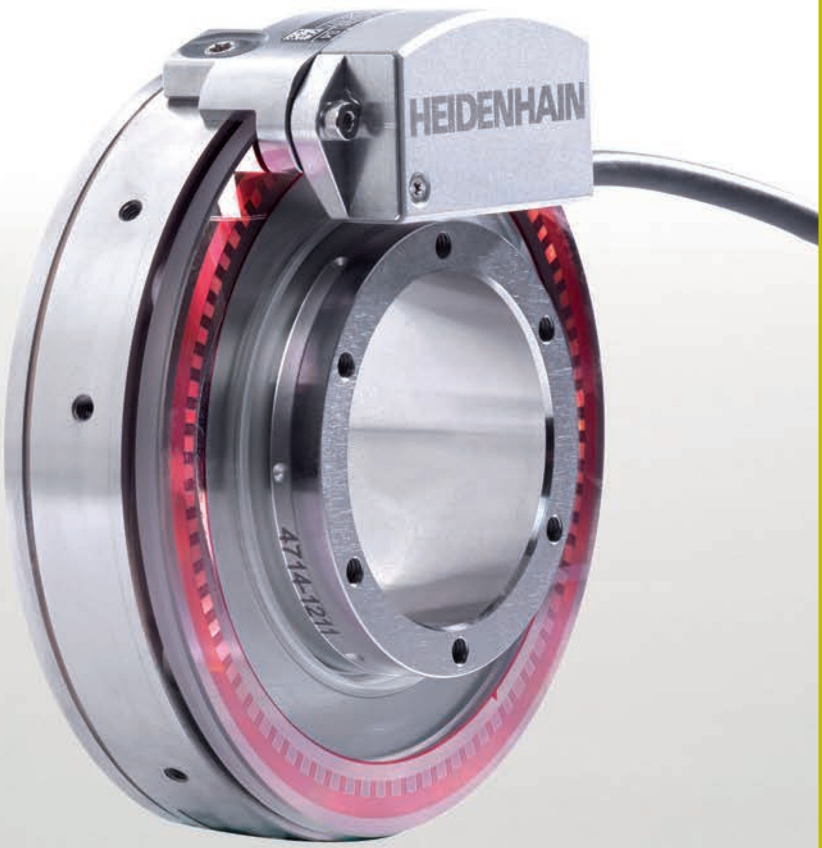
HEIDENHAIN



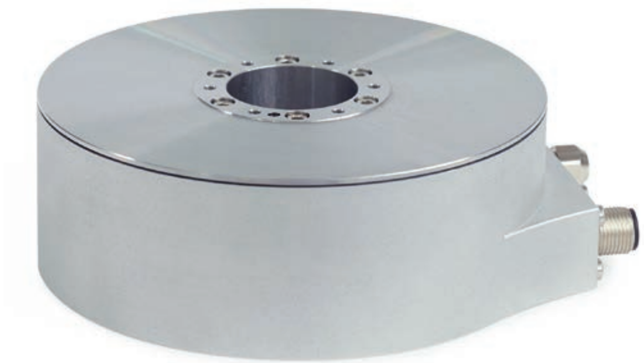
Angle Encoder Modules

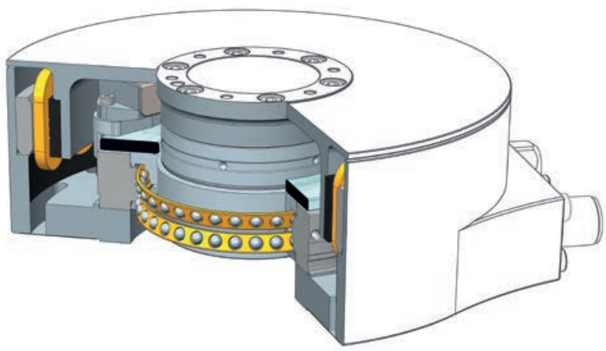
04/2024

Design and applications

The MRP angle encoder modules from HEIDENHAIN are the optimal marriage of an angle encoder with a high-precision bearing. Customers benefit from high measuring accuracy, high bearing accuracy, very high resolution, extreme repeatability and excellent smoothness due to a low starting torque. As complete assemblies with tested specifications, they are easy to handle and install.

SRP angle encoder modules have the added benefit of a built-in torque motor. This compact system consists of a motor, a precision bearing, and a high-accuracy encoder.





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:

For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

Information about the following topics is available upon request or online at *www.heidenhain.com*:

- Angle encoders with integral bearing
- HEIDENHAIN signal converters

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Design and applications

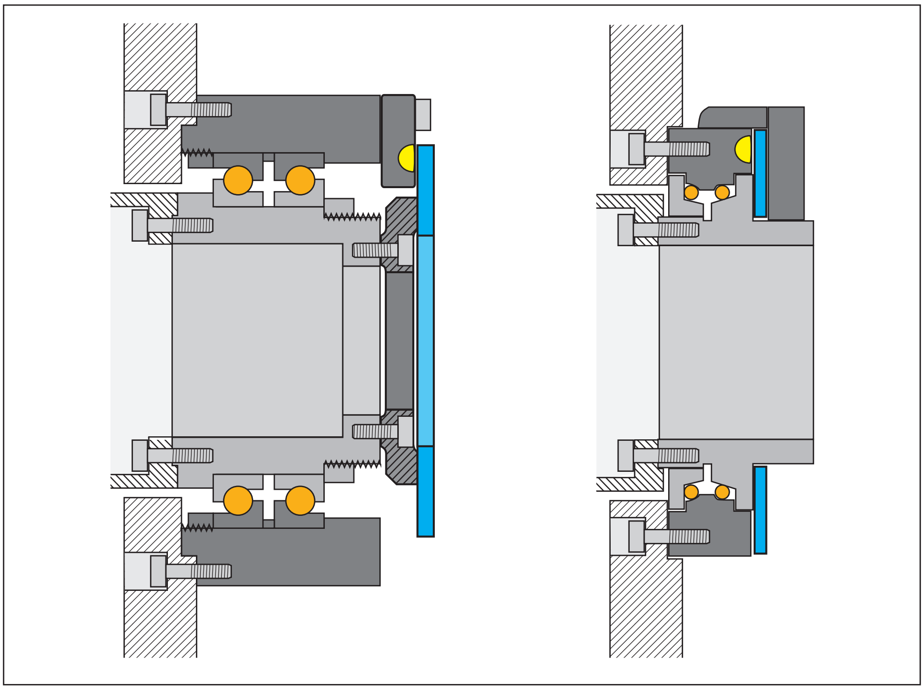
Design
HEIDENHAIN manufactures the bearings and encoders itself, thus ensuring a highly integrated system. Fewer components are needed than with conventional solutions, so there are also fewer joints. The result is a rigid and compact design with a notably small profile. Our angle encoder modules are currently available with 10 mm, 35 mm, 80 mm and 100 mm hollow shafts. The angle encoder modules with a built-in motor are currently available with a 32 mm hollow shaft.

Characteristics
The **rolling bearings** are adapted specifically to the requirements of high-precision rotary axes. They emphasize high guideway accuracy, high rigidity, low starting torque and smooth continuous torque. Priority was also given to a low mass and the most compact form factor possible. Less priority was given to high speeds and load ratings.

These **encoders** meet the rigorous requirements of the metrology and electronics manufacturing industries. Their 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 modules, which feature a built-in **torque motor**, enable uniform motion control. Their high guideway accuracy is ensured by the motor's nearly complete lack of cogging torque and lateral forces.

Advantages
Angle encoder modules are the combination of a bearing and an encoder. Because HEIDENHAIN has already completed the necessary assembly and adjustment work, their technical characteristics have already been defined and tested in accordance with the customer's desired specifications. In addition, their simple mechanical interfaces eliminate the need for all critical mounting processes, thus simplifying the installation process and ensuring that the specified accuracy is attained in the application. The complex task of matching components with each other and with the machine is eliminated, as is the need for testing.

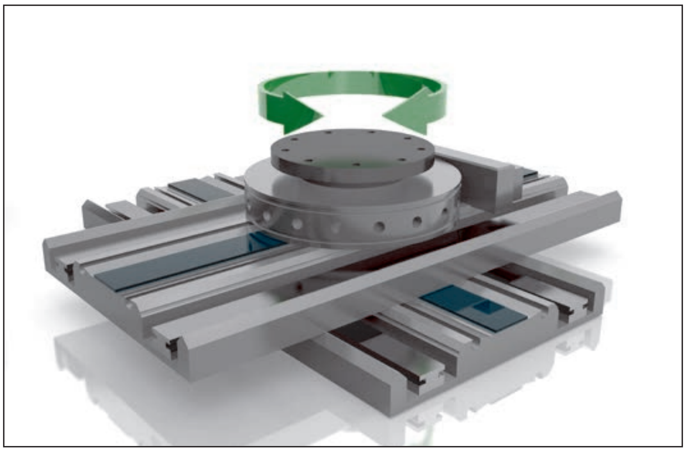


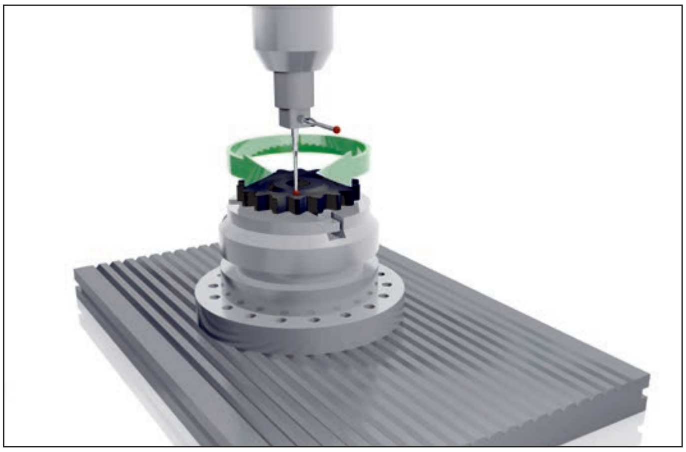
Comparison of a conventional precision axis versus a solution using an angle encoder module from HEIDENHAIN

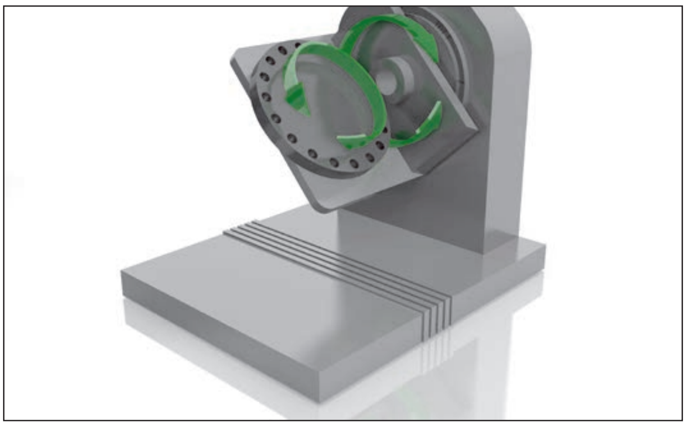
Reproducible guideway accuracy: a key feature of bearings
The absolute guideway accuracy of an unloaded air bearing is often superior to that of a rolling bearing. However, what really matters in many applications is having the highest possible reproducible guideway accuracy. In such cases, angle encoder modules from HEIDENHAIN are a viable alternative to air-bearing axes. Rolling bearings from HEIDENHAIN exhibit exceptional repeatability, and their rigidity is higher than that of comparably sized air bearings by at least a factor of 10, making them the more accurate solution on axes acted on by forces. Because rolling bearings are generally less sensitive to shock loads and do not require a regulated air supply, they are more robust and easier to use.

Areas of application
Our angle encoder modules are designed for high to very high bearing accuracy and extremely high repeatability at low to medium speeds and under medium-sized loads. They are adapted specifically to the requirements of metrology applications. Typical applications include laser trackers in the metrology industry, high-precision rotary tables on measuring machines and wafer-handling machines in the electronics manufacturing 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 HEIDENHAIN angle encoders, the bearing can be adapted to specific customer needs, specifically the preload, lubrication, contact angle and materials used. For more information, please contact your HEIDENHAIN representative.


Wafer handling


High-precision rotary tables


Compact tilting units


Laser trackers

Measuring and bearing accuracy

The accuracy of HEIDENHAIN angle encoder modules depends on the measurement accuracy of their angle encoder and the bearing accuracy of their rolling bearing.

HEIDENHAIN takes the following measuring and bearing accuracies into account when determining the quality of a given angle encoder module:

Measuring accuracy
For determining the specs of a given angle encoder module, the relevant measuring accuracies of the angle encoder by itself are primarily its system accuracy and its reproducibitiliy.

The **system accuracy** of the angle encoder is its position error within a single revolution. It applies to the entire range of the specified axial load.

The angle encoder's repeatability is subcategorized into its single-sided and double-sided repeatability. **Single-sided repeatability** is determined during any number of revolutions in a single direction of motion. Individual measuring points are approached multiple times to determine their maximum deviation. A reference encoder is used for comparison.

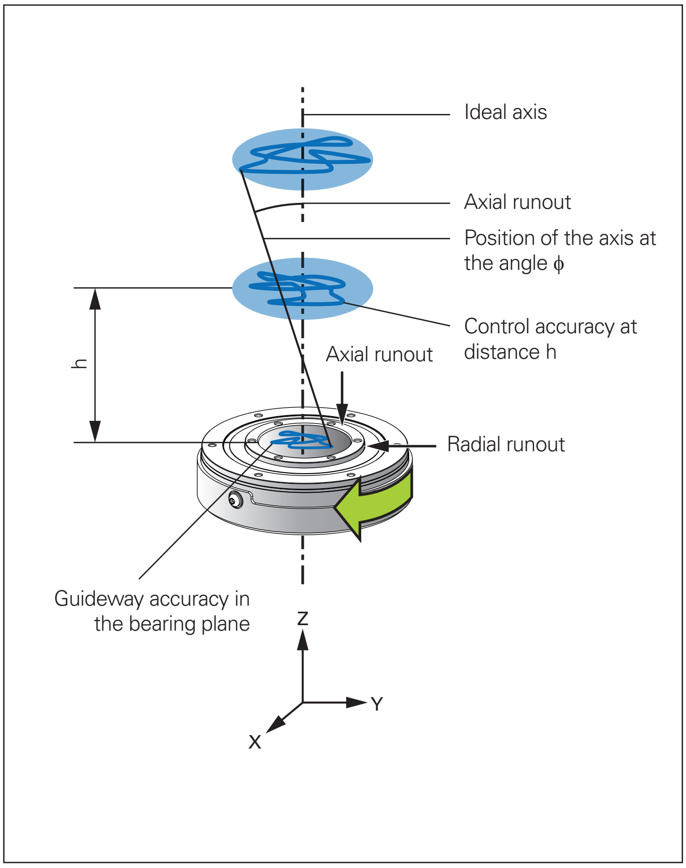
Double-sided repeatability is determined during changing directions of rotation. The measuring points are approached from both sides, and their maximum deviation is determined. The positioning process is supported by a reference encoder.

In both analyses, the absolute deviation relative to the reference encoder is inconsequential and is not the aim of the measurement.

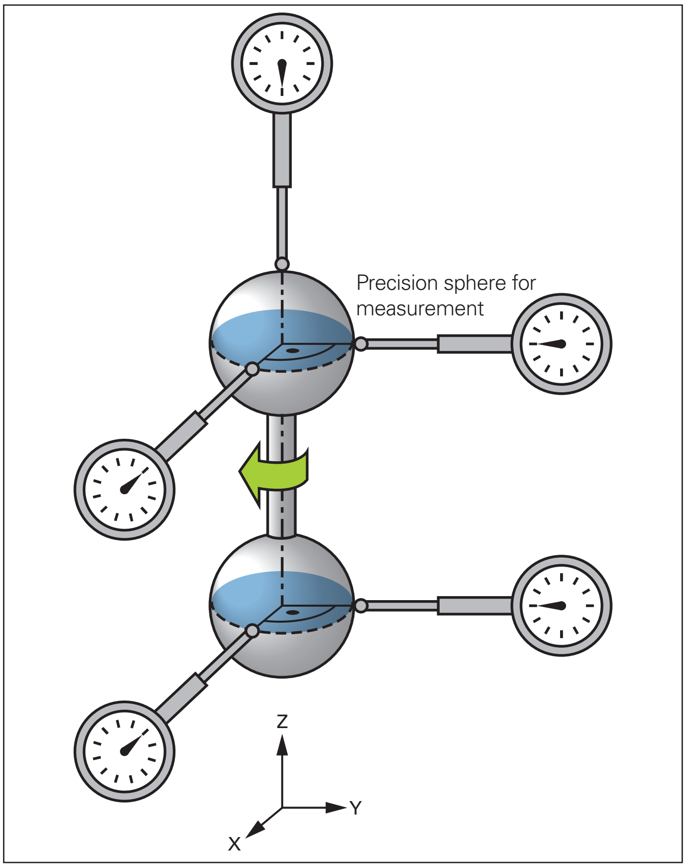
Bearing accuracy
For the evaluation of the bearing accuracy, the oft-cited radial runout accuracy is not as important as the guideway accuracy of the bearing. The guideway accuracy is the deviation of the actual axis of rotation from the ideal nominal axis of rotation of the bearing. The radial and axial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

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

The **radial guideway accuracy** may be measured with two length gauges, for example. They are positioned at right angles and at the height of the sphere center. When the bearing is rotated, the length gauges then measure the sphere's radial deviation in the X and Y directions.



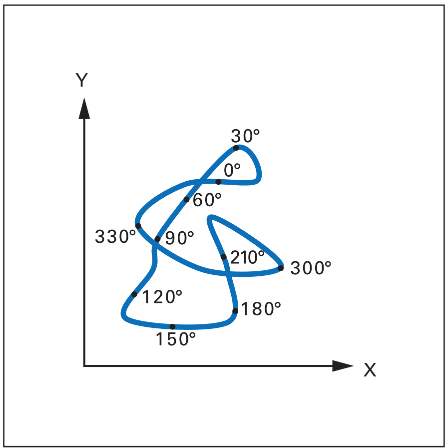
Measured values and measuring locations on the rolling bearing (schematic representation)



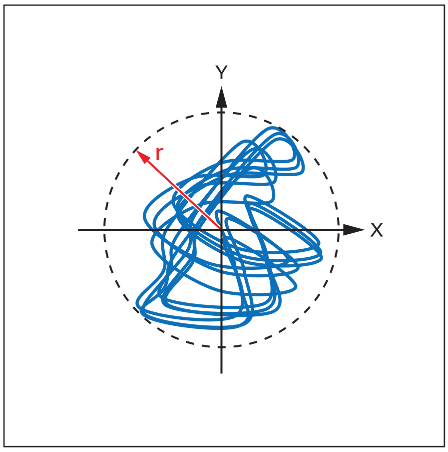
Measurement of the axial and radial guideway accuracy with five length gauges

The radial guideway accuracy varies depending on the distance from the bearing plane and should therefore be measured at different distances. These measurements are performed for a defined number of revolutions. They provide the deviation of the actual axis of rotation from the nominal axis of rotation for every rotational angle of the bearing. The misalignment of the measuring standard relative to the bearing axis is mathematically removed from the result.

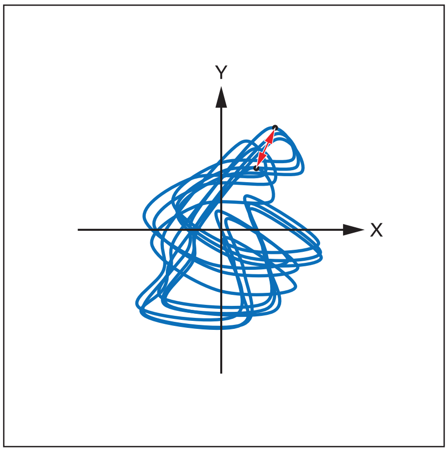
This analysis yields values that contain both recurring (reproducable) errors and random (non-repeatable) errors. Since the measurements are always performed over multiple revolutions, the reproducible errors can be separated from the non-reproducible errors. This enables a reliable assessment of both components of the guideway accuracy and provides clear information about the actual quality of the bearing without external influences.



The amount of **radial error** in the X and Y directions depends on the rotational angle of the bearing. To illustrate the position-dependent deviation, the radial deviation can be shown as a curve.



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



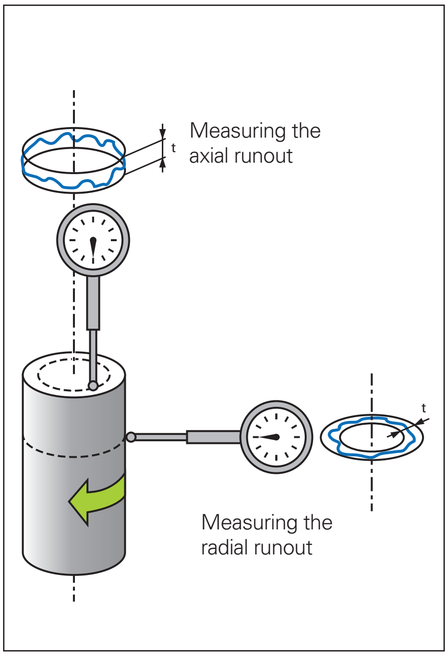
The **non-reproducible radial guideway accuracy** is determined by measuring the deviation within eight revolutions at the same angle of rotation.
The non-reproducible radial guideway accuracy equals the maximum deviation of the ascertained values.

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 refers to 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 stated 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

Bearing loads

Specifications
All specifications of the bearing characteristics assume usage without additional loads. It is also assumed that all of the mounting components 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 specified 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.

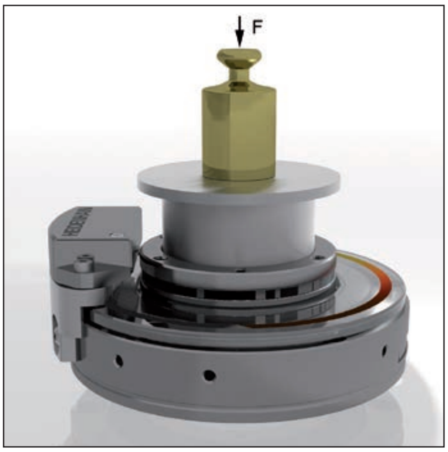


Figure 1: Axial load

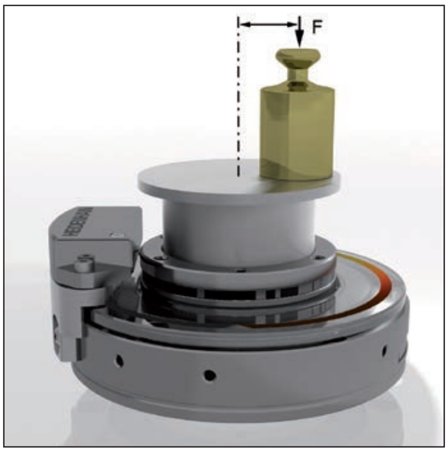
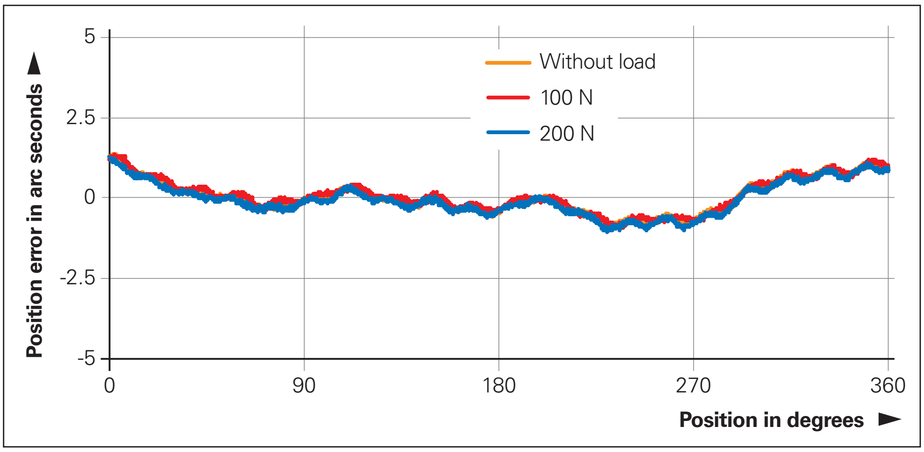
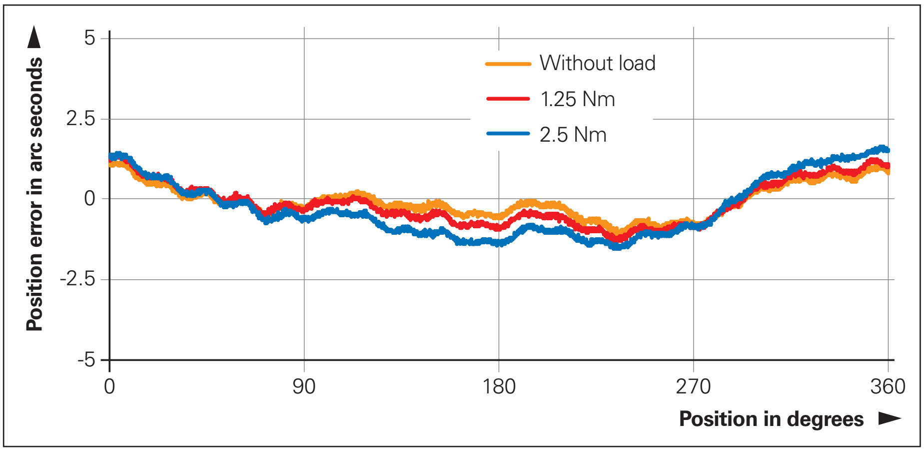


Figure 2: Off-center load



Position error under axial load with the MRP 5080



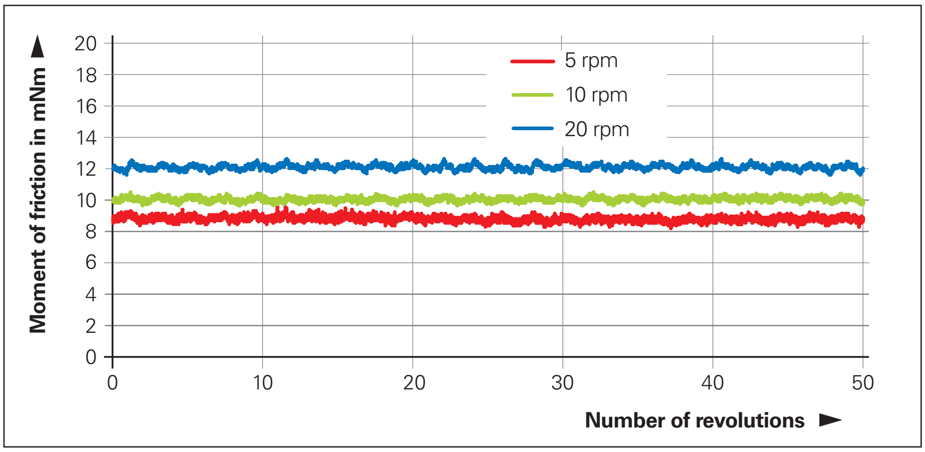
Position error under tilting load with the MRP 5080

Lubrication and moment of friction

Moment of friction
Angle encoder modules from HEIDENHAIN are characterized by a constant moment of friction and low breakaway torque. All of the 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 throughout the service life, so that maintenance is not required. Only high-quality lubricants are used.



Speed-dependent moment of friction with the MRP 5000

The motor

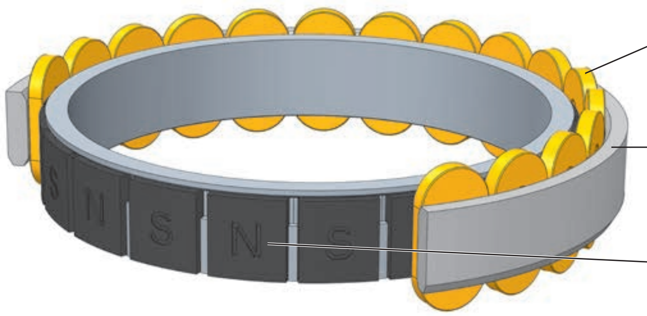
Slotless torque motor
The motor, which was specially developed for the SRP angle encoder module, meets even the highest requirements placed on high-precision rotary axes. The motor is cogging-free and produces no disturbing influences on the high-accuracy bearing. This allows for exceptionally uniform motion control and positioning accuracy.

Motion is provided by a slotless, iron-core torque motor. As such, this motor combines two normally contradictory characteristics—high torque density and low cogging torque. Instead of the slots employed in conventional designs, this motor uses self-retaining coils.

Thanks to the motor's special design and highly symmetrical component configuration, the rotor is exposed to a constant magnetic field throughout its entire rotation.

An iron return ring enables a comparatively large amount of torque.
These are the resulting 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 during operation (shaft speed ≠ 0):

- With continuous current (I_c) over a very long (unlimited) period
- With maximum current (I_p) for at most 1 s. The maximum current (I_p) must not be exceeded.
- For current values between continuous current (I_c) and maximum current (I_p) for more than 1 s, the controller electronics must provide I^2t monitoring to protect the device from thermal overload.

Motor at standstill (shaft speed = 0):

- With stall current (I_s) over a very long (unlimited) time
- With continuous current (I_c) for at most 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, an integrator circuit is activated. Once the integrator circuit reaches the I^2t time limit, the controller must stop the supply of current to the motor.

I^2t RMS current limit	= I_s motor during standstill (shaft speed = 0)
	= I_c motor during operation (shaft 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 servomotors 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.

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.

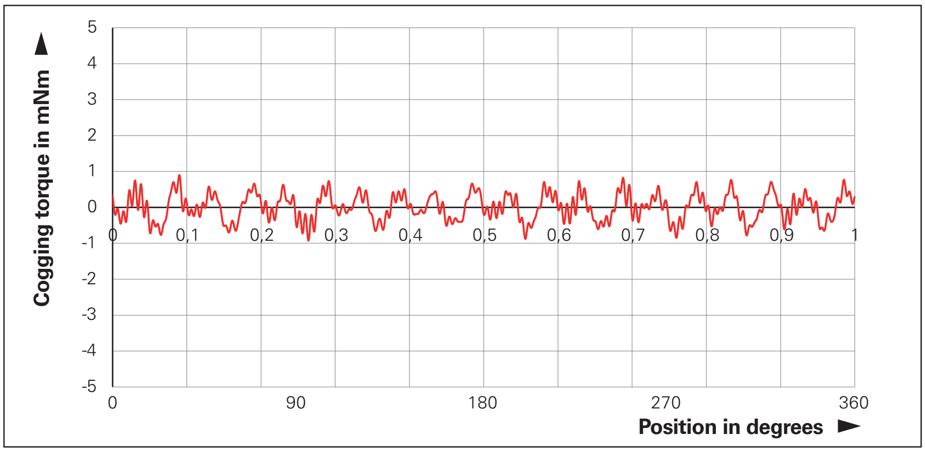
With the recommended AccurET controllers from ETEL, the characteristics for protection against thermal overloading are already integrated.

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

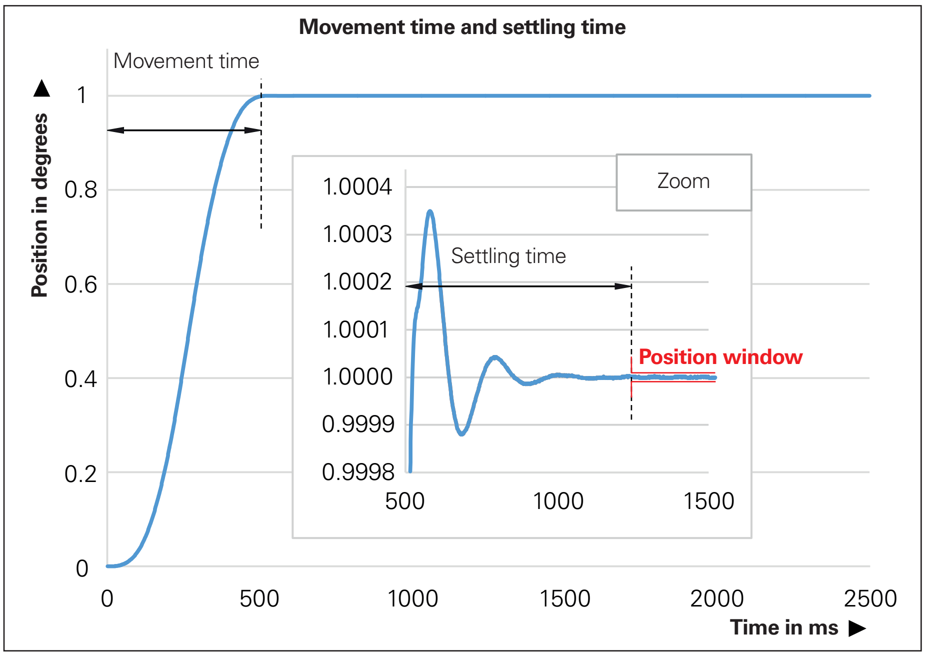
For the plotting of the cogging torque, the integrated torque motor is in its de-energized state and is driven by an external source of torque. The maximum occurring cogging torque is typically compared with the rated torque of the integrated torque motor and is therefore a percentage. For the SRP 5010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



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 duration of motion needed to approach the angular position 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 given application.

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

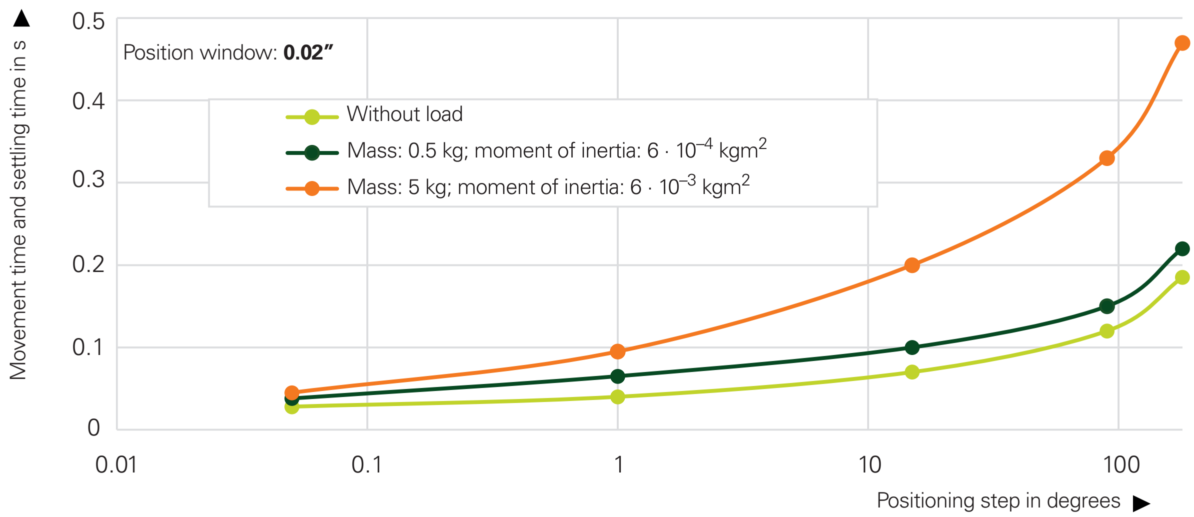
Maximum speed	1800 °/s
Acceleration	34000 °/s²
Jerk time	0.0052 s

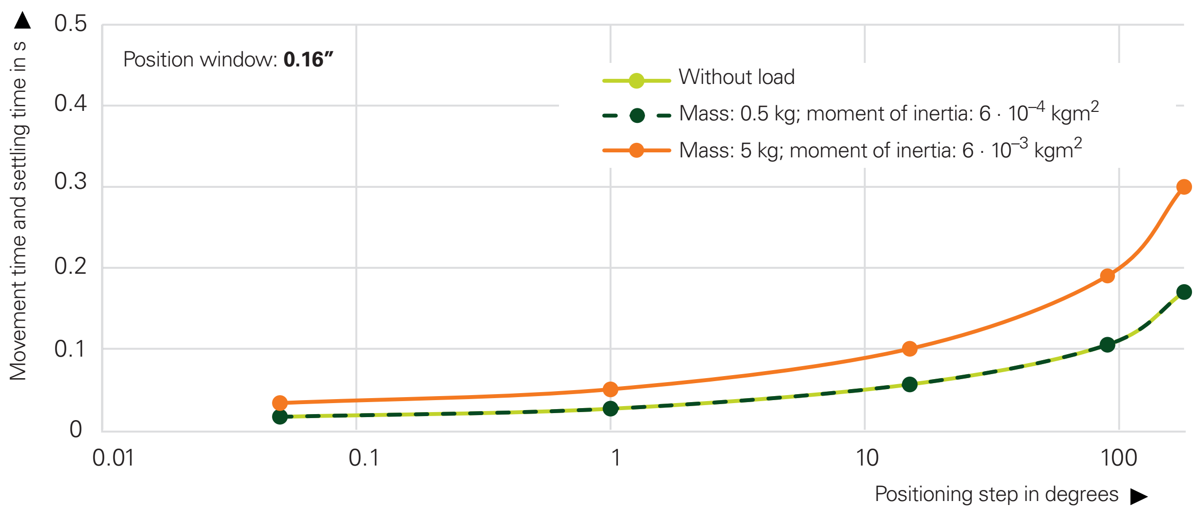
SRP 5000 with different loads

Without load

Mass: 0.5 kg,
Moment of inertia:: 6 · 10^{-4} kgm²

Mass: 5 kg,
Moment of inertia: 6 · 10^{-3} kgm²





Mechanical design types and mounting

The angle encoder module consists of a 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

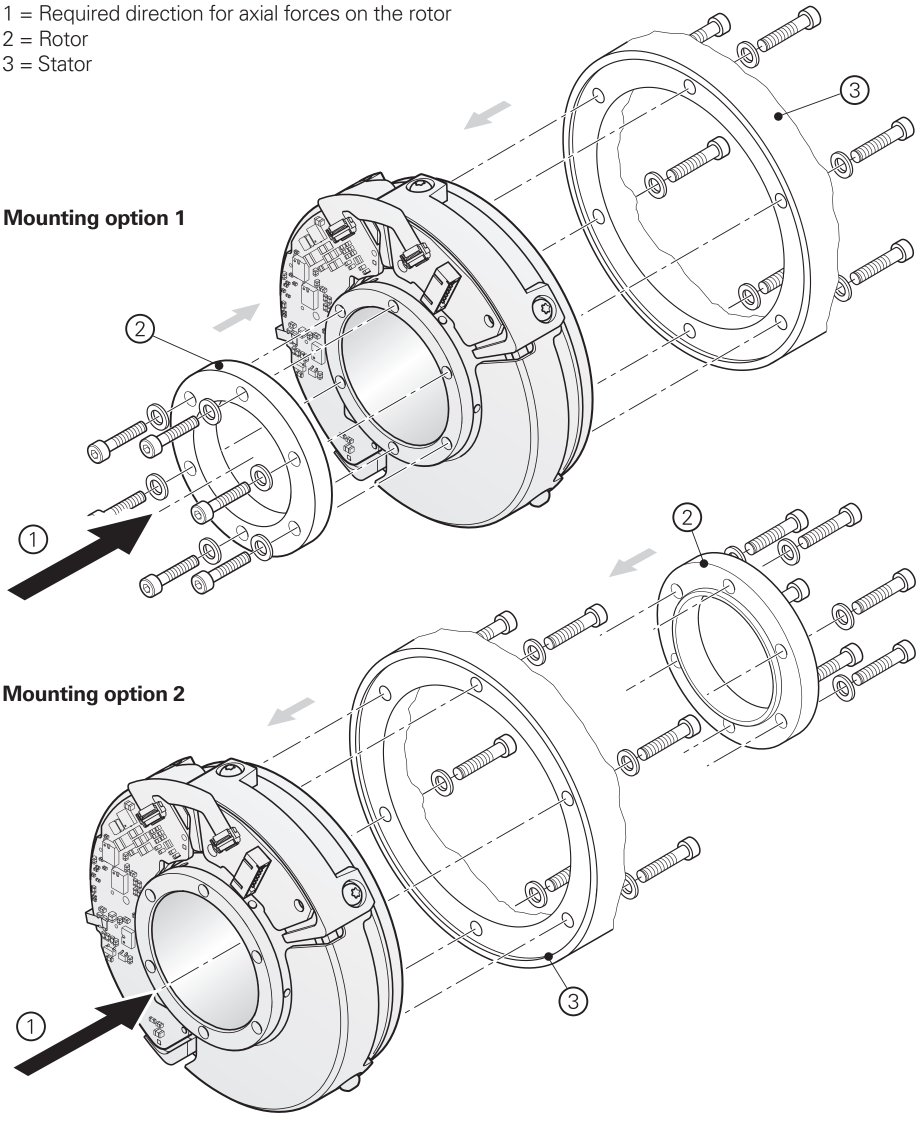
A precise alignment of the angle encoder module is not required, because the angle encoder module and bearing are already optimally aligned relative to each other. Centering collars on the mounting parts, however, can facilitate mounting.

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
Steel is recommended for the mounting part. The material must have a thermal coefficient of expansion of $\alpha = (10 \text{ to } 12) \cdot 10^{-6}\ K^{-1}$. The material must also meet the following specifications:

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

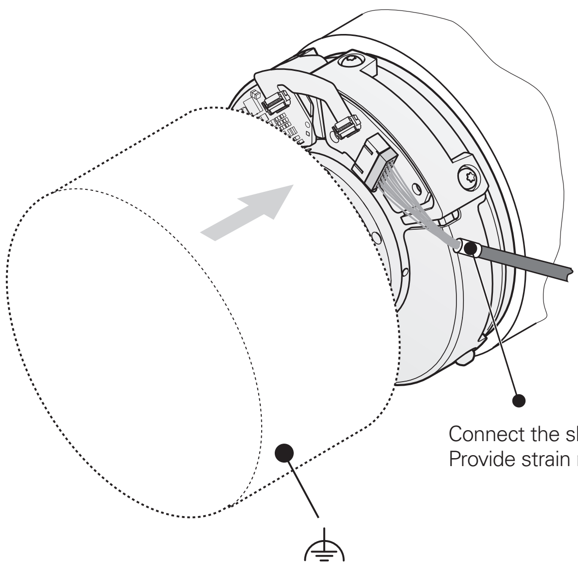
1 = Required direction for axial forces on the rotor
2 = Rotor
3 = Stator



Mounting options of the MRP 5010 devices

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.



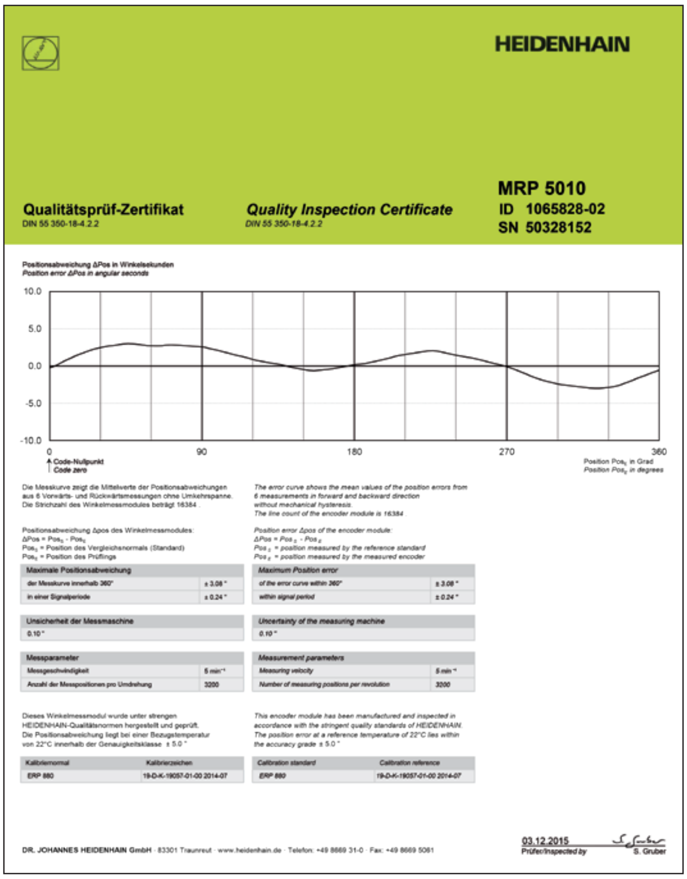
Calibration charts

Prior to shipping, HEIDENHAIN tests each enocoder module for proper functioning.

A Quality Inspection Certificate documents the **system accuracy**, which is determined through eight forward and eight reverse 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.

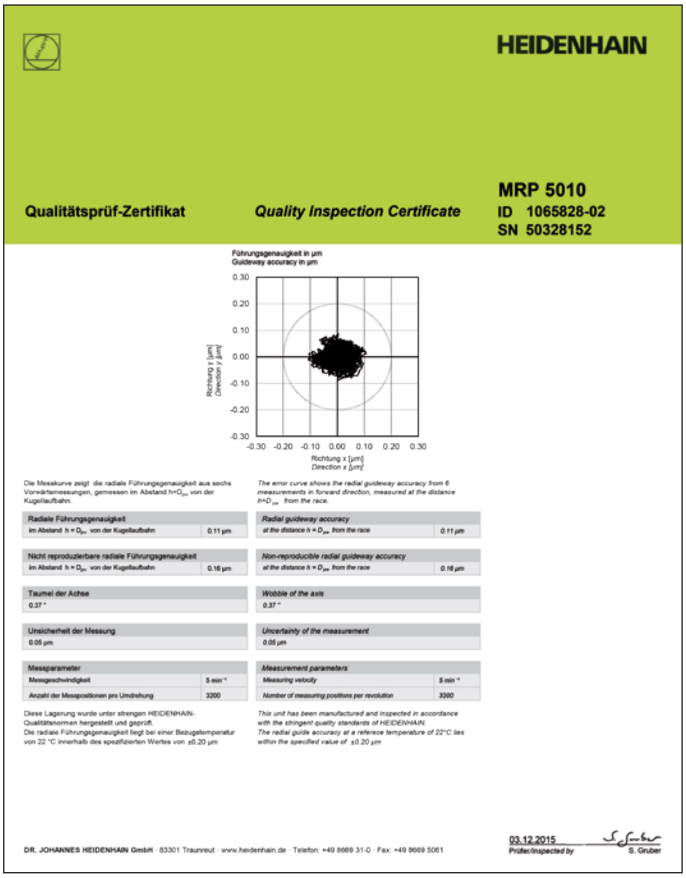


The Quality Inspection Certificate documents the system accuracy.

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

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 radial guideway accuracy.

Transferable accuracy

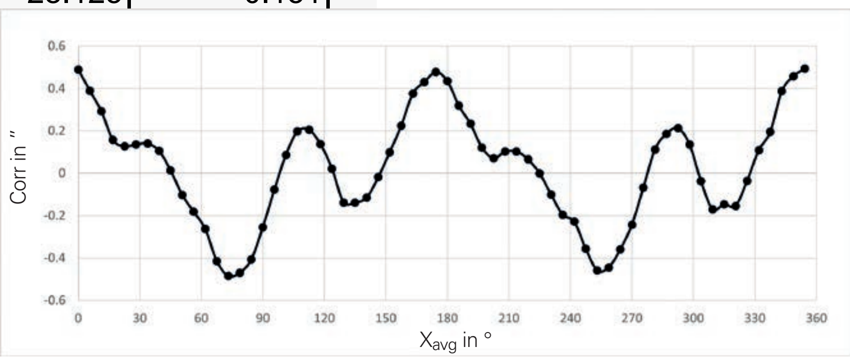
In order to achieve accuracies in the high-end range, customers must often perform a very complex and time-consuming calibration of the entire machine. Under the motto "transferable accuracy," HEIDENHAIN contributes to facilitating the mounting process for the customer and to transferring the high accuracy of its encoders to the customer's application without loss. For the MRP 8081 D*plus* encoders, this is achieved through the following features:

- Robust mechanical mounting interface
- Combination of rigid bearing unit and pre-adjusted scanning
- Four scanning heads for position calculation for robust angle measurement
- Compensation data for boosting the system accuracy

Electrical connection
The MRP 8081 D*plus* angle encoder module has four separate connections (D-sub, 15-pin) with the 1 V_{PP} interface. HEIDENHAIN EIB 74x signal converters can be used to operate the product. The product can also be connected to downstream electronics from third-party suppliers if they provide four 1 V_{PP} inputs.

Compensation data file
The included compensation data file in CSV format contains a two-dimensional table. In this table, the angular positions from the four scanning heads, which have already been taken into account in the calculation, are assigned the corresponding compensation values for boosting accuracy. The compensation data file is provided on a USB flash drive included with the encoder.

X_{avg} in °	Corr in ″
0	0.489
5.625	0.397
11.250	0.274
16.875	0.188
22.500	0.144
28.125	0.151

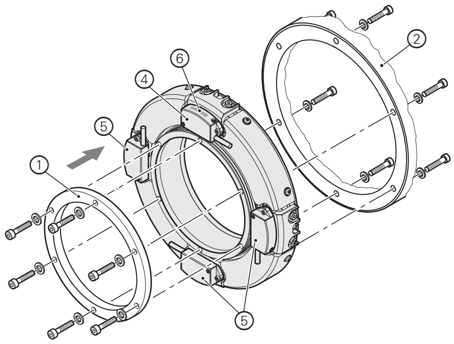


Position calculation with an EIB 74x or downstream electronics from third-party suppliers
For the system to be able to reach the specified accuracy, the positions of all scanning heads must be averaged.

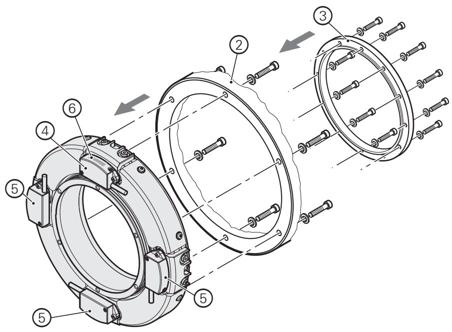
$$X_{avg} = \frac{(X1_{abs} + X2_{abs} + X3_{abs} + X4_{abs})}{4}$$

$X1_{abs}$ ... $X4_{abs}$: Positions of the scanning heads
X_{avg}: Arithmetic mean value of inputs $X1_{abs}$ to $X4_{abs}$

For more information about implementing the position calculation, please refer to the MRP 8081 D*plus* installation instructions.



Mounting option 1



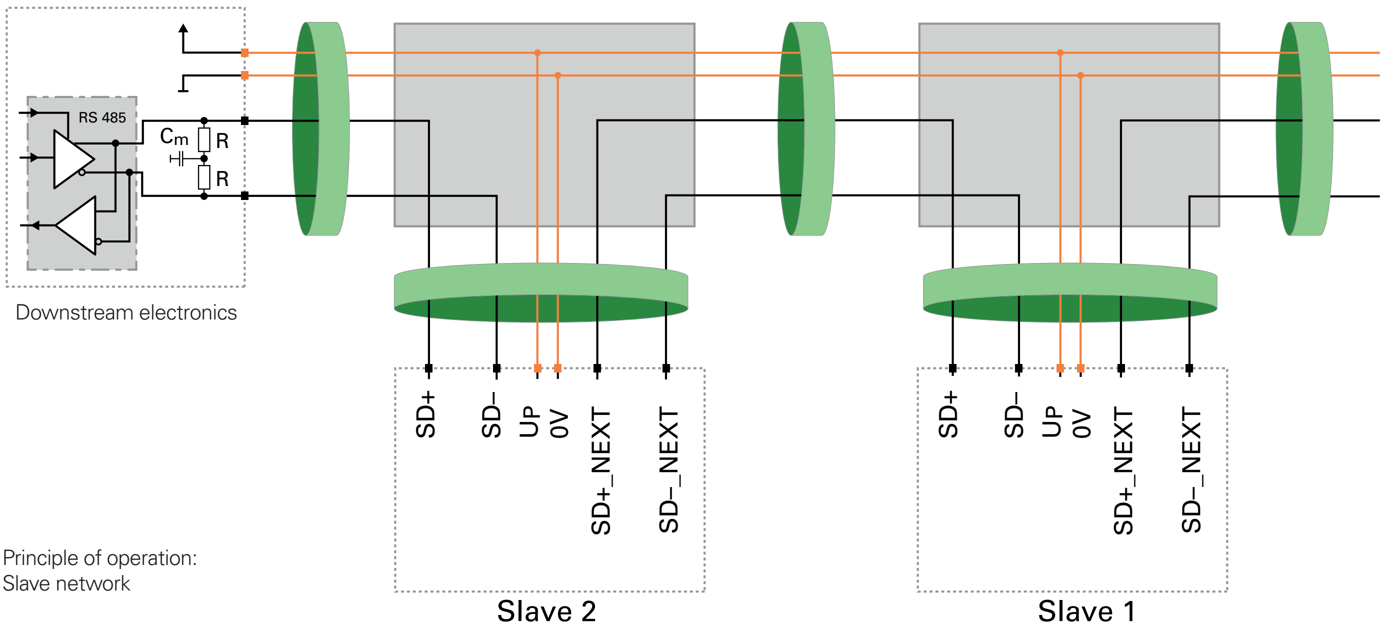
Mounting option 2

1 Customer rotor (mounting option 1)
2 Customer stator
3 Customer rotor (mounting option 2)
4 Scanning head 1 (with ID label)
5 Scanning heads 2 to 4 (without ID label)
6 ID label

Bus operation EnDat 3

Principle of operation

The MRP 2030 and MRS 223x encoders use the EnDat 3 interface, which enables bus operation in daisy-chain mode. Two wire pairs, one for power and one for communication, connect the EnDat 3 Master to the network. Each encoder has four communication connectors (two for each communication wire pair). Each slave listens to all communication as it passes through the slave network.



Principle of operation:
Slave network

Communication

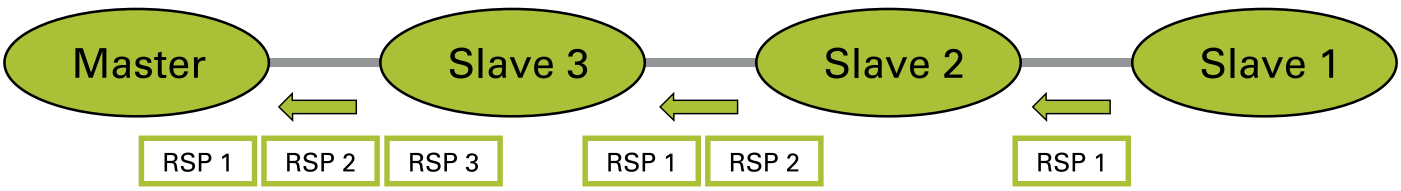
In bus operation, the master sends a request in the form of a broadcast and anticipates responses from all the connected participants. The participant with the address "Slave 1" is the first one o send its response (RSP 1). The next participant ("Slave 2") listens to the response and, immediately after completion of the response, sends its own. The following figure illustrates the procedure for three participants:

Bus communication requires that the corresponding bus addresses must be programmed in the encoder. This can be done with the PWM 21 testing device (ATS software) or with downstream electronics.

Currently valid limitations on the number of participants in bus operation

12.5 Mbit/s*	6 participants at a total cable length of 100 m
25 Mbit/s	3 participants at a total cable length of 40 m

*With the MRP 2030 and MRS 223x encoders, up to 8 participants can be connected to each other with a maximum cable length of 10 m.

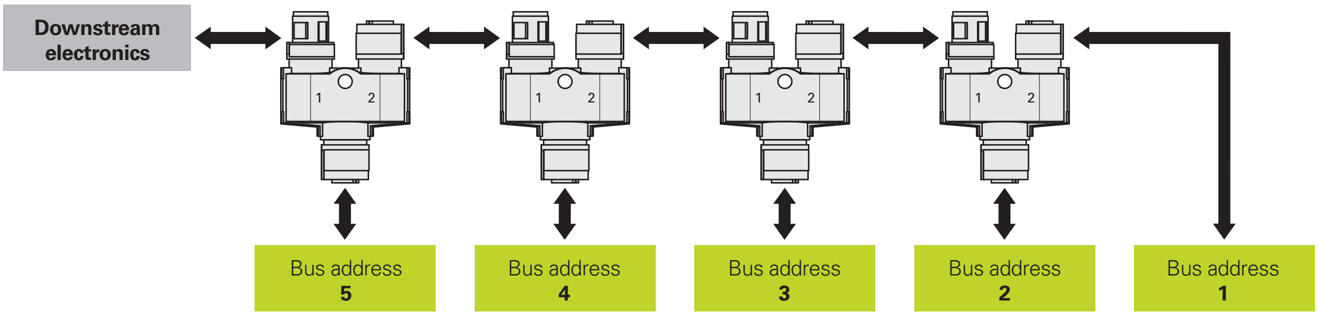


Bus operation: example with 3 participants

Power supply and cables

The interlinking of multiple encoders gives rise to high supply current in individual sections of the network. It is therefore important that the supply wires have a sufficiently large cross section. To limit losses in the cables, comply with the following recommendation: the participant that is farthest away (Bus Address 1) should be supplied with at least 9 V. The cables must be suitable for EnDat 3 communication. We recommend using the Y coupler (ID 1341637-03) and original HEIDENHAIN cable.

For connecting the encoder to the Y coupler, a suitable output cable must be used. For cabling a Y adapter to a Y adapter, EnDat22 cable assemblies can be used (see the *Cables and Connectors* brochure).
See also *General electrical information* in the *Cables of HEIDENHAIN Encoders* brochure. For more information about EnDat 3, visit *www.endat.de*.



Sample setup

MRP 2000 series

Angle encoder modules with built-in encoder and bearing

- **Particularly compact dimensions**
- **High measuring and bearing accuracy**
- **Hollow shaft diameter: 10 mm**

Encoder characteristics	***Incremental*** **MRP 2080**	***Absolute*** **MRP 2010**	**MRP 2030**
Measuring standard	DIADUR circular scale		
Signal periods	2048		
System accuracy	±7″		
Position error per signal period	±1.5″		
Repeatability	*From both directions:* 3″		
RMS position noise	Typically 0.07″	Typically 0.10″	
Interface	∿ 1 V_{PP}	EnDat 2.2	EnDat 3
Ordering designation	–	EnDat22	E30-RB
Position values per revolution	–	25 bits	
Clock frequency Calculation time t_{cal}	–	≤ 16 MHz ≤ 7 µs	
Reference marks	1	–	
Cutoff frequency –3 dB	≥ 210 kHz	–	
Bus operation (daisy chain)	–	–	✓
Data rate	–	–	12.5 Mbit/s (25 Mbit/s)
Cycle time	–	–	Typically > 25 µs
Electrical connection	14-pin PCB connector; adapter cable plus quick connector as an accessory	16-pin PCB connector (12+4 for additional sensor)	
Cable length[1)]	≤ 30 m (with HEIDENHAIN cable)		25 Mbit/s; up to 3 bus *participants:* ≤ 40 m 12.5 Mbit/s; up to 6 bus *participants:* ≤ 100 m 12.5 Mbit/s; up to 8 bus *participants:* ≤ 10 m
Supply voltage	DC 5 V ±0.25 V	DC 3.6 V to 14 V	
Power consumption (maximum)	*5.25 V:* ≤ 0.7 W	*3.6 V:* ≤ 0.6 W *14 V:* ≤ 0.7 W	*3.6 V:* ≤ 0.45 W *14 V:* ≤ 0.65 W
Current consumption (typical)	*Without load:* I_P = 60 mA; max. 120 mA *With load:* max. 130 mA	*5 V:* 85 mA (without load)	*12 V:* 25 mA (without load)

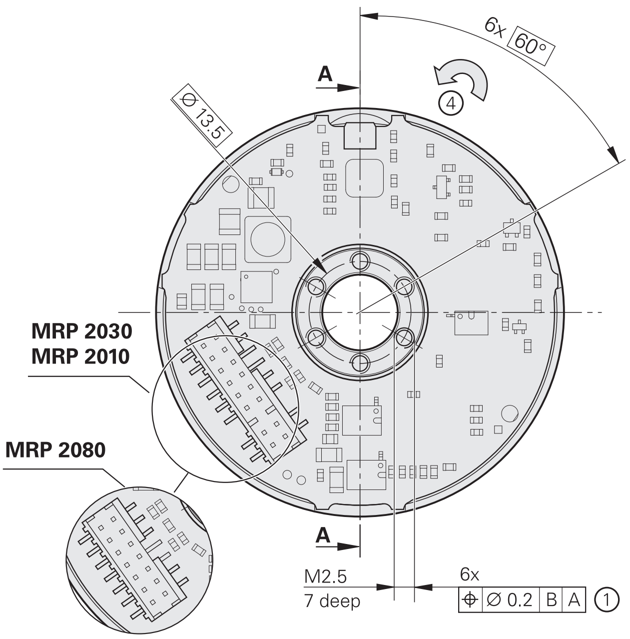
1) The cable length refers to the entire transmission distance.

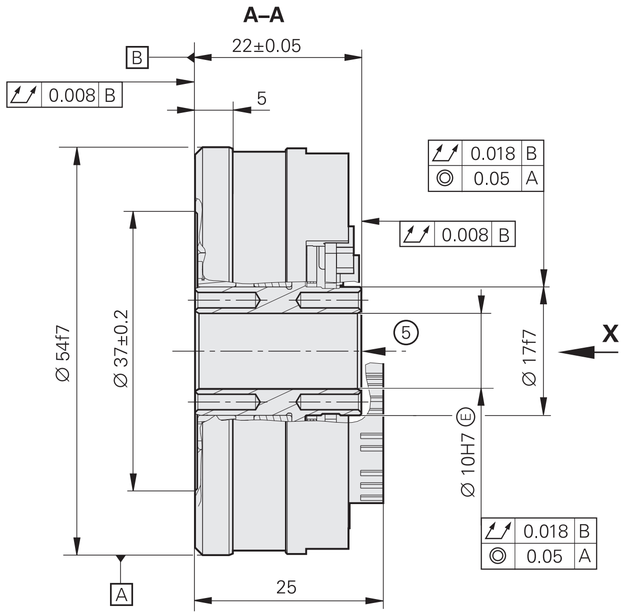
MRP 2080/
MRP 2010/
MRP 2030

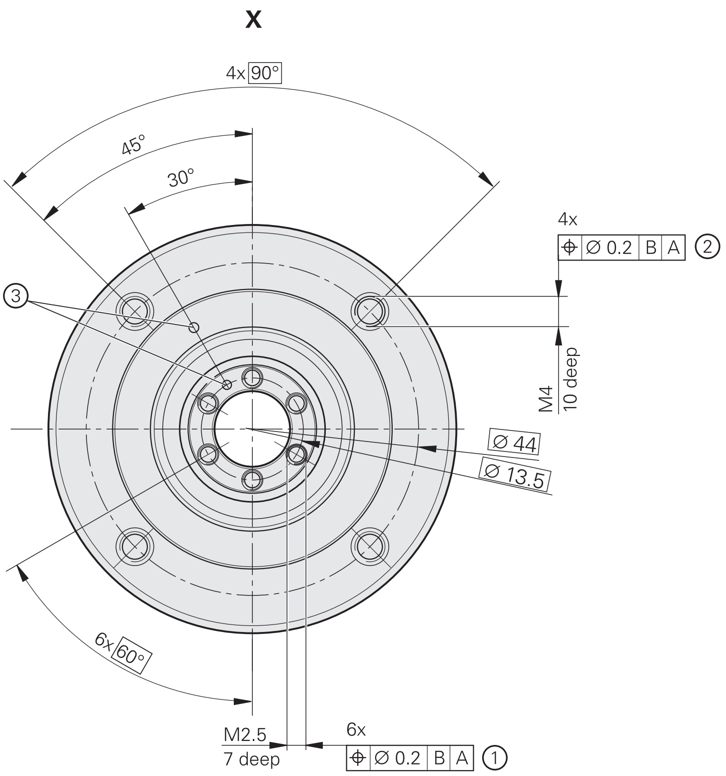
Bearing properties	***Incremental*** **MRP 2080**	***Absolute*** **MRP 2010**	**MRP 2030**
Shaft	Hollow through shaft D = 10 mm		
Max. permissible axial load[3]	50 N (centered load)		
Max. permissible radial load[3]	45 N		
Max. permissible tilting torque[3]	0.8 Nm		
Contact stiffness	*Axial:* 25 N/µm *Radial:* 77 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 a distance of h = 20 mm from the rotor mating surface: ≤ 0.60 µm		
Non-reproducible radial guideway accuracy	Measured at a distance of h = 20 mm from the rotor mating surface: ≤ 0.70 µm		
Axial guideway accuracy	≤ ±0.3 µm		
Axial runout of the surface	≤ 8 µm		
Wobble of the axis	2.5″		
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 1000 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] 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 loads

MRP 2000 series
MRP 2010, MRP 2030, MRP 2080





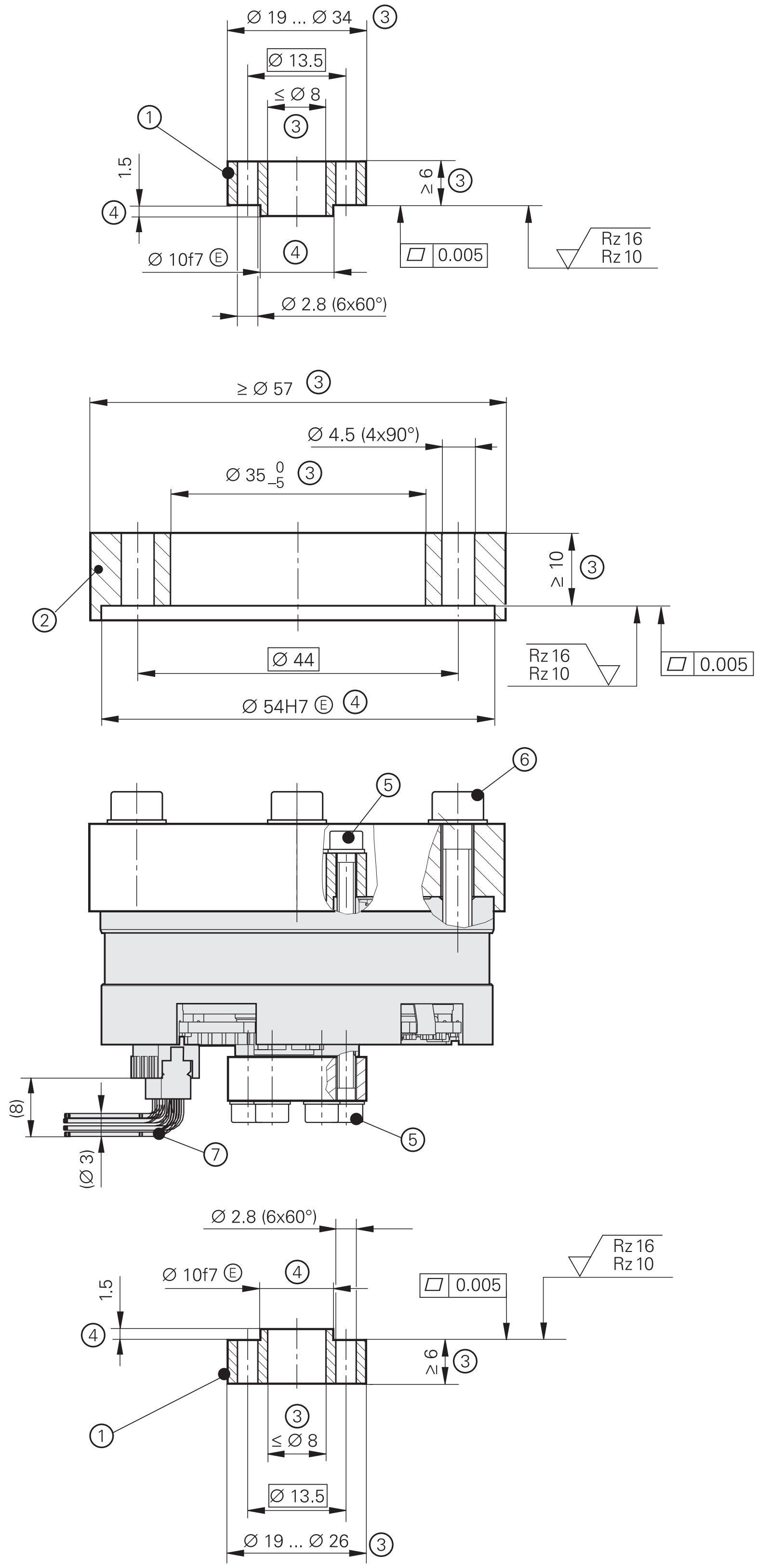


mm

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

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 = Mark for 0° position ±5°
4 = Direction of shaft 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 mating 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 = The customer is responsible for electrical shielding and for connecting cables

MRS 2200 series

Angle encoder module with integrated encoder and bearing
- **Compact dimensions**
- **High measuring and bearing accuracy**
- **Hollow shaft diameter: 10 mm**
- **High resistance to tilt**

Encoder characteristics	***Incremental*** **MRS 2280**	***Absolute*** **MRS 2230**	***Incremental*** **MRS 2281**	***Absolute*** **MRS 2231**
Measuring standard	DIADUR circular scale			
Signal periods	2048			
System accuracy	±10″			
Position error per signal period	±1.5″			
Repeatability	*From both directions:* 3″			
RMS position noise	Typically 0.07″	Typically 0.10″	Typically 0.07″	Typically 0.10″
Interface	∿ 1 V_{PP}	EnDat 3	∿ 1 V_{PP}	EnDat 3
Ordering designation	–	E30-RB	–	E30-RB
Positions/revolution	–	25 bits	–	25 bits
Reference marks	One	–	One	–
Cutoff frequency –3 dB	≥ 210 kHz	–	≥ 210 kHz	–
Bus operation (daisy chain)	–	✓	–	✓
Data rate	–	12.5 Mbit/s (25 Mbit/s)	–	12.5 Mbit/s (25 Mbit/s)
Cycle time	–	Typically > 25 µs	–	Typically > 25 µs
Electrical connection	14-pin PCB connector; *accessory:* adapter cable with quick connector	16-pin PCB connector (12+4 for additional sensor)	14-pin PCB connector; *accessory:* adapter cable with quick connector	16-pin PCB connector (12+4 for additional sensor)
Cable length[1)]	≤ 30 m (with HEIDENHAIN cable)	*25 Mbit/s; up to 3 bus participants:* ≤ 40 m *12.5 Mbit/s; up to 6 bus participants:* ≤ 100 m *12.5 Mbit/s; up to 8 bus participants:* ≤ 10 m	≤ 30 m (with HEIDENHAIN cable)	*25 Mbit/s; up to 3 bus participants:* ≤ 40 m *12.5 Mbit/s; up to 6 bus participants:* ≤ 100 m *12.5 Mbit/s; up to 8 bus participants:* ≤ 10 m
Supply voltage	DC 5 V ±0.25 V	DC 3.6 V to 14 V	DC 5 V ±0.25 V	DC 3.6 V to 14 V
Power consumption (maximum)	5.25 V: ≤ 0.7 W	*3.6 V:* ≤ 0.45 W *14 V:* ≤ 0.65 W	5.25 V: ≤ 0.7 W	*3.6 V:* ≤ 0.45 W *14 V:* ≤ 0.65 W
Current consumption (typical)	*Without load:* I_P = 60 mA; max. 120 mA *With load:* max. 130 mA	*12 V:* 25 mA (without load)	*Without load:* I_P = 60 mA; max. 120 mA *With load:* max. 130 mA	*12 V:* 25 mA (without load)

1) The cable length refers to the entire transmission distance.

MRS 2280/ MRS 2230

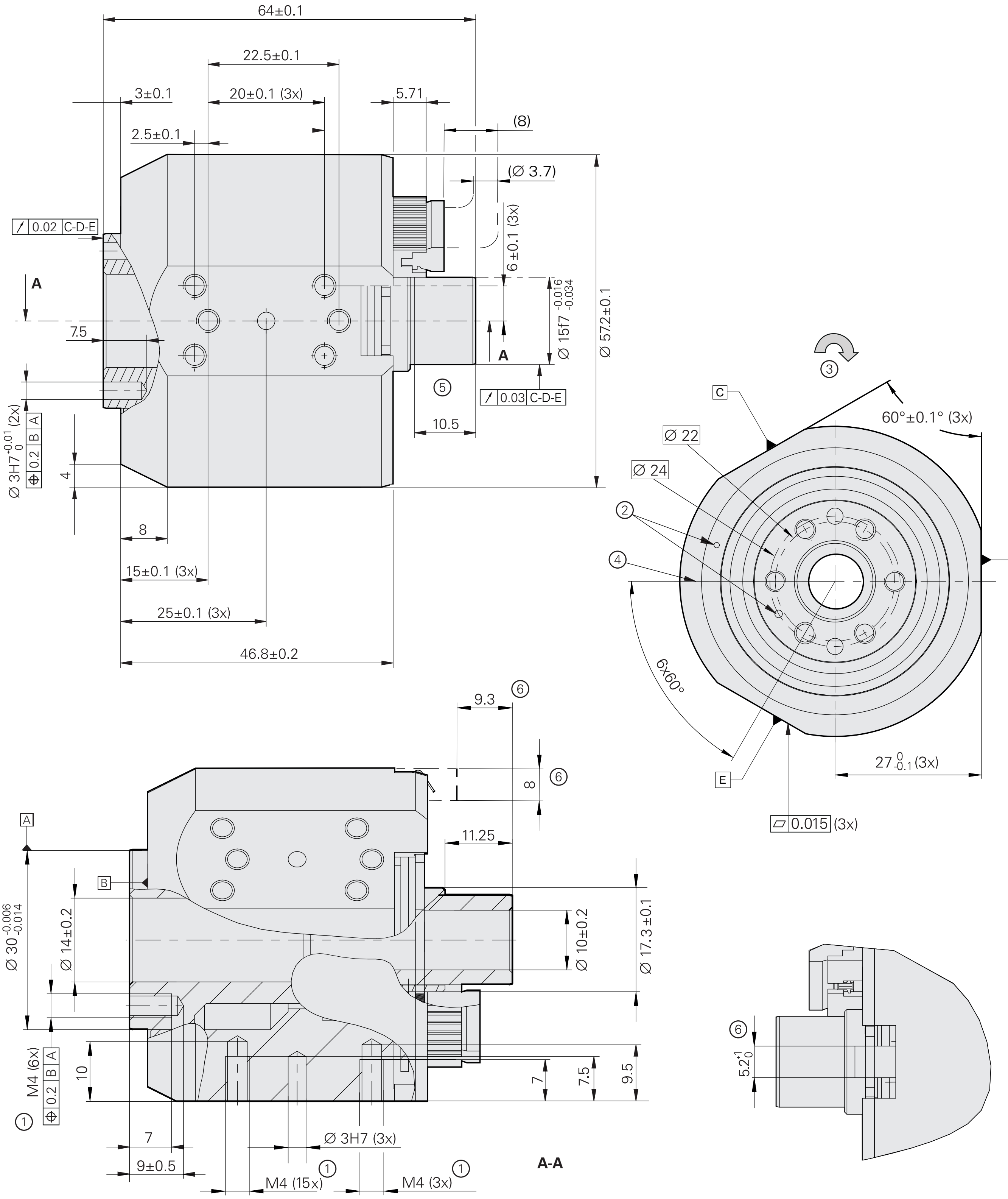
MRS 2281/ MRS 2231

Bearing properties	***Incremental* MRS 2280**	***Absolute* MRS 2230**	***Incremental* MRS 2281**	***Absolute* MRS 2231**
Shaft	Hollow through shaft D = 10 mm			
Max. permissible axial load[1)]	100 N (centered load)		50 N (centered load)	
Max. permissible radial load[1)]	45 N			
Max. permissible tilting torque[1)]	5 Nm		2.5 Nm	
Contact stiffness	*Axial:* 54 N/µm *Radial:* 153 N/µm (calculated values)		*Axial:* 27 N/µm *Radial:* 77 N/µm (calculated values)	
Resistance to tilt	52 Nm/mrad (calculated value)		24 Nm/mrad (calculated value)	
Mech. permissible speed	1000 rpm			
Moment of friction	≤ 20 mNm		≤ 15 mNm	
Starting torque	≤ 30 mNm		≤ 20 mNm	
Max. transferable shaft torque[1)]	1 Nm			
Moment of inertia of rotor	$1.5 \cdot 10^{-5}$ kgm^2		$0.9 \cdot 10^{-5}$ kgm^2	
Radial guideway accuracy	≤ 0.8 µm[2)]		≤ 2.4 µm[2)]	
Non-reproducible radial guideway accuracy	≤ 0.5 µm[2)]		≤ 1.6 µm[2)]	
Axial runout of the surface	≤ 20 µm		≤ 30 µm	
Radial runout	≤ 30 µm		≤ 50 µm	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27) (without load)			
Protection EN 60529	IP00[3)]			
Operating temperature **Storage temperature**	0 °C to 50 °C 0 °C to 50 °C			
Relative air humidity	≤ 75% without condensation			
Mass	0.34 kg (without cable or connector)		0.23 kg (without cable or connector)	

[1)] Purely static load, without additional vibrations or shock load. The overlapping of individual loads is not taken into account.
[2)] Measured at distance of h = 20 mm from the rotor mating surface; see *Measuring and bearing accuracy*
[3)] The electromagnetic compatibility of the complete system must be ensured through appropriate measures during installation.

MRS 2200 series

MRS 2280, MRS 2230

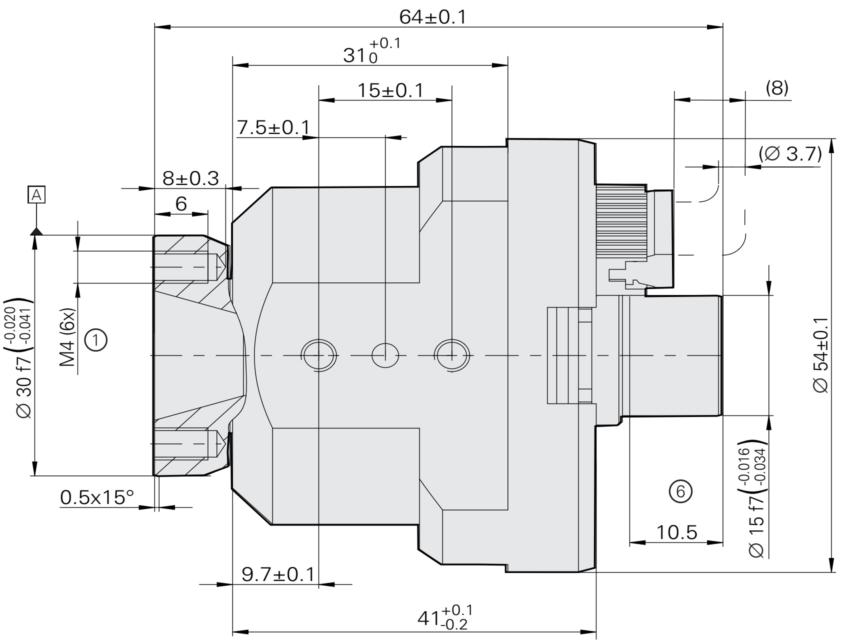


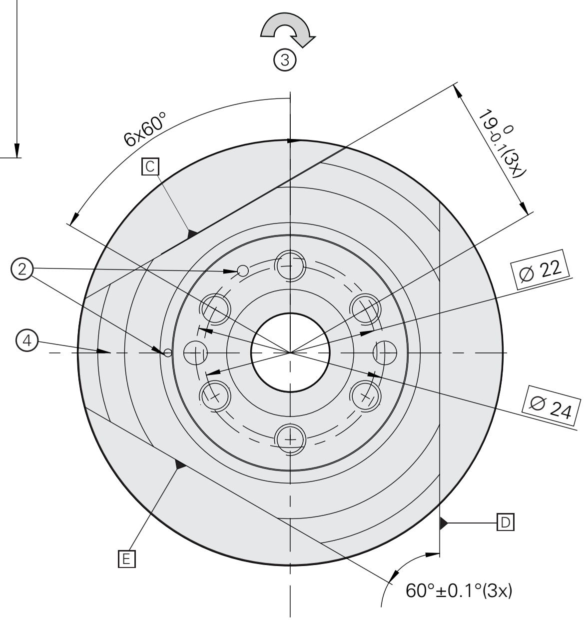
mm

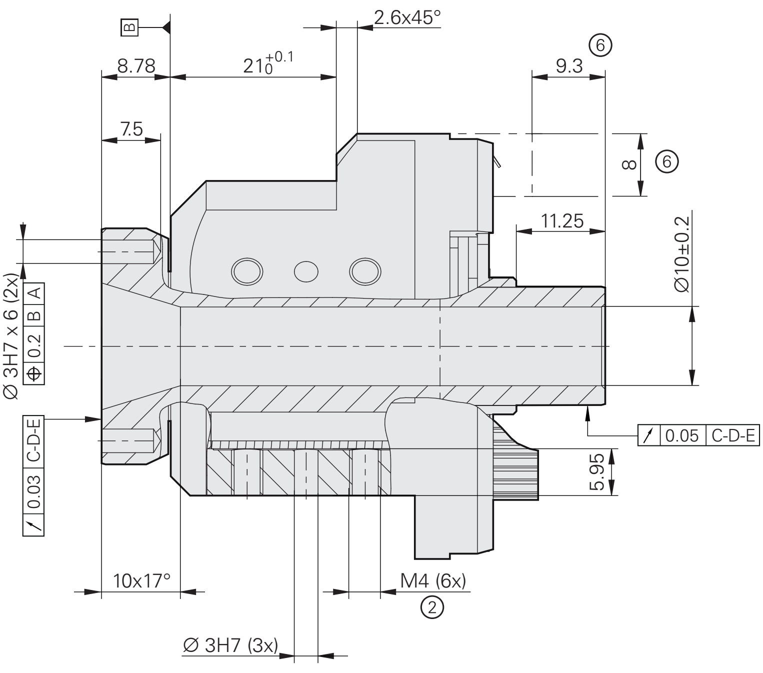
Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

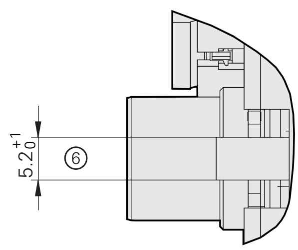
1 = Tightening torque of the M4 – 8.8 cylinder head screw: 2.5 Nm ±0.13 Nm
2 = Mark for 0° position ±5°
3 = Direction of shaft rotation for ascending position values
4 = LED position
5 = Permitted for shaft clamping
6 = Area available for flex PCB

MRS 2281, MRS 2231









mm

Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

1 = Tightening torque of the M4 – 8.8 cylinder head screw: 2.5 Nm ±0.13 Nm
2 = Mark for 0° position ±5°
3 = Direction of shaft rotation for ascending position values
4 = LED position
5 = Permitted for shaft clamping
6 = Area available for flex PCB

MRP 5000 series

Angle encoder modules with integrated encoder and bearing

- **Compact dimensions**
- **High measuring and bearing accuracy**
- **Hollow shaft diameter: 35 mm**

Encoder characteristics	***Incremental*** **MRP 5080**	**MRP 5280**	***Absolute*** **MRP 5010**
Measuring standard	OPTODUR circular scale		DIADUR circular scale
Signal periods	30000		16384
System accuracy*	±2.5″ or ±5″	±2.5″	±2.5″ or ±5″
Position error per signal period	±0.23″	±0.12″	±0.40″
Repeatability	*From both directions:* 0.3″		*From both directions:* 0.9″
RMS position noise	Typically 0.007″	Typically 0.004″	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 µs
Reference marks	80 (distance-coded)		–
Cutoff frequency –3 dB	≥ 500 kHz	≥ 300 kHz	–
Electrical connection	1.5 m cable with 15-pin D-sub connector; interface electronics inside connector		15-pin PCB connector; adapter cable plus quick connector as an 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	*5.25 V:* ≤ 900 mW	*3.6 V:* ≤ 1.1 W *14 V:* ≤ 1.3 W
Current consumption (typical)	175 mA (without load)	105 mA (without load)	*5 V:* 140 mA (without load)

* Please select when ordering

MRP 5080/MRP 5280

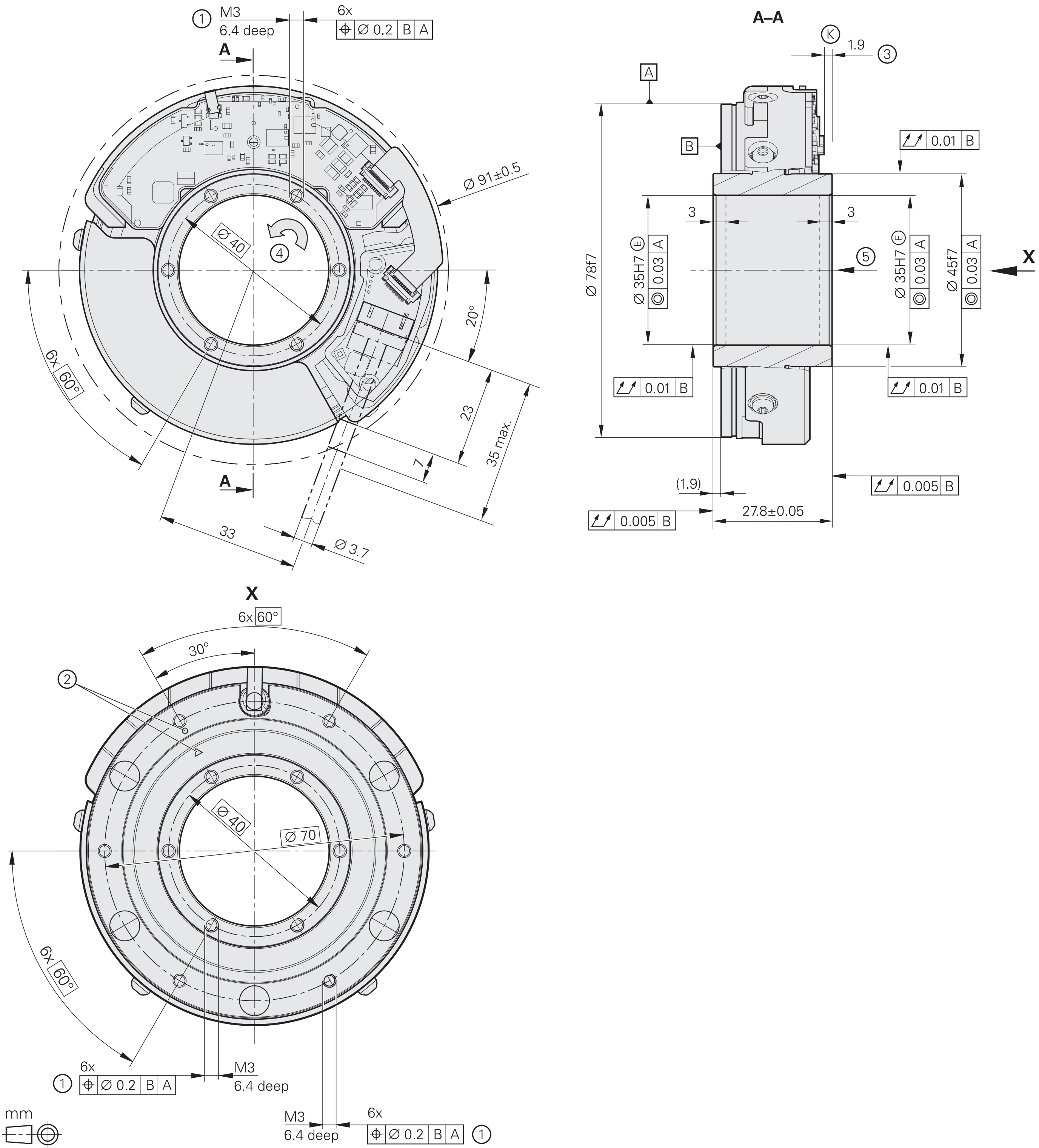
MRP 5010

Bearing properties	*Incremental* MRP 5080	MRP 5280	*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 (values calculated)	*Axial:* 303 N/µm *Radial:* 181 N/µm	*Axial:* 364 N/µm *Radial:* 217 N/µm	*Axial:* 303 N/µm *Radial:* 181 N/µm
Contact stiffness (value calculated)	102 Nm/mrad	122 Nm/mrad	102 Nm/mrad
Mech. permissible speed	300 rpm	150 rpm	300 rpm
Moment of friction	≤ 0.025 Nm	≤ 0.045 Nm	≤ 0.025 Nm
Starting torque	≤ 0.015 Nm	≤ 0.025 Nm	≤ 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 a distance of h = 40 mm from the rotor mating surface: ≤ 0.20 µm (without load)		
Non-reproducible radial guideway accuracy	Measured at a distance of h = 40 mm from the rotor mating surface: ≤ 0.35 µm (without load)		
Axial guideway accuracy	≤ ±0.2 µm		
Axial runout of the shaft	≤ 5 µm		
Wobble of the axis	0.7″		
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 200 m/s2 (EN 60068-2-6) ≤ 1000 m/s2 (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] 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 loads

MRP 5010 with cover

MRP 5000 series
MRP 5010

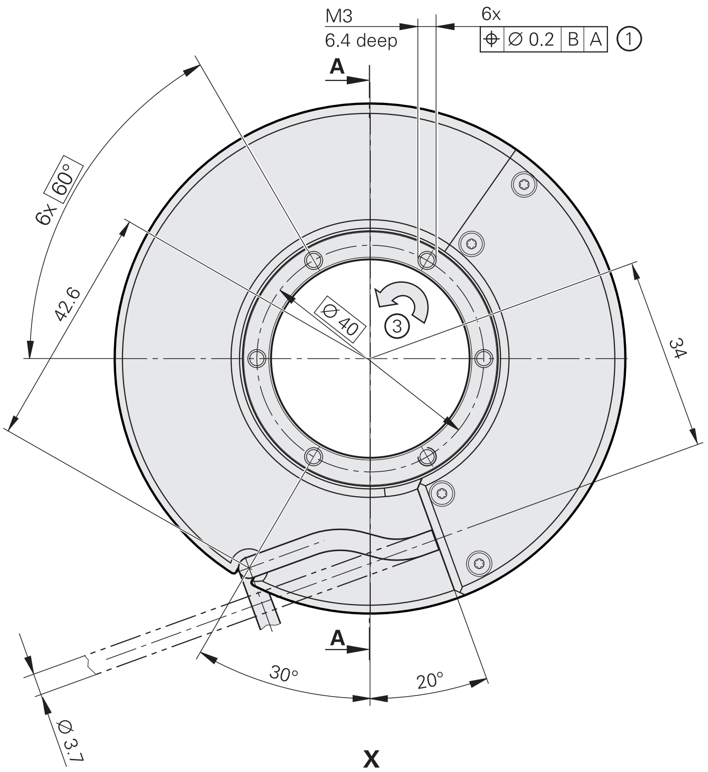


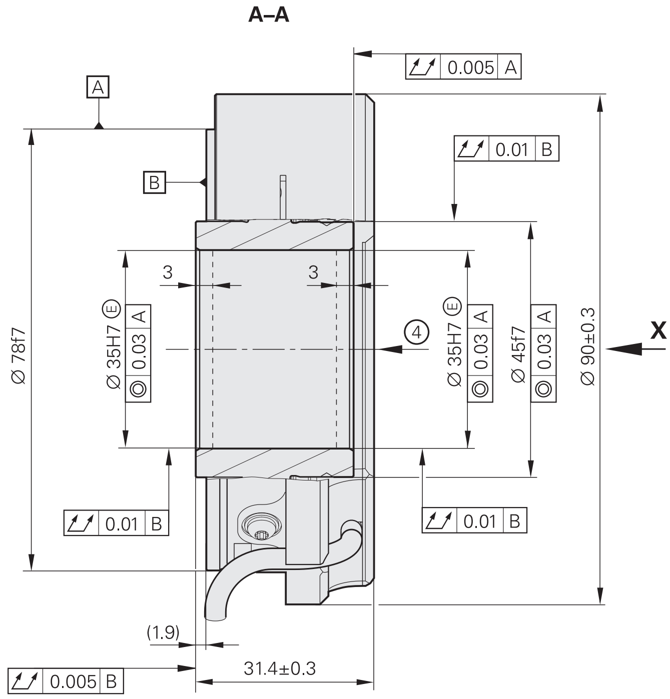
mm

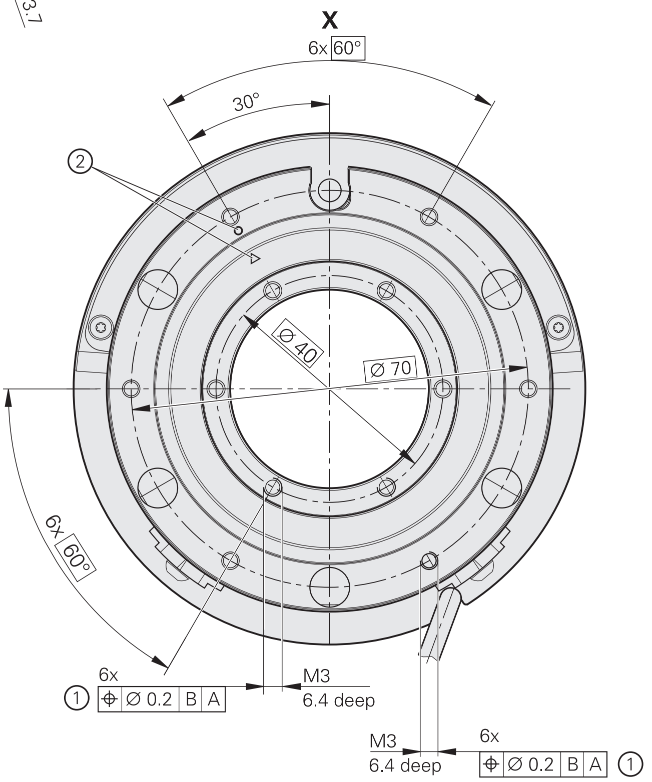
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Ⓚ = Required mating dimensions
1 = Tightening torque of the M3 – 8.8 cylinder head screws: 1.1 Nm ±0.05 Nm
2 = Mark for 0° position ±5°
3 = Comply with distance to the cover
4 = Direction of rotation of the shaft for ascending position values
5 = Required direction for axial forces

MRP 5010 with cover



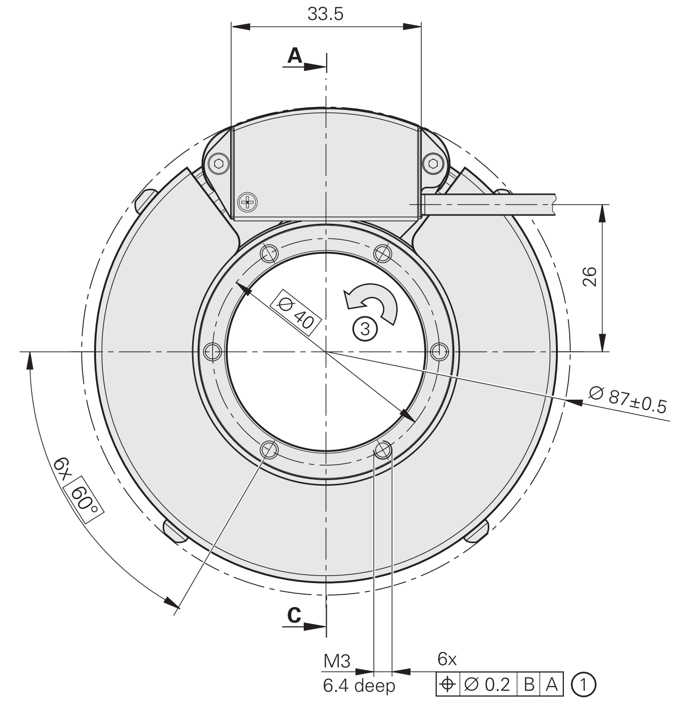


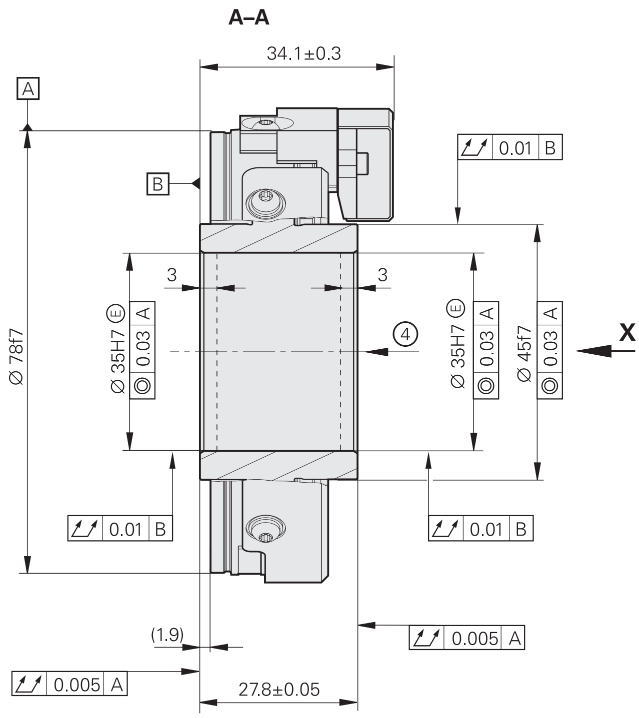


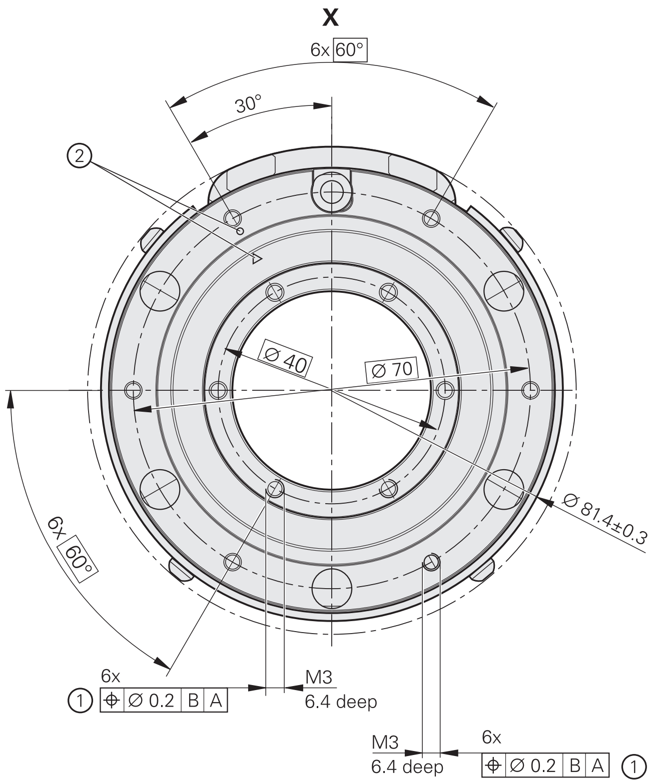
mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

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

MRP 5080, MRP 5280







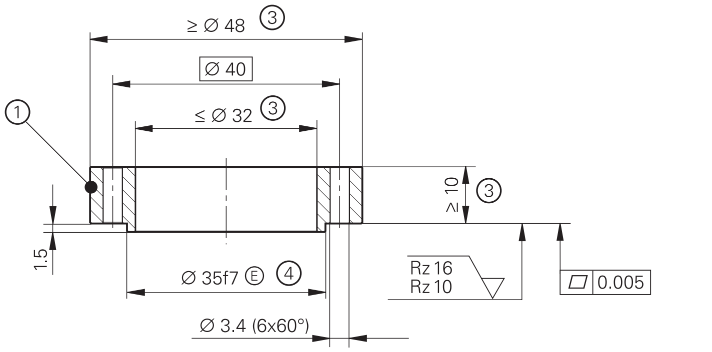
mm

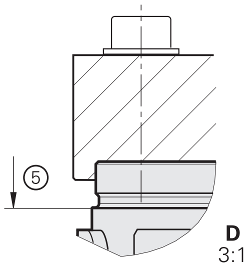
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

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

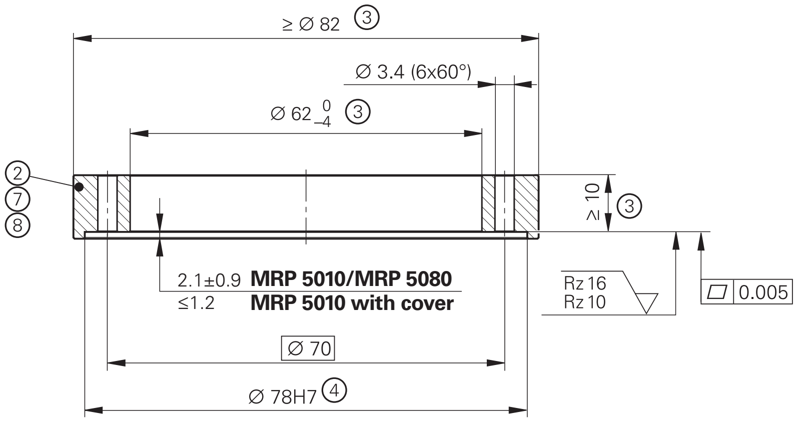
Mating dimensions of the mounting parts

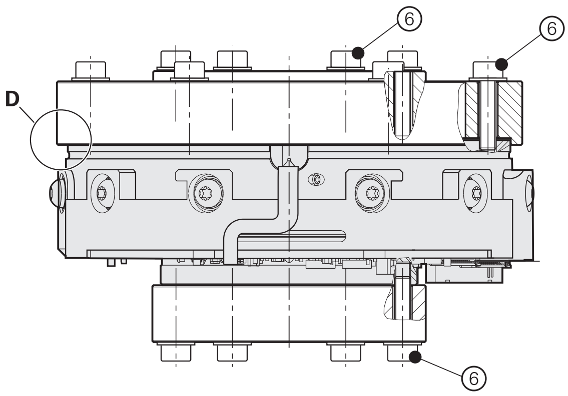
Note the information on mechanical design types and mounting.

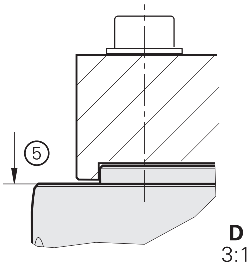




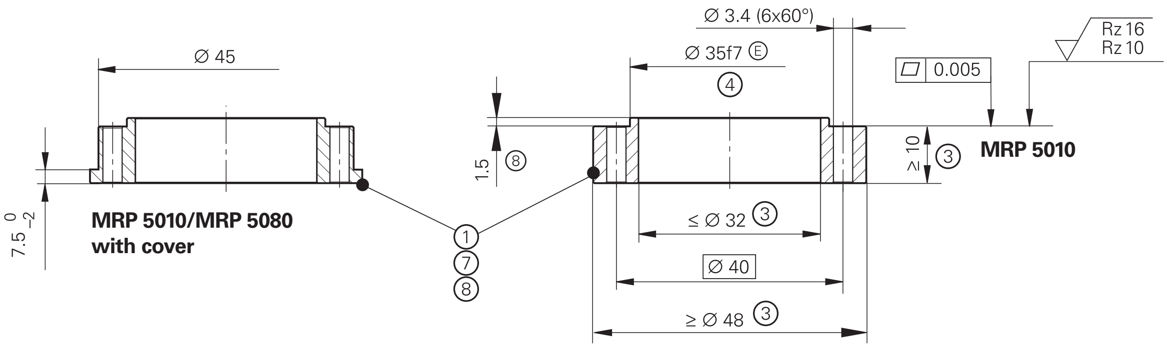
MRP 5010/MRP 5080







MRP 5010 with cover



1 = Rotor
2 = Stator (do not use as rotor)
3 = Required mating 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 = Material for customer's mounted parts: steel
$R_e \geq 235$ N/mm^2 $R_m \geq 400$ N/mm^2
8 = Thermal coefficient of expansion α_{therm}: $10 \cdot 10^{-6}$ K^{-1} to $12 \cdot 10^{-6}$ K^{-1}

MRP 8000 series

Angle encoder modules with integrated encoder and bearing
- **Compact dimensions**
- **High measuring and bearing accuracy**
- **Hollow shaft Ø 100 mm**

Encoder characteristics	***Incremental*** **MRP 8080**	***Absolute*** **MRP 8010**
Measuring standard	OPTODUR circular scale	DIADUR circular scale
Signal periods	63000	32768
System accuracy*	±1″ or ±2″	
Position error per signal period	±0.10″	±0.20″
Repeatability	*From both directions:* 0.2″	*From both directions:* 0.5″
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 µs
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 connector	15-pin PCB connector; adapter cable plus quick connector as an 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

MRP 8080

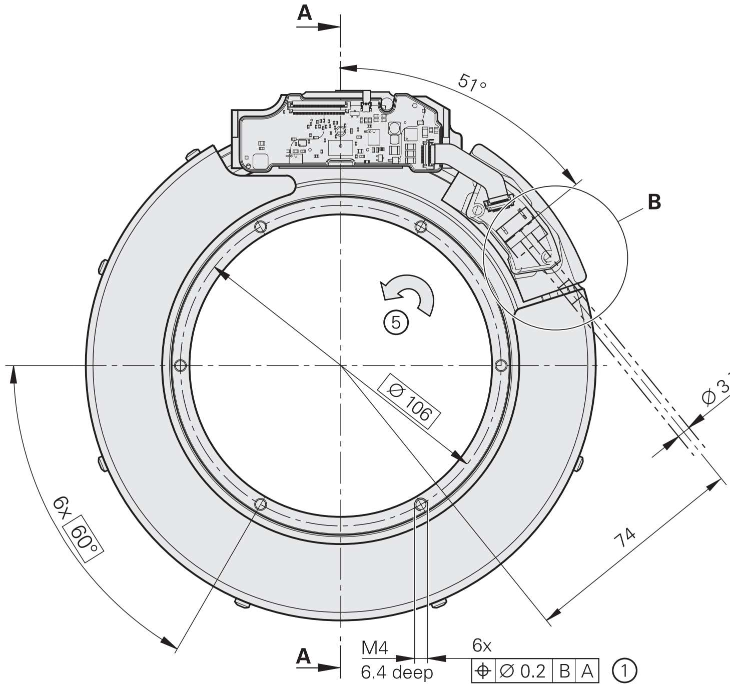
MRP 8010

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	$2.8 \cdot 10^{-3}$ kgm²	
Radial guideway accuracy	Measured at a distance of h = 70 mm from the rotor mating surface: ≤ 0.15 µm	
Non-reproducible radial guideway accuracy	Measured at a distance of h = 70 mm from the rotor mating surface: ≤ 0.20 µm	
Axial guideway accuracy	≤ ±0.15 µm	
Axial runout of the shaft	≤ 4 µm	
Wobble of the axis	0.5"	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 200 m/s² (EN 60068-2-6) ≤ 1000 m/s² (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)	

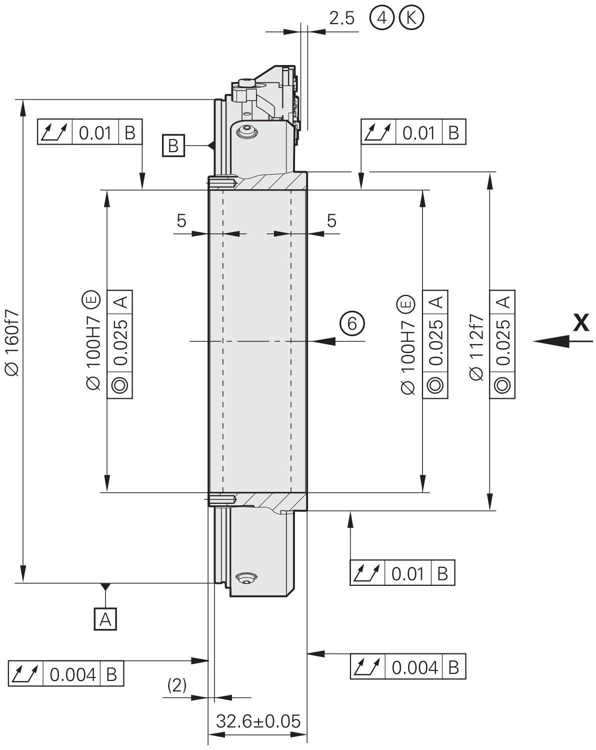
[1] The electromagnetic compatibility of the complete system must be ensured through appropriate measures taken during installation.
[2] When mounted
[3] Purely static load, without additional vibrations or shock loads

MRP 8010 with cover

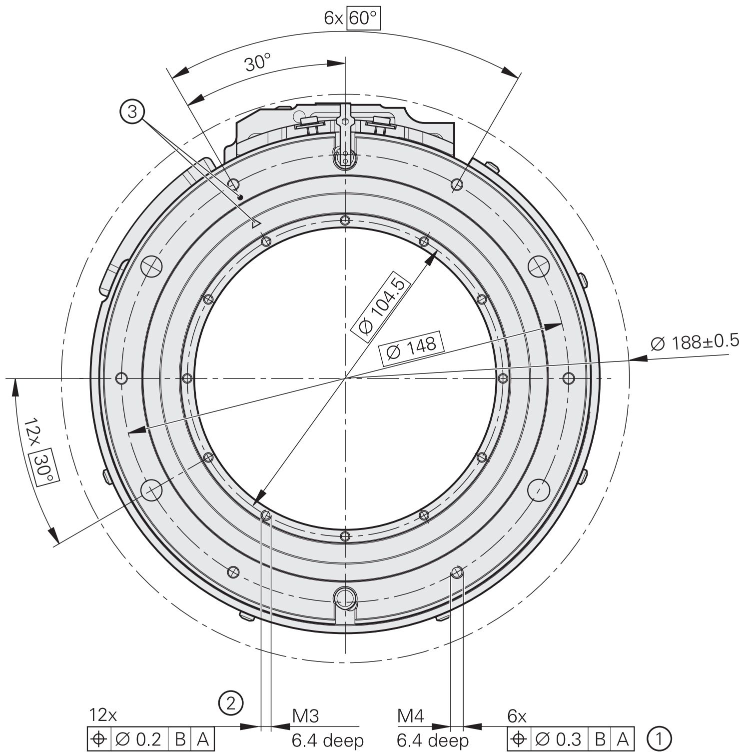
MRP 8000 series
MRP 8010



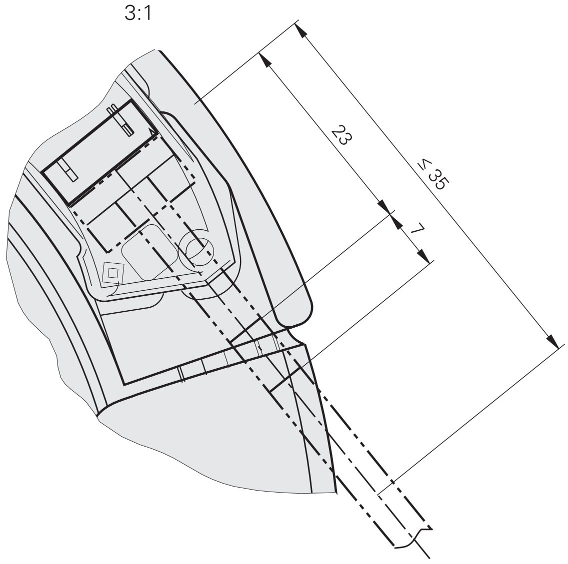
A–A



X



B
3:1

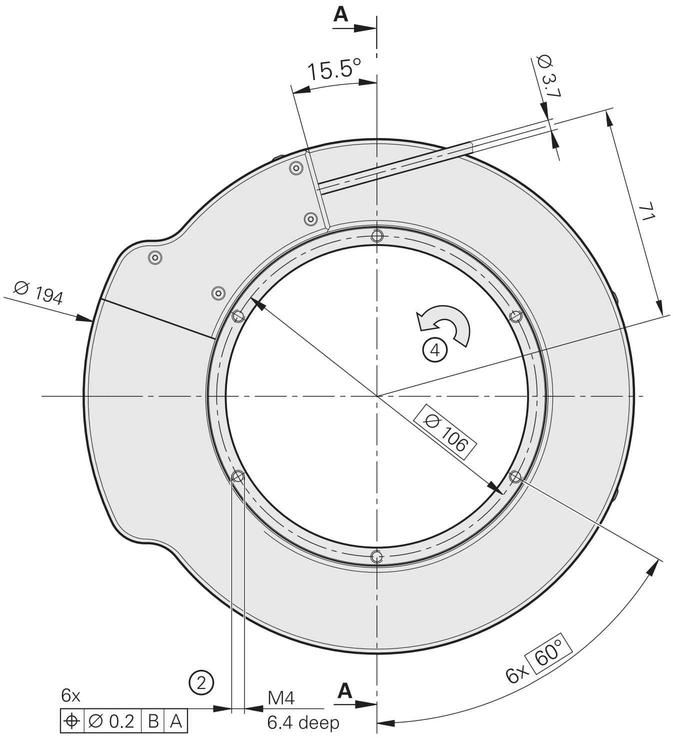


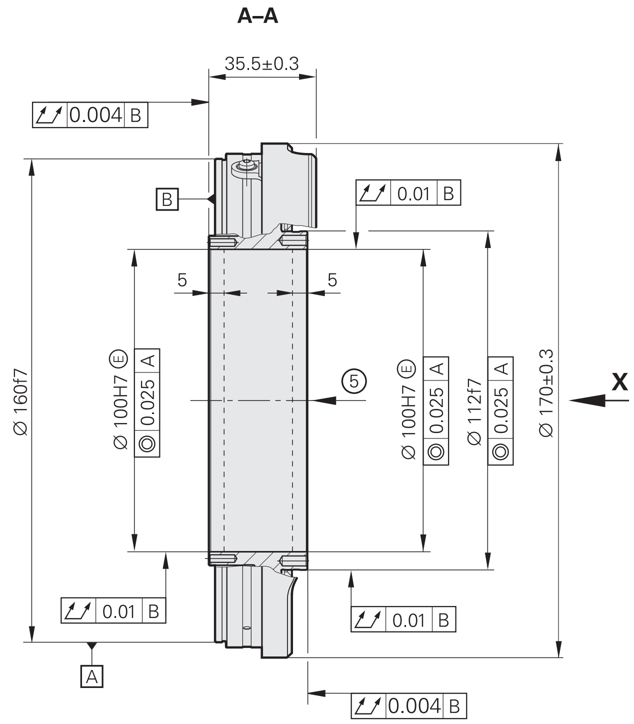
mm

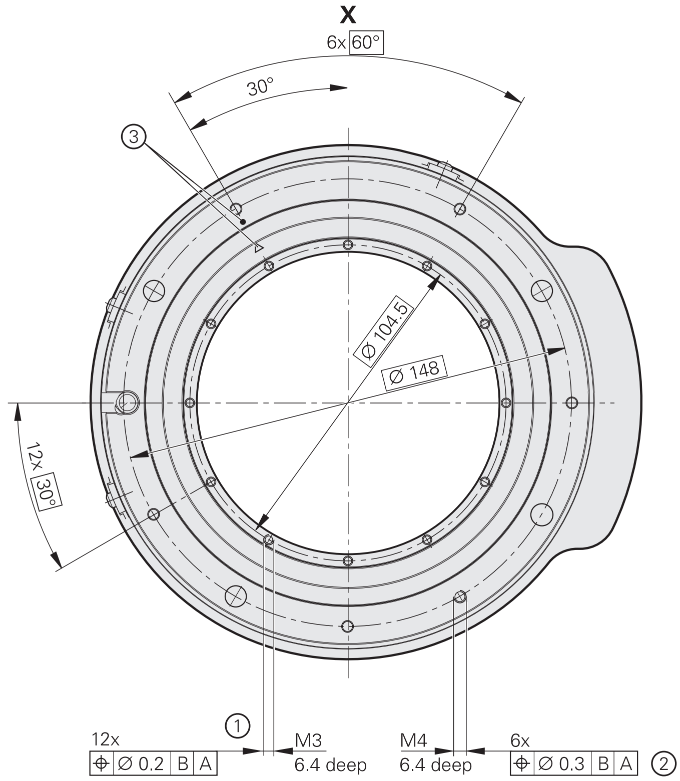
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Ⓚ = 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 = Mark for 0° position ±5°
4 = Minimum clearance
5 = Direction of rotation of the shaft for ascending position values
6 = Required direction for axial forces

MRP 8010 with cover





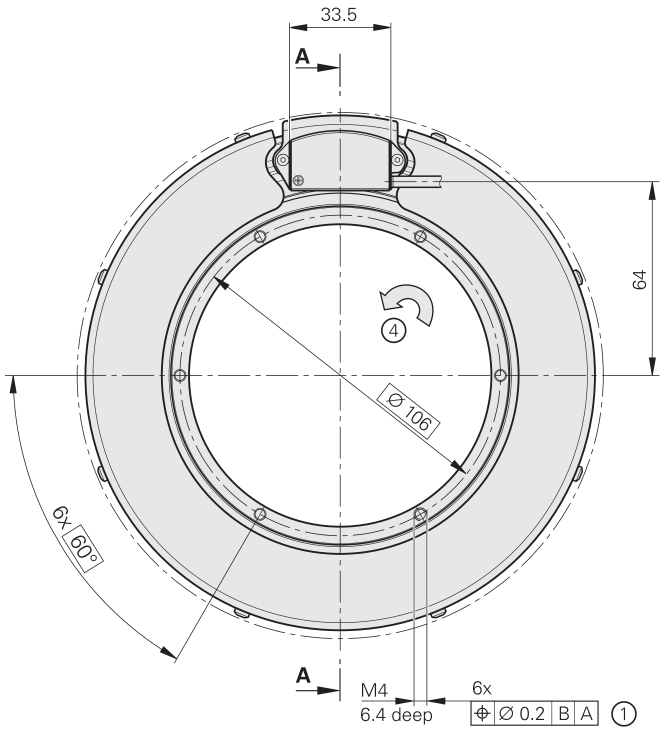


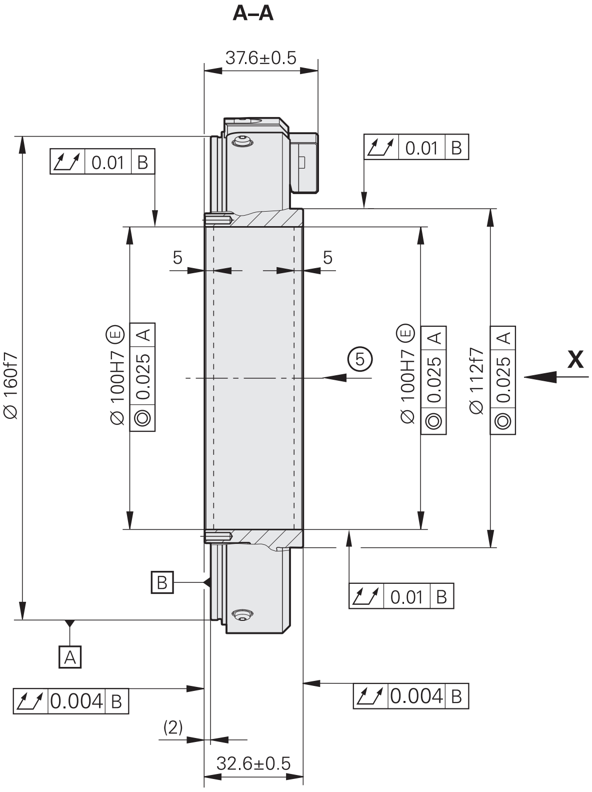
mm

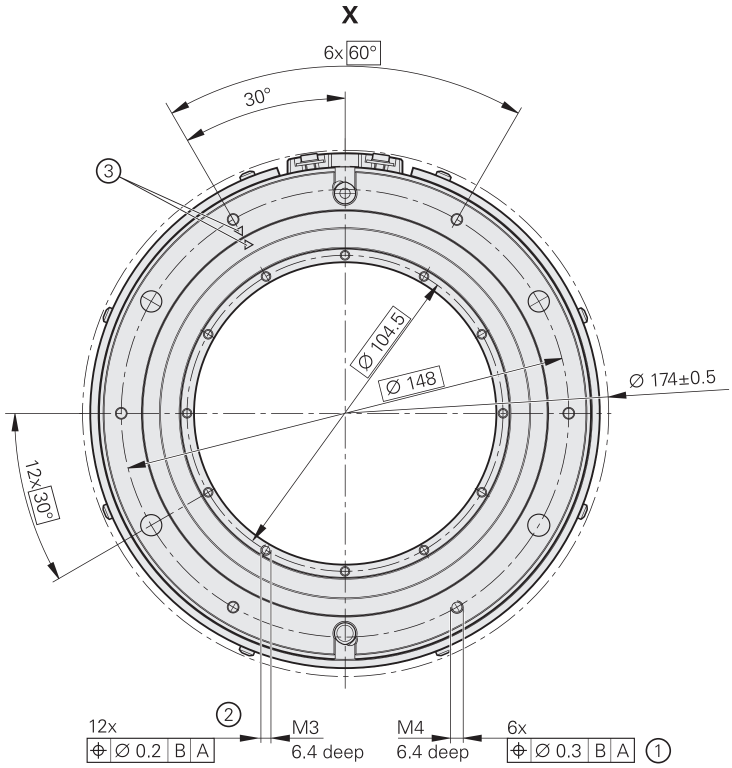
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

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 = Mark for 0° position ±5°
4 = Direction of shaft rotation for ascending position values
5 = Required direction for axial forces

MRP 8080





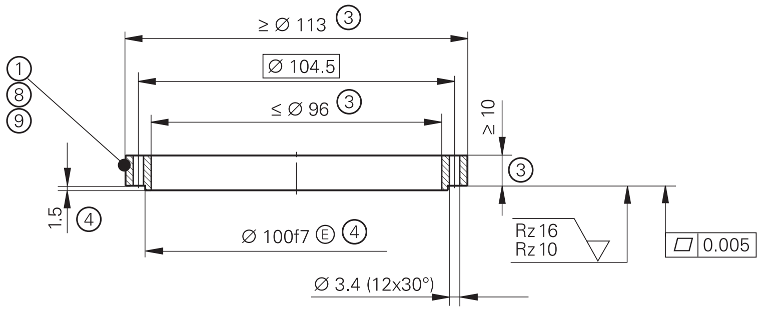


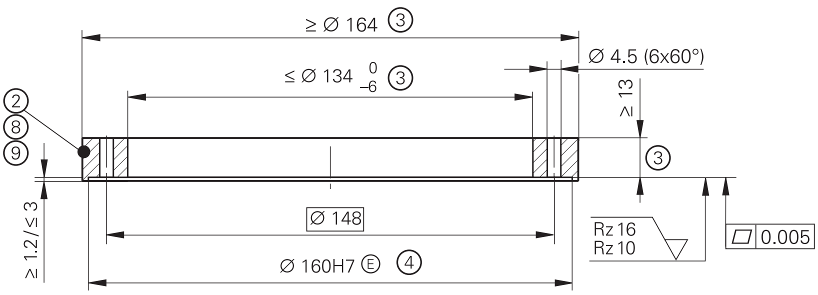
mm

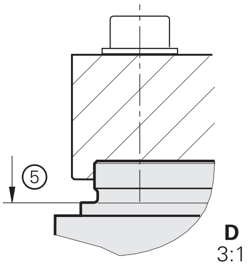
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

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 = Mark for 0° position ±5°
4 = Direction of shaft rotation for ascending position values
5 = Required direction for axial forces

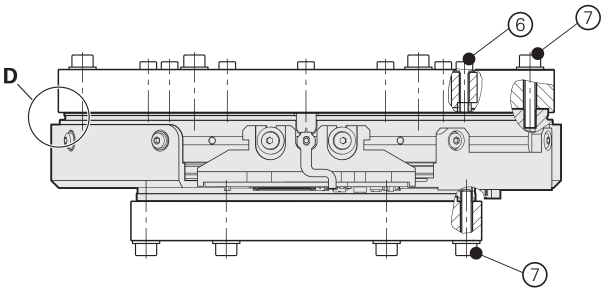
Mating dimensions of the mounting parts

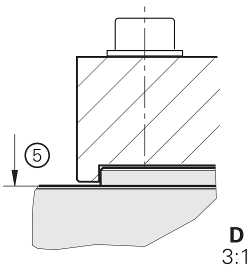




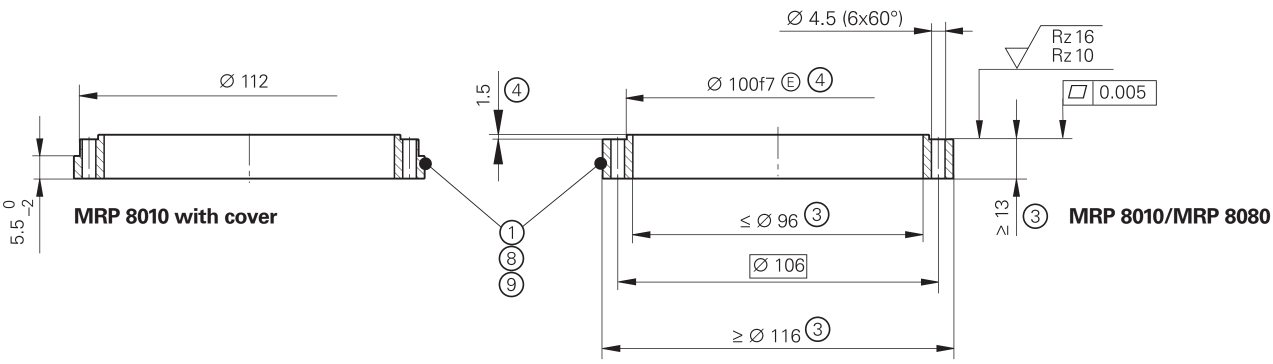


MRP 8010/MRP 8080





MRP 8010 with cover



Note the information on mechanical design types and mounting.

1 = Rotor
2 = Stator (do not use as rotor)
3 = Required mating 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
8 = Material for customer's mounted parts: steel
$R_e \geq 235$ N/mm² $R_m \geq 400$ N/mm²
9 = Thermal coefficient of expansion α_{therm}: $10 \cdot 10^{-6}$ K^{-1} to $12 \cdot 10^{-6}$ K^{-1}

MRP 8081 D*plus*

Angle encoder module with four scanning heads and compensation data

- **Very high system accuracy**
- **Resilient angle measurement**
- **Hollow shaft diameter: 100 mm**
- **Axial load of up to 300 N**

Encoder characteristics	***Incremental*** **MRP 8081 D*plus***
Measuring standard	OPTODUR circular scale
Signal periods	63000
System accuracy	±0.40″
Position error per signal period	±0.06″
Repeatability	*From both directions:* 0.1″
RMS position noise	Typically 0.0015″
Interface[1]	4 x ∼ 1 V_{PP}
Reference marks	150 (distance-coded)
Cutoff frequency –3 dB	≥ 500 kHz
Electrical connection[1]	4 x 1.5 m cable with 15-pin D-sub connector; interface electronics inside the connector
Cable length[1]	≤ 30 m (with HEIDENHAIN cable)
Supply voltage[1]	DC 5 V ±0.25 V
Power consumption[1] (max.)	*5.25 V:* ≤ 950 mW
Current consumption (typical)[1]	175 mA (without load)

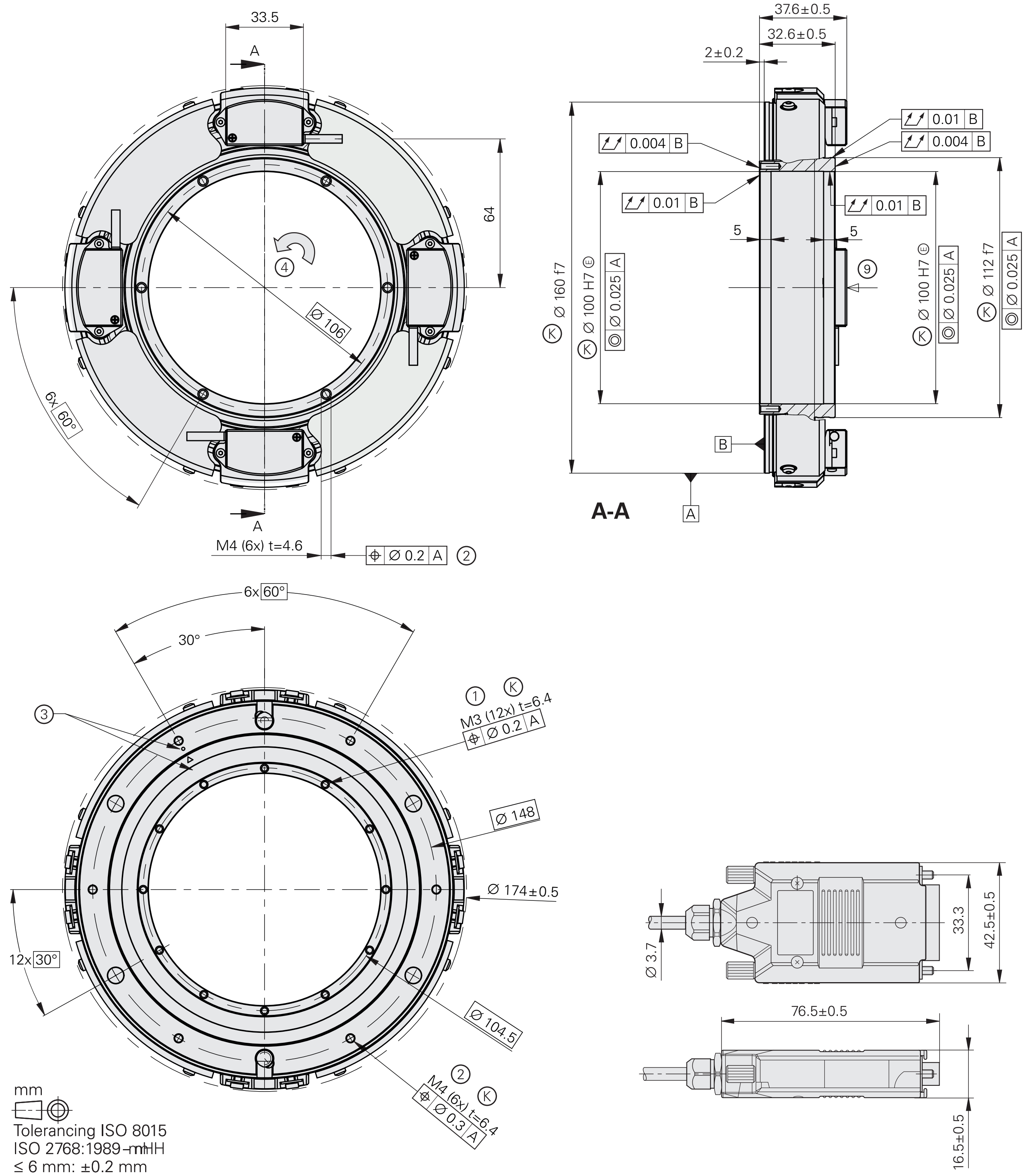
[1] Separate electrical connection for each scanning head

MRP 8081 D*plus*

Bearing properties	***Incremental*** **MRP 8081 D*plus***
Shaft	Hollow through shaft D = 100 mm
Max. permissible axial load[1]	300 N (centered load)
Max. permissible radial load[1]	100 N
Max. permissible tilting torque[1]	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[1]	10 Nm
Moment of inertia of rotor	$2.8 \cdot 10^{-3}$ kgm^2
Radial guideway accuracy	≤ 0.15 µm (measured at a distance of h = 70 mm from the rotor mating surface[2])
Non-reproducible radial guideway accuracy	≤ 0.20 µm (measured at a distance of h = 70 mm from the rotor mating surface[2])
Axial guideway accuracy	≤ ±0.15 µm
Axial runout of the shaft	≤ 4 µm
Wobble of the axis	0.5"
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27) (without load)
Protection EN 60529[3]	IP20
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) Purely static load, without additional vibrations or shock loads
2) See the *Measuring and bearing accuracy*
3) When mounted

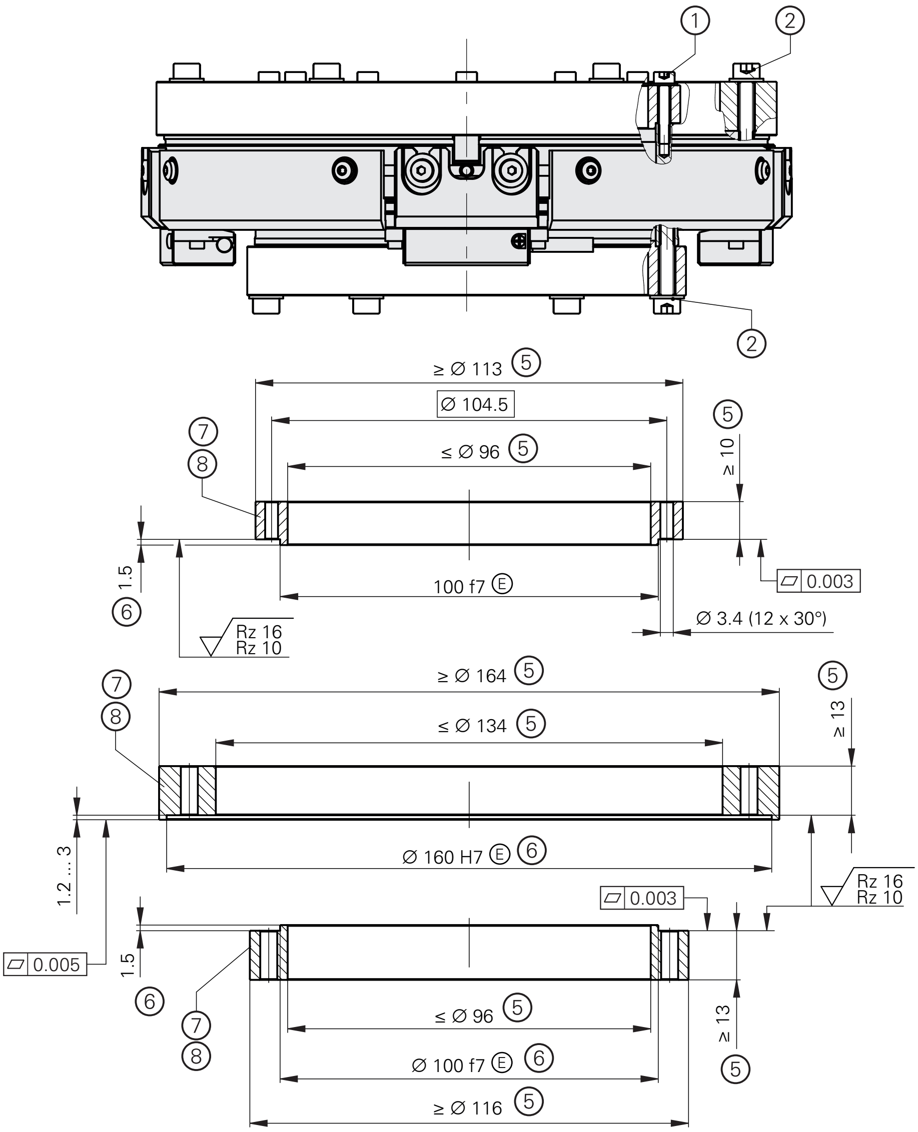
MRP 8081 D*plus*



mm

Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

Mating dimensions of the mounting parts



mm

Tolerancing ISO 8015
ISO 2768:1989-mH
≤ 6 mm: ±0.2 mm

Note the information on mechanical design types and mounting.

Ⓚ = Required mating dimensions
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 = Mark for 0° position ±5°
4 = Direction of shaft rotation for output signals in accordance with the interface description
5 = Required mating dimensions for transferring the maximum permissible loads in accordance with the specifications
6 = Optional recommended customer-side mating dimensions
7 = Material for customer's mounting component: steel
$R_e \geq 235$ N/mm^2 $R_m \geq 400$ N/mm^2
8 = Thermal coefficient of expansion α_{therm}: $10 \cdot 10^{-6}$ K^{-1} to $12 \cdot 10^{-6}$ K^{-1}
9 = Recommended direction of force; if dynamic overloads are possible, then comply with the recommended direction of force

MRP 8100 series

Angle encoder modules with integrated encoder and bearing
- **Compact dimensions**
- **High measuring and bearing accuracy**
- **Hollow shaft diameter: 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*	±1″ or ±2″	
Position error per signal period	±0.10″	±0.20″
Repeatability	*From both directions:* 0.2″	*From both directions:* 0.5″
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 µs
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 connector	15-pin PCB connector; adapter cable plus quick connector as an 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

MRP 8180

MRP 8110

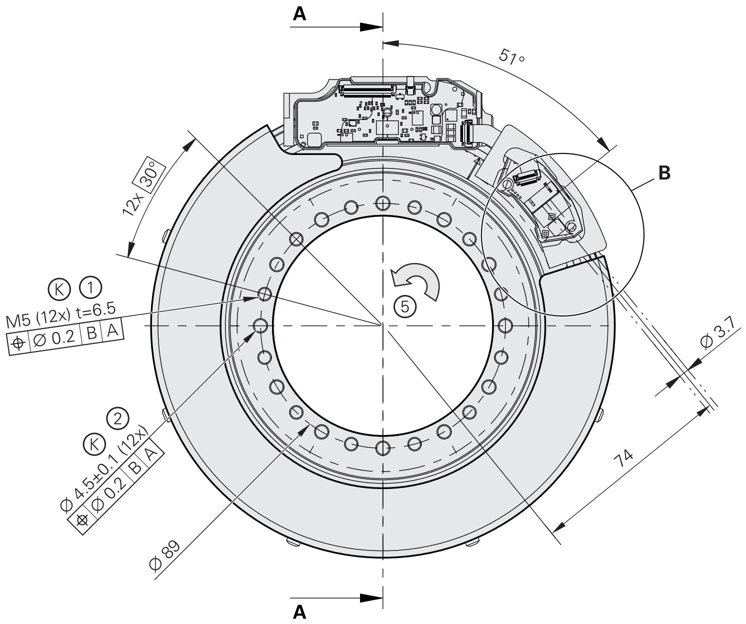
Bearing properties	*Incremental* **MRP 8180**	*Absolute* **MRP 8110**
Shaft	Hollow through shaft D = 80 mm	
Max. permissible axial load[3]	1500 N (centered load)	
Max. permissible radial load[3]	800 N	
Max. permissible tilting torque[3]	100 Nm	
Contact stiffness	*Axial:* 1000 N/µm *Radial:* 500 N/µm (calculated values)	
Resistance to tilt	1700 Nm/mrad (calculated value)	
Mech. permissible 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	$5 \cdot 10^{-3}$ kgm²	
Radial guideway accuracy	Measured at a distance of h = 75 mm from the rotor mating surface: ≤ 0.25 µm	
Non-reproducible radial guideway accuracy	Measured at a distance of h = 75 mm from the rotor mating surface: ≤ 0.30 µm	
Axial guideway accuracy	≤ ±0.25 µm	
Axial runout of the shaft	≤ 4 µm or ≤ 2 µm	
Wobble of the axis	0.7″	
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 1000 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	

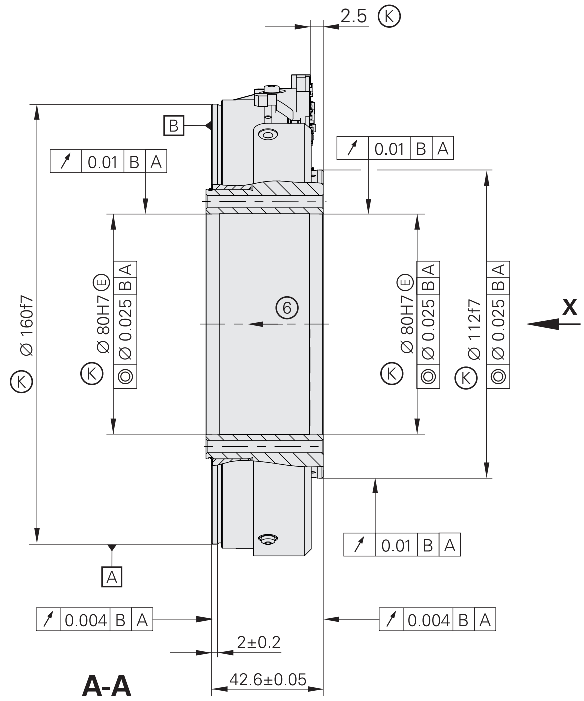
1) The electromagnetic compatibility of the complete system must be ensured through appropriate measures taken during installation.
2) When mounted
3) Purely static load, without additional vibrations or shock loads

MRP 8110 with cover

MRP 8100 series

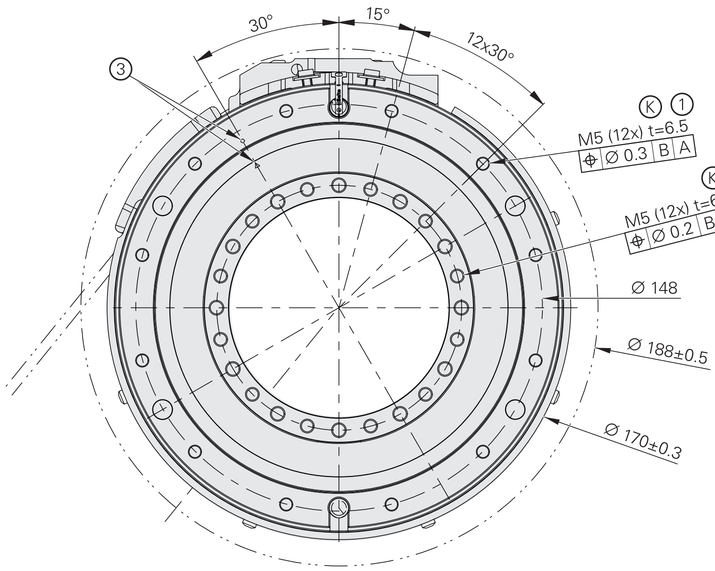
MRP 8110

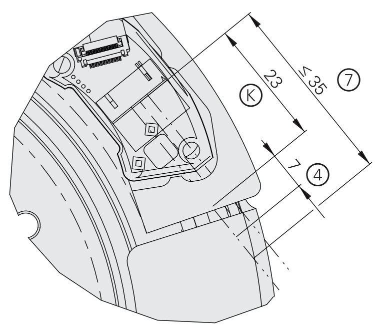




A-A

X



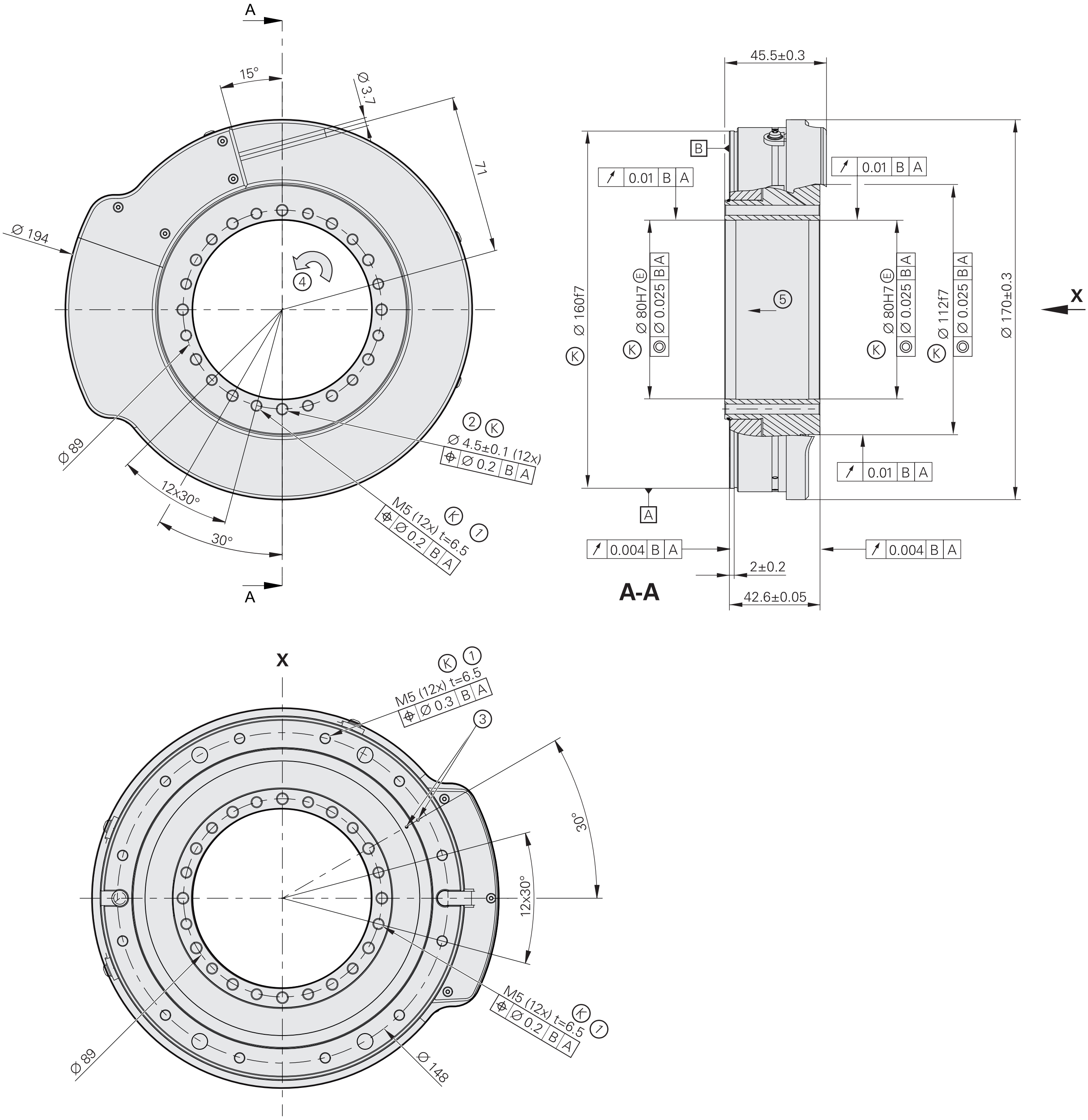


B
2:1

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 = Mark for 0° position ±5°
4 = Customer is responsible for shield coverage
5 = Direction of rotation of the shaft for ascending position values
6 = Recommended direction of force;
if dynamic overloading is possible, then comply with the recommended direction of force
7 = Cable support

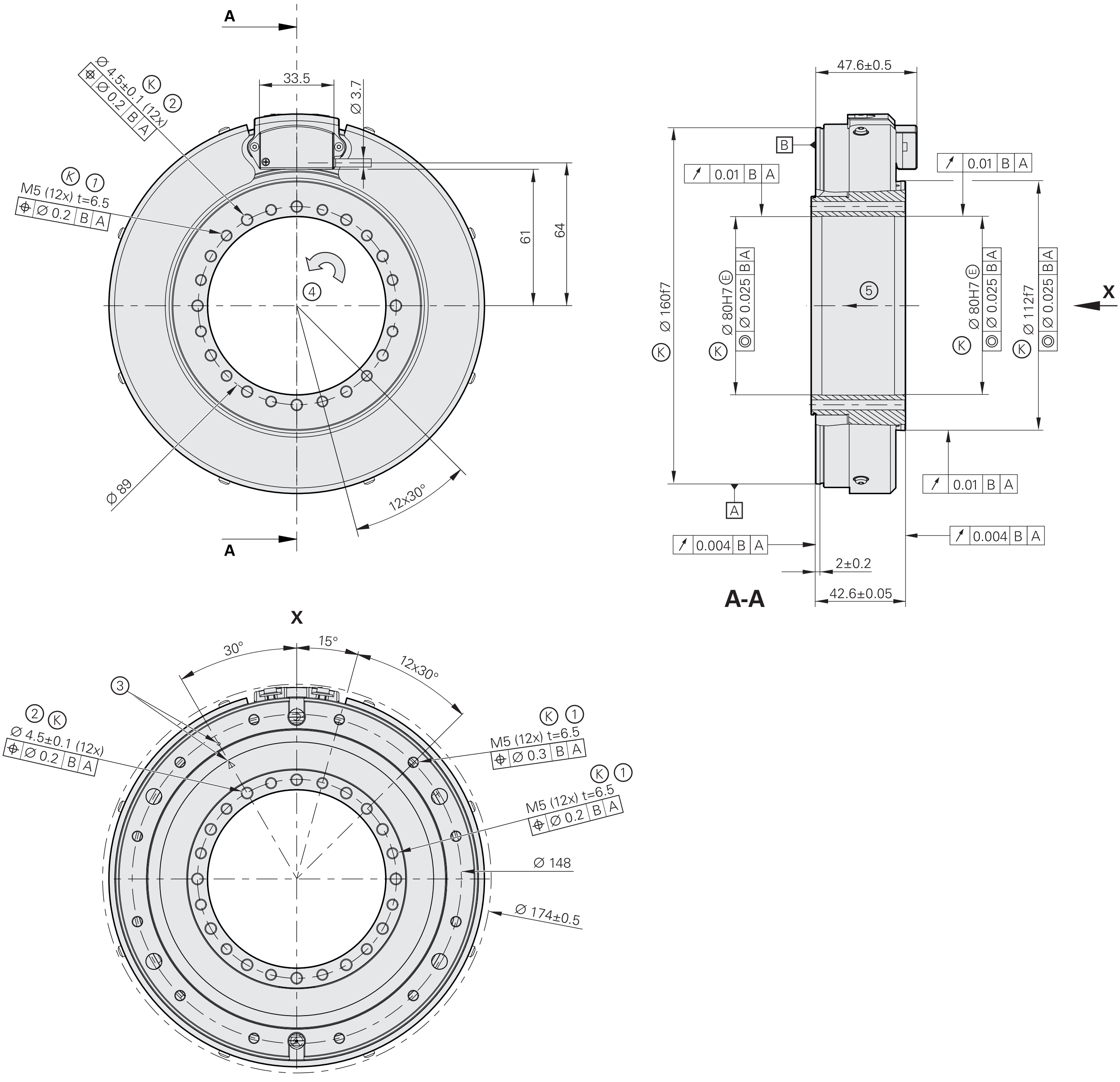
MRP 8110 with cover



Ⓚ = 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 = Mark for 0° position ±5°
4 = Direction of rotation of the shaft for ascending position values
5 = Recommended direction of force;
if dynamic overloading is possible, then comply with the recommended direction of force

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

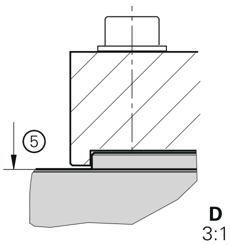
MRP 8180

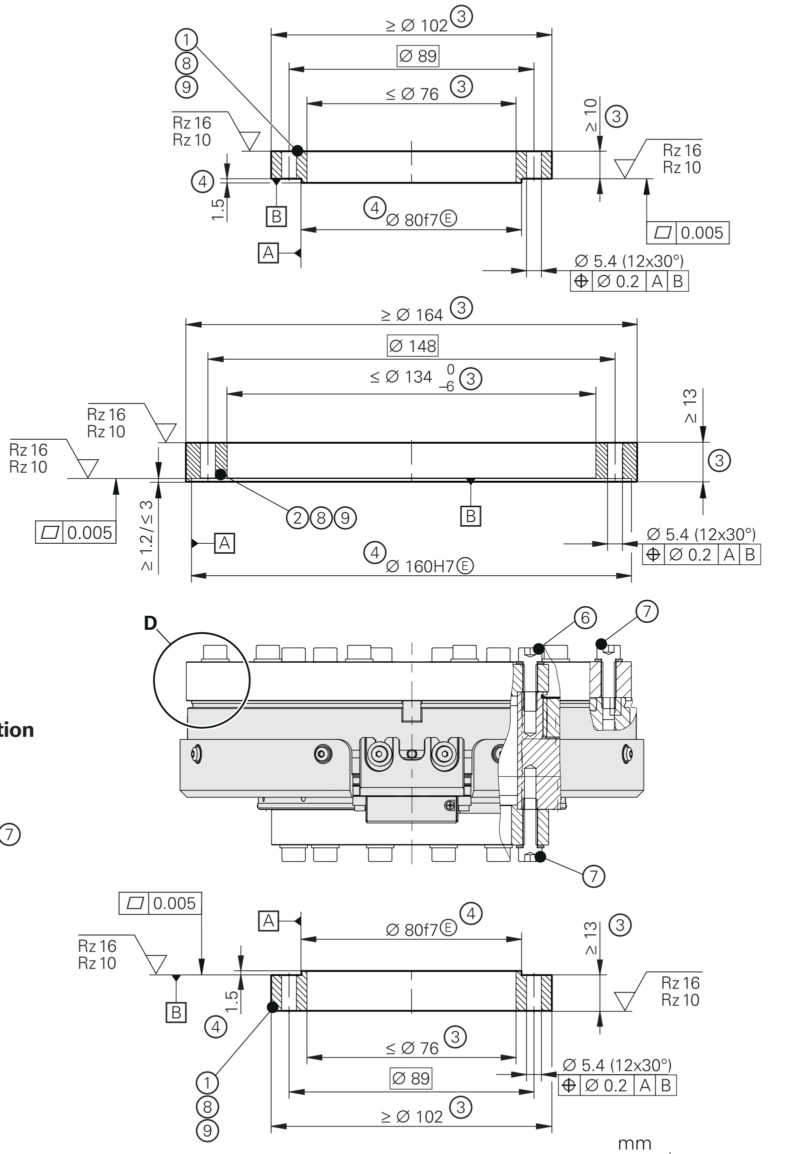


Ⓚ = Required mating dimensions
1 = Tightening torque of the M5 – 8.8 cylinder head screws: 4.5 Nm ±0.25 Nm
2 = Tightening torque of the M4 – 8.8 cylinder head screws: 2.5 Nm ±0.15 Nm
3 = Mark for 0° position ±5°
4 = Direction of rotation of the shaft for ascending position values
5 = Recommended direction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

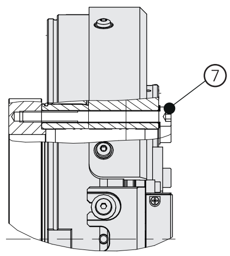
mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Mating dimensions of the mounting parts





Alternative mounting option



mm

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

1 = Rotor
2 = Stator (do not use as rotor)
3 = Required mating dimensions for the transfer of the maximum permissible load as per the specifications
4 = Optional: recommended customer-side mating 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
8 = Material for customer’s mounted parts: steel
$R_e \geq 235$ N/mm² $R_m \geq 400$ N/mm²
9 = Thermal coefficient of expansion α_{therm}: $10 \cdot 10^{-6}$ K^{-1} to $12 \cdot 10^{-6}$ K^{-1}

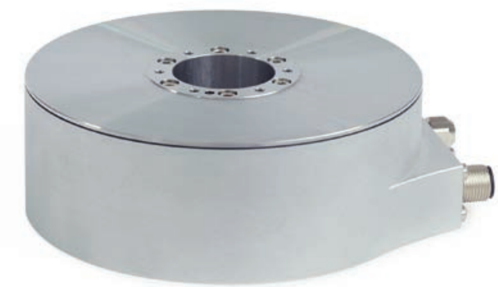
SRP 5000 series

Angle encoder modules with integrated encoder, bearing, and motor

- **Compact dimensions**
- **High measuring and bearing accuracy**
- **Particularly smooth motion control**
- **Hollow shaft diameter: 32 mm**

Encoder characteristics	***Incremental*** **SRP 5080**	***Absolute*** **SRP 5010**
Measuring standard	OPTODUR circular scale	DIADUR circular scale
Signal periods	30000	16384
System accuracy*	±2.5″ or ±5″	
Position error per signal period	±0.23″	±0.40″
Repeatability	*From both directions:* 0.3″	*From both directions:* 0.9″
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 µs
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 inside 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 (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

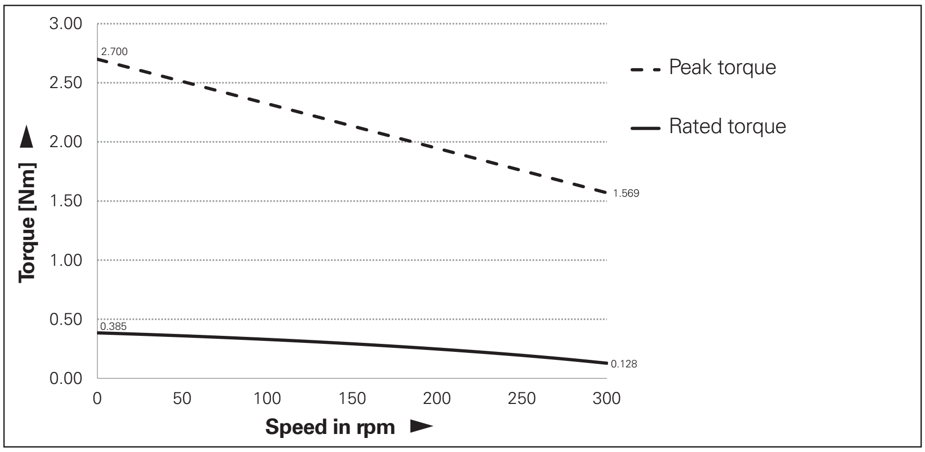


SRP 5000

Mounting conditions

The stated motor characteristics apply to the following mounting conditions:

- Ambient temperature: 20 °C
- Coil temperature: 40 °C
- Stator screwed to steel plate with the following characteristics:
  - Total surface area: 0.016 m^2
  - Specific thermal conductivity: 460 J/kgK (at 20 °C)
  - Specific thermal conductivity: 30 W/mK (at 20 °C)



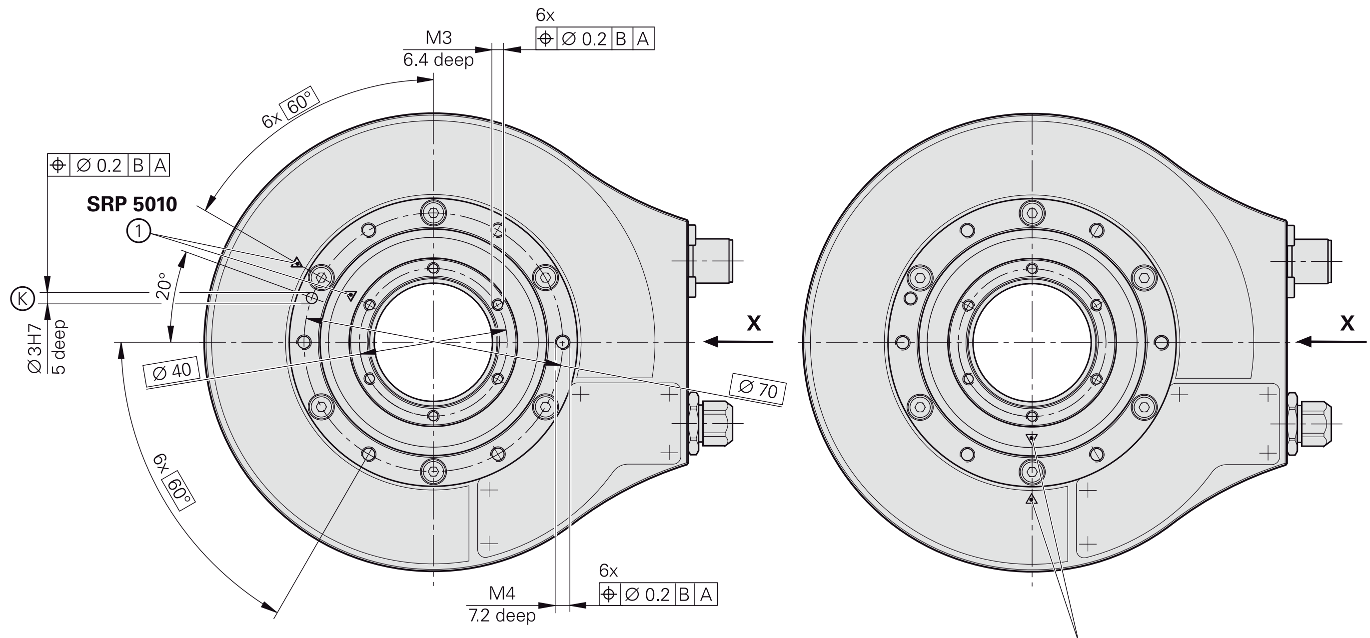
Characteristic curve of torque at DC 48 V

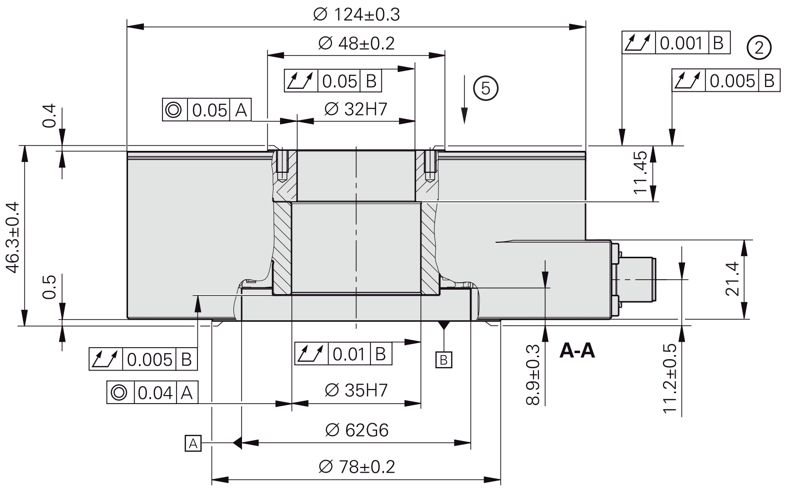
Bearing properties	
Shaft	Hollow through shaft with ∅ 32 mm
Max. permissible axial load[2]	200 N (centered load)
Max. permissible radial load[2]	60 N
Max. permissible tilting torque[2]	2.5 Nm
Contact stiffness	*Axial:* 303 N/µm *Radial:* 181 N/µm (calculated values)
Resistance to tilt	102 Nm/mrad (calculated value)
Mech. permissible speed	300 rpm
Max. transferable shaft torque[2]	2 Nm
Moment of inertia of rotor	$1.16 \cdot 10^{-3}$ kgm^2
Radial guideway accuracy	Measured at a distance of h = 50 mm from the rotor mating surface: ≤ 0.20 µm (without load)
Non-reproducible radial guideway accuracy	Measured at a distance of h = 50 mm from the rotor mating surface: ≤ 0.35 µm (without load)
Axial guideway accuracy	≤ ±0.2 µm
Axial runout of the shaft*	≤ 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) ≤ 1000 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
Elevation	< 2000 m
Mass	1.82 kg (without cable or connector)

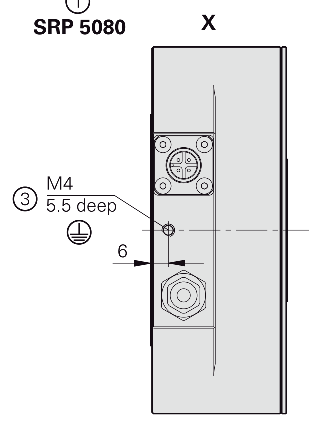
* Please select when ordering
1) When mounted
2) Purely static load, without additional vibrations or shock loads

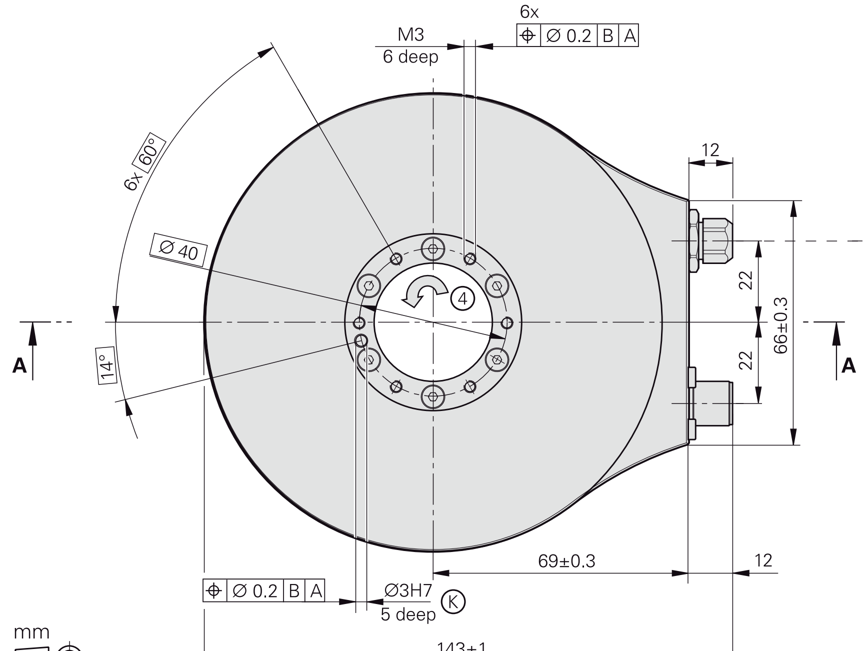
Motor characteristics	
Peak torque	2.70 Nm
Rated torque	0.385 Nm
Stall torque	0.253 Nm
Standstill speed	0.013 rpm
Maximum speed	300 rpm
Torque constant	0.668 Nm/A_{rms}
Back-electromotive force constant	0.397 $V_{rms}/(rad/s)$
Motor constant	0.181 $Nm/\sqrt{W}$
Electrical resistance R20 (at 20 °C)	9.06 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

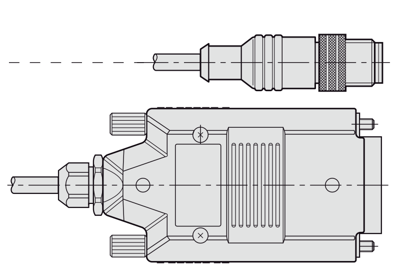
SRP 5010/SRP 5080
Dimensions











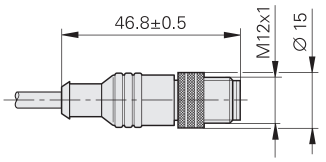
A = Bearing
K = Required mating dimensions
1 = Mark for 0° position ±5°
2 = Please select when ordering
3 = Protective conductor connection
4 = Direction of rotation of the shaft for ascending position values

mm

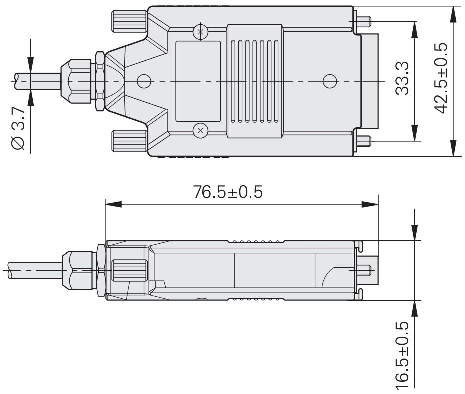
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Dimensions of the connecting elements

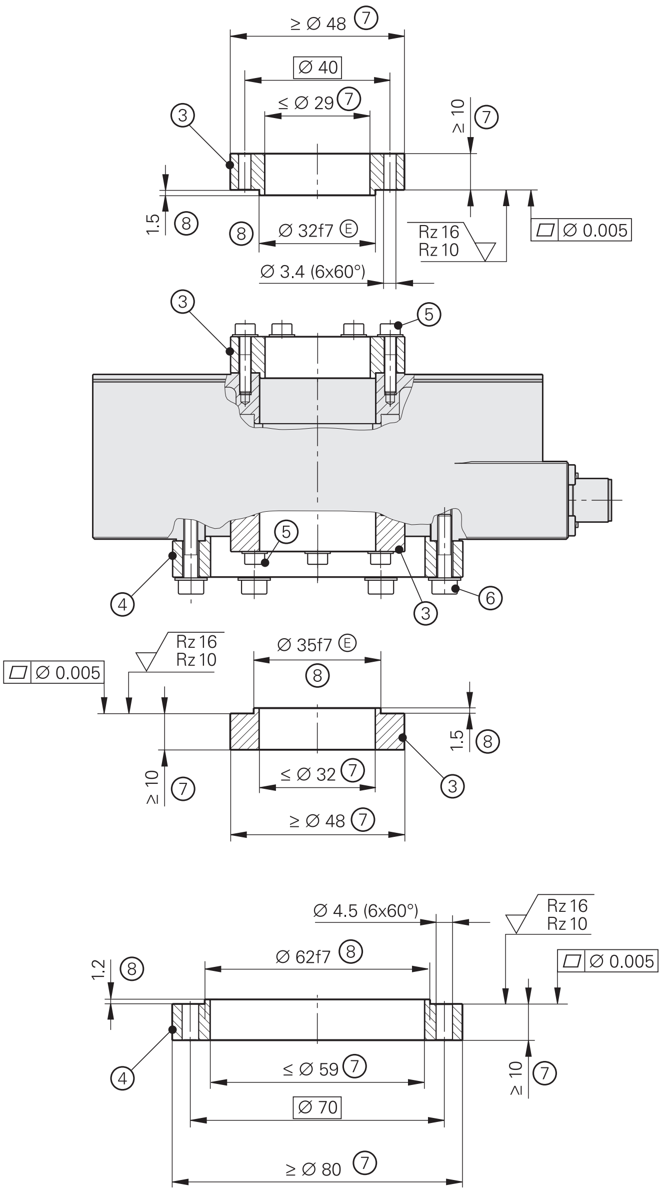
SRP 5010



SRP 5080



Required mating dimensions



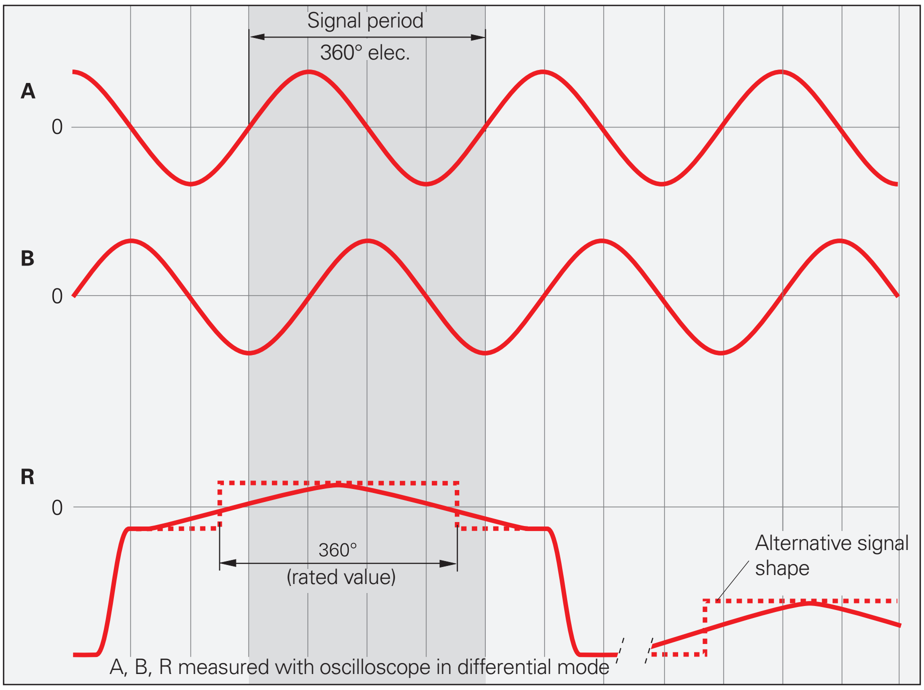
3 = Rotor
4 = Stator
5 = Screw: ISO 4762 – M3 – 8.8; materially bonding threadlocker required; washer: ISO 7092 – 3 – 200HV; tightening torque: 0.95 Nm ±0.05 Nm
6 = Screw: ISO 4762 – M4 – 8.8; materially bonding threadlocker required. Washer: ISO 7092 – 4 – 200HV; tightening torque: 2.2 Nm ±0.12 Nm
7 = Required mating dimensions for the transfer of the maximum permissible load as per the specifications
8 = Optional: recommended mating dimensions

Interfaces
∿ 1 V_{PP} incremental signals

HEIDENHAIN encoders with the ∿ 1 V_{PP} interface provide voltage signals that are highly interpolatable.

The sinusoidal **incremental signals** A and B are phase-shifted by 90° elec. and have a typical amplitude of 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 a unique assignment to the incremental signals. The output signal may be lower next to the reference mark.

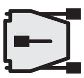
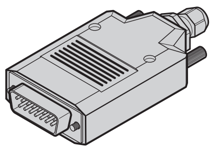
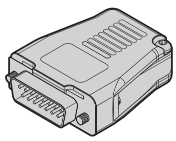
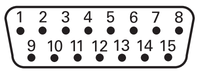


Further information:

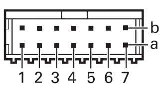
For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

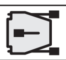
Pin layout

15-pin D-sub connector

14-pin PCB connector


14


	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	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**Vacant**	**Vacant**	**Vacant**
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	/	Violet	Yellow

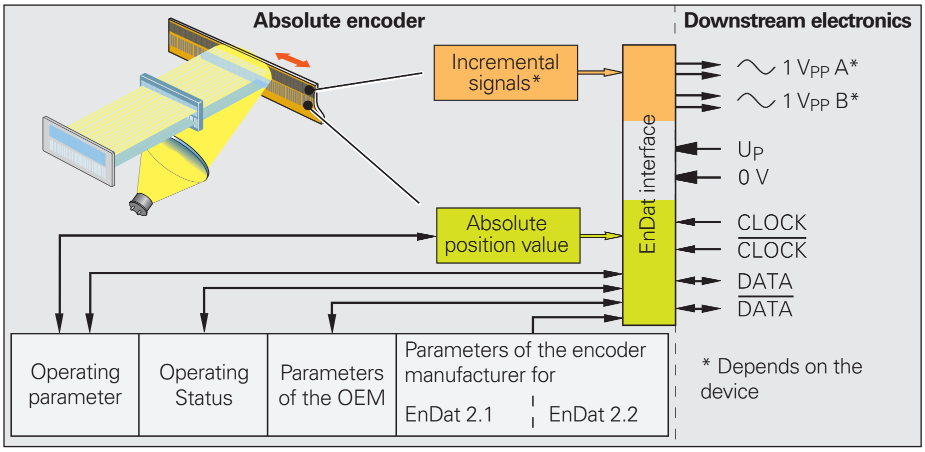
Cable shield connected to housing; **U_P** = Power supply voltage
Sensor: The sense line is connected in the encoder with the corresponding power line.
Vacant pins or wires must not be used!

Position values EnDat

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. Because the interface uses **serial transmission**, only **four signal lines** are required. The data (DATA) are transmitted in **synchronism** with the CLOCK signal from the downstream electronics. The type of transmission (position values, parameters, diagnostics, etc.) is selected via mode commands sent to the encoder by the downstream electronics. Some functions are available only with EnDat 2.2 mode commands.

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

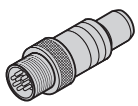


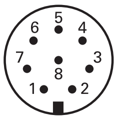
Further information:

For detailed descriptions of all available interfaces, as well as general electrical information, please refer to the *Interfaces of HEIDENHAIN Encoders* brochure.

Pin layout

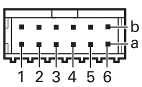
8-pin M12 coupling or flange socket





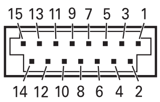
12-pin PCB connector

12



15-pin PCB connector

15



	Power supply				Position values			
M12	**8**	**2**	**5**	**1**	**3**	**4**	**7**	**6**
12	**1b**	**6a**	**4b**	**3a**	**6b**	**1a**	**2b**	**5a**
15	**13**	**11**	**14**	**12**	**7**	**8**	**9**	**10**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**DATA**	**$\overline{DATA}$**	**CLOCK**	**$\overline{CLOCK}$**
	Brown/Green	Blue	White/Green	White	Gray	Pink	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!

Position values EnDat 3

EnDat 3 carries forward the features and benefits of EnDat into the future of digital manufacturing. To achieve this feat, EnDat 3 relies on a new architecture that builds upon proven technology, ensuring optimal continuity and compatibility with predecessor interfaces.

EnDat 3 characteristics:

- Hybrid cable transmission
- Bus topologies
- Sensors: versatile data contents and sensor box
- Functional safety: black-channel communication
- Higher data bandwidth
- Definable send lists
- System installation: introduction of access levels

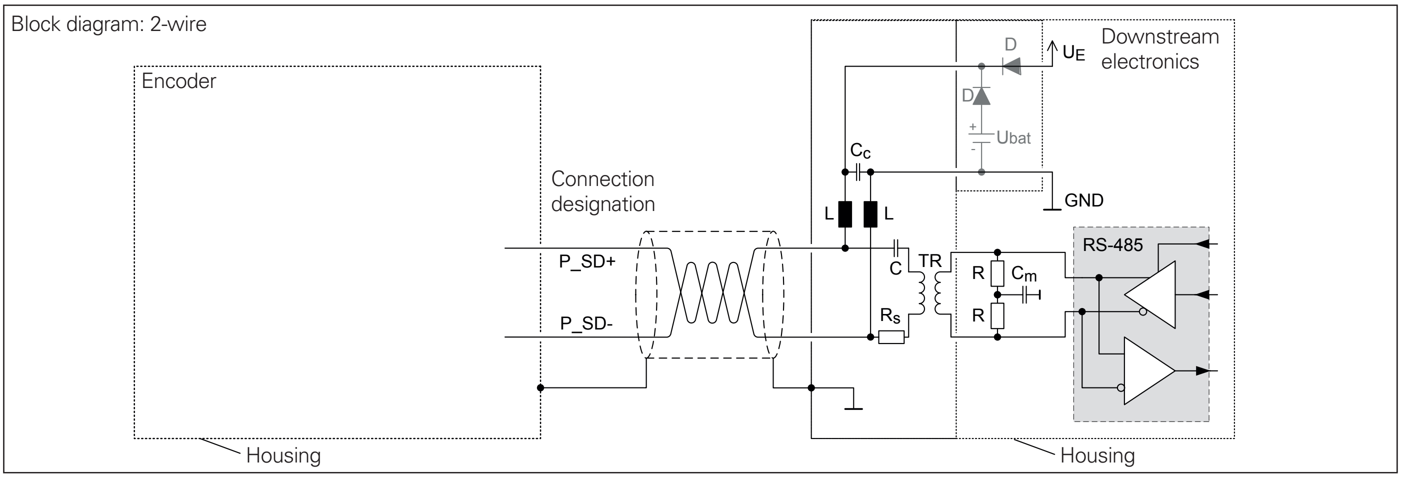
Interface	
Protocol	Request-response procedures in half-duplex mode
Physical layer	RS-485: 4-wire or 2-wire
Data rate	12.5 Mbit/s (25 Mbit/s)
Cable length	For 12.5 Mbit/s: max. 100 m / for 25 Mbit/s: max. 40 m
HPF send time (position availability in the master)	Typically 10 µs (the parameter XEL.timeHPFout indicates the duration between position value generation (stored via latch) and transmission of the complete HPF, without cable effects)
Cycle time	Typically > 25 µs
Bus operation	Daisy chain
Functional safety	Designed for up to SIL 3, black-channel communication

Functions	
Diagnostics	For condition monitoring and predictive maintenance
System information	Automated configuration and storage of operating status data
Access control	User authentication (e.g., for datum shift, OEM memory)

Ordering designations
The ordering designation defines key communication characteristics

Supported communication types	E30-R2	E30-R4	E30-RB
EnDat 3: communication modulated onto power supply wires	✓	–	–
EnDat 3: communication + separate power supply wires (4 wires)	–	✓	✓
EnDat 3: bus operation	–	–	✓
Sensor box integration	–	✓	✓

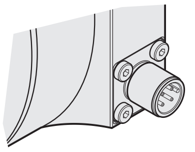
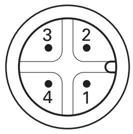
Further information:
www.endat.de



Motor

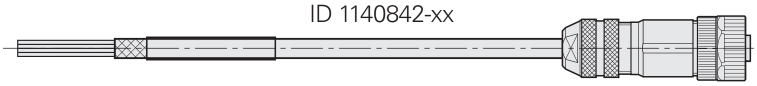
Angle encoder modules with integrated motor have a slotless iron-core permanent-magnet AC synchronous motor with three phases.

Pin layout

	1	2	3	4
	Phase 1	**Phase 2**	**Phase 3**	**GND**

ID 1140842-xx



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

Further information:

For detailed descriptions of cables, please refer to the *Cables and Connectors* brochure.

HEIDENHAIN
Mastering nanometer accuracy

HEIDENHAIN

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