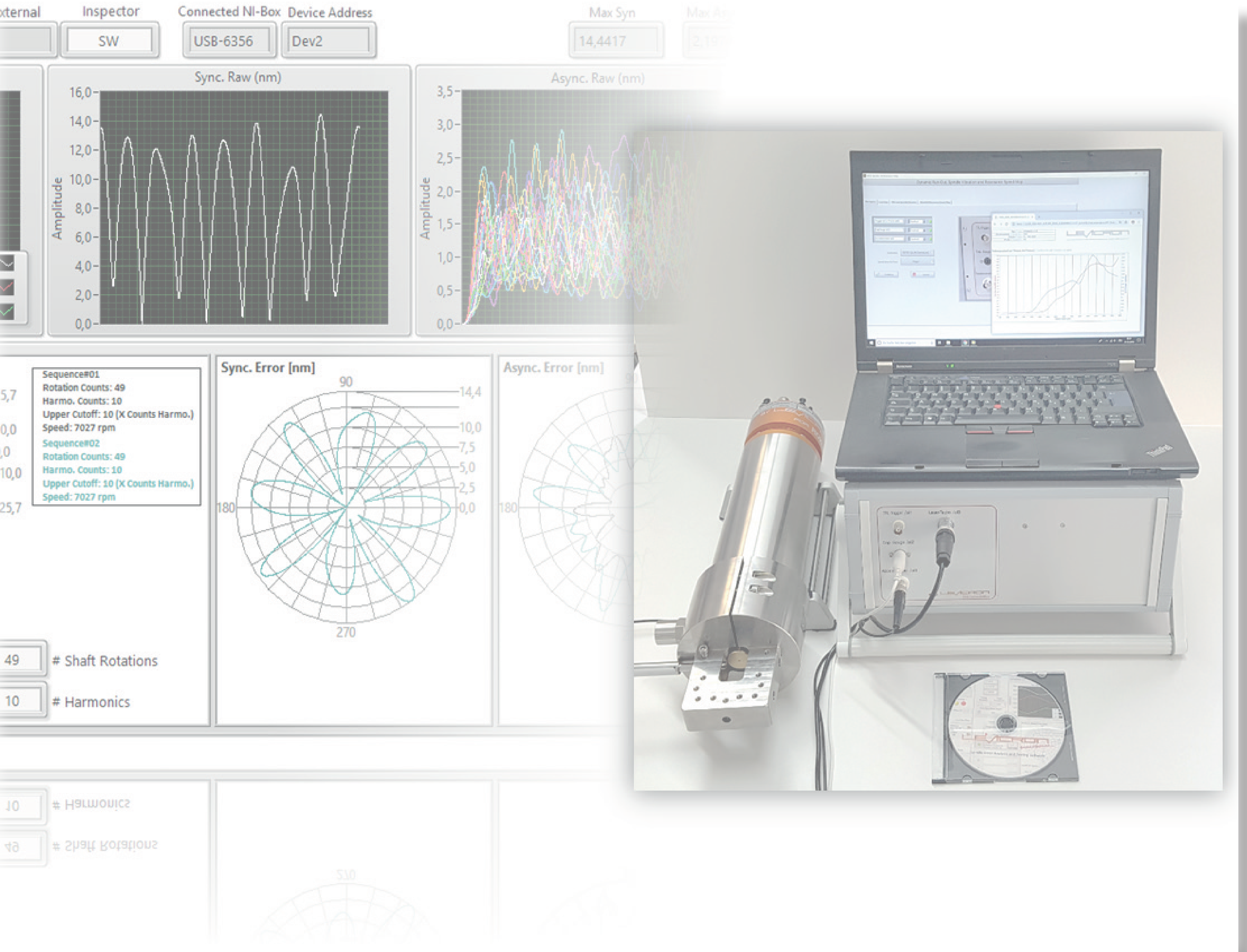
LEVICRON

NON-CONTACT PRECISION MOTION

ShakesBear (Spindleanalyzing and testing systems)



Levicron

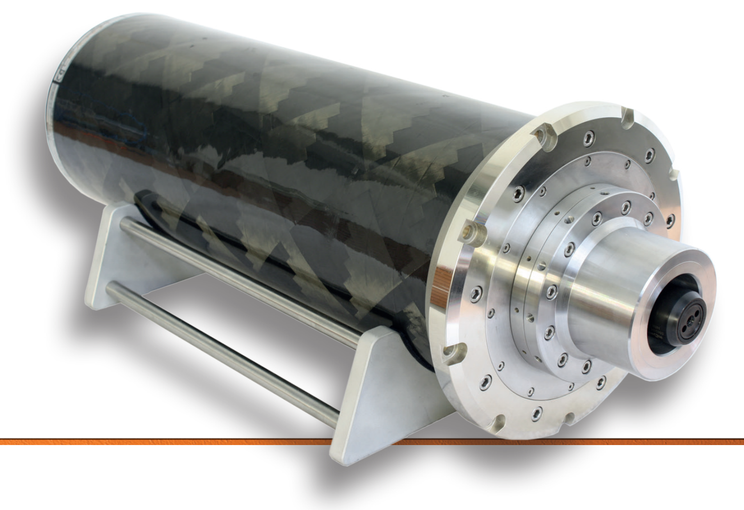
Development, manufacture and sales of motor spindle solutions with non-contact bearing technologies for ultra-precision and CNC machining are Levicron's core businesses. At Levicron bespoke analytical proven methods and simulation tools for structural analysis and fluid dynamics complement sound practical experiences in the field of spindle development and production.

Together with the first-ever aerostatic tool spindle comprising an industrial taper interfaces (HSK) and full CNC functionality, products from Levicron now are used to CNC-machine precision parts with optical surface finish all around the world.

Our very own requirements on our products and those from our customers prevent the use of off-the-shelf components. Therefore not only the patented bearing technology and patent-pending spring-free HSK taper clamping systems can be found in our motor spindles, but also in-house developed motor and encoder and tool clamping solutions. A vertical manufacturing integration of more than 90 % incorporates CNC turning, - milling, - diamond machining, - cylindrical /bore grinding, - wire cut EDM and bespoke machining solutions. Along with our production sophisticated test and dynamic balancing methods can all be found under one roof.

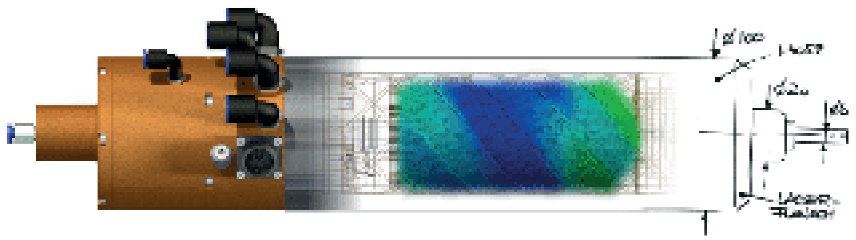
The quality, speed and accuracy of Levicron spindles and the requirements coming from the applications they are used for made it necessary to develop bespoke encoder and motor solutions as well as solutions for HSK tool clamping, HSK tool holding and others. Because of their unique performance and functionality some of these solutions have been made available for our customers as off-the-shelf items. Although Levicron had to re-invented the wheel more than once our customers can confirm that our wheels run smoother and faster than others.

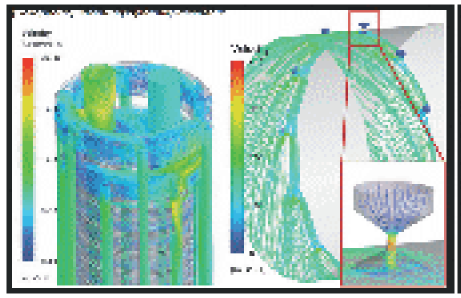
As a result, tool and work-holding spindle solutions for turning, milling and grinding can be provided to the customer which provide a unique thermal stability and robustness at shaft dynamics, erros in shaft motion and speeds that have not been available so far.

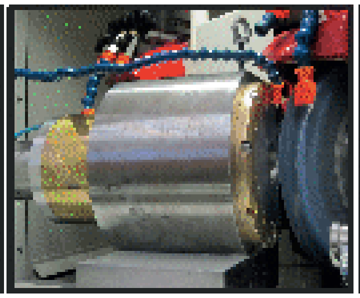


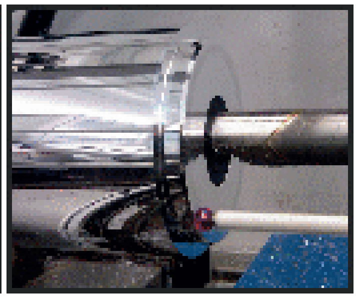
Levicron

All in house developed and manufactured Ultra Precision Technology for CNC Machining









ShakesBear

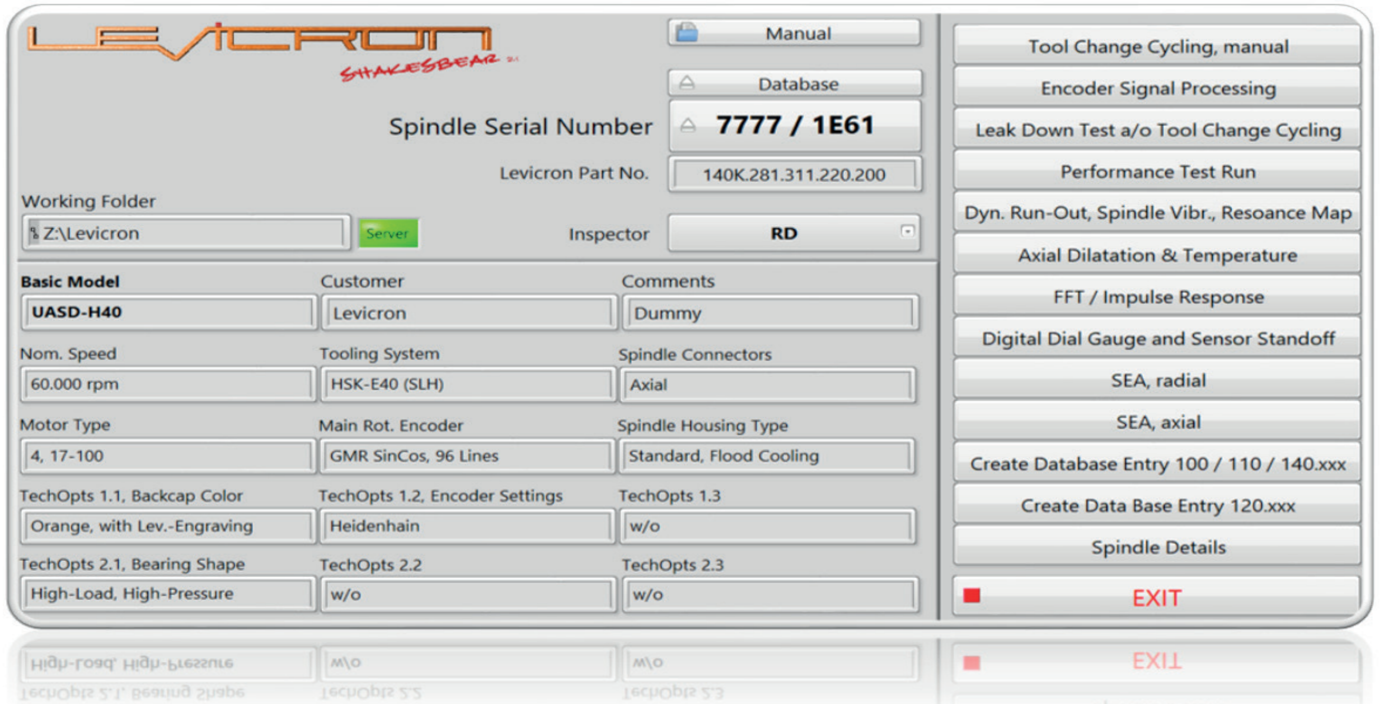
Spindle analyzing and testing systems with nanometer resolution for speeds of up to 100,00 rpm.

Description

Where other spindle manufacturers can rely on suppliers, Levicron is forced to develop key spindle components to achieve and guarantee the quality and performance of their spindle products. As such components are not commercially available their development often leads to new products. This also applies to the technology to analyze, test and verify the properties and quality of spindles that Levicron have been developping since the beginnings and which are unique when it comes to resolution, sampling rate and use.

With our spindle analyzing and testing systems „ShakesBear, Hamlet" and „ShakesBear, Othello" Levicron now can provide all-in-one spindle analysis and testing systems for speeds of up to 100.000 rpm on a nanometer level.

Measurements of dynamic tool run-out, spindle errors (SEA), vibrations with speed and spindle/system resonance maps are stored as reports and raw data in a local or server based spindle/machine database that can be recalled any time required.



All-in-one spindle analyzing systems

ShakesBear „Hamlet"

Our all-in-one spindle analyzing system „ShakesBear, Hamlet" has specifically been developed to acquire spindle errors (error-motion) in radial and axial directions on a nanometer level at speeds of up to 100,000 rpm. The integrated direct error-separation of spindle synchronous and artefact shape errors allows a measurement in a single test set up without any change to the system or the spindle. The mobile rack includes the amplifiers and filters as well as connectors for the sensors and a PC connection.

ShakesBear „Othello"

The all-in-one spindle testing system „ShakesBear, Othello" targets on machine and spindle dynamics like dynamic tool run-out and vibrations, thermal shaft growth and spindle/machine resonance maps. Here the spindle can be used as an excitation to the machining system where a waterfall FFT with spindle speed is generated to identify system resonances. With an optional, integrated PC and a touch screen this system allows a quick and mobile use at the customer site or in your test field. Also for the Othello system all amplifiers , fiters and connectors are part of a mobile rack at which the sensors can be connected to.

Excursion

The largest deviation of the shaft spinning axis in radial and/or axial direction from an ideal axis is defined as Error-Motion. In this case the ideal spinning axis is the one with the least averaged deviation over all measurements.
Spindle errors can be distinguished between **Synchronous Errors** and **Asynchronous Errors**.

» **Synchronfehler**: *Repeat during shaft rotation at the same angular position.*
» **Asychronfehler:** *Are not repeatable between shaft rotations.*

The **Run-Out** (fundamental) is a perfect circle in the spindle error polar plot and represents an off-centered tool. Thus run-out is not a spindle, but a tool error.

Therefore the spindle error (Error-Motion) in radial direction is defined as:

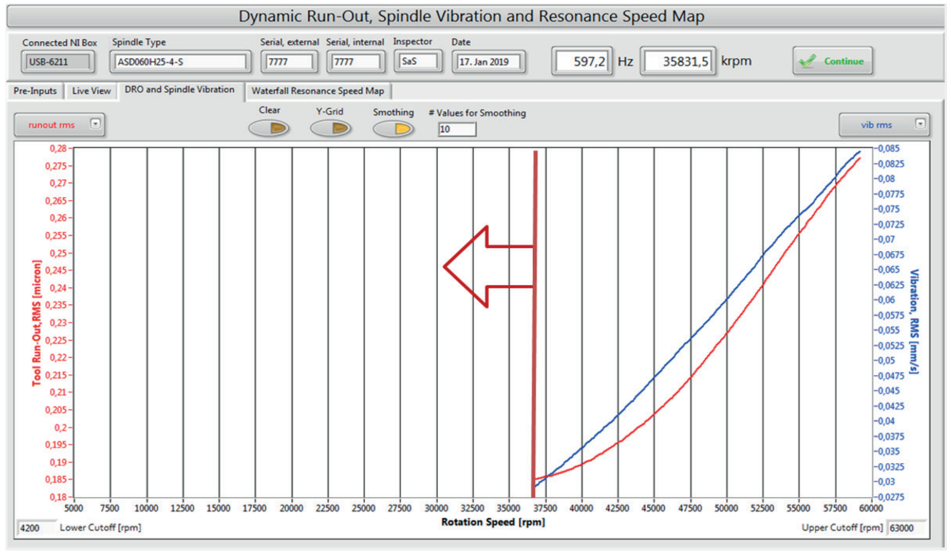
∑Sync.Errors + ∑Async.Errors - Fund. (run-out)

Direct (auto) error-separation

Any measurement of radial spindle errors are taken against the spindle shaft or any object that is attached to it, preferably perpendicular to the equator of a precisely lapped sphere. However, any roundness error of the equator repeats with the shaft rotations and would be detected as a spindle synchronous error. Although there are methods to seperate the target shape error from the spindle synchronous errors those require two measurements and a change in set up in between two measruements and are significantly error-prone.

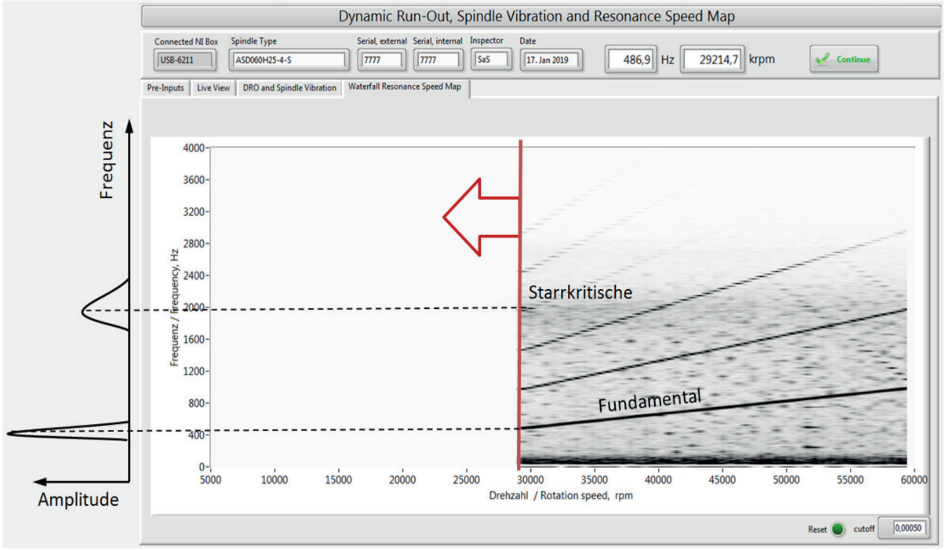
Our solution:

By using at least three radially arranged distance sensors around the spinning axis it is possible to separate spindle synchronous errors from the target shape errors by solving a complex transposed equation system before converting the signal back into the time domain. Levicron has included the direct error-separation into their SEA treatment so that synchronous, asynchronous and target shape errors can be measured and separated from each other in one set up and a single measurement.und protokolliert.



Dynamic Tool Run-Out and Spindle Vibrations over Spindle Speed

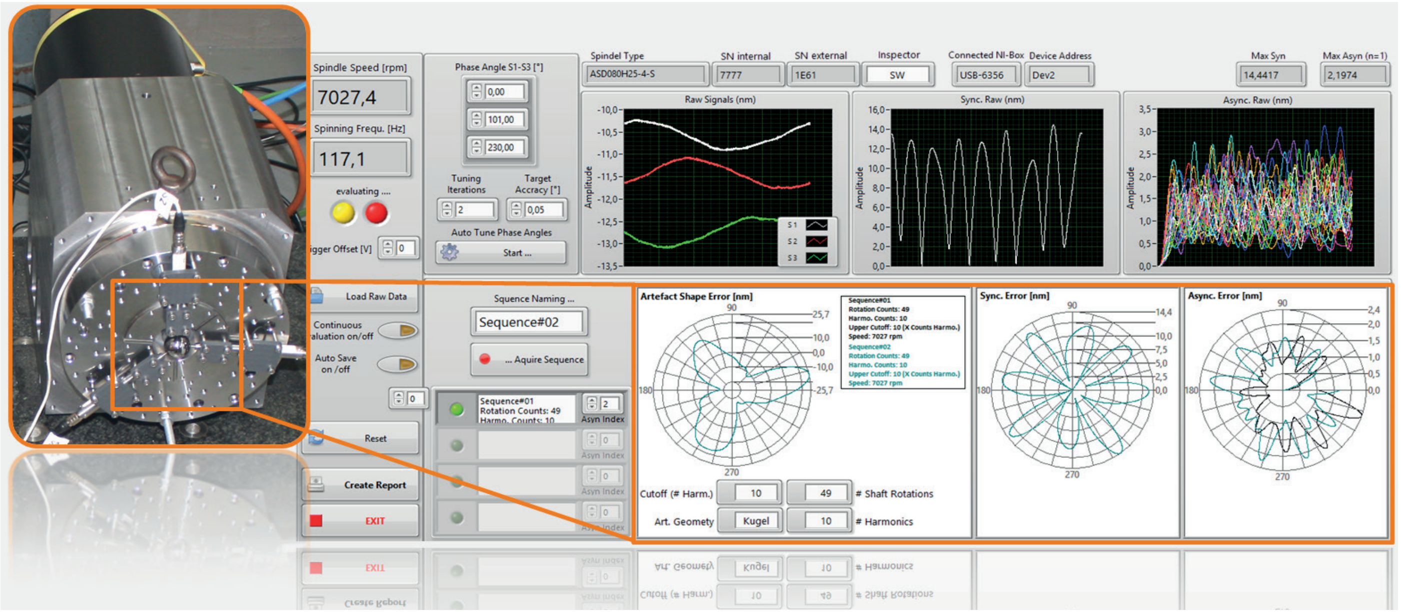
The included low-noise capacitive distance sensor with 2 nm resolution and 100 kHz sampling rate allows a sound measurement of the tool run-out at spindle speeds of up to 100,000 rpm. At the same time a piezo-mass accelerometer detects spindle vibrations, and an external trigger or the included laser-tacho gives the spindle speed to create a continuous dynamic run-out and spindle vibrations chart over speed.

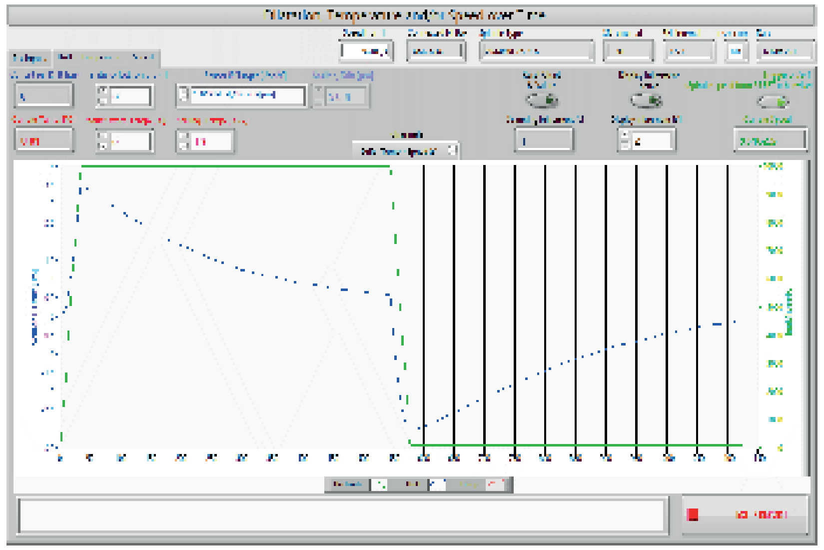


Resonance and natural frequency map

Due to its very high resolution and sampling rate the capacitive distance sensor is not only capable of detecting the amplitude of the fundamental (spinning frequency), but also of any frequencies up to 4 kHz. As vibrations can be measured as a change in distance the capacitive gauge can be used to create an FFT spectrum at discrete spindle speeds. Changing the speed from stand-still to top speed, or vise-versa, allows the creation of a continuous Waterfall-FFT chart where the single FFT charts are lined up and arranged with speed. The resonance speed map feature represents a 2.5-D Waterfall-FFT (looking top-down on a 3-D Waterfall diagram) where dark areas mean higher and light areas lower values.

This allows an identification of spindle and system natural frequencies as well as resonances at which the fundamental (spindle frequency) crosses a system natural frequency.
When the capacitive gauge is used as source spindle natural frequencies are measured dominantly, using the included accelerometer instead gives natural frequencies of the entire system including pumps, hydraulics and chillers e.g. Placing the accelerometer anywhere in the system can thus be used as a tool to identify system natural frequencies with the spindle as a vibration source.





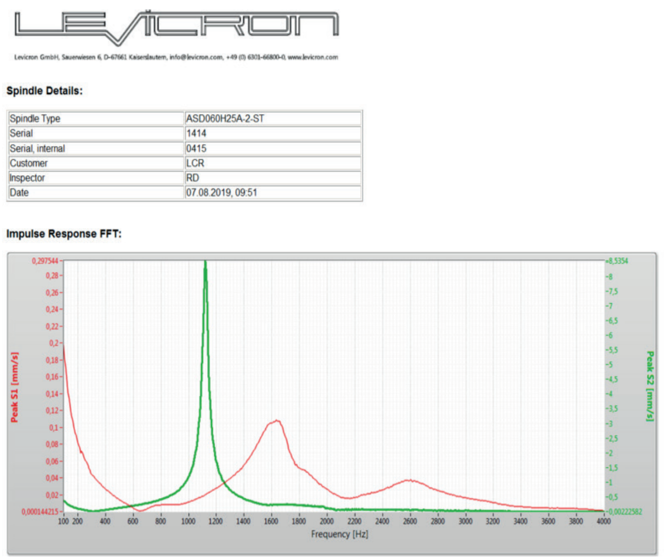
Axial Shaft Growth, Temperature and Spindle Speed over time

When used axially against the spindle shaft the capacitive gauge enables a measurement of the thermal shaft growth with time. Along with an optional temperature sensor which can be placed on any part of the machining system the thermal shaft growth, temperature and spindle speed can be measured with time where the spindle speed can be detected using either an external trigger or the included laser-tacho.

Impulse Response, Drag-Ppointer Diag Gauge, Spindle and Machine Tool Data Base

2-Channel-FFT with Peak-Hold (Impulse Response)

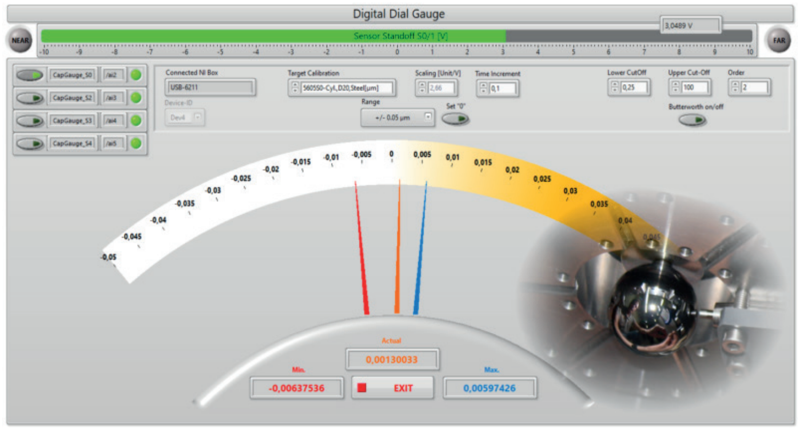
By using the included accelerometers or cap gauges the FFT module offers a easy-to-use tool to measure and display the vibration amplitudes of the frequency spectrum and thus to identify spindle and/or system natural frequencies while running the spindle or as a response to a impulse (Dirac Impulse). A Dirac-Impulse, also known as step response, can be re-assembled as the sum of all harmonics within the frequency spectrum. Means, a gentle hit at the spindle nose or anything in the system would excite all frequencies and thus the spindle or the entire system would respond with larger amplitudes at its natural frequencies.



4-Channel Drag-Pointer Diag Gauge

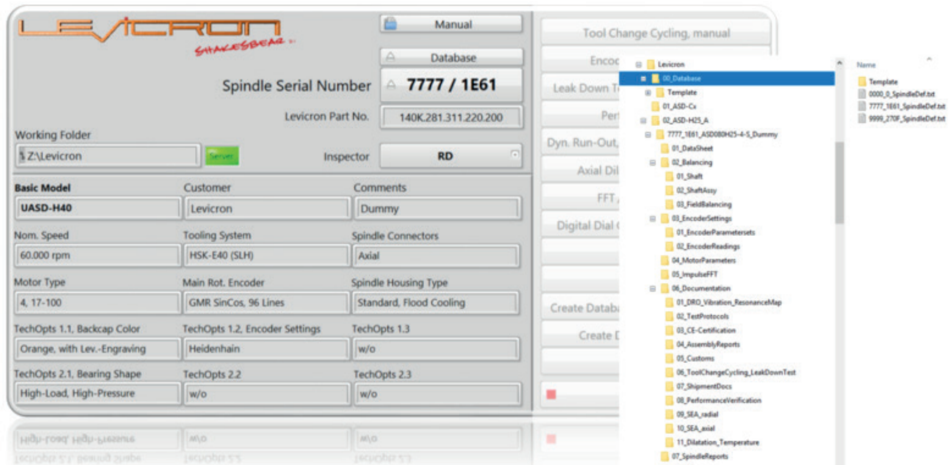
To set up the stand off of the included cap gauges and to radially align the spindle artefact the cap gauges measure against the included 4-channel, digital drag-pointer dial gauge can be used.

It can also be used to measure the static run-out of the artefact when turning the spindle by hand or at low speeds.



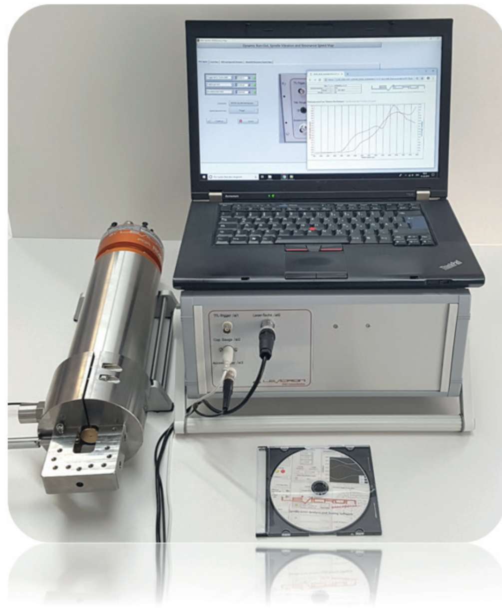
Spindle and Machine Tool Data Base

For an ISO-certification in particular, but also for tracking the quality of the spindle products for internal use or for customers, all measurements and results have to be recorded and stored electronically. For this our ShakesBear Software is designed to work with server systems and is based on a spindle and/or machine tool data base in which all reports and raw data are stored. No matter if connected to a server or working locally, the data base module generates a folder structure for each serial number in which all reports and raw data are stored that can be re-called at any time.



ShakesBear, Hamlet

The all-in-one spindle analyzing system „ShakesBear Hamlet“ was developed to measure, analyze and report spindle errors. With its four low-noise, high resolution and fast capacitive distance sensors the radial and axial shaft error in motion can be measured at spindle speeds of up to 100,000 rpm on a nanometer level along with a direct separation of the spindle synchronous and the target shape errors. All data and results are stored in a spindle/machine data base and can be recalled at any time. Bespoke fixtures can be supplied to match your application and spindle type.



ShakesBear, Othello

The all-in-one spindle analyzing system „ShakesBear Othello“ targets on a portable and flexible use at customer sites or your own test fields to measure, analyze and report spindle and machine dynamics. Beside pure spindle properties the user can analyze machine dynamics and system natural frequencies with the spindle as a vibration source. With an optional RaspberryPi and a touch screen instead of a USB connector the Othello system is well prepared for a mobile use. Also here bespoke fixtures can be supplied to match your application and spindle type.

Data Sheet

		ShakesBear Hamlet	ShakesBear Othello
General	Power Supply	240 VAC	240 VAC
	Internal PC, Touchscreen	n.v.	n.v.
	USB 2.0 (or higher) Connector	ja	ja
A/D Converter	Digital Resolution	16 bit	16 bit
	Number of Channels	8	8
	Evaluation	differential	differential
	Sampling Rate per Channel	1.25 MS/s	250 ks/s
	Analog Signal	+/- 10V	+/- 10V
Distance Sensing	Physical Principal	capazitive	capazitive
	Working Distance	50 µm	50 µm
	Resolution	1.7 nm	1.7 nm
	Sampling Rate	199 kHz	100 kHz
	Number of Sensors	4	1
Vibration Sensing	Physical Principle	Piezo-Mass	Piezo-Mass
	Cutoff Frequency	18 kHz	18 kHz
	Sensitivity	1 V/g	1 V/g
	Number of Sensors	0	1
Software Modules	Spindle/ Machine Data Base	X	X
	Server Connection via Ethernet	X	X
	Dyn. Run-Out, Spindle Vibrations and Resonance Speed Map		X
	Axial Shaft Growth, Temperature and Spindle Speed with Time		X
	FFT Impulse Response		X
	Digital Drag Pointer Dial Gauge (Cap. Gauges)	X	X
	Spindle Error Analysis (SEA), radial	X	
	Spindle Error Analysis (SEA), axial	X	

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