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Piezoelectric Load Cells

Type 9301C ... 9371C

for measuring dynamic and quasistatic tensile and compression forces

Piezoelectric load cells, also known as force transducers or force links, measure dynamic or quasistatic forces, both tensile and compression. These load cells contain a piezoelectric ring force transducer of the 90x1C family: preloaded and calibrated, thus ready to use immediately.

- Calibrated and ready to use
- Simple installation
- Centering seats for exact installation
- Ground-isolated
- Accessories for optimum force introduction

Description
The 93x1C load cell family is the easiest way to measure forces piezoelectrically without the need for sophisticated installation and calibration. The force transducers are factory calibrated and preloaded to measure both tension and compression forces. This means, that the sensor is ready to measure within minutes and provides accurate data from dynamic or quasi-static processes. In addition, the sensor has been installed in an electrically isolated manner, so that ground loops are largely eliminated.

Application
Quasistatic measurements are possible without any problems, but the 93x1C is mainly used where dynamic processes have to be recorded exactly. Due to the extremely high stiffness of the piezoelectric load cell, the elastic behavior of the measured object is practically unchanged.

The force link comes calibrated in 3 different ranges and is immediately ready for use.

Examples of use
Automobile industry
- Safety technology, monitoring of collision forces
- Mechanical shocks in chassis
- Forces on balancing machines

Material testing
- Impact testing, alternate strength testing

Machine tools
- Monitoring on presses, punching, embossing and welding machines
- Force measurements on longitudinal guideways

General machine building
- Monitoring of supporting forces (force oscillations) on machinery mounted on damping elements.
- Clamping processes, e.g. force sensor combined with hydraulic cylinder
- Joining technique (insertion, press fit of components)

Quality control
- Force measurements on switches
- Monitoring of automatic assembly machines

Mounting and force introduction
The mounting of these force transducers is quite simple, but nevertheless it should be done carefully and correctly:
- The contact surfaces must be flat, clean, parallel and as rigid as possible.
- The fixing screws must not touch the threaded base.
- The mounting screw must be tightened so that no gap is created at maximum tensile force.

The force application should be as concentric as possible with the sensor axis. Eccentric force introduction, bending moments, torques and shear forces are only permissible up to a certain degree. For further details, please refer to the user manual.

9301C_003-556e-04.25

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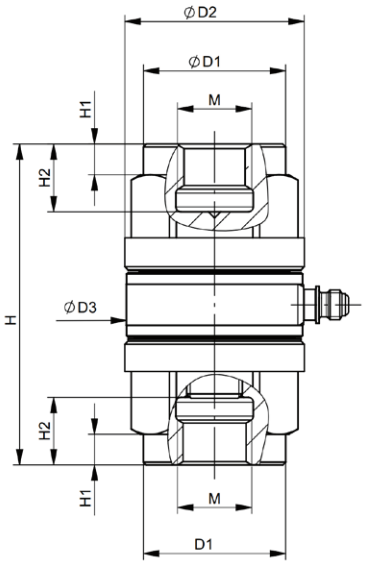
Technical data

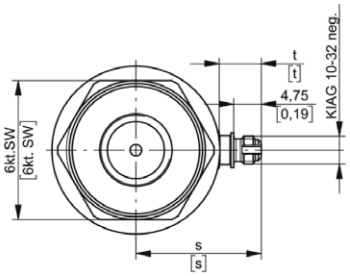
Type		9301C	9311C	9321C	9331C	9341C	9351C	9361C	9371C
Nominal force	kN	±3	±6	±14	±24	±36	±48	±80	±160
Calibrated range 1	kN	0 ... 3	0 ... 6	0 ... 14	0 ... 24	0 ... 36	0 ... 48	0 ... 80	0 ... 160
Calibrated range 2	kN	0 ... 0.03	0 ... 0.06	0 ... 0.14	0 ... 0.24	0 ... 0.36	0 ... 0.48	0 ... 0.8	0 ... 1.6
Calibrated range 3	kN	0 ... –3	0 ... –6	0 ... –14	0 ... –24	0 ... –36	0 ... –48	0 ... –80	0 ... –160
Maximum force	kN	±3.3	±6.6	±15.4	±26.4	±39.6	±52.8	±88	±176
Sensitivity	pC/N	–3.1 ±0.3	–3.4 ±0.3	–3.7 ±0.3	–3.9 ±0.3			–4.0 ±0.3	–3.9 ±0.3
Linearity incl. hysteresis	%FSO	±0.5							±0.7
Natural frequency (free-free) f_{0fz} calc.	kHz	58.5	50.6	41.2	36.9	29.7	27.9	23.8	19.9
Axial stiffness (calc.)	N/µm	245	398	724	1 150	1 510	1 756	2 597	4 794
Lateral stiffness (calc.) [1]	N/µm	6	14	27	48	74	86	136	316
Shear stiffness (calc.)	N/µm	22	47	76	130	210	229	349	733
Torsional stiffness (calc.)	Nm/°	15	53	254	633	1 387	2 269	5 540	21 231
Bending stiffness (calc.)	Nm/°	22	78	355	865	1 926	3 105	7 619	28 411
Maximum bending moment Fz=0 calc.	N·m	4.2	12	49	104	195	312	640	1 955
Temperature sensitivity Sensitivity change (–40°C ... 120°C, Tref = 25°C)	%	±2.5	±1.5						
Operating temperature range	°C	–40 … 120							
Insulation resistance @23°C	Ω	$\geq 10^{13}$							
Ground insulation resistance	Ω	$\geq 10^{8}$							
Sensor capacitance	pF	13.5±1	17±2	33±4	52±5	70±6	93±7	149±10	303±20
Connector type		KIAG 10-32 neg.							
Degree of protection EN60529	IP	See table, page 5							
Weight	g	14	28	90	170	330	480	1 020	2 500

[1] Resistance of the sensor to shear and bending deformation. (Theoretical) assumption: The sensor is fixed at the bottom, the shear force acts at the top, so that the lever length is equal to the total sensor height.



Type	M	D1	D2	D3	SW	H	H1	H2	s	t
9301C	M5	8.5	11	10.3	9	25	2	5	12.75	7.25
9311C	M6	12.5	15	14.5	13	30	3	5.5	14.85	7.25
9321C	M10	18	23	22.5	19	45	5	10	18.6	7.25
9331C	M12	23	29	28.5	24	52	5	11	21.65	7.25
9341C	M16	31	35	34.5	32	62	6	14.5	24.65	7.25
9351C	M20	35	41	40.5	36	72	7	18	27.65	7.25
9361C	M24	45	53	52.5	46	88	9	22	33.65	7.25
9371C	M30	64	76	77.2	65	108	10	28	45	6.75

Dimensions of Types 9301C ... 9371C



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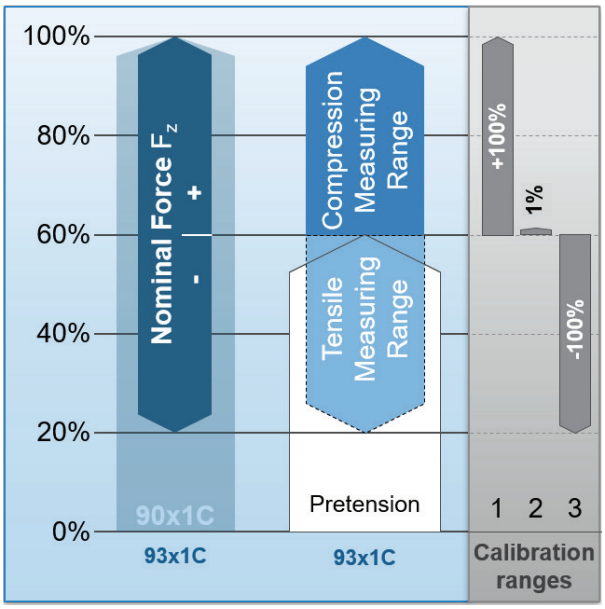
Calibration and measuring ranges

The expected error deviations of a sensor are directly dependent on the size of the measuring range and the choice of the operating point. The smaller the measuring range, the better the linearity and hysteresis.
The piezoelectric force transducers 93x1C are preloaded with 60% of the nominal force of the 90x1C sensor built into them. This enables the measurement of equally large positive and negative forces.
The lowest 20% of the nominal force range is not taken into account, since the susceptibility to moments, shear forces and non-linearities is highest there.

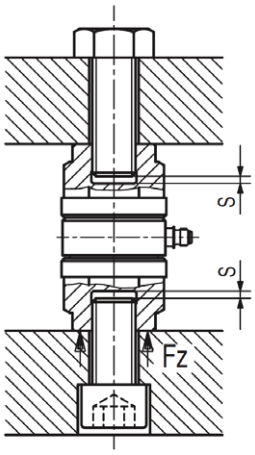
The load cells 93x1C are calibrated in three different ranges: +100%, –100%, +1%.

A detailed operating manual with further explanations of Installation, dimensioning and cabling can be found in the download area of our website www.kistler.com.



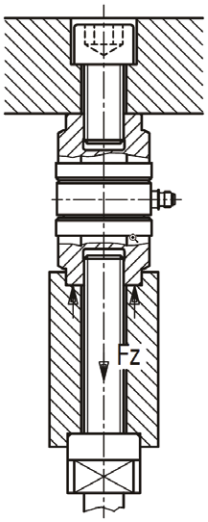
Mounting examples, different types of force introduction

Example A



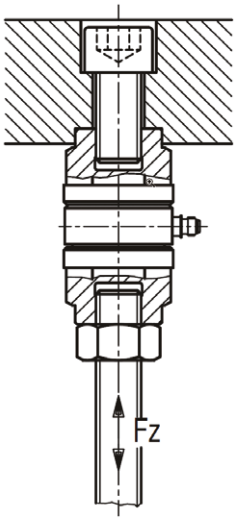
Force introduction of compression forces.

Example B



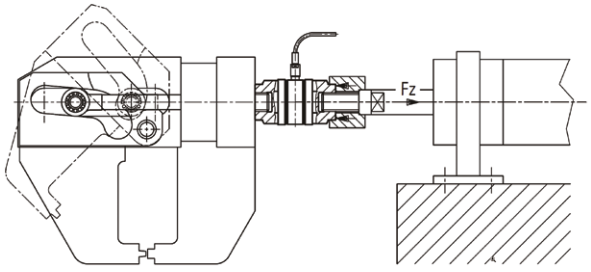
Loading from tensile and compression forces via an extension piece. The preloading force on the sleeve must not be less than a minimum value under the effect of tensile forces.

Example C



Force introduction of tensile and compression forces directly onto the threaded connection. In this case, a lock nut should always be used.

Example D



Mounting example of a force link in a hydraulic clamping device. Monitoring of tensile and compression forces.

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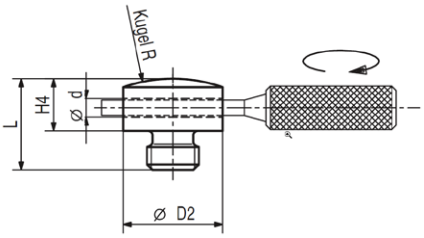
Force distribution cap

If the Force Link is not firmly installed in a structure on both sides, there is always the risk, that the force might be introduced eccentrically. The force distribution cap helps to significantly increase the precision and repeatability of the measurement with an exactly defined point of force application.

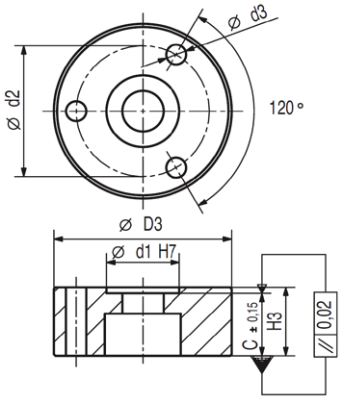


Distributing cap Type 9500A...
The force distributing cap can be screwed in with a cylindrical tool.

Type	Distribut. cap	D2	L	H4	R	d
9301C	9500A0	8.5	8	4	R10	2.2
9311C	9500A1	12.5	10	6	R15	3.2
9321C	9500A2	18	17	9	R25	4.3
9331C	9500A3	23	21	12	R35	4.3
9341C	9500A4	31	28	15	R45	6.4
9351C	9500A5	35	33	18	R50	6.4
9361C	9500A6	45	41	22	R65	8.4
9371C	9500A7	64	57	32	R90	8.4

Flange

If installation with the central bolt is not possible directly, the flange 9501Ax is installed. The precision part can be used for both compressive and tensile forces, as shown examples A...D on page 3.



Flange Type 9501A...
A socket head cap screw is supplied with the flange.

Type	Flange	D3	H3	d1	d2	d3	C	H1 (Fig. 1)	H2 (Fig. 2)
9301C	9501A0	25	9	8,5	18	3.2	8	37	41
9311C	9501A1	34	11	12.5	24	4.3	9	45	48
9321C	9501A2	44	18	18	33	5.3	16	70	77
9331C	9501A3	56	22	23	42	6.4	20	84	92
9341C	9501A4	70	29	31	52	8.4	27	104	116
9351C	9501A5	84	37	35	62	10.5	35	125	142
9361C	9501A6	102	44	45	77	13	42	152	172
9371C	9501A7	136	53	64	106	17	51	191	210

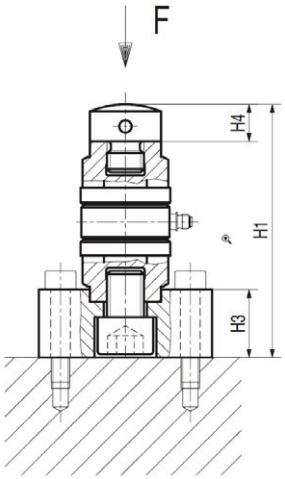


Fig. 1
Force link with flange and pressure distributing cap. Insert for compression force loading.

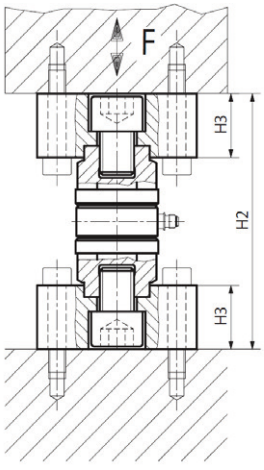


Fig. 2
Force link with flanges fitted on both sides. Insert for compression force loading.

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Measuring chain

Measure | Connect | Amplify

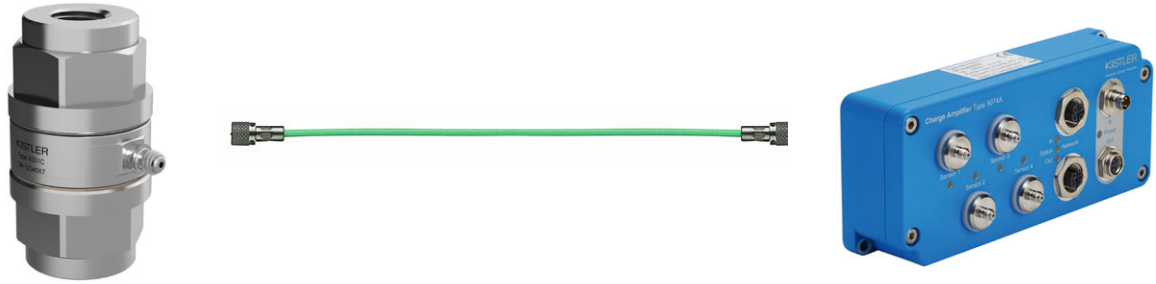

Fig. 3: Measuring chain

Connecting cable

All sensors of 9301C...9371C feature a KIAG 10-32 neg. connection and are compatible accordingly with all KIAG 10-32 pos. cable connectors. Only high-insulation coaxial cables with low capacitance that produce only a very small amount of static electricity may be used as connecting cables for piezoelectric sensors. Kistler uses cables made of high-quality PFA or oil-proof FPM here.

On the sensor side, the IP protection class acc. to EN60529 is generally dependent on the used connector. For IP65, the standard 10-32 KIAG cable connector with knurled nut is used; for increased requirements in harsh environments, the industrial-suited 10-32 KIAG pos. int. version is used which, if necessary, can be tightly welded with the sensor case and IP68 achieved.

Compatibilities of cables and charge amplifiers

											Industrial Amplifier					Laboratory Amplifier					DAQ
											5030A	5039A	5073A...	5074A...	5877B...	5015A...	5018A...	5080A...	5165A...	5167A...	kiDAQ
										Channels	1	1	1-4	1-4	1	1	1	1-8	1.4	4.8	4, ... ,52
Cable	Cable Properties	Length [m] min	Length [m] max	Temp. Range		IEC/EN 60529	Connector Sensor	Connector Amplifier	IEC/EN 60529		IP65	IP65	IP60	IP67	IP53	IP20	IP40	IP40	IP20	IP20	IP20
1631C...	PFA	0.1	100	–55...200°C	Plug screwed	**IP65**	KIAG 10-32 pos.	BNC pos.	**IP40**	Plug screwed	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓
1641B...	PFA	0.1	100				KIAG 10-32 pos. 90°	BNC pos.			-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓
1945A...	PFA Ø 1 mm	0.1	5				KIAG 10-32 pos. int.	Mini-Coax neg.			-	-	-	-	-	-	-	-	-	-	-
1633C...	PFA	0.1	50				KIAG 10-32 pos.	TNC pos.	**IP65**		-	✓	✓	-	-	-	-	-	-	-	-
1635C...	PFA	0.1	15				KIAG 10-32 pos.	KIAG 10-32 pos.			✓	-	-	✓	-	-	-	-	-	-	-
1957A...	PFA, steel braiding	0.1	10				KIAG 10-32 pos.	KIAG 10-32 pos.			✓	-	-	✓	-	-	-	-	-	-	-
1900A23A12..	PFA superflexible, drag chain proven	0.3	20	–40...200°C		**IP67**	KIAG 10-32 pos. hex	BNC pos.	**IP40**		-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓
1900A23A11..							KIAG 10-32 pos. hex	KIAG 10-32 pos. hex	**IP67**		✓	-	-	✓	-	-	-	-	-	-	-
1900A21A120x	FPM flexible steel hose	0.4	20	–20...200°C			KIAG 10-32 pos. hex	BNC pos.	**IP40**		-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓
1900A21A110x							KIAG 10-32 pos. hex	KIAG 10-32 pos. hex	**IP67**		✓	-	-	✓	-	-	-	-	-	-	-
1983AD...	FPM	0.1	20	–20...200°C		**IP68**	KIAG 10-32 pos. int.	BNC pos.	**IP40**		-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓
1939A...	PFA	0.1	20	–55...200°C	Plug welded[1]	**IP67**	KIAG 10-32 pos. int.	BNC pos.	**IP40**		-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓
1941A...	PFA	0.1	20				KIAG 10-32 pos. int.	TNC pos.	**IP65**		-	✓	✓	-	-	-	-	-	-	-	-
1969A...	PFA, steel braiding	0.5	10				KIAG 10-32 pos. int.	KIAG 10-32 pos. int.[2]			✓	-	-	✓	-	-	-	-	-	-	-
1967A...	PFA, steel braiding, isolated	0.5	10				KIAG 10-32 pos. int.	KIAG 10-32 pos. int.[2]			✓	-	-	✓	-	-	-	-	-	-	-
1979A...	FPM	0.1	20	–20...200°C			KIAG 10-32 pos. int.	Fischer 103 Triax			-	-	-	-	-	-	-	-	-	-	-
1983AC...	FPM	0.1	5			**IP68**	KIAG 10-32 pos. int.	KIAG 10-32 pos. int.[2]	IP65		✓	-	-	✓	-	-	-	-	-	-	-

[1] screwed: IP65

[2] welded: IP67

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Charge amplifiers

Various criteria are decisive when selecting the right charge amplifier for a given application. Among the most important are the number of channels, the measuring range, the type of measurement and the frequency range. At this point, only a tabular summary is shown to provide an overview. More detailed information and explanations are available in the force product catalog and in the respective data sheets at www.kistler.com.

Digital laboratory amplifiers: LabAmp

The latest generation of universal laboratory charge amplifiers; with integrated data acquisition for dynamic or quasistatic measurements; network ready with web interface.

Fig. 4: LabAmp Type 5165A and Type 5167A

Analog laboratory amplifiers: Type 5015A, 5018A and 5080A

The proven analog charge amplifiers for laboratories and research. With very wide measuring range and high flexibility (Type 5080A).

Fig. 5: Laboratory charge amplifiers Type 5015A and Type 5080A

Industrial amplifiers

Size- and function-optimized amplifiers for continuous use in daily work. Bus-capable; some with further functions. (evaluation of force curves, etc.)

Fig. 6: Industrial amplifiers Type 5073A and 5074A (from left) At the right is the maXYmos BL Type 5867B…

Ordering key

Type 93 □ 1C

Piezoelectric Force Transducer	
Range ±3 kN	**0**
Range ±6 kN	**1**
Range ±14 kN	**2**
Range ±24 kN	**3**
Range ±36 kN	**4**
Range ±48 kN	**5**
Range ±80 kN	**6**
Range ±160 kN	**7**

Optional accessories	Type
• Distributing cap	9500A...
• Flange	9501A...
• Cables according to table on page 5	

9301C_003-556e-04.25