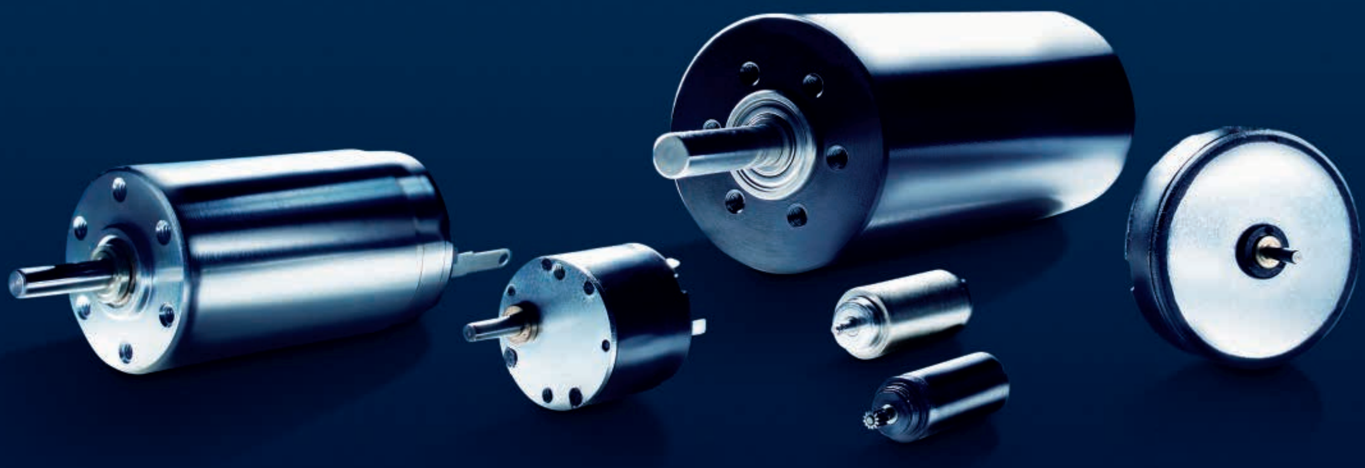
FAULHABER

DC-Motors
Technical Information



WE CREATE MOTION

EN

DC-Micromotors

Technical Information

General information

The FAULHABER Winding:
Originally invented by Dr. Fritz Faulhaber Sr. and patented in 1958, the System FAULHABER coreless (or ironless) progressive, self-supporting, skew-wound rotor winding is at the heart of every System FAULHABER DC Motor. This revolutionary technology changed the industry and created new possibilities for customer application of DC Motors where the highest power, best dynamic performance, in the smallest possible size and weight are required. The main benefits of this technology include:

- No cogging torque resulting in smooth positioning and speed control and higher overall efficiency than other DC motor types
- Extremely high torque and power in relation to motor size and weight
- Absolute linear relationship between load to speed, current to torque, and voltage to speed
- Very low rotor inertia which results in superior dynamic characteristics for starting and stopping
- Extremely low torque ripple and EMI

DC Motor Types:
FAULHABER DC Motors are built with two different types of commutation systems: precious metal commutation and graphite commutation.

The term precious metal commutation refers to the materials used in the brushes and commutator which consist of high performance precious metal alloys. This type of commutation system is used mainly because of its very small size, very low contact resistance and the very precise commutation signal. This commutation system is particularly well suited for low current applications such as battery operated devices.

In general, precious metal commutated motors exhibit the best overall performance at continuous duty with a load at or around the point of maximum nominal efficiency.

The term graphite commutation refers to the brush material used in combination with a copper alloy commutator. This type of commutation system is very robust and is better suited to dynamic high power applications with rapid start / stops or periodic overload conditions.

Magnets:
FAULHABER DC Motors are designed with a variety of different types of magnets to suit the particular performance of the given motor type. These materials include AlNiCo magnets and high performance rare earth types such as SmCo and NdFeB.

Operational Lifetime:
The lifetime of a FAULHABER DC Motor depends mainly on the operational duty point and the ambient conditions during operation. The total hours of operation can therefore vary greatly from some hundreds of hours under extreme conditions to over 25 000 hours under optimal conditions. Under typical load conditions a FAULHABER DC motor will have an operational lifetime anywhere between 1 000 to 5 000 hours.

In general the operational lifetime of a FAULHABER DC Motor is limited by the effects of electrical and mechanical wear on the commutator and brushes. The electrical wear (sparking) depends heavily on the electrical load and the motor speed. As the electrical load and speed increase, the typical motor operational lifetime will normally decrease. The effects of electrical wear are more significant for motors with precious metal commutation and vary depending on the nominal voltage of the winding. Where necessary FAULHABER DC Motors are therefore fitted with integrated spark suppression to minimize the negative effects of sparking on the operational lifetime.

The mechanical wear of the commutation system is dependent on the motor speed and will increase with higher speeds. In general, for applications with higher than specified speeds and loads, a longer operational lifetime can be achieved by graphite commutated motors. It is also important not to exceed the load characteristics for the motor bearings given in the data sheet for continuous duty operation. Doing so will also limit the achievable motor lifetime.

Other effects limiting motor lifetime include ambient conditions like excessive humidity and temperature, excessive vibration and shock, and an incorrect or suboptimal mounting configuration of the motor in the application.

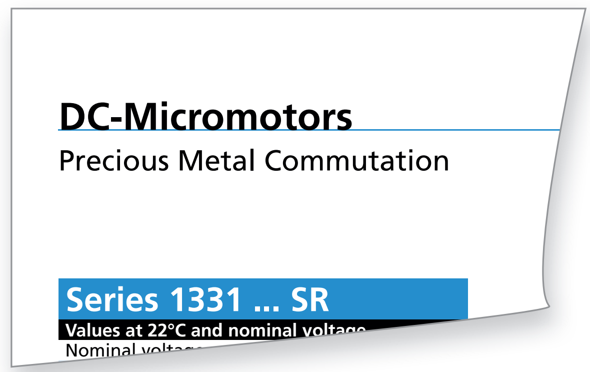
It is also important to note that the method of driving and controlling the motor will have a large effect on the operational lifetime of the motor. For example, for control using a PWM signal, FAULHABER recommends a minimum frequency of 20 kHz.

Modifications:
FAULHABER specializes in the configuration of its standard products to fit the customer application. Available modifications for FAULHABER DC Motors include:

- Many other nominal voltage types
- Motor leads (PTFE and PVC) and connectors
- Configurable shaft lengths and second shaft ends
- Modified shaft dimensions and pinion configurations such as flats, gears, pulley and eccenters
- Modifications for extreme high and low temperature operation
- Modifications for operation in a vacuum (ex. 10^{-5} Pa)
- Modifications for high speed and / or high load applications
- Modifications for motors with tighter than standard electrical or mechanical tolerances

Product Combinations
FAULHABER offers the industry's largest selection of complementary products tailor made for all of its DC Motors including:

- Precision Gearheads (planetary, spur, and low backlash spur)
- High resolution Encoders (Incremental and Absolute)
- High Performance Drive Electronics (Speed Controllers, Motion Controllers)



Notes on technical datasheet

The following values are measured or calculated at nominal voltage with an ambient temperature of 22 °C.

Nominal voltage U_N [V]
The nominal voltage at which all other characteristics indicated are measured and rated.

Terminal resistance R [Ω] ±12%
The resistance measured across the motor terminals.
The value will vary according to the winding temperature. (temperature coefficient: α_{22} = 0,004 K^{-1}).
This type of measurement is not possible for the graphite commutated motors due to the transition resistance of the brushes.

Efficiency $\eta_{max.}$ [%]
The maximum ratio between the absorbed electrical power and the obtained mechanical power of the motor.

$$\eta_{max.} = \left(1-\sqrt{\frac{I_o \cdot R}{U_N}}\right)^2$$

No-load speed n_o [min^{-1}] ±12%
Describes the motor speed under no-load conditions at steady state and 22 °C ambient temperature. If not otherwise defined the tolerance for the no-load speed is assumed to be ±12%.

$$n_o = \frac{U_N - (I_o \cdot R)}{2\pi \cdot k_M}$$

No-load current (typical) I_o [A]
Describes the typical current consumption of the motor without load at an ambient temperature of 22 °C after reaching a steady state condition.

The no-load current is speed and temperature dependent. Changes in ambient temperature or cooling conditions will influence the value. In addition, modifications to the shaft, bearing, lubrication, and commutation system or combinations with other components such as gearheads or encoders will all result in a change to the no-load current of the motor.

Stall torque M_H [mNm]
The torque developed by the motor at zero speed (locked rotor) and nominal voltage. This value may vary due to the magnet type and temperature and the temperature of the winding.

$$M_H = k_M \cdot \frac{U_N}{R} - M_R$$

Friction torque M_R [mNm]
Torque losses caused by the friction of brushes, commutator and bearings. This value varies due to temperature.

$$M_R = k_M \cdot I_o$$

Speed constant k_n [min^{-1}/V]
The speed variation per Volt applied to the motor terminals at constant load.

$$k_n = \frac{n_o}{U_N - I_o \cdot R} = \frac{1}{k_E}$$

Back-EMF constant k_E [mV/min^{-1}]
The constant corresponding to the relationship between the induced voltage in the rotor and the speed of rotation.

$$k_E = 2\pi \cdot k_M$$

Torque constant k_M [mNm/A]
The constant corresponding to the relationship between the torque developed by the motor and the current drawn.

Current constant k_I [A/mNm]
Describes the relation of the current in the motor winding and the torque developed at the output shaft.

$$k_I = \frac{1}{k_M}$$

Slope of n-M curve $\Delta n/\Delta M$ [min^{-1}/mNm]
The ratio of the speed variation to the torque variation. The smaller the value, the more powerful the motor.

$$\frac{\Delta n}{\Delta M} = \frac{R}{k_M^2} \cdot \frac{1}{2\pi}$$

Rotor inductance L [µH]
The inductance measured on the motor terminals at 1 kHz.

Mechanical time constant τ_m [ms]
The time required for the motor to reach a speed of 63% of its final no-load speed, from standstill.

$$\tau_m = \frac{R \cdot J}{k_M^2}$$

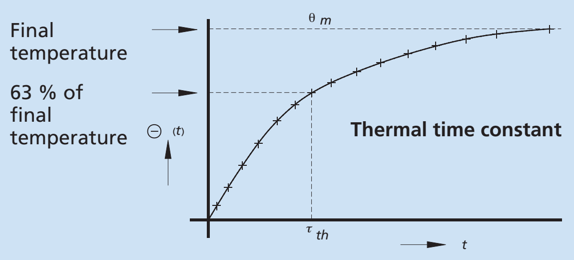
Rotor inertia J [gcm^2]
The dynamic moment of inertia of the rotor.

Angular acceleration $\alpha_{max.}$ [rad/s^2]
The acceleration obtained from standstill under no-load-conditions and at nominal voltage.

$$\alpha_{max.} = \frac{M_H}{J}$$

Thermal resistance R_{th1}, R_{th2}, $R_{th2\,p}$, $R_{th2\,m}$ [K/W]
R_{th1} corresponds to the thermal resistance between the winding and housing. R_{th2} corresponds to the thermal resistance between the housing and the ambient air. $R_{th2\,p}$ corresponds to the thermal resistance of a motor flanged to the plastic flange to the environment. $R_{th2\,m}$ corresponds to the thermal resistance of a motor flanged to the metal flange to the environment. The R_{th2} values can be reduced by enabling heat exchange between the motor and the environment (e.g. by forced ventilation).

Thermal time constant τ_{w1}, τ_{w2}, $\tau_{w2\,p}$, $\tau_{w2\,m}$ [s]
The thermal time constant specifies the time needed for the winding ($\tau_{w1\,p}$, $\tau_{w1\,m}$) and housing (τ_{w2}) to reach a temperature equal to 63% of final steady state value.



Operating temperature range [°C]
Indicates the minimum and maximum standard motor operating temperature, as well as the maximum allowable temperature of the standard motor winding.

Shaft bearings
The bearings used for the DC-Micromotors.

Shaft load max. [N]
The output shaft load at a specified shaft diameter for the primary output shaft. For motors with ball bearings the load and lifetime are in accordance with the values given by the bearing manufacturers. This value does not apply to second, or rear shaft ends.

Shaft play [mm]
The play between the shaft and bearings, including the additional bearing play in the case of ball bearings.

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Housing material
The housing material and the surface protection.

Mass [g]
The typical mass of the motor in its standard configuration.

Direction of rotation
The direction of rotation as viewed from the front face. Positive voltage applied to the (+) terminal gives clockwise rotation of the motor shaft. All motors are designed for clockwise (CW) and counter-clockwise (CCW) operation; the direction of rotation is reversible.

Speed up to $n_{max.}$ [min^{-1}]
The maximum recommended motor speed for continuous operation. This value is based on the recommended operating range for the standard motor bearings, winding, and commutation system. All values in excess of this value will negatively affect the maximum achievable operational lifetime of the motor.

Number of pole pairs
Indicates the number of pole pairs of the standard motor.

Magnet material
Describes the basic type of the magnet used in the standard motor.

Unspecified mechanical tolerances:
Tolerances in accordance with ISO 2768.

≤	6	= ± 0,1 mm
≤	30	= ± 0,2 mm
≤	120	= ± 0,3 mm

The tolerances of values not specified are given on request.

All mechanical dimensions related to the motor shaft are measured with an axial preload of the shaft toward the motor.

Rated values for continuous duty operation

The following values are measured or calculated at nominal voltage with an ambient temperature of 22 °C.

Rated Torque M_N [mNm]

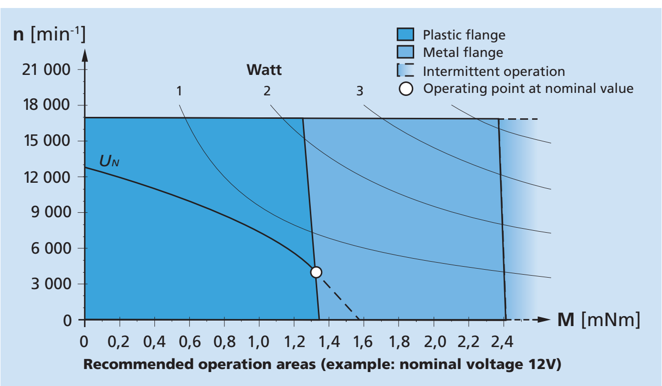
For DC motors with precious metal commutation:
The maximum continuous duty torque at nominal voltage resulting in steady state current and speed not exceeding the capacity of the brush and commutation system. The nominal torque is calculated close to the application with the $R_{th2\,p}$ at the plastic flange. This value can be safely exceeded if the motor is operated intermittently, for example, in S2 operation and/or if more cooling is applied. For the purposes of the rating, certain motors are limited by the resulting rated speed (< 2 500 min^{-1}) at nominal voltage.

Please note, when choosing a precious metal commutated motor that they exhibit the best overall continuous duty performance at or around the point of highest efficiency. For continuous duty operating conditions that require the motor to operate close to its thermal limits, a DC Motor with graphite commutation is recommended.

For DC Motors with graphite commutation:
The maximum continuous duty torque (S1 operation) at nominal voltage resulting in a steady state temperature not exceeding the maximum winding temperature and / or operating temperature range of the motor. The motor is rated with a reduction of the R_{th2} value of 25% which approximates the amount of cooling available from a typical mounting configuration of the motor. This value can be safely exceeded if the motor is operated intermittently, for example, in S2 operation and/or if more cooling is applied.

Rated Current (thermal limit) I_N [A]
The typical maximum continuous current at steady state resulting from the rated continuous duty torque. This value includes the effects of a loss of K_m (torque constant) as it relates to the temperature coefficient of the winding as well as the thermal characteristics of the given magnet material. This value can be safely exceeded if the motor is operated intermittently, during start / stop, in the ramp up phases of the operating cycle and/or if more cooling is applied. For certain series and lower voltage types this current is limited by the capacity of the brush and commutation system.

Rated Speed n_N [min^{-1}]
The typical speed at steady state resulting from the application of the given rated torque. This value includes the effects of motor heating on the slope of the *n*/*M* curve. Higher speeds can be achieved by increasing the input voltage to the motor, however the rated current (thermal limit) remains the same.



Example: Performance diagram for rated values with continuous operation (graphite commutation)

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Explanations on the performance diagram

The diagram indicates the recommended speed in relation to the available torque at the output shaft for a given ambient temperature of 22°C. The diagram shows the motor in different conditions of thermal coupling, i.e. mounted respectively on a plastic flange and a metal flange.

The sector shown dashed describes possible operating points in which the drive can be engaged in intermittent operation or with increased cooling.

Continuous torque M_D [mNm]
Describes the max. recommended continuous torque in the steady-state condition at nominal voltage and with thermal reduction of the $R_{th\,2}$, $R_{th\,2\,p}$ value by 50 % for graphite commutation and by 0 % for precious metal commutation. With brush motors, the continuous torque corresponds to the respective rated torque M_N. The value is independent of the continuous output and can be exceeded if the motor is intermittently operated and/or more cooling is put to use.

Continuous output P_D [W]
Describes the max. possible output in continuous operation in the steady-state condition with thermal reduction of the $R_{th\,2}$, $R_{th\,2\,p}$ value by 50 %. The value is independent of the continuous torque and can be exceeded if the motor is intermittently operated and/or more cooling is put to use.

Nominal voltage characteristic curve U_N [V]
The nominal voltage curve describes the operating points at U_N in the uncooled and cooled state. In steady-state, the starting point corresponds to the no-load speed n_0 of the drive. Operating points above this curve can be attained by an increase, operating points below by a reduction of the nominal voltage .

How to select a DC-Micromotor

This section provides a very basic step-by-step procedure of how to select a DC-Micromotor for an application that requires continuous duty operation under constant load and ambient conditions. The example describes the calculations necessary to create a basic motor characteristic curve to describe the behaviour of the motor in the application. To simplify the calculation, in this example continuous operation and optimum life performance are assumed and the influence of temperature and tolerances has been omitted.

Application data:
The basic data required for any given application are:

Required torque	M
Required speed	n
Duty cycle	δ
Available supply voltage, max.	U
Available current, max.	I
Available space, max.	diameter/length
Shaft load	radial/axial
Ambient temperature	

This example is based on the following application data:

Output torque	M	= 3	mNm
Speed	n	= 5 500	min^{-1}
Duty cycle	δ	= 100	%
Supply voltage	U	= 20	V
Current source, max.	I	= 0,5	A
Space max	diameter	= 25	mm
	length	= 50	mm
Shaft load	radial	= 1,0	N
	axial	= 0,2	N
Ambient temperature		= 22 °C	constant

Preselection
The first step is to calculate the power the motor is expected to deliver:

$$P_2 = M \cdot 2\,\pi n$$

$$P_2 = 3\text{ mNm} \cdot 5\,500\text{ min}^{-1} \cdot 2\pi \qquad = 1{,}73 \quad \text{W}$$

Second, compare the physical dimensions (diameter and length) to the motor sizes given in the data sheets. Then, from the available motor sizes, compare the required output torque to the diagram for the recommended areas of operation for the motor types in question. Please choose a motor type where the required output torque and speed are well within the limits given in the diagram. For the best results it is recommended to operate the motor close to the "operating point at nominal value" indicated in the diagram. Please note that the diagram in the data sheet is a representative example regarding one nominal voltage type and should be used for orientation purposes only.

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The motor selected from the catalogue for this particular application, is **series 2224 U 024 SR** with the following characteristics:

Nominal voltage	U_N	= 24	V
Frame size:	Ø	= 22	mm
	L	= 24	mm
Shaft load, max.:	radial	= 1,5	N
	axial	= 0,2	N
No-load current	I_o	= 0,007	A
No-load speed	n_o	= 7 800	min^{-1}
Stall torque	M_H	= 19	mNm

Optimizing the preselection

To optimize the motor's operation and life performance, the required speed n has to be higher than half the no-load speed n_o at nominal voltage, and the load torque M has to be less than half the stall torque M_H.

$$n \geq \frac{n_o}{2} \qquad M \leq \frac{M_H}{2}$$

From the data sheet for the DC-Micromotor, **2224 U 024 SR** the parameters meet the above requirements.

$n = 5\,500 \text{ min}^{-1}$	is higher than	$\frac{7\,800 \text{ min}^{-1}}{2} = 3\,900 \text{ min}^{-1} = \frac{n_o}{2}$
$M = 3 \text{ mNm}$	is lower than	$\frac{19 \text{ mNm}}{2} = 9{,}5 \text{ mNm} = \frac{M_H}{2}$

This DC-Micromotor will be a good first choice to test in this application. Should the required speed n be less than half the no-load speed n_o, and the load torque M be less than half the stall torque M_H, the motor with the next higher nominal voltage U_N should be selected.

Should the required torque M be compliant but the required speed n be less than half the no-load speed n_o, try a lower supply voltage or another smaller frame size motor.

Should the required speed be well below half the no-load speed and or the load torque M be more than half the stall torque M_H, a gearhead or a larger frame size motor has to be selected.

Performance characteristics at nominal voltage (24 V)

A graphic presentation of the motor's characteristics can be obtained by calculating the stall current I_H and the torque $M_{opt.}$ at its point of max. efficiency. All other parameters are taken directly from the data sheet of the selected motor.

Stall current

$$I_H = \frac{U_N}{R}$$

$$I_H = \frac{24 \text{ V}}{36{,}3\ \Omega} \qquad = 0{,}661 \quad \text{A}$$

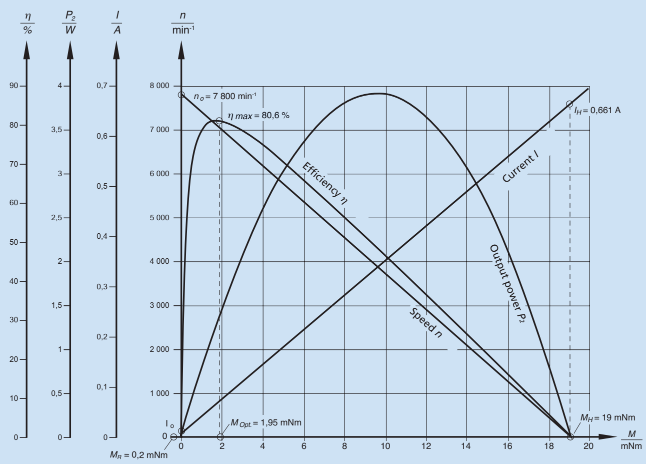
Torque at max. efficiency

$$M_{opt.} = \sqrt{M_H \cdot M_R}$$

$$M_{opt.} = \sqrt{19 \text{ mNm} \cdot 0{,}2 \text{ mNm}} \qquad = 1{,}95 \quad \text{mNm}$$

It is now possible to make a graphic presentation and draw the motor diagram (see diagram 1).

Diagram 1



Calculation of the main parameters

In this application the available supply voltage is lower than the nominal voltage of the selected motor.
The calculation under load therefore is made at 20 V.

No-load speed n_o at 20 V

$$n_o = \frac{U - (I_o \cdot R)}{2\pi \cdot k_M}$$

inserting the values

Supply voltage	U	=	20	V
Terminal resistance	R	=	36,3	Ω
No-load current	I_O	=	0,007	A
Torque constant	k_M	=	29,1	mNm / A

$$n_o = \frac{20\text{ V} - (0{,}007\text{ A} \cdot 36{,}3\ \Omega)}{2\pi \cdot 29{,}1\text{ mNm / A}} \qquad = 6\,481 \quad \text{min}^{-1}$$

Stall current I_H

$$I_H = \frac{U}{R}$$

$$I_H = \frac{20\text{ V}}{36{,}3\ \Omega} \qquad = 0{,}551 \quad \text{A}$$

Stall torque M_H

$$M_H = k_M\left(\frac{U}{R} - I_o\right)$$

$$M_H = 29{,}1\text{ mNm / A} \cdot \left(\frac{20\text{ V}}{36{,}3\ \Omega} - 0{,}007\text{ A}\right) \qquad = 15{,}83 \quad \text{mNm}$$

Efficiency, max. $\eta_{max.}$

$$\eta_{max.} = \left(1 - \sqrt{I_o \cdot \frac{R}{U}}\right)^2$$

$$\eta_{max.} = \left(1 - \sqrt{0{,}007\text{ A} \cdot \frac{36{,}3\ \Omega}{20\text{ V}}}\right)^2 \qquad = 78{,}9 \quad \%$$

At the point of max. efficiency, the torque delivered is:

$$M_{opt.} = \sqrt{M_H \cdot M_R}$$

inserting the values

Friction torque	M_R	=	0,2	mNm
and				
Stall torque with 20 V	M_H	=	15,83	mNm

$$M_{opt.} = \sqrt{15{,}83\text{ mNm} \cdot 0{,}2\text{ mNm}} \qquad = 1{,}78 \quad \text{mNm}$$

Calculation of the operating point at 20 V

When the torque ($M = 3$ mNm) at the working point is taken into consideration I, n, P_2 and η can be calculated:

Current at the operating point

$$I_{Last} = \frac{M + M_R}{k_M}$$

$$I_{Last} = \frac{3\text{ mNm} + 0{,}2\text{ mNm}}{29{,}1\text{ mNm / A}} \qquad = 0{,}11 \quad \text{A}$$

Speed at the operating point

$$n = \frac{U - R \cdot I_{Last}}{2\pi \cdot k_M}$$

$$n = \frac{20\text{ V} - 36{,}3\ \Omega \cdot 0{,}11\text{ A}}{2\pi \cdot 29{,}1\text{ mNm / A}} \qquad = 5\,253 \quad \text{min}^{-1}$$

Output power at the operating point

$$P_2 = M \cdot 2\pi \cdot n$$

$$P_2 = 3\text{ mNm} \cdot 2\pi \cdot 5\,253\text{ min}^{-1} \qquad = 1{,}65 \quad \text{W}$$

Efficiency at the operating point

$$\eta = \frac{P_2}{U \cdot I}$$

$$\eta = \frac{1{,}65\text{ W}}{20\text{ V} \cdot 0{,}11\text{ A}} \qquad = 75{,}0 \quad \%$$

In this example the calculated speed at the working point is different to the required speed, therefore the supply voltage has to be changed and the calculation repeated.

Supply voltage at the operating point

The exact supply voltage at the operating point can now be obtained with the following equation:

$$U = R \cdot I_{Load} + 2\pi \cdot n \cdot k_M$$

$$U = 36{,}3\ \Omega \cdot 0{,}11\text{ A} + 2\pi \cdot 5\,500\text{ min-1} \cdot 29{,}1\text{ mNm / A} = 20{,}75\text{ V}$$

In this calculated example, the parameters at the operating point are summarized as follows:

Supply voltage	U	=	20,75	V
Speed	n	=	5 500	min^{-1}
Output torque	M_N	=	3	mNm
Current	I	=	0,11	A
Output power	P_2	=	1,73	W
Efficiency	η	=	75,7	%

Estimating the temperature of the motor winding in operation:

To ensure that the motor operates within a permissible temperature range, it is necessary to calculate the temperature of the winding and housing under load.
First calculate the approximate motor losses using the following formula:

$$P_{Loss} = I_{Load}^2 \cdot R$$

inserting the values

Current	I_{Load}	= 0,11 A
Resistance	R	= 36,3 Ω

$$P_{Loss} = (0{,}11\ \mathrm{A})^2 \cdot 36{,}3\ \Omega \quad = 0{,}44\ \mathrm{W}$$

Then multiply the value for the power losses by the combined thermal resistances of the motor to estimate the change in the temperature of the motor due to the load.

$$\Delta T = P_{Loss} \cdot (R_{th1} + R_{th2})$$

inserting the values

Thermal resistance 1	R_{th1}	= 5 K/W
Thermal resistance 2	R_{th2}	= 20 K/W

$$\Delta T = 0{,}44\ \mathrm{W} \cdot (5\ \mathrm{K/W} + 20\ \mathrm{K/W}) \quad = 11\ \mathrm{K}$$

Add the resulting change in temperature ΔT to the ambient temperature to estimate the motor winding temperature under load.

$$T_{Winding} = \Delta T + T_{Amb}$$

$$T_{Winding} = 11\ \mathrm{K} + 22\ °\mathrm{C} \quad = 33\ °\mathrm{C}$$

This calculation confirms that the temperature is well within the specified standard operating temperature range as well as the maximum winding temperature.

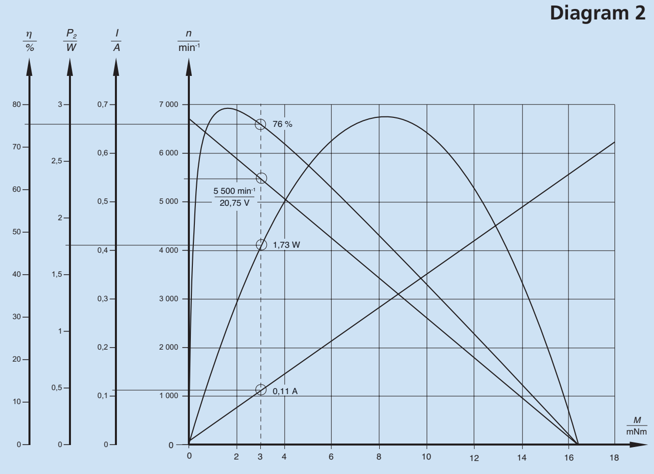
The calculation given above is for the purposes of a quick estimation only. The non-linear effects of temperature on the resistance of the winding and the resulting torque constant (k_M) of the motor due to the temperature coefficient of the magnet material used have not been taken into account and can have a large effect on motor performance at higher temperatures. A more detailed calculation should be performed before operating the motor close to its thermal limits.

Motor characteristic curves

For a specific torque, the various parameters can be read on diagram 2.

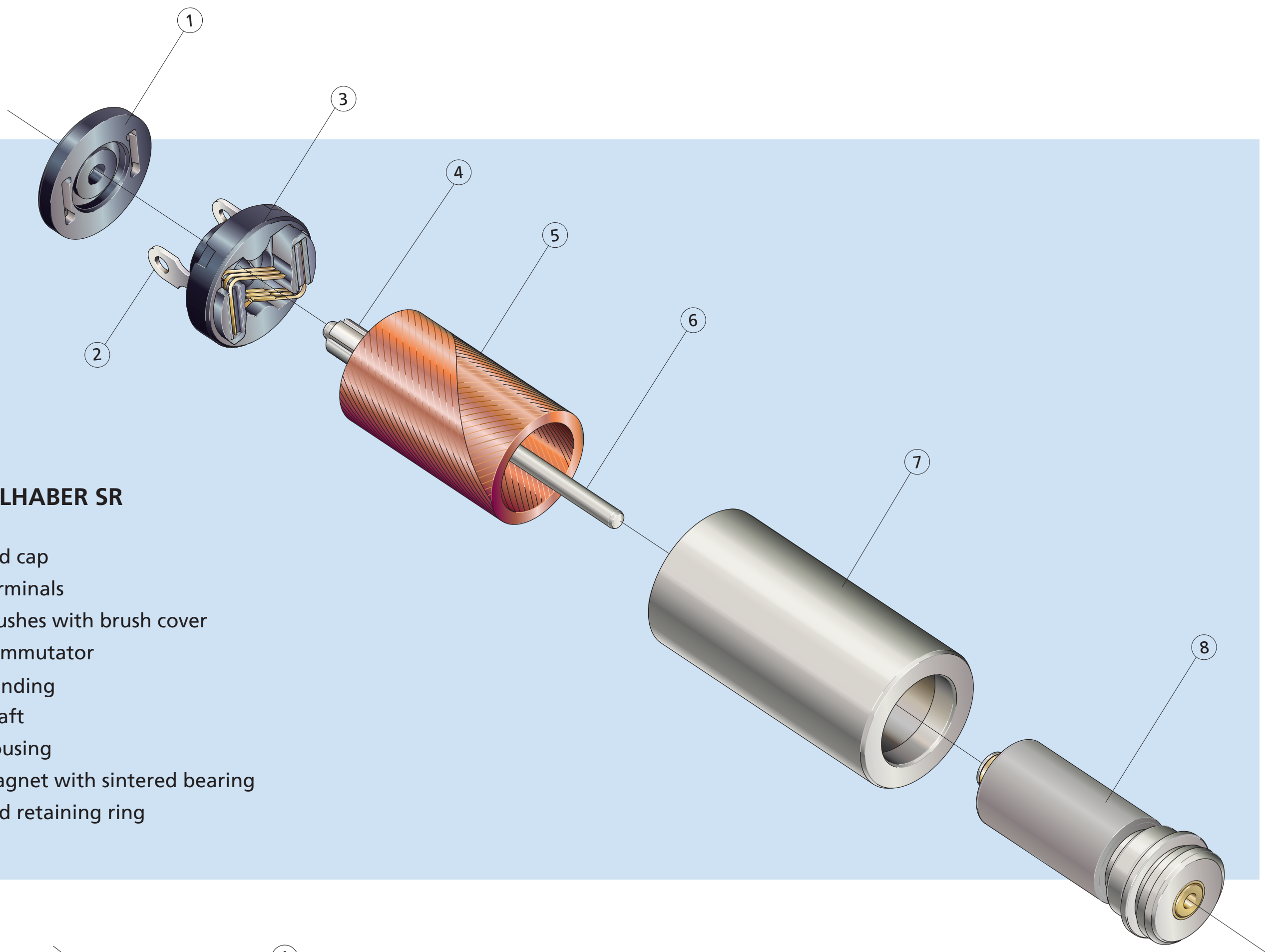
To simplify the calculation, the influence of temperature and tolerances has deliberately been omitted.

Diagram 2



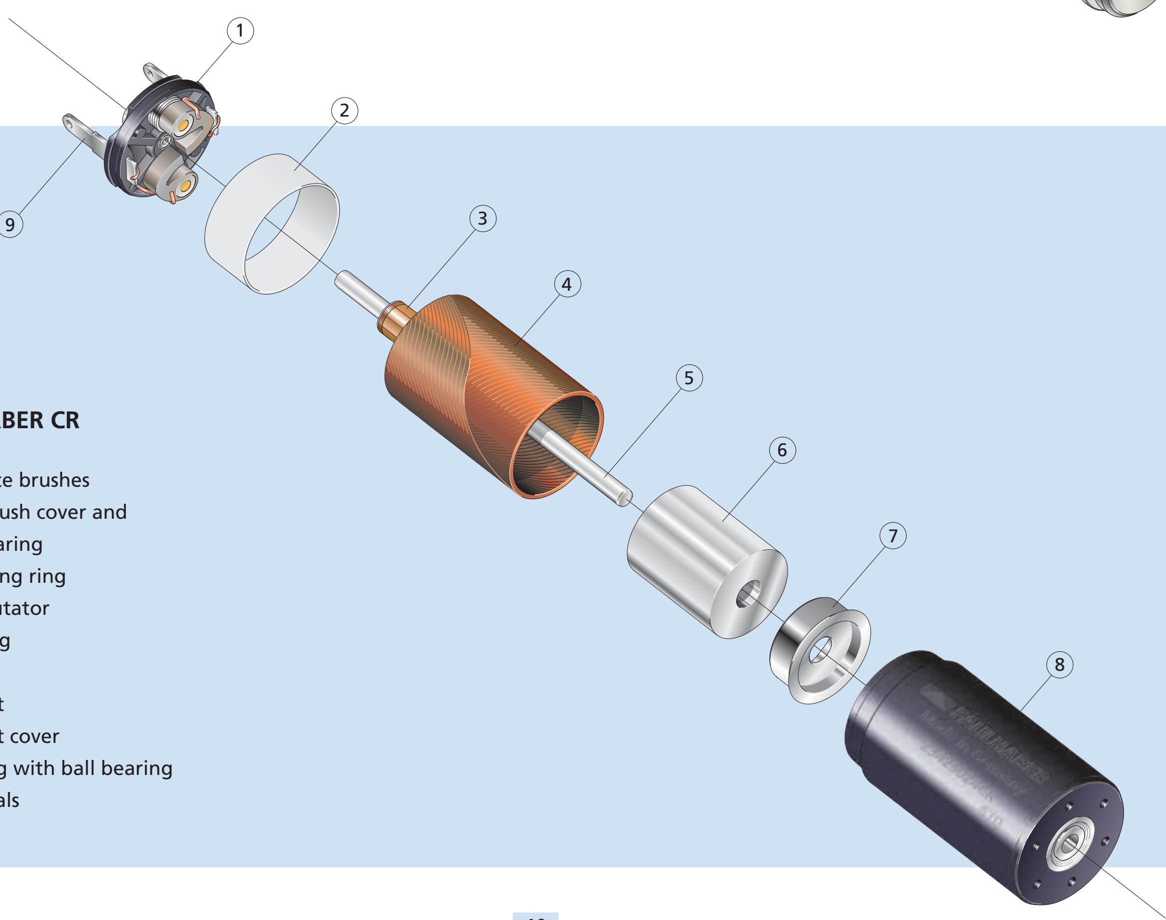
DC-Micromotors

Basic design



FAULHABER SR

① End cap
② Terminals
③ Brushes with brush cover
④ Commutator
⑤ Winding
⑥ Shaft
⑦ Housing
⑧ Magnet with sintered bearing
and retaining ring

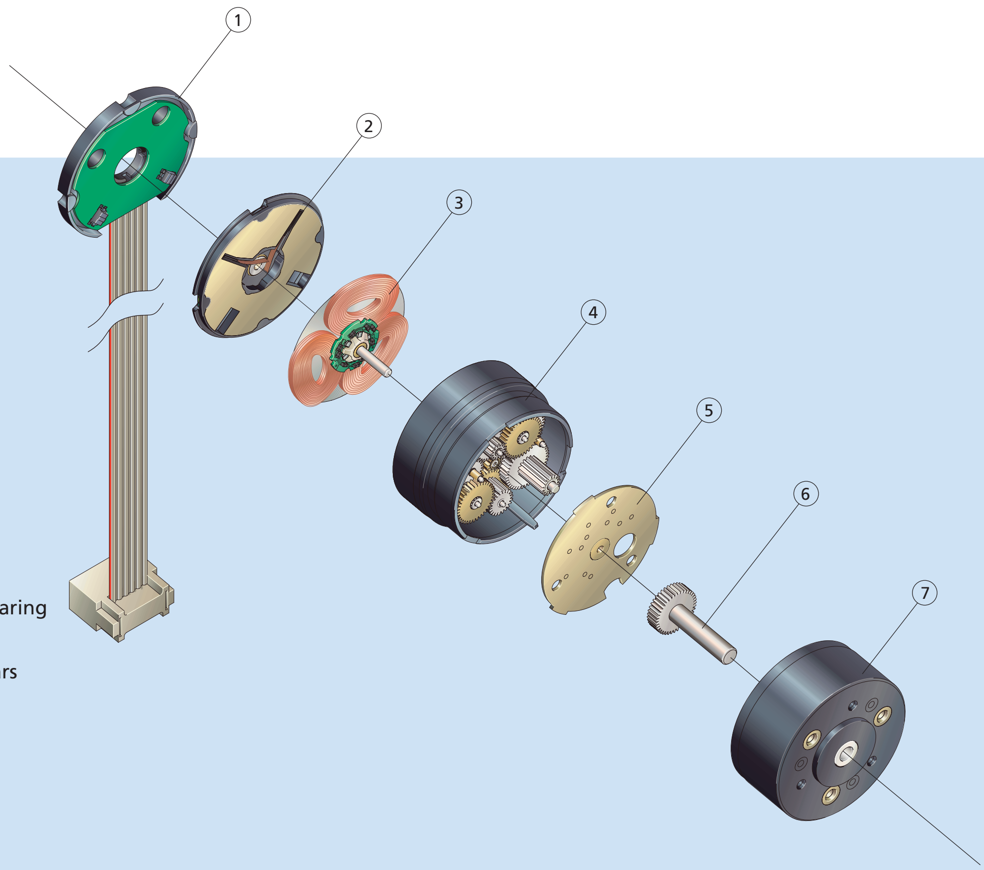


FAULHABER CR

① Graphite brushes
with brush cover and
ball bearing
② Insulating ring
③ Commutator
④ Winding
⑤ Shaft
⑥ Magnet
⑦ Magnet cover
⑧ Housing with ball bearing
⑨ Terminals

Flat DC-Micromotors

Basic design



FAULHABER SR-Flat

① End cap with encoder PCB
② Brush cover with sintered bearing
③ Windings and collector
④ Housing with integrated gears and sintered bearing
⑤ Intermediate plate with sintered bearing
⑥ Output shaft
⑦ Front cover with bearing

DC-Micromotors with precious metal commutation

Originally invented by Dr. Fritz Faulhaber Sr. and patented in 1958, the System FAULHABER coreless (or ironless) progressive, self-supporting, skew wound rotor winding is at the heart of every System FAULHABER DC Motor. This revolutionary technology changed the industry and created new possibilities for customer application of DC Motors where the highest power, best dynamic performance, in the smallest possible size and weight are required.

The main benefits of this technology include no cogging torque resulting in smooth positioning and speed control, higher overall efficiency than other DC Motor types, extremely high torque and power in relation to motor size and weight, and a linear relationship between load to speed, current to torque, and voltage to speed. The very low rotor inertia results in superior dynamic characteristics for starting and stopping and the motors exhibit extremely low torque ripple and EMI.

Series

0615 … S	1219 … G
1516 … S	1624 … S
2230 … S	2233 … S

Key Features

Motor diameter	6 ... 22 mm
Motor length	15 ... 33 mm
Nominal voltage	1,5 ... 40 V
Speed	up to 24.000 min^{-1}
Torque	up to 5,9 mNm
Continuous output	up to 8 W

2230 T 012 S

Product Code

22	Motor diameter [mm]
30	Motor length [mm]
T	Shaft type
012	Nominal voltage [V]
S	Product family

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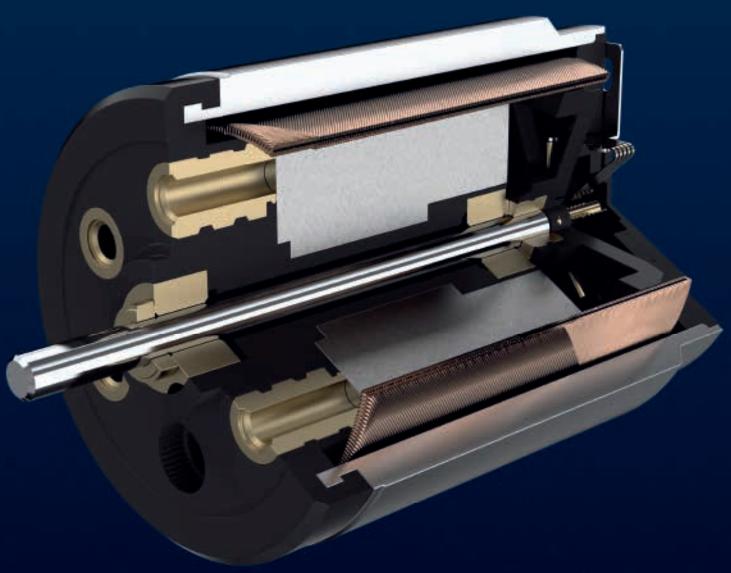
FAULHABER S/G

Advantages of this series at a glance

- Low torque ripple and high efficiency
- Wide operating temperature range
- No cogging torque
- Low current and starting voltage
- Compact and lightweight



DC-Micromotors with precious metal commutation

These ironless DC motors are the most compact in the industry today and most types feature integrated high resolution encoders for use in highly precise positioning and speed control applications.

The commutation system is characterized by its small size, low contact resistance and clean low noise commutation signal. It is ideal for use in battery operated applications where current is at a premium.

Combinations with a wide variety of gearheads and controllers make it possible to create the best system solution for even the most challenging applications.

Series

0816 … SR	1016 … SR
1024 … SR	1224 … SR
1319 … SR	1331 … SR
1516 … SR	1524 … SR
1717 … SR	1724 … SR
2224 … SR	2232 … SR

Key Features

Motor diameter	8 ... 22 mm
Motor length	16 ... 32 mm
Nominal voltage	3 ... 36 V
Speed	up to 17.000 min^{-1}
Torque	up to 10 mNm
Continuous output	up to 8,5 W

Product Code

15	Motor diameter [mm]
24	Motor length [mm]
T	Shaft type
012	Nominal voltage [V]
SR	Product family

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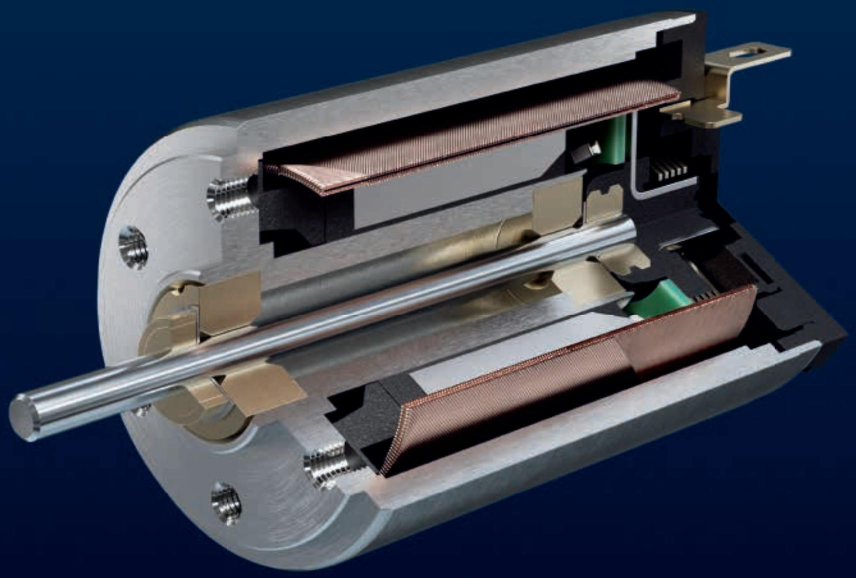
FAULHABER

FAULHABER SR

Advantages of this series at a glance

- Powerful rare-earth magnets
- Wide operating temperature range: -30 °C to +85 °C (optional up to +125 °C)
- All-steel housing with corrosion-resistant coating
- Low torque ripple and high efficiency
- No cogging torque
- Low current and starting voltage
- Extremely compact and lightweight design with integrated encoder



DC-Micromotors with graphite commutation

The CXR series combines power, robustness and control in a compact form. This is ensured by graphite commutation, high-quality neodymium magnets and the tried-and-tested winding of the FAULHABER rotor.

The powerful neodymium magnet gives the motors a high power density with a continuous torque ranging from 3.6 to 40 mNm. The impressive performance data and the compact size open up a wide spectrum of possible applications at an optimised price/performance ratio. The standard drive can be combined with high-resolution optical or magnetic encoders for applications with precise speed control or positioning tasks. A broad and optimally matched selection of gearheads is available to extend the range of requirements that this series is able to fulfil.

Series

1336 … CXR	1727 … CXR
1741 … CXR	2237 … CXR
2642 … CXR	2657 … CXR

Key Features

Motor diameter	13 ... 26 mm
Motor length	27 ... 57 mm
Nominal voltage	6 ... 48 V
Speed	up to 10.000 min^{-1}
Torque	up to 40 mNm
Continuous output	up to 34 W

Product Code

26	Motor diameter [mm]
57	Motor length [mm]
W	Shaft type
024	Nominal voltage [V]
CXR	Product family

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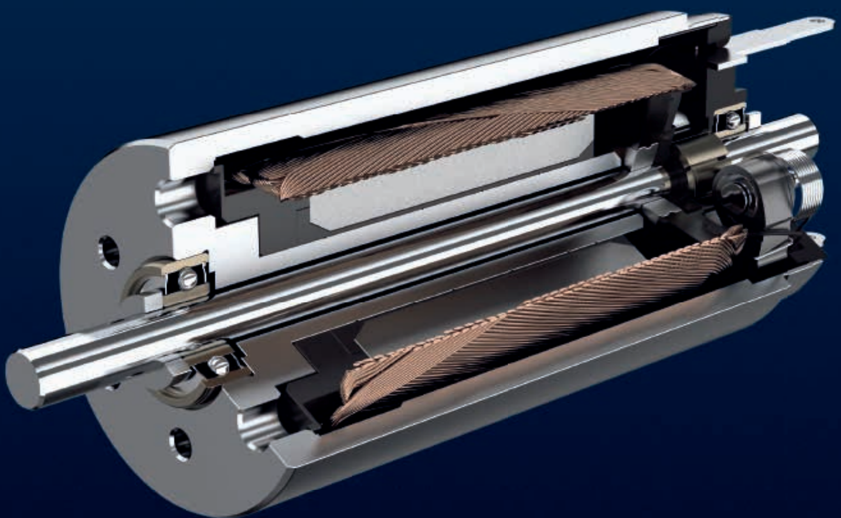
FAULHABER CXR

Advantages of this series at a glance

- Highly dynamic performance due to a low rotor inertia
- Shockproof all-steel housing with corrosion-resistant coating
- Powerful rare-earth magnet
- Wide operating temperature range: -30°C to +100°C (optional -55°C)
- Durable graphite commutation
- No cogging
- Very high power density



DC-Micromotors with graphite commutation

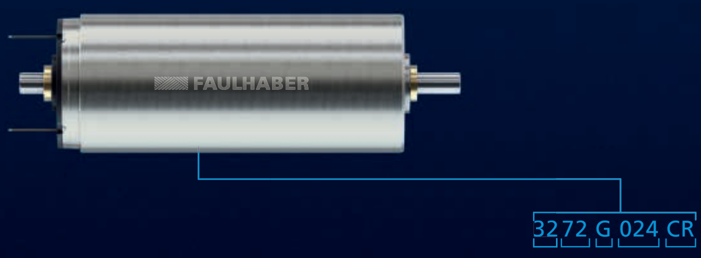
Highly stable and low-wear graphite commutation, extremely powerful neodymium magnets and a particularly high copper content in the winding of the FAULHABER rotor give the CR series its enormous power. The impressive power range of 19 to 224 mNm is ideal for high-performance applications with fast start/stop operation or periodic overload conditions. Thanks to the extremely high power density as well as the outstanding dynamics with minimal rotor inertia, the CR family is the most powerful product family of the entire FAULHABER DC range. The standard drive can be combined with high-resolution optical or magnetic encoders for applications with precise speed control or positioning tasks. A broad and optimally matched selection of gearheads is available to extend the range of requirements that this series is able to fulfil.

Series

2342 … CR	2642 … CR
2657 … CR	2668 … CR
3242 … CR	3257 … CR
3272 … CR	3863 … CR
3890 … CR	

Key Features

Motor diameter	23 ... 38 mm
Motor length	42 ... 90 mm
Nominal voltage	6 ... 48 V
Speed	up to 11.000 min^{-1}
Torque	up to 224 mNm
Continuous output	up to 160 W



Product Code

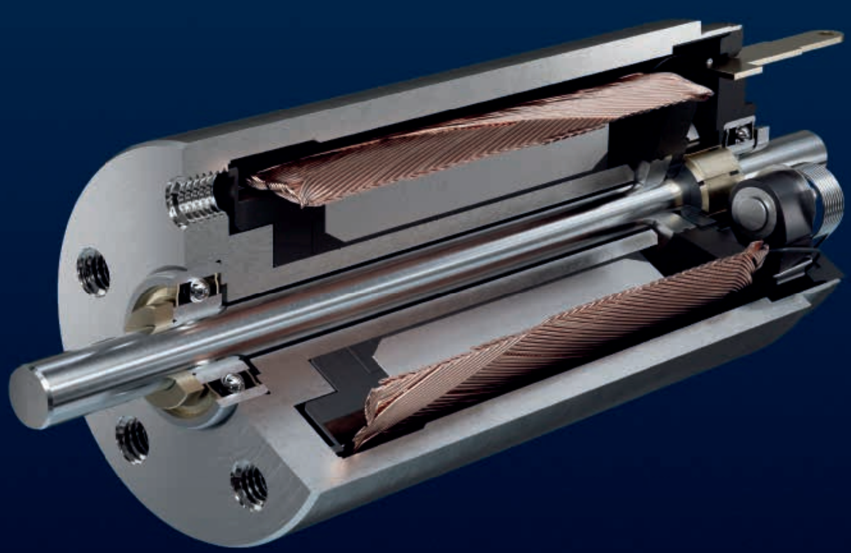
32	Motor diameter [mm]
72	Motor length [mm]
G	Shaft type
024	Nominal voltage [V]
CR	Product family

WE CREATE MOTION

FAULHABER CR

Advantages of this series at a glance

- Best dynamic performance due to a low rotor inertia
- Shockproof all-steel housing with corrosion-resistant coating
- Powerful rare-earth magnet
- Extremely wide operating temperature range -30 °C to 125 °C (optionally -55 °C, winding up to 155 °C)
- Durable graphite commutation
- No cogging
- Highest power density



Flat DC-Micromotors and DC-Gearmotors

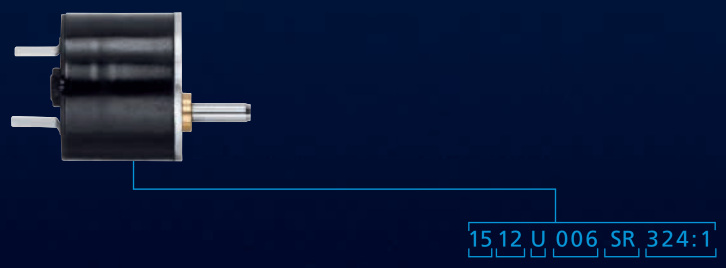
Precious-metal commutated DC-Micromotors with uniquely flat coil technology with three flat, self-supporting copper windings used in the SR-Flat series form the basis for drive systems in applications where space is extremely limited. With their powerful rare-earth magnets, the motors deliver a continuous output of 0.8 W to 4 W and at the same time have only minimal inertia. The motors are available with integrated gearheads and optical encoders – both with an extremely flat design matched to the motors. When combined with integrated gearheads and encoders, they provide a very compact drive system with increased output torque.

Series

1506 … SR	1506 … SR IE2-8
1512 … SR	1512 … SR IE2-8
2607 … SR	2607 … SR IE2-16
2619 … SR	2619 … SR IE2-16

Key Features

Motor diameter	15 ... 26 mm
Motor length	6 ... 19 mm
Nominal voltage	3 ... 24 V
Speed	up to 16.000 min^{-1}
Torque	up to 100 mNm
Continuous output	up to 4 W



Product Code

15	Motor diameter [mm]
12	Motor length [mm]
U	Shaft type
006	Nominal voltage [V]
SR	Product family
324:1	Gearhead reduction

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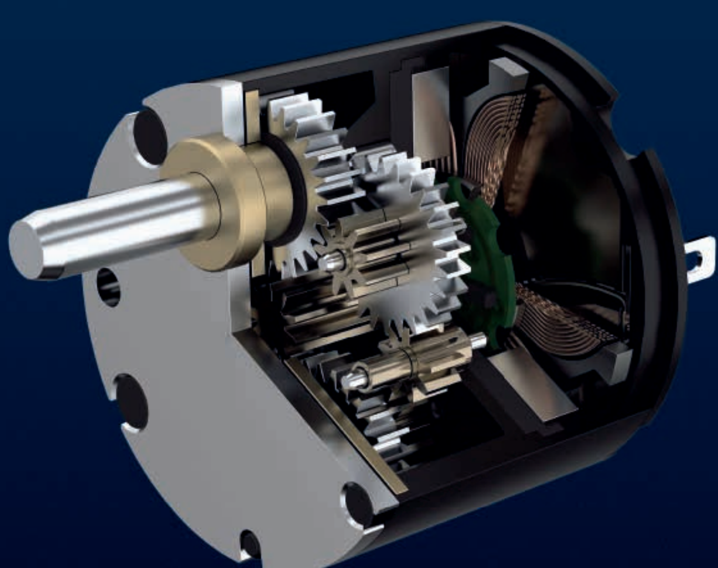
FAULHABER SR-Flat

Advantages of this series at a glance

- Extremely flat design.
  Lengths ranging from 6 mm to 19 mm
- 4-pole design
- Minimal moment of inertia
- Integrated spur gearheads of minimal length with high gear ratio are available
- Available with integrated optical encoders



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