The company

Nanotec GmbH&Co. KG has been providing its customers with dependable support in the implementation of drive solutions since 1991. Our motors and drive electronics are available in a wide range of products and offer the appropriate solution for practically all work tasks.

Well thought-out construction, compliance with tight production tolerances and strict quality control during all stages of the process allow us to provide top-quality and durable drive solutions.

As well as compliance with the requirements of the standards and relevant sets of regulations, certification in accordance with the latest standard ISO 9001:2000 by the TÜV Management Service documents the consistent customer orientation of our processes and the successful efforts towards continuous improvement of internal and external procedures.


ZERTIFIKAT

Nanotec

ISO 9001: 2000

Our vision: Fast and easy - but still personal

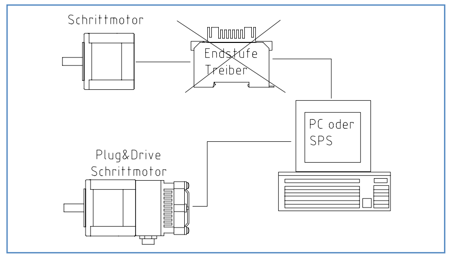
The requirements of drive solutions are diverse and a standard motor or power electronics “out-of-the-box” can only rarely be used if optimum results to be achieved. Therefore, we offer customer-specific versions of our motors and drive electronics in relatively small numbers. Our engineers develop the optimum mechanical and electronic design of a customized solution on request.
In-house production and broad-based warehousing mean we can react flexibly and quickly to customer wishes.

On time and reliable

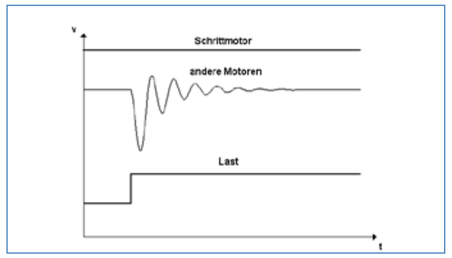
Our performance shows that we do not regard reliability and timeliness as empty words, but as an obligation. For example, by adherence to schedules: Nanotec meets 98 % of all confirmed delivery dates. We endeavor to keep any delays as short as possible in the remaining 2 %. In many cases, we are even able to meet preferred delivery dates.
An achievement that our customers appreciate: The more than 4000 motors and 200 drive electronics we deliver each week speak for themselves, as do the reputations of our well-known customers:

Application advantages of stepper motors

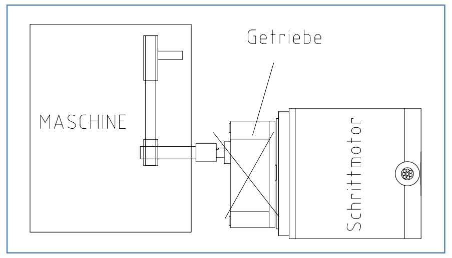
Stepper motors are digitally-controlled and regulated drives that have achieved the highest level of acceptance and prevalence since the technology transition (from analog to digital technology and current software solutions) due to favorable prices with maximum service life and little control required.



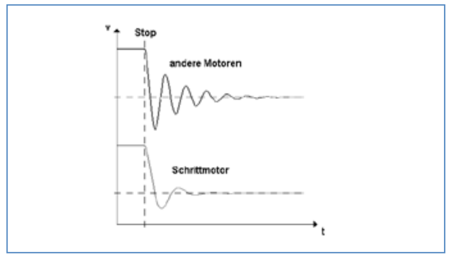
a) PC+PLC-capable (directly controllable via PC, PLC and microprocessor)
The use of the PCs at the lowest, decentralized machine levels have given the Plug & Drive motors the maximum level of productivity. Nanotec was the No. 1 supplier worldwide to fulfill the requirement for a compact, efficient and cost-effective drive system with an industrial Plug & Drive motor.
Not only have the development, wiring and assembly costs of a complete drive unit been drastically reduced, the EMC compatibility and machine availability have been improved, and the commissioning and service also considerably simplified. Continuous further development of the options for customer-specific requirements allow new and close partnerships to grow constantly to the advantage of a better and more economical end product.



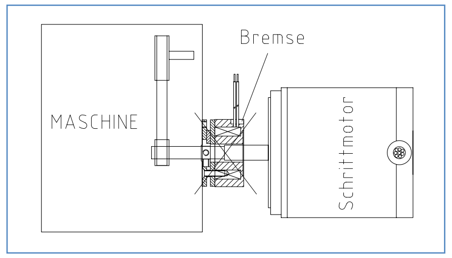
b) Speed stability
“No drop in speed when the load fluctuates”: The stepper motor fulfills this requirement like no other motor at no extra cost. Particularly for precise closed-loop speed, synchronization or ratio controls (e.g. in precision dispensing pumps), the stepper motor can reach higher and finer resolutions thanks to digital processing. The improvement in control, process and surface quality is not only a theoretical advantage.



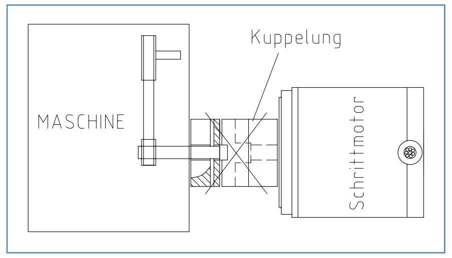
c) Direct drive
Stepper motors have maximum torque in the lower speed range and the Nanotec microstep drivers enable still acceptable concentricity properties of up to approx. 2 rpm. Other motors often need gears for this purpose in order to fulfill the requested speed and force requirements. Direct drives reduce system costs and, at the same time, increase operational safety and life expectancy. Naturally, if the space available is limited or the external moments of inertia are high, gears are essential for power and force adjustment.



d) Positioning accuracy
As well as minimum coastdown, stepper motors also have a minimum transient response because of the narrow step angle. Even without external linear or angular encoders, stepper motors are excellent at fulfilling speed and positioning tasks. The microstep changeover of the Nanotec final output stages can, in fact, further increase the accuracy or resolution at no extra cost. All Nanotec stepper motors are also available with competitively priced encoders for detecting any blockages and for closed-loop applications.



e) High stiffness without brake
Stepper motors have the maximum holding torque at standstill and thus also offer high system rigidity. Because of this property, no external braking mechanism is necessary unless safety braking is required for the Z axis.



f) Avoiding damage to machines and injuries
The disadvantage sometimes referred to as the "loss of sync." if a motor is blocked can even be an advantage in some cases with regard to constantly increasing safety requirements. Sliding clutches and overload clutches in order to meet prescribed safety requirements are not normally necessary in association with stepper motors.

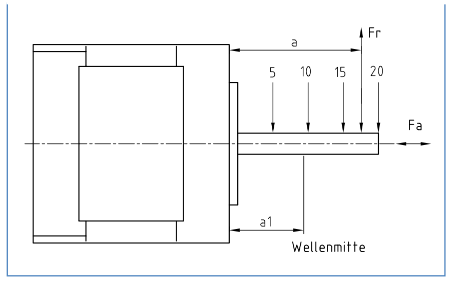
Reliability

All Nanotec motors are brushless, have high-grade ball bearings in the front and rear bearing shells, and achieve an expected service life of more than 20,000 hours of operation under admissible operating conditions. The information on the service life is based on the test results of reputable ball bearing manufacturers as well as our own trials. The calculated L10h values are purely theoretical values for optimum operating conditions and are not subject to any claims under guarantee.

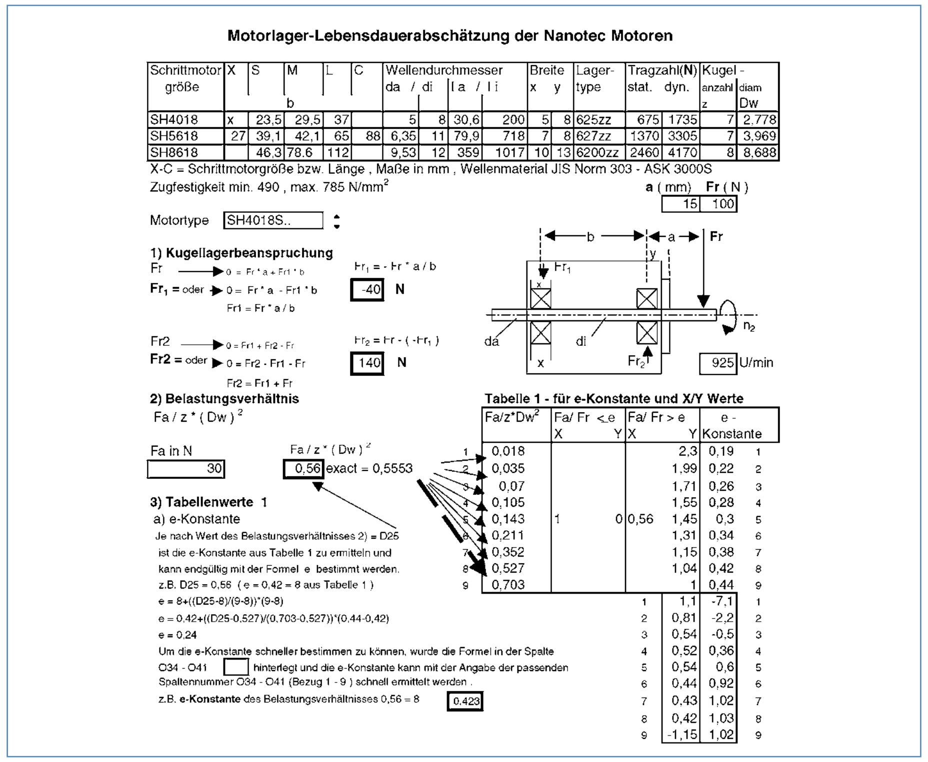
a) Max. admissible axial and radial forces (Fa and Fr)

Forces in N	Radial forces (Fr)				Axial forces (Fa)
Distance a (in mm)	**5**	**10**	**15**	**20**	
ST20; Shafts ∅ 5.00 mm	30	18	14	8	4
ST28; SH40; ST40; DB42 ST42 Shafts ∅ 5.00 mm	58	36	26	20	7
SH56; ST57; ST58; DB57 Shafts ∅ 6.35 mm	130	90	70	52	10
SH56; ST57; ST60 Shafts ∅ 8.00 mm	163	112	85	63	14
SH86; (ST5818D..) Shafts ∅ 9.525 (10) mm	228	169	139	10	25
ST87; DB87 Shafts ∅ 14.0 mm	535	355	265	200	25
ST110 Shafts ∅ 19.05 mm	640	425	320	240	80

Type	Fr (distance a1)	Fa
SP06-SP08	1.0	0.5
SP10-SP20	2.0	1.0
SP25-SP35	3.0	1.5
SP42-SP55	5.0	2.0



b) Reduction of the average expected service life



Motorlager-Lebensdauerabschätzung der Nanotec Motoren

Schrittmotor größe	X	S	M	L	C	Wellendurchmesser da	di	l a	l i	Breite x	y	Lager-type	Tragzahl(N) stat.	dyn.	Kugel - anzahl z	diam Dw
SH4018	x	23,5	29,5	37		5	8	30,6	200	5	8	625zz	675	1735	7	2,778
SH5618	27	39,1	42,1	65	88	6,35	11	79,9	718	7	8	627zz	1370	3305	7	3,969
SH8618		46,3	78.6	112		9,53	12	359	1017	10	13	6200zz	2460	4170	8	8,688

X-C = Schrittmotorgröße bzw. Länge , Maße in mm , Wellenmaterial JIS Norm 303 - ASK 3000S
Zugfestigkeit min. 490 , max. 785 N/mm²

a (mm) 15 — Fr (N) 100

Motortype SH4018S..

1) Kugellagerbeanspruchung
Fr → 0 = Fr * a + Fr1 * b
Fr₁ = oder → 0 = Fr * a - Fr1 * b
Fr1 = Fr * a / b
Fr₁ = - Fr * a / b — **-40 N**

Fr2 → 0 = Fr1 + Fr2 - Fr
Fr2 = oder → 0 = Fr2 - Fr1 - Fr
Fr2 = Fr1 + Fr
Fr₂ = Fr - (-Fr₁) — **140 N**

b, a, Fr, y, Fr₁, x, da, di, Fr₂, n₂ — 925 U/min

2) Belastungsverhältnis
Fa / z * (Dw)²

Fa in N: 30
Fa / z * (Dw)²: 0,56 exact = 0,5553

3) Tabellenwerte 1
a) e-Konstante
Je nach Wert des Belastungsverhältnisses 2) = D25 ist die e-Konstante aus Tabelle 1 zu ermitteln und kann endgültig mit der Formel e bestimmt werden.
z.B. D25 = 0,56 (e = 0,42 = 8 aus Tabelle 1)
e = 8+((D25-8)/(9-8))*(9-8)
e = 0,42+((D25-0,527)/(0,703-0,527))*(0,44-0,42)
e = 0,24
Um die e-Konstante schneller bestimmen zu können, wurde die Formel in der Spalte O34 - O41 hinterlegt und die e-Konstante kann mit der Angabe der passenden Spaltennummer O34 - O41 (Bezug 1 - 9) schnell ermittelt werden .
z.B. **e-Konstante** des Belastungsverhältnisses 0,56 = 8 — 0,423

Tabelle 1 - für e-Konstante und X/Y Werte

	Fa/z*Dw²	Fa/ Fr ≤ e X	Y	Fa/ Fr > e X	Y	e - Konstante	
1	0,018				2,3	0,19	1
2	0,035				1,99	0,22	2
3	0,07				1,71	0,26	3
4	0,105				1,55	0,28	4
5	0,143	1	0	0,56	1,45	0,3	5
6	0,211				1,31	0,34	6
7	0,352				1,15	0,38	7
8	0,527				1,04	0,42	8
9	0,703				1	0,44	9

1	1,1	-7,1	1
2	0,81	-2,2	2
3	0,54	-0,5	3
4	0,52	0,36	4
5	0,54	0,6	5
6	0,44	0,92	6
7	0,43	1,02	7
8	0,42	1,03	8
9	-1,15	1,02	9

Negative influences on the average expected service life L10 specified by Nanotec are:

- Intermittent loads
- Excessive radial and axial loads
- Vibration and oscillation, very high cycl. acceleration
- Inaccurate angular and centering alignment
- Ambient conditions such as dust, humidity, corrosive gases, etc.
- Elevated working temperature (from approx. +70°C the wear life per~+15°C is halved because of the shortened lubrication interval)

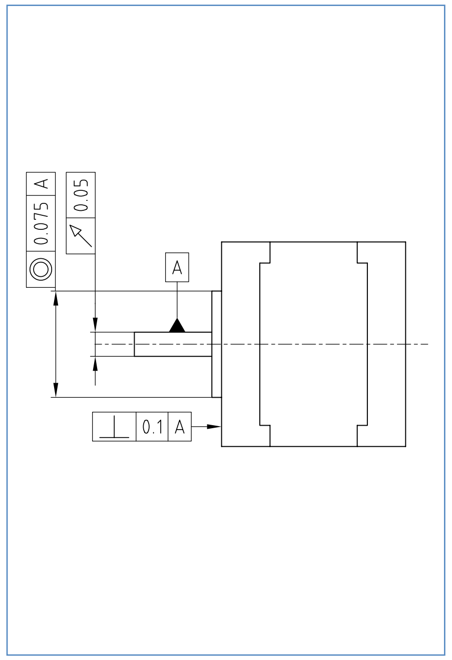
If there are an extremely high number of oscillating movements within an angle of 360°, suitably adapted greasing and lubricant fillings may be necessary under certain conditions. We deliver customer-specific motors with such ball bearings on request.

c) Machining of the motor shaft!

At unduly high radial forces or external blows, the inner shaft becomes bent and the rotor can come into contact with the stator. This can lead to damage of the rotor or stator causing microscopic particles to accumulate in the air gap and resulting in noise and blockages.
Also, in the **mechanical finishing of the motor shafts,** in addition to the maximum deflection, attention must be paid especially to the **necessary sealing,** so that no microparticles can get into the engine compartment through the thrust ball bearings despite the strong magnetic attraction of the rotor.

Common specifications of the SH...; ST... types and DB motors

	Motor size	20 (28)	41 (42)	59 (57.60)	89	110
Concentricity:	↗	0.05 mm	0.05 mm	0.05 mm	0.1 mm	0.05 mm
Parallelism:	⊥	0.1 mm	0.1 mm	0.1 mm	0.075 mm	0.076 mm
Concentricity:	◎	0.075 mm	0.075 mm	0.08 mm	0.075 mm	0.075 mm



Radial play of the shaft:	Max. 0.025mm (at a radial load of 5N)
Axial play of the shaft:	Max. 0.075mm (at an axial load of 10N)
Step angle precision:(SH,ST)	at full step ± 5% non cumulative (no load)
Insulation resistance:	100M Ohm at normal ambient temp. and atmospheric humidity, measured between winding and motor housing
Dielectric strength:	0.5kV at 50Hz for min. 1 min.
Insulation class:	Class B (130°C)
Temperature increase:	80°C or less determined by measuring the change in resistance after the rated voltage has been applied to the blocked stepper motor
Operating temperature range:	-10°C to +50°C
Storage temperature:	-20°C to +70°C
Ambient humidity (working area):	20% to 90% non-condensing (free of corrosion)
Ambient humidity (storage area):	8% to 95% non-condensing (free of corrosion)

Construction, protection classes and safety considerations

a) General construction

Practically all stepper motors are manufactured in accordance with ISO 9001 and, when used as designated, they comply with the safety requirements contained in the relevant standards and regulations. The motors have a closed construction (protection class IP 20) with a through opening provided with a small bushing for the cords. The bearing plates are made of die-cast aluminum and carefully connected by means of a centering ring and rotor rings. Ball bearings lubricated for the whole of their service life are chosen and their machining and smooth running is checked. The metal plates of the stands between the die-cast rings are connected by means of rivets or screws at all corners.

b) Protection classes (acc. to DIN 40050 Aug. 1970)

Nanotec can also offer stepper motors that are suitable for harsh ambient conditions

Protection classes

Ident characters IP (5) (4)

First number

Second number

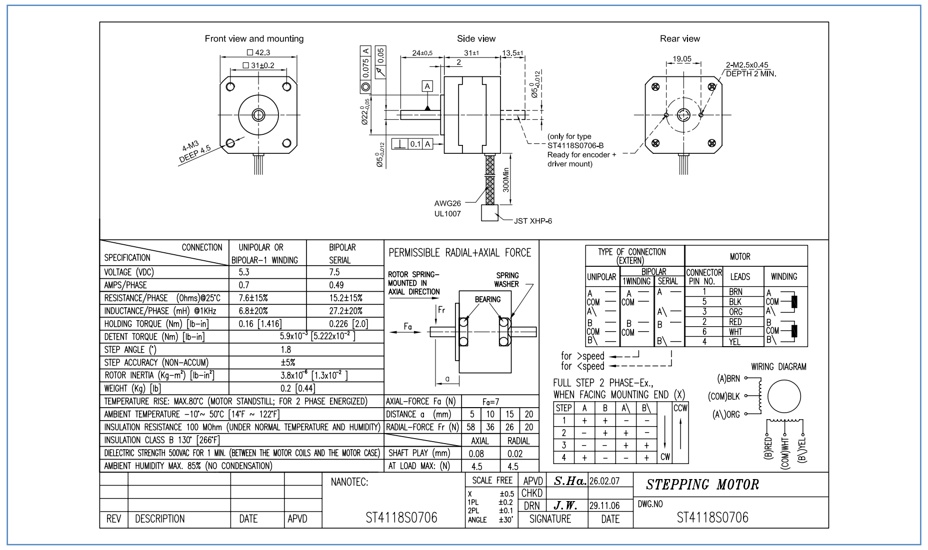
First number	Protection against contact and foreign bodies
0	No protection
1	Protection against large foreign bodies (greater than 50mm ∅)
2	Protection against medium-size foreign bodies (greater than 12.5mm ∅)
3	Protection against small foreign bodies (greater than 2.5mm ∅)
4	Protection against granular foreign bodies (greater than 1mm ∅)
5	Protection against heavy dust deposits
6	Protection against penetration of dust

Second number	Protection against water
0	No protection
1	Protection against vertically dripping water
2	Protection against dripping water falling at an angle (up to 15° to the vertical ↑)
3	Protection against spray water (up to 60° to the vertical ↑)
4	Protection against spray water (from all directions)
5	Protection against hose water (12 l/min; min 0.3 bar)
6	Protection against powerful hose water 100 l/min; p~1 bar
7	Protection against sporadic immersion
8	Protection against submersion

c) Safety instructions

As with any form of concentrated energy, the use of electric motors is associated with possible dangers. The level of danger can be considerably reduced by suitable constructive realization, the correct selection, proper installation and well thought-out application. In terms of the load and ambient conditions, the user must pay attention to correct installation and application of the devices. Therefore, it is of utmost importance that the end user observes all electrical, thermal and mechanical safety instructions.

CAD library



The CAD and PDF formats from Nanotec allow you to integrate the following product drawings quickly and efficiently in your construction:

- Stepper motors + BLDC motors (also in protection class IP 44 and IP 65)
- Stepper motors + brushless DC motors in special versions (with terminal box or plug&socket connection)
- Stepper motor + EC motor with attachment (encoder, brake)
- Stepper motor + servomotor gears (spur gears, worm gears, planetary gears)
- Plug & Drive stepper motors
- Controllers for the installation or on top-hat rails (microstep drive electronics, drivers, positioning controls)

All items can be called up in PDF, DXF or DWG format on the Internet at www.nanotec.de.

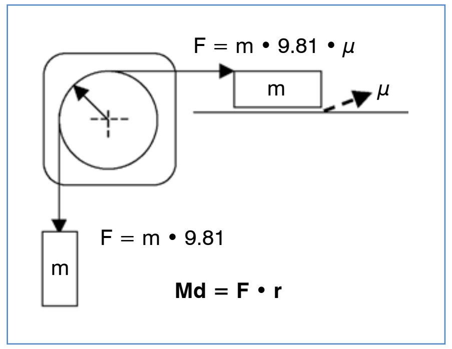
Performance calculation and appropriate motor selection

The necessary power capacity and size of the motor depends primarily on the external mass movements and their frictional conditions.

1) Friction force or moment of friction

a) Linear : F = m • g • μ
The **friction force F** (N) is determined primarily by the mass = **m** (weight kg) and the coefficient of friction = $\boldsymbol{\mu}$.

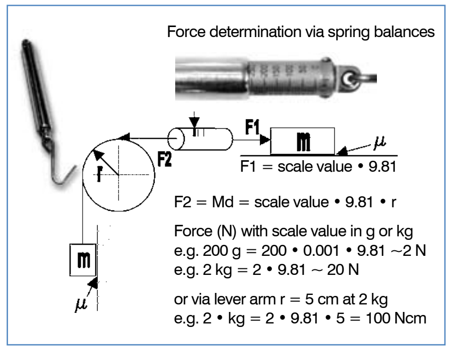
b) Rotation : Md = F • r
The **torque Md** (Ncm) is determined by the **friction force F** (N) and the **lever arm r** (cm) (depending on the point of attack and distance to the force line of action).



2) Acceleration torque
Because of the law of inertia, the force or torque increases, the faster the mass is accelerated:

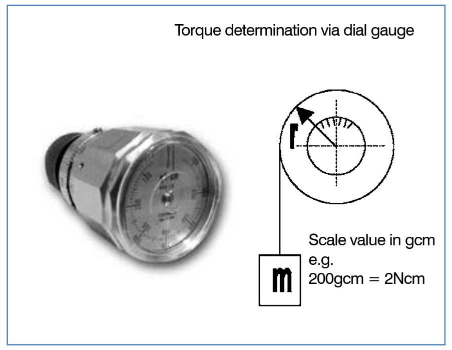
a) Linear : F = m • a
(a = v_e - v_a/t)
v_e = end speed, v_a = starting speed

b) Rotation: Md = J • a
(J= pol. moment of inertia, e.g. full cyl. m • r²)
(a = n_e - n_a/t)
n_e = end rpm, n_a = starting rpm



3) Power rating
P_2 = Md • 6.28 • f/z (Md = torque from the motor characteristics,
f = step frequency in Hz, z = steps/rev.)

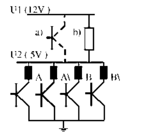
4) Simple torque determination
Apart from the mathematical determination, the determination of force and torque by means of springbalance and torque gauge is especially advantageous because it takes into account the difficult-to-determine friction factor (see Accessories, Measuring equipment).



Controllers and switching features

Practically all stepper motors can be delivered with 4, 6 and 8 power supply cords/leads where 4 leads are suitable for bipolar operation only, 6 leads for unipolar and somewhat restricted bipolar operation, and 8 leads for unipolar and bipolar operation. With only 4 switches, unipolar operation is very easy but is used less often nowadays because of highly-integrated constant current bipolar driver ICs available with a torque that is approx. 30% higher. Also constant voltage operation seldom appears on the market due to its high power loss.

Unipolar connection



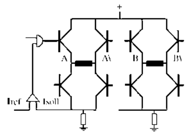
e.g. Constant voltage operation

a) Bilevel

b) Series resistor

Unipolar switching sequences					
Mode		Winding			
1/1	1/2	A	A\	B	B\
1	1	+	0	0	+
	2	+	0	0	0
2	3	+	0	+	0
	4	0	0	+	0
3	5	0	+	+	0
	6	0	+	0	0
4	7	0	+	0	+
	8	0	0	0	+
1	1	+	0	0	+

Bipolar switching sequences



e.g. constant current Operation

Unipolar switching sequences			
Mode		Winding	
1/1	1/2	A	B
1	1	+	+
	2	+	0
2	3	+	-
	4	0	-
3	5	-	-
	6	-	0
4	7	-	+
	8	0	+
1	1	+	+

Stepper motor animation

Stepper motor animation at www.nanotec.de,

Connection arrangement of stepper motors
The stepper motors offered by Nanotec can be operated in different switching modes that give the motor different characteristics in each case. The 4-lead version is already wired up internally so there is only one connection possibility here. Motors with 6 leads can be operated with one half of the winding or serially, the version with 8 leads can be operated in all listed switching modes. We will only consider the bipolar control here, which is used almost exclusively today.

1. One half of the winding: Here only half of the windings of the motor are used, therefore the holding torque that can be achieved is also less than in the other modes. This mode only offers advantages in the high speed range of the 6-lead motors which is clearly apparent from the respective motor diagrams.

2. Parallel: The highest motor power is achieved in this mode. The low inductance keeps the torque of the motor constant, even at higher speeds, although a higher phase current is also required.

3. Serial: This mode is suited to the lower speed range where high torque is reached with low current. But due to the high inductance, the torque drops off quickly at higher speeds.

The values specified in the datasheet always refer to one half of the winding. The following table shows the rule for converting the individual parameters to serial and parallel switching mode. This function can also be listed online on the overview page of the individual stepper motor series (under Type, Control).

Value	1 winding half as in datasheet	Serial	Parallel
Resistor	R	2 * R	R/2
Inductance	L	4 * L	L
Phase current	I	I/√2	I * √2
Holding torque	M	M * √2	M * √2

The holding torque is reached at the respective nominal current. If the current deviates, the value can be calculated accordingly from the proportionality between the phase current and holding torque. Half the current (in the same connection), therefore, leads to half the holding torque.

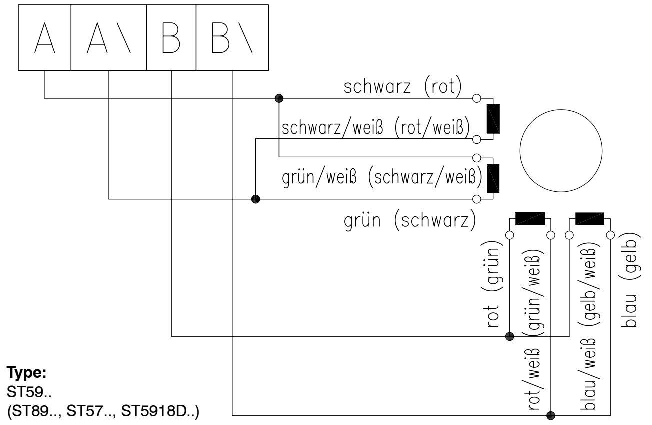
! Note: This correlation only applies for the holding torque and for the lower speed range (where the torque has not yet dropped), but not for the entire motor curve. At high speeds, the set current can no longer reach its maximum value because the switching operations on the winding are then too fast. This (real) current reduction leads to a drop in the motor curve with increasing speed.

It is also possible to operate the motor briefly with higher current. Here, however, attention must be paid that the housing temperature does not exceed 80°. Depending on the motor, saturation is reached at 1.5 - 2 times the value of the nominal current, the torque then no longer increases.

Motor connection: Nanotec stepper motors

8-lead wire - parallel for high frequency > 1 kHz

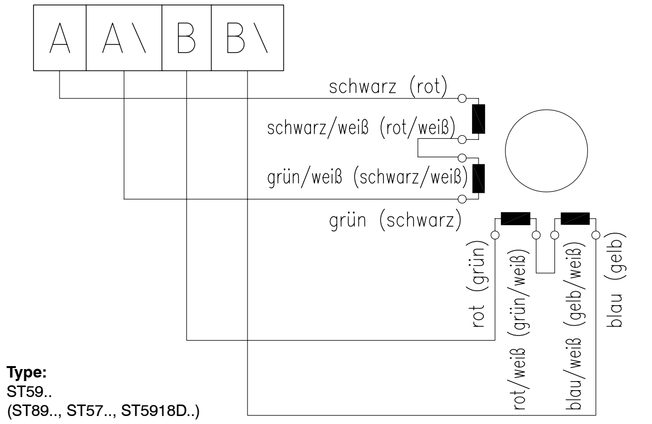
Current per winding x 1.4 = **current per phase**
Example: Current/winding 1A = **1.4A/phase**



Type:
ST59..
(ST89.., ST57.., ST5918D..)

8-lead wire - serial for low frequency < 1 kHz

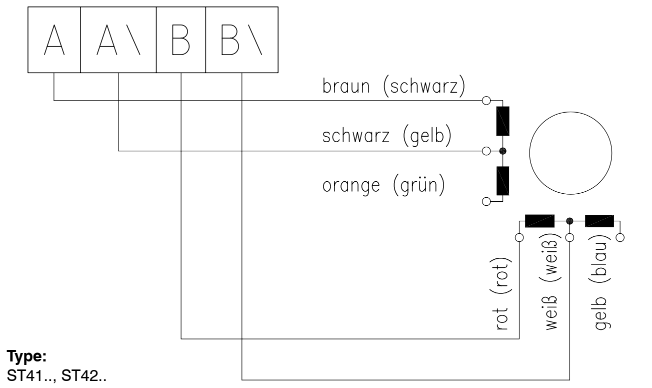
Current per winding x 0.7 = **current per phase**
Example: Current/winding 1A = **0.7A/phase**



Type:
ST59..
(ST89.., ST57.., ST5918D..)

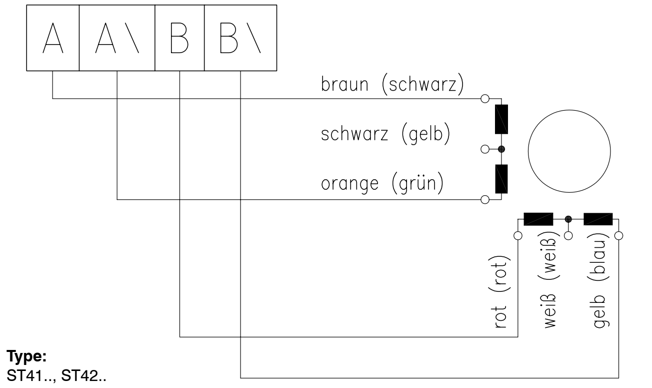
6-lead wire

Current per winding = **current per phase**
Example: Current/winding 1A = **1A/phase**



Type:
ST41.., ST42..
ST28..

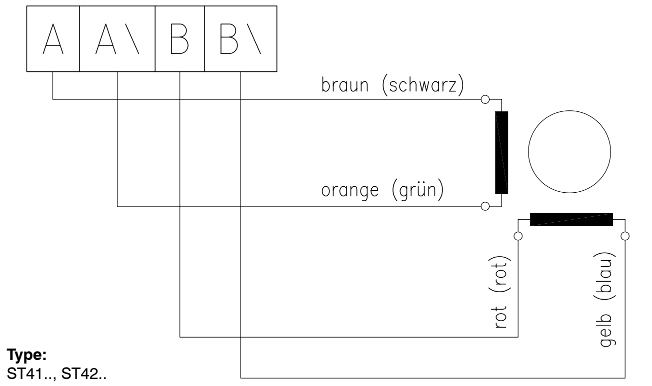
Current per winding x 0.7 = **current per phase**
Example: Current/winding 1A = **0.7A/phase**



Type:
ST41.., ST42..
ST28..

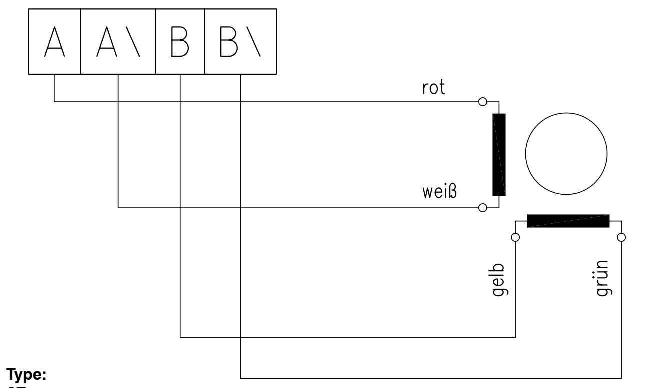
4-lead wire

Current per winding = **current per phase**
Example: Current/winding 1A = **1A/phase**



Type:
ST41.., ST42..
ST20..

Current per winding = **current per phase**
Example: Current/winding 1A = **1A/phase**



Type:
ST110..