measure. analyze. innovate.

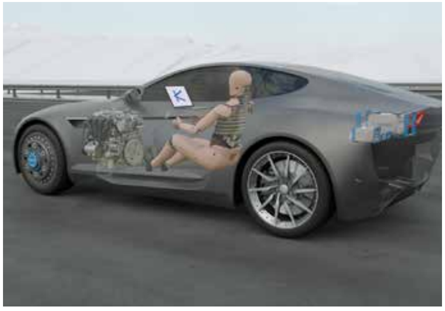
Measuring amplifiers

Signal conditioning for efficient manufacturing processes and research & development

www.kistler.com

Absolute Attention for tomorrow's world

Kistler develops solutions for challenges in measurement technology with a portfolio that comprises sensors, electronics, systems and services. We push the frontiers of physics in fields such as emission reduction, quality control, mobility and vehicle safety: our products deliver top performance to meet the standards of tomorrow's world, providing the ideal basis for Industry 4.0. This is how we pave the way for innovation and growth – for our customers, and with our customers.

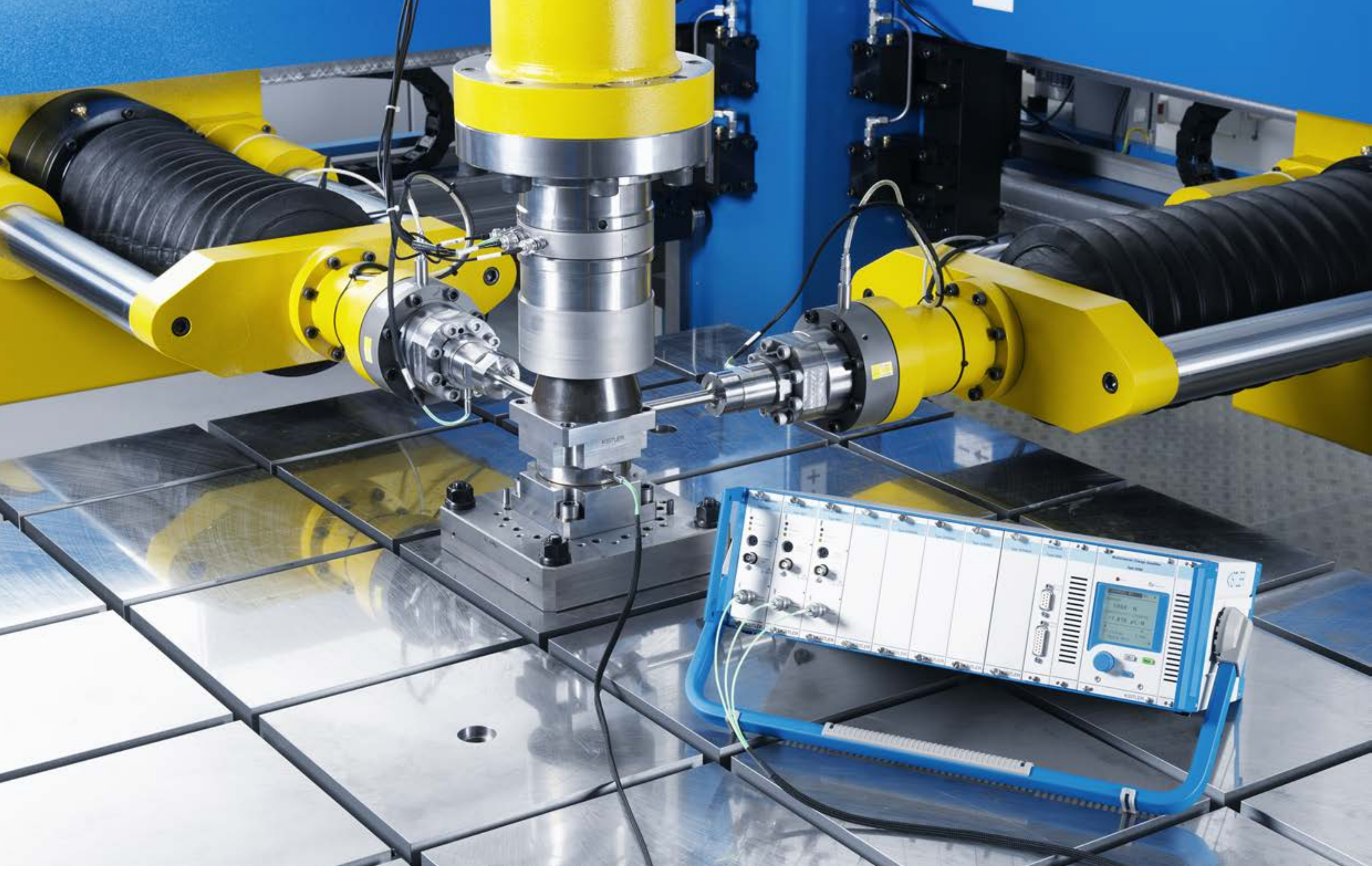


Kistler: the byword for advances in engine monitoring, vehicle safety and vehicle dynamics. Our products deliver data that plays a key part in developing efficient vehicles for tomorrow's world.

Measurement technology from Kistler ensures top performance in sport diagnostics, traffic data acquisition, cutting force analysis and many other applications where absolutely reliable measurements are required despite extreme conditions.

By supporting all the stages in networked, digitalized production, Kistler's systems maximize process efficiency and cost-effectiveness in the smart factories of the next generation.

Contents



Assembly processes and product testing are just two of the many industrial activities where sensors from Kistler are used.

Focus on quality and cost-effectiveness

Quality and precision standards in industrial manufacturing are constantly increasing, and competition is becoming even fiercer – so it's essential to optimize and monitor the entire production chain. Kistler's measurement and system technology can help meet these requirements, laying the foundations for zero-defect industrial production.

Ensuring the quality of the end product is always the top priority in the automotive industry and the medical technology or electrical engineering sectors (to mention only a few examples). This is why strict standards are specified in all these areas. Especially if many individual components are assembled to form one single product, each component must already have been tested by the suppliers: this is the only way to guarantee the quality of the end product.
In many such cases, the only solution is to integrate monitoring systems into the production process.

Optimized process efficiency thanks to technology from Kistler
The objective: to implement zero-defect industrial production at the lowest possible cost. Kistler's response: integrated process monitoring, which means direct verification during each process step. This concept is underpinned by sensor technology based on the piezoelectric principle – an approach that is outstandingly suitable for monitoring and optimizing production processes.

Lower quality assurance costs for plant operators
Process-integrated monitoring cuts the costs of quality assurance. This cost-effective solution protects plant operators against the possibility of faulty parts reaching the customer; it also ensures that there is no disruption to any downstream assembly operations.

Benefits

- Forces and other process variables are measured during the production process
- Process monitoring ensures zero-defect production
- Quality costs are cut because deviations are detected at an early stage
- Process efficiency is optimized because the measuring equipment used is extremely flexible

Product overview – Measuring amplifiers for industrial applications

Piezoelectric amplifiers – Type			Frequency range [Hz] / Measurement range [pC] (0, 100, 1,000, 10,000, 100,000, 1,000,000)	Signal output: Voltage	Current	Digital	Channels	Page
5074B...		Industrial charge amplifier, digital				standard	1 ... 4	8
5028A...		Miniature industrial charge amplifier, analog and IO-Link		standard		standard	1	9
5073A...		Industrial charge amplifier, analog		standard	option		1 ... 4	10
5030A...		Miniature charge amplifier		standard			1	10
5039A...		Miniature charge amplifier		standard	option		1	11
5995A...		Handheld for piezoelectric sensors		standard			1	11

Strain gage amplifiers – Type			Amplification [mV/V] (0, 1, 2, 3, 4, 5)	Signal output: Voltage	Current	Digital	Channels	Page
4701B...		Measuring amplifier for strain gage sensors		standard			1	13
4703B		Handheld for strain gage sensors				standard	1	13

- Frequency range in Hz
- Measurement range in pC
- Amplification in mV/V
- standard
- option

The new standard for measurement in the Industry 4.0 era

Kistler's newly developed 5074B data acquisition unit breaks new ground in industrial charge amplifier technology. This unit is currently the only amplifier on the market for piezoelectric sensors with communication consistently based on Industrial Ethernet (IE).

For the first time, plant and machinery manufacturers can now integrate any desired piezoelectric sensors directly into a real time-capable Ethernet system, so they can easily make settings on the measuring amplifier via the control.

The 5074B charge amplifier is an ideal choice for monitoring and optimizing industrial press-fit, assembly and joining processes, among many others. It can be regarded as a digital version of the tried-and-tested 5073A analog charge amplifier. Complete digitization means that the new unit enables direct communication up to amplifier level. The 5074B features an exceptionally wide range of measuring functions, making it the perfect solution for all applications that call for dynamic and quasistatic measurements via Industrial Ethernet. For applications that require a more compact, lighter measuring chain, the new 5028A mICA amplifier is also available. This miniature industrial charge amplifier allows either analog integration or integration via IO-Link.

Increased process efficiency with Kistler – now online!
View our animation to experience convincing, first-class Kistler solutions – the sure way to optimize process efficiency:
www.kistler.com/ca5074

Charge amplifiers

Industrial charge amplifier, digital

Type 5074B4...

Technical data	Type	5074B1...	5074B2...	5074B3...	5074B4...
Number of channels		1	2	3	4
Charge input		•	•	•	•
Measurement range	pC	±20 … 1,000,000			
Frequency range (–3dB)	Hz	≈20,000 (<±900 pC) ≈10,000 (<±31,000 pC) ≈2,000 (<±1,000,000 pC)			
Time constant		long/short			
Connector type		KIAG 10-32UNF neg.			
Measurement range adjustment		continuously adjustable			
Analog output		–			
Operation	Network commands	PLC configuration			
Interfaces					
EtherCAT	μs_{min}	100			
EtherNet/IP	μs_{min}	1,000			
PROFINET	μs_{min}	250			
Connector type	Network Power	M12 4-pole D-coded M8 4-pole A-coded			
Energy supply					
Operating voltage	VDC	18 … 30			
Power consumption	W	<4			
Deg. of protection to IEC/EN 60529		IP65 (screwed sensor connection) IP67 (welded sensor connection)			
Operating temperature range	°C	–20 … 65			
External dimensions L×H×W	mm	150×64×44			
Other features		Activation of individual channels Peak value acquisition Internal scaling of measurement values Adaptable process data map Low-pass filter Oversampling up to 50kSps Integral value calculation			
Data sheet: see www.kistler.com		**5074B (003-332)**			

Miniature industrial charge amplifier, analog and IO-Link

Type 5028A...

Technical data	Type	5028A..1
Charge input		
Number of measurement ranges		1
Sensor earth to GND		•
Measurement range FS	pC	±500 ±5,000 ±50,000 ±500,000
Frequency range (–3dB)	Hz	≈6,250
Time constant		long/short
Connector type		KIAG 10-32UNF
Analog output		
Output signal	V	±10
Measurement range adjustment		4% … 100% continuously adjustable
Interfaces		
Connector type		M12 4-pole A-coded
SIO mode		DI: Reset / Operate
IO-Link version		V 1.1
Port type		Class A
Smart sensor profile		SSP 3.4 "measuring sensor, high-resolution"
Transmission rate	kBaud	230.4 (COM 3)
Minimum cycle time	ms	0.6
Energy supply		
Operating voltage	VDC	18 … 30
Power consumption	W	<1.2
Degree of protection to IEC/EN 60529		IP65 (screwed sensor connection), IP67 (welded sensor connection)
Operating temperature range	°C	–20 … 65
External dimensions LxWxH	mm	38x25x30
Other features		Operating mode: analog/discrete or IO-Link Analog output, scalable 4% … 100% FS LED operating status display Internal scaling of measurement values Low-pass filter and high-pass filter Threshold value monitoring via IO-Link
Data sheet: see www.kistler.com		**5028A (003-477)**

Industrial charge amplifier, analog

Type 5073A4...

Technical data	Type	5073A1...	5073A2...	5073A3...	5073A4...
Number of channels		1	2	3	4
Number of measurement ranges		2 (switchable)			
Measurement range adjustment		continuously adjustable			
Measurement range 1 FS	pC	±100 ... 1,000,000			
Measurement range 2 FS	pC	±100 ... 1,000,000			
Frequency (–3 dB)	kHz	≈0 ... 20 (<±10,100 pC)			
		≈0 ... 2 (<±1,000,000 pC)			
Output signal	V	±10			
	mA	4 ... 20 (only 5073A1... and 5073A2...)			
Power supply	VDC	18 ... 30			
Signal input	Type/ connector	piezoelectric/acc. to choice BNC neg. TNC neg.			
Operating temperature range	°C	0 ... 60			
Deg. of protection to IEC/EN 60529		acc. to choice IP60 (BNC) IP65 (TNC)			
Interface		RS-232C			
Other features		Peak memory Adjustable output offset Low-pass filter Option: time constant Switch inputs electrically isolated PC software: ManuWare			
Data sheet: see www.kistler.com		**5073A (000-524)**			

Miniature charge amplifier

Type 5030A...

Technical data	Type	5030A...
Number of channels		1
Number of measurement ranges		2 (switchable 10:1)
Measurement range adjustment		Fixed
Measurement ranges FS	pC	acc. to choice ±1,000 / ±100 ±10,000 / ±1,000 ±100,000 / ±10,000
Frequency range (–3 dB)	kHz	≈0 ... 10
Output signal	V	±10
Power supply	VDC	18 ... 30
Signal input	Type/ connector	Piezoelectric/KIAG 10-32 neg.
Operating temperature range	°C	0 ... 70
Deg. of protection to IEC/EN 60529		IP65
Data sheet: see www.kistler.com		**5030A (000-523)**

1-channel handheld charge amplifier

Type 5995A...

Technical data	Type	5995A...
Number of channels		1
Measurement range adjustment		Stages 1, 2, 5
Measurement 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
Signal input		Piezoelectric/BNC neg.
Deg. of protection to IEC/EN 60529		IP50
Other features		Adjustable to physical unit Peak value acquisition Automatic switchoff
Data sheet: see www.kistler.com		**5995A (000-312)**

Miniature charge amplifier

Type 5039A...

Technical data	Type	5039A...
Number of channels		1
Number of measurement ranges		2 (10:1, 4:1 or 2:1)
Measurement range adjustment		Fixed
Measurement ranges FS	pC	±5,000 ... 50,000
Frequency range (–3 dB)	kHz	≈0 ... 17
Output signal	V mA (option)	±10 4 ... 20
Power supply	VDC	18 ... 36
Signal input	Type/connector	Piezoelectric/acc. to choice BNC neg. TNC neg.
Operating temperature range	°C	0 ... 60
Deg. of protection to IEC/EN 60529		acc. to choice IP40 (BNC) IP65 (TNC)
Other features		According to choice: peak value output or current output Switch inputs electrically isolated
Data sheet: see www.kistler.com		**5039A (000-303)**

Accessories

Charge generator for piezoelectric amplifiers

Type 5363A...

Technical data	Type	5363A...
Output charge range	pC pC pC	0 ... ±10^3 (100pF) 0 ... ±10^4 (1nF) 0 ... ±10^5 (10nF)
Output voltage range	V	0 ... ±10
Range adjustment	%	0 ... ±100
Error	% FSO	<±3
Signal output	V Q	BNC neg. BNC neg.
Operating temperature range	°C	0 ... 50
Deg. of protection to IEC/EN 60529		IP50
Dimensions	mm	164×84.6×56.1
Other features		Battery operation 2 × IEC LR6
Data sheet: see www.kistler.com		**5363A (003-336)**

Insulation tester for piezoelectric measuring chains

Type 5493...

Technical data	Type	5493...
Number of channels		1
Measurement range adjustment		–
Measurement range FS	Ω	10^{11} ... $4 \cdot 10^{13}$
Measurement voltage	V	5
Max. parallel capacity (cable length)	nF m	10 100
Power supply (battery)	VDC	9
Signal input		BNC neg.
Deg. of protection to IEC/EN 60529		IP50
Other features		Automatic switch off
Data sheet: see www.kistler.com		**5493 (000-354)**

Strain gage amplifiers

Measuring amplifier for strain gage sensors

Type 4701A...
Version A

Type 4701A...
Versions B and C

Technical data		Type	4701A...
Number of channels			1
Signal input	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)
	Resistive	V	Version C: Input 0 ... 5 (connection resistance 1 ... 5 kΩ)
Cutoff frequency (–3 dB)		kHz	1
Measurement range adjustment Zero point setting		% %	≈±10 ≈±10
Output signal		V	±0 ... 5 or ±0 ... 10
Power supply		VDC	24 non-stabilized (±10%)
Signal input		Type/connector	Strain gage with option of cable gland with soldering terminals (version A) 6-pole connector (version B)
Operating temperature range		°C	0 ... 50
Deg. of protection to IEC/EN 60529			Version a with cable bushings: IP54 Versions B and C with plug connectors: IP40
Data sheet: see www.kistler.com			**4701A (000-621)**

Handheld for strain gage sensors

Type 4703B...

Technical data	Type	4703B...
Number of channels		1
Impedance strain gage full bridge	Ω	350
Sensitivity (S)	mV/V	0.3 ... 5
Sensor supply voltage	VDC/V	5
Measurement rate	1/s	6.25 ... 1600
Power supply (battery)	VDC	3 ... 4.8
Signal input		6-pole binder - round connector
Deg. of protection to IEC/EN 60529		IP54
Dimensions	mm	82×162×54
Other features		USB connection PC software: SensorTool
Data sheet: see www.kistler.com		**4703B (000-762)**

Measuring chains

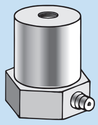
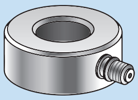
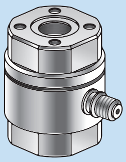
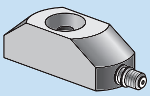
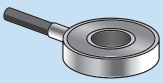
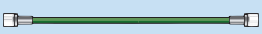
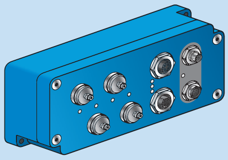
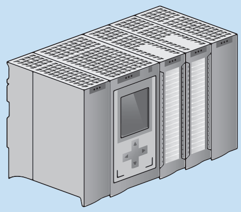
In order to integrate sensor technology into a given application, it is advisable to clarify these points in advance. This will provide the basis for selecting the relevant components to generate the measuring chain:

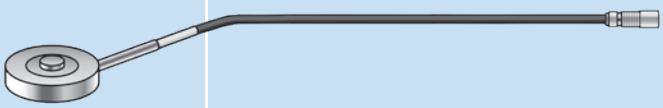
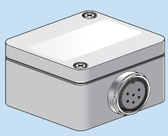
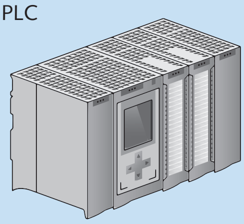
- Type of signal: voltage, frequency, digital (fieldbus/Ethernet) or charge for piezoelectric sensors
- Number of pins of the selected output
- Pin allocation for sensor and evaluation unit (see data sheet)

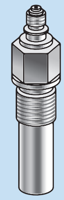
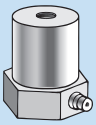
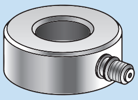
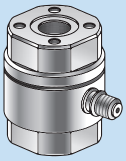
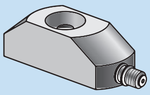
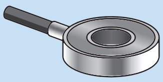
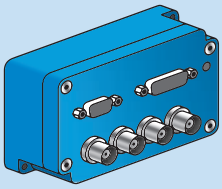
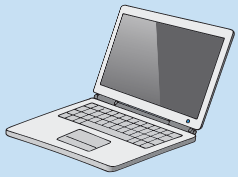
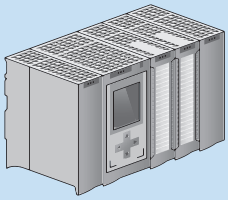
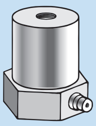
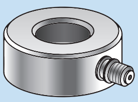
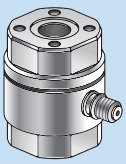
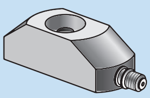
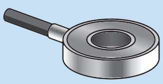
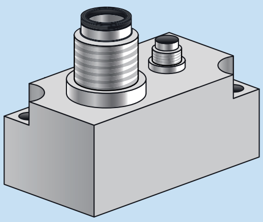
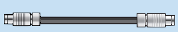
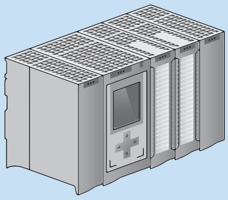
When installing the cables, make sure that the maximum permitted cable length is not exceeded. It is advisable to use original Kistler cables only.

Piezoelectric sensors require a charge amplifier. After the sensor signals have been converted, they can be evaluated by an amplifier in the customer's system.

For the analysis of dedicated XY processes (such as torque-rotation angle monitoring), the maXYmos family is highly suitable thanks to its user-friendly operation and wide variety of interfaces (Y-channel: piezo, strain gage, +/– 10 V; X-channel: potentiometer, +/– 10 V, incremental).

Measure	Connect	Amplify	Connect	Monitor & control
8202A... 8203A...  90x1A 90x1B 910xA  93x3A  9232A...  913×B... 	1635C... 1641B... 1957A... 1967A... 1969A... 1983AC... 	5074B... 	Network cable 1200A195Ax Power cable 1200A239Ax  	PLC 

Measure	Connect	Amplify	Monitor & control
4577A 		4701A 	PLC 

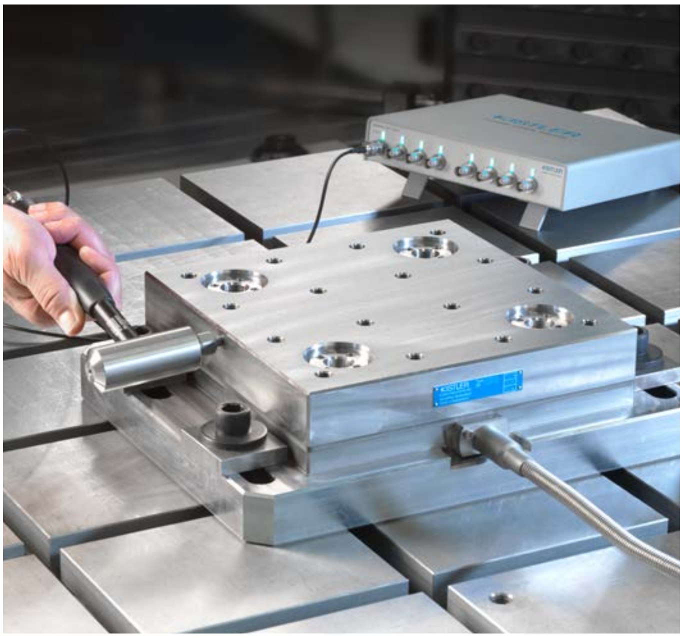
Measure	Connect	Amplify	Connect	Monitor & control
9217A  8202A... 8203A...  90x1A 90x1B 910xA  93x3A  9232A...  913 × B... 	1631C… 1641B… 1939A… 1983AD… 	5073A... 	Configuration (RS232) 2867 System cabling 1500A41A…	Laptop (provided by customer)  Customer Control System 
8202A... 8203A...  90x1A 90x1B 910xA  93x3A  9232A...  913 × B... 	1635C… 1641B… 1957A… 1967A… 1969A… 1983AC… 1900A21A11… 	5028A… 	Analog (4-wire shielded) 1700A129A…  IO-Link (3-wire) 1700A127A… 	Customer Control System 

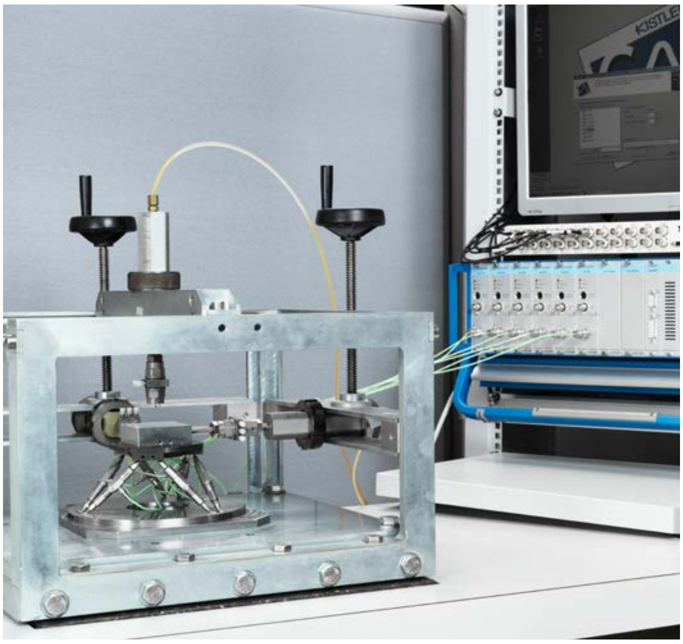
Flexible, user-friendly measurement amplifiers are the key to efficient R&D work

Excellent flexibility combined with impressive precision

Growing requirements to be met by products, stricter specifications defined in standards, and advances into areas of greater technical complexity: in research and development, these trends are creating the need for measurement technology of ever-higher quality to track down target phenomena or selectively optimize specific parameters.

In aerospace and maritime research, and even in the development and design of more or less everyday products that are constantly becoming more complex, it is increasingly important to have flexible equipment that can accomplish a wide variety of measurement tasks. Equipment that is easy to operate makes the everyday measuring routine smoother and more efficient. In every industrial sector and research field, high-caliber laboratory equipment should enable operators to focus quickly on the essentials, with no need for compromises on measurement technology.





A wide specification range yields maximum flexibility
Extensive charge ranges make it possible to measure parameters such as the massive crash forces on a vehicle chassis, or to capture the most minute micro-vibration forces on a satellite reaction wheel – all with the same piezoelectric amplifier. Wide frequency bandwidths allow laboratory instruments to measure slow quasistatic processes and highly dynamic phenomena with equal precision.

Simple operation and integrated data acquisition
Operation of all Kistler laboratory equipment is simple and comfortable: in some cases via a local operating unit, and in others with the help of a cutting-edge web interface that ensures maximum clarity. Products in the LabAmp family also feature integrated data acquisition for transmission of low-noise signals to the PC at high data rates via Ethernet.

Benefits

- Measurement of force, pressure, acceleration, reaction torque and strain with piezoelectric sensors
- Extensive range of applications thanks to high frequency bandwidth and wide charge ranges
- Low-noise signal inputs to ensure high signal quality
- Easy-to-manage measuring chains thanks to equipment with integrated data acquisition
- Intuitive operation to make work more efficient

Product overview – Charge amplifiers for laboratory applications

Charge amplifiers – Type		Frequency range [Hz] Measurement range [pC] (0, 100, 1,000, 10,000, 100,000, 1,000,000)	Chan-nels	Operation: Display and rotary knob	Operation: PC	Operation: LabVIEW (virtual instrument driver)	Data usage: Analog output	Data usage: Integrated data acquisition	Page
5165A... 	Laboratory charge amplifier with integrated data acquisition		1/4		Standard	Standard	Standard	Standard	19
5167A...  	Laboratory charge amplifiers with integrated data acquisition		4/8		Standard	Standard	Standard	Option	20
5015A... 	Laboratory charge amplifier with extensive statistical functions		1	Standard		Standard	Standard		21
5018A... 	Laboratory charge amplifier for low-noise acquisition of piezoelectric signals		1	Standard			Standard		22
5080A... 	Laboratory charge amplifier for low-noise acquisition of piezoelectric signals		1...8	Standard	Standard		Standard		23

■ Frequency range in Hz
■ Measuring range in pC

☐ Standard
☐ Option

LabVIEW is a registered trademark of National Instruments

Charge amplifiers

1/4-channel laboratory charge amplifier with integrated data acquisition

Type 5165A

Technical data	Type	5165A…
Number of channels		1/4
Charge input		•
Measurement ranges	pC	±100 … ±1,000,000
Frequency range (–3 dB)	Hz	0.1 … 100,000
Time constants		Short
Connector type		BNC neg.
Piezotron (IEPE) input		•
Gain		1/10
Sensor voltage supply	V	22
Sensor current supply	mA	4/10
Frequency range (–3 dB)	Hz	0.1 … 100,000
Connector type		BNC neg.
Voltage input		•
Measurement range	V	±1 … 10
Frequency range (–3 dB)	Hz	0 … 100,000
Connector type		BNC neg.
Data acquisition		•
ADC resolution	bits	24
Sampling rate per channel	kSps	200 (adjustable)
Analog output (voltage)		•
Number of analog outputs		1/4
Channel routing		Flexible: every sensor input or virtual channel can be routed to every output
Nominal output range	V	Flexible 2-point scaling within ±10V
Group delay (input to output, filter off)	µs	≤12
Connector type		BNC neg.
Filter		•
High-pass filter (–3 dB)		≥0.1 ... 10,000 Hz (in steps of 0.1 Hz), digital HP filter, 1st order
Low-pass filter (–3 dB)		≥10 Hz (in steps of 1 Hz), digital LP filter, Bessel or Butterworth characteristic, 2nd/4th order
Notch filter (trap frequency)		≥10 Hz (in steps of 1 Hz), digital notch filter, Q factor 0.9 ... 1,000
Virtual channels / summing processor		○ 1/2 virtual channels (1/4-channel version) for real-time calculations with one or more sensor channels
Interfaces		
Ethernet		•
Housing		
Desktop housing		•
19" rack		with 19" rack supporting plate 5748A1
Dimensions (WxHxD)	mm	≈218x50x223 with base and connections
Weight	kg	≈1.2
Degree of protection (EN 60529)		IP 20
Power supply		
Voltage supply		18 … 30 VDC, plug-in power supply 5779A2 including country-specific mains plug (90-264VAC, 47-63Hz)
Power consumption	W	<15
Operating temperature	°C	0 … 60
Data sheet: see www.kistler.com		5165A (003-146)

Key:
• standard
○ optional
– not available

4/8-channel laboratory charge amplifier with integrated data acquisition

Type 5167Ax0

Type 5167Ax1

Technical data	Type	5167A...
Number of channels		4 / 8
Charge input		•
Measurement ranges	pC	±100 … ±1,000,000
Frequency range (–3 dB)	Hz	≈0 … >45,000 (≤195,000 pC) ≈0 … >15,000 (>195,000 pC)
Time constants		long/short
Connector type		BNC neg./Fischer 9-pole
Piezotron (IEPE) input		–
Voltage input		–
Data acquisition		○
ADC resolution	bits	24
Sampling rate per channel	kSps	100 (adjustable)
Analog output (voltage)		•
Number of analog outputs		4/8
Channel routing		Flexible: every sensor input or virtual channel can be routed to every output
Nominal output range	V	Flexible 2-point scaling within ±10V
Group delay (input to output, filter off)	µs	≤14
Connector type		BNC neg.
Filter		•
High-pass filter (–3 dB)		≥0.1 ... 10,000 Hz (in steps of 0.1 Hz), digital HP filter, 1st order
Low-pass filter (–3 dB)		≥10 Hz (in steps of 1 Hz), digital LP filter, Bessel or Butterworth characteristic, 2nd/4th order
Notch filter (trap frequency)		≥10 Hz (in steps of 1 Hz), digital notch filter, Q factor 0.9 ... 1,000
Virtual channels / summing processor		•
Number of virtual channels/sum channels		2/6 virtual channels (4/8-channel version) for real-time calculations with one or more sensor channels
Interfaces		
Ethernet		•
Remote control		• D-sub connector, 9-pole neg., functions: Measure and Trigger
Housing		
Desktop housing		•
19" rack		with 19" rack supporting plate 5748A1/5748A3
Dimensions (WxHxD)	mm	≈218x50x223 (4-channel version) ≈218x93x223 (8-channel version) with base and connections
Weight	kg	≈1.2 (4-channel version), ≈1.8 (8-channel version)
Degree of protection (EN 60529)		IP 20
Power supply		
Voltage supply		18 … 30 VDC, plug-in power supply 5779A2 including country-specific mains plug (90-264VAC, 47-63Hz)
Power consumption	W	<15
Operating temperature	°C	0 … 60
Data sheet: see www.kistler.com		5167A (003-277 and 003-278)

Key:
• standard ○ optional – not available

1-channel laboratory charge amplifier with extensive statistical functions

Type 5015A

Technical data	Type	5015A
Number of channels		1
Charge input		•
Measurement ranges	pC	±2 … ±2,200,000
Frequency range (–3 dB)	Hz	≈0 … >200,000
Time constants		long/medium/short
Connector type		BNC neg.
Piezotron (IEPE) input		○
Gain		1
Sensor voltage supply	V	20
Sensor current supply	mA	4
Frequency range (–3 dB)	Hz	≈0 … >200,000
Connector type		BNC neg.
Voltage input		○
Measurement range	V	±0.002 … 20
Frequency range (–3 dB)	Hz	≈0 … >200,000
Connector type		BNC neg.
Data acquisition		–
Analog output (voltage)		•
Number of analog outputs		1
Channel routing		fixed
Nominal output range	V	±10/±5/±2.5/±2
Group delay (input to output, filter off)	μs	≈10
Connector type		BNC neg.
Filter		•
High-pass filter (–3 dB)		16 / 1.6 / 0.16 / 0.016 / 0.0016 Hz Digital HP filter calculated with DSP, 1st order
Low-pass filter (–3 dB)		5 Hz … 30 kHz (in steps 1, 2, 3, 5) Digital LP filter calculated with DSP, IIR linear phase, 2nd/5th order
Virtual channels / summing processor		–
Interfaces		
RS-232C		•
IEEE-488		○
Remote control		• MiniDin round connector, functions: Measure and Window
Housing		
Desktop housing		○
19" rack		○
Dimensions (WxHxD)	mm	≈105x142x253 (desktop housing)/≈71x129x230 (19" rack)
Weight	kg	≈2.3
Degree of protection (EN 60529)		IP40
Power supply		
Voltage supply		115/230 VAC
Power consumption	W	≈20
Operating temperature	°C	0 … 50
Data sheet: see www.kistler.com		5015A (000-297)

Key:
• standard ○ optional – not available

Low-noise 1-channel laboratory charge amplifier

Type 5018A...

Technical data	Type	5018A...
Number of channels		1
Charge input		•
Measurement ranges	pC	±2 … ±2,200,000
Frequency range (–3 dB)	Hz	≈0 … >200,000
Time constants		long/medium/short
Connector type		BNC neg.
Piezotron (IEPE) input		○
Gain		1
Sensor voltage supply	V	30
Sensor current supply	mA	1 … 15
Frequency range (–3 dB)	Hz	≈0 … >200,000
Connector type		BNC neg.
Voltage input		○
Measurement range	V	±0.02 … 30
Frequency range (–3 dB)	Hz	≈0 … >200,000
Connector type		BNC neg.
Data acquisition		–
Analog output (voltage)		•
Number of analog outputs		1
Channel routing		fixed
Nominal output range	V	±10/±10 with offset –8
Group delay (input to output, filter off)	µs	≈2
Connector type		BNC neg.
Filter		•
High-pass filter (–3 dB)		– (analog time constants only)
Low-pass filter (–3 dB)		10 Hz … 100 kHz (in steps 1, 2, 3, 6) Analog LP filter, Butterworth characteristic, 2nd order
Virtual channels / summing processor		–
Interfaces		
USB 2.0		•
RS-232C		•
Remote control		• MiniDin round connector, function: Measure
Housing		
Desktop housing		○
19" rack		○
Dimensions (WxHxD)	mm	≈105x142x253 (desktop housing), ≈71x129x230 (19" rack)
Weight	kg	≈2.3
Degree of protection (EN 60529)		IP40
Power supply		
Voltage supply		115/230 VAC
Power consumption	W	≈20
Operating temperature	°C	0 … 50
Data sheet: see www.kistler.com		5018A (000-719)

Key:
• standard ○ optional – not available

Low-noise 8-channel laboratory charge amplifier

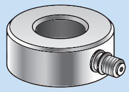
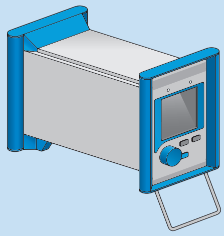
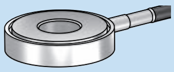
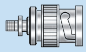
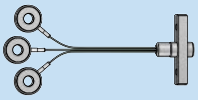
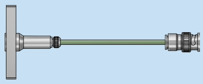
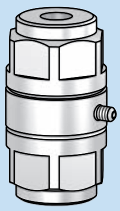
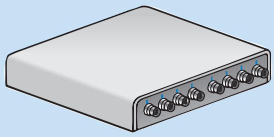
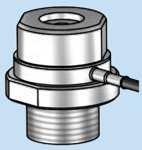
Type 5080A

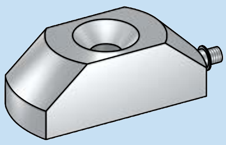
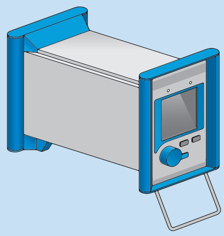
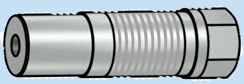
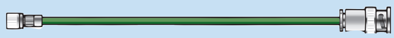
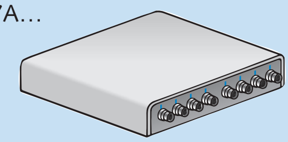
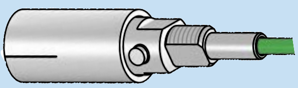
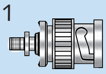
Technical data	Type	5080A…
Number of channels		1…8
Charge input		•
Measurement ranges	pC	±2 … ±2,200,000
Frequency range (–3 dB)	Hz	≈0 … >200,000
Time constants		long/medium/short
Connector type		BNC neg.
Piezotron (IEPE) input		○
Gain		1
Sensor voltage supply	V	30
Sensor current supply	mA	1 … 15
Frequency range (–3 dB)	Hz	≈0 … >200,000
Connector type		BNC neg.
Voltage input		○
Measurement range	V	±0.02 … 30
Frequency range (–3 dB)	Hz	≈0 … >200,000
Connector type		BNC neg.
Data acquisition		–
Analog output (voltage)		•
Number of analog outputs		1 … 8
Channel routing		fixed
Nominal output range	V	±10/±10 with offset –8
Group delay (input to output, filter off)	µs	≈2
Connector type		BNC neg.
Filter		•
High-pass filter (–3 dB)		– (analog time constants only)
Low-pass filter (–3 dB)		10 Hz … 100 kHz (in steps 1, 2, 3, 6) Analog LP filter, Butterworth characteristic, 2nd order
Virtual channels / summing processor		• Summing processor for up to 6 sum channels (depending on number of charge inputs), connector: D-Sub 15-pole neg.
Interfaces		
USB 2.0		•
RS-232C		•
Remote control		• D-sub connector, 9-pole neg., function: Measure
Housing		
Desktop housing		○
19" rack		○
Dimensions (WxHxD)	mm	≈497x141x300 (desktop housing), ≈482x133x236 (19" rack)
Weight	kg	≈10 (8-channel version)
Degree of protection (EN 60529)		IP40
Power supply		
Voltage supply		100 … 240 VAC (○) or 11 … 36 VDC (○)
Power consumption	W	≈95 (8-channel version)
Operating temperature	°C	0 … 50
Data sheet: see www.kistler.com		5080A (000-744)

Key:
• standard ○ optional – not available

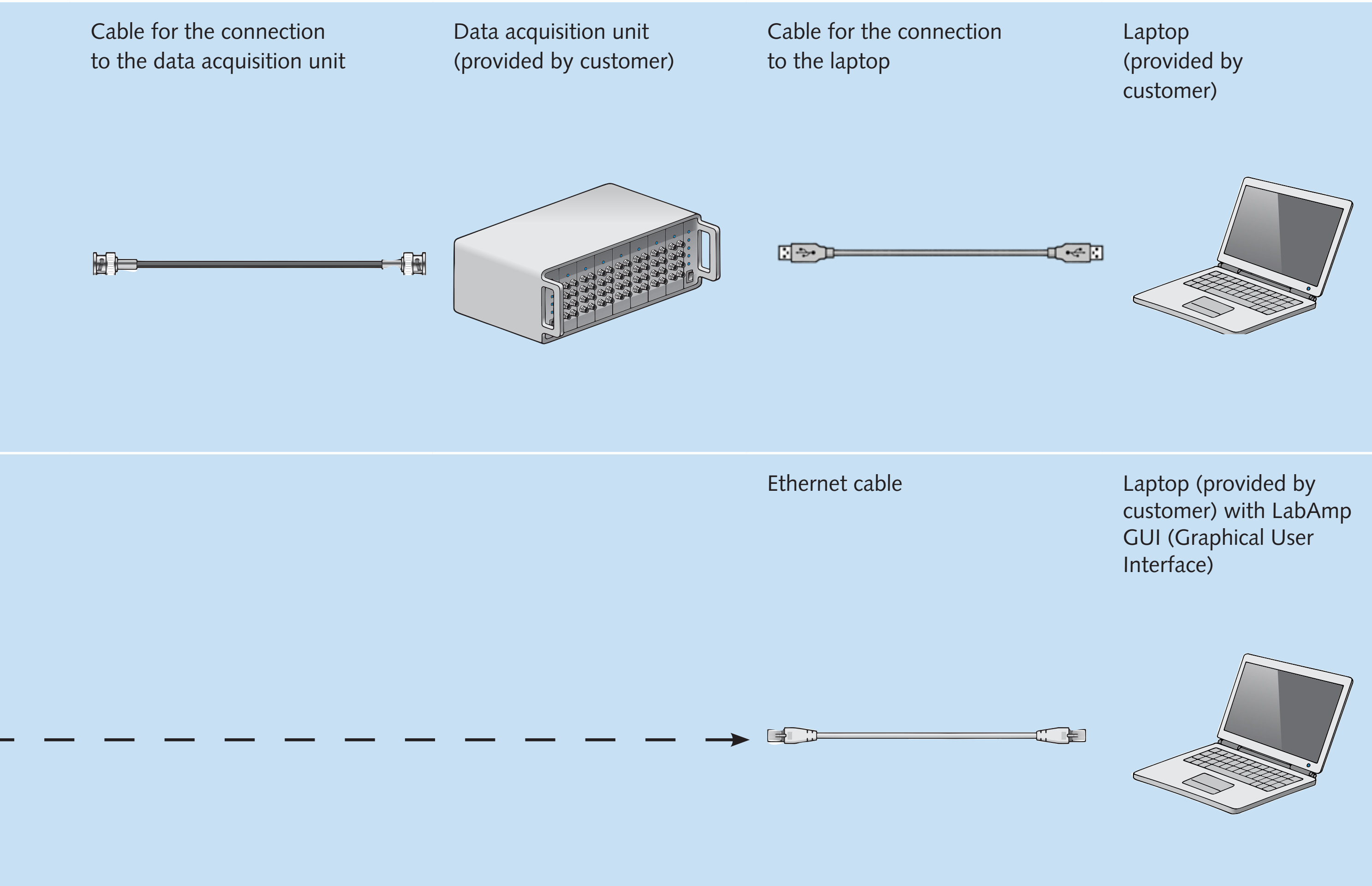
Measuring chains

1-component force
Strain

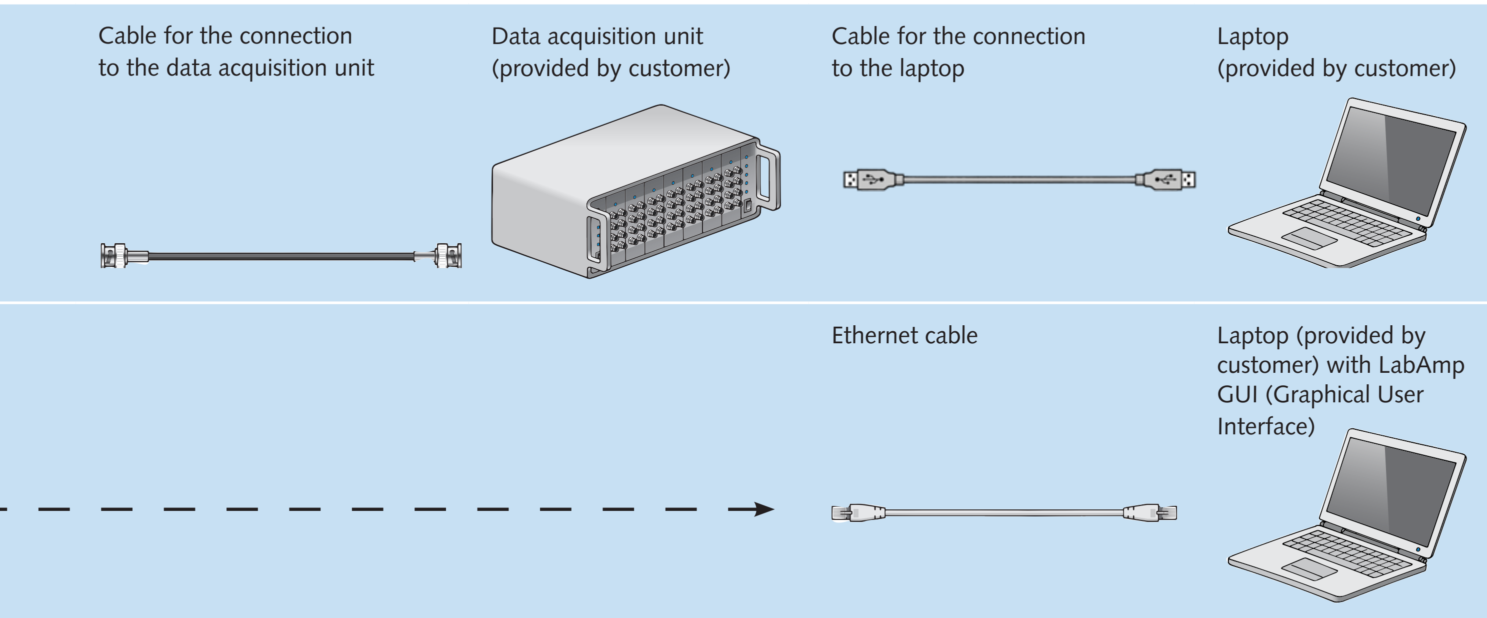
	Measure	Connect	Amplify
Force sensors	90x1A 90x1B 910xA 	1631C… 1939A… 1641B… 1983AD… etc. 	Charge amplifiers **without** integrated data acquisition 5015A... 5018A... 
Force sensors	913xB2… 914xB2… 	Cable integrated in the sensor –> Connection to the charge amplifier with coupling 1721 	
Force sensors	913xBA… 914xBA… 	1971A1… 1973Ax1… 	
Load cells	9203 9205 9207 93x1B 9313AA… 93x3A… 	1631C… 1641B… 1939A… 1983AD… 	Charge amplifiers **with** integrated data acquisition 5165A… 5167A… 
Load cells	917xB 	Cable integrated in the sensor –> Connection to the charge amplifier with cable 1631C… 1641B… etc. 	

		Measure	Connect	Amplify
Surface strain sensors		9232A… 9237B… 	1631C… 1641B… 1939A… 1983AD… etc. 	Charge amplifiers **without** integrated data acquisition 5015A... 5018A... 
Strain measuring pins	Longitudinal measuring pins	9243B 9247A 	1651C… 1923A… 1983AB... 	Charge amplifiers **with** integrated data acquisition 5165A… 5167A… 
Strain measuring pins	Transversal measuring pins	9240AA3 	Cable integrated in the sensor –> Connection to the charge amplifier with coupling 1721 	

Acquire **Analyze**



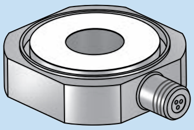
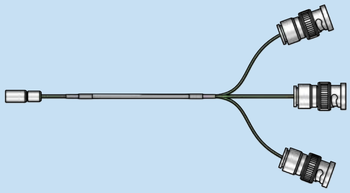
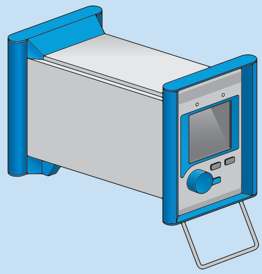
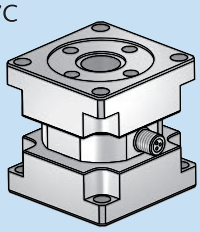
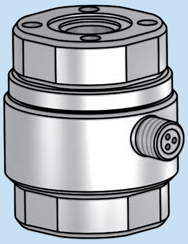
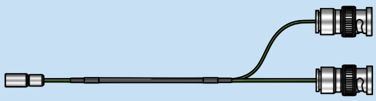
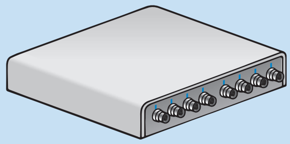
Acquire **Analyze**

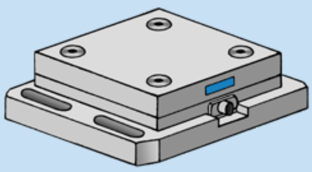
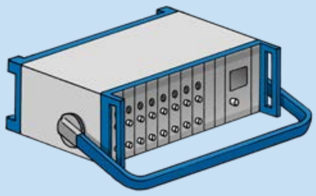
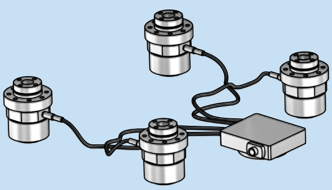
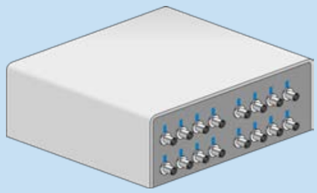


Measuring chains

Multicomponent force/moment

Dynamometers

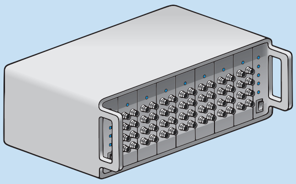
	Measure	Connect	Amplify
Triaxial force sensors	90x7C, 90x8C 	1698AA... 1698AB... 1698ACsp  	Charge amplifiers **without** integrated data acquisition 5015A... 5018A... 
3 axis load cell quartz force links	93x7C 		
2 axis load cell and reaction torque	93x5B 	1698AD... 1698AB... 1698ACsp  	Charge amplifiers **with** integrated data acquisition 5165A... 5167A... 

	Measure	Connect	Amplify
Dynamometers	9119AA2 9139AA 9255C 9257B 	3-component force measurement 1687B... 1689B...  6-component force/torque measurement 1677A... 1679A... 	Charge amplifiers **without** integrated data acquisition 5080A... 
Dynamometer kit (set of four 3 axis load cells)	9366CC... 	3-component force measurement 1687B... 1689B...  6-component force/torque measurement 1677A... 1679A... 	Charge amplifiers **with** integrated data acquisition 5167A... 

Acquire | **Analyze**

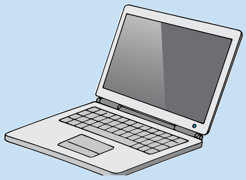
Cable for the connection to the data acquisition unit

Data acquisition unit (provided by customer)

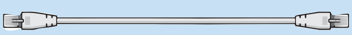


Cable for the connection to the laptop

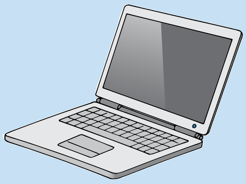
Laptop (provided by customer)



Ethernet cable



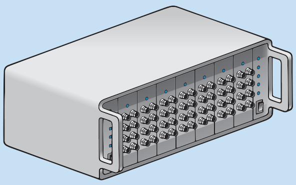
Laptop (provided by customer) with LabAmp GUI (Graphical User Interface)



Acquire | **Analyze**

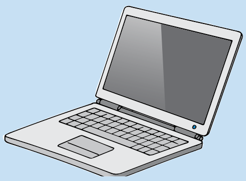
Cable for the connection to the data acquisition unit

Data acquisition unit (provided by customer)



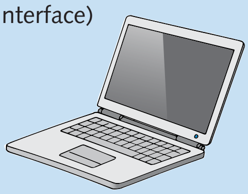
Cable for the connection to the laptop

Laptop (provided by customer)



Ethernet cable

Laptop (provided by customer) with LabAmp GUI (Graphical User Interface)



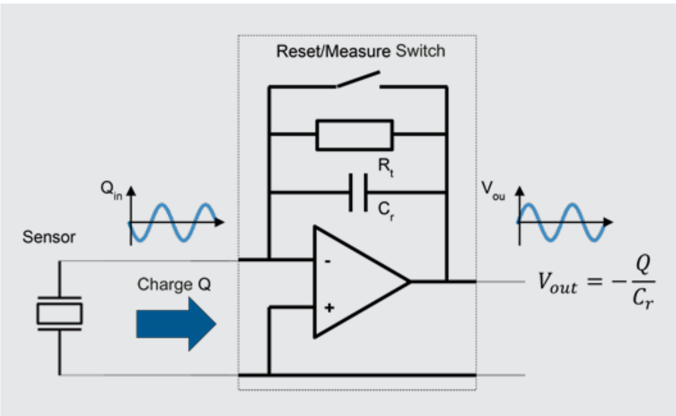
Charge amplifier technology

The charge produced by a piezoelectric sensor is a variable that is difficult to access for measurement. For this reason, electronics are connected downstream of the sensor to convert the charge signal into a voltage signal.

A charge amplifier, as this device is known, converts the negative charge produced by the piezoelectric sensor when it is subjected to loading by a force into a positive voltage that is proportional to the charge or the acting force. Due to their principle of operation, force sensors have negative sensitivity and they produce a negative charge under load.

The next illustration shows the circuit diagram for a charge amplifier, with its three main components:

- Range capacitor C_r
- Time constant resistor R_t
- Reset/Measure switch



Circuit diagram of a charge amplifier

The **range capacitor C_r** is used to set the measurement range of the charge amplifier. This is done by switching between different range capacitors. Switching measurement ranges makes it possible to measure across several decades with an outstanding signal-to-noise ratio. Hence, for example, it is possible to use the same force sensor to measure forces in the 100 kN range and in the 100 N range, simply by switching the measurement range. Furthermore, the signal-to-noise ratio is excellent in both ranges.

The **time constant resistor R_t** defines the time constant of the charge amplifier. Considered in the frequency range, the time constant determines the cut-off frequency for the high-pass characteristic of the charge amplifier. Switching between different time constant resistors makes it possible to change the high-pass characteristic.

The **Reset/Measure switch** is used to control the start of measurement or to set the zero point.

Selection criteria for charge amplifiers

Various criteria determine the choice of a charge amplifier that is suitable for the application. The product overview on page 6 shows a selection of suitable charge amplifiers with all the criteria. The most important selection criteria for choosing a suitable charge amplifier are as follows:

- Number of channels
- Measurement range
- Measurement type
- Frequency range

The following sections give more detailed explanations of the "measurement type" and "frequency range" selection criteria.

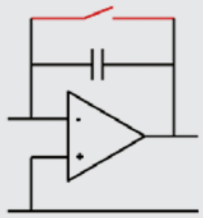
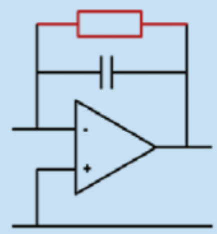
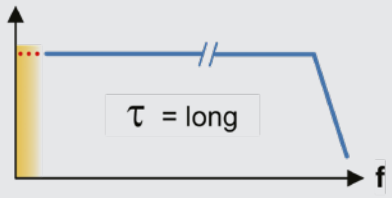
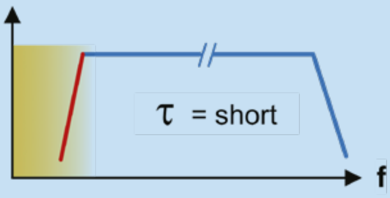
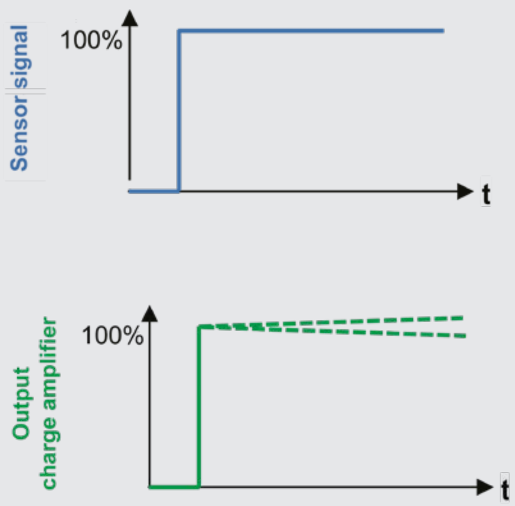
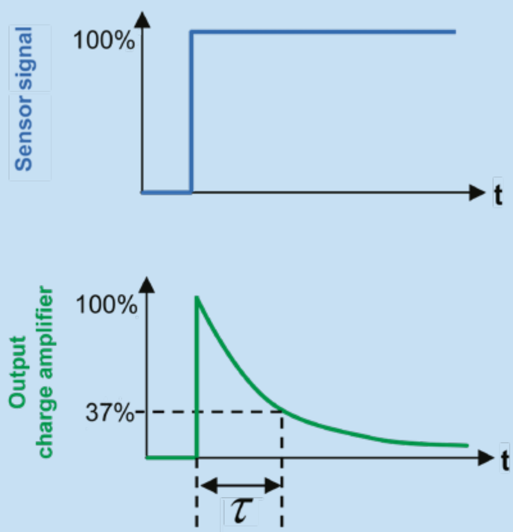
Measurement type – quasistatic versus dynamic measurement

A distinction is made in piezoelectric measurement technology between quasistatic and dynamic measurements. Most charge amplifiers support both types of measurement, but there are some amplifiers that only permit one of the two measurement types. For this reason, it is critically important to have a clear understanding of the type of measurement that should be used for the specific measurement task.

The measurement type determines the behavior of the charge amplifier in the lower frequency range, and is influenced by a key component of the charge amplifier: the time constant resistor, or the time constant. The time constant determines the cut-off frequency for the high-pass characteristic of the charge amplifier, so it also determines the measurement type.

Time constant
The next table shows the influence of the measurement type and/or the time constant on the behavior of the charge amplifier in the frequency and time range.

The time constant determines the cut-off frequency of the high-pass characteristic, or the behavior of the charge amplifier in the lower frequency range.

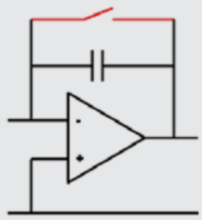
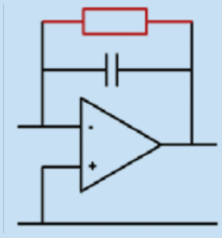
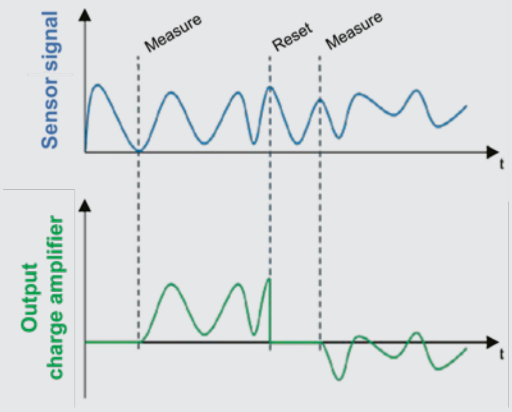
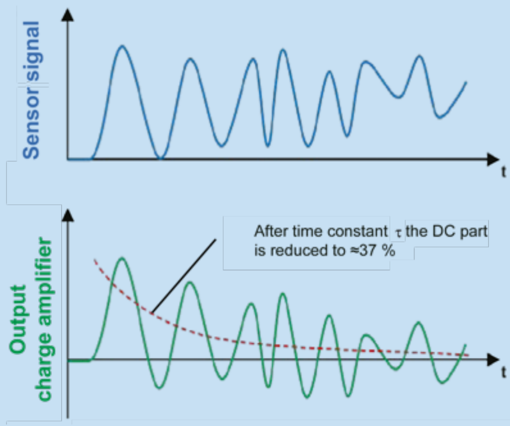
Quasistatic measurement	Dynamic measurement
	
• Time constant "long" (no time constant resistor) • Behavior is comparable to DC mode on the oscilloscope	• Time constant "short" (with time constant resistor) • Behavior is comparable to AC mode on the oscilloscope
• Behavior in the frequency domain: 	• Behavior in the frequency domain: 
• Behavior in the time domain:  -> Drift caused by the operating principle becomes visible in case of longer measuring times	• Behavior in the time domain:  -> No drift due to the time constant

Applications where a static force has to be measured over a lengthy period therefore require a charge amplifier that supports quasistatic measurement (time constant "long").

Reset/measure

Due to its principle of operation, piezoelectric measurement technology does not permit measurements with an absolute zero point reference. For a quasistatic measurement, the zero point is defined on starting the measurement, and starting is controlled by the Reset/Measure switch. For a dynamic measurement, however, it is not possible to set a zero point because measurements are made without a zero point reference on account of the time constant.

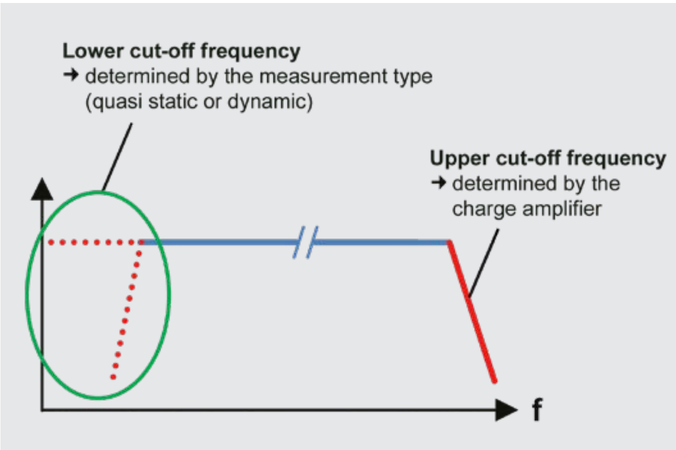
The next table shows the behavior of the charge amplifier as regards the Reset/Measure switch for the two types of measurement.

<table>
<tr><th>Quasistatic measurement</th><th>Dynamic measurement</th></tr>
<tr><td></td><td></td></tr>
<tr><td>• Zero point is set on starting the measurement
• Start of measurement is controlled by the Reset/Measure switch</td><td>• Measurement without zero point reference, due to the time constant
• No Reset/Measure signal is needed, or the charge amplifier is always operated in Measure mode</td></tr>
<tr><td>• Behavior in the time domain:

</td><td>• Behavior in the time domain:

</td></tr>
</table>

Frequency range

The frequency range of a charge amplifier is defined by the lower and upper cut-off frequencies. The lower cut-off frequency is defined by the measurement type (quasistatic or dynamic), which determines the high-pass characteristic. The upper cut-off frequency is defined by the low-pass, which is a feature of all charge amplifiers due to system-related reasons. Consequently, the upper cut-off frequency is only dependent on the design of the charge amplifier, but not on the measurement type.

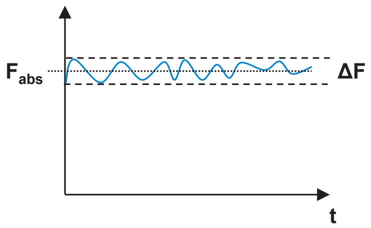
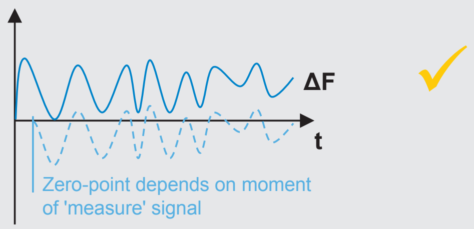
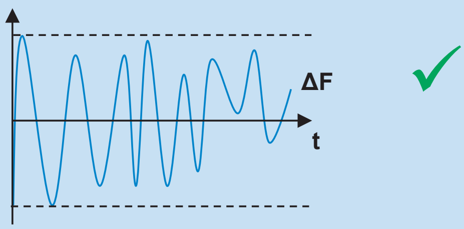
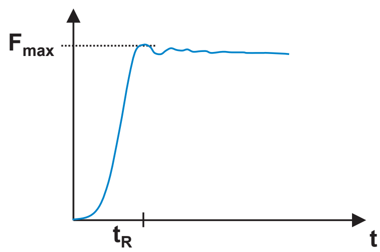
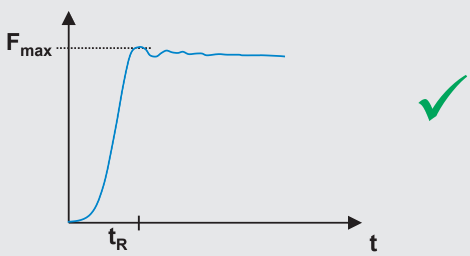
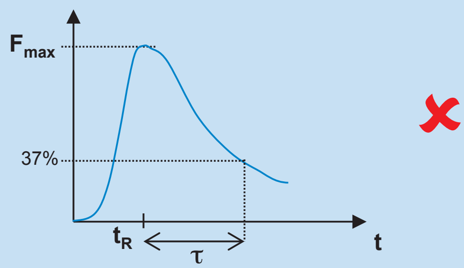
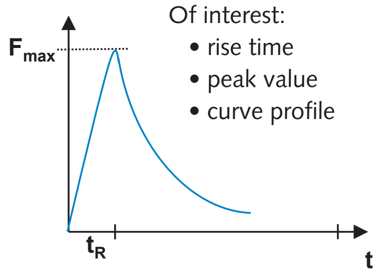
There are virtually no application cases in force measurement technology where the upper cut-off frequency of the charge amplifier is a limiting factor. In most force applications, the natural frequency is in the range up to 10 kHz. an upper cut-off frequency for the charge amplifier in the 20 to 40 kHz range is therefore perfectly adequate for most applications.



Frequency range: charge amplifier

Measurement signals and suitable measurement types

The next table shows the behavior of the charge amplifier for quasistatic and dynamic measurements, with the help of some typical examples of measurement signals encountered in force measurement technology. The examples are intended to assist you with the choice of the right measurement type for the specific measurement assignment.

<table>
<tr><th rowspan="2">Physical force signal</th><th colspan="2">Charge amplifier output</th></tr>
<tr><th>Quasistatic measurement
-> “Long” time constant</th><th>Dynamic measurement
-> “Short” time constant</th></tr>
<tr><td>Small force signal with large static preload ($F_{abs} >> \Delta F$)

</td>
<td>
</td>
<td>
</td></tr>
<tr><td>Rapid increase in force to static level

</td>
<td>
</td>
<td>
</td></tr>
<tr><td>Rapid force pulse
Of interest:
• rise time
• peak value
• curve profile

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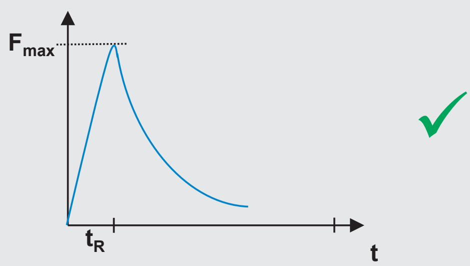
<td>
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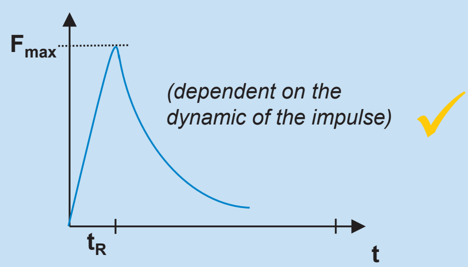
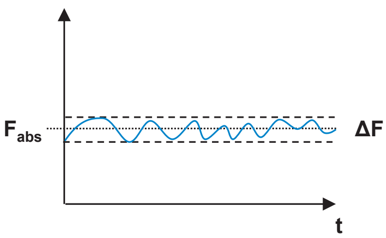
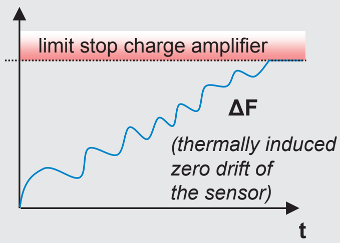
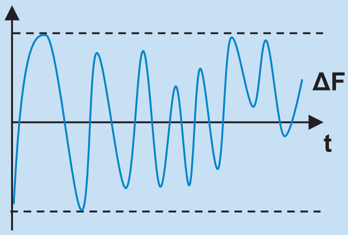
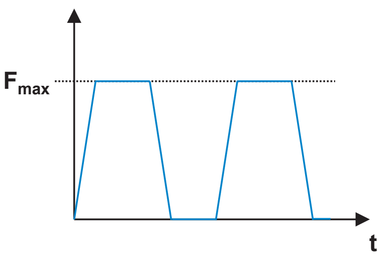
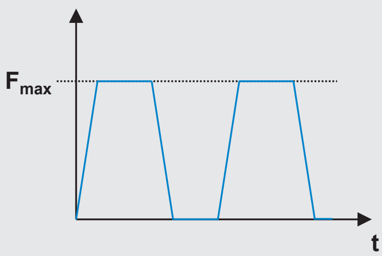
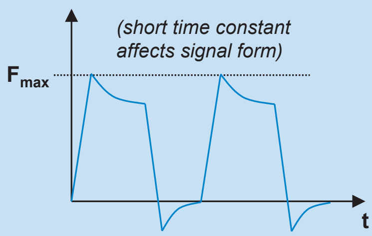
<td>
</td></tr>
</table>

Physical force signal	Charge amplifier output	
	Quasistatic measurement -> "Long" time constant	**Dynamic measurement -> "Short" time constant**
Long measurement time and temperature change 	 ✗	 ✓
Trapezoid force signal 	 ✓	 ✗

Suitability of measurement type

✓ = ideal

✓ = restricted

✗ = unsuitable

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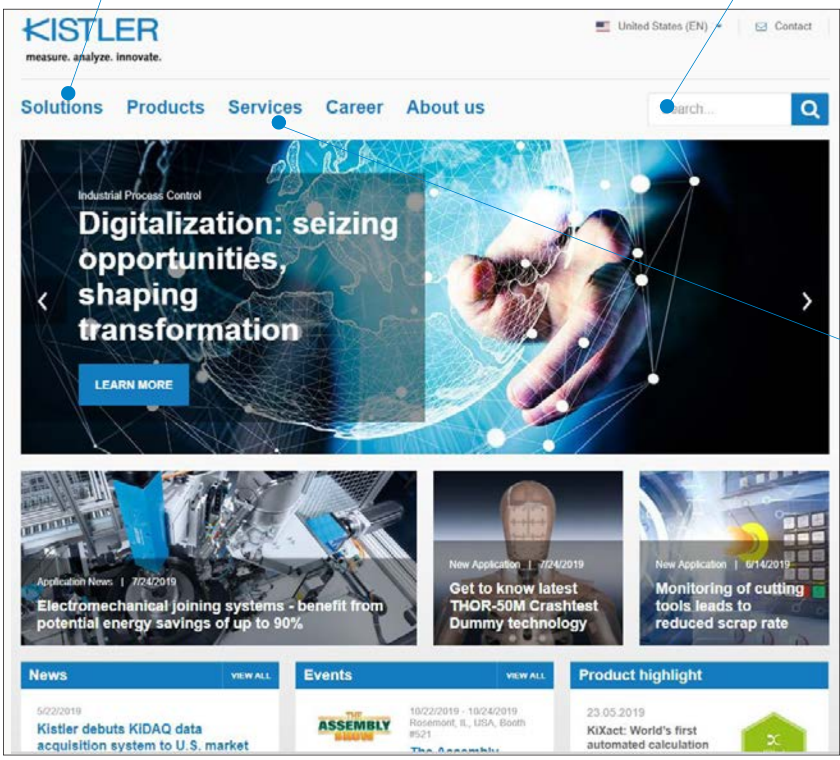

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