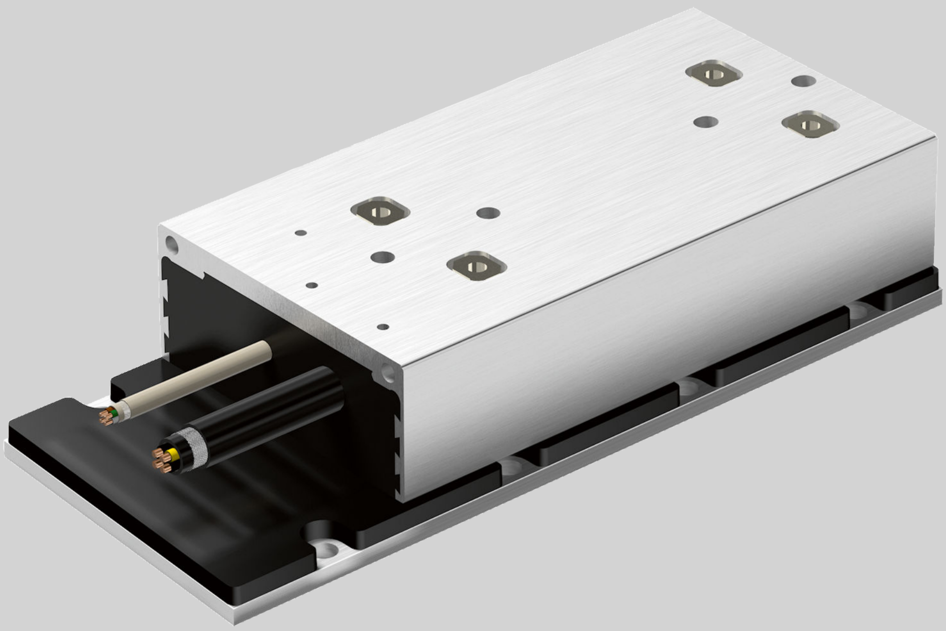
rexroth
A Bosch Company

ML3

Self-Cooled Linear Motors

Project Planning Manual
R911389760

Edition 02



Title	ML3 Self-Cooled Linear Motors
Type of Documentation	Project Planning Manual
Document Typecode	DOK-MOTOR*-ML3********-PR02-EN-P
Internal File Reference	RS-2f66506f7f840b61c0a802867d8e360d-2-en-US-5

Purpose of Documentation

This documentation ...

- explains the product features, possibilities for use, operating conditions and operational limits of the motors
- contains technical data regarding the motors that can be supplied
- provides information regarding product selection, handling and operation.

Record of revisions

Edition 02, 2021-10

See tab. 1-1 "Record of revisions" on page 4

Published by

Bosch Rexroth AG

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

Bgm.-Dr.-Nebel-Str. 2

97816 Lohr, Germany

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http://www.boschrexroth.com/electrics

Note

This document has been printed on chlorine-free bleached paper.

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1 Self-cooled linear motors ML3

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:

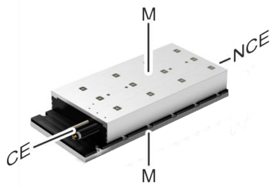
- Printing machinery (e.g. digital and 3D print)
- Paper processing machinery
- Machine tools (e.g. laser cutting/welding)
- Medical technology (e.g. patient tables)
- Semi-conductor technology (e.g. transport systems)
- Laboratory automation
- General automation

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 Electric Drives and Controls, please refer to the online product catalog: http://www.boschrexroth.com/indradyn.

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 60034-5)
Installation altitude	0 ... 1000 m above MSL (without derating)
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 (2x KTY, 2x 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) 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

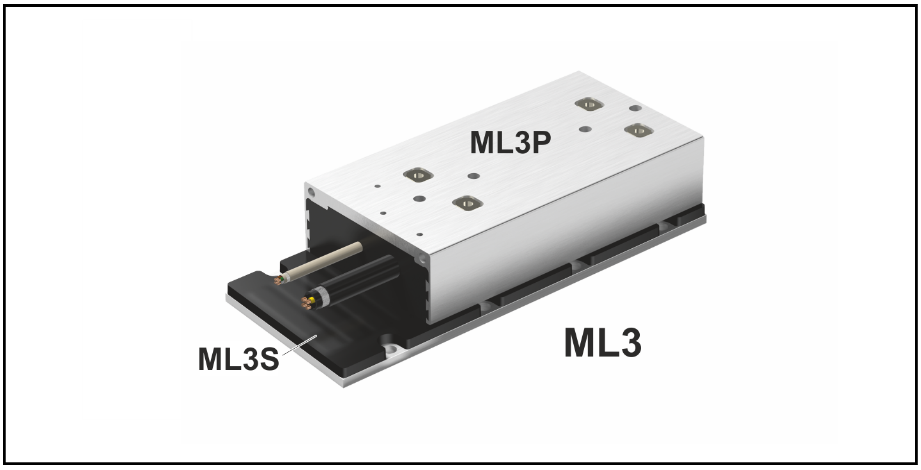


Fig. 1-1: Picture example of ML3 motor

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 figure provides an overview of the power spectrum:

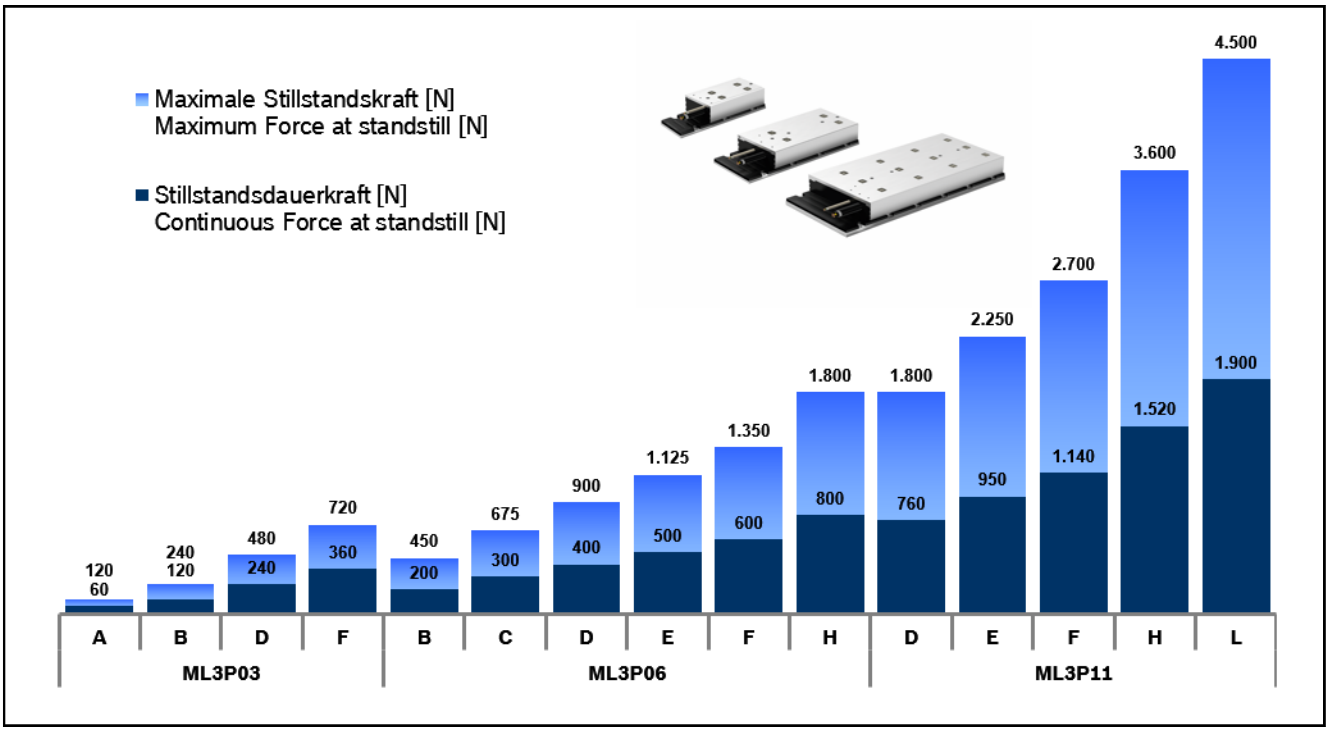


Fig. 1-2: Motor power spectrum

1.5 About this documentation

1.5.1 Editions of this documentation

Edition	Release date	Notes
02	2021-10	Update and addition of new motor types, EAC label removed
01	2019-04	First edition

Tab. 1-1: Record of revisions

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>
<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 for 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="8">Product description</td><td rowspan="8">for planners and designers</td><td></td><td></td></tr>
<tr><td>5</td><td>Specifications</td><td></td><td></td></tr>
<tr><td>6</td><td>Type codes</td><td></td><td></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></td><td></td></tr>
<tr><td>13</td><td>Installation</td><td></td><td></td></tr>
<tr><td>14</td><td>Startup, operation and maintenance</td><td></td><td></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>
</table>

Tab. 1-2: Chapter structure

1.5.3 Information presentation

Safety instructions

The safety instructions in this documentation include signal words (danger, warning, caution, note) and a signal symbol (acc. to ANSI Z535.6-2006).

The signal word is intended to draw your attention to the safety instructions and describes the seriousness of the danger. The warning triangle with exclamation mark indicates the danger for persons.

⚠ 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

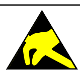
Non-compliance with this safety instructions **can** result in moderate or minor personal injury.

NOTICE

Non-compliance with this safety instructions **can** result in material damage.

Safety symbols

The following internationally standardized safety symbols and graphic symbols are used in this documentation. The meaning of the symbols is described in the table.

Safety symbols	Significance
	Warning against dangerous electric voltage
	Warning against hot surfaces
	Warning against overhead load
	Electrostatic sensitive devices
	No access for persons with cardiac pacemakers or implanted defibrillators.
	Do not carry along metal parts or clocks.

Tab. 1-3: Meaning of safety signs

Markup

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


Reference to supplementary documentation

☞ 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

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

1.5.4 Further documentation

To plan the drive-systems with ML3 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:

http://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 or, in Germany, directly:

BEUTH Verlag GmbH

Burggrafenstraße 6

10787 Berlin, Germany

Tel. +49-(0)30-26 01-22 60

Fax +49-(0)30-26 01-12 60

Internet: http://www.din.de/beuth

E-Mail:postmaster@beuth.de

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 Important instructions on use

2.1 Appropriate use

2.1.1 Introduction

Bosch Rexroth products are designed and manufactured using the latest state-of-the-art-technology. Before shipping, all products are checked for safety.

However, the products may only be used in compliance with their appropriate use. If they are not used as intended, property damage and personal injury may occur.

☞ 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.

2.1.2 Areas of use and application

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

Linear motors ML3 of Bosch Rexroth are intended for use as linear servo drive motors.

The motors have been 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	Rating and performance
EN 60034-5	Degree 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 2006/42/EC and DIN EN 60204-1 (safety of machines).

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.

☞

- 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.

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.

2.2 Inappropriate 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".

ML3 motors must not be used 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.

☞ ML3 motors are not suited to be operated directly on the power supply.

---

3 Safety notes for electric drives and controls

3.1 Term definition

System An installation consists of several devices or systems interconnected for a defined purpose and on a defined site which, however, are not intended to be placed on the market as a single functional unit.

Electrical drive system An electric drive system comprises all components from mains supply to motor shaft; this includes, for example, electric motor(s), motor encoder(s), supply units and drive controllers, as well as auxiliary and additional components, such as mains filter, mains choke and the corresponding lines and cables.

User A user is a person installing, commissioning or using a product which has been placed on the market.

User documentation Application documentation comprises the entire documentation used to inform the user of the product about the use and safety-relevant features for configuring, integrating, installing, mounting, commissioning, operating, maintaining, repairing and decommissioning the product. The following terms are also used for this kind of documentation: Operating Instructions, Commissioning Manual, Instruction Manual, Project Planning Manual, Application Description, etc.

Electrical equipment Electrical equipment encompasses all devices used to generate, convert, transmit, distribute or apply electrical energy, such as electric motors, transformers, switching devices, cables, lines, power-consuming devices, circuit board assemblies, plug-in units, control cabinets, etc.

Device A device is a finished product with a defined function, intended for users and placed on the market as an individual piece of merchandise.

Manufacturer The manufacturer is an individual or legal entity bearing responsibility for the design and manufacture of a product which is placed on the market in the individual's or legal entity's name. The manufacturer can use finished products, finished parts or finished elements, or contract out work to subcontractors. However, the manufacturer must always have overall control and possess the required authority to take responsibility for the product.

Components A component is a combination of elements with a specified function, which are part of a piece of equipment, device or system. Components of the electric drive and control system are, for example, supply units, drive controllers, mains choke, mains filter, motors, cables, etc.

Machine A machine is the entirety of interconnected parts or units at least one of which is movable. Thus, a machine consists of the appropriate machine drive elements, as well as control and power circuits, which have been assembled for a specific application. A machine is, for example, intended for processing, treatment, movement or packaging of a material. The term "machine" also covers a combination of machines which are arranged and controlled in such a way that they function as a unified whole.

Product Examples of a product: Device, component, part, system, software, firmware, among other things.

Project planning manual A Project Planning Manual is part of the application documentation used to support the sizing and planning of systems, machines or installations.

Qualified personnel In terms of this application documentation, qualified persons are those persons who are familiar with the installation, mounting, commissioning and operation of the components of the electric drive and control system, as well as with the hazards this implies, and who possess the qualifications their work requires. To comply with these qualifications, it is necessary, among other things,

1) to be trained, instructed or authorized to switch electric circuits and devices safely on and off, to ground them and to mark them

2) to be trained or instructed to maintain and use adequate safety equipment

3) to attend a course of instruction in first aid

Control system

A control system comprises several interconnected control components placed on the market as a single functional unit.

3.2 General information

3.2.1 Using the Safety instructions and passing them on to others

Do not attempt to install and operate the components of the electric drive and control system without first reading all documentation provided with the product. Read and understand these safety instructions and all user documentation prior to working with these components. If you do not have the user documentation for the components, contact your responsible Rexroth sales partner. Ask for these documents to be sent immediately to the person or persons responsible for the safe operation of the components.

If the component is resold, rented and/or passed on to others in any other form, these safety instructions must be delivered with the component in the official language of the user's country.

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, injury, electric shock or even death.

3.2.2 Requirements for safe use

Read the following instructions before initial commissioning of the components of the electric drive and control system in order to eliminate the risk of injury and/or property damage. You must follow these safety instructions.

- Rexroth is not liable for damages resulting from failure to observe the safety instructions.
- Read the operating, maintenance and safety instructions in your language before commissioning. If you find that you cannot completely understand the application documentation in the available language, please ask your supplier to clarify.
- Proper and correct transport, storage, mounting and installation, as well as care in operation and maintenance, are prerequisites for optimal and safe operation of the component.
- Only qualified persons may work with components of the electric drive and control system or within its proximity.
- Only use accessories and spare parts approved by Rexroth.
- Follow the safety regulations and requirements of the country in which the components of the electric drive and control system are operated.
- Only use the components of the electric drive and control system in the manner that is defined as appropriate. See chapter "Appropriate Use".
- The ambient and operating conditions given in the available application documentation must be observed.
- Applications for functional safety are only allowed if clearly and explicitly specified in the application documentation "Integrated Safety Technolo-

gy". If this is not the case, they are excluded. Functional safety is a safety concept in which measures of risk reduction for personal safety depend on electrical, electronic or programmable control systems.

- The information given in the application documentation with regard to the use of the delivered components contains only examples of applications and suggestions.

  The machine and installation manufacturers must

  – make sure that the delivered components are suited for their individual application and check the information given in this application documentation with regard to the use of the components,

  – make sure that their individual application complies with the applicable safety regulations and standards and carry out the required measures, modifications and complements.

- Commissioning of the delivered components is only allowed once it is sure that the machine or installation in which the components are installed complies with the national regulations, safety specifications and standards of the application.
- Operation is only allowed if the national EMC regulations for the application are met.
- The instructions for installation in accordance with EMC requirements can be found in the section on EMC in the respective application documentation.

  The machine or installation manufacturer is responsible for compliance with the limit values as prescribed in the national regulations.

- The technical data, connection and installation conditions of the components are specified in the respective application documentations and must be followed at all times.

National regulations which the user has to comply with

- European countries: In accordance with European EN standards
- United States of America (USA):
  – National Electrical Code (NEC)
  – National Electrical Manufacturers Association (NEMA), as well as local engineering regulations
  – Regulations of the National Fire Protection Association (NFPA)
- Canada: Canadian Standards Association (CSA)
- Other countries:
  – International Organization for Standardization (ISO)
  – International Electrotechnical Commission (IEC)

3.2.3 Hazards by improper use

- High electrical voltage and high working current! Danger to life or serious injury by electric shock!
- High electrical voltage by incorrect connection! Danger to life or injury by electric shock!
- Dangerous movements! Danger to life, serious injury or property damage by 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! Injury by crushing, shearing, cutting, hitting!
- Risk of injury by improper handling of batteries!
- Risk of injury by improper handling of pressurized lines!

3.3 Danger-related notes

3.3.1 Protection against touch of electric parts and housings

☞ This section concerns components of electric drive and control systems with a voltage **over 50 volt.**

In the case of touching parts with a voltage higher than 50 volt, this can be dangerous for personnell and can lead to electric shock. During operation of components of electric drive and control systems, certain parts of these components are inevitably under dangerous voltage.

High electrical voltage! Danger of life, risk of injury due to electric shock or heavy bodily harm.

- Operation, maintenance and/or repair of components of electric drive and control systems may only be done by qualified personnel.
- Observe the general construction and safety instructions about work on high voltage systems.
- Before switching on, establish the fixed connection of the protective conductor to all electric components according to the interconnection diagram.
- Operation, even for short-term measuring and testing purposes, is only permitted with the protective conductor securely connected to the component points provided.
- Disconnect electric components from the mains or from the power supply, before you have contact with electric parts with a voltage higher than 50 V. Secure the electric components against restarting.
- Observe for electrical components:

  Please, always wait **30 minutes**, after switch-off, so live capacitors discharge before they have access to electric components. To exclude any danger due to any contact, measure electric voltage of live parts before working.
- Before switch-on install the provided covers and protective devices for the touch guard.
- Do not touch any electric junctions of live components.
- Do not disconnect or connect connectors under voltage.

High housing voltage and high discharge current! Danger! Risk of injury due to electric shock!

- Before switch-on and start-up, ground or connect the components of the drive and control system with the protective conductors on the grounding points.

- Connect the protective conductors of the electric drive and control systems always fix and continuously with the external supply network.
- Do a protective conductor connection with a minimum cross section according to the following table.

Cross-sectional area A of the live wires	Minimum cross-sectional area A_{PE} of the protective conductor
A ≤ 16 mm²	A
25 mm² < A ≤ 50 mm²	25 mm²
50 mm² < A	A / 2

Tab. 3-1: Minimum cross-section of protective conductor connection for motors

3.3.2 Protective extra-low voltage as protection against electric shock

Protective extra-low voltage is used to allow connecting devices with basic insulation to extra-low voltage circuits.

On components of an electric drive and control system provided by 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 Rexroth products, the connected extra-low voltage circuits must comply with the requirements for PELV ("Protective Extra-Low Voltage").

3.3.3 Protection against dangerous movements

Dangerous movements can be caused by faulty control of connected motors. Some common examples are:

- Improper or wrong wiring or cable connection
- Operator errors
- Wrong input of parameters before commissioning
- Malfunction of sensors and encoders
- Defective components
- Software or firmware errors

These errors can occur immediately after equipment is switched on or even after an unspecified time of trouble-free operation.

The monitoring functions in the components of the electric drive and control system will normally be sufficient to avoid malfunction in the connected drives. Regarding personal safety, especially the danger of injury and/or property damage, this alone cannot be relied upon to ensure complete safety. Until the integrated monitoring functions become effective, it must be assumed in any case that faulty drive movements will occur. The extent of faulty drive movements depends upon the type of control and the state of operation.

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

A **risk assessment** must be prepared for the installation or machine, with its specific conditions, in which the components of the electric drive and control system are installed.

As a result of the risk assessment, the user must provide for monitoring functions and higher-level measures on the installation side for personal safety. The safety regulations applicable to the installation or machine must be taken into consideration. Unintended machine movements or other malfunctions are possible if safety devices are disabled, bypassed or not activated.

To avoid accidents, 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 coverings
  - Light barriers
- Make sure the safety fences and protective coverings are strong enough to resist maximum possible kinetic energy.
- Mount emergency stopping switches in the immediate reach of the operator. Before commissioning, verify that the emergency stopping equipment works. Do not operate the machine if the emergency stopping 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 axes,
  - adding an external braking/arrester/clamping mechanism or
  - ensuring sufficient counterbalancing of the vertical axes.
- The standard equipment **motor holding brake** or an external holding brake controlled by the drive controller is **not sufficient to guarantee personal safety**!
- Disconnect electrical power to the components of the electric drive and control system using the master switch and secure them from reconnection ("lock out") for:
  - Maintenance and repair work
  - Cleaning of equipment
  - Long periods of discontinued equipment use
- Prevent the operation of high-frequency, remote control and radio equipment near 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.

3.3.4 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.
- Entering these areas can pose an increased risk to the above-mentioned groups of persons. They should seek advice from their physician.
- 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.

3.3.5 Protection against contact with hot parts

Hot surfaces of components of the electric drive and control system. Risk of burns!

- 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.
- Before touching motors after having switched them off, let them cool down for a sufficient period of time. Cooling down can 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 chokes, supply units and drive controllers off, 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 installation must take measures to avoid injuries caused by burns in the final application. These measures can be, for example: Warnings at the machine or installation, guards (shieldings or barriers) or safety instructions in the application documentation.

3.3.6 Protection during handling and mounting

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

- Observe the relevant statutory regulations of accident prevention.
- Use suitable equipment for mounting and transport.
- 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!

3.3.7 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 as this may cause leakage or explosion.
- Do not throw batteries into open flames.
- Do not dismantle 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. Observe the national regulations of your country.

3.3.8 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).
- Observe 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. Observe the national regulations of your country.

3.4 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 meant to draw the reader's attention to the safety instruction and identifies 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

In case of non-compliance with this safety instruction, death or serious injury **will** occur.

⚠ WARNING

In case of non-compliance with this safety instruction, death or serious injury **could** occur.

⚠ CAUTION

In case of non-compliance with this safety instruction, minor or moderate injury could occur.

NOTICE

In case of non-compliance with this safety instruction, property damage could occur.

4 Technical data

4.1 Explanations about technical data

4.1.1 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. Also refer to chapter 9.23 on page 130.

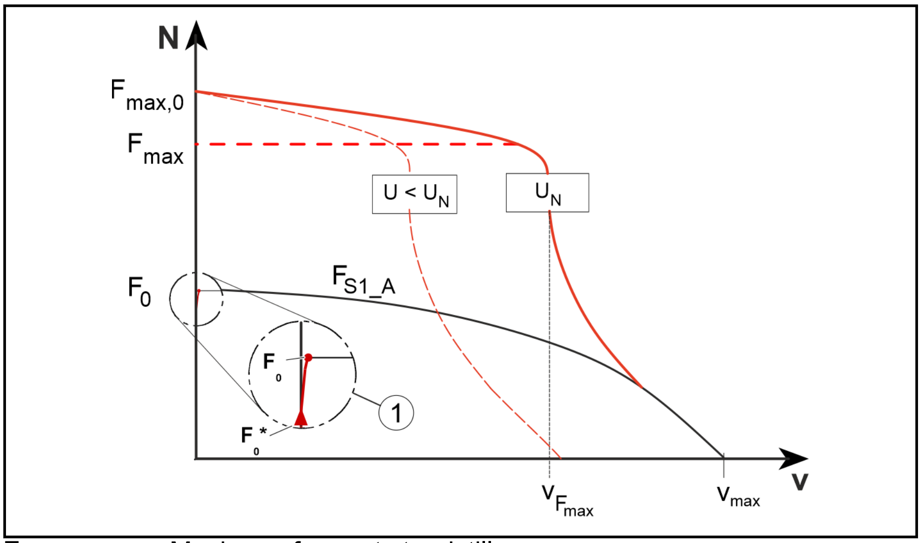
☞ All relationships and data described in the following sections may only apply if exclusively primary and secondary parts of the same size are combined (e.g. ML3P03 with ML3S03).

4.1.2 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 9.24 "Thermal connection - Installation modes" on page 131.



$F_{max,0}$	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. 9-14)
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 9.25 .

Fig. 4-1: Example motor characteristic curve

☞ 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).

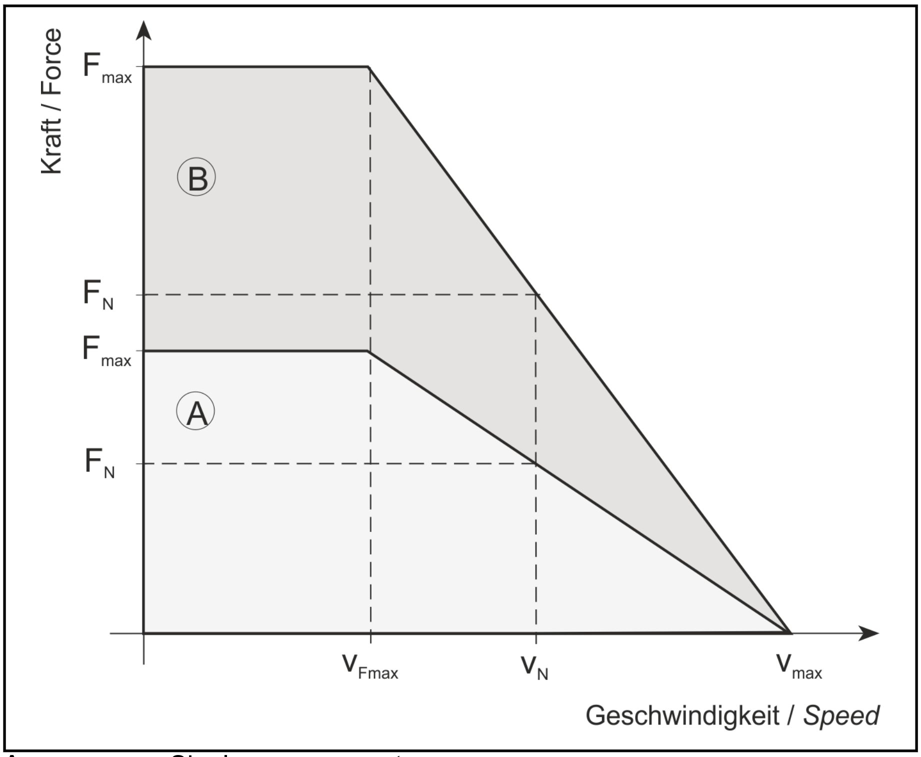
  $F_{total} = 2 \times F_{Motor}$
- Doublication of the voltage within the drive controller (if not limited by it)

  $I_{Inverter} = 2 \times I_{Motor}$
- 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

  $R_{12,total} = 1/2 \times R_{12,Motor}$ / $L_{12,total} = 1/2 \times L_{12,Motor}$



A Single arrangement
B Parallel arrangement

Fig. 4-2: Characteristics force over velocity at single or parallel arrangment of two primary parts on one controller

For parallel connection of two primary parts at one drive controller, relevant motor parameters for start-up are specified in this documentation (see chapter Parallel connection: Several primary parts in series).

4.1.3 IndraSize

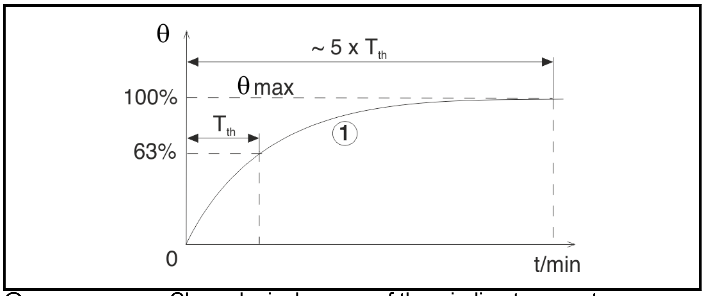
By using the IndraSize software, drive controllers, motors and mechanic gearboxes can be easily sized. The engineering tool covers the entire range of Rexroth drives and motors. Calculate the characteristic curves for your application by using the sizing and calculation tool IndraSize: www.boschrexroth.com/IndraSize

4.1.4 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.

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 force that can be reached depends on the drive control device used. The temperature gradient is 6 K/s at I_{max}.
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 with 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 inductivity	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, please observe the specifications in chapter 8 Connection technique 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.

Designation	Symbol	Unit	Toler-ance	Description
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.  ① Chronological course of the winding temperature θ_{max} Max. winding temperature T_{th} Thermal time constant *Fig. 4-3: Thermal time constant*
Mass primary part with standard encapsulation	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.

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.

4.2 General technical data

The data specified in Tab. 4-1 apply for all motor sizes. In this context, however, the comments on the individual items in Chapter “Application notes” must be observed.

Designation	Symbol	Unit	ML3P	ML3S
Ambient temperature in operation (see also chapter 9.3 Installation altitude and ambient conditions)	T_{amb}	°C	+0 ... +40	
Allowed transport temperature (see also chapter 10.4.1 Notes about transport)	T_T	°C	-20 ... +80	
Allowed storage temperature (see also chapter 10.4.2 Information on storage)	T_L	°C	-25 ... +55	
Max. permitted secondary part temperature in operation	T_{Smax}	°C	/	70 °C
Thermal class acc. to DIN EN 60034-1	-	-	130(B)	/
Warning temperature (winding)	T_{warn}	°C	100	/
Shutdown temperature (winding)	T_{abst}	°C	110	/
Degree of protection according to DIN EN 60034-5	-	-	IP40 (IP64)	
CSA file number			Approval number of CSA (Canadian Space Agency) certified products	

Tab. 4-1: General technical data

4.3 Frame size 03

4.3.1 Primary part ML3P03 - Frame lengths A/B

Designation	Symbol	Unit	ML3P03-A_BW	ML3P03-A_BZ planned *)	ML3P03-B_BW	ML3P03-B_BY planned *)
Maximum force at standstill	$F_{max,0}$	N	120		240	
Maximum current at standstill	$I_{max,0}$	A	4.1	12.6	8.2	19.5
Maximum force	F_{max}	N	100	75	200	160
Maximum current	I_{max}	A	2.9	6.1	5.8	10.2
Continuous force at standstill	F_0	N	60		120	
Continuous current at standstill	I_0	A	1.5	4.7	3.0	7.2
Maximum velocity at F_{max}	v_{Fmax}	m/min	520	1390	530	1,110
Attractive force	F_{ATT}	N	300		500	
Force constant	$K_{F,0}$	N/A	40.0	12.8	40.0	16.7
Voltage constant at 20 °C	K_{EMK}	Vs/m	22.6	7.8	22.6	9.9
Winding resistance at 20 °C	R_{12}	Ohm	10.8	1.12	5.4	0.92
Winding inductance	L_{12}	mH	70	7.3	34.0	6.0
Thermal time constant	T_{th_nom}	min	1.2			
Pole width	τ_p	mm	12			
Power wire cross-section	A	mm^2	0.5			
Primary part mass	m_P	kg	0.6		0.9	
Ground connection cable	m_K	kg/m	0.21			
Latest amendment: 2021-04-14						

*) Expected to be available form Q1/2022

Tab. 4-2: Technical data ML3P03-A / -B

4.3.2 Primary part ML3P03 - Frame lengths D/F

Designation	Symbol	Unit	ML3P03-D_BP planned *)	ML3P03-D_BW	ML3P03-F_BN	ML3P03-F_BU
Maximum force at standstill	$F_{max,0}$	N	480		720	
Maximum current at standstill	$I_{max,0}$	A	8.2	16.4	12.3	25.1
Maximum force	F_{max}	N	450	400	570	520
Maximum current	I_{max}	A	6.9	11.6	8.0	14.6
Continuous force at standstill	F_0	N	240		360	
Continuous current at standstill	I_0	A	3.0	6.0	4.5	9.3
Maximum velocity at F_{max}	v_{Fmax}	m/min	210	525	280	625
Attractive force	F_{ATT}	N	900		1,300	
Force constant	$K_{F,0}$	N/A	80.0	40.0	80.0	38.7
Voltage constant at 20 °C	K_{EMK}	Vs/m	46.0	22.6	46.0	22.6
Winding resistance at 20 °C	R_{12}	Ohm	10.7	2.9	7.2	1.7
Winding inductance	L_{12}	mH	70	15.3	46.0	11.0
Thermal time constant	T_{th_nom}	min	1.2			
Pole width	τ_p	mm	12			
Power wire cross-section	A	mm^2	0.5			0.75
Primary part mass	m_P	kg	1.6		2.3	
Ground connection cable	m_K	kg/m	0.21			
Latest amendment: 2021-04-14						

*) Expected to be available form Q1/2022

Tab. 4-3: Technical data ML3P03-D / -F

4.3.3 ML3S03 secondary part

Designation	Symbol	Unit	ML3S03-__-0096	ML3S03-__-0144	ML3S03-__-0384
Mass secondary part	m_S	kg	0.2	0.3	0.8
Mass secondary part, relative	m_{S_rel}	kg/m	2.1		
Latest amendment: 2018-06-11					

Tab. 4-4: Technical data ML3S03

4.3.4 Characteristic curve ML3P03

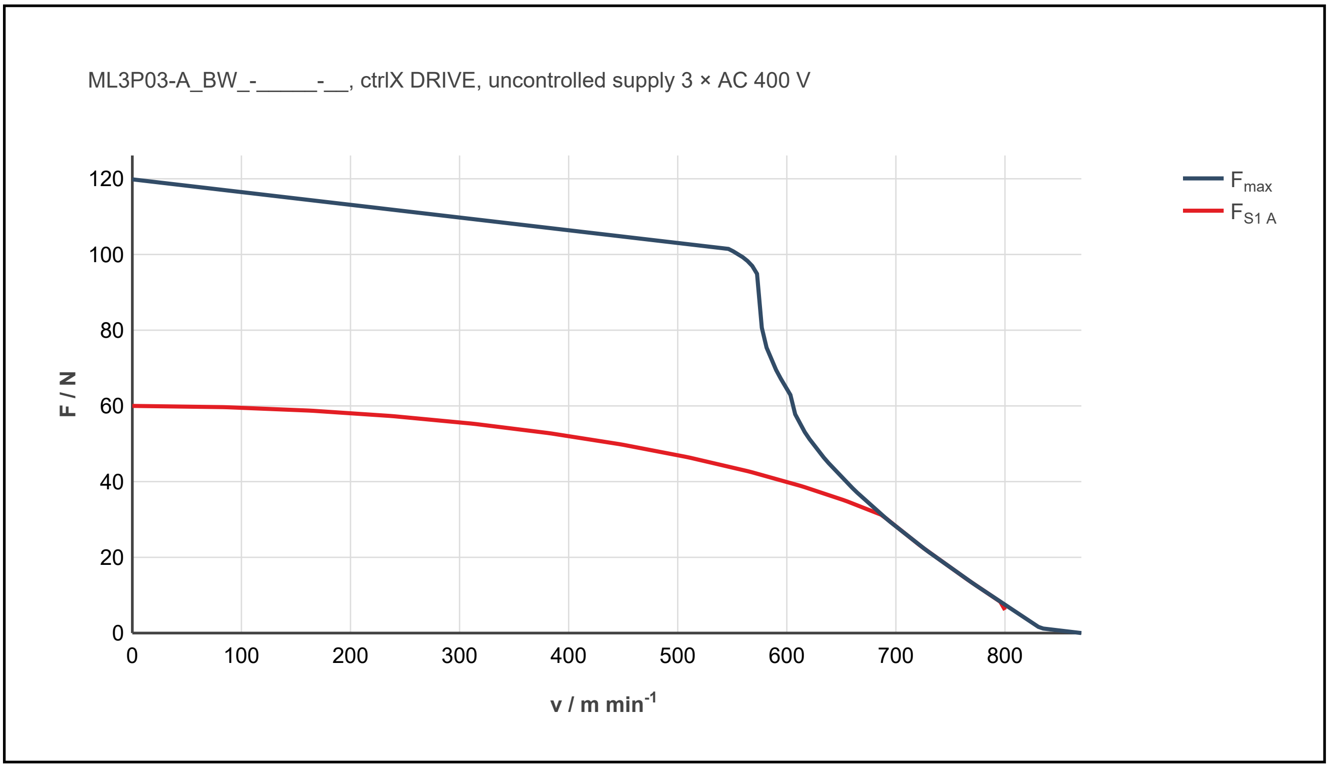


Fig. 4-4: Characteristic curve ML3P03-A_BW

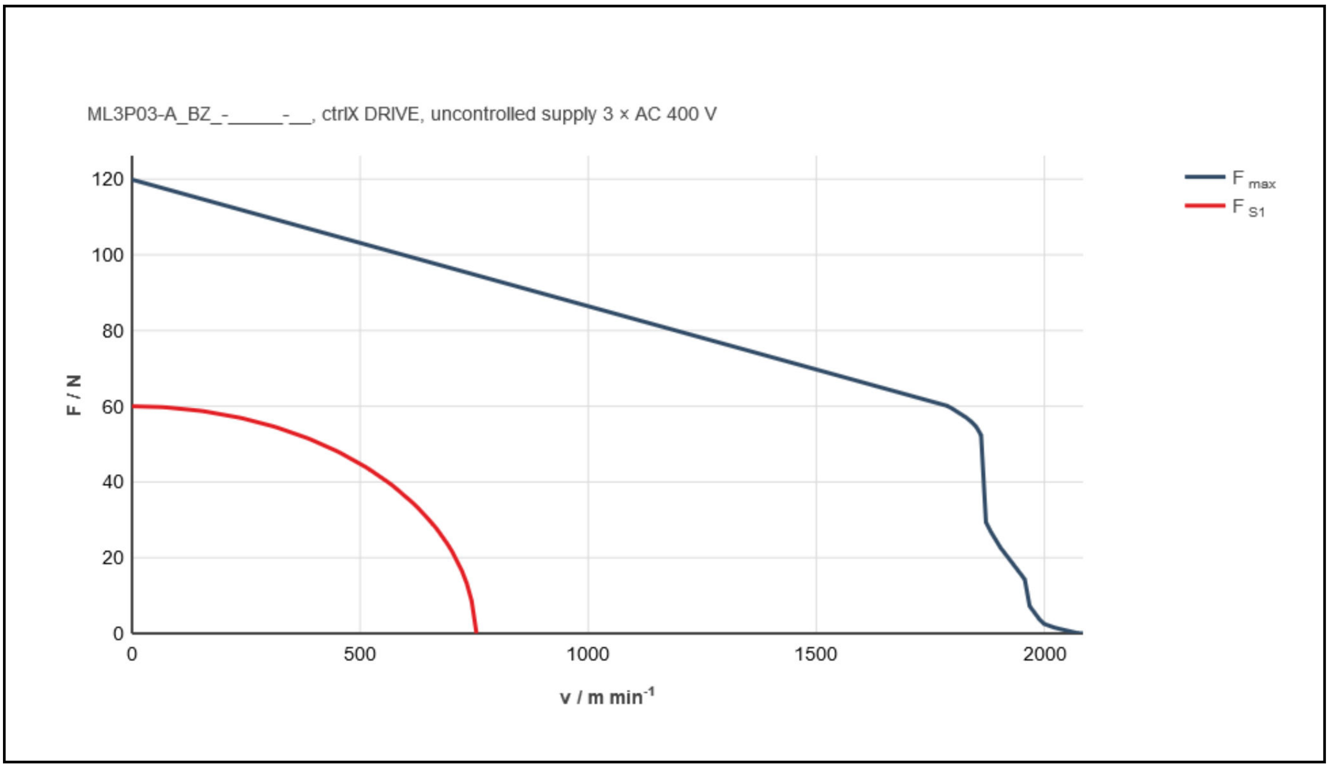


Fig. 4-5: Characteristic curve ML3P03-A_BZ

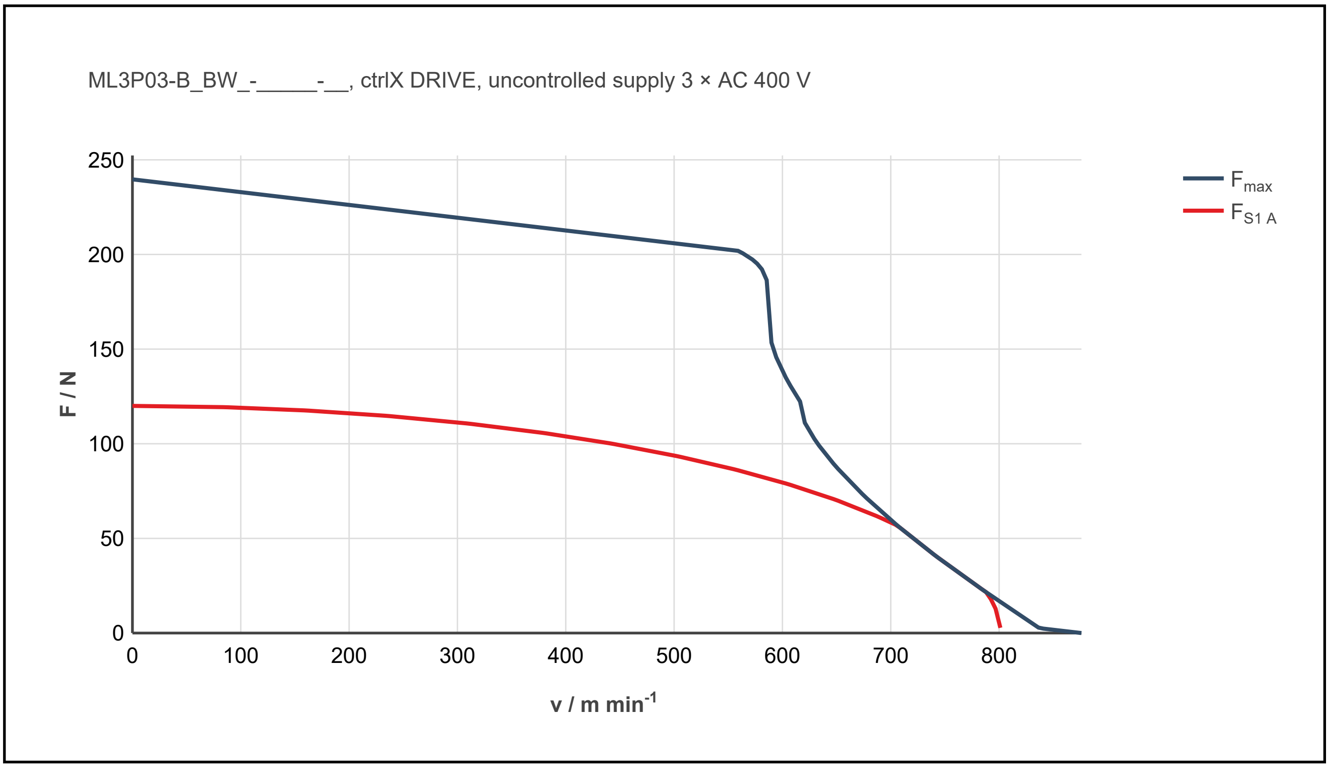


Fig. 4-6: Characteristic curve ML3P03-B_BW

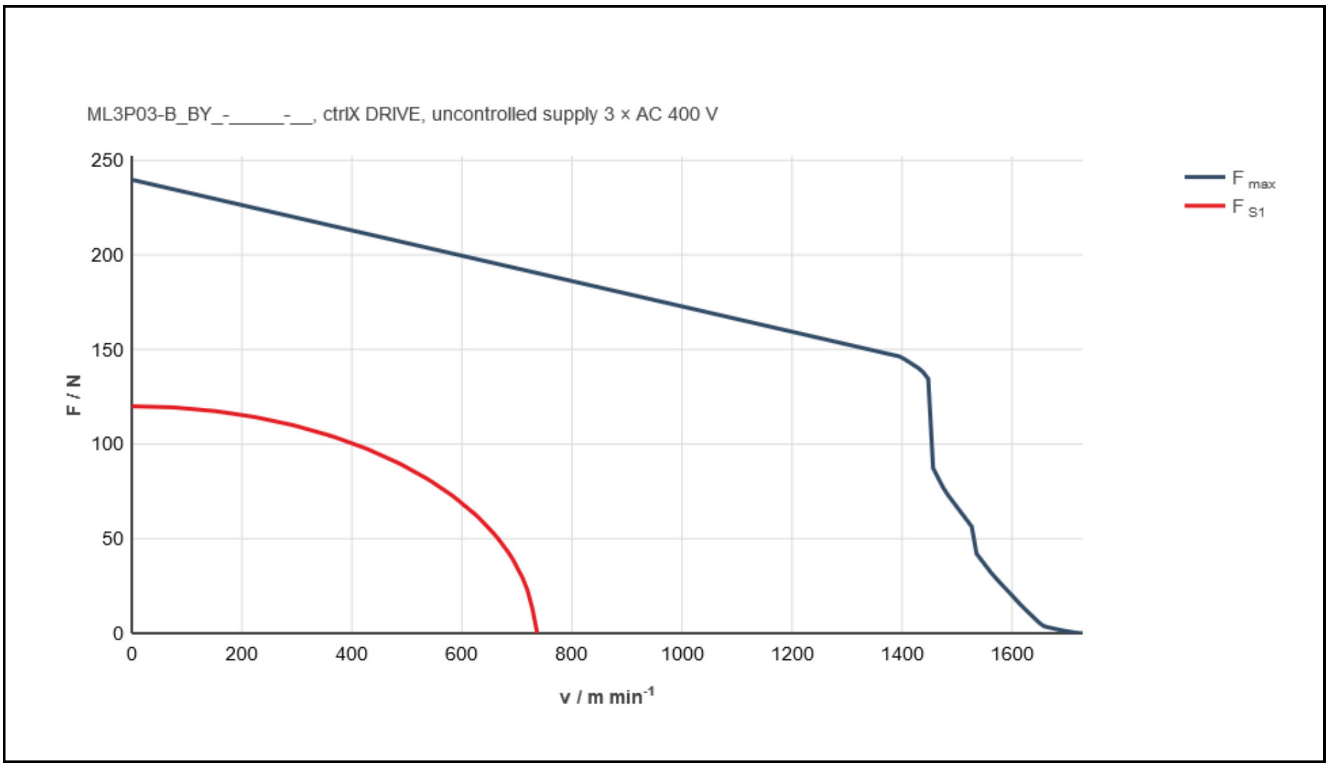


Fig. 4-7: Characteristic curve ML3P03-B_BY

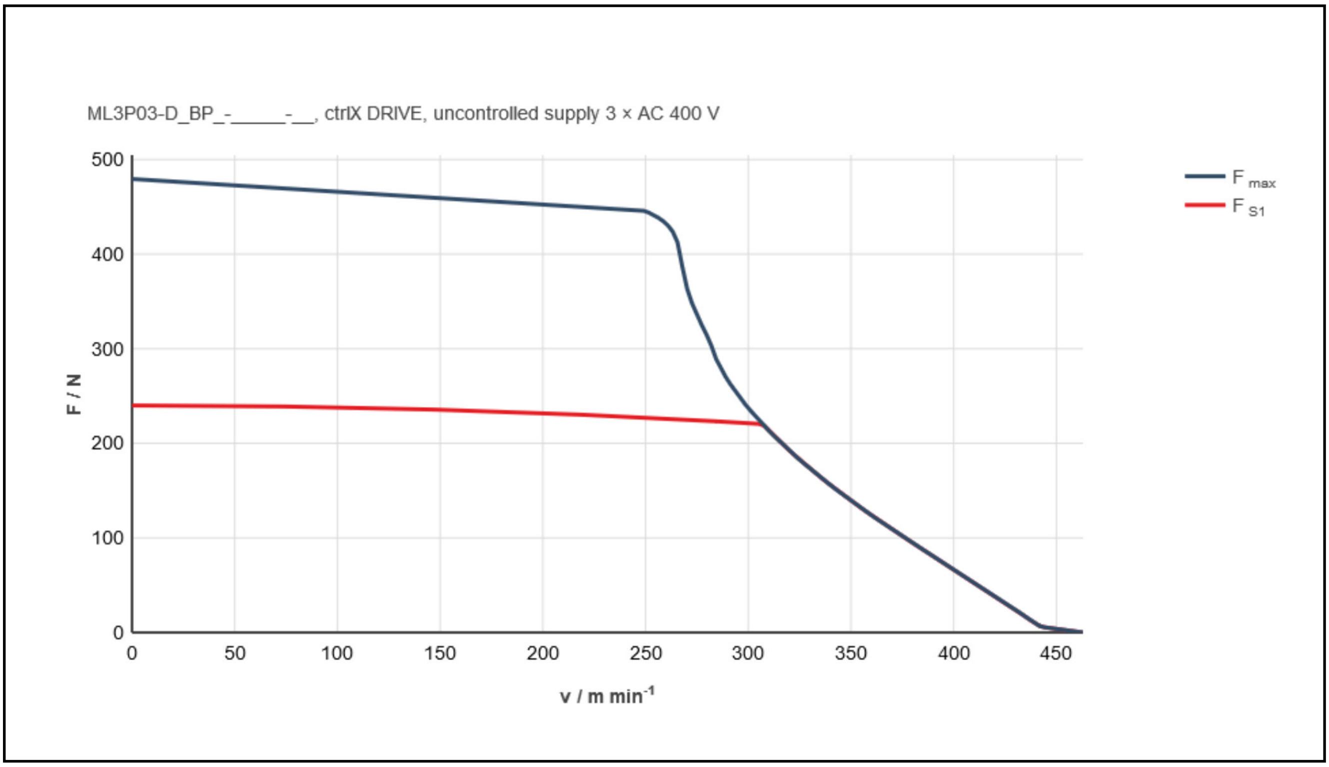


Fig. 4-8: Characteristic curve ML3P03-D_BP

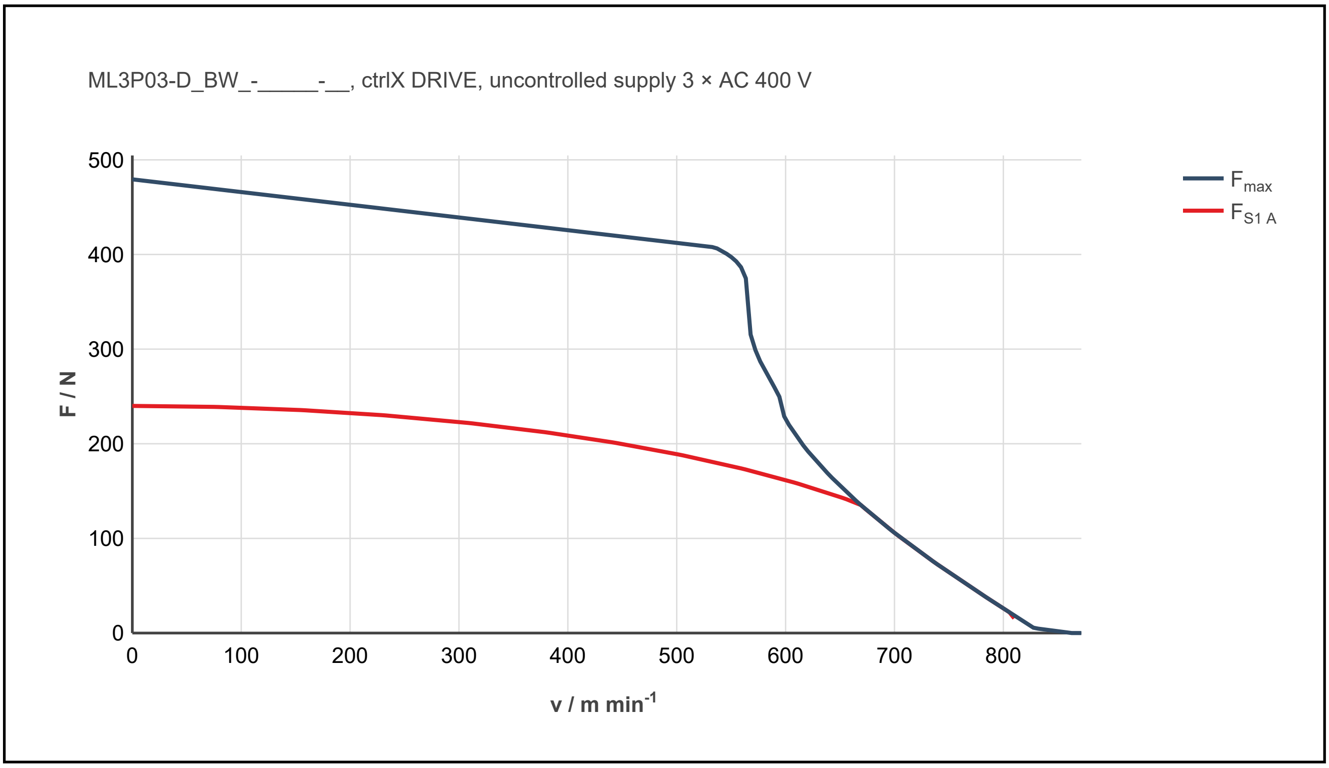


Fig. 4-9: Characteristic curve ML3P03-D_BW

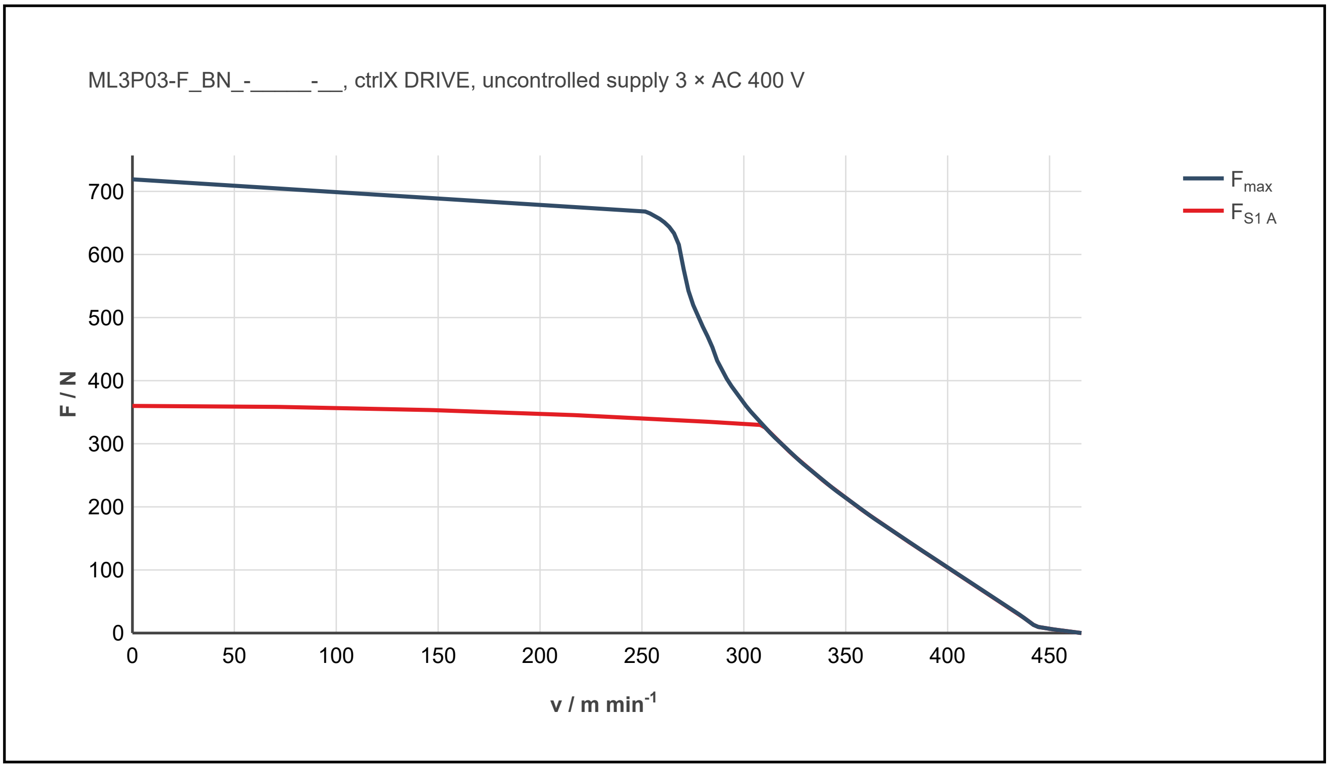


Fig. 4-10: Characteristic curve ML3P03-F_BN

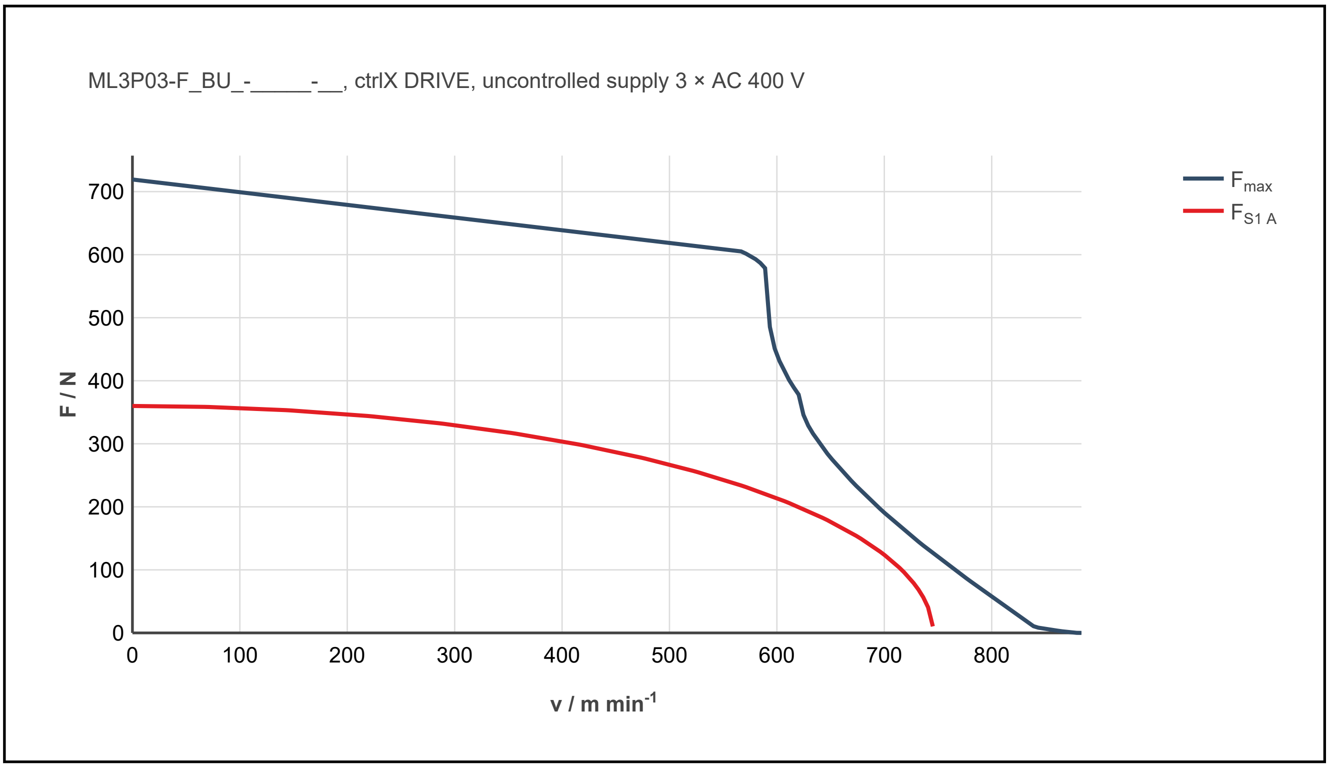


Fig. 4-11: Characteristic curve ML3P03-F_BU

4.4 Frame size 06

4.4.1 Primary part ML3P06 - Frame lengths B / C / D

Designation	Symbol	Unit	ML3P06-B_BK	ML3P06-B_BR	ML3P06-C_BC	ML3P06-C_BR	ML3P06-D_BK	ML3P06-D_BR
Maximum force at standstill	$F_{max,0}$	N	450		675		900	
Maximum current at standstill	$I_{max,0}$	A	6.5	13.1	6.5	19.6	13.1	26.2
Maximum force	F_{max}	N	420	390	650	585	845	780
Maximum current	I_{max}	A	5.5	9.7	5.8	14.5	11.2	19.4
Continuous force at standstill	F_0	N	200		300		400	
Continuous current at standstill	I_0	A	2.2	4.3	2.1	6.4	4.3	8.6
Maximum velocity at F_{max}	v_{Fmax}	m/min	190	415	110	425	190	420
Attractive force	F_{ATT}	N	950		1325		1,700	
Force constant	$K_{F,0}$	N/A	93.0	46.5	140.2	46.5	93.0	46.5
Voltage constant at 20 °C	K_{EMK}	Vs/m	53.7	26.9	80.6	26.9	53.7	26.9
Winding resistance at 20 °C	R_{12}	Ohm	14.4	3.6	21.6	2.42	7.2	1.8
Winding inductance	L_{12}	mH	108.0	28.0	162.0	18.0	54.0	14.0
Thermal time constant	T_{th_nom}	min	1.3					
Pole width	τ_p	mm	12					
Power wire cross-section	A	mm^2	0.5					0.75
Primary part mass	m_P	kg	1.5		2.0		2.6	
Ground connection cable	m_K	kg/m	0.21					
Latest amendment: 2020-01-16								

Tab. 4-5: Technical data ML3P06-B / -C / -D

4.4.2 Primary part ML3P06 - Frame lengths E / F / H

Designation	Symbol	Unit	ML3P06-E_BK	ML3P06-E_BR	ML3P06-F_BK	ML3P06-F_BR	ML3P06-H_BK	ML3P06-H_BR
Maximum force at standstill	$F_{max,0}$	N	1125		1350		1800	
Maximum current at standstill	$I_{max,0}$	A	13.5	32.7	19.6	41.0	26.2	52.0
Maximum force	F_{max}	N	1070	975	1270	1170	1690	1560
Maximum current	I_{max}	A	11.8	24.1	16.7	30.0	22.4	38.5
Continuous force at standstill	F_0	N	500		600		800	
Continuous current at standstill	I_0	A	4.5	10.8	6.4	13.4	8.6	17.2
Maximum velocity at F_{max}	v_{Fmax}	m/min	145	425	190	420	185	420
Attractive force	F_{ATT}	N	2075		2450		3400	
Force constant	$K_{F,0}$	N/A	112.1	46.5	93.0	44.9	93.0	46.5
Voltage constant at 20 °C	K_{EMK}	Vs/m	65.0	26.9	53.7	26.9	53.7	26.9
Winding resistance at 20 °C	R_{12}	Ohm	8.6	1.44	4.82	1.18	3.62	0.92
Winding inductance	L_{12}	mH	64.0	10.8	36.0	8.8	28.0	6.8
Thermal time constant	T_{th_nom}	min	1.3					
Pole width	τ_p	mm	12					
Power wire cross-section	A	mm^2	0.5	1.0	0.5	1.5	0.75	2.5
Primary part mass	m_P	kg	3.2		3.8		5.2	
Ground connection cable	m_K	kg/m	0.21					0.3
Latest amendment: 2020-01-16								

Tab. 4-6: Technical data ML3P06-E / -F / -H

4.4.3 Secondary part ML3S06

Designation	Symbol	Unit	ML3S06-__-0192	ML3S06-__-0288
Mass secondary part	m_S	kg	0.7	1.1
Mass secondary part, relative	m_{S_rel}	kg/m	3.8	
Latest amendment: 2018-06-11				

Tab. 4-7: Technical data ML3S06

4.4.4 Characteristic curve ML3P06

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

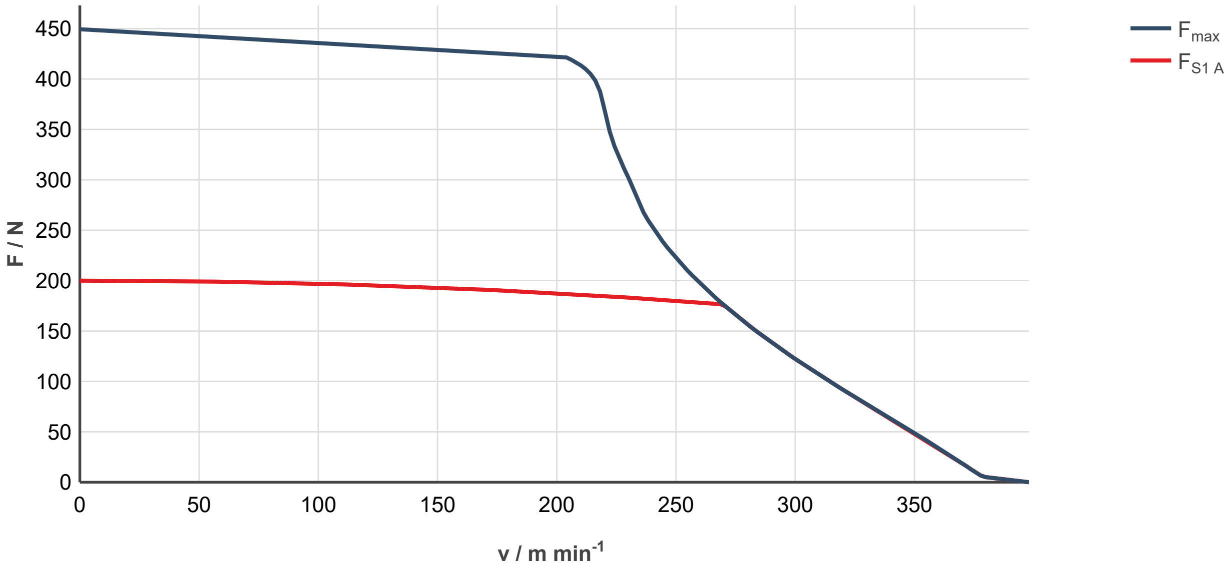


Fig. 4-12: Characteristic curve ML3P06-B_BK

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

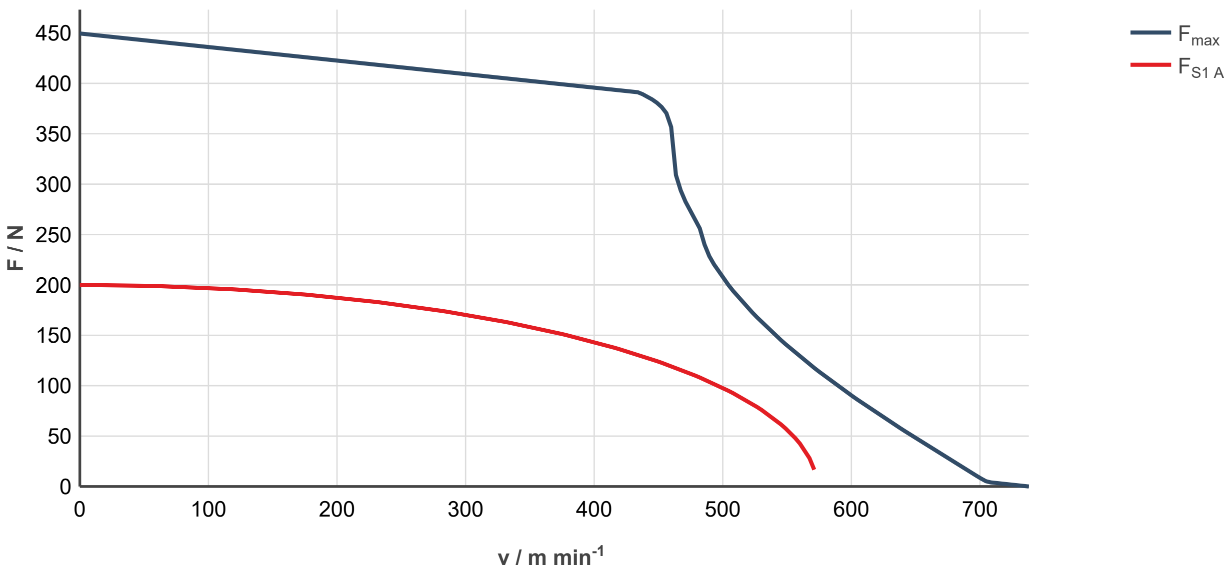


Fig. 4-13: Characteristic curve ML3P06-B_BR

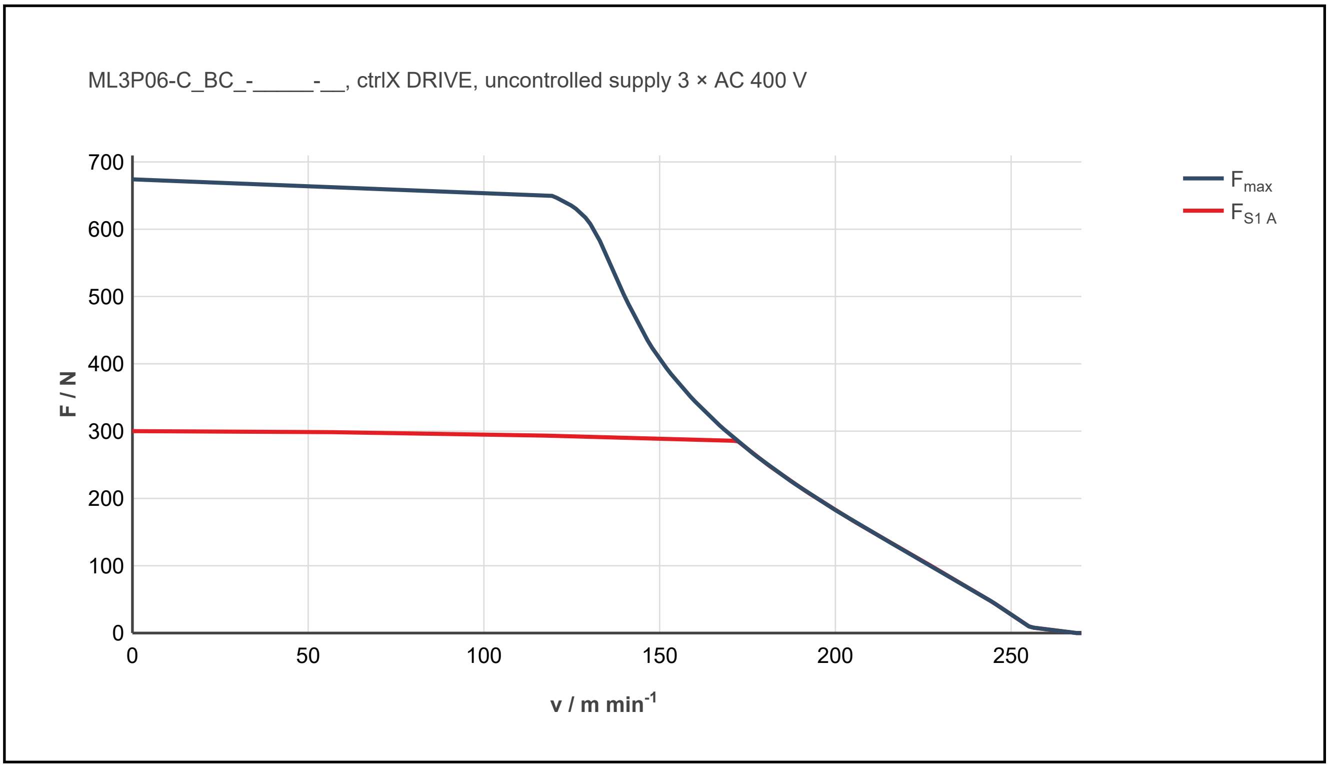


Fig. 4-14: Characteristic curve ML3P06-C_BC

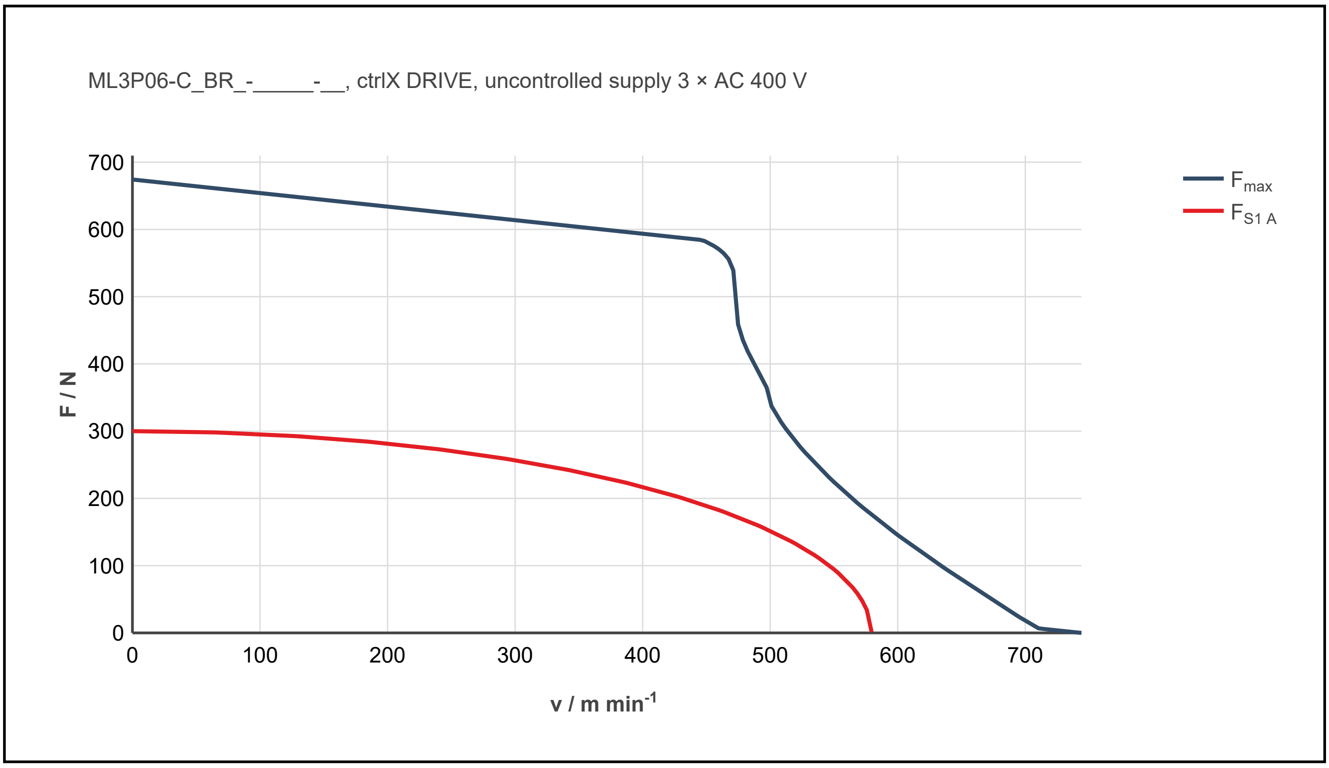


Fig. 4-15: Characteristic curve ML3P06-C_BR

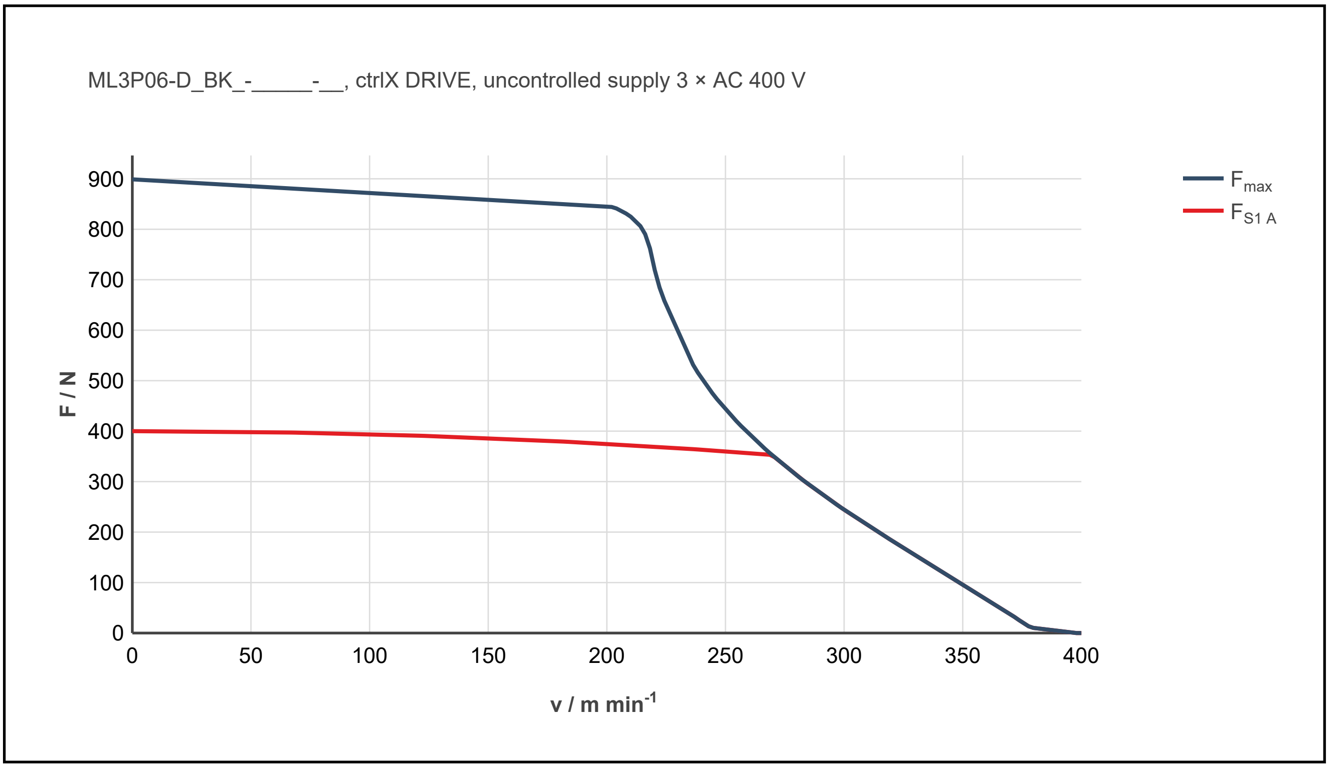


Fig. 4-16: Characteristic curve ML3P06-D_BK

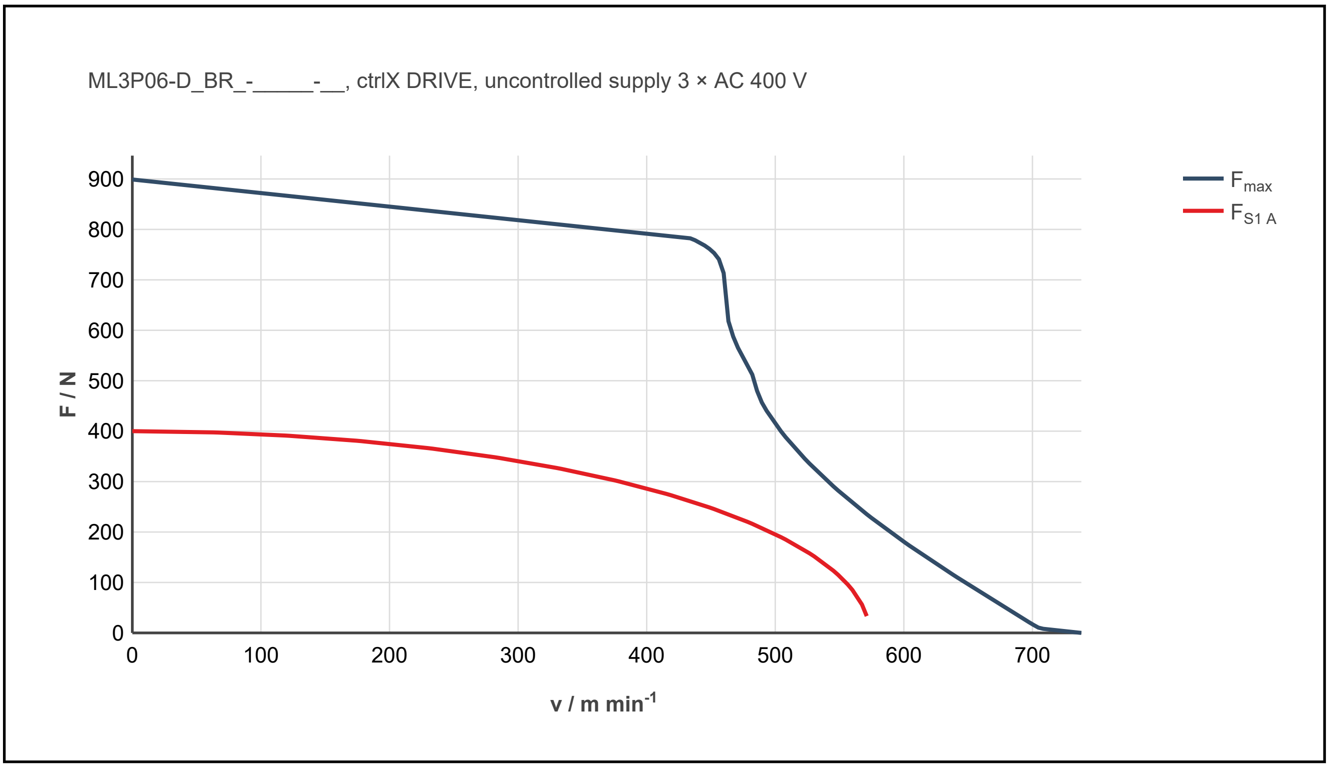


Fig. 4-17: Characteristic curve ML3P06-D_BR

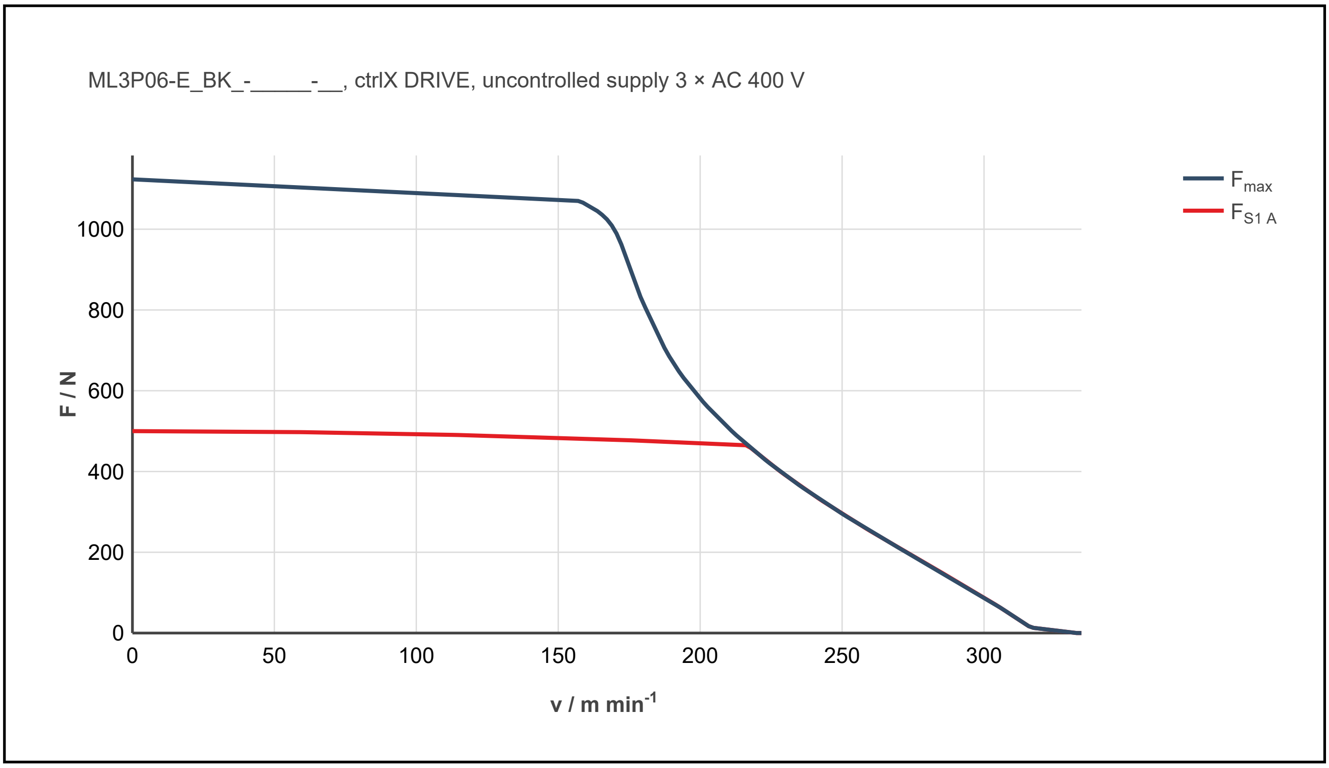


Fig. 4-18: Characteristic curve ML3P06-E_BK

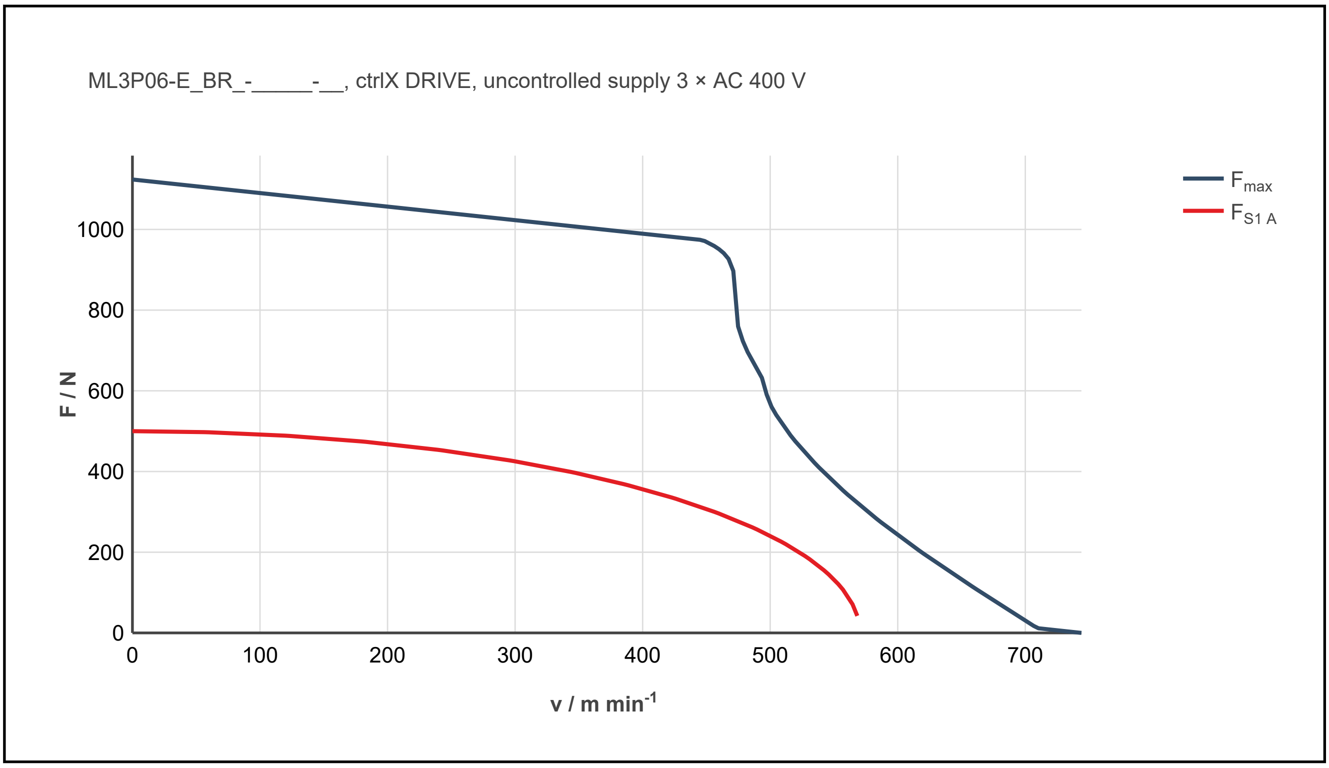


Fig. 4-19: Characteristic curve ML3P06-E_BR

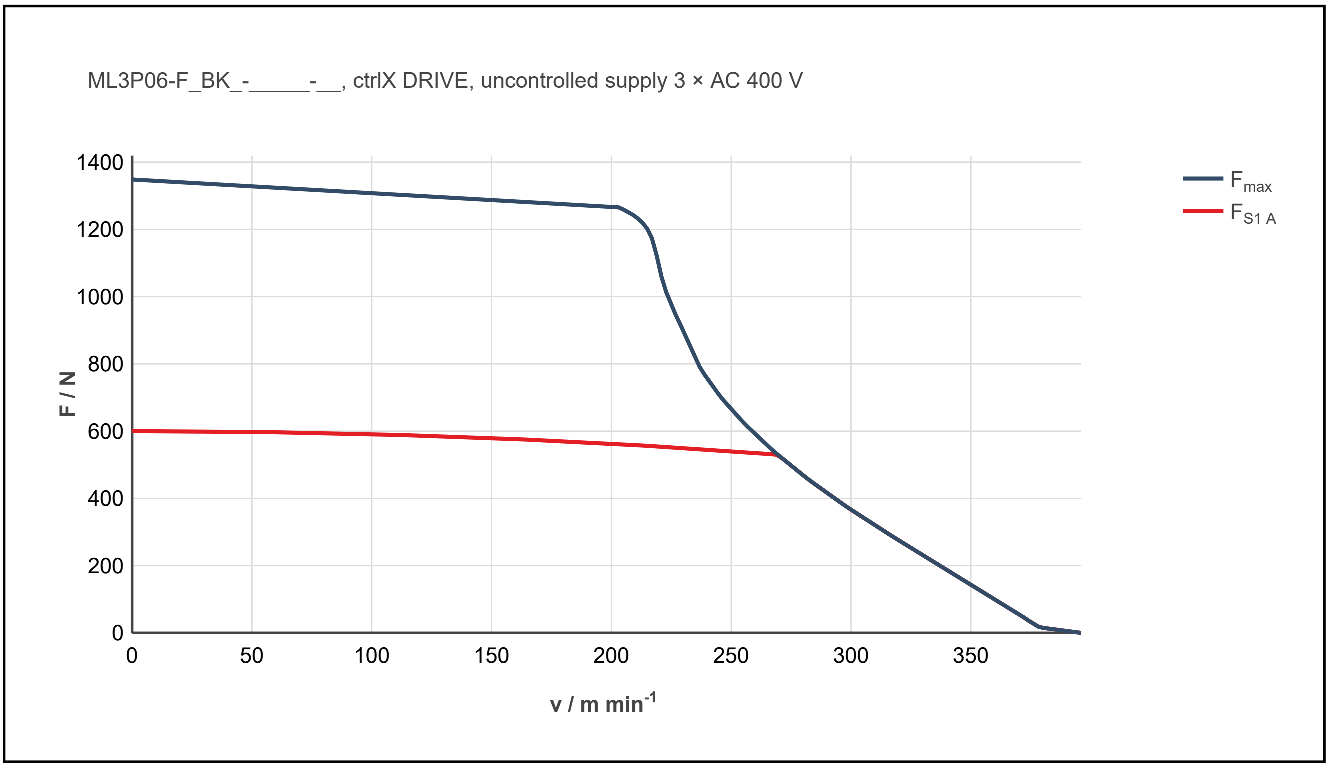


Fig. 4-20: Characteristic curve ML3P06-F_BK

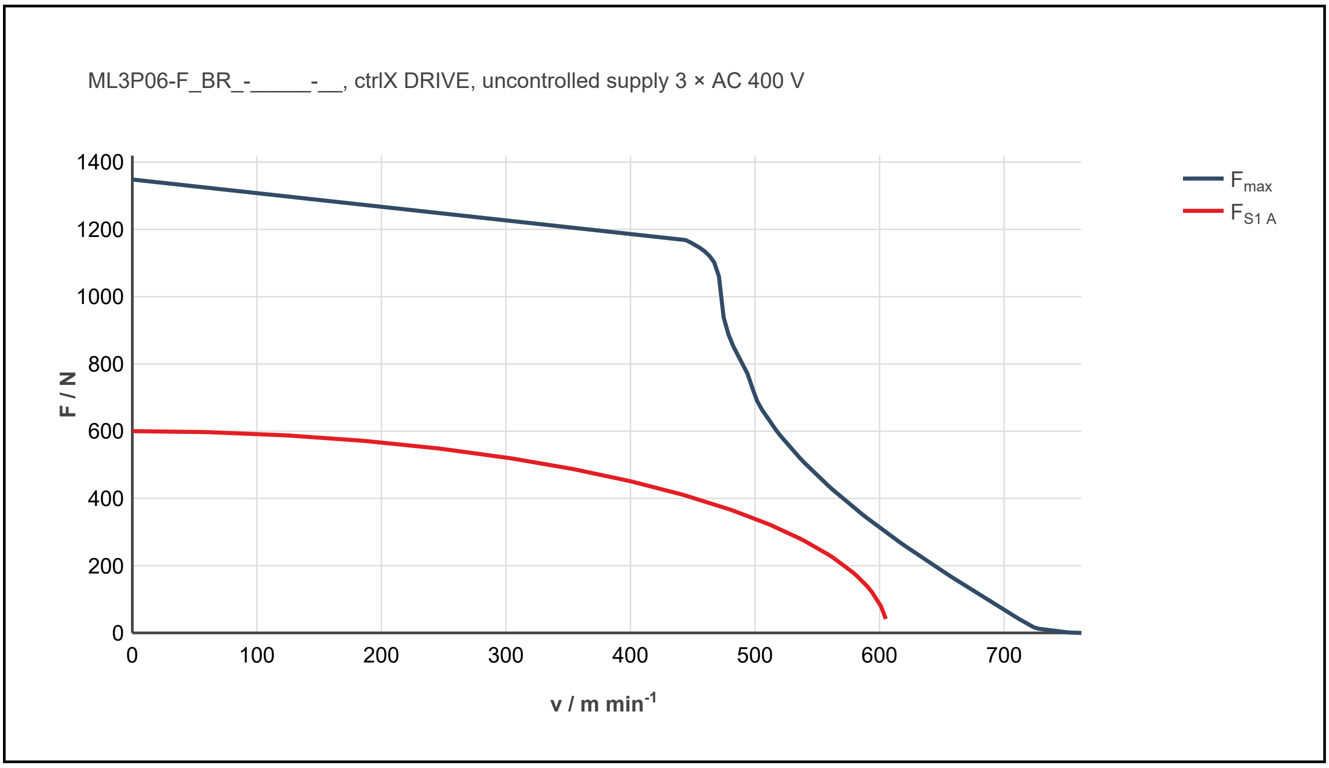


Fig. 4-21: Characteristic curve ML3P06-F_BR

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

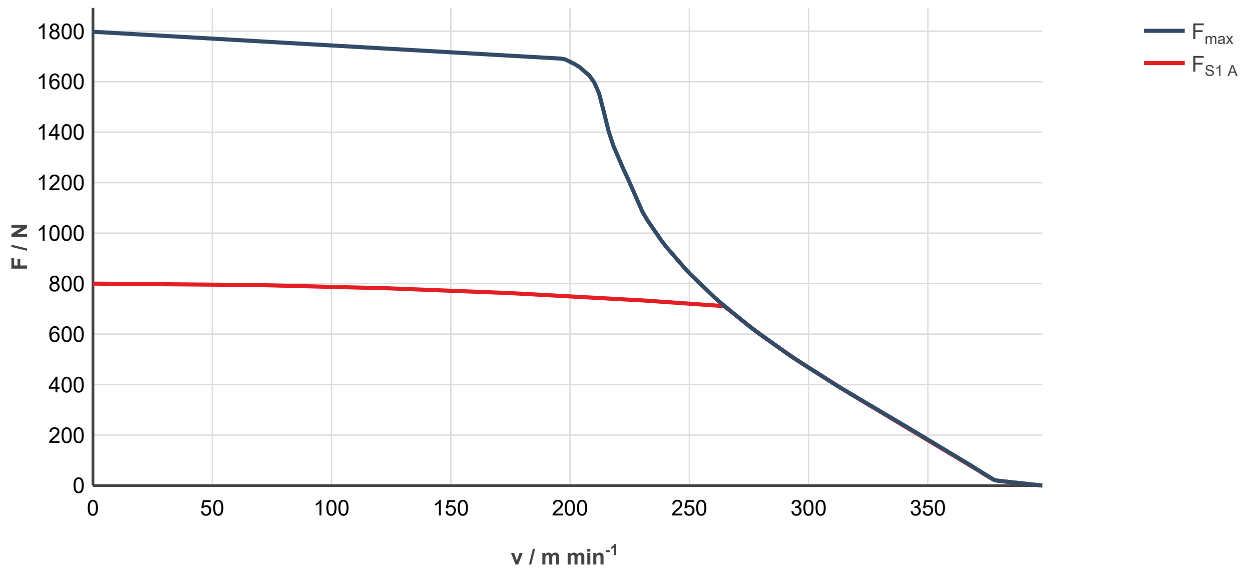


Fig. 4-22: Characteristic curve ML3P06-H_BK

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

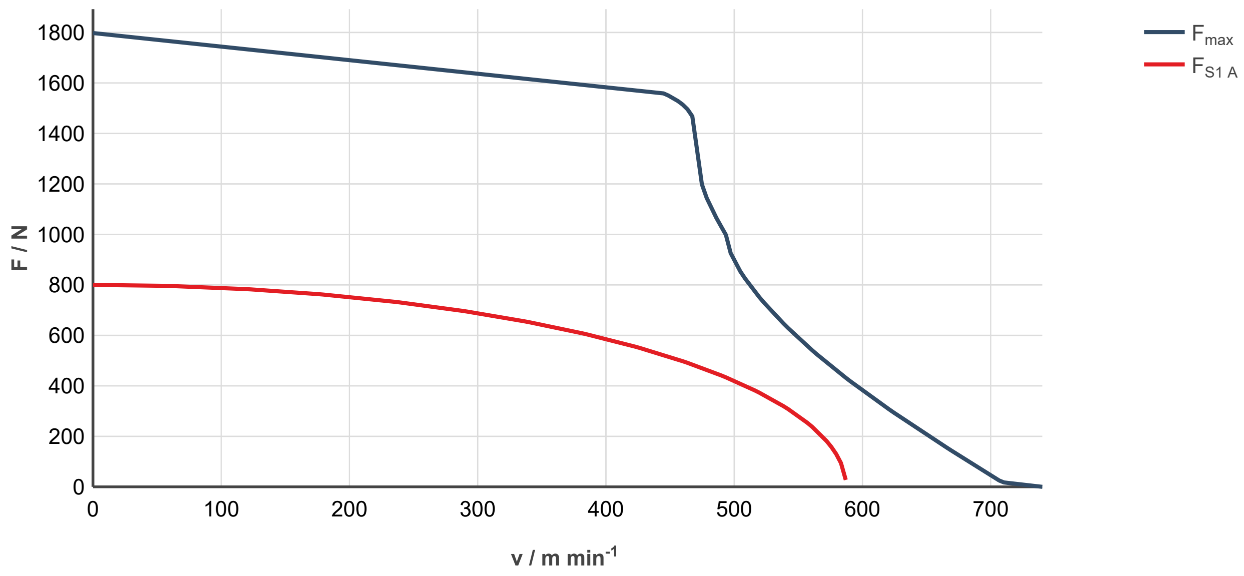


Fig. 4-23: Characteristic curve ML3P06-H_BR

4.5 Frame size 11

4.5.1 Primary part ML3P11 - Frame lengths D/E

Designation	Symbol	Unit	ML3P11-D_BF	ML3P11-D_BQ	ML3P11-E_BC	ML3P11-E_BQ
Maximum force at standstill	$F_{max,0}$	N	1800		2250	
Maximum current at standstill	$I_{max,0}$	A	13.0	26.0	13.5	33.0
Maximum force	F_{max}	N	1750	1680	2,200	2100
Maximum current	I_{max}	A	12.0	22.0	12.5	27.2
Continuous force at standstill	F_0	N	760		950	
Continuous current at standstill	I_0	A	4.1	8.2	4.2	10.2
Maximum velocity at F_{max}	v_{Fmax}	m/min	75	200	50	200
Attractive force	F_{ATT}	N	3,400		4150	
Force constant	$K_{F,0}$	N/A	185.4	92.7	226.2	93.1
Voltage constant at 20 °C	K_{EMK}	Vs/m	107.0	53.7	129.4	53.7
Winding resistance at 20 °C	R_{12}	Ohm	12.6	3.2	15.2	2.6
Winding inductance	L_{12}	mH	102.0	26.0	120.0	20.0
Thermal time constant	T_{th_nom}	min	1.5			
Pole width	τ_p	mm	12			
Power wire cross-section	A	mm^2	0.5	0.75	0.5	0.75
Primary part mass	m_P	kg	4.9		5.9	
Ground connection cable	m_K	kg/m	0.3			
Latest amendment: 2020-09-11						

Tab. 4-8: Technical data ML3P11-D / -E

4.5.2 Primary part ML3P11 - Frame length F / H / L

Designation	Symbol	Unit	ML3P11-F_BF	ML3P11-H_BC	ML3P11-L_BC	ML3P11-L_BQ
Maximum force at standstill	$F_{max,0}$	N	2,700	3600	4,500	
Maximum current at standstill	$I_{max,0}$	A	20.0	21.0	27.0	66.0
Maximum force	F_{max}	N	2600	3500	4400	4200
Maximum current	I_{max}	A	18.0	19.4	25.5	54.5
Continuous force at standstill	F_0	N	1140	1520	1900	
Continuous current at standstill	I_0	A	6.1	6.6	8.5	20.5
Maximum velocity at F_{max}	v_{Fmax}	m/min	75	55	50	200
Attractive force	F_{ATT}	N	4980	6640	8300	
Force constant	$K_{F,0}$	N/A	186.9	230.3	223.5	92.7
Voltage constant at 20 °C	K_{EMK}	Vs/m	107.5	133.6	129.4	53.7
Winding resistance at 20 °C	R_{12}	Ohm	8.4	9.9	7.6	1.3
Winding inductance	L_{12}	mH	67.8	79.2	60.0	10.0
Thermal time constant	T_{th_nom}	min	1.5			
Pole width	τ_p	mm	12			
Power wire cross-section	A	mm^2	0.75			2.5
Primary part mass	m_P	kg	7.1	9.4	11.6	
Ground connection cable	m_K	kg/m	0.3			
Latest amendment: 2020-06-23						

Tab. 4-9: Technical data ML3P11-F / -H / -L

4.5.3 Secondary part ML3S11

Designation	Symbol	Unit	ML3S11-__-0192	ML3S11-__-0288
Mass secondary part	m_S	kg	2.0	3.0
Mass secondary part, relative	m_{S_rel}	kg/m	10.5	
Latest amendment: 2018-06-11				

Tab. 4-10: Technical data ML3S11

4.5.4 Characteristic curves ML3P11

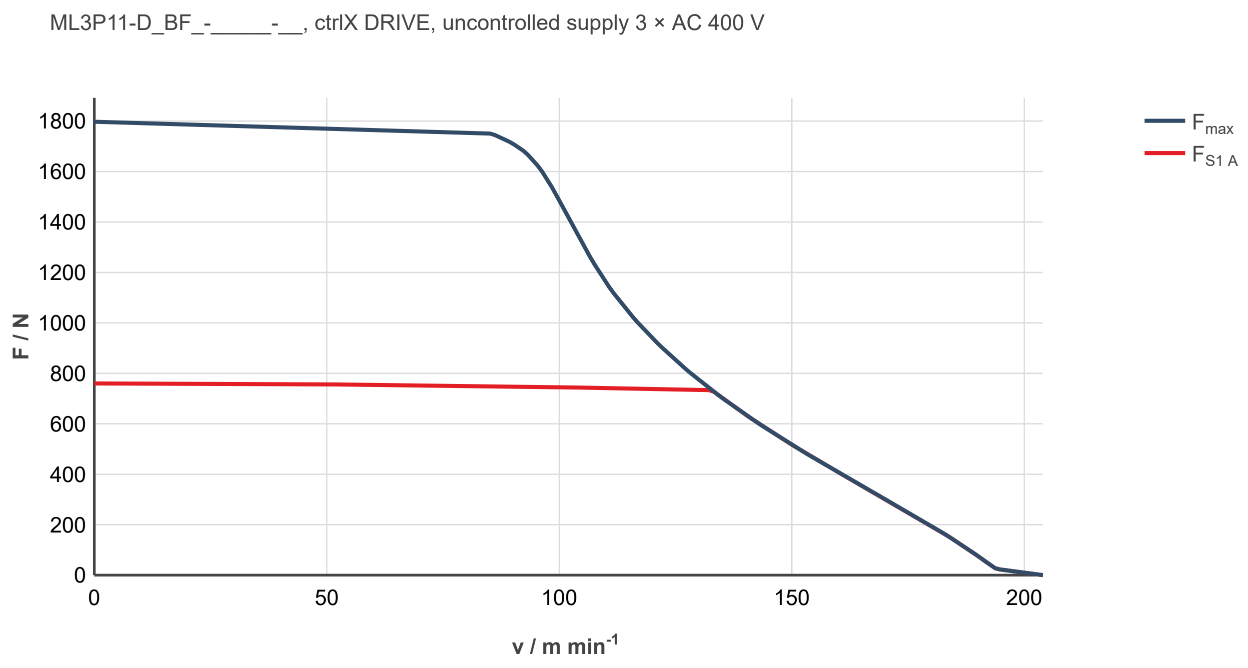


Fig. 4-24: Characteristic curve ML3P11-D_BF

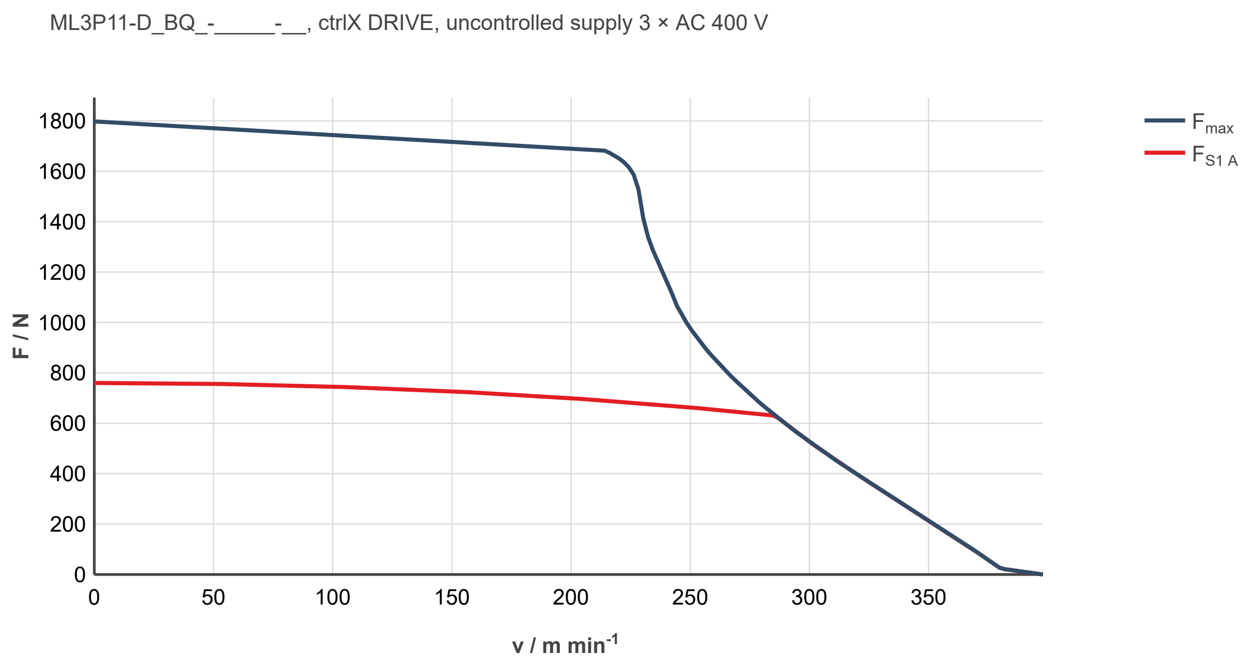


Fig. 4-25: Characteristic curve ML3P11-D_BQ

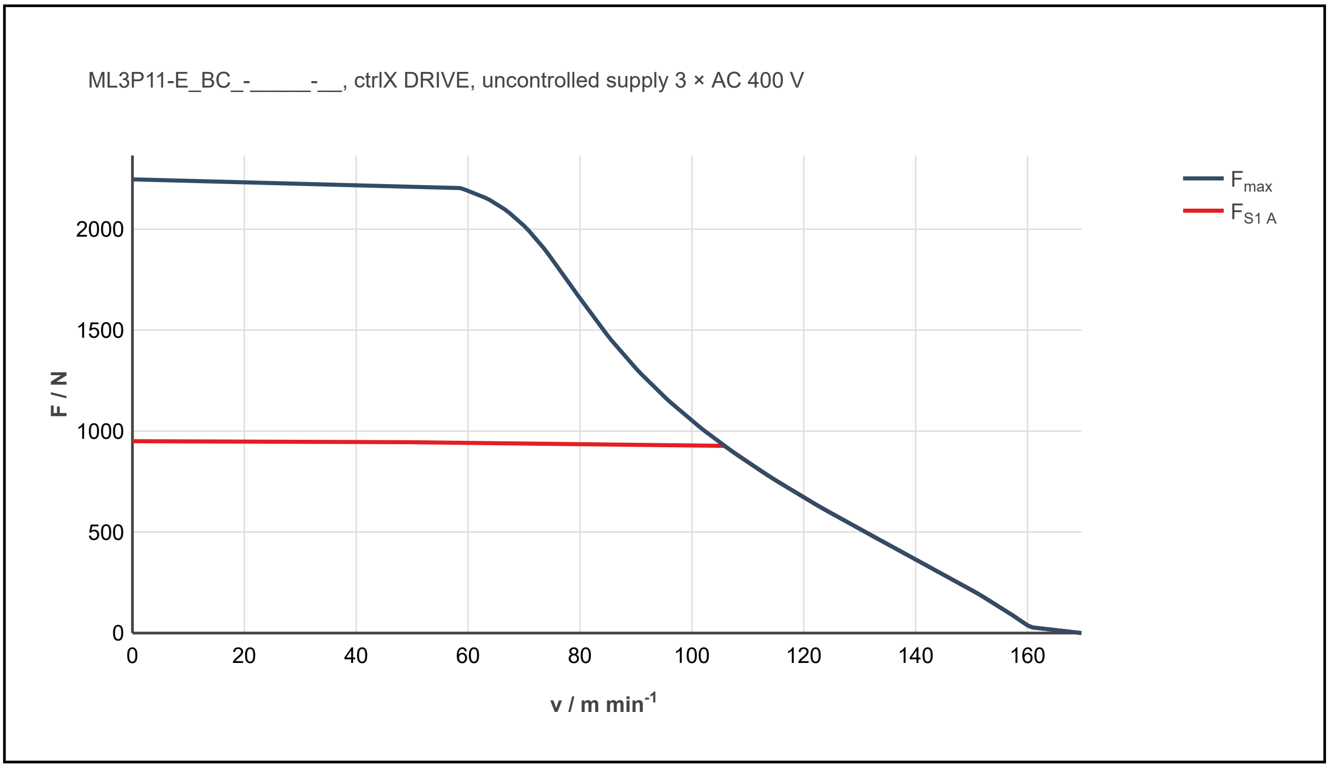


Fig. 4-26: Characteristic curve ML3P11-E_BC

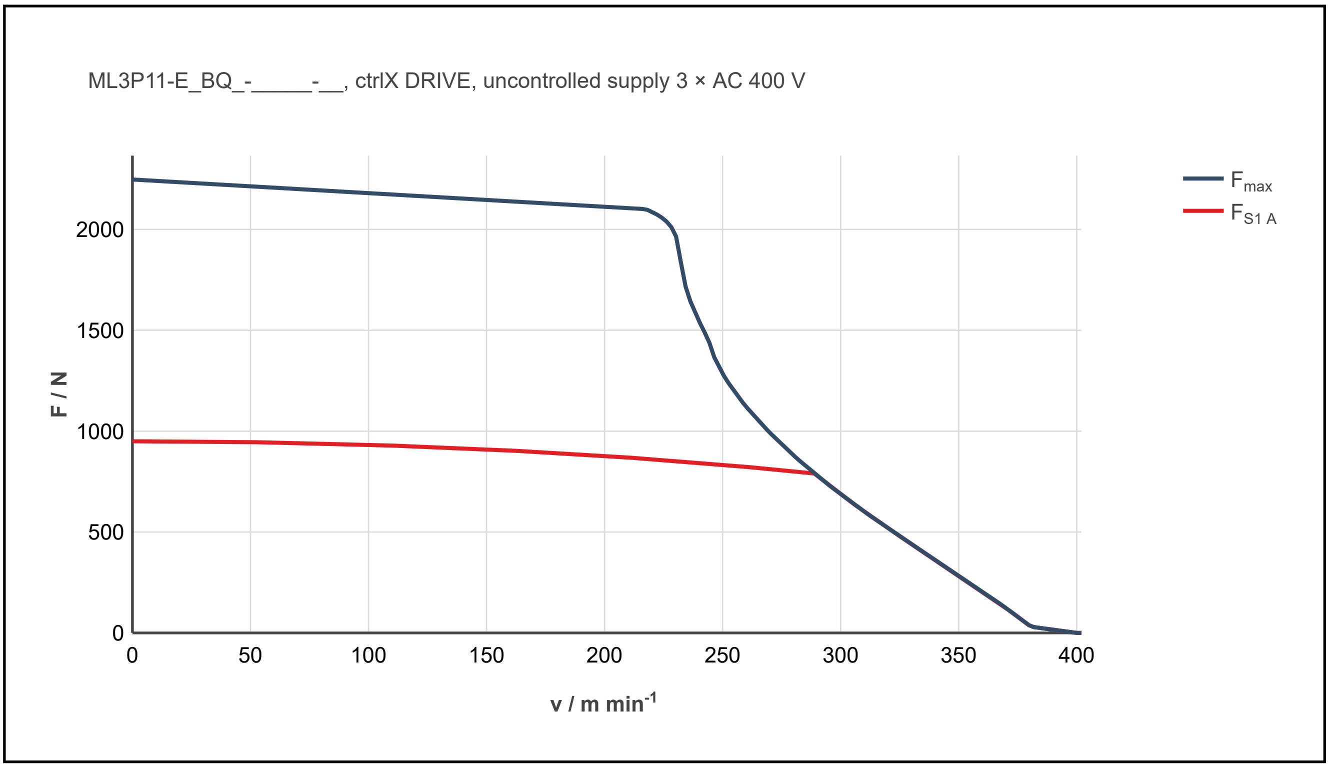


Fig. 4-27: Characteristic curve ML3P11-E_BQ

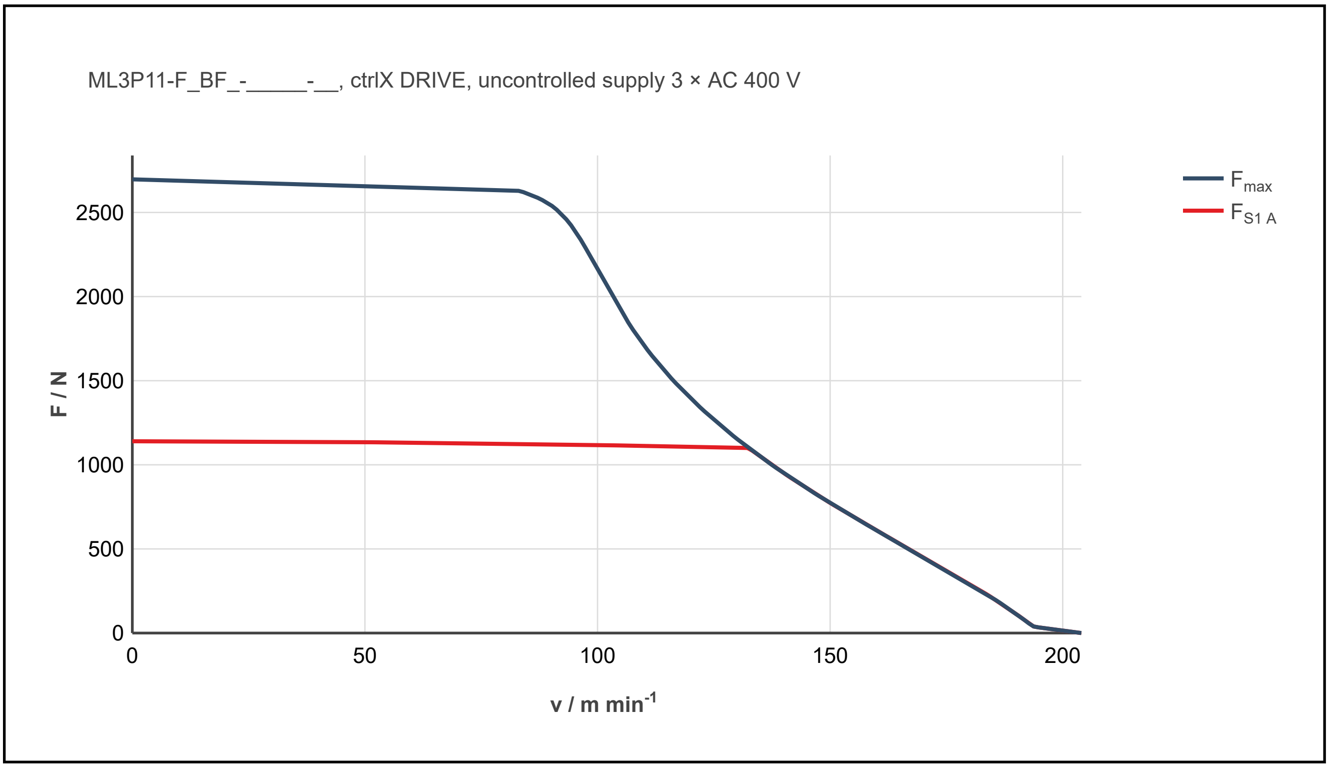


Fig. 4-28: Characteristic curve ML3P11-F_BF

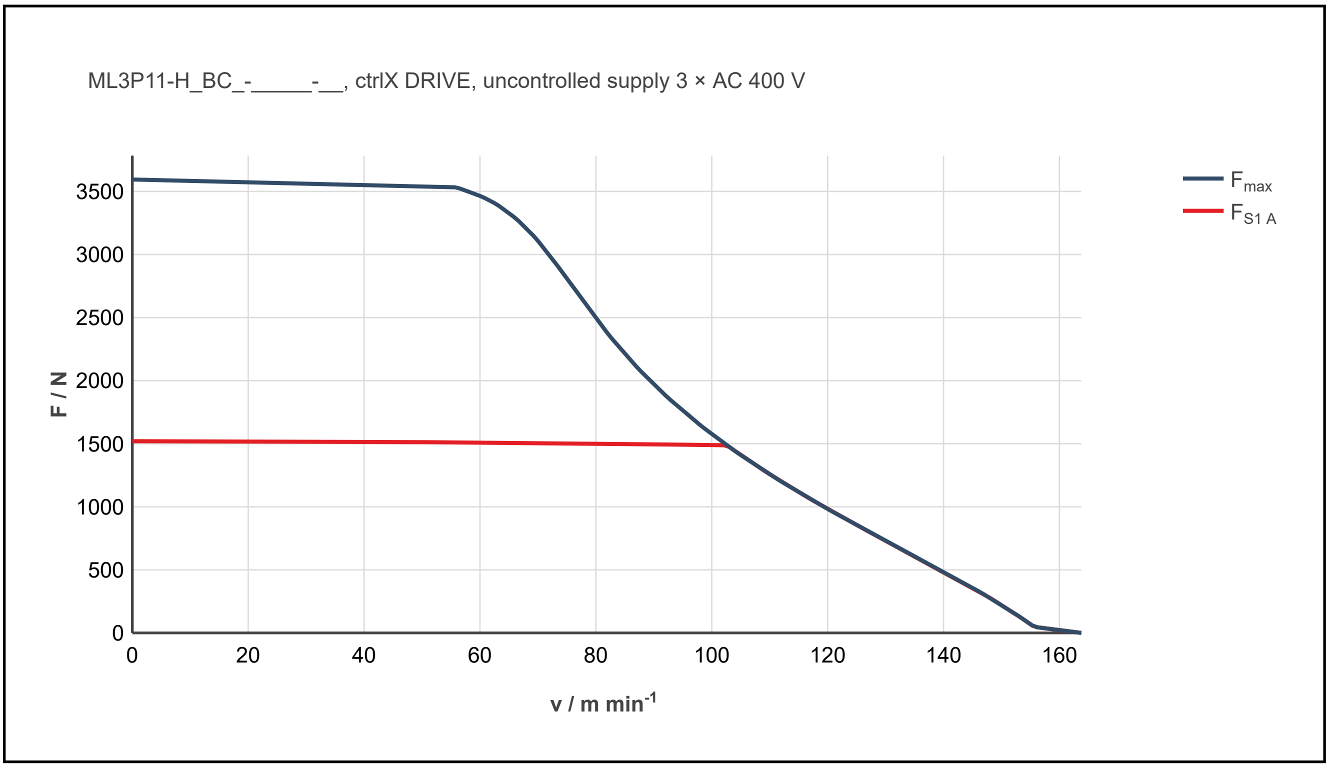


Fig. 4-29: Characteristic curve ML3P11-H_BC

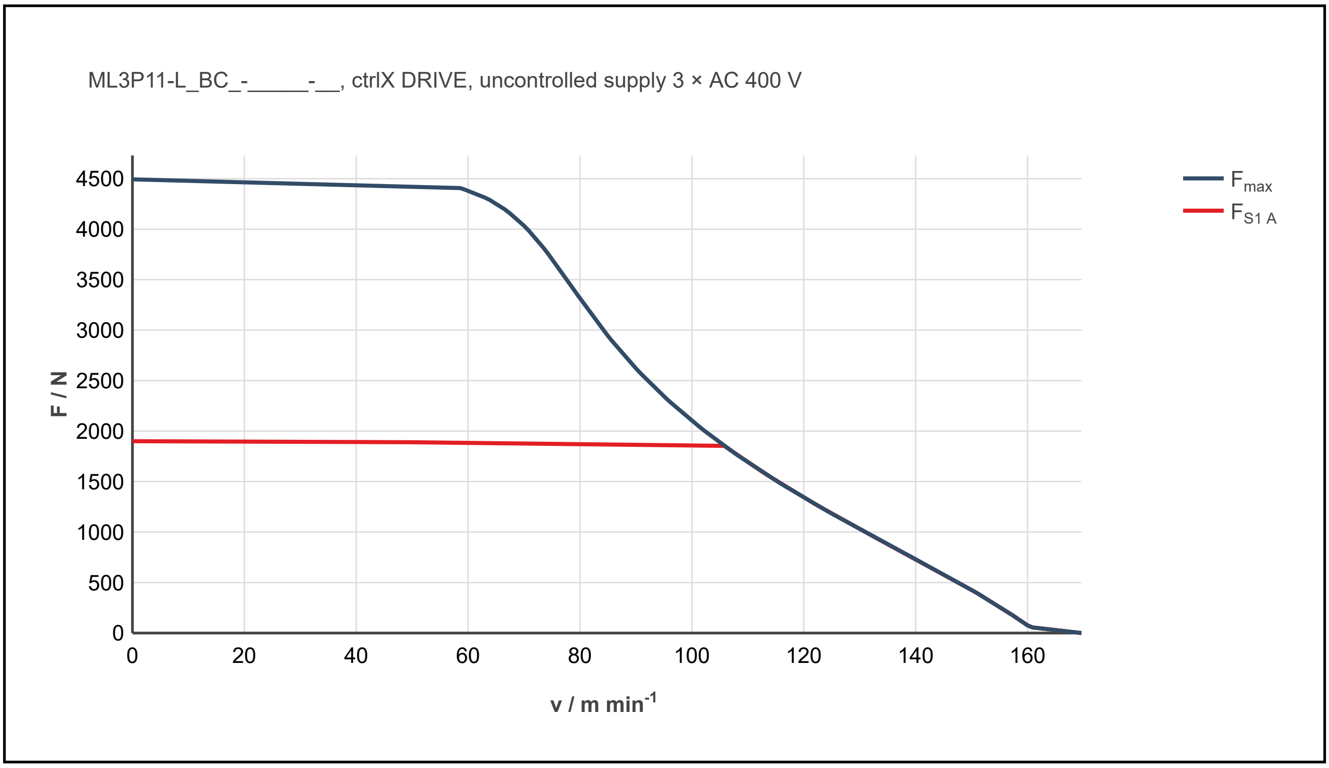


Fig. 4-30: Characteristic curve ML3P11-L_BC

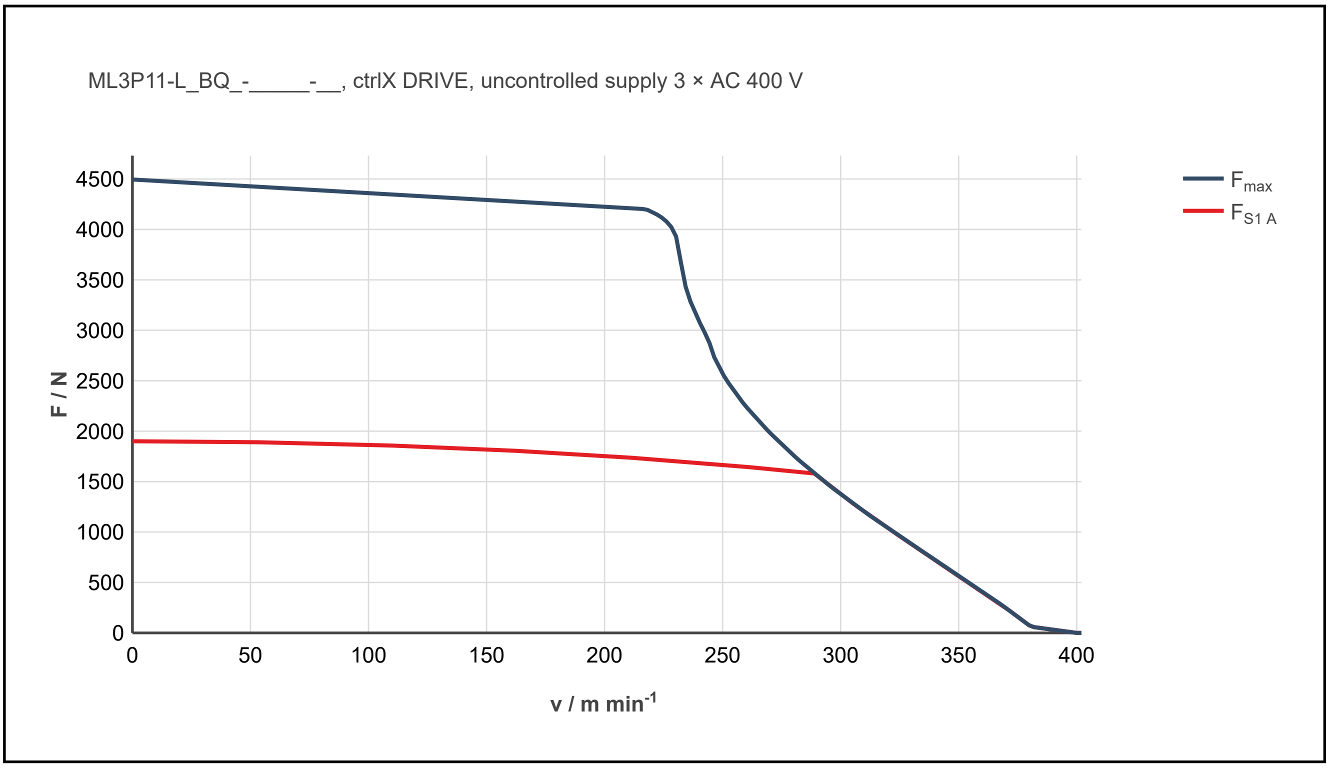


Fig. 4-31: Characteristic curve ML3P11-L_BQ

5 Dimension sheets

5.1 Specifications

5.1.1 General notes

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

5.1.2 Air gap and installation height

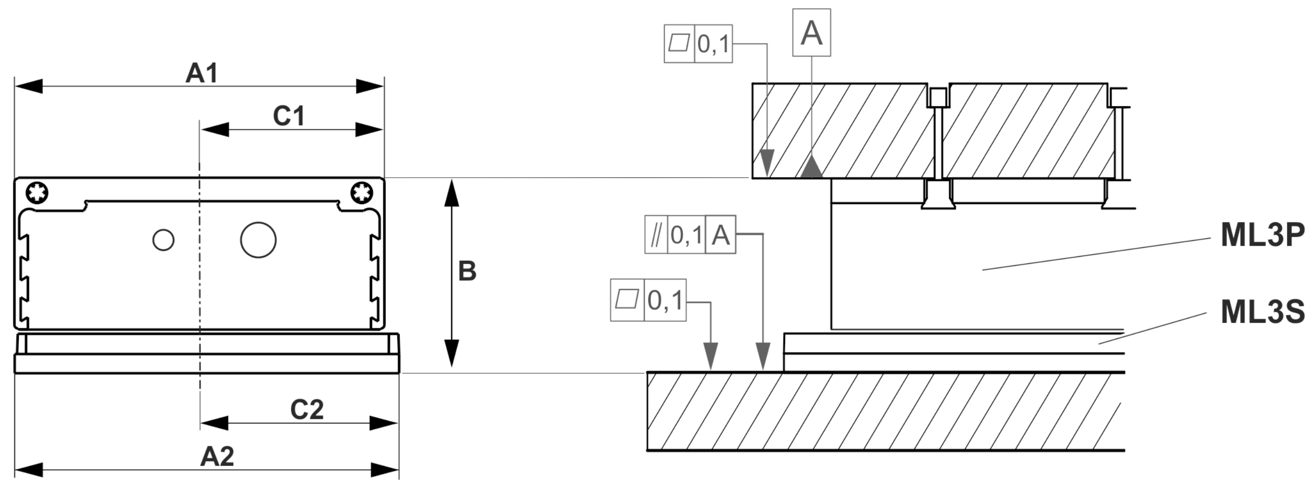
To ensure safe operation and constant force over the entire travel range, an air gap is required between primary and secondary part. For this purpose, the individual parts of the motor are tolerated accordingly. The distance of the mounting surface, the parallelism and the symmetric alignment of the 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.

☞ 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.

5.1.3 Dimensions and tolerances



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	45 mm ± 0.1 mm	60.5 mm	65 mm	125.5 mm	130 mm

*) For tolerance details refer to the dimension sheet

Tab. 5-1: Installation dimensions and tolerances (example frame size 06)

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

5.1.4 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. 5-1.

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

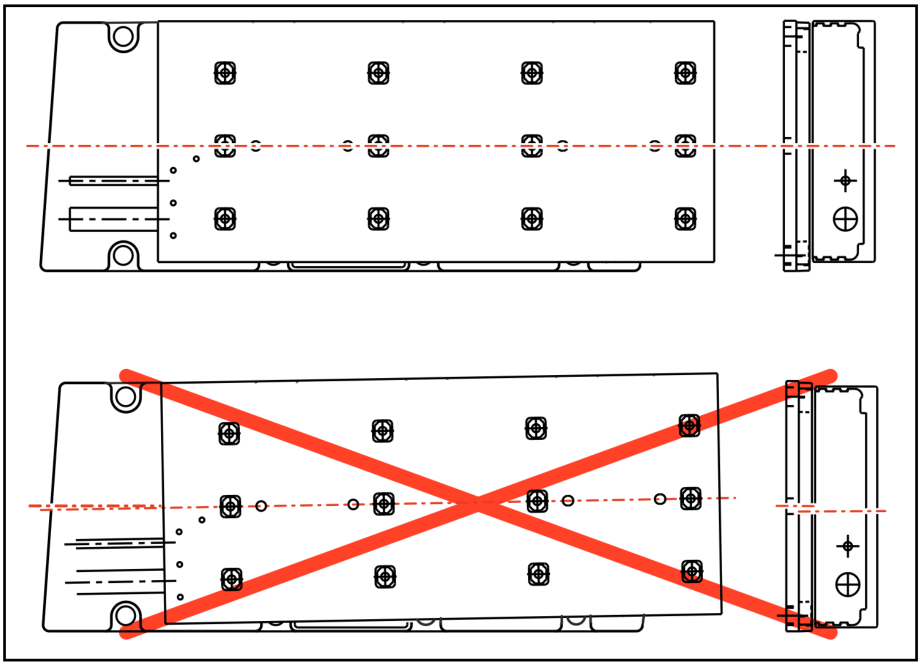


Fig. 5-1: Parallelism and symmetry between primary part and secondary part

5.2 Frame size 03

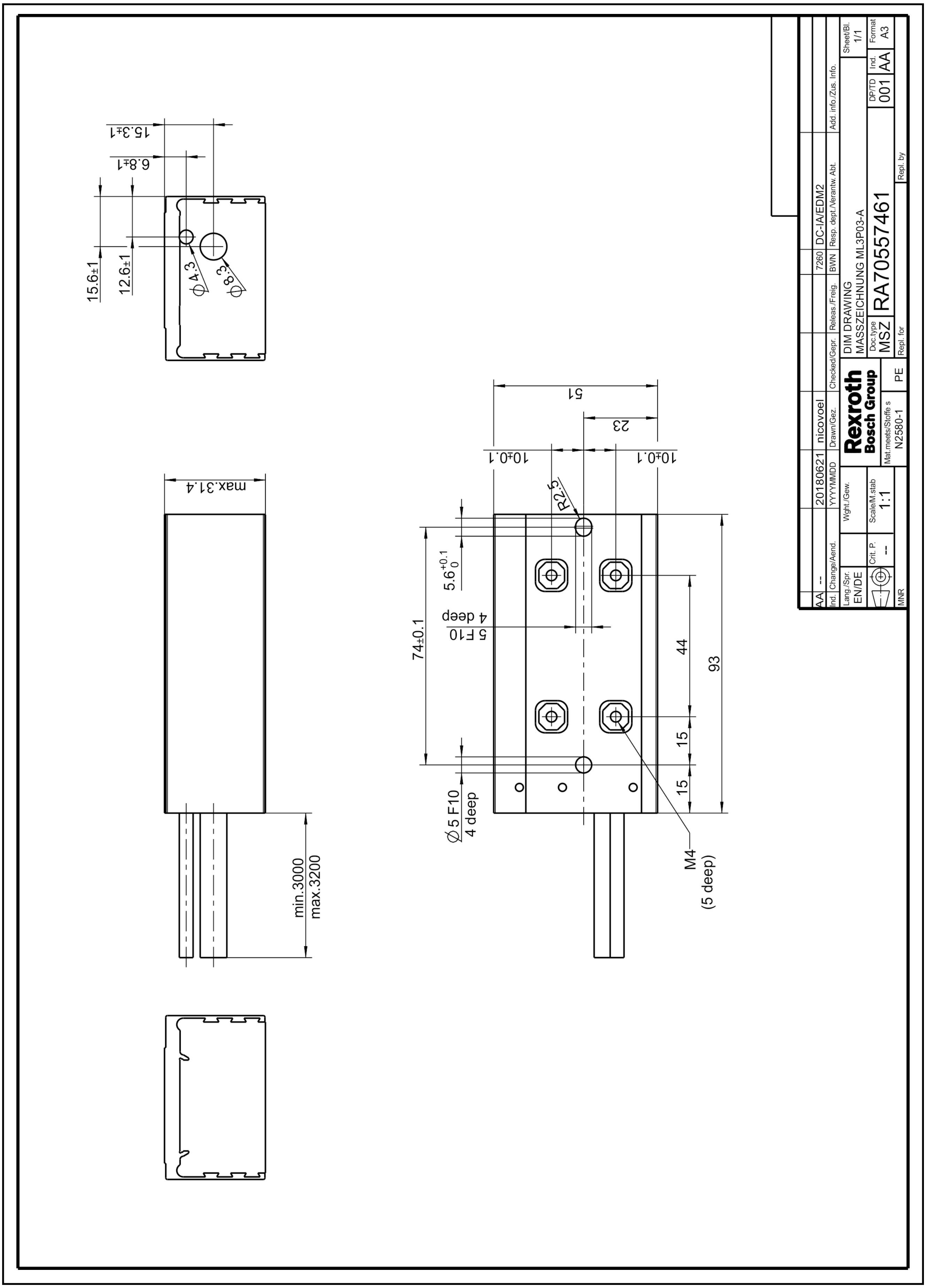
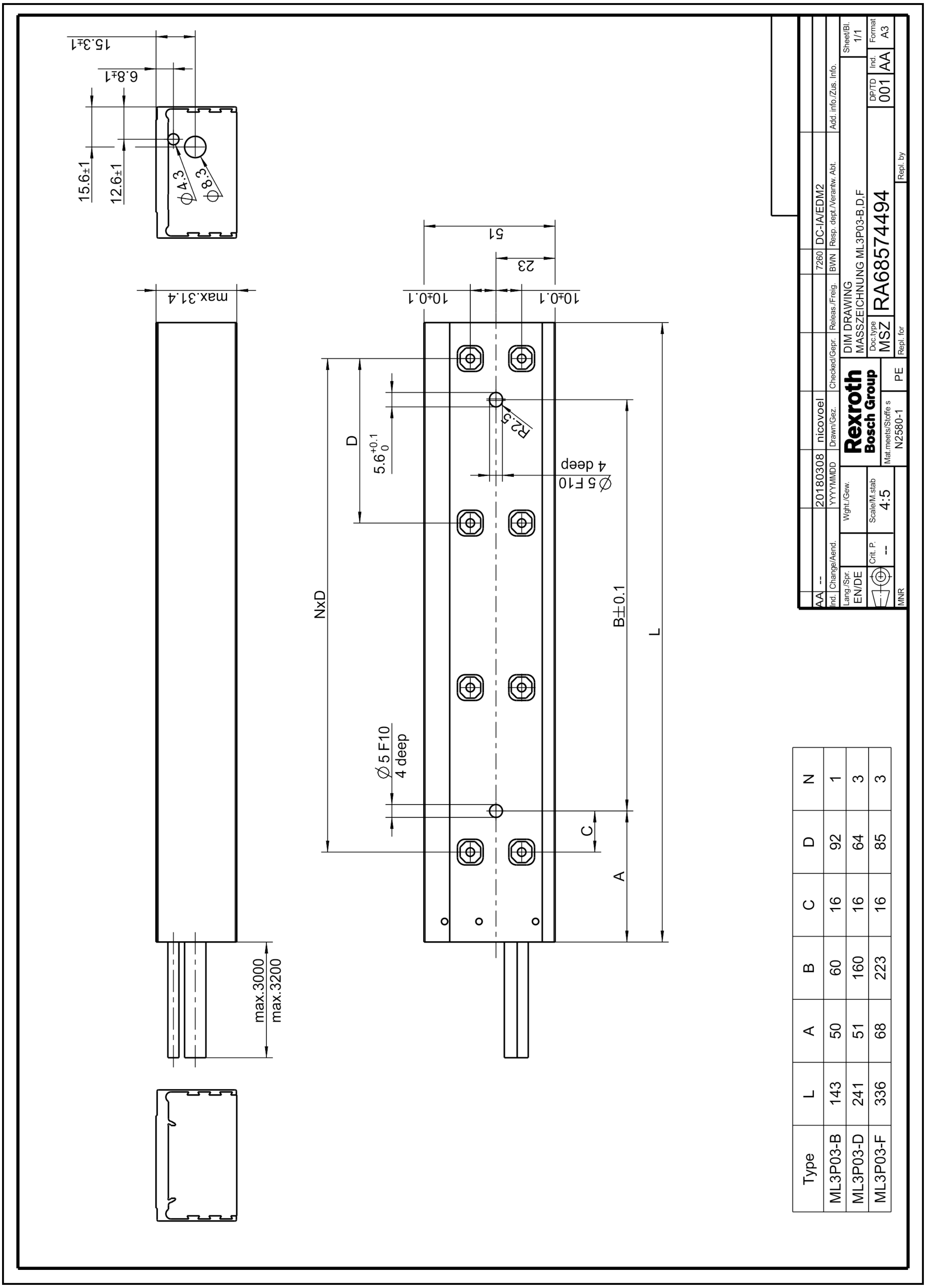


Fig. 5-2: Dimension sheet primary part ML3P03-A



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. 5-3: Dimension sheet primary part ML3P03-B/D/F

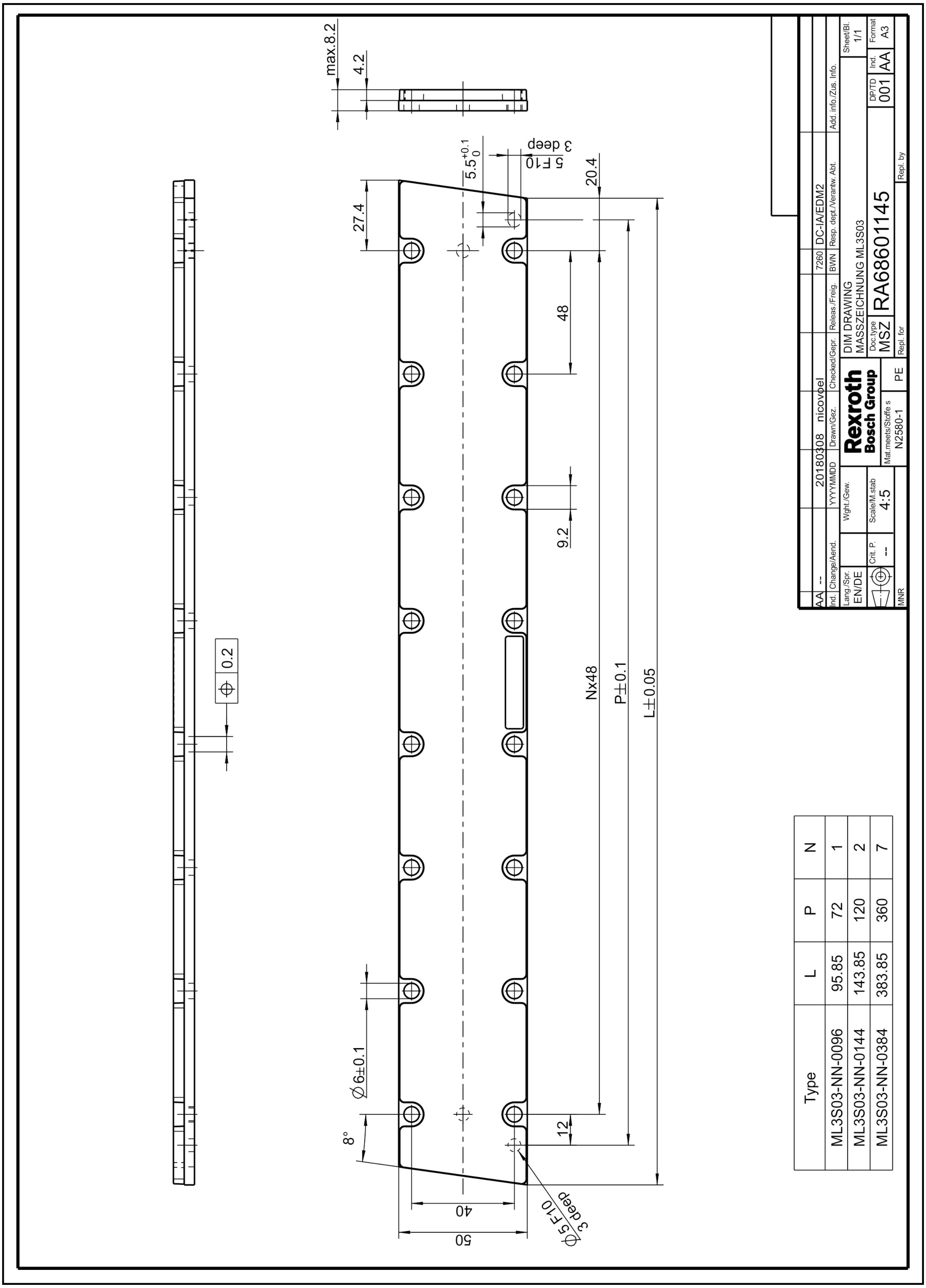


Fig. 5-4: Dimension sheet primary part ML3S03

5.3 Frame size 06

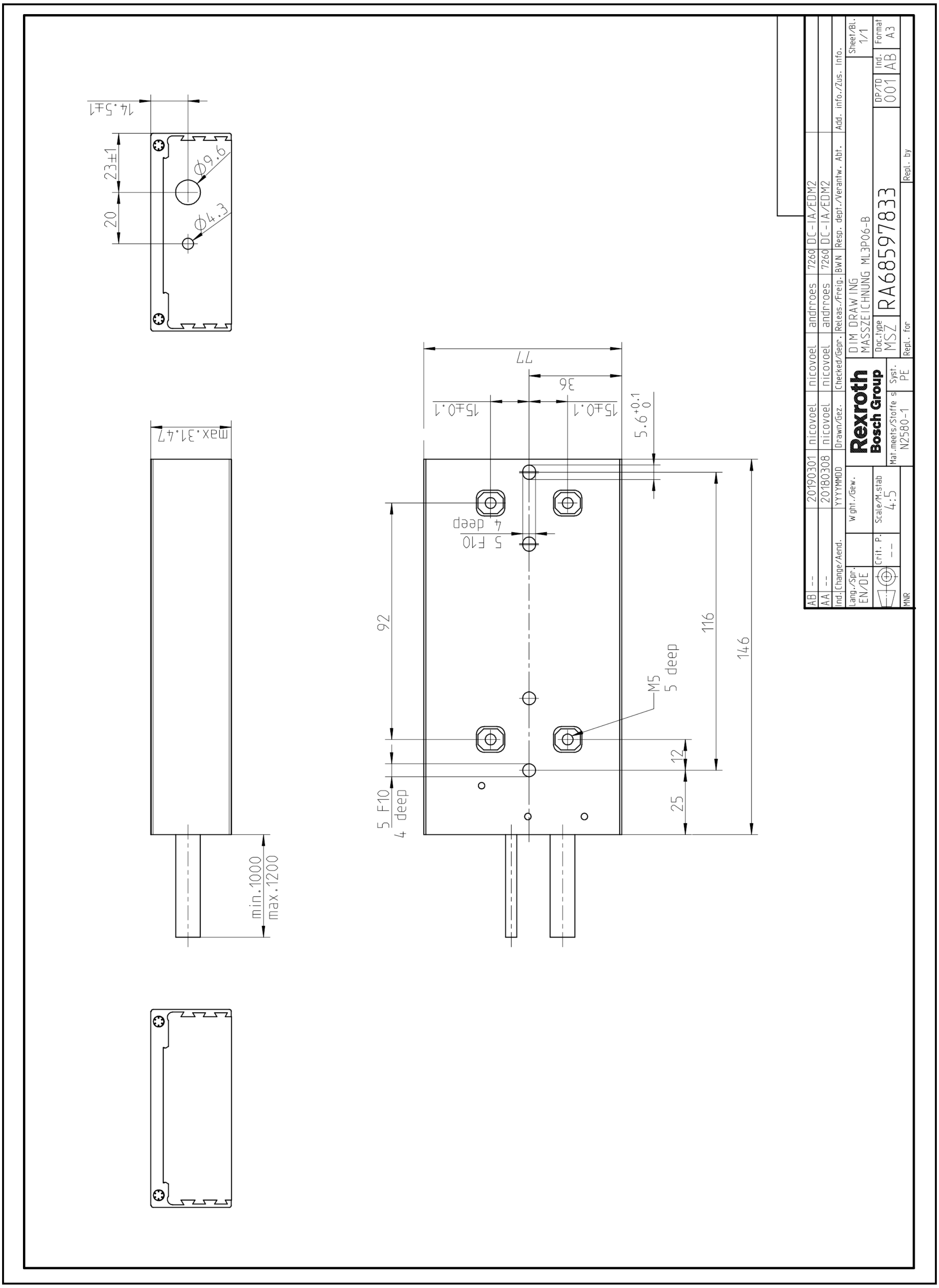
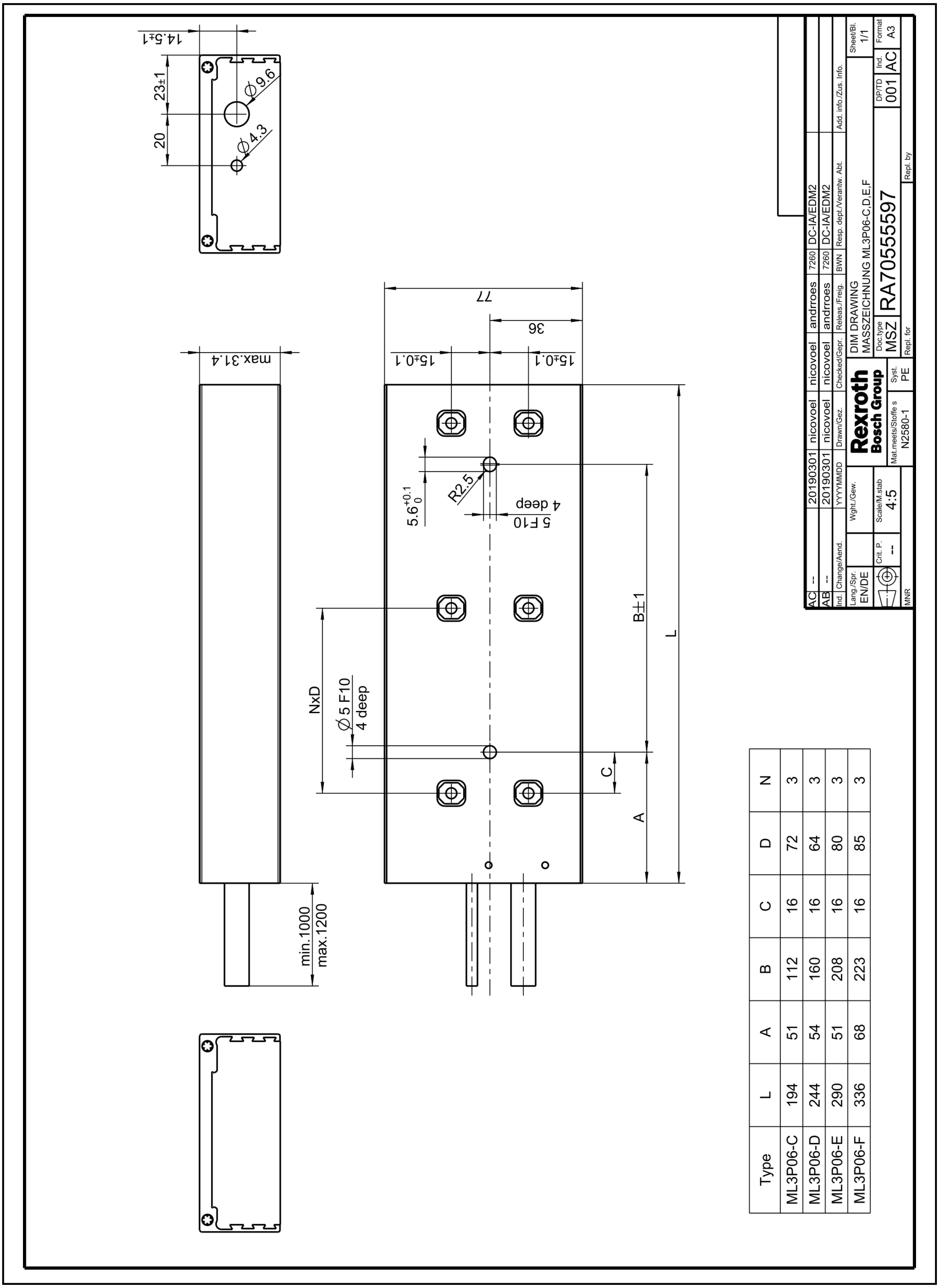


Fig. 5-5: Dimension sheet primary part ML3P06-B



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. 5-6: Dimension sheet primary part ML3P06-C/D/E/F

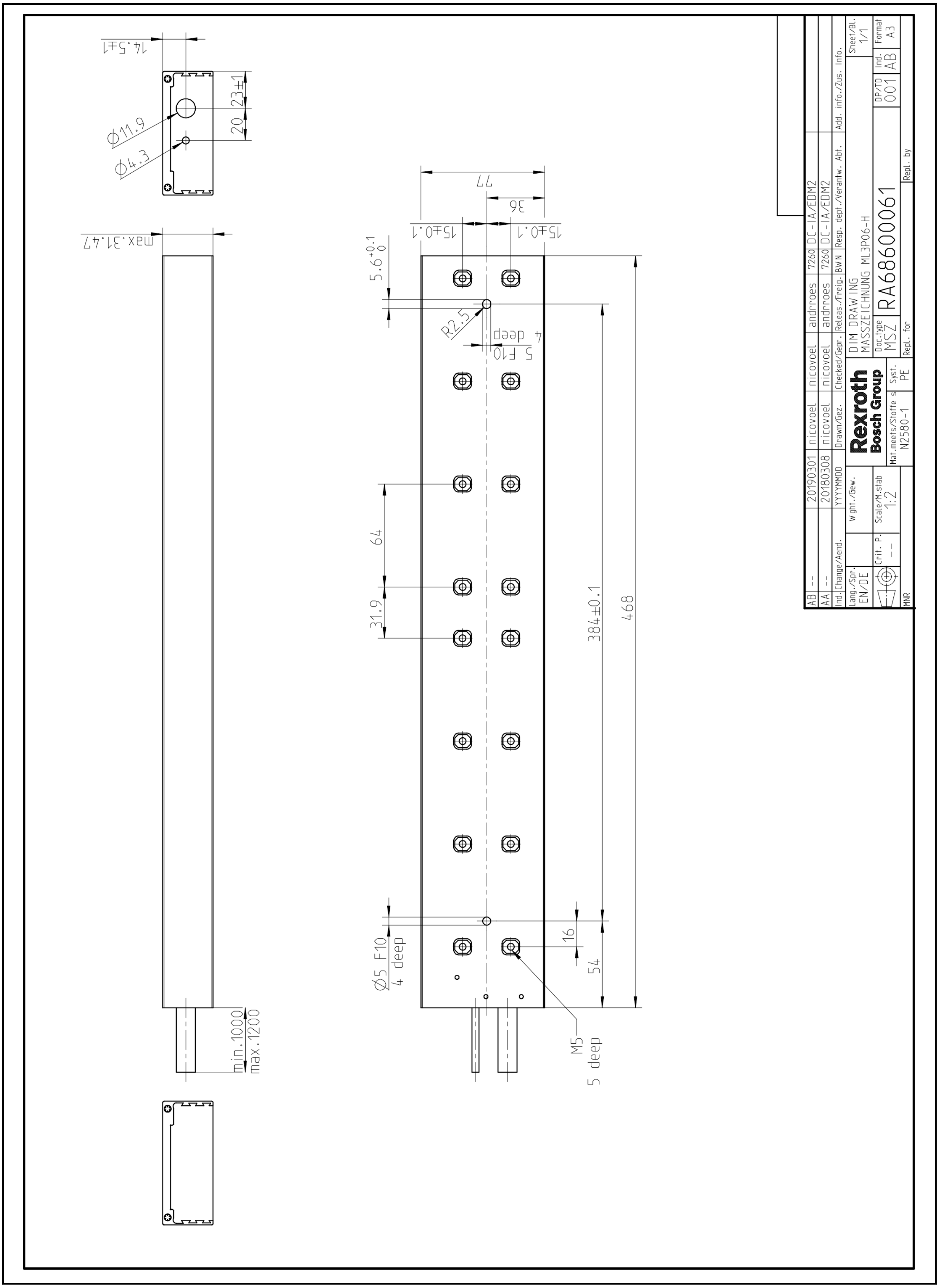


Fig. 5-7: Dimension sheet primary part ML3P06-H

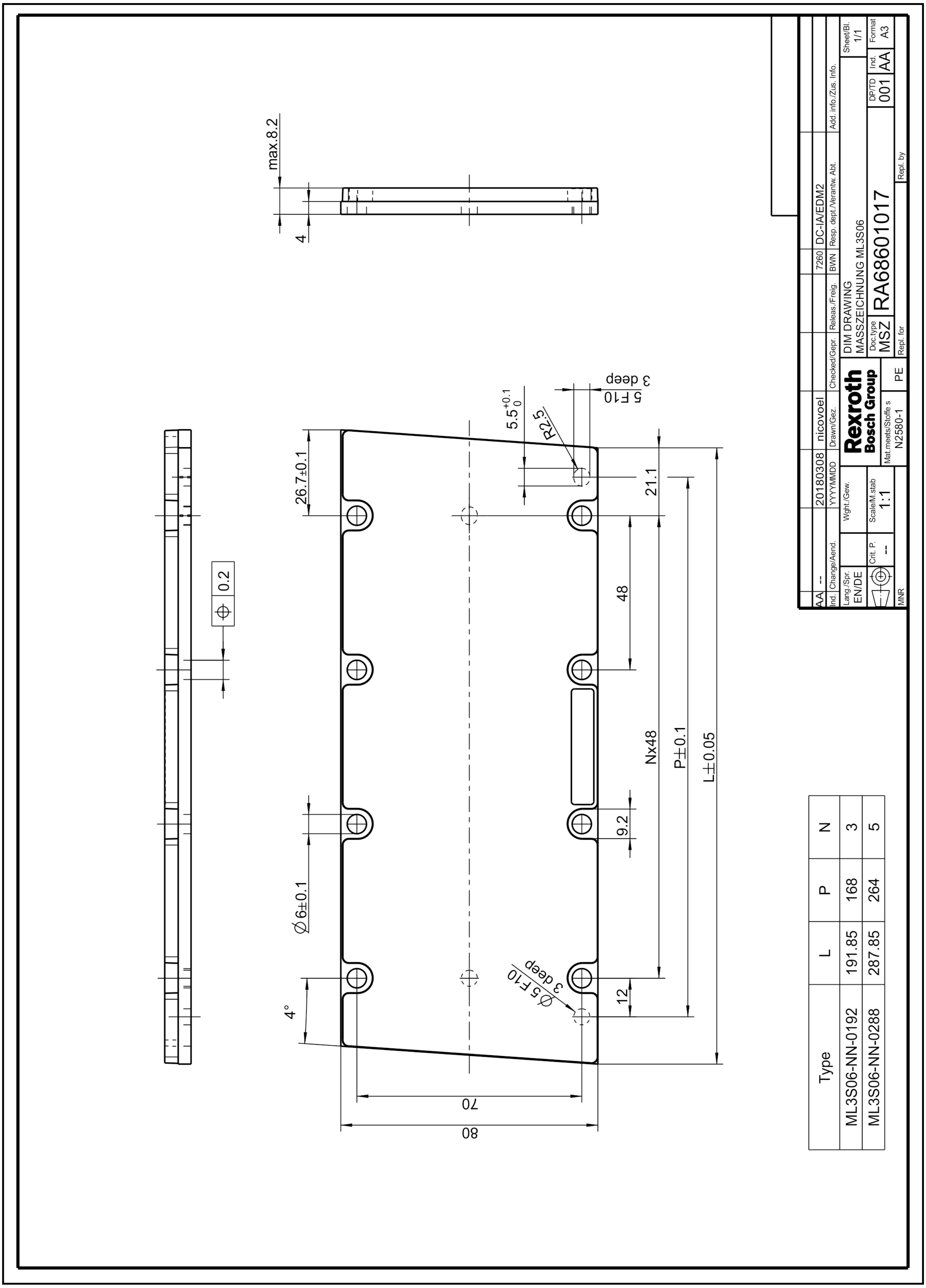
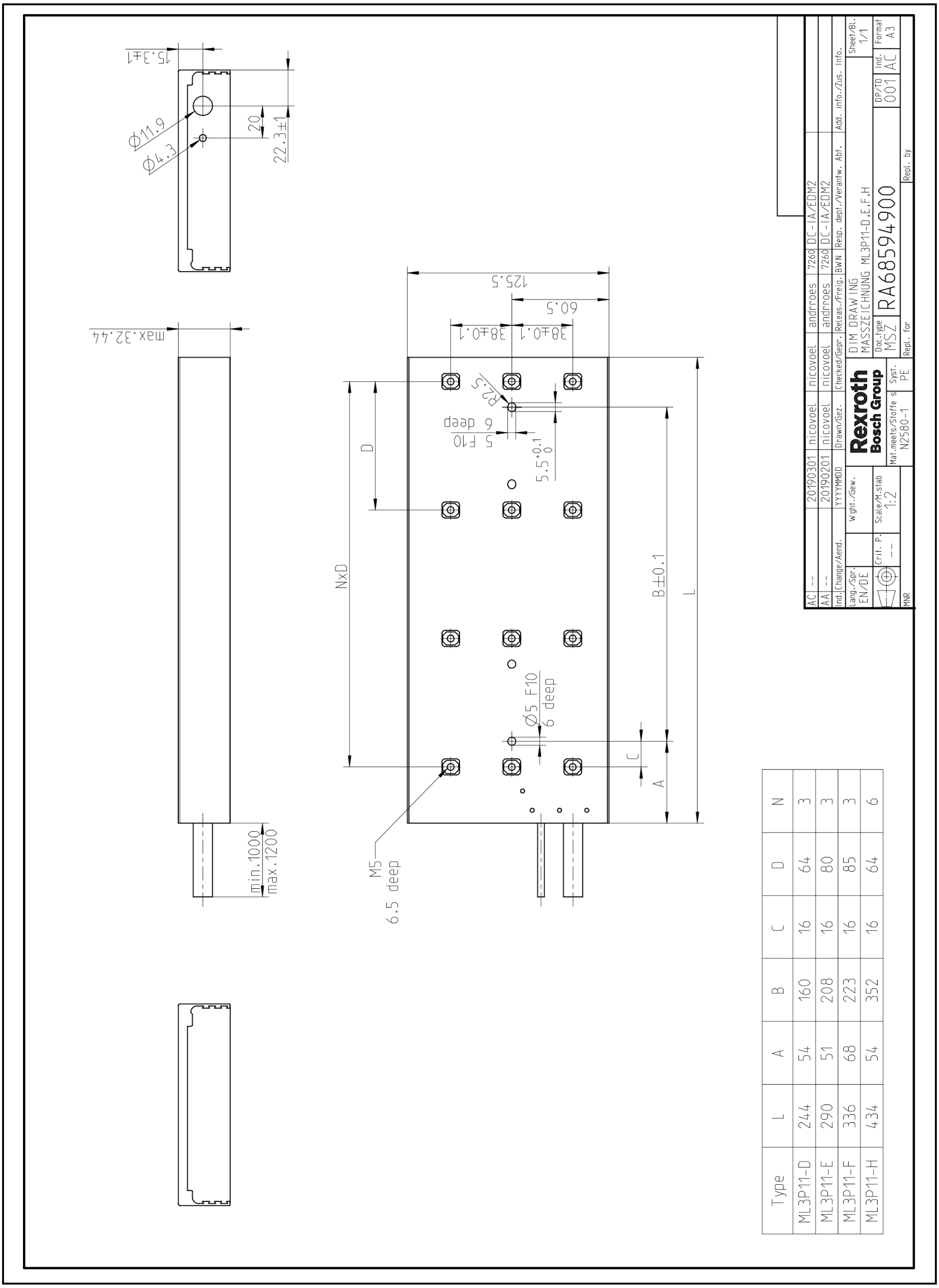


Fig. 5-8: *Dimension sheet secondary part ML3S06*

5.4 Frame size 11



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. 5-9: Dimension sheet primary part ML3P11 Frame lengths D, E, F, H

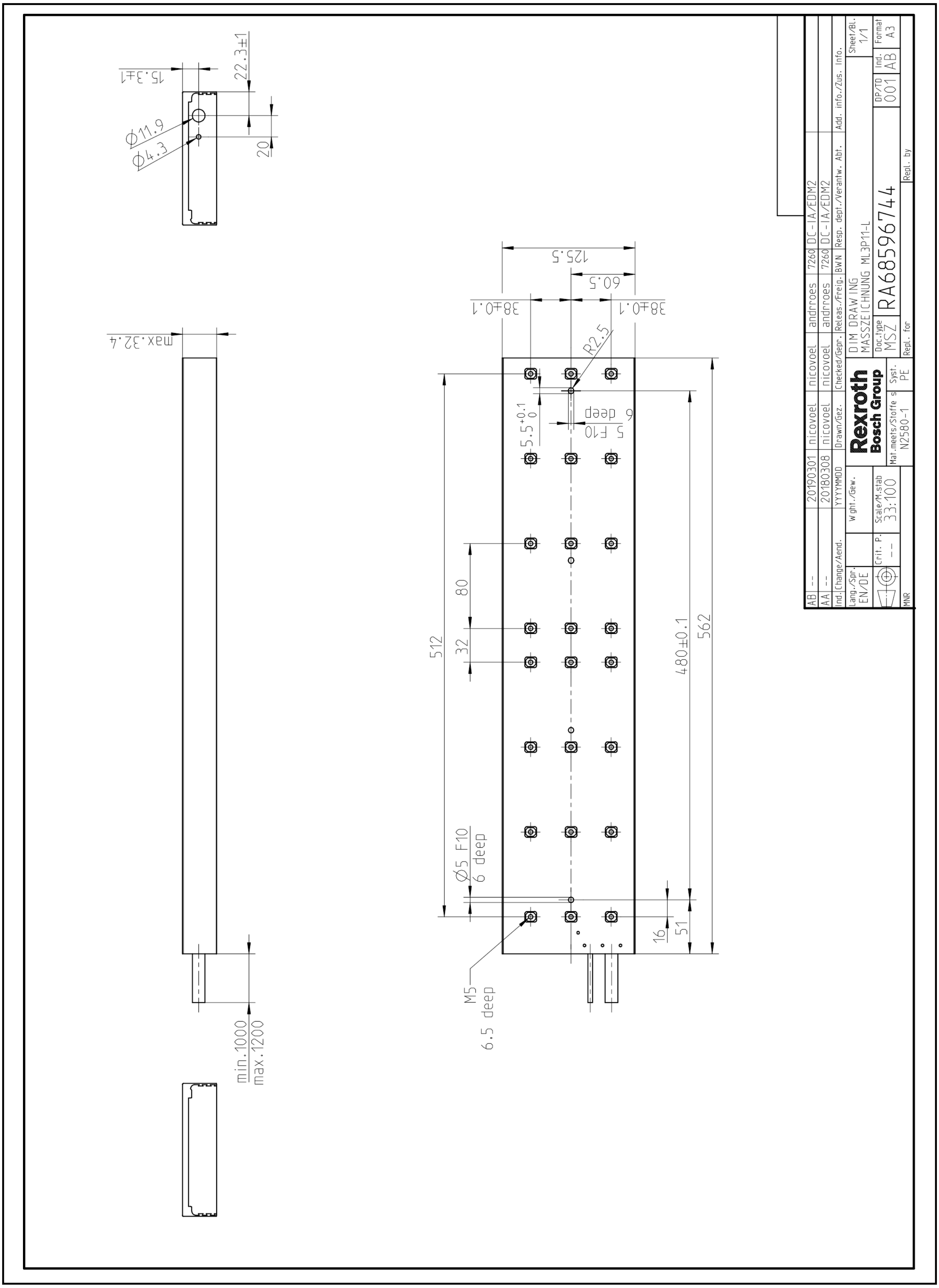
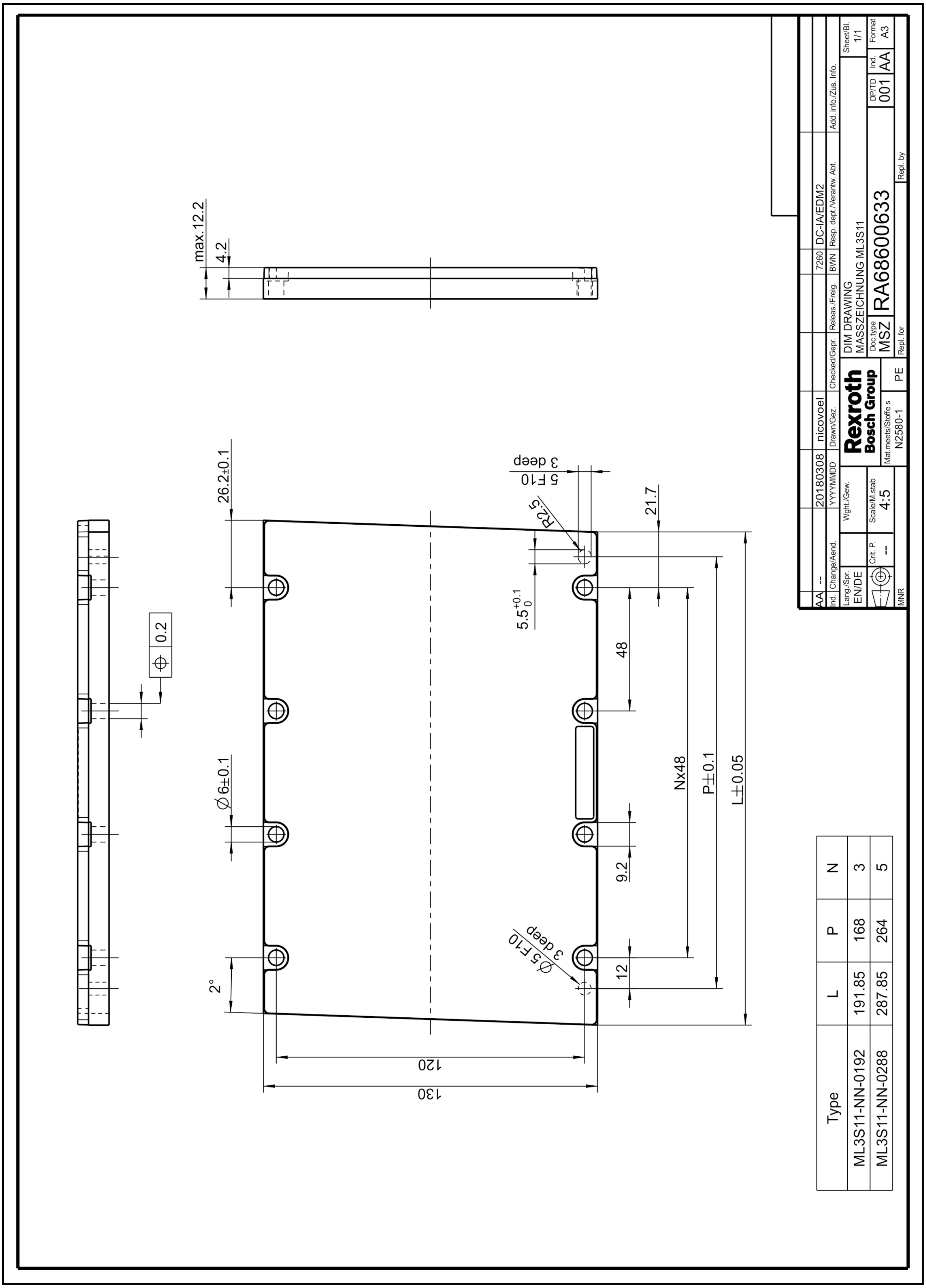


Fig. 5-10: Dimension sheet primary part ML3P11 Frame length L



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

Fig. 5-11: Dimension sheet primary part ML3S11

5.5 Analog Hall unit (option)

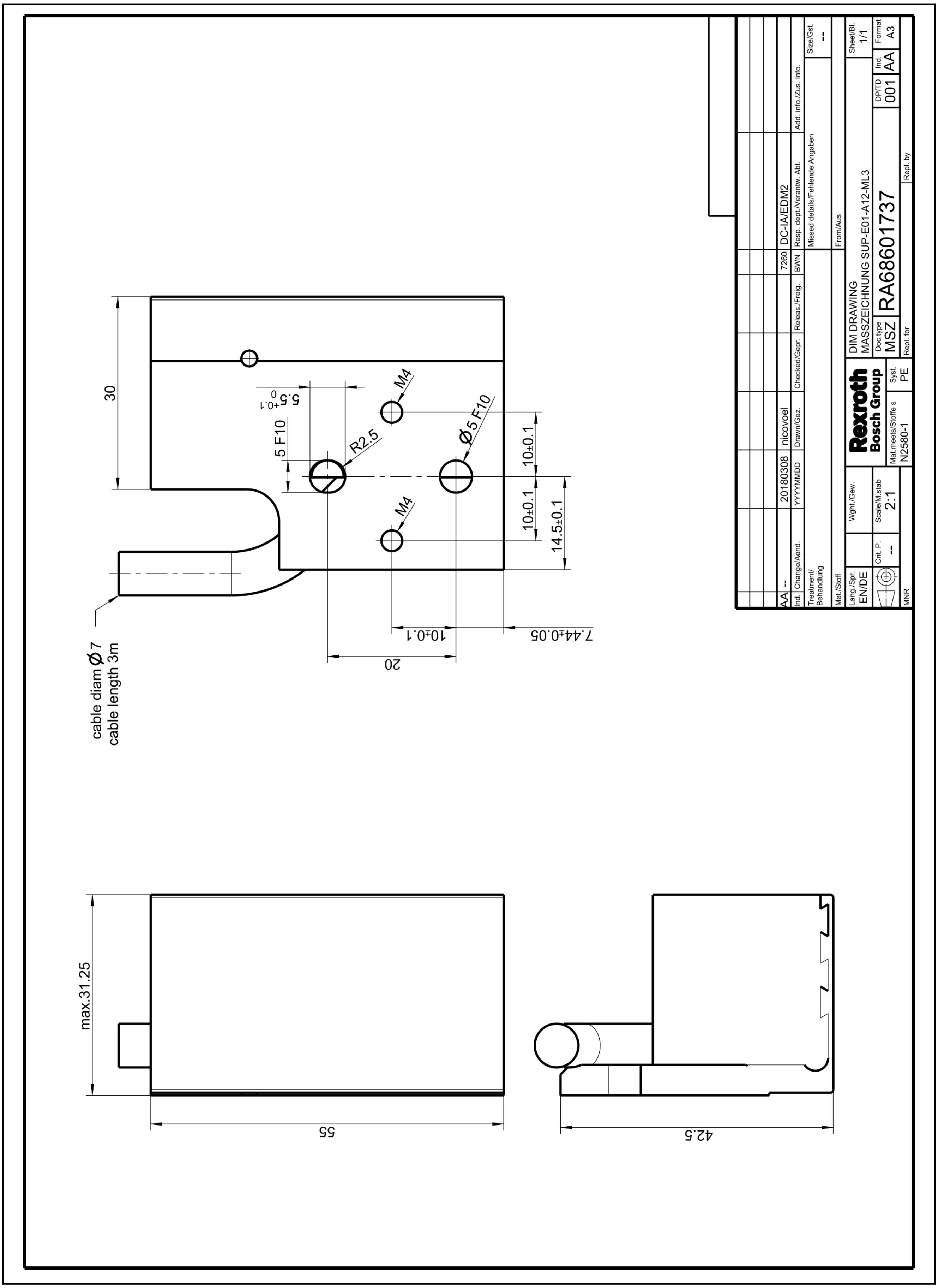


Fig. 5-12: Dimension sheet analog Hall unit

5.6 Digital Hall unit (option)

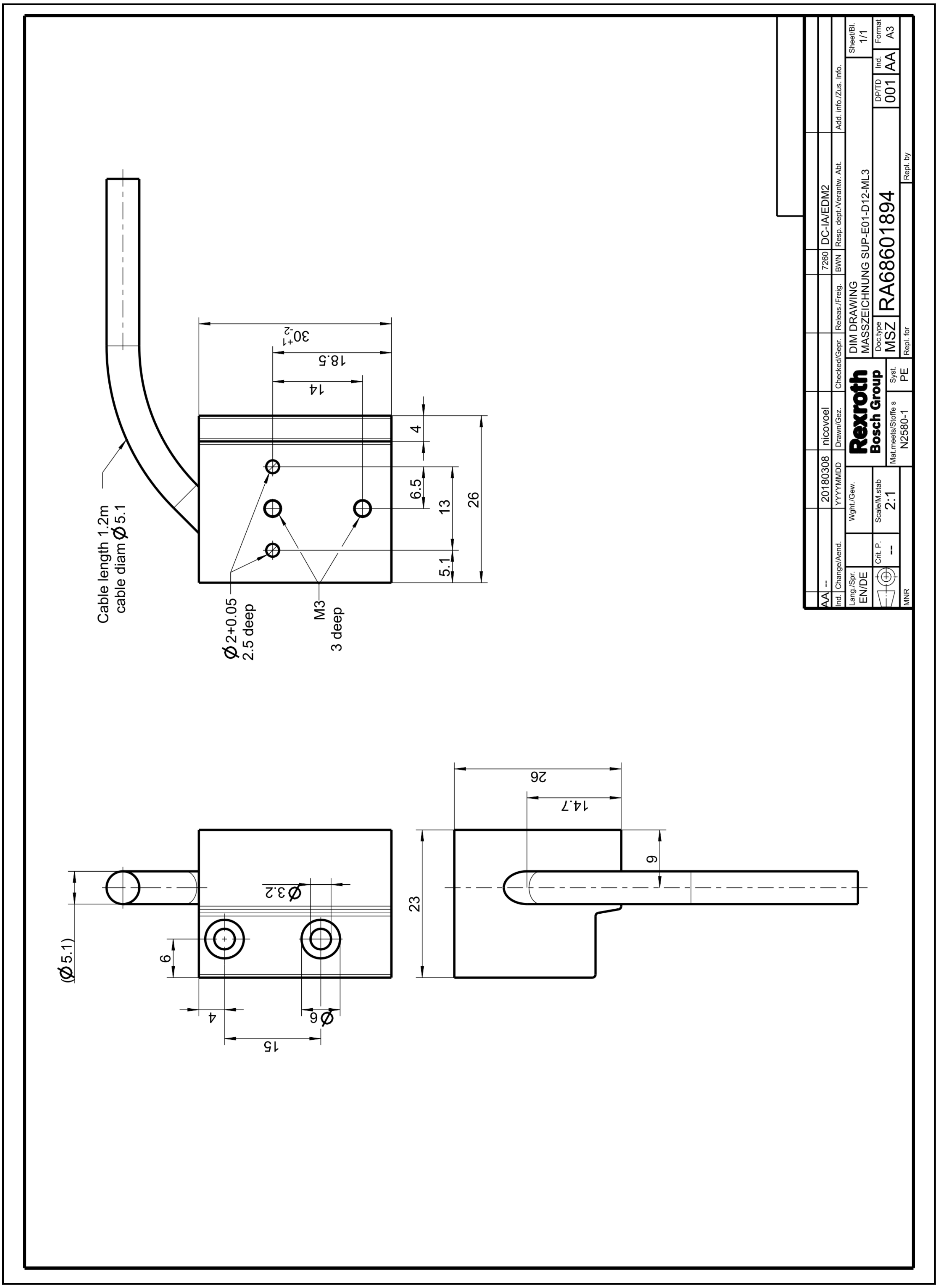


Fig. 5-13: Dimension sheet digital Hall unit

6 Product information

6.1 Type codes

6.1.1 General

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.

6.1.2 Type code primary part ML3P...

Product

Example: **ML3**□□□-□□□□□-□□□□□-□□

ML3 = Product designation

Components

Example: ML3**P**□□-□□□□□-□□□□□-□□

P = Primary part of a ML3 motor

Frame size

Example: ML3P**03**-□□□□□-□□□□□-□□

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-A**N**□□□-□□□□□-□□

N = Standard frame size

Winding

Example: ML3P03-AN**BW**□-□□□□□-□□

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-ANBW**N**-□□□□□-□□

N = Self-cooling

Sensors

Example: ML3P03-ANBWN-**B**□□□□-□□

B = Standard PTC110-EK and KTY83-122

Electrical connection

Example: ML3P03-ANBWN-B**A**□□□-□□

A = 2 cables (separate power and sensors)

Cable design

Example: ML3P03-ANBWN-BA**F**□□-□□

F = Cables suitable for drag chains

Other design

Example: ML3P03-ANBWN-BAF**NN**-□□

NN = No other design

Special design

Example: ML3P03-ANBWN-BAFNN-**NN**

NN = No special design

6.1.3 Type code secondary part ML3S...

Product	Example: **ML3**□□□-□□-□□□□-□□
	ML3 = Product designation
Components	Example: ML3**S**□□-□□-□□□□-□□
	S = Secondary part of a ML3 motor
Frame size	Example: ML3S**03**-□□-□□□□-□□
	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

6.1.4 ML3P03

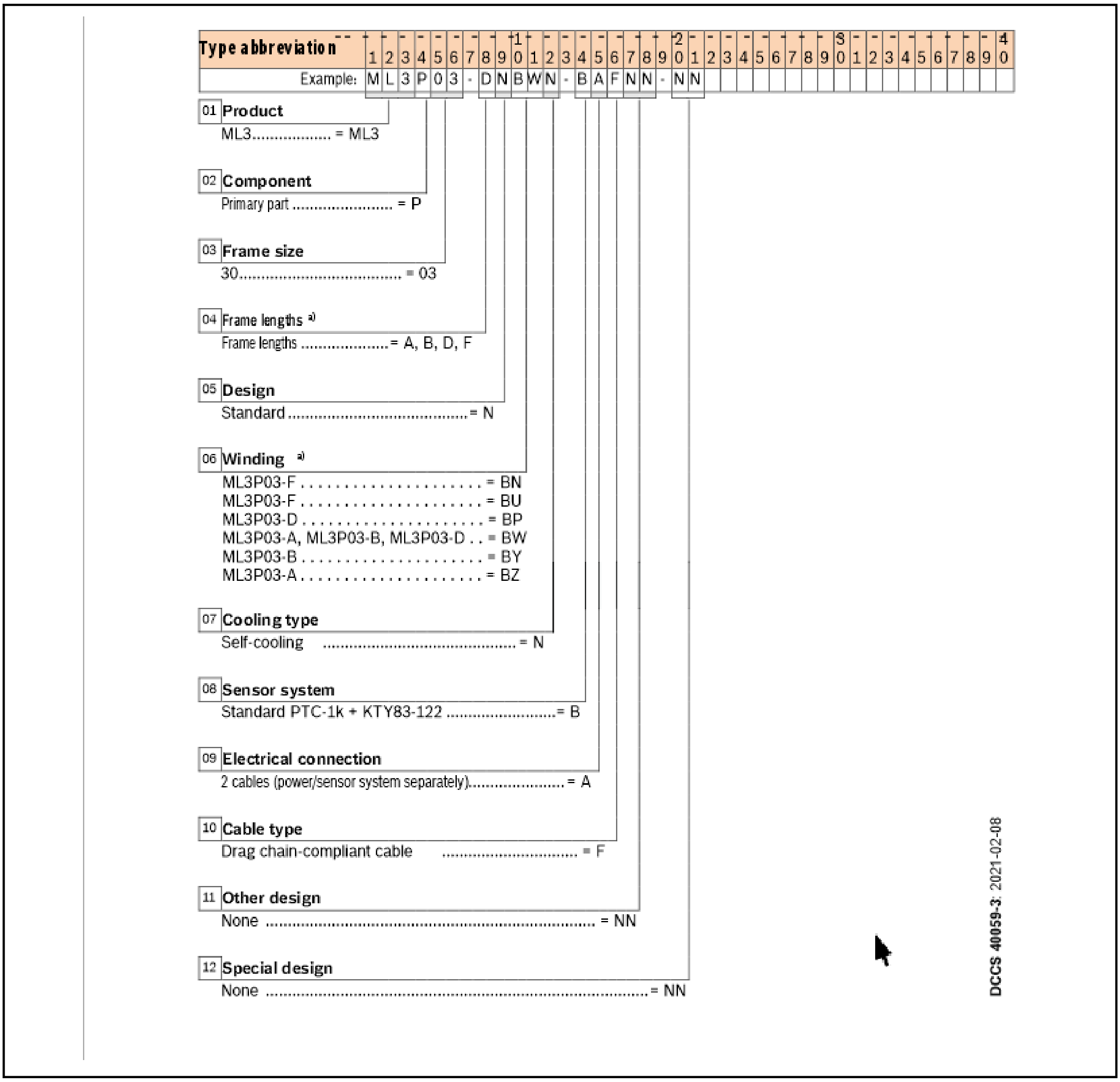


Fig. 6-1: Type code ML3P03 (1/2)

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)

270 m/min.. = BN

600 m/min.. = BU

720 m/min.. = BW

07 Cooling type

Self-cooling .... = N

08 Sensor system

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

09 Electrical connection

2 cables (power/sensor system seperately).................... = A

10 Cable type

Drag chain-compliant cable .... = F

11 Other design

None .... = NN

12 Special design

None ....= NN

DCCS 40059-3 : 2017-07-12

*) Expected to be available form Q1/2022

Fig. 6-2: Type code ML3P03 (2/2)

6.1.5 ML3S03

Short text column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	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. 6-3: Type code ML3S03

6.1.6 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

DCCS 40059-6 : 2017-07-12

Fig. 6-4: Type code ML3P06 (1/2)

Note:

a) Available combinations

•	available	-	not available

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

Fig. 6-5: Type code ML3P06 (2/2)

6.1.7 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. 6-6: Type code ML3S06

6.1.8 ML3P11

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	1	1	-	D	N	B	F	N	-	B	A	N	N	N	-	N	N																			

01 **Product**

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

02 **Component**

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

03 **Frame size**

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

04 **Frame lengths** a)

Frame lengths ....=D, E, F, H, L

05 **Design**

Standard..= N

06 **Winding** a)

ML3P11-E, ML3P11-H, ML3P11-L . . . . =BC

ML3P11-D, ML3P11-F . . . . =BF

ML3P11-D, ML3P11-E, ML3P11-L . . . . =BQ

07 **Cooling type**

Self-cooling .... = N

08 **Sensor system**

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

09 **Electrical connection**

2 cables (power/sensor system seperately) .... = A

10 **Cable type**

Standard cable.. = N

11 **Other design**

None .... = NN

12 **Special design**

None ....= NN

DCCS 40059-11: 2019-05-22

Fig. 6-7: Type code ML3P11 (1/2)

Note:

a) Available combinations

•	Available	-	Not available

Frame lengths	Winding		
	BC	BF	BQ
D	-	•	•
E	•	-	•
F	-	•	-
H	•	-	-
L	•	-	•

DCCS 40059-11: 2019-02-06

Fig. 6-8: Type code ML3P11 (2/2)

6.1.9 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 length192 mm .... = 0192

Secondary part length 288 mm .... = 0288

06 **Special design**

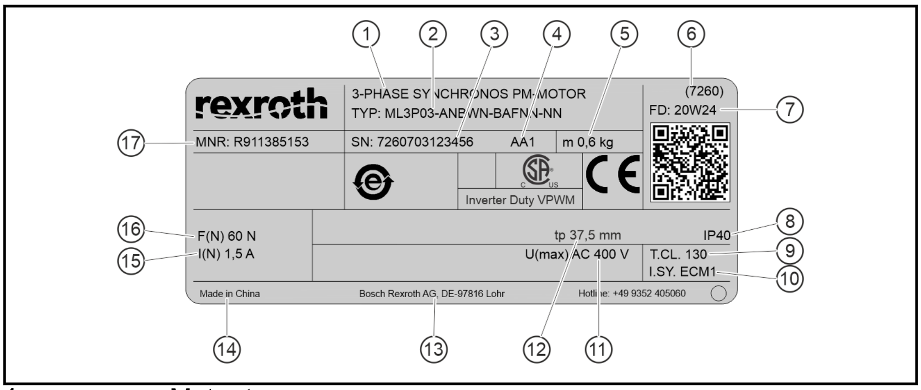
None .... = NN

DCCS 40060-11 : 2017-07-12

Fig. 6-9: Type code ML3S11

6.2 Product labeling

6.2.1 Type plate ML3



1	Motor type
2	Type designation
3	Serial number
4	Change status
5	Mass
6	Factory number
7	Date of manufacture
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

Fig. 6-10: Type plate (example)

Certification mark

Certification mark	Significance
	CSA conformity
	Conformity with applicable EC Directives
	RoHS 2 conformity

Tab. 6-1: Mark of conformity at type plate

☞ Observe the additional information on the mark of conformity under chapter 9.6 "Acceptances and approvals" on page 99.

7 Accessories and options

7.1 Hall unit

7.1.1 General

For control of synchronous motors, the absolute position 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
- at 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 11.6 "Hall unit installation (option)" on page 152.

7.1.2 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).

7.1.3 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. 7-1. The voltage supply is 5 V. A minimum current consumption of 100 mA to the Hall unit must be ensured.

Specifications about the analog hall unit can be found in chapter 5.5 .

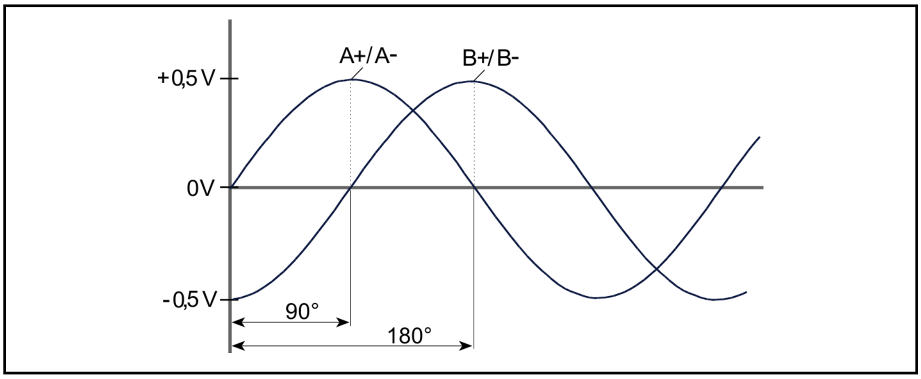


Fig. 7-1: Signal process of an analog Hall unit

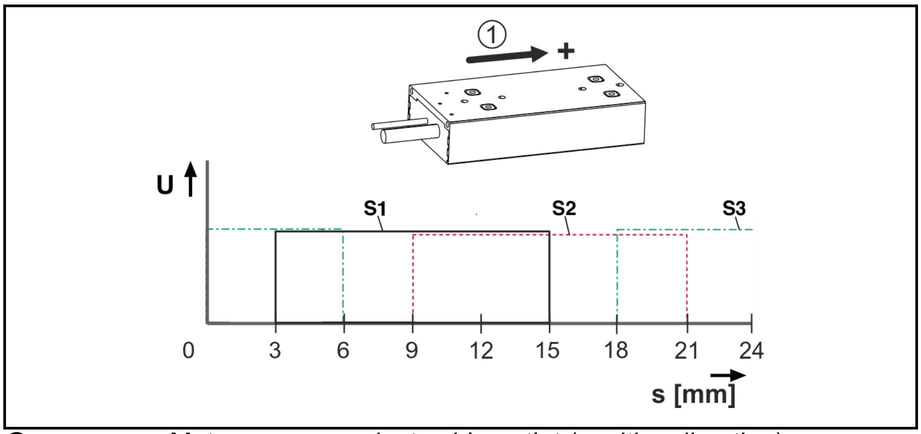
Bosch Rexroth controllers use a supply voltage of 5 V for the analog Hall unit.

The analog Hall unit can also be used as incremental length measuring system. For further information, refer to chapter 9.15 .

7.1.4 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 Fig. 7-2. The voltage supply is 4 ... 28 V with a minimum current consumption of 25 mA.

Specifications about the digital hall unit can be found in chapter 5.6 .



① Motor moves against cable outlet (positive direction)

Fig. 7-2: Signal course of digital Hall unit

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.

7.1.5 Ordering code

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

Tab. 7-1: Hall unit order designation

7.2 SHL03.1 adapter box for digital Hall unit

7.2.1 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 circuit with Rexroth cables is described in Fig. 8-12 and Fig. 8-13.

7.2.2 Hall unit order designation

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

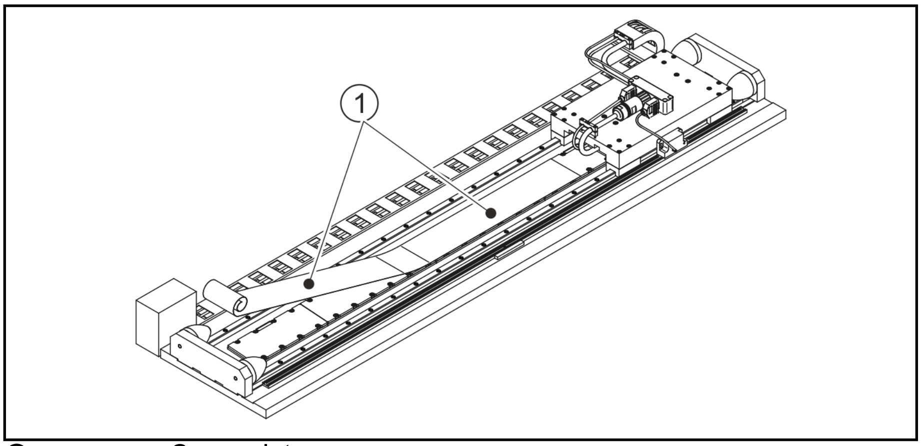
Tab. 7-2: SHL03.1 adapter box order designation

7.3 Cover plate for secondary part

According to chapter 9.13.4 "Protection of the motor installation space" on page 110, 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 11.5 .

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

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). Please refer to the specifications in Tab. 7-3.



① Cover plate

Fig. 7-3: Cover plate at ML3P

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

ML3S	Designation	Steel type	Thickness	Width	Mass	Installation height with cover plate
03	AUS20032 Strip	1.4310	0.1 mm	48 mm	0.0377 kg/m	40.12 mm ±0.1
06	AUS20033 Strip			78 mm	0.0612 kg/m	
11	AUS20031 Strip		0.15 mm	130 mm	0.155 kg/m	45.17 mm ±0.1

Tab. 7-3: Ordering designation of cover sheet

⚠ 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 must not be used for this.

7.4 Magnetic fields label

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

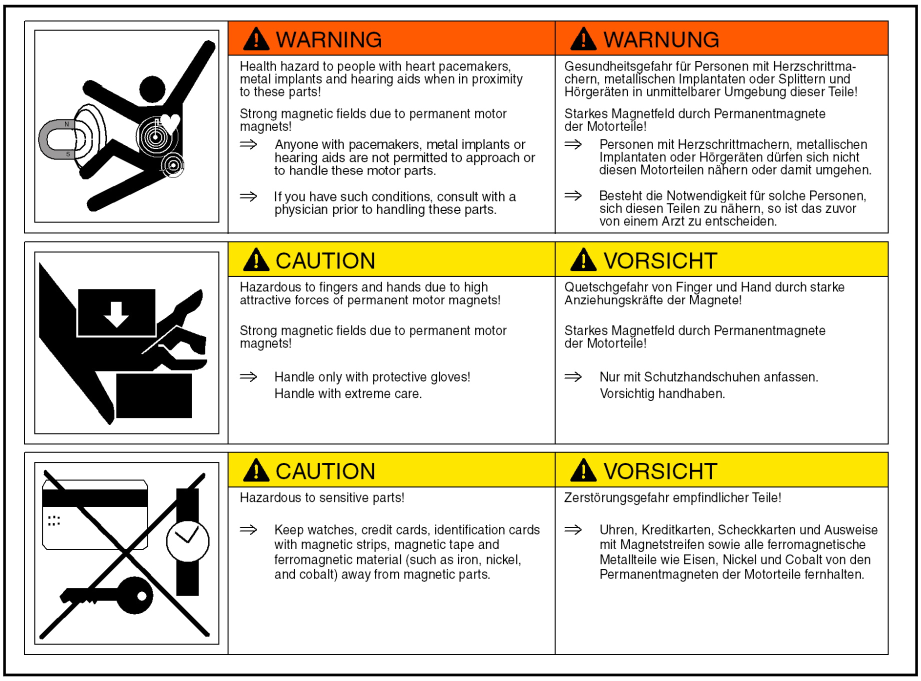


Fig. 7-4: Label (magnetic field of permanent magnets)

- 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 chap. 9 under magnetic fields.

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

Tab. 7-4: Label order designation

8 Connection technique

8.1 Notes

NOTICE **Motor destruction by direct connection to the 50/60 Hz mains power supply (three phase or single phase net)!**

ML3 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 ML3 motors. These cables are optimally adapted to the products and a great variety of requirements.

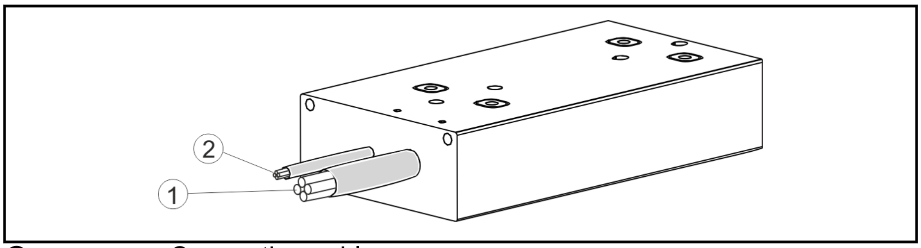
☞ Note that self assembled cables or cable systems of other manufactures possibly do not meet these requirements. Rexroth shall not be held responsible for resulting malfunction states or damage.

8.2 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.



① Connection cable power
② Connection cables temperature sensors

Fig. 8-1: Connection cable on primary part

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	✓	-	-

Tab. 8-1: ML3P connection cables

Wire designation of power connection cable

Power		Wire color / - designation
3-phase	L1	BK / 1
	L2	BK / 2
	L3	BK / 3
Grounding conductor	PE	GNYE
Shield		Metal braiding

Tab. 8-2: Wire designation of power connection cable

Wire designation of temperature sensor connection cable

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

Tab. 8-3: Wire designation of temperature sensor connection cable

Connection cable characteristics

<table>
<tr><th colspan="6">Connection cable power</th></tr>
<tr><th rowspan="2">Primary part</th><th rowspan="2">Cross section
[mm²]</th><th rowspan="2">Diameter
[mm]</th><th colspan="2">Bending radius [R in mm]</th><th rowspan="2">Weight
[kg/m]</th></tr>
<tr><th>statically</th><th>dynamic</th></tr>
<tr><td>ML3P03</td><td>4 x 1.0</td><td>8.3</td><td>33.2</td><td>83</td><td rowspan="2">0.18</td></tr>
<tr><td>ML3P06-B...
ML3P06-C...
ML3P06-D...
ML3P06-E...
ML3P06-F...
ML3P06-HNBK</td><td>4 x 1.0</td><td>9.6</td><td>57.6</td><td rowspan="3">not permitted</td></tr>
<tr><td>ML3P06-HNBR</td><td rowspan="2">4 x 2.5</td><td rowspan="2">11.4</td><td rowspan="2">68.4</td><td rowspan="2">0.27</td></tr>
<tr><td>ML3P11-D…
ML3P11-E…
ML3P11-F…
ML3P11-H…
ML3P11-L…</td></tr>
<tr><th colspan="6">Temperature connection cables</th></tr>
<tr><td>ML3P03
ML3P06
ML3P11</td><td>4 x 0.14</td><td>4.3</td><td>25.8</td><td>not permitted</td><td>0.033</td></tr>
</table>

Tab. 8-4: Connection cable characteristics

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.

8.3 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 Fig. 8-1. Cables that are not suitable for drag chains must be routed in a fixed installation (see Fig. 8-5) to a junction. 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:

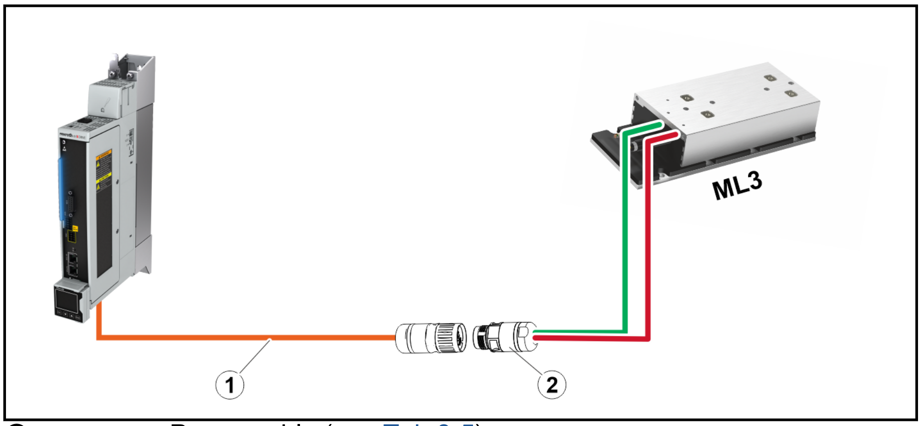
- Connection with connector and cable by Rexroth
- Connection with connector and cable (layout by customer)
- Connection with terminal box (layout by the customer)

☞ When using Rexroth controllers and connection techniques, only the one temperature sensor can be connected and evaluated at the controller. For both variants, the connection are displayed in fig. 8-3 and fig. 8-4.

8.3.1 Connection with connector and cable by Rexroth

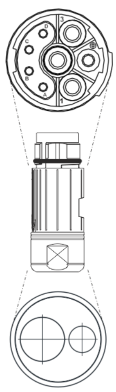
A coordinated range of connector sets and ready-made power cables is available for connecting the ML3 motors to Rexroth controllers. Also refer to the instructions in Tab. 8-5. In order to be able to connect Rexroth power cables to the motor, the motor connection cable must first be assembled by the customer, taking into account the installation situation.

☞ For the assembly, a special tool is required:
Crimping tool R913072332 (manufacturer ID C0.236.00).



① Power cable (see Tab.8-5)
② Connector (connector set to assemble the connecting cable on the motor (refer to tab. 8-5)

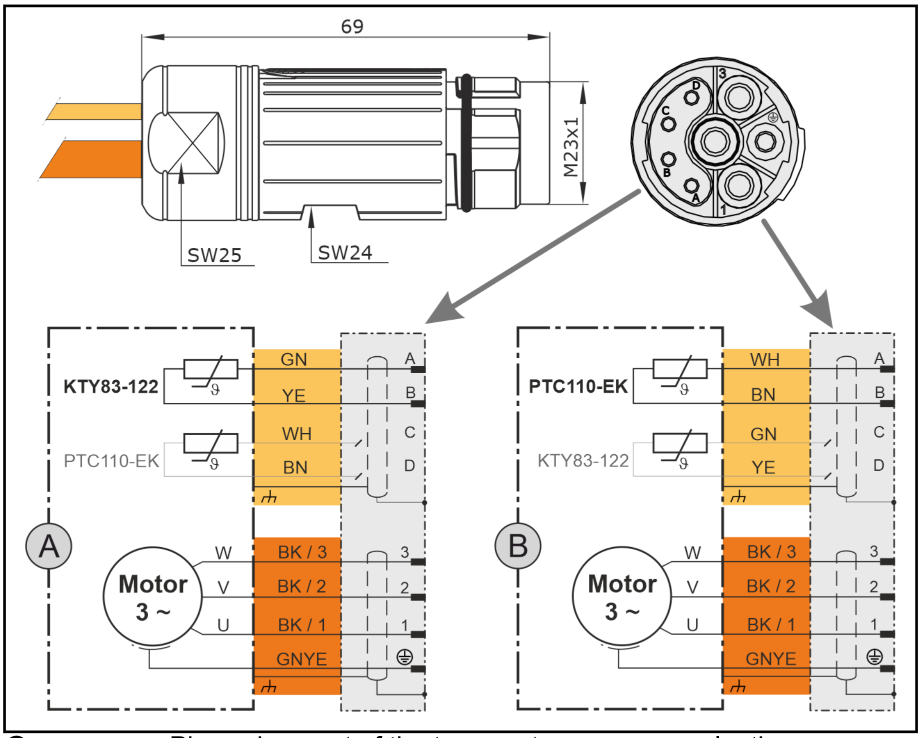
Fig. 8-2: Motor connection with combo plug

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) IndraDrive RLC1-xxxBGB-NN-xxx,x (0.75 mm²) RLC1-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		
ML3P06-HNBR ML3P11-…		RLS2372/CUB3 R911398824		

Tab. 8-5: Connectors and power cables to connect the ML3P

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



Ⓐ Pin assignment of the temperature sensor evaluation KTY83-122
Ⓑ Pin assignment of the temperature sensor evaluation PTC110-EK

Fig. 8-3: Pin assignment of the combo plug

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 connectors listed in Tab. 8-5 can be fitted with a folding flange. The flange can be ordered as an accessory.

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

Tab. 8-6: Mounting flange for connector gland

8.3.2 Connection with connector and cable by third party manufacturers

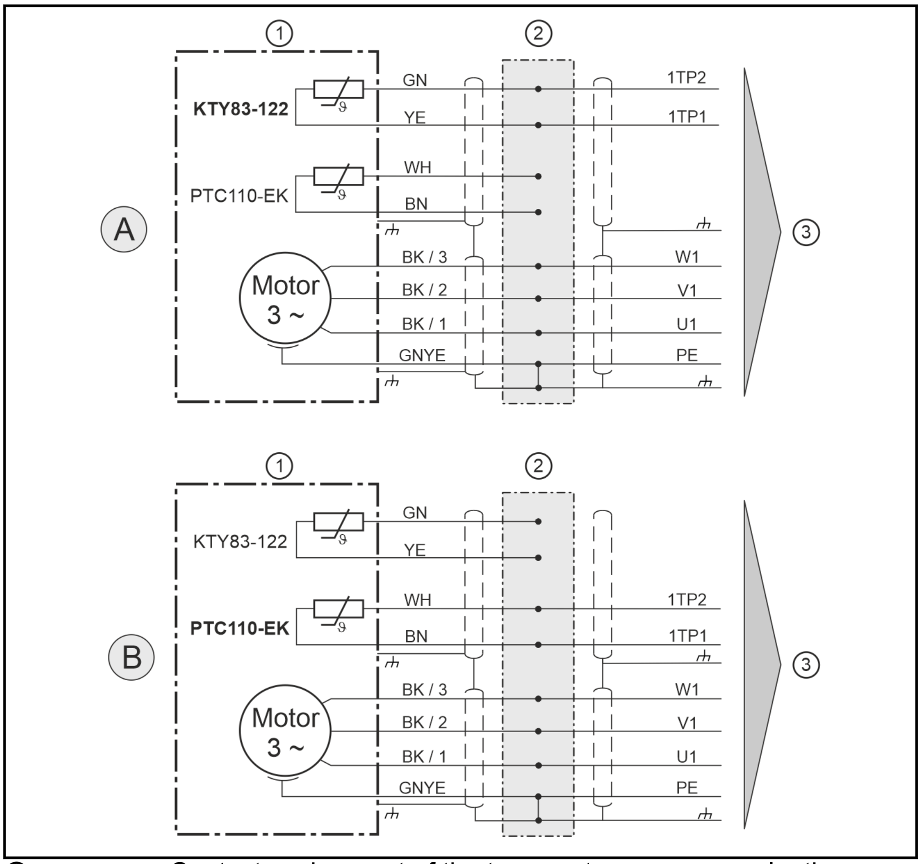
If the motors are not connected using connectors and cables by Rexroth, the customer has to provide all required components. The wire designation required for the assembly can be found under tab. 8-2 and tab. 8-3

☞ 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.

8.3.3 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.



Ⓐ 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
① Controller

Fig. 8-4: Connection example terminal box

8.3.4 Routing of connection cables

NOTICE **Damage of the connection cables and the motor by dynamic bending loads!**

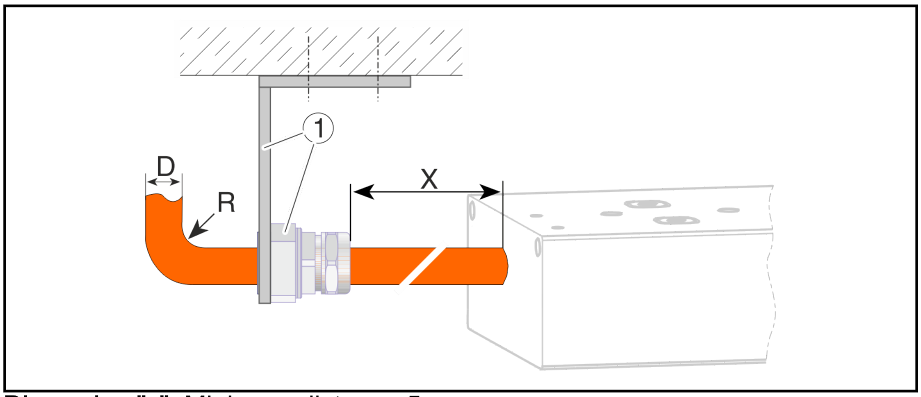
The connection cables of the primary parts ML3P06 and ML3P11 and the temperature sensor cables of all ML3P may not be laid into drag chains. Installation in a cable carrier is only allowed for a cable lead after a junction suitable for energy or drag chains.

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, provide the connection cable with a strain relief (see Fig. 8-5) to protect the cable and the primary part from any 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 conductor.



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

Fig. 8-5: Example for strain relief of connection cable (only valid for ML3P03)

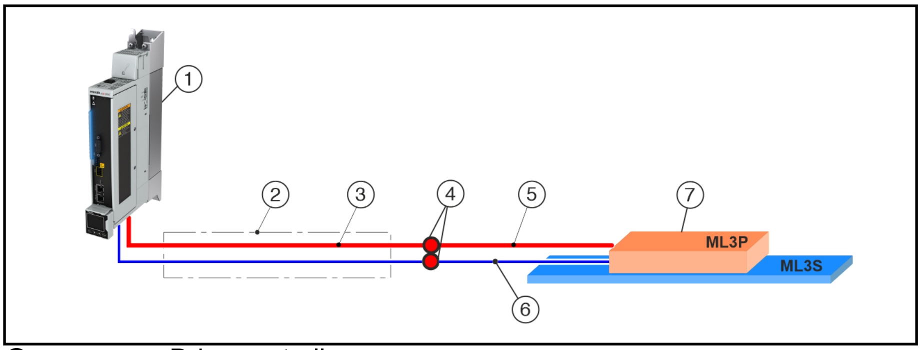
Parallel motor connection

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. 8-7)
- Installation of a collective cable with higher cross section (Fig. 8-8)

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.

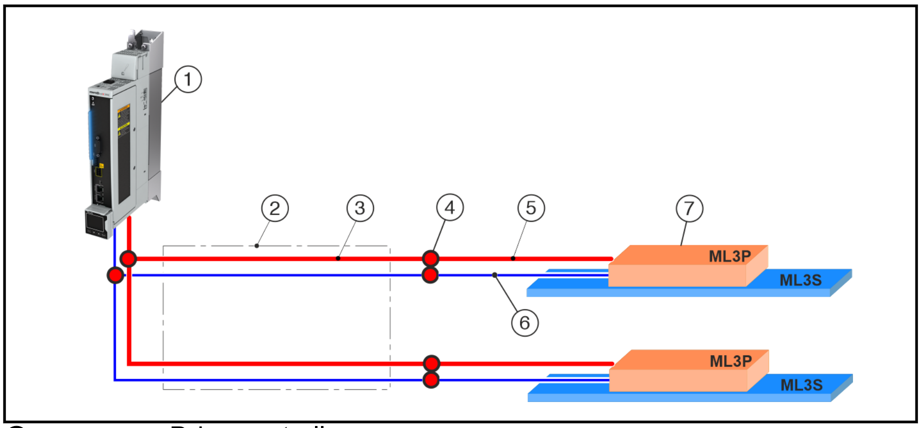
Power connection for single arrangement



① Drive controller
② Energy chain
① Power cables
① Junction (e.g. connector, terminal boxes)
⑤ Connection power
⑥ Connection temperature
⑦ Motor ML3

Fig. 8-6: Power connection for single arrangement

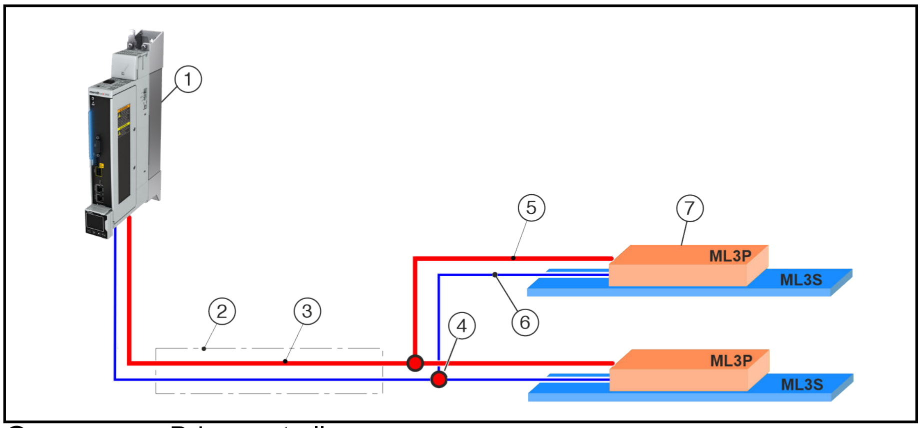
Power connection for parallel arrangement, separate connection cable



① Drive controller
② Energy chain
① Power cables
① Junction (e.g. connector, terminal boxes)
⑤ Connection power
⑥ Connection temperature
⑦ ML3P primary part

Fig. 8-7: Parallel arrangement, separate power cables

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



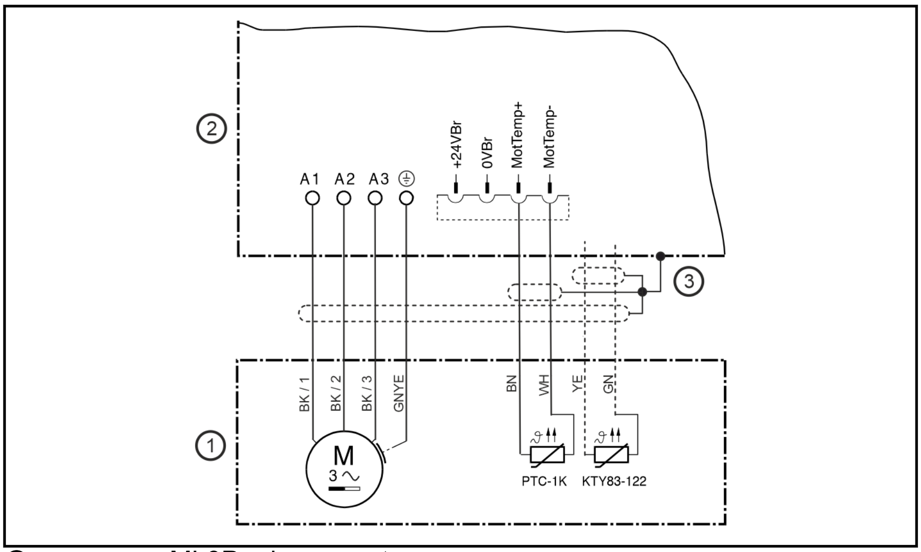
①	Drive controller
②	Energy chain
①	Power cables
①	Junction (e.g. connector, terminal boxes)
⑤	Connection power
⑥	Connection temperature
⑦	ML3P primary part

Fig. 8-8: Parallel arrangement, collective power cable

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

8.4 Connection designations at Rexroth controller

Single arrangement



①	ML3P primary part
②	Rexroth - controller
①	Shield connection on the controller

Fig. 8-9: Connection on drive controller - single arrangement primary part

Parallel arrangement

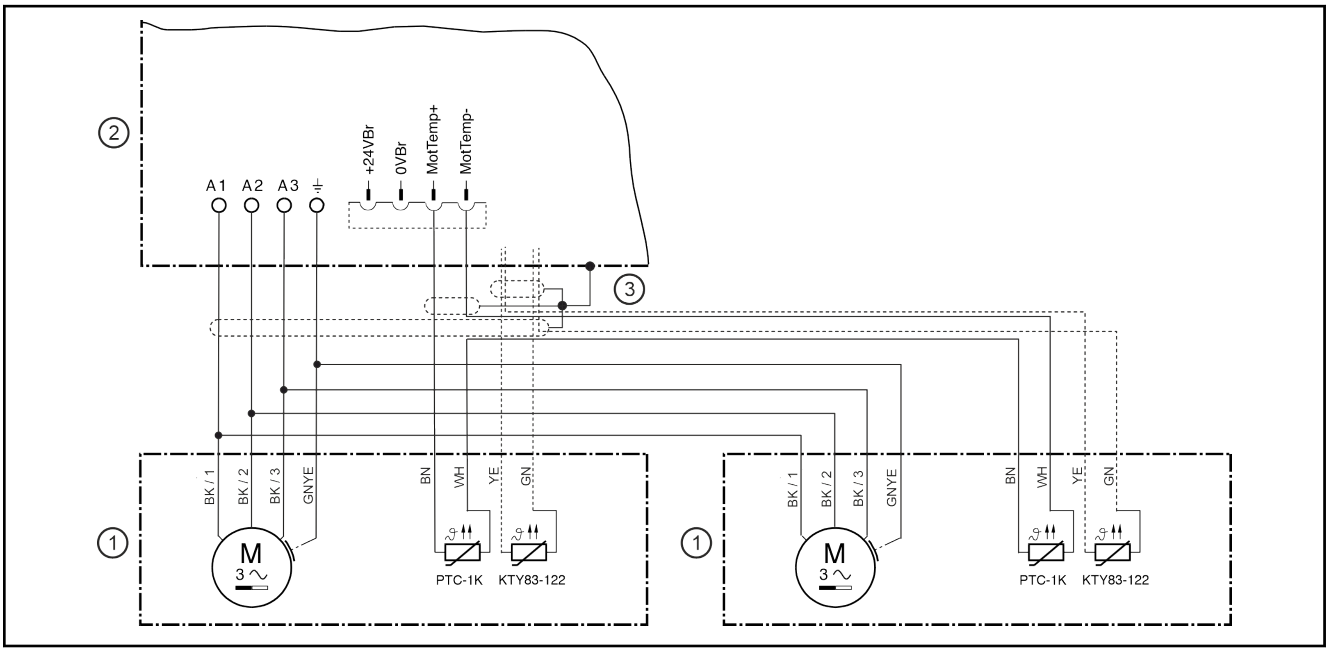


Fig. 8-10: Connection on drive controller - parallel arrangement primary part

☞ For electrical connection of primary parts in parallel arrangement, refer to the information in chapter 9.14.2 on page 111.

8.5 Electrical connection of Hall unit (optional)

8.5.1 Hall unit connection cable

☞ The connection technique describe in this section can be used for ctrlX DRIVE as well as IndraDrive.

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. Also refer to chapter 8.5.2 .

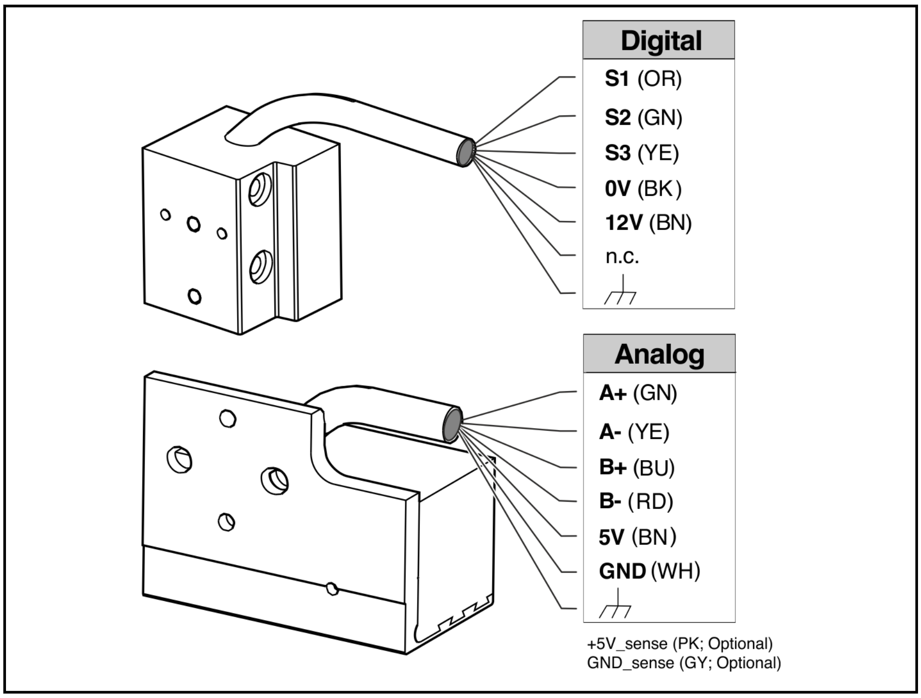


Fig. 8-11: Wire designation connection cable Hall unit

Hall unit connection cable

Hall unit	Diameter / Length	Control wire cross section [mm²]	Allowed bending radius [R]*
Analog	6.2 mm / 3 m	4x 2x 0.14 mm²	6x D (37.2 mm)
Digital	5.0 mm / 1.2 m	6x 0.14 mm²	7.5x D (37.5 mm)

Tab. 8-7: Hall unit connection cable

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 installation is not possible, equip the connection cable of the Hall unit with strain relief (for example, see Fig. 8-5) 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 protection (ESD = electrostatic discharge).

For more information about the Hall unit, please refer to chapter 7.1 "Hall unit" on page 73.

8.5.2 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

PIN	Connection cable Hall unit	
	Analog (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

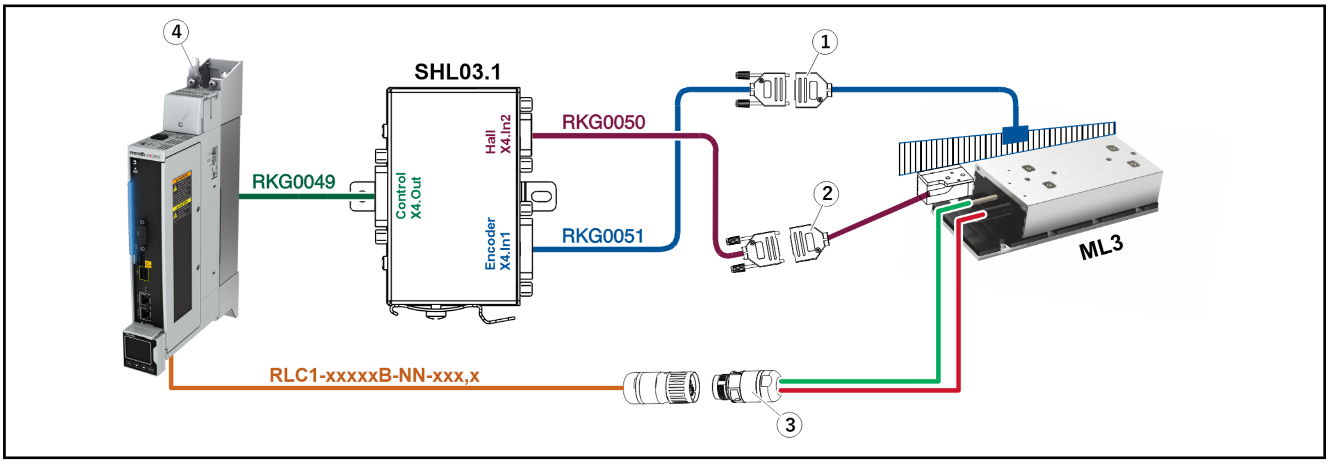
Tab. 8-8: Connection assignment of D-SUB connector for Hall unit connection

8.5.3 Digital Hall unit connection

Observe the information on the SHL03.1 adapter box in documentation DOK-INDRV*-HCS01******-PRxx-xx-P, MNR R911322210 and under chapter 7.1 "Hall unit" on page 73.

To connect 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.

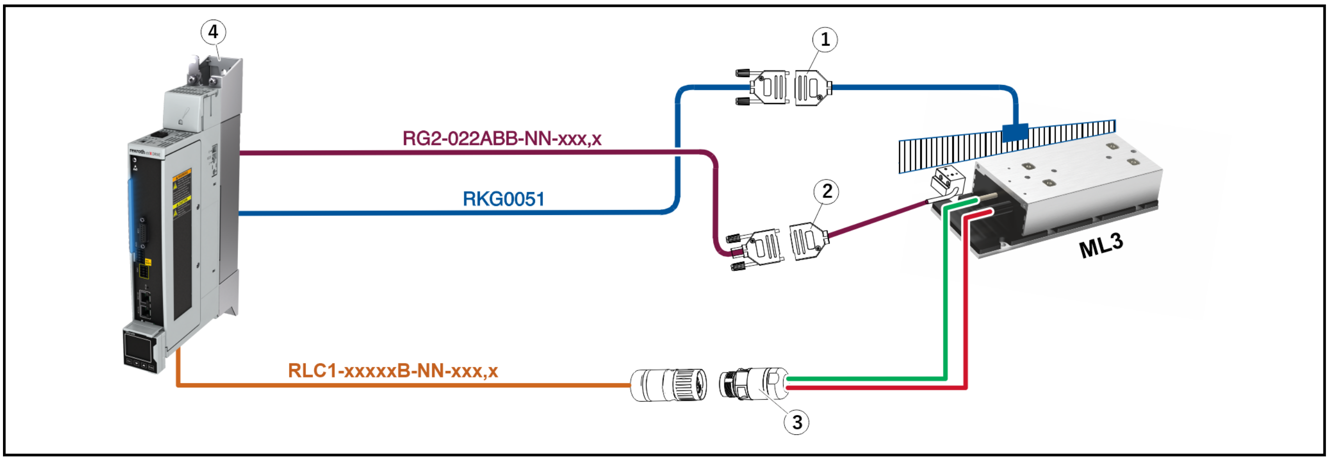


①	Device connector RGS0006 (D-SUB connector, 9-pin)
②	Device connector RGS0005 (D-SUB connector, 9-pin)
①	Connector RLS23x2 (see fig. 8-5)
①	Rexroth controller (ctrlX DRIVE or IndraDrive)
RKG0049	Adapter box ↔ encoder evaluation on drive controller
RKG0050	Digital Hall unit ↔ adapter box (max. cable length 30 m)
RKG0051	Length measuring system ↔ Adapter box
RLC...	Power cables

Fig. 8-12: Connection overview of ML3P with digital Hall unit

8.5.4 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.



①	Device connector RGS0006 (D-SUB connector, 9-pin)
②	Device connector RGS0005 (D-SUB connector, 9-pin)
①	Connector RLS23x2 (see fig. 8-5)
①	Rexroth controller (ctrlX DRIVE or IndraDrive)
RG2-022ABB...	Analog Hall unit ↔ Encoder evaluation at drive controller
RKG0051	Length measuring system ↔ Encoder evaluation at drive controller
RLC...	Power cables

Fig. 8-13: Connection overview of ML3P with analog Hall unit

8.6 Length measuring system

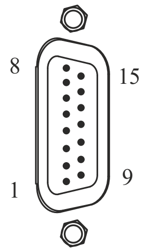
☞ The length measuring system is not in the scope of delivery of the motor and must be prepared and assembled by the machine manufacturer (see chapter 9.15).

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).

	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	n.c.	/
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)	Envoder supply 5 V
13	n.c.	/
14	n.c.	/
15	Sense-	Feedback of reference potential (Sense line)
Connector housing	/	Outer shield

Tab. 8-9: Connection assignment to be done on RGS0006 to connect the length measuring system on the customer-side

9 Application and construction instructions

9.1 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 via linear guide and the linear measuring system. They are mounted into the machine or 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

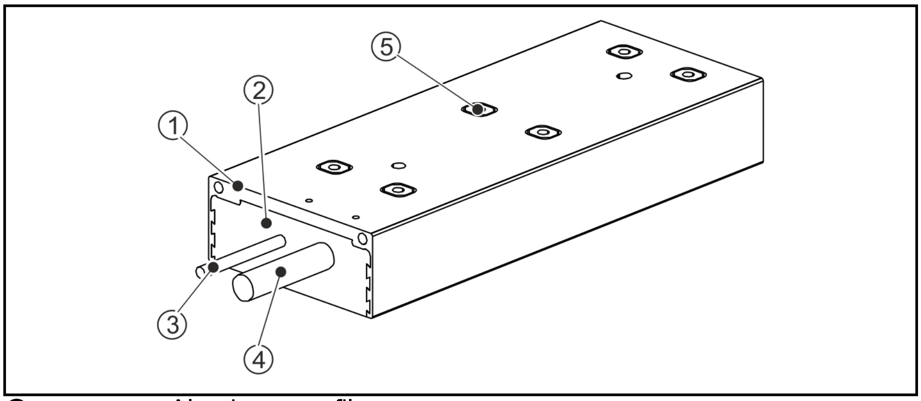
For force multiplication, two or more primary parts can be mechanically coupled or arranged in-line. For further information see chapter 9.14.2 "Several motors per axis" on page 111.

☞ 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.

9.2 Motor design

9.2.1 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.

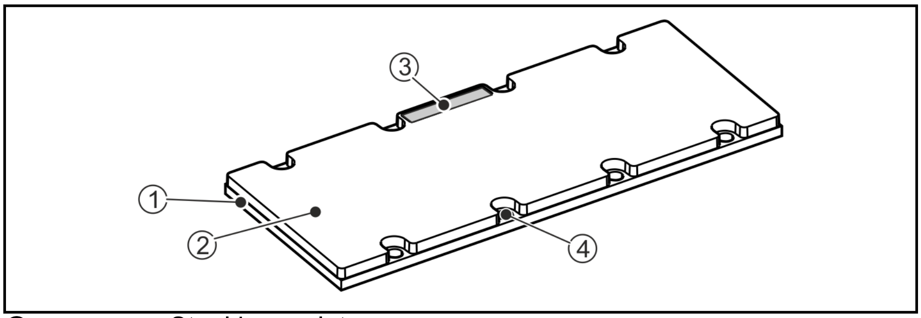


①	Aluminum profile
②	Cast plate package with winding
①	Temperature sensor cable
①	Power cables
⑤	Screw thread

Fig. 9-1: Primary part ML3P06

9.2.2 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 rectangular reference mark.



①	Steel base plate
②	Cast magnets
①	Reference marks
①	Mounting holes

Fig. 9-2: ML3S secondary part

9.2.3 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.

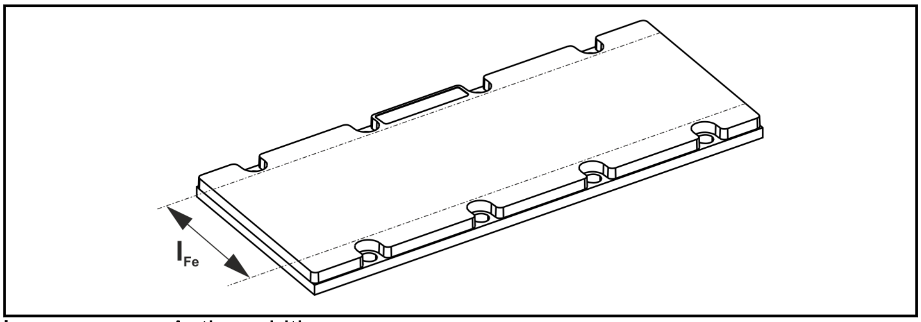
Frame sizes

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

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

Example:

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



l_{Fe} Active width

Fig. 9-3: 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 detailed information about available frame sizes and lengths refer to the type code of the motor in chapter 6.1 "Type codes" on page 61.

Required length of the secondary parts

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

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

L_V Travel length

$L_{ML3P,Fe}$ Active length ML3P (see Fig. 9-8)

Fig. 9-4: Defining the required length of the secondary part

☞ To determine the required travel length and the length of the secondary part distance, also observe chapter Reduced covering between primary and secondary part on page 106.

9.3 Installation altitude and ambient conditions

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 (installation mode A)

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

		Temperature [°C]								
		20	25	30	35	40	45	50	55	60
Height [m]	1000	1	0.97	0.94	0.90	0.87	0.83	0.79	0.75	0.71
	1500	0.98	0.95	0.92	0.88	0.85	0.81	0.77	0.74	0.69
	2000	0.96	0.93	0.90	0.87	0.83	0.80	0.76	0.72	0.68
	2500	0.95	0.91	0.88	0.85	0.82	0.78	0.75	0.71	0.67
	3000	0.93	0.90	0.87	0.84	0.81	0.77	0.74	0.70	0.66

Tab. 9-1: Derating of installation altitude/ambient temperature

☞ 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 data documented in chapter 4 Technical data refer to installation mode A (see chapter 9.24 on page 131). Usually, the less favorable installation modes B to D apply.

9.4 Environmental conditions

Environmental conditions are defined according to DIN EN 60721-3-3 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.

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.

Overview of allowed classes of environmental conditions according to DIN EN 60721-3-3 during operation

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

Tab. 9-2: Allowed classes of environmental conditions during operation

9.5 Type of protection

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

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

Tab. 9-3: Type of protection on ML3 motors

- 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 9.13.4 "Protection of the motor installation space" on page 110 regarding protection modes.

⚠ CAUTION

Any failure to observe the degree of protection of the motor may damage or destroy the motor components or result in personal injury!

The motors or components may only be used in environments where the degree of protection specified is adequate.

9.6 Acceptances and approvals

9.6.1 CE

Certificate of conformity certifying the structure of and the compliance with the valid EN standards and EC guidelines are available for all ML3 motors. If required, the declarations of conformity can be requested from the responsible sales office.

The CE label is applied to the motor type plate.

9.6.2 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.

9.6.3 RoHS

In accordance with our manufacturer's declaration DCTC 30806-1, we confirm that our products conform to the RoHS directive 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment".

9.6.4 China RoHS 2

The ML3 comply with the requirements of RoHS 2.

The label for compliance with RoHS 2 is applied to the motor type plate. Further information can be found online under www.boschrexroth.com.cn/zh/cn/home_2/china_rohs2.

9.7 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.

The above-specified persons are prohibited from accessing areas where such drive components are installed and operated or access is subject to prior medical consultation.

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.

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 (Germany: DIN EN 50 499, DIN VDE 0808-499)
- Standard EN 50527 (Germany: 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 exposition. 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 exposition 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.

9.8 Noise emission

The noise emission of synchronous linear drives can be compared with conventional inverter-operated feed drives. According to experience, it depends on 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)

9.9 Thermal behavior

Power loss

The rated feed force of a synchronous linear motor can be achieved 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.

☞ The maximum allowed winding temperature of the 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.

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

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

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

Fig. 9-5: Power loss of synchronous linear motors

☞ When you determine the power loss according to Fig. 9-5 you must take the temperature-related rise of the electrical resistance into account. 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 figure (Fig. 9-6) 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. 9-7 and Fig. 9-9 are used to define the operating modes, e.g. acc. to DIN EN 60034-1.

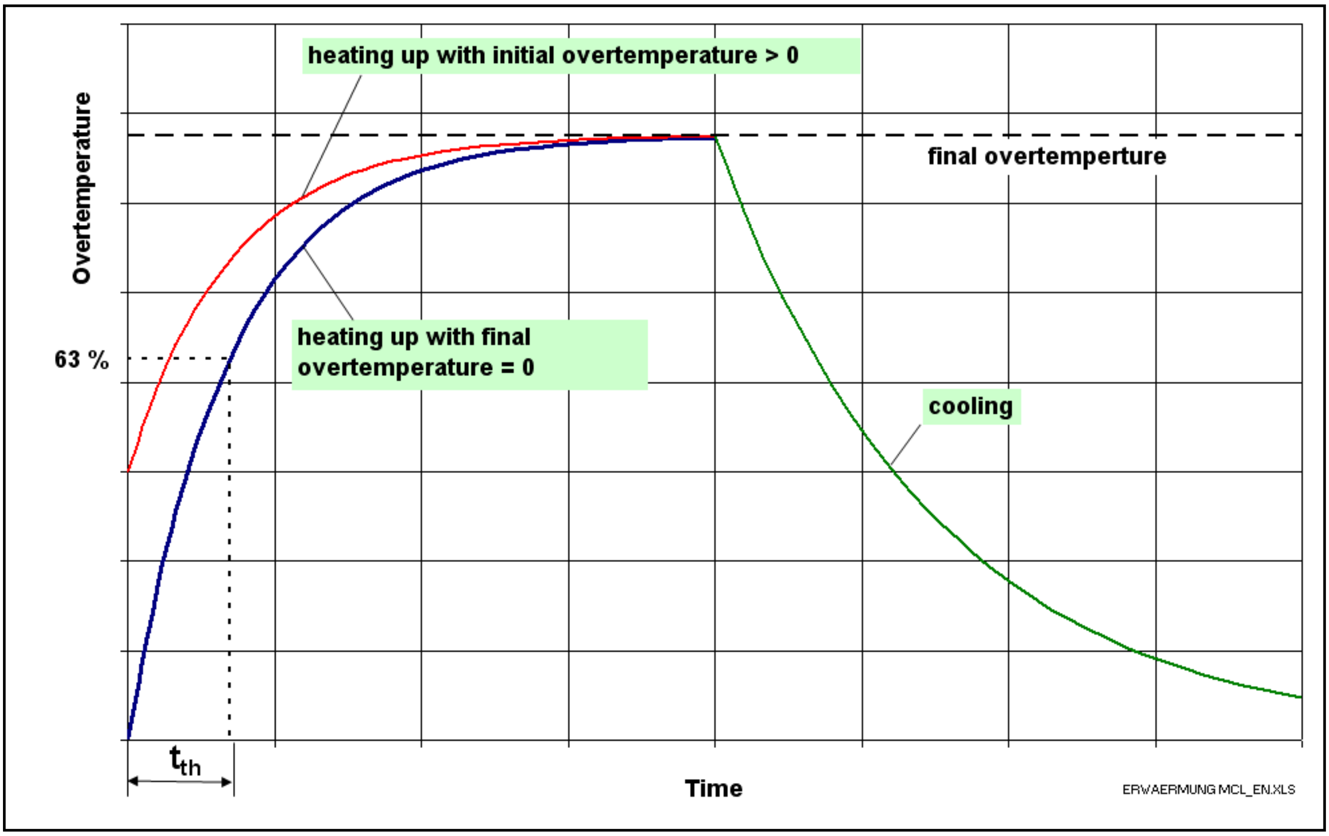


Fig. 9-6: Heating up and cooling down of an electrical machine

Heating up

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

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)

Fig. 9-7: Heating (excess temperature) of an electric machine

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:

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

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)

Fig. 9-8: Expected final excess temperature of the motor

Cooling down

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

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)

Fig. 9-9: Cooling down of an electrical machine

9.10 Motor temperature monitoring

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.

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 9.24 "Thermal connection - Installation modes" on page 131).

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.

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

Tab. 9-4: Parameter settings for temperature sensors

Temperature sensor 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

Tab. 9-5: Reference 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	2012

Tab. 9-6: Resistance values KTY83-122

The response temperatures of the sensor are

⇒100 °C pre-warning temperature

⇒110 °C shut-off temperature

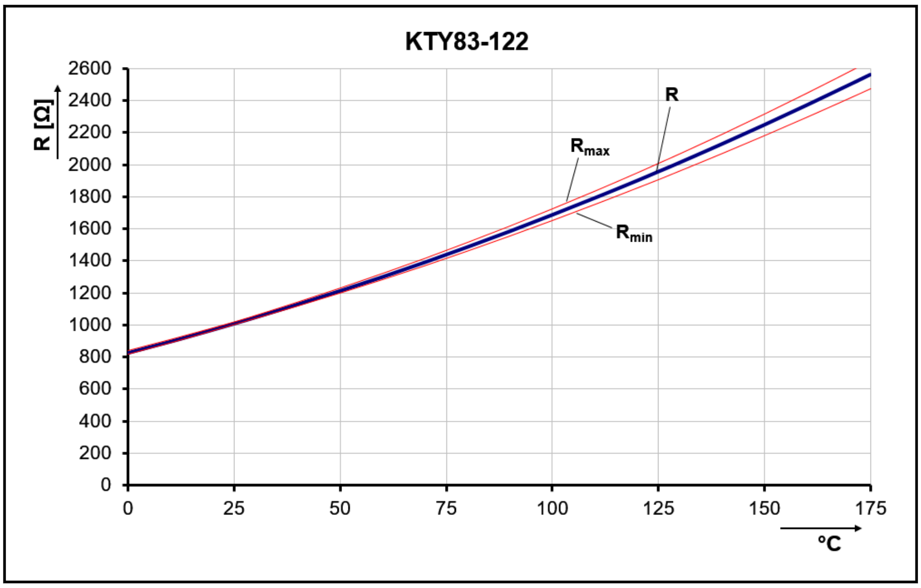
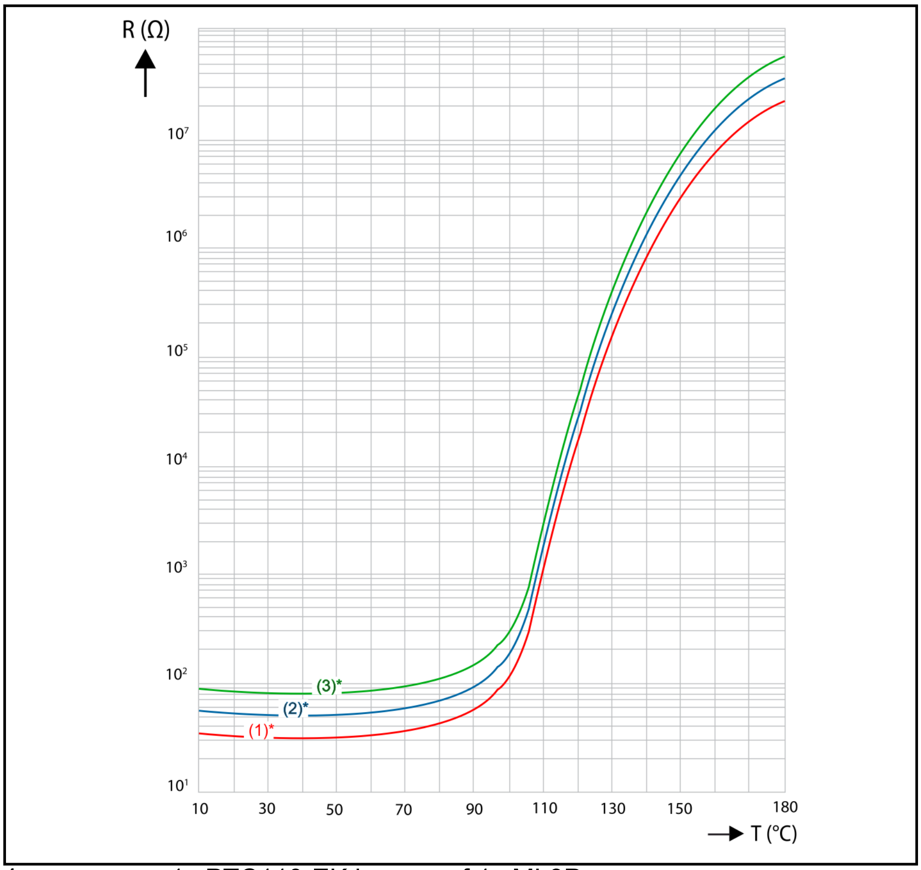


Fig. 9-10: Characteristic temperature sensor KTY83-122

Temperature sensor 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

Tab. 9-7: Recommended values 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

Fig. 9-11: Characteristic temperature sensor PTC110-EK

☞ In case of parallel arrangement of several ML3Ps, the PTC110-EK of the primary part is connected in series for motor temperature monitoring.

9.11 Feed force at reduced covering 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.

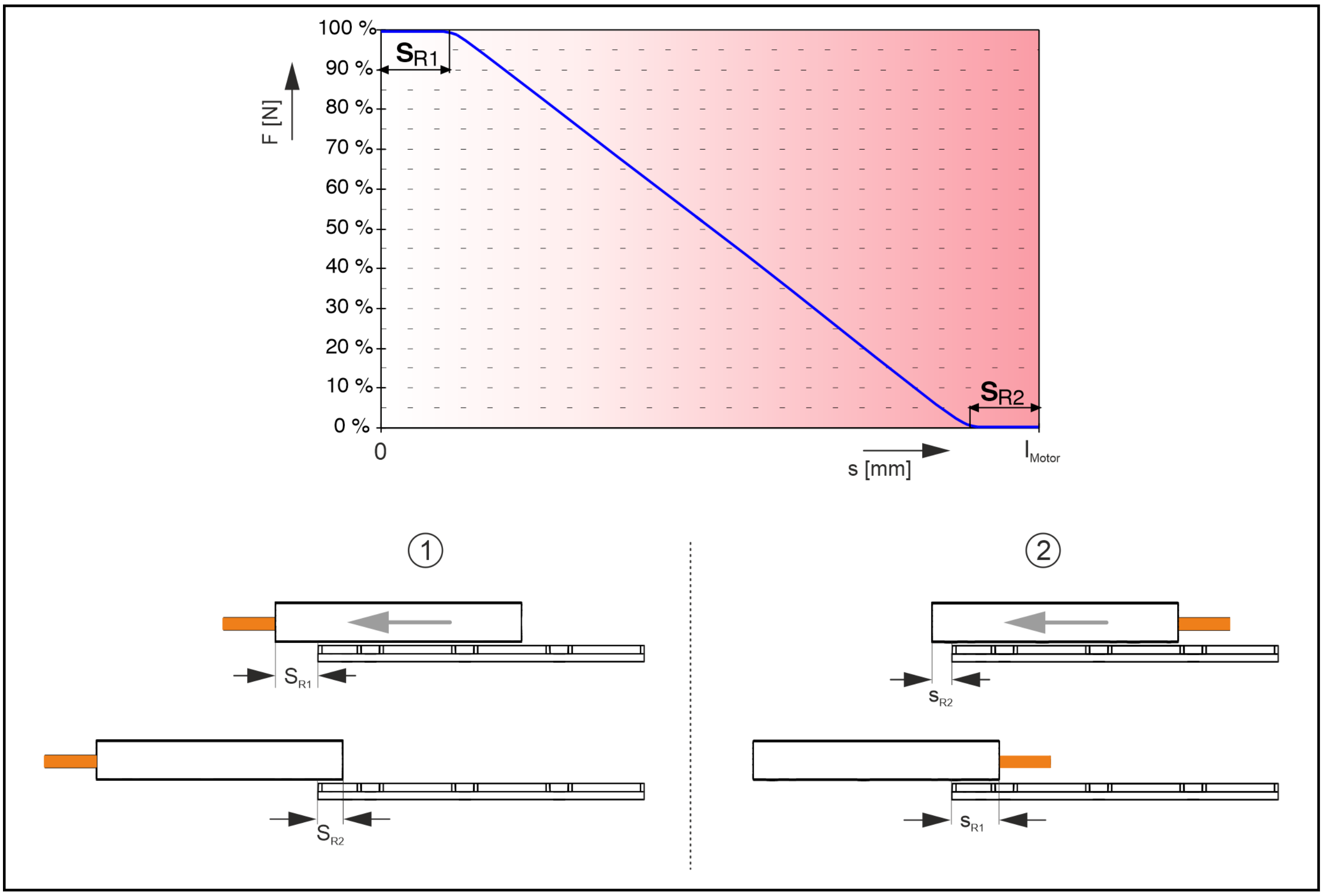
If primary and secondary part are only partially covered, this inevitably results in a reduction of the feed forces.

☞ 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.



① Variant 1 - Overrun distance in direction of cable outlet side
② Variant 2 - Overrun distance in direction against cable outlet side

Fig. 9-12: Force reduction with partial coverage of primary and secondary part

Frame length ML3P		Active length	Overrun distance	
		$L_{ML3P,Fe}$ [mm]	S_{R1} [mm]	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

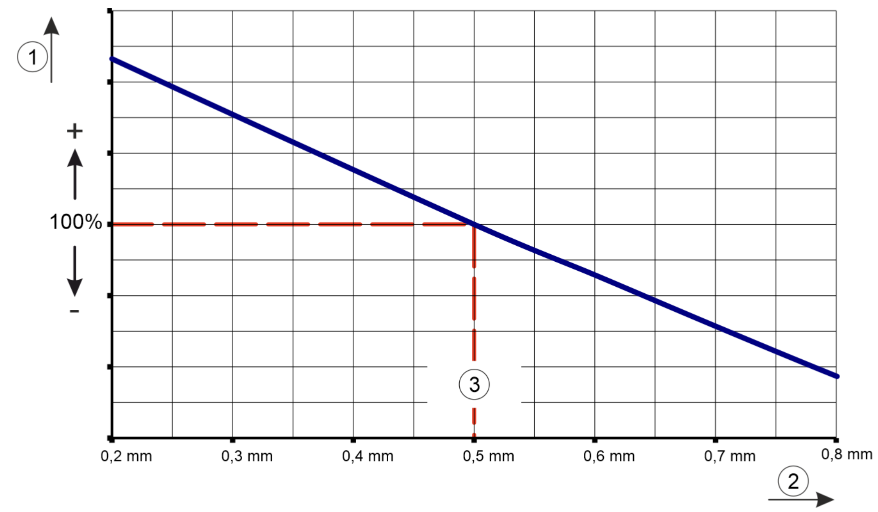
Frame length ML3P		Active length	Overrun distance	
		$L_{ML3P,Fe}$ [mm]	S_{R1} [mm]	S_{R2} [mm]
11	D	216	26	2
	E	257.6	26.2	6.2
	F	305.6	26.7	3.7
	H	401.6	29.2	3.2
	L	529.6	26.2	6.2

Tab. 9-8: Partial coverage between primary and secondary part

9.12 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:



① Feed force
② Air gap
① Motor force in case of nominal air gap

Fig. 9-13: Feed force within the air gap tolerance of synchronous linear motors ML3

9.13 Requirements on the machine design

9.13.1 General

Derived from design and properties of linear direct drives, the machine construction must meet various requirements. For example, minimizing of moving masses with simultaneous high rigidity should be realized.

9.13.2 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. half-timbered construction).

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

9.13.3 Mechanical rigidity

In conjunction with the mass and the resulting resonant frequency, 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 loop bandwidth of linear drives required 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 inside the axis should not be less than 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 is reduced as the mass increases. $f \approx \sqrt{1/m}$

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, cinematic 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 can deform the stationary machine base or cause the fixed machine base body to vibrate.

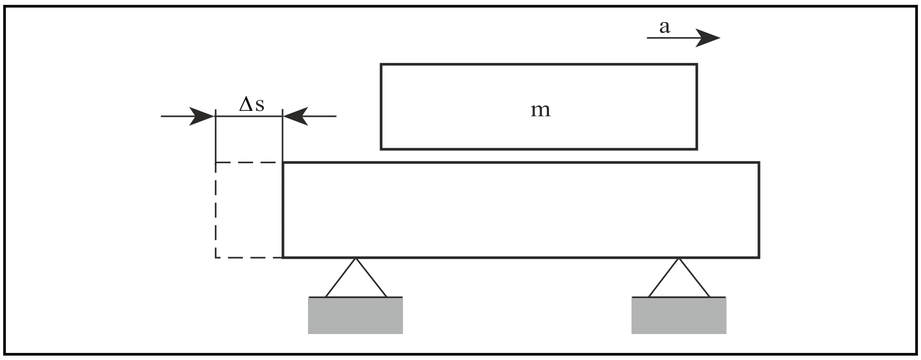


Fig. 9-14: Deformation of the machine base body caused by the reactive force during the acceleration process

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

Δs	Deformation or displacement of the machine base in µm
m	Mass in kg
a	Acceleration in m/s²
c	Rigidity of the machine base body in N/µm

Fig. 9-15: Calculation example of the machine base body deformation

Integrating the linear scale

The rigidity of the length measuring system integration is particularly important. For explanations refer to chapter 9.15 "Length measuring system" on page 120.

9.13.4 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 chapter 9.5 "Type of protection" on page 99).

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...

- an increased heat input 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 effectgrinding 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.

9.14 Arrangement of motor components

9.14.1 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.

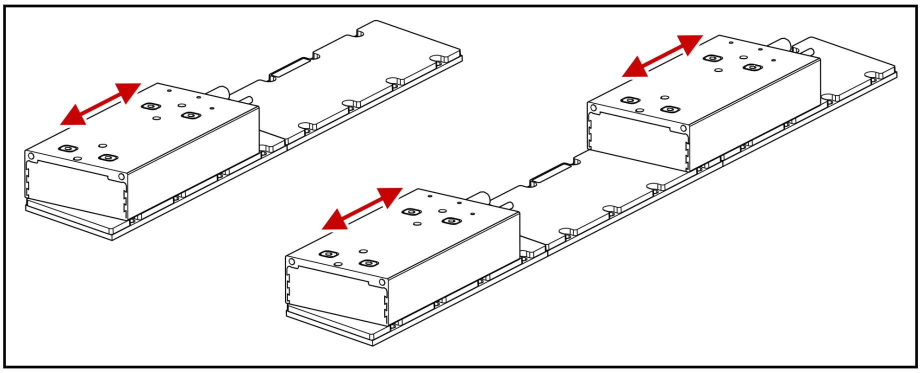
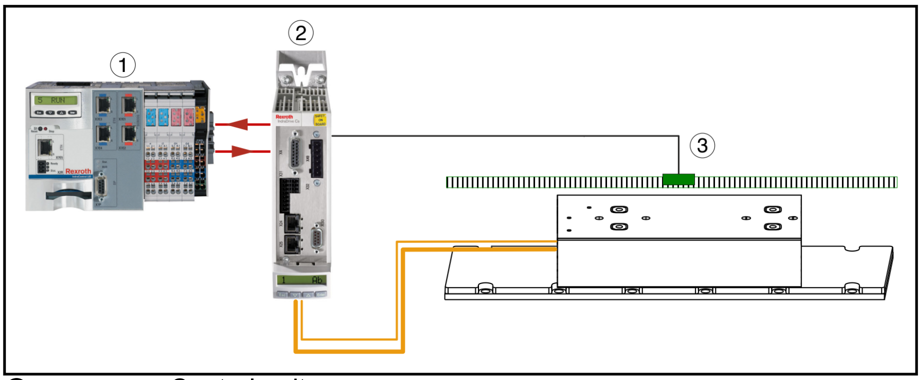


Fig. 9-16: Single axis arrangement of primary parts



① Control unit
② Controller
① Length measuring system

Fig. 9-17: Controlling a linear motor with single arrangement of the motor components

9.14.2 Several motors per axis

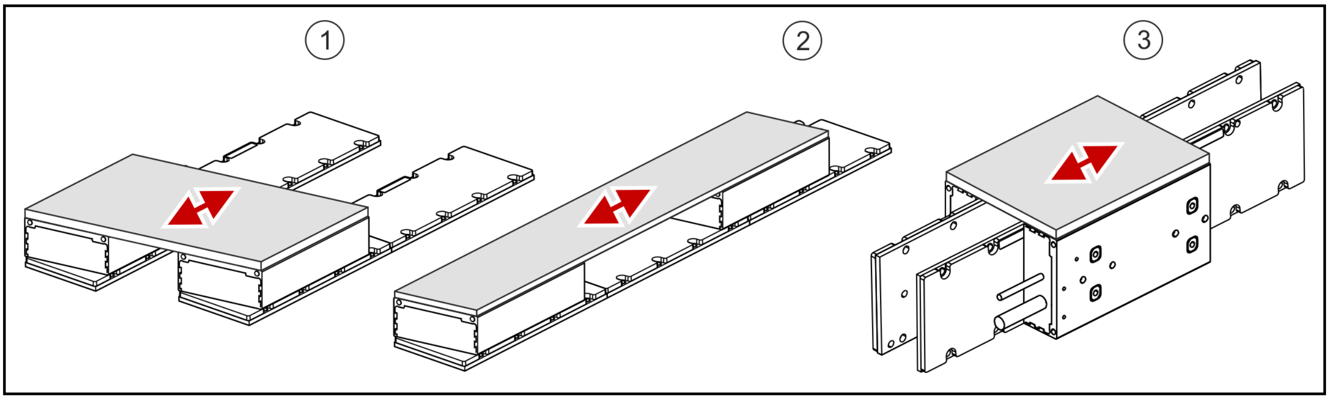
General

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)



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.

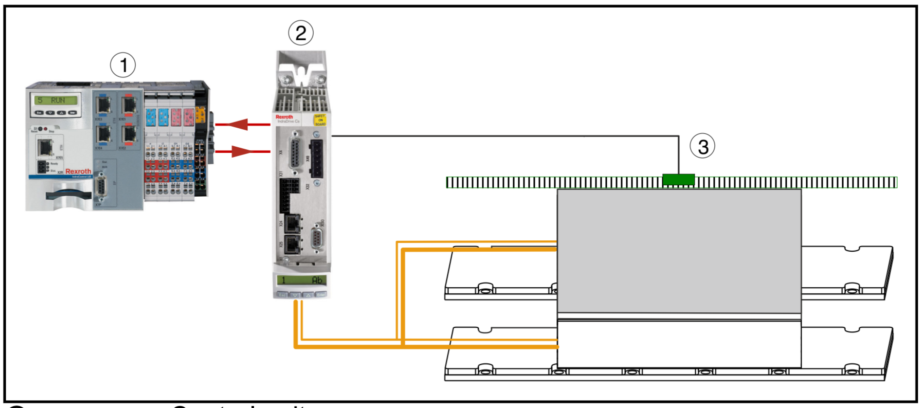
② In case of two motors on the same length, a length scale with two scanning heads can be used.

① 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.

Fig. 9-18: Arrangement of several motors per axis

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.



① Control unit

② Controller

① Length measuring system

Fig. 9-19: Parallel connection of two primary parts on one drive controller in conjunction with a 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. 9-18) 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. 9-20, a distance x_p must be observed.

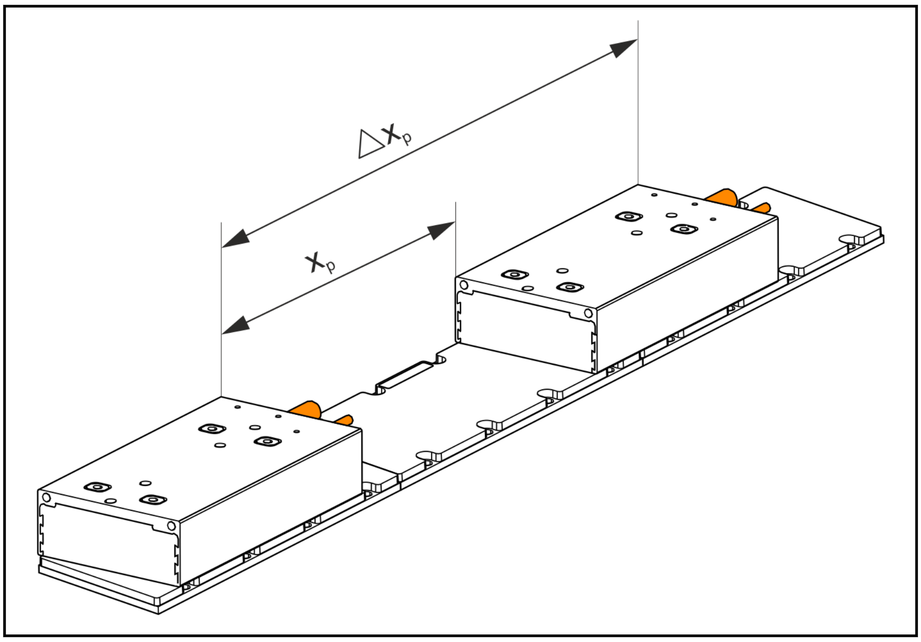


Fig. 9-20: Arrangement of the primary parts behind each other and cable outlets in the same direction

$$x_p = n \cdot 2 \cdot \tau_p + x_{p\,\min}$$
$$x_p > R$$

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. 9-9)
R	Allowed bending radius of the connection cable (see Tab. 8-4)

Fig. 9-21: Determining the distance x_P between the primary parts with cable outlets in the same direction

The grid dimension Δx_P acc. to Fig. 9-20 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).

$$\Delta x_p = n \cdot 2 \cdot \tau_p$$

Δx_p	Required grid dimension between the primary parts in mm
x_P	Distance between the front faces of the primary parts in mm
n	Freely selectable integer factor
τ_P	Pole width (see Chapter Technical data)

Fig. 9-22: Determining the grid dimension between the primary parts with cable outlets in the same direction

The distance x_P between the primary parts according to Fig. 9-20 may not be less than the following minimum distances x_{pmin}:

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

x_P	Distance between the front faces of the primary parts in mm
x_{pmin}	Smallest allowed distance between the primary parts (see Tab. 9-9)

Fig. 9-23: Smallest allowed distance between the primary parts

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	56 mm		U-V-W

*) Reference motor to determine the encoder polarity and commutation adjustment is always primary part 1

Tab. 9-9: Distance and phase sequence at arranged primary parts behind each other and cable outlet in the same direction

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

If the primary parts are arranged according to Fig. 9-24, a defined distance x_P has to be complied with between the front faces of the primary parts.

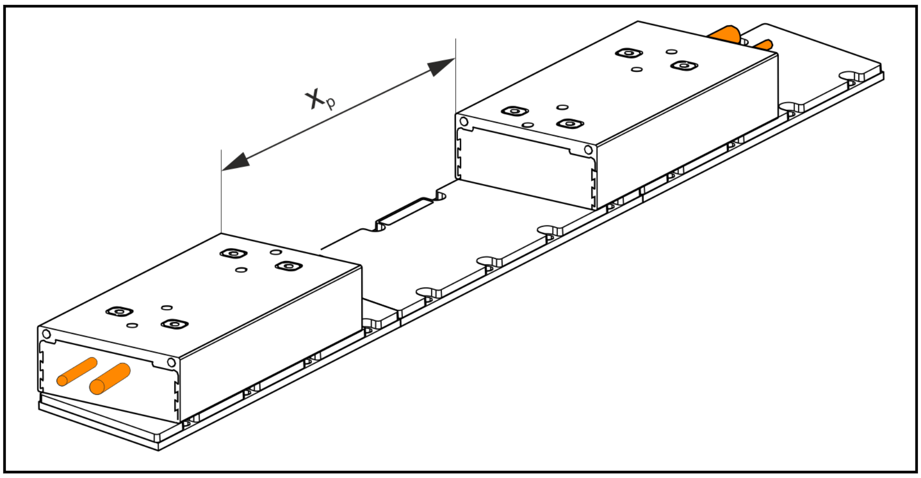


Fig. 9-24: Variant 1: Arrangement of primary parts behind each other with cable outlets in opposite directions

$$x_p = n \cdot 2 \cdot \tau_p + x_{P\,min}$$

x_P	Distance between the front faces of 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. 9-10)

Fig. 9-25: Determining the distance between primary parts with cable outlets in opposite directions

☞ When determining the correct primary part distance according to Fig.9-24, only the distance between the primary part end faces (xpmin) as reference point can be used.

Primary part	Distance x_{Pmin}	Phase sequence L1 / L2 / L3	
		Primary part 1*)	Primary part 2
ML3P03-A	14	U-V-W	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		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
ML3P11-E	2		V-U-W
ML3P11-F	7		V-U-W
ML3P11-H	8		V-U-W
ML3P11-L	6		U-W-V

*) Reference motor to determine the encoder polarity and commutation adjustment is always primary part 1

Tab. 9-10: Distance and phase sequence at arranged primary parts behind each other with cable outlets in opposite directions (option 1)

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

If the primary parts are arranged according to Fig. 9-26, a defined distance x_P has to be complied with between the front faces of the primary parts.

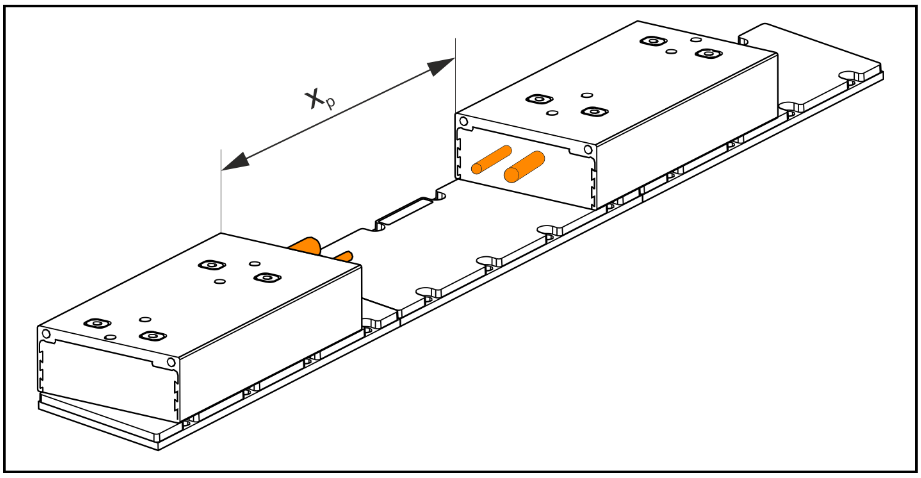


Fig. 9-26: Variant 2: Arrangement of primary parts behind each other with cable outlets in opposite directions

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

x_P	Distance between the front faces of 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. 9-11)
R	Allowed bending radius of the connection cable (see Tab. 8-4)

Fig. 9-27: Determining the distance x_P between the primary parts with cable outlets in the same direction

☞ When determining the correct primary part distance according to Fig.9-26, only the distance between the primary part end faces (xpmin) as reference point can be used.

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
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

***)** Reference motor to determine the encoder polarity and commutation adjustment is always primary part 1

Tab. 9-11: Minimum distance and phase sequence at arranged primary parts behind each other with cable outlets in opposite directions (option 2)

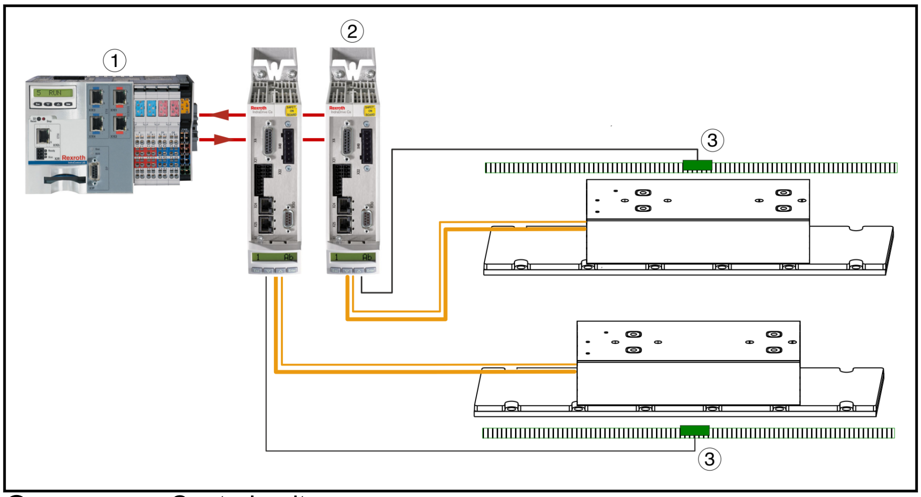
Gantry arrangement

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.



① Control unit
② Controller (2 pcs.)
① Length measuring system (2 pcs.)

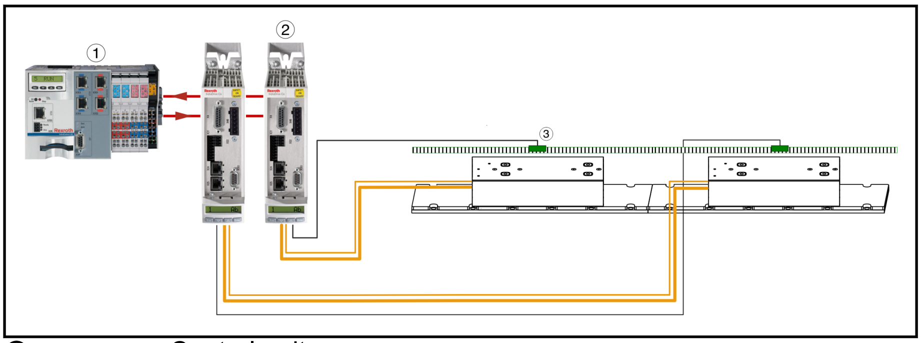
Fig. 9-28: Gantry arrangement (double comb)

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.



① Control unit
② Controller (2 pcs.)
① Length measuring system (1 scale, 2 scanning heads)

Fig. 9-29: Gantry arrangement (primary parts in a row)

9.14.3 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 Fig. 9-2). If the fields are always positioned on the same side of the length, the correct pole sequence is ensured.

For alignment and attachment of secondary parts, please observe the information under chapter 11.4 "Installation of the secondary part segments" on page 146.

9.14.4 Vertical axis

⚠ CAUTION **Uncontrolled movements! Risk of injuries!**

Motors in vertical axes are not self-locking when de-energize. Prevent a sinking of the axis with 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.

9.15 Length measuring system

9.15.1 General

A linear 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 length measuring system is used for high-resolution position recognition and the determination of the actual velocity.

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(tab. 9-12 "Sources of length measuring systems" on page 121).

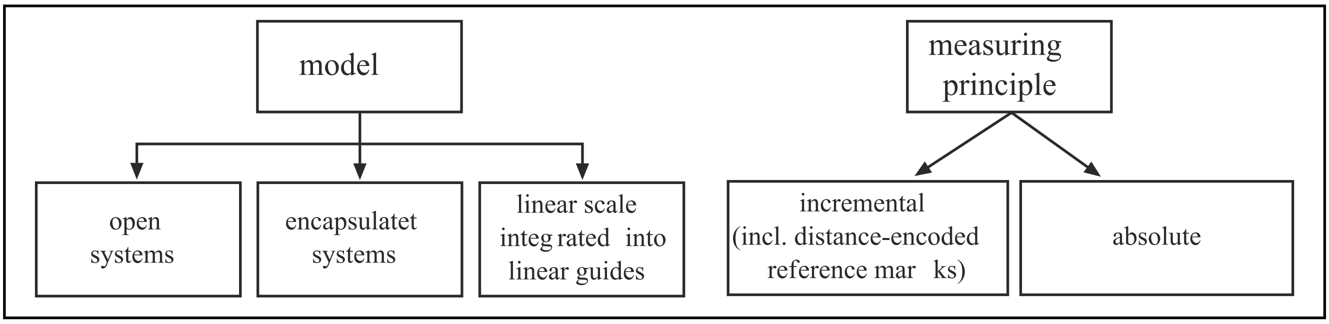


Fig. 9-30: Classification of linear scales

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.

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.

9.15.2 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. See also chapter 9.22 "Position and velocity resolution" on page 129.

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.

Bosch Rexroth AG Linear and assembly technique	Maria-Theresien-Straße 23 97816 Lohr am Main, Germany info@boschrexroth.de http://www.boschrexroth.com/business_units/brl/de/ (Integrated measuring system for profiled rail guide)
Renishaw GmbH	Karl-Benz Straße 12 72124 Pliezhausen, Germany http://www.renishaw.de/
SIKO GmbH	Weihermattenweg 2 79256 Buchenbach, Germany info@siko.de http://www.siko.de/

NUMERIK JENA GmbH	Ilmstraße 4 07743 Jena, Deutschland applikation@numerikjena.de http://www.numerikjena.de/
SICK AG	Erwin-Sick-Straße 1 79183 Waldkirch, Germany http://www.sick.com/
AMO Automatisierung Messtechnik Optik GmbH	NÖFING 4 A-4963 ST. PETER AM HART office@amo.at http://www.amo-gmbh.com
DR. JOHANNES HEIDENHAIN GmbH	Postfach 1260 83292 Traunreut, Germany info@heidenhain.de http://www.heidenhain.de/

Tab. 9-12: Sources of length measuring systems

- 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 in preparation 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, ready-made cables are available from Rexroth (see Table 8-4).

9.16 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.

☞ Due to the forces of attraction between primary and secondary part, the friction forces in the guides can be increased.

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

Manufacturers of linear guiding systems

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

Bosch Rexroth Linear and assembly technique	Maria-Theresien-Str. 23 97816 Lohr am Main, Germany info@boschrexroth.de http://www.boschrexroth.com/business_units/brl/de/

Tab. 9-13: Manufacturers of linear guiding systems

9.17 Braking systems and holding devices

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

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

☞ Further designs about stand-still of linear motors are given in chapter 9.18 "End position shock absorber " on page 124 and chapter 9.21 "Deactivation upon EMERGENCY STOPand in the event of a malfunction " on page 126 as well as in the appropriate functional description of the drive controller.

9.18 End position shock absorber

⚠ WARNING **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).

9.19 Axis cover systems

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 roller covers. 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.

Using a cover plate at secondary part

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

☞ 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. Also observe the information on the cover plate under chapter 7.3 "Cover plate for secondary part" on page 75.

⚠ 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 must not be used for this.

9.20 Motor control and regulation

9.20.1 General

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

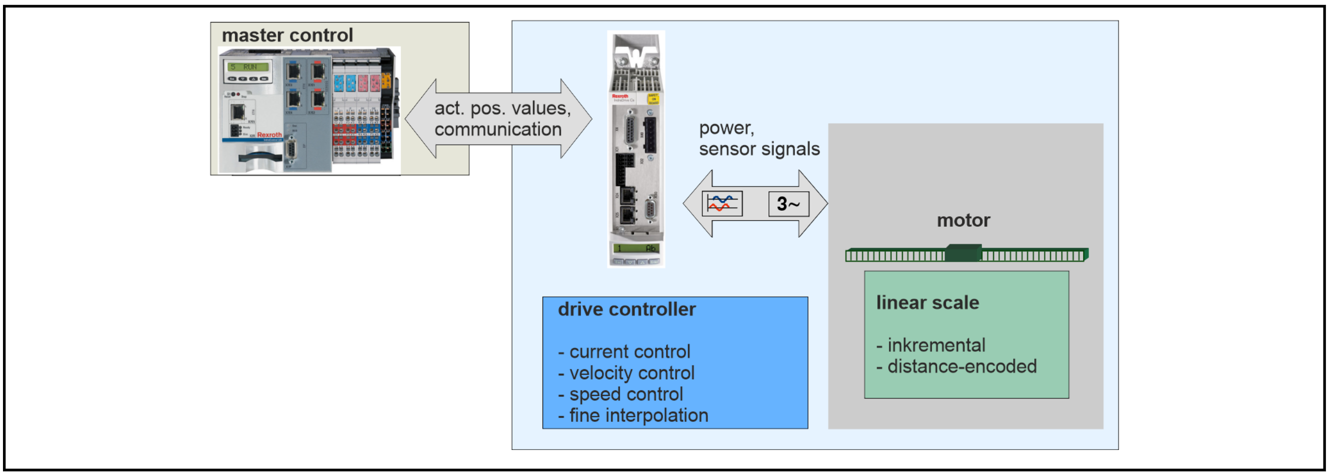


Fig. 9-31: Linear direct drive

9.20.2 Drive controllers

For motor control, different digital drive controllers and power supply modules are available. (see chapter 1.5 "About this documentation" on page 4).

9.20.3 Control systems

A master control is required for generating defined movements. Depending on the functionality of the whole machine and the used control systems, Bosch Rexroth offers different control systems..

9.21 Deactivation upon EMERGENCY STOPand in the event of a malfunction

9.21.1 General

Deactivation of an axis equipped with ML3 motor, 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 motors in case of malfunction, a distinction must be made between

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

9.21.2 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.

9.21.3 Deactivation by a master control

Deactivation by control functions

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

1. The machine PLC or the machine I/O level reports the fault to the CNC control
2. The CNC control deactivates the drives via a ramp in the fastest possible way
3. 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:

1. The machine I/O level reports the fault to the CNC control and SPS
2. 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.
3. The drive responds with the selected error response.
4. 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.

9.21.4 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.

9.21.5 Response to a power outage

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 capacities (capacitors), and /or
- mechanical braking facilities

must be provided.

Determining the required additional DC bus capacity

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 failure for the time of braking! If needed, buffer the control voltage supply or feed the control voltage from the DC intermediate circuit if possible!

The additional capacity required for a deactivation upon a mains failure can be determined as follows:

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

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_{iF}	Motor constant (force constant) in N/A
R_{12}	Winding resistance at 20 °C
F_R	Friction force in N

Fig. 9-32: Determining the required additional DC bus capacitor

Prerequisites:

- final velocity = 0
- velocity-independent friction
- constant deceleration
- winding temperature 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.

9.21.6 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 induction; thereby the motor phases are short-circuited. However, the achievable braking force is not very high and also depends on the velocity. The DC bus short-circuit can therefore only be used to support existing mechanical braking devices.

9.22 Position and velocity resolution

9.22.1 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. 9-34). 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).

$$f_{int} = 2^{31} \cdot \frac{s_p}{x_{max}} \qquad \text{rounding to } 2^n$$

f_{int}	Multiplication factor (S-0-0256, Multiplication 1)
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. 9-33: Multiplication factor

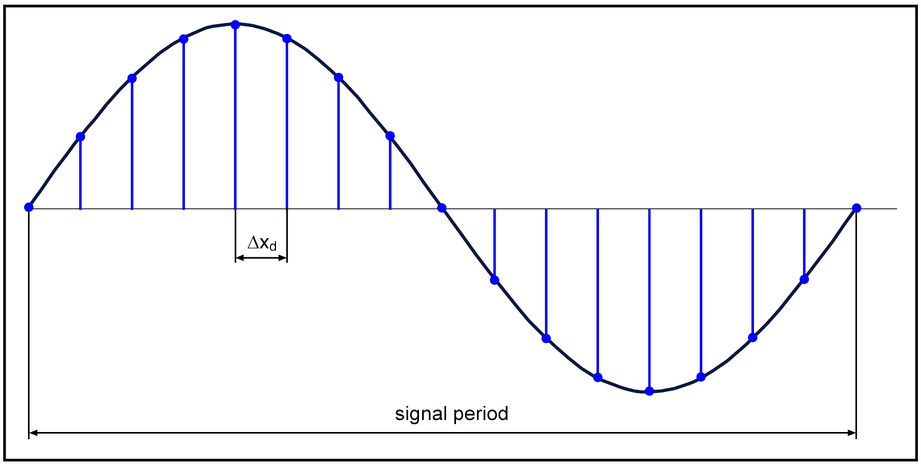


Fig. 9-34: Drive-internal multiplication and/or interpolation of the measuring system signals

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

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

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)

Fig. 9-35: Drive-internal position resolution

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):

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

Δx_d	Drive-internal position resolution
Δx_{abs}	Position accuracy

Fig. 9-36: Estimating the reachable position accuracy

Prerequisites: Optimum controller setting

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

9.22.2 Velocity resolution

The resolution of the velocity is proportional to the position resolution (see fig. 9-35 "Drive-internal position resolution" on page 130) and inversely proportional to the cycle rate t_{AD} from:

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

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)

Fig. 9-37: Velocity resolution

9.23 Motor dimensioning

9.23.1 IndraSize

The IndraSize software makes it easy to dimension drive controllers, motors and mechanical gears. The engineering tool covers the entire range of Rexroth drives and motors. Calculate the characteristic curves for your application with IndraSize: www.boschrexroth.com/indraSize

9.24 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.

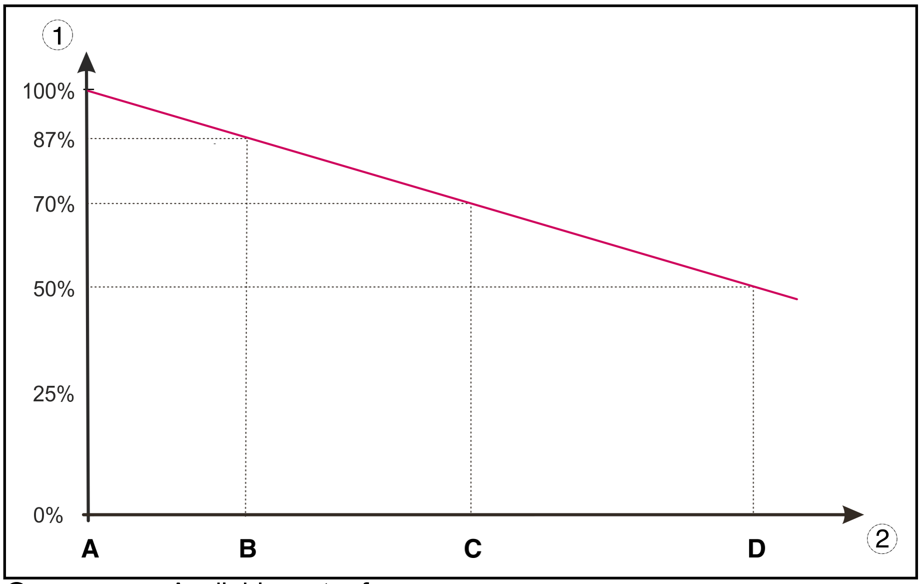
☞ If the contact surfaces of the motor components, particularly of the primary part, are made of a material with low heat conductivity (e.g. plastic), a reduction in motor performance has to be expected.

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 Technical data 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".

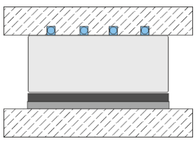
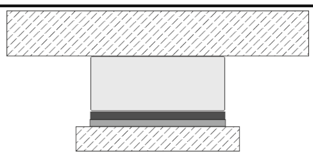
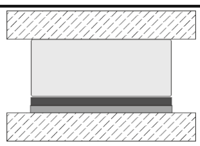
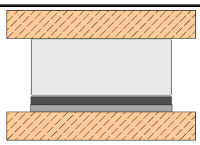


① Available motor force

② Installation mode

Fig. 9-38: Motor force dependent on thermal connection

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 Technical data.
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.

Tab. 9-14: Explanation of installation modes

9.25 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 and be thermally damaged. See also chapter 9.9 "Thermal behavior" on page 102.

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

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

Δθ	Temperature difference between operation temperature and 20 °C
α_{Cu}	Temperature coefficient of the specific resistance of copper = 0.0039 Ohm * m / mm²

Fig. 9-39: Power loss coil

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

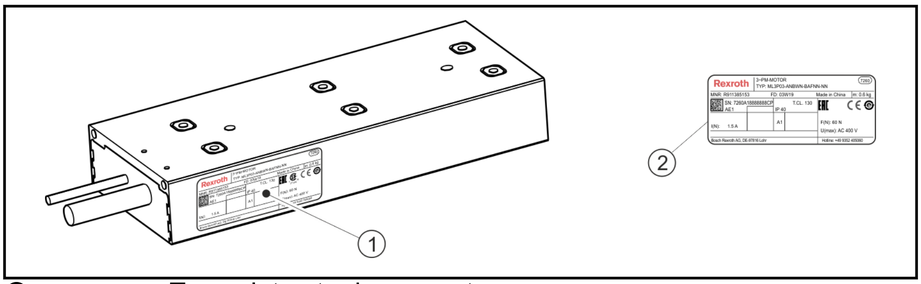
☞ To avoid damaged winding in standstill operation, limit the current or the operation duration. A possible form of an additional motor protection is the limitation of the motor current to 71% of the nominal current.

10 Handling, transport and storage

10.1 Identification of the motor components

10.1.1 Primary part

A type plate label with all relevant data is attached to the primary part. In addition, another type plate is enclosed to the primary part on delivery (see Fig. 6-10 on page 71). This additional type plate can be attached at an accessible position at the machine or used otherwise.



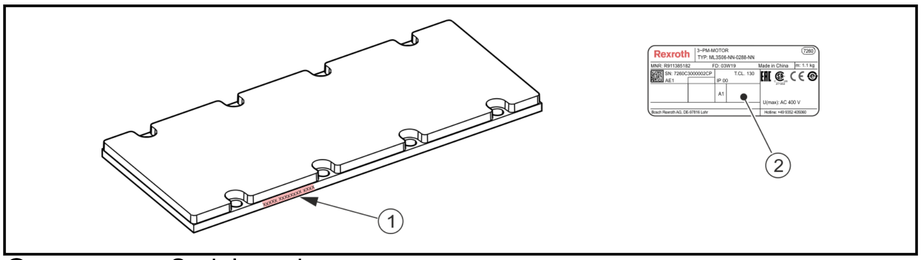
① Type plate at primary part
② Additional type plate (enclosed)

Fig. 10-1: Position of the type plate at the primary part

☞ For legal reasons, the enclosed type plate does not contain a CSA mark.

10.1.2 Secondary part

The type designation of the secondary part is realized according to an engraved serial number at the side of the steel base plate. This additional type plate of the secondary part (see Fig. 6-10 on page 71) is enclosed and can be attached at an accessible position at the machine or used otherwise.



① Serial number
② Type plate with identical serial number (enclosed)

Fig. 10-2: Position of the type designation at secondary part

10.2 Delivery status and packaging

10.2.1 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.

10.2.2 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 package 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 Accessories Magnetic fields label.

10.3 Testing of motor components

10.3.1 Factory checks of the motor components

Electrical testing

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

- High voltage test according to DIN EN 60034-1
- Insulation resistance testing according to DIN EN 60204-1
- 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

☞ A respective test protocol is enclosed to every motor.

⚠ CAUTION **Destruction of motor components due to improperly executed high-voltage testing! Loss of warranty!**

⇒ Avoid repeated testing.

⇒ Comply with the guidelines of DIN EN 60034-1

EMC radio interference suppression

Linear motor components of Bosch Rexroth have been subject to EMC type testing and are certified for compliance

EN 55011 Limit Class B, VDE 0875 Part 11

10.4 Transport and storage

10.4.1 Notes about transport

Our products must be transported in their original package only. Also refer to the specific ambient factors to protect the products from transport damage.

⚠ CAUTION **Risk of injuries and/or damage when handling unpacked secondary parts!**

Do not remove the transport and assembly protection attached at the ML3S as the base plate of the secondary parts is fitted with permanent magnets. Make sure that no small ferromagnetic parts like screws get into contact with the magnets or secondary parts. When handling secondary parts, please observe the warnings under chapter 11.4 "Installation of the secondary part segments" on page 146.

Based on DIN EN 60721-3-2, 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.

Allowed classes of environmental conditions during transport acc. to DIN EN 60721-3-2

Classification type	Allowed class
Classification of climatic environmental conditions	2K11
Classification of biological environmental conditions	2B1
Classification of chemically active materials	2C1
Classification of mechanically active materials	2S5
Classification of mechanical environmental conditions	2M4

Tab. 10-1: Allowed classes of environmental conditions during transport

Air freight

⚠ CAUTION **Possible influence of plane electronic on board through magnet fields!**

If secondary parts are not forwarded in the unopened Rexroth original packaging, applicable packaging and transport regulations must be observed (IATA 953).

10.4.2 Information on storage

Storage conditions

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 dust-free location
- at room temperature
- free from vibrations and oscillations
- protected against light or direct sunlight

Upon delivery, protective sleeves and covers can be attached to Bosch Rexroth motors. They have to remain on the motor for transport and storage. Do not remove these parts until shortly before assembly.

☞ For storage of the ML3S, use the transport and assembly protection in the original packaging.

Based on DIN EN 60721-3-1, 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.

Allowed classes of environmental conditions during transport acc. to DIN EN 60721-3-1

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

Tab. 10-2: Allowed classes of environmental conditions during storage

Storage times

Additional measures have to be 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.

Motors

Storage time	Measures for commissioning
< 1 year	Visual inspection of all parts to be damage-free Check the electric contacts to verify that they are free from corrosion
1 ... 5 years	
> 5 years	

Tab. 10-3: Measures before commissioning motors that have been stored over a prolonged period of time

Cable and plug connector

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

Tab. 10-4: Measures before commissioning of cables and connectors that have been stored over longer periods of time

11 Assembly

11.1 General notes

☞ The machine manufacturer has to consider the special character of their 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 project planning manual ML3 contains a suggestion to assemble 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 sizes (see chapter 5.1.3 "Dimensions and tolerances" on page 46)
- 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.

Screw lock

All screwed connections must be secured against potential impacts and vibrations during operation of the machine. A suitable and field-tested screw lock for all metal thread connections is, e.g., Loctite 243.

Loctite 243 is a liquid screw lock (medium-hard) and is applied to the parts to be mounted immediately prior to assembly. For detailed information on correct handling and processing, please refer to the manufacturer's data sheets under http://www.loctite.de. The manufacturer's homepage also provides information on hardening accelerators or other screw locks.

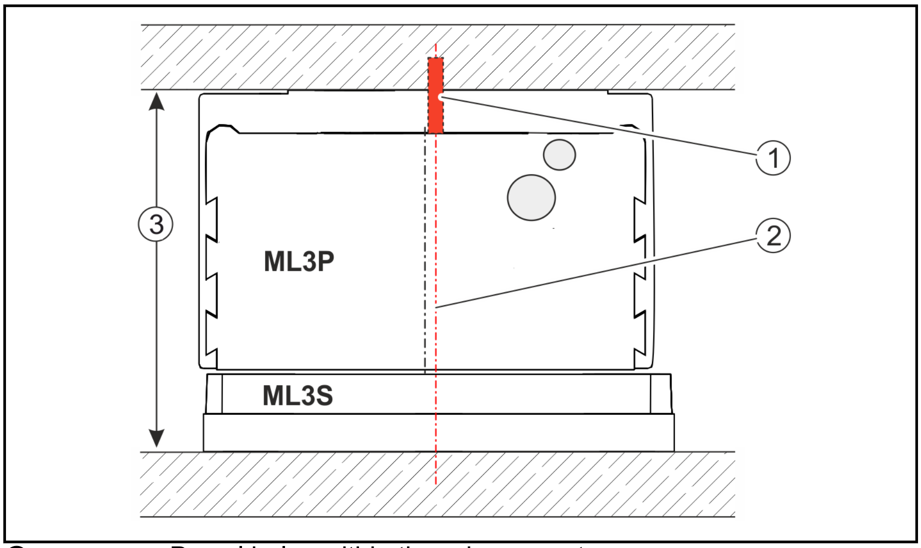
11.2 Mechanical assembly

11.2.1 Air-gap, parallelism and symmetry of the motor components

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 tableTab. 11-1

The exact dimensions and specifications for form and position tolerances can be taken from Fig. 11-2



①	Dowel holes within the primary part
②	Magnetic and mechanic center line of the magnetic plate
①	Installation height (see Fig. 11-1)

Fig. 11-1: Aligning the motor components

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

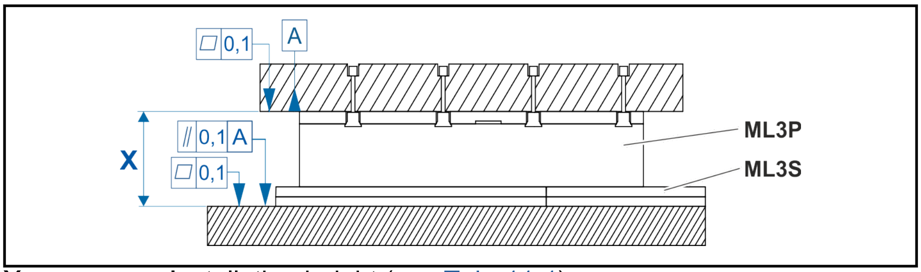
Air gap

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 without cover plate. If cover plates are used, the air gap must be increased by the thickness of the cover plates. In this context, note the following information in chapter 7.3 Cover plate for secondary part.



X Installation height (see Tab. 11-1)

Fig. 11-2: Values for levelness and parallelism

Frame size	Installation height “X”
ML3x03	40 mm ± 0.1 mm
ML3x06	40 mm ± 0.1 mm
ML3x11	45 mm ± 0.1 mm

Tab. 11-1: Installation height ML3 motors

Checking the minimum air gap between primary and secondary part after the assembly is recommended

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.).

☞ 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.

11.3 Assembly of primary parts

To fasten the primary part, only new, unused screws must be used.

- Only use specified screws (seeTab. 11-2).
- Tighten all screws crosswise with the necessary tightening torque - from inside to outside.
- 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 primary part could be damaged.
- After assembly, check if any foreign bodies exist between primary and secondary part.

Fastening screws

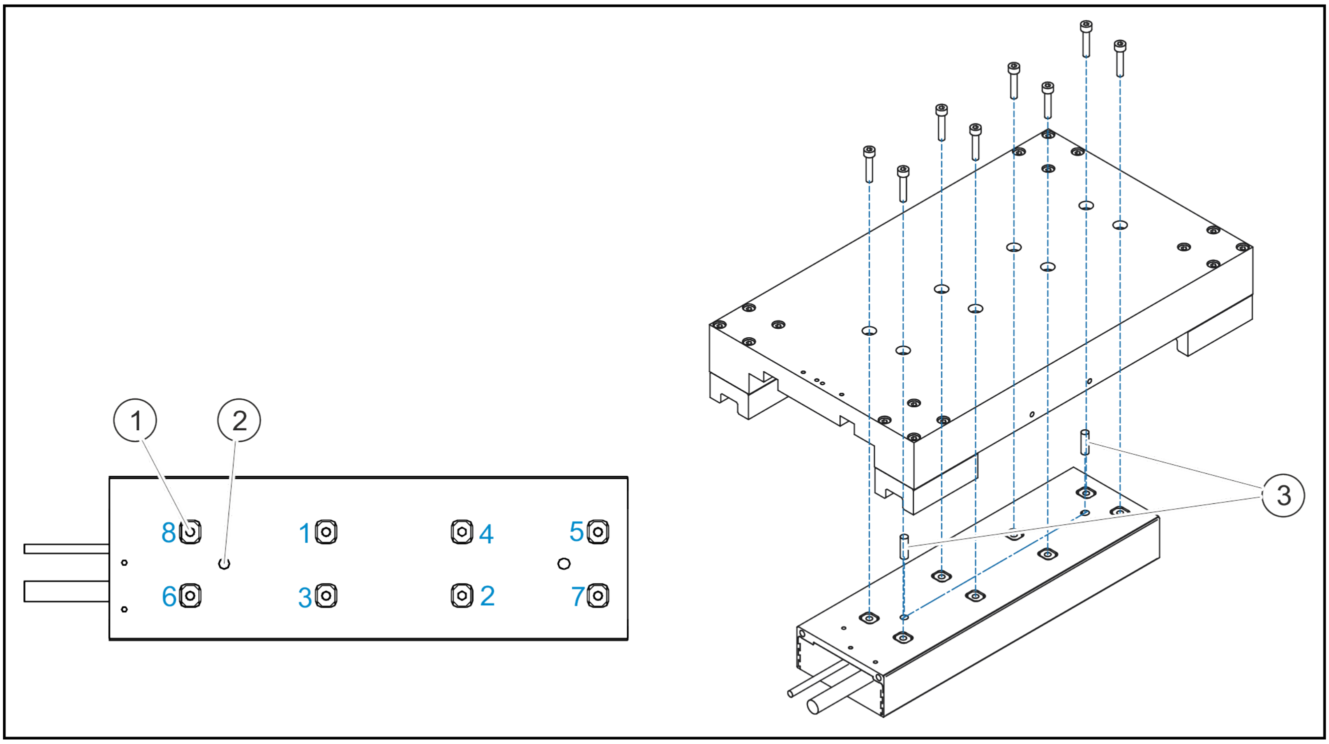
<table>
<tr><th>Frame size</th><th>Screw size</th><th>Screw-in depths</th><th>Strength class</th><th>Tightening torque
(± 10 %)</th></tr>
<tr><td>ML3P03</td><td>M4 (DIN EN ISO 4762)</td><td rowspan="2">min. 4 mm
max. 5 mm</td><td rowspan="3">8.8</td><td>3.1 Nm</td></tr>
<tr><td>ML3P06</td><td>M5 (DIN EN ISO 4762)</td><td>6.1 Nm</td></tr>
<tr><td>ML3P11</td><td>M5 (DIN EN ISO 4762)</td><td>min. 4.5 mm
max. 6 mm</td><td>6.1 Nm</td></tr>
</table>

Tab. 11-2: Fastening screws with tightening torques for ML3P primary parts

Dowels

Size primary part	Dowels (rust-free)
ML3P03 ... 11	5h8 (with internal thread M3 for disassembly)

Tab. 11-3: Dowels for ML3P primary part



①	Fastening tread
②	Dowel holes (blind holes)
1 / 2 / 3 ... Tightening sequence	
①	Dowels

Fig. 11-3: Tightening sequence fastening screws of primary part

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. Insert the dowels into the dowel holes in ML3P and position the primary part on the slide.

☞ 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.

---

2. Fasten the primary part with screws 1, 2, 3 ...x crosswise until the primary part is in contact with the slide.
3. Tighten all screws in the same tightening row 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.

11.4 Installation of the secondary part segments

⚠ 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 such as watches, credit cards, ...

Also see the information in chapter Magnetic fields .

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

- Only use specified screws (see Fig. 11-4).
- 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.

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. 11-4).

The screw-on surfaces and stop faces must be cleaned and be free of grease before the secondary parts can be screwed on the machine construction. The tightening torques of the fastening screws is specified in the following table:

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

Tab. 11-4: Fastening screws with tightening torques for ML3S secondary parts

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

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

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

Tab. 11-5: Dowels for ML3S 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

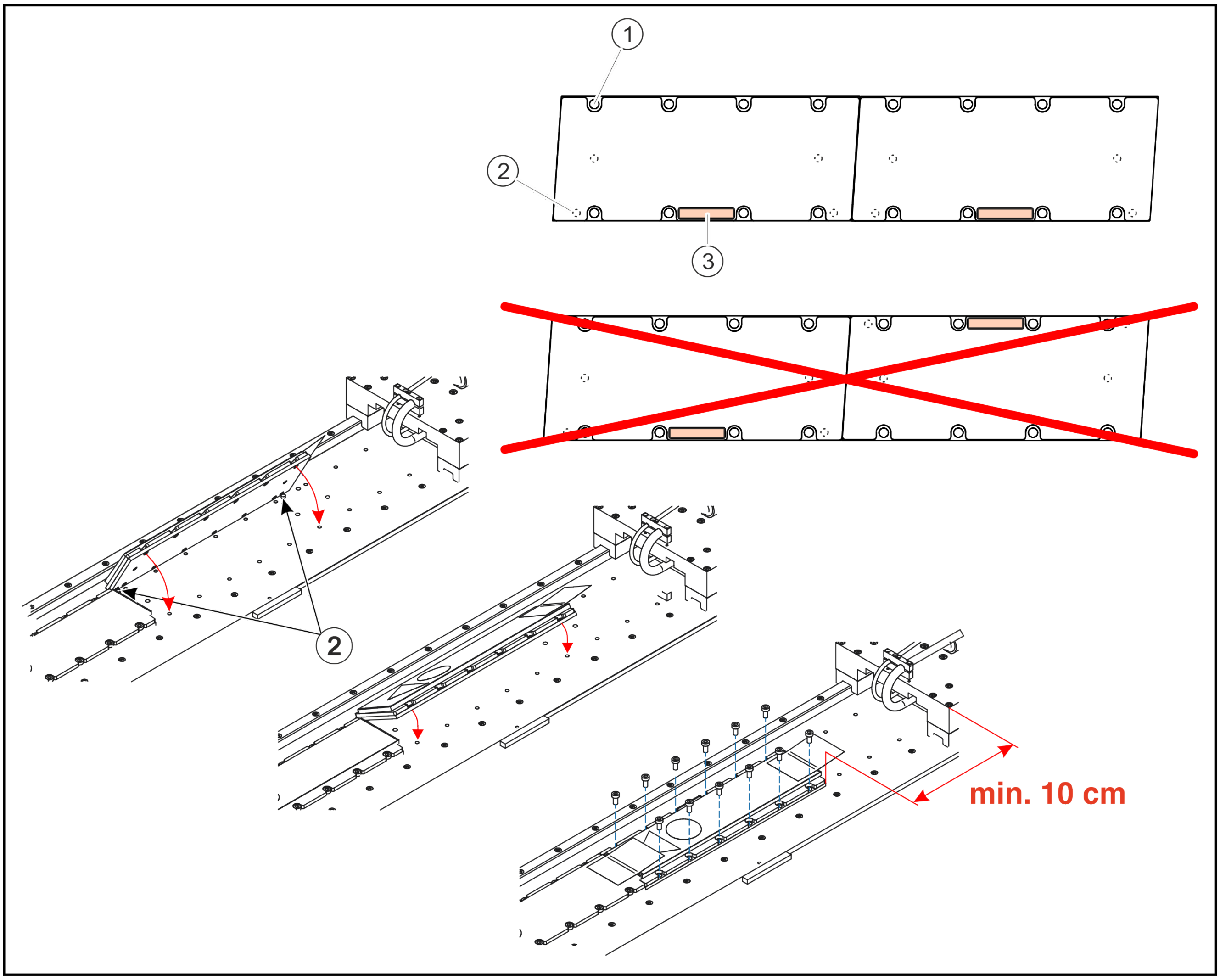
If several secondary part segments are used over the whole travel length, keep the poles and the flush direction at concatenation according to the following figure.

A correct assembly can be ensured as follows:

1. Insert dowels for the first secondary part into the holes on 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.
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.



①	Mounting holes
②	Dowel holes (blind hole at the bottom)
①	Reference marks

Fig. 11-4: Mounting holes, dowel holes and reference marks at ML3S

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

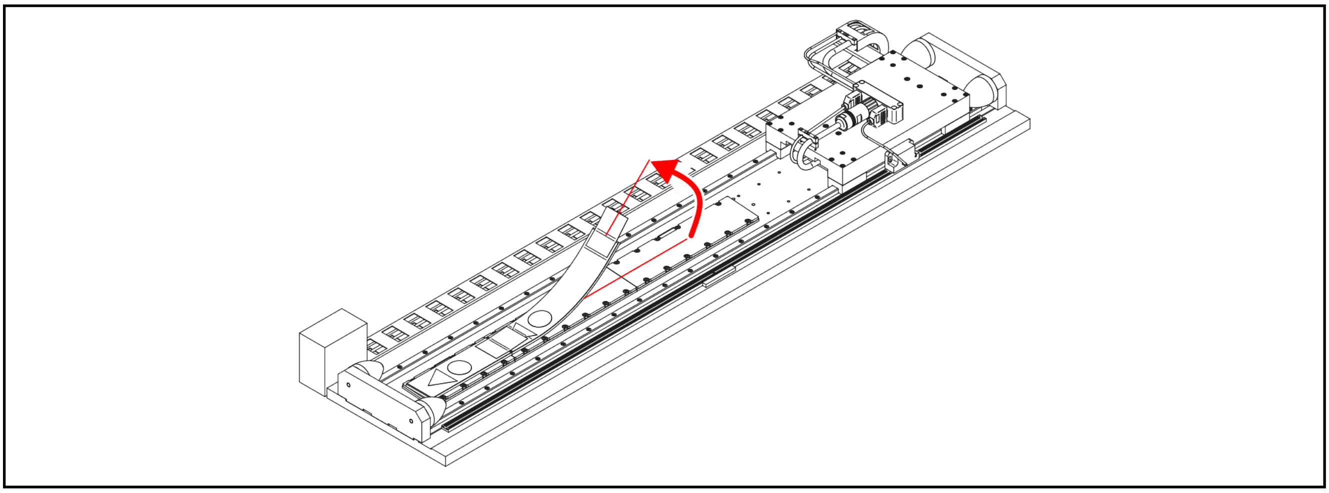


Fig. 11-5:

6. Position the slide with the primary part over the assembled secondary part and lock it against unintended movement.

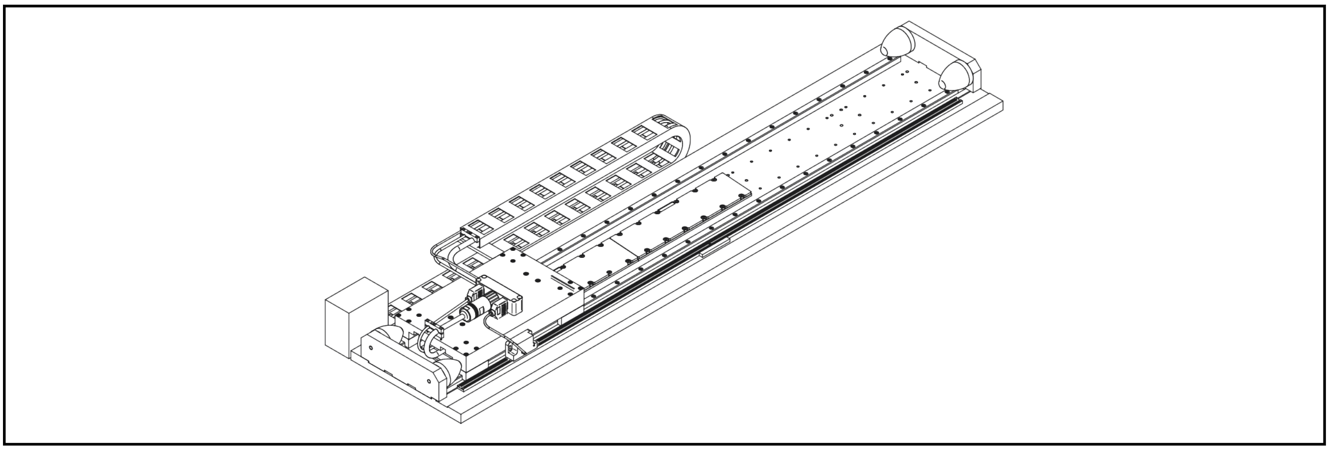


Fig. 11-6:

7. Assemble the remaining secondary parts according to working step 1 - 3.

   Afterwards, remove the transport and assembly protection.

11.5 Cover plate installation (option)

11.5.1 Notes

According to chapter 9.13.4 "Protection of the motor installation space" on page 110, 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 refer to the specifications in Tab. 7-3.

Tools required for installation:

- Protective gloves for handling the cover strip

⚠ CAUTION **The stainless-steel cover strip may have sharp edges.**

Wear protective gloves when handling the cover plate.

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

11.5.2 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.
3. Unroll the strip over the free part of the magnetic strip.

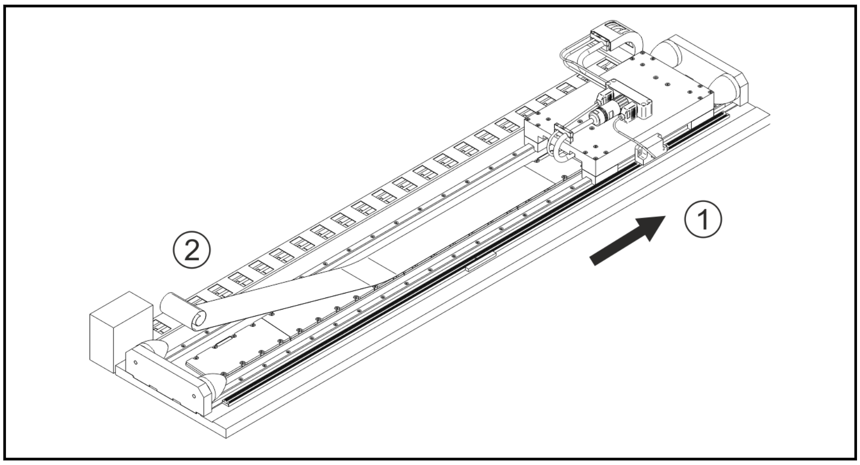


Fig. 11-7: Cover plate attachment at first side

4. Move the slide to the center of the axis

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.

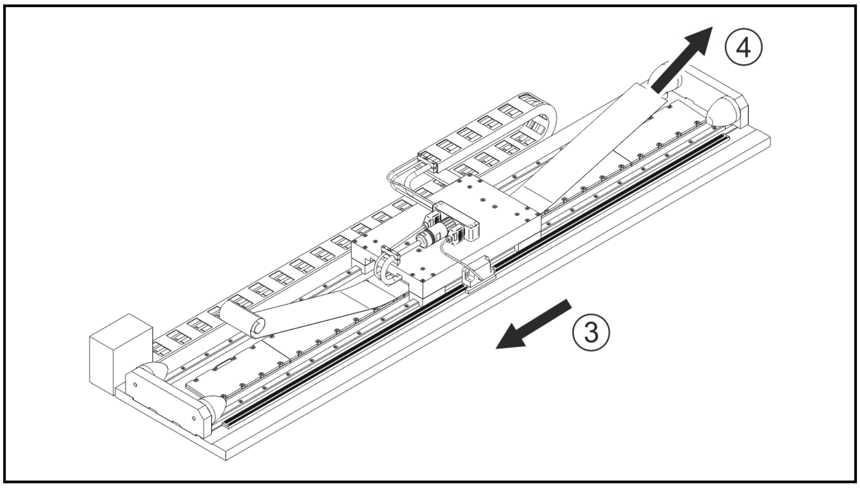


Fig. 11-8: Cover plate attachment at second side

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.

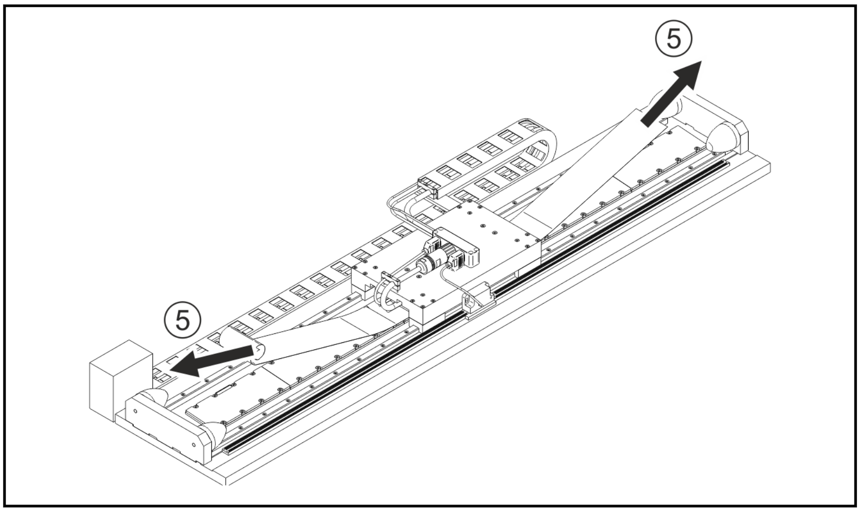


Fig. 11-9: Align cover plate on both sides

☞ 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.

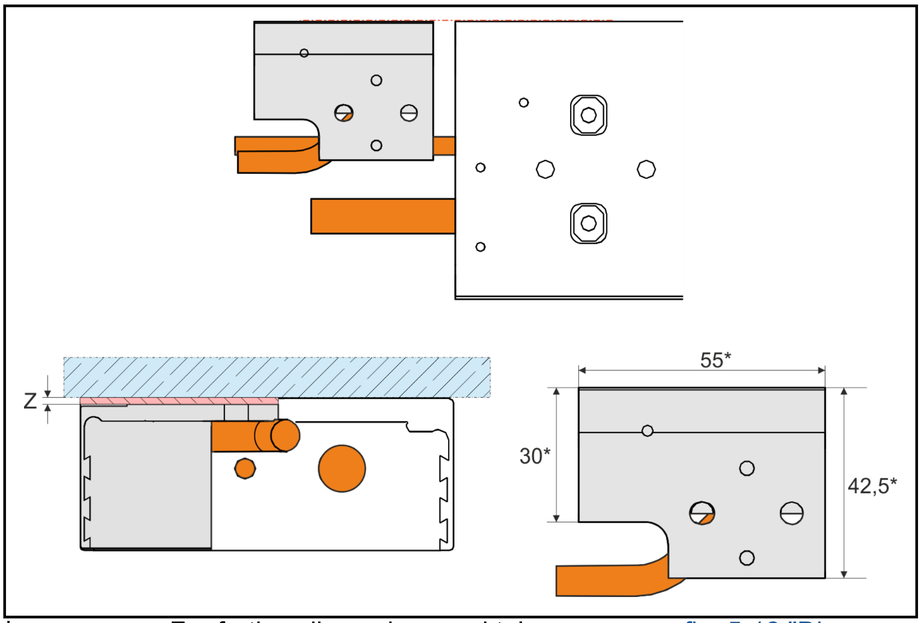
☞ The magnetic strip does not serve as conductive grounding connection of the cover strip. Ensure grounding in accordance with the machine safety standard and check this before commissioning.

11.6 Hall unit installation (option)

11.6.1 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. 11-10). 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 12.6.4 "Hall sensor procedure" on page 163.

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.



* For further dimensions and tolerances, see fig. 5-12 "Dimension sheet analog Hall unit" on page 58

Z Dimensions for spacer thickness

Fig. 11-10: Preferred installation position for the analog Hall unit

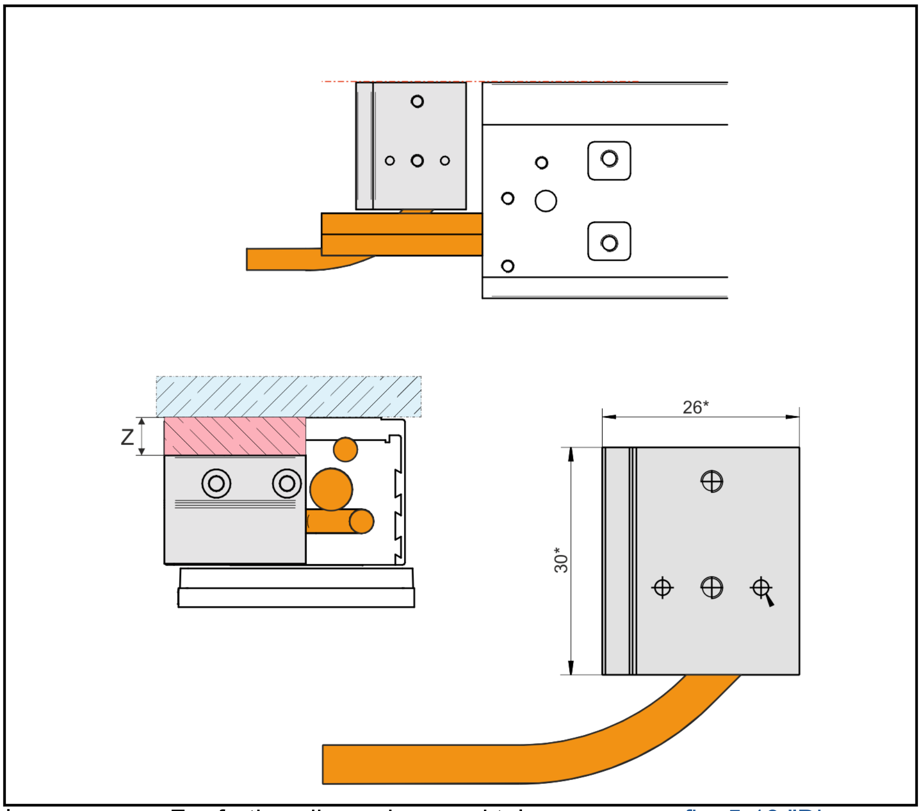
ML3P...	Spacer "Z"	Rotation to the motion axis	Alignment to the side of the primary part	Screws	Tightening torque (+/- 10%)	Dowel pins
03	-	0.5°	± 1 mm	M4	3.1 Nm	Ø 5 F8
06	-					
11	1					

Tab. 11-6: Installation requirements of analog Hall unit

11.6.2 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. 11-11). 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 chapter 12.6.4 "Hall sensor procedure" on page 163.

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.



* For further dimensions and tolerances, see fig. 5-13 "Dimension sheet digital Hall unit" on page 59

Z Dimensions for spacer thickness

Fig. 11-11: Preferred installation position for the digital Hall unit

ML3P...	Distance dimension "Z"	Rotation to the motion axis [degrees]	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	9.4 mm					

Tab. 11-7: Installation requirements of digital Hall unit

11.7 Electrical connection

Perform the electrical connection of the motors according to the instructions in chapter8 . 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.

12 Commissioning, operation and maintenance

12.1 General information for commissioning of ML3 motors

In some points, commissioning of linear motors is different in comparison to rotary servo motors. For commissioning of synchronous linear motors, the following points must be observed in particular:

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 (see chapter 9.13 "Requirements on the machine design" on page 108).

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. Commutation adjustment can only be made after installation of motor components and the length measuring system. The commutation adjustment method depends on the measuring principle of the length measuring system.

12.2 General requirements

12.2.1 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

12.2.2 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
- Ensure correct connection and function of drive controller and control unit

12.2.3 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.

Multimeter Troubleshooting and component checks can be facilitated by a multimeter allowing the measurement of voltage, current and resistance values.

12.3 General commissioning procedure

In the following flow diagram, the commissioning sequence for ML3 linear motors is explained. 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.

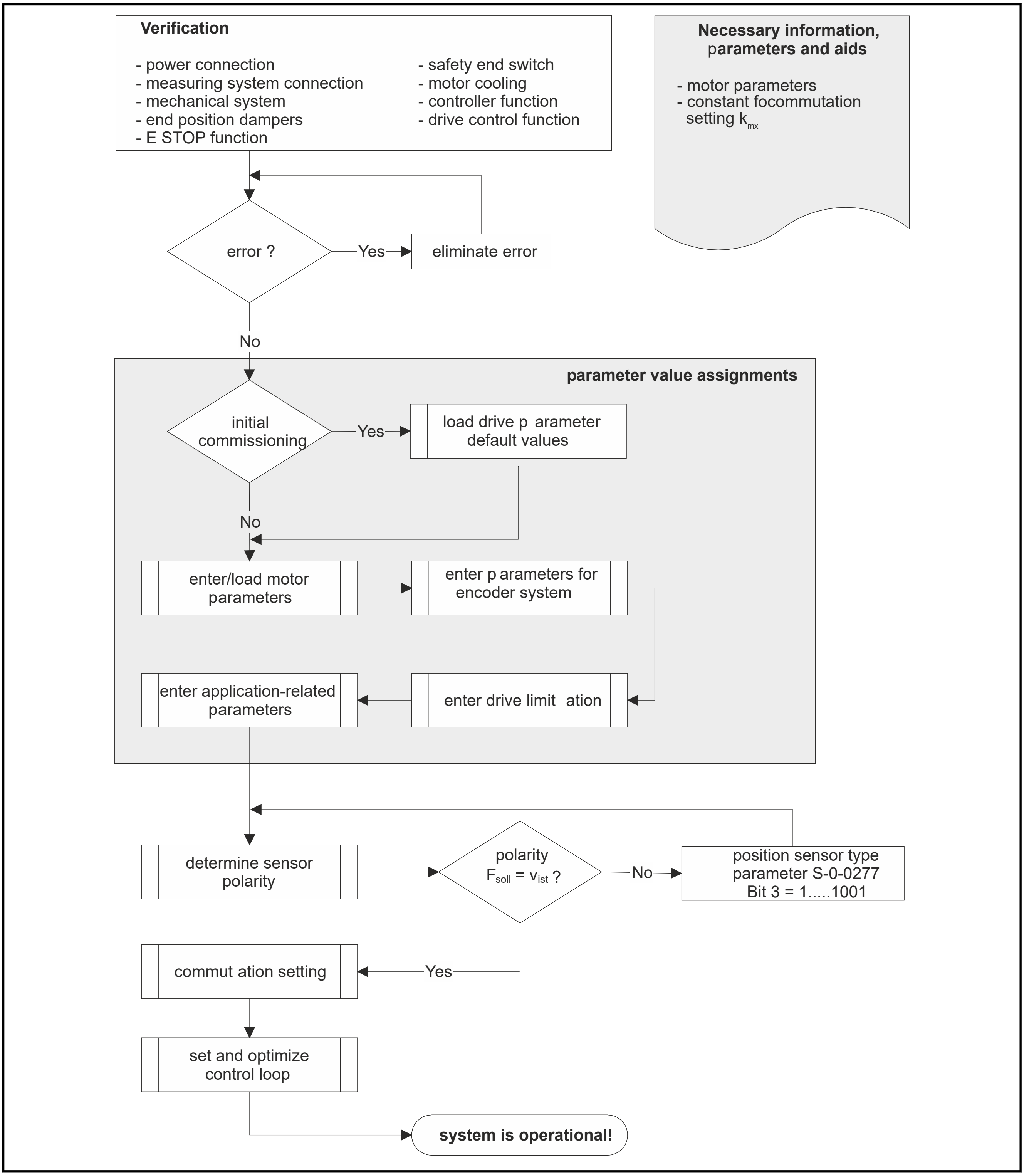


Fig. 12-1: General commissioning procedure for synchronous linear drives

12.4 Parameterization

12.4.1 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.

12.4.2 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.

⚠ WARNING

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

12.4.3 Motor parameter at parallal arrangement

Are two linear motors operated in a control device, the following parameters have to be adjusted when commissioning:

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

Tab. 12-1: Parameter adjustment at parallel arrangement

☞ 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 4.1.3).

12.4.4 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.

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

Tab. 12-2: Encoder parameters

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.

12.4.5 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. See also chapter 12.4.4 "Entering length measuring system parameter" on page 159.

12.5 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.

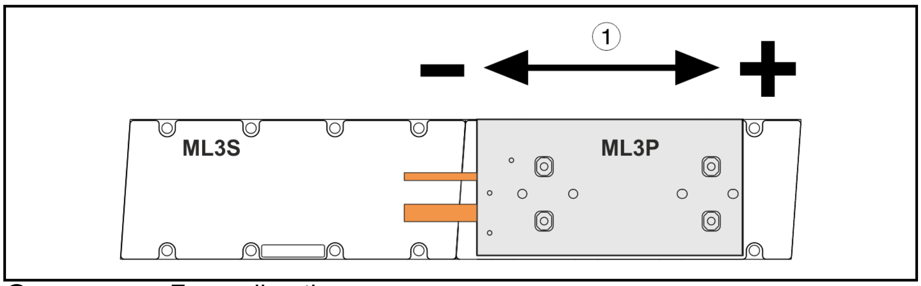
⚠ WARNING **Different effective directions of motor force and count direction of the encoder system cause uncontrolled movements of the motor upon switch-on!**

- 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 in compliance with the connection according to Fig. 12-2.

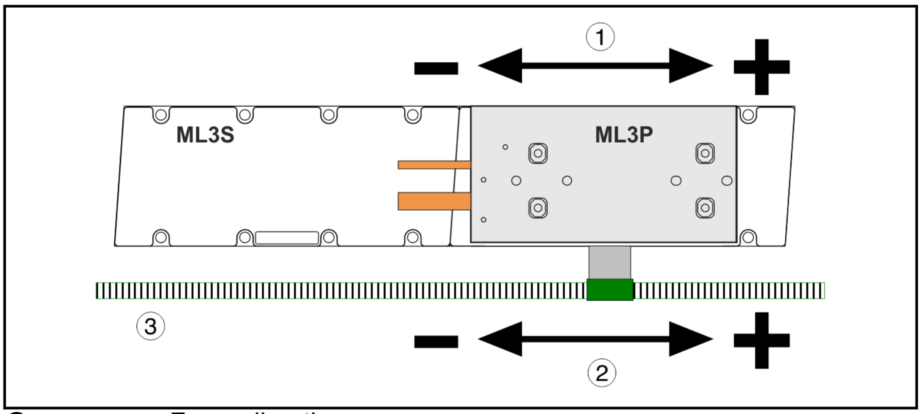


① Force direction

Fig. 12-2: Effective direction of motor force

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:



① Force direction
② Counting direction
① Length measuring system

Fig. 12-3: Effective direction of the motor force = Counting direction of the 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.

The encoder polarity is set via parameters

S-0-0277, Position encoder type 1 (Bit 3)

The encoder type is set via parameters

S-0-0602.x.1, Encoder type

Position, velocity and force data must not be inverted when the length measuring system count direction is set:

S-0-0085, Torque/force polarity parameter: 0000000000000000

S-0-0043, Velocity polarity parameter 0000000000000000

S-0-0055, Position polarity 0000000000000000

12.6 Commutation adjustment

12.6.1 General

The force of the synchronous linear motor can only develop to a maximum and constant degree, if the commutation angle is set correctly.

☞ 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

---

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.

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.

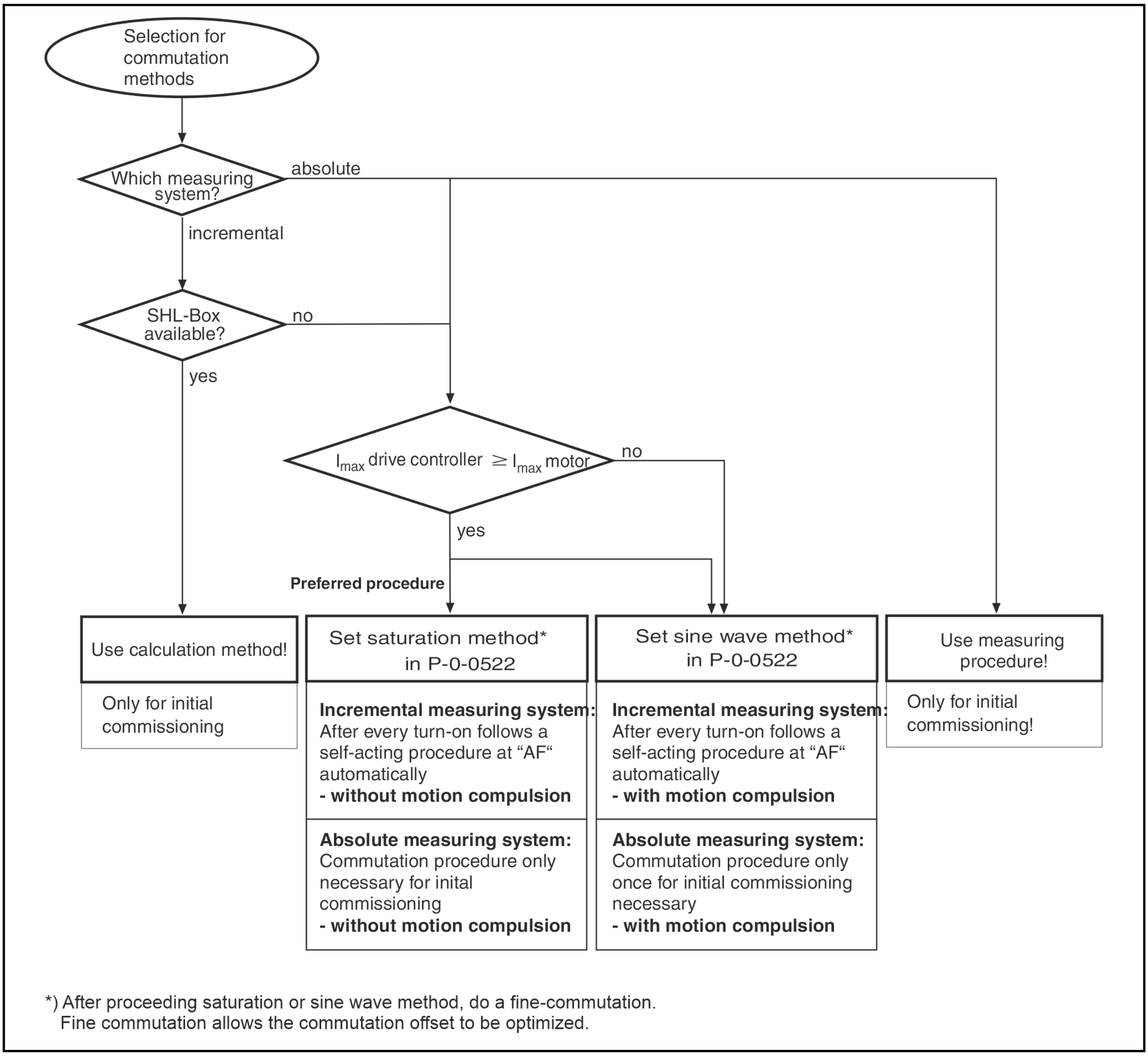


Fig. 12-4: Procedure for commutation adjustment for synchronous linear motors

☞ 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

⚠ DANGER **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 chapter 12.4.4 "Entering length measuring system parameter" on page 159.

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:

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	

Tab. 12-3: Parameters to be checked before commutation adjustment

12.6.2 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)

12.6.3 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)

12.6.4 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 7.1.2 "Functional principle" on page 73.

Commutation by means of analog Hall unit

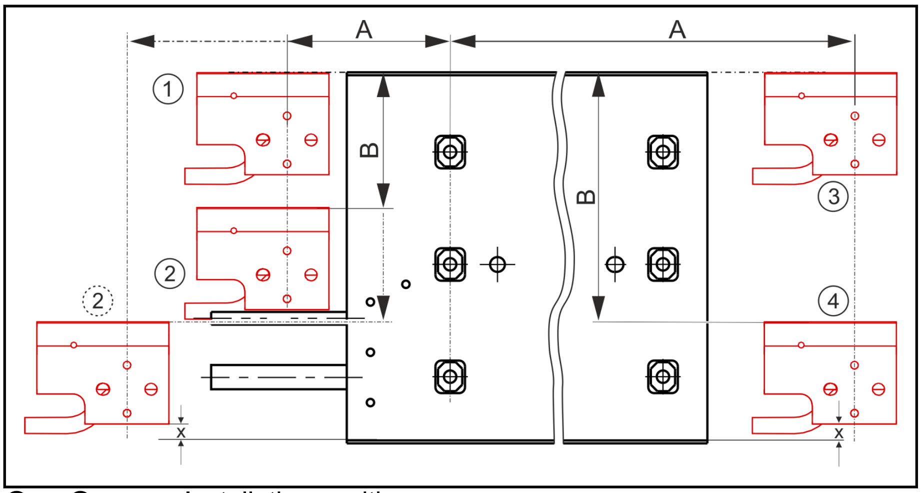
If the analog Hall unit is used, the following parameters must be determined:

Ident number	Description	Value
S-0-0602.1.1	Encoder type	2
S-0-0602.2.1		16
P-0-0508	Commutation offset	Calculated by means of the Installation position of the Hall unit.

Tab. 12-4: Parameters to be checked before commutation adjustment

☞ 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.



① ... ④ Installation positions

Dimension "x" Distance to outer edge of primary part at ML3P03 - 8 mm; ML3P06 - 6 mm; ML3P11 - 6 mm

Fig. 12-5: Possible installation positions of the Hall unit

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. 12-10).

$$P-0-0508 = PK_A + \frac{1024}{2 \times \tau_P} \times A$$

P-0-0508 Commutation offset

PK_A Constant for analog Hall unit (see Tab. 12-7)

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. 12-10)

Fig. 12-6: Formula for installation of the analog Hall unit at the cable outlet side at the primary part

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 Fig. 12-10).

$$P-0-0508 = PK_A + \frac{1024}{2 \times \tau_P} \times (A - B \times C)$$

P-0-0508	Commutation offset
PK_A	Constant (see Tab. 12-7)
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. 12-10)
B	Side offset must not exceed the motor contour on the side
C	Constant (compensation of incline in case of side offset, see Tab. 12-7)

Fig. 12-7: Formula for installation of the analog Hall unit at the cable outlet side with side offset

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 ③ Fig. 12-10).

$$P-0-0508 = PK_A - \frac{1024}{2 \times \tau_P} \times A$$

P-0-0508	Commutation offset
PK_A	Constant (see Tab. 12-7)
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. 12-10)

Fig. 12-8: Formula for installation of the analog Hall unit at the opposite cable outlet side at the primary part

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. 12-10).

$$P-0-0508 = PK_A - \frac{1024}{2 \times \tau_P} \times (A + B \times C)$$

P-0-0508	Commutation offset
PK_A	Constant (see Tab. 12-7)
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. 12-10)
B	Side offset (must not exceed the motor contour on the side)
C	Constant (compensation of incline in case of side offset, see Tab. 12-7)

Fig. 12-9: Formula for installation of the analog Hall unit at the opposite cable outlet side with side offset

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	
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	

Tab. 12-5: PK_A and C constants for calculation of P-0-0508 (commutation offset)

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

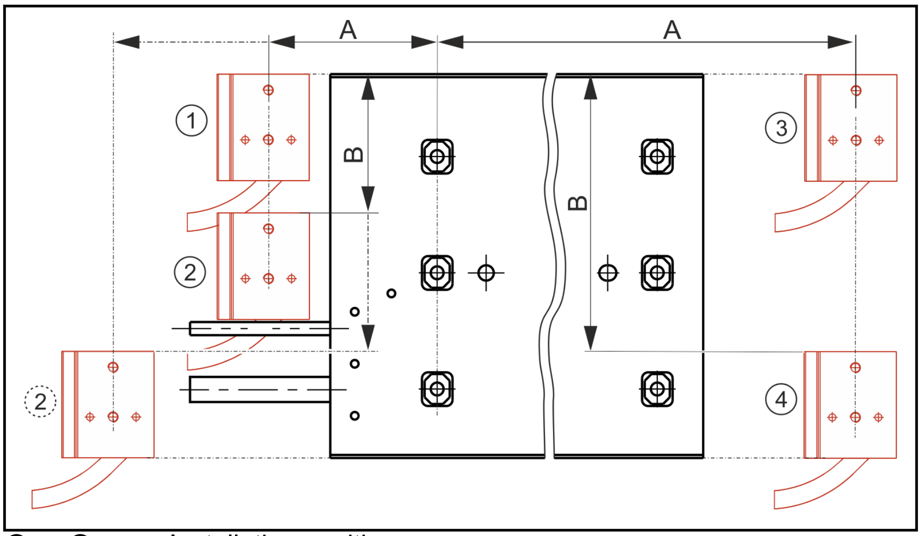
If the digital Hall unit is used, the following parameters must be determined:

Ident number	Description	Value
S-0-0602.x.1	Encoder type	**23**
P-0-0509	Rough commutation offset	Calculated by means of the Installation position of the Hall unit.

Tab. 12-6: Parameters to be checked before commutation adjustment

☞ 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.



① ... ④ Installation positions

Fig. 12-10: Possible installation positions of the Hall unit

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. 12-10).

$$P-0-0509 = PK_D + \frac{1024}{2 \times \tau_P} \times A$$

P-0-0509	Rough commutation offset
PK_D	Constant for digital Hall unit (see Tab. 12-7)
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. 12-10)

Fig. 12-11: Formula for installation of the digital Hall unit at the cable outlet side at the primary part

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. 12-10).

$$P-0-0509 = PK_D + \frac{1024}{2 \times \tau_P} \times (A - B \times C)$$

P-0-0509	Rough commutation offset
PK_D	Constant (see Tab. 12-7)
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. 12-10)
B	Side offset must not exceed the motor contour on the side
C	Constant (compensation of incline in case of side offset, see Tab. 12-7)

Fig. 12-12: Formula for installation of the digital Hall unit at the cable outlet side with side offset

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. 12-10).

$$P-0-0509 = PK_D - \frac{1024}{2 \times \tau_P} \times A$$

P-0-0509	Rough commutation offset
PK_D	Constant (see Tab. 12-7)
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. 12-10)

Fig. 12-13: Formula for installation of the digital Hall unit at the opposite cable outlet side at the primary part

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. 12-10).

$$P-0-0509 = PK_D - \frac{1024}{2 \times \tau_P} \times (A + B \times C)$$

P-0-0509	Rough commutation offset
PK_D	Constant (see Tab. 12-7)
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. 12-10)
B	Side offset (must not exceed the motor contour on the side)
C	Constant (compensation of incline in case of side offset, see Tab. 12-7)

Fig. 12-14: Formula for installation of the digital Hall unit at the opposite cable outlet side with side offset

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	
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	

Tab. 12-7: PK_D and C constants for calculation of P-0-0509 (rough commutation offset)

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.

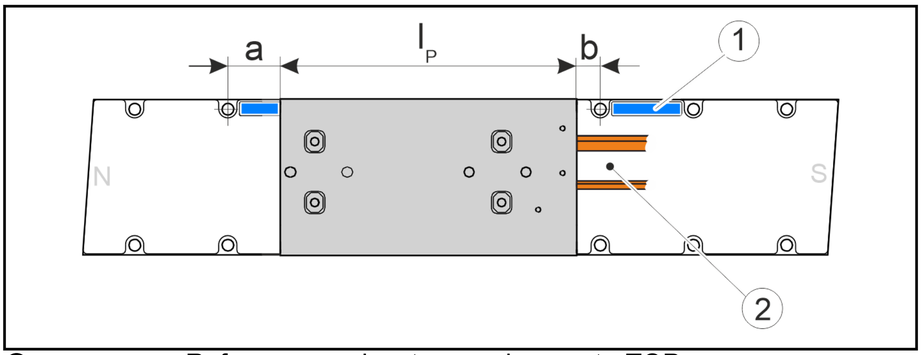
On each restart of the machine, the rough commutation offset (+/- 30°) is determined by switching to operating mode. The drive may now run to the reference point with reduced force. If the reference point is reached or passed, the optimum reference point for the commutation offset is applied by the drive and the maximum force is available to the axis.

12.6.5 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.

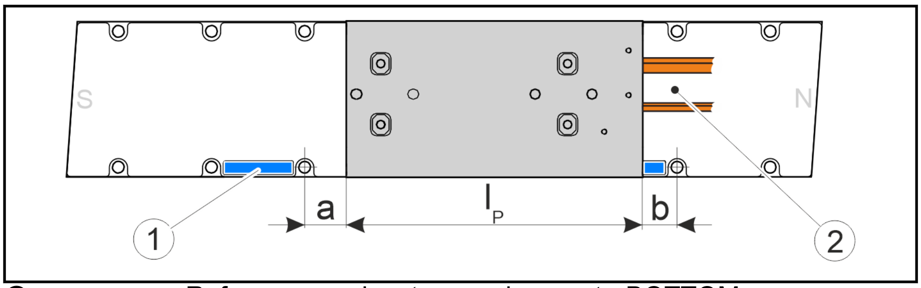
Assembly type 1



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

Fig. 12-15: Measuring of the relative position of the primary to the secondary (assembly type 1)

Assembly type 2



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

Fig. 12-16: Measuring of the relative position of the primary to the secondary (assembly type 2)

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. 12-17 and Tab. 12-8).

①	$P-0-0523=-a-k_{mx}$
②	$P-0-0523=+b+l_P-k_{mx}$

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. 12-8)
l_p　Primary part length in mm

Fig. 12-17: Calculation of P-0-0523, Commutation adjustment measured value

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.

Motor constant k_{mx} for commutation adjustment

Primary part	k_{mx} in mm	
	Assembly type 1 - Fig. 12-15	Assembly type 2 - Fig. 12-16
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

Tab. 12-8: Motor constant k_{mx} for commutation adjustment

Calculation examples

ML3P06-D... with assembly type ①

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... with assembly type ②

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:

1. The drive must be in status A0-13 during the following adjustment procedure (= ready for power switching).
2. 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.

12.7 Setting and optimizing the control loop

12.7.1 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.

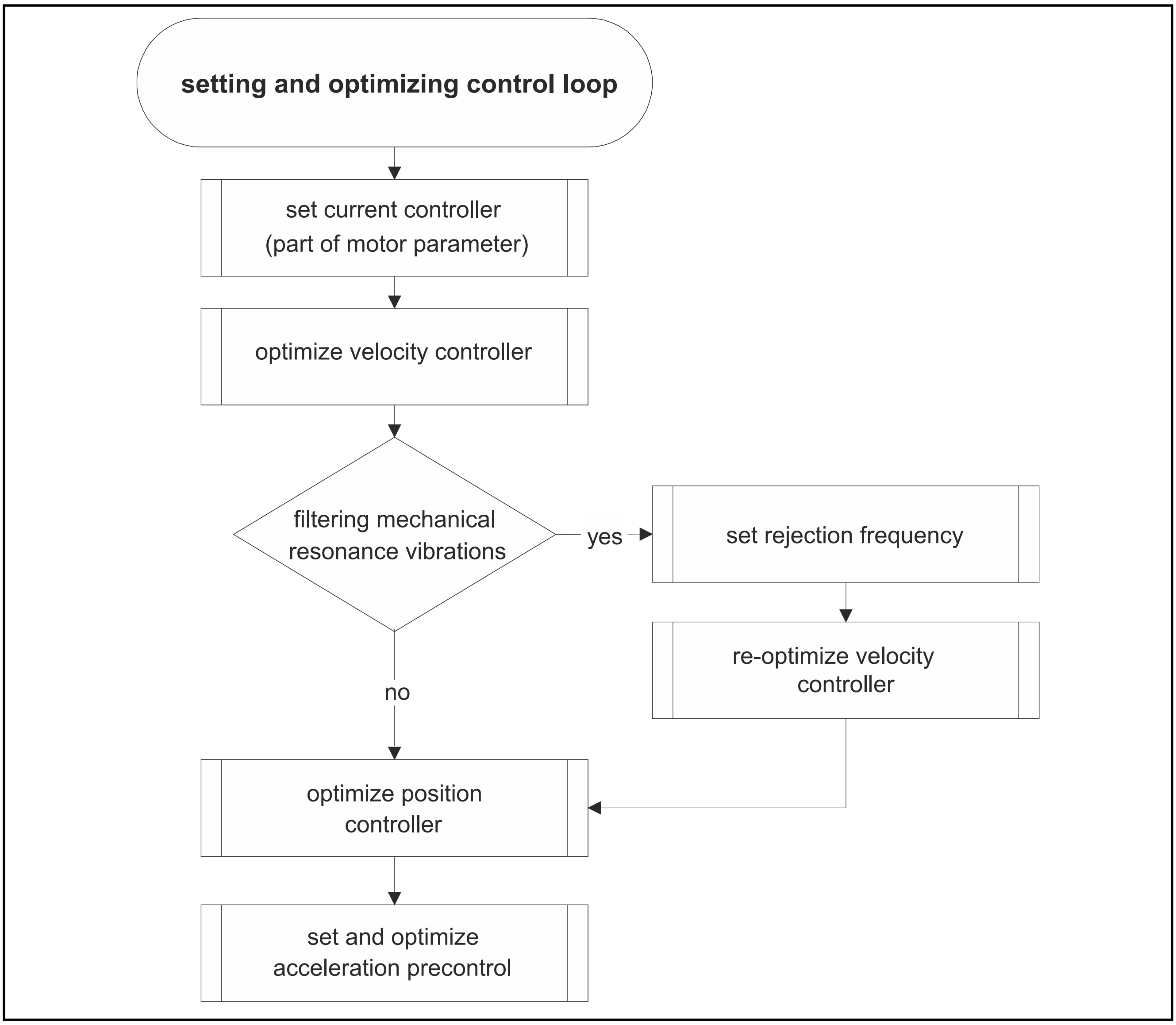


Fig. 12-18: Setting and optimizing the control loop of synchronous linear motors

☞ 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)

Automatic control loop setting

Rexroth drive controllers enable automatic control loop setting.

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!

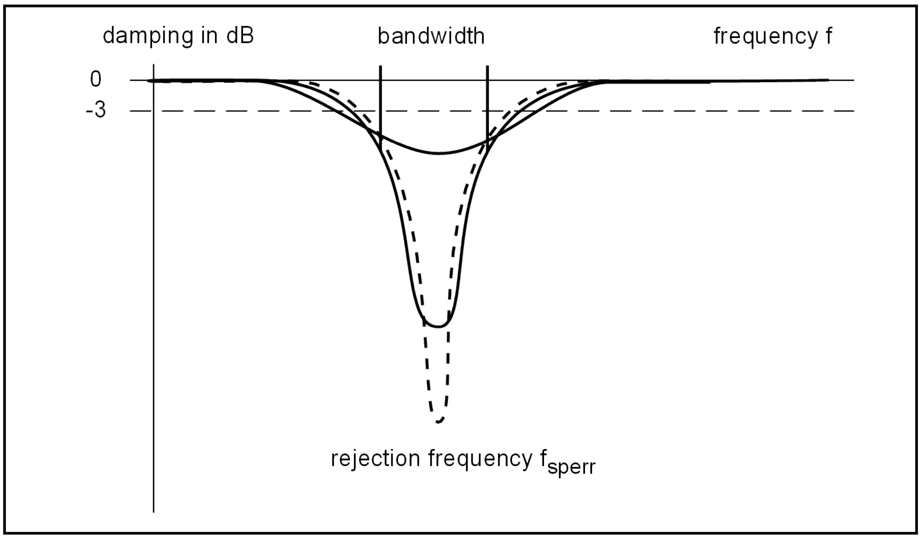


Fig. 12-19: Amplitude response of the rejection filter in relation to the bandwidth, qualitative

12.7.2 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.

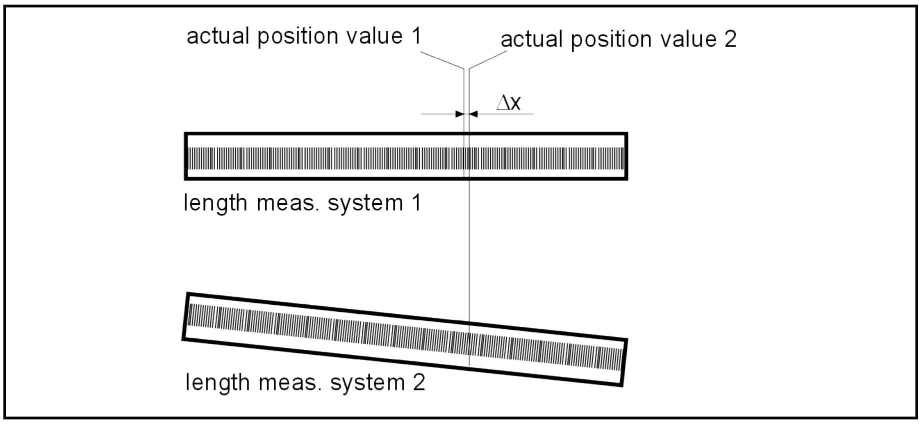


Fig. 12-20: Possible alignment errors at length measuring systems of Gantry axes

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:

$$k_{v1} = k_{v2}$$

$$k_{p1} = k_{p2}$$

k_v	Position controller kv factor S-0-0104
k_p	Velocity loop proportional gain S-0-0100

Fig. 12-21: Proportional gain in position and velocity control loop of both axes

Velocity loop integral action time (integral part)

For velocity loop integral action time (integral part), the following possibilities must be taken into consideration:

	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
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

Tab. 12-9: Parametrization of the velocity loop integral action time S-0-0101 at Gantry axes.

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.

12.7.3 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.

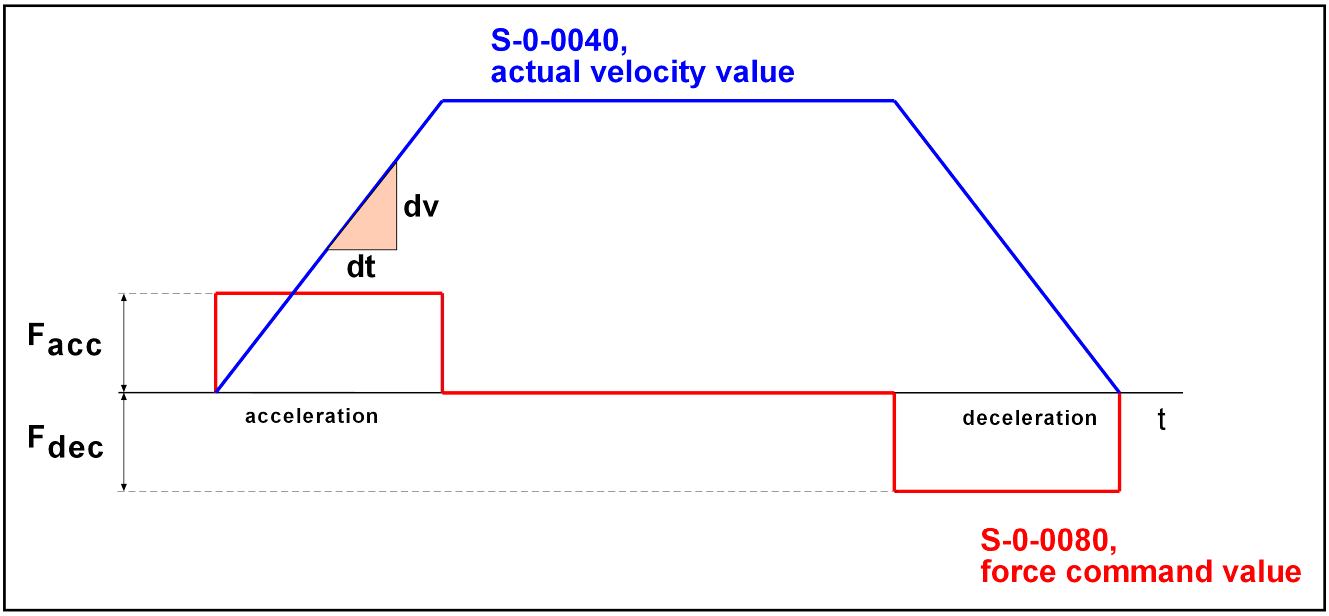


Fig. 12-22: Oscillogram of velocity and force

$$m = 30 \times F_N \times \left(\frac{F_{ACC} + F_{DEC}}{100\%} \right) \times \frac{\Delta t}{\Delta v}$$

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

Fig. 12-23: Determination of the moved axis mass according to recording of a velocity ramp

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.

12.8 Maintenance and checking of motor components

12.8.1 General

The motor components of ML3 motors do not require maintenance. 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.

12.8.2 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
- 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)

12.8.3 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.

12.9 Operation with third-party controllers

Rate of rise of voltage

The electrical insulation 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 IndraDrive converters.

12.10 Environmental protection and disposal

12.10.1 Environmental protection

Production processes

The products are manufactured in energy- and resource-optimized production processes which allow re-using and recycling the resulting waste. We regularly try to replace pollutant-loaded raw materials and supplies by more environment-friendly alternatives.

No release of hazardous substances

Our products do not contain any hazardous substances which may be released in case of appropriate use. Normally, our products will not have any negative influences on the environment.

Significant components

Significant components of our products are:

Electronic devices	Motors
• Steel	• Steel / Stainless steel
• Aluminum	• Aluminum
• Copper	• Copper
• Plastics	• Brass
• Electronic components	• Magnetic materials
	• Elektronic components

12.10.2 Disposal

Return of products

Our products can be returned to us for disposal free of charge. However, this requires that the products be free from oil, grease or other dirt.

Furthermore, the products returned for disposal may not contain any undue foreign material or foreign components.

Deliver the products "free domicile" to the following address:

Bosch Rexroth AG
Electric Drives and Controls
Buergermeister-Dr.-Nebel-Straße 2
97816 Lohr am Main, Germany

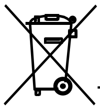
Packaging

Packaging materials consist of cardboard, wood and polystyrene They can be recycled anywhere without any problem.

For ecological reasons, please refrain from returning the empty packages to us.

Batteries and accumulators

Batteries and accumulators can be labeled with this symbol.



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 validity of the EU Directive 2006/66/EC, the particularly 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.

After use, the batteries or accumulators contained in Rexroth products must be properly disposed of according to the country-specific collection systems.

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.

Plastic parts of the products may contain flame retardants. These plastic parts are labeled according to EN ISO 1043. They have to be recycled separately or disposed of according to the applicable legal provisions.

13 Service and support

Our worldwide service network provides an optimized and efficient support. Our experts offer you advice and assistance should you have any queries. 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
E-mail:	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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