DBR AUTOMATION

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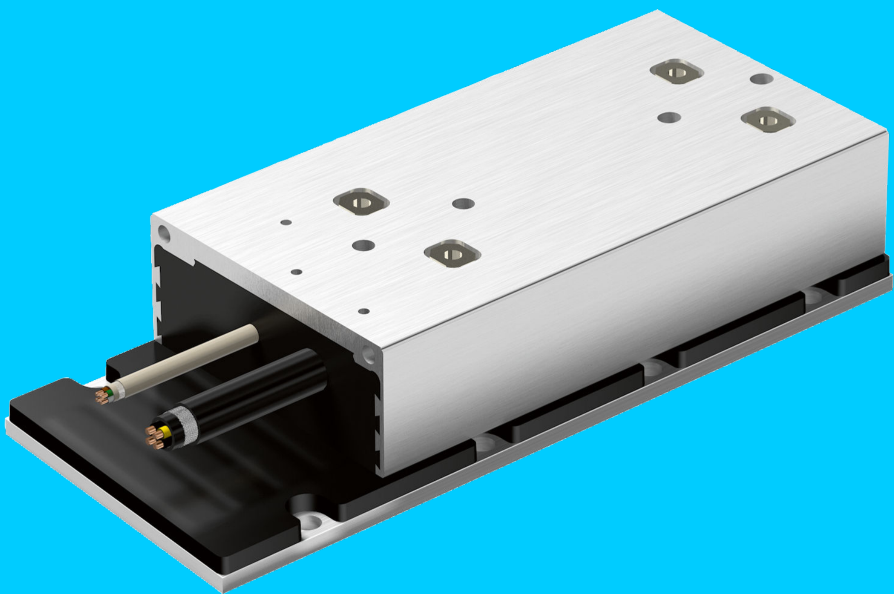
A Bosch Company

Project Planning Manual

ML3

Self-Cooled Linear Motors



R911389760, Edition 03

DOK-MOTOR*-ML3********-PR03-EN-P DC-AE/EPI5 (fs, mb)

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1 Product presentation

1.1 Fields of application

Continuously increasing demands on the economic benefit of electric machines require new problem-solving approaches to fulfill the requirements on dynamic, accuracy and synchronization. Conventional NC-drives, consisting of a rotary electrical motor and mechanical transmission elements like gearboxes, belt transmissions or gear rack pinions, cannot fulfill these demands or, only with high effort.

Self-cooled, iron-core linear direct drive technique ML3 provides innovative product characteristics. Due to the wide application range of the ML3 masses can be moved and positioned in a highly dynamic and highly precise way.

Based on the above-mentioned advantages, typical applications result for example in:

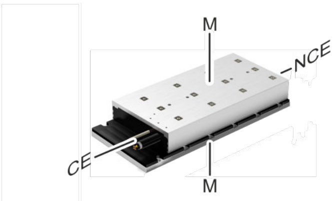
- Printing machinery (e.g. digital and 3D print)
- Paper processing machinery
- Machine tools (e.g. laser cutting/welding)
- Medical technology (e.g. patient tables)
- Semi-conductor technology (e.g. transport systems)
- Laboratory automation
- General automation

Significant advantages of self-cooled iron-core linear motors are:

- Highest dynamic
- Excellent control quality and synchronization
- Low latching forces
- High-precision positioning behavior
- High static and dynamic load rigidity – no mechanical transmission elements like ball screw, toothed belt, gear rack, etc.
- High efficiency - low overhead
- Maintenance-free drive (no wearing parts at the motor)
- Simplified machine structure
- No additional active cooling required

For a comprehensive overview of all product groups of Bosch Rexroth, please refer to the online product catalog: ➦https://www.boschrexroth.com.

1.2 Basic features

Product	3~ PM motor
Type	ML3 consists of ML3P and ML3S
Ambient temperature during operation	0 ... 40 °C
Type of protection	IP40 (IP64) (EN 60034-5)
Cooling mode	IC410, Self-cooling (EN 60034-6)
Installation altitude	0 ... 1,000 m above NN (without de-rating)
Thermal class	130 (B) (EN 60034-1)
Encoder system	Hall sensor digital (SUP-E01-D12-ML3) Hall sensor analog (SUP-E01-A12-ML3)
Electrical connection	Two connection cables with open cable ends: Power connection: 4-wire, shielded cable (3x power + 1x PE) Sensor connection: 4-wire, shielded cable (2 wires for KTY, 2 wires for PTC)
Motor ends	 CE Cable End, *Kabelabgangsseite* NCE Non Cable End, *Nicht-Kabelabgangsseite* M Mounting face, *Montagefläche*

1.3 Setup

Self-cooled iron-core linear motors ML3 consist of the components primary and secondary part and have an optional Hall unit.

The primary part bears the electrically active part of the linear motor. The plated iron package attached to an aluminum cooling housing supports the three-phase winding and is cast in plastic. The cooling housing is also used for installation. The winding contains two temperature sensors. Additionally, one digital and one analog Hall unit are available.

The secondary part consists of a ferromagnetic base plate with permanent magnets and cast in plastic. In most cases, the distance is arranged by means of serial secondary parts (short stator principle). The opposite principle is also possible and is used, for example, by the flexible transport system FTS (Flexible Transport System) of Bosch Rexroth (long stator principle).

For further information on the FTS, please refer to project planning manual DOK-NY4000-HOUSING*ACC-PRxx / MNR R911337672.

The designation of the components is as follows:

- ML3: Motor Linear 3rd Generation
- ML3P: Motor Linear 3rd Generation primary part
- ML3S: Motor Linear 3rd Generation secondary part

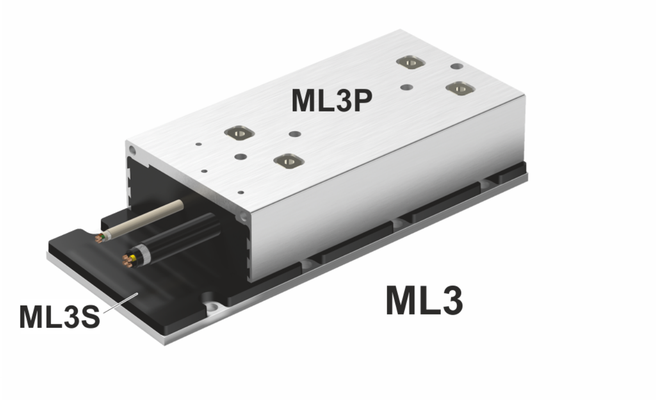


Fig. 1: Picture example of ML3 motor

1.4 Power spectrum

The self-cooled, iron-core linear direct drive technology ML3 offers new solutions due to a high-performance combination of motor technique with digital intelligent drive controllers . The spectrum of ML3 linear drive technique of Bosch Rexroth realizes drives with feed forces of 60 N up to 4,500 N, acceleration up to 250 m/s² and maximum velocity up to 900 m/min.

The following diagram gives an overview of the performance spectrum:

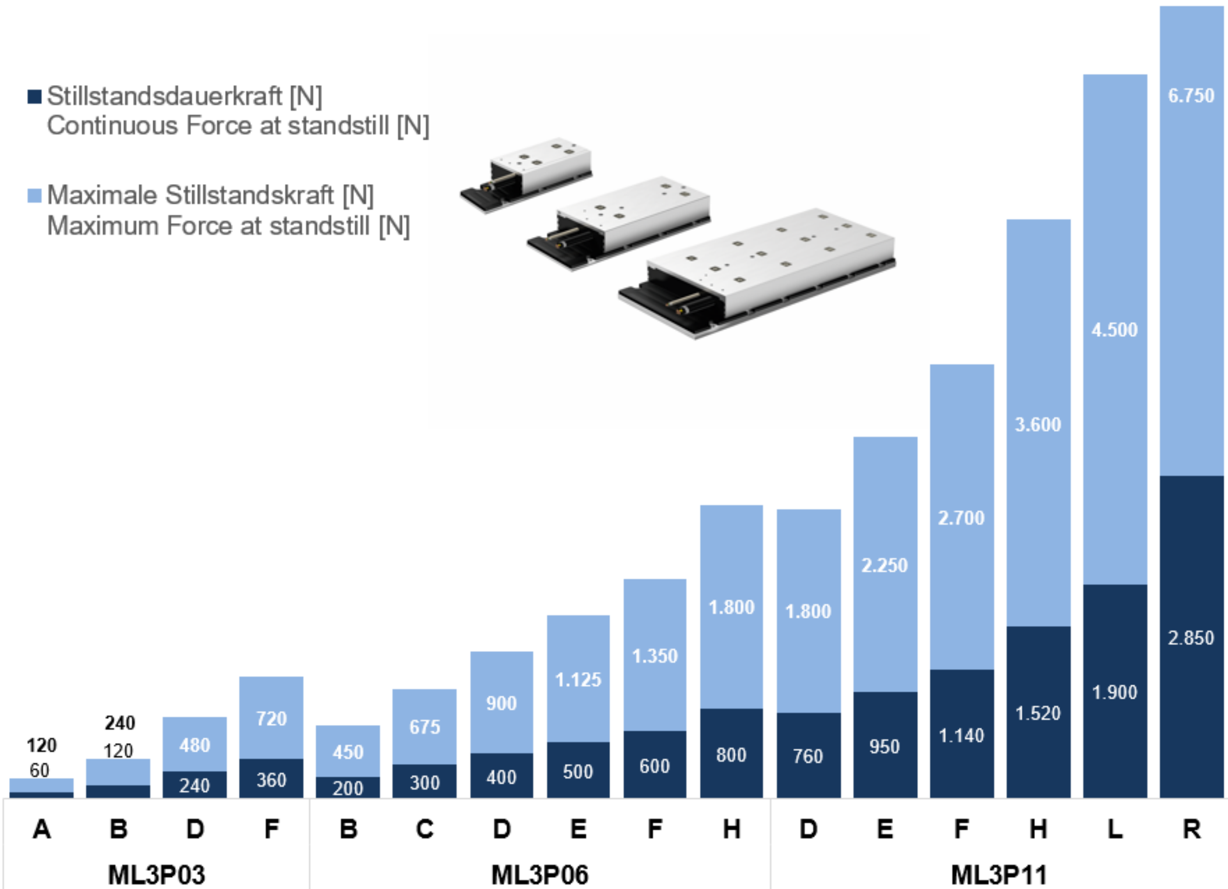


Fig. 2: Motor power spectrum

1.5 About this documentation

1.5.1 Editions of this documentation

Table 1: Record of revisions

Edition	Release date	Notes
01	04/2019	First edition
02	10/2021	Update and addition of new motor types, EAC label removed
03	03/2023	Update and addition of overall length ML3P11-R; UKCA marking included

1.5.2 Document structure

This documentation includes safety-related guidelines, technical data and operating instructions. The following table provides an overview of the contents of this documentation.

Table 2: Chapter structure

<table>
<tr><th>Chapter</th><th>Title</th><th colspan="4">Content</th></tr>
<tr><td>1</td><td>Introduction</td><td colspan="4">Product presentation / Notes regarding reading</td></tr>
<tr><td>2</td><td>Important instructions on use</td><td colspan="4" rowspan="2">Important safety instructions</td></tr>
<tr><td>3</td><td>Safety</td></tr>
<tr><td>4</td><td>Technical data</td><td rowspan="11">Product description</td><td rowspan="8">for designers and project developers</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>5</td><td>Specifications</td></tr>
<tr><td>6</td><td>Type codes</td></tr>
<tr><td>7</td><td>Accessories</td><td rowspan="8">Practice</td><td rowspan="8">for operating and maintenance personnel</td></tr>
<tr><td>8</td><td>Connection technique</td></tr>
<tr><td>9</td><td>Operating condition and application instructions</td></tr>
<tr><td>10</td><td>Motor-control combination</td></tr>
<tr><td>11</td><td>Motor dimensioning</td></tr>
<tr><td>12</td><td>Handling, transport and storage</td><td rowspan="3"></td></tr>
<tr><td>13</td><td>Installation</td></tr>
<tr><td>14</td><td>Startup, operation and maintenance</td></tr>
<tr><td>15</td><td>Service & Support</td><td colspan="4" rowspan="2">Additional information</td></tr>
<tr><td>16</td><td>Index</td></tr>
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1.5.3 Presentation of information

Explanation of signal words and the safety alert symbol

The Safety Instructions in the available application documentation contain specific signal words (DANGER, WARNING, CAUTION or NOTICE) and, where required, a safety alert symbol (in accordance with ANSI Z535.6-2011).

The signal word is intended to draw your attention to the safety instructions and describes the seriousness of the danger.

The safety alert symbol (a triangle with an exclamation point), which precedes the signal words DANGER, WARNING and CAUTION, is used to alert the reader to personal injury hazards.

⚠ **DANGER**	Non-compliance with this safety instructions **will** result in death or severe personal injury.

⚠ WARNING	Non-compliance with this safety instructions **can** result in death or severe personal injury.
⚠ CAUTION	Non-compliance with this safety instructions can result in moderate or minor personal injury.
NOTICE	Non-compliance with this safety instructions can result in material damage.

Table 3: Symbols

Symbol	Meaning
🕮	Reference to supplementary documentation
ℹ	This note gives important information, which must be observed.
▸	Single, independent handling step
1. 2. 3.	Numbered instruction: The numbers show that the action steps must be taken one after the other.
	Warning against dangerous electric voltage.
	Warning against hot surfaces.
	Warning against rotating machine parts.
	Warning against overhead load.
	Warning against crushing hazard.
	Electrostatic sensitive devices.
	Access for persons with cardiac pacemaker forbidden.
	Do not carry along metal parts or clocks.
	Hammer scales are forbidden.

Markup

The following markups are used for a user-friendly text information representation:

🕮 Reference to supplementary documentation

ℹ This note gives important information, which must be observed.

- Listings on the first level contain a bullet point
  - Listings on the second level contain a dash

→ Handling instructions are specified in numbered lists. Please comply with the order of the handling instructions.

Product presentation

1.5.4 Further documentation

For project engineering of drive-systems with Bosch Rexroth motors, additional documentation referring to the used devices may be required. Rexroth provides the complete product documentation in PDF format in the following Bosch Rexroth media directory:

➦ https://www.boschrexroth.com/various/utilities/mediadirectory/index.jsp

1.5.5 Standards

This documentation refers to German, European and international technical standards. Documents and sheets on standards are subject to copyright protection and may not be passed on to third parties by Rexroth. If required, please contact the authorized sales outlets. In Germany, contact:

BEUTH Verlag GmbH

Burggrafenstraße 6

10787 Berlin, Germany

Internet: ➦ https://www.din.de/beuth

1.5.6 Additional components

Documentation for external systems which are connected to Bosch Rexroth components are not included in the scope of delivery and must be ordered directly from the corresponding manufacturers.

1.5.7 Your feedback

Your experiences are an essential part of the improvement process of product and documentation. Please send your feedback to:

Bosch Rexroth AG

Dept. DC-AE/EPI5 (fs,mb)

Buergermeister-Dr.-Nebel-Straße 2

97816 Lohr am Main, Germany

E-Mail: ➦ dokusupport@boschrexroth.de

2 Safety instructions

2.1 Important directions on use

2.1.1 Intended use

Introduction

Bosch Rexroth products are designed and manufactured using the latest state-of-the-art-technology. The products are tested prior to delivery to ensure operational safety and reliability.

⚠ WARNING	**Personal injury and property damage by using products incorrectly!** Failure to use our products in an unintended way may cause situations resulting in property damage and personal injury.

NOTICE	**Inappropriate use** Bosch Rexroth, as the manufacturer, does not provide any warranty, assume any liability, or pay any damages for damage caused by products not being used as intended. Any risks resulting from the products not being used as intended are the sole responsibility of the user.

Before using the products by Bosch Rexroth, the following condition precedent must be fulfilled so as to ensure that they are used as intended:

- Personnel that in any way uses our products must first read and understand the relevant safety instructions and be familiar with their appropriate use.
- Hardware products must be left in their original condition, i.e. no structural changes may be made. Software products must not be decompiled and their source code must not be changed.
- Damaged or defective products must not be installed or put into operation.
- It must be ensured that products are installed in compliance with all regulations specified in the documentation.

Prerequisites for proper and safe use of the motors are proper transport, appropriate storage, proper assembly and connection, careful maintenance, operation and overhaul.

Areas of use and application

Typical applications include, for example:

- Handling and mounting systems
- Packaging and food machines
- Printing and paper converting machines
- Machine tools

The motors have been exclusively designed for installation in industrial machinery. The motors have been designed and manufactured in compliance with the EU directives and harmonized standards specified in the following.

Standards	
EN 60034-1 EN 60034-1:2010 + Cor.:2010	Rating and performance behavior
EN 60034-5 EN IEC 60034-5:2020	Type of protection
Directives	
2014/35/EU	Low voltage directive

The machine manufacturer must evaluate the electric and mechanic safety as well as environmental influences in the assembled state of the machine according to the Machine Directive 2014/35/EC EN 60204-1:2018 (Safety of machinery - Electrical equipment of machines -Part 1: General requirements).

The electrical installation must comply with the protection requirements of EMC Directive 2014/30/EU. The plant manufacturer is responsible for appropriate installation (for example: physical separation of signal and power cables, using shielded cables, ...). The EMC instructions of the converter manufacturer must be observed.

The machine may not be commissioned before conformity with these directives has been confirmed.

For application-specific use of motors, drive controllers with various levels of power, DC bus voltage and different interfaces are available. For regulation and controlling of motors, additional sensors like length measuring systems must be connected.

Before commissioning, every connected drive controller must be programmed according to the specified motor function for the specified application.

- The motors may only be operated under the assembly, mounting and installation conditions, in the normal position, and under the environmental conditions (temperature, degree of protection, humidity, EMC etc.) specified in this documentation.
- The motors may only be used with the accessories and attachments specified in this documentation. Components that are not explicitly specified must not be installed nor connected. The same applies for cables and lines.
- The device may only be operated in the explicitly specified configurations and combination of components and in compliance with the respective functional description of the software and firmware.

2.1.2 Unintended use

Any use of motors outside of the fields of application mentioned above or under operating conditions and technical data other than those specified in this documentation is considered as "non-intended use".

Do not use these motors, if

- the intended application range is not explicitly approved for Bosch Rexroth motors.
- the operating conditions do not comply with the specified ambient conditions. For example, they may not be operated under water, under extreme temperature fluctuations, under extreme maximum temperatures or in potentially explosive atmospheres.

These motors are not suited to be operated directly on the power supply.

Trademark right third parties

Comply with the trademark rights of third parties during assembly and use of single components delivered by Bosch Rexroth. For any infringement of the right, the customer is liable for the accruing damage.

2.2 Qualification of personnel

Any work with or on the described product may only done by qualified or skilled personnel. For the purpose of this manual, qualified personnel means persons who are familiar with transporting, installing, mounting, commissioning and operating the components of the electrical drive and control system and the associated hazards and have an appropriate qualification for their job.

All persons working on, with or in the vicinity of an electrical system must be informed of the relevant safety requirements, safety guidelines and internal instructionsEN 50110-1:2013.

2.3 Safety instructions for electric drive and control systems

2.3.1 Basic information

Using and passing on the safety instructions

Do not install and operate any components of the electric drive and control system before carefully reading all provided documents. These safety instructions and all other user instructions have to be read prior to working with these components. If you do not have the user documentation for the components, contact our Bosch Rexroth sales representative. Request the immediate delivery of these documents to the person or persons in charge of the safe operation of the components.

In the case of vending, rental and/or distribution of the components in any other form, include these safety instructions in the national language of the user.

Improper use of these components, failure to follow the safety instructions in this document or tampering with the product, including disabling of safety devices, could result in property damage, personal injury, electric shock or even death.

Requirements for safe use

Prior to initial commissioning of the components of the electric drive and control system, read the following instructions to avoid personal injury and/or property damage. You must comply with these safety instructions.

- In the case of damage due to non-compliance with the safety instructions, Bosch Rexroth shall not assume any liability.
- Prior to commissioning, read the operating, maintenance and safety instructions. If you are not able to sufficiently understand the language used in the application documentation, please contact and inform your vendor.
- Appropriate and professional transport, storage, assembly and installation, as well as thorough operation and maintenance, are the basis of correct and safe operation of the component.
- Only qualified personnel may use components of the electric drive and control system or work in its close proximity.
- Only use accessories and spare parts approved by Bosch Rexroth.
- Comply with the safety instructions and regulations of the country in which the components of the electric drive and control system are operated.
- Only use components of the electric drive and control system as intended. Please refer to chapter **Intended use**.
- The ambient and operating conditions specified in this application documentation have to be complied with.
- Applications for functional safety are only allowed if they are explicitly and unambiguously specified in the application documentation "Integrated Safety Technology". If this is not the case, these applications are excluded. Functional safety includes parts of the overall safety in which measures of risk reduction for personal safety depend on electric, electronic or programmable controls.
- The specifications contained in the application documentation regarding the use of the provided components are only application examples and recommendations.

Safety instructions

- For their individual application, the machine manufacturer and the system installer have to
  - verify the applicability of the provided components and the specifications made for their use in this application documentation,
  - synchronize the applicability with the safety regulations and standards applicable for their application and to execute the required measures, modifications and additions.
- Commissioning of the provided components is prohibited until is has been established that the machine or the system in which the components are installed corresponds to the country-specific provisions, safety regulations and standards of the application.
- Operation is only allowed when complying with the national EMC regulations for the relevant application.
- For information about EMC-compliant installation, refer to the section on EMC in the relevant application documentation.
- The system or machine manufacturer is responsible for compliance with the limit values specified in the national regulations.
- The technical data, connection and installation conditions of the components are contained in the relevant application documentations and must be complied with.
- Country-specific laws and regulations must be observed.

Hazards due to incorrect use

- High electrical voltage and high operating current! Danger to life or serious personal injury due to electric shock!
- High electrical voltage due to incorrect connection! Danger to life or personal injury due to electric shock!
- Dangerous movements! Danger to life, serious personal injury or property damage due to unintended motor movements!
- Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electric drive systems!
- Risk of burns by hot housing surfaces!
- Risk of injury by improper handling! Personal injury by crushing, shearing, cutting, hitting!
- Risk of injury by improper handling of batteries!
- Risk of injury by improper handling of pressurized lines!

2.3.2 Instructions with regard to specific dangers

Protection against contact with electrical parts and housings

This section concerns components of the electric drive and control system with voltages of **more than 50 volts**.

Contact with parts conducting voltages above 50 volts can cause personal danger and electric shock. When operating components of the electric drive and control system, it is unavoidable that some parts of these components conduct dangerous voltage.

High electrical voltage! Danger to life, risk of injury by electric shock or serious personal injury!

- Only qualified persons are allowed to operate, maintain and/or repair the components of the electric drive and control system.
- Follow the general installation and safety regulations when working on power installations.

- Before switching on, the equipment grounding conductor must have been permanently connected to all electrical components in accordance with the connection diagram.
- Even for short measurements or tests, operation is only allowed with the equipment grounding conductor permanently connected to the specified points of the components.
- Before accessing electrical parts with voltage potentials higher than 50 V, disconnect electrical components from the mains or from the voltge source. Protect the electrical component against restart.
- Observe the following aspects in the case of electrical components:
  Prior to touching an electrical component, always wait for **30 minutes** after switching off power in order for live capacitors to discharge. Before beginning to work, measure the electrical voltage of live parts to make sure that the equipment is safe to touch.
- Install the provided covers and safety devices for protection against contact prior to switch-on.
- Do not touch any electrical connection points of the components while power is turned on.
- Do not connect or disconnect live parts.
- Under certain conditions, electric drive systems can be operated at mains protected by residual-current-operated circuit-breakers sensitive to universal current (RCDs/RCMs).
- Secure built-in devices from penetrating foreign objects and water, as well as from direct contact, by providing an external housing, for example a control cabinet.

High housing voltage and high leakage current! Danger to life, risk of injury by electric shock!

- Prior to switching on and commissioning, ground or connect the electric drive and control system components to the equipment grounding conductor at the grounding points.
- Connect the equipment grounding conductor of the electric drive and control system components permanently to the main power supply at all times. The leakage current is greater than 3.5 mA.
- Establish an equipment grounding connection with a minimum cross section according to the table below. With an outer conductor cross section smaller than 10 mm2 (8 AWG), the alternative connection of two equipment grounding conductors is allowed, each having the same cross section as the outer conductors.

Table 4: Minimum cross section of equipment grounding connection

Cross section of outer conductor	Minimum cross section of equipment grounding conductor Leakage current ≥ 3.5 mA	
	1 equipment grounding conductor	2 equipment grounding conductors
1.5 mm2 (AWG 16)	10 mm2 (AWG 8)	2 × 1.5 mm2 (AWG 16)
2.5 mm2 (AWG 14)		2 × 2.5 mm2 (AWG 14)
4 mm2 (AWG 12)		2 × 4 mm2 (AWG 12)
6 mm2 (AWG 10)		2 × 6 mm2 (AWG 10)
10 mm2 (AWG 8)		-
16 mm2 (AWG 6)	16 mm2 (AWG 6)	-
25 mm2 (AWG 4)		-
35 mm2 (AWG 2)		-
50 mm2 (AWG 1/0)	25 mm2 (AWG 4)	-

Cross section of outer conductor	Minimum cross section of equipment grounding conductor Leakage current ≥ 3.5 mA	
	1 equipment grounding conductor	2 equipment grounding conductors
70 mm2 (AWG 2/0)	35 mm2 (AWG 2)	-

Protective extra-low voltage as protection against electric shock

Protective extra-low voltage is used to connect devices with basic insulation at extra-low voltage circuits.

At components of an electric drive and control system provided by Bosch Rexroth, all connections and terminals with voltages up to 50 volts are PELV (**Protective Extra-Low Voltage**) systems. It is allowed to connect devices equipped with basic insulation, such as programming devices, PCs, notebooks, display units, to these connections.

Danger to life, risk of injury by electric shock! High electrical voltage by incorrect connection!If extra-low voltage circuits of devices containing voltages and circuits of more than 50 volts (e.g., the mains connection) are connected to Bosch Rexroth products, the connected extra-low voltage circuits must comply with the requirements for PELV (**Protective Extra-Low Voltage**).

Protection against dangerous movements

Dangerous movements can be caused by incorrect control of connected motors. In the following, the different reasons are listed:

- Improper or wrong wiring or cable connection
- Operating errors
- Incorrect parameter input prior to commissioning
- Malfunction of sensors and encoders
- Defective components
- Errors in the software or firmware

These errors can occur immediately after switch-on or after an undefined time of operation.

As far as possible, the monitoring functions in the components of the electric drive and control system rule out malfunction in the connected drives. Regarding personal safety, in particular the danger of personal injury and/or property damage, this alone cannot be relied upon to ensure complete safety. Until the implemented monitoring functions are active, it must be assumed in any case that faulty drive movements will occur. The faulty movements depend on the type of control and the operating state.

Dangerous movements! Danger to life, risk of injury, serious injury or property damage!

Prepare a **risk assessment** for the system or machine, with their specific conditions, in which the components of the electric drive and control system are installed.

As specified in the risk assessment, the user has to provide monitoring functions and higher-level measures in the system for personal safety. The safety regulations applicable to the system or machine have to be included. Unintended machine movements or other malfunctions are possible if safety devices are disabled, bypassed or not activated.

To avoid accidents, personal injury and/or property damage:

- Keep free and clear of the machine's range of motion and moving machine parts. Prevent personnel from accidentally entering the machine's range of motion by using, for example:
  - Safety fences
  - Safety guards
  - Protective covering
  - Light barriers
- Make sure the safety fences and protective coverings are strong enough to resist maximum possible kinetic energy.
- Mount emergency stop switches in the immediate reach of the operator. Before commissioning, verify that the emergency stop equipment works. Do not operate the machine if the emergency stop switch is not working.
- Prevent unintended start-up. Isolate the drive power connection by means of OFF switches/OFF buttons or use a safe starting lockout.
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- Additionally secure vertical axes against falling or dropping after switching off the motor power by, for example,
  - mechanically securing the vertical axis,
  - adding an external braking/arrester/clamping mechanism or
  - ensuring sufficient counterweight for the axis.
- The standard equipment **motor holding brake** or an external holding brake controlled by the drive controller is **not sufficient to guarantee personal safety**!
- De-energize the components of the electric drive and control system using the master switch, and make sure they cannot be switched back on in the case of:
  - Maintenance and repairs
  - Cleaning work
  - Long service interruptions
- Avoid operating high-frequency, remote control and radio equipment in close proximity to components of the electric drive and control system and their supply leads. If the use of these devices cannot be avoided, check the machine or installation, at initial commissioning of the electric drive and control system, for possible malfunctions when operating such high-frequency, remote control and radio equipment in its possible positions of normal use. It might possibly be necessary to perform a special electromagnetic compatibility (EMC) test.

Protection against electromagnetic and magnetic fields during operation and mounting

Electromagnetic and magnetic fields!

Health hazard for persons with active implantable medical devices (AIMD) such as pacemakers or passive metallic implants.

- Hazards for the above-mentioned groups of persons by electromagnetic and magnetic fields in the immediate vicinity of drive controllers and the associated current-carrying conductors.
- Access to these areas can pose an increased risk to the above-mentioned groups of persons. They should seek advice from their attending doctor.
- If overcome by possible effects on above-mentioned persons during operation of drive controllers and accessories, remove the exposed persons from the vicinity of conductors and devices.

Protection against contact with hot parts

- Do not touch hot surfaces of, for example, braking resistors, heat sinks, supply units and drive controllers, motors, windings and laminated cores!
- According to the operating conditions, temperatures of the surfaces can be **higher than 60 °C** (140 °F) during or after operation.
- After having switched them off, allow the motors to cool down long enough before touching them. Cooling down may require **up to 140 minutes**. The time required for cooling down is approximately five times the thermal time constant specified in the technical data.
- After switching off chokes, supply units and drive controllers, wait **15 minutes** to allow them to cool down before touching them.
- Wear safety gloves or do not work at hot surfaces.
- For certain applications, and in accordance with the respective safety regulations, the manufacturer of the machine or system must take measures to avoid injuries caused by burns in the final application. Possible measures: warnings at the machine or system, guards (shieldings or barriers) or safety instructions in the application documentation.

Protection during handling and mounting

Risk of injury by improper handling! Personal injury by crushing, shearing, cutting, hitting!

- Comply with the relevant statutory regulations of accident prevention.
- Use suitable mounting and transport equipment.
- Avoid jamming and crushing by appropriate measures.
- Always use suitable tools. Use special tools if specified.
- Use lifting equipment and tools in the correct manner.
- Use suitable protective equipment (hard hat, safety goggles, safety shoes, safety gloves, for example).
- Do not stand under hanging loads.
- Immediately clean up any spilled liquids from the floor due to the risk of falling!

Battery safety

Batteries consist of active chemicals in a solid housing. Therefore, improper handling can cause injury or property damage. Risk of injury by improper handling!

- Do not attempt to reactivate low batteries by heating or other methods (risk of explosion and cauterization).
- Do not attempt to recharge the batteries since this may cause leakage or explosion.
- Do not throw batteries into open flames.
- Do not disassemble any batteries.
- When replacing the battery/batteries, do not damage the electrical parts installed in the devices.
- Only use the battery types specified for the product.

Environmental protection and disposal! The batteries contained in the product are considered dangerous goods during land, air, and sea transport (risk of explosion) in the sense of the legal regulations. Dispose of used batteries separately from other waste. Comply with the national regulations of your country.

Protection against pressurized systems

According to the information given in the Project Planning Manuals, motors and components cooled with liquids and compressed air can be partially supplied with externally fed, pressurized media, such as compressed air, hydraulics oil, cooling liquids and cooling lubricants. Improper handling of the connected supply systems, supply lines or connections can cause injuries or property damage.

Risk of injury by improper handling of pressurized lines!

- Do not attempt to disconnect, open or cut pressurized lines (risk of explosion).
- Comply with the respective manufacturer's operating instructions.
- Before dismounting lines, relieve pressure and empty medium.
- Use suitable protective equipment (safety goggles, safety shoes, safety gloves, for example).
- Immediately clean up any spilled liquids from the floor due to the risk of falling!

Environmental protection and disposal! The agents (e.g., fluids) used to operate the product might not be environmentally friendly. Dispose of agents harmful to the environment separately from other waste. Comply with the national regulations of your country.

Explanation of signal words and the safety alert symbol

The safety instructions in the available application documentation contain specific signal words (DANGER, WARNING, CAUTION, NOTICE) and, where required, a safety alert symbol (in accordance with ANSI Z535.6-2011).

The signal word is intended to draw the reader's attention to the safety instruction and describes the hazard severity.

The safety alert symbol (a triangle with an exclamation point), which precedes the signal words DANGER, WARNING and CAUTION, is used to alert the reader to personal injury hazards.

⚠ DANGER	Non-compliance with this safety instruction **will** result in death or serious personal injury.
⚠ WARNING	Non-compliance with this safety instruction **can** result in death or serious personal injury.
⚠ CAUTION	Non-compliance with this safety instruction can result in moderate or minor personal injury.
NOTICE	Non-compliance with this safety instruction can result in property damage.

2.4 Product- and technology-dependent safety instructions

2.4.1 Protection from electric voltage

Work required on the electric system may only be carried out by skilled electricians. Tools for electricians (VDE tools) are absolutely necessary.

Before working:

- Enable.
- Secure against reactivation.
- Ensure de-energization.
- Ground and short-circuit.
- Cover or shield any adjacent live parts.

After completing the job, cancel the measures in reverse order.

Dangerous voltage occurs during operation! Danger to life, risk of injury by electric shock!

- Before start-up, connect the protective conductors on all electric components according to the connection plan.
- Operation, even for short measuring purposes is only allowed with fixed connected protective conductor on the specified points of the components.

2.4.2 Protection from mechanical danger

Dangerous movements! Danger to life, risk of injury, heavy injury or material damage.

- Do not stay within the motion zone of the machine. Avoid unauthorized access into the danger zone.
- Additionally secure vertical axes to prevent them from sinking or descending after having shutdown the motor, for instance as follows:
  - Mechanically lock the vertical axis,
  - providing an external braking / catching / clamping device, or
  - ensure sufficient weight compensation of the axes.

  Only using the serially delivered **motor holding brake** or an external holding brake activated by the drive controller **is not suitable for personal protection!**

Rotating parts! Danger to life, risk of injury, heavy injury or material damage.

- Secure key and/or transmission elements against ejection.
- Install covers on dangerous rotating machine parts before start-up.

2.4.3 Protection against magnetic and electromagnetic fields

Magnetic and electromagnetic fields are created in the direct environment of live conductors or permanent magnets of electro motors and are a serious danger for certain persons. The machine operator must sufficiently protect personnel working in these areas from possibly occurring damage by suitable measures (e.g. warning notes, protective clothes, designation of the danger zone).

Electro magnetic and magnetic fields!

Observe the country-specific regulations. For Germany, please observe the specifications of the occupational insurance association BGV B11 and BGR B11 regarding “electromagnetic fields”.

Danger for persons with active body aids or passive metallic implants and for pregnant women.

- For persons with active body aids (like heart pacemakers), passive metallic implants (like hip prosthesis) and pregnant women possible hazards exist due to electromagnetic or magnetic fields in direct environment of electric drive and control components and the corresponding live conductors.

  Access into these areas can be dangerous for these persons:
  - Areas, in which components of electrical drive and control systems and corresponding live conductors are mounted, activated or operated.
  - Areas in which motor parts with permanent magnets are stored, repaired or assembled.
- Above mentioned persons must contact their attending physician before entering these areas.
- Please observe the valid industrial safety regulations for plants which are fitted with components of electrical drive and control systems and corresponding live conductors.

Risk of destruction of sensitive parts! Data loss!

- Keep watches, credit cards, check cards and identity cards and all ferromagnetic metal parts, such as iron, nickel and cobalt away from permanent magnets.

Crushing hazard of fingers and hand due to heavy attractive forces of the magnets!

The attractive forces of the permanent magnets influence all magnetizable materials. Especially in an area < 100 mm, the attractive forces rise. Loose or not fastened components made of magnetizable materials can abruptly and inadvertently attracted with the permanent magnets.

- Extreme caution during handling of motor components with permanent magnets. Do never underestimate strong attractive forces.
- Never work alone.
- Use personal safety equipment (e.g. protective gloves, protective glasses).
- Do not unpack several motor components with permanent magnets or directly place them side by side at your working space.
- Unpack single motor components with permanent magnets immediately prior mounting and mount them immediately.
- Do not bring magnetized or magnetizable materials in the area of permanent magnets. If using magnetizable tools cannot be avoided, hold on the tool very tight, move carefully and observe the attractive force effect of the permanent magnets.

Behavior in the case of accidents with permanent magnets

During work with permanent magnets, the following emergency tools must be ready to use in the case of an accident to release impacted body parts (like fingers, hands, arms a.s.o.):

- Hammer (3-5kg) made of non-magnetized material like brass
- Minimum 2 wedges with approx. 10 - 15 ° lip angles made of non-magnetized material like brass, wood or similar to impact driving into the cutting slit.

In the case of an accident:

- Keep calm!
- If the machine is live, immediately de-energize (emergency button).
- Give first aid or request appropriate help (e.g. emergency doctor).
- Separate inherent parts via emergency tools to loose clamped body parts, like fingers, hand, foot, for example.
  - Therefore, beat the wedges with a hammer into the cutting slit to free the caught body parts.

2.4.4 Protection during handling and assembly

Motor components with permanent magnetsPermanent magnets (e.g. secondary parts of a synchronous linear motor or rotor of a synchronous kit motor) create very strong attractive forces from ferromagnetic parts like further motor components with permanent magnets or parts of iron, nickel or cobalt.

Please observe the safety notes about strong attractive forces of permanent magnets under ➦ Chapter 2.4.3 Protection against magnetic and electromagnetic fields on page 24.

The attractive forces of the permanent magnets influence all magnetizable materials. Especially in an area < 100 mm, the attractive forces rise. Surrounding components can abruptly and inadvertently be attracted by the permanent magnets. Apart from crushing hazard, even the danger of chipping recalcitrant material, causing eye injury, exists.

Use the origin package of the motor components for transport and storage only. The origin package of Rexroth is constructed in such a way that the motor components with the permanent magnets are positioned within the package with suitable distance, providing that the package is correctly used.

Observe the following instructions during unpacking and handling.

- Instruct the personal with regard to the danger.
- Use personal safety equipment (e.g. protective gloves, protective glasses).
- Store all components in its origin package until assembly and for transport.
- Do only work on clean working spaces in which no ferromagnetic parts exist.
- If possible, use non-magnetic tools, e.g. made from aluminum or brass.
- Remove only one motor component from the package and secure it on your working space against slipping, rolling away.

Instruct all participating persons about the dangers and if necessary, expand the preliminary instructions.

Store the original package of the motor components with permanent magnets

Store the original package for later use.

In the case of reuse, ensure a good readability of the safety notes on the package. They must not be paste over!

Risk of injuries due to improper handling! Bodily injury due to crushing, scissors, cutting, punching!

- Observe the instructions on the package.
- Store the motor components with permanent magnets in the original package, only.
- Do not internally store or transport the motor components unpacked.
- Observe the accident prevention regulations.
- Use suitable assembly and transport equipment.
- Prevent clamping and squeezing by means of suitable measures.
- Use suitable tools, if necessary use special tools.
- Properly use lifting devices and tools.
- Use suitable safety equipment (like protective helmets, protective glasses, safety shoes, protective gloves).
- Never walk under hanging loads.
- Immediately remove spill on the ground, otherwise risk of falling!

2.4.5 Protection against burns

Risk of burns due to hot motor surfaces!

- Avoid contact with hot motor surfaces. **Temperatures may rise over 60 °C.**
- Allow the motors to cool down long enough before touching them.
- Temperature-sensitive components may not come into contact with the motor surface. Ensure appropriate mounting distance of connection cables and other components.

2.4.6 Electrostatic sensitive devices (ESD)

The motors contain parts which underlie an electrostatic danger. These components, especially temperature sensors of the motor winding can be destroyed by improper use.

Avoid, e.g. direct contact of open wires or contacts of the connection cable of temperature sensors without being electrostatically discharged or grounded.

Remark

Do suitable ESD protective measures before you handle imperiled components (e.g. ESD protective clothes, wristlets, conductive floor, grounded cabinets and working surfaces).

3 Technical data

3.1 Explanations about technical data

3.1.1 Introduction

All relevant technical data of the ML3 motors are provided on the following pages in terms of tables and characteristic curves. The following dependencies are taken into consideration:

- Frame size and frame length of the primary part
- Winding design primary part
- Available power connection or DC bus voltage

All specified data and characteristic curves refer to the following conditions, unless otherwise specified:

- Motor-winding temperature 100 °C.
- Self-cooling, temperature of screw-on 20 °C
- DC bus voltage 540 V_{DC}

Resulting data from certain motor-controller combinations and deviating environmental conditions can differ from the given data. See also ➦ Chapter 8.22 Thermal connection - Installation modes on page 144.

All relationships and data described in the following sections may only apply if exclusively primary and secondary parts of the same size are combined (e.g. ML3P03 with ML3S03).

3.1.2 Operating behavior

The characteristic curve “force over speed” is specified as a characteristic curve. The basic parameters and the run of the characteristic curve is defined by the height of the intermediate circuit voltage and by the corresponding motor specific data, like e.g. inductivity, resistance, force constant and so on. By varying the intermediate circuit voltage (different controllers or supply modules and connection voltages) and different motor windings result in different characteristics result.

Additionally, a continuous force characteristic F_c for installation mode A (optional thermal connection) and a temperature of 20 °C at the screw-on surface is illustrated.

The installation modes are described in ➦ Chapter 8.22.

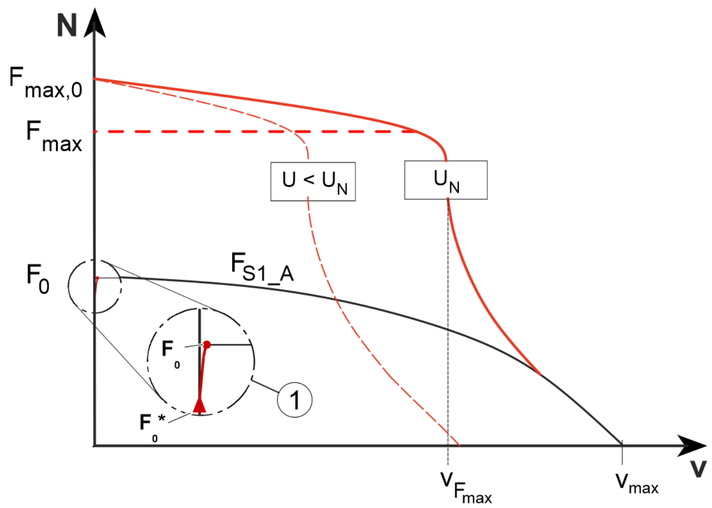


Fig. 3: Example motor characteristic curve

$F_{max,0}$	Maximum force at standstill
F_{max}	Maximum force
F_0	Continuous force at standstill
F_0*	To avoid damaged winding in standstill operation, limit the current or the operation duration.
F_{S1_A}	Continuous force in S1 operation and installation type A (see ➦Tab. 8.22)
U	DC bus voltage reduced
U_N	DC bus voltage 540 V_{DC}
v_{Fmax}	Maximum velocity at F_{max}
v_{max}	Maximum velocity
①	When using the motor in this operating range, observe information specified in ➦Chapter 8.23.

The reachable motor force depends on the drive control device used. The reference value for the technical data and the figured characteristic curves of the motor, is an DC bus voltage of 540 V_{DC}.

The maximum force F_{max} is available up to a speed v_{Fmax}. There, the specified voltage limit is reached due to the DC bus voltage. However, during increasing velocity, the induced voltage of the motor increases. This leads to a dependent reduced maximum force, as the motor control voltage will be reduced due to the constant DC bus voltage.

Parallel operation of two primary parts on a drive controller

It is only allowed to connect primary parts parallel, which features are identical. Usually this is only the case with identically constructed types.

In the following is spoken of “identical” primary parts.

- Same force constant K_{FN} or voltage constant K_{EMF}
- Same winding resistance R_{12}
- Same winding inductivity L_{12}

The following interrelations exist for the parallel connection of two primary parts at one drive controller:

- Doublication of the feed force of the axis in the case of same current in each primary part (it not limited by the drive controller).
  $F_{total} = 2 \times F_{Motor}$
- Doublication of the voltage within the drive controller (if not limited by it)
  $I_{Inverter} = 2 \times I_{Motor}$

- Velocity v_{Fmax}, v_{nenn} and v_{max} as for single arrangement
  $v_{Fmax,total} = v_{Fmax,Motor}$ / $v_{nenn,total} = v_{nenn,Motor}$ / $v_{max,total} = v_{max,Motor}$
- Same motor and voltage constant ($K_{F,0}$, K_{EMF})
  $K_{FN,total} = K_{FN,Motor}$ / $K_{EMK,total} = K_{EMK,Motor}$
- Total motor resistance and inductivity halved
  $R_{12,total} = 1/2 \times R_{12,Motor}$ / $L_{12,total} = 1/2 \times L_{12,Motor}$

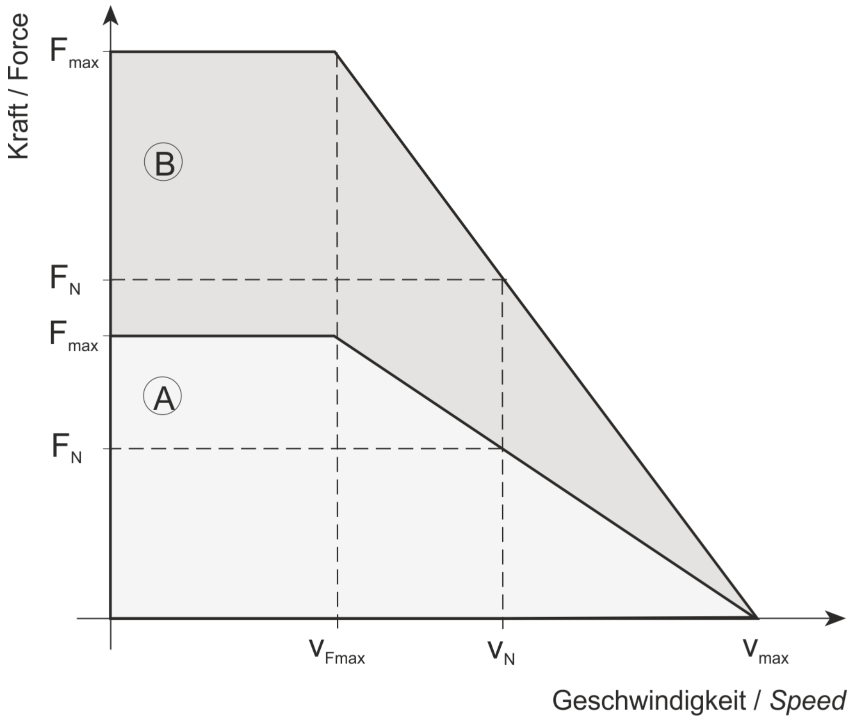


Fig. 4: Characteristics force over velocity at single or parallel arrangment of two primary parts on one controller
A Single arrangement
B Parallel arrangement

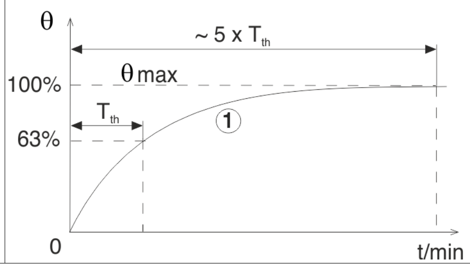
For parallel connection of two primary parts at one drive controller, relevant motor parameters for start-up are specified in this documentation (see ➦ Chapter 8.13 Arrangement of motor components on page 127).

3.1.3 Characteristics

Unless otherwise specified, the values specified in the data sheets are r.m.s. values according to DIN EN 60034-1. Reference value 540 V_{DC} DC bus voltage and 20 °C contact surface temperature.

Table 5: Characteristics for primary parts ML3P...

Designation	Symbol	Unit	Tolerance	Description
Maximum force at standstill	$F_{max,0}$	N	± 5 %	Maximum force at standstill current $I_{max,0}$. The temperature gradient is 10 K/s for $I_{max,0}$.
Maximum current at standstill	$I_{max,0}$	A		Maximum standstill current at maximum standstill force $F_{max,0}$ The temperature gradient is 10 K/s for $I_{max,0}$.
Maximum force	F_{max}	N	± 5 %	Maximum force at maximum current I_{max}. The reachable force depends on the drive control device used. The temperature gradient is 6 K/s at I_{max}.

Designation	Symbol	Unit	Tolerance	Description
Maximum current	I_{max}	A		Maximum current (root-mean-square) of the motor at F_{max}. The temperature gradient is 6 K/s at I_{max}.
Continuous force at standstill	F_0	N	± 5 %	Available continuous nominal force in operating mode S1 (continuous operation) close to standstill.
Continuous current at standstill	I_0	A		Phase current (effective value) of the motor at load with standstill continuous force.
Maximum velocity at F_{max}	v_{Fmax}	m/min		Maximum velocity at maximum force F_{max}. The velocity reached depends on the DC bus voltage of the used drive control device.
Force constant	$K_{F,0}$	N/A	± 5 %	Relation of force increase to increase of force-creating current. Valid until continuous current at standstill I_0.
Voltage constant at 20 °C	K_{EMF}	Vs/m	± 5 %	Induced motor voltage (effective value) dependent on the feed rate regarding the velocity 1 m/s.
Winding resistance at 20 °C	R_{12}	Ω		Measured winding resistance among two strands at 20 °C.
Winding inductance	L_{12}	mH		Measured winding inductivity between two strands. The defined measuring values are fluctuating due to boundary effects. These details are typical values, which are determined with a measuring current of 1 mA at a measuring frequency of 1 kHz.
Power wire cross-section	A	mm²		Necessary power wire cross-section rated for cable assemblies with current carrying capacity according to VDE0298-4 (1992) and installation type B2 according to EN 60204-1 (1993) at 40 °C ambient temperature. The power wire cross section that is specified in the data sheets can vary depending on the selected type of connection - plug or terminal box. When selecting the appropriate power cable, therefore please observe the information given in ➡ Chapter 7 and the documentation of Rexroth about connection cables, MNR R911322949 (EN).
Pole width	τ_P	mm		Distance dimension of pole center to pole center of the magnets on the secondary part.
Attractive force	F_{ATT}	N		Maximum attractive force among primary and secondary part at nominal air gap δ (= 0.5 mm) and currentless primary part.
Thermal time constant	T_{th}			Duration of the temperature rise to 63 % of the final temperature of the winding under load with continuous nominal force in S1-operation and liquid cooling. 

Designation	Symbol	Unit	Toler-ance	Description
Mass primary part with standard encap-sulation	m_P	kg		Mass primary part with cables.
Mass cable per meter	m_K	kg		Mass of power cable and sensor cable per 1 m cable length.

Table 6: Characteristics for secondary parts ML3S

Designation	Symbol	Unit	Toler-ance	Description
Mass secondary part	m_S	kg		Mass secondary part m_S.
	m_{S_rel}	kg/m		Relative mass of the secondary part relating on 1 m length.

3.2 IndraSize

By using the IndraSize software, drive controllers, motors and mechanic gear-boxes can be easily sized. The engineering tool covers the entire range of Rexroth drives and motors. Calculate the characteristic curves for your appli-cation by using the sizing and calculation tool IndraSize: ➦ www.boschrex-roth.com/IndraSize

3.3 General technical data

The specified data in ➦ Tab. 7 are valid for all motor frame sizes. In this context, however, the comments on the individual items in ➦ Chapter 8 Application and construction instructions on page 113 must be observed.

Table 7: General technical data

Designation	Symbol	Unit	ML3P	ML3S
Maximum DC bus voltage	$U_{ZK,max}$	V_{DC}	600	/
Ambient temperature during operation (see also➦ Chapter) 8.3)	T_{um}	°C	+0 ... +40	
Allowed transport temperature (see also➦ Chapter) 9.4.1)	T_T	°C	-20 ... +80	
Allowed storage temperature (see also ➦ Chapter 9.5.1 Notes about storage of ML3P and ML3S on page 153)	T_L	°C	-25 ... +55	
Max. permitted secondary part temper-ature in operation	T_{Smax}	°C	/	70 °C
Thermal class according to DIN EN 60034-1	-	-	130(B)	/
Warning temperature (winding)	T_{warn}	°C	100	/
Shutdown temperature (winding)	T_{abst}	°C	110	/
Protection class acc. to DIN EN 60034-5	-	-	IP40 (IP64)	
CSA-File number			Approval number of CSA (Canadian Space Agency) certified products	

3.4 Frame size 03

3.4.1 Data ML3P03

ML3P03 - Frame length A

Table 8: Technical data ML3P03-A

Designation	Symbol	Unit	ML3P03-A_BW	ML3P03-A_BZ
Maximum force at standstill	$F_{max,0}$	N	120	120
Maximum current at standstill	$I_{max,0}$	A	4.1	12.6
Maximum force	F_{max}	N	100	75
Maximum current	I_{max}	A	2.9	6.1
Continuous force at standstill	F_0	N	60	60
Continuous current at stand-still	I_0	A	1.5	4.7
Maximum velocity at F_{max}	v_{Fmax}	m/min	520	1,390
Attractive force	F_{ATT}	N	300	300
Force constant	$K_{F,0}$	N/A	40	12.77
Voltage constant at 20 °C	K_{EMK}	Vs/m	22.63	7.78
Winding resistance at 20 °C	R_{12}	Ohm	10.8	1.12
Winding inductance	L_{12}	mH	70	7.3
Thermal time constant	T_{th_nenn}	min	1.25	1.25
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mmÂ²	0.5	0.5
Primary part mass	m_P	kg	0.6	0.6
Ground connection cable	m_K	kg/m	0.21	0.21
Latest amendment: 2020-02-19				

ML3P03 - Frame length B

Table 9: Technical data ML3P03-B

Designation	Symbol	Unit	ML3P03-B_BW	ML3P03-B_BY
Maximum force at standstill	$F_{max,0}$	N	240	240
Maximum current at standstill	$I_{max,0}$	A	8.2	19.5
Maximum force	F_{max}	N	200	160
Maximum current	I_{max}	A	5.8	10.2
Continuous force at standstill	F_0	N	120	120
Continuous current at stand-still	I_0	A	3	7.2
Maximum velocity at F_{max}	v_{Fmax}	m/min	530	1,110
Attractive force	F_{ATT}	N	500	500
Force constant	$K_{F,0}$	N/A	40	16.67
Voltage constant at 20 °C	K_{EMK}	Vs/m	22.63	9.90
Winding resistance at 20 °C	R_{12}	Ohm	5.4	0.92
Winding inductance	L_{12}	mH	34.0	6.0
Thermal time constant	T_{th_nenn}	min	1.25	1.25
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mmÂ²	0.5	0.5
Primary part mass	m_P	kg	0.9	0.9
Ground connection cable	m_K	kg/m	0.21	0.21
Latest amendment: 2022-03-21				

ML3P03 - Frame length D

Table 10: Technical data ML3P03-D

Designation	Symbol	Unit	ML3P03-D_BP	ML3P03-D_BW
Maximum force at standstill	$F_{max,0}$	N	480	480
Maximum current at standstill	$I_{max,0}$	A	8.2	16.4
Maximum force	F_{max}	N	450	400
Maximum current	I_{max}	A	6.9	11.6
Continuous force at standstill	F_0	N	240	240
Continuous current at stand-still	I_0	A	3.0	6
Maximum velocity at F_{max}	v_{Fmax}	m/min	210	525
Attractive force	F_{ATT}	N	900	900
Force constant	$K_{F,0}$	N/A	80	40
Voltage constant at 20 °C	K_{EMK}	Vs/m	45.96	22.63
Winding resistance at 20 °C	R_{12}	Ohm	10.7	2.9
Winding inductance	L_{12}	mH	70	15.3
Thermal time constant	T_{th_nenn}	min	1.25	1.25
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mmÂ²	0.5	0.5
Primary part mass	m_P	kg	1.6	1.6
Ground connection cable	m_K	kg/m	0.21	0.21
Latest amendment: 2021-01-05				

ML3P03 - Frame length F

Table 11: Technical data ML3P03-F

Designation	Symbol	Unit	ML3P03-F_BN	ML3P03-F_BU
Maximum force at standstill	$F_{max,0}$	N	720	720
Maximum current at standstill	$I_{max,0}$	A	12.3	25.1
Maximum force	F_{max}	N	570	520
Maximum current	I_{max}	A	8	14.6
Continuous force at standstill	F_0	N	360	360
Continuous current at stand-still	I_0	A	4.5	9.3
Maximum velocity at F_{max}	v_{Fmax}	m/min	280	625
Attractive force	F_{ATT}	N	1300	1300
Force constant	$K_{F,0}$	N/A	80	38.71
Voltage constant at 20 °C	K_{EMK}	Vs/m	45.96	22.63
Winding resistance at 20 °C	R_{12}	Ohm	7.2	1.7
Winding inductance	L_{12}	mH	46.0	11.0
Thermal time constant	T_{th_nenn}	min	1.25	1.25
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mmÂ²	0.5	0.75
Primary part mass	m_P	kg	2.3	2.3
Ground connection cable	m_K	kg/m	0.21	0.21
Latest amendment: 2020-09-01				

3.4.2 Data ML3S03

Table 12: Technical data ML3S03

Designation	Symbol	Unit	ML3S03-__-		
			0096	0144	0384
Mass secondary part	m_S	kg	0.21	0.31	0.81
Mass secondary part, relative	m_{S_rel}	kg/m	2.1	2.1	2.1
Latest amendment: 2017-11-19					

3.4.3 Motor characteristic curves ML3P03

ML3P03-A

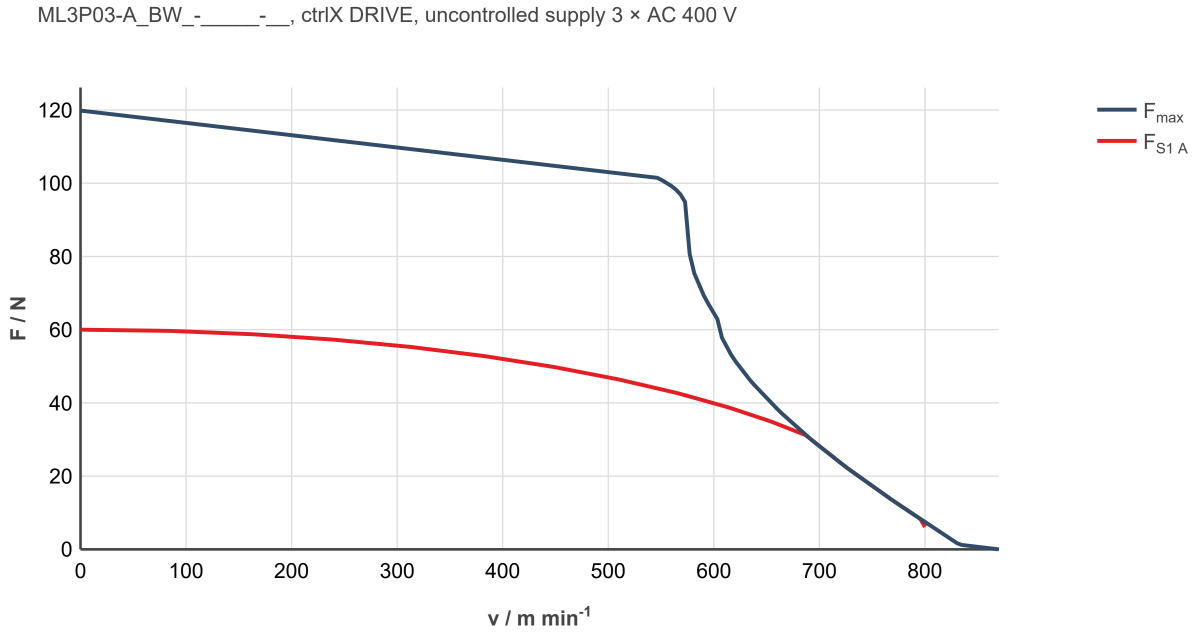


Fig. 5: Characteristic curve ML3P03-A_BW

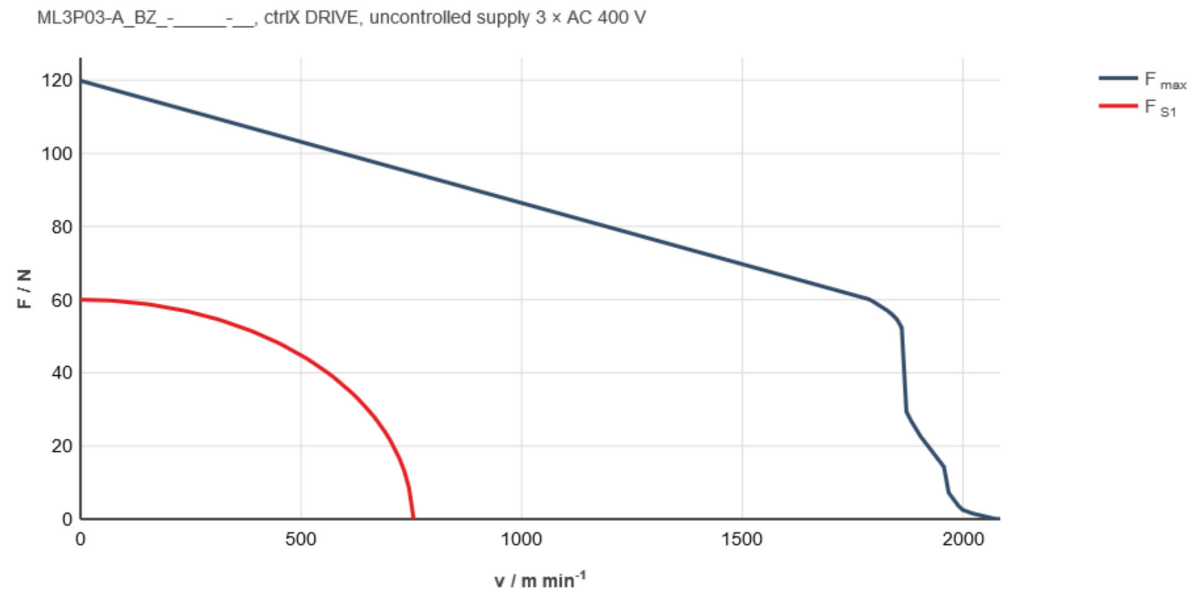


Fig. 6: Characteristic curve ML3P03-A_BZ

ML3P03-B

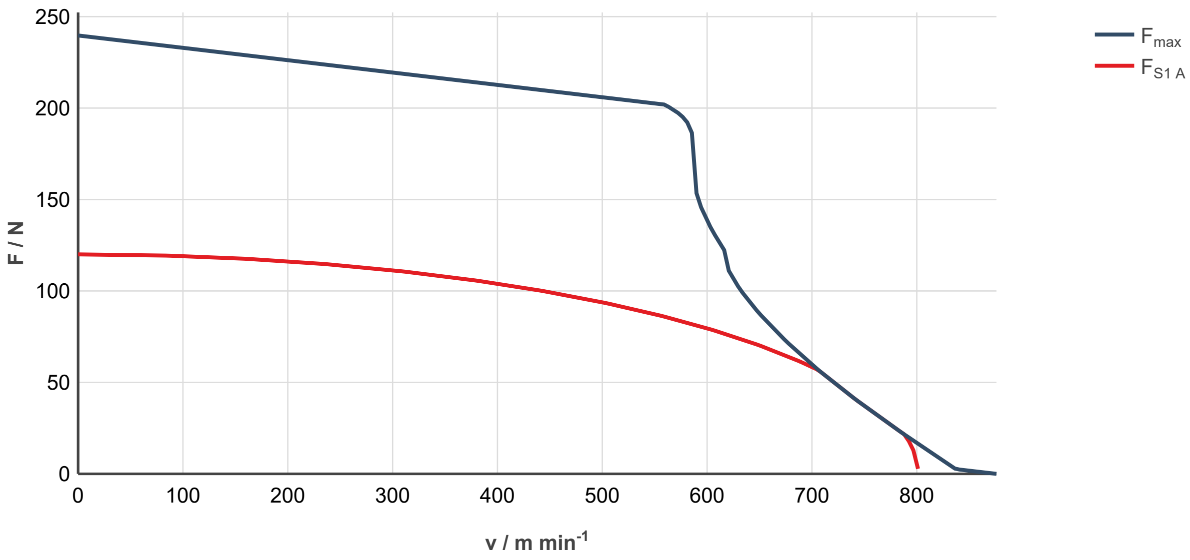


Fig. 7: Characteristic curve ML3P03-B_BW

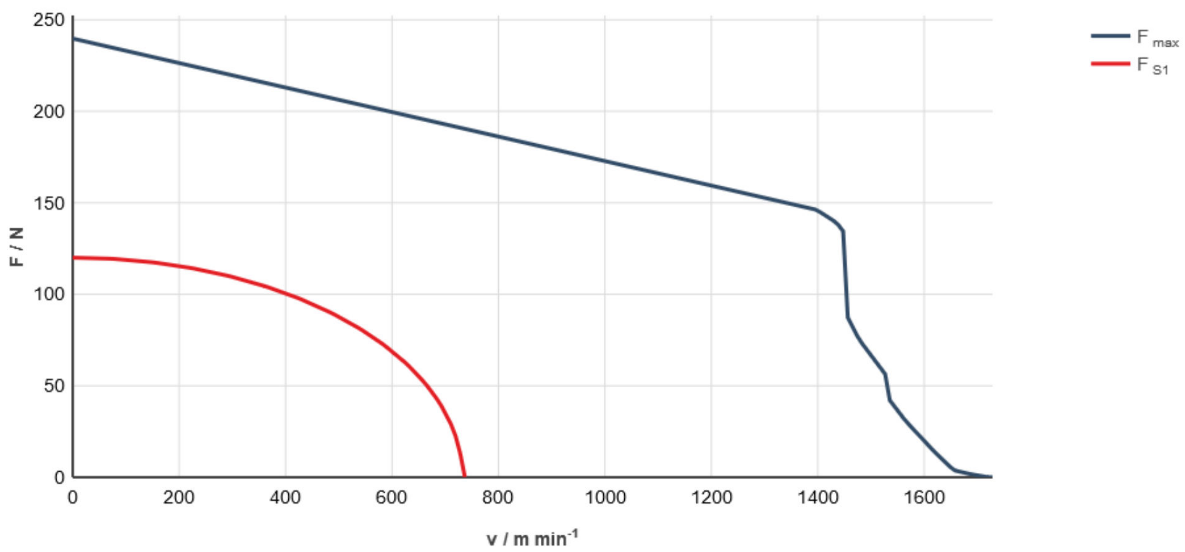


Fig. 8: Characteristic curve ML3P03-B_BY

ML3P03-D

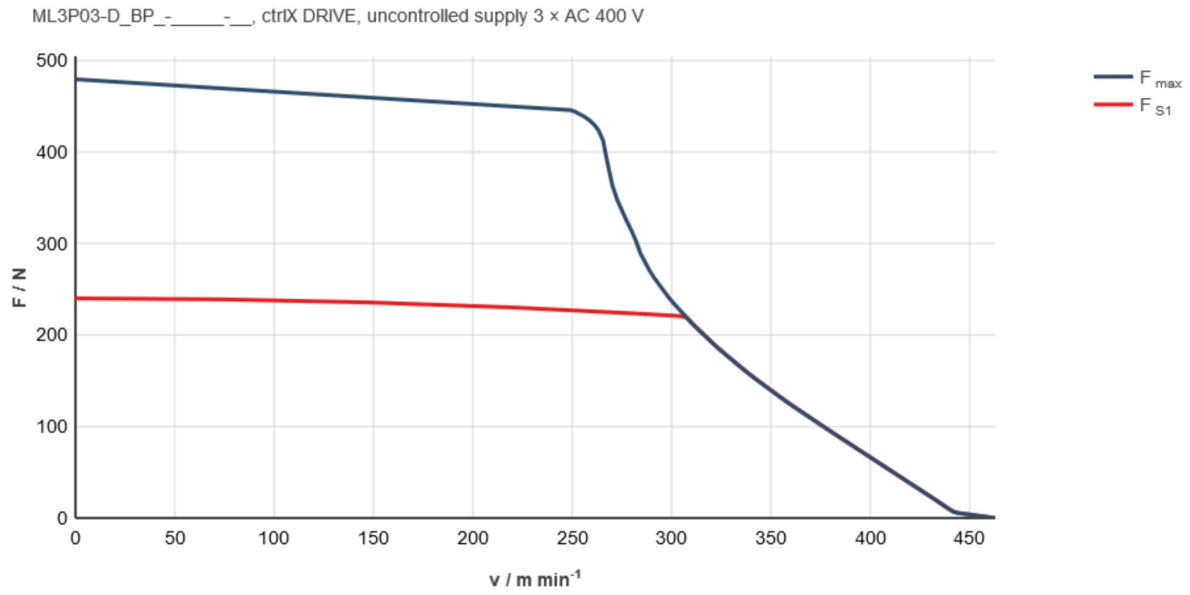


Fig. 9: Characteristic curve ML3P03-D_BP

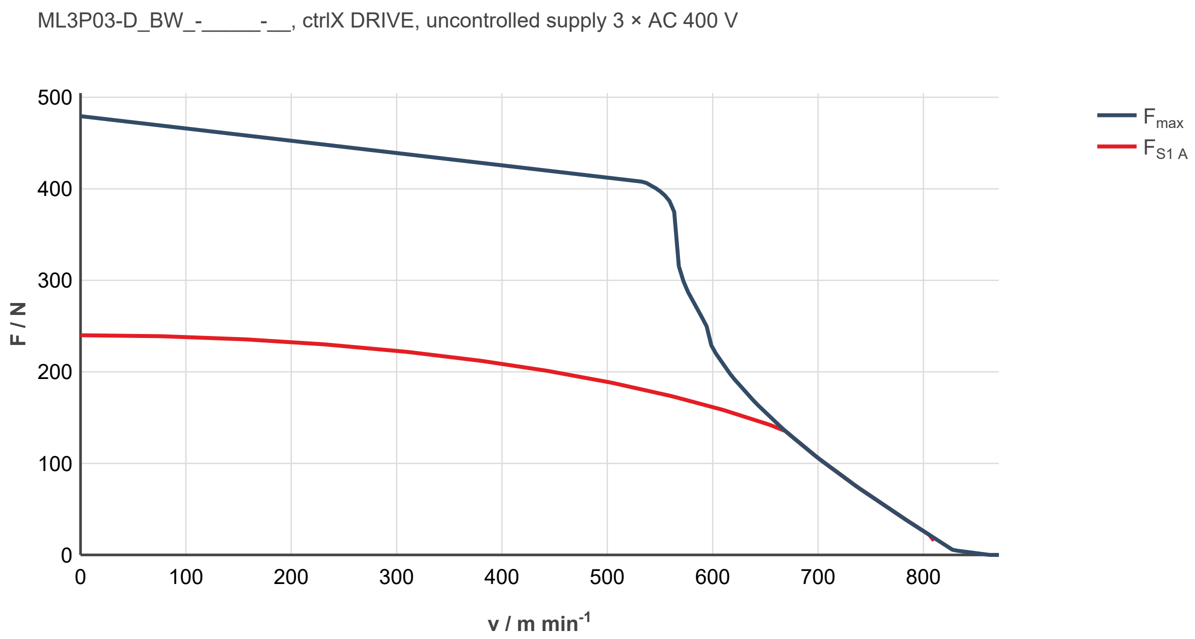


Fig. 10: Characteristic curve ML3P03-D_BW

ML3P03-F

ML3P03-F_BN_-_____-__, ctrlX DRIVE, uncontrolled supply 3 × AC 400 V

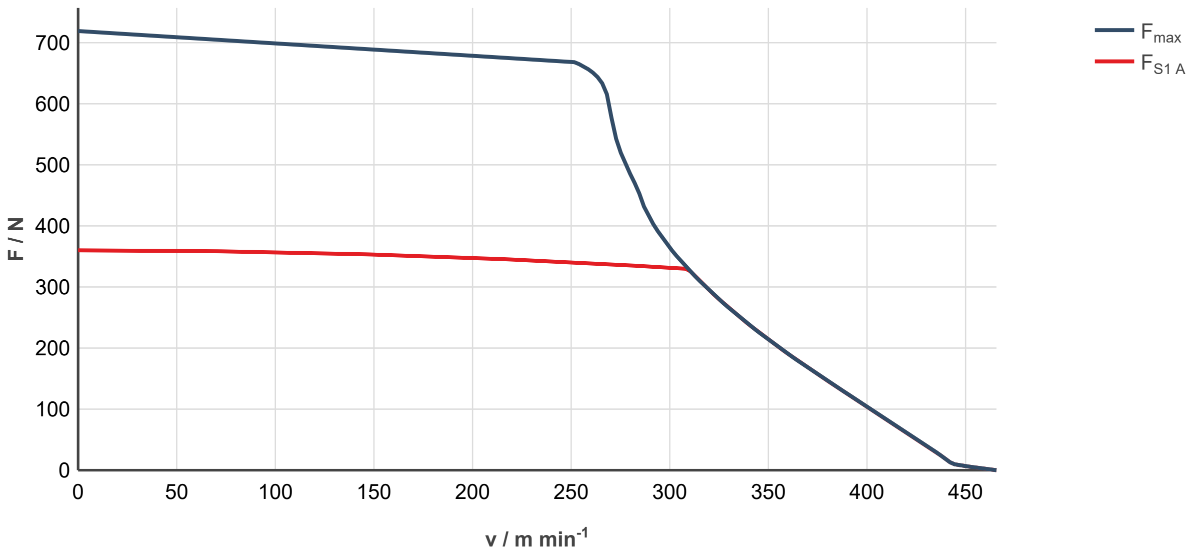


Fig. 11: Characteristic curve ML3P03-F_BN

ML3P03-F_BU_-_____-__, ctrlX DRIVE, uncontrolled supply 3 × AC 400 V

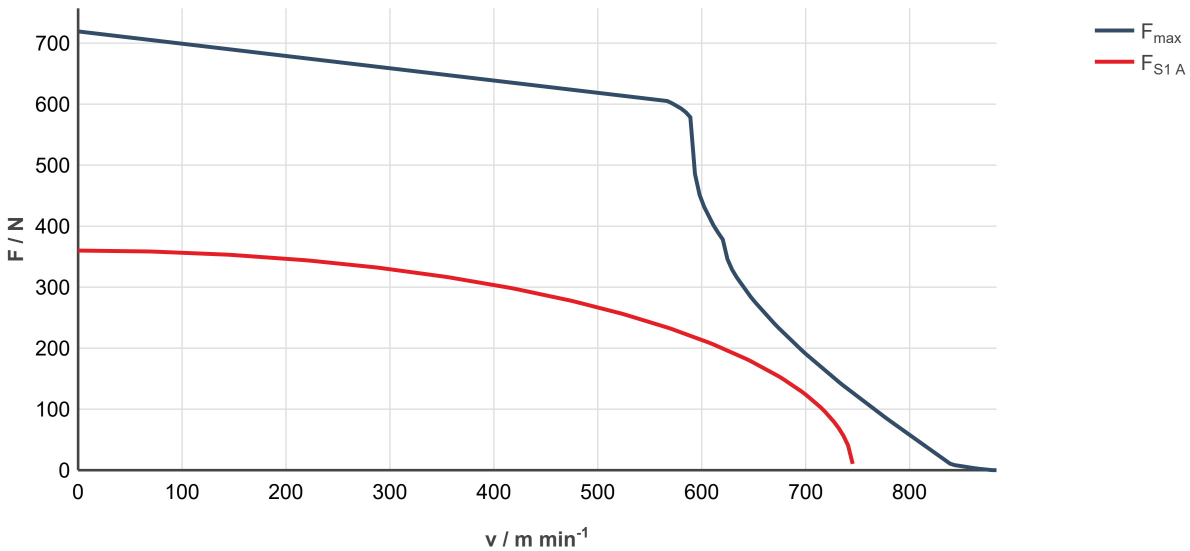


Fig. 12: Characteristic curve ML3P03-F_BU

3.5 Frame size 06

3.5.1 Frame size 06

Primary part ML3P06 - Frame length B

Table 13: Technical data ML3P06-B

Designation	Symbol	Unit	ML3P06-B_BK	ML3P06-B_BR
Maximum force at standstill	$F_{max,0}$	N	450	450
Maximum current at standstill	$I_{max,0}$	A	6.5	13.1
Maximum force	F_{max}	N	420	390
Maximum current	I_{max}	A	5.5	9.7
Continuous force at standstill	F_0	N	200	200
Continuous current at stand-still	I_0	A	2.15	4.3
Maximum velocity at F_{max}	v_{Fmax}	m/min	190	415
Attractive force	F_{ATT}	N	950	950
Force constant	$K_{F,0}$	N/A	93.02	46.51
Voltage constant at 20 °C	K_{EMK}	Vs/m	53.74	26.87
Winding resistance at 20 °C	R_{12}	Ohm	14.4	3.6
Winding inductance	L_{12}	mH	108.0	28.0
Thermal time constant	T_{th_nenn}	min	1.28	1.28
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mm²	0.5	0.5
Primary part mass	m_P	kg	1.5	1.5
Ground connection cable	m_K	kg/m	0.21	0.21
Latest amendment: 2020-01-16				

Primary part ML3P06 - Frame length C

Table 14: Technical data ML3P06-C

Designation	Symbol	Unit	ML3P06-C_BC	ML3P06-C_BR
Maximum force at standstill	$F_{max,0}$	N	675	675
Maximum current at standstill	$I_{max,0}$	A	6.5	19.6
Maximum force	F_{max}	N	650	585
Maximum current	I_{max}	A	5.8	14.5
Continuous force at standstill	F_0	N	300	300
Continuous current at stand-still	I_0	A	2.14	6.45
Maximum velocity at F_{max}	v_{Fmax}	m/min	110	425
Attractive force	F_{ATT}	N	1,325	1,325
Force constant	$K_{F,0}$	N/A	140.19	46.51
Voltage constant at 20 °C	K_{EMK}	Vs/m	80.61	26.87
Winding resistance at 20 °C	R_{12}	Ohm	21.6	2.42
Winding inductivity	L_{12}	mH	162.0	18.0
Thermal time constant	T_{th_nenn}	min	1.28	1.28
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mm²	0.5	0.5
Primary part mass	m_P	kg	2.0	2.0
Ground connection cable	m_K	kg/m	0.21	0.21
Latest amendment: 2022-03-21				

Primary part ML3P06 - Frame length D

Table 15: Technical data ML3P06-D

Designation	Symbol	Unit	ML3P06-D_BK	ML3P06-D_BR
Maximum force at standstill	$F_{max,0}$	N	900	900
Maximum current at standstill	$I_{max,0}$	A	13.1	26.2
Maximum force	F_{max}	N	845	780
Maximum current	I_{max}	A	11.2	19.4
Continuous force at standstill	F_0	N	400	400
Continuous current at stand-still	I_0	A	4.3	8.6
Maximum velocity at F_{max}	v_{Fmax}	m/min	190	420
Attractive force	F_{ATT}	N	1,700	1,700
Force constant	$K_{F,0}$	N/A	93.02	46.51
Voltage constant at 20 °C	K_{EMK}	Vs/m	53.74	26.87
Winding resistance at 20 °C	R_{12}	Ohm	7.2	1.8
Winding inductance	L_{12}	mH	54.0	14.0
Thermal time constant	T_{th_nenn}	min	1.28	1.28
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mm²	0.5	0.75
Primary part mass	m_P	kg	2.6	2.6
Ground connection cable	m_K	kg/m	0.21	0.21
Latest amendment: 2022-03-21				

Primary part ML3P06 - Frame length E

Table 16: Technical data ML3P06-E

Designation	Symbol	Unit	ML3P06-E_BK	ML3P06-E_BR
Maximum force at standstill	$F_{max,0}$	N	1,125	1,125
Maximum current at standstill	$I_{max,0}$	A	13.5	32.7
Maximum force	F_{max}	N	1,070	975
Maximum current	I_{max}	A	11.8	24.1
Continuous force at standstill	F_0	N	500	500
Continuous current at stand-still	I_0	A	4.46	10.75
Maximum velocity at F_{max}	v_{Fmax}	m/min	145	425
Attractive force	F_{ATT}	N	2075	2075
Force constant	$K_{F,0}$	N/A	112.11	46.51
Voltage constant at 20 °C	K_{EMK}	Vs/m	65.05	26.87
Winding resistance at 20 °C	R_{12}	Ohm	8.6	1.44
Winding inductance	L_{12}	mH	64.0	10.8
Thermal time constant	T_{th_nenn}	min	1.28	1.28
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mm²	0.5	1.0
Primary part mass	m_P	kg	3.2	3.2
Ground connection cable	m_K	kg/m	0.21	0.21
Latest amendment: 2022-03-21				

Primary part ML3P06 - Frame length F

Table 17: Technical data ML3P06-F

Designation	Symbol	Unit	ML3P06-F_BK	ML3P06-F_BR
Maximum force at standstill	$F_{max,0}$	N	1350	1350
Maximum current at standstill	$I_{max,0}$	A	19.6	41
Maximum force	F_{max}	N	1,270	1,170
Maximum current	I_{max}	A	16.7	30
Continuous force at standstill	F_0	N	600	600
Continuous current at stand-still	I_0	A	6.45	13.36
Maximum velocity at F_{max}	v_{Fmax}	m/min	190	420
Attractive force	F_{ATT}	N	2450	2450
Force constant	$K_{F,0}$	N/A	93.02	44.91
Voltage constant at 20 °C	K_{EMK}	Vs/m	53.74	26.87
Winding resistance at 20 °C	R_{12}	Ohm	4.82	1.18
Winding inductance	L_{12}	mH	36.0	8.8
Thermal time constant	T_{th_nenn}	min	1.28	1.28
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mm²	0.5	1.5
Primary part mass	m_P	kg	3.8	3.8
Ground connection cable	m_K	kg/m	0.21	0.21
Latest amendment: 2022-03-21				

Primary part ML3P06 - Frame length H

Table 18: Technical data ML3P06-H

Designation	Symbol	Unit	ML3P06-H_BK	ML3P06-H_BR
Maximum force at standstill	$F_{max,0}$	N	1800	1800
Maximum current at standstill	$I_{max,0}$	A	26.2	52
Maximum force	F_{max}	N	1,690	1,560
Maximum current	I_{max}	A	22.4	38.5
Continuous force at standstill	F_0	N	800	800
Continuous current at stand-still	I_0	A	8.6	17.2
Maximum velocity at F_{max}	v_{Fmax}	m/min	185	420
Attractive force	F_{ATT}	N	3400	3400
Force constant	$K_{F,0}$	N/A	93.02	46.51
Voltage constant at 20 °C	K_{EMK}	Vs/m	53.74	26.87
Winding resistance at 20 °C	R_{12}	Ohm	3.62	0.92
Winding inductance	L_{12}	mH	28.0	6.8
Thermal time constant	T_{th_nenn}	min	1.28	1.28
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mm²	0.75	2.5
Primary part mass	m_P	kg	5.2	5.2
Ground connection cable	m_K	kg/m	0.21	0.3
Latest amendment: 2022-03-21				

3.5.2 Secondary part ML3S06

Table 19: Technical data ML3S06

Designation	Symbol	Unit	ML3S06-__-0192	ML3S06-__-0288
Mass secondary part	m_S	kg	0.73	1.1
Mass secondary part, relative	m_{S_rel}	kg/m	3.8	3.8
Latest amendment: 2017-11-19				

Technical data

3.5.3 Motor characteristic curves ML3P06

ML3P06-B

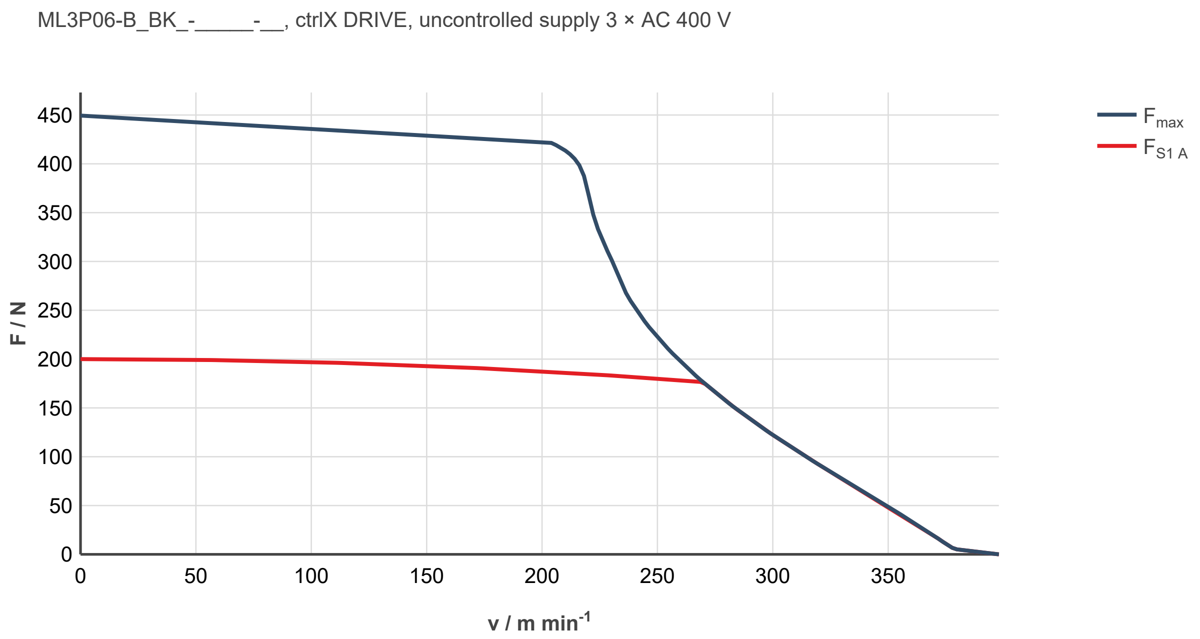


Fig. 13: Characteristic curve ML3P06-B_BK

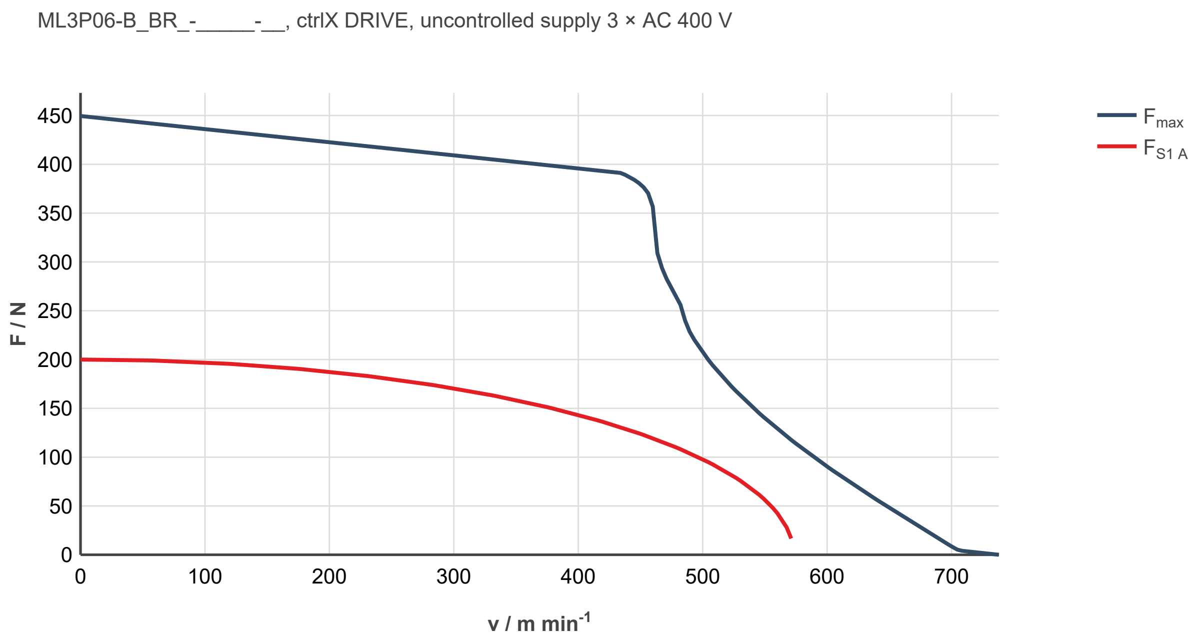


Fig. 14: Characteristic curve ML3P06-B_BR

ML3P06-C

ML3P06-C_BC_-_____-__, ctrlX DRIVE, uncontrolled supply 3 × AC 400 V

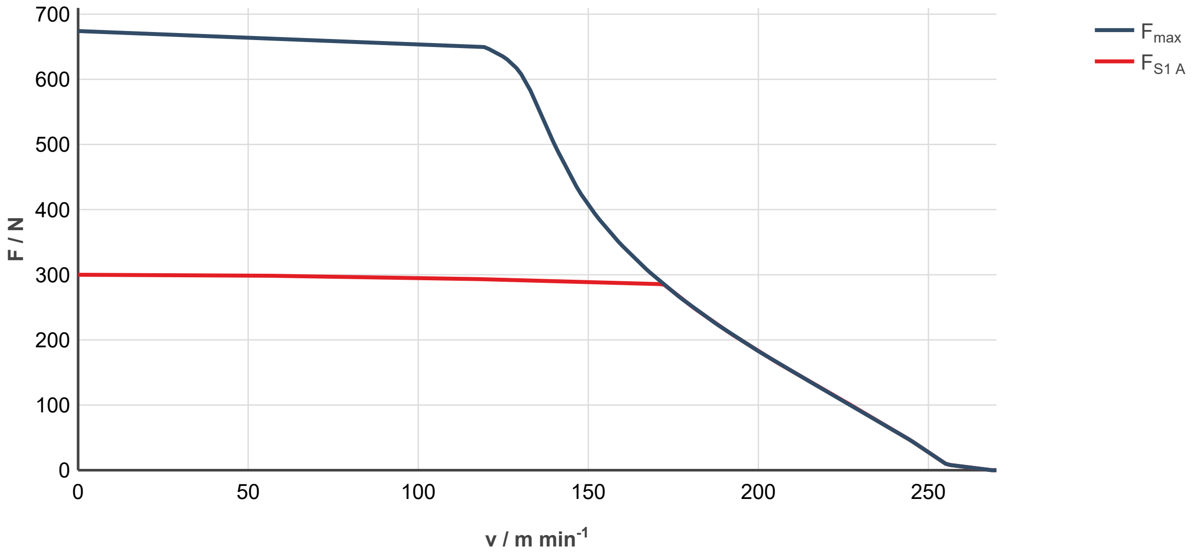


Fig. 15: Characteristic curve ML3P06-C_BC

ML3P06-C_BR_-_____-__, ctrlX DRIVE, uncontrolled supply 3 × AC 400 V

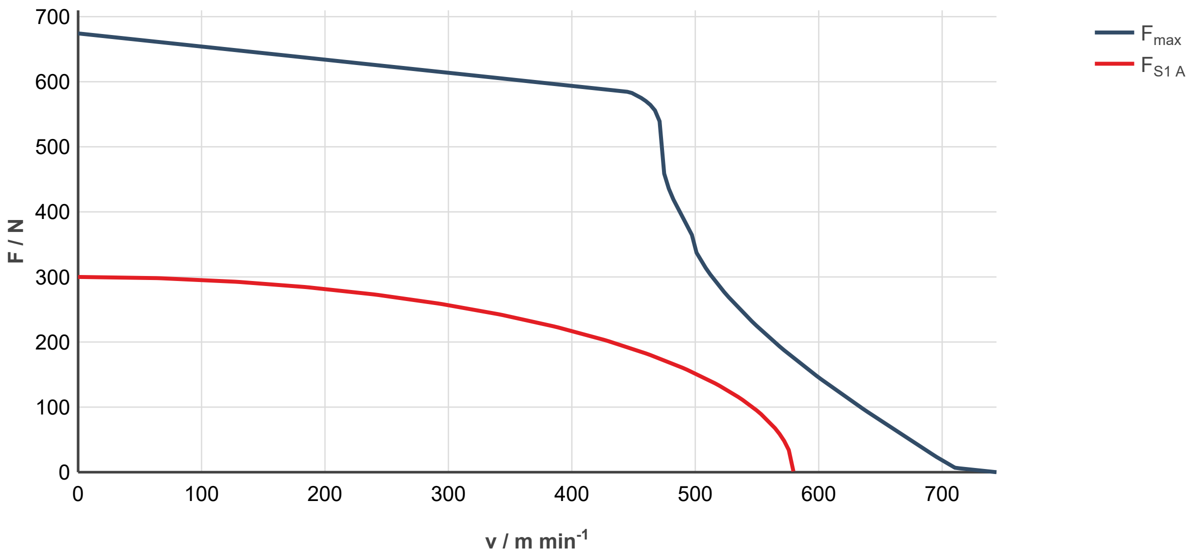


Fig. 16: Characteristic curve ML3P06-C_BR

ML3P06-D

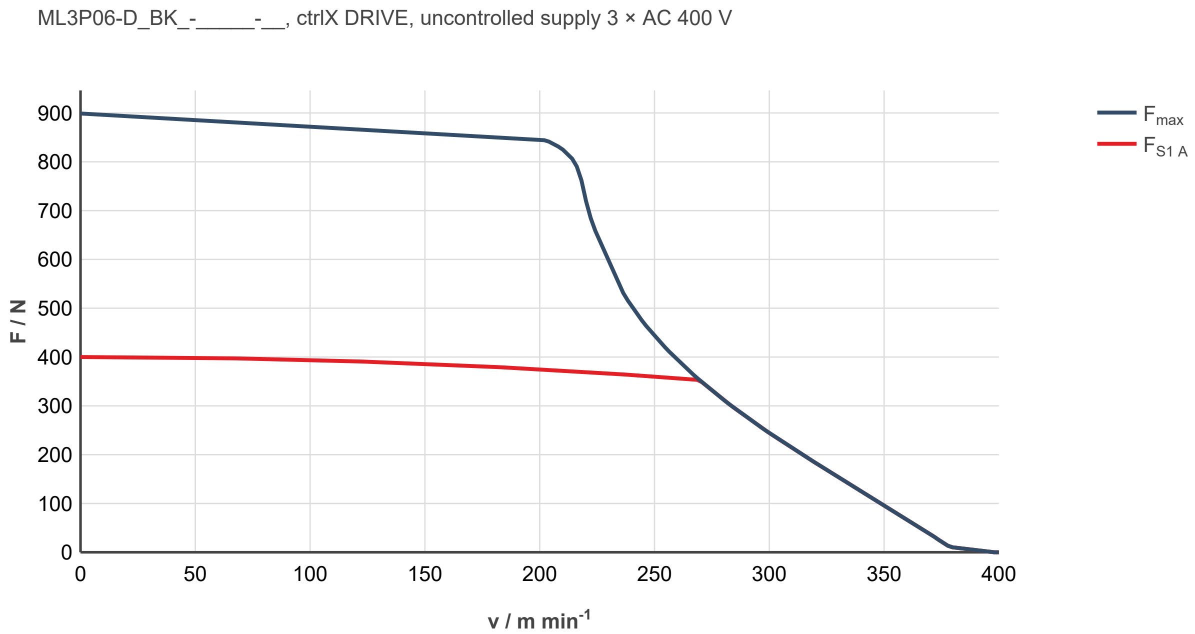


Fig. 17: Characteristic curve ML3P06-D_BK

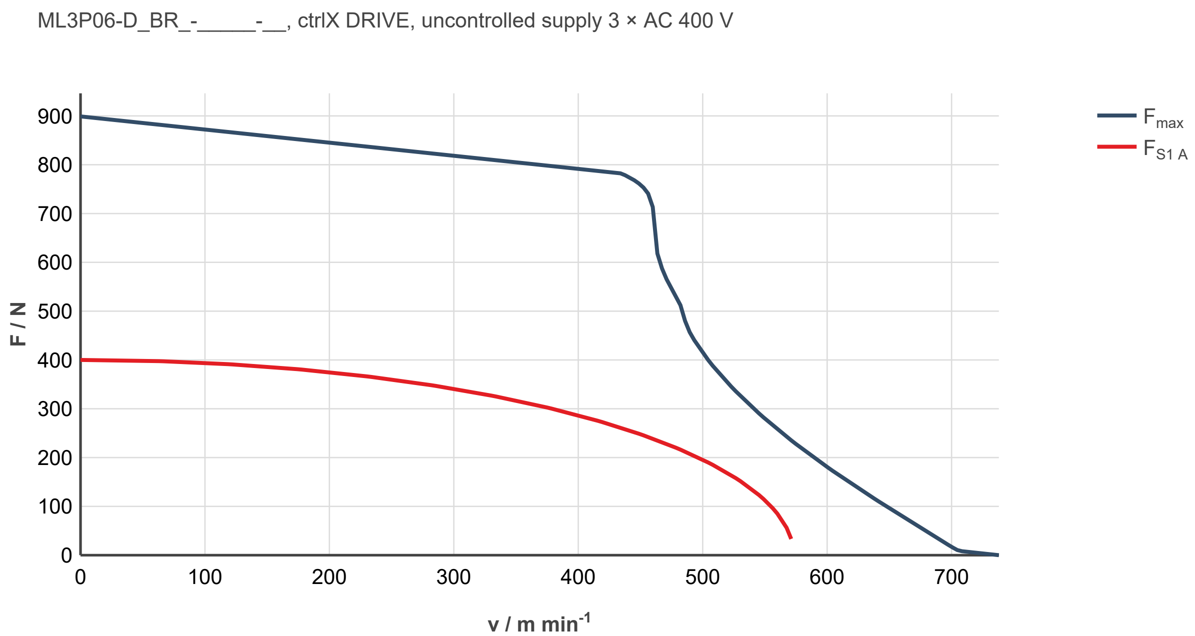


Fig. 18: Characteristic curve ML3P06-D_BR

ML3P06-E

ML3P06-E_BK_-______-__, ctrlX DRIVE, uncontrolled supply 3 × AC 400 V

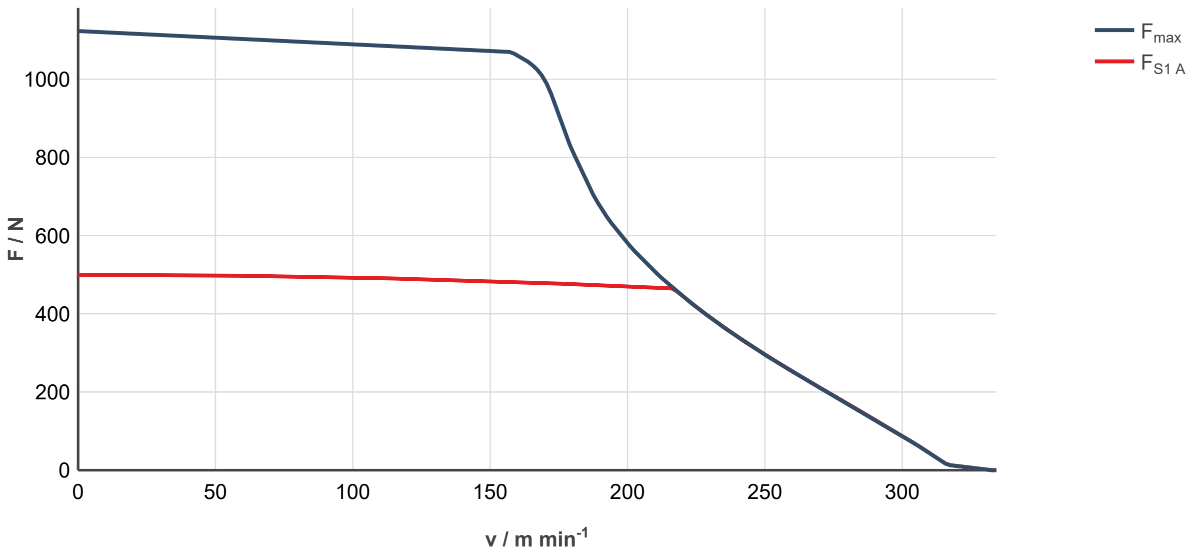


Fig. 19: Characteristic curve ML3P06-E_BK

ML3P06-E_BR_-______-__, ctrlX DRIVE, uncontrolled supply 3 × AC 400 V

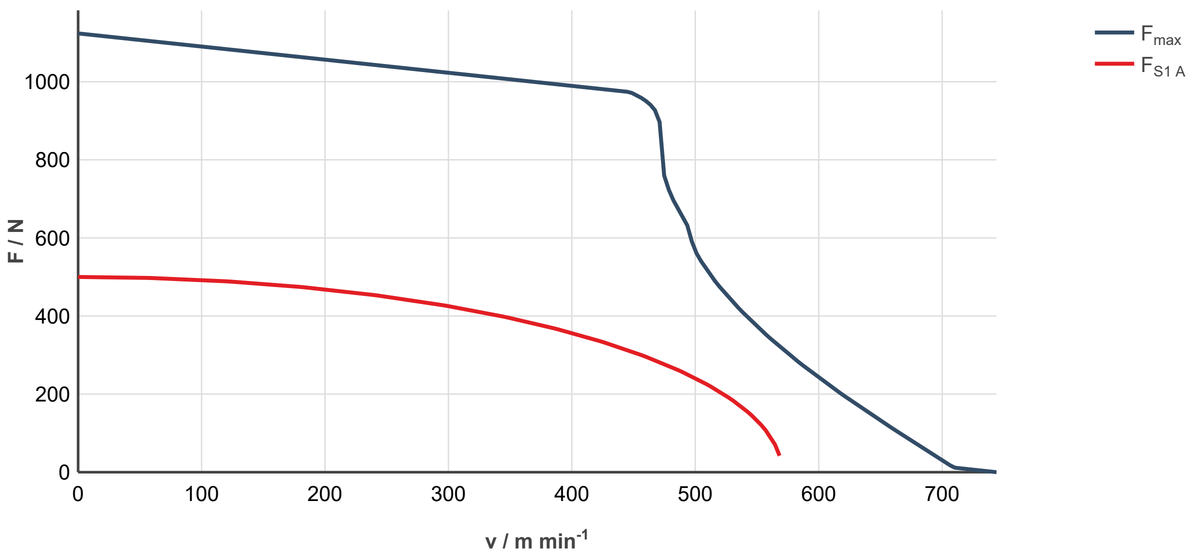


Fig. 20: Characteristic curve ML3P06-E_BR

ML3P06-F

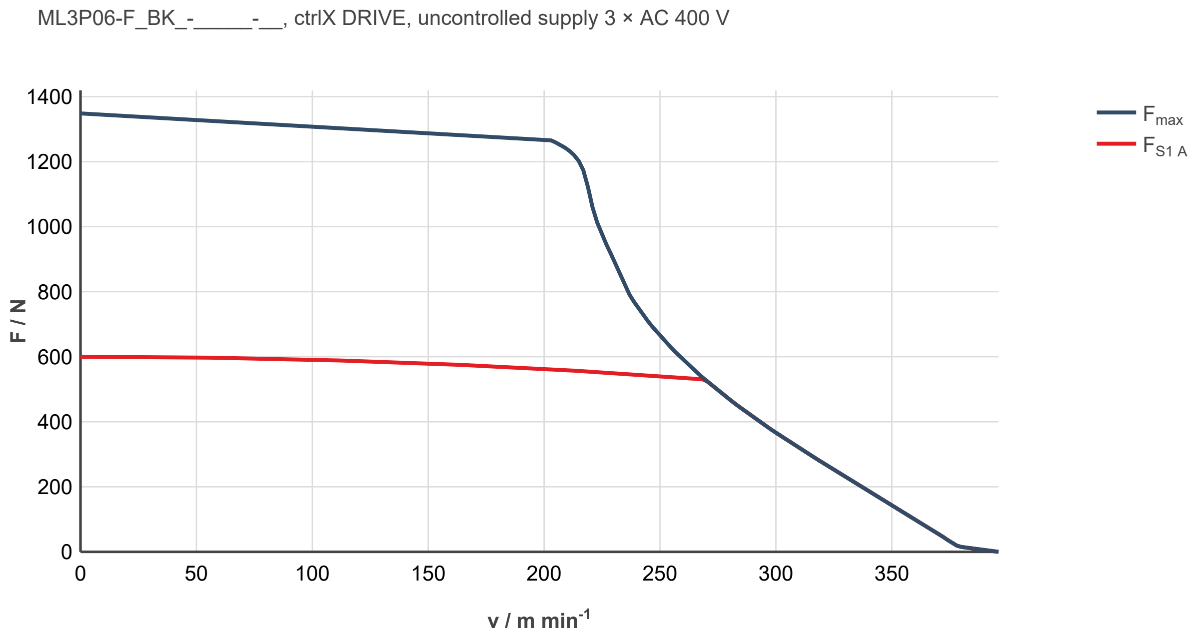


Fig. 21: Characteristic curve ML3P06-F_BK

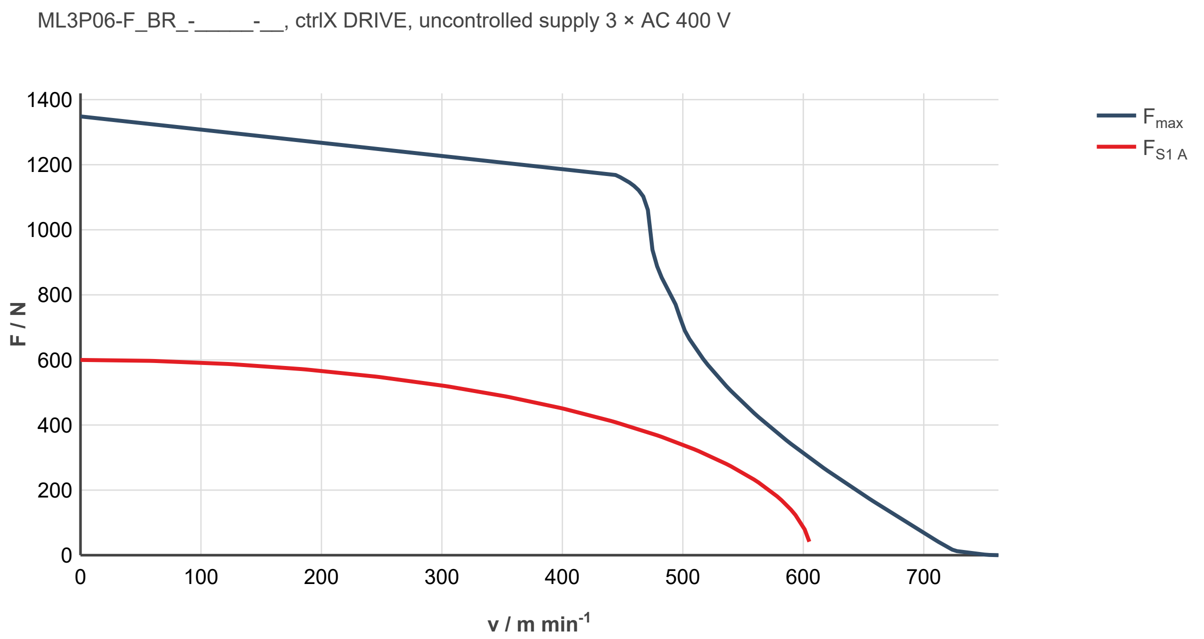


Fig. 22: Characteristic curve ML3P06-F_BR

ML3P06-H

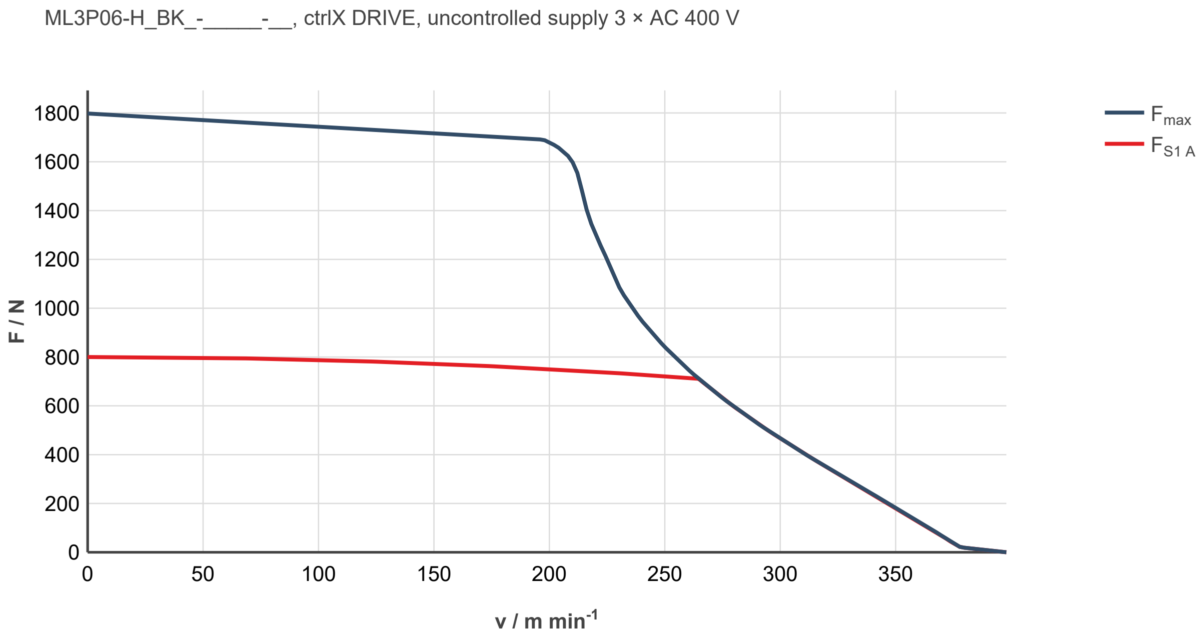


Fig. 23: Characteristic curve ML3P06-H_BK

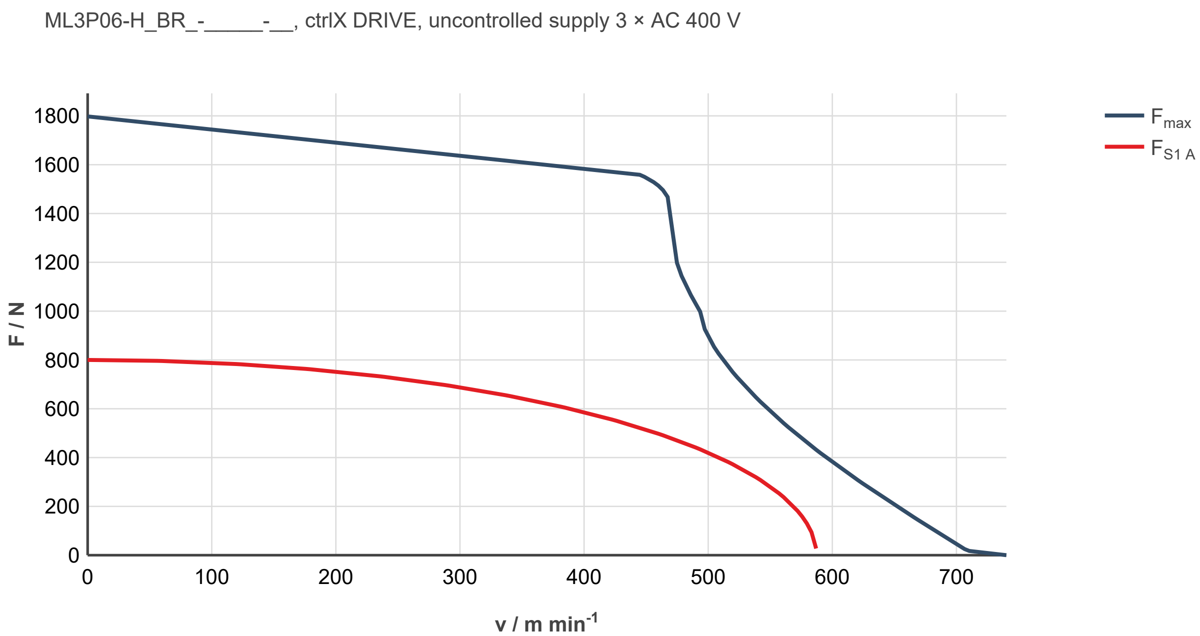


Fig. 24: Characteristic curve ML3P06-H_BR

3.6 Frame size 11

3.6.1 Data ML3P11

Primary part ML3P11 - Frame length D

Table 20: Technical data ML3P11-D

Designation	Symbol	Unit	ML3P11-D_BF	ML3P11-D_BQ
Maximum force at standstill	$F_{max,0}$	N	1800	1800
Maximum current at standstill	$I_{max,0}$	A	13	26
Maximum force	F_{max}	N	1,750	1,680
Maximum current	I_{max}	A	12	22
Continuous force at standstill	F_0	N	760	760
Continuous current at standstill	I_0	A	4.1	8.2
Maximum velocity at F_{max}	v_{Fmax}	m/min	75	200
Attractive force	F_{ATT}	N	3400	3400
Force constant	$K_{F,0}$	N/A	185.4	92.68
Voltage constant at 20 °C	K_{EMK}	Vs/m	107	53.74
Winding resistance at 20 °C	R_{12}	Ohm	12.6	3.2
Winding inductance	L_{12}	mH	102.0	26.0
Thermal time constant	T_{th_nenn}	min	1.5	1.5
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mm²	0.5	0.75
Primary part mass	m_P	kg	4.9	4.9
Ground connection cable	m_K	kg/m	0.3	0.3
Latest amendment: 2020-09-11				

Primary part ML3P11 - Frame length E

Table 21: Technical data ML3P11-E

Designation	Symbol	Unit	ML3P11-E_BC	ML3P11-E_BQ
Maximum force at standstill	$F_{max,0}$	N	2,250	2,250
Maximum current at standstill	$I_{max,0}$	A	13.5	33
Maximum force	F_{max}	N	2,200	2,100
Maximum current	I_{max}	A	12.5	27.2
Continuous force at standstill	F_0	N	950	950
Continuous current at stand-still	I_0	A	4.2	10.2
Maximum velocity at F_{max}	v_{Fmax}	m/min	50	200
Attractive force	F_{ATT}	N	4,150	4,150
Force constant	$K_{F,0}$	N/A	226.19	93.14
Voltage constant at 20 °C	K_{EMK}	Vs/m	129.4	53.74
Winding resistance at 20 °C	R_{12}	Ohm	15.2	2.6
Winding inductance	L_{12}	mH	120.0	20.0
Thermal time constant	T_{th_nenn}	min	1.5	1.5
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mm²	0.5	0.75
Primary part mass	m_P	kg	5.9	5.9
Ground connection cable	m_K	kg/m	0.3	0.3
Latest amendment: 2022-03-21				

Primary part ML3P11 - Frame length F

Table 22: Technical data ML3P11-F

Designation	Symbol	Unit	ML3P11-F_BF
Maximum force at standstill	$F_{max,0}$	N	2,700
Maximum current at standstill	$I_{max,0}$	A	20.0
Maximum force	F_{max}	N	2600
Maximum current	I_{max}	A	18.0
Continuous force at standstill	F_0	N	1,140
Continuous current at stand-still	I_0	A	6.1
Maximum velocity at F_{max}	v_{Fmax}	m/min	75
Attractive force	F_{ATT}	N	4980
Force constant	$K_{F,0}$	N/A	186.87
Voltage constant at 20 °C	K_{EMK}	Vs/m	107.5
Winding resistance at 20 °C	R_{12}	Ohm	8.4
Winding inductance	L_{12}	mH	67.8
Thermal time constant	T_{th_nenn}	min	1.5
Pole width	τ_p	mm	12
Power wire cross-section	A	mm^2	0.75
Primary part mass	m_P	kg	7.1
Ground connection cable	m_K	kg/m	0.3
Latest amendment: 2020-06-23			

Primary part ML3P11 - Frame length H

Table 23: Technical data ML3P11-H

Designation	Symbol	Unit	ML3P11-H_BC
Maximum force at standstill	$F_{max,0}$	N	3600
Maximum current at standstill	$I_{max,0}$	A	21.0
Maximum force	F_{max}	N	3500
Maximum current	I_{max}	A	19.4
Continuous force at standstill	F_0	N	1,520
Continuous current at stand-still	I_0	A	6.6
Maximum velocity at F_{max}	v_{Fmax}	m/min	55
Attractive force	F_{ATT}	N	6,640
Force constant	$K_{F,0}$	N/A	230.3
Voltage constant at 20 °C	K_{EMK}	Vs/m	133.64
Winding resistance at 20 °C	R_{12}	Ohm	9.9
Winding inductance	L_{12}	mH	79.2
Thermal time constant	T_{th_nenn}	min	1.5
Pole width	τ_p	mm	12
Power wire cross-section	A	mm²	0.75
Primary part mass	m_P	kg	9.4
Ground connection cable	m_K	kg/m	0.3
Latest amendment: 2020-03-13			

Primary part ML3P11 - Frame length L

Table 24: Technical data ML3P11-L

Designation	Symbol	Unit	ML3P11-L_BC	ML3P11-L_BQ
Maximum force at standstill	$F_{max,0}$	N	4,500	4,500
Maximum current at standstill	$I_{max,0}$	A	27	66
Maximum force	F_{max}	N	4400	4200
Maximum current	I_{max}	A	25.5	54.5
Continuous force at standstill	F_0	N	1900	1900
Continuous current at stand-still	I_0	A	8.5	20.5
Maximum velocity at F_{max}	v_{Fmax}	m/min	50	200
Attractive force	F_{ATT}	N	8,300	8,300
Force constant	$K_{F,0}$	N/A	223.53	92.68
Voltage constant at 20 °C	K_{EMK}	Vs/m	129.4	53.74
Winding resistance at 20 °C	R_{12}	Ohm	7.6	1.3
Winding inductance	L_{12}	mH	60.0	10.0
Thermal time constant	T_{th_nenn}	min	1.5	1.5
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mm²	0.75	2.5
Primary part mass	m_P	kg	11.6	11.6
Ground connection cable	m_K	kg/m	0.3	0.3
Latest amendment: 2022-03-21				

Primary part ML3P11 - Frame length R

Designation	Symbol	Unit	ML3P11-R_BC	ML3P11-R_BQ
Maximum force at standstill	$F_{max,0}$	N	6,750	6,750
Maximum current at standstill	$I_{max,0}$	A	41	98
Maximum force	F_{max}	N	6,000	6,000
Maximum current	I_{max}	A	31	75
Continuous force at standstill	F_0	N	2850	2850
Continuous current at stand-still	I_0	A	12.7	30.7
Maximum velocity at F_{max}	v_{Fmax}	m/min	50	200
Attractive force	F_{ATT}	N	12450	12450
Force constant	$K_{F,0}$	N/A	224.41	92.83
Voltage constant at 20 °C	K_{EMK}	Vs/m	129.4	53.74
Winding resistance at 20 °C	R_{12}	Ohm	5.2	0.88
Winding inductance	L_{12}	mH	42	6
Thermal time constant	T_{th_nenn}	min	1.5	1.5
Pole width	τ_p	mm	12	12
Power wire cross-section	A	mm²	1.0	6.0
Primary part mass	m_P	kg	18.2	18.2
Ground connection cable	m_K	kg/m	0.6	0.6
Latest amendment: 2022-07-11				

3.6.2 Data ML3S11

Table 25: Technical data ML3S11

Designation	Symbol	Unit	ML3S11-__-0192	ML3S11-__-0288
Mass secondary part	m_S	kg	2.02	3.03
Mass secondary part, relative	m_{S_rel}	kg/m	10.5	10.5
Latest amendment: 2017-11-19				

3.6.3 Motor characteristic curves ML3P11

ML3P11-D

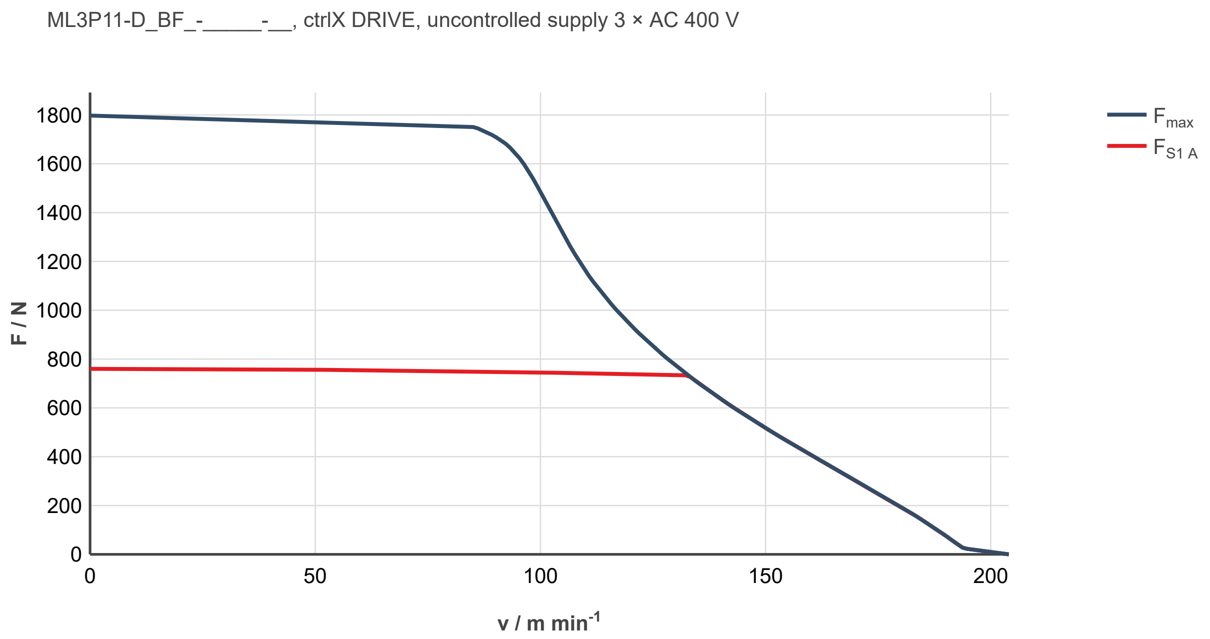


Fig. 25: Characteristic curve ML3P11-D_BF

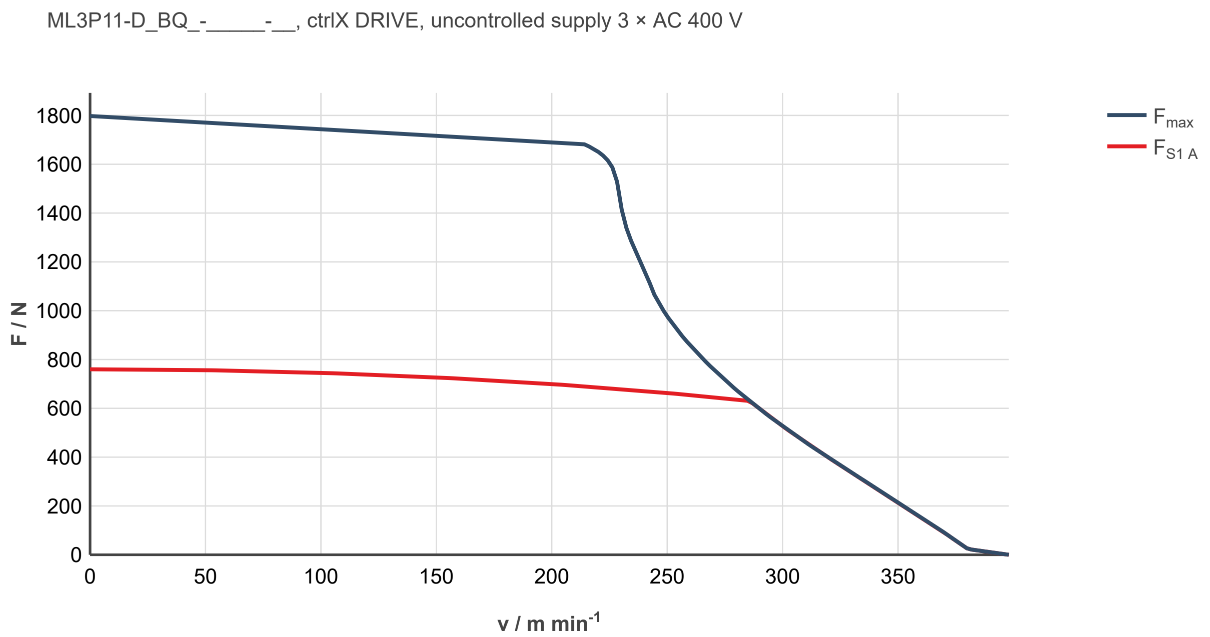


Fig. 26: Characteristic curve ML3P11-D_BQ

ML3P11-E

ML3P11-E_BC_-_____-__, ctrlX DRIVE, uncontrolled supply 3 × AC 400 V

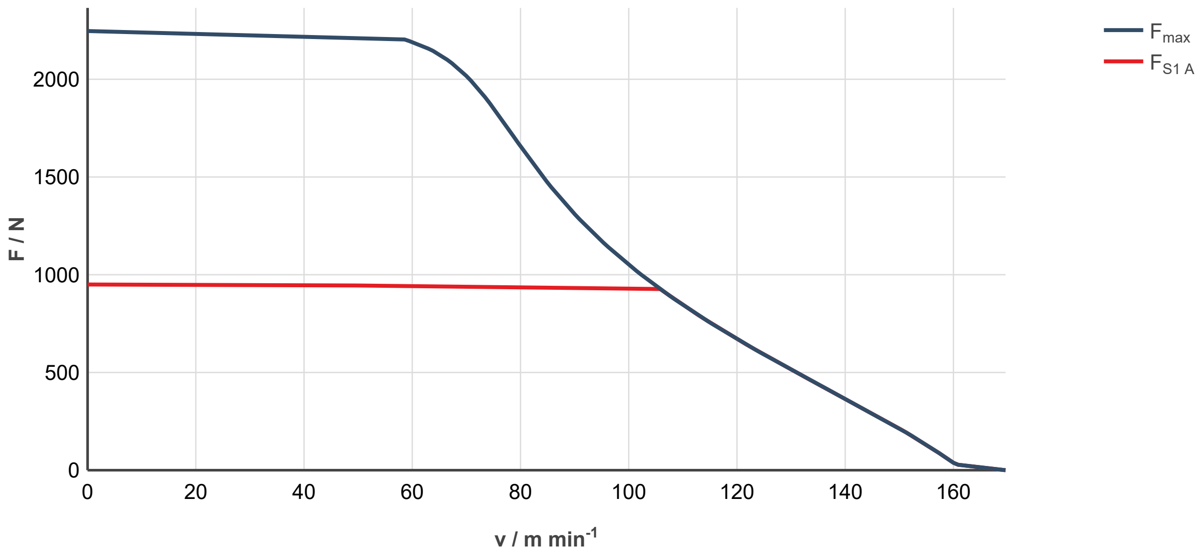


Fig. 27: Characteristic curve ML3P11-E_BC

ML3P11-E_BQ_-_____-__, ctrlX DRIVE, uncontrolled supply 3 × AC 400 V

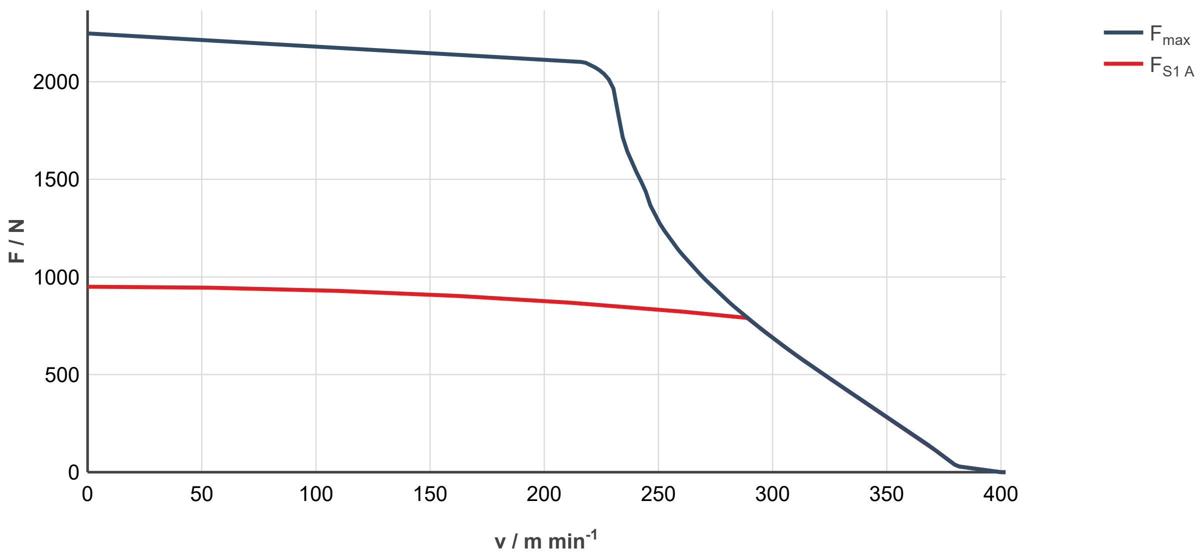


Fig. 28: Characteristic curve ML3P11-E_BQ

ML3P11-F

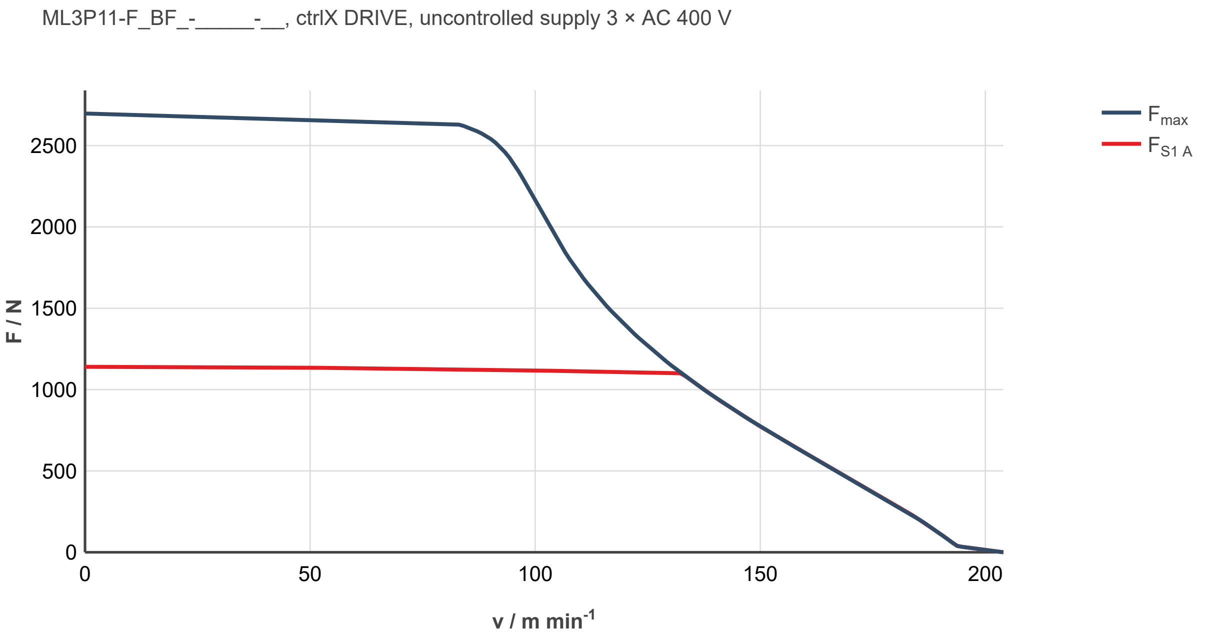


Fig. 29: Characteristic curve ML3P11-F_BF

ML3P11-H

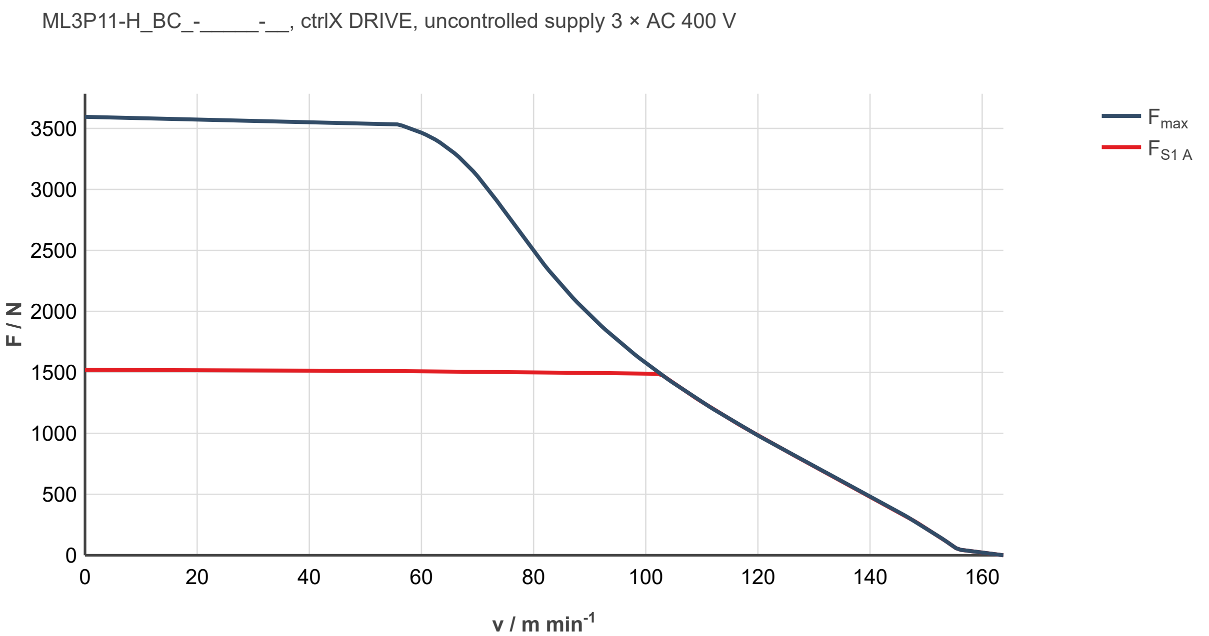


Fig. 30: Characteristic curve ML3P11-H_BC

ML3P11-L

ML3P11-L_BC_-______-__, ctrlX DRIVE, uncontrolled supply 3 × AC 400 V

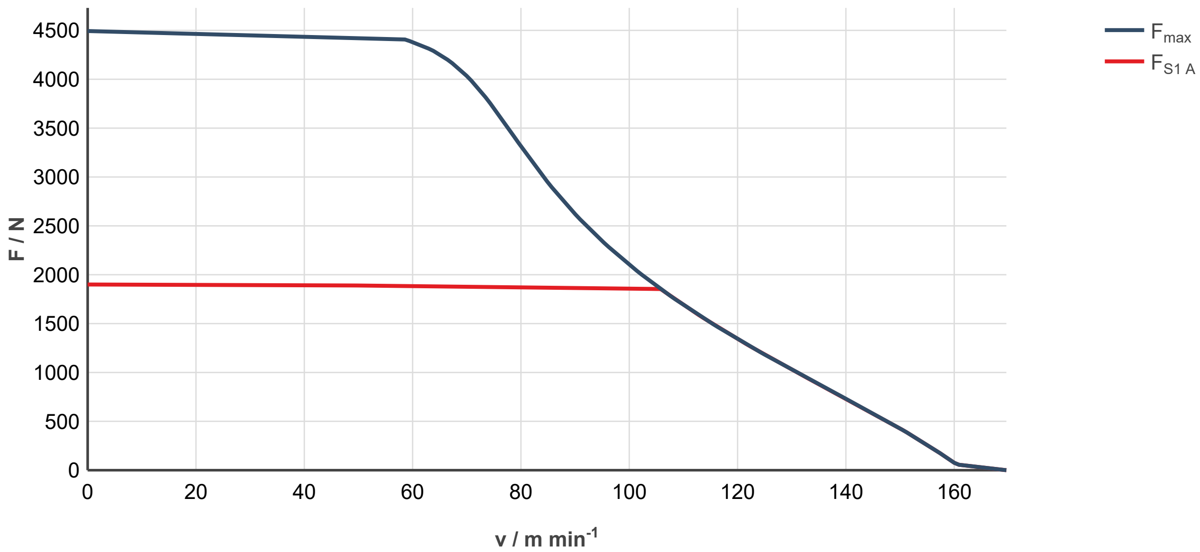


Fig. 31: Characteristic curve ML3P11-L_BC

ML3P11-L_BQ_-______-__, ctrlX DRIVE, uncontrolled supply 3 × AC 400 V

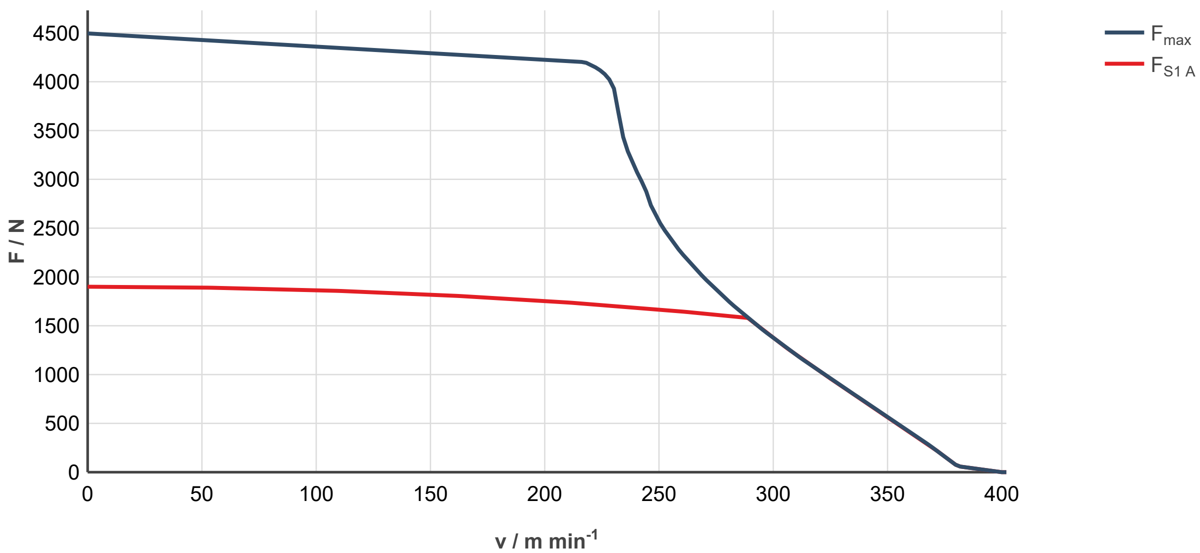


Fig. 32: Characteristic curve ML3P11-L_BQ

ML3P11-R

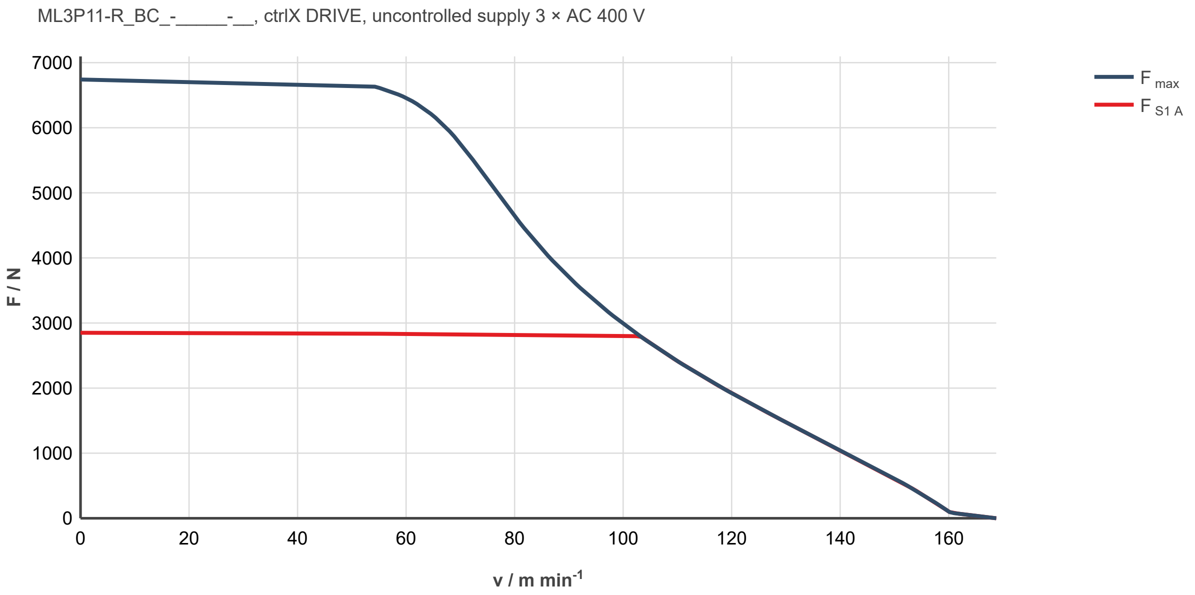


Fig. 33: Characteristic curve ML3P11-R_BC

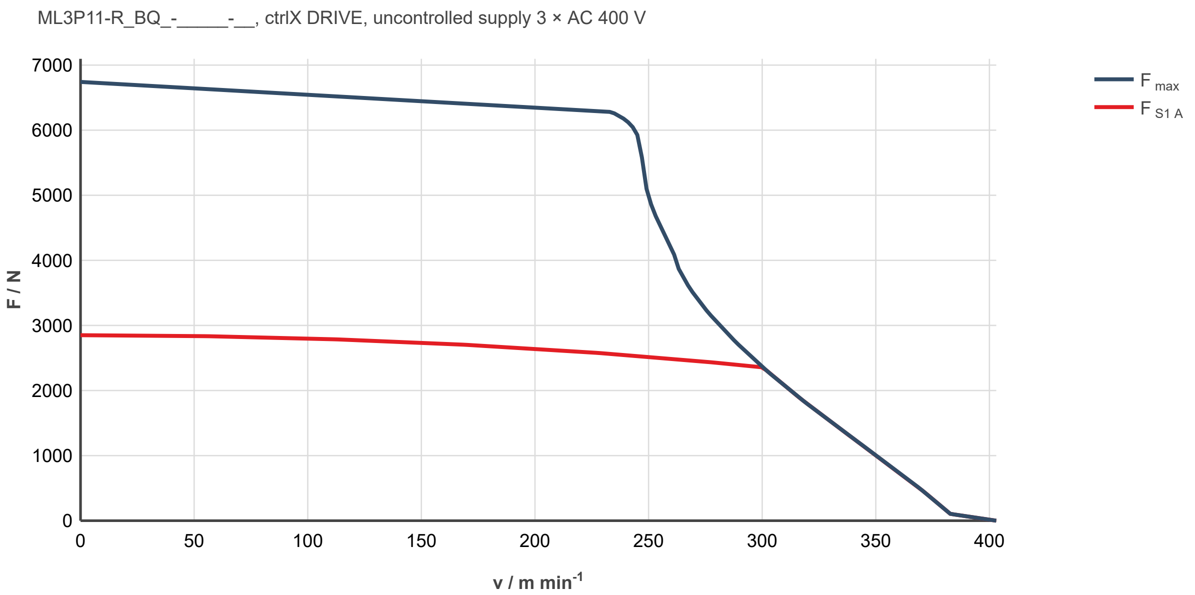


Fig. 34: Characteristic curve ML3P11-R_BQ

4 Dimensional sheets

4.1 Dimensions

4.1.1 General notes

Comply with the trademark rights of third parties during assembly and use of single components delivered by Bosch Rexroth. For any infringement of the right, the customer is liable for the accruing damage.

4.1.2 Air gap and installation height

To ensure safe operation and constant force over the entire travel range, an air gap is required between primary and secondary part. For this purpose, the individual parts of the motor are tolerated accordingly. The distance of the mounting surface, the parallelism and the symmetry of the primary and secondary part of the linear motor in the machine must be within a certain tolerance above the entire travel length. Any deformations that result from weight, attractive forces and process forces must be taken into account.

Deviating specified nominal air gap lead to a reduction or modification of the specified performance data.

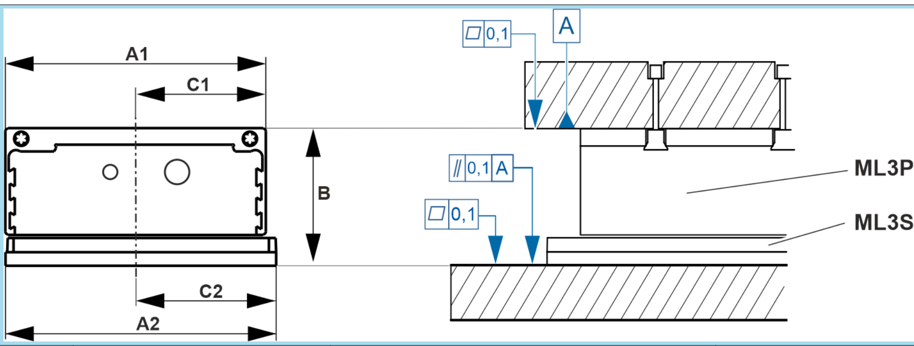
The specified installation dimensions with respective tolerances must always be complied with over the entire travel length. An insufficient air gap may lead to contact between the primary part and the secondary part and thus to damaged and destroyed motor components.

For the installation of the motors into the machine structure, Bosch Rexroth specifies a defined installation position with tolerances. Thus, the specified size and tolerances of the air gap are maintained automatically – even if individual motor components are replaced.

Long distances can make is necessary that the contact surfaces of the motor components must be directly processed from the mounted slide.

4.1.3 Dimensions and tolerances

Table 26: Installation dimensions and tolerances (example frame size 06)



Frame size	Installation height B	Motor axis distance		Width	
		C1*	C2*	ML3P A1*	ML3S A2*
03	40 mm ± 0.1 mm	23 mm	25 mm	51 mm	50 mm
06	40 mm ± 0.1 mm	36 mm	40 mm	77 mm	80 mm
11-D/-E/-F/-H/-L	45 mm ± 0.1 mm	60.5 mm	65 mm	125.5 mm	130 mm
11-R	47 mm ± 0.1 mm	65 mm	65 mm	130 mm	130 mm
*) For tolerance details refer to the dimension sheet					

NOTICE	The specified installation dimensions with respective tolerances must always be complied with over the entire travel length.

4.1.4 Parallelism and symmetry of machine parts

Before primary and secondary part can be mounted, align the parts of the machine. Especially the machine slide is to be brought into a defined position to the machine bed. When aligning, the installation dimensions and tolerances regarding parallelism and symmetry must be kept.

To keep the tolerances, it is necessary that the fastening holes for the primary part and the threaded holes for the primary and secondary part in the machine are strictly realized according to the dimensions of the particular dimension sheets. The alignment of the motor components must be done according to Fig. 35.

You will find further notes regarding assembly of primary and secondary parts in ➦chapter . 10.2.

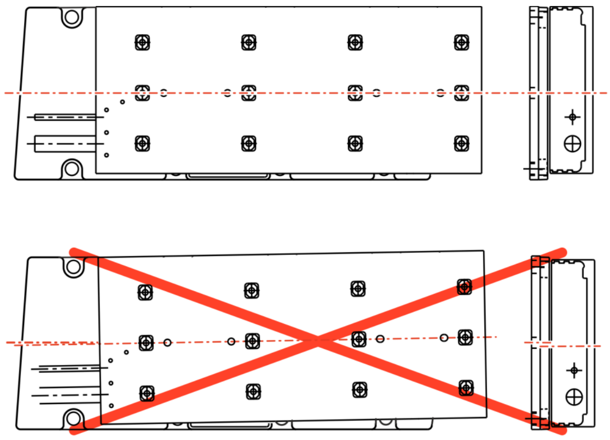


Fig. 35: Parallelism and symmetry between primary part and secondary part

4.2 Frame size 03

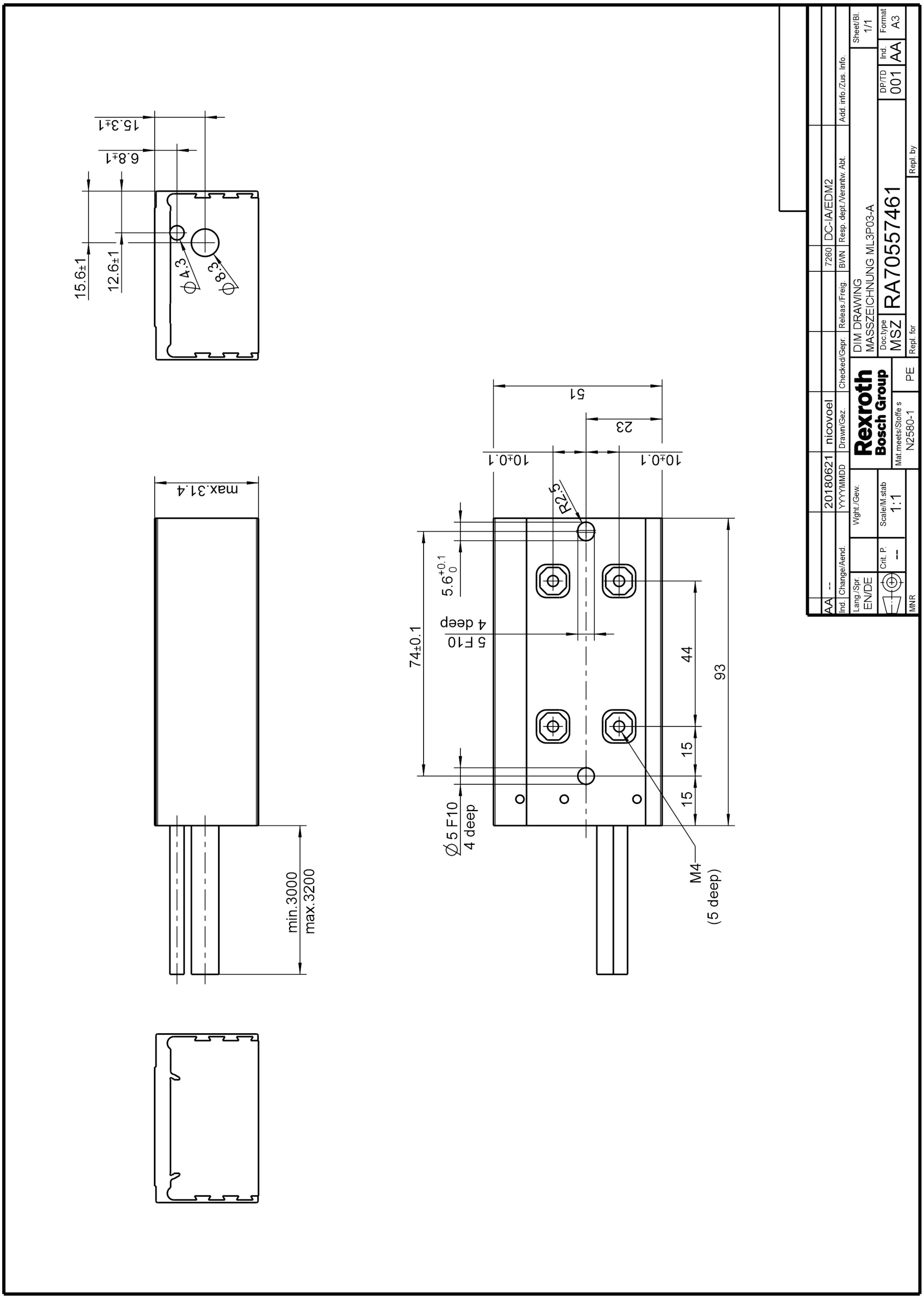
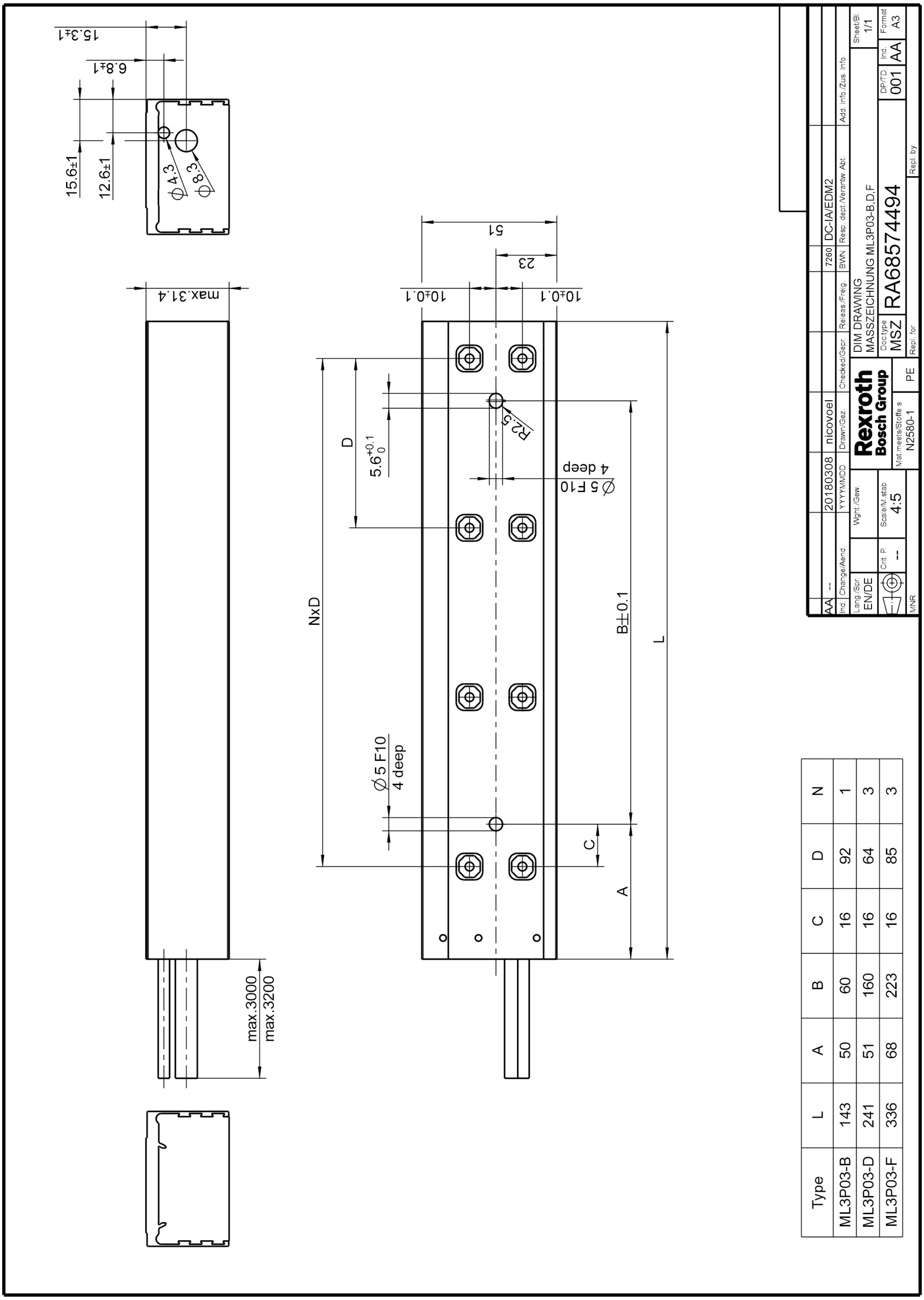
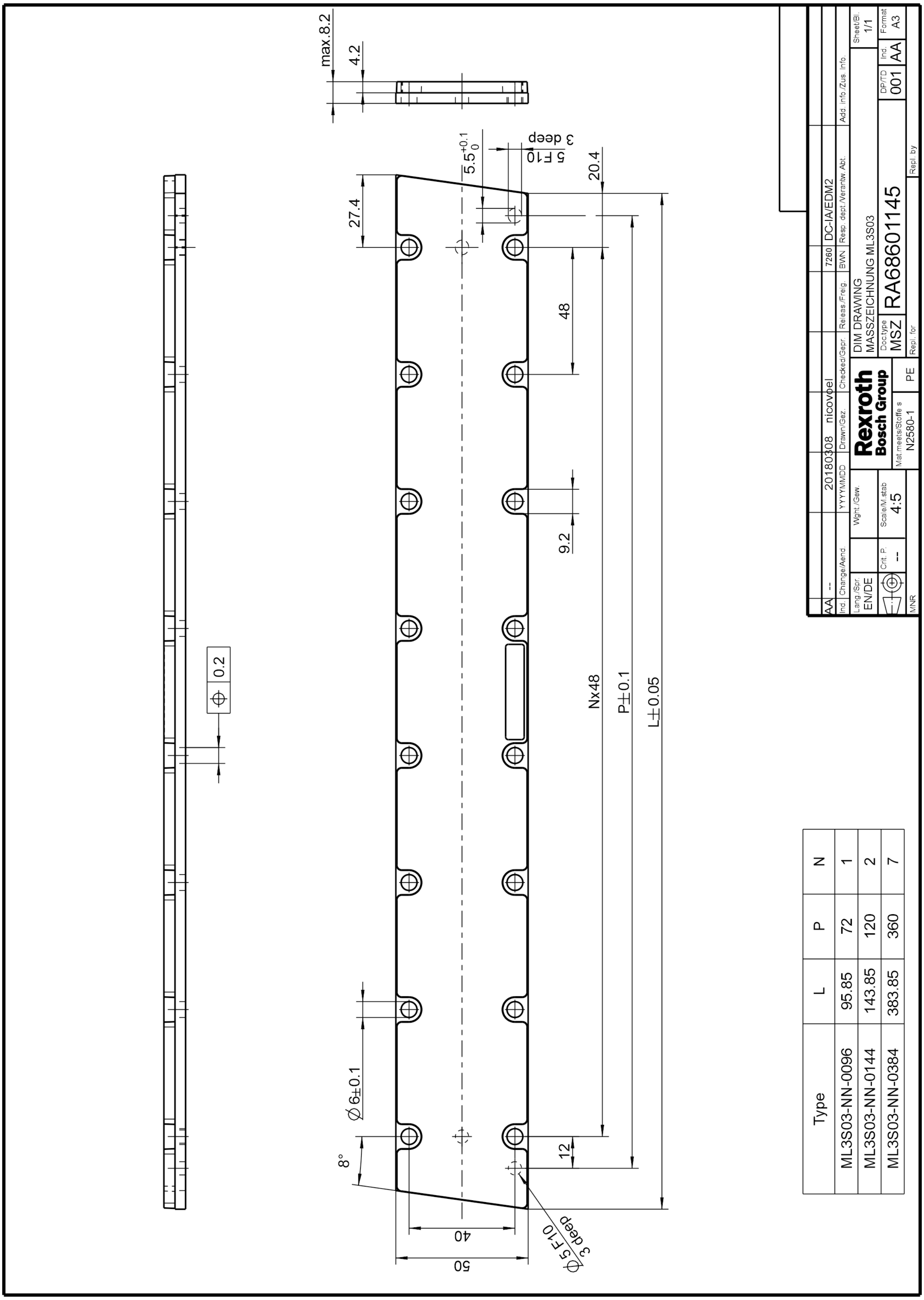


Fig. 36: Dimension sheet primary part ML3P03-A



Type	L	A	B	C	D	N
ML3P03-B	143	50	60	16	92	1
ML3P03-D	241	51	160	16	64	3
ML3P03-F	336	68	223	16	85	3

Fig. 37: Dimension sheet primary part ML3P03-B/D/F



Type	L	P	N
ML3S03-NN-0096	95.85	72	1
ML3S03-NN-0144	143.85	120	2
ML3S03-NN-0384	383.85	360	7

Fig. 38: Dimension sheet secondary part ML3S03

4.3 Frame size 06

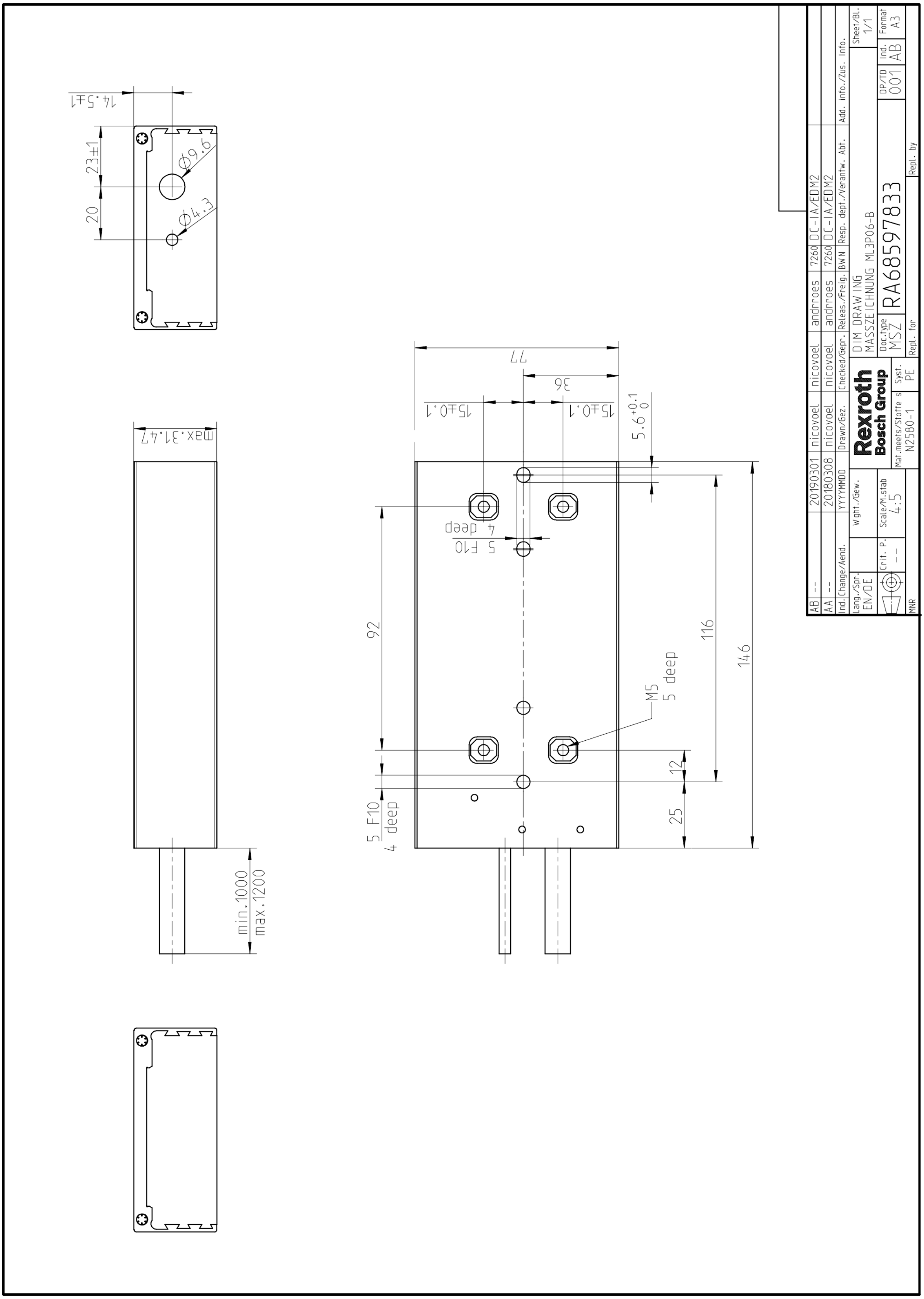
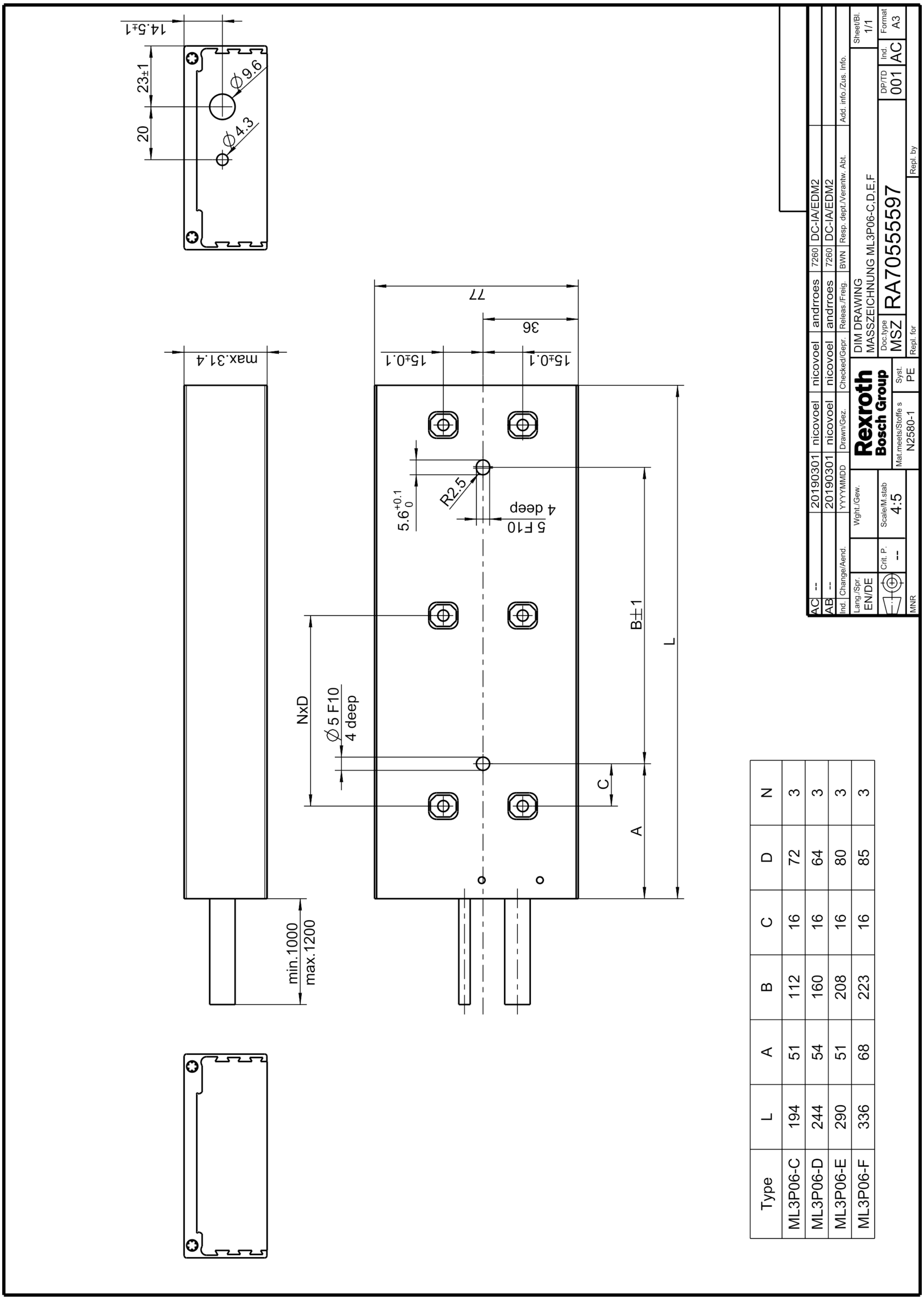


Fig. 39: Dimension sheet primary part ML3P06-B



Type	L	A	B	C	D	N
ML3P06-C	194	51	112	16	72	3
ML3P06-D	244	54	160	16	64	3
ML3P06-E	290	51	208	16	80	3
ML3P06-F	336	68	223	16	85	3

Fig. 40: Dimension sheet primary part ML3P06-C/D/E/F

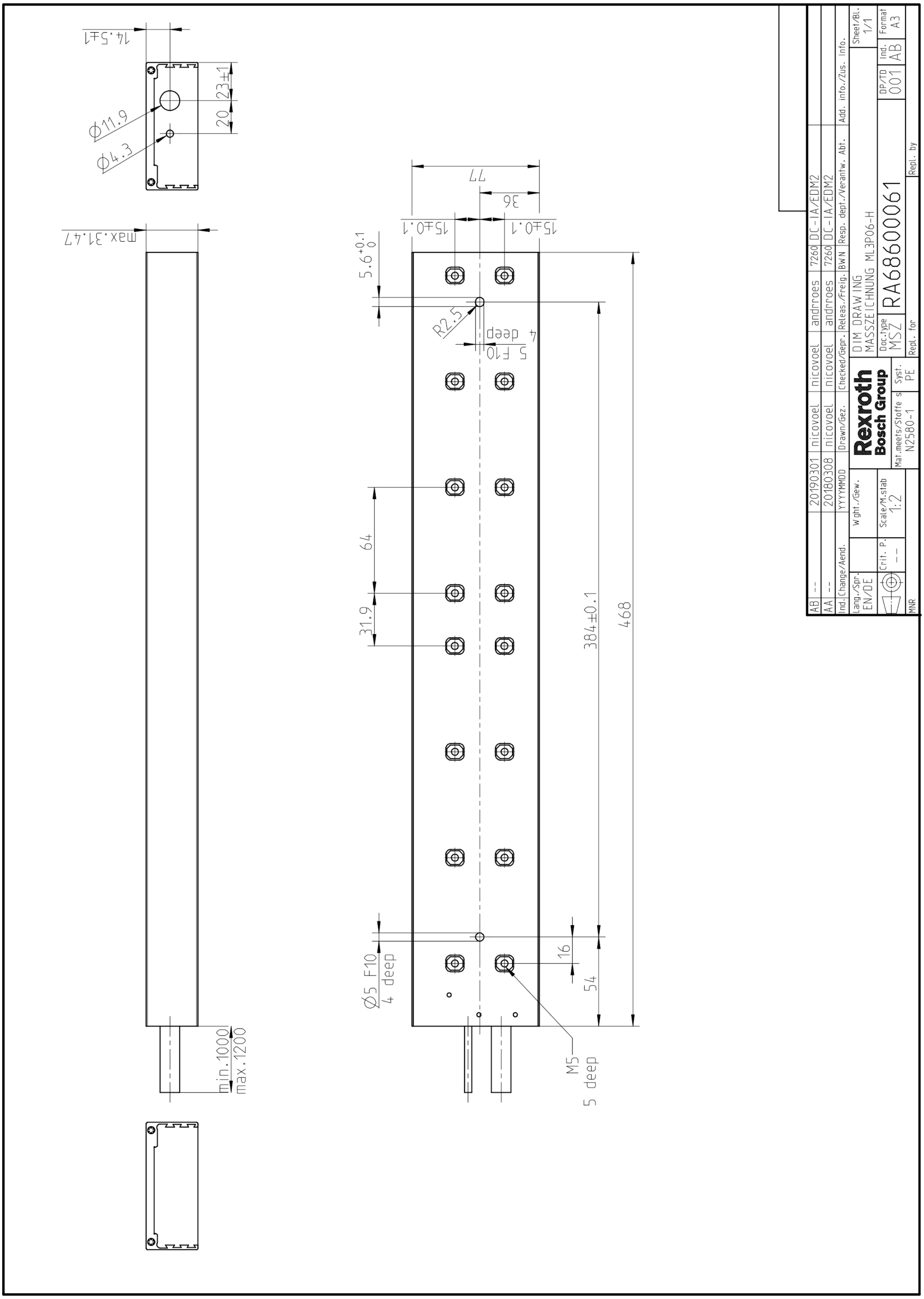


Fig. 41: Dimension sheet primary part ML3P06-H

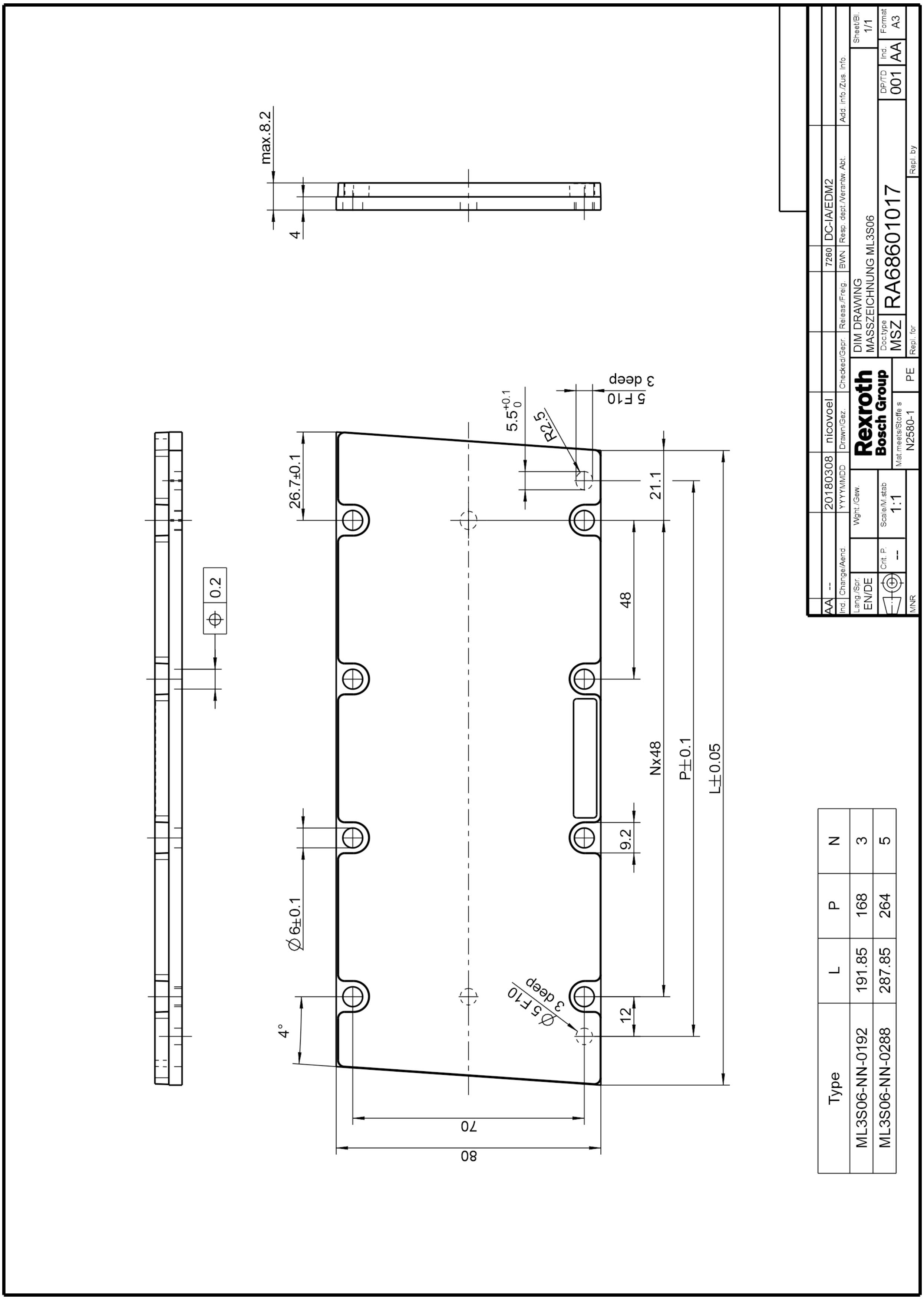
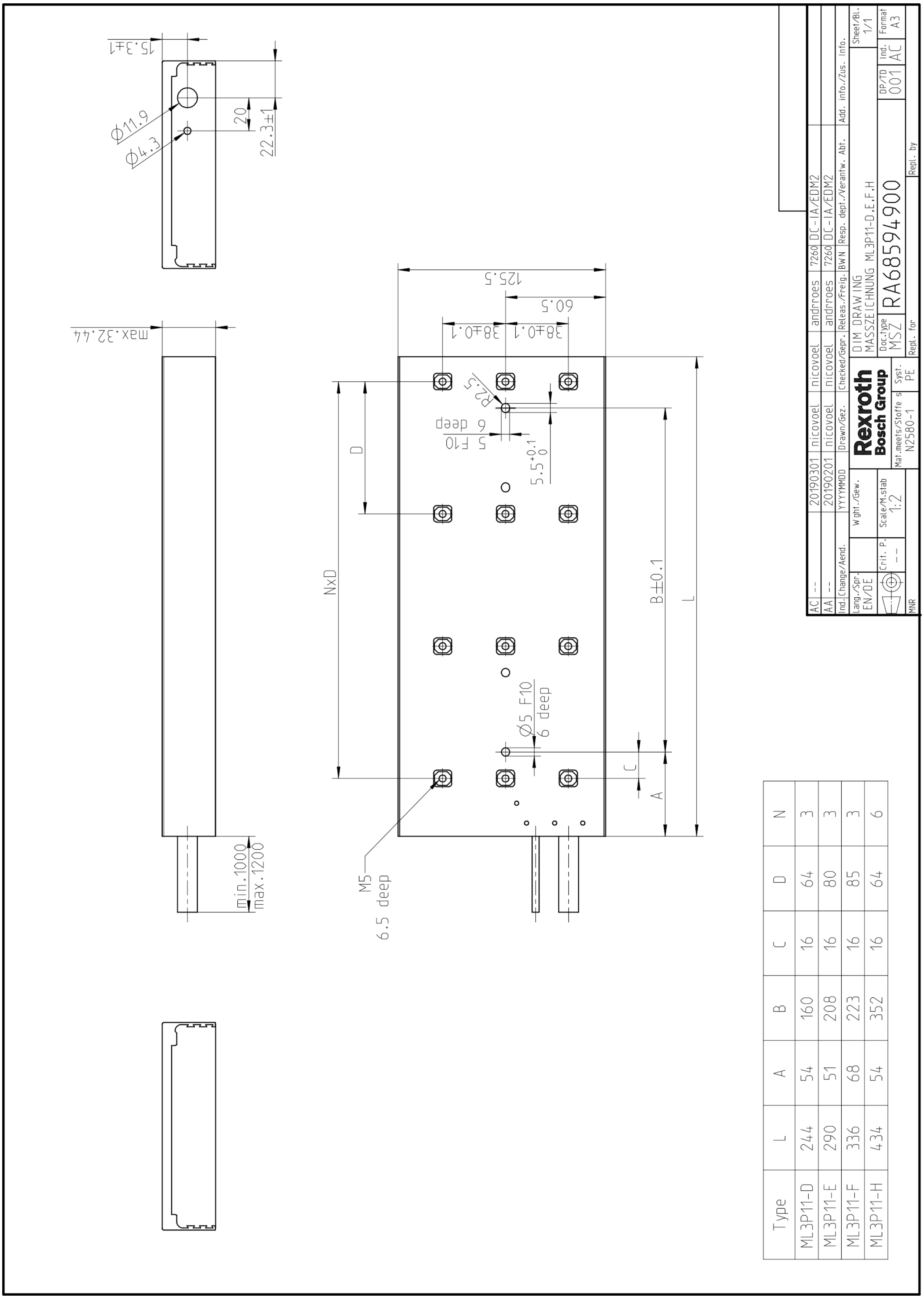


Fig. 42: Dimension sheet secondary part ML3S06

4.4 Frame size 11

ML3P11, Frame lengths D, E, F, H



Type	L	A	B	C	D	N
ML3P11-D	244	54	160	16	64	3
ML3P11-E	290	51	208	16	80	3
ML3P11-F	336	68	223	16	85	3
ML3P11-H	434	54	352	16	64	6

Fig. 43: Dimension sheet primary part ML3P11, frame lengths D, E, F, H

ML3P11, Frame length L

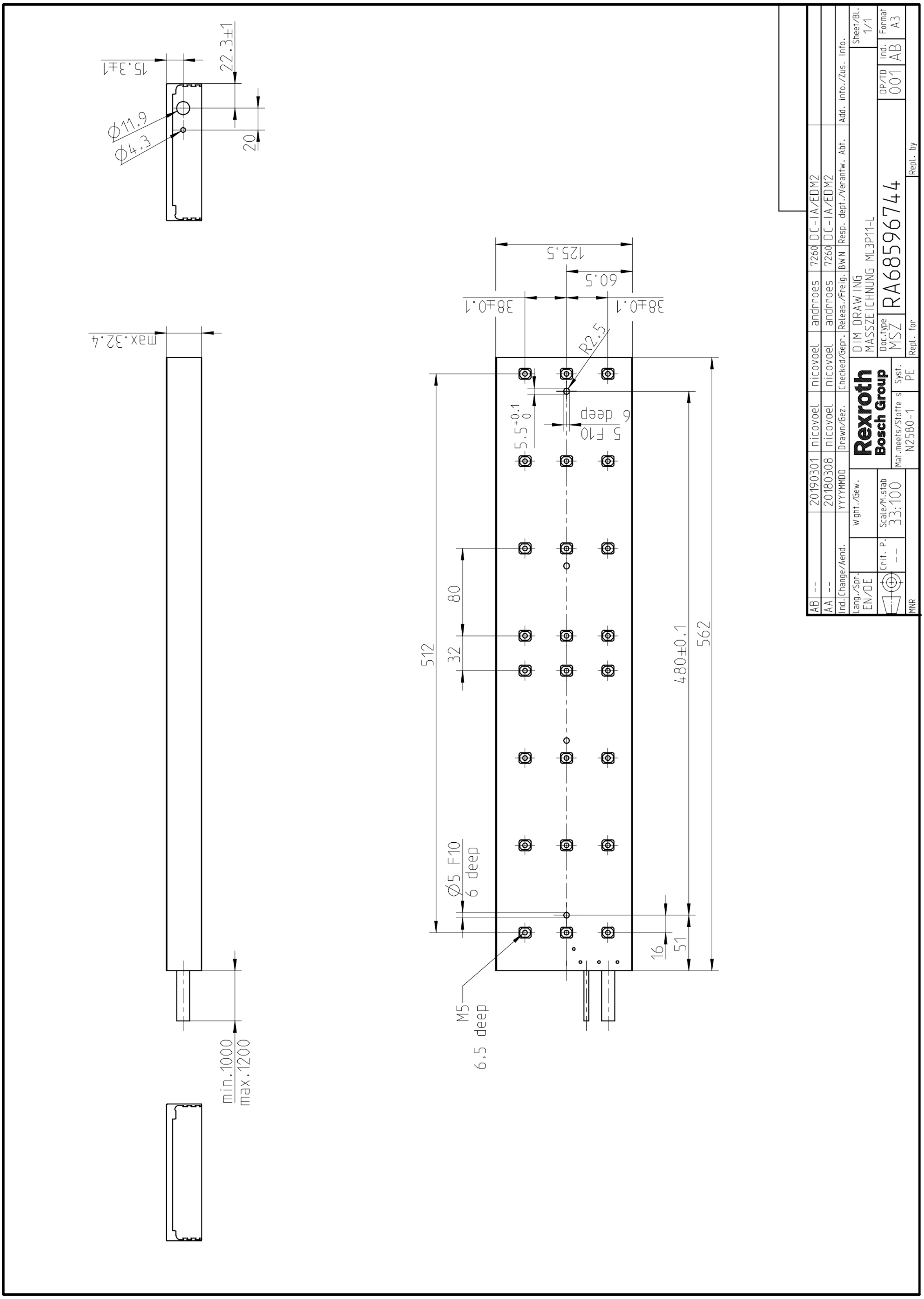


Fig. 44: Dimension sheet ML3P11 primary part, frame length L

ML3P11, Frame length R

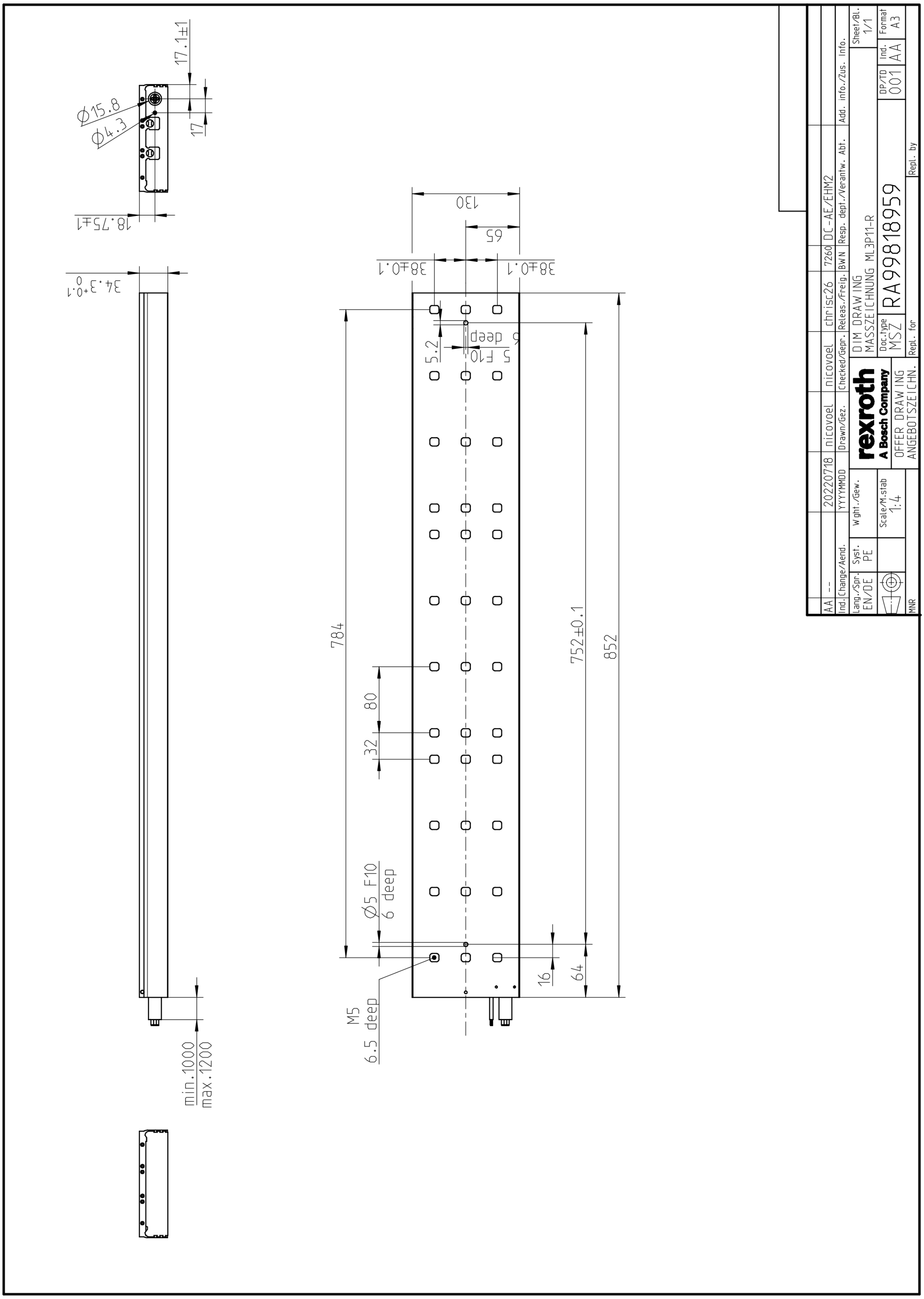
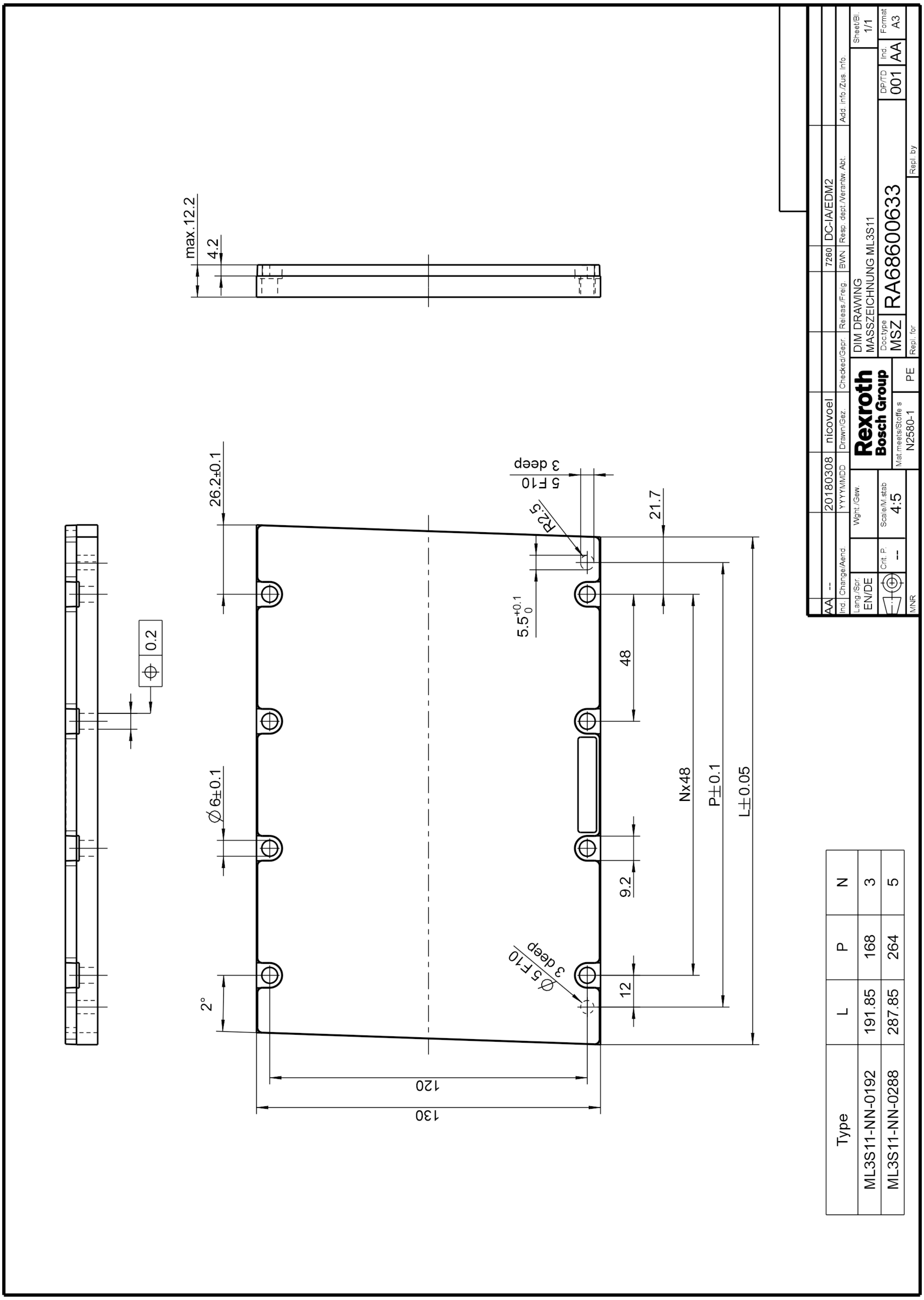


Fig. 45: Dimension sheet ML3P11 primary part, frame length R

ML3S11



Type	L	P	N
ML3S11-NN-0192	191.85	168	3
ML3S11-NN-0288	287.85	264	5

Fig. 46: Dimension sheet secondary part ML3S11

5 Identification

5.1 Notes about type codes

The type code describes the available motor variants. The type code is the basis for selecting and ordering products from Bosch Rexroth. This applies to new products as well as to spare parts and repairs.

ML3 linear motors from Rexroth consist of the assemblies "primary part" and "secondary part". The type code is divided into “Type code primary part MLP3..." and “Type code secondary part ML3S...".

The following descriptions give an overview of the separate columns of the type code ("abbrev. column") and their meaning. The sections below describe the type codes for specific frame sizes.

5.1.1 Type code primary part ML3P...

Product

Example: ML3□□□-□□□□□-□□□□□-□□

ML3 = Product name

Components

Example: ML3P□□-□□□□□-□□□□□-□□

P = Primary part of a ML3 motor

Frame size

Example: ML3P03-□□□□□-□□□□□-□□

The frame size is derived from the mechanical motor dimensions and represents different power ranges.

Frame length

Example: ML3P03-A□□□□-□□□□□-□□

Within a series, increasing primary part frame length is graded by means of code letters. With increasing frame length, the nominal force of the motor is increased.

Frame size

Example: ML3P03-AN□□□-□□□□□-□□

N = Standard frame size

Winding

Example: ML3P03-ANBW□-□□□□□-□□

The two-digit combination of letters indicates the velocity which applies for the respective winding variant.

Example: Winding "BW" represents a maximum velocity of v_{max} = 720 m/min.

The reference value is a DC bus voltage of 540 V_{DC}.

Cooling mode

Example: ML3P03-ANBWN-□□□□□-□□

N = Self-cooling

Sensors

Example: ML3P03-ANBWN-B□□□□-□□

B = Standard PTC110-EK and KTY83-122

Electrical connection

Example: ML3P03-ANBWN-BA□□□-□□

A = 2 cables (separate power and sensors)

Cable design

Example: ML3P03-ANBWN-BAF□□-□□

F = Cables suitable for drag chains

Other design

Example: ML3P03-ANBWN-BAFNN-□□

NN = No other design

Special design

Example: ML3P03-ANBWN-BAFNN-NN

NN = No special design

5.1.2 Type code secondary part ML3S...

Product

Example: ML3□□□-□□-□□□□-□□

ML3 = Product name

Components

Example: ML3S□□-□□-□□□□-□□

S = Secondary part of a ML3 motor

Frame size

Example: ML3S03-□□-□□□□-□□

The frame size is derived from the mechanical motor dimensions and represents different power ranges.

Frame size

Example: ML3S03-NN-□□□□-□□

NN = Standard frame size

Segment length

Example: ML3S03-NN-0096-□□

0096 = Secondary part length in mm

Special design

Example: ML3S03-NN-0096-NN

NN = No special design

5.2 Type code frame size 03

5.2.1 ML3P03

Type abbreviation	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example:	M	L	3	P	0	3	-	D	N	B	W	N	-	B	A	F	N	N	-	N	N																			

01 **Product**
ML3................. = ML3

02 **Component**
Primary part...................... = P

03 **Frame size**
30.................................... = 03

04 **Frame lengths** a)
Frame lengths ....= A, B, D, F

05 **Design**
Standard..= N

06 **Winding** a)
ML3P03-F . . . . = BN
ML3P03-F . . . . = BU
ML3P03-D . . . . = BP
ML3P03-A, ML3P03-B, ML3P03-D . . = BW
ML3P03-B . . . . = BY
ML3P03-A . . . . = BZ

07 **Cooling type**
Self-cooling .... = N

08 **Sensor system**
Standard PTC-1k + KTY83-122 ....= B

09 **Electrical connection**
2 cables (power/sensor system separately) .... = A

10 **Cable type**
Drag chain-compliant cable .... = F

11 **Other design**
None .... = NN

12 **Special design**
None ....= NN

Fig. 47: Type code ML3P03 (1/2)

Identification

DCCS 40059-3: 2021-02-08

Note:

a) Available combinations

•	available	-	not available

Frame lengths	Winding		
	BN	BU	BW
A	-	-	•
B	-	-	•
D	-	-	•
F	•	•	-

DCCS 40059-3 : 2017-07-12

Fig. 48: Type code ML3P03 (2/2)

*) Expected to be available form Q1/2022

5.2.2 ML3S03

Short text column	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example	M	L	3	S	0	3	-	N	N	-	0	0	9	6	-	N	N																							

01 **Product**

ML3................. = ML3

02 **Component**

Secondary part .... = S

03 **Frame size**

30.................................... = 03

04 **Frame design**

Standard ....= NN

05 **Segment lengths**

Secondary part length 96 mm .... = 0096

Secondary part length 144 mm .... = 0144

Secondary part length 384 mm .... = 0384

06 **Special design**

None .... = NN

DCCS 40060-3 : 2017-07-12

Fig. 49: Type code ML3S03

5.3 Type code frame size 06

5.3.1 ML3P06

Short text column	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example	M	L	3	P	0	6	-	D	N	B	R	U	-	B	A	N	N	N	-	N	N																			

01 **Product**
ML3................. = ML3

02 **Component**
Primary part ....= P

03 **Frame size**
60................................... = 06

04 **Frame lenghts** a)
Frame lengths ..... = B, C, D, E, F, H

05 **Frame design**
Standard ....= N

06 **Winding** a)
150 m/min....................................... = BC
210 m/min....................................... = BK
420 m/min....................................... = BR

07 **Cooling mode**
Universal... = U

08 **Sensors**
Standard PTC-1k + KTY83-122 ....= B

09 **Electrical connection**
2 Cables (power/sensors separately) .... = A

10 **Cable design**
Standard cable ....= N

11 **Other design**
None .... = NN

12 **Special design**
None ....= NN

Fig. 50: Type code ML3P06 (1/2)

DCCS 40059-6 : 2017-07-12

Identification

Note:

a) Available combinations

•	available	-	not available

Frame lengths	Winding		
	BC	BK	BR
B	-	•	•
C	•	-	•
D	-	•	•
E	-	•	•
F	-	•	•
H	-	•	•

DCCS 40059-6 : 2017-07-12

Fig. 51: Type code ML3P06 (2/2)

5.3.2 ML3S06

Short text column	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example	M	L	3	S	0	6	-	N	N	-	0	1	9	2	-	N	N																							

01 **Product**

ML3................. = ML3

02 **Component**

Secondary part.............. = S

03 **Frame size**

60.................................... = 06

04 **Frame design**

Standard ....= NN

05 **Segment lengths**

Secondary part length 192 mm............. = 0192

Secondary part length 288 mm............. = 0288

06 **Other design**

None .... = NN

DCCS 40060-6 : 2017-07-12

Fig. 52: Type code ML3S06

5.4 Type code frame size 11

5.4.1 ML3P11

	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Type short description	M	L	3	P	1	1	-	D	N	B	F	N	-	B	A	N	N	N	-	N	N																			

01 **Product**

ML3................. = ML3

02 **Component**

Primary part...................= P

03 **Size**

110.................................. = 11

04 **Lengths**

Length .... =D, E, F, H, L, R

05 **Design**

Standard..= N

06 **Winding**

ML3P11-E, ML3P11-H, ML3P11-L
ML3P11-R . . . . =BC
ML3P11-D, ML3P11-F . . . . =BF
ML3P11-D, ML3P11-E, ML3P11-L
ML3P11-R . . . . =BQ

07 **Cooling mode**

Self-cooling .... = N
Universal .... = U

08 **Sensors**

Standard PTC-1k + KTY83-122 ....= B

09 **Electrical connection**

2 Cables (power/sensors separately)................... = A

10 **Cable design**

Standard cables... = N

11 **Other design**

None .... = NN

12 **Special design**

None ....= NN

Fig. 53: Type code ML3P11 (1/2)

Identification

DCCS 40059-11: 2022-06-21

Note:

a) Available combinations

+	available	-	not available

Length	Winding		
	BC	BF	BQ
D	-	+	+
E	+	-	+
F	-	+	-
H	+	-	-
L	+	-	+
R	+	-	+

DCCS 40059-11 : 2022-06-21

b) Cooling mode “N“ is not available for Length “R“. Cooling mode “U“ is only available for overall length “R“

Fig. 54: Type code ML3P11 (2/2)

5.4.2 ML3S11

Short text column	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
Example	M	L	3	S	1	1	-	N	N	-	0	1	9	2	-	N	N																							

01 **Product**

ML3................. = ML3

02 **Component**

Secondary part.............. = S

03 **Frame size**

110.................................. = 11

04 **Frame design**

Standard ....= NN

05 **Segment lengths**

Secondary part length 192 mm .... = 0192

Secondary part length 288 mm .... = 0288

06 **Special design**

None .... = NN

DCCS 40060-11 : 2017-07-12

Fig. 55: Type code ML3S11

5.5 Identification

5.5.1 Identification primary part

The primary part can be identified by means of the type plate.

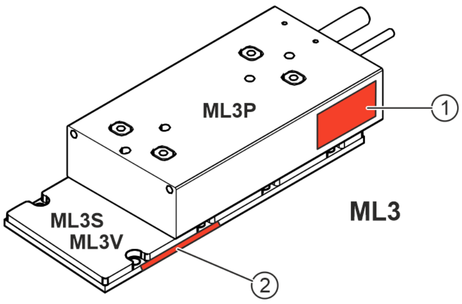


Fig. 56: Position of component designation
① Position of the type plate on the primary part
② Position of engraved serial number on the secondary part

Type plate primary part

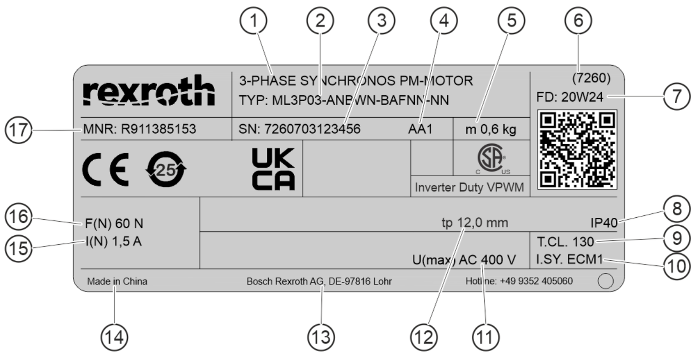


Fig. 57: Type plate ML3P (example)

1 Motor type
2 Type designation
3 Serial number
4 Revision state
5 Mass
6 Factory number
7 Manufacturing date (20W24 = year 2020 / calender week 24)
8 Degree of protection by housing
9 Thermal class
10 Insulation system
11 Maximum voltage CSA
12 Pole pitch
13 Company address
14 Designation of origin
15 Rated current
16 Continuous force at standstill
17 Material number

5.5.2 Identification secondary part

The secondary part can be identified by means of an engraved serial number.

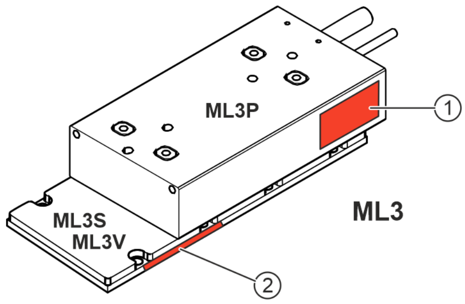


Fig. 58: Position of component designation
① Position of the type plate on the primary part
② Position of engraved serial number on the secondary part

Type plate secondary part

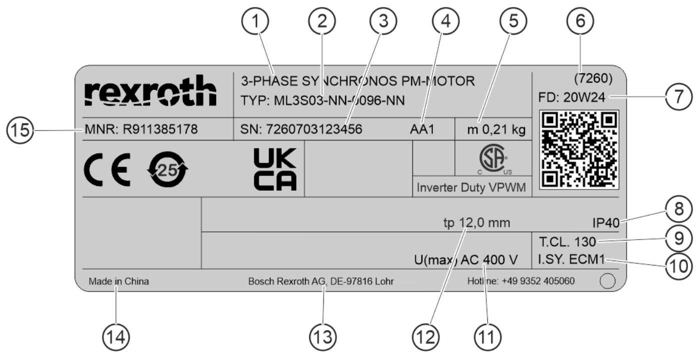


Fig. 59: Type plate ML3S (example)
1 Motor type
2 Type designation
3 Serial number
4 Revision state
5 Mass
6 Factory number
7 Manufacturing date (20W24 = year 2020 / calender week 24)
8 Degree of protection by housing
9 Thermal class
10 Insulation system
11 Maximum voltage CSA
12 Pole pitch
13 Company address
14 Designation of origin
15 Material number

5.5.3 Certifications

CE

Declarations of conformity certifying the design and the compliance with the valid EN standards and EC guidelines are available for all motors. If required, the declarations of conformity can be requested from the responsible sales office. The CE mark is attached to the motor type label of the motors.

CSA

The mark of conformity of the Canadian test center for the American and Canadian market identifies approved component parts which are part of a bigger product or system. The CSA label with the number 271353 is applied to the motor type plate.

RoHS

We confirm in our manufacturer´s declaration TC 30806-1 that our products conform with the RoHS directive 2011/65/EG "Restriction of the use of certain hazardous substances in electrical and electronic equipment".

China RoHS 2

Motors of the ML3 series are according to the specifications of standard SJ/T11364 and they have an EFUP (Environmentally friendly use period) of 25 years. A corresponding labeling is in preparation. For more information, refer to ➡ https://www.boschrexroth.com.cn/zh/cn/home_2/china_rohs2 in section "Kit motors".

UKCA Certification

ML3 motors fulfill the requirements acc. to UKCA. The appropriate identification of the motors is specified on the motor type plate.

6 Accessories

6.1 Hall unit

6.1.1 General

For control of synchronous motors, the absolute position informationPosition information regarding a pole pair is required to recognize the position of the permanent magnets to the motor windings. Only in connection with an electrical commutation offset angle to be determined on initial commissioning, the current with correct phase position to the magnetic field can be set via the controller to enable generation of a defined force in the dedicated travel direction by the motor.

If an incremental length measuring system is used, commutation of the axis has to be performed every time the drive is activated. This is realized by a drive-internal procedure.

Commutation can be supported by using a Hall unit and offers advantages, e.g.:

- in gantry arrangement
- on vertical axes
- in mechanically secured state,
- in axes that must not be moved for safety reasons during commutation.

ML3 linear motors can be equipped with a separately available Hall unit.

For information on installation of the Hall unit, refer to ➦ Chapter 10.6.

6.1.2 Functional principle

The Hall unit (analog or digital) serves for motionless commutation of the linear motor in connection with an incremental measuring system. At the Rexroth controller, the motor commutation is performed automatically on phase switching to operating mode. For this, motion is not required. The motor may also be in a fixed stop or positioned at the end of the travel length (end stop).

6.1.3 Analog Hall unit

The analogue Hall unit generates two sinusoidal signals with a phase offset of 90°. The output voltage is 1 V_{pp} and is provided at the lines according to ➦Fig. . The voltage supply is 5V. A minimum current consumption of 100 mA to the Hall unit must be ensured.

For specifications about the analog Hall unit refer to Fig. 61.

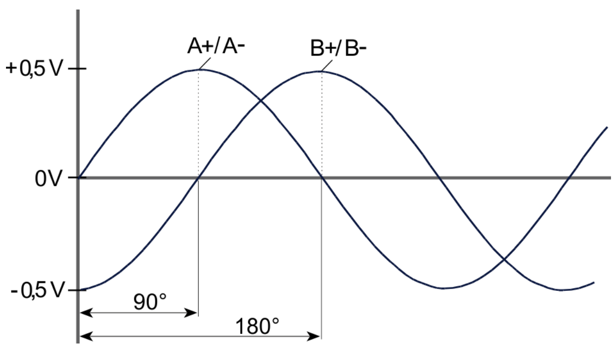


Fig. 60: Signal process of an analog Hall unit

Bosch Rexroth controllers use a supply voltage of 5 V for the analog Hall unit.

Analog Hall unit as length measuring system

The analog Hall unit can also be used as incremental length measuring system. Parametrization complies with parametrization of an incremental length measuring system. As resolution, the pole pair width of the used linear motor has to be used.

Depending on the system, a lower accuracy in comparison with standard length measuring systems is to be expected. However, the repetition accuracy complies with standard measuring systems.

Dimension sheet analog Hall unit

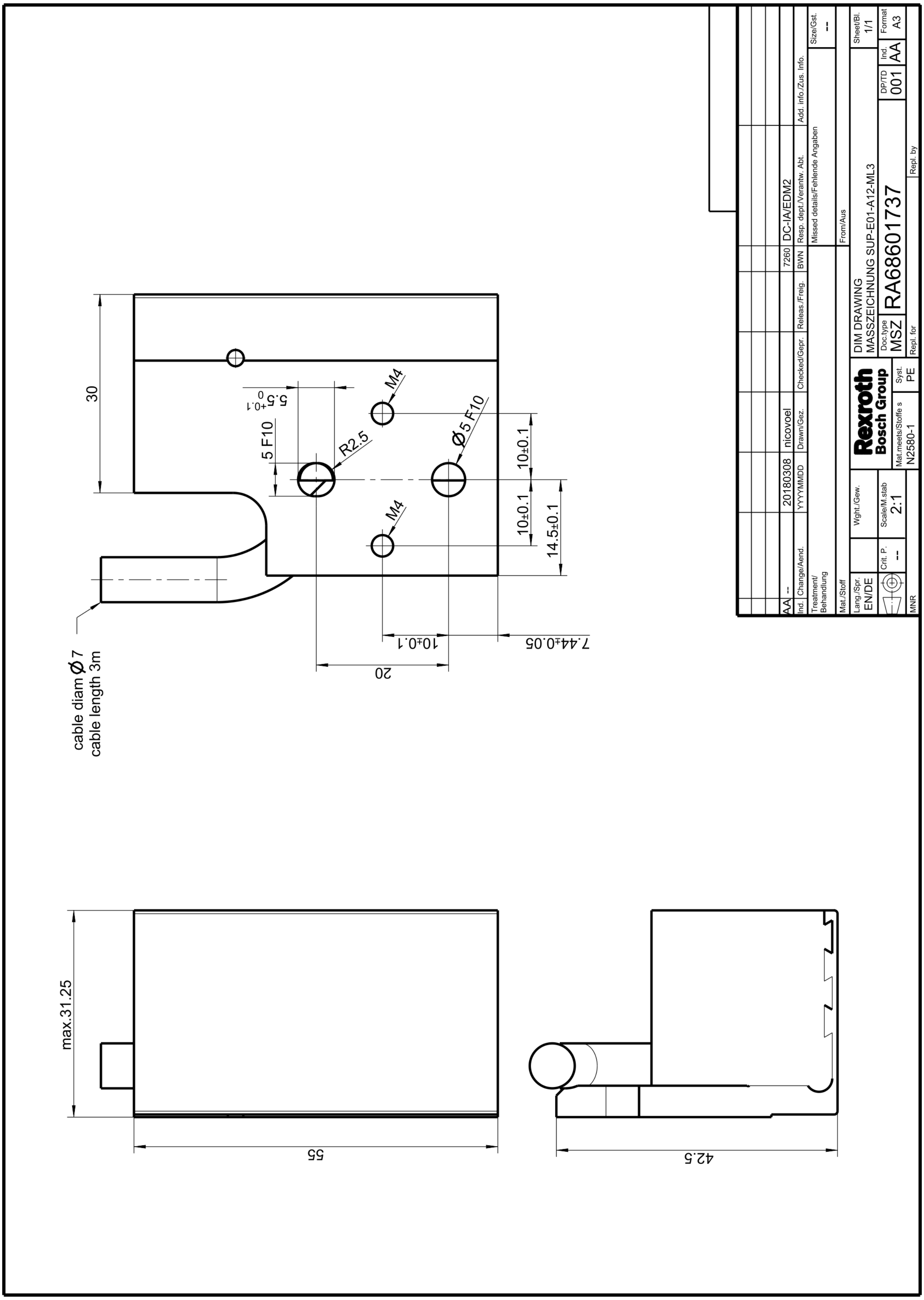


Fig. 61: Dimension sheet analog Hall unit

6.1.4 Digital Hall unit

The digital Hall unit generates three rectangular signals with a phase offset of 120°. The signals from the open-collector circuit are provided at the lines according to ➦ Chapter . The voltage supply is 4 ... 28 V with a minimum current consumption of 25 mA.

For specifications about the analog Hall unit refer to Fig. 63.

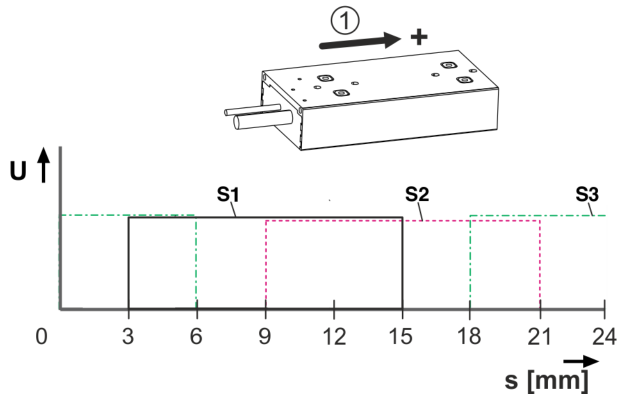


Fig. 62: Signal course of digital Hall unit

① Motor moves against cable outlet (positive direction)

The signal amplitude of the digital Hall unit depends on the supply voltage of the open-collector circuit. Bosch Rexroth controllers use a supply voltage of 12 V.

Dimension sheet digital Hall unit

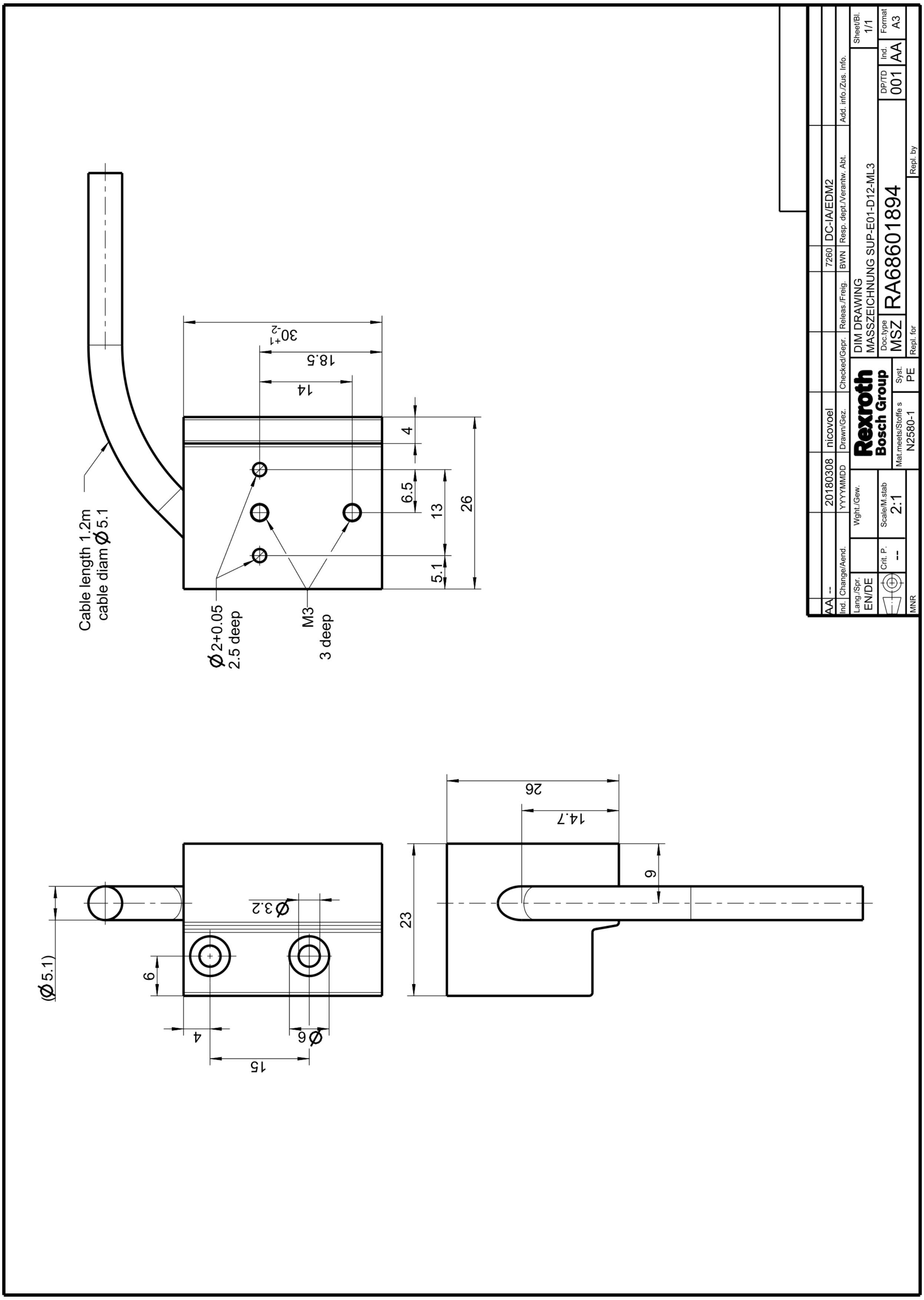


Fig. 63: Dimension sheet digital Hall unit

6.1.5 Ordering designation

Table 27: Ordering code Hall unit

	Hall unit	
	Analog	Digital
Short name	SUP-E01-A12-ML3	SUP-E01-D12-ML3
Material number	R911389392	R911385185

6.2 Hall unit adapter box SHL03.1 for digital Hall unit

6.2.1 General mode of functioning

If Rexroth linear motors are operated at Rexroth controllers, the Hall unit SHL03.1 adapter box enables simultaneous use of a digital Hall unit with an incremental length measuring system. By means of the SHL03.1 adapter box, the signals of these two components are connected and forwarded to the dedicated interface at the Rexroth controller.

A possible circuitry with Rexroth cables is described under chapter “Connection technique”.

6.2.2 Order designation

Table 28: Order designation SHL03.1 adapter box

SHL03.1 Adapter box	
Short name	SHL03.1-NNN-S-NNN
Material number	R911335257

6.3 Cover plate for secondary part

Acc. to ➦ Chapter 8.12.4, a stainless-steel cover plate can be applied at the ML3S for protection against dirt. For information on installation of the cover plate, refer to ➦ chapter . 10.4.

If cover plates are used, it must be ensured that the required mechanical air gap between the motor components is maintained. To achieve this, the installation height must be increased at least by the thickness of the cover plate (incl. tolerances).

Due to the increased air gap, the power of the motor is reduced by installation of a cover plate.

⚠ CAUTION	**Damage or destruction of motor components due to use of cover plates!** – If the installation height of the motor is not adjusted when a cover plate is used (increased), motor components of the ML3 may be damaged or destroyed. – The cover plate must be earthed according to the state of the art. The ML3S may not be used for this purpose.

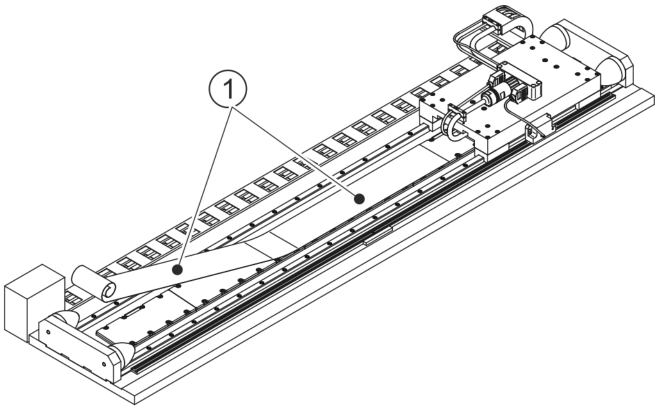


Fig. 64: Cover plate at ML3P
① Cover plate

Material and supplier

The plate consists of spring band steel (stainless) with the material designation X10CrNi18-8 and material number 1.4310.

For example, the plates are available from

➦United Springs B.V

Petroleumhavenstraat 14

Postbus 50

7553 GS Hengelo

The Netherlands

Phone: +31 74 2 555 444 or +31 (0) 74 2 555 411

➦Atlas.sales@sogefigroup.com

Table 29: Ordering designation of cover sheet / dimensions

ML3S	Designation	Steel type	Thickness	Width	Mass
03	AUS20032 Strip	1.4310	0.1 mm	50 mm 49.8 ... 50.5 mm	0.0377 kg/m
06	AUS20033 Strip			80 mm 79.8 ... 80.5 mm	0.0612 kg/m
11	AUS20031 Strip		0.15 mm	130 mm 129.8 ... 130.5 mm	0.155 kg/m

6.4 Magnetic fields label

To support the user in marking of hazard areas with magnetic fields, Bosch Rexroth offers a self-adhesive label for additional indication of such areas.

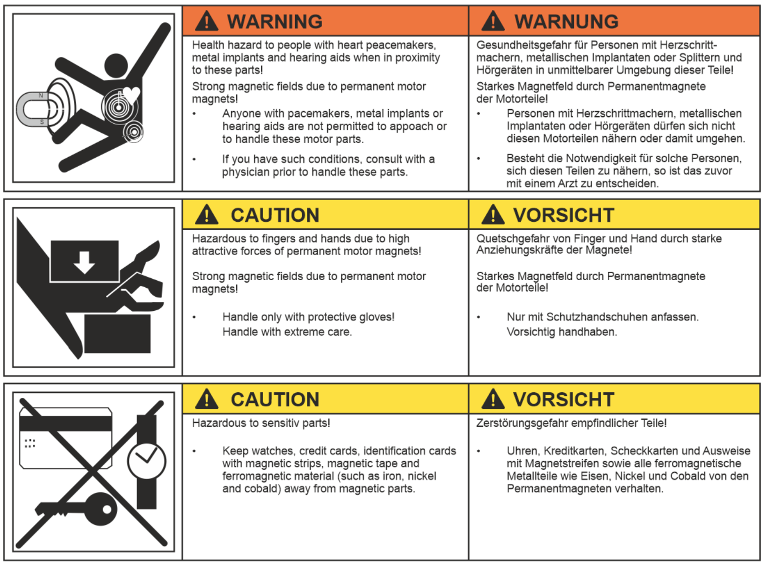


Fig. 65: Label (magnetic field of permanent magnets)

The distance to the potential hazard and the position of the label (well visible) must be defined by the user and are not within the responsibility of Bosch Rexroth. However, please also refer to the information provided under ➦ Chapter 2.4.3.

Table 30: Label order designation

Label (magnetic field of permanent magnets)	
Short name	Permanent magnets warning label
Material number	R911278745

7 Connection technique

7.1 Notes

NOTICE	**Motor destruction by direct connection to the 50/60 Hz power grid (three-wire or single-phase power supply)!** The motors can only be operated with suitable drive controllers with variable output voltage and frequency (converter mode) as specified by Rexroth.

Rexroth provides a wide range of ready-made cables for connecting the motors. These cables are optimally adapted to the products and a great variety of requirements.

Please observe that self-assembled cables or cable systems of other manufacturers might not fulfill these requirements. Rexroth shall not be held responsible for resulting malfunction states or damage.

7.2 Connection cable on primary part

The electrical connection of the primary part is done via two shielded connection cables, which are fixed with the primary part. These connection cables can be shorted according to the machine requirements and be prepared with a connector or a clamping point.

For connection of primary parts to the Rexroth controller, Rexroth offers a wide range of connectors and ready-made cables as accessories. All cables and connectors are perfectly fitted for the products and their requirements. For connection of the primary part with these extending cables, a connector has to be applied at the connection cables. Please note that self-assembled cables or cable systems of other manufactures may not comply with these requirements. Bosch Rexroth shall not be held responsible for resulting malfunctions or damages.

Ensure that the complete machine fulfills all necessary regulations, especially EN 60204.

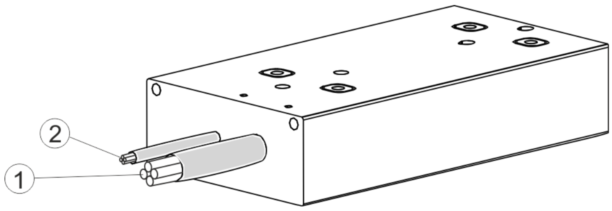


Fig. 66: Connection cable on primary part
① Connection cable power
② Connection cables temperature sensors

Table 31: ML3P connection cables

Connection cables	Cable lengths	Suitable for drag chains	ML3P03	ML3P06	ML3P11
Power	1 m	No	-	✓	✓
	3 m	yes	✓	-	-
Temperature	1 m	No	-	✓	✓
	3 m	No	✓	-	-

Table 32: Wire designation of power connection cable

Power		Wire color / - designation
3-phase	L1	BK / 1
	L2	BK / 2

Power		Wire color / - designation
	L3	BK / 3
Grounding conductor	PE	GNYE
Shield		Metal braiding

Table 33: Wire designation of temperature sensor connection cable

Temperature sensor	Wire color
PTC110-EK	WH
	BN
KTY83-122	GN
	YE
Shield	Metal braiding

Table 34: Connection cable

Connection cable power					
Primary part	Cross section [mm²]	Cable diameter [mm]	Bending radius		Weight [kg/m]
			static [mm]	dynamic [mm]	
ML3P03	4 x 1.0	8.3	33.2	83	0.18
ML3P06-B... ML3P06-C... ML3P06-D... ML3P06-E... ML3P06-F... ML3P06-HNBKN	4 x 1.0	9.6	57.6	Not permitted	
ML3P06-HNBRN ML3P11-D... ML3P11-E... ML3P11-F... ML3P11-H... ML3P11-L...	4 x 2.5	11.4	68.4	Not permitted	0.27
ML3P11-R...	4 x 6.0	15.8	94.8	Not permitted	0.6

Table 35: Temperature connection cables

Temperature connection cables					
Primary part	Cross section [mm²]	Cable diameter [mm]	Bending radius		Weight [kg/m]
			static [mm]	dynamic [mm]	
ML3P03 ML3P06 ML3P11	4 x 0.14	4.3	25.8	Not permitted	0.033

The power connection cable at the primary part is designed for a continuous current at standstill I_0 for installation mode A. The cross-section of the extending power cable has to be selected according to the actual maximum effective current load. The cross sections of both cables may deviate.

7.3 Electrical connection

Before connection of the primary parts, observe the information on suitability for drag chains of individual connection cables at the primary part in ➦ Chapter 7.2. Cables that are not suitable for drag chains must be routed in a fixed installation (see ➦ Chapter Routing of connection cables) From this junction, extending connection cables suitable for drag chains may be routed through the energy chain or the machine construction.

To connect the primary parts, the following options are available:

- Connection with connector and cable by Rexroth
- Connection with connector and cable (layout by customer)
- Connection with terminal box (layout by the customer)

When using Rexroth controllers and connection techniques, only the one temperature sensor can be connected and evaluated at the controller.

7.3.1 Connection with connector and cable by Rexroth

A coordinated range of connector sets and ready-made power cables is available for connecting the ML3 motors to Rexroth controllers. Also refer to the instructions in ➦ Tab. 36. In order to be able to connect Rexroth power cables to the motor, the motor connection cable must first be assembled by the customer, taking into account the installation situation.

For the assembly, a special tool is required:

Crimping tool R913072332 (manufacturer ID C0.236.00).

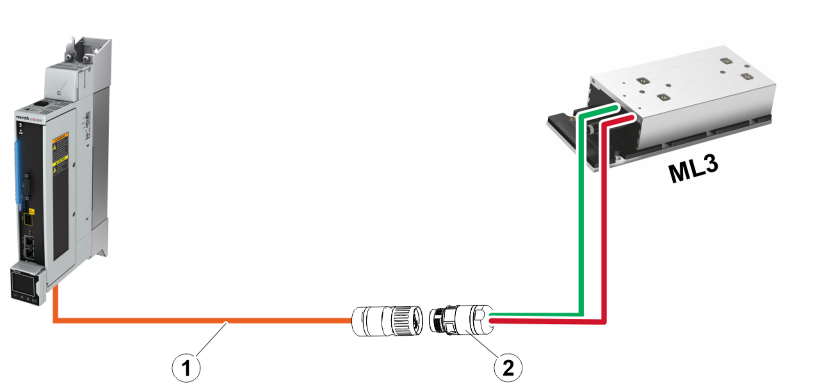
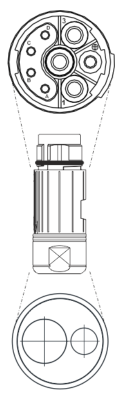


Fig. 67: Motor connection with combo plug

① Power cable (see ➦ Tab.) 36)

② Connector (connector set to assemble the connecting cable on the motor (refer to ➦ Tab.) 36)

Table 36: Connectors and power cables to connect the ML3P

Primary part	Connector set for Motor connection cable		Power cables	Power Extension cable
ML3P03-...		RLS2352/CUB3 R911398822	ctrlX RLC2-xxxBGB-NN-xxx,x (0.75 mm²) RLC2-xxxECB-NN-xxx,x (2.5 mm²)	RLC1-532BGB-NN-xxx,x (0.75 mm²) RLC1-532ECB-NN-xxx,x (2.5 mm²)
ML3P06-B... ML3P06-C... ML3P06-D... ML3P06-E... ML3P06-F... ML3P06-HNBK		RLS2362/CUB3 R911398823	IndraDrive RLC1-xxxBGB-NN-xxx,x (0.75 mm²) RLC1-xxxECB-NN-xxx,x (2.5 mm²)	

Primary part	Connector set for Motor connection cable		Power cables	Power Extension cable
ML3P06-HNBR ML3P11-D... ML3P11-E... ML3P11-F... ML3P11-H... ML3P11-L...		RLS2372/CUB3 R911398824		
ML3P11-R...	in preparation			

The extended cables are assigned to the connection at Rexroth controllers in the following catalog:
Motor cables and connectors (R911401939).

Pin assignment of the connection cables RLS23x2/CUB3

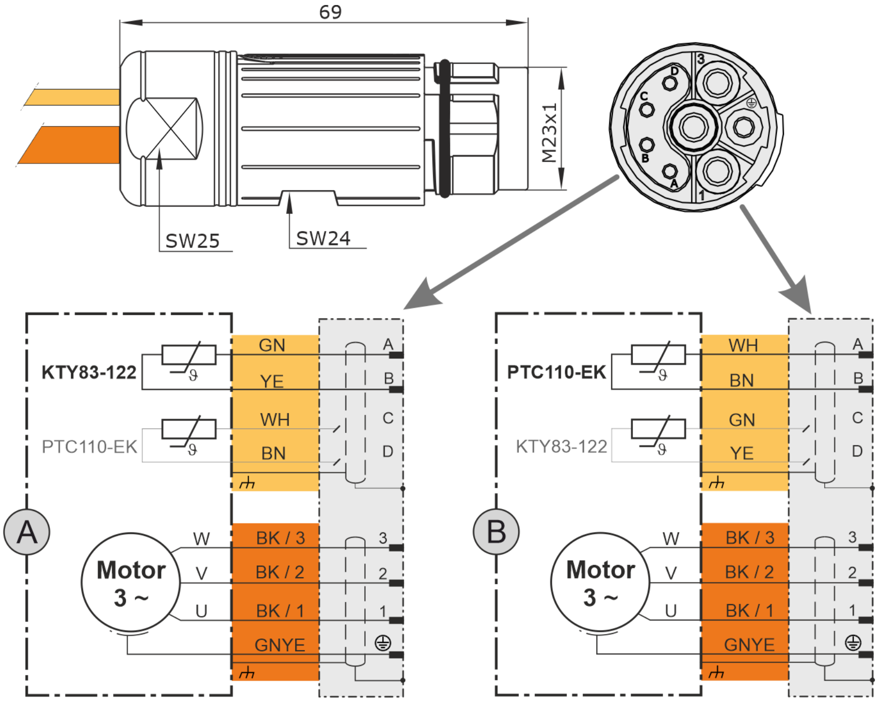


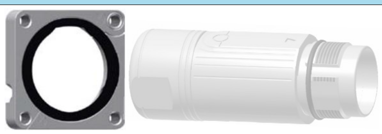
Fig. 68: Pin assignment of the combo plug
Ⓐ Pin assignment of the temperature sensor evaluation KTY83-122
Ⓑ Pin assignment of the temperature sensor evaluation PTC110-EK

When assembling the connector, note that only one of the two temperature sensors is wired to pins A and B. Pins C and D are not evaluated.

Mounting flange for connector gland

To feed the connector through to the machine, the following connectors can be fitted with a folding flange. The flange can be ordered as an accessory.

Table 37: Mounting flange for connector gland

Mounting flange for Connector gland	Connector size	Designation
	M23	CONNECTOR ACCESSORIES Z-SONS**-MONTAGEFLANSCH M23 TE R911404525

Mounting flange for Connector gland	Connector size	Designation
	M40	CONNECTOR ACCESSORIES Z-SONS**-MONTAGEFLANSCH M40 TE R911xxxxxx (in preparation)

7.3.2 Connection with connector and cable by third party manufacturers

If the motors are not connected using connectors and cables by Rexroth, the customer has to provide all required components. The wire designation required for the assembly can be found under ➦ Chapter 7.2.

Please note that self-assembled cables or cable systems of other manufactures may not comply with these requirements. Rexroth shall not be held responsible for resulting malfunction states or damage.

7.3.3 Connection via terminal boxes

The terminal box is not part of the motor delivery. If the motors are not connected using connectors and cables but via a terminal box, the customer has to provide all required components.

Please note that self-assembled cables or cable systems of other manufactures may not comply with these requirements. Rexroth shall not be held responsible for resulting malfunction states or damage.

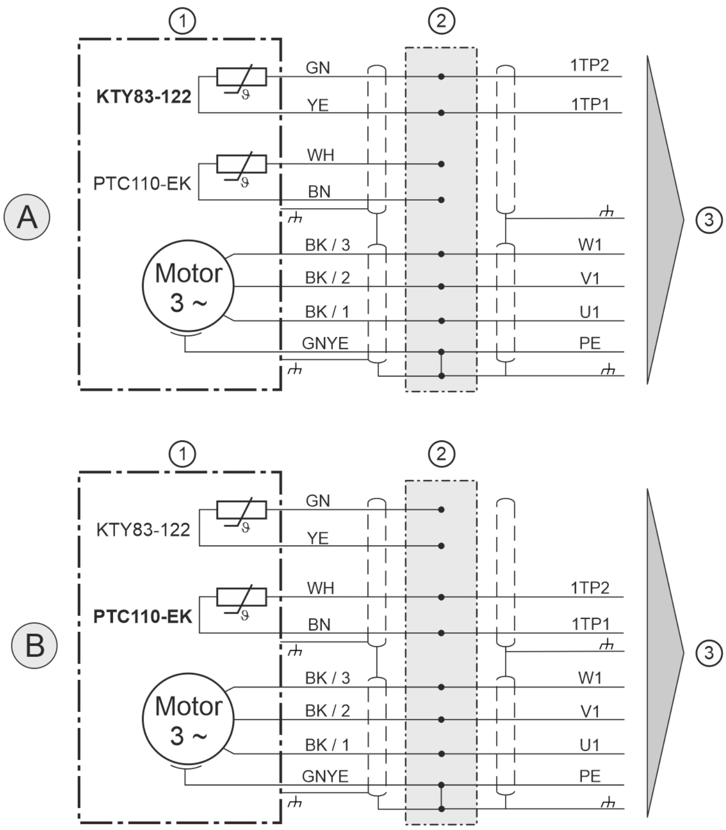


Fig. 69: Connection example terminal box

Ⓐ Contact assignment of the temperature sensor evaluation KTY83-122
Ⓑ Contact assignment of the temperature sensor evaluation PTC110-EK
① ML3P primary part

② Terminal box
③ Controller

7.3.4 Routing of connection cables

NOTICE	**Damage of the connection cables and the motor by dynamic bending loads!** The connection cables of the primary parts ML3P06 and ML3P11 and the temperature sensor cables of all ML3P may not be laid into drag chains. Installation in a cable carrier is only allowed for a cable lead after a junction suitable for energy or drag chains.

NOTICE	**Avoid bending, pulling and pushing loads as well as continuous movements of the connection cable at the point where the cable exits from the primary part. Any load of this kind can lead to irreparable damage (e.g. cable break) on the primary part!** If a fixed installation is not possible, equip the connection cable of the Hall unit with strain relief (for example, see Fig. 70) to protect the cable and the primary part from irreparable damage (e.g. cable break).

If grounding of the secondary parts cannot be ensured due to installation in the customer-side machine construction, the ML3S are to be connected in compliance with DIN VDE 0100-410 to the potential of the protective conductorProtective conductor.

Strain relief clamp

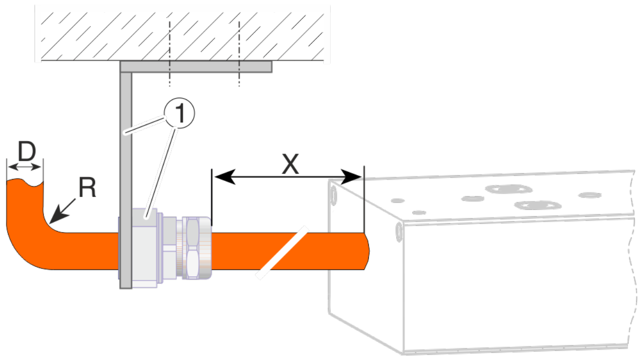


Fig. 70: Example for strain relief of connection cable (only valid for ML3P03)

Dimension "x"	Minimum distance 5 mm
①	Strain relief clamp (example) at MLP03 primary part
D	Diameter of connection cable
R	Allowed bending radius

Parallel motor connection

When connecting a motor parallel on a drive controller, the following possibilities exist to assembly the motor cable.

- Installation of two separate parallel cables (➦Fig.) 7.3.4)
- Installation of a collective cable with higher cross section (➦Fig.) 7.3.4)

The first possibility offers the benefit of smaller bending radii. The whole cross section of parallel installed cables must be according to the increased cross section for parallel motor connections.

Power connection for single arrangement

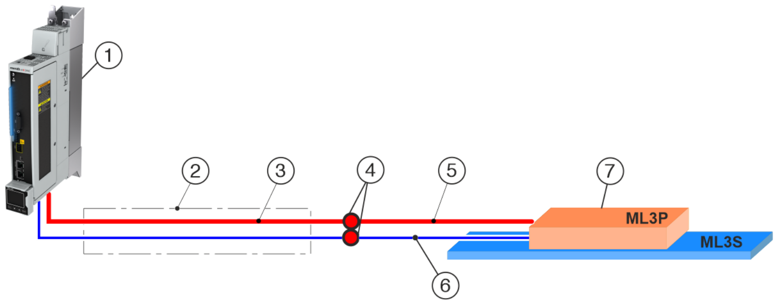


Fig. 71: Power connection for single arrangement
① Drive controller
② Energy chain
③ Power cables
④ Junction (e.g. connector, terminal boxes)
⑤ Connection power
⑥ Connection temperature
⑦ Motor ML3

Power connection for parallel arrangement, separate connection cable

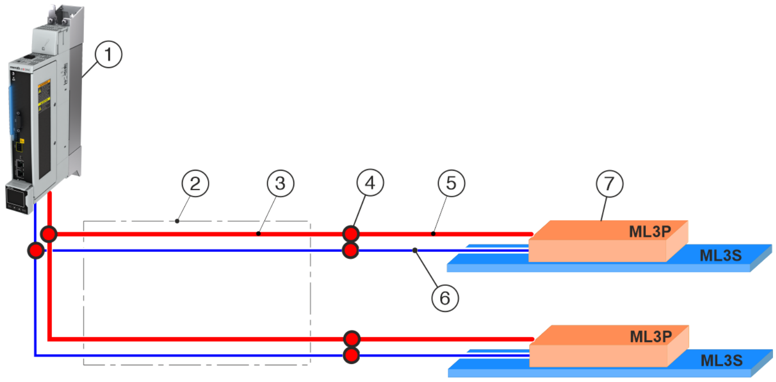


Fig. 72: Parallel arrangement, separate power cables
① Drive controller
② Energy chain
③ Power cables
④ Junction (e.g. connector, terminal boxes)
⑤ Connection power
⑥ Connection temperature
⑦ ML3P primary part

Power connection at parallel arrangement, collective power cable with higher cross section

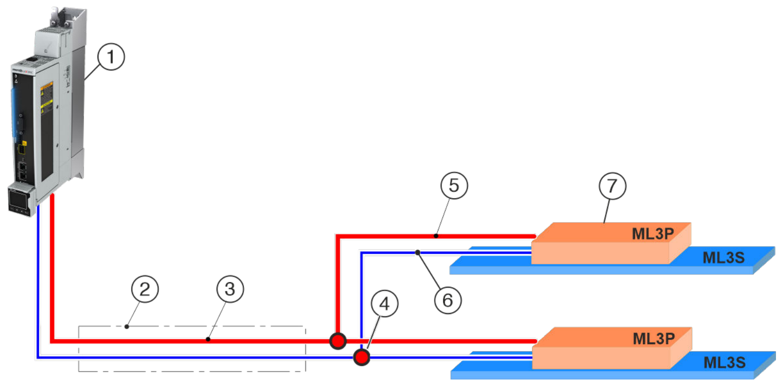


Fig. 73: Parallel arrangement, collective power cable
① Drive controller
② Energy chain
③ Power cables
④ Junction (e.g. connector, terminal boxes)
⑤ Connection power
⑥ Connection temperature
⑦ ML3P primary part

For ML3P03, the junction can also be positioned between drive controller and cable carrier.

7.3.5 Connection designations at Rexroth controller

Single arrangement

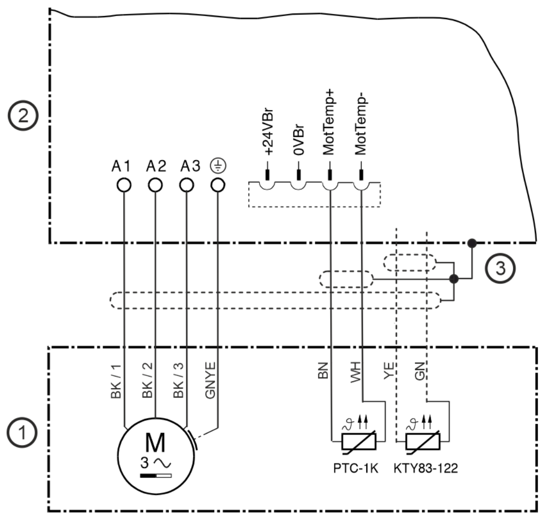


Fig. 74: Connection on drive controller - single arrangement primary part
① ML3P primary part
② Rexroth - controller
③ Shield connection on the controller

Parallel connection

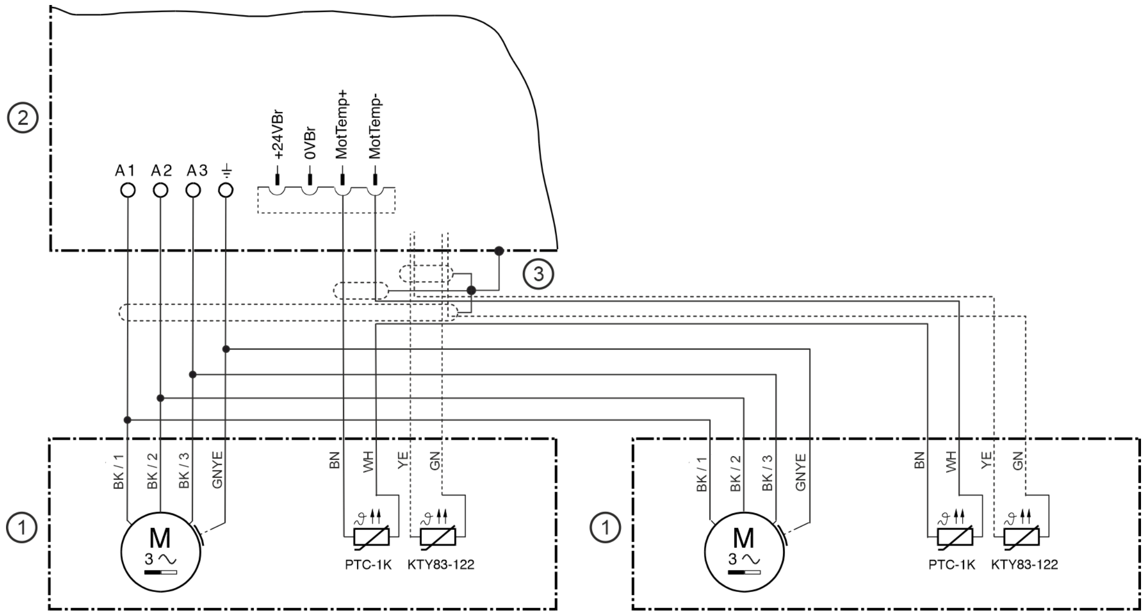


Fig. 75: Connection on drive controller - parallel connection primary parts

For electrical connection of primary parts in parallel arrangement, refer to the ML3 project planning manual for commissioning and parameterization.

7.4 Sensors

7.4.1 Connection temperature sensors

The motor temperature is monitored by

- Temperature sensor (motor) and
- Temperature model (controller)

and ensures the best protection of motors against irreversible damage by thermal overload.

Further notes on the temperature sensors and motor temperature monitoring can be found in the ML3 project planning manual.

The connection of temperature sensors is done, as illustrated in Fig. 68 and Fig. 69.

7.4.2 Length measuring system

The length measuring system is not in the scope of delivery of the motor and must be prepared and assembled by the maschine manufacturer.

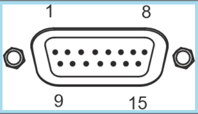
Setting the encoder polarity depends on the direction of rotation of the primary part and must be parameterized at start-up of the controller. Also observe the manufacturer's instruction of the length measuring system.

To connect an incremental length measuring system on a Rexroth controller or on the adapter box SHL03.1, Bosch Rexroth provides two connection cables.

- RKG0049
  For connection of the length measuring system directly on the controller
- RKG0051
  To connect the length measuring system on the SHL03.1

To use this connection cable, fit the connection cable on the incremental length measuring system with a compatible device connector (RGS0006).

Table 38: Pin assignment at RGS0006 to connect the length measuring system

	Signal	Function
1	GND_shld	Connection signal shields (inner shields)
2	A+	Track A positive
3	A -	Track A negative
4	GND_Encoder	Reference potential voltage supplies
5	B+	Track B positive
6	B-	Track B negative
7 ... 8	n.c.	/
9	R+	Reference track positive
10	R-	Reference track negative
11	VCC_Encoder (12 V)	Encoder supply 12 V
12	VCC_Encoder (5 V)	Encoder supply 5 V
13 / 14	n.c.	/
15	Sense-	Feedback of reference potential (Sense line)
Connector housing	/	Outer shield

7.4.3 Electrical connection of Hall unit (optional)

Connection cables Hall units

The connection cable of the Hall unit is generally routed next to the connection cables of the primary part. After motor installation, the cable of the Hall unit can be shortened to the required length and be assembled with a D-sub connector, for example. See also ➦ Chapter Dimensioning of the Hall unit connection cable on page 110.

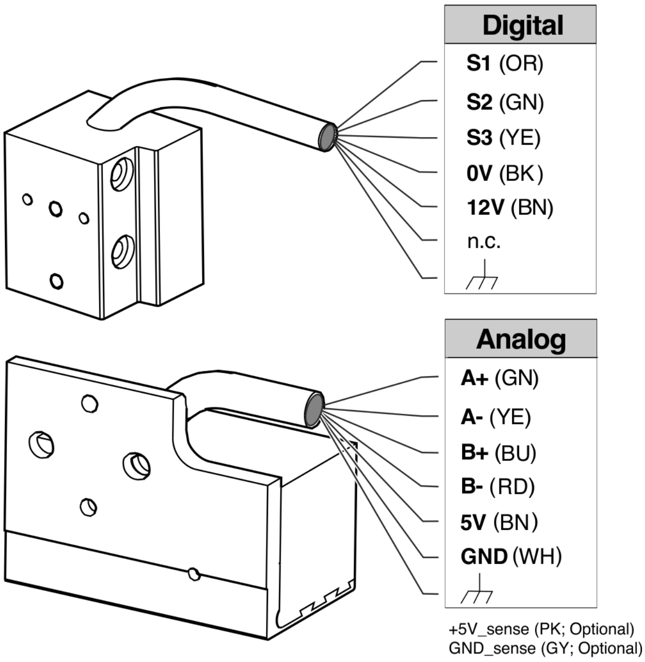


Fig. 76: Wire designation connection cable Hall unit

Table 39: Connection cables Hall units

Hall unit	Diameter / length	Wire cross section	Allowed bending radius [R]
Analoge	6.2 mm / 3 m	4x 2x 0.14 mm^2	6x D (37.2 mm)
Digital	5.0 mm / 1.2 m	6x 0.14 mm^2	7.5x D (37.5 mm)

NOTICE

Avoid bending, pulling and pushing loads as well as continuous movements of the connection cable at the Hall unit. This type of loads can lead to irreparable damage (e.g. cable break)!

The connection cable of the Hall unit can be attached to the power cable by means of cable ties if the power cable is already equipped with strain relief. If a fixed installationConnection cableFixed installation is not possible, equip the connection cable of the Hall unit with strain relief (for example, see Fig. 70) to protect the cable and the primary part from any damage (e.g. cable break).

The Hall unit is a component that may by damaged by ESD. For this reason, the Hall unit is packed in an ESD protection bag on delivery. Before connecting the Hall unit, take appropriate measures for ESD protectionESD protection (ESD = electrostatic discharge).

Dimensioning of the Hall unit connection cable

Before the Hall unit can be connected, the connection cable of the Hall unit must be equipped with a D-SUB connector with pins. The assignment of the connector depends on the type of hall unit (digital or analog).

Table 40: Pin assignment D-SUB connector to connect the Hall unit

PIN	Connection cable Hall unit	
	Analoge (D-SUB 9-pin)	Digital (D-SUB 9-pin)
1	/	12 V (BN)
2	A+ (GN)	S1 (OR)
3	A- (YE)	/
4	0V (WH)	S2 (GN)
5	B+ (BU)	0V (BK)
6	B- (RD)	/
7	5V (BN)	/
8	/	S3 (YE)
9	/	/
Connector housing	Cable shield	Cable shield

Digital Hall unit connection

Observe the information on the SHL03.1 adapter box in documentation DOK-INDRV*-HCS01******-PRxx-xx-P, MNR R911322210.

For connection of a digital Hall unit in combination with an incremental length measuring system to a Rexroth controller, the **SHL03.1 adapter box** has to be used.

The SHL03.1 brings both incoming signal cables of Hall unit and length measuring system together and redirects their signals via a single connection cable to the drive controller for encoder evaluation.

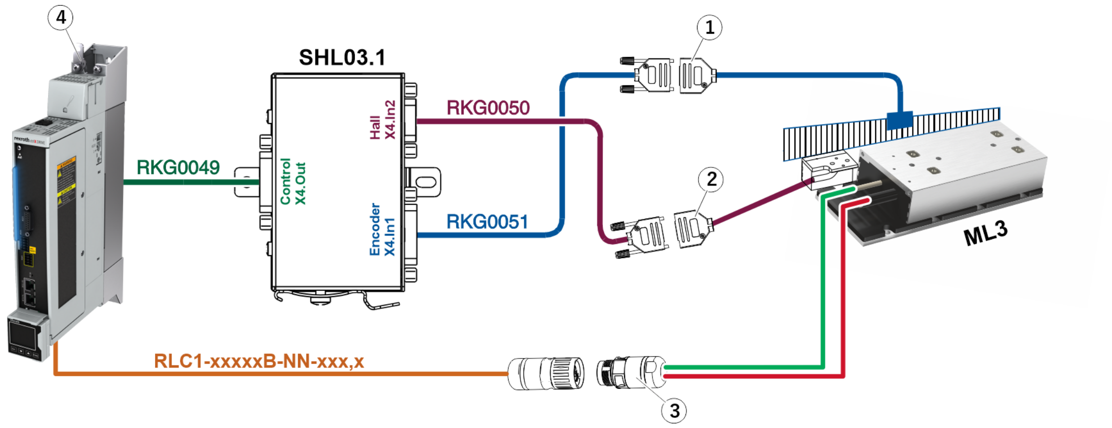


Fig. 77: Connection overview of ML3P with digital Hall unit

①	Device connector RGS0005 (D-SUB connector, 9-pin)
②	Device connector RGS0005 (D-SUB connector, 9-pin)
③	Power and temperature connection points
RKG0049	Adapter box ↔ encoder evaluation on drive controller
RKG0050	Digital Hall unit ↔ adapter box (max. cable length 30 m)
RKG0051	Length measuring system ↔ Adapter box

Analog Hall unit connection

To connect an absolute measuring system and an analog Hall unit, a shelf with 2 encoder interfaces in the Rexroth controller is required.

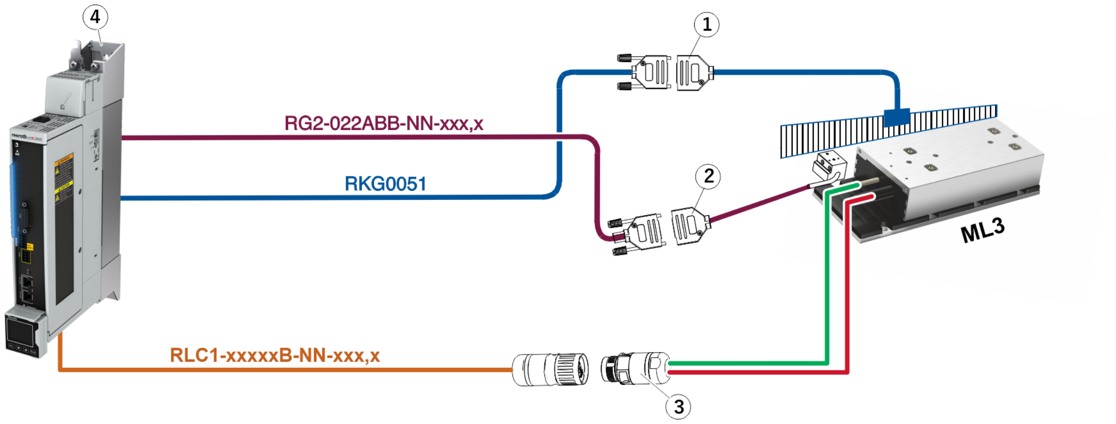


Fig. 78: Connection overview of ML3P with analog Hall unit

①	Device connector RGS0005 (D-SUB connector, 9-pin)
②	Device connector RGS0005 (D-SUB connector, 9-pin)
③	Power and temperature connection points
RG2-022ABB...	Analog Hall unit ↔ Encoder evaluation at drive controller
RKG0051	Length measuring system ↔ Encoder evaluation at drive controller

8 Application and construction instructions

8.1 Mode of functioning

The force generation at synchronous linear motors corresponds to the torque generation at rotary synchronous motors. The primary part (active part) has a winding; the secondary part (passive part) has permanent magnets. Both, the primary part and the secondary part can be moved (short or long stator principle).

Any travel length can be realized by stringing together several secondary or primary parts.

Axis construction

The ML3 motor is a kit motor. The components primary and secondary part(s) are delivered separately and completed by the user by linear guide and the linear measuring system.

The construction of an axis fitted with a linear motor normally consists of

- one or several primary parts with or without Hall unit
- Hall unit adapter box (optional)
- one or more secondary parts with permanent magnets
- Length measuring system
- Linear guides
- Energy flow
- Slide or machine construction

For force multiplication, two or more primary parts can be mechanically coupled or arranged in-line. For further information see ML3 project planning manual.

The scope of delivery of the motor includes primary or secondary parts and Hall units and cables or connection fittings as necessary.

Linear guides and length measuring system as well as further additional components have to be made available by the user. For recommendations on tested additional components, refer to ML3 project planning manual.

8.2 Motor design

8.2.1 Design primary part

The primary part consists of an aluminum profile that includes the plate package with winding and is coated with synthetic resin. The aluminum profile contains screw threads for installation of the primary part at the machine construction.

This coating ensures mechanical strength and thermal optimization of the primary part. It provides only limited protection against humidity foreign bodies or touch of electrically active parts. Protection against contamination and contact with live components is ensured in compliance with protection class IP40. Due to the coating process, sometimes small blowholes can occur on the surface of the coat. They are not relevant for the function and mechanical property of the motor.

The motor cooling happens due to the thermal coupling of the primary part on the machine and via the natural convection.

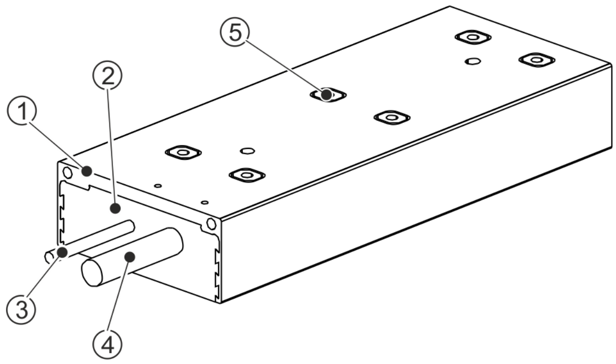


Fig. 79: Primary part ML3P06

① Aluminum profile
② Cast plate package with winding
③ Temperature sensor cable
④ Power cables
⑤ Screw thread

8.2.2 Secondary part design

The ML3S secondary parts consist of a steel base plate with fitted permanent magnets. The fastening holes are located at the side of the magnets along the travel length. To ensure a high corrosion protection, the iron parts of the secondary part are nickel-plated and the permanent magnets are coated with synthetic resin. At one longitudinal side of the ML3S, there is a reference mark.

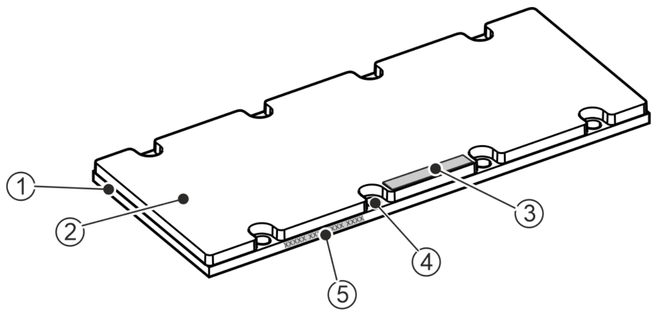


Fig. 80: ML3S secondary part

① Steel base plate
② Cast magnets
③ Reference marks
④ Screw-on holes
⑤ Serial number

Available lengths secondary parts

Secondary parts are available in different lengths. Please also refer to the data under➦Type code. 5.1.2

Required length of the secondary parts

The required length L of the secondary part can be defined as follows:

$$L_{ML3S} \geq L_V + L_{ML3P,Fe}$$

Fig. 81: Defining the required length of the secondary part

L_{ML3S} Total lengths of all secondary parts in a row.

L_V Travel length

$L_{ML3P,Fe}$ Active length ML3P (see ➦ Fig. 8.11)

To determine the required travel length and thus the length of the secondary part distance, also note the following ➦ Chapter 8.11.

8.2.3 Frame size and frame length

For adjusting on different feed force requirements, Bosch Rexroth offers ML3 motors in a modular system in different sizes and lengths.

Frame sizes

The designation of frame size is derived from the active width l_{Fe}.

To determine the frame size of the motor, the width of the magnets is divided by 10.

Example:

l_{Fe} = 60 mm = Frame size ML3P**06** or ML3S**06**

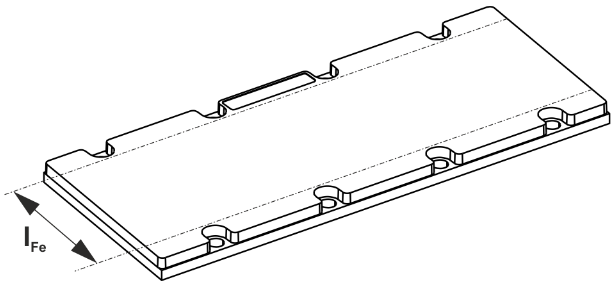


Fig. 82: Active width

l_{Fe} Active width

According to this system, the ML3 modular construction system contains the following motor frame sizes:

- ML3P03 / ML3S03
- ML3P06 / ML3S06
- ML3P11 / ML3S11

Frame lengths

Primary and secondary parts of one size are graduated additionally to different frame sizes. The length designation of the primary part in the type code is done via code letters, like A, B, C. The length designation of the secondary part in the type code is given directly by the length in mm.

For detailled information about the available frame sizes and lengths please refer to the type code of the motor.

8.3 Installation altitude and ambient temperature

The motor performance data specified are applicable for

- Ambient temperature 0 ... +40 °C
- Installation altitudes from 0 to 1000 m above sea level
- Temperature of contact surface cooled to 20 °C (corresponds to installation mode A)

Different conditions lead to a derating of the data according to the following table:

Table 41: Derating of installation altitude/ambient temperature

Height [m]	20 °C	25 °C	30 °C	35 °C	40 °C	45°C	50°C	55°C	60°C
1,000	1	0.97	0.94	0.90	0.87	0.83	0.79	0.75	0.71
1,500	0.98	0.95	0.92	0.88	0.85	0.81	0.77	0.74	0.69
2,000	0.96	0.93	0.90	0.87	0.83	0.80	0.76	0.72	0.68
2,500	0.95	0.91	0.88	0.85	0.82	0.78	0.75	0.71	0.67
3,000	0.93	0.90	0.87	0.84	0.81	0.77	0.74	0.70	0.66

The data regarding utilization capacity depending on the installation altitude and environmental temperature only apply for the motor. Ensure that the reduced data are not exceeded by your application.

During planning, always observe the ambient conditions. The specified data in ➦ Chapter 3 documented data according to the installation mode A (see ➦ Chapter 8.22). Usually, the less favorable installation modes B to D apply.

8.4 Environmental conditions during operation

Environmental conditions during operation

Environmental conditions during operation are defined according to EN IEC 60721-3-3:2019 in different classes. They are based on worldwide long-term experiences and take all influencing variables into account, e.g., air temperature and air humidity.

Table 42: Allowed classes of environmental conditions during operation according to EN IEC 60721-3-3:2019

Classification type	Allowed class
Classification of climatic environmental conditions	3K22
Classification of biological environmental conditions	3B1
Classification of mechanically active materials	3S6
Classification of mechanical environmental conditions	3M12

Based on EN IEC 60721-3-3:2019 , some limit values are partially defined in the following, which our products are allowed to be exposed to during operation. Unless otherwise specified, the values given are the values of the particular class. Observe the detailed description of the classifications to take all of the factors which are specified in the particular class into account.

However, Bosch Rexroth reserves the right to adjust these values at any time based on future experiences or changed environmental factors.

Table 43: Allowed operation conditions

Environmental factor	Unit	Value
Temperature	°C	0 ... +40[1)]
Relative air humidity	%	5 ... 95[1)]
Absolute air humidity	g/m^3	1 ... 29[1)]
Installation altitude	m	up to 1,000 m above sea level
[1)] Deviating from EN IEC 60721-3-3:2019		

8.5 Type of protection

The design of ML3 motors corresponds to the type of protection according to DIN EN 60034-5.

Table 44: Type of protection on ML3 motors

Motor component	Type of protection
Primary part	IP40 (IP64)
Hall unit	IP20

- IP64 - To ensure the protection type over the entire service life, the air gap has to be free from contamination. Movements of the power and sensor cables at the motor have to be prevented. Moreover, the assembly surface of the application requires a complete sealing to prevent that humidity can penetrate through thread and dowel pin holes. Under these conditions, ML3 motors can sporadically be exposed to water according to IP64.
- Observe the notes under chapter➦ regarding protection modes. 8.12.4.

⚠ CAUTION

Failure to observe the motor protection type can result in damage to or destruction of the motor components as well as personal injury!

The use of the motors or components is only permitted in environments for which the specified degree of protection is sufficient.

8.6 Compatibility test

All Rexroth controls and drives are developed and tested according to the state of the art.

However, since it is not possible to keep track of the continuous development of all substances with which our controls and drives may come into contact (e.g. lubricants on machine tools), reactions with the materials we use cannot be ruled out in every case.

Before using our products, carry out a compatibility test with the substances used on site (e.g. coolants and lubricants, cleaning agents, etc.) and our housing or device materials.

8.7 Magnetic fields

During operation of electric motors, electromagnetic fields are generated at live components and connection lines of these motors. The secondary parts equipped with permanent magnets of synchronous linear motors and rotors of synchronous kit motors are magnetically not shielded and permanently generate a static magnetic field (DC field) even if not activated. This is indicated by a warning label attached to each package with open permanent magnet components.

If all regulations and safety measures are complied with, synchronous kit motors with open permanent magnet components do not cause any inadmissible hazards. As of a distance of approx. 100 mm to the surface of open permanent magnet parts, there is practically no effective magnetic attraction of ferromagnetic parts. However, for people with implants, a minimum safety distance of 1 meter (1000 mm) is recommended.

Depending on the operating location, transport ways and storage of the machine and its components, local regulations and laws apply and have to be complied with during construction, transport and operation of the machine.

⚠ WARNING	**Electromagnetic / magnetic fields! Health hazard for persons with heart pacemakers, metal implants or hearing aids! Material damage.** – Hazards due to magnetic and electromagnetic fields at live components or permanent magnets of electric motors. – Persons with active implantable medical devices (AIMD) or passive metallic implants must keep clear from these motor components. – Keep magnetic data carriers, credit cards, check cards and identity cards and all ferromagnetic metal parts away from magnetic fields. Do not wear jewelry, particularly made of ferromagnetic material, during work at magnetic components.

Maximum values induction

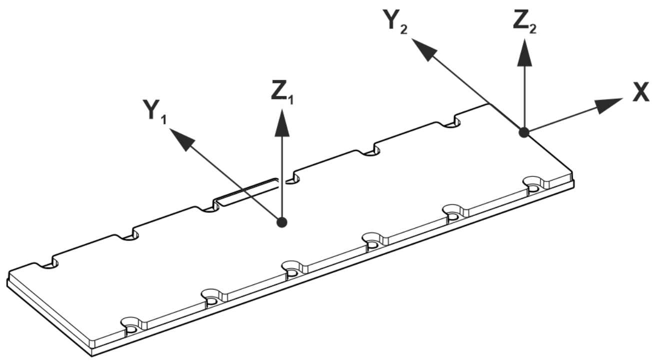


Fig. 83: Magnetic fields (example ML3S06-NN-0288)

Table 45: ML3S Induction values

	Frame size 03 ... 11				
	in the area of the path		at the end of the path		
	Y_1	Z_1	X	Y_2	Z_2
1 mm	500 mT	500 mT	500 mT	500 mT	500 mT
2 mm	200 mT	350 mT	300 mT	250 mT	350 mT
5 mm	50 mT	150 mT	100 mT	75 mT	150 mT
10 mm	10 ml	50 mT	50 mT	30 mT	75 mT
20 mm	1 mT	5 mT	15 mT	10 mT	30 mT
50 mm	0.05 mT	0.1 mT	3 mT	1 mT	5 mT

Safety measures for operating personnel

In the European Community (EU), directive 2004/40/EC specifies minimum requirements for protection of the safety and health of employees from hazards due to electromagnetic and magnetic fields. Regulations and guides for machine manufacturers and machine operators are included in the following documents:

- Standard EN 50499 (DE: DIN EN 50 499, DIN VDE 0808-499)
- Standard EN 50527 (DE: DIN VDE 0848-3)
- In Germany: Accident prevention regulations BGV/GUV-V B11

This list does not claim to be exhaustive. Machine manufacturers and machine operators are required to define the regulations applicable on site and the occupational health and safety measures to be applied for working in the area of exposure. The decisive factors are not the electromagnetic properties of individual machine components but the effective overall exposition in electrical, magnetic and electromagnetic fields in the actual working area.

Construction information

During construction of the machine, suitable covers and safety equipment for safe operation must be applied.

- During construction of the machine, observe applicable standards and regulations on marking of and access to exposure areas.
- Prevent any access of operating personnel in the motion range of motors during operation.
- Prevent any contamination, chips and dirt in the motion range of motors.

8.8 Noise emission

The noise emission of synchronous linear drives can be compared with conventional converter-operated feed drives. Empirically, it is dependent from the following factors:

- the used linear guides (velocity-related travel noise),
- used length measuring system,
- mechanical construction (rotating covers, a.s.o.)
- The settings of drive and controller (e.g. switching frequency)

8.9 Thermal behavior

Power loss

The continuous feed force a synchronous linear motor can reach is mainly determined by the power loss P_V produced during the energy conversion process. The power loss fully dissipates in form of heat. Due to the limited permissible winding temperature, it must not exceed a specific value.

NOTICE	The maximum allowed winding temperature of ML3 motors is 110 °C. During continuous operation, however, 100 °C should not be exceeded.

The total loss of synchronous linear motors is significantly defined by the short-circuit loss of the primary part.

$$P_V \approx P_{VI} = \frac{3}{2} \times I^2 \times R_{12} \times f_T$$

$$fT = 1 + \Delta T \times \alpha_{20}$$

Fig. 84: Power loss of synchronous linear motors

P_V Total loss in W
P_{VI} Short-circuit loss in W
I Current in motor cable in A
R_{12} Electrical resistance of the motor at 20 °C in Ohm (see Chapter 4 ”Technical data”)
f_T Factor temperature-related resistance rise
ΔT Temperature increase in K
α_{20} Temperature coefficient of cupper in 1/K

For power loss determination acc. toFig. 84 consider the temperature-related rise of the electrical resistance. At a temperature rise of 80 K (from 20 °C up to 100 °C), for example, the electrical resistance goes up by the factor f_T = 1.312.

Thermal time constant

The temperature variation vs. the time is determined by the produced power loss and the heat-dissipation and –storage capability of the motor. The heat-dissipation and –storage capability of an electrical machine is (combined in one variable) specified as the thermal time constant.

The following figureFig. 85 shows a typical heating and cooling process of an electrical machine. The thermal time constant is the period within which 63% of the final excess temperature is reached.

Together with the duty cycle, the correlation to Fig. 86 and Fig. 88 are used to define the operating modes, e.g. acc. to DIN EN 60034-1.

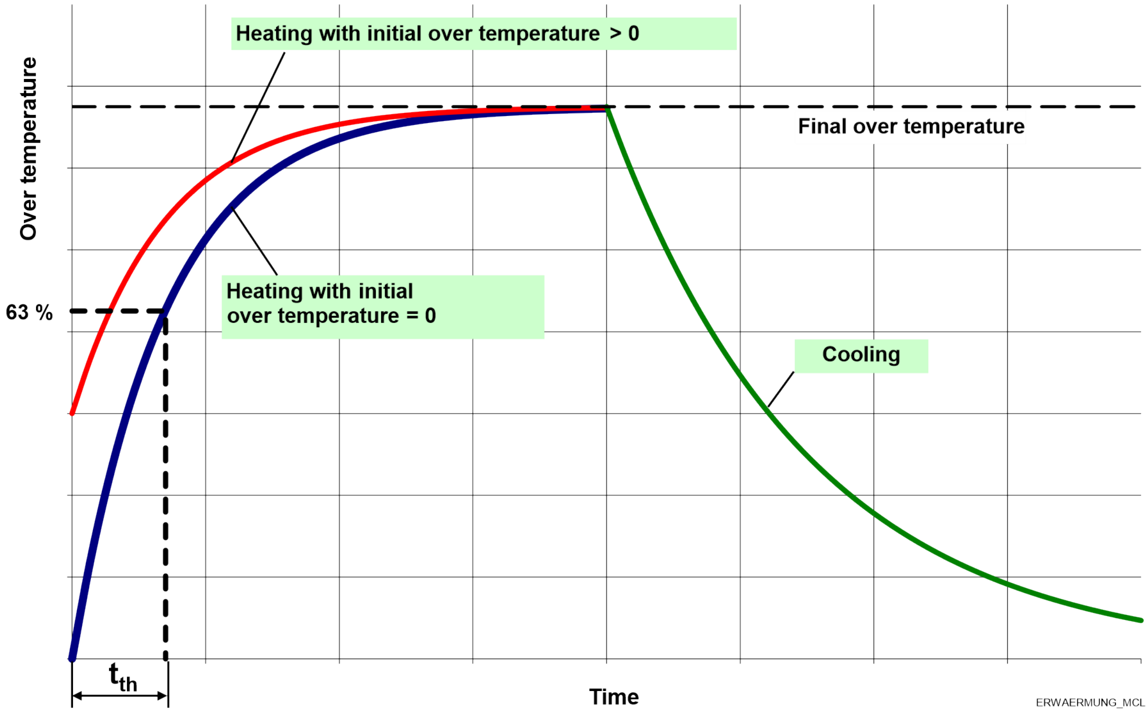


Fig. 85: Heating up and cooling down of an electrical machine

Heating up

$$\vartheta(t) = \vartheta_e \times \left(1 - e^{\frac{t}{t_{th}}}\right) + \vartheta_a \times e^{\frac{t}{t_{th}}}$$

Fig. 86: Heating (excess temperature) of an electric machine

ϑ_e Final excess temperature in K

ϑ_a Initial excess temperature in K

t Time in min

t_{th} Thermal time constant in min (see motor data sheet)

Final excess temperature

Since the final excess temperature is proportional to the power loss, the expected final excess temperature ϑ_e can be estimated according to:

$$\vartheta_e = \frac{P_{ce}}{P_{vN}} \cdot \vartheta_{e\ max} = \frac{F_{eff}^{\ 2}}{F_0^{\ 2}} \cdot \vartheta_{e\ max}$$

Fig. 87: Expected final excess temperature of the motor

P_{ce} Continuous power loss or average power loss over cycle duration in W
P_{vN} Nominal power loss of the motor in W
$\vartheta_{e\ max}$ Maximum final excess temperature of the motor in K
F_{eff} Effective force in N (from application)
F_0 Continuous force at standstill of motor in N (see motor data sheet)

Cooling down

$$\vartheta(t) = \vartheta_e \times e^{\frac{t}{t_{th}}}$$

Fig. 88: Cooling down of an electrical machine

ϑ_e Final excess temperature or shutdown temperature in K
t Time in min
t_{th} Thermal time constant in min (see motor data sheet)

8.10 Motor temperature monitoring

The motor temperature is monitored by the two independently operating systems

- Temperature sensor (motor) and
- Temperature model (controller)

and ensures the best protection of motors against irreversible damage by thermal overload.

As a standard, ML3P primary parts are fitted with an integrated temperature sensor (KTY83-122) for measuring the winding temperature as well as a temperature sensor PTC110-EK (individual PTC element with switching behavior). All-phase monitoring cannot be realized with only one temperature sensor. For this reason, thermal overload of non-monitored phases in standstill operation with continuous currents near the nominal current is possible although measuring values of < 100 °C are indicated. The exclusive use of one or both temperature sensors for temperature monitoring means no sufficient motor protection for the primary parts.

A possible form of an additional motor protection is to limit the motor current at low velocity to 71% of the admissible continuous current at standstill (< 1 m/min) or at movement via a short travel length (< 2 x τ_P). The admissible continuous current at standstill depends on the installation mode (see ➦ Chapter 8.22).

The Rexroth control devices monitor the functionality of the temperature sensors. For more information, please refer to the functional description for controllers. The temperature sensors of the ML3P are available as of firmware MPx20V18.

Table 46: Parameter settings for temperature sensors

Temperature sensor	Parameter P-0-0512
PTC110-EK	9
KTY83-122	10

Temperature sensor KTY83-122

Table 47: Reference values KTY83-122

KTY83-122	Value
Resistance at 25 °C	min. 1000 ... max. 1020 Ohm
Resistance at 100 °C	min. 1650 ... max. 1724 Ohm
Continuous current at 100 °C	2 mA

Table 48: Resistance values KTY83-122

T [°C]	20	25	30	40	50	60	70	80	90	100	110	120	130
R [Ω]	972	1010	1049	1130	1214	1301	1392	1487	1585	1687	1792	1900	2,012

The response temperatures of the sensor are

⇒ **100 °C** Pre-warning temperature

⇒ **110 °C** Cut-off temperature

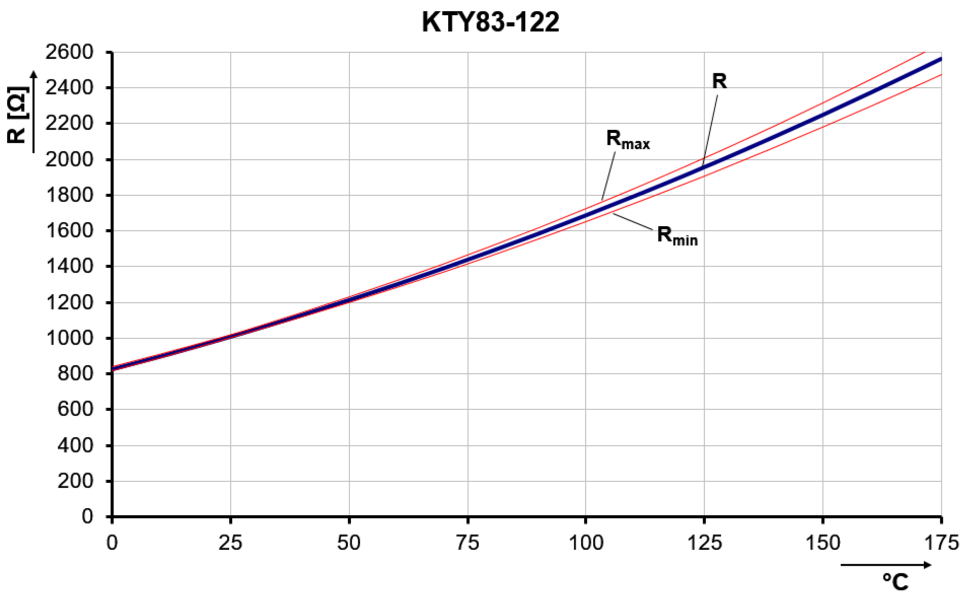


Fig. 89: Characteristic temperature sensor KTY83-122

Temperature sensor PTC110-EK

Table 49: Recommended values PTC110-EK

Temperature	Value
Up to 20 °C under critical temperature (110 °C)	< 250 Ω
Up to 5 °C under critical temperature (110 °C)	< 550 Ω
Nominal switching resistance (110 °C)	1000 Ω
Over critical temperature (110 °C)	> 1330 Ω

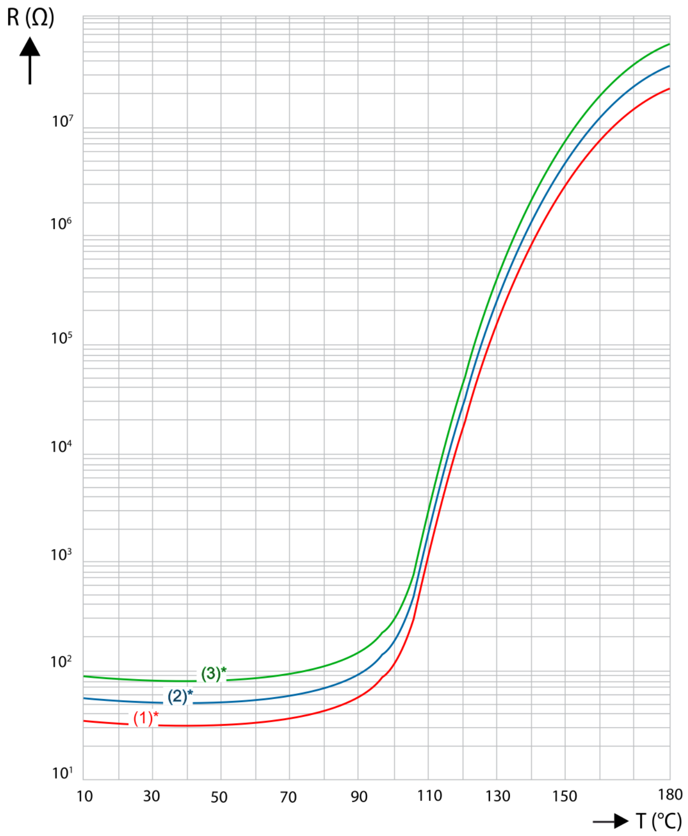


Fig. 90: Characteristic temperature sensor PTC110-EK

(1) 1x PTC110-EK in case of 1x ML3P
2 2x PTC110-EK in case of 2x ML3P
(3) 4x PTC110-EK in case of 4x ML3P

In case of parallel arrangement of several ML3P, the PTC110-EK of the primary part is connected in series for motor temperature monitoring.

8.11 Feed and attractive forces

8.11.1 Reduced coverage between primary and secondary part

When moving in the end position range of an axis, it can be necessary that the primary part moves beyond the end of the secondary part. This results in a partial coverage between primary and secondary part.

If primary and secondary part are only partially covered, this inevitably results in a reduction of the feed forces.

NOTICE

The partial coverage of the active range of the primary part with the secondary part must not be used in continuous operation since there is an increased current consumption of the motor due to control strategies. Instabilities in the control loop can be expected from a certain reduction of the degree of coverage onwards.

When doing the project planning of the machine, first of all please get in touch with your Bosch Rexroth contact person and ask for application support in this regard.

Start of force reduction

Outside the beginning and end areas (s_{R1} or s_{R2}), the reduction of the force is linear with the reduced overlap area. The following diagram illustrates the correlation between the coverage of primary to secondary part and the resulting force reduction.

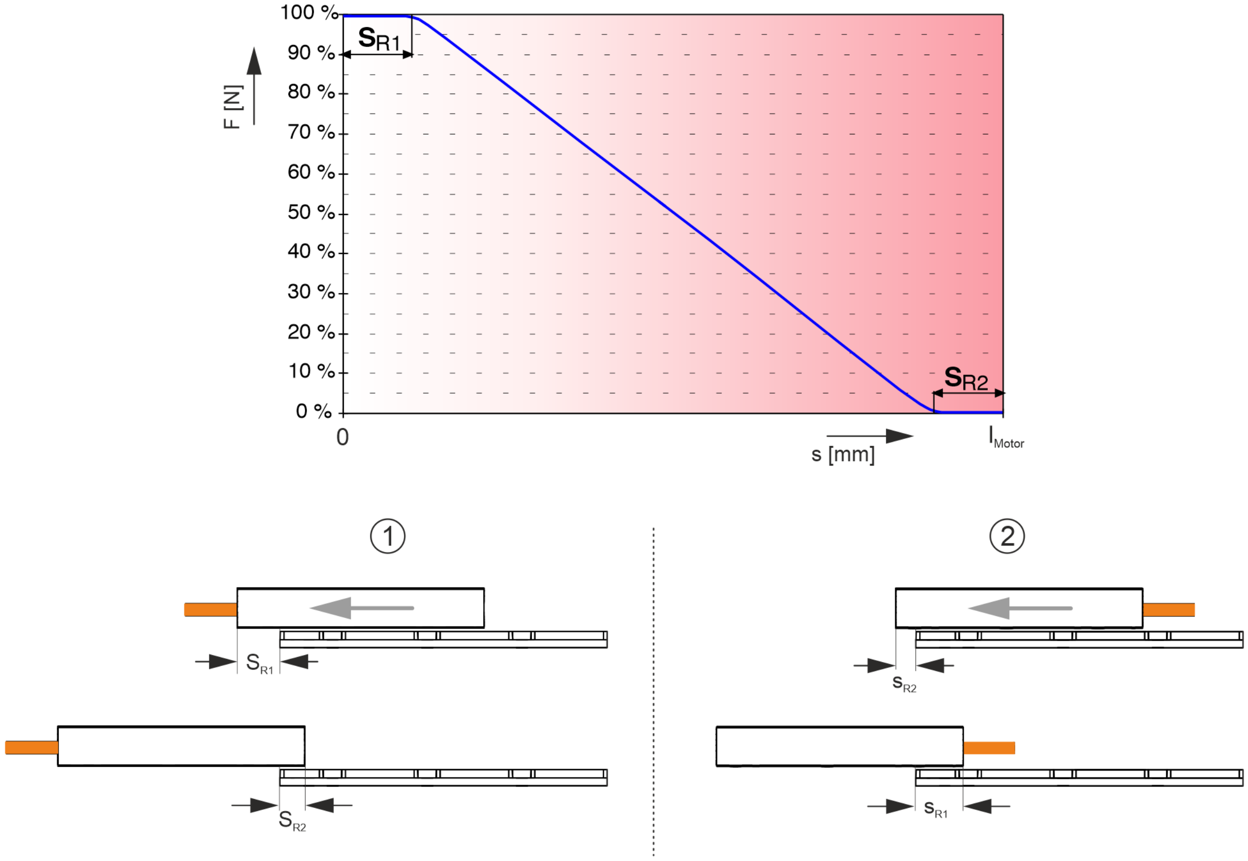


Fig. 91: Force reduction with partial coverage of primary and secondary part
① Variant 1 - Overrun distance in direction of cable outlet side
② Variant 2 - Overrun distance in direction against cable outlet side

Table 50: Partial coverage between primary and secondary part

Frame length ML3P		Active length $L_{ML3P,Fe}$ [mm]	Overrun distance S_{R1} [mm]	Overrun distance S_{R2} [mm]
03	A	66	19	8
	B	114	23	6
	D	216	23	2
	F	305.6	26.7	3.7
06	B	114	26	6
	C	164	25	5
	D	216	26	2
	E	257.6	26.2	6.2
	F	305.6	26.7	3.7
	H	440	26	2
11	D	216	26	2
	E	257.6	26.2	6.2
	F	305.6	26.7	3.7
	H	401.6	29.2	3.2

Frame length ML3P		Active length	Overrun distance	
		$L_{ML3P,Fe}$ [mm]	S_{R1} [mm]	S_{R2} [mm]
	L	529.6	26.2	6.2
	R	tbd	tbd	tbd

8.11.2 Air-gap-related feed force

Air gap tolerances

The feed forces specified in the technical data refer to the indicated nominal air gap. The allowed tolerances for the measurable air gap have an effect on the feed forces that can be reached. The figure below shows this mutual dependence:

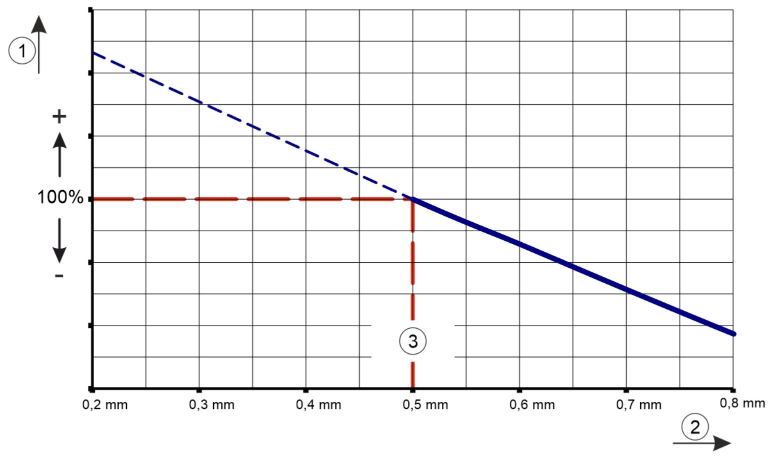


Fig. 92: Feed force within the air gap tolerance of synchronous linear motors ML3
① Feed force
② Air gap
③ Motor force in case of nominal air gap

8.12 Requirements on the machine design

8.12.1 General

Derived from design and properties of linear direct drives, the machine structure has to meet various requirements. For example, the moved masses should be minimized whilst the rigidity is kept at a high level.

NOTICE	Please observe the specifications regarding installation dimensions and tolerances in ➦ Chapter 4.1.3 Dimensions and tolerances on page 65.

8.12.2 Mass reduction

To ensure a high acceleration capability, the mass of the moved machine elements must be reduced to a minimum. This can be done by using materials of a low specific weight (e.g. aluminum or compound materials) and by design measures (e.g. skeleton structures).

If there are no requirements for the highest acceleration, even relative big mass can be moved. A very rigid connection of the motor to the load is a precondiiton.

8.12.3 Mechanical rigidity

In conjunction with the mass and the resulting resonant frequencies, the rigidity of the individual mechanical components within a machine chiefly determines the quality a machine can reach. The rigidity of a motion axis is determined by the overall mechanical structure. The goal of the construction must be to obtain an axis structure that is as compact as possible.

Natural frequency

The increased control bandwidth of linear direct drives requires higher mechanical natural frequencies of the machine structure in order to avoid the excitation of vibrations.

To ensure a sufficient control quality, the lowest natural frequency that occurs within the axis should not be less than an absolute value of approximately 200 Hz. The natural frequencies of axes with masses, that are not constantly moving (e.g. due to work pieces that must be machined differently), change, so that the natural frequency $f = \sqrt{1/m}$ is reduced as the mass increases.

Mechanically coupled axes

With the stiffness of kinematically coupled axes, it should be taken into account that the flexibility of the axes - both the mechanical and the control components - add up.

If several axes must be coupled kinematically in order to produce path motions (e.g. cross-table or gantry structure), the mutual effects of the individual axes on each other should be minimized. Thus, kinematic chains should be avoided in machines with several axes. Axis configurations with long projections that change during operation are particularly critical.

Reactive forces

Initiated by acceleration, deceleration or process forces of the moved axis, reactive forces may cause the stationary machine base to vibrate or deform it.

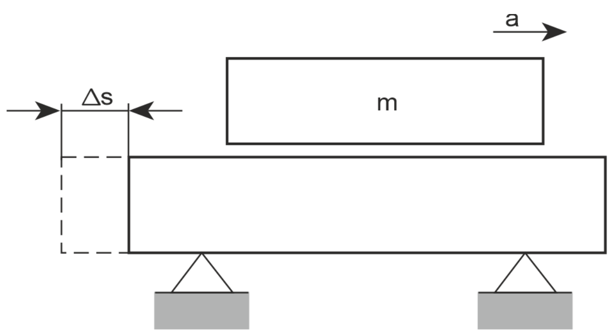


Fig. 93: Deformation of the machine base body caused by the reactive force during the acceleration process

$$\Delta s = \frac{m \times a}{c} = \frac{1kg \times 1000 m/s^2}{1000\, N/\mu m} = 1 \mu m$$

Fig. 94: Calculation example of the machine base deformation

Δs Deformation or displacement of the machine base in µm
m Mass in kg
a Acceleration in m/s^2
c Rigidity of the machine base body in N/µm

Integrating the linear scale

The rigidity of the length measuring system integration is particularly important. Please observe the notes about lengths scale selection under ➦ Chapter. 8.14.

8.12.4 Protection of the motor installation space

Due to protection type of the motor components, the protection of the motor installation space need particular attention. To avoid that dirt comes into the air gap between primary and secondary part (e.g. due to any kind of residues, dust, etc.) during motor operation, the motor installation space must be designed according to the environmental conditions. The motor installation space must be designed in such a way, that the protection class IP65 according to DIN EN 60034-5 equivalent environmental conditions are ensured (see ➦). 8.5).

Heed appropriate protection measures when designing the machine construction. If dirt gets between the motor components due to insufficient protection measures, during operation this can lead to...

- increased heat introduction due to friction between the motor components. This can result in increasing temperatures,, which can cause a motor damage.
- Due to the high mechanical force effect grinding traces and /or scratch-formation on the motor components can result in the destroying of casting compounds on the primary part, to motor breakdown, among others.

Please note that dirt can also enter indirectly into via compressed air or due to other machine parts (e.g. grease of the guides). This must be prevented. Make sure by regularly maintenance of the safety measures that their function is still kept and the motor components could not be damaged.

Using a cover plate at the secondary part

For mechanical protection of the secondary parts, cover plates can be used.

Also observe the information on the cover plate under ➦ Chapter 6.3 Cover plate for secondary part on page 96.

NOTICE	If cover plates are used, it must be ensured that the required air gap between the motor components is maintained. To achieve this, the installation height must be increased by the thickness of the cover plate.

8.13 Arrangement of motor components

8.13.1 Single arrangement

The single arrangement - the independent operation of single primary parts - of the primary part is the most common arrangement. In such an arrangement, the length measuring system can also be equipped with two or more scanning heads.

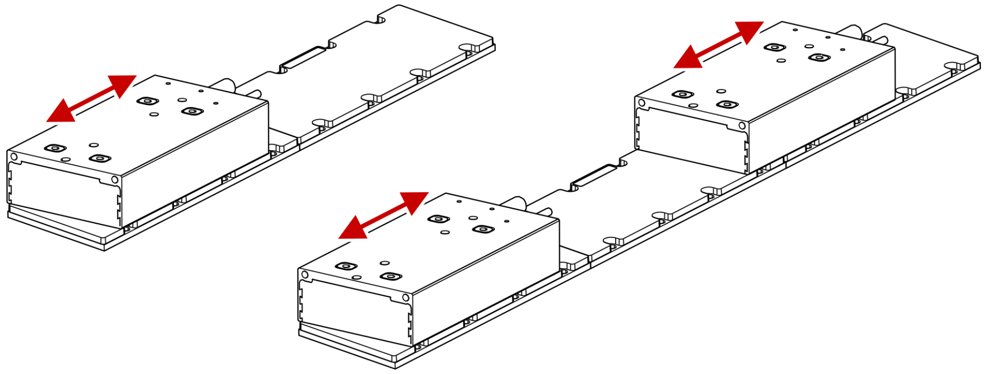


Fig. 95: Single axis arrangement of primary parts

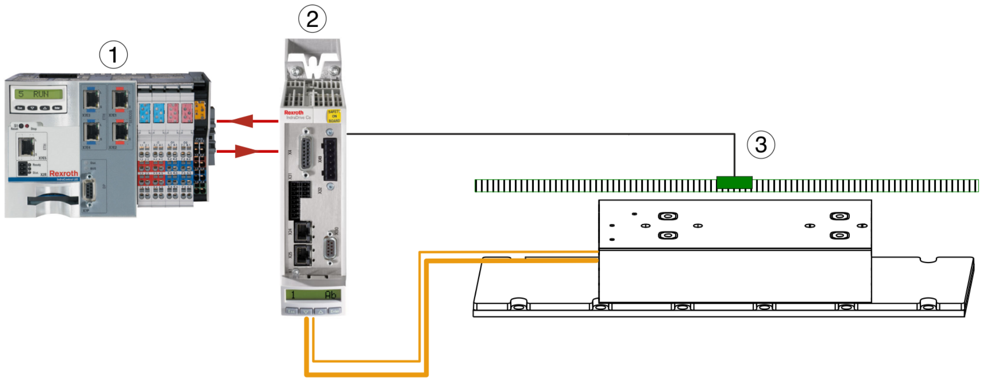


Fig. 96: Controlling a linear motor with single arrangement of the motor components

① Control unit
② Controller
③ Length measuring system

8.13.2 Several motors per axis

General

The arrangement of several motors per axis provides the following benefits:

- Multiplied feed forces
- Optimized utilization of available installation space

Depending on the application, the motors can be controlled in two different ways:

- Two or more motors at one drive controller and one linear scale (parallel connection)
- Two motors at two drive controllers and two linear scales (Gantry arrangement)

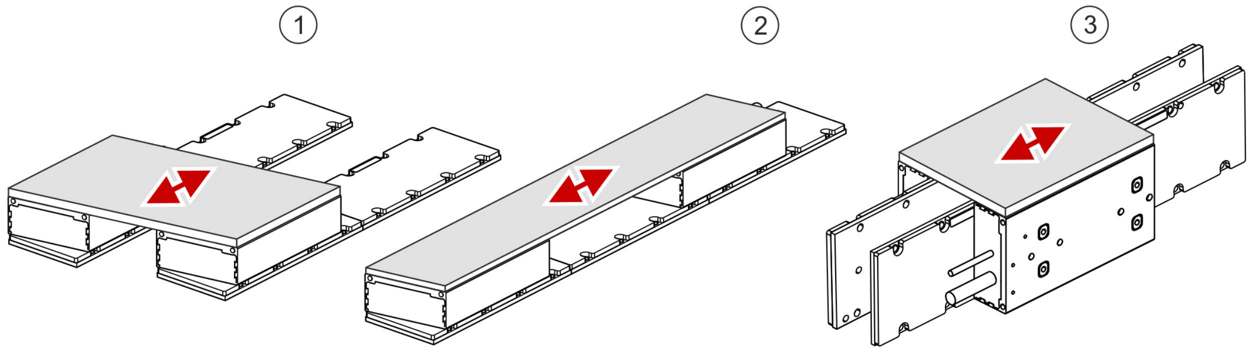


Fig. 97: Arrangement of several motors per axis

① Two length scales with two sensor heads can be used or one length scale is installed between the two travel lengths and can be probed by two scanning heads.
② In case of two motors on the same length, a length scale with two scanning heads can be used.
③ Double comb arrangement: Two length scales with two sensor heads can be used or one length scale is installed between the two travel lengths and can be probed by two scanning heads.

Parallel connection: Several primary parts in parallel

The arrangement of two or more primary parts on one drive controller in conjunction with a linear scale is known as parallel arrangement.

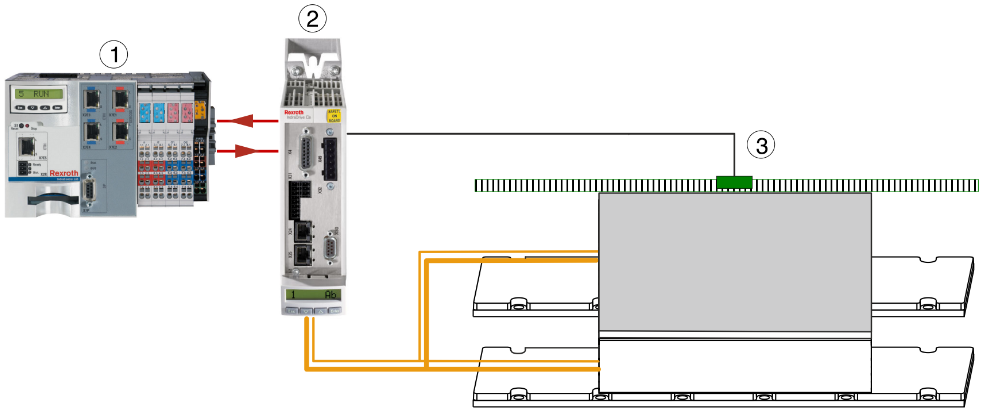


Fig. 98: Parallel connection of two primary parts on one drive controller in conjunction with a length measuring system

① Control unit
② Controller
③ Length measuring system

To ensure successful operation, the following conditions must be fulfilled:

- Use identical primary parts and same line length
- Stiff motor coupling within the axis
- Position offset between the primary parts < 0.5 mm in feed direction
- Position offset between the secondary parts < 0.5 mm in feed direction
- If possible, load stationary and arranged symmetrically with respect to the motors

The determination of the distance that must be adhered depends on the direction of the cable outlet and the permissible bending radius of the power cable.

Parallel connection: Double comb arrangement

In the case of parallel connection, the primary parts in feed direction can be mechanically coupled and arranged in the form of a so-called double comb arrangement (see Fig.) 97). Apart from force multiplication, the attractive forces between primary part and secondary part are compensated outwards. With the appropriate arrangement, the linear guides are not additionally stressed and possibly can be sized smaller. These requirements also apply:

- Identical primary and secondary parts
- Very rigid motor coupling within the axis
- Position offset between the primary parts <1 mm in feed direction
- Position offset between the secondary parts <1 mm in feed direction
- The same pole sequence of the secondary parts to each other
- If possible, load stationary and arranged symmetrically with respect to the motors

In case of a double comb arrangement **no** minimum distance has to be complied with in case of the two secondary part mounting surfaces.

Parallel connection: Several primary parts in series

For parallel connection, primary parts in feed direction can also be arranged in a row, mechanically coupled.

To ensure successful operation, the identical primary parts must be arranged in a specific distance to each other. The determination of the grid dimension that must be complied with depends on the direction of the cable outlet and the permissible bending radius of the power cable.

Cable outlet in the same direction

If the primary parts are arranged behind each other and with cable outlets in the same direction according to Fig. 99, a distance x_p must be observed.

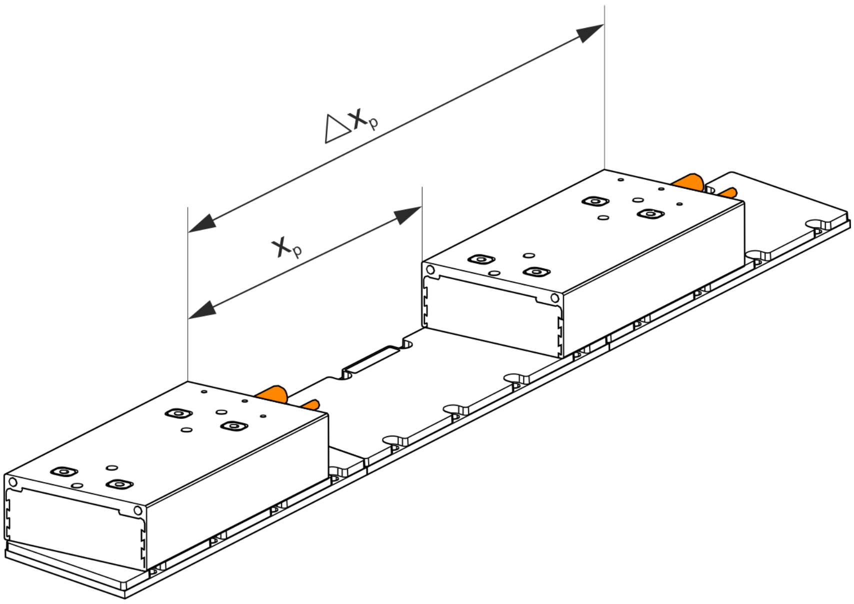


Fig. 99: Arrangement of the primary parts behind each other and cable outlets in the same direction

$$x_P = n \times 2 \times \tau_p + x_{P\min}$$
$$x_P > R$$

Fig. 100: Determining the distance x_P between the primary parts with cable outlets in the same direction

x_p Distance between the primary parts in mm
n Freely selectable integer factor
τ_p Pole width (see Chapter ➦Technical data)
x_{pmin} Smallest allowed distance between the primary parts (see ➦Tab. 51)
R Allowed bending radius of the connection cable (see ➦Tab.) 34)

The grid dimension Δx_P acc. to Fig. 99 must be an integer multiple of the double pole width. Always use the same reference point for both primary parts (e.g. the same fastening hole or the same primary part front face).

$$\Delta x_P = n \times 2 \times \tau_p$$

Fig. 101: Determining the grid dimension between the primary parts with cable outlets in the same direction

Δx_p Required grid dimension between the primary parts in mm
n Freely selectable integer factor
τ_p Pole width

The distance x_p between the primary parts according to Fig. 99 may not be less than the following minimum distances x_{pmin}:

$$X_P \geq X_{p\min}$$

Fig. 102: Smallest allowed distance between the primary parts

x_p Distance between the primary parts in mm
x_{pmin} Smallest allowed distance between the primary parts (see ➦Tab. 51)

Table 51: Distance and phase sequence at arranged primary parts behind each other and cable outlet in the same direction

Primary part	Distance x_{Pmin}	Phase sequence L1 / L2 / L3	
		Primary part 1*)	Primary part 2
ML3P03-A	35 mm	U-V-W	W-U-V
ML3P03-B	49 mm		U-V-W
ML3P03-D	47 mm		U-V-W
ML3P03-F	48 mm		U-V-W
ML3P06-B	46 mm		U-V-W
ML3P06-C	46 mm		U-V-W
ML3P06-D	44 mm		U-V-W
ML3P06-E	46 mm		U-V-W
ML3P06-F	48 mm		U-V-W
ML3P06-H	60 mm		U-V-W
ML3P11-D	60 mm		V-W-U
ML3P11-E	62 mm		V-W-U
ML3P11-F	48 mm		U-V-W
ML3P11-H	62 mm		V-W-U
ML3P11-L	62 mm		U-V-W
ML3P11-R	108		U-V-W

Primary part	Distance x_{Pmin}	Phase sequence L1 / L2 / L3	
		Primary part 1*)	Primary part 2
*) Reference motor to determine the encoder polarity and commutation adjustment is always primary part 1			

Cable outlet in opposite direction (variant 1: back to back)

If the primary parts are arranged according to Fig. 103, a defined distance x_P has to be complied with between the front faces of the primary parts.

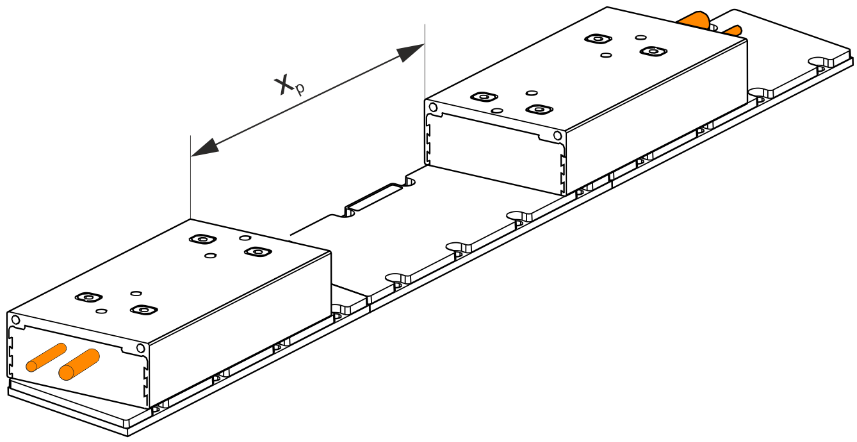


Fig. 103: Variant 1: Arrangement of primary parts behind each other with cable outlets in opposite directions

$$x_P = n \times 2 \times \tau_p + x_{P\min}$$

Fig. 104: Determining the distance between primary parts with cable outlets in opposite directions

x_p Distance between the primary parts in mm
n Freely selectable integer factor
τ_p Pole width
x_{pmin} Smallest allowed distance between the primary parts (see ➦Tab. 52)

When determining the correct primary part distance according to Fig. 103, only the distance between the primary part end faces (xpmin) as reference point can be used.

Table 52: Distance and phase sequence at arranged primary parts behind each other with cable outlets in opposite directions (option 1)

Primary part	Distance x_{Pmin}	Phase sequence L1 / L2 / L3	
		Primary part 1*)	Primary part 2
ML3P03-A	14		W-V-U
ML3P03-B	2		V-U-W
ML3P03-D	4		V-U-W
ML3P03-F	7		V-U-W
ML3P06-B	2		V-U-W
ML3P06-C	2	U-V-W	V-U-W
ML3P06-D	4		V-U-W
ML3P06-E	2		V-U-W
ML3P06-F	7		V-U-W
ML3P06-H	4		W-V-U
ML3P11-D	4		V-U-W

Primary part	Distance x_{Pmin}	Phase sequence L1 / L2 / L3	
		Primary part 1*)	Primary part 2
ML3P11-E	2		V-U-W
ML3P11-F	7		V-U-W
ML3P11-H	8		V-U-W
ML3P11-L	6		U-W-V
ML3P11-R	8		V-U-W
*) Reference motor to determine the encoder polarity and commutation adjustment is always primary part 1			

Cable outlet in opposite direction (variant 2: cables to each other)

If the primary parts are arranged according to Fig. 105, a defined distance x_P has to be complied with between the front faces of the primary parts.

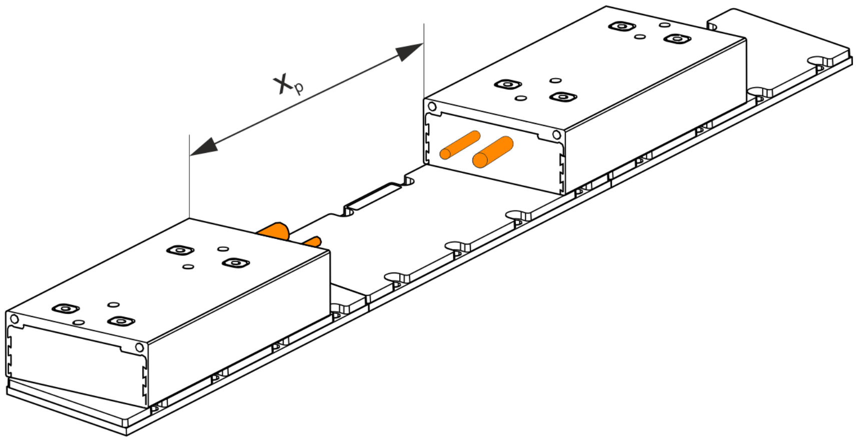


Fig. 105: Variant 2: Arrangement of primary parts behind each other with cable outlets in opposite directions

$$x_P = n \times 2 \times \tau_p + x_{P\,\min}$$

$$x_P > R$$

Fig. 106: Determining the distance x_P between the primary parts with cable outlets in the same direction

x_p Distance between the primary parts in mm
n Freely selectable integer factor
τ_p Pole width (see Chapter ➦ Technical data)
x_{pmin} Smallest allowed distance between the primary parts (see ➦ Tab. 53)
R Allowed bending radius of the connection cable (see ➦ Tab.) 34)

When determining the correct primary part distance according to Fig. 105, only the distance between the primary part end faces (xpmin) as reference point can be used.

Table 53: Minimum distance and phase sequence at arranged primary parts behind each other with cable outlets (option 2)

Primary part	Distance x_{Pmin}	Phase sequence L1 / L2 / L3	
		Primary part 1*)	Primary part 2
ML3P03-A	40	U-V-W	W-V-U
ML3P03-B	48		V-U-W
ML3P03-D	42		V-U-W
ML3P03-F	41		V-U-W

Primary part	Distance x_{Pmin}	Phase sequence L1 / L2 / L3	
		Primary part 1*)	Primary part 2
ML3P06-B	42		V-U-W
ML3P06-C	42		V-U-W
ML3P06-D	52		U-W-V
ML3P06-E	42		V-U-W
ML3P06-F	41		V-U-W
ML3P06-H	52		U-W-V
ML3P11-D	52		U-W-V
ML3P11-E	58		U-W-V
ML3P11-F	57		U-W-V
ML3P11-H	52		U-W-V
ML3P11-L	58		U-W-V
ML3P11-R	112		V-U-W
*) Reference motor to determine the encoder polarity and commutation adjustment is always primary part 1			

Gantry arrangement

If different load conditions occur during operation, both locally and temporally, and a sufficient rigidity between the motors cannot be ensured, the operation should be planned with two linear scales and drive controllers (Gantry arrangement). This is frequently the case with axis in a Gantry structure, for example.

Within a Gantry arrangement, even motors connected in parallel can be used.

Double comb arrangement (Gantry)

Within a Gantry arrangement, the primary parts in feed direction can be mechanically coupled and arranged in the form of a so-called double comb arrangement.

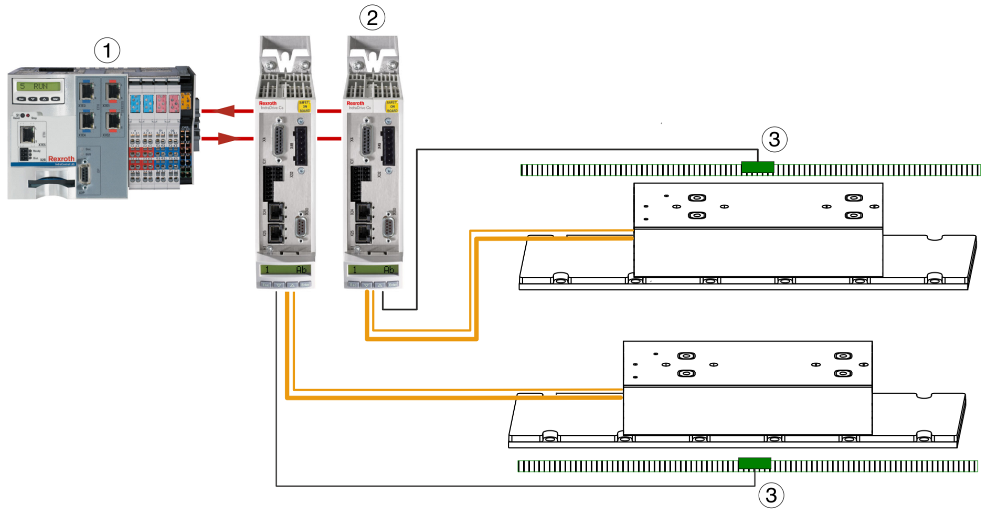


Fig. 107: Gantry arrangement (double comb)
① Control unit
② Controller (2 pcs.)
③ Length measuring system (2 pcs.)

With Gantry arrangements it must be remembered that the motors may be stressed asymmetrically, although the position offset is minimized. As a consequence, this permanently existing base load may lead to a generally higher stress than a single arrangement. This must be taken into account when the drive is selected.

The asymmetric load can be reduced to a minimum by exactly aligning the length measuring systems, the primary and secondary parts to each other, and by the internal axis error correction.

Arrangement of primary parts in a row (Gantry)

Primary parts in feed direction can also be arranged in a row, mechanically coupled.

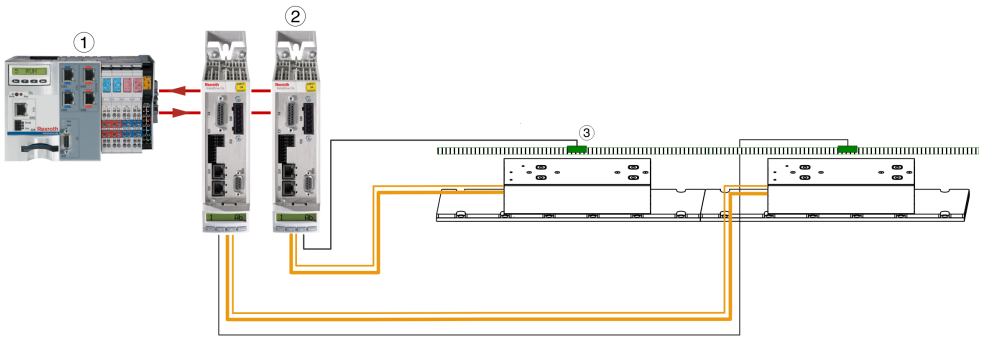


Fig. 108: Gantry arrangement (primary parts in a row)
① Control unit
② Controller (2 pcs.)
③ Length measuring system (1 scale, 2 scanning heads)

8.13.3 Arrangement of secondary parts

For installation, the alignment of the secondary parts must be observed. To support correct alignment, the ML3S are marked on one longitudinal side with a reference mark (see ➦ Chapter 8.2.2). If the fields are always positioned on the same side of the length, the correct pole sequence is ensured.

Please observe the notes in ➦ Chapter 10.3 Assembly of secondary part segments on page 158 and about alignment and fastening of secondary parts.

8.13.4 Vertical axis

⚠ CAUTION	**Uncontrolled movement Risk of injuries!** Motors in vertical axes are not self-locking when the power is switched off. Prevent the axis from sinking by using appropriate holding devices.

- On vertical axis, the use of an absolute measuring system is recommended.
- Incremental measuring systems can only be used, if a Hall unit is additionally used beside the holding device.

Weight compensation

An additionally used weight compensation ensures that the motor is not exposed to an unnecessary thermal stress that is caused by the holding forces and the acceleration capability of the axis is independent of the motion direction. The weight compensation can be pneumatic or hydraulic. Weight compensation with a counterweight is not suitable since the counterweight must also be accelerated.

Application and construction instructions

8.14 Length measuring system

A length measuring system is required for measuring the position and the velocity. Particularly high requirements are placed upon the linear scale and its mechanical connection. The linear scale serves for high-resolution position sensing and to determine the current speed.

The necessary length measuring system is not in the scope of delivery of Bosch Rexroth and has to be provided and mounted from the machine manufacturer themselves (see ➡ Chapter Sources of length measuring systems on page 136).

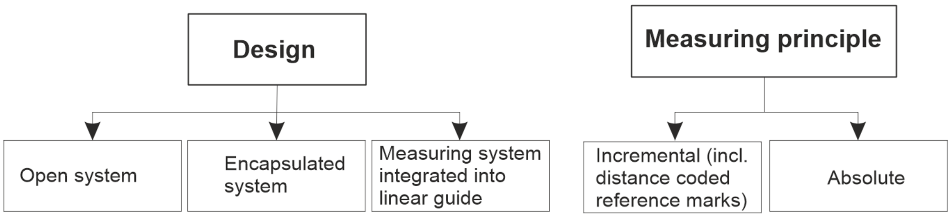


Fig. 109: Classification of linear scales

Particularities of synchronous linear motors

It is necessary at synchronous linear motors to receive the position of the primary part relating on the secondary part by return after start or after a malfunction (pole position recognition). Using an absolute linear scale is the optimum solution here.

8.14.1 Selection criteria for length measuring system

General

Depending on the operating conditions, open or encapsulated linear scales with different measuring principles and signal periods can be used. The selection of a suitable linear scale mainly depends on:

- The maximum feed rate (model, signal period)
- The maximum travel range (measuring length, model)
- If applicable, utilization of coolant lubricants (model)
- Incidental dirt, chips, etc. (frame size)
- the accuracy requirements (signal period)

Sources of length measuring systems

Linear guiding systems are not in the scope of delivery of the motor and must be ordered separately. The selection of a suitable linear guiding system is in the sole responsibility of the machine manufacturer. When selecting linear measuring systems please observe that this system uses sinusoidal instead of rectangular output signals. With sinusoidal output signals, a significantly higher position resolution and better position accuracy is reached via special evaluation revolution of our controllers.

The following selection is exemplary and does not claim to be complete. You can also use products from other manufacturers, according to the encoder interface of the used controller.

Table 54: Sources of length measuring systems

Bosch Rexroth AG Linear and assembly technique	Maria-Theresien-Straße 23 97816 Lohr am Main, Germany ➦www.boschrexroth.com/business_units/brl/de/ (Integrated measuring system for profiled rail guide)
Renishaw GmbH	Karl-Benz Straße 12 72124 Pliezhausen, Germany ➦www.renishaw.de/
SIKO GmbH	Weihermattenweg 2 79256 Buchenbach, Germany ➦www.siko.de/
NUMERIK JENA GmbH	Ilmstraße 4 07743 Jena, Deutschland ➦www.numerikjena.de/
SICK AG	Erwin-Sick-Straße 1 79183 Waldkirch, Germany ➦www.sick.com/
AMO Automatisierung Messtechnik Optik GmbH	NÖFING 4 A-4963 ST. PETER AM HART ➦www.amo-gmbh.com
DR. JOHANNES HEIDENHAIN GmbH	Postfach 1260 83292 Traunreut, Germany ➦www.heidenhain.de/

To ensure maximum interference immunity, Rexroth recommends the voltage interface with 1 V_{SS}.

Please refer to the documents from the corresponding manufacturer for detailed and updated information.

Measuring system cables

Ready-made cables of Rexroth are available for the electrical connection between the output of the linear scale and the input of the scale interface. To ensure maximum transmission and scale interference safety, prefer these cables.

8.15 Linear guiding systems

Linear guiding systems for linear motors are, depending on the motor arrangement, necessary due to feed and process forces as well as the speeds achievable today. The used linear guiding system must be able to adjust process and acceleration force.

Depending on the application, the following linear guides are employed:

- Ball or roll rail guides
- Slide ways
- Hydrostatic guides
- Aerostatic guides

The following requirements should be taken into account when a suitable linear guide system is selected:

- High accuracy and no backlash
- Low friction and no stick-slip effect

- High rigidity
- Steady run, even at high velocities
- Easy mounting and adjustment

Manufacturer

Linear guiding systems are not in the scope of delivery of the motor and must be ordered separately. The selection of a suitable linear guiding system is in the sole responsibility of the machine manufacturer. When selecting linear measuring systems please observe that this system uses sinusoidal instead of rectangular output signals. With sinusoidal output signals, a significantly higher position resolution and better position accuracy is reached via special evaluation revolution of our controllers.

In combination with our motors, we recommend using products from our linear and assembly technology range.

Table 55: Sources of linear guiding systems

Bosch Rexroth AG Linear and assembly technique	Maria-Theresien-Straße 23 97816 Lohr am Main, Germany ➦ www.boschrexroth.com/business_units/brl/de/ (Integrated measuring system for profiled rail guide)

8.16 Braking systems and holding devices

Braking systems and holding devices are not in the scope of delivery of the motor and must be ordered separately. The selection of a suitable system is in the sole responsibility of the machine manufacturer.

The following systems can be used as braking systems and/or holding devices for linear motors:

- External braking facilities
- Clamping elements for linear guides
- Holding brakes integrated in the weight compensation

Further designs about stand-still of linear motors are given in ➦ Chapter 8.17 End position shock absorber on page 138 and ➦ Chapter 8.20 Deactivation upon EMERGENCY STOP and in the event of a malfunction on page 140 as well as in the appropriate functional description of the drive controller.

8.17 End position shock absorber

NOTICE	Damage on machine or motor components when driving against hard stop!
	– Use suitable energy-absorbing end position shock absorber – Adhere to the specified maximum decelerations

Suitable energy-absorbing end position shock absorber must be provided in order to protect the machine during uncontrolled coasting of an axis.

If the maximum deceleration is exceeded, this can cause the primary part to come loose and damage the engine components.

- When moving against a fixed stop, the maximum permissible deceleration must be limited to **250 m/s²** by a suitable energy-absorbing end position damper.
- The necessary spring excursion of the shock absorbers must be taken into account when the end position shock absorbers are integrated into the machine (in particular when the total travel length is determined).

8.18 Axis cover systems

A suitable axis cover system should be configured, if possible, during the early development process of the machine or system – supported by the corresponding specialized supplier.

Depending on the application, design, operational principle and features of synchronous linear motors, the following requirements on axis cover systems apply:

- High dynamic properties (no overshoot, little masses)
- Accuracy and smooth run
- Protection of motor components against chips, dust and foreign objects (in particular ferromagnetic parts),
- Resistance to oil and coolant lubricants
- Robustness and wear resistance

Different covering systems can be used, like bellow covers, telescopic covers or rolle covers.

8.19 Motor control and regulation

8.19.1 General

The following figures shows a complete linear direct drive, consisting of a synchronous linear motor, length scale system, drive controller and superordinate control.

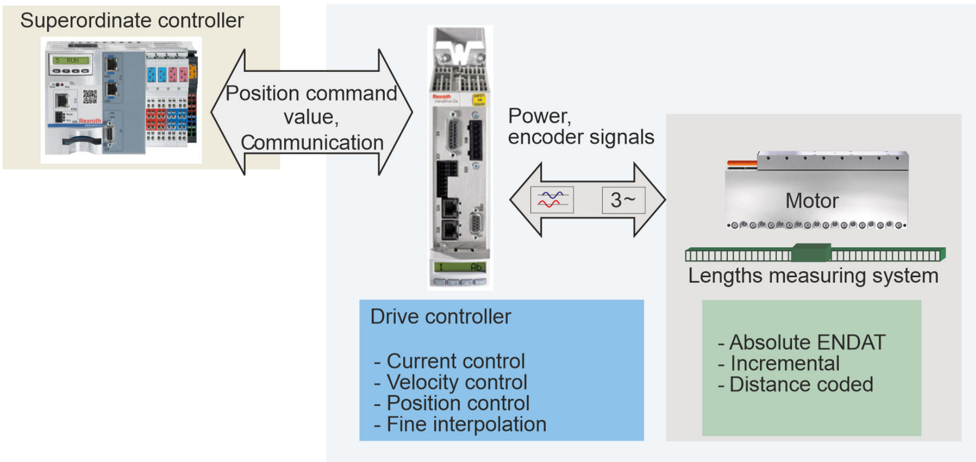


Fig. 110: Linear direct drive

8.19.2 Drive controllers

For motor control, different digital drive controllers and power supply modules are available from Bosch Rexroth.

8.19.3 Control systems

A master control is required for generating defined movements. Depending on the functionality of the overall system and the drive interface used, Bosch Rexroth offers different control systems.

8.20 Deactivation upon EMERGENCY STOP and in the event of a malfunction

8.20.1 General

Deactivation of an axis equipped with a linear motor of Bosch Rexroth, can be initiated by:

- EMERGENCY STOP,
- Drive fault (e.g. response of the encoder monitoring function) or
- Power outage

In the options for deactivation of MCL motors in case of malfunction, a distinction must be made between

- Deactivation by the drive
- Deactivation by a master control
- Deactivation by a mechanical braking device.

In the following, different cases of drive technology of Bosch Rexroth are described.

8.20.2 Deactivation by the drive

As long as there is no fault or malfunction in the drive system, shutdown by the drive is possible. The shutdown possibilities depend on the occurred drive error and on the selected error response of the drive. Certain faults (interface faults or fatal faults) lead to a force disconnection of the drive.

⚠ WARNING	**Death, serious injuries or damage to equipment may result from an uncontrolled coasting of a switched-off linear drive!** – Construction and design according to the safety standards – Protection of people by suitable barriers and enclosures – Using external mechanical braking facilities – Use suitable energy-absorbing end position shock absorber

The parameter values of the drive response to interface faults and non-fatal faults can be selected. The drive switches off at the end of each fault response.

The following fault responses can be selected:

0 – Setting velocity command value to zero

1 - Setting force command value to zero

2 - Setting velocity command value to zero with command value ramp and filter

3 - Retraction

Please refer to the corresponding firmware function description for additional information about the reaction to faults and the related parameter value assignments.

8.20.3 Deactivation by a master control

Deactivation by control functions

Deactivation by the master control should be performed in the following steps:

- The machine PLC or the machine I/O level reports the fault to the CNC control
- The CNC control deactivates the drives via a ramp in the fastest possible way
- The CNC control causes the power at the power supply module to be shut down.

Drive initiated via the control shutdown

Deactivation via means of drive functions should be performed in the following steps:

- The machine I/O level reports the fault to the CNC control and SPS
- The CNC control or the PLC resets the controller enabling signal of the drives. If SERCOS interface is used, it deactivates the ”E-STOP” input at the SERCOS interface module.
- The drive responds with the selected error response.
- The power at the power supply module must be switched off 500 ms after the controller enabling signal has been reset or the ”E-Stop” input has been deactivated.

The delayed power shutdown ensures the safe shutdown of the drive by the drive controller. With an undelayed power shutdown, the drive coasts in an uncontrolled way once the DC bus energy has been used up.

8.20.4 Deactivation via mechanical braking device

Shutdown by mechanical braking devices should be activated simultaneously with switching off the power at the power supply module. Integration into the holding brake control of the drive controllers is possible, too. The following must be observed:

- Braking devices with electrical 24V DC control (electrically-released) and currents < 2 A can directly be triggered.
- Braking devices with electrical 24V DC control and currents > 2 A can be triggered via a suitable protection.

Once the controller enabling signal has been removed, the holding brake control has the following effect:

- Fault reaction ”0”, ”1” and ”3”.
  The holding brake control drops to 0 V once the velocity is less than 10 mm/min or a time of 400 ms has elapsed.
- Fault reaction "2":
  The holding brake control drops to 0 V immediately after the drive enabling signal has been removed.

8.20.5 Response to a mains failure

In order to be able to shut down the linear drive as fast as possible in the event of a power outage:

- either an interruption-free power supply or
- additional DC bus capacitance (capacitors), and /or
- mechanical braking facilities

Determining the required additional DC bus capacitance

Additional capacities in the DC bus represent an additional energy store that can supply the brake energy required in the event of a power outage.

The control voltage must be available even at a power outage for the time of braking! As necessary, buffer the control voltage supply or realize control voltage supply from the DC bus if possible!

The additional capacitance required for a deactivation upon a power outage can be determined as follows:

$$C_{add} = \frac{m \cdot v_{max}}{U_{DC\,max}^{2} - U_{DC\,min}^{2}} \cdot \left[3{,}5 \cdot \frac{F_{max}}{k_{FN}^{2}} \cdot R_{12} - v_{max} \cdot \left(\frac{F_R}{F_{max}} + 0.3 \right) \right]$$

Fig. 111: Determining the required additional DC bus capacitor

C_{add}	Required additional DC bus capacitor in mF
m	Moved mass in kg
v_{max}	Maximum velocity in m/s
U_{DCmax}	Maximum DC bus voltage in V
U_{DCmin}	Minimum DC bus voltage in V
F_{max}	Maximum braking force of the motor in N
k_{FN}	Motor constant (force constant) in N/A
R_{12}	Winding resistance at 20 °C
F_R	Friction force in N

Prerequisites:

- final velocity = 0
- velocity-independent friction
- constant deceleration
- Winding temperature 110 ... 135 °C

The maximum possible DC bus capacity of the employed power supply module must be taken into account when additional capacities are used in the DC bus. Do not initiate a DC voltage short-circuit when additional capacitors are employed.

8.20.6 Short-circuit of DC bus

Most of the power supply modules of Bosch Rexroth permit the DC bus to be shortened when the power is switched off, which also establishes a short-circuit between the motor phases. When the motor moves, this causes a braking effect according to the principle of the induction; thereby the motor phases are shorted. The reachable braking force is not very high and velocity-dependent. The DC bus short-circuit can therefore only be used to support existing mechanical braking devices.

8.21 Position and velocity resolution

8.21.1 Drive internal position resolution and position accuracy

In linear direct drives, a linear scale is used for measuring the position. The linear scale for linear motors supply sinusoidal output signals. The length of such a sine signal is known as the signal period. It is mainly specified in mm or µm.

With the drive controllers from Bosch Rexroth, the sine signals are amplified again in the drive (see Fig.). 113). The drive-internal amplification also depends on the maximum travel area and the signal period of the length measuring system. It always employs 2^n grid points (e.g. 2048 or 4096).

$$f_{\text{int}} = 2^{31} \times \frac{s_p}{x_{\text{max}}}$$

Fig. 112: Multiplication factor

f_{int} Multiplication factor (S-0-0256, Multiplication 1), rounded to 2^n

s_p Linear scale system signal period in mm (S-0-0116 Resolution of encoder 1)

x_{max} Maximum travel (S-0-0278, Maximum travel)

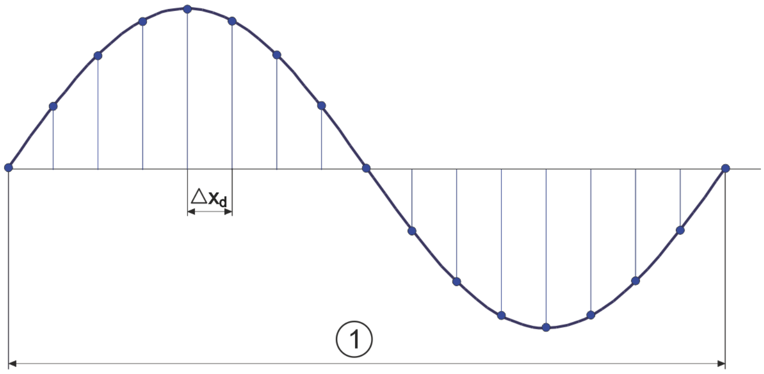


Fig. 113: Drive-internal multiplication and/or interpolation of the measuring system signals

Δx_d Drive-internal position resolution

① Signal period

With a known signal period and a drive-internal multiplication, the drive-internal position resolution results as:

$$\Delta x_d = \frac{s_p}{f_{\text{int}}}$$

Fig. 114: Drive-internal position resolution

Δx_d Drive-internal position resolution

s_p Linear scale system signal period (S-0-0116 Resolution of encoder 1)

f_{int} Multiplication factor (S-0-0256, Multiplication 1)

The drive-internal position resolution is not identical to the reachable positioning accuracy.

Reachable positioning accuracy

The reachable position accuracy depends on the mechanical and control-engineering total system and is not identical to the drive-internal position resolution.

The reachable position accuracy can be estimated as follows (using empirical values):

$$\Delta x_{abs} = \Delta x_d \times 30...50$$

Fig. 115: Estimating the reachable position accuracy

Δx_{abs} Position accuracy

Δx_d Drive-internal position resolution

Prerequisites: Optimum controller setting

The expected position accuracy cannot be better than the smallest position command increment of the superordinate control.

8.21.2 Velocity resolution

The resolution of the velocity is proportional to the position resolution (see Abb. 114) and inversely proportional to the cycle rate t_{AD} from:

$$\Delta v_d = \frac{\Delta x_d}{t_{AD}}$$

Fig. 116: Velocity resolution

Δv_d Velocity resolution in m/s
Δx_d Drive-internal position resolution
t_{AD} Cycle rate in s (IndraDrive:Basic Performance 250 µs / Advanced 125 µs)

8.22 Thermal connection - Installation modes

An effective heat loss dissipation is a prerequisite for achieving the specified motor data. The amount of heat loss in the motor is largely determined by the utilization rate of the motor. How well or how quickly the heat loss can be dissipated determines the performance of the motor.

If the heat of the motor cannot be sufficiently dissipated by means of natural convection, the heat introduction via the contact surfaces into the machine construction is increased. Particularly high heat dissipation is achieved if the contact surfaces of the primary and secondary parts are combined with a highly heat-dissipating machine construction.

In this connection, please observe that an increased heat introduction into the machine construction has a negative impact on the achievable accuracy. During design of a system with maximum accuracy, the operating temperature of the motor winding is decisive.

With increasing winding temperature, the emitted heat of the machine is also increased. If the temperature level of the machine has to be kept at a constant level, the motor should be sufficiently dimensioned or equipped with machine-side cooling.

If the contact surfaces of the motor components, particularly of the primary part, are made of a material with low heat conductivity (e.g. plastic), a reduction in motor performance has to be expected.

In general, the heat dissipation must be increased proportionally with the size and frame length and the respectively higher power loss of the motor if the same utilization capacity of the motor is to be achieved.

For this reason, observe maximum heat dissipation of motor components when designing the machine. Only this way optimum dissipation of the emitted heat of the motor via the surrounding machine components can be ensured.

The following specifications serve as reference to estimate the required motor performance data depending on the thermal connection of the motor. The illustrated installation modes can be selected and taken into account for motor controller dimensioning in IndraSize and for commissioning in IndraWorks.

For planning, the catalog data specified in ➦ Chapter 3 are applied. These apply for optimum thermal connection of primary and secondary part at 20 °C to the contact surface and the environment. This installation mode is referred to with "A".

Table 56: S1 current depending from the motor setup

Motor layout	S1 current in A	% of S1
Primary and secondary part structure with high heat conductivity	3.61	100
Secondary part structure with insulation	3.14	87
Primary part structure with insulation	2.83	78
Primary and secondary part structure with insulation	2.13	59

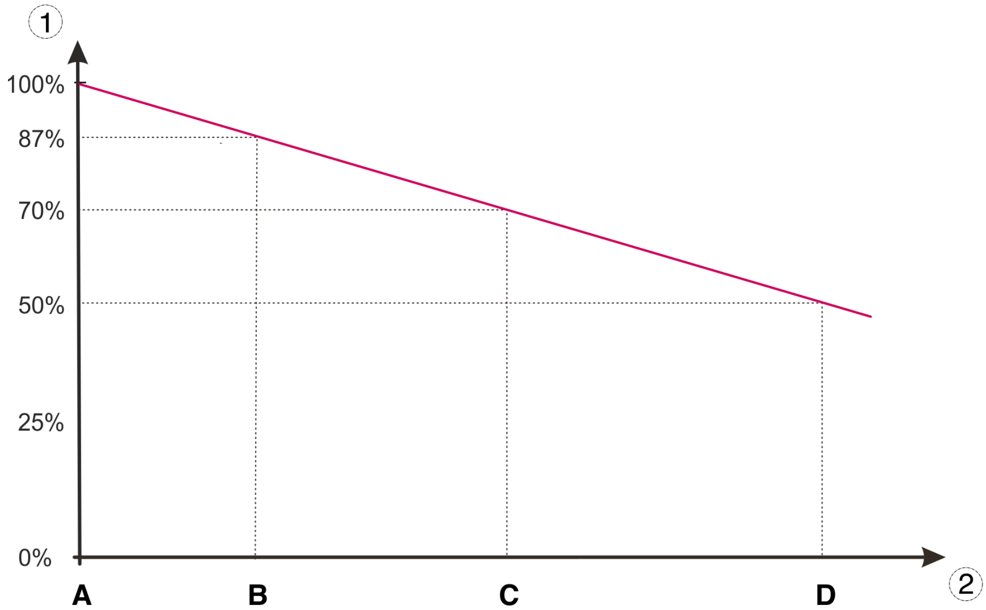
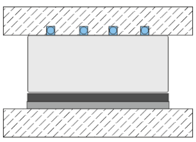
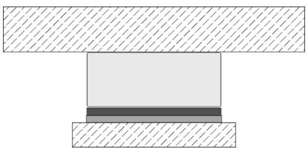
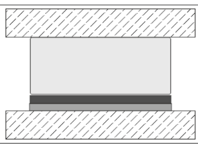
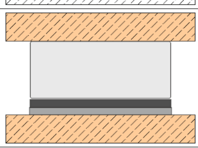


Fig. 117: Motor force dependent on thermal connection

① Available motor force
② Installation mode

Table 57: Explanation of installation modes

Installation mode	Schematic illustration	Description
A		**Installation mode** A requires **good thermal connection** of the motor in combination **with additional cooling**. Regarding the structure of the contact surfaces at the machine, a metal surface with high conductivity is required. The temperature of the contact surface is 20 °C The technical data for this installation mode is specified in ➦ Chapter 3
B		**Installation mode** B requires **good thermal connection** of the motor to the machine. The assembly surface of the motor must be fully applied at the contact surface of the metal fitting element of the machine. The fitting element of the machine must be large enough to ensure sufficient cooling.
C		**Installation mode** C requires moderate thermal heat dissipation with good thermal connection to the machine. The assembly surface of the motor must be fully applied at the contact surface of the metal fitting element of the machine.
D		**Installation mode** D assumes unfavorable thermal connection to the machine, e.g. if the installation surface of the motor is partly fitted with thermal insulation or the connection to the machine does not cover the entire surface.

8.23 Operation at or near motor standstill

If the motor is to be operated at standstill or near standstill, special conditions apply. For means of simplification, this operation is indicated as standstill operation in the following. The standstill operation is marked by one of the following aspects:

- The duration of the standstill operation is longer than 10 % of the respective thermal time constant T_{th}.
- Motor does not move
- Motor performs only very small strokes (≤ 2 * τ_p)
- Motor moves only at very low frequency (f ≤ 0.1 Hz)

Due to the 3-phase system, during standstill operation in one of the three phases there is always an instantaneous value of the current, the amount of which is higher than the permissible continuous current. Does the current flow continuously, the motor will overheat (see➦ Chapter 8.10).

The peak value of the instantaneous current is equal with the amplitude of the sinusoidal assumed phase current. Its value is higher by root 2 than the effective value of the continuous current (I_N). The power loss P_V, created in the coil, is calculated using

$$P_V = 1{,}5 \times I^2 \times R_{12} \times \left(1 + \Delta\vartheta \times \alpha_{Cu}\right)$$

Fig. 118: Power loss coil

$\Delta\vartheta$ Temperature difference between operation temperature and 20 °C

α_{Cu} Temperature coefficient of the specific resistance of copper = 0.0039 Ohm * m / mm²

For the nominal current, a double power loss occurs in the affected coil.

NOTICE	To avoid damaged winding in standstill operation, limit the current or the operation duration. A possible form of an additional motor protection is the limitation of the motor current to **71% of the nominal current.**

8.24 Motor-control combination

8.24.1 General

The technical data and the figure of the motor characteristics of several motors is displayed in➦ Chapter 3.

A dimensioning and selection of individual motors must be done in Gantry arrangement.

8.24.2 IndraSize

By using the IndraSize software, drive controllers, motors and mechanic gearboxes can be easily sized. The engineering tool covers the entire range of Rexroth drives and motors. Calculate the characteristic curves for your application by using the sizing and calculation tool IndraSize: ➦ www.boschrexroth.com/IndraSize

8.24.3 Operation with third-party controllers

Rate of rise of voltage

The electrical insulationInsulation system of the motor is subject to a higher dielectric load in converter mode than when it is operated with a merely sinusoidal source voltage. The voltage load of the winding insulation in converter mode is mainly defined by the following factors:

- Crest value of voltage
- Rise time of pulses at the motor terminals
- Switching frequency of final converter stage
- Length of power cable to the motor

Main components are the switching times of the final converter stage and the length of the power cable to the motor. The rates of rise of the voltage occurring at the motor may not exceed the pulse voltage limits specified in DIN VDE 0530-25 (VDE 0530-25): 2009-08 (picture 14, limit curve A), measured at the motor terminals of two strands in relation to the rise time.

These limits are complied with by the final stages of Rexroth converters.

9 Handling, transport and storage

9.1 Scope of delivery

The total scope of delivery can be seen from the delivery note or the accompanying document. The content, however, can be delivered in several packages. Each package can be identified by a forwarding label.

Compare the ordered and delivered types after receipt of the goods. Reclaim deviations immediately.

9.2 Delivery status and packaging

9.2.1 Scope of delivery

The total scope of delivery can be seen from the delivery note or the accompanying document. The content, however, can be delivered in several packages. Each package can be identified by a forwarding label.

Compare the ordered and delivered types after receipt of the goods. Reclaim deviations immediately.

9.2.2 Packaging

Preferably use the original package for storage, transport and when using the motor components. In particular, keep the packaging of the secondary part for later use for reasons of work and transport safety.

9.2.3 Primary parts

The primary parts are individually packaged in a box. For identification, the package is marked with a label similar to the type plate with the type designation of the primary part.

9.2.4 Secondary parts

The secondary parts are individually packaged in a box. For identification, the package is marked with a label similar to the type plate with the type designation of the secondary part. On delivery, the secondary parts are fitted with magnetic transport and assembly protection. It consists of a rubber mat with a thickness of approx. 5 mm connected with a ferromagnetic cover plate.

For safety reasons, the transport and assembly protection should not be removed from the ML3S until installation. When using the protection cover, make sure that the rubber side is always in contact with the magnets.

Warning notes on the packaging of the secondary parts

A warning sign on the package of secondary parts indicates hazards due to strong magnetic fields after opening of the packaging.

Bosch Rexroth offers an additional sign for attachment in the respective area. For further information, refer to ➡ Chapter 6.4, Magnetic fields label.

9.3 Testing of motor components

9.3.1 Factory checks

Electrical testing

During manufacturing, the following electrical tests are performed at linear motors of Bosch Rexroth:

- High-voltage test acc. to EN 60034-1:2010 + Cor.:2010
- Insulation resistance test acc. to EN 60204-1:2018
- Testing for compliance with electrical characteristics

Mechanical testing

Linear motor components of Bosch Rexroth are subject to the following mechanical testing:

- Shape and position tolerance according to DIN ISO 1101
- Construction and fitting according to DIN 7157
- Surface structure according to DIN ISO1302
- Thread testing DIN 13 part 20

NOTICE	Destruction of motor components due to improperly executed high-voltage testing! Loss of warranty! – Avoid repeated inspections. – Comply with the guidelines of EN 60034-1:2010 + Cor.:2010.

Magnetic testing

Linear motor components with permanent magnets from Bosch Rexroth are checked for correct pole arrangement before delivery.

9.3.2 Tests by the customer

Since all motors are subjected to a standardized test procedure, high-voltage tests by the customer are not necessary. Motors and components could be damaged if they are subjected to repeated high-voltage tests.

NOTICE	Destruction of motor components due to improperly executed high-voltage testing! Loss of warranty! – Avoid repeated inspections. – Comply with the guidelines of EN 60034-1:2010 + Cor.:2010.

9.4 Notes about transport

⚠ CAUTION	Strong attractive forces on the permanent magnets on the secondary part! Risk of injury and danger of crushing body parts by magnetic forces! Please note the safety instructions ➦ Chapter 2.4.3 Protection against magnetic and electromagnetic fields on page 24 and ➦ chapter. 2.4.4.

9.4.1 Environmental conditions

Environmental conditions during transport

Transport our products only in their original package. Also refer to the specific ambient factors to protect the products from transport damage.

Based on EN IEC 60721-3-2:2018, the tables below specify classifications and limit values which are allowed for our products while they are transported by land, sea or air. Refer to the detailed description of the classifications to take all of the factors which are specified in the particular class into account.

Table 58: Allowed classes of environmental conditions during transport according toEN IEC 60721-3-2:2018

Classification type	Class
climatic environmental conditions	2K11
environmental conditions	2B1
classification of chemically active materials	2C1
classification of mechanically active materials	2S5
climatic environmental conditions	2M4

For a better overview, some essential environmental influencing variables of the previously mentioned classifications are listed. Unless otherwise specified, the values given are the values of the particular class. However, Bosch Rexroth reserves the right to adjust these values at any time based on future experiences or changed environmental factors.

Table 59: Permissible ambient conditions deviating from EN IEC 60721-3-2:2018

Environmental factor	Unit	Value
Temperature	°C	-25 ... +70[1)]
Relative air humidity	%	5 ... 75[1)]
Absolute air humidity	g/m^3	1 ... 29[1)]
1) Deviating from EN IEC 60721-3-2:2018		

Before transport, discharge the liquid coolant from liquid-cooled motors to avoid frost damage.

9.4.2 Transport to the machine (internal)

⚠ CAUTION

Risk of injuries and / or damage when handling secondary parts of synchronous linear motors!

- When handling secondary parts, please observe the warnings under ➡ Chapter 2.4.4 and make sure that they are kept.
- Remove the transport and assembly protection of the secondary parts just before or during the assembly. Make sure that no small ferromagnetic parts like screws get into contact with the magnets or secondary parts.

- The ML3 motor components can be transported by hand. The mass of the single components is 0.6 kg up to 18.2 kg, depending from their frame size.
- Transport the secondary part in its original packing to the place of assembly and let it be packed until it must be mounted. Store the original packing after assembly of the secondary part for further use (e.g. re-storage or return). Observe a proper state and good visibility of the affixed warning notes.

NOTICE

Never touch the connection points of electrostatic sensitive devices!

Mounted components (e.g. KTY) can contain parts susceptible to electrical discharge (ESD).

Observe ESD safety measures.

⚠ WARNING

Material damage due to improper handling during transport!

Do not lift or move the primary part on the cable strand.

9.4.3 Transport by air freight

Instructions on transport by air

⚠ CAUTION	**Possible influence of plane electronic on board through magnet fields!** If rmotor components are not forwarded in the unopened Rexroth original packaging, applicable packaging and transport regulations must be observed (IATA 953).

This involves, for example:

- Secondary parts of synchronous linear motors
- Rotors of synchronous kit motors
- Rotors of synchronous housing motors (if these are dispatched as motor component, i.e. separate from the stator or motor housing, in service cases)

For details on the maximum allowed magnetic field strengths as well as information on measurement methods for these magnetic field strengths, please refer to the current IATA DGR.

9.5 Storage instructions

9.5.1 Notes about storage of ML3P and ML3S

Environmental conditions during storage

NOTICE

Damage or destruction of motor components due to improperly handling during storage and transport!

– Use the original packaging for permanent storage.
– Observe the permitted environmental conditions for storage.
– Covers fitted to the motor at the factory must remain on the motor during transport and storage.

Generally, Bosch Rexroth recommends storing all components until they are actually installed in the machine as follows:

- in their original packaging
- at a dry and dustfree location
- at room temperature
- free from vibrations and oscillations
- protected against light or direct sunlight

Based on EN IEC 60721-3-1:2018, the tables below specify classifications and limit values which are allowed for our products while they are stored. Refer to the detailed description of the classifications to take all of the factors which are specified in the particular classification into account.

Table 60: Allowed classes of environmental conditions during storage according to EN IEC 60721-3-1:2018

Classification type	Class
Classification of climatic environmental conditions	1K21
Classification of biological environmental conditions	1B1
Classification of chemically active materials	1C1
Classification of mechanically active materials	1S10
Classification of mechanical environmental conditions	1M11

For a better overview, some essential environmental influencing variables of the previously mentioned classifications are listed. Unless otherwise specified, the values given are the values of the particular class. However, Bosch Rexroth reserves the right to adjust these values at any time based on future experiences or changed environmental factors.

Table 61: Permissible ambient conditions deviating from EN IEC 60721-3-1:2018

Environmental factor	Unit	Value
Air temperature	°C	-25 ... +55[1)]
Relative air humidity	%	5 ... 75[1)]
Absolute air humidity	g/m^3	1 ... 29[1)]
1) Deviating from EN IEC 60721-3-1:2018		

9.5.2 Notes about storage time

Storage times of motors and cables

Additional measures have to taken upon commissioning to ensure smooth functioning – irrespective of the storage time which may be longer than the warranty period of our products. However, this does not entail any additional warranty claims.

Table 62: Measures before commissioning motors that have been stored over a prolonged period of time

Storage time	Measures prior to commissioning
< 1 year	Visual inspection of all parts to be damage-free
1 ... > 5 years	Visual inspection of all parts to be damage-free Check the electric contacts to verify that they are free from corrosion Measure insulation resistance. Dry the winding at a value of < 1kOhm per volt rated voltage.

Table 63: Measures before commissioning of cables and connectors that have been stored over longer periods of time

Storage time	Measures prior to commissioning
< 1 year	None
1 ... 5 years	Check the electric contacts to verify that they are free from corrosion
> 5 years	If the cable or the cable jacket has porous parts, replace it; otherwise check the electric contacts to verify that they are free from corrosion

10 Assembly

10.1 Basic precondition

The machine manufacturer has to consider the special character of his construction and must work out special mounting instructions for the motor components primary and secondary part. The machine manufacturer's mounting instructions are the only binding guidelines.

The range and order of installation of motor components is depending on the machine construction or the available space in the machine. Also, the arrangement of the motor components plays a significant role.

The following information represents a suggestion for mounting the motor components. This suggestion can be understood as a guideline to estimate the necessary assembly effort and to prepare the necessary implements for assembly.

The following points must be considered or checked before starting the assembly work:

- Observation of the necessary installation dimensions
- Machine construction fulfills the requests for mounting (stiffness, attractive force, feed and acceleration force, etc.) and is prepared for installation of the motor components.
- Clean screw-on surfaces between machine and motor components
- Installation of motor components by skilled personnel only
- Compliance of danger and safety notes is guaranteed.

10.2 Air gap and aligning

Parallelism and symmetry

When mounting primary and secondary parts, their position is specified by the holes or threads within the machine slide and prepared within the machine bed. If all installation dimensions were adhered to, the correct arrangement of both motor components to each other results. Take the values of installation dimensions from the following table ➦ Tab. 64 and ➦ Tab. 65.

The exact dimensions and specifications for form and position tolerances can be taken from Fig. 120

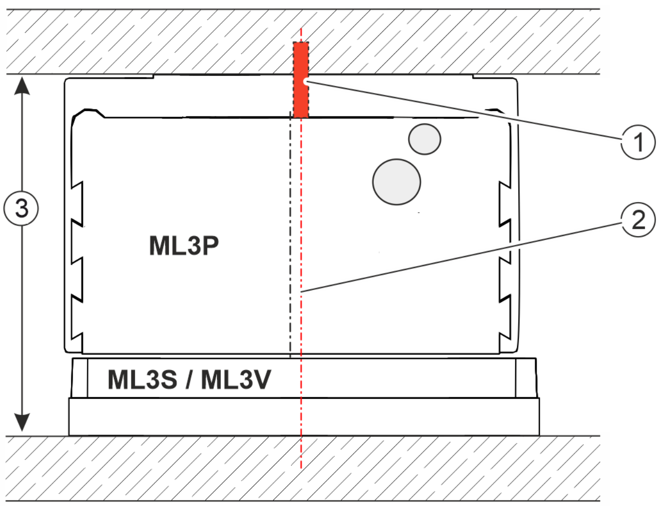


Fig. 119: Aligning the motor components
① Dowel holes within the primary part
② Magnetic and mechanic center line of the magnetic plate
③ Installation height

The primary part is not symmetrically placed over the secondary part, as the winding within the primary part is not centered.

Installation height

Due to keeping the specified installation height at the bottom of the secondary part up to the top of the primary part, the necessary air gap arises and the motor reaches its projected power data.

NOTICE	**Motor damage due to insufficient air gap between primary and secondary part!** After assembly, check the free movement of the motor components to each other immediately. Therefore, move the versatile motor components by hand over the complete travel length. The versatile motor components must be freely movable at each position over the total travel length - without any contact to fixed motor components. This check can detect faulty assembly in time (e.g. dirt under the assembly surfaces, faulty installation dimensions, insufficient machine rigidity etc.).

The following specifications on the air gap refer to the use of secondary parts ML3S without cover plate and ML3V with pre-assembled cover plate.

If cover plates are used for ML3S, the air gap must be increased by the thickness of the cover plates ➦ Installation height with cover plate (option for ML3S only) on page 156Tab. .

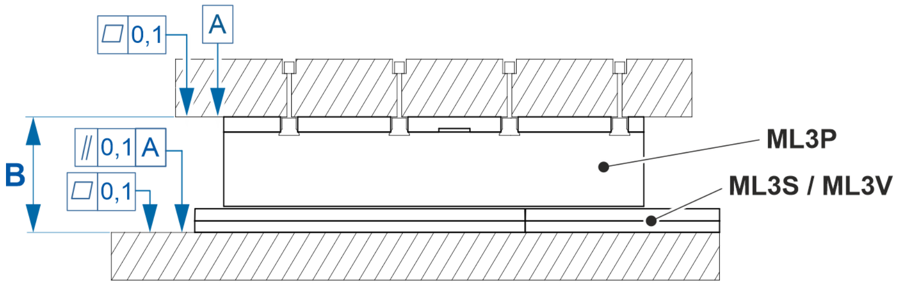


Fig. 120: Values for levelness and parallelism
B Installation height

Table 64: Installation height ML3 motors without cover plate

Frame size	Installation height B
ML3P03 and **ML3S03**	40 mm ± 0.1 mm
ML3P06 and **ML3S06**	40 mm ± 0.1 mm
ML3P11-D, -E, -F, -H, -L and **ML3S11**	45 mm ± 0.1 mm
ML3P11-R and **ML3S11**	47 mm ± 0.1 mm
ML3P03 and **ML3V03**	44.3 mm ± 0.1 mm
ML3P06 and **ML3V06**	tbd

Installation height with cover plate (option for ML3S only)

The plate dimensions are to be selected according to the following table:

Table 65: Installation height ML3 motors with cover plate

Frame size	Cover plate		Installation height “B” with cover plate
	Thickness	Width	
ML3P03 and **ML3S03**	0.1 ± 0.02 mm	50 mm (49.8 - 50.5 mm)	40.12 ± 0.1 mm
ML3P06 and **ML3S06**		80 mm (79.8 - 80.5 mm)	

Frame size	Cover plate		Installation height "B" with cover plate
	Thickness	Width	
ML3P11-D, -E, -F, -H, -L and ML3S11	0.15 ± 0.02 mm	130 mm (129.8 - 130.5 mm)	45.17 ± 0.1 mm
ML3P11-R and ML3S11			47.17 ± 0.1 mm

NOTICE

Damage or destruction of motor components due to use of cover plates!

– If the installation height of the motor is not adjusted when a cover plate is used (increased), motor components of the ML3 may be damaged or destroyed.
– The cover plate must be earthed according to the state of the art. The ML3S may not be used for this purpose.

Air gap

After assembly of the motor components, we recommend to check the minimum air gap between primary and secondary part.

For this reason, insert a test strip made of non-magnetic material (copper, plastics, etc.) with a thickness of

- 0.4 ... 0.5 mm

into the air gap between primary and secondary part. The test strip must be versatile in the air gap on every position of the total length via the complete surface of the primary part.

This measure ensures the minimum necessary air gap between the motor components. This check can detect faulty assembly in time (e.g. dirt under the assembly surfaces, faulty installation dimensions, insufficient machine rigidity etc.).

NOTICE

If the installation height and thus the height of the air gap is exceeded above the tolerances, this leads to an exponential deterioration of the linear motor specifications. A too small air gap can lead to damage or destruction of the motor.

ML3P encapsulation - increased air gap

When operating in a vacuum, the primary part ML3P must be encapsulated, as explained at the beginning. Therefore, additional installation space is required in the area of the air gap. This additional installation space must be added to the installation height "B" in ➦Tab. 64 and safely tolerated.

The encapsulation in the area between ML3P and ML3V increases the electromagnetically effective air gap. This leads to a reduction in feed and attraction forces and thus changes the characteristics of the engine's operating behavior. Please take this into account during project planning and selection of the motor components.

10.3 Assembly of secondary part segments

10.3.1 Assembly ML3S

⚠ WARNING	Danger due to permanent magnets! – Health hazard for persons with heart pacemakers, metallic implants and hearing aids in direct environment of permanent magnets. – Crushing hazard of fingers and hand due to heavy attractive forces of the magnets. – Risk of destruction of sensitive parts like watches, credit cards, ...

To fasten the secondary parts, it is only allowed to use new, unused screws.

– Only use specified screws (see ➦ Tab.). 66).
– Tighten all screws with the necessary tightening torque.
– Lock screw connection with Loctite 243, for example (observe the notes of the adhesive manufacturer).
– When using dowels, ensure that they do not protrude more than specified in the dimension sheets. The secondary part could be damaged.
– After assembly, check that there are no foreign objects on the secondary part.

Cleaning

Basically, the ML3 components (primary part and secondary part) do not require cleaning before assembly. If cleaning should nevertheless be carried out, use a dry cloth for this purpose. In addition, isopropanol or acetone may be used as a cleaning agent for the ML3V.

Before mounting the motor components to the machine structure, the screw-on surfaces must be cleaned and free of oil and grease.

Arrangement and fastening

Short distances consisting of a maximum of 6 ML3S can be built up by placing the secondary parts next to each other. If distances of more than 2m are provided or are analog Hall units used, ensure correctly aligned secondary parts by using dowel holes and dowel pins (also refer to ➦ Fig.). 4).

Table 66: Mounting screws with tightening torque for ML3S secondary part

Frame size	Screw size	Screw-in depths	Strength class	Tightening torque (+/- 10%)
ML3S03 ML3S06	M5x10 (DIN EN 7984)	min. 6.5 mm	8.8	6.1 Nm
ML3S11	M5x16 (DIN EN ISO 4762)			

The calculation of screw connection for fastening the secondary part are based on the assumption that the screwing surface of the secondary part and the screwing surface of the machine is clean and the secondary part is screwed in direct contact with the machine.

– In certain cases, it is not possible to screw the secondary part in direct contact with the machine as additional materials like distance plates, thermal grease and so on, are between the secondary part and the machine. Then a sufficient fastening of the screw connection must be ensured by the machine manufacturer.
– The effect of liquid screw lock is damaged by loosening or re-tightening of screws (e.g. due to torque tests) and must be renewed. Observe the instructions of the adhesive manufacturer about correct screw lock.

Dowels on ML3S

The dowel holes of the ML3 components are designed as free fit. For this reason, dowels cannot be pressurized into these holes. The dowel pin holes in the machine design should be designed as press fits in order to press in the dowel pins and thus be able to fix them securely.

Table 67: Dowels for ML3S secondary part

Frame size	Dowels (rust-free)
ML3S03 ... 11	5h8 (with internal thread M3 for disassembly)

When using dowels, ensure that they do not protrude more than specified in the dimension sheets. This can lead to damaged secondary parts.

Segmented secondary part

⚠ WARNING	**Risk of injuries or material damage due to attractive or repulsive force at concatenation of secondary part segments!** – Secure against uncontrolled movement – Observe correct concatenation of secondary part segments – Remove the transport or assembly protection only when or after mounting into the machine

If several secondary part segments are used over the whole travel length, keep the poles and the flush direction at concatenation according to the following figure.

A correct assembly can be ensured as follows:

1. Pressurize dowels into the holes of the machine bed.

   When using dowels, ensure that they do not protrude more than specified in the dimension sheets. This can lead to damaged secondary parts.

2. Place the secondary part in such a way that the dowels grab into the secondary part and set down slowly.

3. Fasten the secondary part with screws.

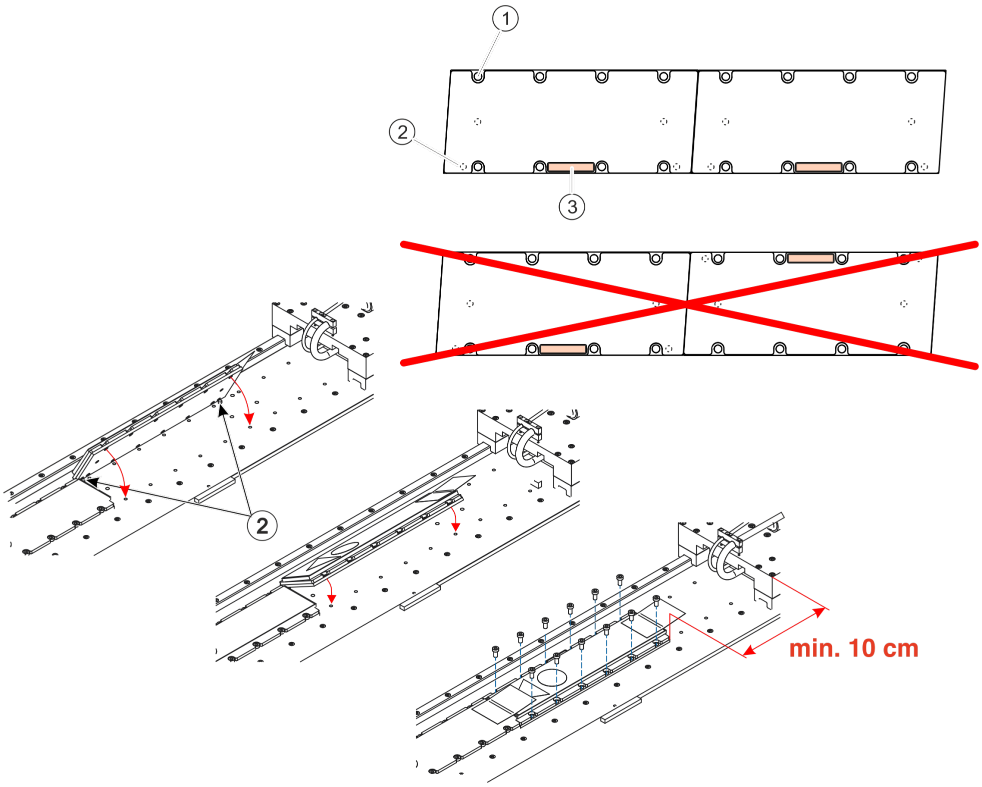


Fig. 121: Screw-on holes, dowel holes and reference marks

① Screw-on holes
② Dowel holes (blind hole at the bottom)
f Reference marks

4. As necessary, install additional secondary parts in the same order. The secondary part that is installed last must have a minimum clearance of 10 cm to the primary part.

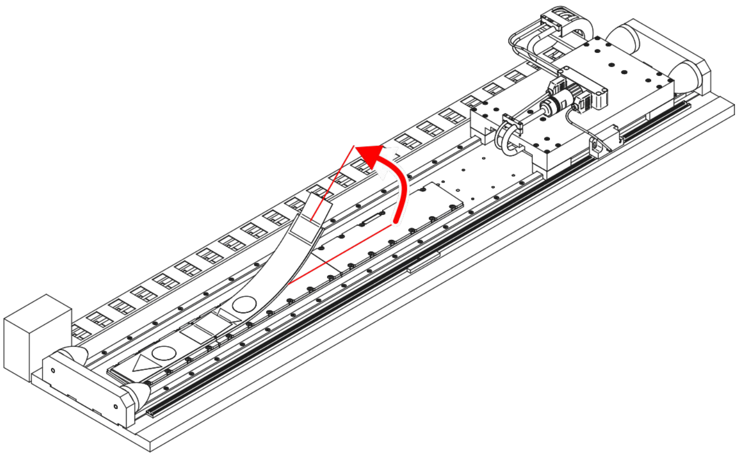


Fig. 122: Remove protective plates

5. Remove the transport and assembly protection from installed secondary parts.

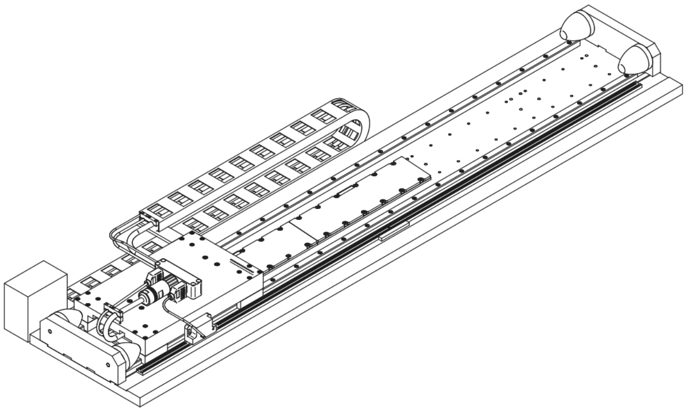


Fig. 123: Secure the slide

6. Position the slide with the primary part over the assembled secondary part and lock it against unintended movement.
7. Assemble the remaining secondary parts according to working step 1 - 3.
   Afterwards, remove the transport and assembly protection.

10.4 Cover plate installation (option for ML3S)

10.4.1 Notes

Acc. to ➦ Chapter 8.12.4, Protection of the motor installation space , a stainless-steel cover plate can be installed at the ML3S for protection against dirt.

If cover plates are used, it must be ensured that the required air gap between the motor components is maintained. To achieve this, the installation height must be increased by the thickness of the cover plate. Please also observe the information provided in ➦ Chapter 6.3.

Tools required for installation:

- Safety gloves
- Cutter for cutting of the strip
- Measuring device for testing of the shielding

⚠ CAUTION	**The stainless steel cover strip may have sharp corners and edges!** Wear protective gloves when handling the cover plate.

10.4.2 Installation

A cover plate can be installed after removal of the transport and assembly protection at the ML3S. Make sure that the entire length is clear. Due to the high magnetic attraction, the cover strip is firmly attached to the magnetic plates. To position the strip, unroll it. Respectively, roll it up to remove it.

Unrolling and rolling up of the strip should be performed by two persons.

1. If not already done, remove the transport and assembly protection from the ML3S.
2. Position the slide at one end of the axis to uncover the majority of the magnetic strip.

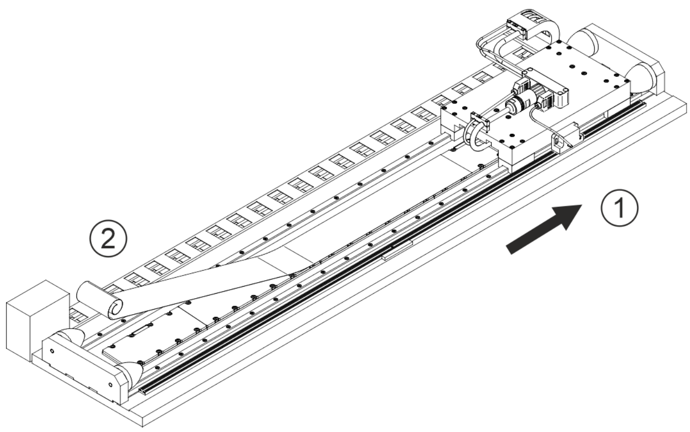


Fig. 124: Cover plate assembly 1v3

3. Unroll the strip over the free part of the magnetic strip.
4. Move the slide to the center of the axis

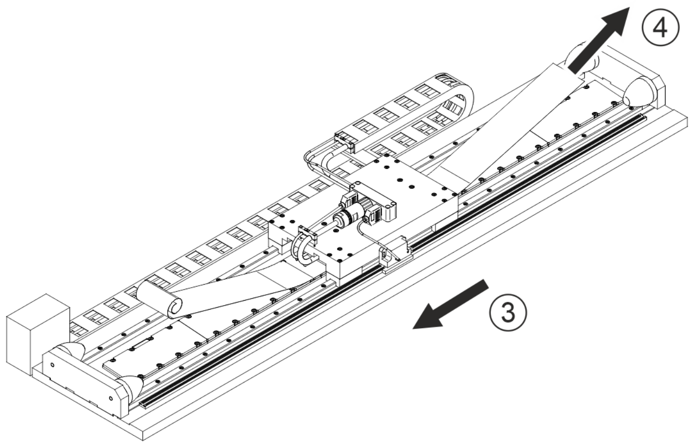


Fig. 125: Cover plate assembly 2v3

5. Pull up the two ends of the cover strip in such a way that only a small section of the strip (under the slide) is in contact with the magnetic strip.

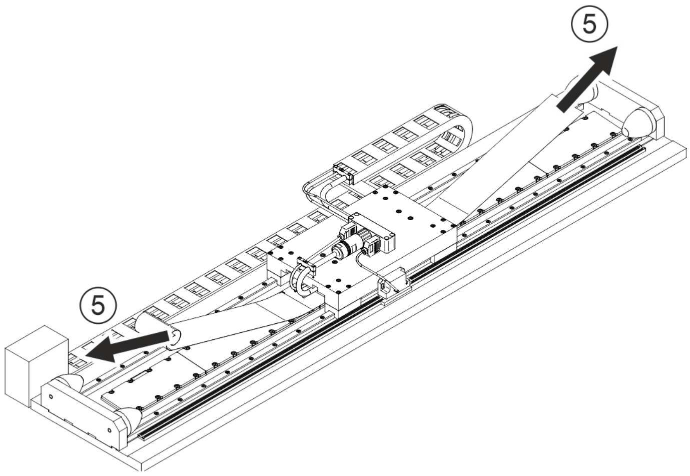


Fig. 126: Cover plate assembly 3v3

6. In this position, the cover strip can be moved over the magnetic strip. Position the strip in such a way that small sections protrude on both sides.

   Make sure that the magnets are mounted at a slight angle. The cover strip must be cut off in this angle to ensure flush alignment with the end of the magnetic strip.

7. Remove any excessive length and precisely align the strip. The cover strip should at least reach up to the end of the magnetic plates.

   The magnetic strip does not serve as conductive grounding connection of the cover strip. Ensure grounding in accordance with the machine safety standard and check this before commissioning.

10.5 Assembly of primary parts

To fasten the primary part, only new, unused screws must be used.

- Do only use screws specified in ➦ Tab. 68
- Tighten all screws with the necessary tightening torque.
  In addition, each screw connection must be secured, e.g. with Loctite 243 (follow the instructions of the adhesive manufacturer).
- When using dowels, ensure that they do not protrude more than specified in the dimension sheets. The primary part could be damaged.
- After assembly, check if any foreign bodies exist between primary and secondary part.

Cleaning

Basically, the ML3 components (primary part and secondary part) do not require cleaning before assembly. If cleaning should nevertheless be carried out, use a dry cloth for this purpose. In addition, isopropanol or acetone may be used as a cleaning agent for the ML3V.

Before mounting the motor components to the machine structure, the screw-on surfaces must be cleaned and free of oil and grease.

Fastening screws

Table 68: Mounting screws with tightening torque

Frame size	Screw size	Screw-in depths	Strength class	Tightening torque (± 10 %)
ML3P03	M4 (DIN EN ISO 4762)	min. 4 mm	8.8	3.1 Nm

Frame size	Screw size	Screw-in depths	Strength class	Tightening torque (± 10 %)
ML3P06	M5 (DIN EN ISO 4762)	max. 5 mm		6.1 Nm
ML3P11	M5 (DIN EN ISO 4762)	min. 4.5 mm max. 6 mm		6.1 Nm

Dowels

Table 69: Dowels for ML3P primary part

Frame size	Dowels (rust-free)
ML3P03 ... 11	5h8 (with internal thread M3 for disassembly)

The dowel holes of the ML3 components are designed as free fit. For this reason, dowels cannot be pressurized into these holes. The dowel pin holes in the machine design should be designed as press fits in order to press in the dowel pins and thus be able to fix them securely.

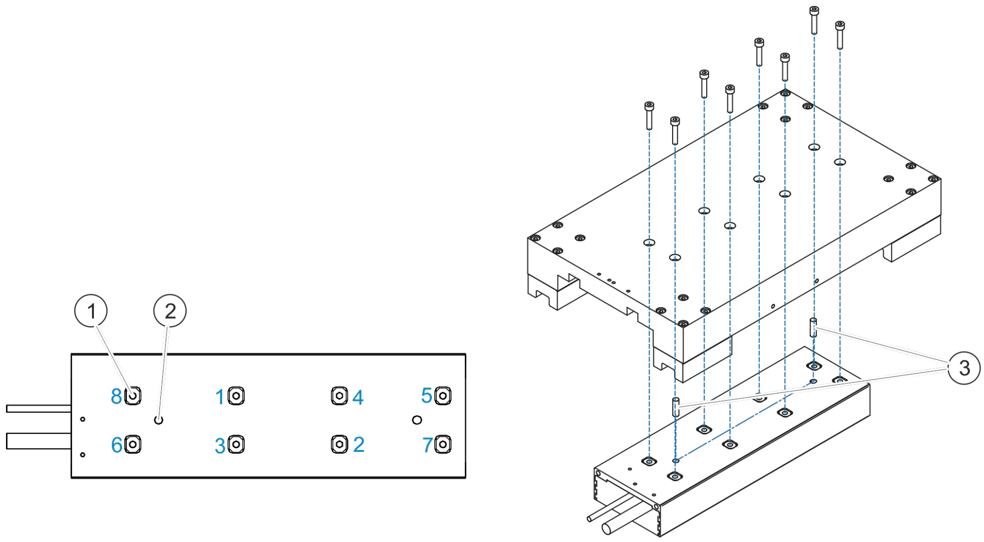


Fig. 127: Tightening sequence fastening screws of primary part

① Fastening tread
② Dowel holes (blind holes)
③ Dowels
1 / 2 / 3 ... Tightening sequence

The screw-on surfaces must be cleaned and be free of grease before the primary parts can be screwed on the machine construction.

Mounting instructions:

1. Pressurize dowels into the holes of the machine construction.
2. Place the primary part in such a way that the dowels grab into the primary part and set down slowly.

   NOTICE When using dowels, ensure that they do not protrude more than specified in the dimension sheets. This can lead to damage of the primary part.
3. Fasten the primary part with screws 1, 2, 3 ...x crosswise until the primary part is in contact with the slide.
4. Tighten all screws in the same tightening sequence with the nominal tightening torque.

The effect of liquid screw lock is damaged by loosening or re-tightening of screws (e.g. due to torque tests) and must be renewed. Observe the instructions of the adhesive manufacturer about correct screw lock.

10.6 Hall unit installation (option)

10.6.1 Analog Hall unit

The preferred installation position of the Hall unit is at the slide at the front end of the primary part with the cable outlet (see Fig.). 128). The Hall unit is aligned at the side of the coil unit. For further installation positions and information on commutation or calculation of parameter P-0-0508, refer to ➦ Chapter 11.6.4.

For installation of the analog Hall unit at frame size MLP11, a spacer (see dimension "Z") is required between the Hall unit and the contact surface of the primary part.

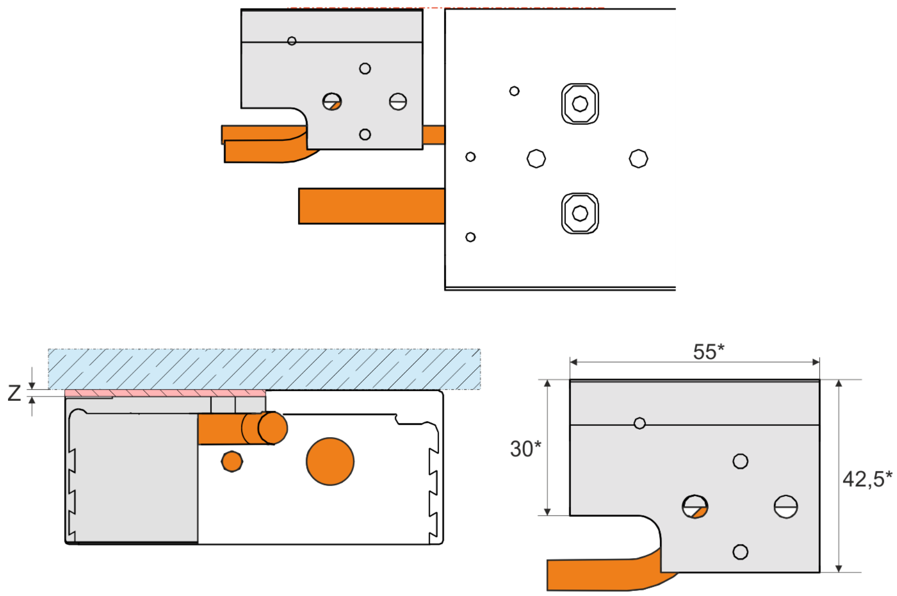


Fig. 128: Preferred installation position for the analog Hall unit

* For further dimensions and tolerances, see ➦ Chapter 6.1

Z Dimensions for spacer thickness

Table 70: Installation requirements of analog Hall unit

ML3P...	Spacer "Z"	Rotation to the motion axis	Alignment to the side of the primary part	Screws	Tightening torque (+/- 10%)	Dowel pins
03	-	0.5°	± 1 mm	M4	3.1 Nm	Ø 5 F8
06	-					
11-D...L	1					
11-R	3					

10.6.2 Digital Hall unit

The preferred installation position of the Hall unit is at the slide at the front end of the primary part with the cable outlet (see Fig.). 129). The Hall unit is aligned at the side of the coil unit. For further installation positions and information on commutation or calculation of parameter P-0-0509, see ➦ Kap. 11.6.4.

For installation of the digital Hall unit, a spacer (see dimension "Z") is required between the Hall unit and the contact surface of the primary part.

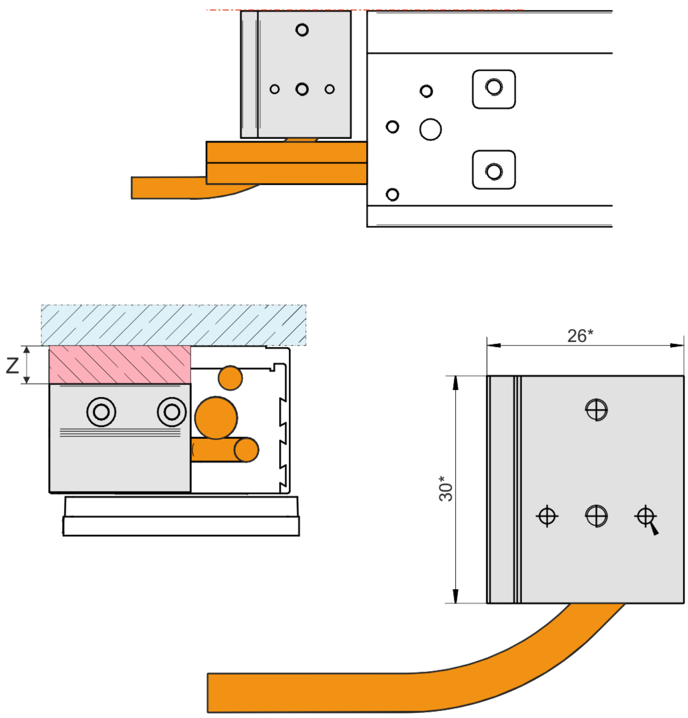


Fig. 129: Preferred installation position for the digital Hall unit

* For further dimensions and tolerances, see ➦ Chapter 6.1

Z Dimensions for spacer thickness

Table 71: Installation requirements of digital Hall unit

ML3P...	Spacer "Z"	Rotation to the motion axis	Alignment to the side of the primary part	Screws	Tightening torque (± 10%)	Dowel pins
03	8.4 mm	0.5°	± 1 mm	M3	1.3 Nm	Ø 5 F8
06	8.4 mm					
11-D...L	9.4 mm					
11-R	11.4 mm	tbd	tbd	tbd	tbd	tbd

10.7 Electrical connection

Connect the motor electrically according to the connection diagrams and the instructions in ➦ Chapter 7.3. Refer to the references to supplementary documentation.

- When using self-manufactured cables, ensure EMC-compliant design and installation.
- Where applicable, ensure that connectors and lines are fastened for strain relief purposes.
- The connection diagrams of the product documentation serve to create system circuit diagrams. Only the machine manufacturer's system wiring diagrams are relevant for the connection of the drive components in the machine.

11 Commissioning, operation and maintenance

11.1 General

In some points, commissioning of linear motors is different in comparison to rotary servo motors. These points are addressed in this chapter.

Further detailed information on commissioning is given in the parameter or application description of the drive controller used.

Example:

- Rexroth IndraDrive MPx-16 to MPx-21 and PSB Parameter description, MNR 911328651
- Rexroth IndraDrive MPx-16 Application description, MNR R911326767
- Rexroth IndraDrive MPx-17 Functions, MNR R911331236
- Rexroth IndraDrive MPx-18 Functions, MNR R911338673
- Rexroth IndraDrive MPx-20 Functions, MNR R911345606
- Rexroth IndraDrive MPx-21 Application description, MNR R911385759 (DE)

Parameters

Synchronous linear motors are kit motors whose single components are directly installed into the machine by the manufacturer – completed by an encoder system. As a result, kit motors do not feature any data memory to provide motor parameters, standard controller settings, etc. All parameters must be manually entered or loaded to the drive during commissioning. The IndraWorks commissioning program provides all Rexroth motor parameters.

Controller optimization

The procedure for controller optimization (current, velocity and position controller) at linear direct drives corresponds to the procedure for rotary servo drives. Only the setting limits of linear drives are higher. For example, this enables setting up to 10 times higher kv factors at linear direct drives in comparison to rotary servo drives. However, this requires a respective machine construction.

Moving masses

With controlled rotary servo drives, there are control limitations in the ratio of motor moment of inertia to load moment of inertia. This restriction does not apply for direct drives with linear motors: The moved external load depends on load of the motor itself.

Encoder polarity

The polarity of the actual velocity (length measuring system) must comply with the force polarity of the motor. Before commutation adjustment, this relation must be established.

Commutation adjustment

It is necessary at synchronous linear motors to receive the position of the primary part relating on the secondary part by return after start or after a malfunction. This is referred to as pole position detection or commutation adjustment. This means that the commutation adjustment is the establishment of a position reference to the electrical or magnetic model of the motor.

The commutation setting can only be made after the motor components and the linear encoder have been installed and is carried out according to the measuring principle of the linear encoder.

11.2 General requirements

11.2.1 General

The following requirements have to be met to ensure successful commissioning:

- Compliance with safety-related guidelines and instructions
- Check of electrical and mechanical components for reliable functioning
- Availability and provision of required tools
- Adherence to the commissioning procedure described below

11.2.2 Checking all electrical and mechanical components

Check all electrical and mechanical components prior to commissioning and pay particular attention to the following issues:

- Ensure safety for man and machine
- Correctly install the motor
- Correct power connection of the motor
- Connect connection of the length measuring system
- Ensure proper function of existing safety limit switches, door switches, etc.
- Ensure correct function of the emergency stop circuit and emergency stop.
- Ensure proper and complete machine construction (mechanical installation)
- Availability and function of suitable end position dampers
- Correct connection and function of the motor cooling system, where necessary
- Ensure correct connection and function of drive controller and control unit

11.2.3 Tools

IndraWorks commissioning software

The motors can be commissioned either directly via an NC terminal or via special commissioning software. The IndraWorks commissioning software allows menu-driven, custom-designed and motor-specific parameterization and optimization.

PC

For commissioning by means of IndraWorks, a conventional Windows PC is required.

Commissioning via NC

Commissioning via the NC control unit requires access to all drive parameters and functionalities.

Oscilloscope

An oscilloscope can be used for drive optimization. Alternatively, IndraWorks provides an individual drive-internal oscilloscope. This oscilloscope serves to display the signals which can be output via the adjustable analog outputs of the drive controller. Viewable signals include nominal and actual values of the speed, position or voltage, lag error, intermediate circuit, etc.

Multimeter

Troubleshooting and component checks can be facilitated by a multimeter allowing the measurement of voltage, current and resistance values.

11.3 General commissioning procedure

The following flow chart illustrates the general commissioning procedure for synchronous linear motors. The individual items are explained in more detail in the chapters following thereafter.

When using Bosch Rexroth controllers, make sure that firmware version MPx-20 V18 or higher is used.

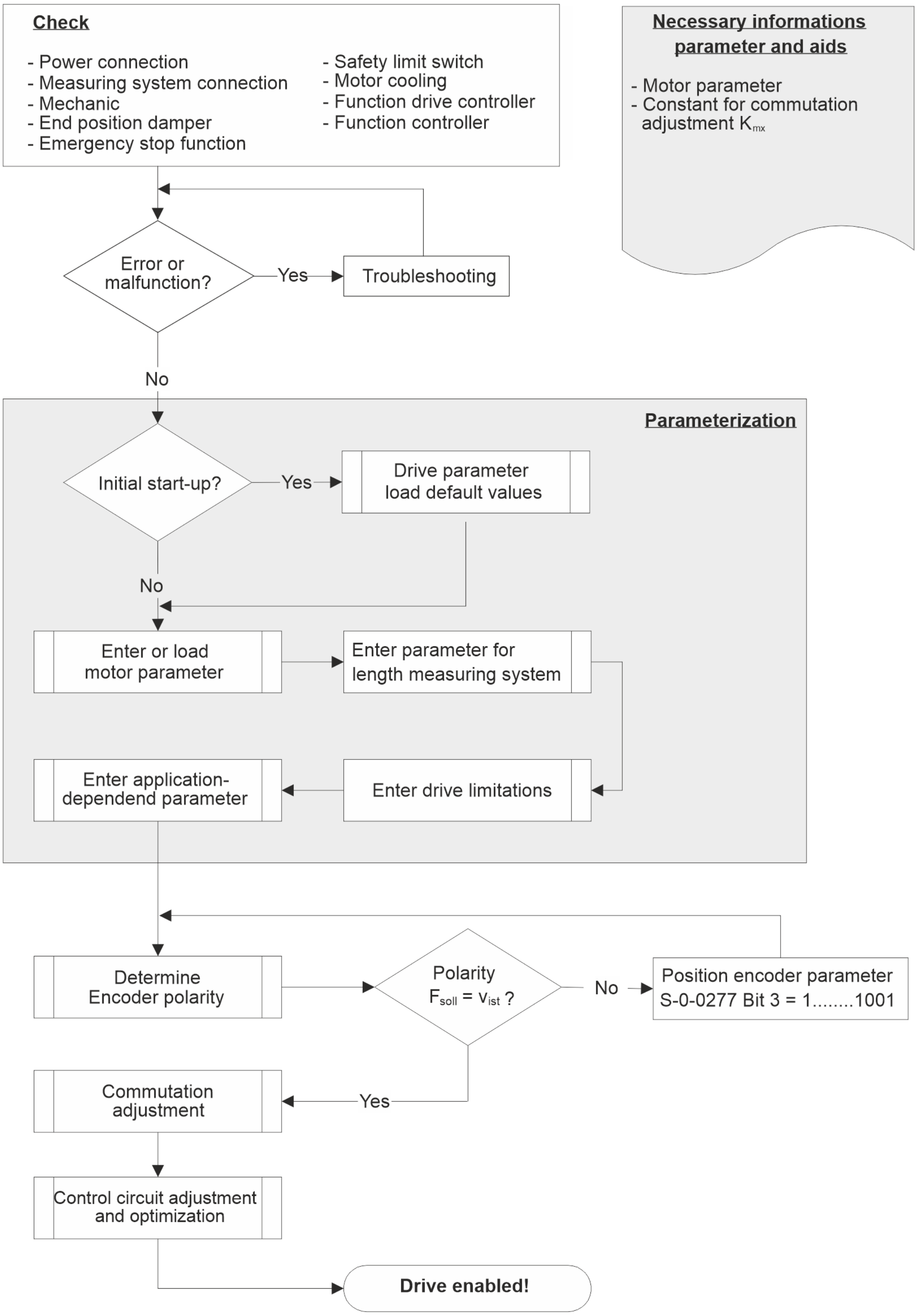


Fig. 130: General commissioning procedure for synchronous linear drives

11.4 Parameterization

11.4.1 General

IndraWorks allows entering or editing certain parameters and executing commands during commissioning by means of menu-driven dialogs and list representations or, optionally, via the control terminal.

Further detailed information on commissioning is given in the parameter or application description of the drive controller used.

Example:

- Rexroth IndraDrive MPx-16 to MPx-21 and PSB Parameter description, MNR 911328651
- Rexroth IndraDrive MPx-16 Application description, MNR R911326767
- Rexroth IndraDrive MPx-17 Functions, MNR R911331236
- Rexroth IndraDrive MPx-18 Functions, MNR R911338673
- Rexroth IndraDrive MPx-20 Functions, MNR R911345606
- Rexroth IndraDrive MPx-21 Application description, MNR R911385759 (DE)

11.4.2 Entering motor parameters

Motor parameters are specified by Rexroth and cannot be changed by the user. If these parameters are not available, commissioning is not possible! In this case, please contact your Rexroth Sales and Service Facility.

⚠ CAUTION	**Activation of the motor immediately after motor parameter input may result in injury and mechanical damage! The motor is not yet ready for operation simply by entering the motor parameters!** ⇒ Enter parameters for length measuring system ⇒ Check and adjust the measuring system polarity ⇒ Configure the commutation settings

The motor parameters can be entered as follows:

- Use IndraWorks to load all motor parameters.
- Enter the individual parameters manually via the controller
- Load a complete parameter set at serial machines via the controller or IndraWorks

11.4.3 Motor parameter at parallal arrangement

Are two linear motors operated in a control device, the following parameters have to be adjusted when commissioning:

Table 72: Parameter adjustment at parallel arrangement

Parameter	Designation	Adjustment factor
P-0-4016	Direct-axis inductance of motor	x 0.5
P-0-4017	Quadrature-axis inductance of motor	x 0.5
P-0-4048	Motor winding resistance	x 0.5
S-0-0106	Current loop proportional gain 1	x 0.5
S-0-0109	Motor peak current	x 2
S-0-0111	Motor current at standstill	x 2

A smaller controller can be used, if the maximum possible continuous nominal force or the maximum possible peak force of the motor is not required. In this case, re-adjust the configured currents to the selected controller. Therefore, use Rexroth IndraSize (see ➦Chapter). 8.24.2).

11.4.4 Entering length measuring system parameter

Encoder type

Depending on the encoder system, the parameters have to be defined. By means of parameter S-0-0602.x.1, Encoder type.

Table 73: Encoder parameters

Encoder parametrization	S-0-602.1.1	S-0-602.2.1
Incremental measuring system	2	-
Absolute encoder with ENDAT interface	6	-
Incremental measuring system with digital Hall unit	23	-
Incremental measuring system with analog Hall unit	2	16

Detailed descriptions can be found in the firmware or parameter description of the drive controller used.

– Rexroth IndraDrive MPx-16 to MPx-xx Parameter description, MNR R911328651
– Rexroth IndraDrive MPx-16 Application description, MNR R911326767

Signal period

Linear scale for linear motors generate and interpret **sinusoid signals**. The signal period has to be entered in parameter S-0-0602.x.3, Resolution of feedback 1.

Please also observe the information provided by the measuring system manufacturer for resolution of encoder signals.

11.4.5 Entering drive limitations and application-related parameters

Drive limitations

The drive limitations that can be set, include:

- Current limitation
- Force limitation
- Velocity limitations
- Travel range limitations

Application-related parameters

Application-related drive parameters include, for example, parameterization of the drive fault reaction.

Detailed descriptions can be found in the firmware or parameter description of the drive controller used.

11.5 Determining the polarity of the linear scale

In order to avoid direct feedback in the velocity control loop, the effective direction (travel direction) of the motor force and the count direction of the length measuring system must be identical.

⚠ CAUTION	**Different effective directions of motor force and count direction of the encoder system cause uncontrolled movements of the motor upon switch-on!** ⇒ Secure against uncontrolled movement ⇒ Setting of the effective direction of the motor force identically to the counting direction of the length measuring system

Effective direction of motor force

The following applies for setting of the correct encoder polarity:

The effective direction of the motor force is always negative in the direction of the cable connection of the primary part.

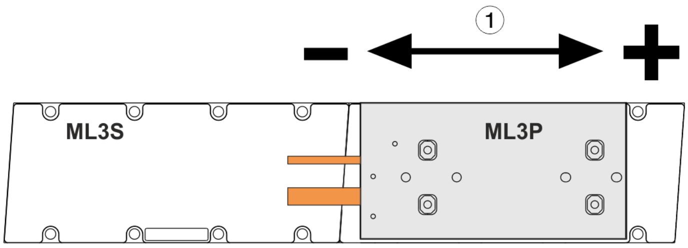


Fig. 131: Effective direction of motor force
1 Force direction

Effective direction of the motor force = Counting direction of the length measuring system

In case of motion of the primary part in the direction of the cable connection, the counting direction of the length measuring system must also be negative:

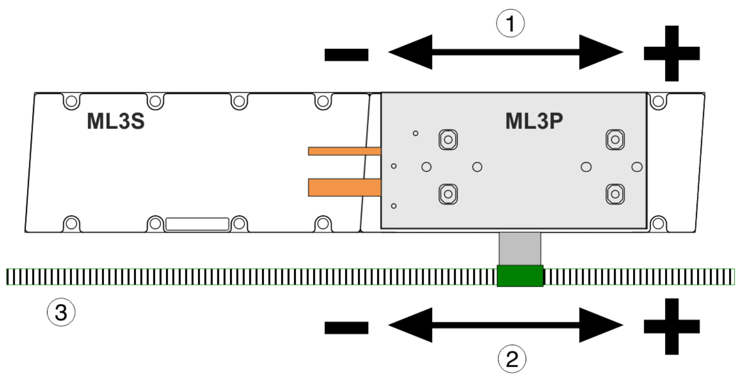


Fig. 132: Effective direction of the motor force = Counting direction of the length measuring system
1 Force direction
2 Counting direction
3 Length measuring system

The encoder polarity is always set in regard to the primary part (cable connection). The installation direction or pole sequence of the secondary part does not have any impact on the encoder polarity setting.

Setting the encoder polarity

Setting via parameter **S-0-0277, Position encoder type 1 (Bit 3)**.

Position, velocity and force data must not be inverted when the length measuring system count direction is set:

S-0-0602.x.1, Encoder type

S-0-0085, Torque/force polarity parameter: 0000000000000000

S-0-0043, Velocity polarity parameter 0000000000000000

S-0-0055, Position polarity 0000000000000000

11.6 Commutation adjustment

11.6.1 General

The force of the synchronous linear motor can only develop to a maximum and constant degree, if the commutation angle or the pole position is set correctly.

This procedure ensures that the angle between the current vector of the primary part and the flux vector of the secondary part is always 90°. The motor supplies the maximum force in this state.

⚠ CAUTION	**Errors in commutation adjustment can result in malfunctions and/or uncontrolled movements of the motor!** Take care when carrying out the commutation adjustment. For commutation, observe the detailed information in the documentation under ➦Kap. 11.4.4.

Commutation adjustment always has to be performed in the following cases:

- Initial commissioning
- Modification of the mechanical attachment of the linear scale
- Length measuring system replacement
- Modification of the mechanical attachment of the primary and/or secondary part

Adjustment procedure

Different commutation adjustment procedures have been implemented in the firmware. The following figure shows the connection between the length measuring system used and the procedure to be applied.

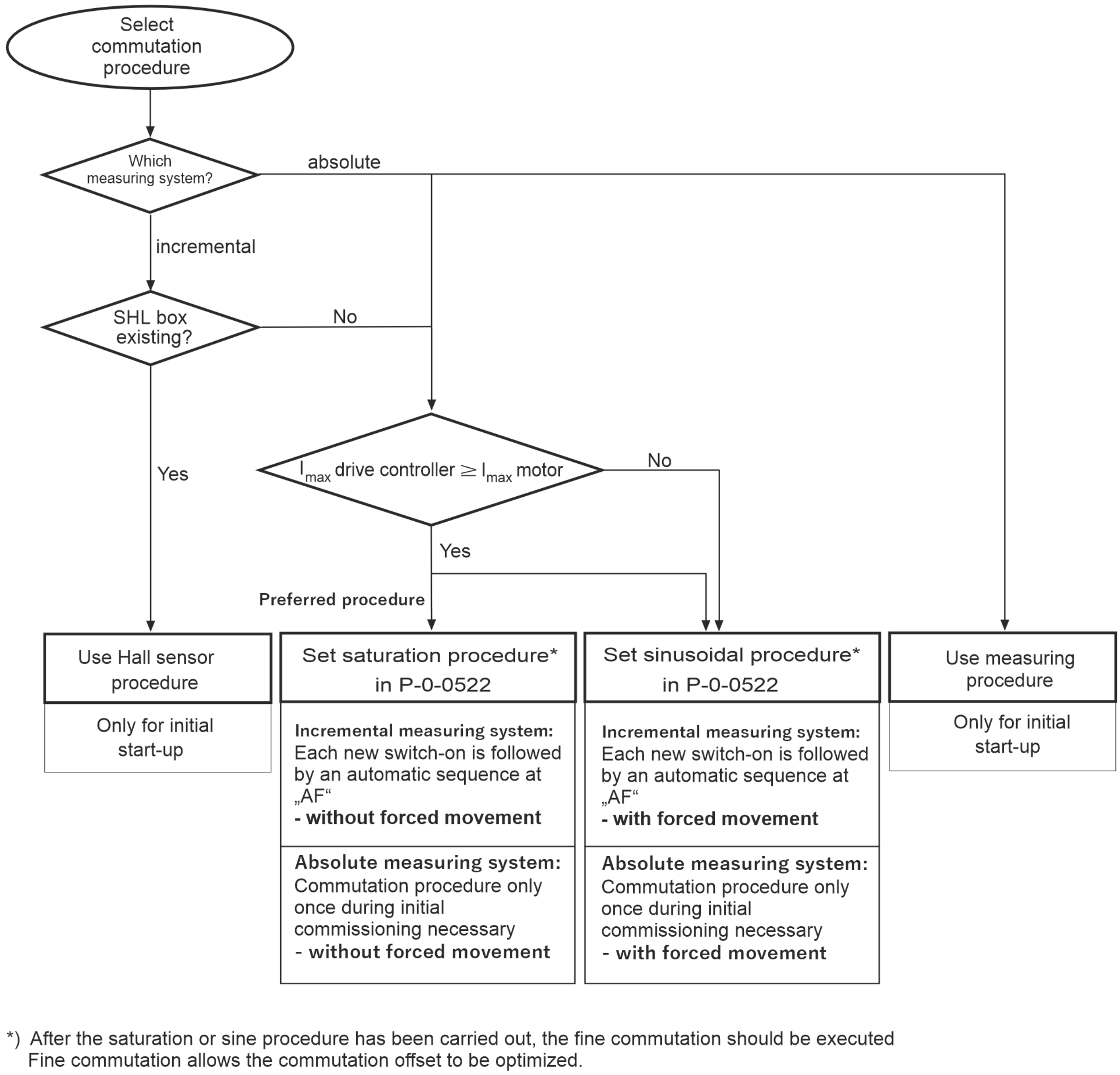


Fig. 133: Procedure for commutation adjustment for synchronous linear motors

Observe the following requirements for commutation adjustment:

- Effective direction of the motor force = Counting direction of the length measuring system
- Correct motor and encoder parameterization
- Complying with the described setting procedures
- Appropriate parameterization of current and velocity control loops
- Correct connection of motor power cable
- Protection against uncontrolled movements

Motor connection

The individual phases of the motor power connection have to be assigned correctly.

Parameter checking

To ensure proper commutation adjustment, the following parameters should be checked again:

Table 74: Parameters to be checked before commutation adjustment

Ident number	Description	Designation/function
S-0-0085	Torque/force polarity parameter	See Rexroth IndraDrive MPx-16 to MPx-xx Parameter description, MNR R911328651
S-0-0043	Velocity polarity parameter	
S-0-0055	Position polarity	
P-0-4014	Type of motor	
P-0-0018	Number of pole pairs/pole pair distance	
S-0-0602.x.3	S-0-0116, Encoder resolution	
P-0-0522	Commutation adjustment control word	
S-0-0602.x.1	Encoder type	

11.6.2 Saturation procedure (preferred procedure for commutation of synchronous linear motors)

The saturation procedure is the preferred procedure for commutation of synchronous linear motors.

For detailed information on the saturation procedure, refer to chapter "Commutation adjustment" of application description DOK-INDRV*-MP*-21VRS**-..., material number R911385759 (DE)

11.6.3 Sinusoidal procedure

For detailed information on the saturation procedure, refer to chapter "Commutation adjustment" of application description DOK-INDRV*-MP*-21VRS**-..., material number R911385759 (DE)

11.6.4 Hall sensor procedure

The Hall sensor procedure is applied if an incremental measuring system is used in combination with a Hall unit in the primary part. Also observe the information on the Hall unit in ➦ Chapter. 6.1.

Commutation by means of analog Hall unit

If the analog Hall unit is used, the following parameters must be determined:

Table 75: Parameters to be checked before commutation adjustment

Ident number	Description	Value
S-0-0602.1.1	Encoder type	2
S-0-0602.2.1		16
P-0-0508	Commutation offset	Calculation by means of Fig. 134.

Determine parameter P-0-0508 depending on the selected assembly position of the hall unit and can only be allocated with an integer number (rounded without comma) between 0 and + +1,024. Is the determined value not within this range, add or subtract the value of 1,024 until a permissible parameter value within the specified range is reached.

In the following, the possible installation positions are described. The respective calculation formula for the installation position and the required PK_A and C constants are specified below.

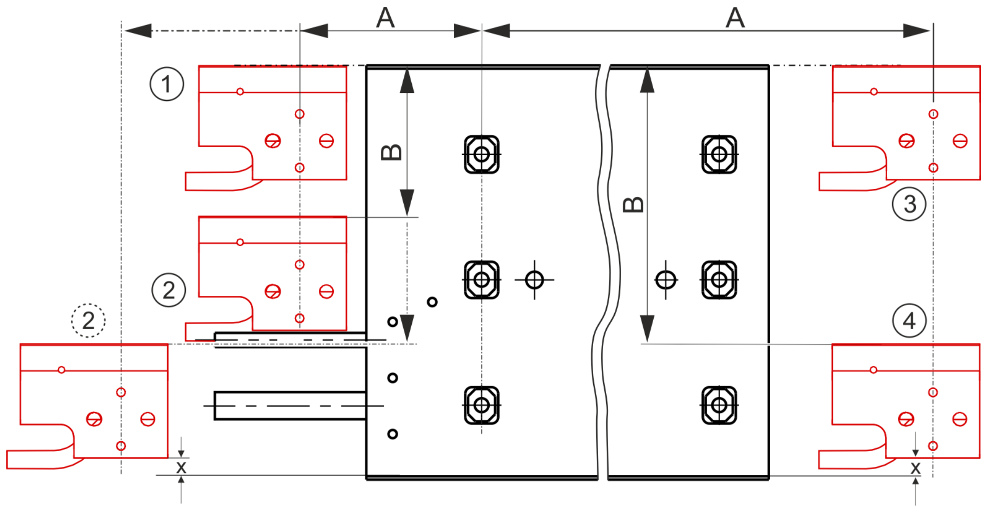


Fig. 134: Possible installation positions of the Hall unit

① ... ④	Installation positions
Dimension "x"	Distance to outer edge of primary part at ML3P03 - 8 mm; ML3P06 - 6 mm; ML3P11 - 6 mm

Installation position 1 (preferred installation):

Installation of the analog Hall unit at the cable outlet side of the primary part. The Hall unit is positioned flush at the side of the primary part (see ① Fig.). 134).

$$P-0-0508 = PK_A + \frac{1024}{2 \times \tau_p} \times A$$

Fig. 135: Formula for installation of the analog Hall unit at the cable outlet side at the primary part

P-0-0508	Commutation offset
PK_A	Constant for analog Hall unit (see ➦Tab.) 76)
τ_P	Pole width
A	Offset between the installation row of analog Hall units and the first installation row on the cable side at the primary part (see Fig.) 134)

Installation position 2:

Installation of the analog Hall unit at the cable outlet side of the primary part. The Hall unit is offset by the dimension "S" on the side in the direction of the cable outlet of the primary part (see ② ➦Tab. 76).

$$P-0-0508 = PK_A + \frac{1024}{2 \times \tau_p} \times (A - B \times C)$$

Fig. 136: Formula for installation of the analog Hall unit at the cable outlet side with side offset

P-0-0508	Commutation offset
PK_A	Constant (see ➦Tab.) 76)
τ_p	Pole width
A	Offset between the installation row of analog Hall units and the first installation row on the cable side at the primary part (see Fig.) 134)

B Side offset must not exceed the motor contour on the side (see Fig. 134)

C Constant (compensation of incline in case of side offset, see ➦Tab.) 76)

Installation position 3:

Installation of the analog Hall unit at the opposite side of the cable outlet at the primary part. The Hall unit is positioned flush at the side of the primary part (see ③Fig.). 134).

$$P-0-0508 = PK_A - \frac{1024}{2 \times \tau_p} \times A$$

Fig. 137: Formula for installation of the analog Hall unit at the opposite cable outlet side at the primary part

P-0-0508 Commutation offset

PK_A Constant for analog Hall unit (see ➦Tab.) 76)

τ_P Pole width

A Offset between the installation row of analog Hall units and the first installation row on the cable side at the primary part (see Fig.) 134)

Installation position 4:

Installation of the analog Hall unit opposite of the cable outlet at the primary part. The Hall unit is offset by the dimension "S" on the side in the direction of the opposite motor flank (see ④ Fig.). 134).

$$P-0-0508 = PK_A - \frac{1024}{2 \times \tau_P} \times (A + B \times C)$$

Fig. 138: Formula for installation of the analog Hall unit at the opposite cable outlet side with side offset

P-0-0508 Commutation offset

PK_A Constant (see ➦Tab.) 76)

τ_p Pole width

A Offset between the installation row of analog Hall units and the first installation row on the cable side at the primary part (see Fig.) 134)

B Side offset must not exceed the motor contour on the side (see Fig.) 134)

C Constant (compensation of incline in case of side offset, see ➦Tab.) 76)

Table 76: Constants (analog Hall unit)

Motor type	PK_A constant	C constant
ML3P03-ANBWN-BAFNN-NN	246	0.14
ML3P03-BNBWN-BAFNN-NN	246	
ML3P03-DNBWN-BAFNN-NN	331	
ML3P03-FNBNN-BAFNN-NN	651	
ML3P03-FNBUN-BAFNN-NN	651	
ML3P06-BNBKU-BANNN-NN	246	0.07
ML3P06-BNBRU-BANNN-NN	246	
ML3P06-CNBCU-BANNN-NN	331	
ML3P06-CNBRU-BANNN-NN	331	

Motor type	PK_A constant	C constant
ML3P06-DNBKU-BANNN-NN	331	
ML3P06-DNBRU-BANNN-NN	331	
ML3P06-ENBKU-BANNN-NN	331	
ML3P06-ENBRU-BANNN-NN	331	
ML3P06-FNBKU-BANNN-NN	651	
ML3P06-FNBRU-BANNN-NN	651	
ML3P06-HNBKU-BANNN-NN	331	
ML3P06-HNBRU-BANNN-NN	331	
ML3P11-DNBFN-BANNN-NN	331	0.035
ML3P11-DNBQN-BANNN-NN	331	
ML3P11-ENBCN-BANNN-NN	331	
ML3P11-ENBQN-BANNN-NN	331	
ML3P11-LNBCN-BANNN-NN	331	
ML3P11-LNBQN-BANNN-NN	331	
ML3P11-R...	tbd	tbd

With the above-specified calculation of P-0-0508, the effective commutation offset (P-0-0521) is automatically calculated on switching to operating mode.

The procedure “Reference point optimum commutation offset” cannot be used in the case of analog Hall units, as the necessary parameter P-0-0508 already uses the procedure “Commutation via analog Hall units”.

Commutation by means of digital Hall unit

If the digital Hall unit is used, the following parameters must be determined:

Table 77: Parameters to be checked before commutation adjustment

Ident number	Description	Value
S-0-0602.x.1	Encoder type	23
P-0-0509	Rough commutation offset	Calculation by means of Fig. 139.

Determine parameter P-0-0509 depending on the selected assembly position of the hall unit and can only be allocated with an integer number (rounded without comma) between 0 and + 1,024. Is the determined value not within this range, add or subtract the value of 1,024 until a permissible parameter value within the specified range is reached.

In the following, the possible installation positions are described. The respective calculation formula for the installation position and the required PK_D and C constants are specified below.

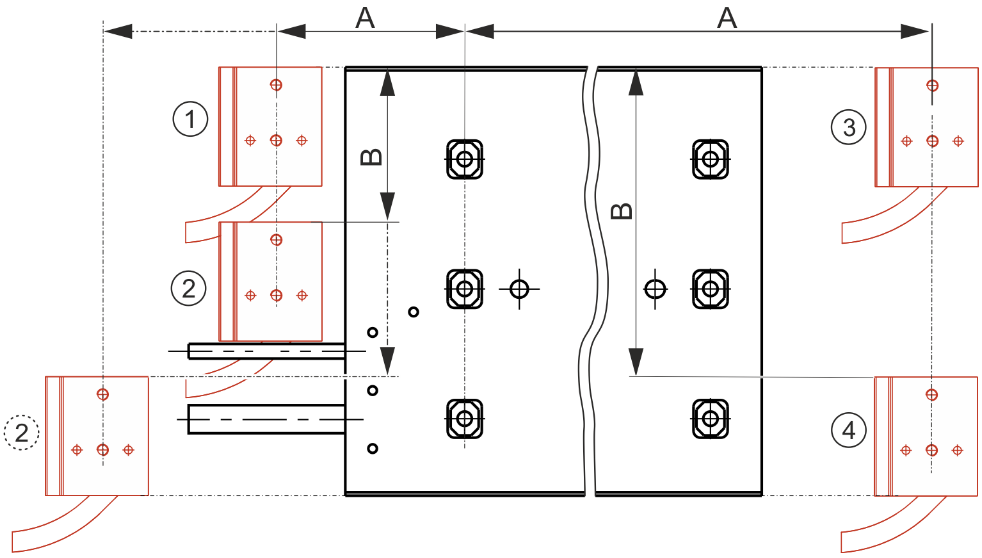


Fig. 139: Possible installation positions of the Hall unit

① ... ④ Installation positions

Installation position 1 (preferred installation):

Installation of the digital Hall unit at the cable outlet side of the primary part. The Hall unit is positioned flush at the side of the primary part (see ① Fig.). 139).

$$P-0-0509 = PK_D + \frac{1024}{2 \times \tau_p} \times A$$

Fig. 140: Formula for installation of the digital Hall unit at the cable outlet side at the primary part

P-0-0509	Rough commutation offset
PK_D	Constant for digital Hall unit (see ➦Tab.) 78)
τ_P	Pole width
A	Offset between the installation row of digital Hall units and the first installation row on the cable side at the primary part (see Fig.) 139)

Installation position 2:

Installation of the digital Hall unit at the cable outlet side of the primary part. The Hall unit is offset by the dimension "S" on the side in the direction of the cable outlet of the primary part (see ② Fig.). 139).

$$P-0-0509 = PK_D + \frac{1024}{2 \times \tau_p} \times (A - B \times C)$$

Fig. 141: Formula for installation of the digital Hall unit at the cable outlet side with side offset

P-0-0509	Rough commutation offset
PK_D	Constant (see ➦Tab.) 78)
τ_P	Pole width
A	Offset between the installation row of digital Hall units and the first installation row on the cable side at the primary part (see Fig.) 139)

B Side offset must not exceed the motor contour on the side (see Fig.) 139Fig. 139

C Constant (compensation of incline in case of side offset, see ➦Tab.) 78)

Installation position 3:

Installation of the digital Hall unit at the opposite side of the cable outlet at the primary part. The Hall unit is positioned flush at the side of the primary part (see ③ Fig.). 139).

$$P-0-0509 = PK_D - \frac{1024}{2 \times \tau_p} \times A$$

Fig. 142: Formula for installation of the digital Hall unit at the opposite cable outlet side at the primary part

P-0-0509 Rough commutation offset

PK_D Constant (see ➦Tab.) 78)

τ_P Pole width

A Offset between the installation row of digital Hall units and the first installation row on the cable side at the primary part (see Fig.) 139)

Installation position 4:

Installation of the digital Hall unit opposite of the cable outlet at the primary part. The Hall unit is offset by the dimension "S" on the side in the direction of the opposite motor flank (see ④ Fig.). 139).

$$P-0-0509 = PK_D - \frac{1024}{2 \times \tau_p} \times (A + B \times C)$$

Fig. 143: Formula for installation of the digital Hall unit at the opposite cable outlet side with side offset

P-0-0509 Rough commutation offset

PK_D Constant (see ➦Tab.) 78)

τ_P Pole width

A Offset between the installation row of digital Hall units and the first installation row on the cable side at the primary part (see Fig.) 139)

B Side offset (must not exceed the motor contour on the side)

C Constant (compensation of incline in case of side offset, see ➦Tab.) 78)

Table 78: Constants (digital Hall unit)

Motor type	PK_D constant	C constant
ML3P03-ANBWN-BAFNN-NN	867	0.14
ML3P03-BNBWN-BAFNN-NN	29	
ML3P03-DNBWN-BAFNN-NN	967	
ML3P03-FNBNN-BAFNN-NN	647	
ML3P03-FNBUN-BAFNN-NN	647	
ML3P06-BNBKU-BANNN-NN	760	0.07
ML3P06-BNBRU-BANNN-NN	760	
ML3P06-CNBCU-BANNN-NN	845	
ML3P06-CNBRU-BANNN-NN	845	
ML3P06-DNBKU-BANNN-NN	67	

Motor type	PK_D constant	C constant
ML3P06-DNBRU-BANNN-NN	67	
ML3P06-ENBKU-BANNN-NN	845	
ML3P06-ENBRU-BANNN-NN	845	
ML3P06-FNBKU-BANNN-NN	141	
ML3P06-FNBRU-BANNN-NN	141	
ML3P06-HNBKU-BANNN-NN	67	
ML3P06-HNBRU-BANNN-NN	67	
ML3P11-DNBFN-BANNN-NN	967	0.035
ML3P11-DNBQN-BANNN-NN	967	
ML3P11-ENBCN-BANNN-NN	967	
ML3P11-ENBQN-BANNN-NN	967	
ML3P11-LNBCN-BANNN-NN	967	
ML3P11-LNBQN-BANNN-NN	967	
ML3P11-R...	tbd	tbd

With the above-specified settings, the effective commutation offset (P-0-0521) is automatically calculated on switching to operating mode. Commutation by means of digital Hall unit only enables reaching of an electrical accuracy of +/- 30°. In this respect, a maximum power loss of 14 % is to be expected.

To ensure that exactly the same commutation offset is available every time the drive is activated again, the optimum commutation offset must be stored at the reference point.

Procedure at IndraDrive Cs:

1. Activate initial commissioning mode (P-0-0522, bit 15)
2. Carry out commutation adjustment using the saturation method.
3. Switch axis to "AF".
4. Start fine commutation.
5. Initiate reference point run.
   ➡ If the reference point is reached, the "reference point of optimum commutation offset" (P-0-0508) is placed there.
6. Deactivate initial commissioning mode.

On each restart of the machine, the rough commutation offset (+/- 30°) is determined by switching to operating mode. The drive may now run to the reference point with reduced force. If the reference point is reached or passed, the optimum reference point for the commutation offset is applied by the drive and the maximum force is available to the axis.

11.6.5 Measuring procedure: Measuring of the relation between primary and secondary part

For commutation setting, this procedure requires determination of the relative position of the primary part in relation to the secondary part. This procedure has the advantage that commutation adjustment does not require any power switching and axis motion. Commutation adjustment only needs to be carried out on initial commissioning.

- The position of the primary part must not be changed before the procedure for commutation adjustment is completed!
- This procedure requires an absolute length measuring system.

Arrangement A

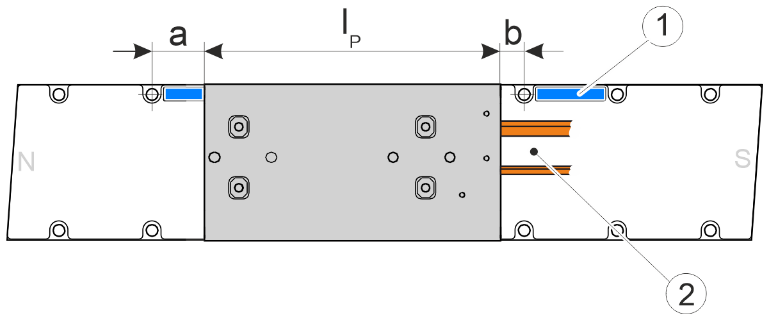


Fig. 144: Measuring of the relative position of the primary to the secondary part (arrangement A)

①	Reference marks at secondary part - TOP
②	Cable output at the primary part - RIGHT
Dimension "a"	Distance of the primary part rear side to the boring center
Dimension "b"	Distance of the primary part front side (cable output) to the boring center
l_p	Primary part length

Arrangement B

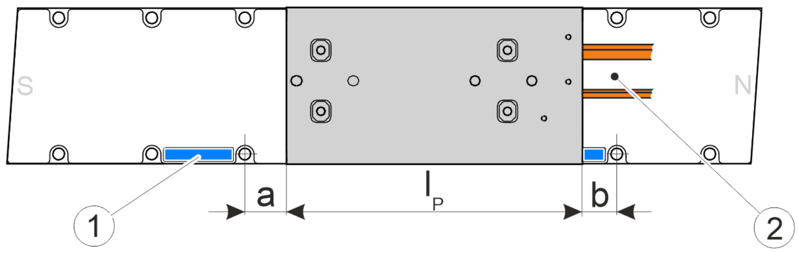


Fig. 145: Measuring of the relative position of the primary to the secondary part (arrangement B)

①	Reference marks at secondary part - BOTTOM
②	Cable output at the primary part - RIGHT
Dimension "a"	Distance of the primary part rear side to the boring center
Dimension "b"	Distance of the primary part front side (cable output) to the boring center
l_p	Primary part length

Calculation of P-0-0523

The input value for P-0-0523 that is required for calculating the commutation offset, is determined depending on the selected assembly type and the measured relative position of the primary part with respect to the secondary part and a motor-related constant k_{mx} (refer to Fig. and Tab.). 146 and ➦Tab. 79).

① $$P-0-0523=-a-k_{mx}$$

② $$P-0-0523=+b+l_P-k_{mx}$$

Fig. 146: Calculation of P-0-0523, Commutation adjustment measured value

①	Calculation of P-0-0523 with determined dimension "a"
②	Calculation of P-0-0523 with determined dimension "b"
P-0-0523	Commutation adjustment measured value in mm
a	determined distance in mm

b determined distance in mm
k_{mx} Motor constant for commutation adjustment in mm (see ➦Tab.) 79)
l_p Primary part length in mm

Ensure that the sign is correct when you determine P-0-0523, Commutation adjustment measured value. If P-0-0523 is determined with a negative sign, this must also be entered in the beginning of the setting procedure.

Table 79: Motor constant kms for commutation setting

Primary part	k_{mx} in mm	
	Arrangement A - acc. to Fig. 144	Arrangement B - acc. to Fig. 145
ML3P03-A...	9	21
ML3P03-B...	7	19
ML3P03-D...	6	18
ML3P03-F...	4.5	16.5
ML3P06-B...	7	19
ML3P06-C...	7	19
ML3P06-D...	6	18
ML3P06-E...	7	19
ML3P06-F...	4.5	16.5
ML3P06-H...	14	2
ML3P11-D...	6	18
ML3P11-E...	7	19
ML3P11-F...	4.5	16.5
ML3P11-H...	4	16
ML3P11-L...	15	3
ML3P11-R...	tbd	tbd

Calculation examples:

ML3P06-D... for arrangement A

Dimension "a" = 35 mm, k_{mx} = 6 mm

P-0-0523 = -a - k_{mx} = -35 mm - 6 mm = **-41 mm**

Dimension "b" = 35 mm, k_{mx} = 244 mm, l_p = 6 mm

P-0-0523 = +b + l_P - k_{mx} = +35 mm + 244 mm -6 mm = **273 mm**

ML3P06-D... for arrangement B

Dimension "a" = 35 mm , k_{mx} = 18 mm

P-0-0523 = -a - k_{mx} = -35 mm - 18 mm = **-53 mm**

Dimension "b" = 35 mm, k_{mx} = 244 mm, l_p = 18 mm

P-0-0523 = +b + l_P - k_{mx} = +35 mm + 244 mm - 18 mm = **261 mm**

Activation of commutation adjustment command

Prerequisites:

- The drive must be in status A0-13 during the following adjustment procedure (= ready for power switching).
- The position of the primary part or the slide must not have changed after measuring of the relative position of the primary to the secondary part.

After the determined value P-0-0523 (Commutation adjustment measured value) is entered, command P-0-0524 (D300 Commutation adjustment command) has to be started. In this process, the commutation offset is calculated.

If the drive is in command start "AB" (drive ready for operation), the commutation offset with the selected procedure (saturation or sinusoidal procedure) is determined for automatic commutation.

Afterwards, the command is to be cleared.

11.7 Setting and optimizing the control loop

11.7.1 General procedure

The control loop settings in a digital drive controller have an essential importance for the properties of the servo axis and require respective expertise. The control loop structure consists of a cascaded position, velocity and current controller. Which controller is active is defined by the operation mode.

The procedure for control loop optimization (current, velocity and position controller) at linear direct drives corresponds to the procedure for rotary servo drives. Only the setting limits of linear drives are higher.

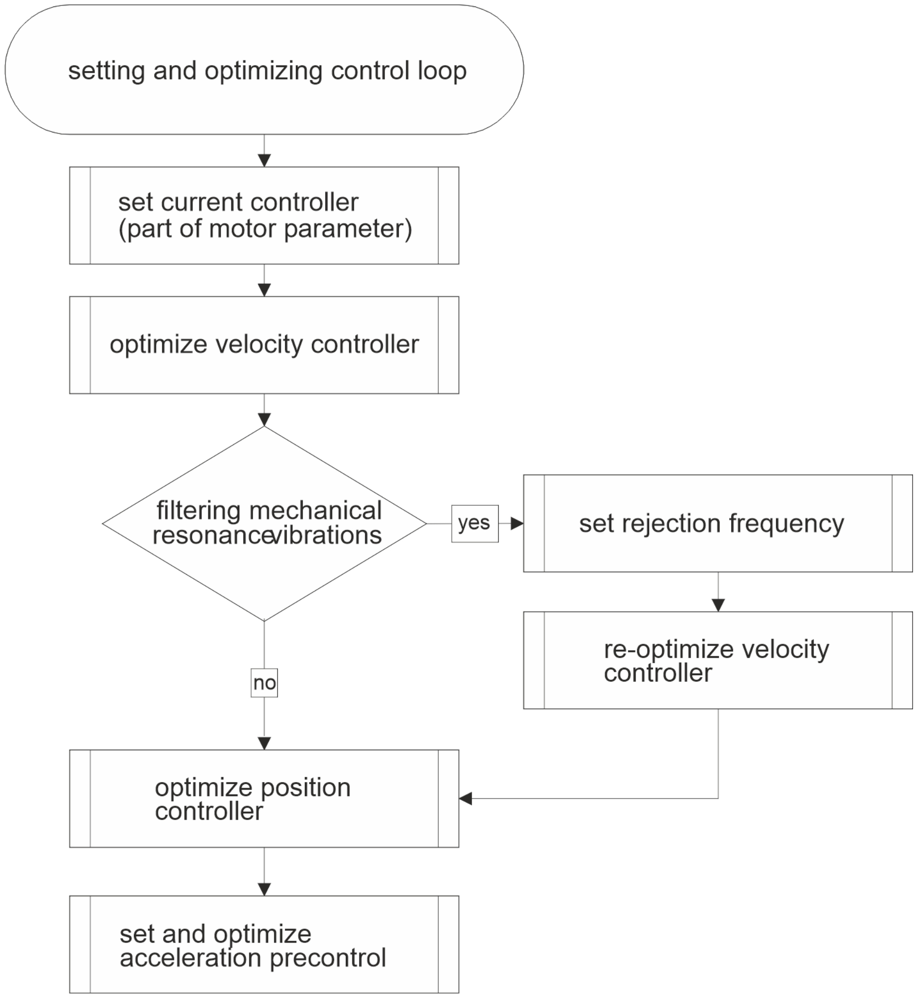


Fig. 147: Setting and optimizing the control loop of synchronous linear motors

Rexroth drive controllers enable automatic control loop setting. For additional and detailed information, refer to

- Rexroth IndraDrive MPx-16 to MPx-xx Parameter Description, MNR R911328651
- Rexroth IndraDrive MPx-21 Application description, MNR R911385759 (DE)

Filtering mechanical resonance vibrations

Digital drives from Rexroth are able to provide a narrow-band suppression of vibrations that are produced due to the power train between motor and mechanical axis system. This results in increased drive dynamics with good stability.

The mechanical system of the slide that is moved by the linear drive is stimulated to vibrate mechanically due to the position and/or velocity return within the closed control loop. This behavior, known as "Two-mass vibrational system", is mainly in the frequency range from 400 to 800 Hz. It depends on the rigidity of the mechanical system and the spatial expansion of the system.

In most cases, this "Two-mass vibrational system" has a clear resonant frequency that can be selectively suppressed by a rejection filter installed in the drive.

When the mechanical resonant frequency is suppressed, the dynamic properties of the velocity control loop and of the position control loop may, under certain circumstances, be improved as compared with closed-loop operation without rejection filter.

This leads to an increased profile accuracy and shorter cycle times for positioning processes at a sufficient distance to the stability limit.

Rejection frequency and bandwidth of the filter can be selected. The rejection frequency is the frequency with the highest attenuation. The bandwidth defines the frequency range in which the attenuation is less than –3 dB. A higher bandwidth leads to less attenuation of the rejection frequency!

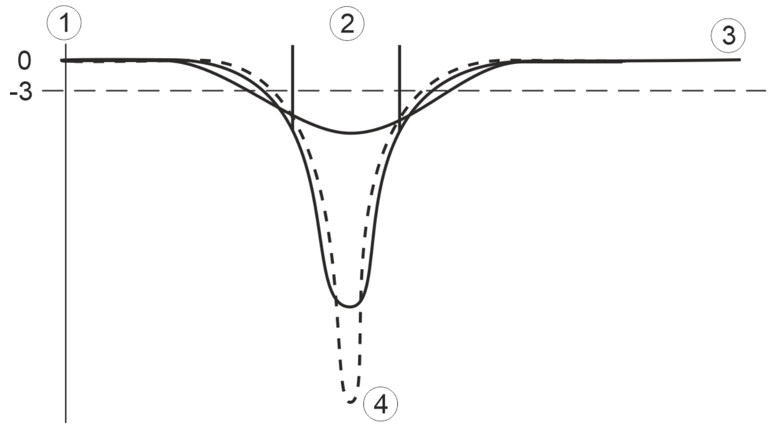


Fig. 148: Amplitude response of the rejection filter in relation to the bandwidth, qualitative

① Damping in dB
② Bandwidth
③ Frequency f
④ Rejection frequency f_{sperr}

11.7.2 Parameter value assignments and optimization of Gantry axes

General

Prerequisites:

- Parametrization or axes is realized identically
- Parallelism of guides of Gantry axes
- Parallelism of length measuring systems
- The axes are registered as individual axes in the control unit

For compensation of alignment errors between two length measuring systems or the mechanical system, drive-internal axis error correction procedures can be applied. Please refer to the corresponding description of functions of the drive controller for a description of the operational principle and the parameter settings.

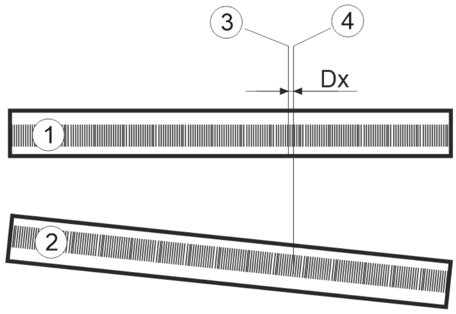


Fig. 149: Possible alignment errors at length measuring systems of Gantry axes
① Length measuring system 1
② Length measuring system 2
③ Position feedback value 1
④ Position feedback value 2

Parametrization

For operation of Gantry axes, identical parameterization of the following parameters must be ensured:

- Motor parameter
- Polarity parameter for force, velocity and position
- Control loop parameter

We have:

$$k_{v1} = k_{v2}$$

$$K_{p1} = k_{p2}$$

Fig. 150: Proportional gain in position and velocity control loop of both axes
k_v Position controller proportional gain S-0-0104
k_p Velocity loop proportional gain S-0-0100

Velocity loop integral action time (integral part)

For velocity loop integral action time (integral part), the following possibilities must be taken into consideration:

Table 80: Parametrization of the velocity loop integral action time S-0-0101 at Gantry axes.

	Possibility 1	Possibility 2	Possibility 3	Possibility 4
Alignment of length measuring systems and guides	ideal	not ideal	not ideal	not ideal
Integral part	in both axes	in both axes	in one axis only	in no axis

	Possibility 1	Possibility 2	Possibility 3	Possibility 4
Behavior of the axes	Tensioning of the mechanical system is not realized as both motors ideally follow the position command value	Both axes work against each other until compensation via the mechanical coupling or until the maximum current is reached at one or both drive controllers and no more control effect can be achieved	The axis without integral part allow continuous position offset. The position offset depends on the stiffness of the mechanical coupling of both axes as well as the proportional gains in the position and velocity control loop	Both axes allow continuous position offset. The position offset depends on the proportional gains in the position and velocity control loop

Optimization

For optimization of velocity and position control loop, the above-described procedure must be observed.

Parameter changes during optimization of Gantry axes must always be carried out at both axes. If this is not possible, the parameter changes during optimization should be carried out subsequently in small steps at both axes.

11.7.3 Estimating the moved mass using a velocity ramp

The moving weight of a machine slide is often not precisely known. This may be obstructed by subsequently installed attachments, moving components, etc.

The procedure described below enables estimation of the moved axis mass according to recording of a velocity ramp. For example, this enables estimation of the acceleration capacity of the axis.

Preparation

Precondition for positioning is oscillographical representation of the following parameters:

- S-0-0040, Velocity actual value
- S-0-0080, Torque/force command value

For this purpose, an oscilloscope or the oscilloscope function of the drive can be used in combination with IndraWorks or NC.

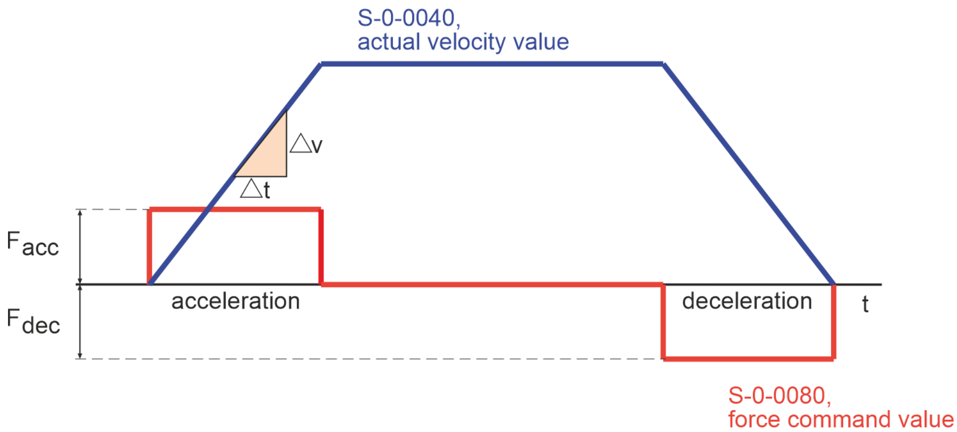


Fig. 151: Oscillogram of velocity and force

$$m = 30 \times F_N \times \left(\frac{F_{ACC} + F_{DEC}}{100\%} \right) \times \frac{\Delta t}{\Delta v}$$

Fig. 152: Determination of the moved axis mass according to recording of a velocity ramp

m Moved axis mass in kg
F_N Continuous nominal force of the motor in N
F_{ACC} Force command value during acceleration in %
F_{DEC} Force command value during deceleration in %
Δv Velocity change during const. acceleration in m/min
Δt Time change during const. Acceleration in s

Prerequisites:

1. Correct parameter settings of the rated motor current (basis of representation S-0-0080)
2. Frictional force not directional
3. Recording of Δv and Δt at constant acceleration
4. Measuring with a motor force between F_N and F_{max}

The procedure is not suitable or suitable only to a limited extend for vertical axes due to potential direction-depending force changes.

11.8 Maintenance and checking of motor components

11.8.1 General

⚠ DANGER	Risk of injury due to moving elements! Risk of injury due to hot surfaces! – Do not carry out any maintenance measures while the machine is running. – While carrying out maintenance work, secure the machine such that it cannot restart or be used by unauthorized persons. – Do not work on hot surfaces.

Maintenance of the motor components is not necessary. During operation, however, external influences may cause damage at motor components.

Within the service intervals of the machine or system, preventive checking of linear motor components should be carried out.

11.8.2 Checking of motor and additional components

The following points should be observed and if necessary restored during the preventive check of motor and auxiliary components:

- Noticeable sound during operation
- Scratches on primary and secondary part
- Dirt (e.g. shavings, dust, grease by guides etc.) within the air gap between primary and secondary part
- if available, tightness of liquid cooling, hoses and connections
- State of power and encoder cables in a drag chain.
- State of length measuring system (e.g. contamination)
- State of guides (e.g. deterioration of linear guides)

11.8.3 Electrical check of motor components

Electrical defects at a primary part are can be indicated in advance by measuring the electrical characteristics. The following variables are relevant:

- Resistance between motor connecting wires 1-2, 2-3 and 1-3
- Inductance between motor connecting wires 1-2, 2-3 and 1-3
- Insulation resistance between motor connecting wired and guides

Resistance and inductivity

The measured values of resistance and inductance can be compared to the values specified in chapter "Technical data". The individual values of resistance and inductance measured between the connections 1-2, 2-3 and 1-3 should be identical within a tolerance of ± 5 %. There can be a phase short circuit, a fault between windings, or a short circuit to ground if one or more values differ significantly. If so, the primary part must be exchanged.

Insulation resistance

The insulation resistance measured between the motor connection wires and ground should be at least 1 MΩ (MegaOhm). If this value is fallen below, replacement of the primary part is recommended.

If necessary, please contact the Bosch Rexroth customer service for inspection of the electrical system.

11.9 Operation with third-party controllers

Rate of rise of voltage

The electrical insulationInsulation system of the motor is subject to a higher dielectric load in converter mode than when it is operated with a merely sinusoidal source voltage. The voltage load of the winding insulation in converter mode is mainly defined by the following factors:

- Crest value of voltage
- Rise time of pulses at the motor terminals
- Switching frequency of final converter stage
- Length of power cable to the motor

Main components are the switching times of the final converter stage and the length of the power cable to the motor. The rates of rise of the voltage occurring at the motor may not exceed the pulse voltage limits specified in DIN VDE 0530-25 (VDE 0530-25): 2009-08 (picture 14, limit curve A), measured at the motor terminals of two strands in relation to the rise time.

These limits are complied with by the final stages of Rexroth converters.

11.10 Environmental protection and disposal

Disposal of the motor components can be done according to the applicable legal process in normal recycling process.

Recycling

Most of the products can be recycled due to their high content of metal. In order to recycle the metal in the best possible way, the products must be disassembled into individual assemblies. Metals contained in electric and electronic assemblies can also be recycled by means of special separation processes.

Basic components

Basically, our motors consist of the following components:

- Steel, stainless steel, aluminum, copper, brass
- Plastic parts, insulation and composite material
- Electronic components
- Permanent magnets

Plastic parts of the products may contain flame retardants. These plastic parts are labeled according to EN ISO 1043-1:2011 + A1:2016. They have to be recycled separately or disposed of according to the applicable legal provisions.

Magnets

⚠ WARNING	Danger due to permanent magnets! – Health hazard for persons with heart pacemakers, metallic implants and hearing aids in direct environment of permanent magnets. – Crushing hazard of fingers and hand due to heavy attractive forces of the magnets. – Risk of destruction of sensitive parts like watches, credit cards, ...

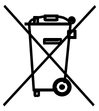
Remark

The permanent magnets must be demagnetized before disposal to avoid injuries or damage. The demagnetization is reached via thermal treatment. The duration of the treatment depends on the size (guide value: 300 °C, 30 min).

Packaging

Our packaging materials do not contain any problematic materials and can therefor be easily disposed. Packaging materials are: wood, cardboard and polystyrene.

Batteries and accumulators



The symbol indicating "separate collection" for all batteries and accumulators is the crossed-out wheeled bin. End users in the EU are legally bound to return used batteries and accumulators. Outside the scope of the EU Directive 2006/66/EC, the applicable regulations must be followed. Batteries and accumulators can contain hazardous substances which can harm the environment or people's health when improperly stored or disposed of. The batteries or accumulators must be returned to the country-specific collection systems for proper disposal.

Disposal by the manufacturer

Our products can be returned to us for disposal. However, this requires that the products are free from oil, grease or other dirt. The motor components must be returned in a suitable packaging (origin package if possible). In the case of a transport by air freight, please observe the dangerous goods regulations (IATA) for the secondary part.
Send the products to the following address, carriage free:

Bosch Rexroth AG
Bgm.-Dr.-Nebel-Str. 2
97816 Lohr a.Main, Germany

12 Service and support

Our worldwide service network provides an optimized and efficient support. Our experts provide you with advice and assistance. You can contact us **24/7**.

Service Germany

Our technology-oriented Competence Center in Lohr, Germany, is responsible for all your service-related queries for electric drive and controls.

Contact the **Service Hotline** and **Service Helpdesk** under:

Phone:	+49 9352 40 5060
Fax:	+49 9352 18 4941
Email:	➦service.svc@boschrexroth.de
Internet:	➦http://www.boschrexroth.com

Additional information on service, repair (e.g. delivery addresses) and training can be found on our internet sites.

Service worldwide

Outside Germany, please contact your local service office first. For hotline numbers, refer to the sales office addresses on the internet.

Preparing information

To be able to help you more quickly and efficiently, please have the following information ready:

- Detailed description of malfunction and circumstances
- Type plate specifications of the affected products, in particular type codes and serial numbers
- Your contact data (phone and fax number as well as your e-mail address)

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