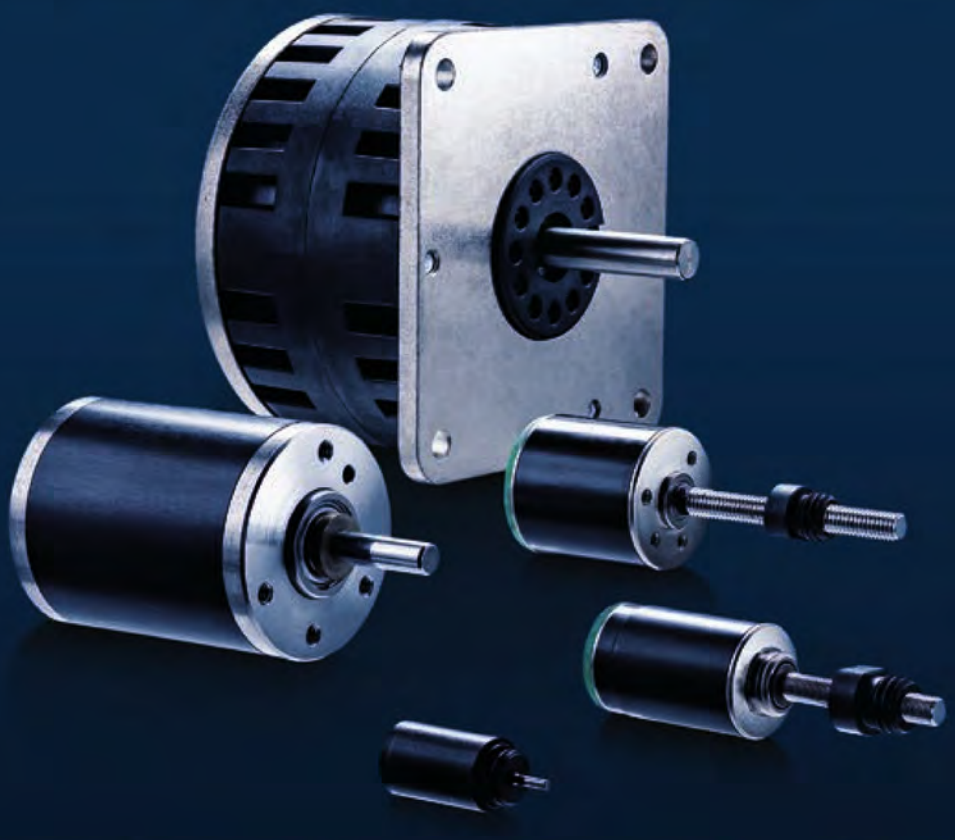
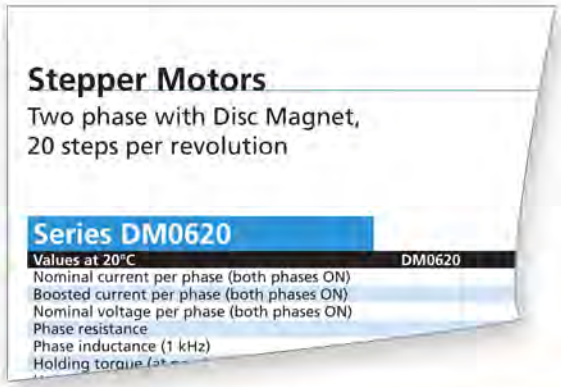
Stepper Motors



WE CREATE MOTION



Notes on technical datasheet

Nominal current per phase [A]
The current supplied to the motor phases that will not exceed, at an ambient temperature of 20 °C, the thermal limits of the motor.

Boosted current per phase [A]
Maximum current which can be supplied to the motor phases for a short period of time not to exceed the thermal capacity of the motor.

Nominal voltage per phase [V]
Voltage necessary to reach the nominal current per phase.

Phase resistance [Ω]
Winding resistance per phase. Tolerance +/- 12%, steady state.

Phase inductance [mH]
Winding inductance per phase measured at 1kHz.

Holding torque [mNm]
The torque generated by the motor at nominal current.

Holding torque at boosted current [mNm]
The torque the motor generates at boosted current. The magnetic circuit of the motor will not be affected by this boosted current, however, to avoid thermal overload the motor should only be boosted intermittently.

Residual torque, typ [mNm]
The typical torque applied to the shaft to rotate it without current to the motor. Residual torque is useful to hold a position without any current to save battery life or to reduce motor temperature.

Back-EMF amplitude [V/k step/s]
Amplitude of the back-EMF measured at 1000 steps/s.

Electrical time constant [ms]
Time needed to establish 63% of the max. possible phase current under a given operation point.

Rotor inertia [kgm²]
This value represents the inertia of the complete rotor.

Step angle (full step) [degree]
Number of angular degrees the motor moves per full-step.

Angular accuracy [% of full step]
The percentage position error per full step, at no load and nominal current. This error is not cumulative between steps.

Angular acceleration, max [rad/s²]
Maximum acceleration the motor can reach in boosted mode and without any load.

$$\alpha_{max.} = \frac{M_{boosted}}{J}$$

Speed up to [min⁻¹]
The maximum recommended motor speed. Exceeding this speed could affect the motor integrity.

Resonance frequency (at no load) [Hz]
The step rate at which the motor at no load will demonstrate resonance. The resonance frequency is load dependent. For the best results the motor should be driven at a higher frequency or in half-step or microstepping mode outside of the given frequency.

$$f = \frac{1}{2\pi} \cdot \sqrt{\frac{M}{J}}$$

Thermal resistance [K/W]
R_{th1} corresponds to the value between the coil and the housing. R_{th2} corresponds to the value between the housing and the ambient air. R_{th2} can be reduced by enabling exchange of heat between the motor and the ambient air (for example using a heat sink or forced air cooling). If only one value is provided, R_{th}, it is the equivalent resistance between the coil and the air.

Thermal time constant [s]
The thermal time constant specifies the time needed for the winding respectively the housing to reach a temperature equal to 63% of the final steady state value.

Operating temperature range [°C]
Temperatures at which the motor can operate.

Winding temperature, max. [°C]
Maximum temperature supported by the windings and the magnets.

Shaft bearings
Self lubricating sintered sleeve bearings or preloaded ball bearings are available.

Shaft load max. [N]
The output shaft load at a specified shaft diameter for the front 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. In case of ball bearings, if the bearing preload is exceeded, reversible shaft displacement of ~200µm may occur.

Shaft play max. [mm]
The play between the shaft and bearings.

Housing material
Material of the motor housing.

Mass [g]
Is the motor mass in grams.

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

How to select a Stepper Motor

The selection of a stepper motor requires the use of published torque speed curves based on the load parameters.

It is not possible to verify the motor selection mathematically without the use of the curves.

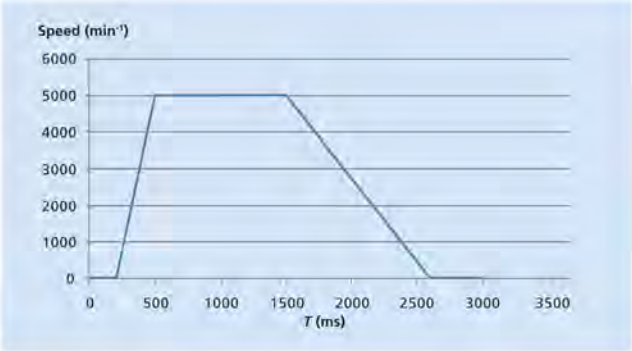
To select a motor the following parameters must be known:

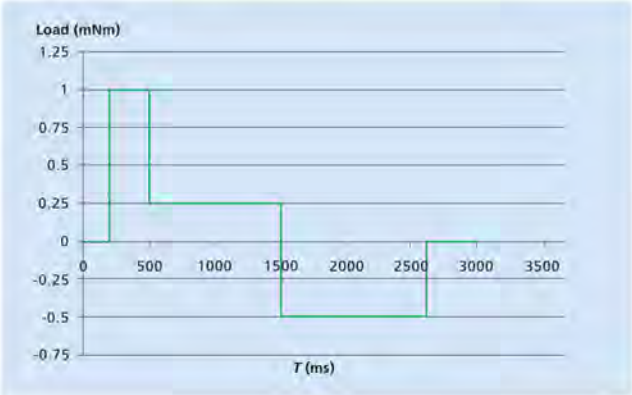
- Motion profile
- Load friction and inertia
- Required resolution
- Available space
- Available power supply voltage

1. Definition of the load parameters at the motor shaft
The target of this step is to determine a motion profile needed to move the motion angle in the given time frame and to calculate the motor torque over the entire cycle using the application load parameters such as friction and load inertia.

The motion and load profiles of the movement used in this example are shown below.
Depending on the motor size suitable for the application it is required to recompute the load parameters with the motor inertia as well.

In the present case it is assumed that a motor with an outside diameter of maximum 15 mm is suitable and the data has been computed with the inertia of the AM1524.





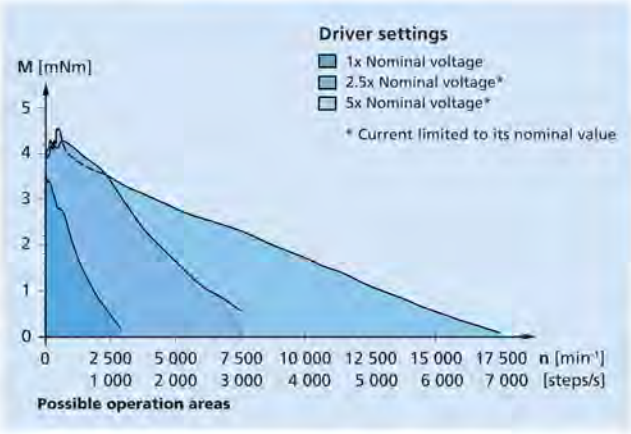
2. Verification of the motor operation.
The highest torque/speed point for this application is found at the end of the acceleration phase. The top speed is then n = 5000 min^{-1}, the torque is M = 1 mNm.

Using these parameters you can transfer the point into the torque speed curves of the motor as shown here with the AM1524 curves.

To ensure the proper operation of the motor in the application, it is highly recommended to use a design margin of 30% during the torque calculation. The shown example assures that the motor will correctly fulfil the requested application conditions.

The use of a higher supply voltage (typically 2.5 to 5 x higher than the nominal voltage) provides a higher torque at higher speed (please refer to the torque-speed curves).

In case no solution is found, it is possible to adapt the load parameters seen by the motor by the use of a reduction gearhead.



3. Verification of the resolution
It is assumed that the application requires a 9° angular resolution.

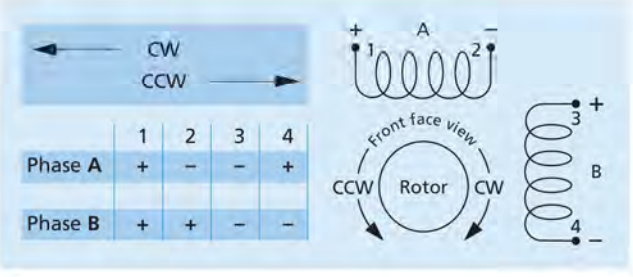
The motor selected, the AM1524, has a full step angle of 15° which is not suitable in full step mode. It can be operated either in half-step, or in microstepping. With microstepping, the resolution can be increased even higher but the angular accuracy is reduced because the error angle (expressed in % of a full-step) is independant from the number of microsteps.

For that reason the most common solution for adapting the motor resolution to the application requirements is the use of a gearhead or a lead-screw where linear motion is required.

4. Operation at low speed
All stepper motors exhibit a resonance frequency.
These are typically below 100Hz. When operating at this frequency stepper motors will exhibit uncontrolled perturbations in speed, direction of rotation and a reduced torque. Thus, if the application requires a speed lower or equal to the resonance frequency, it is recommended to drive the motor in microstepping mode where the higher the microstepping rate, the better performance can be achieved. This will greatly decrease the effects of the resonant frequency and result in smoother speed control.

5. Verification in the application
Any layout based on such considerations has to be verified in the final application under real conditions.
Please make sure that all load parameters are taken into account during this test.

Direction of rotation
All motors will rotate in CCW direction when using the following commutation sequence : 1.A+B+ 2.A-B+ 3.A-B- 4.A+B-. Only exception is the AM1524 which runs CW using here above commutation sequence.



General application notes

In principle each stepper motor can be operated in three modes: full step (one or two phases on), half step or microstep.

Holding torque is the same for each mode as long as dissipated power (I^2R losses) is the same. The theory is best presented on a basic motor model with two phases and one pair of poles where mechanical and electrical angle are equal.

- In full step mode (1 phase on) the phases are successively energised in the following way:
  1. A+ 2. B+ 3. A– 4. B–.
- Half step mode is obtained by alternating between 1-phase-on and 2-phases-on, resulting in 8 half steps per electrical cycle: 1. A+ 2. A+B+ 3. B+ 4. A–B+ 5. A– 6. A–B– 7. B– 8. A+B–.
- If every half step should generate the same holding torque, the current per phase is multiplied by √2 each time only 1 phase is energised.

The two major advantages provided by microstep operation are lower running noise and higher resolution, both depending on the number of microsteps per full step limited by the capability of the controller.

As explained above, one electrical cycle or revolution of the field vector (4 full steps) requires the driver to provide a number of distinct current values proportional to the number of microsteps per full step.

For example, 8 microsteps require 8 different values which in phase A would drop from full current to zero following the cosine function from 0° to 90°, and in phase B would rise from zero to full following the sine function.

These values are stored and called up by the program controlling the chopper driver. The rotor target position is determined by the vector sum of the torques generated in phase A and B:

$$M_A = k \cdot I_A = k \cdot I_o \cdot \cos \varphi$$

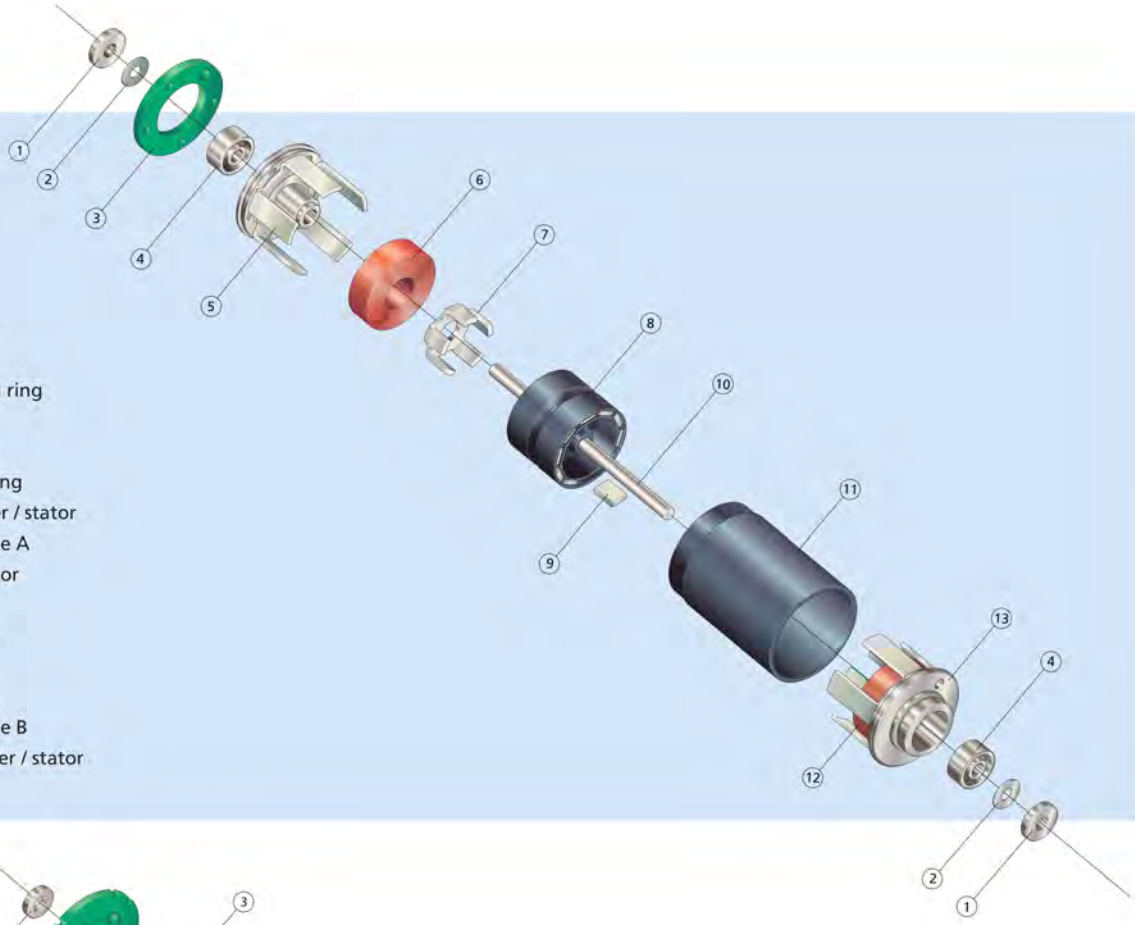
$$M_B = k \cdot I_B = k \cdot I_o \cdot \sin \varphi$$

where M is the motor torque, k is the torque constant and I_o the nominal phase current.

For the motor without load the position error is the same in full, half or microstep mode and depends on distortions of the sinusoidal motor torque function due to detent torque, saturation or construction details (hence on the actual rotor position), as well as on the accuracy of the phase current values.

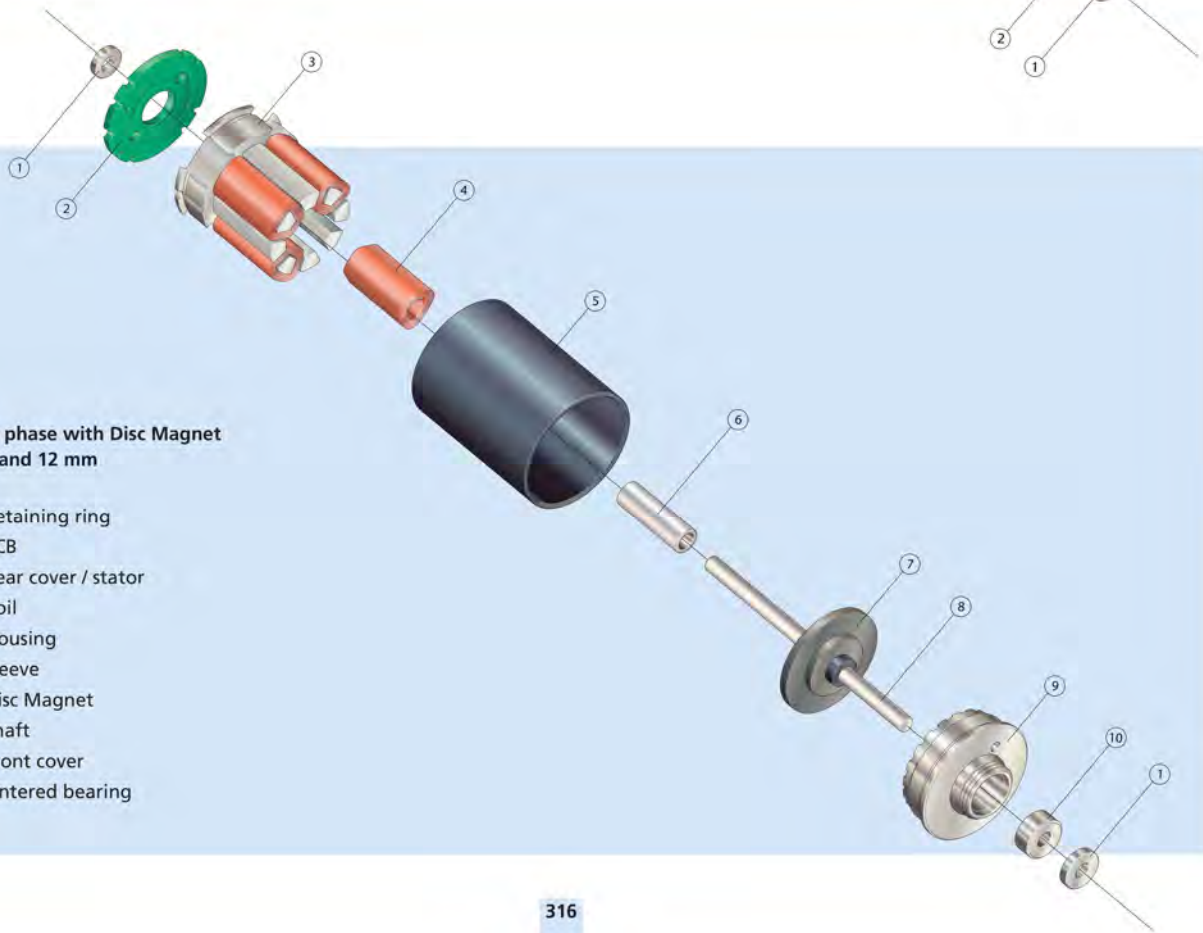
Stepper Motors

Basic design



Two phase

① Retaining ring
② Washer
③ PCB
④ Ball bearing
⑤ Rear cover / stator
⑥ Coil, Phase A
⑦ Inner stator
⑧ Rotor
⑨ Magnets
⑩ Shaft
⑪ Housing
⑫ Coil, Phase B
⑬ Front cover / stator

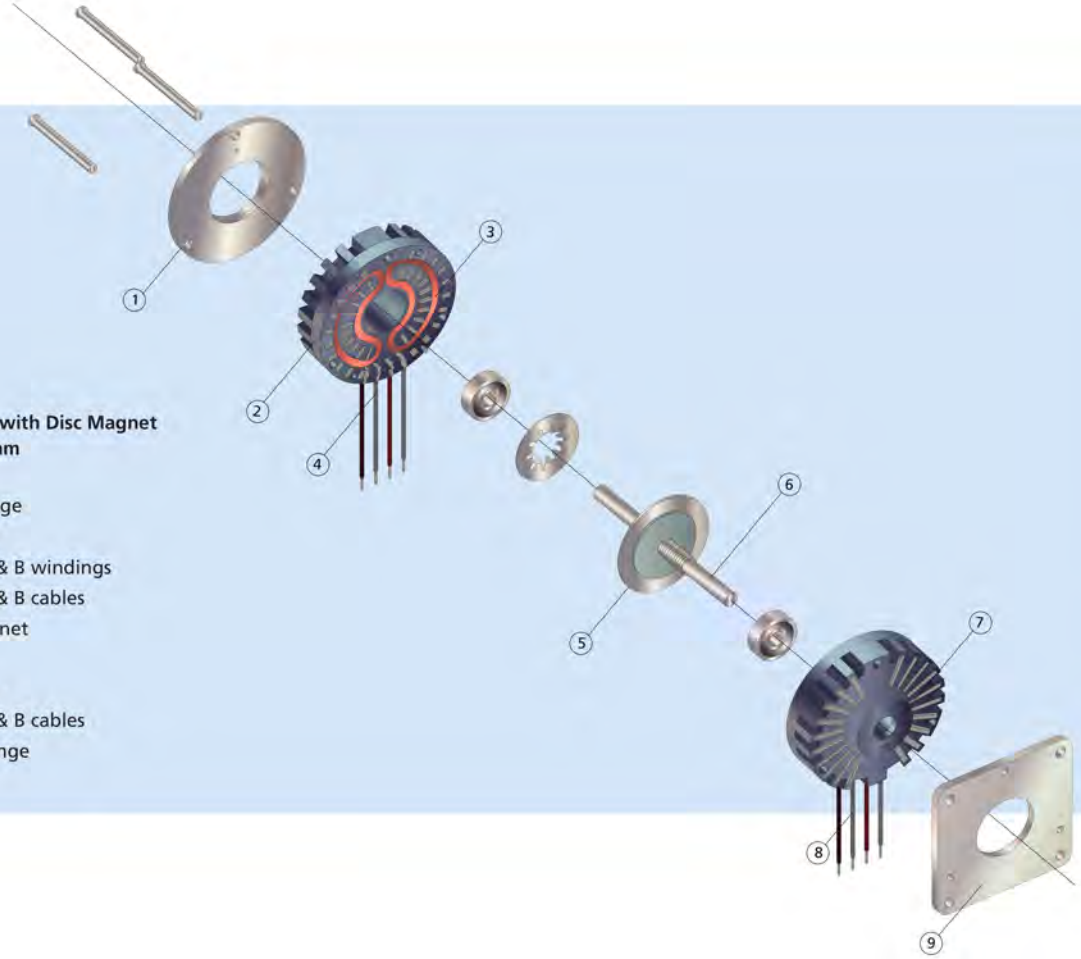


Two phase with Disc Magnet
Ø 6 and 12 mm

① Retaining ring
② PCB
③ Rear cover / stator
④ Coil
⑤ Housing
⑥ Sleeve
⑦ Disc Magnet
⑧ Shaft
⑨ Front cover
⑩ Sintered bearing

Stepper Motors

Basic design



Two phase with Disc Magnet
Ø 40 – 52 mm

① Rear flange
② ½ stator
③ Phase A & B windings
④ Phase A & B cables
⑤ Disc magnet
⑥ Shaft
⑦ ½ stator
⑧ Phase A & B cables
⑨ Front flange

Stepper Motors – 2 phases permanent magnet Technology

The FAULHABER Stepper Motors are two phase multi-polar motors with permanent magnets. The use of rare-earth magnets provides an exceptionally high power to volume ratio. Their rotor design with very low inertia makes them ideally suited for applications requiring very fast acceleration or change of directions and allows to start from the first step with a given speed, reducing further time needed for the acceleration ramp. Their short length and light weight allow them to be used in highly integrated systems.

Thanks to a robust design they can be selected for the harshest environments. Precise, open-loop, speed and position control can be achieved with the application of full step, half step, or microstepping electronics.

The FAULHABER Stepper Motors can be combined with lead-screws or gearheads enabling to reach operational points that are today unmatched in the market.

Series

DM0620	AM2224R3
AM0820	DM40100R
AM1020	DM52100S
DM1220	DM52100R
AM1524	DM52100N
AM2224	

Key Features

Outer diameter	6 ... 52 mm
Motor length	9,5 ... 32,6 mm
Number of steps per revolution	20 / 24 / 100
Holding torque	0,25 (0,39)
(boost)	... 200 (450) mNm

Product Code

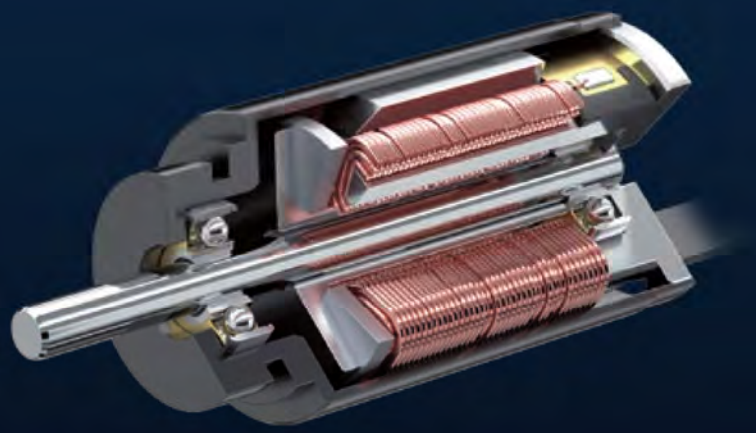
DM	Motor design
06	Motor diameter [mm]
20	Steps per revolution
_	Version (if applicable)
2R	Bearings
0080	Winding
11	Motor execution

FAULHABER

FAULHABER Stepper Motors

Advantages of this series at a glance

- Cost effective positioning drive without encoder
- High power density
- Very high acceleration
- Ultra-fast change of direction capability
- Long operational lifetimes
- Wide operational temperature range
- Speed range up to 16 000 min^{-1} using a current mode chopper driver
- Possibility of full step, half step and microstep operation
- Extremely low rotor inertia



Stepper Motors 0,25 mNm

Two phase with Disc Magnet,
20 steps per revolution

Series DM0620

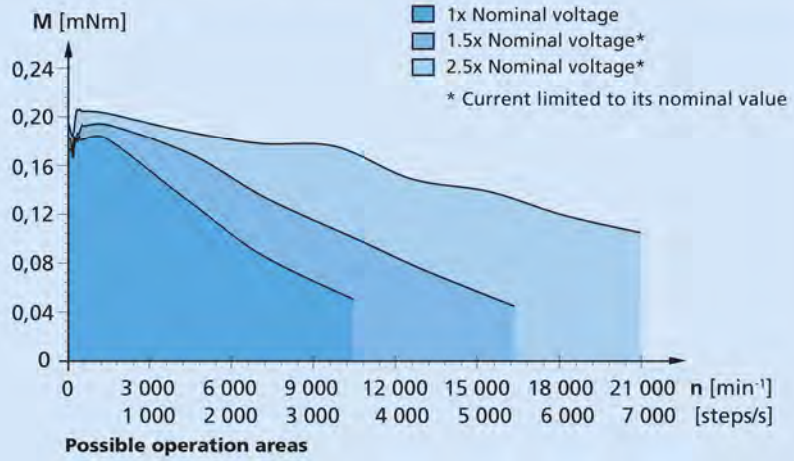
Values at 20°C	DM0620	0130	0080	0040	
Nominal current per phase (both phases ON)		0,13	0,08	0,04	A
Boosted current per phase (both phases ON)		0,26	0,16	0,08	A
Nominal voltage per phase (both phases ON)		2	3	6	V
Phase resistance		13,6	30	120	Ω
Phase inductance (1 kHz)		2	4,5	18,5	mH
Holding torque (at nominal current in both phases)		0,25	0,25	0,25	mNm
Holding torque at boosted current		0,39	0,39	0,39	mNm
Residual torque, typ.		0,03	0,03	0,03	mNm
Back-EMF amplitude		0,53	0,83	1,6	V/k step/s
Electrical time constant	0,15				ms
Rotor inertia	$0{,}5 \cdot 10^{-9}$				kgm²
Step angle (full step)	18				°
Angular accuracy	±5				%
Angular acceleration, max.	$780 \cdot 10^{3}$				rad/s²
Resonance frequency (at no load)	110				Hz
Thermal resistance	15 / 96,6				K/W
Thermal time constant	3,2 / 120				s
Operating temperature range	-35 ... +70				°C
Winding temperature, max.	+130				°C
Shaft bearings [1] [2]	sintered bearing (Bearing code: SB)	ball bearings, preloaded (Bearing code: 2R)			
Shaft load max.:					
– with shaft diameter	1	1			mm
– radial at 5 000 min⁻¹ (3 mm from bearing)	0,3	3			N
– axial at 5 000 min⁻¹	0,5	0,5			N
– axial at standstill	0,5	5,8			N
Shaft play:					
– radial	0,02	0,012			mm
– axial	0	0			mm
Housing material	aluminium, black anodized				
Mass	1,1				g
Magnet material	NdFeB				

[1] Special lubricant options available on request.
[2] 2 preloaded ball bearings available on request for vacuum / low temperature (bearing code: RC).

Driver settings

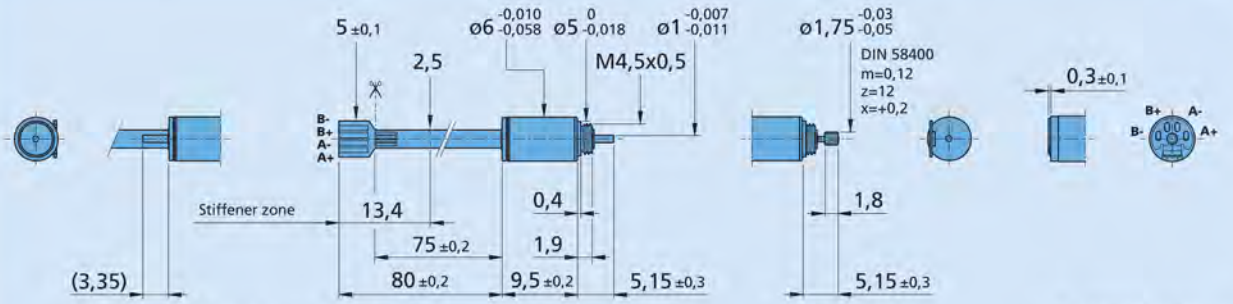
Relevant for 2 phases ON only.
On PWM drivers or chopper (current mode), the current is set to the nominal value and the supply voltage is typically 1.5 to 2.5x higher than the nominal voltage.

Curves measured with a load inertia of $3 \cdot 10^{-9}$ kgm², in half-step mode for the "1 x nominal voltage" curve, in 1/4 micro-stepping mode for the other curves.



Possible operation areas

Dimensional drawing



Recommended connectors
Pitch: 1mm - FPC/FFC, 4 poles
JST 04FMN-SMT-A-TF or similar.
Pitch: 0,5mm - FPC/FFC, 4 poles
Molex 52745 or similar.

Flex PCB
Thickness: 0,15 mm. Bending radius 3 mm min.
Thickness of pads area (stiffener)
0,3 mm (± 0,05), not flexible

Flex PCB for cables
Not available with double output shaft executions.

DM0620 for Gearhead 06/1

Options and connection information

Example product designation: **DM06202R008011**

Motor executions front shaft	Motor executions double shaft	PCB type	Front shaft description
31	30	Flex PCB 80mm p=1mm	Plain shaft, ø1 mm
35	36	Flex PCB 80mm p=1mm	With pinion for gearheads 06/1
76	75	Flex PCB 80mm p=1mm	Plain shaft, for lead screw M1.2
78	77	Flex PCB 80mm p=1mm	Plain shaft, for lead screw M1.6
11		Flex PCB for cable	Plain shaft, ø1 mm
15		Flex PCB for cable	With pinion for gearheads 06/1
26		Flex PCB for cable	Plain shaft, for lead screw M1.2
28		Flex PCB for cable	Plain shaft, for lead screw M1.6

Connection

No.	Function
1	Phase A +
2	Phase A -
3	Phase B +
4	Phase B -

Note : Standard version is delivered with a flex PCB of 80mm that the user can cut himself as indicated on the drawing above. A version with pre-cut PCB is available on request.

Product combination

Precision Gearheads / Lead Screws	Encoders	Drive Electronics	Cables / Accessories
06/1 M1,2 x 0,25 x L1 M1,6 x 0,35 x L1		MCST 3601	List available on request

Stepper Motors 0,65 mNm

Two phase, 20 steps per revolution

Series AM0820

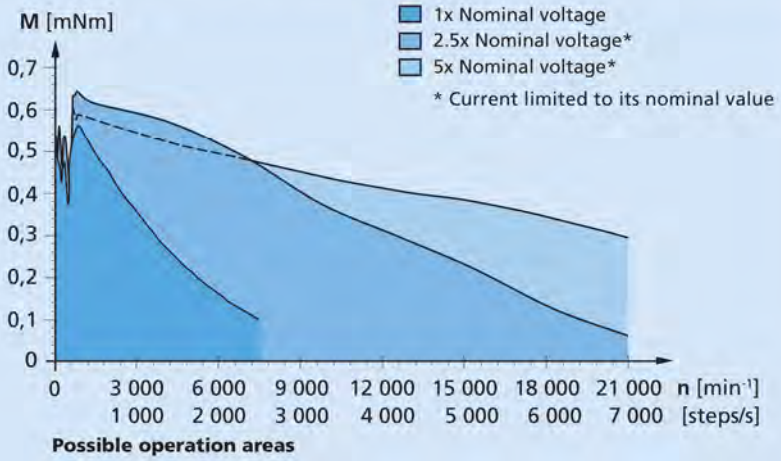
Values at 20°C	AM0820	0225	0150	0080	
Nominal current per phase (both phases ON)		0,225	0,15	0,08	A
Boosted current per phase (both phases ON)		0,45	0,3	0,16	A
Nominal voltage per phase (both phases ON)		2	3	5	V
Phase resistance		7,3	18	56	Ω
Phase inductance (1 kHz)		1,4	3,9	12,6	mH
Holding torque (at nominal current in both phases)		0,65	0,65	0,65	mNm
Holding torque at boosted current		1	1	1	mNm
Residual torque, typ.		0,13	0,13	0,13	mNm
Back-EMF amplitude		0,8	1,3	2,4	V/k step/s
Electrical time constant	0,21				ms
Rotor inertia	$2{,}75 \cdot 10^{-9}$				kgm²
Step angle (full step)	18				°
Angular accuracy	±10				%
Angular acceleration, max.	$363 \cdot 10^{3}$				rad/s²
Resonance frequency (at no load)	75				Hz
Thermal resistance	4,1 / 65,3				K/W
Thermal time constant	3,5 / 160				s
Operating temperature range	-30 ... +70				°C
Winding temperature, max.	+130				°C
Shaft bearings [1] [2]	sintered bearings (Bearing code: SB)	ball bearings, preloaded (Bearing code: 2R)			
Shaft load max.:					
– with shaft diameter	1	1			mm
– radial at 5 000 min⁻¹ (3 mm from bearing)	0,3	3			N
– axial at 5 000 min⁻¹	0,2	1,5			N
– axial at standstill	0,2	5,8			N
Shaft play:					
– radial	0,015	0,012			mm
– axial	0,14	0			mm
Housing material	aluminium, black anodized				
Mass	3,3				g
Magnet material	NdFeB				

[1] Special lubricant options available on request.
[2] 2 preloaded ball bearings available on request for vacuum / low temperature (bearing code: RC).

Driver settings

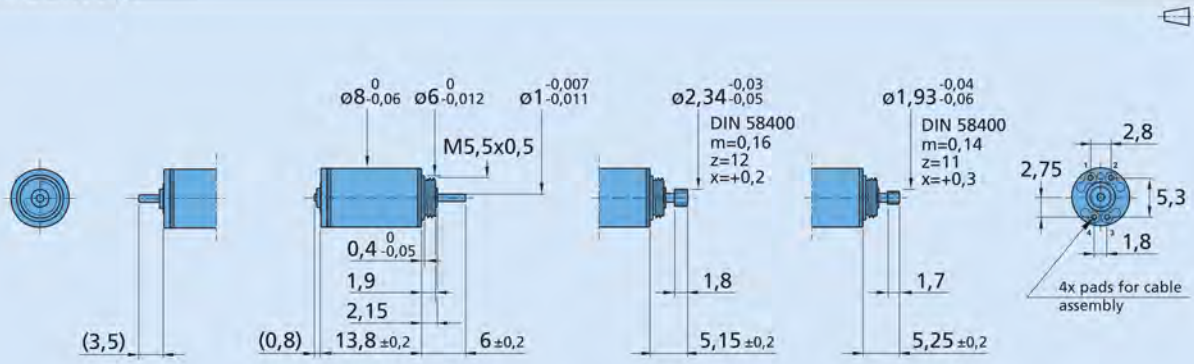
Relevant for 2 phases ON only.
On PWM drivers or chopper (current mode), the current is set to the nominal value and the supply voltage is typically 2.5 to 5x higher than the nominal voltage.

Curves measured with a load inertia of $6 \cdot 10^{-9}$ kgm², in half-step mode for the "1 x nominal voltage" curve, in 1/4 micro-stepping mode for the other curves.



Possible operation areas

Dimensional drawing



AM0820

for Gearhead 08/1

for Gearhead 08/2, 08/3

Options and connection information

Example product designation: **AM08202R015001**

Motor executions front shaft	Motor executions double shaft	Front shaft description
01	00	Plain shaft
08	09	With pinion for gearheads 08/1
10	11	With pinion for gearheads 10/1
12	13	With pinion for gearheads 08/2, 08/3
21	20	Plain shaft for lead screw M1,2
23	22	Plain shaft for lead screw M2 - M3
25	24	Plain shaft for lead screw M1,6

Connection

No.	Function
1	Phase A +
2	Phase A -
3	Phase B +
4	Phase B -

Product combination

Precision Gearheads / Lead Screws	Encoders	Drive Electronics	Cables / Accessories
08/1 08/2 08/3 10/1 M1,2 x 0,25 x L1 M1,6 x 0,35 x L1 M2 x 0,2 x L1 M3 x 0,5 x L1	List available on request	MCST 3601	List available on request

Stepper Motors 1,6 mNm

Two phase, 20 steps per revolution

Series AM1020

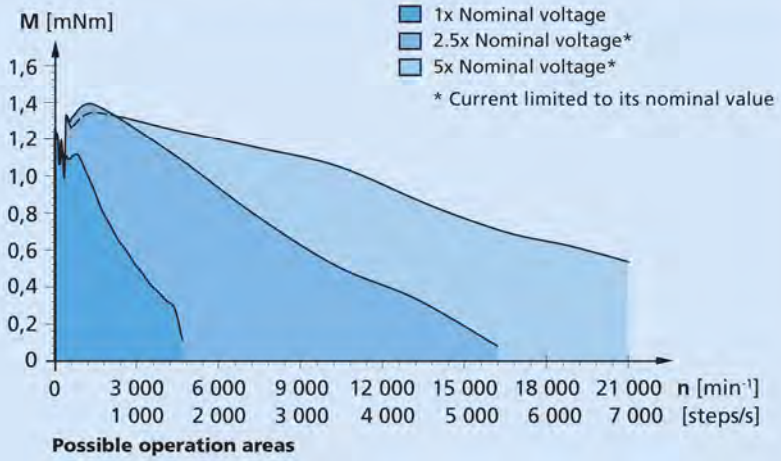
Values at 20°C	AM1020	0250	0180	0090	0045	
Nominal current per phase (both phases ON)		0,25	0,18	0,09	0,045	A
Boosted current per phase (both phases ON)		0,5	0,36	0,18	0,09	A
Nominal voltage per phase (both phases ON)		2	3	6	12	V
Phase resistance		8	16	65	250	Ω
Phase inductance (1 kHz)		2,4	5,2	21,4	80,1	mH
Holding torque (at nominal current in both phases)		1,6	1,6	1,6	1,6	mNm
Holding torque at boosted current		2,4	2,4	2,4	2,4	mNm
Residual torque, typ.		0,14	0,14	0,14	0,14	mNm
Back-EMF amplitude		1,8	2,6	5,3	10,5	V/k step/s
Electrical time constant	0,32					ms
Rotor inertia	$9 \cdot 10^{-9}$					kgm²
Step angle (full step)	18					°
Angular accuracy	±10					%
Angular acceleration, max.	$256 \cdot 10^{3}$					rad/s²
Resonance frequency (at no load)	65					Hz
Thermal resistance	3,9 / 53,8					K/W
Thermal time constant	4,5 / 200					s
Operating temperature range	-35 ... +70					°C
Winding temperature, max.	+130					°C
Shaft bearings [1] [2]	sintered bearings (Bearing code: SB)		ball bearings, preloaded (Bearing code: 2R)			
Shaft load max.:						
– with shaft diameter	1,2		1,2			mm
– radial at 5 000 min⁻¹ (3 mm from bearing)	0,3		4			N
– axial at 5 000 min⁻¹	0,3		3			N
– axial at standstill	0,3		11			N
Shaft play:						
– radial	0,015		0,012			mm
– axial	0,15		0			mm
Housing material	aluminium, black anodized					
Mass	5,5					g
Magnet material	NdFeB					

[1] Special lubricant options available on request.
[2] 2 preloaded ball bearings available on request for vacuum / low temperature (bearing code: RC).

Driver settings

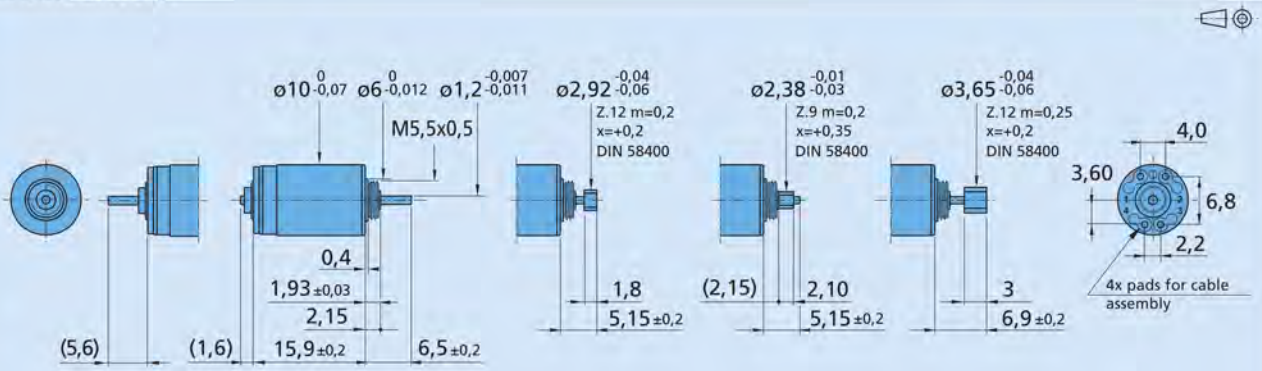
Relevant for 2 phases ON only.
On PWM drivers or chopper (current mode), the current is set to the nominal value and the supply voltage is typically 2.5 to 5x higher than the nominal voltage.

Curves measured with a load inertia of $6 \cdot 10^{-9}$ kgm², in half-step mode for the "1 x nominal voltage" curve, in 1/4 micro-stepping mode for the other curves.



Possible operation areas

Dimensional drawing



AM1020

for Gearhead 10/1

for Gearhead 12/3, 12/5

for Gearhead 12/4

Options and connection information

Example product designation: **AM10202R018001**

Motor executions front shaft	Motor executions double shaft	Front shaft description
01	00	Plain shaft
08	09	With pinion for gearheads 10/1
10	11	With pinion for gearheads 12/3 and 12/5
	12	Plain shaft, Rear = 3,7 mm for encoder
	13	With pinion for gearheads 10/1, rear = 3,7 mm for encoder
	14	With pinion for gearheads 12/3, 12/5 rear = 3,7 mm for encoder
21	20	Plain shaft for lead screw M1,2
23	22	Plain shaft for lead screw M2 - M3
25	24	Plain shaft for lead screw M1,6
31	30	With pinion for gearheads 12/4
	32	With pinion for gearheads 12/4, rear = 3,7 mm for encoder

Connection

No.	Function
1	Phase A +
2	Phase A -
3	Phase B +
4	Phase B -

Product combination

Precision Gearheads / Lead Screws	Encoders	Drive Electronics	Cables / Accessories
10/1 12/3 12/4 12/5 M1,2 x 0,25 x L1 M1,6 x 0,35 x L1 M2 x 0,2 x L1 M3 x 0,5 x L1	List available on request	MCST 3601	List available on request

Stepper Motors 2,4 mNm

Two phase with Disc Magnet, 20 steps per revolution, microstepping motor

Series DM1220

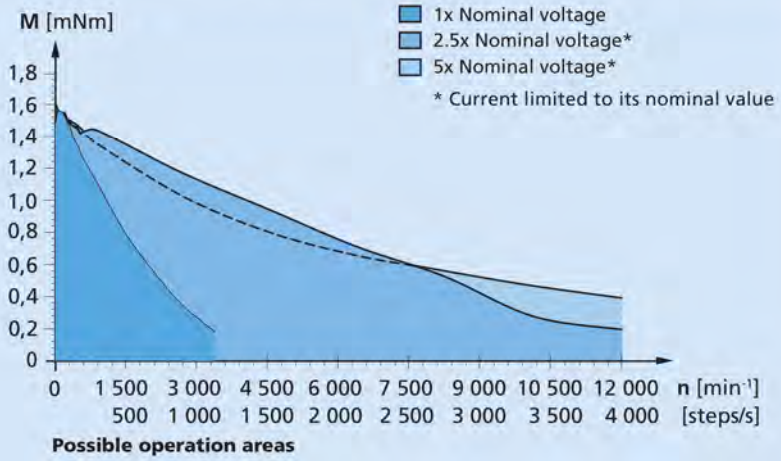
Values at 20°C	DM1220	0330	0220	0110	0055	
Nominal current per phase (both phases ON)		0,33	0,22	0,11	0,055	A
Boosted current per phase (both phases ON)		0,66	0,44	0,22	0,11	A
Nominal voltage per phase (both phases ON)		2	3	6	12	V
Phase resistance		4,5	10,4	41	168	Ω
Phase inductance (1 kHz)		1,3	3,5	13	57	mH
Holding torque (at nominal current in both phases)		2,4	2,4	2,4	2,4	mNm
Holding torque at boosted current		4,1	4,1	4,1	4,1	mNm
Residual torque, typ.		0,07	0,07	0,07	0,07	mNm
Back-EMF amplitude		1,7	2,6	5	10	V/k step/s
Electrical time constant	0,28					ms
Rotor inertia	$18{,}5 \cdot 10^{-9}$					kgm²
Step angle (full step)	18					°
Angular accuracy	±3					%
Angular acceleration, max.	$221 \cdot 10^{3}$					rad/s²
Resonance frequency (at no load)	55					Hz
Thermal resistance	11,9 / 46,5					K/W
Thermal time constant	5 / 300					s
Operating temperature range	-35 ... +70					°C
Winding temperature, max.	+130					°C
Shaft bearings [1] [2]	sintered bearing (Bearing code: SB)		ball bearings, preloaded (Bearing code: 2R)			
Shaft load max.:						
– with shaft diameter	1,5		1,5			mm
– radial at 5 000 min⁻¹ (3 mm from bearing)	0,5		6			N
– axial at 5 000 min⁻¹	3		3			N
– axial at standstill	3		17			N
Shaft play:						
– radial	0,015		0,012			mm
– axial	0		0			mm
Housing material	aluminium, black anodized					
Mass	9					g
Magnet material	NdFeB					

[1] Special lubricant options available on request.
[2] 2 preloaded ball bearings available on request for vacuum / low temperature (bearing code: RC).

Driver settings

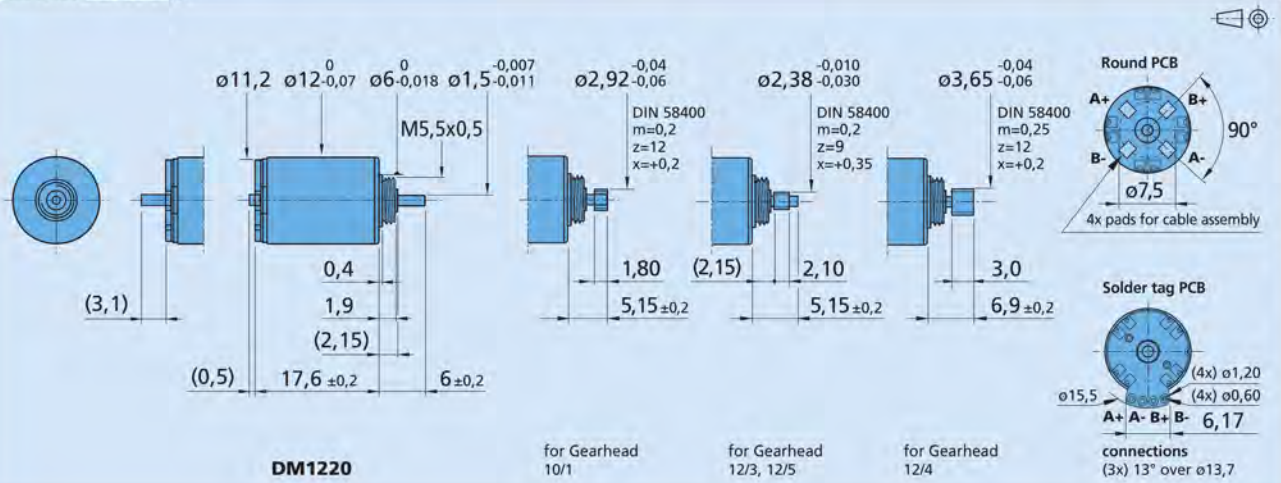
Relevant for 2 phases ON only.
On PWM drivers or chopper (current mode), the current is set to the nominal value and the supply voltage is typically 2.5 to 5x higher than the nominal voltage.

Curves measured with a load inertia of $20 \cdot 10^{-9}$ kgm², in half-step mode for the "1 x nominal voltage" curve, in 1/4 micro-stepping mode for the other curves.



Possible operation areas

Dimensional drawing



DM1220

for Gearhead 10/1

for Gearhead 12/3, 12/5

for Gearhead 12/4

Options and connection information

Example product designation: **DM12202R033051**

Motor executions front shaft	Motor executions double shaft	PCB type	Front shaft description
51	50	Round PCB	Plain shaft, for lead screw M3
55	56	Round PCB	With pinion for gearheads 10/1
57	58	Round PCB	With pinion for gearheads 12/3, 12/5
59	60	Round PCB	With pinion for gearheads 12/4
83	82	Round PCB	Plain shaft, for lead screw M2
31	30	Solder tag PCB	Plain shaft, for lead screw M3
35	34	Solder tag PCB	With pinion for gearheads 10/1
37	36	Solder tag PCB	With pinion for gearheads 12/3, 12/5
39	38	Solder tag PCB	With pinion for gearheads 12/4
53	52	Solder tag PCB	Plain shaft, for lead screw M2

Connection

No.	Function
1	Phase A +
2	Phase A -
3	Phase B +
4	Phase B -

Product combination

Precision Gearheads / Lead Screws	Encoders	Drive Electronics	Cables / Accessories
10/1 12/3 12/4 12/5 M2 x 0,2 x L1 M3 x 0,5 x L1		MCST 3601	List available on request

Stepper Motors 6 mNm

Two phase, 24 steps per revolution

Series AM1524

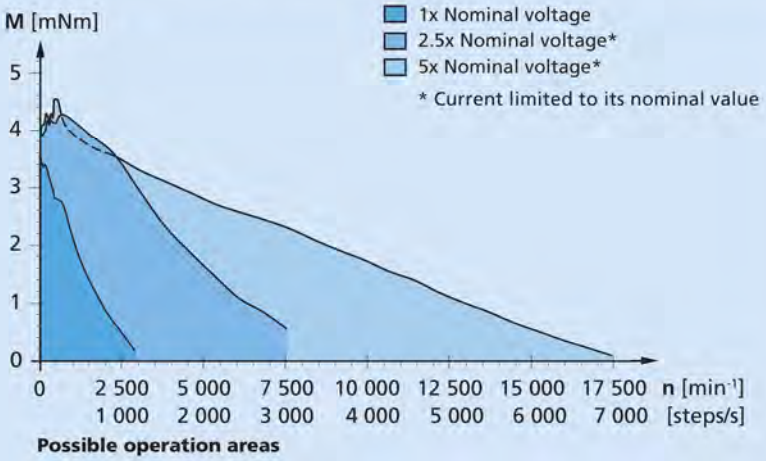
Values at 20°C	AM1524	0450	0250	0150	0075	
Nominal current per phase (both phases ON)		0,45	0,25	0,15	0,075	A
Boosted current per phase (both phases ON)		0,9	0,5	0,3	0,15	A
Nominal voltage per phase (both phases ON)		2	3,5	6	12	V
Phase resistance		3,6	12,5	35	138	Ω
Phase inductance (1 kHz)		1,9	6,3	16,5	70,6	mH
Holding torque (at nominal current in both phases)		6	6	6	6	mNm
Holding torque at boosted current		10	10	10	10	mNm
Residual torque, typ.		0,51	0,51	0,51	0,51	mNm
Back-EMF amplitude		2,4	4,4	7,2	14,7	V/k step/s
Electrical time constant	0,5					ms
Rotor inertia	$45 \cdot 10^{-9}$					kgm²
Step angle (full step)	15					°
Angular accuracy	±10					%
Angular acceleration, max.	$222 \cdot 10^{3}$					rad/s²
Resonance frequency (at no load)	60					Hz
Thermal resistance	12,9 / 31,6					K/W
Thermal time constant	6 / 350					s
Operating temperature range	-35 ... +70					°C
Winding temperature, max.	+130					°C
Shaft bearings [1] [2]	sintered bearings (Bearing code: SB)		ball bearings, preloaded (Bearing code: 2R)			
Shaft load max.:						
– with shaft diameter	1,5		1,5			mm
– radial at 5 000 min⁻¹ (3 mm from bearing)	0,5		6			N
– axial at 5 000 min⁻¹	0,5		2			N
– axial at standstill	0,5		17			N
Shaft play:						
– radial	0,015		0,012			mm
– axial	0,15		0			mm
Housing material	aluminium, black anodized					
Mass	12					g
Magnet material	NdFeB					

[1] Special lubricant options available on request.
[2] 2 preloaded ball bearings available on request for vacuum / low temperature (bearing code: RC).

Driver settings

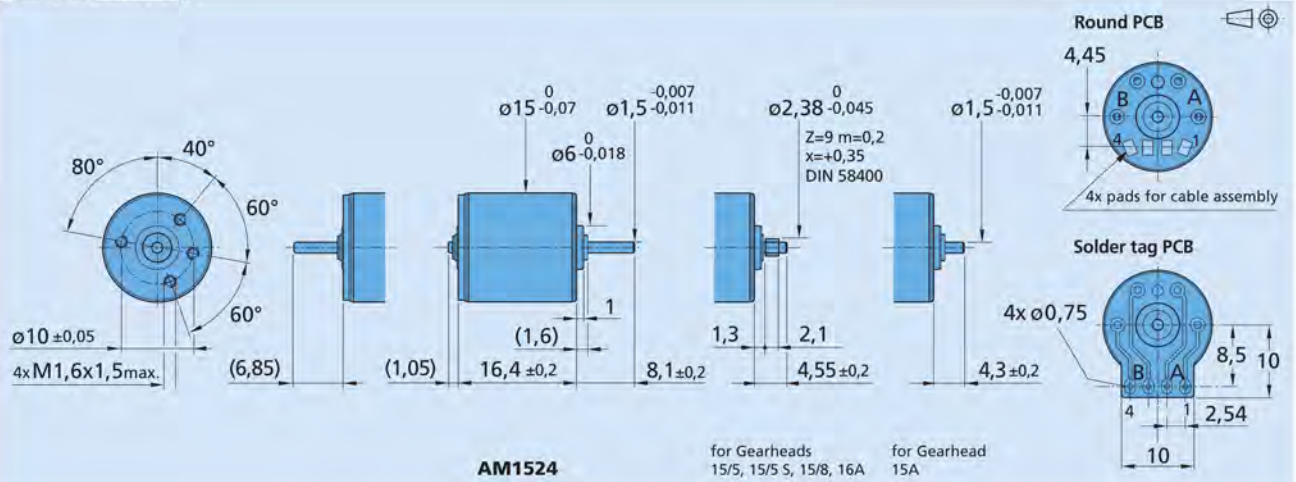
Relevant for 2 phases ON only.
On PWM drivers or chopper (current mode), the current is set to the nominal value and the supply voltage is typically 2.5 to 5x higher than the nominal voltage.

Curves measured with a load inertia of $50 \cdot 10^{-9}$ kgm², in half-step mode for the "1 x nominal voltage" curve, in 1/4 micro-stepping mode for the other curves.



Possible operation areas

Dimensional drawing



Options and connection information

Example product designation: **AM15242R015055**

Motor executions front shaft	Motor executions double shaft	PCB type	Front shaft description
55	54	Round PCB	Plain shaft, L=8,1 mm for gearheads 15/10, 16/7, 17/1 and lead screw M3
57	56	Round PCB	With pinion for gearheads 15/5, 15/5 S, 15/8 and 16A
70	71	Round PCB	Plain shaft, L=4,3 mm for gearheads 15A
83	82	Round PCB	Plain shaft, for lead screw M2
05	04	Solder tag PCB	Plain shaft, L=8,1 mm for gearheads 15/10, 16/7, 17/1 and lead screw M3
07	06	Solder tag PCB	With pinion for gearheads 15/5, 15/5 S, 15/8 and 16A
72	73	Solder tag PCB	Plain shaft, L=4,3 mm for gearheads 15A
23	22	Solder tag PCB	Plain shaft, for lead screw M2
	94	Solder tag PCB	Plain shaft, L=8,1 mm for gearheads 15/10, 16/7, 17/1, lead screw M3 and for encoder
	96	Solder tag PCB	With pinion for gearheads 15/5, 15/5 S, 15/8, 16A and for encoder
	97	Solder tag PCB	Plain shaft, L=4,3 mm for gearheads 15A and for encoder

Connection

No.	Function
1	Phase A +
2	Phase A -
3	Phase B +
4	Phase B -

Product combination

Precision Gearheads / Lead Screws	Encoders	Drive Electronics	Cables / Accessories
15A 15/5 15/5 S 15/8 15/10 16A 16/7 17/1 M2 x 0,2 x L1 M3 x 0,5 x L1	List available on request	MCST 3601	List available on request

Stepper Motors 22 mNm

Two phase, 24 steps per revolution

Series AM2224

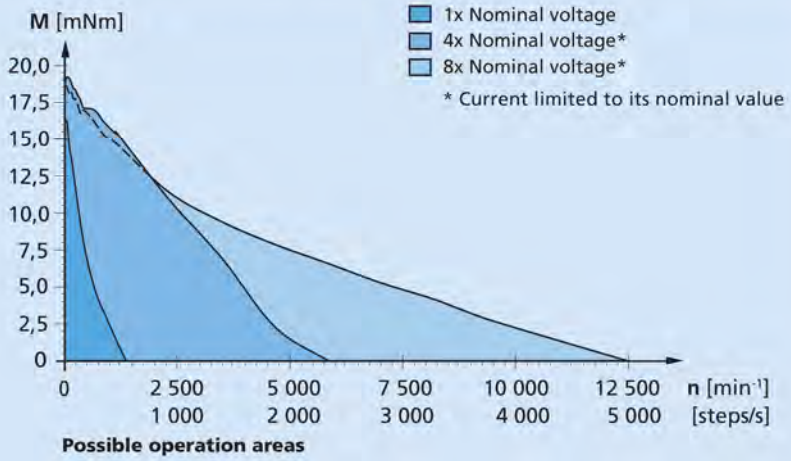
Values at 20°C	AM2224	1000	0500	0250	0125	
Nominal current per phase (both phases ON)		1	0,5	0,25	0,125	A
Boosted current per phase (both phases ON)		2	1	0,5	0,25	A
Nominal voltage per phase (both phases ON)		1,4	3	6	12	V
Phase resistance		0,9	4,8	18	75	Ω
Phase inductance (1 kHz)		0,9	4,3	16,3	65,6	mH
Holding torque (at nominal current in both phases)		22	22	22	22	mNm
Holding torque at boosted current		37	37	37	37	mNm
Residual torque, typ.		1,47	1,47	1,47	1,47	mNm
Back-EMF amplitude		3,8	8,3	16,3	32,7	V/k step/s
Electrical time constant	1,7					ms
Rotor inertia	$253 \cdot 10^{-9}$					kgm²
Step angle (full step)	15					°
Angular accuracy	±10					%
Angular acceleration, max.	$146 \cdot 10^{3}$					rad/s²
Resonance frequency (at no load)	45					Hz
Thermal resistance	4,8 / 20,4					K/W
Thermal time constant	10 / 620					s
Operating temperature range	-35 ... +70					°C
Winding temperature, max.	+130					°C
Shaft bearings [1] [2]	sintered bearings (Bearing code: SB)		ball bearings, preloaded (Bearing code: 2R)			
Shaft load max.:						
– with shaft diameter	2		2			mm
– radial at 5 000 min⁻¹ (3 mm from bearing)	1,5		8			N
– axial at 5 000 min⁻¹	0,5		4			N
– axial at standstill	0,5		24,8			N
Shaft play:						
– radial	0,03		0,015			mm
– axial	0,2		0			mm
Housing material	aluminium, black anodized					
Mass	43					g
Magnet material	NdFeB					

[1] Special lubricant options available on request.
[2] 2 preloaded ball bearings available on request for vacuum / low temperature (bearing code: RC).

Driver settings

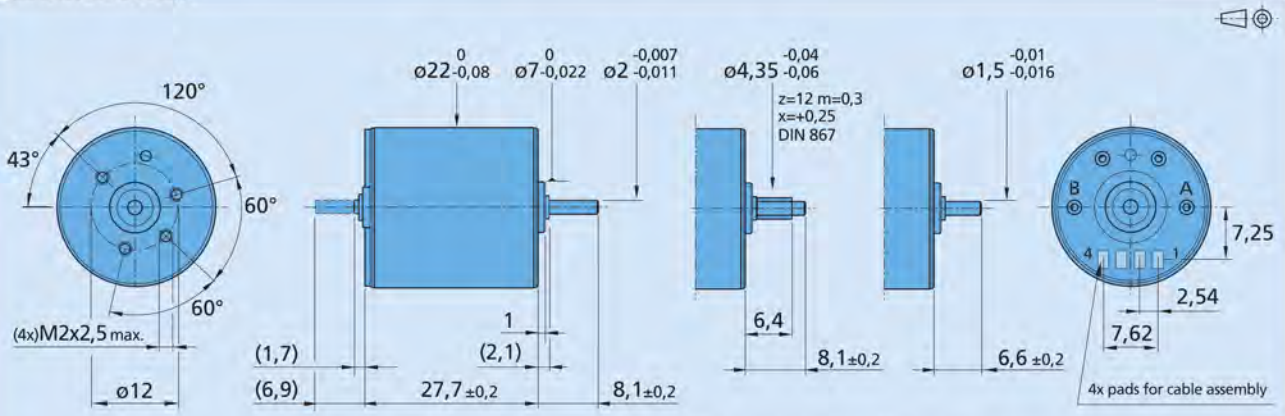
Relevant for 2 phases ON only.
On PWM drivers or chopper (current mode), the current is set to the nominal value and the supply voltage is typically 4 to 8x higher than the nominal voltage.

Curves measured with a load inertia of $600 \cdot 10^{-9}$ kgm², in half-step mode for the "1 x nominal voltage" curve, in 1/4 micro-stepping mode for the other curves.



Possible operation areas

Dimensional drawing



AM2224

for Gearheads 22/2, 22/5

for Gearheads 22E, 22EKV

Options and connection information

Example product designation: **AM22242R050010**

Motor executions front shaft	Motor executions double shaft	Front shaft description
10	11	Plain shaft, L=8,1 mm ø2 mm for gearheads 20/1R, 22/7, 23/1
12	13	Plain shaft, L=6,6 mm ø1,5 for gearheads 22E, 22EKV
14	15	Pinion for gearheads 22/2, 22/5
	16	Plain shaft, L=8,1 mm ø2 mm for gearheads 20/1R, 22/7, 23/1 and encoder PE22-120
	17	Plain shaft, L=6,6 mm ø1,5 for gearheads 22E, 22EKV and encoder PE22-120
	18	Pinion for gearheads 22/2, 22/5 and encoder PE22-120

Connection	
No.	Function
1	Phase A +
2	Phase A -
3	Phase B +
4	Phase B -

Product combination

Precision Gearheads / Lead Screws	Encoders	Drive Electronics	Cables / Accessories
20/1R 22E 22EKV 22GPT 22/2 22/5 22/7 23/1	PE22-120	MCST 3601	List available on request

Stepper Motors 22 mNm

Two phase, 24 steps per revolution

Series AM2224R3

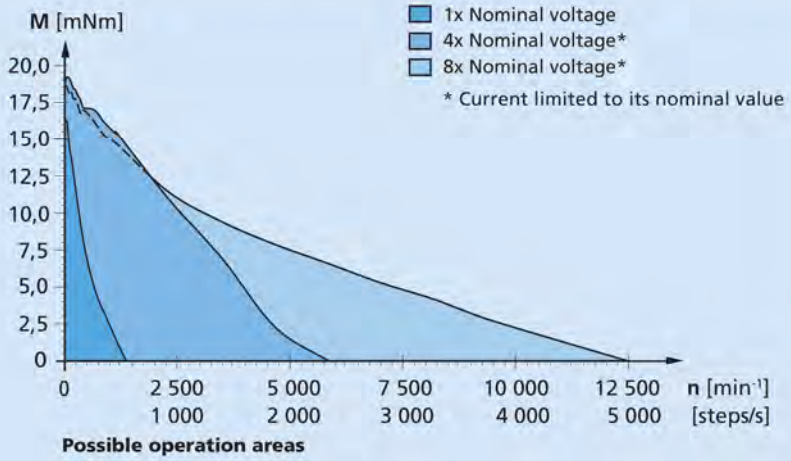
Values at 20°C	AM2224R3	1000	0500	0250	0125	
Nominal current per phase (both phases ON)		1	0,5	0,25	0,125	A
Boosted current per phase (both phases ON)		2	1	0,5	0,25	A
Nominal voltage per phase (both phases ON)		1,4	3	6	12	V
Phase resistance		0,9	4,8	18	75	Ω
Phase inductance (1 kHz)		0,9	4,3	16,3	65,6	mH
Holding torque (at nominal current in both phases)		22	22	22	22	mNm
Holding torque at boosted current		37	37	37	37	mNm
Residual torque, typ.		1,47	1,47	1,47	1,47	mNm
Back-EMF amplitude		3,8	8,3	16,3	32,7	V/k step/s
Electrical time constant	0,92					ms
Rotor inertia	$253 \cdot 10^{-9}$					kgm²
Step angle (full step)	15					°
Angular accuracy	±10					%
Angular acceleration, max.	$146 \cdot 10^{3}$					rad/s²
Resonance frequency (at no load)	45					Hz
Thermal resistance	4,8 / 20,4					K/W
Thermal time constant	10 / 620					s
Operating temperature range	-35 ... +70					°C
Winding temperature, max.	+130					°C
Shaft bearings [1] [2]	ball bearings, preloaded (Bearing code: R3)					
Shaft load max.:						
– with shaft diameter	3					mm
– radial at 5 000 min⁻¹ (3 mm from bearing)	20					N
– axial at 5 000 min⁻¹	4					N
– axial at standstill	56,5					N
Shaft play:						
– radial	0,015					mm
– axial	0					mm
Housing material	aluminium, black anodized					
Mass	50,5					g
Magnet material	NdFeB					

[1] Special lubricant options available on request.
[2] 2 preloaded ball bearings available on request for vacuum / low temperature (bearing code: RC).

Driver settings

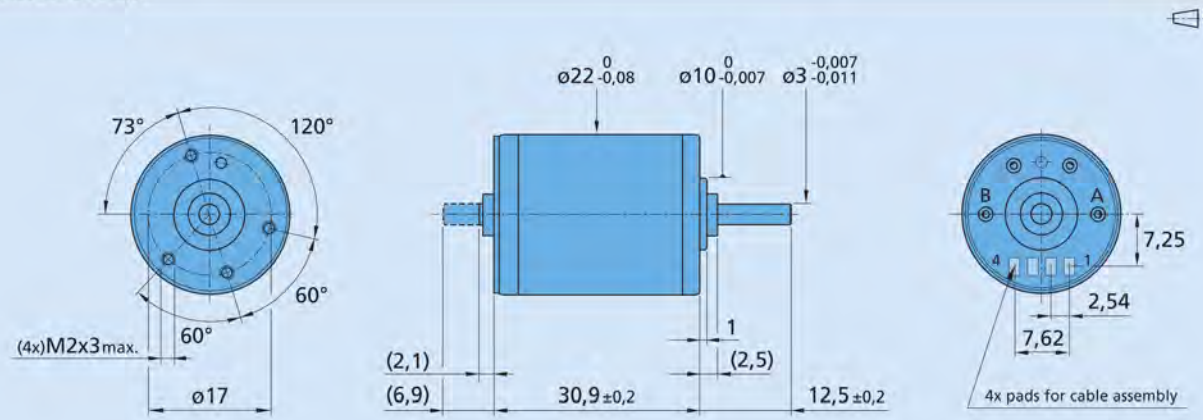
Relevant for 2 phases ON only.
On PWM drivers or chopper (current mode), the current is set to the nominal value and the supply voltage is typically 4 to 8x higher than the nominal voltage.

Curves measured with a load inertia of $600 \cdot 10^{-9}$ kgm², in half-step mode for the "1 x nominal voltage" curve, in 1/4 micro-stepping mode for the other curves.



Possible operation areas

Dimensional drawing



AM2224R3

Option, cable and connection information

Example product designation: **AM2224R3025031**

Motor executions front shaft	Motor executions double shaft	Front shaft description
30	31	Plain shaft for gearheads 26/1, 26/1R
85	84	Plain shaft for lead screw M3
	36	Plain shaft for gearheads 26/1, 26/1R or encoder PE22-120
	86	Plain shaft for lead screw M3 and encoder PE22-120

Connection	
No.	Function
1	Phase A +
2	Phase A -
3	Phase B +
4	Phase B -

Product combination

Precision Gearheads / Lead Screws	Encoders	Drive Electronics	Cables / Accessories
26/1 26/1R M3 x 0,5 x L1	PE22-120	MCST 3601	List available on request

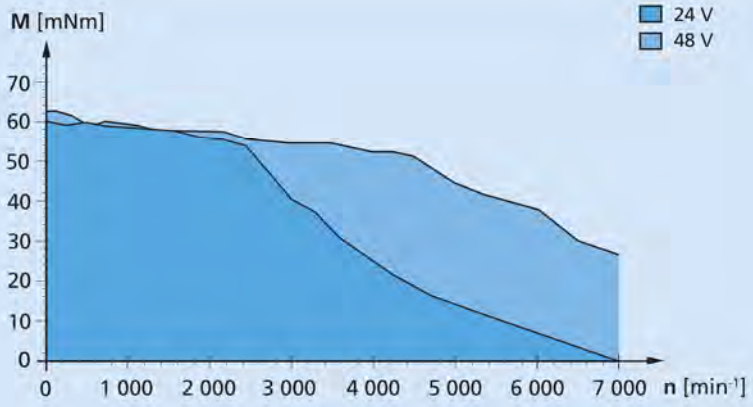
Stepper Motors 62 mNm

Two phase with Disc Magnet,
100 steps per revolution, microstepping motor

Series DM40100R

Values at 20°C	DM40100R	2630		1550		0940		
Connection		Parallel	Serial	Parallel	Serial	Parallel	Serial	
Nominal current per phase (1 phases ON)		2,63	1,32	1,55	0,78	0,94	0,47	A
Boosted current per phase (1 phases ON)		5,09	2,55	4,6	2,3	1,81	0,91	A
Phase resistance		0,9	3,8	2,9	11,8	7,5	30	Ω
Phase inductance (1 kHz)		1,15	4,6	3,3	13,2	9	36	mH
Holding torque at nominal current (1 phases ON)		62	62	62	62	62	62	mNm
Holding torque at boosted current		120	120	120	120	120	120	mNm
Residual torque, typ.		3	3	3	3	3	3	mNm
Back-EMF amplitude		1,47	2,95	2,5	5	4,14	8,27	V/k step/s
Electrical time constant		1,2						ms
Rotor inertia		$2{,}7 \cdot 10^{-7}$						kgm^2
Step angle (full step)		3,6						°
Angular accuracy		±6						%
Angular acceleration, max.		$444 \cdot 10^3$						rad/s^2
Speed up to		10 000						min^{-1}
Resonance frequency (at no load)		75						Hz
Thermal resistance		14						K/W
Thermal time constant		12						min
Operating temperature range		-20 ... +50						°C
Winding temperature, max.		+130						°C
Shaft bearings		ball bearings (Bearing code: 2R)						
Shaft load max.:								
– with shaft diameter		5						mm
– radial at 5 000 min^{-1} (5 mm from bearing)		29						N
– axial at 5 000 min^{-1}		8						N
– axial at standstill		100						N
Shaft play:								
– radial		0,015						mm
– axial		0						mm
Housing material		Polyphenylensulfid (PPS)						
Mass		125						g
Magnet material		NdFeB						

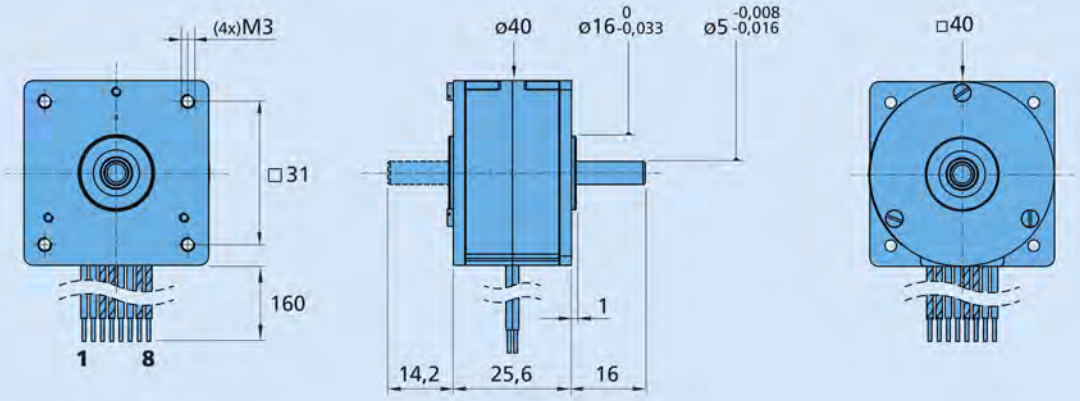
Driver settings
Curve measured with a load inertia of $1{,}49 \cdot 10^{-5}$ kgm^2 on the DM40100R2R263000 motor using a Technosoft IDS640 controller in sin/cos control mode, 256 micro-steps per full step and a peak phase current of 2,63A.



Possible operation areas

Dimensional drawing

Scale reduced



DM40100R

Options and connection information

Example product designation: **DM40100R2R155000**

Motor executions front shaft	Motor executions double shaft	Front shaft description
00	01	Plain shaft, L=16mm
	02	Plain shaft, L=16mm, for encoder

Parallel connection

No.	Colour	Phase
1	brown	A+
2	orange	A+
3	brown-white	A-
4	orange-white	A-
5	red	B+
6	yellow	B+
7	red-white	B-
8	yellow-white	B-

Product combination

Precision Gearheads / Lead Screws	Encoders	Drive Electronics	Cables / Accessories
	IE3-1024		

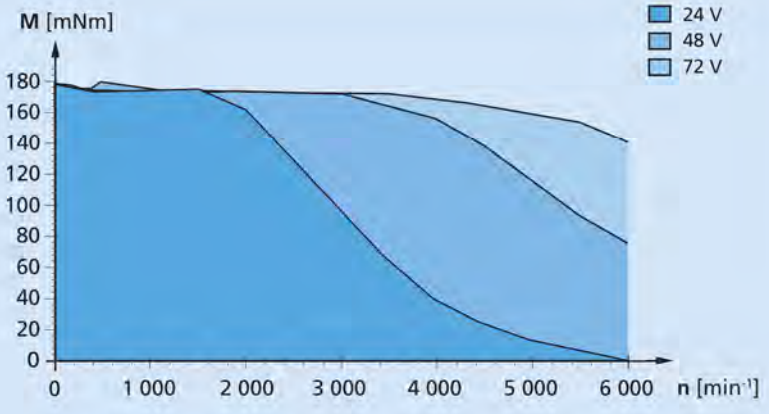
Stepper Motors 200 mNm

Two phase with Disc Magnet,
100 steps per revolution

Series DM52100N

Values at 20°C	DM52100N	5300		2000		
Connection		Parallel	Serial	Parallel	Serial	
Nominal current per phase (1 phases ON)		5,3	2,6	2	1	A
Boosted current per phase (1 phases ON)		12,2	6,1	4,6	2,3	A
Phase resistance		0,35	1,4	2,2	8,8	Ω
Phase inductance (1 kHz)		0,7	2,8	5	20	mH
Holding torque at nominal current (1 phases ON)		200	200	200	200	mNm
Holding torque at boosted current		450	450	450	450	mNm
Residual torque, typ.		20	20	20	20	mNm
Back-EMF amplitude		2,38	4,76	6,3	12,6	V/k step/s
Electrical time constant	2					ms
Rotor inertia	$9{,}4 \cdot 10^{-7}$					kgm²
Step angle (full step)	3,6					°
Angular accuracy	±6					%
Angular acceleration, max.	$478 \cdot 10^3$					rad/s²
Speed up to	5 000					min^{-1}
Resonance frequency (at no load)	75					Hz
Thermal resistance	7,3					K/W
Thermal time constant	18					min
Operating temperature range	-20 ... +50					°C
Winding temperature, max.	+130					°C
Shaft bearings	ball bearings (Bearing code: 2R)					
Shaft load max.:						
– with shaft diameter	5					mm
– radial at 5 000 min^{-1} (5 mm from bearing)	54					N
– axial at 5 000 min^{-1}	12					N
– axial at standstill	167					N
Shaft play:						
– radial	0,015					mm
– axial	0					mm
Housing material	Polyphenylensulfid (PPS)					
Mass	250					g
Magnet material	NdFeB					

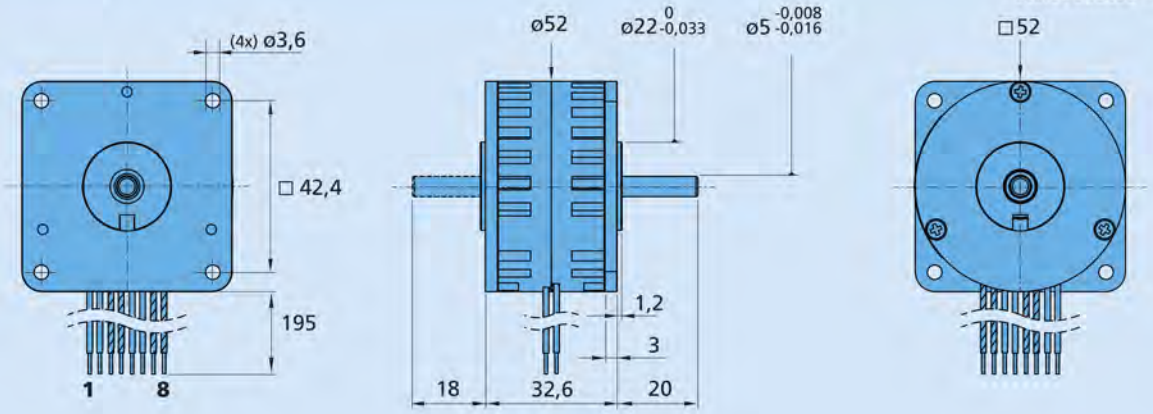
Driver settings
Curve measured with a load inertia of $3{,}96 \cdot 10^{-5}$ kgm² on the DM52100N2R530000 motor using a Technosoft IDS640 controller in sin/cos control mode, 256 micro-steps per full step and a peak phase current of 5,3A.



Possible operation areas

Dimensional drawing

Scale reduced



DM52100N

Options and connection information

Example product designation: **DM52100N2R530000**

Motor executions front shaft	Motor executions double shaft	Front shaft description
00	01	Plain shaft, L=20mm
	02	Plain shaft, L=20mm, for encoder

Parallel connection

No.	Colour	Phase
1	brown	A+
2	orange	A+
3	brown-white	A-
4	orange-white	A-
5	red	B+
6	yellow	B+
7	red-white	B-
8	yellow-white	B-

Product combination

Precision Gearheads / Lead Screws	Encoders	Drive Electronics	Cables / Accessories
	IE3-1024		

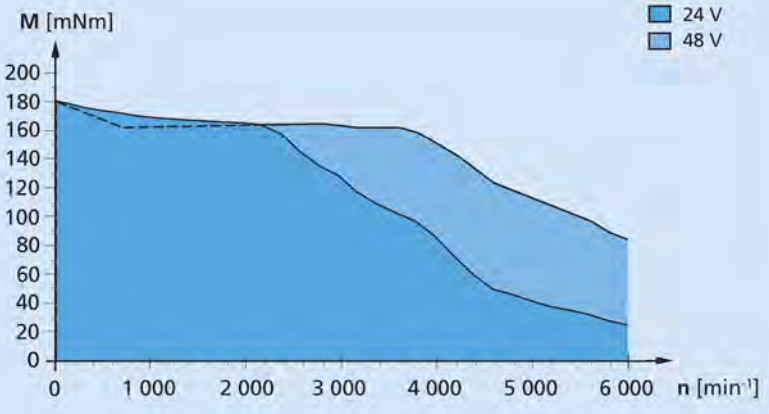
Stepper Motors 180 mNm

Two phase with Disc Magnet,
100 steps per revolution, microstepping motor

Series DM52100R

Values at 20°C	DM52100R	5300		2000		
Connection		Parallel	Serial	Parallel	Serial	
Nominal current per phase (1 phases ON)		5,3	2,6	2	1	A
Boosted current per phase (1 phases ON)		12,2	6,1	4,6	2,3	A
Phase resistance		0,35	1,4	2,2	8,8	Ω
Phase inductance (1 kHz)		0,7	2,8	5	20	mH
Holding torque at nominal current (1 phases ON)		180	180	180	180	mNm
Holding torque at boosted current		400	400	400	400	mNm
Residual torque, typ.		10	10	10	10	mNm
Back-EMF amplitude		2,15	4,3	5,65	11,4	V/k step/s
Electrical time constant	2					ms
Rotor inertia	$9{,}4 \cdot 10^{-7}$					kgm²
Step angle (full step)	3,6					°
Angular accuracy	±6					%
Angular acceleration, max.	$425 \cdot 10^3$					rad/s²
Speed up to	5 000					min⁻¹
Resonance frequency (at no load)	70					Hz
Thermal resistance	7,3					K/W
Thermal time constant	18					min
Operating temperature range	-20 ... +50					°C
Winding temperature, max.	+130					°C
Shaft bearings	ball bearings (Bearing code: 2R)					
Shaft load max.:						
– with shaft diameter	5					mm
– radial at 5 000 min⁻¹ (5 mm from bearing)	54					N
– axial at 5 000 min⁻¹	12					N
– axial at standstill	167					N
Shaft play:						
– radial	0,015					mm
– axial	0					mm
Housing material	Polyphenylensulfid (PPS)					
Mass	250					g
Magnet material	NdFeB					

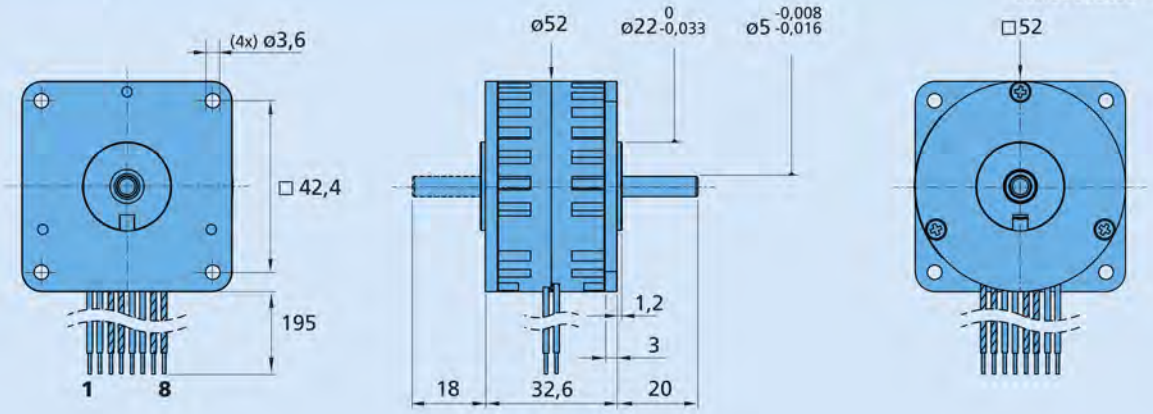
Driver settings
Curve measured with a load inertia of $3{,}96 \cdot 10^{-5}$ kgm² on the DM52100R2R530000 motor using a Technosoft IDS640 controller in sin/cos control mode, 256 micro-steps per full step and a peak phase current of 5,3A.



Possible operation areas

Dimensional drawing

Scale reduced



DM52100R

Options and connection information

Example product designation: **DM52100R2R530000**

Motor executions front shaft	Motor executions double shaft	Front shaft description
00	01	Plain shaft, L=20mm
	02	Plain shaft, L=20mm, for encoder

Parallel connection

No.	Colour	Phase
1	brown	A+
2	orange	A+
3	brown-white	A-
4	orange-white	A-
5	red	B+
6	yellow	B+
7	red-white	B-
8	yellow-white	B-

Product combination

Precision Gearheads / Lead Screws	Encoders	Drive Electronics	Cables / Accessories
	IE3-1024		

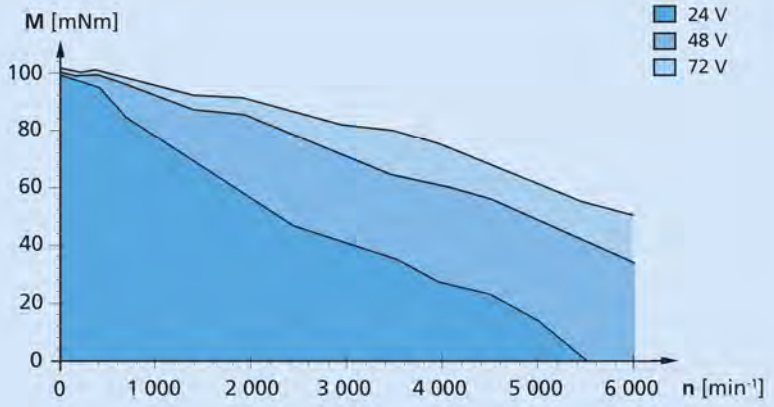
Stepper Motors 116 mNm

Two phase with Disc Magnet,
100 steps per revolution

Series DM52100S

Values at 20°C	DM52100S	3300	1300	
Nominal current per phase (1 phases ON)		3,3	1,3	A
Boosted current per phase (1 phases ON)		5	1,9	A
Phase resistance		0,7	4,4	Ω
Phase inductance (1 kHz)		1,3	8	mH
Holding torque at nominal current (1 phases ON)		116	116	mNm
Holding torque at boosted current		174	174	mNm
Residual torque, typ.		7	7	mNm
Back-EMF amplitude		2,2	5,82	V/k step/s
Electrical time constant	1,8			ms
Rotor inertia	$8 \cdot 10^{-7}$			kgm²
Step angle (full step)	3,6			°
Angular accuracy	±6			%
Angular acceleration, max.	$217 \cdot 10^3$			rad/s²
Speed up to	5 000			min^{-1}
Resonance frequency (at no load)	60			Hz
Thermal resistance	10			K/W
Thermal time constant	14			min
Operating temperature range	-20 ... +50			°C
Winding temperature, max.	+130			°C
Shaft bearings	ball bearings (Bearing code: 2R)			
Shaft load max.:				
– with shaft diameter	5			mm
– radial at 5 000 min^{-1} (5 mm from bearing)	54			N
– axial at 5 000 min^{-1}	12			N
– axial at standstill	167			N
Shaft play:				
– radial	0,015			mm
– axial	0			mm
Housing material	Polyphenylensulfid (PPS)			
Mass	185			g
Magnet material	NdFeB			

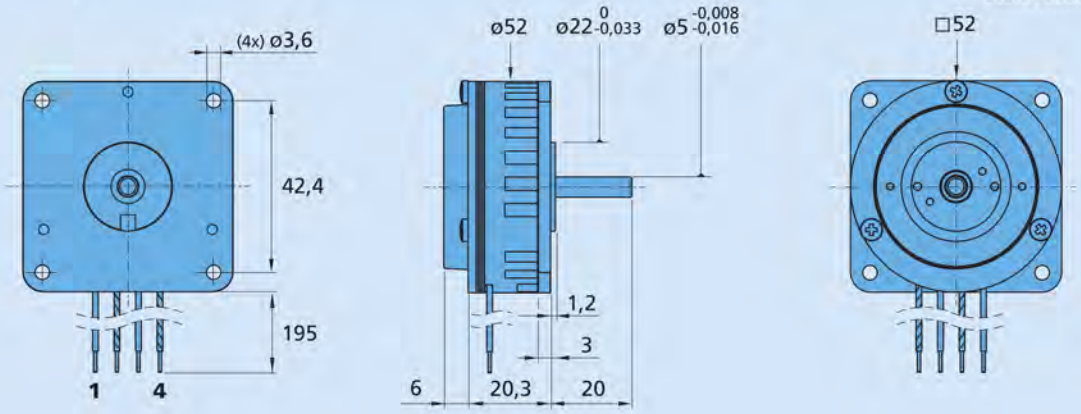
Driver settings
Curve measured with a load inertia of $1{,}49 \cdot 10^{-5}$ kgm² on the DM52100S2R330000 motor using a Technosoft IDS640 controller in sin/cos control mode, 256 micro-steps per full step and a peak phase current of 3,3A.



Possible operation areas

Dimensional drawing

Scale reduced



DM52100S

Options and connection information

Example product designation: **DM52100S2R330000**

Motor executions front shaft	Motor executions double shaft	Front shaft description
00		Plain shaft, L=20mm

Connection

No.	Colour	Phase
1	orange	A+
2	orange-white	A-
3	yellow	B+
4	yellow-white	B-

Product combination

Precision Gearheads / Lead Screws	Encoders	Drive Electronics	Cables / Accessories