



17

Sensor bearing units



17 Sensor bearing units

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Mounting instructions for individual bearings → skf.com/mount

SKF sensor bearing units are used to monitor accurately the status of rotating or linear components and are:

- compact
- robust and reliable
- simple and ready-to-mount

Sensor-integrated solutions engineered by SKF have been well proven in a variety of industrial and automotive applications, such as electric motors, electric vehicles, road rollers, tractors, forklifts and conveyors. Typical uses include:

- motor management
- steering
- speed and position sensing
- measurement of angular position

Motor encoder units

Monitoring the status of rotating components accurately is essential for many applications. This is particularly true for AC motors that require encoders to measure the speed and the direction of rotation continuously.

SKF motor encoder units (**fig. 1**) combine active sensor technology with an SKF Explorer deep groove ball bearing and are:

- able to provide a signal resolution ranging from 32 to 80 digital pulses per revolution
- compact only 6,2 mm wider than the corresponding standard deep groove ball bearing (**fig. 2**)
- ready-to-mount and can be mounted at either bearing position in an AC motor
- available for shaft diameters ranging from 15 to 45 mm



Designs and variants

SKF motor encoder units are compact, integrated units consisting of (fig. 3):

- an SKF Explorer deep groove ball bearing in the 62 series with a snap ring groove in the outer ring and an RS1 contact seal (*Single row deep groove ball bearings, page 241*)
- an impulse ring
- a sensor body
- a connecting cable

The impulse ring, which attaches to the inner ring of the bearing, is a composite magnetized ring that contains between 32 and 80 north and south poles. The number of poles depends on the size of the bearing. The sensor body, which is attached to the outer ring, protects the patented SKF Hall effect cell. The multi-wire connecting cable extends in the radial direction.

The bearing is protected by a contact seal on one side. On the opposite side of the bearing, the impulse ring and sensor body create an effective labyrinth seal to keep lubricant in and solid contaminants out of the bearing.

Sensor technology

SKF motor encoder units use a compact and robust sensor that produces an incremental encoder signal. The sensor is accurate down to zero revolutions per minute. An integrated active circuit (requiring an external voltage supply) in the sensor body contains two Hall effect cells that produce an output signal consisting of two square waves (fig. 4).

The signals can be interpreted by motor controllers in different ways:

- The direction of rotation can be determined from the phase shift, when the rising edge of a signal first appears.
- Low speeds can be determined by measuring the time between two electrical events, such events being the rising and falling edge on either square wave.
- High speeds can be measured by counting the number of electrical events within a given time period.

The two square waves are 90° out of phase with each other. This phase shift changes sign with the direction of rotation. fig. 4 shows the general specifications of the signal. The presence of two signals in quadrature enables a processing unit to multiply the number of angular position increments per revolution. For example, using a standard SKF sensor bearing with 64 pulses per revolution and a standard electronic interface that can detect the rising (Low/High) and falling (High/Low) times of each of the two

Fig. 2

Extended width compared to a standard deep groove ball bearing

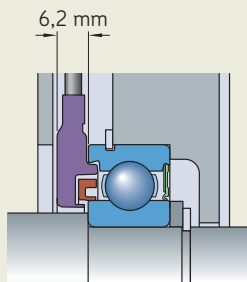


Fig. 3

Motor encoder unit

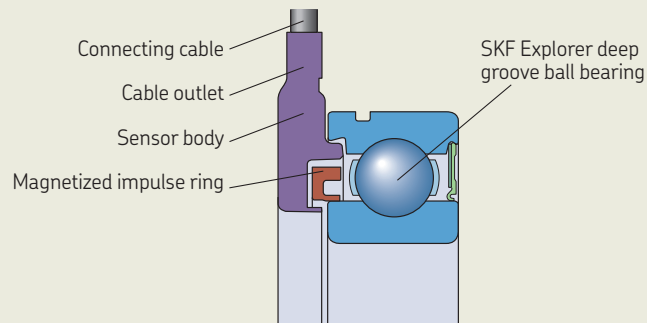
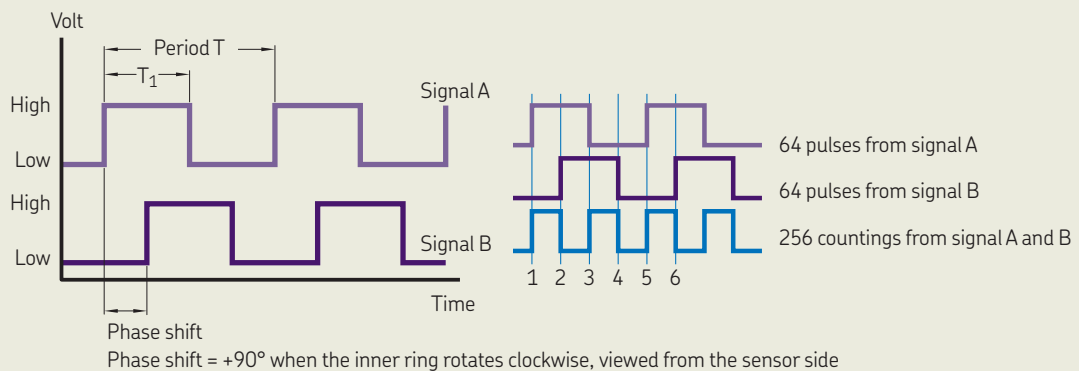


Fig. 4

Sensor technology



N = number of pulses per revolution
Resolution: $R = 360^\circ/N$
Period accuracy = $(T - R)/R$
Duty cycle = $100 T_1/T$



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signals, it is possible to obtain 256 electrical events per revolution, which translates to an angular resolution of $1,4^\circ$ (fig. 4, page 989).

SKF motor encoder units provide accurate and reliable signals for effective motor control and are 100% tested for period accuracy, duty cycle and phase shift during manufacture.

Cable connection

SKF motor encoder units are available as standard with one of the following:

- a free cable end with an output signal consisting of two square waves, designation suffix 008A (fig. 5)
- an AMP Superseal™ connector (AMP Nos. 282106-1 and 282404-1), designation suffix 108A (fig. 6)

Standard cable lengths are listed in the [product table, page 1002](#). For alternative connectors or cable lengths, contact SKF.

Lubrication

SKF motor encoder units are:

- filled, under clean conditions, with a high-quality grease (table 2, page 245) that is suitable for the most common operating conditions of electric motors
- virtually maintenance-free

The grease life in the bearing can be calculated according to the method described under *Grease life for capped bearings*, page 246.

Motor encoder units for extreme operating conditions

Magnetic sensors have temperature and motor power limits. For applications where magnetic sensors are not practical, high-performance inductive technology can be used instead. Inductive sensors use coils to sense the rotation of a specially designed induction tooth ring. For additional information about motor encoder units for extreme operating conditions, contact SKF.



Fig. 5

Free cable end, designation suffix 008A (including dongle, except for unit BMD-6206)

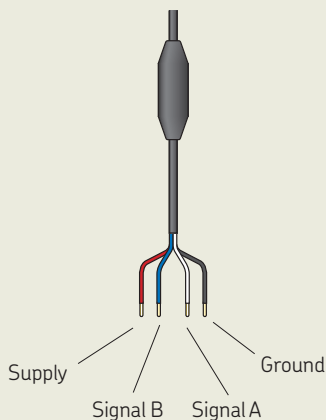
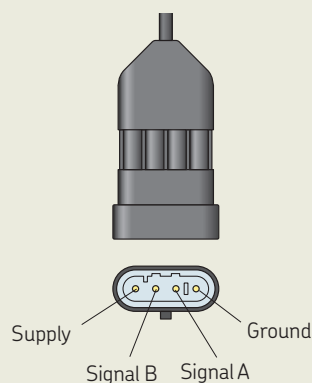


Fig. 6

AMP Superseal™ connector, designation suffix 108A



Product data

Requirements for the receiving interface

The receiving interface must be able to process the signals, which are provided via open collector circuits (fig. 7). Output signal features are listed in table 1. The phase shift is the delay between the two signals' rise events (fig. 4, page 989). It is 1/4 of the period, or 90 electric degrees. The duty cycle value is the high state of the signal compared to the full period (fig. 4). It is nominally 50%.

Power supply

SKF motor encoder units require a regulated voltage supply, which can range from 5 to 18 V DC. For applications above 18 volts, contact SKF.

Resistors

Pull-up resistors (table 2) should be placed between the voltage supply and the conductors for the output signals to limit the output current to 20 mA. The application load resistance between the ground line and the conductors for the output signals should be at least 10 times higher than the resistance of the pull-up resistor. This helps to keep the output signals readable.

Detecting direction of rotation

A positive phase shift corresponds to signal B rising before signal A and indicates the inner ring rotating clockwise when viewed from the sensor side.

Electromagnetic compatibility

SKF motor encoder units can be used in systems operating in very arduous electromagnetic environments as described in the international standard IEC 61000-6-2.

Fig. 7

Typical schematic drawing of a receiving interface

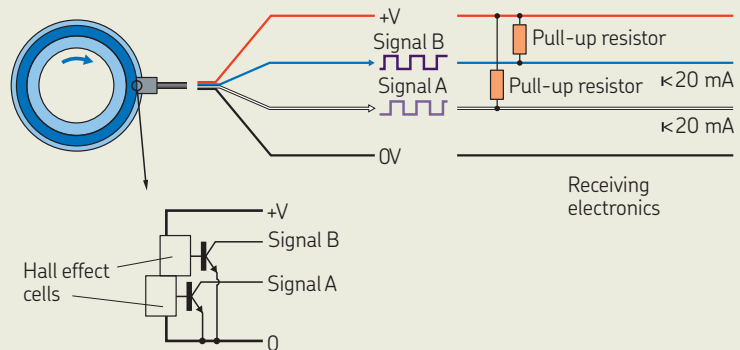


Table 1

Output signal features

Signal type	Digital square
Number of signals	2
Phase shift	90°
Duty cycle	50% of a period

Table 2

Recommended pull-up resistors

Voltage supply	Resistance min.	Power
V DC	Ω	W
5	270	0,25
9	470	0,25
12	680	0,25

High-performance filtering

All standard SKF motor encoder units are protected with high-performance filtering so that they can adapt to the electric environment typically found in industrial and automotive applications:

- Units with a free cable end have the filter included in the overmoulding on the cable.
- Units with an AMP Superseal™ connector have the filter integrated in the connector.

Bearing data

Dimension standards	Boundary dimensions: ISO 15 However, the width of the complete unit is 6,2 mm wider.
Tolerances	d ≤ 25 mm: P5 d ≥ 30 mm: P6
For additional information → page 35	Values: ISO 492 (table 3, page 39 , and fig. 4, page 989)
Internal clearance	C3 Values: ISO 5753-1 (fig. 6, page 990) Values are valid for unmounted bearings under zero measuring load.
For additional information → page 182	

Loads

For information about minimum load and equivalent bearing loads, refer to *Loads*, [page 254](#).

The required minimum load factor k_r and calculation factor f_0 are listed in the [product table, page 1002](#).

Temperature limits

SKF motor encoder units have been tested successfully under various speeds and loads:

- 500 hours at 125 °C (255 °F), with intermittent peaks of up to 10 minutes at 150 °C (300 °F)
- 100 hours at -40 °C (-40 °F)

Where other temperatures are expected, contact SKF.



Fig. 8

Radial notch in the housing

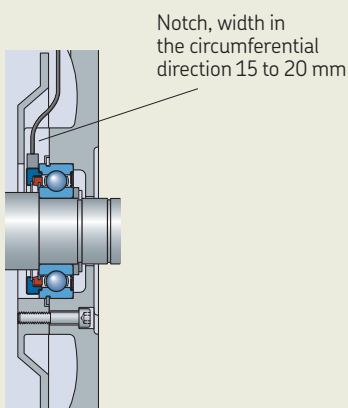


Fig. 9

Motor encoder unit in the non-locating bearing position

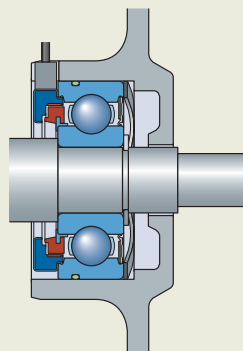
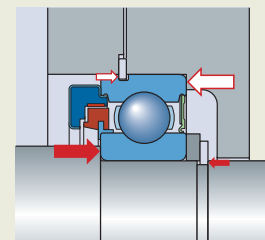


Fig. 10

Recommended load transmission



Permissible speed

The permissible operating speed is limited by the contact seal in the bearing. The sensor can accurately detect speeds from zero revolutions per minute up to the limiting speed listed in the [product table](#), [page 1002](#).

Design considerations

In principle, SKF motor encoder units can be incorporated in designs in the same way as SKF deep groove ball bearings. Some specific recommendations are described below. For additional information about electric motor applications, refer to the SKF handbook *Rolling bearings in electric motors and generators*.

Cable outlet

The cable emerges radially from the motor encoder unit. A sufficiently dimensioned cable duct must be provided in the bearing housing or housing cover. The radial notch in the housing should have a width in the circumferential direction of 15 to 20 mm ([fig. 8](#)).

Motor encoder units in the non-locating bearing position

SKF recommends using motor encoder units in the non-locating bearing position ([fig. 9](#)). However, there is a risk that the outer ring can spin in the housing bore, especially if vibration is a factor. Therefore, SKF recommends placing an O-ring in the snap ring groove to help prevent the outer ring from spinning, which could otherwise damage the cable.

Motor encoder units in the locating bearing position

When using motor encoder units in the locating bearing position, the impulse ring, sensor body and connecting cable should not be subjected to any axial load, whenever possible. When the bearing is subjected to axial loads that act in both directions, the motor encoder unit should be mounted in such a way that the heavier axial load is transmitted to the bearing outer ring side face opposite the sensor ([fig. 10](#)).

Motor encoder units can be located axially in the housing in different ways:

- with a snap ring in the outer ring and a cover bolted to the housing ([fig. 11](#))
- with a spacer sleeve and a snap ring in the housing ([fig. 12](#))
- with a cover engaging the outer ring ([fig. 13](#))

Motor encoder units with $d \leq 25$ mm can only be located axially via a snap ring in the outer ring.

Motor encoder units in floating bearing arrangements

When using motor encoder units in floating bearing arrangements ([page 76](#)), the outer ring should be prevented from spinning by placing an O-ring in the snap ring groove. The motor encoder unit should be mounted in such a way that the axial load acts on the bearing outer ring side face opposite the sensor.

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Fig. 11

Axial location with a snap ring in the outer ring and a cover bolted to the housing

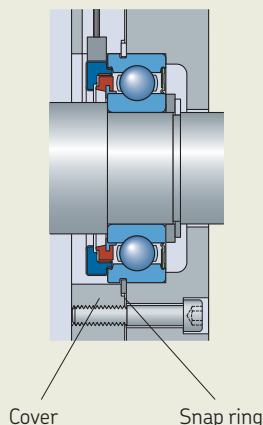


Fig. 12

Axial location with a spacer sleeve and a snap ring in the housing

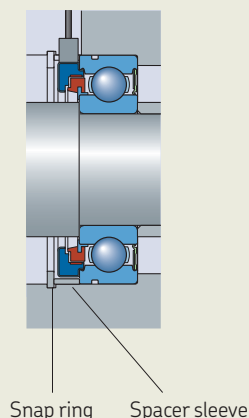
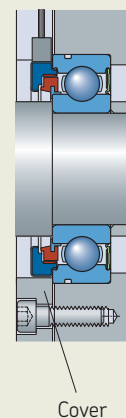


Fig. 13

Axial location with a cover engaging the outer ring



Mounting

SKF motor encoder units must be handled with care to avoid damaging the bearing, sensor and connecting cable. Never apply any force on the cable, cable outlet, sensor body or impulse ring.

On request, SKF can provide assistance in optimizing the mounting and connecting processes.

Mounting a unit on a shaft

Motor encoder units are typically mounted on a shaft with an interference fit. They can be pressed onto the shaft by applying a mounting force via a mounting sleeve or dolly abutting the inner ring side face (fig. 14). To facilitate mounting, the bearing inner ring can be heated:

- Use a temperature-controlled electric hotplate.
- Do not heat the unit above 80 °C (175 °F).
- Place the bearing on a mandrel to heat the inner ring effectively (fig. 15).
- Position the bearing so that the seal is in the lower position to avoid grease leaking out of the bearing.
- Do not use induction heaters as damage to the electronic components may result.

Fig. 14

Mounting force applied via a dolly abutting the inner ring side face

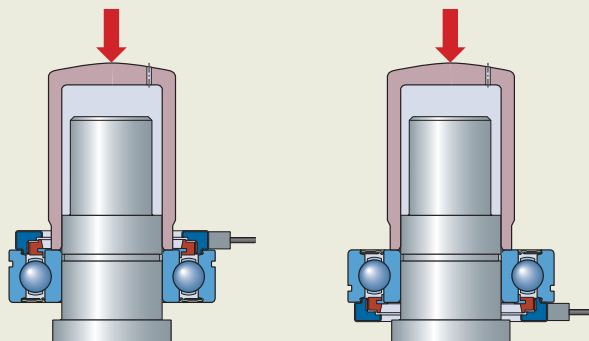
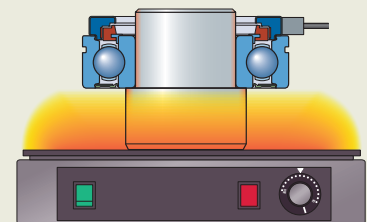


Fig. 15

Bearing on a mandrel to heat the inner ring



Mounting a unit into a housing

When motor encoder units have to be mounted into a housing with an interference fit, they can be pressed into the housing or the housing should be heated. The mounting force should be applied via a mounting sleeve or dolly abutting the outer ring side face or via a snap ring fitted on the outer ring (fig. 16).

In typical electric motor applications, the bearing can be moved into position by using bolts to pull the motor shield and cover together (fig. 17).

Cable connection

The cable should be protected by a duct to prevent it from making sharp turns, being pinched or making contact with any moving parts. To avoid any interference with the sensor signal, do not place the connector near other power cables or wires.

Designation system

Refer to *Designation system*, page 258.

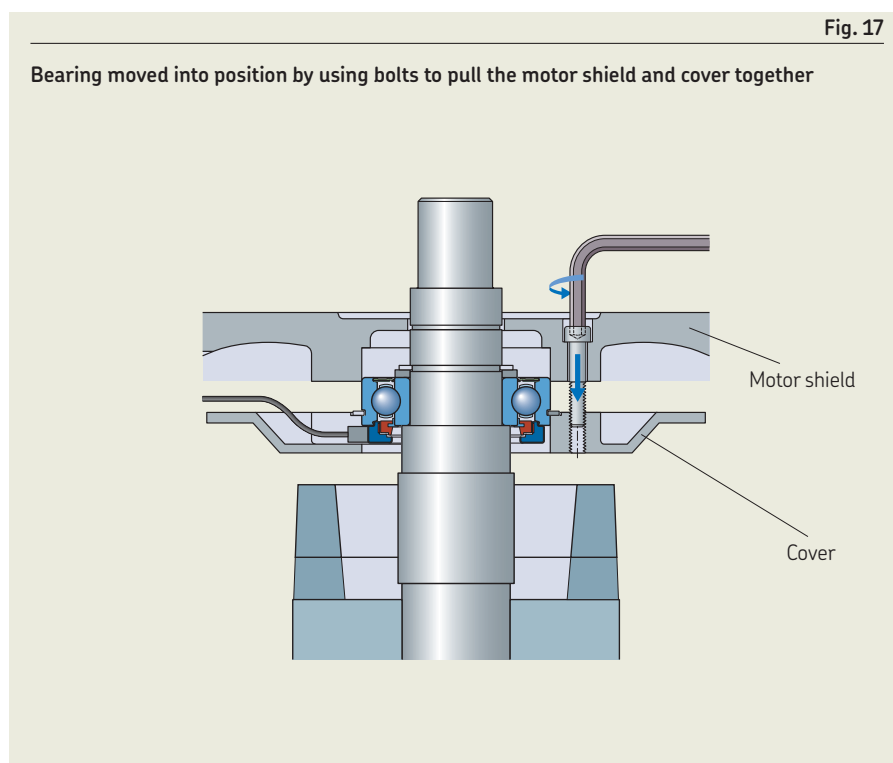
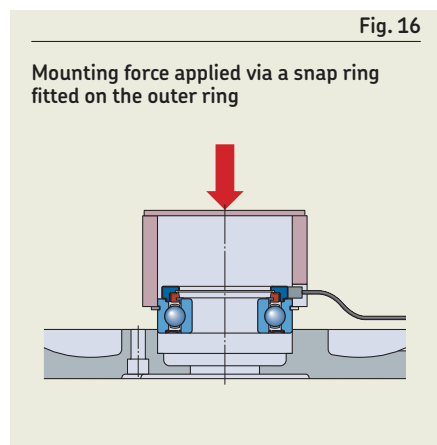
The designation prefixes and suffixes used to identify motor encoder units are explained in the following.

Prefixes

- BMB-** Motor encoder unit BMB series
- BMD-** Motor encoder unit BMD series
- BMO-** Motor encoder unit BMO series

Suffixes

- /032** 32 digital pulses per revolution
- /048** 48 digital pulses per revolution
- /064** 64 digital pulses per revolution
- /080** 80 digital pulses per revolution
- S2** Two signals
- /U** Sales area worldwide
- A** Bearing with a stamped steel cage, ball centred
- B** Bearing with a glass fibre reinforced PA66 cage, ball centred
- 008A** Free cable end
- 108A** AMP Superseal™ connector (AMP Nos. 282106-1 and 282404-1)



Roller encoder units

SKF roller encoder units (fig. 18, table 3) are plug-and-play sensor bearing units designed for applications with outer ring rotation.

The encoder units:

- incorporate a sealed 6201 SKF Explorer deep groove ball bearing, which is lubricated for the life of the bearing
- can be easily integrated into pulleys, cams, rollers, or wheels to provide a compact outer ring rotation encoder assembly
- can be supplied, on request, complete with customized gears, wheels or pulleys



Sensor technology

SKF roller encoder units use similar sensors as SKF motor encoder units (page 988).

They provide two signals, which can be used to determine relative position, speed, acceleration and direction of movement. The requirements for the receiving interface are the same as for SKF motor encoder units.



Roller encoder unit

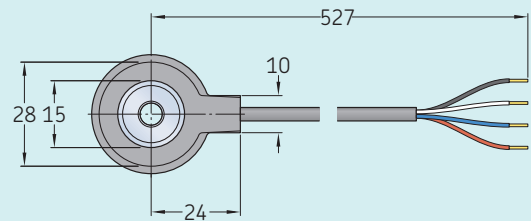
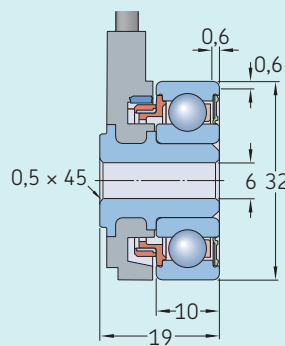


Table 3

Designation	AHE-5509A
Cable connector type	Free cable end
Number of pulses per revolution, N	32
Period accuracy	± 4%
Phase shift output signal	90°
Phase shift output signal tolerance	± 30°
Duty cycle	50%
Duty cycle tolerance	± 10%
Limiting speed	5 000 r/min
Mass	0,066 kg

Steering encoder units

SKF steering encoder units (fig. 19, table 4) are steering input devices for steer-by-wire systems that combine reliable encoder technology with the simplicity of plug-and-play component packaging.

The detailed design of the units is based on well-proven SKF technologies. The units consist of:

- a sealed SKF Explorer deep groove ball bearing for long service life and reliable performance
- bearing encoder technology for precise monitoring
- a friction torque device, which provides feedback to the operator by providing adequate resistance in the steering wheel
- a mechanical interface for mounting
- a shaft to connect the steering wheel

The units reliably fulfil the demands of industrial and off-highway vehicle steer-by-wire systems and:

- do not require any adjustment
- do not require relubrication during their expected service life and are virtually maintenance-free
- are supplied ready-to-mount (connection to a steer-by-wire system is achieved by plugs)

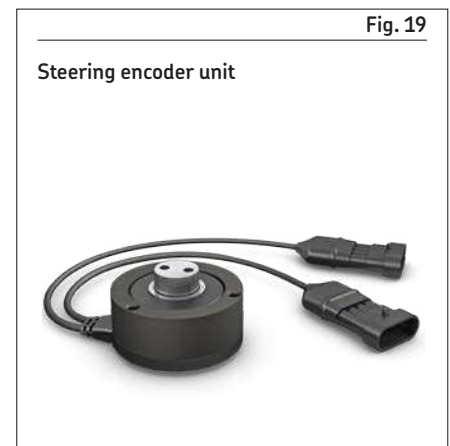
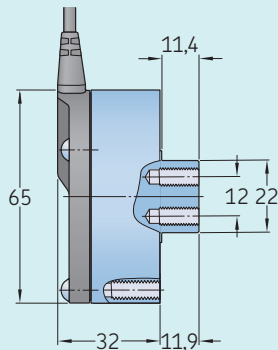


Table 4

Steering encoder units



Designation

Cable connector type

Number of pulses per revolution, N

Period accuracy

Phase shift output signal

Phase shift output signal tolerance

Duty cycle

Duty cycle tolerance

Limiting speed

Mass

AHE-5401D™

AMP Superseal

64

± 8%

90°

± 30°

50%

± 10%

300 r/min

0,57 kg

AHE-5701C™

AMP Superseal

256

± 8%

90°

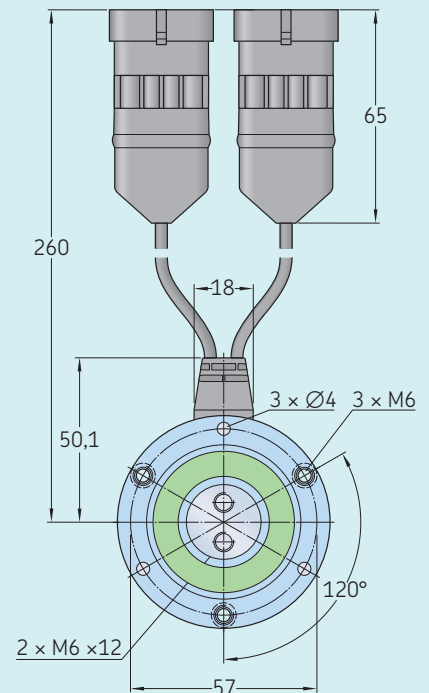
± 30°

50%

± 10%

300 r/min

0,57 kg



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Sensor technology and electrical data

SKF steering encoder units use sensors to track the movement of a steering wheel. They contain two sets to provide redundancy. The sensors:

- are magnetic
- are non-contact and incremental
- do not wear
- are protected from external influences
- are designed to provide maximum service life

SKF steering encoder units comply with the safety requirements of safety-related control systems in accordance with ISO 13849.

SKF steering encoder units provide two independent sets of square wave signals (fig. 20) via open collector circuits. They require:

- a regulated voltage supply, which can range from 5 to 24 V DC
- pull-up resistors (table 2, page 991) that should be placed between the voltage supply and the conductors for the output signals to limit the output current to 20 mA

The application load resistance between the ground line and the conductors for the output signals should be at least 10 times

higher than the resistance of the pull-up resistor. This keeps the output signals readable.

Units providing absolute position information

SKF can provide customized steering units for applications where a combination of absolute position information, variable steering feel, and active end stops are required. For additional information, contact SKF.

Rotor positioning sensor bearing units

Synchronous motors require a sensor that provides the position of the rotor with a high accuracy, to enable accurate motor torque control and to achieve maximum efficiency and dynamics. These motors use either direct drive or sine wave control. SKF rotor positioning sensor bearing units (fig. 21, table 5) can contribute to optimized motor efficiency for both systems.

Units for sine wave or vector control

- provide the shaft angle position in real time throughout the entire motor speed range
- provide a signal (diagram 1) comparable to the one provided by a resolver and can therefore be used by the motor controller's software
- communicate the shaft angle position via a sine/cosine wave signal
- are more compact and cost-effective than inductive resolvers
- are easy to mount (Mounting, page 994)
- do not require special shaft or housing accuracy in comparison with inductive resolvers (Design considerations, page 993)

SKF can adapt the electronics to comply with the interface of the application.

Fig. 20

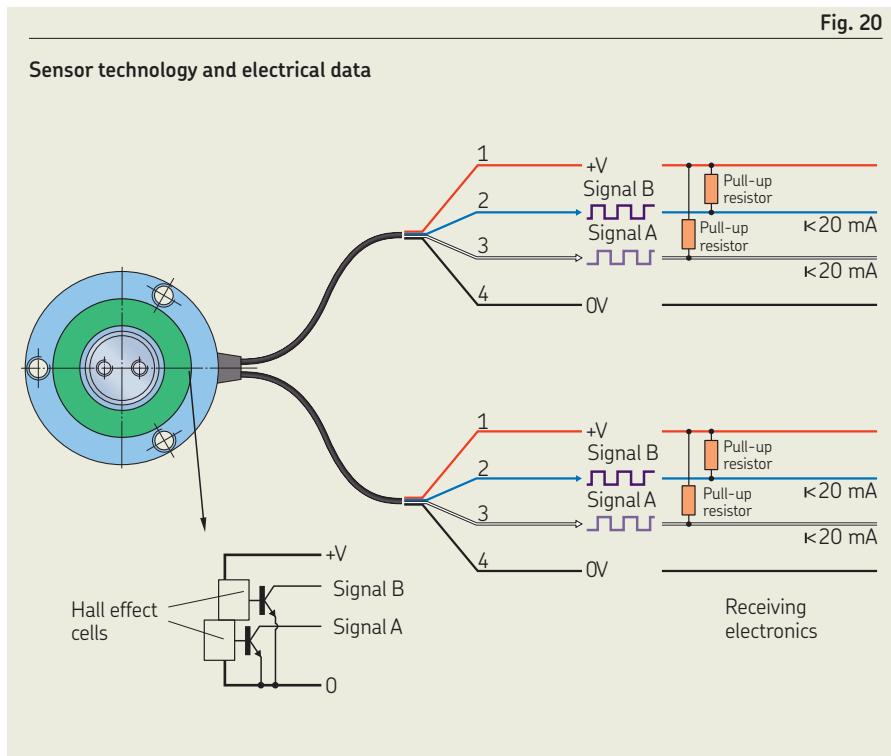


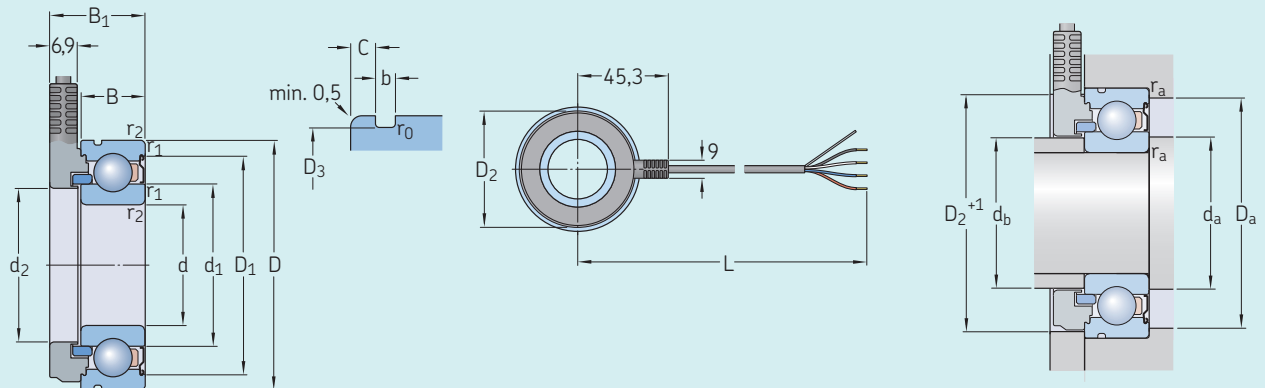
Fig. 21

Rotor positioning sensor bearing unit



Table 5

Rotor positioning sensor bearing unit



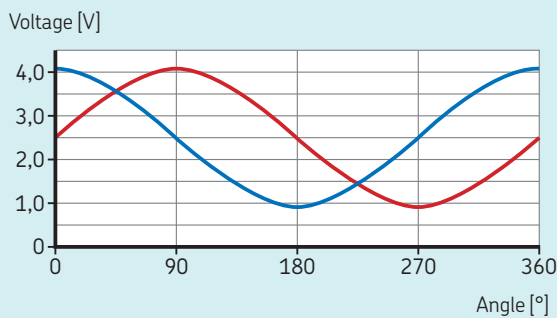
Bore diameter of end cover $\geq D_2 + 1$ mm

Dimensions													Abutment dimensions					
d	D	B ₁	B	d ₁ ≈	d ₂	D ₁ ≈	D ₂	D ₃	C	b	r ₀	r _{1,2} min.	L	d _a min.	d _b min.	d _b max.	D _a max.	r _a max.
mm													mm					
30	62	24,6	16	40,36	38,1	54,1	57,96	59,61	3,28	1,9	0,6	1	515 ±10	35	35	37,5	57	1

Designation	BMB-7052A
Cable connector type	Free cable end
Number of pulses per revolution, N	1
Angle error	± 3.5°
Phase shift	90°
Phase shift tolerance	± 3°
Basic dynamic load rating, C	0,0195 N
Basic static load rating, C₀	0,0112 N
Fatigue load limit, P_u	0,000475 N
Limiting speed	12 000 r/min
Calculation factor, k_r	0,025
Calculation factor, f₀	14
Mass	0,25 kg
Associated snap ring	SP 62

Diagram 1

Analog signal output



Rotor positioning bearings

SKF Rotor positioning bearings (fig. 22, table 6) are customized units with optimized mechanical integration between a magnetic impulse ring and a bearing in an application. The integrated units:

- allow the use of nearly all bearing types
- allow high speeds and temperatures
- generate strong magnetic impulses that are related to the rotor angular position
- can deliver the magnetic field in the axial or radial direction, on a through shaft or at the end of a shaft
- are very robust under severe operating conditions as a result of their high magnetic field strength

Applications

- absolute angular position information for electric motor control in, for example:
 - belt-driven starter generators
 - traction motors
 - e-superchargers and e-turbochargers
- shaft speed detection or low-resolution angular position in, for example:
 - crankshafts
 - transmission shafts

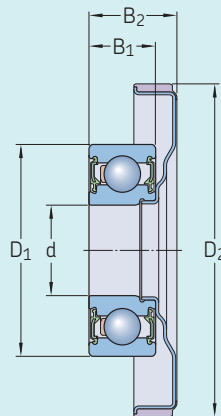


Fig. 22

Rotor positioning bearing

Table 6

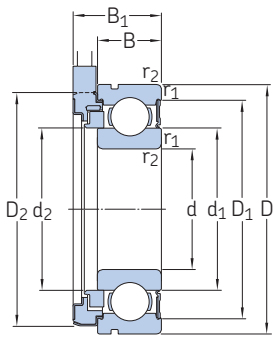
Rotor positioning bearings



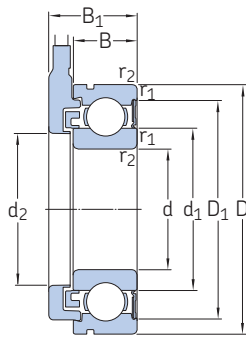
Designation	Bearing size	Principal dimensions					Number of pairs of poles	Limiting speed	Operating temperatures
		d	D ₁	D ₂	B ₁	B ₂			
–	–	mm					–	–	°C (°F)
BMD-0123/ZJ6	6202	15	35	55	11	14,5	6	22 000	–40 to 150 (–40 to 300)
BMD-0123/ZJ8	6202	15	35	55	11	14,5	8	22 000	–40 to 150 (–40 to 300)



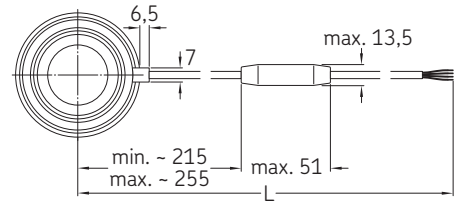
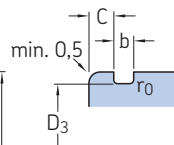
17.1 Motor encoder units
d 15 – 45 mm



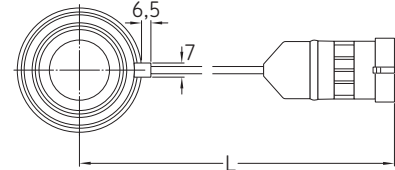
BMB
BMO



BMD



BMB ... 008A (Free cable end)
BMO ... 008A (Free cable end)

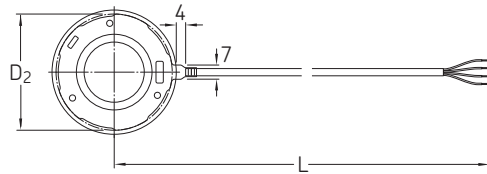


BMB ... 108A (Supersea™)
BMO ... 108A (Supersea™)

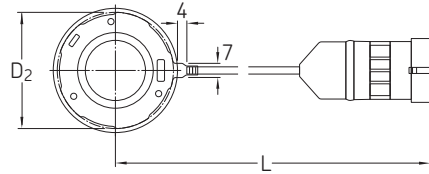
17.1



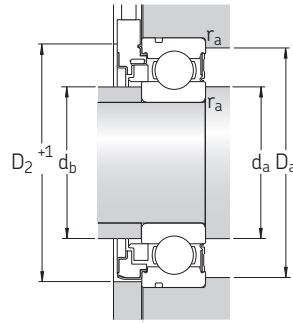
Bearing			Basic load ratings				Fatigue load limit P_u	Limiting speed	Sensor unit			Cable length $L \pm 10$	Mass kg	Designation
Principal dimensions			dynamic	static	No. of pulses N	Period accuracy			Phase shift output signal					
d	D	B	C	C_0										
mm			kN	kN	r/min	–	%	°	mm	kg	–			
15	35	11	7,8	3,75	13 000	32	±3	90 ±30	525	0,062	BMB-6202/032S2/UB008A BMB-6202/032S2/UB108A			
	35	11	7,8	3,75					0,16	13 000		32	±3	90 ±30
20	47	14	12,7	6,55	10 000	48	±3	90 ±20	535	0,13	BMO-6204/048S2/UA008A BMO-6204/048S2/UA108A			
	47	14	12,7	6,55					0,28	10 000		48	±3	90 ±20
25	52	15	14	7,8	8 500	48	±3	90 ±30	535	0,16	BMO-6205/048S2/UA008A BMO-6205/048S2/UA108A			
	52	15	14	7,8					0,335	8 500		48	±3	90 ±30
30	62	16	19,5	11,2	7 500	64	±4	90 ±30	540	0,22	BMD-6206/064S2/UA008A BMD-6206/064S2/UA108A			
	62	16	19,5	11,2					0,475	7 500		64	±4	90 ±30
40	80	18	30,7	19	5 600	80	±5	90 ±30	545	0,45	BMB-6208/080S2/UB008A BMB-6208/080S2/UB108A			
	80	18	30,7	19					0,8	5 600		80	±5	90 ±30
45	85	19	33,2	21,6	5 000	80	±5	90 ±30	545	0,54	BMB-6209/080S2/UB008A BMB-6209/080S2/UB108A			
	85	19	33,2	21,6					0,915	5 000		80	±5	90 ±30



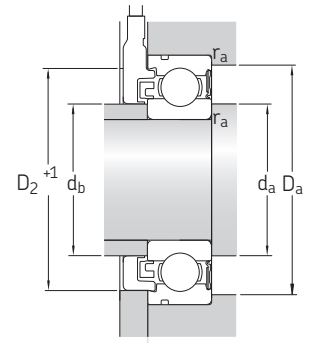
BMD ... 008A (Free cable end)



BMD ... 108A (Superseal™)



BMB
BMO
Bore diameter of end cover
 $\geq D_2 + 1$ mm



BMD
Bore diameter of end cover
 $\geq D_2 + 1$ mm

Dimensions

Abutment and fillet dimensions

Calculation factors

d	d_1 ≈	d_2	D_1 ≈	D_2	D_3	B_1	b	C	r_0	$r_{1,2}$ min.	d_a, d_b min.	d_b max.	D_a max.	r_a max.	k_r	f_0
mm											mm			-		
15	21,7	19,5	30,4	34,46	33,17	17,2	1,35	2,06	0,4	0,6	19	19,4	31	0,6	0,025	13
	21,7	19,5	30,4	34,46	33,17	17,2	1,35	2,06	0,4	0,6	19	19,4	31	0,6	0,025	13
20	28,8	28,69	40,6	46,56	44,6	20,2	1,35	2,46	0,4	1	25	28,6	42	1	0,025	13
	28,8	28,69	40,6	46,56	44,6	20,2	1,35	2,46	0,4	1	25	28,6	42	1	0,025	13
25	34,3	31,6	46,3	51,46	49,73	21,2	1,35	2,46	0,4	1	30	31,3	47	1	0,025	14
	34,3	31,6	46,3	51,46	49,73	21,2	1,35	2,46	0,4	1	30	31,3	47	1	0,025	14
30	40,3	37,4	54,1	58,1	59,61	22,2	1,9	3,28	0,6	1	35	40	57	1	0,025	14
	40,3	37,4	54,1	58,1	59,61	22,2	1,9	3,28	0,6	1	35	40	57	1	0,025	14
40	52,6	48	69,8	75,06	76,81	24,2	1,9	3,28	0,6	1,1	46,5	47,4	73	1	0,025	14
	52,6	48	69,8	75,06	76,81	24,2	1,9	3,28	0,6	1,1	46,5	47,4	73	1	0,025	14
45	57,6	53	75,2	78,86	81,81	25,2	1,9	3,28	0,6	1,1	52	52	78	1	0,025	14
	57,6	53	75,2	78,86	81,81	25,2	1,9	3,28	0,6	1,1	52	52	78	1	0,025	14

