PMCtendo SZ

PILZ

THE SPIRIT OF SAFETY

Operating Manual-1002405-EN-05

1 Introduction

1.1 Purpose of the manual

This operating manual describes PMCtendo SZ synchronous servo motors. It contains information about transport, storage, installation, connection, commissioning, service and disposal.

1.2 Additional support

If you have questions that are not answered in this document, additional support is available at http://www.pilz.com.

2 Safety instructions

2.1 Warranty and liability

These devices can pose certain risks. For this reason, always comply with the safety information listed in the following sections and points and with the technical rules and regulations.

Warranty and liability claims are voided if:

- The product was not used as intended
- Damage can be traced back to noncompliance with the operating manual
- Operating personnel are not properly trained
- Changes of any kind have been made

2.2 Part of the product

The technical documentation is part of a product.

Always keep this operating manual at hand in the area of the device until disposal of the product because it contains important information.

Hand over this operating manual in case of sale, transfer or rental of the product.

2.3 Intended use

The servo motors are intended for installation in machines or systems or for assembly with other components into a machine or system. They must be operated in connection with appropriate, correctly configured servo amplifiers (e.g. PMCtendo DD5 or PMCprotego D).

The thermal winding protection integrated in the motor winding must be monitored and evaluated.

The following are considered non-intended use:

- Direct connection to the supply grid
- Any structural, technical or electrical change
- Use outside of the areas described in this operating manual
- Use deviating from the specified technical data

2.4 Qualified personnel

These devices can pose certain residual risks. Therefore all work on the device, as well as its operation and disposal, may be performed only by qualified personnel who are aware of the potential risks. Qualified personnel are persons who have acquired the authorization to perform these tasks through professional training and/or instruction by specialists.

In addition, applicable regulations, legal provisions, technical standards, this technical documentation and especially the safety information contained within it must be read carefully, understood and observed.

2.5 Working on the machine

Apply the 5 safety rules in the order stated before performing any work on the machine:

1. Disconnect. Also make sure to disconnect the auxiliary circuits.
2. Protect against being turned on again.
3. Check that voltage is not present.
4. Ground and short circuit.
5. Cover adjacent live parts.

2.6 Disposal

Observe the current national and regional regulations! Dispose of individual parts separately depending on their condition and the currently applicable regulations, e.g. as electronic waste (circuit boards), plastic, sheet metal, copper or aluminum.

2.7 Directives and standards

The servo motors fulfill the following guidelines and standards:

- Low Voltage Directive 2014/35/EU
- EMC Directive 2014/30/EU
- DIN EN 50110
- DIN EN 60034-1:2011
- DIN EN 60034-5:2007
- DIN EN 60034-6:1996
- DIN EN 60034-9:2008
- DIN EN 60034-14:2008
- DIN IEC 60364
- UL and CSA certification

  All motors are delivered with the Recognized Component Class 155 (F) motor insulation system approval.

  The approval is registered at Underwriters Laboratories in the United States under UL number E357386 in the areas of OBJY2.GuideInfo Systems, Electrical Insulation - Component and
  OBJY8.E357386 Systems, Electrical Insulation Certified for Canada - Component.

  This approval is primarily relevant for the use of motors and geared motors on the US market, but it also represents a special quality feature in many countries.

2.8 Use of symbols

Safety instructions are identified with the following symbols. They indicate special risks when handling the product and are accompanied by relevant signal words that express the extent of the risk. Furthermore, useful tips and recommendations for efficient, error-free operation are specially highlighted.

DANGER!

Danger

This word with a warning triangle indicates that there is a considerable risk of fatal injury

– if the stated precautionary measures are not taken.

WARNING!

Warning

This word with a warning triangle means there may be a considerable risk of fatal injury

– if the stated precautionary measures are not taken.

CAUTION!

Notice

This indicates that damage to property may occur

– if the stated precautionary measures are not taken.

NOTICE

Important indicates relevant information about the product or serves to emphasize a section in the documentation that deserves special attention from the reader.

3 Product description

The PMCtendo SZ synchronous servo motors have a very short design made possible by using optimal winding technology. This allows for the stator windings to be manufactured with the highest possible copper fill factor. This technology and other optimizations of the mechanics make it possible to shorten the motor length by roughly half without negatively impacting performance.

Fig.: PMCtendo SZ synchronous servo motors

3.1 PMCtendo SZ synchronous servo motors

3.1.1 Nameplate

Designation	Value in example	Meaning
YOM	2018	Year of manufacturing
Type	PMCtendo SZ.31/1/2/2/7/K/H/30/00	Type label
Ser. No.	10251811	Serial number
Ident. No.	8177064	Identification number
M_0	0.95 Nm	Stall torque: Continuous torque at 250 rpm ± 5%
M_N	0.93 Nm	Rated torque; highest continuous torque of the motor at rated speed n_N ± 5%
I_0	2.02 A	Stall current: I_0 is the current flowing at M_0
I_N	1.99 A	Rated current: Continuous current at M_N ± 5% and n_N ± 5%
K_{EM}	40 V/1000 rpm	Voltage constant: Peak value of the induced phase-to-phase voltage at operating temperature (ΔT = 100 K) in generative idling mode
$K_{M,N}$	0.467 Nm/A	Torque constant at the measurement point
n_N	3000 rpm	Rated speed n_N
Therm. class	155 (F)	Thermal class in acc. with EN 60034/VDE 0530
IP	56	Protection class
Therm. prot.	PTC thermistor 145 °C	Thermal winding protection by PTC thermistor
Encoders	EnDat 2.2 EQN 1135 FMA MT	Feedback system
Brake	2.50 Nm/24 V/0.51 A	Permanent magnet holding brake

3.1.2 Type label

Sample code

PMCtendo SZ.	31	1	2	2	7	K	H	30	00
1	2	3	4	5	6	7	8	9	10

1 Type
PMCtendo SZ

2 Size	Code
3x	**3x**
4x	4x
5x	5x
7x	7x
8x	8x

3 Brake and dynamics	Code
Without permanent magnet holding brake and dynamic design	0
With permanent magnet holding brake and dynamic design	**1**
Without permanent magnet holding brake and increased mass moment of inertia (not for SZ.3x, SZ.51, SZ.71)	2
With permanent magnet holding brake and increased mass moment of inertia (not for SZ.3x, SZ.51, SZ.71)	3

4 Feedback	Code
EnDat 2.2 single-turn, inductive (ECI 1118-G2)	1
EnDat 2.2 multi-turn, optical (EQN 1135)	**2**
HIPERFACE DSL multi-turn, optical (EKM36, only for SZ.3x – SZ.75...K)	7

5 Design	Code
B5, smooth shaft	**2**

6 Connection	Code
Angle flange socket (only for SZ.85...F)	6
Rotating angle flange socket	**7**

7 Cooling	Code
Forced ventilation unit (not for SZ.3x)	F
Convection cooling	**K**

8 Voltage	Code
400 V (U_{ZK} = 540 V)	**H**

9 Speed	Code
2000 rpm	20
3000 rpm	**30**
4500 rpm	45
6000 rpm	60

10 Option	Code
Standard	**00**

3.2 Servo amplifiers

The PMCtendo SZ synchronous servo motors have to be operated with speed, torque or position regulation using servo amplifiers, such as the PMCtendo DD5 or PMCprotego D.

The most important selection criteria for the appropriate servo amplifiers and associated cables are:

- Stall torque M_0 [Nm]
- Stall current I_0 [A]
- Nominal speed n_N [rpm]
- Mass moments of inertia for the motor and load J [$kgcm^2$]
- Effective torque of the motor M_{eff} [Nm]
- Regeneration energy in braking operation
- Overload capacity
- EMC

When selecting the servo amplifier, also keep static and dynamic loading in mind (acceleration and braking).

3.3 Feedback

The PMCtendo SZ synchronous servo motors can be equipped with the following feedback systems:

- EnDat 2.2 single-turn, inductive (ECI 1118-G2)
- EnDat 2.2 multi-turn, optical (EQN 1135)
- HIPERFACE DSL multi-turn, optical (EKM36, only for SZ.3x – SZ.75...K)

Single-turn feedback systems deliver an absolute position within one revolution; multi-turn feedback systems provide an absolute position over a number of revolutions.

The purely digital HIPERFACE DSL feedback system is a one cable solution, meaning it is a hybrid cable where the power, brake and feedback wires are consolidated. The hybrid cable decreases wiring complexity and reduces space requirements. For assembly, it simply has to be connected or clamped to the motor or servo amplifier.

3.4 Dynamics

The PMCtendo SZ synchronous servo motors are designed for applications with high dynamics by default. This means that they have the lowest possible mass moment of inertia.

Synchronous servo motors can optionally be delivered with increased mass moment of inertia in order to optimize the inertia ratio between the motor and load.

3.5 Operating mode

PMCtendo SZ synchronous servo motors are designed for continuous operation. This corresponds to the S1 operating mode (in accordance with DIN EN 60 034-1).

3.6 Thermal winding protection

The PMCtendo SZ synchronous servo motors have thermal winding protection that protects the stator winding from damage during constant overload.

The PMCtendo SZ motors are equipped with a PTC thermistor. If the motor temperature reaches a critical value, the resistance of the PTC resistors increases abruptly and thereby indicates the overload of the motor.

NOTICE

Every thermal winding protection has to be monitored and evaluated by a servo amplifier or an external triggering device.

3.7 Cooling

PMCtendo SZ synchronous servo motors are sized for convection cooling by default.

In order to increase the performance of the motors, they can optionally be equipped or upgraded with external forced ventilation systems (IP44 protection class).

In applications requiring a higher protection class than IP44 or a lower noise load, servo motors can be water-cooled in the A-side flange.

3.8 Holding brake

DANGER!

Risk of fatal injury!

The motor brake is not a safety brake.

– Check whether additional protective measures have to be taken, such as when stopping or standing under suspended loads.

Since the synchronous servo motors can be braked actively and quickly using corresponding set value specifications on the servo amplifier, the built-in brakes have the function of a holding brake.

For holding the motor shaft in place without any backlash, the synchronous servo motors can be delivered with a built-in permanent magnet holding brake. It blocks the rotor when de-energized.

An electro-mechanical method is used to release the brake. The applied voltage generates an electromagnetic field that counteracts the field from the permanent magnet and neutralizes its effect.

NOTICE

The air gap in the holding brake cannot be adjusted later.

Additional brakes have to be provided for braking while the motor is turning, e.g. during an emergency stop.

CAUTION!

Damage to the motor or motor components due to electrical connection errors!

– Observe the motor nameplate and this connection plan. Contact Technical Support in case of questions.

DANGER!

Risk of fatal injury due to gravity-loaded vertical axes!

Unsecured gravity-loaded vertical axes can drop unexpectedly due to defective or released brakes.

– Follow the requirements and protective measures for gravity-loaded vertical axes from the DGUV, special area information sheet No. 005, 09/2012 edition.

3.9 Motor shaft and bearing

PMCtendo SZ synchronous servo motors have a smooth shaft end on the drive side (DIN 6885). Surface pressure needs to be achieved for torque transfer in the case of a positive connection. This ensures a reliable transfer of force free of backlash.

The bearings are designed as ball bearings with lifetime lubrication and with non-contact sealing.

4 Transport and storage

4.1 Transport

Secure the shafts and bearings of a synchronous servo motor against impacts during transport. During transport, use the corresponding eyebolts (if present) and a suitable fastening element.

Lift the synchronous servo motor by the eyebolts exclusively without additional attachments. Never transport the motor by the fan hoods or the angle flange socket of the connectors.

4.2 Storage

Store synchronous servo motors in enclosed, dry spaces. Storage on the fan hoods is not permitted. If the motors are protected against all damaging environmental influences and mechanical damage, short-term storage in outdoor areas with roofing is permitted.

Make sure that no condensate forms during storage, such as due to extreme temperature fluctuations with high humidity.

Be sure to protect the motor shaft against corrosion in the case of long-term storage. Be aware that the insulation resistance of the winding must be tested after long-term storage.

5 Installation

DANGER!

Electric shock!

Serious injuries due to contact with live parts!

- Carry out all work on a de-energized motor!
- Make sure that the motor shaft is stationary during all work. A rotating rotor can cause high voltages at the connections.
- Disconnect the supply voltage. Be aware that there may still be dangerously high voltages at the servo amplifier, even 10 minutes after switching off the supply voltage, due to the residual charge of the link capacitors.
- Cover all open electrical connections, e.g. using protective caps.
- Secure the installation location as per regulations, e.g. using locks or warning signs.

DANGER!

Burns!

The surface temperature of a synchronous servo motor can significantly exceed 65 °C through operation.

- Take suitable protective measures against unintentional and intentional contact with the motor.

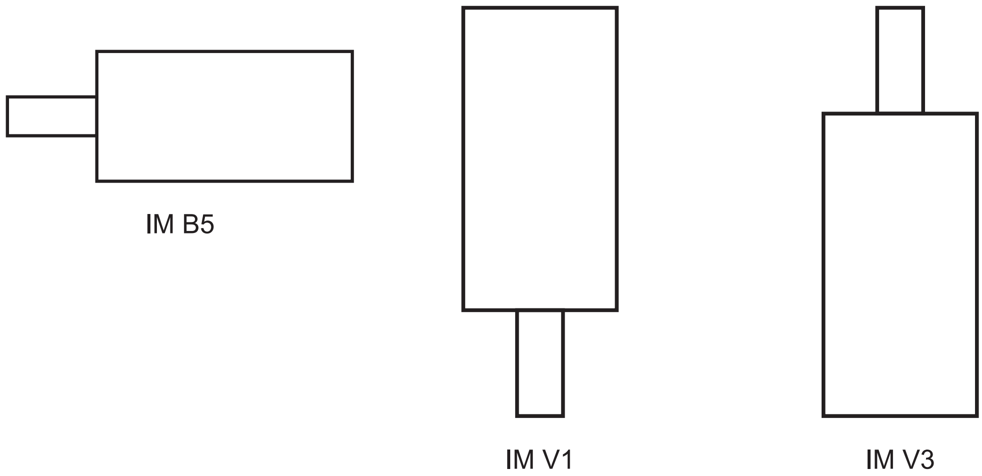
5.1 Installation location

The following requirements apply to the installation location:

- The installation location must be free of any aggressive substances and any electrically conductive atmosphere
- The substructure must be even, free of vibrations and resistant to warpage
- Sufficient heat dissipation must be ensured; for this purpose, ensure compliance with the permitted surrounding temperature and, as needed, provide additional cooling for the motor, such as by using a forced ventilation unit
- If using a forced ventilation unit, ensure compliance with the minimum clearance of the air intake

Type	Forced ventilation unit	Minimum clearance x_{Fmin} [mm]
SZ.4x	FL4	20
SZ.5x	FL5	20
SZ.7x	FL7	30
SZ.8x	FL8	30

The following graphics show permitted mounting positions IM B5, IM V1 and IM V3.



In mounting position IM V3, take special care that no fluid from attachments can get into the motor bearings.

5.2 Motor installation

CAUTION!

Material damage!

Impacts or other uses of force cause damage to the bearings, feedback system and motor shaft.

- Do not hit the motor shaft or motor housing with a hammer or other tools.
- Do not expose the motor to any compressive stress, impacts or high acceleration.
- Use backlash-free, frictional collets or couplings.
- For attaching and releasing couplings, gears or belt drives, always use the intended draw bar thread in the motor shaft. Use a suitable tool!

CAUTION!

Material damage!

Solvents damage the sealing lips of the shaft seal rings.

- Make sure that no solvent comes in contact with the sealing lips of the shaft seal rings.

5.2.1 Preparing the motor for installation

⇨ Check the motor for transport damage. Never install a motor with obvious damage!

⇨ Check the insulation resistance of the motor winding after storage.

⇨ Thoroughly remove any corrosion protection agent and/or dirt from the motor shaft. Use commercially available solvents to do so. Make sure that solvent does not come in contact with the sealing lips of the shaft seal rings. Otherwise, material damage may occur.

⇨ If possible, warm the drive elements, e.g. belt drive.

⇨ Be aware that damage to the finish on the synchronous servo motor is never permitted.

5.2.2 Installing the motor

- ➪ Align the coupling correctly. Misalignment leads to impermissible vibrations and to the destruction of ball bearings and coupling!
- ➪ Avoid mechanically constrained motor shaft mounting. A rigid coupling and/or excessive additional bearings (e.g. in the gear unit) can put excessive stress on the motor shaft.
- ➪ Thoroughly remove any corrosion protection agent and/or dirt from the motor shaft. Use commercially available solvents to do so. Make sure that solvent does not come in contact with the sealing lips of the shaft seal rings. Otherwise, material damage may occur.
- ➪ Prevent contact between temperature-sensitive parts and the motor. The surface of the motor can reach temperatures that are significantly above 65 °C through operation.
- ➪ If you remove the eyebolts after installation, you must seal the tapped hole in a durable way according to the protection class of the motor.

6 Electrical installation

Observe the 5 safety rules in the chapter Working on the machine [7]!

DANGER!

Electric shock!

Serious injuries due to contact with live parts!

- Carry out all work on a de-energized motor!
- Make sure that the motor shaft is stationary during all work. A rotating rotor can cause high voltages at the connections.
- Disconnect the supply voltage. Be aware that there may still be dangerously high voltages at the servo amplifier, even 10 minutes after switching off the supply voltage, due to the residual charge of the link capacitors.
- Cover all open electrical connections, e.g. using protective caps.
- Secure the installation location as per regulations, e.g. using locks or warning signs.

WARNING!

Injury to persons and damage to property due to faulty wiring!

Faulty wiring of the motor and/or feedback system can lead to uncontrolled movements and to personal injury or damage to property as a result.

- Observe the specifications in this operating manual and in the documentation of the servo amplifier used.
- Make sure that components attached to the motor, such as feather keys and coupling elements, are sufficiently secured against centrifugal forces.

6.1 General information

6.1.1 Line routing

Observe the valid provisions for your machine or system, e.g. DIN IEC 60364 or DIN EN 50110, during the installation of electrical equipment.

6.1.2 Grounding, shielding and EMC

Observe the following factors for grounding, shielding and EMC.

- For synchronous servo motors, the connection to PE is made using the cable for the power supply (see Connection method [25]). For additional grounding, the motors have an externally attached and marked grounding connection.
- Use a ring core or a motor throttle near the servo amplifier for the power supply cable as needed. Observe the specifications in the operating manual of the servo amplifier used.
- You need shielded cables for power cables.
  - Apply inner and outer shielding on both sides (e.g. at a shield wire bus bar).
- You need shielded cables for data and control cables.
  - Apply the outer shielding on both sides (e.g. at a shield wire bus bar).
  - Apply the inner shielding on the side of the servo amplifier (e.g. at a shield wire bus bar).
  - If equalizing current is expected when using longer cables, it can be prevented with voltage-equalizing cables.
- Apply (low-impedance) shielding extensively over metallized connector housings or EMC-compatible cable glands.
- Use a suitable connection material to apply the cable shield to the ground rail or shield cable bus bar (e.g. shield clamps, see the following graphic).

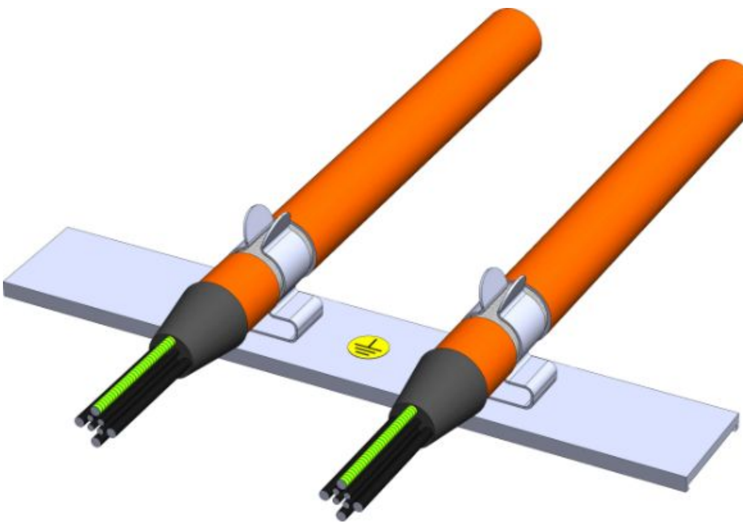


Fig.: Shielded connection of the power cable (graphic: icotek GmbH)

6.1.3 Cable selection

Be aware that the motor, cables and servo amplifier all have electrical properties that influence each other. Failure to coordinate them properly can lead to impermissibly high voltage peaks at the motor and servo amplifier.
Also observe the following factors.

- Select the conductor cross-section based on the permissible continuous stall current of the motor. Also observe the documentation for the servo amplifier.
- Pay attention to the trailing and torsional strength of the cables as necessary.
- Plug connectors are used to connect the cables to the synchronous servo motor. Cables are available as accessories.
- Observe the chapter Connection method [25] when selecting the cross-sections.
- When using a motor brake, observe the drop in the supply voltage on the line.
- Observe the legal requirements for EMC.

6.1.4 speedtec and springtec plug connectors

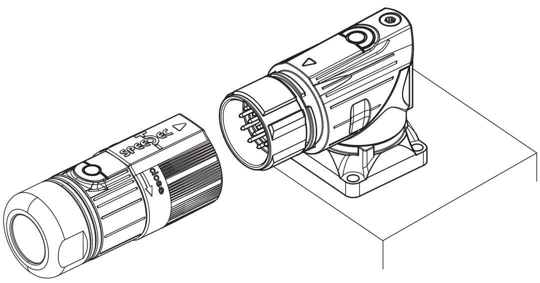
The synchronous servo motors are either equipped with speedtec or springtec angle flange sockets. springtec angle flange sockets are used exclusively in PMCtendo SZ.3x motor types.

The cables are connected as described below.

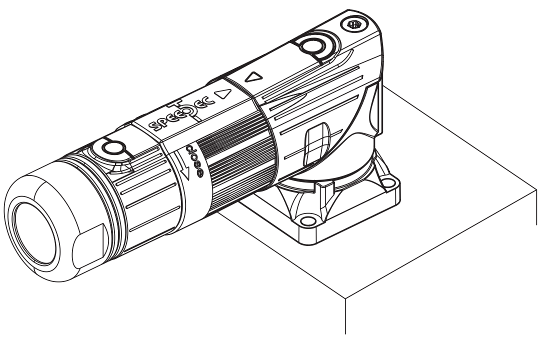
6.1.4.1 Connecting cables using speedtec plug connectors

✓ You have removed the protective caps from the angle flange sockets.

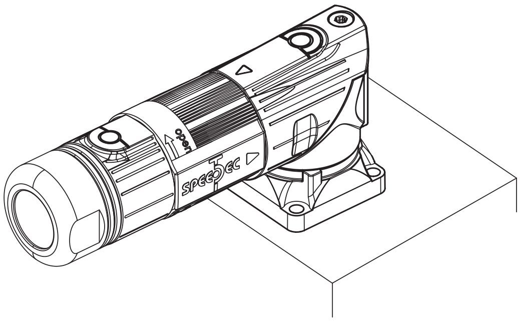
⇨ Align the cap nut so that the arrows on the cap nut and angle flange socket are across from each other:



⇨ Insert the cap nut straight onto the angle flange socket:



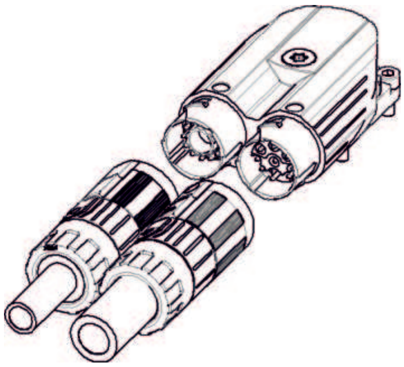
⇨ Turn the screw closure of the cap nut as far as it will go in the close direction:



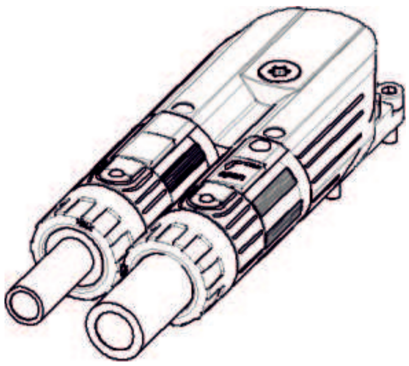
6.1.4.2 Connecting cables using springtec plug connectors

✓ You have removed the protective caps from the angle flange sockets.

⇨ Align the respective cap nuts of the green feedback and orange power plug connectors so that the points on the cap nut and angle flange sockets are across from each other:



⇨ Insert the cap nuts straight onto the angle flange socket:



6.2 Connection method

6.2.1 Connection – Motor housing to grounding conductor system

Connect the motor housing to the grounding conductor system of the machine in order to prevent personal injury and faulty triggering of residual current protective devices.

All attachment parts required for the connection of the grounding conductor to the motor housing are delivered with the motor. The grounding screw of the motor is identified with the ⏚ symbol as per IEC 60417-DB. The cross-section of the grounding conductor has to be at least as large as the cross-section of the lines in the power connection.

6.2.2 EnDat 2.2 power and feedback plug connectors

Synchronous servo motors are equipped with twistable quick-lock plug connectors in the standard version.

For motors with forced ventilation units, avoid collisions between the motor connection cables and the plug connector of the forced ventilation unit. In the event of a collision, turn the motor plug connectors accordingly.

The following images show the position of the plug connectors upon delivery.

PMCtendo SZ.3x – Turning ranges of the plug connectors

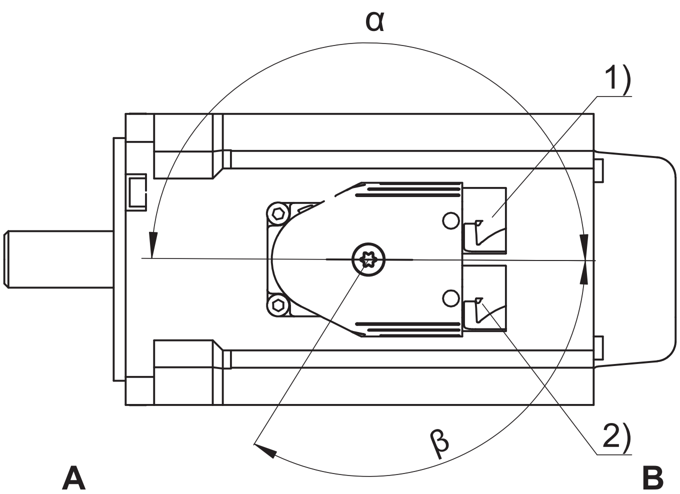


Fig.: PMCtendo SZ.3x – Turning ranges of the plug connectors

Legend

1	Power plug connector	2	Feedback plug connector
A	Attachment or output side of the motor	B	Rear side of the motor

PMCtendo SZ.4x – SZ.8x – Turning ranges of the plug connectors

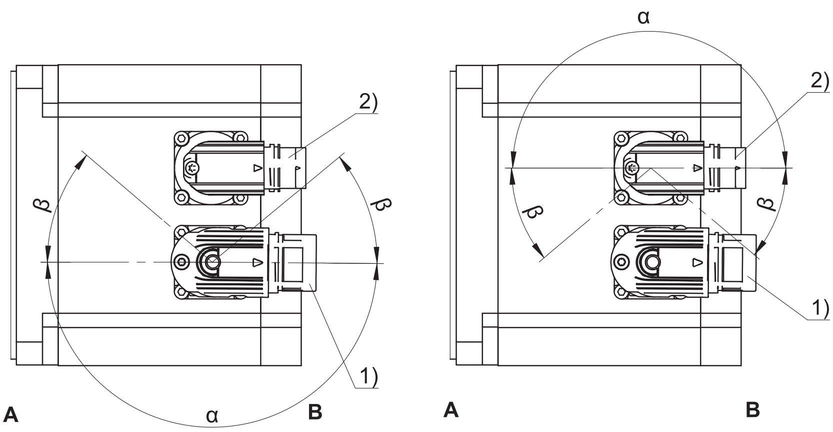


Fig.: PMCtendo SZ.4x – SZ.8x – Turning ranges of the plug connectors

Legend

1	Power plug connector	2	Feedback plug connector
A	Attachment or output side of the motor	B	Rear side of the motor

Features – Power plug connectors

Type	Size	Connection	Turning range	
			α	β
SZ.3x	con.15	Quick lock	180°	120°
SZ.4x, SZ.5x, SZ.71, SZ.73	con.23	Quick lock	180°	40°
SZ.75, SZ.82, SZ.83, SZ.85...K	con.40	Quick lock	180°	40°
SZ.85...F	con.58	Screw thread	0°	0°

Features – Feedback plug connectors

Type	Size	Connection	Turning range	
			α	β
SZ.3x	con.15	Quick lock	180°	120°
SZ.4x, SZ.5x, SZ.7x, SZ.82, SZ.83, SZ.85...K	con.23	Quick lock	180°	40°
SZ.85...F	con.23	Quick lock	180°	0°

Notes

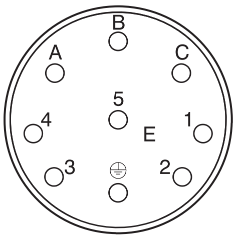
- The number after "con." indicates the approximate external thread diameter of the plug connector in mm (for example, con.23 designates a plug connector with an external thread diameter of about 23 mm).
- In turning range β, the power or feedback plug connectors can be turned only if doing so does not cause them to collide.
- For motor type SZ.3x, the power and feedback plug connectors are connected mechanically and can only be turned together.

6.2.2.1 Terminal assignment – Power plug connectors

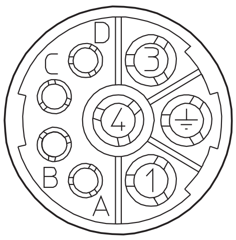
The following power plug connectors are available for PMCtendo SZ motors (the color information relates to the connecting wires and is only relevant for the internal motor wiring).

The size of the plug connector depends on the size of the motor; terminal assignment changes depending on the connector size.

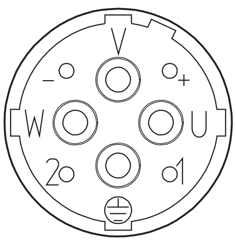
con.15 connector size

Connection diagram	Pin	Connection	Color
	A	1U1	black
	B	1V1	blue
	C	1W1	red
	1		
	2		
	3	1BR+ (brake + DC 24 V)	red
	4	1BR− (brake 0 V)	black
	⏚	PE	green-yellow

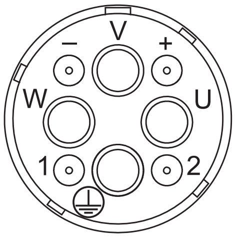
con.23 connector size

Connection diagram	Pin	Connection	Color
	1	1U1	black
	3	1W1	red
	4	1V1	blue
	A	1BR+ (brake + DC 24 V)	red
	B	1BR− (brake 0 V)	black
	C		
	D		
	⏚	PE	green-yellow

con.40 connector sizes

Connection diagram	Pin	Connection	Color
	U	1U1	black
	V	1V1	blue
	W	1W1	red
	+	1BR+ (brake + DC 24 V)	red
	−	1BR− (brake 0 V)	black
	1		
	2		
	⏚	PE	green-yellow

con.58 connector sizes

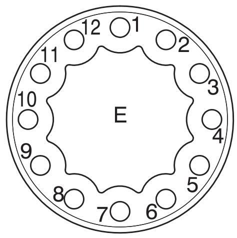
Connection diagram	Pin	Connection	Color
	U	1U1	black
	V	1V1	blue
	W	1W1	red
	+	1BR+ (brake + DC 24 V)	red
	−	1BR− (brake 0 V)	black
	1		
	2		
	⏚	PE	green-yellow

6.2.2.2 Terminal assignment – EnDat 2.2 feedback plug connectors

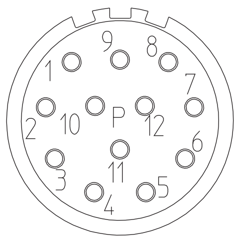
The following EnDat 2.2 plug connectors are available for PMCtendo SZ motors (the color information relates to the connecting wires and is only relevant for internal motor wiring).

The size of the plug connector depends on the size of the motor; the terminal assignment changes depending on the connector size.

EnDat 2.2 – con.15 plug connectors

Connection diagram	Pin	Connection	Color
	1	CLOCK	violet
	2		
	3		
	4	PTC	white
	5	DATA/	pink
	6	DATA	grey
	7		
	8	CLOCK/	yellow
	9		
	10	0 V GND	white green
	11	PTC	black
	12	Up	brown green

EnDat 2.2 – con.23 plug connectors

Connection diagram	Pin	Connection	Color
	1	CLOCK	violet
	2		
	3		
	4	PTC	white
	5	DATA/	pink
	6	DATA	grey
	7		
	8	CLOCK/	yellow
	9		
	10	0 V GND	white green
	11	PTC	black
	12	Up	brown green

6.2.2.3 Overview – Motor types and plug connectors

The following tables show which plug connectors are suitable for which SZ PMCtendo motor types.

NOTICE

Be aware that the assignment of the connector size to the respective minimum cable cross-section $ø_{min}$ refers to a maximum cable length of 100 m.

SZ motors with convection cooling

Type	n_N = 2000 rpm		n_N = 3000 rpm		n_N = 4500 rpm		n_N = 6000 rpm	
	Connector size	$ø_{min}$ [mm^2]	Connector size	$ø_{min}$ [mm^2]	Connector size	$ø_{min}$ [mm^2]	Connector size	$ø_{min}$ [mm^2]
SZ.31...K	—	—	con.15	1.0	—	—	con.15	1.0
SZ.32...K	—	—	con.15	1.0	—	—	con.15	1.0
SZ.33...K	—	—	con.15	1.0	—	—	con.15	1.0
SZ.41...K	—	—	con.23	1.5	—	—	con.23	1.5
SZ.42...K	—	—	con.23	1.5	—	—	con.23	1.5
SZ.44...K	—	—	con.23	1.5	—	—	con.23	1.5
SZ.51...K	—	—	con.23	1.5	—	—	con.23	1.5
SZ.52...K	—	—	con.23	1.5	—	—	con.23	1.5
SZ.53...K	—	—	con.23	1.5	—	—	con.23	1.5
SZ.55...K	—	—	con.23	1.5	con.23	1.5	—	—
SZ.71...K	—	—	con.23	1.5	—	—	con.23	1.5
SZ.72...K	—	—	con.23	1.5	—	—	con.23	2.5
SZ.73...K	—	—	con.23	1.5	con.23	2.5	—	—
SZ.75...K	—	—	con.40	2.5	con.40	4.0	—	—
SZ.82...K	—	—	con.40	4.0	con.40	6.0	—	—
SZ.83...K	—	—	con.40	6.0	—	—	—	—
SZ.85...K	con.40	10.0	—	—	—	—	—	—

SZ motors with forced ventilation units

Type	n_N = 2000 rpm		n_N = 3000 rpm		n_N = 4500 rpm		n_N = 6000 rpm	
	Connec-tor size	$ø_{min}$ [mm²]	Connec-tor size	$ø_{min}$ [mm²]	Connec-tor size	$ø_{min}$ [mm²]	Connec-tor size	$ø_{min}$ [mm²]
SZ.41...F	—	—	con.23	1.5	—	—	con.23	1.5
SZ.42...F	—	—	con.23	1.5	—	—	con.23	1.5
SZ.44...F	—	—	con.23	1.5	—	—	con.23	1.5
SZ.51...F	—	—	con.23	1.5	—	—	con.23	1.5
SZ.52...F	—	—	con.23	1.5	—	—	con.23	1.5
SZ.53...F	—	—	con.23	1.5	—	—	con.23	2.5
SZ.55...F	—	—	con.23	1.5	con.23	2.5	—	—
SZ.71...F	—	—	con.23	1.5	—	—	con.23	1.5
SZ.72...F	—	—	con.23	1.5	—	—	con.23	4.0
SZ.73...F	—	—	con.23	2.5	con.23	4.0	—	—
SZ.75...F	—	—	con.40	4.0	con.40	6.0	—	—
SZ.82...F	—	—	con.40	6.0	con.40	10.0	—	—
SZ.83...F	—	—	con.40	10.0	—	—	—	—
SZ.85...F	con.58	16.0	—	—	—	—	—	—

6.2.3 HIPERFACE DSL power and feedback plug connectors

Single-cable HIPERFACE DSL technology combines the power and feedback connections into one common plug connector.

In motors with forced ventilation, avoid collisions between the motor connection cables and the plug connector of the forced ventilation unit. In the event of a collision, turn the motor plug connectors accordingly.

The following images show the position of the plug connector upon delivery.

PMCtendo SZ.3x...K – Turning range of the plug connector

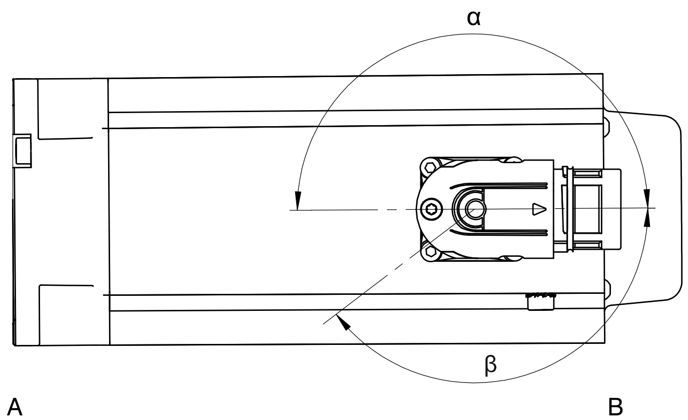


Fig.: PMCtendo SZ.3x...K – Turning range of the plug connector

Legend

A	Attachment or output side of the motor	B	Rear side of the motor

PMCtendo SZ.4x...K – SZ.7x...K – Turning range of the plug connector

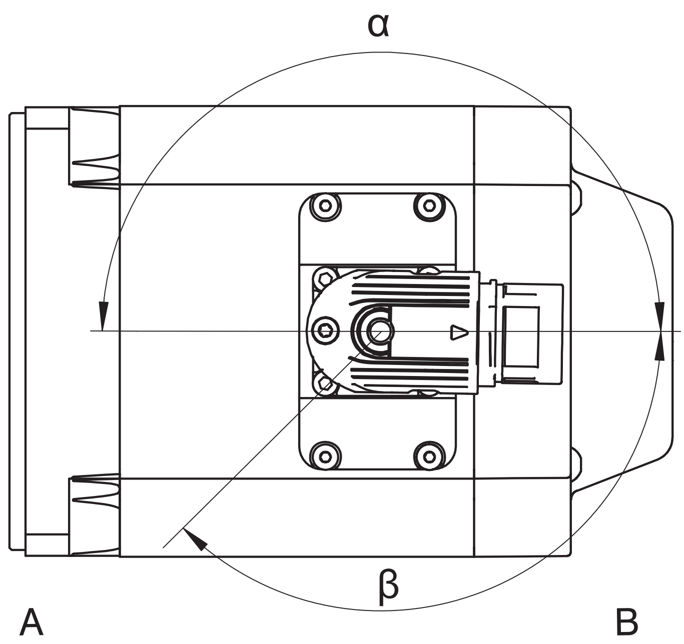


Fig.: PMCtendo SZ.4x...K – SZ.7x...K – Turning range of the plug connector

Legend

A	Attachment or output side of the motor	B	Rear side of the motor

Features – Plug connectors

Type	Size	Connection	Turning range	
			α	β
SZ.3x...K, SZ.4x...K, SZ.5x...K, SZ.71...K, SZ.73...K	con.23	Quick lock	180°	135°
SZ.75...K	con.40	Quick lock	180°	135°

Note

The number after "con." indicates the approximate external thread diameter of the plug connector in mm (for example, con.23 designates a plug connector with an external thread diameter of about 23 mm).

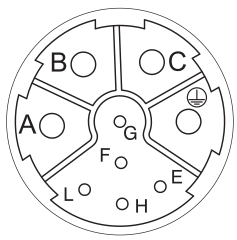
6.2.3.1 Terminal assignment – HIPERFACE DSL plug connectors

The following HIPERFACE DSL plug connectors are available for PMCtendo SZ motors (the color information relates to the connecting wires and is only relevant for internal motor wiring).

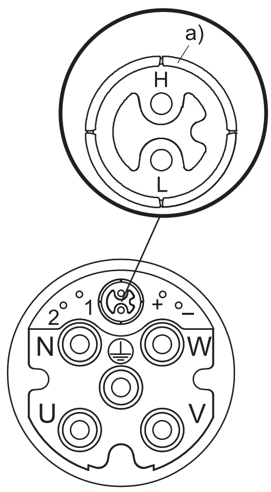
The temperature sensor of the motor is connected to the feedback system internally. The measured values from the temperature sensor are transmitted via the HIPERFACE DSL log of the feedback system.

The size of the plug connector depends on the size of the motor; the terminal assignment changes depending on the connector size.

HIPERFACE DSL – con.23 plug connectors

Connection diagram	Pin	Connection	Color
	A	1U1	black
	B	1V1	blue
	C	1W1	red
	E	DSL− (L)	green
	F	DSL shield	
	G	1BR+ (brake + DC 24 V)	red
	H	DSL+ (H)	grey
	L	1BR− (brake 0 V)	black
	⏚	PE	green-yellow

HIPERFACE DSL – con.40 plug connectors

Connection diagram	Pin	Connection	Color
	U	1U1	black
	V	1V1	blue
	W	1W1	red
	N		
	+	1BR+ (brake + DC 24 V)	red
	−	1BR− (brake 0 V)	black
	1		
	2		
	H	DSL+ (H)	grey
	L	DSL− (L)	green
	⏚	PE	green-yellow
a) Coaxial shield to which the DSL shield is connected			

6.3 Forced ventilation unit

PMCtendo SZ synchronous servo motors offer the option of being cooled with a forced ventilation unit in order to increase performance data while maintaining the same size. Retrofitting with a forced ventilation unit is also possible in order to optimize the drive at a later date. When retrofitting, check whether the conductor cross-section of the power cable of the motor must be increased.

The following plug connection for the connection of the forced ventilation unit is included in the scope of delivery.

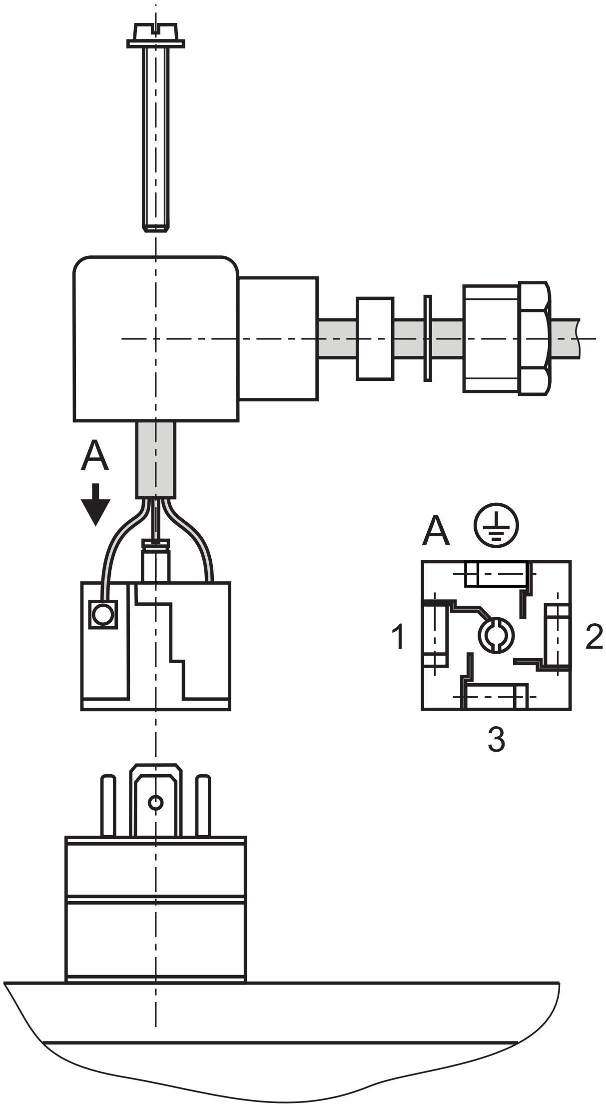


Fig.: Forced ventilation unit

Pin	Signal
1	L1 (phase)
2	N (neutral conductor)
3	—
⏚	PE

7 Commissioning

Observe the 5 safety rules in the chapter Working on the machine [7]!

DANGER!

Electric shock!

Serious injuries due to contact with live parts!

- Carry out all work on a de-energized motor!
- Make sure that the motor shaft is stationary during all work. A rotating rotor can cause high voltages at the connections.
- Disconnect the supply voltage. Be aware that there may still be dangerously high voltages at the servo amplifier, even 10 minutes after switching off the supply voltage, due to the residual charge of the link capacitors.
- Cover all open electrical connections, e.g. using protective caps.
- Secure the installation location as per regulations, e.g. using locks or warning signs.

NOTICE

Be aware that synchronous servo motors may be repaired only by Pilz GmbH & Co. KG. Unauthorized opening of a synchronous servo motor and improper handling will void the warranty.

7.1 Checking the motor installation

DANGER!

Burns!

The surface temperature of a synchronous servo motor can significantly exceed 65 °C through operation.

– Take suitable protective measures against unintentional and intentional contact with the motor.

✓ You have installed a synchronous servo motor as described in the chapter Installation [📖 17].

⇨ Check the general installation and alignment of the synchronous servo motor.

⇨ Check the drive elements (coupling, gear unit, belt drive) for firm placement and correct setting.

⇨ Check whether the motor surface is protected against unintentional or intentional contact.

⇨ Check whether measures have been taken to prevent possible contact with temperature-sensitive motor parts.

⇨ Check whether the rotor of the synchronous servo motor can turn freely.

⇨ If a motor brake is present, it must be released before inspection. Also note the polarity of the connections!

7.2 Checking the motor connection

> **WARNING!**
>
> Risk of injury due to moving parts!
>
> Make sure that:
>
> – No one is put at risk by starting up the motor.
>
> – All protective and safety devices are properly installed, even in test operation.
>
> – Components attached to the drive are sufficiently secured against centrifugal forces (feather keys, coupling elements, etc.).

✓ You have connected a synchronous servo motor as described in the chapter Connection method [📖 25].

⇨ Check whether the grounding was established properly.

⇨ Check whether all live parts are protected against unintentional or intentional contact.

⇨ Check whether the rotor of the synchronous servo motor can turn freely.

⇨ Check the direction of rotation of the synchronous servo motor by actuating it using the corresponding servo amplifier (also observe the documentation of the servo amplifier).

⇨ Check the function of the motor brake by applying control voltage to it (note the polarity). The motor brake must be released.

7.3 Putting the motor into operation

> **WARNING!**
>
> Injury to persons and damage to property due to faulty wiring!
>
> Faulty wiring of the motor and/or feedback system can lead to uncontrolled movements and to personal injury or damage to property as a result.
>
> – Observe the specifications in this operating manual and in the documentation of the servo amplifier used.
>
> – Make sure that components attached to the motor, such as feather keys and coupling elements, are sufficiently secured against centrifugal forces.

Only put the synchronous servo motor into operation if you have reviewed its installation and connection in accordance with this documentation as well as all other necessary requirements specific to your system. In addition, follow the instructions for commissioning your servo amplifier. In multi-unit systems, every drive must be put into operation individually.

7.3.1 Notes for troubleshooting

The following table includes typical faults that can occur on the synchronous servo motor during commissioning. Other possible fault sources include the corresponding servo amplifier, any higher-level controller or the integration of the motor into a multi-unit system. Therefore, observe the respective documentation.

Fault	Possible fault causes	Measure
Motor shaft is not turning	Servo amplifier is not enabled	Set an enable signal for the servo amplifier
	Set value cable interrupted	Check the set value cable
	Motor phases reversed (incorrect rotating magnetic field)	Set the motor phases correctly
	Motor brake not released	▸ Check the brake control ▸ Check the supply voltage of the motor brake
	Drive blocked mechanically	Check the mechanical system
	Torque too low	▸ Check the current limitation in the servo amplifier ▸ Use a more powerful motor or servo amplifier

Fault	Possible fault causes	Measure
Motor shaft turning uncontrolled (positive feedback)	Incorrect feedback offset	Check the feedback offset and set it correctly if necessary
	Motor phases reversed (swapped cyclically, correct rotating magnetic field)	▸ Change the direction of the rotating magnetic field on the servo amplifier ▸ Set the motor phases correctly
Motor vibrates	Feedback cable shield disconnected	▸ Apply the shielding to the feedback cable ▸ Replace the cable if necessary
	Incorrect control parameters	Adjust the control parameters in the servo amplifier
Output-stage error message (at the servo amplifier)	Motor line short-circuited or has ground fault	Replace the cable
	Motor short-circuited or has ground fault	Replace the motor
Feedback error message (at the servo amplifier)	Feedback plug connector not inserted correctly	Check the plug connections
	Feedback cable disconnected, crimped, etc.	Check the cables
Motor temperature message (at the servo amplifier)	Connection to the thermal winding protection interrupted	▸ Apply the shielding to the feedback cable ▸ Check the cables
	Thermal winding protection has activated	▸ Check the thermal situation at the installation location ▸ Use forced ventilation units if necessary
Motor brake not effective	Required torque too high	Check the layout of the motor brake
	Motor brake defective	Replace the motor
	Motor shaft axially overloaded	Check the axial load and reduce it as needed; replace the motor because the bearings are damaged

7.4 Testing and bedding in the brakes

If a brake does not perform any work by friction over a prolonged period, its friction factor can change due to rust deposition or vapors created by high motor temperatures. In the same way, it is possible that slight material deformation becomes noticeable due to high temperature fluctuations.

In order to ensure the unrestricted functional safety of the brakes, including in the case of gravity-loaded vertical axes, the brakes must be subjected to regular brake tests.

Testing the brakes

Load the brake with 1.3x the load torque. When energizing the motor, ensure that the suspended load of a vertical axis exerts a torque on the motor even at a standstill.

Brake re-bedding

If the tested brake torque deviates from the required value, a brake can be bedded again. To perform this action, drive the motor at a maximum of 20 rpm.

Release and close the brake once per second so that the motor has to act against the closed brake for approximately 0.7 seconds. Repeat these steps in the other direction of rotation after approximately 20 cycles.

If the brake's nominal holding torque is still not correct after this bedding process, perform the entire process again.

If the brake torque still has not been set after performing the bedding process four times, check for additional factors that could cause the deviating nominal holding torque, such as reaching the wear limit.

Depending on the specific servo inverter, the bed-in routine can also be automated. Refer to the associated documentation on this topic.

8 Service

Observe the 5 safety rules in the chapter Working on the machine [7]!

DANGER!

Electric shock!

Serious injuries due to contact with live parts!

- Carry out all work on a de-energized motor!
- Make sure that the motor shaft is stationary during all work. A rotating rotor can cause high voltages at the connections.
- Disconnect the supply voltage. Be aware that there may still be dangerously high voltages at the servo amplifier, even 10 minutes after switching off the supply voltage, due to the residual charge of the link capacitors.
- Cover all open electrical connections, e.g. using protective caps.
- Secure the installation location as per regulations, e.g. using locks or warning signs.

NOTICE

Be aware that synchronous servo motors may be repaired only by Pilz GmbH & Co. KG. Unauthorized opening of a synchronous servo motor and improper handling will void the warranty.

8.1 Maintenance

With proper installation, the synchronous servo motors are largely maintenance-free. Since operating conditions vary greatly, maintenance intervals must be adapted to the local conditions (e.g. pollution degree, activation frequency, load).

Maintenance – Regular

- Cleaning the synchronous servo motor

  The cleaning intervals depend on the local pollution degree; note that the original finish must be preserved. Let the motor cool before cleaning; do not use solvents; select the individual cleaning methods based on the protection class of the motor.

Maintenance – Every 500 operating hours, or at least once per quarter

- Inspect the electrical and mechanical connections and retighten as needed.
- Check for smooth operation of the synchronous servo motor and check the installation as needed; if necessary, replace the motor (see the chapter Motor replacement [43]).
- Check the ball bearings for noise and, in the case of deterioration, send in the synchronous servo motor in order to replace the ball bearings.

  Be aware that the ball bearings may be replaced only by Pilz GmbH & Co. KG!

8.2 Procedure in case of faults

Make all personnel working on the machine or motor (machine operators, users, service staff, etc.) aware of any deviations from normal operation. They indicate that function is impaired.
These include:

- Increased power consumption, higher temperatures or increased vibrations.
- Unusual noises or smells.
- (Frequent) triggering of monitoring systems.

In this case, power down the machine and immediately notify the responsible specialist personnel. Check the protective measures that must be taken when in the movement range of a motor, e.g. in the machine/system, especially under raised loads.

8.3 Motor replacement

CAUTION!

Material damage!

Impacts or other uses of force cause damage to the bearings, feedback system and motor shaft.

- Do not hit the motor shaft or motor housing with a hammer or other tools.
- Do not expose the motor to any compressive stress, impacts or high acceleration.
- Use backlash-free, frictional collets or couplings.
- For attaching and releasing couplings, gears or belt drives, always use the intended draw bar thread in the motor shaft. Use a suitable tool!

Observe the following when replacing the motor:

- If servo motors with motor brakes have been stored longer than 2 years, the motor brake must be broken in before using the servo motor.
- Check the insulation resistance of the motor winding after long-term storage.
- Observe the information on the motor installation (see the chapter Installation [17]).
- Reestablish the data reference for the machine coordinate system after replacement.

9 Technical data

9.1 General features

Feature	Description
Design	IM B5, IM V1, IM V3 in accordance with EN 60034-7
Protection class	IP56 / IP66 (option)
Thermal class	155 (F) in accordance with EN 60034-1 (155 °C, heating Δϑ = 100 K)
Surface	Matte black as per RAL 9005
Cooling	IC 410 convection cooling (IC 416 convection cooling with forced ventilation units, optional)
Bearing	Rolling bearing with lifetime lubrication and non-contact sealing
Sealing	Radial shaft seal rings made of FKM (A side)
Shaft	Shaft without feather key, diameter quality k6
Radial runout	Normal tolerance class in accordance with IEC 60072-1
Concentricity	Normal tolerance class in accordance with IEC 60072-1
Axial runout	Normal tolerance class in accordance with IEC 60072-1
Vibration intensity	A in accordance with EN 60034-14
Noise level	Limit values in accordance with EN 60034-9

9.2 Electrical features

Feature	Description
DC link voltage	540 V at servo amplifiers
Winding	Three-phase, single-tooth coil design
Power consumption	See the chapter Type-specific data [51]
Current waveform	Sinusoidal
Circuit	Star, center not led through
Protection class	I (protective grounding) in accordance with EN 61140
Insulation class	F in acc. with EN 60034
Number of poles	▸ 10 (SZ.3x) ▸ 14 (SZ.4x – SZ.7x) ▸ 16 (SZ.8x)

9.3 Ambient conditions

Feature	Description
Surrounding temperature for transport/storage	−30 °C to +85 °C
Surrounding temperature for operation	−15 °C to +40 °C
Installation altitude	≤ 1000 m above sea level
Shock load	≤ 50 m/s² (5 g), 6 ms in accordance with EN 60068-2-27

Notes

- Pilz synchronous servo motors are not suitable for potentially explosive atmospheres in accordance with (ATEX) Directive2014/34/EU.
- Secure the power cables close to the motor so that vibrations of the cable do not place impermissible loads on the motor plug connector.
- Note that the braking torques of the holding brake (optional) may be reduced by shock loading.
- Also take into consideration the shock load of the motor due to output units (such as gear units and pumps) which are coupled with the motor.

9.4 Forced ventilation unit

Type	Forced ventilation unit	$U_{N,F}$ [V]	$I_{N,F}$ [A]	$P_{N,F}$ [W]	$q_{v,F}$ [m³/h]	$L_{p(A)}$ [dBA]	m_F [kg]	Protec-tion class
SZ.4x	FL4	230 V ± 5%, 50/60 Hz	0.07	10	59	41	1.4	IP44
SZ.5x	FL5		0.10	14	160	45	1.9	IP54
SZ.7x	FL7		0.10	14	160	45	2.9	IP54
SZ.8x	FL8		0.20	26	420	54	5.0	IP55

9.5 Feedback connection

EnDat 2.2

Type	Code	Measuring method	Revolu-tions	Resolution	Position per revolution	Operating voltage range
ECI 1118-G2	1	Inductive	–	18 bit	262144	3.6 – 14 V
EQN 1135	2	Optical	4096	23 bit	8388608	3.6 – 14 V

HIPERFACE DSL

Type	Code	Measuring method	Revolu-tions	Resolution	Position per revolu-tion	Operating voltage range
EKM36	7	Optical	4096	20 bit	1048576	7 – 12 V

9.6 Holding brake

Synchronous servo motors can be equipped with a backlash-free permanent magnet holding brake in order to secure the motor shaft when stalled. The holding brake engages automatically if the voltage drops.

Nominal voltage of permanent magnet holding brake: DC 24 V ± 5%, smoothed. Take into account the voltage losses in the connection lines of the holding brake.

Project configuration

- The holding brake is designed to keep the motor shaft from moving. Activate braking processes during operation using the corresponding electrical functions of the drive controller. In exceptional circumstances, the holding brake can be used for braking from full speed (following a power failure or when setting up the machine). The maximum permitted work done by friction $W_{B,Rmax/h}$ may not be exceeded.
- Note that the braking torque M_{Bdyn} may initially be up to 50% less when braking from full speed. As a result, the braking effect has a delayed action and braking distances become longer.
- The holding torque of the brake can be reduced by shock loading. Information about shock loading can be found in the "Ambient conditions" chapter.

Calculation of work done by friction per braking process

$$W_{B,R/B} = \frac{J_{tot} \cdot n^2}{182.4} \cdot \frac{M_{Bdyn}}{M_{Bdyn} \pm M_L}$$

The sign of M_L is positive if the movement runs vertically upwards or horizontally and it is negative if the movement runs vertically down.

Calculation of the stop time

$$t_{dec} = 2.66 \cdot t_{1B} + \frac{n \cdot J_{tot}}{9.55 \cdot M_{Bdyn}}$$

Switching behavior

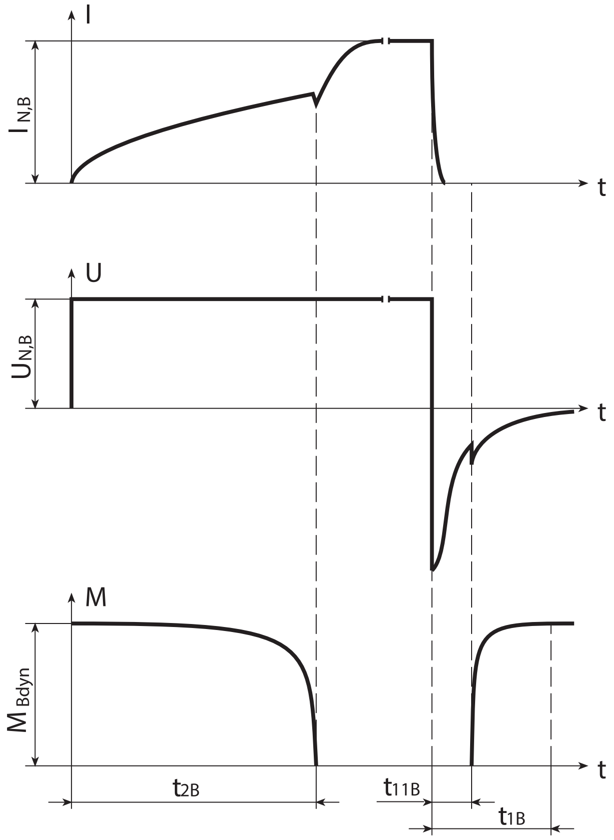


Fig.: Holding brake – Switching behavior

9.6.1 Holding brake – Technical data

Typ	M_{Bstat}	M_{Bdyn}	$I_{N,B}$	$W_{B,Rmax/h}$	$N_{B,stop}$	$J_{B,stop}$	$W_{B,Rlim}$	t_{2B}	t_{11B}	t_{1B}	$x_{B,N}$	ΔJ_B	Δm_B
	[Nm]	[Nm]	[A]	[kJ]		[10^{-4}kgm²]	[kJ]	[ms]	[ms]	[ms]	[mm]	[10^{-4}kgm²]	[kg]
SZ.31	2,5	2,3	0,51	6,0	48000	0,752	180	25	3,0	20	0,2	0,186	0,55
SZ.32	4,0	3,8	0,50	8,5	38000	0,952	180	44	4,0	26	0,3	0,186	0,55
SZ.33	4,0	3,8	0,50	8,5	30000	1,17	180	44	4,0	26	0,3	0,186	0,55
SZ.41	4,0	3,8	0,50	8,5	16000	2,24	180	44	4,0	26	0,3	0,192	0,76
SZ.42	8,0	7,0	0,75	8,5	13500	4,39	300	40	2,0	20	0,3	0,566	0,97
SZ.44	8,0	7,0	0,75	8,5	8500	7,09	300	40	2,0	20	0,3	0,566	0,97
SZ.51	8,0	7,0	0,75	8,5	8700	6,94	300	40	2,0	20	0,3	0,571	1,19
SZ.52	8,0	7,0	0,80	8,5	5200	11,5	300	40	2,0	20	0,3	0,571	1,19
SZ.53	15	12	1,0	11,0	5900	18,6	550	60	5,0	30	0,3	1,721	1,62
SZ.55	15	12	1,0	11,0	4000	27,8	550	60	5,0	30	0,3	1,721	1,62
SZ.71	15	12	1,0	11,0	5400	20,5	550	60	5,0	30	0,3	1,743	1,94
SZ.72	15	12	1,0	11,0	3600	30,9	550	60	5,0	30	0,3	1,743	1,94
SZ.73	32	28	1,1	25,0	5200	54,6	1400	100	5,0	25	0,4	5,680	2,81
SZ.75	32	28	1,1	25,0	3500	79,4	1400	100	5,0	25	0,4	5,680	2,81
SZ.82	65	35	1,7	45,0	6000	149	2250	200	10	50	0,4	16,460	5,40
SZ.83	65	35	1,7	45,0	4500	200	2250	200	10	50	0,4	16,460	5,40
SZ.85	115	70	2,1	65,0	7000	376	6500	190	12	65	0,5	55,460	8,40

9.7 Temperature sensor

Feature	Description
Nominal response temperature ϑ_{NAT}	145 °C ± 5 K
Resistance R −20 °C up to ϑ_{NAT} − 20 K	≤ 250 Ω
Resistance R with ϑ_{NAT} − 5 K	≤ 550 Ω
Resistance R with ϑ_{NAT} + 5 K	≥ 1330 Ω
Resistance R with ϑ_{NAT} + 15 K	≥ 4000 Ω
Operating voltage	≤ DC 7.5 V
Thermal response time	< 5 s

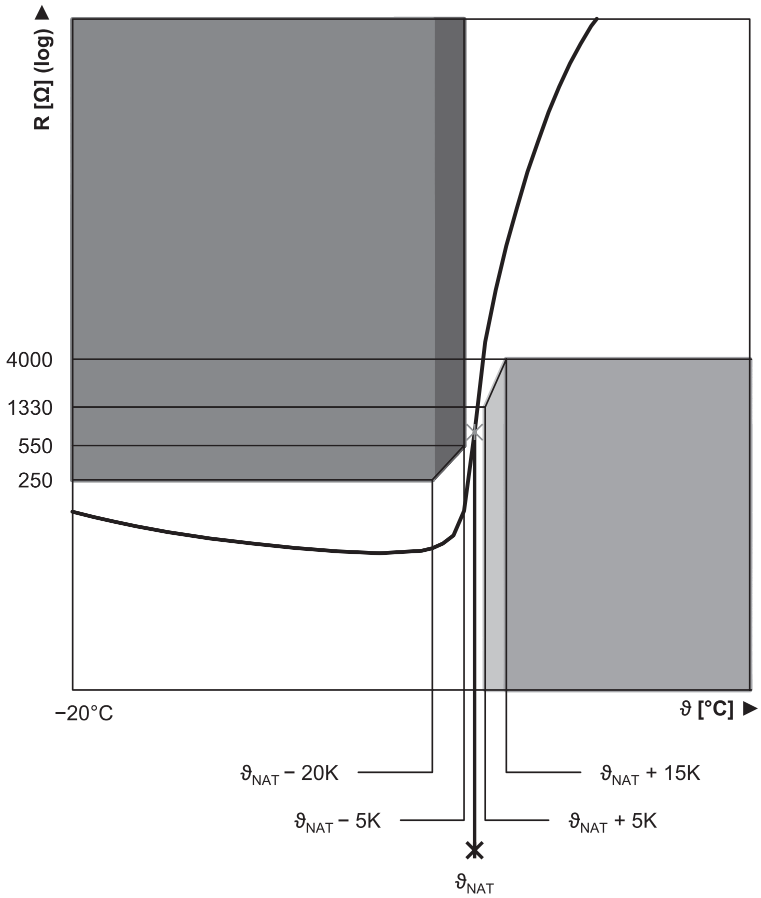


Fig.: PTC thermistor curve (single thermistor)

9.8 Derating

If you use the motor under conditions that differ from the standard ambient conditions, the nominal torque M_N of the motor is reduced.

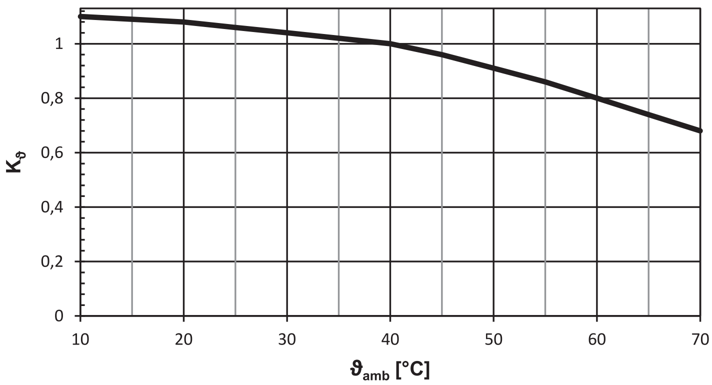


Fig.: Derating depending on the surrounding temperature

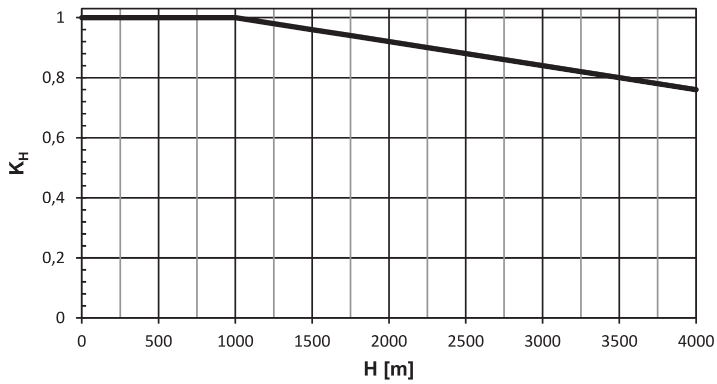


Fig.: Derating depending on the installation height

Calculation

If surrounding temperature ϑ_{amb} > 40 °C:

$M_{Nred} = M_N \cdot K_\vartheta$

If installation altitude H > 1000 m above sea level:

$M_{Nred} = M_N \cdot K_H$

If the surrounding temperature ϑ_{amb} > 40 °C and installation altitude H > 1000 m above sea level:

$M_{Nred} = M_N \cdot K_H \cdot K_\vartheta$

9.9 Type-specific data

9.9.1 Attachment conditions

CAUTION!

Overheating!

Repainting the motor changes its thermal properties. The motor cannot be operated with the nominal data.

– Preserve the finish of the motor (RAL 9005 jet black, matte).

The following technical data applies to the ideal energy configuration of a servo amplifier and was determined under the following thermal attachment conditions:

- Attachment of the synchronous servo motor with a steel bracket to a base plate
- Minimum attachment surfaces between synchronous servo motor and steel bracket and base plate in accordance with the subsequent table.

Type	Dimensions of steel mounting flange (thickness x width x height)	Convection surface area Steel mounting flange
SZ.3x − SZ.5x	23 x 210 x 275 mm	0.16 m^2
SZ.7x − SZ.8x	28 x 300 x 400 mm	0.3 m^2

Make sure that there are comparable thermal attachment conditions in your system.

9.9.2 SZ motors with convection cooling

Typ	K_{EM}	n_N	M_N	I_N	$K_{M,N}$	P_N	M_0	I_0	K_{M0}	M_R	M_{max}	I_{max}	R_{U-V}	L_{U-V}	T_{el}	J_{dyn}	m_{dyn}
	[V/1000	[min⁻¹]	[Nm]	[A]	[Nm/A]	[kW]	[Nm]	[A]	[Nm/A]	[Nm]	[Nm]	[A]	[Ω]	[mH]	[ms]	[10⁻⁴	[kg]
	min⁻¹]															kgm²]	
SZ.31...K	40	6000	0,89	1,93	0,46	0,56	0,95	2,02	0,49	0,04	2,80	12,7	11,70	39,80	3,40	0,19	1,50
SZ.31...K	40	3000	0,93	1,99	0,47	0,29	0,95	2,02	0,49	0,04	2,80	12,7	11,70	39,80	3,40	0,19	1,50
SZ.32...K	42	6000	1,50	3,18	0,47	0,94	1,68	3,48	0,49	0,04	5,00	17,8	4,50	18,70	4,16	0,29	2,10
SZ.32...K	86	3000	1,59	1,60	0,99	0,50	1,68	1,67	1,03	0,04	5,00	8,55	17,80	75,00	4,21	0,29	2,10
SZ.33...K	55	6000	1,96	3,17	0,62	1,2	2,25	3,55	0,65	0,04	7,00	16,9	4,90	21,10	4,31	0,40	2,60
SZ.33...K	109	3000	2,07	1,63	1,27	0,65	2,19	1,71	1,30	0,04	7,00	8,25	20,30	68,70	5,24	0,40	2,60
SZ.41...K	47	6000	2,30	4,56	0,50	1,4	2,80	5,36	0,53	0,04	8,50	33,0	1,94	11,52	5,94	0,93	4,00
SZ.41...K	96	3000	2,80	2,74	1,02	0,88	3,00	2,88	1,06	0,04	8,50	16,5	6,70	37,70	5,63	0,93	4,00
SZ.42...K	60	6000	3,50	5,65	0,62	2,2	4,90	7,43	0,66	0,04	16,0	43,5	1,20	8,88	7,40	1,63	5,10
SZ.42...K	94	3000	4,70	4,40	1,07	1,5	5,20	4,80	1,09	0,04	16,0	26,5	3,00	21,80	7,26	1,63	5,10
SZ.44...K	78	6000	5,80	7,18	0,81	3,6	8,40	9,78	0,86	0,04	29,0	51,0	0,89	7,07	7,94	2,98	7,20
SZ.44...K	116	3000	6,90	5,80	1,19	2,2	8,60	6,60	1,31	0,04	29,0	35,0	1,85	15,00	8,11	2,98	7,20
SZ.51...K	68	6000	3,40	4,77	0,71	2,1	4,40	5,80	0,77	0,06	16,0	31,0	2,10	12,10	5,76	2,90	5,00
SZ.51...K	97	3000	4,30	3,74	1,15	1,4	4,70	4,00	1,19	0,06	16,0	22,0	3,80	23,50	6,18	2,90	5,00
SZ.52...K	72	6000	5,20	7,35	0,71	3,3	7,80	9,80	0,80	0,06	31,0	59,0	0,76	5,60	7,37	5,20	6,50
SZ.52...K	121	3000	7,40	5,46	1,36	2,3	8,00	5,76	1,40	0,06	31,0	33,0	2,32	16,80	7,24	5,20	6,50
SZ.53...K	84	6000	6,20	7,64	0,81	3,9	10,6	11,6	0,92	0,06	43,0	63,5	0,62	5,00	8,06	7,58	8,00
SZ.53...K	119	3000	9,70	6,90	1,41	3,1	11,1	7,67	1,46	0,06	43,0	41,0	1,25	10,00	8,00	7,58	8,00
SZ.55...K	103	4500	9,50	8,94	1,06	4,5	15,3	13,4	1,15	0,06	67,0	73,0	0,50	4,47	8,94	12,2	10,9
SZ.55...K	141	3000	13,5	8,80	1,53	4,2	16,0	10,0	1,61	0,06	67,0	52,0	0,93	8,33	8,96	12,2	10,9

Typ	K_{EM}	n_N	M_N	I_N	$K_{M,N}$	P_N	M_0	I_0	K_{M0}	M_R	M_{max}	I_{max}	R_{U-V}	L_{U-V}	T_{el}	J_{dyn}	m_{dyn}
	[V/1000 min^{-1}]	[min^{-1}]	[Nm]	[A]	[Nm/A]	[kW]	[Nm]	[A]	[Nm/A]	[Nm]	[Nm]	[A]	[Ω]	[mH]	[ms]	[10^{-4} kgm^2]	[kg]
SZ.71...K	76	6000	5,20	6,68	0,78	3,3	7,90	9,38	0,87	0,24	20,0	31,0	0,87	8,13	9,34	8,50	8,30
SZ.71...K	95	3000	7,40	7,20	1,03	2,3	8,30	8,00	1,07	0,24	20,0	25,0	1,30	12,83	9,87	8,50	8,30
SZ.72...K	82	6000	7,20	8,96	0,80	4,5	14,3	16,5	0,88	0,24	41,0	60,5	0,34	3,90	11,47	13,7	10,8
SZ.72...K	133	3000	12,0	8,20	1,46	3,8	14,4	9,60	1,53	0,24	41,0	36,0	1,00	11,73	11,73	13,7	10,8
SZ.73...K	99	4500	12,1	11,5	1,05	5,7	20,0	17,8	1,14	0,24	65,0	78,0	0,36	4,42	12,28	21,6	12,8
SZ.73...K	122	3000	16,5	11,4	1,45	5,2	20,8	14,0	1,50	0,24	65,0	62,0	0,52	6,80	13,08	21,6	12,8
SZ.75...K	106	4500	16,4	14,8	1,11	7,7	30,0	25,2	1,20	0,24	104	114	0,22	2,76	12,55	34,0	18,3
SZ.75...K	140	3000	21,3	14,2	1,50	6,7	30,2	19,5	1,56	0,24	104	87,0	0,33	4,80	14,55	34,0	18,3
SZ.82...K	90	4500	10,5	11,2	0,94	5,0	34,5	33,3	1,05	0,30	100	135	0,13	1,90	14,60	58,0	26,6
SZ.82...K	136	3000	22,3	13,9	1,60	7,0	37,1	22,3	1,68	0,30	100	84,0	0,30	5,00	16,66	58,0	26,6
SZ.83...K	131	3000	26,6	17,7	1,50	8,4	48,2	31,1	1,56	0,30	145	124	0,18	2,79	15,50	83,5	32,7
SZ.85...K	142	2000	43,7	25,9	1,69	9,2	66,1	37,9	1,75	0,30	205	155	0,13	2,22	17,08	133	45,8

9.9.3 SZ motors with forced ventilation units

Typ	K_{EM} [V/1000 min⁻¹]	n_N [min⁻¹]	M_N [Nm]	I_N [A]	$K_{M,N}$ [Nm/A]	P_N [kW]	M_0 [Nm]	I_0 [A]	K_{M0} [Nm/A]	M_R [Nm]	M_{max} [Nm]	I_{max} [A]	R_{U-V} [Ω]	L_{U-V} [mH]	T_{el} [ms]	J_{dyn} [10^{-4} kgm²]	m_{dyn} [kg]
SZ.41...F	47	6000	2,90	5,62	0,52	1,8	3,50	6,83	0,52	0,04	8,50	33,0	1,94	11,52	5,94	0,93	5,40
SZ.41...F	96	3000	3,40	3,40	1,00	1,1	3,70	3,60	1,04	0,04	8,50	16,5	6,70	37,70	5,63	0,93	5,40
SZ.42...F	60	6000	5,10	7,88	0,65	3,2	6,40	9,34	0,69	0,04	16,0	43,5	1,20	8,88	7,40	1,63	6,50
SZ.42...F	94	3000	5,90	5,50	1,07	1,9	6,30	5,80	1,09	0,04	16,0	26,5	3,00	21,80	7,26	1,63	6,50
SZ.44...F	78	6000	8,00	9,98	0,80	5,0	10,5	12,0	0,88	0,04	29,0	51,0	0,89	7,07	7,94	2,98	8,60
SZ.44...F	116	3000	10,2	8,20	1,24	3,2	11,2	8,70	1,29	0,04	29,0	35,0	1,85	15,00	8,11	2,98	8,60
SZ.51...F	68	6000	4,50	6,70	0,67	2,8	5,70	7,50	0,77	0,06	16,0	31,0	2,10	12,10	5,76	2,90	7,00
SZ.51...F	97	3000	5,40	4,70	1,15	1,7	5,80	5,00	1,17	0,06	16,0	22,0	3,80	23,50	6,18	2,90	7,00
SZ.52...F	72	6000	8,20	11,4	0,72	5,2	10,5	13,4	0,79	0,06	31,0	59,0	0,76	5,60	7,37	5,20	8,50
SZ.52...F	121	3000	10,3	7,80	1,32	3,2	11,2	8,16	1,38	0,06	31,0	33,0	2,32	16,80	7,24	5,20	8,50
SZ.53...F	84	6000	10,4	13,5	0,77	6,5	14,8	15,9	1,07	0,06	43,0	63,5	0,62	5,00	8,06	7,58	10,0
SZ.53...F	119	3000	14,4	10,9	1,32	4,5	15,9	11,8	1,35	0,06	43,0	41,0	1,25	10,00	8,00	7,58	10,0
SZ.55...F	103	4500	16,4	16,4	1,00	7,7	22,0	19,4	1,14	0,06	67,0	73,0	0,50	4,47	8,94	12,2	12,9
SZ.55...F	141	3000	20,2	13,7	1,47	6,4	23,4	14,7	1,60	0,06	67,0	52,0	0,93	8,33	8,96	12,2	12,9
SZ.71...F	76	6000	7,50	10,6	0,71	4,7	10,2	12,4	0,84	0,24	20,0	31,0	0,87	8,13	9,34	8,50	13,3
SZ.71...F	95	3000	9,70	9,50	1,02	3,1	10,5	10,0	1,07	0,24	20,0	25,0	1,30	12,83	9,87	8,50	13,3
SZ.72...F	82	6000	12,5	16,7	0,75	7,9	19,3	22,1	0,89	0,24	41,0	60,5	0,34	3,90	11,47	13,7	15,8
SZ.72...F	133	3000	16,6	11,8	1,41	5,2	19,3	12,9	1,51	0,24	41,0	36,0	1,00	11,73	11,73	13,7	15,8
SZ.73...F	99	4500	19,8	20,3	0,98	9,3	27,2	24,2	1,13	0,24	65,0	78,0	0,36	4,42	12,28	21,6	17,8
SZ.73...F	122	3000	24,0	18,2	1,32	7,5	28,0	20,0	1,41	0,24	65,0	62,0	0,52	6,80	13,08	21,6	17,8

Typ	K_{EM}	n_N	M_N	I_N	$K_{M,N}$	P_N	M_0	I_0	K_{M0}	M_R	M_{max}	I_{max}	R_{U-V}	L_{U-V}	T_{el}	J_{dyn}	m_{dyn}
	[V/1000 min⁻¹]	[min⁻¹]	[Nm]	[A]	[Nm/A]	[kW]	[Nm]	[A]	[Nm/A]	[Nm]	[Nm]	[A]	[Ω]	[mH]	[ms]	[10^{-4} kgm²]	[kg]
SZ.75...F	106	4500	27,7	25,4	1,09	13	39,4	32,8	1,21	0,24	104	114	0,22	2,76	12,55	34,0	23,3
SZ.75...F	140	3000	33,8	22,9	1,48	11	41,8	26,5	1,59	0,24	104	87,0	0,33	4,80	14,55	34,0	23,3
SZ.82...F	90	4500	30,6	30,5	1,00	14	47,4	45,1	1,06	0,30	100	135	0,13	1,90	14,60	58,0	31,6
SZ.82...F	136	3000	34,3	26,5	1,29	11	47,9	28,9	1,67	0,30	100	84,0	0,30	5,00	16,66	58,0	31,6
SZ.83...F	131	3000	49,0	35,9	1,37	15	66,7	42,3	1,58	0,30	145	124	0,18	2,79	15,50	83,5	37,7
SZ.85...F	142	2000	77,2	45,2	1,71	16	94,0	53,9	1,75	0,30	205	155	0,13	2,22	17,08	133	51,8

9.9.4 Dimensional drawings

Dimensions can exceed the specifications of ISO 2768-mK due to casting tolerances or accumulation of individual tolerances.

We reserve the right to make dimensional changes due to ongoing technical development.

You can find CAD drawings and models at http://www.pilz.com or receive them by request.

Solid shaft	Tolerance
Shaft ∅ fit ≤ 50 mm	DIN 748-1, ISO k6
Shaft ∅ fit > 50 mm	DIN 748-1, ISO m6

Centering holes in solid shafts in accordance with DIN 332-2, DR shape

Thread size	M4	M5	M6	M8	M10	M12	M16	M20	M24
Thread depth [mm]	10	12.5	16	19	22	28	36	42	50

9.9.4.1 PMCtendo SZ.3x

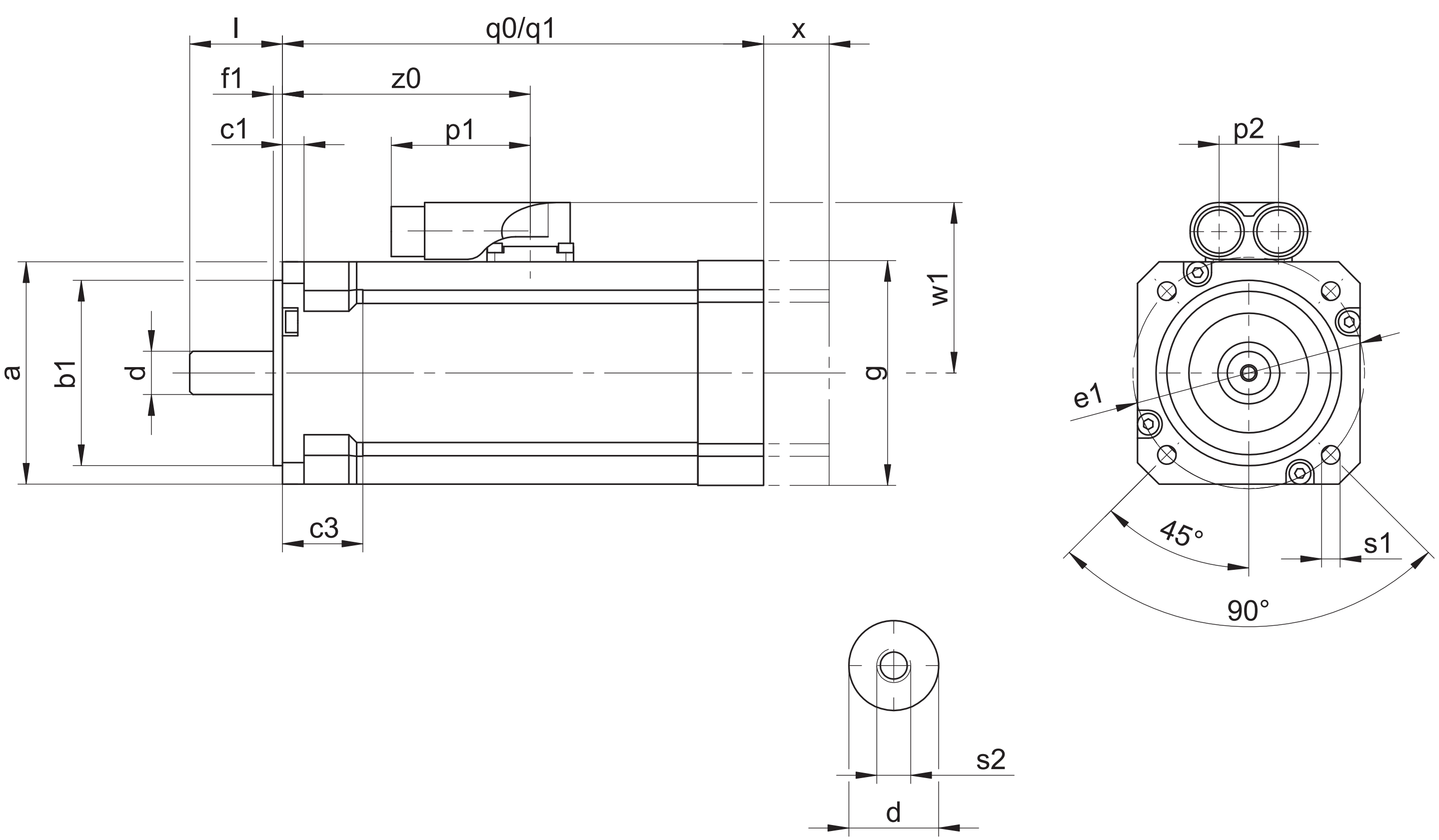


Fig.: PMCtendo SZ.3x – Dimensions

Legend

q0 Applies to motors without holding brake

q1 Applies to motors with holding brake

x Applies to feedback systems with an optical measuring method

Typ	□a	∅b1	c1	c3	∅d	∅e1	f1	□g	l	p1	p2	q0	q1	∅s1	s2	w1	x	z0
SZ.31...K	72	60_{j6}	7	26	14_{k6}	75	3	72	30	45	19	116	156	6	M5	55,5	21	80,5
SZ.32...K	72	60_{j6}	7	26	14_{k6}	75	3	72	30	45	19	138	178	6	M5	55,5	21	102,5
SZ.33...K	72	60_{j6}	7	26	14_{k6}	75	3	72	30	45	19	160	200	6	M5	55,5	21	124,5

9.9.4.2 PMCtendo SZ.3x (HIPERFACE DSL)

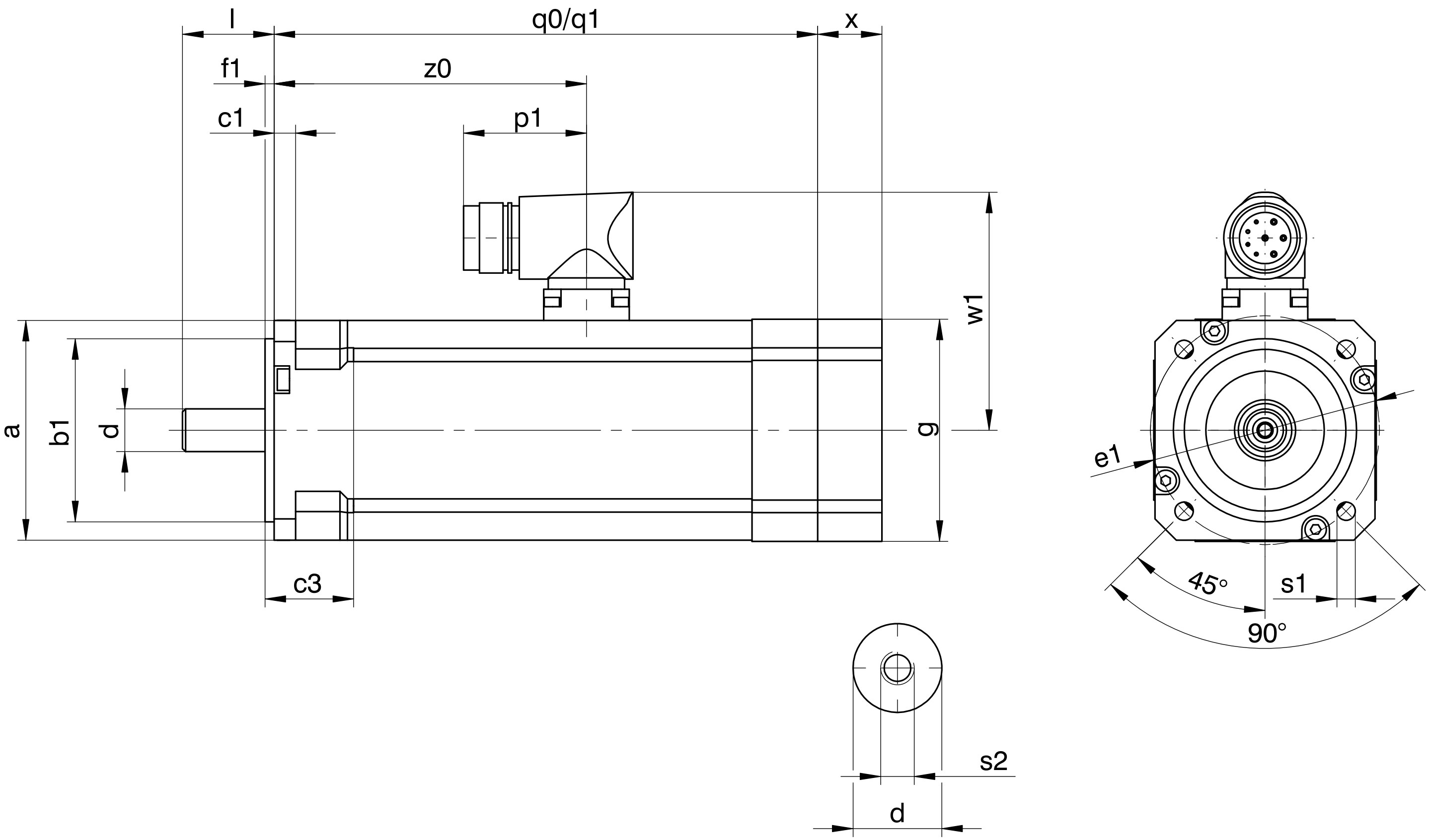


Fig.: PMCtendo SZ.3x (HIPERFACE DSL) – Dimensions

Legend

q0 Applies to motors without holding brake

q1 Applies to motors with holding brake

Typ	□a	∅b1	c1	c3	∅d	∅e1	f1	□g	l	p1	q0	q1	∅s1	s2	w1	x	z0
SZ.31...K	72	60_{j6}	7	26	14_{k6}	75	3	72	30	40	116	156	6	M5	78	21	80,5
SZ.32...K	72	60_{j6}	7	26	14_{k6}	75	3	72	30	40	138	178	6	M5	78	21	102,5
SZ.33...K	72	60_{j6}	7	26	14_{k6}	75	3	72	30	40	160	200	6	M5	78	21	124,5

9.9.4.3 PMCtendo SZ.4x – SZ.8x with convection cooling

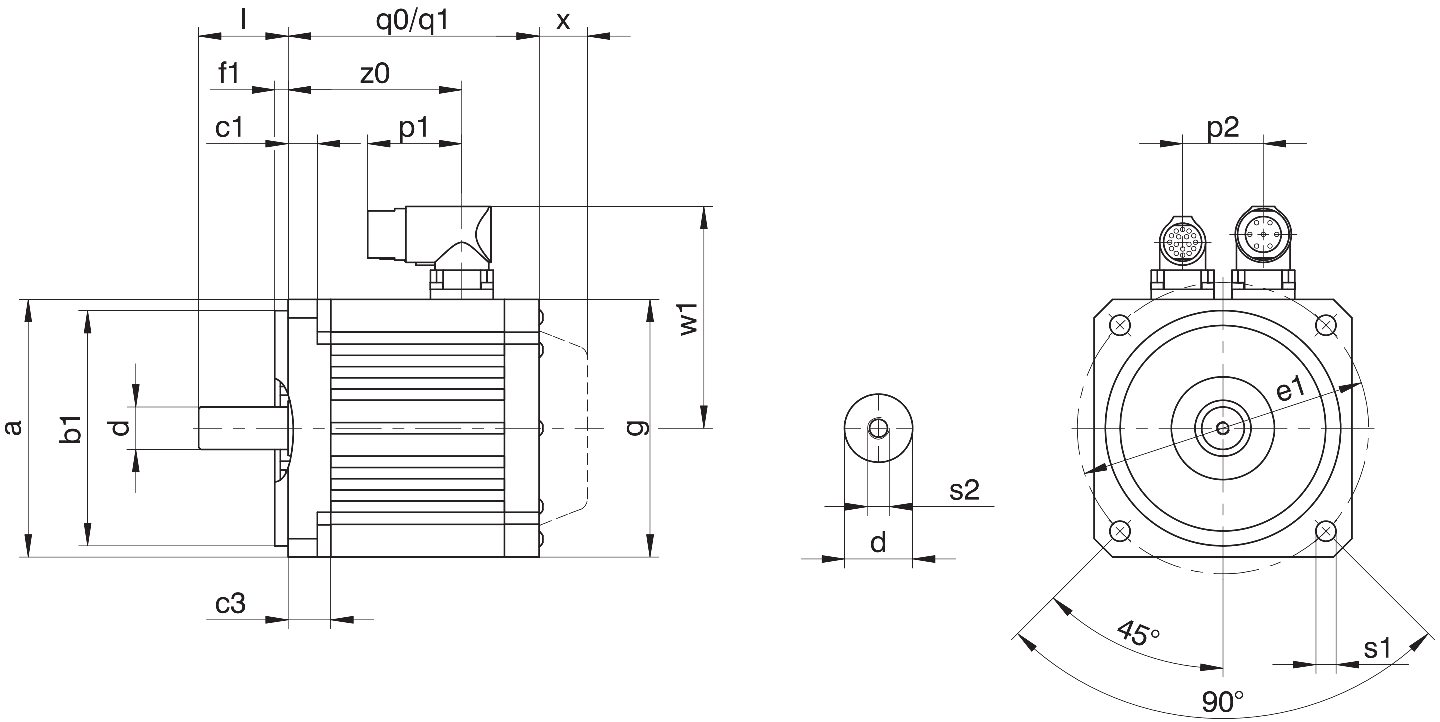


Fig.: PMCtendo SZ.4x – SZ.8x with convection cooling – Dimensions

Legend

q0 Applies to motors without holding brake

x Applies to feedback systems with an optical measuring method

q1 Applies to motors with holding brake

Typ	□a	∅b1	c1	c3	∅d	∅e1	f1	□g	l	p1	p2	q0	q1	∅s1	s2	w1	x	z0
SZ.41...K	98	95_{j6}	9,5	20,5	14_{k6}	115	3,5	98	30	40	32	118,5	167,0	9	M5	91,0	22	76,5
SZ.42...K	98	95_{j6}	9,5	20,5	19_{k6}	115	3,5	98	40	40	32	143,5	192,0	9	M6	91,0	22	101,5
SZ.44...K	98	95_{j6}	9,5	20,5	19_{k6}	115	3,5	98	40	40	32	193,5	242,0	9	M6	91,0	22	151,5
SZ.51...K	115	110_{j6}	10,0	16,0	19_{k6}	130	3,5	115	40	40	36	109,0	163,5	9	M6	100,0	22	74,5
SZ.52...K	115	110_{j6}	10,0	16,0	19_{k6}	130	3,5	115	40	40	36	134,0	188,5	9	M6	100,0	22	99,5
SZ.53...K	115	110_{j6}	10,0	16,0	24_{k6}	130	3,5	115	50	40	36	159,0	213,5	9	M8	100,0	22	124,5
SZ.55...K	115	110_{j6}	10,0	16,0	24_{k6}	130	3,5	115	50	40	36	209,0	263,5	9	M8	100,0	22	174,5
SZ.71...K	145	130_{j6}	10,0	19,0	24_{k6}	165	3,5	145	50	40	42	121,0	180,0	11	M8	115,0	22	83,0
SZ.72...K	145	130_{j6}	10,0	19,0	24_{k6}	165	3,5	145	50	40	42	146,0	205,0	11	M8	115,0	22	108,0
SZ.73...K	145	130_{j6}	10,0	19,0	24_{k6}	165	3,5	145	50	40	42	171,0	230,0	11	M8	115,0	22	133,0
SZ.75...K	145	130_{j6}	10,0	19,0	32_{k6}	165	3,5	145	58	71	42	226,0	285,0	11	M12	134,0	22	184,0
SZ.82...K	190	180_{j6}	15,0	25,0	32_{k6}	215	3,5	190	58	71	60	222,0	299,0	13,5	M12	156,5	22	168,0
SZ.83...K	190	180_{j6}	15,0	25,0	38_{k6}	215	3,5	190	80	71	60	263,0	340,0	13,5	M12	156,5	22	209,0
SZ.85...K	190	180_{j6}	15,0	25,0	38_{k6}	215	3,5	190	80	71	60	345,0	422,0	13,5	M12	156,5	22	277,0

9.9.4.4 PMCtendo SZ.4x – SZ.7x with convection cooling (HIPERFACE DSL)

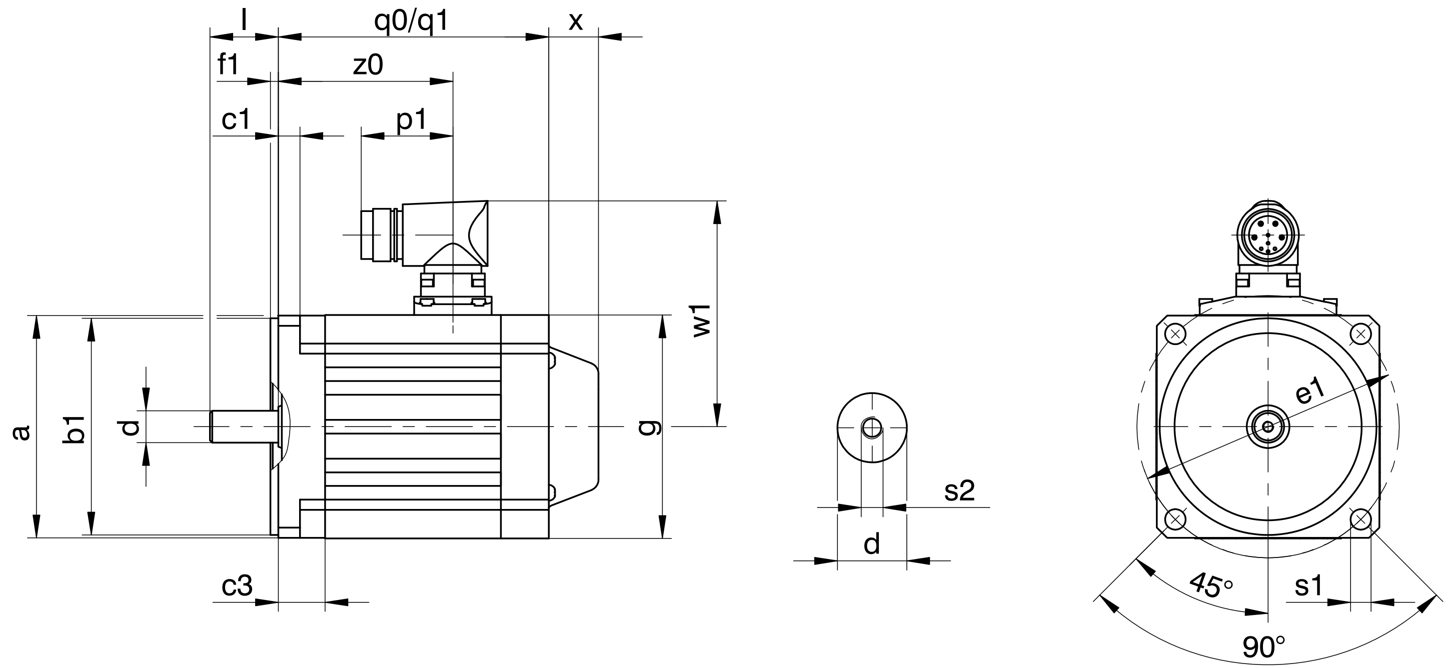


Fig.: PMCtendo SZ.4x – SZ.7x with convection cooling (HIPERFACE DSL) – Dimensions

Legend

q0	Applies to motors without holding brake	q1	Applies to motors with holding brake

Typ	□a	∅b1	c1	c3	∅d	∅e1	f1	□g	l	p1	q0	q1	∅s1	s2	w1	x	z0
SZ.41...K	98	95_{j6}	9,5	20,5	14_{k6}	115	3,5	98	30	40	118,5	167,0	9	M5	99	22	76,5
SZ.42...K	98	95_{j6}	9,5	20,5	19_{k6}	115	3,5	98	40	40	143,5	192,0	9	M6	99	22	101,5
SZ.44...K	98	95_{j6}	9,5	20,5	19_{k6}	115	3,5	98	40	40	193,5	242,0	9	M6	99	22	151,5
SZ.51...K	115	110_{j6}	10,0	16,0	19_{k6}	130	3,5	115	40	40	109,0	163,5	9	M6	110	22	74,5
SZ.52...K	115	110_{j6}	10,0	16,0	19_{k6}	130	3,5	115	40	40	134,0	188,5	9	M6	110	22	99,5
SZ.53...K	115	110_{j6}	10,0	16,0	24_{k6}	130	3,5	115	50	40	159,0	213,5	9	M8	110	22	124,5
SZ.55...K	115	110_{j6}	10,0	16,0	24_{k6}	130	3,5	115	50	40	209,0	263,5	9	M8	110	22	174,5
SZ.71...K	145	130_{j6}	10,0	19,0	24_{k6}	165	3,5	145	50	40	121,0	180,0	11	M8	125	22	83,0
SZ.72...K	145	130_{j6}	10,0	19,0	24_{k6}	165	3,5	145	50	40	146,0	205,0	11	M8	125	22	108,0
SZ.73...K	145	130_{j6}	10,0	19,0	24_{k6}	165	3,5	145	50	40	171,0	230,0	11	M8	125	22	133,0
SZ.75...K	145	130_{j6}	10,0	19,0	32_{k6}	165	3,5	145	58	71	226,0	285,0	11	M12	144	22	184,0

9.9.4.5 PMCtendo SZ.4x – SZ.8x with forced ventilation unit

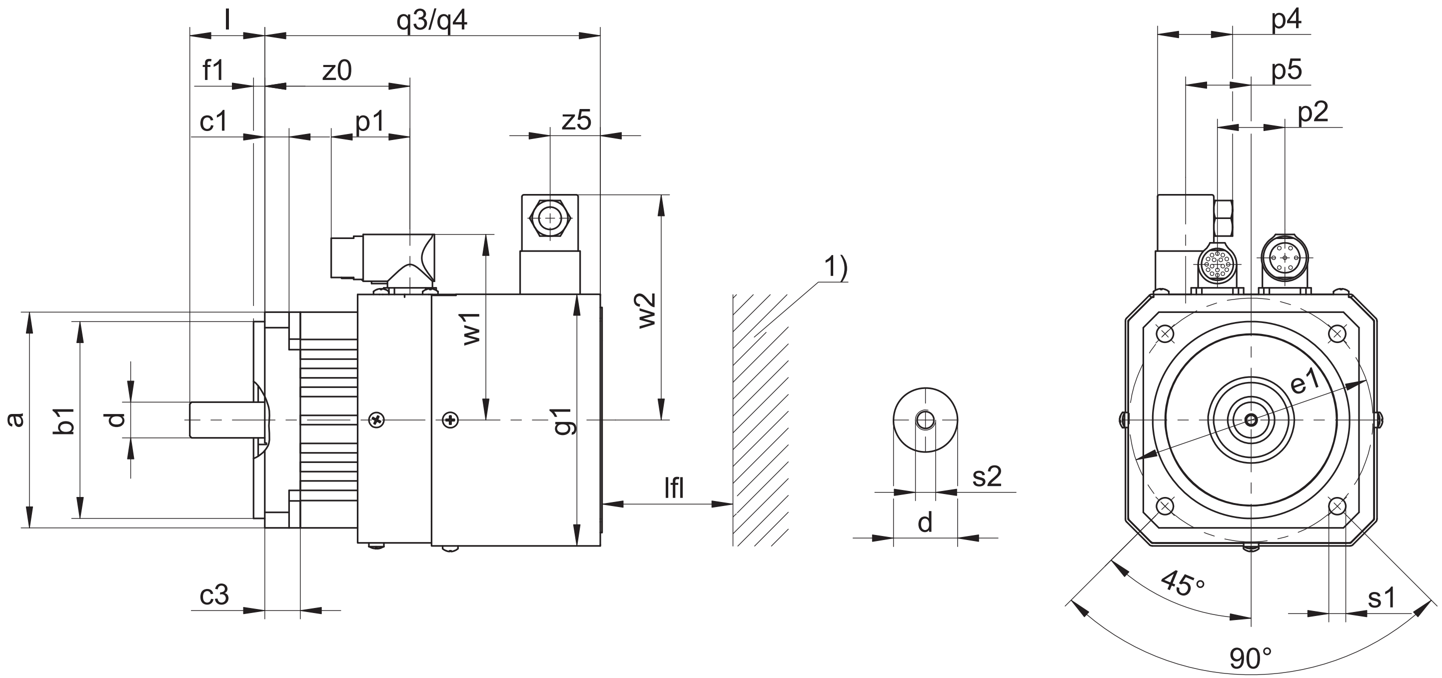


Fig.: PMCtendo SZ.4x – SZ.8x with forced ventilation unit – Dimensions

Legend

q3	Applies to motors without holding brake
q4	Applies to motors with holding brake
1)	Machine wall

Typ	□a	∅b1	c1	c3	∅d	∅e1	f1	□g1	l	lfl$_{min}$	p1	p2	p4	p5	q3	q4	∅s1	s2	w1	w2	z0	z5
SZ.41...F	98	95_{j6}	9,5	20,5	14_{k6}	115	3,5	118	30	20	40	32	37,5	0	175	224	9,0	M5	91,0	111	76,5	25
SZ.42...F	98	95_{j6}	9,5	20,5	19_{k6}	115	3,5	118	40	20	40	32	37,5	0	200	249	9,0	M6	91,0	111	101,5	25
SZ.44...F	98	95_{j6}	9,5	20,5	19_{k6}	115	3,5	118	40	20	40	32	37,5	0	250	299	9,0	M6	91,0	111	151,5	25
SZ.51...F	115	110_{j6}	10,0	16,0	19_{k6}	130	3,5	135	40	20	40	36	37,5	0	179	234	9,0	M6	100,0	120	74,5	25
SZ.52...F	115	110_{j6}	10,0	16,0	19_{k6}	130	3,5	135	40	20	40	36	37,5	0	204	259	9,0	M6	100,0	120	99,5	25
SZ.53...F	115	110_{j6}	10,0	16,0	24_{k6}	130	3,5	135	50	20	40	36	37,5	0	229	284	9,0	M8	100,0	120	124,5	25
SZ.55...F	115	110_{j6}	10,0	16,0	24_{k6}	130	3,5	135	50	20	40	36	37,5	0	279	334	9,0	M8	100,0	120	174,5	25
SZ.71...F	145	130_{j6}	10,0	19,0	24_{k6}	165	3,5	165	50	30	40	42	37,5	0	213	272	11,0	M8	115,0	134	83,0	40
SZ.72...F	145	130_{j6}	10,0	19,0	24_{k6}	165	3,5	165	50	30	40	42	37,5	0	238	297	11,0	M8	115,0	134	108,0	40
SZ.73...F	145	130_{j6}	10,0	19,0	24_{k6}	165	3,5	165	50	30	40	42	37,5	0	263	322	11,0	M8	115,0	134	133,0	40
SZ.75...F	145	130_{j6}	10,0	19,0	32_{k6}	165	3,5	165	58	30	71	42	37,5	0	318	377	11,0	M12	134,0	134	184,0	40
SZ.82...F	190	180_{j6}	15,0	25,0	32_{k6}	215	3,5	215	58	30	71	60	37,5	62	322	399	13,5	M12	156,5	160	168,0	40
SZ.83...F	190	180_{j6}	15,0	25,0	38_{k6}	215	3,5	215	80	30	71	60	37,5	62	363	440	13,5	M12	156,5	160	209,0	40
SZ.85...F	190	180_{j6}	15,0	25,0	38_{k6}	215	3,5	215	80	30	71	60	37,5	62	445	522	13,5	M12	178,0	160	277,0	40

9.9.5 Mass moment of inertia

Type	J_{Motor}	ΔJ	ΔJ_B	Δm	Δm_B
	10^{-4} [kgm^2]			[kg]	[kg]
SZ.31	0.19	—	0.186	—	0.55
SZ.32	0.29	—			0.55
SZ.33	0.4	—			0.55
SZ.41	0.93	0.2	0.192	0.08	0.76
SZ.42	1.63	0.4	0.566	0.15	0.97
SZ.44	2.98	0.8		0.31	0.97
SZ.51	2.9	—	0.571	—	1.19
SZ.52	5.2	1.1		0.22	1.19
SZ.53	7.58	2	1.721	0.43	1.62
SZ.55	12.2	4.1		0.87	1.62
SZ.71	8.5	—	1.743	—	1.94
SZ.72	13.7	4.4		0.41	1.94
SZ.73	21.6	6.3	5.68	0.81	2.81
SZ.75	34	13.6		1.6	2.81
SZ.82	58	14.9	16.46	1.3	5.40
SZ.83	83.5	22.3		1.9	5.40
SZ.85	133	37.2	55.46	3.2	8.40

9.9.6 Permitted shaft load

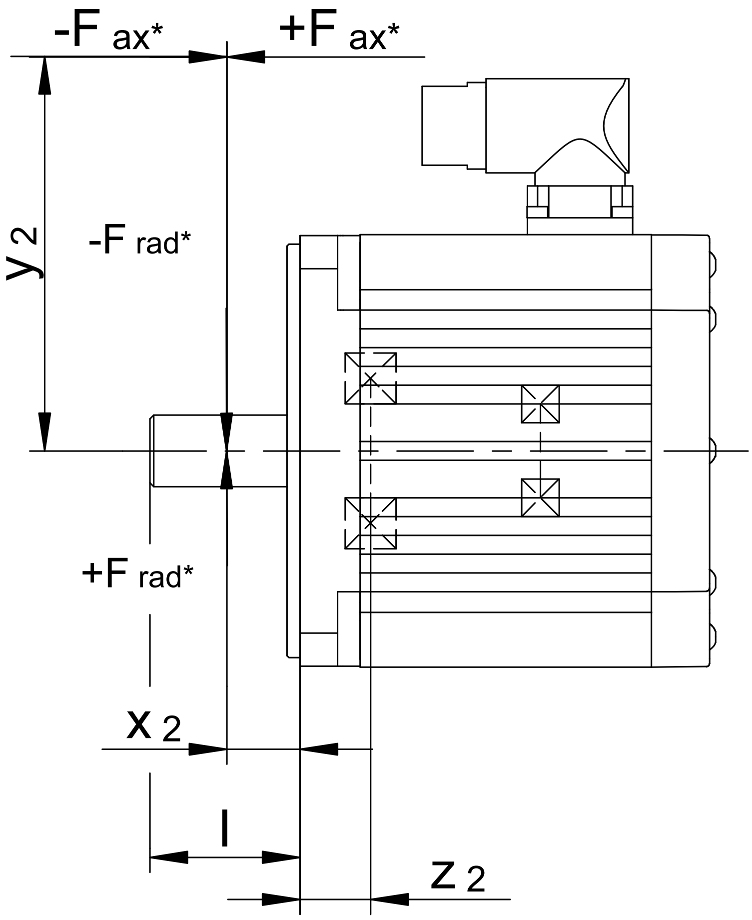


Fig.: PMCtendo SZ output shaft – Dimensions

The following table includes the maximum permitted loads of the motor output shaft. The values apply to the following:

- A force applied at the center of the output shaft: $x_2 = l / 2$ (shaft dimensions can be found in the chapter Dimensional drawings)
- Output speeds $n_{m*} \leq 100$ rpm ($F_{ax} = F_{ax100}$; $F_{rad} = F_{rad100}$; $M_k = M_{k100}$)

Typ	z_2	F_{ax100}	F_{rad100}	M_{k100}
	[mm]	[N]	[N]	[Nm]
SZ.31	24,0	350	1000	39
SZ.32	24,0	350	1000	39
SZ.33	24,0	350	1000	39
SZ.41	19,5	550	1800	62
SZ.42	19,5	550	1800	71
SZ.44	19,5	550	1800	71
SZ.51	19,5	750	2000	79
SZ.52	19,5	750	2400	95
SZ.53	19,5	750	2400	107
SZ.55	19,5	750	2400	107
SZ.71	24,5	1300	3500	173
SZ.72	24,5	1300	4200	208
SZ.73	24,5	1300	4200	208
SZ.75	24,5	1300	4200	225
SZ.82	28,5	1750	5600	384
SZ.83	28,5	1750	5600	384
SZ.85	28,5	1750	5600	384

The following applies to output speeds $n_{m*} > 100$ rpm:

$$F_{ax} = \frac{F_{ax100}}{\sqrt[3]{\frac{n_{m*}}{100\ \text{rpm}}}} \qquad F_{rad} = \frac{F_{rad100}}{\sqrt[3]{\frac{n_{m*}}{100\ \text{rpm}}}} \qquad M_k = \frac{M_{k100}}{\sqrt[3]{\frac{n_{m*}}{100\ \text{rpm}}}}$$

The following applies to other force application points:

$$M_{k*} = \frac{2 \cdot F_{ax*} \cdot y_2 + F_{rad*} \cdot (x_2 + z_2)}{1000} \leq M_{k100}$$

$$F_{rad*} \leq F_{rad100}$$

$$F_{ax*} \leq F_{ax100}$$

For applications with multiple axial and/or radial forces, you must add the forces as vectors.

F_{ax100}: Speeds > 100 rpm

At speeds > 100 rpm, F_{ax100} decreases as follows.

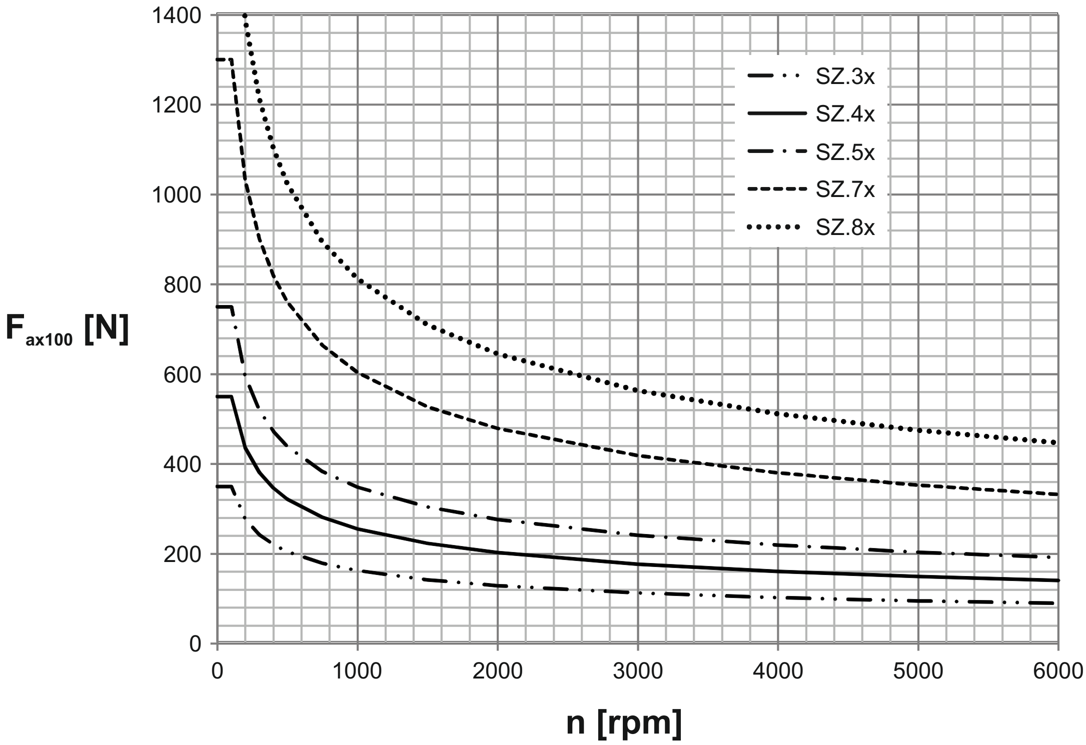


Fig.: SZ.3x – SZ.8x: F_{ax100} at speeds > 100 rpm

F_{rad100}: Speeds > 100 rpm

At speeds > 100 rpm, F_{rad100} decreases as follows.

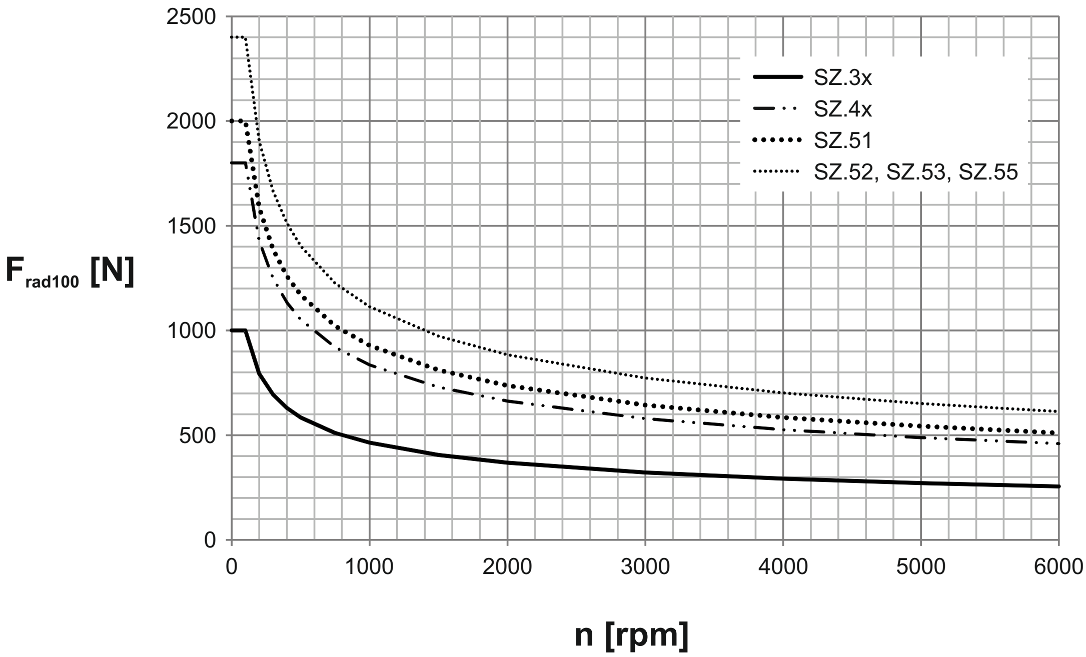


Fig.: SZ.3x – SZ.5x: F_{rad100} at speeds > 100 rpm

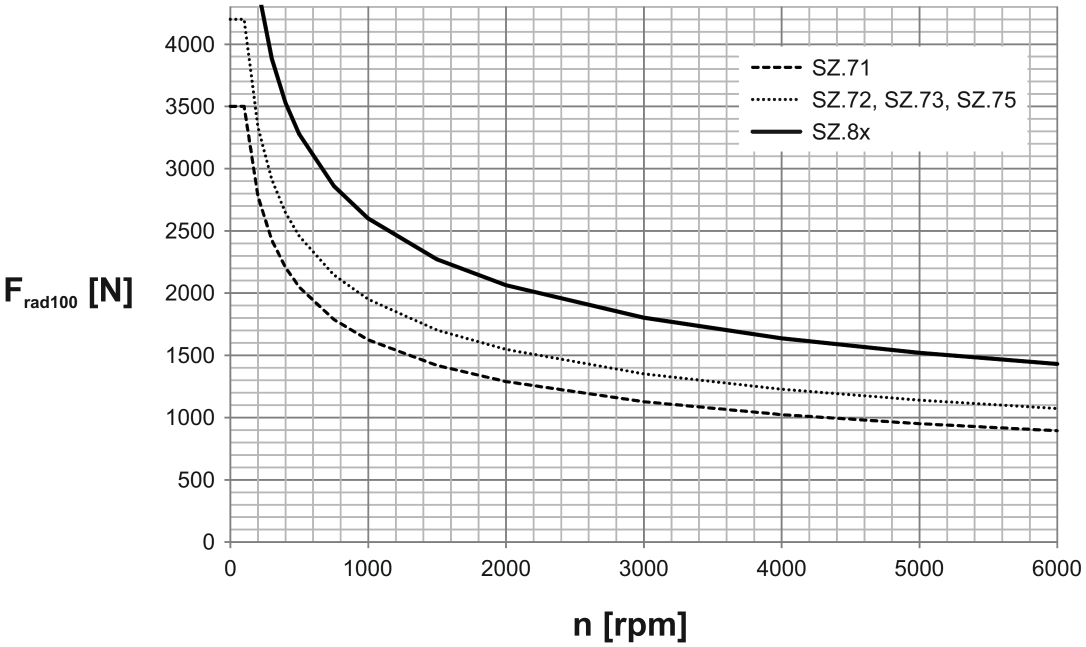


Fig.: SZ.7x – SZ.8x: F_{rad100} at speeds > 100 rpm

M_{k100}: Speeds > 100 rpm

At speeds > 100 rpm, M_{k100} decreases as follows.

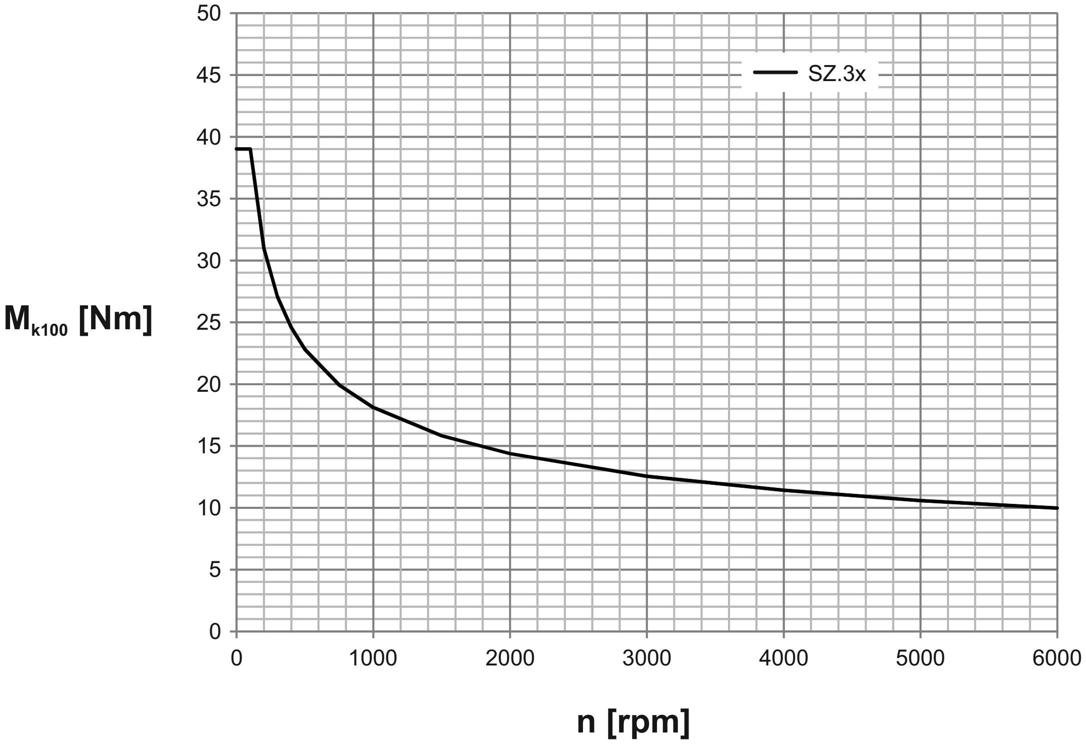


Fig.: SZ.3x: FM_{k100} at speeds > 100 rpm

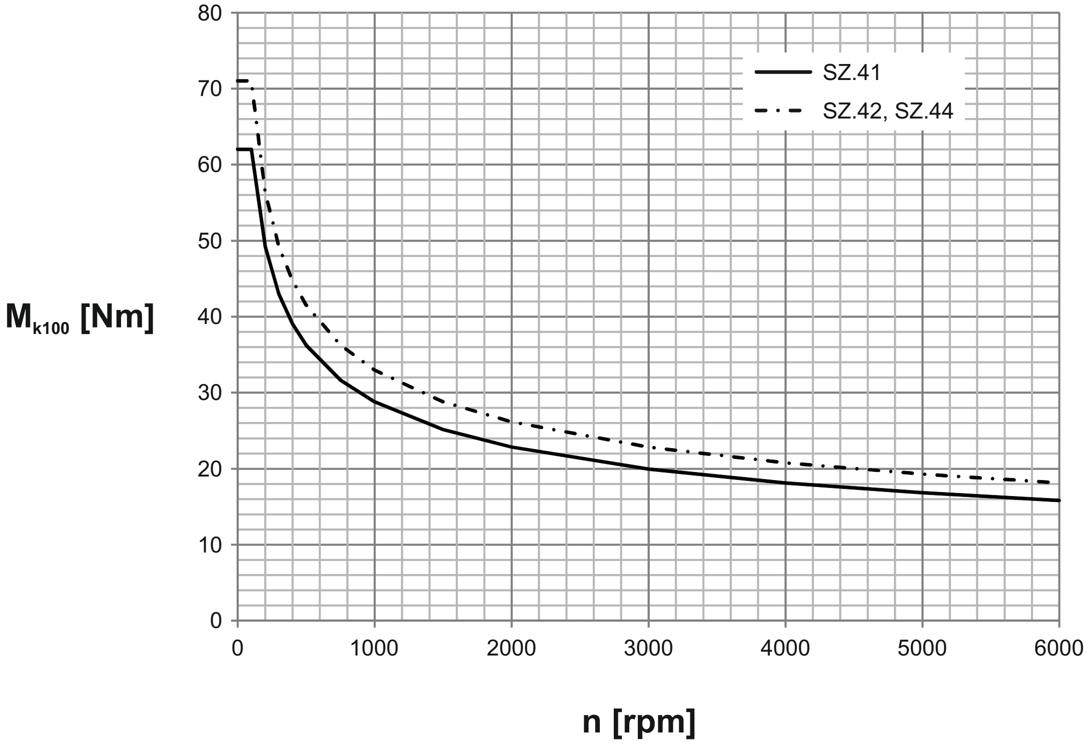


Fig.: SZ.4x: FM_{k100} at speeds > 100 rpm

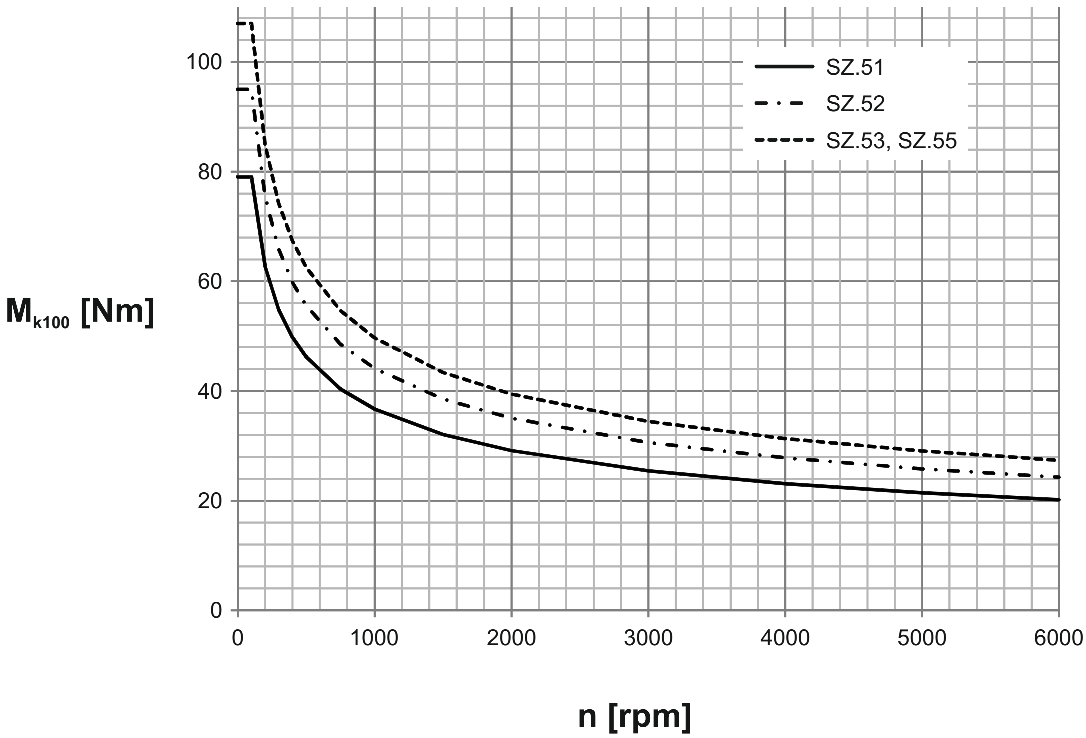


Fig.: SZ.5x: FM_{k100} at speeds > 100 rpm

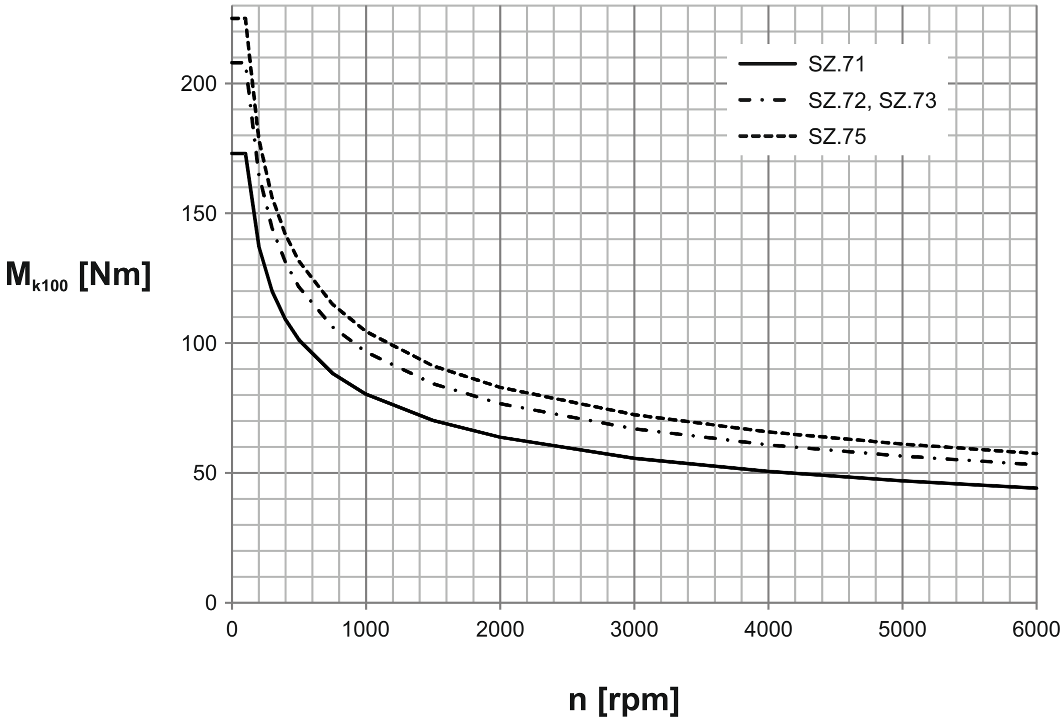


Fig.: SZ.7x: FM_{k100} at speeds > 100 rpm

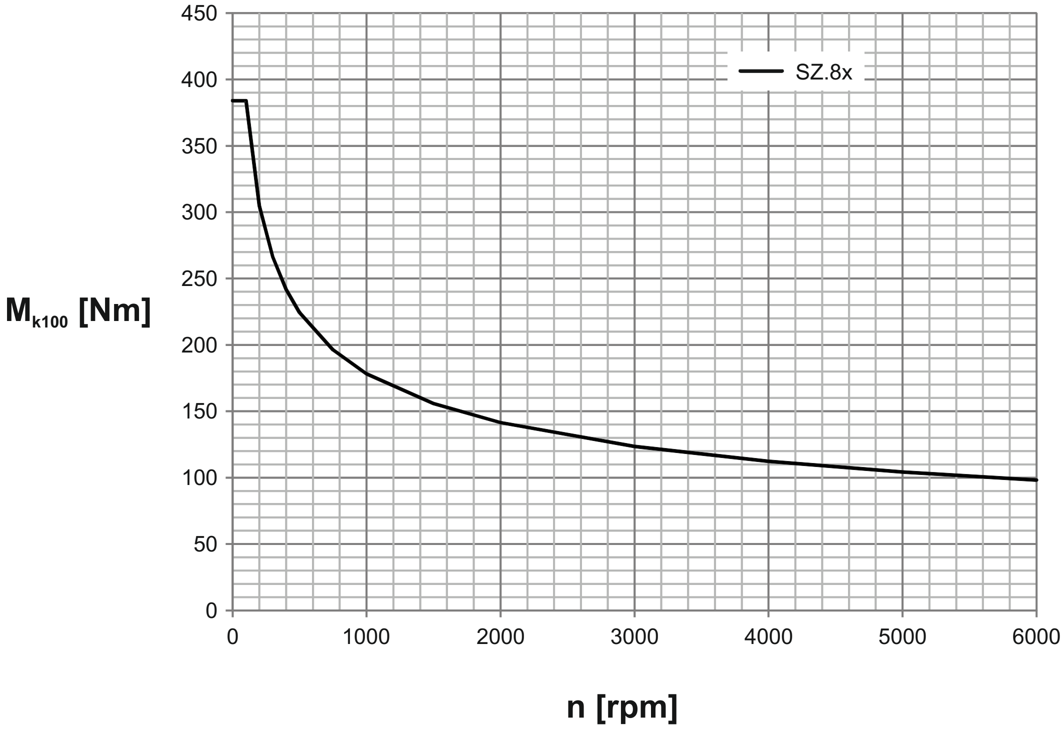


Fig.: SZ.8x: FM_{k100} at speeds > 100 rpm

9.9.7 Torque/speed curves

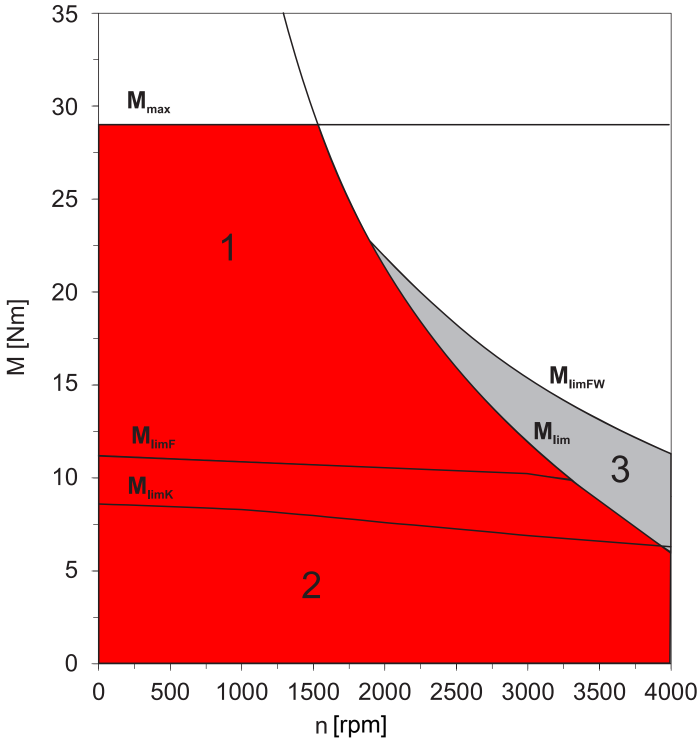


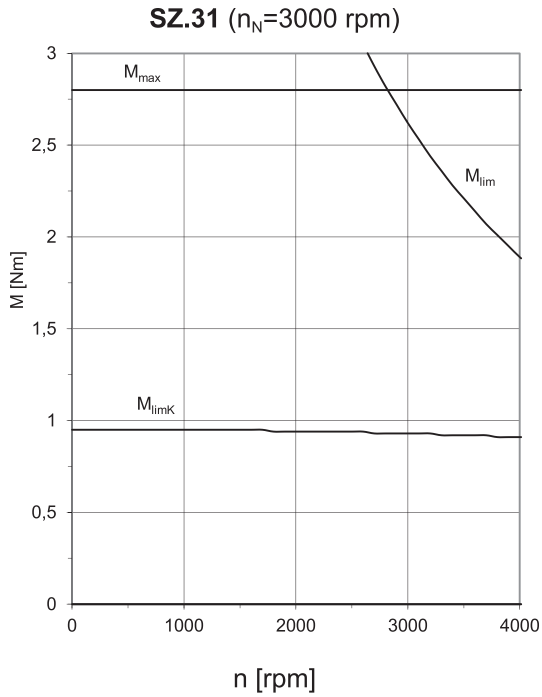
Fig.: Explanation of a torque/speed curve

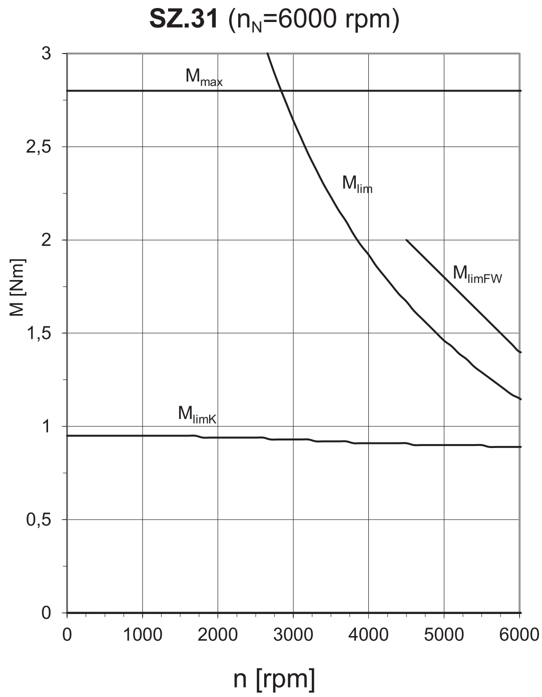
Legend

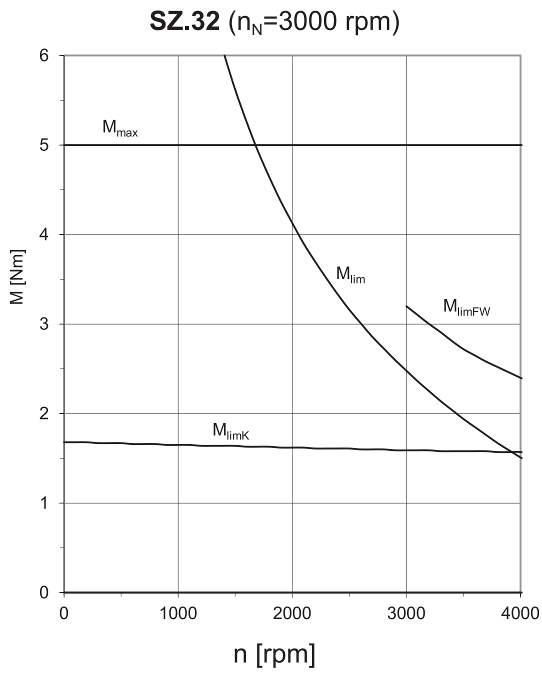
1 Torque range for brief operation (ED_{10} < 100%) with $\Delta\vartheta$ = 100 K

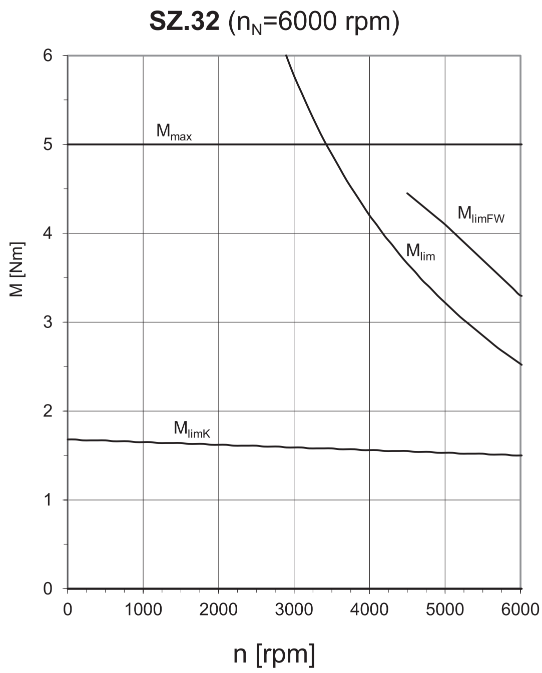
2 Torque range for continuous operation with constant load (S1 mode, ED_{10} = 100%) with $\Delta\vartheta$ = 100 K

3 Field weakening range

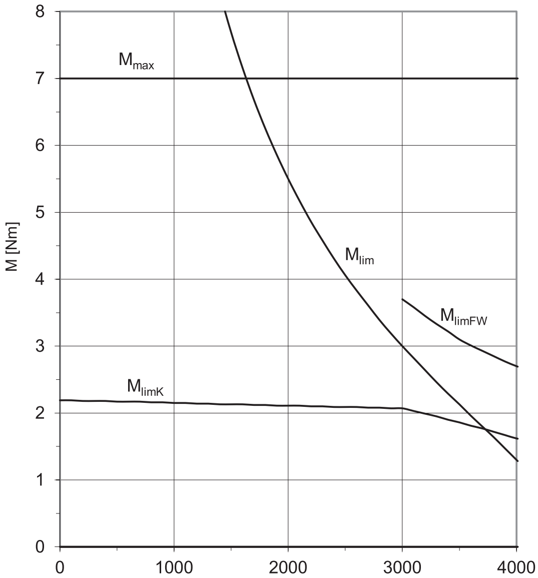

SZ.31 (nN=3000 rpm)
Mmax
Mlim
MlimK
M [Nm]
n [rpm]


SZ.31 (nN=6000 rpm)
Mmax
Mlim
MlimFW
MlimK
M [Nm]
n [rpm]


SZ.32 (nN=3000 rpm)
Mmax
Mlim
MlimFW
MlimK
M [Nm]
n [rpm]

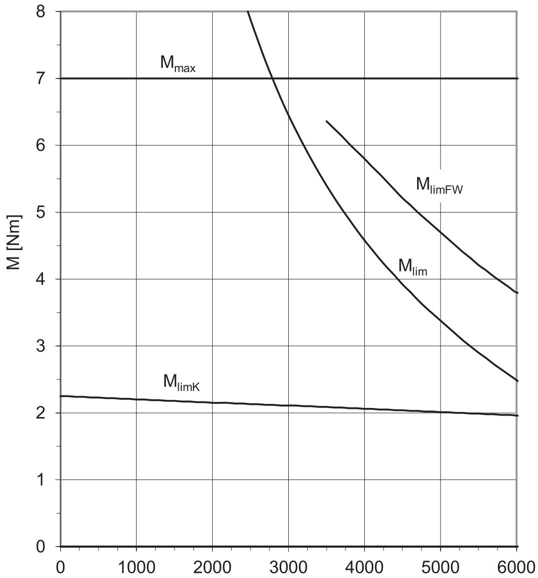

SZ.32 (nN=6000 rpm)
Mmax
MlimFW
Mlim
MlimK
M [Nm]
n [rpm]

SZ.33 (n_N=3000 rpm)



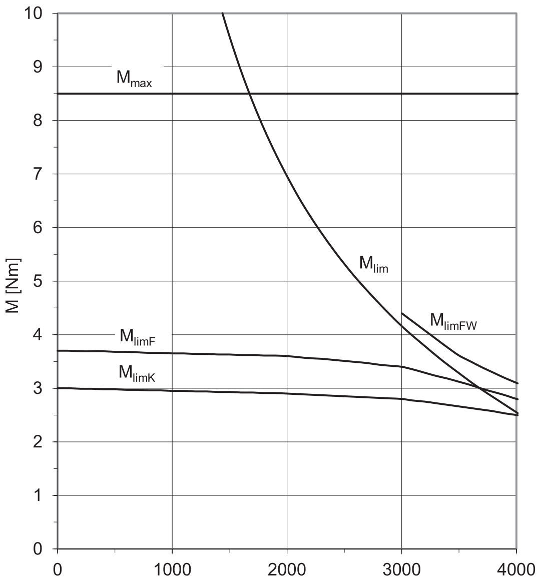
n [rpm]

SZ.33 (n_N=6000 rpm)



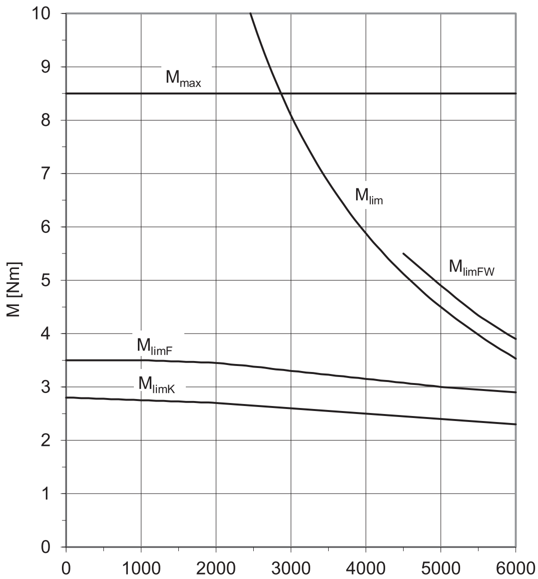
n [rpm]

SZ.41 (n_N=3000 rpm)



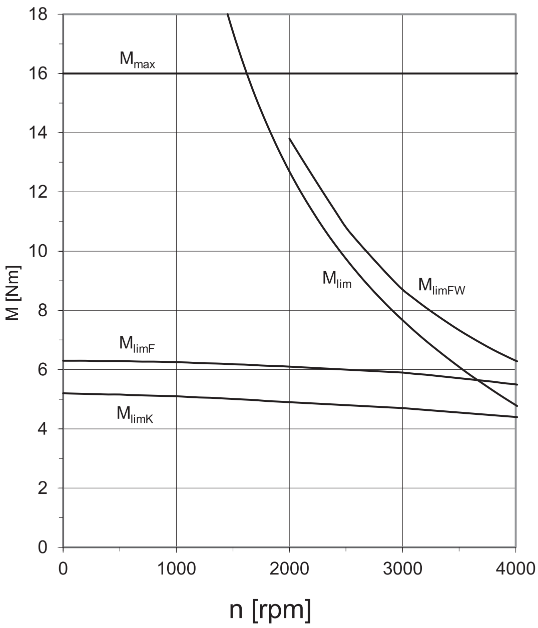
n [rpm]

SZ.41 (n_N=6000 rpm)

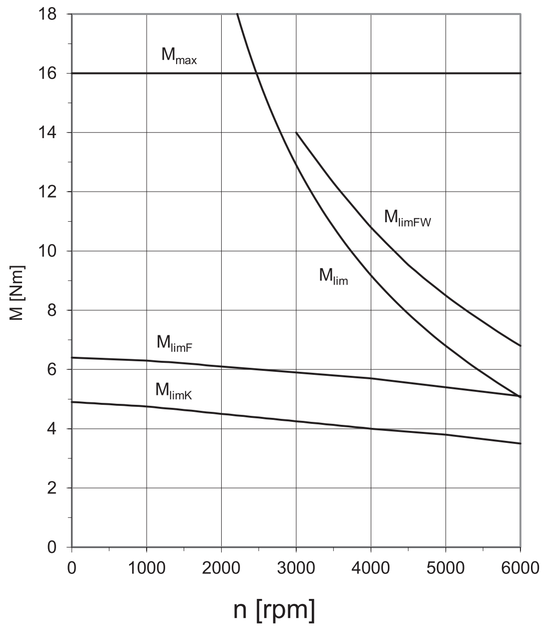


n [rpm]

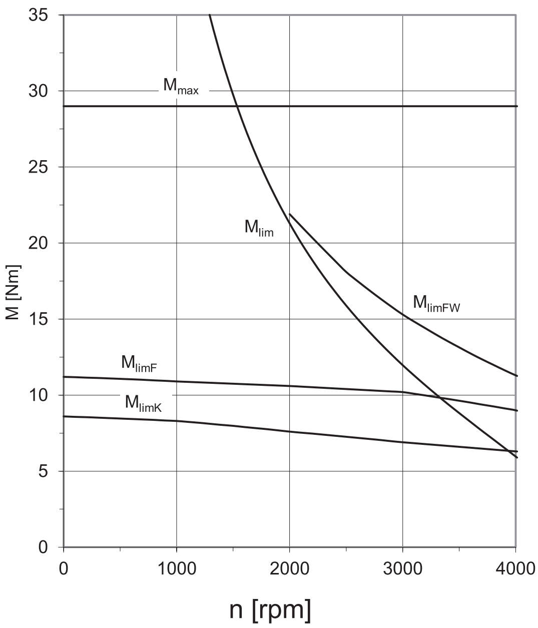
SZ.42 (n_N=3000 rpm)



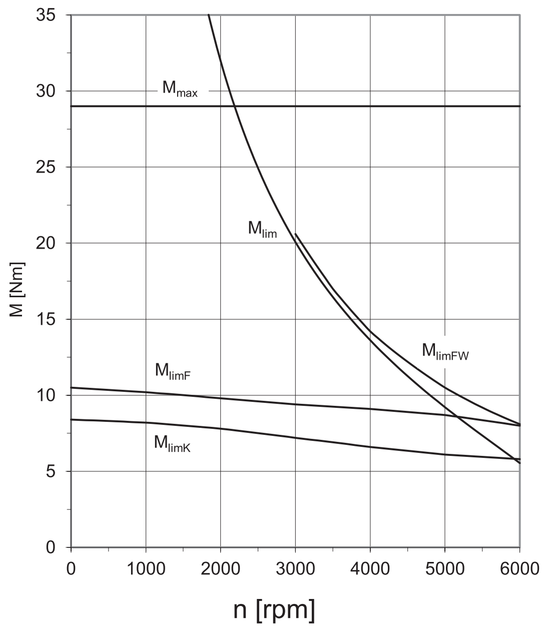
SZ.42 (n_N=6000 rpm)

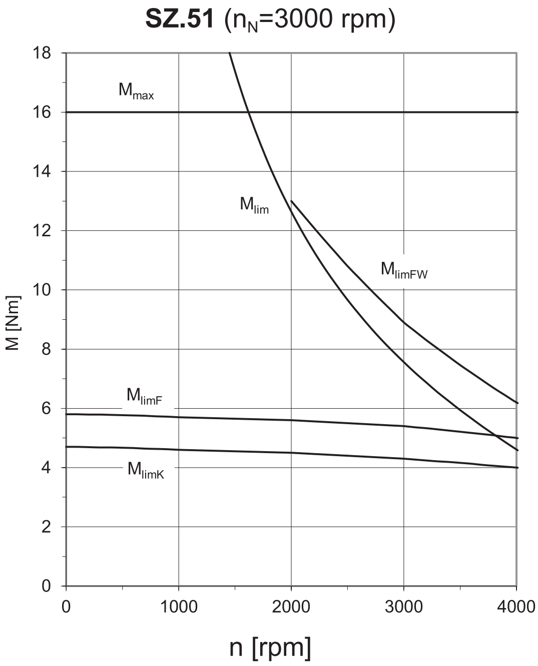


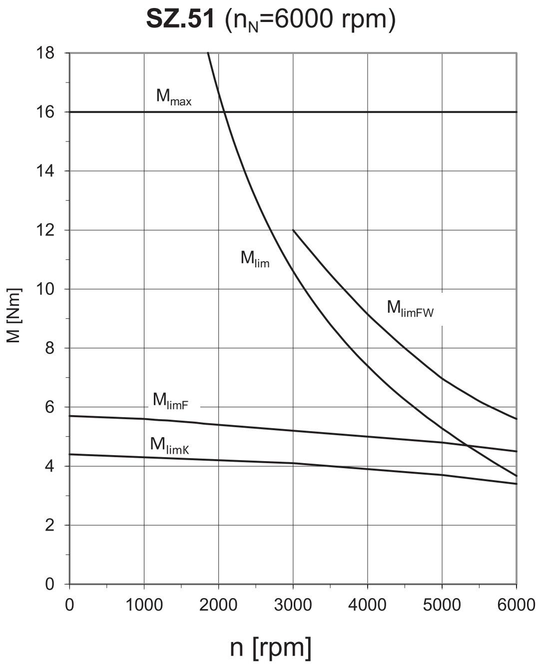
SZ.44 (n_N=3000 rpm)

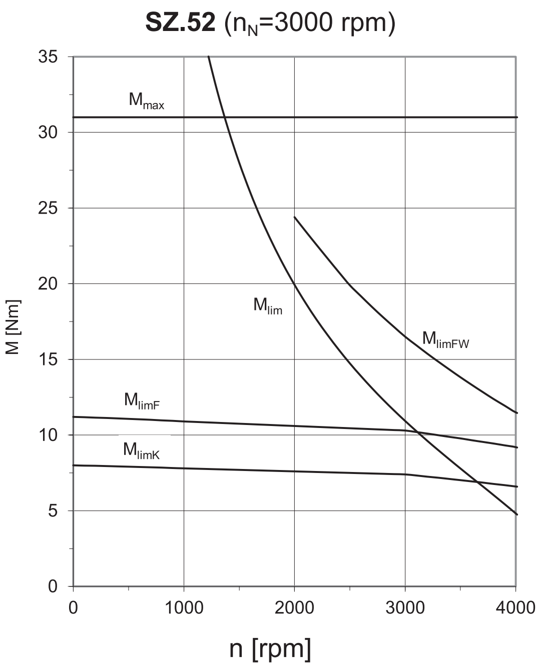


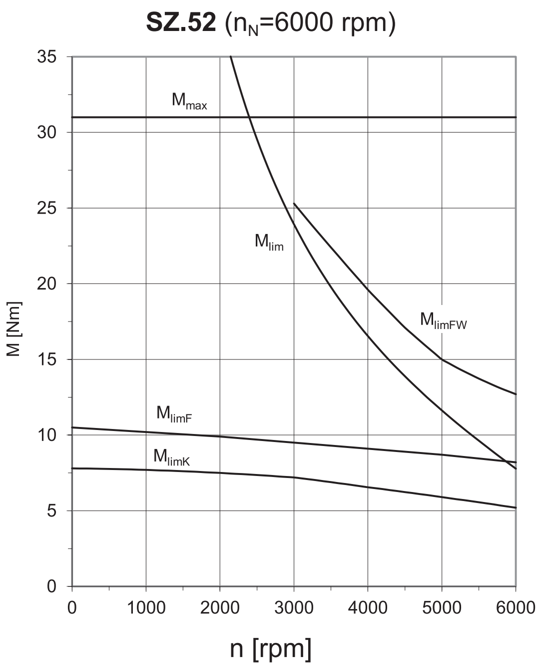
SZ.44 (n_N=6000 rpm)



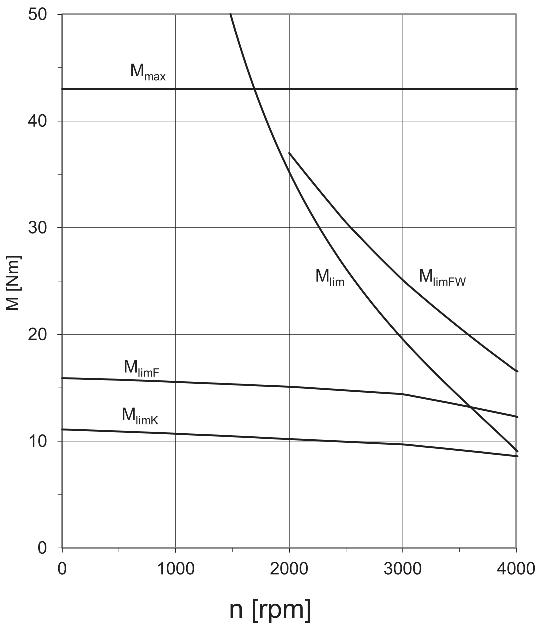

SZ.51 (nN=3000 rpm)
Mmax
Mlim
MlimFW
MlimF
MlimK
M [Nm]
n [rpm]


SZ.51 (nN=6000 rpm)
Mmax
Mlim
MlimFW
MlimF
MlimK
M [Nm]
n [rpm]

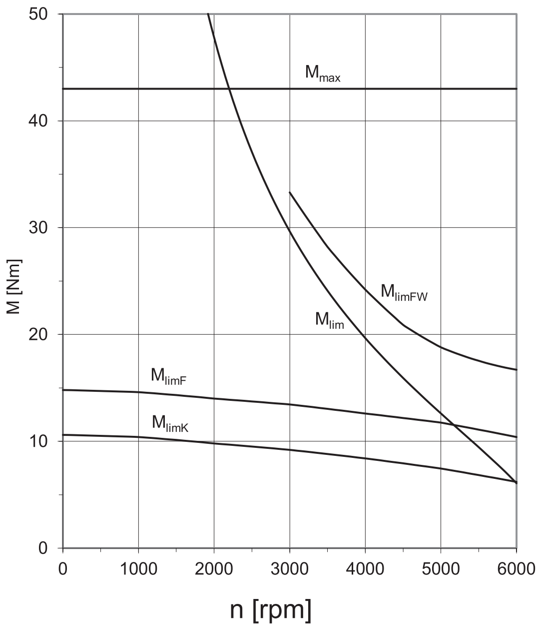

SZ.52 (nN=3000 rpm)
Mmax
Mlim
MlimFW
MlimF
MlimK
M [Nm]
n [rpm]


SZ.52 (nN=6000 rpm)
Mmax
Mlim
MlimFW
MlimF
MlimK
M [Nm]
n [rpm]

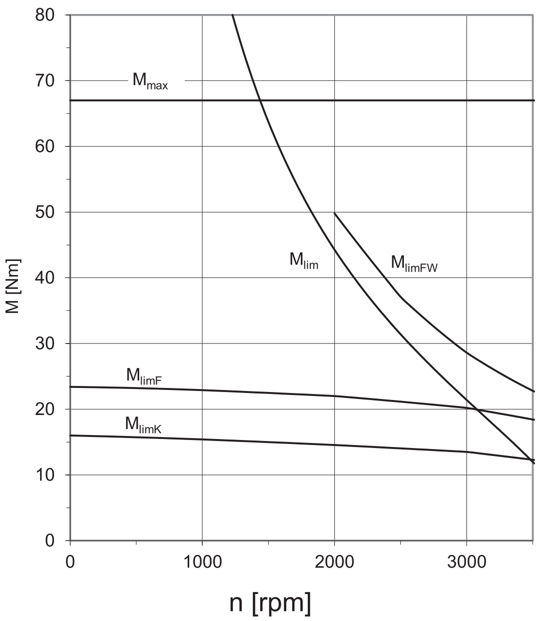
SZ.53 (n_N=3000 rpm)



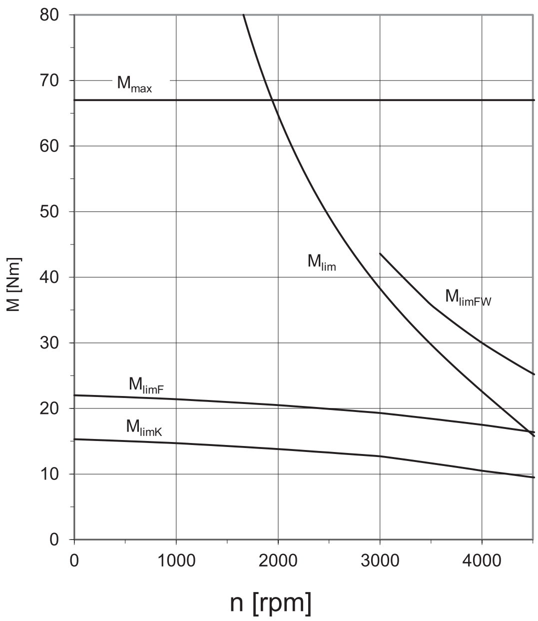
SZ.53 (n_N=6000 rpm)



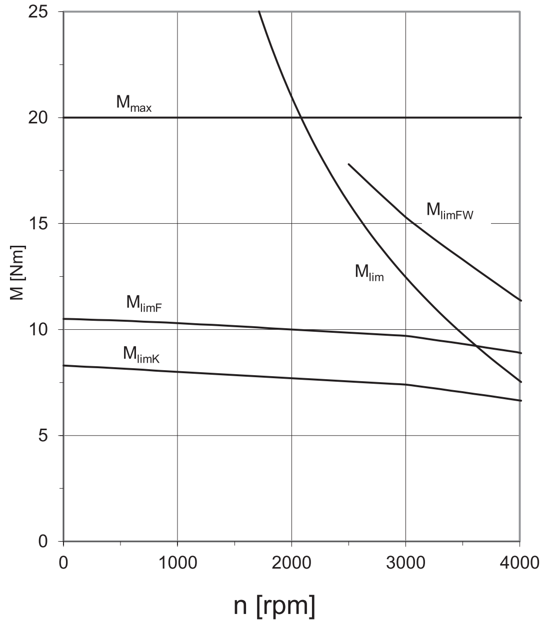
SZ.55 (n_N=3000 rpm)



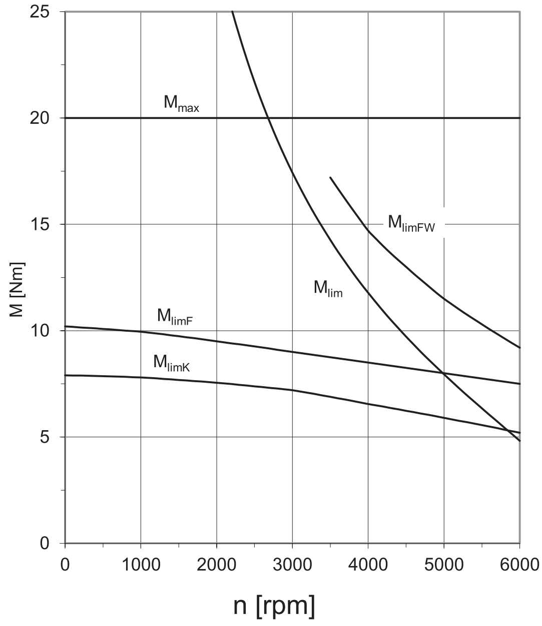
SZ.55 (n_N=4500 rpm)



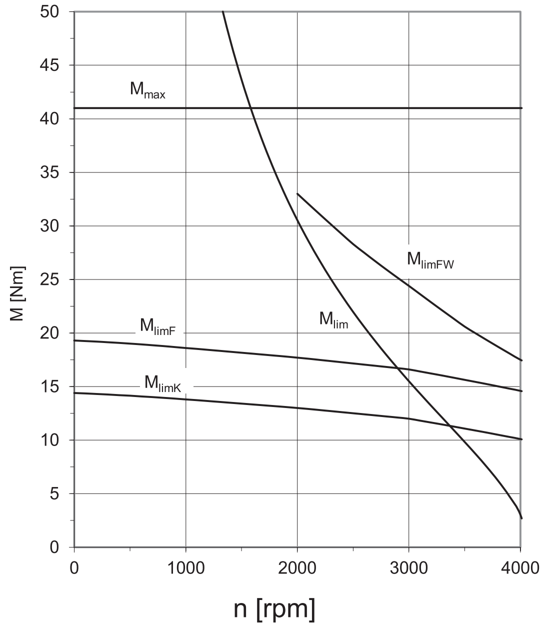
SZ.71 (n_N=3000 rpm)



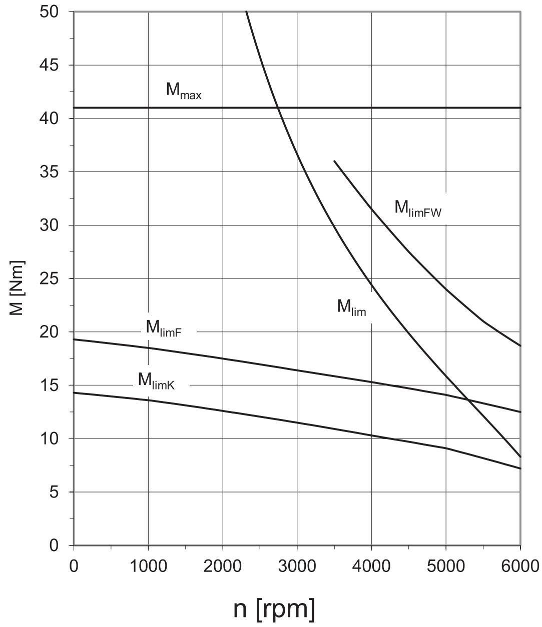
SZ.71 (n_N=6000 rpm)

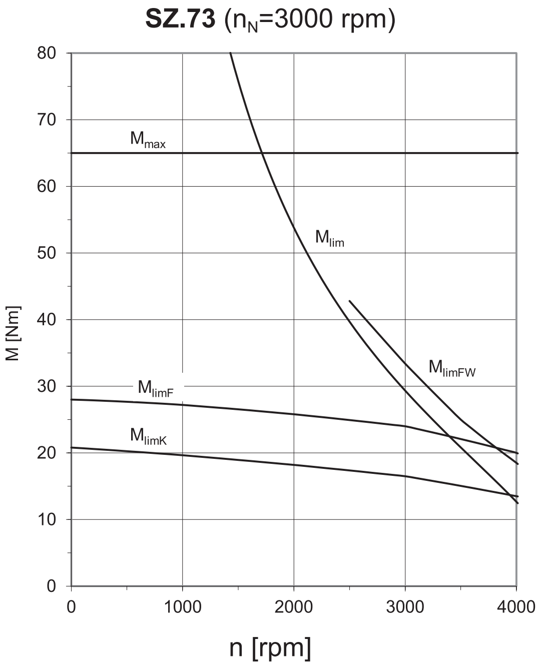


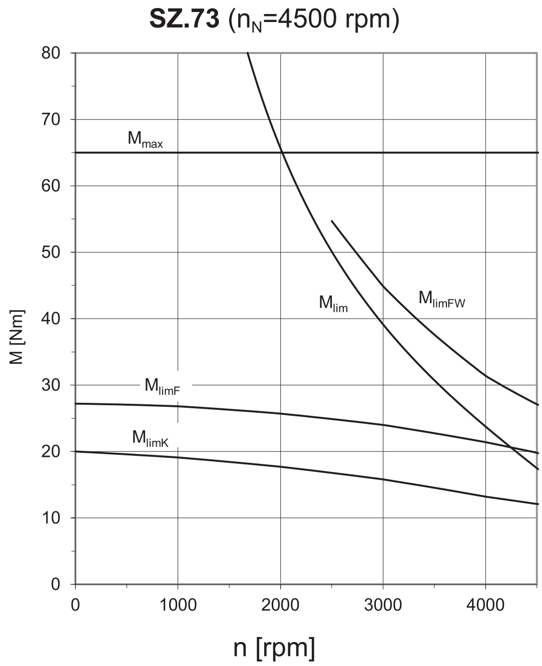
SZ.72 (n_N=3000 rpm)

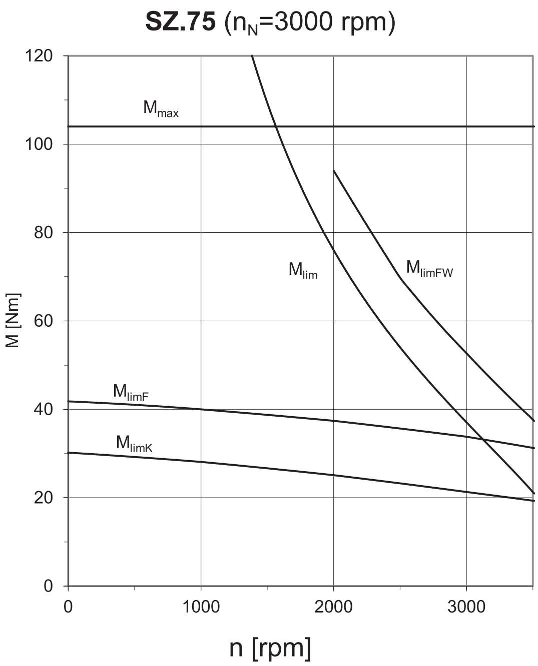


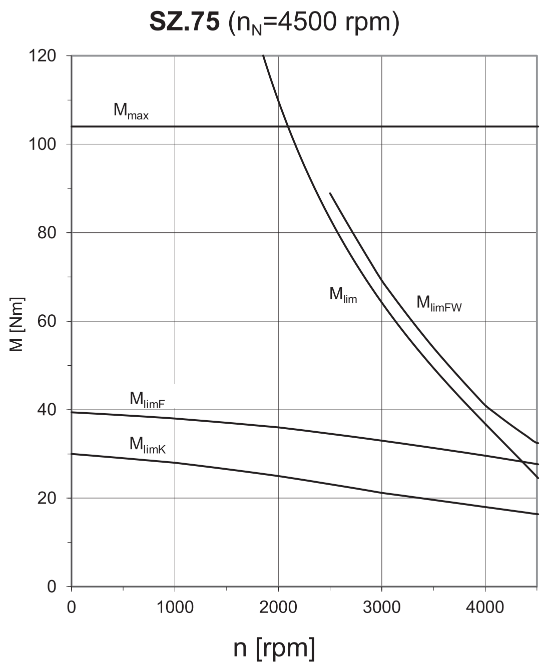
SZ.72 (n_N=6000 rpm)

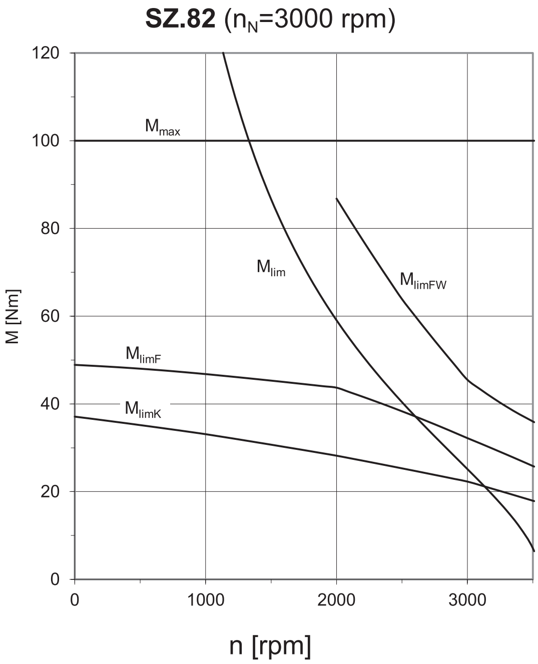


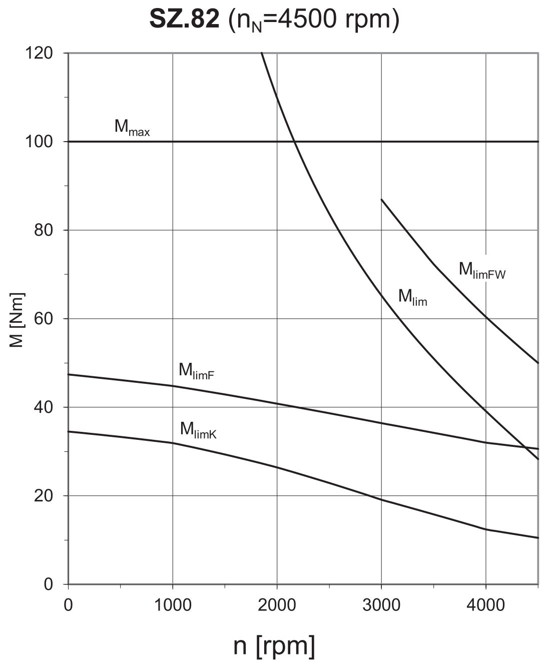

SZ.73 (nN=3000 rpm)
M [Nm]
n [rpm]
Mmax
Mlim
MlimFW
MlimF
MlimK

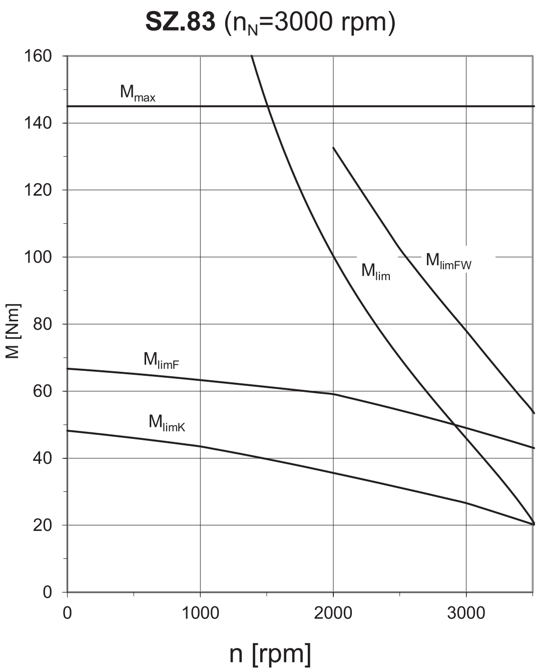

SZ.73 (nN=4500 rpm)
M [Nm]
n [rpm]
Mmax
Mlim
MlimFW
MlimF
MlimK

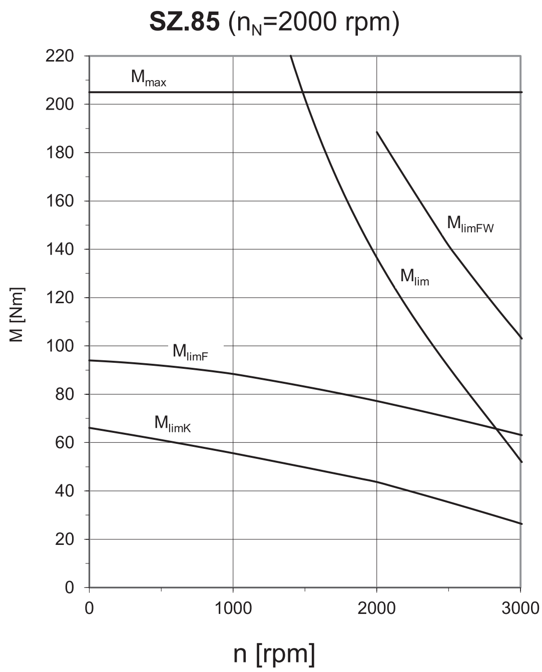

SZ.75 (nN=3000 rpm)
M [Nm]
n [rpm]
Mmax
Mlim
MlimFW
MlimF
MlimK


SZ.75 (nN=4500 rpm)
M [Nm]
n [rpm]
Mmax
Mlim
MlimFW
MlimF
MlimK


SZ.82 (nN=3000 rpm)
Mmax
Mlim
MlimFW
MlimF
MlimK
M [Nm]
n [rpm]


SZ.82 (nN=4500 rpm)
Mmax
MlimFW
Mlim
MlimF
MlimK
M [Nm]
n [rpm]


SZ.83 (nN=3000 rpm)
Mmax
Mlim
MlimFW
MlimF
MlimK
M [Nm]
n [rpm]


SZ.85 (nN=2000 rpm)
Mmax
MlimFW
Mlim
MlimF
MlimK
M [Nm]
n [rpm]

9.9.8 Key safety-related figures

Safety figures – Feedback systems

Type	PFH_D [h^{-1}]	$MTTF_D$ (years)
EnDat 2.2 single-turn, inductive (ECI 1118-G2)	1500×10^{-9}	76
EnDat 2.2 multi-turn, optical (EQN 1135)	15×10^{-9}	> 100
HIPERFACE DSL multi-turn, optical (EKM36)	40×10^{-9}	> 100

Safety figures – Brake

Type	$B10_d$
Permanent magnet holding brake	20 million operations

10 Appendix

10.1 Abbreviations

Abbreviation	Meaning
CSA	Canadian Standards Association
DC	Direct Current
DGUV	Deutsche Gesetzliche Unfallversicherung (en.: German Social Accident Insurance organization)
DIN EN	German acceptance of a European standard
DIN IEC	German standard based on the International Electrotechnical Commission
EMC	Electromagnetic compatibility
FKM	Fluororubber
IEC	International Electrotechnical Commission
IP	International Protection
MTTP, $MTTF_D$	Mean Time To (dangerous) Failure
PE	Protective Earth (i.e. grounding conductor)
PFH, PFH_D	Probability of a (dangerous) Failure per Hour
UL	Underwriters Laboratories

10.2 Formula symbols

Symbol	Unit	Explanation
ΔJ	kgm^2	Additive mass moment of inertia of with increased mass moment of inertia
ΔJ_B	kgm^2	Additive mass moment of inertia of a motor with brake
Δm	kg	Additive weight of a motor with increased mass moment of inertia
Δm_B	kg	Additive weight of a motor with brake
$\Delta\vartheta$	K	Temperature difference
ED_{10}	%	Duty cycle based on 10 minutes
F_{ax100}	N	Permitted axial force on the output for $n_{m*} \leq 100$ rpm
F_{rad}	N	Permitted radial force on the output
F_{rad100}	N	Permitted radial force on the output for $n_{m*} \leq 100$ rpm
H	m	Installation altitude above sea level
I_0	A	Stall current: RMS value of the line-to-line current when the stall torque M_0 is generated (tolerance ±5%)
I_N	A	Nominal current: RMS value of the line-to-line current when nominal torque M_N is generated at the nominal point (tolerance ±5%)
$I_{N,B}$	A	Nominal current of the brake at 20 °C
J	kgm^2	Mass moment of inertia
J_{Bstop}	kgm^2	Reference mass moment of inertia when braking from full speed: $J_{Bstop} = J \times 2$
J_{tot}	kgm^2	Total mass moment of inertia (based on the motor shaft)
K_{EM}	V/1000 rpm	Voltage constant: Peak value of the induced motor voltage at a speed of 1000 rpm and a winding temperature $\Delta\vartheta$ = 100 K (tolerance ±10%)
K_H	–	Derating factor for installation altitude
$K_{M,N}$	Nm/A	Torque constant: ratio of the nominal torque M_N to the nominal current I_N; $K_{M,N} = M_N / I_N$ (tolerance ±10%)
K_ϑ	–	Derating factor for surrounding temperature
M_0	Nm	Stall torque: The continuous torque the motor is able to deliver at a speed of 10 rpm (tolerance ±5%)
M_{Bdyn}	Nm	Dynamic braking torque at 100 °C (Tolerance +40%, −20%)
M_{Bstat}	Nm	Static braking torque at 100 °C (Tolerance +40%, −20%)
M_{eff*}	Nm	Actual effective torque of the motor
M_k	Nm	Permitted breakdown torque on the output
M_{k100}	Nm	Permitted breakdown torque on the output for $n_{m*} \leq 100$ rpm
M_L	Nm	Load torque
M_N	Nm	Nominal torque: the maximum torque of a motor in S1 mode at nominal speed n_N (tolerance ±5%)
M_{Nred}	Nm	Reduced nominal torque of the motor
n	rpm	Speed

Symbol	Unit	Explanation
N_{Bstop}	–	Permitted number of braking processes from full speed (n = 3000 rpm) with J_{Bstop} (M_L = 0). The following applies if the values of n and J_{Bstop} differ: $N_{Bstop} = W_{B,Rlim} / W_{B,R/B}$.
n_N	rpm	Nominal speed: The speed for which the nominal torque M_N is specified
n_{m*}	rpm	Actual average motor speed
n_{mot}	rpm	Speed of the motor
n_N	rpm	Nominal speed: The speed for which the nominal torque M_N is specified
P_N	kW	Nominal power: the power the motor is able to deliver long term in S1 mode at the nominal point (tolerance ±5 %)
t_{1B}	ms	Linking time: time from when the current is turned off until the nominal braking torque is reached
t_{11B}	ms	Response delay: time from when the current is turned off until the torque increases
t_{2B}	ms	Disengagement time: time from when the current is turned on until the torque begins to drop
t_{dec}	ms	Stop time
$\vartheta_{amb,max}$	°C	Maximum surrounding temperature
ϑ_{NAT}	°C	Nominal response temperature
$U_{N,B}$	V	Nominal voltage of brake
$W_{B,R/B}$	J	Work done by friction for braking
$W_{B,Rlim}$	J	Work done by friction until wear limit is reached
$W_{B,Rmax/h}$	J	Maximum permitted work done by friction per hour with individual braking
$x_{B,N}$	mm	Nominal air gap of brake
z_2	mm	Distance of the shaft shoulder to the middle of the output bearing

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List of figures