



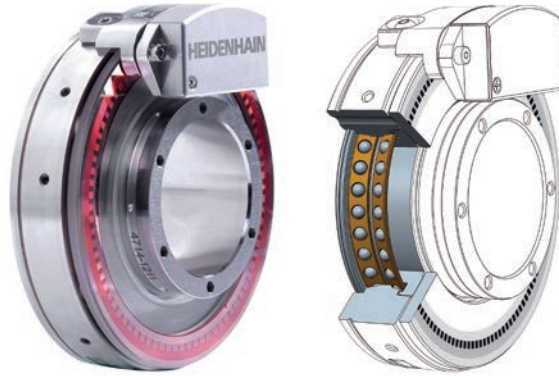
HEIDENHAIN



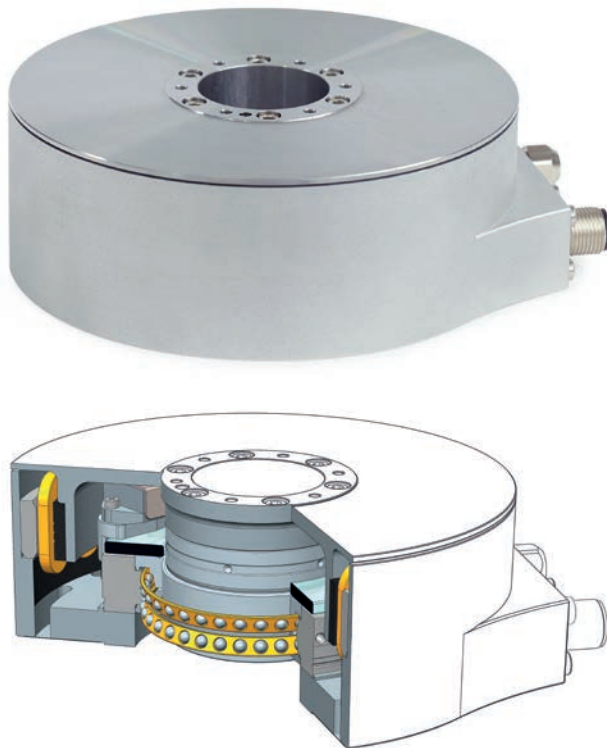
**Angle Encoder
Modules**

Design and applications

The MRP angle encoder modules from HEIDENHAIN consist of an angle encoder and a high-precision bearing that are optimally adjusted to each other. These assemblies feature high measuring and bearing accuracy, very high resolution, and exceptional repeatability, as well as smooth motion thanks to their low starting torque. Their design as specified and tested complete assemblies makes handling and installation easier.



SRP angle encoder modules are additionally equipped with an integrated torque motor. They thus combine a motor, a precision bearing, and an encoder with very high accuracy, all within a single, compact system.



This brochure supersedes all previous editions, which thereby become invalid. The basis for ordering from HEIDENHAIN is always the brochure edition valid when the order is placed.

Standards (ISO, EN, etc.) apply only where explicitly stated in the brochure.

Further information:

Comprehensive descriptions of all available interfaces as well as general electrical information can be found in the *Interfaces of HEIDENHAIN Encoders* brochure.

Information on

- angle encoders with integral bearing and
- HEIDENHAIN interface electronics

is available upon request and on the Internet at www.heidenhain.com.

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Design and applications

Setup

Since HEIDENHAIN manufactures the bearings as well as the encoders, these two functional assemblies are highly integrated. Fewer components are necessary than in conventional solutions, thereby resulting in fewer joints. This permits a very compact and rigid design with particularly low profiles. Currently, angle encoder modules are available with 10 mm, 35 mm and 100 mm hollow shafts. Angle encoder modules with an integrated motor are currently available with a 32 mm hollow shaft.

Properties

The **rolling bearings** used are specifically adapted to the requirements of high-precision rotary axes. Their essential characteristics are very high guideway accuracies, high rigidities, low starting torques, and steady continuous torques. At the same time, value was placed on attaining the most compact dimensions possible and on keeping the mass low. High speeds and high load ratings are not of primary importance.

These **encoders** comply with the high requirements of metrology applications and with those of the electronics industry. Key features include their very high resolution, excellent signal quality, and exceptional repeatability—even under varying operating temperatures. The assemblies are available with either incremental or absolute encoders.

The SRP angle encoder module, which is additionally equipped with an integrated **torque motor** enables smooth motion control. Due to the motor's virtual lack of cogging torque and radial force, the high guideway accuracy of the bearing is not negatively influenced.

Advantages

Angle encoder modules are the combination of a bearing and an encoder. HEIDENHAIN has already completed the necessary assembly and adjustment work. As a result, the characteristics of the angle encoder modules have already been defined and tested in accordance with the customer's desired specifications. Thanks to the simple mechanical interfaces, all critical mounting processes are eliminated. Not only does this greatly simplify the installation process, but it also ensures that the specified accuracy is attained in the application. The effort-intensive matching of all of the individual components to each other and to the machine environment is not necessary, nor is time-consuming testing.

Reproducible guideway accuracy: a decisive characteristic of the bearing

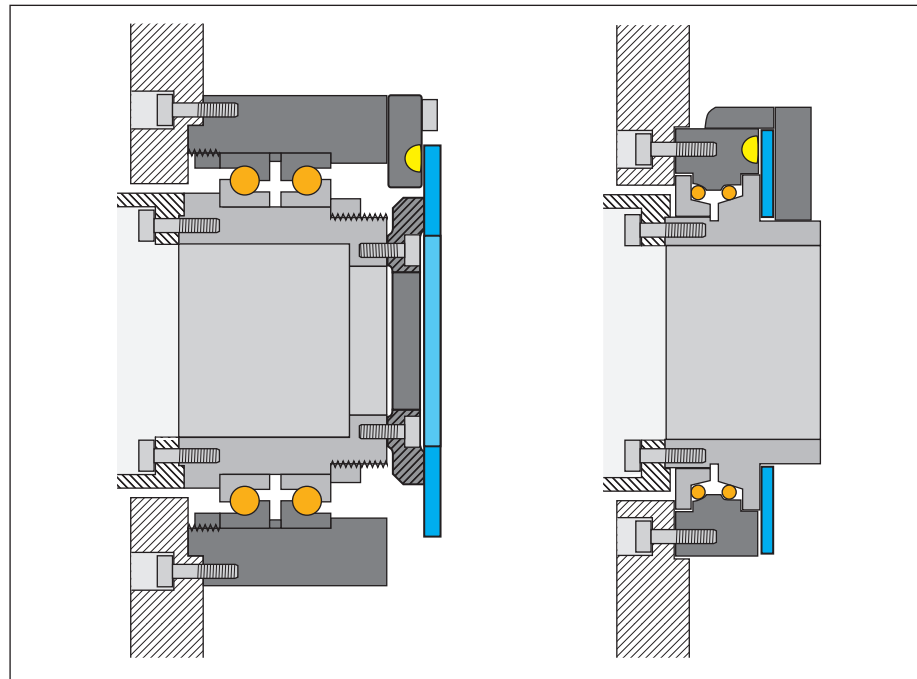
The absolute guideway accuracy of an unloaded air bearing is often superior to that of a rolling bearing. However, in many applications, having the highest possible reproducible guideway accuracy of the bearing is what matters. In this regard, angle encoder modules from HEIDENHAIN can represent an excellent alternative to air-bearing axes. This is because the rolling bearings from HEIDENHAIN exhibit exceptional repeatability, and because the rigidity of the HEIDENHAIN rolling bearings is higher than air bearings of a comparable size by at least a factor of 10. Thus, for axes that are subjected to loads, HEIDENHAIN rolling bearings are the more accurate solution. In addition, rolling bearings are generally less sensitive to shock loads and do not require a regulated air supply—so they are more robust and easier to use.

Areas of application

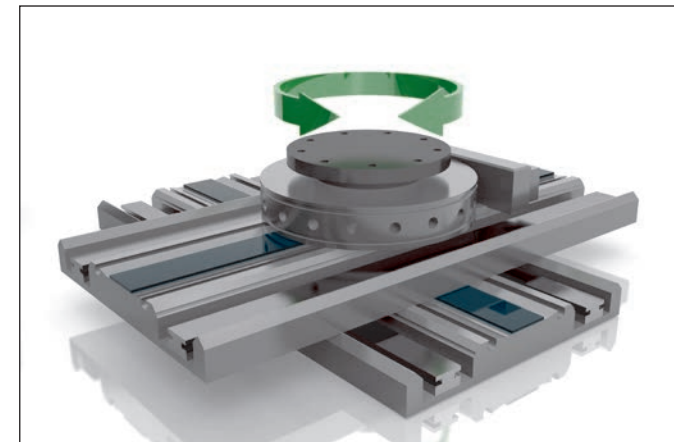
The angle encoder modules are designed for low to medium speeds and medium-sized loads at high to very high bearing accuracy and extremely high repeatability. They are well suited to the special requirements of metrology applications. Typical applications thus include laser trackers in the metrology industry, high-precision rotary tables on measuring machines, and wafer-handling machines in the electronics industry. Angle encoder modules can also be used on machine tools that handle small loads, such as electrical discharge machines or in laser beam machining.

Practical solutions

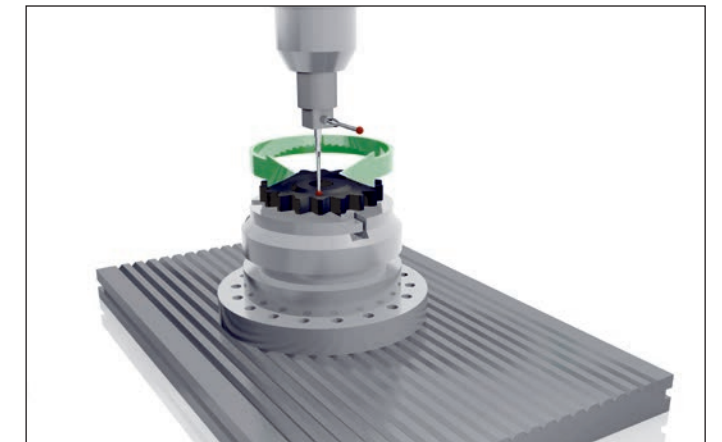
With the angle encoder modules from HEIDENHAIN, the bearing can be adapted to specific customer needs. The preloading, lubrication, contact angle, and materials can be adapted individually to the respective requirements as needed. For more information, please get in touch with your contact person at HEIDENHAIN.



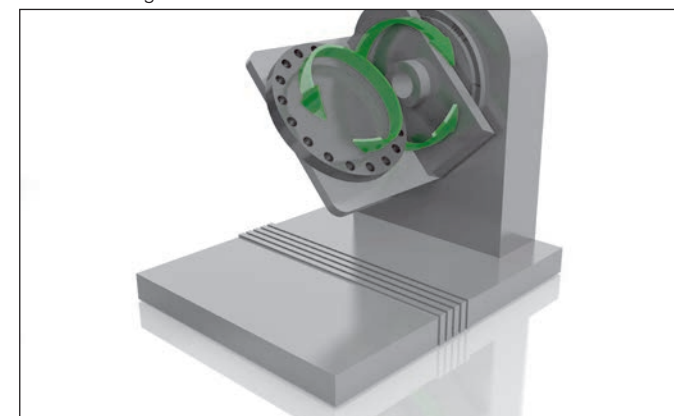
Comparison of a "conventional" precision axis setup and a solution with an angle encoder module from HEIDENHAIN



Wafer handling



High-precision rotary tables



Compact tilting units



Laser trackers

Measuring and bearing accuracy

The accuracy of completely assembled angle encoder modules from HEIDENHAIN depends on the measuring accuracy of their integrated angle encoders and the bearing accuracy of their rolling bearings.

When evaluating the quality of an angle encoder module, HEIDENHAIN takes the following measuring and bearing accuracies into account:

Measuring accuracies

For the measuring accuracies of the integrated angle encoder, the system accuracy and repeatability are of critical importance for the specification of the angle encoder module.

The **system accuracy** of the angle encoder represents the position error within a single revolution, and applies to the entire range of the specified centered load.

A distinction is made between single-sided and double-sided repeatability. **Single-sided repeatability** applies to any number of revolutions as long as the direction of rotation does not change during the measurement. Individual points are approached multiple times, and the maximum deviation among the measured points is determined. This evaluation is performed by means of a comparison with a reference encoder.

For determining the **repeatability** from both directions, the direction of rotation is changed during the measurement. The points are approached from one side and then from the other. The maximum deviation of the measured points among each other is thereby determined. A reference encoder is used for positioning.

For both values, the absolute deviation compared with the reference is inconsequential and is not the goal of the measurement.

Bearing accuracies

For the evaluation of the bearing accuracy, the oft-cited radial runout accuracy is not as important as the guideway accuracy of the bearing. The guideway accuracy is the deviation of the actual axis of rotation from the ideal nominal axis of rotation of the bearing. The radial and axial guideway accuracy of the bearing, as well as the wobble, are determined for the evaluation.

The **guideway accuracy** is measured with the aid of a calibration standard, such as a ceramic sphere with a known roundness. The center point of the sphere is positioned at a defined distance vertically above the center of the bearing raceway.

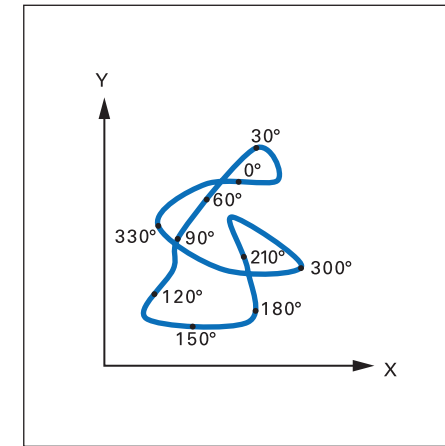
The measurement of the **radial guideway accuracy** is performed with two length gauges. They are positioned at a 90° angle relative to each other at the height of the sphere center. When the bearing is rotated, they measure each radial deviation of the sphere in the X and Y directions.

The radial guideway accuracy depends on the distance to the bearing plane. For this reason, it is best to perform the measurement at various distances to the bearing plane. A defined number of revolutions are used for these measurements. The result is a measure of the deviation of the actual axis of rotation from the ideal nominal axis of rotation for every rotation angle of the

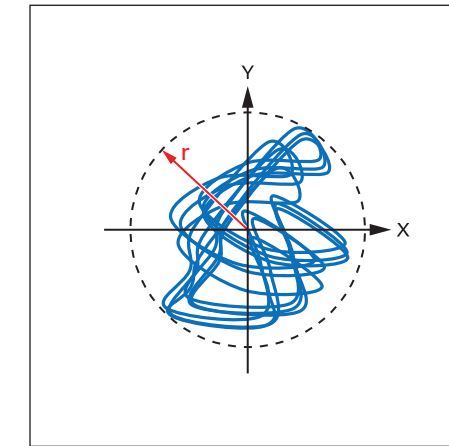
bearing. The misalignment of the measuring standard relative to the bearing axis is mathematically removed from the result.

This analysis yields values that contain both recurring (reproducible) errors and random (non-reproducible) errors. Since the measurements are always performed over multiple revolutions, the reproducible

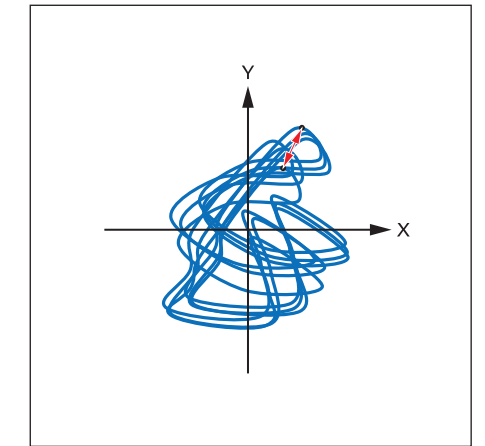
errors can, in turn, be separated from the non-reproducible errors. This ultimately permits a trustworthy assessment of both components of the guideway accuracy, as well as clear information on the actual quality of the bearing without external influences.



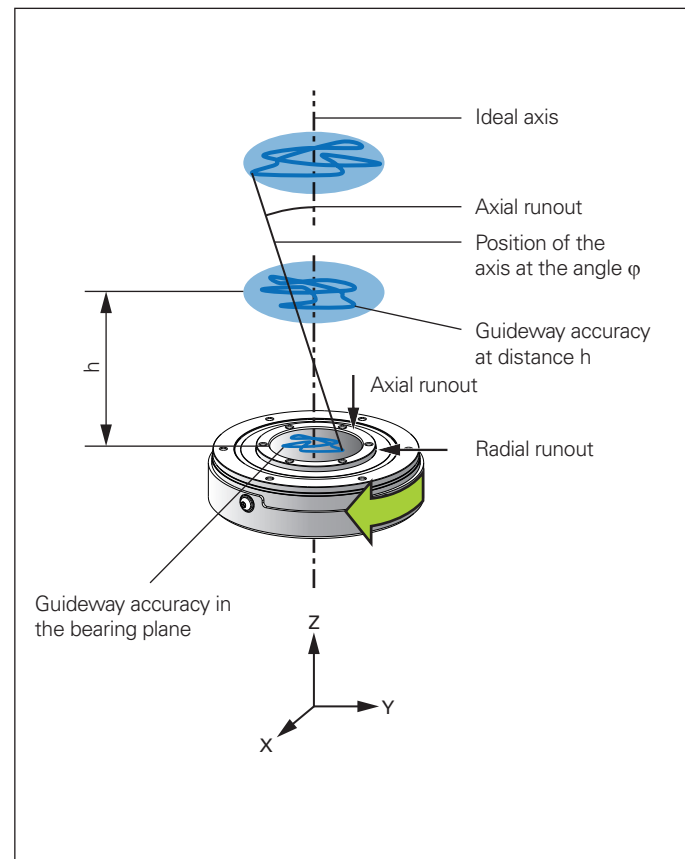
The amount of **radial error** in the X and Y directions depends on the rotation angle of the bearing. In order to illustrate the position-dependent errors, the radial error can be represented as a curve.



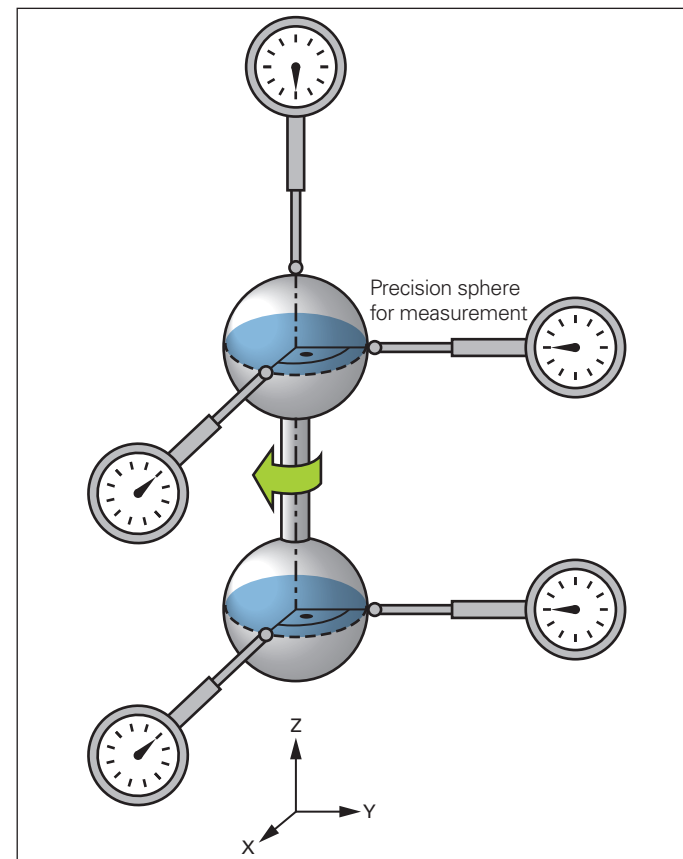
The radius r of the smallest possible circle that encloses all of the curves corresponds to the **radial guideway accuracy**. The radius is determined based on the maximum deviations of the actual axis of rotation relative to the ideal nominal axis of rotation for eight revolutions of the bearing.



For determining the **non-reproducible radial guideway accuracy**, the deviation is measured at the same rotation angle over eight revolutions. The non-reproducible radial guideway accuracy corresponds to the maximum deviation of the determined values.



Measured values and measuring locations on the rolling bearing (schematic representation)



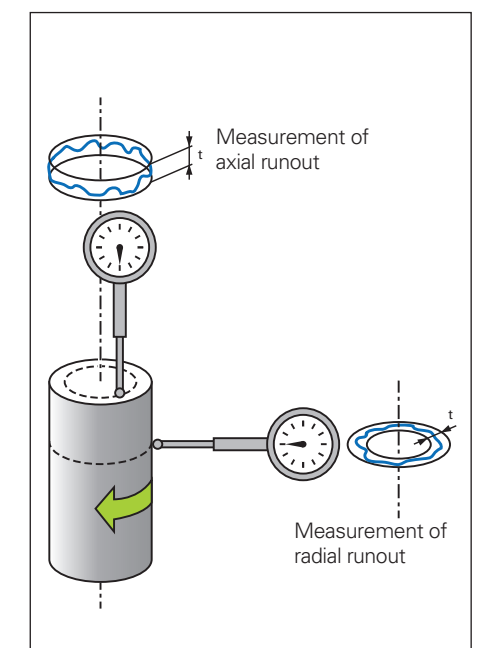
Measurement of the axial and radial guideway accuracy with five length gauges

For the measurement of the **axial guideway accuracy**, a length gauge is centered above the sphere. This gauge then records any up and down movements of the sphere in the Z direction while the bearing is rotating.

Wobble describes the tilt angle of the rotor axis relative to the bearing axis during rotation of the bearing. The maximum value of the measurement is indicated. One method of determining the wobble is to measure the radial guideway accuracy in two planes.

As opposed to the guideway accuracy, the **radial runout** is the value measured by a length gauge perpendicular to a surface. This indicated value therefore includes both the guideway accuracy of the bearing and the form errors in the roundness and coaxiality of the surface being measured.

The **axial runout** is similar. It is the value that is measured in the axial direction perpendicularly to the surface. The guideway accuracy of the bearing and the form errors of the surface are contained in the axial runout as well.



Measurement of axial and radial runout

Information on bearing loads

Specifications

All of the specifications of the bearing characteristics refer to use without additional loads. Moreover, it is assumed that all mounting parts are dimensioned in accordance with the dimension drawings and are made of steel.

Maximum permissible loads

Two factors play a key role in the specifications for the maximum permissible axial, radial, and tilting loads.

One important factor is the position of the axial load. While a strictly axial load (Figure 1) has no influence on the system accuracy, a low influence on the system accuracy is detectable in the case of a tilting load (Figure 2). In both cases, reproducibility is not affected.

A further role is played by the limit values, which are required in order to reach the fatigue limit. For the sake of assuming a fatigue limit of the bearing, the contact stress (Hertzian pressure at contact of the rolling elements) according to DIN ISO 281 must not exceed a value of 1500 MPa. The loads stated in the specifications are defined such that this value is not exceeded. The overlapping of individual loads is not taken into account. In addition, the stated values are for a purely static load.

In many cases, it is possible to exceed the specified loads. The constraints in such cases should be discussed with HEIDENHAIN in order to more closely define possible applications.

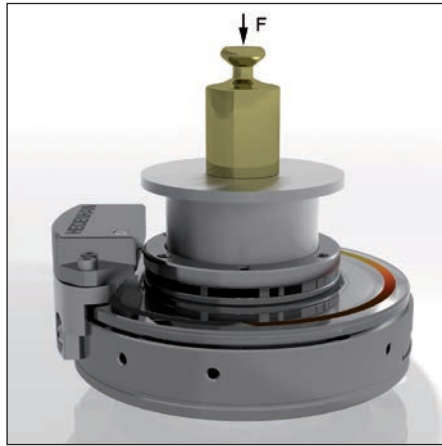


Figure 1: Axial load via center load

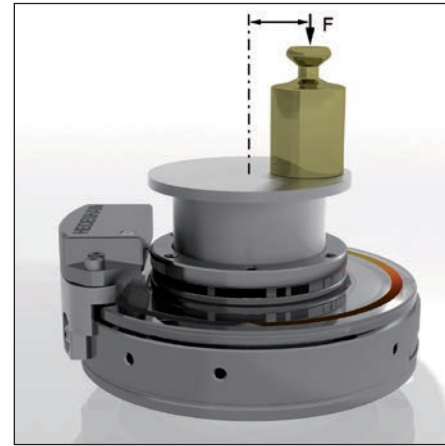
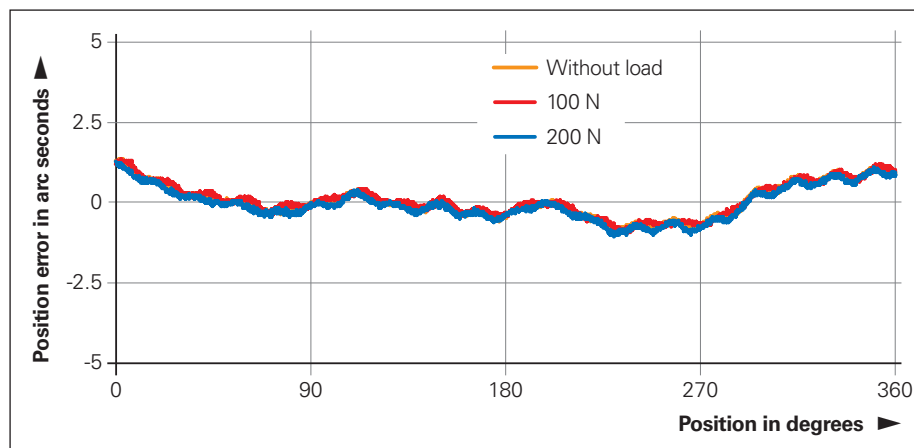
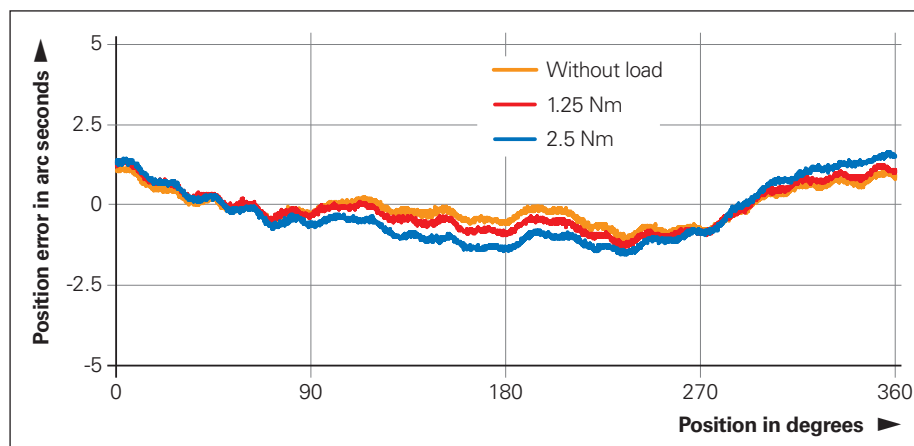


Figure 2: Off-axis tilting load



Position error under axial load with the MRP 5080



Position error under tilting load with the MRP 5080

Information on moment of friction and lubrication

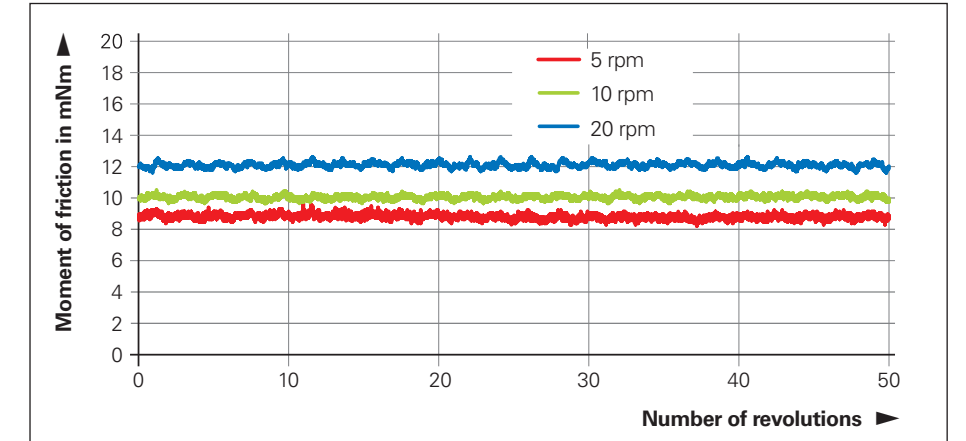
Moment of friction

Angle encoder modules from HEIDENHAIN are characterized by a constant moment of friction and low breakaway torque. All angle encoder modules undergo a run-in process following production. This ensures that the moment of friction remains constant over a long period. In principle, the moment of friction is always dependent on the rotational speed.

The specifications for the moment of friction were determined in the speed range of ≤ 300 rpm.

Lubrication

The lubrication of a HEIDENHAIN angle encoder module is designed to last for the entire service life, so that maintenance is not required. Only high-quality lubricants are used.



Speed-dependent moment of friction with the MRP 5000

Information on the motor

Slotless torque motor

The motor, which was specially developed for the SRP angle encoder module, meets even the highest requirements placed on high-precision rotary axes.

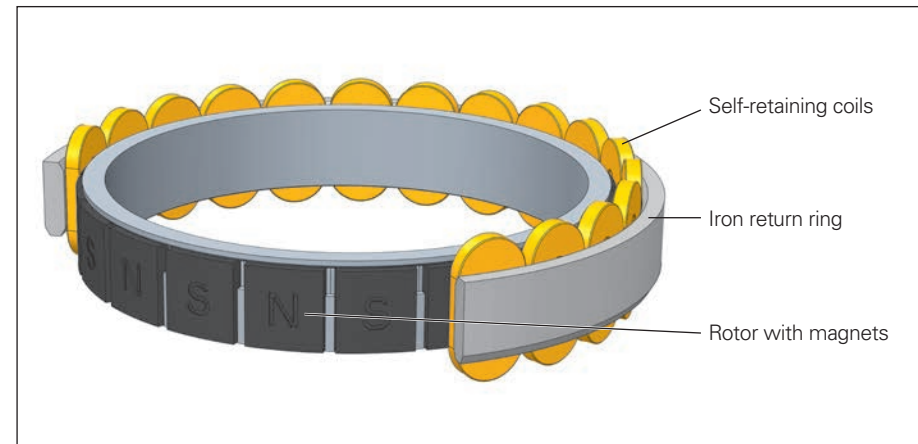
The motor is cogging-free and produces no disturbing influences on the high-accuracy bearing. This allows for exceptionally uniform motion control and positioning accuracy.

The drive uses a slotless, iron-core torque motor. This motor therefore combines two normally contradictory characteristics—high torque density and low cogging torque. This type of motor omits the slots that are found in conventional designs, with self-retaining coils used instead.

Thanks to the motor's special design and the particularly symmetrical arrangement of all of its components, the rotor is always exposed to a constant magnetic field throughout its entire rotation.

An iron return ring enables a comparatively large amount of torque. All of this results in the following benefits:

- Extremely low cogging torque
- No interfering radial forces
- Medium-sized torques
- High dynamics in controlled operation
- Low thermal power loss
- Compact dimensions



Slotless iron-core permanent-magnet-excited AC synchronous motor

Protection from thermal overloading

The SRP 5000 series devices can be operated under the following conditions. The ambient and mounting conditions must be complied with in accordance with the data provided in the data sheet.

Motor in operation (shaft speed ≠ 0):

- At continuous current (I_c): for a very long (unlimited) amount of time
- At maximum current (I_p): for up to 1 s. The maximum current (I_p) must not be exceeded
- With currents between continuous current (I_c) and maximum current (I_p) that flow for longer than 1 s, protection against thermal overloading must be implemented via an I^2t monitor in the controller electronics

Motor at standstill (shaft speed = 0):

- At stall current (I_s): for a very long (unlimited) amount of time
- At continuous current (I_c): for up to 3 minutes.

For protection against thermal overloading, suitable measures are required in the controller electronics (e.g., an I^2t monitor). Direct monitoring of the temperature by means of temperature sensors in the motor windings is not possible.

If the instantaneous current value exceeds the I^2t RMS current limit, then an integrator circuit is activated. If the integrator circuit reaches the I^2t time limit, then the controller must stop the current supply to the motor.

I^2t RMS current limit	= I_s motor at standstill (speed = 0)
	= I_c motor in operation (speed ≠ 0)
I^2t time limit	= $(I_p^2 - I_c^2) \cdot t$

Operation with AccurET position controllers

The AccurET position controllers are the perfect complement to the SRP angle encoder modules. With them, top performance can be attained in terms of dynamics and position stability.

The compact AccurET position controllers accommodate a broad range of voltages and currents. This greatly simplifies the integration of different servo motors into a single machine.

Multiple position controllers connected to the same DC bus voltage can be supplied by a single power supply. Each controller can drive two axes.

Cogging torque

For the plotting of the cogging torque, the integrated torque motor is in its de-energized state and is driven by an external source of torque. The maximum occurring cogging torque is typically compared with the rated torque of the integrated torque motor and is therefore a percentage. For the SRP 5010 and SRP 5080 angle encoder modules, the maximum cogging torque is ≤ 0.2 % of the rated torque.

Since the position controllers do not require a mounting rack, the amount of space required depends only on the number of axes to be controlled. The simplified power and communication cabling, as well as the modular cooling unit, facilitates the installation and maintenance of the machine.

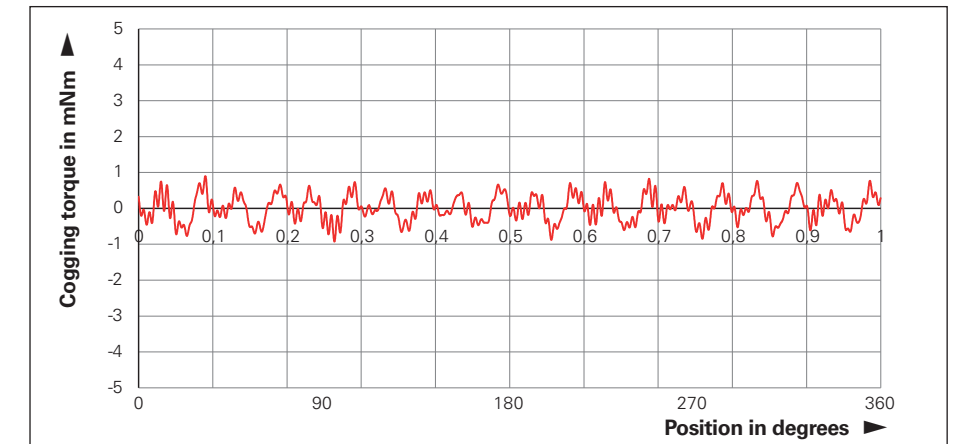
With the recommended AccurET controllers from ETEL, the characteristics for protection against thermal overloading are already integrated.

AccurET Modular 48:

The AccurET Modular 48 controller is available in two versions. One version permits the installation of an optional card, such as the UltimET motion controller or the I/O card.

AccurET VHP 48:

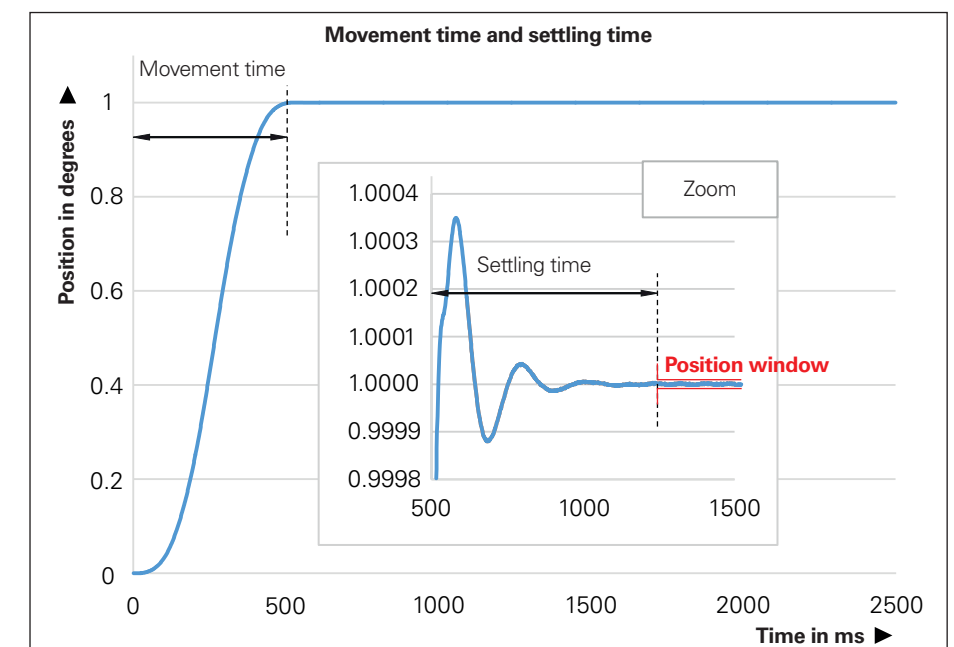
Controller with a high-speed encoder input and special supply module for applications with very high synchronization and position accuracy demands.



Cogging torque with the SRP 5000

Movement time

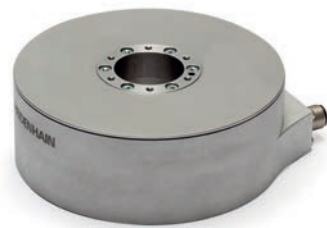
For the evaluation of the dynamic behavior of the SRP 5000, a defined angular position is specified for the device. The movement time during which the angular position is approached depends heavily on the specified parameters for maximum speed, acceleration, and jerk time. The load arising from the given application also influences the movement time.



Movement time and settling time with position window

Settling time and the position window

After the angular position has been reached, the system requires a certain amount of time to settle before the required position window is reached. This time is referred to as the settling time and varies depending on the load applied to the driven angle encoder module. The position window is specified by the respective application.



Without load

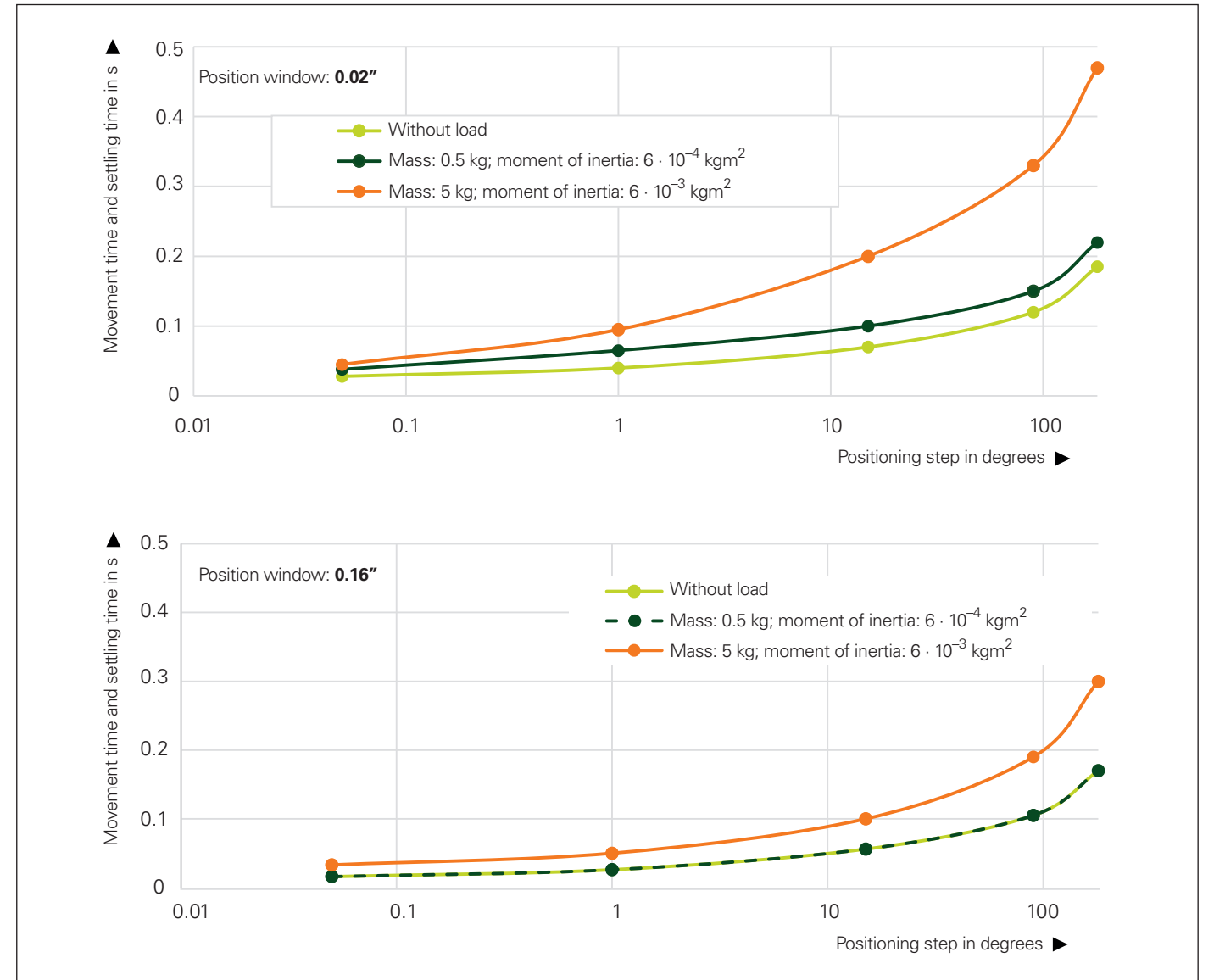


Mass: 0.5 kg;
Moment of inertia: $6 \cdot 10^{-4} \text{ kgm}^2$



Mass: 5 kg;
Moment of inertia: $6 \cdot 10^{-3} \text{ kgm}^2$

SRP 5000 with different loads



Settling time for different position windows with the AccurET VHP 48 position controller and the specified parameters:

Maximum speed	Acceleration	Jerk time
1800 °/s	34000 °/s ²	0.0052 s

Mechanical design types and mounting

The angle encoder module consists of an already preloaded bearing unit with a mounted angle encoder.

Proper mounting is critical for ensuring good guideway accuracy for the bearing. During mounting, please observe the following:

- The flatness of the mounting parts
- Compliance with the specified screw torque values
- The screw tightening sequence
- The specified load direction
- The transferable torque of the respective joints

A precise alignment of the angle encoder module is not required, because the angle encoder module and bearing are already ideally aligned to each other. Centering collars on the mounting parts, however, can facilitate mounting.

Angle encoder modules must not be combined or stressed with a second fixed bearing. If another support bearing is required, then it must be designed as a floating bearing.

Materials for mounting

The mounting parts must be made of steel. The material must exhibit a coefficient of thermal expansion of $\alpha = (10 \text{ to } 16) \cdot 10^{-6} \text{ K}^{-1}$. Additionally, the material must meet the following specifications:

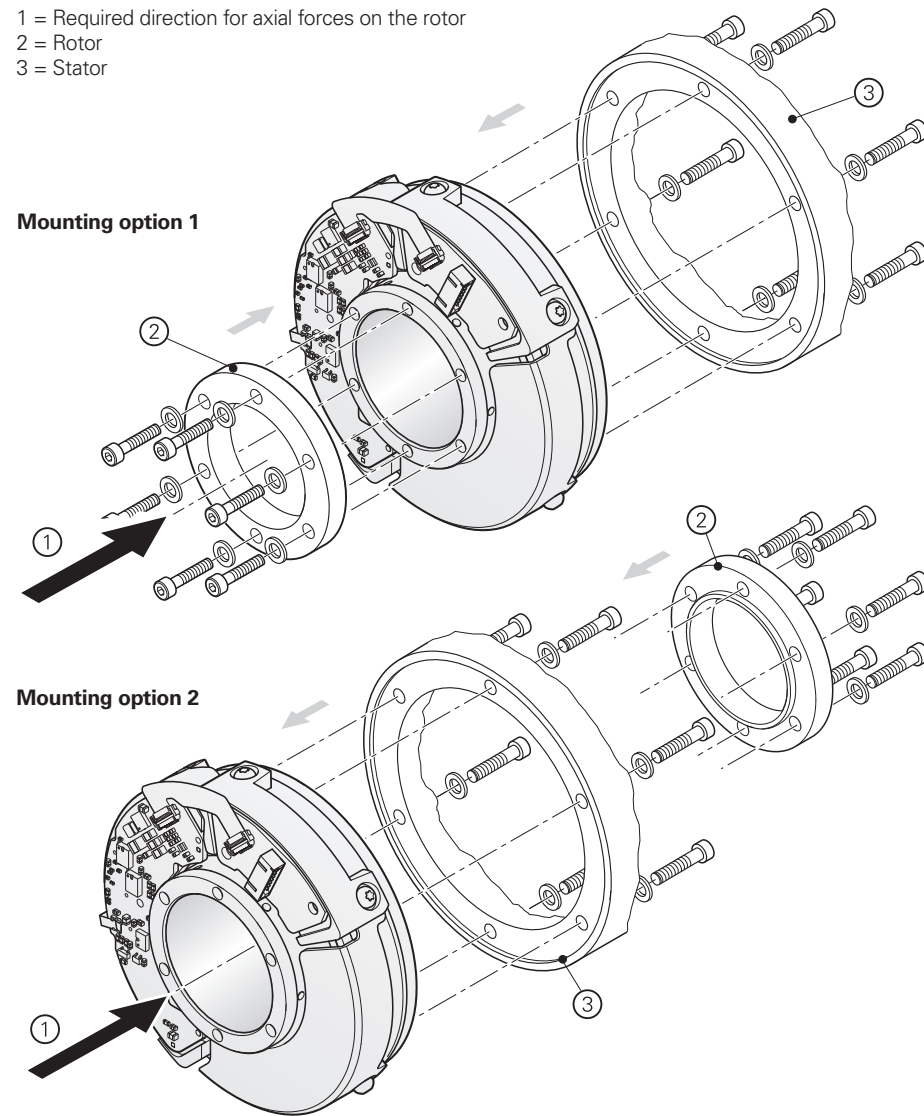
- $R_e \geq 235 \text{ N/mm}^2$
- $R_m \geq 400 \text{ N/mm}^2$

Electromagnetic compatibility

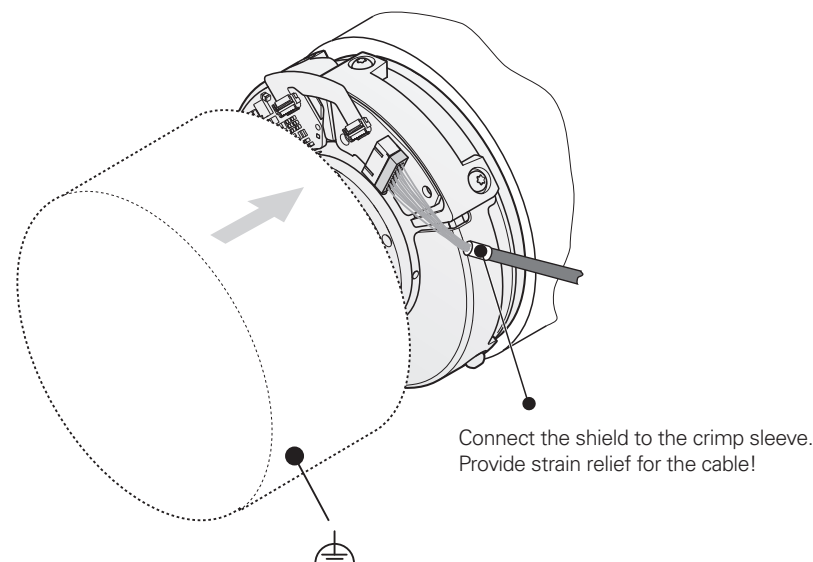
For devices with an IP00 rating, the customer must provide a suitable protective cap and shield connection.

Protection against environmental factors

Suitable measures must be employed in order to protect the devices from environmental factors. The information in the *Specifications* must be complied with.



Mounting options of the MRP 5010 devices



Calibration charts

Prior to shipping, HEIDENHAIN tests the functionality of each angle encoder module and measures its accuracy.

A Quality Inspection Certificate documents the **system accuracy**, which is ascertained via eight forward and eight backward measurements. The measuring positions per revolution are selected such that both the long-range error and the position error within a single signal period are ascertained with great accuracy.

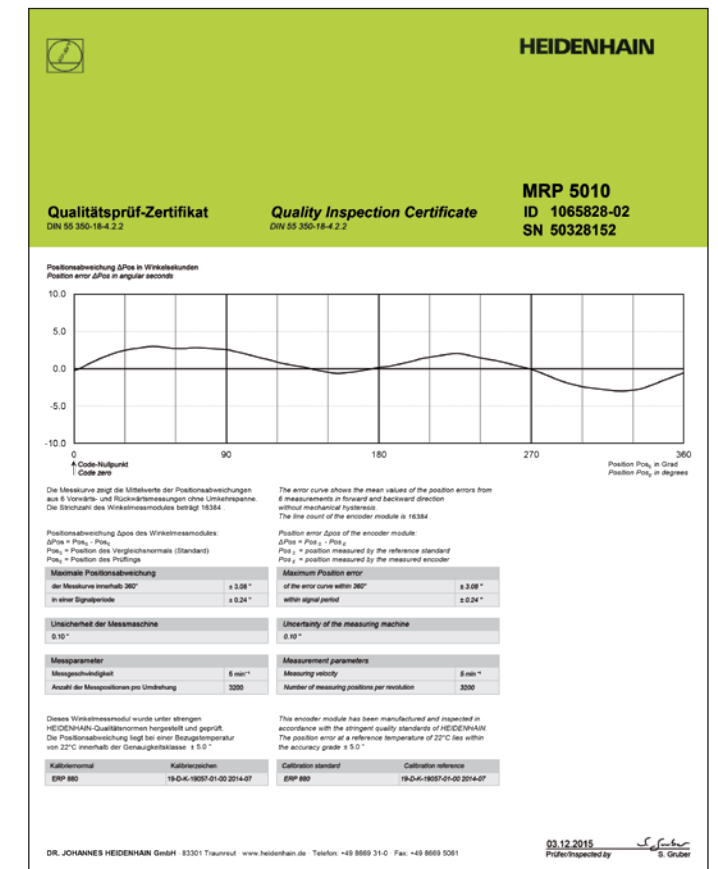
The **mean value curve** shows the arithmetic mean of the measured values. Hysteresis is not taken into consideration.

The **calibration standard** stated in the Quality Inspection Certificate establishes the link to national and international standards and ensures traceability.

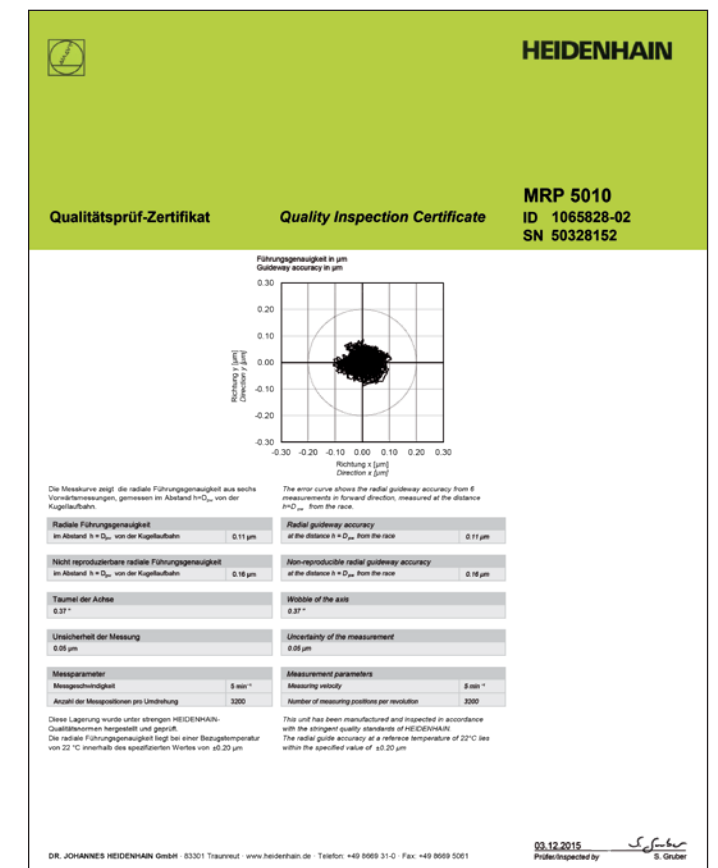
An additional Quality Inspection Certificate documents the **radial guideway accuracy**. This measurement is conducted with eight forward movements at a defined distance vertically above the bearing raceway's center.

The measurement curve shows the deviation of the actual axis of rotation from the ideal nominal axis of rotation with respect to the bearing's rotation angle.

The **non-reproducible radial guideway accuracy** is the maximum deviation among all of the measuring points at the same angular position.



The Quality Inspection Certificate documents the system accuracy.



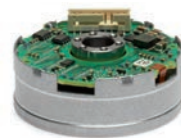
The Quality Inspection Certificate documents the radial guideway accuracy.

MRP 2000 series

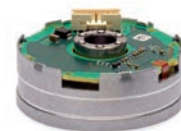
Angle encoder modules with integrated encoder and bearing

- Particularly compact dimensions
- High measuring and bearing accuracy
- Hollow shaft \varnothing 10 mm

Encoder characteristics	Incremental MRP 2080	Absolute MRP 2010
Measuring standard	DIADUR circular scale	
Signal periods	2048	
System accuracy	$\pm 7''$	
Position error per signal period	$\pm 1.5''$	
Repeatability	From both directions: $3''$	
RMS position noise	Typically $0.07''$	Typically $0.01''$
Interface	$\sim 1 V_{PP}$	EnDat 2.2
Ordering designation	–	EnDat22
Position values per revolution	–	25 bits
Clock frequency Calculation time t_{cal}	–	≤ 16 MHz $\leq 7 \mu s$
Reference marks	1	–
Cutoff frequency -3 dB	≥ 210 kHz	–
Electrical connection	14-pin header; adapter cable with quick connector as accessory	12-pin
Cable length	≤ 30 m (with HEIDENHAIN cable)	
Supply voltage	DC 5 V ± 0.25 V	DC 3.6 V to 14 V
Power consumption (max.)	5.25 V: ≤ 700 mW	3.6 V: ≤ 0.6 W 14 V: ≤ 0.7 W
Current consumption (typical)	Without load: $I_p = 60$ mA; max. 120 mA With load: max. 130 mA	5 V: 85 mA (without load)



MRP 2010



MRP 2080

Bearing properties	Incremental MRP 2080	Absolute MRP 2010
Shaft	Hollow through shaft D = 10 mm	
Max. permissible axial load ³⁾	50 N (centered load)	
Max. permissible radial load ³⁾	45 N	
Max. permissible tilting torque ³⁾	0.8 Nm	
Contact stiffness	Axial: 54 N/ μm Radial: 153 N/ μm (calculated values)	
Resistance to tilt	2.16 Nm/mrad (calculated value)	
Mech. permissible speed	2000 rpm	
Moment of friction	≤ 0.020 Nm	
Starting torque	≤ 0.010 Nm	
Max. transferable shaft torque ³⁾	0.3 Nm	
Moment of inertia of rotor	$3.5 \cdot 10^{-6}$ kgm ²	
Radial guideway accuracy	Measured at distance h = 20 mm from the rotor mating surface: $\leq 0.60 \mu m$	
Non-reproducible radial guideway accuracy	Measured at distance h = 20 mm from the rotor mating surface: $\leq 0.70 \mu m$	
Axial guideway accuracy	$\leq \pm 0.3 \mu m$	
Axial runout of the surface	$\leq 8 \mu m$	
Wobble of the axis	$2.5''$	
Vibration 55 Hz to 2000 Hz Shock 6 ms	≤ 200 m/s ² (EN 60068-2-6) ≤ 100 m/s ² (EN 60068-2-27) (without load)	
Protection EN 60529 ²⁾	IP00 ¹⁾	
Operating temperature Storage temperature	0 °C to 50 °C 0 °C to 50 °C	
Relative air humidity	≤ 75 % without condensation	
Mass	0.12 kg (without cable or connector)	

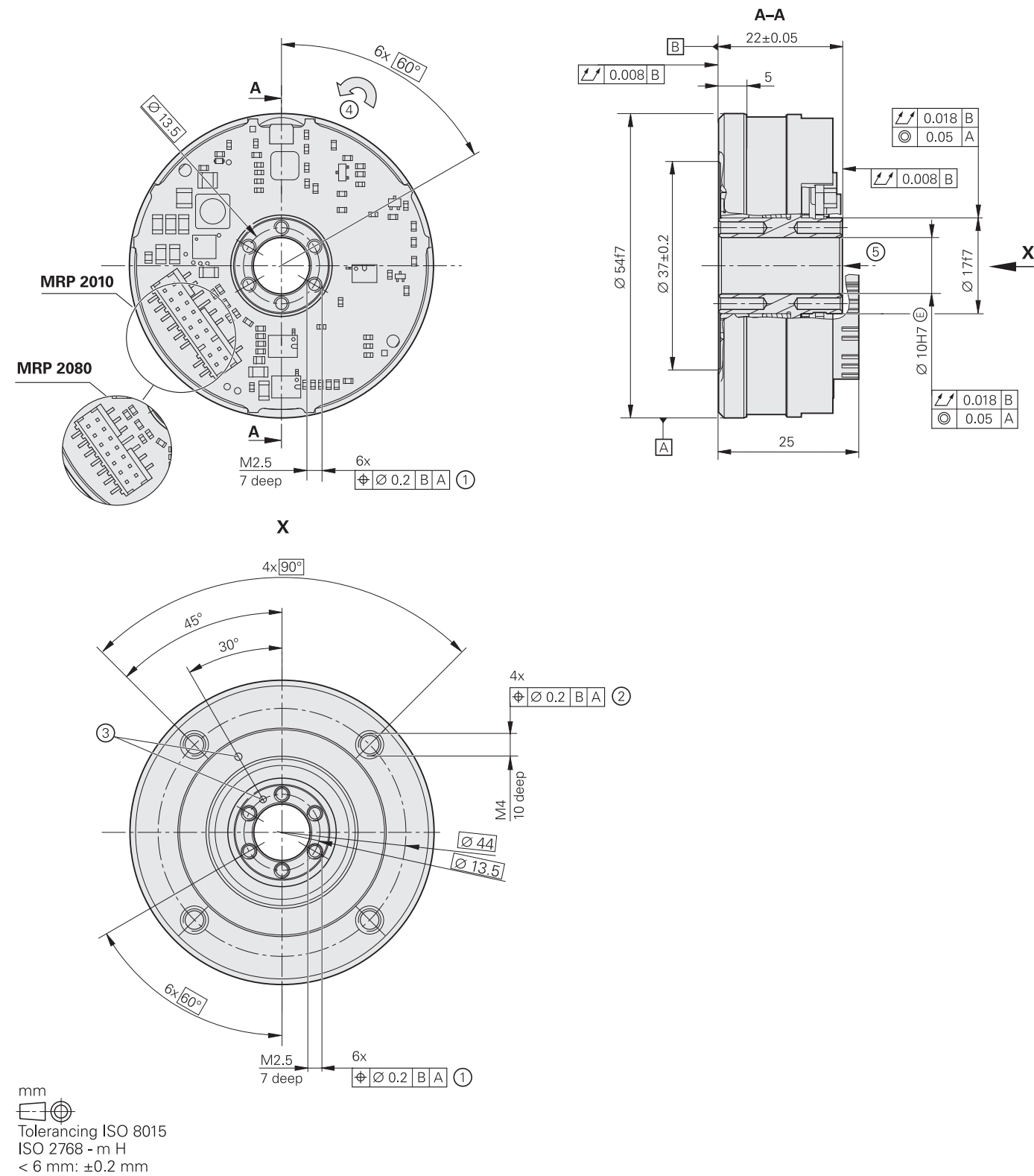
¹⁾ Electromagnetic compatibility must be ensured in the complete system through appropriate installation measures

²⁾ When mounted

³⁾ Purely static load, without additional vibrations or shock load

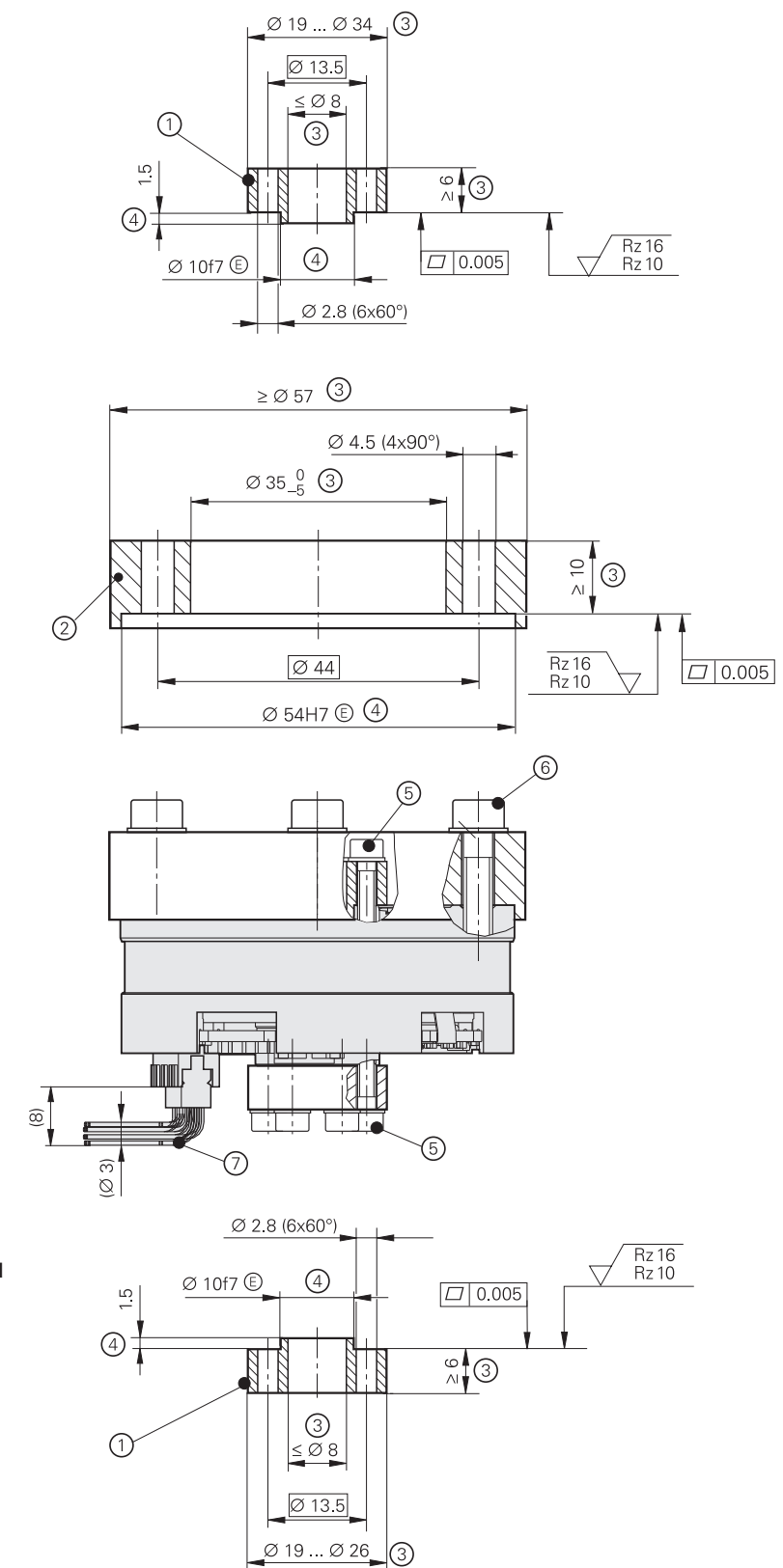
MRP 2000 series

MRP 2010, MRP 2080



- 1 = Tightening torque of the M2.5 – 8.8 cylinder head screws: 0.6 Nm ±0.03 Nm
- 2 = Tightening torque of the M4 – 8.8 cylinder head screws: 2.5 Nm ±0.13 Nm
- 3 = Marking of the 0° position ±5°
- 4 = Direction of rotation for ascending position values
- 5 = Required direction for axial forces

Mating dimensions of the mounting parts



Note the information on mechanical design types and mounting.

- 1 = Rotor
- 2 = Stator (do not use as rotor)
- 3 = Required mounting dimensions for the transfer of the maximum permissible loads as per the specifications
- 4 = Optional recommended mating dimensions
- 5 = Screw: ISO 4762 – M2.5 – 8.8. Materially bonding threadlocker required. Washer: ISO 7092 – 2.5 – 200HV; tightening torque: 0.6 Nm ±0.03 Nm
- 6 = Screw: ISO 4762 – M4 – 8.8. Materially bonding threadlocker required. Washer: ISO 7092 – 3 – 200HV; tightening torque: 2.5 Nm ±0.13 Nm
- 7 = Customer is responsible for electrical shielding and connecting cables

MRP 5000 series

Angle encoder modules with integrated encoder and bearing

- Compact dimensions
- High measuring and bearing accuracy
- Hollow shaft \varnothing 35 mm

Encoder characteristics	Incremental MRP 5080	Absolute MRP 5010
Measuring standard	OPTODUR circular scale	DIADUR circular scale
Signal periods	30000	16384
System accuracy*	$\pm 2.5''$ or $\pm 5''$	
Position error per signal period	$\pm 0.23''$	$\pm 0.40''$
Repeatability	From both directions: $0.3''$	From both directions: $0.9''$
RMS position noise	Typically $0.007''$	Typically $0.020''$
Interface	$\sim 1 V_{PP}$	EnDat 2.2
Ordering designation	–	EnDat22
Position values per revolution	–	28 bits
Clock frequency Calculation time t_{cal}	–	≤ 16 MHz $\leq 5 \mu s$
Reference marks	80 (distance-coded)	–
Cutoff frequency –3 dB	≥ 500 kHz	–
Electrical connection	1.5 m cable with 15-pin D-sub connector; interface electronics integrated into the connector	15-pin header; adapter cable with quick connector as accessory
Cable length	≤ 30 m (with HEIDENHAIN cable)	
Supply voltage	DC 5 V ± 0.25 V	DC 3.6 V to 14 V
Power consumption (max.)	5.25 V: ≤ 950 mW	3.6 V: ≤ 1.1 W 14 V: ≤ 1.3 W
Current consumption (typical)	175 mA (without load)	5 V: 140 mA (without load)

* Please select when ordering

Bearing properties	Incremental MRP 5080	Absolute MRP 5010
Shaft	Hollow through shaft D = 35 mm	
Max. permissible axial load ³⁾	200 N (centered load)	
Max. permissible radial load ³⁾	60 N	
Max. permissible tilting torque ³⁾	2.5 Nm	
Contact stiffness	Axial: 303 N/ μm Radial: 181 N/ μm (calculated values)	
Resistance to tilt	102 Nm/mrad (calculated value)	
Mech. permissible speed	300 rpm	
Moment of friction	≤ 0.025 Nm	
Starting torque	≤ 0.015 Nm	
Max. transferable shaft torque ³⁾	2 Nm	
Moment of inertia of rotor	$0.13 \cdot 10^{-3}$ kgm ²	
Radial guideway accuracy	Measured at distance h = 40 mm from the rotor mating surface: $\leq 0.20 \mu m$ (without load)	
Non-reproducible radial guideway accuracy	Measured at distance h = 40 mm from the rotor mating surface: $\leq 0.35 \mu m$ (without load)	
Axial guideway accuracy	$\leq \pm 0.2 \mu m$	
Axial runout of the shaft	$\leq 5 \mu m$	
Wobble of the axis	0.7''	
Vibration 55 Hz to 2000 Hz Shock 6 ms	≤ 200 m/s ² (EN 60068-2-6) ≤ 100 m/s ² (EN 60068-2-27) (without load)	
Protection EN 60529 ²⁾	IP20	IP00 ¹⁾ or IP40
Operating temperature Storage temperature	0 °C to 50 °C 0 °C to 50 °C	
Relative air humidity	≤ 75 % without condensation	
Mass	0.5 kg (without cable or connector)	

¹⁾ Electromagnetic compatibility must be ensured in the complete system through appropriate installation measures

²⁾ When mounted

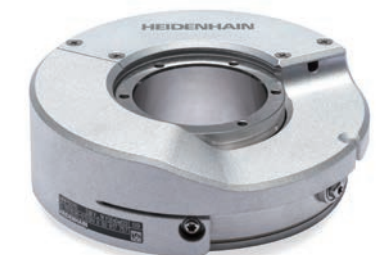
³⁾ Purely static load, without additional vibrations or shock load



MRP 5080



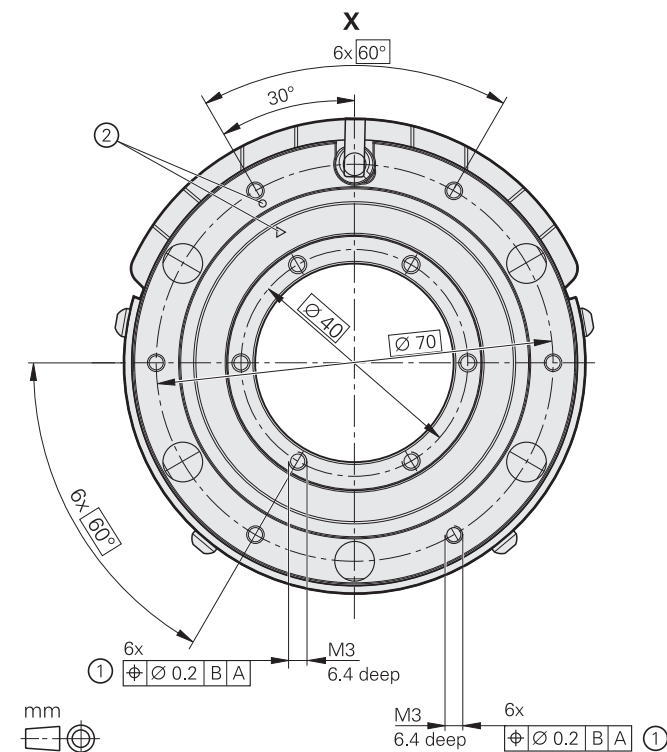
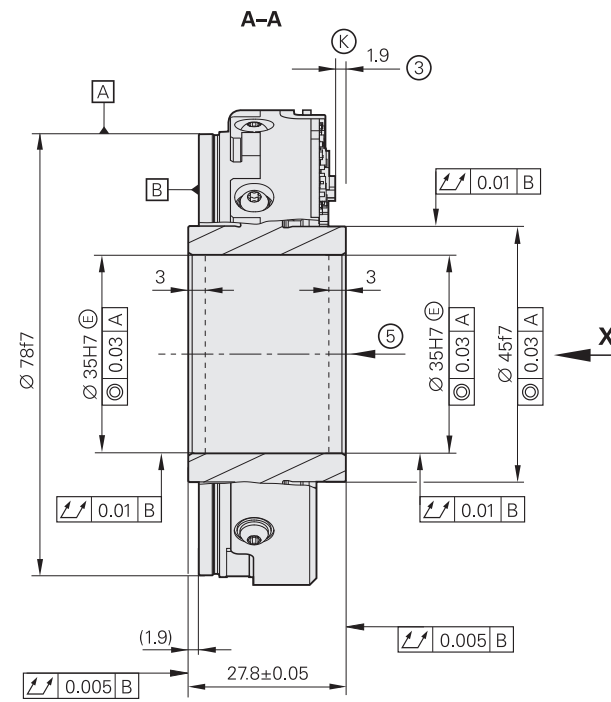
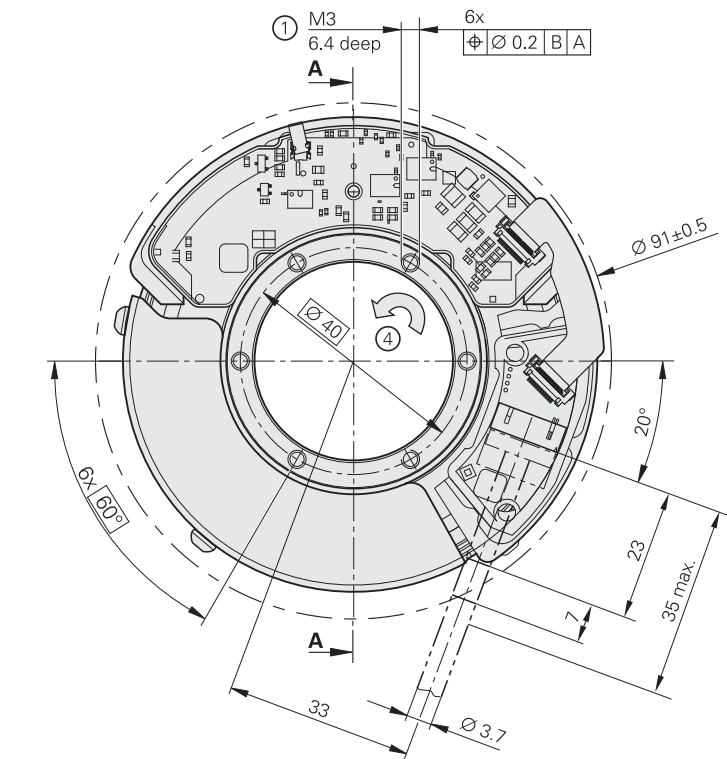
MRP 5010



MRP 5010
with cover

MRP 5000 series

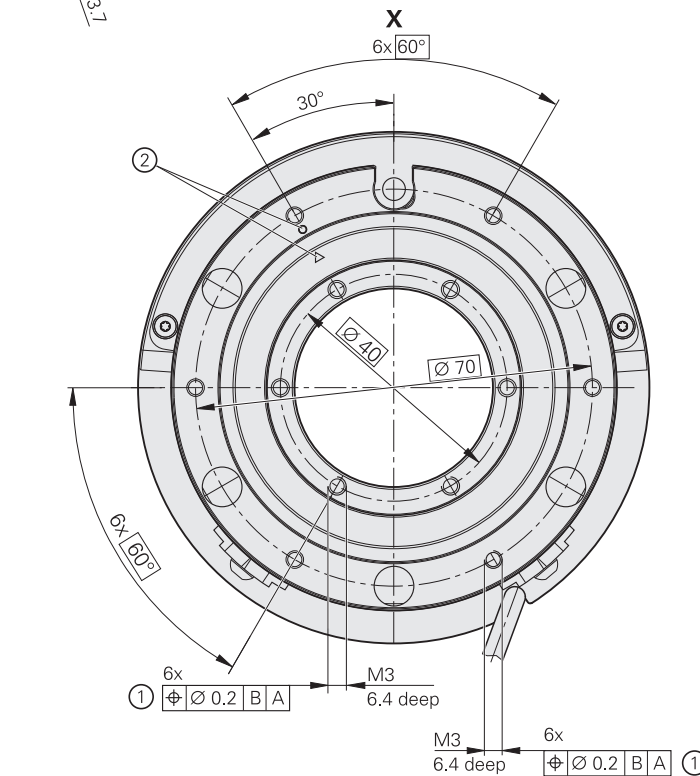
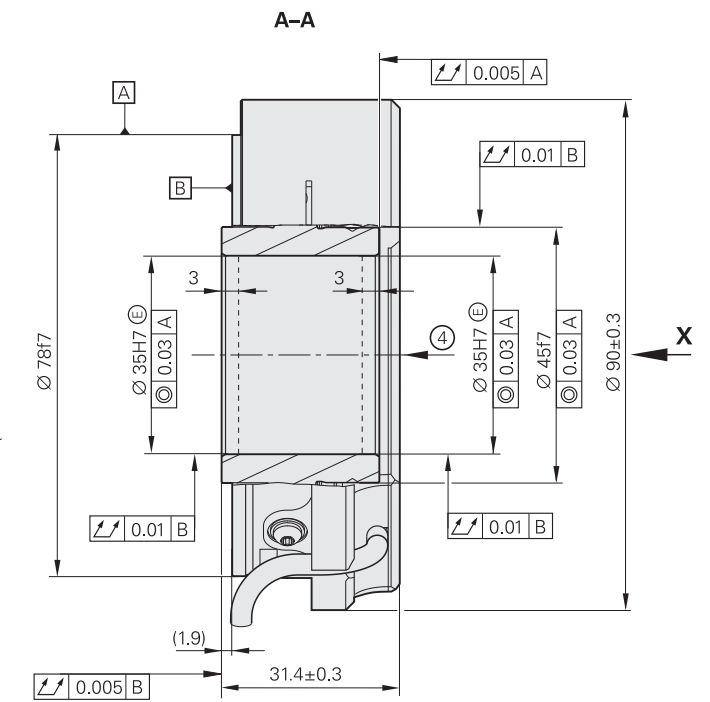
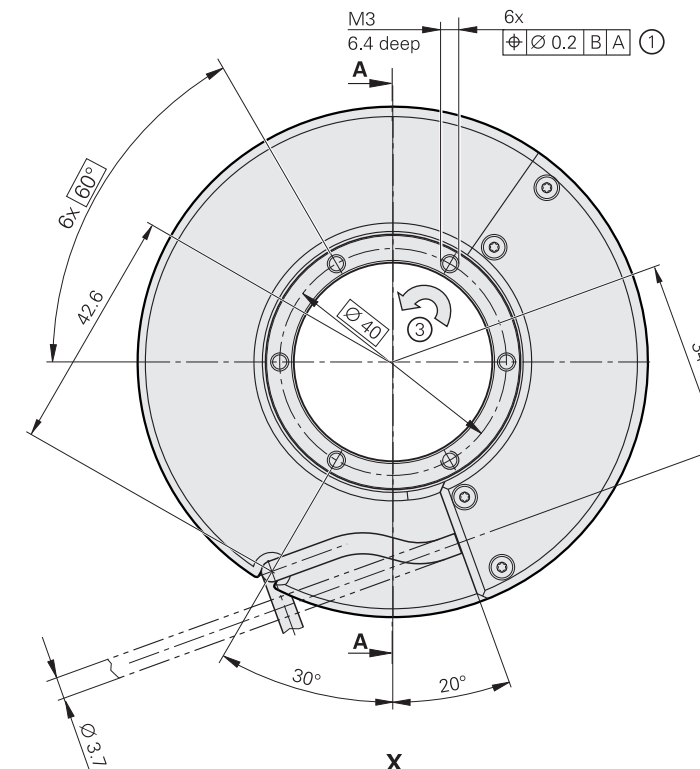
MRP 5010



mm
 Tolerancing ISO 8015
 ISO 2768 - m H
 < 6 mm: ± 0.2 mm

- ⊗ = Required mating dimensions
- 1 = Tightening torque of the M3 – 8.8 cylinder head screws: 1.1 Nm ± 0.05 Nm
- 2 = Marking of the 0° position $\pm 5^\circ$
- 3 = Maintain clearance to cover
- 4 = Direction of rotation for ascending position values
- 5 = Required direction for axial forces

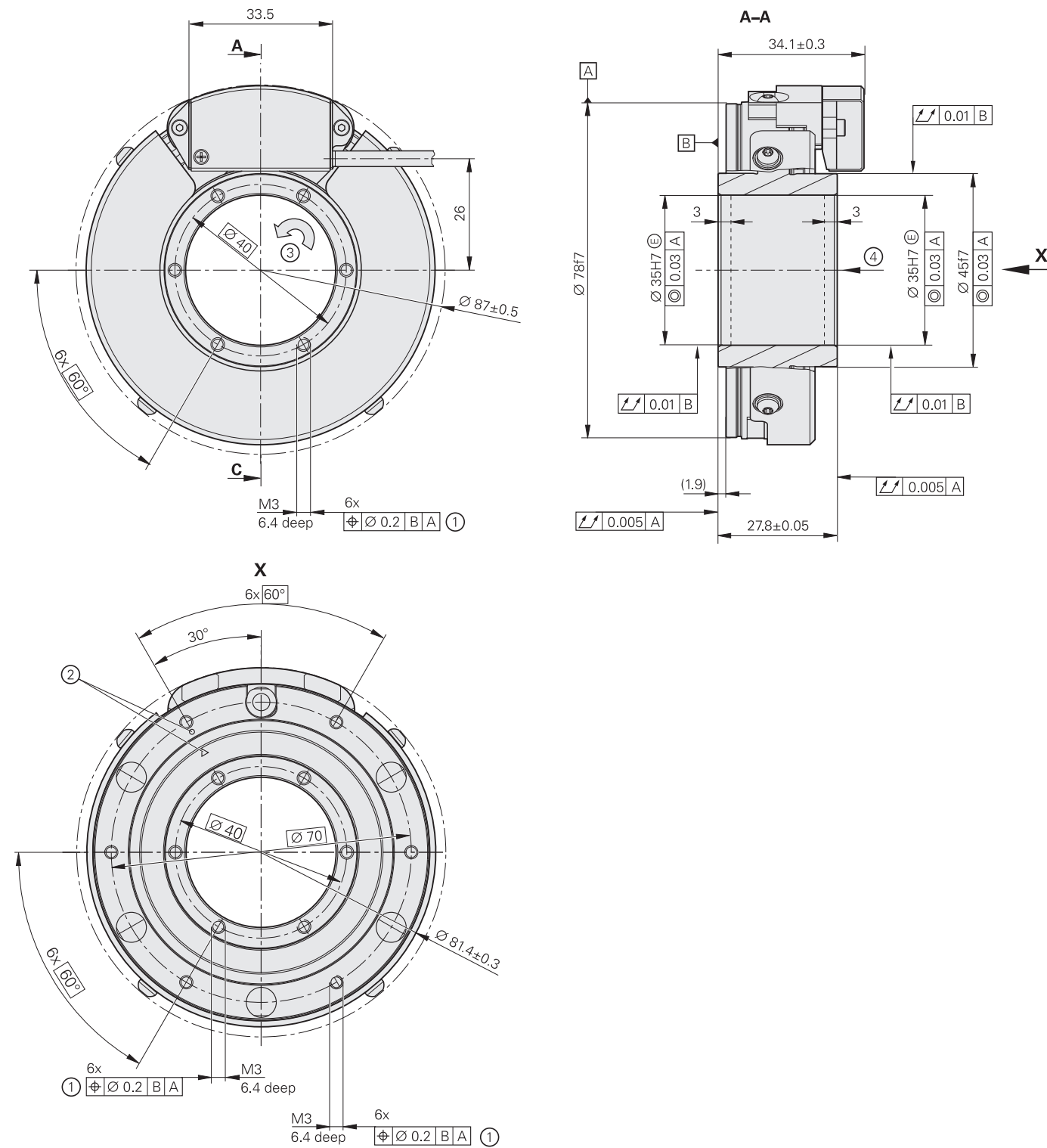
MRP 5010 with cover



mm
 Tolerancing ISO 8015
 ISO 2768 - m H
 < 6 mm: ± 0.2 mm

- 1 = Tightening torque of the M3 – 8.8 cylinder head screws: 1.1 Nm ± 0.05 Nm
- 2 = Marking of the 0° position $\pm 5^\circ$
- 3 = Direction of rotation for ascending position values
- 4 = Required direction for axial forces

MRP 5080

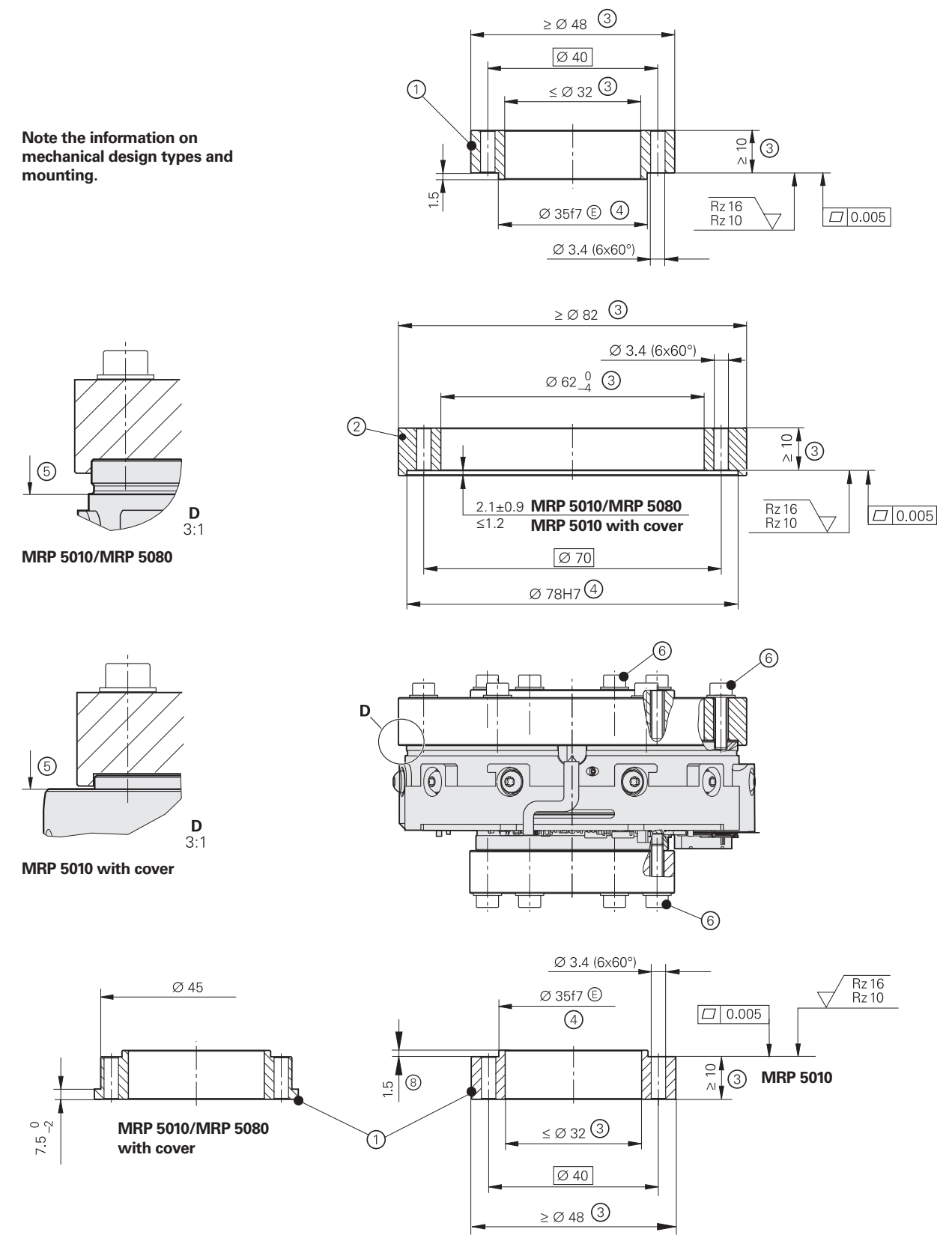


mm
 Tolerancing ISO 8015
 ISO 2768 - m H
 < 6 mm: ±0.2 mm

- 1 = Tightening torque of the M3 – 8.8 cylinder head screws: 1.1 Nm ±0.05 Nm
- 2 = Marking of the 0° position ±5°
- 3 = Direction of rotation for ascending position values
- 4 = Required direction for axial forces

Mating dimensions of the mounting parts

Note the information on mechanical design types and mounting.



- 1 = Rotor
- 2 = Stator (do not use as rotor)
- 3 = Required mounting dimensions for the transfer of the maximum permissible loads as per the specifications
- 4 = Optional recommended mating dimensions
- 5 = Do not use the edge as a stop surface!
- 6 = Screw: ISO 4762 – M3 – 8.8. Materially bonding threadlocker required. Washer: ISO 7092 – 3 – 200HV; tightening torque: 1.1 Nm ±0.05 Nm

MRP 8000 series

Angle encoder modules with integrated encoder and bearing

- Compact dimensions
- High measuring and bearing accuracy
- Hollow shaft \varnothing 100 mm

Encoder characteristics	Incremental MRP 8080	Absolute MRP 8010
Measuring standard	OPTODUR circular scale	DIADUR circular scale
Signal periods	63000	32768
System accuracy*	$\pm 1''$ or $\pm 2''$	
Position error per signal period	$\pm 0.10''$	$\pm 0.20''$
Repeatability	From both directions: 0.2''	From both directions: 0.5''
RMS position noise	Typically 0.003''	Typically 0.010''
Interface	$\sim 1 V_{PP}$	EnDat 2.2
Ordering designation	–	EnDat22
Position values per revolution	–	29 bits
Clock frequency Calculation time t_{cal}	–	≤ 16 MHz $\leq 5 \mu s$
Reference marks	150 (distance-coded)	–
Cutoff frequency –3 dB	≥ 500 kHz	–
Electrical connection	1.5 m cable with 15-pin D-sub connector; interface electronics integrated into the connector	15-pin header; adapter cable with quick connector as accessory
Cable length	≤ 30 m (with HEIDENHAIN cable)	
Supply voltage	DC 5 V ± 0.25 V	DC 3.6 V to 14 V
Power consumption (max.)	5.25 V: ≤ 950 mW	3.6 V: ≤ 1.1 W 14 V: ≤ 1.3 W
Current consumption (typical)	175 mA (without load)	5 V: 140 mA (without load)

* Please select when ordering

Bearing properties	Incremental MRP 8080	Absolute MRP 8010
Shaft	Hollow through shaft D = 100 mm	
Max. permissible axial load ³⁾	300 N (centered load)	
Max. permissible radial load ³⁾	100 N	
Max. permissible tilting torque ³⁾	6 Nm	
Contact stiffness	Axial: 684 N/ μm Radial: 367 N/ μm (calculated values)	
Resistance to tilt	1250 Nm/mrad (calculated value)	
Mech. permissible speed	300 rpm	
Moment of friction	≤ 0.2 Nm	
Starting torque	≤ 0.2 Nm	
Max. transferable shaft torque ³⁾	10 Nm	
Moment of inertia of rotor	$2.8 \cdot 10^{-3}$ kgm ²	
Radial guideway accuracy	Measured at distance h = 70 mm from the rotor mating surface: $\leq 0.15 \mu m$	
Non-reproducible radial guideway accuracy	Measured at distance h = 70 mm from the rotor mating surface: $\leq 0.20 \mu m$	
Axial guideway accuracy	$\leq \pm 0.15 \mu m$	
Axial runout of the shaft	$\leq 4 \mu m$	
Wobble of the axis	0.5''	
Vibration 55 Hz to 2000 Hz Shock 6 ms	≤ 200 m/s ² (EN 60068-2-6) ≤ 100 m/s ² (EN 60068-2-27) (without load)	
Protection EN 60529 ²⁾	IP20	IP00 ¹⁾ or IP40
Operating temperature Storage temperature	0 °C to 50 °C 0 °C to 50 °C	
Relative air humidity	≤ 75 % without condensation	
Mass	2.15 kg (without cable or connector)	

¹⁾ Electromagnetic compatibility must be ensured in the complete system through appropriate installation measures

²⁾ When mounted

³⁾ Purely static load, without additional vibrations or shock load



MRP 8080



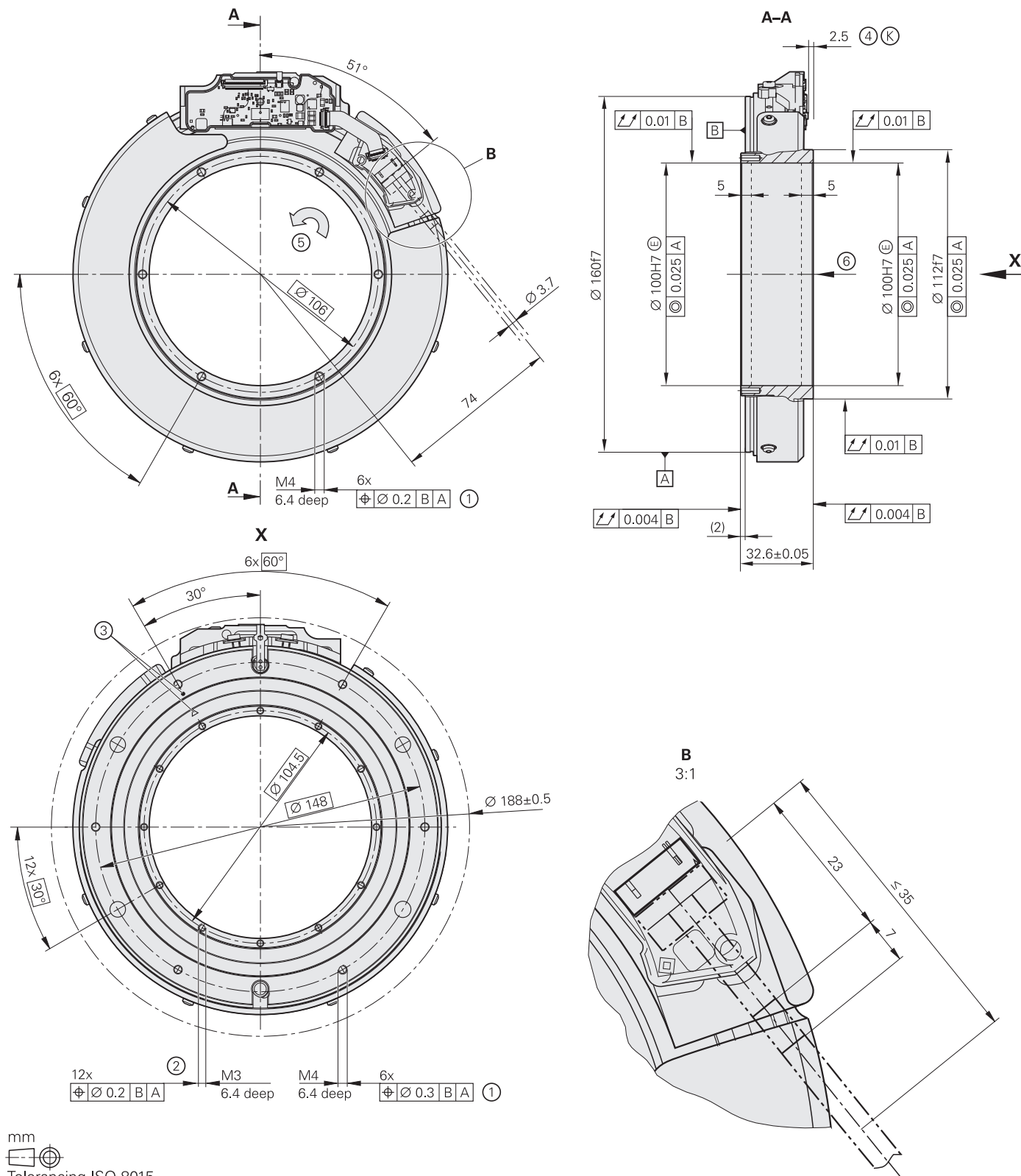
MRP 8010



MRP 8010 with cover

MRP 8000 series

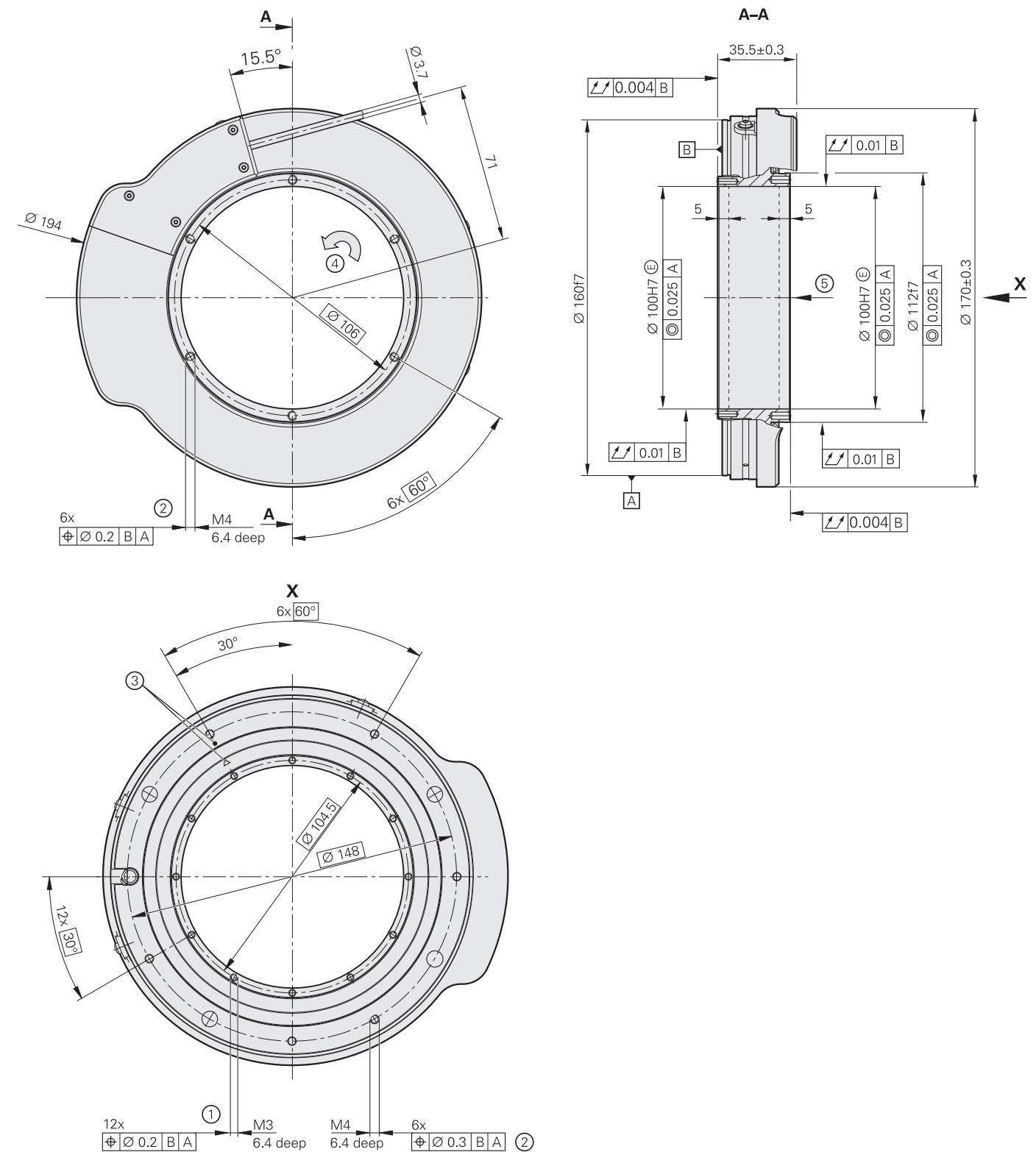
MRP 8010



mm
 Tolerancing ISO 8015
 ISO 2768 - m H
 < 6 mm: ±0.2 mm

- Ⓚ = Required mating dimensions
- 1 = Tightening torque of the M4 – 8.8 cylinder head screws: 2.5 Nm ±0.13 Nm
- 2 = Tightening torque of the M3 – 8.8 cylinder head screws: 1.1 Nm ±0.05 Nm
- 3 = Marking of the 0° position ±5°
- 4 = Minimum clearance
- 5 = Direction of rotation for ascending position values
- 6 = Required direction for axial forces

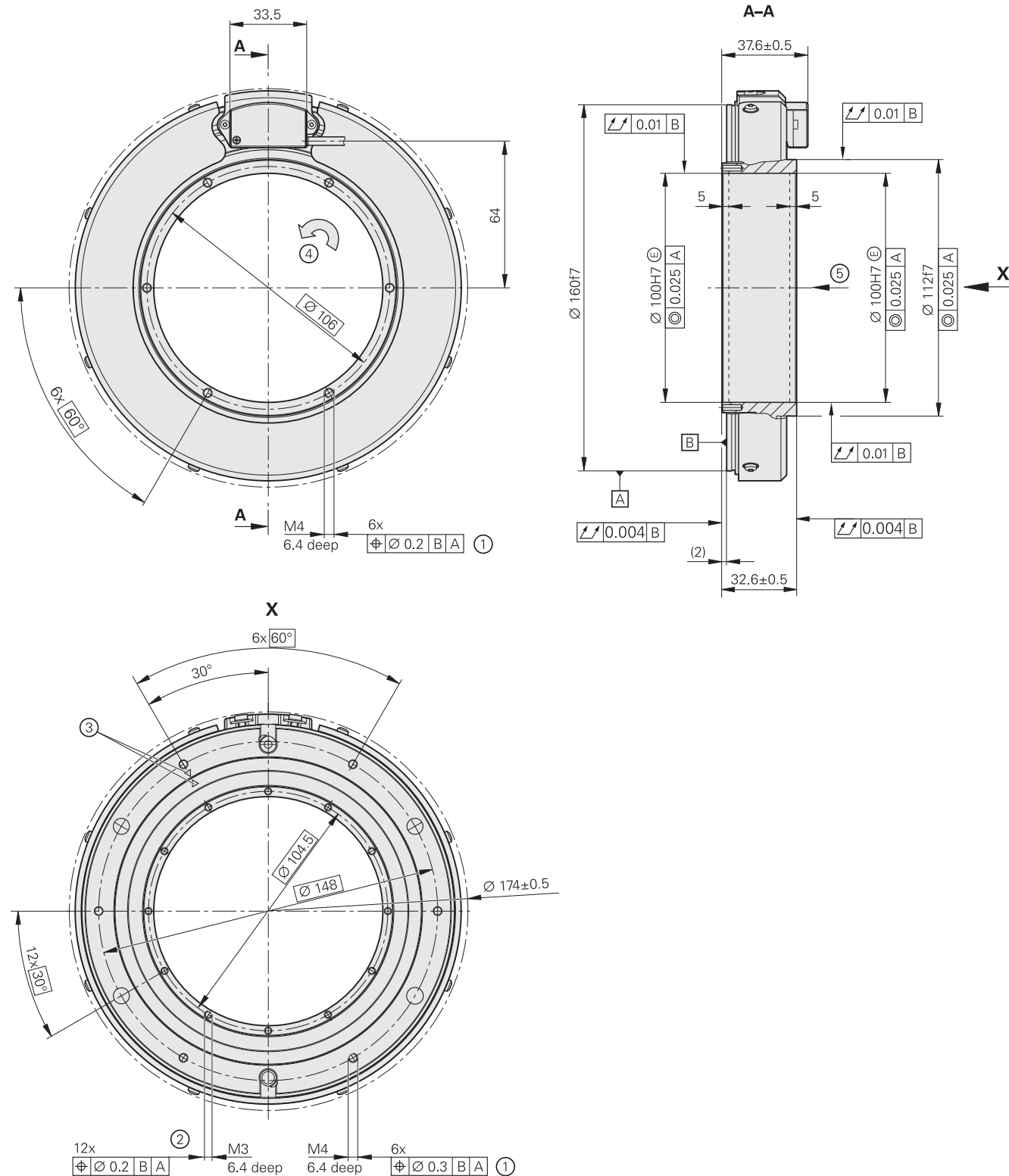
MRP 8010 with cover



mm
 Tolerancing ISO 8015
 ISO 2768 - m H
 < 6 mm: ±0.2 mm

- 1 = Tightening torque of the M3 – 8.8 cylinder head screws: 1.1 Nm ±0.05 Nm
- 2 = Tightening torque of the M4 – 8.8 cylinder head screws: 2.5 Nm ±0.13 Nm
- 3 = Marking of the 0° position ±5°
- 4 = Direction of rotation for ascending position values
- 5 = Required direction for axial forces

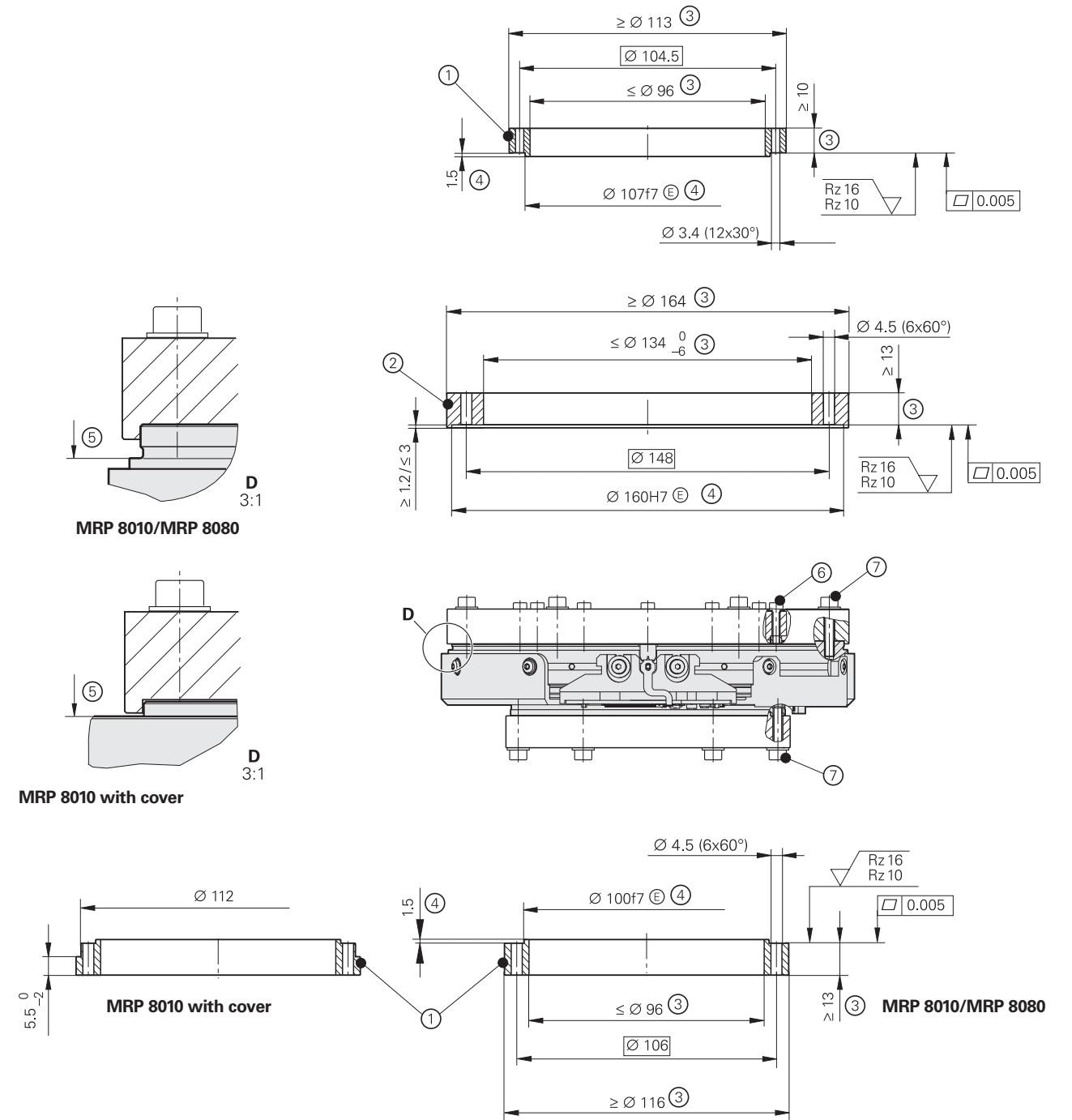
MRP 8080



mm
 Tolerancing ISO 8015
 ISO 2768 - m H
 < 6 mm: ±0.2 mm

- 1 = Tightening torque of the M4 – 8.8 cylinder head screws: 2.5 Nm ±0.13 Nm
- 2 = Tightening torque of the M3 – 8.8 cylinder head screws: 1.1 Nm ±0.05 Nm
- 3 = Marking of the 0° position ±5°
- 4 = Direction of rotation for ascending position values
- 5 = Required direction for axial forces

Mating dimensions of the mounting parts



Note the information on mechanical design types and mounting.

- 1 = Rotor
- 2 = Stator (do not use as rotor)
- 3 = Required mounting dimensions for the transfer of the maximum permissible loads as per the specifications
- 4 = Optional recommended mating dimensions
- 5 = Do not use the edge as a stop surface!
- 6 = Screw: ISO 4762 – M3 – 8.8. Materially bonding threadlocker required. Washer: ISO 7092 – 3 – 200HV; tightening torque: 1.1 Nm ±0.05 Nm
- 7 = Screw: ISO 4762 – M4 – 8.8. Materially bonding threadlocker required. Washer: ISO 7092 – 4 – 200HV; tightening torque 2.5 Nm ±0.13 Nm

MRP 8100 series

Angle encoder modules with integrated encoder and bearing

- Compact dimensions
- High measuring and bearing accuracy
- Hollow shaft \varnothing 80 mm
- Axial load of up to 1500 N

Encoder characteristics	Incremental MRP 8180	Absolute MRP 8110
Measuring standard	OPTODUR circular scale	DIADUR circular scale
Signal periods	63000	32768
System accuracy*	$\pm 1''$ or $\pm 2''$	
Position error per signal period	$\pm 0.10''$	$\pm 0.20''$
Repeatability	<i>From both directions: 0.2''</i>	<i>From both directions: 0.5''</i>
RMS position noise	Typically 0.003''	Typically 0.010''
Interface	~ 1 V _{PP}	EnDat 2.2
Ordering designation	–	EnDat22
Position values per revolution	–	29 bits
Clock frequency Calculation time t_{cal}	–	≤ 16 MHz ≤ 5 μ s
Reference marks	150 (distance-coded)	–
Cutoff frequency –3 dB	≥ 500 kHz	–
Electrical connection	1.5 m cable with 15-pin D-sub connector; interface electronics inside the connector	15-pin header; adapter cable with quick connector as accessory
Cable length	≤ 30 m (with HEIDENHAIN cable)	
Supply voltage	DC 5 V ± 0.25 V	DC 3.6 V to 14 V
Power consumption (maximum)	5.25 V: ≤ 950 mW	3.6 V: ≤ 1.1 W 14 V: ≤ 1.3 W
Current consumption (typical)	175 mA (without load)	5 V: 140 mA (without load)

* Please select when ordering

Bearing properties	Incremental MRP 8180	Absolute MRP 8110
Shaft	Hollow through shaft D = 80 mm	
Max. permissible axial load ³⁾	1500 N (centered load)	
Max. permissible radial load ³⁾	800 N	
Max. permissible tilting torque ³⁾	100 Nm	
Contact stiffness	Axial: 1000 N/ μ m Radial: 500 N/ μ m (calculated values)	
Resistance to tilt	1700 Nm/mrad (calculated value)	
Mechanically perm. speed	300 rpm	
Moment of friction	≤ 0.4 Nm	
Starting torque	≤ 0.4 Nm	
Max. transferable shaft torque ³⁾	20 Nm	
Moment of inertia of rotor	$5 \cdot 10^{-3}$ kgm ²	
Radial guideway accuracy	Measured at a distance of h = 75 mm from the rotor mating surface: ≤ 0.25 μ m	
Non-reproducible radial guideway accuracy	Measured at a distance of h = 75 mm from the rotor mating surface: ≤ 0.30 μ m	
Axial guideway accuracy	$\leq \pm 0.25$ μ m	
Axial runout of the shaft	≤ 4 μ m or ≤ 2 μ m	
Wobble of the axis	0.7''	
Vibration 55 Hz to 2000 Hz Shock 6 ms	≤ 200 m/s ² (EN 60068-2-6) ≤ 100 m/s ² (EN 60068-2-27) (without load)	
Protection EN 60529 ²⁾	IP20	IP00 ¹⁾ or IP40
Operating temperature Storage temperature	0 °C to 50 °C 0 °C to 50 °C	
Relative air humidity	≤ 75 % without condensation	
Mass	4 kg	

¹⁾ The electromagnetic compatibility of the complete system must be ensured through appropriate measures taken during installation.

²⁾ When mounted

³⁾ Purely static load, without additional vibrations or shock loading



MRP 8180



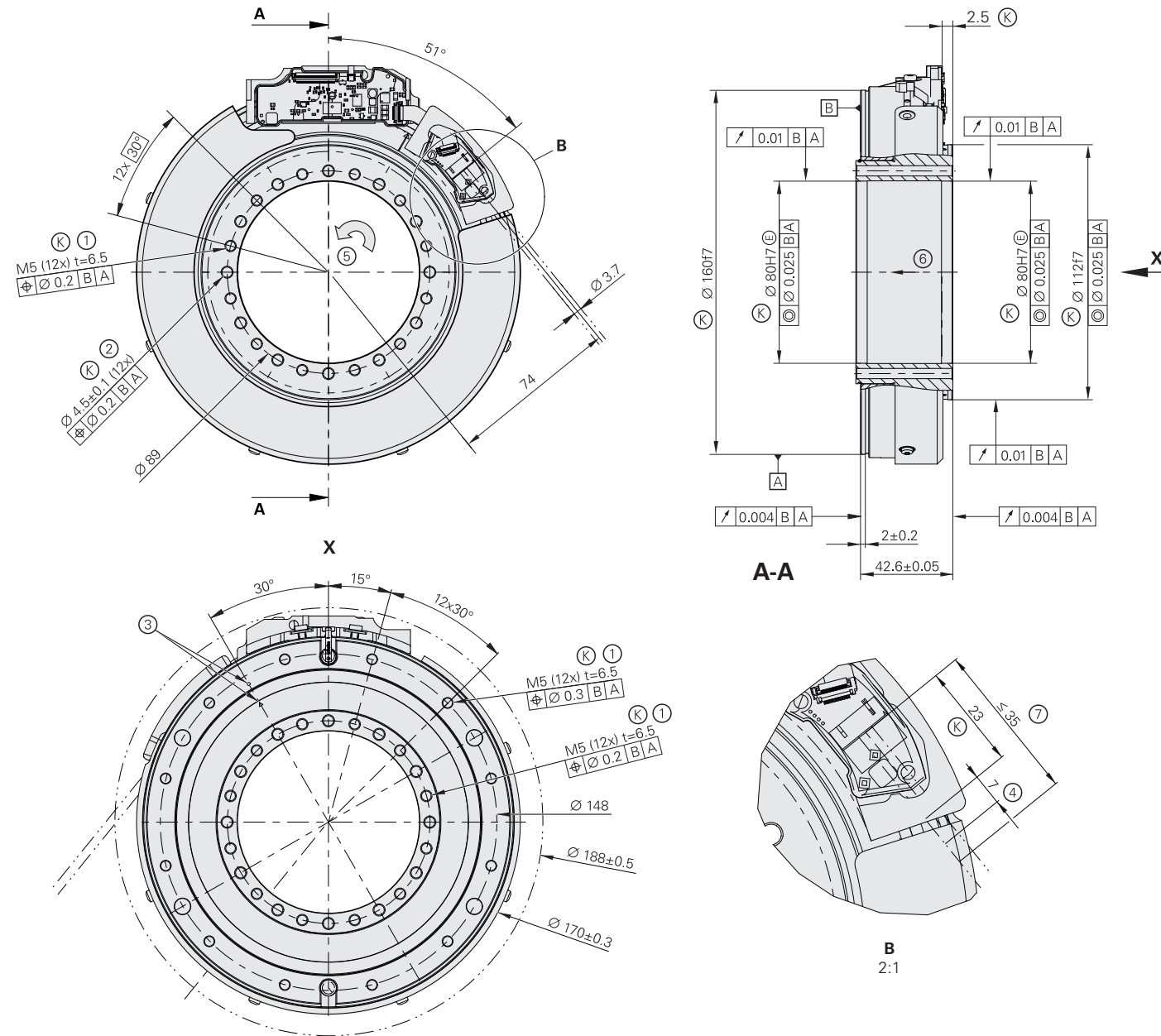
MRP 8110



MRP 8110 with cover

MRP 8100 series

MRP 8110

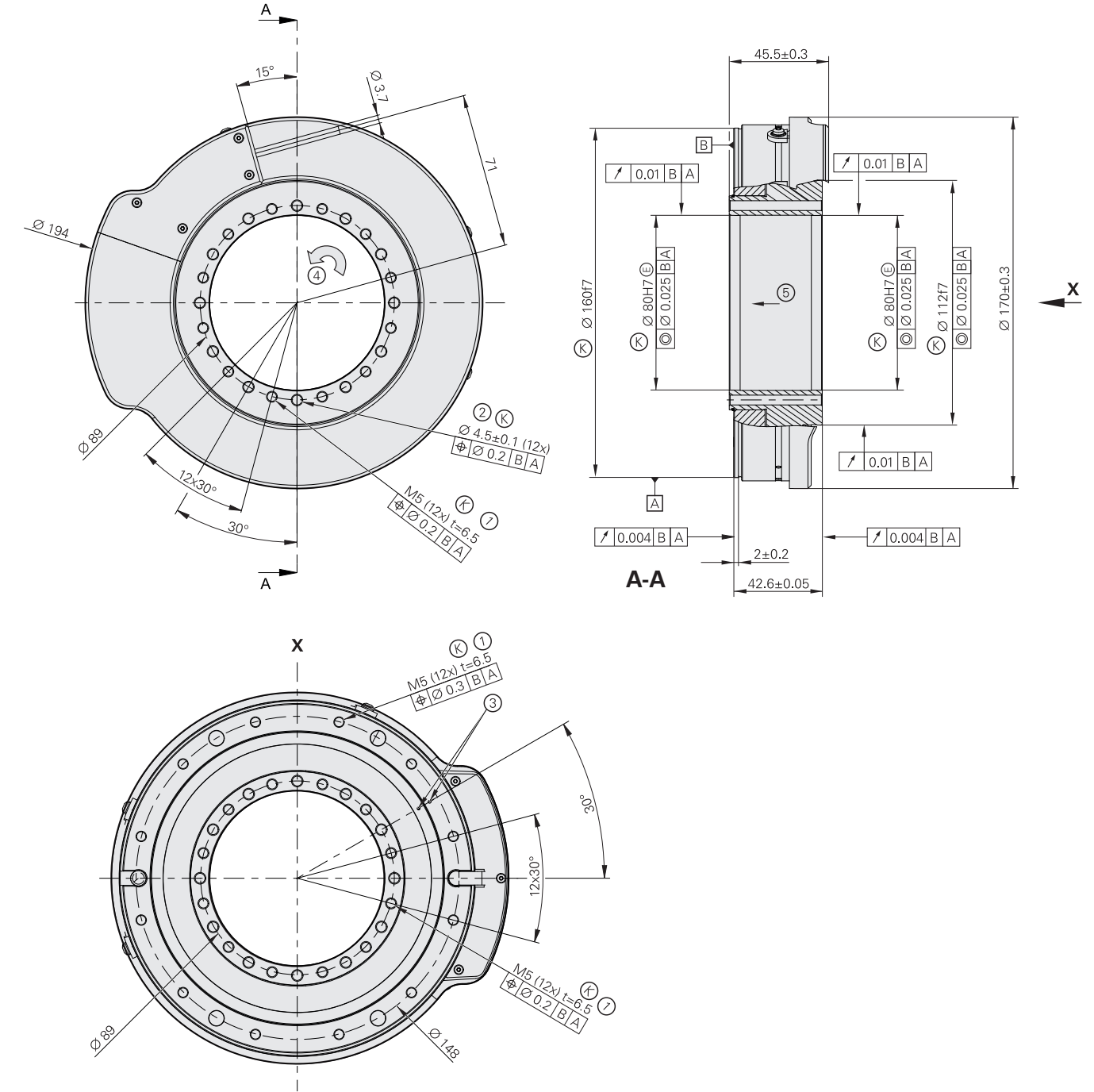


mm

 Tolerancing ISO 8015
 ISO 2768 - m H
 < 6 mm: ±0.2 mm

- ⊗ = Required mating dimensions
- 1 = Tightening torque of the M5 – 8.8 cylinder head screws: 4.5 Nm ±0.25 Nm
- 2 = Tightening torque of the M4 – 8.8 cylinder head screws: 2.5 Nm ±0.15 Nm
- 3 = Marking of the 0° position ±5°
- 4 = Customer is responsible for shielding cover
- 5 = Direction of shaft rotation for ascending position values
- 6 = Recommended direction of force;
if dynamic overloading is possible, then the recommended direction of force must be complied with.
- 7 = Cable support

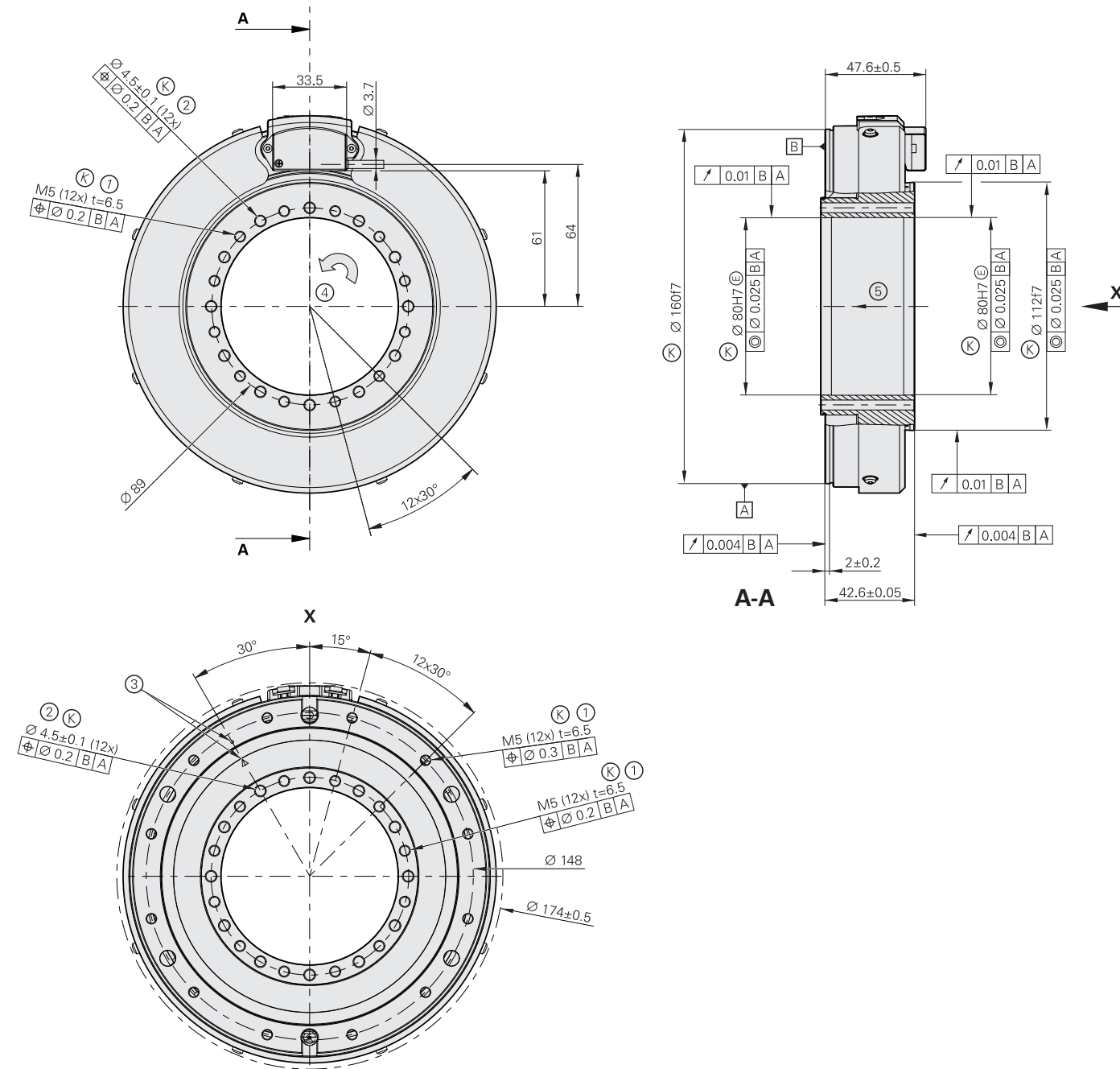
MRP 8110 with cover



mm

 Tolerancing ISO 8015
 ISO 2768 - m H
 < 6 mm: ±0.2 mm

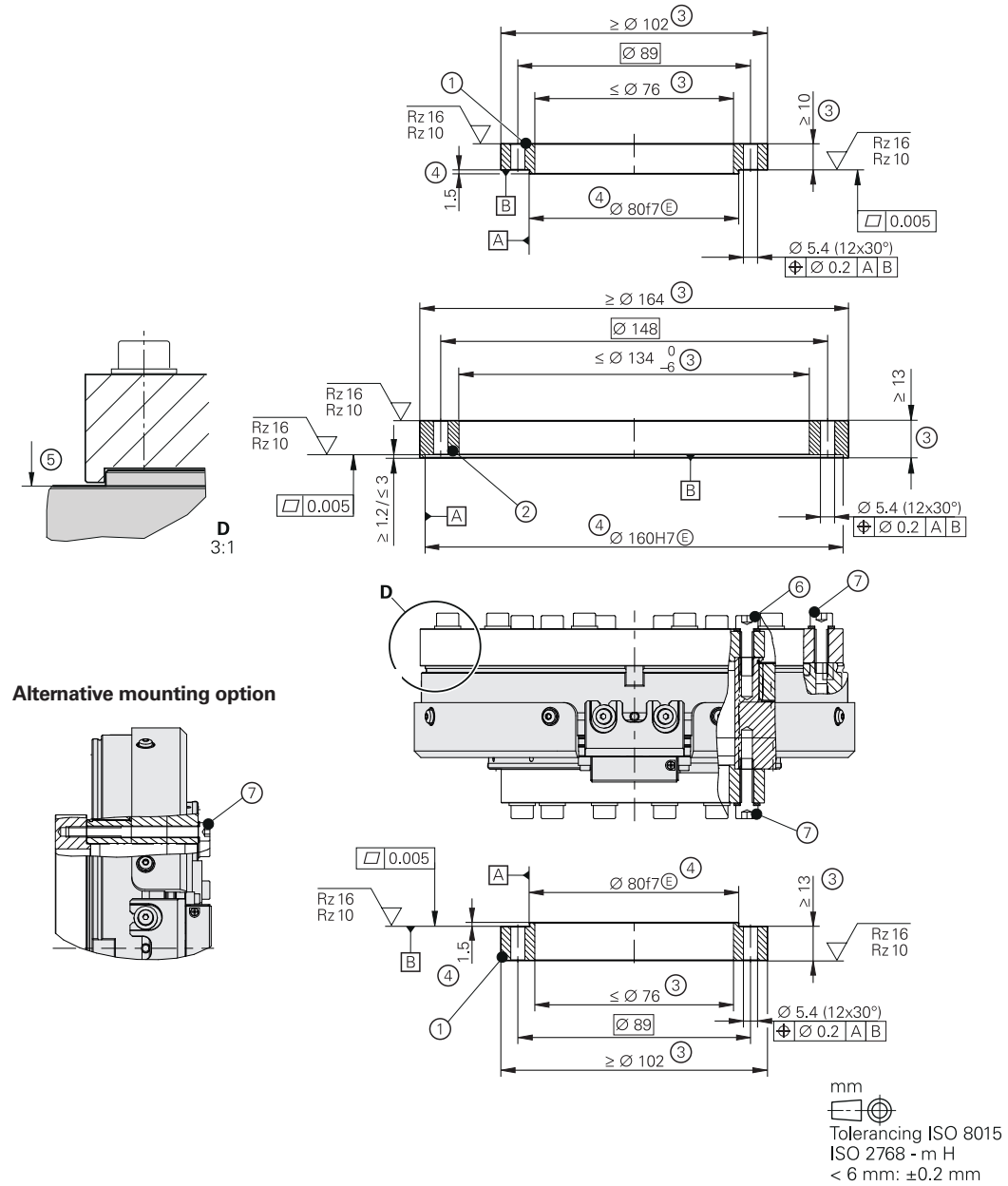
- ⊗ = Required mating dimensions
- 1 = Tightening torque of the M5 – 8.8 cylinder head screws: 4.5 Nm ±0.25 Nm
- 2 = Tightening torque of the M4 – 8.8 cylinder head screws: 2.5 Nm ±0.15 Nm
- 3 = Marking of the 0° position ±5°
- 4 = Direction of shaft rotation for ascending position values
- 5 = Recommended direction of force;
if dynamic overloading is possible, then the recommended direction of force must be complied with.



- ⊗ = Required mating dimensions
- 1 = Tightening torque of the M5 – 8.8 cylinder head screws: 4.5 Nm ±0.25 Nm
- 2 = Tightening torque of the M4 – 8.8 cylinder head screws: 2.5 Nm ±0.15 Nm
- 3 = Marking of the 0° position ±5°
- 4 = Direction of shaft rotation for ascending position values
- 5 = Recommended direction of force;
if dynamic overloading is possible, then the recommended direction of force must be complied with.

mm

 Tolerancing ISO 8015
 ISO 2768 - m H
 < 6 mm: ±0.2 mm



Alternative mounting option

- 1 = Rotor
- 2 = Stator (do not use as rotor)
- 3 = Required mounting dimensions for the transfer of the maximum permissible load as per the specifications
- 4 = Optional: recommended customer-side mounting dimensions
- 5 = Do not use the edge as a stop surface!
- 6 = Screw: ISO 4762 – M5 – 8.8. Materially bonding threadlocker required. Washer: ISO 7092 – 5 – 200HV; tightening torque: 4.5 Nm ±0.25 Nm
- 7 = Screw: ISO 4762 – M4 – 8.8. Materially bonding threadlocker required. Washer: ISO 7092 – 4 – 200HV; tightening torque: 2.5 Nm ±0.15 Nm

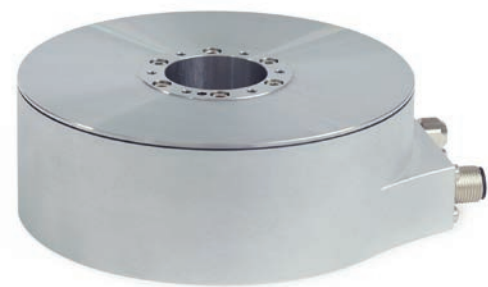
SRP 5000 series

Angle encoder modules with integrated encoder, bearing, and motor

- Compact dimensions
- High measuring and bearing accuracy
- Particularly smooth motion control
- Hollow shaft \varnothing 32 mm

Encoder characteristics	Incremental SRP 5080	Absolute SRP 5010
Measuring standard	OPTODUR circular scale	DIADUR circular scale
Signal periods	30000	16384
System accuracy*	$\pm 2.5''$ or $\pm 5''$	
Position error per signal period	$\pm 0.23''$	$\pm 0.40''$
Repeatability	<i>From both directions: 0.3''</i>	<i>From both directions: 0.9''</i>
RMS position noise	Typically 0.007''	Typically 0.020''
Interface	~ 1 V _{PP}	EnDat 2.2
Ordering designation	–	EnDat22
Position values per revolution	–	28 bits
Clock frequency Calculation time t_{cal}	–	≤ 16 MHz ≤ 5 μ s
Reference marks	80 (distance-coded)	–
Cutoff frequency –3 dB	≥ 500 kHz	–
Electrical connection	1.5 m cable with 15-pin D-sub connector; interface electronics integrated into the connector	1.5 m cable with 8-pin M12 coupling
Cable length	≤ 30 m (with HEIDENHAIN cable)	
Supply voltage	DC 5 V ± 0.25 V	DC 3.6 V to 14 V
Power consumption (max.)	5.25 V: ≤ 950 mW	3.6 V: ≤ 1.1 W 14 V: ≤ 1.3 W
Current consumption (typical)	175 mA (without load)	5 V: 140 mA (without load)

* Please select when ordering

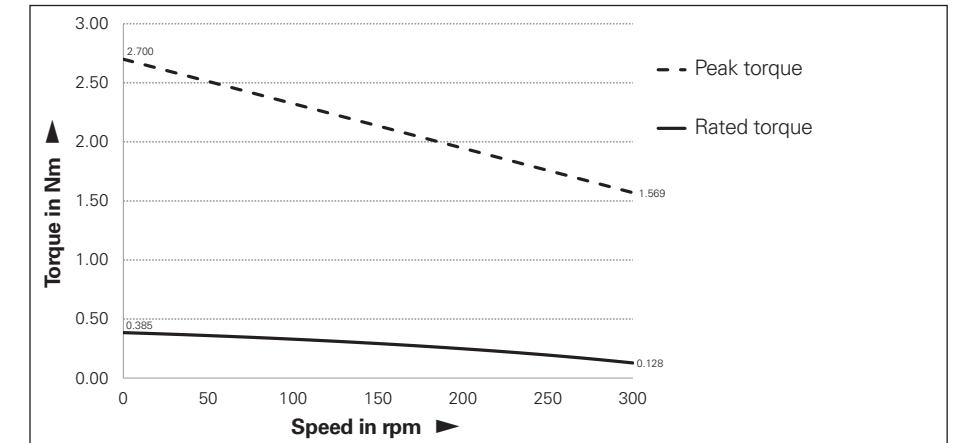


SRP 5000

Mounting situation

The stated motor characteristics apply to the following mounting situation:

- Ambient temperature: 20 °C
- Coil temperature: 40 °C
- Stator screwed to steel plate with the following characteristics:
 - Total surface area: 0.016 m²
 - Specific thermal capacity: 460 J/kgK (at 20 °C)
 - Specific thermal conductivity: 30 W/mK (at 20 °C)



Torque characteristic at DC 48 V

Bearing properties	
Shaft	Hollow through shaft with Ø 32 mm
Max. permissible axial load ²⁾	200 N (centered load)
Max. permissible radial load ²⁾	60 N
Max. permissible tilting torque ²⁾	2.5 Nm
Contact stiffness	<i>Axial:</i> 303 N/μm <i>Radial:</i> 181 N/μm (calculated values)
Resistance to tilt	102 Nm/mrad (calculated value)
Mech. permissible speed	300 rpm
Max. transferable shaft torque ²⁾	2 Nm
Moment of inertia of rotor	$1.16 \cdot 10^{-3} \text{ kgm}^2$
Radial guideway accuracy	Measured at distance h = 50 mm of rotor mating surface: ≤ 0.20 μm (without load)
Non-reproducible radial guideway accuracy	Measured at distance h = 50 mm of rotor mating surface: ≤ 0.35 μm (without load)
Axial guideway accuracy	≤ ±0.2 μm
Axial shaft runout*	≤ 5 μm or ≤ 1 μm
Wobble of the axis	0.7"
Vibration 55 Hz to 2000 Hz Shock 6 ms	≤ 20 m/s ² (EN 60068-2-6) ≤ 100 m/s ² (EN 60068-2-27) (without load)
Protection EN 60529 ¹⁾	IP40
Operating temperature Storage temperature	0 °C to 40 °C 0 °C to 50 °C
Relative air humidity	≤ 75 % without condensation
Altitude	< 2000 m
Mass	≈ 1.82 kg (without cable or connector)

* Please select when ordering

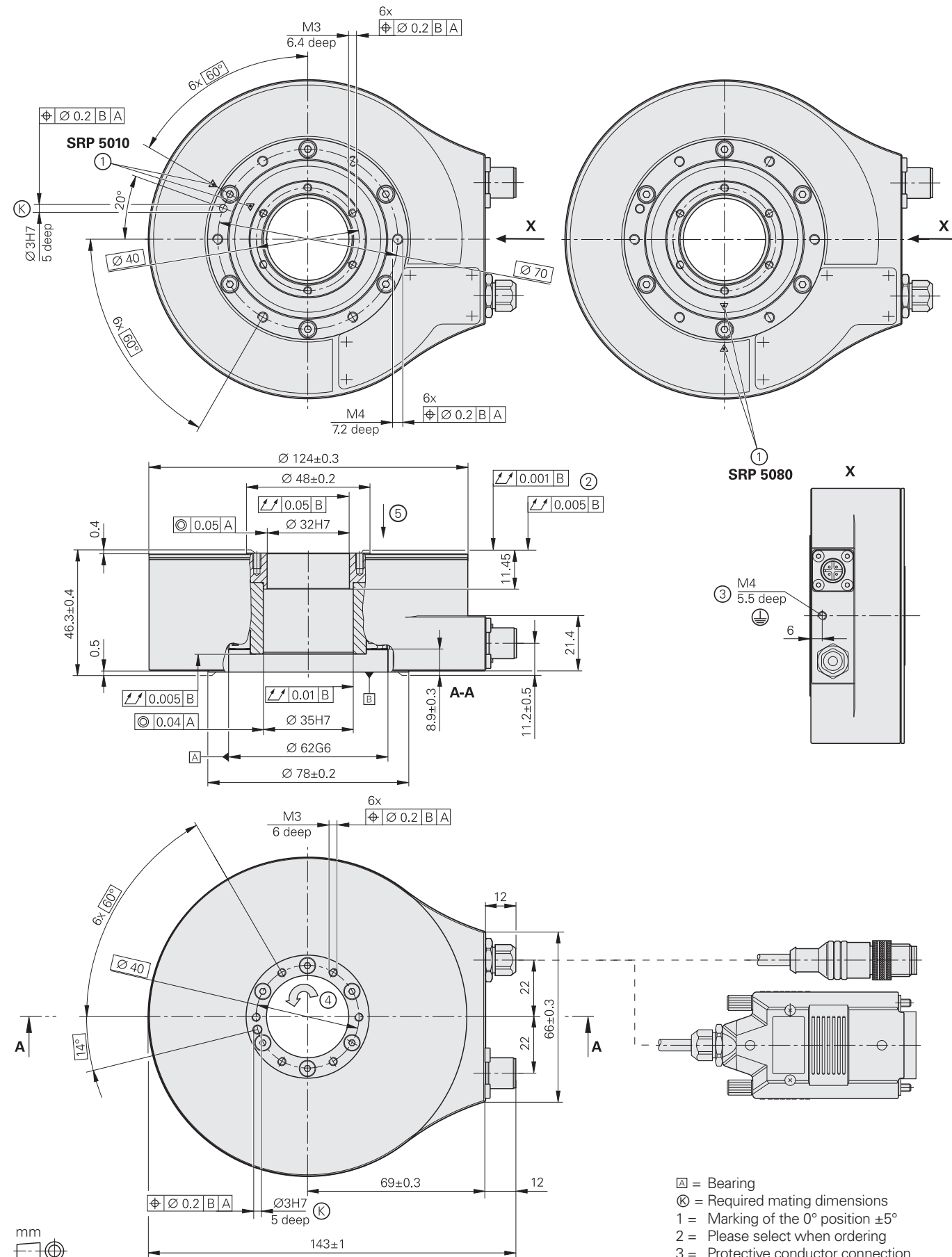
¹⁾ When mounted

²⁾ Purely static load, without additional vibrations or shock load

Motor characteristics	
Peak torque	2.70 Nm
Rated torque	0.385 Nm
Stall torque	0.253 Nm
Standstill speed	0.013 rpm
Maximum speed	300 rpm
Torque constant	0.668 Nm/A _{rms}
Back-electromotive force constant	0.397 V _{rms} /(rad/s)
Motor constant	0.181 Nm/√W
Electrical resistance R20 (at 20 °C)	9.06 Ω
Electrical inductance	2.42 mH
Maximum current	4.24 A _{rms}
Rated current	0.688 A _{rms}
Stall current	0.487 A _{rms}
Max. rated power loss	6.94 W
Max. DC-link voltage	DC 48 V
Number of poles	20
Max. cogging torque	< 0.2 % of rated torque
Electrical connection	4-pin M12 (male)
Cable diameter	Ø 7.0 mm
Cable length	≤ 5 m
Number of phases	3

SRP 5010/SRP 5080

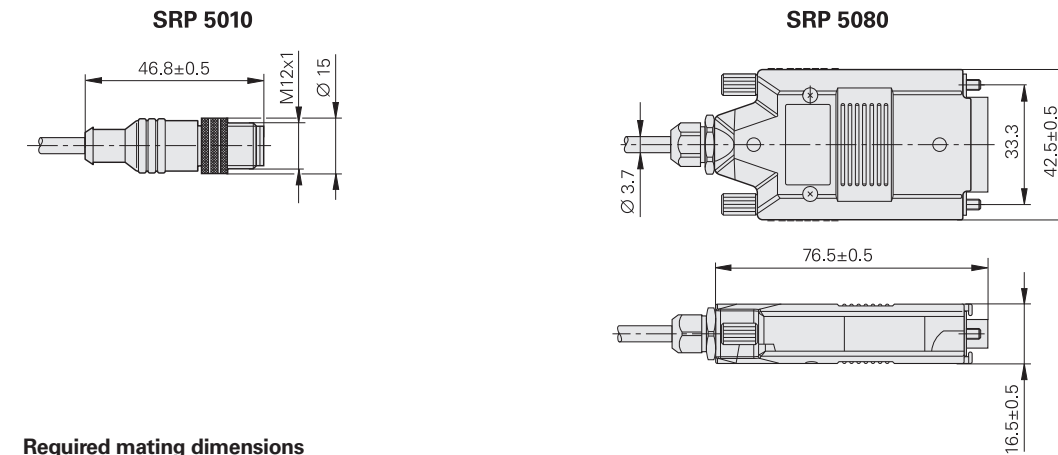
Dimensions



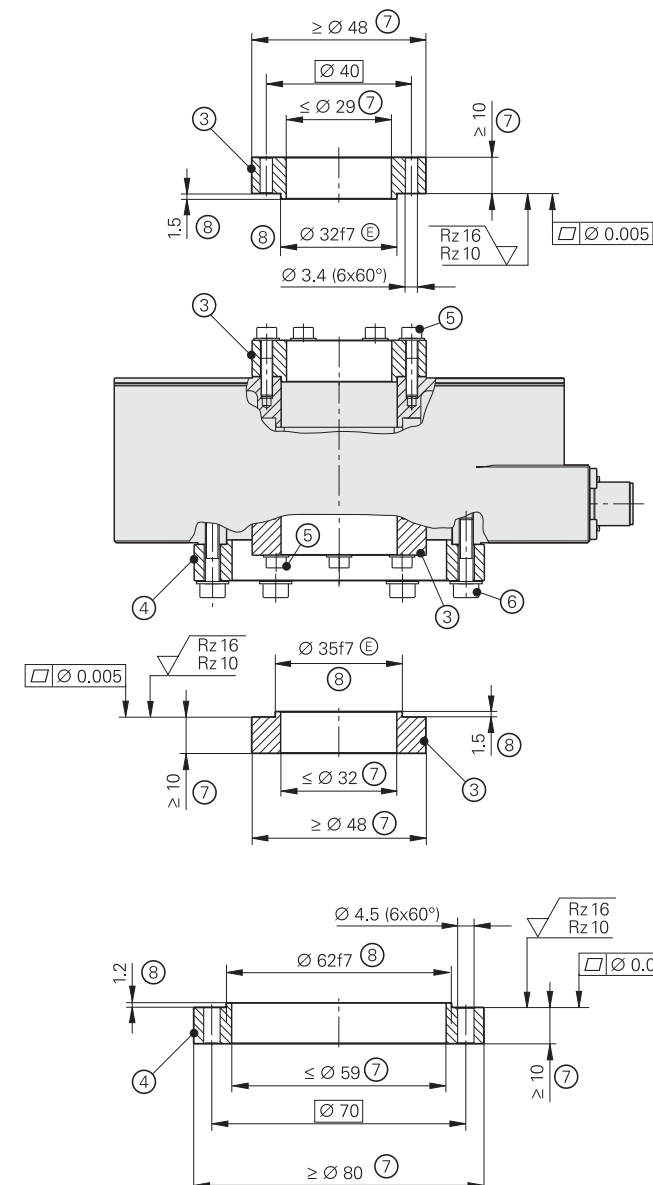
mm
 Tolerancing ISO 8015
 ISO 2768 - m H
 < 6 mm: ±0.2 mm

- ⊠ = Bearing
- ⊗ = Required mating dimensions
- 1 = Marking of the 0° position ±5°
- 2 = Please select when ordering
- 3 = Protective conductor connection
- 4 = Direction of rotation for ascending position values
- 5 = Required direction for axial forces

Dimensions of the connecting elements



Required mating dimensions



- 3 = Rotor
- 4 = Stator
- 5 = Screw: ISO 4762 - M3 - 8.8. Materially bonding threadlocker required. Washer: ISO 7092 - 3 - 200HV; tightening torque 1.1 Nm±0.05 Nm
- 6 = Screw: ISO 4762 - M4 - 8.8. Materially bonding threadlocker required. Washer: ISO 7092 - 4 - 200HV; tightening torque: 2.5 Nm ±0.13 Nm
- 7 = Required mating dimensions for the transfer of the maximum permissible load as per the specifications
- 8 = Optional recommended customer dimensions

AccurET position controllers

	AccurET Modular 48		AccurET VHP 48	
DC-link voltage	DC 48 V			
Number of axes	2			
RMS continuous current	2.5 A	5 A	1.5 A	5 A
RMS peak current	5 A	10 A	3 A	10 A
Supply voltage	DC 15 V to 48 V			
RMS current consumption	10 A			
PWM frequency	10 kHz, 20 kHz		-	
Encoder input	1 V _{PP} (up to 16384-fold) TTL EnDat 2.1 and EnDat 2.2		1 V _{PP} (up to 131072-fold) TTL EnDat 2.1 and EnDat 2.2	
Interfaces	USB 2.0 (for configuration) ETEL real-time bus Ethernet (TCP/IP)			
Digital I/O	4/2 per axis		4/4 per axis	
Fast digital I/O	6/4 for both axes			
Analog I/O	With additional expansion board		4/4 for both axes	

AccurET VHP 48



AccurET Modular 48



Further information:

For detailed information about AccurET position controllers, visit: www.etel.ch.

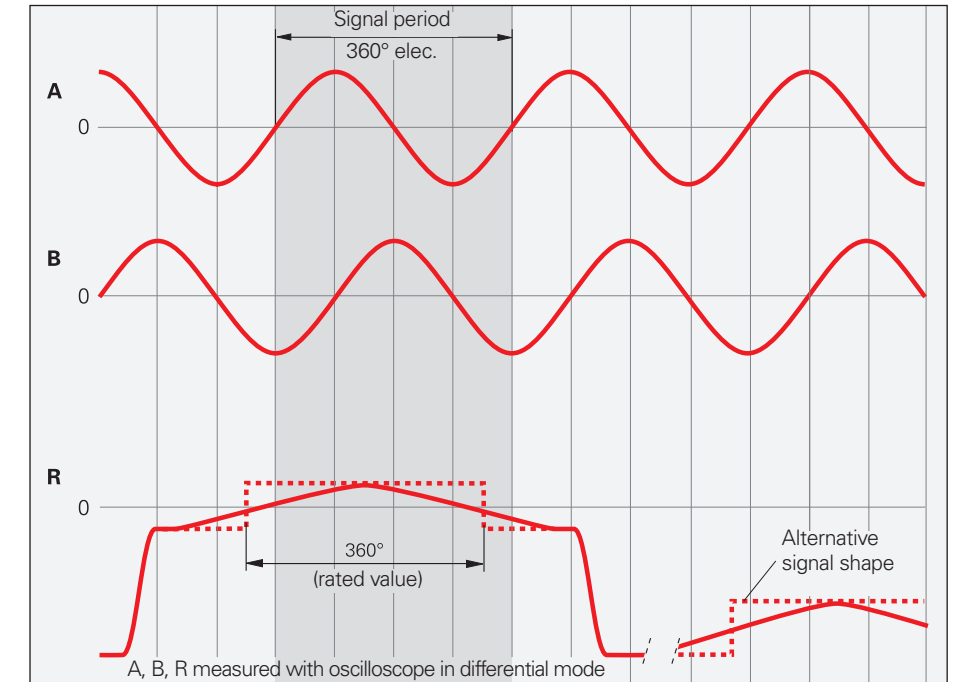
Interfaces

~ 1 V_{PP} incremental signals

HEIDENHAIN encoders with the ~ 1 V_{PP} interface provide voltage signals that can be highly interpolated.

The sinusoidal **incremental signals** A and B are phase-shifted by 90° elec. and have amplitudes of typically 1 V_{PP}. The illustrated sequence of output signals—with B lagging A—applies to the direction of motion shown in the dimension drawing.

The **reference mark signal** R has an unambiguous assignment to the incremental signals. The output signal may be lower next to the reference mark.

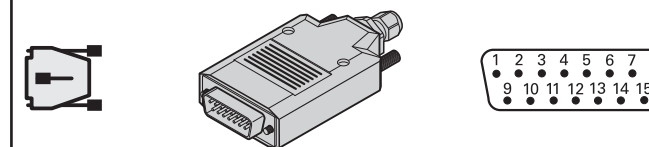


Further information:

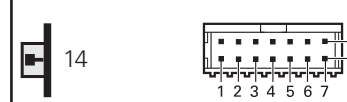
Comprehensive descriptions of all available interfaces as well as general electrical information can be found in the *Interfaces of HEIDENHAIN Encoders* brochure.

Pin layout

15-pin D-sub connector



14-pin PCB connector



	Power supply				Incremental signals						Other signals		
	4	12	2	10	1	9	3	11	14	7	5/6/8/15	13	/
	1b	7a	5b	3a	6b	2a	3b	5a	4b	4a	/	/	/
	U _P	Sensor U _P	0V	Sensor 0V	A+	A-	B+	B-	R+	R-	Vacant	Vacant	Vacant
	Brown/Green	Blue	White/Green	White	Brown	Green	Gray	Pink	Red	Black	/	Violet	Yellow

Cable shield connected to housing; **U_P** = Power supply voltage

Sensor: The sense line is connected in the encoder with the corresponding power line. Vacant pins or wires must not be used!

Interfaces

EnDat position values

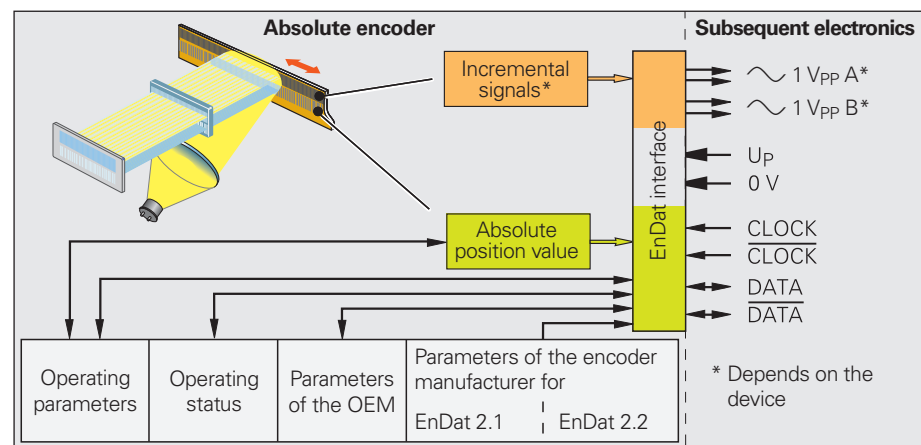
The EnDat interface is a digital, **bidirectional** interface for encoders. It is able to output **position values** and read information stored in the encoder, as well as update this information or store new information. Thanks to the **serial transmission method**, only **four signal lines** are required. The DATA data are transmitted in **synchronism** with the CLOCK signal from the subsequent electronics. The type of transmission (position values, parameters, diagnostics, etc.) is selected via mode commands sent to the encoder by the subsequent electronics. Some functions are available only with EnDat 2.2 mode commands.

Further information:

Comprehensive descriptions of all available interfaces as well as general electrical information can be found in the *Interfaces of HEIDENHAIN Encoders* brochure.

Ordering designation	Command set	Incremental signals
EnDat01	EnDat 2.1 or EnDat 2.2	With
EnDat21		Without
EnDat02	EnDat 2.2	With
EnDat22	EnDat 2.2	Without

Versions of the EnDat interface



Pin layout

8-pin M12 coupling or flange socket								
12-pin PCB connector				15-pin PCB connector				
	Power supply				Position values			
	8	2	5	1	3	4	7	6
	1b	6a	4b	3a	6b	1a	2b	5a
	13	11	14	12	7	8	9	10
	Up	Sensor Up	0V	Sensor 0V	DATA	DATA	CLOCK	CLOCK
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

Cable shield connected to housing; **Up** = Power supply voltage

Sensor: The sense line is connected in the encoder with the corresponding power line.

Vacant pins or wires must not be used!

Interfaces

Motor

Angle encoder modules with integrated motor have a slotless iron-core permanent-magnet AC synchronous motor with three phases.






Pin layout

	1	2	3	4
	Phase 1	Phase 2	Phase 3	GND

	1	2	3	4
	Phase 1	Phase 2	Phase 3	GND
	White	Brown	Green	Yellow





Cables

1 V_{pp} cables

PUR output cables Ø 3.7 mm 6 × (2 × 0.05 mm ²)			
With 14-pin PCB connector and 15-pin D-sub connector (female)		1160480-xx	
PUR connecting cable 6 × (2 × 0.19 mm ²); A _P = 0.19 mm ²			
PUR connecting cable 4 × (2 × 0.14 mm ²) + (4 × 0.5 mm ²); A _P = 0.5 mm ²		Ø 8 mm	Ø 6 mm ¹⁾
With 15-pin D-sub connector (female) and 12-pin M23 connector (male)		331693-xx	355215-xx
With 15-pin D-sub connector (female) and free cable end		332433-xx	355209-xx
With 15-pin D-sub connector (female) and 15-pin D-sub connector (male)		335074-xx	355186-xx
Cable only		816317-xx	816323-xx




¹⁾ Cable length for Ø 6 mm: max. 9 m A_P: Cross section of power supply lines

EnDat cables

PUR output cable Ø 3.7 mm (4 × 0.06 mm ²) + 4 × 0.06 mm ²			
With 15-pin PCB connector and 8-pin M12 coupling (male)		1137151-xx	
With 12-pin PCB connector and 8-pin M12 coupling (male)		1129083-xx	
PUR connecting cable Ø 6 mm (4 × 0.14 mm ²) + (4 × 0.34 mm ²); A _P = 0.34 mm ²			
With 8-pin M12 connector (female) and 8-pin M12 coupling (male)		368330-xx	
With 8-pin M12 connector (female) and free cable end		634265-xx	

A_P: Cross section of power supply lines Ø: Cable diameter

Cables for the direct connection to an AccurET position controller

Motor connecting cable Ø 7 mm (4 × 0.5 mm ²)			
4-pin M12 connector (female) and free cable end		1140842-xx	
Adapter cable for 1 V_{pp} Ø 6 mm 6 × (2 × 0.19 mm ²)			
15-pin D-sub connector (female) and 15-pin D-sub connector (male)		1159446-xx	
Adapter cable for EnDat 2.2 Ø 6 mm 2 × (2 × 0.09 mm ²) + 2 × (2 × 0.14 mm ²)			
8-pin M12 connector (female) and 15-pin D-sub connector (male)		1165032-xx	

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