KISTLER

measure. analyze. innovate.

Process Instrumentation and Automation

Measuring Systems for Process Monitoring and Quality Assurance in Manufacturing, Assembly and Test Stands

Kistler –
Your Partner for Efficiency and Quality

Sensors and systems for measuring forces and torques, analyzing force-displacement and force-time characteristics, and documenting quality data during assembly and product testing are just a few elements of the solutions for the sector provided by Kistler Instruments AG. From our headquarters in Switzerland, we supply assembly and testing technology as well as specific sensors and monitoring systems for combustion engines, automotive engineering, plastics processing and biomechanical engineering.
Kistler's core competency lies in the development, production and implementation of sensors for pressure, force and acceleration measurement. Kistler electronic systems and expertise used for conditioning measurement signals allow analysis, control and optimization of physical processes as well as enhancement of product quality for the manufacturing industry.

Year after year the company invests 10 % of its sales in R&D to facilitate technically innovative yet cost-effective state of the art solutions.
With a combined workforce of around 850, the Kistler Group is the world market leader in dynamic measurement technology. Twenty three group companies worldwide and more than 30 distributors ensure close contact with the customer, individual application engineering support and short lead times.

Contents

Process Monitoring for Enhanced Quality and Efficiency

Precision and quality are imperative in industrial manufacturing. Stiffer competition necessitates optimization of all manufacturing processes and reduction of production costs. At the same time, OEM suppliers have to move towards zero-defect production to meet more stringent quality requirements. Integrated process monitoring and quality assurance are therefore essential elements of modern automated manufacture.

Quality:
The ultimate challenge for industry
Many industrial segments such as automotive, aerospace or medical engineering consider quality assurance to be the ultimate challenge, the "decathlon of engineering". Precise tuning and flawless operation of a wide range of components from different manufacturers is of crucial importance particularly in cars, aircraft and medical equipment. Such complexity calls for comprehensive information on the quality of all products, assemblies and production processes. This information is the cornerstone of well-documented quality assurance as required for certification such as ISO/TS 16949.

The adherence to quality standards is of particular importance for processes such as the assembly of individual modules, as it determines the perceived value of the finished product and hence the cost-effectiveness of the entire production process. Identifying deviations immediately after individual production sequences allows prompt and specific corrective measures and hence more accurate components for greater overall efficiency. The sooner a fault is rectified the lower the product's life cycle costs.

Sensors and measuring systems: Key components for quality production

Consistent documentation of measurement and test data as a means of ensuring reliable processes and product quality is a prerequisite for efficient manufacturing of premium products. Suitable tests have to be efficiently scheduled and integrated into the manufacturing process.

Kistler measuring systems play a key role in achieving these objectives. Force and torque sensors in particular offer insight into electronically visualized and documented production, assembly and test processes. On a wider scale, turnkey electromagnetic NC systems combine joining with related force monitoring. All in all, the comprehensive range of measuring instrumentation enhances the precision, repeatability, quality and reliability of industrial operations.

Kistler technology is therefore a critical factor in improving the quality of products and cost-effectiveness of complex production processes.

Monitoring Assembly Processes

Assembly relies upon systematic application of press-fit, joining and threaded connection forces and torques measured and monitored in real time. Product operating or actuation forces are then determined in the course of testing. Both tasks can only be performed out on the basis of reliable force and torque measurement.

With zero-defect production the main objective of manufacturing, quality assurance and monitoring requirements is becoming increasingly exacting. For cost reasons quality assurance is often integrated directly into the workflow to allow prompt rectification of process or quality deviations. Post-production testing of press-fit connections, for example, is often scarcely possible without damage to the finished product - yet another reason why quality control has to be integrated into the production process. More often than not, assembly is a cyclical and therefore a dynamic process. Force measurement has been tried and tested as the most appropriate method of monitoring such operations.

Plus Points of Monitoring Force and Torque

+ Critical parameters in the assembly process
+ Easy, cost-efficient integration into the production process
+ Quick and easy segregation of good and bad parts
+ Easy documentation of process data
+ Simple testing of product characteristics

Force monitoring during assembly
For reliable processing and quality testing, the forces (for example joining, press-fitting or positioning) generated during assembly have to be documented and evaluated. Evaluation of the characteristic force-displacement curve is the ideal way of assessing press-fitting processes. This involves plotting dependent variables such as joining force and displacement to assess their functional relationship.

The results can be used for rejecting defective parts for post-production processing or sorting them into tolerance classes.

Force measurement is also used to protect workpieces from overload. The introduction of force limits, for example, can be useful for defining the maximum joining force. Press-fitting forces can be measured directly in the load path or indirectly as a function of strains in the frame of the machine.

Benefits of Force and Torque Measurement for Assembly Processes

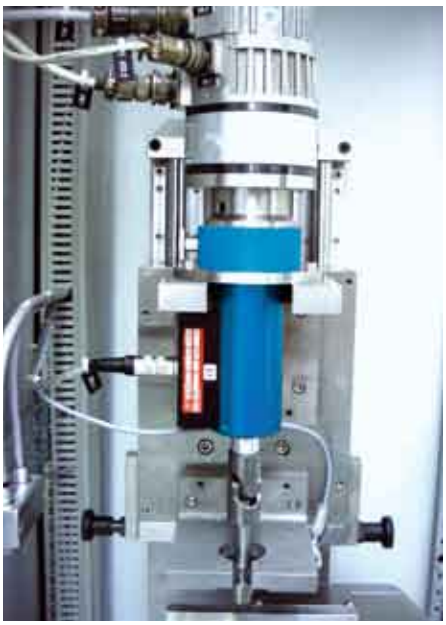
Joining systems with integral force monitoring
Electromechanical NC joining systems offer great flexibility, accurate positioning, extremely high repeatability and accurately defined joining forces. They are increasingly supplanting hydraulic presses and joining modules, particularly in press-fit applications. With its new generation of electromechanical NC joining modules Kistler offers a particularly compact and precise system solution for a wide variety of force-displacement monitored press-fitting and joining tasks.

Torque-controlled screw connection
Like press fitting, screw connection is one of the key methods used in assembly technology. Its most important use is application of defined preloads. Most modern mass-produced threaded connections are power assembled. As preloading forces are usually measured indirectly as a function of the tightening torque, torque-controlled screw connection is the most widespread approach in industrial manufacturing. Many threaded connections are tightened to controlled torque levels as the most cost-effective solution.

The resultant preload force is mainly dependent on the tightening torque. Kistler's piezoelectric torque sensors can extremely accurately monitor and record the torque curve of any screw connection made. By preventing overloads and prior damage to these connections, this ensures more reliable, higher-quality products.

Quality assurance during product testing
Force and torque measurement is not only suitable for testing and monitoring production processes, but can also be used during automated production for checking finished products and their functions, for example in electric, electronic, mechanical and mechatronic systems. For instance, contact forces of plug and receptacle connectors, operating forces of pushbutton and other switches, ignition and other rotary switches, cap screw torques and torque characteristics of gearboxes and motors can be used as quality criteria. Highly sensitive sensors from Kistler monitor within very tight tolerances a very wide range of these compression and tensile forces and torques, which with ongoing miniaturization are often minute.

The reliability of electrical connections involving non-screw terminals can be checked by measuring the insertion force or using a test connector. Rotational movements in applications such as potentiometers, spark plugs or cap screws, where a reliable and reproducible method of measuring small torques is required, can also be checked. Kistler reaction torque sensors are ideal for this purpose.



Sensor Type 9215 with an outside front diameter of only 5 mm at front for measuring minute forces. This type of sensor makes it possible to scale down miniature force plates and sensor arrays to a spacing of 7,5 mm for checking applications such as cell phone keypads at just one test station

Monitoring Assembly Processes

Force and torque measurement can make assembly and testing processes more transparent. Recording force or torque as a function of time, displacement or angle is an ideal method of monitoring, controlling and documenting such processes. Kistler ControlMonitors can be used to display, evaluate and document the resulting curves.

Assembly operations such as joining and screw driving and related testing are often made by automated production lines and special machinery. As the production sequence is often largely automated and the various machines unattended, the processes can only be monitored directly with some difficulty. Random checks of the finished parts are the most widely used quality control method, as 100 % monitoring of the workpieces in the course of post-production quality control during extremely short cycles is usually not considered cost-effective. As a result, production defects are detected too late and in the worst cases entire lots have to be scrapped.

Robust instrumentation in production
Integral process monitoring and quality assurance are essential elements of modern automated production. Identification of deviations immediately after individual process steps allows prompt, targeted corrective measures that improve accuracy and cut costs.

Process Monitoring with ControlMonitors

Consistent documentation of measurement and test data as a means of ensuring reliable processes and high-quality products is an essential requirement of cost-effective manufacturing. However, this demanding environment often takes its toll on integral instrumentation. The sensors must withstand dirt and mechanical stresses yet remain sufficiently versatile and durable. Reasonable costs and convenient operation are just some of the other basic requirements these systems are expected to meet.

Variety of evaluation tools for systematic analysis

In addition to protecting machinery and tools with real-time thresholds, force and torque measurement in process monitoring is often also intended to separate good (OK) and bad (NOK) parts. The evaluation objects (EOs) used as criteria are preferably specified on the basis of the measurement curves of these two categories. The EOs must be defined to reliably identify bad parts yet tolerate the standard deviation exhibited by their good counterparts.

Monitoring and documentation

Kistler offers a broad range of CoMo® ControlMonitors to meet these extensive and varied measurement and documentation requirements. A common feature of all single- and multichannel CoMos is their monitoring, evaluation and classification of sensor signals (force, torque or strain) as a function of time or a second signal (displacement or angle) in accordance with user-defined criteria. ControlMonitors are effective for a wide variety of product testing and quality assurance tasks in addition to process monitoring. For example, the CoMo Torque uses input torque and rotational speed to additionally determine the power levels of driven assemblies.

Monitoring Assembly Processes

User-defined functionality
Monitoring plays a major role in improving the quality and safety of industrial manufacturing processes. Kistler's CoMo family provides such functionality for each and every application.

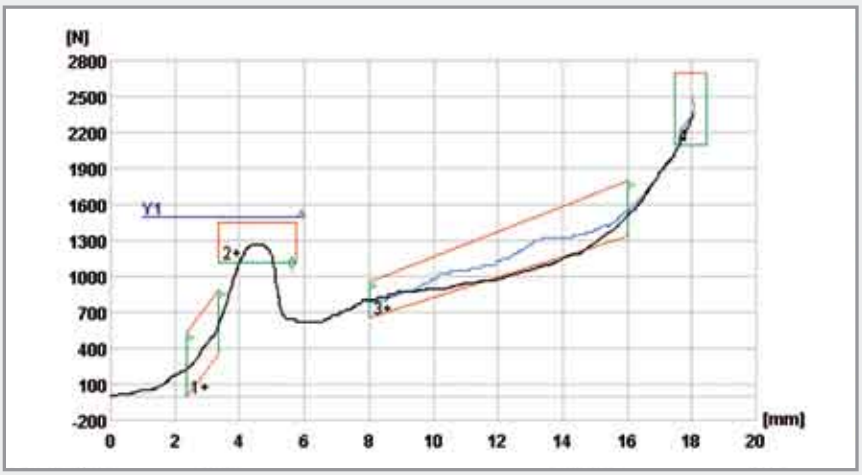
Process evaluation with up to twelve evaluation functions
For process monitoring, the system allows combination of up to twelve different evaluation functions such as boxes, thresholds, end positioning, dy/dt or dy/dx gradient, integral and hysteresis. It can display the point of intersection with each evaluation object as a trend or statistics such as the mean, standard deviation, cp or cpk value. The corresponding process values can also be displayed and saved in numerical form. A control signal for the result of the process evaluation (OK/NOK) is available at the interfaces (digital outputs, Profibus DP or Ethernet).

Limit value monitoring in real time
Real-time thresholds can be set for monitoring safety criteria such as overload protection, or for actuating trigger signals to control the process.

Evaluation function	Numerical process values
	Entry/exit point
	Point of intersection
	Maximum value y,x/y,t End position y,x/y,t
	Difference y_{max}-y_{min} Maximum value y,x/y,t Minimum value y,x/y,t
	Gradient dy/dx, dy/dt Hysteresis dy, dx
	dy, dx Hysteresis

Evaluation functions and process values

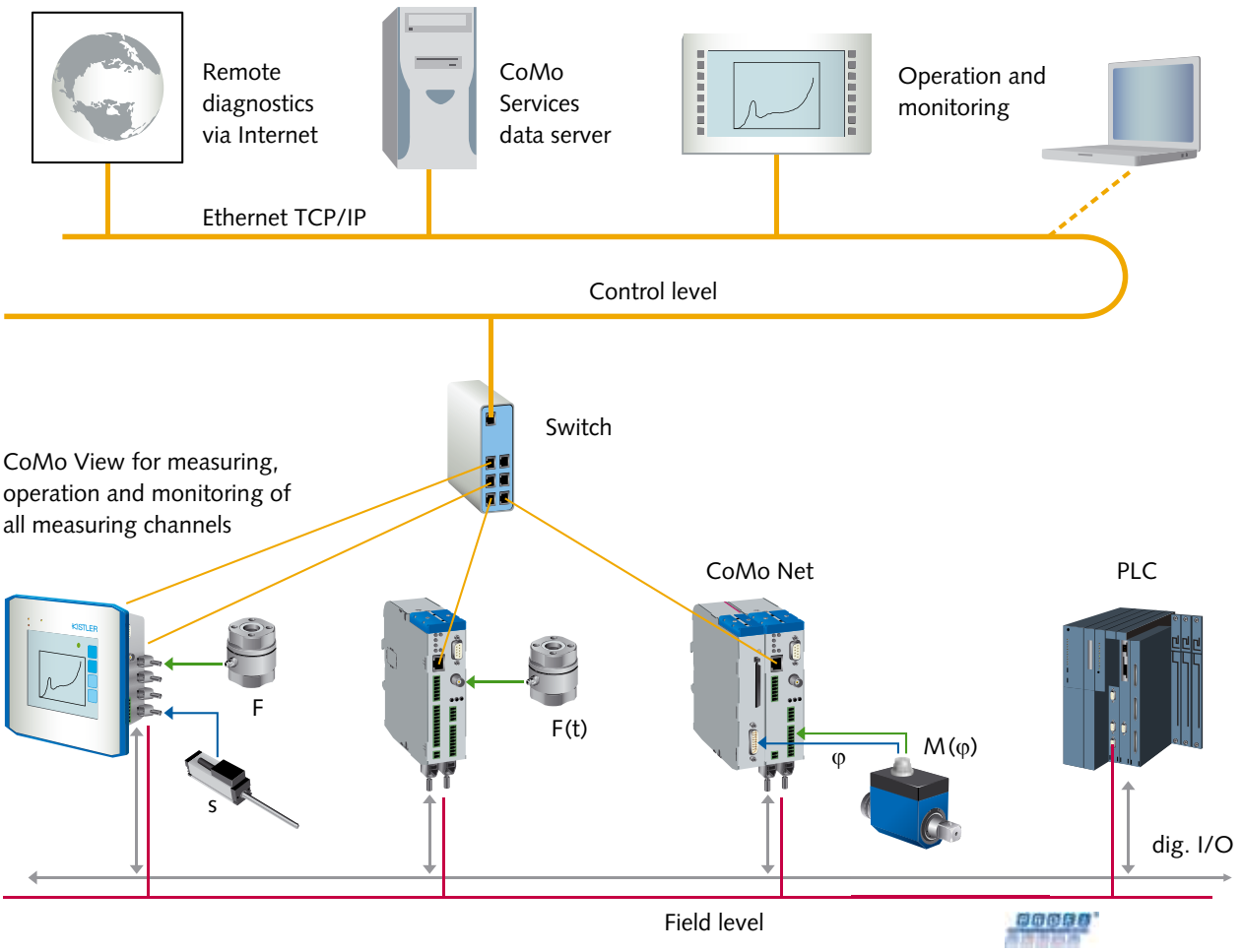
Easy calibration
Transfer function accuracy of all amplifiers (charge, displacement and strain gage) are calibrated prior to delivery. All calibration values are stored in the device, which can be recalibrated with an external charge or voltage source. Kistler recommends recalibration at two-year intervals. All devices are CE certified and comply with EMC standards. Inputs and outputs are protected against electrostatic charges (ESD) with varistors.



Typical force-displacement curve of Press-Fit process with evaluation box sequence

Evaluation with box functions
The box function is used to monitor the behavior of the signal trace as to how it enters or exits the box through the specified sides. The remaining sides must not be touched. The maximum, minimum or differential value is determined and monitored within a box. The figure shows the force curve for a bearing from force application though the actual press-fitting operation to the end position. The signal race must pass through all of the boxes. Other possible evaluation objects are end position, thresholds, hysteresis, gradient or integral.

Process Monitoring with ControlMonitors



Integration of ControlMonitors into production network

PLC compatibility and internet capability
The members of the CoMo family of ControlMonitors provide PLC compatible, digital I/Os for embedding into the machine's control system. Some devices can also be networked via TCP/IP and Ethernet. All parameters can be set by means of a standard web browser via Ethernet on a PC or with the Kistler browser (Applet Viewer), on a web terminal with the Windows CE® operating system or on an existing operating unit. Integral web servers control the HTML operator pages. Access rights for different menu levels for operators, supervisors or service personnel are password protected.

The system can therefore be accessed and operated from anywhere in the world. Remote maintenance and diagnostics allow prompt, expert, cost-effective on-site support and assistance whenever service is required. Optional field level communication via Profibus DP is also supported.

Data export to production data acquisition systems
The use of an existing network structure makes centralized storage of quality data in large, complex production facilities much easier and is a significant cost advantage. Process values and measurement curves can be transmitted periodically to the network data server. CoMo/data server compatibility servicing is included as standard.

Monitoring Assembly Processes

CoMo Logic®

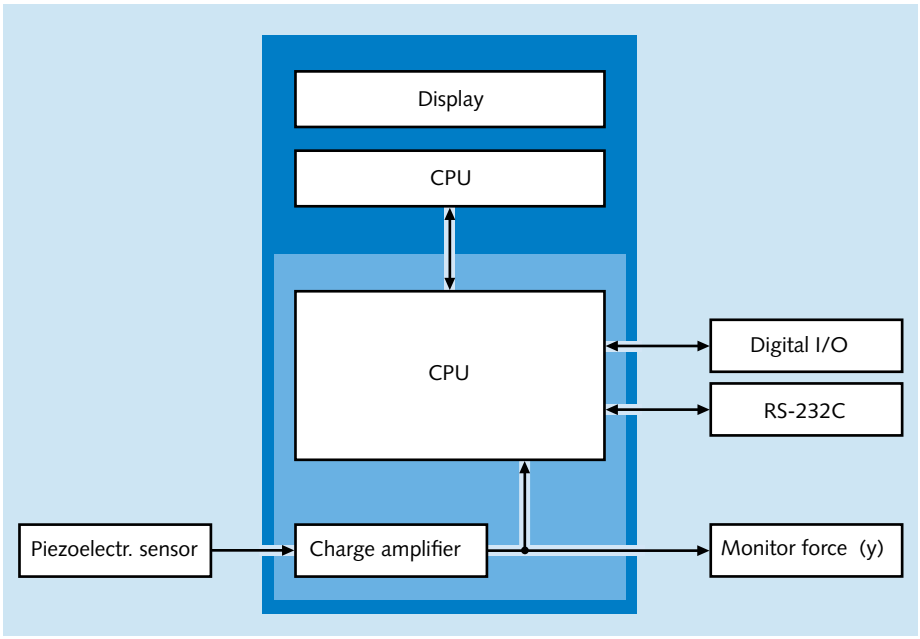
Single-Channel y(t) ControlMonitor

CoMo Logic is a single-channel y(t) ControlMonitor with graphics display and charge input for monitoring time-dependent measurands in manufacturing processes. It is designed for monitoring force/time characteristics of manual and automated assembly and test processes.

Three real-time thresholds programmable

CoMo Logic has three real-time thresholds and an elementary post-cycle curve analysis function. Different operating modes display the signal trace y(t) and most peak values as a trend or numerical display. For installation and adjustment both the actual and the peak value can be displayed continuously and the sensitivity adjusted during measurement. The device is operated with the front panel controls or with a PLC via the digital I/Os.

CoMo Logic consists of a measuring and a display unit, each controlled by a microprocessor. The measuring unit (monitor) scales the sensor signal and monitors the signal characteristics at a sampling rate of 10 kHz. Whenever defined real-time events occur in the cycle, such as thresholds being exceeded, the associated digital outputs are set immediately. After the cycle has been completed the curve is analyzed and the digital outputs assigned to the corresponding post-cycle events set. The measured values are then transferred to the display unit, which displays them in graphical or numerical form depending on the selected mode. A memory with 480 measurements is available for displaying the y(t) signal trace.



Block diagram of CoMo Logic®

CoMo Logic® at a Glance

CoMo Logic®

- Time-dependent measurement y(t)
- Measurement and monitoring of
  · F(t) – force as a function of time
  · M(t) – torque as a function of time
- Measuring ranges
  · FS ±50 … 500 000 pC
- Three real-time thresholds
- Graphical display of y(t) signal trace
- Graphical display of trend of the last 118 cycle peaks
- Monitoring of up to 1 000 cycles per minute

For more information on CoMo Logic, please refer to page 121.

Optimal Process Monitoring with ControlMonitors

CoMo Net®/CoMo View®

y(x) ControlMonitor with Integral Web Server

As single-channel control servers with web server functionality, CoMo Net and CoMo View are ideal for monitoring and classifying industrial processes.

CoMo View is a multi-purpose ControlMonitor with inputs for piezoelectric and strain gage sensors, sensors with voltage output and potentiometric displacement and angle sensors. Six PLC-compatible digital I/Os allow integration into a machine control system. The devices can be networked via TCP/IP and Ethernet. All parameters (programming and visualization) can be set with a standard web browser via Ethernet on a PC or with the Kistler browser (Applet Viewer), on a web terminal with Windows CE operating system or on an existing operating unit. Intuitive operator guidance allows fast, reliable setting up of the measuring process. Real-time capability via digital I/Os and fast process and curve data export are essential monitoring features even during high throughput rates. A Profibus DP interface is available as an option (transmission rate up to 12 Mbaud).

CoMo View as Terminal for CoMo Net
CoMo View's touch screen display allows direct adjustment of almost all settings. Working in a network with multichannel applications, CoMo View supports the operation and visualization of up to 24 additional CoMo Net devices. The terminal can be used in the most appropriate location without having to lay unnecessarily long signal and control connections (Ethernet and power connection only).

For more information on CoMo Net and CoMo View, refer to page 122/123.

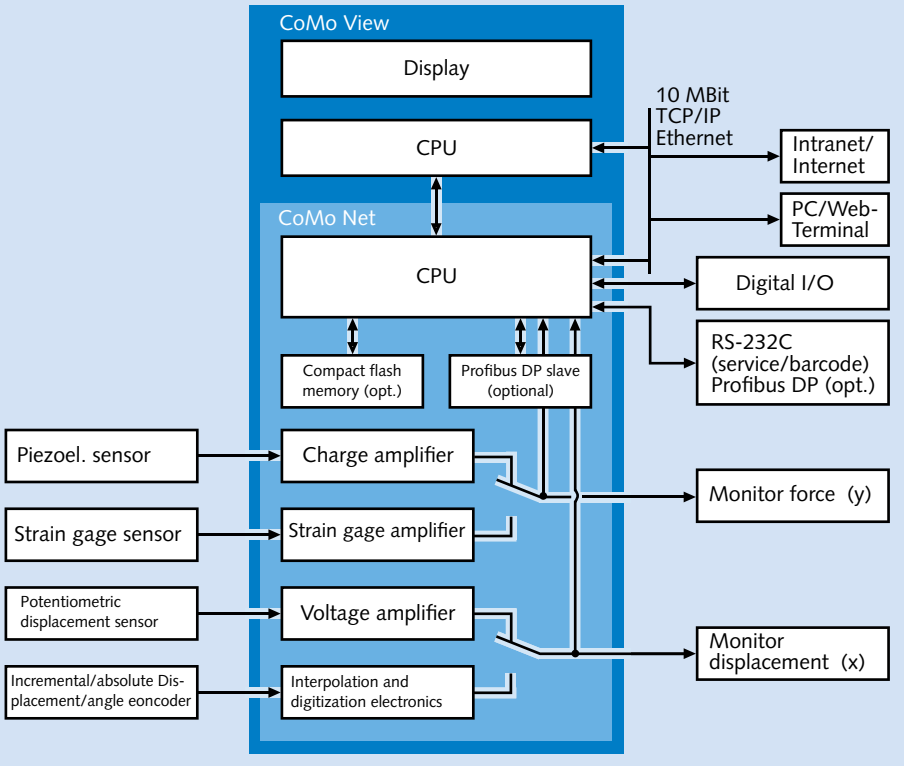
CoMo Net® and CoMo View® at a Glance

- Displacement-dependent y(x) or time-dependent y(t) measurement
- Measurement and monitoring of parameters such as:
  · F(t) – force as a function of time
  · F(s) – force as a function of displacement
  · M(t) – torque as a function of time
  · M() – torque as a function of rotational angle
  · s(t) – displacement as a function of time
- 12 different evaluation functions can be combined for monitoring, installation force, curve, gradient, hysteresis, blocking force and end position
- Real-time thresholds for overload protection or speed control
- Monitor up to 20 cycles per second
- 16 sets of parameters
- High-speed data transmission for logging process
- Off-line data transformation into XML, HTML, Text, CSV with curve superimposition and Q-DAS formats
- Incremental/absolute displacement/angle encoder
- Profibus DP interface (optional)
- Compact flash memory extension module (optional)

CoMo Net®

CoMo View® with integral 5,7" color touch screen display (320 x 240 pixels)

Terminal with 5,7" color touch screen display (320 x 240 pixels)



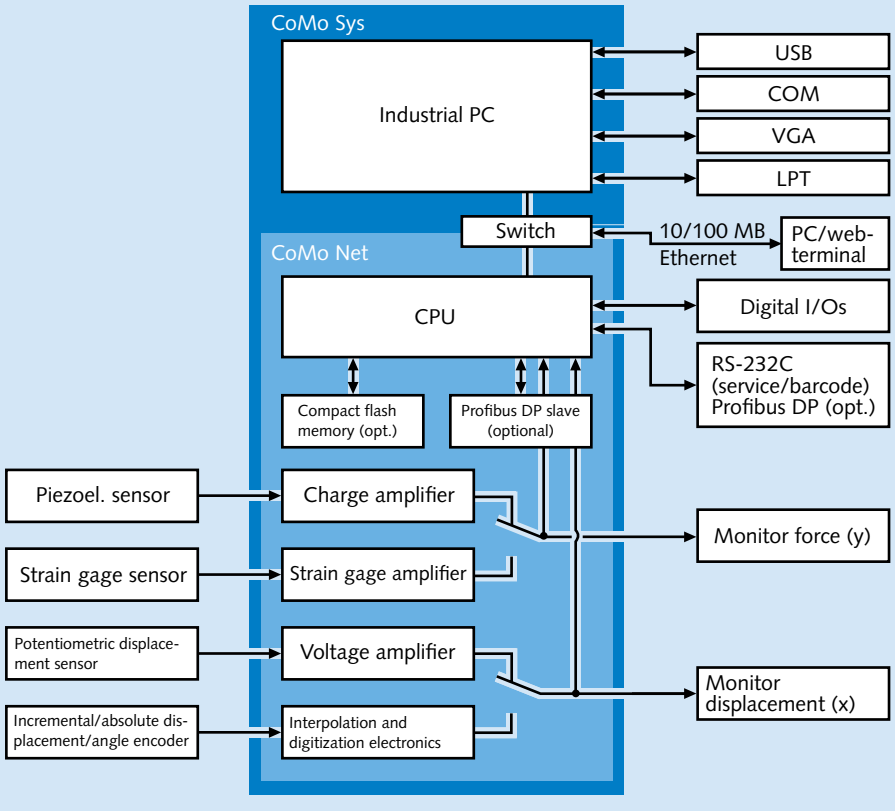
Block diagram of CoMo Net®/CoMo View®

Monitoring Assembly Processes

CoMo Sys® at a Glance

- Displacement-dependent y(x) or time-dependent y(t) measurement
- Expandable to maximum of 7 measuring channels
- Measurement and monitoring of
  · F(t) – force as a function of time
  · F(s) – force as a function of displacement
  · M(t) – torque as a function of time
  · M(φ) – torque as a function of rotational angle
  · s(t) – displacement as a function of time
- 12 different evaluation functions can be freely combined for monitoring installation force, curve, gradient, hysteresis, blocking force and end position
- Real-time thresholds for overload protection or speed control
- Monitors up to 20 cycles per second
- Memory for the last 20 measuring curves for error analysis
- 16 sets of parameters for each channel
- Windows-based PC software with user management and macroprogramming
- Data storage on internal hard disk in CSV format or Q-DAS transfer format
- Comprehensive process logging (measurement curve memory, statistical memory, export filter for Microsoft Excel and operational data acquisition systems)

CoMo Sys®



Block diagram of CoMo Sys®

CoMo Sys®

Multichannel y(x) Measuring System*

CoMo Sys is a modular system with up to seven measuring channels for force, torque or pressure as a function of displacement or time.

CoMo View has inputs for piezoelectric and strain gage sensors, sensors with voltage output and for potentiometric displacement and angle sensors. These can be flexibly tailored to the requirements of various stations to be monitored in production systems. Sixteen parameter sets or applications can be stored in memory for each channel.

The integral PC allows convenient logging of the processes. Real-time processing and subsequent evaluation are performed on the same measuring channel, with visualization on an internal 6,5" TFT color display (640x480 pixels) or an external monitor. With Windows-based PC software CoMo Sys can be used to set up, configure and manage projects.

For more information on CoMo Sys, please refer to page 125.

*Only available in Germany

CoMo Torque

Evaluation Instrument for Torque Sensors

The CoMo Torque allows synchronous acquisition of torque and speed signals of rotating strain gage torque sensors Types 4501A... to ... 4504A... .

CoMo Torque is ideal for industrial and R&D applications. Strain gage sensors with standardized sensitivity or voltage/ frequency output can be connected directly.

The ease with which parameters can be set enables the CoMo Torque to be used for evaluating torque/speed or torque / rotation angle measurements in manufacturing. Its intuitive menu system allows rapid reconfiguration for new measurement and test tasks. All functions, such as taring, saving of peak values, averaging, specifying limits, display range, units and interface parameters, are easily set.

The unit has a very wide variety of industrial applications:

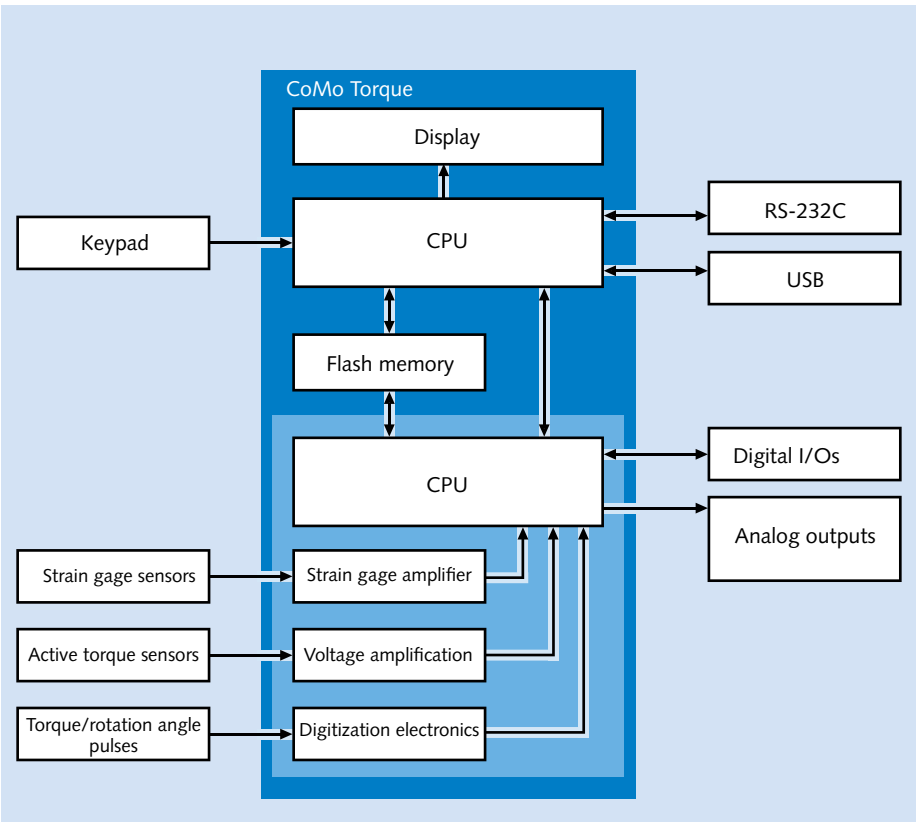
- Determination of the performance of driven assemblies from input torque and speed
- Design of transmission components or systems (such as clutches, brakes, gearboxes, engines and turbines)
- Monitoring of screw driving or verification of breakover point of torque wrenches
- Monitoring of assembly through evaluation of torque and rotation angles
- Checking of seat adjustments and hinges.

CoMo Torque at a Glance

- Displacement- or time-dependent M(t) and n(t) or φ(t) measurement
- Correct display for measurand (torque, speed, rotation angle, force and mechanical power)
- Units: N·mm, N·cm, N·m, kN·m, N, kN, rpm, W, kW, MW, degrees and Imperial/American units
- 4x20 character display
- Multilingual operator guidance
- High measuring accuracy of <0,05 %
- High sampling rate of 10 kHz
- Low-pass filter (off, 1 Hz … 5 kHz)
- Measurement memory with up to 5 000 measured values per channel
- Min.-/Max. determination and limit monitoring
- Software and hardware trigger functions
- USB or RS-232C serial data transfer
- Integration with SensorTool (PC software)
- Normalized analog outputs

CoMo Torque

For more information on CoMo Torque, please refer to page 126.



Block diagram of CoMo Torque

Monitoring Assembly Processes

Integration of process monitoring into automated manufacture is a desirable goal. Force-displacement monitoring is a tried and tested approach recommended for joining and press fitting. The various benefits of electromechanical NC joining systems with integral force monitoring mean they are increasingly supplanting presses and hydraulic systems. For up to 300 kN Kistler offers a comprehensive selection of such joining systems - ranging from a compact individual module up to a complete manufacturing solution in the form of a manual workstation with integral joining station.

In addition to less environmental impact, a more favorable energy balance, compact design, ease of installation and very low-maintenance operation, it is primarily production advantages that make an electromechanical system the obvious choice for the system designer. These include flexibility, exact positioning, extremely high repeatability and accurately defined joining forces.

Even for a long idle stroke, the high speed offers a quick return stroke and hence short machine cycle. Standard availability of both tensile and compression forces leaves considerable machine design freedom. The toolholder is designed as an individually usable flange. With its electromechanical NC joining modules Kistler offers a particularly compact and precise system solution for a wide variety of force-displacement monitored press-fit and joining tasks.

Integral piezoelectric force monitoring
The electromechanical NC joining systems NCFH Type 2151B… with integral piezoelectric force sensors are particularly compact. They rely on a special AC hollow-shaft motor mounted directly around the actual spindle drive. The spindle drive connected to the ram of the press translates straight along the axis of rotation of the motor and is actuated directly by the spindle nut. This eliminates gearing and belts and the positioning and control discrepancies caused by their slippage. Their unrivalled shortness and compactness makes the NCFH modules suitable even for under-bench mounting. From an overall length of just 475 or 795 mm, they offer a stroke of 200 or 400 mm, which enables deep end points, such as bearings in half-shell gearboxes, to be reached.

At a Glance

Electromechanical NC joining systems are synonymous with:
- Compactness
- Ease of installation
- Very low-maintenance operation

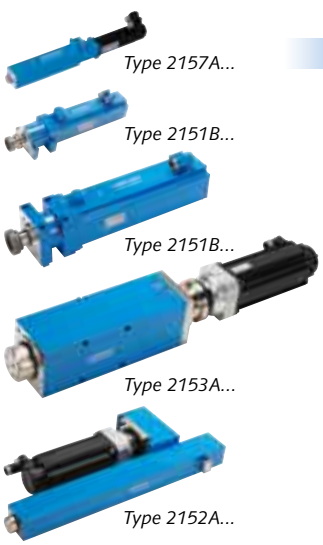
They offer
- Great versatility
- Exact positioning
- Extremely high levels of repeatability
- Accurately defined press-fitting forces

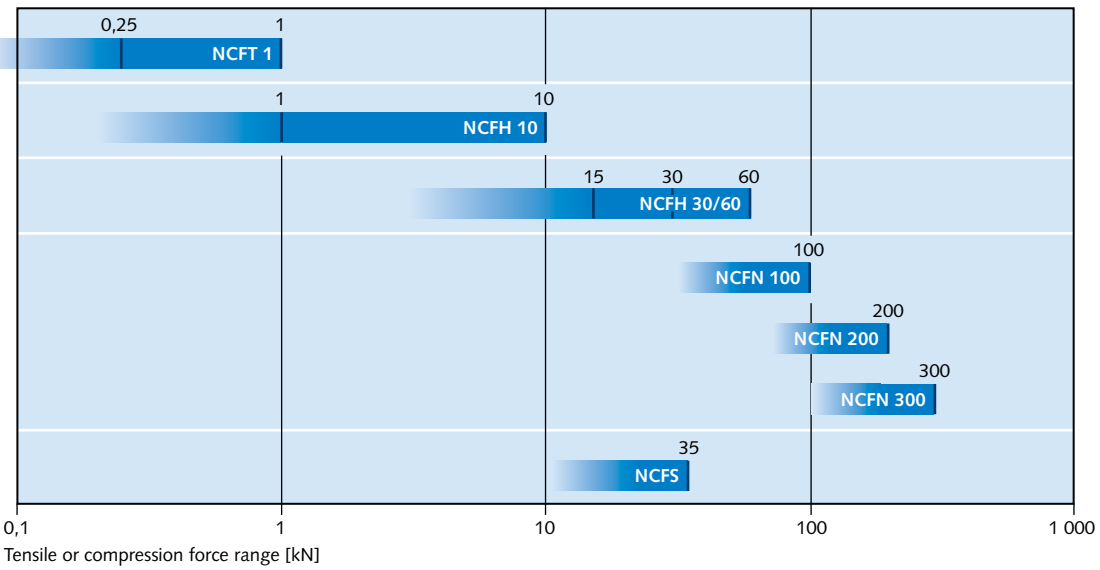
and bring the user
- Substantial energy savings
- Higher process reliability
- Improved product quality
- More cost-effective production

Plus Points of Electromechanical NC Joining Systems

+ High speeds up to 300 mm/s
+ Force control system
+ Dynamic operation
+ Integral force-displacement monitoring

Electromechanical NC joining systems from Kistler cover full range of forces from 300 kN





NC Joining Systems with Integral Force Monitoring

Overload-resistant piezoelectric force measurement in just two sizes of modules to cover the wide measuring range between 1 ... 60 kN – small for up to 10 kN and large for up to 60 kN. The force signal employed by the force-displacement monitoring system is used to control movement involved in highly specialized joining operations. The force control system increases the application versatility of the electromechanical NC joining system. Spring elements, for example, can be loaded to specific values or their displacement continuously monitored.

Two central lubrication points for guide and bearing ensure very low-maintenance operation. The threaded spindle drive is permanently lubricated. As the active deflection compensation system eliminates the effect of bending of the spindle and customer's assembly, the positioning accuracy is no longer influenced by the force.

Mounting station in German automotive factory with electromechanical NC joining module NCFH

Benefits of Piezoelectric Force Measurement

- Single electromechanical NC joining module covers large number of measuring ranges
- Presetting of "correct" measuring range unnecessary
- Low sensitivity to disturbance variables
- Wide variety of parts on a station makes mixed production feasible on single machine
- Overload factor of up to 15
- Cuts spare parts inventory and design costs
- Rigidity ensures highly dynamic response

Plus Points of Electromechanical NCFH Joining Systems

+ Gearing eliminated by hollow-shaft motor design
+ Hollow-shaft motor mounted directly around threaded spindle drive
+ Long spindle stroke yet compact size
+ Active deflection compensation system
+ Force control system
+ Standard holding brake
+ Highly dynamic operation
+ Ideal for under-bench mounting

For more information on electromechanical NC joining systems, please refer to page 132.

Universal Manual Workstations with NC Joining Systems

Electromechanical NC joining systems are also available in complete workstations. These universal manual workstations from Kistler can be operated on a standalone basis, or with force-displacement or force-time monitoring in a multistage assembly process using handling, feed and discharge systems.

Ten models up to 300 kN

The manual workstations are compact and designed for use in development, prototyping or small-scale production. Dimensions and processes can be customized. A total of 10 standard models span a very wide measuring range from 0,25 kN to 300 kN. This comprehensively covers the requirements of sectors from watchmaking to stamping truck bodies. Alternatives carefully tailored to customers' needs are also available.

Kistler Measurement Technology

Kistler supplies piezoelectric, piezoresistive, capacitive and strain gage sensors. Piezoelectric designs are particularly suitable for measurement imposing extreme requirements in terms of geometry, temperature range and dynamics. Kistler therefore relies mainly on the piezoelectric principle for measuring dynamic forces in assembly and testing.

Piezoelectric (derived from the Greek piezein, which means to squeeze or press) materials generate an electric charge when subjected to mechanical load. Pierre and Jacques Curie discovered the piezoelectric effect in 1880. As electric charges do not readily lend themselves to experimental research, piezoelectricity only gained practical significance in the middle of the 20th century. With the help of so-called electrometer amplifiers, the charge produced by piezoelectric material could then be converted into a proportional electric voltage for the very first time.

In 1950, Walter P. Kistler received a patent for the very first charge amplifier for piezoelectric signals, paving the way for exploitation of an effect that had been known for decades. The development of highly insulating materials such as Teflon® and Kapton® significantly improved the performance of these measuring systems and propelled the use of piezoelectric sensors into virtually all areas of modern technology and industry.

Most Kistler sensors rely on a quartz force link, which basically consists of thin quartz plates, disks/washers or rods. The sensor is connected to an electronic device for converting the charge signal into a voltage signal proportional to the mechanical force. The conversion is made either by means of a separate charge amplifier or an impedance converter with coupler, which is usually integrated into the sensor.

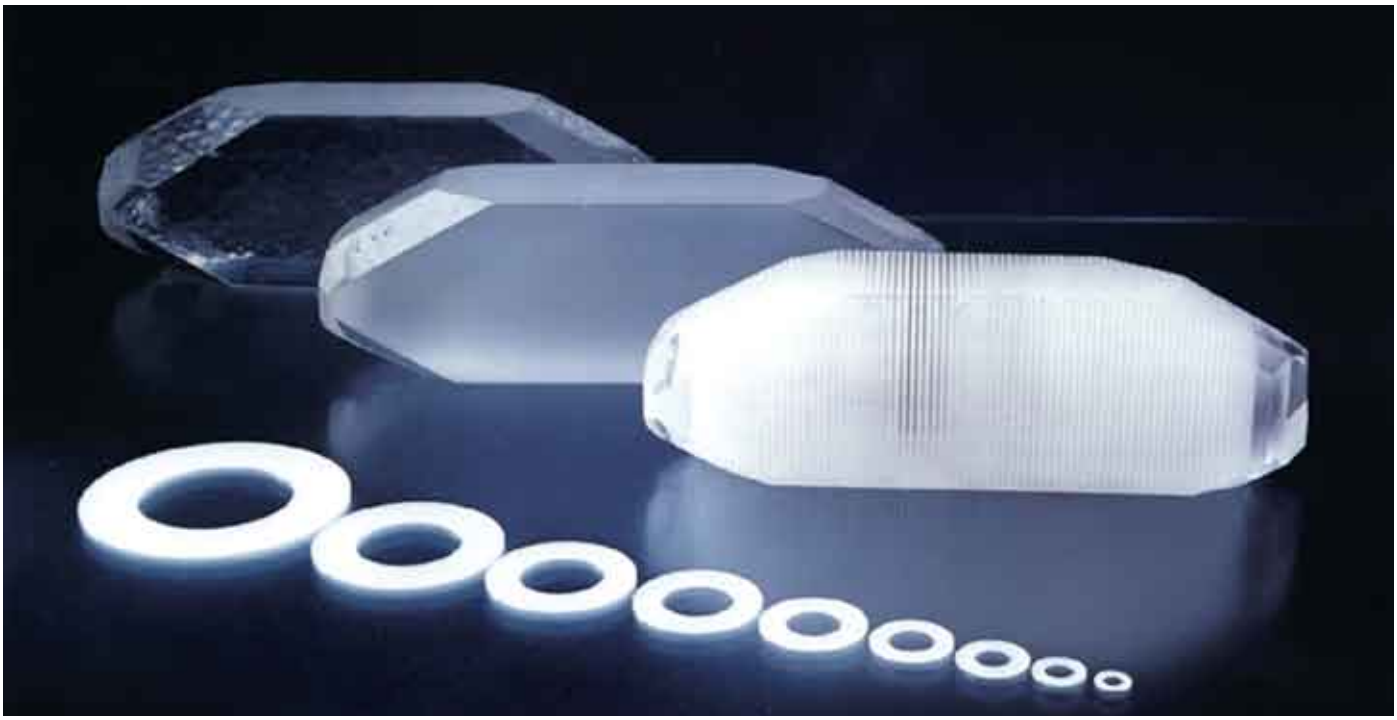
The finite insulation resistance does not permit truly static measurement with piezoelectric sensors. Nonetheless, used in combination with suitable signal conditioners, piezoelectric sensors offer excellent quasistatic measuring properties.

The Piezoelectric Effect in Detail

The term "piezoelectricity" refers to a linear electromechanical interaction between the mechanical and electrical state of anisotropic crystals that is those without a center of symmetry with lattice structure. These crystals have one or more polar axes along which the piezoelectric effect occurs as a result of an external force deforming the crystal lattice and pushing its positive and negative elements against one another. This produces an electric dipole moment.

Depending on the orientation of the axes with respect to the applied force, three different effects can be discerned:

- Longitudinal
- Shear
- Transverse



Basics of Piezoelectric Measurement Technology

Longitudinal effect
A charge is developed on the surfaces to which the force is applied, where it can be measured. In the case of the longitudinal piezoelectric effect, the magnitude of the electric charge Q depends only on the applied force Fx and not on the dimensions of the crystal disks. The only way to increase this charge is to connect several disks mechanically in series and electrically in parallel. The magnitude of the output charge then becomes:

$$Q_x = d_{11} \cdot F_x \cdot n$$

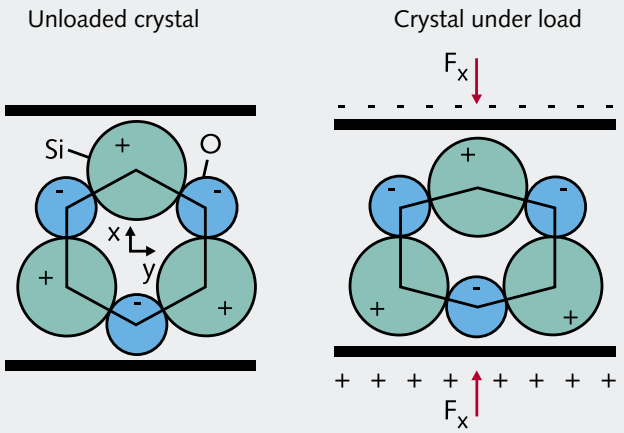
The piezoelectric coefficient d_{11} is dependent on direction and indicates the crystal's degree of force sensitivity in the direction of the corresponding axis. The position of the crystal cut therefore determines the properties and the area of application of the quartz force link. Piezoelectric elements cut to produce the longitudinal effect are sensitive to compression forces and therefore suitable for simple and sturdy sensors for measuring forces.

Shear effect
Similarly to the longitudinal effect, the piezoelectric sensitivity involved in the shear effect is independent of the size and shape of the piezoelectric element. The charge is also developed on the piezo element's loaded surfaces. In the case of a load in the x-direction applied to n elements connected mechanically in series and electrically in parallel, the charge is:

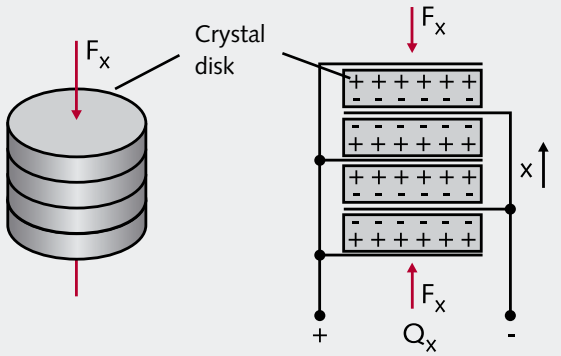
$$Q_x = 2 \cdot d_{11} \cdot F_x \cdot n$$

Shear-sensitive piezo elements are used for sensors measuring shear forces, torque and strain. They are suitable for manufacturing sensors whose excellent performance is unaffected by temperature changes, as the changes in the stresses in the sensor structure caused by changes in the temperature act in a direction perpendicular to the sensitive shear axis.

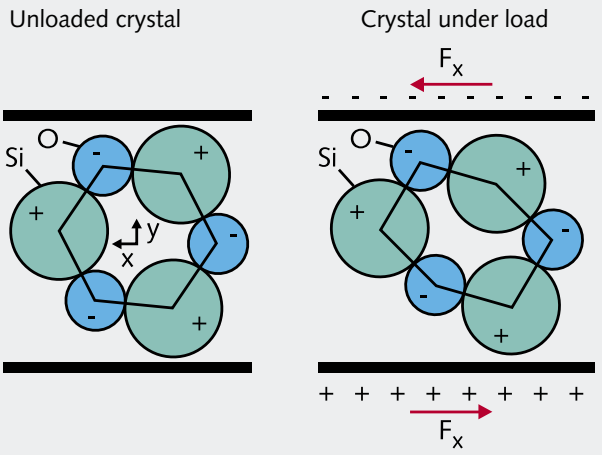
Principle of the longitudinal piezoelectric effect



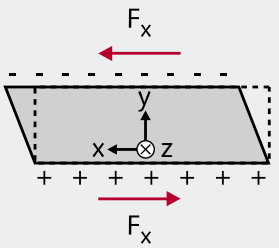
Potential for increasing the charge output



Principle of the shear effect



Direction of applied force



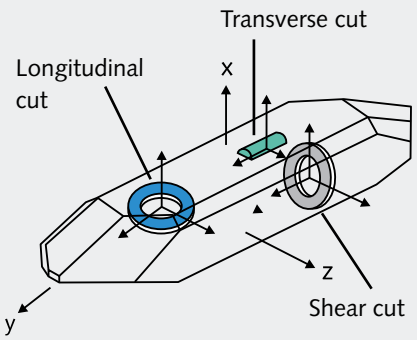
d_{11}: piezoelectric coefficient (−2,3 pC/N for quartz crystals)
F_x: force in x-direction
n: number of crystal disks

Transverse effect
In the transverse effect, a force F_y in the direction of one of the neutral axes y produces a charge on the surfaces of the corresponding polar axis x. In contrast to the longitudinal piezoelectric effect the magnitude of this charge, which occurs on unloaded surfaces, is dependent on the geometry of the piezoelectric element. Assuming element dimensions a and b, the charge is:

$$Q_y = -d_{11} \cdot F_y \cdot b/a$$

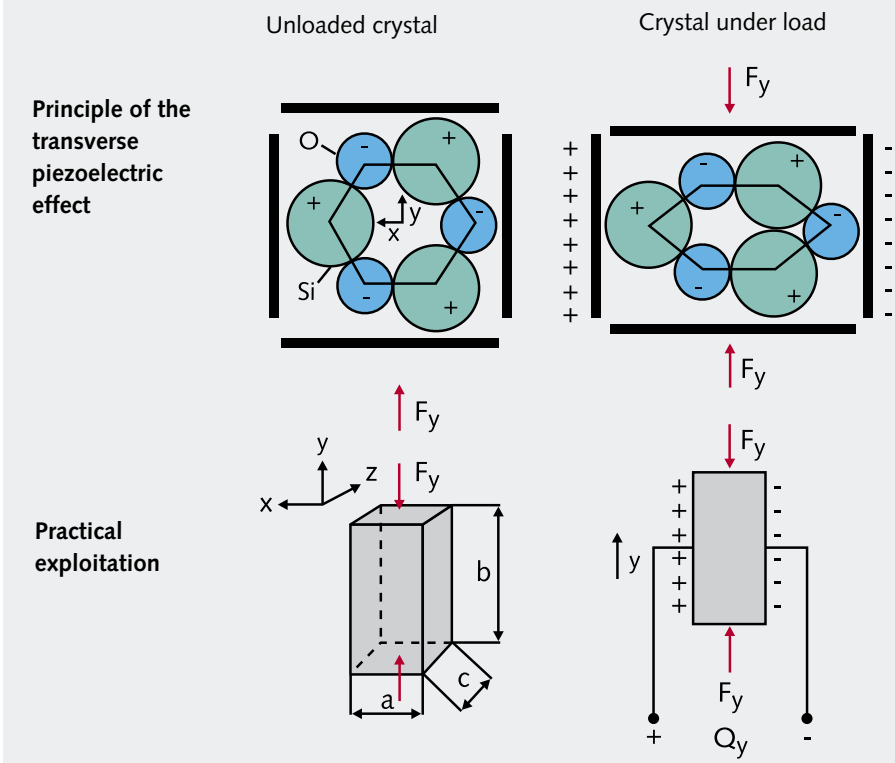
The transverse effect therefore makes it possible to obtain a greater charge through suitable shaping and alignment of the piezoelectric elements. Elements exhibiting this effect can be used for high-sensitivity pressure, strain and force sensors.

Possible cutting angles in the quartz element



Principle of the transverse piezoelectric effect

Practical exploitation



Quartz as a piezoelectric material
Piezoelectric materials for sensor elements must primarily exhibit very high mechanical strength and rigidity. Another requirement is stability of the mechanical and electrical properties across a wide temperature range and for long service periods. High sensitivity, good linearity, negligible hysteresis that is the rising and falling calibration curves are identical and high electrical insulation resistance are also advantageous.

In meeting all these requirements quartz is ideal for sensors. It can be synthesized and has other qualities beneficial for measurement. A synthetic quartz element, for example, can be used in temperatures of up to 400 °C. Quartz can be cut at different angles to exhibit sensitivity to compression or shear forces, depending on which of the three piezoelectric effects is to be used.

The quartz crystal produces a charge signal proportional to the acting force. Due to the high rigidity of the crystal, the measurement displacement is low, usually in the range of a few micrometers.

The high natural frequency of the quartz element is advantageous for measuring instantaneous dynamic processes. Virtually displacement-free measurement produces minimal measuring errors when measuring slow, quasistatic phenomena.

The extraordinary stability, sturdiness and compactness of quartz sensors has led to them being used not only in research and development, but also more widely for industrial production and testing.

Quartz at a Glance

Quartz has excellent properties for use as a force link:

- High permissible surface pressure of 150 N/mm² or more
- Withstands temperatures up to 300 °C
- Very high rigidity
- High linearity
- Negligible hysteresis
- Virtually constant sensitivity across wide temperature range
- High frequency range
- Withstands almost unlimited number of load cycles.

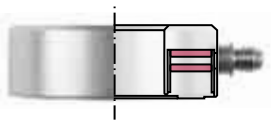
Direct and indirect measurement
Kistler quartz sensors are suitable for direct and indirect force measurement. For direct measurement the sensor is mounted right in the path of the force and measures the total force. This method delivers very exact measurement results, which are almost independent of the force application point. In cases where the sensor cannot be positioned directly in the path of the force, it will measure only a fraction of the total force, while the remainder passes through the structure in which it is mounted, the so-called force shunt. With indirect force measurement, strain sensors are used to indirectly measure the process force via the structural strain.

For more information on this topic, please refer to page 24 onwards.

Force Sensors, Strain Sensors and Torque Sensors

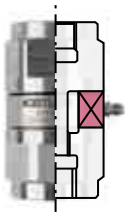
Quartz disks with piezoelectric properties can be stacked in sensors to allow the measurement of one or more force components or a torque vector. Kistler offers the following piezoelectric sensors for application in assembly and product testing:
- Single-component force sensors
- Multicomponent force sensors
- Strain sensors
- Torque sensors

Single-component force sensors
Single-component force sensors, which are available in different types, are particularly suitable for measuring forces in a specified direction. One variant is the so-called load washer, which is ideal for practical applications.
Two lightly preloaded quartz disks are sandwiched between the base plate and the cover plate in a welded case. The electrode located between the two quartz disks receives the measurement signal and transmits it to the connector. Load washers are sturdy and highly versatile in application. Their central hole allows easy integration into various structures in a variety of different configurations and preloading by means of a screw.



Load washer

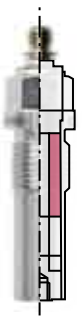
Preloaded between two special nuts, the washer forms what is termed a force link. The preloaded sensor is ideal for measuring compression and tensile forces, for example in rod assemblies. Preloaded sensors, which are supplied calibrated, are easy mounting for immediate use. Sensors for measuring small forces have an essentially different design. Slender quartz rods are mounted under preload between the parts used to introduce the force. Compared with the quartz rings used in load washers, the piezoelectric transverse effect in these slender quartz rods significantly increases the sensitivity.



Quartz force link

Multicomponent force sensors
The piezoelectric measuring principle is also ideal for the manufacture of multicomponent force sensors. The design of the sensor is similar to that of a single-component load washer. A pair of quartz washers cut for the longitudinal effect measures the normal component Fz, while each of two additional pairs of washers cut for the shear effect measures one of the two shear components (Fx and Fy). As shear forces can only be transmitted by means of static friction, multicomponent force sensors must always be under a sufficiently high mechanical preload when mounted.

Multicomponent force sensors are usually not used alone, but are mounted in a group of three or four of similar sensitivity in what is called a dynamometer or force plate.



Sensor for small forces

For more information on single-component force sensors, please refer to page 71 onwards.

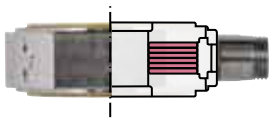
Kistler Measurement Technology

The components of the resultant force acting on a dynamometer are proportional to the algebraic sums of the corresponding components of the individual forces generated as a result of parallel arrangement. A dynamometer is therefore nothing but a multicomponent force sensor that measures the three components of the force independently of its point of application. In order to determine the three components of the resultant moment as well, the individual sensor signals need to be added or subtracted as required. Most Kistler dynamometers and force plates are suitable for both three-component force measurement and six-component force-moment measurement.

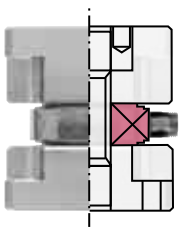
Strain sensors
Strain sensors determine the process forces indirectly from the surface or structural strain. Kistler strain sensors convert strain into proportional force and generate a corresponding charge signal.

Torque sensors
The torque vector is measured by sensors containing several shear-effect quartz disks in a circular arrangement. The shear-sensitive crystal axes of the quartz disks are tangential to the circle. The external shape of torque sensors is similar to that of single-component load washers. In order to allow transmission of the shear forces by means of static friction, the quartz disks must be mounted under high mechanical preload. Torque acting on the sensor generates tangential shear stresses in the quartz disks. As all quartz disks are connected electrically in parallel, the total output signal is proportional to the torque acting on the sensor.

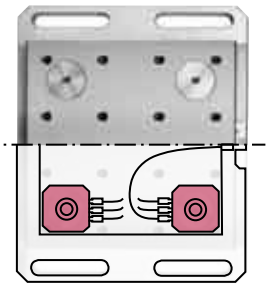
Torque sensors are used in applications such as quality testing of rotary switches. Stationary torque dynamometers are ideal for testing pneumatic screwdrivers.



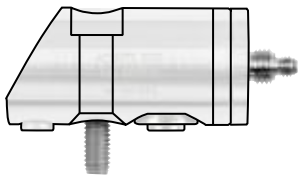
3-component force sensor



3-component force link



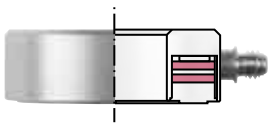
Multicomponent dynamometer with four integral force sensors



Surface strain sensor for indirect force measurement

Transverse measuring pin

Longitudinal measuring pin



Torque sensor

Reaction torque sensor

For more information on multi-component force sensors, please refer to page 88.

For more information on strain sensors, please refer to page 99.

For more information on torque sensors, please refer to page 104.

Charge Amplifiers

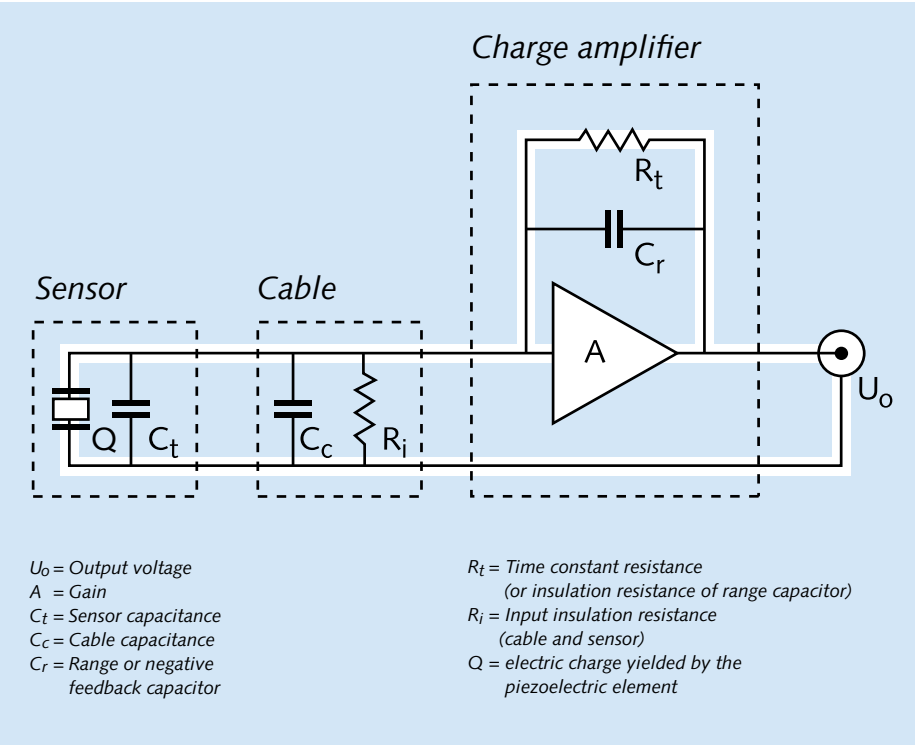
Charge amplifiers convert the charge produced by a piezoelectric sensor into a proportional voltage, which is used as an input variable for monitoring and control processes. A charge amplifier basically consists of an inverting voltage amplifier with high open-loop gain and capacitive negative feedback. It has a metal oxide semiconductor field effect transistor (MOSFET) or a junction field effect transistor (JFET) at its input to create the necessary high insulation resistance and ensure a minimum of leakage current. Neglecting R_t and R_i, the resulting output voltage becomes:

$$U_o = \frac{-Q}{C_r} \cdot \frac{1}{1+\frac{1}{AC_r}(C_t+C_r+C_c)}$$

If the open-loop gain is sufficiently high, the quotient $1/AC_r$ will approach zero. The cable and sensor capacitance can therefore be neglected, leaving the output voltage dependent only on the input charge and the range capacitance.

$$U_o = \frac{-Q}{C_r}$$

The amplifier acts as a charge integrator that constantly compensates for the sensor's electrical charge with a charge of equal magnitude and opposite polarity on the range capacitor. The voltage across the range capacitor is proportional to the charge generated by the sensor and therefore proportional to the acting measurand. In effect, the charge amplifier converts an electric charge input Q into an easily usable proportional output voltage U_o. As most Kistler charge amplifiers allow adjustment of sensor sensitivity and measuring range, the measured value is displayed directly in mechanical units of the measurand and the output signal is an integer multiple of the measurand.



Block diagram of a measuring chain

Time constant and drift

Two of the more important considerations in the practical use of charge amplifiers are time constant and drift. The time constant τ is defined as the discharge time of a capacitor by which 1/e (37%) of the initial value has been reached. The time constant of a charge amplifier is determined by the product of the capacitance of the range capacitor C_r and the time constant resistance R_t:

$$\tau = R_t \cdot C_r$$

Drift is defined as an undesirable change in the output signal over a long period of time that is not a function of the measurand. Even the best MOSFETs and JFETs have leakage currents (MOSFET: $I_l < 10$ fA, JFET: $I_l < 100$ fA), which are the main cause of drift. If the input insulation resistance R_i is too low, it can cause additional drift. However, as long as the input insulation resistance in the negative feedback circuit is sufficiently high ($>10^{13}\,\Omega$) and no additional time constant resistor is connected in parallel, the charge amplifier will drift relatively slowly towards the negative or positive limit (MOSFET: <±0,03 pC/s, JFET: <±0,3 pC/s). This determines the potential duration of quasistatic measurement and is independent of the selected measuring range.

Frequency and time domain

The time constant affects the time domain as well as the frequency range. It determines the lower cut-off frequency $f_u = ½ \pi\tau$ at an amplitude attenuation for sinusoidal signals of 3 dB (30 %). The longer the time constant, the better this frequency and the longer the usable measuring time. For quasistatic measurement during assembly and testing, the longest possible time constant is always selected.

Force can be measured directly in the path of the force of a split component, in the force shunt mode or indirectly as a function of strain. With direct force measurement, the entire process force passes through the sensor, while with the force shunt mode, the sensor only measures part of this force. Strain sensors measure the process force indirectly as a function of strain on the surface or inside the structure of machinery.

All elements through which part of the process force can pass in addition to the sensor form a force shunt n. Force shunts are also created by preloading elements, which are installed for direct measurement, but in most of these cases the shunt is less than 10 %. Measurement in the force shunt mode exploits this effect. The sensor is mounted so it only measures a fraction of the process force. The bulk of the process force passes through the machine structure. This approach allows measurement of forces greatly exceeding the measuring range of the sensor. As strain sensors only measure a negligibly small fraction of the process force, the force shunt created during indirect measurement is usually 99 % or more. If the force shunt is changed, calibration of the sensor must always be repeated, irrespective of the type of installation or sensor.

Measuring Methods at a Glance

Direct measurement in the path of the force
The entire process force passes through the sensor (n <≈ 10 %).

Force shunt measurement
A fraction of the process force passes through the sensor
(force shunt n ≈10 ... 99 %).

Indirect force measurement
Only a negligible part of the process force passes through the sensor
(n >>99 %).

Direct Force Measurement in Path of Force

Direct force measurement necessitates splitting the component or member perpendicular to the load path to allow mounting of the calibrated force sensor. The mounted sensor therefore has to meet the component's strength and rigidity requirements. The sensors used for direct force measurement are usually calibrated and preloaded prior to mounting, as installation does not affect their force shunt. Direct force measurement with calibrated and preloaded sensors is used wherever absolute force measurement is required and calibration of the system after mounting is not necessary, such as monitoring of joining forces or measurement of small forces during product testing.

Direct Measurement at a Glance

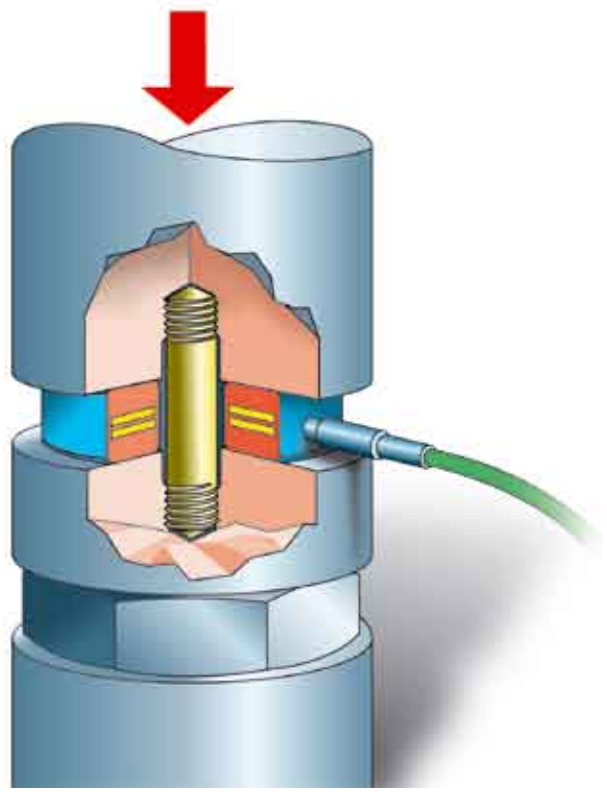
The sensor is mounted directly in the load path and measures the entire process force.

Advantages:

- High sensitivity
- High measuring accuracy
- High repeatability
- Good linearity and low hysteresis
- Wide range of preloaded, easy mounting, calibrated sensors

Disadvantages:

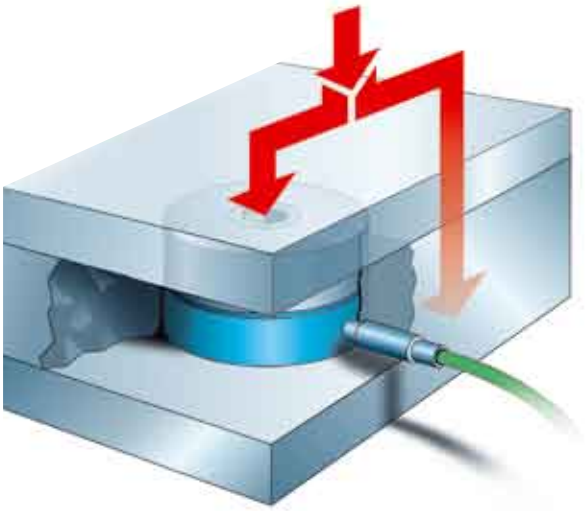
- Interference from acceleration forces when sensors are installed in moving parts
- Alteration of strength or rigidity of machine
- Possible restriction of workspace



Force Shunt Measurement

Sensors are often mounted in a force shunt configuration when large forces need to be measured or the sensor cannot be mounted directly in the force path. As the sensor then only measures part of the process force and the remainder passes into the force shunt, the measuring range can usually be narrower than that required for direct measurement and hence the solution more cost effective.

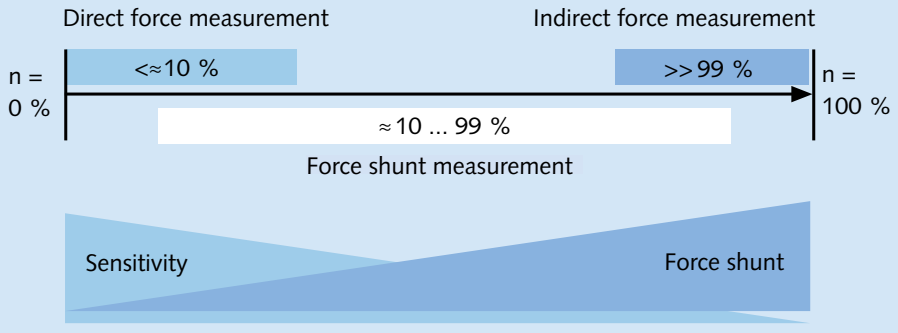
Another benefit of force shunt measurement is a high level of protection against overload. In order to deliver absolute values, sensors mounted in a force shunt configuration always need to be calibrated after mounting. As the sensitivity is determined by the force shunt, and this in turn depends on the point of application of the force, calibration only remains valid while the force shunt remains unchanged. Force shunt measurement is therefore the preferred method of measurement for applications with a fixed point of application, for example for monitoring presses. It should be noted that the mounting configuration and the point of force application affect not only the sensitivity of the sensor but also its linearity and hysteresis.



Force shunt $n\,[\%] = 100 \cdot F_n / F_p$

n = Force shunt (proportion of the process force not measured by the sensor)
n = 0 (for unmounted sensors without preloading elements)
F_n = Shunt force
F_p = Process force
S_0 = Sensitivity of the unmounted sensor
S = Sensitivity of the mounted sensor

$$S = S_0 \cdot \left(1 - \frac{n}{100}\right)$$



Force Shunt Measurement at a Glance

The sensor is mounted in the structure of the machine and most of the process force usually passes into the force shunt.

Advantages:

- Overload protection
- Cost-effective construction
- Measurement of process forces up to 100/(100-n) times the sensor's measuring range
- Good measurement accuracy under constant conditions
- High repeatability

Disadvantages:

- Measurement dependent on point of application and path of force
- On-site calibration required for measuring absolute values

Kistler Measurement Technology

Indirect Force Measurement

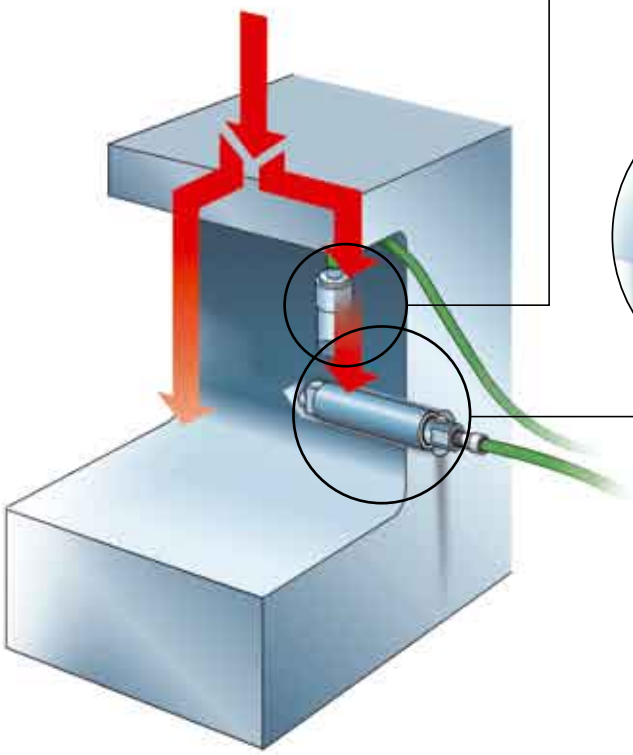
The deformation resulting from application of force to a structure can be measured as force-proportional strain. The process force is therefore determined indirectly from the surface or structural strain. Kistler strain sensors convert strain into proportional force and generate a corresponding charge signal. They are consequently often referred to as force-strain sensors.

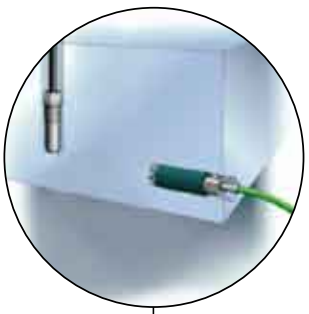
The sensitivity is determined as electric charge Q (pC) per unit strain με (μm/m) and is generally not calibrated, as the strain is usually negligible as a measured value. When used to determine absolute values, the sensitivity of strain measuring chains (V/kN) must always be calibrated against a force sensor as a reference. Particularly for cyclical processes it is often sufficient to monitor deviations from the force curve without any knowledge of the absolute values.

Calibration

Preloaded piezoelectric force sensors are calibrated by Kistler in the factory prior to shipment and are ready for direct force measurement with absolute values. Sensors mounted in a force shunt configuration, strain sensors or measuring pins, however, must always be calibrated after mounting (on-site) for measuring absolute values. Kistler offers a comprehensive calibration service for such cases.

Strain sensors can be very easy mounted on a surface with just a single screw





Transverse or longitudinal measuring pins can be mounted and preloaded in specially prepared holes at a suitable point in the structure of the machine

Indirect Force Measurement at a Glance

Advantages:

- Most convenient mounting method
- Easy retrofitting of existing machines
- Overload protection
- Cost-efficient implementation

Disadvantages:

- Measurement dependent on point of application and path of force
- On-site calibration required for measuring absolute values

Factory and On-site Calibration at a Glance

Factory and on-site calibration is only applicable to a specific, unchanging force shunt configuration.

Changes to this configuration as a result of measures such as the following invalidate the calibration:

- Mounting of sensor in the preloading arrangement or structure of machine
- Shift in the point of force application
- Changes in the force path

Basics of Strain Gage Measurement Technology

The principle of operation of the strain gage is based on the physical effect of the electrical resistance of a wire changing in proportion to any change in length caused by stretching or compression. Kistler uses this principle to measure the torque on rotating shafts and in some force sensors.

The strain gage was developed independently by two people in the USA in the 1930s. The underlying principle had already been described by William Thomson (later Lord Kelvin) as early as 1856. The first industrially manufactured strain gages designated SR-4 were produced from the 1940s onwards and very quickly found a wide range of applications.

Principle of operation
When the measuring wire undergoes a strain ε its length L, cross-sectional area A and specific resistance ρ of its material change. To obtain practical resistance values, the wire has to be very thin (diameter ≈0,02 mm) and as long as possible. In the case of a strain gage this wire is attached to an insulating support in a meandrous pattern and provided with solderable terminals.

The wire is commonly replaced with thin (≈0,005 mm) metallic foil from which the pattern is etched to form a measuring grid. This produces very small such as 1x1 mm grid strain gages capable of measuring at virtually an exact point.

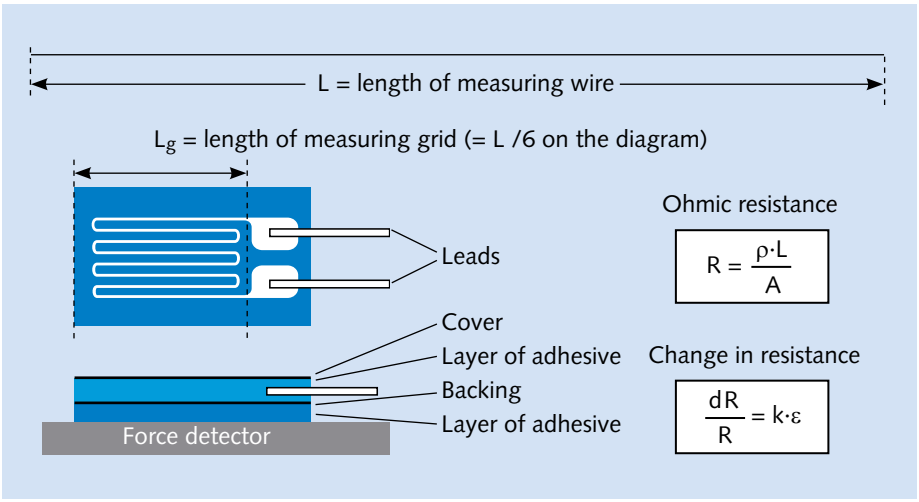
The proportionality factor k between the strain and change in resistance to be measured is called the gage factor (k). It is constant within the elastic range of the conductor. For selected materials such as constantan this factor remains constant even when the conductor is undergoing plastic deformation.

Force detector
For use in strain gage load sensors the gages are bonded onto a force detector made of a selected material that exhibits linearly elastic characteristics up to the rated load. This means that the mechanical stress σ produced by the load on the force detector is linearly related to the strain ε according to Hooke's law:

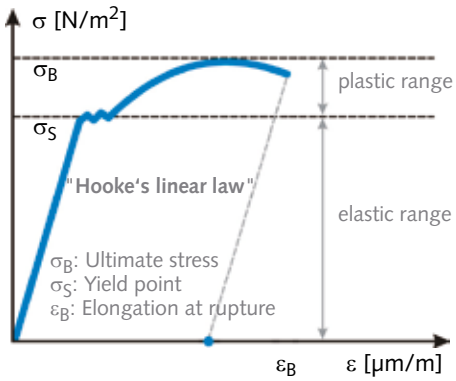
$$\sigma = E \cdot \varepsilon$$

where the material constant E is called the modulus of elasticity. A further increase in load exceeds the elastic range and the force detector finally plastically deforms and is rendered unusable.

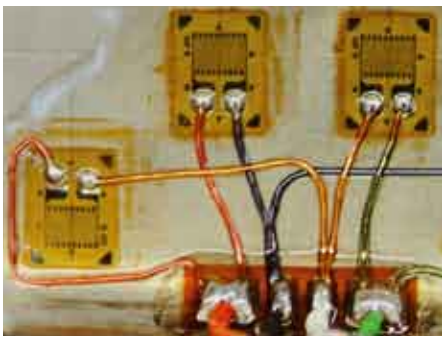
The firm connection with the detector prevents the measuring wire deforming under compression. Due to its low rigidity the strain gage does not affect the behavior of the force detector under load, and can therefore resolve strains of around 1 micron/m (10^{-6} m/m).



Schematic of Strain Gage

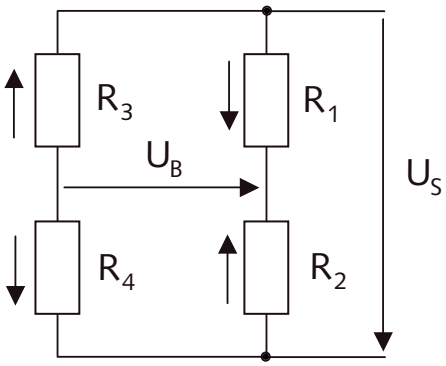


Strain gages measure deformation of structures in linearly elastic range



Strain gages soldered onto a structure

Wheatstone bridge
A Wheatstone bridge is generally used to convert the very small changes in resistance caused by the deformation of a force detector in the strain gages into a voltage signal capable of evaluation.



Wheatstone bridge
R_1 … R_4: Resistors or strain gages
U_S: Supply voltage
U_B: Output voltage
E_B: Bridge sensitivity

This bridge consists of four resistors or strain gages. It is supplied with voltage U_S. The output voltage U_B is taken off the middle of the bridge. The sensitivity of the bridge E_B gives the relationship between output voltage with gage factor (k) and strain ε. Depending on the design, different numbers of resistors can take the form of strain gages. In the case of a full bridge all four resistors are strain gages and the value of their resistance is changed by an external factor such as torque or force.

$$E_B = \frac{U_B}{U_S} = k \cdot \varepsilon$$

The arrangement of the strain gages on the force detector shown in the diagram results in two gages being compressed (resistance of R_1 and R_4 reduces) and two stretched (resistance of R_3 and R_2 increases). The type of force detector and the load do not always allow strain gages to be stretched and compressed with a single loading direction. In this case either two (half bridge), or even three resistors (quarter bridge) must be replaced with fixed resistors. In this case the sensitivity of the bridge is correspondingly lower.

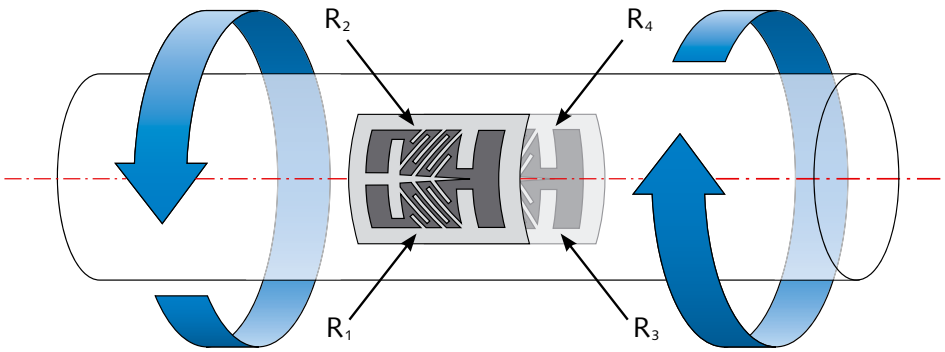
As the temperature dependency of the bridge is a very important quality characteristic, in quarter and half bridges the fixed resistors generally also take the form of strain gages, which are geometrically very close to one another and unaltered by the load. In the event of a change in temperature the resistance values of the strain gages (for example, of R_1 and R_3) increase by the same amount, so the output voltage does not change.

For strain gage sensors full bridges are used almost exclusively. The bridge is generally supplemented with other resistors to compensate for various factors.

Advantages of Strain Gage Sensors

+ Allow tensile and compression measurements without having to preload measuring elements.
+ Static measurements over long period of time possible.
+ Simple static calibration with weight loading.

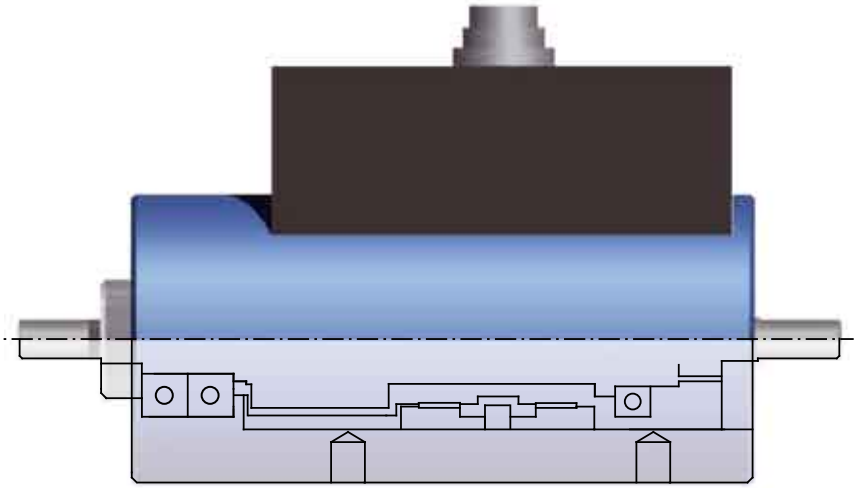
Measuring chain with strain gages
The voltages produced by the bridge are in the range of a few mV. The leads for the unamplified analog signals are kept as short as possible to minimize the effect of any electromagnetic fields. A differential amplifier generally amplifies and then digitizes the voltage. Such amplifiers have a very high input resistance and high common-mode rejection.

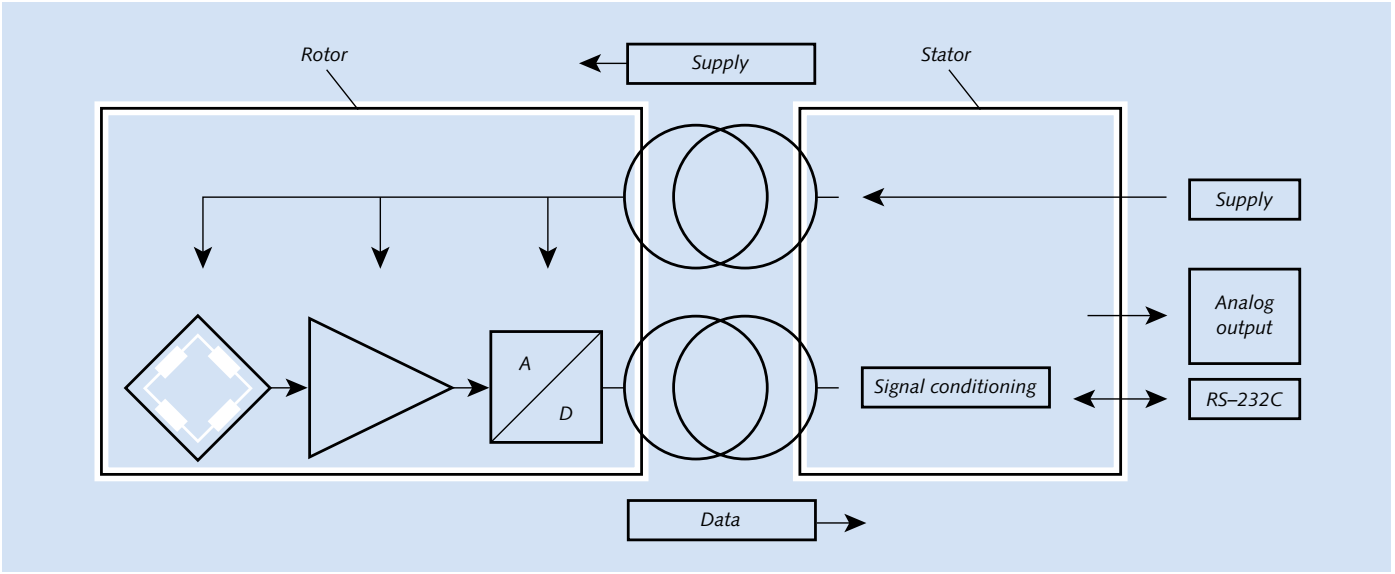


An applied torque twists a measuring shaft, thereby affecting the resistors of the full bridge R_1 to R_4 and producing a voltage proportional to the torque

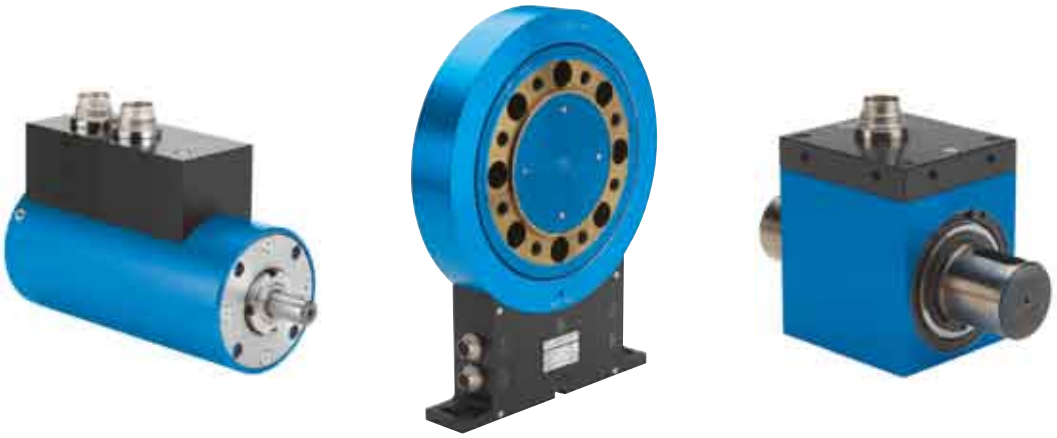
Basics of Strain Gage Measurement Technology

Rotating torque sensors
Rotating torque sensors have two pairs of coils. The first pair transfers the power to supply the rotor, and data from stator to rotor. The digital data from the rotor is transferred to the stator by means of the other pair of coils. The electronics with the differential amplifier and the analog-to-digital converter are mounted on the rotor.





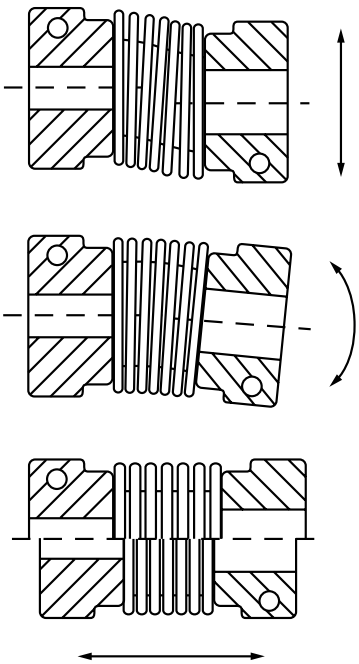
Schematic of a torque sensor for rotating shafts



Kistler Measurement Technology

The torque on rotating shafts is measured directly in the machine's powertrain between a drive and a loading machine. Couplings are used to eliminate external factors such as transverse or axial forces and bending moments that can affect the measurement signal.

Couplings for use between shaft and sensor differ in their flexibility. Single-flexible couplings, which can only compensate for mechanical misalignment in one direction, contrast with couplings which are flexible in two (double flexible) or all directions.



Couplings compensate for radial (top), angular (middle) or axial misalignment (bottom)

Choice of coupling
The choice of coupling can be critical in achieving a high standard of measurement. For highly dynamic measurements the coupling has to be very torsionally rigid to assure exact transmission of the torque. It should also be noted that the coupling with its torsion resistance can shift the resonances of the mechanical arrangement. Questions of cost, ease of mounting and removal, and the maximum speed and torque also play an important role in this choice.

Basic principle: The mechanical arrangement and orientation of the individual components must be as accurate as possible to ensure the couplings only have to accommodate minimal differences!

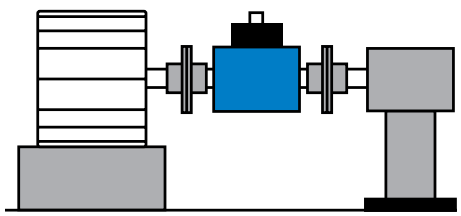
Arrangement of torque measuring shafts
There are two arrangements of torque measuring shafts. The floating arrangement only protects the sensor from being twisted. In this case single-flexible couplings must be used. Moreover, this arrangement should only be used for torques >50 N·m and speeds < 5 000 rpm. If the base is bolted to the machine bed, double-flexible couplings should be used to accommodate parallel and angular misalignment.

Arrangement of torque measuring flange
Torque measuring flanges (for example, Type 4504A...) are generally connected directly to the drive with a flange, whereas the measurement side is provided with a double-flexible coupling.

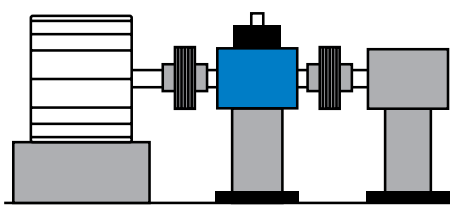
Selection Criteria for Couplings

- Maximum speed
- Maximum torque
- Ease of removal
- Dynamic measurement
- Cost
- Required compensation

Torque sensor with base and two double-flexible couplings



Floating test arrangement with single-flexible couplings



Test arrangement with fixed torque sensor and double-flexible couplings

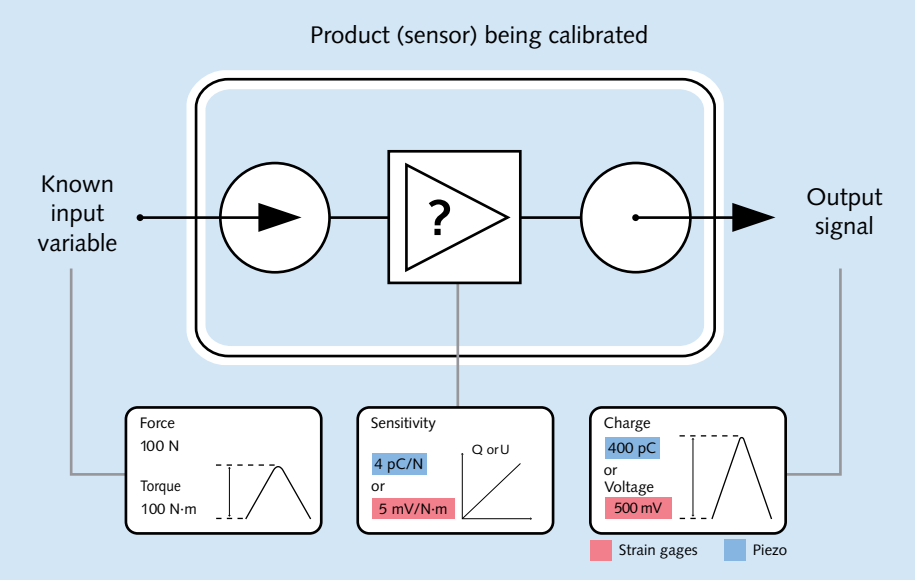
Basics of Calibration

Sensors and measuring instruments must be calibrated at regular intervals, as their characteristics and hence the measurement uncertainties can change over time as a result of frequent use, aging and environmental factors. Instruments used for calibration are traceable to national standards and subject to a uniform international quality control. Calibration certificates document calibration values and conditions.

Safe and reliable measurement
Quality assurance systems and product liability laws call for systematic monitoring of all test equipment needed for measuring quality characteristics. This is the only way of ensuring measurement and test results provide a reliable and dependable benchmark for quality control.

All sensors and almost all electronic measuring devices are subject to certain measurement uncertainties. As the deviations involved can change over time, the test equipment must be calibrated at regular intervals.

Basic Principle: Calibration is the use of a defined method under specified conditions to determine the relationship between a known input variable and a measured output variable.

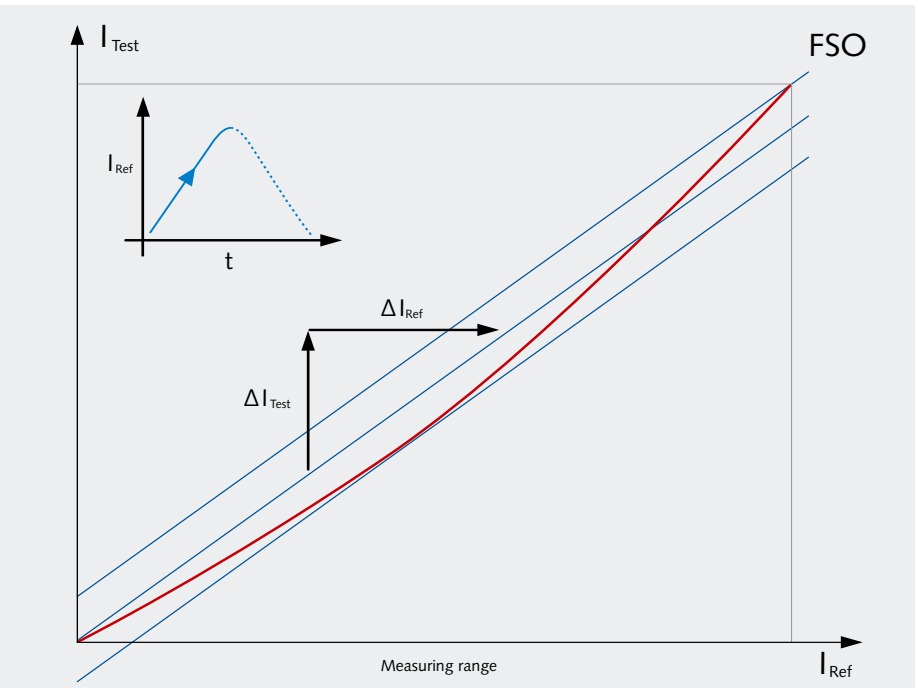


This involves determining the deviation of the measured value from an agreed reference value, which is also referred to as the calibration standard. The result of a calibration can either be used to assign the actual values of the measurand to the readings or for establishing correction factors for them. The required information is documented on the calibration certificate.

Calibration at a Glance

Calibration helps ensure:

- Precise and reliable measurement
- Internationally comparable measurements
- Similar products are metrologically compatible



Sensitivity: Ratio of the change in the signal ΔI_{Test} and the change in the reference variable ΔI_{Ref}, where I represents a charge, voltage or other indicated variable

Basic Calibration Terms

Calibration
Calibration is the use of a defined method under specified conditions to determine the relationship between a known input variable and a measured output variable. The calibration standard is the reference value. For example, the calibration of scales involves placing a defined and calibrated test weight (calibration standard) on the scales to reveal deviations in the weight reading.

Calibration certificate
The calibration certificate documents all values measured during calibration and the calibration conditions.

Calibration curve
This curve shows the output variable of a sensor as a function of the input variable.

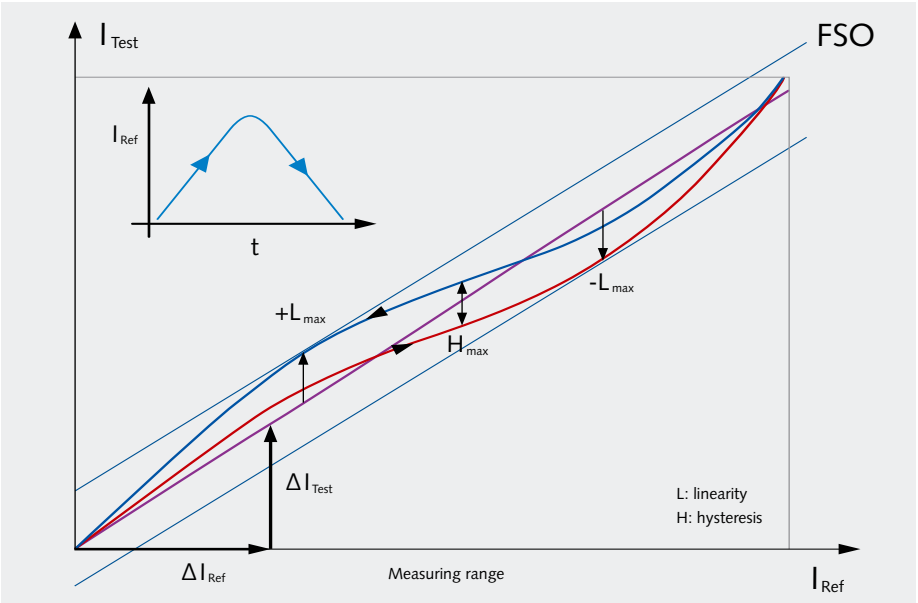
Calibration standard
The calibration standard, which is traceable to national or international "standards", is the reference value used for calibrating sensors or measuring instruments.

Characteristic value
Output signal of the strain gage sensor at rated load, reduced by the zero signal after mounting.

FSO
Full Scale Output or full range signal. The difference between the output signal at zero and at the end of the measuring range.

Hysteresis
Maximum difference, H_{max}, between rising load characteristic and falling load characteristic.

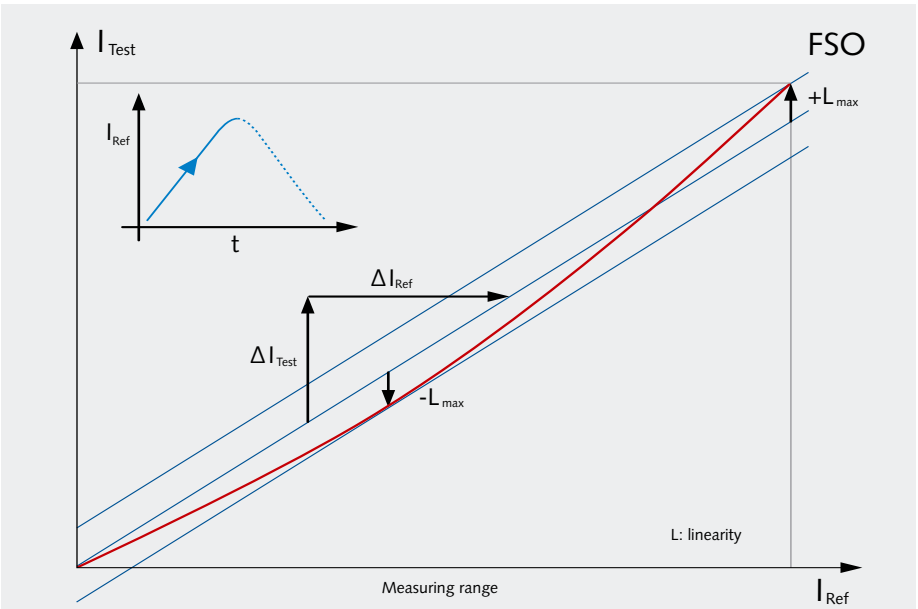
The relationship between the true value of the measurand and the output variable of the sensor is not exactly linear



Hysteresis: maximum difference between increasing load characteristic and decreasing load characteristic

Linearity
In practical application there is not an exactly linear (or constant) relationship between the measurand and the output variable of the sensor. The linearity L_{max} of a sensor corresponds to the maximum deviation of the ideal from the actual output signal curve in relation to the measurand within a certain measuring range. It is expressed as a percentage of the limit of the full measuring range (% FSO).

Sensitivity
Value of the change in output signal divided by the corresponding change in the input variable: $\Delta Q/\Delta I_{Ref}$ for piezoelectric sensors or $\Delta U/\Delta I_{Ref}$ in the case of strain gage sensors.



Basics of Calibration

The relationship between measurand and sensor output variable is determined by means of a simple linear regression analysis. The linearity including hysteresis indicates that the calibration curve of the loading and unloading characteristic has been used to determine the characteristic values.

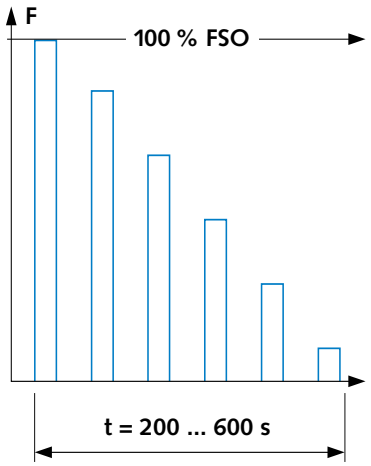
Best straight line
Determination of a linear function passing through the origin to form the calibration curve, with two parallel straight lines with the same gradient and shortest distance apart enveloping all of the calibration values.

Least squares function
Determination of a linear function to form the calibration curve that minimizes the sum of the squares of the errors (differences between calibration curve and linear function).

Calibration Methods

During calibration, sensors are subjected to known quantities of a physical measurand such as force or torque and the corresponding values of the output variable recorded. The magnitude of this load is accurately known, as it is measured with a traceably calibrated "factory standard" at the same time. Depending on the method, sensors are calibrated either across the entire measuring range or in a partial range:
- at a single point,
- stepwise at several different points or
- continuously.

Step-by-step calibration involves the application of a defined load with or without unloading between successive increases or decreases, depending on the calibration method used. The process is halted after each increment until the measurement stabilizes.



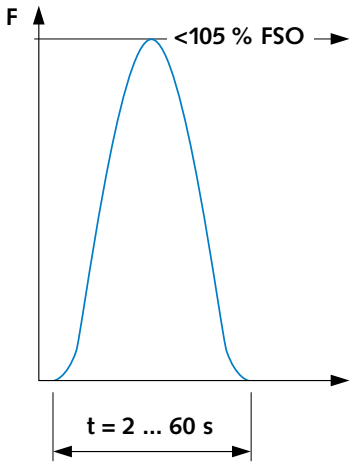
Machine for torque calibration up to 3 000 N·m to reference standard

Kistler Measurement Technology

During **continuous calibration**, the load is continuously increased to the required value within a defined time and then reduced to zero within the same time. A "best straight line" passing through the origin is defined for the resultant characteristic, which is never exactly linear. The gradient of this line corresponds to the sensitivity of the sensor within the calibrated measuring range.

Linearity is determined by the deviation of the characteristic from the best line. Hysteresis corresponds to the maximum difference between rising and falling characteristic.

Most Kistler single- or multiaxial force and torque sensors are factory calibrated.



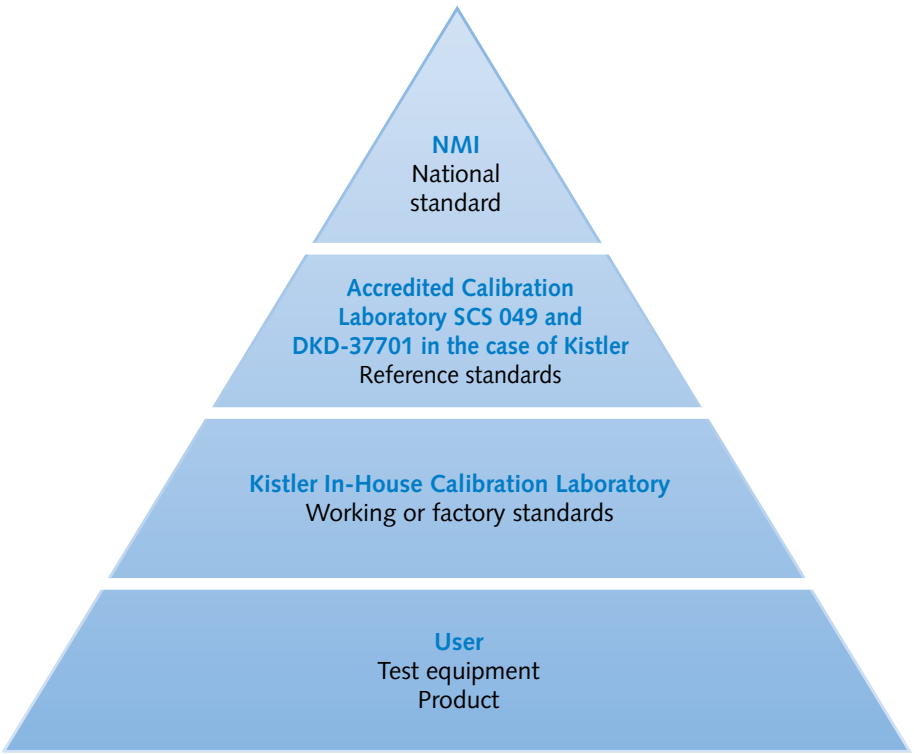
The continuous approach is the most suitable calibration method for piezoelectric sensors. Strain gage sensors are preferably calibrated step by step, torque sensors in line with the requirements of DIN 51309 standard.

Calibration Documents

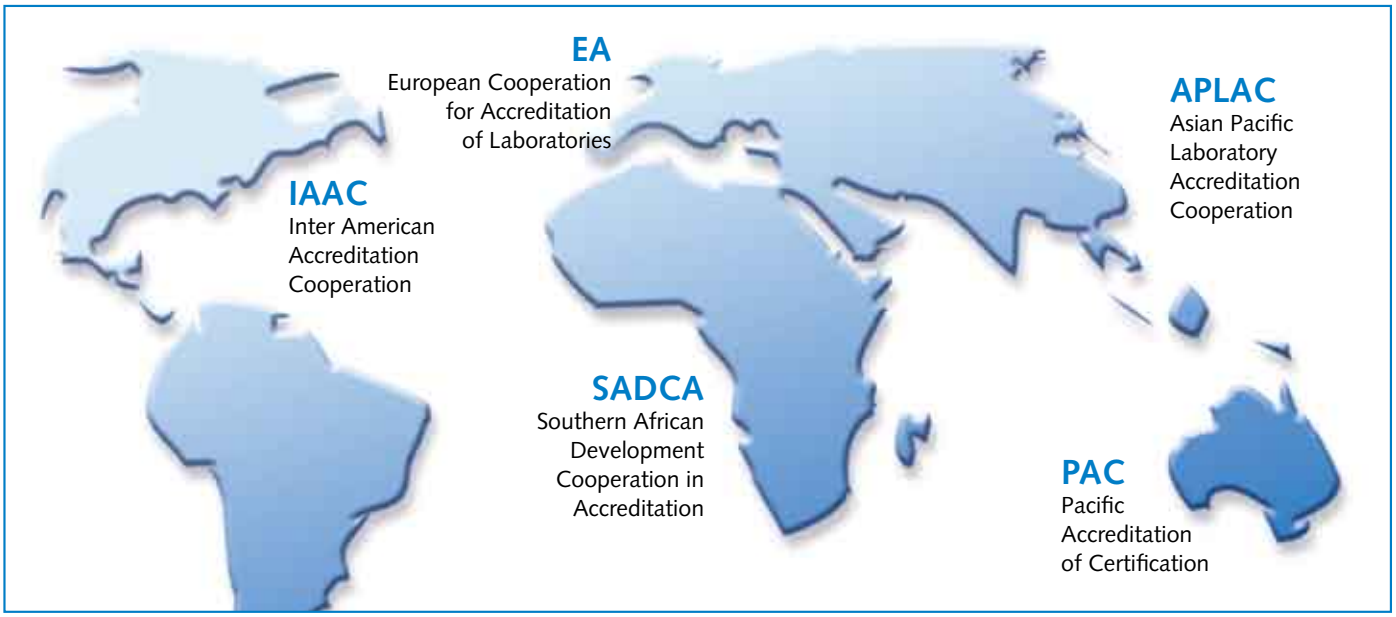
To ensure consistent quality standards worldwide, the test equipment has to meet standard quality assurance criteria. The European series of standards for quality management systems (EN 29000) – which is identical to the international ISO 9000 – demands traceability to the national measuring standards for all measuring instruments used for this purpose.

Hence the result of calibrating a measuring device or system is compared with a higher measurement standard. This results in a "calibration hierarchy" with the national measurement standard at the top.

System for accredited force calibration up to 200 kN



Basics of Calibration



International standards specify the required calibration methods and measurement uncertainties.

Different institutes coordinate international cooperation on calibration. They are also responsible for the accreditation of national calibration laboratories. Documentation guidelines may differ slightly from one country to another.

The following calibration documents are available for most Kistler sensors:

- Manufacturer's declaration
- CE declaration of conformity
- Factory certificate
- Test certificate
- Factory test certificate
- Calibration certificate
- SCS calibration certificate
- Traceability chart

At a Glance

Kistler offers a comprehensive calibration service:

- Calibration of test equipment
- Accredited calibration laboratory (SCS 049 DKD-37701)
- Extensive functional testing
- Range of different calibration documents

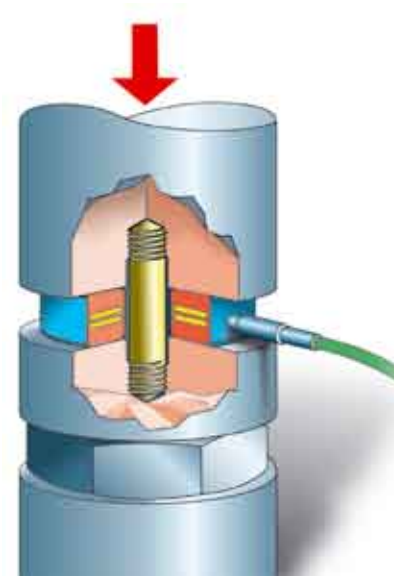
Kistler Measurement Technology

Numerous mechanical, electrical and climatic parameters affect the calibration result and hence the accuracy of a measuring chain. For maximum calibration accuracy, assembly errors have to be avoided and the correct position and angle of force application achieved. Factors such as the non-linearity of various electrical parameters along the measuring chain must be considered. Last but not least, temperature and humidity also have a decisive effect.

Simultaneous calibration of three force components or three moments is one of the greatest challenges in calibrating multicomponent sensors. On Kistler's 3-component calibration system the loading is applied sequentially, with the sensor being calibrated remaining in its mounted position.

Influence of assembly
Mechanical interference due to size or positional inaccuracies significantly affects the calibration result. Force and torque sensors are often deformed in the course of assembly. Factors such as flatness, roughness, parallelism and contact surface pressure are highly important in the transmission of force or torque. Evaluation of the effect of assembly is based on a range of individual measurements taken from a typical device to be calibrated after repeated mounting in a calibration system. The characteristic value of errors caused by these operations can be used to determine the effect of assembly on the calibration result.

Non-linearity
The overall characteristic of electrical devices is usually non-linear, as linear behavior of all structural components is rare. This also applies to charge calibrators, charge amplifiers and bridge amplifiers, whose very slight non-linearity affects the calibration result. Force and torque sensors also exhibit non-linear characteristics. The linearity determined by the calibration is documented on the calibration certificate and affects evaluation of the measuring uncertainties involved in calibration. The linearity of the reference sensor is already included in the measurement uncertainty and need not be further taken into account.



Humidity
Relative humidity influences the behavior of electronic components including the capacitors used in charge amplifiers and charge calibrators. Type approval tests record and document the thermal characteristics of electric measuring instruments. This information can be used to determine the effects of variations in humidity on the calibration result.

Effective number of bits (ENOB)
Measuring cards, for example, have a measuring range of –10 … 10 V and a resolution of 16 bits. The true signal is rounded up or down to the nearest bit value, which causes a maximum rounding error of half a bit.

Best measurement capability
Comparative calibration involves the use of a reference sensor with best measurement capability, which has a documented measurement uncertainty as a result of being calibrated against a higher standard. Prior to calibration of the sensor, the charge amplifier must also be calibrated using a precision charge calibrator to ensure that the output voltage displayed by the amplifier is matched with the charge generated by the force sensor. The absolute standard method employs a calibration system with preset physical input variable. This system also has best measurement capability.

Effect of temperature
Mechanical components are subject to thermal expansion and the resistance of electronic components depends on temperature. Temperature variation during the calibration process therefore has a direct effect on the result. The effect of this parameter on the sensitivity of piezoelectric sensors and the characteristic value of strain gage sensors is analyzed as part of the type approval test. Force and torque sensors using strain gages have special compensation modules to minimize thermal changes. There is also reliable data on the thermal behavior of charge calibrators and charge amplifiers. Charge calibrators have temperature compensation that makes their thermal dependence very slight.

Accuracy Evaluation

Range errors in charge amplifiers and charge calibrators
The tolerance of electric components limits the accuracy of charge amplifiers and charge calibrators. It manifests itself as a range error, which depends on the preset measuring range and the measured value. The maximum range error is specified for each device.

Drift
The drift of a charge amplifier is a global description of the shift of the signal zero level, which is mainly due to a loss of feedback capacitor charge and leakage currents at the amplifier input. A leakage current across the insulation resistance causes an exponential decay in the feedback capacitor charge with a time constant given by the product of insulation resistance and the capacitor's capacitance. As a sufficiently high insulation resistance leads to a very high time constant, the problem of discharge only affects very long measuring periods. Given the drift characteristics of charge amplifiers are well known from extensive research, the peak value can be used to evaluate the effect of drift on the calibration result.

Instability of charge amplifiers over time
Charge amplifiers are subject to instability over time. To minimize the effect of this instability on force sensor calibration, it is advisable to calibrate in advance with a precision charge calibrator the charge amplifiers of both the reference measuring chain and the measuring chain of the device to be calibrated together with all corresponding cables, display and evaluation devices. This approach also identifies all potential influences from contacts and electrical connections within the measuring chain.

Stability of charge calibrators
Under normal circumstances, charge calibrators are calibrated at regular intervals (generally annually). Within these intervals the calibration values undergo slight changes, which are characteristic of specific devices and as such constant. The stability of charge calibrators must be considered in evaluating the calibration results.

Calibration of strain gage sensors
This requires the use of a bridge amplifier and a reference standard. Despite being balanced at the start of the calibration process the bridge amplifier is subject to a certain measurement uncertainty. The reference signal is characterized by the values shown on the calibration certificate.

Crosstalk in multiaxial sensors and sensor systems
Complex sensor systems such as dynamometers are generally fitted with multicomponent sensors. With such configurations crosstalk of individual variables is observed in other measurement components. With a unidirectional force load in the direction of one axis minimal signals in the direction of the other two orthogonal axes or minimal moment will be indicated. This phenomenon affects all of the possible force and moment directions and the values involved have to be taken considered in assessing measurement uncertainties.

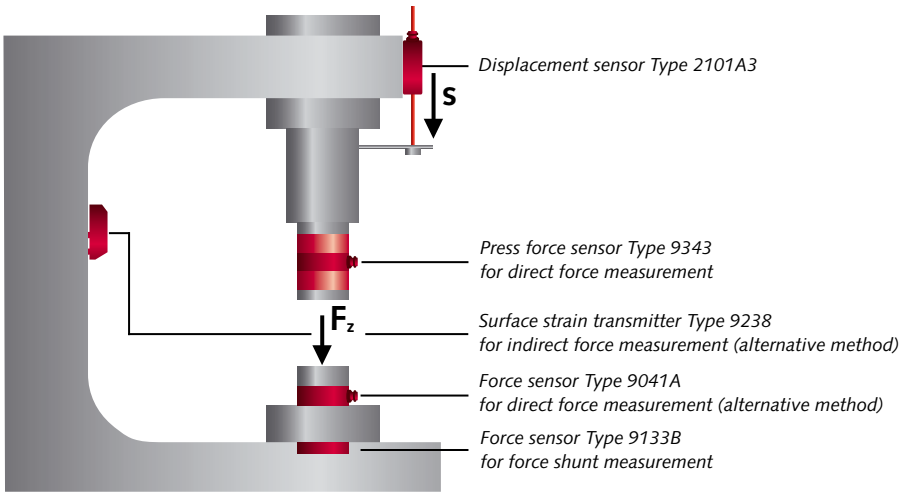
Ripple in rotating sensor systems
Rotating sensor systems exhibit ripple. The value of this ripple describes the change in sensitivity as a function of the rotation angle relative to the reference point. During calibration, the angular range of a full revolution is measured with a limited number of data points, which are then approximated by an optimized interpolation curve. The difference between the interpolation curve and the measured points reflects the measurement uncertainty.

Threshold
The threshold is the smallest change in the input variable that leads to a discernable change in the value of the output variable of a force or torque sensor. From experience, it is two or three times the rms value of the signal noise. This noise consists of the background noise of sensor and amplifier.

Force and Torque Measurement in Practical Applications

Measuring the joining force as a function of displacement is a very precise way of monitoring press fitting of bearings, sleeves or shafts into assemblies such as housings or gearboxes. The resultant force characteristic is sufficiently distinctive for assessment of the quality of both the process and the finished product. CoMo ControlMonitors are used to analyze this characteristic in order to determine whether a part is "OK" or "NOT OK".

During press fitting ControlMonitors record the interdependent measurands of joining force and displacement in pairs. This functional relationship is evaluated at the end of the cycle. The parameters for the system's monitoring and evaluation functions can be selected across a wide range of options to suit the specific requirements of the press-fitting process.



Kistler Plus Points

Monitoring press fitting with CoMo ControlMonitors offers the following benefits:

+ Protection against joining of defective parts
+ Zero-defect output increases production efficiency
+ Protection of machine, tool and workpiece from damage
+ Process visualization and statistical process monitoring ensure optimum process control
+ Transparent and continuous process documentation allows optional benchmarking against other processes
+ Optional integration into host (PC-based) quality assurance systems

Process evaluation

To enable visualization of deviations from a reference component, a reference curve from an optimal joining process can be highlighted in blue and then stored in the CoMo ControlMonitor.

The press-fitting process is analyzed by means of evaluation objects such as thresholds, tolerance windows and end boxes. These objects can be positioned graphically with cursor keys or by keying in the corresponding coordinates on the keypad. Almost any required position, size and evaluation mode (entry and exit, passage, minimum and maximum force, etc.) can be defined.

A conforming part is signaled only if the measurement curve has passed through specified evaluation objects according to definition. An evaluation object is clearly defined by entry and exit of the curve. Failure to pass through an evaluation object correctly will result in the part being evaluated as "NOT OK". Entry and exit sides are marked in green and an arrow indicates the direction of passage. Red limits must not be exceeded. A maximum of twelve evaluation objects can be combined as required.

Force-displacement monitoring of press fitting of needle bearings into gearbox

Monitoring Press-Fitting Processes

Typical process curve of a press-fitting process with evaluation using boxes

Disturbances can be eliminated with the help of relative tolerance windows

Process monitoring
During the initial phase of the press-fitting process, the variation in the fitting force required can be monitored within strictly defined limits by means of the trapezoidal function (1+). Non-centered or incorrect mating parts can cause an excessive rise in this force. In order to protect both the tool and the machine from overload, a real-time force threshold (Y1) can also be introduced. Any breach of this threshold promptly actuates a digital output that stops the joining process immediately. Box (2+) monitors the maximum force.

The second phase is the actual press fitting. An additional trapezoidal function (3+) ensures the joining force remains within the permissible limits. The third phase deals with the "end position" and "blocking force". The last pair of values acquired for the end position must be positioned within the end box (4+). A maximum permissible value of the blocking force can be defined within this box if required.

Pneumatically assisted press assembly of ball bearings in shells with good/bad decision taken by CoMo Net® ControlMonitor with external terminal

Superimposing any number of measurement curves (data export format for Excel) is an easy method of determining the process variation. This can then be used to program the ControlMonitor for large-scale production.

Evaluation results can be affected by a range of different conflicting factors. These are usually not directly related to the signal curve to be analyzed, but are superimposed as a result of mechanical tolerances. To eliminate these factors tolerance (4+) can therefore also be referenced in relation to the point at which a threshold is crossed (5+). Multichannel ControlMonitors allow, for example, various press-fit stations of a rotary indexing table to be monitored simultaneously. Rapid switching between different parameter sets during production also permits monitoring of various joining processes on a single press-fitting station.

Force and Torque Measurement in Practical Applications

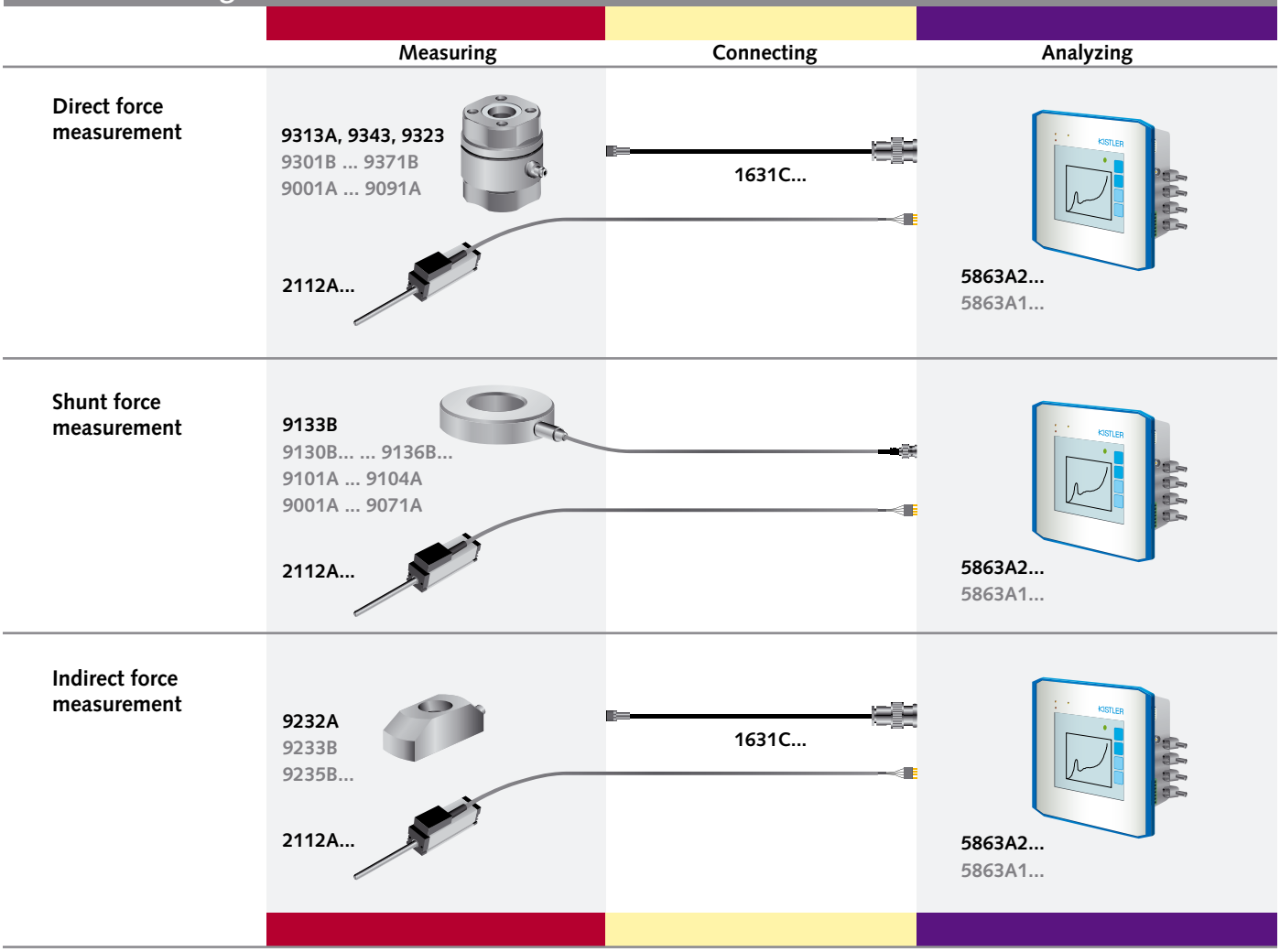
Application sectors
ControlMonitors for press-fitting processes are used by the automobile industry and its suppliers, in the aerospace industry and many other sectors. Typical process monitoring applications include:

- Ball bushings, bearings, pinions and shafts in gearbox assembly
- Bearings, bushes, seal rings, etc., in steering column assembly
- Bearing shafts in assembly of electric motors and injection pumps
- Bearing shells in washing machine drums

Kistler Products

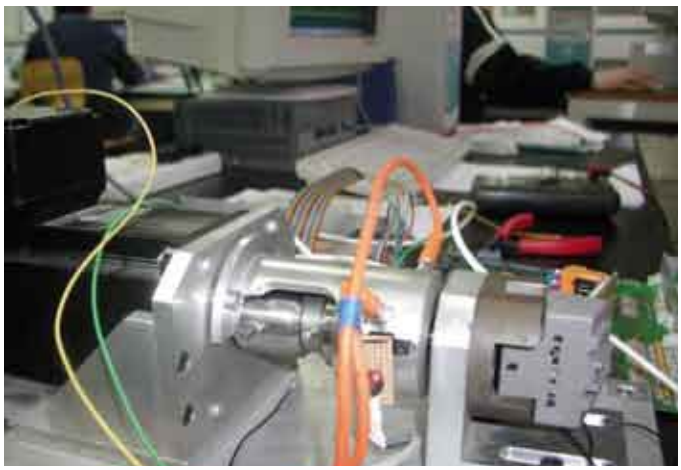
- Piezoelectric press force sensor Type 9343 for direct measurement of joining forces
- Alternative: piezoelectric SlimLine sensor Type 9133B for measuring joining forces in force shunt
- Alternative: piezoelectric strain sensor Type 9232A for indirect joining force measurement
- Standard cable Type 1631C…
- ControlMonitor CoMo View Type 5863A2… .

Measuring Chains for Press-Fit Processes



Standard equipment Alternative

Testing Rotary and Spring-Loaded Switches



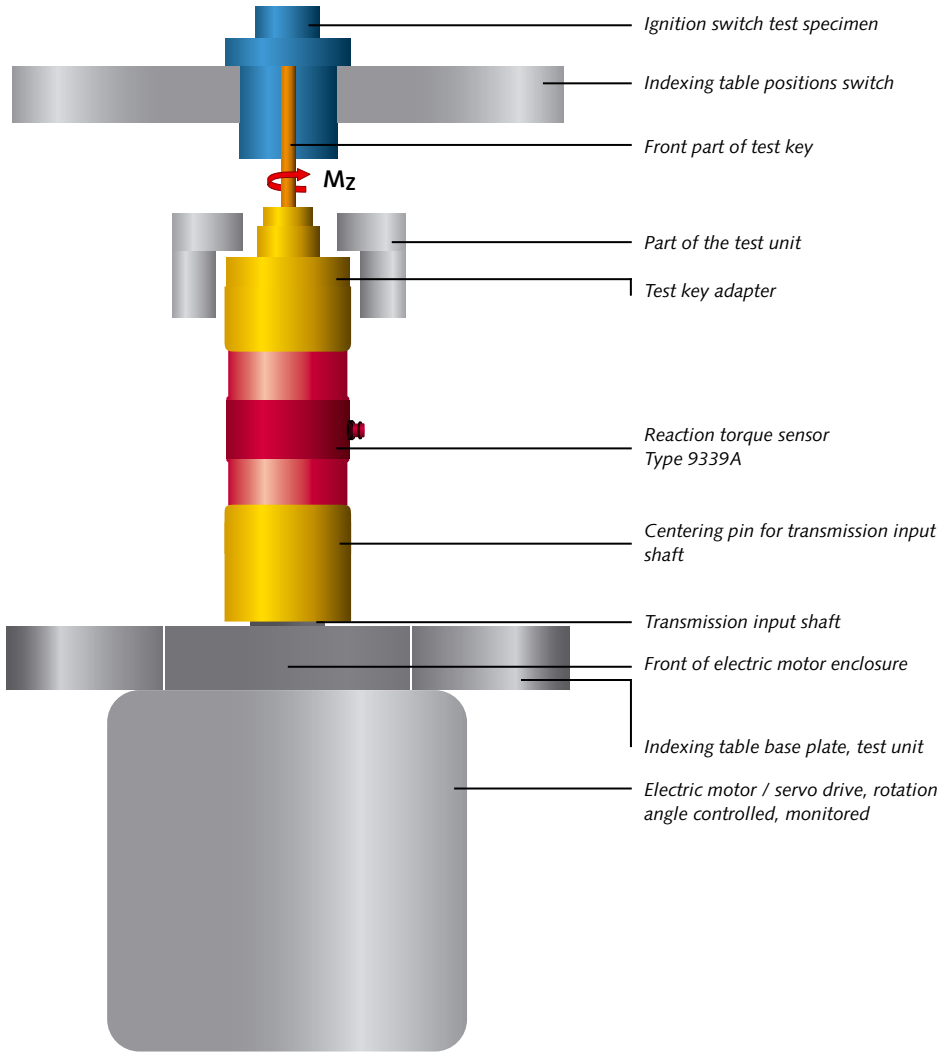
A reaction torque sensor Type 9339A tests ignition switches by measuring the torque from 1 … 3 N·m against the spring preload during mass production (left) and in laboratory tests on an experimental set-up (right)

As automotive components with a direct bearing on safety, ignition switches, control pedals and locking systems leave no room for production errors. Torque sensors can determine the operating torque of components such as ignition switches in the course of actual production. ControlMonitors analyze this parameter as a function of rotation angle, check it against specified tolerances and reject defective products.

Each and every step involved in the production of components that affect safety is monitored by sensors. Suppliers to the automotive industry can guarantee flawless operation of their components by conducting in-line tests to reliably avoid failures in the customer's product.

Testing ignition switches with torque sensors

Torque sensors can test operation of assembled ignition switches on the production line. The torque measured during rotation of the spring-loaded components must lie within specified tolerances. Torque sensors can check typical ranges, for example from 1 N·m to 3 N·m, within short production cycles. The sensors are positioned pneumatically before being rotated by the required angle (such as 120 °) to check the torques applied to a spring-loaded ignition switch.



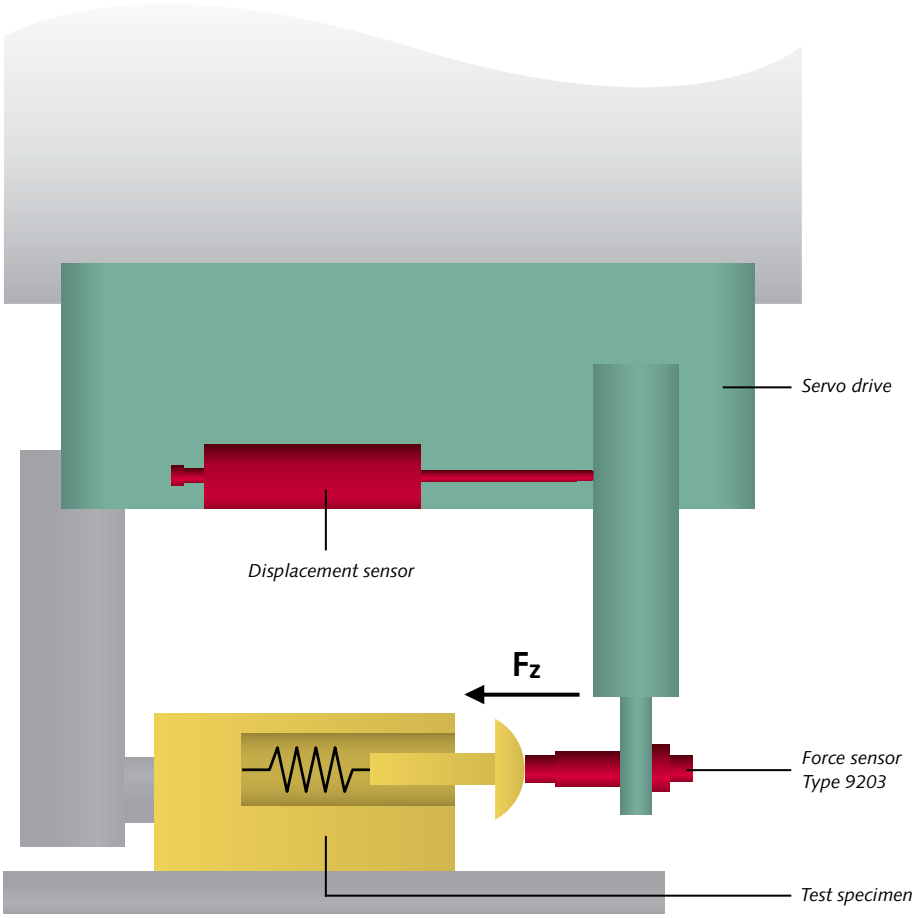
Force and Torque Measurement in Practical Applications

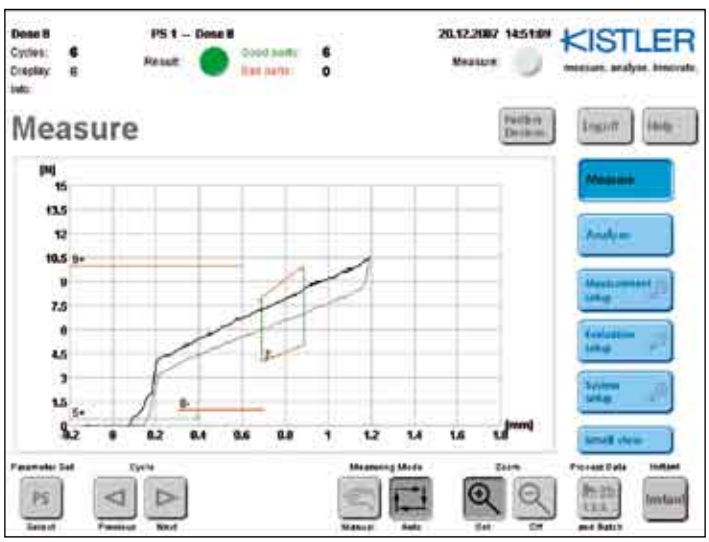
Testing spring-loaded switches with force fensors

The brake pedal, clutch pedal or accelerator is equipped with between four and eight spring-loaded switches, depending on the particular model of car. They activate the brake lights and generate a signal for different vehicle control systems. The resilience of these switches can be tested in special test stands, which are equipped with sensitive sensors for small forces. The test involves the displacement-controlled movement of a sensor against the test spring by means of a servo motor.

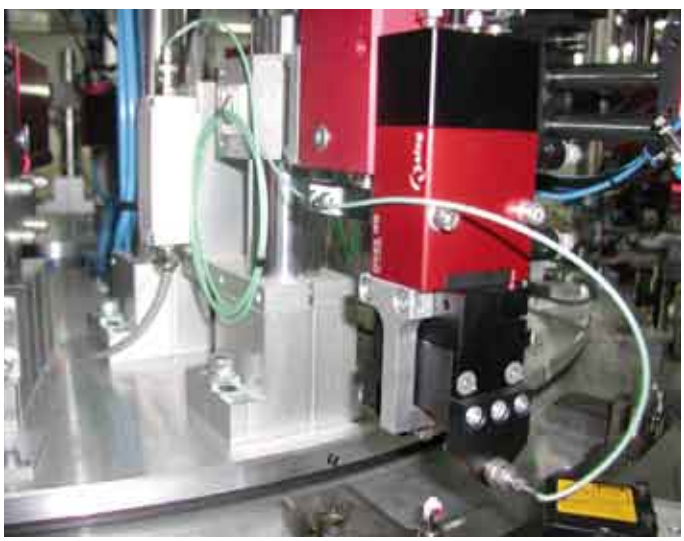
Process monitoring via machine control

If the assembly or test unit is equipped with a control system and monitor, it can be used to visualize and analyze the force or torque curve. A charge amplifier converts the charge yielded by the sensor into a proportional electrical voltage. The machine's control system can use this voltage as an input value. As an alternative to charge amplifiers and visualization in the machine control system, the measurement results can be analyzed with ControlMonitors such as CoMo View or CoMo Net.





Force curve of spring test with CoMo View® ControlMonitor



Testing spring-loaded switches for car brake or clutch pedals and accelerators with force sensors Type 9203 andcharge amplifier Type 5037B1211

Testing Rotary and Spring-Loaded Switches

Kistler Products

Testing rotary switches

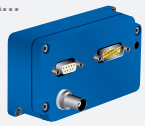
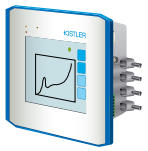
- Standard cable Type 1631C2
- High-sensitivity reaction torque sensor Type 9339A
- ICAM single-channel charge amplifier Type 5073A1...

Kistler Products

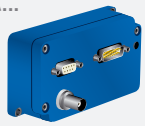
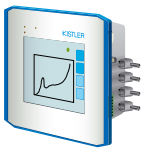
Testing spring-loded switches

- High-sensitivity, preloaded force sensor Type 9203…
- Standard cable Type 1631C2
- ICAM single-channel charge amplifier Type 5073A1…

Measuring Chains for Testing Rotational Switches

	Measuring	Connecting	Amplifying	Analyzing
Measurement of reaction torque, evaluation with machine control system	 **9339A** 9329A ... 9389A	 **1631C2**	**5073A1...** 5030A... 	
Measurement of reaction torque, evaluation with CoMo View ControlMonitor	 **9339A** 9329A ... 9389A	 **1631C2**		**5863A2...** 5863A1... 5875A... 

Measuring Chains for Spring-Loaded Switches

	Measuring	Connecting	Amplifying	Analyzing
Measurement of small switch force, evaluation with machine control system	**9203** 9205 9207 9215 9217 	 **1631C2**	**5073A1...** 5030A... 	
Measurement of small switch force, evaluation with CoMo View ControlMonitor	**9203** 9205 9207 9215 9217 	 **1631C2**		**5863A2...** 5863A1... 5875A... 

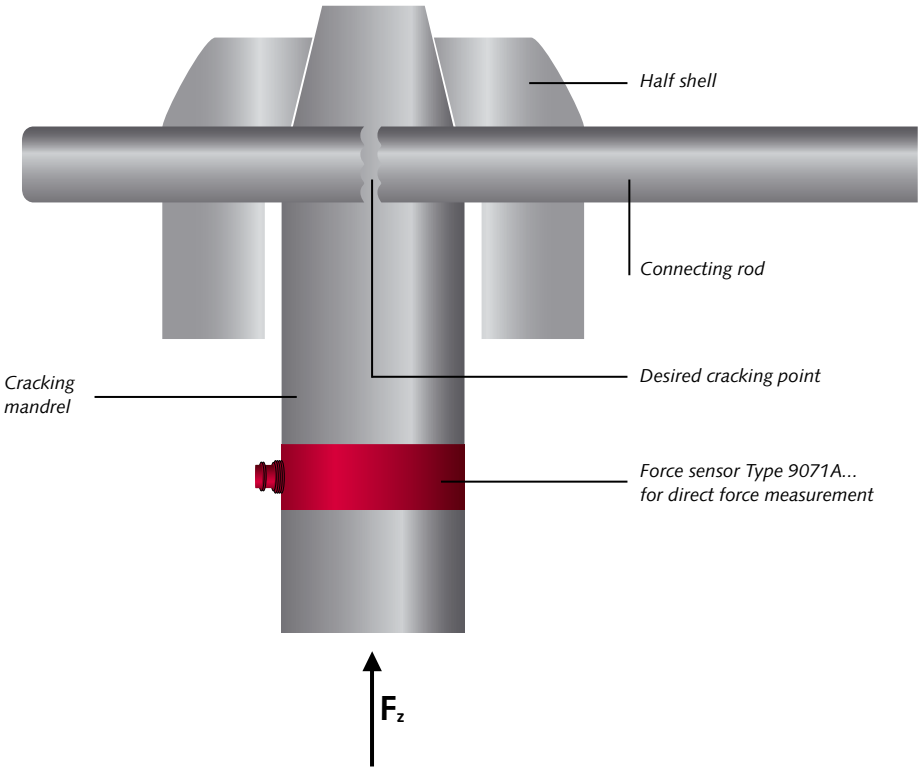
Standard equipment Alternative

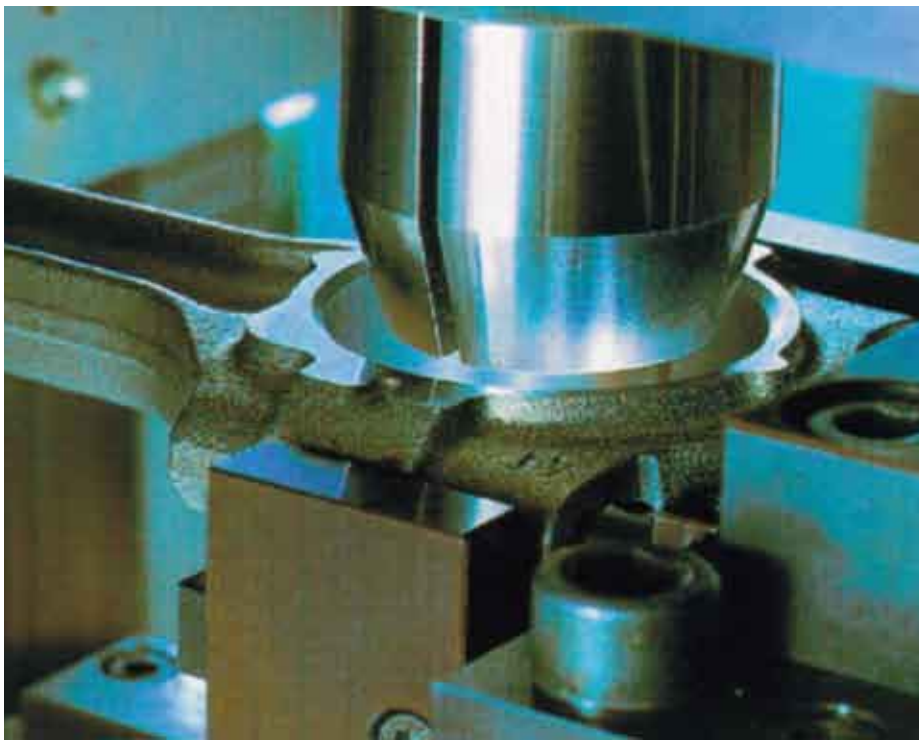
Force and Torque Measurement in Practical Applications

Today connecting rods are manufactured as single-piece precision forgings. The big end is then cracked into two parts at a predefined point so the fracture surfaces fit together exactly. Unlike flat surfaces, the interlocking microscopic irregularities produced can also resist shear forces. During the critical phase of cracking the force-time curve can be measured, monitored and documented with the CoMo Sys* ControlMonitor.

There are bearings at both ends (small and big) of the generally i-section connecting rod. The wrist pin is inserted through the small end.

Two bolts are almost always used to hold the split big end together as the "eye" of the connecting rod. The bottom, removable part is called the bearing "cap". In Europe, cracked connecting rods have been manufactured from steel (C70) since around 1995. Initially monolithic connecting rods are notched (scribed mechanically in the case of sintered rods and laser machined for steel rods) and deliberately broken (cracked) into two parts.





System with tapered mandrel (center) for cracking connecting rods

Kistler Plus Points

Monitoring of cracking with CoMo monitors offers the following advantages:

+ Detection of material failure in vendor part
+ Detection of wear in the cracking system.

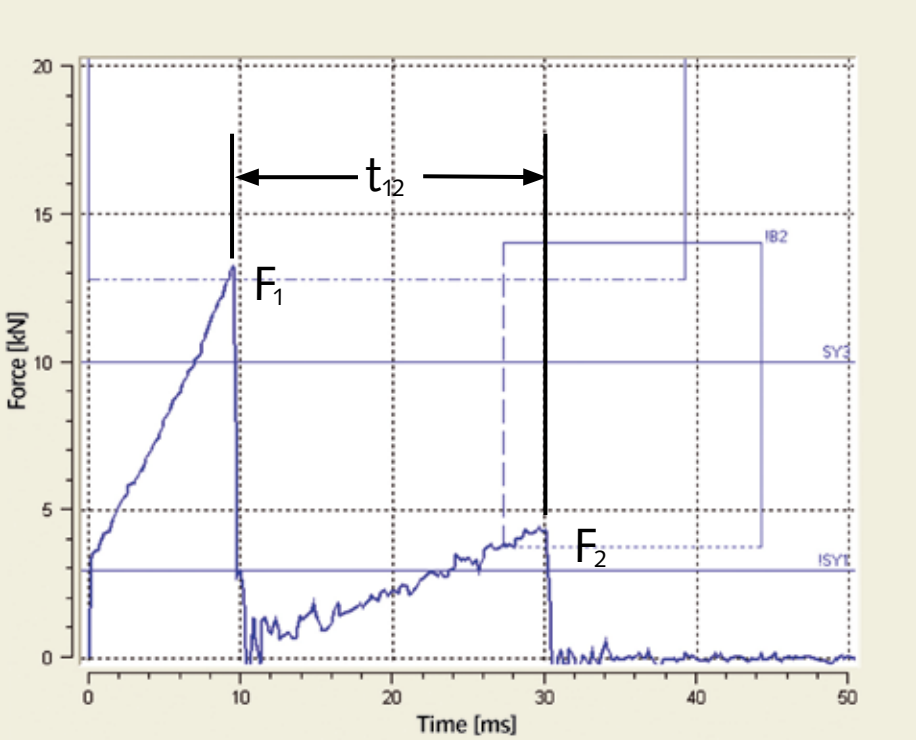
*Only available in Germany

Cracking Force Measurement

Fracture surfaces have advantages in terms of strength, cost and production accuracy. As the two parts are an exact match for assembling the connecting rod, the joint is virtually invisible afterwards. The connecting rod and its bearing cap must always remain together and cannot be replaced individually.

Process monitoring
The entire cracking process only takes milliseconds. The two fractures can be simultaneous or the second can occur after a slight delay. The force-time exhibits a virtually linear rise in force to F_1 until the first fracture occurs. It then falls to zero and climbs again virtually linearly to the value F_2. After the second fracture the force falls to zero again. The CoMo Sys* ControlMonitor is used to monitor and document for quality assurance maximum force values F_1 and F_2, their variation with time and delay t_{12} between them.

Last but not least, force monitoring makes cracking technology transparent and controllable. The automobile industry also uses it in a similar way for crankshaft bearings in engine blocks.



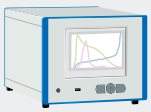
CoMo Sys® monitors force-time curve and delay (t_{12}) between peaks (F_1 and F_2) in fracture force

Machines with several cracking mandrels, each installed with a force sensor, are often used in parallel in manufacturing. The multichannel version of the CoMo Sys* is ideal for this process monitoring.

Kistler Products

- Piezoelectric force sensor Type 9071A…
- Cable Type 1631C3
- CoMo Sys ControlMonitor Type 5885A…

Measuring Chains for Cracking Force Measurement

	Measuring	Connecting	Analyzing
Measurement of cracking force with load washer, evaluation with CoMo Sys ControlMonitor	**9071A...** 	 **1631C3**	 **5885A...*** 5863A1... 5863A2...

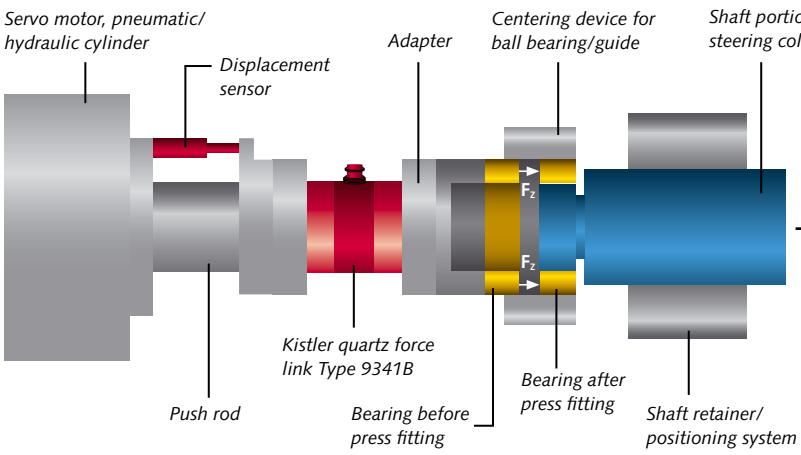
Standard equipment Alternative *Only available in Germany

Force and Torque Measurement in Practical Applications

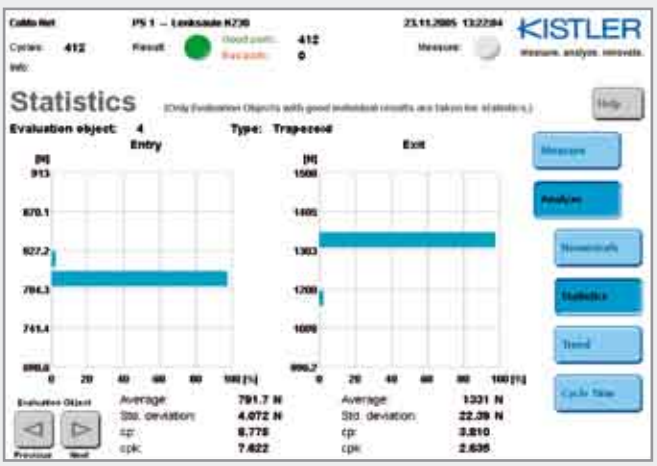
Car steering columns must meet extremely stringent safety requirements. Assembly of their components (particularly bearings) has to be monitored and documented. Force-displacement monitoring ensures reliable separation of good and bad parts and documentation of each joining operation in compliance with manufacturing guidelines for components affecting safety.

Column bearings come into this category. They are usually pressed onto a shaft so they are held by friction. Force-displacement monitoring is conventionally employed as a means of quality control of such press-fitting operations. Special quartz force links calibrated for tensile and compressive forces can be readily integrated into the push rod of the press. These links are ideal for measuring the sometimes very high joining forces. The force-displacement curve recorded using the links together with an additional displacement sensor and a ControlMonitor can be used to assess the quality of the press-fit connection.

Process monitoring
Different evaluation strategies featuring thresholds, boxes, gradients and special end positions can be used for monitoring mounting of the steering column's bearing with ControlMonitors such as CoMo View and CoMo Net.



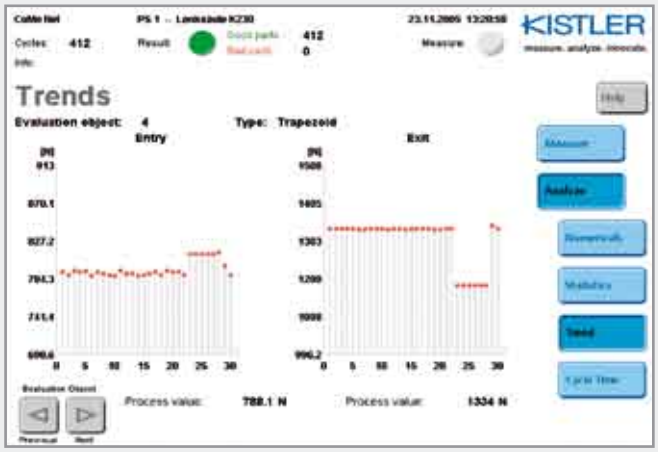
Monitoring of joining force and bearing position: box 2 monitors assembly force while boxes 3 and 4 and gradient 7 monitor joining force and box 5 end position



Histogram of entry and exit of evaluation object 4 with important statistics

Monitoring Assembly of Steering Columns

Active evaluation objects with result and process values for each cycle



Exhibited by entry and exit values of evaluation object 4

These strategies allow reliable identification of good and bad parts to ensure cars are only built with properly assem-bled steering columns. The force-displacement curve documented for each individual assembly process ensures the full traceability that has become a universal requirement. The statistical function of either CoMo Net or CoMo View documents each and every operation involved in the joining of components and assemblies affecting safety. Fast export of measurement curves and/or process data allows all relevant data to be saved on a server. More transparent processes help optimize cycle times and increase output. As such assembly lines output up to two million units per year, process monitoring is an important factor in their cost-effectiveness.

Kistler Benefits

- The compactness of piezoelectric sensors means they are more readily integrated into the existing machine environment than strain gage sensors.
- The calibrated measuring ranges, freedom from wear, long-term stability and robustness of piezoelectric sensors ensures maximum 24/7 reliability over the approximately 7-year production life cycle of a car model.
- The wide measuring range of piezoelectric sensors makes them very versatile – even in the face of changing parameters and/or operating conditions.
- Fast data export facilitates process analysis, process configuration and documentation of statistics for quality management.

Kistler Products

- Quartz force link Type 9341B…
- Standard cable Type 1631C…
- CoMo Net ControlMonitor Type 5863A1…

Measuring Chain for Force Measurement during Steering Column Assembly

	Measuring	Connecting	Analyzing
Measuring of force with press force sensors and monitoring with CoMo Sys ControlMonitor	**9341B** 9301B … 9371B 9001A … 9091A 9323 … 9363	**1631C…**	**5863A1…** 5863A2…

Standard equipment Alternative

Force and Torque Measurement in Practical Applications

During fully automated insertion of components into printed circuit boards (PCBs), the leads or pins of the electronic components have to pass through the matching holes with a minimum of friction. Mounted in the appropriate position on the assembly station, force sensors can measure these insertion forces, and ControlMonitors are used to monitor the process as a whole. If a permissible insertion force is exceeded, the assembly process is stopped extremely quickly. This avoids post-production costs and ruined circuit boards.

By the time conventional components such as capacitors, resistors, diodes, transformers, coils, filters or multiway connectors are being inserted, the boards have already passed though a whole series of production stages. As these include placement and soldering of surface mounted devices (SMDs), the printed-board assemblies (PBAs) have already acquired significant value. Reliable protection during subsequent component insertion is particularly important.

During fully automated in-line assembly, the component leads must be inserted through the matching holes with virtually no friction. Care must be taken to avoid any misaligned leads being bent or snapped on the surface of the board, which with damaged circuitry would have to be repaired or even scrapped. Operators of insertion machines can rely on high-precision line technology. However, the machines also need to compensate for variations in component geometry and dimensional discrepancies caused by earlier production steps. Thus they check the force applied for each insertion.

Controlling setting force with high-sensitivity sensor

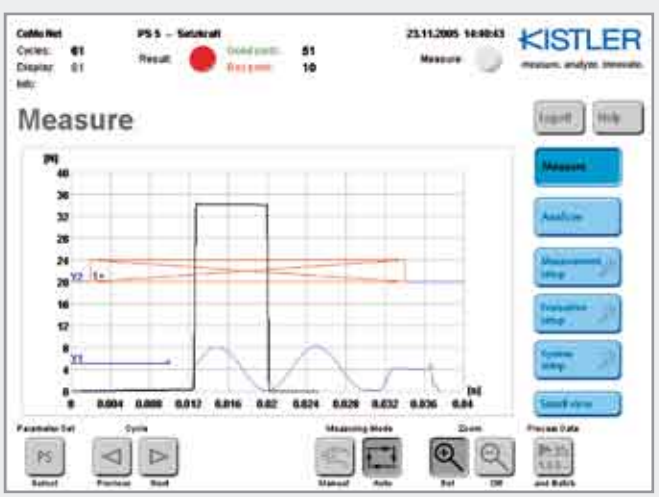
The heads of the machines are equipped with several grippers for picking up the components from the automated delivery stations and positioning them on the printed circuit board.

During component insertion the active gripper arrangement allows measurement of the involved force with a central sensor. As all grippers rotate around a fixed part of the insertion head, the measured force would be exactly zero under the ideal conditions of no lead friction. Because any forces actually encountered are very small, use of a high-sensitivity piezoelectric sensor such as Type 9215 or a force-calibrated M5 strain sensor Type 9247A is recommended.

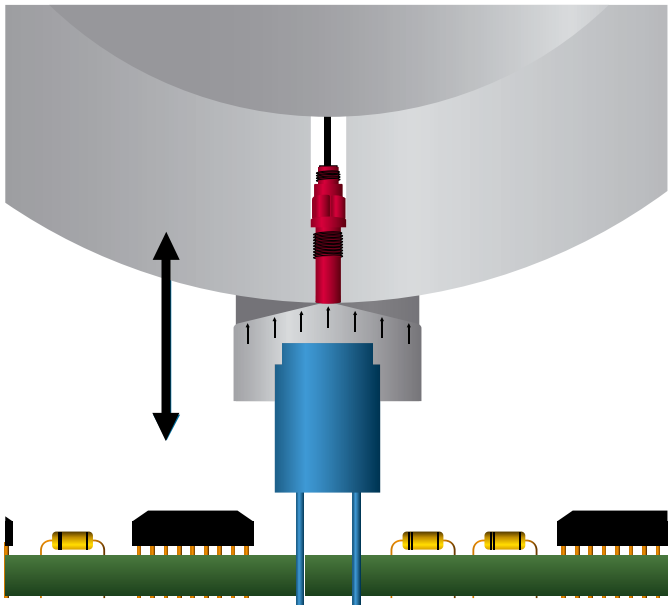
Kistler Benefits

- High-sensitivity, extremely high resolution, compact piezoelectric force sensor for small forces
- Easy integration of CoMo operation and control into existing machine control system saves hardware and engineering costs
- CoMo Net allows easy integration of monitoring processes into company LANs
- Response time of a few milliseconds
- Fast program changeover

The force measured during insertion only increases if any leads are forced onto the surface of the circuit board adjacent to the holes rather than being inserted through the actual holes, or the through-hole in the board is non existent or too small in diameter to allow passage. CoMo Net monitors a specified force threshold (Y2). If the force remains below this threshold, the insertion procedure is assessed as "OK". If it exceeds it the CoMo immediately sends a signal to one of the digital outputs. This real-time signal is registered by the machine's control system, which immediately stops the insertion process. Box 4+ is used to decide whether each



The blue curve is the reference curve for an "OK" insertion, black that for "Not OK". If the insertion force remains below the specified threshold the operation is assessed as "OK"



Monitoring Insertion Force to Protect PCBs

part is good or bad. If the signal enters the box the CoMo will send a "not OK" message. The machine operator then has to decide whether an equivalent component is to be inserted into the PCB or the board reworked.

Insertion check
As during perfect insertion the applied force will not encounter any resistance, the system monitoring the insertion force cannot detect whether a component is missing. Successful insertion is therefore checked separately. This involves clinching the component leads on the underside of the board with a defined force. This prevents components being dislodged during subsequent feeding of the PBA. Monitoring of the clinching force also provides aproof of the presence of the inserted component.

Monitoring with CoMo Net and visualization using machine's control system
Insertion machines are equipped with their own control system, with PC and touch screen. This means a networkable CoMo Net ControlMonitor, which can be integrated into machinery and corporate LANs, is ideal for monitoring insertion and clinching forces. Insertion is monitored through force-time analysis. CoMo graphics, such as the curve of the measured clinching or insertion force, are displayed on the machine's monitor. Control signals are linked directly to the PLC via digital I/Os. A "Max-Min box" superimposed on the second half of the force curve is used to evaluate clinching.

Some manufacturers of insertion machines already offer insertion force and detailed monitoring as standard.

If the clinching force does not exit the confines of the evaluation box, the existence of an assembly component is confirmed

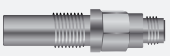
Kistler Services

- Support and engineering ensure optimal customization of Kistler sensors
- Support for process optimization and cycle time reduction

Kistler Products

- Sensor Type 9215 for small forces
- Standard cable Type 1631C…
- CoMo Net ControlMonitor Type 5863A1…

Measuring Chain for Insertion Force Monitoring

	Measuring	Connecting	Analyzing
Measurement of extremely small forces and evaluation with the CoMo Net ControlMonitor	 **9215** 9247A	 **1631C...**	 **5863A1...** 5863A2...

Standard equipment Alternative

Force and Torque Measurement in Practical Applications

Low-play planetary gearboxes are subjected to 100 % final production testing before shipping to the customer. The breakaway torque, no-load torque, operating noise, axial runout, radial runout and gearbox backlash are determined in an automated sequence. The key components of the gearbox test stand are compact torque measuring flanges from Kistler.

Two torque measuring flanges Type 4504A... with no mechanical bearings and signals transmitted without contact measure the dynamic torques on the input shaft and the output shaft, which are represented by an voltage output. The sensors are configured with the aid of the digital interface.

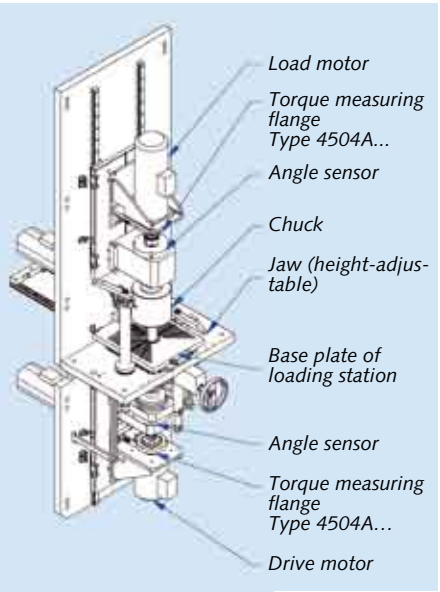
Output drive torque control allows continuous measurement and evaluation of gearbox play under constant conditions, with high-resolution angle sensors transmitting the current input and output drive positions in the microsecond range. The gearbox play is measured to a system accuracy of 10".

Optimized test procedure ensures short cycle times

To start with the model of gearbox is identified with a barcode reader. The loading station with mounted gearbox is retracted into the test chamber, where jaws clamp the gearbox in position. The bottom carriage is then raised and the motor shaft adapter coupled to the gearbox. The breakaway torque, no-load torque and operating noise are measured. Next, the top carriage is lowered and the load motor coupled to the gearbox to measure its play. The brake motor is then uncoupled and raised. The test stand measures the radial and axial runout. After the drive motor has been uncoupled and lowered the loading station is taken out of the stand to allow removal of the gearbox.

Test stand for planetary gearboxes

The dynamically recorded measurands are visualized, evaluated and saved in a process database online. The high-precision measurement results also allow conclusions to be drawn about gearbox optimization and development. The optimized test procedure shortens cycle times to boost productivity.

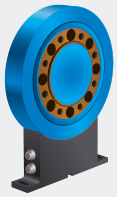


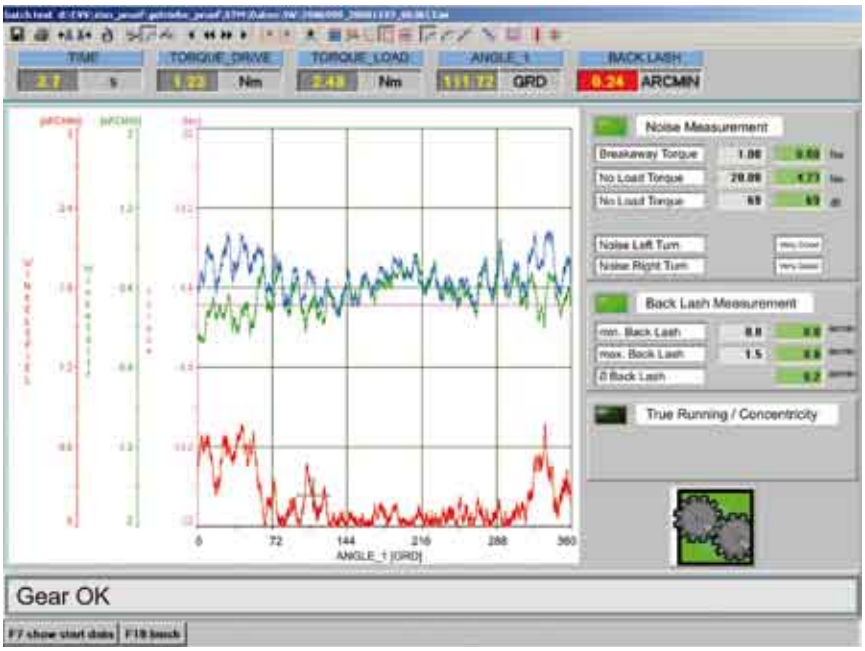
Measurement assembly

Drivetrain with torque measuring flange Type 4504A... and angle sensor

Fully Automated 100 % Testing of Gearboxes

Measuring Chain for Automated Testing of Gearboxes

	Measuring	Connecting	Analyzing
Testing of characteristic torques and evaluation with test stand control system	4504A... 	See page 111 or data sheet for cables matching sensor	



Measurement results transferred to screen of test stand control system

Kistler Services

- Engineering
- Programming
- Detailed training
- Introductory training
- Calibration
- Maintenance agreements
- Hotline
- Customer service

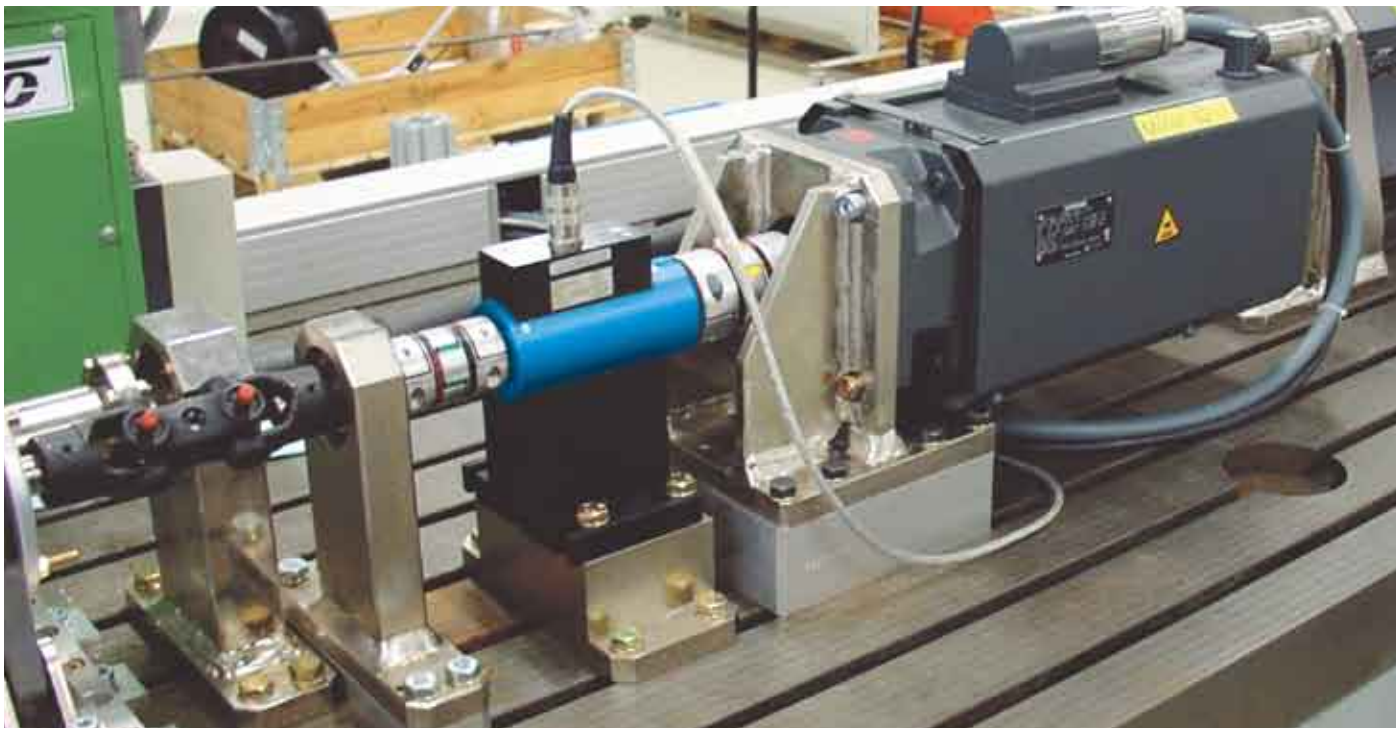
Kistler Benefits

+ Very compact torque measuring flange
+ Configurable via the RS-232C interface

Kistler Products

- Torque measuring flange Type 4504A…
- Evaluation with customized software

Force and Torque Measurement in Practical Applications



The drive unit drives the gearbox (extreme right) via the torque sensor Type 4503A... . Via an output drive the gearbox is loaded by a second motor unit to simulate flap movement. (photo: Liebherr Aerospace).

Landing flaps are extensions to the trailing edges of aircraft wings. During the approach they increase lift to enable the flying speed to be reduced for landing. To meet stringent quality requirements, the service life and wear characteristics of special gearboxes with output drive in flap control components must be tested. Realistic flap movements are simulated on a wear test stand with drive and load motors applying specific load profiles to the gearbox.

Liebherr Aerospace is a supplier of systems for business jets, feeder aircraft, wide-bodied civil aircraft, helicopters and military aircraft. These flight control, actuation and hydraulic systems include aircraft landing flaps, which require extensive realistic load tests. Special gearboxes with output drive for flat control components are checked out on a wear test stand using motors to apply specific load profiles.

To enable reliability assessment the input torque is measured as a function of speed with a Kistler sensor Type 4503A… . Incorporation of the speed measuring system into the sensor allows the drivetrain to be clearly and compactly arranged in the test bay.

CoMo Torque Type 4700A... evaluation instrument can be used to display the characteristic measurands provided by the bay. It supplies the torque measuring sensor with power and receives the measurands of torque and speed returned by the sensor. Mechanical power is calculated and displayed by the evaluation unit.

CoMo Torque Type 4700A… mounted in test cabinet to display torque, speed and mechanical input power of gearbox (photo: Liebherr Aerospace).

Gearbox Endurance Test for Landing Flap Systems

Kistler Benefits

Type 4503A…

+ Compact torque measuring system with integral speed / rotation angle measurement
+ Robust, wear-free design with noncontact digital data transmission between rotor and stator
+ Low maintenance costs
+ Available as single- or dual-range sensor
+ Sensor signal supplied as voltage, frequency or digital signal

CoMo Torque Type 4700A…

+ Conversion of any measurands into output voltage signals
+ Amplification and conditioning of small signal amplitudes
+ Displaying of torque, speed / rotation angle and mechanical power
+ Monitoring of measurands with adjustable limits
+ Full remote control via serial interface possible

Kistler Services

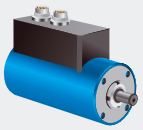
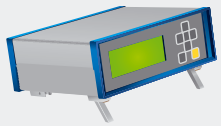
- Engineering of sensor geometries, OEM solutions
- Training in Kistler premises or on site
- Introductory training and set-up assistance
- Periodic calibration to German Calibration Service (DKD) accreditation and other official requirements
- Expert, focused hotline
- Prompt, flexible customer service

Kistler Products

- Torque sensor Type 4503A…
- Cable for analog signals Type KSM186420-5
- CoMo Torque Type 4700A… evaluation instrument

All of the measured and calculated variables are provided by CoMo Torque (which converts speed into a tachometer voltage signal) as analog voltage values, which are passed on to the measurement acquisition system based on a PC. Options include scaling of the input torque and output of the mechanical power as an analog variable. The test bay operator can define all parameters of the evaluation instrument on-site or by remote control via a serial interface.

Measuring Chain for Gearbox Endurance Test for Landing Flap Systems

	Measuring	Connecting	Analyzing
Measuring of torques and evaluation with CoMo Torque ControlMonitor	**4503A...** 	**See page 110 or data sheet for cables matching sensor**	**4700A...** 

Force and Torque Measurement in Practical Applications

Various types of suspension struts for stabilizing the tracking of vehicles are used with different elastomer bushings to improve handling. Two electromechanical NC joining modules with force-displacement monitoring have replaced four separate hydraulic machines for this purpose on a manufacturing island. This cost-effective, space-saving investment with 20 alternative programs offers low energy consumption and maintenance costs, and a very rapid return on capital expenditure.

The manufacturing island of a leading carmaker is a flexible assembly unit for various struts used for ride improvement in the axle area. The elastomer bushings improve handling as well as deadening noise and vibration.

The manufacturing island can handle various strut types and lengths with different designs of elastomer bushings. The main reason for awarding the contract for the system to a particular machine manufacturer was the advantages of the electromechanical joining systems from Kistler. The manufacturing island accommodates two electromechanical NC joining systems with integral force sensor for joining forces of up to 60 kN and a maximum stroke of 200 mm. The DMF-P A300 NCF Type 4734A… force-displacement measuring system monitors the process, the PLC of the system is a Siemens S7-315 with Profibus and a SINUMERIK operator panel front OP 012 and PCU 50.

Two NC joining systems replace four hydraulic units

The versatility of the NC joining systems enabled the automobile manufacturer to replace four individual machines with just two NC joining systems. By contrast with the hydraulic unit, the joining modules can very easily reach different end points. The additional cost of the electromechanical joining systems over separate machines with hydraulic joining units was recovered in no time at all. The NC joining systems are also more environmentally acceptable and significantly quieter than their hydraulic counterparts.

20 programs on single system

The system can be used for future struts as they evolve. The as-supplied configuration has four programs to replace four separate machines. The plan is to map up to 20 different programs onto a single system. The flexibility of the system makes it possible to cut costs by making more efficient use of the shop floor and reducing the number of personnel required.

Lower installation, energy and maintenance costs

The fast payback period of the higher investment involved in NC joining systems is the result of: lower energy consumption, reduced maintenance costs due to elimination of oil and filter changes, the compact arrangement without hydraulic units and measures to contain oil leaks, and cost-effective installation without pipework.

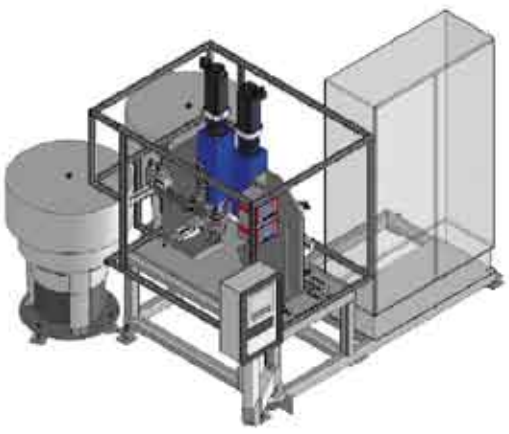
Focus on automated production sequence

The cycle time for each strut is just 10 seconds:

1. The struts are placed on a timed conveyor belt by hand.
2. Two sorting hoppers automatically feed the elastomer bushings to the press-fit units.
3. Both bushings are automatically lubricated prior to the joining operation.
4. The Kistler systems press two bushings into a strut simultaneously with a positioning accuracy of ±0,5 mm.

The standardly furnished I-P.M. interface of the force-displacement measuring system DMF-P A300 NCF ensures easy connection to an existing system employing this format. I-P.M. is used for documentation, detailed analysis and statistical process and measurement data. The system is installed on a server for accessing with a web browser. Measurement signatures can be visualized and archived for any preset period of time. The system can also automatically warn production, quality assurance or maintenance managers of any exceeded limits. Sets of limits can be monitored with the module for changing parameters. The following statistical analysis functions are available:

- EWMA
- Shewart
- Frequency curve
- Q-DAS transfer format (qs-stat)



Manufacturing island with two electromechanical NC joining systems and parts fed by two sorting hoppers

Fast, Flexible and Firm Joining

Kistler Benefits

+ Very compact arrangement
+ Very compact and no oil maintenance
+ Different end points accessible without modifications
+ Greater versatility
+ Significantly quieter
+ Low energy consumption
+ Maintenance costs cut by elimination of oil and filter changes
+ Short payback period

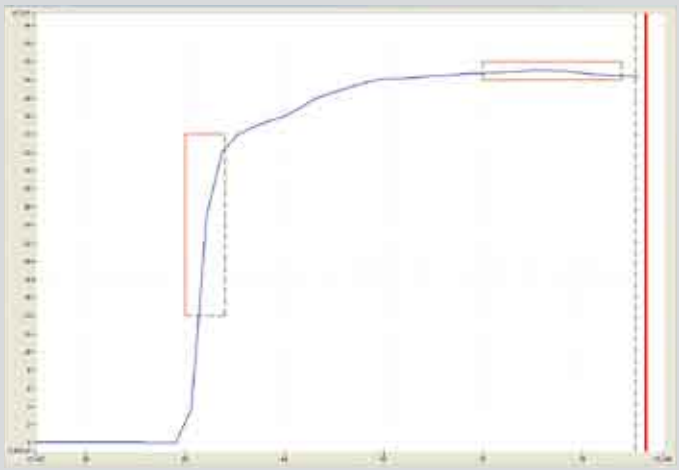
Kistler Products

- Electromechanical NC joining system NCFN Type 2153A0602003HG
- NCFN 60/100 kN IndraDrive 70 A PB Type KSM031634
- NCF SSI displacement IndraDrive Type KSM301750-5
- NCFN(S) strain gage force cable Type KSM206000-5
- Force-displacement measuring system DMF-P A300 NCF Type 4734A…
- TraceControl – Software for force-displacement measuring systems Type 4735A

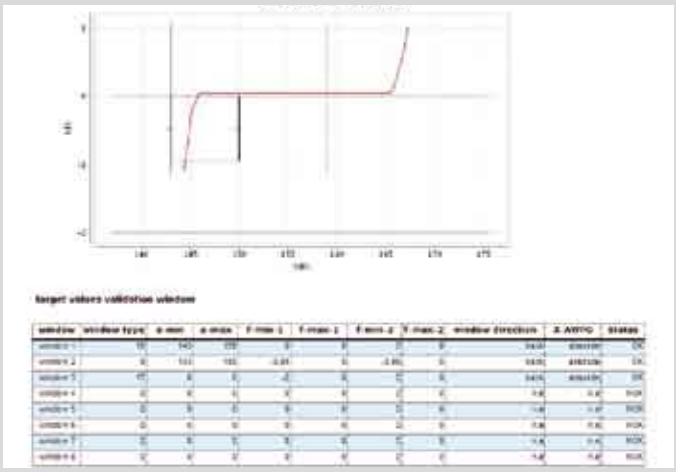
Kistler Services

- Support with start up
- Parameter configuration

Two electromechanical NC joining systems press elastomer bushings into struts



Typical force-displacement curve in joining process, visualized by Kistler TraceControl (Freeware)
1. Window type 3 for monitoring increase in force
2. Window/Box type 1 for monitoring the min/max force during joining
3. Window/Box 0 for monitoring the end point



I-P.M. used for documentation as well as extended analysis and statistics of process and measurement data.

Measuring Chain for Joining of Elastomer Bushings

	Measuring	Connecting	Analyzing
Indirect measurement of joining force and force-displacement monitoring in the system	**2153A...** 	**See page 136 or data sheet for cables matching NC joining system**	**4734A...** 

Force and Torque Measurement in Practical Applications

NC joining system NCFH used to press-fit bearings on production line

Compactness of hollow-shaft motor allows 795 mm long NC joining module NCFH to offer 400 mm stroke

Very accurate positioning and repeatability is vital when pressing small bearings into a housing or delicate gears into miniature gearing. Electromechanical NC joining systems with integral force-displacement monitoring combine joining and quality assurance in a single operation; their piezoelectric force sensors allow highly dynamic monitoring of minute joining forces.

The electromechanical NC joining systems NCFH Type 2151B… with integral piezoelectric force sensors have a special AC hollow-shaft motor mounted on the actual spindle. The spindle connected to the ram of the press translates along the axis of rotation of the motor when actuated directly by the spindle nut. This arrangement avoids belts and gearing and eliminates positioning and control discrepancies caused by slippage.

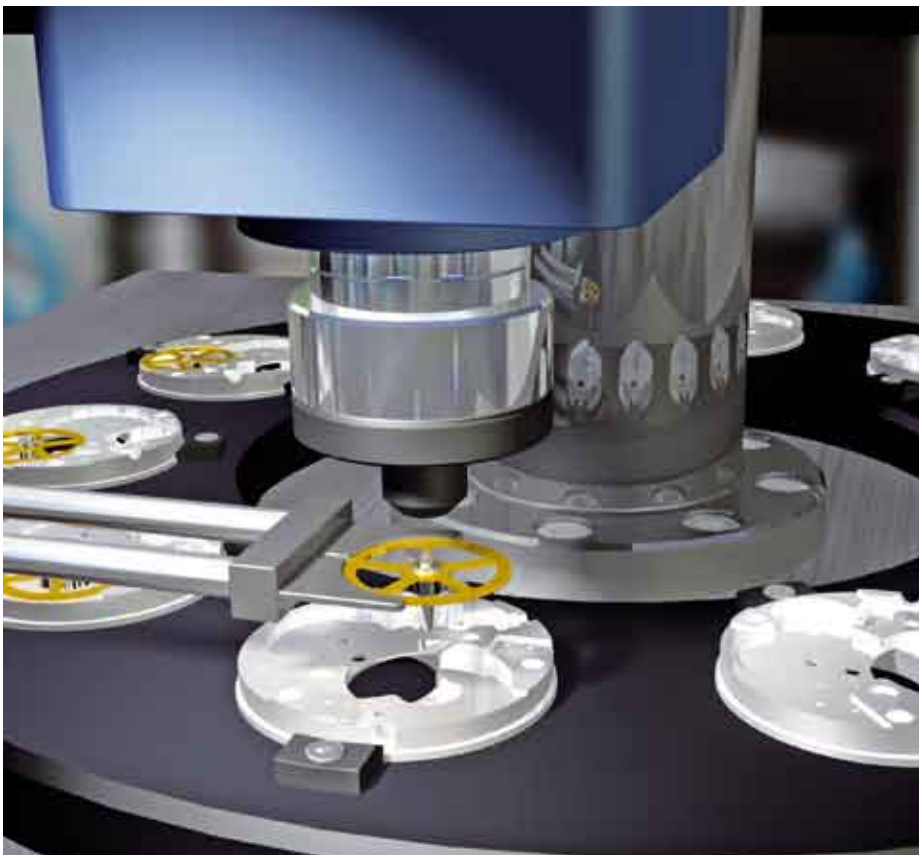
Their unrivalled shortness and compactness makes the NCFH modules suitable for even under-bench mounting. From an overall length of only about 475 or 795 mm, they generate a stroke of 200 or 400 mm, which allows deep end points, such as bearings in half-shell gearboxes, to be reached.

Benefits of Kistler NC Joining System NCFH

+ Gearing eliminated by hollow-shaft motor design
+ Hollow-shaft motor mounted directly on threaded spindle drive
+ Long spindle stroke despite compact dimensions
+ Active compression compensation system
+ Force control system
+ Standard holding brake
+ Highly responsive operation
+ Ideal for under-bench mounting

Press Fitting with Extremely Small Forces

Indexing table in industrial clock manufacture with feed station for press fitting gears



NC joining system NCFT pressing shaft-mounted gears into clock movement with force-displacement monitoring

NC joining systems even for miniscule forces

With its integral piezoelectric force sensor and nominal joining force of 1 kN the electromechanical NC joining system NCFT Type 2157A… is suitable for both automated precision manufacture and standalone workstations required to offer high sensitivity and dynamics in a very compact package.

Its extremely high repeatability of 0,005 mm and speed of up to 300 mm/s are designed to accommodate fast, highly-precise cycles with short return strokes. The slender profile allows close spacing of neighboring stations on an assembly line. The measuring ranges of 0,25 kN, 0,5 kN and 1 kN meet even the most stringent requirements, as in industrial clockmaking.

The NC joining system consists of the NC joining module NCFT Type 2157A..., the force-displacement measuring system DMF-P A300 NCF Type 4734A... and the IndraDrive servo controller. The electronics in this controller monitor the operating range of the threaded spindle drive. The powerful and versatile force-displacement monitoring system displays the force curve and uses fully programmable tolerance windows to continuously evaluate all phases of the assembly process.

Advantages of Kistler NC Joining System NCFT

+ Compactness
+ Particularly slender profile
+ Low joining forces for precision manufacture
+ Measuring ranges of 0,25, 0,5 and 1 kN
+ Repeatability of 0,005 mm
+ Highly responsive operation
+ Extremely high speed of up to 300 mm/s

Other Force and Torque Applications in Manufacturing, Assembly and Testing

Assembly and product testing are just two of the many industrial applications in which force, torque or strain measurement plays a major role. Kistler sensors also measure highly dynamic production processes involved in operations such as primary forming, re-shaping, cutting and machining, and in all joining procedures such as punching and welding. The sensors help monitor, document and ultimately improve the quality of the manufactured product.

Used for measuring and monitoring, piezoelectric sensors offer numerous advantages. To mention just one their wide measuring range generally protects them against overload. They are ideal for measuring dynamic and cyclical processes and have a virtually unlimited service life.

Only piezoelectric measuring chains tailored to the application will deliver optimal results. Their sensors, cables, charge amplifiers and display and evaluation equipment can be used for monitoring, testing, closed-loop control and open-loop control of a wide variety of manufacturing processes.

The practical value of sensors used to monitor assembly processes and test products is discussed in detail in this catalog. However, their ability to measure force, torque, pressure and acceleration is also useful in other areas of industrial production.

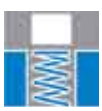
Joining
During joining processes in general and longitudinal presswork, clinching and bonding to produce permanently joined parts in particular, deviations within large-scale production processes are best monitored by measuring the applied force. Process monitoring allows documentation of the joining process, an objective means of detecting good and bad parts, and continuous checking of the machine's condition.

Measuring the force during crimping of the ends of cables ensures reliable electrical contacts for consistently high-quality volume production. Measuring the electrode clamping force during resistance welding optimizes joint quality in applications such as vehicle body manufacture.

Measuring the strain proportional to the force in the structures of clinching tools, riveting tools and wobble-riveting machines ensures reliable monitoring of these widely used joining methods.

Primary forming
The molding of powder or melt into a solid body is referred to as primary forming. Application of the correct amount of force and pressure plays a key role in this process. Versatile and reliable force measurement technology optimizes the shape, density and hardness of parts produced by powder compaction, such as tablets, pellets or sintered metals, and of metal die castings. The main benefit of process force monitoring is the production of finished parts within a specified tolerance range.

Testing


Elastic force


Contact force


Connector force


Rotary switches


Torque

Joining


Crimping


Screw connection

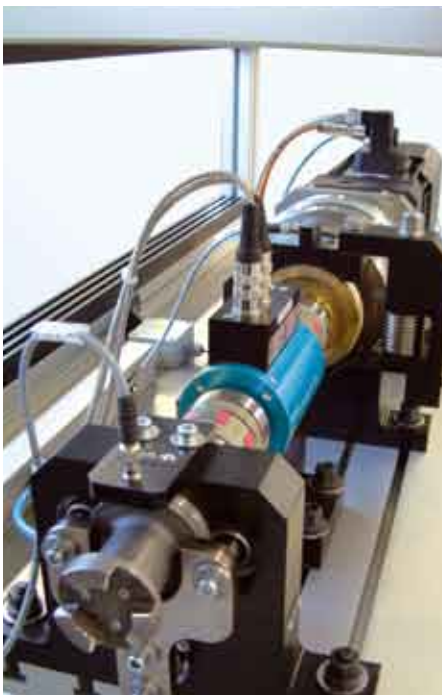

Riveting


Spot welding


Bonding


Press fitting


Clinching



Re-shaping
Piezoelectric force sensors promptly reveal any defects or errors during re-shaping processes such as embossing, sheet metal rolling, deep drawing, forging, punching or stamping of metal blanks.

On-line monitoring of process forces helps detect dimensional and material errors as well as insertion discrepancies to protect against damage or overstressing of machinery, tools, molds and workpieces.

Cutting and machining
Piezoelectric force sensors and dynamometers with up to three components monitor the cutting force during machining processes such as turning, milling, grinding or drilling. This yields significant data on the cutting, feed and passive forces involved. Preliminary analysis of cutting forces improves process capability for large-scale production. Monitoring of these forces subsequently helps detect overloading, tool collisions and tool damage.

Test stand systems
Test stand systems with torque sensors are indispensable for end-of-line testing of electric motors, converters or gearboxes. Optimal operation of such systems basically depends on choosing the right mechanical and instrumentation components. Tried and tested modules and reliable mechanical, electrical, hardware and software systems ensure extremely accurate measurement over long periods of time.

Kistler test stand systems have proven effective over the decades in R&D as well as production and quality assurance. Their project portfolio includes mechanical components such as drive measurement add-ons with torque sensors, small test stands with torque-speed measurement and manual or external control, and computer-controlled turnkey solutions for analysis and documentation of electrical machinery.

Cutting | *Primary forming* | *Re-shaping*

Setting force | *Grinding* | *Drilling* | *Turning* | *Milling* | *Tapping* | *Powder pressing* | *Sheet metal rolling* | *Embossing* | *Punching* | *Deep drawing*

Selection Criteria for Force Sensors

Single-Component Force Sensors

Direct Force Measurement

Piezoelectric sensors

F_z sensors						
Type		9001A … 9091A	9101A … 9107A	9130B … 9137B	9130BA … 9137BA	9601A1…
Name		Load washer	Load washer	SlimLine sensor	SlimLine assembly kit	VarioComp
Measuring direction		↓	↓	↓	↓	↓
Measuring range	kN	0 … 0,75 to 0 … 1 200	0 … 20 to 0 … 700	0 … 2,5 to 0 … 80	0 … 2,5 to 0 … 80	0 … 30
Further details on page		72	73	74	74	83

Calibrated measuring elements				
Type		9173B … 9176B	9313AA …	9323A … 9363A
Name		Quartz force link	Press force sensor	Press force sensor
Measuring direction		↓	↓	↓
Measuring range	kN	0 … 12 to 0 … 60	0 … 0,05 to 0 … 20	0 … 0,1 to 0 … 120
Further details on page		76	81	81

Calibrated force links		
Type		9301B … 9371B
Name		Quartz force link
Measuring direction		↕
Measuring range	kN	–2,5 … 2,5 to –120 … 120
Further details on page		80

High-sensitivity calibrated measuring elements for very small forces						
Type		9203	9205	9207	9215	9217A
Name		Sensor for small forces	Sensor for small forces	Sensor for small forces	Sensor for small forces	Sensor for small forces
Measuring direction		↕	↕	↕	↓	↕
Measuring range	N	–50 … 50 to –500 … 500	–0,5 … 0,5 to –50 … 50	–0,5 … 0,5 to –50 … 50	0 … 2 to 0 … 200	–5 … 5 to –500 … 500
Further details on page		77	78	78	79	79

Calibrated measuring elements, miniature force sensors			
Type		9211/9211B	9213/9213B
Name		Miniature force sensor	Miniature force sensor
Measuring direction		↓	↓
Measuring range	kN	0 … 0,25 to 0 … 2,5	0 … 0,25 to 0 … 2,5
Further details on page		76	77

Single-Component Force Sensors

Direct Force Measurement

Calibrated measuring elements for very large forces		
Type		9931A ...
Name		MN press force calibration sensor
Measuring direction		↓
Measuring range	MN	0 … 2,5 to 0 … 20
	kN	0 ... 2 500 to 0 ... 20 000
Further details on page		83

Force sensor			
Type		9602A1…	9602AA ...
Name		Force transmitter	Force transmitter
Measuring direction		↓	↓
Measuring range	kN	–5 … 5	0 … 25
Further details on page		84	84

Calibrated force transmitter, force link				
Type		9337A…	9831C…	9833C…
Name		Press force transmitter	Welding force calibration transmitter	Welding force calibration transmitter
Measuring direction		↓	↓	↓
Measuring range	kN	0 … 2 to 0 … 70	0 … 5 to 0 … 45	0 … 5 to 0 … 25
Further details on page		82	85	85

F_y sensors		
Type		9143B … 9147B
Name		SlimLine sensor (shear)
Measuring direction		↙
Measuring range F_y	kN	–0,9 … 0,9 to –8 … 8
Further details on page		75

SG-sensors

F_z sensors			
Type		4576A ...	4577A ...
Name		Tensile and compression sensor	Miniature compression force sensor
Measuring direction		↕	↓
Measuring range	kN	–0,5 … 0,5 to –200 … 200	0,1 ... 200
Further details on page		86	87

Selection Criteria for Force Sensors

Single-Component Force Sensors

Shunt Force Measurement

F_z sensors					
					
Type		9101A … 9107A	9130B … 9137B	9130BA … 9137BA	9601A1…
Name		Load washer	SlimLine sensor	SlimLine assembly kit	VarioComp
Measuring direction		↓	↓	↓	↓
Measuring range	kN	0 … 20 to 0 … 700	0 … 2,5 to 0 … 80	0 … 2,5 to 0 … 80	0 … 30
Further details on page		73	74	74	83

Force sensor			
			
Type		9602A1…	9602AA …
Name		Force transmitter	Force transmitter
Measuring direction		↓	↓
Measuring range	kN	–5 … 5	0 … 25
Further details on page		84	84

F_y sensors		
		
Type		9143B … 9147B
Name		SlimLine sensor (shear)
Measuring direction		↙
Measuring range F_y	kN	–0,9 … 0,9 to –8 … 8
Further details on page		75

Single-Component Force Sensors

Indirect Force Measurement

Piezoelectric strain sensors


Type		9232A	9237A…
Name		Surface strain sensor	Surface strain sensor
Measuring direction		↔	↔
Measuring range	με	–600 … 600	–800 … 800
Further details on page		101	100

Piezoelectric strain transmitter

Type		9238A…
Name		Surface strain transmitter
Measuring direction		↔
Measuring range	με	–800 … 800
Further details on page		100

Piezoelectric measuring pins




Type		9241C…	9243B…	9245B…	9247A…
Name		Transverse measuring pin	Longitudinal measuring pin	Longitudinal measuring pin	Longitudinal measuring pin
Measuring direction		↕	↕	↕	↕
Measuring range	με	–0 … 500	–1 500 … 1 500	–1 500 … 1 500	–1 400 … 1 400
Further details on page		102	102	103	103

Selection Criteria for Force Sensors

Multicomponent Force Sensors

Direct Force Measurement

Sensors									
Type		9017B/9018B	9047C/9048C	9067/9068	9067C/9068C	9077C/9078C	9251A/9252A	9601A2…	9601A3…
Name		3-comp. force sensor	3-comp. force sensor	3-comp. force sensor	3-comp. force sensor	3-comp. force sensor	3-comp. force sensor	3-comp. force sensor	3-comp. force sensor
Measuring direction									
Meas. range F_x, F_y	kN	–1 … 1	–15 … 15	–20 … 20	–30 … 30	–75 … 75	–2,5 … 2,5	–2,5 … 2,5	–2,5 … 2,5
Meas. range F_z	kN	–2 … 2	–30 … 30	–40 … 40	–60 … 60	–150 … 150	–5 … 5	–5 … 5	–5 … 5
Further details on page		89	90	90	91	92	89	95	95

Force sensor		
Type		9602A3…
Name		3-comp. force transmitter
Measuring direction		
Meas. range F_x, F_y	kN	–5 … 5
Meas. range F_z	kN	–5 … 5
Further details on page		96

Calibrated force link						
Type		9317B	9327A/9328A	9347C/9348C	9367C	9377C/9378C
Name		3-component force link	3-component force link	3-component force link	3-component force link	3-component force link
Measuring direction						
Meas. range F_x, F_y	kN	–1 … 1	–2,5 … 2,5	–15 … 15	–30 … 30	–75 … 75
Meas. range F_z	kN	–2 … 2	–5 … 5	–30 … 30	–60 … 60	–150 … 150
Further details on page		92	93	93	94	95

Calibrated 2-component M_z/F_z measuring element			
Type		9345B	9365B
Name		M_z/F_z measuring element	M_z/F_z measuring element
Measuring direction			
Meas. range F_z	kN	–10 … 10	–20 … 20
Meas. range M_z*	N·m	–25 … 25	–200 … 200
Further details on page		82, 107	82, 107

*) Reaction torque

Selection Criteria for Torque Sensors

Torque Sensors

Reaction Torque Sensors

Sensors		
Type		9039 … 9069
Name		Torque sensor
Measuring direction		
Measuring range	N·m	–5 … 5 to –200 … 200
Further details on page		105

Calibrated measuring elements		
Type		9329A … 9389A
Name		Reaction torque sensor
Measuring direction		
Measuring range	N·m	–1 … 1 to –1 000 … 1 000
Further details on page		106

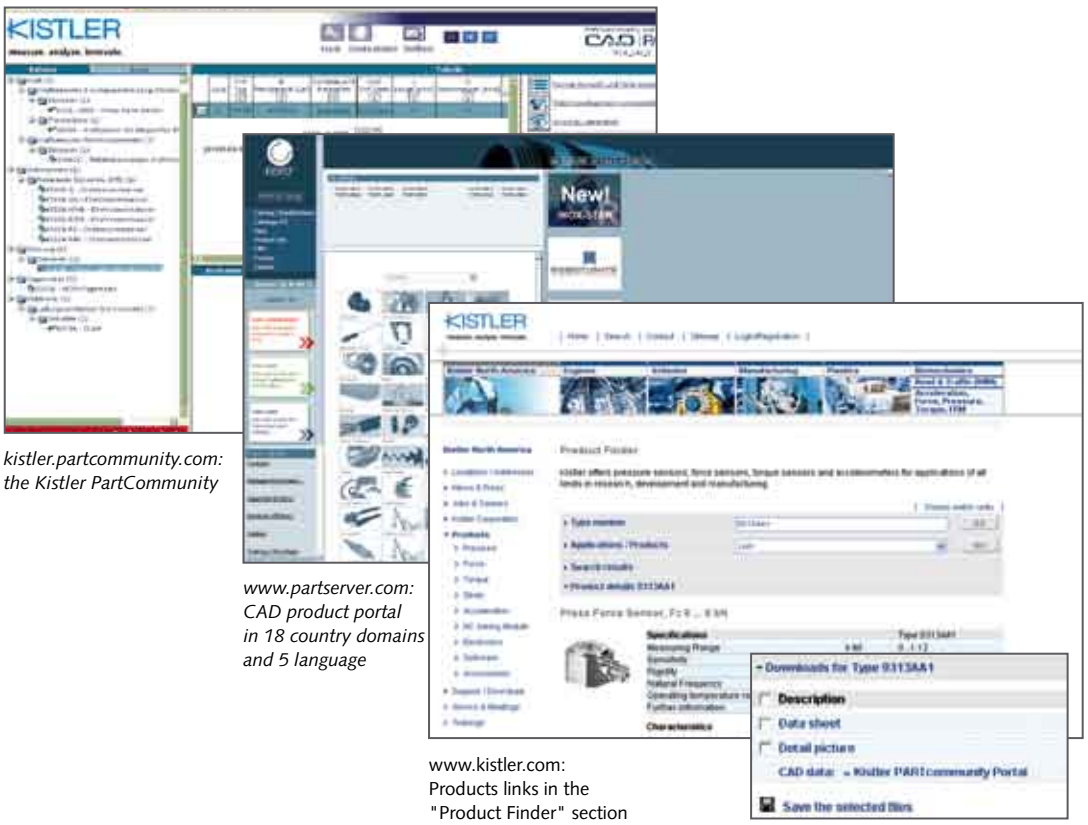
Calibrated 2-component M_z/F_z measuring element			
Type		9345B	9365B
Name		M_z/F_z measuring element	M_z/F_z measuring element
Measuring direction			
Meas. range F_z	kN	–10 … 10	–20 … 20
Meas. range M_z*	N·m	–25 … 25	–200 … 200
Further details on page		82, 107	82, 107

*) Reaction torque

Rotating Torque Sensors

Sensors					
Type		4501A…	4502A…	4503A…	4504A…
Name		Slip ring torque sensor	MiniSmart torque sensor	Dual-range torque sensor	Torque measuring flange
Measuring direction					
Rated torque	N·m	2 ... 1 000	0,5 ... 1 000	0,2 ... 5 000	50 ... 5 000
Further details on page		109	109	110	111

Kistler CAD Download Service



kistler.partcommunity.com: the Kistler PartCommunity

www.partserver.com: CAD product portal in 18 country domains and 5 language

www.kistler.com: Products links in the "Product Finder" section

To enable integration of Kistler products into CAD designs, the Kistler CAD Download Services offers prospective and existing customers 3D CAD models free of charge. These can be quickly and easily downloaded from the internet and used directly in CAD designs. Twenty four different file formats are available for the numerous CAD systems. The service can also be employed to download data sheets in the form of PDF files and 2D drawings as DXF files.

The Kistler CAD download service can be accessed in three different ways:

- On the Kistler homepage **www.kistler.com > Products > Product-Finder** using direct product links ("deep links") in the download
- Using the CAD product portal **www.partserver.com**, which can be accessed in 18 country domains and 5 languages
- Through the Kistler PartCommunity: **http://kistler.partcommunity.com**

Selection Criteria for Charge Amplifiers

Charge amplifiers									
Type		5015A...	5070A...	5073A...	5027A...	5030A...	5037B...	5041E...	5058A...
Name		Charge meter		ICAM		MiniAmp			
Application sector		Laboratory	Laboratory	Industry	Industry	Industry	Industry	Industry	Industry
Main application	Conversion of a charge output by a piezoelectric sensor into a voltage signal	Plus display of the mechanical measurand and quick changes to setup.	Display of the mechanical measurand and quick changes to setup.	All-purpose standard amplifier for demanding industrial environments	Can be integrated into existing machine structures very effectively.	Miniature amplifier for confined spaces.	All-purpose standard amplifier for demanding industrial environments.	Panel mounted version. Gain easily adjusted with thumbwheel switch.	Suitable for side-by-side mounting in 19" rack. Ideal for multichannel applications.
Meas. range for FSO min. [pC] 0 .... ±		2	200	100	150	100	20	100	10
Meas. range for FSO max. [pC] 0 ... ±		2 200 000	600 000	1 000 000	450 000	10 000	650 000	100 000	1 000 000
Number of measuring channels		1	4 / 8	1 ... 4	1	1	1	1	1
Number of measuring ranges per measuring channel		1	1	2	1	2	1	1	5
Measuring range switching via				digital input		digital input			digital input
Measuring range switching when measuring				■					■
Output signal		±2/2,5/5/10	±10 V	±10 V	±5 V	±10 V	±10 V	±10 V	±10 V
Sum signal from n measuring channels			■	■					
Peak memory (+peak, -peak)		+P, -P	+P, -P	+P, -P, (P-P)/2					+P, -P
Track hold memory		■							■
Reset using semiconductor switch (option)							■		
Overload monitoring signal (dig. out)									■
Electrical isolation of input/output									■
Signal input (type/connector)		BNC neg.	BNC neg.	BNC/TNC	KIAG 10-32	KIAG 10-32	BNC/TNC/ KIAG 10-32	BNC neg.	MiniCoax/ BNC
Signal output (type/connector)		BNC	D-Sub	D-Sub	DIN 45326	M12 8-pole	PC/terminal	Terminal	DIN 41612
Cut-off frequency (–3 dB)		200 kHz	45 kHz	20 kHz	10 kHz	10 kHz	30 kHz	50 kHz	80 kHz
Selectable filter		■	■	■					■
Adjustable zero point offset				■					
RS-232C (S = setup, M = measurement data)		S, M	S, M	S, M		S, M			
IEEE-488 (S = setup, M = measurement data)		■	S, M						
Power supply		115 / 230 VAC	100 ... 240 VAC	24 VDC	24 VDC	24 VDC	±15 V	±15 V / 24 V	±15 V
Display for measurements and setting up		■	■						
Mounting	For panel mounting	■	■		■			■	
	Screw mounted			■	■	■	■		
	Unit for 19" rack system	■	■						■
	Desktop case	■	■						
Setup	Turn and click knob	■	■						
	Potentiometer / DIP switches				■		■		■
	PC tool ManuWare (RS-232C)			■					
	Thumbwheel switch							■	
Degree of protection to IEC/EN 60529		IP40	IP40	IP 60/65	IP65	IP65	IP60/IP65/IP67	IP40	IP40
Further details on page		113	114	115	116	116	117	117	118

ControlMonitors






Type		5863A2...	5863A1...	5885A...*	5875A....	4700A...	5629A2
Name		CoMo View®	CoMo Net®	CoMo Sys®	CoMo Logic®	CoMo Torque	Terminal
Main application	Monitoring of relationships between two measurands such as force and displacement or torque and rotation angle. Produces as a good or bad signal to the PLC.	Measurement and monitoring module with graphical display	Measurement and monitoring module (black box), visualization with CoMo View, channel expansion module for CoMo View.	Measurement and monitoring system for special custom applications, very universal and versatile.	Measurement and monitoring module for one measurand as a function of time, evaluation with three thresholds.	Measurement and monitoring system for torque sensors, measurement of torque and speed/rotation angle, calculation of mechanical power.	Can be networked purely as a monitor and control unit with CoMo Net / CoMo View.
Number of measuring channels per unit		1 (x/y)	1 (x/y)	1 … 7/8 (x/y)	1 (y)	2 (y)	
Relationship between the measuring channels		y = f(x), y = f(t)	y = f(x), y = f(t)	y = f(x), y = f(t)	y = f(t)	y1 = M(t), y2 = n(t)	
Sensor channel X	Potentiometer	■	■	■			
	SSI	■	■	■			
	Incremental (A+B track)	■	■	■			
	Process signal	±10 V	±10 V	±10 V			
Sensor channel Y	Piezoelectric	■	■	■	■		
	Strain gage	■	■	■		■	
	Process signal	±10 V	±10 V	±10 V		±10 V	
	Frequency signal					≤300 kHz	
	Incremental (A+B track)					■ (speed, angle)	
Cascadable up to n pairs of x/y channels		24	no limits	24			
Number of parameter sets		16	16	16 per channel	8	20	
Switching between parameter sets		dig. in/bus	dig. in/bus	dig. in/bus/LAN/ RS-232C	dig. in	RS-232C/USB	
Evaluation methods	Evaluation windows (boxes)	■	■	■			
	Envelope curve			■			
	Monitoring of fitting force	■	■	■			
	Hysteresis	■	■	■			
	Gradient	■	■	■			
	Min - max thresholds	■	■	■		■	
Real-time thresholds y, x		y, x	y, x	y, x	y	y	
Sampling rate [S/s]		10 kHz/channel	10 kHz/channel	10 kHz/channel	10 kHz	10 kHz	
Memory depth (pairs of values per cycle)		1 000	1 000	1 000	480	5 000	
Interfaces / bus types	Profibus	■	■	■			
	Ethernet	■	■	■			■
	RS-232C	■	■	■	■	■	
	USB 2.0			■		■	
	Dig. I/O (24 V)	■	■	■	■	■	
Setup / visualization with	Web browser	■	■				■
	PC tool ManuWare	■	■	■			
	Remote maintenance	■	■	■		■	■
	Graphical display	■		■	■		■
	Alphanumeric display				■	■	
Export	Q-DAS transfer format (qs-stat)	■	■	■			
	CSV	■	■	■	■		
	XML	■	■				
	HTML	■	■				
Mounting	Panel mounted	■			■		
	Wall mounted						■
	Unit for 19" rack system			■	■		
	Desktop version	■		■	■	■	
	DIN rail mounted		■				
Degree of protection to IEC/EN 60529		IP40/IP65	IP40	IP54	IP40	IP40	IP65
Power supply		24 VDC	24 VDC	100 … 230 V	24 VDC	115/230 VAC	24 VDC
Further details on page		123	122	125	121	126	124

*Only available in Germany

Selection Criteria for ControlMonitors and Monitoring Units

Monitoring units				
Type		4734A…	4737A…	4733A…
Name		DMF-P A300 NCF	DMF-P A300	DMF-P A400 advanced
Main application	Monitoring of joining and press-fit processes. Supplying of result as a good or bad signal to the PLC.	Measurement and monitoring system specifically for electromechanical NC joining modules (e.g. NCFH Type 2151B… etc.)	Measurement and monitoring system for general joining and press-fit processes.	Dual-channel measurement and monitoring system for general joining and press-fit processes. Two independent channels in a single unit.
Number of measuring channels per unit		1 (x/y)	1 (x/y)	2 (x/y)
Relationship between the measuring channels		y = f(x)	y = f(x), y = f(t)	y = f(x), y= f(t)
Sensor channel x	Potentiometer		■	■
	SSI	■	■	■
	Incremental	■	■	■
	Process signal		±10 V	±10 V
Sensor channel y	Piezoelectric	Mounted in the NC joining module	■	■
	Strain gage	■	■	■
	Process signal	±10 V	±10 V	±10 V
Cascadable up to n pairs of x/y channels				8
Number of parameter sets		32	32	32 per channel
Switching between parameter sets		dig. in/bus/LAN	dig. in/bus/LAN	dig. in/bus/LAN
Evaluation methods	Evaluation windows (boxes)	■	■	■
	Monitoring of fitting force	■	■	■
	Hysteresis	■	■	■
	Gradient	■	■	■
	Inflection point	■	■	■
Real-time thresholds y, x		y, x	y, x	y, x
Sampling rate [S/s]		5 kHz	5 kHz	5 kHz per channel
Memory depth (pairs of values per cycle)		4 000	4 000	4 000 per channel
Interfaces / bus types	Profibus	■	■	■
	Interbus S		□	□
	DeviceNet		□	□
	ProfiNet I/O	□	□	□
	Ethernet	■	■	■
	RS-232C	■	■	■
	Dig. I/O (24 V)	■	■	■
Web browser		■	■	■
Remote maintenance		■	■	■
Graphics display		■	■	■
Export	Q-DAS transfer format (qs-stat)	■	■	■
	I.-P.M. data format	■	■	■
	CSV	■	■	■
	TXT	■	■	■
Mounting	Panel mounted	■	■	■
	Wall mounted	■	■	■
	Desktop version	■	■	■
Degree of protection to IEC/EN 60529		IP40/IP54	IP40/IP54	IP40/IP54
Power supply		24 VDC	24 VDC	24 VDC
Further details on page		137	127	128

Key: ■ = *standard* □ = *option (alternative)*

Measuring

When it comes to measuring dynamic forces, Kistler mainly relies on the piezoelectric principle. Under mechanical load piezoelectric materials produce positive or negative electric charges. Charge amplifiers convert the charge generated by the piezoelectric material into a proportional voltage. Quartz disks with piezoelectric properties can be arranged in sensors to measure one or several force components or one torque vector.

Kistler provides the following piezoelectric sensors for assembly and product testing:
- Single-component force sensors
- Multicomponent force sensors
- Strain sensors
- Torque sensors

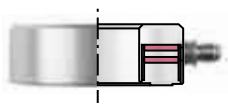
Strain gage technology is the preferred method of measuring torque on rotating shafts. For use in product and component testing Kistler therefore supplies:
- Strain gage torque sensors for rotating shafts

Single-component force sensors
Single-component force sensors, various types of which are available, are particularly suitable for measuring forces in one defined direction. The so-called load washer is one of these designs that is ideal for practical applications. Preloaded between two special nuts, the washer forms a force link. The preloaded sensor is ideal for measuring tensile and compression forces. In sensors for measuring small forces, the piezoelectric effect exhibited by slender quartz rods results in sensitivity around thirty times that of a load washer.

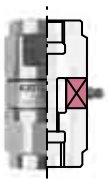
Multicomponent force sensors
In multicomponent force sensors, a pair of quartz rings cut for the longitudinal effect measures the normal component F_z of forces acting on the sensor, while each of two pairs of rings cut for the shear effect measures one of the two shear components (F_x and F_y). Multicomponent force sensors are usually mounted in groups of three or four in a dynamometer or force plate rather than individually. Most Kistler dynamometers and force plates are suitable for both 3-component force measurement and 6-component force-torque measurement.

Strain sensors
In most areas of application, strain measurement is used for indirect force measurement on or in components. Changes in the measured length of the component are transmitted to the elastic piezoelectric sensor element, where it acts as a shear force. As strains can form in different directions, Kistler offers sensors for measuring them longitudinally or transversely to the mounting hole. To accommodate both tensile and compressive strains, the sensors are mechanically preloaded inside the bore.

Torque sensors
Kistler supplies a variety of sensors for measuring torque. Examples include strain gage designs for rotating shafts, and piezoelectric sensors mounted under a high mechanical preload for measuring reaction torques. Torque dynamometers are used mainly for calibrating torque wrenches.



Load washer



Force link

Low-level sensor
for small forces

Single-component force sensors

The **load washer** is the traditional standard force sensor. It involves two lightly preloaded quartz disks mounted between the base plate and the cover plate, which are welded to the jacket to form an airtight case. This protects the highly sensitive internal parts against all external influences. The measurement signal is received by an electrode between the two quartz disks, and transmitted to the connector. Load washers are sturdy and extraordinarily versatile in application. They are often integrated into machine structures with a slight initial preload before being fully preloaded as required.

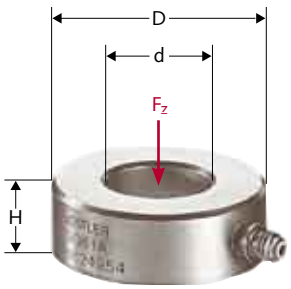
Calibrated and preloaded between two special nuts, the washer forms a **force link**. Preloaded sensors, which are available already calibrated, are easily mounted and can be used immediately for measuring compression and tensile forces.

Devices for measuring extremely small forces, termed **low-level force sensors**, have an essentially different design. Slender quartz rods are mounted under preload between parts used to introduce the force. The length of these rods results in them achieving up to thirty times the sensitivity of load washers and, even from minute forces, producing very significant charge levels for processing by the charge amplifier.

Press force transmitters operate without any external charge amplifier at all. The components used to condition the signal are accommodated within the sensor itself. The user therefore does not need to worry about preloading the sensor or installing an additional amplifier. Transmitters supply a voltage output signal.

Single-Component Force Sensors

Load Washer, 0 ... 750 N to 0 ... 400 kN



Type 9041A

Technical data		Type 9001A	Type 9011A	Type 9021A	Type 9031A
Measuring range	kN	0 ... 7,5	0 ... 15	0 ... 35	0 ... 60
Calibrated meas. ranges	kN	0 ... 0,75 0 ... 7,5	0 ... 1,5 0 ... 15	0 ... 3,5 0 ... 35	0 ... 6 0 ... 60
Rigidity	kN/µm	≈1	≈1,8	≈3,5	≈6
D	mm	10,3	14,5	22,5	28,5
d	mm	4,1	6,5	10,5	13
H	mm	6,5	8	10	11
Weight	g	3	7	20	36

Technical data		Type 9041A	Type 9051A	Type 9061A	Type 9071A
Measuring range	kN	0 ... 90	0 ... 120	0 ... 200	0 ... 400
Calibrated meas. ranges	kN	0 ... 9 0 ... 90	0 ... 12 0 ... 120	0 ... 20 0 ... 200	0 ... 40 0 ... 400
Rigidity	kN/µm	≈7,5	≈9	≈14	≈26
D	mm	34,5	40,5	52,5	75,5
d	mm	17	21	26,5	40,5
H	mm	12	13	15	17
Weight	g	70	80	157	370

General technical data		
Sensitivity	pC/N	≈–4,3
Operating temp. range	°C	–196 ... 200
Deg. of protection to IEC/EN 60529		IP65 with connected cable IP67 with cable Type 1983AD… and welded connector
Connector		KIAG 10-32 neg.

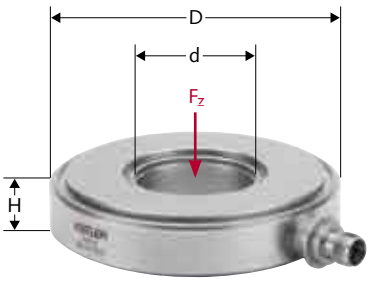
Characteristics
Wide measuring range, high rigidity, compact design, mounting accessories.

Applications
Materials testing, machine testing, measurement of impact, bearing reaction, screw, clamping or punching forces.

Accessories
Connecting cable Type 1631C…
Mounting set Type 9422A...
Preloading elements Type 9420A…
Mounting accessories
Type 9505 … 9579

Data sheet 9001A_000-105

Load Washer, 0 ... 65 kN, 0 ... 1 200 kN



Type 9081A

Technical data		Type 9081A	Type 9091A
Measuring range	kN	0 ... 650	0 ... 1 200
Calibrated meas. ranges	kN	0 ... 65 / 0 ... 650	0 ... 120 / 0 ... 1 200
Rigidity	kN/µm	≈30	≈65
D	mm	100	145
d	mm	40,5	66
H	mm	22	28
Weight	g	905	2 350

General technical data		
Sensitivity	pC/N	≈–2,2
Operating temp. range	°C	–50 ... 100
Deg. of protection to IEC/EN 60529		IP65 with connected cable
Connector		TNC neg.

Characteristics
For forces up to 1.2 MN, very high rigidity, compact design.

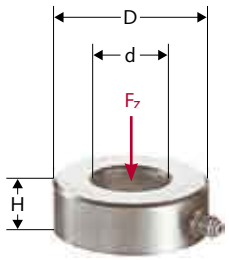
Applications
Measurement of impact, punching or tire contact forces.

Accessories
Connecting cable Type 1609B…

Data sheet 9081A_000-106

Single-Component Force Sensors

Load Washer, 0 ... 20 kN to 0 ... 700 kN



Type 9101A

Technical data		Type 9101A	Type 9102A	Type 9103A	Type 9104A
Measuring range	kN	0 ... 20	0 ... 50	0 ... 100	0 ... 140
Rigidity	kN/µm	≈1,8	≈3,5	≈6	≈7,5
D	mm	14,5	22,5	28,5	34,5
d	mm	6,5	10,5	13	17
H	mm	8	10	11	12
Weight	g	7	20	36	70

Technical data		Type 9105A	Type 9106A	Type 9107A
Measuring range	kN	0 ... 190	0 ... 330	0 ... 700
Rigidity	kN/µm	≈9	≈14	≈26
D	mm	40,5	52,5	75,5
d	mm	21	26,5	40,5
H	mm	13	15	17
Weight	g	80	157	370

General technical data		
Calibrated meas. ranges		not calibrated
Sensitivity	pC/N	≈–4,3
Operating temp. range	°C	–40 ... 120
Deg. of protection to IEC/EN 60529		IP65 with connected cable IIP67 with cable Type 1983AD... and welded connector
Connector		KIAG 10-32 neg.

Characteristics
Wide measuring range, high rigidity, compact design.

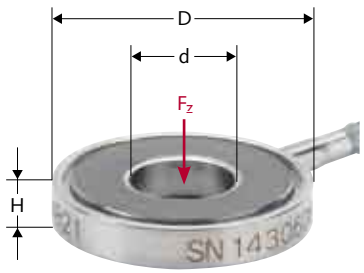
Applications
Industrial monitoring functions.

Accessories
Connecting cables Type 1939A..., 1941A..., 1943A..., 1945A...
Mounting set Type 9422A...
Preloading elements Type 9420A...

Data sheet 9101A_000-108

Single-Component Force Sensors

SlimLine Sensor, 0 ... 3 kN to 0 ... 80 kN



Type 9134B

Technical data		Type 9130B...	Type 9131B...	Type 9132B...	Type 9133B...
Measuring range	kN	0 ... 3	0 ... 2,5	0 ... 7	0 ... 14
Sensitivity	pC/N	≈–3,5	≈–4	≈–3,8	≈–3,8
Rigidity	kN/µm	≈1	≈0,7	≈1,8	≈2,5
D	mm	8	7	12	16
d	mm	2,7	–	4,1	6,1
H	mm	3	3	3	3,5
Weight (without cable)	g	1	1	2	3

Technical data		Type 9134B...	Type 9135B...	Type 9136B...	Type 9137B...
Measuring range	kN	0 ... 26	0 ... 36	0 ... 62	0 ... 80
Sensitivity	pC/N	≈–3,8	≈–3,8	≈–3,8	≈–3,8
Rigidity	kN/µm	≈5,6	≈7	≈8	≈16
D	mm	20	24	30	36
d	mm	8,1	10,1	12,1	14,1
H	mm	3,5	3,5	4	5
Weight (without cable)	g	5	7	14	27

General technical data		
Calibrated meas. ranges		not calibrated
Operating temp. range	°C	–20 ... 120
Deg. of protection to IEC/EN 60529		IP65
Connector		optional: KIAG 10-32 pos. Mini Coax neg.

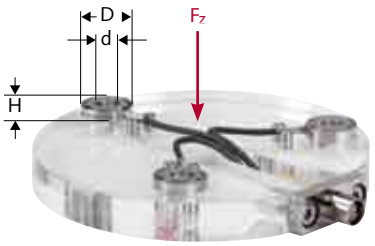
Characteristics
Very slim design, high rigidity, flexible mounting in structures, integral connecting cable.

Applications
Measurement of press-fitting and punching forces, etc., tool monitoring, measurement of large forces in force shunt mode.

Accessories
Preloading disk Type 9410A…

Data sheet 9130B_000-110

SlimLine Assembly Kit



Type 9133BA...

Technical data		Type 9130BA...	Type 9131BA...	Type 9132BA...	Type 9133BA...
Kit consists of	Type	9130B	9131B	9132B	9133B

Technical data		Type 9134BA...	Type 9135BA...	Type 9136BA...	Type 9137BA...
Kit consists of	Type	9134B	9135B	9136B	9137B

General technical data	
Deg. of protection to IEC/EN 60529	IP65 with connected cable
Connector	Fischer flange 7-pole neg.

Characteristics
Ready-to-connect assembly kit with 2, 3 or 4 SlimLine sensors ground level, flexible and compact mounting in structure, optional measurement of total or individual sensor forces, cable length options to suit individual sensor.

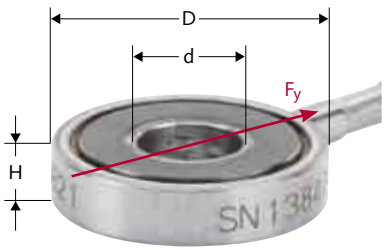
Applications
Measurement of press-fitting and punching forces, etc., monitoring of follow-on tools, measurement of large forces in force shunt mode, manufacture of small force plates.

Accessories
Connecting cable for summing signal Type 1971A…
Connecting cable for single signal Type 1973A…

Data sheet 9130BA_000-109

Single-Component Force Sensors

SlimLine Sensor for Shear Force, –0,9 ... 0,9 kN to –8 ... 8 kN



Type 9143B...

Technical data		Type 9143B...	Type 9144B...	Type 9145B...	Type 9146B...
Measuring range	kN	–0,9 ... 0,9	–1,7 ... 1,7	–2,7 ... 2,7	–4 ... 4
Sensitivity	pC/N	≈–6	≈–7	≈–7	≈–7
Rigidity	kN/µm	≈2,5	≈5,6	≈7	≈8
Preloading force	kN	9	17	27	40
D	mm	16	20	24	30
d	mm	6,1	8,1	10,1	12,1
H	mm	3,5	3,5	3,5	4
Weight (without cable)	g	3	5	7	14

Technical data		Type 9147B...
Measuring range	kN	–8 ... 8
Sensitivity	pC/N	≈–8
Rigidity	kN/µm	≈16
Preloading force	kN	80
D	mm	36
d	mm	14,1
H	mm	5
Weight (without cable)	g	27

General technical data		
Calibrated meas. ranges		not calibrated
Operating temp. range	°C	–20 ... 120
Deg. of protection to IEC/EN 60529		IP65
Connector		optional: KIAG 10-32 pos. Mini Coax neg.

Characteristics
High rigidity, very slim and small design, flexible mounting in structures, integral connecting cable.

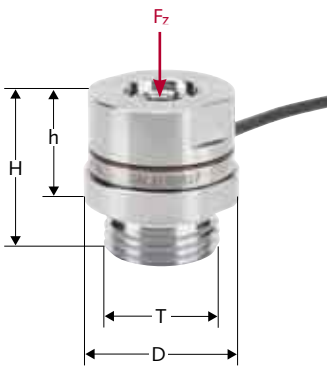
Applications
Monitoring of shear forces in machines, tools and assembly processes, manufacture of compact force plates.

Accessories
Preloading disk Type 9410A

Data sheet 9143B_000-113

Single-Component Force Sensors

SlimLine Quartz Force Link for Tensile and Compression Forces, 0 … 12 kN to 0 … 60 kN



Type 9173B

Technical data		Type 9173B	Type 9174B	Type 9175B	Type 9176B
Measuring range	kN	0 ... 12	0 ... 20	0 ... 30	0 ... 60
Calibrated measuring range	kN	0 ... 12	0 ... 20	0 ... 30	0 ... 60
Permissible tensile force	kN	0 ... –3	0 ... –5	0 ... –8	0 ... –16
Natural frequency	kHz	≈75	≈70	≈60	≈55
D	mm	18	22	26	32
H	mm	22	24	28	34
h	mm	14	16	19	23
T		M12x1,25	M16x1,5	M20x1,5	M24x2
Weight (ohne Kabel)	g	28	40	81	147

General technical data		
Sensitivity	pC/N	≈–3,5
Operating temp. range	°C	–20 ... 80
Deg. of protection to IEC/EN 60529		IP65
Connector		KIAG 10-32 neg.

These sensors are preloaded and calibrated

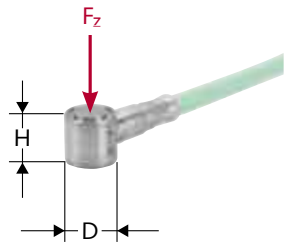
Characteristics
High rigidity, very flat and compact design, measures tensile and compression forces, integral cable.

Applications
Force measurement in robotic systems, monitoring of presses, punch presses, embossing and welding units, clamping processes, joining.

Accessories
Connecting cable Type 1631C...
Force distributing cap Type 9416A...

Data sheet 9173B_000-112

Miniature Sensor for Compression Forces, 0 … 250 N to 0 … 2,5 kN



Type 9211...

Technical data		Type 9211...
Measuring range	kN	0 ... 2,5
Calibrated meas. ranges	kN	0 ... 0,25 0 ... 2,5
Sensitivity	pC/N	≈–4,4
Natural frequency	kHz	≈200
Operating temp. range	°C	–40 ... 150
D	mm	6
H	mm	6
Weight	g	1,2
Deg. of protection to IEC/EN 60529		IP65
Connector		BNC pos.

This sensor is preloaded and calibrated

Characteristics
Extremely small design, very high natural frequency, integral connecting cable.

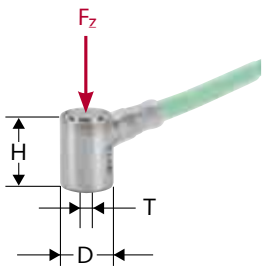
Applications
Measurement of punching, bearing reaction, joint and vibration forces, force measurement under adverse conditions as in confined spaces.

Accessories
Extension cable Type 1603B…

Data sheet 9211_000-131

Single-Component Force Sensors

Miniature Sensor for Compression Forces, 0 … 250 N to 0 … 2,5 kN



Type 9213...

Technical data		Type 9213...
Measuring range	kN	0 ... 2,5
Calibrated meas. ranges	kN	0 ... 0,25 0 ... 2,5
Sensitivity	pC/N	≈–4,4
Natural frequency	kHz	≈200
Operating temp. range	°C	–40 ... 150
D	mm	6
H	mm	8,5
T		M2,5 (female thread)
Weight	g	2
Deg. of protection to IEC/EN 60529		IP65
Connector		BNC pos.

This sensor is preloaded and calibrated

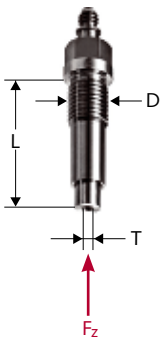
Characteristics
Extremely small design, very high natural frequency, integral connecting cable.

Applications
Measurement of punching, bearing reaction, joint and vibration forces, force measurement under adverse conditions as in confined spaces.

Accessories
Extension cable Type 1603B…

Data sheet 9213_000-132

Sensor for Tensile and Compression Forces, –5 … 5 N to –500 … 500 N



Type 9203

Technical data		Type 9203
Measuring range	N	–500 ... 500
Calibrated meas. ranges	N	0 ... 5 0 ... –50 / 0 ... 50 0 ... –500 / 0 ... 500
Sensitivity	pC/N	≈–45
Natural frequency	kHz	>27
Operating temp. range	°C	–150 ... 240
D		M10x1
L	mm	28,5
T		M3 (female thread)
Weight	g	13
Deg. of protection to IEC/EN 60529		IP65 with connected cable IP67 with cable Type 1983AD and welded connector
Connector		KIAG 10-32 neg.

This sensor is preloaded and calibrated

Characteristics
High sensitivity, extremely low threshold, high natural frequency, measures tensile and compression forces, small dimensions.

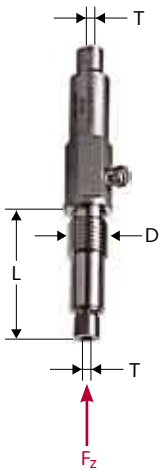
Applications
Measurement of contact forces of push-button switches, relays, etc., measurement of spring characteristics, extraction and assembly machine forces. The slender design allows arrays of closely spaced sensors, for example for simultaneous testing of the haptic behavior of a complete cell phone keypad.

Accessories
Connecting cable Type 1631C…

Data sheet 9203_000-127

Single-Component Force Sensors

Sensor for Tensile and Compression Forces, –0,5 … 0,5 N to –50 … 50 N, Radial Connection



Type 9205

This sensor is preloaded and calibrated.

Technical data		Type 9205
Measuring range	N	–50 ... 50
Calibrated meas. ranges	N	0 ... 0,5 / 0 ... –0,5 0 ... 5 / 0 ... –5 0 ... 50 / 0 ... –50
Sensitivity	pC/N	≈–115
Natural frequency	kHz	>10
Operating temp. range	°C	–50 ... 150
D		M10x1
L	mm	28,5
T		M3 (female thread)
Weight	g	19
Deg. of protection to IEC/EN 60529		IP65 with connected cable IP67 with cable Type 1983AD… and welded connector
Connector		KIAG 10-32 neg., radial

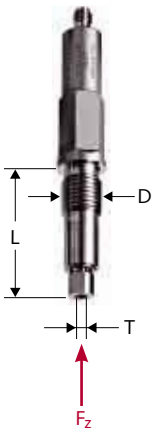
Characteristics
High sensitivity, extremely low threshold, high natural frequency, measures tensile and compression forces, small dimensions.

Applications
Measurement of contact forces of push-button switches, relays, etc., measurement of spring characteristics, extraction and assembly machine forces.

Accessories
Connecting cable Type 1631C…
Coupling element Type 9405

Data sheet 9205_000-129

Sensor for Tensile and Compression Forces, –0,5 … 0,5 N to –50 … 50 N, Axial Connection



Type 9207

This sensor is preloaded and calibrated.

Technical data		Type 9207
Measuring range	N	–50 ... 50
Calibrated meas. ranges	N	0 ... –0,5 / 0 ... 0,5 0 ... –5 / 0 ... 5 0 ... –50 / 0 ... 50
Sensitivity	pC/N	≈–115
Natural frequency	kHz	>10
D		M10x1
L	mm	28,5
T		M3 (female thread)
Weight	g	19
Operating temp. range	°C	–50 ... 150
Deg. of protection to IEC/EN 60529		IP65 with connected cable IP67 with cable Type 1983AD… and welded connector
Connector		KIAG 10-32 neg., axial

Characteristics
High sensitivity, extremely low threshold, high natural frequency, measures tensile and compression forces, small dimensions.

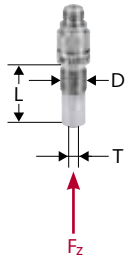
Applications
Measurement of contact forces of push-button switches, relays, etc., measurement of spring characteristics, extraction and assembly machine forces.

Accessories
Connecting cable Type 1631C…
Coupling element Type 9405

Data sheet 9207_000-130

Single-Component Force Sensors

Sensor for Compression Forces, 0 … 2 N to 0 … 200 N



Type 9215

Technical data		Type 9215
Measuring range	N	–20 ... 200
Calibrated meas. ranges	N	0 ... 2 0 ... 20 0 ... 200
Sensitivity	pC/N	≈–81
Natural frequency	kHz	>50
D		M5x0,5
L	mm	12,5
T		M2 (female thread)
Weight	g	2,5
Operating temp. range	°C	–50 ... 180
Deg. of protection to IEC/EN 60529		IP65 with connected cable IP67 with cable Type 1983AD… and welded connector
Connector		M4x0,35 neg.

This sensor is preloaded and calibrated.

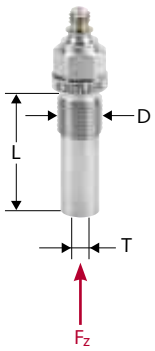
Characteristics
The highly sensitive force link used gives the sensor a very high rigidity and low transverse sensitivity. Measuring surface is tapped M2 hole.

Applications
With its small dimensions, the sensor is ideal for mounting in confined spaces. Wide range of applications in product testing and high-sensitivity force measurement in research and development. Construction of miniature force plates and arrays of sensors at spacings ≥7,5 mm.

Accessories
Connecting cable Type 1651C…

Data sheet 9215_000-487

Sensor for Tensile and Compression Forces, M10x1, –50 … 50 N to –500 … 500 N



Type 9217A

Technical data		Type 9217A
Measuring range	N	–500 ... 500
Calibrated meas. ranges	N	0 ... 5 0 ... –50 / 0 ... 50 0 ... –500 / 0 ... 500
Sensitivity	pC/N	≈–105
Natural frequency	kHz	>20
D		M10x1
L	mm	28,5
T		M3 (female thread)
Weight	g	16
Operating temp. range	°C	–50 ... 150
Deg. of protection to IEC/EN 60529		IP65 with connected cable IP67 with cable Type 1983AD… and welded connector
Connector		KIAG 10-32 neg.

This sensor is preloaded and calibrated.

Characteristics
Sturdy piezoelectric force sensor with a high sensitivity for small tensile and compression forces starting from a few mN. High rigidity and very low transverse sensitivity. Measuring surface is tapped M3 hole.

Applications
Wide range of applications in product testing – of push-button and other switches, connectors, springs, etc. as well as general use for highly sensitive force measurement in research and development. The slender design allows arrays of closely spaced sensors, for example for simultaneous testing of the haptic behavior of a complete cell phone keypad.

Accessories
Connecting cable Type 1631C…

Data sheet 9217A_000-546

Single-Component Force Sensors

Quartz Force Link for Tensile and Compression Forces, –2,5 … 2,5 kN to –120 … 120 kN

Type 9301B

Technical data		Type 9301B	Type 9311B	Type 9321B	Type 9331B
Measuring range	kN	–2,5 ... 2,5	–5 ... 5	–10 ... 10	–20 ... 20
Calibrated meas. ranges	kN	0 ... –2,5 0 ... 0,025 0 ... 2,5	0 ... –5 0 ... 0,05 0 ... 5	0 ... –10 0 ... 0,1 0 ... 10	0 ... –20 0 ... 0,2 0 ... 20
Rigidity	kN/µm	≈0,3	≈0,6	≈0,9	≈1
Natural frequency	kHz	≈90	≈70	≈55	≈45
D	mm	11	15	23	29
H	mm	25	30	45	52
T		M5	M6	M10	M12
Weight	g	14	28	90	170

Technical data		Type 9341B	Type 9351B	Type 9361B	Type 9371B
Measuring range	kN	–30 ... 30	–40 ... 40	–60 ... 60	–120 ... 120
Calibrated meas. ranges	kN	0 ... –30 0 ... 0,3 0 ... 30	0 ... –40 0 ... 0,4 0 ... 40	0 ... –60 0 ... 0,6 0 ... 60	0 ... –120 0 ... 1,2 0 ... 120
Rigidity	kN/µm	≈1,8	≈2	≈2,8	≈4
Natural frequency	kHz	≈40	≈33	≈28	≈22
D	mm	35	41	53	76
H	mm	62	72	88	108
T		M16	M20	M24	M30
Weight	g	330	480	1 020	2 500

General technical data		
Sensitivity	pC/N	≈–4
Operating temp. range	°C	–40 ... 120
Deg. of protection to IEC/EN 60529		IP65 with connected cable IP67 with cable Type 1983AD… and welded connector
Connector		KIAG 10-32 neg.

These sensors are preloaded and calibrated.

Characteristics
Measures tensile and compression forces, easy mounting with centering seats for accuracy, ground-isolated.

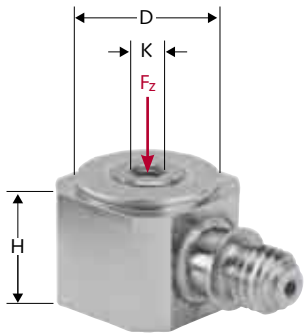
Applications
Impact forces, shock loads on landing gear, impact tests, supporting and compression forces. Quality control through measurement of forces in switches and monitoring of assembly machines.

Accessories
Connecting cable Type 1631C…
Force distributing cap Type 9500A…
Flange Type 9504A…

Data sheet 9301B_000-107

Single-Component Force Sensors

Press Force Sensor for Compression Forces, 0 … 50 N to 0 … 20 kN



Type 9313AA...

Technical data		Type 9313AA1	Type 9313AA2
Measuring range	kN	0 ... 5	0 ... 20
Calibrated meas. ranges	kN	0 ... 0,05 0 ... 0,5 0 ... 5	0 ... 0,2 0 ... 2 0 ... 20
Permissible tensile force	kN	0 ... –0,5	0 ... –2
Sensitivity	pC/N	≈–10	≈–10
D	mm	13	19
K		M2,5	M4
H	mm	10	14
Weight	g	10	25

General technical data		
Operating temp. range	°C	–40 ... 120
Deg. of protection to IEC/EN 60529		IP65 with connected cable IP67 with cable Type 1983AD… and welded connector
Connector		KIAG 10-32 neg.

These sensors are preloaded and calibrated.

Characteristics
Compact, ready-to-mount force sensor, flexible adaptation, central hole.

Applications
Monitoring sensor for joining processes, compression force measurement on presses, for test equipment.

Accessories
Flange Type 9580A…
Force distributing cap Type 9500AA…
Mounting stud Type 9590A…

Data sheet 9313_000-705

Press Force Sensor for Compression Forces, 0 … 100 N to 0 … 120 kN

Type 9323A... to 9363A...

Technical data		Type 9323AA	Type 9323A	Type 9333A	Type 9343A	Type 9363A
Measuring range	kN	0 ... 10	0 ... 20	0 ... 50	0 ... 70	–20 ... 120
Calibrated meas. ranges	kN	0 ... 0,1 0 ... 1 0 ... 10	0 ... 0,2 0 ... 2 0 ... 20	0 ... 0,5 0 ... 5 0 ... 50	0 ... 0,7 0 ... 7 0 ... 70	0 ... 1,2 0 ... 12 0 ... 120
Permissible tensile force	kN	0 ... –1	0 ... –2	0 ... –5	0 ... –10	0 ... –20
Sensitivity	pC/N	≈–10	≈–3,9	≈–4	≈–4	≈–4
D	mm	20	20	30	36	54
P		M5x0,5	M5x0,5	M9x0,5	M13x1	M20x1,5
H	mm	26	26	34	42	60
Weight	g	50	47	137	240	800

General technical data		
Operating temp. range	°C	–40 ... 120
Deg. of protection to IEC/EN 60529		IP65 with connected cable IP67 with cable Type 1983AD… and welded connector
Connector		KIAG 10-32 neg.

These sensors are preloaded and calibrated.

Characteristics
Compact, ready-to-mount force sensor, flexible adaptation, central hole.

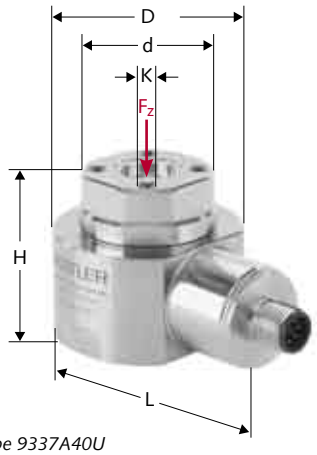
Applications
Monitoring sensor for joining processes, compression force measurement on presses, for test equipment.

Accessories
Flange Type 9580A…
Force distributing cap Type 9582A…
Female thread adapter Type 9584A…
Male thread adapter Type 9586A…

Data sheet 9323_000-704

Single-Component Force Sensors

Press Force Transmitter, 0 … 2 kN to 0 … 70 kN in Each of Two Switchable Ranges



Type 9337A40U

Technical data		Type 9337A40	Type 9337A40U
Measuring ranges I/II, factory		0 ... 50 / 0 ... 5	Custom preset and calibrated from 0 … 70/50/20/10/5/2 for each meas. range
Calibrated meas. ranges	kN	0 ... 50 / 0 ... 5	As chosen by customer

General technical data		
Max. measuring ranges	kN	0 ... 70
Output signal [FSO]	V	0 ... 10
D	mm	50
d	mm	36
K		4 x M5
L	mm	66,5
H	mm	45
Weight	g	520
Operating temp. range	°C	–10 ... 70
Deg. of protection to IEC/EN 60529		IP67
Connector		M12x1 8-pole

This sensor is preloaded and calibrated.

The parameters of this transmitter can be configured quickly and easily with the ManuWare PC program.

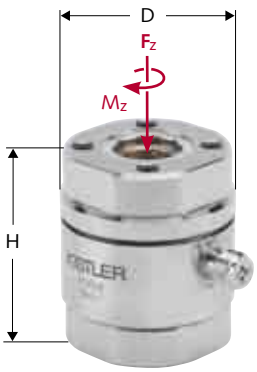
Characteristics
Robust press force sensor with integral, configurable, fully digital charge amplifier for dynamic and quasistatic forces.

Applications
Direct measurement of dynamic and quasistatic compression forces on presses and joining systems; measurement of feed and pressing forces; measurement of signatures in product testing; use as reference sensor, for instance for on-site calibration of force and strain sensors mounted in the structure of a machine.

Accessories
Flange Type 9594A1
Force distributing cap Type 9582A1
Female thread adapter Type 9584A1
Male thread adapter Type 9586A1
USB 1.1 to RS-232C converter Type 2867

Data sheet 9937A_000-664

2-Component Sensor Fz, Mz, 0 … 1 kN to 0 … 20 N plus 0 … 2,5 N·m to 0 … 200 N·m



Type 9345A

Technical data		Type 9345B	Type 9365B
Measuring range F_z	kN	–10 ... 10	–20 ... 20
Calibrated meas. ranges	kN	0 ... 1 0 ... 10	0 ... 2 0 ... 20
Sensitivity F_z	pC/N	≈–3,7	≈–3,6
Rigidity c_z	kN/µm	≈1,7	≈2,8
Measuring range M_z	N·m	–25 ... 25	–200 ... 200
Calibrated meas. ranges	N·m	0 ... –2,5 / 0 ... 2,5 0 ... –25 / 0 ... 25	0 ... –20 / 0 ... 20 0 ... –200 / 0 ... 200
Sensitivity M_z	pC/N·m	≈–200	≈–140
Rigidity c (calculated)	N·m/µrad	≈0,19	≈0,92
D	mm	39	56,5
H	mm	42	60
Weight	g	267	834
Operating temp. range	°C	–40 ... 120	–40 ... 120
Deg. of protection to IEC/EN 60529		IP65 with connected cable	IP65 with connected cable
Connector		M8x0,75 3-pole neg.	V3 neg.

These sensors are preloaded and calibrated.

Characteristics
Reaction torque sensor with the option of measuring an additional tensile/compression force acting.

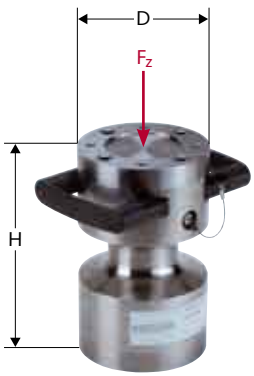
Applications
Examination of the correlation between drilling torque and rupture force for PCBs, tightening torque and stripping forces in screw connections and similar processes.

Accessories
Connecting cables Type 1693A…, 1694A..., 1695A..., 1698A...

Data sheet 9345B_000-630

Single-Component Force Sensors

MN Press Force Calibration Sensor for Large Compression Forces, 0 … 2,5 MN to 0 … 20 MN



Type 9931A2

This sensor is preloaded and calibrated.

Technical data		Type 9931A1	Type 9931A2	Type 9931A3	Type 9931A4
Measuring range	MN	0 ... 2,5	0 ... 5	0 ... 10	0 ... 20
Calibrated meas. ranges	MN	0 ... 2,5	0 ... 5	0 ... 10	0 ... 20
Sensitivity	pC/kN	≈–14	≈–10	≈–7	≈–5
D	mm	120	144	192	262
H	mm	200	220	260	310
Weight	kg	14	22	46	100

General technical data		
Operating temp. range	°C	0 ... 70
Deg. of protection to IEC/EN 60529		IP65 with connected cable
Connector		Fischer DBEE102 A 014-60 neg.

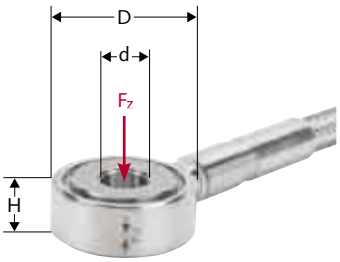
Characteristics
Piezoelectric force sensor for measuring quasistatic and dynamic compression forces in the mega-newton range in large industrial presses.

Applications
Portable force link for checking and calibration of compression forces in mechanical or hydraulic presses. Measurement of force distribution in large presses.

Accessories
Tapered flange Type 9588A3x
Cover plate Type 95880x
Connecting cables Types 1661A… and 1667B…

Data sheet 9931A_000-525

VarioComp Force Sensor, 0 … 30 kN



Type 9601A11...

Technical data		Type 9601A11...
Measuring range	kN	0 ... 30
Calibrated meas. ranges		not calibrated
Sensitivity	pC/N	≈–4,2
Rigidity	kN/µm	≈1,25
D	mm	25
d	mm	8,1
H	mm	10
Weight	g	≈24
Operating temp. range	°C	–50 ... 120
Deg. of protection to IEC/EN 60529		IP65 with PUR sheath IP67 with steel sheath
Connector		option KIAG 10-32 pos. Mini Coax neg.

Characteristics
Compact and robust design, integral cable with steel or PUR sheath, also available as multicomponent force sensor with selection of measuring axes in the x, y and z direction (see VarioComp multicomponent force sensor Type 9601A2…/A3…).

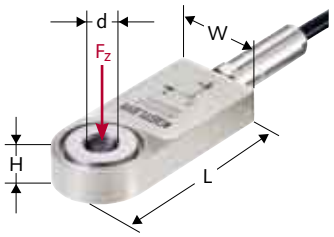
Applications
Monitoring of machinery and tools.

Accessories
Preloading key Type 9463
Set of preloading elements Type 9461
Connecting cable Mini Coax pos. - BNC pos. Type 1937A…

Data sheet 9601A_000-172

Single-Component Force Sensors

Force Sensor with Integral Electronics, 2 Measuring Ranges , –5 … 5 kN



Type 9602A1...

Technical data		Type 9602A1...
Number of measuring ranges		2 (switchable 5:1)
Measuring range adjustment		fixed
Measuring ranges	kN	–1 ... 1 –5 ... 5
Calibrated meas. ranges		not calibrated
Sensitivity (nom.)	mV/N	≈1 ≈5
Output signal	V	±5
Rigidity	kN/µm	1,25
L	mm	57
W	mm	25
d	mm	8,1
H	mm	10
Weight	g	30
Operating temp. range	°C	0 ... 60
Deg. of protection to IEC/EN 60529		IP67
Connector		optional Fischer 7-pole pos. D102 or integral cable

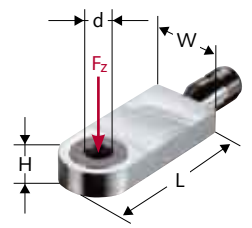
Characteristics
Integral charge amplifier electronics, two measuring ranges, sturdy, compact design, straight or right-angled connector outlet (also available in 3-component version, see Type 9602A3…).

Applications
Process monitoring in metal cutting machine tools, presses (joining and assembly processes) and forming machines.

Accessories
Connecting cable Type 1783A…
Preloading key Type 9463
Preloading disk Type 9408

Data sheet 9602A_000-173

Force Sensor with Integral Electronics, 0 … 25 kN



Type 9602AA...

Technical data		Type 9602AA...
Number of measuring ranges		2 (switchable 5:1)
Measuring range adjustment		incremental (0 ... 99)
Measuring ranges	kN	0 ... 5 0 ... 25
Calibrated meas. ranges		not calibrated
Sensitivity (nom.)	mV/N	≈0,4 ... 4 ≈2 ... 20
Output signal	V	±10
Rigidity	kN/µm	1,25
L	mm	57
W	mm	25
d	mm	8,1
H	mm	10
Weight	g	30
Operating temp. range	°C	0 ... 60
Deg. of protection to IEC/EN 60529		IP67 with connected cable
Connector		optional Lumberg M12x1, 8-pole pos. or integral cable

Characteristics
Integral charge amplifier electronics, two measuring ranges, sturdy, compact design, straight or right-angled connector outlet.

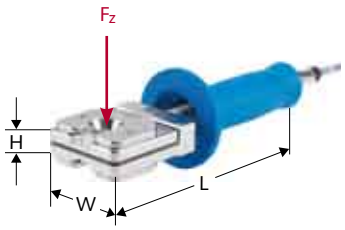
Applications
Process monitoring in metal cutting machine tools, presses (joining and assembly processes) and forming machines.

Accessories
Connecting cable Type 1787A…
Preloading key Type 9463
Preloading disk Type 9408

Data sheet 9602A_000-526

Single-Component Force Sensors

Electrode Force Calibration System for Spot Welding, 0 … 5 kN to 0 … 45 kN



Type 9831C1...

Type 9831C0001

This sensor is preloaded and calibrated.

Technical data		Type 9831C1...	Type 9831C2...	Type 9831C3...
Measuring range	kN	0 ... 5	0 ... 10	0 ... 45
Calibrated meas. range	kN	0 ... 5	0 ... 10	0 ... 45
Sensitivity	V/kN	≈1	≈0,5	≈0,1
Output signal	V	±5	±5	±4,5

General technical data		
L	mm	240
H	mm	30
W	mm	70
Weight	kg	1,4
Operating temp. range	°C	0 ... 60
Deg. of protection to IEC/EN 60529		IP65 with connected cable
Connector		Amphenol circular connector, 8-pole pos. DIN 45326

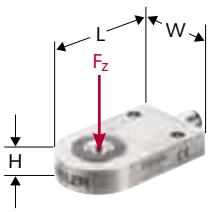
Characteristics
Minimal electrode spacing of 3 mm, replaceable inserts for adapting the transmitter to suit different electrode types, maximum safety standard, portable or stationary use, optional measuring range.

Applications
Interval control measurement on welding robots, optimization of welding tong life, servicing work on test stands, setting up of stationary welding lines, quality management (ISO 9001).

Accessories
Connecting cable Type 1500A35
Inserts Type 9426Bxx
Welding monitor Type 5825A2
Welding force measuring case Type 9831C0001

Data sheet 9831C_000-535

Electrode Force Test Sensor with Integral Electronics 0 … 5 kN to 0 … 25 kN



Type 9833C1

Technical data		Type 9833C1...	Type 9833C2...	Type 9833C3...
Measuring ranges	kN	0 ... 1 0 ... 5	0 ... 5 0 ... 10	0 ... 10 0 ... 25
Calibrated meas. ranges	kN	0 ... 1 0 ... 5	0 ... 5 0 ... 10	0 ... 10 0 ... 25
Sensitivity	mV/N	≈1 ≈5	≈0,5 ≈1	≈0,2 ≈0,5

General technical data		
Number of measuring ranges		2 (switchable 5:1)
Measuring range adjustment		fixed
Output signal	V	±5
H	mm	14,5
L	mm	72
W	mm	43
Weight	g	280
Operating temp. range	°C	0 ... 60
Deg. of protection to IEC/EN 60529		IP65 with connected cable
Connector		Lumberg M12, 5-pole pos.

Characteristics
With Types 9833C1…/9833C2… minimal electrode spacing of only 6,2 mm (electrodes Type F, ø13 mm), calibrated sensor, no uniform sensitivity, sensor design not ground isolated, switchable measuring range.

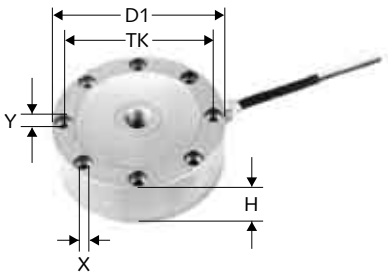
Applications
Quality assurance in vehicle body manufacture, periodic testing of electrode clamping force of robot welding tongs on resistance welding production lines.

Accessories
Connecting cable Type 1785A…

Data sheet 9833C_000-575

Single-Component Force Sensors

Strain Gage Sensor for Tensile and Compression Forces, 0,5 … 200 kN



Type 4576A...

Technical data		Type 4576A0,5...	Type 4576A1...	Type 4576A2...	Type 4576A5...
Measuring range	kN	0,5	1	2	5
H	mm	16	16	16	16
D1	mm	54,5	54,5	54,5	54,5
TK	mm	45	45	45	45
X	mm	4,5	4,5	4,5	4,5
Y	mm	8	8	8	8

Technical data		Type 4576A10...	Type 4576A20...	Type 4576A50...	Type 4576A100...
Measuring range	kN	10	20	50	100
H	mm	16	25	35	50
D1	mm	54,5	79	119	155
TK	mm	45	68	105	129
X	mm	4,5	4,5	6,6	13,5
Y	mm	8	8	11	20

Technical data		Type 4576A200...
Measuring range	kN	200
H	mm	50
D1	mm	155
TK	mm	129
X	mm	13,5
Y	mm	20

General technical data		
Nominal character. value	mV/V	1,5 (optional 1,0)
Weight	kg	0,25 ... 5
Operating temperature range	°C	15 ... 70
Service temperature range	°C	–30 ... 80
Deg. of protection to IEC/EN 60529		IP52 (<0 ... 10 kN) IP65 (>0 ... 20 kN)
Bridge resistance	Ω	350
Connector		Binder connector, 6-pole

Characteristics
Robust, compact tensile and compression force sensor with continuous thread on the central axis for force application through a load button or an adapter depending on application, economical measurement solution, force must be applied avoiding torsion or transverse force, mounting on ground and hardened bearing surfaces using holes through outside ring.

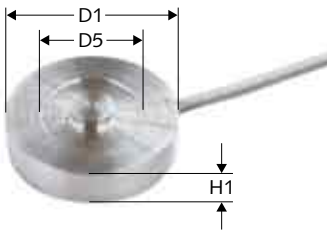
Applications
Measurement of static, quasistatic and dynamic press-fitting and insertion forces, spring forces, cutting forces, measurement and monitoring of assembly forces, determination of drilling machine feed force.

Accessories
None

Data sheet 4576A_000-675

Single-Component Force Sensors

Miniature Strain Gage Sensor for Compression Forces 0,1 … 200 kN



Type 4577A...

Technical data		Type 4577A0,1	Type 4577A0,2	Type 4577A0,5	Type 4577A1
Measuring range	kN	0,1	0,2	0,5	1
Bridge resistance	Ω	350	350	350	350
H1	mm	9,9	9,9	9,9	9,9
D1	mm	31,8	31,8	31,8	31,8
D5	mm	19	19	19	19

Technical data		Type 4577A2	Type 4577A5	Type 4577A10	Type 4577A20
Measuring range	kN	2	5	10	20
Bridge resistance	Ω	350	700	700	700
H1	mm	9,9	9,9	9,9	16
D1	mm	31,8	31,2	31,2	37,6
D5	mm	19	21,1	21,1	27,4

Technical data		Type 4577A50	Type 4577A100	Type 4577A200
Measuring range	kN	50	100	200
Bridge resistance	Ω	700	700	350
H1	mm	16	25,4	38,1
D1	mm	37,6	50,3	76,2
D5	mm	27,4	34,8	45

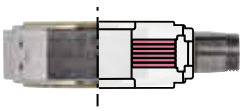
General technical data		
Nominal character. value	mV/V	1
Weight	kg	0,04 ... 1,2
Operating temperature range	°C	15 ... 70
Service temperature range	°C	–20 ... 100
Deg. of protection to IEC/EN 60529		IP64
Connector		Binder connector, 6-pole

Characteristics
Robust, compact compression force sensor designed as flat cylindrical disk with a load button for force application, economical force solution, force must be applied concentrically avoiding transverse force, mounting on flat, smooth surfaces, body of sensor sealed.

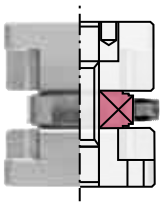
Applications
Force monitoring during press fitting, measurement of static and dynamic compression forces in equipment manufacture, on production lines, in measurement and monitoring equipment and manufacturing of jigs and fixtures and special machinery. Resists demanding corrosive industrial atmospheres.

Accessories
None

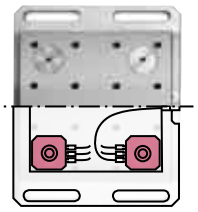
Data sheet 4577A_000-674



3-component force sensor



3-component force plate



3-component dynamometer with four mounted force sensors

Multicomponent Force Sensors

The piezoelectric measuring principle is an ideal basis for manufacturing multicomponent force sensors, whose design is similar to that of the single-component load washer.

A pair of quartz washers cut for the longitudinal effect measures the normal component Fz of forces acting on the sensor, while each of two pairs of washers cut for the shear effect measures one of the two shear components Fx and Fy. As the shear forces are transmitted through friction alone, multicomponent force sensors must always be mounted under sufficient mechanical preload.

Multicomponent force sensors are usually mounted in so called **dynamometers** or **force plates** in groups of three of four rather than individually. This configuration exploits the particular characteristics of these piezoelectric designs, which allow sensors with the same sensitivity to be directly electrically connected in parallel.

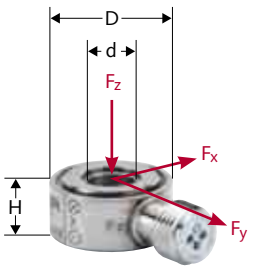
The output signal obtained corresponds to the algebraic sum of all of the individual forces acting upon the sensors. A dynamometer therefore acts as a single multicomponent force sensor to measure the three components of the acting force independently of its point of application.

Although moments acting upon the dynamometer do apply a load to the sensor, parallel connection prevents them being measured. These moments can, however, be determined from the individual output signals of those sensors not connected in parallel. Such a system measures the three components of the resultant force and the three components of the resultant moment in terms of the coordinates defined by the sensors.

Most Kistler dynamometers and force plates are suitable for both 3-component force measurement and 6-component force/moment measurement.

Multicomponent Force Sensors

3-Component Force Sensor, ø16,5 mm, –2 ... 2 kN



Type 9017B

Technical data			Type 9017B, 9018B, 9016B4
Measuring range	F_x, F_y F_z	kN kN	–1 ... 1 –2 ... 2 Standard mounting with a preload of 10 kN
Calibrated meas. ranges	F_x, F_y F_z F_z	kN kN kN	0 ... 1 0 ... 2 0 ... 12 (not preloaded)
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–26 ≈–11,5
Rigidity	c_x, c_y c_z	N/µm N/µm	≈170 ≈740
D		mm	16,5
d		mm	6,5
H		mm	8
Weight		g	8,5
Operating temp. range		°C	–50 ... 120
Deg. of protection to IEC/EN 60529			IP65 with connected cable
Connector			M8x0,75 3-pole neg.

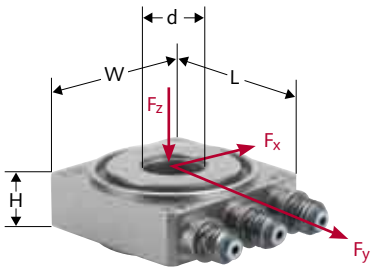
Characteristics
Wide measuring range, high rigidity and sensitivity, smallest 3-component force sensor, multi-pole connector.
Types 9017B and 9018BB differ in terms of the position of their coordinate system.
Type 9016B4: set of four selected sensors Types 9017B and 9018B.

Applications
Measurement of three orthogonal force components, – in miniature cutting force dynamometers for superfinishing, wind tunnel balances, measurement in confined spaces.

Accessories
Connecting cables Types 1639A... and 1694A...
Wrench adapter Type 9479

Data sheet 9017B_000-465

3-Component Force Sensor, 24x24 mm, –5 ... 5 kN



Type 9251A

Technical data			Type 9251A, 9252A, 9250A4, 9251A4
Measuring range	F_x, F_y F_z	kN kN	–2,5 ... 2,5 –5 ... 5 Standard mounting with a preload of 25 kN
Calibrated meas. ranges	F_x, F_y F_z F_z	kN kN kN	0 ... 2,5 0 ... 5 0 ... 30 (not preloaded)
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–8 ≈–4
Rigidity	c_x, c_y c_z	kN/µm kN/µm	≈1 ≈2,6
LxWxH		mm	24x24x10
d		mm	8,1
Weight		g	32
Operating temp. range		°C	–60 ... 150
Deg. of protection to IEC/EN 60529			IP65 with connected cable
Connector			3 x KIAG 10-32 neg.

Characteristics
Wide measuring range, high rigidity and sensitivity, low crosstalk, compact design, Types 9251A and 9252A differ by the position of their coordinate system.
Type 9250A4: set of four selected sensors Type 9251A and 9252A.
Type 9251A4: set of four selected sensors Type 9251A.

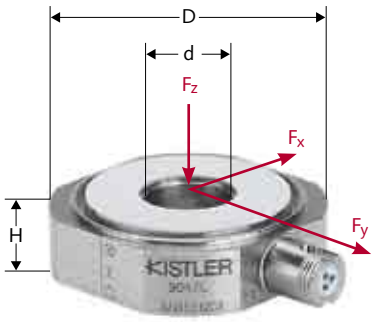
Applications
Cutting, impact, vibration and recoil forces, dynamic forces on vibrating tables, measurement in wind tunnels, determination of coefficients of friction.

Accessories
Connecting cable Type 1631C...
Set of preloading elements Type 9461
Wrench adapter Type 9475

Data sheet 9251A_000-145

Multicomponent Force Sensors

3-Component Force Sensor, 40x40x14 mm, –30 ... 30 kN



Type 9047C

Technical data			Type 9047C, 9048C, 9046C4
Measuring range	F_x, F_y F_z	kN kN	–15 ... 15 –30 ... 30 Standard mounting with a preload of 70 kN
Calibrated meas. ranges	F_x, F_y F_z F_z	kN kN kN	0 ... 15 0 ... 30 0 ... 100 (not preloaded)
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–8,1 ≈–3,7
Rigidity	c_x, c_y c_z	kN/µm kN/µm	≈0,6 ≈1,4
D		mm	45
d		mm	14,1
H		mm	14
Weight		g	91
Operating temp. range		°C	–40 ... 120
Deg. of protection to IEC/EN 60529			IP65 with connected cable Type 1698AA/AB IP67 with connected cable Type 1698ACsp
Connector			V3 neg.

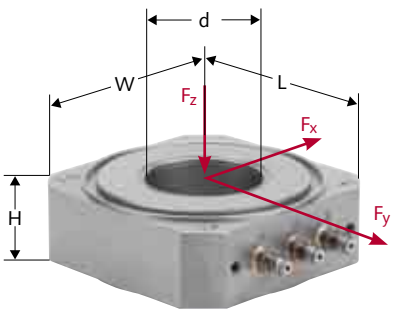
Characteristics
Accurate measurement irrespective of force application point, wide frequency range, easy mounting, sealed stainless sensor case, robust multi-pole connector.

Applications
3-component force sensors measure cutting forces during machining, impact forces in crash tests, rocket engine recoil forces, vibration forces on aerospace components, friction forces, forces in product testing, vehicle forces on road and test stand, forces on wind tunnel balances.

Accessories
Set of preloading elements, M14x1,5, Type 9465
Wrench adapter Type 9742 for Type 9465
3-wire connecting cables Types 1698AA, 1698AB and 1698Csp
Summing box Type 5417

Data sheet 9047C_000-592

3-Component Force Sensor, 56x56 mm, –40 ... 40 kN



Type 9067

Technical data			Type 9067, 9068, 9066A4, 9067A4
Measuring range	F_x, F_y F_z	kN kN	–20 ... 20 –40 ... 40 Standard mounting with a preload of 160 kN
Calibrated meas. ranges	F_x, F_y F_z F_z	kN kN kN	0 ... 20 0 ... 40 0 ... 200 (not preloaded)
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–8 ≈–3,8
Rigidity	c_x, c_y c_z	kN/µm kN/µm	≈0,7 ≈4,5
LxWxH		mm	56x56x20
d		mm	26,5
Weight		g	270
Operating temp. range		°C	–50 ... 150
Deg. of protection to IEC/EN 60529			IP65 with connected cable
Connector			3 x KIAG 10-32 neg.

Characteristics
Very wide measuring range, high rigidity and sensitivity, low crosstalk, compact design. Types 9067 and 9068 differ by the position of their coordinate system.
Type 9066A4: set of four sensors Type 9067.

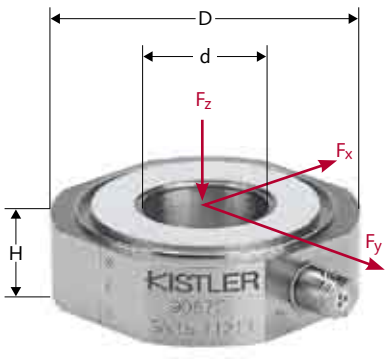
Applications
Cutting forces, impact forces, recoil forces, dynamic forces on vibrating tables, determination of coefficients of friction.

Accessories
Connecting cable Type 1631C...
Set of preloading elements Type 9451 or 9459 for Type 9465
Wrench adapter Type 9471 or 9477

Data sheet 9067_000-118

Multicomponent Force Sensors

3-Component Force Sensor, 60x60x21 mm, –60 ... 60 kN



Type 9067C

Technical data			Type 9067C, 9068C, 9066C4
Measuring range	F_x, F_y F_z	kN kN	–30 ... 30 –60 ... 60 Standard mounting with a preload of 140 kN
Calibrated meas. ranges	F_x, F_y F_z F_z	kN kN kN	0 ... 30 0 ... 60 0 ... 200 (not preloaded)
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–8,1 ≈–3,9
Rigidity	c_x, c_y c_z	kN/µm kN/µm	≈0,7 ≈4,5
D		mm	65
d		mm	26,5
H		mm	21
Weight		g	285
Operating temp. range		°C	–40 ... 120
Deg. of protection to IEC/EN 60529			IP65 with connected cable Type 1698AA/AB IP67 with connected cable Type 1698ACsp
Connector			V3 neg.

Characteristics
Accurate measurement irrespective of force application point, wide frequency range, easy mounting, sealed stainless sensor case, robust multi-pole connector.

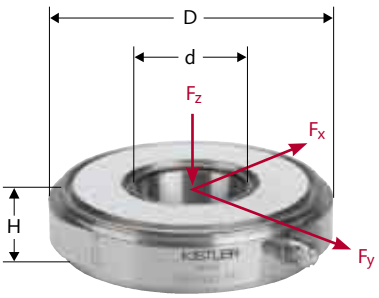
Applications
3-component force sensors measure cutting forces during machining, impact forces in crash tests, rocket engine recoil forces, vibration forces on aerospace components, friction forces, forces in product testing, vehicle forces on road and test stand, forces on wind tunnel balances.

Accessories
Set of preloading elements, M20x1,5, Type 9451A
Wrench adapter Type 9471 for Type 9451A
Set of preloading elements M26x0,75 Type 9459
Wrench adapter Type 9477 für Type 9459
3-wire connecting cables Types 1698AA, 1698AB and 1698ACsp
Summing box Type 5417

Data sheet 9067C_000-609

Multicomponent Force Sensors

3-Component Force Sensor, 100x100x26 mm, –150 … 150 kN , 100x100x26, –150 ... 150 kN



Type 9077C

Technical data			Type 9077C, 9078C, 9076C4
Measuring range	F_x, F_y F_z	kN kN	–75 ... 75 –150 ... 150 Standard mounting with a preload of 350 kN
Calibrated meas. ranges	F_x, F_y F_z F_z	kN kN kN	0 ... 75 0 ... 150 0 ... 500 (not preloaded)
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–4,2 ≈–2,0
Rigidity	c_x, c_y c_z	kN/µm kN/µm	≈1,8 ≈8
D		mm	105
d		mm	40,5
H		mm	26
Weight		kg	1,02
Operating temp. range		°C	–40 ... 120
Deg. of protection to IEC/EN 60529			IP65 with connected cable Type 1698AA/AB IP67 with connected cable Type 1698ACsp
Connector			V3 neg.

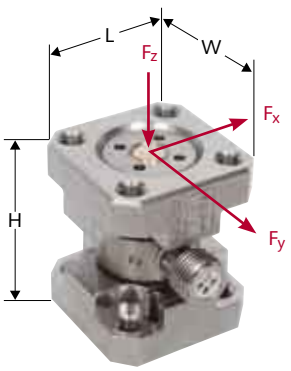
Characteristics
Very wide measuring range, high rigidity, low crosstalk, compact design, robust multi-pole connector. Types 9077C and 9078C differ by the position of their coordinate system,
Type 9076C4: set of four selected sensors Type 9077C/9087C.

Applications
Cutting, impact and recoil forces, dynamic forces on vibrating tables, measurement in wind tunnels, determination of coefficients of friction.

Accessories
3-wire connecting cables Types 1698AA, 1698AB and 1698ACsp
Set of preloading elements Type 9455
Wrench adapter Type 9473

Data sheet 9077C_000-610

3-Component Force Link, 25x25x30 mm, –2 … 2 kN



Type 9317B

Technical data			Type 9317B
Measuring range	F_x, F_y F_z	kN kN	–1 ... 1 –2 ... 2
Calibrated meas. ranges	F_x, F_y F_z	kN kN	0 ... 0,06 0 ... 0,6 0 ... 0,2 0 ... 2
Max. moments	$M_{x,y}$	N·m	–5/5
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–26 ≈–11
Natural frequency	$f_n(x)$, $f_n(y)$ $f_n(z)$	kHz kHz	≈5 ≈21
LxWxH		mm	25x25x30
Weight		g	85
Operating temp. range		°C	–50 ... 80
Deg. of protection to IEC/EN 60529			IP65 with connected cable Type
Connector			M8x0,75, 3-pole neg.

This sensor is preloaded and calibrated.

Characteristics
Very wide measuring range, high rigidity, low crosstalk, easy mounting, multi-pole connector.

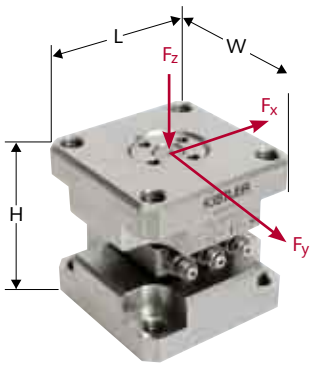
Applications
Cutting and impact forces, determination of coefficients of friction.

Accessories
Connecting cables Types 1693A… and 1694A…

Data sheet 9317B_000-464

Multicomponent Force Sensors

3-Component Force Link, 42x42x42 mm, –5 … 5 kN



Type 9327A

Technical data			Type 9327A, 9328A
Measuring range	F_x, F_y F_z	kN kN	–2,5 … 2,5 –5 … 5
Calibrated meas. ranges	F_x, F_y F_z	kN kN	0 … 0,125 0 … 1,25 0 … 0,5 0 … 5
Max. moments	$M_{x,y}$	N·m	–14 / 14
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–7,9 ≈–3,8
Natural frequency	$f_n(x)$, $f_n(y)$ $f_n(z)$	kHz kHz	≈3,3 ≈11,5
LxWxH		mm	42x42x42
Weight		g	390
Operating temp. range		°C	–50 … 80
Deg. of protection to IEC/EN 60529			IP65 with connected cable
Connector			3 x KIAG 10-32 neg.

These sensors are preloaded and calibrated.

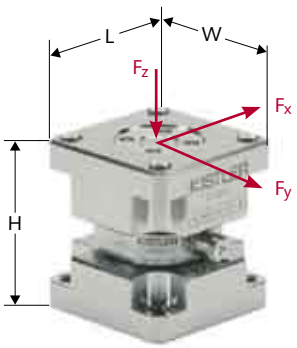
Characteristics
Very wide measuring range, high rigidity, low crosstalk, easy mounting, Types 9327A and 9328A differ by the position of their coordinate system.

Applications
Cutting and impact forces, dynamic forces on vibrating tables, determination of coefficients of friction.

Accessories
Connecting cable Type 1631C…

Data sheet 9327A_000-167

3-Component Force Link, 55x55x60 mm, –30 … 30 kN



Type 9347C

Technical data			Type 9347C, 9348C
Measuring range	F_x, F_y F_z	kN kN	–15 … 15 –30 … 30
Calibrated meas. ranges	F_x, F_y F_z	kN kN	0 … 0,5 / 0 … 5 (force application point 10 mm below surface of cover plate) 0 … 30 / 0 … 3 (force applied concentrically)
Max. moments	$M_{x,y,z}$ (F_z = 0)	N·m	–150 / 150
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–7,9 ≈–3,8
Natural frequency	$f_n(x)$, $f_n(y)$ $f_n(z)$	kHz kHz	≈3,6 ≈10
LxWxH		mm	55x55x60
Weight		kg	1
Operating temp. range		°C	–40 … 80
Deg. of protection to IEC/EN 60529			IP65 with connected cable Type 1698AA..., 1698AB... IP67 with connected cable Type 1698ACsp
Connector			V3 neg.

These sensors are preloaded and calibrated.

Characteristics
Accurate measurement irrespective of force application point, wide frequency range, easy mounting, sealed stainless sensor case, robust multi-pole connector.

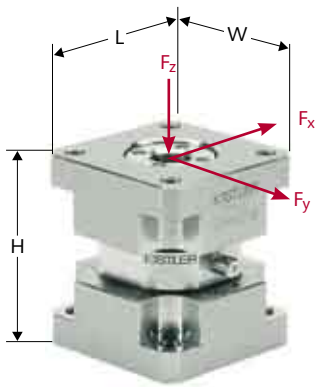
Applications
Cutting forces during machining, impact forces in crash tests, rocket engine recoil forces, vibration forces on aerospace components, friction forces, forces in product testing, vehicle forces on road and test stand, forces on wind tunnel balances.

Accessories
3-wire connecting cables Types 1698AA, 1698AB and 1698ACsp
Summing box Type 5417

Data sheet 9347C_000-604

Multicomponent Force Sensors

3-Component Force Link, 80x80x90 mm, –60 … 60 kN



Type 9367C

Technical data			Type 9367C
Measuring range	F_x, F_y F_z	kN kN	–30 … 30 –60 … 60
Calibrated meas. ranges	F_x, F_y F_z	kN kN	0 … 1 0 … 10 0 … 6 0 … 60
Max. moments	$M_{x,y}$	N·m	–500 / 500
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–7,6 ≈–3,9
Natural frequency	$f_n(x)$, $f_n(y)$ $f_n(z)$	kHz kHz	≈2,4 ≈6
LxWxH		mm	80x80x90
Weight		kg	3
Operating temp. range		°C	–40 … 80
Deg. of protection to IEC/EN 60529			IP65 with connected cable Type 1698AB IP67 with welded cable
Connector			V3 neg.

This sensor is preloaded and calibrated.

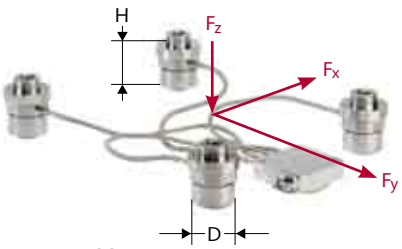
Characteristics
Accurate measurement irrespective of force application point, wide frequency range, easy mounting, sealed stainless sensor case, robust multi-pole connector.

Applications
Cutting forces during machining, impact forces in crash tests, rocket engine recoil forces, vibration forces on aerospace components, friction forces, forces in product testing, vehicle forces on road and test stand, forces on wind tunnel balances.

Accessories
3-wire connecting cables Types 1698AA, 1698AB and 1698ACsp
Summing box Type 5417

Data sheet 9367C_000-613

Multicomponent Force Link Set, ø72 mm, –25 … 60 kN



Type 9366CC...

Technical data			Type 9366CC...
Measuring range mounted on 300x300x35 mm steel cover plate	F_x, F_y F_z	kN kN	–25 … 25 –25 … 60
Calibrated meas. ranges mounted on 300x300x35 mm steel cover plate	F_x, F_y F_z	kN kN	0 … 2,5 / 0 … 25 0 … 6 / 0 … 60
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–7,8 ≈–3,7
Natural frequency	f_n	Hz	≈200 … ≈1 500 depending on size and material of cover plate
D		mm	72
H		mm	89,3
Weight		kg	7
Operating temp. range		°C	–20 … 70
Deg. of protection to IEC/EN 60529			IP67
Connector			Fischer flange, 9-pole neg.

These sensors are preloaded and calibrated.

Characteristics
Ready-to-connect set of four force links for user assembly of multicomponent force plates, cover plate size 300x300 to 1 000x700, integral connecting cables and summing box, easy mounting, reliable, flexible, corrosion-resistant, splash and cutting fluid proof.

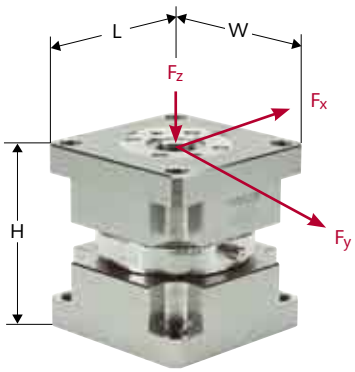
Applications
Dynamic and quasistatic measurement of the three orthogonal components of a force, cutting, punching, pressing, impact and wheel forces, recoil forces, bearing forces on machine foundations.

Accessories
Connecting cables Type 1687B5..., 1677A5…

Data sheet 9366C_000-681

Multicomponent Force Sensors

3-Component Force Link, 120x120x125 mm, –150 … 150 kN



Type 9377C

Technical data			Type 9377C, 9378C
Measuring range	F_x, F_y F_z	kN kN	–75 … 75 –150 … 150
Calibrated meas. ranges	F_x, F_y F_z	kN kN	0 … 3 0 … 30 0 … 15 0 … 150
Max. moments	$M_{x,y}$	N·m	–2 000 / 2 000
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–3,9 ≈–2
Natural frequency	$f_n(x)$, $f_n(y)$ $f_n(z)$	kHz kHz	≈1,7 ≈3,8
LxWxH		mm	120x120x125
Weight		kg	10,5
Operating temp. range		°C	–40 … 80
Deg. of protection to IEC/EN 60529			IP65 with connected cable Type 1698AB IP67 with welded cable
Connector			V3 neg.

These sensors are preloaded and calibrated.

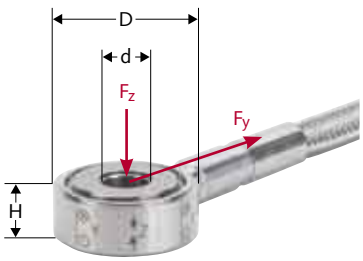
Characteristics
Very wide measuring range, high rigidity, low crosstalk, easy mounting, multi-pole connector.

Applications
Cutting, impact and recoil forces, dynamic forces on vibrating tables, determination of coefficients of friction.

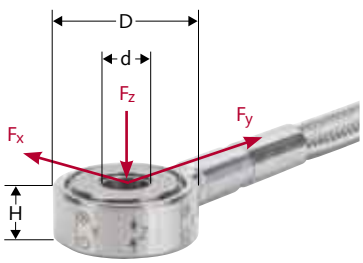
Accessories
3-wire connecting cables Types 1698AA, 1698AB and 1698ACsp
Connecting cable Type 1631C…

Data sheet 9377C_000-612

VarioComp 2/3-Component Force Sensor, ø25 mm, –5 … 5 kN



Type 9601A21...



Type 9601A31...

Technical data			Type 9601A21..., 9601A31..., 9601A32...
Measuring range	F_x, F_y F_z	kN kN	–2,5 … 2,5 –5 … 5 Standard mounting with a preload of 25 kN
Calibrated meas. ranges			not calibrated
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–3,2 ≈–3,8
Rigidity	c_x, c_y c_z	kN/µm kN/µm	≈0,2 ≈1,3
D		mm	25
d		mm	8,1
H		mm	10
Weight		g	24
Operating temp. range		°C	–50 … 120
Deg. of protection to IEC/EN 60529			IP65 with PUR sheath IP67 with steel sheath
Connector			Mini Coax neg. / KIAG 10-32 pos.

Characteristics
Compact and robust design, integral cable with steel or PUR sheath, also available as multicomponent force sensor with selection of measuring axes in the y and z or x, y and z direction. Types 9601A31 and 9601A32 differ by the position of their coordinate system.

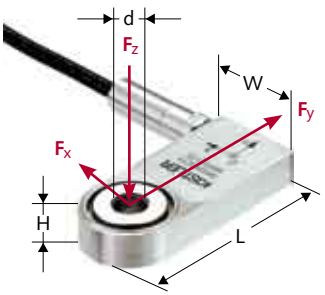
Applications
Monitoring of machinery and tools.

Accessories
Preloading key Type 9463

Data sheet 9601A_000-172

Multicomponent Force Sensors

3-Component Force Sensor with Integral Charge Amplifier, –5 … 5 kN



Type 9602A3...

Technical data			Type 9602A3...
Number of measuring ranges			2 (switchable 5:1)
Measuring range adjustment			fixed
Measuring ranges	F_x, F_y	kN	–0,5 ... 0,5 –2,5 ... 2,5
	F_z	kN	–1 ... 1 –5 ... 5
			Standard mounting with a preload of 25 kN
Calibrated meas. ranges			not calibrated
Sensitivity	F_x, F_y	mV/N	≈2 ≈10
	F_z	mV/N	≈1 ≈5
Rigidity	c_x, c_y	kN/µm	≈0,25
	c_z	kN/µm	≈1,25
Output signal		V	±5
LxWxH		mm	57x25x10
d		mm	8,1
Weight		g	30
Operating temp. range		°C	0 ... 60
Deg. of protection to IEC/EN 60529			IP67
Connector			Fischer 7-pole pos. D102 or integral cable

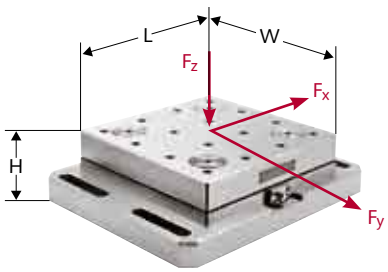
Characteristics
Integral charge amplifier electronics, two measuring ranges, sturdy, compact design, straight or right-angled connector outlet.

Applications
Process monitoring on metal cutting machine tools, presses (joining and assembly processes) and forming machines.

Accessories
Connecting cable Type 1783A…
Preloading key Type 9463
Preloading disk Type 9408

Data sheet 9602A_000-173

Multicomponent Dynamometer with 260x260 mm Cover Plate, –10 … 40 kN



Type 9255B

Technical data			Type 9255B
Measuring range	F_x, F_y	kN	–20 ... 20
	F_z	kN	–10 ... 40
Calibrated meas. ranges	F_x, F_y	kN	0 ... 2 0 ... 20
	F_z	kN	0 ... 4 0 ... 40
Sensitivity	F_x, F_y	pC/N	≈–8
	F_z	pC/N	≈–3,7
Natural frequency	$f_n(x)$, $f_n(y)$	kHz	≈2
	$f_n(z)$	kHz	≈3,3
LxWxH		mm	260x260x95
Weight		kg	52
Operating temp. range		°C	0 ... 70
Deg. of protection to IEC/EN 60529			IP67 with connected cable
Connector			Fischer flange 9-pole neg.

This sensor is calibrated and ready for measurement.

Characteristics
Sturdy dynamometer for heavy machining. The connection between the base plate and the machine table can be reinforced by also attaching the dynamometer at the center of the four sensor arrangement. This increases the natural frequency of the measurement configuration.

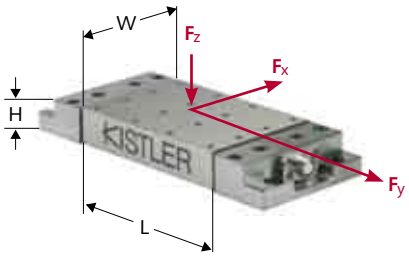
Applications
Dynamic and quasistatic measurement of the three orthogonal components of a force. Measurement of cutting forces on larger workpieces, punching and pressing forces, bearing forces on machine foundations, recoil forces.

Accessories
Connecting cables
Type 1687B5 (3-comp.)
Type 1689B5 (6-comp)

Data sheet 9255B_000-148

Multicomponent Force Sensors

CompactDyn: Multicomponent Dynamometer up to 1 kN



Type 9254

Technical data			Type 9254
Measuring range	F_x, F_y F_z	N N	±500 ±1 000
Calibrated meas. ranges	F_x, F_y F_z	N N	±0 ... 5 ±0 ... 10
Sensitivity	F_x, F_z F_y	pC/N pC/N	≈–8,1 ≈–4,3
Natural frequency	$f_n(x)$ $f_n(y)$ $f_n(z)$	kHz kHz kHz	≈2 ≈3 ≈1,8
L		mm	150
W		mm	105
H		mm	32
Weight		kg	5,1
Operating temp. range		°C	0 ... 70
Deg. of protection to IEC/EN 60529			IP67 with connected cable
Connector			Fischer 9-pole neg.

This sensor is calibrated and ready for measurement.

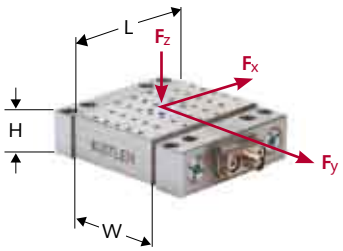
Characteristics
This dynamometer›s slim profile and low temperature error makes it ideal for measurements on precision machinery. It can be mounted on the table of the machine tool with screws or claws or simply using a magnetic table.

Applications
Dynamic and quasistatic measurement of the 3 orthogonal components of a force, measurement of cutting forces involved in superfinishing (milling and grinding).

Accessories
Connecting cables
Types 1687B5/1689B5 (3-comp.)
Types 1677A5/1679A5 (6-comp.)

Data sheet 9254_000-147

MiniDyn: Multicomponent Dynamometer up to 250 N



Type 9256C2

Technical data			Type 9256C1	Type 9256C2
Measuring range	F_x, F_y, F_z	N	±250	±250
Calibrated meas. ranges	F_x, F_y, F_z	N	0 ... 25 0 ... 250	0 ... 25 0 ... 250
Sensitivity	F_x, F_z F_y	pC/N pC/N	≈–26 ≈–13	≈–26 ≈–13
Natural frequency	$f_n(x)$, $f_n(y)$, $f_n(y)$	kHz	≈5	4
L		mm	80	80
W		mm	39	55
H		mm	25	25
Weight		g	750	870
Operating temp. range		°C	0 ... 70	0 ... 70
Deg. of protection to IEC/EN 60529			IIP67 with connected cable Types 1696A5 or 1697A5	
Connector			Fischer 7-pole neg.	

This sensor is calibrated and ready for measurement.

Characteristics
The dynamometer with the smallest mounting dimensions. The cover plate is manufactured from titanium to achieve natural frequencies in excess of 5 kHz in all three force directions. A sensitivity three times that of quartz dynamometers allows reliable measurement of minute process forces.

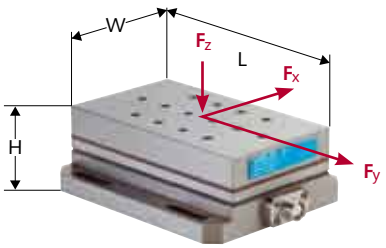
Applications
Dynamic and quasistatic measurement of the 3 orthogonal components of a force, measurement of cutting forces involved in superfinishing, wafer cutting, grinding of hard drive read heads, diamond turning, high-speed machining, ultra-precision machining of hard and brittle materials

Accessories
Connecting cables
Type 1697A5 (3-comp.)
Type 1696A5 (5-comp.)
Steel toolholder Type 9402

Data sheet 9256C_000-484

Multicomponent Force Sensors

Multicomponent Dynamometer with 100x170 Cover Plate, –5 … 5 kN



Type 9257B

Technical data			Type 9257B
Measuring range	F_x, F_y, F_z	kN	–5 … 5
Calibrated meas. ranges	F_x, F_y F_z	kN kN	0 … 0,05 / 0 … 0,5 / 0 … 5 0 … 0,1 / 0 … 1 / 0 … 10
Sensitivity	F_x, F_y F_z	pC/N pC/N	≈–7,5 ≈–3,7
Natural frequency	$f_n(x)$, $f_n(y)$ $f_n(z)$	kHz kHz	≈2,3 ≈3,5
L		mm	170
W		mm	100
H		mm	60
Weight		kg	7,3
Operating temp. range		°C	0 … 70
Deg. of protection to IEC/EN 60529			IP67 with connected cable
Connector			Fischer flange 9-pole neg.

This sensor is calibrated and ready for measurement.

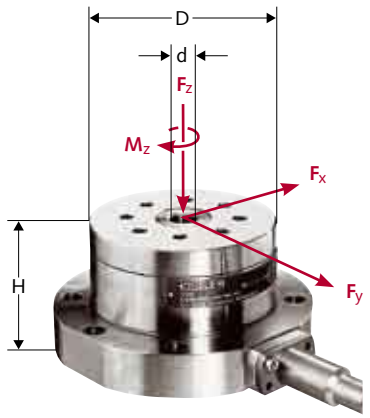
Characteristics
All-purpose dynamometer. The practical size and ideal measuring range for a wide variety of applications have made Type 9257B dynamometers a best seller.

Applications
Dynamic and quasistatic measurement of the 3 orthogonal components of a force. Measurement of cutting forces involved in turning, milling, grinding and other processes. Measurements on wind tunnel models.

Accessories
Connecting cables
Types 1687B5/1689B5 (3-comp.)
Types 1677A5/1679A5 (6-comp.)
Toolholder Type 9403

Data sheet 9257B_000-151

4-Component Dynamometer, Fx, Fy, Fz and Mz



Type 9272

Technical data			Type 9272
Measuring range	F_x, F_y F_z M_z	kN kN N·m	–5 … 5 –5 … 20 –200 … 200
Calibrated meas. ranges	F_x, F_y F_z M_z	kN kN N·m	0 … 0,5 0 … 5 0 … 2 0 … 20 0 … –200 / 0 … –20 0 … 200 / 0 … 20
Sensitivity	F_x, F_y F_z M_z	pC/N pC/N pC/N·m	≈–7,8 ≈–3,5 ≈–160
Natural frequency	$f_n(x)$, $f_n(y)$ $f_n(z)$ $f_n(M_z)$	kHz kHz kHz	≈4 ≈7 ≈5
D		mm	100
d		mm	15
H		mm	70
Weight		kg	4,2
Operating temp. range		°C	0 … 70
Deg. of protection to IEC/EN 60529			IP67 with connected cable
Connector			Fischer flange 9-pole neg.

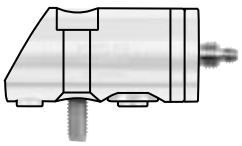
This sensor is calibrated and ready for measurement.

Characteristics
The stationary 4-component dynamometer for cutting force measurement during drilling processes.
The central hole through the dynamometer accommodates, for example, shafts for torque measurement.

Applications
Measurement of cutting forces during drilling processes or torque measurement.

Accessories
Connecting cables
Type 1677A5 and
Type 1679A5 (4-comp.)
Toolholder Type 9404

Data sheet 9272_000-153



Surface strain sensor

Longitudinal measuring pin

Transverse measuring pin

Strain Sensors

A force acting as a load on a component results in a mechanical stress of

$$\sigma = \frac{F}{A}$$

and a strain of

$$\varepsilon = \frac{\Delta l}{l_0}$$

Strain is a relative change in the length of the component under load and therefore dimensionless.

In most applications strain measurement is used for indirect force measurement on or in components. This has the advantage that mounting of the sensor does not significantly affect the component. Unlike sensors used for direct force measurement, strain sensors are rather small and their strain measurement signal depends on the force application point.

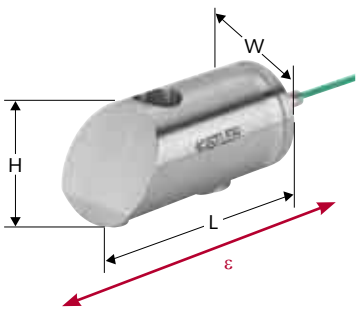
The strain is measured on the component surface or directly inside the structure. The piezoelectric **surface strain sensor** is attached to the outside surface of the component at a suitable point with just a single screw. This mounting screw ensures force transmission between the two contact areas of the sensor and the component through static friction. Changes in the measured length of the component are transmitted to the elastic sensor element, where they act as a shear force. In complex structures, a suitable point for mounting surface sensors has to be determined by trial and error.

Strain sensors in the form of **measuring pins** can also be mounted inside structures in a cylindrical hole at a location offering optimal conditions. As strains occur in different directions, Kistler offers sensors for measuring strains longitudinal or transverse to the mounting hole. To allow both tensile and compression force measurement, the sensors are mechanically preloaded inside the mounting hole.

Piezoelectric strain sensors achieve ultra-high sensitivity compared with familiar strain gage technology.

Strain Sensors

Surface Strain Sensor, –800 ... 800 με



Type 9237A...

Technical data		Type 9237A...
Measuring range	με	–800 ... 800
Calibrated meas. range*	με	0 ... 500
Sensitivity*	pC/με	≈–24
L	mm	51,5
W	mm	25,4
H	mm	26,9
Weight	g	190
Operating temp. range	°C	–30 ... 120
Deg. of protection to IEC/EN 60529		IP65 with connected cable IP67 for Type 9237A20 with special cable
Connector		KIAG 10-32 neg.

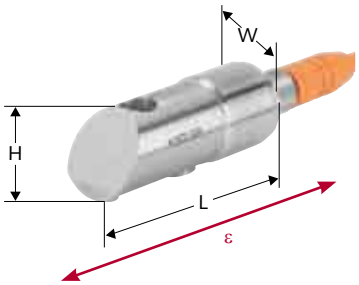
Characteristics
This robust strain sensor is ideal for measuring dynamic and quasistatic forces on stationary or moving machine parts. For this purpose it uses force-proportional strain on machinery or structural surfaces for indirect force measurement.

Applications
Monitoring of machinery such as mechanical presses to prevent overloads; quality assurance on production lines for joining processes such as wobble riveting, clinching and resistance spot welding; monitoring of machine tools for timely detection of potential tool breakage or tool collision.

Accessories
Highly insulated connecting cables with KIAG0-32 pos. connector Types 1983A..., 1939A... and 1979A... .
High-temperature connecting cable in sealed sheath Type 1915A1

Data sheet 9237A_000-662

Surface Strain Transmitter, –800 ... 800 με



Type 9238A...

Technical data		Type 9238A...
Measuring range	με	–800 ... 800
Calibrated meas. ranges*	με	0 ... 50 0 ... 500
Output signal	V	±10 (programmable ±1 ... 10)
L	mm	68,1
W	mm	26,9
H	mm	27,5
Weight	g	190
Operating temp. range	°C	–10 ... 70
Deg. of protection to IEC/EN 60529		IP67
Connector		M12x1,8 8-pole shielded
Serial interface		RS-232C

The parameters of this transmitter can be configured quickly and easily with the ManuWare PC program.

Characteristics
This robust strain sensor with integral, fully digital charge amplifier is ideal for measuring dynamic and quasistatic forces on stationary or moving machine parts. For this purpose it uses force-proportional strain on machine or structural surfaces for indirect force measurement.

Applications
Monitoring of machinery such as mechanical presses to prevent overloads; quality assurance on production lines for joining processes such as wobble riveting, clinching and resistance spot welding; monitoring of machine tools for timely detection of potential tool breakage or tool collision.

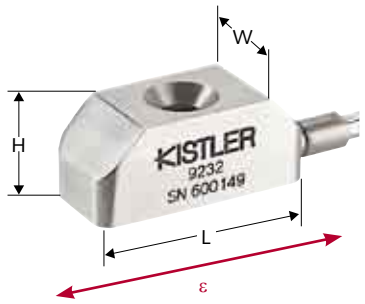
Accessories
Connecting cable Type 1787A5
Connecting cable Type 1789A5
Intermediate service cable Type 1787A-1

Data sheet 9238A_000-663

*Values only apply to the test setup used at Kistler.
For accurate force measurement the sensor must be recalibrated after mounting.

Strain Sensors

Surface Strain Sensor, High-Sensitivity, –600 ... 600 με



Type 9232A

Technical data		Type 9232A
Measuring range	με	–600 ... 600
Calibrated meas. ranges*	με	0 ... –300 0 ... 300
Sensitivity*	pC/με	≈–80
Natural frequency	kHz	≥12
L	mm	40
W	mm	17
H	mm	15
Weight	g	50
Operating temp. range	°C	0 ... 70
Deg. of protection to IEC/EN 60529		IP65 with connected cable
Connector		KIAG 10-32 neg.

Characteristics
Very high sensitivity, extremely low acceleration sensitivity, also effective for measurements on moving parts, overload protected, optional ground-isolated design.

Applications
Indirect force measurement on mechanical presses, machine tools, high-speed production machinery, assembly machinery.

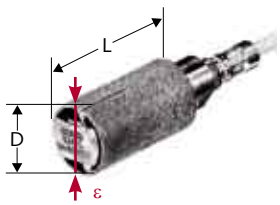
Accessories
Connecting cables
Types 1979A..., 1635C...

Data sheet 9232A_000-137

*Values only apply to the test setup used at Kistler.
For accurate force measurement the sensor must be recalibrated after mounting.

Strain Sensors

Transverse Measuring Pin for Mounting in Structures, –500 ... 500 με



Type 9241C...

Technical data		Type 9241C...
Measuring range	με	–500 ... 500
Calibrated meas. ranges*	με	0 ... 200
Sensitivity*	pC/με	≈–15
D	mm	10
L	mm	18
Weight	g	38
Operating temp. range	°C	–40 ... 200
Deg. of protection to IEC/EN 60529		IP64
Connector		optional KIAG 10-32 pos. Mini Coax neg.

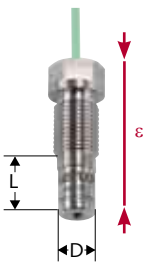
Characteristics
Preloading allows measurement of compression and tensile forces, can be secured in mounting bore in required direction and at necessary depth, integral cable, easy mounting, ground-isolated.

Applications
Indirect measurement of forces in structures of machines, tools, etc., for industrial monitoring.

Accessories
Mounting tool Type 1393B...

Data sheet 9241C_000-140

Quartz Longitudinal Measuring Pin, M10, for Mounting in Structures, –1 500 ... 1 500 με



Type 9243B...

Technical data		Type 9243B...
Measuring range	με	–1 500 ... 1 500
Calibrated meas. ranges*	με	0 ... 350
Sensitivity*	pC/με	≈–15
Natural frequency	kHz	>110
D	mm	8
L	mm	13
Hollow preloading bolt		M10x1
Weight	g	4,8 (without cable and preloading bolt)
Operating temp. range	°C	–40 ... 200
Deg. of protection to IEC/EN 60529		IP64 with connected cable IP67 with cable Type 1983AB... and welded connector
Connector		M4x0,35 neg.

Characteristics
Measures forces of almost any size indirectly though strain, preloaded for measurement of tensile as well as compression forces, can be mounted at virtually any depth in the structure.

Applications
Indirect measurement of forces in structures of machines, tools, etc., for industrial monitoring purposes, monitoring of tie bar forces in injection molding machines.

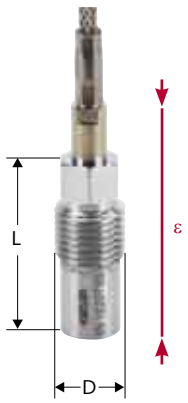
Accessories
Connecting cables Types 1923A..., 1645C... and 1983AB...,
Force distribution cap Type 9841,
Ground isolation set Type 9487A

Data sheet 9243B_000-538

*Values only apply to the test setup used at Kistler.
For accurate force measurement the sensor must be recalibrated after mounting.

Strain Sensors

High-Temperature Longitudinal Measuring Pin, M10, up to 350 °C, wit Metal-Sheathed Cable, –1 500 ... 1 500 με



Type 9245B...

Technical data		Type 9245B2..., 9245B3
Measuring range	με	–1 500 ... 1 500
Calibrated meas. ranges*	με	0 ... 350
Sensitivity*	pC/με	≈–15 / ≈15
Natural frequency	kHz	>50
D	mm	M10x1
L	mm	29
Weight	g	36
Operating temp. range	°C	–40 ... 350
Deg. of protection to IEC/EN 60529		IP65 with connected cable
Connector		Fischer KE 102 neg.

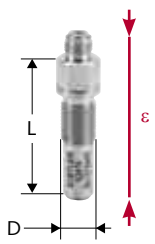
Characteristics
Very wide operating temperature range available with separable Kapton steel-sheathed cable.

Applications
Melt pressure measurement in injection molding machine cylinders, strain measurement in hot machine structures.

Accessories
Extension cable Type 1661A
End finishing tool Type 1300A21
Connecting cable Type 1951A…

Data sheet 9245B_000-142

Miniature Longitudinal Measuring Pin, –1 400 ... 1 400 με, for Installation in Structures



Type 9247A...

Technical data		Type 9247A...
Measuring range	με	–1 400 ... 1 400
Calibrated meas. ranges		not calibrated
Sensitivity*	pC/με	≈–8,6
D	mm	M5x0,5
L	mm	23,7
Weight	g	2,5
Operating temp. range	°C	–40 ... 200
Deg. of protection to IEC/EN 60529		IP65 with connected cable IP67 with cable Type 1983AB… and welded connector
Connector		M4x0,35 neg.

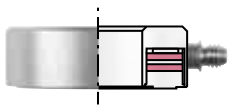
Characteristics
Very small sensor for tensile and compression measurement, indirect measurement of forces into the meganewton range, can be mounted at virtually any depth in the structure.

Applications
Sheet metal forming, connection and joining technology, plastic injection molding machines and assembly processes.

Accessories
Connecting cables Types 1926A… and 1929A…
Mounting wrench Type 1300A9
Finishing tool Type 1300A79
Special tap Type 1357A

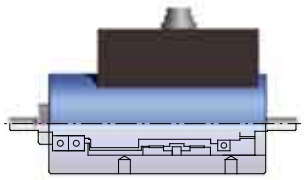
Data sheet 9247A_000-143

*Values only apply to the test setup used at Kistler.
For accurate force measurement the sensor must be recalibrated after mounting.



Torque sensor

Reaction
torque sensor



Torque sensor
for rotating shafts

Torque sensors

Kistler sensors for measuring torque on rotating shafts are based on the strain gage principle. They offer maximum accuracy, very high rigidity and high thermal stability. These measuring shafts transmit power and measurement signals without contact. Some types even operate without mechanical bearings for complete freedom from wear as well as extreme accuracy. Their noncontact digital signal transmission from rotor to stator, integral signal conditioning, normalized analog and frequency outputs and wealth of interfaces make them much easier to integrate into existing test systems.

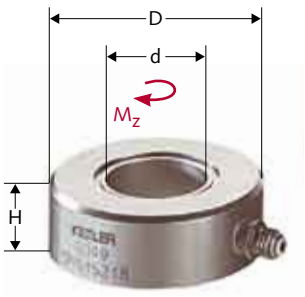
Piezoelectric sensors mounted under high mechanical preload are used as **reaction torque sensors**. Each of a number of shear-sensitive quartz disks is positioned with its shear axis tangential to a circle in which the disks are arranged. The configuration and the shape of the sensors are similar to those of single-component load washers. And this type of the sensor likewise has to be mounted under high mechanical preload to allow transmission of shear forces through static friction. Torque acting on the sensor generates tangential shear stresses in the quartz disks. As all of the disks are connected electrically in parallel, the total output signal is proportional to the acting torque.

Kistler reaction torque sensors are characterized by being mounted between a preloading bolt and a nut under high axial preload. This ensures the torque is transmitted to the shear-sensitive quartz disks through static friction. Their high resolution allows measurement of minute dynamic changes in high torques. These Kistler reaction torque sensors are calibrated prior to delivery and are ready for immediate use. A central hole accommodates shafts.

The construction of **torque dynamometers** is essentially identical to that of reaction torque sensors. A larger footprint and a cover plate with a flexible hole pattern allow easy adaptation to suit a variety of applications. These sensors are mainly used for calibrating torque wrenches.

Torque Sensors

Torque Sensor, –5 … 5 N·m to –200 … 200 N·m



Type 9039

Technical data		Type 9039	Type 9049	Type 9069
Measuring range	N·m	–5 ... 5	–25 ... 25	–200 ... 200
Calibrated meas. ranges	N·m	0 ... –5 0 ... –0,5 0 ... 0,5 0 ... 5	0 ... –25 0 ... –2,5 0 ... 2,5 0 ... 25	0 ... –200 0 ... –20 0 ... 20 0 ... 200
Sensitivity	pC/N·m	≈–600	≈–250	≈–175
Rigidity	N·m/µrad	≈7	≈12	≈50
Preloading force	kN	15	25	120
D	mm	28,5	36	52
d	mm	13	17	26,5
H	mm	11	12	15
Weight	g	38	61	150

General technical data		
Operating temp. range	°C	–150 ... 150
Deg. of protection to IEC/EN 60529		IP65 with connected cable IP67 with cable Type 1983AD… and welded connector
Connector		KIAG 10-32 neg.

Characteristics
Wide measuring range, compact design, very high rigidity, very low threshold, sturdy, welded construction.

Applications
Monitoring of torques of pneumatic screwdrivers, testing of friction clutches, measurement of motor starting torques and variations in synchronization.

Accessories
Connecting cable Type 1631C…
Preloading elements Type 9420A…

Data sheet 9039_000-111

Torque Sensors

Reaction Torque Sensor, –1 … 1 N·m to –1 000 … 1 000 N·m

Type 9329A

Technical data		Type 9329A	Type 9339A	Type 9349A	Type 9369A
Measuring range	N·m	–1 … 1	–10 … 10	–25 … 25	–200 … 200
Calibrated meas. ranges	N·m	0 … –1 0 … –0,1 0 … 0,1 0 … 1	0 … –10 0 … –1 0 … 1 0 … 10	0 … –25 0 … –2,5 0 … 2,5 0 … 25	0 … –200 0 … –20 0 … 20 0 … 200
Sensitivity	pC/N·m	≈–2 170	≈–460	≈–230	≈–130
D	mm	20	30	36	54
H	mm	26	34	42	60
Weight	g	50	137	243	800
Operating temp. range	°C	–20 … 80	–40 … 120	–40 … 120	–40 … 120

Technical data		Type 9389A
Measuring range	N·m	–1 000 … 1 000
Calibrated meas. ranges	N·m	0 … –1 000 0 … –100 0 … 100 0 … 1 000
Sensitivity	pC/N·m	≈–100
D	mm	100
H	mm	130
Weight	g	6 720
Operating temp. range	°C	–40 … 120

General technical data	
Deg. of protection to IEC/EN 60529	IP65 with connected cable IP67 with cable Type 1983AD… and welded connector
Connector	KIAG 10-32 neg.

These sensors are preloaded and calibrated.

Characteristics
Compact, ready-to-mount reaction torque sensor, highly adaptable, centering seat.

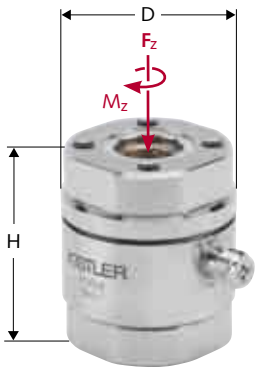
Applications
Measurement of torque about the sensor axis, torque setting and testing of screw connections, calibration of manual torque wrenches, testing of spring torsion, measurements on friction clutches and electric motors, product testing of rotary controls and switches.

Accessories
Mounting flange Type 9580A…

Data sheet 9329A_000-463

Torque Sensors

2-Component Sensor, F_z, M_z



Type 9345B

Technical data		Type 9345B	Type 9365B
Measuring range F_z	kN	–10 ... 10	–20 ... 20
Calibrated meas. ranges	kN	0 ... 1 0 ... 10	0 ... 2 0 ... 20
Sensitivity F_z	pC/N	≈–3,7	≈–3,6
Rigidity c_z	kN/µm	≈1,7	≈2,8
Measuring range M_z	N·m	–25 ... 25	–200 ... 200
Calibrated meas. ranges	N·m	0 ... –25 0 ... –2,5 0 ... 2,5 0 ... 25	0 ... –200 0 ... –20 0 ... 20 0 ... 200
Sensitivity M_z	pC/N·m	≈–200	≈–140
Rigidity c (calculated)	N·m/µrad	≈0,19	≈0,92
D	mm	39	56,5
H	mm	42	60
Weight	g	267	834
Operating temp. range	°C	–40 ... 120	–40 ... 120
Deg. of protection to IEC/EN 60529		IP65 with connected cable	IP65 with connected cable
Connector		M8x0,75 3-pole neg.	V3 neg.

These sensors are preloaded and calibrated.

Characteristics
Reaction torque sensor with option of measurement of an additional tensile/compression acting force.

Applications
Examination of the correlation between drilling torque and rupture force for PCBs, tightening torque and stripping forces in screw connections and similar processes.

Accessories
Connecting cables Types 1693A..., 1694A..., 1695A... and 1698A...

Data sheet 9345B_000-630

Torque Dynamometer, –200 ... 200 N·m

Type 9275

Technical data		Type 9275
Measuring range	N·m	–200 ... 200
Calibrated meas. ranges	N·m	0 ... –200 0 ... –20 0 ... 20 0 ... 200
Sensitivity	pC/N·m	≈–170
Natural frequency	kHz	≈3,5
D	mm	100
d	mm	18,4
H	mm	70
Weight	kg	2,9
Operating temp. range	°C	0 ... 70
Deg. of protection to IEC/EN 60529		IP65 with connected cable
Connector		TNC neg.

This sensor is calibrated and ready for measurement.

Characteristics
Precise, extremely high sensitivity, compact, sturdy design, non-rotating.

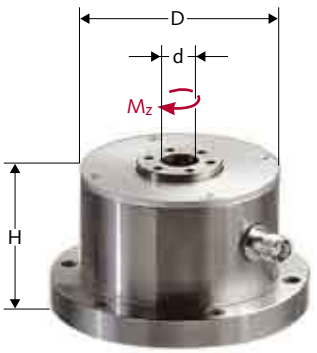
Applications
Testing of torque wrenches, testing of spring torsion, ergonomic measurements, testing of screw connections, measurement of starting torque of small and stepper motors.

Accessories
Connecting cable Type 1609B...

Data sheet 9275_000-154

Torque Sensors

Torque Dynamometer, –5 ... 5 N·m up to –25 ... 25 N·m



Type 9277A25

Technical data		Type 9277A5	Type 9277A25
Measuring range	N·m	–5 ... 5	–25 ... 25
Calibrated meas. ranges	N·m	0 ... –5 0 ... –0,5 0 ... 0,5 0 ... 5	0 ... –25 0 ... –2,5 0 ... 2,5 0 ... 25
Sensitivity	pC/N·m	≈–600	≈–250
Natural frequency	kHz	≈10	≈15

General technical data		
D	mm	78
d	mm	8,5
H	mm	60
Weight	g	1 700
Operating temp. range	°C	0 ... 70
Deg. of protection to IEC/EN 60529		IP65 with connected cable
Connector		TNC neg.

This sensor is calibrated and ready for measurement.

Characteristics
Precise, extremely high sensitivity, high natural frequency, compact, sturdy design, non-rotating.

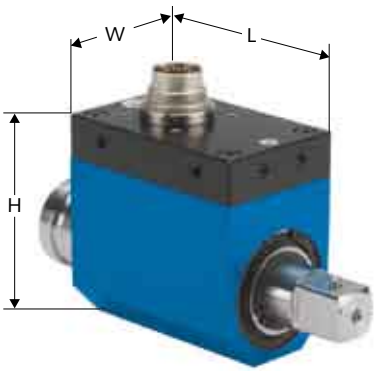
Applications
Testing of torque wrenches, testing of spring torsion, ergonomic measurements, testing of screw connections, measurement of starting torque of small and stepper motors.

Accessories
Connecting cable Type 1609B…

Data sheet 9277A_000-155

Rotating Torque Sensors

Slip-Ring Rotating Torque Sensor, 2 up to 1 000 N·m



Type 4501A...

Technical data		Type 4501A...
Rated torque M_{nom}	N·m	2 / 6 / 10 / 12 / 20 / 25 / 50 /63 / 100 / 160 / 200 / 500 / 1 000
Maximum torque		1,5 x rated torque
Accuracy class	%	0,2
Rated value	mV/V	±1 ... 2 (depending on model)
Speed measurement	pulses/rev.	2 x 360
Rated speed	rpm	≤3 000
Operating temp. range	°C	5 ... 50
Case		hard-anodized aluminum
L	mm	44 ... 73
W	mm	28 ... 73
H	mm	52 ... 90
Deg. of protection to IEC/EN 60529		IP40
Connector		Binder, 6- or 12-pole

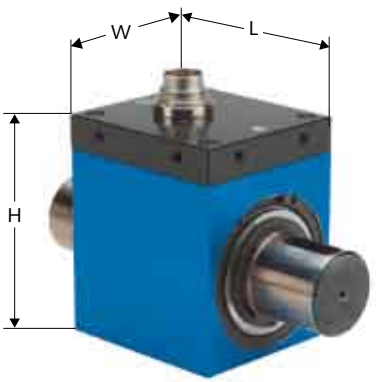
Characteristics
All-purpose rotating torque sensor, compact, broad variety of shaft connections.

Applications
Intended specifically for use in screw driving assembly. Typical applications include testing stationary screw spindles and measuring torque applied by hand or power tools for screw driving. For brief, intermittent measurement of torque at low speeds.

Accessories
Connector, 6-pole
Type KSM000822
Connector, 12-pole
Type KSM000703
Connecting cables
Types KSM071860-5, KSM103820-5 and KSM183150-5
Measuring amplifier for strain gage sensors Type 4701A…
see data sheet for other accessories

Data sheet 4501A_000-596

Mini-Smart Rotating Torque Sensor, 0,5 up to 1 000 N·m



Type 4502A...

Technical data		Type 4502A...
Rated torque M_{nom}	N·m	0,5 / 1 / 2 / 5 / 6 / 10 / 12 / 18 / 20 / 50 / 63 / 100 / 150 / 160 / 200 / 250 / 300 / 500 / 1 000
Maximum torque		1,5 x rated torque
Accuracy class	%	0,2
Output signal at M_{nom} (rated value)	VDC	±0 ... 5
Speed measurement	pulses/rev.	2 x 360 or 60
Rated speed	rpm	≤12 000
Operating temp. range	°C	10 ... 60
Case		hard-anodized aluminum
L	mm	44 ... 73
W	mm	28 ... 73
H	mm	52 ... 90
Deg. of protection to IEC/EN 60529		IP40
Connector		Binder, 12-pole

Characteristics
All-purpose rotating torque sensor with non-contact signal transmission, integral electronic measuring system and high interference immunity. Compact, broad variety of shaft connections.

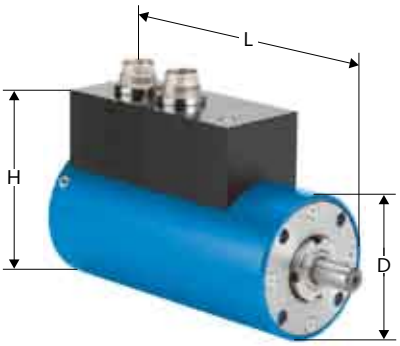
Applications
Suitable for dynamic measurement of tightening and unscrewing torques in screw driving and assembly as well as quality control in manufacturing and the laboratory. Suitable for continuous use, for example in process monitoring.

Accessories
Connector, 12-pole,
Type KSM000703
Connecting cable
Types KSM124970-5
Couplings Types 2301A… to 2303A…
see data sheet for other accessories

Data sheet 4502A_000-597

Rotating Torque Sensors

Dual-Range Sensor with Non-Contact Transmission, 0,2 up to 5 000 N·m



Type 4503A...

Technical data		Type 4503A...
Rated torque M_{nom}	N·m	0,2 / 0,5 / 1 / 2 / 5 / 10 / 20 / 50 / 100 / 200 / 500 / 1 000 / 2 000 / 5 000
Maximum torque		1,5 x rated torque
Alternating torque		0,7 x rated torque
Accuracy class	%	0,1
Linearity error including hysteresis	% FSO	<±0,1 Opt. C: <±0,05
Output signal at M_{nom} (rated value)	VDC kHz	±0 ... 5 or ±0 ... 10 or 100 ±40 and RS-232C
Speed measurement	pulses/rev.	60 or 2 x 360
Rated speed	rpm	≤50 000
Operating temp. range	°C	10 ... 60
Case		hard-anodized aluminum or stainless steel (depending on model)
L	mm	113 ... 137
D	mm	58 ... 148
H	mm	83 ... 178
Deg. of protection to IEC/EN 60529		IP40
Connector		Binder, 7- or 12-pole

Characteristics
Sensor for two separately calibrated measuring ranges (optional). Integral electronic measuring system, maximum accuracy and extremely high speed ranges, digital signal processing. A single-range version is also available.

Applications
Universal application in the development laboratory, in manufacturing and in quality assurance.

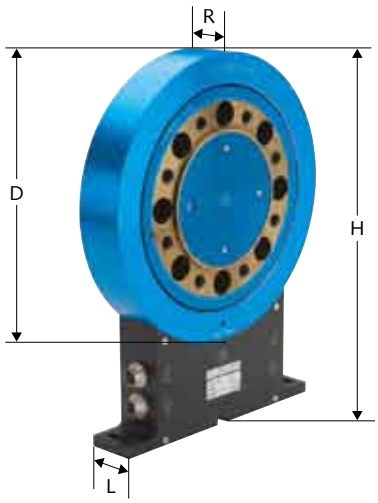
Accessories
Connector, 7-pole
Type KSM000517
Connector, 12-pole
Type KSM000703
Connecting cables
Types KSM124970-5
and KSM219710-5
Sensor tool Type 4706A…
Couplings Types 2301A… to 2303A…

see data sheet
for other accessories

Data sheet 4503A_000-595

Rotating Torque Sensors

Torque Measuring Flange - Slim, Robust, Bearingless, High Accuracy, 50 up to 5 000 N·m



Type 4504A...

Technical data		Type 4504A...
Rated torque M_{nom}	N·m	50 / 100 / 200 / 500 / 1 000 / 2 000 / 3 000 / 5 000
Maximum torque		2 x rated torque
Alternating torque		1 x rated torque
Accuracy class	%	0,1
Linearity error including hysteresis	% FSO	<±0,1 Opt. C: <±0,05
Output signal at M_{nom} (rated value)	VDC kHz	±0 ... 10 or 10 ±5, 60 ±20, 100 ±40 and RS-232C
Speed measurement	pulses/rev.	60 or 2 x 180 ... 2 x 3 600 or 2 x 128 ... 2 x 5 120 (depending on model)
Rated speed	rpm	≤15 000
Operating temp. range	°C	10 ... 60
Case		hard-anodized aluminum
L	mm	40,5 ... 64
D	mm	172 ... 311
H	mm	243,5 ... 382
R	mm	25 ... 64
Deg. of protection to IEC/EN 60529		IP54
Connector		Binder, 7-, 8- and 12-pole

Characteristics
Torque measuring flange based on the strain gage principle. Integral digital measurement conditioning system produces analog or digital output signals, which are transmitted without contact. Rotor runs in the stator ring without bearings and is free of wear.

Applications
The extremely narrow profile makes this measuring flange ideal for test stand applications including engines, gearboxes, rollers, electric motors and pumps.

Accessories
Connector, 7-pole
Type KSM000517
Connector, 12-pole
Type KSM000703
Connecting cable
Type KSM219710-5
SensorTool Type 4706A…
Couplings Types 2301A…
see data sheet
for other accessories

Data sheet 4504A_000-598

Amplifying

Signal conditioning is essential in measuring mechanical quantities such as force, strain or torque. **Charge amplifiers** convert the charge output by a piezoelectric sensor into a proportional voltage; whereas **strain gage amplifiers** boost the small measurement voltage signal. These voltage signals are then also used as input variables for monitoring and control processes.

To meet practical industrial requirements, Kistler offers a wide range of charge amplifiers with different designs, numbers of measuring channels, precision, measuring ranges, sensitivity, bandwidth, filter characteristics, scaling options and signal processing.

Charge Amplifiers for Piezoelectric Sensors

Single-Channel Charge Amplifier

Type 5015A...

Technical data		Type 5015A...	
Number of channels		1	
Measuring range adjustment		continuously variable	
Measuring range FS	pC	±2 ... 2 200 000	
Frequency range (–3 dB)	kHz	≈0 ... 200	
Output signal	V	±2 ... 10	
Supply voltage	VAC	115, 230	
Input signal	Type/connector	piezoelectric, piezotron (voltage) / BNC neg.	
Deg. of protection to IEC/EN 60529		IP40	
Interface		optional	RS-232C RS-232C and IEEE-488
Case		optional	19" cassette for rack mounting desktop unit with support bracket 19" cassette with panel mounting set
Other features			
		· Voltage input with supply voltage for "Piezotron sensors" · Display of peak values · Display of mechanical measurands	

Characteristics
Charge meter with LCD display and menu-driven operation; all important settings are visible at a glance, direct display of measurand as well as maximum, minimum and mean values, LED status displays; measurement range continuously variable, long-medium-short time constants, flexible adjustment of high- and low-pass filters, overload display, automatic zero monitoring and correction, remote control via digital inputs, RS-232C serial interface for parameter configuration and transfer of measurement data.

Applications
Measurement of mechanical quantities (pressure, force, acceleration) with piezoelectric sensors.

Accessories
RS-232C null modem cable, l = 5 m, D-Sub 9-pole pos. / D-Sub 9-pole neg. Type 1200A27

PC-link cable, RS-232C cable, l = 3 m, D-Sub 25-pole. pos. / D-Sub 9-pole neg. Type 1465A3

D-Sub adapter, D-Sub 9-pole pos. / D-Sub 25-pole neg. Type 1479.

Data sheet 5015A_000-297

Charge Amplifiers for Piezoelectric Sensors

Multichannel Charge Amplifier for Multicomponent Force Measurement

Type 5070A...

Technical data	5070Ax0xxx	5070Ax1xxx	5070Ax2xxx
Number of channels	4	8	8 with 6-component summing calculator

General technical data			
Measuring range adjustment		continuously variable	
Measuring ranges FS	pC	optional	±200 ... 200 000 ±600 ... 600 000
Frequency range (–3 dB)	kHz	≈0 ... 45	
Output signal	V	±10	
Supply voltage	VAC	100 ... 240	
Input signal	Type/connector	piezoelectric / optional	BNC neg. Fischer 9-pole neg.
Deg. of protection to IEC/EN 60529		IP40	
Interface		optional	RS-232C RS-232C and IEEE-488
Case		optional	19" cassette for rack mounting desktop unit with support bracket 19" cassette with panel mounting set
Other features			
		· Display of peak values · Display of mechanical measurands	

Characteristics
This amplifier is ideal for multicomponent force-torque measurement with piezoelectric dynamometers or force plates.

Applications
The 4-channel amplifier is effective for measuring cutting forces with Kistler dynamometers.
The 8-channel amplifier is suitable for 6-component force-torque measurement in laboratories, research and development.

Accessories
RS-232C null modem cable, l = 5 m, D-Sub 9-pole pos. / D-Sub 9-pole neg. Type 1200A27
Connecting cable for signal outputs from charge amp to data acquisition card, l = 2 m, D-Sub 15-pole pos. / D-Sub 37-pole neg. Type 1500B15
Connecting cable for signal outputs from 6-component summing calculator to data acquisition card, l = 2 m, D-Sub 15-pole pos. / D-Sub 37-pole neg. Type 1500A7
Inductive proximity switch Type 2233.

Data sheet 5070A_000-485

Charge Amplifiers for Piezoelectric Sensors

ICAM Charge Amplifier with Wide Measuring Range and Peak Memory

Type 5073A4...

Technical data	Type 5073A1...	Type 5073A2...	Type 5073A3...	Type 5073A4...
Number of channels	1	2	3	4

Technical data	Type 5073A5...
Number of channels	1 (charges of 4 inputs on one channel summed)

General technical data			
Number of measuring ranges		2 (switchable)	
Measuring range adjustment		continuously variable	
Measuring range 1 FS Measuring range 2 FS	pC pC	±100 ... 1 000 000 ±100 ... 1 000 000	
Frequenzy range (–3 dB)	kHz	≈0 ... 20 (±10 000 pC) ≈0 ... 2 (±1 000 000 pC)	
Output signal	V	±10	
Supply voltage	VDC	18 ... 30	
Input signal	Type/connector	piezoelectric / optional	BNC neg. TNC neg.
Deg. of protection to IEC/EN 60529		optional	IP60 (BNC) IP65 (TNC)
Interface		RS-232C	
Other features			
		· Peak memory · Adjustable output offset · Low-pass filter	

The parameters of this unit can be configured quickly and easily with the ManuWare PC program.

Characteristics
All-purpose industrial charge amplifier with rugged metal case; very wide variable measuring range, two independent, externally switchable measuring ranges, integral peak memory for each channel; PLC connection possible.

Applications
Monitoring, control and optimization of machinery and industrial processes.

Accessories
RS-232C null modem cable, l = 5 m, D-Sub 9-pole pos. / D-Sub
9-pole neg. Type 1200A27
Cable D-Sub / 15-pole neg. with flying leads one end.
Type 1500A41...

Data sheet 5073A_000-524

Charge Amplifiers for Piezoelectric Sensors

In-Line Charge Amplifier

Type 5027A...

Technical data		Type 5027A...		
Number of channels		1		
Measuring range adjustment		continuously variable		
Measuring ranges FS	pC	optional	±150 ... 4 800	(Type 5027A1)
			±4 800 ... 145 000	(Type 5027A2)
			±145 000 ... 450 000	(Type 5027A3)
Frequency range (–3 dB)	kHz	≈0 ... 10		
Output signal	V	±5		
Supply voltage	VDC	10 ... 36		
Input signal	Type/connector	piezoelectric / KIAG 10-32 neg.		
Deg. of protection to IEC/EN 60529		IP65		
Other features				
		Calibrated as required		

Characteristics
Wide measuring range, scaled for chosen measuring range if required, compact design, user adjustable FS range.

Applications
Conditioning of measurement signals of piezoelectric sensors. Flange plate for easy positioning anywhere on machine frame.

Accessories
Remote ControlMonitor for power supply and calibration
Type 5825A1
Calibration device Type Z16401
Mounting bracket Type 1413
8-pole round connector
Type 1500A57
Aluminum cap for round connector
Type 1433
Mounting wrench Type 1300A59

Data sheet 5027A_000-299

MiniAmp Miniature Charge Amplifier

Type 5030A...

Technical data		Type 5030A...	
Number of channels		1	
Number of measuring ranges		2 (switchable 10:1)	
Measuring range adjustment		fixed	
Measuring ranges FS	pC	optional	±100 / ±1 000
			±1 000 / ±10 000
			±10 000 / ±100 000
Frequency range (–3 dB)	kHz	≈0 ... 10	
Output signal	V	±10	
Supply voltage	VDC	18 ... 30	
Input signal	Type/connector	piezoelectric / KIAG 10-32 neg.	
Deg. of protection to IEC/EN 60529		IP65	

Characteristics
Single-channel miniature charge amplifier with rugged, dust- and waterproof aluminum case, wide measuring range, two externally switchable fixed measuring ranges (10:1), connection to PLC possible.

Applications
Conditioning of measurement signals of piezoelectric sensors. Light yet rugged design for industrial use mounted on moving machine parts.

Accessories
Connecting cable
Lumberg M12, 8-pole neg. to remote ControlMonitor
Type 5825A1 Type 1700A66
Connecting cable for PLC
Type 1787A5.

Data sheet 5030A_000-523

Charge Amplifiers for Piezoelectric Sensors

Charge Amplifier for Small Charges

Type 5037B...

Technical data		Type 5037B1...	Type 5037B3...Y39
Number of channels		1	3

Technical data			
Measuring range adjustment		continuously variable	
Measuring range FS	pC	±20 ... 650 000	
Frequency range (–3 dB)	kHz	≈0 ... 30 (<±200 000 pC)	
Output signal	V	±10	
Supply voltage	VDC	±15	
Input signal	Type/connector	piezoelectric / optional	BNC neg. TNC neg. KIAG 10-32 neg. M13x1 fitting for protective sheath Fischer connector DBEE 103A015-18
Deg. of protection to IEC/EN 60529		optional	IP60 (BNC) IP65 (TNC, KIAG 10-32) IP67 (M13x1 fitting with protective sheath)
Other features			
		Semiconductor rather than reed relay reset (… Y39)	

Characteristics
Rugged, sealed plastic case with different connection options; also available with ranges calibrated for specific sensors.

Applications
Conditioning of measurement signals of piezoelectric sensors. With its rugged design, the amplifier is ideal for in-line use in machine monitoring systems

Accessories
none

Data sheet 5037B_000-302

Charge Amplifier for Control Panel Mounting, with Digital Range Adjustment

Type 5041E...

Technical data		Type 5041E...	
Number of channels		1	
Measuring range adjustment		digital adjustment	
Measuring range FS	pC	±100 ... 99 000	
Frequency range (–3 dB)	kHz	≈0 ... 50	
Output signal	V	±10	
Supply voltage	VDC	optional	±15 24
Input signal	Type/connector	piezoelectric / BNC neg.	
Deg. of protection to IEC/EN 60529		IP40	

Characteristics
Suitable for front panel mounting, scaling with thumbwheel switch, LED for "Operate" and "Overload".

Applications
Ideal for laboratory applications and frequent changes of sensor.

Accessories
none

Data sheet 5041E_000-305

Charge Amplifiers for Piezoelectric Sensors

Charge Amplifier on Eurocard, for Multichannel 19" Racks

Type 5058A...

Technical data		Type 5058A...
Number of channels		1
Number of measuring ranges		5 (switchable, decade resistor)
Measuring range adjustment		continuously variable / digital
Measuring ranges FS	pC	±10 ... 100 ±100 ... 1 000 ±1 000 ... 10 000 ±10 000 ... 100 000 ±100 000 ... 1 000 000
Frequency range –3 dB, without internal filter –3 dB, without internal filter (integral LP filter as standard: 10 kHz)	kHz kHz	 ≈0 ... 80 (range: < ±100 000 pC) ≈0 ... 15 (all ranges)
Output signal	V	±10
Supply voltage	VDC	±15
Input signal	Type/connector	piezoelectric / Mini Coax, neg.
Deg. of protection to IEC/EN 60529		IP40
Other features		
		· Programmable measuring range · Manual operation · Peak memory · Low-pass filter · Electrical isolation

Characteristics
Five measuring ranges, positive and negative peak memories, low-pass filter as standard , "track/hold" and "track/peak" toggle, manual operation or external control.

Applications
For use in industrial instrumentation, particularly for multichannel systems and for mounting in 19" racks.

Accessories
M 105 series, multipole connector, 52 + 2 poles, rows a + c
Wire wrap 13 mm,
Art. no 5.512.123.

Data sheet 5058A_000-308

Strain Gage Amplifiers

Measuring Amplifier for Strain Gage Sensors and Resistive Travel Sensors

Version A

Version B and C

Technical data			Type 4701A...
Number of channels			1
Input signal	strain gage	mV/V	Version A: approx 1,5 Version B: approx 1,0 (0,5 … 3,0, full or half bridge, max. bridge input resistance 500 Ω)
	resistiv	V	Version C: input 0 … 5 (input resistance 1 … 5 kΩ)
Cutoff frequency (–3 dB)		kHz	1
Output signal		V	±5 or ±10
Supply voltage		VDC	24 non-stabilized (±10 %)
Input signal		Type/connector	Strain gage with opt. of cable gland with soldering terminals (version A) 6-pole connector (version B)
Deg. of protection to IEC/EN 60529			Version A with cable glands: IP54 Versions B and C with connectors: IP40

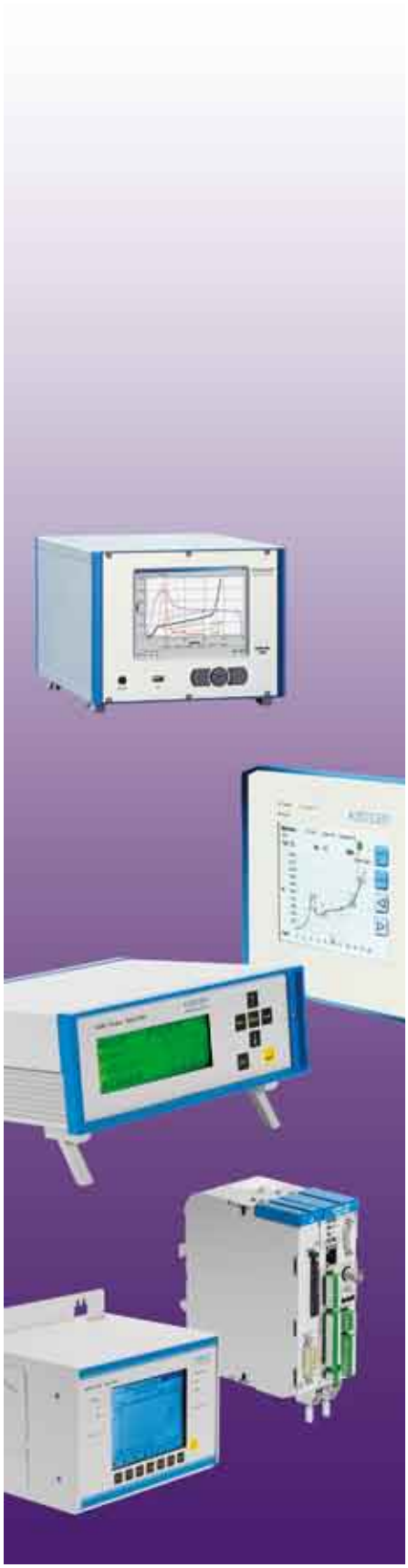
Characteristics
Industrial measuring amplifier with rugged metal case. Gain and zero adjustment set with fixed resistors and potentiometers.

Applications
Designed for panel mounting in industrial applications. It is an all-purpose solution for strain gage sensors and resistive displacement sensors. Suitable for torque sensors Type 4501A…

Accessories
Connecting cable
Type KSM071860-5
Connecting cable
Type KSM103820-5

Data sheet 4701A_000-621

Analyzing



Transparency of assembly and testing processes can be achieved by measuring force and/or torque.

As a function of time, displacement or angle is an ideal method of monitoring, controlling and documenting these processes. **ControlMonitors** (brand name: CoMo®) can be used to display, evaluate and document the resulting curves. Parameters for monitoring and evaluation functions can be freely selected within a wide range. Their configuration takes into account the specific requirements of different processing methods.

The DMF-P series of digital measuring systems for joining processes supplement the range of products for monitoring automatic assembly, particularly in conjunction with electromechanical NC joining modules.

In addition to the CoMo and DMF-P families of evaluation units, Kistler offers **DynoWare**, the multipurpose operator-friendly software for force measurement with dynamometers, single-component or multicomponent force sensors. DynoWare® provides technicians with an on-line display of measured curves as well as with useful calculation and graphics functions for signal analysis. In addition to straightforward configuration of the most important measuring instruments, the software supports operator-specific documentation of the measuring process as well as the storage of configuration and measurement data.

The **ManuWare** PC software enables quick and easy configuration of the parameters of force and strain transmitters as well as the all-purpose ICAM charge amplifier.

SensorTool, another PC software, enables the operator to process sensor and measurement data of torque sensors or supply and evaluation systems. This includes setting device parameters, numerical and graphical display of measurands, evaluation of measurements and measurement curves, reading and display of sensor and equipment data, and definition of speed output pulses.

TraceControl PC software is used to configure and control monitoring equipment of the DMF-P family with the aid of convenient graphics functions. It allows reading of equipment controller outputs and simulation of digital control by PLC, and supports system setup, production, and quality assurance.

Control and Monitoring Devices

CoMo Logic® ControlMonitor y(t)

Type 5875A...

Technical data		Type 5875A...
Number of channels	y/t	1
Measuring range adjustment		continuously variable
Measuring ranges FS	pC	optional ±50 ... 5 000 ±500 ... 50 000 ±1 000 ... 100 000 ±5 000 ... 500 000
Sampling rate	kHz	10
Frequency range (–3 dB)	kHz	≈0 ... 4
Output signal (monitor)	V	±10
Supply voltage	VDC	18 ... 30
Input signal	Type/connector	piezoelectric / BNC neg.
Deg. of protection to IEC/EN 60529		IP40
Interface		RS-232C
Case		optional 19" cassette for rack mounting desktop unit with support bracket 19" cassette with panel mounting set
Other features		
		· LCD graphics display · 3 real-time thresholds · Memory for 8 parameter sets · Flashloader

Characteristics
CoMo Logic is a single-channel y(t) ControlMonitor with graphical display, three real-time thresholds and elementary post-cycle curve analysis. The monitor is operated with front panel controls or with a PLC via digital I/Os. An analog monitor output with scaled sensor signal is available for external data acquisition. Eight parameter sets make it easy to switch between different operating modes and applications.

Applications
CoMo Logic is designed for monitoring time-dependent measurands in production processes. It is particularly suitable for monitoring force/time characteristics of manual and automated assembly and test processes.

Accessories
RS-232C null modem cable l = 5 m, D-Sub 9-pole pos. / D-Sub 9-pole neg. Type 1200A27
Connecting cable for monitor output, 2 x 2 mm connector / BNC pos. Type 1700A57

Data sheet 5875A_000-492

Control and Monitoring Devices

CoMo Net® ControlMonitor y(x) for Top-Hat Rail Mounting

Type 5863A14

Technical data		Type 5863A1...
Number of channels	y/t, y/x	1
Measuring range adjustment		continuously variable
Measuring range FS	pC V mV/V	±100 ... 1 000 000 ±0,005 ... 10 0,25 ... 40
Sampling rate	kHz	10
Frequency range (–3 dB)	kHz	≈0 ... 3
Output signal (monitor)	V	±10
Supply voltage	VDC	18 ... 30
Input signal	Type/connector	piezoelectric / BNC neg., strain gage / Phoenix 3,5 mm, piezoresistive / Phoenix 3,5 mm, voltage / Phoenix 3,5 mm, incremental encoder / D-Sub 9-pole pos. absolute encoder (SSI) / D-Sub 9-pole pos.
Deg. of protection to IEC/EN 60529		IP40
Interface		· Ethernet TCP/IP · RS-232C · 6 digital inputs · 6 digital outputs
Options		
		· Profibus DP · Incremental/absolute encoder · Compact flash memory expansion module
Other features		
		· 12 freely combinable evaluation functions · Horizontal and vertical real-time thresholds · Cycle control through displacement · Memory for storing 20 curves · Memory for 16 parameter sets · Web server · Flashloader · Software service for fast data export · Transfer formats: Q-DAS, CSV, XML, text and HTML

Characteristics
Single-channel ControlMonitor for DIN rail mounting, operates on a 24 V industrial supply, 6 PLC-compatible digital inputs and outputs enable the system to be integrated into a machine control system, networkable via TCP/IP and Ethernet, RS-232C interface for connecting equipment such as a barcode reader, operation (parameter configuration and visualization) by means of either a standard web browser via Ethernet on a PC or with the Kistler Browser and web terminal with Windows CE®. The web server integrated in CoMo Net, controls HTML pages for operating purposes, data server controls the exchange of process data with the outside world, remote diagnostics and remote maintenance capability. Access to the various menu levels is password-controlled for operators, supervisors or service personnel, intuitive operation for fast and safe setting up of the measuring process.

Applications
In-process visualization, monitoring, evaluation and classification of industrial processes like joining, separating, primary forming, re-shaping and testing. Recording of interdependent measurands – force and torque as a function of displacement, time or angle and evaluation of their functional relationship, for instance for reject separation, reworking or re-running to different tolerances.

Accessories
RS-232C null modem cable, l = 5 m, D-Sub 9-pole pos. / D-Sub
9-pole neg. Type 1200A27
Control unit with 5,7" color touch screen display Type 5629A2

Data sheet 5863A_000-444

Control and Monitoring Devices

CoMo View® ControlMonitor y(x) with Color Touch Screen Display

Type 5863A2...

Type 5863A2…
in desktop case Type 5745A…

Technical data		Type 5863A2...
Number of channels	y/t, y/x	1
Measuring range adjustment		continuously variable
Measuring range FS	pC V mV/V	±100 ... 1 000 000 ±0,005 ... 10 0,25 ... 40
Sampling rate	kHz	10
Frequency range (–3 dB)	kHz	≈0 ... 3
Output signal (monitor)	V	±10
Supply voltage	VDC	18 ... 30
Input signal	Type/connector	piezoelectric / BNC neg., strain gage / Phoenix 3,5 mm, piezoresistive / Phoenix 3,5 mm, voltage / Phoenix 3,5 mm, incremental encoder / D-Sub 9-pole pos. absolute encoder (SSI) / D-Sub 9-pole pos.
Deg. of protection to IEC/EN 60529		IP40 IP65 (front in panel mounting)
Interface		· Ethernet TCP/IP · RS-232C · 6 digital inputs · 6 digital outputs
Display		5,7"-STN color touch screen display
Options		
		· Profibus DP · Incremental/absolute encoder · Desktop case set
Other features		
		· 12 freely combinable evaluation functions Horizontal and vertical real-time thresholds · Cycle control through displacement · Memory for 20 measurement curves · 16 parameter sets · Flash Memory expansion module · Web server · Flashloader · Software service for fast data export · Transfer formats: Q-DAS, CSV, XML, text and HTML · Visualization of other CoMo Nets on the network

Characteristics
Single-channel ControlMonitor with integral 5,7" color touch screen display (320x240 pixels), operates on a 24 V industrial supply, 6 PLC-compatible digital inputs and outputs enable the system to be integrated into a machine control system, networkable via TCP/IP and Ethernet, RS-232C interface for connecting equipment such as a barcode reader, parameter configuration by means of a standard web browser via Ethernet on a PC or with the Kistler Browser and web terminal with Windows CE®. The web server integrated in CoMo Net controls HTML pages for operating purposes, visualization via PC or web terminal and using integral color display. Data server controls the exchange of process data with the outside world, remote diagnostics and remote maintenance capability, access to the various menu levels is password-controlled for operators, supervisors or service personnel, intuitive operation for fast and safe setting up of the measuring process.

Applications
In-process visualization, monitoring, evaluation and classification of industrial processes like joining, separating, primary forming, re-shaping and testing. Recording of interdependent measurands – force and torque as a function of displacement, time or angle and evaluation of their functional relationship, for instance for reject separation, reworking or allocation of production results to different tolerances.

Accessories
RS-232C null modem cable,
l = 5 m, D-Sub 9-pole pos. /D-Sub 9-pole neg. Type 1200A27
Desktop case Type 5745A…
Plug-in power pack Type 5781A1
matching desktop case
Type 5745A21
30W plug-in power pack
Type 5779A2

Data sheet 5863A_000-519

Control and Monitoring Devices

Control Unit with 5,7" Color Touch Screen Display

Type 5692A2

Technical data		Type 5629A2
Display		5,7" STN color touch screen monitor (320x240 pixels)
Interface		Ethernet 10-Base T (electrically isolated)
Operating temp. range	°C	0 ... 45
Length	mm	208
Width	mm	172
Height	mm	30
Other features		
		Fixed mounting on wall or pivot mounting on wall or machinery

Characteristics
The control unit with the 5,7" color touch screen display can be used for configuring CoMo Net ControlMonitor Type 5863A… and for displaying the force-displacement curve and evaluation results. 5,7" STN color touch screen display; rugged IP65 construction; wall or pivot mounting; for CoMo Net operation and process visualization.

Applications
The control unit is Ethernet (TCP/IP) networkable and can be detached from CoMo Net measuring unit for use as a standalone terminal. The rugged IP65 mechanical construction of the control unit makes it suitable for use in tough industrial environments. The terminal is supplied with power via the round connector on the side. An angle connector is included for this purpose.

Accessories
Power supply 100 … 240 VAC; 50 … 60 Hz, 24 VDC; 3 A; 14-pole pos. Binder connector 423 Type 5781A3

Data sheet 5629A_000-682

Control and Monitoring Devices

CoMo Sys® ControlMonitor y(x)*, Multichannel, with Integral PC

Type 5885A...

Technical data		Type 5885A...
Number of channels	y/t, y/x	optional 1 ... 2 (42 TE-Case) 1 ... 4 (63 TE-Case) 1 ... 7 (84 TE-Case)
Measuring range adjustment		continuously variable within range defined by hardware
Measuring ranges FS	pC V mV/V	±100 ... 1 000 000 ±0,005 ... 10 0,25 ... 40
Sampling rate	kHz	≈10
Frequency range (–3 dB)	kHz	≈0 ... 3
Output signal (monitor)	V	±10
Supply voltage	VAC	100 ... 230
Input signal	Type/connector	piezoelectric / BNC neg., strain gage / Phoenix 3,5 mm, piezoresistive / Phoenix 3,5 mm, voltage / Phoenix 3,5 mm, incremental encoder / D-Sub 9-pole pos. absolute encoder (SSI) / D-Sub 9-pole pos.
Interface		· Ethernet TPC/IP · RS-232C · 6 digital inputs · 6 digital outputs
Interfaces on integral PC		PS/2 for external keyboard 2 x USB 1 x RS-232C (COM2) 1 x parallel (LPT) 1 x VGA output for additional external monitor 1 x Ethernet 10/100 Mbit
Display		6,5" TFT color monitor, 640x480 pixels
Deg. of protection to IEC/EN 60529		IP40
Other features		
		· Cycle control through displacement thresholds · Integral hard disk for data storage · Slot for compact flash card · Storage of process data in Q-DAS transfer format · Wealth of special functions enabled by macro functionality
Options		
		· Profibus DP interface for each measuring channel · Incremental/absolute encoder

Characteristics
Multichannel ControlMonitor with integral 6,5" color display (640x480 pixels). Parameter configuration, visualization and logging of process by means of integral PC with hard disk, (or alternatively FlashDisk), and Windows-based user interface; two USB interfaces, serial and parallel interface, Ethernet port, PC/104 expansion slot. Each measuring channel has 6 digital intputs and outputs, voltage input for displacement sensor, optional Profibus DP interface.

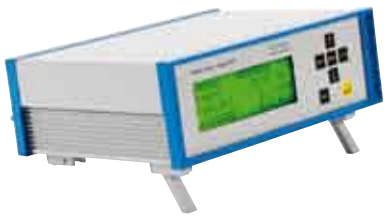
Applications
In-process visualization, monitoring, evaluation and classification of industrial processes like joining, separating, re-shaping and testing. Recording of interdependent measurands – force and torque as a function of displacement, time or angle and evaluation of their functional relationship, for instance for reject separation, reworking or re-running to different tolerances.

Accessories
Potentiometric displacement sensor e.g. Type 2112A75
Connecting cable for displacement sensor
e.g. Type KIG 4367A3 (3 m)

*Only available in Germany

Control and Monitoring Devices

CoMo Torque Evaluation Instrument for Torque Sensors



Type 4700A...

Technical data		Type 4700A...	
Number of channels $y_1 = M/t$, $y_2 = n/t$		2	
Signal inputs			
strain gage	mV/V	0,5 … 3,5 (full bridge, 4/6-wire)	
active	VDC	±5 ... 10	
frequency	kHz	≤300	
Cut-off frequency (–3 dB)	kHz	≈0 ... 5	
Speed / rotation angle input			
tracks A and B	kHz	≤300	
Sensor excitation voltages	V	24	stabilized
		5	strain gage unipolar
		5	stabilized
		±12	stabilized
Output signals			
3 channels	V	±10	
Digital control		8 digital inputs	TTL
		8 digital outputs	TTL bzw. 24 VDC
Interfaces		RS-232C and USB 2.0	
Operating temp. range (rated temperature range)	°C	10 ... 60	

Compatible with SensorTool PC program for parameter configuration and evaluation.

Characteristics
Universal measuring amplifier for connecting passive and active force and torque sensors. Torque/speed or torque/rotation angle measurements can be evaluated. The unit calculates and displays mechanical power. It also has digital inputs and outputs, min/max peak detection and a measurement curve memory function.

Applications
The unit is ideal for factory instrumentation and in test and laboratory environments.

Accessories
Connecting cable
Type KSM185350
for Type 4501A… Q/R,
Type KSM185370
for Type 4501A… QA,
Type KSM186420 l = 2,5 m for Type 4503… / 4504A… analog,
Type KSM186430 l = 2,5 m for Type 4503A… / 4504A… frequency

Data sheet 4700A_000-620

Remote ControlMonitor for Transmitter Actuation

Type 5825A1

Technical data			Type 5825A1
Number of channels			1
Measuring range adjustment			–
Measuring range		V	±10
Sampling rate		ms	<2 (>0,5 kHz)
Output signal		V	±10
Supply voltage	battery	VDC	9
	external	VDC	18 ... 30
Input signal			8-pole Binder round connector
Deg. of protection to IEC/EN 60529			IP50

Characteristics
Battery-powered handheld terminal, ideal for mobile on-site high-precision data acquisition during high-speed processes. Rugged design for industrial application with impact protection and membrane keypad, large LCD graphics display. Comes with one monitor output and one RS-232C data transmission interface.

Applications
For actuation of different transmitters like Types 9234A…, 9602AA… and 9833B… and charge amplifiers like Types 5030A… and 5027A… . Depending on the electronics, the RCM allows the configuration of basic settings or measuring ranges to suit the application. When used with older electronic equipment, the RCM can act as a power supply or a simple voltmeter.

Accessories
RS-232C null modem cable,
l = 5 m, D-Sub 9-pole pos. / D-Sub
9-pole neg. Type 1200A27
Connecting cable Lumberg M12, 8-pole neg., – for connection to Type 9234A... Type 1700A66
Desktop power pack 5.510.220

Data sheet 5825A_000-527

Control and Monitoring Devices

Single-Channel Force-Displacement Unit DMF-P A300 for General Joining and Press-Fitting Processes

Type 4737AWD...

Technical data		Type 4737A...
Number of channels	y/t, y/x	1
Measuring range adjustment for each range		continuously variable
Measuring range FS	mV/V V pC	±0,25 ... 5 ±0,5 ... 10 ±40 000 ... 1 500 000
Sampling rate	kHz	5
Resolution of analog input (automatic scaling to measuring range)	Bit	12
Output signal (monitor)	V	±10
Supply voltage	VDC	24 ±10 %
Input signal	Type/ connector	for force (torque optional)/displacement signal strain gage and voltage/Binder 6-pole piezoelectric/BNC incremental/8-pole Binder SSI/D-Sub 9-pole
Deg. of protection to IEC/EN 60529		IP40 IP54 (wall mounted/panel case)
Interfaces		Ethernet TPC/IP 2 x RS-232C Profibus DP LPT for HP-compatible printer PS/2 for external keyboard
Display		5,7" STN monochrome
Options		
		· Wall mounted case (bottom cable exit) · Desktop or panel case (rear cable exit) · Profinet I/O · DeviceNet · Interbus · 16 digital inputs · 16 digital outputs
Other features		
		· 30 freely combinable evaluation functions · Horizontal and vertical real-time thresholds · Memory for 100 measurement curves · Memory for 1 000 joining results · 32 parameter sets · Integral web server · Flashloader, upload/download · Data export in CSV, Q-DAS or I.-P.M. format · Remote parameter configuration with TraceControl possible

Characteristics
For monitoring joining and press-fitting processes. Developed for use in systems and plants with joining processes. Recording of force curve as a function of displacement or time. Online or offline evaluation (after data storage) depending on type of freely programmable criteria. Data exchange with option of external visualization via Ethernet. Logging of measurement results in CSV or standardized formats such as Q-DAS or I.-P.M. Networked to plant via fieldbus or corresponding control inputs. Configuration and setup on monitoring system with screen or PC via web browser. Clear and simple operator guidance. Integration of user evaluation methods. TraceControl software supports equipment setup, production and quality assurance.

Applications
Monitoring of assembly characteristic with adjustable windows. This allows the operator to define critical parts of the assembly cycle. Monitoring of assembly force, end position, overload and variable windows. In addition, speed of process and gradient of measurement curve can be measured and evaluated.

Accessories
24 V power supply 120 … 240 V
Type KSM028659
24 V power supply 120 … 240 V
with US connector
Type KSM028660

Data sheet 4737A_000-684

Control and Monitoring Devices

Multichannel Force-Displacement Unit DMF-P A400 advanced for General Joining and Press-Fitting Processes

Type 4733AWD...

Technical data		Type 4733A...
Number of channels	y/x, y/t	2
Adjustment of each measuring range		continuously variable
Measuring range FS	mV/V V pC	±0,25 ... 5 ±0,5 ... 10 ±40 000 ... 1 500 000
Sampling rate for each chan.	kHz	5
Resolution of analog input (automatic scaling to measuring range)	Bit	12
Output signal for each channel (monitor)	V	±10
Supply voltage	VDC	24 ±10 %
Input signal	Type/ connector	for force (torque optional)/displacement signal strain gage and voltage/Binder 6-pole piezoelectric/BNC incremental/Binder 8-pole SSI/D-Sub 9-pole
Deg. of protection to IEC/EN 60529		IP40 IP54 (wall mounted/panel case)
Interfaces		Ethernet TPC/IP 2 x RS-232C Profibus DP LPT for HP-compatible printer PS/2 for external keyboard 16 digital inputs 16 digital outputs
Display		5,7" STN monochrome
Options		
		· Wall mounted case (bottom cable exit) · Desktop or panel case (rear cable exit) · Profinet-IO · DeviceNet · Interbus
Other features		
		· 30 freely combinable evaluation functions · Horizontal and vertical real-time thresholds · Memory for 100 measurement curves · Memory for 1 000 joining results · 32 parameter sets
General features		
		· Integral web server · Flashloader, upload/download · Networking of other DMF-Ps via Ethernet · Data export in CSV, Q-DAS or I.-P.M. format · Remote parameter configuration with TraceControl possible

Characteristics
For monitoring joining and press-fitting processes. Developed for use in systems and plants with several joining processes requiring mutually independent monitoring. Expansion up to 8 independent channels can be achieved by linking a number of units. Online or offline evaluation (after data storage) depending on type of freely programmable criteria. Data exchange with option of external visualization via Ethernet. Independent operation is an option in extreme cases, mutually independent channels. Logging of measurement results in CSV or standardized formats such as Q-DAS or I.-P.M. Networking to plant via fieldbus or corresponding control inputs. Configuration and setup on monitoring system with screen or PC with web browser. Integration of user evaluation methods. TraceControl software supports equipment setup, production and quality assurance.

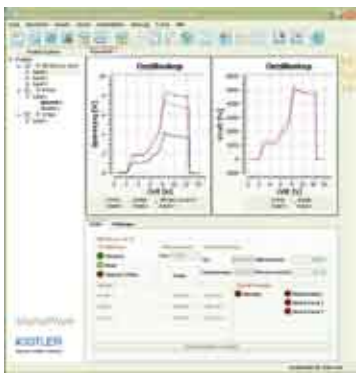
Applications
Monitoring of assembly characteristic with adjustable windows. This allows the operator to define critical parts of the assembly cycle. Monitoring of assembly forces, end position, overload and variable windows. In addition, speed of process and gradient of measurement curve can be measured and evaluated.

Accessories
24 V power supply 120 … 240 V
Type KSM028659
24 V power supply 120 … 240 V with US connector
Type KSM028660

Data sheet 4733A_000-623

Software

ManuWare – PC Tool for Setup of Parameters of Industrial Charge Amplifiers and Transmitters



Technical data	
Supported equipment:	Industrial charge amplifier ICAM Type 5073A… Transmitters Types 9337A… (force) and 9238A… (strain)

Characteristics
Versatile PC tool for configuring parameters of charge amplifiers, force and strain transmitters. Autoscan function provides automatic detection and listing of connected equipment; status of recognized instruments shown; intuitive parameter configuration with dialogs tailored to each particular instrument; a graphical display of the test measurements and auxiliary functions for scaling indirect measurement help the operator set up force measurement applications; the settings of the fully configured devices can be saved on PC.

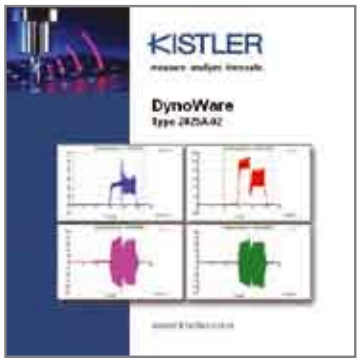
Applications
Test measurements with the supported equipment.

Options
None

Accessories
None

CD 7.643.035
can be ordered free of charge

DynoWare – Software for Data Acquisition and Evaluation



Characteristics
Simple operation, configuration and control of Kistler measuring instruments via RS-232C or IEEE-488 interface, high-performance graphics, useful signal evaluation and calculation functions, simultaneous recording of up to 8 measuring channels. Is also ideal for acquisition and evaluation of any physical measurands.

Applications
Windows® software for data acquisition and evaluation. All-purpose, operator-friendly software, especially effective for force measurement with dynamometers and single- or multicomponent force sensors. For signal analysis DynoWare provides an online display of measurement curves as well as useful calculation and graphics functions. In addition to easy configuration of the most important measuring instruments, DynoWare supports individual documentation of the measurement process as well as storage of configuration and measurement data.

Options
None

Accessories
Data acquisition card CIO-DAS 1602/12 Type 2855A3
Data acquisition card PCIM-DAS 1602/16 Type 2855A4
Data acquisition card PC card DAS 16/16 Type 2855A5
Connecting cable Type 15008B15
Connecting cable Type 15008A67
Connecting cable Type 15008B69
USB - RS-232C converter Type 2867

Data sheet 2825A_000-371

Software

SensorTool – PC Software for Setup and Evaluation of Torque Sensor Technology

Technical data	Type 4706A
Supported equipment:	Torque sensors Types 4503A… and 4504A…, CoMo Torque evaluation instrument Type 4700A…
Further information	See data sheet

Characteristics
Configuration of instrument parameters; numerical and graphical display of measurands; evaluation of measurement values and measurement curves; reading and display of sensor and instrument data; definition of speed output pulses (magnetoresistive system in the Type 4504A…); measurement value taring; storage of recorded measurement curves in TXT or CSV format; multilingual (German/English) menu guidance.

Applications
Straightforward PC software for processing sensor and measurement data from torque sensors or evaluation systems; numerical and graphical display of all of the involved measurands (torque, speed, rotation angle, mechanical power and rotor temperature of torque sensors) on the PC screen; particularly useful during initial setup, testing or optimization; all relevant sensor data (such as serial number, sensor Type, etc,) can be displayed onscreen for a quick check of the torque sensors; defined functions can be triggered to test the sensor.

Options
None

Accessories
None

Data sheet 4706A_000-626

TraceControl – PC Software for Monitoring Units

Technical data	Type 4735A
Supported equipment:	Type 4734A... (model DMF-P A300 NCF) Type 4737A... (model DMF-P A300) Type 4733A... (model DMF-P A400 advanced)
Further information	See data sheet

Characteristics
Operator-friendly software for connecting monitoring units Type 4734A… model DMF-P A300 NCF, Type 4737… model DMF-P A300 and Type 4733A… model DMF-P A400 advanced to PC; simple, intuitive operation, configuration and control of instrument via Ethernet; remote control of instrument from PC screen (1:1 representation); convenient graphical functions; support for system setup, production and quality assurance; export of configured set point value windows (evaluation ranges) and complete families of curves in image files (JPG, BMP, PNG and GIF), function for adding comments to measurement curve ranges of interest.

Applications
Simplified placement of different measurement curves for easy positioning of target value / set point windows of a monitoring unit; all digital inputs and outputs of the equipment controller can be read or set with a click of the mouse, which allows simulation of digital control by PLC; additional monitoring of measurement process using any PC on the network is possible during production; for quality assurance the not OK (NOK) measurement curves can be quickly filtered and any defects efficiently investigated.

Options
None

Accessories
None

Data sheet 4735A_000-666

Electromechanical NC Joining Modules

Electromechanical NC joining systems are taking over from the familiar hydraulic presses and conventional joining modules. In addition to environmental, energy, space, installation and maintenance benefits, it is primarily manufacturing criteria that sway the system designer towards an electromechanical system. These include flexibility, exact positioning, extremely high repeatability and accurately defined joining forces.

With its electromechanical NC joining systems Kistler offers a particularly compact, high-precision system for a wide variety of force-displacement monitored press-fitting and joining tasks.

The wealth of alternatives covers the full range of forces up to 300 kN.

NC joining modules with piezoelectric force monitoring
Electromechanical NC joining module NCFT Type 2157A… has a integral piezoelectric force sensor, nminal joining force of 1 kN and selection of measuring ranges of 0,25, 0,5 and 1 kN. Its force range and slenderness make it ideal for precision manufacturing or manual workstations.

With their space-saving, gearless, hollow-shaft motor and integral piezoelectric force sensor, particularly compact electromechanical NC joining modules NCFH Type 2151B… are designed for nominal joining forces of 10, 30 and 60 kN. They come in different sizes for measuring ranges from 1 ... 60 kN.

NC joining modules with strain gage force monitoring
As electromechanical NC joining modules with integral strain gage sensors for rated joining forces of 100, 200 and 300 kN, Types 2153A… with optional safety brakes cover the higher force ranges.

The slim profile of electromechanical NC joining module NCFS Type 2152A… with integral strain gage sensor and a nominal joining force of 35 kN makes it perfect for closely spaced workstations.

Electromechanical NC Joining Modules

NC Joining Module NCFT with Integral Force Monitoring, Measuring Range 0,25 … 1 kN

Technical data		Type 2157A1	Type 2157A2	Type 2157A3
Nominal joining force	kN	1	1	1
Measuring range 1	kN	0,5	1	1
Measuring range 2	kN	0,25	0,25	0,5

General technical data		
Measuring direction		compression/tension
Max. straight line velocity	mm/s	300
Repeatability	mm	0,005
Stroke	mm	100
Weight	kg	5,8
Tool weight	kg	≤5
L	mm	567
H	mm	60
W	mm	60
Operating temp. range	°C	10 ... 40
Deg. of protection to IEC/EN 60529		IP54

Characteristics
NC joining module with integral piezoelectric force sensor for force-displacement monitored press-fitting and joining processes with a nominal joining force of 1 kN and measuring ranges of 0,25, 0,5 and 1 kN. Its compact dimensions, slender design and small joining forces are ideal for precision manufacturing of products such as small motors, clocks and watches.

Applications
Suitable for use in automated production plants or manual workstations. Can be mounted horizontally or vertically on machine frame using wall fixings or flanges. The holder on ram allows accurate tool positioning.

Accessories
Servo controller for Type 2157A...
IndraDrive 12 A PB
Type KSM031534
Servo controller for Type 2157A...
with integrated safety option
IndraDrive 12A PB S
Type KSM032763
Force-displacement measuring system DMF-P A300 NCF
Type 4734A...
NCFT motor cable RKL4302 l = 5 m
Type KSM031533-5
NCFT feedback cable RKL4200
l = 5 m Type KSM303500-5
NCF SSI displacement cable
IndraDrive l = 5 m
Type KSM030175-5
NCF IndraDrive data cable
l = 5 m Type KSM030164-5
NCF force transmitter cable
l = 5 m Type KSM313720-5
NCF F - analog force signal l = 5 m
Type KSM030176
NCF/ XTE, YTE IndraDrive cable
l = 5 m Type KSM314030-5

Data sheet 2157A_000-707

Electromechanical NC Joining Modules

NC Joining Module NCFH with Hollow-Shaft Motor and Integral Force Monitoring, Measuring Ranges 1 … 60 kN

Size 1
Measuring range 1 ... 10 kN
Type 2151B020... to Type 2151B100...

Size 2
Measuring range 15 ... 60 kN
Type 2151B30... to Type 2151B60...

Technical data		Type 2151B02012001	Type 2151B05012001	Type 2151B05022001
Nominal joining force	kN	10	10	10
Measuring range 1	kN	2	5	5
Measuring range 2	kN	1	1	2

Technical data		Type 2151B10012001	Type 2151B10022001	Type 2151B10052001
Nominal joining force	kN	10	10	10
Measuring range 1	kN	10	10	10
Measuring range 2	kN	1	2	5

Technical data		Type 2151B30154002	Type 2151B60154002	Type 2151B60304002
Nominal joining force	kN	30	60	60
Measuring range 1	kN	30	60	60
Measuring range 2	kN	15	15	30

General technical data		Size 1	Size 2
Measuring direction		compression/tension	compression/tension
L	mm	471	795
H	mm	100	165
W	mm	100	165
Repeatability	mm	0,01	0,01
Max. straight line velocity	mm/s	300	300
Stroke	mm	200	400
Weight	kg	17	80 ... 87
Tool weight	kg	≤50	≤100
Operating temp. range	°C	10 ... 40	10 ... 40
Deg. of protection to IEC/EN 60529		IP54	IP54

Characteristics
NC joining module with integral piezoelectric force sensor with joining forces from 1 … 60 kN for force-displacement monitored press fitting and joining processes. Due to integral hollow-shaft motor the NCFH is extremely short and suitable for highly dynamic measurement; 2 calibrated switchable force measuring ranges available as standard. Force control; straight line velocity; repeatability <0,01 mm, high measuring accuracy; active deflection compensation system for more accurate positioning, high overload capacity of approximately 150 %; ease of operation.

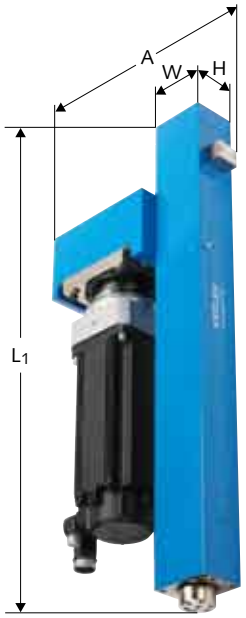
Applications
Suitable for use as linear actuator for assembly and joining tasks in automated production plants. Can be mounted horizontally or vertically on the machine frame using wall fixings or flanges. The holder on ram allows accurate tool positioning.

Accessories
Servo controller for Type 2151B... 10, 30 kN IndraDrive 54A PB
Type KSM030106
Servo controller for Type 2151B... 60 kN IndraDrive 70A PB
Type KSM031182
Force-displacement measuring system DMF-P A300 NCF
Type 4734A...
NCFH motor and feedback cable l = 5 m for size 1
Type KSM301660-5
NCFH motor and feedback cable l = 5 m for size 2
Type KSM307390-5
NCF IndraDrive SSI displacement cable l = 5 m
Type KSM301750-5
IndraDrive data cable l = 5 m
Type KSM301640-5
NCF force transmitter cable l = 5 m
Type KSM313720-5
NCF analog force signal cable l = 5 m KSM301760-5
NCF/ XTE, YTE IndraDrive cable l = 5 m Type KSM314030-5

Data sheet 2151A_000-690

Electromechanical NC Joining Modules

NC Joining Module NCFS with Motor, Gearing and Integral Force Monitoring, Rated Joining Force 35 kN



Technical data		Type 2152A35450
Nominal joining force	kN	35
Measuring direction		compression/tension
Stroke	mm	450
L_1	mm	928
H	mm	86
W	mm	110
A	mm	380
Repeatability	mm	0,01
Max. straight line velocity	mm/s	200
Operating temp. range	°C	10 ... 40
Deg. of protection to IEC/EN 60529		IP54

Characteristics
NC joining module with integral strain gage force sensor for joining forces up to 35 kN in extremely compact arrangements. The slim design allows closer spacing of individual workstations promoting better synchronization and efficient cycling.

Applications
Suitable for use in automated production plants. Can be mounted horizontally or vertically on the machine frame using flanges. The holder on ram allows accurate tool positioning.

Accessories
Servo controller IndraDrive
Type KSM030341
Force-displacement measuring system DMF-P A300 NCF
Type 4734A...
NCFS motor cable RKL4309
l = 5 m Type KSM030349-5
NCFS feedback cable RKG4200
l = 5 m Type KSM030350-5
NCF SSI IndraDrive displacement cable l = 5 m Type KSM030175-5
NCF IndraDrive Data cable
l = 5 m Type KSM030164-5
NCF Strain gage force cable
L = 5 m Type KSM020600-5
NCF F analog force signal cable
l = 5 m Type KSM030176
NCF/ XTE, YTE IndraDrive cable
l = 5 m Type KSM314030-5

Data sheet 2152A_000-627

Electromechanical NC Joining Modules

NC Joining Module NCFN with opt. Safety Device and Integrated Force Monitoring for Nominal Forces of 30 ... 300 kN

Type 2153A...
without safety device

Technical data		Type 2153A030200	Type 2153A030400	Type 2153A060200
Nominal joining force	kN	30	30	60
Stroke	mm	200	400	200
L / L*	mm	1 042 / 1 236*	1 242 / 1 436*	1 173 / 1 367*
W	mm	148	148	177
H	mm	150	150	180
Max. straight line velocity	mm/s	250	250	250
Weight	kg	75	95	115

* Dimensions with safety device

Technical data		Type 2153A060400	Type 2153A100200	Type 2153A100400
Nominal joining force	kN	60	100	100
Stroke	mm	400	200	400
L / L*	mm	1 373 / 1 567*	1 329 / 1 554*	1 529 / 1 754*
W	mm	177	227	227
H	mm	180	230	230
Max. straight line velocity	mm/s	250	200	200
Weight	kg	140	225	270

* Dimensions with safety device

Technical data		Type 2153A200400	Type 2153A300400
Nominal joining force	kN	200	300
Stroke	mm	400	400
L / L*	mm	1 754 / 1 979*	1 882 / 2 107*
W	mm	247	297
H	mm	250	300
Max. straight line velocity	mm/s	140	100
Weight	kg	355	790

* Dimensions with safety device

General technical data		
Measuring direction		compression/tension
Operating temp. range	°C	10 ... 40
Deg. of protection to IEC/EN 60529		IP54
Repeatability	mm	0,01
Tool weight	kg	100

Characteristics
NC joining module with integral strain gage force sensor with rated joining forces from 30 … 300 kN for force-displacement monitored joining processes, particularly including manual workstations with safety brakes, force control, high straight line velocity; repeatability <0,01 mm; high measuring accuracy; active deflection compensation system for more accurate positioning, high overload capacity (approx. 150 %); ease of operation.

Applications
Suitable for use in automated production plants or manual workstations. The module can be mounted horizontally or vertically on the machine frame using wall fixings or flanges. The holder on ram allows accurate tool positioning.

Accessories
NCFN(S) 30 (35) IndraDrive 54 A PB Type KSM030341
NCFN 60/100 kN IndraDrive 70 A PB Type KSM031634
NCFN 200/300 kN IndraDrive 100 A PB Type KSM030757
Force-displacement measuring system DMF-P A300 NCF 4734A...
NCFN(S) 30 (35) motor cable RKL4309 l = 5 m
Type KSM303490-5
NCFN 60 motor cable RKL4314 l = 5 m Type KSM305640-5
NCFN 100 motor cable RKL4323 l = 5 m Type KSM307530-5
NCFN 200/300 motor cable RKL4329 l = 5 m
Type KSM316330-5
NCFN(S) MSK feedback cable RKG4200 l = 5 m
Type KSM303500-5
NCF IndraDrive SSI displacement cable l = 5 m
Type KSM301750-5
NCF IndraDrive data cable l = 5m Type KSM301640-5
NCFN(S) strain gage force cable L = 5 m Type KSM206000-5
NCF F IndraDrive analog force signal cable l = 5 m
Type KSM301760-5
NCF/ XTE, YTE IndraDrive cable l = 5 m Type KSM314030-5

Data sheet 2153A_000-669

Control and Monitoring Devices

Single-Channel Force-Displacement Measuring System DMF-P A300 NCF for Electromechanical NC Joining Modules

Type 4734AWD...

Technical data		Type 4734A...
Number of channels	y/x	1
Measuring range spread for joining modules with piezo technology	ranges	2
Adjustment of each measuring range		continuously variable
Measuring range FS	mV/V V	±0,25 ... 5 ±0,5 ... 10
Sampling rate	kHz	5
Resolution of analog inputs (automatic scaling to measuring range)	Bit	12
Output signal (monitor)	V	±10
Supply voltage	VDC	24 ±10 %
Input signal	Type/ connector	force signal/Binder 6-pole displacement, incremental/Binder 8-pole displacement SSI/D-Sub 9-pole
Deg. of protection to IEC/EN 60529		IP40 IP54 (wall/panel mounted case)
Interfaces		Ethernet TPC/IP 2 x RS-232C Profibus DP LPT for HP-compatible printer PS/2 for external keyboard 16 digital inputs 16 digital outputs
Display		5,7" STN monochrome
Options		
		· Wall mounted case (bottom cable exit) · Desktop or panel mounted case (rear cable exit)
Other features		
		· 30 freely combinable evaluation functions · Horizontal and vertical real-time thresholds · Memory for 100 measurement curves · Memory for 1 000 joining results · 32 parameter sets · Integral web server · Flashloader, upload/download · Data export in CSV, Q-DAS or I.-P.M. format · Remote parameter configuration with TraceControl possible

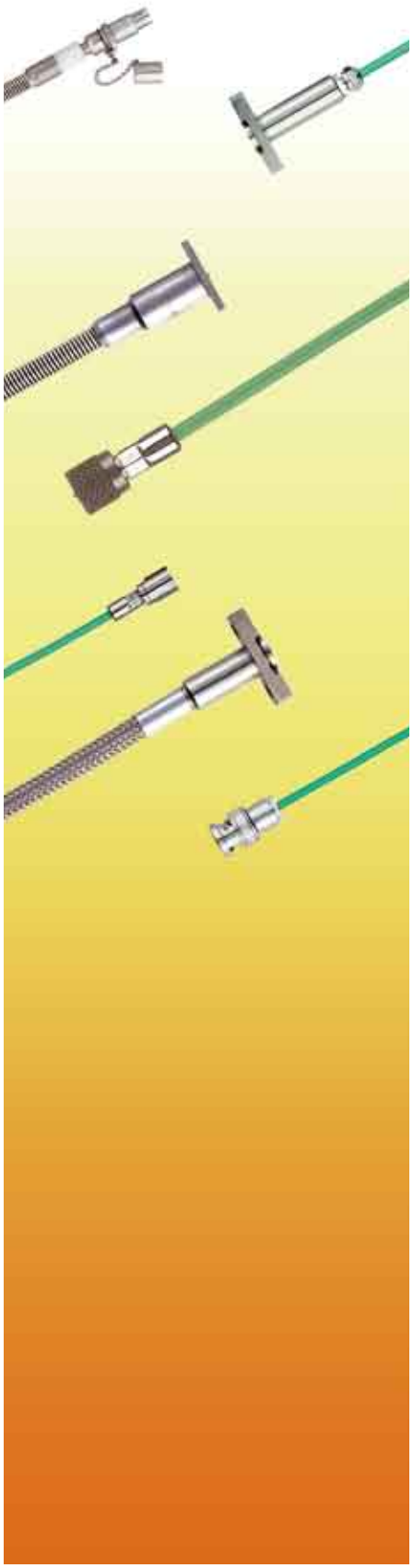
Characteristics
For monitoring joining and press-fitting processes. Developed for use in systems and plants with electromechanical NC joining modules NCFH Type 2151B..., NCFS Type 2152A… and NCFN Type 2153A… . Recording of force curve as a function of displacement or time. Online or offline evaluation (after data storage) depending on type of freely programmable criteria. Management of setpoint records and transmission to Bosch Rexroth servo controller (EcoDrive or IndraDrive) with firmware. Data exchange with option of external visualization via Ethernet. Logging of measurement results in CSV or standardized formats such as Q-DAS or I.-P.M. Neworking to plant via fieldbus or corresponding control inputs. Configuration and setup on monitoring system with screen or PC with web browser. Clear and simple operator guidance. Characteristics consistent with multichannel system DMF-P A400 advanced Type 4733A… and single-channel system DMF-P A300 Type 4737A… for general joining processes, expansion with additional functions. Integration of user evaluation methods. TraceControl software supports equipment setup, production and quality assurance.

Applications
Monitoring of assembly characteristic with adjustable windows. This allows the operator to define critical part of the assembly cycle. Monitoring of assembly force, end position, overload and variable windows. In addition, speed of process and gradient of measurement curve can be measured and evaluated.

Accessories
24 V power supply (120 … 240 V) Type KWM028659
24 V power supply (120 … 240 V) with US connector Type KSM028660

Data sheet 4734A_000-622

Connecting



Special cables are used to interconnect piezoelectric sensors and charge amplifiers in a similar way to their strain gage counterparts. Original Kistler connecting cables with their high insulation resistance, low level of triboelectricity, low capacitance, high shielding factor and wide temperature range meet all conceivable industrial and laboratory requirements.

KIAG 10-32 pos.
(connector with union nut)

KIAG 10-32 pos. int.
(threaded connector (can be welded to sensor))

Single-Wire Connecting Cables

Connecting Cables for Sensors with KIAG 10-32. neg. Connector

Technical data		Type 1631C...
Connector		KIAG 10-32 pos. – BNC pos.
Length	m	0,5 / 1 / 2 / 3 / 5 / 10 / 20 / sp* (L_{min} = 0,1 m / L_{max} = 50 m)
Diameter	mm	2 (PFA)
Deg. of protection to IEC/EN 60529		IP65 – IP40

Technical data		Type 1641A...
Connector		KIAG 10-32 pos. 90° – BNC pos.
Length	m	0,5 / 1 / 2 / 5 / sp* (L_{min} = 0,1 m / L_{max} = 50 m)
Diameter	mm	2 (PFA)
Deg. of protection to IEC/EN 60529		IP40 – IP40

Technical data		Type 1633C...
Connector		KIAG 10-32 pos. – TNC pos.
Length	m	0,5 / 1 / 2 / 5 / sp* (L_{min} = 0,1 m / L_{max} = 50 m)
Diameter	mm	2 (PFA)
Deg. of protection to IEC/EN 60529		IP65 – IP65

Technical data		Type 1635C...
Connector		KIAG 10-32 pos. – KIAG 10-32 pos.
Length	m	0,5 / 1 / 2 / 5 / 10 / sp* (L_{min} = 0,1 m / L_{max} = 30 m)
Diameter	mm	2 (PFA)
Deg. of protection to IEC/EN 60529		IP65 – IP65

Technical data		Type 1957A...
Connector		KIAG 10-32 pos. – KIAG 10-32 pos.
Length	m	1 / sp* (L_{min} = 0,1 m / L_{max} = 10 m)
Diameter	mm	2,6 (PFA with stainless steel sheath)
Deg. of protection to IEC/EN 60529		IP65 – IP65

Technical data		Type 1939A...
Connector		KIAG 10-32 pos. int. – BNC pos.
Length	m	1 / 2 / 3 / sp* (L_{min} = 0,1 m / L_{max} = 20 m)
Diameter	mm	2 (PFA)
Deg. of protection to IEC/EN 60529		IP65 – IP40

Technical data		Type 1983AD...
Connector		KIAG 10-32 pos. int. – BNC pos.
Length	m	2 / 5 / sp* (L_{min} = 0,1 m / L_{max} = 5 m)
Diameter	mm	2 (Viton®)
Deg. of protection to IEC/EN 60529		IP65 threaded connector – IP40 IP67 welded connector – IP40

Technical data		Type 1941A...
Connector		KIAG 10-32 pos. int. – TNC pos.
Length	m	1 / 2 / 3 / sp* (L_{min} = 0,1 m / L_{max} = 20 m)
Diameter	mm	2 (PFA)
Deg. of protection to IEC/EN 60529		IP65 – IP65

*sp: Special length to customer specifications

Single-Wire Connecting Cables

Connecting Cables for Sensors with KIAG 10-32. neg. Connector

Technical data		Type 1967A...
Connector		KIAG 10-32 pos. int. – KIAG 10-32 pos. int.
Length	m	1 / sp* (L_{min} = 0,5 m / L_{max} = 10 m)
Diameter	mm	2,6 (ground-isolated stainless steel sheath)
Deg. of protection to IEC/EN 60529		IP65 – IP65

Technical data		Type 1969A...
Connector		KIAG 10-32 pos. int. – KIAG 10-32 pos. int.
Length	m	1 / sp* (L_{min} = 0,5 m / L_{max} = 10 m)
Diameter	mm	2,6 (PFA with stainless steel sheath)
Deg. of protection to IEC/EN 60529		IP65 – IP65

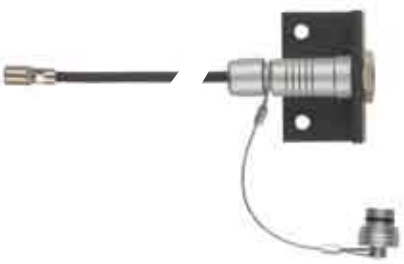
Technical data		Type 1983AC...
Connector		KIAG 10-32 pos. int. – KIAG 10-32 pos. int.
Length	m	0,5 / 1 / 1,5 / 2 / 3
Diameter	mm	2 (Viton®)
Deg. of protection to IEC/EN 60529		IP65 threaded connector – IP65 IP67 welded connector – IP65

Technical data		Type 1943A...
Connector		KIAG 10-32 pos. int. – Mini-Coax neg.
Length	m	1 / 2 / 3 / sp* (L_{min} = 0,1 m / L_{max} = 10 m)
Diameter	mm	2 (PFA)
Deg. of protection to IEC/EN 60529		IP65 – IP40

Technical data		Type 1945A...
Connector		KIAG 10-32 pos. int. – Mini-Coax neg.
Length	m	1 / 2 / sp* (L_{min} = 0,1 m / L_{max} = 5 m)
Diameter	mm	1 (PFA)
Deg. of protection to IEC/EN 60529		IP65 – IP40

Data sheet 000-352

Connecting Cables for Sensors with KIAG 10-32. neg. Connector, incl. Clamping Angle for Cable Coupling



Technical data		Type 1979A...
Connector		KIAG 10-32 pos. int. – Fischer Triax neg. KE 103A015-12
Length	m	1 / sp* (L_{min} = 0,1 m / L_{max} = 20 m)
Diameter	mm	3,2 (Viton®)
Deg. of protection to IEC/EN 60529		IP65 – IP65

General technical data		
Operating temp. range	°C	–55 ... 200

Data sheet 1631C_000-346

KIAG 10-32 pos. Connector with union nut
KIAG 10-32 pos. int. Threaded connector (can be welded to sensor)
*sp: Special length to customer specifications

Single-Wire Connecting Cables

Connecting Cables for Sensors with M4x0,35 neg. Connector

Technical data		Type 1651C...
Connector		M4x0,35 pos. – BNC pos.
Length	m	0,5 / 1 / 2 / 5 / 10 / sp* (L_{min} = 0,3 m / L_{max} = 10 m)
Diameter	mm	2 (PFA)
Operating temp. range	°C	–55 ... 200
Deg. of protection to IEC/EN 60529		IP65 – IP40

Technical data		Type 1951A...
Connector		M4x0,35 pos. int. – KIAG 10-32 pos.
Length	m	0,4 / sp* (L_{min} = 0,1 m / L_{max} = 5 m)
Diameter	mm	2,6 (Kapton® with stainless steel sheath)
Operating temp. range	°C	–55 ... 300
Deg. of protection to IEC/EN 60529		IP65 – IP65

Technical data		Type 1923A...
Connector		M4x0,35 pos. int. – KIAG 10-32 pos. int.
Length	m	1 / sp* (L_{min} = 0,1 m / L_{max} = 5 m)
Diameter	mm	2 (PFA)
Operating temp. range	°C	–55 ... 200
Deg. of protection to IEC/EN 60529		IP65 – IP65

Technical data		Type 1983AB...
Connector		M4x0,35 pos. int. – KIAG 10-32 pos. int.
Length	m	0,5 / 1 / 1,5 / 2 / 3 / 5
Diameter	mm	2 (Viton®)
Operating temp. range	°C	–55 ... 200
Deg. of protection to IEC/EN 60529		IP65 threaded connector – IP65 IP67 welded connector – IP65

Data sheet 1631C_000-346

Connecting Cables for Sensors with TNC neg. Connector

Technical data		Type 1609B...
Connector		TNC pos. – BNC pos.
Length	m	2 / 5 / 10 / 20 / 50 / sp* (L_{min} = 0,1 m / L_{max} = 50 m)
Diameter	mm	3,2 (PVC)
Operating temp. range	°C	–25 ... 70
Deg. of protection to IEC/EN 60529		IP40 – IP40

Technical data		Type 1610A...
Connector		TNC pos. – BNC pos.
Length	m	2 / 5 / 10 / sp* (L_{min} = 0,1 m / L_{max} = 20 m)
Diameter	mm	2 (PFA)
Operating temp. range	°C	–55 ... 200
Deg. of protection to IEC/EN 60529		IP65 – IP40

Technical data		Type 1619B...
Connector		TNC pos. – BNC pos.
Length	m	5 / 10 / sp* (L_{min} = 0,1 m / L_{max} = 20 m)
Diameter	mm	9,7 (metal sheath)
Operating temp. range	°C	–25 ... 70
Deg. of protection to IEC/EN 60529		IP65 – IP40

*sp: Special length to customer specifications

Data sheet 1631C_000-346

Single-Wire Connecting Cables

Connecting Cables for Sensors with BNC neg. Connector

Technical data		Type 1601B...
Connector		BNC pos. – BNC pos.
Length	m	0,5 / 1 / 2 / 5 / 10 / 20 / sp* (L_{min} = 0,1 m / L_{max} = 50 m)
Diameter	mm	3,2 (PVC)
Operating temp. range	°C	–25 ... 70
Deg. of protection to IEC/EN 60529		IP40 – IP40

Technical data		Type 1615B...
Connector		TNC pos. – TNC pos.
Length	m	5 / sp* (L_{min} = 1 m / L_{max} = 10 m)
Diameter	mm	9,7 (metal sheath)
Operating temp. range	°C	–25 ... 70
Deg. of protection to IEC/EN 60529		IP65 – IP65

See page 145 for cable connectors, couplings and accessories

Data sheet 1631C_000-346

Extension Cables

BNC Extension Cable

Technical data		Type 1603B...
Connector		BNC neg. – BNC pos.
Length	m	2 / 5 / 10 / 20 / 50 / sp* (L_{min} = 0,1 m / L_{max} = 50 m)
Diameter	mm	3,2 (PVC)
Operating temp. range	°C	–25 ... 70
Deg. of protection to IEC/EN 60529		IP40 – IP40

Data sheet 1631C_000-346

KIAG 10-32 Extension Cable

Technical data		Type 1637C...
Connector		KIAG 10-32 neg. – KIAG 10-32 pos.
Length	m	5 / sp* (L_{min} = 0,3 m / L_{max} = 5 m)
Operating temp. range	°C	–55 ... 200
Deg. of protection to IEC/EN 60529		IP65 – IP65

Data sheet 1631C_000-346

Multi-Wire Connecting Cables

Connecting Cable for SlimLine Kits with Fischer Flange 7-pole neg. Connector

Technical data		Type 1971A1...
Connector		Fischer flange 7-pole pos. – 1 x BNC pos.
Length	m	3
Diameter	mm	2 (PFA)
Number of conductors		1
Deg. of protection to IEC/EN 60529		IP65 – IP40

*sp: Special length to customer specifications

Multi-Wire Connecting Cables

Connecting Cables for SlimLine Kits with Fischer Flange 7-pole neg. Connector

Technical data		Type 1973AX1...
Connector		Fischer flange 7-pole pos. – 2 … 4 x BNC pos.
Length	m	3
Diameter	mm	7,2 (protective sheath)
Number of conductors		2 ... 4
Deg. of protection to IEC/EN 60529		IP67 – IP40

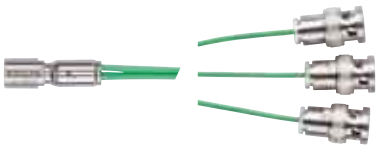
Technical data		Type 1971A2...
Connector		Fischer flange 7-pole pos. – 1 x Mini Coax neg.
Length	m	3
Diameter	mm	2 (PFA)
Number of conductors		1
Deg. of protection to IEC/EN 60529		IP65 – IP40

Technical data		Type 1973AX2...
Connector		Fischer flange 7-pole pos. – 4 x Mini Coax neg.
Length	m	3
Diameter	mm	7,2 (protective sheath)
Number of conductors		2 ... 4
Deg. of protection to IEC/EN 60529		IP67 – IP40

General technical data		
Operating temp. range	°C	–20 ... 120

Data sheet 9131A_000-109

Connecting Cables for 3-Component Sensors with V3 neg. Connector



Technical data		Type 1698AA...
Connector		V3 pos. – 3 x BNC pos.
Length	m	1 / 2 / 5 / sp* (L_{min} = 0,2 m / L_{max} = 20 m)
Diameter	mm	3 x 2 (PFA with plastic sheath)
Number of conductors		3
Deg. of protection to IEC/EN 60529		IP65 – IP40

Technical data		Type 1698AB...
Connector		V3 pos. – Fischer 9-pole pos.
Length	m	1 / 2 / 5 / sp* (L_{min} = 0,5 m / L_{max} = 20 m)
Diameter	mm	3,6 (PFA)
Number of conductors		3
Deg. of protection to IEC/EN 60529		IP65 – IP65

Technical data		Type 1698AC...
Connector		V3 pos. – Fischer 9-pole pos.
Length	m	sp* (L_{min} = 2 m / L_{max} = 5 m)**
Diameter	mm	9,7 (Viton® with stainless steel sheath)
Number of conductors		3
Deg. of protection to IEC/EN 60529		IP67 – IP65

General technical data		
Operating temp. range	°C	–40 ... 120

*sp: Special length to customer specifications

Data sheet 1687B_000-545

Multi-Wire Connecting Cables

Connecting Cables for Multicomponent Dynamometers with Fischer Flange 9-pole neg. Connector

Technical data	Type 1677A5
Connector	Fischer flange 9-pole pos. – Fischer 9-pole pos.
Number of conductors	8
Application	6-component measurement

Technical data	Type 1679A5
Connector	Fischer flange angle 9-pole pos. – Fischer 9-pole pos.
Number of conductors	8
Application	6-component measurement

Technical data	Type 1687B5
Connector	Fischer flange 9-pole pos. – Fischer 9-pole pos.
Number of conductors	3
Application	3-component measurement

Technical data	Type 1689B5
Connector	Fischer flange angle 9-pole pos. – Fischer 9-pole pos.
Number of conductors	3
Application	3-component measurement

General technical data		
Deg. of protection to IEC/EN 60529		IP67 – IP65
Length	m	5
Diameter	mm	12,3 (flexible stainless steel sheath)

Data sheet 1687B_000-545

Connecting Cables for Multicomponent Dynamometers with Fischer Flange 7-pole neg. Connector

Technical data	Type 1696A...
Connector	Fischer flange 7-pole pos. – Fischer 9-pole pos.
Number of conductors	6
Application	5-component measurement

Technical data	Type 1697A...
Connector	Fischer flange 7-pole pos. – Fischer 9-pole pos.
Number of conductors	3
Application	3-component measurement

General technical data		
Deg. of protection to IEC/EN 60529		IP67 – IP65
Length	m	5 / sp* (L_{min} = 1 m / L_{max} = 5 m)
Diameter	mm	7 (Viton® with stainless steel sheath)

Data sheet 1687B_000-545

*sp: Special length to customer specifications
** The sheath is torsion proof. To allow a secure Fischer connection, a 0,5 m longer cable must always be ordered.

Multi-Wire Connecting Cables

Connecting Cables for Transmitters with M12x1 8-pole pos. Connector

Technical data		Type 1787A...
Connector		M12x1 8-pole neg. – flying leads
Length	m	5 / 20
Diameter	mm	6,6
Number of conductors		8
Deg. of protection to IEC/EN 60529		IP67 at the transmitter end

Accessories

Couplings

Technical data	Type 1701
Connector	BNC neg. – BNC neg.

Technical data	Type 1711
Connector	TNC neg. – TNC neg.

Technical data	Type 1723
Connector	TNC pos. – KIAG 10-32 neg.

Technical data	Type 1733
Connector	BNC pos. – Bananenstecker neg.

Technical data	Type 1749
Connector	KIAG 10-32 pos. – 2 x KIAG 10-32 neg.

Technical data	Type 1705
Connector	BNC pos. – M4x0,35 neg.

Technical data	Type 1721
Connector	BNC pos. – KIAG 10-32 neg.

Technical data	Type 1729A
Connector	KIAG 10-32 neg. – KIAG 10-32 neg.

Technical data	Type 1743
Connector	BNC pos. – 2 x BNC neg.

Technical data	Type 1700A29
Connector	KIAG 10-32 pos. (int.) – KIAG 10-32 neg.

Data sheet 1700_000-347

Feed-Through Couplings

Technical data	Type 1713
Connector	TNC neg. – TNC neg.

Technical data	Type 1703
Connector	BNC neg. – BNC neg.

Data sheet 1700_000-347

Plastic Protection Caps

Technical data	Type 1851
Area of application	BNC neg.

Technical data	Type 1871
Area of application	TNC neg.

Technical data	Type 1861A
Area of application	BNC pos.

Technical data	Type 1891
Area of application	KIAG 10-32 neg.

Data sheet 1700_000-347

Accessories

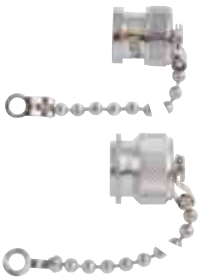
Cover for Sockets, with Chain

Technical data	Type 1853
Area of application	BNC neg.

Technical data	Type 1873
Area of application	TNC neg.

Data sheet 1700_000-347

Short-circuit Cover for Sockets, with Chain



Technical data	Type 1855
Area of application	BNC neg.

Technical data	Type 1875
Area of application	TNC neg.

Technical data	Type 1865
Area of application	BNC pos.

Data sheet 1700_000-347

See **data sheet** 1700_000-347 for other cable connectors, couplings and accessories

Connecting Cables for Rotating Torque Sensors

Connecting Cables for Sensors Types 4501A... to 4504A...

Technical data		Type KSM071860-5
Connector		6-pole neg. – 6-pole pos.
Length	m	5
Diameter	mm	6
Deg. of protection to IEC/EN 60529		IP40

Technical data		Type KSM103820-5
Connector		6-pole neg. – flying leads
Length	m	5
Diameter	mm	6
Deg. of protection to IEC/EN 60529		IP40

Technical data		Type KSM183150-5 (only for 4501A..., QA and HA)
Connector		12-pole neg. – flying leads
Length	m	5
Diameter	mm	6
Deg. of protection to IEC/EN 60529		IP40

Technical data		Type KSM124970-5
Connector		12-pole neg. – flying leads
Length	m	5
Diameter	mm	6
Deg. of protection to IEC/EN 60529		IP40

Technical data		Type KSM219710-5
Connector		7-pole neg. – flying leads
Length	m	5
Diameter	mm	6
Deg. of protection to IEC/EN 60529		IP40

Connecting Cables for Torque Sensors

Cables for Connecting Sensors Types 4501A… to 4504A… to CoMo Net®

Technical data		Type 1200A121A1
Connector		M16x0,75 12-pole neg. – D-Sub 15-pole neg. / Phoenix 3,5 mm 9-pole
Length	m	5 / sp* (L_{min} = 0,5 m / L_{max} = 5 m)
Diameter	mm	6,5
Deg. of protection to IEC/EN 60529		IP40
Application		CoMo Net/View Type 5863A…

Technical data		Type 1200A121A2
Connector		M16x0,75 12-pole neg. – D-Sub 15-pole neg. / Phoenix 3,5 mm 9-pole / 2-pole flying leads
Length	m	5 / sp* (L_{min} = 0,5 m / L_{max} = 5 m)
Diameter	mm	5,2
Deg. of protection to IEC/EN 60529		IP40
Application		CoMo Net/View Type 5863A…

Technical data		Type 1200A121A3
Connector		M16x0,75 12-pole neg. – D-Sub 15-pole neg. / Phoenix 3,5 mm 9-pole / 2-pole flying leads
Length	m	5 / sp* (L_{min} = 0,5 m / L_{max} = 5 m)
Diameter	mm	6,5
Deg. of protection to IEC/EN 60529		IP40
Application		CoMo Net/View Type 5863A...

Connector for Torque Sensors and Force Sensors Types 4576A… and 4577A…

Female Cable Connectors for Sensors Types 4501A… to 4504A…

Technical data	Type KSM000822, KSM000517, KSM000703
Connector	6-, 7- or 12-pole neg.
Deg. of protection to IEC/EN 60529	IP40

See **data sheet** KSM_000-615 for other female cable connectors

*sp: Special length to customer specifications

Accessories

Professional installation and calibration of systems consisting of force sensors and matching electronics is the only way of achieving reliable results. Kistler's wide range of mechanical and electrical accessories, calibration and test equipment makes this tried and tested approach possible.

Piezoelectric force sensors are characterized by their extreme rigidity and high natural frequency, but also require great care during mounting. The mechanical loads in the sensor element must not exceed the permissible limit at any point and peaks are to be avoided. The sensor preload also has to meet a range of requirements. Shear forces, for example, are transmitted by means of static friction and closure of microscopic gaps between the sensor and the components introducing the load ensures the high rigidity is maintained. The preload must also accommodate all loads on the sensor. The measuring ranges of Kistler sensors are specified to minimize the risk of fractures.

Calibrated load washers are supplied with a tested mounting set. Higher preloading forces are best accommodated by high-strength **preloading elements**. Multicomponent force sensors should always be mounted with the designated preloading elements. Suitable **mounting accessories** allow mounting of force sensors even under adverse conditions.

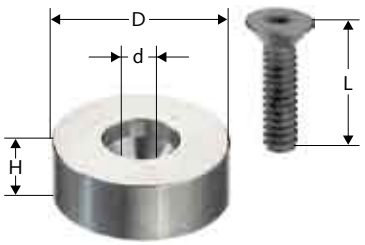
Mounting sensors in dynamometers requires base and cover plates of sufficient rigidity to prevent unacceptable deflection of the cover plate and eccentric loading of the sensor under point loads. **Accessories** such as distributing caps and rings are used to ensure centric force application.

Preload measuring instruments are employed for on-site charge measurements to determine parameters such as the preload of piezoelectric strain sensors required for mounting. Such instruments are small, light, accommodate integral charge amplifiers and do not require external power. Summing and distribution boxes can collect and distribute the charge signals.

Strain gage sensors for measuring torque on rotating shafts are basically mounted with **couplings**. These decouple interference from the measuring shaft, ensure accurate measurement and increase the service life of the sensor. Kistler's range caters for a wide variety of geometric and power requirements.

Preloading Elements

Preloading Disk for SlimLine Sensors



Technical data		Type 9410A0	Type 9410A2	Type 9410A3	Type 9410A4
for sensor	Type	9130B...	9132B...	9133B...	9134B...
Thread		M2	M2,5	M3	M4
D, outside ø	mm	8	12	16	20
d, inside ø	mm	2,7	2,7	3,2	4,3
H, disk thickness	mm	3,55	3,55	4,25	4,25
L, screw length	mm	8	8	10	10

Technical data		Type 9410A5	Type 9410A6	Type 9410A7
for sensor	Type	9135B...	9136B...	9137B...
Thread		M5	M6	M8
D, outside ø	mm	24	30	36
d, inside ø	mm	5,3	6,4	8,4
H, disk thickness	mm	4,25	5,5	7
L, screw length	mm	10	14	16

Supplied with 1 countersunk screw

Data sheet 9130B_000-110

Set of Preloading Elements for Load Washers

Technical data		Type 9420A01	Type 9420A11	Type 9420A21	Type 9420A31
for sensor	Type	9001A	9011A	9021A	9031A
Inside ø of sensor	mm	4,1	6,5	10,5	13
Preloading screw Thread L, Length	 mm	 M4x0,5 22	 M5x0,5 28	 M8x1 40	 M10x1 46
Preloading force	kN	4	7	18	30

Technical data		Type 9420A41	Type 9420A51	Type 9420A61	Type 9420A71
for sensor	Type	9041A	9051A	9061A	9071A
Inside ø of sensor	mm	17	21	26,5	40,5
Preloading bolt Thread L, Length	 mm	 M12x1 60	 M14x1,5 62	 M20x1,5 80	 M27x2 102
Preloading force	kN	45	60	100	200

Characteristics
Standardized preloading element for mounting load washers Types 9001A … 9071A. A set of preloading elements consists of a preloading bolt, a hexagonal nut, a centering sleeve and two insulating washers. High-strength, corrosion resistant materials are used.

Applications
Preloading of load washers and torque sensors for optimized force application and ground-isolated mounting.

Data sheet 9420A_000-192

Preloading Elements

Preloading Screw for Load Washers

Technical data		Type 9422A01	Type 9422A11	Type 9422A21	Type 9422A31
for sensor	Type	9001A	9011A	9021A	9031A
Inside ø of sensor	mm	4,1	6,5	10,5	13
Preloading screw Thread L, Length	 mm	 M3x0,5 16	 M5x0,8 20	 M8x1,25 30	 M10x1,5 35
Preloading force	kN	2,5	5	10	20

Technical data		Type 9422A41	Type 9422A51
for sensor	Type	9041A	9051A
Inside ø of sensor	mm	17	21
Preloading screw Thread L, Length	 mm	 M12x1,75 40	 M14x2 45
Preloading force	kN	30	40

Characteristics
Standardized preloading screw for mounting load washers Types 9001A … 9051A. Centering clip is used to align the sensor with screw. The preloading screw is supplied with each sensor Type 9001A … 9015A.

Applications
Preloading of load washer for general force measurement.

Data sheet 9001A_000-105
9001A_000-182

Set of Preloading Elements, M20x1,5

Technical data		Type 9451A...
for sensor	Type	9067..., 9068...
Inside ø of sensor	mm	26,5
Thread		M20x1,5
Preloading force	kN	160

Characteristics
Standardized high-strength preloading elements.

Applications
For mounting 3-component force sensors, optimized force application and temperature compensation.

Accessories
Wrench adapter Type 9471

Data sheet 9451A_000-194

Set of Preloading Elements, M40x2

Technical data		Type 9455
for sensor	Type	9077C..., 9078C...
Inside ø of sensor	mm	40,5
Thread		M40x2
Preloading force	kN	300

Characteristics
Standardized high-strength preloading elements. Hollow preloading screw allows mounting on base plate through the sensor.

Applications
For mounting 3-component force sensors, optimized force application and temperature compensation.

Accessories
Wrench adapter Type 9473

Data sheet 9455_000-195

Preloading Elements

Set of Preloading Elements, M26x0,75

Technical data		Type 9459
for sensor	Type	9067..., 9068...
Inside ø of sensor	mm	26,5
Thread		M26x0,75
Preloading force	kN	160

Characteristics
Standardized high-strength preloading elements. Hollow preloading screw allows installation on base plate through the sensor.

Applications
For mounting 3-component force sensors, optimized force application and temperature compensation.

Accessories
Wrench adapter Type 9477

Data sheet 9459_000-196

Set of Preloading Elements, M8x1

Technical data		Type 9461
for sensor	Type	9251A..., 9252A..., 9601A
Inside ø of sensor	mm	8,1
Thread		M8x1
Preloading force	kN	25

Characteristics
Standardized high-strength preloading elements.

Applications
For mounting 3-component force sensors, optimized load application and temperature compensation.

Accessories
Wrench adapter Type 9475

Data sheet 9461_000-197

Set of Preloading Elements, M14x1,5

Technical data		Type 9465
for sensor	Type	9047C..., 9048C...
Inside ø of sensor	mm	14,1
Thread		M14x1,5
Preloading force	kN	60

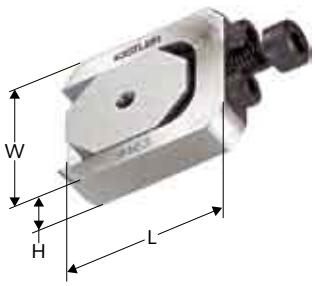
Characteristics
Standardized high-strength preloading elements.

Applications
For mounting 3-component force sensors, optimized force application and temperature compensation.

Accessories
Wrench adapter Type 9472

Data sheet 9465_000-198

Preloading Key for Multicomponent Force Sensor



Technical data		Type 9463
for sensor	Type	9601A..., 9602A...
Inside ø of sensor	mm	8,1
LxWxH	mm	28x24x6
Preloading force	kN	25

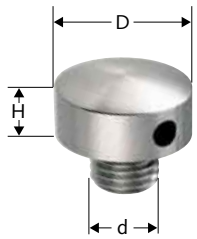
Characteristics
Slim design, easily installed and removed.

Applications
For mounting 3-component force sensors in machine structures.

Data sheet 9601A_000-172
9601A_000-451

Accessories for Force Introduction

Force Distributing Cap for Force Links

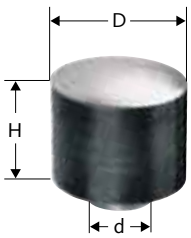


Technical data		Type 9500A0	Type 9500A1	Type 9500A2	Type 9500A3
for sensor	Type	9301B	9311B	9321B	9331B
D	mm	8,5	12,5	18	23
d		M5	M6	M10	M12
H	mm	4	6	9	12

Technical data		Type 9500A4	Type 9500A5	Type 9500A6	Type 9500A7
for sensor	Type	9341B	9351B	9361B	9371B
D	mm	31	35	45	64
d		M16	M20	M24	M30
H	mm	15	18	22	32

Data sheet 9301B_000-107

Force Distributing Cap for Load Washers



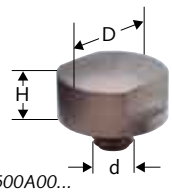
Technical data		Type 9509	Type 9519	Type 9529	Type 9539
for sensor	Type	9001A	9011A	9021A	9031A
D	mm	10	14	22	28
d	mm	4,1	6,5	10,5	13
H	mm	10	15	20	25

Technical data		Type 9549	Type 9559	Type 9569	Type 9579
for sensor	Type	9041A	9051A	9061A	9071A
D	mm	34	40	52	75
d	mm	17	21	26,5	40,5
H	mm	30	40	50	60

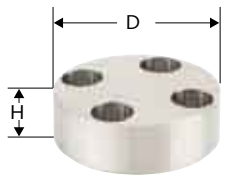
Standardized accessory for special mounting requirements for load washers
Types 9001A … 9071A

Data sheet 9505_000-193

Force Distributing Cap for Press Force Sensors



Type 9500A00...



Type 9582A...

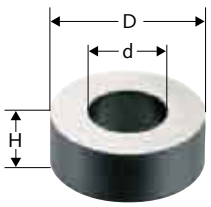
Technical data		Type 9500A00	Type 9500A01
for sensor	Type	9313AA1	9313AA2
D	mm	6	10,5
d		M2,5	M4
H	mm	3	5

Technical data		Type 9582A0	Type 9582A1	Type 9582A2
for sensor	Type	9333A	9343A	9363A
D	mm	30	36,5	56
H	mm	11	13	22

Data sheet 9333_000-454

Accessories for Force Application

Force Distributing Ring for Load Washers



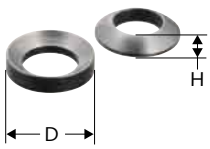
Technical data		Type 9505	Type 9515	Type 9525	Type 9535
for sensor	Type	9001A	9011A	9021A	9031A
D	mm	10	14	22	28
d	mm	4,1	6,5	10,5	13
H	mm	6	8	10	11

Technical data		Type 9545	Type 9555	Type 9565	Type 9575
for sensor	Type	9041A	9051A	9061A	9071A
D	mm	34	40	52	75
d	mm	17	21	26,5	40,5
H	mm	12	13	15	17

Standardized accessory for special mounting requirements for load washers
Types 9001A … 9071A

Data sheet 9505_000-193

Spherical Washer for Load Washers



Technical data		Type 9513	Type 9523	Type 9533	Type 9543
for sensor	Type	9011A	9021A	9031A	9041A
D	mm	12	21	24	30
H (overall)	mm	4	6	7	8

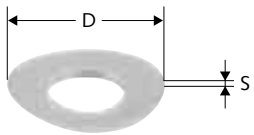
Technical data		Type 9553	Type 9563	Type 9573
for sensor	Type	9051A	9061A	9071A
D	mm	36	52	75
H (overall)	mm	10	14	20

Standardized accessory for special mounting requirements for load washers
Types 9001A … 9071A

Data sheet 9505_000-193

Mounting Accessories

Insulating Washer for Load Washers



Technical data		Type 9517	Type 9527	Type 9537	Type 9547
for sensor	Type	9011A	9021A	9031A	9041A
D	mm	14	22	28	34
H	mm	1	1	1	2
S	mm	0,13	0,13	0,13	0,13

Technical data		Type 9557	Type 9567	Type 9577
for sensor	Type	9051A	9061A	9071A
D	mm	40	52	75
H	mm	2	2	2
S	mm	0,13	0,13	0,13

Standardized accessory for special mounting requirements for load washers
Types 9001A … 9071A

Data sheet 9505_000-193

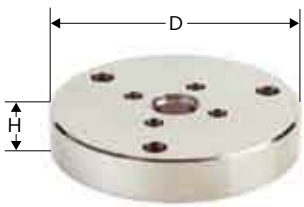
Flange for Force Links

Technical data		Type 9501A0	Type 9501A1	Type 9501A2	Type 9501A3
for sensor	Type	9301B	9311B	9321B	9331B
D	mm	25	34	44	56
H	mm	8	9	16	20

Technical data		Type 9501A4	Type 9501A5	Type 9501A6	Type 9501A7
for sensor	Type	9341B	9351B	9361B	9371B
D	mm	70	84	102	136
H	mm	27	35	42	51

Data sheet 9301B_000-107

Flange for Press Force Sensors and Reaction Torque Sensors



Technical data		Type 9580A7	Type 9580A8	Type 9580A9	Type 9580A0
for press force sensor	Type	9313AA1	9313AA2	9323A / 9323AA	9333A
for reaction torque sensor	Type	–	–	9329A	9339A
D	mm	27	35	40	62
H	mm	7	8	8	11

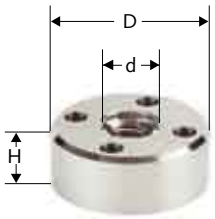
Technical data		Type 9580A1	Type 9580A2	Type 9580A4	Type 9594A1
for press force sensor	Type	9343	9363	–	9337A40X
for reaction torque sensor	Type	9349A	9369A	9389A	–
D	mm	70	100	180	80
H	mm	13	22	30	13

Data sheets 9333_000-454
9329A_000-463
9337A_000-664

Accessories

Mounting Accessories

Female Thread Adapter for Press Force Sensors



Technical data		Type 9584A9	Type 9584A0	Type 9584A1	Type 9584A2
for sensor	Type	9323A / 9323AA	9333A	9343A/9337A	9363A
D	mm	20	30	36,5	56,0
d	mm	M4	M8	M12	M18
H	mm	8	11	14	21

Data sheet 9333_000-454

Male Thread Adapter for Press Force Sensors

Technical data		Type 9586A9	Type 9586A0	Type 9586A1	Type 9586A2
for sensor	Type	9323A / 9323AA	9333A	9343A/9337A	9363A
D	mm	20	30	36,5	56
d	mm	M4	M8	M12	M18
H	mm	8	11	14	21

Data sheet 9333_000-454

Couplings for Torque Sensors

Torsion Proof Multi-Disk Coupling for Torque Measurement Flange Type 4504A...

Type 2300A... variant S

Type 2300A... variant F

Type 2300A... variant H

Type 2300A... variant A

General technical data			Type 2300A10…	Type 2300A25…	Type 2300A40…
Coupling for sensor Type			4504A50/100…	4504A200…	4504A500…
Rated torque	T_{KN}	N·m	100	420	650
Peak transient torque	T_{Kmax}	N·m	150	630	975
Coupling outside diameter	D_{aK}	mm	69	89	104
Torsion resistance (per assembly)	C_T	10^3·N·m/rad	60	290	320
Overall torsion resistance	$C_{T\ overall}$	10^3·N·m/rad	30	145	160

General technical data			Type 2300A100…	Type 2300A300…	Type 2300A500…
Coupling for sensor Type			4504A1K…	4504A2K…	4504A3K…
Rated torque	T_{KN}	N·m	1 600	3 500	5 800
Peak transient torque	T_{Kmax}	N·m	2 400	5 250	8 700
Coupling outside diameter	D_{aK}	mm	143	167	198
Torsion resistance (per assembly)	C_T	10^3·N·m/rad	1 900	3 480	11 900
Overall torsion resistance	$C_{T\ overall}$	10^3·N·m/rad	950	1 740	5 950

General technical data			Type 2300A850…
Coupling for sensor Type			4504A5K…
Rated torque	T_{KN}	N·m	9 500
Peak transient torque	T_{Kmax}	N·m	14 250
Coupling outside diameter	D_{aK}	mm	234
Torsion resistance (per assembly)	C_T	10^3·N·m/rad	20 600
Overall torsion resistance	$C_{T\ overall}$	10^3·N·m/rad	10 300

Characteristics
Torsion proof multi-disk coupling for effective, space-saving connection of torque sensor Type 4504A… into the shafting.

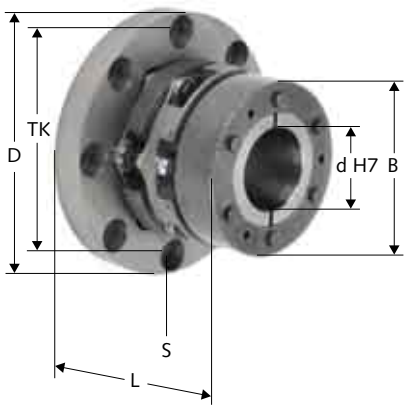
Applications
The multi-disk coupling is used to compensate for axial, radial and angular misalignment with a torque sensor. This is always essential to avoid measurement errors and damage to the sensor.
The different variants allow easy integrating of the sensor into virtually any application.

Included accessories
Screws for assembly with sensor Type 4504A…

Data sheet 2300A_000-667

Couplings for Torque Sensors

Torsion Proof Multi-Disk Coupling for Torque Measuring Flange Type 4504A… with Tension Ring Hub (Variant S)



Type 2300A… variant S
Coupling with tension ring hub

Technical data			Type 2300A10S…	Type 2300A25S…	Type 2300A40S…
Max. speed	n_{max}	rpm	15 000	15 000	12 000
Moment of inertia	J	10^{-3}·kg·m²	0,81	4,3	13,4
Mass		kg	0,85	2,7	5,6
B		mm	68	82	100
d H7 (min … max)		mm	19 … 38	32 … 52	40 … 60
D		mm	100	120	155
TK		mm	87	105	133
L		mm	62,5	84	97,2
S		8 x 45°	M6	M8	M12

Technical data			Type 2300A100S…	Type 2300A300S…	Type 2300A500S…
Max. speed	n_{max}	rpm	12 000	10 000	10 000
Moment of inertia	J	10^{-3}·kg·m²	56	100	210
Mass		kg	14,1	21	35
B		mm	143	167	198
d H7 (min … max)		mm	55 … 90	50 … 85	60 … 100
D		mm	185	210	232
TK		mm	133	165	165
L		mm	137,2	158,4	192
S		8 x 45°	M12	M14	M14

Technical data			Type 2300A850S…
Max. speed	n_{max}	rpm	8 000
Moment of inertia	J	10^{-3}·kg·m²	540
Mass		kg	60
B		mm	234
d H7 (min … max)		mm	70 … 120
D		mm	284
TK		mm	206
L		mm	231
S		8 x 45°	M18

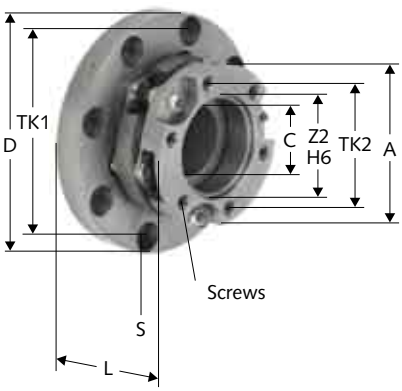
Applications
Adapts sensor Type 4504A... to a device with straight shaft end; suitable for high-speed applications with small axial misalignment.

Accessories
None

Data sheet 2300A_000-667

Couplings for Torque Sensors

Coupling for Torque Measuring Flange Type 4504A… with Flange (Variant F)



Type 2300A… variant F
Coupling with flange

Technical data			Type 2300A25F…	Type 2300A40F…	Type 2300A100F…
Max. speed	n_{max}	1/min	15 000	12 000	12 000
Moment of inertia	J	10^{-3}·kg·m²	3,4	11	43,5
Mass		kg	1,9	3,8	9,3
A		mm	89	104	143
C		mm	41	46	66
D		mm	120	155	185
TK1		mm	105	133	133
TK2		mm	75	86	116
Z2 H7		mm	55	65	92
Screws			6 x M8	6 x M10	6 x M12
L		mm	54	65,2	97,2
S		8 x 45°	M8	M12	M12

Technical data			Type 2300A300F…	Type 2300A500F…	Type 2300A850F…
Max. speed	n_{max}	1/min	10 000	10 000	8 000
Moment of inertia	J	10^{-3}·kg·m²	80,7	160	407,5
Mass		kg	13,9	22	39
A		mm	178	210	250
C		mm	61	66	76
D		mm	210	232	284
TK1		mm	165	165	206
TK2		mm	150	175	210
Z2 H7		mm	100	120	140
Screws			6 x M16	8 x M16	8 x M20
L		mm	110,4	133	160
S		8 x 45°	M14	M14	M18

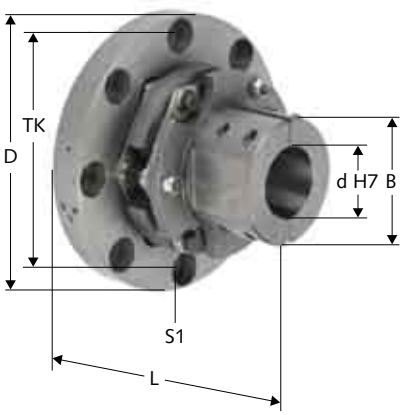
Applications
Adapts sensor Type 4504A... to a device with straight shaft end; suitable for high-speed applications with small axial misalignment.

Accessories
None

Data sheet 2300A_000-667

Couplings for Torque Sensors

Coupling for Torque Measuring Flange Type 4504A… with Half-Shell Hub (Variant H)



Type 2300A… variant F
Coupling with flange

Technical data			Type 2300A25H…	Type 2300A40H…	Type 2300A100H…
Max. speed	n_{max}	1/min	8 200	7 000	5 100
Moment of inertia	J	10^{-3}·kg·m²	3,5	11,6	46,5
Mass		kg	2,6	4,5	12
B		mm	60	70	100
d H7		mm	22 … 32	25 … 40	35 … 60
D		mm	120	155	185
TK		mm	105	133	133
L		mm	84	102,2	152,2
S1		8 x 45°	M8	M12	M12

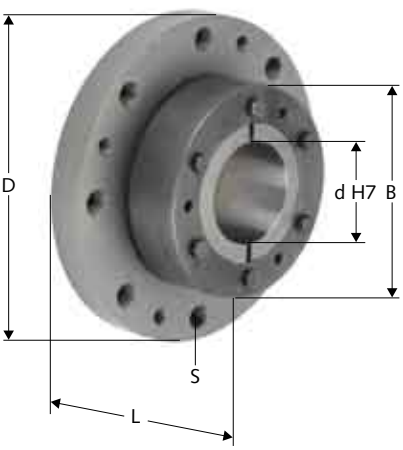
Technical data			Type 2300A300H…	Type 2300A500H…	Type 2300A850H…
Max. speed	n_{max}	1/min	4 300	3 600	3 100
Moment of inertia	J	10^{-3}·kg·m²	84	160	380
Mass		kg	18	28	45
B		mm	121	141	164
d H7		mm	50 … 80	60 … 95	70 … 110
D		mm	210	232	284
TK		mm	165	165	206
L		mm	173,4	197	241
S1		8 x 45°	M14	M14	M18

Applications
Adapts sensor Type 4504A…; for connection with or without keyway to shaft of assembly being tested; for lower-speed applications with larger axial misalignment.

Accessories
None

Data sheet 2300A_000-667

Adapter Flange for Torque Measuring Flange Type 4504A… with Tension Ring Hub (Variant A)



Type 2300A… variant A
Adapter flange with tension ring hub

Technical data		Type 2300A10A…	Type 2300A25A…	Type 2300A40A…
d H7	mm	19 … 38	32 … 52	40 … 60
D	mm	100	120	155
L	mm	34	45	53
B	mm	68	82	100
S	8 x 45°	M6	M8	M12

Technical data		Type 2300A100A…	Type 2300A300A…	Type 2300A500A…
d H7	mm	55 … 90	50 … 85	60 … 100
D	mm	155	190	190
L	mm	61	72	79
B	mm	143	164	198
S	8 x 45°	M12	M14	M14

Technical data		Type 2300A850A…
d H7	mm	70 … 120
D	mm	238
L	mm	98
B	mm	234
S	8 x 45°	M18

Characteristics
Adapter flange for space-saving connection of torque sensor Type 4504A… into the shafting. Provides adaption only – no coupling compensation for misalignment.

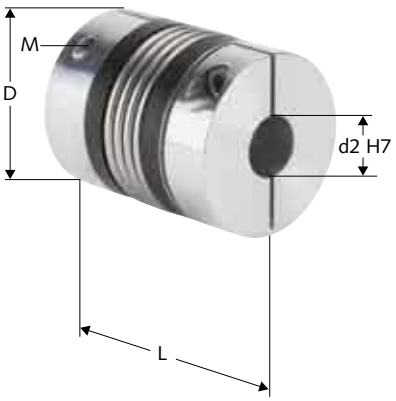
Applications
For rigid drive-side adaptation of sensor Type 4504A… to a drive or loading machine.

Accessories
None

Data sheet 2300A_000-667

Couplings for Torque Sensors

Metal Bellows Coupling with Clamping Hubs



Technical data			Type 2301A15	Type 2301A30	Type 2301A60
Rated torque	T_{KN}	N·m	15	30	60
Torsion resistance	C_{Tdyn}	10^3·N·m/rad	20	39	76
Moment of inertia	J	10^{-3}·kg·m²	0,06	0,12	0,32
L		mm	59	69	83
d2 H7 (min … max)		mm	8 … 28	10 … 30	12 … 35
D		mm	49	55	66
M			M5	M6	M8
Mass		kg	0,15	0,3	0,4

Technical data			Type 2301A80	Type 2301A150	Type 2301A200
Rated torque	T_{KN}	N·m	80	150	200
Torsion resistance	C_{Tdyn}	10^3·N·m/rad	129	175	191
Moment of inertia	J	10^{-3}·kg·m²	0,8	1,9	3,2
L		mm	94	95	105
d2 H7 (min … max)		mm	14 … 42	19 … 42	22 … 45
D		mm	81	81	90
M			M10	M10	M12
Mass		kg	0,8	1,7	2,5

Technical data			Type 2301A300	Type 2301A500	Type 2301A800
Rated torque	T_{KN}	N·m	300	500	800
Torsion resistance	C_{Tdyn}	10^3·N·m/rad	450	510	780
Moment of inertia	J	10^{-3}·kg·m²	7,6	14,3	16,2
L		mm	111	133	140
d2 H7 (min … max)		mm	24 … 60	35 … 60	40 … 75
D		mm	110	124	134
M			M12	M16	2xM16
Mass		kg	4	6,3	5,7

Technical data			Type 2301A1500
Rated torque	T_{KN}	N·m	1 500
Torsion resistance	C_{Tdyn}	10^3·N·m/rad	1 304
Moment of inertia	J	10^{-3}·kg·m²	43
L		mm	166
d2 H7 (min … max)		mm	50 … 80
D		mm	157
M			2 x M20
Mass		kg	12

General technical data			
Peak transient torque	T_{Kmax}	N·m	brief overload of up to 1,5 times value permissible
Max. speed	n_{max}	1/min	<10 000 / >10 000 on request
Operating temp. range		°C	–30 … 120

Characteristics
Torsion proof stainless steel bellows for coupling both sides of a torque sensor with fixed housing or mounting support into shafting. Low moment of inertia; requires little space; wear and maintenance free.

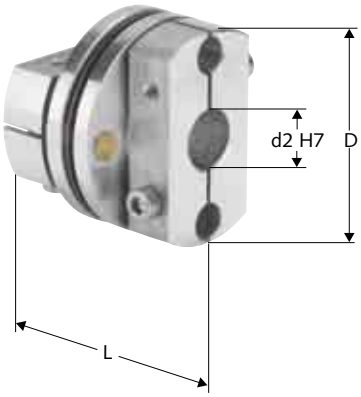
Applications
The coupling compensates for misalignment where fixed mounting of the torque sensor in shafting is required. This is always essential to avoid measurement errors and damage to the sensor. A double-flexible coupling must be used with clamping hubs on both sides of sensors mounted with rigid housing or mounting support. The clamped connection relying on friction allows completely backlash-free installation.

Accessories
None

Data sheet 2301A_000-673

Couplings for Torque Sensors

Torsion Proof Miniature Coupling, Single-Flexible with Clamping Hubs



Technical data			Type 2302A25	Type 2302A37	Type 2302A50
Rated torque	T_{KN}	N·m	0,39	1,56	6,17
Peak transient torque	T_{Kmax}	N·m	0,54	2,19	8,64
Torsion resistance	C_{Tdyn}	10^3·N·m/rad	3,89	25,986	39,768
Moment of inertia	J	10^{-6}·kg·m²	1,83	11,1	28,56
Max. speed	n_{max}	1/min	64 000	44 000	36 000
L		mm	20,2	29,1	30,4
d2 H7 (min … max)		mm	3 … 10	4 … 14	6 … 18
D		mm	25,4	35,8	44,5
Mass		g	22	62	100

Technical data			Type 2302A62	Type 2302A75
Rated torque	T_{KN}	N·m	24,7	36,2
Peak transient torque	T_{Kmax}	N·m	34,6	50,7
Torsion resistance	C_{Tdyn}	10^3·N·m/rad	103,572	161,76
Moment of inertia	J	10^{-6}·kg·m²	78,61	159,4
Max. speed	n_{max}	1/min	28 000	24 000
L		mm	36,6	41
d2 H7 (min … max)		mm	10 … 24	12 … 28
D		mm	57,4	64
Mass		g	195	278

Characteristics
Torsion proof miniature coupling for self-supporting mounting of torque sensors without fixed housing in shafting; high speed range; light, low moment of inertia, high torsion resistance, wear and maintenance free; corrosion free, antimagnetic.

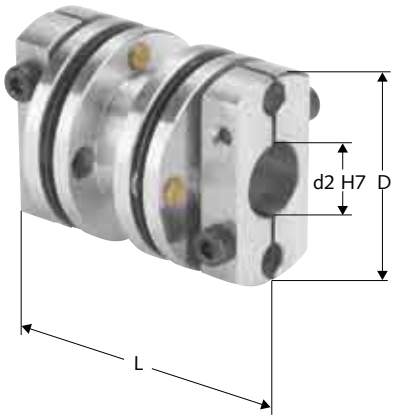
Applications
This coupling compensates for misalignment where self-supporting mounting of torque sensors in shafting is required. This is always essential to avoid measurement errors and damage to the sensor.

Accessories
None

Data sheet 2302A_000-671

Couplings for Torque Sensors

Torsion Proof Miniature Coupling, Double-flexible with Clamping Hub



Technical data			Type 2303A25	Type 2303A37	Type 2303A50
Rated torque	T_{KN}	N·m	0,39	1,56	6,17
Peak transient torque	T_{Kmax}	N·m	0,54	2,19	8,64
Torsion resistance	C_{Tdyn}	10^3·N·m/rad	1,945	12,993	19,884
Moment of inertia	J	10^{-6}·kg·m^2	2,33	14,01	37,99
Max. speed	n_{max}	1/min	64 000	44 000	36 000
L		mm	34	48	54
d2 H7 (min … max)		mm	3 … 10	4 … 14	6 … 18
D		mm	25,4	35,8	44,5
Mass		g	28	77	133

Technical data			Type 2303A62	Type 2303A75
Rated torque	T_{KN}	N·m	24,7	36,2
Peak transient torque	T_{Kmax}	N·m	34,6	50,7
Torsion resistance	C_{Tdyn}	10^3·N·m/rad	51,786	80,88
Moment of inertia	J	10^{-6}·kg·m^2	104,28	203,55
Max. speed	n_{max}	1/min	28 000	24 000
L		mm	66	71
d2 H7 (min … max)		mm	10 … 24	12 … 28
D		mm	57,4	64
Mass		g	260	355

Characteristics
Torsion proof miniature coupling for connecting both sides of torque sensors with fixed housing or mounting support into shafting; high speed range; light, low moment of inertia, high torsion resistance, wear and maintenance free; corrosion free, antimagnetic.

Applications
This coupling compensates for misalignment where fixed mounting of torque sensor in the shafting is required. This is always essential to avoid measurement errors and damage to the sensor. A double-flexible coupling with clamping hubs has to be provided on both sides of sensors with fixed housing or mounting support.

Accessories
None

Data sheet 2303A_000-672

Electronic Accessories

Distributing Box, Fischer 9-pole neg. – 8 x BNC neg.

Technical data		Type 5405A
Input signal		Fischer 9-pole neg.
Output signal		8 x BNC neg.
Dimensions LxWxH	mm	73x99x33

Data sheet 9255A_000-188

Distributing Box, Fischer 9-pole neg. – 3 x BNC neg.

Technical data		Type 5407A
Input signal		Fischer 9-pole neg.
Output signal		3 x BNC neg.
Dimensions LxWxH	mm	73x99x33

Data sheet 9255_000-188

Summing Box, 4 x Fischer 9-pole neg. – Fischer 9-pole neg.

Technical data		Type 5417
Input box		4 x PG7
Input signal		4 x Fischer 9-pole neg.
Output signal		Fischer 9-pole neg.
Dimensions LxWxH	mm	35x148x62
Application		Cable 2 x 1693A…

Data sheet 9047C_000-592
9067C_000-609
9077C_000-610

Summing Box, 12 x Mini Coax pos. – Fischer flange 9-pole neg.

Technical data		Type 5433
Input box		4 x M13x1
Input signal		12 x Mini-Coax pos.
Output signal		Fischer 9-pole neg.
Dimensions LxWxH	mm	93x93x33
Application		Cable 4 x 1695A…

Data sheet 9017B_000-465
9047C_000-592
9067C_000-609
9077C_000-610

Electronic Accessories

Input Low-Pass Filter

Technical data		Type 5321A...
Resistance	kΩ MΩ	10 / 33 / 100 / 330 1 / 7,5 / 15 / 30 / 70
Insulation resistance	Ω	$>10^{14}$
Input signal		BNC neg.
Output signal		BNC pos.
Dimensions LxD	mm	81x16

Characteristics
Consists of a series resistor installed in a highly-insulated metal surround. In combination with sensor and cable capacitance provides a simple RC filter.

Applications
Filters unwanted frequency components from the useful signal and protects charge amplifier from being overdriven by high-frequency interference signals and momentary peaks.

Accessories
None

Data sheet 5321A_000-325

Charge Attenuator

Technical data		Type 5361A...
Attenuation	n	2 : 1* 5 : 1* 10 : 1 20 : 1* 100 : 1* 200 : 1* 1 000 : 1*
Insulation resistance	Ω	$>10^{14}$
Input signal	Type/connector	charge (piezoelectric) / BNC neg.
Output signal	Type/connector	charge (piezoelectric) / BNC pos.
Dimensions LxWxH	mm	57x35x33

Characteristics
Consists of two high-insulation capacitors, one is connected in parallel with the input, the other between the input and output terminals.

Applications
Multiplies the largest measuring range of a charge amplifier by a factor of n.

Accessories
None

Data sheet 5361A_000-326

*= Special modifications

Calibration Capacitor

Technical data		Type 5371A...
Capacitance	pF	9,5 ... 10,5 100 1 000 10 000 100 000
for max. voltage	V	30
Input signal	Type/connector	voltage / BNC neg.
Output signal	Type/connector	charge (piezoelectric) / BNC pos.
Dimensions LxD	mm	81x16

Characteristics
Consists of a high-insulation precision capacitor in a shielded metal surround.

Applications
High-insulation precision capacitor for converting voltage into electric charge. This simulates a mechanical measurand and is used to check and calibrate a piezoelectric measuring system.

Accessories
None

Data sheet 5371A_000-336

Calibration and Test Equipment

Handheld charge amplifier

Technical data		Type 5995A
Number of channels		1
Measuring range adjustment		increments 1, 2, 5
Measuring range FS	pC	±200 ... 200 000
Frequency range (–3 dB)	kHz	≈0 ... 10
Display	digits	3½ (2 000)
Output signal	V	±2
Power supply (battery)	VDC	9
Input signal Type/Connector		piezoelectric / BNC neg.
Deg. of protection to IEC/EN 60529		IP50

Characteristics
Practical battery-operated charge amplifier, instant display and evaluation, offers charge amplification, preload testing and evaluation in one and the same instrument.

Applications
Measurement with piezoelectric sensors. The instrument operates in two modes:
1. Measurement of mechanical measurands such as force, pressure, strain, torque and acceleration.
2. As a preload tester (charge measurement in pC for preloading sensors).

Accessories
None

Data sheet 5995A_000-312

Insulation Tester

Technical data		Type 5493A
Number of channels		1
Measuring range adjustment		–
Measuring range FS	Ω	10^{11} ... $4 \cdot 10^{13}$
Measuring voltage	V	5
Max. parallel capacitance (cable length)	nF m	10 100
Power supply (battery)	VDC	VDC 9
Input signal Type/Connector		BNC neg.
Deg. of protection to IEC/EN 60529		IP50

Characteristics
Service device for measuring insulation resistance. Logarithmic display, extremely simple operation, switches off automatically when not in use.

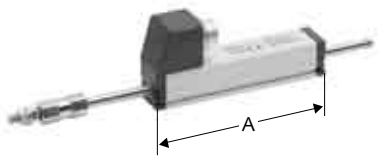
Applications
Battery powered tester ideal for routine and field checking of piezoelectric sensors, charge amplifiers and cables.

Accessories
None

Data sheet 5493A_000-354

Displacement Sensors

Potentiometric Displacement Sensor Type TS with Actuating Shaft and Ball Coupling



Technical data		Type 2117A25	Type 2117A75	Type 2117A100	Type 2117A150
Measuring range	mm	0 ... 25	0 ... 75	0 ... 100	0 ... 150
Case length A	mm	63	113	138	188
Mechanical stroke	mm	30	80	105	155
Weight	g	86	132	150	190

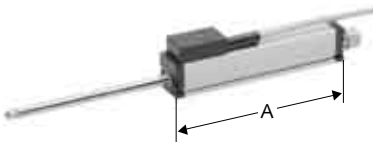
General technical data		
Deg. of protection to IEC/EN 60529		IP40
Max. speed	m/s	10
Connector		5-pole connector

Characteristics
Displacement sensor with dual-bearing actuating shaft, ball coupling to avoid shear force.

Applications
Force-displacement monitoring

Data sheet 000-504

Potentiometric Displacement Sensor Type TR with Restoring Spring



Technical data		Type 2118A10	Type 2118A25	Type 2118A50	Type 2118A75
Measuring range	mm	0 ... 10	0 ... 25	0 ... 50	0 ... 75
Case length A	mm	48	63	94,4	134,4
Mechanical stroke	mm	15	30	55	80
Weight	g	80	120	150	180

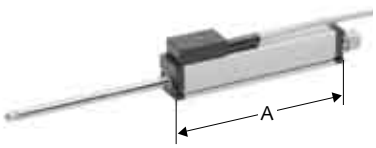
General technical data		
Deg. of protection to IEC/EN 60529		IP40
Max. speed	m/s	10
Connector		Type 2118Axx: flying leads Type 2118AxxA01: 5-pole cable connector

Characteristics
Displacement sensor with restoring spring, dual-bearing actuating shaft, sensor tip with carbide ball.

Applications
Force-displacement monitoring

Data sheet 000-504

Potentiometric Displacement Sensor Type TRS with Restoring Spring



Technical data		Type 2112A25	Type 2112A50	Type 2112A75	Type 2112A100
Measuring range	mm	0 ... 25	0 ... 50	0 ... 75	0 ... 100
Case length A	mm	63	94,4	134,4	166
Mechanical stroke	mm	30	55	80	105
Weight	g	74	100	128	150

General technical data		
Deg. of protection to IEC/EN 60529		IP40
Max. speed	m/s	10
Connector		5-pole connector

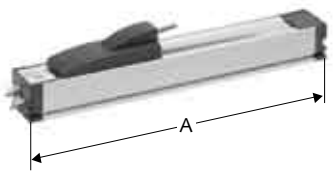
Characteristics
Displacement sensor with restoring spring, dual-bearing actuating shaft, sensor tip with carbide ball.

Applications
Force-displacement monitoring

Data sheet 000-504

Displacement Sensors

Potentiometric Displacement Sensor Type TLH with Side Slider



Technical data		Type 2119A100	Type 2119A225	Type 2119A1250
Measuring range	mm	0 ... 100	0 ... 225	0 ... 1 250
Case length A	mm	250	376	1 418
Mechanical stroke	mm	108	234	1 276
Weight	g	440	620	2 110

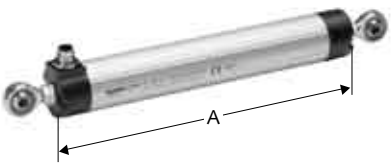
General technical data		
Deg. of protection to IEC/EN 60529		IP40
Max. speed	m/s	10
Connector		4-pole DIN 43650 (hydraulic connector)

Characteristics
Displacement sensor with side slider; ball coupling to avoid shear force.

Applications
Force-displacement monitoring

Data sheet 000-504

Potentiometric Displacement Sensor Type LWG with Twin-Bearing Actuating Rod



Technical data		Type 2121A75	Type 2121A100	Type 2121A150	Type 2121A225
Measuring range	mm	0 ... 75	0 ... 100	0 ... 150	0 ... 225
Case length A	mm	201	227	277	354
Mechanical stroke	mm	79	105	155	231
Weight	g	400	500	600	700

Technical data		Type 2121A300	Type 2121A360	Type 2121A450	Type 2121A500
Measuring range	mm	0 ... 300	0 ... 360	0 ... 450	0 ... 500
Case length A	mm	430	505	619	684
Mechanical stroke	mm	307	368	460	510
Weight	g	800	850	900	1 300

Technical data		Type 2121A750
Measuring range	mm	0 ... 750
Case length A	mm	994
Mechanical stroke	mm	764
Weight	g	1 900

General technical data		
Deg. of protection to IEC/EN 60529		IP65
Max. speed	m/s	5
Connector		3-pole connector

Characteristics
Displacement sensor with twin-bearing actuating shaft; backlash-free pivot head attachment.

Applications
Force-displacement monitoring

Data sheet 000-504

Technical Literature

Special Reprints and Application Brochures

The Basics of Piezoelectric Measuring Technology

Guide to the Measurement of Force	20.193
Piezoelectric Theory	20.290
Measuring with Crystals (book published by Verlag Moderne Industrie) ISBN 3-478-93269-6)	900-335
Piezoelectric Sensors – Extending Functionality and Simplifying Applications with Microelectronics	920-228
Investigation of Piezoelectric Force Measuring Devices in Force Calibration and Force Standard Machines	920-232
Dynamic Properties and Investigation of Piezoelectric Force Measuring Devices	920-233
Anwendungsgerechte Kalibrierung von Drehmomentaufnehmern	920-339

The references are Kistler Group document numbers. Most of these documents are available for downloading from www.kistler.com.

Monitoring of Manufacturing, Assembly and Testing Processes

Electromechanical NC Joining Systems	300-542
Monitored Press-Fitting and Joining Processes	920-223
Process Monitoring – for Better Quality and Increased Production	920-224
Simple Monitoring of Joining Processes through Force-Strain Measurement	920-236
Reliable Connection through Monitoring of Joining Forces	920-351
From Sensor to Transmitter - Robust Industrial Sensors through Integration of Electronics	920-361

General Force Measurement

The ITEA Journal of Test and Evaluation, Force-limited Vibration Tests at JPL	920-268
Force and Moment Measurements in Aerodynamics and Aeroelasticity Using Piezoelectric Transducers	920-363

Monitoring of Resistance Welding Processes

Electrode Force Measurement – Spot Welds that Stay	300-322
Force Measurement in Resistance Welding	920-332
Force Monitoring Optimizes Resistance Welding and Related Joining Processes	920-345

Monitoring of Cutting Processes

New Rotating Dynamometer for High Speed Cutting Processes	920-229
Advanced Cutting Process Analysis - Practical Experience with the Rotating High Speed Dynamometer	920-335
Sensors and Signal Analysis in High Performance Cutting	920-340
H3 - Metal Cutting Force Measurement	920-347

Test Stand Systems

Test Stand Systems for Electric Motors and Gearboxes in the Laboratory, Manufacturing and Quality Assurance	300-604

Product Overview by Type Numbers

* Only available in Germany

Kistler worldwide

Europe

Austria
Kistler GmbH
Lemböckgasse 49f
1230 Wien
Tel. +43 1 867 48 67 0
sales.at@kistler.com

Czech Republic/Slovakia
Kistler, s.r.o.
Zelený pruh 99/1560
140 00 Praha 4
Tel. +420 296 374 878
sales.cz@kistler.com

Denmark/Norway/Sweden
Kistler Nordic AB
Aminogatan 34
431 53 Mölndal
Tel. +46 31 871 566
info.se@kistler.com

Finland
Kistler Nordic AB
Särkiniementie 3
00210 Helsinki
Tel. +358 9 612 15 66
info.fi@kistler.com

France
Kistler France
ZA de Courtabœuf 1
15, avenue du Hoggar
91953 Les Ulis cedex
Tel. +33 1 69 18 81 81
info.fr@kistler.com

Germany
Kistler Instrumente GmbH
Daimlerstrasse 6
73760 Ostfildern
Tel. +49 711 34 07 0
info.de@kistler.com

Italy
Kistler Italia s.r.l.
Via Ruggero di Lauria, 12/B
20149 Milano
Tel. +39 02 481 27 51
sales.it@kistler.com

Netherlands
Kistler B.V. Nederland
Leeghwaterstraat 25
2811 DT Reeuwijk
Tel. +31 182 304 444
sales.nl@kistler.com

Switzerland/Liechtenstein
Kistler Instrumente AG
Verkauf Schweiz
Eulachstrasse 22
8408 Winterthur
Tel. +41 52 224 12 32
sales.ch@kistler.com

United Kingdom
Kistler Instruments Ltd.
13 Murrell Green Business Park
London Road
Hook, Hampshire RG27 9GR
Tel. +44 1256 74 15 50
sales.uk@kistler.com

Asia

China, People's Republic of
Kistler China Ltd.
Unit D, 24/F Seabright Plaza
9-23 Shell Street North Point
Hong Kong
Tel. +852 25 915 930
sales.cn@kistler.com

India
Kistler Instruments (Pte) Ltd.
India Liaison Office
2B Century Plaza
560/562 Anna Salai
Teynampet, Chennai 600 018
Tel. +91 44 4213 2089
sales.in@kistler.com

Japan
Kistler Japan Co., Ltd.
23rd floor, New Pier Takeshiba North Tower
1-11-1, Kaigan, Minato-ku
Tokyo 105-0022
Tel. +81 3 3578 0271
sales.jp@kistler.com

Korea, Republic of
Kistler Korea Co., Ltd.
Gyeonggi Venture Anyang
Technical College Center 801
572-5, Anyang-Dong, Manan-Gu,
Anyang-City, Gyeonggi-Do 430-731
Tel. +82 31 465 6013
sales.kr@kistler.com

Singapore
Kistler Instruments (Pte) Ltd.
50 Bukit Batok Street 23
#04-06 Midview Building
Singapore 659578
Tel. +65 6316 7331
sales.sg@kistler.com

Taiwan
Kistler Representative Office in Taiwan
Room 9, 8F, No. 6, Lane 180
Sec. 6, Mincyuan E. Road
Taipei 114
Tel. +886 2 7721 2121
sales.tw@kistler.com

Thailand
Kistler Instrument (Thailand) Co., Ltd.
26/56 TPI Tower, 20th Floor
Nanglingee Rd., (Chan Tat Mai Rd.)
Thungmahamek, Sathorn
Bangkok 10120
Tel. +66 2678 6779-80
sales.thai@kistler.com

America

USA/Canada/Mexico
Kistler Instrument Corp.
75 John Glenn Drive
Amherst, NY 14228-2171
Tel. +1 716 691 5100
sales.us@kistler.com

Australia

Australia
Kistler Instruments Australia Pty Ltd
G21 / 202 Jells Rd.
Wheelers Hill, Victoria 3150
Tel. +61 3 9560 5055
sales.au@kistler.com

Other countries

Kistler Instrumente AG
Export Sales
Eulachstrasse 22, 8408 Winterthur
Switzerland
Tel. +41 52 224 11 11
sales.export@kistler.com

Headquarters

Switzerland
Kistler Group
Eulachstrasse 22, 8408 Winterthur
Tel. +41 52 224 11 11
Fax +41 52 224 14 14
info@kistler.com

www.kistler.com

KISTLER
measure. analyze. innovate.

300-460e-02.09 Sän3000