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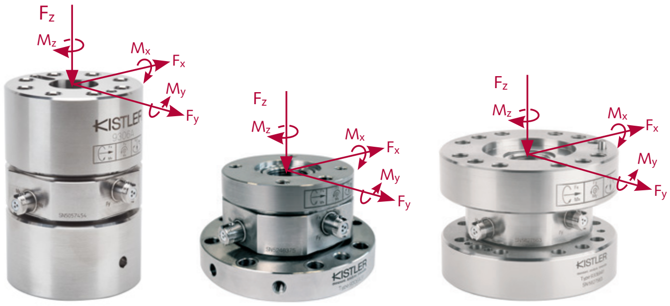
6-Axis Force/Torque Sensor

Type 9306A, 9306A31, 9306A41

The 6 Axis Force/Torque Sensor measures all forces and the corresponding moments on the three orthogonal axis. All forces and moments are captured as physical, piezoelectric signals and do not need to be calculated. The unique measurement setup of Kistlers multi-axis force/torque sensor allows an extremely small and compact design. Therefore concise models of 3-dimensional dynamic and quasi-static processes are possible even in narrow installations.



- Very wide measuring range
- Large frequency range
- Easy installation with numerous centering options
- Stainless, sealed sensor case
- Robust multipole connector (one connector each for forces and torques)

Description

Pretensioned piezoelectric 6-Axis Force/Torque Sensor with two mounting flanges. Measures forces and reaction torques in both tensile and compression directions.
A force or reaction torque generates a proportional electrical charge. This is transferred by an electrode to the corresponding connector.
The multi-axis force/torque sensor consists of large-area quartz discs and is therefore very rigid. The resulting high natural frequency is a prerequisite for high dynamic force and torque measurements.
The two 3-pole V3 neg. connectors are provided with an anti-twist lock. One connector each for force and torque signals. After it has been correctly installed the 6-axis force/torque sensor is immediately ready for use without recalibration.

Application

- Forces and moments during inspection of springs and damping elements
- Dynamic force and moment measurements during inspection of prostheses
- Forces and torques during the product inspection
- Dynamic forces and torques on objects in the wind tunnel
- Forces and torques during assembly processes with robots

Technical data (Tref = 25 °C)

			9306A	9306A31	9306A41
Shear forces range (as vector) [1]	$\overrightarrow{F_x, F_y}$	kN	–5 … 5	–1 … 1	–5 ... 5
Force range [1]	F_z	kN	–5 … 10	–2 … 2	–5 ... 10
Reaction torque range (as vector) [1]	$\overrightarrow{M_x, M_y, M_z}$	N·m	±200	±100	±150
Overload	F_x, F_y, F_z	%	10	20	20
Force calibrated range [2]	$\overrightarrow{F_x, F_y}$ [3] F_z	kN kN	±10 ±30	±5 ±10	±5 ±10
Moment calibrated range (force-free) [2]	$\overrightarrow{M_x, M_y}$, M_z	N·m N·m	±400 ±400	±300 ±175	±300 ±200
Force threshold	F_x, F_y, F_z	N	<0.01	<0.01	<0.01
Reaction torque threshold	M_x, M_y, M_z	N·m	<0.0002	<0.0002	<0.0002
Force sensitivity	F_x, F_y	pC/N	≈–7.3	≈–6.9	≈–7.0
	F_z	pC/N	≈–3.7	≈–3.7	≈–3.5
Reaction torque sensitivity	M_x, M_y	pC/N·m	≈–255	≈–265	≈–255
	M_z	pC/N·m	≈–225	≈–205	≈–220
Axial stiffness	$C_{A,z}$	N/µm	≈3 600	≈5 400	≈3 462
Shear stiffness	$C_{S,xy}$	N/µm	≈740	≈1 620	≈1 386
Lateral stiffness [4]	$C_{L,xy}$	N/µm	≈250	≈900	≈520
Bending stiffness	$C_{B,xy}$	N·m/°	≈12 300	≈16 700	≈13 074
Torsional stiffness	$C_{T,z}$	N·m/°	≈13 100	≈18 600	≈18 286

[1] All load combinations possible (F_x, F_y on cover-plate surface, F_z central)

[2] Considerably higher forces and moments are permitted for individual loading (F_x, F_y and M_x, M_y as vector)

[3] Force application point below cover plate surface, so that no moments are introduced

[4] 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 toal sensor height

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Additional technical data (Tref = 25 °C)

			9306A	9306A31	9306A41
Force linearity, incl. hysteresis	F_x, F_y, F_z	%FSO	≤±0.5	≤±1.5	≤±0.5
Moment linearity, incl. hysteresis	M_x, M_y, M_z	%FSO	≤±1	≤±1.5	≤±1
Crosstalk	$F_z \rightarrow F_x, F_y$	%FSO	≤±2 [1)]	≤±2 [3)]	≤±2 [1)]
	$F_x \leftrightarrow F_y$	%FSO	≤±2.5 [1)]	≤±2 [3)]	≤±2.5 [1)]
	$F_x, F_y \rightarrow F_z$	%FSO	≤±3.5 [2)]	≤±4 [3)]	≤±3.5 [2)]
Natural frequency (free – free)	f_n (F_x, F_y, F_z)	kHz	≈18	≈13	≈12
	f_n (M_x, M_y, M_z)	kHz	≈11	≈11	≈8.5
Operating temperature range		°C	–40 … 80	0 … 50	–40 … 80
Insulation resistance		Ω	$>10^{12}$	$>10^{12}$	$>10^{12}$
Ground isolation		Ω	$>10^{8}$	$>10^{8}$	$>10^{8}$
Connector, 2 x			V3 neg.	V3 neg.	V3 neg.
Weight		kg	1.53	0.94	1.75

[1)] FSO: 20 kN
[2)] FSO: 60 kN
[3)] FSO: 8 kN

Measurement range Type 9306A31

Different maximum values are permitted depending on the combination of forces F_x, F_y, F_z and reaction moments M_x, M_y, M_z:

$\overrightarrow{F_s} = F_x, F_y$ [kN] Select one of the proposals	Force application point (relating to cover-plate surface)	High shear forces (F_x, F_y)	High axial forces (F_z)	High bending moments (M_x, M_y)	High torque moments (M_z)
	(az = 22 mm)	**±7**	±2	±1	±1
	(az = 0 mm)	**±5**	±1.5	±1	±1
	(az = –40 mm)	**±3**	±1	±1	±0.5
F_z [kN]		±2	**±20**	±2	±2
Mb $\overrightarrow{M_x, M_y}$ [N·m]		±20	±50	**±300**	±20
M_z [N·m]		±20	±50	±20	**±140**

Table 2: Permitted loads Type 9306A31

Measurement range Type 9306A

Different maximum values are permitted depending on the combination of forces F_x, F_y, F_z and reaction torques M_x, M_y, M_z:

$\overrightarrow{F_s} = F_x, F_y$ [kN]	Force application point (relating to cover-plate surface)	High shear forces (F_x, F_y)	High axial forces (F_z)	High bending moments (M_x, M_y)	High torque (M_z)
	(az = 45 mm)	**±20**	±14	±12	±3
	(az = 0 mm)	**±9**	±2.5	±1	±1.5
	(az = –40 mm)	**±4.5**	±1	±0.5	±1
F_z [kN]		±5	**±40**	±5	±5
Mb [N·m]		±50	±50	**±400**	±50
M_z [N·m]		±50	±100	±100	**±400**

Table 1: Permitted loads Type 9306A

Measurement range Type 9306A41

Different maximum values are permitted depending on the combination of forces F_x, F_y, F_z and reaction moments M_x, M_y, M_z:

$\overrightarrow{F_s} = F_x, F_y$ [kN] Select one of the proposals	Force application point (relating to cover-plate surface)	High shear forces (F_x, F_y)	High axial forces (F_z)	High bending moments (M_x, M_y)	High torque moments (M_z)
	(az = 31 mm)	**±15**	±3.5	±3.5	±3.5
	(az = 0 mm)	**±9**	±2.5	±2	±2
	(az = –40 mm)	**±6**	±1.5	±1.5	±1.5
F_z [kN]		±4	**±50**	±4	±4
Mb $\overrightarrow{M_x, M_y}$ [N·m]		±35	±100	**±500**	±100
M_z [N·m]		±35	±100	±100	**±300**

Table 3: Permitted loads Type 9306A41

Mounting

Please refer to the manual for mounting instructions (Doc. No. 002-873).

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Dimensions of 6-Axis Force/Torque Sensor Type 9306A

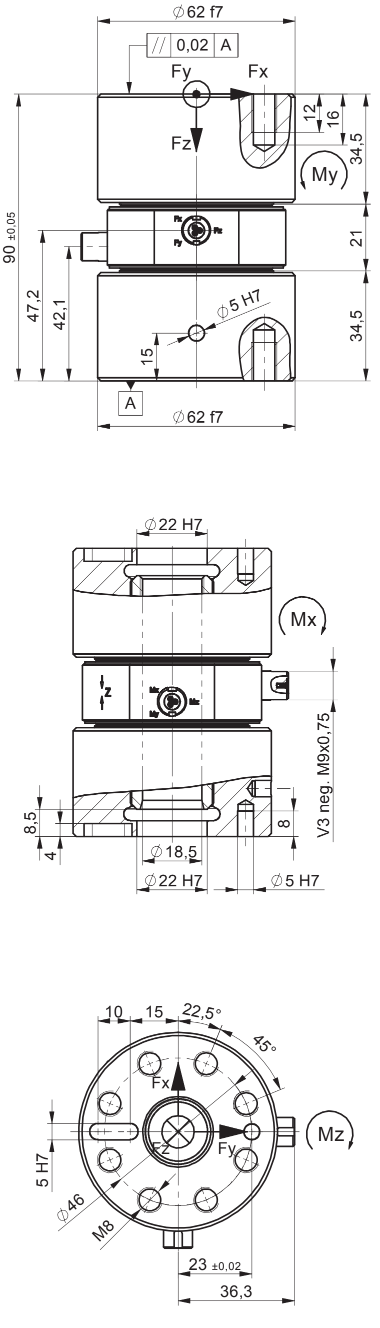

Fig. 1: Dimensions of the 6-Axis Force/Torque Sensor Type 9306A

Dimensions of 6-Axis Force/Torque Sensor Type 9306A31

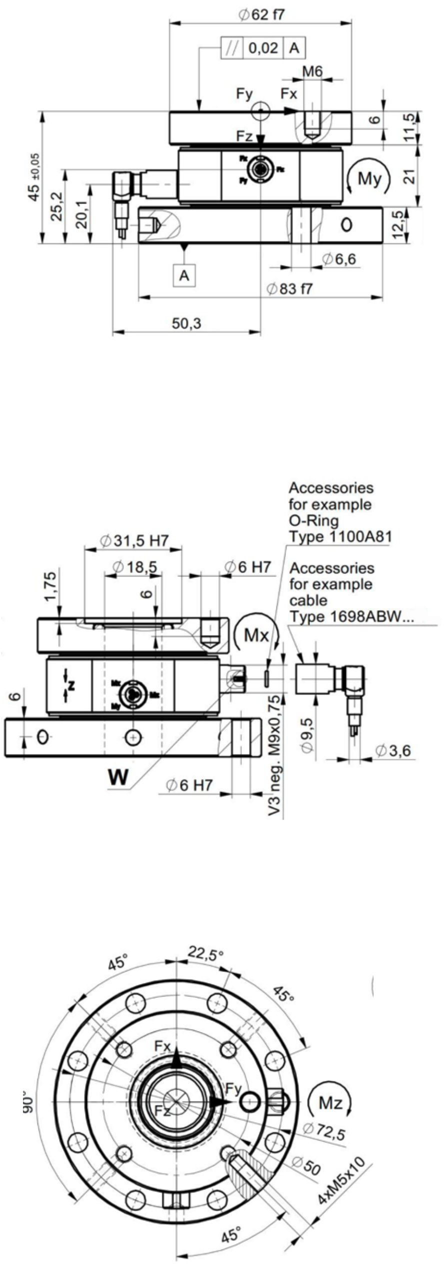

Fig. 2: Dimensions of the 6-Axis Force/Torque Sensor Type 9306A31

Dimensions of 6-Axis Force/Torque Sensor Type 9306A41

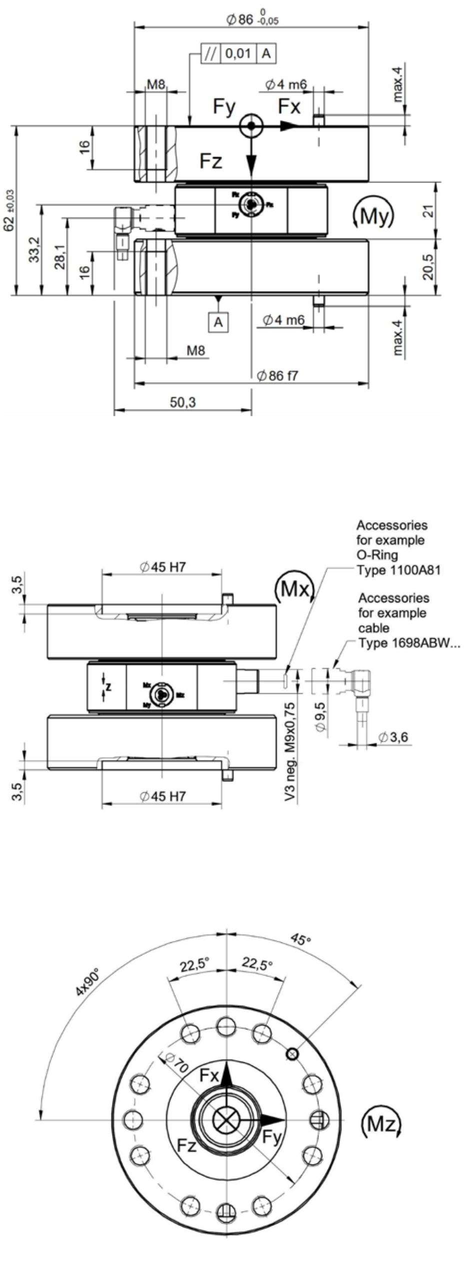

Fig. 3: Dimensions of the 6-Axis Force/Torque Sensor Type 9306A41

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Force application

If possible, the resulting force vector should pass through the center of the sensor. Eccentric force application creates a moment loading on the sensor. This is only permitted up to the specified values. The maximum force and torque ranges must be reduced correspondingly.
In particular the bending moments M_x, M_y must be observed.
The resulting bending moments are calculated as follows:

$$M_x = F_y * (a_zM_x - (-a_z)) + Fz * a_y$$
$$M_y = -F_x * (a_zM_y - (-a_z)) - Fz * a_x$$

Any force-free torques must also be considered.

Application

Type 9306A multi-axis force/torque sensor is built-in with the top side flushmounted in the wind tunnel. The high stiffness and resolution allow measurement of small and high dynamic effects such as vortex formation.

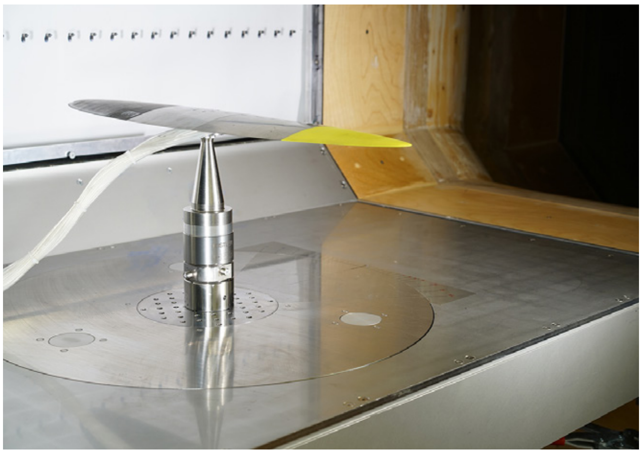

Fig. 4: Type 9306A in the ZHAW wind tunnel (before installation)

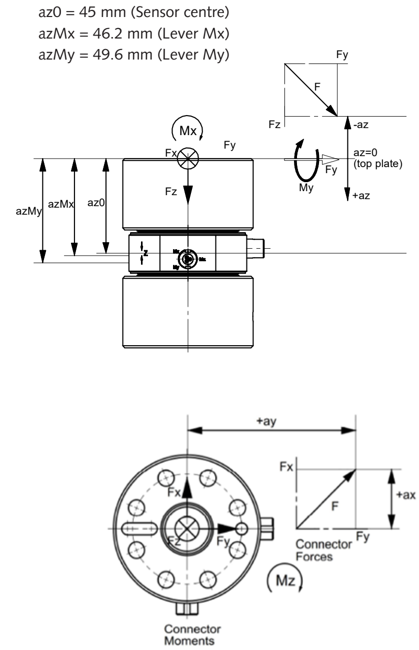

Fig. 5: Description of Type 9306A lever arms

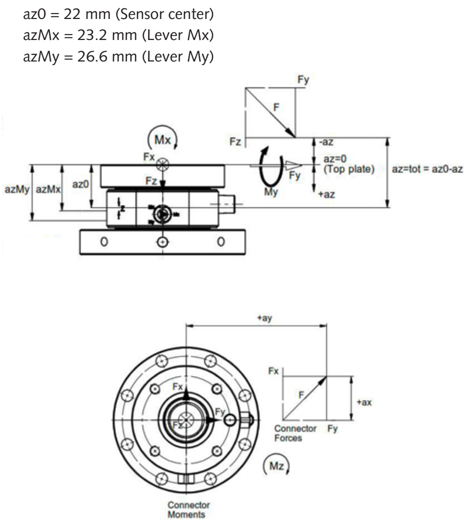

Fig. 6: Description of Type 9306A31 lever arms

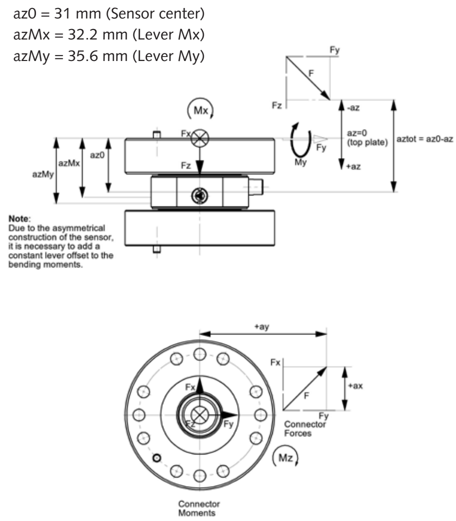

Abb. 7: Description of Type 9306A41 lever arms

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Measuring chain with 6-Axis Force/Torque Sensor

Output Signal	Cable	Cable Properties	Length [m] min	Length [m] max	Temp. Range	IEC/EN 60529 (Plug screwed*)	Connector Sensor	Connector Amplifier	IEC/EN 60529 (Plug screwed)	Industrial Amplifier 5030A	5039A	5073A...	5074A...	5877B...	Laboratory Amplifier 5015A...	5018A...	5080A...	5165A...	5167A...	DAQ KiDAQ	SumBox 5417
									Channels	1	1	1-4	1-4	1	1	1	1-8	1,4	4,8	4, ... ,52	12->8
									IEC/EN 60529	IP65	IP65	IP60	IP67	IP53	IP20	IP40	IP40	IP20	IP20	IP20	IP65
separate 3	1698AA...	PFA synthetic braiding	0.2	20	-40...120°C	IP65	V3 pos.	3x BNC pos.	IP40	-	(✓)	✓	-	(✓)	(✓)	(✓)	✓	✓	✓	✓	-
separate 3	1698AH...	PFA synthetic braiding	0.5	20	-40...120°C	IP65	V3 pos.	3x SMC neg.	IP40	-	-	-	-	-	-	-	-	-	-	-	-
separate 3	1698AE...	PFA synthetic braiding	0.2	20	-40...120°C	IP65	V3 pos.	3x KIAG 10-32 pos.	IP65	(✓)	-	-	✓	-	-	-	-	-	-	-	-
separate 3	1698AN...	TPC black Ø3.6mm	0.1	20	-40...120°C	IP67	V3 pos. 90°	3x KIAG 10-32 pos.	IP65	(✓)	-	-	✓	-	-	-	-	-	-	-	-
separate 3	1698AK...	TPC black Ø3.6mm	0.5	20	-40...120°C	IP67	V3 pos. 90°	Fischer 9-pole pos.	IP65	-	-	-	-	-	-	-	✓	-	✓	-	✓
separate 3	1698AF...	TPC black Ø3.6mm	0.5	20	-40...120°C	IP68	V3 pos.	3x Mini Coax neg.	IP40	-	-	-	-	-	-	-	-	-	-	-	-
separate 3	1698AL...	TPC black Ø3.6mm	0.5	20	-40...120°C	IP68	V3 pos.	3x KIAG 10-32 pos.	IP65	(✓)	-	-	✓	-	-	-	-	-	-	-	-
separate 3	1698AM...	PFA, steel braiding	0.3	10	-40...120°C	IP68	V3 pos.	3x KIAG 10-32 pos.	IP65	(✓)	-	-	✓	-	-	-	-	-	-	-	-
separate 3	1698AB...	TPC black Ø3.6mm	0.5	20	-40...120°C	IP68	V3 pos.	Fischer 9-pole pos.	IP65	-	-	-	-	-	-	-	✓	-	✓	-	✓
separate 3	1698AI...	PFA, steel braiding Ø7.5mm	0.3	10	-40...120°C	IP68	V3 pos.	Fischer 9-pole pos.	IP65	-	-	-	-	-	-	-	✓	-	✓	-	✓
separate 6	1698ABW...	TPC, Ø3.6mm, Y-Cable	0.5	20	-40...120°C	IP67	2x V3 pos. 90°	Fischer 9-pole pos.	IP65	-	-	-	-	-	-	-	✓	-	✓	-	
separate 6	1698ABB...	TPC, Ø3.6mm, Y-Cable	0.5	20	-40...120°C	IP68	2x V3 pos.	Fischer 9-pole pos.	IP65	-	-	-	-	-	-	-	✓	-	✓	-	

*no welding possible

(✓) more than one Amp needed

Note: The information provided corresponds to the current state of knowledge. Information subject to change without notice.

Fig. 8: Measuring chain 9306A with cable and charge amplifier

Signal processing

6 charge amplifier channels are needed for the complete measuring system. They convert the measurement signal into electrical voltage. The measured value is exactly proportional to the applied force or torque.

Type 5167A80... and Type 5080A... multichannel charge amplifiers were built specifically for multi-component force sensors.

Type 5080A... is ideal for measuring very small forces and is characterized by its extremely low noise level.

Type 5167A80... offers voltage output as well as digital data (Ethernet interface).

Fig. 7: Multichannel charge amplifier Type 5167A80... and Type 5080A...

Included accessories

- Centering ring D 22 (2 x)
- Cylindrical pin D5 x 12 (2 x)

Optional accessories

Optional accessories	Type
▪ Connecting cable 3-core	1698A...
▪ Connecting Y-cable 2x 3-core	1698ABB...
	1698ABW...

Ordering code

Ordering code	Type
▪ 6-Axis Force/Torque Sensor D 62x90 mm, ±5kN / ±200 N·m	9306A
▪ 6-Axis Force/Torque Sensor D 83x45 mm, ±1kN / ±100 N·m	9306A31
▪ 6-Axis Force/Torque Sensor D 86x45 mm, ±5kN / ±150 N·m	9306A41

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