SINAMICS S120

1FW6 built-in torque motors

Configuration Manual · 05/2009

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SINAMICS S120

Drive Technology
1FW6 Built-in torque motors

Configuration Manual

05/2009
6SN1197-0AE00-0BP3

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

CAUTION
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

NOTICE
indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation for the specific task, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be adhered to. The information in the relevant documentation must be observed.

Trademarks

All names identified by ® are registered trademarks of the Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Industry Sector
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GERMANY

Ordernumber: 6SN1197-0AE00-0BP3
℗ 05/2009

Preface

Information on the documentation

At http://www.siemens.com/motioncontrol/docu information is available on the following topics:

- Ordering documentation
  Here you can find an up-to-date overview of publications
- Downloading documentation
  Links to more information for downloading files from Service & Support.
- Researching documentation online
  Information on DOConCD and direct access to the publications in DOConWeb.
- Compiling documentation individually on the basis of Siemens content with the My Documentation Manager (MDM), see http://www.siemens.com/mdm
  The My Documentation Manager offers you a range of features for creating your own machine documentation.
- Training and FAQs
  Information on the range of training courses and FAQs (frequently asked questions) are available via the page navigation.

Target group

This manual is aimed at planning, project, and design engineers as well as electricians, fitters, and service personnel.

Benefits

This configuration manual enables the target group to comply with the rules and guidelines that apply when torque motors are configured. It helps you select products and functions.

Standard scope

This documentation describes the functionality of the standard version. Extensions or changes made by the machine manufacturer are documented by the machine manufacturer.

Other functions not described in this documentation might be able to be executed in the drive system. This does not, however, represent an obligation to supply such functions with a new delivery or when servicing.

For reasons of clarity, this documentation does not contain all the detailed information about all types of the product and cannot cover every conceivable case of installation, operation or maintenance.

Technical Support

If you have any technical questions, please contact our hotline:

	Europe / Africa
Phone	+49 180 5050 222
Fax	+49 180 5050 223
	0.14 €/min. from German landlines (mobile call charges may differ)
Internet	http://www.siemens.com/automation/support-request

	America
Telephone	+1 423 262 2522
Fax	+1 423 262 2200
E-mail	mailto:techsupport.sea@siemens.com

	Asia / Pacific
Telephone	+86 1064 757 575
Fax	+86 1064 747 474
E-Mail	mailto:support.asia.automation@siemens.com

Note

For technical support telephone numbers for different countries, go to:
http://www.automation.siemens.com/partner

Questions about this documentation

Please send any questions about the technical documentation (e.g. suggestions, corrections) to the following fax number or E-Mail address:

Fax	+49 (0) 9131 / 98-2176
E-mail	E-mail to: docu.motioncontrol@siemens.com

A fax form is available in the appendix of this document.

Internet address for products

http://www.siemens.com/motioncontrol

EC Declaration of Conformity

The EC Declaration of Conformity (to Low-Voltage Directive 2006/95/EC) is available at the following Internet address in the folder "Drive Technology":

http://support.automation.siemens.com/WW/llisapi.dll?func=cslib.csinfo&lang=de&siteid=csius&objid=19183574

If you do not have access to the Internet, contact your local Siemens office to obtain a copy of the EC Declaration of Conformity.

Table of contents

1 General safety guidelines

Please observe all the relevant safety instructions to avoid personal and/or material damage. In particular, you must observe the safety instructions and notes regarding the powerful permanent magnets installed in the rotor of the built-in torque motor.

The rotor is secured in the stator by means of transportation locks and a spacer film. The original packaging for the built-in torque motor and the transportation locks (incl. the screws) are required for storage/transport purposes and should, therefore, be kept in a safe place. This documentation should also be kept in a safe place and made available to the personnel responsible.

Residual risks of power drive systems

When carrying out a risk assessment of the machine in accordance with the EU Machinery Directive, the machine manufacturer must consider the following residual risks associated with the control and drive components of a power drive system (PDS).

1. Unintentional movements of driven machine components during commissioning, operation, maintenance, and repairs caused by, for example:
   - Hardware defects and/or software errors in the sensors, controllers, actuators, and connection technology
   - Response times of the controller and drive
   - Operating and/or ambient conditions not within the scope of the specification
   - Parameterization, programming, cabling, and installation errors
   - Use of radio devices / cellular phones in the immediate vicinity of the controller
   - External influences / damage
2. Exceptional temperatures as well as emissions of light, noise, particles, or gas caused by, for example:
   - Component malfunctions
   - Software errors
   - Operating and/or ambient conditions not within the scope of the specification
   - External influences / damage
3. Hazardous shock voltages caused by, for example:
   - Component malfunctions
   - Influence of electrostatic charging
   - Induction of voltages in moving motors
   - Operating and/or ambient conditions not within the scope of the specification
   - Condensation / conductive contamination
   - External influences / damage

4. Operational electrical, magnetic, and electromagnetic fields that can pose a risk to people with a pacemaker and/or implants or metallic objects if they are too close.
5. Release of environmentally hazardous materials and emissions during improper operation and / or improper disposal of components.

For more information about residual risks of the power drive system components, see the relevant chapters in the technical user documentation.

DANGER

It may be dangerous for people to remain in the immediate proximity of the product – especially for those with pacemakers, implants or similar – due to electric, magnetic and electromagnetic fields (EMF) occurring as a consequence of operation.

The machine/system operator and the people present near the product must observe the relevant guidelines and standards! These are, for example, in the European Economic Area (EEA) the Electromagnetic Fields Directive 2004/40/EC and the standards EN 12198-1 to 12198-3 and in the Federal Republic of Germany the Employer's Liability Insurance Association Regulations for the Prevention of Industrial Accidents BGV 11, with the relevant rule BGR 11 "Electromagnetic Fields".

Then a risk assessment must be carried out for every workplace, activities for reducing dangers and exposure for people decided upon and implemented, as well as determining and observing exposure and danger areas.

1.1 Observing and complying with safety guidelines

DANGER

There is a danger of death, severe physical injury, and/or damage to property if the safety instructions are not observed and complied with.

It is essential that you observe the safety instructions in this documentation. This includes the special safety instructions in the individual sections.

Observe all warning and information plates.

Make sure that your end product satisfies all relevant standards and legal specifications. The applicable national, local, and machine-specific safety regulations and requirements must also be taken into account.

In addition to the safety instructions included in this documentation, the detailed specifications in the catalogs and offers also apply to the special motor versions.

Also observe the relevant operating instructions when working on the drive system.

1.2 Handling direct drives and components

DANGER

There is danger of death, serious bodily injury and/or property damage when untrained personnel is allowed to handle direct drives and/or their components.

Only personnel who are familiar with and who observe the safety guidelines are allowed to handle direct drives and their components.

Installation, commissioning, operation and maintenance may only be performed by qualified, trained and instructed personnel. The personnel must be thoroughly familiar with the content of this guide.

All work must be performed by at least two persons.

Note

Make sure that the information about the sources of danger and the safety measures is available at all times! Keep all the descriptions and safety guidelines concerning direct drives and their components if possible!

All descriptions and safety guidelines can also be requested from your local Siemens office.

1.3 Use for the intended purpose

DANGER

There is a risk of death, serious personal injury and/or serious material damage when direct drives or their components are used for a purpose for which they were not intended.

The motors are designed for industrial or commercial machines. It is prohibited to use them in areas where there is a risk of explosion (Ex-zone) unless they are designed expressly for this purpose (observe the separately enclosed additional instructions where applicable). If increased demands (e.g. touch protection) are made in special cases – for use in non-commercial systems – these conditions must be ensured on the machine side during installation.

Direct drives and their components may only be used for the applications specified by the manufacturer. Please contact your Siemens branch responsible if you have any questions on this matter.

The motors must be protected from dirt and contact with aggressive substances.

Special versions and design variants whose specifications vary from the motors described herein are subject to consultation with your Siemens branch.

The motors are designed for an ambient temperature range of -5 °C to +40 °C. Any alternative requirements specified on the rating plate must be noted! The on-site conditions must comply with the rating plate specifications and the condition specifications contained in this documentation. Any differences regarding approvals or country-specific guidelines must be taken into account separately.

DANGER

The products included in the scope of delivery are exclusively designed for installation in a machine. Commissioning is prohibited until it has been established that the end product conforms with Directive 98/37/EC. All safety instructions must be observed and given to the end user for his/her information.

DANGER

Risk of electric shock if a hazardous voltage is present on the stator when operated as a single component.

To ensure that the components have sufficient shock-hazard protection, voltage must only be applied to the motors once they have been installed.

1.4 Danger from strong magnetic fields

Occurrence of magnetic fields

Strong magnetic fields occur in the components of the motor that contain permanent magnets. The magnetic field strength of the motors results exclusively from the magnetic fields of the components with permanent magnets in the de-energized state. Electromagnetic fields also occur during operation.

Components with permanent magnets

⚠ CAUTION
The permanent magnets of the 1FW6 torque motors are located in the rotor.

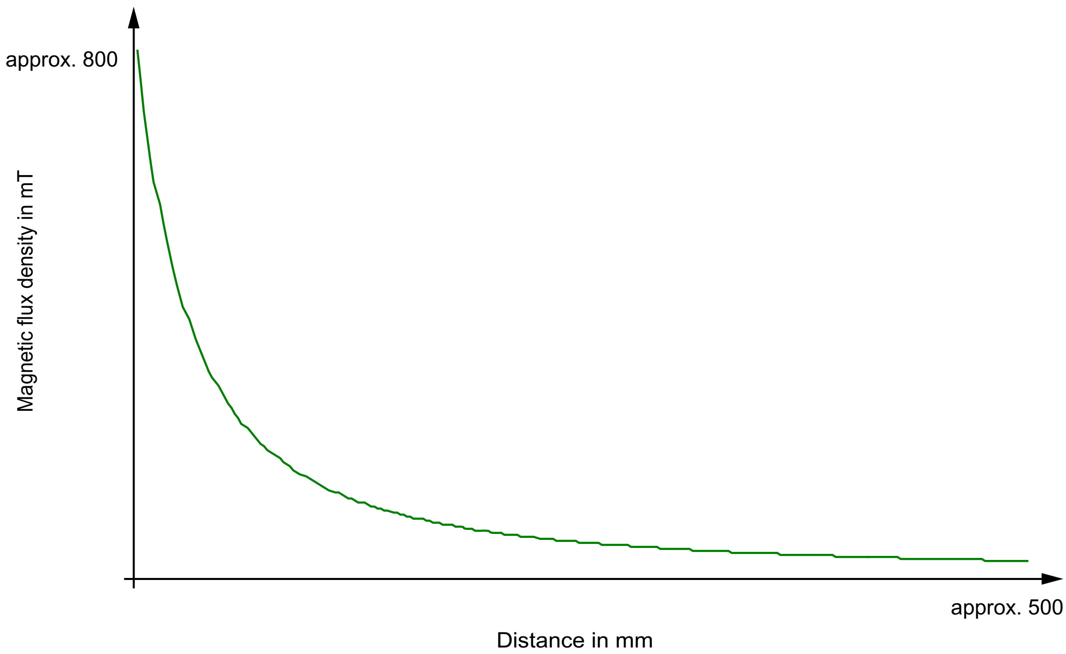


Figure 1-1 Schematic representation of the static magnetic field of a rotor, as a function of distance

Danger from strong magnetic fields

DANGER

Strong magnetic fields can pose a risk to personnel and cause damage.

With regard to the effect of strong magnetic fields on people, the work guideline BGV B 11 "Electromagnetic Fields" applies in Germany. This specifies all the requirements that must be observed in the workplace. In other countries, the relevant applicable national and local regulations and requirements must be taken into account.

People with active electrical component implants (e.g. pacemakers, insulin pumps), metal implants and magnetic or electrically conducting foreign bodies are urgently advised to avoid direct contact with components containing permanent magnets. This applies to, e.g., any work connected with assembly, maintenance or storage.

BGV B 11 specifies a limit value of 212 mT for static magnetic fields. This must be observed for distances greater than 20 mm from a rotor.

The requirements of BGV B 11 must also be taken into account with regard to strong magnetic fields (BGV B11 §14).

DANGER

Personnel who are exposed to magnetic fields in their daily work must maintain a distance of at least 50 mm from a rotor.

Personnel with pacemakers must maintain a distance of at least 500 mm from a rotor.

Humans have no sensory organs for picking up strong magnetic fields and have no experience with them as a rule. Therefore, the magnetic forces of attraction emanating from strong magnetic fields are often underestimated.

The magnetic forces of attraction may be several kN in the vicinity of the motor components containing permanent magnets (within a distance of less than 100 mm). – Example: Magnetic attractive forces are equivalent to a mass of several hundred kilos, which can trap a part of the body (hands, fingers, feet etc.)!

DANGER

Strong attractive forces on magnetizable materials lead to a great danger of crushing in the vicinity of components with permanent magnets (distance less than 100 mm).

Do not underestimate the strength of the attractive forces!

Do not carry any objects made of magnetizable materials (e. g. watches, steel or iron tools) and/or permanent magnets close to the motor or close to a component with permanent magnets.

For the event of accidents when working with permanent magnets, the following objects must be on hand to free clamped body parts (hands, fingers, feet etc.):

- a hammer (about 3 kg) made of solid, non-magnetizable material
- two pointed wedges (wedge angle approx. 10° to 15°) made of solid, non-magnetizable material (e.g. hard wood)

First aid in the case of accidents involving permanent magnets

- Stay calm.
- Press the emergency stop switch and, where necessary, switch off the main switch if the machine is live.
- Administer FIRST AID. Call for further help if required.
- To free jammed body parts (e.g., hands, fingers, feet), pull apart components that are clamped together.
  - To do this, use a hammer to drive a wedge into the separating rift
  - Release the jammed body parts.
- If necessary, call for an EMERGENCY DOCTOR.

CAUTION

Magnetic fields can lead to a loss of data on magnetic or electronic data media and damage watches.

Keep all magnetic or electronic data media (e.g. credit cards, disks, etc.) and watches away from the rotor (< 100 mm).

1.5 Electrical shock hazard!

DANGER

Electrical shock hazard! When an installed torque motor rotates, potentially dangerous voltages are induced at the cable ends of the motor.

Insulate terminals and leads in open cable ends or take measures to prevent torque motors that have been installed from rotating.

There is also a risk of compression.

DANGER

Danger due to high leakage currents

If high leakage currents are present, more stringent requirements may apply to the PE conductor. Warning signs may also be required on the PDS. You can find more detailed information in the standard EN 61800-5-1.

Protective measures against residual voltages

DANGER

There is a shock hazard danger due to the residual voltages at the motor terminals!

When the power supply voltage is switched-out, active parts of the motor can have a charge of more than 60 µC. In addition, at open-circuit cable ends - e.g. when a connector is withdrawn - even after the power has been disconnected, a voltage or more than 60 V can be present for 1 s. This is the reason that you must apply the appropriate measures to provide protection against residual voltages!

1.6 Attaching warning signs

All danger areas must be identified by well visible warning and prohibiting signs (pictograms) in the immediate vicinity of the danger. The associated texts must be available in the language of the country in which the product is used.

1.7 Pictograms supplied for 1FW6

To indicate dangers, the following durable adhesive stickers are supplied:

Table 1- 1 Warning signs to BGV A8 / DIN 4844-2 and what they indicate

Sign	Meaning	Sign	Meaning
	Warning: strong magnetic field (D-W013)		Warning: hand injuries (D-W027)
	Warning: hazardous electric voltage (D-W008)		Warning: hot surfaces (D-W026)

Table 1- 2 Prohibiting signs to BGV A8 / DIN 4844-2 and what they indicate

Sign	Meaning	Sign	Meaning
	No pacemakers (D-P011)		No metal implants (D-P016)
	No metal objects or watches (D-P020)		No magnetic or electronic data media (D-P021)

Description of the motor 2

1FW6 built-in torque motor

2.1 Properties

2.1.1 Overview

1FW6 torque motors are designed as built-in motors for use in low-speed direct drives with a high torque output.

Built-in torque motors are liquid-cooled, permanent-magnet-excited, (high pole number) three-phase synchronous motors with hollow-shaft rotors. The motors are provided as built-in components which, on delivery, are secured together by means of transportation locks and spacer film. For a complete drive unit, an additional bearing and rotary transducer are required.

The product range includes 7 frame sizes (or external diameters), each with at least 4 different axis lengths. Each motor is available for at least two different speed ranges. The stator and rotor are equipped with flanges at both ends with centering surfaces and tapped holes, which allow them to be integrated in a machine.

Standards and regulations

The product complies with the standards relating to the Low-Voltage Directive stated in the EC Declaration of Conformity.

2.1.2 Benefits

Features of the motors:

- Extremely high power density
- High torque with a compact design and low unit volume
- Wide range of types
- High overload capability (factor 1.6 to 2.2); the current input of the windings is adjusted in line with the Motor Modules in the SINAMICS S120 drive system.
- Low moment of inertia
- High degree of availability as there are no gearbox components in the mechanical drive transmission line which are subject to wear
- Water cooling to increase the rated power
- Directly flanged to the machine
- Cable outlet, axial, radial towards the outside or tangential for all frame sizes

As a result of water cooling, they fulfill high requirements regarding the thermal behavior within the machine assembly.

2.1.3 Applications

In conjunction with the SINAMICS S120 drive system (booksize or blocksize format), the built-in torque motors can be used as a direct drive for the following machine applications:

- Rotary indexing machines, rotary tables, swivel axes
- Rotary axes (A, B, C axes in 5-axes machine tools)
- Rotary tables, rotary indexing machines, sub-machine assemblies
- Turret indexing and drum indexing for single-spindle and multi-spindle machines
- Dynamic tool magazines
- Rotating spindles in milling machines
- Roller and cylinder drives
- Infeed and handling axes

WARNING

The motors cannot be operated directly on the supply system, but may only be operated with a suitable drive system.

Note

Note that when 1FW6 direct motors (torque motors) are used in fork heads for machine tools or robots, a license for US patent US5584621 and the associated international patent protection may be required.

2.2 Technical features

Note

The values specified in the following table only apply in conjunction with the system prerequisites described in "System integration".

Table 2- 1 Standardversion of the 1FW6 torque motor

Technical feature	Version
Motor type	Synchronous motor with permanent magnet rotor, multi-pole (no. of rotor poles: 44 to 98)
Design	Individual components: stator, rotor
Degree of protection to EN 60034-5 and EN 60529	Motor: IP23 The final degree of protection (minimum degree of protection: IP54) of the built-in motor must be realized by the machine manufacturer.

Technical feature	Version
Cooling method	Water cooling: Jacket cooling, size 1FW609, 1FW613, 1FW615 Integrated cooling, size 1FW616, 1FW619, 1FW623, 1FW629
Pressure in the cooling circuit	Max. 10 bar (static)
Cooler connection	Motors with a cooling jacket: Must be connected by customer Motors with integrated cooling: Connection with/without cooling connection adapter (see "Installing the motor")
Temperature sensor	2 x PTC thermistor triplet with response threshold +130 /150 °C (to DIN 44081/44082) and 1 x KTY84 thermistor (to EN 60034-11) in the stator.
Insulation of stator winding according to EN 60034-1	Temperature class 155 (F)
Magnet material	Rare earth material
Connection, electrical	Cable outlet: Axial radial outward tangential (not in the case of motors with single cores) Connection type: Permanently connected power and signal cables with open core ends Length: 2 m Permanently connected power cables with single cores and signal cables with open core ends Length: 1 m Permanently connected power and signal cables pre-assembled with connectors (not in the case of motors with single cores) Length: 0.5 m
Motor supply cables	For the specifications of the motor supply cables, see "Interfaces".
Torque ripple	≤ 1.5% M_0

Ambient conditions for long-term storage, transport, and use in fixed locations

Based on DIN EN 60721-3-1 (for long-term storage), DIN EN 60721-3-2 (for transport), and DIN EN 60721-3-3 (for use in fixed, weather-protected locations)

Table 2- 2 Climatic ambient conditions

Lower air temperature limit:	- 5 °C
Upper air temperature limit:	+ 40 °C (deviates from 3K5)
Lower relative humidity limit:	5 %
Upper relative humidity limit:	85 %
Rate of temperature fluctuations:	< 0.5 K/min
Condensation:	Not permissible
Formation of ice:	Not permissible

Long-term storage:	Class 1K3 and class 1Z1 have a different upper relative humidity
Transport:	Class 2K2
Fixed location:	Class 3K3

Storage, transport and operation permissible only in locations that are fully protected against the weather (in halls or rooms).

Table 2- 3 Biological ambient conditions

Long-term storage:	Class 1B1
Transport:	Class 2B1
Fixed location:	Class 3B1

Table 2- 4 Chemical ambient conditions

Long-term storage:	Class 1C1
Transport:	Class 2C1
Fixed location:	Class 3C2 Operating site in the immediate vicinity of industrial plants with chemical emissions

Table 2- 5 Mechanically active ambient conditions

Long-term storage:	Class 1S2
Transport:	Class 2S2
Fixed location:	Class 3S1

Table 2- 6 Mechanical ambient conditions

Long-term storage:	Class 1M2
Transport:	Class 2M2
Fixed location:	Class 3M3

UL approval

The torque motors described in this documentation have been approved by Underwriters Laboratories Inc. (USA) (UL).

Validity

Generally the approvals for the motor are listed on the rating plate. As a rule, these approvals are valid for the operating mode specified in the data sheets. More detailed information on the conditions for the validity of an approval can be obtained from your local Siemens office.

The installation conditions according to Underwriters Laboratories Inc. (USA) - UL for short - can be taken from the Conditons of Acceptability.

Direction of rotation

The rotor for the built-in torque motor rotates clockwise if the built-in torque motor is connected to phase sequence U, V, W. You can see this when you look at the A flange of the motor.

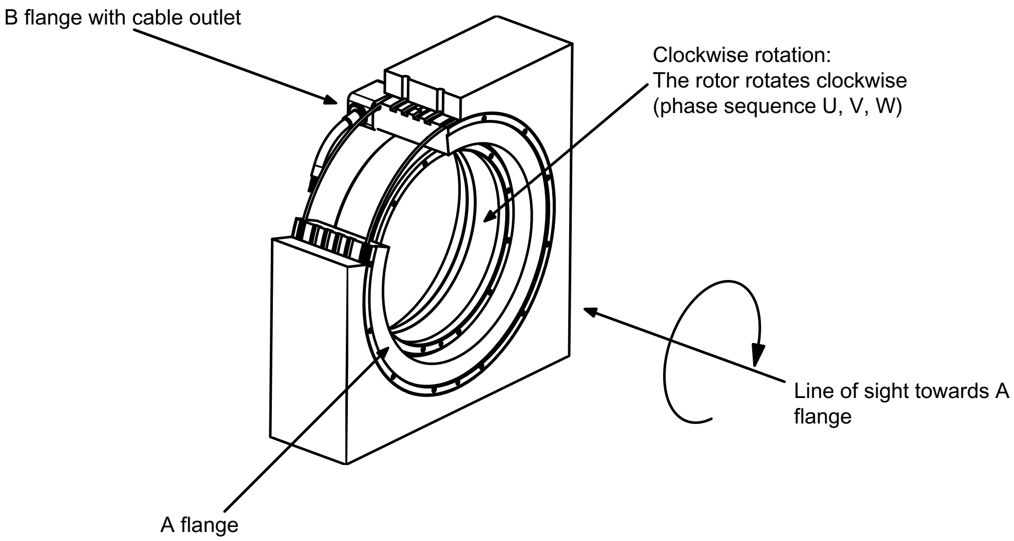


Figure 2-1 Line of sight for determining the direction of rotation

2.3 Selection and ordering data

Table 2- 7 Built-in torque motors: overview (part 1 of 2)

Order desig. / Size	Rated torque[1)] M_N in Nm	Max. torque M_{MAX} in Nm	Rated current[1)] I_N in A	Max. current I_{MAX} in A	Max. speed at rated torque[2)] $n_{MAX,MN}$ in rpm	Max. speed at max. torque[2)] $n_{MAX,MMAX}$ in rpm
1FW6090-xxB05-0Fxx	113	179	5.6	9.5	140	46
1FW6090-xxB05-0Kxx	109	179	7.4	13	250	140
1FW6090-xxB07-0Kxx	154	251	9.5	16	220	120
1FW6090-xxB07-1Jxx	142	251	13	26	430	270
1FW6090-xxB10-0Kxx	231	358	7.9	13	82	8.7
1FW6090-xxB10-1Jxx	216	358	14	26	270	170
1FW6090-xxB15-1Jxx	338	537	15	26	150	78
1FW6090-xxB15-2Jxx	319	537	23	43	310	200
1FW6130-xxB05-0Kxx	241	439	9	18	130	47
1FW6130-xxB05-1Jxx	217	439	14	32	310	180
1FW6130-xxB07-0Kxx	344	614	10	20	96	21
1FW6130-xxB07-1Jxx	324	614	15	32	200	110
1FW6130-xxB10-1Jxx	484	878	16	32	120	50
1FW6130-xxB10-2Jxx	450	878	24	53	250	150
1FW6130-xxB15-1Jxx	744	1320	18	36	78	14
1FW6130-xxB15-2Jxx	714	1320	26	54	150	77
1FW6150-xxB05-1Jxx	338	710	17	44	230	110
1FW6150-xxB05-4Fxx	298	710	36	100	650	330
1FW6150-xxB07-2Jxx	470	994	25	66	260	130
1FW6150-xxB07-4Fxx	445	994	38	100	450	230
1FW6150-xxB10-2Jxx	688	1420	26	66	170	76
1FW6150-xxB10-4Fxx	664	1420	40	100	300	150
1FW6150-xxB15-2Jxx	1050	2130	26	66	100	32
1FW6150-xxB15-4Fxx	1030	2130	41	100	190	89
1FW6160-xxB05-1Jxx	431	716	16	31	140	84
1FW6160-xxB05-2Jxx	404	716	24	49	250	150
1FW6160-xxB05-5Gxx	314	716	36	98	590	320
1FW6160-xxB07-1Jxx	620	1000	16	31	96	53
1FW6160-xxB07-2Jxx	594	1000	25	49	170	100
1FW6160-xxB07-5Gxx	514	1000	43	98	390	230
1FW6160-xxB07-8Fxx	432	1000	51	140	610	330
1FW6160-xxB10-1Jxx	903	1430	17	31	60	29
1FW6160-xxB10-2Jxx	878	1430	26	49	110	65
1FW6160-xxB10-5Gxx	804	1430	47	98	260	160
1FW6160-xxB10-8Fxx	732	1430	61	140	390	230

Order desig. / Size	Rated torque[1] M_N in Nm	Max. torque M_{MAX} in Nm	Rated current[1] I_N in A	Max. current I_{MAX} in A	Max. speed at rated torque[2] $n_{MAX,MN}$ in rpm	Max. speed at max. torque[2] $n_{MAX,MMAX}$ in rpm
1FW6160-xxB10-2Pxx	622	1430	73	190	600	330
1FW6160-xxB15-2Jxx	1350	2150	26	49	66	34
1FW6160-xxB15-5Gxx	1280	2150	50	98	160	97
1FW6160-xxB15-8Fxx	1220	2150	68	140	240	150
1FW6160-xxB15-2Pxx	1120	2150	88	190	360	220
1FW6160-xxB15-0Wxx	961	2150	100	280	560	320
1FW6160-xxB20-5Gxx	1750	2860	52	98	110	68
1FW6160-xxB20-8Fxx	1690	2860	72	140	170	110
1FW6160-xxB20-2Pxx	1600	2860	95	190	260	160
1FW6160-xxB20-0Wxx	1460	2860	120	280	400	240
1FW6190-xxB05-1Jxx	633	990	17	31	97	54
1FW6190-xxB05-2Jxx	605	990	24	47	160	96
1FW6190-xxB05-5Gxx	509	990	40	95	380	210
1FW6190-xxB07-1Jxx	905	1390	17	31	63	33
1FW6190-xxB07-2Jxx	879	1390	25	47	110	64
1FW6190-xxB07-5Gxx	791	1390	44	95	250	150
1FW6190-xxB07-8Fxx	704	1390	56	130	390	220
1FW6190-xxB10-1Jxx	1310	1980	17	31	38	14
1FW6190-xxB10-2Jxx	1290	1980	26	47	70	39
1FW6190-xxB10-5Gxx	1210	1980	48	95	170	100
1FW6190-xxB10-8Fxx	1130	1980	64	130	260	150
1FW6190-xxB10-2Pxx	955	1980	84	210	450	250
1FW6190-xxB15-2Jxx	1970	2970	26	47	40	17
1FW6190-xxB15-5Gxx	1890	2970	50	95	100	62
1FW6190-xxB15-8Fxx	1820	2970	69	130	160	97
1FW6190-xxB15-2Pxx	1670	2970	99	210	270	160
1FW6190-xxB15-0Wxx	1540	2970	110	270	370	210
1FW6190-xxB20-5Gxx	2570	3960	51	95	73	42
1FW6190-xxB20-8Fxx	2500	3960	71	130	110	68
1FW6190-xxB20-2Pxx	2360	3960	100	210	200	120
1FW6190-xxB20-0Wxx	2250	3960	120	270	260	160
1FW6230-xxB05-1Jxx	799	1320	15	31	69	34
1FW6230-xxB05-2Jxx	774	1320	22	45	110	59
1FW6230-xxB05-5Gxx	660	1320	40	100	290	160
1FW6230-xxB07-1Jxx	1140	1840	16	31	45	19
1FW6230-xxB07-2Jxx	1120	1840	22	45	73	38
1FW6230-xxB07-5Gxx	1010	1840	44	100	190	110
1FW6230-xxB07-8Fxx	923	1840	56	130	290	160

Order desig. / Size	Rated torque[1)] M_N in Nm	Max. torque M_{MAX} in Nm	Rated current[1)] I_N in A	Max. current I_{MAX} in A	Max. speed at rated torque[2)] $n_{MAX,MN}$ in rpm	Max. speed at max. torque[2)] $n_{MAX,MMAX}$ in rpm
1FW6230-xxB10-2Jxx	1630	2630	23	45	46	21
1FW6230-xxB10-5Gxx	1520	2630	48	100	130	74
1FW6230-xxB10-8Fxx	1450	2630	62	130	190	110
1FW6230-xxB10-2Pxx	1320	2630	80	190	290	160
1FW6230-xxB15-4Cxx	2440	3950	32	63	43	19
1FW6230-xxB15-5Gxx	2380	3950	49	100	80	44
1FW6230-xxB15-8Fxx	2310	3950	66	130	120	67
1FW6230-xxB15-2Pxx	2190	3950	90	190	180	100
1FW6230-xxB15-0Wxx	2020	3950	110	270	270	150
1FW6230-xxB20-5Gxx	3230	5260	51	100	56	29
1FW6230-xxB20-8Fxx	3160	5260	69	130	84	47
1FW6230-xxB20-2Pxx	3050	5260	94	190	130	74
1FW6230-xxB20-0Wxx	2890	5260	120	270	190	110
1FW6290-xxB07-5Gxx	2060	4000	52	110	110	59
1FW6290-xxB07-0Lxx	1910	4000	86	210	210	110
1FW6290-xxB07-2Pxx	1810	4000	100	270	270	150
1FW6290-xxB11-7Axx	3320	6280	59	130	73	40
1FW6290-xxB11-0Lxx	3200	6280	91	210	130	71
1FW6290-xxB11-2Pxx	3100	6280	110	270	170	93
1FW6290-xxB15-7Axx	4590	8570	61	130	53	28
1FW6290-xxB15-0Lxx	4480	8570	94	210	89	50
1FW6290-xxB15-2Pxx	4390	8570	110	270	120	67
1FW6290-xxB20-0Lxx	5760	10900	95	210	68	38
1FW6290-xxB20-2Pxx	5670	10900	120	270	91	51

[1)] Water cooling with 35 °C intake temperature; [2)] Speed and current values at converter DC link voltage U_{ZK} = 600 V (regulated)/converter output voltage (rms value) U_{amax} = 425 V (regulated)

Table 2- 8 Built-in torque motors: overview (part 2 of 2)

Order desig. / size	Rated power loss[1] $P_{V,N}$ in kW	External diameter of stators in mm	Internal diameter of rotors in mm	Length of stator in mm	Motor mass[3] in kg	Moment of inertia of rotor J_L in 10^{-2}kgm^2
1FW6090-xxB05-0Fxx	2.19	230	140	90	9.2	1.52
1FW6090-xxB05-0Kxx	2.12	230	140	90	9.2	1.52
1FW6090-xxB07-0Kxx	2.69	230	140	110	12.2	2.2
1FW6090-xxB07-1Jxx	2.67	230	140	110	12.2	2.2
1FW6090-xxB10-0Kxx	3.5	230	140	140	17.2	3.09
1FW6090-xxB10-1Jxx	3.5	230	140	140	17.2	3.09
1FW6090-xxB15-1Jxx	4.87	230	140	190	27.2	4.65
1FW6090-xxB15-2Jxx	4.96	230	140	190	27.2	4.65
1FW6130-xxB05-0Kxx	2.93	310	220	90	13.2	6.37
1FW6130-xxB05-1Jxx	2.93	310	220	90	13.2	6.37
1FW6130-xxB07-0Kxx	3.73	310	220	110	18.2	8.92
1FW6130-xxB07-1Jxx	3.71	310	220	110	18.2	8.92
1FW6130-xxB10-1Jxx	4.88	310	220	140	25.2	12.7
1FW6130-xxB10-2Jxx	4.98	310	220	140	25.2	12.7
1FW6130-xxB15-1Jxx	6.81	310	220	190	38.2	19.1
1FW6130-xxB15-2Jxx	6.81	310	220	190	38.2	19.1
1FW6150-xxB05-1Jxx	2.57	385	265	110	21.7	10.1
1FW6150-xxB05-4Fxx	2.52	385	265	110	21.7	10.1
1FW6150-xxB07-2Jxx	3.28	385	265	130	33.5	14.2
1FW6150-xxB07-4Fxx	3.23	385	265	130	33.5	14.2
1FW6150-xxB10-2Jxx	4.36	385	265	160	47.5	20.9
1FW6150-xxB10-4Fxx	4.28	385	265	160	47.5	20.9
1FW6150-xxB15-2Jxx	6.14	385	265	210	70.8	31.3
1FW6150-xxB15-4Fxx	6.04	385	265	210	70.8	31.3
1FW6160-xxB05-1Jxx	2.84	440	280	110	36.3	19
1FW6160-xxB05-2Jxx	2.85	440	280	110	36.3	19
1FW6160-xxB05-5Gxx	2.88	440	280	110	36.3	19
1FW6160-xxB07-1Jxx	3.59	440	280	130	48.3	25.8
1FW6160-xxB07-2Jxx	3.61	440	280	130	48.3	25.8
1FW6160-xxB07-5Gxx	3.64	440	280	130	48.3	25.8
1FW6160-xxB07-8Fxx	3.73	440	280	130	48.3	25.8
1FW6160-xxB10-1Jxx	4.72	440	280	160	66.3	36
1FW6160-xxB10-2Jxx	4.74	440	280	160	66.3	36
1FW6160-xxB10-5Gxx	4.77	440	280	160	66.3	36
1FW6160-xxB10-8Fxx	4.9	440	280	160	66.3	36
1FW6160-xxB10-2Pxx	4.77	440	280	170	67.4	36
1FW6160-xxB15-2Jxx	6.62	440	280	210	95.3	53.1

Order desig. / size	Rated power loss[1] $P_{V,N}$ in kW	External diameter of stators in mm	Internal diameter of rotors in mm	Length of stator in mm	Motor mass[3] in kg	Moment of inertia of rotor J_L in 10^{-2}kgm^2
1FW6160-xxB15-5Gxx	6.67	440	280	210	95.3	53.1
1FW6160-xxB15-8Fxx	6.84	440	280	210	95.3	53.1
1FW6160-xxB15-2Pxx	6.67	440	280	220	96.4	53.1
1FW6160-xxB15-0Wxx	6.84	440	280	220	96.4	53.1
1FW6160-xxB20-5Gxx	8.57	440	280	260	124.3	70.1
1FW6160-xxB20-8Fxx	8.79	440	280	260	124.3	70.1
1FW6160-xxB20-2Pxx	8.57	440	280	270	125.4	70.1
1FW6160-xxB20-0Wxx	8.79	440	280	270	125.4	70.1
1FW6190-xxB05-1Jxx	3.51	502	342	110	42.8	35.8
1FW6190-xxB05-2Jxx	3.51	502	342	110	42.8	35.8
1FW6190-xxB05-5Gxx	3.51	502	342	110	42.8	35.8
1FW6190-xxB07-1Jxx	4.44	502	342	130	55.8	48.6
1FW6190-xxB07-2Jxx	4.44	502	342	130	55.8	48.6
1FW6190-xxB07-5Gxx	4.44	502	342	130	55.8	48.6
1FW6190-xxB07-8Fxx	4.57	502	342	130	55.8	48.6
1FW6190-xxB10-1Jxx	5.83	502	342	160	75.8	67.8
1FW6190-xxB10-2Jxx	5.83	502	342	160	75.8	67.8
1FW6190-xxB10-5Gxx	5.83	502	342	160	75.8	67.8
1FW6190-xxB10-8Fxx	6	502	342	160	75.8	67.8
1FW6190-xxB10-2Pxx	5.87	502	342	170	77.1	67.8
1FW6190-xxB15-2Jxx	8.14	502	342	210	107.8	99.8
1FW6190-xxB15-5Gxx	8.14	502	342	210	107.8	99.8
1FW6190-xxB15-8Fxx	8.39	502	342	210	107.8	99.8
1FW6190-xxB15-2Pxx	8.21	502	342	220	109.1	99.8
1FW6190-xxB15-0Wxx	8.39	502	342	220	109.1	99.8
1FW6190-xxB20-5Gxx	10.5	502	342	260	136.2	132
1FW6190-xxB20-8Fxx	10.8	502	342	260	136.2	132
1FW6190-xxB20-2Pxx	10.5	502	342	270	137.5	132
1FW6190-xxB20-0Wxx	10.8	502	342	270	137.5	132
1FW6230-xxB05-1Jxx	3.54	576	416	110	44.8	62.2
1FW6230-xxB05-2Jxx	3.65	576	416	110	44.8	62.2
1FW6230-xxB05-5Gxx	3.58	576	416	110	44.8	62.2
1FW6230-xxB07-1Jxx	4.47	576	416	130	58.8	84.3
1FW6230-xxB07-2Jxx	4.61	576	416	130	58.8	84.3
1FW6230-xxB07-5Gxx	4.52	576	416	130	58.8	84.3
1FW6230-xxB07-8Fxx	4.53	576	416	130	58.8	84.3
1FW6230-xxB10-2Jxx	6.05	576	416	160	81.8	118
1FW6230-xxB10-5Gxx	6.09	576	416	160	81.8	118

Order desig. / size	Rated power loss[1] $P_{V,N}$ in kW	External diameter of stators in mm	Internal diameter of rotors in mm	Length of stator in mm	Motor mass[3] in kg	Moment of inertia of rotor J_L in 10^{-2}kgm^2
1FW6230-xxB10-8Fxx	5.95	576	416	160	81.8	118
1FW6230-xxB10-2Pxx	6.1	576	416	160	81.8	118
1FW6230-xxB15-4Cxx	8.51	576	416	210	117.8	173
1FW6230-xxB15-5Gxx	8.29	576	416	210	117.8	173
1FW6230-xxB15-8Fxx	8.31	576	416	210	117.8	173
1FW6230-xxB15-2Pxx	8.53	576	416	210	117.8	173
1FW6230-xxB15-0Wxx	8.31	576	416	220	119.4	173
1FW6230-xxB20-5Gxx	10.7	576	416	260	153.8	228
1FW6230-xxB20-8Fxx	10.7	576	416	260	153.8	228
1FW6230-xxB20-2Pxx	11	576	416	260	153.8	228
1FW6230-xxB20-0Wxx	10.7	576	416	270	155.4	228
1FW6290-xxB07-5Gxx	5.19	730	520	140	103.6	228
1FW6290-xxB07-0Lxx	5.19	730	520	140	103.6	228
1FW6290-xxB07-2Pxx	5.2	730	520	160	108.8	228
1FW6290-xxB11-7Axx	7.13	730	520	180	159	334
1FW6290-xxB11-0Lxx	7.14	730	520	180	159	334
1FW6290-xxB11-2Pxx	7.16	730	520	200	164.2	334
1FW6290-xxB15-7Axx	9.08	730	520	220	214.6	440
1FW6290-xxB15-0Lxx	9.09	730	520	220	214.6	440
1FW6290-xxB15-2Pxx	9.12	730	520	240	219.8	440
1FW6290-xxB20-0Lxx	11	730	520	260	260.6	546
1FW6290-xxB20-2Pxx	11.1	730	520	280	265.8	546

[1] Water cooling with 35 °C intake temperature; [3] Motor mass not including mass of transportation locks

2.4 Order designation

2.4.1 Structure of the order designations

The order designation (MLFB) comprises a combination of digits and letters. It is divided into three hyphenated blocks. Also refer to the following diagrams.

The first block has 7 positions and designates the motor type (1FW6) and the stator size (in mm). Additional features are coded in the second and third blocks.

Please note that not every theoretical combination is possible.

2.4.2 Standard 1FW6 built-in torque motor

1FW6 xx0 - 0 x B xx - xx x 2

Directly-driven hollow-shaft motor as three-phase synchronous motor

Frame size (external diameter of stator)
09 = 230 mm
13 = 310 mm
15 = 385 mm
16 = 440 mm
19 = 502 mm
23 = 576 mm
29 = 730 mm

Built-in motor, pre-assembled

Component (position of the interfaces)
P = Cooling jacket and axial cable outlet
Q = Cooling jacket and radial cable outlet (outward)
N = Cooling jacket and tangential cable outlet
W = Integrated cooling and axial cable outlet
V = Integrated cooling and radial cable outlet (outward)
T = Integrated cooling and tangential cable outlet

Length of active component in [cm]
05 = 50 mm
07 = 70 mm
10 = 100 mm
11 = 110 mm
15 = 150 mm
20 = 200 mm

Current requirements (information on Motor Module)
0F = SINAMICS S120 Motor Module 5 A/10 A
0K = SINAMICS S120 Motor Module 9 A/18 A
1J = SINAMICS S120 Motor Module 18 A/36 A
2J = SINAMICS S120 Motor Module 30 A/56 A
4C = SINAMICS S120 Motor Module 45 A/85 A
4F = SINAMICS S120 Motor Module 45 A/85 A
5G = SINAMICS S120 Motor Module 60 A/113 A
7A = SINAMICS S120 Motor Module 85 A/141 A
8F = SINAMICS S120 Motor Module 85 A/141 A
0L = SINAMICS S120 Motor Module 132 A/212 A
2P = SINAMICS S120 Motor Module 132 A/212 A or 200 A/282 A
0W = SINAMICS S120 Motor Module 200 A/282 A

Connection type:
B = Permanently connected power cables (single cores) and signal cables with open core ends
Length: 1 m
C = Permanently connected power and signal cables with open core ends
Length: 2 m
D = Permanently connected power and signal cables pre-assembled with connectors
Length: 0.5 m

2.4.3 Stator as individual component

1FW6 xx0 - 8 x B xx - xx x 2

Directly-driven hollow-shaft motor as
three-phase synchronous motor

Frame size (external diameter of stator)
09 = 230 mm
13 = 310 mm
15 = 385 mm
16 = 440 mm
19 = 502 mm
23 = 576 mm
29 = 730 mm

Individual component

Component (position of the interfaces)
P = Cooling jacket and axial cable outlet
Q = Cooling jacket and radial cable outlet (outward)
N = Cooling jacket and tangential cable outlet
W = Integrated cooling and axial cable outlet
V = Integrated cooling and radial cable outlet (outward)
T = Integrated cooling and tangential cable outlet

Length of active component in [cm]
05 = 50 mm
07 = 70 mm
10 = 100 mm
11 = 110 mm
15 = 150 mm
20 = 200 mm

Current requirements (information on Motor Module)
0F = SINAMICS S120 Motor Module 5 A/10 A
0K = SINAMICS S120 Motor Module 9 A/18 A
1J = SINAMICS S120 Motor Module 18 A/36 A
2J = SINAMICS S120 Motor Module 30 A/56 A
4C = SINAMICS S120 Motor Module 45 A/85 A
4F = SINAMICS S120 Motor Module 45 A/85 A
5G = SINAMICS S120 Motor Module 60 A/113 A
7A = SINAMICS S120 Motor Module 85 A/141 A
8F = SINAMICS S120 Motor Module 85 A/141 A
0L = SINAMICS S120 Motor Module 132 A/212 A
2P = SINAMICS S120 Motor Module 132 A/212 A or 200 A/282 A
0W = SINAMICS S120 Motor Module 200 A/282 A

Connection type:
D = Permanently connected power and signal cables pre-assembled with connectors
Length: 0.5 m

2.4.4 Rotor as individual component

1FW6 xx0 - 8 R A xx - 0AA0

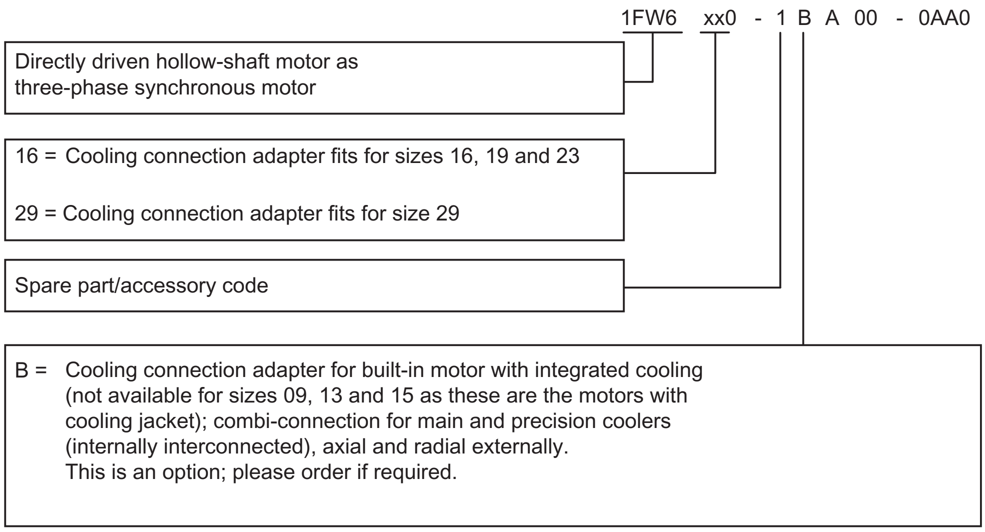
- 1FW6: Directly-driven hollow-shaft motor as three-phase synchronous motor
- xx0: Frame size (external diameter of stator)
  09 = 230 mm
  13 = 310 mm
  15 = 385 mm
  16 = 440 mm
  19 = 502 mm
  23 = 576 mm
  29 = 730 mm
- 8: Individual component
- R: Rotor
- xx: Length of active part in [cm]
  05 = 50 mm
  07 = 70 mm
  10 = 100 mm
  11 = 110 mm
  15 = 150 mm
  20 = 200 mm

2.4.5 Round sealing ring (O ring)

1FW6 xx0 - 1 E A 00 - 0AA0

- 1FW6: Directly driven hollow-shaft motor as three-phase synchronous motor
- xx0: Size (external diameter stator)
  09 = 230 mm
  13 = 310 mm
  15 = 385 mm
- 1: Spare part/accessory code
- E: E = O-ring

2.4.6 Cooling connection adapter



2.4.7 Plug connector

Connector type	Connector size	MLFB
Power connection	1.5	6FX2003-0LA10
Power connection	1	6FX2003-0LA00
Signal connection	M17	6FX2003-0SU07

2.4.8 Ordering notes

The complete built-in motor (stator, rotor with transportation locks) can be obtained with just one order designation (MLFB). Spare parts and accessories can be ordered by stating separate order designations (see order examples).

Note

Since the cable outlet cannot be changed retrospectively, you must ensure that you state the correct order designation (MLFB).

The cooling connection adapter is not included in the standard built-in torque motor and has a separate MLFB (see "Order designation, cooling connection adapter").

When selecting a motor, refer to the "Specifications of the motor supply cables" tables in "Interfaces".

Note

If, for design reasons, only individual components can be installed (stator and rotor separately), these can be ordered and shipped separately.

DANGER

Due to the risk of compression caused by the attractive forces of the rotor, an installation device must be provided by the customer when the stator and rotor are installed separately.

2.4.9 Ordering examples

Example 1:

Stator and rotor preassembled with transportation locks; cooling jacket; axial cable outlet for SINAMICS S120 drive system, Motor Modules 18 A / 36 A:

MLFB 1FW6090–0PB15–1JC2

Example 2:

Stator and rotor preassembled with transportation locks; integrated cooling; radial cable outlet towards the outside for SINAMICS S120 drive system, Motor Modules 18 A / 36 A:

MLFB 1FW6190–0VB07–1JC2

Example 3:

Cooling connection adapter (axial/radial) for sizes 1FW616, 1FW619, and 1FW623:

MLFB 1FW6160–1BA00–0AA0

Example 4:

Individual component/stator as spare part: MLFB 1FW6190–8VB07–1JD2

Individual component/rotor as spare part: MLFB 1FW6190–8RA07–0AA0

Individual component/round sealing ring as spare part MLFB 1FW6090–1EA00–0AA0

(for size 1FW609)

2.5 Motor rating plate

Note

A motor rating plate is attached to each stator. A second rating plate, which the customer can attach to the machine in which the motor is installed, is also included in the delivery. The motor rating plates must be used for their intended purpose only. When a motor rating plate is removed from the motor or machine, it must be rendered unusable.

If stators and rotors are separated, you must ensure that they can be correctly assigned to each other at a later stage.

Data on the motor rating plate

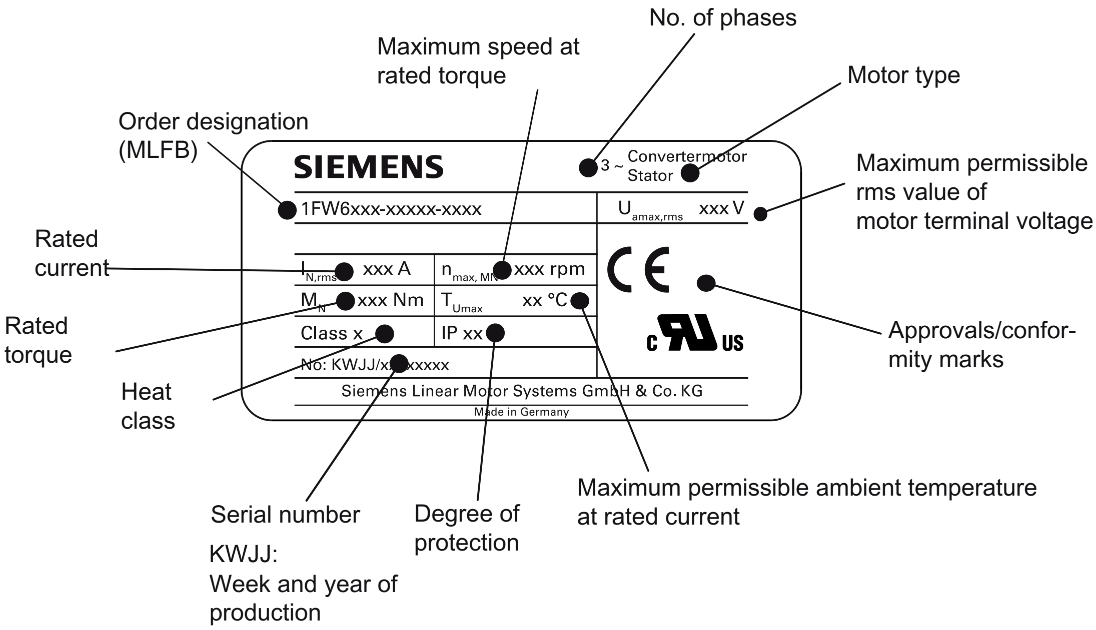


Figure 2-2 1FW6 motor rating plate (diagram)

Note

The data on the motor rating plate only applies in conjunction with the corresponding rotor.

Motor components of the built-in motor and options 3

3.1 Overview of the motor construction

Motor components

The built-in torque motor contains the following components:

- Stator:
  this comprises an iron core and a 3-phase winding.
  The winding is encapsulated to ensure that the heat loss can be dissipated more effectively. The motor is designed for water cooling (main cooler). The cooler has a different design for each of the different sizes (external diameter).
- Rotor:
  this is the reaction part of the motor. It comprises a cylindrical hollow steel shaft with permanent magnets around its circumference.
- Cooling connection adapter (optional):
  this can be ordered for motors with integrated cooling whereby the main and precision cooler are operated in parallel on one heat-exchanger unit.

Motors with a cooling jacket

The cooling jacket surface of the motor contains circular grooves which, in conjunction with a surrounding construction provided by the machine manufacturer, create a closed liquid cooling circuit.

The coolant inlet/return flow circuit must be provided by the machine manufacturer in the surrounding construction.

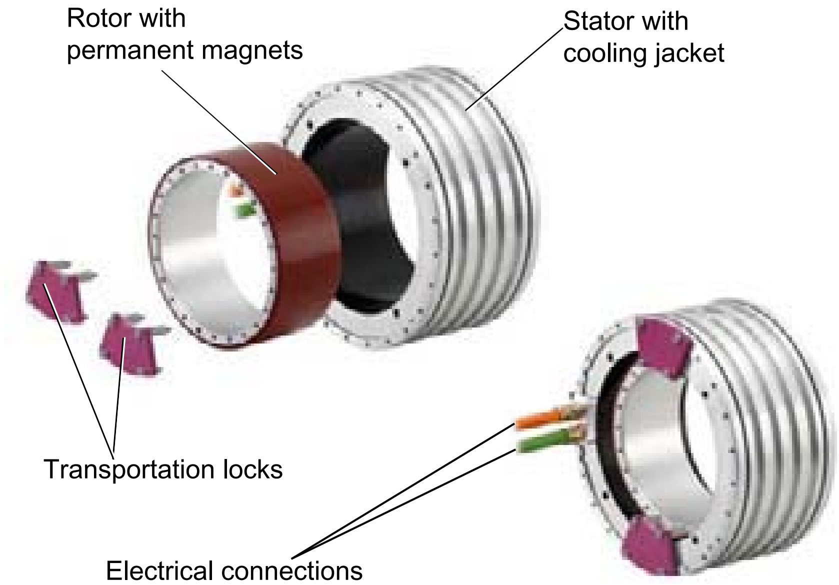


Figure 3-1 1FW6 motor components with a cooling jacket

Scope of delivery of the built-in torque motor with a cooling jacket

- The rotor is secured in the stator by means of transportation locks and a spacer film
- Stator with a cooling jacket; one cable for the power connection and one cable for the signal connection with connector or open core ends
- Transportation locks with spacers and screws
- O-rings (x 2) 2)
- Motor rating plate (attached); additional motor rating plate (not attached)
- Safety information

Motors with integrated cooling

These motors are equipped with a ready-to-connect, integrated dual-circuit cooling system, which provides considerable thermal insulation vis-à-vis the mechanical axes construction.

The dual-circuit cooling system comprises a main and precision cooler (thermo-sandwich® principle).

An internal cooling circuit (main cooler) dissipates most of the winding losses P_v of the stator. A thermal insulation layer between the stator and the mounting flanges of the stator prevents heat from flowing from the motor winding to the machine construction.

Any heat that does flow through the insulation layer is captured, for the most part, by a second heat sink (precision cooler) on the flange surfaces and dissipated. This ensures that the temperature on the mounting surfaces of the stator remains suitably low under all permissible operating conditions.

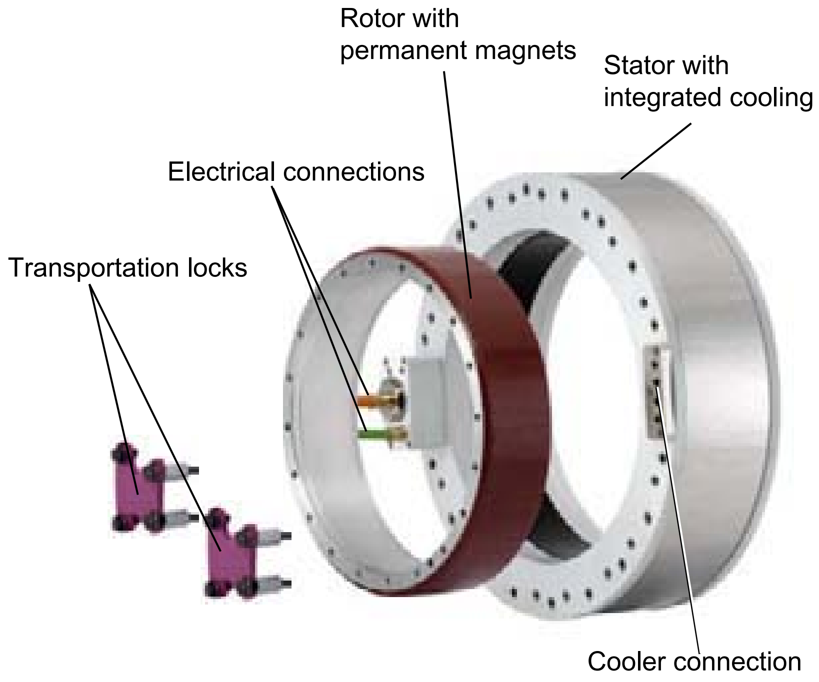


Figure 3-2 1FW6 motor components with integrated cooling

Scope of delivery of the built-in torque motor with integrated cooling

- The rotor is secured in the stator by means of transportation locks and a spacer film
- Stator with ready-to-connect dual cooling circuit; one cable for the power connection and one cable for the signal connection with connector or open core ends
- Transportation locks with spacers and screws
- Motor rating plate (attached); additional motor rating plate (not attached)
- Safety information

Cooling method

The stator in the built-in torque motors is equipped with a liquid cooler for dissipating heat loss.

The cooling method used depends on the size (external diameter) of the motor (see table below).

Table 3- 1 Cooling method

Size	Cooling jacket	Integrated cooling
1FW609	X	
1FW613	X	
1FW615	X	
1FW616		X
1FW619		X
1FW623		X
1FW629		X

3.2 Thermal motor protection

3.2.1 Description of the temperature sensors

Temperature sensor

1FW6 stators are equipped with the two temperature monitoring circuits described below (Temp-S and Temp-F) in order to protect the stator against excessive thermal stress and to monitor the temperature during commissioning and operation.

Temp–S

There are two temperature shutdown circuits, consisting of PTC temperature sensors (PTC elements), for monitoring the motor winding:

- 1 x PTC 130 °C element for each phase winding (U, V, and W), i.e. switching threshold at 130 °C, and
- 1 x PTC 150 °C element for each phase winding (U, V, and W), i.e. switching threshold at 150 °C.

The PTC elements for the two temperature shutdown circuits are connected in series, with each element connected to a triplet.

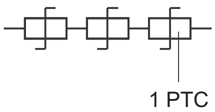
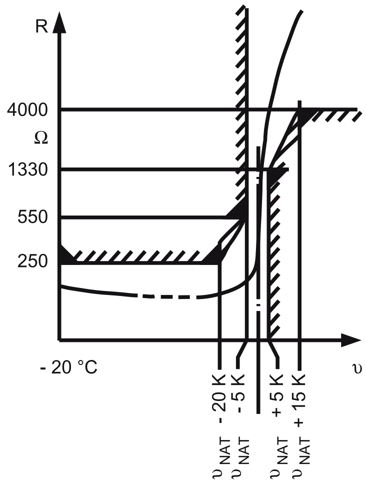
The characteristics of the PTC elements comply with DIN VDE 0660 Part 303, DIN 44081, and DIN 44082 (see also the table below).

The cable connection is also monitored with PTCs 80 °C on the housing. A PTC 80 °C is connected to the PTC 130 °C triplet and a PTC 80 °C is connected to the PTC 150 °C triplet in series.

Function:

Each PTC element has a "quasi-switching" characteristic, that is, a sudden increase in resistance occurs at the rated response temperature ϑ_{NAT} (switching threshold). As a result of the low thermal capacity and the good thermal contact between the PTC element and the motor winding, the sensors - and therefore also the system - quickly respond to inadmissibly high stator temperatures.

Table 3- 2 Technical data for the PTC thermistor triplet (PTC triplet)

Name	Description
Type	PTC triplet (acc. to DIN 44082- M180)
Response temperature (rated response temperature ϑ_{NAT})	130 °C ± 5 K 150 °C ± 5 K
PTC resistance (20 °C) at the triplet from - 20 °C up to ϑ_{NAT} - 20K	≤ 3 · 250 Ω (750 Ω), refer to the characteristic
Minimum triplet resistance when hot at T = ϑ_{NAT} – 5 K at T = ϑ_{NAT} + 5 K at T = ϑ_{NAT} + 15 K	 ≤ 3 · 550 Ω (1650 Ω), refer to the characteristic ≥ 3 · 1330 Ω (3990 Ω), refer to the characteristic ≥ 3 · 4000 Ω (12000 Ω), refer to the characteristic
Connection	Connect signal cable with connector to SME12x module.
Application	It is mandatory that a PTC triplet is connected in order to protect the motor against overtemperature. At the very least, the Temp-S must be connected with the rated response temperature of 130°C.
Typical characteristic R(ϑ) of a PTC temperature sensor Temp-S comprises 3 PTC temperature sensors connected in series! 	

Note

As a result of the additional PTC to monitor the power connection, the values for the PTC resistance and the minimum resistance change when warm. Factor "4" must be used instead of factor "3".

Note

The PTC thermistors do not have a linear characteristic and are, therefore, not suitable to determine the instantaneous temperature.

Temp–F

The temperature sensor circuit comprises a temperature sensor (KTY 84). For torque motors with integrated cooling, there is a KTY 84 temperature sensor between two phase windings. For torque motors with cooling jacket, there is a KTY 84 temperature sensor in a phase winding.

Function:

The KTY 84 has a progressive characteristic that is approximately linear (temperature resistance). Like the PTC elements in the Temp–S circuit, it also has a low thermal capacity and good thermal contact with the motor winding.

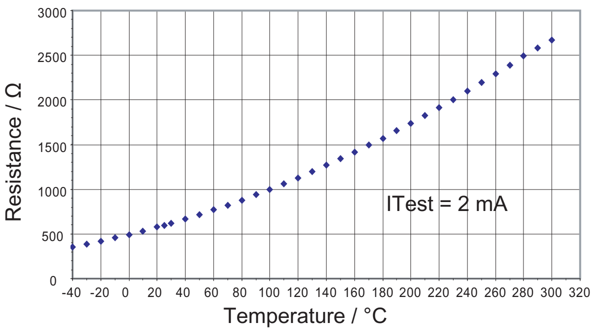
Temp–F is used to monitor the temperature.

⚠ WARNING
It is not permissible to evaluate the Temp–F to protect the motor.

The temperature is measured using Temp–F only between two phase windings or in one phase winding. If an overtemperature occurs in a phase winding that is not monitored, then this cannot be immediately displayed or evaluated. Further, the Temp–F has a slow characteristic and is not sufficient for fast tripping.

The individual phase windings have different current load levels and therefore different thermal loads if the motor is stationary or only slowly rotates but at the same time is generating a torque.

Table 3- 3 Technical data of the KTY 84 PTC thermistor

Name	Description
Type	KTY 84
Transfer range	- 40 °C ... + 300 °C
Resistance when cold (20 °C)	approx. 580 Ω
Resistance when hot (100 °C)	approx. 1000 Ω
Connection	Connect signal cable with connector to SME12x module.
Application	Temperature monitoring to determine the motor utilization.
Temperature characteristic	

DANGER

Electrical shock hazard!

To fulfill the requirements of electrical separation in accordance with EN 61800-5-1, it is not enough to connect the signal cable (cores ws and br) to the SMC20 Sensor Module. The temperature monitoring circuits must be connected to the drive control via the SME12x module.

NOTICE

When connecting temperature sensors with open cable ends, please pay attention to how the core colors are assigned (described in the section dealing with connections).

3.2.2 Evaluation of the temperature sensors for motor protection

Temp–S

Temp–S is used to reliably protect the motor against overheating. If Temp–S responds, then the drive must be quickly shut down in order to prevent the drive converter from continuing to supply current to the stator (= additional thermal load). The current load level setpoint(s), requested from the closed-loop control, causes this thermal load and this can destroy the stator.

Temp-S is evaluated by the SME12x module. The PTC 130°C is used for issuing a warning. If the temperature continues to rise, the PTC 150°C responds when its response temperature is reached at which point the stator must be immediately disconnected from the power supply.

Temp–F

Temp–F supplies an analog signal that is proportional to the temperature and for a symmetrical current load of the three-phase windings provides information about the average motor temperature.

Note

The temperature sensor (Temp–F) only senses the winding temperature between two phases or in one phase in the stator. However, the phases in the synchronous motor are loaded to different degrees depending on the particular operating mode, so that in the worst case, the phases that have not been measured have the higher temperatures.

3.3 Cooling

The heat loss generated by the stator winding must be dissipated by a water-cooling system. For this purpose, the machine manufacturer must connect the cooling duct to a cooling circuit in a heat-exchanger unit. For characteristic curves indicating a rise in temperature and drop in pressure of the cooling medium between the inlet and return flow circuit in the cooler as a function of the volume flow rate, see "Technical data and characteristics".

In certain operating statuses (e.g. at high speeds or in S1 mode), the rotor can heat up further due to iron loss. The rated motor torques specified in the data sheets (see "Technical data and characteristics") are valid during operation with water cooling with an inlet temperature of 35 °C and a rotor flange temperature of max. 60 °C. To ensure that these conditions are maintained, additional measures may have to be taken to cool the rotor.

NOTICE
If the heat from the rotor cannot be sufficiently dissipated via the flange, this can cause the rotor to heat up excessively in the upper speed range in S1 mode, which could demagnetize the magnets.

Note

Depending on the load and operating mode, the average temperature in the stator and rotor can reach 120°C. Different temperature conditions in the stator and rotor can cause the motor components to expand. The amount of heat transferred into the machine construction as well as the radial and axial thermal expansion of the motor must be taken into account in the design.

Effects when water cooling is not used

If water cooling is not used, the motor can only be loaded in continuous operation (depending on the size, power loss, emissions area, convection, and installation conditions in the machine) with a significantly reduced continuous torque ($M \ll M_N$). The max. torque M_{MAX} of the motor can be fully utilized here.

⚠ WARNING

Without water cooling:

Significant reduction of continuous torque (depending on the thermal connection to the surrounding construction) and considerable rise in the temperature of the machine construction.

- This is why a water-cooling system is essential.
- In the case of axes that are to be operated without water cooling, the reduction of the continuous motor torque and the thermoelastic deformation of the machine construction (warping through expansion) must be taken into account in the drive configuration and design.

Note

Motors with integrated cooling should not be operated without water cooling.

3.3.1 Cooling circuits

Cooling circuit requirements

We recommend that the cooling circuits be designed as closed systems, to prevent the growth of algae. The maximum permissible pressure is 10 bar.

Note

We do not recommend that the cooling circuits of machines are also used to cool the motors: Due to accumulated dirt and long-term deposits, blockage may result! This especially applies to cooling-lubricating medium circuits.

If the cooling circuits of the machines are also used to cool the motors, then they must fulfill all of the requirements listed here. Also note the demands on the cooling medium as well as the maximum standstill times of cooling circuits according to the specifications of the cooling medium manufacturer!

Materials used in the cooling circuits of torque motors

Table 3- 4 Materials in the cooling circuits of torque motors (not including the material used for the connections)

Cooling jacket for 1FW609, 1FW613 and 1FW615	Integrated cooling (main cooler) for 1FW616 to 1FW629	Integrated cooling (precision cooler) for 1FW616 to 1FW629	Cooling connection adapter for 1FW616 to 1FW629
1FW609, 1FW613: • EN AW-5083 (EN 573-3) • Viton® (FPM) gasket 1FW615: • S355J2G3 (EN 10025) • Viton® (FPM) gasket	• X6CrNiTi18-10 (EN 10088) • SF-Cu (DIN 17671) • CW617N (DIN EN 12165) • Viton® (FPM) gasket • Silicon hose • Ag 102 (EN 1045) + welding flux EN 1045-FH10	• X6CrNiTi18-10 (EN 10088) • SF-Cu (DIN 17671) • CW617N (DIN EN 12165) • Viton® (FPM) gasket • Silicon hose	• CW617N (DIN EN 12165) • Viton® (FPM) gasket

Calculating the thermal power that can be dissipated by the cooler

$$Q = \rho \cdot c_p \cdot \dot{V} \cdot \Delta T$$

Average density of the coolant:	ρ	in	kg/m³
Average specific heat capacity of the coolant:	c_p	in	J/(kg K)
Temperature deviation vis-à-vis the inlet temperature:	ΔT	in	K
Volume flow rate:	$\dot{V}$	in	m³/s

Coolant intake temperature

The intake temperatures must be selected in such a way that no condensation forms on the surface of the motor. Condensation can lead to corrosion in the machine.

$T_{kühl} \geq T_{Umgeb}$ - 2 K

The motors are designed in accordance with DIN EN 60034–1 for operation at coolant temperatures of up to 35°C (rated value of the coolant intake temperature). If the intake temperature is different, the continuous motor current changes as shown below:

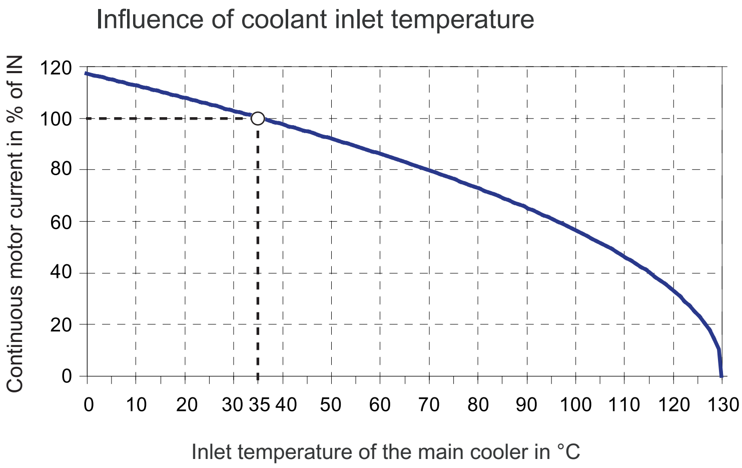


Figure 3-3 Principal dependency of the continuous motor current on the intake temperature of water cooling in the main cooler when the rotor losses are disregarded

Heat-exchanger unit

A heat-exchanger unit must be used to ensure a coolant inlet temperature of 35°C. More than one motor can be operated on a single heat-exchanger unit. The heat-exchanger units are not included in the scope of supply.

The cooling power is calculated from the sum of the power losses of the connected motors. The pump power must be adjusted in accordance with the specified flow and pressure loss of the cooling circuit.

For a list of companies and addresses from whom you can obtain heat-exchanger units, see the appendix.

Dimensioning the heat-exchanger unit

The power loss generated in the motor during continuous operation causes a heat flow, most of which is dissipated via the coolant in the cooling system. A smaller proportion of it is dissipated via the surrounding machine construction. The cooling power of the heat-exchanger unit in the cooling system must be designed in such a way that it can dissipate at least 85 - 90% of the generated power loss. If several motors are operated simultaneously on one cooling system, this value applies to the combined total power loss.

During continuous operation, the motor can only be loaded to the extent that the effective continuous torque M_{eff} does not exceed the rated torque M_N. As a result, therefore, the effective power loss cannot exceed the rated power loss $P_{V,N}$.

$$\frac{P_V}{P_{V,N}} = \left(\frac{M_{eff}}{M_N}\right)^2$$

If the actual effective loss is impossible to predict or too complex to calculate, the total combined continuous power loss (table values) of all the motors deployed can be used instead to calculate the required cooling power.

In this case, the resulting discrepancy vis-à-vis the actual effective power loss may mean that the cooling system is overdimensioned.

The cooling system must be sufficiently powerful to ensure the required coolant pressure even at the maximum volume flow rate.

3.3.2 Coolant

Provision of the cooling medium

The customer must provide the cooling medium. Only water with anti-corrosion agent should be used as the cooling medium.

⚠ WARNING
Oil must not be used as a coolant because it is incompatible with materials used in motors with a cooling jacket and may cause O-rings to corrode. In motors with integrated cooling, oil can corrode the hoses of the cooling system inside the motor.

Reason for the use of water with an anti-corrosion agent

The use of untreated water may lead to considerable damage and malfunctions due to water hardness deposits, the formation of algae and slime, as well as corrosion, for example:

- Worsening of the heat transfer
- Higher pressure losses due to reductions in cross-sectional area
- Blockage of nozzles, valves, heat exchangers and cooling ducts

For this reason, water as a cooling medium must contain an anti-corrosion agent that reliably prevents deposits and corrosion even under extreme conditions.

General requirements placed on the cooling medium

The cooling medium must be pre-cleaned or filtered in order to prevent the cooling circuit from becoming blocked. The formation of ice is not permitted!

Note

The maximum permissible size for particles in the cooling medium is 100 µm.

Requirements placed on the water

The water used as the basis of the cooling medium must fulfill the following minimum requirements:

- Concentration of chloride: c < 100 mg/l
- Concentration of sulfate: c < 100 mg/l
- 6.5 ≤ pH value ≤ 9.5

Please check further requirements with the manufacturer of the anti-corrosion agent!

Requirements placed on the anti-corrosion agent

The anti-corrosion agent must fulfill the following requirements:

- The basis is ethylene glycol (also called ethanediol)
- The water and anti-corrosion agent do not segregate
- The freezing point of the water used is reduced to at least -5° C
- The anti-corrosion agent used must be compatible with the fittings and cooling system hoses used as well as the materials of the motor cooler

Check these requirements, especially in regard to material compatibility, with the cooling unit manufacturer and the manufacturer of the anti-corrosion agent!

Suitable mixture

- 25 % - 30 % ethylene glycol (= ethanediol)
- The water used contains a maximum of 2 g/l dissolved mineral salt and is largely free from nitrates and phosphates

Manufacturer recommendations: see appendix

4 Coupled motors

4.1 Parallel operation of several motors

Parallel operation of several motors on one axes

Provided that certain prerequisites are fulfilled, built-in torque motors can be operated in parallel on a single axis and supplied by a joint power unit. Drawings: see the end of this section

---

Note

Only torque motors that are the same size and have the same current requirements (same winding design) can be connected in parallel. The order designations (MLFB) of the motors must only differ with regard to the "component (position of the interfaces)" and "connection type". The direction of the cable outlets and the length of the cables are irrelevant in the case of an electrical parallel configuration. To illustrate this, a dummy MLFB is shown below in which the wildcards indicated by boxes represent the positions that can vary between the MLFBs; the wildcards indicated by "x" represent the positions that must be the same in the MLFBs:

1FW6xxx-x□xxx-xx□x

If you have any questions about configuring/designing drive systems with torque motors in parallel operation, contact your local Siemens office.

When more than one motor is operated in parallel on a single power unit, the relevant national regulations must be observed. In particular, special precautions must be taken in North America (special motor protection).

Requirements

The following must be taken into account when motors are operated in parallel on one axes:

- Only identical motors are suitable for parallel operation.
- The phase angles of the EMFs of the parallel motors must be the same, and the commutation angle must be set precisely.
- The markings (notch and/or locating hole) on the stator/rotor in the motor must be aligned. The motors can be positioned in relation to each other as required here.

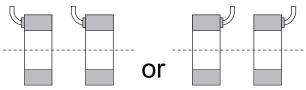
The machine manufacturer must attach a mechanical angular position adjustment device in the surrounding construction (e.g. via an adapter flange with oblong holes) for this purpose either on a stator or rotor. An adjustment angle of +/-0.5% must be set (mechanically) to ensure that the phase angles of the parallel motors can be set accordingly.

> **CAUTION**
>
> **If the angular position is set incorrectly, this can result in a thermal overload of one of the two parallel motors during continuous operation at the rated load.**
>
> For this reason, it may be necessary to reduce the torque depending on the load to prevent shutdown triggered by the PTCs.
>
> Mechanical fine-tuning should always be carried out.

Motor arrangements

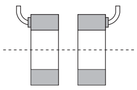
When two motors are operated in parallel, they can be arranged as follows:

Tandem arrangement



The cable outlets of the motors are located on the same side. When standard motors are used, they both rotate in the same direction.

Janus arrangement



The cable outlets of the motors are located on opposite sides. When standard motors are used, the stoker must be connected (as described below) in such a way that both motors rotate in the same direction.

Master and stoker

The "stoker" refers to the second motor on an axes, which does not rotate in the same direction as the first motor ("master") with respect to the U V W phases. To ensure that the stoker rotates in the same direction, the V and W phases must be swapped when the stoker is connected.

4.1.1 Power connection for parallel operation

Table 4- 1 Power connection when two torque motors are operated in parallel

Converter	Master	Stoker Tandem arrangement	Stoker Janus arrangement
U2	U	U	U
V2	V	V	W
W2	W	W	V

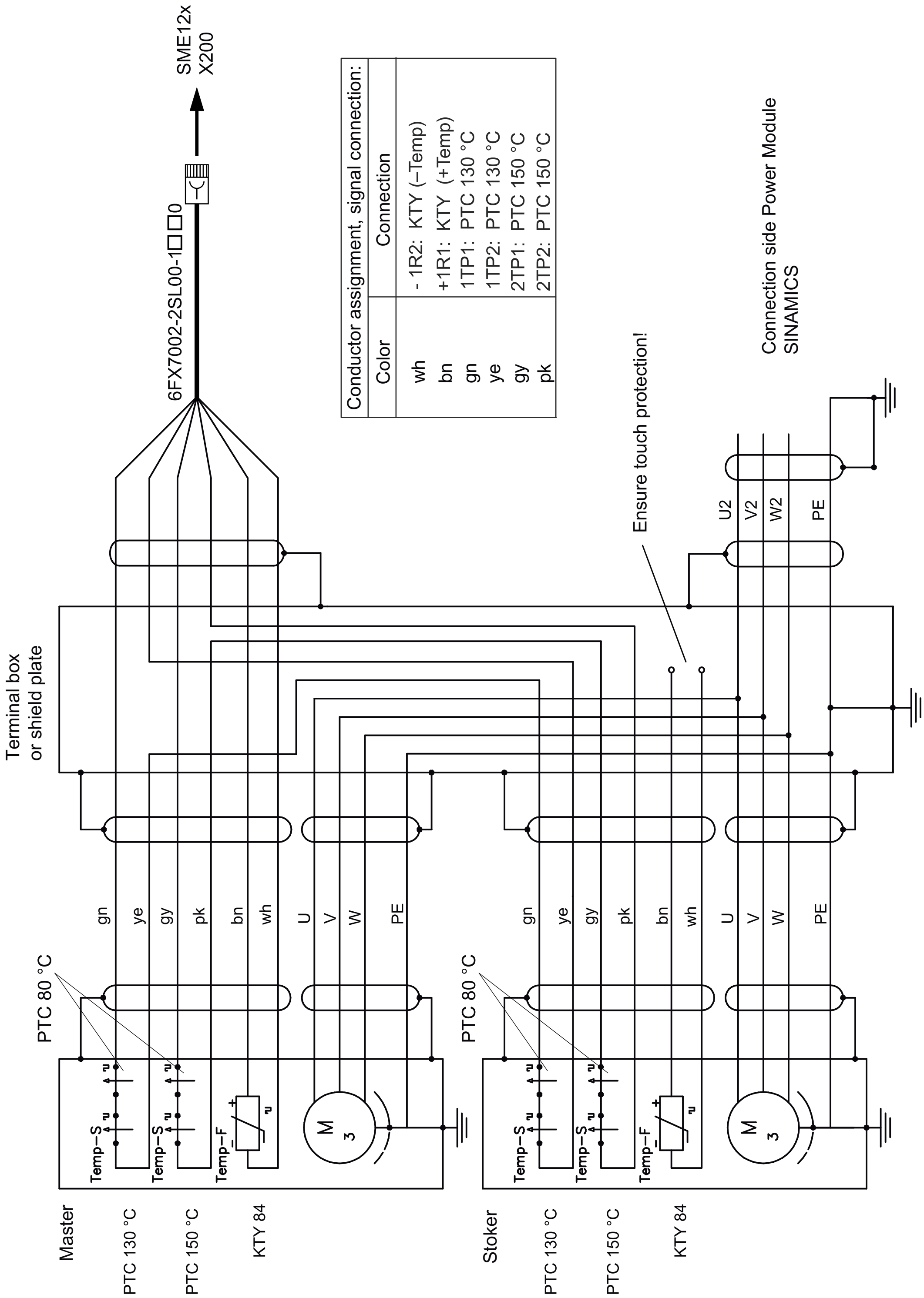


Figure 4-1 Connection diagram: two torque motors connected in parallel (tandem arrangement); PTC 130°C and PTC 150°C connected via SME12x

DANGER

Risk of electric shock!

Signal conductors left unassigned must be insulated. The insulation must be able to withstand the rated voltage of the motor.

Note

When connecting torque motors in parallel, the power cables should be of equal length in order to ensure even current distribution.

4.1.2 Janus arrangement

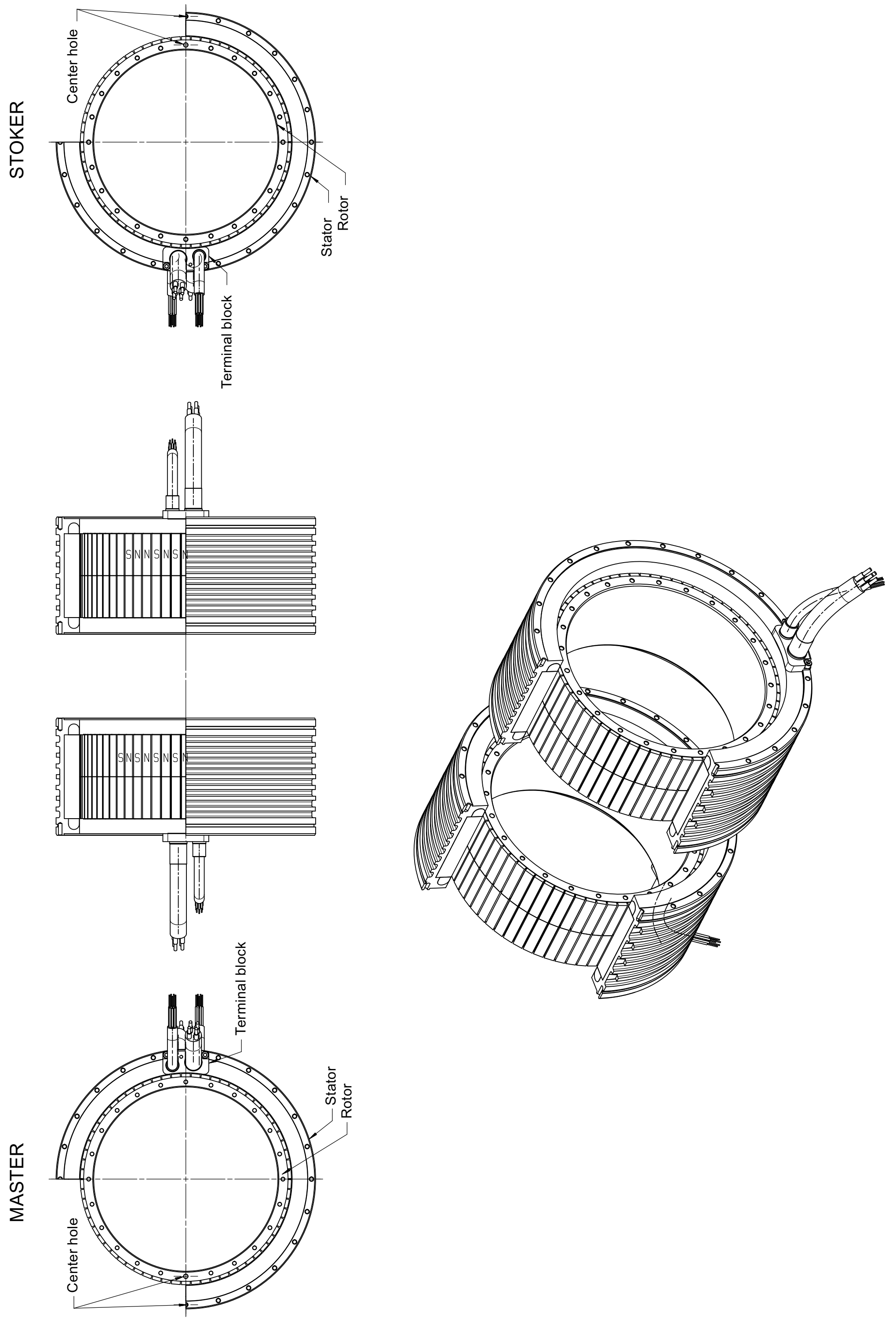


Figure 4-2 Janus arrangement for motors with a cooling jacket

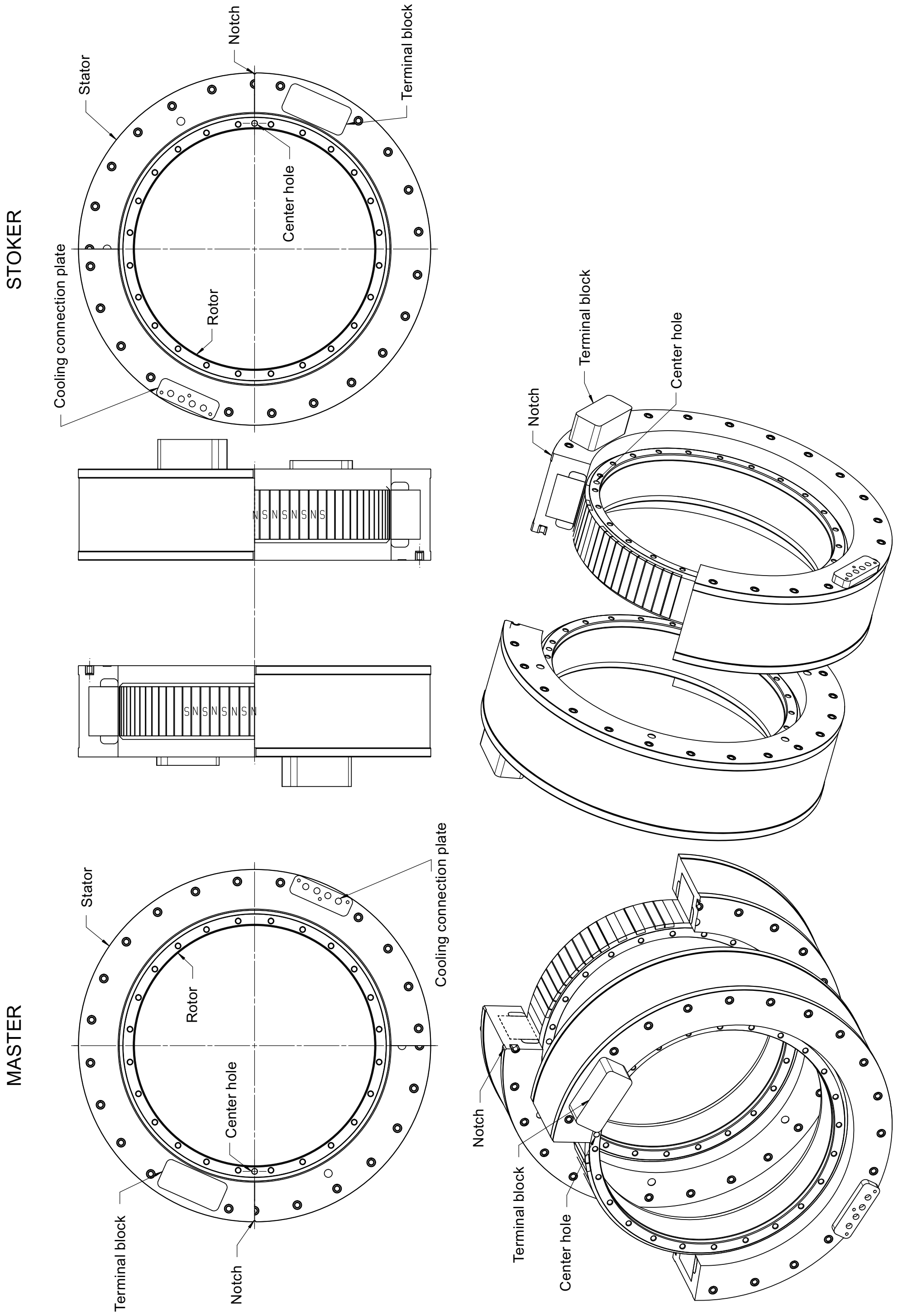


Figure 4-3 Janus arrangement for motors with integrated cooling

5 Configuring the motor

5.1 Procedure

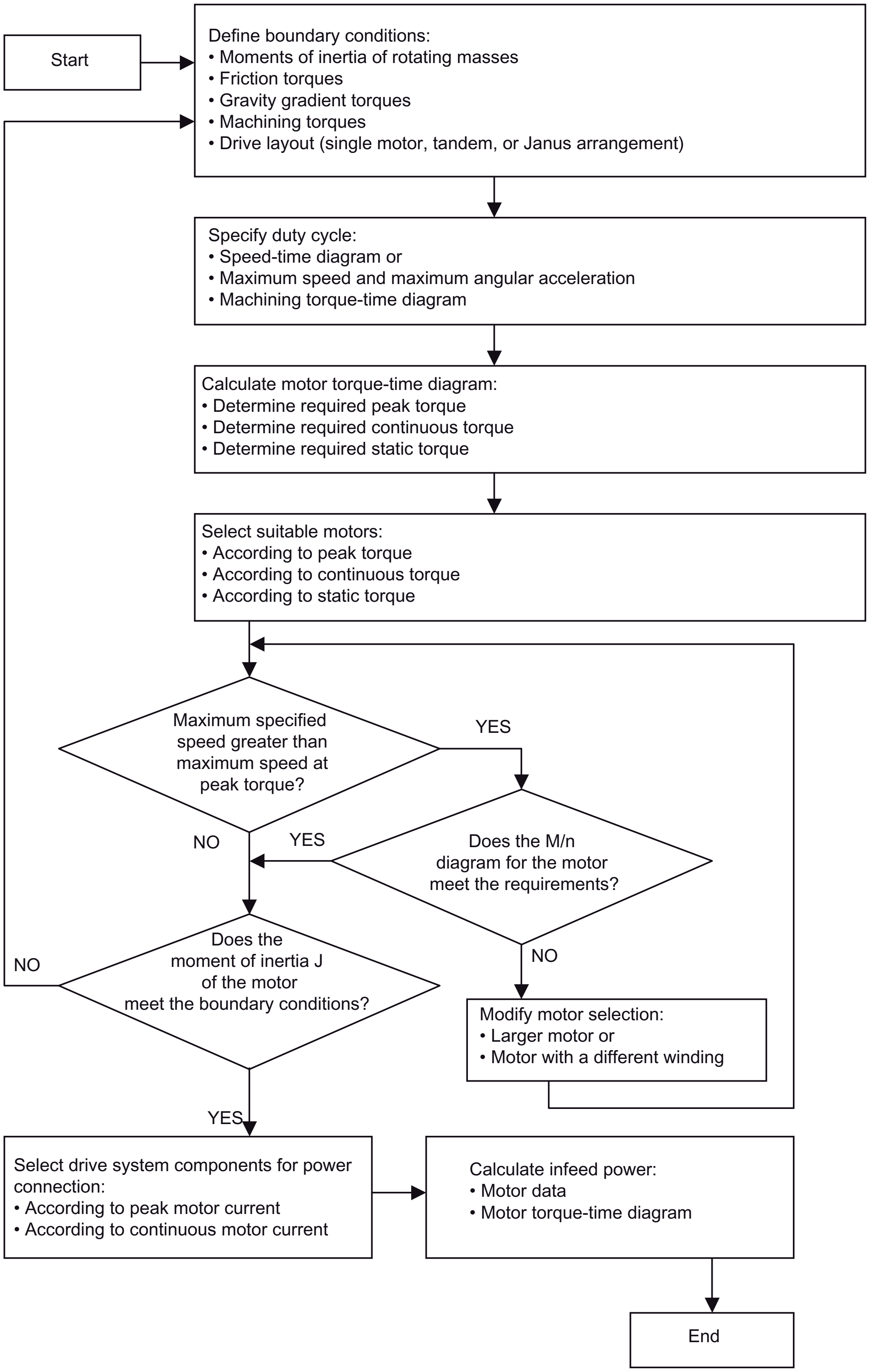
Requirements

Your choice of torque motor depends on the following factors:

- The peak and continuous torque required for the application
- The required speed and angular acceleration
- The installation space available
- The required/possible drive arrangement (single/parallel operation)
- The required cooling method

Procedure

Selecting the motors is generally an iterative process because - in particular with highly-dynamic direct drives - the moment of inertia of the motor type is a factor in determining the required torques.


Start
Define boundary conditions:
• Moments of inertia of rotating masses
• Friction torques
• Gravity gradient torques
• Machining torques
• Drive layout (single motor, tandem, or Janus arrangement)
Specify duty cycle:
• Speed-time diagram or
• Maximum speed and maximum angular acceleration
• Machining torque-time diagram
Calculate motor torque-time diagram:
• Determine required peak torque
• Determine required continuous torque
• Determine required static torque
Select suitable motors:
• According to peak torque
• According to continuous torque
• According to static torque
Maximum specified speed greater than maximum speed at peak torque?
YES
NO
Does the M/n diagram for the motor meet the requirements?
YES
NO
Does the moment of inertia J of the motor meet the boundary conditions?
NO
YES
Modify motor selection:
• Larger motor or
• Motor with a different winding
Select drive system components for power connection:
• According to peak motor current
• According to continuous motor current
Calculate infeed power:
• Motor data
• Motor torque-time diagram
End

5.1.1 General mechanical conditions

Moment of inertia

The kinetic energy generated by a rotating body is directly proportional to its moment of inertia J in kgm^2. The moment of inertia takes into account the rotating mass and its spatial distribution across the entire volume of the body with respect to the rotary axes. The rotating mass comprises the mass of the rotating mechanical structure (e.g. tool and holder) and the mass of the rotor.

Frictional torque

The frictional torque M_r is in opposition to the direction in which the rotor rotates. It can be approximately calculated from a combination of the constant "adhesion component" M_{RH} and "sliding friction component" M_{RG}. Both components also depend on the bearing used and its load.

Depending on the mechanical design, loads here generally include axial forces and clamping forces between the bearing components.

Further procedure

The moment of inertia of a suitable motor type can be used here initially.

If it transpires that the discrepancy between the assumed and actual moment of inertia is too great when further calculations are made, you then have to carry out a further iterative step when selecting the motor. To calculate the frictional torque, use the relevant specifications issued by the bearing manufacturer.

5.1.2 Specification of the duty cycle

Significance of the duty cycle

In addition to the frictional torque, you must also take into account the duty cycle when selecting the motor. The duty cycle contains information regarding the sequence of motion of the drive axes and the machining forces that occur in the process.

Motional sequence

The motional sequence can be specified as a rotation angle-time diagram, angular velocity-time diagram, speed-time diagram, or angular acceleration-time diagram. The torques resulting from the motional sequence (accelerating torque M_a) are proportional with respect to the angular acceleration α and moment of inertia J, and are in opposition to the acceleration.

$$M_a = J \cdot \alpha$$

Angle-time diagrams and speed-time diagrams can be converted to angular acceleration-time diagrams α (t) in accordance with the following correlations:

$\alpha(t) = \frac{dn(t)}{dt}$ $\alpha(t) = \frac{d^2\varphi(t)}{dt^2}$

Example

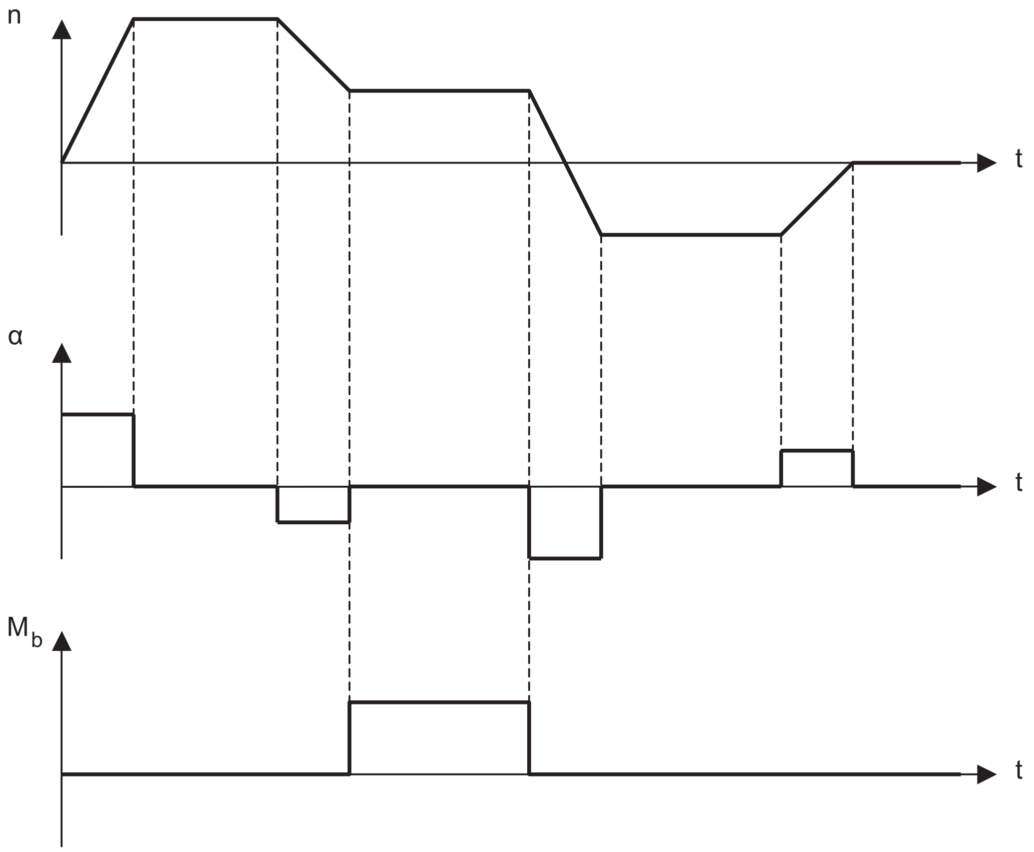


Figure 5-1 Example of a duty cycle with a speed-time diagram n(t), the resulting angular acceleration-time diagram α(t), and a machining torque-time diagram M_b(t)

5.1.3 Torque-time diagram

Required motor torque

The required motor torque M_m is always the sum of the individual torques. The sign in front of the torque specifications must always be taken into account.

$M_m = M_a + M_b + M_r$

M_a : Accelerating torque

M_b: Machining torque

M_r: Frictional torque

Determining the required motor torque

The frictional torque characteristic can be determined on the basis of the speed characteristic. The totals formula can then be used to create the motor torque-time diagram (see diagram below) from which the required peak torque M_{mMAX} can be read directly.

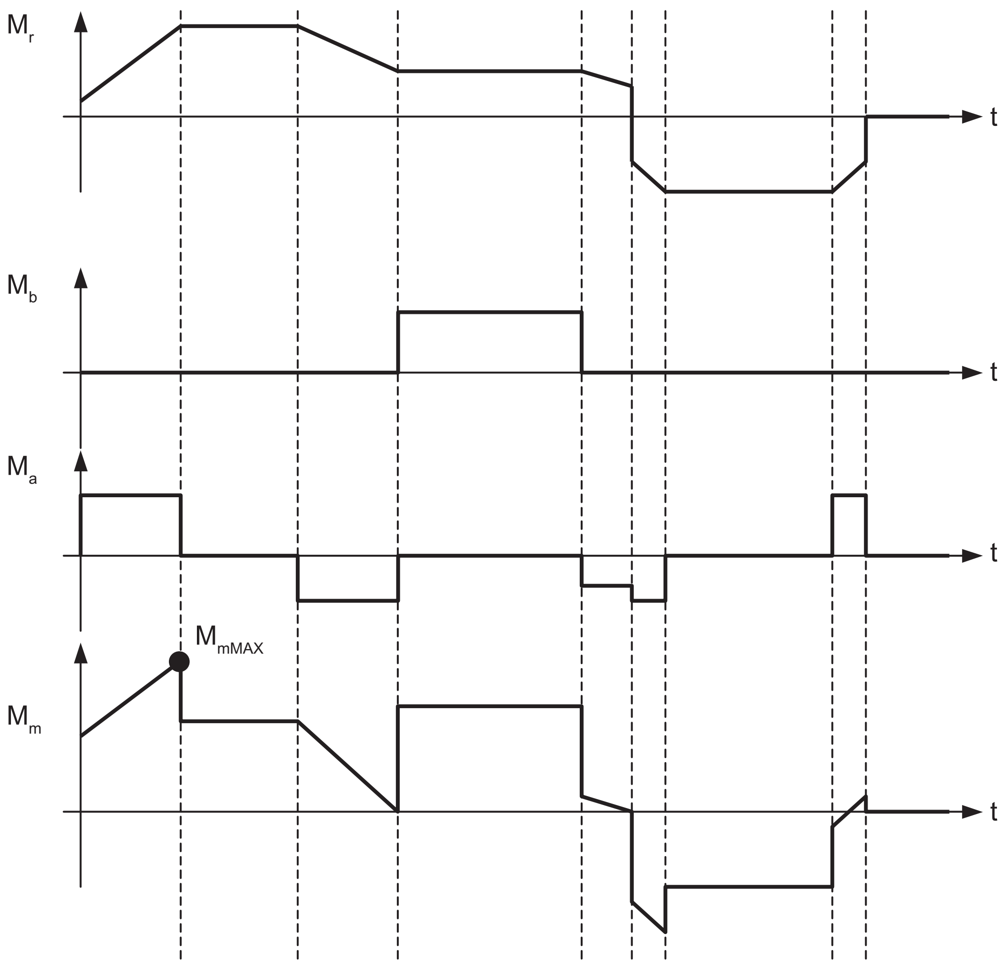


Figure 5-2 Characteristic for individual torques and the resulting required motor torque M_m in a torque drive

In addition to the peak torque M_{mMAX}, the required continuous torque M_{eff} of the motor is also a crucial factor in determining how the motor is dimensioned. The continuous torque M_{eff} responsible for the temperature rise in the motor can be derived from the motor torque-time diagram by means of quadratic averaging and must not exceed the rated torque M_N.

$$M_{eff} = \sqrt{\frac{1}{t} \cdot \int_0^t M^2(t)\, dt} \leq M_N$$

If the individual torques are stable in each section, the integral can be simplified to create a totals formula (see also the following diagram).

$$M_{eff} = \sqrt{\frac{M_1^2 \cdot \Delta t_1 + M_2^2 \cdot \Delta t_2 + M_3^2 \cdot \Delta t_3 + M_4^2 \cdot \Delta t_4 + \ldots}{\Delta t_1 + \Delta t_2 + \Delta t_3 + \Delta t_4 + \ldots}}$$

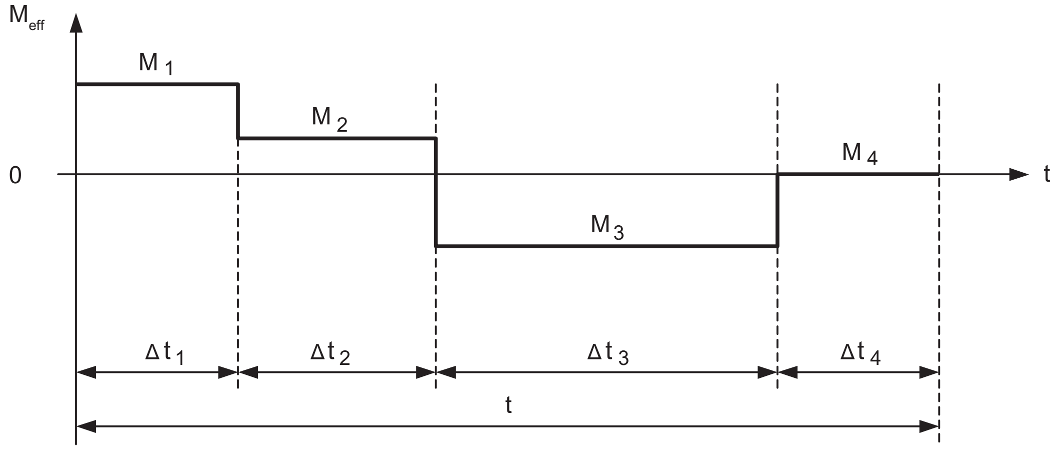


Figure 5-3 Motor torque-time diagram

5.1.4 Selecting the motors

You can choose a suitable torque motor using the values determined for the peak torque M_{mMAX} and continuous torque M_{eff}.

You must take the following factors into account when selecting motors:

- Regarding the maximum torque M_{MAX}, the motor should have a control reserve of approx. 10% vis-à-vis the required value M_{mMAX} to prevent unwanted limiting effects if the control loops are overshot.
- The rated motor torque M_N must be at least as high as the continuous torque value M_{eff} determined for the duty cycle.
- If certain general conditions (e.g. machining torque or frictional torque) are not known, you are advised to plan for even larger reserves.
- In addition to the requirements resulting from the duty cycle, mechanical installation conditions may influence your choice of motor. For instance, the same motor torque can often be generated in a long motor with a smaller diameter as well as in a short motor with a larger diameter.
- If more than one torque motor generates torque on one axes, the values of the peak and continuous torques of the individual motors must be added together.

5.1.5 Uneven current load

If the load is uneven over a long period of time, the motor must only be operated at no more than 70% of the rated torque (see also M_0* in "Technical data").

For exact configurations, contact your local Siemens office.

NOTICE
Not all of the three phases are necessarily evenly loaded in all motor operating modes. Examples of uneven current load: • Standstill with current feed of the motor, e.g. for: – Compensation of a weight force – Start-up against a brake system (damping and impact absorption elements) • Low speeds over a long period (n << 1 [rpm]) • Cyclic rotation (path on rotor circumference < pole width)

5.1.6 Motor torque-speed diagram

Checking the torques and speeds

At high speeds, the maximum available motor torque is limited by the available DC link voltage. If the speeds that occur in the motional sequence are greater than the maximum speed $n_{MAX,MMAX}$ specified for the motor type at the maximum torque M_{MAX}, you may have to check the torques and speeds using the motor torque-speed diagram. This diagram is included with the motor specifications.

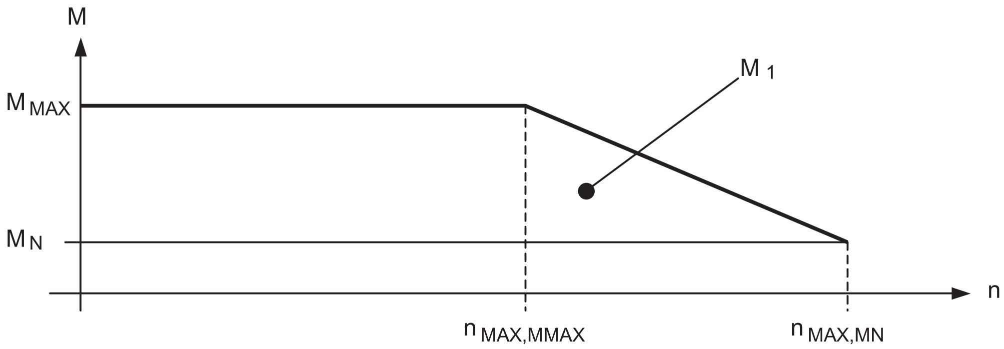


Figure 5-4 Motor torque-speed diagram

Determining the motor torque-speed diagram

If a motor torque-speed diagram is not available, the relevant values can be determined with sufficient accuracy using the specifications for the maximum torque M_{MAX}, the rated torque M_N, and the associated speeds $n_{MAX,MMAX}$ and $n_{MAX,MN}$ as shown in "Motor torque-speed diagram".

This diagram must be compared with the motor torque-time diagram and the speed-time diagram (see diagram below). To do so, it is normally sufficient to locate the critical points in the torque-time diagram at which the maximum speed $n_{MAX,MMAX}$ is exceeded at the peak torque. For these points, the motor torque (in this example: M_1) can be read from the motor torque-time diagram and checked to determine whether it lies below the characteristic in the motor torque-speed diagram.

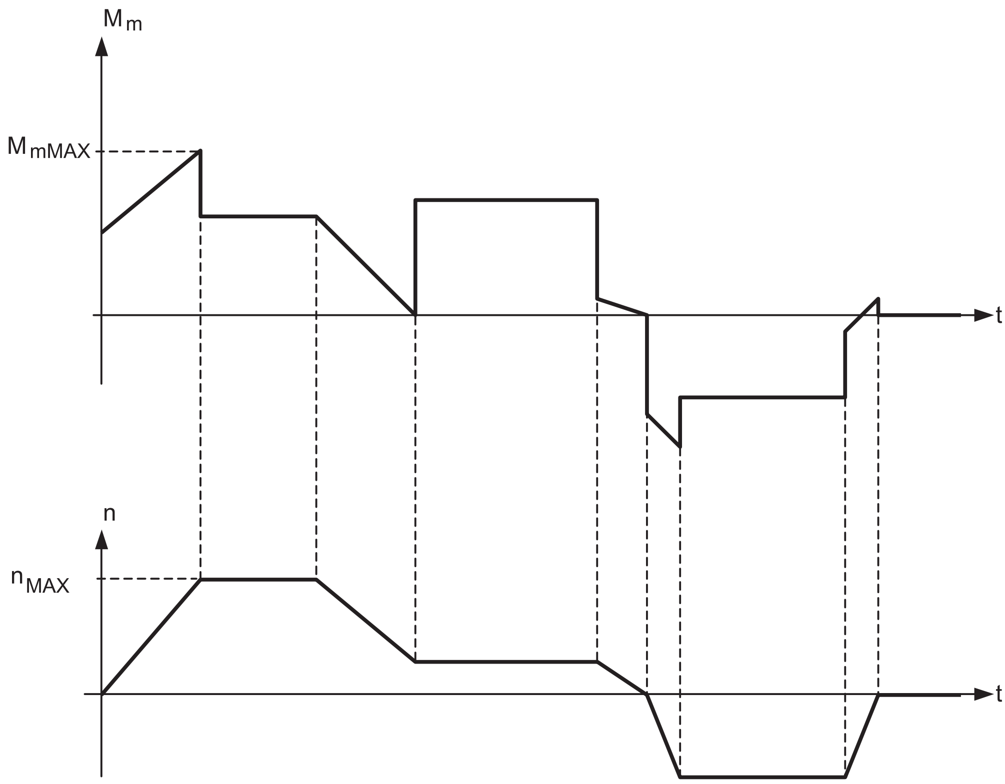


Figure 5-5 Motor torque-time diagram and associated speed-time diagram

5.1.7 Torque-speed requirements

Fulfilling the torque-speed requirements

If the selected torque motor cannot fulfill the torque-speed requirements, the following solutions are available:

- Override:
  Provided that no special requirements regarding precision have been specified for the high speed range (e.g. rapid traverse without machining), the maximum speed can be overridden. In this case, the converter output voltages and, in turn, the motor currents are

no longer purely sinusoidal. As a result, the torque generated by the motor is no longer uniform but instead has a ripple. The extent to which the maximum speed can be overridden depends on the permissible following error and positioning error in the controller as well as the motor type.

- Motor with different winding
  Several winding variants are available for some motor sizes. Windings with lower inductance allow higher speeds with the same motor size and maximum torque. One drawback here, however, is the higher motor current.
- Larger motor type
  If the first two solutions are not feasible, a motor with a higher peak torque must be used to ensure that sufficient torque reserves are available for the required torque M_1 in the upper speed range (see figure below).

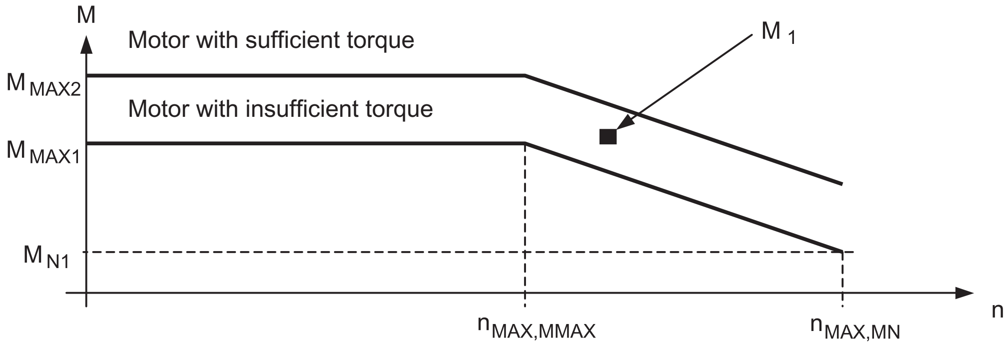


Figure 5-6 Motor torque-speed diagram with the required operating point M_1

5.1.8 More than one torque motor on one axes

If the torque motors on the same axes are operated on separate drive systems with separate angular position measuring systems, the rotation-angle-related alignment of the individual stators with respect to each other and the individual rotors with respect to each other is irrelevant.

Electrical parallel connection

If the motors are operated on the same drive system (electrical parallel connection), the individual rotors must be precisely aligned with each other when they are mounted on the axes. The individual stators must also be precisely aligned with each other when they are installed (see "Parallel operation of more than one motor").

5.1.9 Checking the moments of inertia

Once a suitable motor has been selected, the moment of inertia of the rotating mass on the axis has been determined. This value can be used to check the assumptions made regarding the duty cycle.

Recalculating the duty cycle

If the moment of inertia initially assumed deviates significantly from the actual moment of inertia, the duty cycle may have to be recalculated.

5.1.10 Selecting the drive system components for the power connection

The drive system components for the power connection are selected on the basis of the peak and continuous currents that occur in the duty cycle. If more than one motor is operated in parallel on a single power unit, the total values of the peak and continuous currents must be taken into account.

Note

In systems where direct drives are used on controlled infeeds, electrical oscillations can occur with respect to ground potential. These oscillations are, among other things, influenced by:

- The lengths of the cables
- The rating of the infeed/regenerative feedback module
- The number of axes
- The size of the motor
- The winding design of the motor
- The type of line supply
- The place of installation

The oscillations lead to increased voltage loads and may damage the main insulation! We thus recommend using an HFD commutating reactor with damping resistance for damping the oscillations. For specific details, refer to the documentation of the drive system being used or contact your local Siemens office.

5.1.11 Calculating the required infeed power

Infeed power

The electrical infeed power of the motors can be determined from the mechanical power delivered and the resulting electrical losses.

$$P_{EL} = P_{mech} + P_V = M \cdot \omega + 3 \cdot R_{STR}(T) \cdot I^2$$

With

$$I = \frac{M}{k_T(T)}$$

Here, M represents the motor torque in Nm, ω represents the angular velocity in 1/s, and k_T represents the torque constant of the motor in Nm/A (see also "Explanations of the formula abbreviations)".

The speed n in rpm can be converted to the angular velocity as follows:

Example: converting the speed n = 80 rpm to the angular velocity ω

$$\omega = \frac{80}{\text{min}} \cdot 2\pi \cdot \frac{1\text{min}}{60\,\text{s}} = \frac{8.38}{\text{s}}$$

The value for the rated temperature of the motor winding must be applied for the phase resistance R_{STR} (T) (see also "Explanations of the formula abbreviations").

This equation can be used for every point in time in the duty cycle.

Selecting an infeed unit

When you select an infeed unit for the DC link for highly-dynamic direct drives, it is generally sufficient to determine the peak infeed power that occurs in the duty cycle because the continuous power is usually much lower. The peak infeed power is normally required when the motor accelerates to the maximum speed (see operating point M_1 in "Motor torque-speed diagram with the required operating point M_1").

If more than one axes is operated, the infeed powers of the individual axes must be added together with the corresponding simultaneity conditions for the purpose of selecting the infeed unit.

5.2 Example(s)

Note

The data used here may deviate from the values specified in "Technical data". This does not affect the configuration procedure, however.

General conditions for positioning within a defined period

- Moment of inertia in kgm^2: $J = 5.1\ kg\ m^2$;
  moving cylindrical mass m = 30 kg with substitute radius r = 0.583 m; rotary axes of moving mass and motor are identical;
  calculated from:

$$J = \frac{1}{2} \cdot m \cdot r^2$$

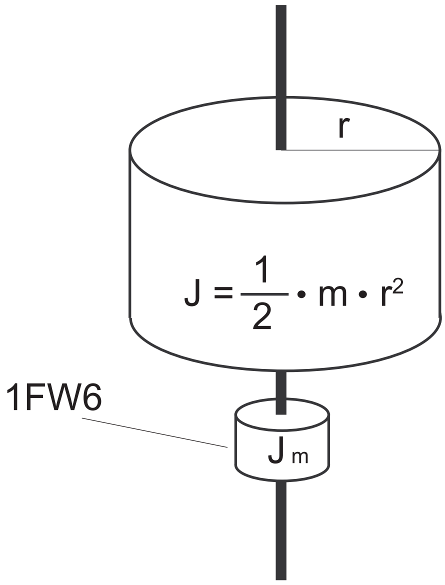


Figure 5-7 Moments of inertia of moving cylindrical mass and torque motor

- Rotation angle in ° or rad: $\varphi = 120° = 2/3\ \pi$
- Traversing time in s: $t_1 = 0.4$ s
- Constant frictional torque in Nm: $M_r = 100$

The following must be determined:

- Suitable torque motor
- Angular velocity ω in rad/s or speed n in rpm
- Angular acceleration α in rad/s^2 or acceleration in rev/s^2

The shape of the traversing profile is not stipulated, but the angle to be traversed and the duration are specified for this.

Provided that no restrictive requirements regarding angular acceleration and/or angular velocity have been specified, the most straightforward suitable traversing operation simply involves acceleration followed by deceleration.

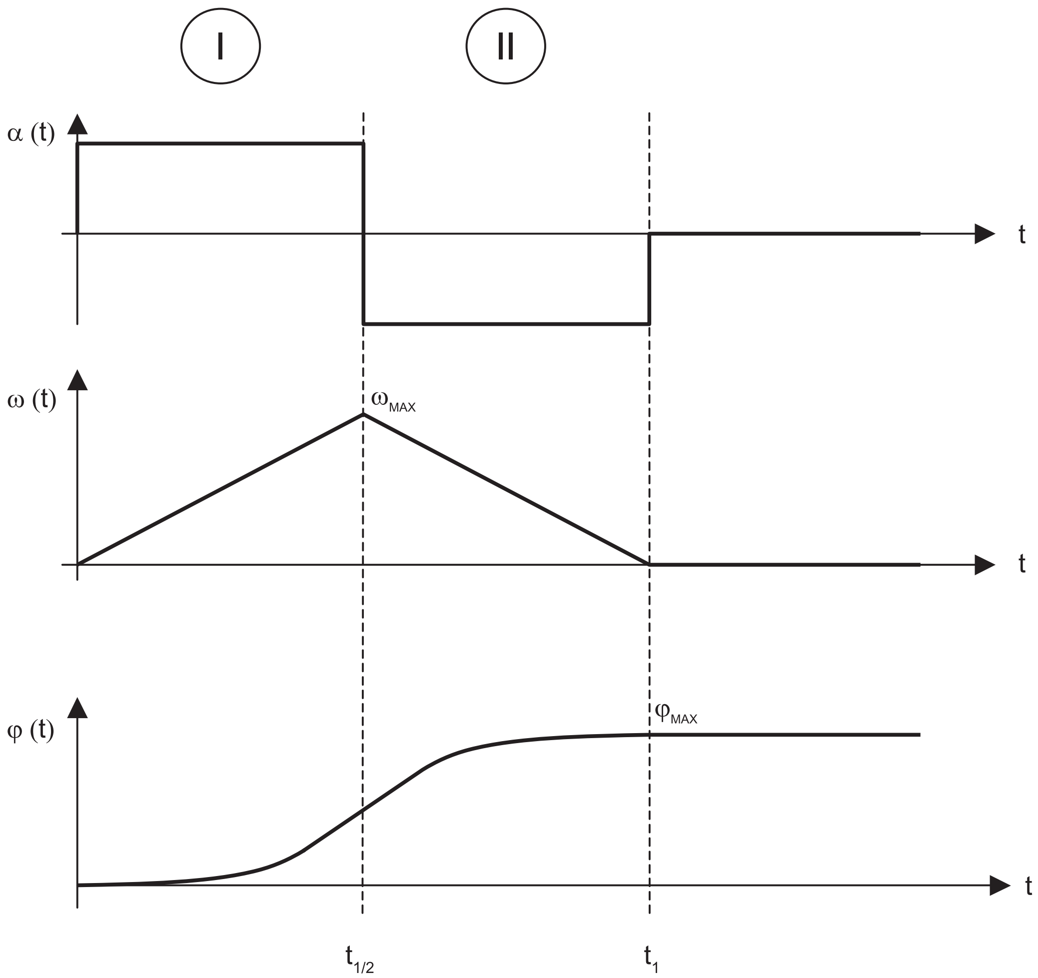


Figure 5-8 Ideal traversing profile with angular acceleration α (t), angular velocity ω (t), and angle φ (t)

Table 5- 1 Functions of the individual sections in the traversing profile

Section I	Section II
α_I (t) = α	α_{II} (t) = - α
ω_I (t) = α t	ω_{II} (t) = - α t + α t_1
φ_I (t) = ½ α t^2	φ_{II} (t) = - ½ α t^2 + α t_1 t + φ_{MAX}

The angular acceleration α (t) is constant across all sections. The angular velocity ω (t) increases to the maximum value (linear) and then decreases to standstill in the second section (linear).

In sections I and II, the rotation angle φ (t) traversed increases in accordance with parabolic functions. This type of traversing profile allows the shortest positioning times.

The required constant angular acceleration or angular delay can be calculated from the defined end angle φ_{MAX} and the corresponding time t_1. For the sake of simplicity, momentary transitional phases between acceleration/deceleration and the resulting angle changes are not taken into account.

Since the areas below the curves for ω (t) are the same in both sections, the following applies:

$$\varphi_{MAX} = 2 \cdot \left[\frac{\alpha}{2} \cdot \left(\frac{t_1}{2} \right)^2 \right] \quad \text{in } ° \text{ or in rad} \qquad \alpha = \frac{4 \cdot \varphi_1}{(t_1)^2} \quad \text{in rad/s}^2$$

The angular velocity ω_{MAX} achieved at $t_{1/2}$ can be determined from the calculated angular acceleration:

$$\omega_{MAX} = \alpha \cdot \frac{t_1}{2} \quad \text{in rad/s}$$

The speed n can be calculated from n = $\omega_{MAX}/2\pi$.

Note

1 rad = 180°/π = 57.296 °

1 rotation U = 360° or 2 π rad

The following can be calculated with the values specified:

Angular acceleration α = 52.36 rad/s^2

Angular velocity ω_{MAX} = 10.47 rad/s

Speed n = 100 rpm

The following applies for the required acceleration torque:

$M_a = (J + J_m) \cdot \alpha$

Since the moment of inertia J_m for the 1FW6 motor is not known at this stage of the configuration process, J_m = 0 kgm^2 must be assumed for the time being.

M_a = 5.1 kgm^2 • 52.36 rad/s^2 = 267 Nm

To accelerate the specified mass, a torque M_a of 267 Nm is required.

$M_m = M_r + M_a$

M_m = 100 Nm + 267 Nm = 367 Nm

In conjunction with the constant frictional torque M_r, therefore, the motor torque M_m = 367 Nm.

A suitable motor can be selected from the "Built-in torque motors: overview" table in accordance with the following criteria:

Max. torque: at least 367 Nm

Max. speed (at max. torque): at least 100 rpm

Suitable motors:
1FW6090-0PA15-2JC2 (diameter: 230 mm; length: 190 mm)

1FW6130-0PA05-1JC2 (diameter: 310 mm; length: 90 mm)

Moment of inertia of motor 1FW6090-0PA15-2JC2: J = 0.0465 kgm^2

The accelerating torque M_a can now be corrected as follows:

M_a = (5.1 kgm^2 + 0.0465 kgm^2) • 52.36 rad/s^2 = 269 Nm

As a result, the total required motor torque $M_m = M_r + M_a$ increases to 369 Nm.

Moment of inertia of motor 1FW6130-0PA05-1JC2: J = 0.0637 kgm^2

The accelerating torque M_a can now be corrected as follows:

M_a = (5.1 kgm^2 + 0.0637 kgm^2) • 52.36 rad/s^2 = 270 Nm

As a result, the total required motor torque $M_m = M_r + M_a$ increases to 370 Nm.

Evaluation

Both motors are suitable for this positioning task. The installation requirements govern which motor is better suited. During positioning, the motor generates a torque that far exceeds the rated torque M_N and the resulting power loss is much greater than the permissible continuous power loss. Provided that positioning only takes a short time and the winding temperature remains below the shutdown limit, this high load is permissible. See "Periodic duty S3".

Periodic duty cycle (S3 mode)

The motor can repeat a drive operation (e.g. positioning) where M is occasionally > M_N for as long as necessary provided that sufficient zero-current pauses for the windings exist between the load phases. See also "Periodic duty S3".

The "duty cycle" comprises the load phase and the zero-current (cooling) phase. The cooling phases are crucial here: during the pauses, the effective torque of the duty cycle is reduced to the value of the rated torque M_N of the motor.

If the future duty cycle is either not known or cannot be estimated, the motor can only be selected on the basis of the required maximum speed and peak torque. This is why the maximum permissible continuous torque is also defined for the duty cycle. This results in a very short cooling phase, the length of which must not be undershot.

As an example, let us take a highly simplified duty cycle comprising three time periods of lengths Δt_1, Δt_2, and Δt_3. The following torques are generated in these periods: M_1, M_2, M_3. Each of these torques can be any value between + M_{MAX} and – M_{MAX}. The effective torque M_{eff} of this duty cycle (in Nm) can be calculated using the following formula:

$$M_{eff} = \sqrt{\frac{M_1^2 \cdot \Delta t_1 + M_2^2 \cdot \Delta t_2 + M_3^2 \cdot \Delta t_3}{\Delta t_1 + \Delta t_2 + \Delta t_3}}$$

The cycle duration here ($\Delta t_1 + \Delta t_2 + \Delta t_3$) should not exceed 10% of the thermal time constant t_{TH}.

The duty cycle is permissible provided that M_{eff} is ≤ M_N.

5.3 Short-time duty S2 and intermittent duty S3

Short-time duty S2

In the case of short-time duty S2, the load time is so short that the final thermal state is not reached. The subsequent zero-current break is so long that the motor practically cools down completely.

CAUTION
An excessive load can lead to the destruction of the motor.
The load may not exceed the value I_{MAX} specified in the data sheets!

The motor may only be operated for a limited time $t < t_{MAX}$ with a current $I_N < I_M \leq I_{MAX}$. The time t_{MAX} can be calculated using the following logarithmic formula:

$$t_{MAX} = t_{TH} \cdot \ln\left(\frac{v}{v-1}\right)$$

with $v = (I_M / I_N)^2$ and the thermal time constant t_{TH}.

The thermal time constants, the maximum currents and the rated currents of the motors can be taken from the data sheets.

Note

The above equation applies with the prerequisite that the starting temperature of the motor is the same as the intake temperature of the water cooling system T_{VORL} in accordance with the data sheet.

Example

Motor 1FW6190-xxx15-2Jxx is to be operated from a cold state at maximum current.

- I_{MAX} = 47 A, I_N = 26 A; this results in v = 3.268
- t_{TH} = 180 s

$$t_{MAX} = 180\ s \bullet \ln\left[\frac{3.268}{3.268 - 1}\right]$$

$$t_{MAX} \approx 66\ s$$

The motor can be operated for a maximum of 66 s at maximum current.

Intermittent duty S3

With intermittent duty S3, periods of load time Δt_B with constant current alternate with periods of downtime Δt_S with no current feed. The motor heats up during the load time and then cools down again while at standstill. After a sufficient number of duty cycles with cycle duration $\Delta t_{Spiel} = \Delta t_B + \Delta t_S$, the temperature characteristic oscillates between a constant maximum value T_o and a constant minimum value T_u; see figure below.

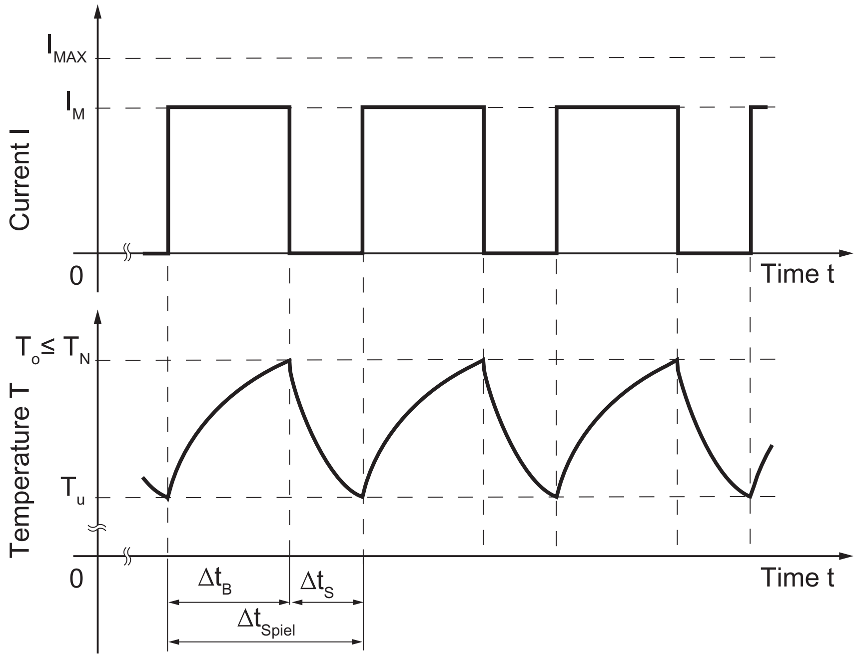


Figure 5-9 Current and temperature characteristic for intermittent duty S3

For currents $I_N < I_M \leq I_{MAX}$, the rms continuous current may not exceed the rated current:

$$I_{eff} = \sqrt{\frac{1}{\Delta t_{Spiel}} (I_M{}^2 \cdot \Delta t_B)} = I_M \sqrt{\frac{\Delta t_B}{\Delta t_{Spiel}}} < I_N$$

In this respect, the cycle duration should not exceed 10% of the thermal time constant t_{TH}. If a longer cycle duration is necessary, please contact your local Siemens office.

Example

When the thermal time constant t_{TH} = 180 s, this results in the following maximum permissible cycle duration:

t_{Spiel} = 0.1 · 180 s = 18 s

Motor assembly 6

6.1 Motor assembly

Important information about motor assembly

Before assembling the motor, the assembly instructions provided in this documentation must be read carefully.

DANGER

Installing torque motors involves carrying out work in the vicinity of unpacked rotors. The resulting danger from strong magnetic fields is, therefore, particularly high.

You must read the "Safety information" section along with the safety information provided in this section.

Only remove the packaging for the built-in torque motor when you are ready to assemble it.

At least two people are required to install the motor.

Use the installation equipment provided.

Never place metal on magnetic surfaces (and vice versa).

Keep magnetizable objects and/or permanent magnets away from magnetic surfaces.

Never use magnetizable tools. If such tools are required, however, they must be held firmly with both hands and moved slowly toward the built-in torque motor.

The motor must only be installed when it is disconnected from the power supply.

When installing individual components, you must use special equipment and follow specific procedures.

WARNING

The transportation locks must not be removed until the torque motor has been installed in the axes construction. You must carry out the steps in the specified sequence (see "Procedure for installing the motor").

WARNING

The machine construction must be designed in such a way that both the rotor and the stator are each secured on one side only. See "Installation examples". If they are secured on both sides, this can result in significant material deformation in the machine construction due to thermal expansion, which could destroy the motor.

DANGER

Defective connecting cables can cause an electric shock and/or material damage (e.g. by fire).

When installing the motor, make sure that the connection cables...

- are not damaged
- are not under tension
- cannot come into contact with any rotating parts

Note the permissible bending radii (see "Interfaces").

The motor must not be held or pulled by the cables.

DANGER

Electrical shock hazard! When an installed torque motor rotates, potentially dangerous voltages are induced at the cable ends of the motor.

Insulate terminals and leads in open cable ends or take measures to prevent torque motors that have been installed from rotating.

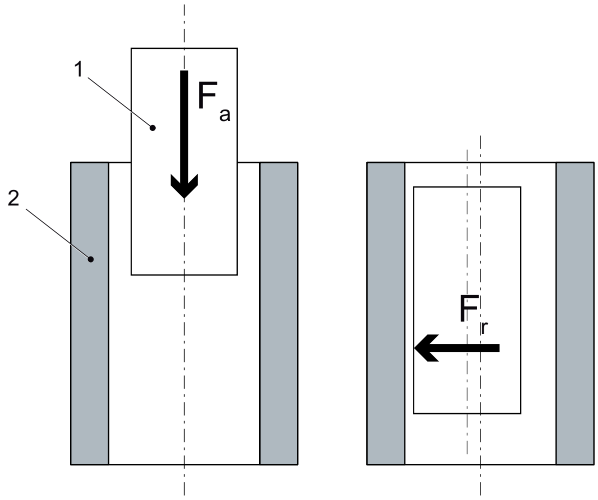
There is also a risk of compression.

WARNING

Sharp edges can cause cuts and falling objects can injure feet.

Always wear work gloves and safety shoes.

Radial and axial forces



1 Rotor with permanent magnets
2 Stator
F_a Axial attractive force
F_r Radial attractive force

Figure 6-1 Active forces when stators and rotors are installed

Radial forces between the stator and rotor

The following table shows the active radial forces (in N per 0.1 mm centering error) between the stator and rotor. The longer the active component, the greater the radial force.

Table 6- 1 Radial forces in N/0.1 mm with radial centering errors during installation

	Length of active component: 50 mm	Length of active component: 70 mm	Length of active component: 100 mm	Length of active component 110 mm	Length of active component: 150 mm	Length of active component 200 mm
1FW609	240	330	470	-	710	-
1FW613	360	500	710	-	1070	-
1FW615	330	460	660	-	990	-
1FW616	290	410	590	-	880	1180
1FW619	350	490	710	-	1060	1410
1FW623	420	590	840	-	1260	1680
1FW629	-	600	-	940	1280	1630

Note

You must note the radial forces between the stator and rotor as well as the maximum permissible concentricity error specified in the dimension drawings.

Example

With torque motor 1FW6090-0Px010-xxxx (active component length: 100 mm), the eccentricity is 0.2 mm, for example.

The active radial force as a result of this centering error is, therefore:

$$0.2\ \text{mm} \cdot \frac{470\ \text{N}}{0.1\ \text{mm}} = \underline{\underline{940\ \text{N}}}$$

Axial forces between the stator and rotor

Table 6- 2 Axial forces (in N) between the stator and rotor during installation

	1FW609	1FW613	1FW615	1FW616	1FW619	1FW623	1FW629
Axial forces (in N)	80	120	150	210	250	300	450

NOTICE
The attractive forces between the stator and rotor are approximately four to five times greater when the rotor is about to be inserted in the stator.

Requirements of the installation device

The installation device is designed to ensure that the stator and rotor are aligned centrically during the entire installation procedure. The active axial forces must be taken into account during installation.

The installation device must be adapted by the customer in line with the machine construction. It must be sufficiently rigid so that it is not warped by the strong attractive forces between the stator and rotor. Radial forces must be taken into account when the installation device is dimensioned.

The installation device must not have any loose parts.

⚠ WARNING
The stator and rotor must not come into contact with each other during centering and installation. The stator and rotor cannot be separated. The motor can no longer be used. This is why an installation device must be used.

Mounting system

The following must be taken into account when the torque motor is mounted:

- Only use new (unused) fixing screws.
- The mounting surfaces must be free of oil and grease.
- Note the maximum permissible depth of engagement of the fixing screws in the stator and rotor (refer to the relevant installation drawing).
- Minimum depth of engagement of the fixing screws in the stator:
  1.3 x d (for 1FW609 to 1FW613);
  1.0 x d (for 1FW615 and larger)
- Minimum depth of engagement of the fixing screws in the rotor flange: 1.0 x d (in steel)
- To secure the screws, choose long clamping lengths l_k, l_k / d > 5 if possible; alternatively (if l_k / d > 5 is not possible), check pretensioning of the screws at regular intervals (tighten with calibrated torque wrench).
- Note the tightening torques specified in the table below.
- Tighten the screws in such a way that the angle of rotation is controlled. Using a calibrated torque wrench with the shortest possible bit insert, however, ensure that they are tightened in diagonally opposite (180°) pairs.
- Tighten all the screws to minimize the risk of them penetrating other materials.
- Do not use any liquids for securing the screws.

Explanations:

l_k = Clamping length of the screw in mm

d = Nominal diameter of the screw in mm (e.g. M8 screw: d = 8 mm)

Screw material and tightening torques

Screws of varying strength classes are required to secure the motor to the machine structure. The table below shows the required strength classes and tightening torques for the stator and rotor fixing screws.

Table 6- 3 Required strength classes and tightening torques for the stator and rotor

Type series	Screw (strength class)	Tightening torque M_A in Nm
1FW6090-xxB05-xxxx to 1FW6090-xxB15-xxxx	M5 (8.8)	4.5
1FW6130-xxB05-xxxx to 1FW6130-xxB15-xxxx	M5 (8.8)	5.2
1FW6150-xxB05-xxxx to 1FW6150-xxB15-xxxx	M6 (8.8)	9

Type series	Screw (strength class)	Tightening torque M_A in Nm
1FW6160-xxB05-xxxx to 1FW6160-xxB15-xxxx	M8 (8.8)	21.6
1FW6160-xxB20-xxxx	M8 (10.9)	31.8
1FW6190-xxB05-xxxx to 1FW6190-xxB15-xxxx	M8 (8.8)	21.6
1FW6190-xxB20-xxxx	M8 (10.9)	31.8
1FW6230-xxB05-xxxx to 1FW6230-xxB15-xxxx	M8 (8.8)	21.6
1FW6230-xxB20-xxxx	M8 (10.9)	31.8
1FW6290-xxB07-xxxx to 1FW6290-xxB15-xxxx	M10 (8.8)	43
1FW6290-xxB20-xxxx	M10 (10.9)	61.8

Note

Underlying friction factor μ_{ges} = 0.1

With lower friction factors, the tightening torques may have to be reduced.

Also note the maximum tightening torques of the screws used. These may be lower than the values specified in the table above.

6.1.1 Procedure for installing the motor

Sequence for installing the motor

⚠ DANGER

If the components are installed in a different sequence, this can endanger personnel and/or destroy motor components.

1. Preparing and cleaning the mounting surfaces for motor parts and the machine.
   – Deburr and round off the holes (e.g. cooling inlet/outlet holes) inside the machine housing.
   – Carefully remove any machining residue (e.g. chippings, dirt, foreign bodies, etc.).
   – Grease or oil the components.
   – For motors with cooling jacket:
     grease the O-rings and components. Take into account compatibility with the O-ring material (fluoric rubber, Viton®). Do not use any lubricants containing solid particles (e.g. molybdenum disulfide or zinc sulfide).
2. This point only applies to motors with cooling jacket:
   Guide both O–rings over the cooling jacket surface of the motor into the grooves provided.
   – Do not overstretch the O-rings (O-rings maximum of up to 10% during installation, otherwise installation and leak tightness problems may occur).
   – Do not twist the O-rings.
   – Do not use any sharp objects.
   – Use special tools to help you position the components correctly.
   – Use installation devices whenever possible.
3. If necessary, insulate the power connections properly (to prevent risk of induced voltage and ripple in the event of a phase short-circuit when the motor rotates).
4. The stator and rotor are installed via transportation locks at flange B (flange with cable outlet) with the delivery of the motor.
   If this is the side to be secured, remove the transportation locks here.
   If the side to be secured is flange A (flange without cable outlet), loosen the transportation locks at flange B.
   If transportation locks have been removed or loosened, the motor must only be moved with caution.
   Keep transportation locks safe, as they may be needed for future maintenance work or in the event of removing the motor.
   Do not center and install the stator and rotor as individual components by hand due to a risk of crushing.
   Use a special installation device for this purpose. Please refer to the description of the installation device in this chapter.
5. This point only applies to motors with cooling jacket:
   Insert the motor with the free flange face forwards into the prepared locating hole of the machine housing.
   In this case, the O–rings must not be forced out of the slot and damaged.
   Ensure that the motor does not become canted in the installation space during the installation procedure. If the motor does however become slightly canted, this can be corrected by gently hitting the flange with a rubber mallet.
6. Screw the flange face of the stator to the machine housing and the flange face of the rotor to the adjustable axle. In this case, observe the specified torques and the mounting technology specifications listed in this chapter.
   If the stator and rotor on opposite flange faces are screwed to the machine construction, a special mounting device is required.
7. This point no longer applies to stators and rotors as individual components.
   Fully remove existing transportation locks.

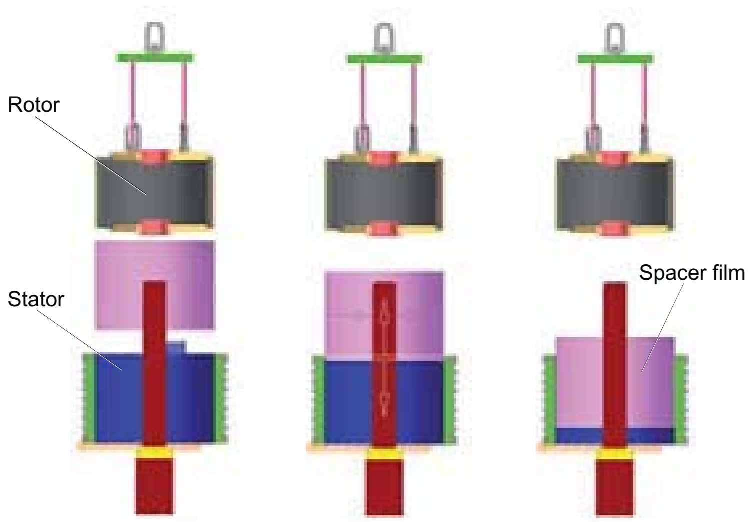
8. Remove the spacer film. When the stator and rotor are correctly centered, the spacer film can be easily removed by hand. Keep spacer film safe for subsequent transport, packaging and storage of the motor.
9. Make sure that the rotor can move without hindrance. Make sure that the spacer film and all other foreign bodies are removed from the air gap.
10. Connect the coolant ducts.
11. Connect the power and signal cables.

If the motors are delivered as separate components, a special installation device must be used.

> **⚠ DANGER**
>
> **Danger of compression when the stator and rotor are centered and installed.**
>
> Do not install or center the stator and rotor manually.

Example: centering and installing motors with a cooling jacket

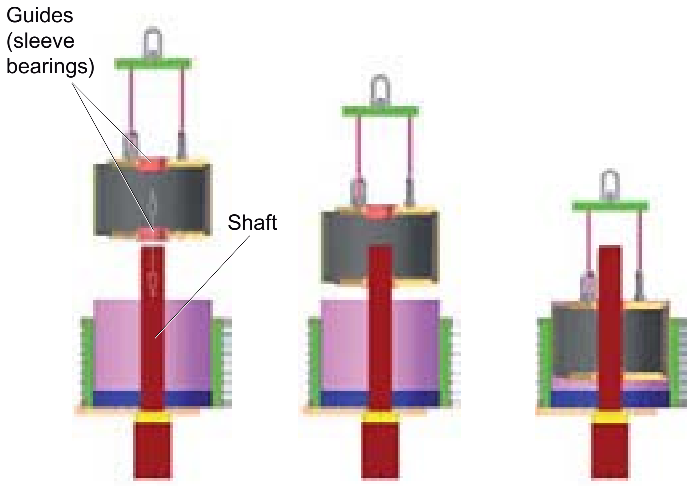
1. Insert the spacer film in the stator in such a way that approx. 1/4 of the spacer film is still visible.



Stator located centrally in the receptacle in the lower part of the installation device

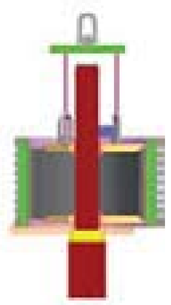
Rotor located centrally in the receptacle in the upper part of the installation device

2. Carefully lower the rotor using the top part of the installation device and fit it into the lower part of the installation device in such a way that the rotor can be aligned centrically over the sleeve bearing and shaft in the stator.

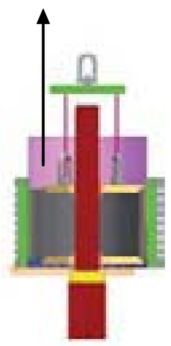


> **⚠ DANGER**
>
> **Risk of compression when the rotor is lowered.**
>
> Take extreme care.

3. Using the top part of the installation device, lower the rotor as far as it will go into the lower part of the installation device.



4. Install and secure the stator and rotor. Tighten the screws to the specified torque.
5. Remove the spacer film. When the stator and rotor are correctly centered, the spacer film can be easily removed by hand.



6.1.2 Cooler connection

For more information about connecting the cooler, see "Interfaces".

Installing the cooling connection adapter

The components required for connecting the cooler for motors with integrated cooling can usually be installed with standard tools.

The cooling connection adapter is installed using three cylinder-head screws. The cooling ducts are sealed by means of O-rings (see the following diagrams). The cylinderhead screws and O-rings are supplied with the cooling connection adapter.

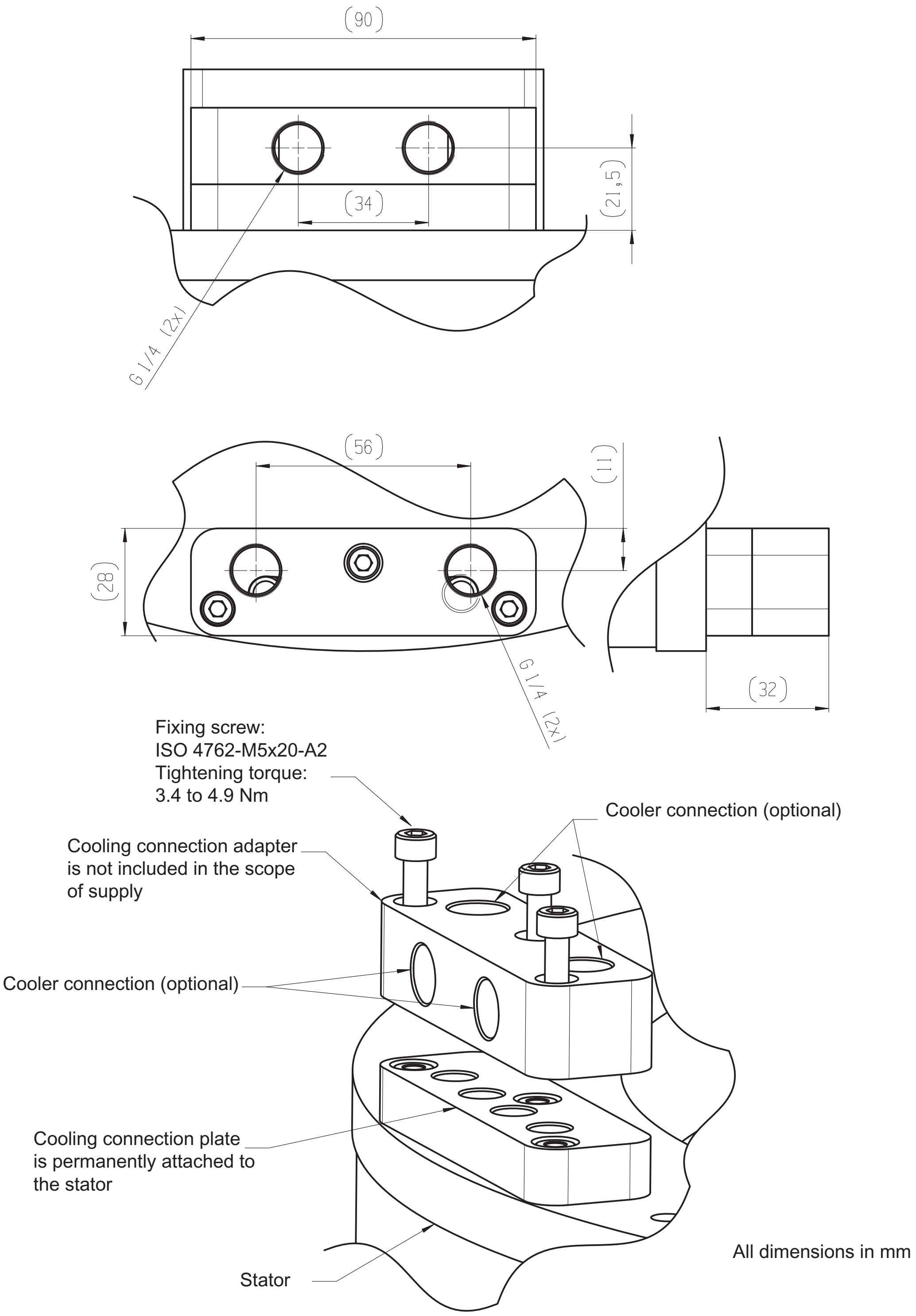


Figure 6-2 Installing the cooling connection adapter 1FW616, 1FW619, 1FW623

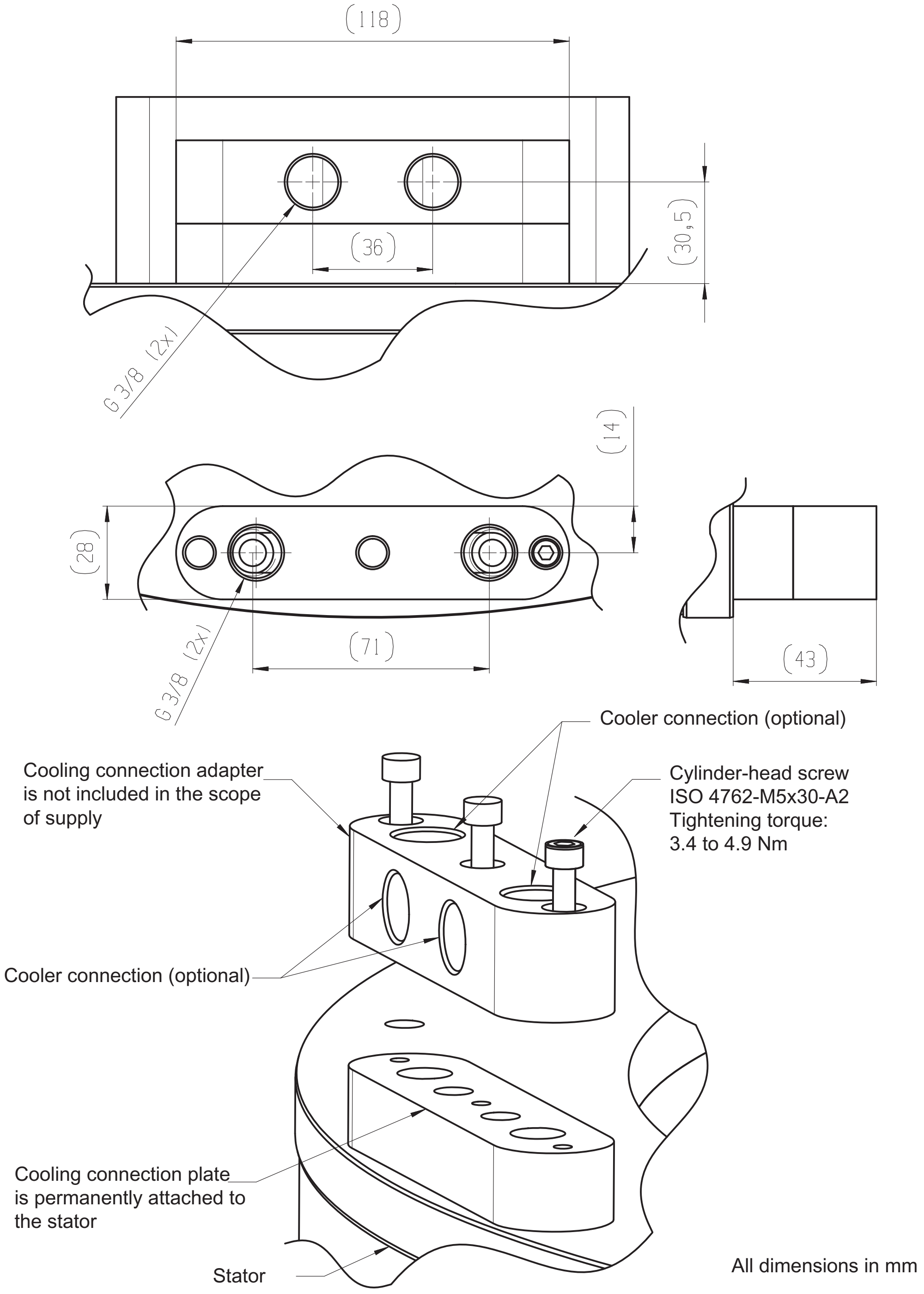


Figure 6-3 Installing the cooling connection adapter 1FW629

6.1.3 Information on routing cables

The cables must be appropriately selected corresponding to the mechanical forces caused by higher rates of acceleration and higher speeds. Further, they must be suitable for the bending stresses that occur.

The following should be observed when routing and connecting up motor supply cables:

- The minimum bending radii (see "Electrical connections") for moving power cables must be observed (see catalog NC 61).
- The cables may not chafe anywhere.
- The cables must be permanently routed and clamped at 200 mm intervals.
- When connecting PELV cables with open cable ends, electrical separation specifications (according to EN 61800-5-1) must be taken into account.

6.1.4 Checking the work carried out

Checking the installation work

Once installation has been carried out, make sure that the rotor can move without hindrance. Before doing so, remove all tools and objects from the area of the rotor and air gap.

DANGER

Electrical shock hazard!

Before the motor is rotated, the power connections must be properly connected and insulated.

- The mounted rotary axes must always be able to move without hindrance.
  Examples of axes that cannot necessarily be checked by hand:
  - Large axes with a high friction torque
  - Blocking in a current-free state
  - Uneven weight forces

  DANGER

  Risk if axes moves in an uncontrolled manner.

  Take care when removing a block or releasing a brake when the motor when is disconnected from the power supply and in an uncontrolled state.

- All supply cables must be routed and secured in such a way that they cannot be bent, damaged, or pressed against rotating parts.
- Coolant supply ducts must be easily accessible and the coolant must be allowed to flow freely.

6.1.5 Installation examples

Note

The examples provided below are not necessarily complete nor are they suitable for all applications.

Note that the rotor and stator are secured on one side on the machine construction. Depending on the machine construction, the stator can be secured on the same side as the rotor or on the opposite side.

Table 6- 4 Explanations for the following installation examples

Image title	Description
Rotary table with torque motor with integrated cooling	The construction shown is ideal for precision applications and tilting tables with strong machining forces. The phase-angle encoder is integrated in the bearing.
Rotary table with torque motor with cooling jacket	The construction shown is ideal for precision applications, dividing units, applications with holding operation, and tilting tables with an integrated brake. It is compact and, therefore, easy to integrate.
Part-turn actuator with torque motor with integrated cooling	The construction shown is ideal for robots, robot systems, and tool changers. The phase-angle encoder is sufficiently decoupled from the heat source (motor winding).
Installing a torque motor with integrated cooling on the shaft extension of a part-turn actuator	1.: The stator and rotor are installed via transportation locks on flange B (flange with cable outlet) with the delivery of the motor. The spacer film can be found between the stator and rotor. The transportation locks are loosened and the rotor is attached to the shaft extension with its mount. In this case, observe the specified torques and mounting technology specifications. 2.: The stator is positioned and screwed into its mount. In this case, observe the specified torques and mounting technology specifications. At this point, the transportation locks and spacer film can be removed.

Image title	Description
Part-turn actuator with torque motor with cooling jacket	The construction shown is ideal for moderate load forces and medium precision requirements (e.g. woodworking, packaging systems, tool changers). For roller drives, this construction is only suitable for short axes with low deflection.
Roller drive with low shaft deflection with torque motor with integrated cooling	The construction shown is ideal for roller drives with high concentricity requirements and low positioning accuracy. A rotary encoder with a moderate angular resolution is sufficient here. The encoder must be decoupled from the thermal expansion of the shaft by means of a suitable interface.

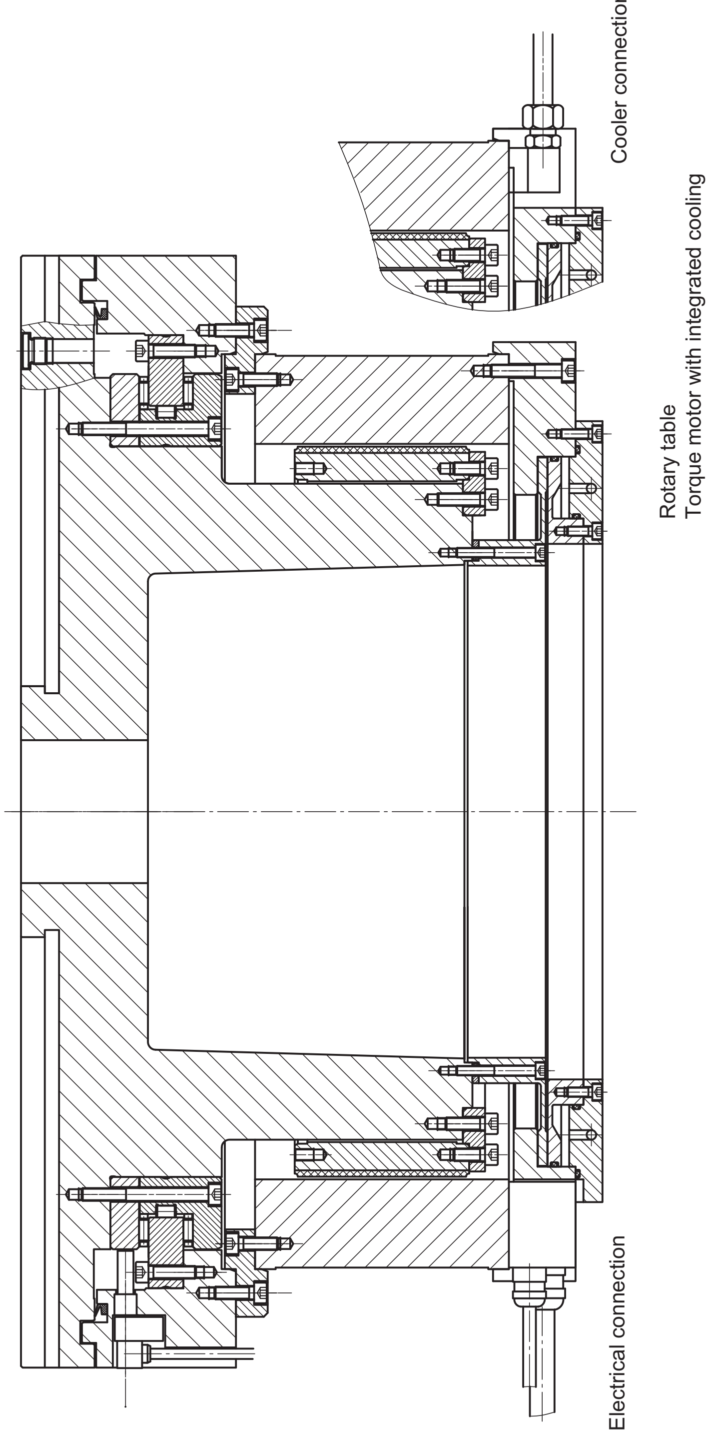


Figure 6-4 Rotary table with torque motor with integrated cooling

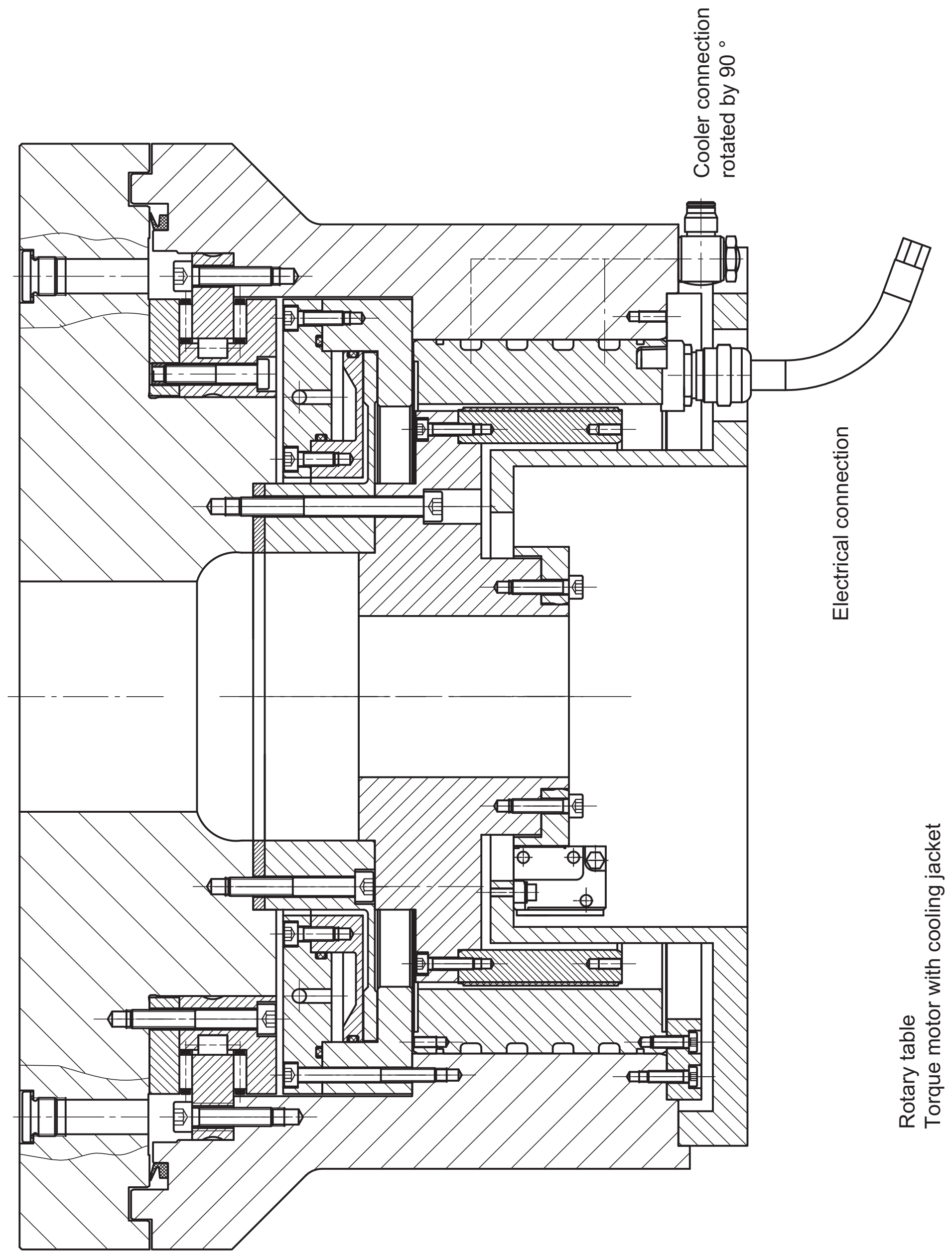


Figure 6-5 Rotary table with torque motor with cooling jacket

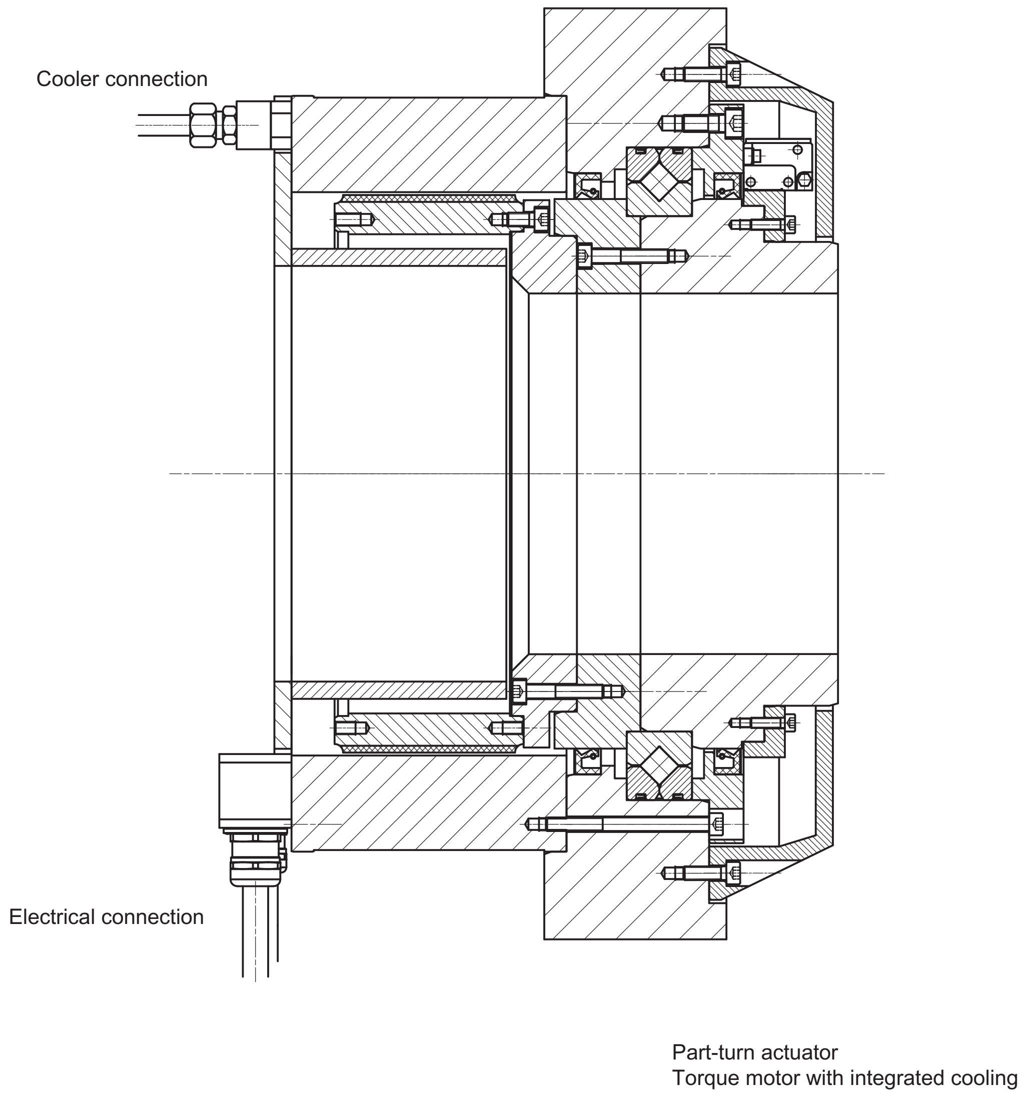


Figure 6-6 Part-turn actuator with torque motor with integrated cooling

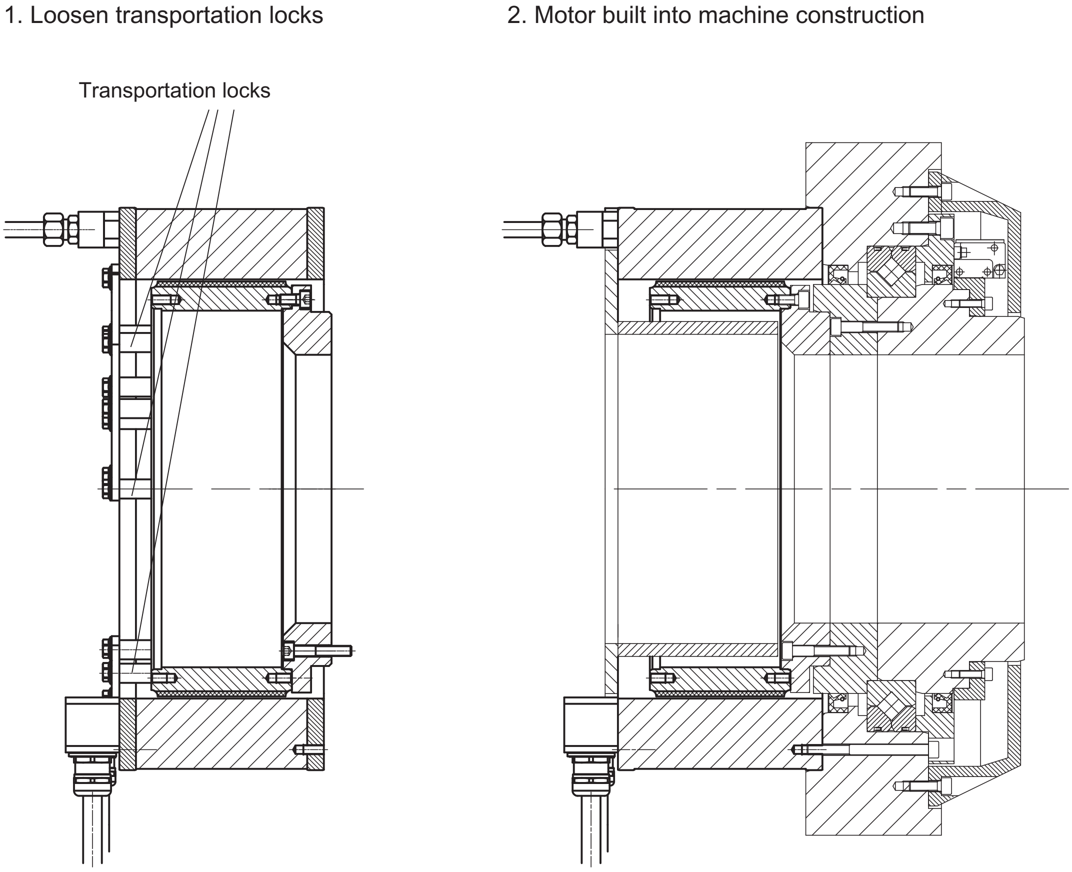


Figure 6-7 Installing a torque motor with integrated cooling on the shaft extension of a part-turn actuator

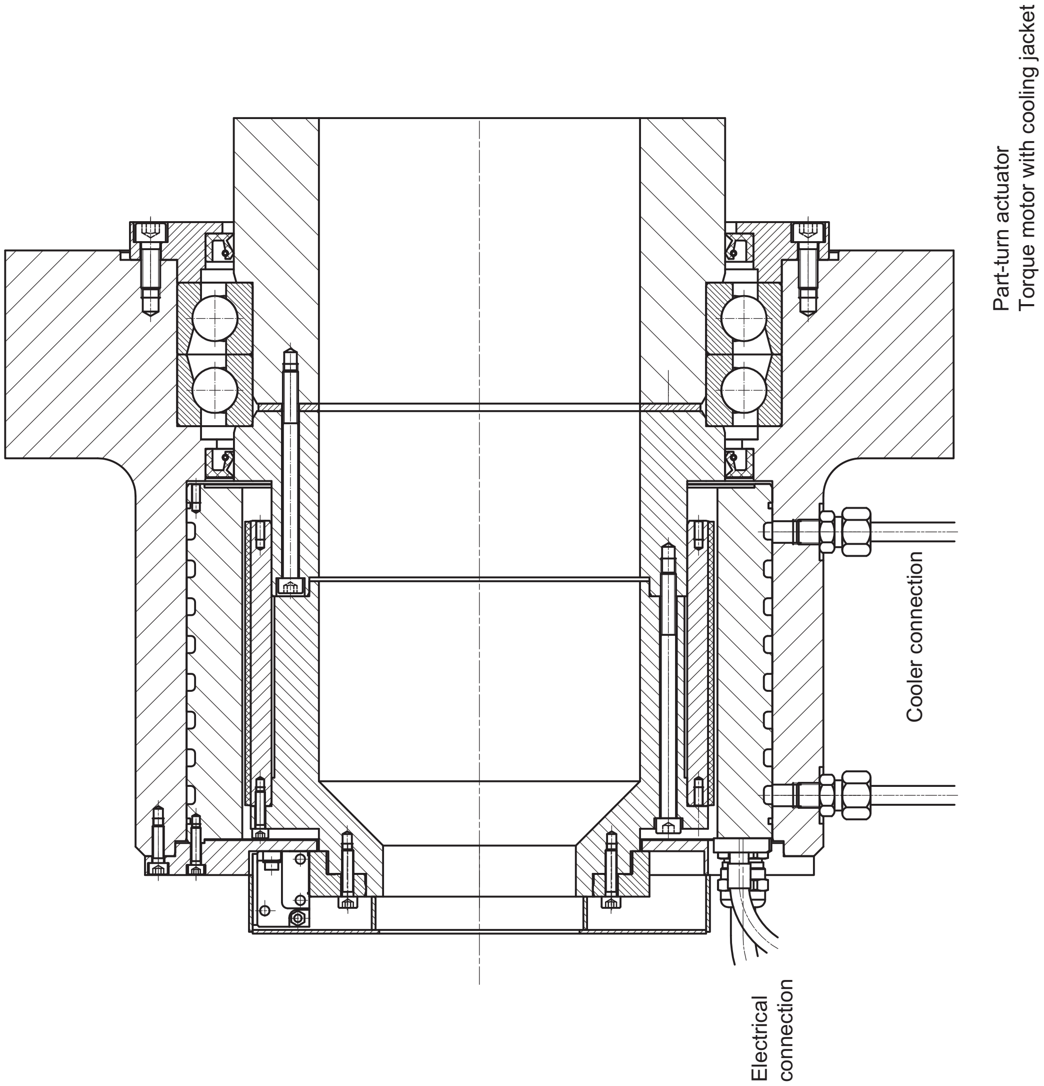


Figure 6-8 Part-turn actuator with torque motor with cooling jacket

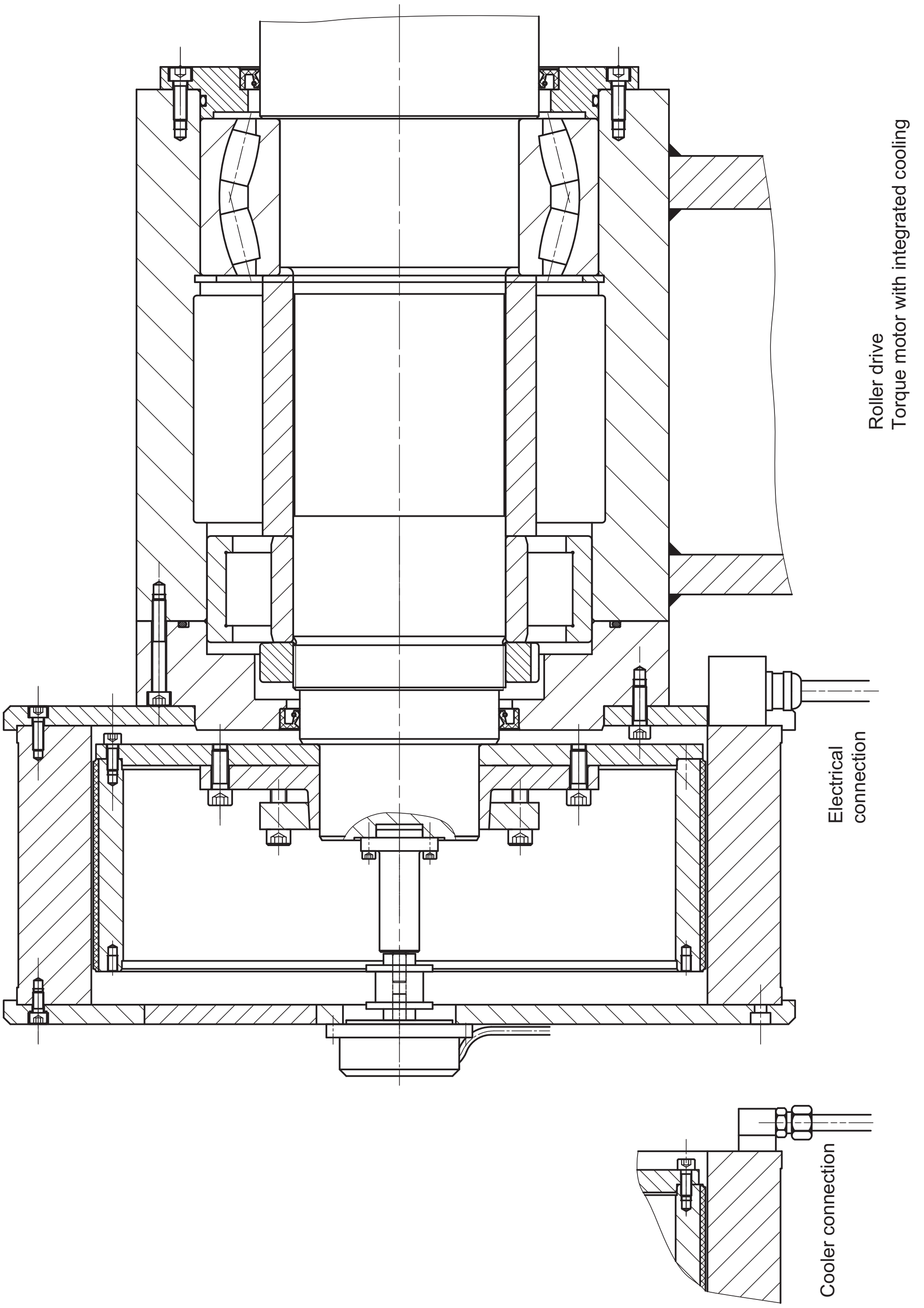


Figure 6-9 Roller drive with low shaft deflection with torque motor with integrated cooling

6.2 Protecting the motor components

Degree of protection

The machine construction surrounding the motor must fulfill at least degree of protection IP54 (to EN 60529).

The degree of protection for built-in motors is governed by the surrounding machine construction. The better the motor installation space is protected against the ingress of foreign particles (ferromagnetic particles), the longer the service life.

In particular, foreign particles in the air gap between the stator and rotor can destroy the motor during operation.

This also applies to corrosive chemicals (e.g. coolants, oil) that could penetrate the motor compartment. Corrosive chemicals can damage the magnetic bonds of the rotor.

Liquids can compromise the insulation resistance of the stator.

The thermal properties of the motor are influenced by the ingress of liquids and foreign particles.

WARNING
Contamination in the motor compartment can cause the motor to stop functioning or cause wear and tear.

System integration 7

7.1 System requirements

Components

The drive system that feeds a motor comprises an infeed module, a power module and a control module. For the SINAMICS S120 drive system, these modules are called "Line Modules", "Motor Modules" and "Control Units". The Line Module is either regulated with feedback (ALM, Active Line Module), unregulated with feedback (SLM, Smart Line Module), or unregulated without feedback (BLM, Basic Line Module).

To operate several motors simultaneously on a single drive system, either one Motor Module per motor or one Motor Module for several motors can be provided, depending on the application. The appropriate Line Module is determined by the power consumption of the motors used.

Note

The order designations for the power cables in the figures below do not apply to motors with single cores.

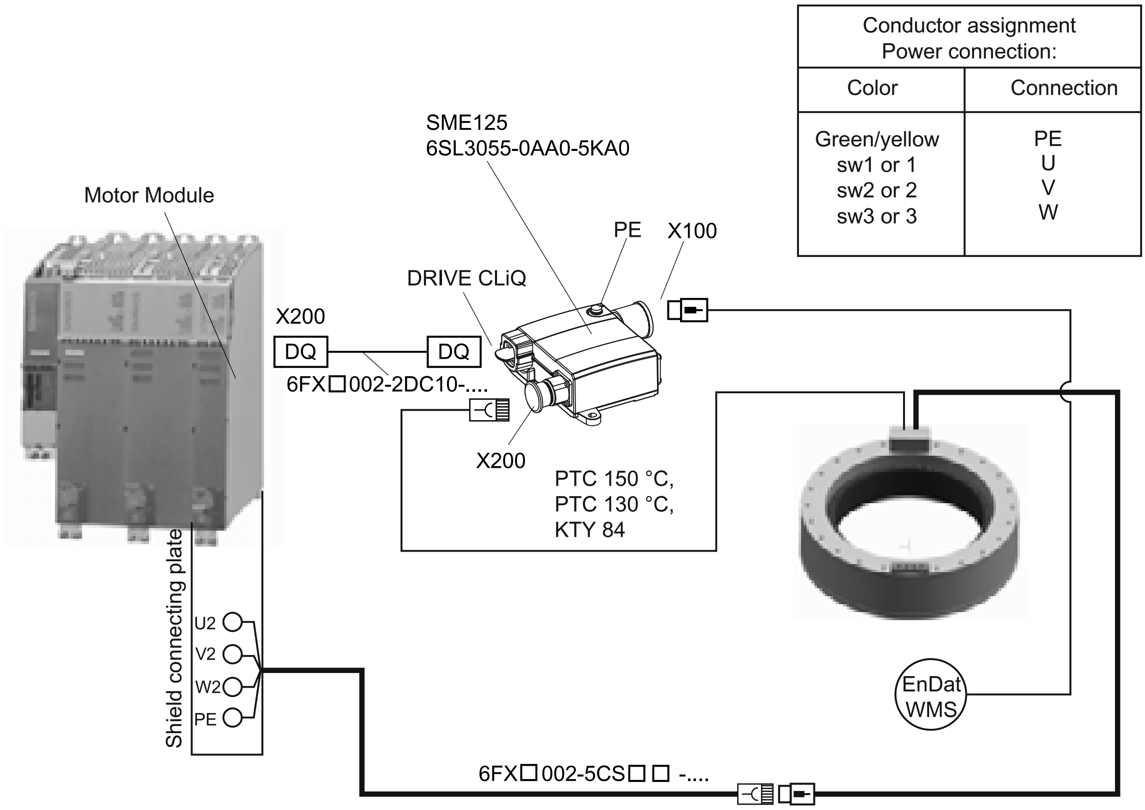


Figure 7-1 System integration with connection of PTC 150 °C, PTC 130 °C, and KTY 84 via SME125; WMS: EnDat

Conductor assignment Power connection:	
Color	Connection
Green/yellow sw1 or 1 sw2 or 2 sw3 or 3	PE U V W

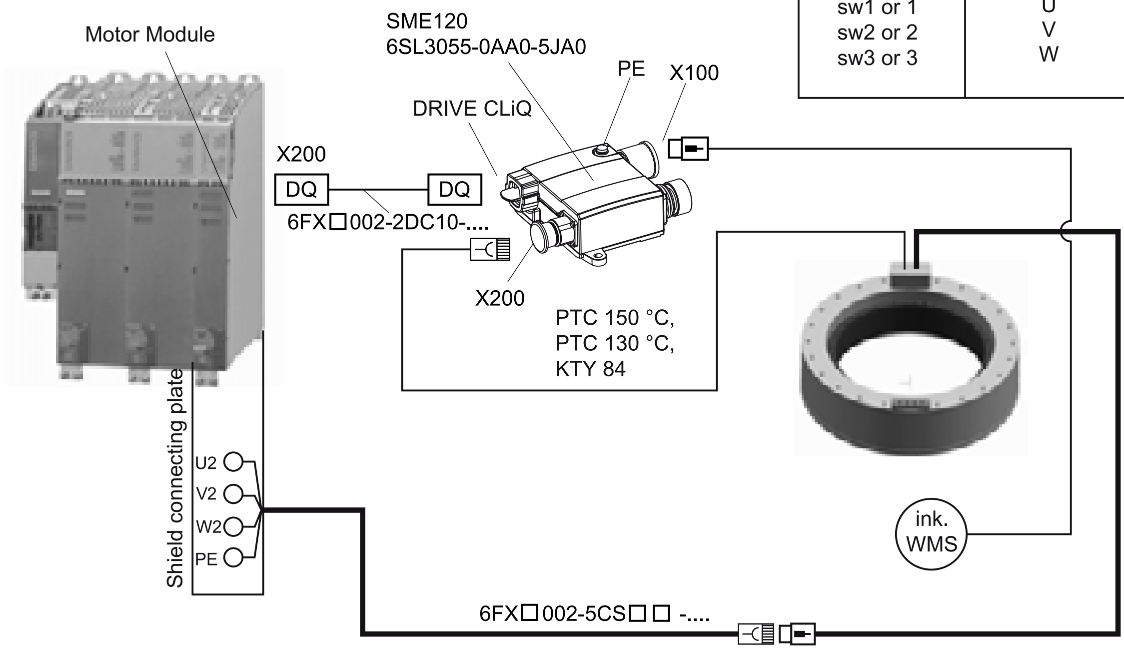


Figure 7-2 System integration with connection of PTC 150 °C, PTC 130 °C, and KTY 84 via SME120; WMS: Incremental

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Note

For the connector sizes, refer to the table "Data of the power cable at the stator" in the Chapter "Interfaces".

Note

For more information about the SME12x, see the Equipment Manual "SINAMICS S120 Control Units and Additional System Components", which can be obtained from your local Siemens office.

Permissible voltages

The following table shows the permissible line voltages of TN line supply systems for the motors.

Table 7- 1 Permissible line voltages of TN line supply systems, resulting DC link voltages and converter output voltages

Permissible line supply voltage	Resulting DC link voltage U_{ZK}	Drive output voltage (rms value) U_{amax}
400 V	600 V (controlled) 528 V (uncontrolled)	425 V (controlled) 380 V (uncontrolled)
480 V	634 V (uncontrolled)	460 V (uncontrolled)

In combination with the drive system SINAMICS S120, the motors are generally approved for operation on TN and TT networks with grounded neutral and for IT networks. Protective equipment which will shut down the drive system in the event of a ground fault must be provided for motors operated on IT systems.

In operation with a grounded external conductor, an isolating transformer with grounded neutral (secondary side) must be connected between the supply and the drive system to protect the motor insulation from excessive stress.

Requirements

- The power unit is selected depending on the motor current at torque M_0 and a speed 1 [rev/min] or according to the maximum motor current.
- The encoder system used must be harmonized with the particular application.

Drive system

Table 7- 2 Open-loop and closed-loop control systems for the SINAMICS S120 drive system

Closed-loop control	Open-loop control
--	CU-320
SINUMERIK 840D sl	NCU-7x0 / NX1x
SINUMERIK 840Di sl	CU-320
SIMATIC	CU-320
SIMOTION	D4x0 /CX32

Note

Read the corresponding documentation about open-loop and closed-loop control systems.

Note

In systems where direct drives are used on controlled infeeds, electrical oscillations can occur with respect to ground potential. These oscillations are, among other things, influenced by:

- The lengths of the cables
- The rating of the infeed/regenerative feedback module
- The number of axes
- The size of the motor
- The winding design of the motor
- The type of line supply
- The place of installation

The oscillations lead to increased voltage loads and may damage the main insulation! We thus recommend using an HFD commutating reactor with damping resistance for damping the oscillations. For specific details, refer to the documentation of the drive system being used or contact your local Siemens office.

Accuracy

The accuracy of a direct drive with torque motor is governed by the:

- Mechanical design of the machine
- Control technology used
- Resolution and measuring accuracy of the encoder

Mechanics

The potential machining accuracy of a drive system with torque motor is influenced by the:

- Mechanical rigidity and noise immunity of the drive system
- Running smoothness

The running smoothness in the axial and radial direction depends on the bearing version and its accuracy. The requirements here can be fulfilled by means of a suitable axes design.

Control quality

The control quality of a direct drive with torque motor is governed by the:

- Rigidity of the drive system (dynamic quality of the housing and machine construction, bearing, encoder installation)
- The precision when mounting and adjusting the encoder system

- Quantification of the angular signal and speed signal (the number of encoder lines and their multiplication in the encoder evaluation of the converter for each axes rotation and the measuring accuracy of the encoder are crucial here).
- Sampling time of the current, speed, and position controller.

7.2 Encoders

Encoder system

The encoder system has a range of different functions:

- Actual speed value encoder for closed-loop speed control
- Position encoder for closed-loop position control
- Rotor position encoder (commutation)

The encoder system is not included in the scope of supply. Due to the wide range of different applications, it is impossible to provide a comprehensive list of suitable encoders.

Example of absolute phase-angle encoder with EnDat: RCN series (Heidenhain)

Examples of incremental single-phase encoders (1 V_{pp}): RON, ERA, ROD series (Heidenhain)

NOTICE
We cannot guarantee the composition, nature, state, or quality of non-Siemens products. Read the detailed text in "Manufacturer recommendations" in the appendix.

Requirements regarding the encoder

Your choice of encoder depends on the general application and converter-specific conditions. The encoder resolution depends on requirements regarding accuracy and noise immunity. Refer also to the documentation for the drive system used.

⚠ WARNING
Incorrect commutation can result in uncontrolled motor movements. When the encoder is replaced, make sure that the commutation setting is correct. The procedures involved here must only be carried out by trained personnel.

Note

To ensure a high control loop dynamic response (high k_V factor), rapid, overshoot-free positioning, and smooth running, measuring systems that emit a minimum of approx. 10,000 pulses/revolution are recommended.

Note

To protect against contamination, the housing for the encoder on the axes construction of the built-in torque motor must fulfill degree of protection IP54 to EN 60529.

The permissible mechanical speed and limit frequency of the encoder and Control Unit must be taken into account. Refer to the appropriate documentation issued by the manufacturer when configuring, installing, and adjusting the encoder

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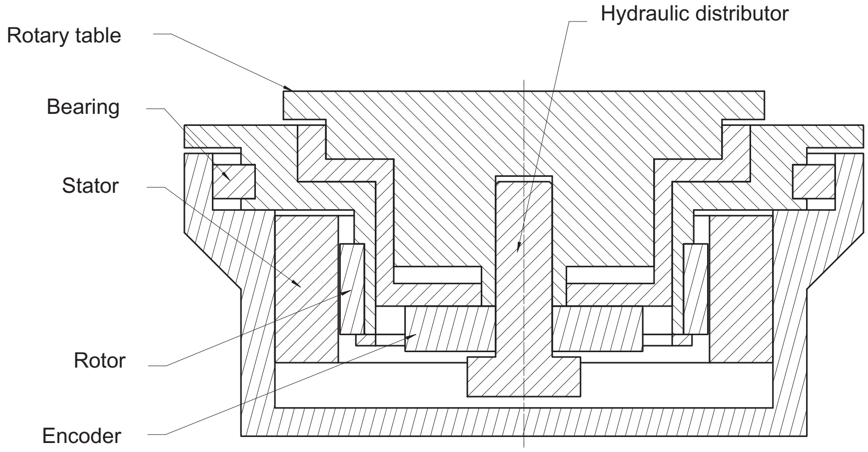
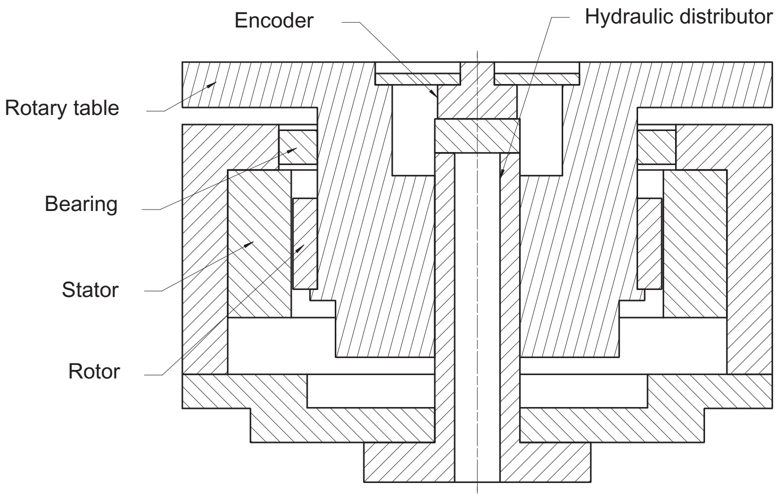
Good encoder arrangement



- Small distance between the motor and motor encoder
- Motor encoder securely attached
- No force introduction between the motor and motor encoder

Bad encoder arrangement



- Large distance between the motor and motor encoder
- Lack of rigidity due to an excessively thin plate for securing the motor encoder
- Force introduction between the motor and motor encoder

Figure 7-3 Installation diagram (example)

Note

For more installation examples, see "Motor assembly".

7.3 Bearings

Selecting the bearing

1FW6 torque motors are built-in motors for direct rotary or swivel axes. To set up a complete drive unit, a bearing between the stator and rotor is required in addition to the phase-angle encoder system.

Your choice of bearing is governed by the following factors:

- Geometric requirements (internal and external diameter)
- Speed
- Load (magnitude, direction)
- Rigidity (accuracy, pretension)
- Service life

The bearing is not included in the scope of supply.

⚠ WARNING
Bearing currents and static charging of the rotor: Depending on the design and properties of the bearing, the rotor may become statically charged. Measures must be taken to prevent this (e.g. insulated bearing design or grounding).

Note

Radial forces are generated between the stator and rotor. These must be taken into account when you select the bearing (see also "Motor assembly)".

7.4 Braking concepts

⚠ WARNING
Malfunctions on a rotating machine axes can lead to the drive coasting to a stop in an uncontrolled manner. Measures must be taken to brake the drive at its maximum possible kinetic energy in the event of a fault.

The design of mechanical braking systems depends on the maximum kinetic energy, that is, the maximum moment of inertia of the rotating mass and its maximum speed.

Possible malfunctions

Malfunctions can occur e.g. for:

- Power failure
- Encoder failure, encoder monitoring responds
- Higher-level control failure (e.g., NCU); bus failure
- Control Unit failure
- Drive fault
- NC fault

Below are a number of options showing how rotating masses can be braked in the event of a malfunction.

Braking concepts

In the case of rotating axes that are restricted to a rotation angle of < 360°, damping and impact absorption elements at the limits of the rotation range offer reliable protection.

To dissipate the kinetic energy of the rotating mass before it comes into contact with the damping elements, the following measures should be taken to support mechanical braking systems:

1. Electrical braking via the energy in the DC link:
   The DC link must be equipped with capacitor modules that store sufficient energy to reliably brake the rotating masses in the event of a power failure. Braking resistors that prevent the voltage in the DC link from exceeding the maximum permissible value must also be installed.
   Drawback: This measure is ineffective if the Control Unit fails. It may also be ineffective if the encoder system fails. See also the documentation for the drive system.
2. Electrical braking via armature short-circuiting of the stator:
   If the drive system does not feature a suitable function, the motor connection terminals are disconnected from the drive system and short-circuited in the event of a fault with a contactor that closes automatically. See also the documentation for the drive system.
   Drawback: The braking torque depends on the speed and may not be sufficient to bring the rotating masses to a standstill.

Note

If armature short-circuiting braking is used without braking resistors, special contactors are required because the currents can be very high. - The release timing for the drive system must be taken into account.

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3. Mechanical braking via braking elements:
   The braking capacity must be dimensioned as highly as possible so that the rotating masses can be reliably braked at maximum kinetic energy.
   Drawback: Depending on the speed, the relatively long response time of the brake controller may mean that the rotating mass continues to rotate for a while without being braked.

We recommend that all three measures be implemented together. Measures (2) and (3) are used as an additional protection here in case measure (1) fails: The short-circuiting of the stator works at high speeds to begin with and then the mechanical brake takes effect at lower speeds.

A list of recommended braking element manufacturers is provided in the appendix.

Deploying a holding brake

Due to cogging torques, torque motors can be pulled into a preferable magnetic operating position if the motor is no longer supplied with power from the drive. If the drive is already at a standstill, this can cause unexpected movements in up to a half magnetic pole pitch in both directions. To prevent any damage to the workpiece and/or tool, it may be advisable to use a holding brake.

Due to the lack of a mechanical self-locking system, a holding brake should be installed for inclined or horizontal drives without weight compensation so that the drive can be shut down and de-energized in any position.

⚠ WARNING
For inclined and horizontal axes, the load may be reduced in an uncontrolled manner if the center of gravity is outside the rotary axes when the system is disconnected from the power supply.

A holding brake may also be required if:

- The bearing friction does not compensate or exceed the cogging torques and unexpected movements result.
- Unexpected movements of the drive can lead to damage (e.g. a motor with a large mass also generates strong kinetic energy).
- Weight-loaded drives must be shut down and de-energized in any position.

To prevent movements when the drive is switched on or off, the holding brake response must be synchronized with the drive.

During commissioning, refer to the documentation for the drive system being used.

Interfaces 8

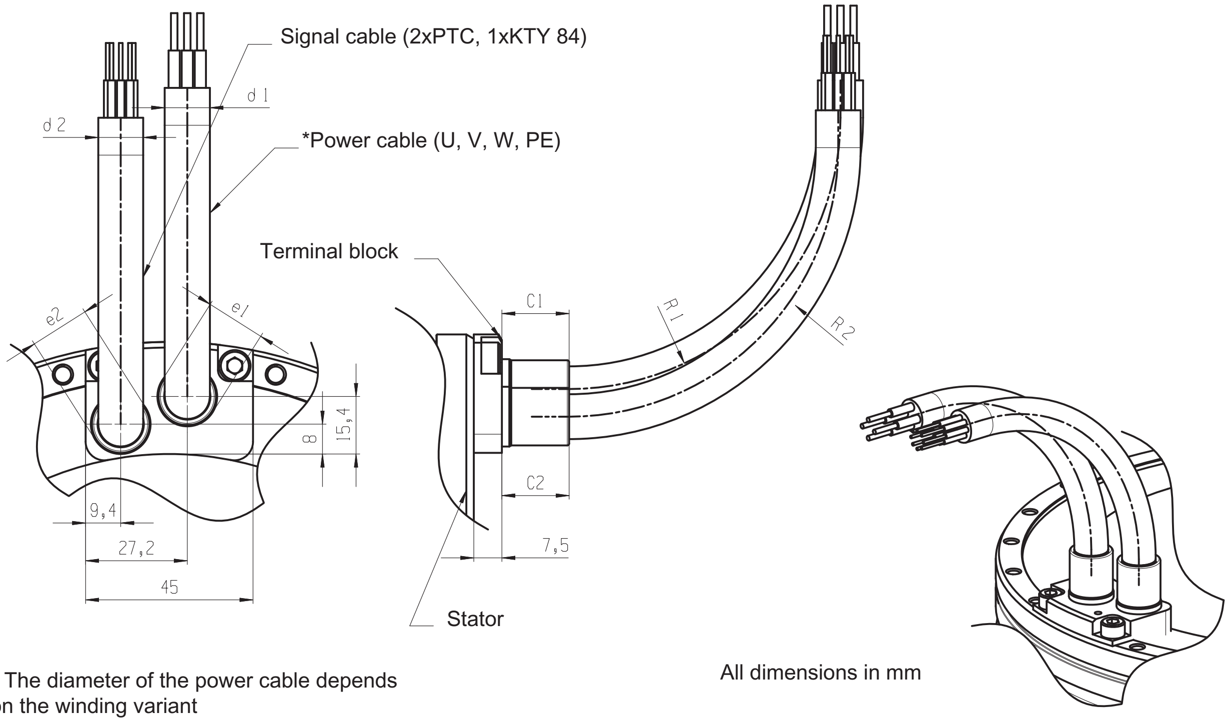
8.1 Overview

Electrical connection components

Table 8- 1 Overview of available motor types with respect to the position of the electrical connection

MLFB	Outgoing feeder	Strain relief
1FW6090-0PBxx-xxxx	Axial	Sleeve
1FW6090-0QBxx-xxxx	Radial (outward)	Sleeve
1FW6090-0NBxx-xxxx	Tangential	Sleeve
1FW6130-0PBxx-xxxx	Axial	Sleeve
1FW6130-0QBxx-xxxx	Radial (outward)	Sleeve
1FW6130-0NBxx-xxxx	Tangential	Sleeve
1FW6150-0PBxx-xxxx	Axial	Sleeve
1FW6150-0QBxx-xxxx	Radial (outward)	Sleeve
1FW6150-0NBxx-xxxx	Tangential	Sleeve
1FW6160-0WBxx-xxxx	Axial	Sleeve
1FW6160-0VBxx-xxxx	Radial (outward)	Sleeve
1FW6160-0TBxx-xxxx	Tangential	Sleeve
1FW6190-0WBxx-xxxx	Axial	Sleeve
1FW6190-0VBxx-xxxx	Radial (outward)	Sleeve
1FW6190-0TBxx-xxxx	Tangential	Sleeve
1FW6230-0WBxx-xxxx	Axial	Sleeve
1FW6230-0VBxx-xxxx	Radial (outward)	Sleeve
1FW6230-0TBxx-xxxx	Tangential	Sleeve
1FW6290-0WBxx-xxxx	Axial	Sleeve
1FW6290-0VBxx-xxxx	Radial (outward)	Sleeve
1FW6290-0TBxx-xxxx	Tangential	Sleeve

Dimensions of the electrical connections



* The diameter of the power cable depends on the winding variant

All dimensions in mm

Figure 8-1 Electrical connection (axial) with sleeve for 1FW609

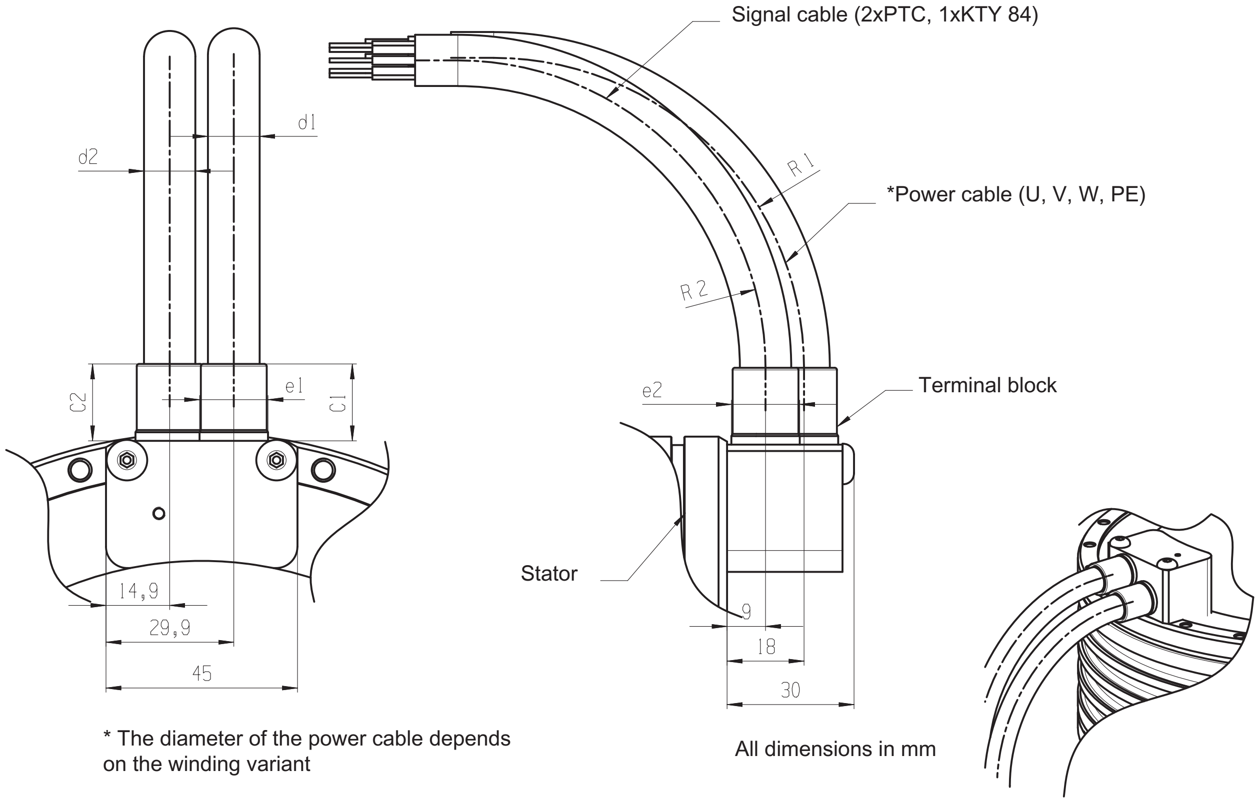


Figure 8-2 Electrical connection (radial, outward) with sleeve for 1FW609

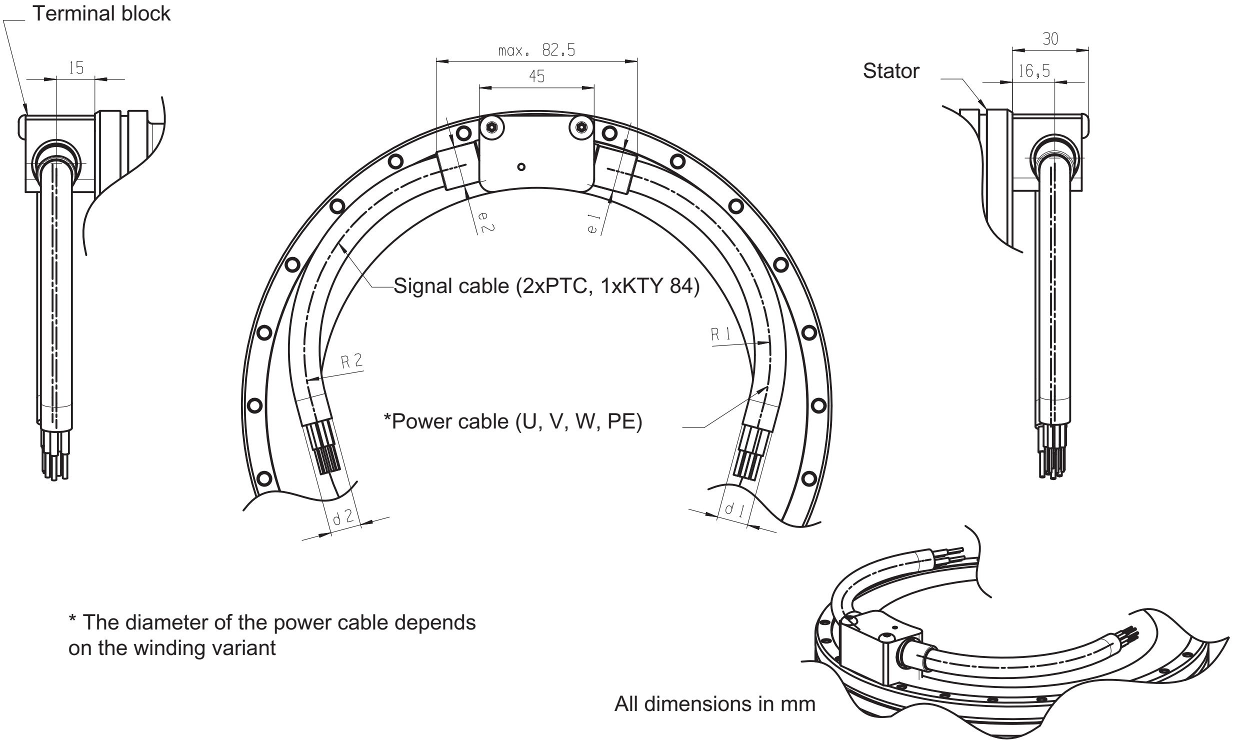


Figure 8-3 Electrical connection (tangential) with sleeve for 1FW609

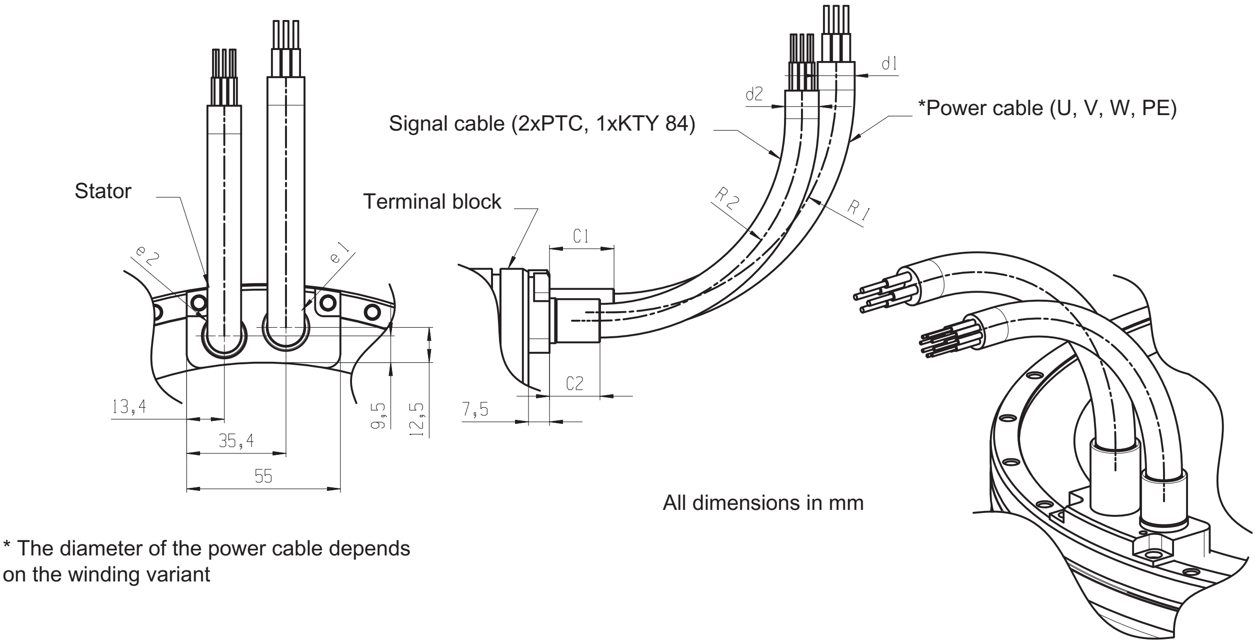


Figure 8-4 Electrical connection (axial) with sleeve for 1FW613

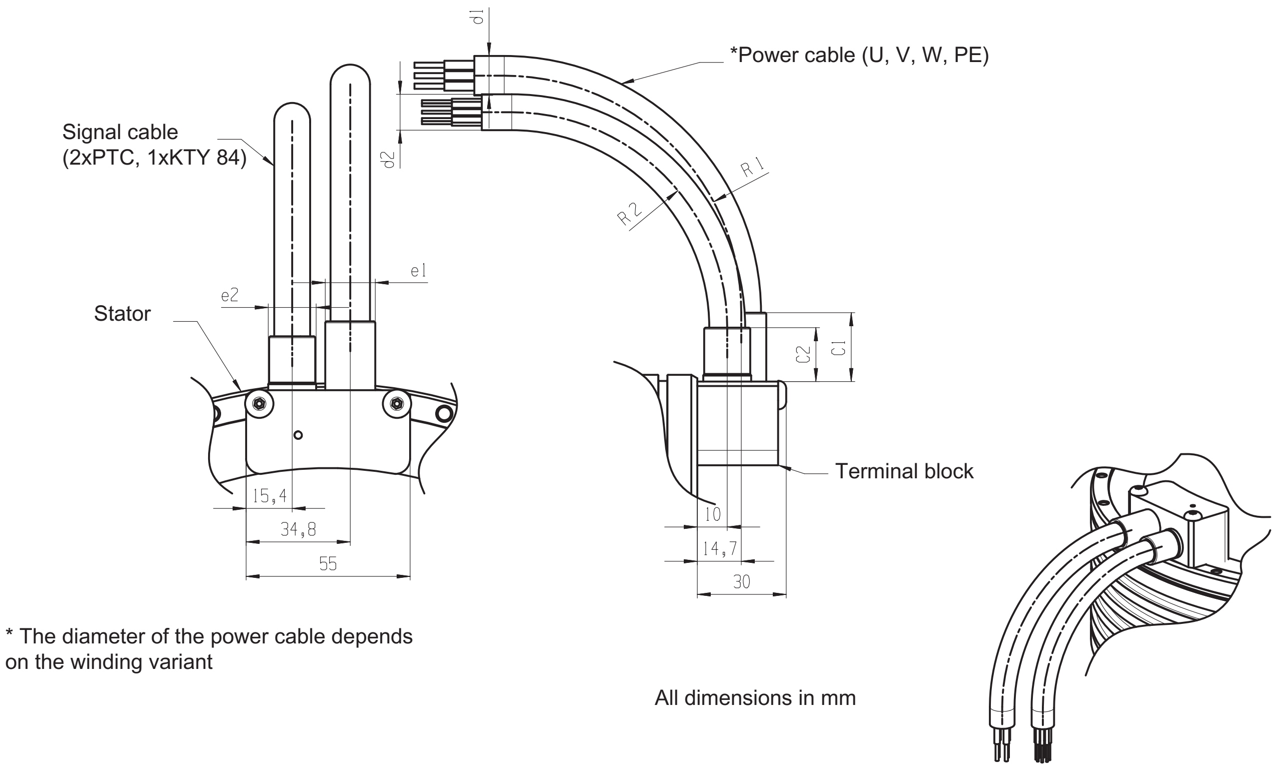


Figure 8-5 Electrical connection (radial, outward) with sleeve for 1FW613

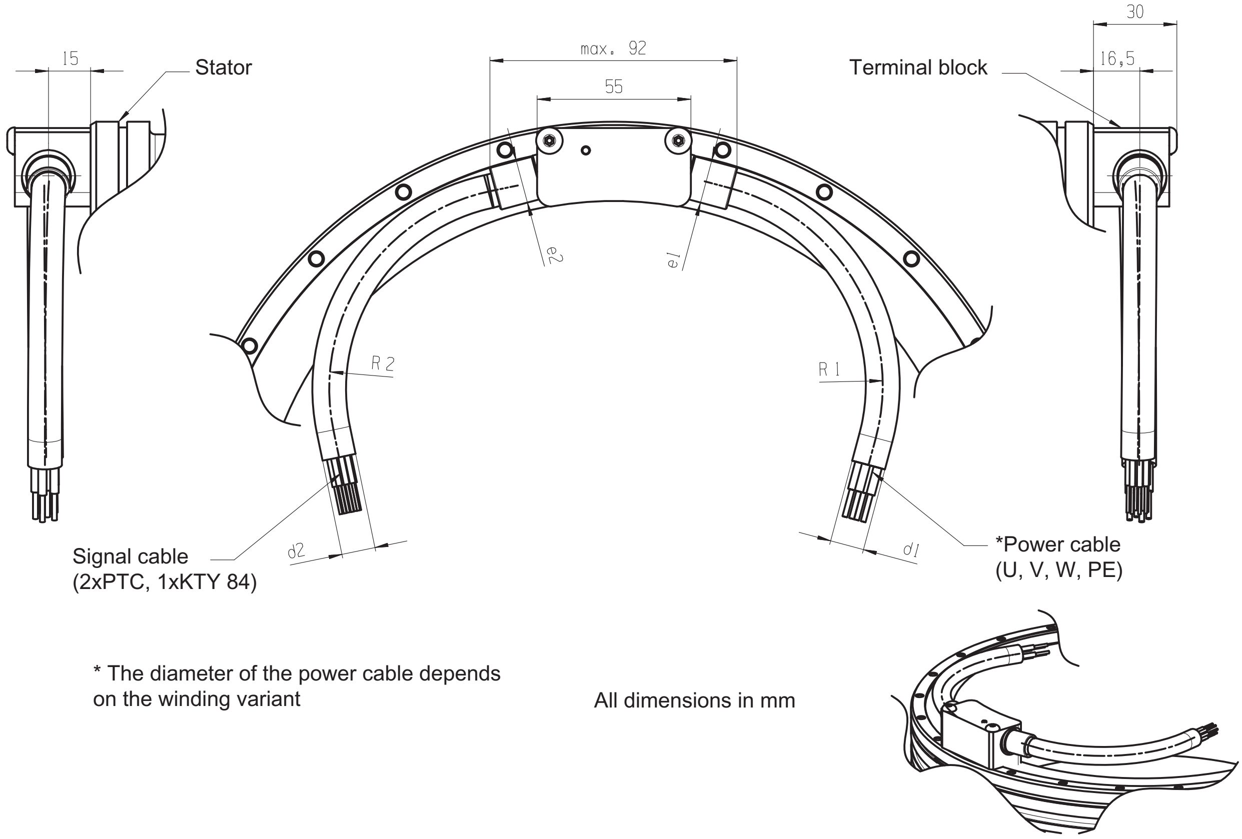


Figure 8-6 Electrical connection (tangential) with sleeve for 1FW613

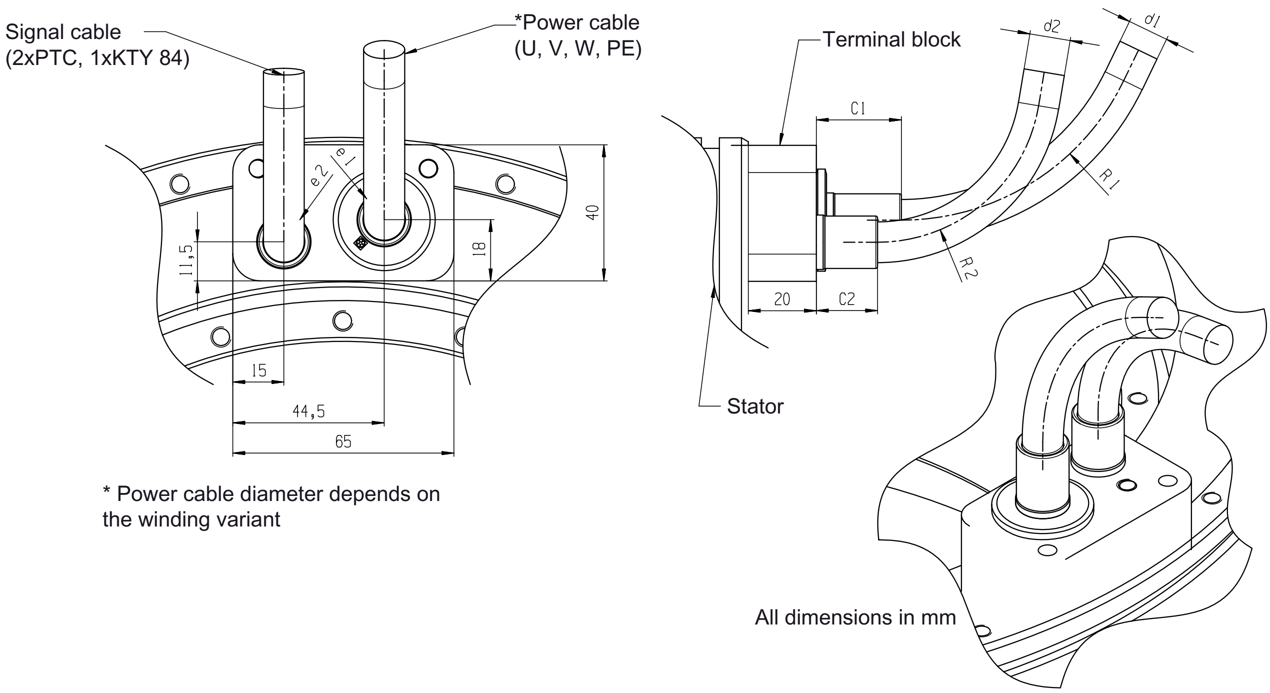


Figure 8-7 Electrical connection (axial) with sleeve for 1FW615

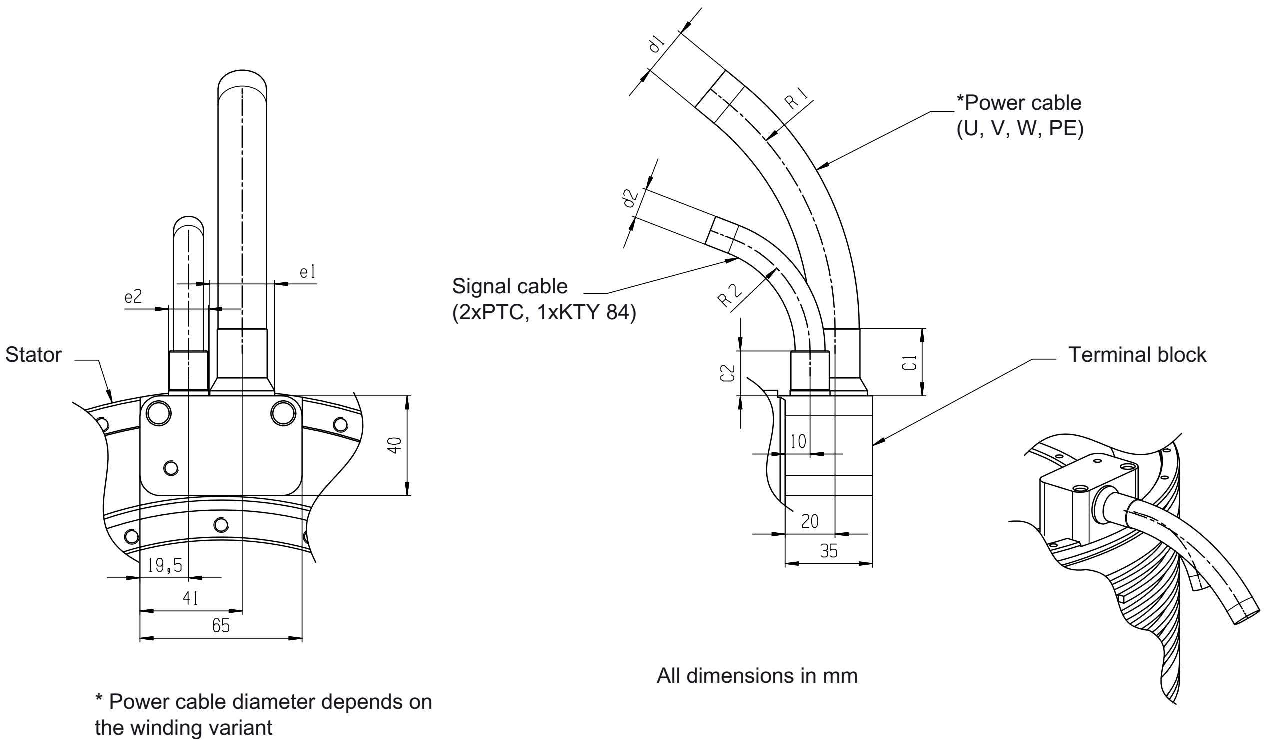


Figure 8-8 Electrical connection (radial, outward) with sleeve for 1FW615

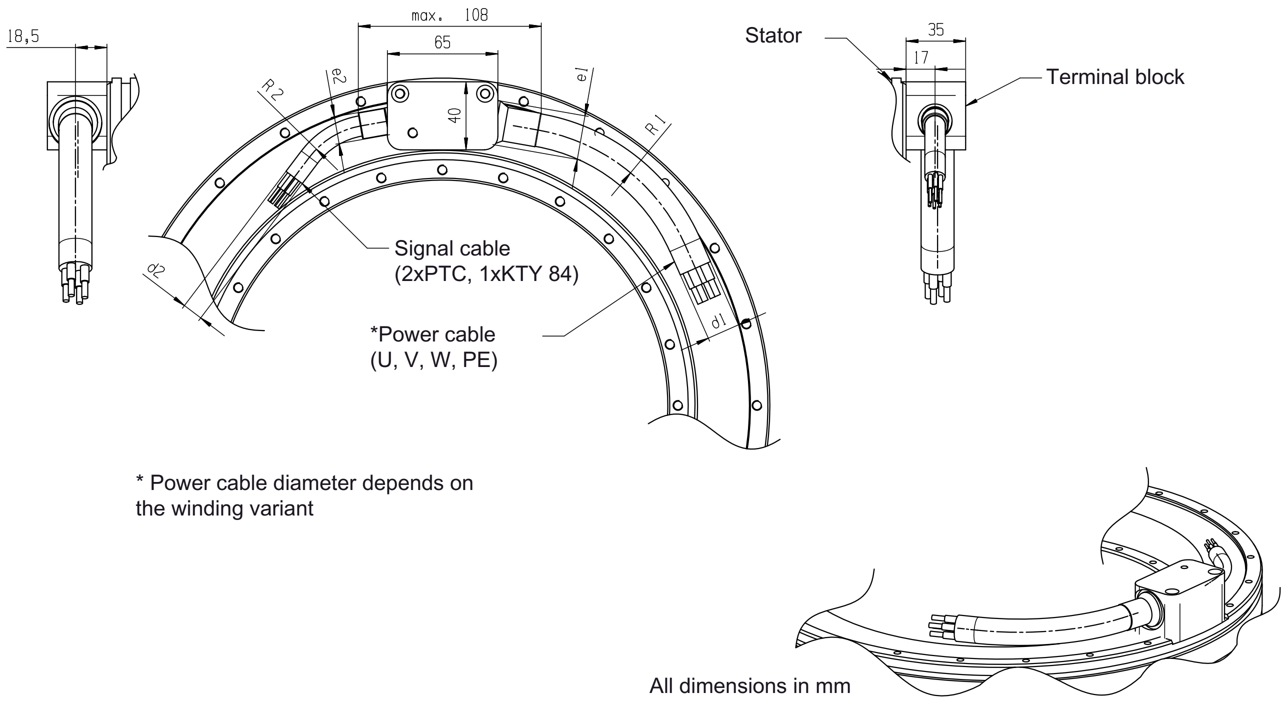


Figure 8-9 Electrical connection (tangential) with sleeve for 1FW615

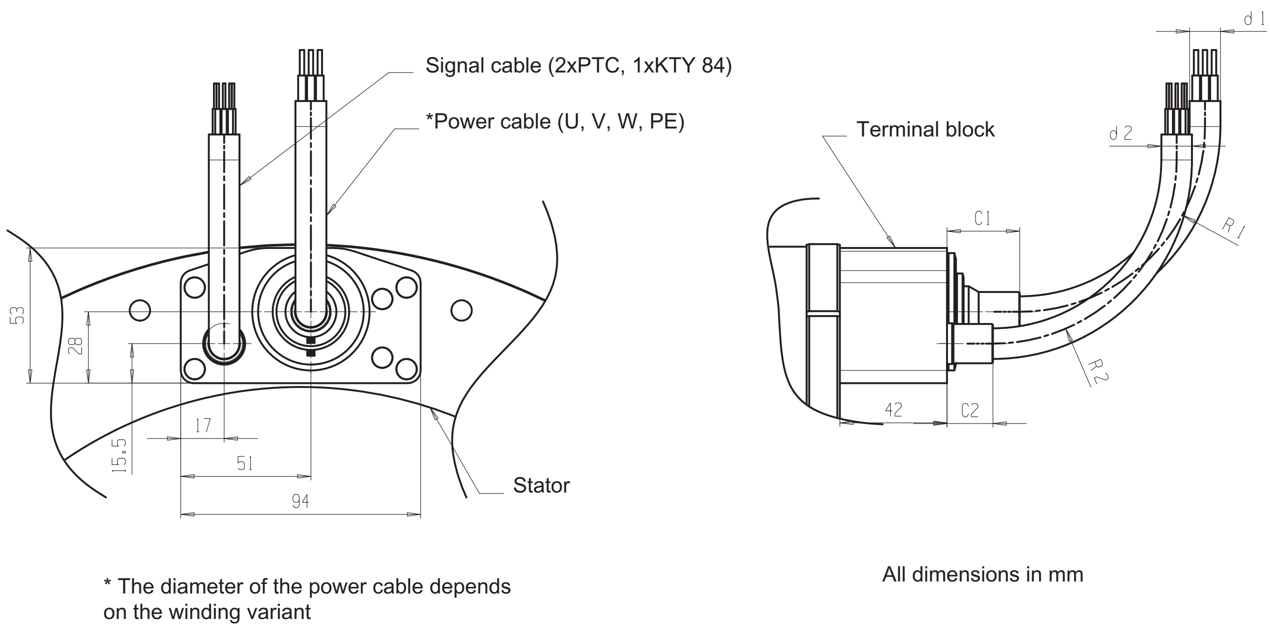
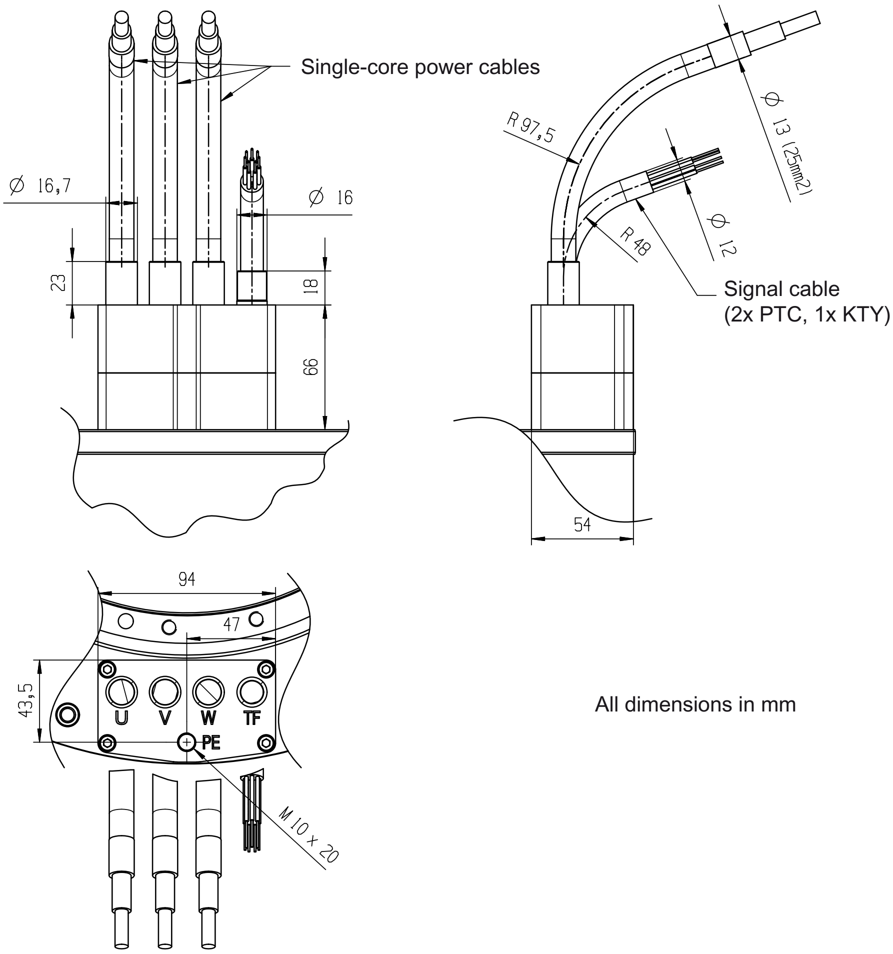


Figure 8-10 Electrical connection (axial) with sleeve for 1FW616, 1FW619, and 1FW623



All dimensions in mm

Figure 8-11 Electrical connection (axial) with sleeve and single core for 1FW616, 1FW619, and 1FW623, 25 mm² core cross-section

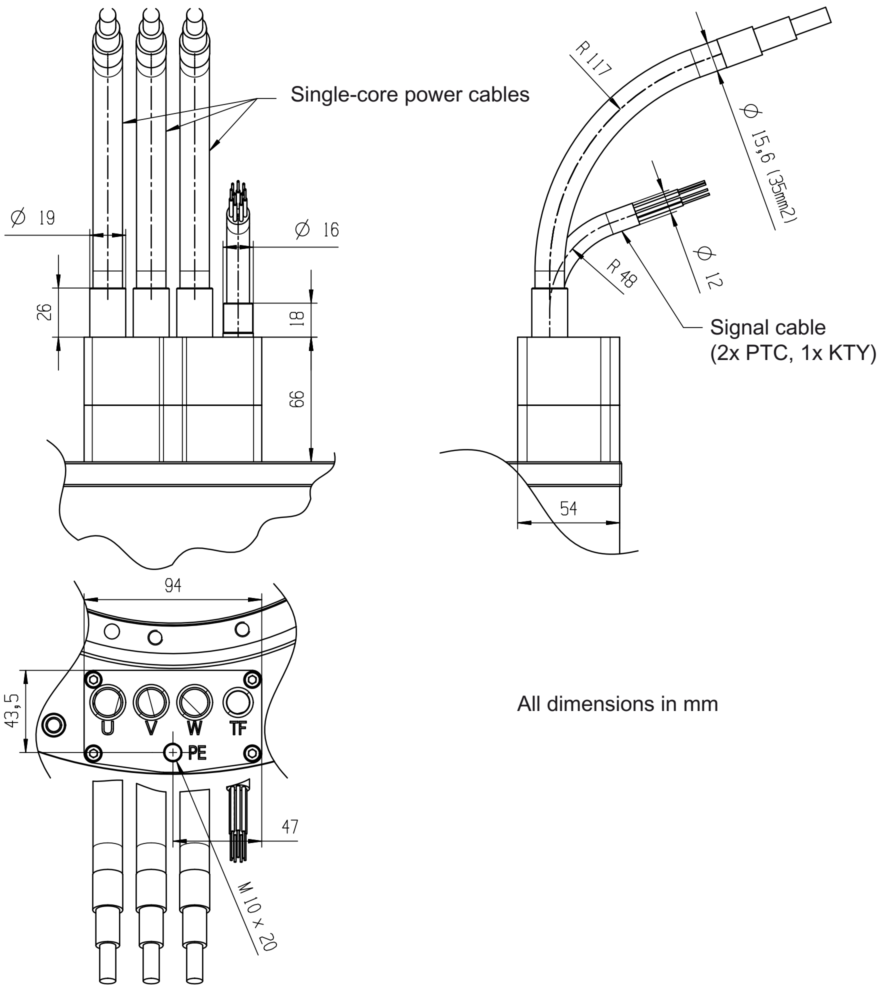


Figure 8-12 Electrical connection (axial) with sleeve and single core for 1FW623, 35 mm² core cross-section

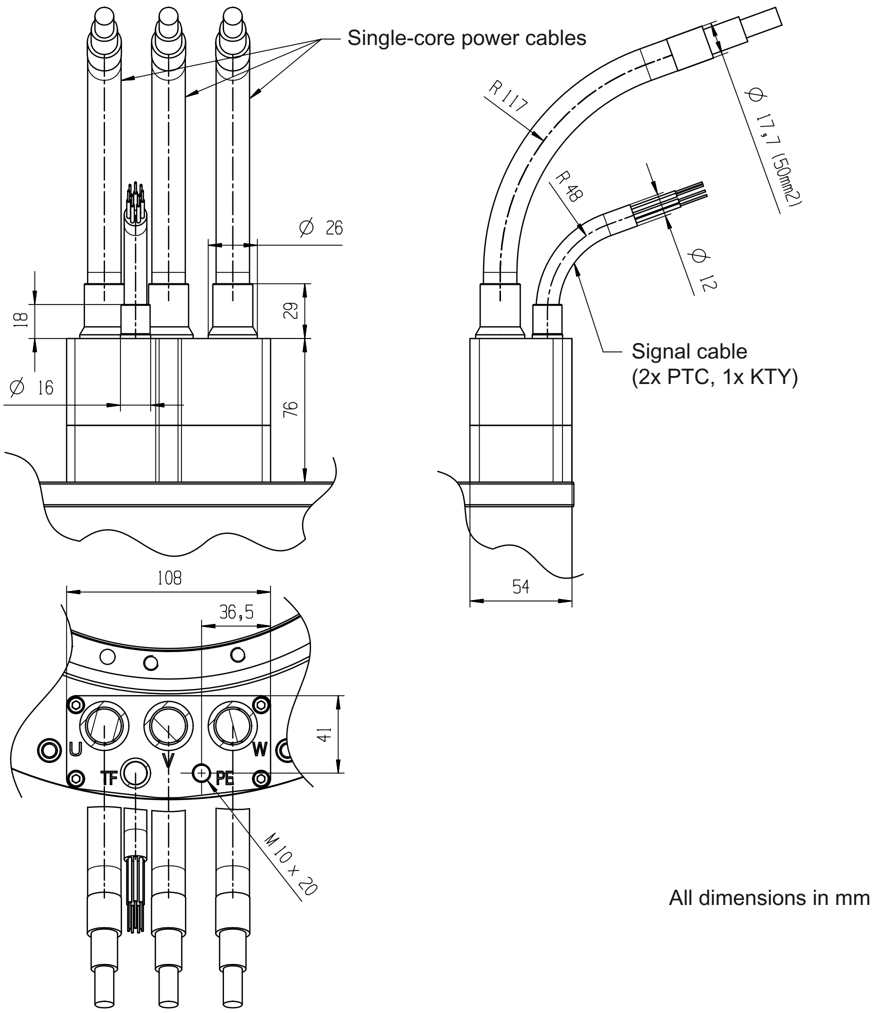


Figure 8-13 Electrical connection (axial) with sleeve and single core for 1FW616 and 1FW619, 50 mm² core cross-section

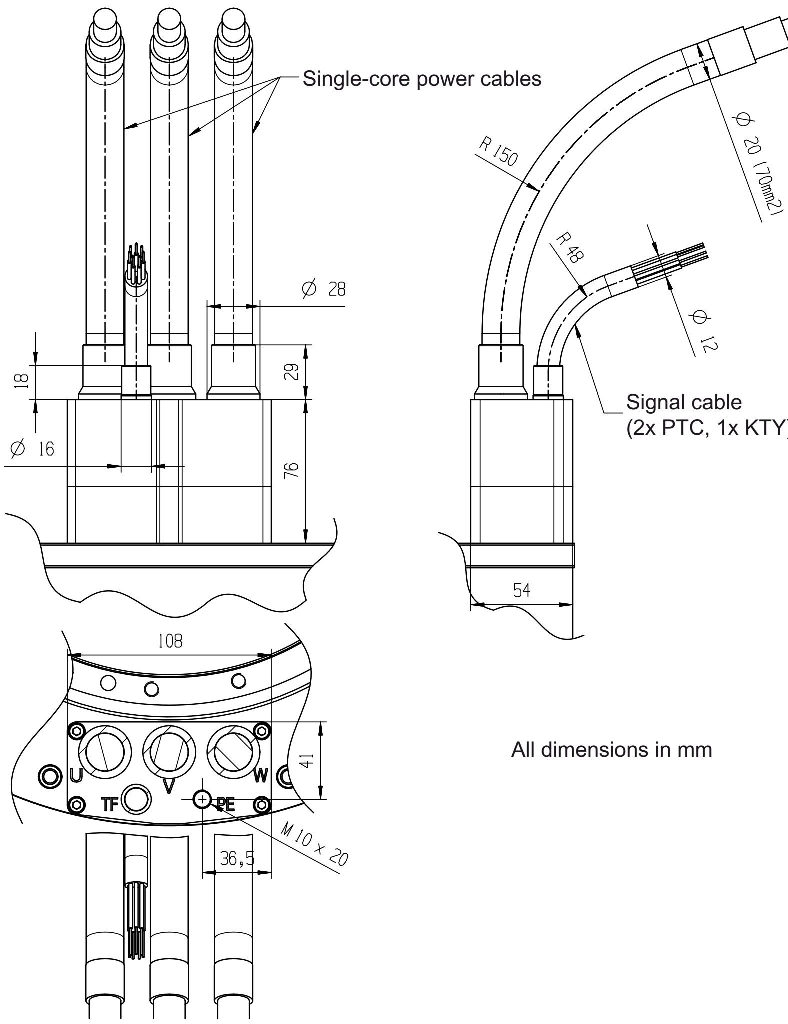


Figure 8-14 Electrical connection (axial) with sleeve and single core for 1FW616, 1FW619, and 1FW623, 70 mm^2 core cross-section

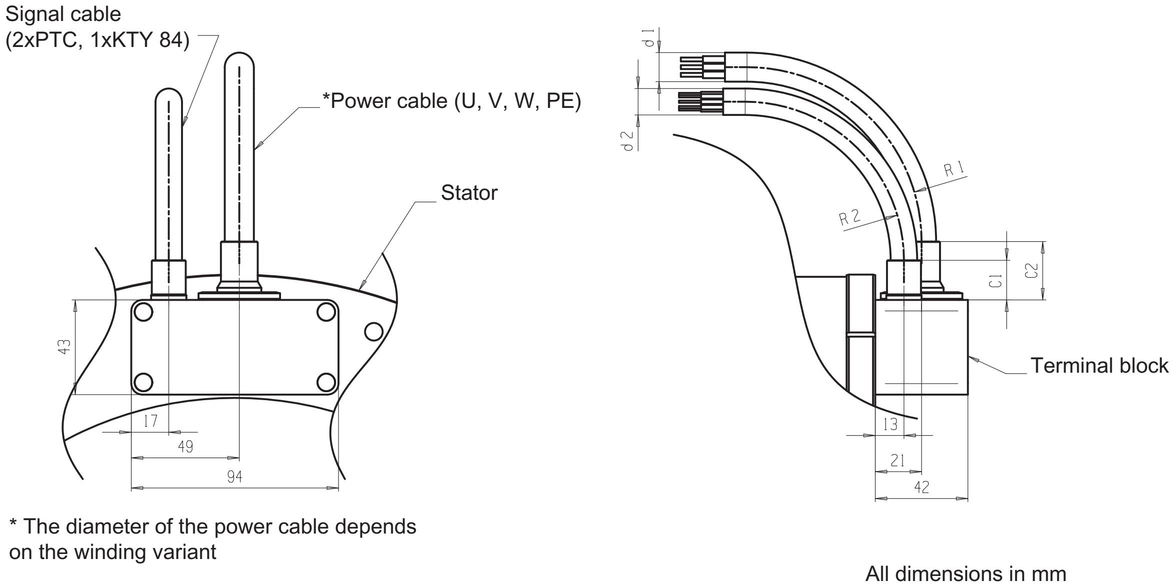


Figure 8-15 Electrical connection (radial, outward) with sleeve for 1FW616, 1FW619, and 1FW623 up to 6 mm² core cross-section

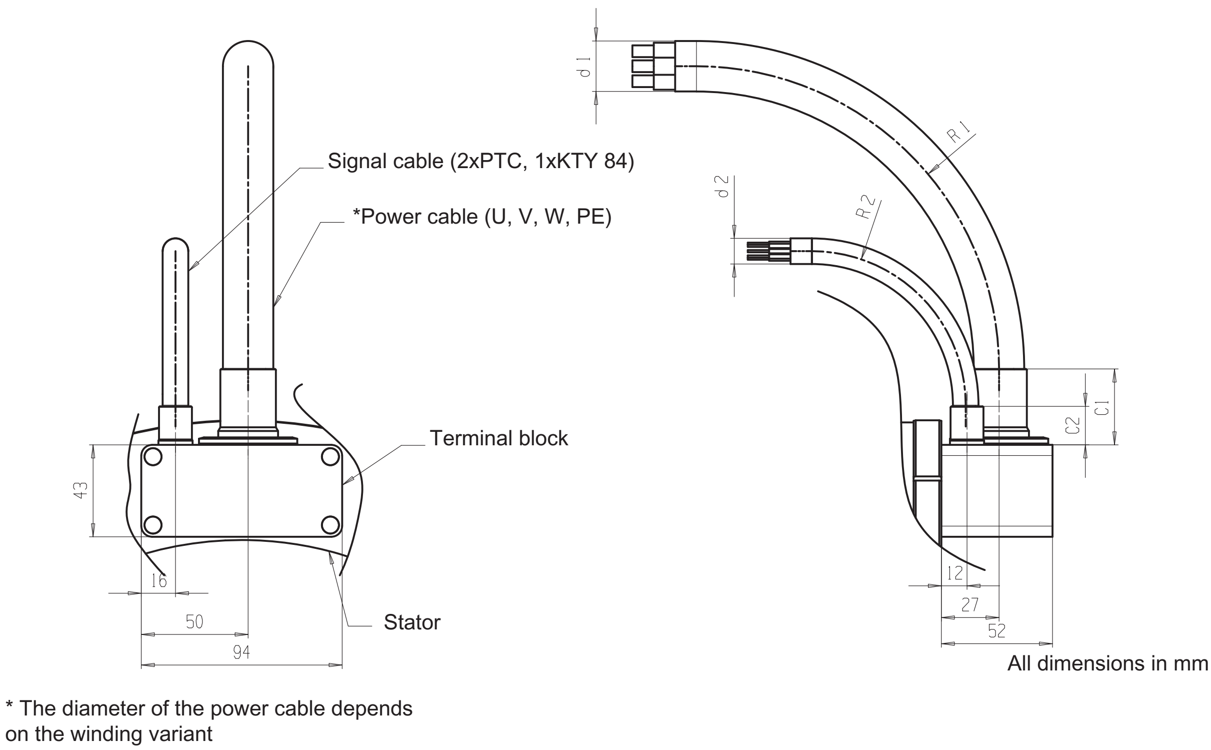


Figure 8-16 Electrical connection (radial, outward) with sleeve for 1FW616, 1FW619, and 1FW623 as of 10 mm² core cross-section

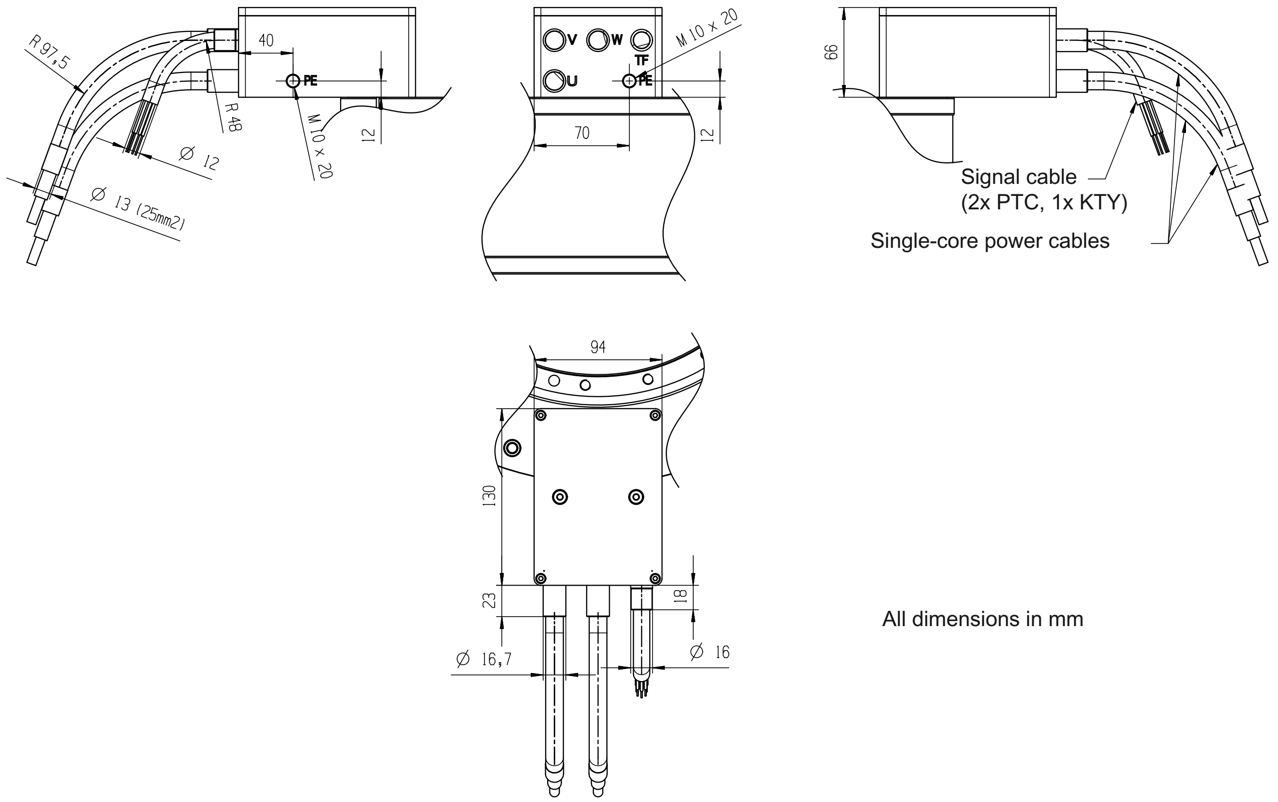


Figure 8-17 Electrical connection (radial, outward) with sleeve and single core for 1FW616, 1FW619, and 1FW623, 25 mm² core cross-section

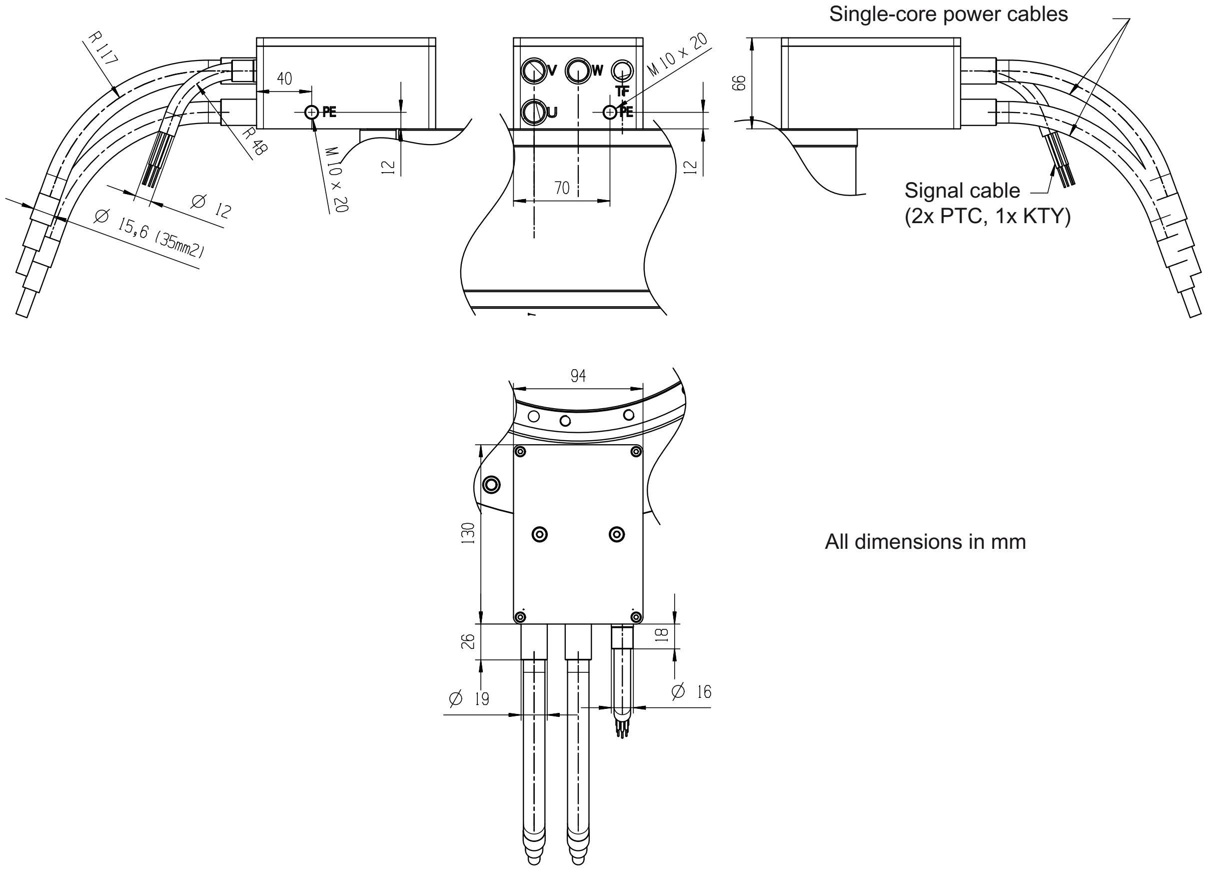


Figure 8-18 Electrical connection (radial, outward) with sleeve and single core for 1FW623, 35 mm^2 core cross-section

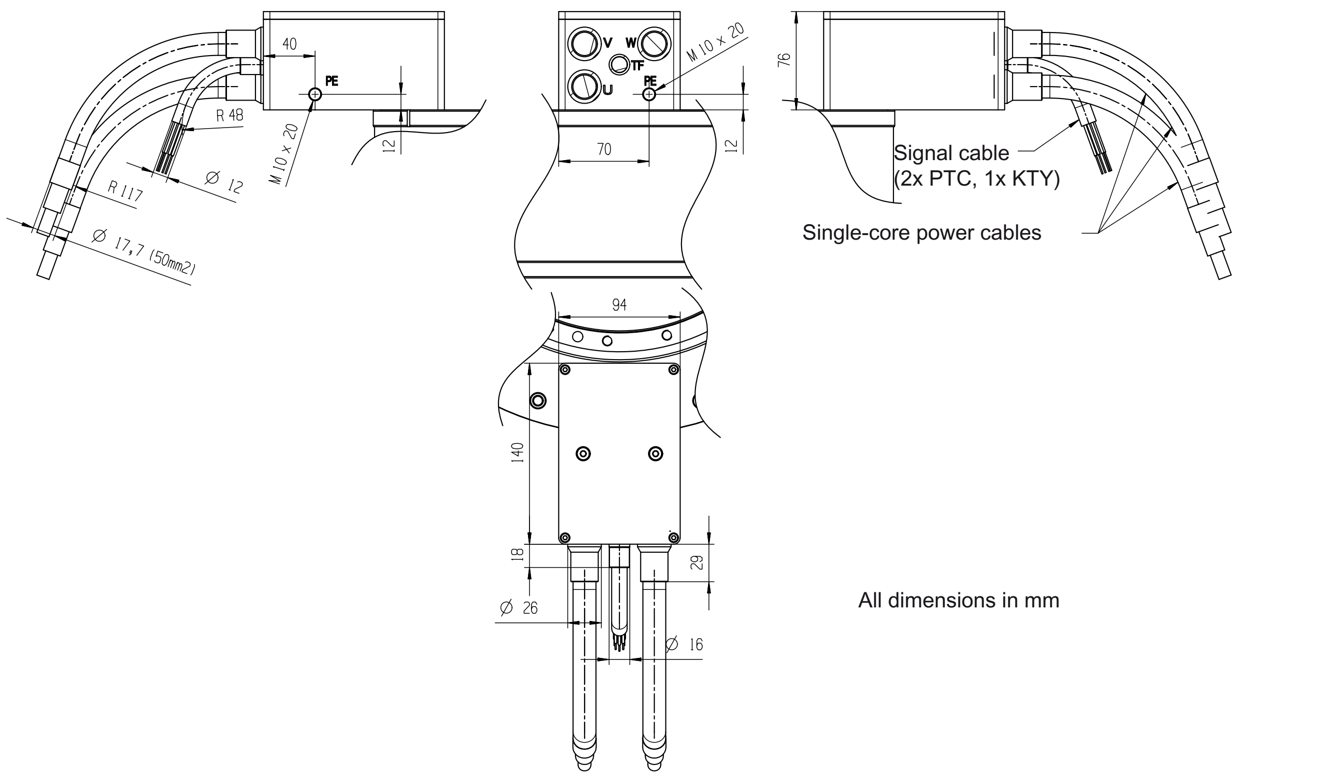


Figure 8-19 Electrical connection (radial, outward) with sleeve and single core for 1FW616 and 1FW619, 50 mm² core cross-section

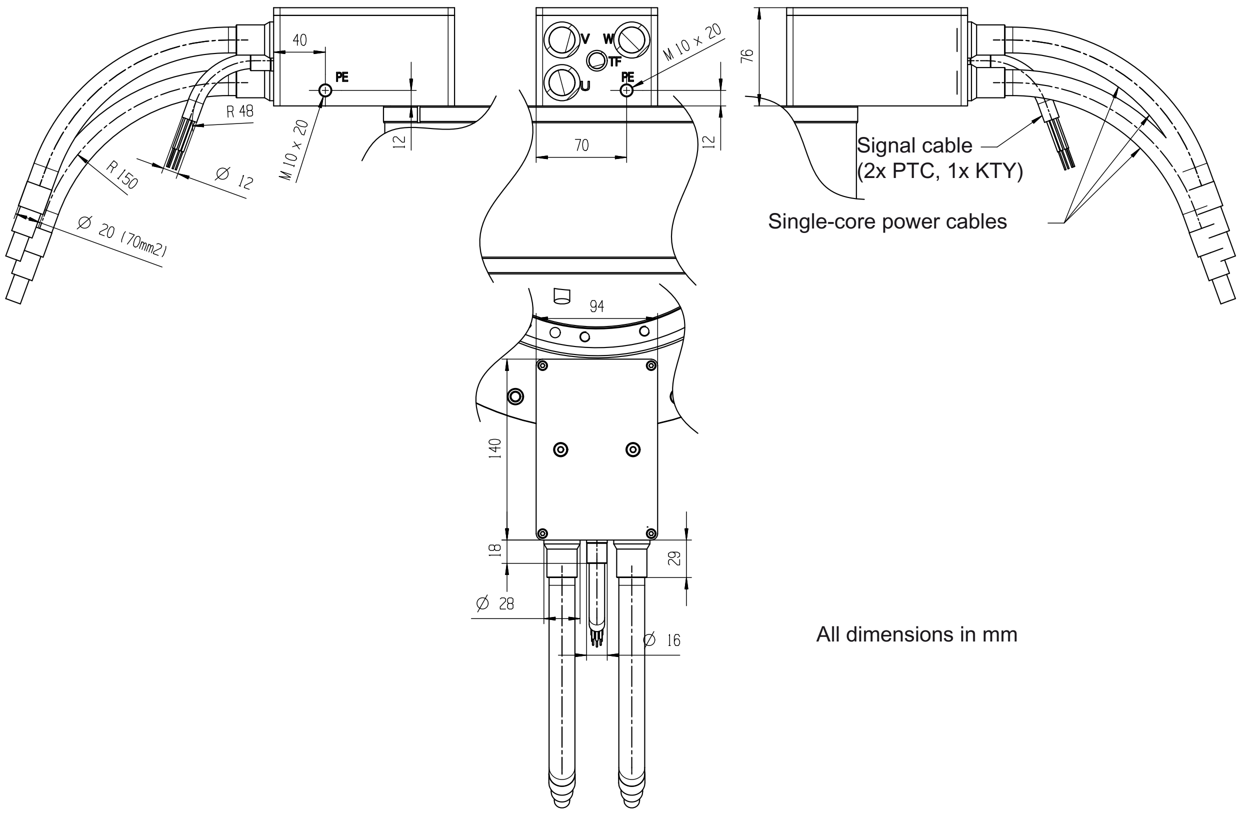
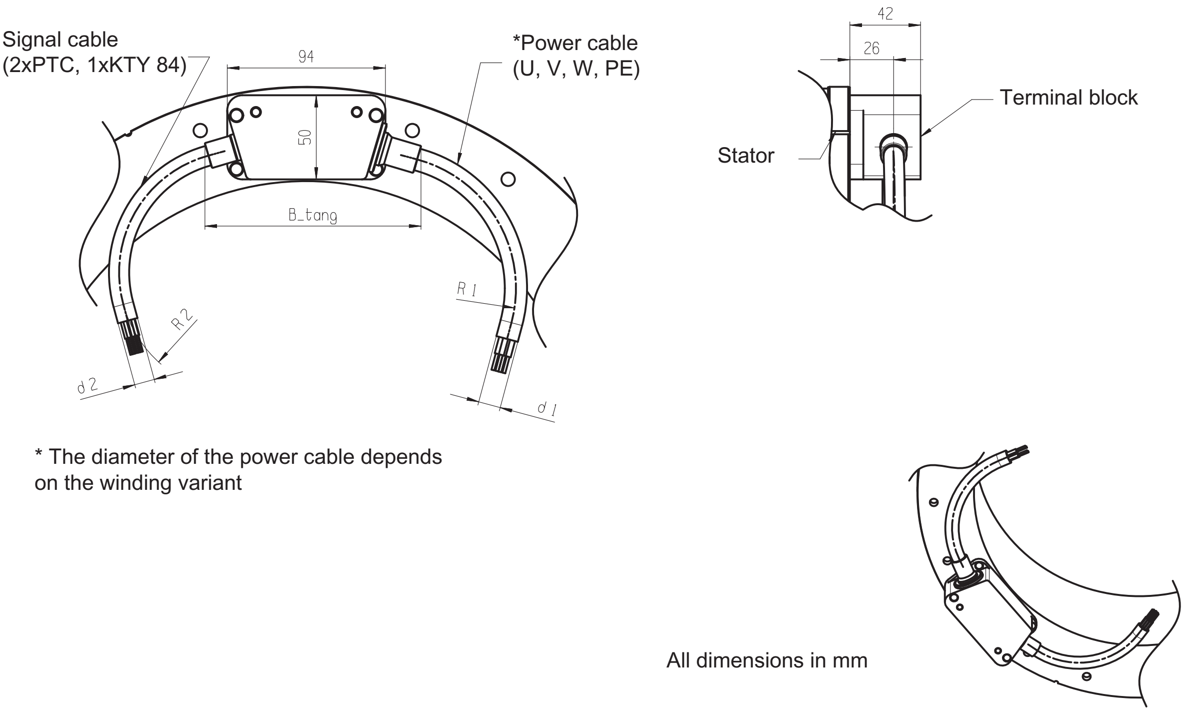
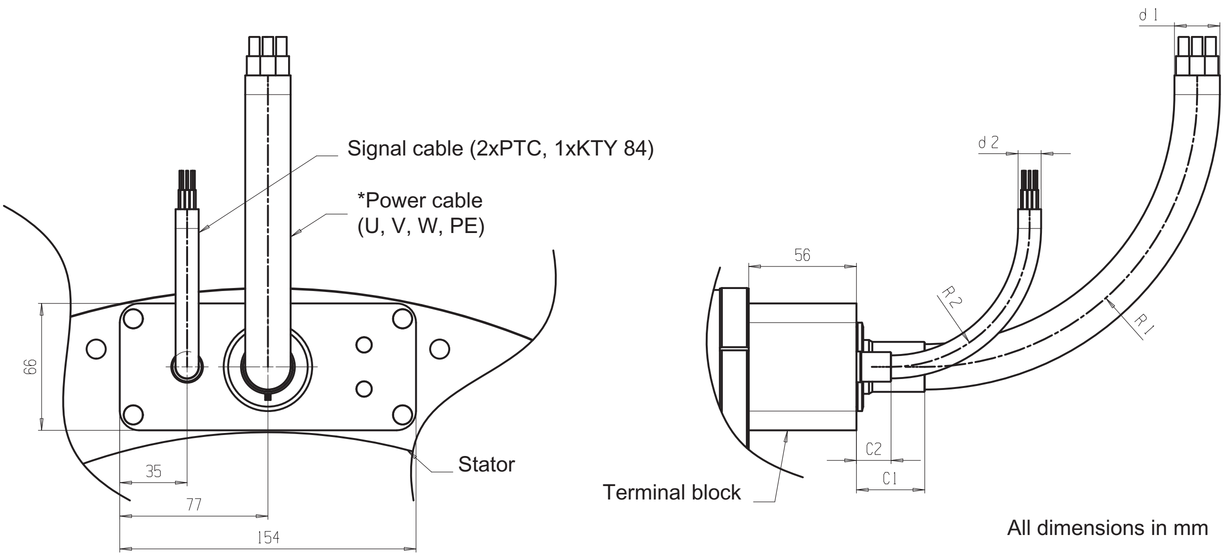


Figure 8-20 Electrical connection (radial, outward) with sleeve and single core for 1FW616, 1FW619, and 1FW623, 70 mm² core cross-section



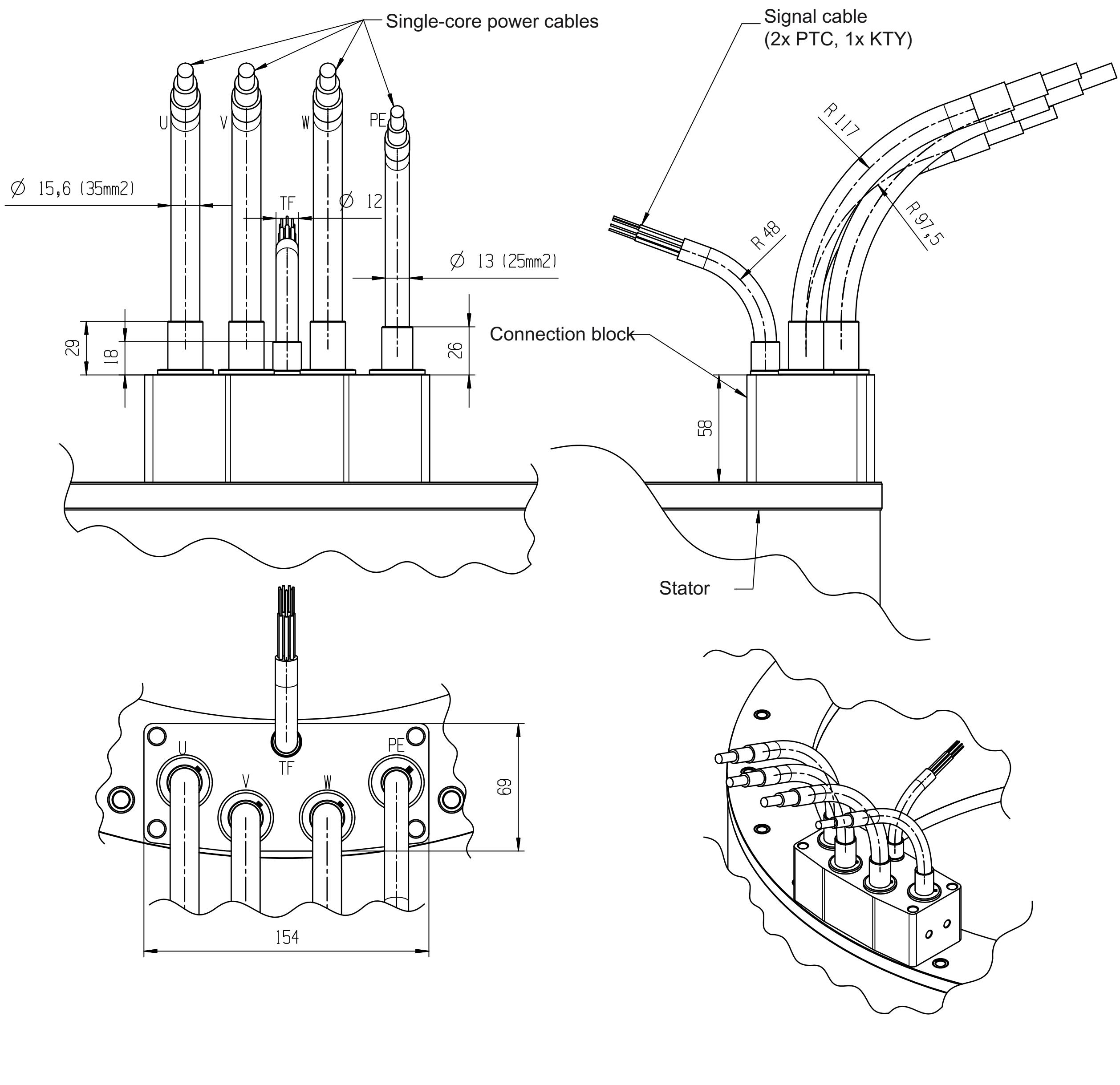
* The diameter of the power cable depends on the winding variant

Figure 8-21 Electrical connection (tangential) with sleeve for 1FW616, 1FW619, and 1FW623



* The diameter of the power cable depends on the winding variant

Figure 8-22 Electrical connection (axial) with sleeve for 1FW629



All dimensions in mm

Figure 8-23 Electrical connection (axial) with sleeve and single core for 1FW629, 35 mm² core cross-section

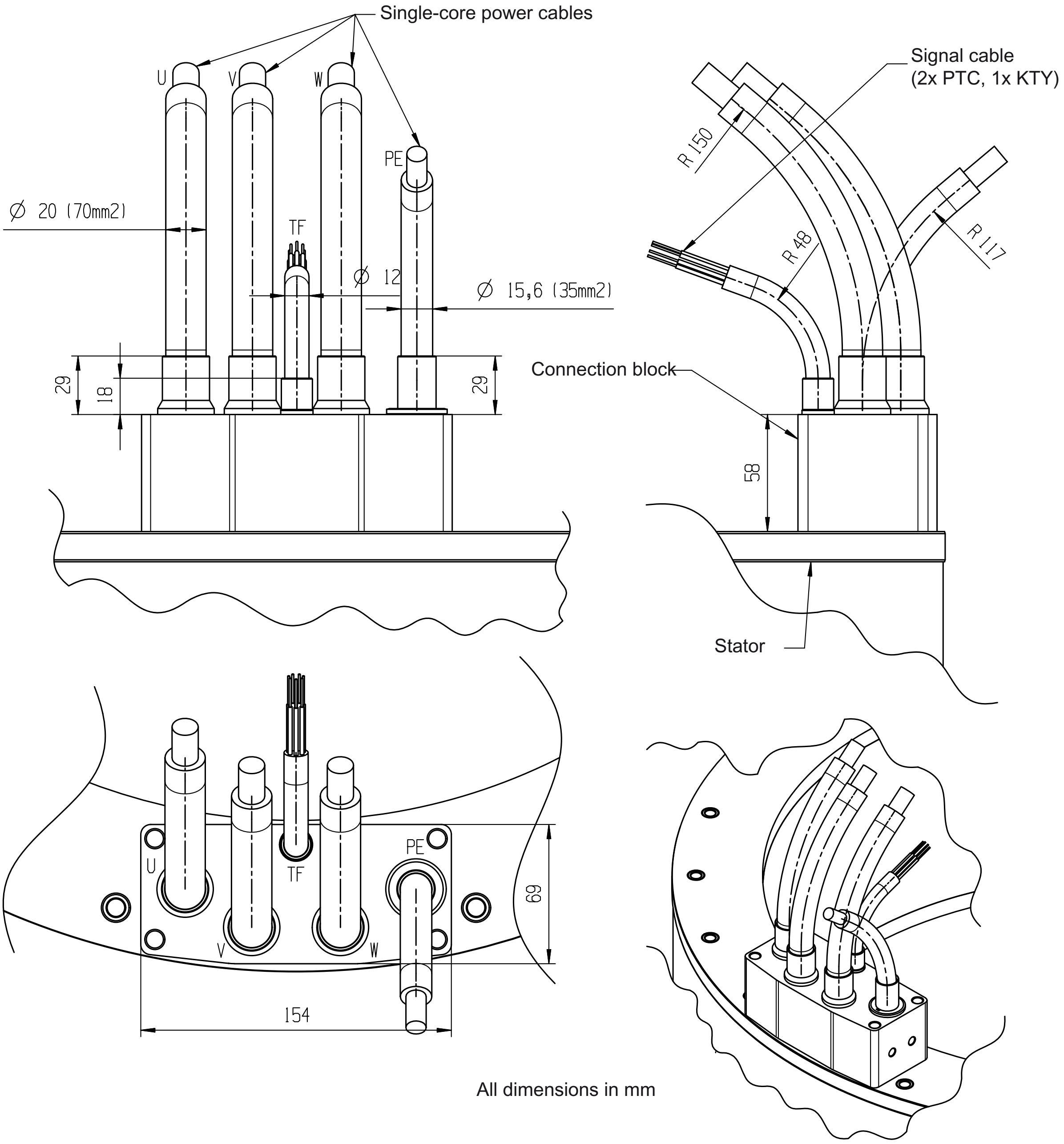


Figure 8-24 Electrical connection (axial) with sleeve and single core for 1FW629, 70 mm² core cross-section

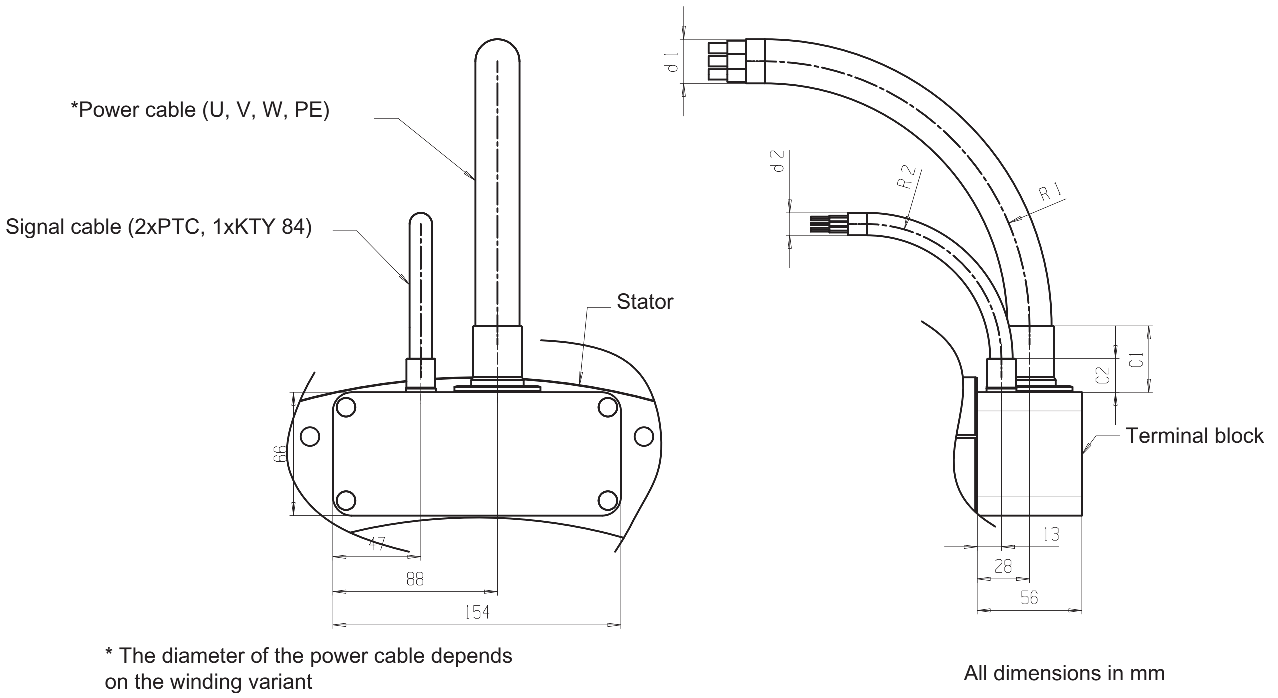


Figure 8-25 Electrical connection (radial, outward) with sleeve for 1FW629

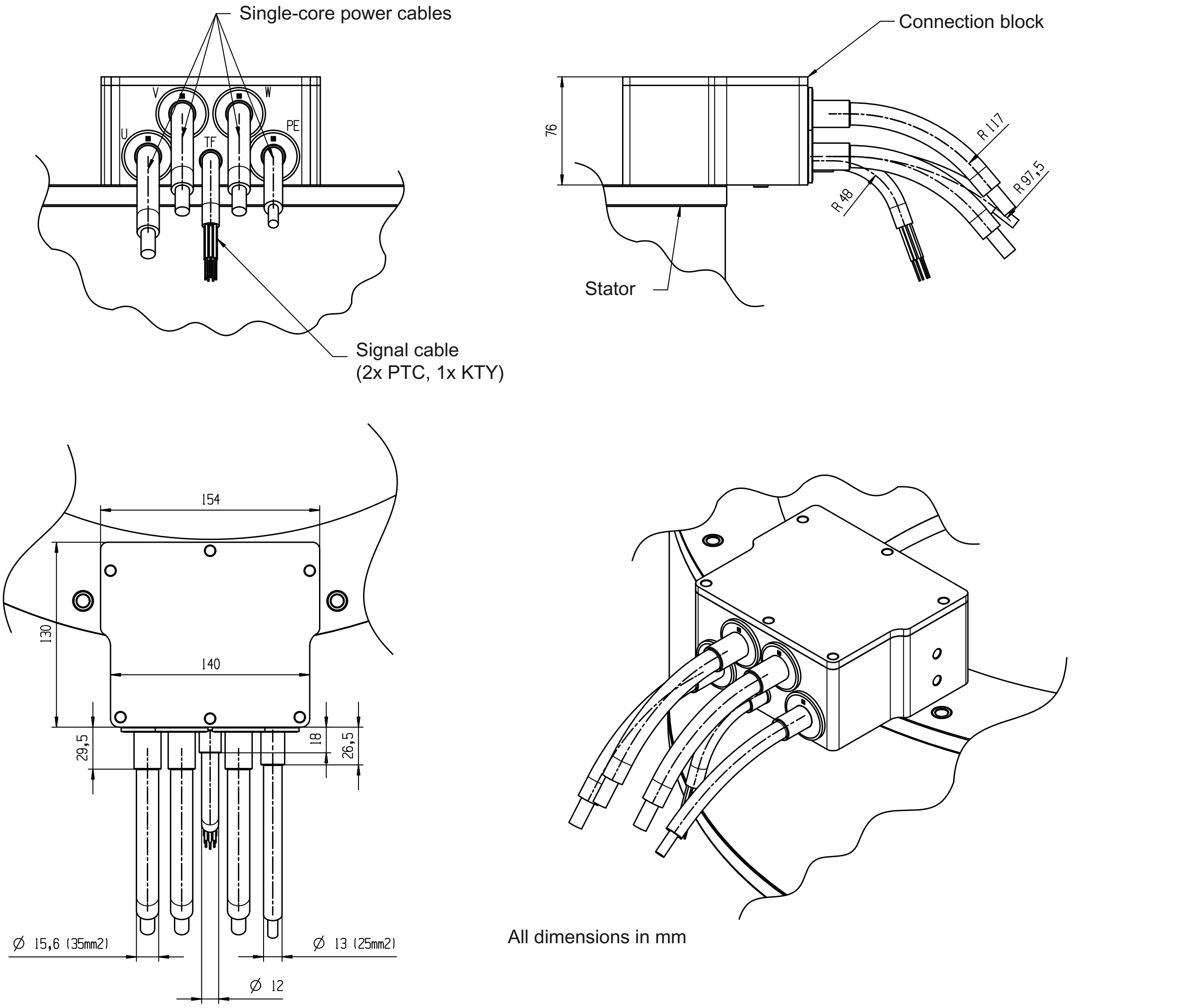


Figure 8-26 Electrical connection (radial, outward) with sleeve and single core for 1FW629, 35 mm² core cross-section

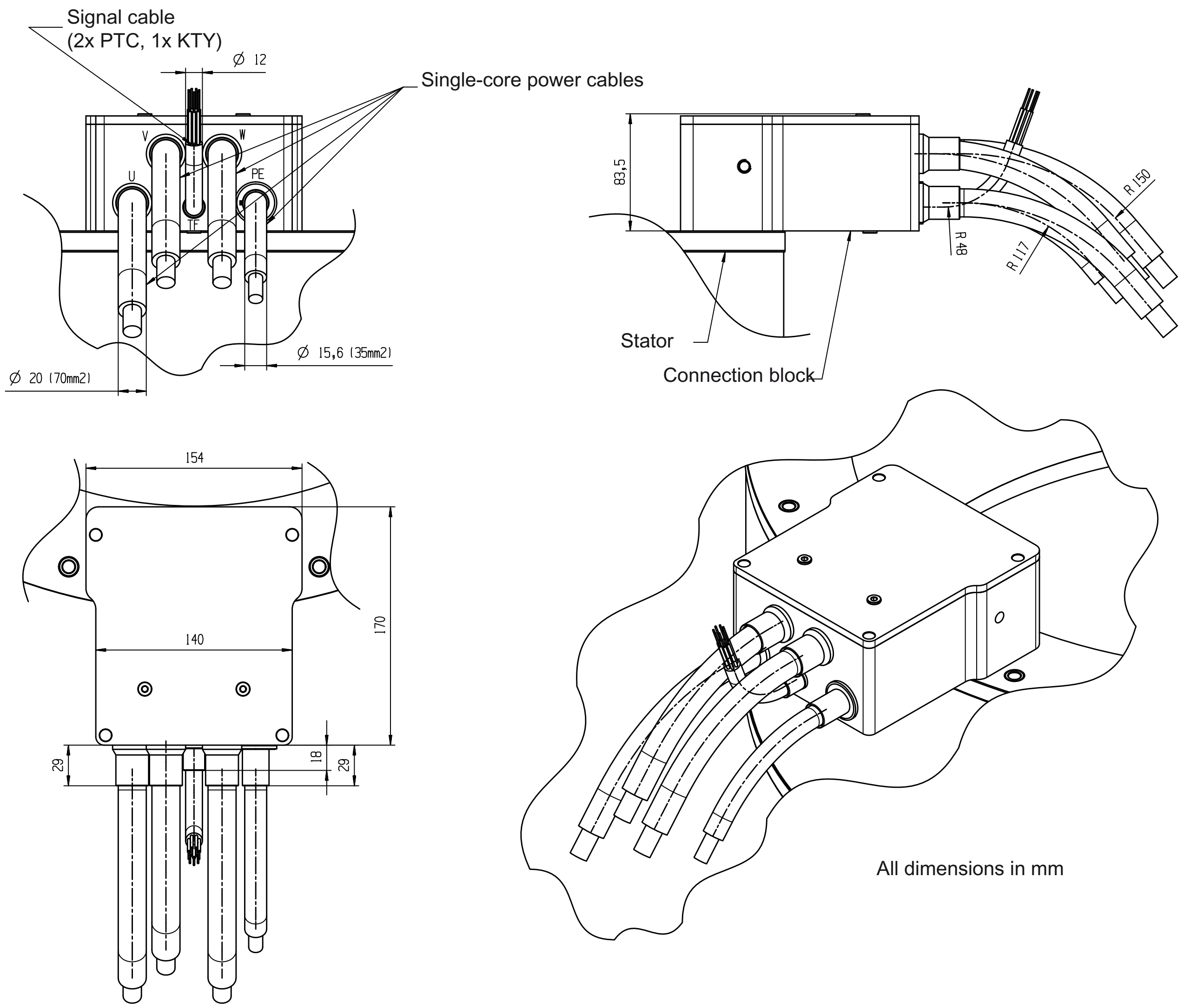


Figure 8-27 Electrical connection (radial, outward) with sleeve and single core for 1FW629, 70 mm² core cross-section

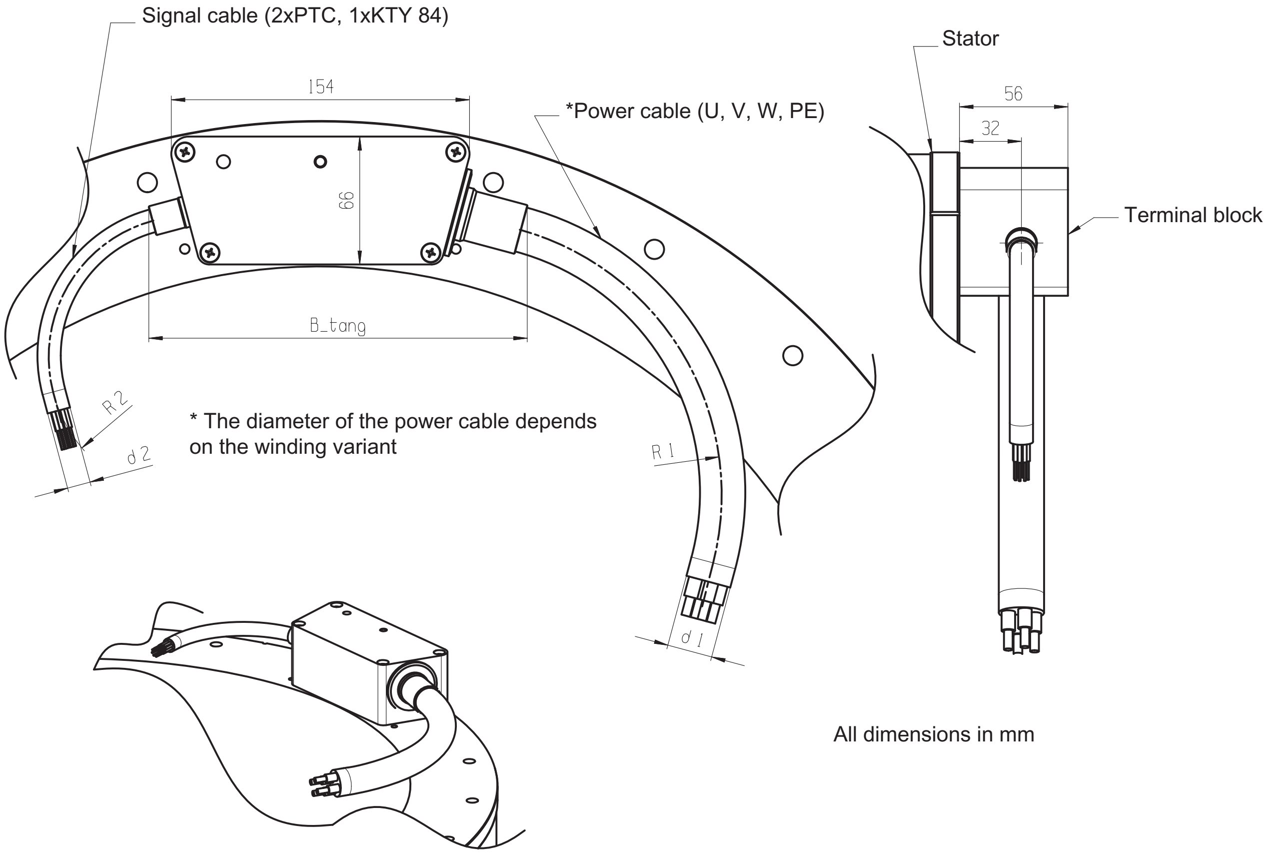


Figure 8-28 Electrical connection (tangential) with sleeve for 1FW629

Table 8- 2 Specifications for the power cable on the stator

Motor type	Max. diameter "d1" in mm 1)	No. of cores x crosssection in mm²	Min. bending radius "R1" in mm 1)	Height of sleeve "C1" in mm	Connector size 2)
1FW6090-xxB05-0Fxx	12.1	4x2.5	73	18	1
1FW6090-xxB05-0Kxx	12.1	4x2.5	73	18	1
1FW6090-xxB07-0Kxx	12.1	4x2.5	73	18	1
1FW6090-xxB07-1Jxx	12.1	4x2.5	73	18	1
1FW6090-xxB10-0Kxx	12.1	4x2.5	73	18	1
1FW6090-xxB10-1Jxx	12.1	4x2.5	73	18	1
1FW6090-xxB15-1Jxx	12.1	4x2.5	73	18	1
1FW6090-xxB15-2Jxx	13.2	4x4.0	79	23	1.5
1FW6130-xxB05-0Kxx	12.1	4x2.5	73	18	1
1FW6130-xxB05-1Jxx	12.1	4x2.5	73	18	1
1FW6130-xxB07-0Kxx	12.1	4x2.5	73	18	1
1FW6130-xxB07-1Jxx	12.1	4x2.5	73	18	1
1FW6130-xxB10-1Jxx	12.1	4x2.5	73	18	1

Motor type	Max. diameter "d1" in mm [1])	No. of cores x crosssection in mm²	Min. bending radius "R1" in mm [1])	Height of sleeve "C1" in mm	Connector size [2])
1FW6130-xxB10-2Jxx	13.2	4x4.0	79	23	1.5
1FW6130-xxB15-1Jxx	12.1	4x2.5	73	18	1
1FW6130-xxB15-2Jxx	13.2	4x4.0	79	23	1.5
1FW6150-xxB05-1Jxx	12.1	4x2.5	73	25	1
1FW6150-xxB05-4Fxx	19.4	4x10.0	116	27	1.5
1FW6150-xxB07-2Jxx	13.2	4x4.0	79	26	1.5
1FW6150-xxB07-4Fxx	19.4	4x10.0	116	27	1.5
1FW6150-xxB10-2Jxx	13.2	4x4.0	79	26	1.5
1FW6150-xxB10-4Fxx	19.4	4x10.0	116	27	1.5
1FW6150-xxB15-2Jxx	13.2	4x4.0	79	26	1.5
1FW6150-xxB15-4Fxx	19.4	4x10.0	116	27	1.5
1FW6160-xxB05-1Jxx	12.1	4x2.5	73	28.5	1
1FW6160-xxB05-2Jxx	13.2	4x4.0	79	29.5	1.5
1FW6160-xxB05-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6160-xxB07-1Jxx	12.1	4x2.5	73	28.5	1
1FW6160-xxB07-2Jxx	13.2	4x4.0	79	29.5	1.5
1FW6160-xxB07-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6160-xxB07-8Fxx	13.0	3x(1x25) + M10 f. PE (1x25)*)	97.5	23	-
1FW6160-xxB10-1Jxx	12.1	4x2.5	73	28.5	1
1FW6160-xxB10-2Jxx	13.2	4x4.0	79	29.5	1.5
1FW6160-xxB10-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6160-xxB10-8Fxx	13.0	3x(1x25) + M10 f. PE (1x25)*)	97.5	23	-
1FW6160-xxB10-2Pxx	17.7	3x(1x50) + M10 f. PE (1x25)*)	133	29	-
1FW6160-xxB15-2Jxx	13.2	4x4.0	79	29.5	1.5
1FW6160-xxB15-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6160-xxB15-8Fxx	13.0	3x(1x25) + M10 f. PE (1x25)*)	97.5	23	-
1FW6160-xxB15-2Pxx	17.7	3x(1x50) + M10 f. PE (1x25)*)	133	29	-
1FW6160-xxB15-0Wxx	20.0	3x(1x70) + M10 f. PE (1x35)*)	150.0	29	-
1FW6160-xxB20-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6160-xxB20-8Fxx	13.0	3x(1x25) + M10 f. PE (1x25)*)	97.5	23	-
1FW6160-xxB20-2Pxx	17.7	3x(1x50) + M10 f. PE (1x25)*)	133	29	-
1FW6160-xxB20-0Wxx	20.0	3x(1x70) + M10 f. PE (1x35)*)	150.0	29	-
1FW6190-xxB05-1Jxx	12.1	4x2.5	73	28.5	1

Motor type	Max. diameter "d1" in mm [1])	No. of cores x crosssection in mm^2	Min. bending radius "R1" in mm [1])	Height of sleeve "C1" in mm	Connector size [2])
1FW6190-xxB05-2Jxx	13.2	4x4.0	79	29.5	1.5
1FW6190-xxB05-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6190-xxB07-1Jxx	12.1	4x2.5	73	28.5	1
1FW6190-xxB07-2Jxx	13.2	4x4.0	79	29.5	1.5
1FW6190-xxB07-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6190-xxB07-8Fxx	13.0	3x(1x25) + M10 f. PE (1x25)*)	97.5	23	-
1FW6190-xxB10-1Jxx	12.1	4x2.5	73	28.5	1
1FW6190-xxB10-2Jxx	13.2	4x4.0	79	29.5	1.5
1FW6190-xxB10-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6190-xxB10-8Fxx	13.0	3x(1x25) + M10 f. PE (1x25)*)	97.5	23	-
1FW6190-xxB10-2Pxx	17.7	3x(1x50) + M10 f. PE (1x25)*)	133	29	-
1FW6190-xxB15-2Jxx	13.2	4x4.0	79	29.5	1.5
1FW6190-xxB15-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6190-xxB15-8Fxx	13.0	3x(1x25) + M10 f. PE (1x25)*)	97.5	23	-
1FW6190-xxB15-2Pxx	17.7	3x(1x50) + M10 f. PE (1x25)*)	133	29	-
1FW6190-xxB15-0Wxx	20.0	3x(1x70) + M10 f. PE (1x35)*)	150.0	29	-
1FW6190-xxB20-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6190-xxB20-8Fxx	13.0	3x(1x25) + M10 f. PE (1x25)*)	97.5	23	-
1FW6190-xxB20-2Pxx	17.7	3x(1x50) + M10 f. PE (1x25)*)	133	29	-
1FW6190-xxB20-0Wxx	20.0	3x(1x70) + M10 f. PE (1x35)*)	150.0	29	-
1FW6230-xxB05-1Jxx	12.1	4x2.5	73	28.5	1
1FW6230-xxB05-2Jxx	13.2	4x4.0	79	29.5	1.5
1FW6230-xxB05-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6230-xxB07-1Jxx	12.1	4x2.5	73	28.5	1
1FW6230-xxB07-2Jxx	13.2	4x4.0	79	29.5	1.5
1FW6230-xxB07-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6230-xxB07-8Fxx	13.0	3x(1x25) + M10 f. PE (1x25)*)	97.5	23	-
1FW6230-xxB10-2Jxx	13.2	4x4.0	79	29.5	1.5
1FW6230-xxB10-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6230-xxB10-8Fxx	13.0	3x(1x25) + M10 f. PE (1x25)*)	97.5	23	-
1FW6230-xxB10-2Pxx	15.6	3x(1x35) + M10 f. PE (1x25)*)	117.0	26	-

Motor type	Max. diameter "d1" in mm 1)	No. of cores x crosssection in mm^2	Min. bending radius "R1" in mm 1)	Height of sleeve "C1" in mm	Connector size 2)
1FW6230-xxB15-4Cxx	16.0	4x6.0	96	31.5	1.5
1FW6230-xxB15-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6230-xxB15-8Fxx	13.0	3x(1x25) + M10 f. PE (1x25)*)	97.5	23	-
1FW6230-xxB15-2Pxx	15.6	3x(1x35) + M10 f. PE (1x25)*)	117.0	26	-
1FW6230-xxB15-0Wxx	20.0	3x(1x70) + M10 f. PE (1x35)*)	150.0	29	-
1FW6230-xxB20-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6230-xxB20-8Fxx	13.0	3x(1x25) + M10 f. PE (1x25)*)	97.5	23	-
1FW6230-xxB20-2Pxx	15.6	3x(1x35) + M10 f. PE (1x25)*)	117.0	26	-
1FW6230-xxB20-0Wxx	20.0	3x(1x70) + M10 f. PE (1x35)*)	150.0	29	-
1FW6290-xxB07-5Gxx	23.6	4x16.0	142	35.5	1.5
1FW6290-xxB07-0Lxx	d(35) = 15.6 d(25) = 13.0	3x(1x35)+1x25	R(35) = 133 R(25) = 97.5	26	-
1FW6290-xxB07-2Pxx	d(70) = 20.0 d(35) = 15.6	3x(1x70)+1x35	R(70) = 150.0 R(35) = 132.5	29	-
1FW6290-xxB11-7Axx	23.6	4x16.0	142	35.5	1.5
1FW6290-xxB11-0Lxx	d(35) = 15.6 d(25) = 13.0	3x(1x35)+1x25	R(35) = 133 R(25) = 97.5	26	-
1FW6290-xxB11-2Pxx	d(70) = 20.0 d(35) = 15.6	3x(1x70)+1x35	R(70) = 150.0 R(35) = 132.5	29	-
1FW6290-xxB15-7Axx	23.6	4x16.0	142	35.5	1.5
1FW6290-xxB15-0Lxx	d(35) = 15.6 d(25) = 13.0	3x(1x35)+1x25	R(35) = 133 R(25) = 97.5	26	-
1FW6290-xxB15-2Pxx	d(70) = 20.0 d(35) = 15.6	3x(1x70)+1x35	R(70) = 150.0 R(35) = 132.5	29	-
1FW6290-xxB20-0Lxx	d(35) = 15.6 d(25) = 13.0	3x(1x35)+1x25	R(35) = 133 R(25) = 97.5	26	-
1FW6290-xxB20-2Pxx	d(70) = 20 d(35) = 15.6	3x(1x70)+1x35	R(70) = 150.0 R(35) = 132.5	29	-

1) Power cable fixed; 2) Applies to motors with connector

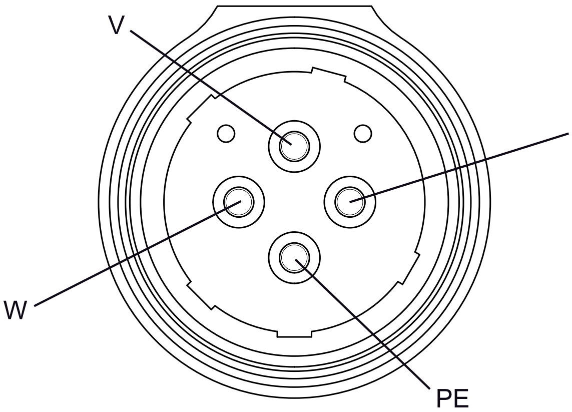
*) PE cable to be connected separately; not included in scope of delivery

Table 8- 3 Specifications for the signal cable on the stator

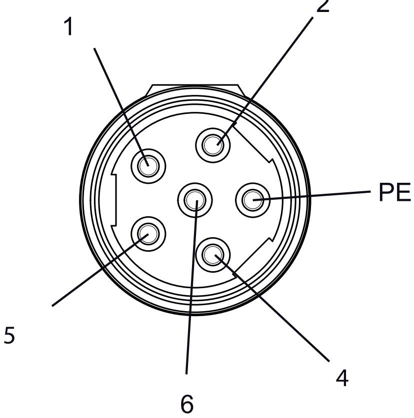
Motor type	Diameter "d2" in mm [1])	No. of cores (signal cores) x crosssection + no. of cores (PE) x cross-section in mm²	Min. bending radius "R2" in mm [1])	Height of sleeve "C2" in mm	Connector size [2])
1FW6xxx-xxxxx-xxxx	12	6 x 0.5 + 1 x 1.0	48	18	M17

[1]) Signal cable fixed; [2]) Applies to motors with connector

Power connector size 1.5
Pole pattern, view of mating side



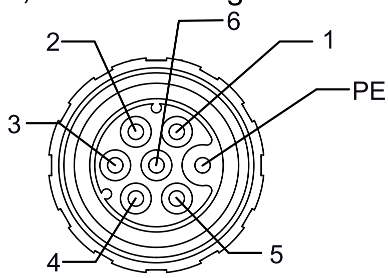
Power connector size 1.0
Pole pattern, view of mating side



Electrical connector pin assignments

PIN	1FW6
1	U
2	V
PE	PE
4	-
5	-
6	W

Signal connector M17
Pole pattern, view of mating side



Electrical connector pin assignments

PIN	1FW6
1	-1R2: KTY -
2	+1R1: KTY +
3	1TP1: PTC 130 °C
4	1TP2: PTC 130 °C
5	2TP1: PTC 150 °C *
6	2TP2: PTC 150 °C *
⏚	PE

* is not evaluated by the SME9x

Figure 8-29 PIN assignments for the connectors

8.2 Electrical connections

DANGER

Risk of death, serious personal injury (electrical shock), and/or material damage if direct drives are connected incorrectly.

Motors must be connected in accordance with the circuit diagram provided in this documentation and require a sinusoidal current injection. They must not be connected directly to the three-phase supply because this will damage them.

The motors are designed to be operated on drive systems that are supplied via power supply networks grounded with low resistance (TN systems).

See also the documentation for the drive system.

DANGER

Components in electrical devices may be under hazardous voltage. There is an electrical shock hazard!

When the rotor is rotating, a voltage is present at the motor terminals that increases proportionally with the speed. At no-load speed, the amplitude value of the voltage at the motor terminals is the same as the voltage value of the converter DC link voltage.

All work involving the electrics must only be carried out by skilled personnel when the device is disconnected from the power supply and the motor is at a standstill.

Note the regulations for working on electrical installations.

In particular, the following safety rules for working on electrical installations in accordance with EN 50110-1/BGV A3 must be observed:

- Disconnect the system.
- Protect against reconnection.
- Make sure that the equipment is de-energized.
- Ground and short-circuit.
- Cover or enclose adjacent components that are still live.

Only work on electrical devices when they are de-energized. The protective conductor should be the first thing to be connected and the last to be disconnected.

All PELV circuits must meet the requirements of electrical separation in accordance with EN 61800-5-1.

WARNING

The connection block on the motor for the motor supply cables (power and signal cables) must never be removed.

This could destroy the motor.

The cables for the power connection are brought out at the front of the stator (B side). The open cable ends must be connected in a terminal box, which must be provided by the machine manufacturer. Sufficient installation space must be provided in the axes construction. Standard MOTION–CONNECT cables, which are available with the standard range of accessories for the drive system, can be used from this EMC-compliant terminal box (minimum degree of protection: IP54).

8.2.1 Power connection

Connection assignment

Table 8- 4 Power connection for torque motor

Converter	Torque motor/stator
U2	U
V2	V
W2	W

For information on connecting the power, please also refer to the figures relating to system integration in the section titled "System requirements". The rotor rotates clockwise if the torque motor is connected to phase sequence U, V, W. Also refer to "Direction of rotation" in Chapter "Technical features".

8.2.2 Signal connection

The temperature monitoring circuits must not be connected without a protection module.

⚠ DANGER

Electrical shock hazard!

The circuits of Temp–S and Temp–F do not have safety isolation with respect to the power circuits according to the specifications for safety isolation in compliance with EN 61800-5-1 (previously, safety isolation according to EN 50178 (VDE 0160)).

Connecting the temperature monitoring circuits to the SMC20 Sensor Module does not fulfill the requirements of protective separation to EN 61800-5-1. The temperature monitoring circuits must be connected via the SME12x.

Temperature sensor connection

A connector is used to connect the signal cable to the SME12x (Sensor Module External) whose output is connected to the converter. Refer to the figures relating to system integration in the section titled "System requirements", as well as the connection overview below.

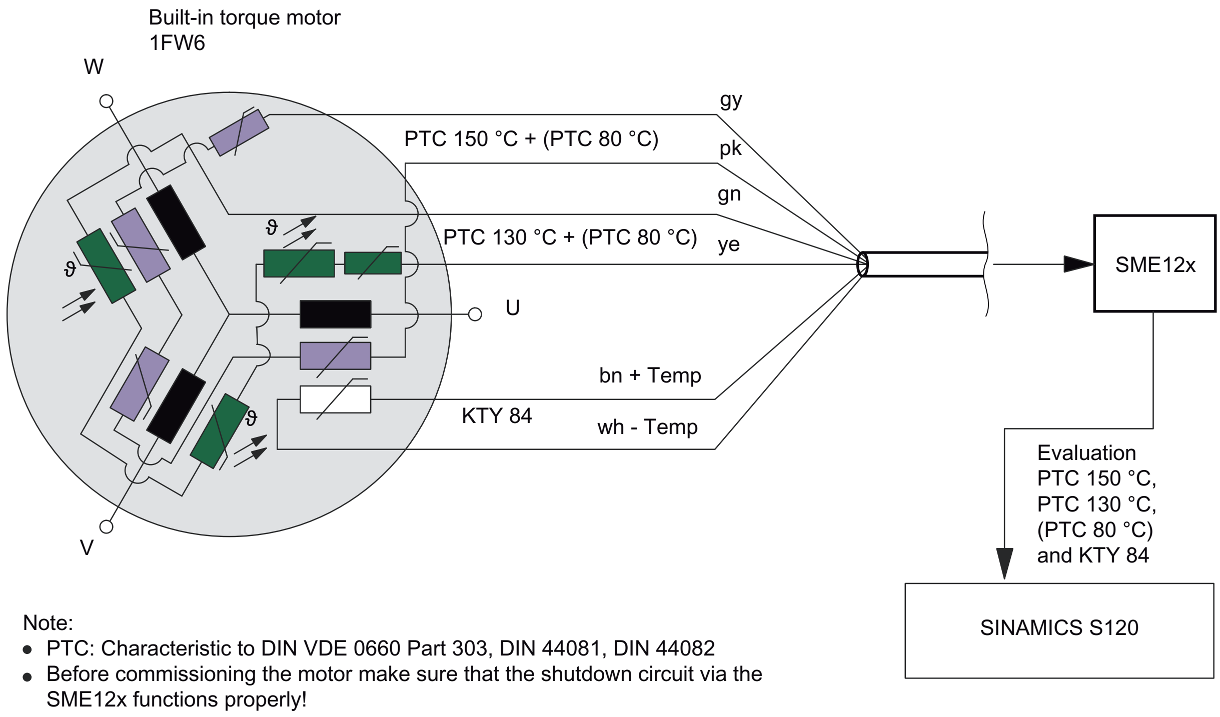


Figure 8-30 Connection overview with SME12x

SME12x

Direct measuring systems outside the cabinet can be connected to the Sensor Module External 12x (SME12x). The SME12x evaluates these measuring systems and converts the calculated values to DRIVE-CLiQ.

For more information about the SME12x, see the Equipment Manual "SINAMICS S120 Control Units and Additional System Components", which can be obtained from your local Siemens office.

8.2.3 Shielding, grounding, and equipotential bonding

Rules

Correct installation and connection of the cable shields and protective conductors is very important, not only for personal safety but also for the effect on emissivity and noise immunity. Therefore, the following must be carefully observed:

- All cable shields must be connected to the respective housing using clamps or suitable terminal or screwed connectors
- Connecting only a few shield conductors or combining shield conductors in one cable is not permitted
- We recommend that the shield connections of the drive system are used to connect the shield of the power cable to the power module.
- Refer to the EMC installation guidelinelines (order number 6FC5297-□AD30-0AP□) issued by the converter manufacturer.

⚠ DANGER

Risk of electric shock!

Open cables lead to voltages due to capacitive coupling.

Open or unused cables, especially electric cables which can be touched, must be insulated. The insulation must be able to withstand the rated voltage.

NOTICE

Unshielded or incorrectly shielded cables can lead to faults in the drive – particularly the encoder – or in external devices.

Note the topics mentioned above!

NOTICE

High leakage currents may damage other devices if the motor PE is not directly connected to the power unit.

Connect the motor PE to the power unit over a large surface area and without taking a circuitous route.

NOTICE
With 1FW6 built-in torque motors featuring single-core power cables without a PE cable, a connection point is provided for the PE. A separate PE cable must be connected to this to ensure a direct connection to the power unit.

8.2.4 Requirements for the motor supply cables

Motor supply cables

The length of the power and signal cables from the motor to the converter must not exceed 50 m.

NOTICE
The permissible acceleration rates of the cables must be carefully taken into consideration. In particular, this applies when the cables are routed via a tow chain. To prevent wear and tear, the cables fixed permanently to the motor should not be routed via a tow chain because they cannot be replaced if they are damaged.

Also refer to integrating into the system. Data for the motor supply cables: see "Overview" and catalog NC 61.

MOTION-CONNECT cables from the terminal box provided by the customer or extensions for the power and signal connection: see catalog NC 61.

Specification of the motor supply cables

The built-in torque motors are shipped with MOTION-CONNECT cables in accordance with catalog NC 61, which contains the technical specifications:

Power cable: MOTION-CONNECT 800, type 6FX8

Signal cable: MOTION-CONNECT 700, type 6FX7

8.3 Cooler connection

Cooler connection for motors with a cooling jacket

The cooler for motors with a cooling jacket is connected via the built-in construction. The cooling water cable cross-sections depend on the cross-sections of the cooling slots in the jacket. These slots are sealed by means of the housing provided by the customer and the O-rings.

In the case a built-in torque motor with a cooling jacket, the coolant must be supplied/discharged via two holes (cut by the user) in the axes construction (see following diagrams). For information on the installation hole fit, refer to the section titled "Installation drawings/Dimension drawings".

To ensure optimized, uniform cooling across all cooling slots, the coolant infeed for torque motors 1FW609 and 1FW613 must be offset by 90° vis-à-vis the cable outlet for the electrical supply. If a different location is selected for the coolant inlet/outlet, the coolant is not distributed evenly in the cooling slots. The least favorable position for the coolant inlet/outlet is at an angle of 90° counter-clockwise because, in this case, the coolant can barely flow through the foremost or rearmost cooling slots.

The coolant infeed must be positioned directly above the exit point of the electrical cable outlets on 1FW615 torque motors.

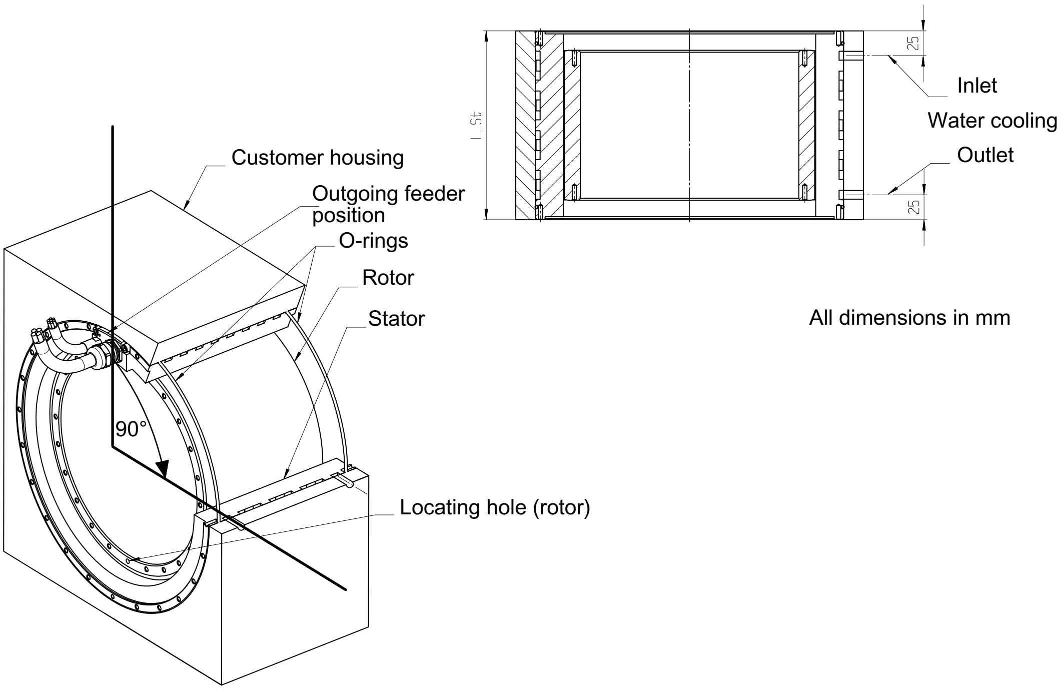


Figure 8-31 Cooler connection for 1FW609 and 1FW613 (example)

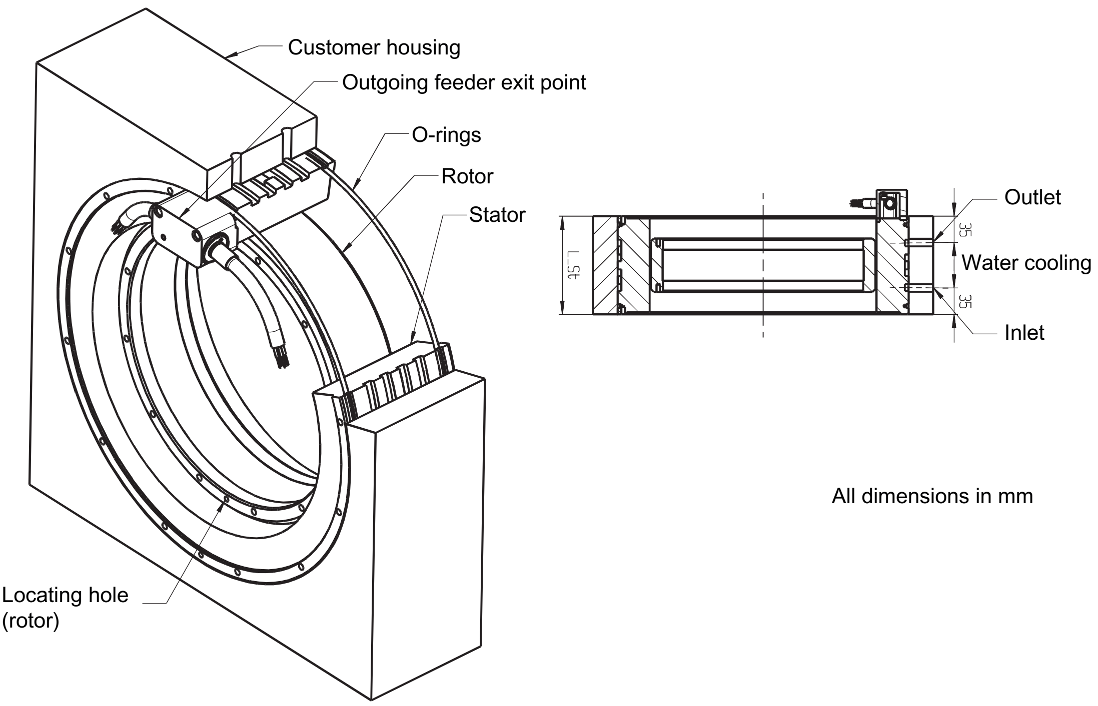


Figure 8-32 Cooler connection for 1FW615 (example)

Cooler connection for motors with integrated cooling

For built-in torque motors with integrated cooling, no alterations need to be made on the machine construction for connecting the cooler. Precision and main coolers can be connected directly via fittings (1/8" pipe thread DIN 2999), whereby each cooling circuit can be supplied and switched separately.

Note

In a series connection, the coolant must flow through the precision cooler first and then the main cooler.

Suitable connectors are required for connecting the hoses. The connectors can generally be installed using standard tools.

A cooling connection adapter is available for connecting precision and main coolers in parallel in a single heat-exchanger unit. This needs to be ordered separately as it is not included in the scope of delivery. To minimize pressure loss, you are advised to connect the precision and main cooler in parallel immediately upstream of the cooler connections.

The cooling connection adapter can be connected via a 1/4" pipe thread (DIN 2999) either axially or radially (outward).

The pressure losses of the individual cooling components and the piping must be checked beforehand and compared with the capacity of the heat-exchanger unit.

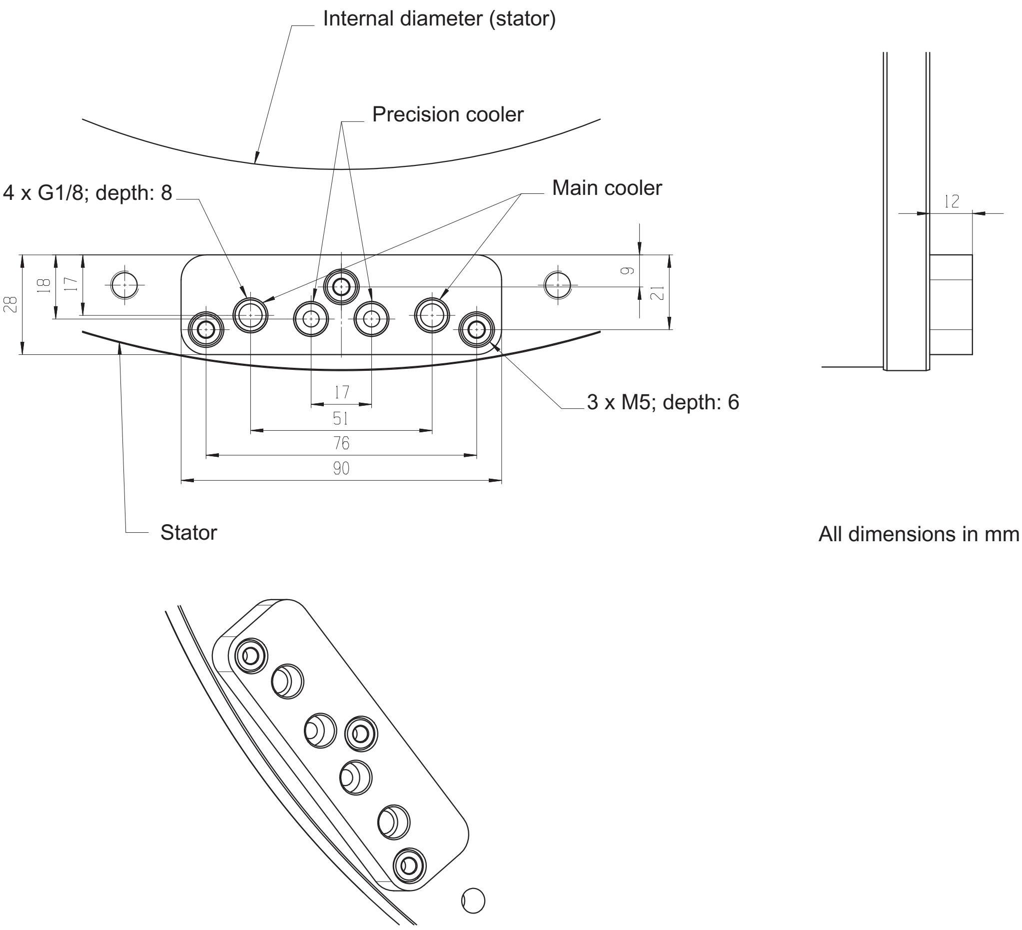


Figure 8-33 Cooling connection plate for 1FW616, 1FW619, and 1FW623

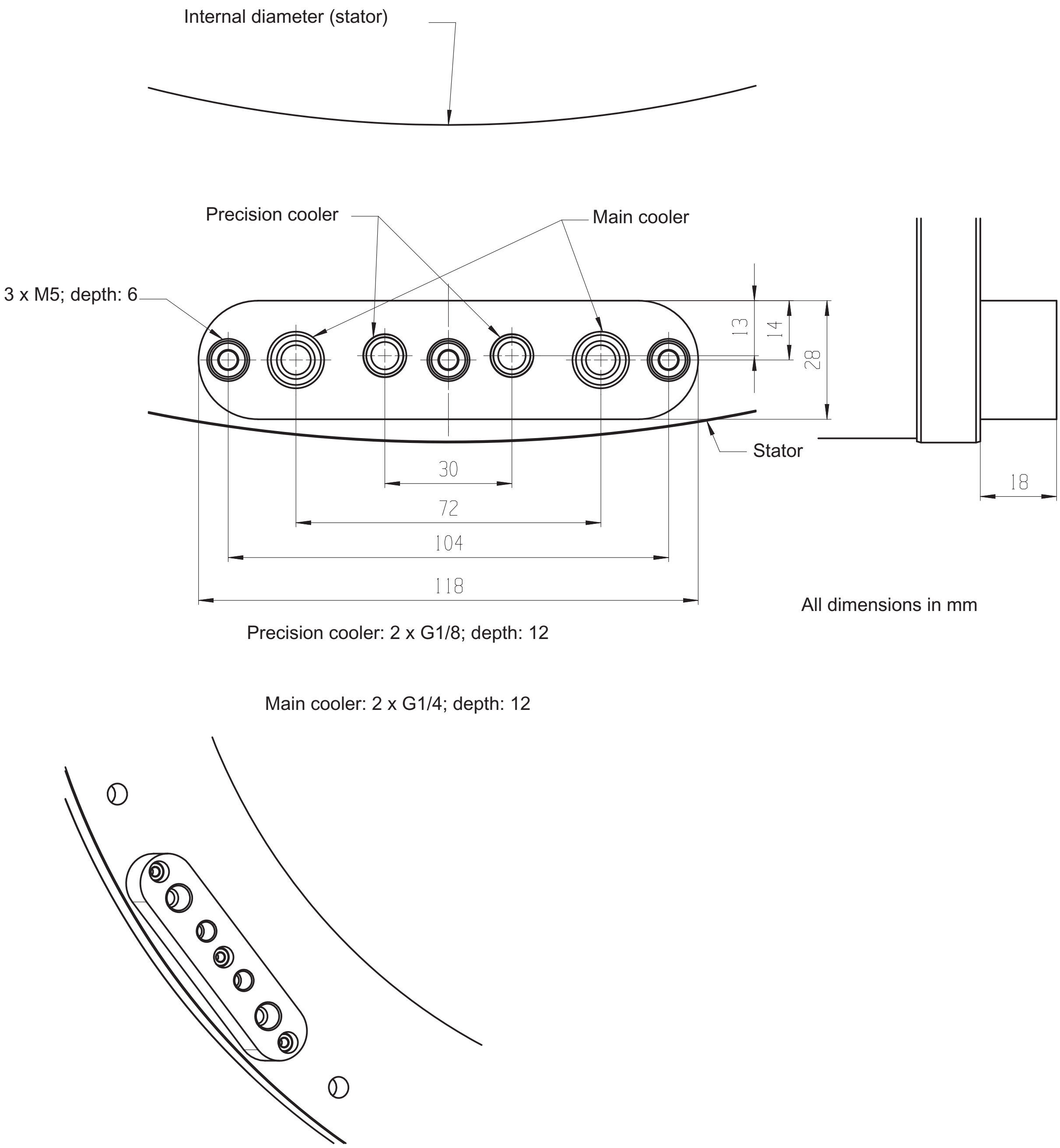


Figure 8-34 Cooling connection plate for 1FW629

⚠ WARNING
The cooling connection plate is permanently mounted. The motor may be destroyed if the cooling connection plate is removed.

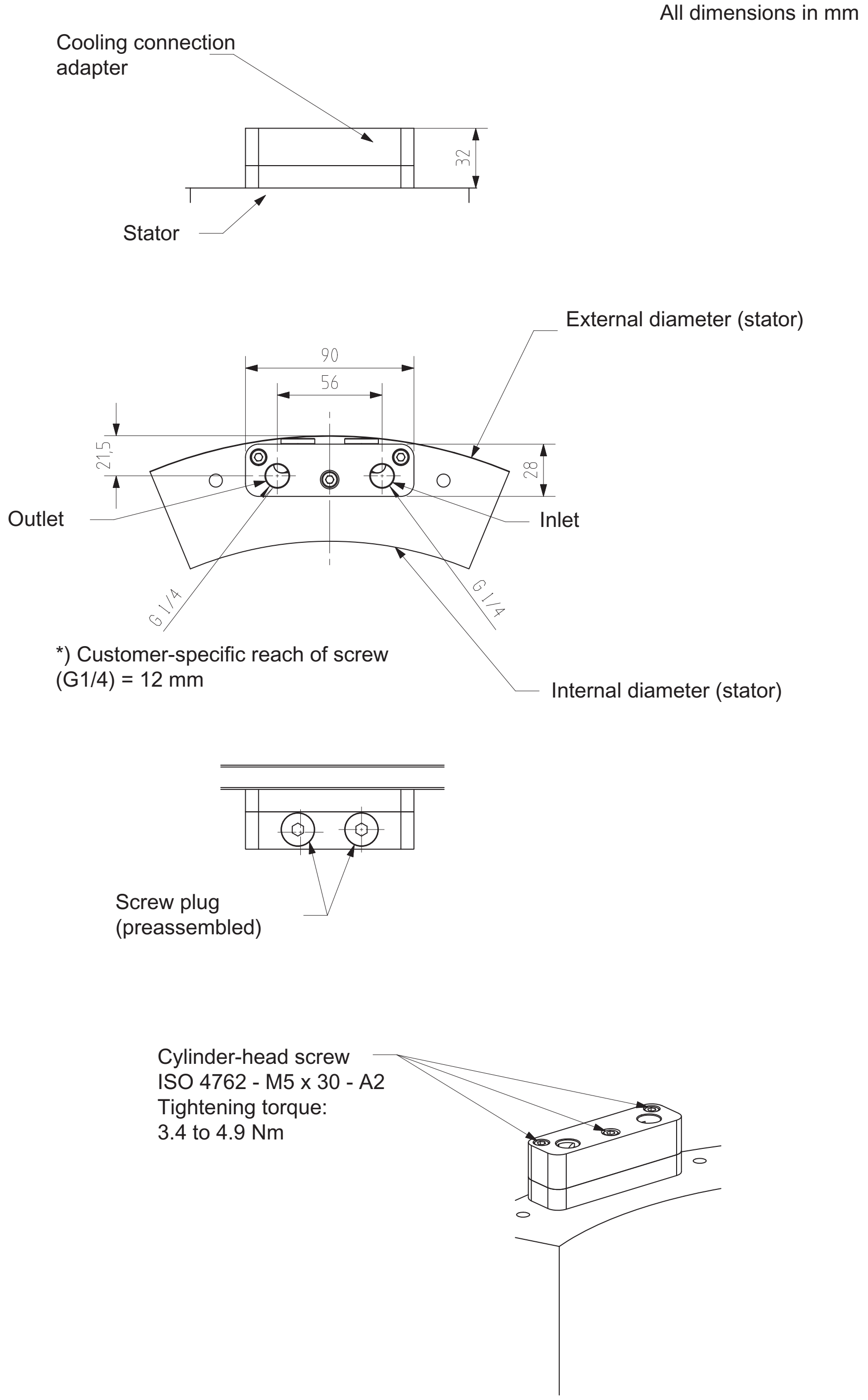


Figure 8-35 Cooler connection (axial) for 1FW616, 1FW619, and 1FW623

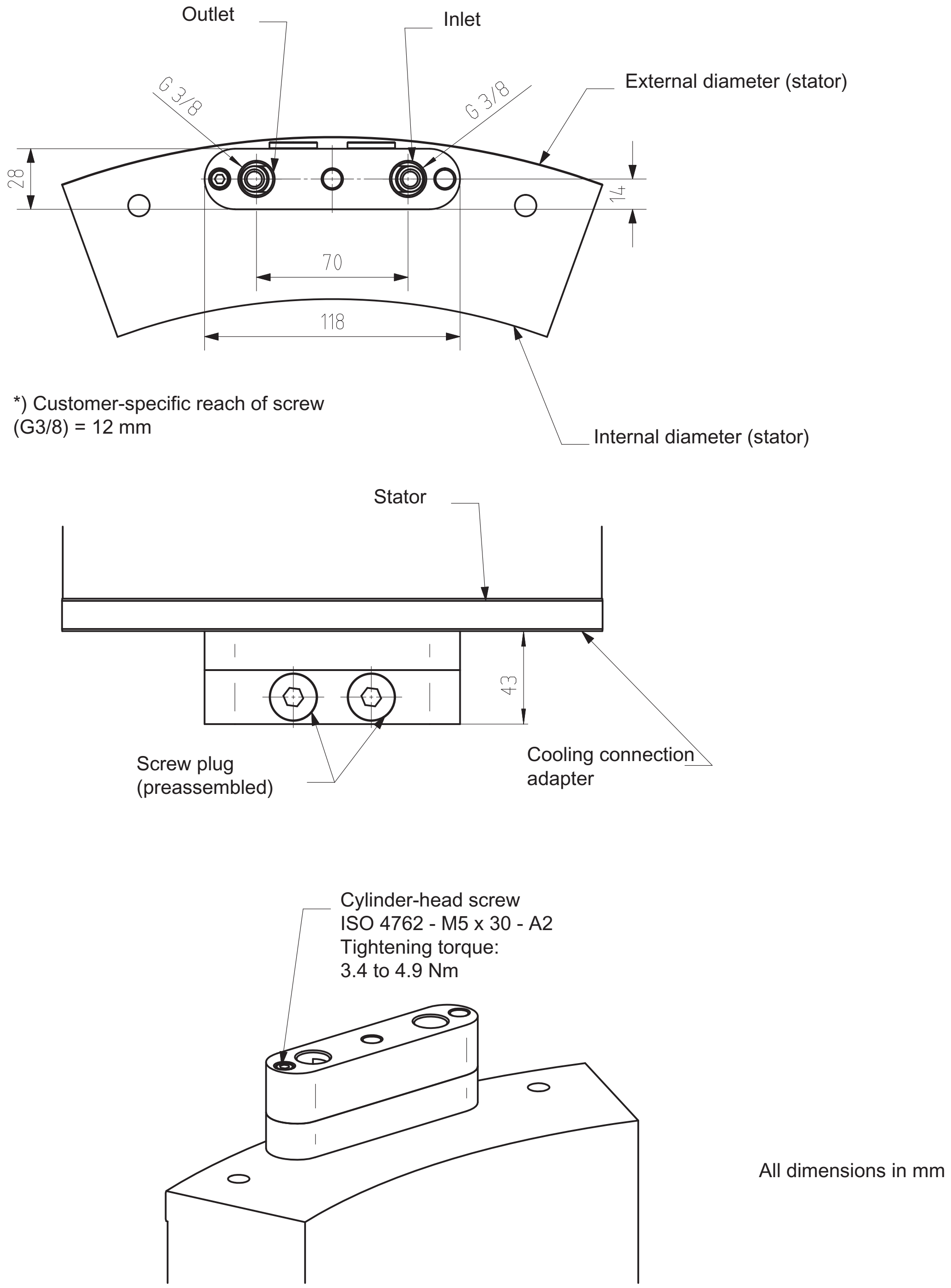


Figure 8-36 Cooler connection (axial) for 1FW629

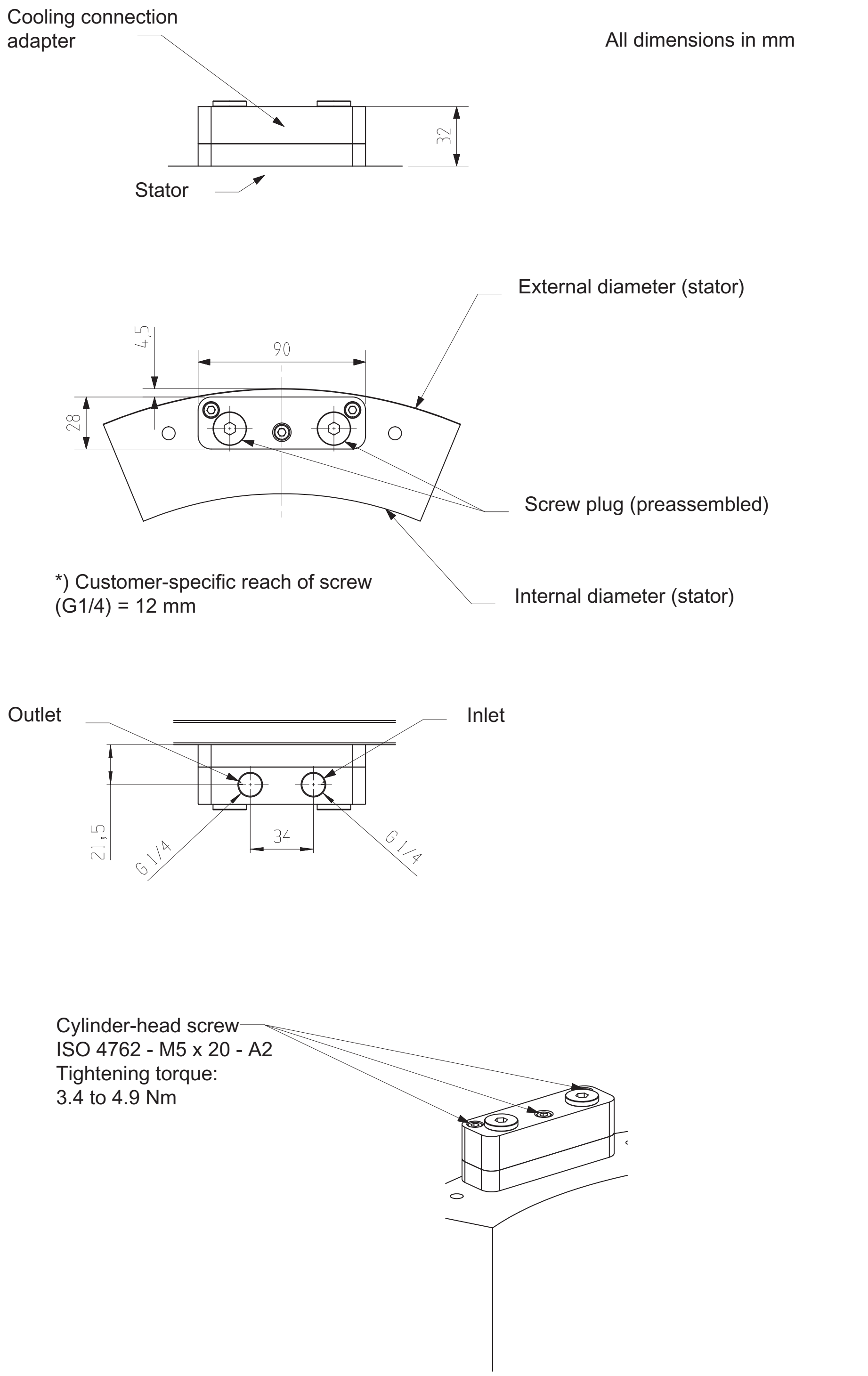


Figure 8-37 Cooler connection (radial, outward) for 1FW616, 1FW619, and 1FW623

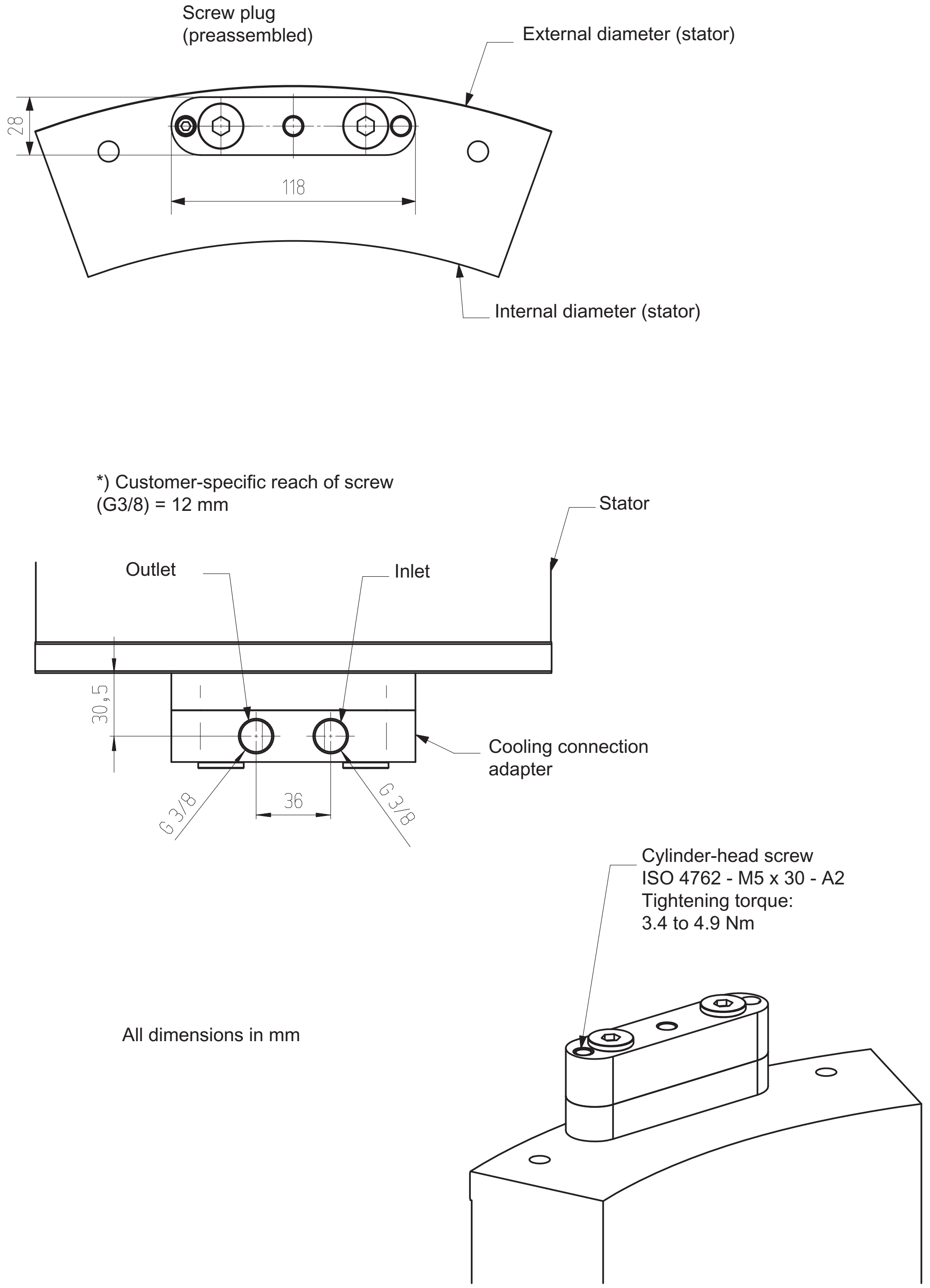


Figure 8-38 Cooler connection (radial, outward) for 1FW629

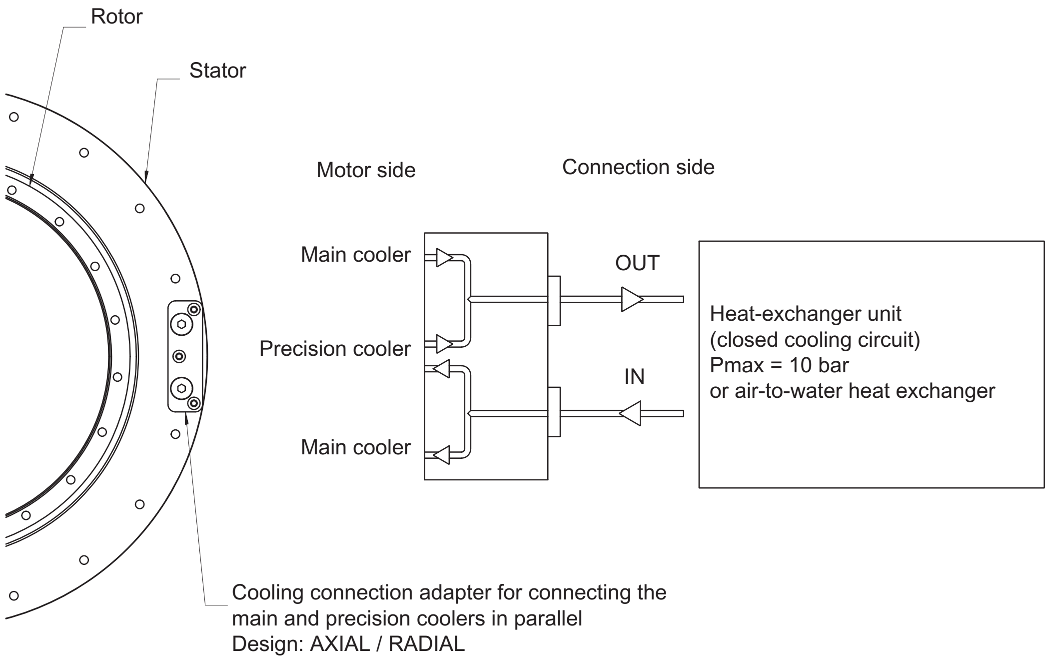


Figure 8-39 Cooling connection adapter for parallel connection of main cooler and precision cooler for 1FW616, 1FW619, 1FW623, and 1FW629

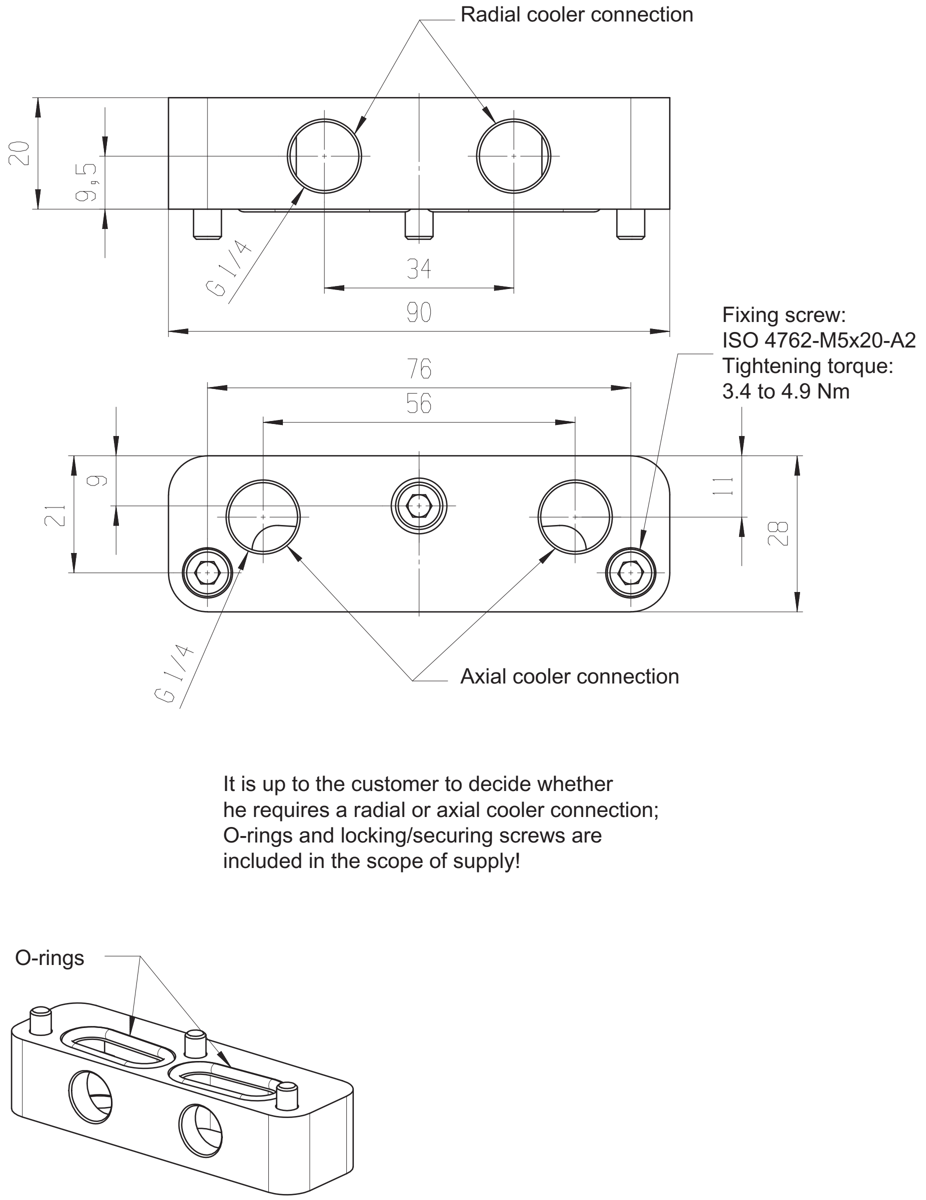
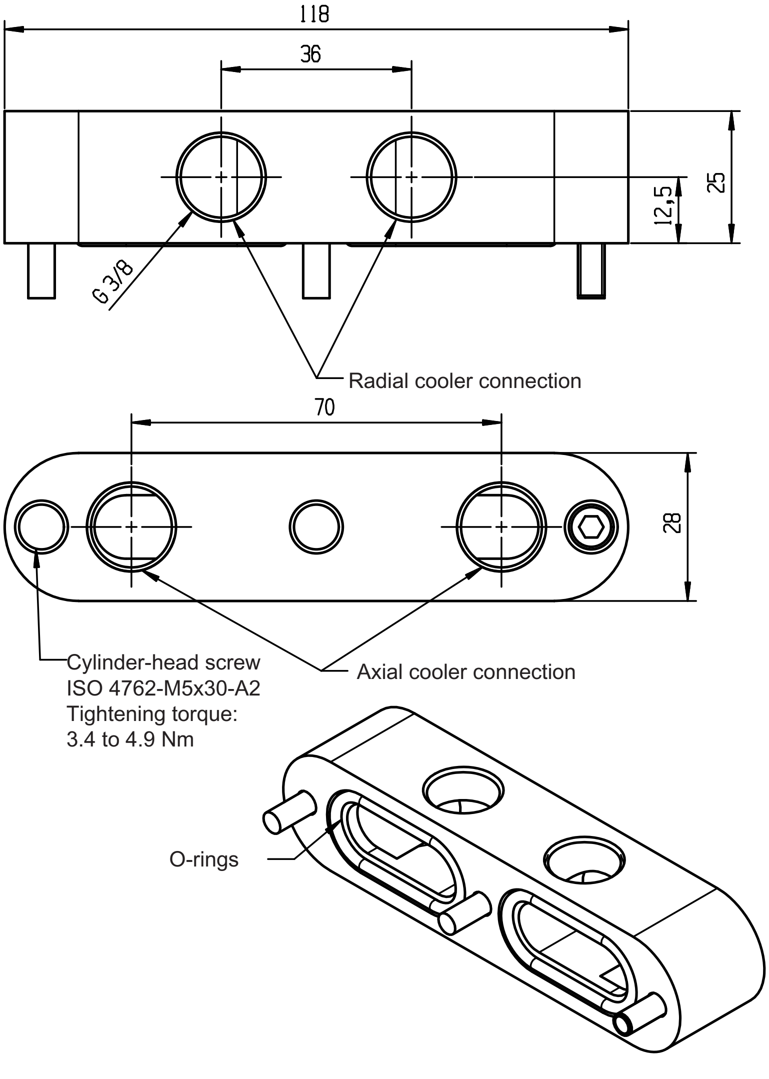


Figure 8-40 Cooling connection adapter 1FW616, 1FW619, 1FW623



It is up to the customer to decide whether he requires a radial or axial cooler connection; O-rings and locking/securing screws are included in the scope of supply!

Figure 8-41 Cooling connection adapter 1FW629

Hoses for the cooling system

The hoses for the cooling system must be highly resistant to the coolant, flexible, and abrasion proof. The hoses for the cooling system should not be chosen until all the materials used in the cooling system and the applicable boundary conditions are known.

When using a cooling connection adapter with motors featuring integrated cooling, overly thin hoses should not be used directly following the cooling connection adapter in order to prevent pressure drops.

For a list of companies and addresses from whom you can obtain connectors and accessories for cooling systems, see the appendix.

NOTICE
We cannot guarantee the composition, nature, state, or quality of non-Siemens products. Read the detailed text in "Manufacturer recommendations" in the appendix.

9 Commissioning

9.1 Safety guidelines for commissioning

> **DANGER**
>
> **Risk of death, serious personal injury, and/or material damage if a machine that does not fulfill the recognized safety requirements is commissioned.**
>
> Plants and machines with converter-fed low-voltage three-phase motors must fulfill the protection requirements of the EMC Directive 2004/108/EC. The plant engineer is responsible for ensuring that installation is carried out in an EMC-compliant manner. The signal and power cables must be shielded. Refer to the EMC installation guideline (order designation 6FC5297-□AD30-0AP□) issued by the converter manufacturer.

> **DANGER**
>
> **Unexpected movements of the motor may result in a risk of death, serious personal, and/or material damage.**
>
> Danger from rotating rotor. Never carry out work in the vicinity of rotating parts when the machine is switched on.
>
> Keep persons away from rotating parts and areas where there is a danger of crushing.
>
> Ensure that the rotors can rotate without hindrance.
>
> Check the commutation setting before switching on the machine. Note also the commissioning instructions issued for the drive system.
>
> Limit the motor currents.
>
> Set low values for speed limiting.
>
> Monitor limit positions.

WARNING

The surface temperature of the motors may be more than 100 °C (212 °F). Risk of burns

Make sure that the cooling system (if available) is working properly.

Do not touch the motor during/directly after use.

Display the "Hot Surface Do Not Touch" (D-W026) warning sign clearly in the vicinity of the motor.

Temperature-sensitive parts (electric cables, electronic components) may not be placed on hot surfaces.

CAUTION

The motor may overheat without temperature protection and be destroyed.

Before(!) switching on for the first time (for testing), check whether the temperature protection is effective!

WARNING

During torque motor operation, the rotor must not exceed a temperature of 120°C otherwise the permanent magnet may become demagnetized.

This must be ensured during initial commissioning by carrying out the appropriate checks.

Special attention should be paid here to non-uniform current loads during standstill or operation with short, cyclic rotation because this can generate extremely high, localized temperatures.

Commutation setting

DANGER

Risk of death, serious personal injury and/or material damage if the safety guidelines and instructions are not observed.

Note the safety information provided in this documentation.

For 1FW6 torque motors, the commutation setting required for synchronous motors can be made via the software-based automatic rotor position identification procedure.

The following two methods can be used for all 1FW6 torque motor sizes:

- Movement-based procedure
- Inductance-based procedure

Motion-based technique

The movement-based procedure of the SINAMICS S120 drive system can be used as of software version 2.4.

This technique can also be used as commissioning support when determining the angular commutation offset for the first time or checking the angular commutation offset, in conjunction with an absolute measuring system (e.g. RCN 727 from Heidenhain).

The procedure can be applied for vertical and horizontal axes whose load cannot be reduced in an uncontrolled manner when the machine is disconnected from the power supply. In this case, the axes must be able to be freely moved and not be braked. (static friction < 10% of the rated motor torque).

In the worst-case scenario, the rotor can move in the range of ± 5 degrees when this procedure is used.

⚠ WARNING
For inclined and horizontal axes, the load may be reduced in an uncontrolled manner if the center of gravity is outside the rotary axes when the system is disconnected from the power supply. At certain times the axes angle cannot be monitored.

Inductance-based technique

The inductance-based technique of the SINAMICS S120 drive system can be used as of software version 2.4.

This technique does not require the rotor to move, which means that it can also be used for axes that are locked (e.g. using a brake). Axes that are not locked can rotate, however. Depending on the actual mechanical design, this technique can result in a higher noise level when the axes is powered up during the identification routine.

Note

The inductance-based technique requires fine synchronization for precise operation; i.e. either a measuring system with zero mark that can be evaluated or an absolute measuring system is required.

Commissioning the cooling circuits

Before the cooling circuits are charged, they must be rinsed with the cooling medium.

NOTICE
The maximum permissible pressure in the cooling circuit (see "Technical features") must not be exceeded.

9.2 Procedure

Checks for commissioning in a current-free state

Cooling circuit

Make sure that the cooling circuit and the coolant meet the requirements outlined in the "Cooling" section of the 1FW6 Configuration Manual (1FW6 CM) for built-in torque motors, and that the cooling circuit is functioning correctly.

Mechanical components

- The axis must be able to rotate freely throughout the entire rotating range.
- In the case of motors connected in parallel, motor installation and the installation positions of the stator and rotor must comply with the installation drawings and specifications in the 1FW6 CM.
- A "vertical axis (large imbalance)" requires a fully functional counterweight (this may or may not be provided).
- If a brake is provided, it must be controlled correctly.
- If there is a limit on the travel range, mechanical limit stops must be present and permanently attached at both ends of the rotating range.
- Moving cables must be correctly laid in a tow chain.

Measuring system

- Incremental measuring system:
  Grid spacing _ _ _ _ _ _ _inc./rotation
  Number of zero marks _ _ _ _ _ _

OR

- Absolute (EnDat) measuring system:
  Grid spacing _ _ _ _ _ _ _ inc./rotation
- Determine positive drive direction of rotation:
  The positive counting direction of the measuring system must be determined.
  It may be necessary to invert the direction of rotation.

Wiring

- The connection to the phase sequence U, V, W (clockwise rotating field) must be correctly configured on the power unit.
- The PE must be connected.
- The shielding must be installed.
- The temperature sensors should be evaluated as outlined in the section titled "Thermal motor protection" in the1FW6 CM. The signal connection is shown in the sections titled "System integration" and "Interfaces".

Measuring system cable

Make sure that the measuring system cable is correctly connected; refer to the section titled "System integration" in the1FW6 CM.

Additional checks to be carried out for commissioning purposes

- Make sure that the temperature sensor evaluation function is working properly.
- Determining the control direction:
  The control direction of an axis is correct if the positive direction of the drive (clockwise rotating field with phase sequence U, V, W) matches the positive counting direction of the measuring system.

  Note

  The data used to determine the drive direction is only valid for 1FW6 motors.

  If the positive direction of the drive and positive counting direction of the measuring system *do not match*, the actual speed value must be inverted when carrying out commissioning using the software.

  The control sense can also be checked by first parameterizing the drive and then manually moving it, with the enable signals inhibited.

  If the axis rotates in the positive direction, the actual speed value must also count in the positive direction.

- Determining the drive direction:
  For the defined direction of rotation of the 1FW6 motor, refer to the section titled "Technical features" in the 1FW6 CM. The direction of the 1FW6 motor is positive if the rotor is rotating clockwise when you look in the direction of the arrow.
- Determining the counting direction of the measuring system:
  The counting direction of the measuring system can be determined by means of manual motion (with enable signals inhibited). In doing this you must observe any inversion parameters that have been set.

Entering the motor data

Select the MLFB of the motor you are using from the commissioning tool list. The motor data will be accepted automatically. Data for motors that are not in the list must be entered manually. For Siemens motors, you can request a data sheet containing converter set values from your relevant Siemens office.

Operation 10

10.1 Safety guidelines for operation

⚠ DANGER
Due to the high speeds and acceleration as well as the friction and self-locking, machine parts that are driven with torque motors pose a considerable risk of injury (e.g crushing).
Keep persons away from moving parts and areas where there is a danger of crushing.

⚠ WARNING
Improper operation can lead to serious material damage.
Operation is allowed only in locations with full weather protection: The environment must be dry and protected against heat and cold.
Keep the motor compartment free from foreign bodies (chips, particles, liquids, oils, screws, tools, etc.).
Make sure that the cooling system for the torque motor functions properly.

10.2 Dealing with faults

Listen for noise. If you hear anything unusual, contact your local Siemens office.

If you experience any problems regarding accuracy with the workpiece, make sure that the rotor can move without hindrance and check the current consumption of the motor. Problems with accuracy may also have other causes (e.g. machine design).

11 Maintenance and repairs

11.1 Safety information for maintenance and repairs

⚠ DANGER

Risk of death, serious personal injury and/or material damage if maintenance and repair work is carried out by inexperienced personnel.

Make sure that maintenance personnel possess the knowledge, ability, and experience required to carry out their work safely.

All repairs to the motor must be carried out at one of the Siemens service centers. For addresses of Siemens service centers, see:

http://www.automation.siemens.com/partner/index.asp.

⚠ DANGER

Risk of death, serious personal injury and/or material damage if work is carried out when the machine is switched on. Before carrying out work in the vicinity of rotating parts, switch off the machine (disconnect it from the power supply).

Before carrying out work in the vicinity of rotating parts, disconnect the machine from the power supply to prevent accidental rotation.

⚠ DANGER

If work is carried out on the motor immediately after it has been in operation, there is a risk of burns if you come into contact with hot surfaces. The cooling water temperature can also increase after the motor has already been switched off.

To cool the motor down to the level of the inlet temperature T_{VORL}, the cooler must remain in operation for at least 30 minutes after the motor has been switched off. If the cooler is switched off, however, it takes significantly longer for the motor to cool down. This depends to a large extent on the installation situation.

DANGER

Risk of burns

Risk of pressure surges: Do not switch the cooler on if the motor was operated without a cooler beforehand. The major build-up of steam can cause burns or destroy the motor.

When you open the cooling circuit, you risk burning yourself when the hot cooling water and steam escapes. If the motor is operated with the cooler, the cooling water in the cooling system heats up.

Do not open the motor cooling circuit until the motor has cooled down.

DANGER

Risk of death, serious personal injury and/or material damage during dismantling work.

When dismantling the motor, refer to the notes provided in "Procedure for installing the motor".

WARNING

Sharp edges can cause cuts and falling objects can injure feet.

Always wear work gloves and safety shoes.

11.2 Safety guidelines for high-voltage test

Guidelines for inspecting the insulation resistance (high-voltage test)

WARNING
An insulation resistance inspection under high-voltage conditions can damage the motor insulation!
If insulation resistance inspections need to be carried out on a machine/plant with direct drives or directly on the motors (e.g. installation inspection, preventative maintenance, troubleshooting), only inspection devices that comply with EN 61557-1, EN 61557-2, and EN 61010-1 (or the relevant IEC standards) can be used.
The inspection may only be carried out with a maximum direct voltage of 1000 V for a maximum time of 60 s! The test voltage should be measured with respect to ground or the motor enclosure. If a higher DC or AC voltage is necessary for the purposes of inspecting the machine/system, you must arrange the inspection with your local Siemens office.
Please follow the operating instructions for the test device!

Inspections of the insulation resistance on individual motors must always be carried out as follows:

1. Connect all winding and temperature sensor connectors with each other; inspection voltage not to exceed 1000 VDC, 60 s against PE connection.
2. Connect all temperature sensor connectors to the PE connector and all winding connectors with each other; the inspection voltage must not exceed 1000 VDC, 60 s, winding against PE connector.

Each insulation resistance must be at least 10 MΩ, otherwise the motor insulation is defective.

11.3 Maintenance

Performing maintenance work on the motor

WARNING
Note the safety information provided in this documentation.

Due to their principle of operation, torque motors are free of wear. To ensure that the motor functions properly and remains free of wear, the following maintenance work needs to be carried out:

- Regularly check that the rotary axes can move without hindrance.
- Keep the air gap free of chippings and particles.
- Regularly check the condition of the motor components.
- Check the current consumption in the test cycle defined beforehand.

Ensure that the motor compartment remains free of contamination (e.g. chippings, oil, etc.). Depending on the local level of contamination, clean the machine to ensure that it functions properly and that heat loss is properly dissipated.

Check the cables to ensure that they are not damaged and are free of wear and tear. Do not use electrical devices with damaged cables.

Make sure that the cable glands are secure.

Intervals between maintenance

Since operating conditions differ greatly, it is not possible to specify intervals between maintenance work.

Indications that maintenance work is required

- Dirt in the motor cabinet
- Distinctive changes in the behavior of the machine
- Unusual sounds emitted by the machine
- Problems with positioning accuracy
- Higher current consumption

11.4 Test and replacement intervals of the cooling medium

Test and replacement intervals of the cooling medium

The test and replacement intervals for the cooling medium should be agreed with the manufacturers of the anti-corrosion agent and the cooling system.

Storage and transport 12

12.1 Packaging, storage, and transport guidelines

When packing/unpacking and transporting torque motors or rotors, take measures to minimize risks posed by strong magnetic fields from the rotors (see also "Danger from strong magnetic fields").

> **DANGER**
>
> **Risk of death, injury and/or material damage if the devices are packed, stored, or transported incorrectly.**
>
> Personnel must be familiar with and observe the safety precautions regarding storage and transport.
>
> When transporting machines or machine parts, take measures to ensure that the rotary axes (axes) cannot move unintentionally (no self-locking).
>
> Hazards during lifting and transport!
>
> Devices and tools that are badly designed, unsuitable, or damaged can result in personal injury and/or material damage.
>
> Lifting devices, industrial trucks, and load bearing equipment must comply with requirements.
>
> IATA regulations must be observed when components are transported by air.
>
> Storage areas for rotors must be specially identified with pictograms (see "Attaching warning and prohibiting signs").
>
> Keep storage areas dry and ensure that they are not subject to heat or cold.
>
> Note the warnings on the packaging.
>
> Wear safety shoes and work gloves.
>
> Take into account the maximum loads that personnel can lift and carry. The motors and their components can weigh more than 13 kg.
>
> Never store or transport built-in torque motors or rotors when they are unpacked.
>
> Only use undamaged original packaging.
>
> Damaged packaging must be replaced immediately. If rotors are not packaged properly, they are not sufficiently protected against the sudden attractive forces that can occur in their immediate vicinity. Dangerous movements of the rotor can also occur when it is stored or shifted.

Note

If possible, make sure that you retain the packaging for torque motors and rotors. Original packaging can also be requested from your local Siemens office.

DANGER

Danger of tilting Motors, stators, and rotors must not be stacked too high – risk of death, personal injury and/or material damage.

Motors, stators, and rotors must not be stacked excessively (packed or unpacked).

Motors and rotors must only be stored and transported horizontally.

Read the warnings and handling instructions on the packaging.

12.2 Safety note regarding lifting devices

WARNING

Improper use of lifting devices can cause plastic deformation of the motor.

To lift the motor (or stator/rotor), at least three lifting eyebolts are required. These must be screwed into the tapped holes on the flat motor (or stator/rotor) so that they are symmetrical with each other.

Motors (or stators/rotors) must only be lifted horizontally. The lifting ropes must be the same length. The tightened lifting ropes must form an angle of at least 50° between the lifting rope and motor (or stator/rotor).

13 Environmental compatibility

13.1 Environmental compatibility during production

- There is no need to transport hazardous materials.
- The packaging material is made primarily from cardboard.
- Energy consumption during production was optimized.
- Production has low emission levels.

13.2 Disposal

The product must be disposed of in the normal recycling process in compliance with national and local regulations.

13.2.1 Guidelines for disposal

⚠ DANGER

Death, serious bodily injury and/or property damage may result from improper disposal of direct drives or their components (especially components with permanent magnets).

Direct drives or their components must be disposed of properly.

Main constituents of a proper disposal procedure

- Complete demagnetization of the components that contain permanent magnets
- Components that are to be recycled should be separated into:
  - Electronics scrap (e.g. encoder electronics, sensor modules)
  - Electrical scrap (e.g. laminated cores, motor windings, cables)
  - Iron to be recycled
  - Aluminum
  - Insulating materials
- No mixing with solvents, cold cleaning agents, or remains of paint, for example

13.2.2 Disposing of 1FW6 rotors

Disposing of and demagnetizing 1FW6 rotors

The magnetized rotors must be subject to a special thermal disposal procedure so that they do not pose any risk during or after disposal. For this reason, they must be disposed of by a specialist disposal company.

Once the motor has been dismantled, the rotors must be packaged individually in the undamaged original packaging in accordance with the relevant guidelines.

⚠ DANGER

Due to the strong magnetic fields, unpacked rotors can cause personal and/or material damage.

Read the safety information provided in this documentation.

Demagnetizing the rotors

Disposal companies who specialize in demagnetization use special disposal furnaces. The interior of the disposal furnace is made of non-magnetic material.

The secondary sections are placed inside a solid, heat-resistant container (such as a skeleton container), which is made of non-magnetic material and left in the furnace during the entire demagnetization procedure. The temperature in the furnace must be at least 300°C over a holding time of at least 30 minutes.

Escaping gases must be collected and decontaminated without damaging the environment.

13.2.3 Disposal of packaging

The packaging and packing aids we use contain no problematic materials. With the exception of wooden materials, they can all be recycled and should always be disposed of for reuse. Wooden materials should be burned.

Only recyclable plastics are used as packing aids:

- Code 02 PE-HD (polyethylene)
- Code 04 PE-LD (polyethylene)
- Code 05 PP (polypropylene)
- Code 04 PS (polystyrene)

14 Technical data and characteristics

The technical data and characteristics for the 1FW6 Built-in torque motors are specified in this Chapter. This data collection provides the motor data required for configuration and contains a number of additional data for more detailed calculations for detailed analyses and problem analyses. Technical data subject to change.

Note

System-specific data refer to the combination of built-in torque motors 1FW6 with SINAMICS S120 drive systems.

Unless otherwise specified, the following boundary conditions apply here:

- The DC link voltage U_{ZK} is 600 V, while the converter output voltage U_{amax} is 425 V.
- The motor is water-cooled with the recommended minimum flow rate according to the data sheet and a water intake temperature T_{VORL} of 35 °C
- The rated temperature of the motor winding T_N is 130 °C
- Voltages and currents are specified as rms values.
- Installation altitude of the motors up to 4000 m above sea level.
- For motors with integrated cooling, the performance data has been determined with the use of a cooling connection adapter.

14.1 Explanations of the formula abbreviations

Content of the data sheet

The data specified on the data sheets is explained in the following section. It is categorized as follows:

- Boundary conditions
- Rated data
- Limit data
- Physical constants
- Data for the motor cooler

Boundary conditions

U_{ZK}	Converter DC link voltage (direct voltage value). Comment: For converter output voltages U_{amax}: see "System requirements".
T_{VORL}	Maximum intake temperature of the water cooler for the main cooler and precision cooler if the motor is to be utilized up to its rated torque M_N. For details of the dependency of the continuous motor current on intake temperature of the water cooler, see the characteristic curve in "Cooling".
T_N	Rated temperature of the motor winding.

Rated data

M_N	Rated torque of the motor.
I_N	Rated motor current at the rated torque M_N
$n_{MAX,MN}$	Maximum speed up to which the motor can deliver the rated torque M_N.
$P_{V,N}$	Power loss of the motor at the rated point (M_N,$n_{MAX,MN}$) at the rated temperature T_N.

Limit data

M_{MAX}	Maximum motor torque.
I_{MAX}	Maximum motor current at maximum torque M_{MAX}. Maximum possible load duration: see "Short-time duty S2".
$P_{EL,MAX}$	Electric power input of the motor at point (M_{MAX},$n_{MAX,MMAX}$) at rated temperature T_N.

Note

The sum of the mechanical output P_{mech} and the power loss P_V equals the electric power input of the motor P_{EL}.

See also "Calculating the required infeed power".

The electrical rated power of the motor at the rated point with $M = M_N$ and $n = n_{MAX,MN}$ can be calculated as follows:

$P_{EL,N} = P_{mech,N} + P_{V,N} = 2\pi \cdot M_N \cdot n_{MAX,MN} + 3 \cdot R_{130} \cdot I_0^2$

Frictional and eddy current losses are taken into account by using the larger current I_0 in the calculation instead of I_N.

$n_{MAX,MMAX}$	Maximum speed up to which the motor can deliver the maximum torque M_{MAX}.
$n_{MAX,0}$	No-load speed; max. speed without load.
M_0	Torque for speed n = 1 [rpm] at which the load and power loss are still evenly distributed across all three motor lines.
I_0	Current (rms value) of the motor at torque M_0 and speed n = 1 [rpm].
M_0*	Thermal static torque when the current is unevenly distributed across the three motor lines. An uneven current load occurs in the following operating modes: • Standstill • Operation with short cyclic rotations (< 1 pole pitch) • For n << 1 [rpm] Since the saturation effect can be disregarded for the rated current, the following applies (approximately): $M_0^* \approx 1/\sqrt{2} \cdot M_0$
I_0*	Thermal stall current (rms value) of the motor at M_0^*. The following applies: $I_0^* \approx 1/\sqrt{2} \cdot I_0$

Physical constants

$k_{T,20}$	Motor torque constants at a rotor temperature of 20 °C (refers to the lower linear range of the torque–current characteristic).
k_E	Voltage constants for calculating the mutually induced line-to-line voltage.
$k_{M,20}$	Motor constant at a winding temperature of T = 20 °C. The motor constant $k_M(T)$ may be calculated for other temperatures: $k_M(T) = k_{M,20} \cdot [1 + \alpha(T - 20\ °C)]$ with temperature coefficient $\alpha = -0.001$ 1/K for magnets $k_M(T) = k_{M,20} \cdot [1 - 0.001 \cdot (T - 20\ °C)]$
t_{TH}	Thermal time constant of the motor winding. This is derived from the temperature characteristic in the winding with a sudden load and constant current. See diagram below. When the time t_{TH} has elapsed, the motor winding reaches approximately 63% of its final temperature T_{GRENZ} if thermal protection was not active prior to this.

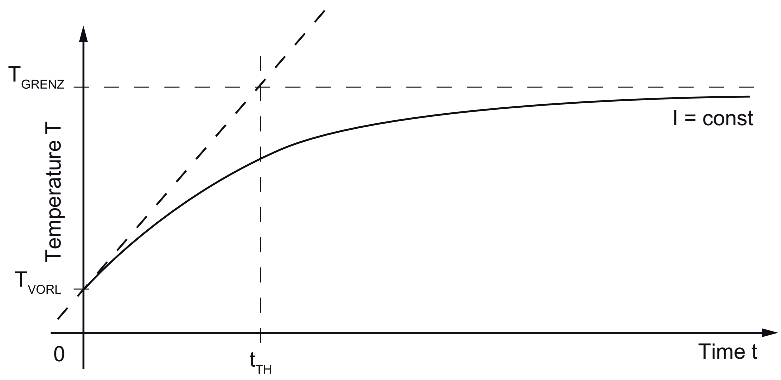


Figure 14-1 Thermal time constant

P	Number of pole pairs of the motor.
M_{COG}	Cogging torque. This is the torque generated by the interaction between the laminated core and permanent magnets at the air gap in stators that have been disconnected from the power supply.
m_s	Mass of the stator without fixing screws, connectors, connection cables, and coolant.
m_L	Mass of the rotor without fixing screws.
J_L	Rotor moment of inertia
$R_{STR,20}$	Phase resistance of the winding at a winding temperature of 20 °C. The value of the phase resistance is required for calculating the power loss, among other things. You can convert R_{20} to other phase resistances using the following formula: $R_{STR}(T) = R_{STR,20} \bullet [1 + \alpha(T - 20°C)]$ with temperature coefficient α = 0.00393 • 1/K for copper. For $R_{STR,130}$, the following applies: $R_{STR,130} = R_{STR,20} \bullet 1.4323$.
L_{STR}	Phase inductance of the stator winding with integrated fan.

Data, main motor cooler

$Q_{H,MAX}$ Maximum heat loss dissipated via the main cooler when the motor is utilized up to the rated torque M_N and at the rated temperature T_N.

$\dot{V}_{H,MIN}$ Recommended minimum volume flow rate in the main cooler to achieve the rated torque M_N.

ΔT_H The temperature increase of the coolant between the inlet and return flow circuit of the main cooler at operating point $Q_{H,MAX}$ and $\dot{V}_{H,MIN}$ can be estimated using the following formula:

$$\Delta T_H = \frac{Q_{H,MAX}}{\rho \cdot c_p \cdot \dot{V}_{H,MIN}}$$

Average water density: $\rho = 1000$ kg/m³
Average specific thermal capacity of water: $c_p = 4.18 \cdot 10^3$ J/(kg K)
Temperature deviation from intake temperature: ΔT_H in K
Volume flow: in m³/s

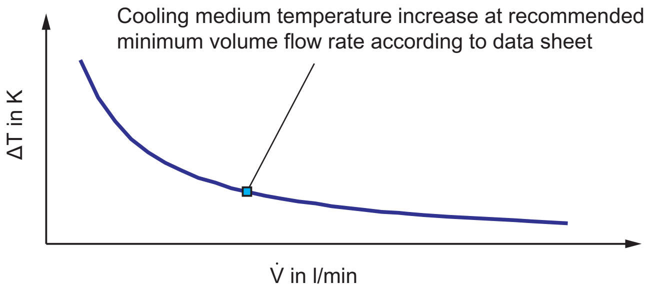


Figure 14-2 Sample characteristic "Temperature increase of the coolant between the inlet and return flow circuit of the main cooler"

Δp_H Coolant pressure drop between the inlet and return flow circuit of the main cooler with volume flow $\dot{V}_{H,MIN}$.
The main and precision coolers for motors with integrated cooling are connected in parallel. The volume flow rates of the main and precision coolers are combined to create the total volume flow rate; the pressure drop in the main cooler Δp_H is the same as that in the precision cooler Δp_P.

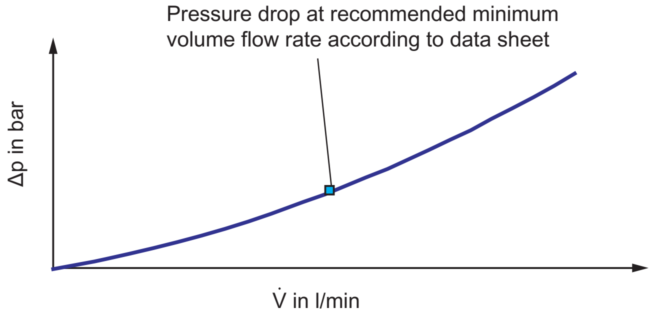


Figure 14-3 Sample characteristic: "Pressure losses in the main cooler over volume flow rate"

Data, precision motor cooler

$Q_{P,MAX}$ Maximum heat loss dissipated via the precision cooler when the motor is utilized up to the rated torque M_N and at the rated temperature T_N.

$\dot{V}_{P,MIN}$ Recommended minimum volume flow rate in the precision cooler to achieve a minimum temperature increase on the mounting surface of the stator vis-à-vis T_{VORL}.

ΔT_p The temperature increase of the coolant between the intake and return flow circuit of the precision cooler at operating point $Q_{P,MAX}$ and $\dot{V}_{P,MIN}$ can be estimated using the following formula:

$$\Delta T_P = \frac{Q_{P,MAX}}{\rho \cdot c_p \cdot \dot{V}_{P,MIN}}$$

Average water density: $\rho = 1000\ kg/m^3$
Average specific thermal capacity of water: $c_p = 4.18 \cdot 10^3\ J/(kg\ K)$
Temperature deviation from intake temperature: ΔT_P in K
Volume flow: in m^3/s

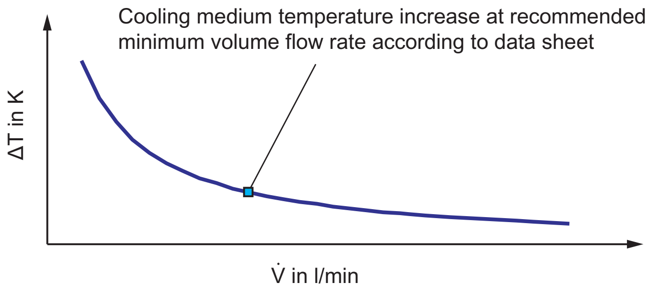


Figure 14-4 Sample characteristic "Temperature increase of the coolant between the inlet and return flow circuit of the precision cooler"

Speed-torque diagram

The circle on the torque axes shown in the following diagram represents M^*_0.

The motors described are multi-pin and have a sufficiently large thermal time constant. This means that the torque M_0 can be generated even at very low speeds.

The torque-speed diagrams for the motors can be found in "Technical data and characteristics".

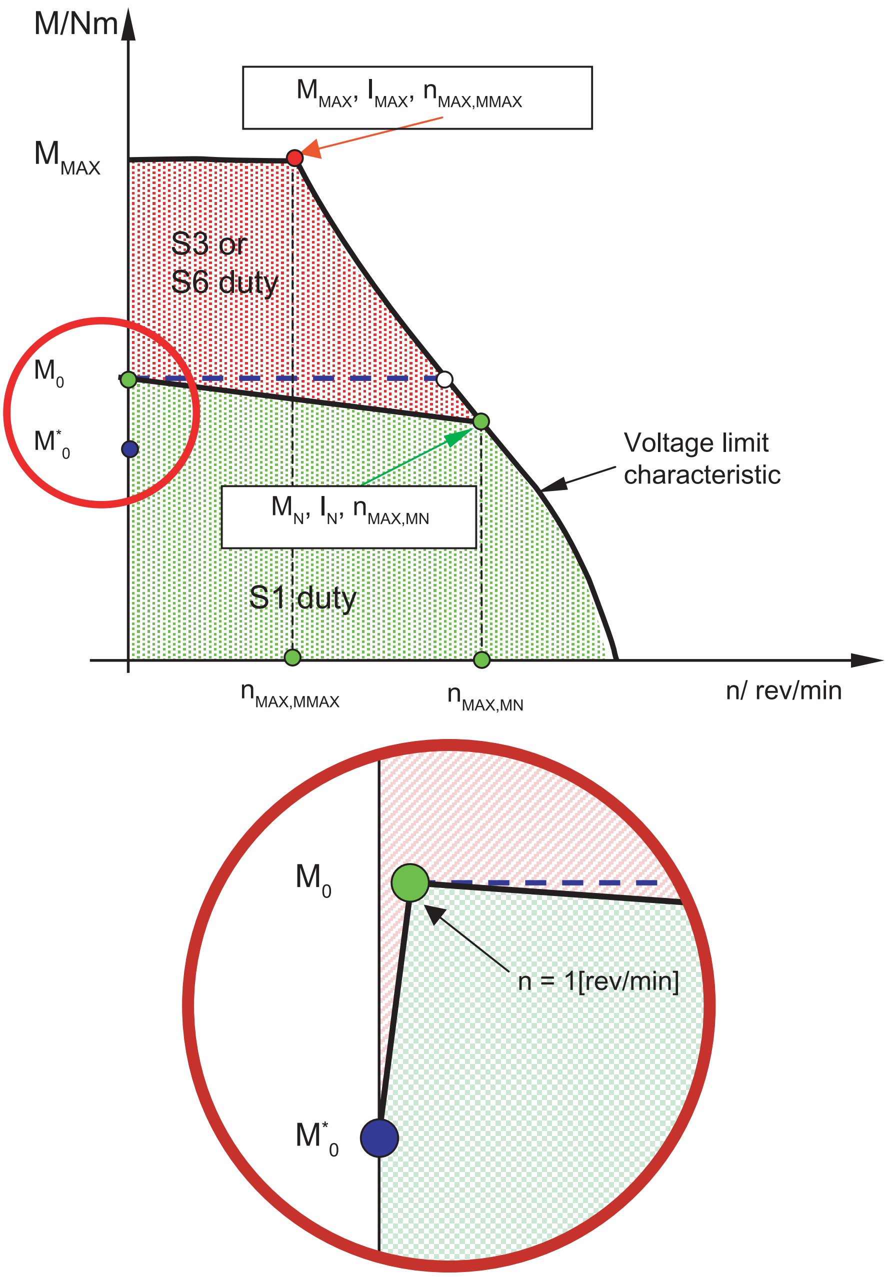


Figure 14-5 Description of a torque–speed diagram (example)

14.2 Data sheets and diagrams

14.2.1 1FW6090-xxxxx-xxxx

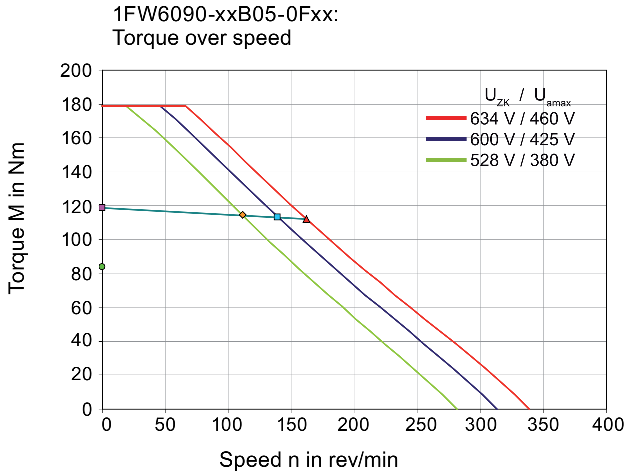
Data sheet 1FW6090-xxB05-xxxx

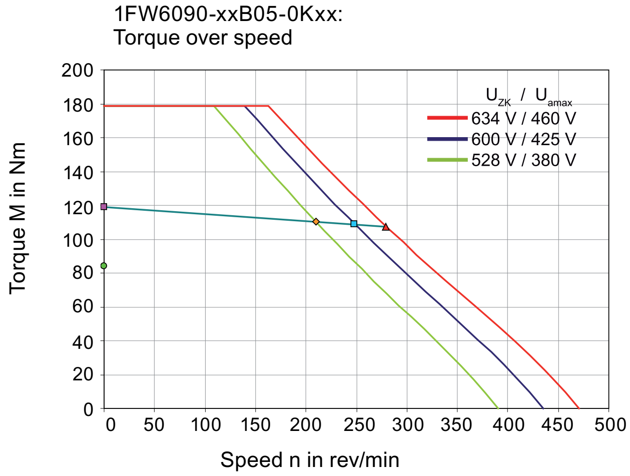
Table 14- 1 1FW6090-xxB05-0Fxx, 1FW6090-xxB05-0Kxx

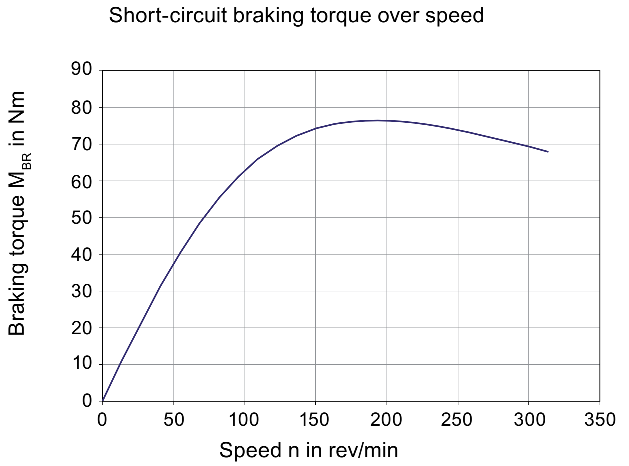
Technical data 1FW6090	Symbol	Unit	-xxB05-0Fxx	-xxB05-0Kxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling intake temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	113	109
Rated current	I_N	A	5.6	7.4
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	140	250
Rated power loss	$P_{V,N}$	kW	2.19	2.12
Limit data				
Maximum torque	M_{MAX}	Nm	179	179
Maximum current	I_{MAX}	A	9.5	13
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	6.55	8.12
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	46	140
No-load speed	$n_{MAX,0}$	rpm	310	430
Torque at n = 1 [rpm]	M_0	Nm	119	119
Current at M_0 and n = 1 [rpm]	I_0	A	5.9	8.2
Thermal static torque	M_0*	Nm	84.1	84.1
Thermal stall current	I_0*	A	4.1	5.6
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	20.8	15
Voltage constant	k_E	V/(1000/min)	1258	906.2
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	2.64	2.68
Thermal time constant	t_{TH}	s	60	60
No. of pole pairs	p	-	22	22
Cogging torque	M_{COG}	Nm	1.2	1.2
Stator mass	m_S	kg	6.6	6.6
Rotor mass	m_L	kg	2.6	2.6
Rotor moment of inertia	J_L	10^{-2} kgm^2	1.52	1.52
Phase resistance of winding at 20 °C	$R_{STR,\ 20}$	Ω	14.9	7.5
Phase inductance of winding	L_{STR}	mH	47.1	24.4

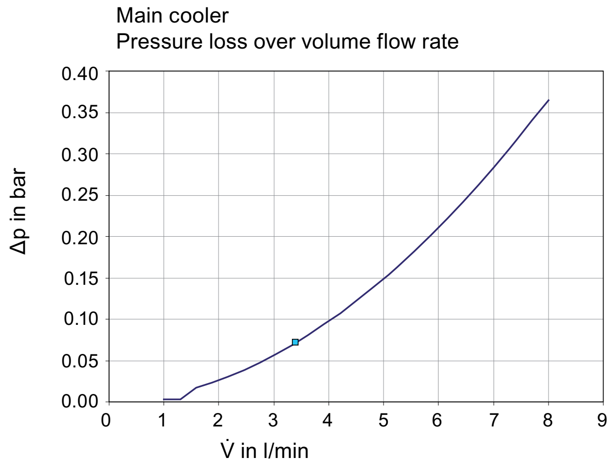
Technical data 1FW6090	Symbol	Unit	-xxB05-0Fxx	-xxB05-0Kxx
Data, main motor cooler				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	1.82	1.76
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	3.4	3.4
Temperature increase of the coolant	ΔT_H	K	7.7	7.5
Pressure drop	Δp_H	bar	0.2	0.2

Characteristics for 1FW6090-xxx05-xxxx









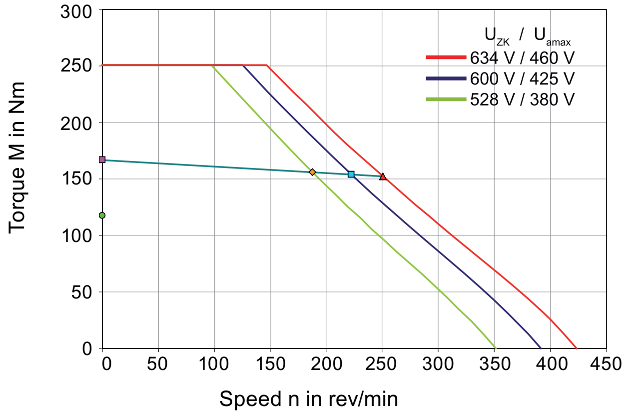
Data sheet 1FW6090-xxB07-xxxx

Table 14- 2 1FW6090-xxB07-0Kxx, 1FW6090-xxB07-1Jxx

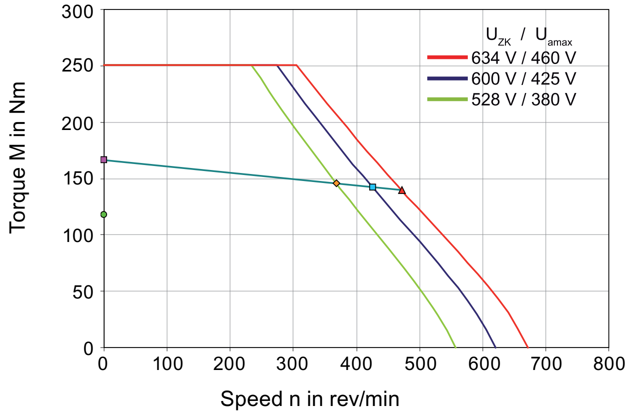
Technical data 1FW6090	Symbol	Unit	-xxB07-0Kxx	-xxB07-1Jxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	154	142
Rated current	I_N	A	9.5	13
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	220	430
Rated power dissipation	$P_{V,N}$	kW	2.69	2.67
Limit data				
Maximum torque	M_{MAX}	Nm	251	251
Maximum current	I_{MAX}	A	16	26
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	10.3	14.1
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	120	270
No-load speed	$n_{MAX,0}$	rpm	390	620
Torque at n = 1 [rpm]	M_0	Nm	166	166
Current at M_0 and n = 1 [rpm]	I_0	A	10	16
Thermal static torque	M_0*	Nm	118	118
Thermal stall current	I_0*	A	7.1	11
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	16.6	10.5
Voltage constant	k_E	V/(1000/min)	1007	634.3
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	3.33	3.34
Thermal time constant	t_{TH}	s	60	60
No. of pole pairs	p	-	22	22
Cogging torque	M_{COG}	Nm	1.7	1.7
Stator mass	m_S	kg	8.6	8.6
Rotor mass	m_L	kg	3.6	3.6
Rotor moment of inertia	J_L	10^{-2} kgm^2	2.2	2.2
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	5.98	2.36
Phase inductance of winding	L_{STR}	mH	21.2	8.4
Data, main motor cooler				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	2.24	2.22
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	4.1	4.1
Temperature increase of the coolant	ΔT_H	K	7.8	7.8
Pressure drop	Δp_H	bar	0.2	0.2

Characteristics for 1FW6090-xxx07-xxxx

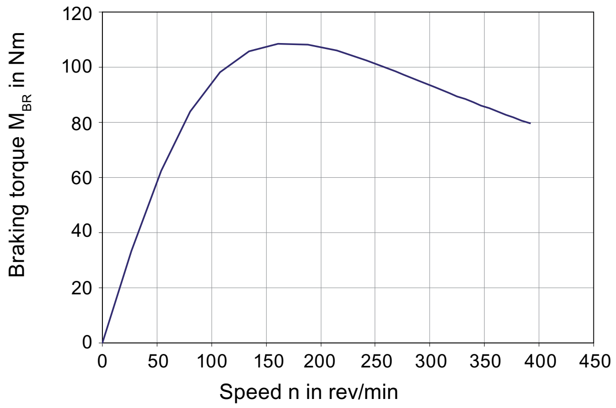
1FW6090-xxB07-0Kxx:
Torque over speed



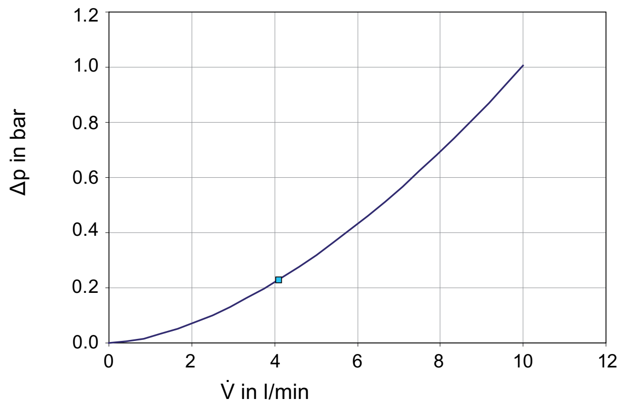
1FW6090-xxB07-1Jxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler
Pressure loss over volume flow rate

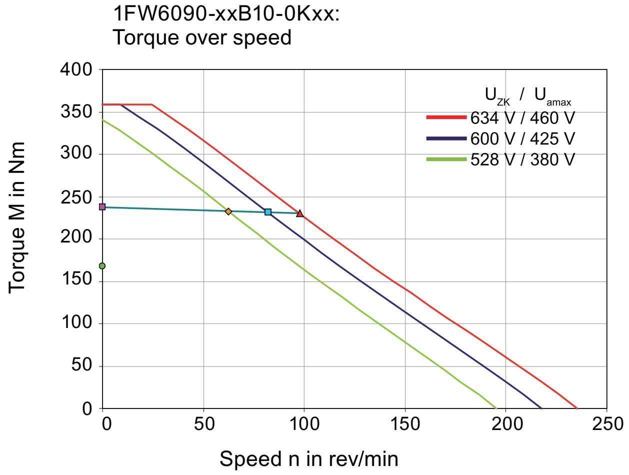


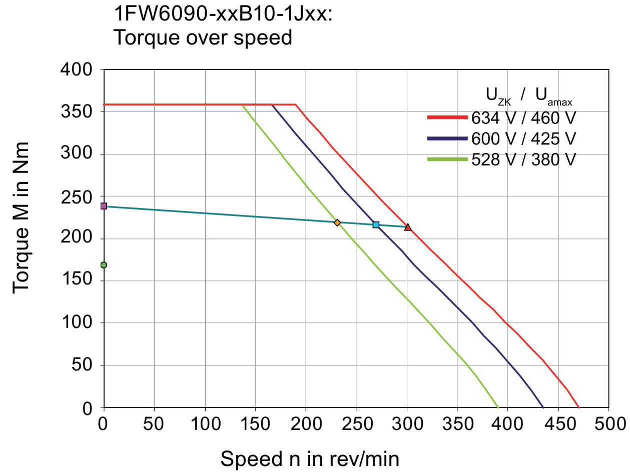
Data sheet 1FW6090-xxB10-xxxx

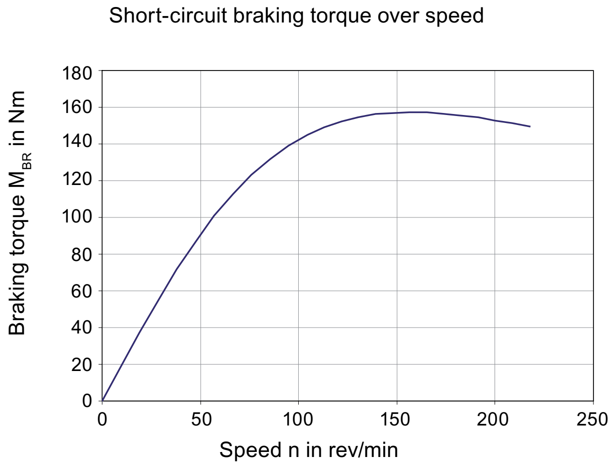
Table 14- 3 1FW6090-xxB10-0Kxx, 1FW6090-xxB10-1Jxx

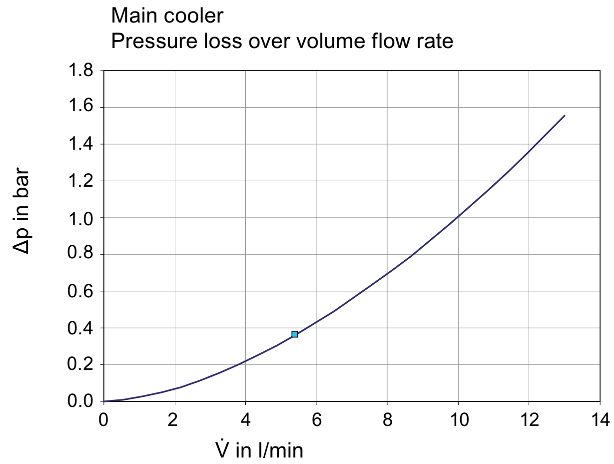
Technical data 1FW6090	Symbol	Unit	-xxB10-0Kxx	-xxB10-1Jxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	231	216
Rated current	I_N	A	7.9	14
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	82	270
Rated power dissipation	$P_{V,N}$	kW	3.5	3.5
Limit data				
Maximum torque	M_{MAX}	Nm	358	358
Maximum current	I_{MAX}	A	13	26
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	9.43	15.3
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	8.7	170
No-load speed	$n_{MAX,0}$	rpm	220	430
Torque at n = 1 [rpm]	M_0	Nm	238	238
Current at M_0 and n = 1 [rpm]	I_0	A	8.2	16
Thermal static torque	M_0*	Nm	168	168
Thermal stall current	I_0*	A	5.6	11
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	30	15
Voltage constant	k_E	V/(1000/min)	1812	906.2
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	4.17	4.17
Thermal time constant	t_{TH}	s	60	60
No. of pole pairs	p	-	22	22
Cogging torque	M_{COG}	Nm	2.4	2.4
Stator mass	m_S	kg	12.1	12.1
Rotor mass	m_L	kg	5.1	5.1
Rotor moment of inertia	J_L	10^{-2} kgm^2	3.09	3.09
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	12.4	3.09
Phase inductance of winding	L_{STR}	mH	47.5	11.9
Data, main motor cooler				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	2.91	2.91
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	5.4	5.4
Temperature increase of the coolant	ΔT_H	K	7.7	7.7
Pressure drop	Δp_H	bar	0.4	0.4

Characteristics for 1FW6090-xxx10-xxxx







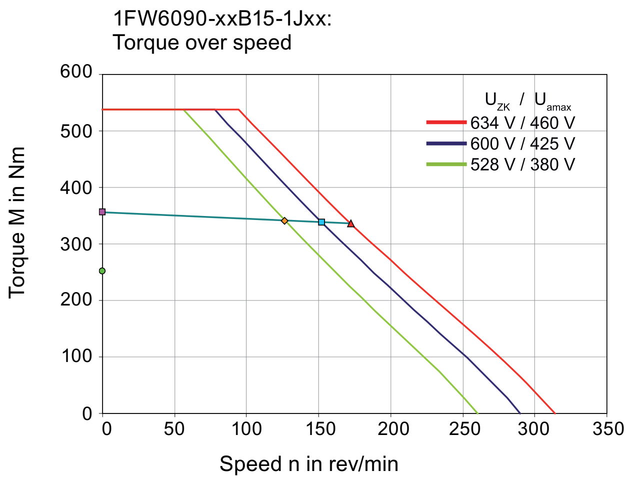


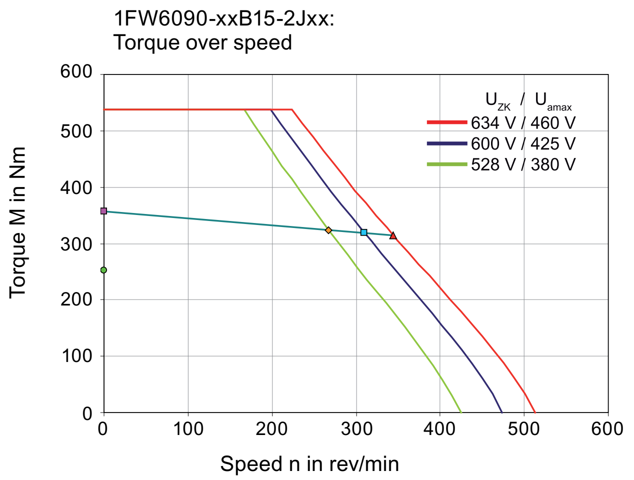
Data sheet 1FW6090-xxB15-xxxx

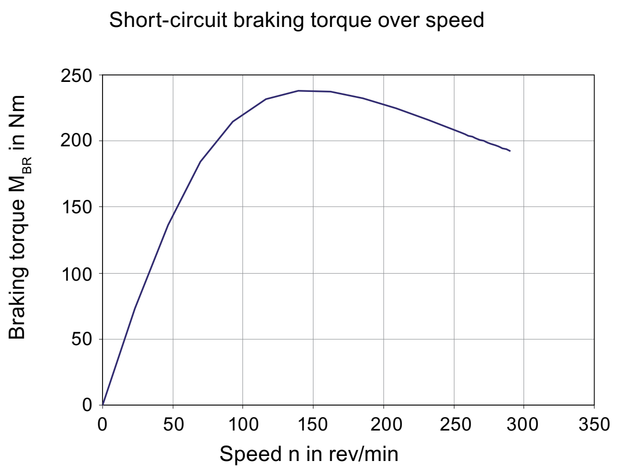
Table 14- 4 1FW6090-xxB15-1Jxx, 1FW6090-xxB15-2Jxx

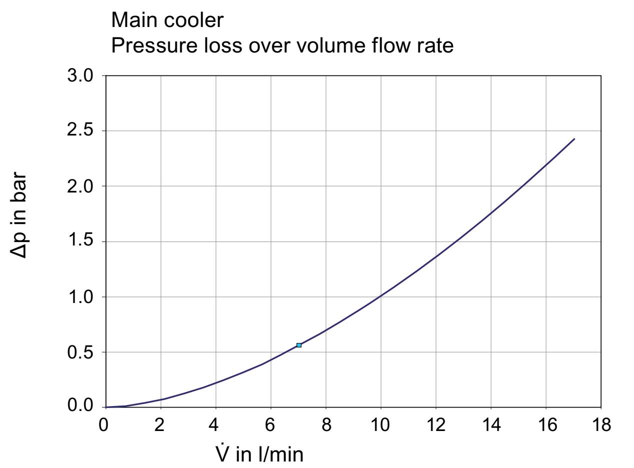
Technical data 1FW6090	Symbol	Unit	-xxB15-1Jxx	-xxB15-2Jxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	338	319
Rated current	I_N	A	15	23
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	150	310
Rated power dissipation	$P_{V,N}$	kW	4.87	4.96
Limit data				
Maximum torque	M_{MAX}	Nm	537	537
Maximum current	I_{MAX}	A	26	43
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	17.1	24.1
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	78	200
No-load speed	$n_{MAX,0}$	rpm	290	470
Torque at n = 1 [rpm]	M_0	Nm	357	357
Current at M_0 and n = 1 [rpm]	I_0	A	16	26
Thermal static torque	M_0*	Nm	252	252
Thermal stall current	I_0*	A	11	18
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	22.5	13.7
Voltage constant	k_E	V/(1000/min)	1359	831.3
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	5.3	5.25
Thermal time constant	t_{TH}	s	60	60
No. of pole pairs	p	-	22	22
Cogging torque	M_{COG}	Nm	3.6	3.6
Stator mass	m_S	kg	19.5	19.5
Rotor mass	m_L	kg	7.7	7.7
Rotor moment of inertia	J_L	10^{-2} kgm^2	4.65	4.65
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	4.3	1.64
Phase inductance of winding	L_{STR}	mH	17.7	6.6
Data, main motor cooler				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	4.05	4.13
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	7	7
Temperature increase of the coolant	ΔT_H	K	8.3	8.5
Pressure drop	Δp_H	bar	0.6	0.6

Characteristics for 1FW6090-xxx15-xxxx









14.2.2 1FW6130-xxxxx-xxxx

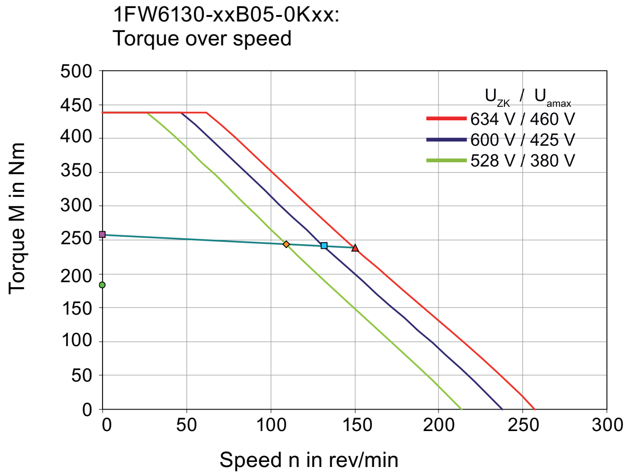
Data sheet 1FW6130-xxB05-xxxx

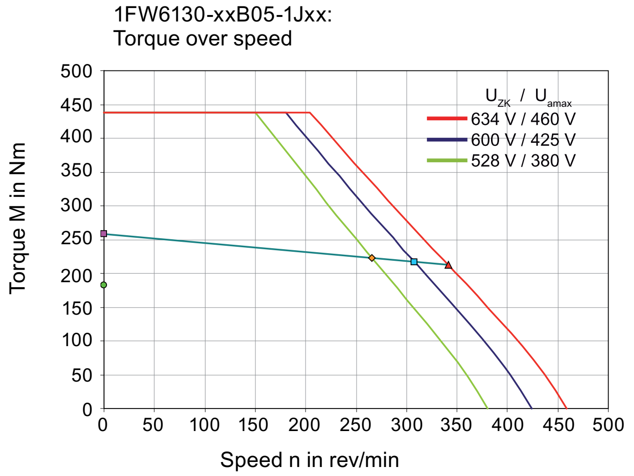
Table 14- 5 1FW6130-xxB05-0Kxx, 1FW6130-xxB05-1Jxx

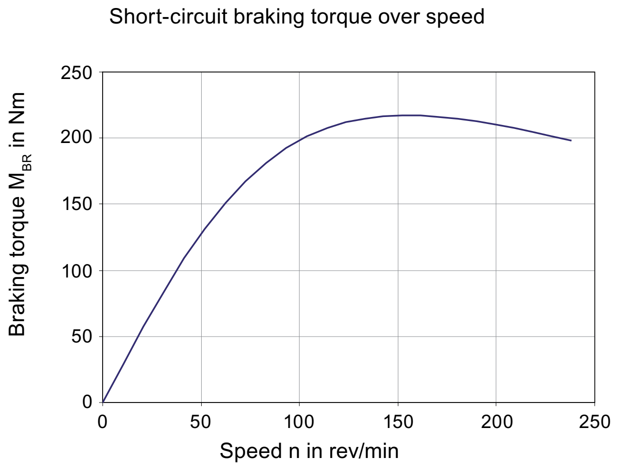
Technical data 1FW6130	Symbol	Unit	-xxB05-0Kxx	-xxB05-1Jxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	241	217
Rated current	I_N	A	9	14
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	130	310
Rated power dissipation	$P_{V,N}$	kW	2.93	2.93
Limit data				
Maximum torque	M_{MAX}	Nm	439	439
Maximum current	I_{MAX}	A	18	32
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	12.2	18.3
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	47	180
No-load speed	$n_{MAX,0}$	rpm	240	420
Torque at n = 1 [rpm]	M_0	Nm	258	258
Current at M_0 and n = 1 [rpm]	I_0	A	9.7	17
Thermal static torque	M_0*	Nm	183	183
Thermal stall current	I_0*	A	6.7	12
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	27.3	15.3
Voltage constant	k_E	V/(1000/min)	1650	924.9
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	4.93	4.92
Thermal time constant	t_{TH}	s	60	60
No. of pole pairs	p	-	33	33
Cogging torque	M_{COG}	Nm	1.3	1.3
Stator mass	m_S	kg	8.7	8.7
Rotor mass	m_L	kg	4.5	4.5
Rotor moment of inertia	J_L	10^{-2} kgm^2	6.37	6.37
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	7.34	2.31
Phase inductance of winding	L_{STR}	mH	19.2	6
Data, main motor cooler				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	2.43	2.44
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	4.1	4.1

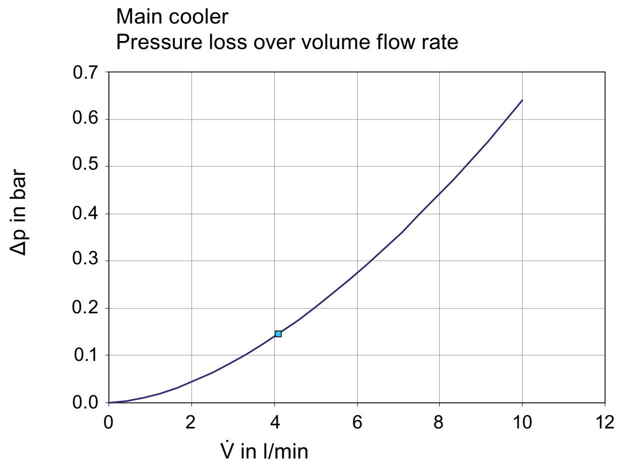
Technical data 1FW6130	Symbol	Unit	-xxB05-0Kxx	-xxB05-1Jxx
Temperature increase of the coolant	ΔT_H	K	8.5	8.6
Pressure drop	Δp_H	bar	0.1	0.1

Characteristics for 1FW6130-xxx05-xxxx









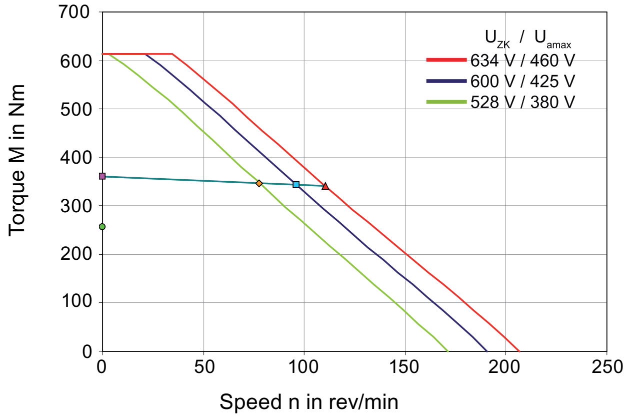
Data sheet 1FW6130-xxB07-xxxx

Table 14- 6 1FW6130-xxB07-0Kxx, 1FW6130-xxB07-1Jxx

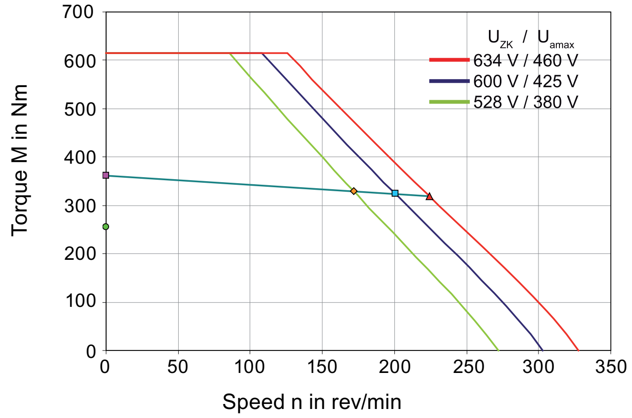
Technical data 1FW6130	Symbol	Unit	-xxB07-0Kxx	-xxB07-1Jxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	344	324
Rated current	I_N	A	10	15
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	96	200
Rated power dissipation	$P_{V,N}$	kW	3.73	3.71
Limit data				
Maximum torque	M_{MAX}	Nm	614	614
Maximum current	I_{MAX}	A	20	32
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	14.2	19.7
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	21	110
No-load speed	$n_{MAX,0}$	rpm	190	300
Torque at n = 1 [rpm]	M_0	Nm	361	361
Current at M_0 and n = 1 [rpm]	I_0	A	10	17
Thermal static torque	M_0*	Nm	256	256
Thermal stall current	I_0*	A	7.6	12
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	34	21.4
Voltage constant	k_E	V/(1000/min)	2056	1295
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	6.11	6.13
Thermal time constant	t_{TH}	s	60	60
No. of pole pairs	p	-	33	33
Cogging torque	M_{COG}	Nm	1.8	1.8
Stator mass	m_S	kg	11.9	11.9
Rotor mass	m_L	kg	6.3	6.3
Rotor moment of inertia	J_L	10^{-2} kgm^2	8.92	8.92
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	7.41	2.92
Phase inductance of winding	L_{STR}	mH	21	8.3
Data, main motor cooler				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	3.1	3.09
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	5.2	5.2
Temperature increase of the coolant	ΔT_H	K	8.6	8.5
Pressure drop	Δp_H	bar	0.2	0.2

Characteristics for 1FW6130-xxx07-xxxx

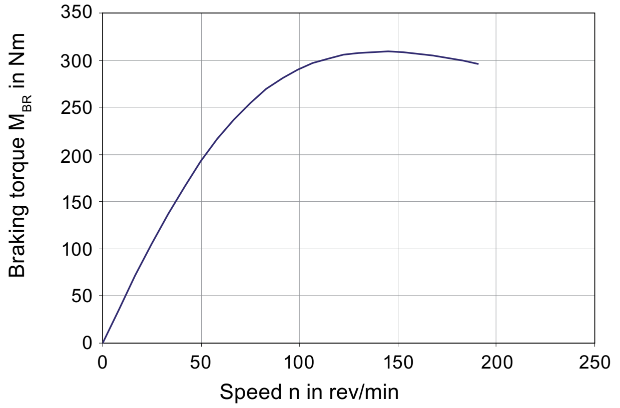
1FW6130-xxB07-0Kxx:
Torque over speed



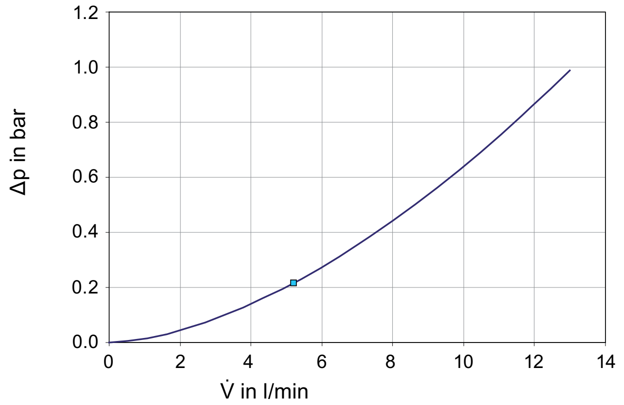
1FW6130-xxB07-1Jxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler
Pressure loss over volume flow rate



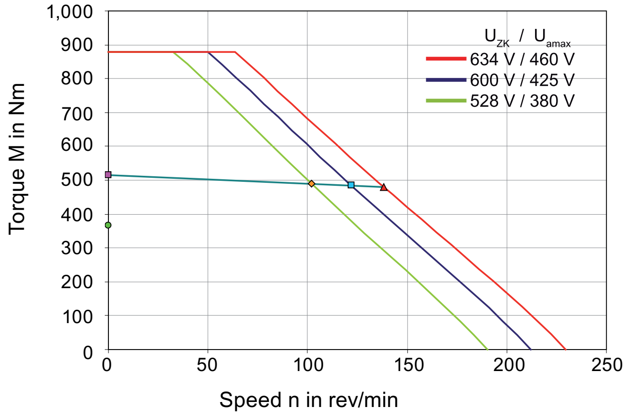
Data sheet 1FW6130-xxB10-xxxx

Table 14- 7 1FW6130-xxB10-1Jxx, 1FW6130-xxB10-2Jxx

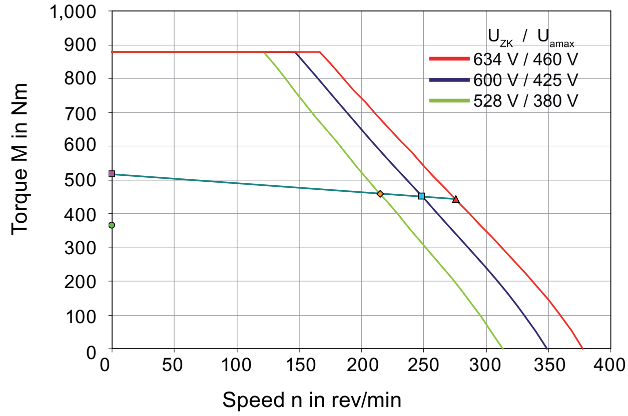
Technical data 1FW6130	Symbol	Unit	-xxB10-1Jxx	-xxB10-2Jxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling intake temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	484	450
Rated current	I_N	A	16	24
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	120	250
Rated power loss	$P_{V,N}$	kW	4.88	4.98
Limit data				
Maximum torque	M_{MAX}	Nm	878	878
Maximum current	I_{MAX}	A	32	53
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	21.4	30.6
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	50	150
No-load speed	$n_{MAX,0}$	rpm	210	350
Torque at n = 1 [rpm]	M_0	Nm	516	516
Current at M_0 and n = 1 [rpm]	I_0	A	17	28
Thermal static torque	M_0*	Nm	365	365
Thermal stall current	I_0*	A	12	19
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	30.6	18.6
Voltage constant	k_E	V/(1000/min)	1850	1124
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	7.63	7.55
Thermal time constant	t_{TH}	s	60	60
No. of pole pairs	p	-	33	33
Cogging torque	M_{COG}	Nm	2.6	2.6
Stator mass	m_S	kg	16.2	16.2
Rotor mass	m_L	kg	9	9
Rotor moment of inertia	J_L	10^{-2} kgm^2	12.7	12.7
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	3.84	1.45
Phase inductance of winding	L_{STR}	mH	11.7	4.3
Data, main motor cooler				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	4.06	4.15
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	7	7
Temperature increase of the coolant	ΔT_H	K	8.3	8.5
Pressure drop	Δp_H	bar	0.4	0.4

Characteristics for 1FW6130-xxx10-xxxx

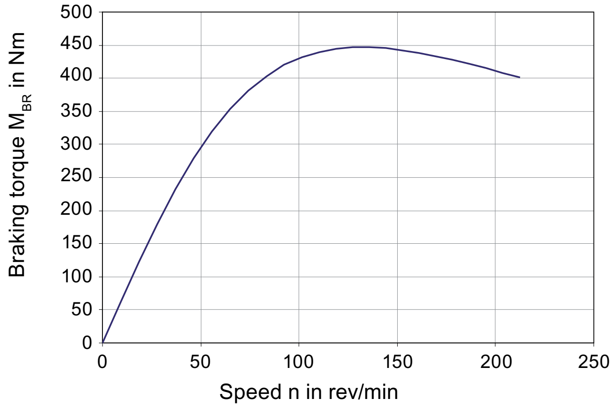
1FW6130-xxB10-1Jxx:
Torque over speed



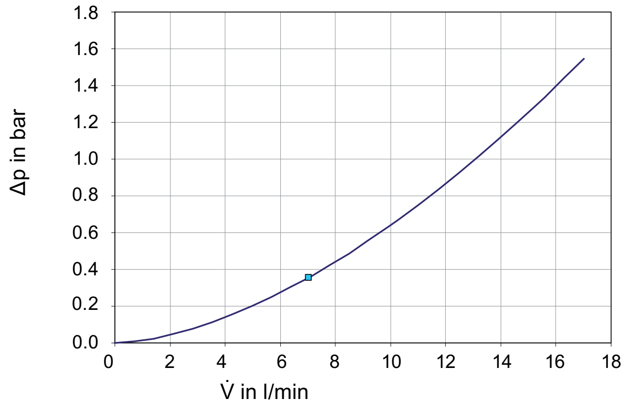
1FW6130-xxB10-2Jxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler
Pressure loss over volume flow rate



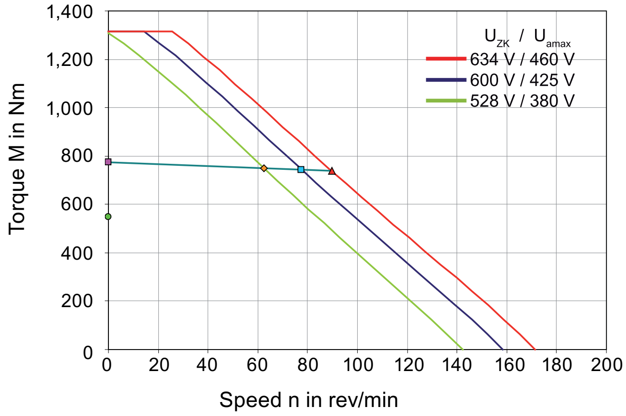
Data sheet 1FW6130-xxB15-xxxx

Table 14- 8 1FW6130-xxB15-1Jxx, 1FW6130-xxB15-2Jxx

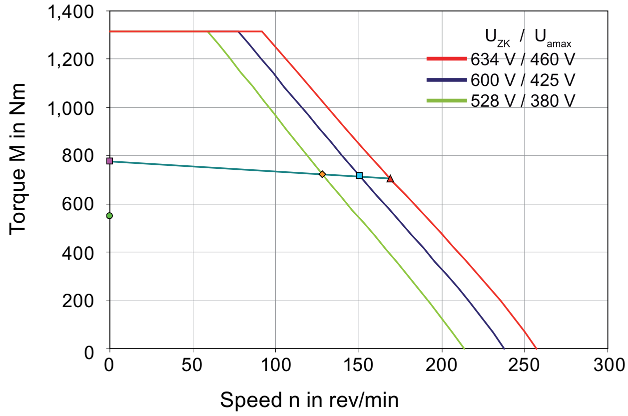
Technical data 1FW6130	Symbol	Unit	-xxB15-1Jxx	-xxB15-2Jxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	744	714
Rated current	I_N	A	18	26
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	78	150
Rated power dissipation	$P_{V,N}$	kW	6.81	6.81
Limit data				
Maximum torque	M_{MAX}	Nm	1320	1320
Maximum current	I_{MAX}	A	36	54
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	25.4	34.1
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	14	77
No-load speed	$n_{MAX,0}$	rpm	160	240
Torque at n = 1 [rpm]	M_0	Nm	775	775
Current at M_0 and n = 1 [rpm]	I_0	A	19	29
Thermal static torque	M_0*	Nm	548	548
Thermal stall current	I_0*	A	13	20
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	40.9	27.3
Voltage constant	k_E	V/(1000/min)	2475	1650
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	9.69	9.69
Thermal time constant	t_{TH}	s	60	60
No. of pole pairs	p	-	33	33
Cogging torque	M_{COG}	Nm	3.9	3.9
Stator mass	m_S	kg	24.7	24.7
Rotor mass	m_L	kg	13.5	13.5
Rotor moment of inertia	J_L	10^{-2} kgm^2	19.1	19.1
Phase resistance of winding at 20 °C	$R_{STR,20}$	Ω	4.27	1.9
Phase inductance of winding	L_{STR}	mH	13.9	6.2
Data, main motor cooler				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	5.67	5.67
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	9.8	9.8
Temperature increase of the coolant	ΔT_H	K	8.3	8.3
Pressure drop	Δp_H	bar	0.6	0.6

Characteristics for 1FW6130-xxx15-xxxx

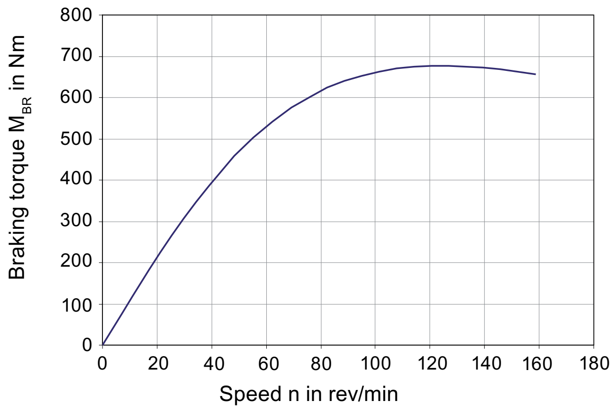
1FW6130-xxB15-1Jxx:
Torque over speed



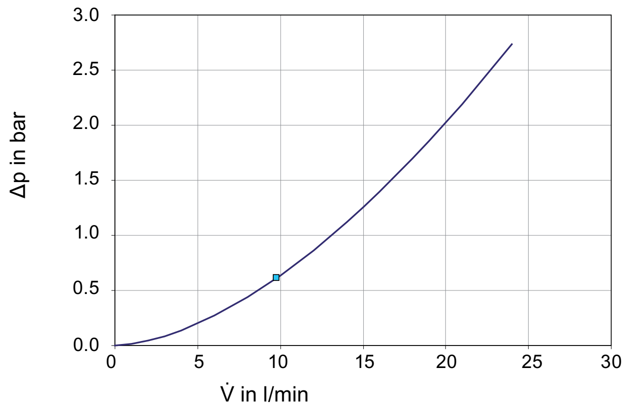
1FW6130-xxB15-2Jxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler
Pressure loss over volume flow rate



14.2.3 1FW6150-xxxxx-xxxx

Data sheet 1FW6150-xxB05-xxxx

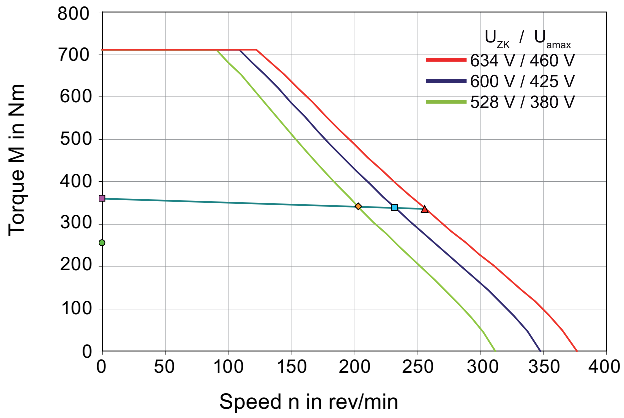
Table 14- 9 1FW6150-xxB05-1Jxx, 1FW6150-xxB05-4Fxx

Technical data 1FW6150	Symbol	Unit	-xxB05-1Jxx	-xxB05-4Fxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	338	298
Rated current	I_N	A	17	36
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	230	650
Rated power dissipation	$P_{V,N}$	kW	2.57	2.52
Limit data				
Maximum torque	M_{MAX}	Nm	710	710
Maximum current	I_{MAX}	A	44	100
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	22.8	39.4
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	110	330
No-load speed	$n_{MAX,0}$	rpm	350	830
Torque at n = 1 [rpm]	M_0	Nm	360	360
Current at M_0 and n = 1 [rpm]	I_0	A	18	44
Thermal static torque	M_0*	Nm	255	255
Thermal stall current	I_0*	A	12	30
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	19.8	8.26
Voltage constant	k_E	V/(1000/min)	1199	499.6
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	7.2	7.26
Thermal time constant	t_{TH}	s	60	60
No. of pole pairs	p	-	33	33
Cogging torque	M_{COG}	Nm	1.8	1.8
Stator mass	m_S	kg	17.9	17.9
Rotor mass	m_L	kg	3.8	3.8
Rotor moment of inertia	J_L	10^{-2} kgm^2	10.1	10.1
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	1.82	0.31
Phase inductance of winding	L_{STR}	mH	9.4	1.6
Data, main motor cooler				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	2.13	2.1
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	4.5	4.5

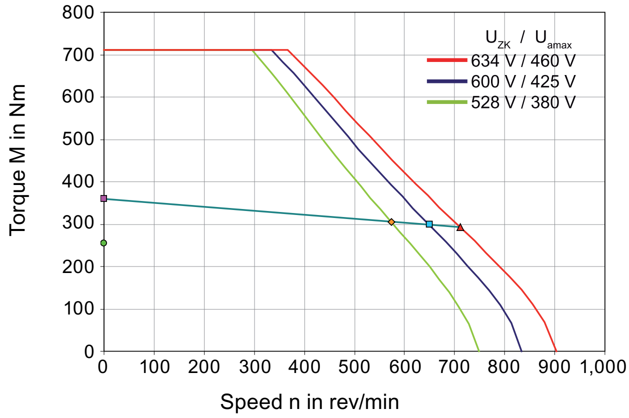
Technical data 1FW6150	Symbol	Unit	-xxB05-1Jxx	-xxB05-4Fxx
Temperature increase of the coolant	ΔT_H	K	6.8	6.7
Pressure drop	Δp_H	bar	0.2	0.2

Characteristics for 1FW6150-xxx05-xxxx

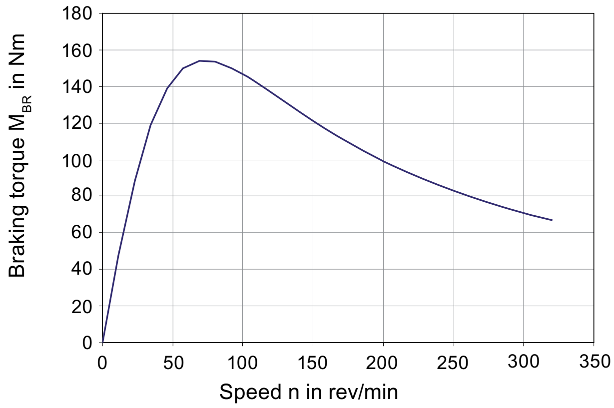
1FW6150-xxB05-1Jxx:
Torque over speed



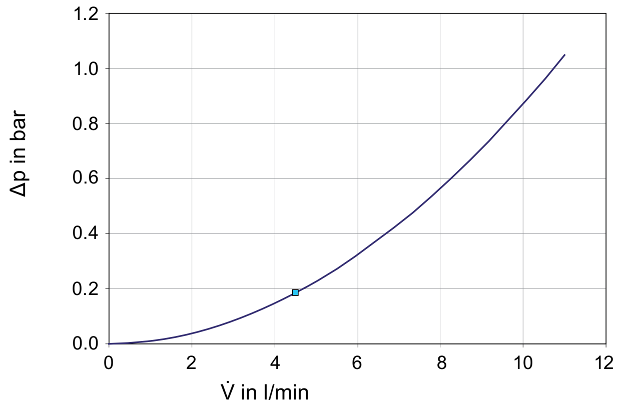
1FW6150-xxB05-4Fxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler
Pressure loss over volume flow rate

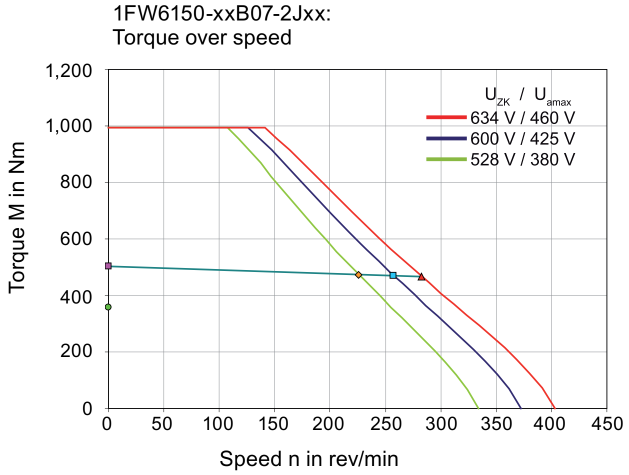


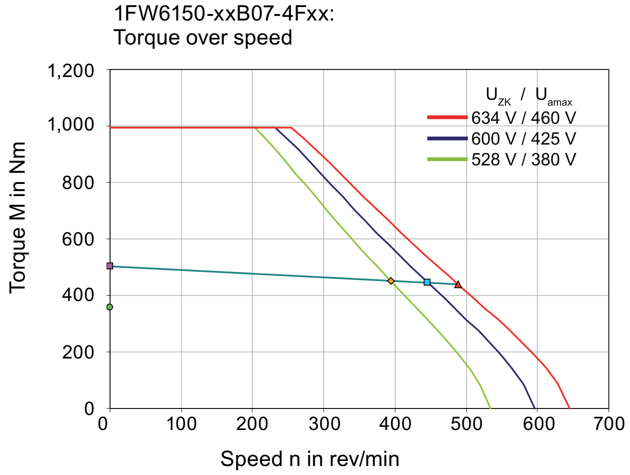
Data sheet 1FW6150-xxB07-xxxx

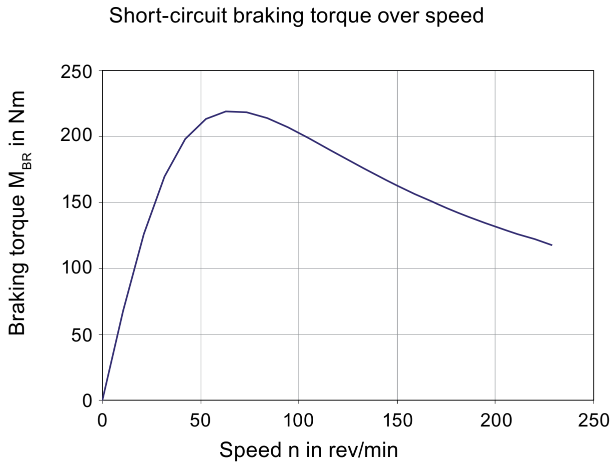
Table 14- 10 1FW6150-xxB07-2Jxx, 1FW6150-xxB07-4Fxx

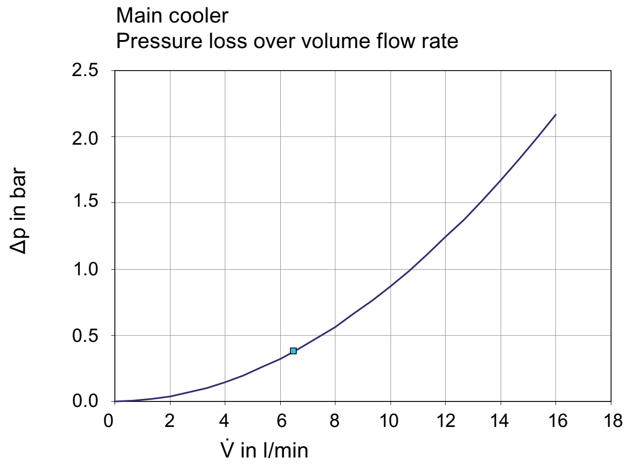
Technical data 1FW6150	Symbol	Unit	-xxB07-2Jxx	-xxB07-4Fxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	470	445
Rated current	I_N	A	25	38
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	260	450
Rated power dissipation	$P_{V,N}$	kW	3.28	3.23
Limit data				
Maximum torque	M_{MAX}	Nm	994	994
Maximum current	I_{MAX}	A	66	100
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	32	42.7
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	130	230
No-load speed	$n_{MAX,0}$	rpm	370	600
Torque at n = 1 [rpm]	M_0	Nm	504	504
Current at M_0 and n = 1 [rpm]	I_0	A	27	44
Thermal static torque	M_0*	Nm	356	356
Thermal stall current	I_0*	A	19	30
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	18.5	11.6
Voltage constant	k_E	V/(1000/min)	1119	699.4
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	8.91	8.99
Thermal time constant	t_{TH}	s	60	60
No. of pole pairs	p	-	33	33
Cogging torque	M_{COG}	Nm	2.5	2.5
Stator mass	m_S	kg	24.7	24.7
Rotor mass	m_L	kg	8.8	8.8
Rotor moment of inertia	J_L	10^{-2} kgm^2	14.2	14.2
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	1.03	0.396
Phase inductance of winding	L_{STR}	mH	5.8	2.3
Data, main motor cooler				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	2.73	2.68
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	6.5	6.5
Temperature increase of the coolant	ΔT_H	K	6	5.9
Pressure drop	Δp_H	bar	0.4	0.4

Characteristics for 1FW6150-xxx07-xxxx







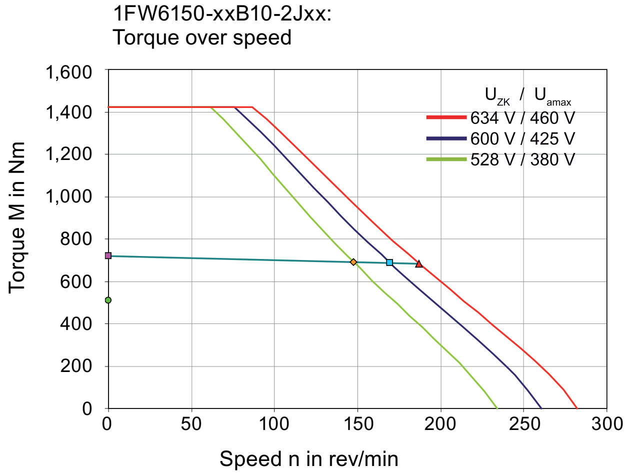


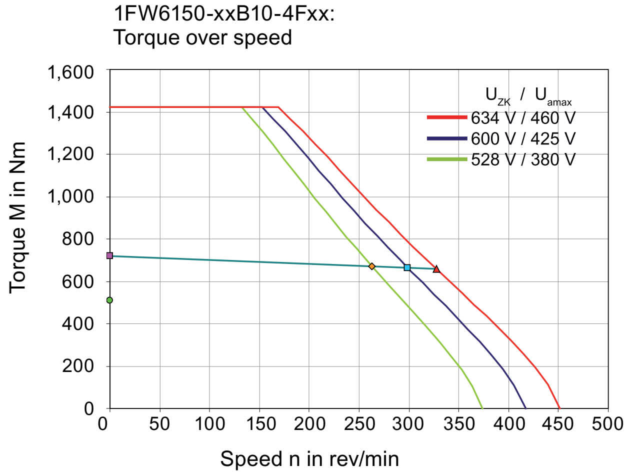
Data sheet 1FW6150-xxB10-xxxx

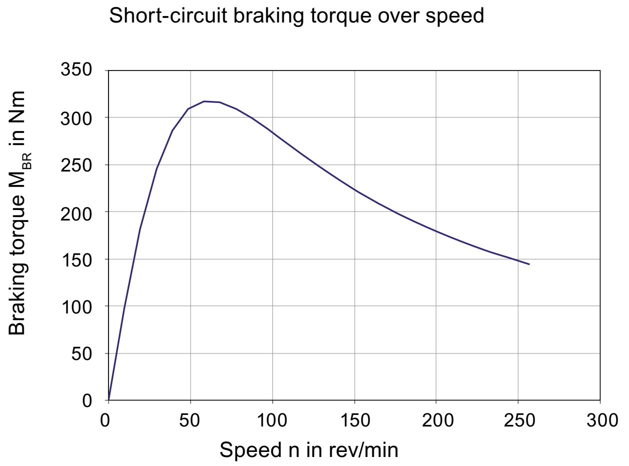
Table 14- 11 1FW6150-xxB10-2Jxx, 1FW6150-xxB10-4Fxx

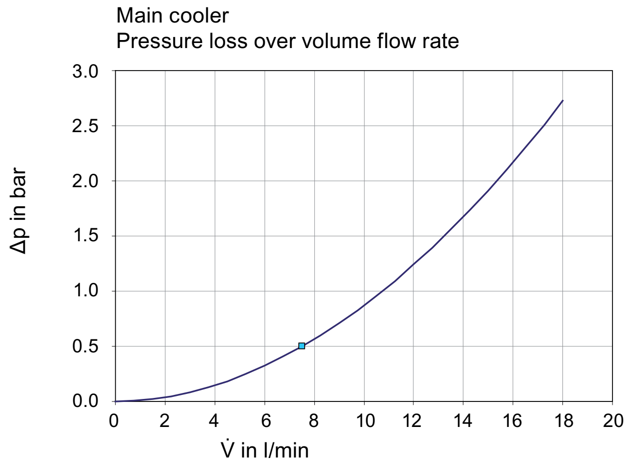
Technical data 1FW6150	Symbol	Unit	-xxB10-2Jxx	-xxB10-4Fxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	688	664
Rated current	I_N	A	26	40
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	170	300
Rated power dissipation	$P_{V,N}$	kW	4.36	4.28
Limit data				
Maximum torque	M_{MAX}	Nm	1420	1420
Maximum current	I_{MAX}	A	66	100
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	36.2	47.3
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	76	150
No-load speed	$n_{MAX,0}$	rpm	260	420
Torque at n = 1 [rpm]	M_0	Nm	720	720
Current at M_0 and n = 1 [rpm]	I_0	A	27	44
Thermal static torque	M_0*	Nm	509	509
Thermal stall current	I_0*	A	19	30
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	26.4	16.5
Voltage constant	k_E	V/(1000/min)	1599	999.1
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	11.1	11.1
Thermal time constant	t_{TH}	s	60	60
No. of pole pairs	p	-	33	33
Cogging torque	M_{COG}	Nm	3.6	3.6
Stator mass	m_S	kg	34.9	34.9
Rotor mass	m_L	kg	12.6	12.6
Rotor moment of inertia	J_L	10^{-2} kgm^2	20.9	20.9
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	1.37	0.526
Phase inductance of winding	L_{STR}	mH	8.2	3.2
Data, main motor cooler				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	3.62	3.56
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	7.5	7.5
Temperature increase of the coolant	ΔT_H	K	6.9	6.8
Pressure drop	Δp_H	bar	0.5	0.5

Characteristics for 1FW6150-xxx10-xxxx









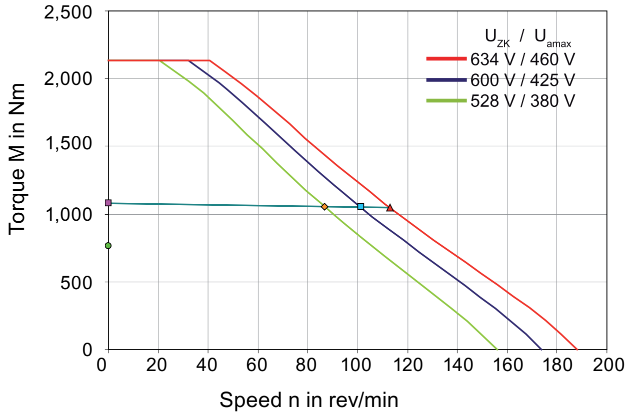
Data sheet 1FW6150-xxB15-xxxx

Table 14- 12 1FW6150-xxB15-2Jxx, 1FW6150-xxB15-4Fxx

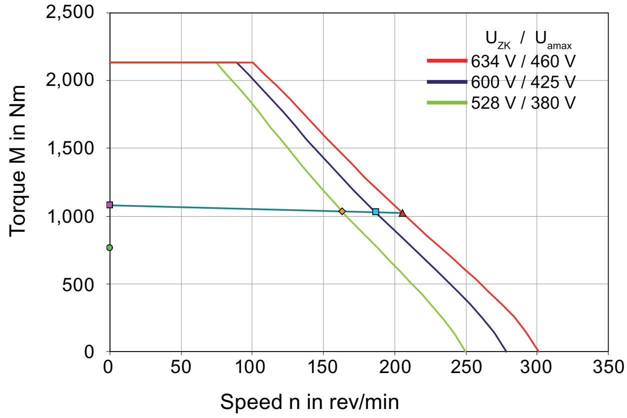
Technical data 1FW6150	Symbol	Unit	-xxB15-2Jxx	-xxB15-4Fxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	1050	1030
Rated current	I_N	A	26	41
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	100	190
Rated power dissipation	$P_{V,N}$	kW	6.14	6.04
Limit data				
Maximum torque	M_{MAX}	Nm	2130	2130
Maximum current	I_{MAX}	A	66	100
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	42.4	54.5
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	32	89
No-load speed	$n_{MAX,0}$	rpm	170	280
Torque at n = 1 [rpm]	M_0	Nm	1080	1080
Current at M_0 and n = 1 [rpm]	I_0	A	27	44
Thermal static torque	M_0*	Nm	764	764
Thermal stall current	I_0*	A	19	30
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	39.7	24.8
Voltage constant	k_E	V/(1000/min)	2398	1499
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	14	14.1
Thermal time constant	t_{TH}	s	60	60
No. of pole pairs	p	-	33	33
Cogging torque	M_{COG}	Nm	5.4	5.4
Stator mass	m_S	kg	51.9	51.9
Rotor mass	m_L	kg	18.9	18.9
Rotor moment of inertia	J_L	10^{-2} kgm^2	31.3	31.3
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	1.93	0.742
Phase inductance of winding	L_{STR}	mH	12.3	4.8
Data, main motor cooler				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	5.11	5.03
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	9.5	9.5
Temperature increase of the coolant	ΔT_H	K	7.7	7.6
Pressure drop	Δp_H	bar	0.8	0.8

Characteristics for 1FW6150-xxx15-xxxx

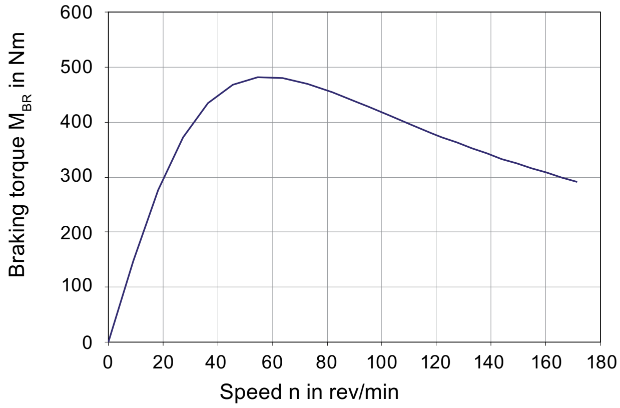
1FW6150-xxB15-2Jxx:
Torque over speed



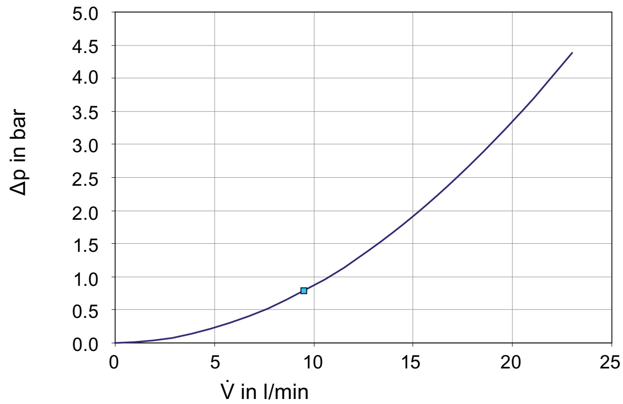
1FW6150-xxB15-4Fxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler
Pressure loss over volume flow rate



14.2.4 1FW6160-xxxxx-xxxx

Data sheet 1FW6160-xxB05-xxxx

Table 14- 13 1FW6160-xxB05-1Jxx, 1FW6160-xxB05-2Jxx, 1FW6160-xxB05-5Gxx

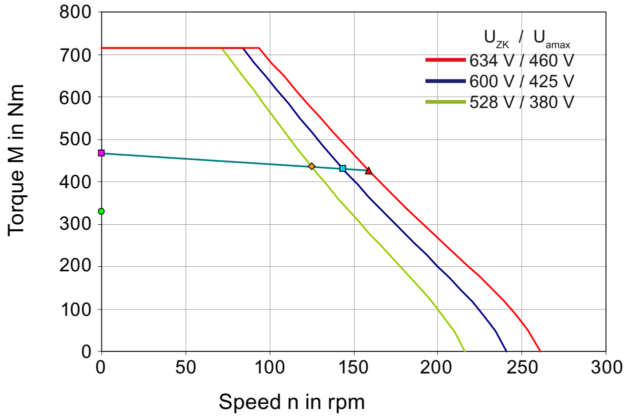
Technical data 1FW6160	Symbol	Unit	-xxB05-1Jxx	-xxB05-2Jxx	-xxB05-5Gxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	431	404	314
Rated current	I_N	A	16	24	36
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	140	250	590
Rated power dissipation	$P_{V,N}$	kW	2.84	2.85	2.88
Limit data					
Maximum torque	M_{MAX}	Nm	716	716	716
Maximum current	I_{MAX}	A	31	49	98
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	15.1	20	33.1
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	84	150	320
No-load speed	$n_{MAX,0}$	rpm	240	380	750
Torque at n = 1 [rpm]	M_0	Nm	467	467	467
Current at M_0 and n = 1 [rpm]	I_0	A	17	28	56
Thermal static torque	M_0*	Nm	330	330	330
Thermal stall current	I_0*	A	12	19	38
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	26.6	17	8.51
Voltage constant	k_E	V/(1000/min)	1608	1029	514.5
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	8.96	8.95	8.91
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	35	35	35
Cogging torque	M_{COG}	Nm	2.3	2.3	2.3
Stator mass	m_S	kg	27.2	27.2	27.2
Rotor mass	m_L	kg	9.1	9.1	9.1
Rotor moment of inertia	J_L	10^{-2} kgm^2	19	19	19
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	2.11	0.866	0.218
Phase inductance of winding	L_{STR}	mH	18.1	7.4	1.9
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	2.13	2.14	2.16
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	3.8	3.8	3.8

Technical data 1FW6160	Symbol	Unit	-xxB05-1Jxx	-xxB05-2Jxx	-xxB05-5Gxx
Temperature increase of the coolant	ΔT_H	K	8	8	8.1
Pressure drop	Δp_H	bar	0.3	0.3	0.3
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.23	0.231	0.233
Recommended minimum volume flow rate	$\dot{V}_{P,MIN}$	l/min	1.5	1.5	1.5
Temperature increase of the coolant	ΔT_P	K	2.3	2.3	2.3
Pressure drop	Δp_P	bar	0.3	0.3	0.3

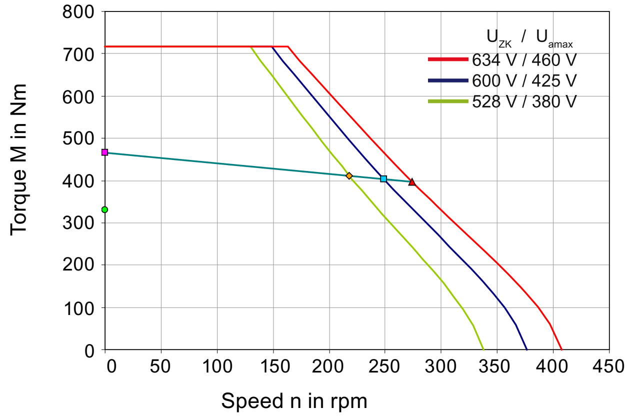
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6160-xxx05-xxxx

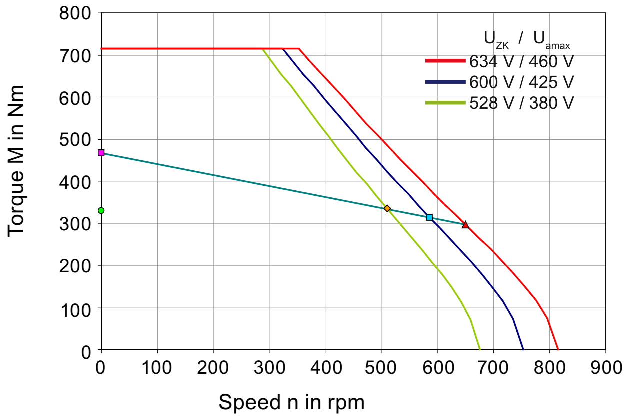
1FW6160-xxB05-1Jxx:
Torque over speed



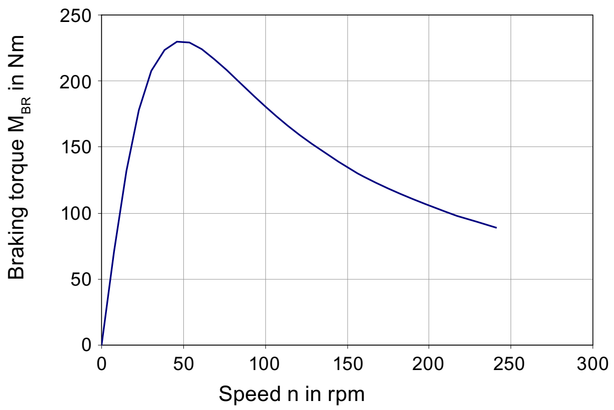
1FW6160-xxB05-2Jxx:
Torque over speed



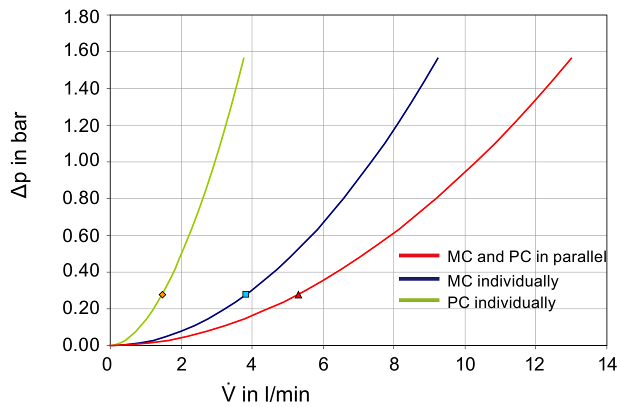
1FW6160-xxB05-5Gxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate



Data sheet 1FW6160-xxB07-xxxx

Table 14- 14 1FW6160 xxB07-1Jxx, 1FW6160-xxB07-2Jxx, 1FW6160-xxB07-5Gxx

Technical data 1FW6160	Symbol	Unit	-xxB07-1Jxx	-xxB07-2Jxx	-xxB07-5Gxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	620	594	514
Rated current	I_N	A	16	25	43
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	96	170	390
Rated power dissipation	$P_{V,N}$	kW	3.59	3.61	3.64
Limit data					
Maximum torque	M_{MAX}	Nm	1000	1000	1000
Maximum current	I_{MAX}	A	31	49	98
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	16.7	21.8	35.2
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	53	100	230
No-load speed	$n_{MAX,0}$	rpm	170	270	540
Torque at n = 1 [rpm]	M_0	Nm	653	653	653
Current at M_0 and n = 1 [rpm]	I_0	A	17	28	56
Thermal static torque	M_0*	Nm	462	462	462
Thermal stall current	I_0*	A	12	19	38
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	37.2	23.8	11.9
Voltage constant	k_E	V/(1000/min)	2251	1441	720.4
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	11.2	11.1	11.1
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	35	35	35
Cogging torque	M_{COG}	Nm	3.3	3.3	3.3
Stator mass	m_S	kg	36.2	36.2	36.2
Rotor mass	m_L	kg	12.1	12.1	12.1
Rotor moment of inertia	J_L	10^{-2} kgm^2	25.8	25.8	25.8
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	2.66	1.09	0.276
Phase inductance of winding	L_{STR}	mH	25.1	10.3	2.6
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	2.7	2.71	2.73
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	4.8	4.8	4.8
Temperature increase of the coolant	ΔT_H	K	8.2	8.2	8.3
Pressure drop	Δp_H	bar	0.4	0.4	0.4
Data for precision motor cooler *)					

Technical data 1FW6160	Symbol	Unit	-xxB07-1Jxx	-xxB07-2Jxx	-xxB07-5Gxx
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.291	0.292	0.294
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	1.8	1.8	1.8
Temperature increase of the coolant	ΔT_P	K	2.3	2.3	2.3
Pressure drop	Δp_H	bar	0.4	0.4	0.4

*) Parallel connection of main and precision motor cooler

Table 14- 15 1FW6160-xxB07-8Fxx

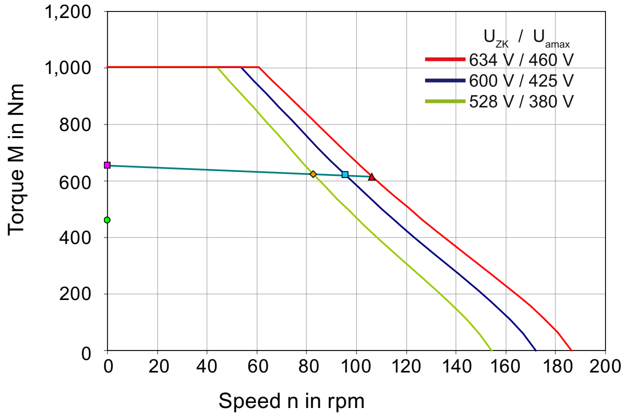
Technical data 1FW6160	Symbol	Unit	-xxB07-8Fxx
Boundary conditions			
DC link voltages	U_{ZK}	V	600
Water cooling inlet temperature	T_{VORL}	°C	35
Rated temperature of winding	T_N	°C	130
Rated data			
Rated torque	M_N	Nm	432
Rated current	I_N	A	51
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	610
Rated power dissipation	$P_{V,N}$	kW	3.73
Limit data			
Maximum torque	M_{MAX}	Nm	1000
Maximum current	I_{MAX}	A	140
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	46.7
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	330
No-load speed	$n_{MAX,0}$	rpm	770
Torque at n = 1 [rpm]	M_0	Nm	653
Current at M_0 and n = 1 [rpm]	I_0	A	80
Thermal static torque	M_0*	Nm	462
Thermal stall current	I_0*	A	55
Physical constants			
Torque constant at 20 °C	$k_{T,20}$	Nm/A	8.34
Voltage constant	k_E	V/(1000/min)	504.3
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	11
Thermal time constant	t_{TH}	s	180
No. of pole pairs	p	-	35
Cogging torque	M_{COG}	Nm	3.3
Stator mass	m_S	kg	36.2
Rotor mass	m_L	kg	12.1
Rotor moment of inertia	J_L	10^{-2} kgm²	25.8

Technical data 1FW6160	Symbol	Unit	-xxB07-8Fxx
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.139
Phase inductance of winding	L_{STR}	mH	1.3
Data for main motor cooler *)			
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	2.8
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	4.8
Temperature increase of the coolant	ΔT_H	K	8.5
Pressure drop	Δp_H	bar	0.4
Data for precision motor cooler *)			
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.302
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	1.8
Temperature increase of the coolant	ΔT_P	K	2.4
Pressure drop	Δp_H	bar	0.4

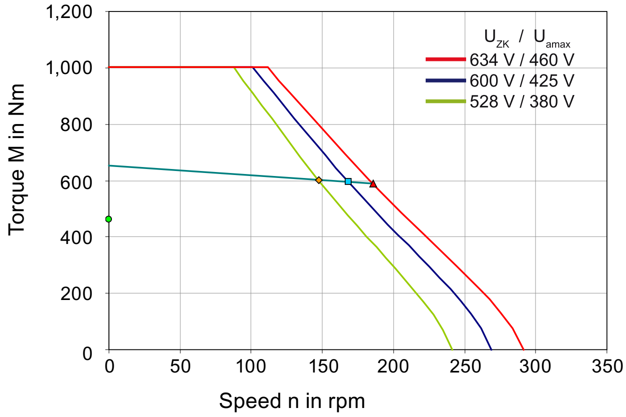
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6160-xxx07-xxxx

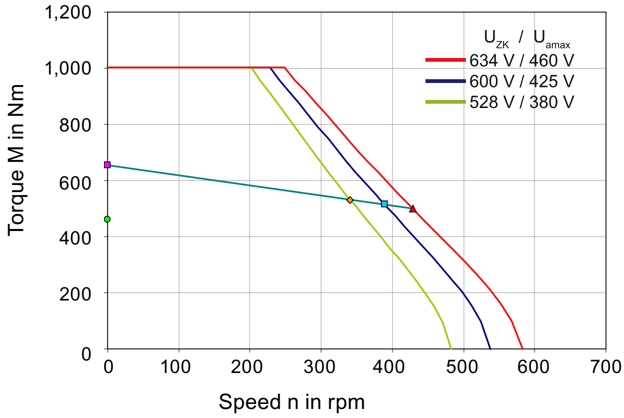
1FW6160-xxB07-1Jxx:
Torque over speed



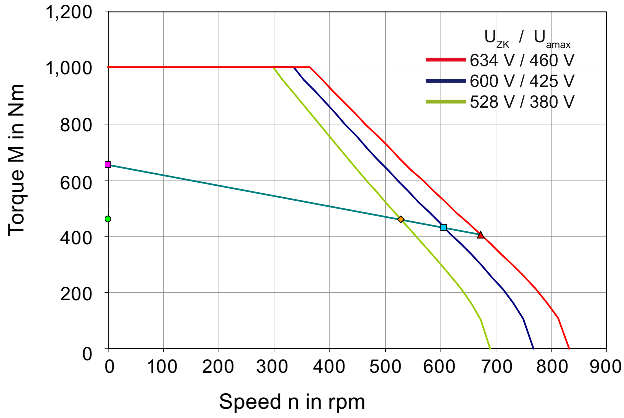
1FW6160-xxB07-2Jxx:
Torque over speed



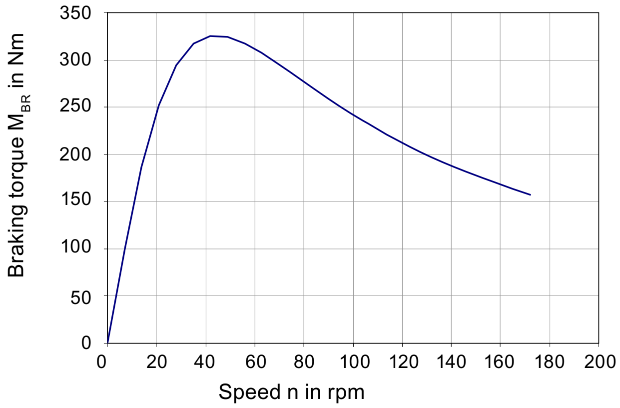
1FW6160-xxB07-5Gxx:
Torque over speed



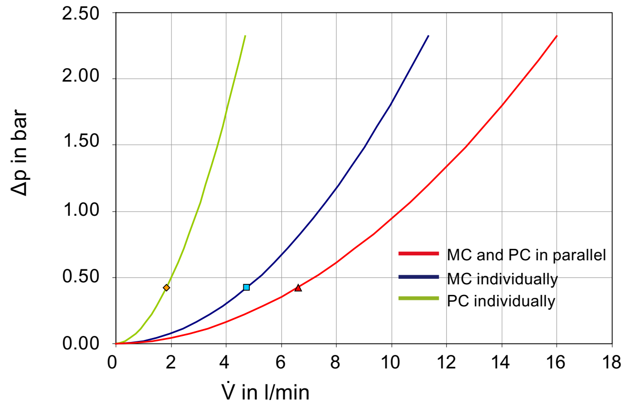
1FW6160-xxB07-8Fxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate



Data sheet 1FW6160-xxB10-xxxx

Table 14- 16 1FW6160-xxB10-1Jxx, 1FW6160-xxB10-2Jxx, 1FW6160-xxB10-5Gxx

Technical data 1FW6160	Symbol	Unit	-xxB10-1Jxx	-xxB10-2Jxx	-xxB10-5Gxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	903	878	804
Rated current	I_N	A	17	26	47
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	60	110	260
Rated power dissipation	$P_{V,N}$	kW	4.72	4.74	4.77
Limit data					
Maximum torque	M_{MAX}	Nm	1430	1430	1430
Maximum current	I_{MAX}	A	31	49	98
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	19	24.4	38.1
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	29	65	160
No-load speed	$n_{MAX,0}$	rpm	120	190	380
Torque at n = 1 [rpm]	M_0	Nm	933	933	933
Current at M_0 and n = 1 [rpm]	I_0	A	17	28	56
Thermal static torque	M_0*	Nm	660	660	660
Thermal stall current	I_0*	A	12	19	38
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	53.2	34	17
Voltage constant	k_E	V/(1000/min)	3216	2058	1029
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	13.9	13.9	13.8
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	35	35	35
Cogging torque	M_{COG}	Nm	4.7	4.7	4.7
Stator mass	m_S	kg	49	49	49
Rotor mass	m_L	kg	17.3	17.3	17.3
Rotor moment of inertia	J_L	10^{-2} kgm^2	36	36	36
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	3.49	1.44	0.362
Phase inductance of winding	L_{STR}	mH	35.5	14.5	3.6
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	3.54	3.56	3.59
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	6.4	6.4	6.4
Temperature increase of the coolant	ΔT_H	K	8	8	8.1
Pressure drop	Δp_H	bar	0.8	0.8	0.8
Data for precision motor cooler *)					

Technical data 1FW6160	Symbol	Unit	-xxB10-1Jxx	-xxB10-2Jxx	-xxB10-5Gxx
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.382	0.384	0.387
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	2.5	2.5	2.5
Temperature increase of the coolant	ΔT_P	K	2.2	2.2	2.2
Pressure drop	Δp_H	bar	0.8	0.8	0.8

*) Parallel connection of main and precision motor cooler

Table 14- 17 1FW6160-xxB10-8Fxx, 1FW6160-xxB10-2Pxx

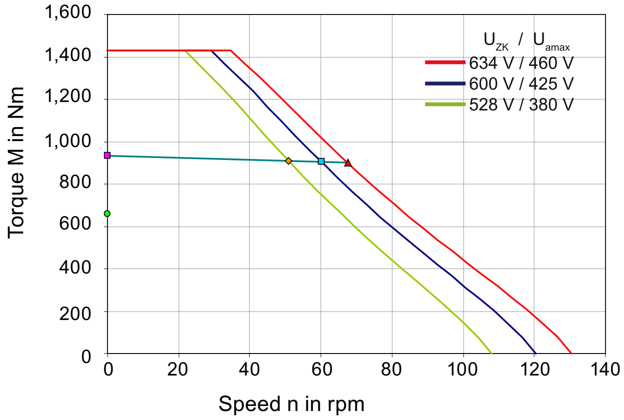
Technical data 1FW6160	Symbol	Unit	-xxB10-8Fxx	-xxB10-2Pxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	732	622
Rated current	I_N	A	61	73
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	390	600
Rated power dissipation	$P_{V,N}$	kW	4.9	4.77
Limit data				
Maximum torque	M_{MAX}	Nm	1430	1430
Maximum current	I_{MAX}	A	140	190
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	49.8	64.6
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	230	330
No-load speed	$n_{MAX,0}$	rpm	540	750
Torque at n = 1 [rpm]	M_0	Nm	933	933
Current at M_0 and n = 1 [rpm]	I_0	A	80	110
Thermal static torque	M_0*	Nm	660	660
Thermal stall current	I_0*	A	55	77
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	11.9	8.51
Voltage constant	k_E	V/(1000/min)	720.4	514.5
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	13.7	13.8
Thermal time constant	t_{TH}	s	180	180
No. of pole pairs	p	-	35	35
Cogging torque	M_{COG}	Nm	4.7	4.7
Stator mass	m_S	kg	49	50.1
Rotor mass	m_L	kg	17.3	17.3
Rotor moment of inertia	J_L	10^{-2} kgm^2	36	36

Technical data 1FW6160	Symbol	Unit	-xxB10-8Fxx	-xxB10-2Pxx
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.182	0.0906
Phase inductance of winding	L_{STR}	mH	1.8	0.9
Data for main motor cooler *)				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	3.68	3.59
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	6.4	6.4
Temperature increase of the coolant	ΔT_H	K	8.3	8.1
Pressure drop	Δp_H	bar	0.8	0.8
Data for precision motor cooler *)				
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.397	0.387
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	2.5	2.5
Temperature increase of the coolant	ΔT_P	K	2.3	2.2
Pressure drop	Δp_H	bar	0.8	0.8

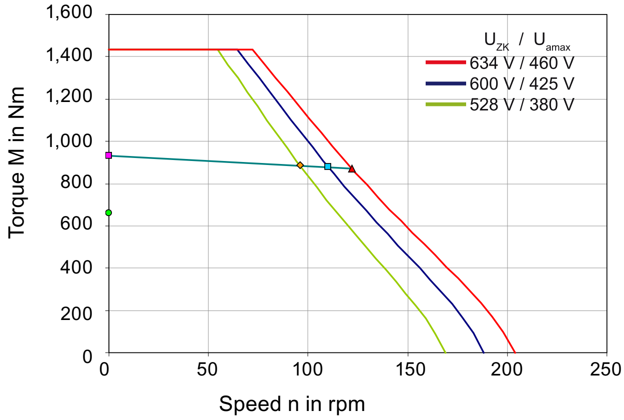
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6160-xxx10-xxxx

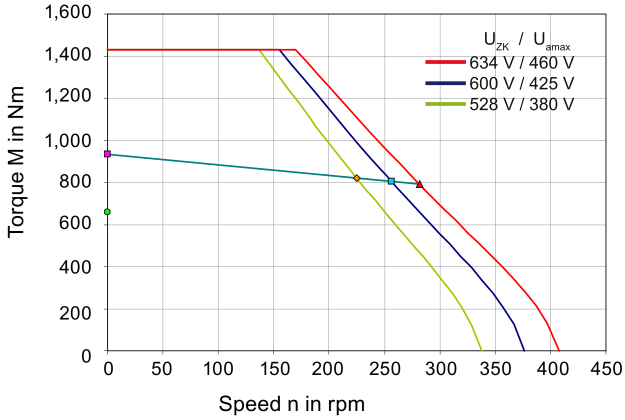
1FW6160-xxB10-1Jxx:
Torque over speed



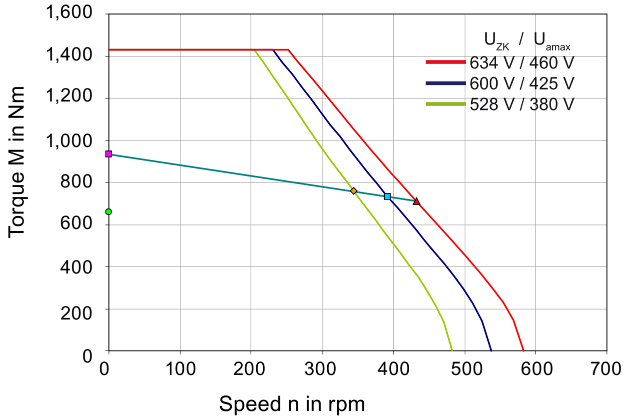
1FW6160-xxB10-2Jxx:
Torque over speed



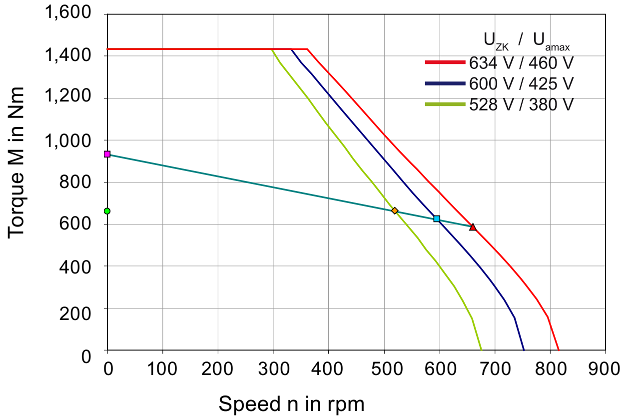
1FW6160-xxB10-5Gxx:
Torque over speed

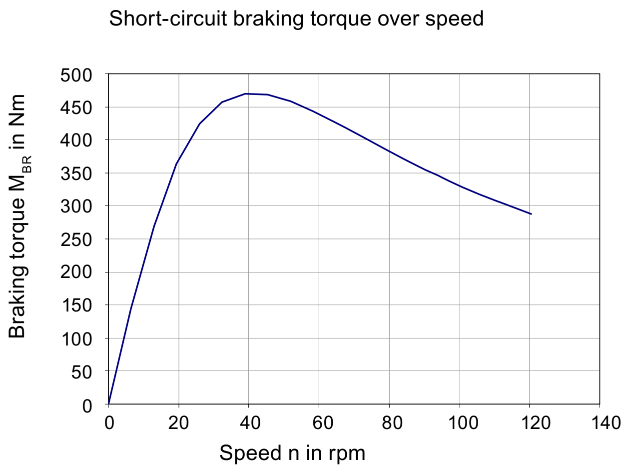


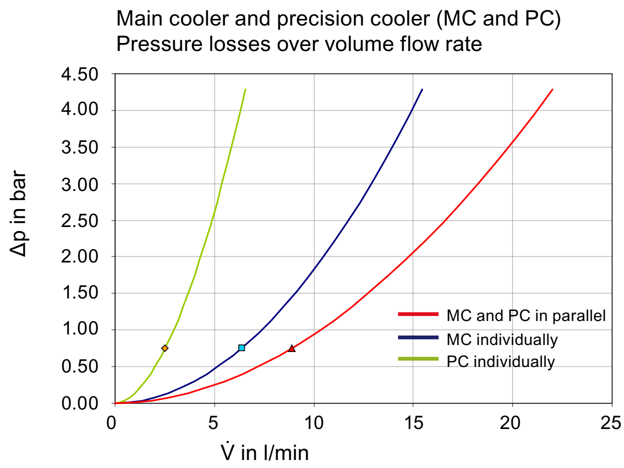
1FW6160-xxB10-8Fxx:
Torque over speed



1FW6160-xxB10-2Pxx:
Torque over speed




Short-circuit braking torque over speed
Braking torque M_{BR} in Nm
500
450
400
350
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140
Speed n in rpm


Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate
Δp in bar
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
5
10
15
20
25
$\dot{V}$ in l/min
MC and PC in parallel
MC individually
PC individually

Data sheet 1FW6160-xxB15-xxxx

Table 14- 18 1FW6160-xxB15-2Jxx, 1FW6160-xxB15-5Gxx, 1FW6160-xxB15-8Fxx

Technical data 1FW6160	Symbol	Unit	-xxB15-2Jxx	-xxB15-5Gxx	-xxB15-8Fxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	1350	1280	1220
Rated current	I_N	A	26	50	68
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	66	160	240
Rated power dissipation	$P_{V,N}$	kW	6.62	6.67	6.84
Limit data					
Maximum torque	M_{MAX}	Nm	2150	2150	2150
Maximum current	I_{MAX}	A	49	98	140
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	28.2	42.6	54.6
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	34	97	150
No-load speed	$n_{MAX,0}$	rpm	130	250	360
Torque at n = 1 [rpm]	M_0	Nm	1400	1400	1400
Current at M_0 and n = 1 [rpm]	I_0	A	28	56	80
Thermal static torque	M_0*	Nm	990	990	990
Thermal stall current	I_0*	A	19	38	55
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	51.1	25.5	17.9
Voltage constant	k_E	V/(1000/min)	3087	1544	1081
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	17.6	17.6	17.3
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	35	35	35
Cogging torque	M_{COG}	Nm	7	7	7
Stator mass	m_S	kg	69.8	69.8	69.8
Rotor mass	m_L	kg	25.5	25.5	25.5
Rotor moment of inertia	J_L	10^{-2} kgm^2	53.1	53.1	53.1
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	2.01	0.506	0.254
Phase inductance of winding	L_{STR}	mH	21.7	5.4	2.7
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	4.97	5.01	5.14
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	8.9	8.9	8.9
Temperature increase of the coolant	ΔT_H	K	8.1	8.1	8.3
Pressure drop	Δp_H	bar	1.4	1.4	1.4

Technical data 1FW6160	Symbol	Unit	-xxB15-2Jxx	-xxB15-5Gxx	-xxB15-8Fxx
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.536	0.54	0.554
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	3.6	3.6	3.6
Temperature increase of the coolant	ΔT_P	K	2.1	2.2	2.2
Pressure drop	Δp_H	bar	1.4	1.4	1.4

*) Parallel connection of main and precision motor cooler

Table 14- 19 1FW6160-xxB15-2Pxx, 1FW6160-xxB15-0Wxx

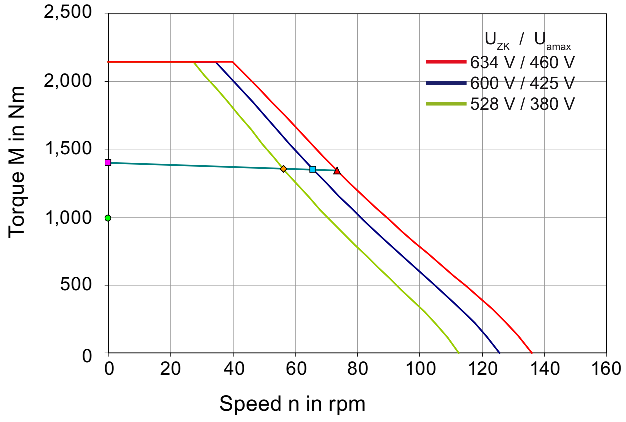
Technical data 1FW6160	Symbol	Unit	-xxB15-2Pxx	-xxB15-0Wxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	1120	961
Rated current	I_N	A	88	100
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	360	560
Rated power dissipation	$P_{V,N}$	kW	6.67	6.84
Limit data				
Maximum torque	M_{MAX}	Nm	2150	2150
Maximum current	I_{MAX}	A	190	280
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	69.5	92.8
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	220	320
No-load speed	$n_{MAX,0}$	rpm	500	720
Torque at n = 1 [rpm]	M_0	Nm	1400	1400
Current at M_0 and n = 1 [rpm]	I_0	A	110	160
Thermal static torque	M_0*	Nm	990	990
Thermal stall current	I_0*	A	77	110
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	12.8	8.94
Voltage constant	k_E	V/(1000/min)	771.8	540.3
Motor constant at 20 °C	$k_{M,20}$	Nm/(W)$^{0.5}$	17.6	17.3
Thermal time constant	t_{TH}	s	180	180
No. of pole pairs	p	-	35	35
Cogging torque	M_{COG}	Nm	7	7
Stator mass	m_S	kg	70.9	70.9
Rotor mass	m_L	kg	25.5	25.5

Technical data 1FW6160	Symbol	Unit	-xxB15-2Pxx	-xxB15-0Wxx
Rotor moment of inertia	J_L	10^{-2} kgm^2	53.1	53.1
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.127	0.0636
Phase inductance of winding	L_{STR}	mH	1.4	0.7
Data for main motor cooler *)				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	5.01	5.14
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	8.9	8.9
Temperature increase of the coolant	ΔT_H	K	8.1	8.3
Pressure drop	Δp_H	bar	1.4	1.4
Data for precision motor cooler *)				
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.54	0.554
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	3.6	3.6
Temperature increase of the coolant	ΔT_P	K	2.2	2.2
Pressure drop	Δp_H	bar	1.4	1.4

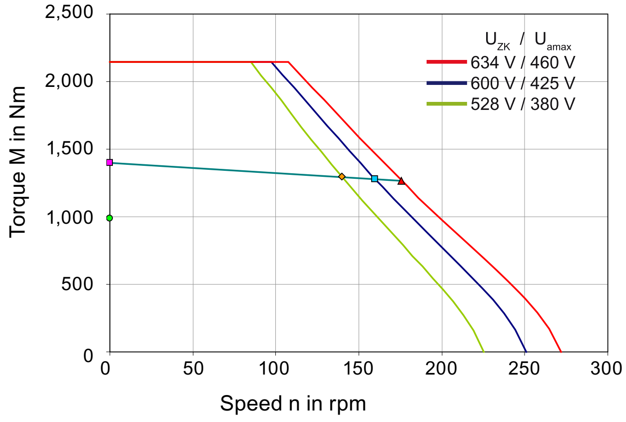
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6160-xxx15-xxxx

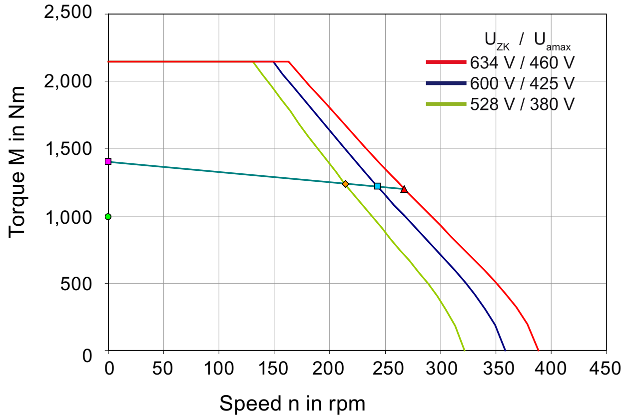
1FW6160-xxB15-2Jxx:
Torque over speed



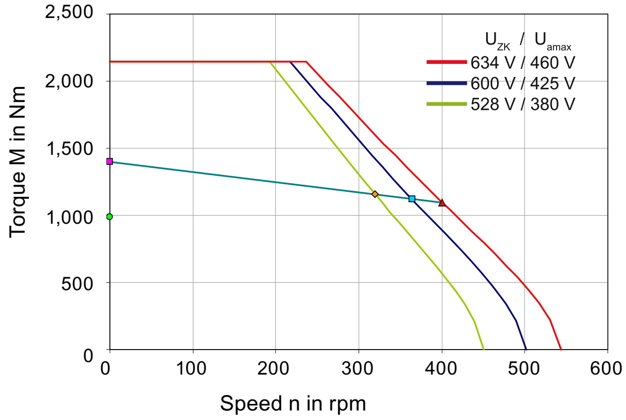
1FW6160-xxB15-5Gxx:
Torque over speed



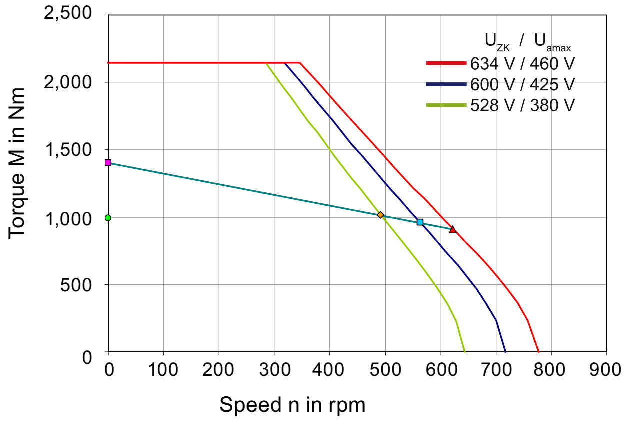
1FW6160-xxB15-8Fxx:
Torque over speed

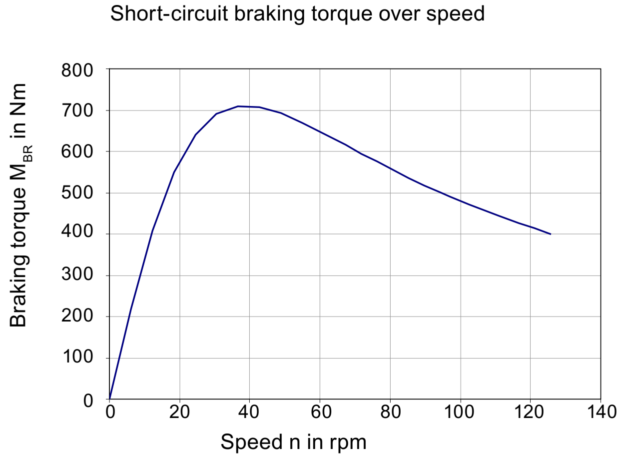


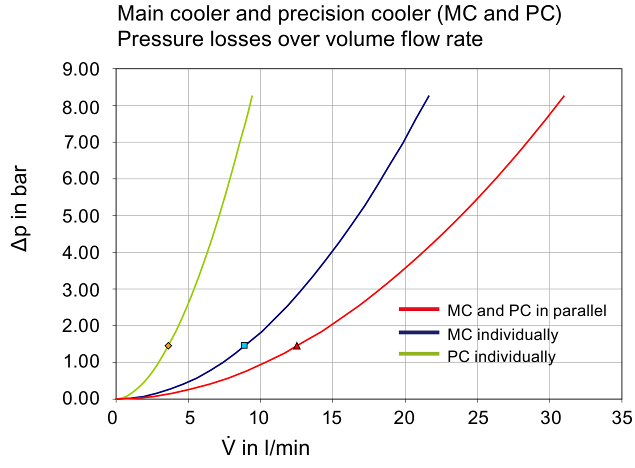
1FW6160-xxB15-2Pxx:
Torque over speed



1FW6160-xxB15-0Wxx:
Torque over speed




Short-circuit braking torque over speed
Braking torque M_{BR} in Nm
800
700
600
500
400
300
200
100
0
0
20
40
60
80
100
120
140
Speed n in rpm


Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate
Δp in bar
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
5
10
15
20
25
30
35
V̇ in l/min
MC and PC in parallel
MC individually
PC individually

Data sheet 1FW6160-xxB20-xxxx

Table 14- 20 1FW6160-xxB20-5Gxx, 1FW6160-xxB20-8Fxx, 1FW6160-xxB20-2Pxx

Technical data 1FW6160	Symbol	Unit	-xxB20-5Gxx	-xxB20-8Fxx	-xxB20-2Pxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	1750	1690	1600
Rated current	I_N	A	52	72	95
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	110	170	260
Rated power dissipation	$P_{V,N}$	kW	8.57	8.79	8.57
Limit data					
Maximum torque	M_{MAX}	Nm	2860	2860	2860
Maximum current	I_{MAX}	A	98	140	190
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	46.9	59.2	74.2
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	68	110	160
No-load speed	$n_{MAX,0}$	rpm	190	270	380
Torque at n = 1 [rpm]	M_0	Nm	1870	1870	1870
Current at M_0 and n = 1 [rpm]	I_0	A	56	80	110
Thermal static torque	M_0*	Nm	1320	1320	1320
Thermal stall current	I_0*	A	38	55	77
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	34	23.8	17
Voltage constant	k_E	V/(1000/min)	2058	1441	1029
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	20.6	20.4	20.6
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	35	35	35
Cogging torque	M_{COG}	Nm	9.3	9.3	9.3
Stator mass	m_S	kg	90.6	90.6	91.7
Rotor mass	m_L	kg	33.7	33.7	33.7
Rotor moment of inertia	J_L	10^{-2} kgm^2	70.1	70.1	70.1
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.65	0.327	0.163
Phase inductance of winding	L_{STR}	mH	7.2	3.5	1.8
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	6.43	6.6	6.43
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	11.4	11.4	11.4
Temperature increase of the coolant	ΔT_H	K	8.1	8.4	8.1
Pressure drop	Δp_H	bar	2.3	2.3	2.3

Technical data 1FW6160	Symbol	Unit	-xxB20-5Gxx	-xxB20-8Fxx	-xxB20-2Pxx
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.694	0.712	0.694
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	4.7	4.7	4.7
Temperature increase of the coolant	ΔT_P	K	2.1	2.2	2.1
Pressure drop	Δp_H	bar	2.3	2.3	2.3

*) Parallel connection of main and precision motor cooler

Table 14- 21 1FW6160-xxB20-0Wxx

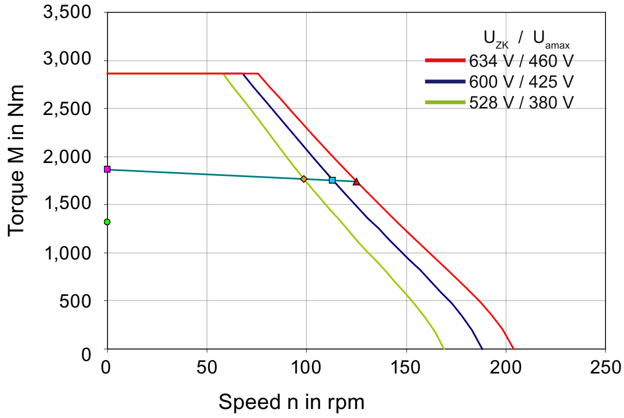
Technical data 1FW6160	Symbol	Unit	-xxB20-0Wxx
Boundary conditions			
DC link voltages	U_{ZK}	V	600
Water cooling inlet temperature	T_{VORL}	°C	35
Rated temperature of winding	T_N	°C	130
Rated data			
Rated torque	M_N	Nm	1460
Rated current	I_N	A	120
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	400
Rated power dissipation	$P_{V,N}$	kW	8.79
Limit data			
Maximum torque	M_{MAX}	Nm	2860
Maximum current	I_{MAX}	A	280
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	97.7
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	240
No-load speed	$n_{MAX,0}$	rpm	540
Torque at n = 1 [rpm]	M_0	Nm	1870
Current at M_0 and n = 1 [rpm]	I_0	A	160
Thermal static torque	M_0*	Nm	1320
Thermal stall current	I_0*	A	110
Physical constants			
Torque constant at 20 °C	$k_{T,20}$	Nm/A	11.9
Voltage constant	k_E	V/(1000/min)	720.4
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	20.4
Thermal time constant	t_{TH}	s	180
No. of pole pairs	p	-	35
Cogging torque	M_{COG}	Nm	9.3
Stator mass	m_S	kg	91.7
Rotor mass	m_L	kg	33.7

Technical data 1FW6160	Symbol	Unit	-xxB20-0Wxx
Rotor moment of inertia	J_L	10^{-2} kgm²	70.1
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.0817
Phase inductance of winding	L_{STR}	mH	0.9
Data for main motor cooler *)			
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	6.6
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	11.4
Temperature increase of the coolant	ΔT_H	K	8.4
Pressure drop	Δp_H	bar	2.3
Data for precision motor cooler *)			
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.712
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	4.7
Temperature increase of the coolant	ΔT_P	K	2.2
Pressure drop	Δp_H	bar	2.3

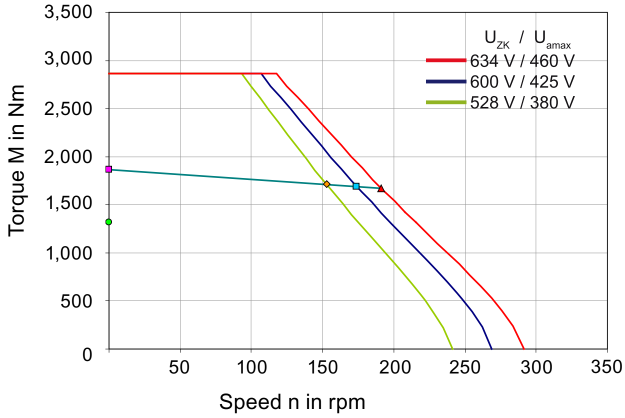
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6160-xxx20-xxxx

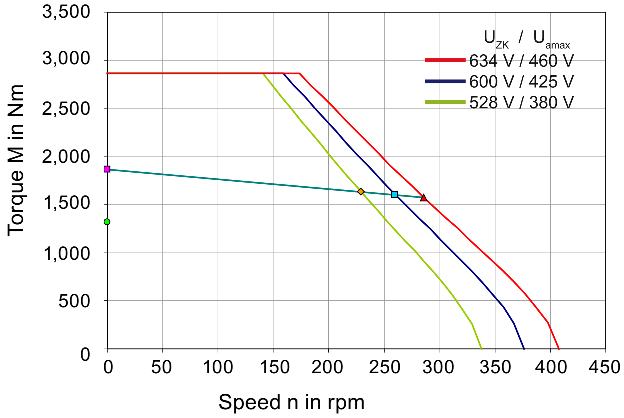
1FW6160-xxB20-5Gxx:
Torque over speed



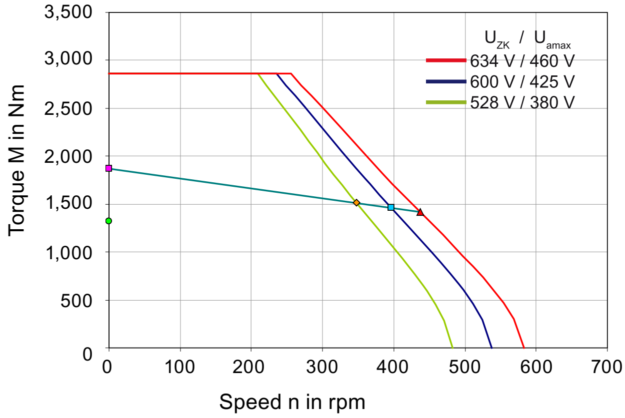
1FW6160-xxB20-8Fxx:
Torque over speed



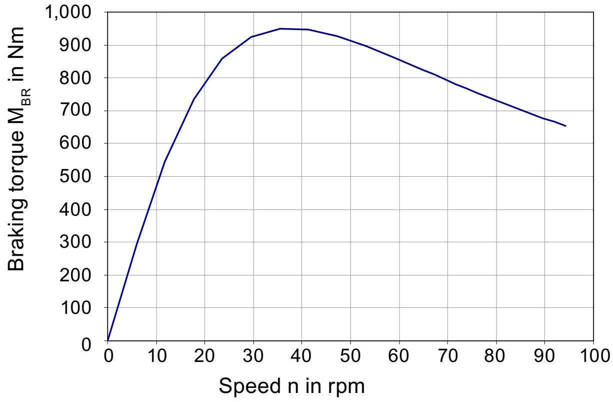
1FW6160-xxB20-2Pxx:
Torque over speed



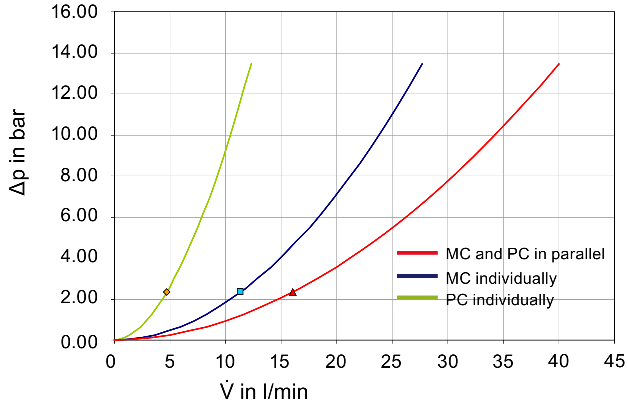
1FW6160-xxB20-0Wxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate



14.2.5 1FW6190-xxxxx-xxxx

Data sheet 1FW6190-xxB05-xxxx

Table 14- 22 1FW6190-xxB05-1Jxx, 1FW6190-xxB05-2Jxx, 1FW6190-xxB05-5Gxx

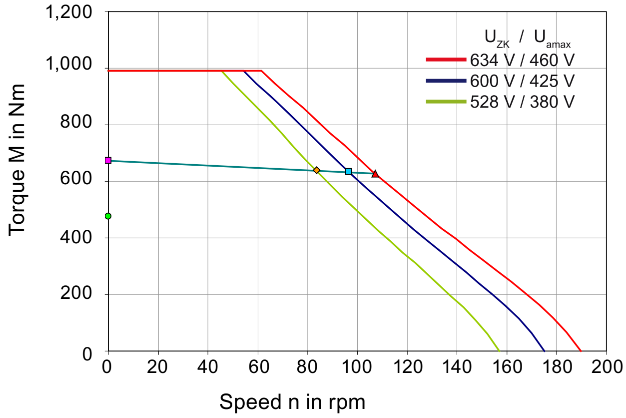
Technical data 1FW6190	Symbol	Unit	-xxB05-1Jxx	-xxB05-2Jxx	-xxB05-5Gxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	633	605	509
Rated current	I_N	A	17	24	40
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	97	160	380
Rated power dissipation	$P_{V,N}$	kW	3.51	3.51	3.51
Limit data					
Maximum torque	M_{MAX}	Nm	990	990	990
Maximum current	I_{MAX}	A	31	47	95
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	16.3	20.6	32.9
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	54	96	210
No-load speed	$n_{MAX,0}$	rpm	180	260	530
Torque at n = 1 [rpm]	M_0	Nm	672	672	672
Current at M_0 and n = 1 [rpm]	I_0	A	18	27	54
Thermal static torque	M_0*	Nm	475	475	475
Thermal stall current	I_0*	A	12	18	37
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	38.7	25.8	12.9
Voltage constant	k_E	V/(1000/min)	2338	1559	779.4
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	11.9	11.9	11.9
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	42	42	42
Cogging torque	M_{COG}	Nm	3.4	3.4	3.4
Stator mass	m_S	kg	32.1	32.1	32.1
Rotor mass	m_L	kg	10.7	10.7	10.7
Rotor moment of inertia	J_L	10^{-2} kgm²	35.8	35.8	35.8
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	2.53	1.12	0.281
Phase inductance of winding	L_{STR}	mH	21.5	9.6	2.4
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	2.64	2.64	2.64
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	5.2	5.2	5.2

Technical data 1FW6190	Symbol	Unit	-xxB05-1Jxx	-xxB05-2Jxx	-xxB05-5Gxx
Temperature increase of the coolant	ΔT_H	K	7.3	7.3	7.3
Pressure drop	Δp_H	bar	0.5	0.5	0.5
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.284	0.284	0.284
Recommended minimum volume flow rate	$\dot{V}_{P,MIN}$	l/min	1.8	1.8	1.8
Temperature increase of the coolant	ΔT_P	K	2.3	2.3	2.3
Pressure drop	Δp_H	bar	0.5	0.5	0.5

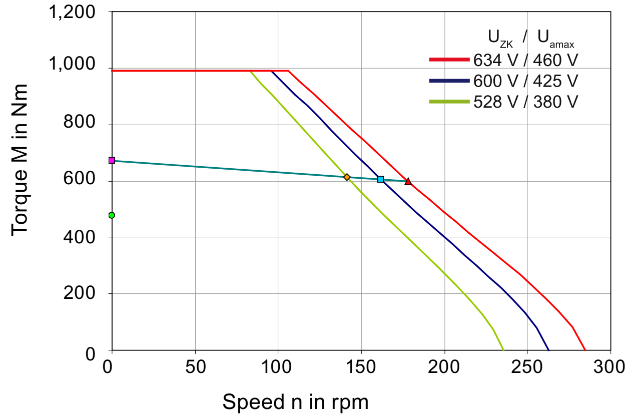
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6190-xxx05-xxxx

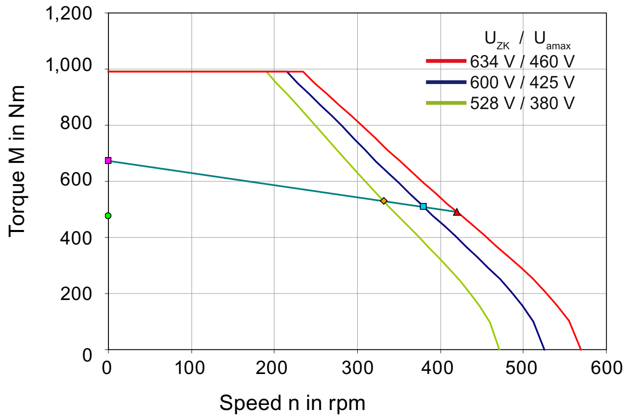
1FW6190-xxB05-1Jxx:
Torque over speed



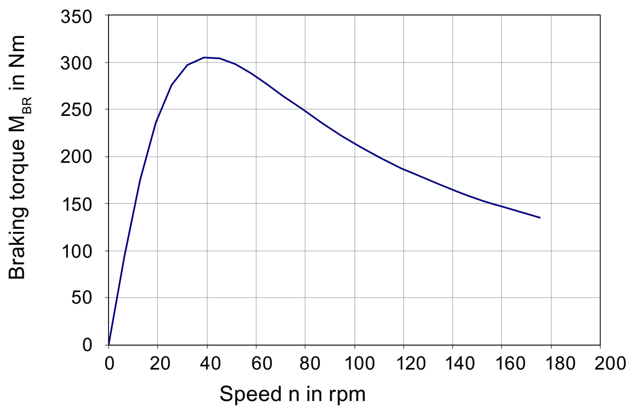
1FW6190-xxB05-2Jxx:
Torque over speed



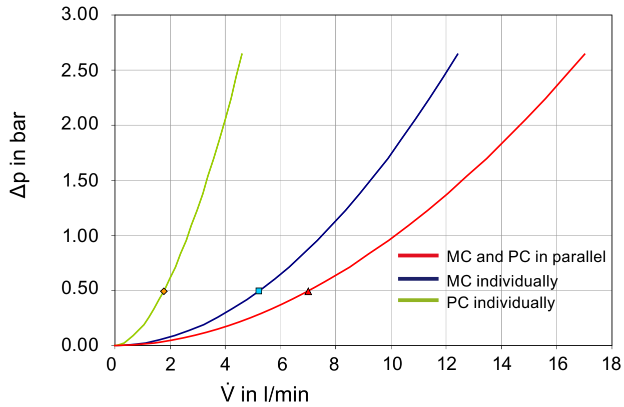
1FW6190-xxB05-5Gxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate



Data sheet 1FW6190-xxB07-xxxx

Table 14- 23 1FW6190-xxB07-1Jxx, 1FW6190-xxB07-2Jxx, 1FW6190-xxB07-5Gxx

Technical data 1FW6190	Symbol	Unit	-xxB07-1Jxx	-xxB07-2Jxx	-xxB07-5Gxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	905	879	791
Rated current	I_N	A	17	25	44
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	63	110	250
Rated power dissipation	$P_{V,N}$	kW	4.44	4.44	4.44
Limit data					
Maximum torque	M_{MAX}	Nm	1390	1390	1390
Maximum current	I_{MAX}	A	31	47	95
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	18.2	22.7	35.4
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	33	64	150
No-load speed	$n_{MAX,0}$	rpm	130	190	380
Torque at n = 1 [rpm]	M_0	Nm	941	941	941
Current at M_0 and n = 1 [rpm]	I_0	A	18	27	54
Thermal static torque	M_0*	Nm	666	666	666
Thermal stall current	I_0*	A	12	18	37
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	54.1	36.1	18
Voltage constant	k_E	V/(1000/min)	3274	2182	1091
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	14.8	14.8	14.8
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	42	42	42
Cogging torque	M_{COG}	Nm	4.7	4.7	4.7
Stator mass	m_S	kg	41.2	41.2	41.2
Rotor mass	m_L	kg	14.6	14.6	14.6
Rotor moment of inertia	J_L	10^{-2} kgm^2	48.6	48.6	48.6
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	3.19	1.42	0.355
Phase inductance of winding	L_{STR}	mH	29.8	13.2	3.3
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	3.33	3.33	3.33
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	5.9	5.9	5.9
Temperature increase of the coolant	ΔT_H	K	8.1	8.1	8.1
Pressure drop	Δp_H	bar	0.6	0.6	0.6

Technical data 1FW6190	Symbol	Unit	-xxB07-1Jxx	-xxB07-2Jxx	-xxB07-5Gxx
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.359	0.359	0.359
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	2	2	2
Temperature increase of the coolant	ΔT_P	K	2.5	2.5	2.5
Pressure drop	Δp_H	bar	0.6	0.6	0.6

*) Parallel connection of main and precision motor cooler

Table 14- 24 1FW6190-xxB07-8Fxx

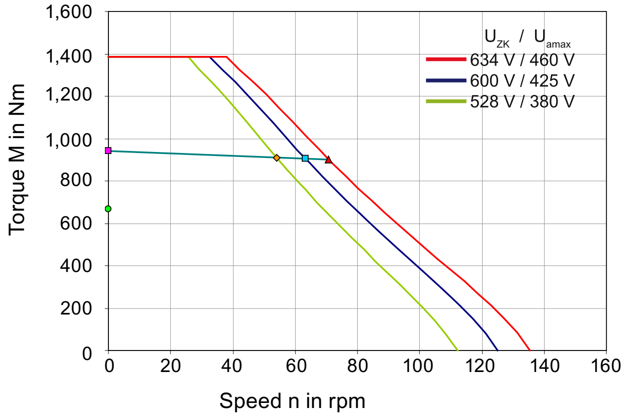
Technical data 1FW6190	Symbol	Unit	-xxB07-8Fxx
Boundary conditions			
DC link voltages	U_{ZK}	V	600
Water cooling inlet temperature	T_{VORL}	°C	35
Rated temperature of winding	T_N	°C	130
Rated data			
Rated torque	M_N	Nm	704
Rated current	I_N	A	56
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	390
Rated power dissipation	$P_{V,N}$	kW	4.57
Limit data			
Maximum torque	M_{MAX}	Nm	1390
Maximum current	I_{MAX}	A	130
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	46.3
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	220
No-load speed	$n_{MAX,0}$	rpm	540
Torque at n = 1 [rpm]	M_0	Nm	941
Current at M_0 and n = 1 [rpm]	I_0	A	78
Thermal static torque	M_0*	Nm	666
Thermal stall current	I_0*	A	53
Physical constants			
Torque constant at 20 °C	$k_{T,20}$	Nm/A	12.6
Voltage constant	k_E	V/(1000/min)	763.8
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	14.6
Thermal time constant	t_{TH}	s	180
No. of pole pairs	p	-	42
Cogging torque	M_{COG}	Nm	4.7
Stator mass	m_S	kg	41.2
Rotor mass	m_L	kg	14.6

Technical data 1FW6190	Symbol	Unit	-xxB07-8Fxx
Rotor moment of inertia	J_L	10^{-2} kgm^2	48.6
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.179
Phase inductance of winding	L_{STR}	mH	1.6
Data for main motor cooler *)			
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	3.43
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	5.9
Temperature increase of the coolant	ΔT_H	K	8.3
Pressure drop	Δp_H	bar	0.6
Data for precision motor cooler *)			
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.370
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	2
Temperature increase of the coolant	ΔT_P	K	2.6
Pressure drop	Δp_H	bar	0.6

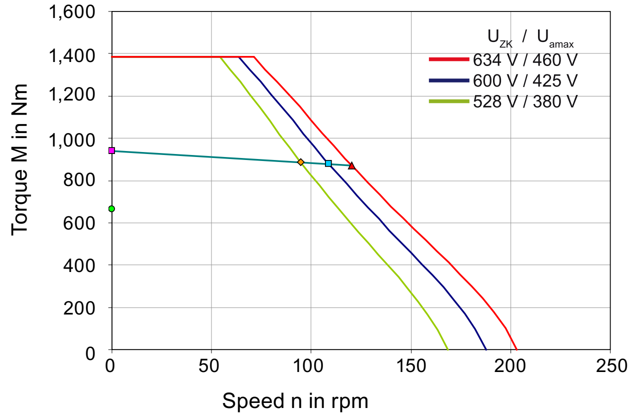
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6190-xxx07-xxxx

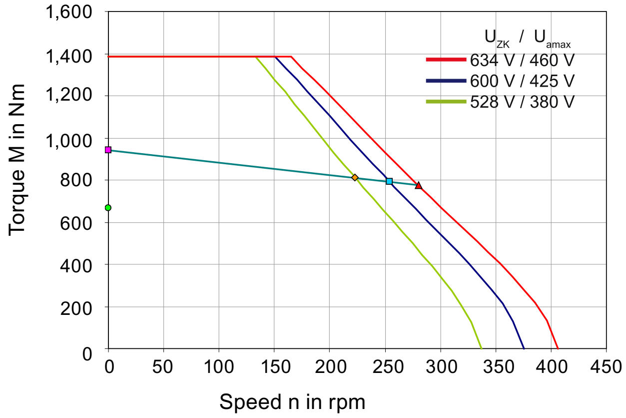
1FW6190-xxB07-1Jxx:
Torque over speed



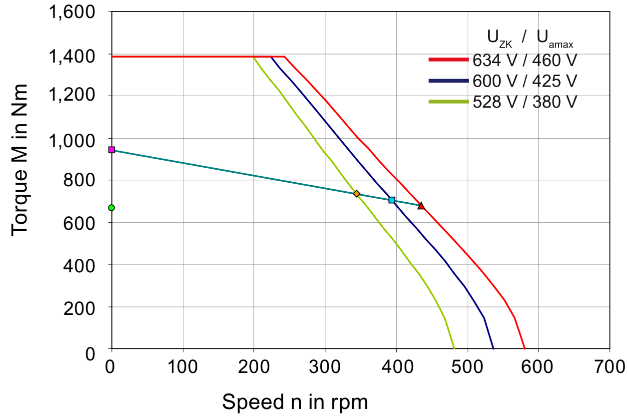
1FW6190-xxB07-2Jxx:
Torque over speed



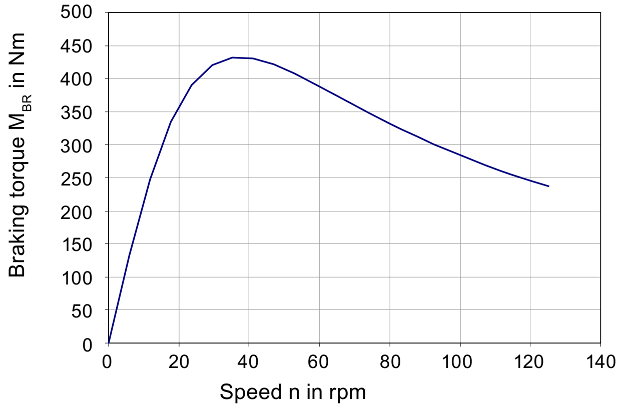
1FW6190-xxB07-5Gxx:
Torque over speed



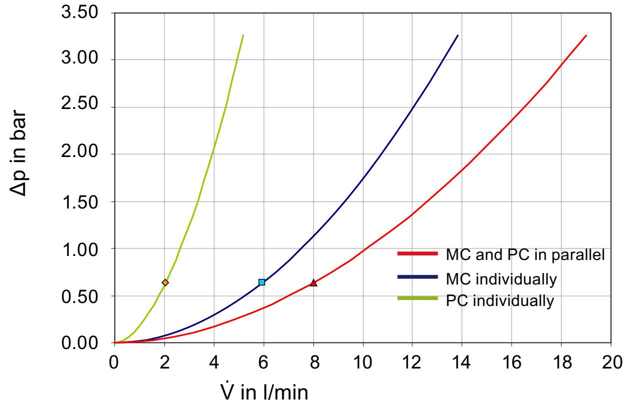
1FW6190-xxB07-8Fxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate



Data sheet 1FW6190-xxB10-xxxx

Table 14- 25 1FW6190-xxB10-1Jxx, 1FW6190-xxB10-2Jxx, 1FW6190-xxB10-5Gxx

Technical data 1FW6190	Symbol	Unit	-xxB10-1Jxx	-xxB10-2Jxx	-xxB10-5Gxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	1310	1290	1210
Rated current	I_N	A	17	26	48
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	38	70	170
Rated power dissipation	$P_{V,N}$	kW	5.83	5.83	5.83
Limit data					
Maximum torque	M_{MAX}	Nm	1980	1980	1980
Maximum current	I_{MAX}	A	31	47	95
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	20.7	25.7	38.7
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	14	39	100
No-load speed	$n_{MAX,0}$	rpm	88	130	260
Torque at n = 1 [rpm]	M_0	Nm	1340	1340	1340
Current at M_0 and n = 1 [rpm]	I_0	A	18	27	54
Thermal static torque	M_0*	Nm	951	951	951
Thermal stall current	I_0*	A	12	18	37
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	77.3	51.6	25.8
Voltage constant	k_E	V/(1000/min)	4676	3118	1559
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	18.5	18.5	18.5
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	42	42	42
Cogging torque	M_{COG}	Nm	6.7	6.7	6.7
Stator mass	m_S	kg	55.5	55.5	55.5
Rotor mass	m_L	kg	20.3	20.3	20.3
Rotor moment of inertia	J_L	10^{-2} kgm^2	67.8	67.8	67.8
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	4.19	1.86	0.466
Phase inductance of winding	L_{STR}	mH	42.2	18.8	4.7
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	4.38	4.38	4.38
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	6.7	6.7	6.7
Temperature increase of the coolant	ΔT_H	K	9.4	9.4	9.4
Pressure drop	Δp_H	bar	0.8	0.8	0.8

Technical data 1FW6190	Symbol	Unit	-xxB10-1Jxx	-xxB10-2Jxx	-xxB10-5Gxx
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.472	0.472	0.472
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	2.3	2.3	2.3
Temperature increase of the coolant	ΔT_P	K	2.9	2.9	2.9
Pressure drop	Δp_H	bar	0.8	0.8	0.8

*) Parallel connection of main and precision motor cooler

Table 14- 26 1FW6190-xxB10-8Fxx, 1FW6190-xxB10-2Pxx

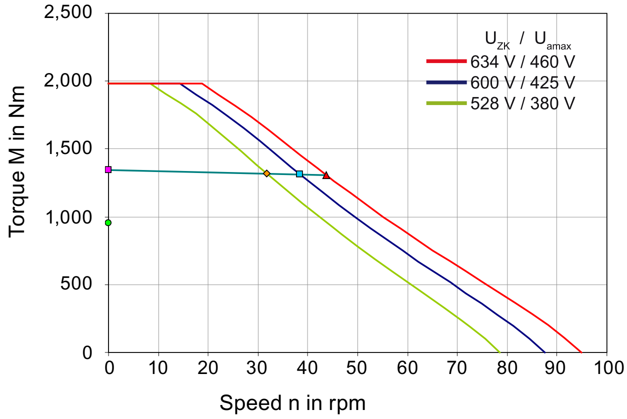
Technical data 1FW6190	Symbol	Unit	-xxB10-8Fxx	-xxB10-2Pxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	1130	955
Rated current	I_N	A	64	84
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	260	450
Rated power dissipation	$P_{V,N}$	kW	6	5.87
Limit data				
Maximum torque	M_{MAX}	Nm	1980	1980
Maximum current	I_{MAX}	A	130	210
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	49.9	69.9
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	150	250
No-load speed	$n_{MAX,0}$	rpm	380	590
Torque at n = 1 [rpm]	M_0	Nm	1340	1340
Current at M_0 and n = 1 [rpm]	I_0	A	78	120
Thermal static torque	M_0*	Nm	951	951
Thermal stall current	I_0*	A	53	83
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	18	11.5
Voltage constant	k_E	V/(1000/min)	1091	693.7
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	18.2	18.4
Thermal time constant	t_{TH}	s	180	180
No. of pole pairs	p	-	42	42
Cogging torque	M_{COG}	Nm	6.7	6.7
Stator mass	m_S	kg	55.5	56.8
Rotor mass	m_L	kg	20.3	20.3

Technical data 1FW6190	Symbol	Unit	-xxB10-8Fxx	-xxB10-2Pxx
Rotor moment of inertia	J_L	10^{-2} kgm²	67.8	67.8
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.235	0.093
Phase inductance of winding	L_{STR}	mH	2.3	0.9
Data for main motor cooler *)				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	4.51	4.41
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	6.7	6.7
Temperature increase of the coolant	ΔT_H	K	9.7	9.5
Pressure drop	Δp_H	bar	0.8	0.8
Data for precision motor cooler *)				
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.486	0.476
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	2.3	2.3
Temperature increase of the coolant	ΔT_P	K	3	2.9
Pressure drop	Δp_H	bar	0.8	0.8

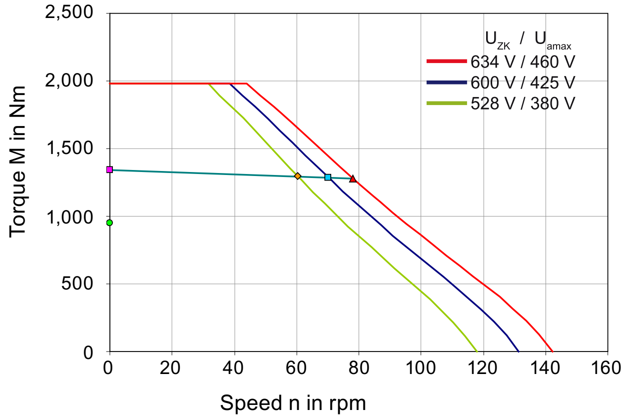
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6190-xxx10-xxxx

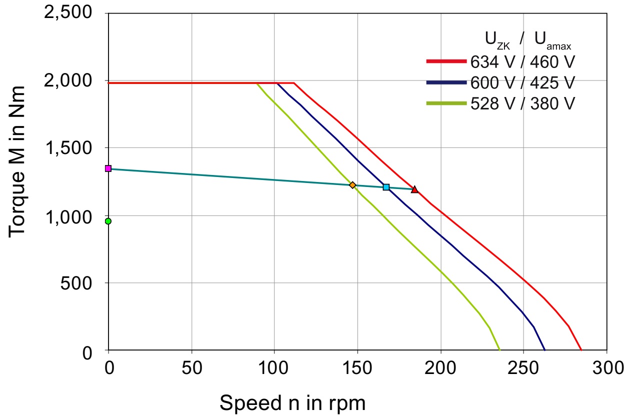
1FW6190-xxB10-1Jxx:
Torque over speed



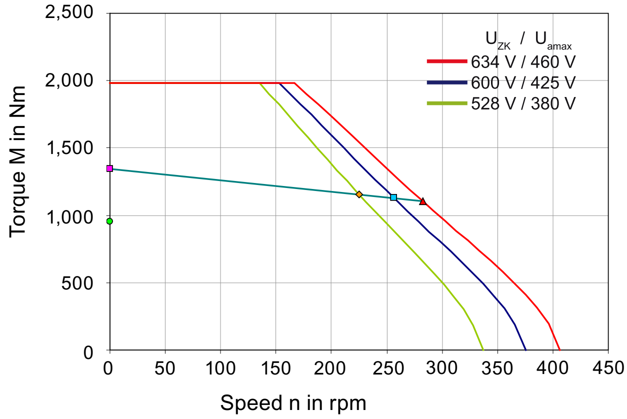
1FW6190-xxB10-2Jxx:
Torque over speed



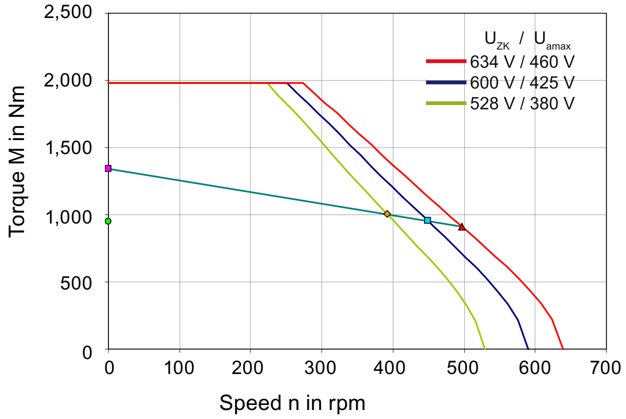
1FW6190-xxB10-5Gxx:
Torque over speed

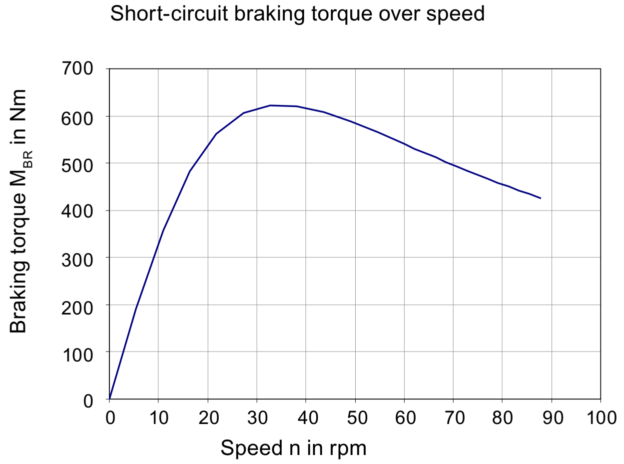


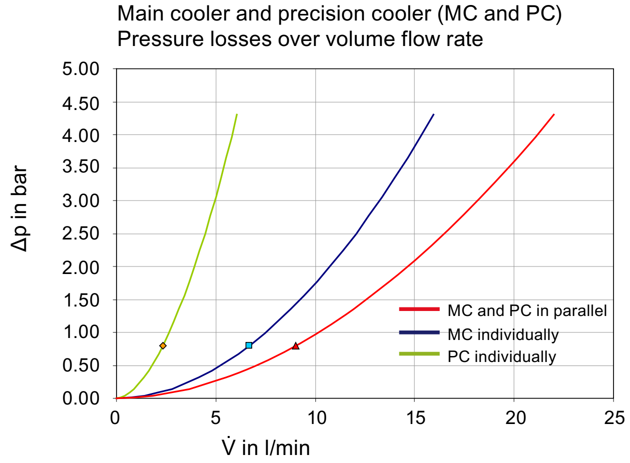
1FW6190-xxB10-8Fxx:
Torque over speed



1FW6190-xxB10-2Pxx:
Torque over speed




Short-circuit braking torque over speed
700
600
500
400
300
200
100
0
Braking torque M_BR in Nm
0 10 20 30 40 50 60 70 80 90 100
Speed n in rpm


Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Δp in bar
0 5 10 15 20 25
V̇ in l/min
MC and PC in parallel
MC individually
PC individually

Data sheet 1FW6190-xxB15-xxxx

Table 14- 27 1FW6190-xxB15-2Jxx, 1FW6190-xxB15-5Gxx, 1FW6190-xxB15-8Fxx

Technical data 1FW6190	Symbol	Unit	-xxB15-2Jxx	-xxB15-5Gxx	-xxB15-8Fxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	1970	1890	1820
Rated current	I_N	A	26	50	69
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	40	100	160
Rated power dissipation	$P_{V,N}$	kW	8.14	8.14	8.39
Limit data					
Maximum torque	M_{MAX}	Nm	2970	2970	2970
Maximum current	I_{MAX}	A	47	95	130
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	30.1	44.1	55.6
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	17	62	97
No-load speed	$n_{MAX,0}$	rpm	88	180	250
Torque at n = 1 [rpm]	M_0	Nm	2020	2020	2020
Current at M_0 and n = 1 [rpm]	I_0	A	27	54	78
Thermal static torque	M_0*	Nm	1430	1430	1430
Thermal stall current	I_0*	A	18	37	53
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	77.3	38.7	27.1
Voltage constant	k_E	V/(1000/min)	4676	2338	1637
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	23.4	23.4	23.1
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	42	42	42
Cogging torque	M_{COG}	Nm	10	10	10
Stator mass	m_S	kg	77.8	77.8	77.8
Rotor mass	m_L	kg	30	30	30
Rotor moment of inertia	J_L	10^{-2} kgm^2	99.8	99.8	99.8
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	2.6	0.651	0.329
Phase inductance of winding	L_{STR}	mH	28	7	3.4
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	6.11	6.11	6.3
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	8.8	8.8	8.8
Temperature increase of the coolant	ΔT_H	K	9.9	9.9	10.2
Pressure drop	Δp_H	bar	1.4	1.4	1.4

Technical data 1FW6190	Symbol	Unit	-xxB15-2Jxx	-xxB15-5Gxx	-xxB15-8Fxx
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.659	0.659	0.679
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	3.2	3.2	3.2
Temperature increase of the coolant	ΔT_P	K	3	3	3.1
Pressure drop	Δp_H	bar	1.4	1.4	1.4

*) Parallel connection of main and precision motor cooler

Table 14- 28 1FW6190-xxB15-2Pxx, 1FW6190-xxB15-0Wxx

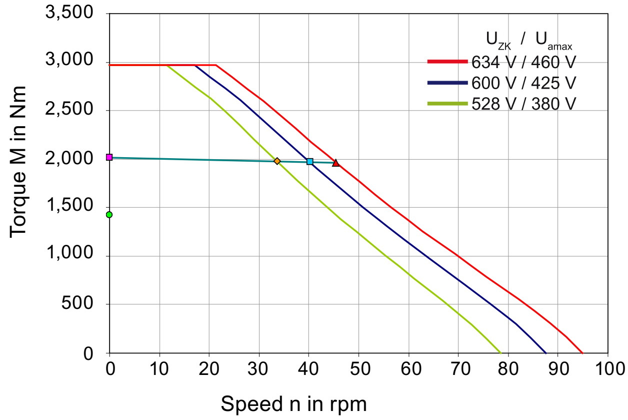
Technical data 1FW6190	Symbol	Unit	-xxB15-2Pxx	-xxB15-0Wxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	1670	1540
Rated current	I_N	A	99	110
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	270	370
Rated power dissipation	$P_{V,N}$	kW	8.21	8.39
Limit data				
Maximum torque	M_{MAX}	Nm	2970	2970
Maximum current	I_{MAX}	A	210	270
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	75.8	91.5
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	160	210
No-load speed	$n_{MAX,0}$	rpm	390	500
Torque at n = 1 [rpm]	M_0	Nm	2020	2020
Current at M_0 and n = 1 [rpm]	I_0	A	120	150
Thermal static torque	M_0*	Nm	1430	1430
Thermal stall current	I_0*	A	83	100
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	17.2	13.5
Voltage constant	k_E	V/(1000/min)	1041	818.4
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	23.3	23.1
Thermal time constant	t_{TH}	s	180	180
No. of pole pairs	p	-	42	42
Cogging torque	M_{COG}	Nm	10	10
Stator mass	m_S	kg	79.1	79.1
Rotor mass	m_L	kg	30	30

Technical data 1FW6190	Symbol	Unit	-xxB15-2Pxx	-xxB15-0Wxx
Rotor moment of inertia	J_L	10^{-2} kgm²	99.8	99.8
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.13	0.0822
Phase inductance of winding	L_{STR}	mH	1.4	0.9
Data for main motor cooler *)				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	6.17	6.3
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	8.8	8.8
Temperature increase of the coolant	ΔT_H	K	10	10.2
Pressure drop	Δp_H	bar	1.4	1.4
Data for precision motor cooler *)				
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.665	0.679
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	3.2	3.2
Temperature increase of the coolant	ΔT_P	K	3	3.1
Pressure drop	Δp_H	bar	1.4	1.4

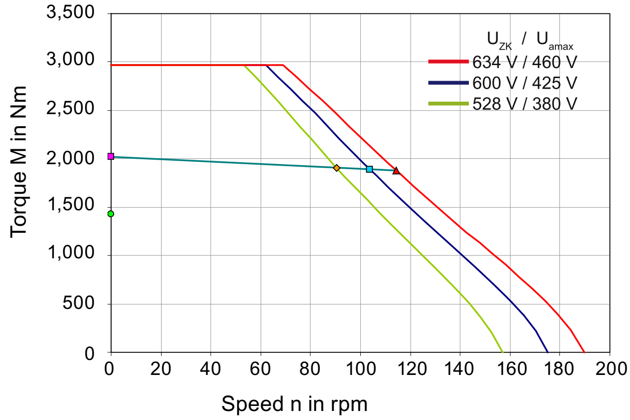
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6190-xxx15-xxxx

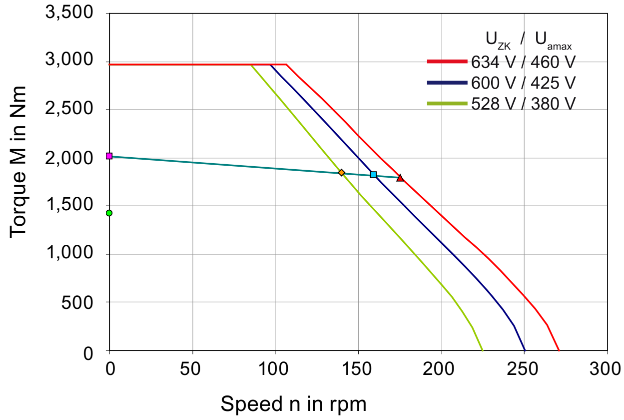
1FW6190-xxB15-2Jxx:
Torque over speed



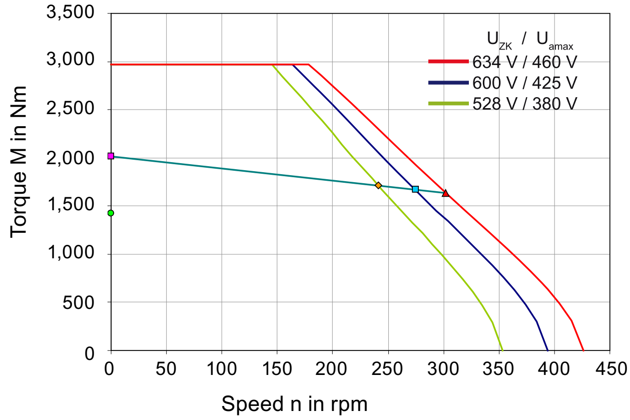
1FW6190-xxB15-5Gxx:
Torque over speed



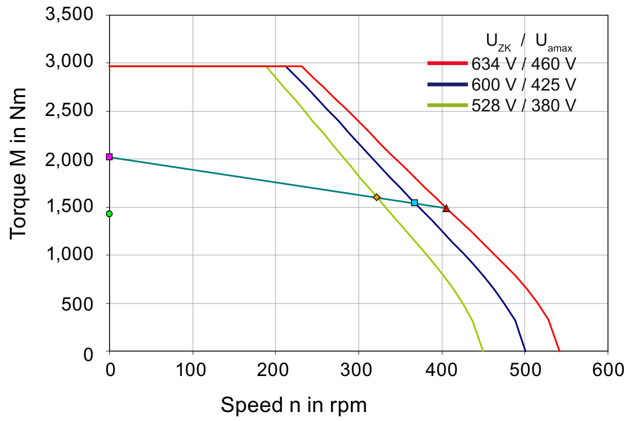
1FW6190-xxB15-8Fxx:
Torque over speed

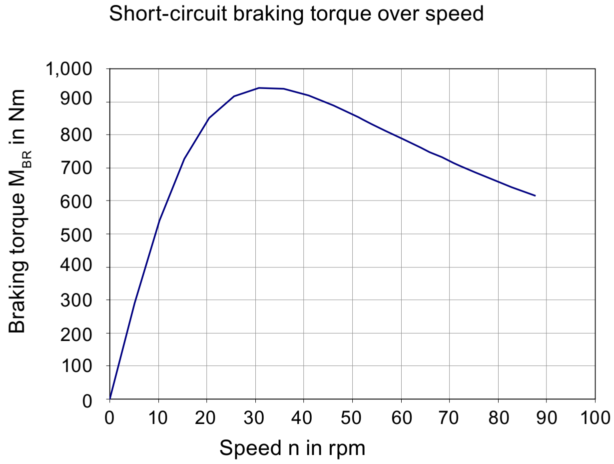


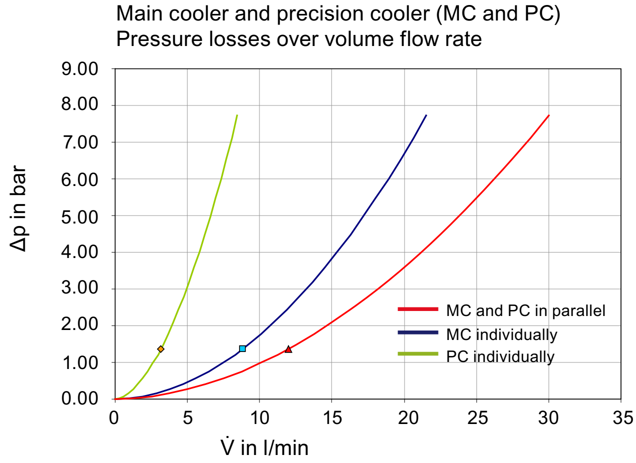
1FW6190-xxB15-2Pxx:
Torque over speed



1FW6190-xxB15-0Wxx:
Torque over speed




Short-circuit braking torque over speed
1,000
900
800
700
600
500
400
300
200
100
0
Braking torque M_{BR} in Nm
0
10
20
30
40
50
60
70
80
90
100
Speed n in rpm


Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Δp in bar
0
5
10
15
20
25
30
35
V̇ in l/min
MC and PC in parallel
MC individually
PC individually

Data sheet 1FW6190-xxB20-xxxx

Table 14- 29 1FW6190-xxB20-5Gxx, 1FW6190-xxB20-8Fxx, 1FW6190-xxB20-2Pxx

Technical data 1FW6190	Symbol	Unit	-xxB20-5Gxx	-xxB20-8Fxx	-xxB20-2Pxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	2570	2500	2360
Rated current	I_N	A	51	71	100
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	73	110	200
Rated power dissipation	$P_{V,N}$	kW	10.5	10.8	10.5
Limit data					
Maximum torque	M_{MAX}	Nm	3960	3960	3960
Maximum current	I_{MAX}	A	95	130	210
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	49	61.1	81.5
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	42	68	120
No-load speed	$n_{MAX,0}$	rpm	130	190	300
Torque at n = 1 [rpm]	M_0	Nm	2690	2690	2690
Current at M_0 and n = 1 [rpm]	I_0	A	54	78	120
Thermal static torque	M_0*	Nm	1900	1900	1900
Thermal stall current	I_0*	A	37	53	83
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	51.6	36.1	22.9
Voltage constant	k_E	V/(1000/min)	3118	2182	1387
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	27.6	27.2	27.5
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	42	42	42
Cogging torque	M_{COG}	Nm	13	13	13
Stator mass	m_S	kg	96.6	96.6	97.9
Rotor mass	m_L	kg	39.6	39.6	39.6
Rotor moment of inertia	J_L	10^{-2} kgm^2	132	132	132
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.836	0.422	0.167
Phase inductance of winding	L_{STR}	mH	9.3	4.6	1.8
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	7.85	8.09	7.92
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	12.8	12.8	12.8
Temperature increase of the coolant	ΔT_H	K	8.9	9.1	8.9
Pressure drop	Δp_H	bar	2.8	2.8	2.8

Technical data 1FW6190	Symbol	Unit	-xxB20-5Gxx	-xxB20-8Fxx	-xxB20-2Pxx
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.847	0.873	0.854
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	4.7	4.7	4.7
Temperature increase of the coolant	ΔT_P	K	2.6	2.6	2.6
Pressure drop	Δp_H	bar	2.8	2.8	2.8

*) Parallel connection of main and precision motor cooler

Table 14- 30 1FW6190-xxB20-0Wxx

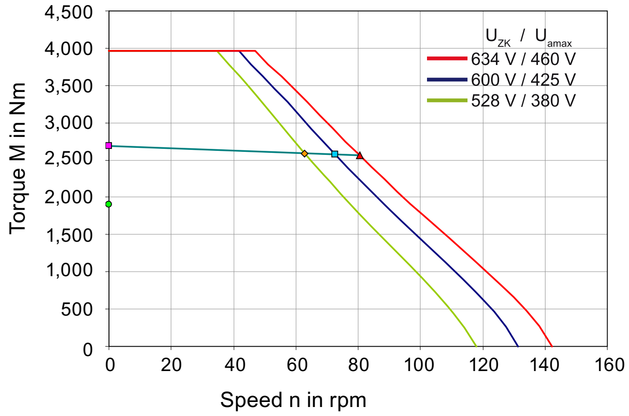
Technical data 1FW6190	Symbol	Unit	-xxB20-0Wxx
Boundary conditions			
DC link voltages	U_{ZK}	V	600
Water cooling inlet temperature	T_{VORL}	°C	35
Rated temperature of winding	T_N	°C	130
Rated data			
Rated torque	M_N	Nm	2250
Rated current	I_N	A	120
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	260
Rated power dissipation	$P_{V,N}$	kW	10.8
Limit data			
Maximum torque	M_{MAX}	Nm	3960
Maximum current	I_{MAX}	A	270
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	97.4
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	160
No-load speed	$n_{MAX,0}$	rpm	380
Torque at n = 1 [rpm]	M_0	Nm	2690
Current at M_0 and n = 1 [rpm]	I_0	A	150
Thermal static torque	M_0*	Nm	1900
Thermal stall current	I_0*	A	100
Physical constants			
Torque constant at 20 °C	$k_{T,20}$	Nm/A	18
Voltage constant	k_E	V/(1000/min)	1091
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	27.2
Thermal time constant	t_{TH}	s	180
No. of pole pairs	p	-	42
Cogging torque	M_{COG}	Nm	13
Stator mass	m_S	kg	97.9
Rotor mass	m_L	kg	39.6

Technical data 1FW6190	Symbol	Unit	-xxB20-0Wxx
Rotor moment of inertia	J_L	10^{-2} kgm^2	132
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.106
Phase inductance of winding	L_{STR}	mH	1.1
Data for main motor cooler *)			
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	8.09
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	12.8
Temperature increase of the coolant	ΔT_H	K	9.1
Pressure drop	Δp_H	bar	2.8
Data for precision motor cooler *)			
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.873
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	4.7
Temperature increase of the coolant	ΔT_P	K	2.6
Pressure drop	Δp_H	bar	2.8

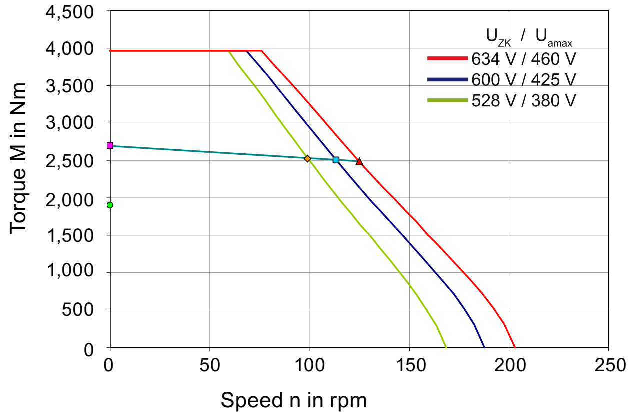
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6190-xxx20-xxxx

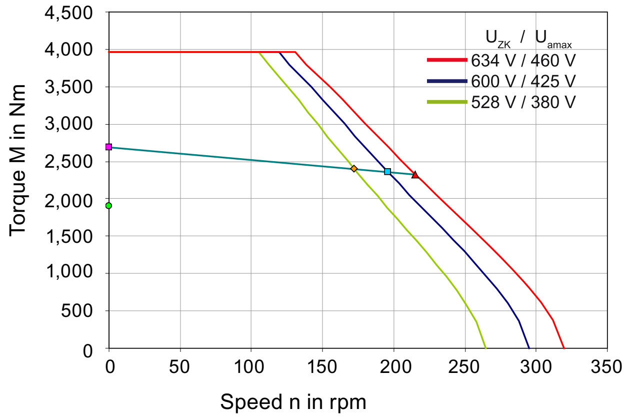
1FW6190-xxB20-5Gxx:
Torque over speed



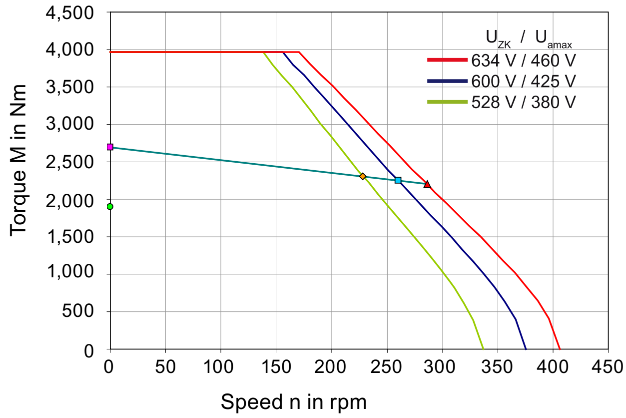
1FW6190-xxB20-8Fxx:
Torque over speed



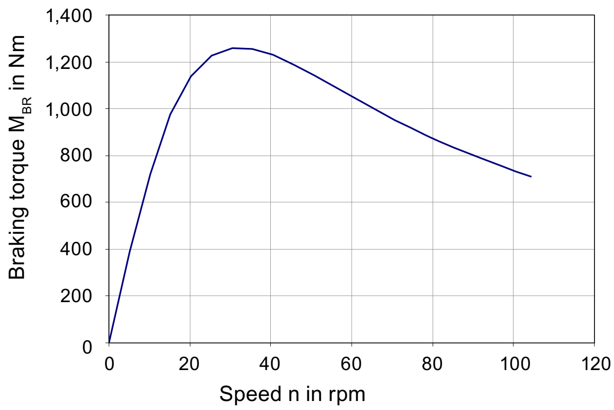
1FW6190-xxB20-2Pxx:
Torque over speed



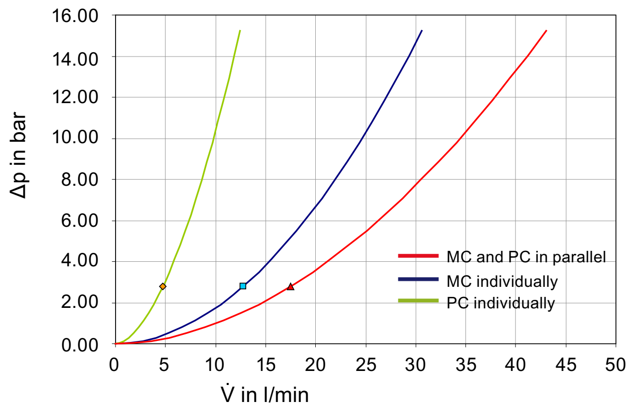
1FW6190-xxB20-0Wxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate



14.2.6 1FW6230-xxxxx-xxxx

Data sheet 1FW6230-xxB05-xxxx

Table 14- 31 1FW6230-xxB05-1Jxx, 1FW6230-xxB05-2Jxx, 1FW6230-xxB05-5Gxx

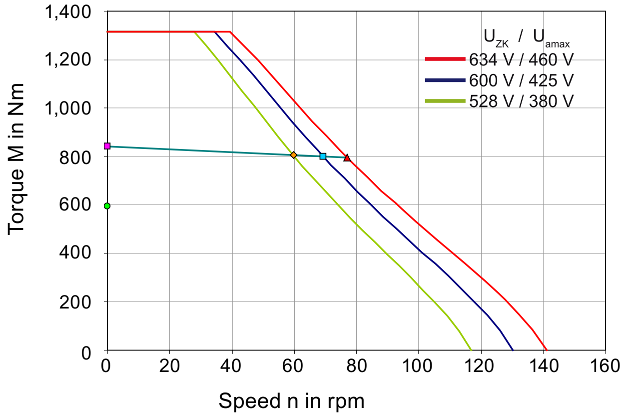
Technical data 1FW6230	Symbol	Unit	-xxB05-1Jxx	-xxB05-2Jxx	-xxB05-5Gxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	799	774	660
Rated current	I_N	A	15	22	40
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	69	110	290
Rated power dissipation	$P_{V,N}$	kW	3.54	3.65	3.58
Limit data					
Maximum torque	M_{MAX}	Nm	1320	1320	1320
Maximum current	I_{MAX}	A	31	45	100
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	17.3	21	34.1
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	34	59	160
No-load speed	$n_{MAX,0}$	rpm	130	190	410
Torque at n = 1 [rpm]	M_0	Nm	841	841	841
Current at M_0 and n = 1 [rpm]	I_0	A	16	24	53
Thermal static torque	M_0*	Nm	594	594	594
Thermal stall current	I_0*	A	11	16	36
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	52.7	36.9	16.7
Voltage constant	k_E	V/(1000/min)	3188	2231	1011
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	15	14.8	14.9
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	49	49	49
Cogging torque	M_{COG}	Nm	4.2	4.2	4.2
Stator mass	m_S	kg	31.9	31.9	31.9
Rotor mass	m_L	kg	12.9	12.9	12.9
Rotor moment of inertia	J_L	10^{-2} kgm^2	62.2	62.2	62.2
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	2.95	1.49	0.299
Phase inductance of winding	L_{STR}	mH	26.9	13.2	2.7
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	2.66	2.74	2.68
Recommended minimum volume flow rate	$\dot{V}_{H,MIN}$	l/min	4.8	4.8	4.8

Technical data 1FW6230	Symbol	Unit	-xxB05-1Jxx	-xxB05-2Jxx	-xxB05-5Gxx
Temperature increase of the coolant	ΔT_H	K	8	8.2	8.1
Pressure drop	Δp_H	bar	0.5	0.5	0.5
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.287	0.295	0.29
Recommended minimum volume flow rate	$\dot{V}_{P,MIN}$	l/min	1.6	1.6	1.6
Temperature increase of the coolant	ΔT_P	K	2.6	2.6	2.6
Pressure drop	Δp_H	bar	0.5	0.5	0.5

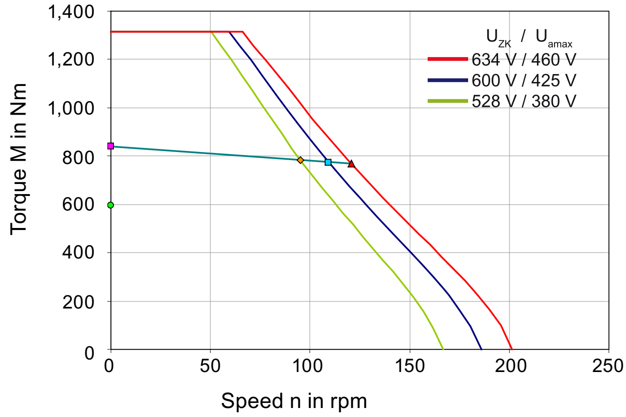
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6230-xxx05-xxxx

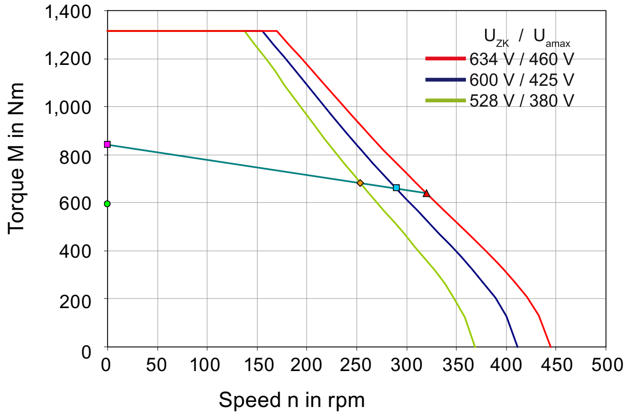
1FW6230-xxB05-1Jxx:
Torque over speed



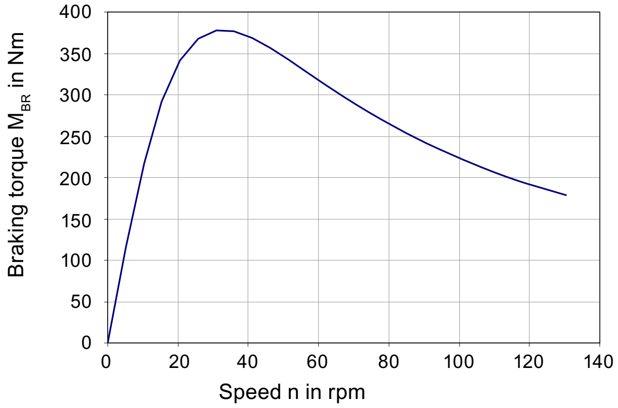
1FW6230-xxB05-2Jxx:
Torque over speed



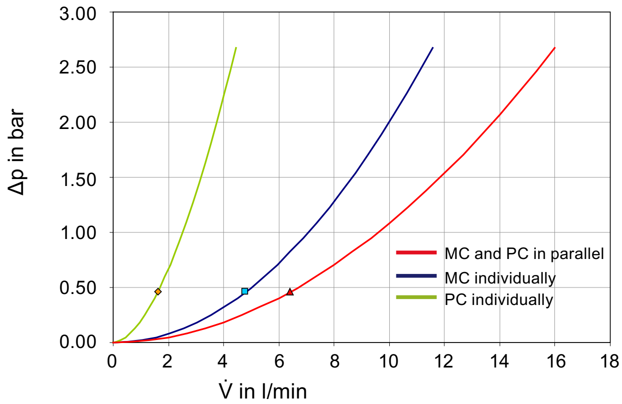
1FW6230-xxB05-5Gxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate



Data sheet 1FW6230-xxB07-xxxx

Table 14- 32 1FW6230-xxB07-1Jxx, 1FW6230-xxB07-2Jxx, 1FW6230-xxB07-5Gxx

Technical data 1FW6230	Symbol	Unit	-xxB07-1Jxx	-xxB07-2Jxx	-xxB07-5Gxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	1140	1120	1010
Rated current	I_N	A	16	22	44
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	45	73	190
Rated power dissipation	$P_{V,N}$	kW	4.47	4.61	4.52
Limit data					
Maximum torque	M_{MAX}	Nm	1840	1840	1840
Maximum current	I_{MAX}	A	31	45	100
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	19.4	23.6	36.9
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	19	38	110
No-load speed	$n_{MAX,0}$	rpm	93	130	290
Torque at n = 1 [rpm]	M_0	Nm	1180	1180	1180
Current at M_0 and n = 1 [rpm]	I_0	A	16	24	53
Thermal static torque	M_0*	Nm	832	832	832
Thermal stall current	I_0*	A	11	16	36
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	73.8	51.7	23.4
Voltage constant	k_E	V/(1000/min)	4463	3124	1415
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	18.7	18.4	18.6
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	49	49	49
Cogging torque	M_{COG}	Nm	5.9	5.9	5.9
Stator mass	m_S	kg	41.4	41.4	41.4
Rotor mass	m_L	kg	17.4	17.4	17.4
Rotor moment of inertia	J_L	10^{-2} kgm^2	84.3	84.3	84.3
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	3.73	1.88	0.379
Phase inductance of winding	L_{STR}	mH	37.3	18.3	3.7
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	3.36	3.46	3.39
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	6.1	6.1	6.1
Temperature increase of the coolant	ΔT_H	K	7.9	8.1	7.9
Pressure drop	Δp_H	bar	0.8	0.8	0.8

Technical data 1FW6230	Symbol	Unit	-xxB07-1Jxx	-xxB07-2Jxx	-xxB07-5Gxx
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.362	0.373	0.366
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	2.1	2.1	2.1
Temperature increase of the coolant	ΔT_P	K	2.4	2.5	2.5
Pressure drop	Δp_H	bar	0.8	0.8	0.8

*) Parallel connection of main and precision motor cooler

Table 14- 33 1FW6230-xxB07-8Fxx

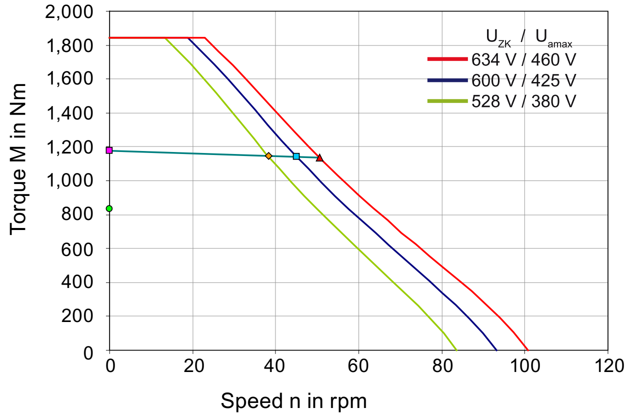
Technical data 1FW6230	Symbol	Unit	-xxB07-8Fxx
Boundary conditions			
DC link voltages	U_{ZK}	V	600
Water cooling inlet temperature	T_{VORL}	°C	35
Rated temperature of winding	T_N	°C	130
Rated data			
Rated torque	M_N	Nm	923
Rated current	I_N	A	56
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	290
Rated power dissipation	$P_{V,N}$	kW	4.53
Limit data			
Maximum torque	M_{MAX}	Nm	1840
Maximum current	I_{MAX}	A	130
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	46.3
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	160
No-load speed	$n_{MAX,0}$	rpm	410
Torque at n = 1 [rpm]	M_0	Nm	1180
Current at M_0 and n = 1 [rpm]	I_0	A	74
Thermal static torque	M_0*	Nm	832
Thermal stall current	I_0*	A	50
Physical constants			
Torque constant at 20 °C	$k_{T,20}$	Nm/A	16.9
Voltage constant	k_E	V/(1000/min)	1020
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	18.6
Thermal time constant	t_{TH}	s	180
No. of pole pairs	p	-	49
Cogging torque	M_{COG}	Nm	5.9
Stator mass	m_S	kg	41.4
Rotor mass	m_L	kg	17.4

Technical data 1FW6230	Symbol	Unit	-xxB07-8Fxx
Rotor moment of inertia	J_L	10^{-2} kgm^2	84.3
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.197
Phase inductance of winding	L_{STR}	mH	1.9
Data for main motor cooler *)			
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	3.4
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	6.1
Temperature increase of the coolant	ΔT_H	K	8
Pressure drop	Δp_H	bar	0.8
Data for precision motor cooler *)			
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.367
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	2.1
Temperature increase of the coolant	ΔT_P	K	2.5
Pressure drop	Δp_H	bar	0.8

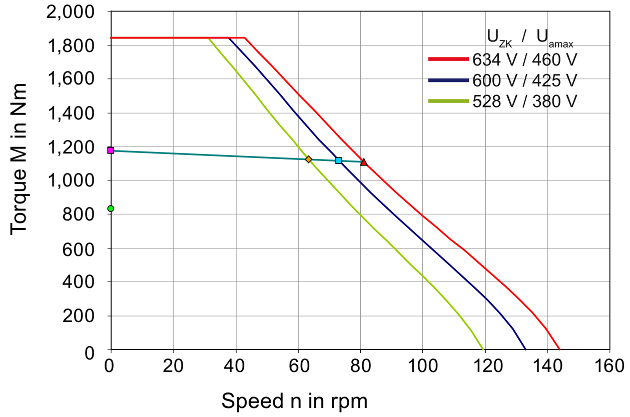
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6230-xxx07-xxxx

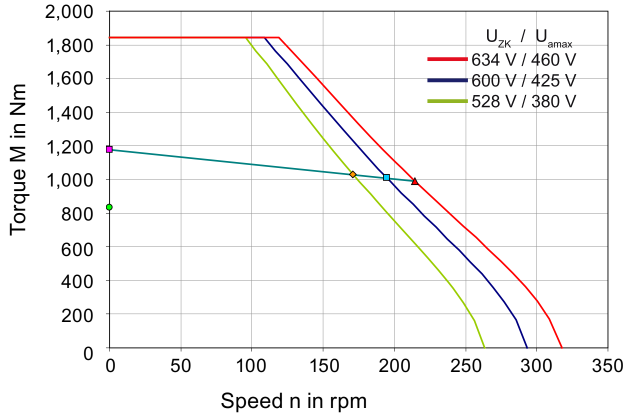
1FW6230-xxB07-1Jxx:
Torque over speed



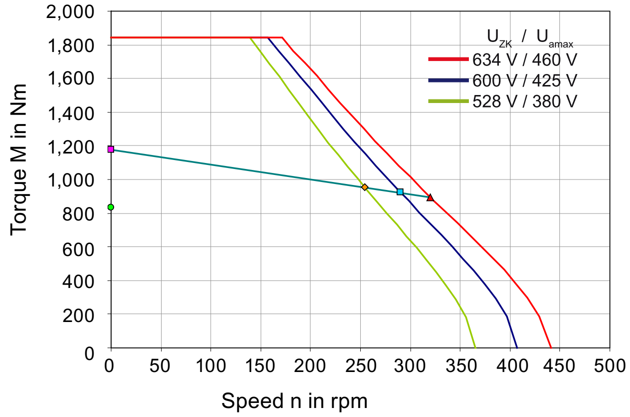
1FW6230-xxB07-2Jxx:
Torque over speed



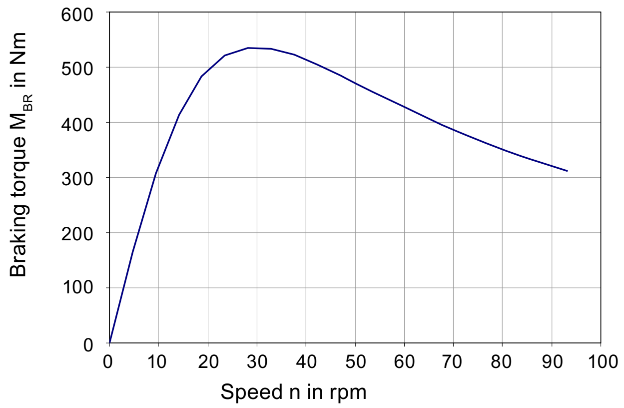
1FW6230-xxB07-5Gxx:
Torque over speed



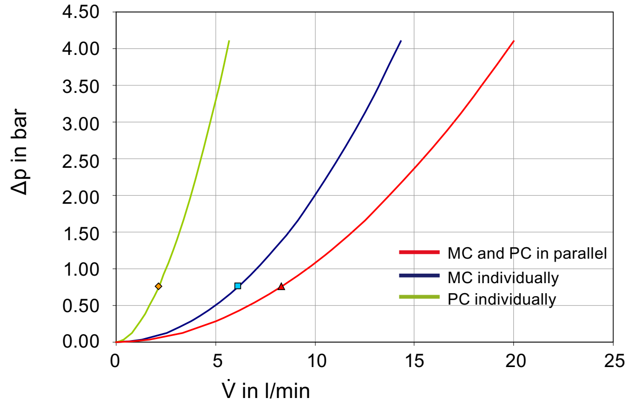
1FW6230-xxB07-8Fxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate



Data sheet 1FW6230-xxB10-xxxx

Table 14- 34 1FW6230-xxB10-2Jxx, 1FW6230-xxB10-5Gxx, 1FW6230-xxB10-8Fxx

Technical data 1FW6230	Symbol	Unit	-xxB10-2Jxx	-xxB10-5Gxx	-xxB10-8Fxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	1630	1520	1450
Rated current	I_N	A	23	48	62
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	46	130	190
Rated power dissipation	$P_{V,N}$	kW	6.05	6.09	5.95
Limit data					
Maximum torque	M_{MAX}	Nm	2630	2630	2630
Maximum current	I_{MAX}	A	45	100	130
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	27.1	42	50.6
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	21	74	110
No-load speed	$n_{MAX,0}$	rpm	93	210	290
Torque at n = 1 [rpm]	M_0	Nm	1680	1680	1680
Current at M_0 and n = 1 [rpm]	I_0	A	24	54	74
Thermal static torque	M_0*	Nm	1190	1190	1190
Thermal stall current	I_0*	A	16	37	50
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	73.8	32.7	24.1
Voltage constant	k_E	V/(1000/min)	4463	1976	1457
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	23	22.9	23.2
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	49	49	49
Cogging torque	M_{COG}	Nm	8.4	8.4	8.4
Stator mass	m_S	kg	57.5	57.5	57.5
Rotor mass	m_L	kg	24.3	24.3	24.3
Rotor moment of inertia	J_L	10^{-2} kgm^2	118	118	118
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	2.47	0.488	0.259
Phase inductance of winding	L_{STR}	mH	25.9	5.1	2.8
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	4.54	4.58	4.47
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	8	8	8
Temperature increase of the coolant	ΔT_H	K	8.2	8.2	8.1
Pressure drop	Δp_H	bar	1.3	1.3	1.3

Technical data 1FW6230	Symbol	Unit	-xxB10-2Jxx	-xxB10-5Gxx	-xxB10-8Fxx
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.490	0.493	0.482
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	2.9	2.9	2.9
Temperature increase of the coolant	ΔT_P	K	2.4	2.4	2.4
Pressure drop	Δp_H	bar	1.3	1.3	1.3

*) Parallel connection of main and precision motor cooler

Table 14- 35 1FW6230-xxB10-2Pxx

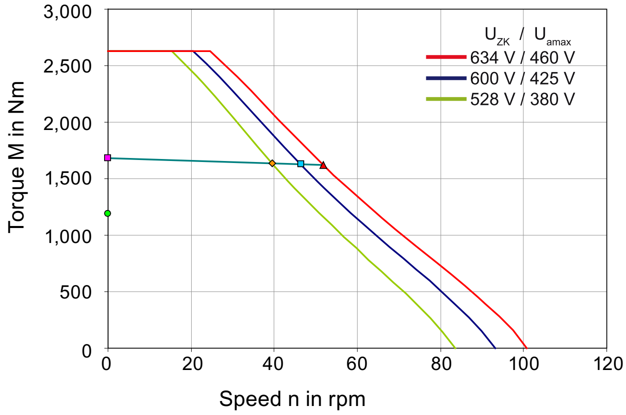
Technical data 1FW6230	Symbol	Unit	-xxB10-2Pxx
Boundary conditions			
DC link voltages	U_{ZK}	V	600
Water cooling inlet temperature	T_{VORL}	°C	35
Rated temperature of winding	T_N	°C	130
Rated data			
Rated torque	M_N	Nm	1320
Rated current	I_N	A	80
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	290
Rated power dissipation	$P_{V,N}$	kW	6.1
Limit data			
Maximum torque	M_{MAX}	Nm	2630
Maximum current	I_{MAX}	A	190
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	65.4
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	160
No-load speed	$n_{MAX,0}$	rpm	410
Torque at n = 1 [rpm]	M_0	Nm	1680
Current at M_0 and n = 1 [rpm]	I_0	A	100
Thermal static torque	M_0*	Nm	1190
Thermal stall current	I_0*	A	72
Physical constants			
Torque constant at 20 °C	$k_{T,20}$	Nm/A	16.9
Voltage constant	k_E	V/(1000/min)	1020
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	22.9
Thermal time constant	t_{TH}	s	180
No. of pole pairs	p	-	49
Cogging torque	M_{COG}	Nm	8.4
Stator mass	m_S	kg	57.5
Rotor mass	m_L	kg	24.3

Technical data 1FW6230	Symbol	Unit	-xxB10-2Pxx
Rotor moment of inertia	J_L	10^{-2} kgm²	118
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.13
Phase inductance of winding	L_{STR}	mH	1.4
Data for main motor cooler *)			
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	4.58
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	8
Temperature increase of the coolant	ΔT_H	K	8.3
Pressure drop	Δp_H	bar	1.3
Data for precision motor cooler *)			
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.494
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	2.9
Temperature increase of the coolant	ΔT_P	K	2.5
Pressure drop	Δp_H	bar	1.3

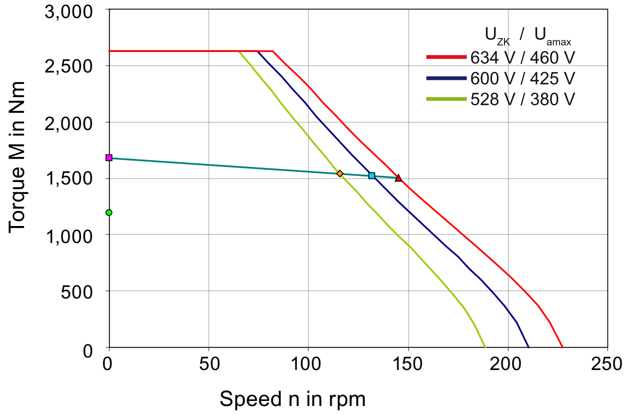
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6230-xxx10-xxxx

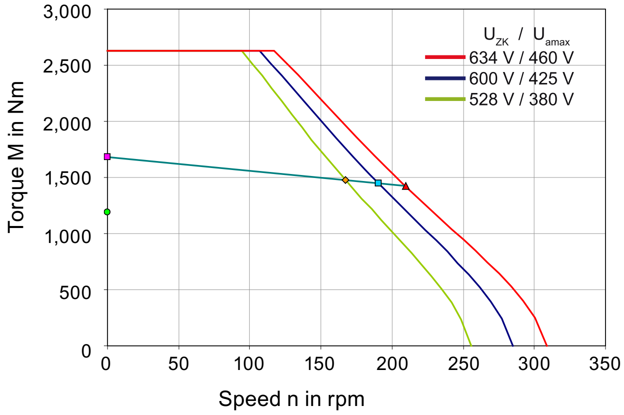
1FW6230-xxB10-2Jxx:
Torque over speed



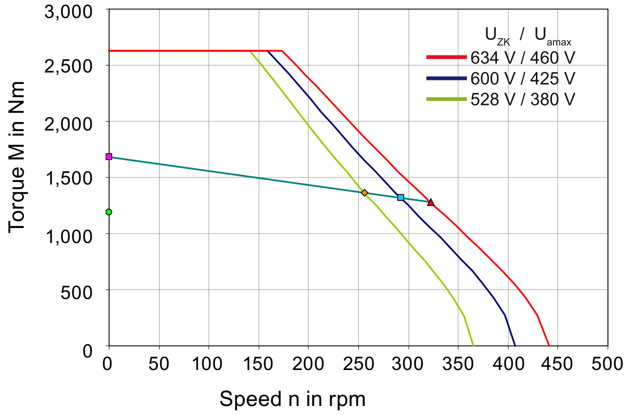
1FW6230-xxB10-5Gxx:
Torque over speed



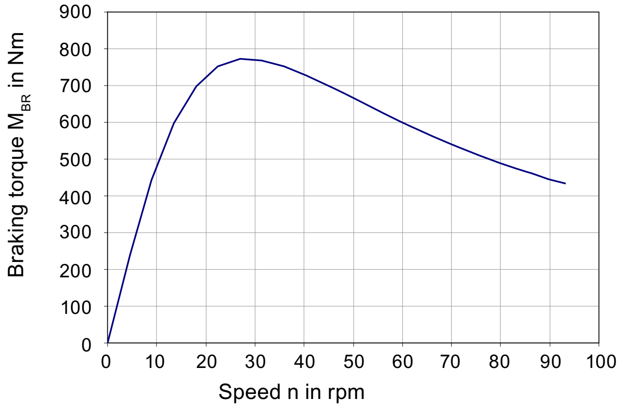
1FW6230-xxB10-8Fxx:
Torque over speed



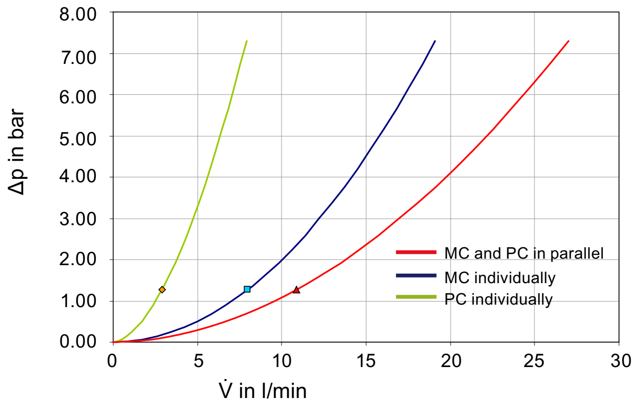
1FW6230-xxB10-2Pxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate



Data sheet 1FW6230-xxB15-xxxx

Table 14- 36 1FW6230-xxB15-4Cxx, 1FW6230-xxB15-5Gxx, 1FW6230-xxB15-8Fxx

Technical data 1FW6230	Symbol	Unit	-xxB15-4Cxx	-xxB15-5Gxx	-xxB15-8Fxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	2440	2380	2310
Rated current	I_N	A	32	49	66
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	43	80	120
Rated power dissipation	$P_{V,N}$	kW	8.51	8.29	8.31
Limit data					
Maximum torque	M_{MAX}	Nm	3950	3950	3950
Maximum current	I_{MAX}	A	63	100	130
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	38	47.4	57.3
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	19	44	67
No-load speed	$n_{MAX,0}$	rpm	87	140	190
Torque at n = 1 [rpm]	M_0	Nm	2520	2520	2520
Current at M_0 and n = 1 [rpm]	I_0	A	33	53	74
Thermal static torque	M_0*	Nm	1780	1780	1780
Thermal stall current	I_0*	A	23	36	50
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	79.1	50.2	36.2
Voltage constant	k_E	V/(1000/min)	4782	3033	2186
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	29.1	29.4	29.4
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	49	49	49
Cogging torque	M_{COG}	Nm	13	13	13
Stator mass	m_S	kg	82.1	82.1	82.1
Rotor mass	m_L	kg	35.7	35.7	35.7
Rotor moment of inertia	J_L	10^{-2} kgm^2	173	173	173
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	1.77	0.695	0.362
Phase inductance of winding	L_{STR}	mH	19.7	7.9	4.1
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	6.39	6.23	6.24
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	10.5	10.5	10.5
Temperature increase of the coolant	ΔT_H	K	8.7	8.5	8.5
Pressure drop	Δp_H	bar	2.2	2.2	2.2

Technical data 1FW6230	Symbol	Unit	-xxB15-4Cxx	-xxB15-5Gxx	-xxB15-8Fxx
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.69	0.672	0.673
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	4	4	4
Temperature increase of the coolant	ΔT_P	K	2.5	2.4	2.4
Pressure drop	Δp_H	bar	2.2	2.2	2.2

*) Parallel connection of main and precision motor cooler

Table 14- 37 1FW6230-xxB15-2Pxx, 1FW6230-xxB15-0Wxx

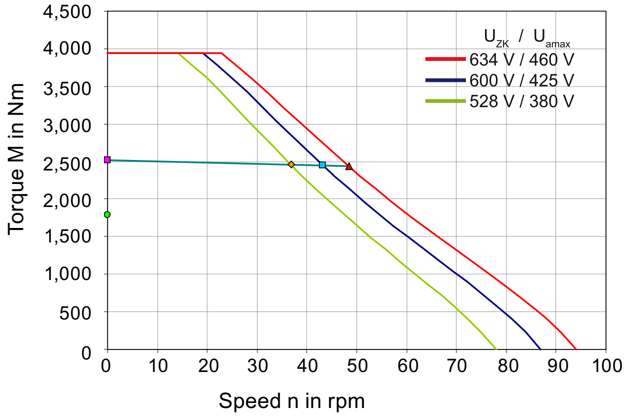
Technical data 1FW6230	Symbol	Unit	-xxB15-2Pxx	-xxB15-0Wxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	2190	2020
Rated current	I_N	A	90	110
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	180	270
Rated power dissipation	$P_{V,N}$	kW	8.53	8.31
Limit data				
Maximum torque	M_{MAX}	Nm	3950	3950
Maximum current	I_{MAX}	A	190	270
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	72.5	91.2
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	100	150
No-load speed	$n_{MAX,0}$	rpm	270	380
Torque at n = 1 [rpm]	M_0	Nm	2520	2520
Current at M_0 and n = 1 [rpm]	I_0	A	100	140
Thermal static torque	M_0*	Nm	1780	1780
Thermal stall current	I_0*	A	72	100
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	25.3	18.1
Voltage constant	k_E	V/(1000/min)	1530	1093
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	29	29.4
Thermal time constant	t_{TH}	s	180	180
No. of pole pairs	p	-	49	49
Cogging torque	M_{COG}	Nm	13	13
Stator mass	m_S	kg	82.1	83.7
Rotor mass	m_L	kg	35.7	35.7

Technical data 1FW6230	Symbol	Unit	-xxB15-2Pxx	-xxB15-0Wxx
Rotor moment of inertia	J_L	10^{-2} kgm^2	173	173
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.182	0.0904
Phase inductance of winding	L_{STR}	mH	2	1
Data for main motor cooler *)				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	6.4	6.24
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	10.5	10.5
Temperature increase of the coolant	ΔT_H	K	8.8	8.5
Pressure drop	Δp_H	bar	2.2	2.2
Data for precision motor cooler *)				
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.691	0.673
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	4	4
Temperature increase of the coolant	ΔT_P	K	2.5	2.4
Pressure drop	Δp_H	bar	2.2	2.2

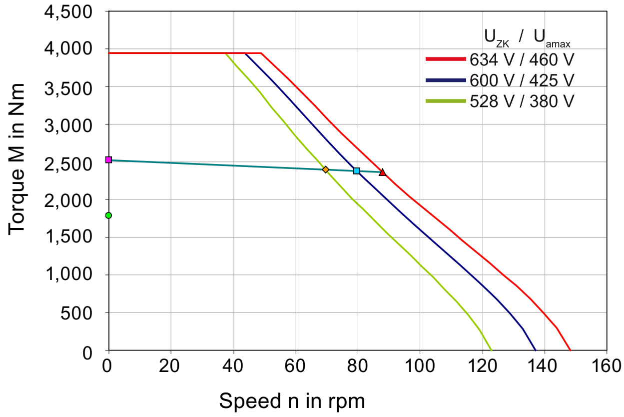
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6230-xxx15-xxxx

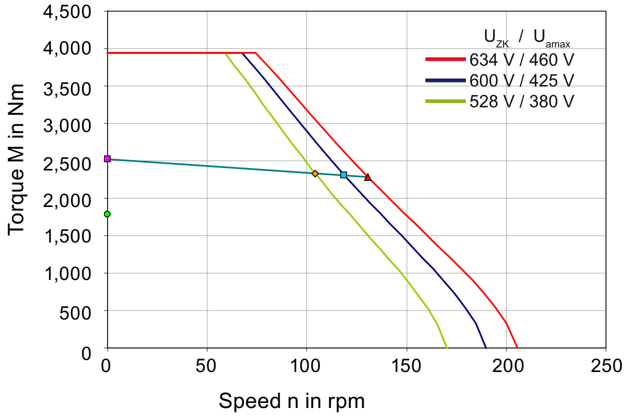
1FW6230-xxB15-4Cxx:
Torque over speed



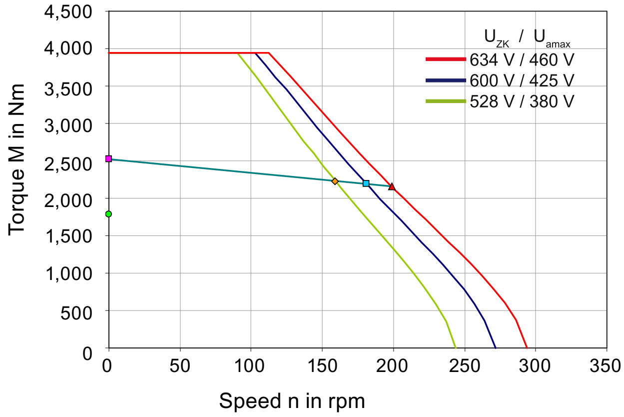
1FW6230-xxB15-5Gxx:
Torque over speed



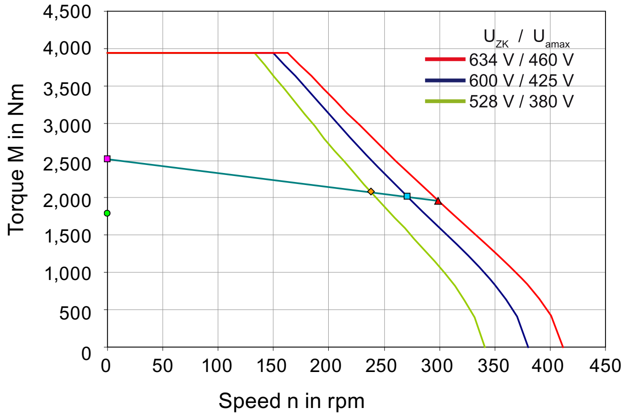
1FW6230-xxB15-8Fxx:
Torque over speed

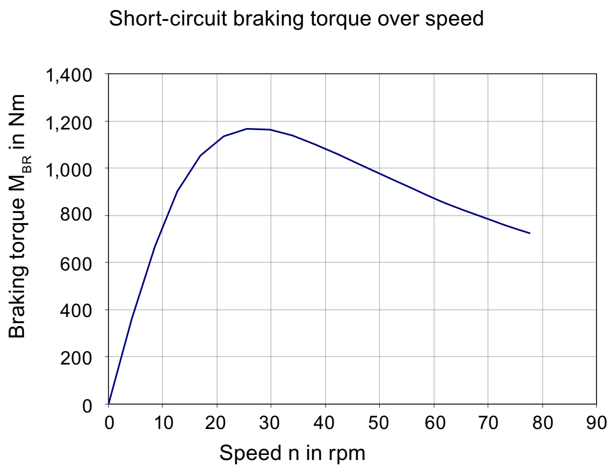


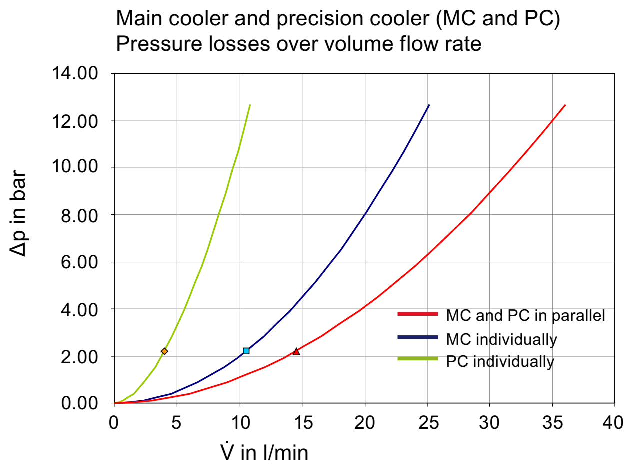
1FW6230-xxB15-2Pxx:
Torque over speed



1FW6230-xxB15-0Wxx:
Torque over speed




Short-circuit braking torque over speed
Braking torque M_BR in Nm
1,400
1,200
1,000
800
600
400
200
0
0
10
20
30
40
50
60
70
80
90
Speed n in rpm


Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate
Δp in bar
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
5
10
15
20
25
30
35
40
V̇ in l/min
MC and PC in parallel
MC individually
PC individually

Data sheet 1FW6230-xxB20-xxxx

Table 14- 38 1FW6230-xxB20-5Gxx, 1FW6230-xxB20-8Fxx, 1FW6230-xxB20-2Pxx

Technical data 1FW6230	Symbol	Unit	-xxB20-5Gxx	-xxB20-8Fxx	-xxB20-2Pxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	3230	3160	3050
Rated current	I_N	A	51	69	94
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	56	84	130
Rated power dissipation	$P_{V,N}$	kW	10.7	10.7	11
Limit data					
Maximum torque	M_{MAX}	Nm	5260	5260	5260
Maximum current	I_{MAX}	A	100	130	190
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	53.5	63.7	79.4
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	29	47	74
No-load speed	$n_{MAX,0}$	rpm	100	140	200
Torque at n = 1 [rpm]	M_0	Nm	3360	3360	3360
Current at M_0 and n = 1 [rpm]	I_0	A	53	74	100
Thermal static torque	M_0*	Nm	2380	2380	2380
Thermal stall current	I_0*	A	36	50	72
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	66.9	48.2	33.7
Voltage constant	k_E	V/(1000/min)	4044	2915	2040
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	34.6	34.6	34.2
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	49	49	49
Cogging torque	M_{COG}	Nm	17	17	17
Stator mass	m_S	kg	106.7	106.7	106.7
Rotor mass	m_L	kg	47.1	47.1	47.1
Rotor moment of inertia	J_L	10^{-2} kgm^2	228	228	228
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.892	0.465	0.233
Phase inductance of winding	L_{STR}	mH	10.5	5.5	2.7
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	8	8.02	8.22
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	13	13	13
Temperature increase of the coolant	ΔT_H	K	8.8	8.9	9.1
Pressure drop	Δp_H	bar	3.4	3.4	3.4

Technical data 1FW6230	Symbol	Unit	-xxB20-5Gxx	-xxB20-8Fxx	-xxB20-2Pxx
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.863	0.865	0.887
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	5.1	5.1	5.1
Temperature increase of the coolant	ΔT_P	K	2.4	2.4	2.5
Pressure drop	Δp_H	bar	3.4	3.4	3.4

*) Parallel connection of main and precision motor cooler

Table 14- 39 1FW6230-xxB20-0Wxx

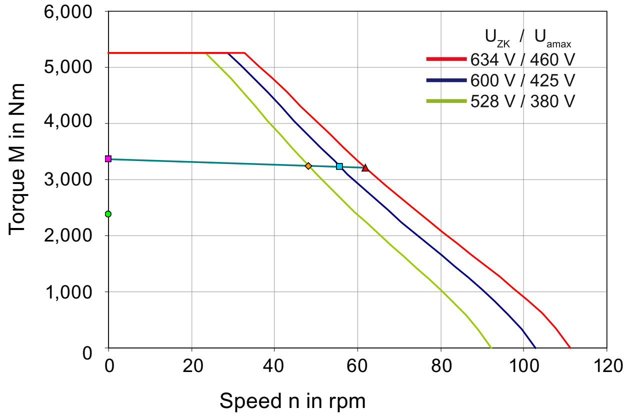
Technical data 1FW6230	Symbol	Unit	-xxB20-0Wxx
Boundary conditions			
DC link voltages	U_{ZK}	V	600
Water cooling inlet temperature	T_{VORL}	°C	35
Rated temperature of winding	T_N	°C	130
Rated data			
Rated torque	M_N	Nm	2890
Rated current	I_N	A	120
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	190
Rated power dissipation	$P_{V,N}$	kW	10.7
Limit data			
Maximum torque	M_{MAX}	Nm	5260
Maximum current	I_{MAX}	A	270
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	98.1
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	110
No-load speed	$n_{MAX,0}$	rpm	290
Torque at n = 1 [rpm]	M_0	Nm	3360
Current at M_0 and n = 1 [rpm]	I_0	A	140
Thermal static torque	M_0*	Nm	2380
Thermal stall current	I_0*	A	100
Physical constants			
Torque constant at 20 °C	$k_{T,20}$	Nm/A	24.1
Voltage constant	k_E	V/(1000/min)	1457
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	34.6
Thermal time constant	t_{TH}	s	180
No. of pole pairs	p	-	49
Cogging torque	M_{COG}	Nm	17
Stator mass	m_S	kg	108.3
Rotor mass	m_L	kg	47.1

Technical data 1FW6230	Symbol	Unit	-xxB20-0Wxx
Rotor moment of inertia	J_L	10^{-2} kgm^2	228
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.116
Phase inductance of winding	L_{STR}	mH	1.4
Data for main motor cooler *)			
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	8.02
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	13
Temperature increase of the coolant	ΔT_H	K	8.9
Pressure drop	Δp_H	bar	3.4
Data for precision motor cooler *)			
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.865
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	5.1
Temperature increase of the coolant	ΔT_P	K	2.4
Pressure drop	Δp_H	bar	3.4

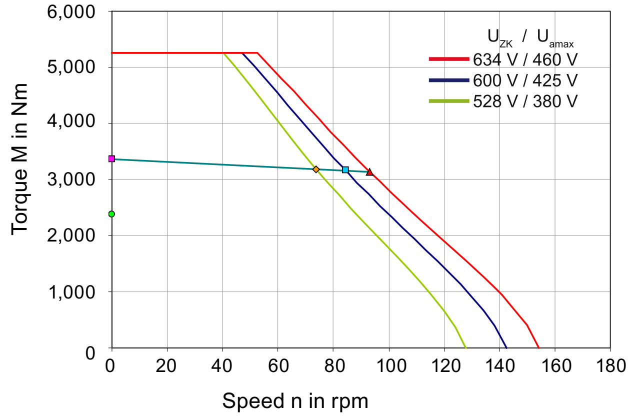
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6230-xxx20-xxxx

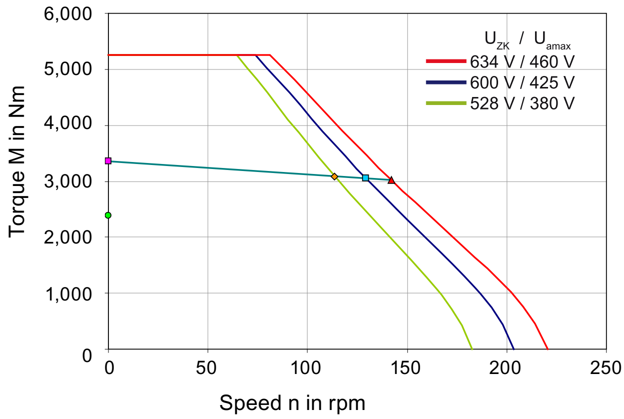
1FW6230-xxB20-5Gxx:
Torque over speed



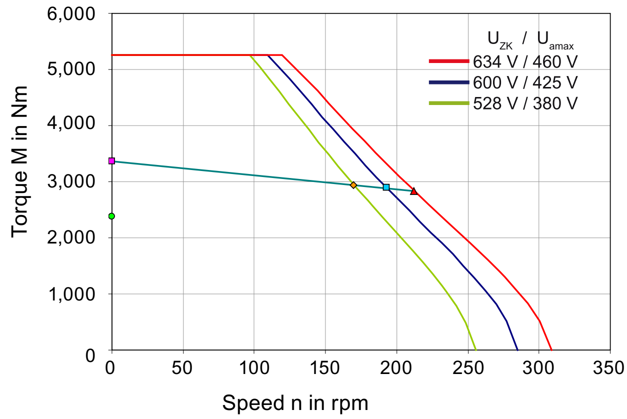
1FW6230-xxB20-8Fxx:
Torque over speed



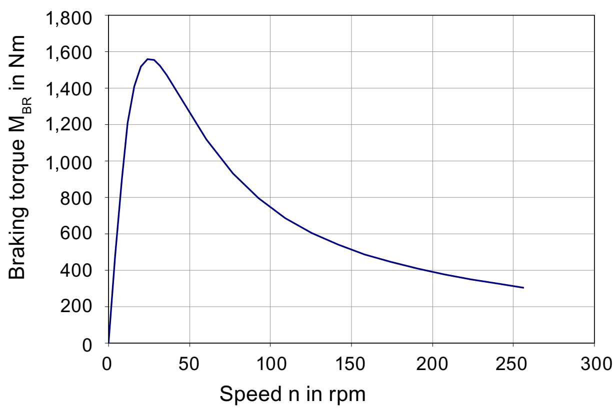
1FW6230-xxB20-2Pxx:
Torque over speed



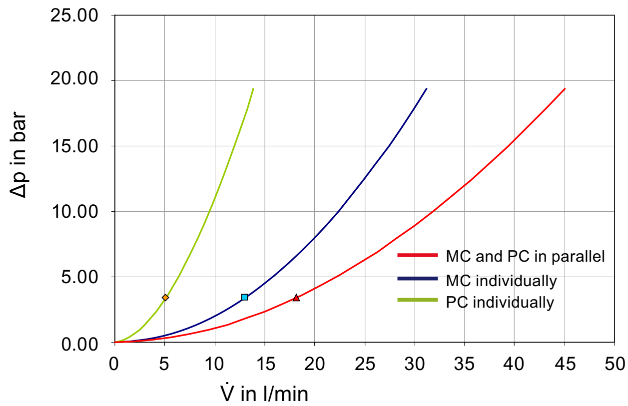
1FW6230-xxB20-0Wxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate



14.2.7 1FW6290-xxxxx-xxxx

Data sheet 1FW6290-xxB07-xxxx

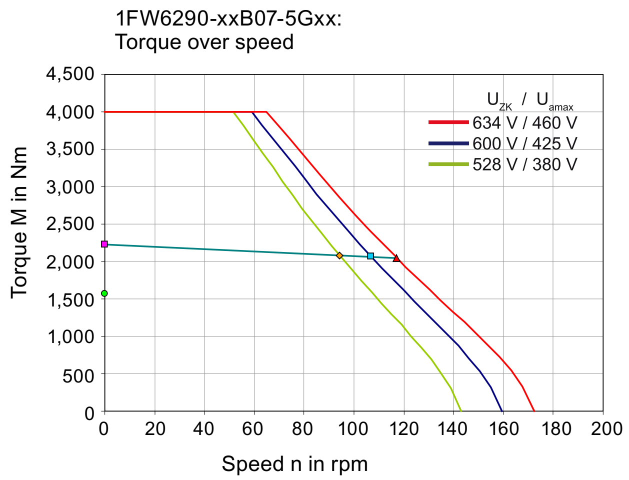
Table 14- 40 1FW6290-xxB07-5Gxx, 1FW6290-xxB07-0Lxx, 1FW6290-xxB07-2Pxx

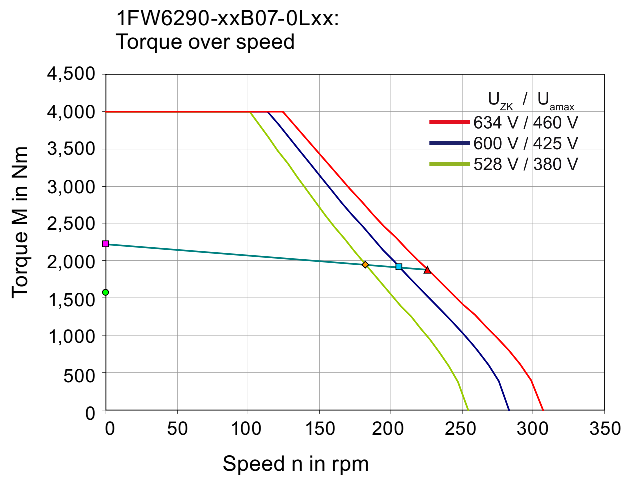
Technical data 1FW6290	Symbol	Unit	-xxB07-5Gxx	-xxB07-0Lxx	-xxB07-2Pxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	2060	1910	1810
Rated current	I_N	A	52	86	100
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	110	210	270
Rated power dissipation	$P_{V,N}$	kW	5.19	5.19	5.2
Limit data					
Maximum torque	M_{MAX}	Nm	4000	4000	4000
Maximum current	I_{MAX}	A	110	210	270
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	47.7	70.6	85.4
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	59	110	150
No-load speed	$n_{MAX,0}$	rpm	160	280	360
Torque at n = 1 [rpm]	M_0	Nm	2220	2220	2220
Current at M_0 and n = 1 [rpm]	I_0	A	56	100	120
Thermal static torque	M_0*	Nm	1570	1570	1570
Thermal stall current	I_0*	A	39	70	90
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	39.8	22.4	17.4
Voltage constant	k_E	V/(1000/min)	2405	1352	1053
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	31.2	31.2	31.2
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	42	42	42
Cogging torque	M_{COG}	Nm	11	11	11
Stator mass	m_S	kg	72.6	72.6	77.8
Rotor mass	m_L	kg	31	31	31
Rotor moment of inertia	J_L	10^{-2} kgm^2	228	228	228
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.389	0.123	0.0747
Phase inductance of winding	L_{STR}	mH	6.4	2	1.2
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	3.9	3.9	3.91
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	5.8	5.8	5.8

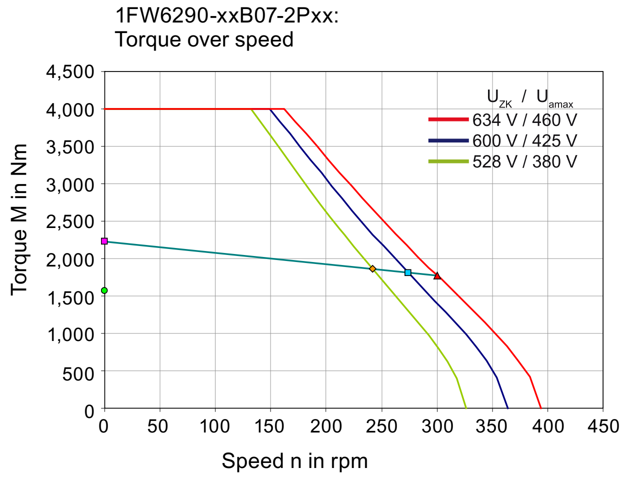
Technical data 1FW6290	Symbol	Unit	-xxB07-5Gxx	-xxB07-0Lxx	-xxB07-2Pxx
Temperature increase of the coolant	ΔT_H	K	9.7	9.7	9.7
Pressure drop	Δp_H	bar	0.4	0.4	0.4
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.42	0.42	0.421
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	2.2	2.2	2.2
Temperature increase of the coolant	ΔT_P	K	2.7	2.7	2.7
Pressure drop	Δp_H	bar	0.4	0.4	0.4

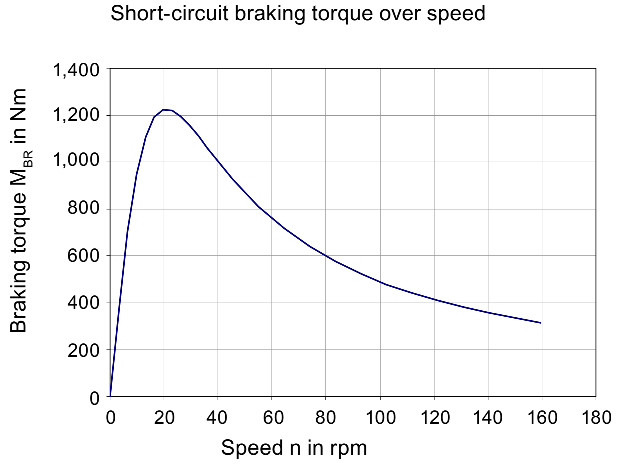
*) Parallel connection of main and precision motor cooler

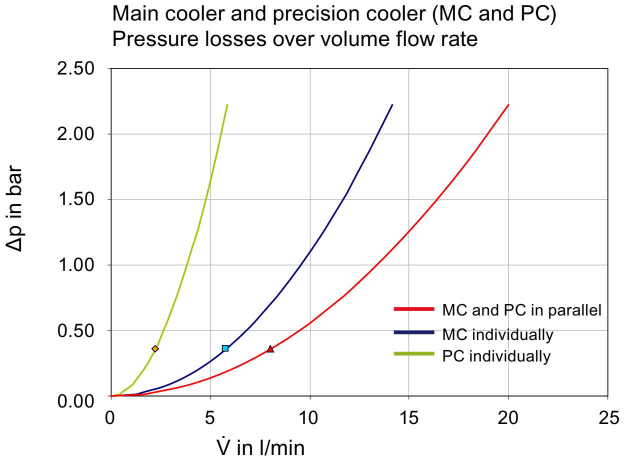
Characteristics for 1FW6290-xxx07-xxxx











Data sheet 1FW6290-xxB11-xxxx

Table 14- 41 1FW6290-xxB11-7Axx, 1FW6290-xxB11-0Lxx, 1FW6290-xxB11-2Pxx

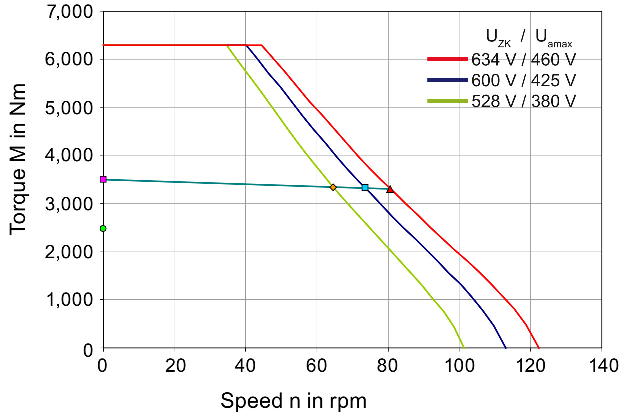
Technical data 1FW6290	Symbol	Unit	-xxB11-7Axx	-xxB11-0Lxx	-xxB11-2Pxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	3320	3200	3100
Rated current	I_N	A	59	91	110
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	73	130	170
Rated power dissipation	$P_{V,N}$	kW	7.13	7.14	7.16
Limit data					
Maximum torque	M_{MAX}	Nm	6280	6280	6280
Maximum current	I_{MAX}	A	130	210	270
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	58	78.2	93.2
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	40	71	93
No-load speed	$n_{MAX,0}$	rpm	110	180	230
Torque at n = 1 [rpm]	M_0	Nm	3490	3490	3490
Current at M_0 and n = 1 [rpm]	I_0	A	62	100	120
Thermal static torque	M_0*	Nm	2470	2470	2470
Thermal stall current	I_0*	A	44	70	90
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	56.1	35.1	27.4
Voltage constant	k_E	V/(1000/min)	3393	2124	1655
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	41.9	41.8	41.8
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	42	42	42
Cogging torque	M_{COG}	Nm	17	17	17
Stator mass	m_S	kg	114	114	119.2
Rotor mass	m_L	kg	45	45	45
Rotor moment of inertia	J_L	10^{-2} kgm^2	334	334	334
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.43	0.169	0.103
Phase inductance of winding	L_{STR}	mH	8	3.1	1.9
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	5.35	5.36	5.38
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	8.6	8.6	8.6
Temperature increase of the coolant	ΔT_H	K	9	9	9
Pressure drop	Δp_H	bar	0.8	0.8	0.8

Technical data 1FW6290	Symbol	Unit	-xxB11-7Axx	-xxB11-0Lxx	-xxB11-2Pxx
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.577	0.578	0.58
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	3.4	3.4	3.4
Temperature increase of the coolant	ΔT_P	K	2.4	2.4	2.4
Pressure drop	Δp_H	bar	0.8	0.8	0.8

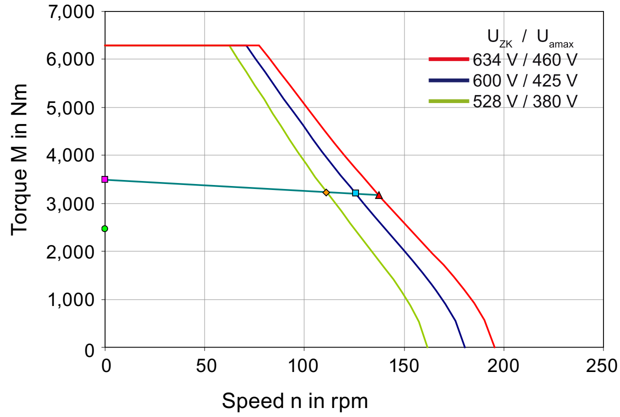
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6290-xxx11-xxxx

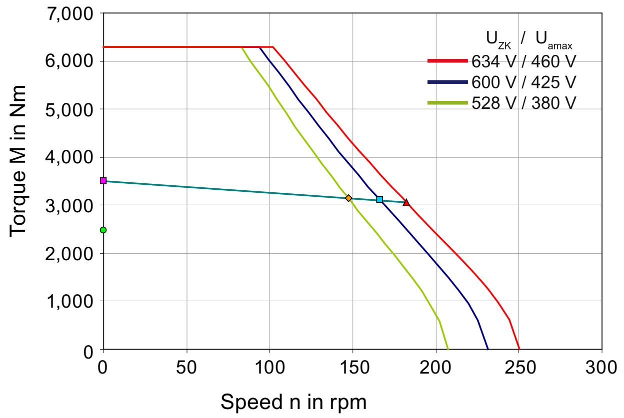
1FW6290-xxB11-7Axx:
Torque over speed



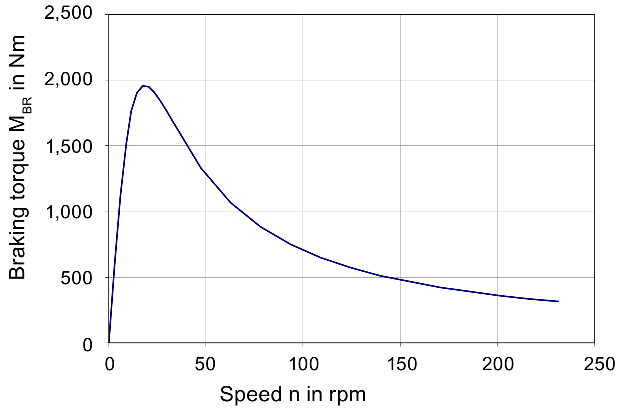
1FW6290-xxB11-0Lxx:
Torque over speed



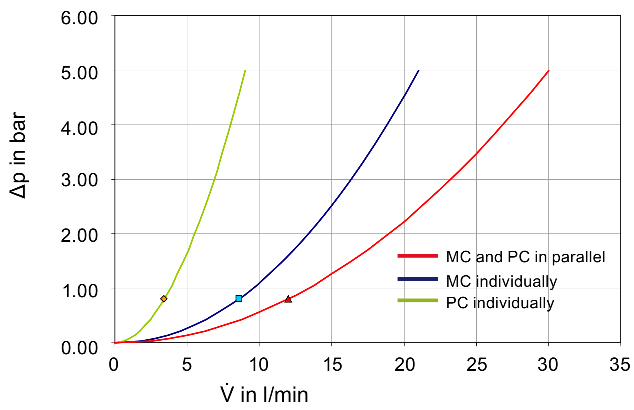
1FW6290-xxB11-2Pxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate



Data sheet 1FW6290-xxB15-xxxx

Table 14- 42 1FW6290-xxB15-7Axx, 1FW6290-xxB15-0Lxx, 1FW6290-xxB15-2Pxx

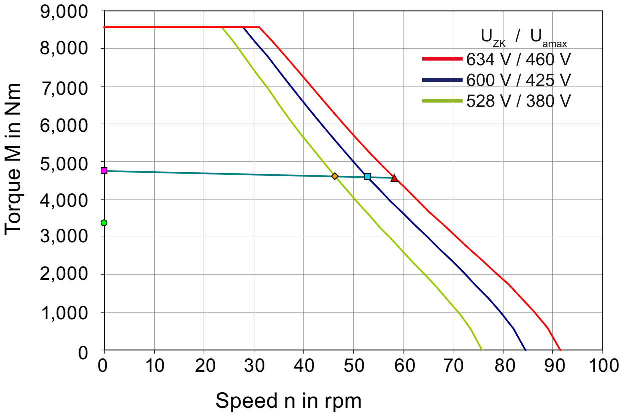
Technical data 1FW6290	Symbol	Unit	-xxB15-7Axx	-xxB15-0Lxx	-xxB15-2Pxx
Boundary conditions					
DC link voltages	U_{ZK}	V	600	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35	35
Rated temperature of winding	T_N	°C	130	130	130
Rated data					
Rated torque	M_N	Nm	4590	4480	4390
Rated current	I_N	A	61	94	110
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	53	89	120
Rated power dissipation	$P_{V,N}$	kW	9.08	9.09	9.12
Limit data					
Maximum torque	M_{MAX}	Nm	8570	8570	8570
Maximum current	I_{MAX}	A	130	210	270
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	65.2	85.2	101
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	28	50	67
No-load speed	$n_{MAX,0}$	rpm	85	130	170
Torque at n = 1 [rpm]	M_0	Nm	4760	4760	4760
Current at M_0 and n = 1 [rpm]	I_0	A	64	100	120
Thermal static torque	M_0*	Nm	3370	3370	3370
Thermal stall current	I_0*	A	44	70	90
Physical constants					
Torque constant at 20 °C	$k_{T,20}$	Nm/A	75	47.9	37.3
Voltage constant	k_E	V/(1000/min)	4533	2896	2257
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	50.6	50.5	50.5
Thermal time constant	t_{TH}	s	180	180	180
No. of pole pairs	p	-	42	42	42
Cogging torque	M_{COG}	Nm	24	24	24
Stator mass	m_S	kg	155.6	155.6	160.8
Rotor mass	m_L	kg	59	59	59
Rotor moment of inertia	J_L	10^{-2} kgm^2	440	440	440
Phase resistance of winding at 20 °C	$R_{STR,20}$	Ω	0.526	0.215	0.131
Phase inductance of winding	L_{STR}	mH	10.4	4.2	2.6
Data for main motor cooler *)					
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	6.82	6.83	6.85
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	12.8	12.8	12.8
Temperature increase of the coolant	ΔT_H	K	7.7	7.7	7.7
Pressure drop	Δp_H	bar	1.8	1.8	1.8

Technical data 1FW6290	Symbol	Unit	-xxB15-7Axx	-xxB15-0Lxx	-xxB15-2Pxx
Data for precision motor cooler *)					
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.736	0.737	0.739
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	5.2	5.2	5.2
Temperature increase of the coolant	ΔT_P	K	2	2	2
Pressure drop	Δp_H	bar	1.8	1.8	1.8

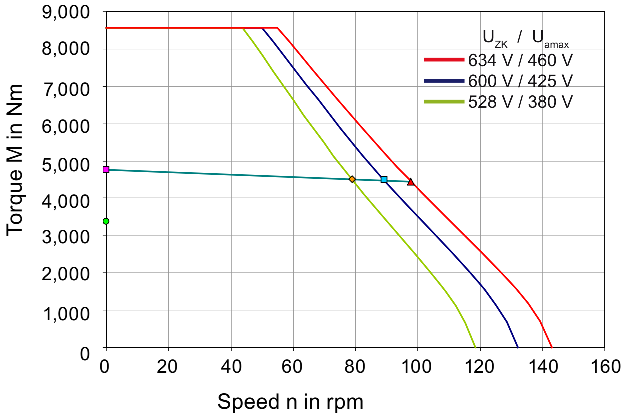
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6290-xxx15-xxxx

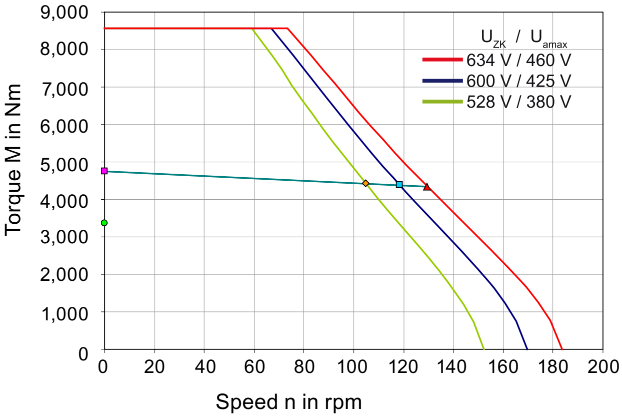
1FW6290-xxB15-7Axx:
Torque over speed



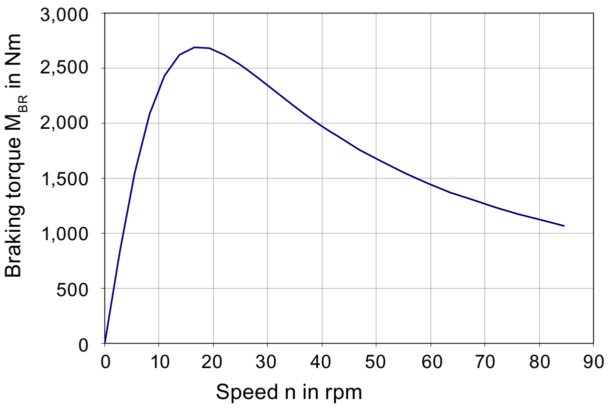
1FW6290-xxB15-0Lxx:
Torque over speed



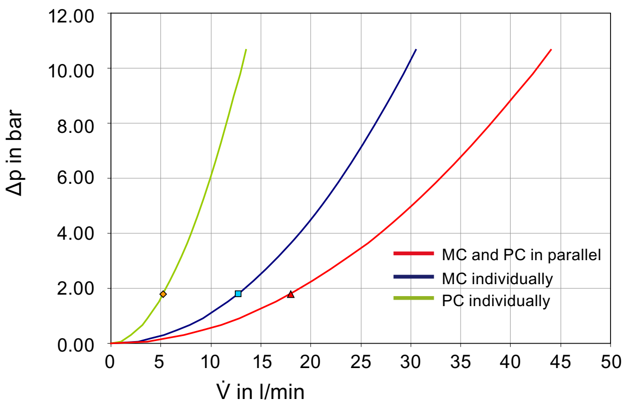
1FW6290-xxB15-2Pxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate



Data sheet 1FW6290-xxB20-xxxx

Table 14- 43 1FW6290-xxB20-0Lxx, 1FW6290-xxB20-2Pxx

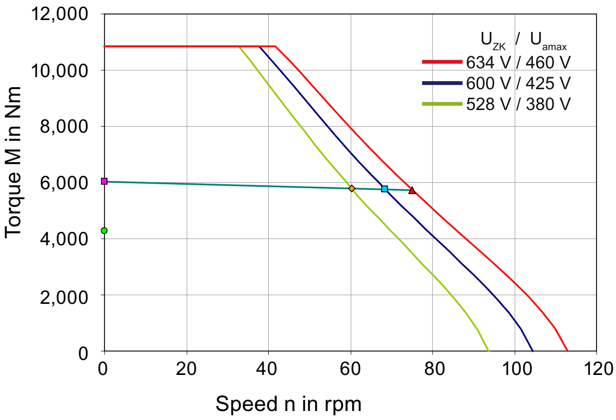
Technical data 1FW6290	Symbol	Unit	-xxB20-0Lxx	-xxB20-2Pxx
Boundary conditions				
DC link voltages	U_{ZK}	V	600	600
Water cooling inlet temperature	T_{VORL}	°C	35	35
Rated temperature of winding	T_N	°C	130	130
Rated data				
Rated torque	M_N	Nm	5760	5670
Rated current	I_N	A	95	120
Maximum speed at rated torque	$n_{MAX,MN}$	rpm	68	91
Rated power dissipation	$P_{V,N}$	kW	11	11.1
Limit data				
Maximum torque	M_{MAX}	Nm	10900	10900
Maximum current	I_{MAX}	A	210	270
Electric power of motor at M_{MAX}	$P_{EL,MAX}$	kW	91.9	10.7
Maximum speed at maximum torque	$n_{MAX,MMAX}$	rpm	38	51
No-load speed	$n_{MAX,0}$	rpm	100	130
Torque at n = 1 [rpm]	M_0	Nm	6030	6030
Current at M_0 and n = 1 [rpm]	I_0	A	100	120
Thermal static torque	M_0*	Nm	4260	4260
Thermal stall current	I_0*	A	70	90
Physical constants				
Torque constant at 20 °C	$k_{T,20}$	Nm/A	60.7	47.3
Voltage constant	k_E	V/(1000/min)	3669	2859
Motor constant at 20 °C	$k_{M,20}$	$Nm/(W)^{0.5}$	58.1	58
Thermal time constant	t_{TH}	s	180	180
No. of pole pairs	p	-	42	42
Cogging torque	M_{COG}	Nm	30	30
Stator mass	m_S	kg	187.6	192.8
Rotor mass	m_L	kg	73	73
Rotor moment of inertia	J_L	10^{-2} kgm^2	546	546
Phase resistance of winding at 20 °C	$R_{STR, 20}$	Ω	0.261	0.159
Phase inductance of winding	L_{STR}	mH	5.4	3.2
Data for main motor cooler *)				
Maximum dissipated thermal power	$Q_{H,MAX}$	kW	8.3	8.32
Recommended minimum volume flow	$\dot{V}_{H,MIN}$	l/min	14.1	14.1
Temperature increase of the coolant	ΔT_H	K	8.4	8.5
Pressure drop	Δp_H	bar	2.2	2.2

Technical data 1FW6290	Symbol	Unit	-xxB20-0Lxx	-xxB20-2Pxx
Data for precision motor cooler *)				
Maximum dissipated thermal power	$Q_{P,MAX}$	kW	0.895	0.897
Recommended minimum volume flow	$\dot{V}_{P,MIN}$	l/min	5.9	5.9
Temperature increase of the coolant	ΔT_P	K	2.2	2.2
Pressure drop	Δp_H	bar	2.2	2.2

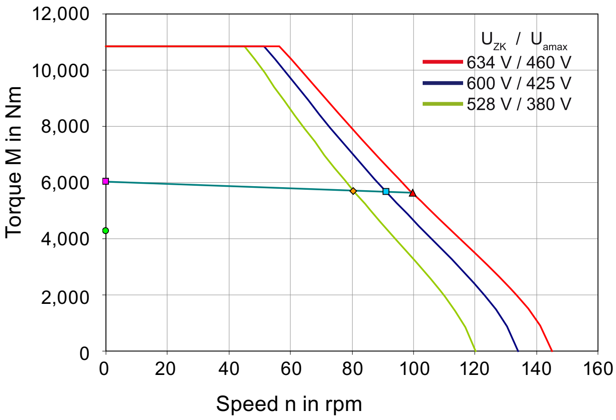
*) Parallel connection of main and precision motor cooler

Characteristics for 1FW6290-xxx20-xxxx

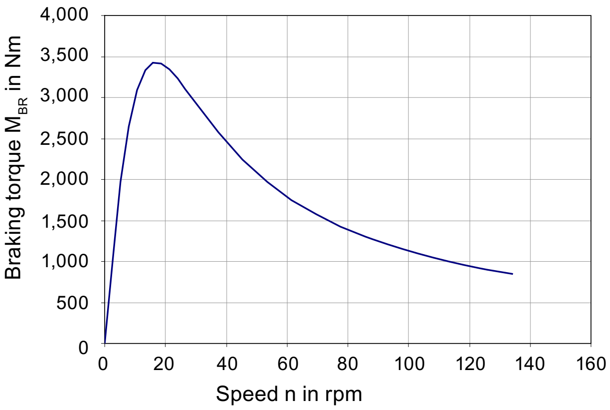
1FW6290-xxB20-0Lxx:
Torque over speed



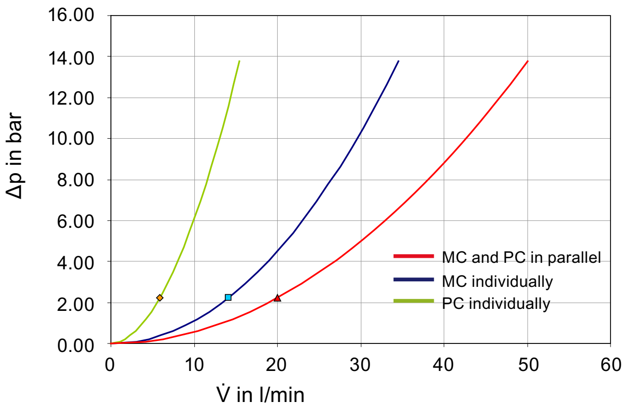
1FW6290-xxB20-2Pxx:
Torque over speed



Short-circuit braking torque over speed



Main cooler and precision cooler (MC and PC)
Pressure losses over volume flow rate



Installation drawings/Dimension drawings 15

15.1 Installation situation for motors with a cooling jacket

Design information for installation hole and O ring

- Provide insertion inclines: Minimum length Z at 15°: 3 mm, at 20°: 2 mm, edges rounded and polished
  Debur and round inside holes (cooling water connections)
- Surface quality of the opposite sealing surfaces: R_{max} ≤ 16 µm, R_z ≤ 10 µm, R_a ≤ 1.6 µm
- Note the installation hole fit (H8). If the play is too great, the O-ring does not provide sufficient sealing or the permissible gap is too large.

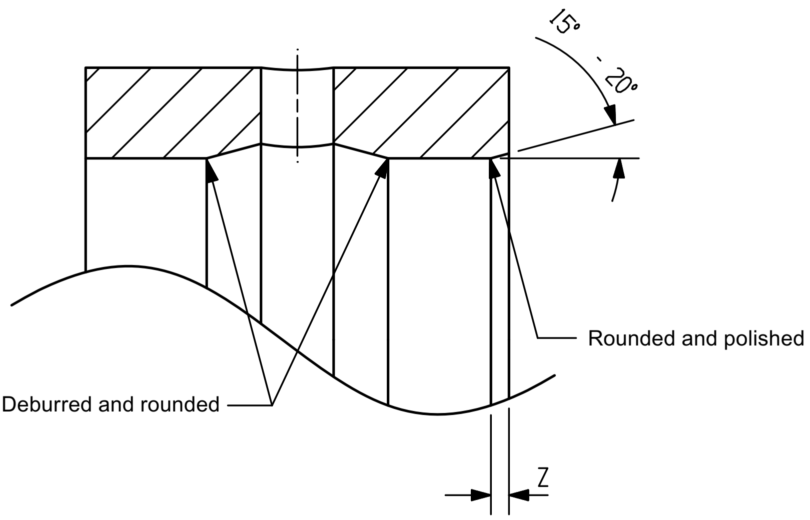
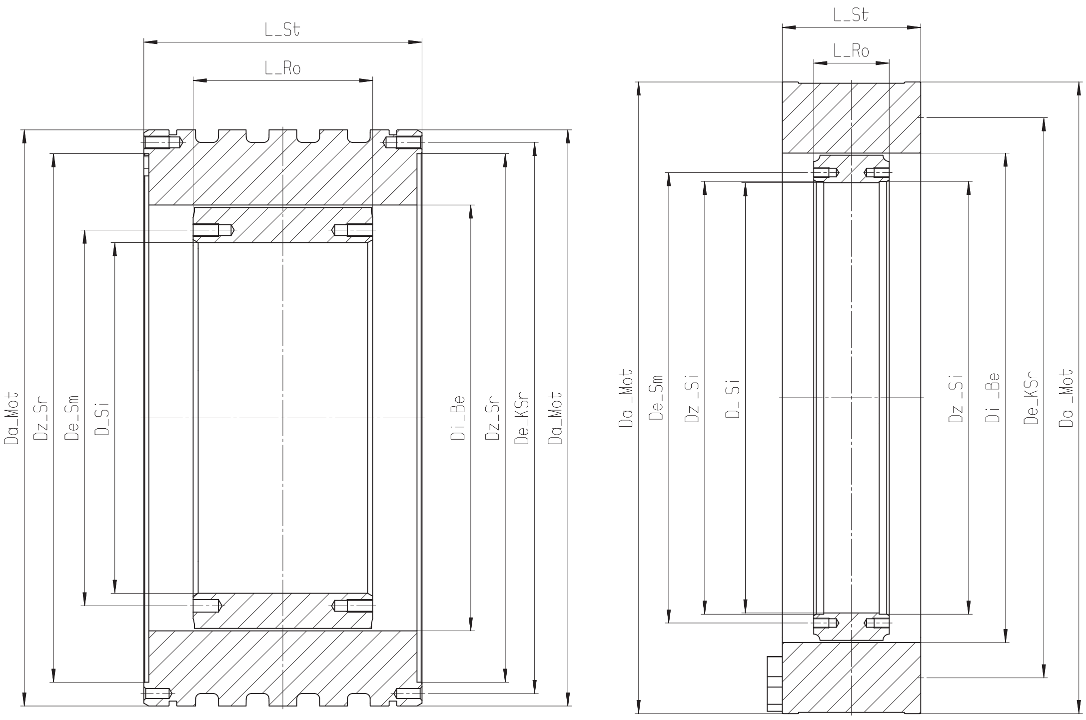


Figure 15-1 Design information for installation hole and O ring

15.2 Explanation of installation drawings

Installation dimensions

The following design-related dimensions must be taken into account.



1FW609, 1FW613 1FW616, 1FW619, 1FW623, 1FW629

Figure 15-2 Geometry data for 1FW6 Built-in torque motors

Explanation of the abbreviations in "Geometry data for 1FW6 Built-in torque motors":

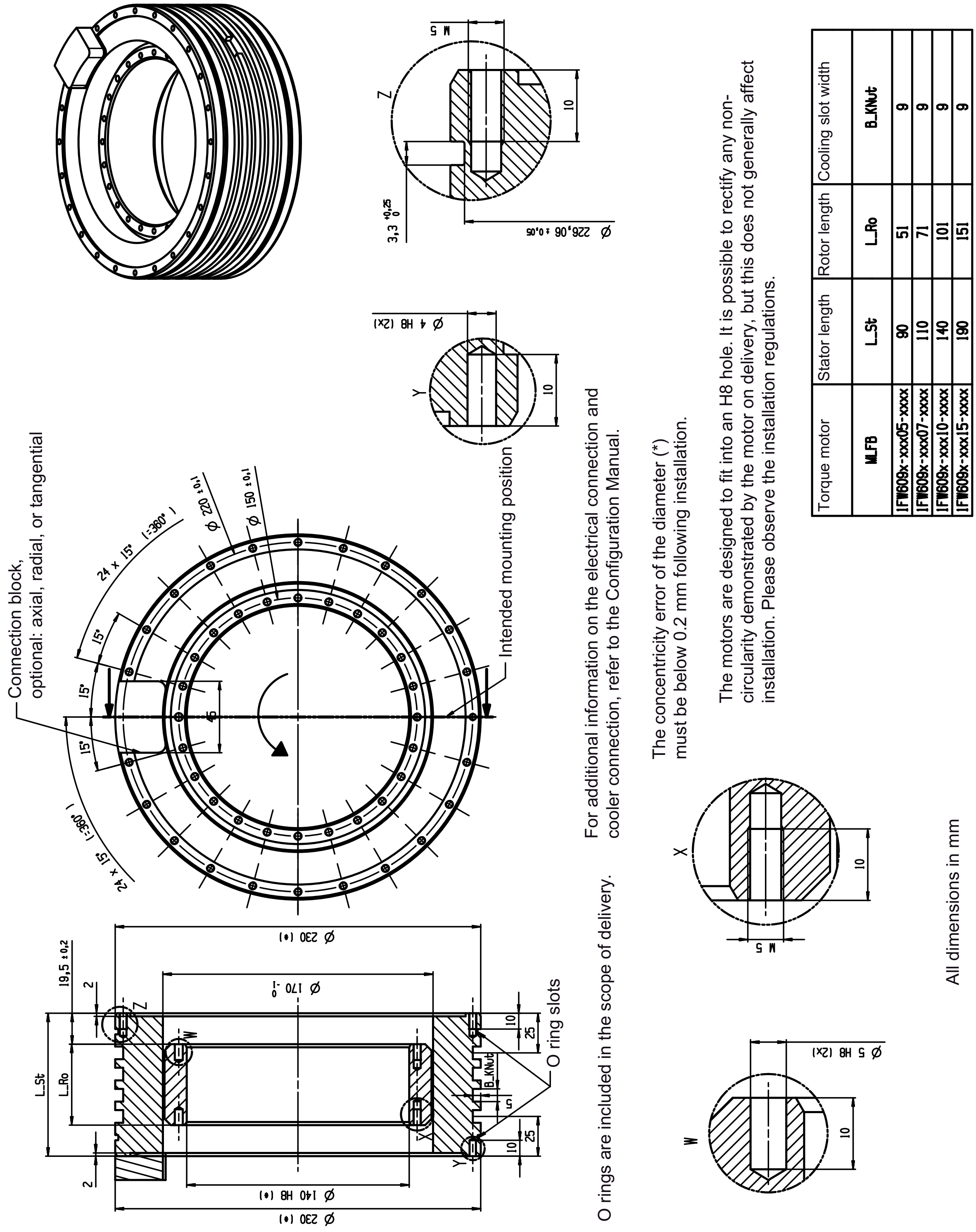
L_St	Length of stator
L_Ro	Length of rotor
Dz_Sr	Diameter of centering hole on stator
Da_Mot	External diameter of motor
De_Sm	Diameter of hole for fixing screws on rotor
De_KSr	Diameter of hole for fixing screws on stator
Di_Be	Internal diameter of stator
Dz_Si	Diameter of centering hole on rotor
D_Si	Internal diameter of rotor

Note

Siemens AG reserves the right to change the motor dimensions as part of design improvements without prior notification. The dimension drawings provided in this documentation, therefore, may not necessarily be up to date.

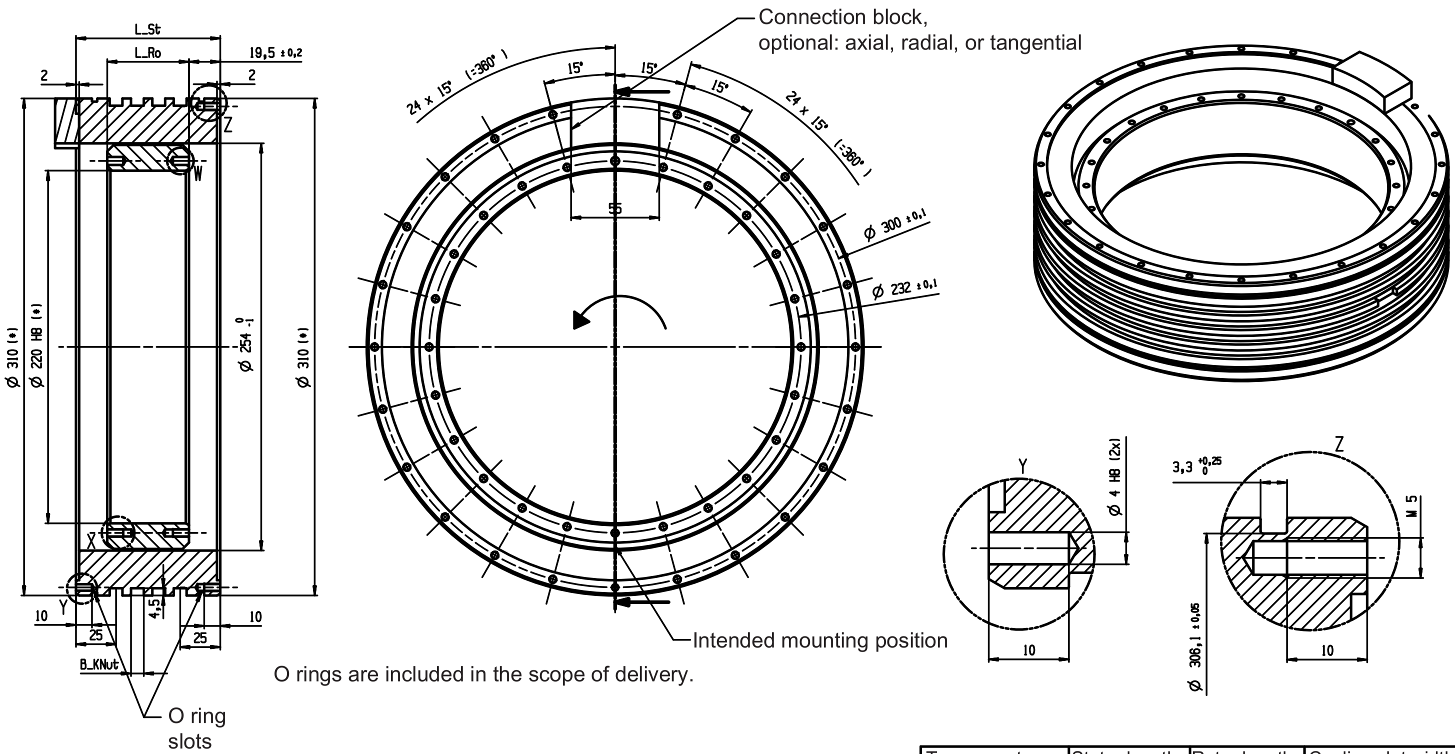
Up-to-date dimension drawings can be requested at no charge.

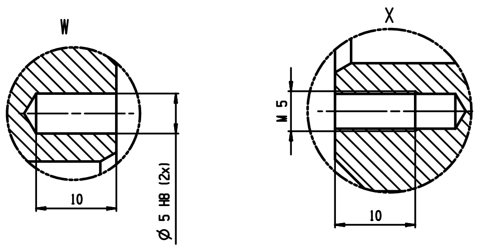
15.3 Installation drawings/Dimension drawings



Torque motor MLFB	Stator length L_St	Rotor length L_Ro	Cooling slot width B_KNut
1FW609x-xxx05-xxxx	90	51	9
1FW609x-xxx07-xxxx	110	71	9
1FW609x-xxx10-xxxx	140	101	9
1FW609x-xxx15-xxxx	190	151	9

Figure 15-3 1FW6090-xxB





All dimensions in mm

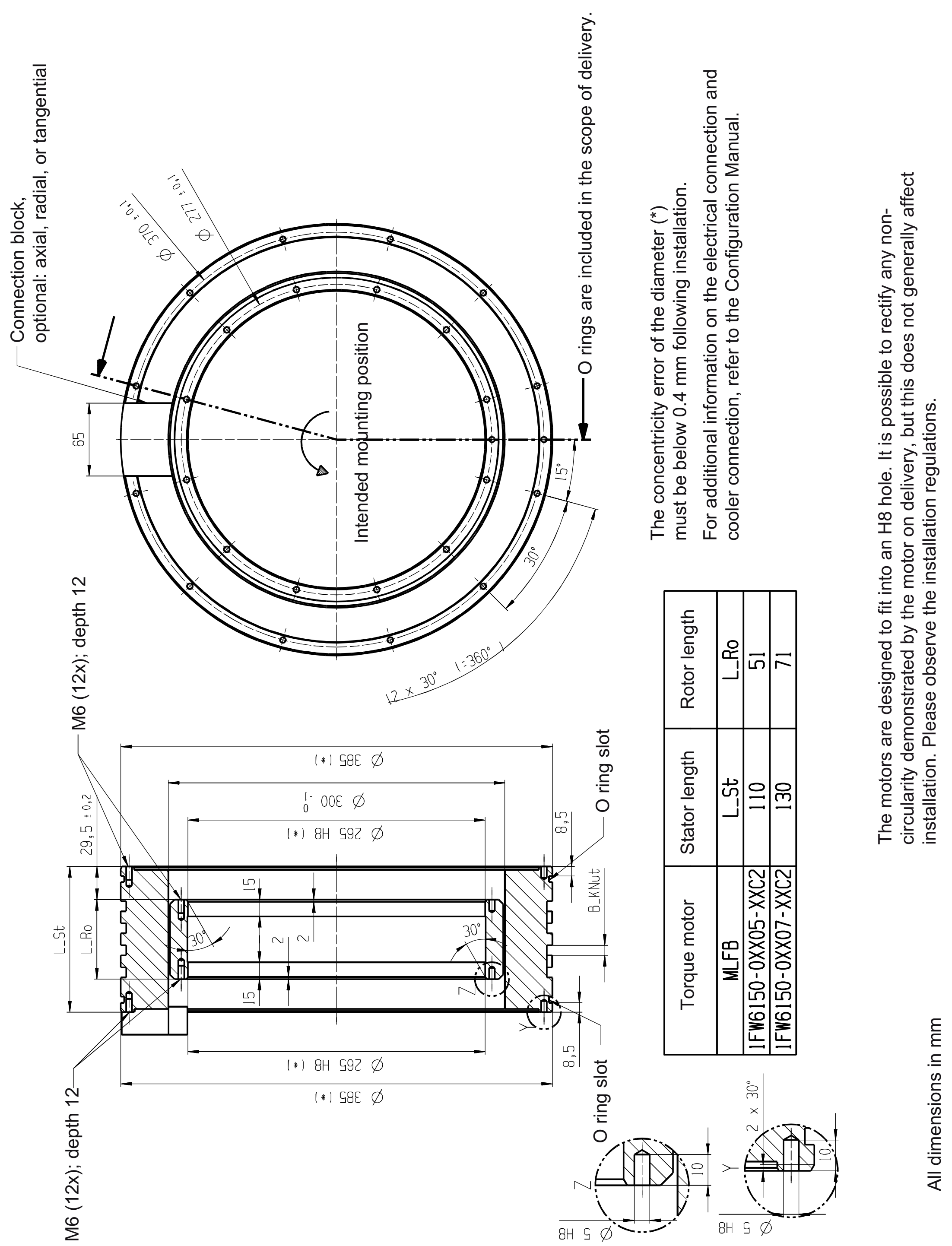
Torque motor	Stator length	Rotor length	Cooling slot width
MLFB	L_St	L_Ro	B_KNut
1FW613x-xxx05-xxx	90	51	8
1FW613x-xxx07-xxx	110	71	9
1FW613x-xxx10-xxx	140	101	8
1FW613x-xxx15-xxx	190	151	9

The concentricity error of the diameter (*) must be below 0.2 mm following installation.

For additional information on the electrical connection and cooler connection, refer to the Configuration Manual.

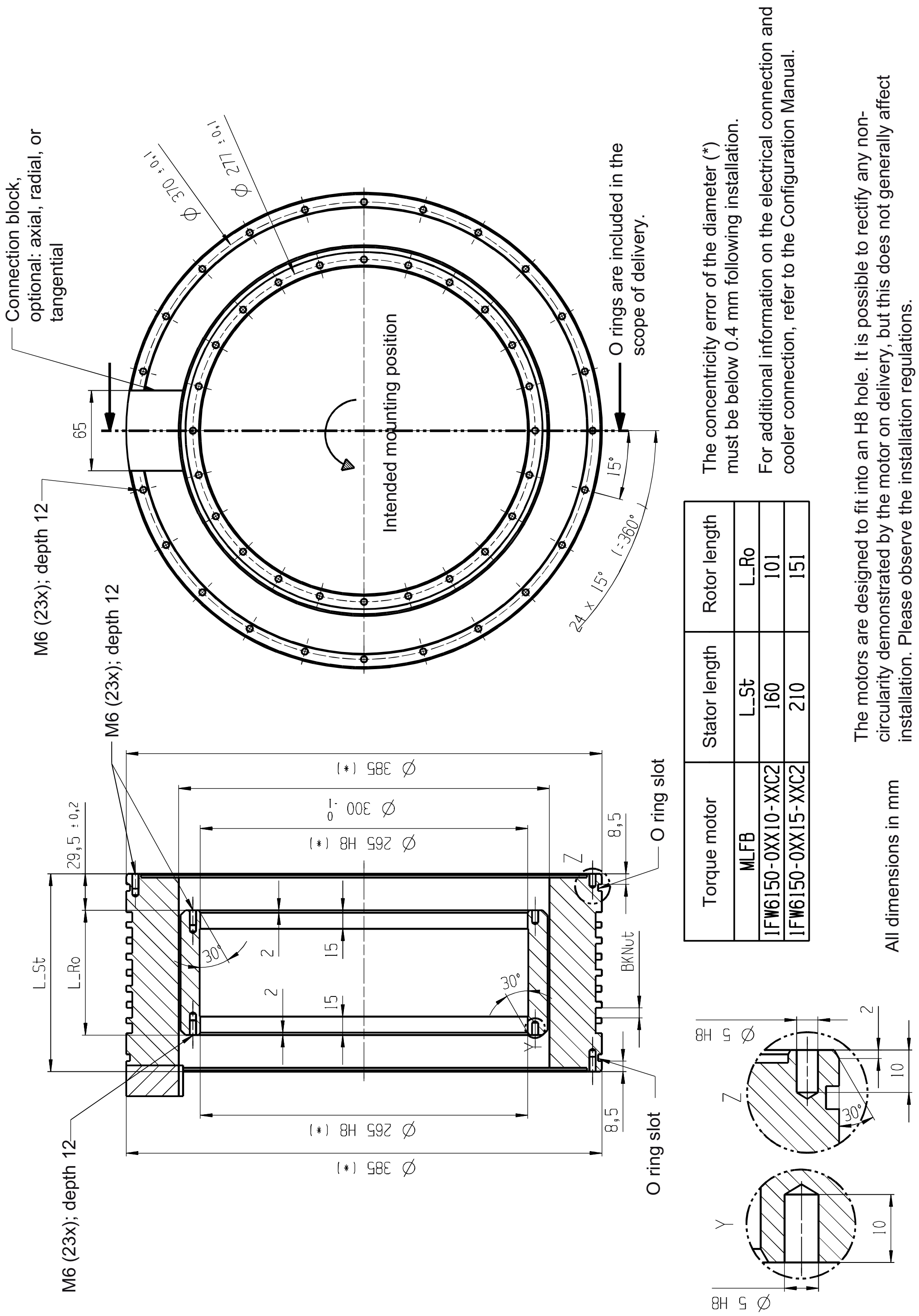
The motors are designed to fit into an H8 hole. It is possible to rectify any non-circularity demonstrated by the motor on delivery, but this does not generally affect installation. Please observe the installation regulations.

Figure 15-4 1FW6130-xxB



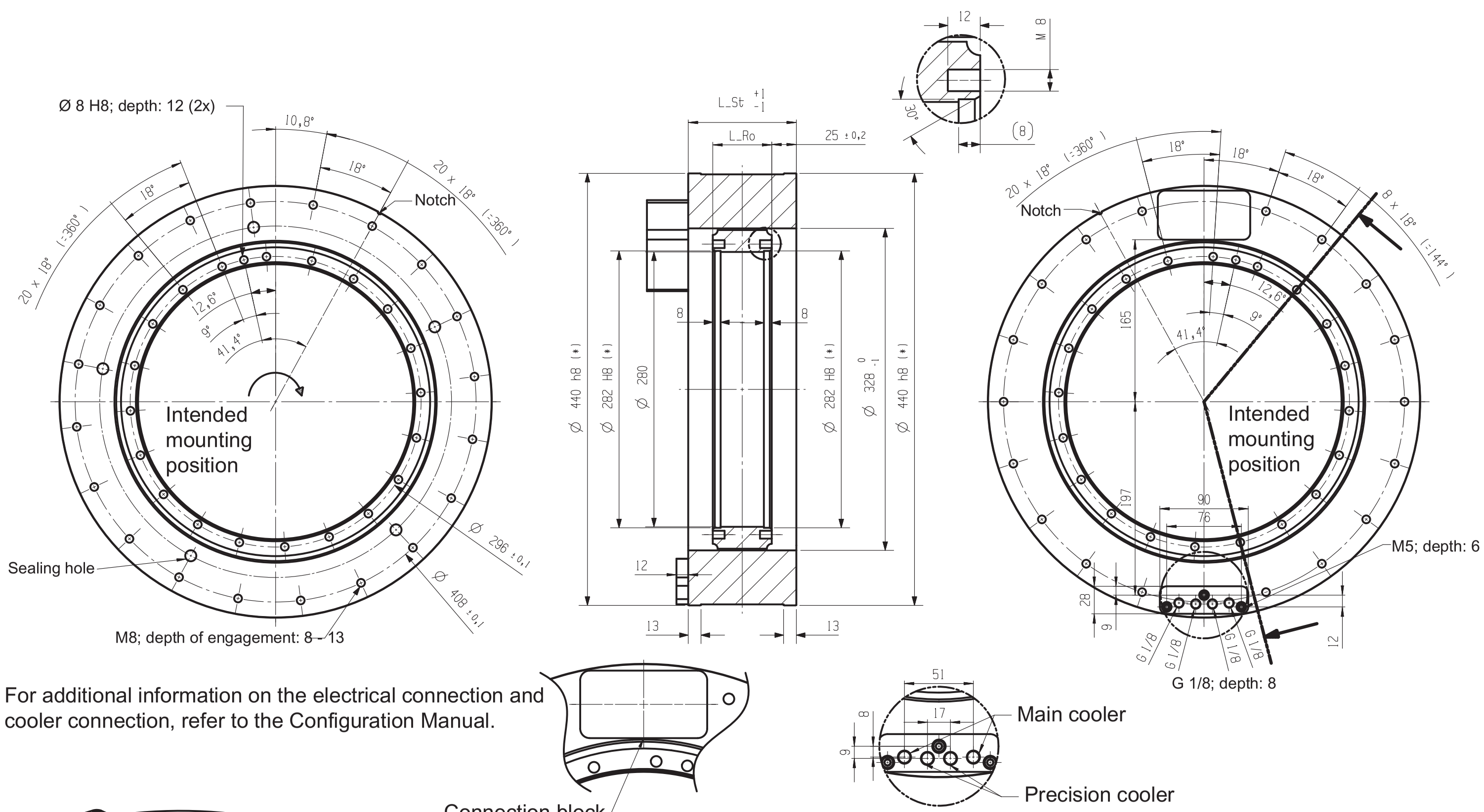
Torque motor	Stator length	Rotor length
MLFB	L_St	L_Ro
1FW6150-0XX05-XXC2	110	51
1FW6150-0XX07-XXC2	130	71

Figure 15-5 1FW6150-xxB (active component lengths 05 and 07)

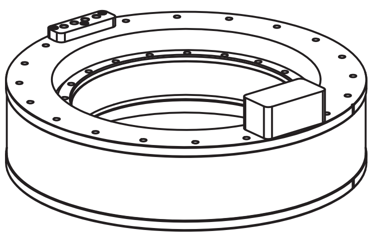


Torque motor	Stator length	Rotor length
MLFB	L_St	L_Ro
1FW6150-0XX10-XXC2	160	101
1FW6150-0XX15-XXC2	210	151

Figure 15-6 1FW6150-xxB (active component lengths 10 and 15)



For additional information on the electrical connection and cooler connection, refer to the Configuration Manual.



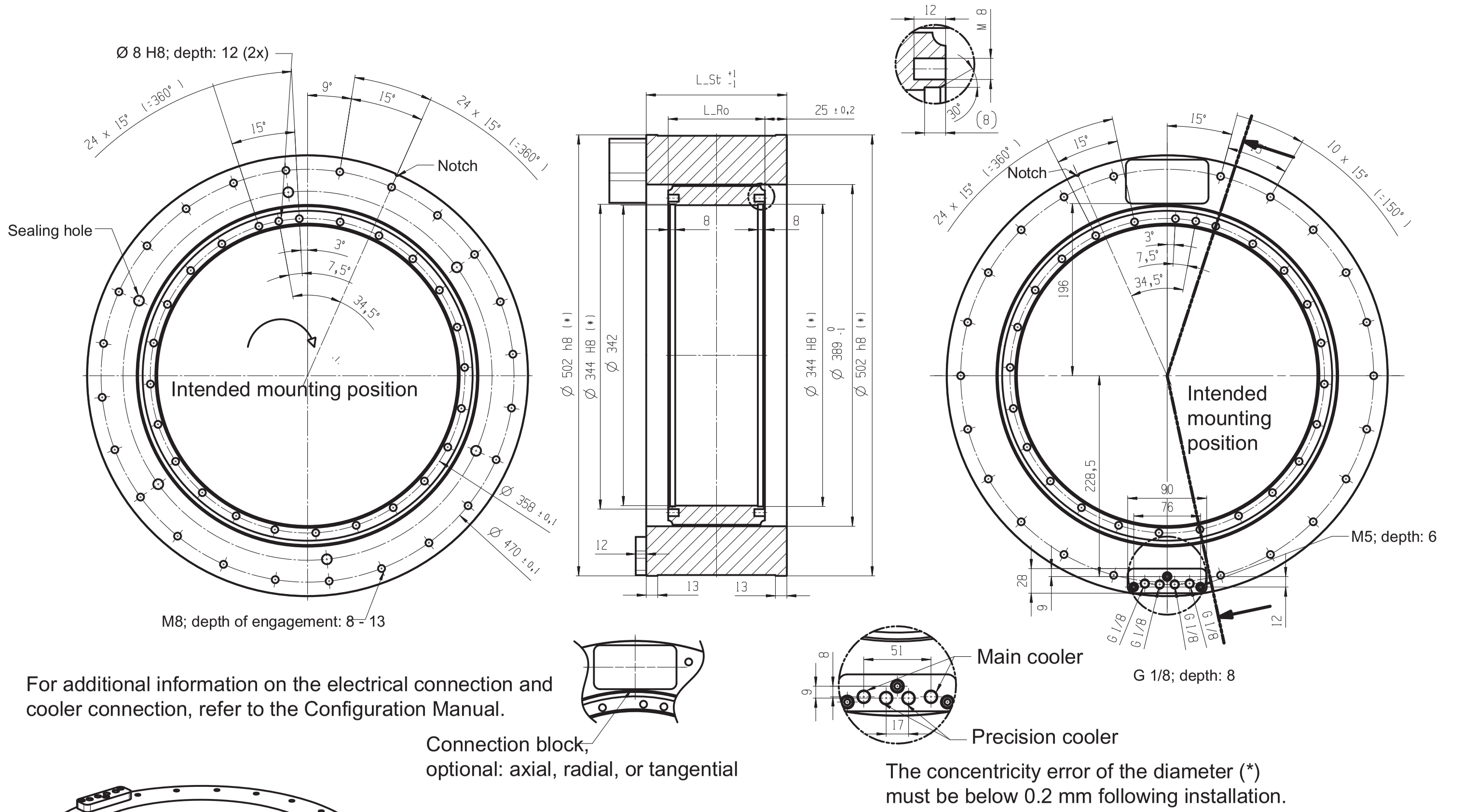
The concentricity error of the diameter (*) must be below 0.2 mm following installation.

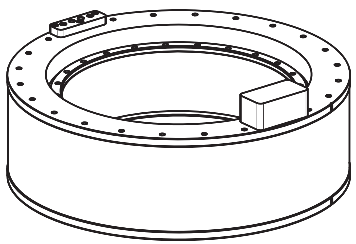
All dimensions in mm

Torque motor MLFB	Stator length L_St	Rotor length L_Ro
1FW6160-xxB05-1Jxx	110	60
1FW6160-xxB05-2Jxx	110	60
1FW6160-xxB05-5Gxx	110	60
1FW6160-xxB07-1Jxx	130	80
1FW6160-xxB07-2Jxx	130	80
1FW6160-xxB07-5Gxx	130	80
1FW6160-xxB07-8Fxx	130	80
1FW6160-xxB10-1Jxx	160	110
1FW6160-xxB10-2Jxx	160	110
1FW6160-xxB10-5Gxx	160	110
1FW6160-xxB10-8Fxx	160	110
1FW6160-xxB10-2Pxx	170	110

Torque motor MLFB	Stator length L_St	Rotor length L_Ro
1FW6160-xxB15-2Jxx	210	160
1FW6160-xxB15-5Gxx	210	160
1FW6160-xxB15-8Fxx	210	160
1FW6160-xxB15-2Pxx	220	160
1FW6160-xxB15-0Wxx	220	160
1FW6160-xxB20-5Gxx	260	210
1FW6160-xxB20-8Fxx	260	210
1FW6160-xxB20-2Pxx	270	210
1FW6160-xxB20-0Wxx	270	210

Figure 15-7 1FW6160-xxB



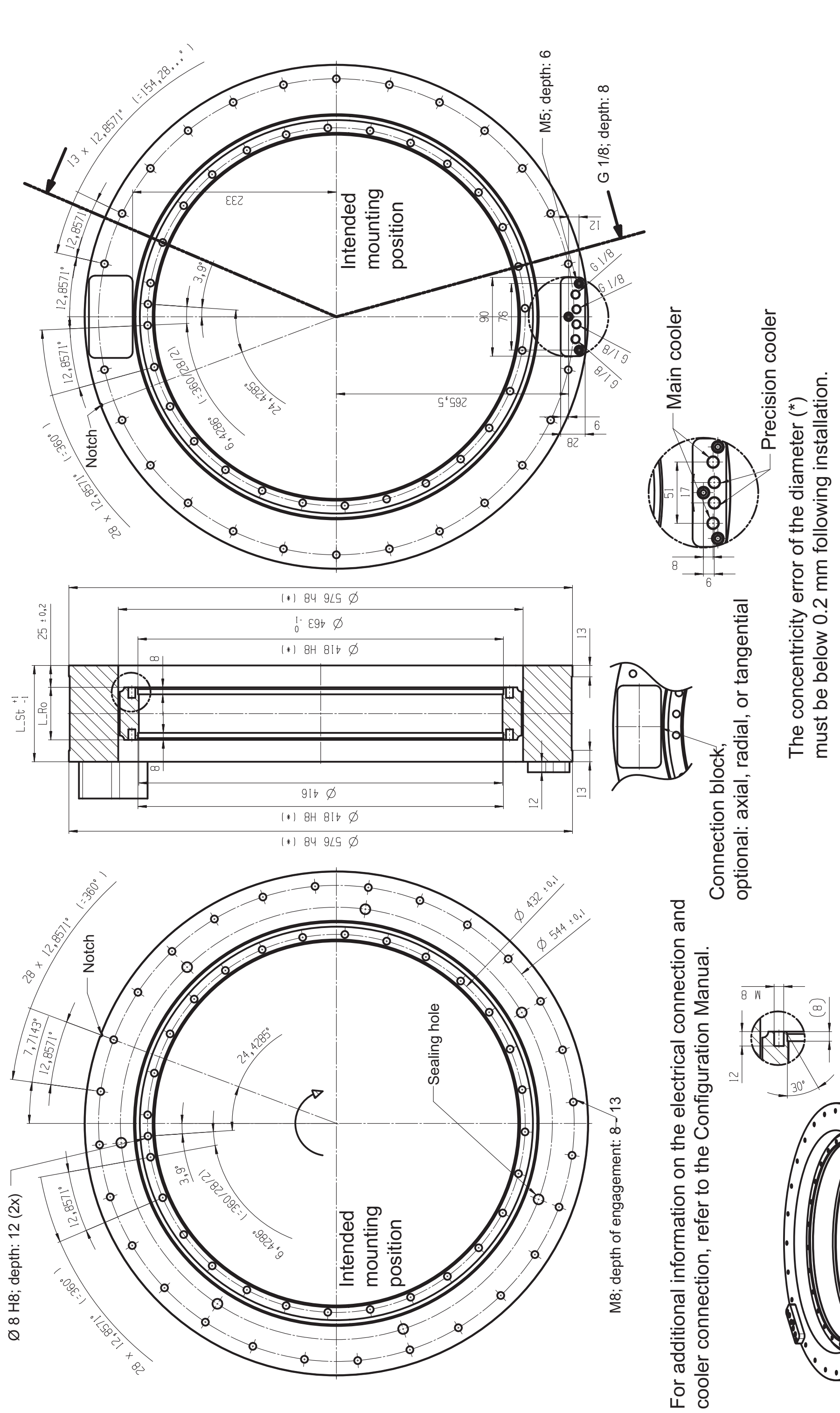


All dimensions in mm

Torque motor MLFB	Stator length L_St	Rotor length L_Ro
1FW6190-xxB05-1Jxx	110	60
1FW6190-xxB05-2Jxx:	110	60
1FW6190-xxB05-5Gxx	110	60
1FW6190-xxB07-1Jxx	130	80
1FW6190-xxB07-2Jxx	130	80
1FW6190-xxB07-5Gxx	130	80
1FW6190-xxB07-8Fxx	130	80
1FW6190-xxB10-1Jxx	160	110
1FW6190-xxB10-2Jxx	160	110
1FW6190-xxB10-5Gxx	160	110
1FW6190-xxB10-8Fxx	160	110
1FW6190-xxB10-2Pxx	170	110

Torque motor MLFB	Stator length L_St	Rotor length L_Ro
1FW6190-xxB15-2Jxx	210	160
1FW6190-xxB15-5Gxx	210	160
1FW6190-xxB15-8Fxx	210	160
1FW6190-xxB15-2Pxx	220	160
1FW6190-xxB15-0Wxx	220	160
1FW6190-xxB20-5Gxx	260	210
1FW6190-xxB20-8Fxx	260	210
1FW6190-xxB20-2Pxx	270	210
1FW6190-xxB20-0Wxx	270	210

Figure 15-8 1FW6190-xxB

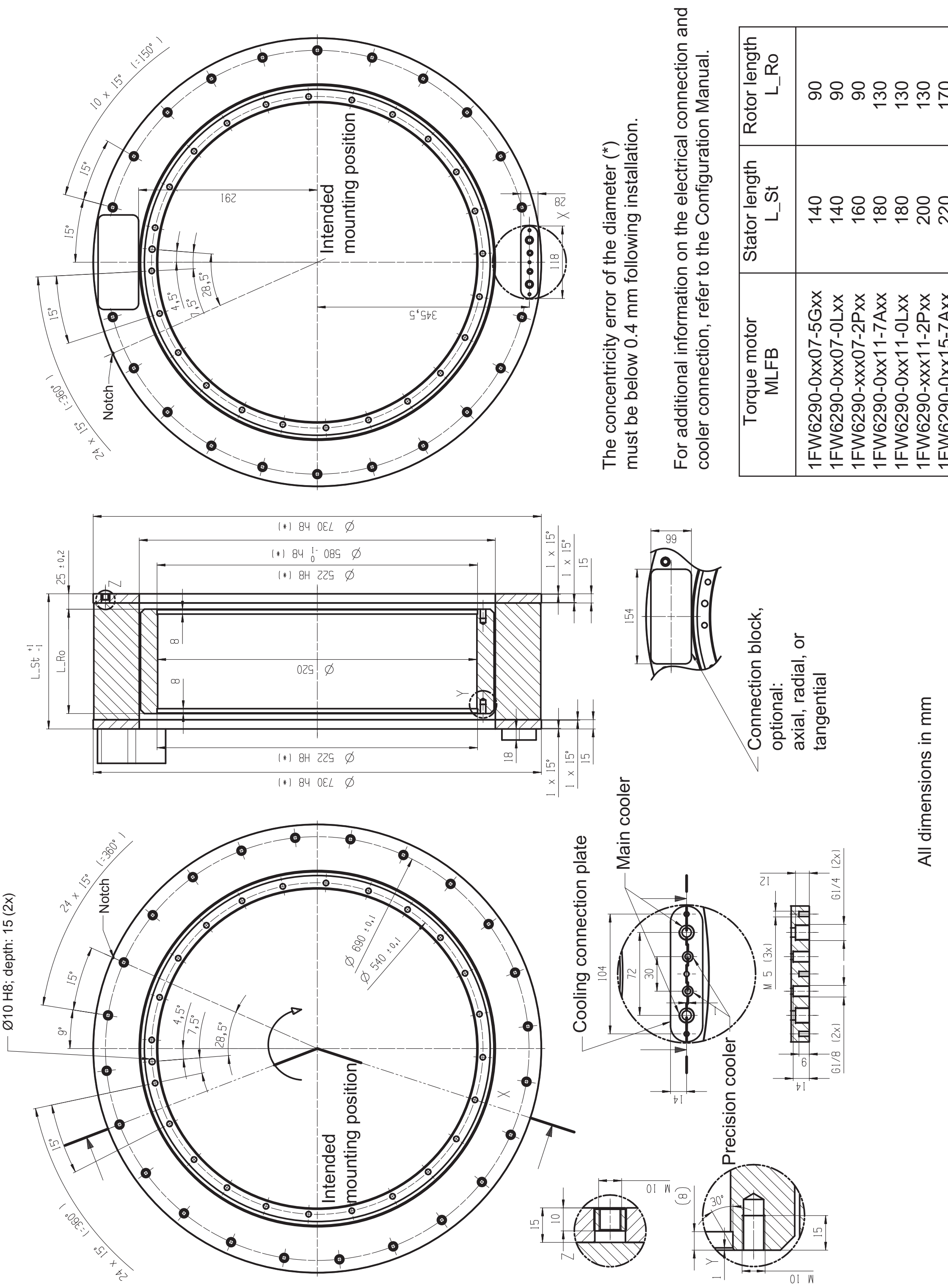


Torque motor MLFB	Stator length L_St	Rotor length L_Ro
1FW6230-xxx05-1Jxx	110	60
1FW6230-xxx05-2Jxx	110	60
1FW6230-xxx05-5Gxx	110	60
1FW6230-xxx07-1Jxx	130	80
1FW6230-xxx07-2Jxx	130	80
1FW6230-xxx07-5Gxx	130	80
1FW6230-xxx07-8Fxx	130	80
1FW6230-xxx10-2Jxx	160	110
1FW6230-xxx10-5Gxx	160	110
1FW6230-xxx10-8Fxx	160	110

Torque motor MLFB	Stator length L_St	Rotor length L_Ro
1FW6230-xxx10-2Pxx	160	110
1FW6230-xxx15-4Cxx	210	160
1FW6230-xxx15-5Gxx	210	160
1FW6230-xxx15-8Fxx	210	160
1FW6230-xxx15-2Pxx	210	160
1FW6230-xxx15-0Wxx	220	160
1FW6230-xxx20-5Gxx	260	210
1FW6230-xxx20-8Fxx	260	210
1FW6230-xxx20-2Pxx	260	210
1FW6230-xxx20-0Wxx	270	210

All dimensions in mm

Figure 15-9 1FW6230-xxB



The concentricity error of the diameter (*) must be below 0.4 mm following installation.

For additional information on the electrical connection and cooler connection, refer to the Configuration Manual.

Torque motor MLFB	Stator length L_St	Rotor length L_Ro
1FW6290-0xx07-5Gxx	140	90
1FW6290-0xx07-0Lxx	140	90
1FW6290-xxx07-2Pxx	160	90
1FW6290-0xx11-7Axx	180	130
1FW6290-0xx11-0Lxx	180	130
1FW6290-xxx11-2Pxx	200	130
1FW6290-0xx15-7Axx	220	170
1FW6290-0xx15-0Lxx	220	170
1FW6290-xxx15-2Pxx	240	170
1FW6290-0xx20-0Lxx	260	210
1FW6290-xxx20-2Pxx	280	210

Figure 15-10 1FW6290-xxB

Appendix A

A.1 Recommended manufacturers

Information regarding third-party products

NOTICE
This document contains recommendations relating to third-party products. This involves third-party products whose fundamental suitability is familiar to us. It goes without saying that equivalent products from other manufacturers may be used. Our recommendations are to be seen as helpful information, not as requirements or regulations. We cannot accept any liability for the quality and properties/features of third-party products.

A.1.1 Supply sources for connection components and accessories for heat-exchanger units

Rectus GmbH	
	Daimlerstrasse 7 D-71735 EBERDINGEN-NUSSDORF, Germany Phone: +49 (0) 70 42 - 1 00 - 0 Fax: +49 (0) 70 42 - 1 00 - 147 E-mail: info@rectus.de www.rectus.de

Festo AG & Co. KG	
	Ruiter Strasse 82 D-73734 ESSLINGEN-BERKHEIM, Germany Phone: +49 (0) 1 80 - 3 03 11 11 Fax: +49 (0) 7 11 - 3 47 26 28 E-mail: info_de@festo.com www.festo.com

Serto GmbH	
	Kasseler Strasse 64 D-34277 FULDABRÜCK, Germany Phone: +49 (0) 5 61 - 5 80 04 - 0 Fax: +49 (0) 5 61 - 5 80 04 - 44 E-mail: info@serto.de www.serto.com

SMC Pneumatik GmbH	
	Boschring 13 - 15 63329 EGELSBACH Phone: +49 (0) 61 03 - 4 02 - 0 Fax: +49 (0) 61 03 - 4 02 - 1 39 E-mail: info@smc-pneumatik.de www.smc-pneumatik.de

A.1.2 Supply sources for cooling systems

Pfannenberg GmbH	
	Werner-Witt-Strasse 1 D-21035 HAMBURG, Germany Phone: +49 (0) 40 - 7 34 12 - 0 Fax: +49 (0) 40 - 7 34 12 - 1 01 E-mail: sales.support@pfannenberg.com www.pfannenberg.de

BKW Kälte-Wärme-Versorgungstechnik GmbH	
	Benzstrasse 2 D-72649 WOLFSCHLUGEN, Germany Phone: +49 (0) 70 22 - 50 03 - 0 Fax: +49 (0) 70 22 - 50 03 - 30 E-mail: info@bkw-kuema.de www.bkw-kuema.de

Helmut Schimpke und Team Industriekühlanlagen GmbH + Co. KG	
	Ginsterweg 25 - 27 42781 Haan, Germany Phone: 49 (0) 21 29 - 94 38 - 0 Fax: 49 (0) 21 29 - 94 38 - 99 E-mail: info@schimpke.de www.schimpke.de

Hydac International GmbH	
	Industriegebiet 66280 Sulzbach/Saar, Germany Phone: +49 (0) 68 97 - 5 09 - 01 E-mail: info@hydac.com www.hydac.com

Rittal GmbH & Co. KG	
	Auf dem Stützelberg 35745 Herborn, Germany Phone: +49 (0) 27 72 - 5 05 - 0 Fax: +49 (0) 27 72 - 5 05 - 23 19 E-mail: info@rittal.de www.rittal.de

A.1.3 Supply sources for anti-corrosion agents

TYFOROP CHEMIE GmbH	
	Anton-Rée-Weg 7 D-20537 HAMBURG, Germany Phone: +49 (0) 40 - 61 21 69 Fax: +49 (0) 40 - 61 52 99 E-mail: info@tyfo.de www.tyfo.de

Clariant Produkte (Deutschland) GmbH	
	Werk Gendorf Industrieparkstrasse 1 84508 Burgkirchen, Germany Phone: +49 (0) 8679 - 7 - 0 Fax: +49 (0) 8679 - 7 - 4545 www.clariant.de

A.1.4 Supply sources for braking elements

HEMA Maschinen und Apparateschutz GmbH	
	Seligenstädter Straße 82 63500 SELIGENSTADT Phone: +49 (0) 61 82 - 7 73 - 0 Fax: +49 (0) 61 82 - 7 73 - 35 E-mail: info@hema-schutz.de www.hema-schutz.de

Chr. Mayr GmbH + Co. KG	
	Eichenstraße 1 87665 MAUERSTETTEN Phone: +49 (0) 83 41 - 8 04 - 0 Fax: +49 (0) 83 41 - 8 04 - 4 21 E-mail: info@mayr.de www.mayr.de

A.2 Fax form for suggestions/corrections (copy template)

Should you come across any printing errors when reading this publication, please notify us on this sheet. We would also be grateful for any suggestions and recommendations for improvement.

To: SIEMENS AG I DT MC MS1 P.O. Box 3180 D-91050 Erlangen, Federal Repub- lic of Germany Fax: +49 (0) 9131 / 98 - 2176 (documentation) mailto:docu.motioncontrol@siemens.com http://www.siemens.com/automation/service&support	From Name:
	Address of your Company/Dept.
	Street:
	Postal code: Location:
	Phone: /
	Fax: /

Suggestions and/or corrections

A.3 List of abbreviations

abs. WMS	Absolute angular position measuring system, absolute encoder
BGR	Health and safety at work regulations (in Germany)
BGV	Binding national health and safety at work regulations (in Germany)
CE	Communauté Européenne (European Community)
DAC	Digital-to-analog converter
DIN	Deutsches Institut für Normung (German standards organization)
DQ	DRIVE-CLiQ
EU	European Union
EMF	Electromotive force
EMC	Electromagnetic compatibility
EN	Europäische Norm (European standard)
EEC	European Economic Community
FAQ	Frequently asked questions
HFD	High-frequency damping
HW	Hardware
IATA	International Air Transport Association
IEC	International Electrotechnical Commission
Incr. WMS	Incremental angular position measuring system, incremental encoder
IP	International Protection
K_V factor	Proportional gain
KTY	Temperature sensor with progressive, almost linear characteristic
MLFB	Maschinenlesbare Fabrikatebezeichnung (order designation)
LI	Line infeed
NC	Numerical control
NCK	Numerical control kernel: NC kernel with block preparation, travel range, etc.
PE	Protective earth
PELV	Protective extra low voltage
PDS	Power drive system
ph value	Concentration of hydrogen ions in a liquid
PLC	Programmable logic controller
PTC	Temperature sensor with positive temperature coefficients and "quasi-switching" characteristic
RLI	Rotor position identification ("pole position identification"); procedure for determining the commutation angle offset
S1	"Continuous operation" mode
S2	"Short-time operation" mode
S3	"Intermittent operation" mode
SME	Sensor Module External

SW	Software
Temp-F	Circuit for monitoring the temperature the motor winding
Temp-S	Temperature monitoring circuit for shutting down the drive in the event of overtemperature
TN	Terre Neutral
TM	Torque motor
UL	Underwriters Laboratories
VDE	Association of Electrical Engineering, Electronics and Information Technology (in Germany)

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