

# RoaDyn<sup>®</sup> S: Multi-Component Wheel Force Transducers

## For Durability and Vehicle Dynamics Measurements



### RoaDyn S625 sp CFRP: Light 6-Component Wheel Force Transducer (WFT) for Cars



Technical Data		Type 9266A...
Measuring range $F_x$	kN	-20 ... 20
$F_y$	kN	-15 ... 15
$F_z$	kN	-20 ... 20
$M_x$	kN·m	-4 ... 4
$M_y$	kN·m	-4 ... 4
$M_z$	kN·m	-4 ... 4
Rim sizes	Inch	14 ... 18
Data sheet	No.	9266A_000-495

**Description** For research into vehicle dynamics, tire testing and capturing road load data for virtual and experimental simulation with cars. With inboard or outboard near field telemetry transmission. Available in two versions: CFRP for rim sizes of 14 ... 18" or aluminum for rim sizes of 12 ... 19".

### RoaDyn S630 sp CFRP: Light 6-Component Wheel Force Transducer (WFT) for Large Cars and Light SUVs



Technical Data		Type 9279A...
Measuring range $F_x$	kN	-30 ... 30
$F_y$	kN	-18 ... 18
$F_z$	kN	-30 ... 30
$M_x$	kN·m	-5 ... 5
$M_y$	kN·m	-5 ... 5
$M_z$	kN·m	-5 ... 5
Rim sizes	Inch	17 ... 22
Data sheet	No.	9279A_000-692

**Description** For research into vehicle dynamics, tire testing and capturing road load data for virtual and experimental simulation with large cars and light SUVs. With inboard or outboard near field telemetry transmission.

### RoaDyn S635 sp Aluminum: 6-Component Wheel Force Transducer (WFT) for Large Cars and Light SUVs



Technical Data		Type 9267A...
Measuring range $F_x$	kN	-35 ... 35
$F_y$	kN	-20 ... 20
$F_z$	kN	-35 ... 35
$M_x$	kN·m	-5 ... 5
$M_y$	kN·m	-5 ... 5
$M_z$	kN·m	-5 ... 5
Rim sizes	Inch	15 ... 22
Data sheet	No.	9267A_000-559

**Description** For research into vehicle dynamics, tire testing and capturing road load data for virtual and experimental simulation with large cars and light SUVs. With inboard or outboard near field telemetry transmission.

### RoaDyn S650 sp: 6-Component Wheel Force Transducer (WFT) for SUVs and Light Trucks



Technical Data		Type 9268A...
Measuring range $F_x$	kN	-50 ... 50
$F_y$	kN	-30 ... 30
$F_z$	kN	-50 ... 50
$M_x$	kN·m	-6 ... 6
$M_y$	kN·m	-6 ... 6
$M_z$	kN·m	-6 ... 6
Rim sizes	Inch	15 ... 22
Data sheet	No.	9268A_000-497

**Description** For research into vehicle dynamics, tire testing and capturing road load data for virtual and experimental simulation with SUVs and light trucks. With inboard or outboard near field telemetry transmission. Available as single wheel, twin wheel and super single wheel.

# RoaDyn® S: Multi-Component Wheel Force Transducers

## For Durability and Vehicle Dynamics Measurements



### RoaDyn S660 sp: 6-Component Wheel Force Transducer (WFT) for SUVs, NASCAR and Light Trucks



Technical Data		Type 9248A...
Measuring range $F_x$	kN	-60 ... 60
$F_y$	kN	-36 ... 36
$F_z$	kN	-60 ... 60
$M_x$	kN·m	-7,5 ... 7,5
$M_y$	kN·m	-8,5 ... 8,5
$M_z$	kN·m	-7,5 ... 7,5
Rim sizes	Inch	15 ... 22
Data sheet	No.	9248A1_000-970

**Description** For research into vehicle dynamics, tire testing and capturing road load data for virtual and experimental simulation with SUVs, NASCAR and light trucks. With inboard or outboard near field telemetry transmission. Available as single wheel, twin wheel and super single wheel.

### RoaDyn S6ST sp: 6-Component Wheel Force Transducer (WFT) for Light Commercial Vehicles



Technical Data		Type 9282A...
Measuring range $F_x$	kN	-80 ... 80
$F_y$	kN	-50 ... 50
$F_z$	kN	-80 ... 80
$M_x$	kN·m	-15 ... 15
$M_y$	kN·m	-25 ... 25
$M_z$	kN·m	-15 ... 15
Rim sizes	Inch	16 ... 24
Data sheet	No.	9282A_000-696

**Description** For research into vehicle dynamics, tire testing and capturing road load data for virtual and experimental simulation with light commercial vehicles. With inboard or outboard near field telemetry transmission. Available as single wheel, twin wheel and super single wheel.

### RoaDyn S6MT sp: 6-Component Wheel Force Transducer (WFT) for Medium Size Commercial Vehicles



Technical Data		Type 9270A...
Measuring range $F_x$	kN	-120 ... 120
$F_y$	kN	-70 ... 70
$F_z$	kN	-120 ... 120
$M_x$	kN·m	-18 ... 18
$M_y$	kN·m	-30 ... 30
$M_z$	kN·m	-18 ... 18
Rim sizes	Inch	17,5 ... 24
Data sheet	No.	9270A_000-858

**Description** For research into vehicle dynamics, tire testing and capturing road load data for virtual and experimental simulation with medium size commercial vehicles. With inboard or outboard near field telemetry transmission. Available as single wheel, twin wheel and super single wheel.

### RoaDyn S6HT sp: 6-Component Wheel Force Transducer (WFT) for Heavy and Special Commercial Vehicles



Technical Data		Type 9262A...
Measuring range $F_x$	kN	-220 ... 220
$F_y$	kN	-100 ... 100
$F_z$	kN	-220 ... 220
$M_x$	kN·m	-40 ... 40
$M_y$	kN·m	-60 ... 60
$M_z$	kN·m	-40 ... 40
Rim sizes	Inch	≥19,5
Data sheet	No.	9262A_000-862

**Description** For research into vehicle dynamics, tire testing and capturing road load data for virtual and experimental simulation with heavy agricultural and off-highway vehicles. With inboard or outboard near field telemetry transmission. Available as single wheel, twin wheel and super single wheel.

# RoaDyn<sup>®</sup> S625 System 2000

Type 9266A...

## Wheel Force Sensor for Passenger Cars

Wheel force sensor for measuring three forces and moments on a rotating wheel; a major constituent in modern vehicle development.

- Very light yet rigid sensor/measuring wheel
- Precise signal acquisition with individually calibrated strain gage load cells
- Sensor identification and digitization in wheel electronics
- Digital data transfer with in-board or out-board transmission
- Tested fatigue strength, e.g. to SAE J378
- For 12" or 13" rims in aluminium, from 14 ... 18" rims in composite CFR/aluminium

### Description

The wheel force sensor is mounted on a vehicle as a complete wheel and measures multiaxial loads imposed on the vehicle by the pavement. It enables precise measurement of forces and moments, each of which are represented as three vectors in an orthogonal reference system. During measurement the measuring wheel replaces the standard wheel. It therefore has to meet the latter's strength requirements and must not affect the kinematics or the handling. In particular, a sensor must be sufficiently adaptable to cater for a particular range of wheel sizes and hub connection geometries. The geometry and if necessary the heat dissipation of the brake components must be taken into account.

The wheel force sensor with carbon fiber reinforced composite rim comes much closer to the standard weight than competing concepts made of aluminium or steel. The rim design for 14 ... 18" wheel diameters combines an aluminium rim ring with a matched wheel disk manufactured from carbon fiber reinforced plastic (CFR). The positive and frictional nature of the connection makes it very strong. The "inside part" makes the connection with the hub and also consists of CFR. Four load cells connect the rim and this part. The assembly is adapted to suit the different hub geometries with an adapter package and wheel offset adapter.

The measuring wheels for 12" and 13" rims represent a special version. These wheels are also equipped with four load cells, but all of the adapter parts are made of aluminium and due to the limited amount of room around the hub are only offered with an out-board transmission.



The RoaDyn S6xy family of measuring wheels use normalized individual 9190A load cells, which are individually calibrated after manufacture. Serial number, calibration data and zero of the individual forces are stored on an ID chip. The three measured signals are compensated for temperature. In addition the interchangeable load cells can be used for all sensors of the RoaDyn S6xy family.

When the electronics are switched on, sensor components identify themselves and allow systematic computation based on the available individual values.

The high measuring accuracy of the precision load cells is retained during transmission. This is because digitization takes place on the measuring wheel to prevent transmission interference (for example from brake heat, movement, vibration, etc) having any effect. The measurement of individual values with separate load cells also leads to an improvement in the interchannel crosstalk. And the fact that the original load cell signals are known allows rapid error diagnostics. Individual load cells can be replaced without impairing the overall quality of the sensor.

The integration of cutting edge digital transmission and data processing techniques leads to reliable provision of measurement data free from interference and to user friendly system operation. In addition to the wheel load data, further sensors can be connected to the wheel transmission unit. Provision has been made for the option of storing signals from (for example, steering angle or camber angle) sensors in the vicinity

of the wheel that have been amplified and converted with the wheel data. The measured signals are filtered and digitized in the Type 5241A... wheel electronics unit. A pulse code module (PCM) modulates a serial stream of data transmitted at 2Mbps. Transmission into the interior of the automobile is standard, as this offers major advantages for tests carried out on public roads or off-road.

The wireless data transmission unit consists of a Type 5242A4 rotor rotating with the wheel and a Type 5240A... stator for mounting on the spring/shock absorber system of the automobile. For exact positioning and alignment of the stator a Type Z39911 alignment gage is included. Kistler offers alternative the Type 5248A0 external transmission unit if this data transfer configuration is required. The transmission units are described in detail on separate data sheets 5240A\_000-561 and 5248A\_000-562.

From the raw data in the rotating wheel coordinate system, the Type 9891A... on-board electronics system performs real-time computation of the required data in a coordinate system fixed relative to the wheel. The System 2000 on-board electronics are described on data sheet 9891A\_000-563.

**Application**

To obtain measurement data from particular vehicles they are generally mounted with four or with two RoaDyn S625 measuring wheels. For corresponding measurements for component or tire development only one measuring wheel is used.

The ongoing process of measurement and data acquisition allows continuous improvement and development of active chassis and powertrain systems (such as ABS, ESP, etc) for controlling vehicle dynamics. The acquired measurement data can be used to supplement fatigue calculations and numerical simulations. The measuring wheels yield precise raw data and measurements for developing computer models of entire automobiles or components of specific models. Load assumptions underlying automobile design can be verified when a prototype is available and design errors uncovered promptly. As a supplementary service Kistler provides adapters for optical sensors from various suppliers for measuring kinematic variables such as camber angle, slip angle, side slip angle, speed and acceleration. The particular adapters for mounting the different sensors are available from Kistler.



Fig. 1: Passenger car with RoaDyn® S625 System 2000

The measuring wheel system described above can also be used on a vehicle test stand. Its daily exclusive use on a test stand requires, among other things, special technical characteristics, which have led to the development of a special system Type 9266A2 in aluminium. Further information is contained in the data sheet 9266A\_000-580.



Fig. 2: Race car with RoaDyn® S625 System 2000

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**Technical Data**

Measuring range (with 4 load cells)	$F_x$	kN	$\pm 20$
	$F_y$	kN	$\pm 15$
	$F_z$	kN	$\pm 20$
	$M_x$	kN·m	$\pm 4$
	$M_y$	kN·m	$\pm 4$
	$M_z$	kN·m	$\pm 4$
Rotation angle accuracy		°	$\approx 0,1$
Max. weight* of measuring wheel	m	kg	$\approx 10$

**Maximum Loads**

Fatigue strength (SAE J328)	kN	2,6
Degree of Protection		IP64
Operating temperature range		
Aluminium components	°C	<120
CFR components	°C	<110

Maximum speed ( $\approx 280$ km/h)		$\text{min}^{-1}$	2 300
Max. shock acceleration	x	g	$\leq 40$
	y	g	$\leq 20$
	z	g	$\leq 40$

**Accuracy**

Crosstalk	$F_y \rightarrow F_x, F_z$	%	$\leq 1$
	$F_x \leftrightarrow F_z$	%	$\leq 1$
	$F_x, F_z \rightarrow F_y$	%	$\leq 2$
Linearity		% FSO	$\leq 0,5$
Hysteresis		% FSO	$\leq 0,5$

\*including 14" rim, hub adapter and stator, but excluding tire

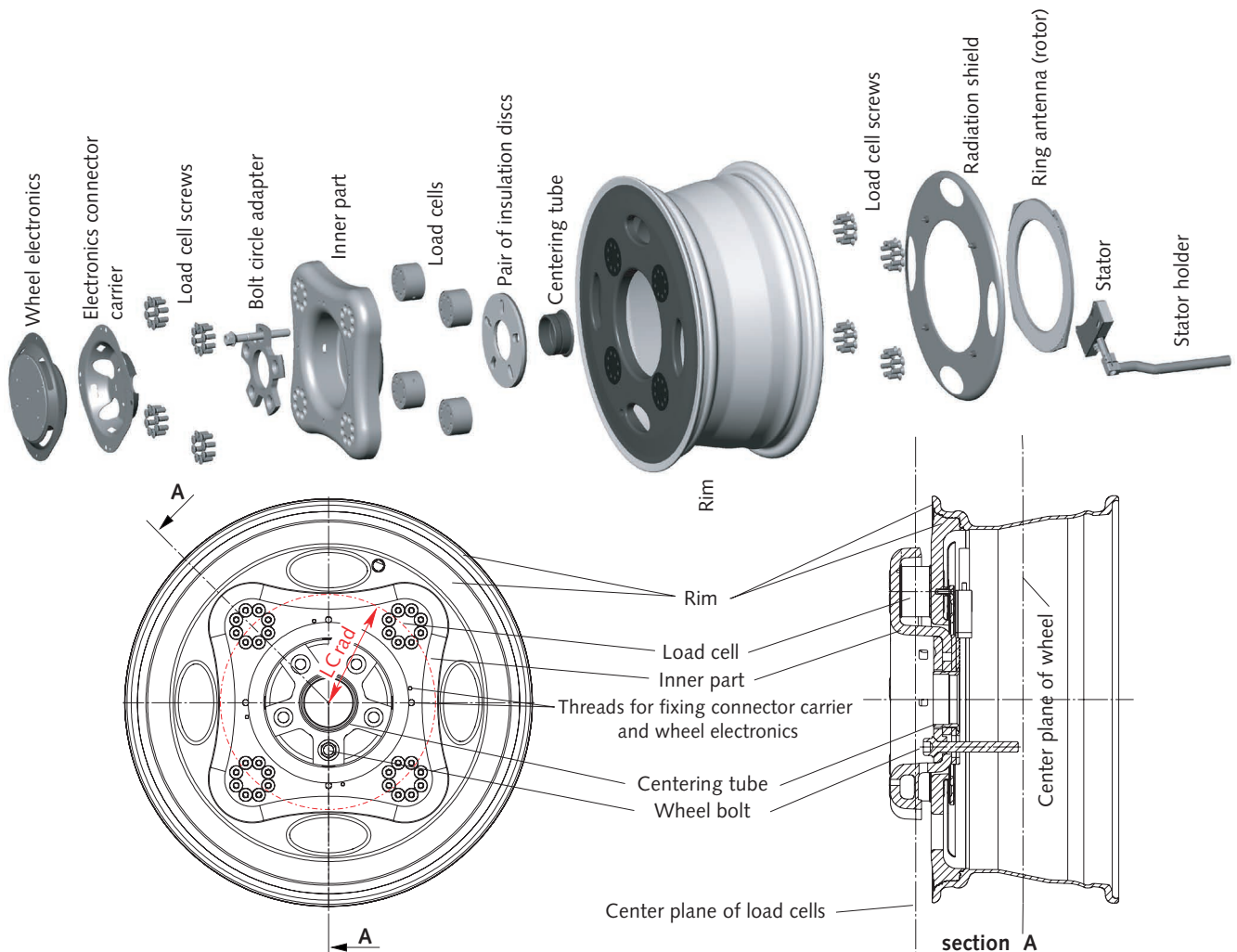


Fig. 3: Exploded view showing arrangement of components of RoaDyn® S625 with in-board transmission unit

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**Configuration of RoaDyn® S625 System 2000**

<p><b>Sensor</b></p> <p>Type 9266A1</p> 	<p><b>In-Board Transmission Unit consisting of Rotor, Stator and Cable for Connection to System 2000 On-Board Electronics</b></p> <p>Type 5242A..., 5240A..., Z30430Ax</p> 	<p><b>System 2000 On-Board Electronics</b></p> <p>Type 9891A...</p> 	<p><b>Remote Control Unit for System 2000 On-Board Electronics</b></p> <p>Type 5685A2</p> 
<p><b>Sensor</b></p> <p>Type 9266A1</p> 	<p><b>Out-Board Transmission Unit for System 2000 with Connecting Cable</b></p> <p>Type 5248A..., Z30430Ax</p> 	<p><b>System 2000 On-Board Electronics</b></p> <p>Type 9891A...</p> 	<p><b>Remote Control Unit for System 2000 On-Board Electronics</b></p> <p>Type 5685A2</p> 

### Accessories Included

- Stator mounting gage

### Type/Art. No.

Z39911

### Ordering Key

Type 9266A

### Optional Accessories

- Load cell bolts, titanium, 16 pcs. per cell Type/Art. No. Z30074
- Stator mounting gage, 1 pc. per measuring system Z39907
- Carrying case for on-board electronics system, 1 pc. per measuring system V712.0001
- Carrying case for accessories, 1 pc. per measuring system V712.0002
- Carrying case for 1 measuring wheel with tire, 1 pc. per measuring wheel V712.0004
- Precision spirit level, 1 pc. per measuring system Z30208
- Load cell tester, 1 pc. per measuring system 5984A
- Tire mounting aid, 1 pc. per measuring system Z30210
- Universal adapter for balancing machine 1 pc. per measuring system V035.0000
- Wrench for centering sleeve Type Z39901, 1 pc. per measuring system Z30205
- Protective board, 1 pc. per measuring system Z39909
- Strain gage bridge amplifier (SGAM) 2237A1
- Thermocouple amplifier (TCAM) 2237A2

RoaDyn S625 CFR Wheel force sensor for passenger cars	<b>1</b>
RoaDyn S625 aluminium Wheel force sensor for passenger cars for 12" and 13" rim size	<b>3</b>



Fig. 4: RoaDyn® S625 made of aluminium with out-board transmission for small rims

9266A\_000-495e-10.09

# RoaDyn® S630 sp System 2000

Type 9279A1

## Wheel Force Transducer (WFT) for Passenger Cars

Wheel force transducer for measuring three forces and three moments on a rotating wheel to determine road load data for passenger cars.

- Very light yet rigid design
- Customized adapters, weight and strength optimized
- Modular design based on five individual 3-component strain gage load cells
- Outstanding signal quality due to digitization on the wheel
- In-board and out-board telemetry
- High-precision measurement ensured by calibration of individual load cells and overall system
- Certified calibration procedure
- Excellent temperature stability
- Tested fatigue strength, e.g. to SAE J 328
- For 17 ... 22 inch rims

### Description

RoaDyn S630 is a modular wheel force measuring system consisting of five 3-component strain gage load cells, carbon fiber reinforced polymer (CFRP) inner and outer part, wheel electronics, telemetry and on-board electronics. During measurement RoaDyn S630 replaces a standard wheel and measures the forces and moments applied through the tire contact patch in the three directions of the wheel coordinate system. The signals are converted into digital form in the wheel electronics. They are then transmitted by means of in-board or out-board near-field telemetry from the rotating wheel to a fixed stator and then via cable to the on-board electronics. In the latter the three forces and three moments relative to the car coordinate system are calculated online from the raw signals and output via analog and digital interfaces.

One important constraint on the use of wheel force transducers is the need to ensure they change the characteristics of the car and components to be tested as little as possible. For this reason the masses of the unsprung components and moment of inertia of the rotating system must correspond as closely to or differ as little as possible from those of the particular standard wheel. Kistler's consistent exploitation of lightweight materials (CFRP and Al) and computer-aided engineering (FEM) take account of this need without compromising durability.



Hence, for example, the inner part, which is bolted to the hub of the car, and the outer part, which provides the connection to the rim, are manufactured from a CFRP. The rims, whose weight has also been minimized, are generally manufactured from forged aluminum blanks, although depending on the application commercial aluminum rims can also be used. The outer part can be screwed to or laminated into the rim.

The individual strain gage load cells are interchangeable and can be used for all RoaDyn S6xy wheel force transducers for cars, SUVs and vans.

The RoaDyn S6xy family of wheel force transducers uses normalized separate Type 9190A load cells, which are individually calibrated after manufacture. Serial number, calibration data and zero of the individual forces are stored on an ID chip. The three measured signals are temperature-compensated. When the electronics are switched on, the components identify themselves and allow computation based specifically on the available individual values.



The high measuring accuracy of the precision load cells is retained during transmission, since digitization takes place on the wheel to eliminate transmission interference.

Measuring separate signals with individual load cells also cut crosstalk. Knowledge of the original load cell signals allows rapid troubleshooting. Individual cells can be replaced without impairing the overall quality of the wheel force transducer.

Not just the individual load cells, but the entire system consisting of cells, inner and outer part, rim and tire is calibrated. This improves accuracy by factoring in the effect of these components on the sensitivity of the system as a whole. Cutting-edge digital transmission and data processing techniques ensure user-friendly system operation and reliable provision of measurement data free from interference.

The measured signals are filtered and digitized in the Type 5241A... wheel electronics. Pulse code modulation (PCM) generates a serial 2 Mbit/s data stream. As it offers major advantages for tests on both public roads and off-road, in-board transmission is standard.

The telemetric transmission unit consists of a Type 5242A3286Q5 rotor rotating with the wheel, and a Type 5240A stator for mounting on the car's spring/shock absorber system. For exact positioning and alignment of the stator a Type Z39911 alignment gage is included. Kistler offers the Type 5248A0 out-board transmission unit as an alternative if this form of transmission is required. The transmission units are described in greater detail on data sheets 5240A\_000-561 and 5248A\_000-562.

The on-board electronics Type 9891A... perform real-time conversion of the raw data from the rotating wheel coordinate system into a coordinate system relative to the car. The System 2000 on-board electronics are described on data sheet 9891A\_000-563.

## Application

In many areas of vehicle development wheel force transducers are used to obtain information about the force relationships at the tire contact patch. For example, they help record load spectra used as input variable for simulating durability on road simulators.



Fig. 1: RoaDyn® S630 System 2000 on a Pkw

In multibody simulation as well, the forces and moments on the wheel are needed for both modeling and validation of the computed results. Car design loads adopted in the initial design phase can be verified when a prototype becomes available and design errors detected in good time.

Data recorded with wheel force transducers is indispensable in determining characteristic parameters for tire models.

Optimal vehicle tuning is a compromise between agility and ride comfort. One aim of vehicle dynamics testing is objective measurement of the required kinematic characteristics. Important contributory parameters include the forces and moments on the wheel. Other key vehicle dynamics parameters include camber angle, slip angle, drift angle, speed and acceleration. As these measurands sometimes also have to be recorded on the wheel, adaptation of appropriate sensor systems to suit the wheel force transducer is possible.

**Technical Data**

Measuring range	$F_x$	kN	$\pm 30$
	$F_y$	kN	$\pm 18$
	$F_z$	kN	$\pm 30$
	$M_x$	kN-m	$\pm 5$
	$M_y$	kN-m	$\pm 5$
	$M_z$	kN-m	$\pm 5$
Rotary angle accuracy		°	$\approx 0,1$
Max. weight* wheel force transducer	m	kg	$\approx 13$

**Maximum Loads**

Durability (SAE J328)		kN-m	4
Degree of protection			IP64
Operating temperature range			
Al components		°C	<120
CFK components		°C	<110
Temperature at the hub		°C	<125
Maximum speed			
In-board transmission		min <sup>-1</sup>	2 300
Out-board transmission		min <sup>-1</sup>	4 000
Max. impact accelerations			
x		g	$\leq 40$
y		g	$\leq 20$
z		g	$\leq 40$

**Accuracy**

Crosstalk (without compensation)	$F_y \rightarrow F_x, F_z$	%	$\leq 1$
	$F_x \leftrightarrow F_z$	%	$\leq 1$
	$F_x, F_z \rightarrow F_y$	%	$\leq 2$
Linearity		%FSO	$\leq 0,5$
Hysteresis		%FSO	$\leq 0,5$

\* with "18" x 8,5 rim, inner and outer part, hub electronics, stator and cable, without tire

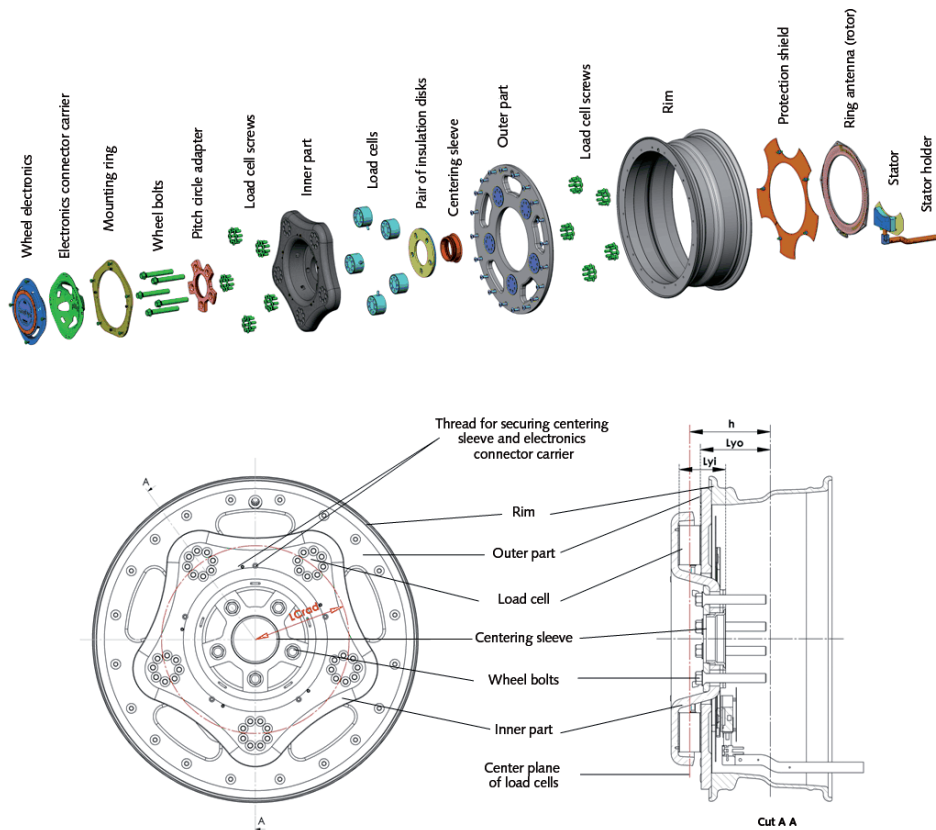


Fig. 2: Assembly/components of RoaDyn® S630 with in-board transmission

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**Configuration of RoaDyn® S630 System 2000**

<p><b>Sensor</b></p> <p>Type 9279A1</p> 	<p><b>In-board transmission unit consisting of rotor, stator and connection cable to on-board electronics System 2000</b></p> <p>Type 5242A..., 5240A..., Z30430A...</p> 	<p><b>On-board electronics System 2000</b></p> <p>Type 9891A...</p> 	<p><b>Remote control for on-board electronics System 2000</b></p> <p>Type 5685A...</p> 
<p><b>Sensor</b></p> <p>Type 9279A1</p> 	<p><b>Out-Board Transmission Unit for System 2000 with connection cable</b></p> <p>Type 5248A..., Z30430A...</p> 	<p><b>On-board electronics System 2000</b></p> <p>Type 9891A...</p> 	<p><b>Remote control for on-board electronics System 2000</b></p> <p>Type 5685A...</p> 

**Included Accessories**

- Adjustment gage for stator mounting

**Type/Art. No.**

Z39911

**Ordering Code**

- RoaDyn S630 sp System 2000  
wheel force transducer for passenger cars

**Type 9279A1**

**Optional Accessories**

- Load cell screws, titanium  
16 per load cell
- Adjustment gage for mounting stator  
1 per measuring system
- Case for on-board electronics,  
1 per measuring system
- Case for accessories,  
1 per measuring system
- Case for one wheel force transducer  
with tire
- Precision spirit level
- Spirit level, electronic with holder
- Load cell tester
- Tire mounting tool
- Universal adapter for balancing machine
- Key for centering sleeve, Type Z39901
- Timber facing,  
1 per wheel force transducer
- Strain gage bridge amplifier (SGAM)  
1 per wheel force transducer
- Thermocouple amplifier (TCAM)  
1 per wheel force transducer
- DSP firmware, Version 4.01
- 4-channel analog input card  
1 per measuring system
- CAN interface card for System 2000  
1 per measuring system
- RoaDyn System 2000 Ethernet interface,  
1 per measuring system
- Driver for Ethernet interfaces for  
DAQ software
- RoaDyn System 2000 UDP SCoUT,  
1 per measuring system
- RoaDyn System 2000 software for  
correcting angular error
- RoaDyn DAQ software

**Type/Art. No.**

Z30074

Z39911

V712.0005

V712.0002

V712.0004

Z30208

Z31840

5984A

Z30210

V035.0000

Z30205

Z39909

2237A1

2237A2

2889A4.01

5293A31

5621A4

5621A6Q1

2837A01

2885A4.01

2889A2

2837A10

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## RoaDyn<sup>®</sup> S635 System 2000

Type 9267A1

### Wheel Force Sensor for Heavy PassCars and High Performance Sports Cars

Wheel force sensor for measuring three forces and three moments on a rotating wheel; a major constituent in modern vehicle development.

- Modular sensor design with replaceable measuring cells and components
- CAD/FEM supported design: optimization of local stresses
- Low measuring wheel weight combined with high rigidity
- Precise signal measurement with individually calibrated strain gage load cells
- Automatic identification of components by ID chip
- Individual load cell calibration values taken into account
- Tested structural fatigue strength e.g. to SAEJ328

#### Description

The RoaDyn S635 measuring wheel has a modular, highly versatile design for mounting on different hubs and rim geometries. Five individual load cells are connected by adapter parts to a rim and to the vehicle hub. The requirements are met with regard to strength, mass and moment of inertia. The signals are amplified immediately in the load cells and fed via short cables to the wheel electronics Type 5241A... . Here they are filtered, digitized and coded. The data stream is transmitted via a rotor/stator pair Type 5242A5/5240A1,5... to the wheel inner side, transformed in the on-board electronic unit Type 9891A... and output to a data acquisition device.

With regard to production wheels, the measuring wheel should not exceed an excess weight of 10 %. Otherwise the vibration behavior of the wheel suspension and the inertial behavior of the wheel will change, and thus also the measuring results and vehicle handling characteristics.

Modern CAD and FEM techniques are used for design purposes. Vibration fatigue limit investigations on individual components and measuring wheels of various sizes make it possible to estimate the life of the measuring wheel structure.

Individual load cells Type 9190A are calibrated in the factory and produce temperature-compensated, amplified measuring signals in the three spatial directions. Identification data, calibration data and zero positions of the individual forces are saved allowing appropriate analysis in the vehicle coordinate system on the basis of individual calibrated values.



High measuring accuracy is retained during transmission, since digitization takes place on the wheel, thus eliminating transmission interference. Knowledge of the individual measured signals allows rapid diagnosis in the event of malfunctions. Individual cells can be exchanged without impairing the function of the wheel force sensor.

Additional signals on the rotating wheel, such as tire pressure, temperature, etc. can be directly connected to the wheel electronics and transmitted along with the wheel signals. Kistler offers optional amplifier module Type 2237A... for this purpose. Wheel electronics Type 5241A... is available in versions with 17 ... 24 channels. It can be used for all measuring wheel types S6xy, V6HT and V6MT. The unit is equipped with analog filters and digitizes all incoming measuring signals and modulates a data stream, which is fed from the rotating measuring wheel via the transmission unit to the on-board electronics.

For transmission to the on-board electronic unit Type 9891A..., preference is given to the inside of the wheel using rotor Type 5242A5 and stator Type 5240A1.5... . Out-board transmission unit Type 5248A0 is also offered as an alternative.

Note: see data sheets 5240A\_000-561, 5248A\_000-562 and 9891A\_000-563 for the transmission units and the on-board electronics.

## Technical Data

Measuring range <sup>1)</sup>	$F_x$	kN	-35 ... 35
	$F_y$	kN	-20 ... 20
	$F_z$	kN	-35 ... 35
	$M_x$	kN·m	-5 ... 5
	$M_y$	kN·m	-5 ... 5
	$M_z$	kN·m	-5 ... 5
Rotary angle accuracy		°	≈0,1
Max. weight measuring wheel <sup>2)</sup>	m	kg	≈16,5

## Maximum Loads

Permitted alternating stress (rotating bending fatigue test) Requirements according to SAE J328 are exceeded 500 000 LW 4,0 kN·m			
Degree of protection			IP64
Operating temperature range			
Al components		°C	<120
CFK components (Temperature warning)		°C	<110
Maximum speed (≈280 km/h)		min <sup>-1</sup>	2 300
Max. impact accelerations	x	g	40
	y	g	20
	z	g	40

## Accuracy

Crosstalk	$F_y \rightarrow F_x, F_z$	%	≤1
	$F_x \leftrightarrow F_z$	%	≤1
	$F_x, F_z \rightarrow F_y$	%	≤2
Linearity		% v.E.	≤0,5
Hysteresis		% v.E.	≤0,5

<sup>1)</sup> It is assumed that these extreme values do not occur simultaneously. The moments refer to the wheel center.

<sup>2)</sup> With 7x16" aluminum rim, rotor, wheel electronics, hub adapter, but without ET adapter, wheel bolts and tires.

- Details for the modal analysis should always refer to the measuring wheel with rim and tire system. The tires attenuate frequencies above 300 Hz. Parameters are available for several combinations, which can be viewed on request.
- Overloads: The design of the wheel force sensor allows overloads to occur without restricting measurability. We will be pleased to provide you with information in this regard. The tolerance to overloads depends very much on their multi-axle situation; it is not possible to give an accurate estimate within a general description because of the many combination possibilities. A separate indication of overloads for individual force directions is not appropriate, since no single axle load conditions occur at the wheel. If the wheel force sensor is overloaded, its remaining service life may be reduced, even if no immediate damage is visible or detectable.

## Application

- Measuring operating loads during typical vehicle driving maneuvers
- Input data for the design of new components
- Verification of design loads
- Measuring test stand control data for road simulators
- (Permanent) application as multi-axle force measuring unit in road simulators
- Development of active chassis control systems such as ABS, ESP, etc.
- Investigations of vehicle behavior in specific or critical driving situations
- Input data for fatigue calculations and numeric simulations
- Development of computer models (MKS, Adams)

Usually several measuring wheels (4 or 2 wheels) are used. Occasionally measurements with a single measuring wheel are also employed for component or tire development. The various test vehicles often require adaptation to new wheel/hub geometries. The modular design of the measuring wheels and proficient support by Kistler application centers has proved successful for this purpose.

At the same time as the measuring wheels, systems for wheel motion measurement or optical sensors (such as Corrsys sensors or sensors from other manufacturers for measuring tire and body slip angle, speed or accelerations) can also be used. Adaptations for applying individual sensors to the measuring wheels are available in the Kistler product range.

The measuring wheel system described above can also be used on a vehicle test stand. Its daily exclusive use on a test stand requires, among other things, certain special technical characteristics, which have led to the development of a special system Type 9267A2. Further information is contained in the data sheet 9267A\_000-581.

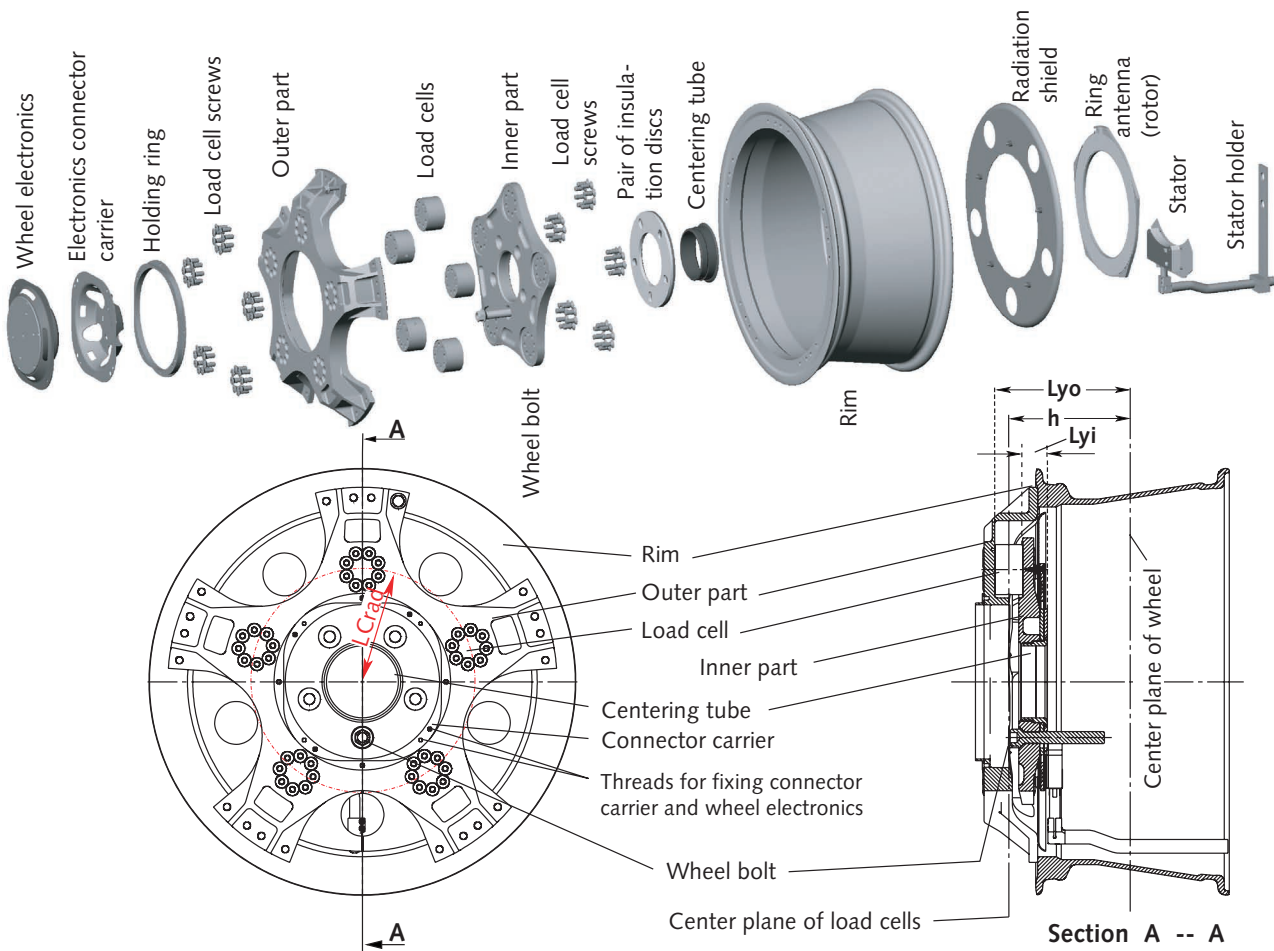


Fig. 1: RoaDyn® S635 structure/components with in-board transmission

S625

S635

S650

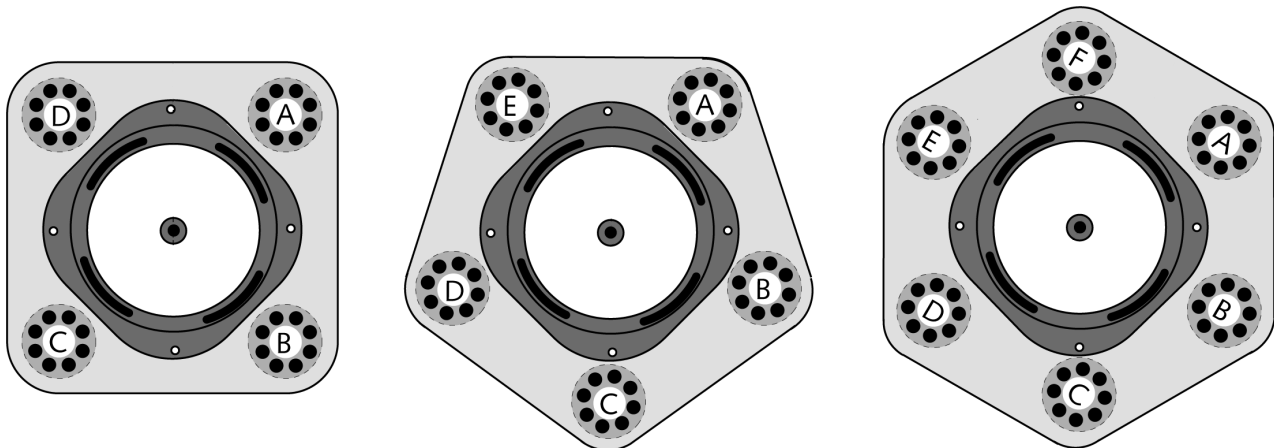





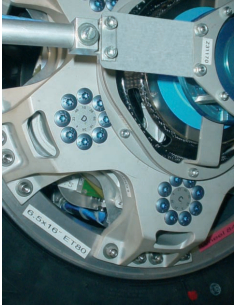




Fig. 2: Expandability of the RoaDyn® S measuring wheel system. The measuring wheel can be adapted for higher load limits or a test stand by expanding the wheel force system with exchangeable measuring cells and mechanical adaptations

9267A\_000-559e-10.09

9267A\_000-559e-10.09

**Configuration of the RoadDyn® S635 System 2000**

<p><b>Measuring Wheel with Wheel Force Sensor, Wheel Electronics, Outer Part, Rim and Tires</b></p> <p>Type 9267A1 with 9731A5, Z39913A..., 5241A...</p>			<p><b>In-Board Transmission Unit consisting of Rotor and Stator</b></p> <p>Type 5242A..., 5240A...</p>			<p><b>Extension Cable</b></p> <p>Type 30430Axx Connection between Stator and On-Board Electronics</p>			<p><b>On-Board Electronics</b></p> <p>Type 9891A...</p>			<p><b>Remote Control for On-Board Electronics with Connecting Cable</b></p> <p>Type 5685A2</p>	
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<p><b>Measuring Wheel with Wheel Force Sensor, Wheel Electronics, Outer Part, Rim and Tires</b></p> <p>Type 9267A1 with 5241A..., 5248A0, 9731A5, Z39913A...</p>			<p><b>Out-Board Transmission Unit</b></p> <p>Type 5248A0</p>			<p><b>Extension Cable</b></p> <p>Type 30430Axx Connection between Stator and On-Board Electronics</p>			<p><b>On-Board Electronics</b></p> <p>Type 9891A...</p>			<p><b>Remote Control for On-Board Electronics with Connecting Cable</b></p> <p>Type 5685A2</p>	
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**Mounting**

The sensor can be mounted with rims of most available sizes. For further information, please contact Kistler applications advisers.

**Adaptation to the Hub**

There is a wide variety of hub geometries on present-day vehicles. They are described among other characteristics by the following parameters:

- Number of stay bolts or tapped holes
- Dimensions of wheel bolts or stay bolts and nuts (thread diameter, pitch, length, thread length)
- Hole-circle diameter of the wheel bolt connections
- Dimensions of the axle centering as fitting dimension
- Wheel offset
- Brake contours
- Parts protruding from the hub

This makes it necessary to obtain precise details prior to adapter manufacture. For this purpose, a check list may be found in Kistler document 002-280 which, when filled out precisely, will considerably shorten the time spent on clearing up details.

**Mounting the Stator Type 5240A... with In-Board Transmission**

With in-board transmission, a suitable mounting device is mounted on the wheel carrier or suspension strut for the stator. The position of the stator and the location of the support is then established with a gauge.

With the stator installed, mounting a measuring wheel is comparable with that of a production wheel. The stator can also remain mounted on the vehicle if this is running on production wheels. When the measuring wheels are remounted, measurements can be made again immediately.

<b>Included Accessories</b>	<b>Type/Art. No.</b>
• Precision load cells (Strain gage basis), completely encapsulated, 1 set (5) per wheel	9190A46.5
• Internal part, 1 per wheel	9729A5
• Connector holder for wheel electronics, 1 per wheel	Z39904
• Radiation shield, 1 per wheel	Z39902
• Load cell screws for fastening, 1 set per wheel	Z30073

**Accessories (absolutely essential for completing a measuring wheel)**

• External part, 1 per measuring wheel	9731A5
• Rim, 1 off per measuring wheel	Z39913A...
• Ring antenna (rotor), 1 per measuring wheel	5242A5
• Wheel electronics, 1 per measuring wheel	5241A...
• Hub adapter package, containing heat absorbing washers, centering sleeve and wheel bolts – 1 per measuring wheel	9711A3 Z39900 Z39901
• Wheel offset adapter, 1 per wheel	9713A...
• Load cell screws, titanium, 16 per measuring cell	Z30074

**Optional Accessories**

<b>Optional Accessories</b>	<b>Type/Art. No.</b>
• Transport case for 1 measuring wheel with tires, 1 per measuring wheel	V712.0004
• Precision spirit level, 1 per measuring system	Z30208
• Adjuster gage for stator mounting, 1 per system	Z39911
• Load cell tester, 1 per measuring system	5984A
• Tire mounting device, 1 per measuring system	Z30210
• Universal adapter for balancing machine, 1 per measuring system	V035.0000
• Key for centering sleeve Type Z39901, 1 per measuring system	Z30205
• Strain gage bridge amplifier (SGAM)	2237A1
• Thermocouple amplifier (TCAM)	2237A2

**Ordering Code**

• RoaDyn S635 Wheel force sensor for heavy Pkw and high performance sports cars	<b>Type</b> <b>9267A1</b>
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9267A\_000-559e-10.09

## RoaDyn® S660 System 2000

Type 9248A1

### Wheel Force Transducer (WFT) for Heavy Pkw, SUV, Transporters and Light Trucks

Wheel force sensor for measuring three forces and three moments on a rotating wheel; a major constituent in modern vehicle development.

- Modular design with replaceable measuring cells and components
- CAD/FEM supported design: optimization of local stresses
- High strength/low measuring wheel weight in combination with high rigidity
- Excellent signal quality due to digitization already in the wheel electronics
- Automatic identification of components by ID chip
- Calibration of the individual load cells as well as of the WFT assembly
- Tested structural fatigue strength e.g. to SAEJ328



#### Description

The RoaDyn S660 measuring wheel has a modular, versatile design for mounting on hubs and rim geometries. Six 3-component strain gage load cells are connected by adapter parts to a rim and to the vehicle hub. The signals are amplified immediately in the load cells and fed via short cables to the wheel electronics. Here they are filtered, digitized and coded. The data stream is transmitted via a rotor/stator pair to the wheel inner side, transformed in the on-board electronic unit and output to a data acquisition device.

This measuring wheel is designed for exceptionally high forces and moments associated with heavy vehicles such as SUVs, off-road and light commercial vehicles. Because of often large wheel offsets, the load on the wheels is particularly high, specially with regard to moments. The anticipated stresses are determined using FEM methods, and the design optimized with regard to strength, safety and weight. Vibration fatigue limit investigations on individual components and measuring wheels of various sizes make it possible to estimate the life of the measuring wheel structure.

Additional signals on the rotating wheel, such as tire pressure, temperature, etc. can be directly connected to the wheel electronics and transmitted along with the wheel signals. Kistler offers optional amplifier modules for this purpose. The wheel electronics is available in versions with 20 ... 24 channels. It can be used for all measuring wheel types S6.

Note: see data sheets 5240A\_000-561, 5248A\_000-562 and 9891A\_000-563 for the transmission units and the on-board electronics.

## Technical Data

Measuring range <sup>1)</sup>	F <sub>x</sub>	kN	-60 ... 60
	F <sub>y</sub>	kN	-36 ... 36
	F <sub>z</sub>	kN	-60 ... 60
	M <sub>x</sub>	kN·m	-7,5 ... 7,5
	M <sub>y</sub>	kN·m	-8,5 ... 8,5
	M <sub>z</sub>	kN·m	-7,5 ... 7,5
Rotary angle accuracy		°	≈0,1
Weight measuring wheel <sup>2)</sup>	m	kg	≈18,3

## Maximum Loads

Degree of protection			IP64
Operating temperature range			
AI components		°C	<160
Maximum speed		mph	>180
Max. impact accelerations	x	g	50
	y	g	50
	z	g	50

## Accuracy

Crosstalk	F <sub>y</sub> → F <sub>x</sub> , F <sub>z</sub>	%	≤0,5
	F <sub>x</sub> ↔ F <sub>z</sub>	%	≤0,5
	F <sub>x</sub> , F <sub>z</sub> → F <sub>y</sub>	%	≤0,5
Linearity		% v.E.	≤0,5
Hysteresis		% v.E.	≤0,5

Permitted alternating stress (rotating bending fatigue test)

The requirements according to SAE J328 are exceeded.

500 000 LW 5,5 kN·m

<sup>1)</sup> It is assumed that these extreme values do not occur simultaneously. The moments refer to the wheel center.

<sup>2)</sup> With 6x16" aluminum rim, rotor, wheel electronics, hub adapter, but without ET adapter, wheel bolts and tires

<sup>3)</sup> wit crosstalk compensation

- Overloads: The design of the wheel force sensor allows overloads to occur without restricting measurability. We will be pleased to provide you with information in this regard. The tolerance to overloads depends very much on their multi-axle situation; it is not possible to give an accurate estimate within a general description because of the many combination possibilities. A separate indication of overloads for individual force directions is not appropriate, since no single axle load conditions occur at the wheel. If the wheel force sensor is overloaded, its remaining service life may be reduced, even if no immediate damage is visible or detectable.

## Application

- Measuring operating loads during typical vehicle driving maneuvers
- Input data for the design of new components
- Verification of design loads
- Measuring test stand control data for road simulators
- (Permanent) application as multi-axle force measuring unit in road simulators
- Development of active chassis control systems such as ABS, ESP, etc.
- Investigations of vehicle behavior in specific or critical driving situations
- Input data for fatigue calculations and numeric simulations
- Development of computer models (MKS, Adams)

Usually several measuring wheels (4 or 2 wheels) are used. Occasionally measurements with a single measuring wheel are also employed for component or tire development. The various test vehicles require adaptation to new wheel/hub geometries. The modular design of the measuring wheels and proficient support by Kistler application centers has proved successful for this purpose.

At the same time as the measuring wheels, systems for wheel motion measurement or optical sensors (such as from Corrsys-Datron for measuring tire and body slip angle, speed or accelerations) can also be used.

Adaptations for applying individual sensors to the measuring wheels are available in the Kistler product range.

The measuring wheel system described above can also be used on a vehicle test stand. Its daily exclusive use on a test stand requires, among other things, special technical characteristics, which have led to the development of a special system. Further information is contained in the data sheet 9248A2\_000-696.

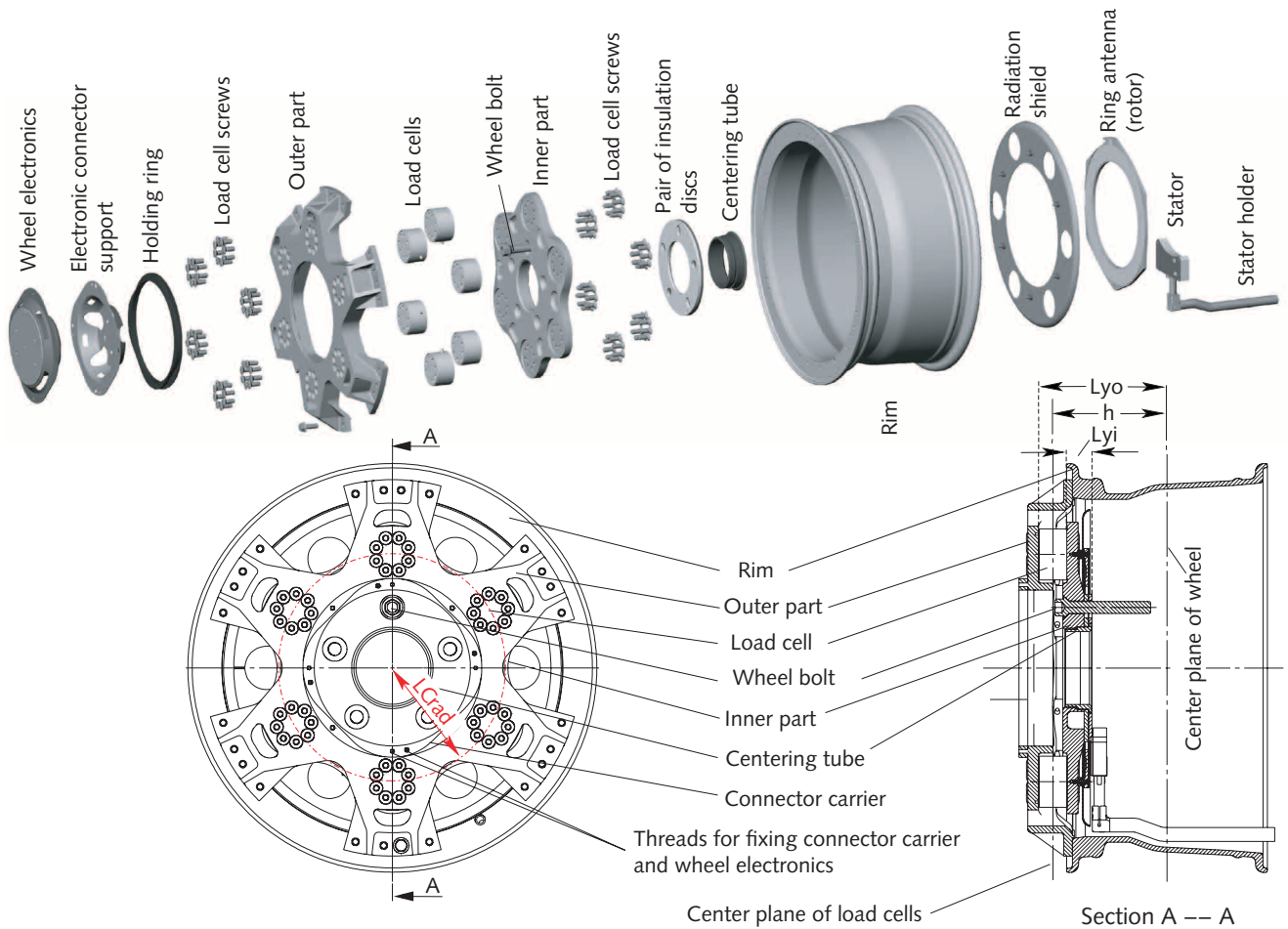
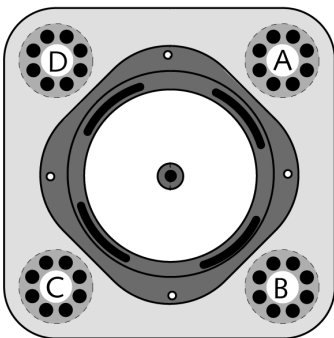
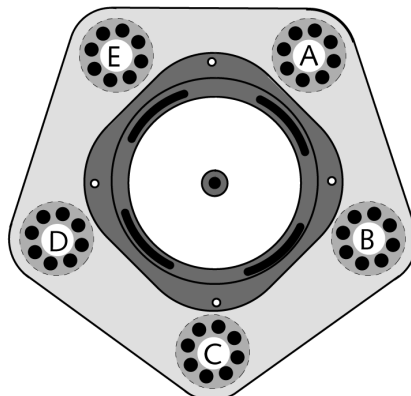


Fig. 1: RoaDyn® S650/S660 structure/components for standard applications with in-board transmission

S625



S635



S650/S660

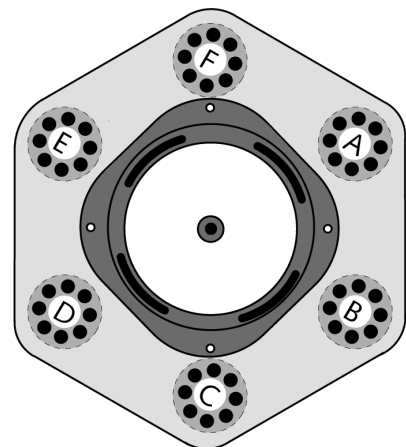












Fig. 2: Expandability of the RoaDyn® S wheel force transducer system. The wheel force transducer can be adapted for lower load ranges or a test rig by altering the number of load cells and the mechanical adaptations

9248A1\_000-970e-09.11

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**Configuration of the RoadDyn® S660 System 2000**

<p><b>Measuring Wheel with Wheel Force Sensor, Wheel Electronics, Outer Part, Rim and Tires</b></p> <p>Type 9248A1 with 9731A6, Z39913A..., 5241A...</p> 	<p><b>In-Board Transmission Unit consisting of Rotor and Stator</b></p> <p>Type 5242A..., 5240A...</p> 	<p><b>Extension Cable</b></p> <p>Type 30430Axx Connection between Stator and On-Board Electronics</p> 	<p><b>On-Board Electronics</b></p> <p>Type 9891A...</p> 	<p><b>Remote Control for On-Board Electronics with Connecting Cable</b></p> <p>Type 5685A2</p> 
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<p><b>Measuring Wheel with Wheel Force Sensor, Wheel Electronics, Outer Part, Rim and Tires</b></p> <p>Type 9248A1 with 5141A..., 5248A0, 9731A6, Z39913A...</p> 	<p><b>Out-Board Transmission Unit</b></p> <p>Type 5248A0</p> 	<p><b>Extension Cable</b></p> <p>Type 30430Axx Connection between Stator and On-Board Electronics</p> 	<p><b>On-Board Electronics</b></p> <p>Type 9891A...</p> 	<p><b>Remote Control for On-Board Electronics with Connecting Cable</b></p> <p>Type 5685A2</p> 
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**Mounting**

Kistler offers weight and strength optimized mechanical structural parts to adapt to the customer's vehicles.

**Mounting the Stator with In-Board Transmission**

With in-board transmission, a suitable mounting device is mounted on the wheel carrier or suspension strut for the stator. The position of the stator and the location of the support is then established with a gauge.

With the stator installed, mounting a measuring wheel is comparable with that of a production wheel. The stator can also remain mounted on the vehicle if this is running on production wheels. When the measuring wheels are remounted, measurements can be made again immediately.

With out-board transmission, a support arm must additionally be included in the vehicle setup, to which the cable to the on-board electronics is fixed.

**Optional Accessories**

- Transport case for 1 measuring wheel with tires, 1 per measuring wheel Type/Art. No. V712.0004
- Precision spirit level, 1 per measuring system Z30208
- Adjuster gage for stator mounting, 1 per system Z39911Q
- Load cell tester, 1 per measuring system 5984A
- Tire mounting tool, 1 per measuring system Z30210
- Key for centering sleeve Type Z39901, 1 per measuring system Z30205
- 3-channel strain gage bridge amplifier (SGAM) 2237A1
- 3-channel thermocouple amplifier (TCAM) 2237A2

**Included Accessories**

- |  |            |
|--|------------|
| • 3-component strain gage load cells, completely encapsulated, 6 per wheel                 | 9190A876   |
| • Internal part, 1 per wheel   | 9729A6     |
| • Connector holder for wheel electronics, 1 per wheel                                      | Z39904     |
| • On-board electronics   | 9891A...   |
| • External part, 1 per measuring wheel   | 9731A6...  |
| • Rim, 1 per measuring wheel   | Z39913A... |
| • Ring antenna (rotor), 1 per measuring wheel  | 5242A6     |
| • Wheel electronics, 1 per measuring wheel   | 5241A2...  |
| • Hub adapter package, containing heat absorbing washers, centering sleeve and wheel bolts | 9711A3     |
| • Wheel offset adapter, 1 per wheel  | 9713A...   |

**Ordering Code**

- RoaDyn® S660 System 2000 – wheel force transducer (WFT) for heavy Pkw, SUV, transporters and light trucks **Type 9248A1**

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