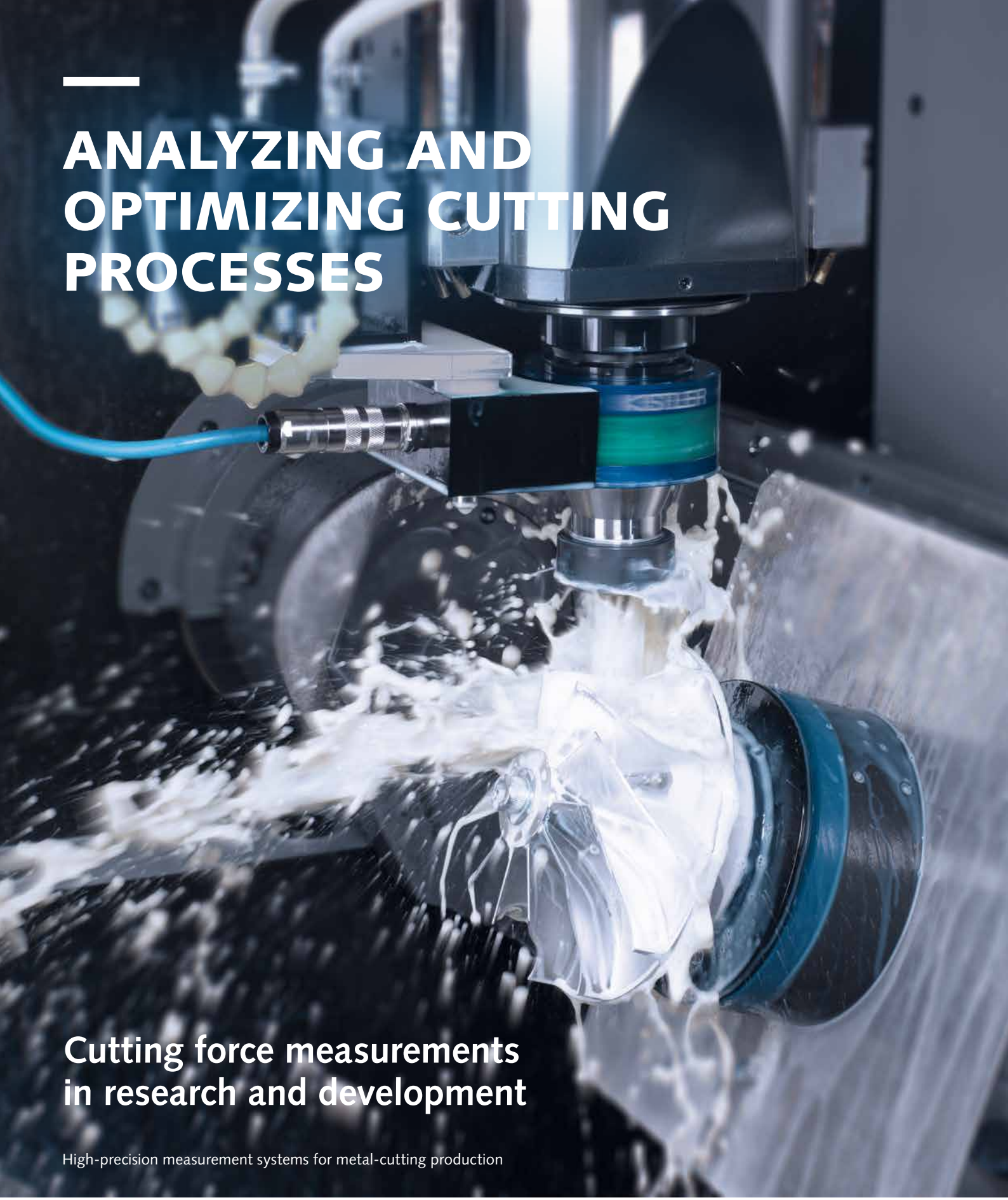


ANALYZING AND OPTIMIZING CUTTING PROCESSES

Cutting force measurements in research and development

High-precision measurement systems for metal-cutting production

KISTLER

measure. analyze. innovate.

www.kistler.com

Contents

Milling high-alloy steel with a Type 9255C dynamometer

Fundamentals of cutting force measurement

Metal-cutting is still the most important machining process, and it provides the basis for technical products of all kinds. There has been a constant increase in the requirements to be met by cutting processes and the products manufactured with them, resulting in major changes to this method of production over recent decades.

Regardless of batch size, the manufactured products are expected to offer convincing quality and they must be cost-effective. Detailed knowledge of cutting processes is essential in order to meet these requirements. Key indicators include the acting forces and moments: if they are not known, it is impossible to make any statements whatsoever about the quality of the manufacturing process. The highly dynamic forces that occur during a cutting process can only be measured and analyzed with sensor systems developed on the basis of professional expertise, for use in the harsh environments where machinery is operated.

Capturing highly dynamic forces in cutting processes
Kistler's piezoelectric sensors record highly dynamic processes with optimum signal quality. They offer valuable insights into the actual process, providing the basis for reliable, productive and reproducible manufacturing processes.

Development and assessment of tools and materials
- Optimizing tools and clamping devices under real operational conditions
- Assessing cooling lubricants
- Determining the machinability of materials
- Verifying simulations and process models
- Highlighting unique product characteristics

Process analysis and optimization
- Analysis of cutting processes and targeted error/fault diagnosis
- Comparing and developing machining strategies
- Identifying unfavorable cutting situations
- Identifying unused potentials: tool edge life and productivity
- Identifying the influences of different material batches

Processes
- Turning, milling, drilling, sawing, screw tapping, broaching, hobbing, and many others.
- Grinding, honing, polishing, and many others.

Benefits of force measurement technology by Kistler
- High rigidity and natural frequencies enable resolution of individual cutting edge engagements
- Measurement of three force directions and torque
- Measurement range from micromachining to heavy-duty cutting
- Robust and resistant to coolants (IP67)
- Simple to integrate and handle thanks to compact structure
- Extremely long service lifetimes

Overview of dynamometers

Stationary dynamometers
A stationary dynamometer is often the connecting element between the machine tool's table and the workpiece. The workpiece is fixed on the dynamometer, enabling measurement of reaction forces in production processes such as milling or drilling. Stationary dynamometers can also be used for turning applications. In this case, appropriate machine adapters are used to position the dynamometers directly on the turret head. Then, the tool is positioned on the dynamometer with a suitable tool holder. Depending on the structure, the forces occurring are captured by one or more multi-component force sensors and are available at the dynamometer connector in the form of charge signals.

Rotating dynamometers
Rotating dynamometers (RCDs) are inserted directly into the machine spindle via the spindle interface. The tool is mounted on the RCD with the help of a tool holder. RCDs are mainly used in milling and drilling processes. RCDs differ from stationary dynamometers in several ways: for example, only one multi-component sensor is installed in an RCD to measure the moment directly on the tool. The rotor contains not only the sensor but also the charge amplifiers The measurement data is transferred via data transmission technology to a signal conditioner, where it is subsequently available as analog voltage signals. Depending on the system, a different data transmission technology is used.

		Type	Measurable components	Temperature influences inimized	Turning	Milling	Drilling/thread tapping	Grinding	Micromachining — Heavy-duty cutting	Application	Page
rotary		9170B	F_x, F_y, F_z, M_z	no		■	■		■	Rotating system for measurements on the tool, at high speeds of up to 16 000 rpm and small to medium forces	34
		9171A	F_x, F_y, F_z, M_z	no		■	■		■	Rotating system for large forces and speeds of up to 12 000 rpm, different adapters provide excellent flexibility	36
stationary		9109AA	F_x, F_y, F_z	yes		■		■	■	The expert solution for micromachining with forces below 1 N and up to 500 N, and speeds of up to 160 000 rpm	23
		9119AA1	F_x, F_y, F_z	yes		■		■	■	Table-mounted system for precision machining with forces of less than 1 N up to 4 000 N and speeds of up to 60 000 rpm	24
		9119AA2	F_x, F_y, F_z	yes	■	■		■	■	The expert solution for precision machining, suitable for table mounting or as a modular system for mounting on turning turrets	24
		9129AA	F_x, F_y, F_z	yes	■	■		■	■	Best-seller and all-rounder for table mounting or as a modular system for mounting on turning turrets	26
		9139AA	F_x, F_y, F_z	yes		■		■	■	Compact solution for somewhat larger forces (up to 30 000 N)	28
		9257B	F_x, F_y, F_z	no		■		■	■	The classic model for table mounting and forces of up to 10 000 N	29
		9255C	F_x, F_y, F_z	no		■		■	■	Robust platform, optimized for medium to extremely large forces (up to 60 000 N)	30
		9253B	F_x, F_y, F_z	no				■	■	Solution for large workpieces with workpiece-side measurement	31
		9272	F_x, F_y, F_z, M_z	no			■		■	The expert solution for drilling trials with direct torque measurement in the center of the platform	32
		9366CC	F_x, F_y, F_z	no		■			■	Pre-loaded, ready calibrated set of force sensors to set up custom clamping solutions	33

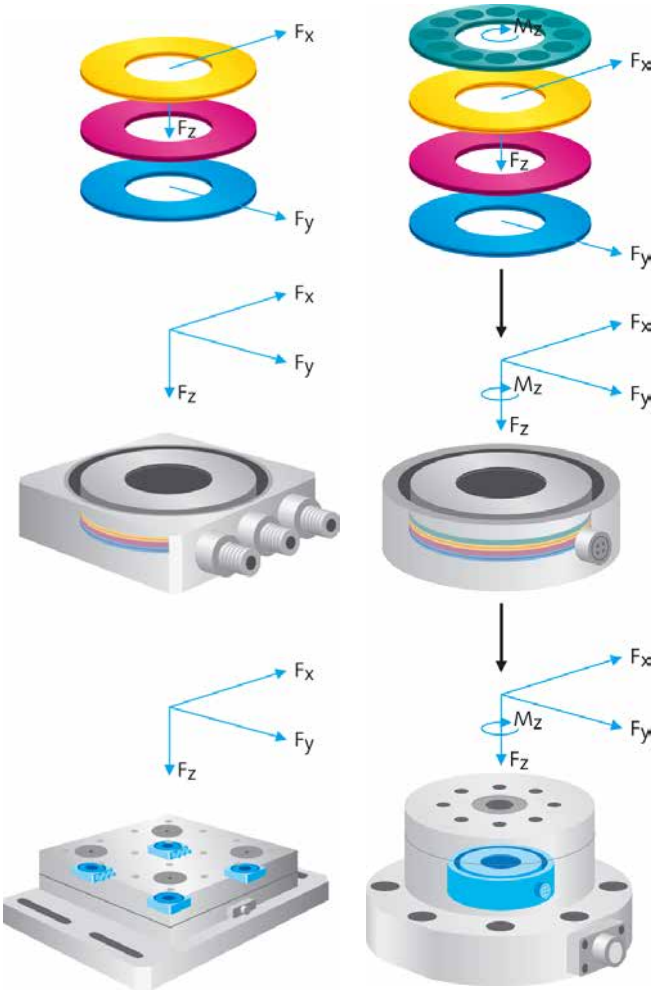
■ suitable ■ limited suitability

Stationary dynamometers: force and moment measurements

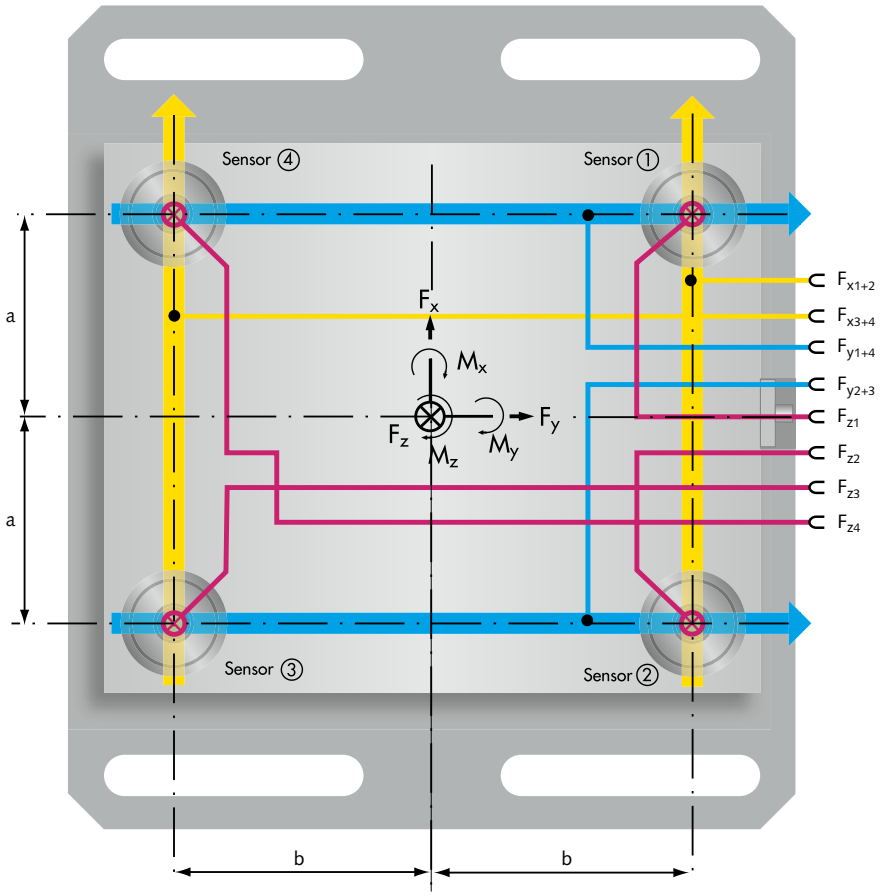
Application
All stationary 3-component dynamometers share the same advantage: they can be used both as a purely 3-component dynamometer and also as a 6-component dynamometer. The four 3-component force sensors inside the dynamometer are switched as appropriate to make this possible. Forces F_x, F_y and F_z are measured directly, whereas moments M_x, M_y and M_z are calculated with the help of the individual force components and sensor distances. Suitable adapters enable mounting of the dynamometers on milling tables as well as lathe turrets.

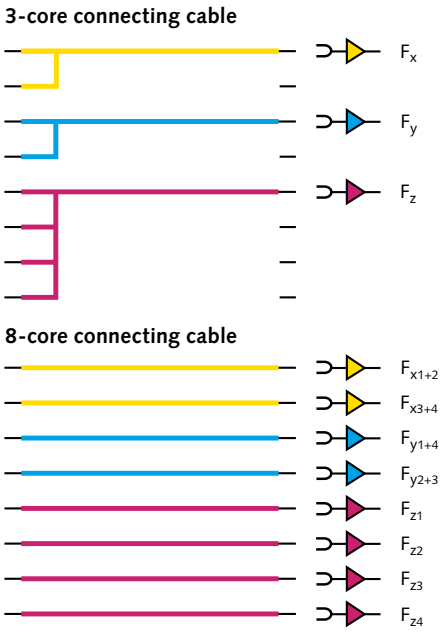
Structure of a stationary dynamometer
The dynamometers consist of multi-component force sensors mounted under high preload between two base plates and a cover plate. Preloading is needed so that frictional forces can be transmitted. Ground-isolated installation of the force sensors largely eliminates ground loop problems. The dynamometers meet the requirements for degree of protection IP 67; they are rust-resistant and are protected against penetration by splash water and coolants. Various mounting bores and tapped holes on the cover plate open up numerous clamping options.

Stationary dynamometer measuring chain
The measuring chain for stationary dynamometers consists of a sensor and a charge amplifier with a data acquisition box to record the signals, or just one LabAmp (with a laboratory charge amplifier and data acquisition box combined in one device).



Benefits of a stationary dynamometer
- Stationary dynamometers can be used for a highly versatile range of applications. For milling, drilling, turning or other types of machining, the possibilities are virtually limitless
- Thanks to piezo technology and robust geometry, large dynamometers can also be used to measure small forces
- When used correctly, Kistler's dynamometers have extremely long service lifetimes





3-component force measurement
In 3-component force measurement, the eight output signals from the dynamometer are summed in the three-core connecting cable (as shown in the illustration). Three charge amplifiers are needed to convert the charge signals into proportional output voltages.

6-component force and moment measurement
In 6-component force and moment measurement, the eight output signals are fed directly to the eight charge amplifiers via the 8-core connecting cable. These amplifiers convert the charge signals into proportional output voltages and they also calculate moments M_x, M_y and M_z, depending on the specification of the charge amplifier.

Calculation of the three forces F_x, F_y, F_z and three moments M_x, M_y, M_z

$$F_x = F_{x1+2} + F_{x3+4}$$

$$F_y = F_{y1+4} + F_{y2+3}$$

$$F_z = F_{z1} + F_{z2} + F_{z3} + F_{z4}$$

$$M_x = b\,(F_{z1} + F_{z2} - F_{z3} - F_{z4})$$

$$M_y = a\,(-F_{z1} + F_{z2} + F_{z3} - F_{z4})$$

$$M_z = b\,(-F_{x1+2} + F_{x3+4}) + a\,(F_{y1+4} - F_{y2+3})$$

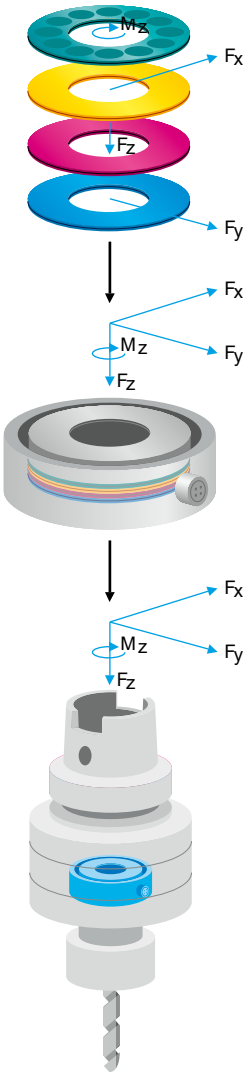
Calculating forces and moments
Kistler's DynoWare software calculates the three forces (F_x, F_y and F_z) and the three moments (M_x, M_y and M_z); the 6-component summing processor in the charge amplifier can also perform the calculation in the same way. The distance from the sensors must be included when calculating the moments.

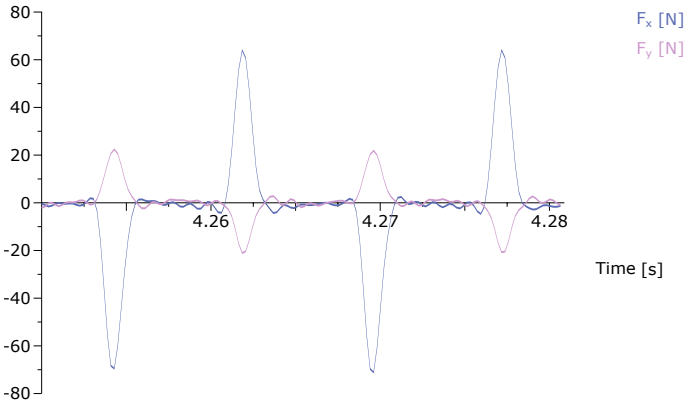
Rotating dynamometers: force and moment measurements

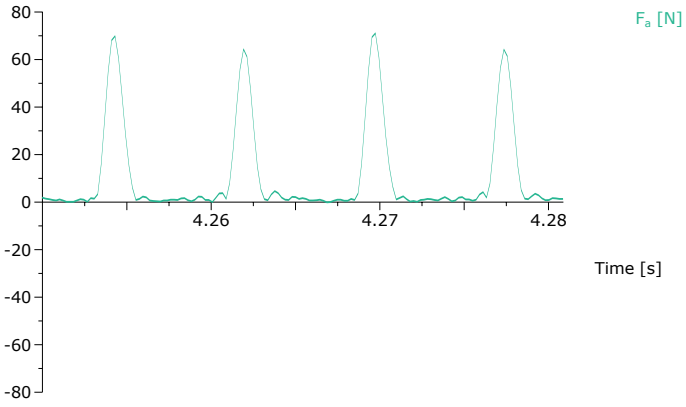
Application
A rotating dynamometer can measure the three orthogonal force components F_x, F_y and F_z — as well as the torque M_z — in machining processes, including milling and drilling in particular. The 4-component force sensor is installed between the spindle and the tool. The forces and moment are captured near the tool edge, so the force vector acting on the tools can be determined directly.

Structure of a rotating dynamometer (RCD)
In the installed state, the measurement system's rotor (with the force sensor) is connected to the machine spindle, so it rotates along with the spindle. This means that the RCD's coordinate system also rotates around the vertical Z axis. The RCD can be ordered with various spindle adapters so that it can be used on many different machine types.

RCD measuring chain
The measurement chain of a rotating dynamometer (RCD) consists of a rotor with integrated charge amplification, power supply and wireless communication, as well as a wireless receiver which processes the received digital data from the rotor and provides it for analysis.







Force signals from milling with a double-edged tool during finishing; left: forces in the x- and y-directions of the rotating dynamometer; right: resultant active force in the x-y plane

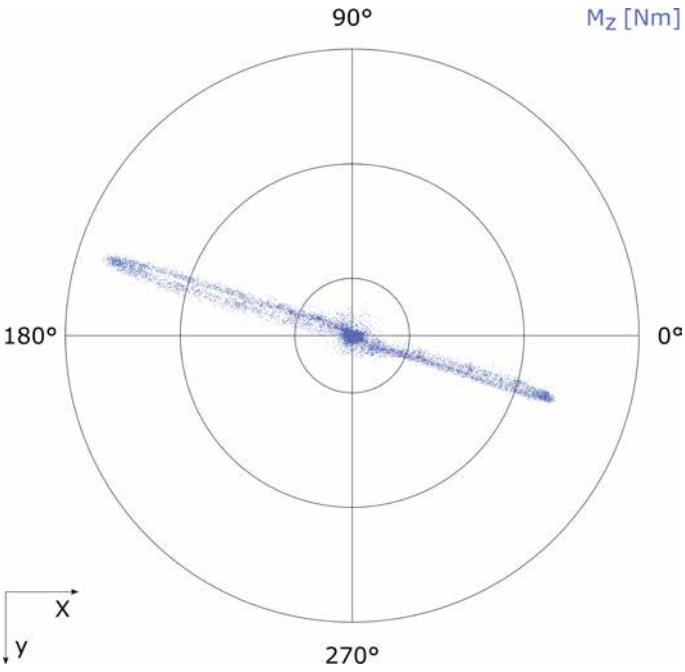
Benefits of a rotating dynamometer

- The torque to be applied for cutting is measured directly. This allows an accurate assessment of the tool condition (regarding tool wear, for example)
- The rotor in a rotating dynamometer rotates along with the tool, so the mechanical load can be quantified directly in the tool coordinate system
- Because the measurement process is independent of the mass, dimensions and form of the workpiece, forces and moments can be measured in the cutting process for complex and cost-intensive parts

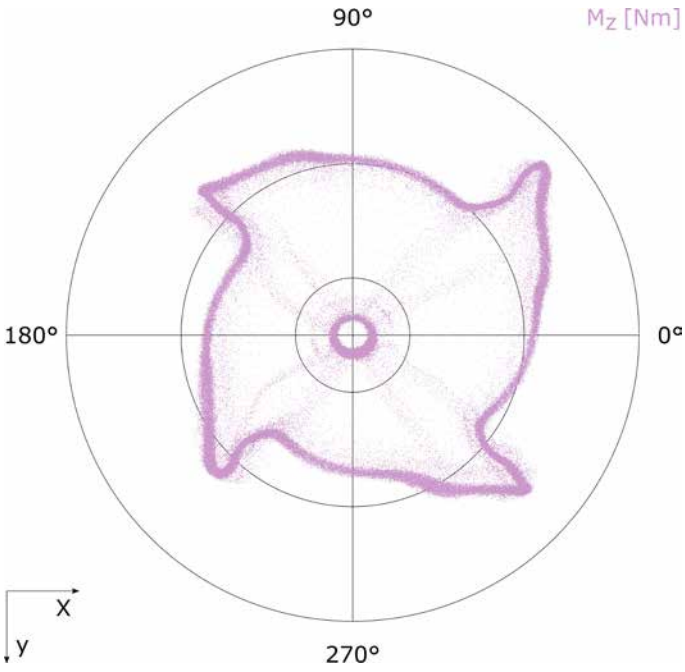
Rotating dynamometer in a milling application

RCD coordinate system

The RCD's coordinate system rotates along with the tool. This allows direct determination of the edge-related tangential and normal cutting forces (F_c and F_{cN}), for example during face milling (see below). The cutting force can also be plotted in a polar diagram.



Polar plot milling with a double-edged tool during finishing



Polar plot milling with a four-edge tool, half-sectional view

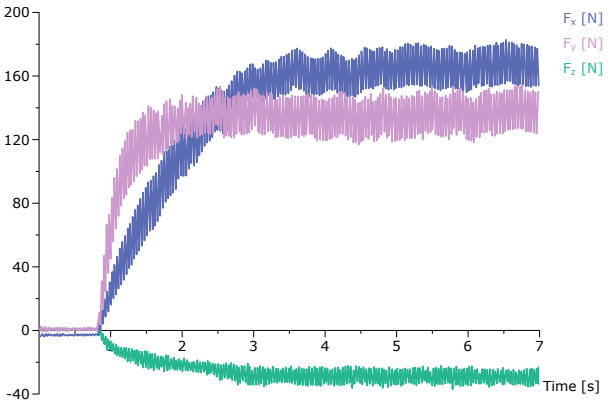
Milling with a Type 9129AA stationary dynamometer

Cutting force measurement: milling

Stationary dynamometers
The stationary dynamometer is mounted on the machine tool table and the workpiece is positioned on top of it. To reduce the mass on the dynamometer and thus minimize the negative influence on its dynamics, the workpiece is bolted directly onto the dynamometer; this eliminates the need for heavy (and often non-rigid) vises. In a few simple steps, the active force F_a acting in the working plane can be calculated from the feed force and the normal feed force.

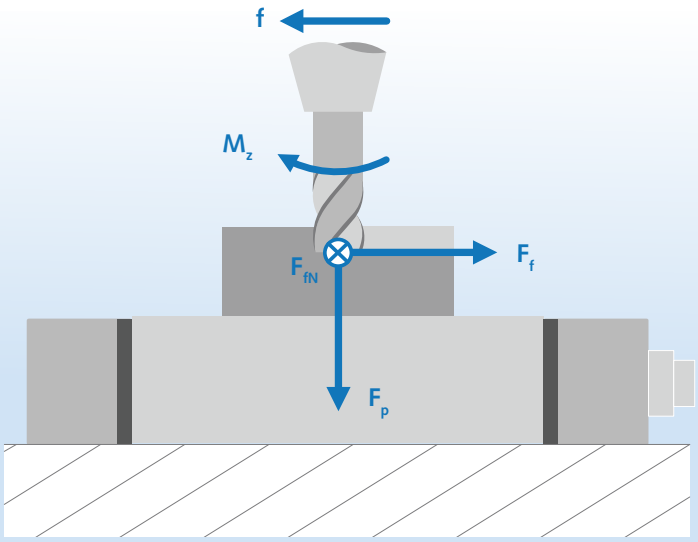
Rotating dynamometers
A rotating dynamometer (RCD) is inserted directly into the machine spindle, while the tool is connected to the RCD with suitable tool holders. Because it is connected to the machine spindle, the RCD rotates with it during operation. RCDs have two advantages over stationary dynamometers: on the one hand, the measuring instrument's dynamics are not influenced by changing masses, because the tool mass remains constant. And on the other hand, the installed multi-component sensor makes it possible to measure the moment M_z directly throughout the entire measurement — so, for example, targeted statements about tool wear become possible.

When RCDs are used, the active force F_a that acts on the working plane can also be calculated from from forces F_x and F_y in a few simple steps. The acting cutting force F_c and the normal cutting force F_{cN} can be calculated with the help of the torque M_z and the active force.



Typical measurement signals during milling (captured with a stationary dynamometer)

Services for tool and machine performance optimization: Productive Machines partners with Kistler



Forces measurable with a stationary dynamometer during milling

- **Feed force** F_f
  (force in the tool's direction of feed)
- **Normal feed force** F_{fN}
  (force perpendicular to F_f)
- **Passive force** F_p

Forces measurable with a rotating dynamometer during milling

- **Spindle moment** M_z
- **Passive force** F_p
- **Forces F_x and F_y**
  in the working plane

Forces and torque during face milling

Drilling with a Type 9170A rotating dynamometer

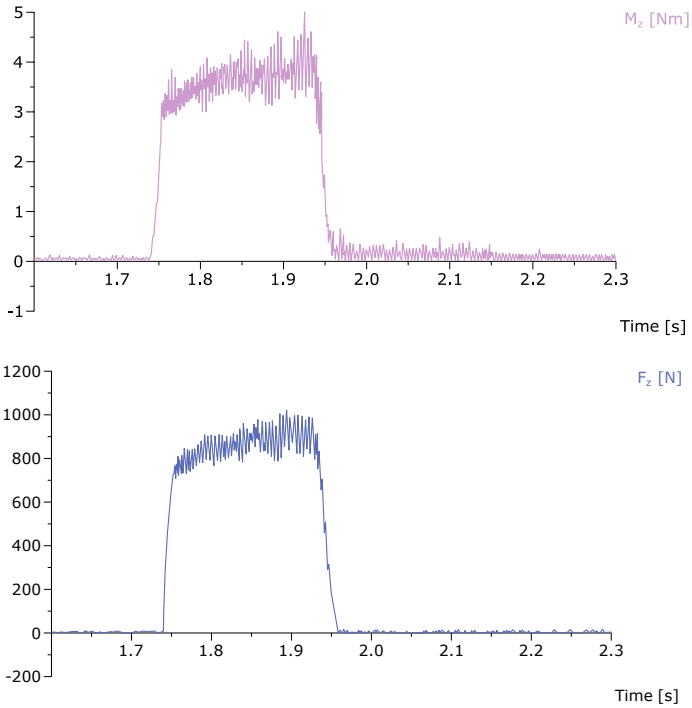
Cutting force measurement: drilling

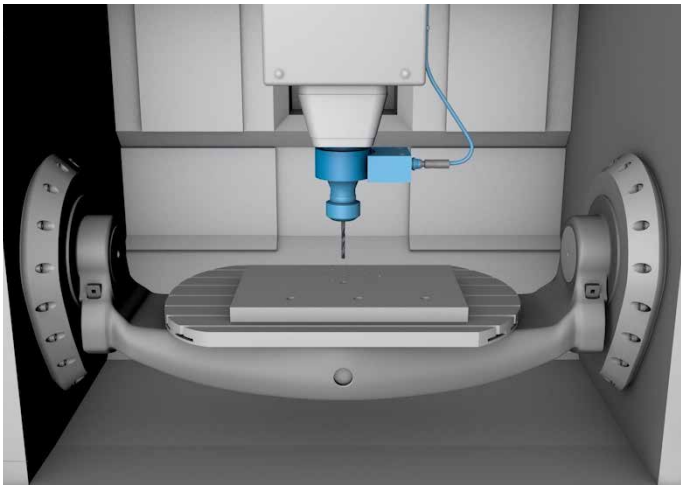
Both stationary and rotating dynamometers (RCDs) can be used to measure the process forces during drilling. An RCD is inserted directly into the machine spindle, while the tool is connected to the RCD with suitable tool holders. Because it is connected to the machine spindle, the RCD rotates with it during operation.

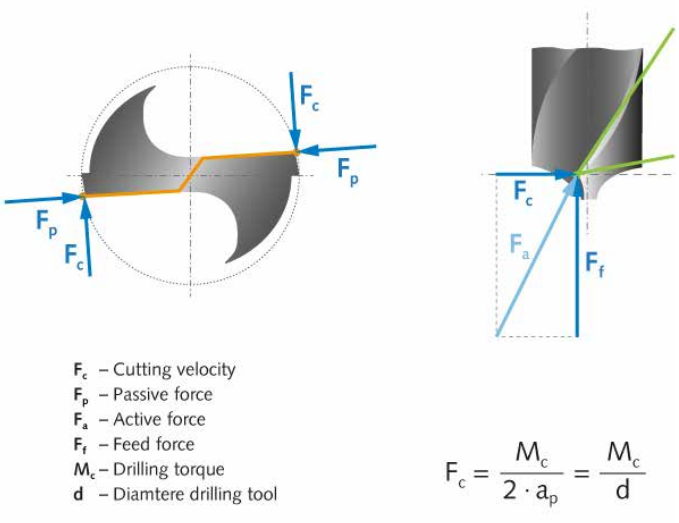
The cutting force Fc and passive force Fp acting on the drilling tool can be calculated with the help of the drilling moment Mz and the deflective forces Fx, Fy; the feed force Ff can be determined directly.

Rotating dynamometers
Rotating dynamometers are ideal for measuring forces during drilling. They measure the drilling moment directly, and accurately record the wear status of tools in the process.

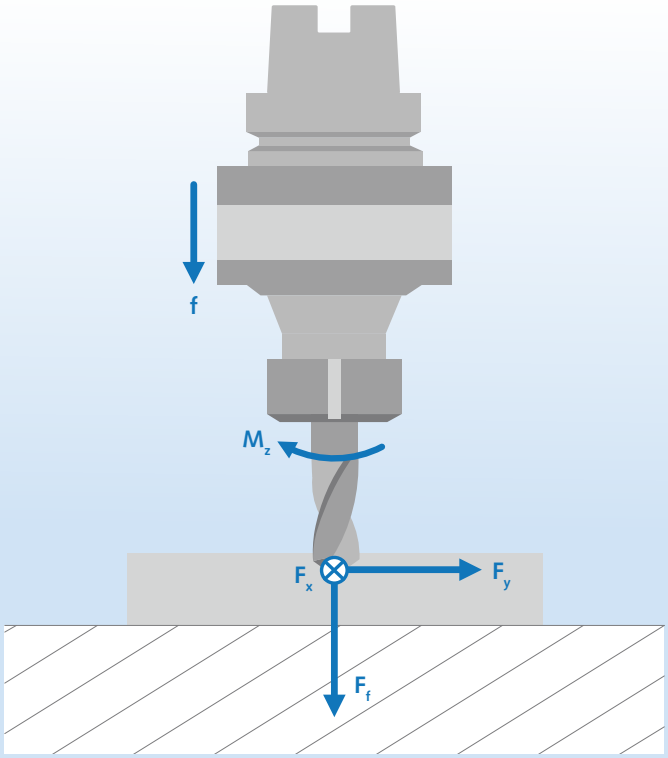
Stationary dynamometers
Stationary dynamometers are also suitable for recording forces during drilling. They measure the forces in three directions. In this case, however, the torque is not measured directly but is calculated using the various measurement signals from the force sensors.







Force components during drilling operations



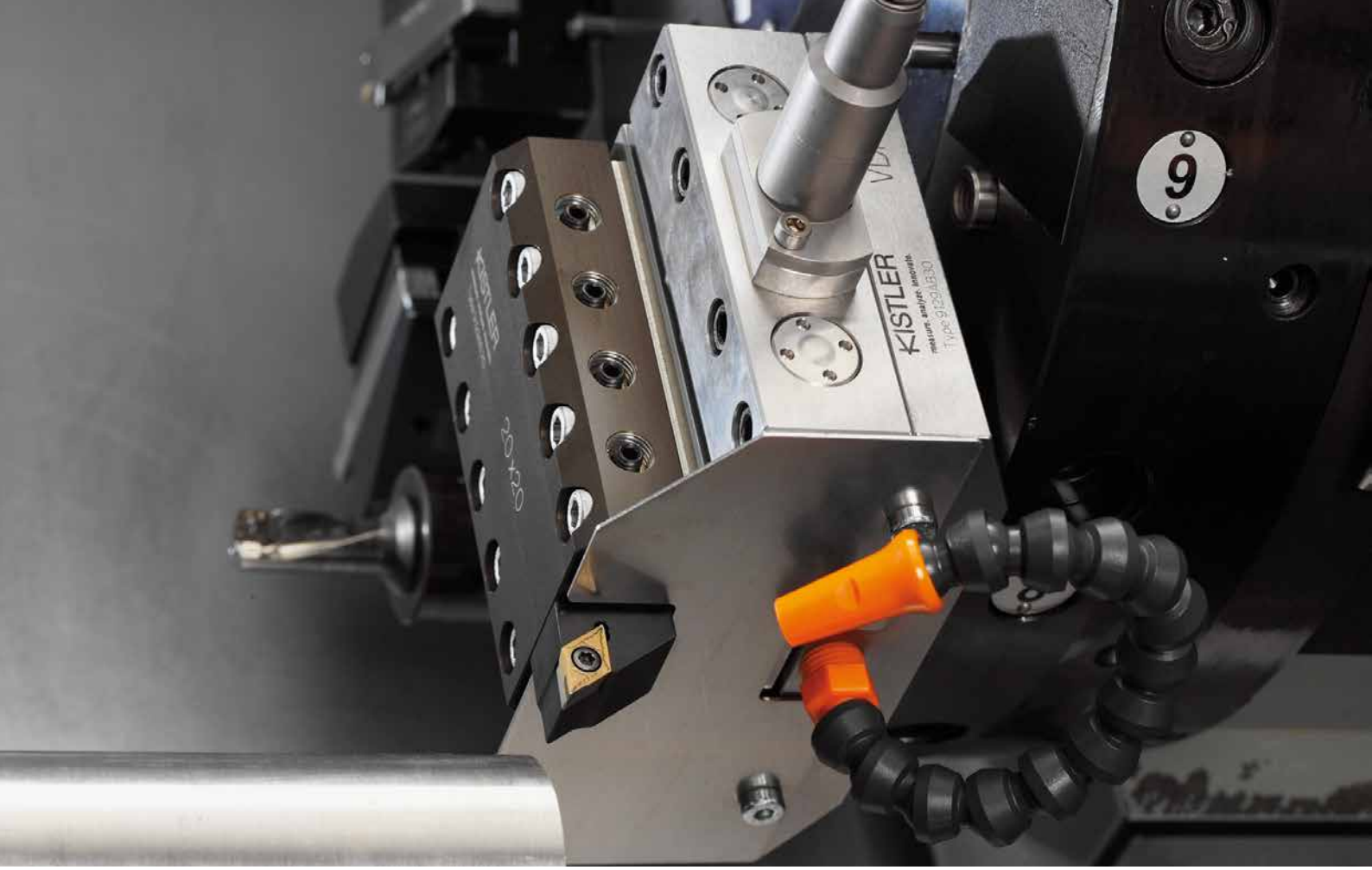
Components that can be measured directly by a rotating dynamometer during drilling processes

- Drilling moment M_z
- Deflective force F_x
- Deflective force F_y
- Feed force F_f

Components that can be measured directly by a stationary dynamometer during drilling processes

- Feed force F_f
- Deflective force F_x
- Deflective force F_y

Forces and torque during drilling



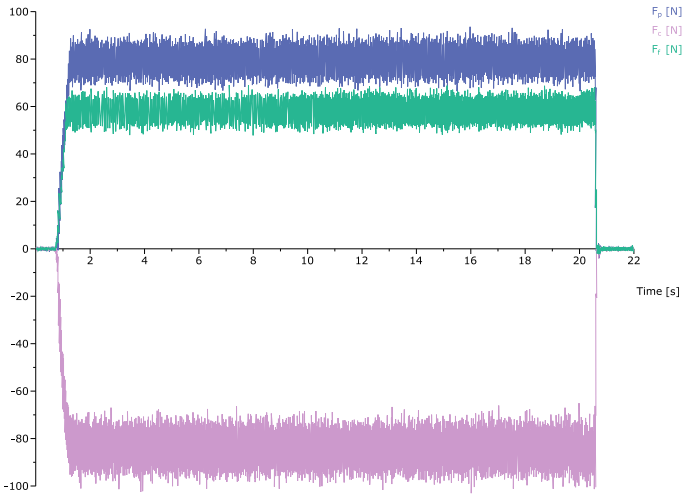
Turning with a Type 9129AA dynamometer

Cutting force measurement: turning

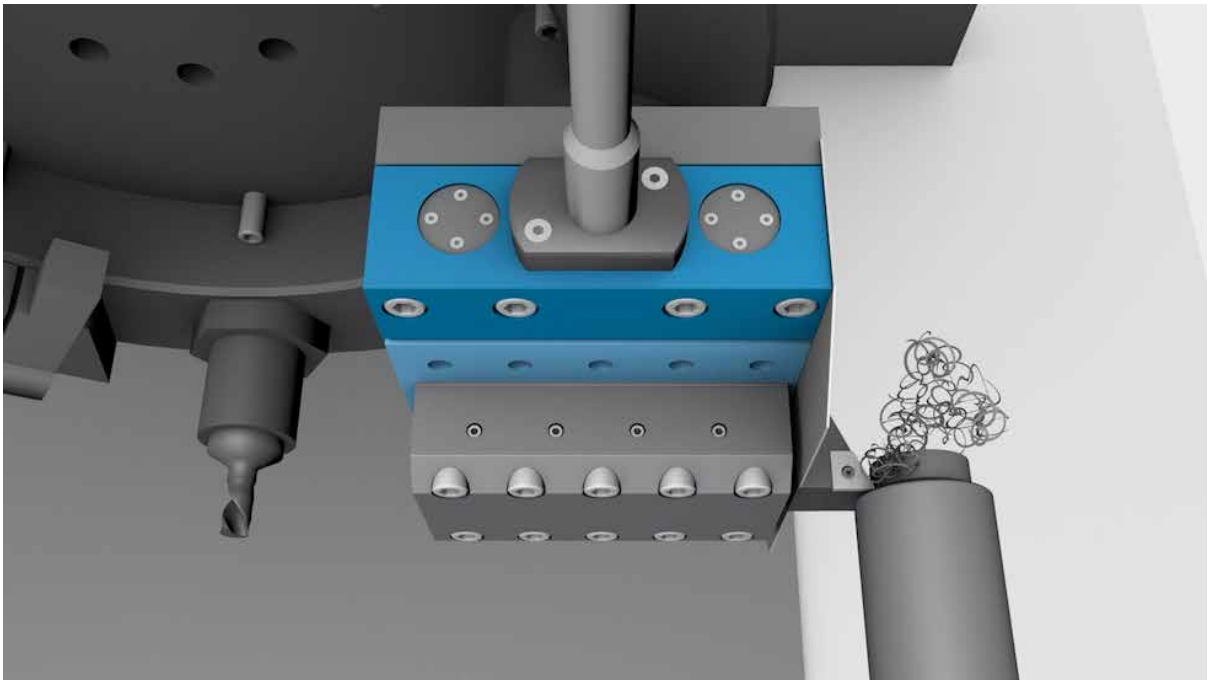
Turning: a model machining process
Turning — and longitudinal turning in particular — is a model case for machining with a geometrically defined cutting edge; because the edge is constantly engaged in cutting, it is used to determine and characterize specific forces (k_c, k_p, k_f) for certain materials subject to different boundary conditions. Cutting forces are often measured during the turning operation in order to examine plastic-mechanical processes within the actual cutting process, to analyze chip formation and its influence on the process, or to substantiate wear processes with force progressions.

Stationary dynamometers for turning
Stationary dynamometers are used to measure forces during turning processes. These dynamometers have a partially modular structure; they are usually mounted on the machine tool's turret head with the help of a suitable adapter. The tool is mounted on the dynamometer with a tool holder, so the dynamometer is embedded between the tool and the turret head. This structure allows accurate and highly dynamic force measurements so that even the smallest changes in the process chain can be quantified immediately.

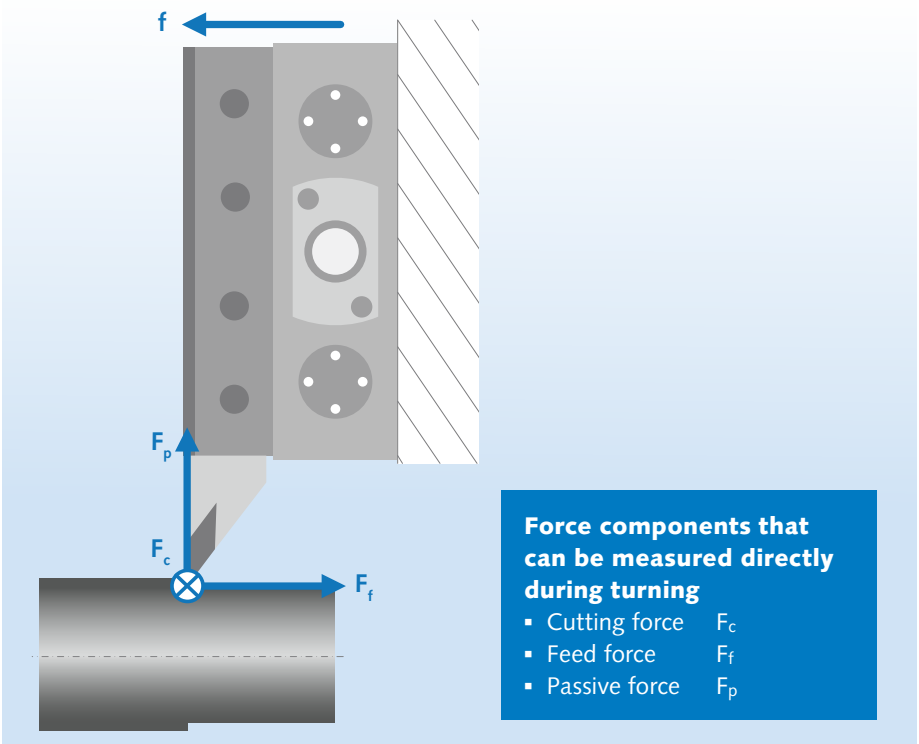
With the help of multi-component dynamometers, the main cutting force generated by the turning process is broken down directly into the three components: cutting force F_c, feed force F_f and passive force F_p.



Typical measurement signals for turning



Basic turning trials with a Type 9129AA dynamometer



Force components that can be measured directly during turning

- Cutting force F_c
- Feed force F_f
- Passive force F_p

Forces in longitudinal turning

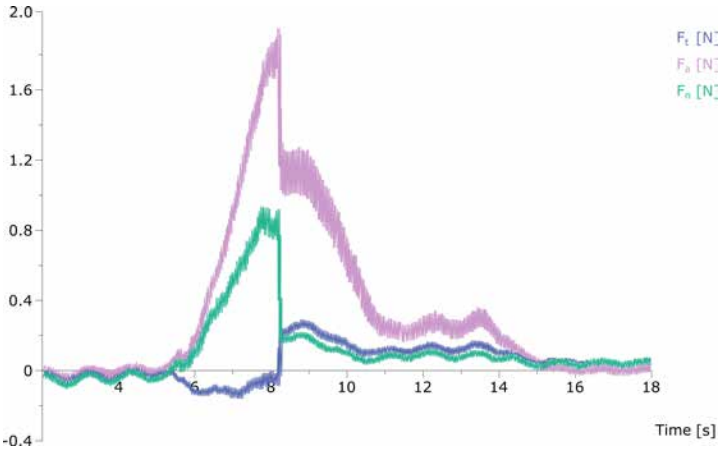
Modular structure of stationary dynamometers

Depending on the dimensions of the machine tool, tools and loads, users can choose from several dynamometers to measure cutting forces in turning operations. Thanks to their modular design, they can be fitted with various machine adapters and tool holders in just a few working steps. Because negative thermal effects are minimized by the structural design of the dynamometer, the signals are of considerably higher quality and are much more informative.

Grinding with a Type 9129AA dynamometer

Cutting force measurement: grinding

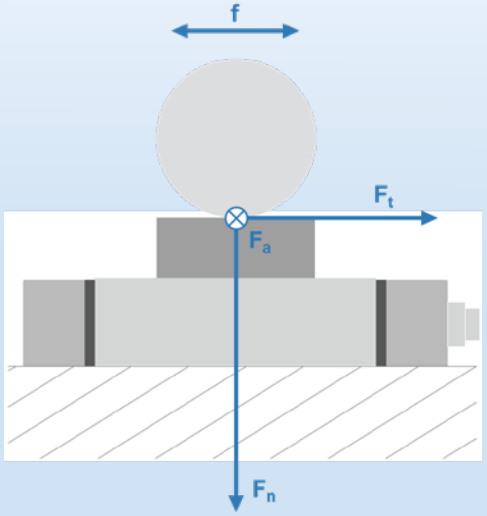
Grinding is often the final machining operation performed in the process of manufacturing a part. This means that it plays a very important role in the quality of the finished part. Strictly defined quality requirements such as roughness and peripheral zone properties must be met, but it is also essential to avoid production faults such as grinding burns and cracks. To achieve these goals, it is important to understand the relationships between process input and output parameters. The measurement of the cutting force is an appropriate parameter for determining cause-effect relationships and identifying the reasons for undesirable results. Our extensive product portfolio and the flexibility of our dynamometers allow force measurements for a wide variety of grinding processes.



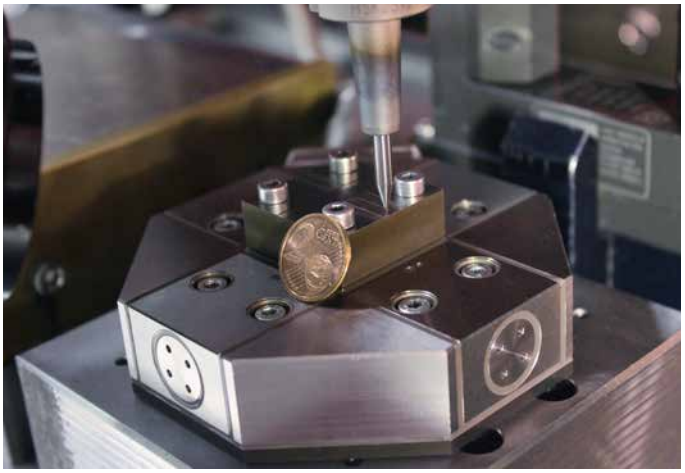
Typical measuring signal for grinding

Force components that can be measured directly during grinding

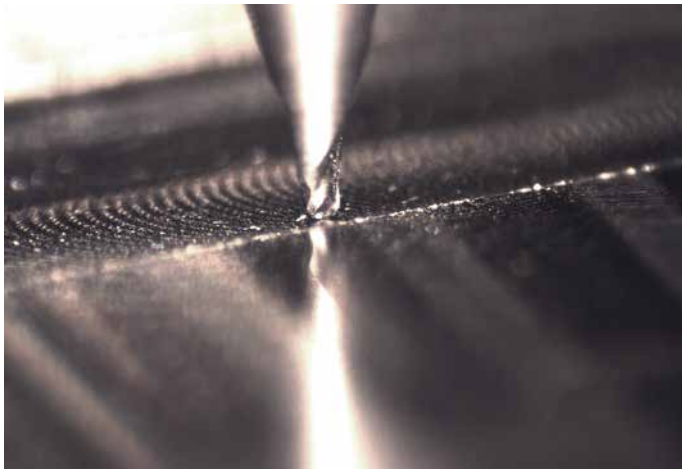
- Normal force Fn
- Axial force Fa
- Tangential force Ft



Cutting force measurement: micromachining



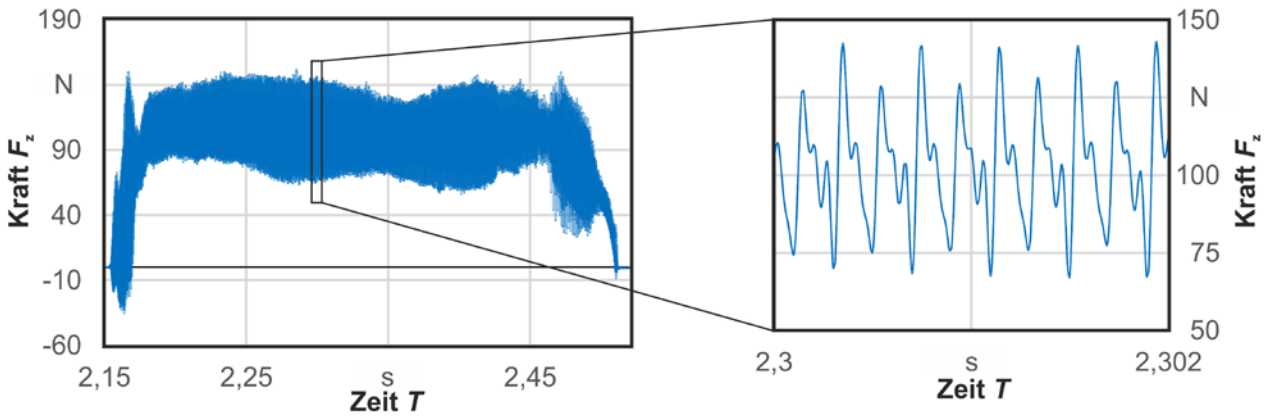
MicroDyn 9109AA on the machining table of a micromachining center



Double-edge ball-nose milling cutter with diameter d= 0.2 mm for micromachining

Piezoelectric measurement technology is an excellent solution to meet the requirements for micromachining. Thanks to the use of highly sensitive, rugged crystals, one single measuring instrument can be used to measure force signals in ranges from well below 1 N to over 500 N. The advantages here are that the measurement setup does not need to be changed between tests, and reproducible measurements are guaranteed. Kistler offers measuring instruments that are specifically designed for use in micromachining. Thanks to their optimized rigidity and mass, these dynamometers achieve exceptionally high natural frequencies. In tests with double-edge tools at a spindle speed of 160 000 rpm, for example, it has been proven that the MicroDyn 9109AA can still reliably capture the force signals for each individual engagement of the cutting edge.

Micromachining sets extremely demanding requirements for measuring technology in terms of sensitivity, and also as regards the dynamics of the signals to be captured. The forces that occur during micromachining range from 1 N to more than 250 N. These must be mapped precisely and distinctly in a process sequence. Another key criterion for recording the process dynamics is the natural frequency of the measurement equipment. If the frequency range containing the natural frequencies of the force measurement equipment is too small, the result will be over-excitation of the measurement setup. There is then a risk that the amplitudes of the force signals will tend to be overstated in the high frequency range. In the worst case, the measurement setup will be excited at its natural frequency, and the vibration of the setup will be greater than the forces that actually occur in the process. This must be prevented at all costs.



Force signals recorded with a MicroDyn 9109AA The individual force curves for the engagements of both edges can be seen clearly — with engagement times of less than 1 ms

Cutting force measurement: application examples

Machining test for cylindrical grinding
The Institute of Machine Tools and Factory Management at the Technical University of Berlin (TU Berlin) used a special dynamometer to analyze grinding processes. This made it possible to determine and improve part quality, wear mechanisms and the critical material removal rate limit.

Using a special dynamometer to measure broaching forces
In this case too, the unique benefits of Kistler's piezoelectric technology were clearly proven. In the Laboratory for Machine Tools and Production Engineering (WZL) at Aachen, a large dynamometer was successfully used to measure and analyze extremely small forces.

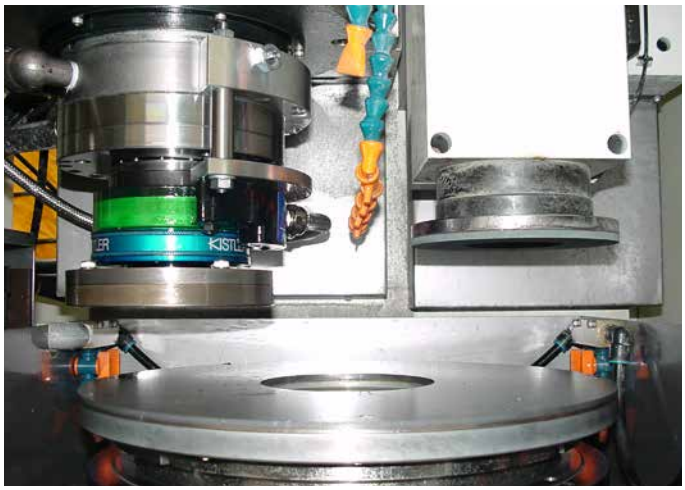
Kistler as your development partner
We view every application as an exciting challenge — broaching, sawing, thread tapping, polishing and honing, as well as classical applications such as milling, drilling, turning and grinding. We shall be glad to act as your development partner, working with you to devise individual solutions for your measurement tasks. We can draw on our lengthy experience as specialists in measuring a variety of parameters including force, acceleration and acoustic emissions. Our services range from advisory support through to engineering of ready-to-install solutions.

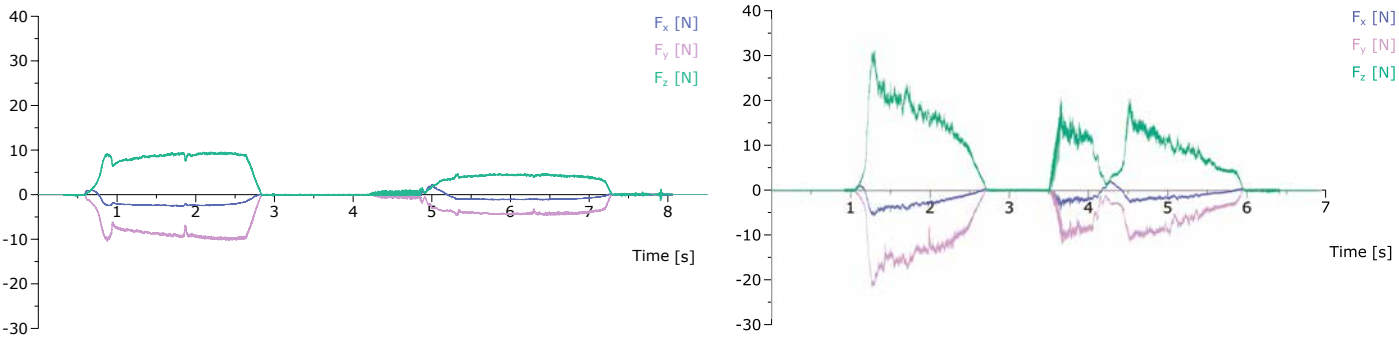
Kistler also uses dynamometers to manufacture its own products

Manufacturing thin-walled parts from materials that are difficult to machine — such as membranes for pressure sensors — is an operation that sets demanding requirements for the process stability and surface quality of the parts. The process was analyzed with the help of measurement technology from Kistler — leading to significantly increased tool edge life and process stability. The results: reduced production costs and a lower scrap rate.

A high-precision flat honing machine with Kistler dynamometers

In wafer fabrication, quality is determined by flatness, surface roughness and the thickness of the disk. The material is usually very hard and brittle. In the past, it was polished or honed with the use of paste containing loose particles. Quality was ensured, but the method was not efficient and contamination levels were high. In Japan, Tohoku University collaborated with the Matsushita Electronic Components Company to find a way of making the process more efficient — thanks to technology by Kistler. This special design was used to measure and analyze the use of diamond-coated disks. And there were additional benefits, too: handling was optimized and the error rate was reduced.





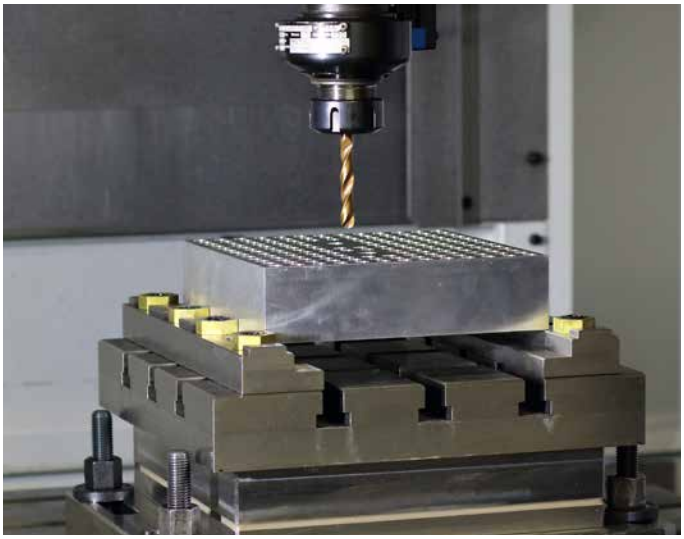
Force signals during a turning process on materials that are difficult to machine; left: new tool; right: worn tool

Evaluation of cooling lubricants under operational conditions

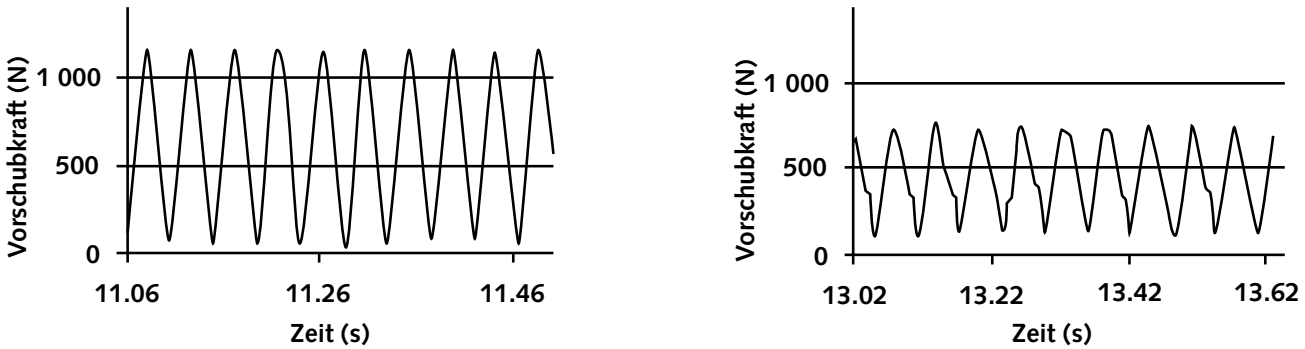
Blaser Swisslube AG, located in Hasle-Rüegsau, is a leading manufacturer of lubricants for metal machining. When it comes to developing new cooling lubricants, this Swiss company puts its trust in Kistler's measurement expertise. Thanks to high-precision measurement data, cooling lubricants are adapted exactly to the application requirements during the practical testing phase — so customers can rest assured that they will function reliably later on.

Process optimization

Process optimization is the critical factor in boosting productivity and enhancing the quality of machining processes — key factors in ensuring that machining companies maintain their competitive edge. For over ten years, MITIS has been developing systems for vibration-assisted drilling. Systems of this sort are the solution of choice in applications where chip breaking has a decisive influence on the stability and efficiency of the process. Our Type 9255 cutting force systems are regularly deployed to optimize the machining parameters and adjust the axial travel of the vibration. As the result, cost-relevant process parameters can be optimized without risking deformation of parts due to excessive axial forces.



MITIS systems in operation: in this photograph, the workpiece is clamped onto a Kistler 9255C dynamometer

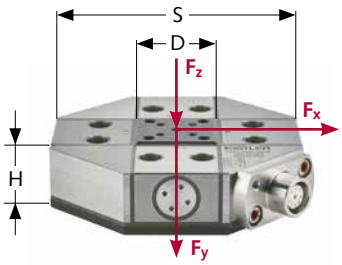


Fluctuation of axial force in vibration-assisted drilling. Force signals are used to optimize the parameters so that the tools are always engaged in cutting, chips break reliably and the forces are minimized so as to prevent any part deformations

Products

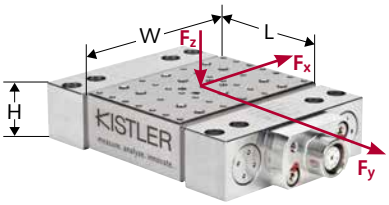
Stationary dynamometers

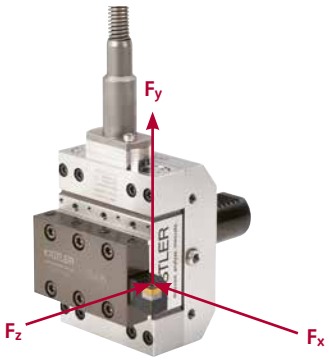
MicroDyn: multi-component dynamometer with cover plate 30x30 mm, up to 500 N



Technical data	**Type**	**9109AA**
Measurement range		
F_x, F_y, F_z (centrical)	N	–500 … 500
M_z (single component)	N·m	–50 … 50
Calibrated measurement ranges		
F_x, F_y, F_z	N	0 … 500
	N	0 … 50
	N	0 … 10
Average sensitivity		
F_x, F_y,	pC/N	≈–12.5
F_z	pC/N	≈–20
Natural frequency (without additional mass)		
f_n(x)	kHz	>15
f_n(y)	kHz	>15
f_n(z)	kHz	>15
Operating temperature range	°C	–20 … 70
DxSxH	mm	30x100x26
Weight	kg	1.04
Degree of protection: IEC/EN 60529 (with connected cable)		IP67
Connector		Fischer flange, 9-pole neg.
Data sheet: see www.kistler.com	**No.**	**9109AA_003-346**
Key characteristics	As a newly-developed addition to our range of stationary dynamometers, this 4-component dynamometer can also measure the moment M_z in the center of the dynamometer. A very compact and rugged dynamometer with high sensitivity and natural frequency. Ideal for measuring cutting forces in micromachining.	
Accessories		
Steel baseplate for magnetic attachment	**Art. No.**	**55174784**
Mounting screws, M4x25	**Art. No.**	**65012704**
Accessories (optional)		
Connecting cable for 6-comp. force measurement	**Type**	**1677A5/1677AQ02/1679A5**

MiniDyn: multi-component dynamometer, up to 4 kN





		FOR TABLE MACHINING		FOR TURNING OPERATIONS
Technical data	**Type**	**9119AA1**	**9119AA2**	**9119AA2** [1]
Measurement range				
F_x, F_z	kN	–4 … 4	–4 … 4	–2 … 2 [2]
F_y	kN	–4 … 4	–4 … 4	–3 … 3 [2]
Calibrated measurement ranges				
F_x, F_z	N	0 … 4 000	0 … 4 000	0 … 2 000
	N	0 … 400	0 … 400	0 … 200
	N	0 … 40	0 … 40	
F_y	N	0 … 4 000	0 … 4 000	0 … 3 000
	N	0 … 400	0 … 400	0 … 300
	N	0 … 40	0 … 40	
Sensitivity				
F_x, F_z	pC/N	≈–26	≈–26	≈–26
F_y	pC/N	≈–13	≈–13	≈–13
Natural frequency				
$f_n(x)$	kHz	≈6.0	≈4.3	≈1.25 [3]
$f_n(y)$	kHz	≈6.4	≈4.6	≈1.5 [3]
$f_n(z)$	kHz	≈6.3	≈4.4	≈2.5 [3]
Pretensioning direction		horizontal	horizontal	
Operating temperature range	°C	–20 … 70	–20 … 70	–20 … 70
Clamping surface (area)	mm	39x80x26	55x80x26	55x80
Weight	g	930	1 350	depending on adapter
Degree of protection: IEC/EN 60529 (with connected cable)		IP67	IP67	IP67
Connector		Fischer flange, 9-pole neg.	Fischer flange, 9-pole neg.	Fischer flange, 9-pole neg.

Key characteristics

The dynamometer with the smallest mounting dimensions. Thanks to its optimized design and specially selected materials, this dynamometer can attain natural frequencies of over 6 kHz in all three force directions (Type 9119AA1). The highly sensitive crystals used in the dynamometer enable it to achieve sensitivities three times greater than those of conventional dynamometers. The benefit: even the very smallest forces can be measured accurately. The horizontal pretensioning direction guarantees that any influence of thermal effects on the measurement signals is minimized.

[1] with adapters, Type 9119A...

[2] depending on the adapter

[3] applies to dynamometer Type 9119AA2 with machine adapter Type 9119AB30S and tool holder Type 9119AE16, with tool (280 g)

Tool holders

Turning tool, Type 9119AE...
Boring bar, Type 9119AF16

MiniDyn 9119AA2

Accessories (optional):
Connecting cable for 3-comp. force measurement
Type: 1687B5/1687BQ02/1688B5/1689B5
Connecting cable for 6-comp. force measurement
Type: 1677A5/1677AQ02/1678A5/1679A5

Data sheet: 9119AA1_003-060
9119AA2_003-055

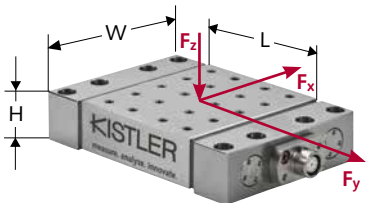
Machine adapters

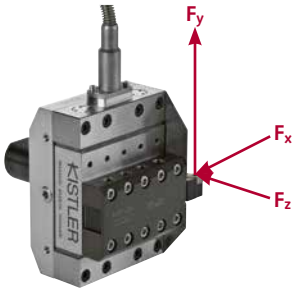
Straight shank (VDI), Type 9119AB...
Capto, Type 9119AC...
HSK-T, Type 9119AH63...

Key characteristics
Modular measuring system based on the Type 9119AA2 dynamometer. Machine adapters and tool holder nuts are easy to mount. We offer a wide range of commonly used adapters to fit the Type 9119AA2 dynamometer.

Grinding with a Type 9119AA2 dynamometer

MidiDyn: multi-component dynamometer with 90x105 mm coverplate, up to 10 kN





		FOR TABLE MACHINING	FOR TURNING OPERATIONS
Technical data	**Type**	**9129AA**	**9129AA[1)]**
Measurement range			
F_x, F_z	kN	–10 ... 10	–5 ... 5 [2)]
F_y	kN	–10 ... 10	–8 ... 8 [2)]
Calibrated measurement ranges			
F_x, F_z	kN kN kN	0 ... 10 0 ... 1 0 ... 0.1	0 ... 5 0 ... 0.5
F_y	kN kN kN	0 ... 10 0 ... 1 0 ... 0.1	0 ... 8 0 ... 0.8
Sensitivity			
F_x, F_z	pC/N	≈–8	≈–8
F_y	pC/N	≈–4.1	≈–4.1
Natural frequency			
$f_n(x)$	kHz	≈3.5	≈1.5 [3)]
$f_n(y)$	kHz	≈4.5	≈1.5 [3)]
$f_n(z)$	kHz	≈3.5	≈2.5 [3)]
Pretensioning direction		horizontal	
Operating temperature range	°C	0 ... 70	0 ... 70
LxWxH	mm	90x105x32	90x105
Weight	kg	3.2	depending on adapter
Degree of protection: IEC/EN 60529 (with connected cable)		IP67	IP67
Connector		Fischer flange, 9-pole neg.	Fischer flange, 9-pole neg.

Key characteristics

Low overall height and a wide measuring range make this dynamometer the ideal instrument for measurements on high-precision machines. Its structure guarantees high natural frequencies in all three force directions. Negative influences due to temperature effects during the measurement are significantly reduced thanks to the horizontal pretensioning direction.

[1)] with adapters, Type 9129A...

[2)] depending on the adapter

3) applies to dynamometer Type 9129AA with machine adapter Type 9129AB40 and tool holder Type 9129AE25, with tool (280 g)

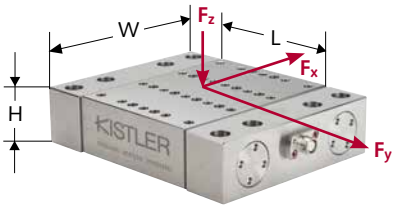
Milling with a Type 9129AA dynamometer

Tool holders	MidiDyn 9129AA	Machine adapters
		
Turning tool, Type 9129AE... Boring bar, Type 9129AF40 CoroTurn SL, Type 9129AG40	**Accessories (optional):** Connecting cable for 3-comp. force measurement Type: 1687B5 / 1687BQ02 / 1688B5 / 1689B5 Connecting cable for 6-comp. force measurement Type: 1677A5 / 1677AQ02 / 1678A5 / 1679A5 **Data sheet:** 9129AA_000-709 9129AA_000-710	Straight shank (VDI), Type 9129AB... Clamping wedge, Type 9129AD... Capto, Type 9129AC...

Key characteristics
Modular measuring system based on the Type 9129AA dynamometer, featuring a wide measurement range. Machine adapters as well as tool holders can be mounted on this dynamometer with minimum effort. We offer a wide range of commonly used adapters to fit the Type 9129AA dynamometer.

Turning with a Type 9129A dynamometer

MaxiDyn: multi-component dynamometer with 140x190 mm cover plate, up to 30 kN



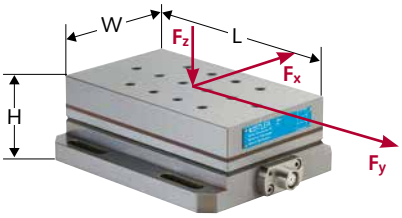
Technical data	Type	9139AA
Measurement range (max. allowable)		
F_x, F_y, F_z	kN	–30 ... 30
Calibrated measurement ranges	kN	0 ... 30
F_x, F_y, F_z	kN	0 ... 3
	kN	0 ... 0.3
Sensitivity		
F_x, F_z	pC/N	≈–8.2
F_y	pC/N	≈–4.2
Natural frequency		
$f_n(x)$	kHz	≈2.9
$f_n(y)$	kHz	≈2.9
$f_n(z)$	kHz	≈3.0
Pretensioning direction		horizontal
Operating temperature range	°C	–20 ... 70
LxWxH	mm	140x190x58
Weight	kg	≈12.9
Degree of protection: IEC/EN 60529 (with connected cable)		IP67
Connector		Fischer flange, 9-pole neg.
Data sheet: see www.kistler.com	**No.**	**9139AA_003-198**

Key characteristics	In this compact and robust dynamometer, the horizontal pretensioning direction largely eliminates the negative effects of temperature variations during measurement. Force measurements in heavy-duty cutting processes are possible thanks to the wide measurement range.

Accessories (optional)		
Connecting cable for 3-comp. force measurement	**Type**	**1687B5/1687BQ02/1688B5/1689B5**
Connecting cable for 6-comp. force measurement	**Type**	**1677A5/1677AQ02/1678A5/1679A5**

Milling with a Type 9139AA dynamometer

Multi-component dynamometer with cover plate, 100x170 mm, up to 10 kN



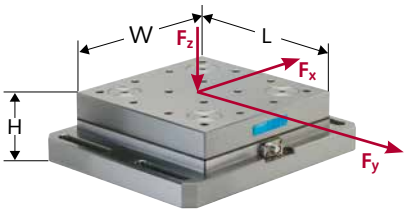
Technical data	Type	9257B
Measurement range		
F_x, F_y	kN	–5 ... 5
F_z	kN	–5 ... 10
Calibrated measurement ranges		
F_x, F_y	kN	0 ... 5
	kN	0 ... 0.5
F_z	kN	0 ... 10
	kN	0 ... 1
Sensitivity		
F_x, F_y	pC/N	≈–7.5
F_z	pC/N	≈–3.7
Natural frequency		
$f_n(x)$, $f_n(y)$	kHz	≈2.3
$f_n(z)$	kHz	≈3.5
Pretensioning direction		vertical
Operating temperature range	°C	0 ... 70
LxWxH	mm	170x100x60
Weight	kg	7.3
Degree of protection: IEC/EN 60529 (with connected cable)		IP67
Connector		Fischer flange, 9-pole neg.
Data sheet: see www.kistler.com	**No.**	**9257B_000-151**

Key characteristics	Dynamometer for universal use. Because of its handy dimensions and ideal measurement range for many applications, the Type 9257B is manufactured in larger numbers than any other multi-component dynamometer. It is connected to the machine table via lateral flanges with oblong holes.

Accessories (optional)		
Connecting cable for 3-comp. force measurement	**Type**	**1687B5/1687BQ02/1688B5/1689B5**
Connecting cable for 6-comp. force measurement	**Type**	**1677A5/1677AQ02/1678A5/1679A5**
Tool holder	**Type**	**9403**
Waterproof protective cap for cable connection	**Type**	**1431A1**

Screw tapping with a Type 9257B dynamometer

Multi-component dynamometer with cover plate, 260x260 mm, up to 60 kN



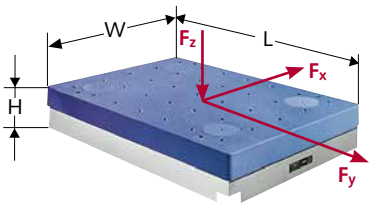
Technical data	Type	9255C
Measurement range		
F_x, F_y	kN	–30 ... 30
F_z	kN	–10 ... 60
Calibrated measuring ranges		
F_x, F_y	kN	0 ...30
	kN	0 ... 3
F_z	kN	0 ... 60
	kN	0 ... 6
Sensitivity		
F_x, F_y	pC/N	≈–7.9
F_z	pC/N	≈–3.9
Natural frequency		
f_n(x)	kHz	≈2.2
f_n(y)	kHz	≈2.2
f_n(z)	kHz	≈3.3
Pretensioning direction		vertical
Operating temperature range	°C	–20 ... 70
LxWxH	mm	260x260x95
Weight	kg	52
Degree of protection: IEC/EN 60529 (with connected cable)		IP67
Connector		Fischer flange, 9-pole neg.
Data sheet: see www.kistler.com	**No.**	**9255C_003-051**

Key characteristics	Rugged dynamometer for heavy-duty machining, with the largest force range of all our dynamometers. It is connected to the machine tool table via lateral flanges with oblong holes. The dynamometer can also be fixed through the center of the four sensors, which increases its natural frequency.

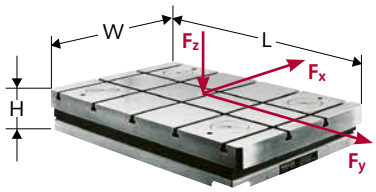
Accessories (optional)		
Connecting cable for 3-comp. force measurement	**Type**	**1687B5/1687BQ02/1688B5/1689B5**
Connecting cable for 6-comp. force measurement	**Type**	**1677A5/1677AQ02/1678A5/1679A5**
Waterproof protective cap for cable connection	**Type**	**1431A1**

Milling with a Type 9255C dynamometer

Multi-component force plate with cover plate, 400x600 mm, up to 30 kN



Type 9253B22 [1]



Type 9253B23 [2]

[1] cover plate with tapped hole, M10x18

[2] cover plate with T-grooves, 10H12

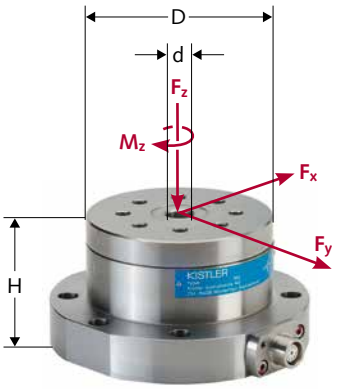
Technical data	Type	9253B22	9253B23
Measurement range			
F_x, F_y	kN	–15 ... 15	–12 ... 12
F_z	kN	–15 ... 30	–12 ... 25
Calibrated measurement ranges			
F_x, F_y	kN	0 ...15	0 ... 12
	kN	0 ... 1.5	0 ... 1.2
F_z	kN	0 ... 30	0 ... 25
	kN	0 ... 3	0 ... 2.5
Sensitivity			
F_x, F_y	pC/N	≈±7.8	≈±7.8
F_z	pC/N	≈±3.7	≈±3.7
Natural frequency			
$f_n(x)$	Hz	≈580	≈610
$f_n(y)$	Hz	≈550	≈570
$f_n(z)$	Hz	≈720	≈570
Pretensioning direction		vertical	vertical
Operating temperature range	°C	–20 ... 70	–20 ... 70
LxWxH	mm	600x400x100	600x400x100
Weight	kg	90	85
Degree of protection: IEC/EN 60529 (with connected cable)		IP67	IP67
Connector		Fischer flange, 9-pole neg.	Fischer flange, 9-pole neg.
Data sheet: see www.kistler.com	**No.**	**9253B_000-146**	**9253B_000-146**

Key characteristics

The cover plate measuring 400x600 mm also ensures safe mounting of larger workpieces. The force plate is mounted on the machine tool table through the center of the four feet. In this case, the base plate is not used (in contrast to all other stationary dynamometers).

Accessories (optional)		
Connecting cable for 3-comp. force measurement	**Type**	**1687B5/1687BQ02/1688B5/1689B5**
Connecting cable for 6-comp. force measurement	**Type**	**1677A5/1677AQ02/1678A5/1679A5**
Waterproof protective cap for cable connection	**Type**	**1431A1**

4-component dynamometer to measure cutting forces during drilling



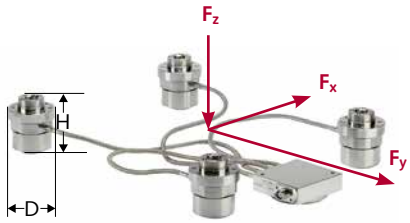
Technical data	Type	9272
Measurement range		
F_x, F_y	kN	–5 ... 5
F_z	kN	–5 ... 20
M_z	N·m	–200 ... 200
Calibrated measurement ranges		
F_x, F_y	kN	0 ... 5
	kN	0 ... 0.5
F_z	kN	0 ... 20
	kN	0 ... 2
M_z	N·m	0 ... ±200
	N·m	0 ... ±20
Sensitivity		
F_x, F_y	pC/N	≈–7.8
F_z	pC/N	≈–3.5
M_z	pC/N·m	≈–160
Natural frequency		
$f_n(x)$, $f_n(y)$	kHz	≈3.1
$f_n(z)$	kHz	≈6.3
f_n (M_z)	kHz	≈4.2
Pretensioning direction		vertical
Operating temperature range	°C	0 ... 70
DxdxH	mm	ø100xø15x70
Weight	kg	4.2
Degree of protection: IEC/EN 60529 (with connected cable)		IP67
Connector		Fischer flange, 9-pole neg.
Data sheet: see www.kistler.com	**No.**	**9272_000-153**

Key characteristics	This 4-component dynamometer is the only stationary model that allows direct measurement of the moment M_z in the center of the dynamometer, in addition to the three force directions. This allows precise determination of the torque.

Accessories (optional)		
Connecting cable for 4-comp. force measurement	**Type**	**1677A5/1677AQ02/1678A5/1679A5**
Tool holder	**Type**	**9404**
Waterproof protective cap for cable connection	**Type**	**1431A1**

Force measurement during quartz cutting with a Type 9272 dynamometer

Multi-component quartz force link kit, up to 60 kN

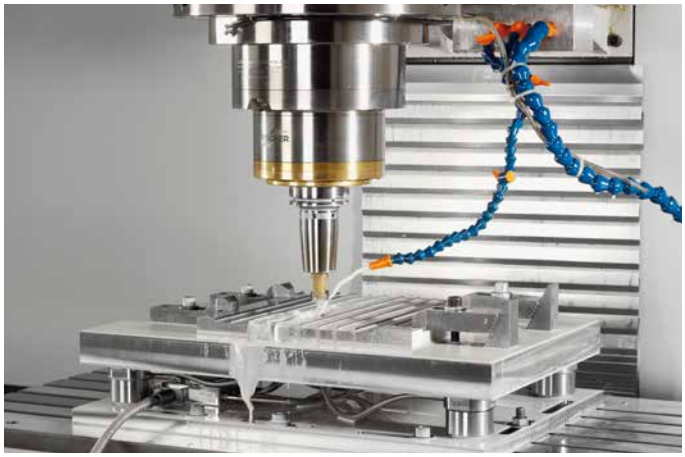


Technical data	Type	9366CC...
Measurement range		
F_x, F_y	kN	–25 ... 25 [1]
F_z	kN	–25 ... 60 [1]
Calibrated measurement ranges		
F_x, F_y	kN	0 ... 25
	kN	0 ... 2.5
F_z	kN	0 ... 60
	kN	0 ... 6
Sensitivity		
F_x, F_y	pC/N	≈–7.8
F_z	pC/N	≈–3.8
Natural frequency		
$f_n(x)$, $f_n(y)$, $f_n(z)$	Hz	≈200 ... 1 600 [1]
Pretensioning direction		vertical
Operating temperature range	°C	–20 ... 70
DxH	mm	72x90
Max. size of the cover plate	mm	900x900
Weight	kg	7
Degree of protection: IEC/EN 60529 (with connected cable)		IP67
Connector		Fischer flange, 9-pole neg.
Data sheet: see www.kistler.com	**No.**	**9366CC_000-681**

Key characteristics	Users can assemble their own multi-component force plates with this ready-to-connect pre-calibrated multi-component kit. Cover plate sizes from 300x300 mm to 900x900 mm are possible.

Accessories (optional)		
Connecting cable for 3-comp. force measurement	**Type**	**1687B5/1687BQ02/1688B5/1689B5**
Connecting cable for 6-comp. force measurement	**Type**	**1677A5/1677AQ02/1678A5/1679A5**
Waterproof protective cap for cable connection	**Type**	**1431A1**

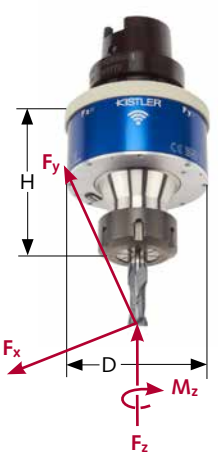
[1] depending on cover plate size and material



Machining titanium with a Type 9366CC dynamometer

Rotating dynamometers

Wireless 4-component dynamometer (RCD) to measure cutting forces up to 16 000 rpm



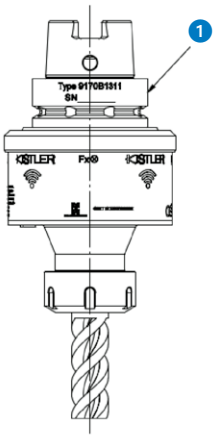
Technical data	Type	9170B...
Measurement range (nominal)		
F_x, F_y	kN	–5 ... 5 [1]
F_z	kN	–20 ... 20 [1]
M_z	N·m	–100 ... 100 [1]
Speed, max.	1/min	16 000 [1]
Sensitivity (min./max.)		
F_x, F_y	mV/N	≈2/≈20
F_z	mV/N	≈0.5/≈5
M_z	mV/N·m	≈66/≈1 000
Natural frequency		
$f_n(x)$	kHz	≈2.0 [2]
$f_n(y)$	kHz	≈2.0 [2]
$f_n(z)$	kHz	≈5.3 [2]
Operating temperature range	°C	0 ... 60
DxH	mm	94x148 [2]
Weight of rotor	kg	2.0 [2]
Degree of protection: IEC/EN 60529		IP67
Signal transmission		Radio link (GFSK)
Data sheet: see www.kistler.com	**No.**	**9170B_003-608**

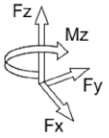
Key characteristics

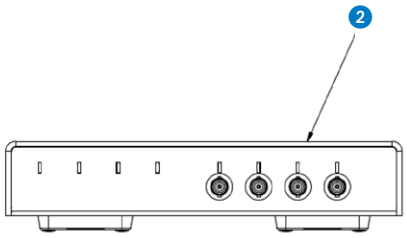
This rotating 4-component wireless dynamometer (WiRCD) measures the forces in the radial direction (F_x, F_y) and the axial direction (F_z) and also the torque in cutting processes with spindle speeds of up to 16 000 rpm. Internal cooling lubricant supply is possible. Measurement signal transmission is wireless and power supply is via integrated rechargeable battery. We offer a wide variety of commonly used spindle adapters for this RCD.

[1] depending on spindle adapter and force application point

[2] applies to rotor with spindle adapter HSK-A63 and integrated ER collet chuck adapter (without tool)





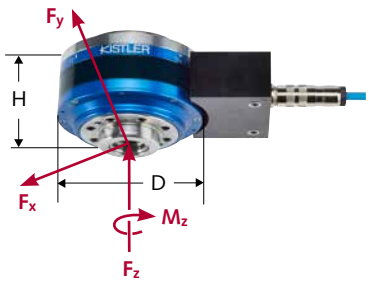


1 Wireless RCD, Type 9170B...
2 LabAmp, Type 5347A4...

Rotor

Technical data	Type	9170B...
Spindle adapters		HSK-A40, HSK-A50, HSK-A63, HSK E40, HSK-E50, HSK-E63 DIN ISO7388-1–AD30, DIN ISO7388-1–AD40, MAS 403 BT 30, MAS 403 BT 40,CAT 30, CAT 40, Capto C5, Capto C6, other spindle adapters available on request
Key characteristics	Spindle and tool adapters are permanently installed in the RCD 9170B. It is no longer possible to exchange the adapters after installation.	

Rotating 4-component dynamometer to measure cutting forces in heavy-duty machining, up to 12 000 rpm



Technical data	Type	9171A...
Measurement range (nominal)		
F_x, F_y	kN	–20 ... 20 [3]
F_z	kN	–30 ... 30 [3]
M_z	N·m	–1 000 ... 1 000 [3]
Speed, max.	1/min	12 000
Sensitivity (min./max.)		
F_x, F_y	mV/N	≈0.5/≈4.8
F_z	mV/N	≈0.3/≈4.8
M_z	mV/N·m	≈9/≈96
Natural frequency		
$f_n(x)$	kHz	≈1.1 [1]
$f_n(y)$	kHz	≈1.1 [1]
$f_n(z)$	kHz	≈7.6 [1]
Operating temperature range	°C	0 ... 60
DxH	mm	118x85
Weight	kg	3.3 [2]
Degree of protection: IEC/EN 60529		IP67
Signal transmission		contact-free
Data sheet: see www.kistler.com	**No.**	**9171A_003-155**

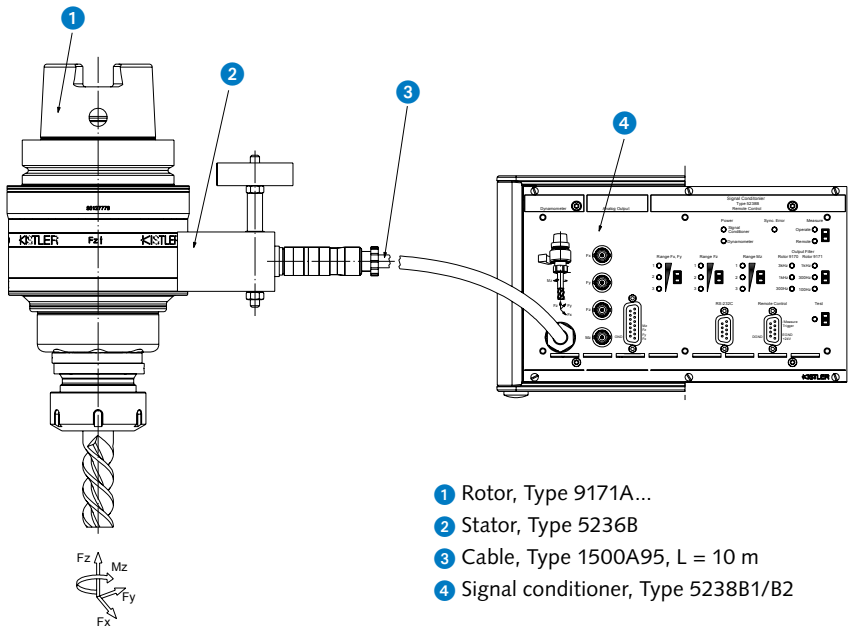
Key characteristics

Thanks to its wide measurement range and speeds of up to 12 000 rpm, this rotating 4-component dynamometer is especially suitable for heavy-duty cutting applications. The rotor's modular design makes it easy to exchange different spindle and tool adapters at any time. Internal cooling lubricant supply is possible. Measurement signal transmission and energy supply are contact-free, so wear is entirely eliminated.

[1] applies to rotor with spindle adapter HSK-A100, without tool adapter

[2] applies to rotor without spindle adapter and without tool adapter

[3] measurement range depends on spindle adapter type. See the data sheet



1 Rotor, Type 9171A...
2 Stator, Type 5236B
3 Cable, Type 1500A95, L = 10 m
4 Signal conditioner, Type 5238B1/B2

Rotor

Technical data	Type	9171A
Spindle adapters		HSK-A63, HSK-A80, HSK-A100 DIN 69871-AD40, DIN 69871-AD50 MAS 403 BT 40, MAS 403 BT 50 CAT 40, CAT 50 Capto C6, Capto C8
Tool adapters		▪ Collet chuck, type PowRgrip PG32-SG by Rego Fix ▪ Collet chuck, type ER32 (DIN 6499-B32) ▪ Collet chuck, type ER40 (DIN 6499-B40) ▪ Collet chuck, MEGA New Baby Chuck by BIG KAISER ▪ TENDO hydraulic expansion toolholder by Schunk
Data sheet: see www.kistler.com	**No.**	**9171A_003-155**

Key characteristics	Spindle adapters and tool adapters are built into the RCD 9171A on a modular basis, or they can be obtained singly. Adapters can be changed at any time. (Important: The rotor must be balanced after every changeover.)

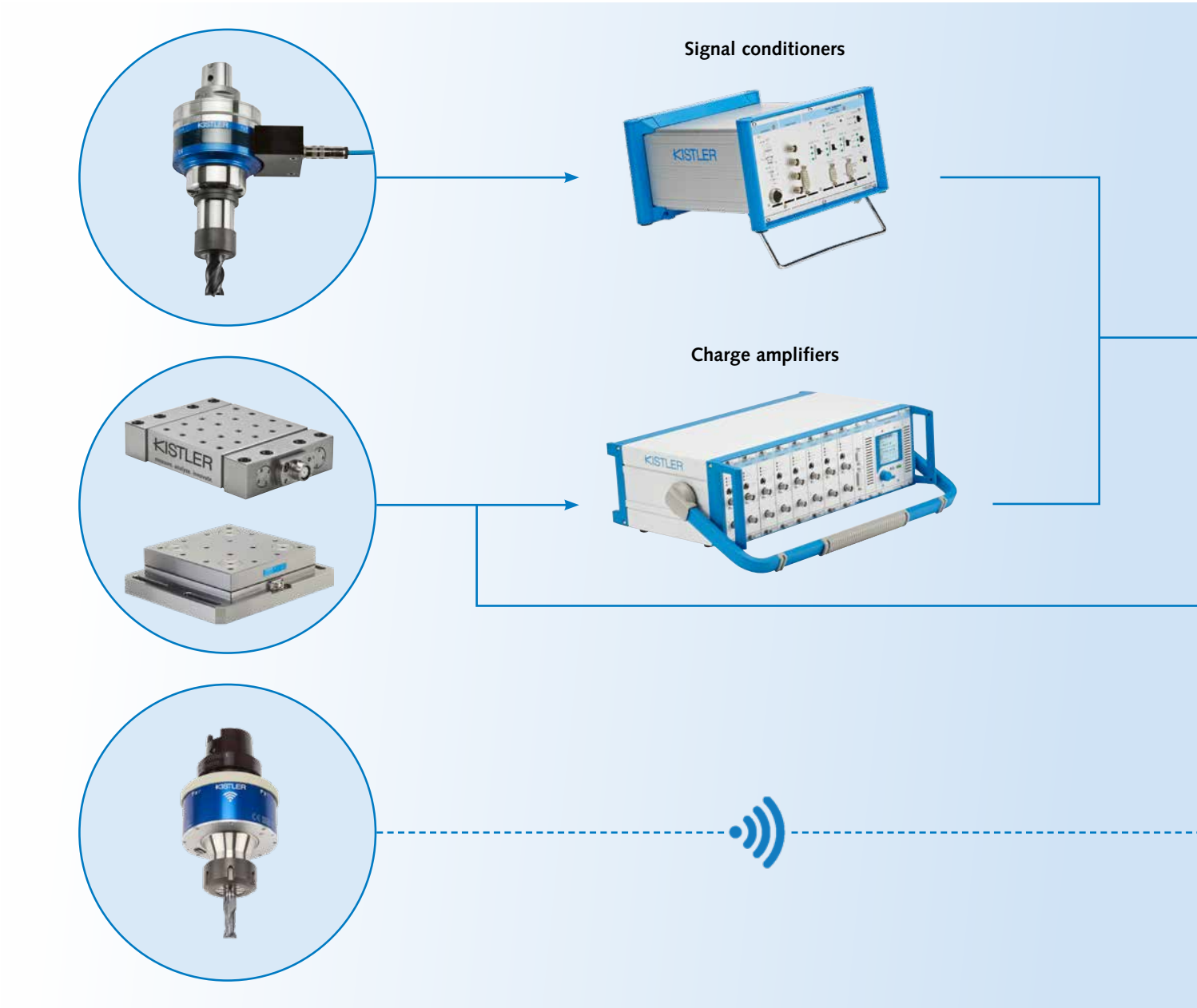
BIG KAISER
MEGA New Baby Chuck

Schunk
TENDO

Rego Fix
SecuRgrip

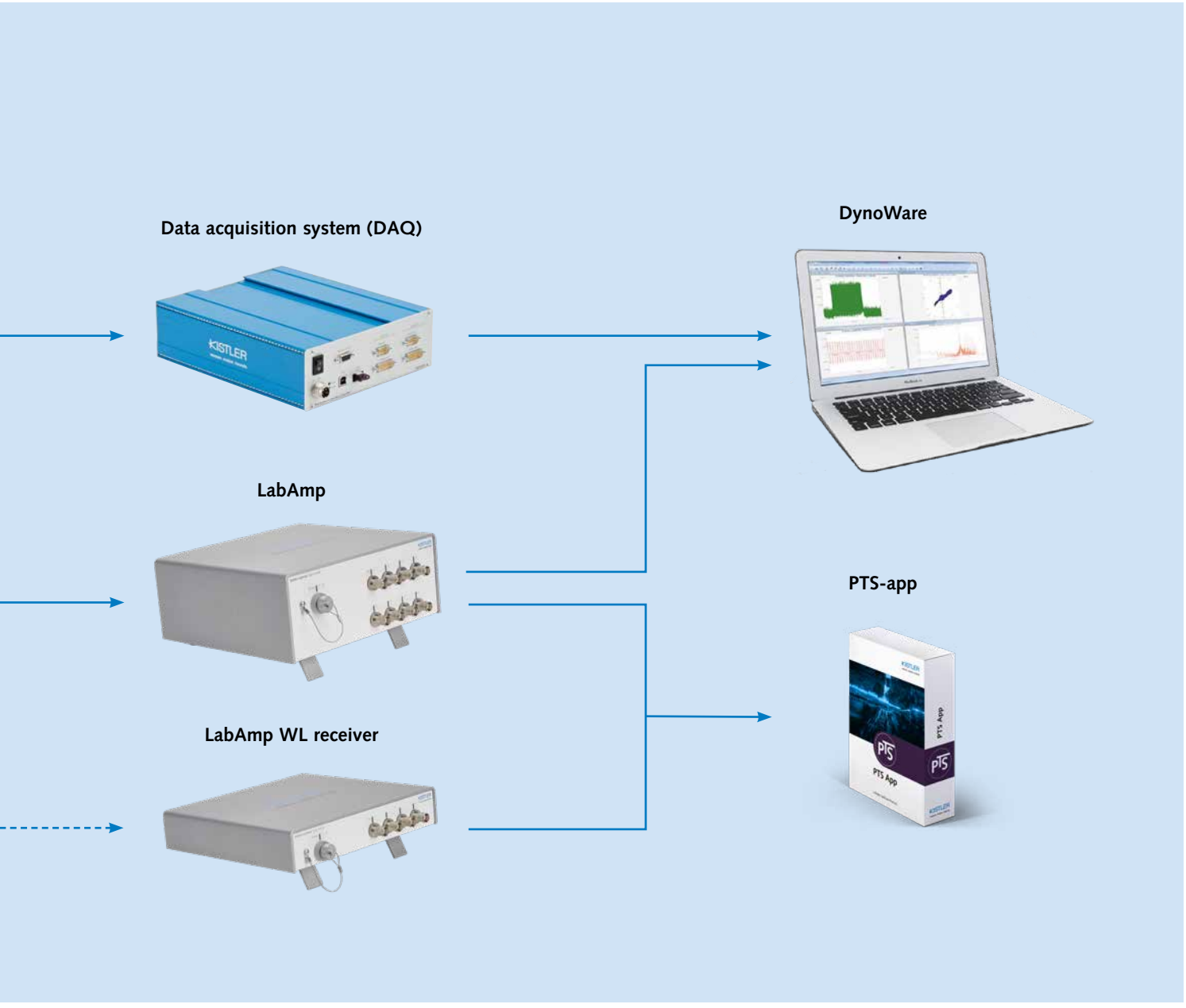
Amplification, acquisition and evaluation – all from one single source

Measurement **Amplification and acquisition**



The dynamometer is the centerpiece of every measurement setup. It captures the physical variable to be measured, and transmits it to the charge amplifier in the form of a charge signal. Two types of dynamometer are used: stationary dynamometers are usually mounted on the machine table, whereas rotating dynamometers are inserted into the spindle via the spindle interface, and they rotate with the spindle.

Kistler offers standalone data acquisition systems as well as systems with an integrated charge amplifier. For stationary dynamometers, the LabAmp 5167A charge amplifier can be used directly; it converts the charge signal into a voltage and performs an analog-to-digital conversion. Users can then view n and analyze the data in the PTS-App software. The integrated data acquisition principle is also already possible with the 9170B rotating dynamometer.



The charge amplification is integrated in the rotor and is transmitted wirelessly to the LabAmp 5347A4K where it can then be analyzed and visualized using the PTS app. For the types 9170A and 9171A with stator, a downstream signal conditioner is necessary to supply the rotor and to transmit the data. For rotating dynamometers and for high accuracy measurements with the 5080 charge amplifier, the 5697 data acquisition system is used. The system is only compatible with DynoWare to analyze and visualize the data.

The PTS-App is an all-purpose, easy-to-use software that is particularly suitable for force measurements with dynamometers and single-component or multi-component force sensors. For signal analysis, PTS-App users benefit from online visualization of measurement curves as well as helpful calculation and graphics functions.

The LabAmp family

The LabAmp family comprises Types 5167A and 5165A:
Together, they can amplify and record large numbers of signals from different sensor types. Charge amplifier 5165A is suitable for dynamic measurements of voltages, IEPE (Integrated Electronics Piezo-Electric) and charge signals. As opposed to LabAmp 5165A, the LabAmp 5167A system is designed for static force measurements.

Physical variables
- Force
- Acceleration
- Pressure
- Voltage

High-precision measurement and acquisition of forces in cutting processes
Together with the stationary dynamometers, the LabAmp 5167A charge amplifier forms a complete measuring chain to capture forces and moments in cutting processes. This charge amplifier's high-insulation inputs ensure measurements with minimal drift. Its low-noise design also makes it possible to measure small force signals. The 4- or 8-channel version can be used according to the dynamometer and application area.

To record additional force, acceleration, pressure or voltage signals, the LabAmp 5167A can be combined with further 5165A/5167A devices. This makes the LabAmp family an integral solution for cutting process analyses.

Data visualization in PTS-App
PTS-App (or other software provided by the user) handles further data processing and visualization. The application has a variety of features and functions designed specifically for analyzing force signals in cutting processes. Examples include temperature drift compensation and numerous filter options. LabAmp 5167A communicates with the PC via Ethernet and is configured via browser.

Software and configuration
- PTS app for data analysis
- Web User-Interface for configuration
- LabVIEW interface

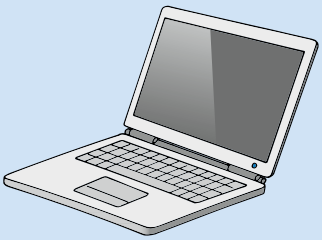
Multi Device Client
The Precision Time Protocol (PTP) feature enables networking with additional LabAmp devices (such as the 5165A/5167A) via Ethernet. The measurement signals of the different devices are given synchronized time stamps for this purpose.

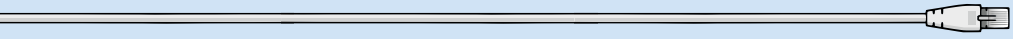
Remote control
The LabAmp 5167A has separate digital inputs for automated measurements so that measurements can be remote-controlled. Measurements can also be triggered by signal rises on individual channels.

Measuring chains

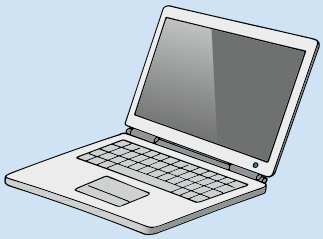
	Measurement	Connection	Amplification and acquisition	
3 or 8 components	9119AA1 9119AA2 9129AA 9139AA	1687B5 (3 components) 1689B5 (3 components)	LabAmp 5167A81 LabAmp 5167A41	Ethernet cable
4 components	9272	1677A5	LabAmp 5167A81 LabAmp 5167A41	Ethernet cable
3, 4 or 8 components, high-precision	9119AA1 9119AA2 9129AA 9139AA	1687B5 (3 components) 1689B5 (3 components)	5080A...	1700A111A2
Rotating dynamometers	9170A... 5236B	1500A95	5238B...	1700A111A2
Rotating dynamometers (wireless)	9170B			

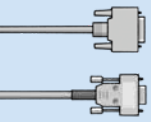
Notebook



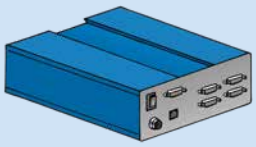


Notebook



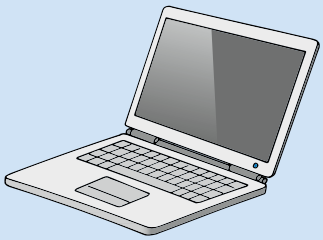


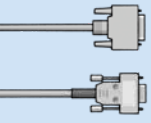
5697A...



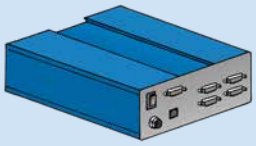
USB cable

Notebook



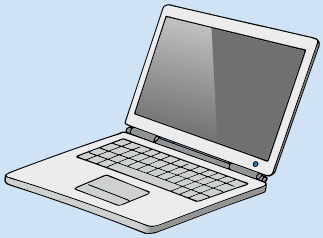


5697A...

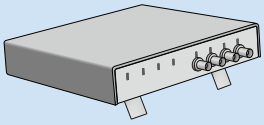


USB cable

Notebook

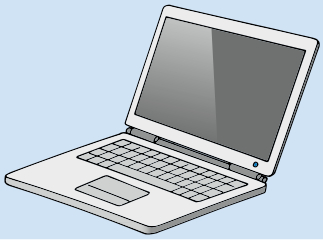


LabAmp 5347A4K



Ethernet cable

Notebook



Charge amplifiers

High-end multi-channel charge amplifier for multi-component force measurements

Technical data	Type	5080A...
Number of channels		1 ... 8
Measurement range FS	pC	±2 ... 2 200 000
Measurement range adjustment		continuously variable
Frequency range (–3 dB)	kHz	0 ... 200
Output signal	V	±10/–8 ... 10
Modules, optional		▪ charge amplifier ▪ Dual Mode (charge/Piezotron)
Power supply		
	VAC	100 ... 240
	VDC	11 ... 36
Input signal	Type/ connector	Piezoelectric, according to choice with: ▪ BNC neg. ▪ Fischer 9-pole neg.
Output signal	Type/ connector	▪ BNC neg. ▪ D-Sub 15-pole neg.
Degree of protection: IEC/EN 60529		IP40
Interface		▪ RS-232C ▪ USB 2.0
Case, optional		▪ 19" rack module (DIN 41494) ▪ Desktop unit with support bracket
Other features		Display of mechanical variable
Data sheet: see www.kistler.com	**No.**	**5080A_000-744**

Key characteristics	This charge amplifier has outstanding properties that make very precise measurements possible, particularly when small forces are involved. Thanks to its highly flexible structural design, it can be modified in line with requirements at any time. As well as pure charge amplifier modules, we also offer dual-mode modules that allow connection of sensors with a charge output as well as sensors with integrated electronics (Piezotron).

Accessories (optional)		
RS-232C cable	**Type**	**1200A27**
Connecting cable	**Type**	**1700A111A2**
Connecting cable	**Type**	**1700A113A2**
Inductive proximity switch	**Type**	**2233B**

Data acquisition system with integrated charge amplifier

Charge amplifier and data acquisition system for multi-component force measurement

Technical data	Type	5167A...
Number of channels		
Type 5167A41		4
Type 5167A81		8
Input connector		Fischer 9-pole neg.
Output connector		BNC neg.
Ethernet interface		2xRJ45
Remote control		D-Sub 9f
Measurement range	pC	±100 … 1 000 000
Frequency range (–3 dB)	Hz	≈0 … >45 000
Nominal output voltage	V	±10
Output impedance	Ω	10
ADC resolution	Bits	24
ADC sampling rate	kSps	625
Output rate per channel (configurable)	kSps	100
Filter type		Bessel or Butterworth
Order		2./4.
Data sheet: see www.kistler.com	**No.**	**5167Ax1_003-278**

Key characteristics	This data acquisition system includes integrated charge amplifiers and is suitable for multi-component force measurements. Control is via Ethernet. The system can also be configured with DynoWare to visualize the data. An ideal choice for measurements with stationary dynamometers in cutting processes.

Accessories
Ethernet cable

Dynamic multi-channel charge amplifier and data acquisition system

Technical data	Type	5165A...
Number of channels		4
Input connector		BNC neg.
Output connector		BNC neg.
Measurement range	pC	±100 … 1 000 000
Nominal output voltage	V	±10
ADC resolution	Bits	24
ADC sampling rate	kSps	625
Output rate per channel (configurable)	kSps	100
Filter type		Bessel or Butterworth
Order		2./4.

Key characteristics	Kistler's Type 5165A LabAmp charge amplifier is the universal laboratory amplifier for dynamic signals. Piezoelectric sensors, Piezotron sensors (IEPE) and voltage signals are all digitized and processed with high resolution. Simple data acquisition functions as well as freely configurable analog outputs highlight the extensive range of applications for this device.

Data acquisition system

LabAmp Wirless Receiver – for rotary Dynamometer 9170B

Technical data	Type	5347A4K
Number of measuring channels		4
Output connector		BNC neg.
Nominal output voltage	V	±10
Time shift analog output	ms	320 … 400
Max. Output current	mA	±2
Digital low-pass filter [1)] Cutoff-frequency (-3 dB) Selection in 1 Hz steps	Hz	≥10
Key characteristics	The Kistler LabAmp WL Receiver Type 5347A4K is a high performance data acquisition device that transmits the digitized measured values via Ethernet to a higher-level computer with the Piezo-Tool-System application for further evaluation.	

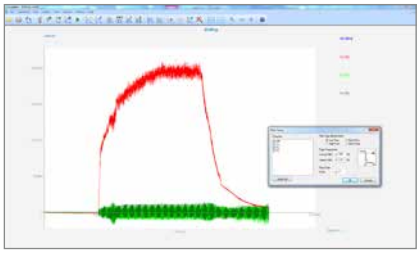
DAQ system for data acquisition from up to 28 measuring channels

Technical data	Type	5697A...
Number of measuring channels		28
Resolution	Bits	16
Sampling rate, max.		
with 1 channel	kS/s	1 000
with 8 channels	kS/s	125
with 16 channels	kS/s	62.5
Interface to PC		USB 2.0 type B, fem.
Dimensions	mm	208x70x249
Weight	kg	2.2
Data sheet: see www.kistler.com	**No.**	**5697A_000-745**
Key characteristics	This universal-use data acquisition system samples analog signals up to 1 MHz. When combined with our DynoWare software, it can be used to control all Kistler laboratory charge amplifiers and signal conditioners. The connection with the PC is via a USB interface. DynoWare software is available in the package together with the data acquisition system.	

Accessories (optional)		
RS-232C cable	**Type**	**1200A27**
Connecting cable	**Type**	**1700A111A2**
Connecting cable	**Type**	**1700A113A2**
Inductive proximity switch	**Type**	**2233B**

Software

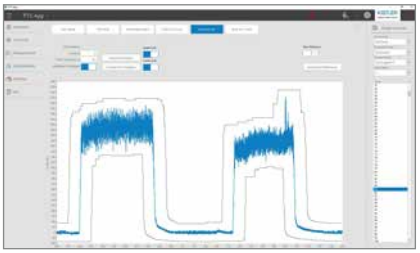
DynoWare: Windows data acquisition software



Technical data	Type	2825A...
Supported charge amplifiers	Types	5011, 5015A..., 5018A..., 5017, 5019, 5070A..., 5080A...
Supported signal conditioners for rotating dynamometers (RCD)	Types	5223B..., 5237A..., 5238B...
For further information		see the data sheet
Supported operating systems		Windows 10 Windows 11
Data sheet: see www.kistler.com	**No.**	**2825A_000-371**

Accessories		
Data acquisition system	**Type**	**5697A...**

PTS-Application: Windows data acquisition software

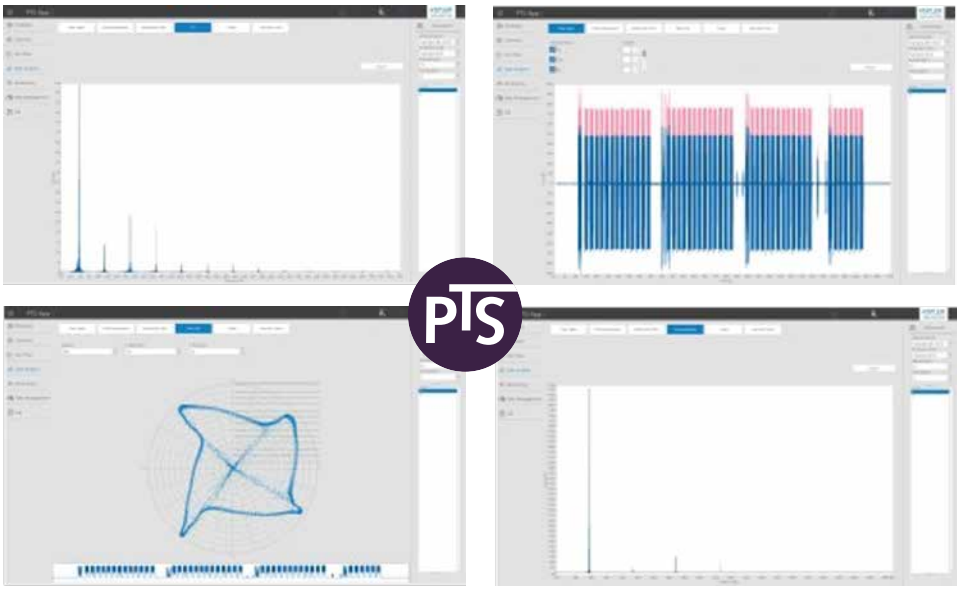


Technical data	Type	2935A
Supported charge amplifiers	Types	5347A4K, 5165A..., 5167A...
For further information		see the data sheet
Supported operating systems		Windows 10 Windows 11
Data sheet: see www.kistler.com	**No.**	**2935A_003-663e**

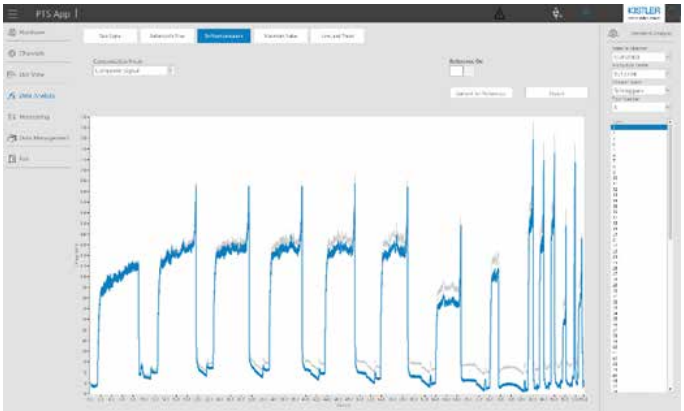
Software

PTS App
The Kistler PTS App offers a high-performance backend and an intuitive user interface for pre-processing measurement data sets as well as an interactive statistical visualization option for trends. Basic applications in the field of process monitoring can also be implemented effortlessly with the help of the app. The measurement data is also stored in a structured format so that it can be made available for further processing in third-party software.

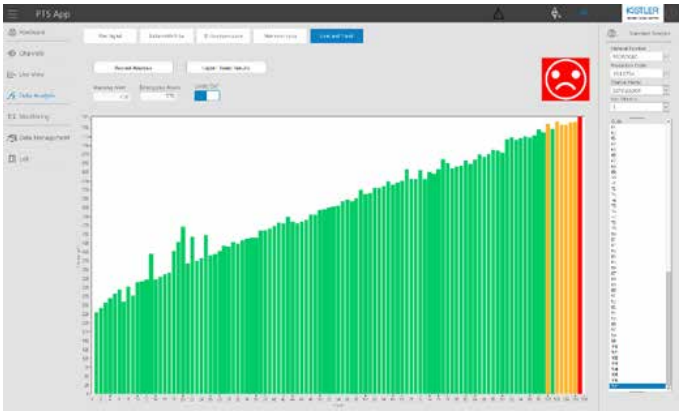
The following tools are available in the software for data processing:
- Digital Butterworth filter for smoothing the main signal.
- Drift compensation to clean up the signal from temperature influences, etc.
- Fast Fourier Transformation (FFT) for the decomposition of the signal into the spectral components (frequency components)
- Power spectrum analysis for evaluating the signal strength as a function of the respective frequency.
- Various selection parameters for defining analysis ranges in the measurement signal.
- Individually configurable calculation of virtual / calculated channels.



Data preprocessing options
For the pre-processing of the raw measurement signals, the PTS App offers a wide range of common tools, which make it possible to reduce interfering signals, eliminate drifts due to temperature influences or similar, or to break down frequency frequencies in a signal by means of FFT, if required.



Data trend analysis capabilities
Using the selected data pre-processing parameters, trends can be analyzed and visualized in the app in terms of maximum measured values, average values, integral or standard deviations. These trends can also be classified visually by defining warning and alarm thresholds.



Connecting cables, high-insulation

Cable, 8-core/3-core, temperature range –5 ... 70°C

Technical data	Type	1677A5	1687B5
Connector		Fischer 9-pole pos., flange Fischer 9-pole pos.	Fischer 9-pole pos., flange Fischer 9-pole pos.
Length	m	5	5
Diameter	mm	12.3 (metal sheath)	12.3 (metal sheath)
Number of conductors		8	3
Used for		6-component measurements	3-component measurements

Cable with angle connector, 8-core/3-core, temperature range: –5 ... 70°C

Technical data	Type	1679A5	1689B5
Connector		Fischer angle connector, 9-pole pos., flange Fischer 9-pole pos.	Fischer angle connector, 9-pole pos., flange Fischer 9-pole pos.
Length	m	5	5
Diameter	mm	12.3 (metal sheath)	12.3 (metal sheath)
Number of conductors		8	3
Used for		6-component measurements	3-component measurements

Cable, 8-core with flexible metal-mesh jacket, temperature range: –5 ... 70°C

Technical data	Type	1677AQ02	1687BQ02
Connector		Fischer 9-pole pos., flange Fischer 9-pole pos.	Fischer 9-pole pos., flange Fischer 9-pole pos.
Length	m	5	5
Diameter	mm	10.5 (metal mesh jacket)	10.5 (metal mesh jacket)
Number of conductors		8	3
Used for		6-component measurements	3-component measurements

Accessories

Cable for transmission of measurement signals

Technical data	Type	1700A111A2
Connector		D-Sub 15-pole neg. D-Sub 15-pole pos.
Length	m	2
Number of conductors		15

Cable for transmission of measurement signals

Technical data	Type	1700A113A2
Connector		D-Sub 15-pole neg. BNC pos.
Length	m	2
Number of conductors		8

Cable for transmission of communication signals

Technical data	Type	1200A27
Connector		D-Sub 9-pole pos. D-Sub 9-pole neg.
Length	m	5
Number of conductors		9

Waterproof protective cap for cable connection

Technical data	Type	1431A1
Connector		Fischer 9-pole pos.

Additional sensors for frequency analyses

Technical data	Type	9722A500	9722A2000
Range	N	0 ... 500	0 ... 2 000
Overload	N	2 500	10 000
Sensitivity, nom.	mV/N	10	2
Resonant frequency	kHz	27	27

Technical data	Type	8202A10	8203A50
Range	g	±2 000	±1 000
Threshold (noise 100µVrms)	g_{ms}	0.001	0.001
Sensitivity, nom.	pC/g	–10	–50
Resonant frequency, installed, nom.	kHz	45	24

Our full range of accelerometers is presented in catalog 900-380e.

Kistler service: customized solutions from A to Z

For over 50 years, Kistler has been setting standards in cutting force measurement. As your experienced partner, we're there to help you with our extensive technical expertise and our application-specific know-how.

Kistler's team of engineers is on hand to assist you with every step of the process — from planning, commissioning and on-site system training through to routine maintenance and repairs. Drawing on our lengthy experience and thanks to close cooperation with our customers, we can supply custom solutions that meet the specific requirements of your application.

To learn more about our solutions for cutting force measurement, visit:
www.kistler.com/cutting-force

Our services at a glance
- Custom engineering
- Advisory support
- Commissioning support
- Periodic calibration
- Training courses/workshops

Would you like to learn more about our applications? Explore now:

www.kistler.com/applications

Kistler Group
Eulachstrasse 22
8408 Winterthur
Switzerland

Tel. +41 52 224 11 11

The Kistler Group includes Kistler Holding AG and all its subsidiaries in Europe, Asia, the Americas and Australia.

Find your local contact at
www.kistler.com

KISTLER
measure. analyze. innovate.