FAG

FAG VarioSense Bearings

Modular sensor bearings

SCHAEFFLER

Foreword

The machine and equipment building sector is characterised by the trend towards intelligent, networked machines. It is becoming increasingly important to gain information about the operating mode of machinery. Everywhere that machine components move, there is a need for data on measurement values such as velocities, speeds, forces or temperatures. The bearing position is often the ideal location for collecting these data. The high precision of rolling bearings and the accuracy of the adjacent construction facilitate high quality of measurement at this point.

Bearings with integrated speed, temperature or force sensor technology have existed for many years. In general, these are products that have been specially developed for a specific application. With the FAG VarioSense bearing, Schaeffler is now introducing a product series that, through the combination of standard rolling bearings and a modular sensor concept, facilitates a flexible, rapid and economical solution for a wide variety of applications.

In a first stage, deep groove ball bearings and the measurement values of speed, bearing temperature and radial displacement are being offered, where the measurement of displacement allows a conclusion to be drawn as to the load on the bearing. The customer can then, depending on his requirements, select a configuration that contains precisely the sensor functions required.

The modular concept of the sensor unit facilitates implementation in the future of further sensor functions, such as vibration measurement, or a variant with wireless signal transmission. Schaeffler is already working on the expansion of the FAG VarioSense bearing to include other bearing types and sizes as well as other sensor functions.

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FAG VarioSense bearings

Features

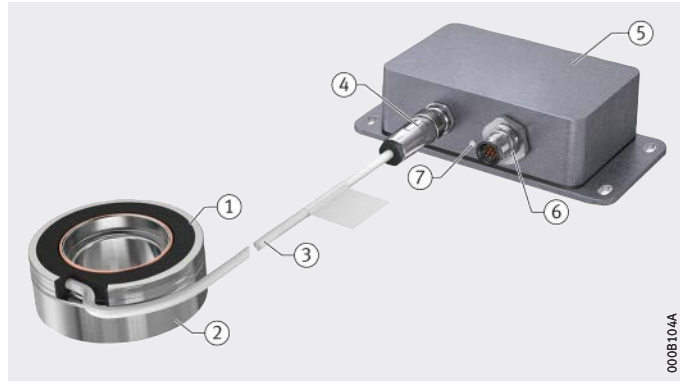
A fundamental feature of the FAG VarioSense bearing is its modular design, which allows a configuration of the sensors that is flexibly and ideally matched to the application. In order to further increase the possible applications, Schaeffler is working on the integration of further sensor functions and the expansion of the available bearing types and sizes.

The following sections describe the product portfolio available as standard. For requirements extending beyond these or where there is a need for customer-specific product configurations, please consult Schaeffler.

Design

The sensors for the recording of measurement values are integrated in a sensor unit fitted on the side of the bearing, *Figure 1*. This is connected via a cable by means of a detachable plug connection with an interface unit. This carries out conversion and preparation of the measurement signals resulting from the measurement of temperature, displacement and speed. The interface unit also has an LED for display of the operating mode and a flange plug for customer-side connection.

If a product configuration is selected that contains speed measurement as the only sensor function, the interface unit is not necessary.



① Sensor unit
② Rolling bearing
③ Cable
④ Detachable plug connection
⑤ Interface unit
⑥ Customer-side connection
⑦ LED for operating mode

Figure 1
Design

Sensor functions

The FAG VarioSense bearing can be equipped with sensors for speed, temperature and displacement. All the sensors are integrated in the sensor unit.

Speed measurement

The speed sensor records the signals from a magnetic scale that is connected to the inner ring of the bearing. As an output signal, the sensor delivers two phase-offset signals. With the aid of the signals, speeds of up to 15 000 min^{-1} as well as the direction of rotation can be determined.

Temperature measurement

The temperature sensor records the temperature in the vicinity of the bearing outer ring. The resolution is 0,5 K.

Displacement measurement

In the measurement of displacement, the radial displacement between the inner ring and outer ring is recorded.
From this, information can be derived about the load on the bearing and the adjacent construction.

The measurement of displacement is subject not only to the radial load but also to a series of other influences such as axial load, tilting and temperature. These influences must be taken into consideration in the interpretation of the measurement results.

In order to ensure correct interpretation of the displacement measurement in relation to the bearing load, we recommend comprehensive analysis of the application and advisory work by Schaeffler.

FAG VarioSense bearings

Product variants

The concept of the FAG VarioSense bearing allows the versatile combination of different sensors. Each combination of sensors is assigned a product configuration. The product configurations available as standard are shown below, see table.
Further combinations of the available sensor functions are available by agreement.

Product configurations

Product configuration	Sensor			Interface unit
	Speed	Temperature	Displacement	
001	●	–	–	Optional
002	●	●	–	●
003	●	●	●	●
004	–	–	●	●

● Component of product configuration

In addition to the combination of sensors, the selection of a FAG VarioSense bearing allows the variation of other product characteristics such as the sealing of the bearing or the internal clearance. A product variant is clearly described by means of the ordering designation, see page 13.

Interfaces

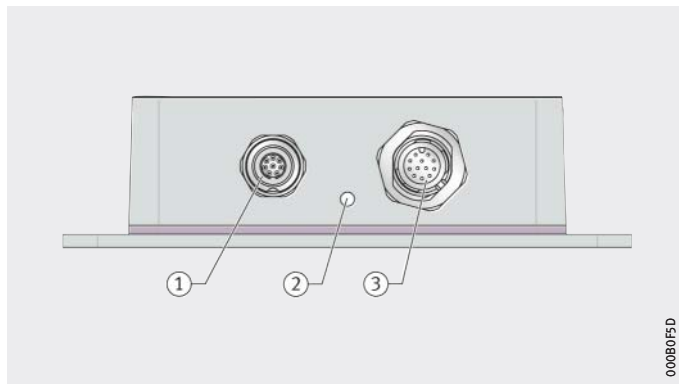
The interface unit forms the interface between the sensor unit fitted to the bearing and the customer system for processing of the measurement results.

Interfaces of interface unit

All product variants that have at least one more sensor function in addition to speed measurement are equipped with an interface unit.

The interface unit has the following interfaces, *Figure 2*:

- flange socket for connection of the sensor unit
- flange plug for the customer-side connection.
  This interface is used for the output of measurement signals and status as well as the supply of voltage
- USB communication interface, integrated in the flange plug for customer-side connection. This interface is provided for installing new software versions and for reading out the error and status memory from service activities
- RS485 interface, integrated in the flange plug for customer-side connection.
  This interface is used for the exchange of measurement values
- LED for display of the operating and error status.
  Display is carried out by means of different colour and flashing modes.



① Flange socket for connection of sensor unit
② LED for operating mode
③ Flange plug for customer-side connection, with integrated USB communication interface and integrated RS485 interface

Figure 2
End face of interface unit

The flange plug for the customer-side connection is used to receive signals (Input) and provide signals (Output). It is also used for the supply of voltage, see table and *Figure 3*.

Pin assignment of flange plug

Signal direction	Signal	Pin
Input	Supply voltage	5
	Mass	8
	USB supply voltage	10
Output	Speed signal A (Open Collector)	1
	Speed signal B (Open Collector)	3
	Current output 1, 4 – 20 mA, signal assignment, see table below	2
	Current output 2, 4 – 20 mA, signal assignment, see table below	9
	Digital error output	7
Input/output (bidirectional)	USB-D–	11
	USB-D+	12
	RS485– (half-duplex)	4
	RS485+ (half-duplex)	6

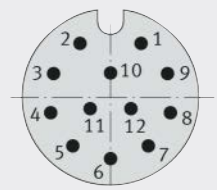


Figure 3
Pin numbering of flange plug

The signal assignment of the current outputs in the flange plug depend on the product configuration, see table. Other assignments are possible by agreement.

Signal assignment of current outputs

Product configuration	Signal	
	Current output 1	Current output 2
001[1)]	Speed	–
002	Temperature	Speed
003	Temperature	Displacement/load
004	Displacement/load	–

[1)] In the case of product configuration 001, the interface unit is not necessary but can be ordered as an option.

Interfaces in pure speed measurement

The product configuration 001, in which the only sensor function is speed measurement, does not have an interface unit.
In this case, the cable on the sensor unit forms the external interface. This product configuration is supplied with four stripped and tin-coated cable ends, see table.

By agreement, the cable for the sensor unit can also be supplied with a plug, see table and *Figure 4*.

Colour and pin assignment of connection on sensor unit

Signal direction	Signal	Cable colour	Pin
Input	Supply of voltage to sensor unit	Red	2
	Mass	Black	5
Output	Speed signal A	White	6
	Speed signal B	Blue	1

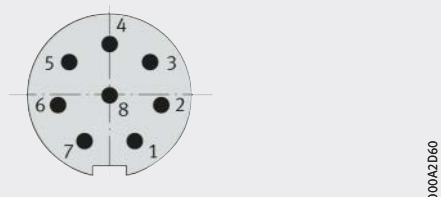


Figure 4
Pin numbering of plug on sensor unit

The supply of voltage to the sensor unit in the case of product configuration 001 can be between 4,5 V and 28,8 V. If the optional interface unit is used, the supply voltage range corresponds to the range for the interface unit, see table, page 15.

Plug connections

The coupling for connection to the 12 pin customer interface of the interface unit must be ordered separately, see table and *Figure 5*.

The table also includes the plug connections for the interface unit and sensor unit that are included in the scope of delivery according to the product configuration.

Orders can be placed directly with the relevant supplier using the following address details:

- **Franz Binder GmbH & Co. Elektrische Bauelemente KG**
  Rötelstraße 27 · 74172 Neckarsulm · Germany
  www.binder-connector.de
- **Phoenix Contact Deutschland GmbH**
  Flachsmarktstraße 8 · 32825 Blomberg · Germany
  www.phoenixcontact.com

Ordering numbers of plug connections

Plug connection			Manufacturer	Manufacturer ordering number
①	Flange plug		Phoenix	1441943
②	Flange socket		Binder	09 0428 30 08
③	Plug		Binder	99 0425 10 08
④	Coupling with cable, free connection end:			
	Cable length	0,5 m	Phoenix	1437083
		1,5 m	Phoenix	1430129
		3 m	Phoenix	1430132
		5 m	Phoenix	1430145
		10 m	Phoenix	1430158
⑤	Coupling without cable (alternative to ④)		Binder	99 1492 812 12

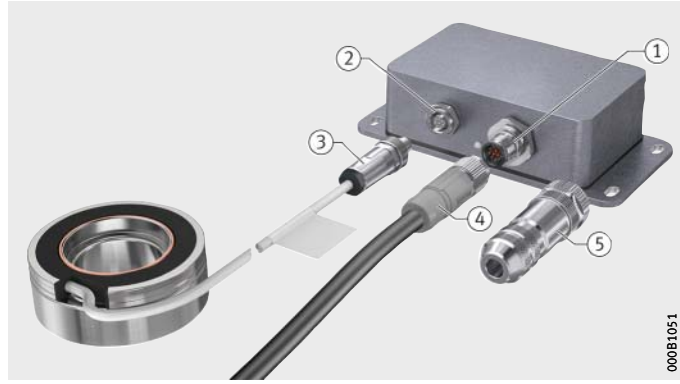


Figure 5
Plug connection

Rolling bearings

The product series FAG VarioSense currently includes the following standard rolling bearings with integrated sensor technology:

- single row deep groove ball bearings of Generation C in the sizes 6205-C to 6210-C.

For the future, the intention is to expand the product series FAG VarioSense to include other rolling bearings.

Deep groove ball bearings of Generation C

Deep groove ball bearings of Generation C correspond in their structure to single row deep groove ball bearings but are specially optimised in relation to:

- significantly quieter running
- even more effective sealing
- a further reduction in the already very low frictional torque.

These optimisations were achieved by means of design modifications such as new seals and cages, improvements in bearing kinematics and refined manufacturing processes.

Sealing of bearings

Within the product series FAG VarioSense, the bearings are available with the following seals:

- gap seals on both sides 2Z
- lip seals on both sides 2HRS.

Lubricating greases

Within the product series FAG VarioSense, the bearings can be supplied with various lubricating greases in accordance with customer request. Selection of the lubricating grease is based on the information given in the publication TPI 165.

Upon customer request, other lubricating greases are also available, however these must be checked in advance in conjunction with the sensor unit. If necessary, please contact Schaeffler.

Further information

- TPI 165, Deep Groove Ball Bearings, Generation C
- Catalogue HR 1, Rolling Bearings.

Rating life

The rating life of the interface unit, sensor unit and rolling bearing must be considered separately.

Interface unit and sensor unit

The rating life of the interface unit and sensor unit is achieved if one of the following criteria is exceeded:

- 25 000 operating hours
- operating life of 10 years.

The data on the rating life apply in each case for one specific temperature spectrum, see table.

Temperature spectra

Temperature	Time proportion of rating life		
	Interface unit	Sensor unit	
		Without displacement measurement	With displacement measurement
°C	%	%	%
–40	6	1	1
–20	–	4	4
0	–	10	10
+23	20	25	25
+50	65	30	30
+60	8	25	25
+80	1	–	–
+105	–	–	5
+125	–	5	–

Rolling bearings

The basic load ratings and speeds valid for a rolling bearing remain unchanged even if the bearing is used as a FAG VarioSense bearing. The calculation methods established for the design and rating life calculation can be applied unchanged.

Further information

- Catalogue HR 1, Rolling Bearings.

Ordering designation

The structure of the ordering designation is shown in *Figure 6*.

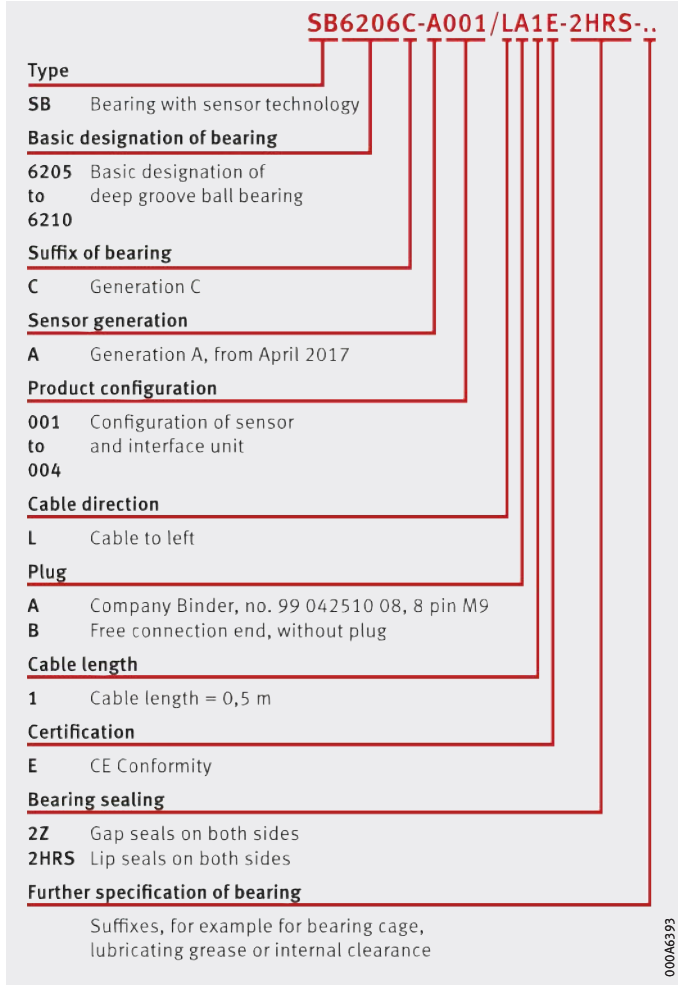


Figure 6
Ordering designation

Design and safety guidelines

Mounting dimensions

This section contains the mounting dimensions and other dimensions of components of the FAG VarioSense bearing.

Bearing with sensor unit

The width of the sensor unit is identical for all sensor units that are combined with deep groove ball bearings of series 62. It is 7 mm.

Further dimensions are shown in the dimension table, see page 18.

The dimensions of the deep groove ball bearings used in the sensor unit correspond to the standard dimensions of these bearings.

Further information

- TPI 165, Deep Groove Ball Bearings, Generation C
- Catalogue HR 1, Rolling Bearings.

Connection cables and plug connections

The specification of the connection cable between the sensor unit on the bearing and the interface unit is independent of the product configuration, see table and *Figure 7*.

Dimensions

Designation			Product configuration	
			001	002, 003, 004
Cable length Y		m	0,5	
Cable diameter d_K		mm	3,8 ± 0,2	
Minimum bending radius of cable		mm	10	
Plug diameter D_S		mm	14	
Delivery	Without plug	–	Standard	–
	With plug	–	By agreement	Standard

In the case of product configuration 001 (pure speed measurement), the connection cable is supplied without a plug. By agreement, delivery with a plug is possible.

In the case of product configuration 002, 003 and 004, delivery with a plug is only possible, since the plug is necessary for connection to the interface unit.

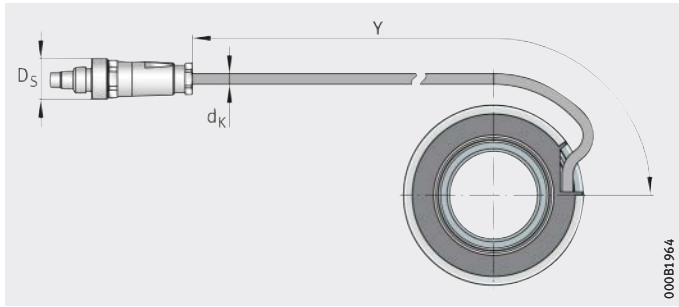


Figure 7
Dimensions

Interface unit

The dimensions of the interface unit, *Figure 8*, are identical for all product configurations of the FAG VarioSense bearing and for all bearing sizes.

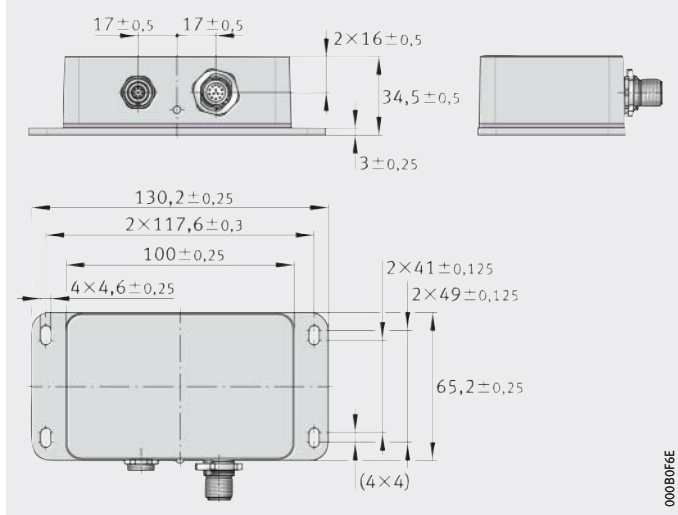


Figure 8
Interface unit

Voltage supply

The supply of voltage to the interface unit, see table, is carried out via the 12 pin flange plug.

Supply of voltage to interface unit

Designation		Value
Supply voltage, nominal	VDC	24
Tolerance range of supply voltage	VDC	14,4 – 28,8
Overcurrent protection necessary on customer side	A	1

If supply voltages are above the stated range, the interface unit will be electrically destroyed.

Shielding

In order to ensure electromagnetic compatibility, the cable of the sensor unit is shielded. If you require further information on shielding, please consult Schaeffler.

Stationary outer ring

Due to the cable connection arrangement, the FAG VarioSense bearing is restricted to applications with a stationary outer ring.

A means of preventing rotation of the outer ring must be provided by the customer.

FAG VarioSense bearings

Operating limits

The FAG VarioSense bearing is intended exclusively for applications in the machine and equipment building sector where no particular protection requirements apply.

The exclusion criteria and ambient conditions stated below must be observed.

Exclusion criteria

The following areas of application are excluded:

- explosive environments (ATEX)
- nuclear power
- aerospace
- rail
- military
- medical equipment.

In addition to the areas of application that are explicitly excluded, the FAG VarioSense bearing is also excluded from all other applications in which the use of the measurement values has an influence on the safety of the machine or equipment itself, of the adjacent systems or of persons.

Ambient conditions

Excluded ambient conditions:

- Magnetically or electrically conductive dusts or particles.

Protection type in accordance with ISO 20653:

- The sensor and interface unit are designed in accordance with the protection type IP67.

Air pressure:

- The permissible ambient pressure for the sensor and interface unit is in the range from 700 hPa to 1050 hPa.

Temperature:

- The maximum storage and operating temperatures are dependent on the sensors used and therefore differ in accordance with the product configuration, see table.

Temperature limits of sensor and interface unit

Component		Temperature			
		Storage		Operation	
		min. °C	max. °C	min. °C	max. °C
Sensor unit of product configuration	001	+5	+40	–40	+125
	002	+5	+40	–40	+125
	003	+5	+40	–40	+105
	004	+5	+40	–40	+105
Interface unit		+5	+40	–40	+80

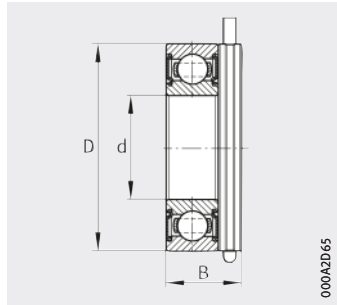
In addition to the temperature limits of the sensor and interface unit, the permissible operating temperature of the bearing must always also be taken into consideration.

Further information

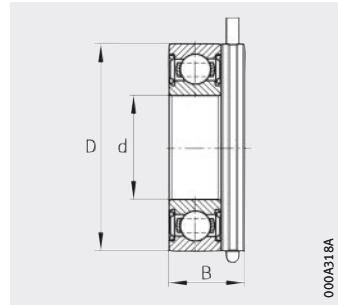
- TPI 165, Deep Groove Ball Bearings, Generation C.

FAG VarioSense bearings

Deep groove ball bearings, Generation C



Seal 2HRS



Seal 2Z

Dimension table · Dimensions in mm

Designation		Dimensions		
Bearing with sensor unit	Bearing	d	D	B
SB6205C	**6205-C**	**25**	52	22
SB6206C	**6206-C**	**30**	62	23
SB6207C	**6207-C**	**35**	72	24
SB6208C	**6208-C**	**40**	80	25
SB6209C	**6209-C**	**45**	85	26
SB6210C	**6210-C**	**50**	90	27

For further dimensions and characteristics of the bearings, see TPI 165, Deep Groove Ball Bearings, Generation C.

TPI 253 / 01 / GB-D / 201807.5 / Printed in Germany by pms

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Issued: 2018, July

TPI 253 GB-D