

2-Phase Hybrid Stepper Motor



ZSH Precision Stepper Motors

The highly dynamic ZSH 2-phase hybrid stepper motors are constructed for operation in industrial environment.

Holding torques: 0.45 to 17 Nm.

ZSH stepper motors are available in size 57, 87, 88 or 107 mm in diameter. Each motor size includes 3 or 4 motor types of the same diameter but different length. Furthermore, each motor type can be delivered with 2 or 3 different standard windings.

When installed and wired correctly, ZSH stepper motors meet the requirements of the EMC and Low Voltage Directives.

Overview: Extensions

- **Stepper motor**
- **Stepper motor with motor brake**
Permanent magnet brake for 24V_{DC} supply
- **Stepper motor with encoder**
Resolution: 50, 200 or 500 lines
2 or 3 channels
- **Stepper motor with encoder and motor brake**
- **Stepper motor with low-backlash planetary gear**
1, 2 or 3 stages
Reduction ratios from 3:1 to 512:1

Types / Mechanical Characteristics

Stepper motor type	Standard winding ^{1),2)}	Holding torque ¹⁾	Detent torque	Rotor mass inertia	Permissible bearing load		Weight	Key	Flange and shaft	
					axial	radial			metric version	inch version
ZSH 57/1	1.4 / 4.2 / 5.5	0.45	0.01	0.125	80	150	0.6	³⁾		
ZSH 57/2	2.1 / 2.8 / 4.2	0.85	0.017	0.25	80	150	1		■	
ZSH 57/3	2.1 / 4.2 / 6.5	1.25	0.025	0.375	80	150	1.35			
ZSH 87/1	2.3 / 4.2 / 7	1.8	0.026	0.65	180	280	1.7			
ZSH 87/2	5 / 6.5 / 8.4	3.6	0.05	1.3	180	280	2.65	■	■	□
ZSH 87/3	5 / 8.4 / 10	5.4	0.08	1.95	180	280	3.65			
ZSH 88/1	2 / 4 / 8	3	0.042	1.35	180	280	1.7			
ZSH 88/2	2 / 4 / 8	6	0.08	2.7	180	280	2.65	■	■	□
ZSH 88/3	4 / 8 / 12	9	0.13	4.05	180	280	3.65			
ZSH 107/1	7 / 8 / 12.5	5	0.11	4	400	650	4.3			
ZSH 107/2	8 / 10 / 12.5	9	0.21	8	400	650	7.2	■	■	□
ZSH 107/3	10 / 12.5	13	0.3	12	400	650	9.8			
ZSH 107/4	12.5	17	0.4	16	400	650	12.5			

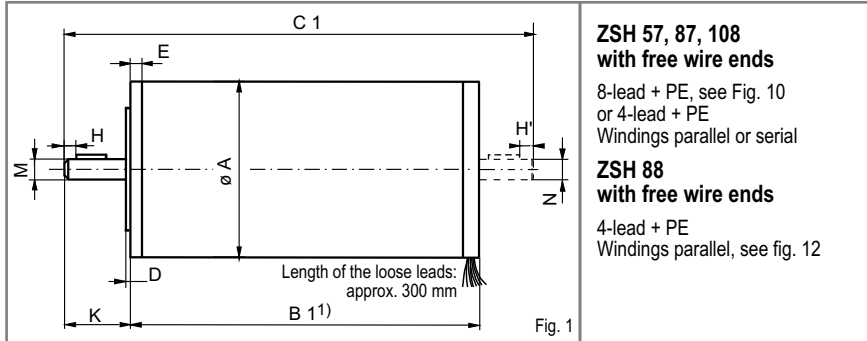
¹⁾ Bipolar operation mode ■ standard □ optional
²⁾ red . = popular type
³⁾ Optional for size 57: Woodruff key (DIN 6888)

Technical Information

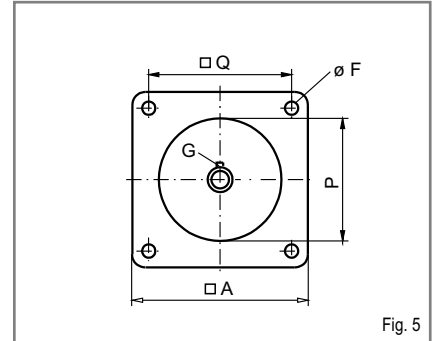
- 2-phase hybrid stepper motors
- Number of steps: 200 / step angle: 1.8°
- Standard version: 4-leads, parallel windings, with terminal box
- Holding torques from 0.45 to 17 Nm
- Protection class: IP 54, optional: IP 68
- Permiss. operation temperature: -30 to +80 °C (up to 100 °C for short time)
- Design voltage: 250 V_{AC} acc. to EN 60034
- Insulation class F acc. to VDE 0530
- Test voltage: 1800 V_{AC} (1 sec)
- High permissible axial and radial bearing loads
- Step accuracy: ±3% (ref. to 1.8° step angle, not cumulative)
- Optional:
 - 2nd shaft (IP 41)
 - Free wire ends (IP 41)
 - Different types of flange and shaft (mm or inch)
 - Motor brake
 - Encoder
 - Low-backlash planetary gear

Any questions? Please contact us.

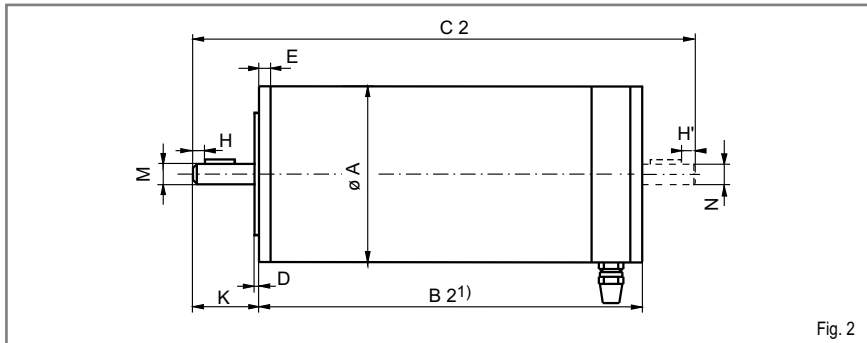
ZSH Stepper Motor with Free Wire Ends (optional)



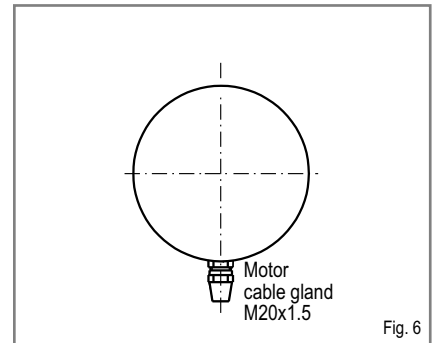
Standard Flange



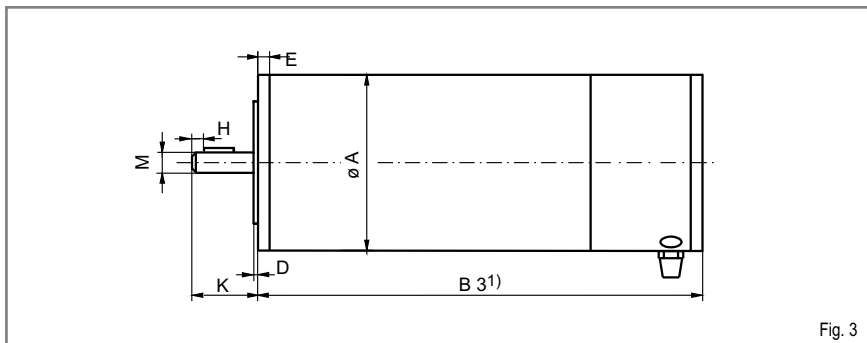
ZSH Stepper Motor with Terminal Box (Standard Design)



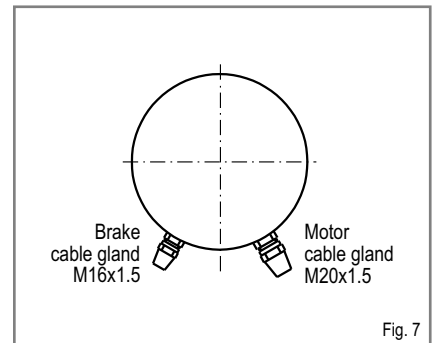
Rear View: Motor with Terminal Box



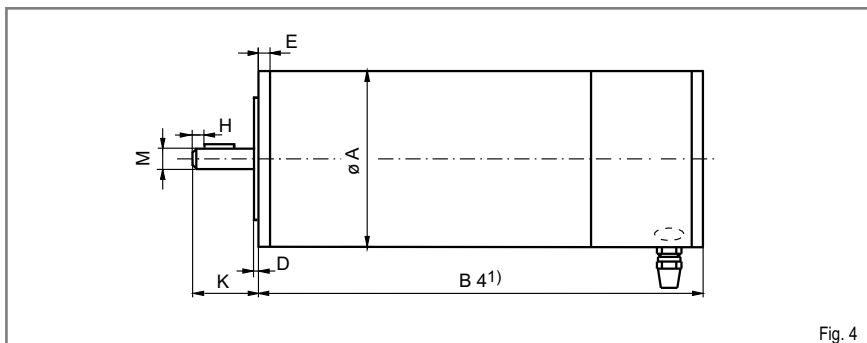
ZSH Stepper Motor with Brake (optional)



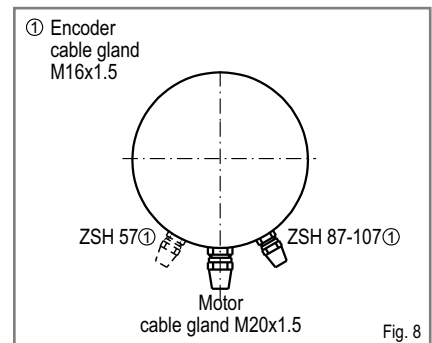
Rear View: Motor with Brake



ZSH Stepper Motor with Encoder (optional)



Rear View: Motor with Encoder



1) Required space for terminal box cover fixing screws: up to 2 mm

Dimensions Stepper Motor / Brake / Encoder / Cable Glands

Dimensions¹⁾ Stepper Motor / Brake / Encoder

Stepper motor	Ø Motor	ZSH with free wire ends	ZSH with terminal box	ZSH + KEB	ZSH + E50	ZSH + H200/500	ZSH + KEB + E50	ZSH + KEB + H200/500						
	A	±0.5 B1	±0.5 B2	±0.5 B3	±0.5 B4	±0.5 B5	±0.5 B6	±0.5 B7	C1	C2	D	E	F	+0.5 K
ZSH 57/1	56.5	50	76	116	88	98	128	137.5	90	108	1.5	5	5.3	21
ZSH 57/2	56.5	76	102	142	114	124	154	163.5	116	134	1.5	5	5.3	21
ZSH 57/3	56.5	104	130	170	142	152	182	191.5	144	162	1.5	5	5.3	21
ZSH 87/1	86	60.5	85.5	131	85.5	104	131	153	137	137	1.5	5.7	6.5	31.5
ZSH 87/2	86	92.5	117.5	163	117.5	136	163	185	169	169	1.5	5.7	6.5	31.5
ZSH 87/3	86	124.5	149.5	195	149.5	168	195	217	201	201	1.5	5.7	6.5	31.5
ZSH 88/1	86	68.5	93.5	139	93.5	112	139	161	145	145	1.5	5.7	6.5	31.5
ZSH 88/2	86	100.5	125.5	171	125.5	144	171	193	177	177	1.5	5.7	6.5	31.5
ZSH 88/3	86	132.5	157.5	203	157.5	176	203	225	209	209	1.5	5.7	6.5	31.5
ZSH 107/1	108	89.5	111	161	111	136	161	193	–	170	1.5	9	8.5	32
ZSH 107/2	108	139.5	161	211	161	186	211	243	–	238	1.5	9	8.5	50
ZSH 107/3	108	189.5	211	261	211	236	261	293	–	288	1.5	9	8.5	50
ZSH 107/4	108	239.5	261	311	261	286	311	343	–	338	1.5	9	8.5	50

¹⁾ Dimensions in mm

Dimensions Key / Flange / Shaft

Stepper motor	Key DIN 6885 T1			Flange / shaft: mm				Flange / shaft: inch			
	G	H	H'	-0.02 M	-0.02 N	-0.05 P	Q	-0.02 M	-0.02 N	-0.05 P	Q
	mm			mm				mm (inch)			
ZSH 57/1	2)							6.35	6.35	38.1	47
ZSH 57/2								(0.25)	(0.25)	(1.5)	(1.85)
ZSH 57/3											
ZSH 87/1	up to Ø10: A3x3x15 from Ø12: A4x4x15	6	1.5	10	10	73	70	9.52	9.52	73	70
ZSH 87/2				12	12			(0.375)	(0.375)	(2.87)	(2.76)
ZSH 87/3											
ZSH 88/1	up to Ø10: A3x3x15 from Ø12: A4x4x15	6	1.5	12	12	73	70	9.52	9.52	73	70
ZSH 88/2				10	10			(0.375)	(0.375)	(2.87)	(2.76)
ZSH 88/3											
ZSH 107/1	A5x5x20	5	5	12	10	60	90	12.7 (0.5)			
ZSH 107/2				16	10			15.87 (0.625)			
ZSH 107/3				16	12			15.87 (0.625)	12.7	55.54	88.9
ZSH 107/4				16	12			15.87 (0.625)	(0.5)	(2.186)	(3.5)

²⁾ Optional for size 57: Woodruff key 2x2.6 DIN 6888

Bold = standard version

¹⁾ Dimensions in mm

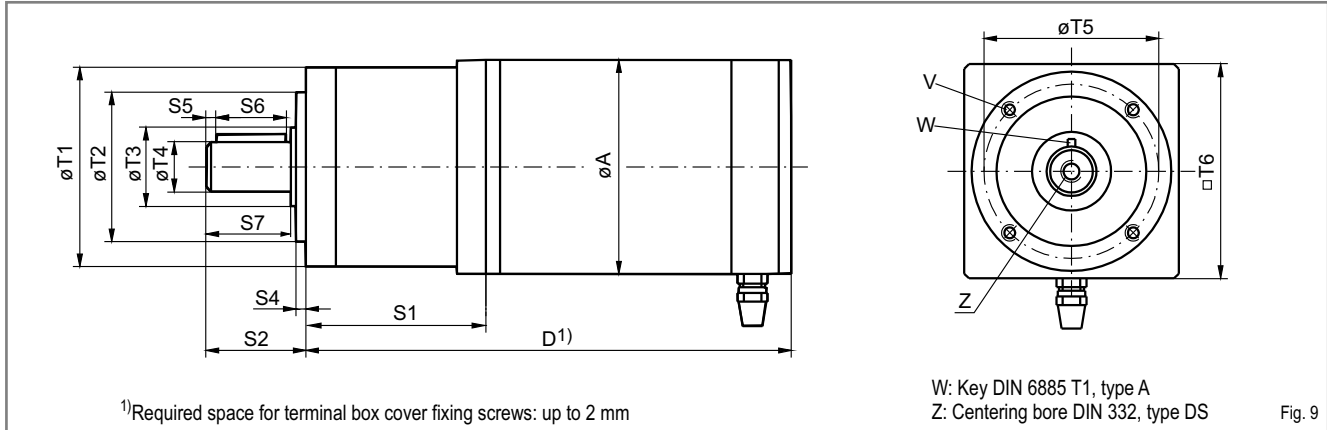
Metric Cable Glands¹⁾

	Thread	Cable Ø	Thread length	Wrench size
Stepper motor connection	20 x 1.5	9 – 13	6	22
Encoder connection	16 x 1.5	5 – 9	5	17
Motor brake connection	16 x 1.5	5 – 9	5	17

- For shielded cables
- Material: nickel plated brass
- Protection class: IP 68 up to 5 bar
- Neoprene sealing rings
- O-Ring on external thread

Stepper Motor with PLE Low-backlash Planetary Gear

ZSH 57 / 87 / 88 / 107 Stepper Motor with PLE Planetary Gear



Dimensions Stepper Motor / Gear

Gear	Stages	Dimensions in mm																			
		A	Total length gear/motor with terminal box D				S1	S2	S4	S5	S6	S7	T1	T2	T3	T4	T5	T6	V	W	Z
PLE 60	1	56.5	ZSH 57/1	ZSH 57/2	ZSH 57/3	55	35	3	2.5	25	30	60	40	17	14	52	60	M5 x 8	5 x 5 x 25	M5 x 12	
	2		131	157	185																
	3		143	169	197																
PLE 80	1	86	ZSH 87/1	ZSH 87/2	ZSH 87/3	72	40	3	4	28	36	80	60	25	20	70	86	M6 x 10	6 x 6 x 28	M6 x 16	
	2		157.5	189.5	221.5																
	3		174.5	206.5	238.5																
	1		ZSH 88/1	ZSH 88/2	ZSH 88/3	72															
	2		165.5	197.5	229.5																
	3		182.5	214.5	246.5																
PLE 120	1	108	ZSH 107/1	ZSH 107/2	ZSH 107/3	ZSH 107/4	131.5	55	4	5	40	50	115	80	35	25	100	115	M10 x 16	8 x 7 x 40	M10 x 22
	2		242.5	292.5	342.5	392.5															
	3		269.5	319.5	369.5	419.5															

Mechanical Gear Characteristics

Gear	Stages	Torsional stiffness	Absolute backlash	Efficiency	Weight without motor	Maximum axial load ²⁾	Maximum radial load ²⁾
		Nm/arcmin	angular minutes	%(approx.)	kg	N	N
PLE 60	1	2.3	<20	96	0.65	600	500
	2	2.5	<25	94	0.82		
	3	2.5	<30	90	1		
PLE 80	1	6	<12	96	1.6	1200	950
	2	6.5	<17	94	2.2		
	3	6.3	<22	90	2.8		
PLE 120	1	12	<8	96	6.5	2800	2000
	2	13	<12	94	9		
	3	12	<16	90	11.5		

²⁾ referred to center of output shaft

PLE Planetary Gear

- Low-backlash / high efficiency
- Torque shaft bearing: ball bearing
- Lifetime lubrication
- Recommended operation temperature range: -25 to +90 °C
- Mounting position: any
- Standard protection class: IP 54
- Optional: protection class IP 65
These gears are specially sealed. Output shaft and keyway are made of stainless steel.
- Angled gears on request

Mechanical Characteristics

Gear	Stages	Reduction Ratio	Permissible gear output torque	Mass inertia (without motor) ¹⁾
			Nm	10 ⁻⁴ kg m ²
			ZSH 57	
PLE 60	1	3:1	28	6.5
		4:1	38	3.3
		5:1	40	2.2
		8:1	18	1.2
	2	9:1	44	7.2
		12:1	44	7
		15:1	44	2.4
		16:1	44	3.4
		20:1	44	2.4
		25:1	40	2.3
		32:1	44	1.2
	40:1	40	1.2	
	64:1	18	1	
	3	60:1	44	2.4
		80:1	44	2.4
100:1		44	2.4	
120:1		44	1.2	
160:1		44	0.1	
200:1		40	0.1	
256:1		44	0.1	
320:1		40	0.1	
512:1		18	0.1	
			ZSH 87	
PLE 80	1	3:1	85	63
		4:1	115	25
		5:1	110	14
		8:1	50	8
	2	9:1	130	63
		12:1	120	26
		15:1	110	62
		16:1	120	25
		20:1	120	15
		25:1	110	15
		32:1	120	8
	40:1	110	8	
	64:1	50	6	
	3	60:1	110	25
		80:1	120	18
		100:1	120	15
		120:1	110	60
		160:1	120	8
200:1		110	8	
256:1		120	8	
320:1		110	6	
512:1		50	6	

Gear	Stages	Reduction Ratio	Permissible gear output torque	Mass inertia (without motor) ¹⁾
			Nm	10 ⁻⁴ kg m ²
			ZSH 88	
PLE 80	1	3:1	85	63
		4:1	115	25
		5:1	110	14
		8:1	50	8
	2	9:1	130	63
		12:1	120	26
		15:1	110	62
		16:1	120	25
		20:1	120	15
		25:1	110	15
		32:1	120	8
	40:1	110	8	
	64:1	50	6	
	3	60:1	110	25
		80:1	120	18
100:1		120	15	
120:1		110	60	
160:1		120	8	
200:1		110	8	
256:1		120	8	
320:1		110	6	
512:1		50	6	
			ZSH 107	
PLE 120	1	3:1	115	2.6
		4:1	155	1.79
		5:1	195	1.63
		8:1	120	1.32
	2	9:1	210	2.62
		12:1	260	2.56
		15:1	230	2.53
		16:1	260	1.75
		20:1	260	1.5
		25:1	230	1.49
		32:1	260	1.3
	40:1	230	1.3	
	64:1	120	1.3	
	3	60:1	260	2.57
		80:1	260	1.5
		100:1	260	1.5
		120:1	230	2.5
		160:1	260	1.3
200:1		230	1.3	
256:1		260	1.3	
320:1		230	1.3	
512:1		120	1.3	

Motor/Gear Output Torque

The output torque of the motor/gear combination can be calculated as follows:

Motor torque at the required speed (see frequency characteristics) multiplied with reduction ratio and gear efficiency.

Red = popular type

¹⁾Mass inertia referred to motor shaft

Electrical Characteristics

Stepper motor type	Standard winding 1 ²⁾				Standard winding 2 ²⁾				Standard winding 3 ²⁾			
	3)	4)	5)	3)	4)	5)	3)	4)	5)	3)	4)	5)
	Phase current unipolar	Phase current bipolar	Resistance per winding	Inductivity per winding	Phase current unipolar	Phase current bipolar	Resistance per winding	Inductivity per winding	Phase current unipolar	Phase current bipolar	Resistance per winding	Inductivity per winding
A	A	Ω	mH	A	A	Ω	mH	A	A	Ω	mH	
ZSH 57/1	1	1.4	5.5	9	3	4.2	0.7	1	3.9	5.5	0.5	0.64
ZSH 57/2	1.5	2.1	4.1	9	2	2.8	2.6	5	3	4.2	1.1	2.6
ZSH 57/3	1.5	2.1	4.3	9	3	4.2	1.6	3	4.6	6.5	0.8	1.2
ZSH 87/1	1.6	2.3	3	6	3	4.2	0.8	1.6	5	7	0.3	0.7
ZSH 87/2	3.5	5	0.8	3	4.6	6.5	0.5	1.5	6	8.4	0.3	1
ZSH 87/3	3.5	5	1.1	5	6	8.4	0.5	1.7	7	10	0.4	1
ZSH 88/1 ¹⁾	-	2	1.88	11.1	-	4	0.5	2.5	-	8	0.13	0.75
ZSH 88/2	-	2	3.61	26	-	4	0.74	5.5	-	8	0.21	1.5
ZSH 88/3	-	4	1.14	10.9	-	8	0.29	2.6	-	12	0.14	1
ZSH 107/1	5	7	0.3	1.6	5.7	8	0.2	1.2	8.8	12.5	0.1	0.55
ZSH 107/2	5.7	8	0.4	2.4	7.1	10	0.3	1.6	8.8	12.5	0.2	1.15
ZSH 107/3	7.1	10	0.4	2.7	8.8	12.5	0.3	1.9				
ZSH 107/4	8.8	12.5	0.4	2.7								

¹⁾ Size 88 for bipolar operation only

red = popular types

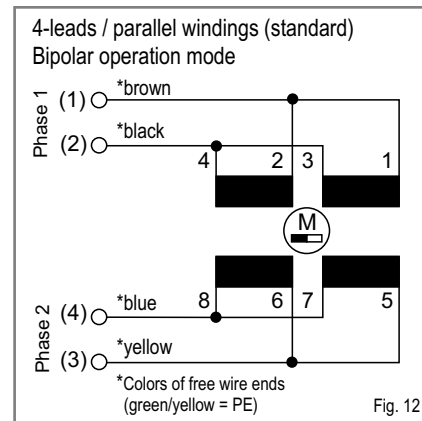
²⁾ The current value given in the ordering data (e. g. ZSH 107/2.200.8) refers to the bipolar mode (parallel windings).

³⁾ Current in unipolar mode = 0.7 x current in bipolar mode

⁴⁾ Resistance per phase in bipolar mode = 0.5 x resistance per winding

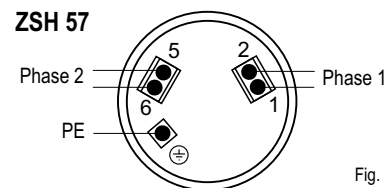
⁵⁾ The inductivity values apply for each single winding as well as for two parallel windings.
For series mounted windings, the inductivity is multiplied by 4.

Motor Connection Diagram (Standard)

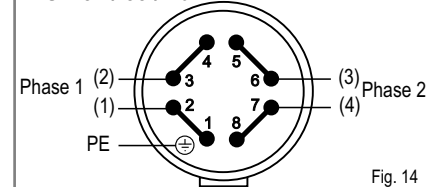


Terminal Box

ZSH 57



ZSH 87 / 88 / 107

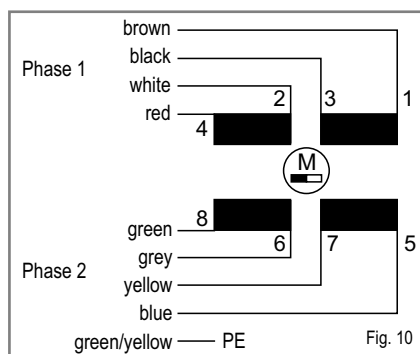


The drawings above show the standard terminal box wiring of ZSH motors with parallel connected windings.

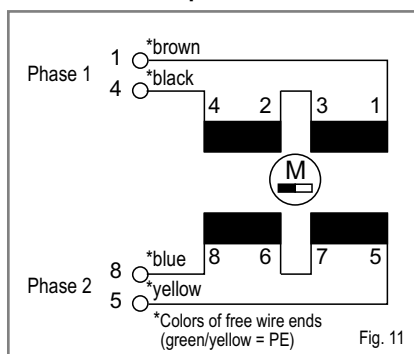
Operation mode: bipolar

For more information please download the ZSH motor connection leaflet from the phytron homepage www.phytron.de.

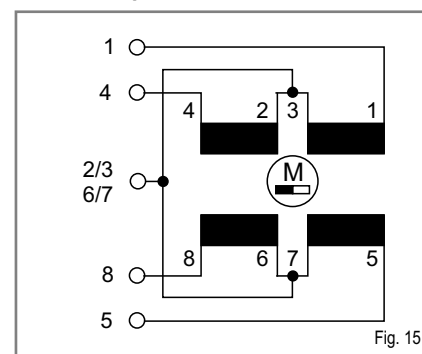
Motor Connection Diagram 8-lead / Free Wire Ends



Motor Connection Diagram 4-lead / Serial / Bipolar Mode



Motor Connection Diagram 5-lead / Unipolar Mode



Frequency Characteristics

The curves correspond to the limit values of the operational characteristics as a function of the control pulses (frequency/speed), for two different supply voltages (U_b).

The motor windings are connected in parallel (fig. 11), the motors are powered by bipolar stepper motor power stages in the half-step mode.

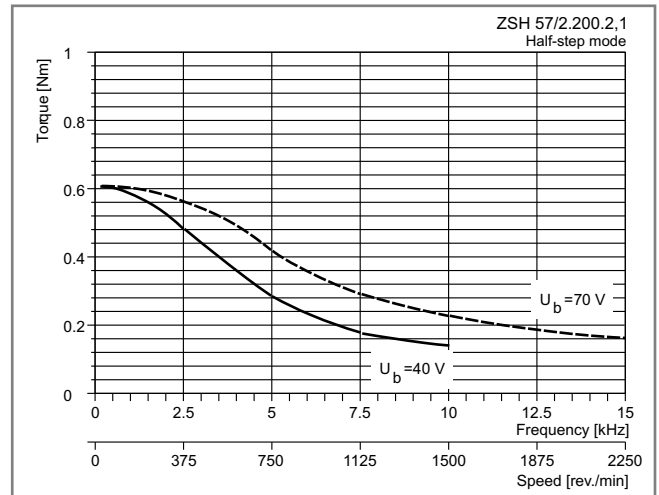


Fig. 17

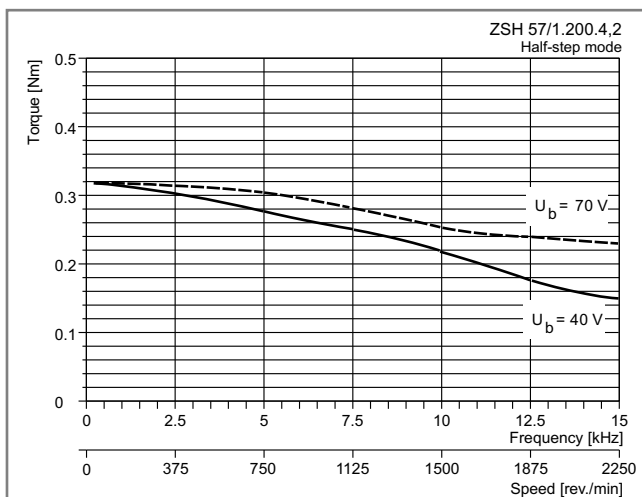


Fig. 15

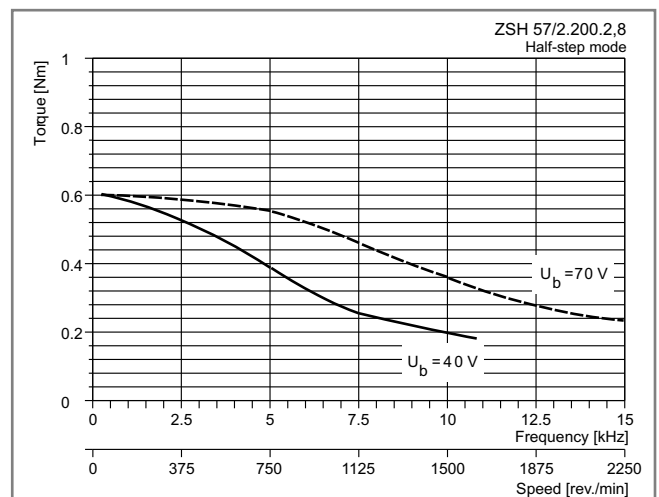


Fig. 18

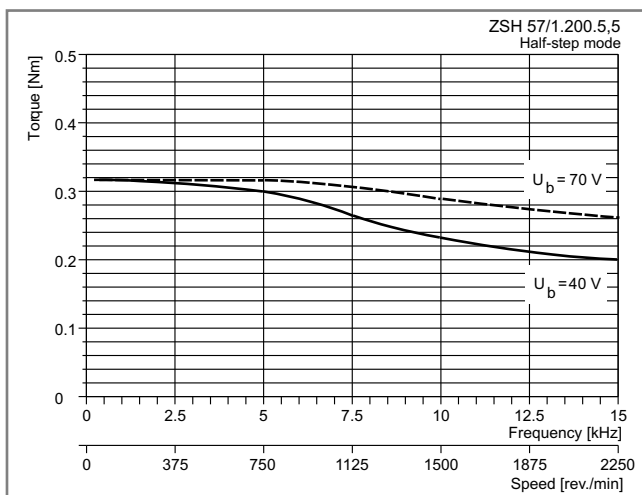


Fig. 16

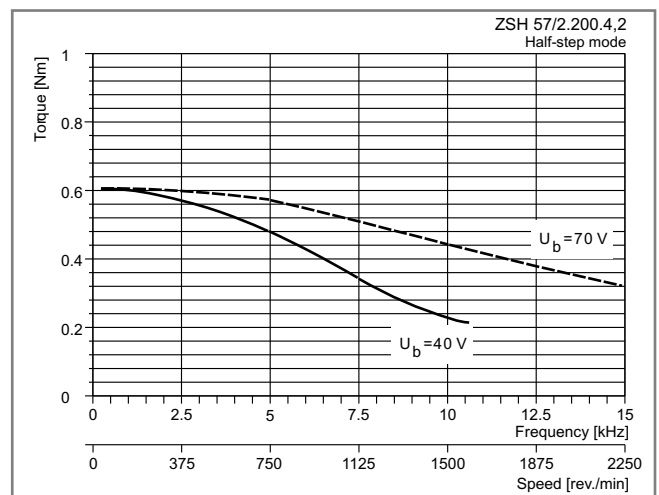


Fig. 19

Frequency Characteristics

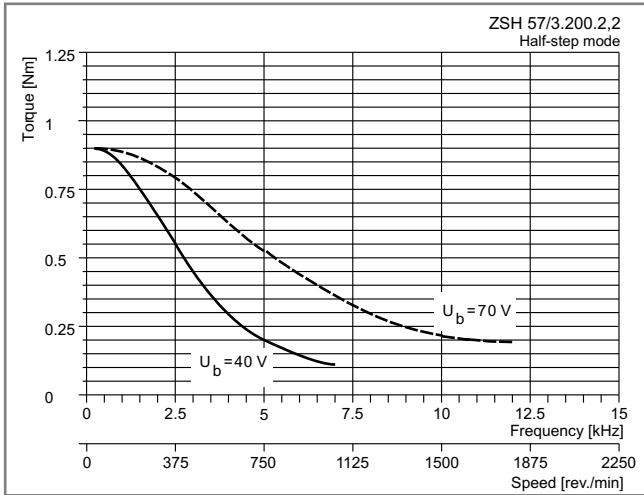


Fig. 21

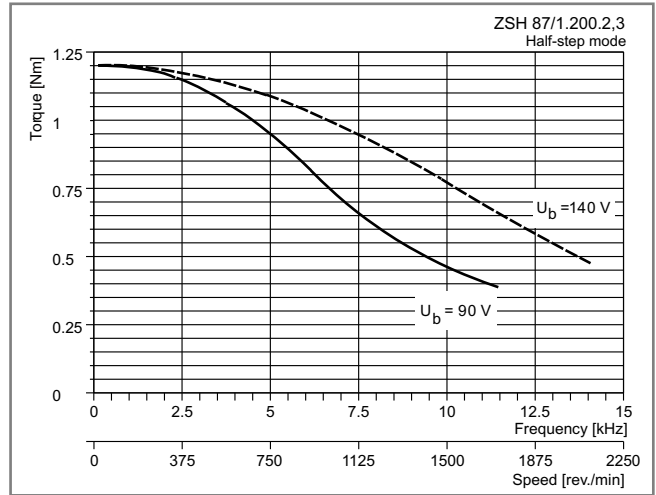


Fig. 24

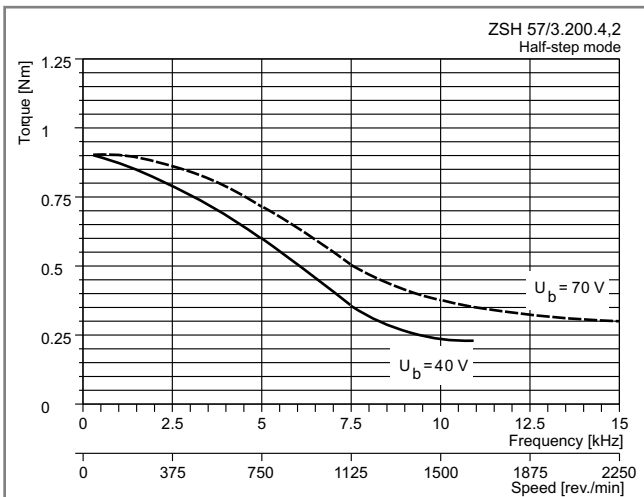


Fig. 22

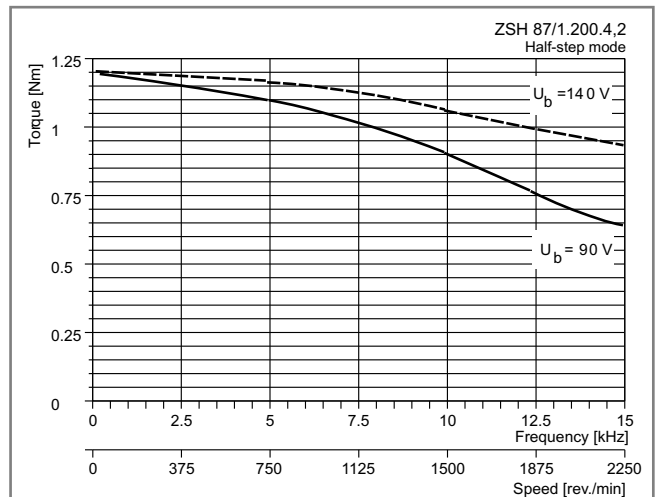


Fig. 25

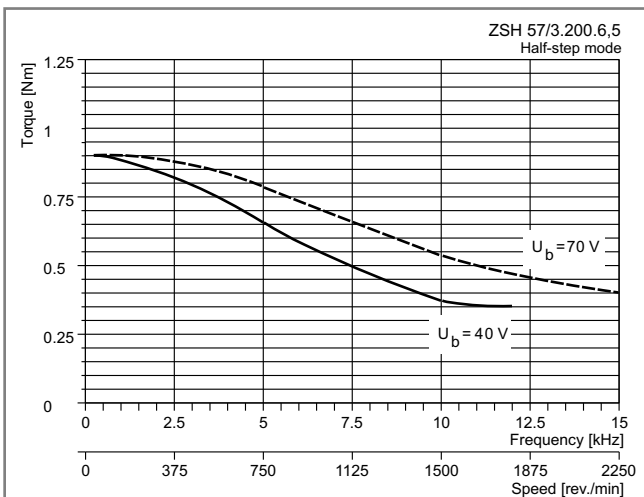


Fig. 23

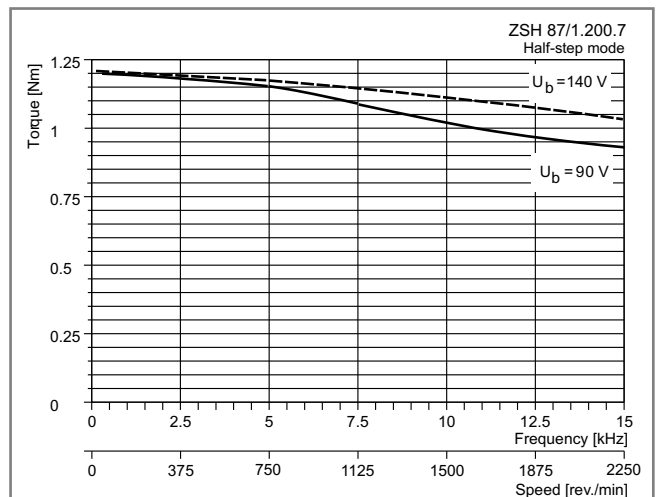


Fig. 26

Frequency Characteristics

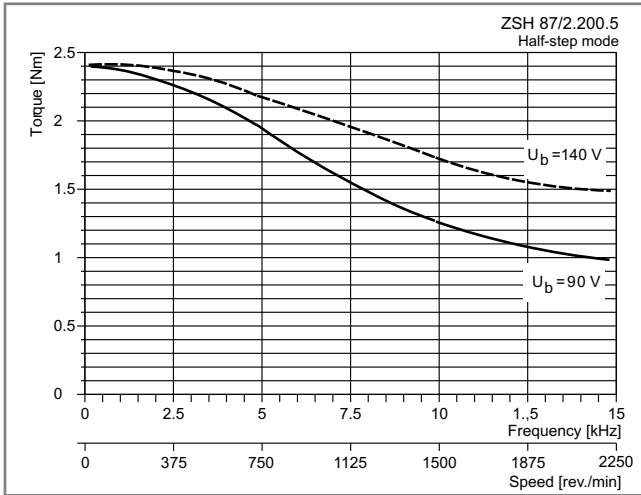


Fig. 27

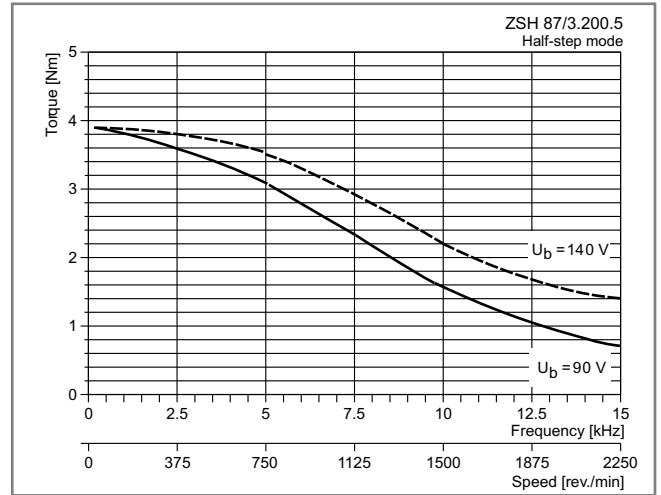


Fig. 30

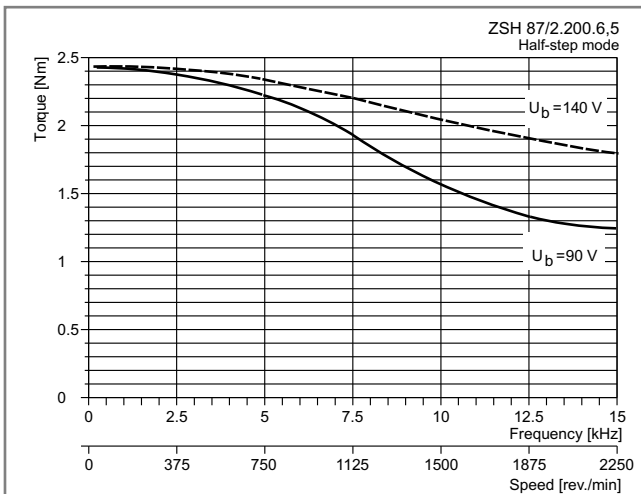


Fig. 28

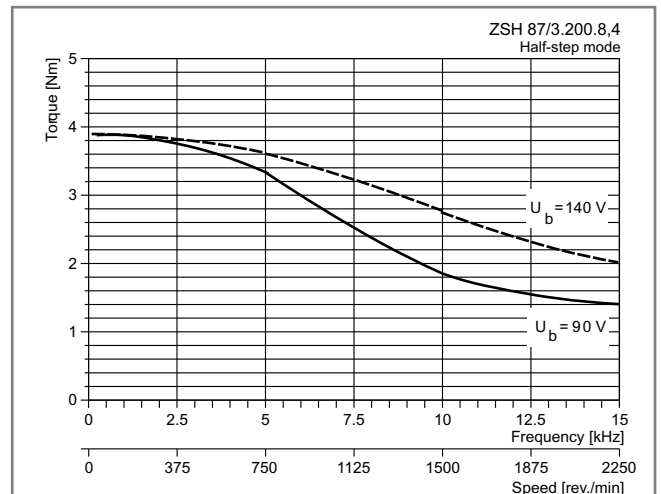


Fig. 31

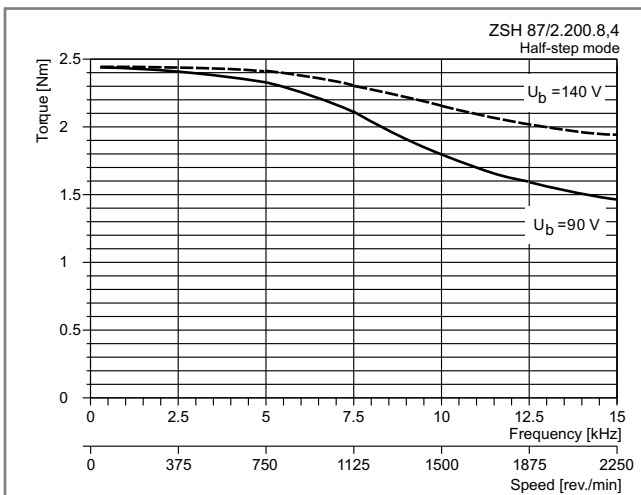


Fig. 29

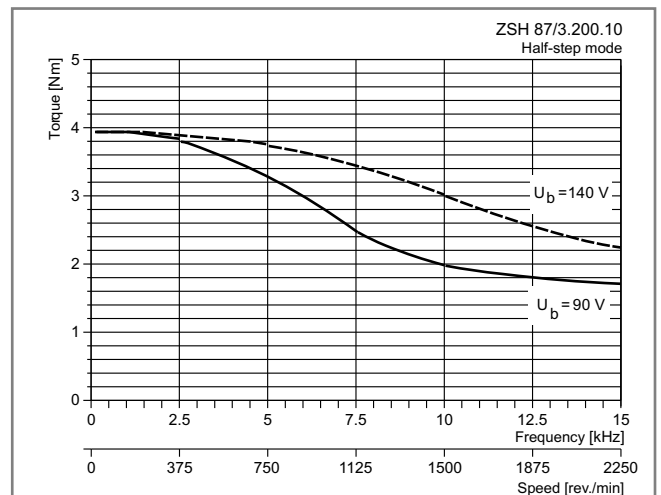


Fig. 32

Frequency Characteristics

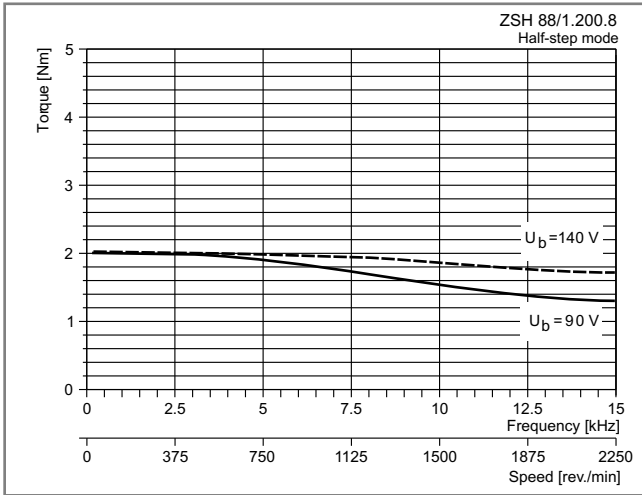


Fig. 33

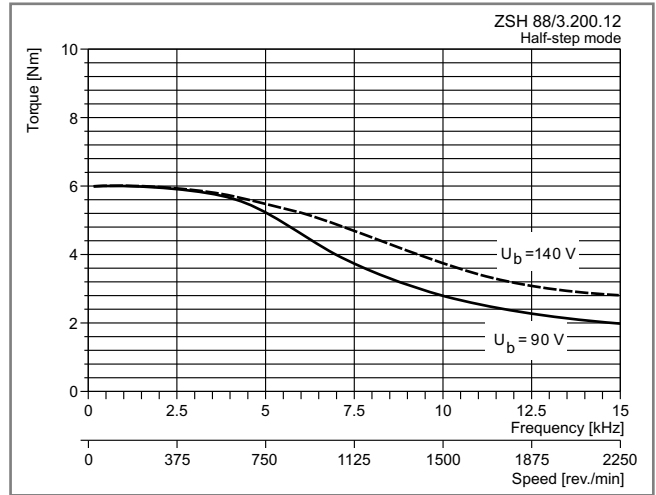


Fig. 36

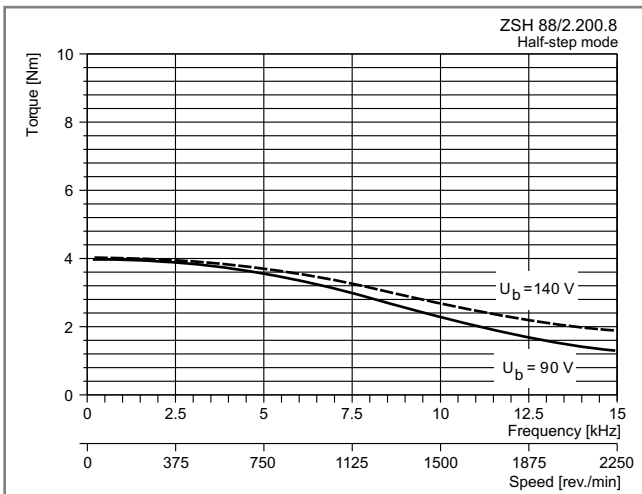


Fig. 34

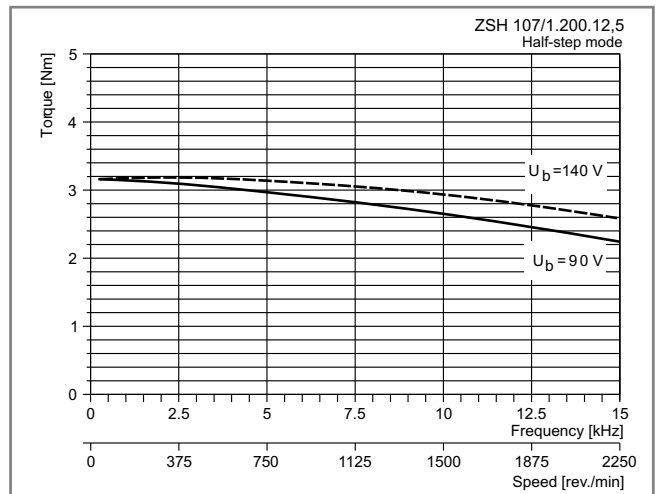


Fig. 37

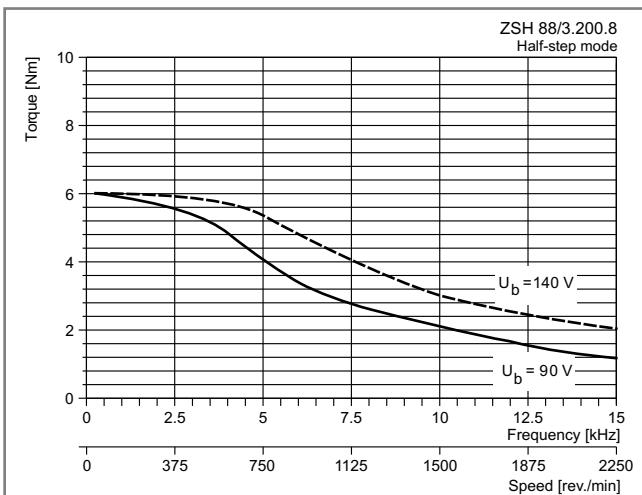


Fig. 35

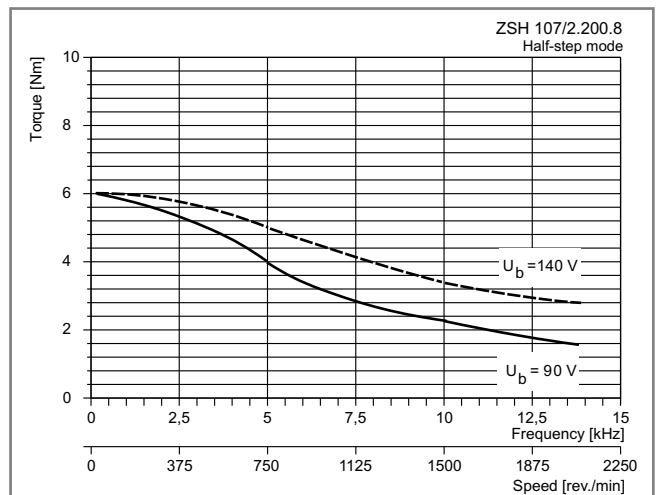


Fig. 38

Frequency Characteristics

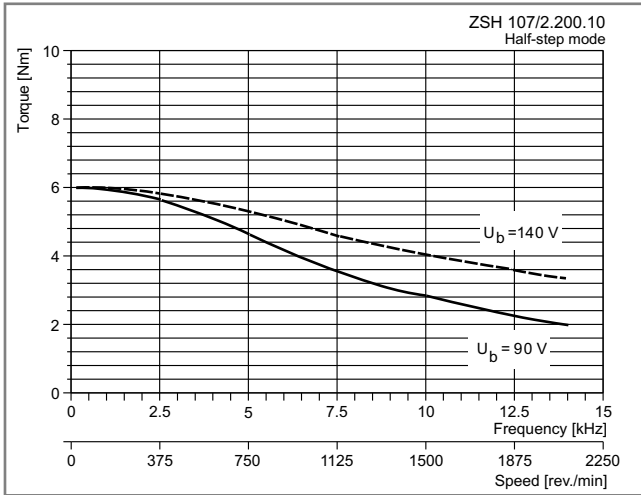


Fig. 39

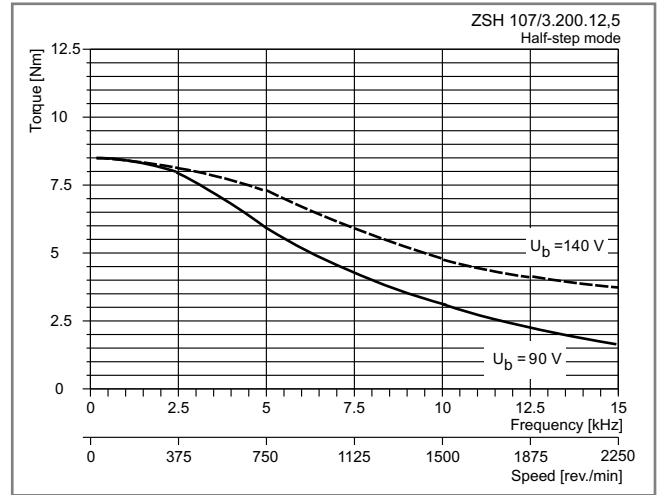


Fig. 42

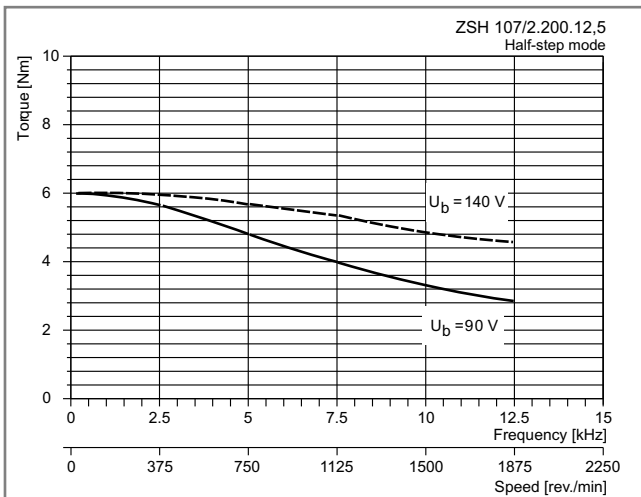


Fig. 40

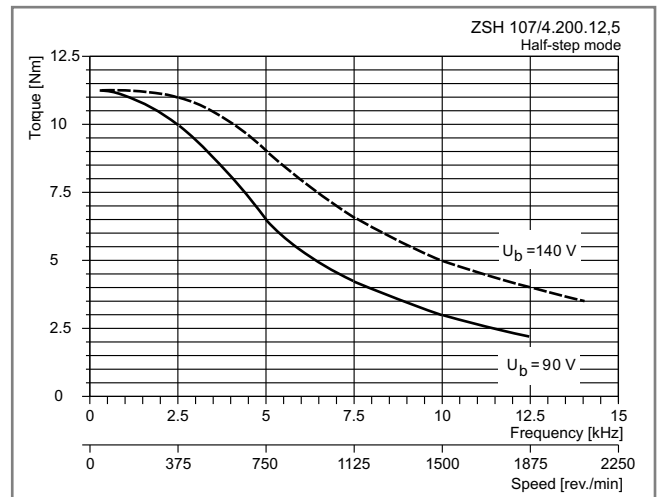


Fig. 43

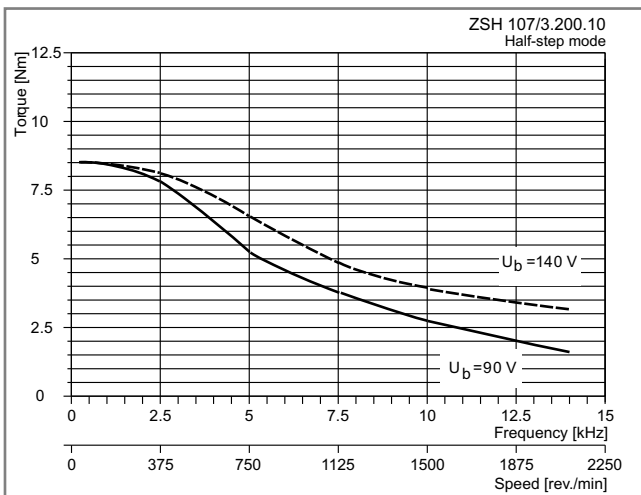


Fig. 41

Optional: PLE Low-backlash Planetary Gear

The use of a gear box is recommended if a high resolution of the drive system or a low output speed is required.

The overall unit – motor with planetary reducing gear – has a higher output torque and reduced mass inertia.

- 1-stage, 2-stage or 3-stage gear with reduction ratios from 3:1 to 512:1
- High driving torque up to 260 Nm, depend. on motor size and reduction ratio
- High torsional stiffness
- Low torsional backlash:
< 8 to <30 angular minutes depend. on gear size and reduction ratio
- High permissible axial and radial shaft loads
- Low running noise
- Temperature range –25 to +90 °C
- Lifetime grease lubrication

Drawings, dimensions and mechanical characteristics see page 4/5.

EU-Directives and CE marking

When installed appropriately, ZSH stepper motors meet the requirements of the EMC and Low Voltage Directives. ZSH stepper motors are marked CE and comply with EN 60034-1 European standard.

When wired correctly, ZSH stepper motors meet the requirements of the EMC Directive. Information concerning the connection of the motor cable to the control unit or the power stage is given in the corresponding manuals.

According to the Machine Directive, the stepper motor is only a part of a machine. The machine manufacturer must take appropriate measures to ensure that the entire system meets the requirements of the applicable EU-Directives.

Optional: KEB Motor Brake

For vertically mounted positioning systems, stepper motors with brake are recommended.

The permanent magnet brake is activated when the brake is de-energized. The permanent magnet pulls a rotor disk in the axial direction towards the contact surface, thus creating a friction-tight junction, free of rotatory backlash.

When the current is activated, the force acting on the rotor disk is suppressed. The contact surfaces are separated without a residual friction moment by means of a riveted spring.

- Supply voltage 24 V_{DC}
- Electrical connection by means of a metrical cable gland.
- Current consumption
KEB 02: approx. 350 mA
KEB 05: approx. 450 mA
KEB 06: approx. 550 mA

For drawings and dimensions, please refer to pages 2 and 3.

Optional: E 50, H 200 or H 500 Encoder

ZSH stepper motors with mounted encoder are specially adapted for applications with variable speed drives or to monitor the drive.

Short-circuit-proof RS 422 line driver

E 50 Encoder

- Supply voltage: 5 to 24 V_{DC}
- Resolution: 50 lines
- Output signals:
Channels A and B, \bar{A} and \bar{B}
The A and B (\bar{A} and \bar{B}) signals are 90° phase-shifted.

H 200 / H 500 Encoder

- Supply voltage: 5 V_{DC} ± 5%
- Resolution: 200 / 500 lines
- Output signals:
Channels A and B, \bar{A} and \bar{B}
The A and B (\bar{A} and \bar{B}) signals are 90° phase-shifted.
- 0 und $\bar{0}$ reference pulses

For drawings and dimensions, please refer to pages 2 and 3.

Ordering Code

	ZSH 87 / 3 . 200 . 10 - H200 - PLE/12:1 - IP68 - 4s
Stepper motor series	ZSH
Size	57 / 87 / 88 / 107
Length	1 / 2 / 3 / 4
Number of steps	200
Winding	available windings see page 1
Optional:	
Ø Shaft/Flange	not specified = standard design
2nd shaft	E
Free wire ends	FD (FD and E can be combined)
Motor brake	KEB
Encoder	E50 / H200 / H500
Encoder and motor brake	E50-KEB / H200-KEB / H500-KEB
Gear/reduction ratio	PLE 12:1 (reduction ratios see page 5)
Protection class IP 68	not specified = standard protection class IP 54
Connection of the windings	not specified = standard wiring scheme: 4-lead/parallel windings 4s = 4-lead/serial windings, 5 = 5-lead, 8 = 8-lead