according to ISO 17123-4) for measurements on Leica round prisms (GPH1P) and 2 mm + 2 ppm for measurements on arbitrary, natural surfaces. In addition to the measuring accuracies, it is the performance of the total station with respect to short positioning and measuring times which is a decisive criterion for the user. This is where the motorization of the new Leica TS30 convinces, with its high accelerations, high speeds and precise start-up behavior of instrument and telescope. It thus combines the most accurate angle and distance measurements with optimized automation of the measuring processes. Surveyors all over the world appreciate this. Such technological progress, however, could not have been achieved with conventional drive technology.

The installation space available is very limited (Fig. 2), nevertheless the requirement is for speeds of at least 180 degrees per second, four times the previous norm, at high acceleration and short positioning times. These requirements in combination with the desired positioning accuracy and the demands concerning the reliability when used outside under meteorologically challenging environmental conditions required future-oriented, alternative drive solutions.

In the application described, the speed reduction gears required by typical DC or stepper motors can become the weak point, because mechanical components naturally always suffer wear.

Moreover, the noise inevitably generated can be undesirable in some fields of application, e. g. where the instruments operate round the clock for monitoring measurements in residential areas or inner city locations.

Magnetic direct drive solutions are available alongside conventional stepper motor solutions in the surveying instrument market. Since magnetic drive technology lacks the natural mechanical stopping force which is necessary for precision measurements, this friction must be generated electrically, which leads to high energy consumption and undesirable heat effects in mobile use.

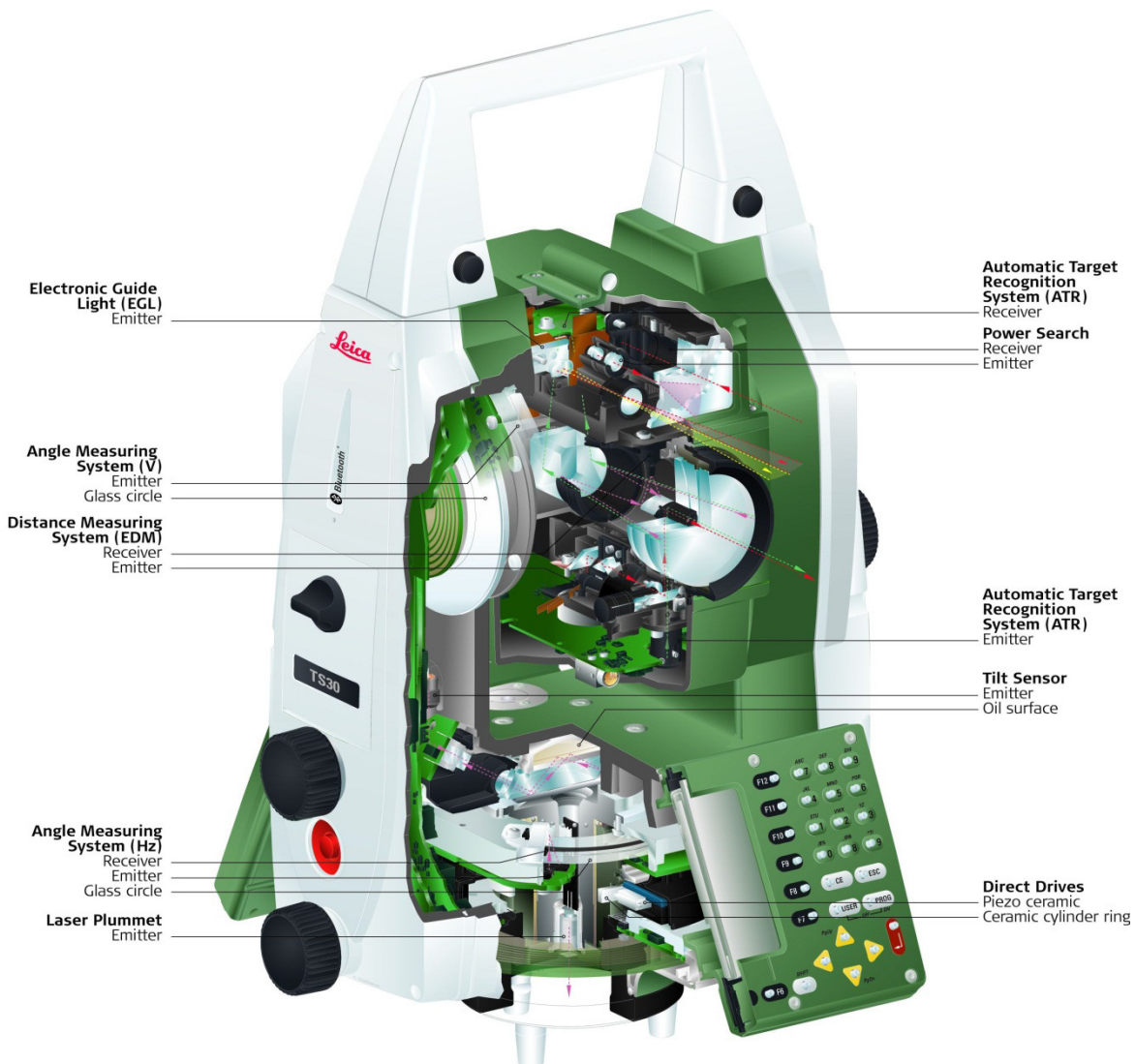
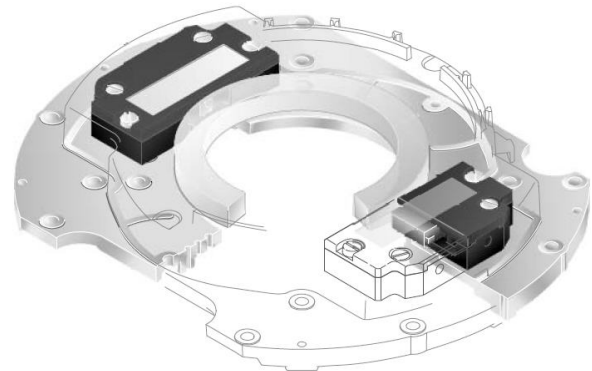


Fig. 2 The cross-section through the total station shows the limited installation space available for the drives (Image: Leica Geosystems AG, Switzerland)

## Piezo Ultrasonic Drives Produce the Rotational Movements

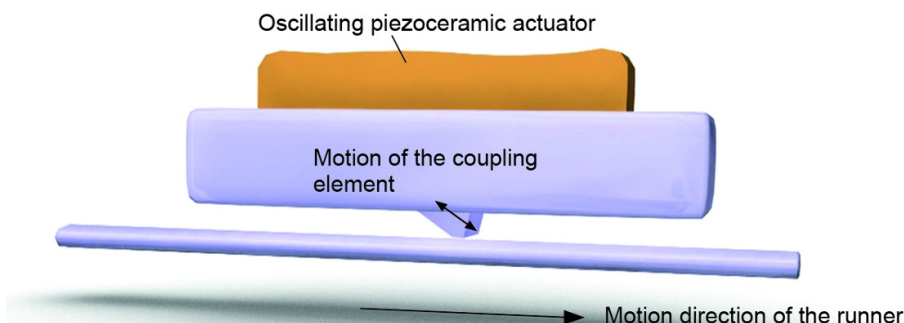
Direct drives operating on the piezo principle were therefore chosen for the vertical and the horizontal motion of the measuring optics of the total station. They allow an as yet unrivaled speed (of more than 180°/s) and high accelerations (up to 360°/s<sup>2</sup>). The drives are self-locking, i.e. they generate high holding forces even when no electrical power is applied. They also run almost noiselessly, are maintenance free and operate at ambient temperatures between -20 °C and + 50 °C. The ultrasonic piezo drives used in the total station have been developed by PI (Physik Instrumente), a company with more than 40 years of experience in the field of micropositioning and nanopositioning technology which is now one of the leading companies in the global market.

The operating principle of the ultrasonic piezo drives used for the vertical and horizontal rotation of the measuring optics is simple to understand (Fig. 3). Each rotation is generated by two ultrasonic motors, which are tangentially preloaded against a friction ring. The friction ring is pivot mounted. The preloaded force against the ring clamps the drive when at rest; the positional jitter that can be observed in the case of magnetic direct drives is therefore also absent here.



*Fig. 3 The rotations are produced by two ultrasonic motors which are preloaded tangentially against a friction ring. The friction ring is pivot mounted (Image: Leica Geosystems AG/ Physik Instrumente (PI))*

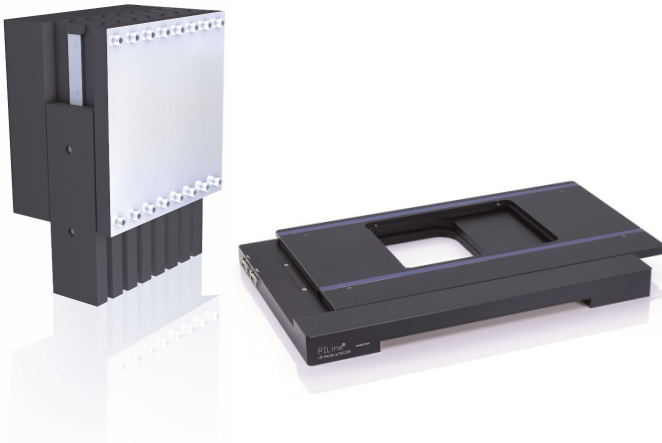
In operation, the ceramic piezomotors then oscillate synchronously with ultrasonic frequencies. The oscillation displaces the friction tip. This in conjunction with the preloading produces a feed motion for the friction ring. Since no mechanical components, such as gears for the power transmission, are necessary, the drive operation is almost wear-free and very reliable. In addition, the drive solution is easy to integrate. It is just as easy and effective to realize linear motions with ultrasonic piezomotors. The tangential drive principle is then applied to a linearly-tracked friction bar (Fig. 4).



*Fig. 4 It is just as easy and effective to realize linear motions with ultrasonic piezomotors. The tangential drive principle is then applied to a linearly-tracked friction bar (Image: Physik Instrumente (PI))*

## Applications Galore

Ultrasonic piezomotors are therefore suitable for a large number of further applications where small size, high speeds and reliability are also the decisive factors. Stages for biohandling or microscopy are available, for example, which excel by having a particularly low-profile and a design which can easily be integrated (Fig. 5).



*Fig. 5 Biodispenser and microscopy XY stage with ultraflat PLine® ultrasonic piezomotors. Their low height means they are simple to integrate into the existing assembly (Image: Physik Instrumente (PI))*

Examples of typical industrial applications range from the manufacture of semiconductors and photonics through general handling tasks to metrology and medical engineering. As the described application illustrates, ultrasonic piezomotors continue to expand into new fields of application, one can only guess as to which of the applications will provide the next contribution to advancing the technical development even further.

## Ultrasonic Piezomotors: Small and Fast

In ultrasonic piezo drives, a piezo ceramic oscillating at high frequency is preloaded against a friction bar, a traveling wave generating the feed. The drive is simple in its set-up and consists of a piece of ceramic, a spring and the friction element, which is normally fixed to the moving part, a tracked slider, for example. This results in lightweight, maintenance-free drives which are suitable for driven speeds up to 0.5 m/s and high accelerations. They open up many areas of application – mainly because of their low-profile, compact size – because they are often a more practical replacement for classic motor lead screw combinations. The self-locking ultrasonic motors act directly without intermediate elements such as lead screws or gears and are free from hysteresis errors. Since they are also offered in various integration stages (Fig. 6), they can be adapted well to the respective application.



*Fig. 6 Piezo ultrasonic drives are offered in various stages of integration. They can thus be adapted well to the respective application (Image: Physik Instrumente (PI))*



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## About PI (Physik Instrumente)

In the past four decades, PI (Physik Instrumente) with headquarters in Karlsruhe, Germany has become the leading manufacturer of nanopositioning systems with accuracies in the nanometer range.

With four company sites in Germany and ten sales and service offices abroad, the privately managed company operates globally. Over 700 highly qualified employees around the world enable the PI Group to meet almost any requirement in the field of innovative precision positioning technology. All key technologies are developed in-house. This allows the company to control every step of the process, from design right down to shipment: precision mechanics and electronics as well as position sensors.

The required piezoceramic elements are manufactured by our subsidiary PI Ceramic in Lederhose, Germany, one of the global leaders for piezo actuator and sensor products. PI miCos GmbH in Eschbach near Freiburg, Germany, is a specialist for positioning systems for ultrahigh vacuum applications as well as parallel-kinematic positioning systems with six degrees of freedom and custom-made designs.