Magnetic incremental encoder
for heavy duty applications

GEL 293

Technical information

Version 2023-02-17

General

- High-resolution magnetic incremental rotary encoder with robust mechanical design
- Worldwide proven technology in various applications, suitable for harsh industrial environments
- Hollow shaft encoder with integrated, highly flexible and torsionally rigid hollow shaft coupling for shaft diameters of 16 mm
- High reliability and long service life characterize the magnetic incremental encoders

Properties

- High resolution up to 266,240 pulses per revolution
- Interpolation up to 1024-fold
- Optional additional current output
  0 to 20 mA, 4 to 20 mA, -20 to + 20 mA
- Reference signal
- High electromagnetic compatibility

Advantages

- Absolute operational reliability even in case of high humidity (condensation) and frequent change of ambient temperature
- Withstands extreme impacts and vibration
- Resistant to dirt and oil
- No ageing of the magnetic sensor technology

Field of application

- Heavy industry
- Vibration motors
- Shipbuilding
- Offshore engineering

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Description

Design and construction

The magnetic incremental rotary encoders are based on contactless magnetic scanning of an target wheel integrated in the encoder. The resilent housing with a diameter of 115 mm is available with radial connector or cable outlet. The rotary encoder is mounted on the drive shaft with a diameter of 16 mm with the integrated flexible hollow shaft coupling. By assembling the encoder with the aid of DS 290 pressure plate a force-fit connection between the hollow shaft coupling and the drive shaft is ensured. In this case the preload of the hollow shaft coupling must be observed. To prevent the encoder shaft from slipping, it is recommended to perform the drive shaft with a driver fitting the groove of the hollow shaft coupling (force-fit).
Optionally, the GEL 293 can include, for example, a condensed water outlet or additional protection measures against humidity and vibration for harsh environmental conditions. Encoders with condensed water outlet must be mounted so that the condensed water outlet points downwards.
If the flange side of the rotary encoder should be dust- and water-protected, assembling with an intermediate flange and shaft adapter or mounting flange is recommended.

Sensing principle

The rotary encoders work with differential, magnetic field-dependent sensors and a precision target wheel. The sensors scan without contact the tooth structure of the target wheel and output a sine and cosine voltage. The integrated evaluation electronics converts the analog sensor signals into incremental output signals.

Output signals

Square-wave signals are output with different signal patterns which provide a clear direction detection and high data reliability. Additionally, a reference signal can be output. For display and control purposes, a standard measuring current of 0 to 20 mA, 4 to 20 mA or -20 to +20 mA can be obtained from the pulse frequency. The current depends on rotational speed and direction. To this end, the measuring pulses are integrated and converted into impressed current. There is a strictly linear interrelation between measuring current and pulse frequency (see current outputs). The polarity of the measuring current dependent on direction of rotation (current output option A) can be reversed by the connection assignment. For encoders with signal pattern S, by reversing the measuring current polarity the direction-dependent S signal is also reversed.

Available number of pulses

The GEL 293 is a high-resolution rotary encoder with pulse numbers of up to 266,240 pulses per revolution.
The realizable pulse numbers can be found online at www.lenord.de and are available upon request.

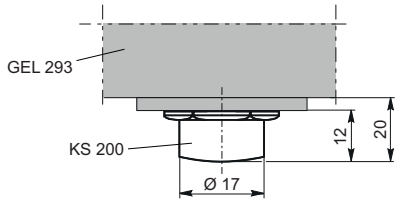
Additional protective measures

Protection against humidity

The encoder electronics are coated with a highly effective protection against humidity, salt water atmosphere and corrosive vapors. This ensures years of trouble-free operation even in harsh environments.

Condensed water outlet

Water can accumulate in the encoder if condensation is present repeatedly. This water can drain off through the condensed water outlet. When installing the encoder, make sure that the outlet points downwards. The degree of protection goes down to IP 64.



The position of the condensed water outlet must be specified when ordering.

Vibration protection

By additionally fixing mechanical parts with special plastic, vibrations of the electronics and connection technology in the encoder are prevented. This enables flawless continuous operation even under extreme vibration and shock loads.

Current output – Options

A: 

Direction of rotation-dependent measuring current
nominal range: -20 to +20 mA
(reversible)

B: 

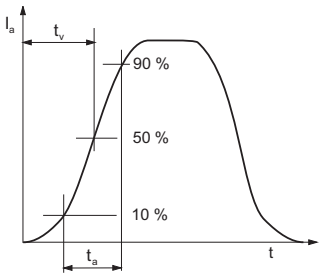
Direction of rotation-independent measuring current
nominal range: 0 to +20 mA

C: 

Direction of rotation-independent measuring current
nominal range: +4 to +20 mA

General

Due to the high resolution 40 to 266,240 (direction of rotation-dependent pulses per revolution), a DC output current (I_a) is obtained which shows a low harmonic content even at a very low rotational speed range (for example, 0 to 0.5 min^{-1}). The harmonic content depends on the pulse frequency and the determined attenuation *d*, the latter influencing the rise and fall times (t_a) as well as the delay time (t_v) in case of erratic changes of the speed.

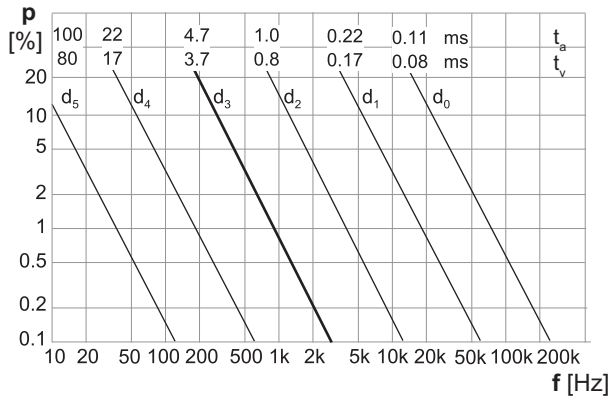


Rise time t_a and delay time t_v after a erratic change in speed

I_a DC output current

Attenuation

The attenuation is adjusted according to the diagram below. The desired factory default setting must be specified in the order. Default is set to d_3.
The rotational speed for the maximum current of 20 mA, which was specified in the order, is indicated on the rating plate (for example, “4000 min^{-1}”). The attenuation is factory set so that the harmonic content p at rated speed is ≤ 1 %, it is also indicated on the rating plate (for example, ‘d5’).



Harmonic content of the output current as a function of the pulse frequency (f) and the selectable attenuation (d_n)

d Attenuation
f Effective pulse frequency (= *n*×*i*)
p Harmonic content (= I_{eff}/I_a)
t_a Rise time (= *f(d)*)
t_v Delay time (= *f(d)*)

Technical data

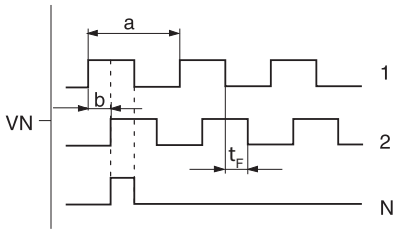
Current output		
Maximum burden	R_a	550 Ω
Instrument class	K	1
Rated current tolerance		< 1 %
Linearity error		< 1 %
Reproducibility	r	100 %
Temperature drift	I_{aT}	< ±3 µA/1 K
Minimum rotational speed (for attenuation d_5)	$n_{min\ electrical}$	1.5 x 10^3/i min^{-1}
Maximum rotational speed	$n_{max\ electrical}$	6 x 10^6/i min-1

i = rated number of pulses

Output signals

Signal pattern V, VN

The "V" signal pattern refers to two tracks with square-wave signals offset by 90°. On the third track N a reference signal of defined length is output once per revolution.



a 360° electrical

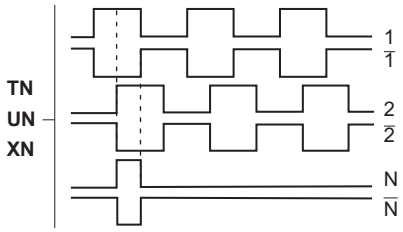
b 90° phase offset

t_F Time between edges (at an output frequency of 200 kHz the time between edges is t_F > 0.6 µs)(1)

	U_B(2)	U_{out}(3)
V, VN	10 to 30 V DC	HTL

Signal pattern T, TN, U, UN, X, XN

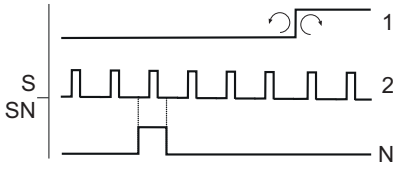
The two pulse outputs and the reference signal are also output as inverse signals.



	U_B(2)	U_{out}(3)
T, TN	+ 5 V DC ± 5 %	TTL
U, UN	10 to 30 V DC	TTL
X, XN	10 to 30 V DC	HTL

Signal pattern S, SN

Pulses independent of the direction of rotation and of constant duration are derived from the square-wave signals as per signal pattern V and are output on the second track. In addition, a signal dependent on the direction of rotation is obtained from the signal pattern (counting direction) and is output on the first track. On the third track N (option) a reference signal is output once per revolution. The pulses follow a possible change in the direction of rotation with a short delay so that any downstream counting circuit can be set to the counting direction prior to the pulse.



	U_B(2)	U_{out}(3)
S, SN	10 to 30 V DC	HTL

Output signal level

The signal patterns S, SN, V, VN, X and XN have HTL output signal levels; the signal patterns T, TN, U and UN have TTL output signal levels. All outputs have a push-pull power amplifier and have sustained short circuit protection. The peak output current for discharging the cable capacitance is 100 mA.

Maximum cable lengths

The following data for each signal pattern are standard values and refer to cable type LiYCY 6 (10) × 0.25 mm^2 between the encoder and subsequent electronics.

Maximum cable lengths

Signal pattern		at output frequency f of						
		5	**10**	**20**	**50**	**100**	**200**	**[kHz]**
T, TN, U, UN	TTL (U_{out} = 5 V) (4)	200	200	200	200	145	72	[m]
S, SN, V, VN	HTL (at U_{out} = 20 V)	200	200	200	80	40	20	[m]
X, XN	HTL (at U_{out} = 20 V)	200	200	100	40	20	10	[m]

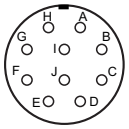
(1) Applies also to the other signal patterns except S(N)
(2) Supply voltage
(3) Output signal level
(4) The given lengths are valid for a power supply with Sense control.

	T, TN	U, UN	S, SN	V, VN	X, XN
General					
Resolution (pulses per revolution)	40 to 266,240				
Error limit	0.07°				
Measuring step deviation	0.01°				
Repeat accuracy	0.005°				
Electrical data					
Supply voltage U_B	5 V DC ± 5 %	10 to 30 V DC			
Power consumption without load	≤ 1.3 W				
Output signals	Two square-wave signals phase-shifted by 90° and their inverse signals (1/2) Option: Reference signal (N)				
Output signal level (U_{OUT})	TTL		HTL		
Output level High	≥ U_B - 1.00 V at I = 10 mA; ≥ U_B - 1.20 V at I = 30 mA	≥ 4.00 V at I = 10 mA; ≥ 3.85 V at I = 30 mA	≥ U_B - 1.80 V at I = 10 mA; ≥ U_B - 2.20 V at I = 30 mA		
Output level Low	≤ 0.75 V at I = 10 mA; ≤ 1.00 V at I = 30 mA		≤ 1.15 V at I = 10 mA; ≤ 1.55 V at I = 30 mA		
Mechanical data					
Moment of inertia of rotor	8× 10^{-5} kgm^2				
Maximum rotational speed	8000 min^{-1}				
Weight	≈ 0.7 kg				
Permissible coupling offset axial lateral	 ±1.0 mm ±0.5 mm				
Bearing life	> 1.5 × 10^9 revolutions				
Housing material	Polyamid glass fiber reinforced				
Flange material	Stainless steel X12CrMoS17 - 1.4104				
Ambient data					
Working temperature range (1)	0 to +70°C (Option **1**) -20°C to +85°C (Option **3**)				
Operating temperature range	-20 °C to +85 °C				
Storage temperature range	-40 °C to +105 °C				
Degree of protection (EN/IEC 60529)	IP 66 IP 64 for designs with condensed water outlet				
Vibration resistance (EN/IEC 60068-2-6)	100 m/s^2 (10 to 2000 Hz)				
Shock resistance (EN/IEC 60068-2-27)	1000 m/s^2 (11 ms)				
Electromagnetic compatibility	DIN EN 61000-6-1:2007-10, EN 61000-6-1:2007 DIN EN 61000-6-2:2006-03, EN 61000-6-2:2005 DIN EN 61000-6-3:2011-09, EN 61000-6-3:2007 + A1:2011 DIN EN 61000-6-4:2011-09, EN 61000-6-4:2007 + A1:2011				
Insulation resistance	500 V DC, > 1 MΩ				
Voltage sustaining capability	500 V AC, 1 minute				
Special requirements					
Rail transport standards	upon request				

(1) According to the selected option in the type code

Connection

Assignment

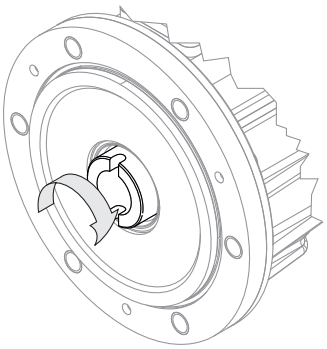
Signal	With connector outlet type L	With cable outlet type I	Description
	10-pole, male contact  *Plug-in view*	10-core	
U_B	F	red	Supply voltage
GND	A	blue	Weight
Track 1	C	white	Track 1
Track /1	H	brown	Track 1, inverted
Track 2	B	pink	Track 2
Track /2	G	black	Track 2, inverted
Track N	D	violet	Reference signal
Track /N	I	yellow	Reference signal, inverted
A/ B/ C	E	gray	Current output
	J	green	Direction reversal

Direction reversal

The polarity of the measuring current dependent on direction of rotation (current output option A) can be reversed by the connection assignment. For encoders with signal pattern S, by reversing the measuring current polarity the direction-dependent S signal is also reversed.

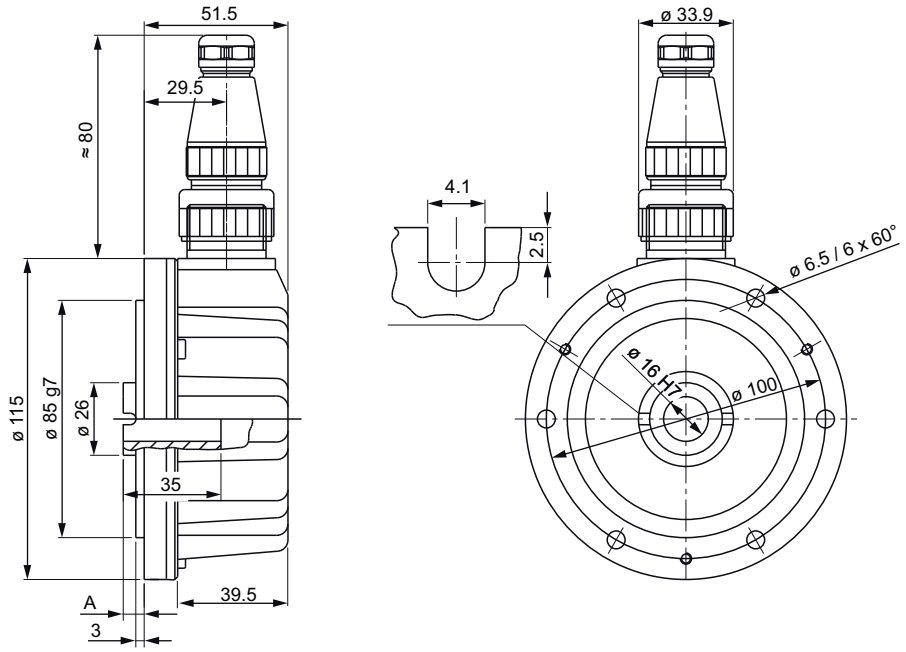
Polarity of the measuring current by clockwise rotation the shaft

Pin J/green core wired with		Polarity of current output A	S signal (track 1)
GND (Low)	Standard	positive	High
U_B (High)	Direction reversal	negative	Low



All dimensions in mm

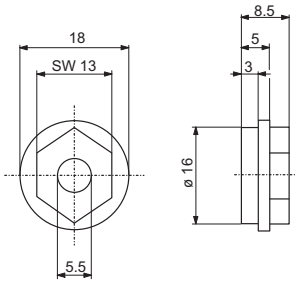
Dimensional drawing – GEL 293



Installation dimensions

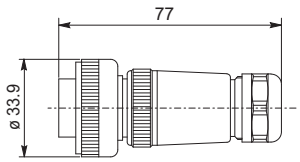
Axial shaft motion (application-dependent)	Dimension A: Delivered status without preload	Preload[1]
1 mm	6.0 mm	7.5 mm
2 mm		8.5 mm
3 mm		9.5 mm

Pressure plate **DS 290** (included in scope of supply)

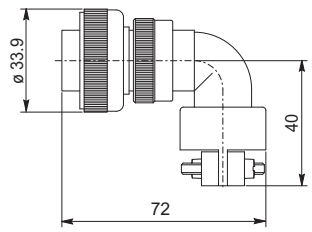


Dimensional drawing – mating connector

GG 106 10-pole, straight
(included in scope of supply)



GW 106 10-pole, 90° offset

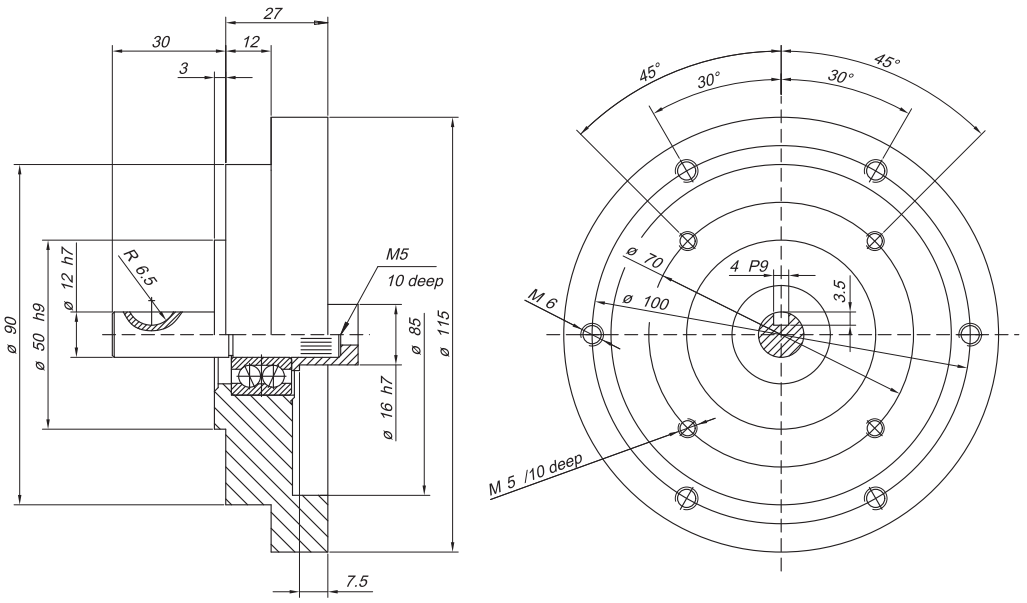


(1) Contains the minimum preload of 1.5 mm required for assembly with an axial shaft movement of 1 mm.

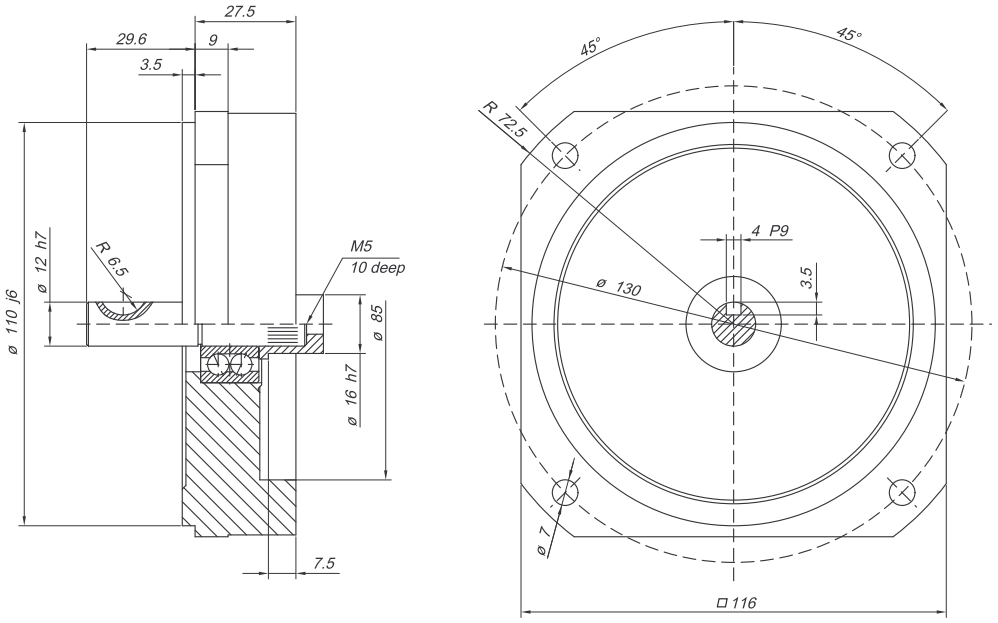
Dimensional drawings

Dimensional drawings – mounting flanges

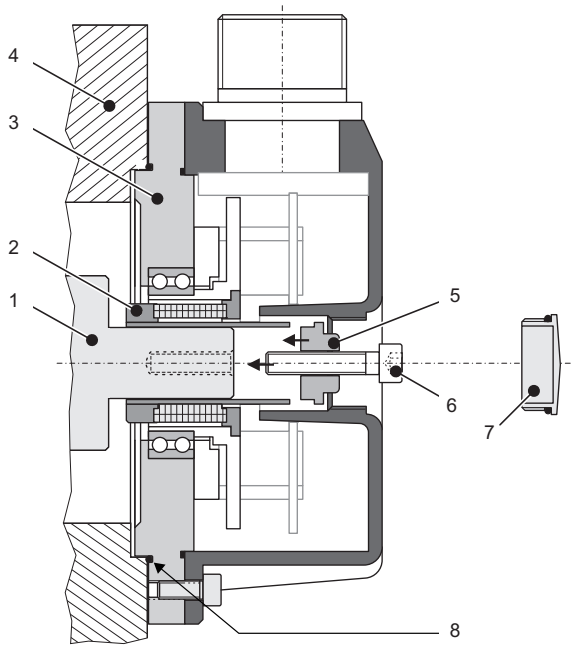
BF 292 mounting flange round



BF 292 mounting flange rectangular



Installation diagram – offset drive shaft



1 Drive shaft[1]
Connection pin diameter 16 mm
2 Flexible hollow shaft coupling
3 Encoder flange
4 Mounting device with centering (85 ^{H7})
for example bearing cover, motor flange
5 Pressure plate DS 290
6 Cheese-head screw M5 (not included in scope of supply)
7 Screw cap
8 Sealing ring

Assembling to other drive shafts is in principle possible.
When assembling with aid of pressure plate DS 290 the position of the zero signal is adjustable at the rear side.
Extensive assembly accessories such as shaft adapters and assembly flanges are available.
When assembling on shaft preload the coupling (see dimensional drawing of GEL 293).

[1] To prevent the encoder shaft from slipping, it is recommended to perform the drive shaft shoulder with a driver fitting the groove of the hollow shaft.

Type code GEL 293

	Current output								
	–	without							
	A	-20 mA to + 20 mA							
	B	0 mA to + 20 mA							
	C	+4 mA to + 20 mA							
		Signal pattern							
		S	Output of constant pulses independent of the direction of rotation and a signal for counting direction						
		V	2 square-wave signals phase-shifted by 90° (HTL)						
		X	2 square-wave signals phase-shifted by 90° and their inverse signals (HTL)						
		U	2 square-wave signals phase-shifted by 90° and their inverse signals (TTL)						
		T	2 square-wave signals phase-shifted by 90° and their inverse signals (TTL)						
			Reference signal						
			–	without					
			N	with reference signal (only possible if number of pulses ≥ 60)					
				Possible number of pulses per revolution					
				000000	**00040** to **266,240**				
					Connector/cable outlet				
					L	10-pole connector outlet, straight			
					I	10-core cable, radial (standard cable length 1 m, specify other cable lengths when ordering)			
						Shaft type			
						0	Standard (16 mm hollow shaft)		
							Protection of electronic parts		
							0	without additional protection	
							1	Humidity protection	
							2	Vibration protection	
							3	Humidity and vibration protection	
							4	Humidity protection and condensed water outlet	
							5	Humidity and vibration protection and condensed water outlet	
								Working temperature range	
								1	0 °C to +70 °C
								3	-20 °C to +85 °C
293	_	_	_	_ _ _ _ _ _	_	_	_	_	

Please specify the following additional parameters when ordering:

- Current output **A/B/C**:
  Desired attenuation (d) and desired rotational speed for maximum current of 20 mA
- Signal pattern **S/SN**:
  Desired pulse width ($_{i}$)
- Protection of electronic parts **4 / 5**:
  Position of condensed water outlet (see drawing 293KW0001)

Customized designs

Customized adaptations of mechanical and electrical properties are generally possible.

Assembly accessories

Description	Item number
DS 290 pressure plate(1), diameter 18 mm (SW 13)	BZ1202
BF 292 mounting flange round	BF1325
BF 292 mounting flange rectangular	BF1310
ZF 206 intermediate flange, for assembly by means of bearing or measuring pedestal	BF1301
WA 206 shaft adapter to ZF 206 intermediate flange	BZ1115

Special flanges with customized dimensions are available on request.

Connection accessories

Description	Item number
GG 106 mating connector straight(1), thread 1 1/8-18UNEF-2A, 10-pole, IP 65	BS1112
GW 106 mating connector angled, thread 1 1/8-18UNEF-2A, 10-pole, IP 65	FS1132

(1) Included in the scope of supply of the encoder

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