IndraDrive

Drive Systems with HMV01/02
HMS01/02, HMD01, HCS02/03

Project Planning Manual
R911309636

Edition 07

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1 System presentation

1.1 System platform

The following products are part of the **IndraDrive** system platform:

IndraDrive platform							
Control sections			Power sections		Supply units		Additional components
Economy **CSE** Single-axis	Basic **CSB/CDB** Single-axis/ double-axis	Advanced **CSH** Single-axis	Modular **HM*** Single-axis/ double-axis	Compact **HC*** Single-axis	**HMV-E**	**HMV-R**	**HNF** **HNL** **HLB** **HLC** **HLR**

Tab. 1-1: IndraDrive system platform

Hierarchical levels of IndraDrive

The assignment of the fundamental components to the hierarchical levels system platform, type, range, series and component is illustrated in the figure below.

Platform	IndraDrive							
Type	IndraDrive Power sections					IndraDrive control sections		
Range	Rexroth IndraDrive C		Rexroth IndraDrive M			Economy	Basic	Advanced
Series	HCS02	HCS03	HMV01 HMV02	HMS01 HMS02	HMD01	CSE	CSB CDB	CSH
Component	W0012… W0070	W0070… W0350	W0015… W0120	W0020… W0350	W0012… W0036	02	01 02	01 02

Tab. 1-2: Hierarchical levels Rexroth IndraDrive C and M

Short designations

For an overview of the short designations, such as HMV, HCS, CSH, etc., see Appendix of this documentation, chapter 18.1 System elements - product overview, short designations, page 277.

1.2 Rexroth IndraDrive C drive system - compact converters

Rexroth IndraDrive C is the compact converter type of the IndraDrive product range.

Basic features of the Rexroth IndraDrive C product range:

- Integrated power supply
- Integrated braking resistor (as an option, external for HCS03)
- Integrated inverters
- Integrated 24V control voltage supply (optional for HCS02)
- Additional components:
  - DC bus resistor units
  - DC bus capacitor units
  - Braking resistors

The figure below illustrates the system structure of the Rexroth IndraDrive C drive system. Allowed combinations of components: See chapter 8 "Configuring the drive system" on page 73

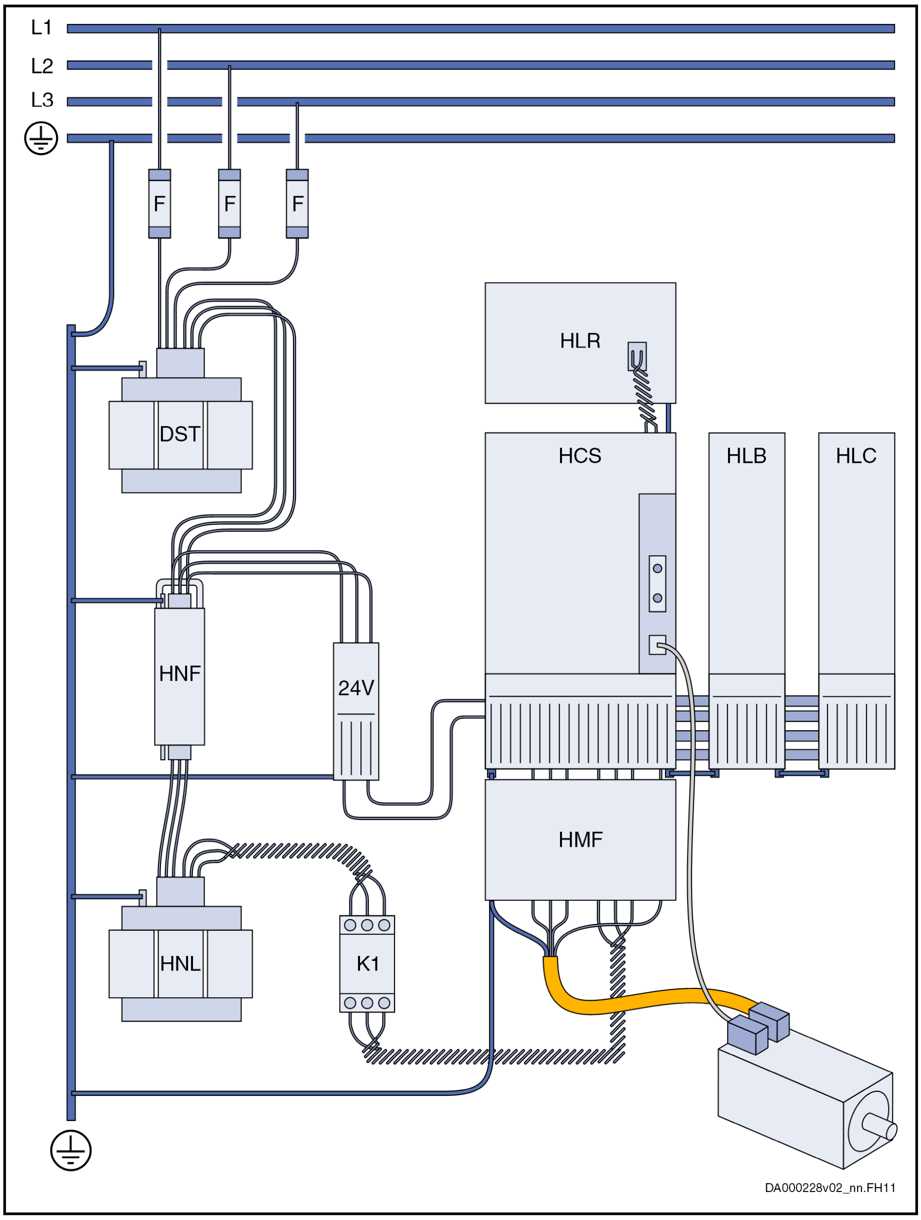


Fig. 1-1: Rexroth IndraDrive C drive system

☞ When using an HNK mains filter at HCS03 devices, connect the mains contactor between mains supply and mains filter.

1.3 Rexroth IndraDrive M drive system - modular system

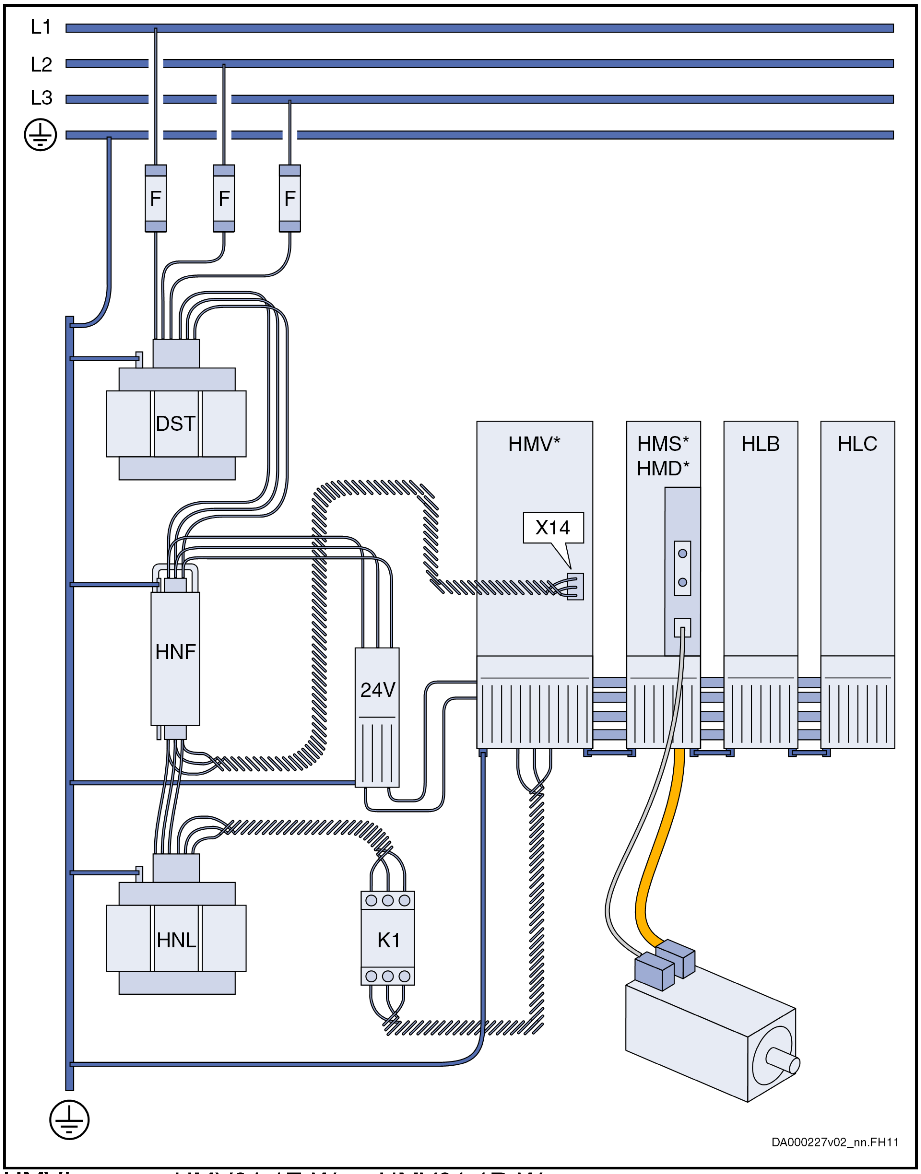
Rexroth IndraDrive M is the modular system type of the IndraDrive product range.

Combining an HMV supply unit with HMS and HMD drive controllers to form a modular drive system allows multiple motors to be operated.

Basic features of the Rexroth IndraDrive M product range:

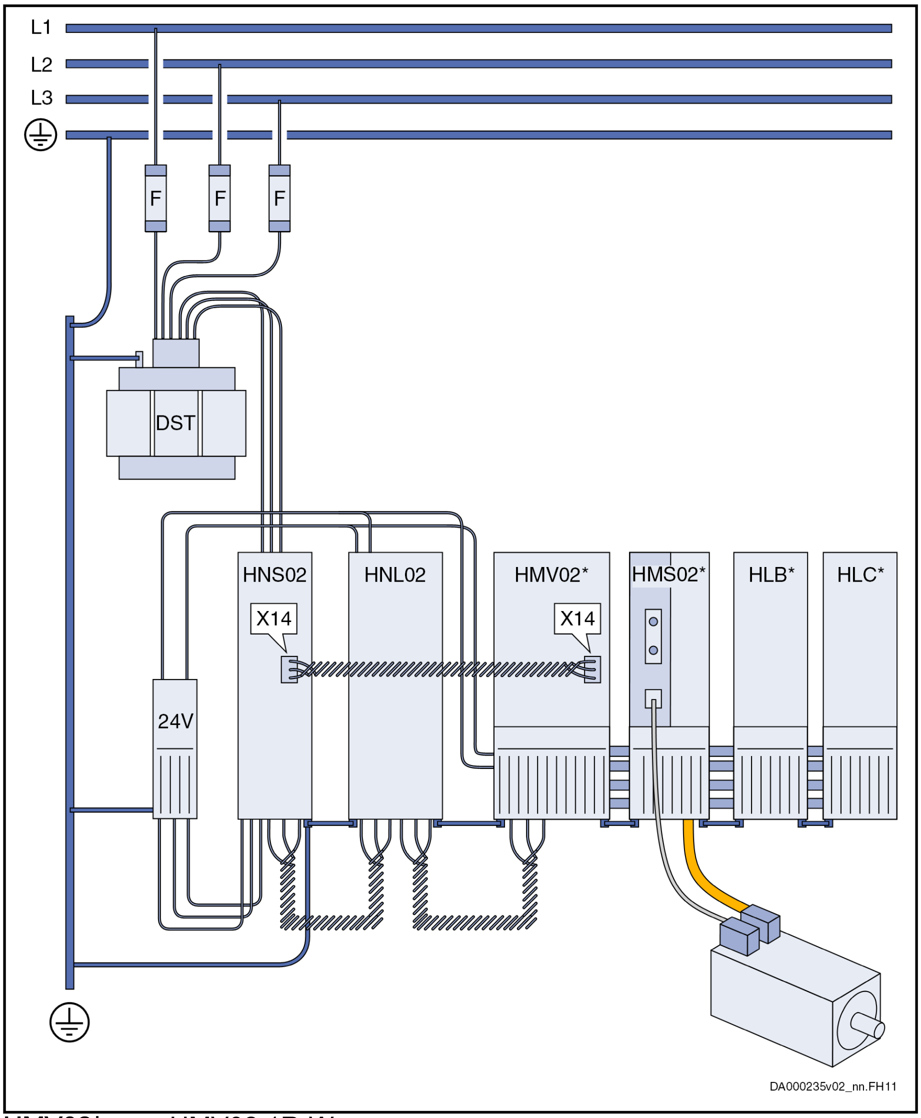
- Scalable power supply
- Integrated mains contactor (except for HMV01.1R-W0120)
- Modular extension of number of axes is possible
- Two series (mounting depths) of HMV and HMS available
- Additional components:
  - DC bus resistor units
  - DC bus capacitor units

The figure below illustrates the system structure of the Rexroth IndraDrive M drive system. Allowed combinations of components: See chapter 8 "Configuring the drive system" on page 73



HMV*	HMV01.1E-W…; HMV01.1R-W…
HMS*; HMD*	HMS01.1N-W…; HMD01.1N-W…
K1	External mains contactor K1 required for HMV01.1R-W0120 only
HNL	Optional mains choke (HNL) for HMV01.1E, required for HMV01.1R
HNF	Optional mains filter (HNF); depends on EMC requirements

Fig. 1-2: Rexroth IndraDrive M drive system (01 series)



HMV02*	HMV02.1R-W…
HMS02*	HMS02.1N-W…
HLB*	HLB01.1C (optional)
HLC*	HLC01.1C (optional)

Fig. 1-3: Rexroth IndraDrive M drive system (02 series)

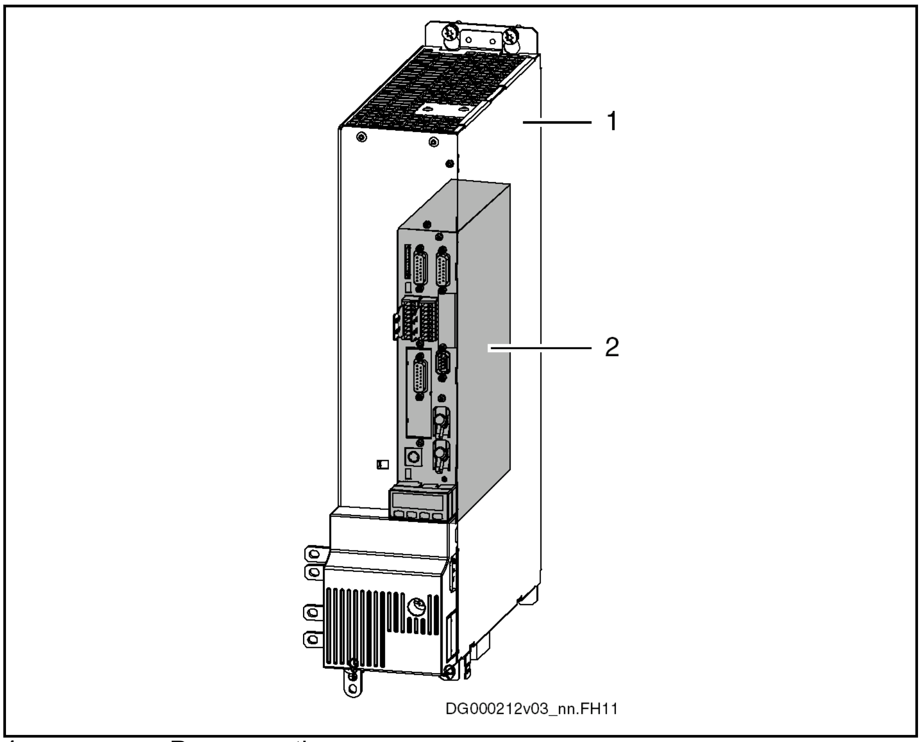
1.4 Combining Rexroth IndraDrive C with Rexroth IndraDrive M

On the common IndraDrive platform, it is possible to combine components of the Rexroth IndraDrive C, Rexroth IndraDrive M product ranges to form cost-optimized drive systems providing an optimum performance.

Allowed combinations of components: See chapter 8 "Configuring the drive system" on page 73

1.5 Basic design of the devices

1.5.1 General information



1 Power section
2 Control section

Fig. 1-4: Basic design of a drive controller

A drive controller consists of two essential parts:

- Power section
- Control section

1.5.2 Power section

The power section incorporates the control section and has the following connections:

- Mains voltage connection (at HCS devices)
- Motor connection (with optional motor holding brake and motor temperature monitor)
- 24 V control voltage
- DC bus connection
- Module bus connection for cross communication in the case of DC bus connection with other devices
- Connection for external braking resistor (at HCS devices)

📖 For detailed information on the power sections, see Project Planning Manual "IndraDrive Supply Units and Power Sections".

1.5.3 Control section

The control section is a separate component which is plugged into the power section. The control section consists of:

- Basic control section circuit board with interfaces
- Optional modules (only for configurable control sections)

The drive controller is supplied complete with a factory-installed (possibly configured) control section.

☞ Only especially trained staff are allowed to replace control sections.

📖 For detailed information on the control sections, see Project Planning Manual "IndraDrive Drive Controllers Control Sections".

1.6 Overview of type currents and type performances

1.6.1 General information

To allow appropriate drive controllers to be selected for a multitude of applications, the IndraDrive product range includes a wide range of type currents and performances. The table below shows the fundamental data of drive controllers and supply units.

For detailed technical data, see Project Planning Manual "IndraDrive Supply Units and Power Sections".

1.6.2 Drive controllers

The order of the following table lines conforms with the peak currents of the devices.

Compact converters	Modular inverters	Type current	Contin. current $I_{out\_cont\_4k}$ [A] 1)	Peak current $I_{out\_max\_4k}$ [A] 1)	Nominal motor power [kW] 2)
HCS02	-	W0012	4	12	1.5
-	HMD01	W0012	6.9	12	-
-	HMS01	W0020	12.1	20	-
-	HMD01	W0020	12.1	20	-
HCS02	-	W0028	11	28	4.0
-	HMS02	W0028	13	28	-
-	HMS01	W0036	21.3	36	-
-	HMD01	W0036	20	36	-
HCS02	-	W0054	22	54	7.5
-	HMS01	W0054	35	54	-
-	HMS02	W0054	25	54	-
HCS02	-	W0070	28	70	11
HCS03	-	W0070	45	70	18.5
-	HMS01	W0070	42.4	70	-
HCS03	-	W0100	73	100	30
-	HMS01	W0110	68.5	110	-
HCS03	-	W0150	95	150	45
-	HMS01	W0150	100	150	-
HCS03	-	W0210	145	210	75
-	HMS01	W0210	145	210	-
HCS03	-	W0280	165	280	75
-	HMS01	W0300	150	300	-

Compact converters	Modular inverters	Type current	Contin. current $I_{out\_cont\_4k}$ [A] 1)	Peak current $I_{out\_max\_4k}$ [A] 1)	Nominal motor power [kW] 2)
HCS03	-	W0350	200	350	90
-	HMS01	W0350	250	350	-

1) At fs = 4 kHz; without overload
2) For standard motor 3 AC 400 V; use of mains choke HNL01; variable torque

Tab. 1-3: Type current and type performances

1.6.3 Supply units and converters

The order of the following table lines conforms with the continuous power of the devices.

Compact converters	Modular mains supply	Type current or performance	Contin. power "ON" P_{DC_cont} [kW] 1)	Peak power "ON" P_{DC_peak} [kW] 1)	Contin. braking power [kW]	Max. braking power [kW]
HCS02	-	E-W0012	2.1	5	0.05	4
HCS02	-	E-W0028	4.2	10	0.15	10
HCS02	-	E-W0054	9.1	16	0.35	18
HCS02	-	E-W0070	13.3	19	0.5	25
-	HMV01	R-W0018	18	45	0.4	36
HCS03	-	E-W0070	25	40	opt.	opt.
-	HMV01	E-W0030	30	45	1.5	36
HCS03	-	E-W0100	43	59	opt.	opt.
HCS03	-	E-W0150	56	89	opt.	opt.
-	HMV02	R-W0015	15	37.5	0.3	33
-	HMV01	R-W0045	45	112	0.4	90
-	HMV01	R-W0065	65	162	0.4	130
-	HMV01	E-W0075	75	112	2	90
HCS03	-	E-W0210	85	124	opt.	opt.
HCS03	-	E-W0280	100	170	opt.	opt.
HCS03	-	E-W0350	120	210	opt.	opt.
-	HMV01	E-W0120	120	180	2.5	130
-	HMV01	R-W0120	120	180	0	0

opt. Equipment to be optionally ordered
1) With use of mains choke HNL01; at 3 AC 400 V

Tab. 1-4: Performance data of mains supply units

The data of peak power and continuous power show the maximum possible limit values.

📖 For the actually available performance profiles, see Project Planning Manual "IndraDrive Supply Units and Power Sections" → chapter of the respective component → "Technical data" → "Exemplary data for applications" → "Performance profiles".

1.7 Overview of functions

1.7.1 Supply units and power sections

📖 For an overview of the functions of supply units and power sections, see Project Planning Manual "IndraDrive Supply Units and Power Sections" → "Functions and connection points" → "Overview of functions, power sections and supply units".

1.7.2 Control sections

📖 For an overview of the functions of control sections, see Project Planning Manual "IndraDrive Drive Controllers Control Sections" → "IndraDrive control sections" → "Overview of functions and interfaces of the control sections".

1.8 Documentations

1.8.1 About this documentation

Purpose

⚠ WARNING **Personal injury and property damage by incorrect configuration of applications, machines and installations!**

Observe the contents of the documentations relevant to your drive system.

This documentation contains

- Overview of the IndraDrive system
- Description of the allowed combinations of IndraDrive system components
- Selection of the system components of the IndraDrive system
- Specification applying to all components (ambient and operating conditions)
- Application description of system characteristics

Editions

Edition	Release date	Notes
01	2004-12	-
02	2005-03	-
03	2006-01	-
04	2007-08	-
05	2007-09	-

Edition	Release date	Notes
06	2013-08	-
07	2019-06	Changes in comparison to previous edition: • Added HCS03.1E-W0280 • Added HCS03.1E-W0350 • Replaced some additional components by their follow-up types: – old: HNL01.1E-0100-N0202-A-480-NNNN (R911306578) new: HNL01.1E-0100-N0220-A-480-NNNN (R911379296) – old: HNF01.1A-F240-E0202-A-480-NNNN (R911307938) new: HNF01.2D-F240-E0202-A-480-NNNN (R911373247) – old: HNF01.1A-M900-E0202-A-480-NNNN (R911306536) new: HNF01.2D-M900-E0202-A-480-NNNN (R911382796) – old: HNF01.1A-F240-R0026-A-480-NNNN (R911306539) new: HNF01.2D-F240-R0026-A-480-NNNN (R911382794) – old: HNF01.1A-M900-R0026-A-480-NNNN (R911306535) new: HNF01.2D-M900-R0026-A-480-NNNN (R911382795) – old: HNF01.1A-F240-R0065-A-480-NNNN (R911306533) new: HNF01.2D-F240-R0065-A-480-NNNN (R911382792) – old: HNF01.1A-M900-R0065-A-480-NNNN (R911306534) new: HNF01.2D-M900-R0065-A-480-NNNN (R911382793) – old: HNF01.1A-F240-R0094-A-480-NNNN (R911306295) new: HNF01.2D-F240-R0094-A-480-NNNN (R911380993) – old: HNF01.1A-M900-R0094-A-480-NNNN (R911306296) new: HNF01.2D-M900-R0094-A-480-NNNN (R911382791) • Included note on RoHS conformity of the CSB01, CSH01 and CDB01 control sections (chapter "Important directions for use") • Updated chapter "Overview of documentations" • Included MS2N and MS2E motors • Added chapter with a basis of calculation for sizing mains filters in drive systems (chapter 18.6 "Sizing mains filters (drive system)" on page 290) • Removed IndraDrive Mi (KSM, KMS, KCU) components. There is a separate Project Planning Manual for these components: "IndraDrive Mi Drive Systems with KCU02, KSM02, KMS02/03, KMV03, KNK03, KLC03" (R911335703) • Removed IndraDrive Cs (HCS01) components. There is a separate Project Planning Manual for these components: "IndraDrive Cs Drive Systems with HCS01" (R911322210) • Removed HCS04 components. These components were discontinued.

Tab. 1-5: Editions

1.8.2 Overview of documentations

Drive systems, system components

Title IndraDrive …	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
Drive Systems with HMV01/02 HMS01/02, HMD01, HCS02/03	Project Planning Manual	SYSTEM*****-PRxx-EN-P	309636
Mi Drive Systems with KCU02, KSM02, KMS02	Project Planning Manual	KCU02+KSM02-PRxx-EN-P	335703
Supply Units, Power Sections HMV, HMS, HMD, HCS02, HCS03	Project Planning Manual	HMV-S-D+HCS-PRxx-EN-P	318790
Control Sections CSB01, CSH01, CDB01	Project Planning Manual	CSH********-PRxx-EN-P	295012
Control Sections CSE02, CSB02, CDB02, CSH02	Project Planning Manual	Cxx02******-PRxx-EN-P	338962
Additional Components and Accessories	Project Planning Manual	ADDCOMP****-PRxx-EN-P	306140

1) In the document typecodes, "xx" is a placeholder for the current edition of the documentation (e.g.: PR01 is the first edition of a Project Planning Manual)

Tab. 1-6: Documentations – overview

Title	Type of documentation	Document typecode[1)]	Material number R911…
Automation Terminals of the Rexroth Inline Product Range	Application Manual	DOK-CONTRL-ILSYSINS***-AWxx-EN-P	317021

1) In the document typecodes, "xx" is a placeholder for the current edition of the documentation (e.g.: AW01 is the first edition of an Application Manual)

Tab. 1-7: Documentations – overview

Motors

Title	Type of documentation	Document typecode[1)] DOK-MOTOR*-…	Material number R911…
MAD / MAF Asynchronous Motors MAD / MAF	Project Planning Manual	MAD/MAF****-PRxx-EN-P	295781
MBS-H Synchronous Kit Spindle Motors	Project Planning Manual	MBS-H******-PRxx-EN-P	297895
MLF Synchronous Linear Motors	Project Planning Manual	MLF********-PRxx-EN-P	293635
MCL Ironless Linear Motors MCL	Project Planning Manual	MCL********-PRxx-EN-P	330592

Title	Type of documentation	Document typecode[1)] DOK-MOTOR*-…	Material number R911…
MKE Synchronous Motors Synchronous Servo Motors for Potentially Explosive Areas acc. to ATEX and UL / CSA	Project Planning Manual	MKE*GEN2***-PRxx-EN-P	297663
MSK Synchronous Servo Motors	Project Planning Manual	MSK********-PRxx-EN-P	296289
MSK Synchronous Servo Motors for Potentially Explosive Areas	Project Planning Manual	MSK*EXGIIK3-PRxx-EN-P	312709
MSM Synchronous Servo Motors	Data Sheet	MSM********-DAxx-EN-P	329338
MS2E Synchronous Servo Motors acc. to ATEX Directive 2014/34/EU	Project Planning Manual	MS2E*******-PR01-EN-P	394140
MS2N Synchronous Servo Motors	Project Planning Manual	MS2N*******-PRxx-EN-P	347583
MBT Synchronous Torque Motors	Project Planning Manual	MBT********-PRxx-EN-P	298798

1) In the documentation typecodes, "xx" is a placeholder for the current edition of the documentation (e.g.: PR01 is the first edition of a Project Planning Manual)

Tab. 1-8: Documentations – motors

Cables

Title	Type of documentation	Document typecode[1)] DOK-…	Material number R911…
Connection Cables IndraDrive and IndraDyn	Selection Data	CONNEC-CABLE*INDRV-CAxx-EN-P	322949

1) In the document typecodes, "xx" is a placeholder for the current edition of the documentation (e.g.: CA02 is the second edition of the "Selection Data" documentation)

Tab. 1-9: Documentations – overview

Firmware

Title Rexroth IndraDrive …	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Part number R911…
Firmware for Drive Controllers MPH-08, MPB-08, MPD-08, MPC-08	Functional Description	MP*-08VRS**-APxx-EN-P	332643
Firmware for Drive Controllers MPH-07, MPB-07, MPD-07, MPC-07	Functional Description	MP*-07VRS**-FKxx-EN-P	328670

Title Rexroth IndraDrive …	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Part number R911…
Firmware for Drive Controllers MPH-06, MPB-06, MPD-06, MPC-06	Functional Description	MP*-06VRS**-FKxx-EN-P	326766
Firmware for Drive Controllers MPH-05, MPB-05, MPD-05	Functional Description	MP*-05VRS**-FKxx-EN-P	320182
Firmware for Drive Controllers MPH-04, MPB-04, MPD-04	Functional Description	MP*-04VRS**-FKxx-EN-P	315485
Firmware for Drive Controllers MPH-03, MPB-03, MPD-03	Functional Description	MP*-03VRS**-FKxx-EN-P	308329
Firmware for Drive Controllers MPH-02, MPB-02, MPD-02	Functional Description	MP*-02VRS**-FKxx-EN-P	299223
Drive Controllers MPx-02 to MPx-08	Parameter Description	GEN-**VRS**-PAxx-EN-P	297317
MPx-02 to MPx-08 and HMV	Troubleshooting Guide	GEN-**VRS**-WAxx-EN-P	297319
Integrated Safety Technology	Functional and Application Description	SI*-**VRS**-FKxx-EN-P	297838
Integrated Safety Technology According to IEC61508	Functional Description	SI2-**VRS**-FKxx-EN-P	327664
Rexroth IndraMotion MLD	Application Manual	MLD-**VRS**-AWxx-EN-P	306084
Rexroth IndraMotion MLD Library	Library Description	MLD-SYSLIB*-FKxx-EN-P	309224

1) In the document typecodes, "xx" is a wild card for the current edition of the documentation (example: FK02 is the second edition of a Functional Description)

Tab. 1-10: Documentations – Overview

Title	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
IndraDrive MPx-21 Functions	Application Manual	MP*-21VRS**-APxx-EN-P	385758
IndraDrive MPx-20 Functions	Application Manual	MP*-20VRS**-APxx-EN-P	345608
IndraDrive MPx-20 Version Notes	Release Notes	MP*-20VRS**-RNxx-EN-P	345606

Title	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
IndraDrive Power Supply Basic PSB-21 Functions	Application Manual	PSB-21VRS**-APxx-EN-P	385754
IndraDrive Power Supply Basic PSB-21 Version Notes	Release Notes	PSB-21VRS**-RNxx-EN-P	385752
IndraDrive Power Supply Basic PSB-20 Functions	Application Manual	PSB-20VRS**-APxx-EN-P	345610
Rexroth IndraDrive Power Supply Basic PSB-19 Functions	Application Manual	PSB-19VRS**-APxx-EN-P	345602
Rexroth IndraDrive MPx-18 Functions	Application Manual	MP*-18VRS**-APxx-EN-P	338673
Rexroth IndraDrive MPx-18 Version Notes	Release Notes	MP*-18VRS**-RNxx-EN-P	338658
Rexroth IndraDrive MPx-17 Functions	Application Manual	MP*-17VRS**-APxx-EN-P	331236
Rexroth IndraDrive MPx-17 Version Notes	Release Notes	MP*-17VRS**-RNxx-EN-P	331588
Rexroth IndraDrive MPx-16 Functions	Application Manual	MP*-16VRS**-APxx-EN-P	326767
Rexroth IndraDrive MPx-16 Version Notes	Release Notes	MP*-16VRS**-RNxx-EN-P	329272
IndraDrive MPx-16 to MPx-21 and PSB Parameters	Reference Book	GEN1-PARA**-RExx-EN-P	328651
IndraDrive MPx-16 to MPx-21 and PSB Diagnostics	Reference Book	GEN1-DIAG**-RExx-EN-P	326738

Title	Type of documentation	Document typecode[1)] DOK-INDRV*-…	Material number R911…
Rexroth IndraDrive Integrated Safety Technology "Safe Torque Off" (as of MPx-16)	Application Manual	SI3-**VRS**-APxx-EN-P	332634
IndraDrive Integrated Safety Technology "Safe Motion" (as of MPx-18)	Application Manual	SI3*SMO-VRS-APxx-EN-P	338920
Rexroth IndraDrive Rexroth IndraMotion MLD Libraries as of MPx-17	Reference Book	MLD-SYSLIB2-RExx-EN-P	332627
IndraDrive Rexroth IndraMotion MLD Libraries as of MPx-18	Reference Book	MLD-SYSLIB3-RExx-EN-P	338916
Rexroth IndraDrive Rexroth IndraMotion MLD as of MPx-17	Application Manual	MLD2-**VRS*-APxx-EN-P	334351
IndraDrive IndraMotion MLD MPx-18 and above	Application Manual	MLD3-**VRS*-APxx-EN-P	338914

1) In the document typecodes, "xx" is a placeholder for the current edition of the documentation (e.g.: RE02 is the second edition of a Reference Book)

Tab. 1-11: Documentations – firmware

Title	Type of documentation	Document typecode[1)]	Material number R911…
Productivity Agent Extended Diagnostic Functions with Rexroth IndraDrive	Application Manual	DOK-INDRV*-MLD-PAGENT*-AWxx-EN-P	323947

1) In the document typecodes, "xx" is a placeholder for the current edition of the documentation (e.g.: AW01 is the first edition of an Application Manual)

Tab. 1-12: Documentations – overview

1.8.3 Your comments

☞ Your experience is important for our improvement processes of products and documentations.

If you find any mistakes in this documentation or have suggestions for changes, please send your feedback to the following address:

Bosch Rexroth AG

Dept. DC-AE/EPI5

Bürgermeister-Dr.-Nebel-Str. 2

97816 Lohr am Main, Germany

Email: dokusupport@boschrexroth.de

2 Important directions for use

2.1 Intended use

2.1.1 Introduction

Rexroth products are developed and manufactured to the state-of-the-art. The products are tested prior to delivery to ensure operational safety and reliability.

⚠ WARNING **Personal injury and property damage by using products incorrectly!**

The products have been designed for use in an industrial environment and may only be used as intended. Failure to use them in the intended way may cause situations resulting in property damage and personal injury.

Rexroth as the manufacturer shall not honor any warranty, liability or compensatory claims for damages resulting from unintended use of the products. The user alone shall bear the risks of unintended use of the products.

Before using Rexroth products, make sure that all the prerequisites for an intended use of the products are satisfied:

- Personnel that in any way, shape or form uses our products must first read and understand the relevant safety instructions and be familiar with their intended use.
- Leave hardware products in their original state, i.e., do not make any structural modifications. It is not permitted to decompile software products or alter their source codes.
- Do not install damaged or faulty products or put them into operation.
- Make sure that the products have been installed as described in the relevant documentation.

2.1.2 Areas of use and application

Drive controllers by Rexroth are designed to control electric motors and monitor their operation.

Controlling and monitoring the Drive controllers may require additional sensors and actuators.

The drive controllers may only be used with the accessories and attachments specified in this documentation. Components that are not expressly mentioned may neither be attached nor connected. The same applies to cables and lines.

Operation is only allowed in the specified configurations and combinations of the components using the software and firmware as specified in the relevant functional descriptions.

Drive controllers have to be programmed before commissioning to ensure that the motor executes the functions specific to the application.

Drive controllers of the IndraDrive series have been developed for use in single- and multi-axis drive and control tasks.

Device types with different drive power and interfaces are available for using the Drive controllers in specific applications.

Typical applications include, for example:

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

Drive controllers may only be operated under the assembly and installation conditions specified in this documentation, in the specified position of normal use and under the specified ambient conditions (temperature, degree of protection, humidity, EMC, etc.).

☞ Note regarding the **RoHS Directive 2011/65/EU**:

The CSB01, CSH01 and CDB01 control sections do not meet the requirements of the RoHS Directive 2011/65/EU.

However, the CSB01, CSH01 and CDB01 control sections may still be placed on the market within the EU if they are exclusively used in applications that are so-called "large-scale stationary industrial tools" or so-called "large-scale fixed installations".

This is stated by the derogation contemplated by Article 2, paragraph 4 of the RoHS Directive 2011/65/EU. Article 3 of this Directive specifies the definitions.

2.2 Unintended use

"Unintended use" refers to using the Drive controllers outside of the operating conditions, technical data and specifications described in this documentation.

Drive controllers must not be used, if …

- they are exposed to operating conditions that do not meet the specified ambient conditions. This includes, for example, operation under water, under extreme temperature fluctuations or extreme maximum temperatures.
- Furthermore, Drive controllers may not be used in applications that have not been expressly authorized by Rexroth. Therefore, please carefully follow the specifications outlined in the general safety instructions!

☞ Components of the IndraDrive system are **products of Category C3** (with restricted distribution) in accordance with IEC 61800-3. This Category comprises EMC limit values for line-based and radiated noise emission. Compliance with this Category (limit values) requires the appropriate measures of interference suppression to be used in the drive system (e.g., mains filters, shielding measures).

These components are not provided for use in a public low-voltage mains supplying residential areas. If these components are used in such a mains, high-frequency interference is to be expected. This can require additional measures of interference suppression.

3 Safety instructions for electric drives and controls

3.1 Definitions of terms

Application 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.

Component 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.

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

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.

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.

Electric 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.

Installation 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.

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.

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.

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 persons 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,

- to be trained, instructed or authorized to switch electric circuits and devices safely on and off, to ground them and to mark them.
- to be trained or instructed to maintain and use adequate safety equipment.
- to attend a course of instruction in first aid.

Qualified personnel for handling functionally safe products

Individuals configuring, commissioning and operating functionally safe products must have the knowledge specified under "Qualified persons". Additionally, these individuals must be familiar with technical safety concepts as well as prevailing standards and regulations in the field of functional safety.

User

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

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 Technology". 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 Instructions with regard to specific dangers

3.3.1 Protection against contact with electrical parts and housings

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

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

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

- Only qualified persons are allowed to operate, maintain and/or repair the components of the electric drive and control system.
- Follow the general installation and safety regulations when working on power installations.
- Before switching on, the equipment grounding conductor must have been permanently connected to all electric components in accordance with the connection diagram.
- Even for brief measurements or tests, operation is only allowed if the equipment grounding conductor has been permanently connected to the points of the components provided for this purpose.
- Before accessing electrical parts with voltage potentials higher than 50 V, you must disconnect electric components from the mains or from the power supply unit. Secure the electric component from reconnection.
- With electric components, observe the following aspects:

  Always wait **30 minutes** after switching off power to allow live capacitors to discharge before accessing an electric component. Measure the electrical voltage of live parts before beginning to work to make sure that the equipment is safe to touch.

- Install the covers and guards provided for this purpose before switching on.
- Never touch any electrical connection points of the components while power is turned on.
- Do not remove or plug in connectors when the component has been powered.
- Under specific conditions, electric drive systems can be operated at mains protected by residual-current-operated circuit-breakers sensitive to universal current (RCDs/RCMs).
- Secure built-in devices from penetrating foreign objects and water, as well as from direct contact, by providing an external housing, for example a control cabinet.

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

- Before switching on and before commissioning, ground or connect the components of the electric drive and control system to the equipment grounding conductor at the grounding points.
- Connect the equipment grounding conductor of the components of the electric drive and control system permanently to the main power supply at all times. The leakage current is greater than 3.5 mA.
- Establish an equipment grounding connection with a minimum cross section according to the table below. With an outer conductor cross section smaller than 10 mm^2 (8 AWG), the alternative connection of two equipment grounding conductors is allowed, each having the same cross section as the outer conductors.

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

Tab. 3-1: Minimum cross section of the equipment grounding connection

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 Brief description, use

4.1 General information

In terms of "intended use", cases of operation and applications not mentioned in this chapter are not allowed.

In this context, observe the chapter 8 Configuring the drive system, page 73.

4.2 Applications of the Drive System IndraDrive

The digital, intelligent drive system IndraDrive is the cost-efficient solution with a high degree of functionality for single-axis and multi-axis drive and control tasks.

The drive system IndraDrive fulfills a large number of drive tasks in the most varied applications.

Typical applications are the industrial sectors:

- Printing and paper converting
- Packaging and food
- Mounting and handling
- Wood machining
- Machine tools
- Metal forming
- General automation

For these applications there are different device types of graduated performance.

4.3 Mains Transformers DST and DLT

DST and DLT transformers are used to transform mains voltages to the allowed nominal voltages of the devices.

DLT transformers are used to

- prevent overvoltage between outer conductor and ground
- protect other loads against leakage currents

Type	Usage
DST autotransformer	Adjusting voltage range in **grounded** mains
DLT isolating transformer	Adjusting voltage range in **ungrounded** mains

Tab. 4-1: Usage of Transformers

As a matter of principle, DLT isolating transformers have to be used at ungrounded mains.

4.4 Mains filters HNF, HNK, NFE, HNS02 and NFD

Mains filters reduce radio interference and mains pollution.

☞ When using HNF01, NFD03, HNS02 and HNK01 mains filters at **mains grounded via outer conductor**, use an isolating transformer between mains and mains filter.

Type	Use
NFE01.1	Interference suppression of power supply units up to 230 V
NFE02.1	Interference suppression of single-phase drive controllers up to 230 V
NFD03.1	Interference suppression of three-phase drive controllers up to 480 V for 1-6 axes and motor cable lengths up to max. 75 m single-axis / 120 m multi-axis
HNF01.x	Interference suppression of three-phase drive controllers up to 480 V for drive systems with a high number of axes and long motor cables
HNK01.1	Interference suppression of three-phase drive controllers HCS03.1E up to 500 V
HNS02	Interference suppression of three-phase drive controllers up to 480 V for drive systems with a maximum of 12 axes and a maximum of 200 m motor cable length Integrated switch-disconnector

Tab. 4-2: Use of mains filters

☞ Only operate expressly allowed components at the mentioned mains filters.

Do not connect any other loads at the connection from the mains filter output to the mains connection of the supply unit or controller. For motor fans and power supply units, for example, use separate mains filters.

4.5 Mains chokes HNL01 and HNL02

HNL01.xE, HNL01.xR and HNL02.1R **(standard)** mains chokes

- reduce harmonics in the mains current
- increase the allowed DC bus continuous power of certain converters
- allow regenerative supply units to be operated at the mains

Current-compensated mains chokes HNL01.1E-****-S and HNL01.1R-****-S reduce asymmetric currents (leakage currents) in the mains connection phase of the drive system.

The different types may be used **exclusively** as follows:

Type	Use
HNL01.xR	For connection to components with regeneration to the power grid (HMV01.1R)
HNL01.xE	For connection to components without regeneration to the power grid (HMV01.1E, HCS02.1E, HCS03.1E)

Type	Use
HNL01.1*-****-S	Current-compensated chokes for use with HNL01.1 mains chokes to reduce asymmetric currents (leakage currents) in the mains connection phase of the drive system (HMV01.1E, HMV01.1R, HCS02.1E, HCS03.1E)
HNL02.1R	Mains chokes in housing for control cabinet mounting for connection to components with regeneration to the supply mains (HMV02.1R)

Tab. 4-3: Use of mains chokes

4.6 Supply units HMV01 / HMV02

HMV supply units supply modular HMS and HMD drive controllers.

Type	Use
HMV01.1E	**Feeding** Supplies HMS01 and HMD01 drive controllers
HMV01.1R	**Regenerative** Supplies HMS01 and HMD01 drive controllers
HMV02.1R	**Regenerative** Supplies HMS02 drive controllers

Tab. 4-4: Use of supply units

4.7 Drive Controllers HMS01, HMS02 and HMD01

In the modular drive system, HMS and HMD drive controllers control single and double axes.

Type	Usage
HMD01.1	• Have two power outputs to operate two motors independently of each other • Are operated at HMV supply units and HCS drive controllers
HMS01.1	• Have a power output to operate a motor • Are operated at HMV01 supply units and HCS02 and HCS03 drive controllers
HMS02.1	• Have a power output to operate a motor • Are operated at HMV02 supply units and HCS02 drive controllers

Tab. 4-5: Usage of HM Drive Controllers*

4.8 Control sections CSB, CSE, CSH, CDB

CSB, CSE, CSH and CDB control sections:

- allow HCS, HMS, HMD drive controllers to be operated
- fulfill open-loop and closed-loop control tasks with command value input
- require a certain firmware:
  - CSB01, CSH01, CDB01: ≤ MPx08
  - CSB02, CSH02, CDB02, CSE02: ≥ MPx18

Type	Use
CSH	**Advanced** In HMS01, HMS02, HCS02, HCS03 drive controllers
CSB	**BASIC - single-axis** In HMS01, HMS02, HCS02, HCS03 drive controllers
CSE	**ECONOMY - single-axis** In HMS01, HMS02, HCS02, HCS03 drive controllers
CDB	**BASIC - double-axis** In HMD01 drive controllers

Tab. 4-6: Use of control sections

4.9 Drive Controllers HCS02

HCS02 drive controllers control single axes.

Type	Usage
HCS02	• Have a power output to operate a motor • Power range: 1.5 kW to 11 kW

Tab. 4-7: Usage of HCS02 Drive Controllers

4.10 Drive controllers HCS03

HCS03 drive controllers control single axes.

Type	Use
HCS03	• Have a power output to operate a motor • Power range: 18.5 kW to 120 kW

Tab. 4-8: Use of HCS03 drive controllers

☞ In their standard design -NNNV, HCS03 drive controllers are not regenerative.

For applications where regenerative power is generated, use HCS03.1 of the -NNBV design and HLR braking resistors.

4.11 DC Bus Resistor Unit HLB01

DC bus resistor units HLB01

- Convert generated kinetic energy into thermal energy
- Increase the continuous regenerative power in the drive system
- Increase the peak regenerative power in the drive system
- Allow the DC bus short circuit function ("ZKS") in the drive system

Type	Usage
HLB01.1C	In drive systems of the Rexroth IndraDrive C product range with a device mounting depth of 265 mm.
HLB01.1D	In drive systems of the Rexroth IndraDrive M product range with a device mounting depth of 322 mm.

Tab. 4-9: DC Bus Resistor Units HLB

4.12 Braking Resistor HLR01

HLR01.1N-xxxx-Nxxx-A-007-NNNN braking resistors convert generated kinetic energy into thermal energy. For this purpose, the line covers a wide range of continuous power and energy absorption capacity.

Type	Usage
HLR01.1**A**	**Type of construction A** (version for device mounting): To be mounted to drive controllers of the Rexroth IndraDrive C product range. For this purpose, the drive controllers must be equipped with a brake chopper.
HLR01.1**N**	**Type of construction N** (version for free assembly): For free assembly in the installation, operated by drive controller of the Rexroth IndraDrive C product range. For this purpose, the drive controllers must be equipped with a brake chopper.

Tab. 4-10: Braking Resistors HLR

Designs of type of construction N:

- Fixed resistor IP 20 **type A**

  Cement-coated, wire-wound, tube-type fixed resistors; screwed on side walls; perforated cover; connections in terminal box with PG gland
- Steel-grid fixed resistor IP 20 **type B**

  Fixed resistor in steel-grid design; connection depending on type
- Steel-grid fixed Resistor IP 20 **type C**

  Fixed resistor in steel-grid design; connection depending on type

4.13 DC Bus Capacitor Unit HLC01

DC bus capacitor units HLC01 store energy in the DC bus of the drive system.

Type	Usage
HLC01.1C	In drive systems of the product ranges Rexroth IndraDrive C and Rexroth IndraDrive M
HLC01.1D	In drive systems of the product ranges Rexroth IndraDrive C and Rexroth IndraDrive M

Tab. 4-11: DC Bus Capacitor Units HLC

4.14 Fan Unit HAB01

HAB01 fan units cool specific HMV01 and HMS01 devices.

Type	Usage
HAB01.1	At HMS01.1N-W0350 drive controllers At HMV01.1R-W0120 supply units

Tab. 4-12: Usage of HAB01 Fan Unit

4.15 Motor Filters HMF01

HMF01 motor filters

- reduce the rise of the output voltage of drive controllers
- reduce leakage currents of the motor lines
- reduce interference voltage on the motor lines

Type	Usage
HMF01.1	At the motor output of HCS drive controllers

Tab. 4-13: Usage of HMF01 Motor Filters

4.16 Accessories HAS

The HAS accessories support the operation and combination of components in the IndraDrive system.

4.17 Housing for Control Sections HAC01

Additional components HAC01 are used to

- insert control sections in them
- supply control sections with 24V control voltage

Type	Usage
HAC01.1-002-NNN-NN	To insert CDB control sections in it

Tab. 4-14: HAC01 Type

4.18 Hall Sensor Box SHL

The additional component SHL is used when the commutation setting of linear motors (e.g., IndraDyn L and LSF) is to be carried out, mechanical movement mustn't take place and the automatic commutation methods of the drive firmware cannot be used.

The drive firmware provides automatic commutation methods which can be used for sophisticated motion tasks.

📖 See also Functional Description of the firmware, index entry "Saturation method" (requires I_{out_max}) and "Sine-wave method" (requires unrestricted movement of the axis).

5 General data and specifications

5.1 Acceptance tests and approvals

Declaration of conformity

Declarations of conformity confirm that the components comply with the valid EN standards and EC directives. If required, our sales representative can provide you with the declarations of conformity for components.

CE	Drive controllers, Supply units	Motors
CE conformity regarding Low-Voltage Directive	EN 61800-5-1:2007	EN 60034-1:2010+Cor.:2010 EN 60034-5:2001+A1:2007
CE conformity regarding EMC product standard	EN 61800-3:2004 + A1:2012	

Tab. 5-1: CE - applied standards

C-UL-US listing

The components are listed by **UL** (Underwriters Laboratories Inc.®).

Proof of certification can be found online. Enter the terms "UL" and "databases" in a search engine to get to the relevant UL web page. With the file number you will find the proof of certification.

c UL US **Listed** **POW. CONV. EQ.** **97Y4**	• UL standard: UL 508C • CSA standard: C22.2 No. 274-13
	Company Name BOSCH REXROTH ELECTRIC DRIVES & CONTROLS GMBH Category Name: Power Conversion Equipment
	File numbers IndraDrive components: • E134201 • E227957 The **control sections** are part of the listed components. The **HAB01.1-0350-1640-NN fan unit** is part of the listed components HMV01.1R-W0210 and HMS01.1N-W0350.

Tab. 5-2: C-UL listing

☞ **UL ratings**

When using the component in the scope of CSA / UL, observe the UL ratings for each component.

Only the following components have been approved in the scope of CSA / UL for supplying HMS, HMD, KCU, KSM, KMS components:

- HMV01.1E
- HMV01.1R
- HMV02.1R
- HCS02.1E
- HCS03.1E

Make sure that the specified **short-circuit current rating SCCR** is not exceeded, e.g. by providing appropriate fuses in the mains connection of the supply unit.

☞ **UL wiring material**

In the scope of CSA / UL, use copper 60/75 °C only; class 1 or equivalent only.

☞ **Allowed pollution degree**

Comply with the allowed pollution degree of the components (see "Ambient and operating conditions").

C-UR-US listing

The components are listed by **UL** (Underwriters Laboratories Inc.®).

Proof of certification can be found online. Enter the terms "UL" and "databases" in a search engine to get to the relevant UL web page. With the file number you will find the proof of certification.

CUR_Zeichen.fh11	• UL standard: UL 1004-1 • CSA standard: Canadian National Standard C22.2 No. 100
	Company Name BOSCH REXROTH ELECTRIC DRIVES & CONTROLS GMBH Category Name: Servo and Stepper Motors - Component
	File numbers MSK, MSM motors: E335445

Tab. 5-3: C-UR listing

☞ **UL wiring material (ready-made Rexroth cables)**

In the scope of CSA / UL, use copper only; class 6 or equivalent only with minimum allowed wire temperature of 75°C.

☞ **Allowed pollution degree**

Comply with the allowed pollution degree of the components (see "Ambient and operating conditions").

CCC (China Compulsory Certification)

The CCC mark is a compulsory certification of safety and quality for certain products mentioned in the product catalog "First Catalogue of Products Subject to Compulsory Certification" and in the CNCA document "Application Scope for Compulsory Certification of Products acc. first Catalogue" and put in circulation in China. This compulsory certification has existed since 2003.

CNCA is the Chinese authority responsible for certification guidelines. When a product is imported in China, the certification will be checked at customs using the entries in a database. Three criteria are typically critical for certification being required:

1. Customs tariff number (HS code) according to CNCA document "Application Scope for Compulsory Certification of Products acc. first Catalogue".
2. Area of application according to CNCA document "Application Scope for Compulsory Certification of Products acc. first Catalogue".
3. For the IEC product standard used, a corresponding Chinese GB-standard must exist.

For the drive components by Rexroth described in this documentation, **certification is currently not required**, so they are not CCC certified. Negative certifications will not be issued.

5.2 Transport and storage

5.2.1 Transporting the components

Ambient and operating conditions for transport

Description	Symbol	Unit	Value
Temperature range	T_{a_tran}	°C	-20 … +70
Relative humidity		%	5 … 95
Absolute humidity		g/m³	1 … 60
Climatic category (IEC 721)			2K3
Moisture condensation			Not allowed
Icing			Not allowed

Tab. 5-4: Ambient and operating conditions for transport

5.2.2 Storing the components

NOTICE **Risk of damage to components from long-term storage!**

Some components contain electrolytic capacitors which may deteriorate during storage.

When storing the following components for a longer period of time, run them **once a year for at least 1 hour**:

- Converters and supply units: Operated with mains voltage U_{LN}
- Inverters and DC bus capacitor units: Operated with DC bus voltage U_{DC}

Ambient and operating conditions - storage

Description	Symbol	Unit	Value
Temperature range	T_{a_store}	°C	-20 … +55
Relative humidity		%	5 … 95
Absolute humidity		g/m^3	1 … 29
Climatic category (IEC721)			1K3
Moisture condensation			Not allowed
Icing			Not allowed

Tab. 5-5: Ambient and operating conditions - storage

5.3 Installation conditions

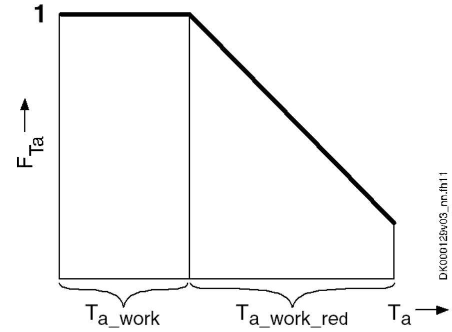
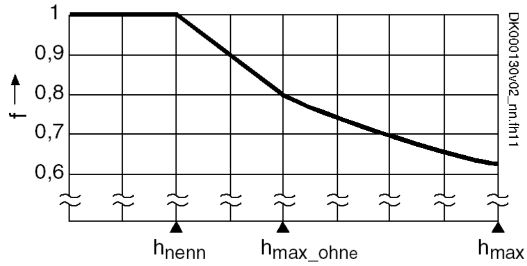
5.3.1 Ambient and operating conditions

Check that the ambient conditions, in particular the control cabinet temperature, are complied with by calculating the heat levels in the control cabinet. Afterwards, make the corresponding measurements to verify that the ambient conditions have actually been complied with.

In the technical data of the individual components, the power dissipation is specified as an important input value for calculating the heat levels.

Ambient and operating conditions (HCS, HMV, HMS, HMD, HCQ, HCT, KCU, HLC, HNF)

Description	Symbol	Unit	Value
Conductive dirt contamination	-	-	Not allowed Protect the devices against conductive dirt contamination by mounting them in control cabinets with the degree of protection IP54 (in accordance with IEC529).
Degree of protection of the device (IEC529)	-	-	IP20
Use within scope of CSA / UL	-	-	For use in NFPA 79 Applications only!
Temperature during storage	-	-	See chapter 5.2.2 "Storing the components" on page 39
Temperature during transport	-	-	See chapter 5.2.1 "Transporting the components" on page 39
Allowed mounting position Definition of mounting positions: See chapter "Mounting positions of components" on page 42	-	-	G1 [3)]
Installation altitude	h_{nenn}	m	1000
Ambient temperature range	T_{a_work}	°C	0 … 40

Description	Symbol	Unit	Value
Derating vs. ambient temperature: The performance data are reduced by the factor F_{Ta} in the ambient temperature range $T_{a\_work\_red}$: $F_{Ta} = 1 - [(T_a - 40) \times f_{Ta}]$ Example: With an ambient temperature T_a = 50 °C and a capacity utilization factor f_{Ta} = 2 %/K, the rated power is reduced to $P_{DC\_cont\_red} = P_{DC\_cont} \times F_{Ta} =$ P_{DC_cont} x (1 - [(50 - 40) x 0.02]) = P_{DC_cont} x 0.8 Operation at ambient temperatures outside of T_{a_work} and $T_{a\_work\_red}$ is not allowed!			
	$T_{a\_work\_red}$	°C	40 … 55
	f_{Ta}	%/K	2.0 Exception HMV02.1R-W0015-A-07-NNNN: 2.7
Derating vs. installation altitude: At an installation altitude h > h_{nenn}, the available performance data are reduced by the **factor f**[2]. At an installation altitude in the range h_{max_ohne} to h_{max}, an isolating transformer has to be installed at the drive system mains connection. Operation above h_{max} is not allowed!			
	h_{max_ohne}	m	2000
	h_{max}	m	4000
Simultaneous derating for ambient temperature **and** installation altitude	Allowed; reduce performance data with the product f × F_{Ta}		
Relative humidity	-	%	5 … 95
Absolute humidity	-	g/m^3	1 … 29
Climatic category (IEC 60721-3-3)	-	-	3K3
Allowed pollution degree (EN 50178)	-	-	2
Resistance to chemically active substances (IEC 60721-3-3)	-	-	Class 3C1
Vibration sine: amplitude (peak-peak) at 10 … 57 Hz [1]	-	mm	0.15
Vibration sine: acceleration at 57 … 150 Hz [1]	-	g	1
Overvoltage category	-	-	III (according to IEC 60664-1)

1) According to EN 60068-2-6
2) Reduced performance data for drive controllers: allowed DC bus continuous power, braking resistor continuous power, continuous current; additionally for HCS01, HCQ, HCT drive controllers: allowed mains voltage

3) Some components can be operated in mounting positions other than G1. The allowed mounting positions are specified in the technical data of the components.

Tab. 5-6: Ambient and operating conditions (HCS, HMV, HMS, HMD, HCQ, HCT, KCU, HLC, HNF)

5.3.2 Mounting position

Mounting positions of components

NOTICE **Risk of damage to the components by incorrect mounting position!**

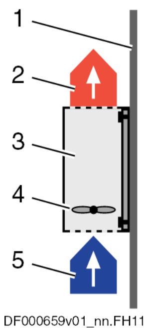
Only operate the components in their allowed mounting positions. The allowed mounting positions are specified in the technical data of the components.

For supply units and drive controllers installed in control cabinets, only the mounting position G1 is usually allowed.

Some components can also be operated in mounting positions other than G1. The allowed mounting positions are specified in the technical data of the component.

Mounting positions

The allowed mounting positions are specified with G1, G2, G3, G4 or G5 in the technical data of the components.

Mounting position	Description
G1	 **Normal mounting position** The air heated inside the component can flow unimpeded vertically upward. In the case of components with integrated fans, the natural convection supports the forced cooling air current. 1. Mounting surface 2. Outgoing, heated air 3. Component 4. Fan within the component (forces the cooling air current) 5. Cooling air
G2	180° to normal mounting position
G3	90° to normal mounting position
G4	bottom mounting; mounting surface on the bottom
G5	top mounting; mounting surface at the top

Tab. 5-7: Mounting positions

5.3.3 Compatibility with foreign matters

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

As it is impossible to follow the continuing development of all materials (e.g. lubricants in machine tools) which may interact with the controls and drives, it cannot be completely ruled out that any reactions with the materials we use might occur.

For this reason, before using the respective material a compatibility test has to be carried out for new lubricants, cleaning agents etc. and our housings/ materials.

5.4 Voltage testing and insulation resistance testing

According to standard, the **components** of the IndraDrive range are tested with voltage.

Testing	Test rate
Voltage testing	100% (EN 61800-5-1)
Insulation resistance testing	100% (EN 60204-1)

Tab. 5-8: Applied standards

5.5 Control voltage (24V supply)

☞ **PELV[1] for 24V power supply unit**

For the 24V supply of the devices of the IndraDrive range, use a power supply unit or a control-power transformer with protection by PELV according to IEC 60204-1 (section 6.4).

In the scope of CSA/UL, the data of the control-power transformer are limited to:

- Max. output voltage: 42.4 V_{peak} or 30 V_{ac}
- Max. output power: 10000 VA

The data in the table below generally apply to the 24V supply of the devices of the IndraDrive range. For other data, such as power consumption and inrush currents, see the technical data for each device.

The specified values apply at the connections (+24V, 0V) to the "24V supply" of the devices!

Description	Symbol	Unit	Value
Control voltage for drive systems **without** operation of **motor holding brakes** in Rexroth motors	U_{N3}	V	**20.4 … 28.8** (24 +20% -15%) When using HMV01.1E, HMV01.1R, HMV02.1R, HLB01.1D supply units: **22.8 … 27.3** (24 -5%, 26 +5%)
Control voltage for drive systems **with** operation of **motor holding brakes** in Rexroth motors	U_{N3}	V	Depending on the motor cable length, the control voltage has to be within the following voltage ranges: • Motor cable length < 50 m: **22.8 … 25.2** (24 ±5%) • Motor cable length > 50 m: **24.7 … 27.3** (26 ±5%) Take the data of the corresponding motor holding brake into account.

1) *Protective Extra Low Voltage*

Description	Symbol	Unit	Value
External control voltage at HCS02 devices of "NNNV" design (see HCS02 type code; other design: DC 24 V power supply from the DC bus and external)	U_{N3}	V	**26 … 28.8** The output voltage of the internal switching power supply unit is 24 ±10%.
Max. ripple content	w	-	The amplitudes of the alternating component on U_{N3} must be within the specified voltage range.
Maximum allowed overvoltage	U_{N3max}	V	33 (max. 1 ms)

Tab. 5-9: Control voltage

Overvoltage

Overvoltage greater than 33 V has to be discharged by the appropriate electrical equipment of the machine or installation.

This includes:

- 24V power supply units that reduce incoming overvoltage to the allowed value.
- Overvoltage limiters at the control cabinet input that limit existing overvoltage to the allowed value. This also applies to long 24V lines that have been run in parallel to power cables and mains cables and can absorb overvoltage by inductive or capacitive coupling.

Applies to all devices except HCS01 and HMV02:

Insulation monitoring impossible

The input 0 V is connected in conductive form to the housing potential. Insulation monitoring at +24 V and 0 V against housing is impossible.

6 Project Planning of Control Voltage (24V Supply)

6.1 General Information

To operate the drive system, supply the devices with control voltage. For the project planning of the 24V supply of the drive system, take the requirements of the devices used into account:

- Voltage and voltage tolerances depending on line lengths and use of holding brake.

  See also chapter 5.5 "Control voltage (24V supply) " on page 43
- Power consumption of the drive controllers with control section and power section
- Power consumption of other components, e.g. holding brakes
- Current carrying capacity of the connections for "looping through"
- Buffering the control voltage supply might possibly be necessary

For the requirements of the supply units and converters, see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → Chapter of the respective device → "Technical Data" → "Basic Data" → table "Data for Control Voltage Supply".

6.2 Selecting the 24V Supply

6.2.1 General Information

The components need the 24V supply for correct operation. At Components of the Rexroth IndraDrive group, the external 24V supply takes place via the connection X13 or via the connections 24V and 0V at the terminal block.

Via these connections, the components are supplied with 24V for

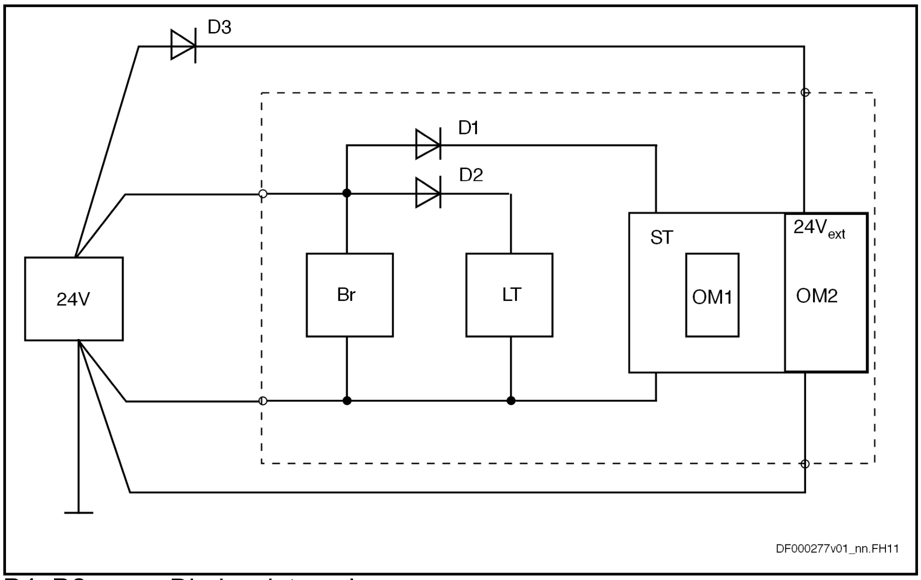
- the power section of the drive controller or supply unit
- brake control via X6
- the control section of the drive controller

In particular, take mains failure situations into account and use power supply units with buffer (UPS), if necessary.

The inputs/outputs of the I/O extensions MA1, MD1 and MD2 are not supplied with voltage via the control section, but have their own connections.

Take the additional power required for these connections into account.

HCS02/HCS03 converters of the **design "-N**V"** have an **integrated 24V supply**. In applications without motor holding brake and with CSB01.1N-FC control section, they can be operated without external 24V supply. Observe the notes on project planning for the mains connection.



D1, D2	Diodes, internal
D3	Protective diode, external
LT	Power section
BR	Circuit motor holding brake
ST	Control section
OM1	Optional modules
OM2	Optional modules with supply voltage connection, e.g. MA1, MD2

Fig. 6-1: Block Diagram of 24V Supply

6.2.2 Electrical Requirements

The following parameters contain the essential electrical requirements on the power supply unit:

- **Output voltage** or range of output voltage
- **Continuous power** which the power supply unit must supply during operation
- **Peak current** which the power supply unit must supply when switching on

Which Output Voltage Must the Power Supply Unit Have?

The output voltage of the power supply unit must have been dimensioned such that the voltage at the input of the devices ("24V supply": 24V; 0V) is within the allowed voltage U_{N3}.

☞ Take into account that due to voltage drops, the output voltage of the power supply unit is lower than the voltage at the devices. Check the voltage at the input of the "24V supply" of the devices.

Use power supply units

- with adjustable output voltage from 24 V to 26 V
- which have been equipped with Sense inputs (this allows compensating for the voltage drops on the line between power supply unit and input "24V supply")

📖 See Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → Chapter of the respective device → "Technical Data" → "Basic Data" → "Data for Control Voltage Supply".

Control voltage when using motor holding brakes!

Depending on the motor cable length, a higher output voltage of the power supply unit is required for operating the motor holding brakes. Observe the data for operating motors with holding brakes (see chapter 5.5 "Control voltage (24V supply) " on page 43).

Which Continuous Power Must the Power Supply Unit Supply?

The continuous power of the power supply unit must be greater than the sum of power consumptions P_{N3} of the components to be supplied.

For the power consumption P_{N3}, see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → Chapter of the respective device → "Technical Data" → "Basic Data" → "Data for Control Voltage Supply".

For the power consumption of the control sections (basic control section circuit board or optional modules), see Project Planning Manual "Rexroth IndraDrive Control Sections" → index entry "Power consumption"

If required, determine the continuous current I_{N3} for selecting the power supply unit:

$I_{N3} = P_{N3} / U_{N3}$

The power consumption is indicated as maximum value of the respective component and can occur at **individual components.**

In drive systems with **several components**, the occurring power consumption under statistical assumptions will be lower than the calculated one.

Experience has shown that the **typical power consumption** of drive systems is at only **approx. 70%** of the calculated maximum value.

Which Peak Current Must the Power Supply Unit Supply?

When switched on, the power supply unit must supply the sum of the occurring inrush currents I_{EIN3} or charges $I_{EIN3} \times t_{EIN3Lade}$.

When the power supply unit is switched on, the power supply unit is loaded with the charging current to the capacitors of the 24V supply input of the connected devices. An electronic circuit in each drive controller limits this charging current to the value I_{EIN3}.

For the data of the inrush current I_{EIN3} and its pulse width $t_{EIN3Lade}$ for the individual devices, see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → Chapter of the respective device → "Technical Data" → "Basic Data" → "Data for Control Voltage Supply".

The occurring charging process $I_{EIN3} \times t_{EIN3Lade}$ is controlled by power supply units with **integrated dynamic current limitation**, if the power supply units allow the 1.2-fold continuous current for at least 1 second. Therefore, use power supply units with integrated dynamic current limitation the continuous power of which is at least 20% above the determined sum of power consumptions P_{N3}.

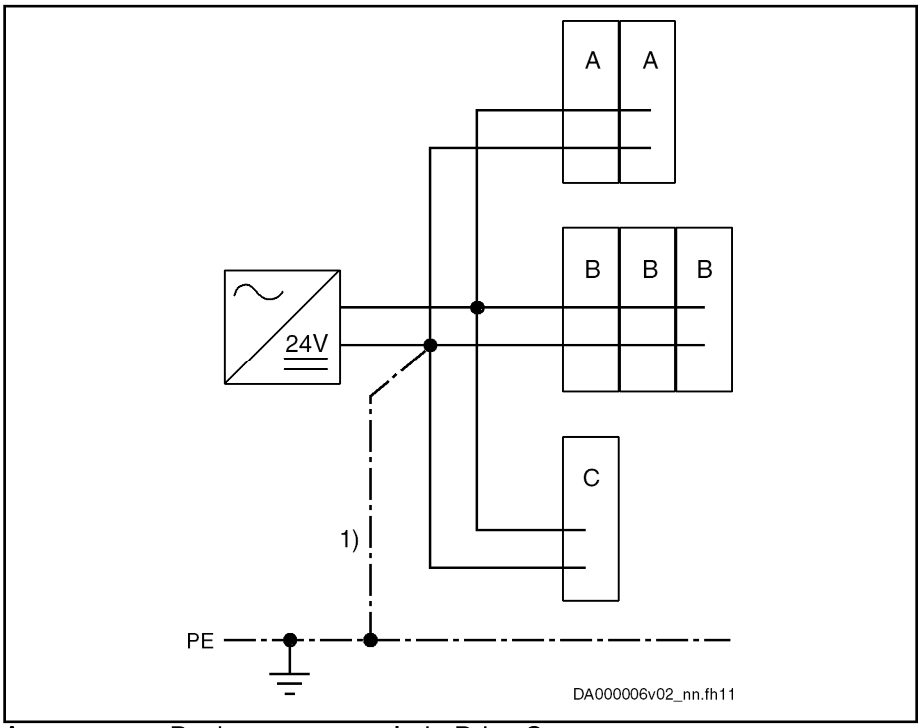
Power supply units with buffer (UPS)

For HMV supply units, use 24 V supplies with buffer times of at least 100 ms (e.g. UPS), if commutation drops and short-time interruptions in the application exceed the specified values.

For the 24V supply, take notes on project planning of the mains connection into account (see chapter 7 "Project planning of mains connection" on page 51).

6.3 Installing the 24V Supply

As a matter of principle, the 24V supply of the devices of the drive system IndraDrive has to be designed in star-shaped form, i.e. for each group of drive controllers or third-party components it is necessary to run separate supply lines. This, too, applies to multiple-line arrangement in the case of supply from a supply unit, for example.



A	Device group, e.g. IndraDrive C
B	Device group, e.g. IndraDrive M
C	Third-party component (e.g. PLC, valve etc.)
1)	Connection to central ground point (e.g. earth-circuit connector)

Fig. 6-2: Installing the 24V Supply

If you use several power supply units for 24 V supply:

- Interconnect reference conductors 0 V of the individual power supply units with low impedance
- The output voltages of the power supply units must be within the allowed voltage range.
- Switch the power supply units on and off synchronously.

Reduce load-dependent voltage drops by using lines with sufficiently dimensioned line cross sections.

Chronological Order of 24V Supply and Mains Voltage

Before mains voltage or DC bus voltage is applied to the devices, they have to be supplied by the 24V supply.

In this context, observe the chapter 9 Circuits for the mains connection, page 125.

6.4 Looping Through the Control Voltage Supply

NOTICE **Property damage in case of error caused by too small line cross section!**

Make use of the contact bars provided to loop-through and observe the current carrying capacity of the connections for 24V supply at the devices used (see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → "Terminal Block, 24 - 0V (24V Supply)" and "X13, Control Voltage").

At the drive controllers, the 24V supply is looped through via contact bars from one device to the next (for HCS02, HLB01.1C and HLC01.1C via lines at X13).

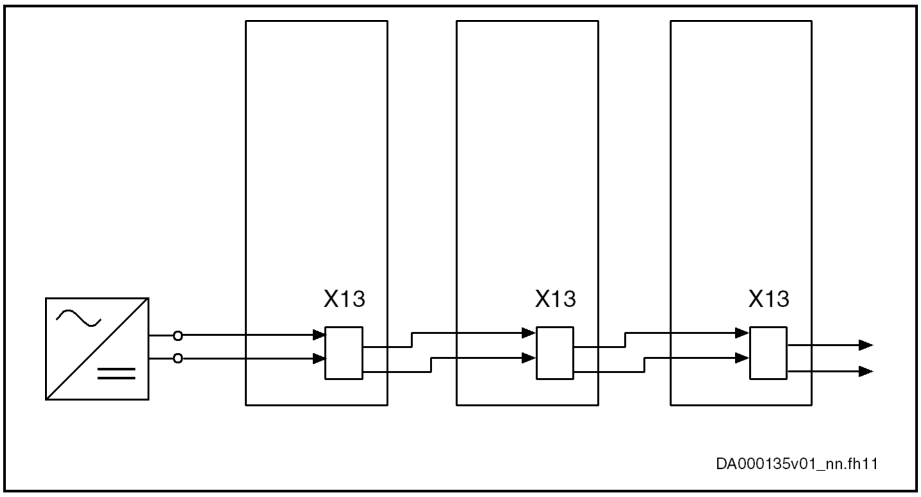


Fig. 6-3: Looping Through the Control Voltage, Example HCS02.1E-W0012

Exemplary calculation for 3 drive controllers:

$$I_D = 3 \times \frac{P_{N3}}{U_{N3}}$$

Fig. 6-4: Continuous Current

The result I_D must be smaller than the specified current carrying capacity of the connection point.

Looping through at HCS02

The current carrying capacity of X13 at HCS02 is only suited for looping through low currents. Limit the looping through to loads with low power consumption, such as HCS02.1E-W0012 with CSB01.1N-FC and additional components HLB01.1C.

Inrush current I_{EIN}

When connecting the control voltage source to the connection point for 24V supply, a higher inrush current I_{EIN} will flow for the specified duration $t_{EIN3Lade}$.

The inrush current is increased with every additional drive controller.

7 Project planning of mains connection

7.1 General information

To supply the drive system with power, it is connected to the local supply mains via the mains connection. For the project planning of the mains connection, observe the requirements of the supply mains and of the devices used.

The essential requirements are:

- Mains voltage U_{LN} (depending on mains type) with mains frequency f_{LN}, number of phases and rotary field
- Mains connected load S_{LN}, mains short-circuit power S_{k_min} and system impedance
- Short-circuit current I_{SCCR}, particularly when used in the scope of C-UL
- Mains circuit breakers and mains contactor
- Protection systems that can be used, such as residual-current-operated circuit-breakers and insulation monitoring devices

7.2 Mains voltage supply

☞ **Permanent mains connection**

A permanent connection to the power grid is required for IndraDrive controllers.

☞ Make sure that **all** components participating in the mains connection are operated in their allowed voltage ranges.

Description	Symbol	Unit	Value of the respective component
Short circuit current rating (UL)	SCCR	A rms	See chapter 7.4.2 "Mains Short-Circuit Power" on page 58
Nominal mains voltage	U_{LN_nom}	V	Reference value for performance data, for example
Mains voltage, single-phase	U_{LN}	V	Voltage of mains must be within the specified voltage range.
Mains voltage at **TN-S, TN-C, TT mains**1)			Phase-to-phase voltage of mains has to be within the specified voltage range; otherwise, use **matching transformer**.
Mains voltage at **IT mains**1)			Phase-to-phase voltage of mains has to be within the specified voltage range; otherwise, use **isolating transformer with grounded neutral point**.
Mains voltage at mains **with grounded outer conductor**1)			
🕮 For the data of the individual devices, see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → chapter of the respective device → "Technical data" → "Basic data" → table "Mains voltage supply data".			
In TN-S, TN-C, TT, IT mains type and mains grounded via outer conductor:			
Rotary field			No rotary field condition
Allowed range of mains frequency	f_{LN}	Hz	(50…60) ±2

Description	Symbol	Unit	Value of the respective component
Maximum allowed mains frequency change	$\Delta f_{LN} /t$	Hz/s	$2\% \times f_{LN}$
Maximum allowed voltage unbalance according to IEC 61000-2-4, class 3			3%
Maximum allowed voltage dips on the mains voltage according to IEC 60146-1-1 - class 3			40% of the mains amplitude; Voltage dip should not exceed 250% × degrees (see diagram " Maximum allowed voltage dips in % of the mains voltage, page 52")
Maximum allowed THD according to IEC 61000-2-4, class 3			10%
Short-time interruptions			n.s., see section " Notes on project planning, short-time interruptions, page 52"

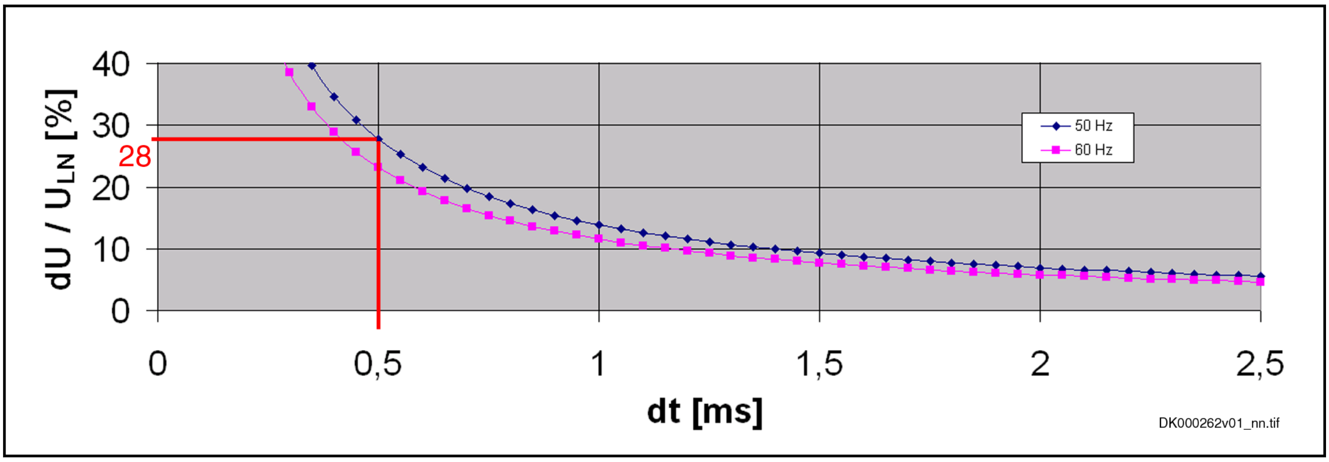
1) Explanations: See chapter 7.3 "Mains types" on page 54

Tab. 7-1: Standard range of power voltage

Allowed voltage dip

The curves in the figure show the relation between duration and allowed relative value of voltage dips with mains frequencies of 50 Hz and 60 Hz.

$$dt \times f_{LN} \times dU/U_{LN} \times 360^\circ \approx 250\% \times {}^\circ$$



dt Duration of voltage dip
dU/U_{LN} Relative voltage dip
f_{LN} Mains frequency
U_{LN} Mains voltage

Fig. 7-1: Maximum allowed voltage dips in % of the mains voltage

How to read the example:

Mains frequency f_{LN} = 50 Hz and duration of voltage dip dt = 0.5 ms

⇒ maximum allowed voltage dip: 28% of applied mains voltage U_{LN}

Notes on project planning, "short-time interruptions"

The drive system is used for energy conversion and a voltage dip is a loss of available energy.

The effect of the voltage dip (energy reduction) on the process cannot be determined without detailed knowledge of the respective process. The effect is a system and rating aspect and generally will be greatest when the power demand (including the losses) of the drive system is greater than the available power.

In the case of a voltage dip on the mains, the voltage in the DC bus can be reduced. This can cause the drive system to be cut off the mains when voltage falls below certain levels and certain times are exceeded. When voltage returns, the drive system has to be reactivated in order to continue operation.

Notes on project planning, "installation altitude"

If connection to the power grid is permanent and stationary in an industrial environment (subsequent to the main distribution board), there are no overvoltage limitation measures required up to an installation altitude of 2000 m (h_{max_ohne}; see chapter 5.3 "Installation conditions" on page 40). Installation altitudes of more than 2000 m to a maximum of 4000 m require an isolating transformer as the overvoltage limitation measure.

Notes on project planning, "overvoltages"

Overvoltages at the devices can occur due to

- inductive or capacitive coupling on lines
- lightning strikes

Use overvoltage arrestors (e.g., varistors) at the machine or installation if the overvoltages at the devices are greater than the maximum allowed overvoltages.

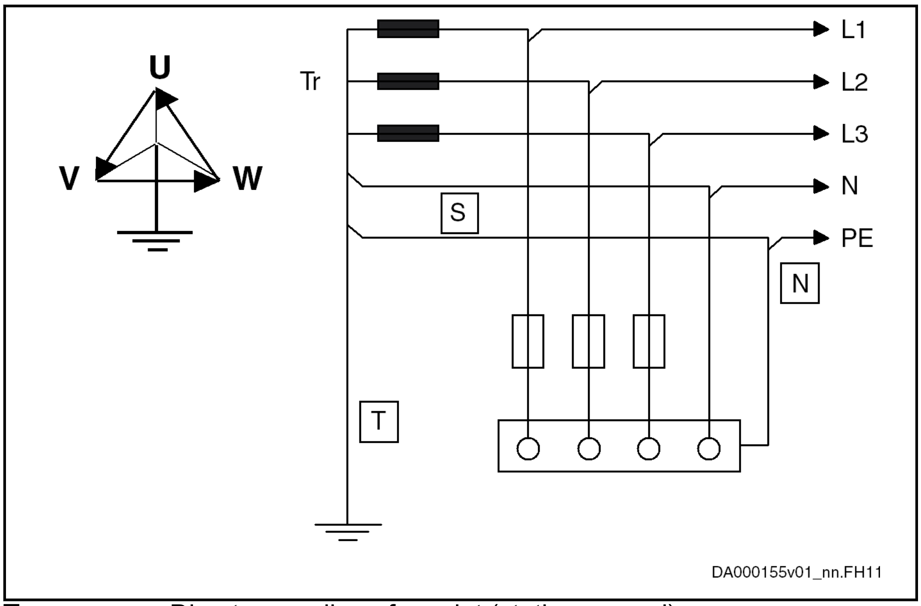
Use the overvoltage arrestors at long lines of the drive system run through the building in parallel with power and mains cables.

Electrically place the overvoltage arrestors as near as possible to the point of entrance of the lines at the control cabinet.

7.3 Mains types

7.3.1 TN-S mains type

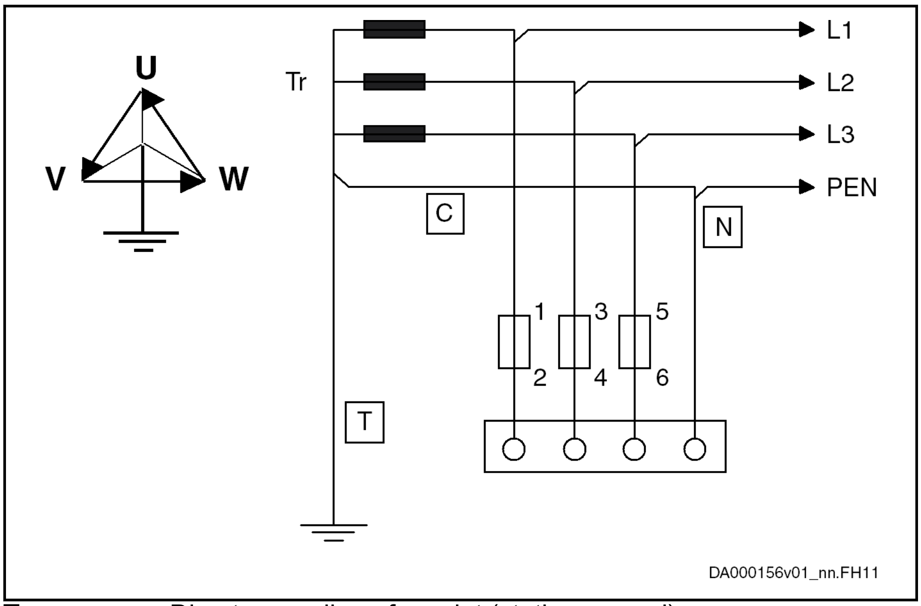
The TN-S mains type is the usual mains type in Europe.



T =	Direct grounding of a point (station ground)
N =	Exposed conductive parts directly connected to station ground
S =	Separate neutral conductor and equipment grounding conductor in entire mains

Fig. 7-2: TN-S mains type

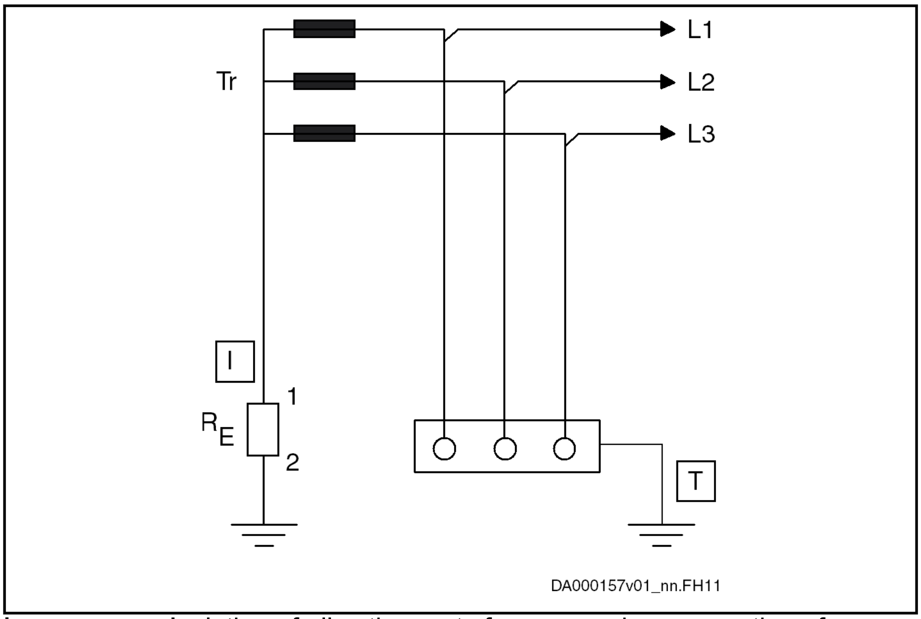
7.3.2 TN-C mains type



T =	Direct grounding of a point (station ground)
N =	Exposed conductive parts directly connected to station ground
C =	Neutral conductor and equipment grounding conductor functions in entire mains combined in a single conductor, the PEN conductor.

Fig. 7-3: TN-C mains type

7.3.3 IT mains type



I	Isolation of all active parts from ground or connection of one point to ground via an R_E impedance
T	Exposed conductive parts directly grounded, independent of grounding of current source (station ground)

Fig. 7-4: IT mains type

Notes on project planning

NOTICE **Risk of damage to the devices by voltage flashovers!**

For applications with static charging (e.g., printing, packaging) and operation at **IT mains type**, use an **isolating transformer** with $U_K \leq 2.5\%$.

NOTICE **Risk of damage to the devices by voltage increase in the case of ground fault!**

If a "ground fault" occurs in the IT mains type, the voltages against ground (device housing) acting on the device are higher than in error-free operation.

For operation on the IT mains type, the drive system including mains filter and mains choke should be electrically separated from the mains by an **isolating transformer**.

In this way, the ground fault detection or monitoring can remain effective in the system.

☞ Do not operate **HCS03** drive controllers at IT mains types.

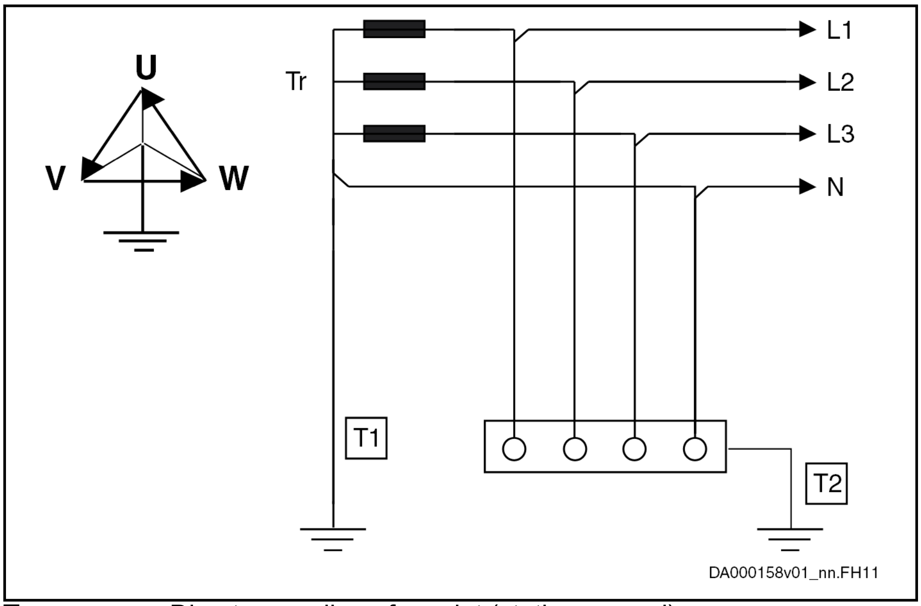
When operating IndraDrive C (HCS02) drive systems in other applications **without isolating transformer** at the IT mains type:

- Observe the permitted mains voltage U_{LN} on the IT mains type of each device
- Observe the permitted switching frequency f_s; see note below

- Check whether the ground fault detection of the mains does not trigger accidentally
- Check whether the interference suppression (that is only activated via the parasitic mains capacitances of the ungrounded mains) is still sufficient to observe the required limit values

  The EMC requirements are only complied with by additional measures (such as specific mains filters)!

7.3.4 TT system

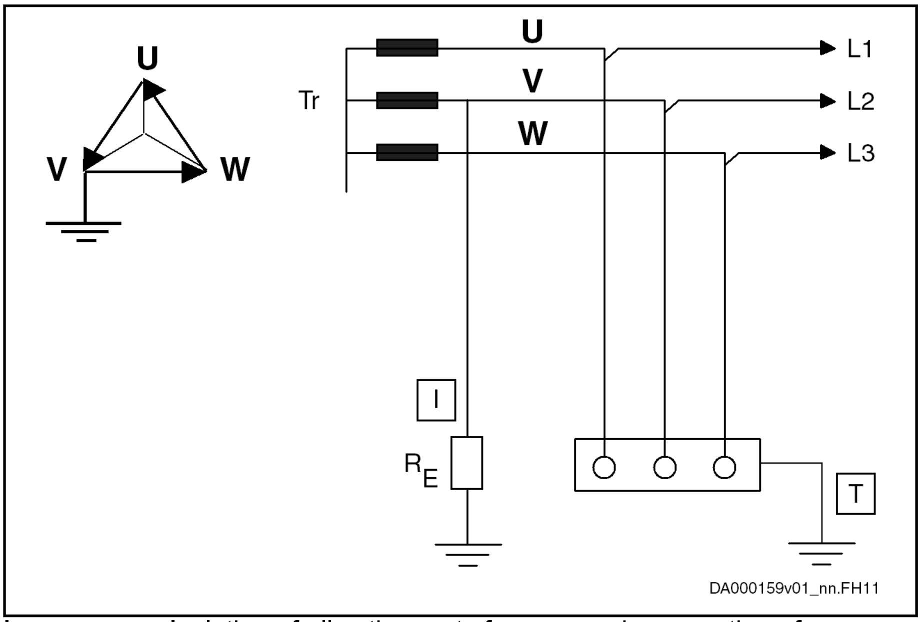


T =	Direct grounding of a point (station ground)
T =	Exposed conductive parts directly grounded, independent of grounding of current source (station ground)

Fig. 7-5: TT mains system

The EMC requirements are only complied with by specific measures (such as specific mains filters).

7.3.5 Mains with grounded outer conductor (Corner-grounded delta mains)



I =	Isolation of all active parts from ground, connection of one phase - generally phase V - to ground or via an impedance R_E
T =	Exposed conductive parts directly grounded, independent of grounding of current source (station ground)

Fig. 7-6: Mains with grounded outer conductor

Notes on project planning

- Observe the allowed mains voltages.
- The EMC requirements are only complied with by specific measures (such as specific mains filters).

☞ **HNF01, HNS02, NFD mains filters on mains grounded with outer conductor**

HNF01, HNS02 or NFD03.1 mains filters are not suited for operation on mains grounded with outer conductor. Use isolating transformers.

Allowed mains connection voltage: see technical data for each device

---

7.4 Mains short-circuit power and mains connected load

7.4.1 General information

Apart from the mains connected load, observe the following corridor of the mains short-circuit power for the mains connection:

- **Minimum required mains short-circuit power** (mains connected load) for interference-free operation

  The smaller the mains short-circuit power, the greater the mains pollution due to the load current with harmonics on the supply voltage of the device. This can disturb both the device and other devices at the same mains node.

  Minimum mains short-circuit power is required to limit mains pollution and to have sufficiently high voltage for realizing the drive performance.

- **Maximum allowed mains short-circuit power** (for device protection)

  The higher the mains short-circuit power, the greater the short-circuit currents occurring in the case of error.

  Use mains chokes to limit the short-circuit currents in the case of high mains short-circuit power S_k. .

☞ Explanations on the short designations used: See chapter 15.2 "Calculations for the mains connection" on page 248

7.4.2 Mains Short-Circuit Power

Definition of Mains Short-Circuit Power

Power at nominal voltage U_N between the phases and the maximum mains short-circuit current I_K at the connection point:

$$S_k = \sqrt{3}\, U_N \times I_k$$

S_k	Short-circuit power of the mains
I_k	Short-circuit current
U_N	Mains voltage

Fig. 7-7: Mains Short-Circuit Power

☞ For the mains short circuit power of the point of supply, ask your local power supply company.

Definition of Mains Short-Circuit Current

The mains short-circuit current I_K results in the case of a short circuit at the point of power supply connection.

$$I_k = \frac{U_N}{\sqrt{3} X_k}$$

X_K	System impedance
U_N	Mains voltage

Fig. 7-8: Mains Short-Circuit Current

☞ **UL requirement "maximum short-circuit current SCCR"**

In the scope of CSA/UL, devices with C-UL listing may only be operated at mains nodes with a symmetrical short-circuit current smaller than the indicated value SCCR.

For the SCCR value, see the technical data of the device.

If necessary, use mains chokes to increase the system impedance and reduce the short-circuit current.

SCCR = I_K

Mains Classes According to Short-Circuit Power

We basically distinguish mains classes graded according to mains short-circuit power and system impedance:

		U_N = 400 V		U_N = 480 V	
Classification	S_k	X_k	L_k	X_k	L_k
	MVA	mOhm	µH	mOhm	µH
1 Rigid mains	200	0,80	2,55	1,15	3,67
	150	1,07	3,40	1,54	4,89
	100	1,60	5,09	2,30	7,33
	50	3,20	10,19	4,61	14,67
2 Semi-rigid mains	40	4,00	12,73	5,76	18,33
	30	5,33	16,98	7,68	24,45
	20	8,00	**25,46**	11,52	36,67
	15	10,67	33,95	15,36	48,89
	10	16,00	50,93	23,04	73,34
	5	32,00	101,86	46,08	146,68
	4	40,00	127,32	57,60	183,35
3 Non-rigid mains	3	53,33	169,77	76,80	244,46
	2	80,00	254,65	115,20	366,69
	1	160,00	509,30	230,40	733,39
	0,6	266,67	848,83	384,00	1222,31

S_k Short-circuit power of the mains
X_K System impedance
L_k Inductance of mains phase

Tab. 7-2: Mains Classified According to Mains Short Circuit Power and Mains Internal Resistance

---

☞ **Minimum inductance**

The specified minimum inductances protect the drive controllers (especially the DC bus capacitors) during operation at mains with low impedance and high mains short-circuit power.

Use mains chokes at mains with $L_k < L_{min}$.

Example:

U_N = 400 V; S_K > 20 MVA; L_k = 25.46 µH

Data L_{min} of drive controller in technical data: 40 µH

$L_k < L_{min}$: Use of assigned mains choke is required.

7.4.3 Mains connected load

Definition of mains connected load

The drive system loads the mains with active power and reactive power, both together make the so-called apparent power. At the mains connection, the apparent power of the drive system is the mains connected load.

The mains connected load is calculated from the planned power in the DC bus P_{DC} and the power factor (cosφ with sinusoidal mains current and TPF with non-sinusoidal mains current):

$$S_{LN} = \frac{P_{DC}}{TPF}$$

S_{LN} Mains connected load in VA
P_{DC} DC bus continuous power in W
TPF Total Power Factor λ

Fig. 7-9: Calculating the mains connected load

For the data of the **TPF**, see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → chapter of the respective device → "Technical data" → "Basic data" → table "Mains voltage supply datag".

Maximum allowed connected load at the mains

The maximum allowed connected load at the mains depends on the allowed distortion of the mains voltage due to the load current with harmonics (mains pollution). The distortion is described by the total harmonic distortion (THD) of the mains current (see chapter 15 "Calculations" on page 235).

To limit the distortion of the mains voltage, take the mains short-circuit ratio R_{SC} (ratio of the source) into account:

$$R_{sc} = \frac{I_k}{I_{1N}} = \frac{S_k}{S_A} = \frac{S_k}{\sum S_{LN}}$$

I_k Mains short-circuit current
I_{1N} Fundamental wave of nominal current of all loads at connection point
S_k Mains short-circuit power
S_A Connected load of all electric loads at connection point (apparent power of fundamental wave)
ΣS_{LN} Sum of mains connected loads of the supply units or converters

Fig. 7-10: Mains short-circuit ratio

The following table is used for a first **estimation** of the maximum allowed connected load S_A at the point of power supply connection in low-voltage mains at known mains short-circuit power S_K. The table does not replace the described "selecting mains connection components" procedure (see "Selecting mains connection components" on page 62).

		R_{sc} = 250	R_{sc} = 200	R_{sc} = 100	R_{sc} = 50
Classification	S_k	S_A	S_A	S_A	S_A
	MVA	kVA	kVA	kVA	kVA
1 Rigid mains	200	800	1000	2000	4000
	150	600	750	1500	3000
	100	400	500	1000	2000
	50	200	250	500	1000

		R_{sc} = 250	R_{sc} = 200	R_{sc} = 100	R_{sc} = 50
Classification	S_k	S_A	S_A	S_A	S_A
2 Semi-rigid mains	40	160	200	400	800
	30	120	150	300	600
	20	80	100	200	400
	15	60	75	150	300
	10	40	50	100	200
	5	20	25	50	100
	4	16	20	40	80
3 Non-rigid mains	3	12	15	30	60
	2	8	10	20	40
	1	4	5	10	20
	0.6	2.40	3	6	12

R_{sc} Mains short-circuit ratio
S_k Mains short-circuit power
S_A Connected load of all electric loads at connection point (apparent power of fundamental wave)

Tab. 7-3: Maximum allowed connected load

Measures for compliance with allowed THD or distortion factor

The following mains connections are distinguished for **public** mains:

- Mains connections with **I ≤ 16 A** (EN 61000-3-2):

  With an R_{sc} ≥ 1000, the allowed mains current distortion normally is not restricted (according to EN 61000-3-2).

- Mains connections with **I > 16 A**;**I < 75 A** (EN 61000-3-12; **I > 75 A** not defined by any standard at present):

  The power supply company determines the restrictions. Unless there are other values available, the following data can be considered as guide values.

R_{sc}	Allowed THD of mains current	Allowed distortion factor of mains current
≥ 1000	THD > 48%	K > 45%
≥ 120	THD ≤ 48%	K ≤ 45%
> 33	THD < 13%	K < 12%

Tab. 7-4: Allowed THD / distortion factor with given R_{sc} of the mains (U < 600 V)

Measures to comply with the maximum allowed THD or distortion factor:

- Use of mains chokes
- Use of supply units with incorporated power factor correction PFC

☞ The following fact applies to the mains choke: The higher the inductance of the mains choke, the lower the TDH / distortion factor and the mains pollution.

The THD values specified in the table below can be obtained under the following conditions:

- Supply unit operated with nominal power
- Operation with constant load
- Low degree of voltage distortion at the point of power supply connection at which the supply unit has been connected (according to EN 61000-2-4, compatibility level in accordance with class 2)

Device type	Achievable THD of mains current	Achievable distortion factor of mains current	Supply unit or drive controller with and without mains choke	
All devices	THD ≥ 50%	K ≥ 60%	HMV01.1E HMV02.1E HCS03.1 HCS02.1	without
Devices with mains choke	THD < 48%	K < 45%	HMV01.1E HCS03.1 HCS02.1	HNL01.1
Devices with Power Factor Control (PFC)	THD < 13%	K < 12%	HMV01.1R HMV02.1R	HNL01.1 HNL02.1

Tab. 7-5: Achievable THD / distortion factor for drive controllers

☞ The allowed distortion factors can be achieved with the specified combinations of drive controller and mains choke.

📖Observe the assignment of mains choke to drive controller in the Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → chapter of the respective device → "Technical data" → "Basic data" → table "Mains voltage supply data".

For detailed information on the emitted harmonics, see this Project Planning Manual in the chapter 15.2.3 Calculations for the mains harmonics, page 249.

Selecting mains connection components

Procedure for selecting the required mains supply units and, if necessary, mains choke:

1. Determine maximum current of mains connection at place of destination of application.
2. Determine mains short-circuit power S_k of mains at place of destination of application (ask power supply company).
3. Determine sum of connected loads S_A.
4. Determine ratio R_{sc}.
5. Read allowed THD or distortion factor K of mains current at place of destination of application from table "Allowed THD...".
6. Select appropriate mains supply unit and HNL mains choke from table "Achievable THD...".

7.5 Protection systems at the mains connection

7.5.1 General information

Protection against contact always depends on the type and structure of the power grid and the mains conditions. For project planning of an installation, the typical behavior of the devices and power grids should always be taken into account.

For protection against contact (indirect contact) in a machine or installation in which a drive system is used, the overcurrent protective device normally used is one with protective grounding according to IEC 60204-1 and IEC 61800-5-1. This is also specified in UL 508C (Industrial Control Equipment) for North America. Housing cover or encapsulation by closed housing is used as protection against direct contact with live conductors.

7.5.2 Protective grounding

General information

⚠ CAUTION **High contact voltage in case of error caused by too long disconnecting time of mains circuit breaker!**

Select the mains circuit breaker such that the disconnecting time in the case of error (short circuit or ground fault) is shorter than 5 s according to EN 60204-1 (Annex A.1).

Keep the fault loop impedance[1)] of the electrical equipment (machine, installation) as low as possible so that, in the case of error, the circuit breaker can trigger within the specified disconnecting time.

Overcurrent protection here is implemented in the form of fuses or overcurrent release devices (circuit breakers, motor circuit breakers) installed at the mains connection. For details see figure.

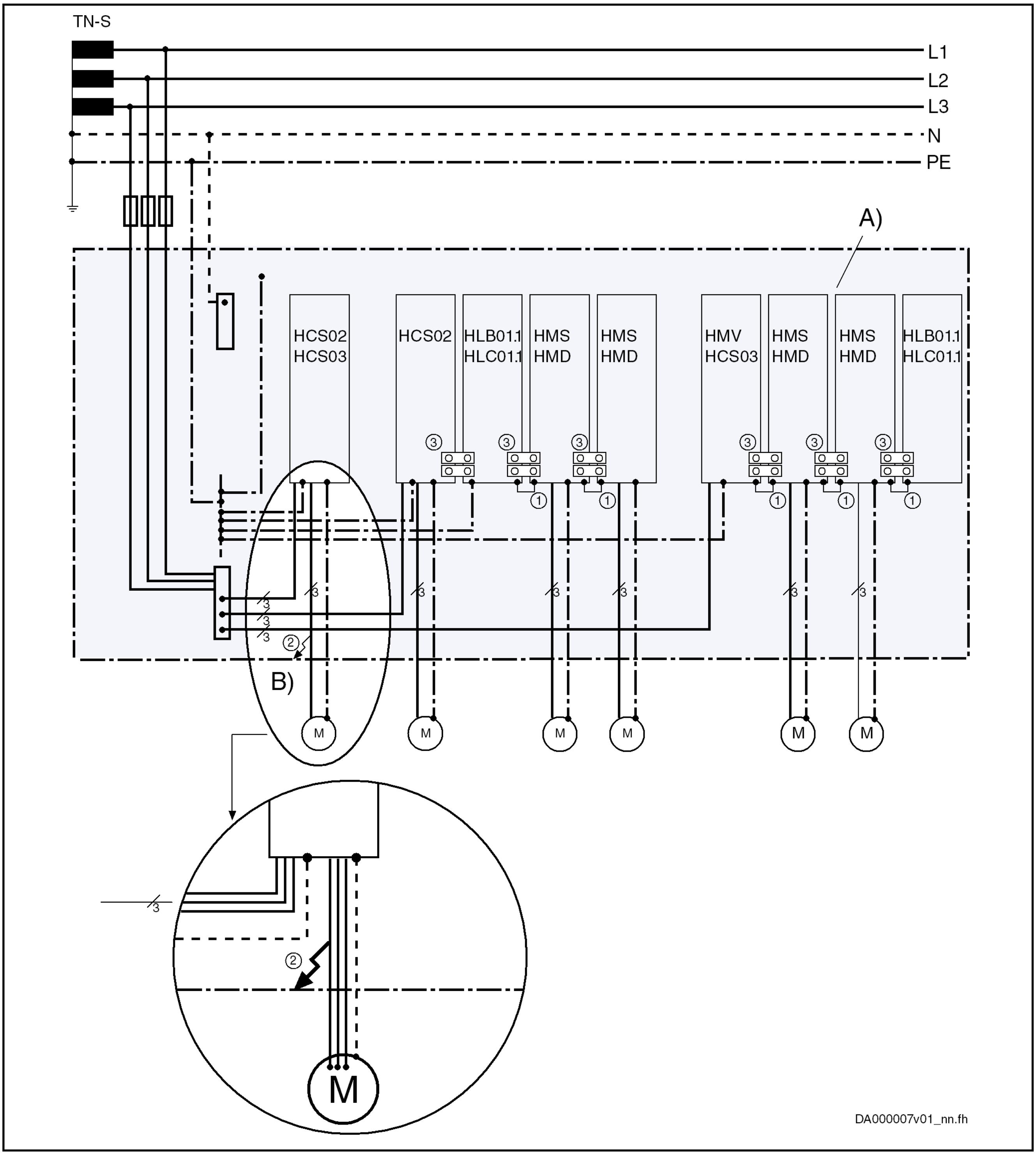
Overcurrent protection generally is sized or set with a release current of 1.3 × nominal current of the loads connected to this connection point.

In the case of an insulation error or a connection between mains phase and device housing connected to the equipment grounding conductor, the drive is disconnected from the mains.

☞ For dimensioning the fuses, comply with these data: See chapter 15.3.4 "Mains Contactor and Fusing " on page 254

1) *__Fault loop impedance__ is the cumulative impedance from the current source via the active conductors to the fault location and back to the current source via the equipment grounding conductor (see EN 60204-1, Annex A.2). The fault loop impedance must be determined either by means of calculation or by means of measurement. Line lengths and the line cross sections have an influence on the fault loop impedance.*

Fusing by protective grounding in TN-S mains



A) Control cabinet
B) Error
① Joint bar of equipment grounding conductor
② Aim of protective measures: Contact voltage < 50 V at housing
③ DC bus connection L+/L-

Fig. 7-11: Protection against contact by protective grounding with overcurrent protection device in TN-S mains

HCS02

NOTICE **Risk of fire caused by missing fuses!**

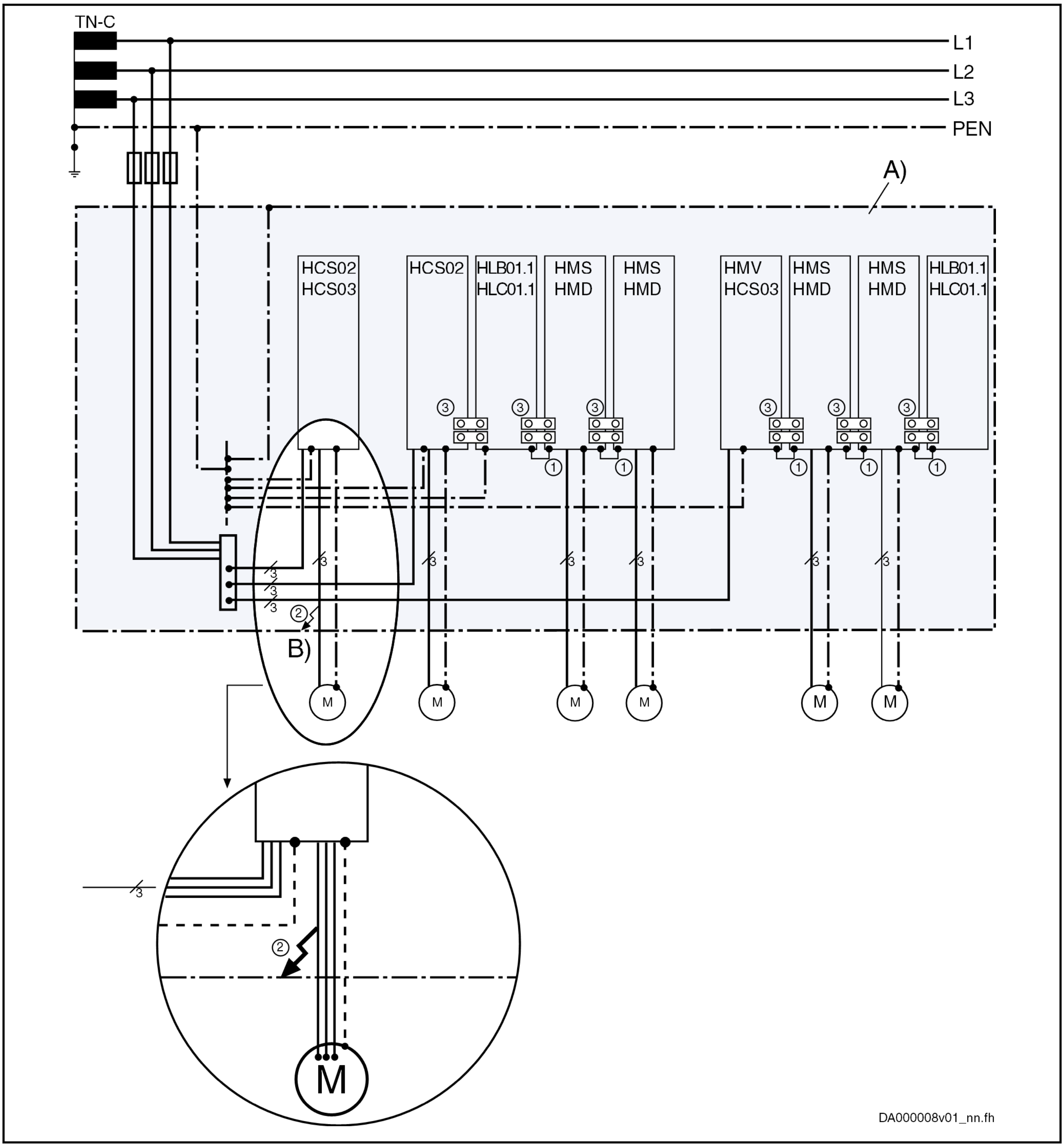
Install a fuse **before each drive controller**. In case a short circuit occurs in the drive controller, a fuse provides optimum safety against overheating or fire (see also IEC 61800-5-1 and UL 508C).

For distribution in North America, single fuses are required for this type of mains connection (see UL 508A).

In the scope of international and European standards (IEC/EN, not North America), it is allowed to use a group fuse instead of the single fuses. When selecting the nominal current of the group fuse, observe the loop impedance, the line length and the line cross section of the mains supply feeder (see IEC 60204-1, chapter Appendix A).

Observe the data for dimensioning line cross sections and fuses (see also IEC 60204-1, UL 508A and NFPA 79).

Fusing by protective grounding in TN-C mains



A) Control cabinet
B) Error
① Joint bar of equipment grounding conductor
② Aim of protective measures: Contact voltage < 50 V at housing
③ DC bus connection L+/L-

Fig. 7-12: Protection against contact by overcurrent protection device in TN-C mains

HCS02

NOTICE	Risk of fire caused by missing fuses!

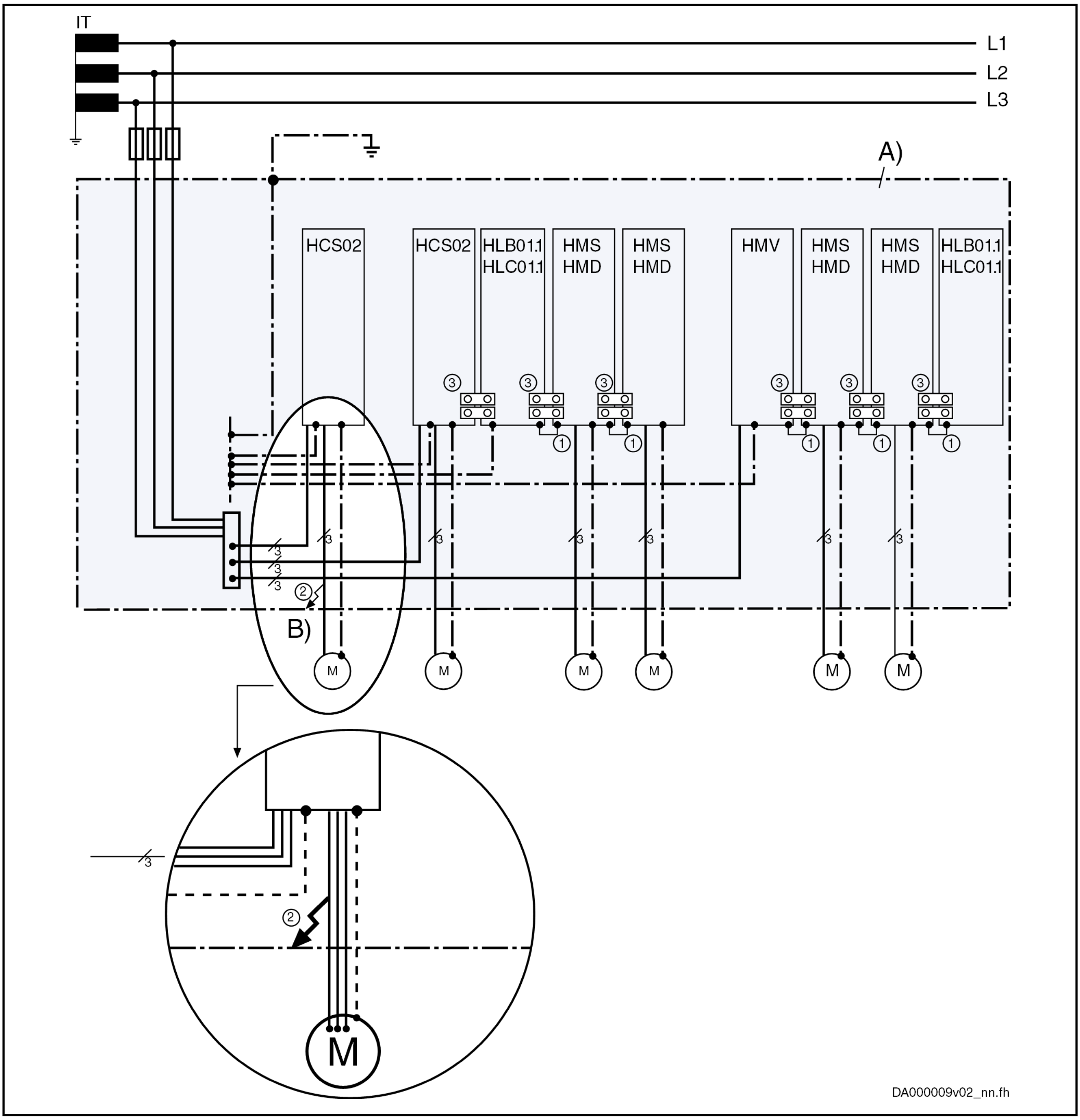
Install a fuse **before each drive controller**. In case a short circuit occurs in the drive controller, a fuse provides optimum safety against overheating or fire (see also IEC 61800-5-1 and UL 508C).

For distribution in North America, single fuses are required for this type of mains connection (see UL 508A).

In the scope of international and European standards (IEC/EN, not North America), it is allowed to use a group fuse instead of the single fuses. When selecting the nominal current of the group fuse, observe the loop impedance, the line length and the line cross section of the mains supply feeder (see IEC 60204-1, chapter Appendix A).

Observe the data for dimensioning line cross sections and fuses (see also IEC 60204-1, UL 508A and NFPA 79).

Fusing by protective grounding in IT mains (ungrounded mains)



A)	Control cabinet
B)	Error
①	Joint bar of equipment grounding conductor
②	Aim of protective measures: Contact voltage < 50 V at housing
③	DC bus connection L+/L-

Fig. 7-13: Protection against contact by overcurrent protection device in IT mains

7.5.3 Connection for the equipment grounding conductor

General information

⚠ WARNING **Lethal electric shock when touching the housing caused by faulty connection of equipment grounding conductor!**

Observe the mentioned notes on installation in any case, in order to exclude danger by electric shock when touching the housing, even in case an equipment grounding conductor connection is broken.

Equipment grounding connection between the components

Observe the notes on installation.

See chapter 13.1.4 "Connection Point of Equipment Grounding Conductor and Equipment Grounding Connections" on page 209).

Connecting equipment grounding conductor to mains

According to the standard "Adjustable speed electrical power drive systems" (IEC 61800-5-1, chapter 4.3.5.5.2), a **stationary connection** of the equipment grounding conductor is required and one or more of the following requirements have to be complied with:

- Cross section of equipment grounding conductor at least 10 mm^2 (reason: sufficient mechanical stability required)
- Mains and power supply automatically cut off when equipment grounding conductor interrupted (case of error)
- Routing of a second equipment grounding conductor, via separate terminal connectors, with the same cross section as the first equipment grounding conductor. Mounting of an additional terminal connector for this equipment grounding conductor.

7.5.4 Residual-current-operated circuit breakers (RCD, RCCB) as additional fusing

General information

The following designations are used for residual-current-operated circuit breakers:

- RCCB (Residual-Current-Operated Circuit Breaker)
- RCD (Residual-Current-Operated Device)
- RCM (Residual-Current Monitoring Device)
- Earth-leakage circuit breaker (voltage-independent)
- Residual-current circuit breaker (voltage-dependent)

☞ It is only to a limited extent that residual-current-operated circuit breakers can be used with IndraDrive systems.

If these circuit breakers are to be used, the company erecting the installation has to check the mutual compatibility of the residual-current-operated circuit breakers and installation or machine with the drive system, in order to avoid accidental triggering of the residual-current-operated circuit breaker. This has to be taken into account

- for switch-on processes, due to high asymmetric inrush currents and

- during operation of the installation, due to leakage currents produced in normal operation.

Cause of leakage currents

For the purpose of stepless speed variation with a high degree of positioning accuracy and dynamic response, certain modulation procedures are necessary for drive systems. For physical reasons, these modulation procedures give rise to inevitable leakage current produced during normal operation. Especially with unbalanced loads of the mains phases or a large number of drives it can easily reach some amperes (rms value).

The leakage current is not sinusoidal but pulse-shaped. For this reason, measuring instruments normally sized for alternating currents in the range of 50 Hz are not suited. Use measuring instruments with rms value measuring ranges.

The degree of leakage current depends on the following features of the installation:

- Type of inrush current limitation
- Number, type and size of drives used
- Length and cross section of connected motor power cables
- Grounding conditions of the mains at the site of installation
- Unbalance of the three-phase network
- Types of filters and chokes connected in the incoming circuit
- EMC measures that are taken

If measures are taken to improve the electromagnetic compatibility (EMC) of the installation (mains filters, shielded lines), the leakage current in the ground wire is inevitably increased, especially when switching on or in the case of mains unbalance. Given these operating conditions, residual-current-operated circuit breakers can trigger without an error having occurred.

The EMC measures are mainly based on capacitive short-circuiting of the interference currents within the drive system. Inductive filter measures can reduce the leakage currents, but affect the dynamic response of the drive and bring about

- higher construction volume
- higher weight
- expensive core material

Possibilities of use

Motor cable lengths

Keep the motor cables as short as possible. Only short motor cables make low leakage currents possible and thereby enable residual-current-operated circuit breakers to work.

Types of residual-current-operated circuit breakers

There are two types of residual-current-operated circuit breakers:

1. **Residual-current-operated circuit breakers sensitive to power pulse current** (type A acc. to IEC 60755)

   These are normally used. However, it is only pulsating direct fault currents of a maximum of 5 mA and sinusoidal alternating fault currents that they switch off safely. This is why they are not allowed for devices that can generate smoothed direct fault currents. In the case of smoothed direct fault currents that can be produced in power supply units, mains rectifiers and drive controllers with power converters in B6 circuit, the residual-current-operated circuit breaker is not triggered. This blocks the triggering of a residual-current-operated circuit breaker sensitive to power pulse current in the case of ground contact, i.e. in the case of error.

Residual-current-operated circuit breakers sensitive to power pulse current do not provide any protection against inadmissible contact voltage.

2. **Residual-current-operated circuit breakers sensitive to universal current** (type B acc. to IEC 60755)

   These circuit breakers are suited for smoothed direct fault currents, too, and safely switch off devices with B6 input rectifiers.

   If a current with 30 mA triggers the residual-current-operated circuit breaker, it is possible to use a residual-current-operated circuit breaker with a higher tripping current for machine protection.

   If this residual-current-operated circuit breaker triggers accidentally, too, check in how far the above conditions and dependencies can be improved (for example, by connecting current-compensated mains chokes in the incoming circuit, increasing the inrush current limitation).

Using isolating transformer to reduce leakage current in mains

If no improvement is achieved and the residual-current-operated circuit breaker, due to specific mains conditions on site, has to be used nevertheless on the mains input side, connect an isolating transformer between mains connection and power connection of the drive system. This reduces the leakage current in the ground wire of the mains that is produced during normal operation which allows the residual-current-operated circuit breaker to be used. Connect the neutral point of the secondary winding of the isolating transformer to the equipment grounding conductor of the drive system.

Adjust the ground-fault loop impedance to the overcurrent protective device so that the unit can be switched off in the case of failure.

Before operating enable, check the correct function of the overcurrent protection device including activation in the case of failure.

Exclusive fusing by residual-current-operated circuit breaker

For drive systems with electronic drive controllers, exclusive protection by means of a residual-current-operated circuit breaker normally is not possible and not allowed.

Electronic equipment that has a nominal power higher than 4 kVA or is destined for permanent connection normally does not need residual-current-operated circuit breakers. Observe the country-specific standards.

According to IEC 60204-1 and IEC 61800-5-1, the mains-side protection against indirect contact, i.e. in the case of insulation failure, has to be provided in a different way, for example by means of an overcurrent protection device, protective grounding, protective-conductor system, protective separation or total insulation.

Using residual-current-operated circuit breakers at HCS drive controllers

HCS drive controllers at residual-current-operated circuit breaker

Residual-current-operated circuit breakers can be used under the following conditions:

- Residual-current-operated circuit breaker is of type B (IEC60755)
- Trip limit of the residual-current circuit breaker is ≥ 300 mA
- Supplying TN-S mains
- Maximum length of motor cable 20 m in shielded design
- Use of an HNF01 or NFD03 mains filter

- Each residual-current-operated circuit breaker only supplies one drive controller
- Only Rexroth components and accessories including cables and filters are used

Using residual-current-operated circuit breakers at HMV supply units

HMV01.1R, HMV02.1R at residual-current-operated circuit breaker

Due to their function, regenerative HMV0x.1R supply units are unsuitable for the use of residual-current-operated circuit breakers.

7.5.5 Insulation monitoring devices

Insulation monitoring devices are normally used in IT mains with insulated neutral point. The aim is to have a monitor triggered in the case of ground fault - which means in the case of error - without having to switch off the electrical equipment.

When the monitor signals an error, the ground fault is detected and removed without operation being interrupted. Switch-off only takes place if a second ground fault occurs before the first one has been removed.

Since insulation monitoring devices also measure the ground current at the mains input of the building, too high leakage current can cause accidental false triggering.

The same notes on application apply as mentioned in the previous chapter 7.5 Protection systems at the mains connection, page 63.

8 Configuring the drive system

8.1 General information

Within the IndraDrive product range, it is possible to combine components of the following subranges.

You have to select:

Type of supply

- Supply units
- Converter
- Type of mains connection

  Additional component for mains filter

  Other additional components for mains connection

Drive

- Motors with measuring systems
- Power sections
- Control sections with options
- Firmware for selected power sections with control section

Additional components

- For the DC bus
- For the motor output

Cables

- For power supply to the motor
- For signal evaluation from motor to control electronics

8.2 Type of supply for power sections

8.2.1 General information

The requirements to the individual axes are known from the drive task and the appropriate drive controllers - the drive system - have been selected for this purpose. For this drive system, select the appropriate supply. The following list will be explained in detail in this chapter:

- Supply by HMV supply unit
  - In central supply
  - In parallel operation
- Supply by HCS converter
  - In central supply
  - In parallel operation
- Supply by third-party supply units
  - RD500 - SFT converter

Supply of IndraDrive components

In the scope of UL, it is exclusively the following supply units which have been approved for supplying IndraDrive components HMS, HMD and KCU:

- HMV01.1R
- HMV01.1E
- HMV02.1R
- HCS02.1E
- HCS03.1E

For the project planning of HMS and HMD inverters at HCS converters, take the following aspects into account for use in the scope of UL:

- The maximum output voltage (U_{DC}) of the supplying device (e.g. HCS) must be smaller than the allowed input voltage of the inverter (e.g. HMS).
- The symmetrical nominal short-circuit current at the mains connection (I_{SCCR}) of the supplying device (e.g. HCS) must be smaller than the symmetrical nominal short-circuit current specified for the inverter (e.g. HMS).

NOTICE **Property damage caused by operation of combinations which are not allowed!**

Only operate the listed, allowed combinations.

Operating components not mentioned in this documentation at the common DC bus with IndraDrive components requires Rexroth's explicit confirmation.

Supply unit / converter	Inverter			Converter	
	HMS01	HMS02.1N -W	HMD01	HCS02	HCS03
HMV01.1E-W	■	-	■	-	-
HMV01.1R-W	■	-	■	-	-
HMV02.1R-W	-	■	-	-	-

Supply unit / converter	Inverter			Converter	
	HMS01	HMS02.1N -W	HMD01	HCS02	HCS03
HCS02.1E-W0054, -W0070	■ 2)	■ 1)	■ 2)	■	-
HCS03.1E	■	-	■	-	■

■ Allowed

\- Not allowed!

1) Do not operate HMS02 at the same DC bus with HMS01/HMD01

2) Different mounting depths: Control cabinet adapter HAS03 required

Tab. 8-1: Supply units for power sections and motor-integrated / near motor servo drives

Notes on project planning for number of axes, C_y

Converters and supply units can supply inverters at their DC buses.

Detailed combinations of HCS converter, mains filter, mains choke:

See chapter 8.3.3 "Mains connection for HCS converters" on page 92

Detailed combinations of HMV supply unit, mains filter, mains choke:

See chapter 8.3.2 "Mains connection for HMV supply units" on page 88

In the tables, observe the value C_y (capacitance against housing) in the "Explanation" column. This value limits the number of inverters (number of axes).

Orientation guide for selecting the type of supply

	HMV supply unit		HCS converter	
Criterion	Central supply with HMVxx.x	Parallel operation with HMVxx.xE (not W0030)	Central supply	Parallel operation
Number of axes = 1	■	□	■	-
Number of axes ≤ 6 $C_y \leq 2 \times 600$ nF	■	□	■	■
Number of axes ≤ 18 with "F240" mains filter $C_y \leq 2 \times 1225$ nF	■	□	□	□
Number of axes ≤ 40 with "M900" mains filter $C_y \leq 2 \times 2040$ nF	■	■	-	-
High overload ratio	■	■	□	□
Regenerative operation with great energy contents	■ HMVxx.xR	□	□	□

	HMV supply unit		HCS converter	
Criterion	Central supply with HMVxx.x	Parallel operation with HMVxx.xE (not W0030)	Central supply	Parallel operation
High kinetic energies in the case of mains failure	□ Additionally use HLR braking resistors			
Single-phase operation	-	-	□ Only HCS02	-

■ Recommended
□ Allowed
- Not allowed

Tab. 8-2: Orientation guide

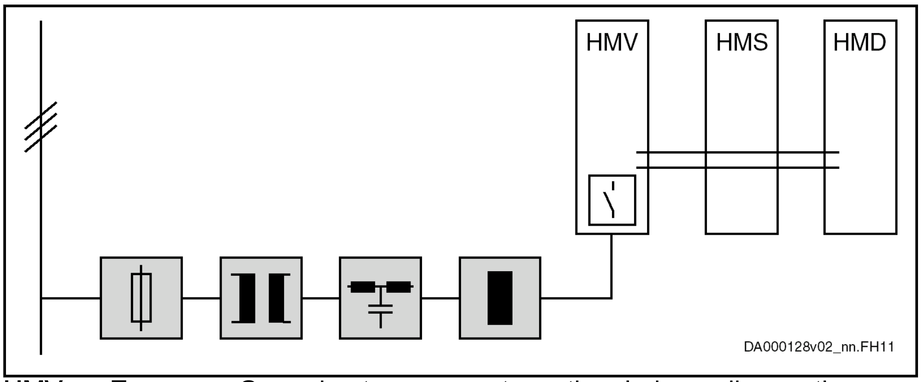
8.2.2 HMV supply units for HMS/HMD power sections

Central supply HMV

Brief description

The mains connection "central supply" (individual supply) is the standard type of connection for HMV. The "central supply" is characterized by one mains connection (mains circuit breaker, mains transformer, mains filter, mains choke) for the drive system. Other drive controllers and additional components are connected to the supply unit.

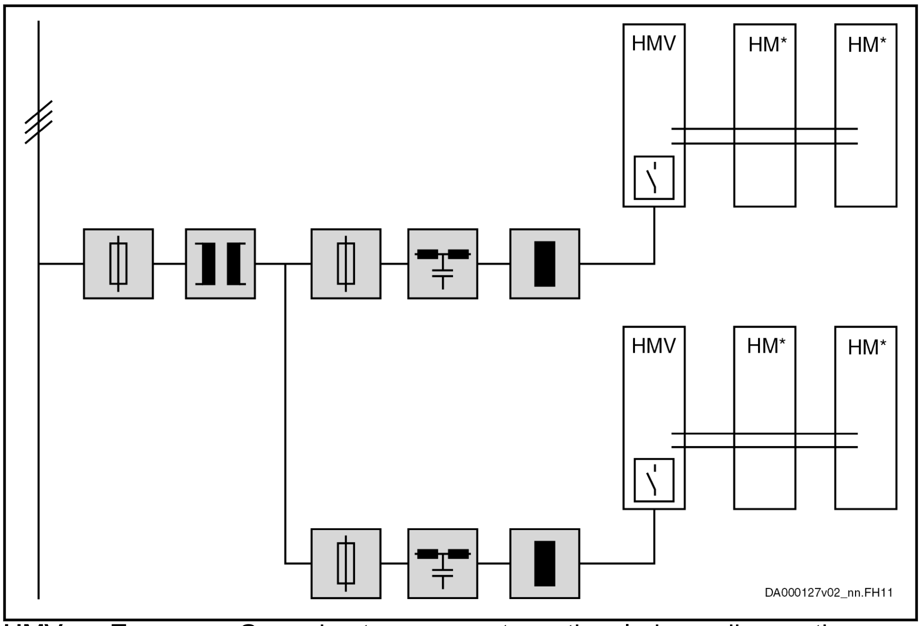
Block diagram



HMVxx.xE Grayed out components: optional, depending on the application
HMVxx.xR Mains filter and mains choke; necessary
HMVxx.xR-W0120 Mains filter, mains choke, external mains contactor; necessary

Fig. 8-1: Central supply HMV

The "group supply without DC bus connection of the groups" has to be handled like individual supply for HMV.



HMVxx.xE	Grayed out components: optional, depending on the application
HMVxx.xR	Mains filter and mains choke; necessary
HMVxx.xR-W0120	Mains filter, mains choke, external mains contactor; necessary

Fig. 8-2: Group supply HMV without DC bus connection of the groups

☞ When **dimensioning the fuses** in the supply feeder and in branches, make sure to provide protection against overcurrent and overload in the case of error.

See chapter 15.3.5 "Sizing the line cross sections and fuses " on page 254

Notes on project planning

The maximum allowed **number of devices** at the common DC bus is limited by the ability of HMV to charge capacitances against housing (C_y).

Use more HMVs, if the determined capacitance C_y exceeds the maximum allowed value.

NOTICE **Damage to the supply unit!**

Do not exceed allowed peak and continuous powers in the DC bus.

Comply with minimum value of mean phase control factor ā (see data of continuous power of supply unit in the technical data, calculation see chapter 15 Calculations, page 235), to avoid overloading the integrated DC bus capacitors by wattless currents.

High load due to reactive current is generated, when, for example, synchronous motors permanently deliver high torque at low speed or asynchronous motors are operated with high magnetization currents.

In these cases of operation, use additional capacitances at the DC bus.

Smart Energy Mode

Regenerative supply units of the HMV0x.1R-W0***-A-07-**FNN2** design (Smart Energy Mode) reduce current and power peaks on the mains side. The Smart Energy Mode limits the maximum device current to the 1.1-fold value of the nominal current.

For the project planning of a drive system with Smart Energy Mode, there is a separate documentation. Write an e-mail to drivesupport@boschrexroth.de, if you need this documentation (Indrv_HMV0xR_Smart_Energy_Mode_xx.pdf).

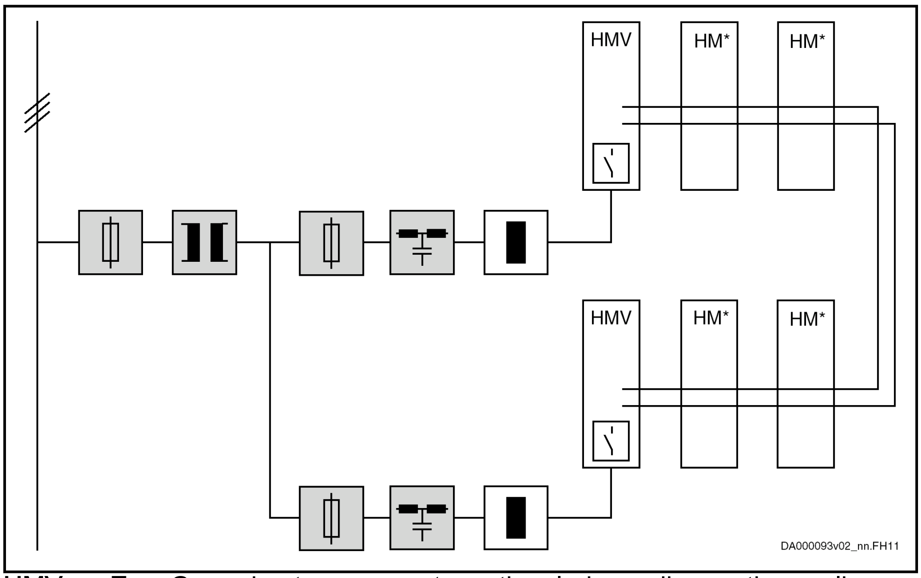
Parallel operation HMV - group supply with DC bus connection HMV01, HMV02

Brief description

"Group supply with DC bus connection" increases the available regenerative power, the continuous braking resistor and infeeding power in the common DC bus of multiple drive controllers.

This mains connection is mainly used to cover the power range above the biggest modular supply unit.

Block diagram



HMVxx.xE Grayed out components: optional, depending on the application

Fig. 8-3: Parallel operation - group supply HMV with DC bus connection

When **dimensioning the fuses** in the supply feeder and in branches, make sure to provide protection against overcurrent and overload in the case of error.

See chapter 15.3.5 "Sizing the line cross sections and fuses " on page 254

Notes on project planning

Parallel operation of regenerative supply units **HMV0x.xR is not allowed**!

Supply unit	Supply units at DC bus
HMV01.1E-W0030	Two of the same type
HMV01.1E-W0075	
HMV01.1E-W0120	
HMV01.1R	Parallel connection is not allowed!
HMV02.1R	

Tab. 8-3: Parallel operation HMV

For mains connection, observe the control circuit for the mains connection.

Parallel operation of HMV01 supply units

- is allowed with HMV01.1E supply units of the same **type current**
- requires a **mains choke** for each supply unit (for current sharing)
- does not increase the maximum allowed number of drive controllers or axes when operated without mains filter
- requires a master-slave control circuit; see chapter 9 Circuits for the mains connection, page 125.

8.2.3 HCS converter as supply unit

General information

Converters are designed for operating a single drive (see also individual supply with HCS). In particular, the power supply with the capacitors in the DC bus and the mains supply have been dimensioned with regard to operation under rated conditions of the converter. When HCS converters are used as supply units, the power of the converter (P_{DC_cont}, P_{DC_peak}) is available at the DC bus connection for its own motor output and for further drive controllers.

Operating HCS converters as supply unit causes higher load of the capacitors in the DC bus.

Additional capacitors in the DC bus reduce the additional load by distributing the current.

NOTICE **Damage to the converter!**

Operation as supply unit additionally loads the converter. Observe the allowed peak power and continuous power (P_{DC_cont}, P_{DC_peak}) of the converter.

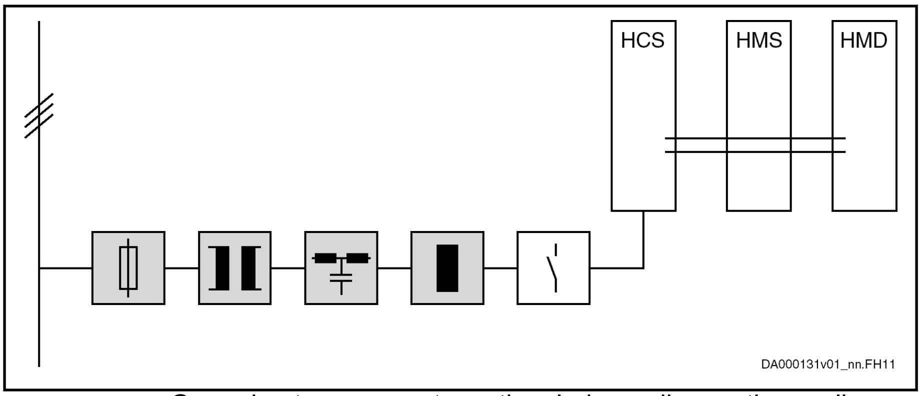
Operate additional capacitors C_{DC_ext} at the DC bus and observe the notes on project planning.

Central supply - HCS supply HCS or HMS/HMD drive controllers

Brief description

The "central supply" via HCS converters is the mains supply with which the converter supplies further drive controllers.

Block diagram

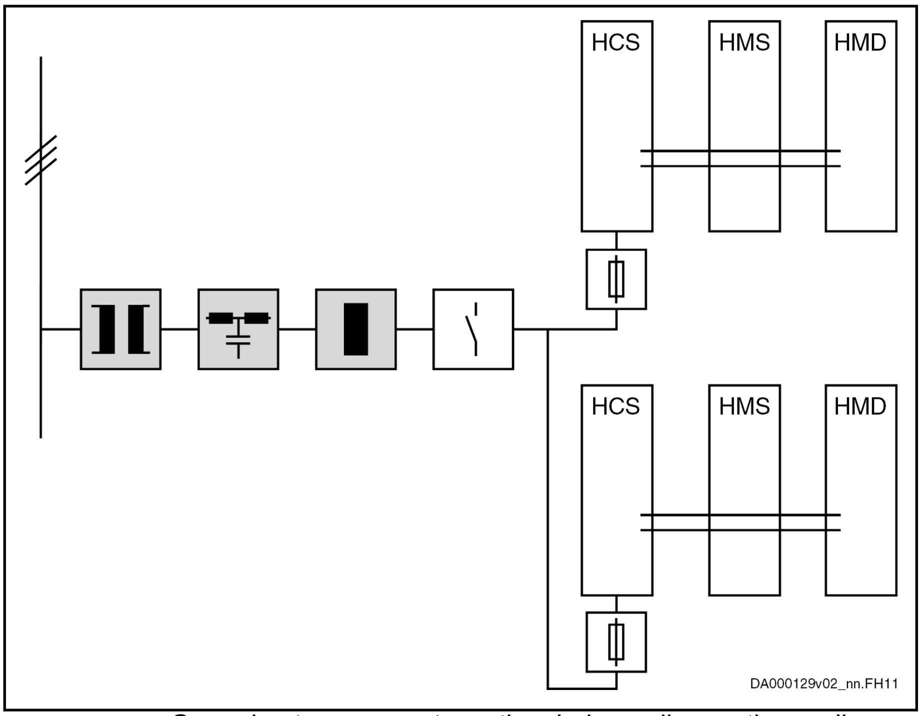


Grayed out components: optional, depending on the application

Fig. 8-4: Central supply HCS

☞ Use HNF mains filters and HNL mains chokes.

The "group supply without DC bus connection of the groups" allows the additional components (HNL, HNF, etc.) to be used in the mains connection for multiple similar supplies.



Grayed out components: optional, depending on the application

Fig. 8-5: Group supply HCS without connection of the groups

☞ When **dimensioning the fuses** in the supply feeder and in branches, make sure to provide protection against overcurrent and overload in the case of error.

See chapter 15.3.5 "Sizing the line cross sections and fuses " on page 254

☞ Control the mains contactor in such a way (connect Bb contacts in series) that errors of both groups lead to circuit interruption!

Notes on project planning for HCS02 as supply unit for HMS/HMD

The HCS02.1E-W0054 and -W0070 types are allowed as supply units.

The HCS02.1E-W0012 and -W0028 types are not allowed.

HCS02 converters as supply units for HMS/HMD require:

- **HAS03** accessory (to adjust different mounting depths)
- **HAS04** accessory (capacitances C_y at DC bus against ground)
- Additional capacitors C_{DC_ext} at the DC bus (external DC bus capacitance C_{DCext}), if
  - the arithmetical mean of the output currents I_{out} is **greater than** I_{out_cont} of the supplying device
  - the accumulated chronological sequences of the output currents I_{out} and the DC bus power P_{DC} (superposition of the individual load profiles) are **greater than** the allowed load profiles

Additional capacitance C_{DC_ext} required for HCS02!

To determine the additionally required capacitance C_{DC_ext}, the following **guide values** apply when using an HLC01.1 DC bus capacitor unit:

- HMS01: Install **10 µF** per A type current
- HMD01: Install **20 µF** per A type current
- HMS02: **No** additional capacitance required

Arranging HCS02

Place HCS02 to the left of HMS01, HMS02 or HMD01.

Place the HAS04 accessory at the left of HCS02.

Place the DC bus capacitor unit HLC01.1 at the junction from HCS02 to HMS01, HMS02 or HMD01.

Notes on project planning for HCS03

HCS03 converters as supply units for HMS01/HMD01 require braking resistors.

Operate HCS03 with HLR!

To supply HMD01 and HMS01, operate HCS03 converters with brake chopper (option -NNBV) and HLR braking resistor.

HCS03 with external capacitors in the DC bus

External capacitors in the DC bus (e.g., HLC) can only be operated at HCS03.1E-W0210.

Thus, central supply with HCS03 is impossible.

Arranging HCS03

Place HCS03 to the left of HMS01 and HMD01.

Place the HAS04 accessory at the left of HCS03.

Commissioning information

When converters are operated as supply units for inverters or supplied as inverters from another converter, the drive controller has to be parameterized for this purpose.

For information on how to configure and parameterize the drive controllers, see Functional Description of firmware in chapter "Power supply", and the parameters involved

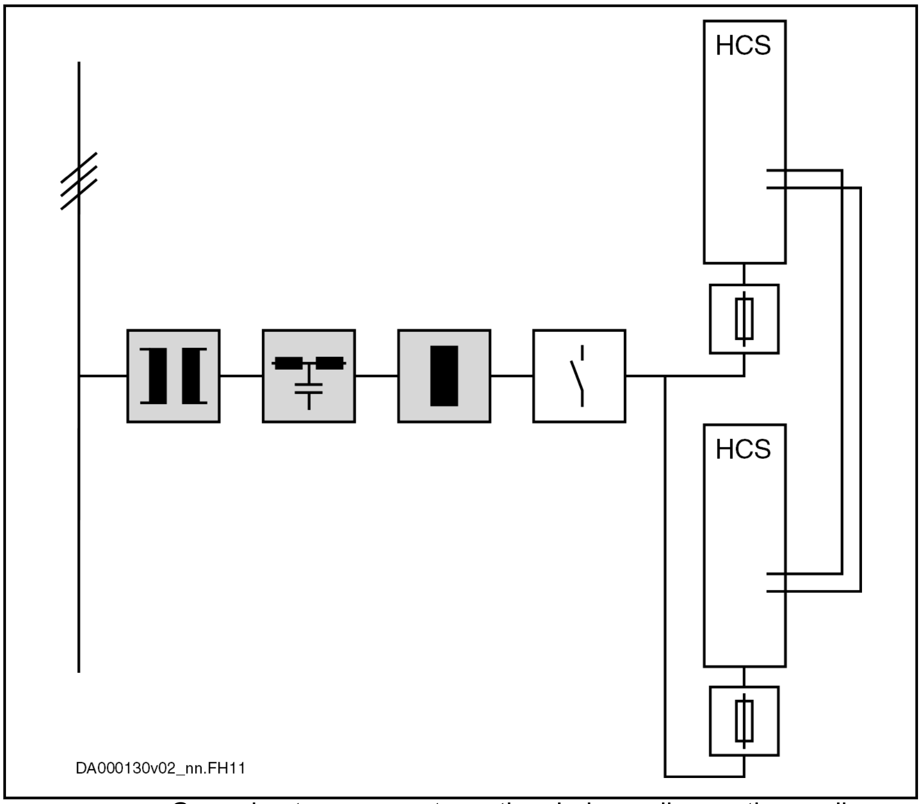
- P-0-0860, Converter configuration
- P-0-0861, Power supply status word

Parallel operation HCS - group supply with DC bus connection of the groups

Brief description

"Group supply with DC bus connection" increases the available regenerative power, the continuous braking resistor and infeeding power in the common DC bus of multiple drive controllers or drive systems.

Block diagram



Grayed out components: optional, depending on the application

Fig. 8-6: Parallel operation HCS

Notes on project planning

☞ **Parallel operation** is only allowed with drive controllers of the same type current.

☞ **Mains contactor**

When using the component HCS03.1E with HNK01.1, connect the mains contactor electrically before HNK and HCS03.

Control mains contactors in such a way that error messages at the converters connected in parallel can interrupt the power supply from the mains (e.g., connect Bb contacts of HCS in series).

When controlling multiple mains contactors, additionally make sure that the mains contactors are always controlled simultaneously and synchronously so that each HCS only has to charge its own DC bus capacitors when **power voltage is switched on**.

☞ When **dimensioning the fuses** in the supply feeder and in branches, make sure to provide protection against overcurrent and overload in the case of error.

See chapter 15.3.5 "Sizing the line cross sections and fuses " on page 254

For **selecting the components in the mains connection**, observe the pieces of information contained in the following chapters:

- chapter 15.1 "Determining the appropriate drive controller" on page 235
- chapter 15.3.2 "Determining the mains filter" on page 252
- chapter 15.3.1 "Determining the Mains Choke" on page 252

The **connection lines** to the drive controllers should preferably have the same impedances in order to achieve balanced load distribution at the power inputs of the drive controllers. From the common node of the lines, you therefore have to make sure that

- the lengths of the supply lines and
- the cross sections of the supply lines are the same.

At the common DC bus there is less than the sum of the device-specific performance data available. This particularly applies to the continuous DC bus power $P_{DC\ cont}$ and the continuous regenerative power P_{BD}. The sum is generated with reduced performance data. The reduction takes place with the corresponding **balancing factors for parallel operation.**

For these data, see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → chapter of the respective device → "Technical data" → "Basic data" → table "Power section data - DC bus".

Parallel operation HCS - number of components

	Components at common DC bus		
Converter HCS02		HLB01.1	HLC01.1
HCS02.1E-W0012	No DC bus connection		
HCS02.1E-W0028	8	1	Limited to charging ability C_{DCext} of the individual HCS
HCS02.1E-W0054	6		
HCS02.1E-W0070	4		
HCS03 converter			
HCS03.1E-W0070	10	1	Not allowed, since no charging ability C_{DCext}
HCS03.1E-W0100	8		
HCS03.1E-W0150	6		
HCS03.1E-W0210	4	1	Limited to charging ability C_{DCext} of the individual HCS
HCS03.1E-W0280			
HCS03.1E-W0350			

Tab. 8-4: Parallel operation of IndraDrive converters

Example Allowed parallel operation of HCS03.1E:

6 × HCS03.1E-W00150

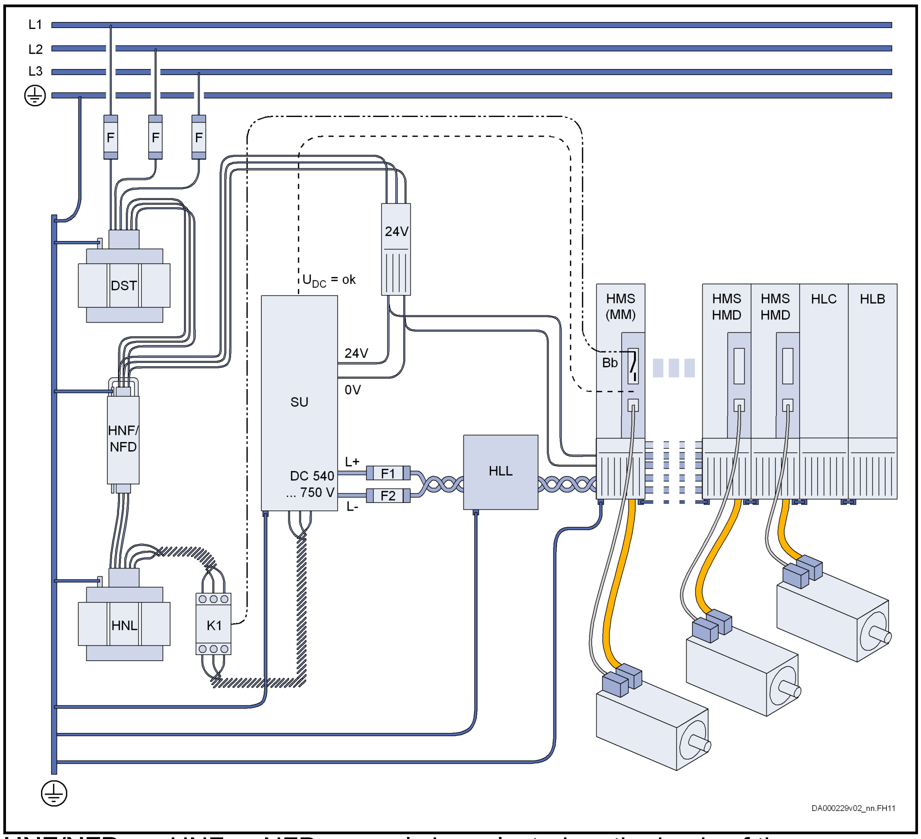
8.2.4 Third-party supply units

General information

HMS01 and HMD01 power sections are designed to be supplied via HMV supply units or HCS converters. In exceptional cases, other supply units (called "third-party supply units" in the following paragraphs) can be used as supply units (e.g., SFT from the product range RD500). Third-party supply units cause loading which requires **additional measures**.

☞ The **C-UL listing** of HMS and HMD applies provided that they are supplied by HMV supply units or HCS converters.

Block diagram



HNF/NFD	HNF or NFD can only be selected on the basis of the components actually used
HLL	DC bus choke
MM	Module bus master
SU	Third-party supply unit

Fig. 8-7: Third-party supply unit with one drive system

Notes on project planning

Only HMS01 / HMD01 inverters, as well as additional components HLB and HLC, may be operated with third-party supply units.

Requirements on the third-party supply unit:

- **Minimum inductance**: In the mains connection of the third-party supply unit, install a mains choke with at least 100 µH.
- **DC bus voltage**: The DC bus voltage of the third-party supply unit has to be in the range of DC 540 … 750 V. Take the limit values $U_{DC\_LIMIT\_max}$ of the supplied devices into account.
- **Allowed voltage control**: Sine-wave modulation with $f_s \geq 4.2$ kHz.

Third-party supply units with block modulation or flat-top modulation are **not** allowed.

Requirements on the drive system:

- **DC bus choke**: Per drive system, use one additional component HLL01.1N for connection to the DC bus of the third-party supply unit.
- **DC bus current**: Comply with maximum allowed DC bus current of 100 A.
- **Additional capacitances**: Use at least **50 µF**per kW of installed continuous power in the form of DC bus capacitor unit HLC01.
- **Leakage capacitance C_{ab}**: The leakage capacitance per drive system (motors and motor cables) mustn't be more than a maximum of 500 nF.
- **Capacitances against housing C_Y**: Per drive system, the capacitance against housing should not exceed 2 × 850 nF (850 nF at L+, 850 nF at L-) and should not fall below 2 × 300 nF (300 nF at L+, 300 nF at L-).
- **Peak voltage**: Limit voltage L+ against ⏚ and L- against ⏚ to a maximum of 1 kV.
- If the drive system can be disconnected from the third-party supply unit in operation (e.g., in the case of overcurrent by fuses), use **DC bus resistor unit HLB01** with $W_{max} \geq W_{max\_installiert}$.

Commissioning information

Supply units, converters, inverters and additional components of the IndraDrive product range have a module bus X1. Via the module bus, information on the status within the drive system is exchanged and the power supply from the mains is influenced.

Supply units of other product ranges have no module bus. With the drive firmware version MPx-04VRS and above, you can configure an inverter as a module bus master. Integrate the relay contact of the module bus master configured as a Bb contact in the power supply control circuit in such a way that opening the relay contact causes the power to be disconnected.

📖 For information on how to configure and parameterize the drive controllers, see Functional Description of firmware in chapter "Power supply", and the parameters involved

- P-0-0860, Converter configuration
- P-0-0861, Power supply status word

Take the information on circuits for the mains connection into account (see chapter 9 "Circuits for the mains connection" on page 125).

8.3 Mains connection for supply units and converters

8.3.1 General information

The mains connection consists of:

- Protection against overload (e.g., fuses for line protection)

☞ When **dimensioning the fuses** in the supply feeder and in branches, make sure to provide protection against overcurrent and overload in the case of error.

See chapter 15.3.5 "Sizing the line cross sections and fuses " on page 254

- If necessary, an autotransformer or isolating transformer for voltage adjustment
- HNF mains filter
- HNL mains choke
- If necessary, combination of mains filter and HNK mains choke
- Mains contactor (integrated for some HMV)

Notes on project planning

From the tables in the following chapters, select the mains connection for the projected supply (HMV or HCS) and take the given values into account. If necessary, split the drive system up or use a more powerful mains filter (e.g., type "M900" instead of type "F240").

- C_y (capacitance against housing)

  This capacitance has to be charged by the supply unit or converter when the mains voltage is switched on and is limited by the charging ability of the supply units and converters.

  In the technical data, you can find the value of C_y for each component at the DC bus.

  The value C_y should not fall below the required minimum value to attenuate and avoid oscillation in the mains connection.

- Max. number of axes

  The allowed number of axes is limited by the mains filter, because the leakage current generated by the drive system loads the mains filter.

- Max. leakage capacitance C_{ab_g}

  Due to the leakage capacitance (capacitance of cables and motor), leakage current, which loads the mains filter, is generated by the switching at the output of the inverter.

  In the "EMC limit value class to be achieved" column, you can find, for the selected mains connection (mains filter, mains choke), the leakage capacitance with which the combination can comply with the respective EMC limit value class.

- Motor cable length

  The length of the motor cable determines the leakage capacitance. With the switching frequency which has been set, the leakage current is generated due to the leakage capacitance. The specified values of the motor cable length (switching frequency f_s) cause the same load and filter effect at the mains filter and are to be understood as guide values.

NOTICE **Property damage due to mains filter overload!**

- Do not connect mains filters in series, as this can cause resonance effects on current and voltage.
- Comply with the specified limits of C_y (capacitances against housing), maximum leakage capacitance C_{ab_g} and maximum number of axes, because otherwise the mains filter may lose its effect and get damaged.
- Only operate expressly allowed components at mains filters.

  Do not operate any other components, such as additional power supply units and fans, at HNF mains filters.

With mains filters at compensation units, make sure there are no resonance effects on current and voltage.

Observe the allowed harmonic limit values (THD) of the filter components (see chapter 15.3.7 "Determining the Allowed Operating Data of Mains Filters" on page 266).

Make sure that the nominal current of the mains contactor does not exceed the nominal current of the mains filter.

☞ **Circuit for the mains connection**

Observe the chapter 9 Circuits for the mains connection, page 125.

☞ **HNF01, NFD mains filters on mains grounded with outer conductor**

HNF01.1 or NFD03.1 mains filters are not suited for operation on mains grounded with outer conductor.

Observe the allowed mains connection voltage in the technical data of the respective component.

Install an isolating transformer.

☞ **Performance data without mains choke**

Operation without mains choke is only allowed for certain supply units and converters.

Take into account that supply units and converters, when operated **without mains choke**, have **reduced performance data** in comparison to normal operation with mains choke.

Performance data: see technical data of the respective component

EMC limit values and mains filter selection

Explanation on the sizing criterion EMC limit value class:

- See chapter 10.1.3 "Noise emission of the drive system" on page 168
- Calculation formulas for determining the allowed leakage capacitances:

  See chapter 15.3.6 "Determining the Leakage Capacitance" on page 265
- The mains filters used have been specifically sized for Rexroth drive systems. For filters by other manufacturers, Rexroth cannot guarantee mains interference suppression with regard to allowed limit values.
- The specified EMC limit values apply to **grounded** mains. Ungrounded mains require additional measures.

The selection tables do not contain all practical applications (e.g., mains filters and mains chokes used by multiple drive systems). For such cases, mains filters and mains choke can be selected, too:

- See chapter 15.3.1 "Determining the Mains Choke" on page 252
- See chapter 15.3.2 "Determining the mains filter" on page 252

8.3.2 Mains connection for HMV supply units

Mains connection for HMV supply units - additional components

Use HNL mains choke and HNF mains filter

For interference-free operation of supply units with regeneration back to the mains (HMVxx.x**R**), use appropriate HNL mains chokes and HNF mains filters in the mains connection.

Supply unit	Transformer		Mains filter			Mains choke		
	DST (auto)	DLT (isolating)	HNF01.x*-****-R****	HNF01.x*-****-E****	HNS 02.1	HNL01.xE; HNL01.xE-****-S	HNL01.xR; HNL01.xR-****-S	HNL 02.1
HMV01.1E-W	■	■	-	■	-	■	-	-
HMV01.1R-W	■	■	■ (!)	-	-	-	■ (!)	-
HMV02.1R-W	■	■	-	-	■ (!)	-	-	■ (!)

■ Allowed
■ (!) Must be used
\- Not allowed

Tab. 8-5: Additional components for mains connection

Mains connection for HMV01.1E supply units

Supply unit	Mains chokes	Mains filter	Explanation	EMC limit value class to be achieved[1]: max. leakage capacitance C_{ab_g}; motor cable length
HMV01.1E-W0030	HNL01.2E-0400-N0051	HNF01.2D-F240-E0051	Standard combination for axis systems with $C_y \leq 2 \times 1225$ nF Number of axes ≤ 18	A1: 290 nF; 280 m (f_s = 8 kHz) 110 m (f_s = 12 kHz)
	without		Reduced performance data; see Project Planning Manual	
	HNL01.2E-0400-N0051	HNF01.2D-M900-E0051	Standard combination for axis systems with $C_y \leq 2 \times 2040$ nF Number of axes ≤ 40	A1: 1100 nF; 1050 m (f_s = 8 kHz) 270 m (f_s = 12 kHz)
	without		Reduced performance data; see Project Planning Manual	
	HNL01.2E-0400-N0051 with HNL01.1E-5700-S0051	Customer-side	Standard mains choke connected in series with current-compensated mains choke to reduce line-frequency leakage currents	not specified
	without	without	Not allowed	
HMV01.1E-W0075	HNL01.1E-0200-N0125	HNF01.2D-F240-E0125	Standard combination for axis systems with $C_y \leq 2 \times 1225$ nF Number of axes ≤ 18	A2.2: 290 nF; 280 m (f_s = 8 kHz) 110 m (f_s = 12 kHz)
	without		Reduced performance data; see Project Planning Manual	
	HNL01.1E-0200-N0125	HNF01.2D-M900-E0125	Standard combination for axis systems with $C_y \leq 2 \times 2040$ nF Number of axes ≤ 40	A2.2: 1100 nF; 1050 m (f_s = 8 kHz) 270 m (f_s = 12 kHz)
	without		Reduced performance data; see Project Planning Manual	
	HNL01.1E-0200-N0125 with HNL01.1E-2800-S0125	Customer-side	Standard mains choke connected in series with current-compensated mains choke to reduce line-frequency leakage currents	not specified
	without	without	1 axis (1 HMD01)	A2.1: 40 nF; 40 m (f_s = 8 kHz) 40 m (f_s = 12 kHz)

Supply unit	Mains chokes	Mains filter	Explanation	EMC limit value class to be achieved[1)]: max. leakage capacitance C_{ab_g}; motor cable length
HMV01.1E-W0120	HNL01.1E-0100-N0220	HNF01.2D-F240-E0202	Standard combination for axis systems with C_y ≤ 2 × 1225 nF Number of axes ≤ 18	A2.2: 290 nF; 280 m (f_s = 8 kHz) 110 m (f_s = 12 kHz)
	without		Reduced performance data; see Project Planning Manual	
	HNL01.1E-0100-N0220	HNF01.2D-M900-E0202	Combination for axis systems with C_y ≤ 2 × 2040 nF Number of axes ≤ 40	A2.2: 1100 nF; 1050 m (f_s = 8 kHz) 270 m (f_s = 12 kHz)
	without		Reduced performance data; see Project Planning Manual	
	HNL01.1E-0100-N0220 with HNL01.1E-3400-S0202	Customer-side	Standard mains choke connected in series with current-compensated mains choke to reduce line-frequency leakage currents	not specified
	without	without	**1 axis** (1 HMD01)	A2.1: 40 nF; 40 m (f_s = 8 kHz) 40 m (f_s = 12 kHz)

1) for line-based noise emission in grounded mains

Tab. 8-6: Selecting the HMV01.1E mains connection

Mains connection for HMV01.1R supply units

Supply unit	Mains chokes	Mains filter	Explanation	EMC limit value class to be achieved[1)]: max. leakage capacitance C_{ab_g}; motor cable length
HMV01.1R-W0018	HNL01.1R-0980-C0026	HNF01.2D-F240-R0026	Standard combination for axis systems with C_y ≤ 2 × 1225 nF Number of axes ≤ 18	A1: 290 nF; 280 m (f_s = 8 kHz) 110 m (f_s = 12 kHz)
	HNL01.1R-0980-C0026	HNF01.2D-M900-R0026	Standard combination for axis systems with C_y ≤ 2 × 2040 nF Number of axes ≤ 40	A1: 1100 nF; 1050 m (f_s = 8 kHz) 270 m (f_s = 12 kHz)
	HNL01.1R-0980-C0026 with HNL01.1R-4200-S0026	Customer-side	Standard mains choke connected in series with current-compensated mains choke to reduce line-frequency leakage currents	n.s.

Supply unit	Mains chokes	Mains filter	Explanation	EMC limit value class to be achieved[1)]: max. leakage capacitance C_{ab_g}; motor cable length
HMV01.1R-W0045	HNL01.1R-0590-C0065	HNF01.2D-F240-R0065	Standard combination for axis systems with C_y ≤ 2 × 1225 nF Number of axes ≤ 18	A1: 290 nF; 280 m (f_s = 8 kHz) 110 m (f_s = 12 kHz)
	HNL01.1R-0590-C0065	HNF01.2D-M900-R0065	Standard combination for axis systems with C_y ≤ 2 × 2040 nF Number of axes ≤ 40	A1: 1100 nF; 1050 m (f_s = 8 kHz) 270 m (f_s = 12 kHz)
	HNL01.1R-0590-C0065 with HNL01.1R-6300-S0065	Customer-side	Standard mains choke connected in series with current-compensated mains choke to reduce line-frequency leakage currents	n.s.
HMV01.1R-W0065	HNL01.2R-0540-C0094	HNF01.2D-F240-R0094	Standard combination for axis systems with C_y ≤ 2 × 1225 nF Number of axes ≤ 18	A2.2: 290 nF; 280 m (f_s = 8 kHz) 110 m (f_s = 12 kHz)
	HNL01.2R-0540-C0094	HNF01.2D-M900-R0094	Standard combination for axis systems with C_y ≤ 2 × 2040 nF Number of axes ≤ 40	A2.2: 1100 nF; 1050 m (f_s = 8 kHz) 270 m (f_s = 12 kHz)
	HNL01.2R-0540-C0094 with HNL01.1R-3000-S0094	Customer-side	Standard mains choke connected in series with current-compensated mains choke to reduce line-frequency leakage currents	n.s.
HMV01.1R-W0120	HNL01.1R-0300-C0180	HNF01.1A-H350-R0180	Standard combination for axis systems with C_y ≤ 2 × 1020 nF Number of axes ≤ 15	A2.2: 450 nF; 350 m (f_s = 8 kHz)

1) for line-based noise emission in grounded mains

Tab. 8-7: Selecting the HMV01.1R mains connection

Mains connection for HMV02.1R supply units

Supply unit	Mains choke	Mains filter	Explanation	EMC limit value class to be achieved[1)]; motor cable length
HMV02.1R-W0015	HNL02.1R-0980-C0023	HNS02.1A-Q200-R0023	Standard combination for axis systems with C_y ≤ 2 × 1225 nF Number of axes ≤ 12	A2.1; 200 m (f_s = 8 kHz)

1) for line-based noise emission in grounded mains

Tab. 8-8: Selecting the HMV02.1R mains connection

Supply unit	Mains choke	Mains filter	Explanation	EMC limit value class to be achieved[1]; motor cable length
HMV02.1R-W0015	HNL02.1R-0980-C0023	HNS02.1A-Q200-R0023	Standard combination for axis systems with $C_y \leq 12 \times 200$ nF	A2.1; 200 m (f_s = 8 kHz)

1) for line-based noise emission in grounded mains

Tab. 8-9: Mains connection for HMV02.1R

For the connections from the supply unit to the axis systems, observe the information contained in chapter chapter 13.1.6 "Connection of the DC Bus Connections" on page 214.

8.3.3 Mains connection for HCS converters

Mains connection for HCS converters - additional components

Converter	Transformer		Mains filter			Mains choke		
	DST (auto)	DLT (isolating)	NFD03.1	HNF01.x*-****-R****	HNF01.x*-****-E****	HNK01.1	HNL01.xE; HNL01.xE-****-S	HNL01.xR; HNL01.xR-****-S
HCS02.1E	■	■	■	■ 1)	■ 1)	-	■	-
HCS03.1E	■	■	■ 2)	■ 1)	■ 1)	■	■	-

■ Allowed

\- Not allowed

1) Observe the note "Minimum value capacitance against ground at the DC bus!"

2) Maximum allowed motor cable length: 5 m

Tab. 8-10: Additional components in the mains connection of converters

Minimum value capacitance against housing at the DC bus!

When using HNF01.1 mains filters at HCS02.1 or HCS03.1, or when using HMS01, HMS02 or HMD01 at HCS02.1 or HCS03.1, make sure that at least **330 nF** each take effect against ground at the DC bus of the combined drive system at L+ and L-.

Use the **HAS04** accessory if the drive system falls below this capacitance value.

See Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → chapter of the respective device → "Technical data" → "Mechanics and mounting" → "Dimensions, mass, insulation, sound pressure level"

Drive controller	Capacitance against housing C_y[1)]	Use of HAS04 [2) 3)] required if …
HMS01.1N: < W0110	2 × 68 nF	Number of HMS01 ≤ 3
HMS01.1N: ≥ W0110	2 × 100 nF	Number of HMS01 ≤ 2
HMS02	2 × 68 nF	Number of HMS02 ≤ 3
HMD01	2 × 68 nF	Number of HMD01 ≤ 3
HCS02	2 × 100 nF	Number of HCS02 ≤ 2 [4)]
HCS03	2 × 100 nF	Number of HCS03 ≤ 2 [4)]
HAS04 accessory		
HAS04.1-001 for HCS02	2 × 470 nF	
HAS04.1-002 for HCS03	2 × 470 nF	

1) See also Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections"
2) See Project Planning Manual "Rexroth IndraDrive Additional Components and Accessories"
3) The number of drive controllers specified in this column already allows for the available capacitance (100 nF) of an HCS02 or HCS03 in the drive system. Example of a drive system with HCS02 and HMS02: 1 × HCS02 + 3 × HMS02 = 1 × 100 nF + 3 × 68 nF = 304 nF; 304 nF < 330 nF ⇒ HAS04 required; HAS04 would not be required with 1 × HCS02 + 4 × HMS02
4) HAS04 is only required, when an HNF01.1 mains filter is present in the drive system

Tab. 8-11: C_y, capacitances against housing

Mains connection for HCS02 converters

Converter	Mains chokes	Mains filter	Explanation	EMC limit value class to be achieved[1)]: max. leakage capacitance C_{ab_g}
HCS02.1E-W0012	HNL01.1E-1000-N0012 (optional)	NFD03.1-480-007	Standard combination for **1 converter**	A2.1
	HNL01.1E-1000-N0020	NFD03.1-480-016	*Group supply* • Type current HCS02 ≤ W0012 • Motor cable length ≤ 120 m (f_s = 8 kHz)	A2.2: 60 nF A1: 50 nF B1: 40 nF
HCS02.1E-W0028	HNL01.1E-1000-N0012 (optional)	NFD03.1-480-016	Standard combination for **1 converter**	A2.1
	HNL01.1E-0600-N0032	NFD03.1-480-030	*Group supply* • Type current HCS02 ≤ W0028 • Motor cable length ≤ 120 m (f_s = 8 kHz)	A2.2: 80 nF A1: 50 nF

Converter	Mains chokes	Mains filter	Explanation	EMC limit value class to be achieved[1]: max. leakage capacitance C_{ab_g}
HCS02.1E-W0054	HNL01.1E-1000-N0020	NFD03.1-480-030	Standard combination for **1 converter**	A2.1
	HNL01.1E-1000-N0020	NFD03.1-480-030	*Central supply to axis systems* • Type current HMS ≤ W0054 • Type current HMD ≤ W0020 • Type current HCS ≤ W0054 • Sum of type currents ≤ 198 (without mains choke ≤ 120) • C_y ≤ 2 × 600 nF • Motor cable length ≤ 120 m (f_s = 8 kHz)	A2.2: 80 nF A1: 50 nF
	HNL01.1E-1000-N0020	NFD03.1-480-055		A2.2: 110 nF A1: 70 nF B1: 55 nF
	HNL01.1E-1000-N0020	HNF01.2D-F240-R0026	*Central supply to axis systems* • Type current HMS ≤ W0054 • Type current HMD ≤ W0020 • Type current HCS ≤ W0054 • Sum of type currents ≤ 198 (without mains choke ≤ 120) • 2 × 330 nF ≤ C_y ≤ 2 × 1225 nF • Motor cable length ≤ 240 m (f_s = 8 kHz)	A2.2: 350 nF A1: 300 nF B1: 89 nF
	HNL01.1E-1000-N0020	HNF01.2D-M900-R0026	*Central supply to axis systems* • Type current HMS ≤ W0054 • Type current HMD ≤ W0020 • Type current HCS ≤ W0054 • Sum of type currents ≤ 198 (without mains choke ≤ 120) • 2 × 330 nF ≤ C_y ≤ 2 × 1225 nF • Motor cable length ≤ 900 m (f_s = 8 kHz)	A2.2: 350 nF
	HNL01.1E-1000-N0020	HNF01.2D-M900-E0051		A2.2: 350 nF A1: 350 nF B1: 350 nF

Converter	Mains chokes	Mains filter	Explanation	EMC limit value class to be achieved[1]: max. leakage capacitance C_{ab_g}
HCS02.1E-W0070	HNL01.1E-0600-N0032	NFD03.1-480-055	Standard combination for **1 converter**	A2.1
	HNL01.1E-0600-N0032	NFD03.1-480-055	*Central supply to axis systems* • Type current HMS ≤ W0054 • Type current HMD ≤ W0036 • Type current HCS ≤ W0070 • Sum of type currents ≤ 270 (without mains choke ≤ 120) • Motor cable length ≤ 120 m (f_s = 8 kHz)	A2.2: 100 nF A1: 70 nF B1: 52 nF
	HNL01.1E-0600-N0032	NFD03.1-480-075		A2.2: 110 nF A1: 70 nF B1: 55 nF
	HNL01.1E-0600-N0032	HNF01.2D-M900-E0051	*Central supply to axis systems* • Type current HMS ≤ W0054 • Type current HMD ≤ W0036 • Type current HCS ≤ W0070 • Sum of type currents ≤ 270 • 2 × 330 nF ≤ C_y • Motor cable length ≤ 900 m (f_s = 8 kHz)	A2.2: 350 nF

1) In grounded mains

Tab. 8-12: Selecting the HCS02 mains connection

Mains connection for HCS03 converters

☞ With HCS03.1E drive controllers, the **limit value class A2** (see "Limit values for line-based disturbances") can be achieved in grounded mains when using the listed mains filters HNF01.1A or HNK01.1A or NFD03.1.

Observe the notes in chapter 11 Arranging the components in the control cabinet , page 175.

Converter	Mains chokes	Mains filter	Explanation
HCS03.1E-W0070	HNK01.1A-A075-E0050		Standard combination for **1 converter** Motor cable length ≤ 75 m
	HNL01.1E-0571-N0050	-	Standard for operating one drive controller without mains filter
	HNL01.1E-0571-N0050	NFD03.1-480-055	Combination for **1 converter** Motor cable length **≤ 5 m**
	HNL01.1E-0571-N0050	HNF01.2D-F240-E0051	*Central supply to axis systems* • Type current HMS ≤ W0054 • Type current HMD ≤ W0036 • Sum of type currents ≤ 270 • 2 × 330 nF ≤ C_y ≤ 2 × 600 nF • Motor cable length ≤ 240 m (f_s = 8 kHz)
	HNL01.1E-0571-N0050	HNF01.2D-M900-E0051	*Central supply to axis systems* • Type current HMS ≤ W0054 • Type current HMD ≤ W0036 • Sum of type currents ≤ 270 • 2 × 330 nF ≤ C_y ≤ 2 × 1225 nF • Motor cable length ≤ 900 m (f_s = 8 kHz)
	HNL01.2E-0400-N0051 with HNL01.1E-5700-S0051	Customer-side	Standard mains choke connected in series with current-compensated mains choke to reduce line-frequency leakage currents

Converter	Mains chokes	Mains filter	Explanation
HCS03.1E-W0100	HNK01.1A-A075-E0080		Standard combination for **1 converter** Motor cable length ≤ 75 m
	HNL01.1E-0362-N0080	-	Standard for operating one drive controller without mains filter
	HNL01.1E-0362-N0080	NFD03.1-480-075	Combination for **1 converter** Motor cable length **≤ 5 m**
	HNL01.1E-0362-N0080	HNF01.2D-F240-E0125	*Central supply to axis systems* • Type current HMS ≤ W0070 • Type current HMD ≤ W0036 • Sum of type currents ≤ 270 • 2 × 330 nF ≤ C_y ≤ 2 × 600 nF • Motor cable length ≤ 240 m (f_s = 8 kHz)
	HNL01.1E-0362-N0080	HNF01.2D-M900-E0125	*Central supply to axis systems* • Type current HMS ≤ W0070 • Type current HMD ≤ W0036 • Sum of type currents ≤ 270 • 2 × 330 nF ≤ C_y ≤ 2 × 1225 nF • Motor cable length ≤ 900 m (f_s = 8 kHz)
	HNL01.1E-0362-N0080 with HNL01.1E-2800-S0125	Customer-side	Standard mains choke connected in series with current-compensated mains choke to reduce line-frequency leakage currents

Converter	Mains chokes	Mains filter	Explanation
HCS03.1E-W0150	HNK01.1A-A075-E0106		Standard combination for **1 converter** Motor cable length ≤ 75 m
	HNL01.1E-0240-N0106	-	Standard for operating one drive controller without mains filter
	HNL01.1E-0240-N0106	NFD03.1-480-130	Combination for **1 converter** Motor cable length **≤ 5 m**
	HNL01.1E-0240-N0106	HNF01.2D-F240-E0125	*Central supply to axis systems* • Type current HMS ≤ W0070 • Type current HMD ≤ W0036 • Sum of type currents ≤ 270 • 2 × 330 nF ≤ C_y ≤ 2 × 600 nF • Motor cable length ≤ 240 m (f_s = 8 kHz)
	HNL01.1E-0240-N0106	HNF01.2D-M900-E0125	*Central supply to axis systems* • Type current HMS ≤ W0070 • Type current HMD ≤ W0036 • Sum of type currents ≤ 270 • 2 × 330 nF ≤ C_y ≤ 2 × 1225 nF • Motor cable length ≤ 900 m (f_s = 8 kHz)
	HNL01.1E-0240-N0106 with HNL01.1E-2800-S0125	Customer-side	Standard mains choke connected in series with current-compensated mains choke to reduce line-frequency leakage currents

Converter	Mains chokes	Mains filter	Explanation
HCS03.1E-W0210	HNK01.1A-A075-E0146		Standard combination for **1 converter** Motor cable length ≤ 75 m
	HNL01.1E-0170-N0146	-	Standard for operating one drive controller without mains filter
	HNL01.1E-0170-N0146	NFD03.1-480-180	Combination for **1 converter** Motor cable length **≤ 5 m**
	HNL01.1E-0170-N0146	HNF01.2D-F240-E0202	*Central supply to axis systems* • Type current HMS ≤ W0150 • Type current HMD ≤ W0036 • Sum of type currents ≤ 270 • 2 × 330 nF ≤ C_y ≤ 2 × 600 nF • Motor cable length ≤ 240 m (f_s = 8 kHz)
	HNL01.1E-0170-N0146	HNF01.2D-M900-E0202	*Central supply to axis systems* • Type current HMS ≤ W0150 • Type current HMD ≤ W0036 • Sum of type currents ≤ 270 • 2 × 330 nF ≤ C_y ≤ 2 × 1225 nF • Motor cable length ≤ 900 m (f_s = 8 kHz)
	HNL01.1E-0170-N0146 with HNL01.1E-3400-S0202	Customer-side	Standard mains choke connected in series with current-compensated mains choke to reduce line-frequency leakage currents
HCS03.1E-W0280	HNL01.1E-0100-N0220	HNF01.1C-F240-E0225	Without any technical restriction, the mains choke can also be operated at a mains voltage 500 V AC +10%.
HCS03.1E-W0350			

Tab. 8-13: Selecting the HCS03 mains connection

8.4 Additional components

8.4.1 Additional components at the DC bus

General information

Converters and supply units basically differ in the following features:

- Braking resistor integrated
- Possible connection for external HLR braking resistor
- Operation of DC bus resistor unit HLB
- Operation of DC bus capacitor unit HLC
- Need of HLL chokes for operation

Take value C_{DCext} into account when operating HLC01!

Observe the different abilities which HMV supply units and HCS converters have to charge external capacitances at the DC bus (L +, L-).

Take the value C_{DCext} into account which is contained in the technical data of the respective device.

See also Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → "HCS03 power sections" → "Technical data" → "Basic data" → Power section data - DC bus

In the HCS03 product series, it is only allowed to operate external capacitances at the DC bus for the HCS03.1E-W0210 type.

Allowed combinations

The table below shows which additional components are allowed at the DC bus of HMV supply units and HCS converters.

Project planning of HLC

Take the charging ability C_{DC_ext} of the used supply unit or converter into account.

Supply unit or converter	HLB01.1C	HLB01.1D	HLC01.1C	HLC01.1D	HLR01.1	HLL02.1
HMV01.1E-W	-	■ ≤ 2	■ 2)	■	-	-
HMV01.1R-W	-		■ 2)	■	-	-
HMV02.1R-W	■ ≤ 2	-	■	-	-	-
HCS02.1	■	■ 2)	■	■ 2)	■ 3)	-
HCS03.1	■ 2)	■	-	■ 1)	■ 4)	-

■	Allowed
■ (!)	Has to be used
-	Not allowed
1)	Only HCS03.1E-…-W0210
2)	Different mounting depths: Control cabinet adapter HAS03 required
3)	HCS02.1E-W0054, -W0070 (standard equipment: braking transistor integrated)
4)	HCS03.1E in optional design -xxBx (integrated braking transistor) required

Tab. 8-14: Combinations with additional components

HLR braking resistors and DC bus resistor units HLB

NOTICE **High temperatures in the proximity of braking resistors!**

Mount the braking resistors to temperature-resistant mounting surfaces in such a way that the air can freely enter and escape and heat does not accumulate.

Take the minimum distances d_{top}, d_{bot} and d_{hor} into account.

Take into account that the temperatures in the range of the indicated minimum distances can be above 250 °C.

Leave sufficient distance to combustible objects and take into account that braking resistors dissipate a lot of heat.

Make sure there is free cooling air supply at the bottom d_{bot} and cooling air discharge at the top d_{top}.

The space must be able to discharge the energy converted by the braking resistor.

Selection aid for additional components HLR, HLB

Criterion	DC bus resistor unit HLB	Braking resistor HLR
Regenerative operation with great energy contents, e.g. • Deceleration of great centrifugal masses at centrifuges • Long braking processes for crane lifting gears	□ Take energy absorption capacity and continuous power into account	■ Type of construction N Check use of HMVxx.xR
Kinetic energy is generated in control cabinet and can be dissipated	■	□ Type of construction A
Kinetic energy cannot be dissipated in control cabinet	-	■ Type of construction N Observe degree of protection
Quick discharge of DC bus required	■ DC bus short circuit device Observe the note "Risk of fire caused by the "sacrificing behavior" of the ZKS stage!"	-
Deceleration of synchronous motors in the case of error "mains failure"	■	-
Supply unit HMV01.1R-W0120	■	-
Converter HCS02 selected	■	■
Converter HCS03 selected	■	■ Option -xxBx required

■ Recommended
□ Suited to a limited extent
- Not allowed

Tab. 8-15: Selection aid

NOTICE **Risk of fire caused by the "sacrificing behavior" of the ZKS stage!**

The "ZKS" input activates the "DC bus short circuit" function, when the 24V control voltage has not been applied and when there isn't any current flowing to the input. This condition can occur in the following situations:

- Failure of 24V control voltage
- Wire break
- Activation of serially connected contacts (e.g. axis limit switches)

If the kinetic energy of the mechanical axis system regenerated when braking is greater than the energy absorption capacity of HLB, the HLB device remains active when braking via ZKS takes place, until it is thermally destroyed (sacrificing behavior). Risk of fire! In this case, braking via ZKS may only come into effect in the case of an emergency (e.g. activation of an axis limit switch causes the mains supply to be cut off and simultaneously causes the 24V supply of the ZKS input to be interrupted).

Install a 24V UPS, if the "sacrificing behavior" of HLB is relevant to your drive system in the case of an emergency. This prevents the braking via ZKS which causes HLB to be destroyed due to the failure of the 24V control voltage. Braking via ZKS then will only take place in cases of emergency.

☞ **Required type data**

To select an appropriate HLR braking resistor, the following type data of the application are required:

- Peak regenerative power $P_{RS, Anlage}$

  (See chapter 15.1.7 "Peak Regenerative Power" on page 245)
- Continuous regenerative power $P_{RD, Anlage}$

  (See chapter 15.1.6 "Continuous Regenerative Power" on page 243)
- Regenerative power $W_{R, Anlage}$

  (See chapter 15.1.4 "Regenerative Power" on page 239)

☞ **HCS02, HCS03 with HLR01 and HLB01 simultaneously**

- The continuous power of the selected HLR01 has to be at least as high as the continuous power of the HLB used.
- Due to differences in balance, the total continuous power is lower than the sum of the individual continuous powers. The balancing factor of 0.8 is regarded as the guide value.

☞ **Function of integrated braking resistor in HCS02 for operation with HLR01**

Braking resistors have been integrated in HCS02 drive controllers. When operating external HLR01 baking resistors, the integrated braking resistors are not loaded.

See also parameter

- P-0-0859, Data of internal braking resistor
- P-0-0860 Converter configuration

Observe degree of protection!

When mounted outdoor or at the outside of the control cabinet, observe the degree of protection IP20 of the braking resistor.

Protect the devices against intrusion of water.

Protection against overload!

The HCS drive controller monitors the external braking resistor by the firmware calculating a thermal image with the current braking power. When the limit values for the thermal image are exceeded, the converter switches off with the error "F8820 Braking resistor overload" to protect the baking resistor against overload.

- Exclusively operate the combinations of converter - braking resistor type listed below.
- At the drive controllers HCS02 and HCS03, parameterize the performance data of the selected braking resistor in parameter "P-0-0858, Data of external braking resistor". For this purpose, from the technical data take the data on:
  - Resistance value
  - Braking resistor continuous power
  - Maximum regenerative power to be absorbed
- Activate the selected braking resistor by setting bit 8 = 1 in parameter "P-0-0860, Converter configuration".

HLR01 braking resistors for HCS02

Converter	Braking resistor type[1]	Type of construction [2]	Type Dimensions [3]
HCS02.1E-W0054-A-03-xNNx	HLR01.1N-01K8-N40R0-…	N	A7
HCS02.1E-W0054-A-03-xNNx	HLR01.1N-03K8-N40R3-…	N	B1
HCS02.1E-W0070-A-03-xNNx	HLR01.1N-02K4-N28R0-…	N	A8
HCS02.1E-W0070-A-03-xNNx	HLR01.1N-05K5-N28R2-…	N	B2

1) Complete type with: A-007-NNNN
2) A: device mounting; N: version for free assembly
3) See Project Planning Manual "Rexroth IndraDrive Additional Components and Accessories", HLR dimensions tables

Tab. 8-16: HLR braking resistors ↔ HCS02 assignment

HLR01 braking resistors for HCS03

Converter	Braking resistor type	Type of construction[1]	Type Dimensions[2]
HCS03.1E-W0070-A-05-xxBx	HLR01.1N-0300-N17R5-A-007-NNNN	A	See corresponding dimensional drawing
HCS03.1E-W0100-A-05-xxBx	HLR01.1N-0470-N11R7-A-007-NNNN		
HCS03.1E-W0150-A-05-xxBx	HLR01.1N-0780-N07R0-A-007-NNNN		
HCS03.1E-W0210-A-05-xxBx	HLR01.1N-1K08-N05R0-A-007-NNNN		
HCS03.1E-W0070-A-05-xxBx	HLR01.1N-01K6-N18R0-A-007-NNNN	N	A5
	HLR01.1N-01K6-N18R0-A-007-NNNU		A9

Converter	Braking resistor type	Type of construction1)	Type Dimensions2)
HCS03.1E-W0100-A-05-xxBx	HLR01.1N-02K0-N15R0-A-007-NNNN	N	A6
	HLR01.1N-02K0-N15R0-A-007-NNNU		O10
HCS03.1E-W0150-A-05-xxBx	HLR01.1N-04K5-N07R4-A-007-NNNN	N	B1
HCS03.1E-W0210-A-05-xxBx	HLR01.1N-06K5-N06R1-A-007-NNNN	N	B2
HCS03.1E-W0070-A-05-xxBx	HLR01.1N-03K5-N19R0-A-007-NNNN	N	B1
HCS03.1E-W0100-A-05-xxBx	HLR01.1N-05K0-N15R0-A-007-NNNN	N	B2
HCS03.1E-W0150-A-05-xxBx	HLR01.1N-08K5-N08R0-A-007-NNNN	N	B3
HCS03.1E-W0210-A-05-xxBx	HLR01.1N-12K5-N05R5-A-007-NNNN	N	B4
HCS03.1E-W0070-A-05-xxBx	HLR01.1N-04K5-N18R0-A-007-NNNN	N	B2
HCS03.1E-W0100-A-05-xxBx	HLR01.1N-07K0-N14R0-A-007-NNNN	N	B3
HCS03.1E-W0150-A-05-xxBx	HLR01.1N-11K0-N07R3-A-007-NNNN	N	B3
HCS03.1E-W0210-A-05-xxBx	HLR01.1N-17K0-N05R1-A-007-NNNN	N	B5
HCS03.1E-W0070-A-05-xxBx	HLR01.1N-06K5-N18R0-A-007-NNNN	N	B2
HCS03.1E-W0100-A-05-xxBx	HLR01.1N-09K5-N13R0-A-007-NNNN	N	B3
HCS03.1E-W0150-A-05-xxBx	HLR01.1N-15K0-N08R1-A-007-NNNN	N	B4
HCS03.1E-W0210-A-05-xxBx	HLR01.1N-23K0-N05R5-A-007-NNNN	N	C2
HCS03.1E-W0070-A-05-xxBx	HLR01.1N-10K0-N18R0-A-007-NNNN	N	B3
HCS03.1E-W0100-A-05-xxBx	HLR01.1N-14K5-N13R0-A-007-NNNN	N	B4
HCS03.1E-W0150-A-05-xxBx	HLR01.1N-24K0-N07R2-A-007-NNNN	N	C3
HCS03.1E-W0210-A-05-xxBx	HLR01.1N-36K0-N05R4-A-007-NNNN	N	C4
HCS03.1E-W0280-A-05-xxBx HCS03.1E-W0350-A-05-xxBx	HLR01.1N-1K08-N05R0-A-007-NNNN	A	See corresponding dimensional drawing
	HLR01.1N-06K5-N06R1-A-007-NNNN	N	B2
	HLR01.1N-12K5-N05R5-A-007-NNNN	N	B4
	HLR01.1N-17K0-N05R1-A-007-NNNN	N	B5
	HLR01.1N-23K0-N05R5-A-007-NNNN	N	C2
	HLR01.1N-36K0-N05R4-A-007-NNNN	N	C4

1) A: device mounting; N: version for free assembly
2) See Project Planning Manual "Rexroth IndraDrive Additional Components and Accessories", HLR dimensions tables

Tab. 8-17: HLR braking resistors ↔ HCS03 assignment

8.4.2 Additional components at the motor output

General information

In conjunction with long motor cables, the steep switching edges at the motor output of the drive controllers can cause transient overvoltages and high rise of voltage at the motor. HMF01 motor filters reduce the overvoltages and rise of voltage.

Guide value "Rise of voltage at output"

Observe that the voltage load at the motor is almost independent of the power section used.

Especially when using **standard motors**, make sure that they comply with the occurring voltage load.

Observe the information on third-party motors at drive controllers (see documentation "Rexroth IndraDrive Drive Systems With HMV01/02 HMS01/02, HMD01, HCS02/03", index entry "Third-party motors → On drive controllers").

Use HMF01 motor filters when the allowed rise of voltage of the third-party motor is lower than the rise of voltage at the output of the inverter used (see "Power section data - inverter").

As a matter of principle, operating motors of the **IndraDyn** product range at converters and inverters of the IndraDrive product range does not require motor filters under the specified operating conditions.

HMF01 motor filters

NOTICE **Damage caused by too high switching frequency!**

Only operate HMF01 motor filters up to their maximum allowed switching frequency f_s.

Drive controller	HMF01 motor filter
HCS02.1E-W0012 HCS02.1E-W0028	HMF01.1A-N0K2-M0012
HCS02.1E-W0054 HCS02.1E-W0070	HMF01.1A-N0K2-M0028
HCS03.1E-W0070	HMF01.1A-N0K2-D0045-…
HCS03.1E-W0100	HMF01.1A-N0K2-D0073-…
HCS03.1E-W0150	HMF01.1A-N0K2-D0095-…
HCS03.1E-W0210	HMF01.1A-N0K2-D0145-…
HCS03.1E-W0280	-
HCS03.1E-W0350	-

Tab. 8-18: HMF01 to HCS02/HCS03 assignment

8.5 Power section, control section, firmware

8.5.1 General information

The modular structure of the IndraDrive controllers allows control sections and power sections to be combined. There are these dependencies which are represented in tables:

- Power sections require control sections with firmware
- Encoder systems require encoder evaluations in control sections

8.5.2 Power section - control section

Control section	Power section				
	HMS01	HMS02	HMD01	HCS02	HCS03
CSH01.1C 1)	■	■	-	■	■
CSH01.2C 1)	■	■	-	■	■
CSH01.3C 1)	■	■	-	■	■
CSB01.1N 2)	■	■	-	■	■
CSB01.1C 1)	■	■	-	■	■
CDB01.1C 1)	-	-	■	-	-
CSH02.1B 4)	■	■	-	■	■
CSB02.1A 3)	■	■	-	■	■
CSB02.1B 4)	■	■	-	■	■
CSE02.1A 3)	■	■	-	■	■
CDB02.1B 4)	-	-	■	-	-

■ Allowed
\- Not allowed
1) Control section can be configured
2) Control section cannot be configured
3) Basic scope
4) Extended scope

Tab. 8-19: Control section - power section combination

Power sections with power supply from the DC bus (xxxV) cannot use the optional safety technology in conjunction with Cxx02 control sections.

NOTICE **Risk of damage to the control section or power section by mounting and dismounting the control section too often!**

The control section of a drive controller cannot be mounted and dismounted more than a maximum of **20 times**.

8.5.3 Control section - firmware

For scopes of functions and configurations of firmware versions, see Functional Description of corresponding firmware version in chapter "Reference documentations".

Control section type 1)					Firmware version
CSB01	.	1	N	-FC	As of MPB-02VRS
CSB01	.	1	N	-AN	As of MPB-02VRS
CSB01	.	1	C		As of MPB-02VRS

Control section type 1)					Firmware version
CDB01	.	1	C		As of MPD-02VRS
CSH01	.	1	C		As of MPH-02VRS
CSH01	.	2	C		As of MPH-04VRS to MPH-05VRS
CSH01	.	3	C		As of MPC-06V06
CSB02	.	1	A		As of MPB-18VRS
CSB02	.	1	B		As of MPB-18VRS
CSH02	.	1	B		As of MPH-18VRS
CDB02	.	1	B		As of MPD-18VRS
CSE02	.	1	A		As of MPE-18VRS

1) Non-configured basic design

Tab. 8-20: Required Firmware Versions for Control Sections

8.5.4 Power section - firmware

The tables show from which firmware version on the corresponding products are supported. The mentioned products need this or a more recent firmware version for operation. More recent firmware versions are marked with "RS" (e.g., MPH-02V**RS**).

Inverters HMS01, HMS02, HMD01

Product Series		Type current			Design	Supported from firmware version
HMS01.1N	-	W0020	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0036	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0054	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0070	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0110	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0150	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0210	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0300	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0350	-	A-07-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS

Product Series		Type current			Design	Supported from firmware version
HMS02.1N	-	W0028	-	A-07-	NNNN	MPH-02V24; MPB-02V24; MPx-18VRS MPH-03V12; MPB-03V12; MPx-18VRS
	-	W0054	-	A-07-	NNNN	MPH-02V24; MPB-02V24; MPx-18VRS MPH-03V12; MPB-03V12; MPx-18VRS
HMD01.1N	-	W0012	-	A-07-	NNNN	MPD-02VRS; MPx-18VRS
	-	W0020	-	A-07-	NNNN	MPD-02VRS; MPx-18VRS
	-	W0036	-	A-07-	NNNN	MPD-02VRS; MPx-18VRS

Tab. 8-21: Required firmware versions for inverters

Converters HCS02, HCS03

Product Series		Type current			Design	Supported from firmware version
HCS02.1E	-	W0012	-	A-03-	LNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0012	-	A-03-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0012	-	A-03-	NNNV	MPH-02V20; MPB-02V20; MPx-18VRS
	-	W0028	-	A-03-	LNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0028	-	A-03-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0028	-	A-03-	NNNV	MPH-02V20; MPB-02V20; MPx-18VRS
	-	W0028	-	S-03-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0054	-	A-03-	LNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0054	-	A-03-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0054	-	A-03-	NNNV	MPH-02V20; MPB-02V20; MPx-18VRS
	-	W0070	-	A-03-	LNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0070	-	A-03-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0070	-	A-03-	NNNV	MPH-02V20; MPB-02V20; MPx-18VRS

Product Series		Type current			Design	Supported from firmware version
HCS03.1E	-	W0070	-	A-05-	LNBV	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0070	-	A-05-	LNNV	MPH-02V11; MPB-02V11; MPx-18VRS
	-	W0070	-	A-05-	NNBV	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0070	-	A-05-	NNNV	MPH-02V11; MPB-02V11; MPx-18VRS
	-	W0070	-	A-05-	NNNN	MPH-02V11; MPB-02V11; MPx-18VRS
	-	W0070	-	A-15-	PSPV	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0100	-	A-05-	LNBV	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0100	-	A-05-	LNNV	MPH-02V11; MPB-02V11; MPx-18VRS
	-	W0100	-	A-05-	NNBV	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0100	-	A-05-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0100	-	A-05-	NNNV	MPH-02V11; MPB-02V11; MPx-18VRS
	-	W0150	-	A-05-	LNBV	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0150	-	A-05-	LNNV	MPH-02V11; MPB-02V11; MPx-18VRS
	-	W0150	-	A-05-	NNBV	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0150	-	A-05-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0150	-	A-05-	NNNV	MPH-02V11; MPB-02V11; MPx-18VRS
	-	W0210	-	A-05-	LNBV	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0210	-	A-05-	LNNV	MPH-02V11; MPB-02V11; MPx-18VRS
	-	W0210	-	A-05-	NNBV	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0210	-	A-05-	NNNN	MPH-02VRS; MPB-02VRS; MPx-18VRS
	-	W0210	-	A-05-	NNNV	MPH-02V11; MPB-02V11; MPx-18VRS
	-	W0280	-	A-05-	LNBV	MPx-08V16; MPx-18V26; MPx-20V10
	-	W0280	-	A-05-	LNNV	MPx-08V16; MPx-18V26; MPx-20V10
	-	W0280	-	A-05-	NNBV	MPx-08V16; MPx-18V26; MPx-20V10
	-	W0280	-	A-05-	NNNN	MPx-08V16; MPx-18V26; MPx-20V10
	-	W0280	-	A-05-	NNNV	MPx-08V16; MPx-18V26; MPx-20V10
	-	W0350	-	A-05-	LNBV	MPx-08V16; MPx-18V26; MPx-20V10
	-	W0350	-	A-05-	LNNV	MPx-08V16; MPx-18V26; MPx-20V10
	-	W0350	-	A-05-	NNBV	MPx-08V16; MPx-18V26; MPx-20V10
	-	W0350	-	A-05-	NNNN	MPx-08V16; MPx-18V26; MPx-20V10
	-	W0350	-	A-05-	NNNV	MPx-08V16; MPx-18V26; MPx-20V10

Tab. 8-22: Required firmware versions for converters

8.5.5 Motor - firmware

Motor type	With encoder system	Firmware version from	Notes
MHD		MPx-02VRS	
MKD		MPx-02VRS	
MKE		MPx-02VRS	
	A, C	MPx-16VRS	
MSK		MPx-02VRS	
MSM	M5	MPx-16VRS	
MS2N	AS/AM, BS/BM, CS/CM, HS/HM, DS/DM	MPx-20VRS	
MS2E	CS/CM	MPx-20VRS	
MAF		MPx-02VRS	
	M1, M2, M6, S1, S2, S6, N0	MPx-16VRS	
MAD		MPx-02VRS	
	M1, M2, M6, S1, S2, S6, N0	MPx-16VRS	
MSP		MPx-05VRS	
MSD		MPx-02VRS	
	M1, M2, S1, S2	MPx-16VRS	
IndraDyn L MLF		MPx-02VRS	
MBS			
IndraDyn H MBSxx2		MPx-02VRS	
IndraDyn T MBT		MPx-02VRS	

Tab. 8-23: Firmware versions vs. motors

8.5.6 Encoder system - encoder evaluation

8.5.7 Introduction

The control sections of the IndraDrive product range support different encoder systems. Evaluating these encoder systems requires the mentioned encoder evaluations as optional modules or optional equipment.

☞ Operating other encoder systems than the mentioned ones requires detailed control of the technical data of the encoder system used and the interface specification of the control section.

When using third-party encoders, observe that the optional modules provide different supply voltages.

8.5.8 Optional modules

Supported by firmware versions MPx-08 and below

Encoder system [1)]	Notes	Optional module encoder evaluation	Cable for direct connection [2)]
	Rexroth IndraDyn **S, A, T, H, L**		
R0	Resolver	EN1	IKS4043
R1	Resolver with integrated absolute multi-turn encoder	EN1	IKS4043
S0	Optical encoder single-turn IIC, 512 increments, supply voltage 8 V	EN1	IKS4042
S1	Optical encoder single-turn HIPERFACE, 128 increments, supply voltage 7 … 12 V	ENS	RKG4200
S2	Optical encoder single-turn EnDat2.1, 2048 increments, supply voltage 12 V	ENS	RKG4200
S3	Capacitive encoder single-turn HIPERFACE, 16 increments, supply voltage 7 … 12 V	ENS	RKG4200
S5	Optical encoder, single-turn with 128 increments (at QSK motors) At HCQ02 requires interface code "1S" or "1N" (e.g., HCQ02.1E-W025- A-03-B-L4-**1S**)	ES	RKG4200
S6	Optical encoder single-turn EnDat2.1, 2048 increments, supply voltage 12 V	ENS	RKG4200
M1	Optical encoder multi-turn absolute HIPERFACE, 128 increments, supply voltage 7 … 12 V	ENS	RKG4200
M2	Optical encoder multi-turn absolute EnDat2.1, 2048 increments, supply voltage 12 V	ENS	RKG4200
M3	Capacitive encoder multi-turn absolute HIPERFACE, 16 increments, supply voltage 7 … 12 V	ENS	RKG4200
M5	Optical encoder, multi-turn absolute with 128 increments (at QSK motors) At HCQ02 requires interface code "1S" or "1N" (e.g., HCQ02.1E-W025- A-03-B-L4-**1S**)	ES	RKG4200
M6	Optical encoder multi-turn absolute EnDat2.1, 2048 increments, supply voltage 12 V	ENS	RKG4200
C0	Optical encoder incremental 1 V_{pp}, 2048 increments (sin/cos)	EN2	RKG0014
SHL01.1	Hall sensor box for position detection of primary part of, for example, IndraDyn L and LSF motors	EN1[3)]	IKS4042
SHL02.1	Hall sensor box for position detection of primary part of, for example, IndraDyn L and LSF motors	EN1[4)]	IKS4042
		ENS	RKG0027
	Rexroth ServoDyn D servo motors **SF**		
STG	Single-turn encoder, absolute	EN2	RKG0015
MTG	Multi-turn encoder, 4096 revs. absolute	EN2	RKG0015
	Rexroth ServoDyn D servo motors **SR**		

Encoder system [1]	Notes	Optional module encoder evaluation	Cable for direct connection [2]
	Resolver	Not supported	
Rexroth motors **MKE, MKD, MHD**			
A	See encoder system S1	ENS	Depending on motor type: RKG0020 or RKG0022
C	See encoder system M1	ENS	
B	See encoder system S2	ENS	
D	See encoder system M2	ENS	
K	See encoder system R1	EN1	Depending on motor type: IKS0223 or IKS0226
G	See encoder system R0	EN1	
N	See encoder system S0	EN1	
P	See encoder system M0	EN1	

1) See following note
2) Without extension and control cabinet duct
3) With MPx04VRS and below, only allowed on option 2 (X8)
4) With MPx04VRS and below, only allowed on option 2 (X8); configurable with MPx05VRS and above

Tab. 8-24: Combination of control section equipment - motor encoder

For the encoder system, see the type code of the selected motor.

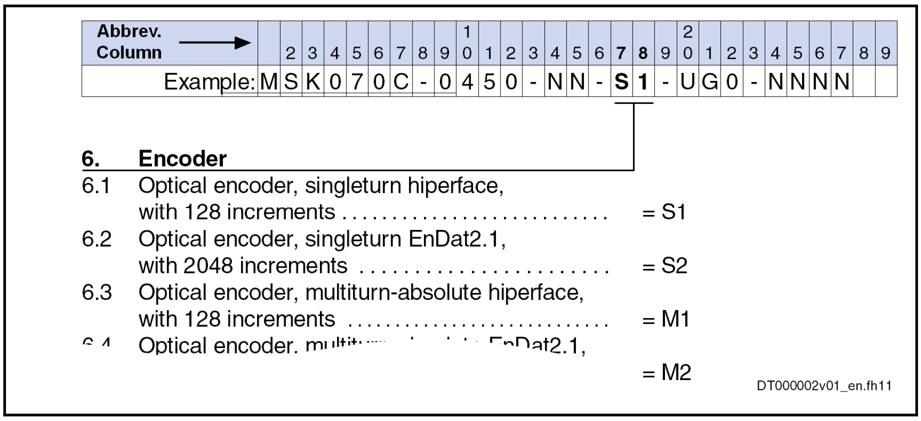


Fig. 8-8: Excerpt from motor type code

Supported by firmware versions MPx-16 and above

Encoder system [1]	Notes	Optional module encoder evaluation	Cable for direct connection [2]
Rexroth IndraDyn **S, A, T, H, L**		EC	
R0	Resolver		IKS4043
R1	Resolver with integrated absolute multi-turn encoder		IKS4043
S0	Optical encoder single-turn IIC, 512 increments, supply voltage 8 V		IKS4042
S1	Optical encoder single-turn HIPERFACE, 128 increments, supply voltage 7 … 12 V		RKG4200
S2	Optical encoder single-turn EnDat2.1, 2048 increments, supply voltage 12 V		RKG4200
S3	Capacitive encoder single-turn HIPERFACE, 16 increments, supply voltage 7 … 12 V		RKG4200
S5	Optical encoder, single-turn with 128 increments (at QSK motors) At HCQ02 requires interface code "1S" or "1N" (e.g., HCQ02.1E-W025- A-03-B-L4-**1S**)		RKG4200
S6	Optical encoder single-turn EnDat2.1, 2048 increments, supply voltage 12 V		RKG4200
M1	Optical encoder multi-turn absolute HIPERFACE, 128 increments, supply voltage 7 … 12 V		RKG4200
M2	Optical encoder multi-turn absolute EnDat2.1, 2048 increments, supply voltage 12 V		RKG4200
M3	Capacitive encoder multi-turn absolute HIPERFACE, 16 increments, supply voltage 7 … 12 V		RKG4200
M5	Optical encoder, multi-turn absolute with 128 increments (at QSK motors) At HCQ02 requires interface code "1S" or "1N" (e.g., HCQ02.1E-W025- A-03-B-L4-**1S**)		RKG4200
M6	Optical encoder multi-turn absolute EnDat2.1, 2048 increments, supply voltage 12 V		RKG4200
C0	Optical encoder incremental 1 V_{pp}, 2048 increments (sin/cos)		RKG0014
SHL01.1	Hall sensor box for position detection of primary part of, for example, IndraDyn L and LSF motors		IKS4042
SHL02.1	Hall sensor box for position detection of primary part of, for example, IndraDyn L and LSF motors		IKS4042 RKG0027
SHL03.1	Hall sensor adapter box for position detection of the primary part of IndraDyn L MCL motors		RKG0049
Rexroth ServoDyn D servo motors **SF**			
STG	Single-turn encoder, absolute		RKG0015
MTG	Multi-turn encoder, 4096 revs. absolute		RKG0015
Rexroth ServoDyn D servo motors **SR**			

Encoder system [1]	Notes	Optional module encoder evaluation	Cable for direct connection [2]
	Resolver	Not supported	
Rexroth motors **MKE, MKD, MHD**		EC	
A	See encoder system S1		Depending on motor type: RKG0020 or RKG0022
C	See encoder system M1		
B	See encoder system S2		
D	See encoder system M2		
K	See encoder system R1		Depending on motor type: IKS0223 or IKS0226
G	See encoder system R0		
N	See encoder system S0		
P	See encoder system M0		

1) See following note
2) Without extension and control cabinet duct

Tab. 8-25: Combination of control section equipment - motor encoder

☞ For the encoder system, see the type code of the selected motor.

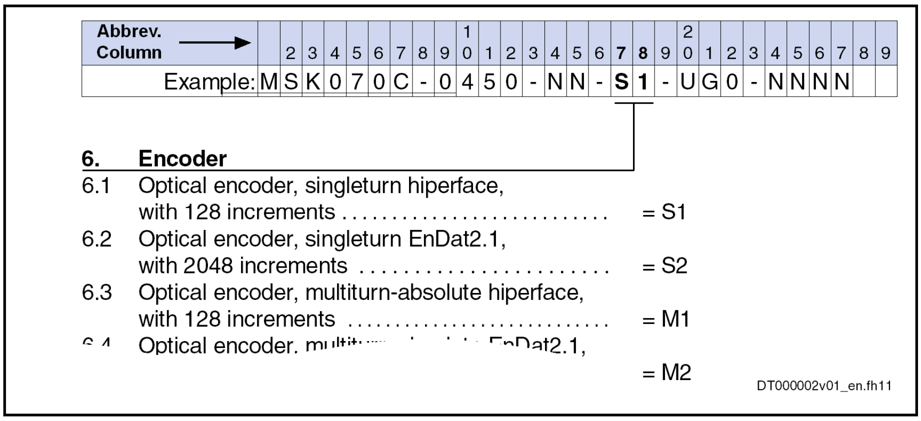


Fig. 8-9: Excerpt from motor type code

Supported by firmware versions MPx-20 and above

Encoder system [1)]	Notes	Optional module encoder evaluation	Cable for direct connection [2)]
Rexroth IndraDyn **S MS2N**		EC	
AS	Capacitive encoder single-turn HIPERFACE, 16 increments, supply voltage 7 … 12 V		RG2-002AB
AM	Capacitive encoder multi-turn HIPERFACE, 16 increments, supply voltage 7 … 12 V		RG2-002AB
BS	Optical encoder single-turn HIPERFACE, 128 increments, supply voltage 7 … 12 V		RG2-002AB
BM	Optical encoder multi-turn HIPERFACE, 128 increments, supply voltage 7 … 12 V		RG2-002AB
CS	Optical encoder single-turn ACURO®link, digital, 20 bit, supply voltage 7 … 12 V, SIL2, PL d		RG2-002AA
CM	Optical encoder multi-turn ACURO®link, digital, 20 bit, supply voltage 7 … 12 V, SIL2, PL d		RG2-002AA
DS	Optical encoder single-turn ACURO®link, digital, 24 bit, supply voltage 7 … 12 V		RG2-002AA
DM	Optical encoder multi-turn ACURO®link, digital, 24 bit, supply voltage 7 … 12 V		RG2-002AA
HS	Optical encoder single-turn ACURO®link, digital, 20 bit, supply voltage 7 … 12 V, SIL3, PL e		RG2-002AA
HM	Optical encoder multi-turn ACURO®link, digital, 20 bit, supply voltage 7 … 12 V, SIL3, PL e		RG2-002AA
	Rexroth IndraDyn **S MS2E**	EC	
CS	Optical encoder single-turn ACURO®link, digital, 20 bit, supply voltage 7 … 12 V, SIL2, PL d		RG2-002AA
CM	Optical encoder multi-turn ACURO®link, digital, 20 bit, supply voltage 7 … 12 V, SIL2, PL d		RG2-002AA

1) See following note

Tab. 8-26: Combination of control section equipment - motor encoder

☞ For the encoder system, see the type code of the selected motor.

Short type designation	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	S	2	N	x	x	-	C	0	B	N	N	-	A	S	D	H	0	-	N	N	N	N	N	-	N	N													
														⑦	⑧																									

⑦	**Encoder performance** A = Basic - 16 signal periods, Hiperface B = Standard - 128 signal periods, Hiperface C = Advanced - 20-bit, ACURO®link (SIL2, PL d) D = High - 24-bit, ACURO®link H = Advanced - 20-bit, ACURO®link (SIL3, PL e)
⑧	**Encoder design** S = Single-turn - 1 revolution absolute M = Multi-turn - 4096 revolutions absolute

Tab. 8-27: Excerpt from MS2N type code

Short type designation	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	S	2	E	x	x	-	C	0	B	N	N	-	C	S	S	K	0	-	N	N	N	N	N	-	N	N													
														⑦	⑧																									

⑦	**Encoder performance** C = Advanced - 20-bit, ACURO®link (SIL2, PL d)
⑧	**Encoder design** S = Single-turn - 1 revolution absolute M = Multi-turn - 4096 revolutions absolute

Tab. 8-28: Excerpt from MS2E type code

8.5.9 Rexroth motors

<table>
<tr><th>Motor</th><th>Encoder</th><th>IndraDrive interface</th><th>Cables
Direct connection</th></tr>
<tr><td rowspan="4">IndraDyn A
MAD
MAF</td><td>C0</td><td>EN2</td><td>RKG0014</td></tr>
<tr><td>S0
M0</td><td>EN1</td><td>Straight device connector:
IKS4042
Angular device connector:
IKS4044</td></tr>
<tr><td>S2
M2</td><td>ENS/EC/ES</td><td rowspan="2">RKG4200</td></tr>
<tr><td>S6
M6</td><td>ENS/EC/ES</td></tr>
<tr><td>IndraDyn S
MKE037, 047, 098</td><td rowspan="2">A
B
C
D</td><td>ENS/EC/ES</td><td>RKG0020</td></tr>
<tr><td>IndraDyn S
MKE118</td><td>ENS/EC/ES</td><td>RKG0022</td></tr>
</table>

Motor	Encoder	IndraDrive interface	Cables Direct connection
IndraDyn S MSK	M1 M2 M3 S1 S2 S3	ENS/EC/ES	RKG4200
IndraDyn S MSM	M5	EC	RKG0033 RKG0062
IndraDyn S MS2N	AS AM BS BM	EC	RG2-002AB
	CS CM DS DM HS HM	EC	RG2-002AA
IndraDyn S MS2E	CS CM	EC	RG2-002AA

Tab. 8-29: Connection cables (direct connection) for motor encoder - IndraDrive

8.5.10 Third-party manufacturer

Encoder	Device socket at encoder	IndraDrive interface	Cables Direct connection
Absolute 5V EnDat	M23 17-pin union nut female connector	EC / ES	RKG0036
	M23 17-pin union nut female connector	EN2	IKS4038
	M23 17-pin union nut female connector	EN2	RKG0004
	M23 17-pin union nut female connector	EN2	RKG0006
	M23 17-pin union nut female connector	EN2	RKG0011
Absolute 5V SSI	M23 12-pin external thread female connector	MD2	RKG4400
Absolute 12V EnDat	M23 10-pin union nut female connector	ENS/EC/ES	RKG4200
	M23 10-pin union nut female connector	ENS/EC/ES	RKG4200
	M23 10-pin union nut female connector	ENS/EC/ES	RKG4202
Absolute 12V Hiperface	M23 10-pin union nut female connector	ENS/EC/ES	RKG4200
	M23 10-pin union nut female connector	ENS/EC/ES	RKG4200
	M23 10-pin union nut female connector	ENS/EC/ES	RKG4202
	D1000 8-pin female connector	ENS/EC/ES	RKG0047

Encoder	Device socket at encoder	IndraDrive interface	Cables Direct connection
Incremental 5V 1Vpp	M23 12-pin union nut female connector	EC/ES	RKG0035
	M23 12-pin union nut female connector	EN2	RKG0026
	M23 17-pin union nut female connector	EN2	RKG0013
	M23 17-pin union nut female connector	EN2	RKG0014
	M23 17-pin union nut female connector	EN2	IKS40xx
	M23 17-pin union nut female connector	EN2	RKG0015
	M23 12-pin external thread female connector	EN2	RKG0031
	M23 12-pin external thread female connector	EN2	IKS4040
Incremental 5V TTL	M23 12-pin union nut female connector	EN2	IKS4039
Incremental 12V 1Vpp	M23 12-pin union nut female connector	ENS/EC/ES	RKG0017
MEM 1Vpp	D-Sub 15-pin	AEH	RKG0025
	D-Sub 15-pin	EN2	RKG0024
SHL BOX	M23 12-pin union nut female connector	ENS	RKG0027
Unknown	Unassigned connection (open ends AEH)	EN2	RKG0030
	Unassigned connection (open ends AEH)	ENS/EC/ES	RKG0029

Tab. 8-30: Connection cables (direct connection) for encoders by third-party manufacturers

8.6 Combination with other Rexroth components

8.6.1 Combination with components of the Rexroth IndraControl V range

VCP operator terminals

To easily operate the IndraDrive system with the IndraControl V range, use VCP operator terminals.

The operator terminals VCP02, VCP05, VCP08, VCP20 and VCP25 are suited for control cabinet mounting and operated via the serial interface RS232 (X2) of the control sections.

The comfort control panel VCP01 is operated directly at the drive controller at the connection "H1". It then replaces the supplied standard control panel. The scope of functions is described in the Operating Instructions "Rexroth IndraDrive C Drive Controllers HCS02.1, HCS03.1".

☞ Simultaneous operation of VCP operator terminals and standard control panels or comfort control panels is allowed.

8.6.2 Sercos analog converter

General information

To modernize machines, the IndraDrive range provides the possibility of operating drive controllers of the "ANAX" and "Diax 02" ranges with analog command value input.

Sercos analog converter

The Sercos analog converter is used to

- connect control units with a Sercos interface to components with an analog interface
- convert Sercos position command values to analog speed command values

The Sercos analog converter consists of:

- Housing for HAC01.1-002 control sections
- Configurable control section with Sercos master communication
  - For MAC motors at TDM drive controllers:

    BASIC CDB01.1C-SE-EN1-EN1-MA1-MA1--NN-S-NN-FW
  - For MDD motors at DDS drive controllers:

    BASIC CDB01.1C-SE-EN2-EN2-MA1-MA1--NN-S-NN-FW
  - BASIC CDB01.1C-SE-ENS-ENS-MA1-MA1-NN-S-NN-FW (preliminary)
- Firmware, e.g. FWA-INDRV*-MPD-04VRS-**-*-***-**
- Optional HAS01.1-065-NNN-CN accessory

☞ Make sure that the parameter "P-0-0860, Converter configuration" has been set to operation as "Sercos analog converter" (bit 15 = 1). The wrong setting will generate the error message "F8091 Power section defective".

8.7 Connection cables to motor

8.7.1 General information

The connection from drive controller to motor is established by two cables:

- Motor cable (power cable)
- Encoder cable

The motor cable contains lines to connect the drive controller

- to the motor windings
- to the motor holding brake
- to the temperature measurement system of the motor

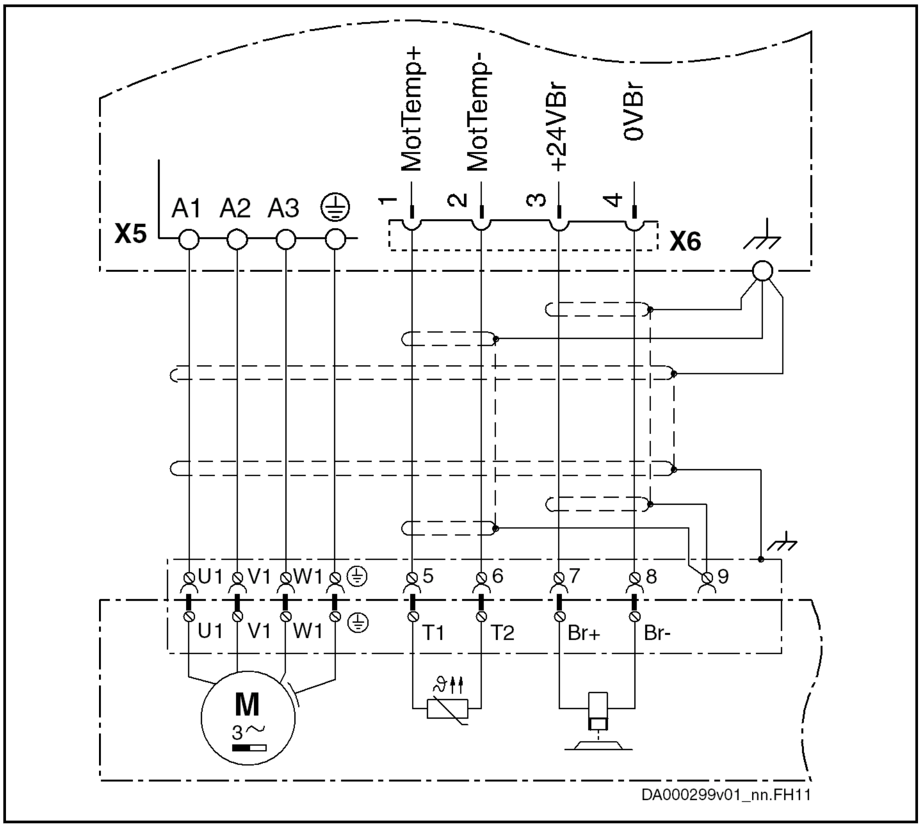


Fig. 8-10: Power cable to connect drive controller to motor

Use shielded motor cables of the RKL series for IndraDrive systems.

To select the motor cables and other connections (e.g., encoder cables), use the documentation "Rexroth Connection Cables".

8.7.2 Motor cable

General information

For project planning and selecting the motor cable, observe the following aspects:

- Required **cross section** depending on occurring loading with continuous current and peak current

  Allowed **length** depending on PWM frequency, output filter and shielding
- Length due to **voltage drop** on connection line to motor brake
- Other **mechanical requirements** resulting from use of motor cable, such as bending radiuses, material compatibility; see documentation "Rexroth Connection Cables".

Selecting the motor cable

To find the appropriate cable for the selected combination of motor and drive controller, see documentation "Rexroth Connection Cables".

Cables for MS2N and MS2E motors: Please contact our sales representative.

Allowed length of motor cable

The length of the motor power cable is limited to protect the drive controllers. The longer the motor cable and the higher the switching frequency f_s of the drive controller which has been set, the higher the occurring losses.

☞ Observe that the allowed motor cable length depends on the switching frequency f_s of the power output stage which has been set. As a matter of principle, the higher the switching frequency, the shorter the allowed cable length to protect the drive controllers against overload.

Only set switching frequencies that are supported by the components being used. Observe the technical data for drive controllers and motors.

See also description of parameter "P-0-0001, Switching frequency of the power output stage".

Allowed cable lengths at ambient temperature T_{a_work} ≤ 40 °C according to EN 60 204:

PWM frequency / kHz	Allowed cable length / m		
	Without motor filter		With motor filter[3)]
	Shielded	Unshielded[1)]	
2 [2)]	100	175	200
4	75	150	200
8	38	150	Not allowed
12	25	Not allowed	Not allowed
16	18	Not allowed	Not allowed

1) Only allowed for HCS02/HCS03 drive controllers, observe note "Unshielded motor cables" below
2) Depending on the drive controller which is used
3) Additional components for HMF

Tab. 8-31: Line lengths

☞ **Unshielded motor cables**

Operation with unshielded motor cable

- aims at applications with "sensorless operation" (open-loop operation)
- does not include the control voltage lines to the motor; brake supply and evaluation of the temperature sensors in the motor might possibly require further measures
- requires additional measures with regard to EMC on the part of the machine end-user

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☞ For lines **connected in parallel**, half the indicated lengths apply.

Voltage drop on connection to motor holding brake

The motor holding brake is controlled via the drive controller. For this purpose, the 24V supply is connected to the output at connection point X6. To operate the motor holding brake reliably, observe its requirements on power supply.

For operating the integrated motor holding brakes of the Rexroth IndraDyn motor series at IndraDrive controllers with Rexroth connection cables, the data of 24V supply are considered as guide values.

📖 For the data of 24V supply, see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → chapter of the respective device → "Technical data" → "Basic data" → "Control voltage supply data".

Mechanical requirements

Depending on the application, there are different requirements.

📖 See the technical data of the cables in the documentation "Rexroth Connection Cables" for whether the properties comply with the requirements.

Third-party power cables

Requirements on third-party motor power cables:

Maximum allowed **cable length** at A1, A2, A3:

- See chapter 8.7 Connection cables to motor, page 119

Maximum allowed **capacitance per unit length** at A1, A2, A3:

- Against ground, each: 0.5 nF/m
- Against each other: 0.5 nF/m

Maximum allowed **inductance per unit length** at A1, A2, A3:

- 100 nH/m each

☞ If third-party motor cables are used that do not correspond to the requirements, Rexroth's guarantee for the drive system will expire.

Use ready-made cables by Rexroth.

📖 Use the documentation "Rexroth Connection Cables" to select the cables.

8.7.3 Encoder cables

📖 To find the appropriate cable for the selected combination of motor with encoder and the respective encoder evaluation, see documentation "Rexroth Connection Cables" in chapter "Select encoder cables"

8.8 Using Rexroth IndraDyn motors

8.8.1 Rexroth IndraDyn H – synchronous kit spindle motors

When selecting the drive controllers and supply units, make sure that, when using **MBS** motors, the occurring peak power does not cause overvoltage in the DC bus.

Therefore, make sure for your selection that the developed peak power of the motor is smaller than the peak power (or sum of peak powers) of the braking resistors at the DC bus. Take into account that, in particular during operation in the field weakening range, high peak powers occur when control voltage fails.

The assignment table below shows the supply units or drive controllers basically suited for operating MBS motors.

Drive controller or supply unit	IndraDyn H	Notes
	MBS	
HMV01	■	
HMV02	■	
HCS02	-	Capacity P_{BS} of braking resistor is too low for occurring peak power.
HCS03	■	

■ Allowed
- Not allowed

Tab. 8-32: Combinations

9 Circuits for the mains connection

9.1 General information

The controls of mains contactor and DC bus short circuit for supply units and drive controllers suggested in this documentation describe the **functional principles**.

☞ The selection of the control and its effects depend on the extent of the functions and the operating sequence of the installation or machine. The installation or machine manufacturer is responsible for selecting the control of mains contactor and DC bus short circuit.

9.2 Mains contactor, Bb contact

The main components in the circuit for the mains connection are:

- Mains contactor
- Bb contact

Mains contactor

Mains contactors in the power circuit of the mains connection switch the power supply. In the case of error, mains contactors interrupt the energy flow from the power grid and thereby the power supply of the drive controllers.

When the drive system is supplied via another circuit, e.g. in regenerative form via **permanently** driven motor:

- Integrate this supply in the circuit for the mains connection.
- Take this into account when selecting the drive controllers and additional components.

NOTICE **Risk of fire caused by the "sacrificing behavior" of the ZKS stage!**

The "ZKS" input activates the "DC bus short circuit" function, when the 24V control voltage has not been applied and when there isn't any current flowing to the input. This condition can occur in the following situations:

- Failure of 24V control voltage
- Wire break
- Activation of serially connected contacts (e.g. axis limit switches)

If the kinetic energy of the mechanical axis system regenerated when braking is greater than the energy absorption capacity of HLB, the HLB device remains active when braking via ZKS takes place, until it is thermally destroyed (sacrificing behavior). Risk of fire! In this case, braking via ZKS may only come into effect in the case of an emergency (e.g. activation of an axis limit switch causes the mains supply to be cut off and simultaneously causes the 24V supply of the ZKS input to be interrupted).

Install a 24V UPS, if the "sacrificing behavior" of HLB is relevant to your drive system in the case of an emergency. This prevents the braking via ZKS which causes HLB to be destroyed due to the failure of the 24V control voltage. Braking via ZKS then will only take place in cases of emergency.

Switching off the power supply protects the supply units and drive controllers against permanently present error states and damage being caused by the persistent effect of these error states.

The **mains contactor does not replace overcurrent protection devices connected in the incoming circuit**, but is a functional complement. The mains contactor itself needs overcurrent protection to allow it to be reliably operated after switch-off processes.

In conjunction with the corresponding "circuit for the mains connection", the mains contactor only switches the DC bus voltage to the drive controllers when they are ready to consume power voltage and no error is present.

In order that the drive controllers can signal their status, they have to be supplied with the 24V control voltage.

The following scenarios are typical cases in which the circuit for the mains connection is to switch off the mains contactor and lead to the power supply being switched off:

- Short circuit at the output of the inverters with error "F8060 Overcurrent in power section"
- Switch-on upon activated DC bus short circuit (ZKS) with error message "F2820 Braking resistor overload"
- Operation at mains voltages outside of the allowed range with error message "F2815 Overvoltage in mains"

🕮 See also firmware documentation "Diagnostics, Reference Book" which contains the descriptions of the error messages (diagnostic messages).

Bb contact

The mains contactor has to be controlled depending on the error status of the supply unit or drive controller.

At the control section of the HCS drive controllers and at the supply units, there is an isolated contact available for this purpose (Rel1 relay contact) that has been configured as Bb contact in the condition as supplied. When the Bb contact closes, the drive or drive system is ready for power on.

☞ **Danger of consequential damage!**

Make sure that the mains contactor interrupts power supply from the mains when the Bb contact opens.

☞ **Load of Bb contact**

Observe the load capability limits of the Bb contact (see Project Planning Manual "Rexroth IndraDrive, Drive Controllers, Control Sections" for the control section used [connection point X31.1, X31.2]).

Use contactor relays to control contactors with AC excitation and contactors exceeding the load capability limits of the involved contact elements (Bb contacts, etc.).

🕮See also Functional Description of firmware → Power supply

Suppressor circuit for contactor coil

When the mains contactor is switched off, the contactor coil causes overvoltages. These overvoltages may result in premature failure of the Bb contact.

To attenuate overvoltages, use:

- For contactor coils with **DC voltage**: Overvoltage limiters with diode combination
- For contactor coils with **AC voltage**: Varistors

Avoid varistors and RC elements at contactor coils for DC voltage, because varistors are subject to aging and increase their reverse currents, and RC elements can overload the switching capacity of the Bb contact.

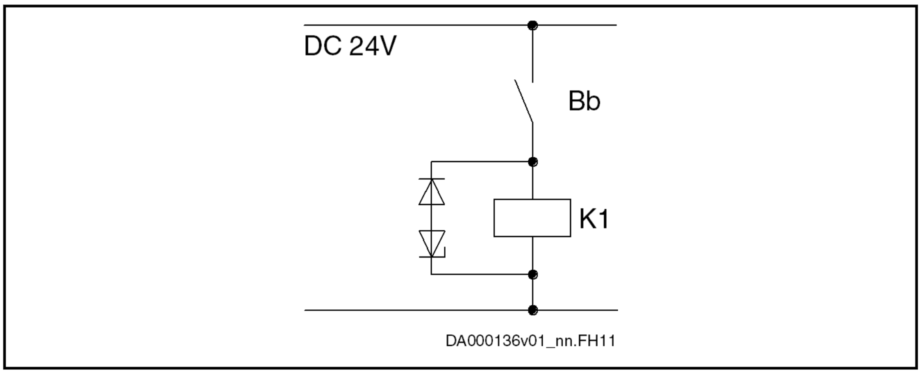


Fig. 9-1: Recommended suppressor circuit

Switching on the power supply

Switch-on sequence

1. Apply 24V control voltage
2. Wait for readiness for operation of the connected components
3. Switch on power supply (e.g., close mains contactor)

Switching off the power supply

If mains contactor is switched off frequently

In order to prevent the external mains contactor from being overloaded by the load current in the case of frequent switch-off:

- First switch off the drive, e.g. via drive enable in the master communication
- Then switch off the mains contactor

Switch-off sequence

1. Switch off drive
2. Switch off power supply
3. Switch off 24V control voltage, if required

Using and arranging the mains contactor

For HCS drive controllers of the Rexroth IndraDrive C product range, use an external mains contactor in the mains connection for the circuit. Connect the mains contactor electrically between mains filter and mains input (with HCS03 devices and HNK01 mains filters, the mains contactor may be connected electrically before the HNK01 mains filter).

The HMV01.1 supply units of the Rexroth IndraDrive M range have an integrated mains contactor (exception: HMV01.1R-W0120 have no integrated mains contactor and require an external mains contactor).

⚠ WARNING **Lethal injuries caused by live parts with more than 50 V!**

Design and install the mains connection according to the valid standards.

Observe the protection goals

- Electrical safety
- Mechanical safety in the case of incorrect movements
- Protection against fire

Make sure you can provide evidence of the mechanisms of protection by means of FMEA and hazard analysis.

Make use of the protection by mains contactors in the mains connection.

For the data for rating appropriate mains contactors incl. fuses and cable cross section, see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → chapter of the respective device → "Technical data" → "Basic data" → table "Mains voltage supply data".

Using and arranging an additional mains contactor

If the safety regulations require the circuit interruption in the mains connection to be carried out in redundant form, it is necessary to have additional mains contactors in the mains connection.

Additional mains contactors are allowed at

- HMV supply units
- HCS drive controllers

Place the additional mains contactor **electrically before**:

- Mains filter
- Mains choke
- Mains contactor (integrated or externally installed)
- Mains input of supply unit or drive controller

Observe the following aspect for **PLC programming**:

The additional mains contactor must already have been closed, before the "power ON" request is applied to the supply unit or drive controller.

Input EIN2

If the supply unit is operated with an additional mains contactor, the signal at the input EIN2 (X32.4) must be switched to level "L" within the tolerated mains failure time, when this additional mains contactor is switched off.

See also "F2819 Mains failure" in the firmware documentation "Troubleshooting Guide"

At installations with additional mains contactor, there are **2 mains contactors** effective:

1. Integrated or external mains contactor of the supply unit or drive controller which is controlled by the circuit for mains connection
2. Additional mains contactor which is controlled by an independent circuit (e.g., from a PLC)

9.3 Circuits for mains connection of Rexroth IndraDrive C controllers

9.3.1 General information

The mains contactor connected in the incoming circuit controls the energy flow to the drive controller. This allows separation from the mains in the case of error. The Bb contact at the control section of the drive controller or the Bb contact of the mains supply decisively influences the circuit.

HCS02 circuits

For HCS02 drive controllers, the following circuits for the mains connection are described:

- Control of external mains contactor
- Control of external mains contactor for devices with integrated control voltage supply
- Control of external mains contactor with DC bus resistor unit HLB01.1C

HCS03 circuits

For HCS03 drive controllers, the following circuits for the mains connection are described:

Control of external mains contactor

Configuration "Rel 1" as Bb Contact

Power voltage is only switched to drive system, when the closing of the Bb contact signals readiness for power voltage on.

For this purpose, there is the isolated contact "Rel 1" at the control sections. The behavior of this contact can be configured via the parameter "P-0-0860, Converter configuration":

- Behaves as **converter**, if drive controller is to get supply voltage via mains connection (e.g., for type of mains connection "individual supply" or "central supply")
- Behaves as **inverter**, if drive controller is to get supply voltage via connection DC bus (L+, L-) (e.g., for type of mains connection "central supply" as supplied device)

Include the converter contacts in the circuit in such a way that they make the mains contactor drop out in the case of error (when the contact opens).

You can assign other information to the "Rel 1" contacts of the drive controllers configured as inverters. Via this contact you can, for example, control a second holding brake by entering a signal from "S-0-0398, IDN list of configurable data in signal status word" in parameter "P-0-0300, Digital I/Os, assignment list".

(See also Functional Description of firmware: "Power Supply" and Parameter Description of firmware for P-0-0300 and P-0-0861)

9.3.2 Control of external mains contactor for HCS02 and HCS03

General information

NOTICE	**Risk of damage!**

Before switching the drive controller back on, wait at least for **300 ms plus the switch-off delay of the mains contactor**.

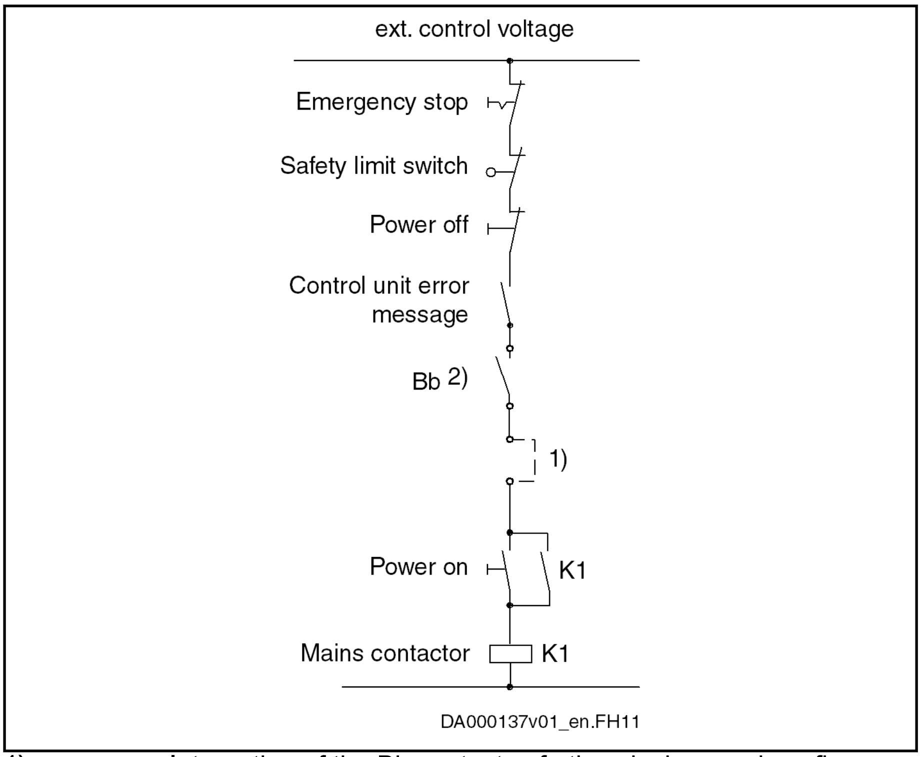
☞ **HCS02/HCS03 mains connection without mains contactor**

You can do without mains contactors in the mains connection, if without mains contactors you achieve the same safety for operator protection as with mains contactors. For this purpose, the following conditions must **simultaneously** apply to the respective application:

- The **safety-related requirements** of the application allow this
- The **local safety regulations** at the site of installation allow this
- HCS02 or HCS03 of the -NNNN design with **external 24V supply** (DC bus power supply unit) are used.
  - Recommended **DC bus power supply units**:

    PI 050/A by KEBA or SUH1000-2440 by MGV
  - **"Central supply"** type of supply
  - **No** components with DC bus short circuit protection device **ZKS** (e.g., HLB) at the DC bus
  - Passive charging current limitation available via charging resistor in drive controller (HCS02.1E-W0012…0070; HCS03.1E-W0070…0150)
  - The **24V supply** of the drive controllers (e.g., HMS, HMD) operated at the same DC bus has to have been applied **before the mains voltage is switched on**

Standard design for HCS02 and HCS03 drive controllers



1) Integration of the Bb contacts of other devices and configuration (see "Configuration Rel 1 as Bb Contact" on page 129)

2) Take switching capacity of Bb contact into account (see Project Planning Manual "Rexroth IndraDrive Control Sections"); CSB01.1N-FC control sections have switch contacts with higher switching capacity

Fig. 9-2: Circuit

Design for HCS02 and HCS03 drive controllers with integrated 24V control voltage supply

Drive controllers with integrated 24V control voltage supply (HCS02.1E-…-NNNV, HCS03.1E-…-NNNV) are used, for example, to maintain signal processing for controlled return motion in case the external 24V control voltage supply fails.

☞ The integrated 24V control voltage supply cannot be used for motor brake supply.

To supply the motor brakes, use an external 24V supply.

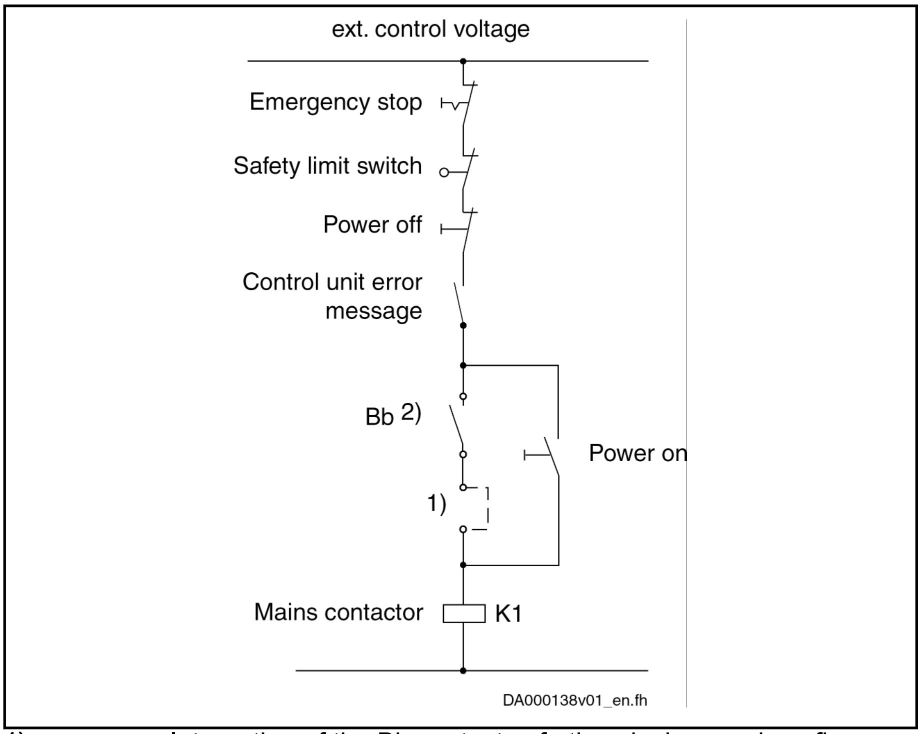
HCS02, HCS03 with integrated 24V control voltage supply and CSB01.1N-FC control sections

HCS02.1E-…-NNNV und HCS03.1E-…-NNNV drive controllers with CSB01.1N-FC control sections can be operated with control circuits the "external control voltage" of which is up to 1 AC 250 V.

- Observe the allowed switching capacity of the Bb contact of the CSB01.1-FC control sections.

  Compared to other control sections, only the CSB01.1-FC control section has a Bb contact with (higher) allowed switching voltage of AC 250 V.
- Until the internal supply voltages are built up and the firmware is actively working in the drive controller, the Bb contact at the control section of the drive controller is open.

  Take these times into account for the design of the circuit for the mains connection.



1) Integration of the Bb contacts of other devices and configuration (see "Configuration Rel 1 as Bb Contact" on page 129)

2) Take switching capacity of Bb contact into account (see Project Planning Manual "Rexroth IndraDrive Control Sections"); CSB01.1N-FC control sections have switch contacts with a high switching capacity

Fig. 9-3: Circuit for HCS02.1E-…-NNNV and HCS03.1E-…-NNNV drive controllers with CSB01.1N-FC control sections

9.3.3 HCS02 and HCS03 circuits with DC bus resistor unit HLB01.1C or HLB01.1D

Application Use this variant if

- only motors with permanent magnet excitation are connected
- motors with permanent magnet excitation and asynchronous motors (induction machines) are connected

Features Due to the DC bus short circuit (ZKS), motors with permanent magnet excitation can be decelerated even if the drive electronics is disturbed.

⚠ WARNING **Personal injury caused by uncontrolled axis motion!**

The DC bus short circuit protects machines in the case of drive errors. By itself it cannot assume the function of personal protection. In the case of errors in the drive or supply unit, uncontrolled drive motion can occur even when the DC bus short circuit has been activated.

Asynchronous machines do not decelerate when the DC bus has been short-circuited. Personal injury can occur depending on the machine design.

Install additional monitors and protective devices on the system side.

Suggested circuit

☞ Connect the **Bb contact of HLB in series** with the Bb contacts of the involved IndraDrive components so that the mains contactor can be opened even if the module bus is defective.

Take the switching capacity of the involved contacts into account (see technical data of the components).

☞ **Avoid switching on upon active DC bus short circuit!**

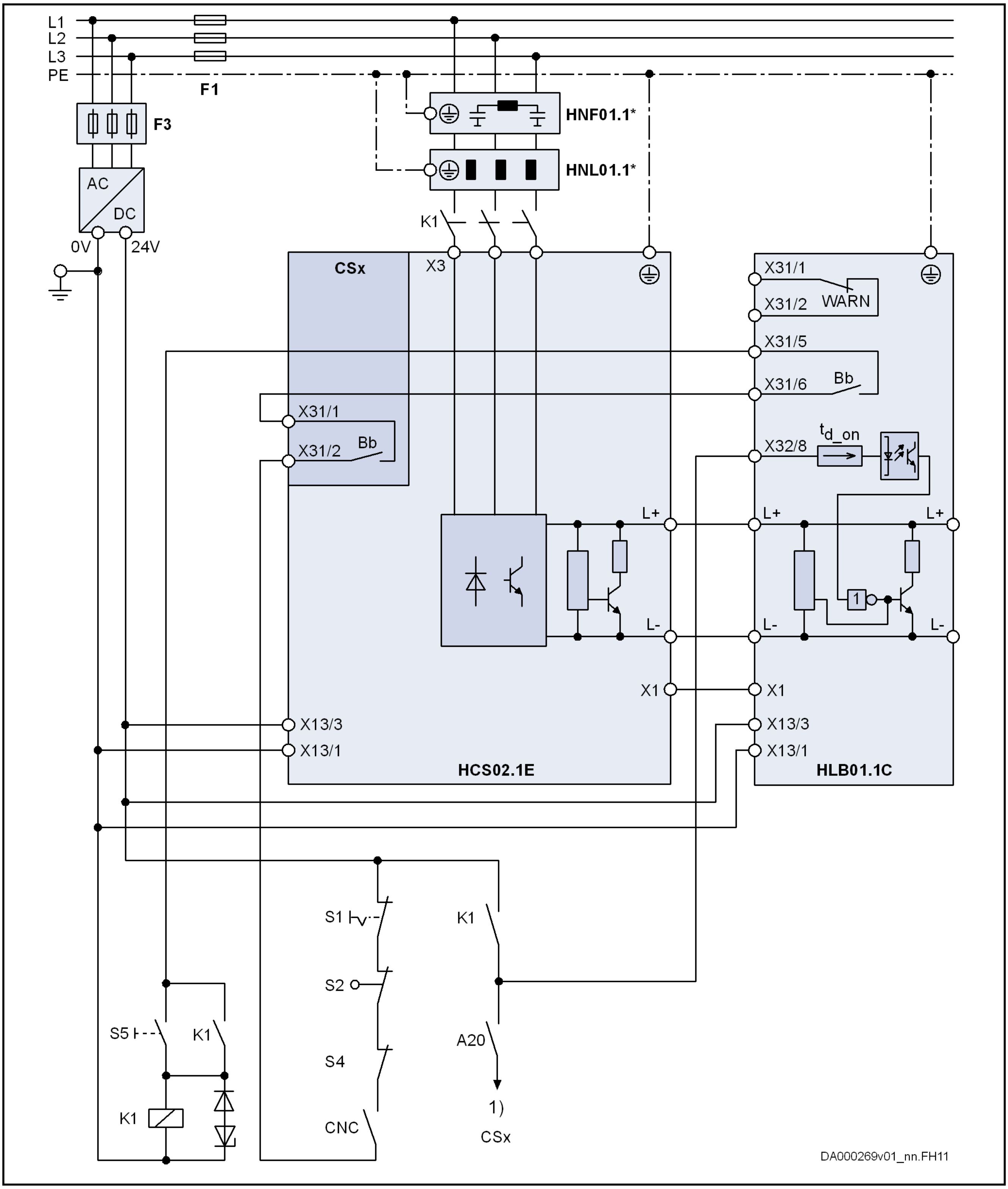
Switch the N/O contact K1 before the ZKS1 input so that the DC bus short circuit device is deactivated before the mains contactor K1 switches power to the drive controller.

NOTICE **Risk of damage! Only apply mains voltage when 24V supply has been applied!**

Only switch the mains voltage to HCS02 when the 24V supply has been applied to HLB01 and HCS02.

When the 24V supply has been switched off, the DC bus short circuit device in HLB01 is active and can damage HCS02.

Suggestion for Control Circuit for the Mains Connection of HCS02 Converters and DC Bus Resistor Units HLB01.1C

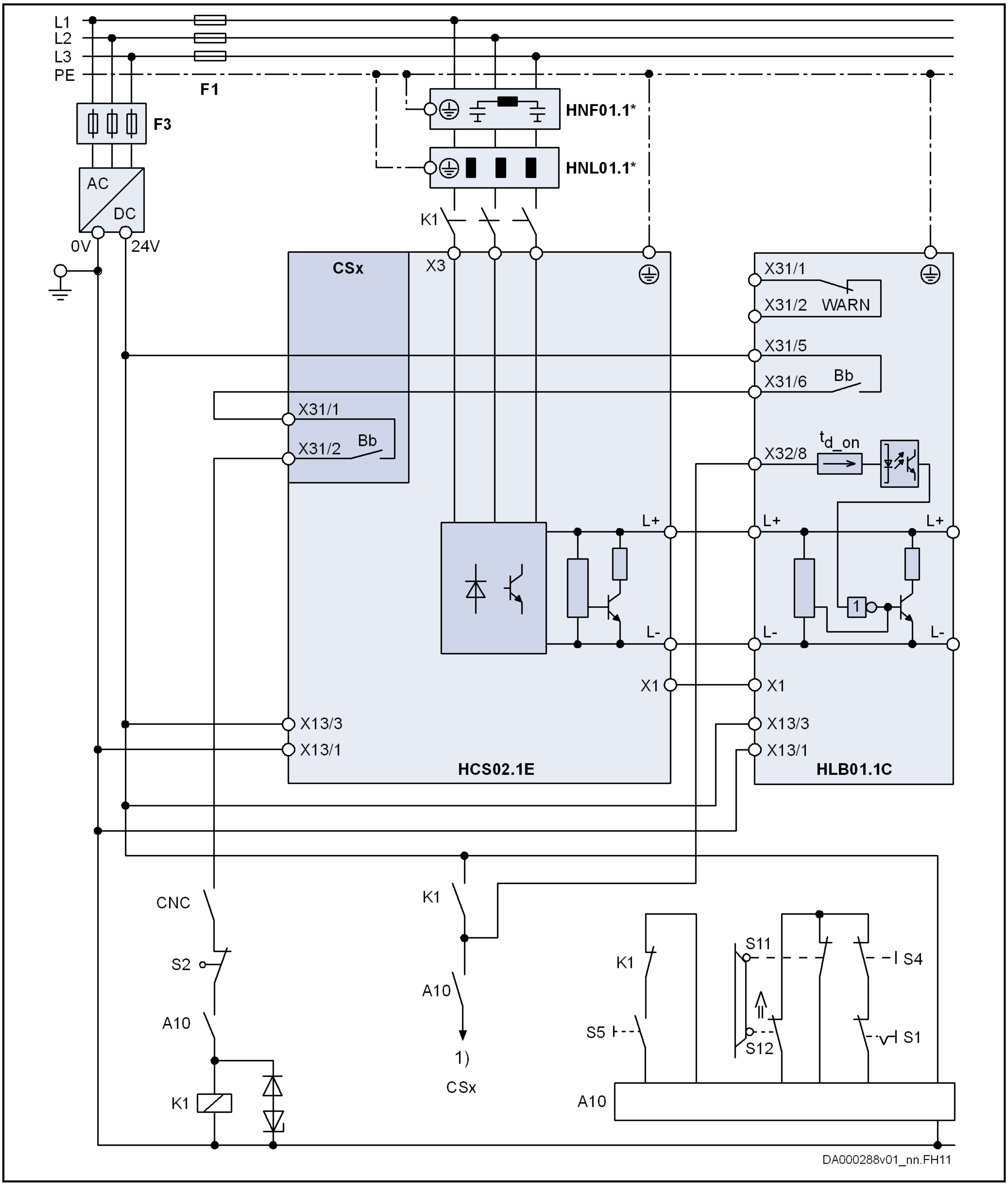


*	Optional
1)	Drive enable (via input at control section or via master communication); depending on parameter "P-0-4028, Device control word"

A20	Optional contact for drive enable
Bb	Bb contact (see control section X31.1 and X31.2); Bb contact HLB01
CNC	Lag error message of control unit
F1	Fuse of power supply
F3	Fuse of 24V power supply unit
K1	External mains contactor (OFF delay must be smaller than td_on)
S1	Emergency stop
S2	Axis end position
S4	Power Off
S5	Power On
t_{d_on}	Delay of input X32/8
X1	Module bus

Fig. 9-4: Control Circuit for Mains Connection of HCS02 and HLB01.1C

Suggestion for Control Circuit for the Mains Connection of HCS02 Converters and DC Bus Resistor Units HLB01.1C and Emergency Stop Relay

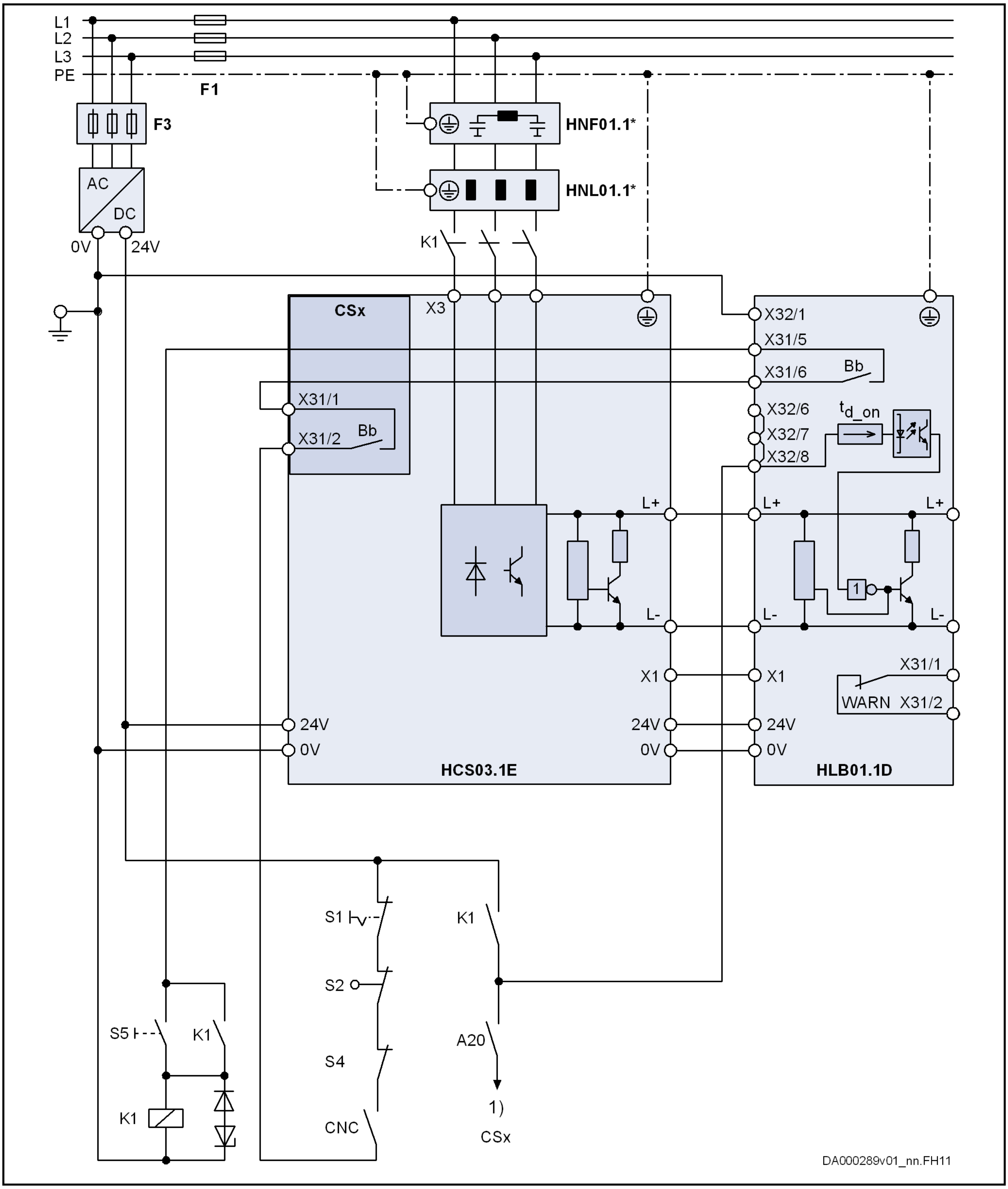


*	Optional
1)	Drive enable (via input at control section or via master communication); depending on parameter "P-0-4028, Device control word"

A10	Emergency stop relay (example of circuit; optional design)
Bb	Bb contact (see control section X31.1 and X31.2); Bb contact HLB01
CNC	Lag error message of control unit
F1	Fuse of power supply
F3	Fuse of 24V power supply unit
K1	External mains contactor (OFF delay must be smaller than td_on)
S1	Emergency stop
S2	Axis end position
S4	Power Off
S5	Power On
t_{d_on}	Delay of input X32/8
X1	Module bus

Fig. 9-5: Control Circuit for Mains Connection of HCS02 and HLB01.1C and Emergency Stop Relay

Suggestion for Control Circuit for the Mains Connection of HCS03 Converters and DC Bus Resistor Units HLB01.1D



*	Optional; alternatively HNK01
1)	Drive enable (via input at control section or via master communication); depending on parameter "P-0-4028, Device control word"

A20	Optional contact for drive enable
Bb	Bb contact (see control section X31.1 and X31.2); Bb contact HLB01
CNC	Lag error message of control unit
F1	Fuse of power supply
F3	Fuse of 24V power supply unit
K1	External mains contactor (OFF delay must be smaller than td_on)
S1	Emergency stop
S2	Axis end position
S4	Power Off
S5	Power On
t_{d_on}	Delay of input X32/8
X1	Module bus

Fig. 9-6: Control Circuit for Mains Connection of HCS03 and HLB01.1D

9.4 Circuits for mains connection of Rexroth IndraDrive M supply units

9.4.1 General information

NOTICE **Damage to the supply unit!**

At **HMV01.1R** supply units, there have to be **at least 10 ms** between the mains OFF request (signal at X32.6 / X32.7) and the disconnection of the mains voltage, so that the energy flow has been interrupted when the disconnection process starts.

You can make sure this order is observed by using appropriate switch elements (e.g., by a control cabinet main switch with leading auxiliary contact). For this purpose, connect the auxiliary contact in series with mains OFF.

☞ **Do not switch on HMV supply units simultaneously!**

In the switch-on sequence of the supply unit, the supplying mains is loaded with the current $I_{L\_trans\_max\_on}$ for the purpose of analysis.

During the unloading process, voltage overshoot can occur at the mains components connected in the incoming circuit (e.g. mains filters) due to inductances connected in the incoming circuit, e.g. the leakage inductance of the mains transformer.

With **3 or more HMV supply units at the common supply mains**: Switch on supply units one after the other with a time interval of at least 0.5 seconds so that the inrush currents are not added.

HMV control circuits

For HMV01.1E, HMV01.1R and HMV02.1R supply units, the following control circuits for the mains connection are described:

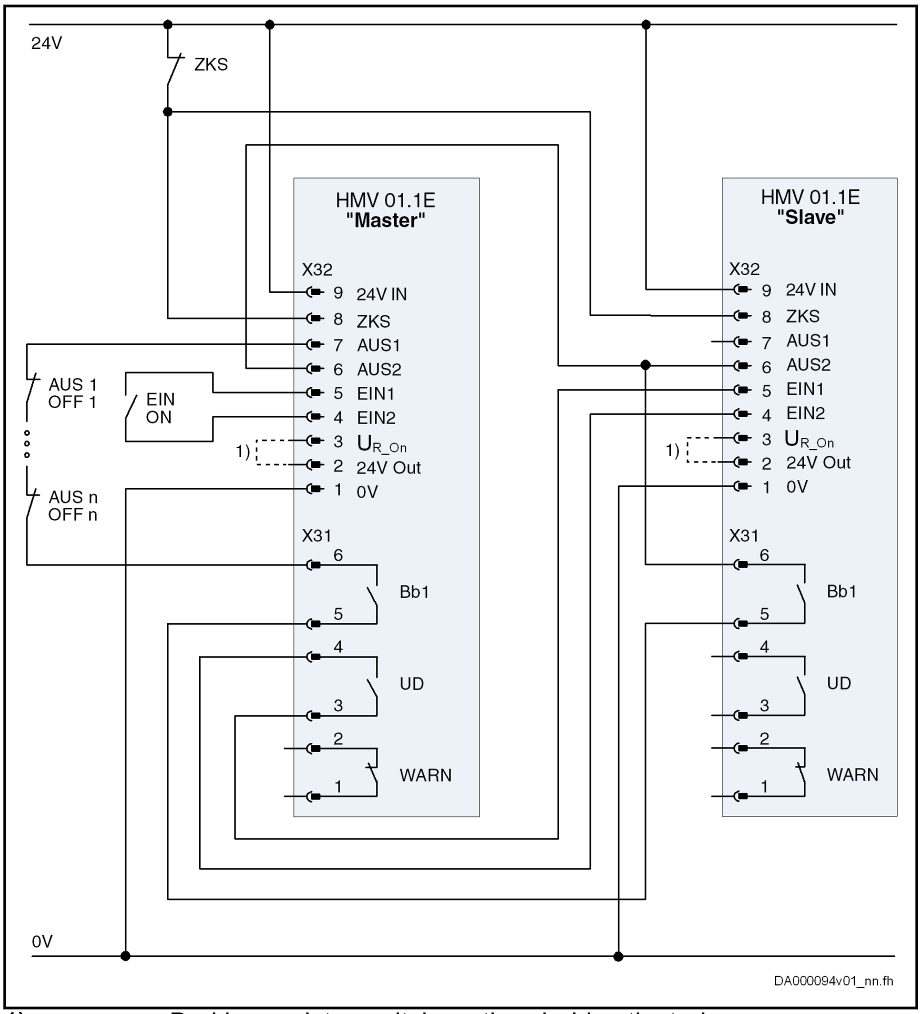
- Control circuit for parallel operation HMV01.1E master-slave
- Deceleration in the case of disturbed drive electronics
- Deceleration in the case of emergency stop or mains failure
- Control by emergency stop relay with DC bus short circuit
- Control by emergency stop relay without DC bus short circuit
- Control by control unit

- Combination with DC bus resistor unit HLB01.1D

9.4.2 Parallel operation HMV01

For the type of mains connection "group supply with DC bus connection", use the control circuit master-slave when using HMV01.1E supply units. See the block diagram below:

Control circuit for parallel operation HMV01.1E master-slave



1) Braking resistor switch-on threshold activated

Fig. 9-7: Block diagram control circuit master-slave for parallel operation HMV01.1E

9.4.3 Deceleration in the case of disturbed drive electronics (DC bus short circuit is activated)

General information

DC bus short circuit ZKS

If the drive electronics is disturbed, motors can coast to stop in an uncontrolled way. In these cases, it is possible to short-circuit the DC bus voltage as a measure in addition to decelerating the drives if the electronics is disturbed.

In HMV supply units (exception: HMV01.1R-W0120), a circuit has been integrated which can discharge the DC bus as quickly as possible to low voltage. This circuit is called **DC bus short circuit (ZKS)**. With active DC bus short circuit, a low-impedance resistor is connected to the DC bus between L + and L- via a wear-free switch.

NOTICE	Risk of fire caused by the "sacrificing behavior" of the ZKS stage!

The "ZKS" input activates the "DC bus short circuit" function, when the 24V control voltage has not been applied and when there isn't any current flowing to the input. This condition can occur in the following situations:

- Failure of 24V control voltage
- Wire break
- Activation of serially connected contacts (e.g. axis limit switches)

If the kinetic energy of the mechanical axis system regenerated when braking is greater than the energy absorption capacity of HLB, the HLB device remains active when braking via ZKS takes place, until it is thermally destroyed (sacrificing behavior). Risk of fire! In this case, braking via ZKS may only come into effect in the case of an emergency (e.g. activation of an axis limit switch causes the mains supply to be cut off and simultaneously causes the 24V supply of the ZKS input to be interrupted).

Install a 24V UPS, if the "sacrificing behavior" of HLB is relevant to your drive system in the case of an emergency. This prevents the braking via ZKS which causes HLB to be destroyed due to the failure of the 24V control voltage. Braking via ZKS then will only take place in cases of emergency.

☞ **Type of motor and DC bus short circuit**

Asynchronous drives do not decelerate when the DC bus voltage has been short-circuited!

When the DC bus has been short-circuited, motors with permanent magnet excitation generate braking torque and are decelerated.

Control circuits with DC bus short circuit (ZKS)

If you control the mains contactor in the supply unit by an emergency stop relay and short-circuit the DC bus, you achieve a high degree of safety with little effort. The monitoring functions of the drive system are then used in the most effective way.

☞ **DC bus short circuit at HMV without integrated circuit for DC bus short circuit**

Use HLB01 DC bus resistor units for DC bus short circuit.

It is not recommended to short-circuit the motor connections.

Application

Use this variant if

- only motors with permanent magnet excitation are connected
- motors with permanent magnet excitation and asynchronous motors (induction machines) are connected
- the emergency stop switch has to be duplicated or a safety door monitor, for example, is required
- your drive system has an extensive emergency stop circuit

☞ **Maximum resistance of control circuit**

The pickup current of the auxiliary relay for controlling the mains contactor flows via the emergency stop circuit. In order that the mains contactor picks up reliably, the total resistance of the emergency stop circuit taking effect between connections X32/1 and X32/9 has to be less than 45 Ω!

Features

Due to the DC bus short circuit, motors with permanent magnet excitation can be decelerated even if the drive electronics is disturbed. In order to trigger a DC bus short circuit in such a case, the Bb contacts **of the drive controllers** have to be connected in series with the control contact and wired in the emergency stop circuit. The DC bus short circuit only takes effect in the case of drive failure. If emergency stop is actuated, asynchronous drives therefore are braking, too.

When the Bb contacts **of the supply unit** are connected in series with the control contact in the emergency stop circuit, the DC bus short circuit is only triggered in the case of a supply unit error.

In the case of emergency stop or when the monitors of the supply unit trigger (e.g., mains failure), the drive electronics of the drives decelerates them according to the error reaction that was set.

⚠ WARNING **Personal injury caused by uncontrolled axis motion!**

The circuit for DC bus short circuit protects machines in the case of drive errors. By itself it cannot assume the function of personal protection. In the case of errors in the drive and supply unit, uncontrolled drive motion can occur even when the DC bus short circuit has been activated.

Asynchronous machines do not decelerate when the DC bus has been short-circuited. Personal injury can occur depending on the machine design.

Use additional monitors and protective devices on the system side.

Use Rexroth‘s "Integrated Safety Technology".

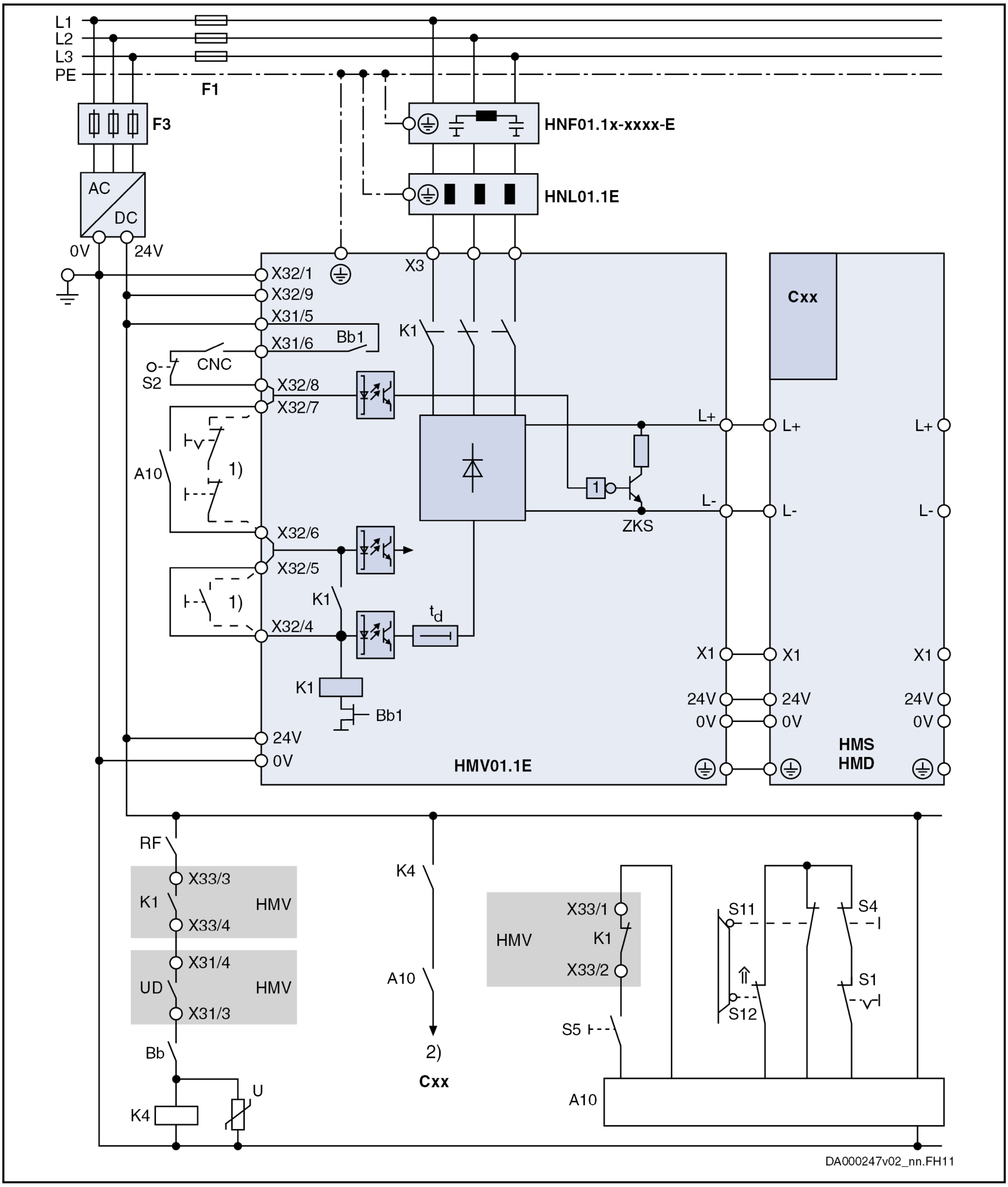
Operating principle

When the emergency stop pushbutton is activated, the mains contactor in the supply unit opens. The emergency stop relay or an auxiliary contact of the mains contactor switches off the drive enable signals. The drives are decelerated according to the error reaction set in the drive controller.

The mains contactor is switched off and the DC bus short circuit (ZKS) takes effect, when

- the supply unit (Bb1 contact) outputs a drive error message
- the control unit (CNC contact) outputs an error message
- the limit switch (S2) is passed

Control Circuit "DC Bus Short Circuit (ZKS) in the Case of Disturbed Electronic System of Drive" for the Mains Connection of HMV01.1E Supply Units With Integrated Mains Contactor (e.g. HMV01.1E-W0030, -W0070, -W0120)

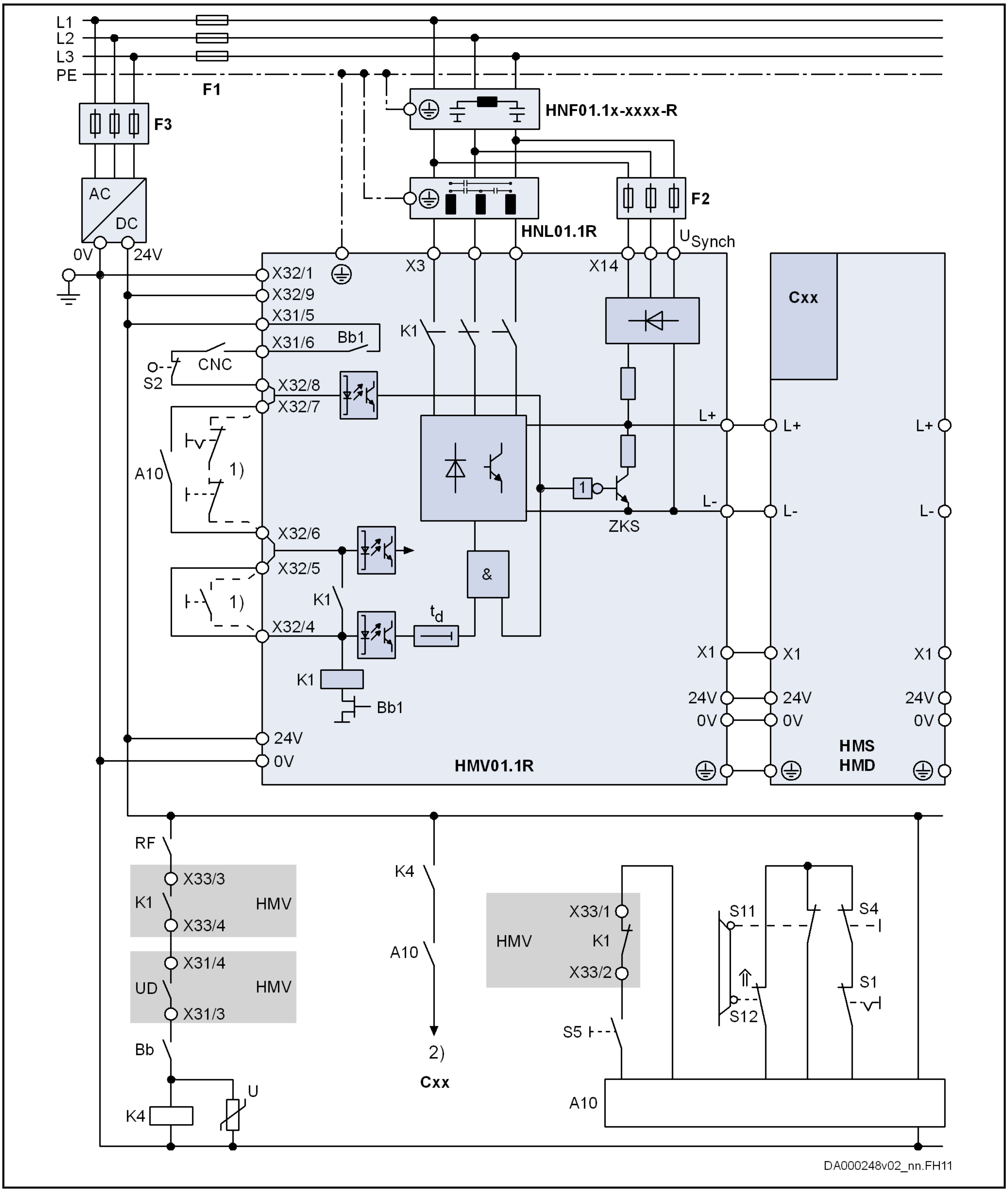


F1	Fuse of power supply
F3	Fuse of 24V power supply unit
1)	Control of K1, if A10 is not used

2)	Drive enable (via input at control section or via master communication); see also parameter "P-0-4028, Device control word"
A10	Emergency stop relay (example of circuit)
Bb1	Readiness for operation of supply unit
Bb	Readiness for operation of drive controllers (see control section X31.1 and X31.2)
CNC	Lag error message of control unit
K1	Integrated mains contactor
K4	Control of drive enable
S1	Emergency stop
S2	Axis end position
S4	Power Off
S5	Power On
S11, S12	Safety door monitor
ZKS	DC bus short circuit
HNL, HNF	Optional, depending on the application

Fig. 9-8: Control Circuit DC Bus Short Circuit (ZKS) in the Case of Disturbed Electronic System of Drive for HMV01.1E Supply Units With Integrated Mains Contactor

Control Circuit "DC Bus Short Circuit (ZKS) in the Case of Disturbed Electronic System of Drive" for the Mains Connection of HMV01.1R Supply Units With Integrated Mains Contactor (e.g. HMV01.1R-W0018, -W0045, -W0065)



F1	Fuse of power supply
F2	Fuse of synchronization connection X14
F3	Fuse of 24V power supply unit

1)	Control of K1, if A10 is not used
2)	Drive enable (via input at control section or via master communication); see also parameter "P-0-4028, Device control word"
A10	Emergency stop relay (example of circuit)
Bb1	Readiness for operation of supply unit
Bb	Readiness for operation of drive controllers (see control section X31.1 and X31.2)
CNC	Lag error message of control unit
K1	Integrated mains contactor
K4	Control of drive enable
S1	Emergency stop
S2	Axis end position
S4	Power Off
S5	Power On
S11, S12	Safety door monitor
ZKS	DC bus short circuit

Fig. 9-9: Control Circuit DC Bus Short Circuit (ZKS) in the Case of Disturbed Electronic System of Drive for HMV01.1R Supply Units With Integrated Mains Contactor

Operating principle with HLB01.1D

When the emergency stop pushbutton is activated, the mains contactor in the supply unit drops out. The emergency stop relay or an auxiliary contact of the mains contactor switches off the drive enable signals. The drives are decelerated according to the error reaction set in the drive controller.

The mains contactor is switched off and the DC bus short circuit (ZKS) takes effect in HMV and HLB, when

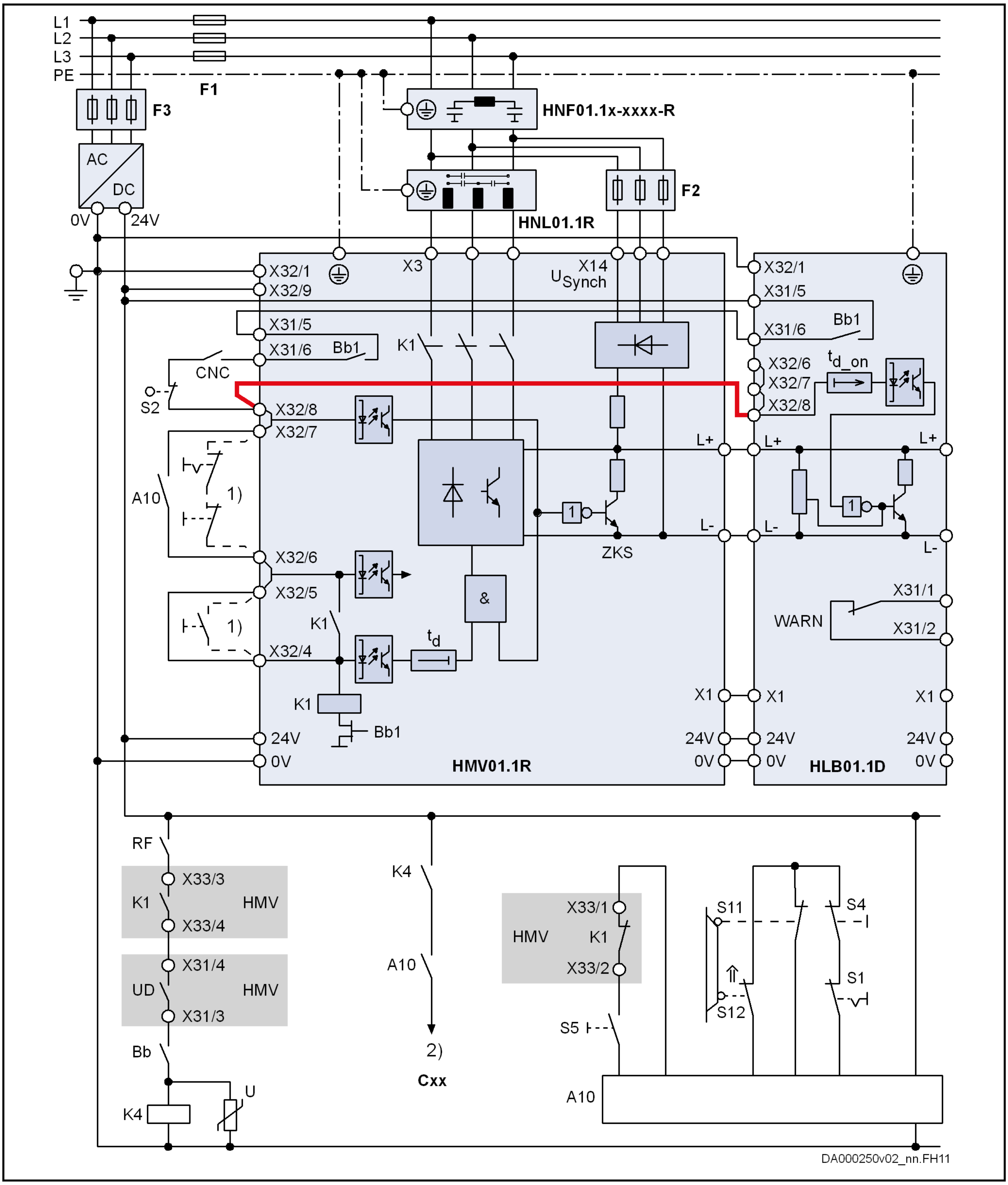
- the supply unit (Bb1 contact) outputs a drive error message
- the control unit (CNC contact) outputs an error message
- the limit switch (S2) is passed

NOTICE **Risk of damage to the device!**

Establish connection from HMV_X32/8 to HLB_X32/7.

This avoids energy from the mains connection being supplied and the DC bus short circuit protection device of the DC bus resistor unit HLB being simultaneously active.

Control circuit "DC bus short circuit (ZKS) at HMV and HLB in the case of disturbed drive electronics" for the mains connection of HMV01.1R with integrated mains contactor (e.g., HMV01.1R-W0018, -W0045, -W0065) and HLB01.1D

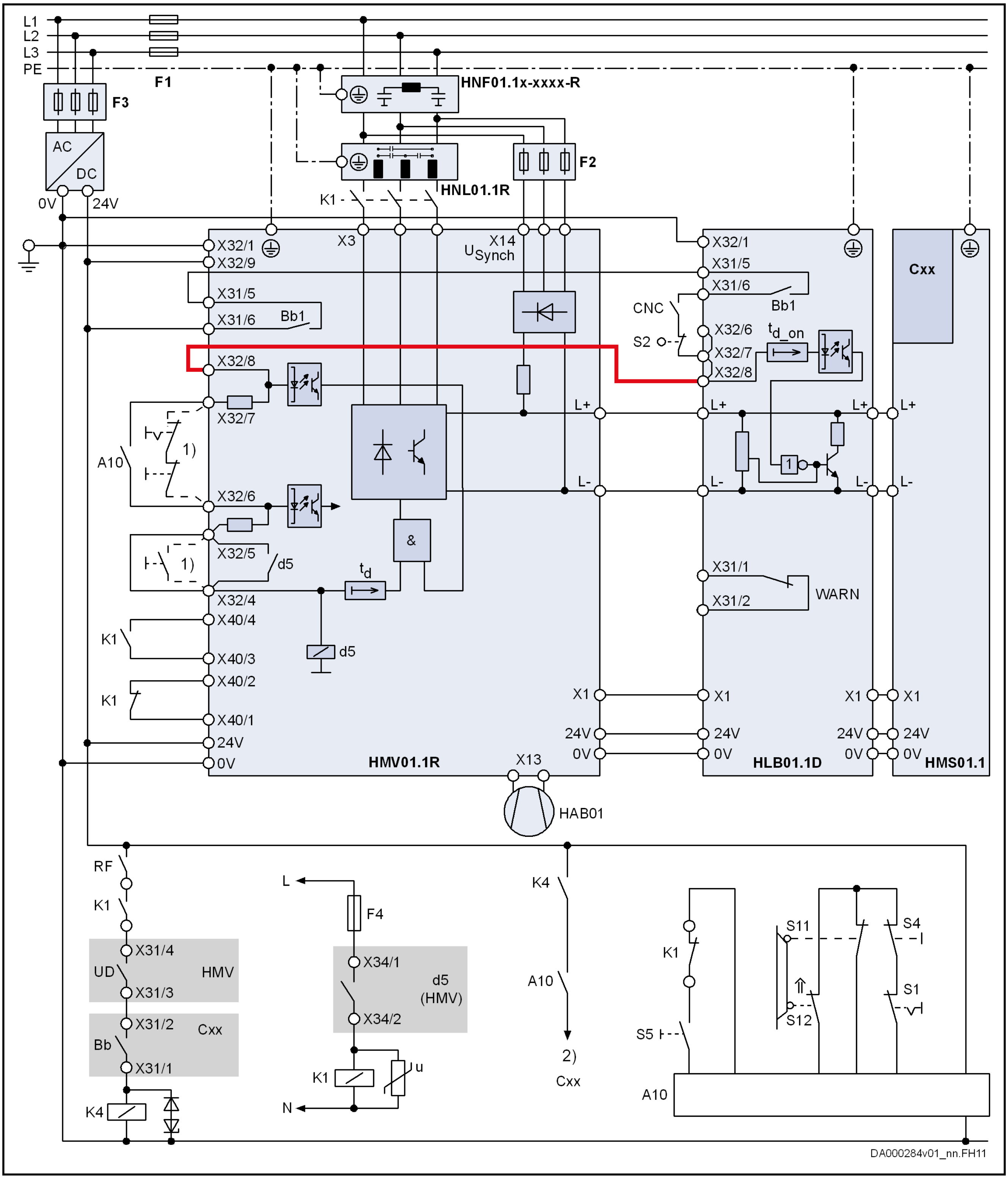


F1	Fuse of power supply
F2	Fuse of synchronization connection X14
F3	Fuse of 24V power supply unit

1)	Control of K1, if A10 is not used
2)	Drive enable (via input at control section or via master communication); see also parameter "P-0-4028, Device control word"
A10	Emergency stop relay (example of circuit)
Bb1	Readiness for operation of supply unit
Bb	Readiness for operation of drive controllers (see control section X31.1 and X31.2)
CNC	Lag error message of control unit
K1	Integrated mains contactor
K4	Control of drive enable
S1	Emergency stop
S2	Axis end position
S4	Power Off
S5	Power On
S11, S12	Safety door monitor
WARN	Prewarning contact
ZKS	DC bus short circuit

Fig. 9-10: Control circuit DC bus short circuit (ZKS) at HMV and HLB in the case of disturbed drive electronics for HMV01.1R supply units with integrated mains contactor and HLB01.1D

Suggestion for control circuit "HMV and HLB with DC bus short circuit (ZKS) in the case of disturbed drive electronics" for mains connection of HMV01.1R-W0120 with external mains contactor and HLB01.1D



1)	Control of K1, if A10 is not used
2)	Drive enable (via input at control section or via master communication); depending on parameter "P-0-4028, Device control word"

A10	Emergency stop relay (example of circuit; optional design)
Bb	Readiness for operation of drive controllers (control section X31.1 and X31.2)
Bb1	Readiness for operation of supply unit
CNC	Lag error message of control unit
d5	Internal relay in supply unit
F1	Fuse of power supply
F2	Fuse of synchronization connection X14
F3	Fuse of 24V power supply unit
F4	Fuse 2 A
HAB01	External fan unit
HLB01.1D	DC bus resistor unit
K1	External mains contactor
K4	Control of drive enable
L, N	AC supply mains contactor
S1	Emergency stop
S2	Axis end position
S4	Power Off
S5	Power On
S11, S12	Safety door monitor
X1	Module bus
WARN	Prewarning contact
ZKS	DC bus short circuit
t_{d_on}	Switch-on delay DC bus short circuit
t_d	Delay in HMV

Fig. 9-11: HMV and HLB control circuit with DC bus short circuit (ZKS) in the case of disturbed drive electronics for HMV01.1R-W0120 supply units with external mains contactor and HLB01.1D

☞ **Observe Off delay and pick-up delay of K1!**

Off delay K1:

Select K1 mains contactors with an Off delay shorter than the On delay t_{d_on} of the DC bus short circuit device. Otherwise, the DC bus short circuit device switches on with applied mains voltage and causes tripped fuse (F1) or damage to the supply unit.

Circuits for overvoltage protection increase the Off delay. Observe the data of the selected mains contactor!

Pick-up delay K1:

Select K1 mains contactors with a pick-up delay of less than 100 ms. Otherwise, the error message F2835 will be generated.

9.4.4 Deceleration in the case of emergency stop or mains failure

General information

In the case of emergency stop or mains failures, the drives normally are decelerated by the drive control.

In the case of emergency stop or when the drive-internal monitors trigger, the drive control inputs the command value "zero". The drives thereby decelerate in a controlled way with maximum torque.

In some applications (e.g., electronically coupled gear cutting machines) it is required that the drive deceleration is controlled by the control unit in the case of emergency stop or mains failures. In the case of emergency stop or when the drive-internal monitors trigger, the control unit decelerates the drives in a position-controlled way. In such applications, the **DC bus short circuit must not be activated**.

For further details, see the Functional Description of the firmware under the index entry "Best possible deceleration".

Control circuit "position-controlled deceleration by the control unit" without DC bus short circuit (ZKS)

If the mains contactor is controlled by the control unit, the drive, in the case of emergency stop or when the drive-internal monitor triggers, can be decelerated in a position-controlled way by a control unit.

Application This type of mains contactor control is mainly used for electronically coupled drives that are decelerated synchronously even in the case of mains failure.

Features The DC bus voltage is not short-circuited so that there is energy available for position-controlled deceleration of the drives.

☞ The energy stored in the DC bus or the regenerated energy has to be greater than the energy required for excitation of asynchronous machines or for return motions.

The parameter "Activation of NC reaction on error" has to be set accordingly in the drive controller (P-0-0117, bit 0 = 1).

In the case of emergency stop or when the monitors of the supply unit trigger (e.g., mains failure), the drives are decelerated in a position-controlled way by the positioning control.

Operating principle When the emergency stop circuit opens or the monitors of the supply unit trigger (e.g., mains failure), the mains contactor in the supply unit drops out.

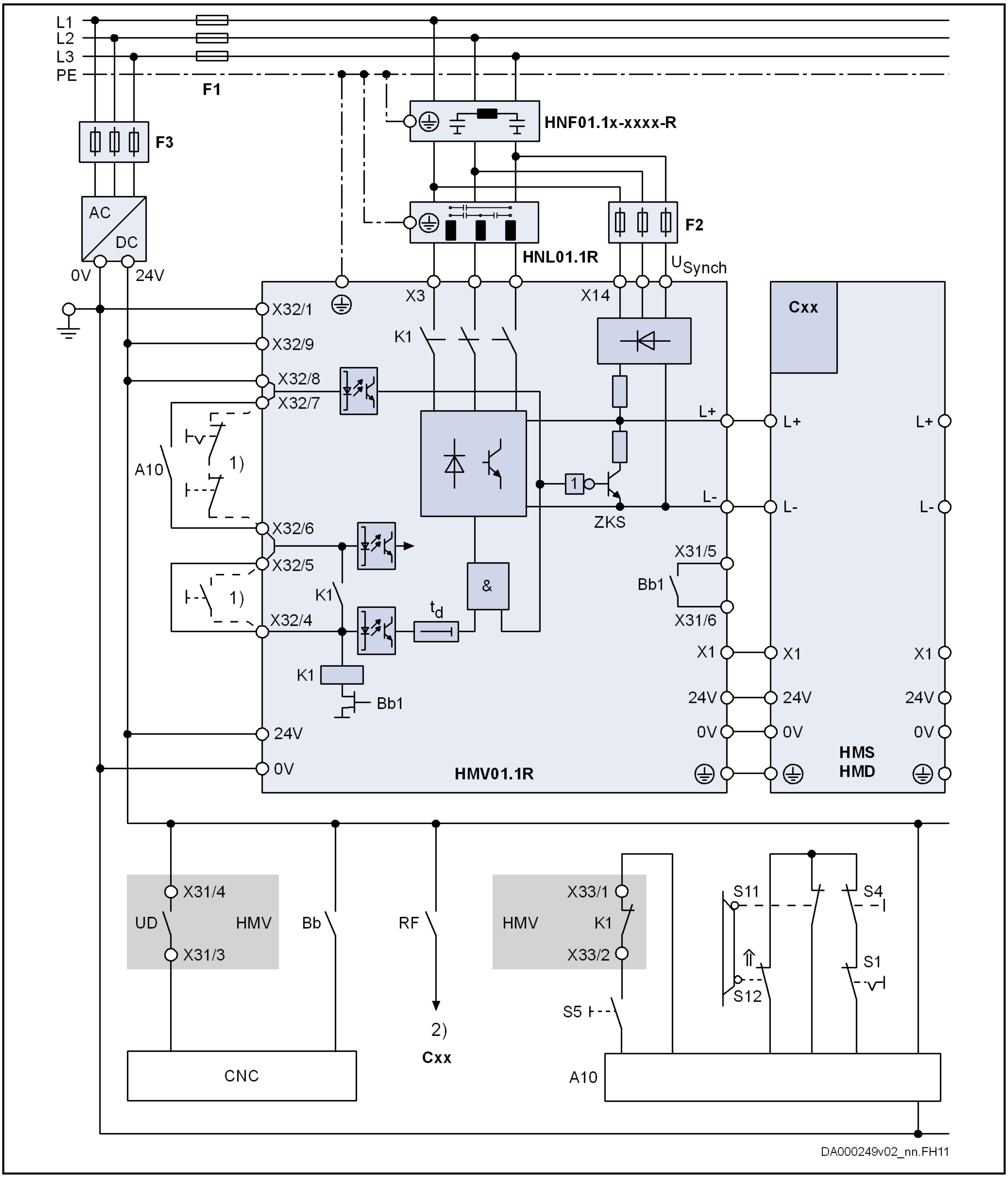
For drives with Sercos interface, the error is signaled to the control unit and the drives can be decelerated in a position-controlled way.

For drives without Sercos interface, the control unit has to evaluate the UD contact. When the UD contact triggers, the control unit has to decelerate the drives.

NOTICE **Damage to machines caused by unbraked coasting to stop of the drives in case DC bus voltage is too low!**

The control unit should evaluate the UD contact and decelerate the drives when the contact triggers.

Control Circuit "Position-Controlled Shutdown by the Control Unit" for the Mains Connection of HMV01.1R Supply Units With Integrated Mains Contactor (e.g. HMV01.1R-W0018, -W0045, -W0065)



F1	Fuse of power supply
F2	Fuse of synchronization connection X14
F3	Fuse of 24V power supply unit
1)	Control of K1, if A10 is not used

2)	Drive enable (via input at control section or via master communication); see also parameter "P-0-4028, Device control word"
A10	Emergency stop relay (example of circuit)
Bb1	Readiness for operation of supply unit
Bb	Readiness for operation of drive controllers (see control section X31.1 and X31.2)
CNC	Control unit of installation
K1	Integrated mains contactor
K4	Control of drive enable
S1	Emergency stop
S2	Axis end position
S4	Power Off
S5	Power On
S11, S12	Safety door monitor
ZKS	DC bus short circuit

Fig. 9-12: Control Circuit Without DC Bus Short Circuit (ZKS), Position-Controlled Shutdown by the Control Unit for HMV01.1R Supply Units With Integrated Mains Contactor

Control circuit emergency stop relay without DC bus short circuit (ZKS)

Application

- If unbraked coasting to stop of the drives does not damage the installation.
- If only asynchronous motors are connected to the supply unit.
- If the end positions of the feed axes have been sufficiently cushioned.
- If external braking devices are used.

Features

The DC bus voltage is not short-circuited.

In the case of emergency stop or when the monitors of the supply unit trigger (e.g., mains failure), the drives are decelerated according to the error reaction set in the drive controller.

Operating principle

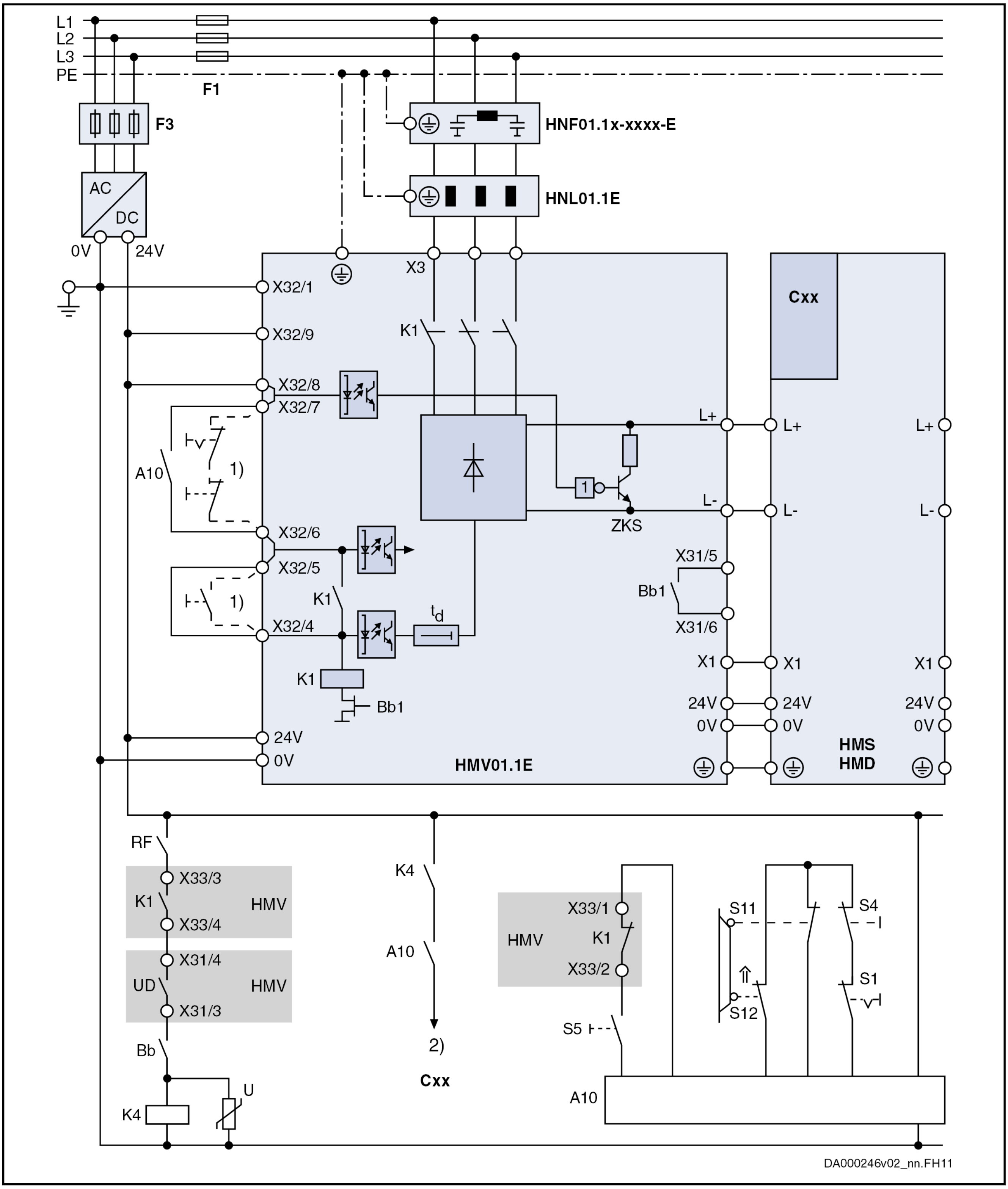
When the emergency stop circuit opens, the mains contactor in the supply unit drops out immediately. The emergency stop relay or an auxiliary contact of the mains contactor switches off the drive enable signals. The drives are decelerated according to the error reaction set in the drive controller.

NOTICE **Damage to machines caused by unbraked coasting to stop of the drives in case their electronics is disturbed!**

Use motors with a mechanical brake (a holding brake cannot be used as a service brake).

Sufficiently cushion end positions of feed axes.

Example Control Circuit "Without DC Bus Short Circuit (ZKS)" for the Mains Connection of HMV01.1E Supply Units With Integrated Mains Contactor (e.g. HMV01.1E-W0030, -W0070, -W0120)

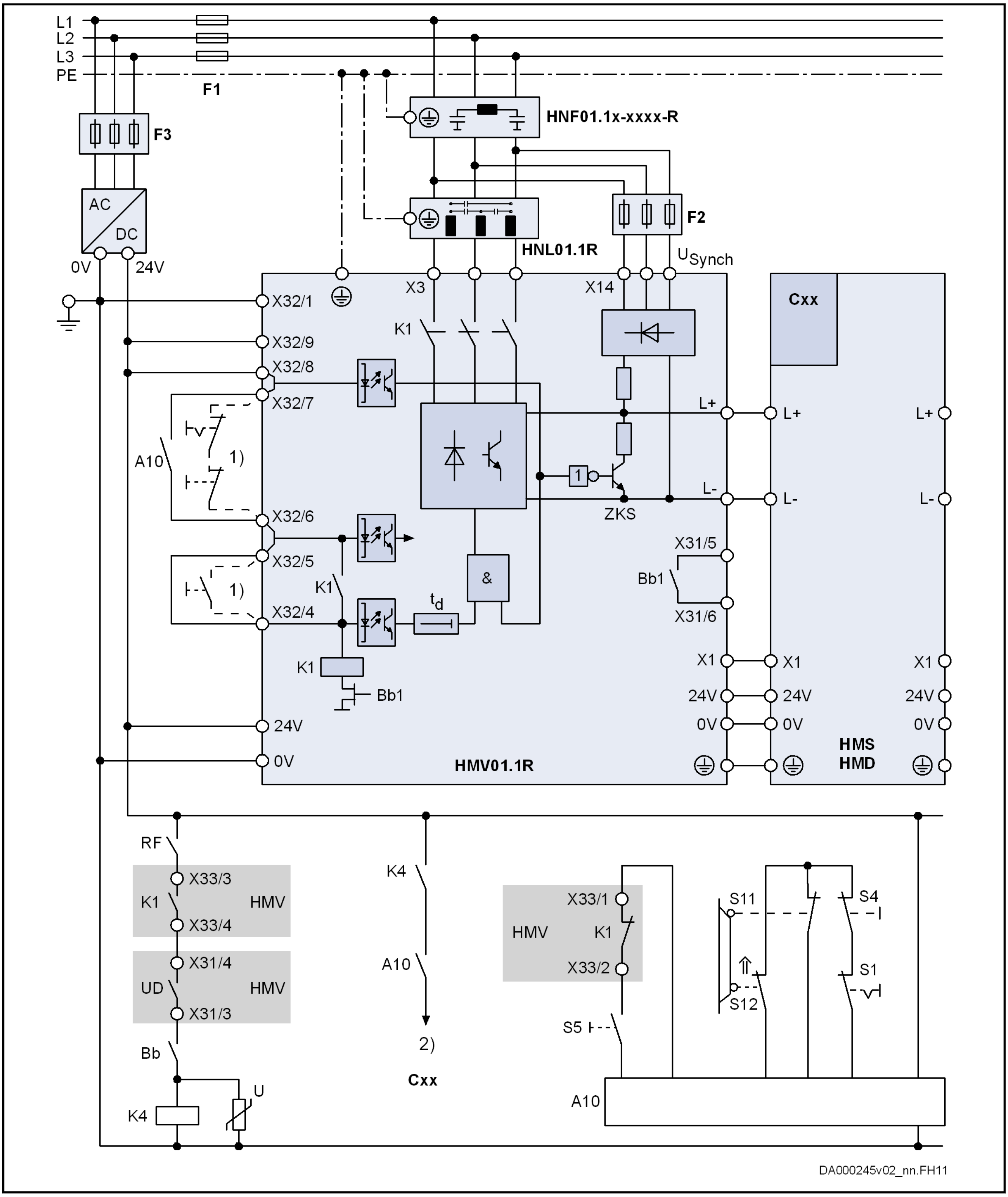


F1	Fuse of power supply
F3	Fuse of 24V power supply unit
1)	Control of K1, if A10 is not used

2)	Drive enable (via input at control section or via master communication); see also parameter "P-0-4028, Device control word"
A10	Emergency stop relay (example of circuit)
Bb1	Readiness for operation of supply unit
Bb	Readiness for operation of drive controllers (see control section X31.1 and X31.2)
K1	Integrated mains contactor
K4	Control of drive enable
S1	Emergency stop
S4	Power Off
S5	Power On
S11, S12	Safety door monitor
ZKS	DC bus short circuit
HNL, HNF	Optional, depending on the application

Fig. 9-13: Control Circuit Without DC Bus Short Circuit (ZKS) for HMV01.1E Supply Units With Integrated Mains Contactor

Example Control Circuit "Without DC Bus Short Circuit (ZKS)" for the Mains Connection of HMV01.1R Supply Units With Integrated Mains Contactor (e.g. HMV01.1R-W0018, -W0045, -W0065)

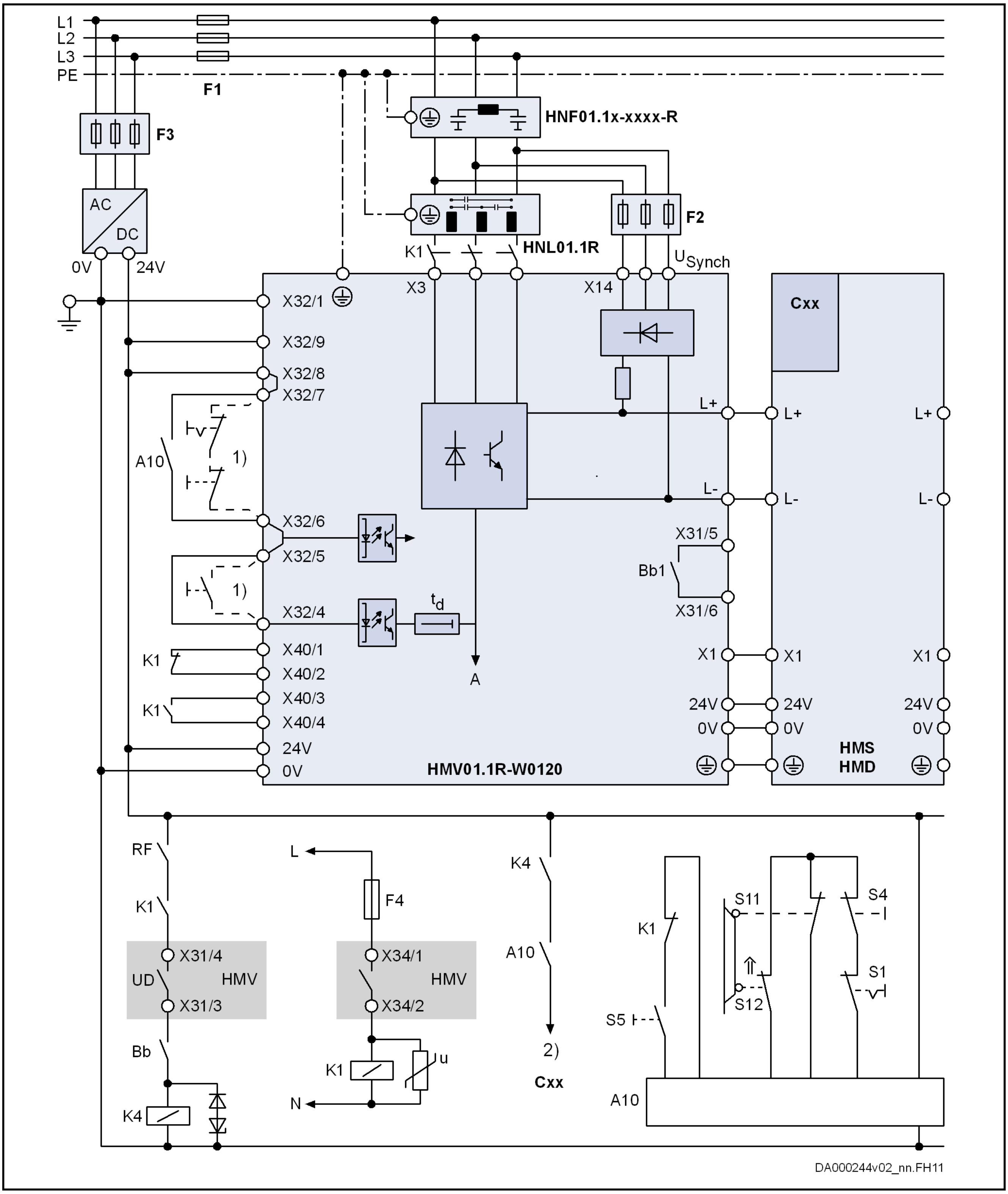


F1	Fuse of power supply
F2	Fuse of synchronization connection X14
F3	Fuse of 24V power supply unit

1)	Control of K1, if A10 is not used
2)	Drive enable (via input at control section or via master communication); see parameter "P-0-4028, Device control word"
A10	Emergency stop relay (example of circuit)
Bb1	Readiness for operation of supply unit
Bb	Readiness for operation of drive controllers (see control section X31.1 and X31.2)
K1	Integrated mains contactor
K4	Control of drive enable
S1	Emergency stop
S4	Power Off
S5	Power On
S11, S12	Safety door monitor
ZKS	DC bus short circuit

Fig. 9-14: Control Circuit Without DC Bus Short Circuit (ZKS) for HMV01.1R Supply Units With Integrated Mains Contactor

Example Control Circuit "Without DC Bus Short Circuit (ZKS)" for the Mains Connection of HMV01.1R Supply Units Without Integrated Mains Contactor (e.g. HMV01.1R-W0120)



F1	Fuse of power supply
F2	Fuse of synchronization connection X14 (see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections")
F3	Fuse of 24V power supply unit

F4	Fuse of contactor control X34 (see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections")
1)	Control of K1, if A10 is not used
2)	Drive enable (via input at control section or via master communication); see also parameter "P-0-4028, Device control word"
A10	Emergency stop relay (example of circuit)
Bb1	Readiness for operation of supply unit
Bb	Readiness for operation of drive controllers (see control section X31.1 and X31.2)
K1	Mains contactor
K4	Control of drive enable
L, N	AC supply mains contactor
S1	Emergency stop
S4	Power Off
S5	Power On
S11, S12	Safety door monitor

Fig. 9-15: Control Circuit Without DC Bus Short Circuit (ZKS) for HMV01.1R Supply Units Without Integrated Mains Contactor

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☞ **Observe Off delay and pick-up delay of K1!**

Off delay K1:

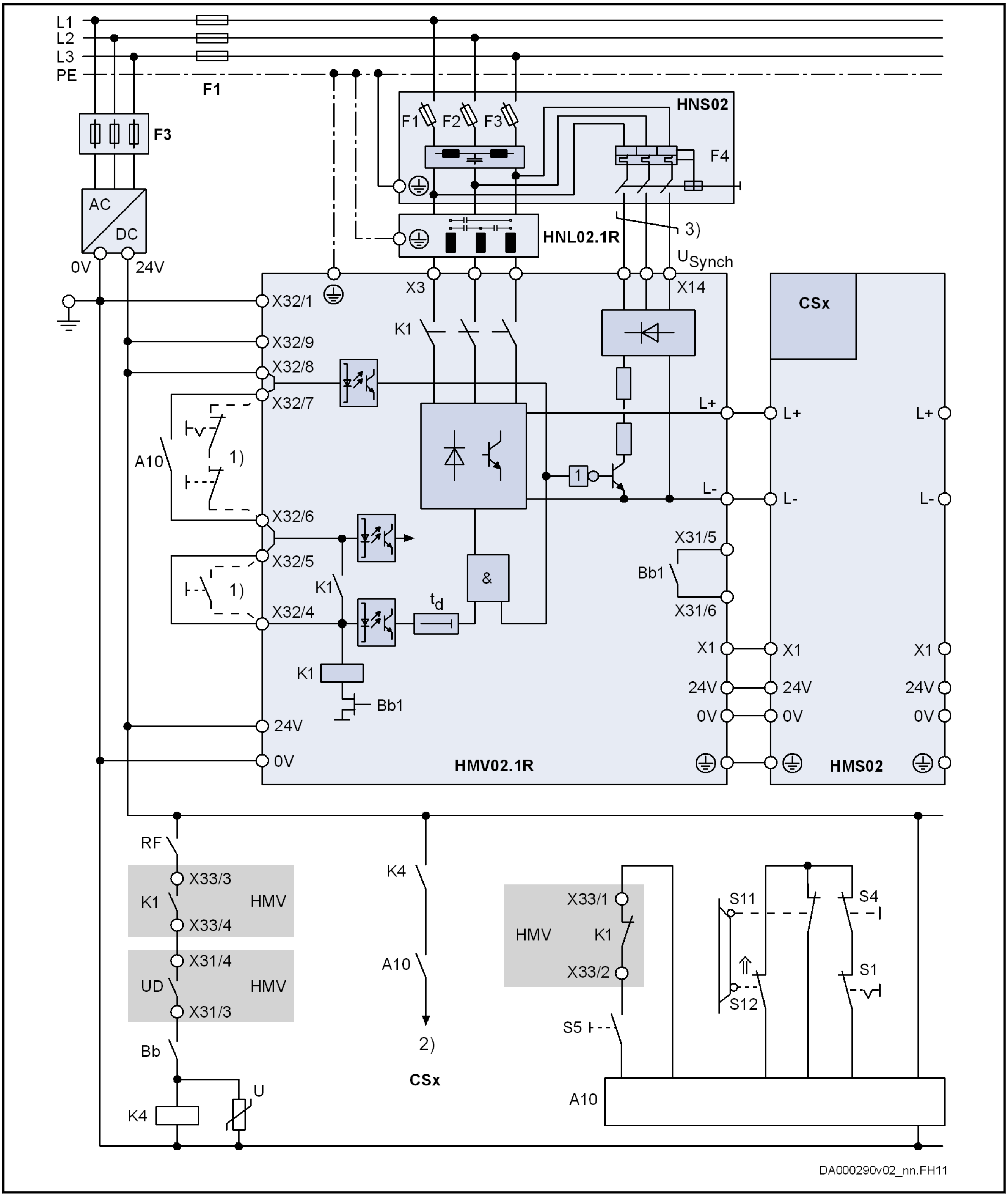
Select K1 mains contactors with an Off delay shorter than the On delay t_{d_on} of the DC bus short circuit device. Otherwise, the DC bus short circuit device switches on with applied mains voltage and causes tripped fuse (F1) or damage to the supply unit.

Circuits for overvoltage protection increase the Off delay. Observe the data of the selected mains contactor!

Pick-up delay K1:

Select K1 mains contactors with a pick-up delay of less than 100 ms. Otherwise, the error message F2835 will be generated.

Example control circuit "without DC bus short circuit (ZKS)" for the mains connection of HMV02.1R supply units with integrated mains contactor (e.g., HMV02.1R-W0015)



F1	Fuse of power supply
F3	Fuse of 24V power supply unit

F4	Fuse of synchronization connection X14 (integrated in HNS02 mains filter)
1)	Control of K1, if A10 is not used
2)	Drive enable (via input at control section or via master communication); see parameter "P-0-4028, Device control word"
3)	Twist wires
O10	Emergency stop relay (example of circuit)
Bb1	Readiness for operation of supply unit
Bb	Readiness for operation of drive controllers (see control section X31.1 and X31.2)
K1	Integrated mains contactor
K4	Control of drive enable
S1	Emergency stop
S4	Power Off
S5	Power On
S11, S12	Safety door monitor
ZKS	DC bus short circuit

Fig. 9-16: Control circuit without DC bus short circuit (ZKS) for HMV02.1R supply units with integrated mains contactor

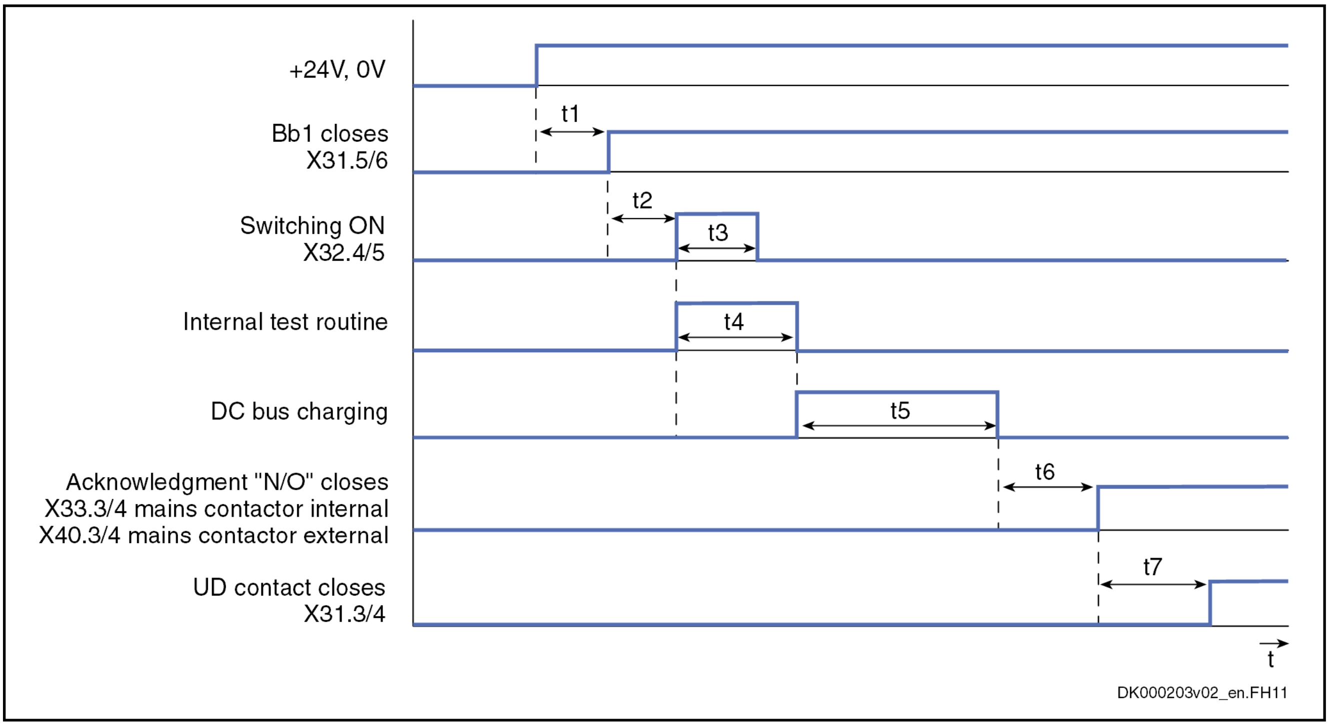
9.4.5 Signal sequences when switching on and off HMV supply units

Switching on

NOTICE **Risk of damage to the supply units when they are switched on simultaneously!**

With 3 or more HMV supply units at common power grid: Switch on supply units one after the other with a **time interval of at least 0.5 seconds** so that the inrush currents are not added.

In the switch-on sequence of the supply unit, the supplying mains is loaded with the current $I_{L\_trans\_max\_on}$ for the purpose of analysis. During the unloading process, voltage overshoot can occur at the mains components connected in the incoming circuit (e.g., mains filters) due to inductances connected in the incoming circuit, e.g. the leakage inductance of the mains transformer.



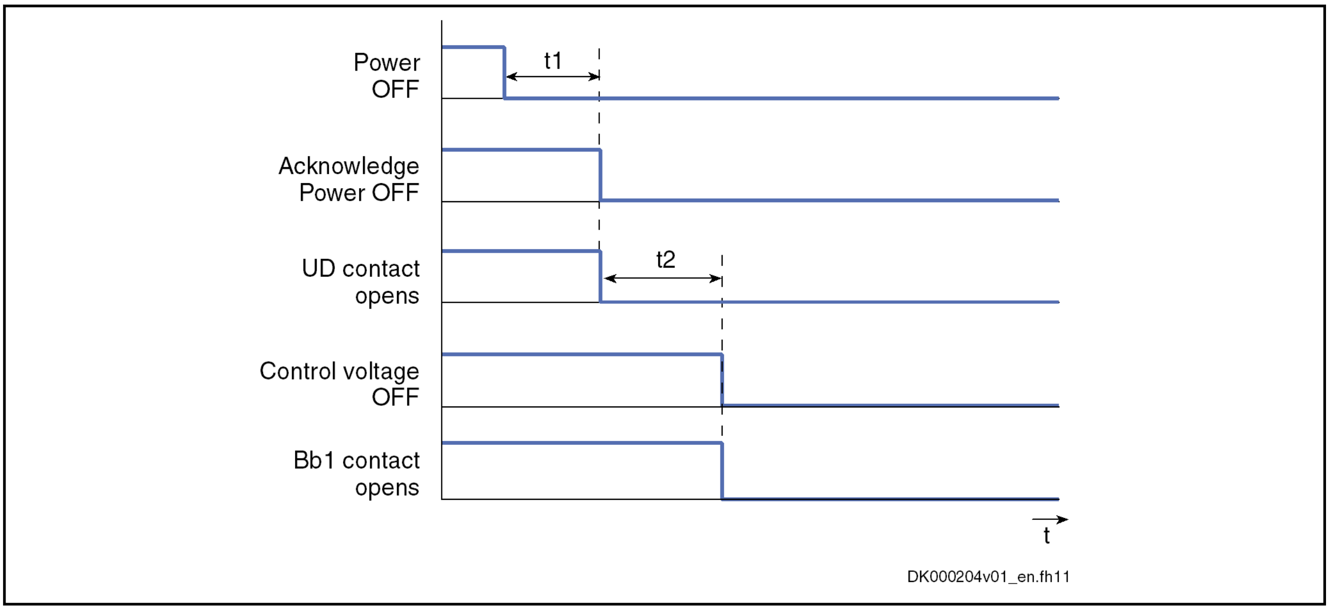
t1	5.2 s; time for internal booting until Bb1 contact closes
t2	Time can be set by the user. Take the time into account which is required for run-up of all devices connected to the module bus. This time depends on the control unit or the machine.
t3	At least 250 ms; switch-on pulse
t4	500 ms; time for internal test routines before the DC bus is charged
t5	Time depends on DC bus capacitance (internal, external) and mains voltage
t6	500 ms; delay time until mains contactor closes
t7	Maximum 200 ms; depends on device (ON delay of mains contactor)

Fig. 9-17: Signal sequences when switching on

Involved connection points

See "Rexroth IndraDrive Supply Units and Power Sections" → chapter "Functions and connection points"

Switching off



t1 Maximum 200 ms; depends on device (OFF delay of mains contactor)

t2 Time can be set by the user

Fig. 9-18: Signal sequences when switching off

NOTICE **Damage to the supply unit!**

At **HMV01.1R** supply units, there have to be **at least 10 ms** between the mains OFF request (signal at X32.6 / X32.7) and the disconnection of the mains voltage, so that the energy flow has been interrupted when the disconnection process starts.

You can make sure this order is observed by appropriate switch elements (e.g., by a control cabinet main switch with leading auxiliary contact). For this purpose, connect the auxiliary contact in series with mains OFF.

Involved connection points

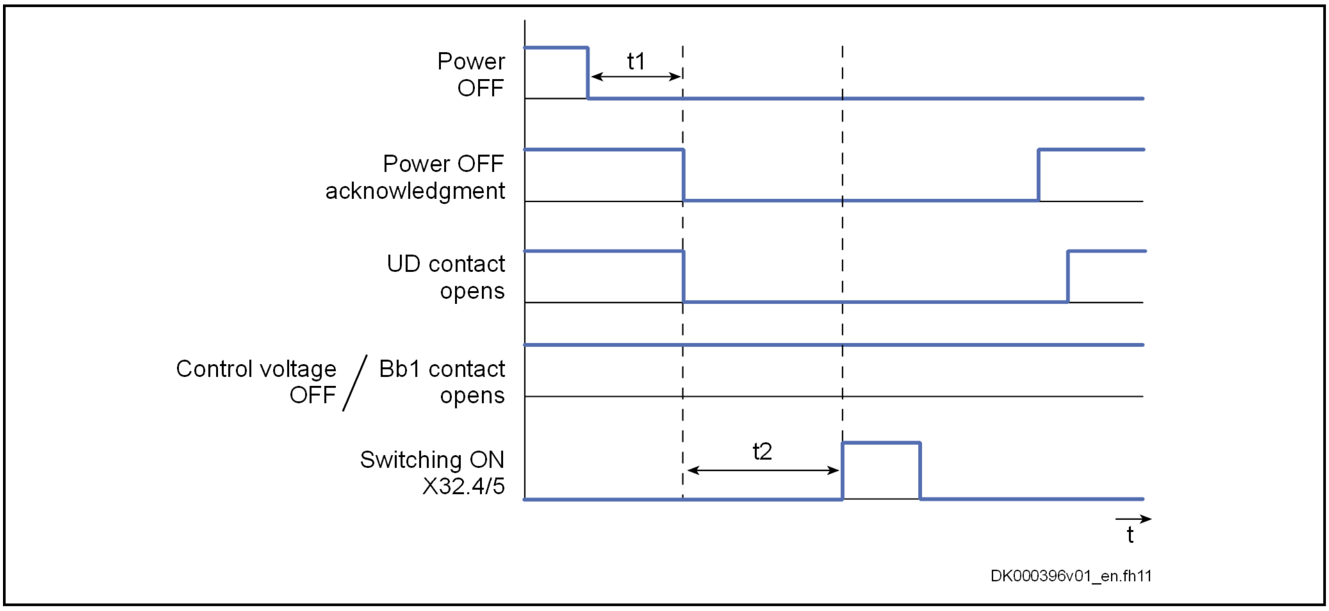
📖 See "Rexroth IndraDrive Supply Units and Power Sections" → chapter "Functions and connection points"

Switching back on

NOTICE **Risk of damage to the supply units when they are switched on simultaneously!**

With 3 or more HMV supply units at common power grid: Switch on supply units one after the other with a **time interval of at least 0.5 seconds** so that the inrush currents are not added.

In the switch-on sequence of the supply unit, the supplying mains is loaded with the current $I_{L\_trans\_max\_on}$ for the purpose of analysis. During the unloading process, voltage overshoot can occur at the mains components connected in the incoming circuit (e.g., mains filters) due to inductances connected in the incoming circuit, e.g. the leakage inductance of the mains transformer.



t1	Maximum 200 ms; depends on device (OFF delay of mains contactor)
t2	At least 500 ms; (time required to detect "power ON")

Fig. 9-19: Signal sequences when switching off and switching back on

Observe allowed number of switch-on processes.

Involved connection points

See "Rexroth IndraDrive Supply Units and Power Sections" → chapter "Functions and connection points"

10 Electromagnetic compatibility (EMC)

10.1 EMC requirements

10.1.1 General information

The electromagnetic compatibility (EMC) or electromagnetic interference (EMI) includes the following requirements:

- Sufficient **noise immunity** of an electric installation or an electric device against external electric, magnetic or electromagnetic interference via lines or through air
- Sufficiently low **noise emission** of electric, magnetic or electromagnetic noise of an electrical installation or an electric device to other surrounding devices via lines or through air

10.1.2 Noise immunity in the drive system

Basic structure for noise immunity

The figure below illustrates the interfaces for defining the noise immunity requirements in the drive system.

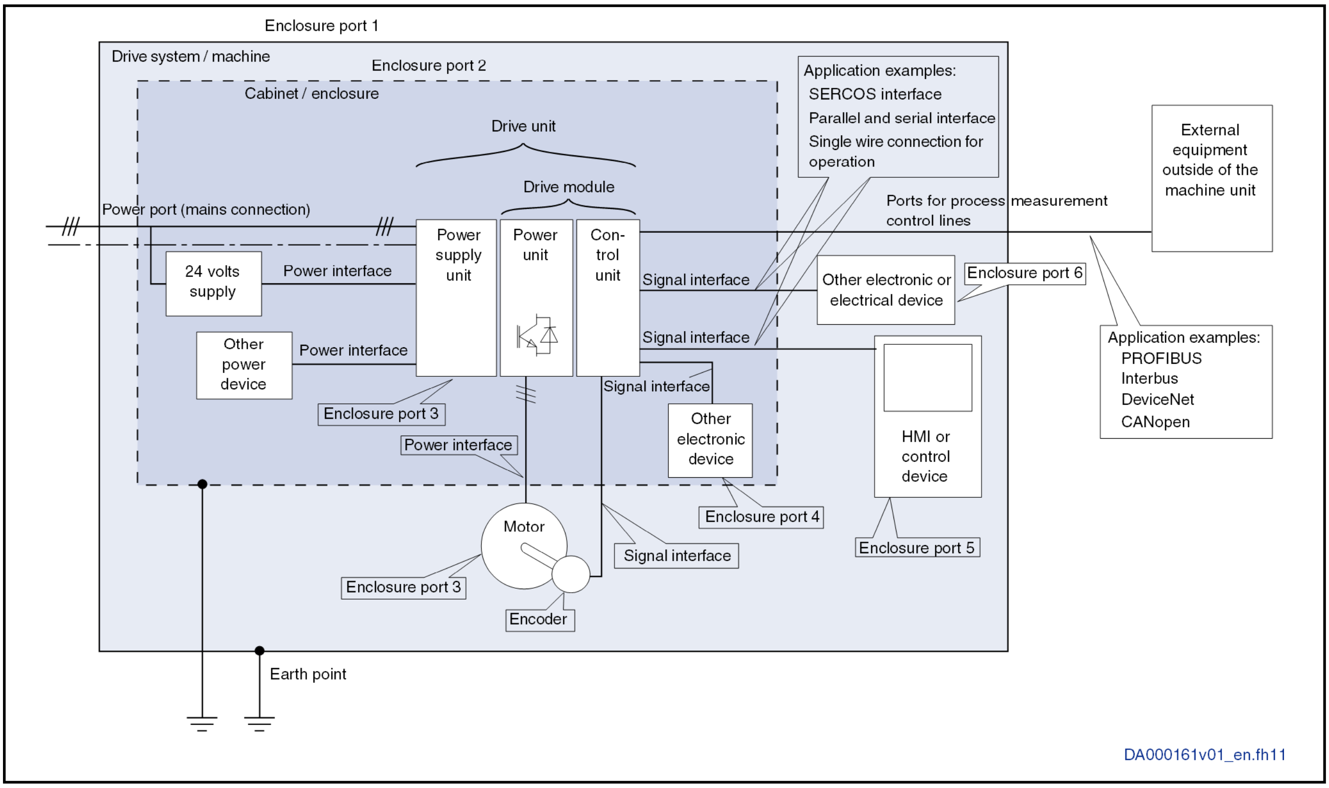


Fig. 10-1: Basic structure for noise immunity

Limit values for noise immunity

No	Place of effect	Phenomenon	Standard	Conditions	Coupling	Test values according standard EN 61800-3	Performance level
	Enclosure port		IEC 61000-4-2		CD, AD	6 kV CD, 8 kV AD, if CD not possible	B
		RF Field	IEC 61000-4-3		Via antenna on EUT	10 V / m	A
	Power port	Burst	IEC 61000-4-4	length > 3 m	mains connection I < 100 A: discoupling network I > 100 A: clamp	4 kV / 2.5 kHz (clamp)	B
		Surge	IEC 61000-4-5	Only mains connection; I < 63 A, light load test		Line - line 1 kV (2 Ohm) Line - earth 2 kV (12 Ohm)	B
			IEC 61000-4-6	length > 3 m	clamp	10 V, 0,15-80 MHz	A
	Power Interface	Burst	IEC 61000-4-4	length > 3 m	clamp		B
	Signal Interface	Burst	IEC 61000-4-4	length > 3 m	clamp		B
			IEC 61000-4-6	length > 3 m	Clamp or CDN	10 V, 0,15-80 MHz	B
	Ports of process; measurement control lines	Burst	IEC 61000-4-4	length > 3 m	clamp		B
			IEC 61000-4-6	length > 3 m	Clamp or CDN	10 V, 0,15-80 MHz	A

Tab. 10-1: Noise immunity limit values

Evaluation criterion	Explanation (abbreviated text from EN 61800-3)
A	Deviations within allowed range
B	Automatic recovery after interference
C	Switched off without automatic recovery. Device remains undamaged.

Tab. 10-2: Evaluation criterion

10.1.3 Noise emission of the drive system

Causes of noise emission

Controlled variable-speed drives contain converters containing snappy semiconductors. The advantage of modifying the speed with high precision is achieved by pulse width modulation of the converter voltage. This can generate sinusoidal currents with variable amplitude and frequency in the motor.

The steep voltage rise, the high clock rate and the resulting harmonics cause unwanted but physically unavoidable emission of interference voltage and interference fields (wide band interference). The interference mainly is asymmetric interference against ground.

The propagation of this interference strongly depends on:

- Configuration of the connected drives
- Number of the connected drives
- Conditions of mounting
- Site of installation
- Radiation conditions
- Wiring and installation

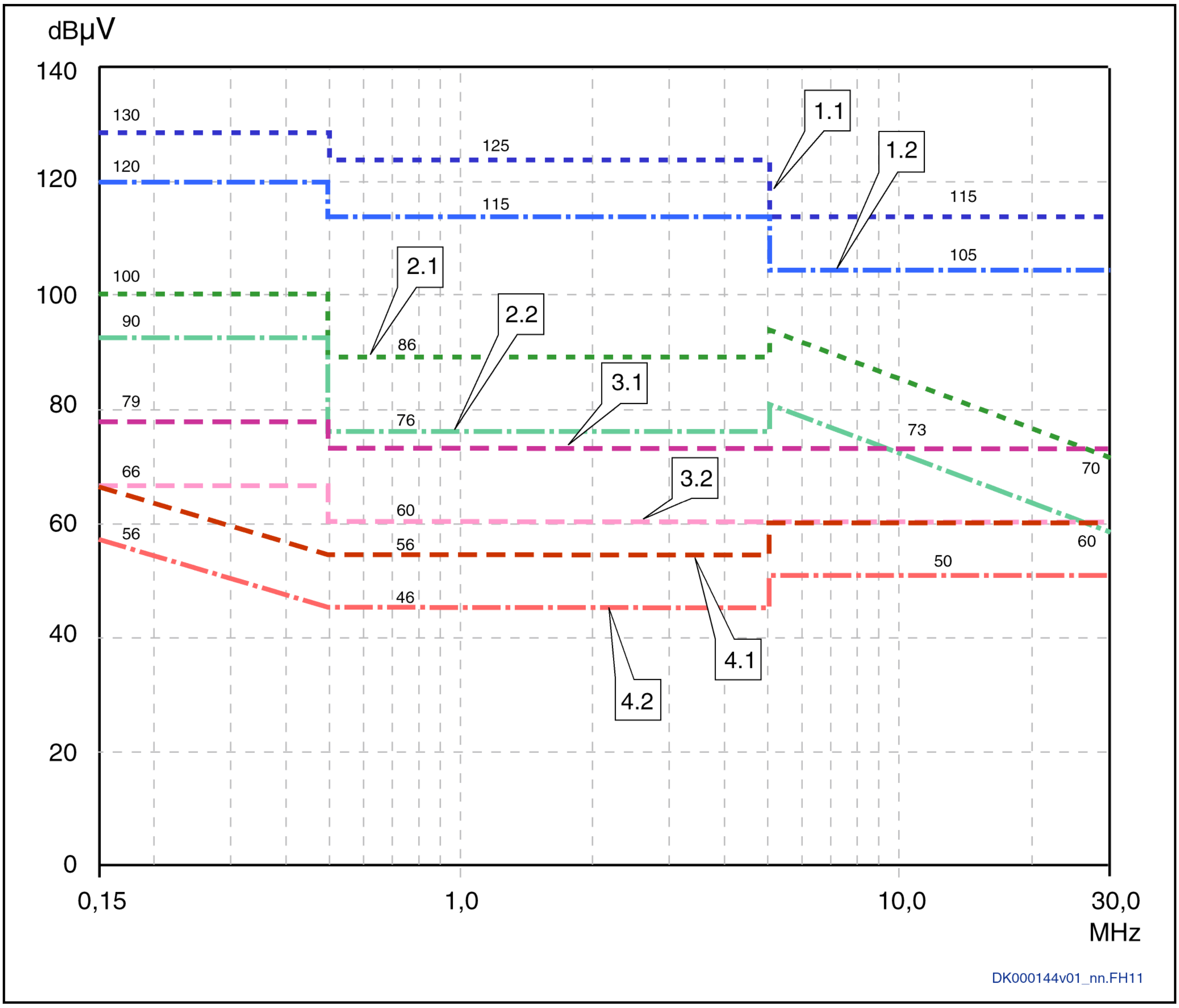
When the interference gets from the device to the connected lines in unfiltered form, these lines can radiate the interference into the air (antenna effect). This applies to power lines, too.

Limit values for line-based disturbances

According to IEC EN 61800-3 or CISPR 11 (corresponds to EN55011), the limit values in the table below are distinguished. For this documentation both standards are combined in the limit value classes A2.1 to B1.

IEC / EN 61800-3	CISPR 11 (EN55011)	Explanation	In this documentation	Curves of limit value characteristic
Category C4 2nd environment	None	One of the following 3 requirements must have been fulfilled: Mains connection current >400 A, IT mains or required dynamic drive behavior not reached by using EMC filter. Adjust limit values to use and operation on site. User has to carry out and provide evidence of EMC planning.	None	-
Category C3 2nd environment	Class A; Group 2 I > 100 A	Limit value in industrial areas to be complied with for applications operated at supply mains with nominal currents > 100 A.	A2.1	1.1 1.2
Category C3 2nd environment	Class A; Group 2 I < 100 A	Limit value in industrial areas to be complied with for applications operated at supply mains with nominal currents < 100 A.	A2.2	2.1 2.2
Category C2 1st environment; Restricted distribution	Class A; Group 1	Limit value in residential area or at facilities at low-voltage mains supplying buildings in residential areas. To be complied with for applications with restricted distribution.	A1	3.1 3.2
Category C1 1st environment; Unrestricted distribution	Class B; Group 1	Limit value in residential areas to be complied with for applications with unrestricted distribution.	B1	4.1 4.2

Tab. 10-3: Limit value classes



1.1	Category C3: Second environment, QSP, I > 100 A (class A, group 2, I > 100 A)
1.2	Category C3: Second environment, AV, I > 100 A (class A, group 2, I > 100 A)
2.1	Category C3: Second environment, QSP, I < 100 A (class A, group 2, I < 100 A)
2.2	Category C3: Second environment, AV, I < 100 A (class A, group 2, I < 100 A)
3.1	Category C2: First environment, restricted distribution, QSP (first environment, even if source of interference in second environment) (class A, group 1)
3.2	Category C2: First environment, restricted distribution, AV (first environment, even if source of interference in second environment) (class A, group 1)
4.1	Category C1: First environment, unrestricted distribution, QSP (first environment, even if source of interference in second environment) (class B, group 1)
4.2	Category C1: First environment, unrestricted distribution, AV (first environment, even if source of interference in second environment) (class B, group 1)

Notes (1) Limit value for first environment is also relevant, if source of interference of second environment affects first environment.
(2) Designations "class" and "group" according to IEC CISPR 11.
QSP: measuring method quasi peak measurement; AV: measuring method arithmetic averaging

Fig. 10-2: Limit values for line-based disturbances (IEC 61800-3); limit value characteristic through frequency range

Second environment, industrial area

Facilities not directly connected to a low-voltage grid to supply buildings in residential areas.

If the limit values in an industrial area separated from public supply by a transformer station only have to be complied with at the property boundary or in the neighboring low-voltage mains, the filter might not be necessary. In the vicinity of broadcast receivers or other sensitive devices as regards high-frequency, such as measuring sensors, measuring lines or measuring devices, it is normally required to use the interference suppression filter.

Increasing the noise immunity of a sensitive device can often be the economically better solution compared to measures of interference suppression at the drive system of the installation.

First environment

Environment containing residential areas and facilities directly connected, without interstage transformer, to a low-voltage mains supplying buildings in residential areas.

Medium-sized manufacturing plants and industrial establishments can be connected to the public low-voltage mains together with residential buildings. In this case, there is a high risk for radio and television reception if there aren't any measures for radio interference suppression taken. Therefore, the indicated measures are generally recommended.

Nominal current of power grid

The nominal current of the power grid (> 100 A or < 100 A) is specified by the local power supply company at the connection point of the grid. For industrial plants, for example, such connection points are the interconnecting stations from the power supply system.

Unrestricted distribution

Channel of distribution for which placing on the market is independent of the EMC expert knowledge of the customer or user of electric drives.

Restricted distribution

Channel of distribution for which the placing on the market is restricted to traders, customers or users who individually or together have technical expert knowledge of EMC for the use of electric drives.

It is impossible to obtain the lower limit values for residential areas in all applications by taking the usual measures (like for example in the case of large and electrically not closed installations, longer motor cables or a large number of drives). Therefore, the following note included in EN 61800-3 has to be observed.

☞ Components of the IndraDrive system are **products of Category C3** (with restricted distribution) in accordance with IEC 61800-3. This Category comprises EMC limit values for line-based and radiated noise emission. Compliance with this Category (limit values) requires the appropriate measures of interference suppression to be used in the drive system (e.g., mains filters, shielding measures).

These components are not provided for use in a public low-voltage mains supplying residential areas. If these components are used in such a mains, high-frequency interference is to be expected. This can require additional measures of interference suppression.

See the following chapters for the limit value classes (as per categories C1, C2, C3, C4 according to EN 61800-3) which can be reached for the individual drive systems and devices:

- chapter "Mains connection for HMV01.1E supply units" on page 89
- chapter "Mains connection for HMV01.1R supply units" on page 90
- chapter "Mains connection for HMV02.1R supply units" on page 91
- chapter "Mains connection for HCS02 converters" on page 93
- chapter "Mains connection for HCS03 converters" on page 95

10.2 Ensuring the EMC requirements

Standards and laws

On the European level there are the EU Directives. In the EU states these Directives are transformed into laws valid on a national level. The relevant directive for EMC is EU Directive 2004/108/EC which was transformed on the national level in Germany into the EMVG law ("Law concerning electromagnetic compatibility of devices") of 2008-02-26.

EMC properties of components

Drive and control components by Rexroth are designed and engineered, in accordance with the present state-of-the-art of standardization, according to legal regulations of the EU Directive EMC 2004/108/EC and the German EMC law.

The compliance with EMC standards was tested using a typical arrangement with a test setup conforming to standard with the specified mains filters. The limit values according to product standard EN 61800-3 have been complied with.

Apart from the internal test at the factory, a conformity test was carried out for individual drive systems in an accredited laboratory of a CE-responsible authority.

Applicability for finished product

Measurements of the drive system with an arrangement typical for the system are not in all cases applicable to the state as installed in a machine or installation. Noise immunity and noise emission strongly depend on:

- Configuration of the connected drives
- Number of the connected drives
- Mounting conditions
- Site of installation
- Radiation conditions
- Wiring and installation

In addition, the required measures depend on the requirements of electric safety technology and economic efficiency in the application.

In order to prevent interference as far as possible, notes on mounting and installation are contained in the documentations of the components and in this documentation.

☞ Observe the descriptions and notes in chapter 11 Arranging the components in the control cabinet , page 175.

Cases to distinguish for declaration of EMC conformity

For validity of the harmonized standards, we distinguish the following cases:

- Case 1: **Delivery** of the drive system.

  According to the regulations, the product standard EN 61800-3 is complied with for Rexroth drive systems. The drive system is listed in the declaration of EMC conformity. This fulfills the legal requirements according to EMC directive.

- Case 2: **Acceptance test** of a machine or installation with the installed drive systems.

  The product standard for the respective type of machine/installation, if existing, applies to the acceptance test of the machine or installation. In the last years, some new product standards were created for certain machine types and some are being created at present. These new product standards contain references to the product standard EN 61800-3 for drives or specify higher-level requirements demanding increased filter and installation efforts. If the machine manufacturer wants to place the machine/installation on the market, the product standard relevant to their machine/installation has to be complied with for their finished "machine/installation" product. The authorities and test laboratories responsible for EMC normally refer to this product standard.

This documentation specifies the EMC properties which can be achieved, in a machine or installation, with a drive system consisting of the standard components.

It also specifies the conditions under which the indicated EMC properties can be achieved.

10.3 Measures to reduce noise emission

10.3.1 General information

To reduce noise emission, there are mainly three possible measures:

- Filtering by means of mains filter
- Shielding by mounting and shielded cables
- Grounding by electrical bonding

Noise emission of the drive systems

To comply with the limit values for noise emission (mainly line-based radio interference of more than 9 kHz) at the connection points of the machine or installation, observe the notes on application contained in this documentation.

10.3.2 Shielding

Sufficient metallic shielding prevents radiation into the air. This is achieved by mounting the devices in a grounded control cabinet or in a housing (metallic encapsulation). The shielding of line connections is implemented by shielded cables and lines, the shield has to be grounded over a large surface area.

To connect the shield at the motor, a suitable PG gland with shield connection can be used. Make sure that the connection between the motor terminal box and the motor housing has a low impedance (if necessary, use an additional grounding strap). Never use plastic motor terminal boxes!

10.3.3 Grounding

Grounding discharges interference to ground and makes it flow back to the source of interference over the shortest distance. Grounding has to be implemented via a sufficiently **short connection over the largest possible surface area** in order to achieve low inductive resistance with a low degree of line inductance. The higher the frequency of disturbances, the lower the line inductance of grounding has to be.

☞ In ungrounded mains, the "grounding" measure cannot be generally used.

10.3.4 Filtering

Filtering prevents emission of noise via the lines, especially via the mains connection. For this purpose, there are special interference suppression filters available with which

- the allowed limit values of the line-based noise emission can be complied within the range of 50 kHz to 30 MHz.
- interference via the mains connection to devices connected near by (e.g., control unit components) can be reduced.

11 Arranging the components in the control cabinet

11.1 Dimensions and distances

11.1.1 Main dimensions of the system components

General information

☞ The **mounting depths** of the devices of the IndraDrive product range have been optimized for mounting in control cabinets:

- Mounting depths up to **265 mm**: for control cabinets with a depth of 300 mm
- Mounting depths up to **322 mm**: for control cabinets with a depth of 400 mm

The figure below contains a rough overview of the main dimensions.

📖 For other data and required mounting dimensions, see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → chapter of the respective device → "Technical data" → "Mechanics and mounting"

Device depths and device heights

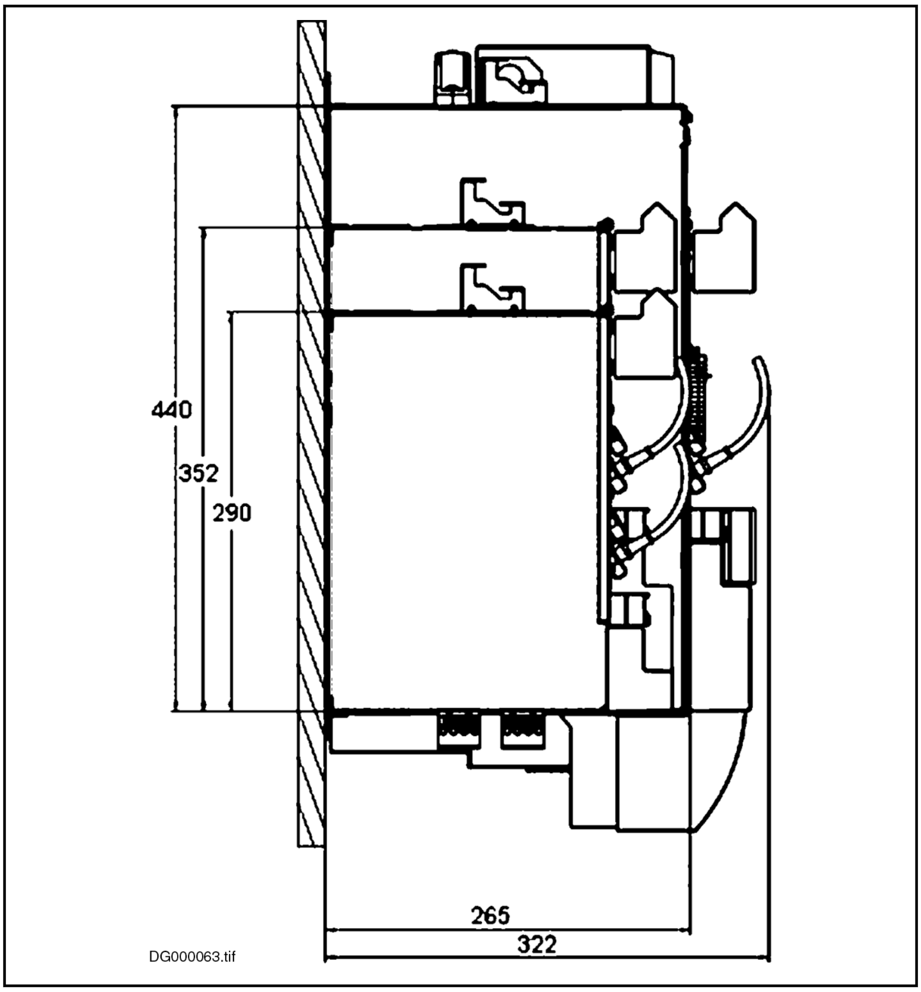


Fig. 11-1: Main dimensions in mm

11.1.2 Distances

General information

In addition to the mounting dimensions, the devices of the IndraDrive range require additional mounting clearance:

- To ventilate the devices
- To mount accessories and connections
- To take temperature limits of neighboring mounting parts, such as cable ducts etc., into account

For the required mounting clearance in the control cabinet, take additional distances between the devices and on their tops and bottoms into account.

For the distances to be complied with d_{top} (distance to top of device), d_{bot} (distance to bottom of device) and d_{hor} (distance to side of device) see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → chapter of the respective device → "Technical data" → "Mechanics and mounting" → "Power dissipation, mounting position, cooling, distances"

Distance between the devices

Owing to power dissipation in the devices, especially due to integrated braking resistors, the temperatures of neighboring devices are rising. In the case of lateral mounting, trouble-free operation therefore requires the following minimum distances (in mm) between the devices.

Minimum distance [mm]						
Between	and					
	HCS02	HCS03 (HNK01, HLR01)	HMV01	HMV02	HMS01 / HMD01	HMS02
HCS02.1E	5	--	--	--	0 (HMS to the right of HCS) 5 (HMS to the left of HCS)	0 (HMS to the right of HCS) 5 (HMS to the left of HCS)
HCS03.1E with HNK01 and HLR01	--	0	--	--	0	--
HMV01.1E / HMV01.1R	--	--	0	--	0	--
HMS01.1 / HMD01.1	0 (HMS to the right of HCS) 5 (HMS to the left of HCS)	0	0	--	0	--
HMV02.1R	--	--	--	--	--	0
HMS02.1	0 (HMS to the right of HCS) 5 (HMS to the left of HCS)	0	0	0	0	0

-- Not allowed

Tab. 11-1: Minimum distances

☞ For arrangement of the devices in the control cabinet, take the required minimum distances into account besides the device dimensions.

Distance to the bottom of the devices

In order that there is sufficient cooling air available for cooling the devices, a minimum distance to other devices has to be complied with from the bottom of the devices. This applies both to the intake space of devices with forced cooling and to devices with cooling by natural convection.

In the thermal steady-state condition of the drive system, the temperature at the **air intake** of the device is the ambient temperature of the device. The temperature at the air intake is relevant for checking whether the allowed ambient temperature range T_{a_work} (see technical data of the respective device) has been complied with.

☞ Keep the space at the air intake free from unnecessary barriers.

Run the cables as short as possible and without loops.

Do not place loads with power dissipation (e.g., mains chokes, braking resistors) near the air intake.

Use barrier plates, if necessary.

Form a **channel** which is as obstacle-free as possible and corresponds at least to the cross section "d_{bot} × mounting depth". The channel should lead with at least this cross section to the air intakes at the bottom and at the top of the devices.

☞ If there are different minimum distances for the individual devices in a drive system, the greatest value determines the minimum distance to be observed for the entire row in the drive system.

Distance to the top of the devices

In order that the cooling systems can transport the cooling air through the devices and heat does not accumulate, a minimum distance to the top of the devices has to be complied with.

☞ Keep the space at the air outlet free from unnecessary barriers.

Where possible, run the cables and lines outside the outlet apertures.

The supplied cooling air is heated up due to the power dissipation generated in the devices.

In a distance of d_{top} above the devices, the temperature of the cooling air is up to 105 °C.

Directly at the outlet holes - especially of devices with integrated braking resistor and DC bus short circuit device - the temperature of the cooling air can be significantly higher than 105 °C.

NOTICE **Risk of fire caused by the "sacrificing behavior" of the ZKS stage!**

The "ZKS" input activates the "DC bus short circuit" function, when the 24V control voltage has not been applied and when there isn't any current flowing to the input. This condition can occur in the following situations:

- Failure of 24V control voltage
- Wire break
- Activation of serially connected contacts (e.g. axis limit switches)

If the kinetic energy of the mechanical axis system regenerated when braking is greater than the energy absorption capacity of HLB, the HLB device remains active when braking via ZKS takes place, until it is thermally destroyed (sacrificing behavior). Risk of fire! In this case, braking via ZKS may only come into effect in the case of an emergency (e.g. activation of an axis limit switch causes the mains supply to be cut off and simultaneously causes the 24V supply of the ZKS input to be interrupted).

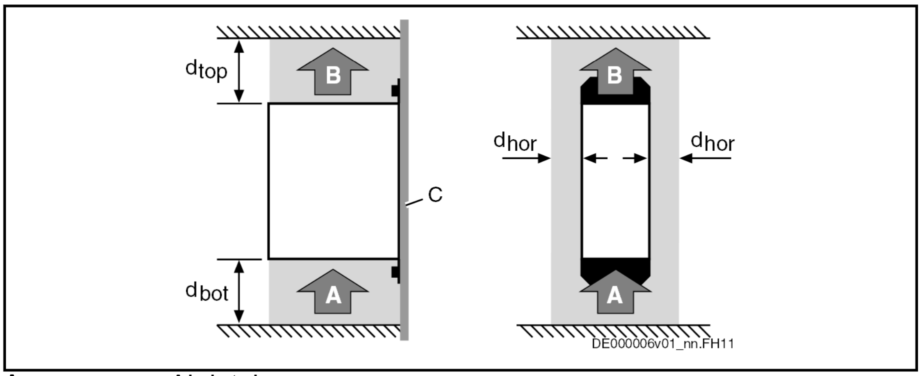
Install a 24V UPS, if the "sacrificing behavior" of HLB is relevant to your drive system in the case of an emergency. This prevents the braking via ZKS which causes HLB to be destroyed due to the failure of the 24V control voltage. Braking via ZKS then will only take place in cases of emergency.

NOTICE **Property damage due to temperatures higher than 105 °C!**

Observe the indicated minimum distances!

Above the devices there may only be such materials which

- are not combustible
- are insensitive to the occurring high temperatures



A Air intake
B Air outlet
C Mounting surface in control cabinet
d_{top} Distance top
d_{bot} Distance bottom
d_{hor} Distance horizontal

Fig. 11-2: Air intake and air outlet at device

If there are different minimum distances for the individual devices in a drive system, the greatest value determines the minimum distance to be observed for the entire row in the drive system.

For example, if a supply unit with integrated braking resistor is used and operated with nominal power, its minimum distance d_{top} of for example 300 mm determines the minimum distance for the connected HMS / HMD drive controllers, see figure "Minimum distance at HMV supply units".

Minimum distance of HMV supply units

The braking resistor in HMV01.1E heats up during operation, the braking resistor in HMV01.1R and HMV02.1R does so particularly after power has been switched off.

Under rated load, the escaping cooling air has cooled down in the minimum distance to below 105 °C. If the integrated braking resistor is not loaded, the distance can be reduced to 80 mm.

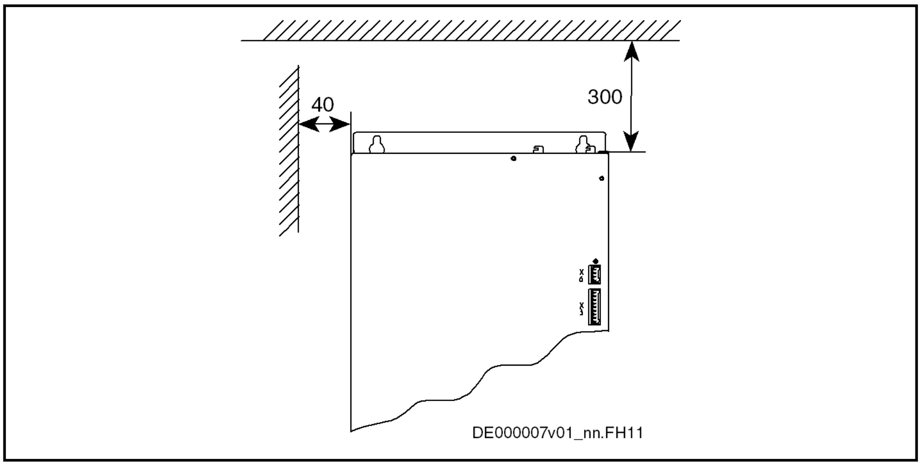


Fig. 11-3: Minimum distance at HMV supply units

Lateral distance at drive system

In order that the cooling air can circulate in the closed control cabinet, a distance at the sides of the drive system is required in addition to the distances at the top and at the bottom.

In the closed control cabinet, the circulation is provoked by the natural convection and supported by the device-internal fans.

11.1.3 Boring dimensions for the mounting plate

Individually arranged devices

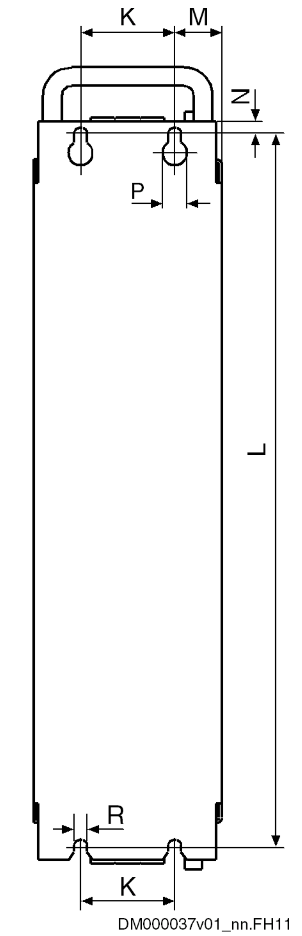


Fig. 11-4: Boring dimensions

☞ The figure shows the back of a device.

Device	K [mm]	L [mm]	M [mm]	P [mm]	R [mm]	Notes
HCS02.1E-W0012	0	316	32.5	13	7	Observe additional distance to lateral neighboring devices
HCS02.1E-W0028	0	378	32.5	13	7	Observe additional distance to lateral neighboring devices
HCS02.1E-W0054	55	378	25	13	7	Observe additional distance to lateral neighboring devices
HCS02.1E-W0070	55	378	25	13	7	Observe additional distance to lateral neighboring devices
HCS03.1E-W0070	75	466	25	13	7	
HCS03.1E-W0100	175	466	25	13	7	
HCS03.1E-W0150	175	466	25	13	7	

Device	K [mm]	L [mm]	M [mm]	P [mm]	R [mm]	Notes
HCS03.1E-W0210	250	466	50	13	7	
HCS03.1E-W0280	250	466	50	13	7	
HCS03.1E-W0350	250	466	50	13	7	
HMV01.1E-W0030	100	466	25	13	7	
HMV01.1E-W0075	200	466	25	13	7	
HMV01.1E-W0120	300	466	25	13	7	
HMV01.1R-W0018	125	466	25	13	7	
HMV01.1R-W0045	200	466	25	13	7	
HMV01.1R-W0065	300	466	25	13	7	
HMV01.1R-W0120	300	466	25	13	7	
HMV02.1R-W0015	100	378	25	13	7	
HMS01.1N-W0020	0	466	25	13	7	
HMS01.1N-W0036	0	466	25	13	7	
HMS01.1N-W0054	0	466	25	13	7	
HMS01.1N-W0070	50	466	25	13	7	
HMS01.1N-W0150	100	466	25	13	7	
HMS01.1N-W0210	150	466	25	13	7	
HMS01.1N-W0300	150	466	25	13	7	
HMS01.1N-W0350	300	466	25	13	7	
HMS02.1N-W0028	0	378	25	13	7	
HMS02.1N-W0054	0	378	25	13	7	
HMD01.1N-W0012	0	466	25	13	7	
HMD01.1N-W0020	0	466	25	13	7	
HMD01.1N-W0036	0	466	25	13	7	
HNL02.1	100	378	20	13	7	
HNS02.1	0	378	55	13	7	
HLB01.1C	0	378	32.5	13	7	
HLB01.1D	50	466	25	13	7	
HLC01.1C-01M0	0	378	25	13	7	
HLC01.1C-02M4	0	378	25	13	7	
HLC01.1D-05M0	0	466	25	13	7	

Tab. 11-2: Boring dimensions

Ground the housings of the devices!

1. Connect the bare metal back panel of the device in conductive form to the mounting surface in the control cabinet.

2. Use the supplied mounting screws and fix the screws with a tightening torque of typically 6 Nm.
3. Connect the mounting surface of the control cabinet in conductive form to the equipment grounding system.

Combining devices of the Rexroth IndraDrive M product range

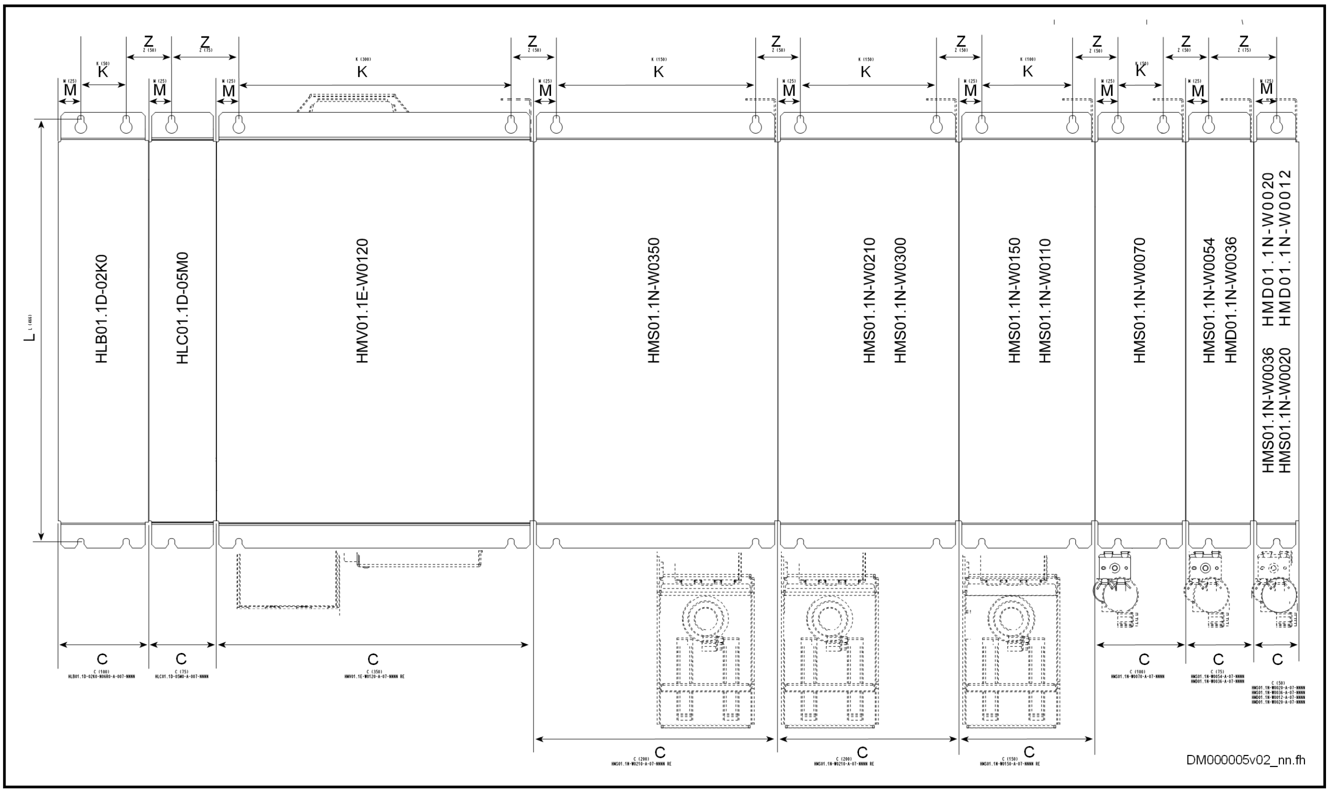


Fig. 11-5: Rexroth IndraDrive M devices

The prevailing grid of mounting holes within the Rexroth IndraDrive M product range is **25 mm.**

Arrange the drive controllers with high capacity as close to the supplying device as possible.

The **HAS02** accessories in the figure require additional downward mounting clearance.

Dimension Z is significantly determined by the involved devices. The table below contains the dimensions Z between the device arranged to the left and the device arranged to the right.

Device to the left	Device to the right	Dimension Z [mm]
HMV01.1E-W0030 HMV01.1E-W0075 HMV01.1E-W0120 HMV01.1R-W0018 HMV01.1R-W0045 HMV01.1R-W0065 HMV01.1R-W0120 HMS01.1N-W0020 HMS01.1N-W0036 HMS01.1N-W0070 HMS01.1N-W0110 HMS01.1N-W0150 HMS01.1N-W0210 HMS01.1N-W0300 HMS01.1N-W0350 HMD01.1N-W0012 HMD01.1N-W0020	HMS01.1N-W0020 HMS01.1N-W0036 HMS01.1N-W0054 HMS01.1N-W0070 HMS01.1N-W0110 HMS01.1N-W0150 HMS01.1N-W0210 HMS01.1N-W0300 HMS01.1N-W0350 HMD01.1N-W0012 HMD01.1N-W0020 HMD01.1N-W0036 HLC01.1D-05M0 HLB01.1D	50
HMV01.1E-W0030 HMV01.1E-W0075 HMV01.1E-W0120 HMV01.1R-W0018 HMV01.1R-W0045 HMV01.1R-W0065 HMV01.1R-W0120 HMS01.1N-W0020 HMS01.1N-W0036 HMS01.1N-W0070 HMS01.1N-W0110 HMS01.1N-W0150 HMS01.1N-W0210 HMS01.1N-W0300 HMS01.1N-W0350 HMD01.1N-W0012 HMD01.1N-W0020	HLB01.1C	57.5

Device to the left	Device to the right	Dimension Z [mm]
HMS01.1N-W0054 HMD01.1N-W0036 HLC01.1D-05M0	HMV01.1E-W0030 HMV01.1E-W0075 HMV01.1E-W0120 HMV01.1R-W0018 HMV01.1R-W0045 HMV01.1R-W0065 HMS01.1N-W0020 HMS01.1N-W0036 HMS01.1N-W0070 HMS01.1N-W0110 HMS01.1N-W0150 HMS01.1N-W0210 HMS01.1N-W0300 HMS01.1N-W0350 HMD01.1N-W0012 HMD01.1N-W0020 HLC01.1D-05M0 HLB01.1D	75
HLC01.1C-01M0 HLC01.1C-02M4	HMV01.1E-W0030 HMV01.1E-W0075 HMV01.1E-W0120 HMV01.1R-W0018 HMV01.1R-W0045 HMV01.1R-W0065 HMV01.1R-W0120 HMS01.1N-W0020 HMS01.1N-W0036 HMS01.1N-W0070 HMS01.1N-W0110 HMS01.1N-W0150 HMS01.1N-W0210 HMS01.1N-W0300 HMS01.1N-W0350 HMD01.1N-W0012 HMD01.1N-W0020 HLC01.1D-05M0 HLB01.1D	57.5
HLC01.1C-01M0 HLC01.1C-02M4	HLC01.1C-01M0 HLC01.1C-02M4	65

Tab. 11-3: Table for dimension Z

Combining drive controllers of the Rexroth IndraDrive C product range

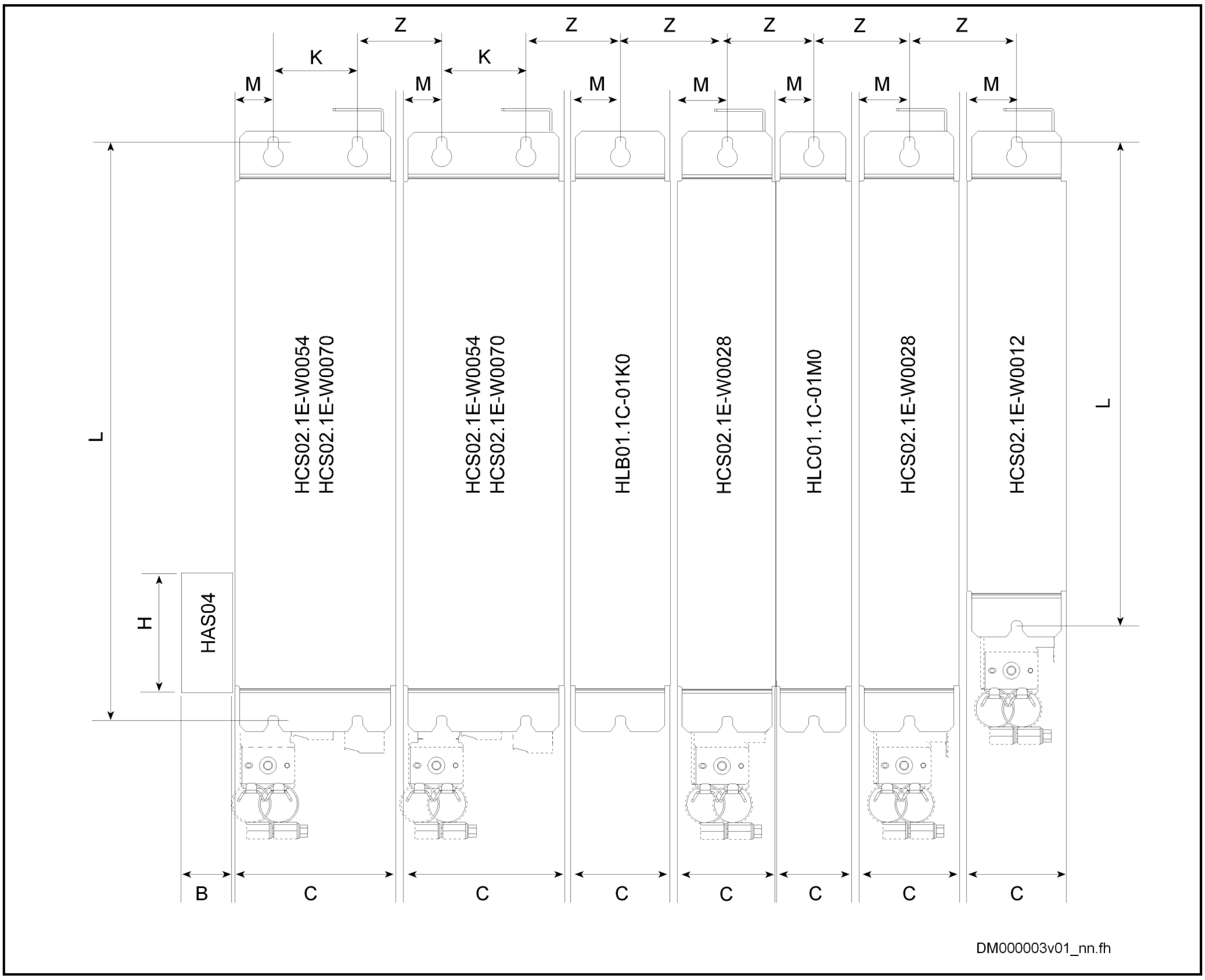


Fig. 11-6: Rexroth IndraDrive C devices

☞ The accessory HAS04 requires additional mounting clearance at the HCS arranged at the utmost left position.

IndraDrive devices are arranged in line **to the right** of the supplying device. Arrange the drive controllers with high capacity as close to the supplying device as possible.

The HAS02 accessories in the figure require additional downward mounting clearance.

Dimension Z is significantly determined by the involved devices. The table below contains the dimensions Z between the device arranged to the left and the device arranged to the right.

Device to the left	Device to the right	Dimension Z [mm]
HCS02.1E-W0012 HCS02.1E-W0028 HLB01.1C	HCS02.1E-W0012 HCS02.1E-W0028 HLB01.1C	70
HCS02.1E-W0054 HCS02.1E-W0070	HCS02.1E-W0054 HCS02.1E-W0070	55
HLC01.1C-01M0 HLC01.1C-02M4 HCS02.1E-W0054 HCS02.1E-W0070	HLC01.1C-01M0 HLC01.1C-02M4	50 (without a distance between the devices)
HCS02.1E-W0012 HCS02.1E-W0028 HLB01.1C	HLC01.1C-01M0 HLC01.1C-02M4	57.5 (without a distance between the devices)
HCS02.1E-W0054 HCS02.1E-W0070 HLC01.1C-01M0 HLC01.1C-02M4	HCS02.1E-W0012 HCS02.1E-W0028 HLB01.1C	62.5
HCS03.1E-W0070 HCS03.1E-W0100 HCS03.1E-W0150	HCS03.1E-W0070 HCS03.1E-W0100 HCS03.1E-W0150	50 (without a distance between the devices)
HCS03.1E-W0210 HCS03.1E-W0280 HCS03.1E-W0350	HCS03.1E-W0210 HCS03.1E-W0280 HCS03.1E-W0350	100 (without a distance between the devices)
HCS03.1E-W0070 HCS03.1E-W0100 HCS03.1E-W0150	HCS03.1E-W0210 HCS03.1E-W0280 HCS03.1E-W0350	75 (without a distance between the devices)
HCS03.1E-W0210 HCS03.1E-W0280 HCS03.1E-W0350	HCS03.1E-W0070 HCS03.1E-W0100 HCS03.1E-W0150	75 (without a distance between the devices)

Tab. 11-4: Table for dimension Z

Combining drive controllers of the Rexroth IndraDrive C and M product ranges

☞ The accessory **HAS04** requires additional mounting clearance at the HCS arranged at the utmost left position.

Rexroth IndraDrive M devices are arranged in line **to the right** of the supplying HCS drive controller.

Dimension Z is significantly determined by the involved devices. The table below contains the dimensions Z between the device arranged to the left and the device arranged to the right.

HCS02 drive controllers

Device to the left	Device to the right	Dimension Z [mm]
HCS02.1E-W0054 HCS02.1E-W0070	HMS01.1N-W0020 HMS01.1N-W0036 HMS01.1N-W0054 HMS02.1N-W0028 HMS02.1N-W0054 HMD01.1N-W0012 HMD01.1N-W0020 HMD01.1N-W0036 HLC01.1D-05M0 HLB01.1D	50 (without a distance between the devices)

Tab. 11-5: Table for dimension Z

HCS03 drive controllers

Device to the left	Device to the right	Dimension Z [mm]
HCS03.1E-W0070 HCS03.1E-W0100 HCS03.1E-W0150	HMS01.1N-W0020 HMS01.1N-W0036 HMS01.1N-W0054 HMS01.1N-W0070 HMD01.1N-W0012 HMD01.1N-W0020 HMD01.1N-W0036	50 (without a distance between the devices)
HCS03.1E-W0210 HCS03.1E-W0280 HCS03.1E-W0350	HMS01.1N-W0020 HMS01.1N-W0036 HMS01.1N-W0054 HMS01.1N-W0070 HMS01.1N-W0110 HMS01.1N-W0150 HMS01.1N-W0210 HMS01.1N-W0300 HMD01.1N-W0012 HMD01.1N-W0020 HMD01.1N-W0036	75 (without a distance between the devices)

Tab. 11-6: Table for dimension Z

☞ For the dimensions Z between other combinations see previous tables.

11.2 Arranging components from the electrical point of view

11.2.1 General information

The section below contains information and recommendations on the arrangement of the devices in the control cabinet from mainly electrical points of view. These points of view include aspects of performance-dependent arrangement and electromagnetically compatible installation.

11.2.2 Performance-dependent arrangement

Arrangement with HMV

The **HMV01** supply units can supply HMS and HMD drive controllers **on both sides.**

☞ When HNS02 and HNL02 are used, the **HMV02** supply units only can be mounted on one side to the **right**.

- Arrange drive controllers according to their performance. Arrange drive controllers with high performance as close to the supply unit as possible. Ideally, the drive controllers should be distributed equally to the left and right side of the supply unit.
- Arrange DC bus capacitor unit (HLC) next to the supply unit.
- Arrange DC bus resistor unit (HLB) next to the supply unit.
- When simultaneously using DC bus resistor unit and DC bus capacitor unit in a drive system, arrange the DC bus capacitor unit between supply unit and DC bus resistor unit.

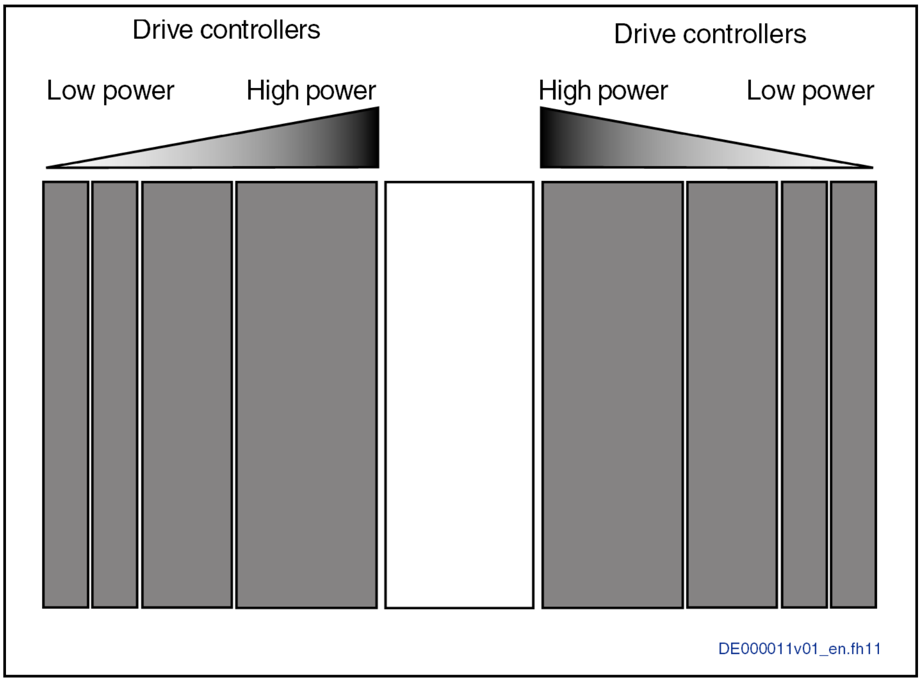


Fig. 11-7: Example of arrangement

Arrangement with HCS

When you operate **HCS** converters in the "central supply" type of mains connection, place the supplied drive controllers to the **right** of the HCS converters.

- Arrange DC bus capacitor unit next to drive controller with the greatest DC bus continuous power.

- Arrange DC bus resistor unit next to drive controller with the greatest regenerative power.
- When simultaneously using DC bus resistor unit and DC bus capacitor unit in a drive system, arrange the DC bus capacitor unit to the right of HCS and the DC bus resistor unit to the right of the DC bus capacitor unit.
- Arrange HLR braking resistors in "standard" design above the HCS03 drive controller.

11.2.3 EMC measures for design and installation

Rules for design of installations with drive controllers in compliance with EMC

The following rules are the basics for designing and installing drives in compliance with EMC.

Mains filter

Use an appropriate mains filter recommended by Rexroth for radio interference suppression in the supply feeder of the drive system.

Control cabinet grounding

Connect all metal parts of the cabinet with one another over the largest possible surface area to establish a good electrical connection. This, too, applies when mounting the mains filter. If required, use serrated washers which cut through the paint surface. Connect the cabinet door to the control cabinet using the shortest possible grounding straps.

Line routing

Avoid coupling routes between lines with a high potential of noise and noise-free lines. Therefore, signal, mains and motor lines and power cables have to be routed separately from another. Minimum distance: 10 cm. Provide separating sheets between power and signal lines. Ground separating sheets several times.

Lines with a high potential of noise include:

- Lines at the mains connection (incl. synchronization connection)
- Lines at the motor connection
- Lines at the DC bus connection

Generally, interference injections are reduced by routing cables close to grounded sheet steel plates. For this reason, cables and wires should not be routed freely in the cabinet, but close to the cabinet housing or mounting plates. Separate the incoming and outgoing cables of the radio interference suppression filter.

Interference suppression elements

Provide the following components in the control cabinet with interference suppression combinations:

- Contactors
- Relays
- Solenoid valves
- Electromechanical operating hours counters

Connect these combinations directly at each coil.

Twisted wires

Twist unshielded wires belonging to the same circuit (supply and return lines) or keep the surface between supply and return lines as small as possible. Wires that are not used have to be grounded at both ends.

Lines of measuring systems

Lines for measuring systems have to be shielded. Connect the shield to ground at both ends and over the largest possible surface area. The shield should not be interrupted, e.g., using intermediate terminals.

Digital signal lines

Ground the shields of digital signal lines at both ends (transmitter and receiver) over the largest possible surface area and with low impedance. In the case of bad ground connection between transmitter and receiver, additionally route a bonding conductor (min. 10 mm²). Braided shields are better than foil shields.

Analog signal lines

Ground the shields of analog signal lines at one end (transmitter **or** receiver) over the largest possible surface area and with low impedance. This avoids low-frequency interference current (in the mains frequency range) on the shield.

Connecting the mains choke

Keep connection lines of the mains choke at the drive controller as short as possible and twist them.

With regenerative supply units, use shielded lines with the shield grounded at both ends for the connection between supply unit and mains choke.

Installing the motor power cable

- Use shielded motor power cables or run motor power cables in a shielded duct
- Use the shortest possible motor power cables
- Ground shield of motor power cable at both ends over the largest possible surface area to establish a good electrical connection
- Run motor lines in shielded form inside the control cabinet
- Do not use any steel-shielded lines
- The shield of the motor power cable should not be interrupted by mounted components, such as output chokes, sine filters or motor filters.

Optimum EMC installation in facility and control cabinet

General information

For optimum EMC installation, a spatial separation of the interference-free area (mains connection) and the interference-susceptible area (drive components) is recommended, as shown in the figures below.

☞ Recommendation: For optimum EMC installation in the control cabinet, use a separate control cabinet panel for the drive components.

Division into areas (zones)

Exemplary arrangements in the control cabinet: See section Control cabinet design according to interference areas - exemplary arrangements, page 191.

We distinguish three areas:

1. Interference-free area of control cabinet **(area A)**:

   This includes:

   - Supply feeder, input terminals, fuse, main switch, mains side of mains filter for drives and corresponding connecting lines
   - Control voltage or auxiliary voltage connection with power supply unit, fuse and other parts unless connection is run via the mains filter of the AC drives
   - All components that are not electrically connected with the drive system
2. Interference-susceptible area **(area B)**:
   - Mains connections between drive system and mains filter for drives, mains contactor
   - Interface lines of drive controller

3. Strongly interference-susceptible area **(area C)**:
    - Motor power cables including single cores

Never run lines of one of these areas in parallel with lines of another area so that there is no unwanted interference injection from one area to the other and that the filter is jumpered with regard to high frequency. Use the shortest possible connecting lines.

Recommendation for complex systems: Install drive components in one cabinet and the control units in a second, separate cabinet.

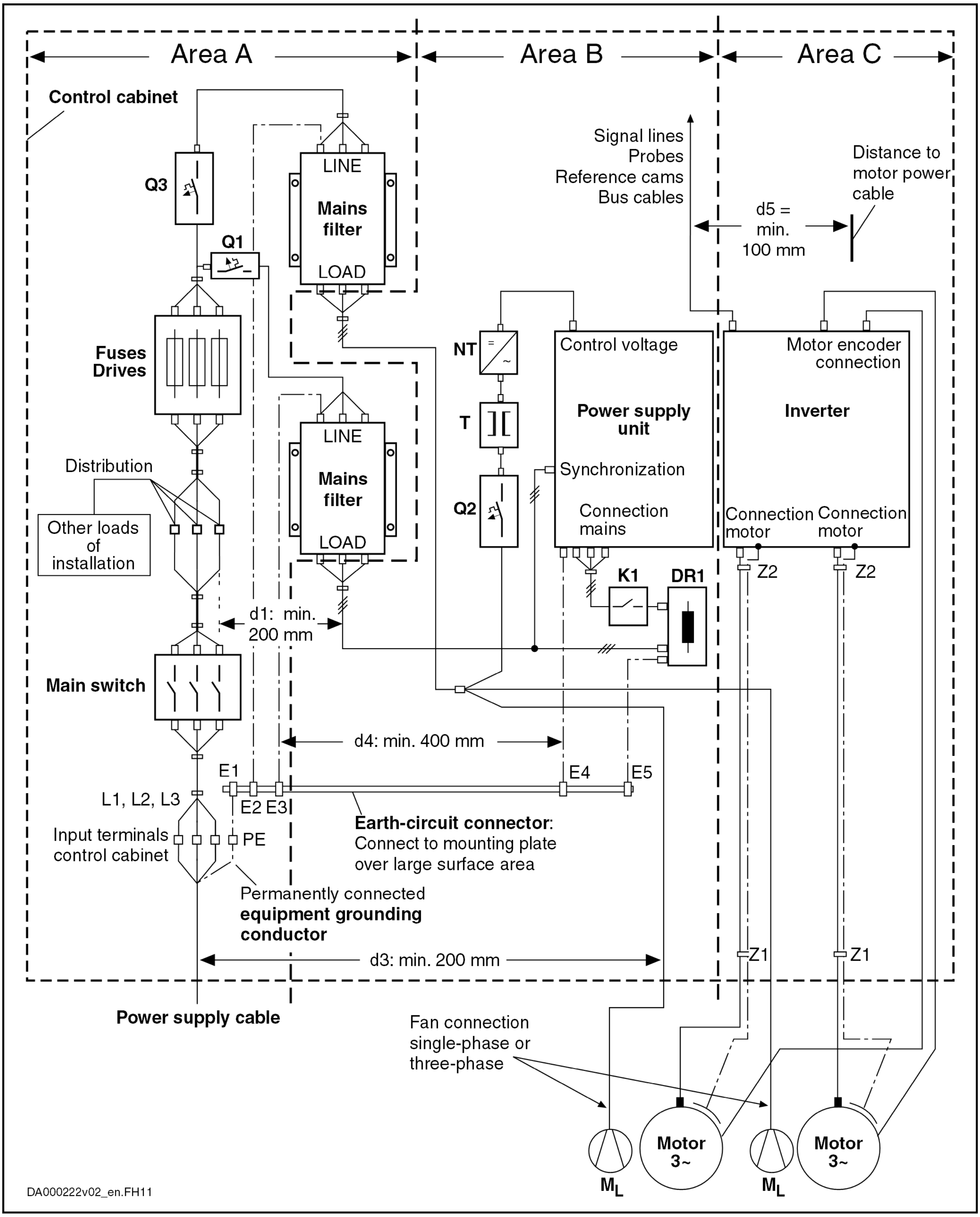
Badly grounded control cabinet doors act as antennas. For this reason, connect the control cabinet doors to the cabinet on top, in the middle and on the bottom with short equipment grounding conductors with a cross section of at least 6 mm^2 or, even better, with grounding straps of the same cross section. Make sure connection points have good contact.

Control cabinet design according to interference areas - exemplary arrangements

☞ **Do not operate any additional loads at the mains filter!**

Do not run any other loads at the connection from the mains filter output to the mains connection of the supply unit.

For motor fans and power supply units, for example, use separate mains filters.



DR1	Mains choke
E1…E5	Equipment grounding conductor of the components

K1	External mains contactor for supply units without integrated mains contactor
M_L	Motor fan
NT	Power supply unit
Q1, Q2, Q3	Fusing
T	Transformer
Z1, Z2	Shield connection points for cables

Fig. 11-8: EMC areas in the control cabinet

Design and installation in area A - control cabinet area free from interference

Arranging the components in the control cabinet

Comply with recommended distance of at least **200 mm** (distance d1 in the figure):

- Between components and electrical elements (switches, pushbuttons, fuses, terminal connectors) in interference-free area A and the components in the two other areas B and C

Comply with recommended distance of at least **400 mm** (distance d4 in the figure):

- Between magnetic components (such as transformers, mains chokes and DC bus chokes that are directly connected to the power connections of the drive system) and the interference-free components and lines between mains and filter including the mains filter in area A

If these distances are not complied with, the magnetic leakage fields are injected to the interference-free components and lines connected to the mains, and the limit values at the mains connection are exceeded in spite of the installed filter.

Cable routing for interference-free lines to the mains connection

Comply with recommended distance of at least **200 mm** (distances d1 and d3 in the figure):

- Between supply feeder or lines between filter and exit point from the control cabinet in area A and the lines in areas B and C

If this is impossible, there are two alternatives:

1. Install lines in shielded form and connect the shield at several points (at least at the beginning and at the end of the line) to the mounting plate or the control cabinet housing over a large surface area.
2. Separate lines from the other interference-susceptible lines in areas B and C by means of a grounded distance plate vertically attached to the mounting plate.

Install the shortest possible lines within the control cabinet and install them directly on the grounded metal surface of the mounting plate or of the control cabinet housing.

Mains supply lines from areas B and C should not be connected to the mains without a filter.

☞ In case you do not observe the information on cable routing given in this section, the effect of the mains filter is totally or partly neutralized. This will cause the noise level of the interference emission to be higher within the range of 150 kHz to 40 MHz and the limit values at the connection points of the machine or installation will thereby be exceeded. Consider the specified distances to be recommended data, provided that the dimensions of the control cabinet allow installing the lines accordingly.

Routing and connecting a neutral conductor (N)

If a neutral conductor is used together with a three-phase connection, it should not be installed unfiltered in zones B and C, in order to keep interference off the mains.

Motor fan at mains filter

Single-phase or three-phase supply lines of motor fans, that are usually routed in parallel with motor power cables or interference-susceptible lines, have to be filtered:

- In drive systems with **regenerative supply units** via a **separate** single-phase (NFE type) or three-phase filter (NFD type) near the mains connection of the control cabinet
- In drive systems with **only feeding supply units** via the available three-phase filter of the drive system

  On the load side of the mains filter, voltage against ground with a high rise of voltage dv/dt can be present and interfere with the additional loads connected there.

When switching power off, make sure the fan is not switched off.

Loads at drive system mains filter

☞ **Only operate allowed loads at the mains filter of the drive system!**

At the three-phase filter for the power connection of regenerative supply units, it is only allowed to operate the following loads:

- HMV supply unit with mains choke and, if necessary, mains contactor

Do not operate any motor fans, power supply units etc. at the mains filter of the drive system.

Shielding mains supply lines in the control cabinet

If there is a high degree of interference injection to the mains supply line within the control cabinet, although you have observed the above instructions (to be found out by EMC measurement according to standard), proceed as follows:

- Only use shielded lines in area A
- Connect shields to the mounting plate at the beginning and the end of the line by means of clips

The same procedure may be required for long cables of more than 2 m between the point of power supply connection of the control cabinet and the filter within the control cabinet.

Mains filters for AC drives

Ideally mount the mains filter on the parting line between the areas A and B. Make sure the ground connection between filter housing and housing of the drive controllers has good electrically conductive properties.

If **single-phase** loads are connected on the load side of the filter, their current may be a maximum of 10% of the three-phase operating current. A highly unbalanced load of the filter would deteriorate its interference suppression capacity.

If the mains voltage is more than 480 V, connect the filter to the output side of the transformer and not to the supply side of the transformer.

Grounding

In the case of bad ground connections in the system, the distance between the lines to grounding points E1 and E2 in area A and the other grounding points of the drive system should be at least d4 = 400 mm in order to minimize interference injection from ground and ground cables to the mains supply lines.

See also Division into areas (zones), page 190.

Equipment grounding conductor connection point at machine, system, control cabinet

The equipment grounding conductor of the power cable for the machine, system or control cabinet has to be **permanently connected** at point PE and have a **cross section of at least 10 mm^2**, or be complemented by a second equipment grounding conductor using separate terminals (according to EN 61800-5-1:2007+A1:2017, section 4.3.5.5.2). If the cross section of the outer conductor is bigger, the cross section of the equipment grounding conductor has to be accordingly bigger.

Design and installation in area B - control cabinet area prone to interference

Arranging components and lines

Modules, components and lines in area B have to be placed at a distance of at least **d1 = 200 mm** from modules and lines in area A.

Alternative: Shield modules, components and lines in area B using distance plates mounted vertically on the mounting plate from modules and lines in area A or use shielded lines.

Only connect power supply units for auxiliary or control voltage connections in the drive system to the mains via a mains filter. See Division into areas (zones), page 190.

Install the shortest possible lines between drive controller and filter.

Control voltage or auxiliary voltage connection

Only in exceptional cases should you connect power supply unit and fusing for the control voltage connection to phase and neutral conductor. In this case, mount and install these components in area A far away from the areas B and C of the drive system. For details see section Design and installation in area A - control cabinet area free from interference, page 193.

Run the connection between the control voltage connection of the drive system and the power supply unit used through area B over the shortest distance.

Line routing

Run the lines along grounded metal surfaces, in order to minimize radiation of interference fields to area A (transmitting antenna effect).

Design and installation in area C - control cabinet area highly prone to interference

Area C mainly concerns the motor power cables, especially at the connection point at the drive controller.

Influence of the motor power cable

The longer the motor power cable, the greater its leakage capacitance. To comply with a certain EMC limit value, the allowed leakage capacitance of the mains filter is limited. For the calculation of the leakage capacitance, see the documentation on the drive system of the drive controller used.

☞

- Run the shortest possible motor power cables.
- Only use **shielded** motor power cables by Rexroth.

Routing the motor power cables and motor encoder cables

Route the motor power cables and motor encoder cables along grounded metal surfaces, both inside the control cabinet and outside of it, in order to minimize radiation of interference fields. If possible, route the motor power cables and motor encoder cables in metal-grounded cable ducts.

Route the motor power cables and motor encoder cables

- with a distance of at least **d5 = 100 mm** to interference-free lines, as well as to signal cables and signal lines

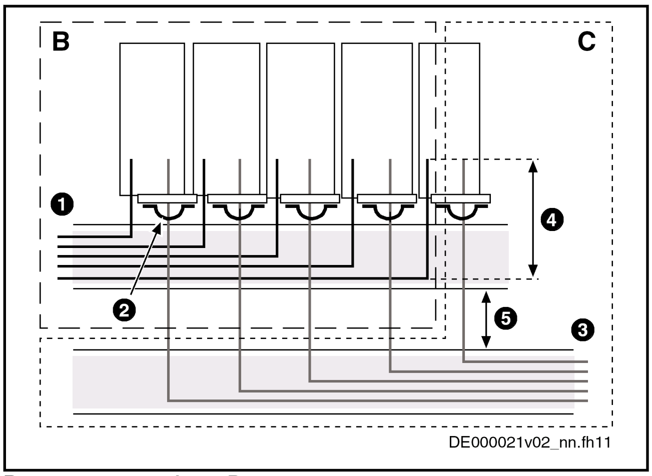
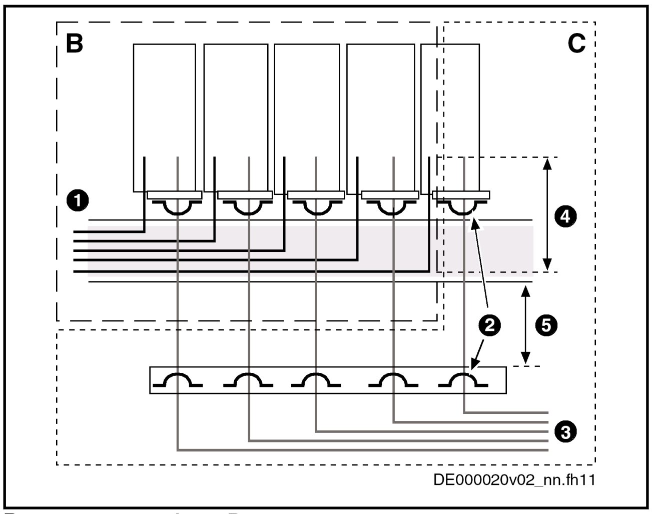
  (alternatively separated by a grounded distance plate)
- in separate cable ducts, if possible

Routing the motor power cables and mains connection lines

For converters (drive controllers with individual mains connection), route motor power cables and (unfiltered) mains connection lines **parallel to one another for a maximum distance of 300 mm.** After that distance, route motor power cables and power supply cables in opposite directions and preferably in separate cable ducts.

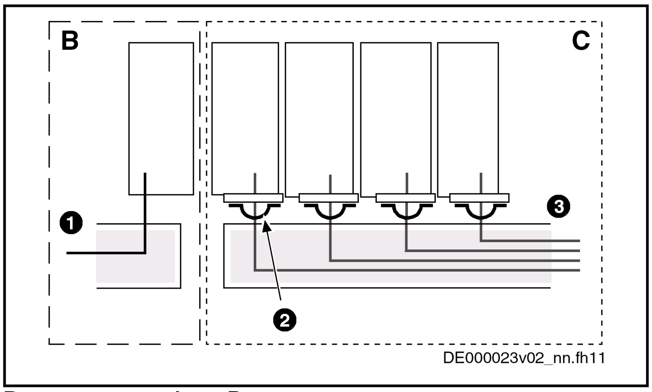
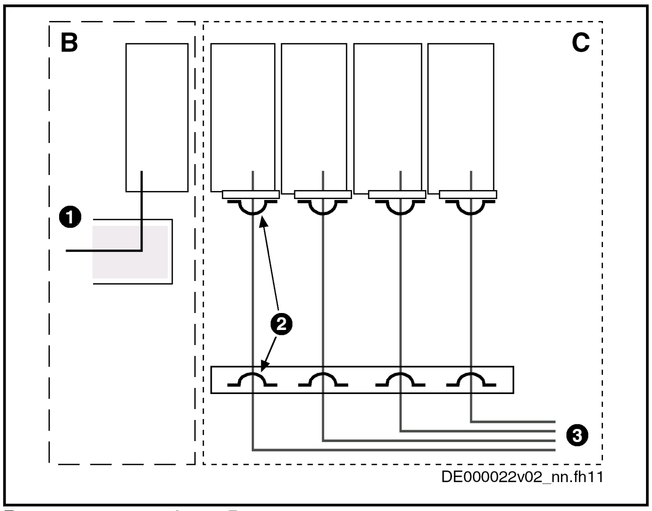
Ideally, the motor power cables should exit the control cabinet at a distance of at least d3 = 200 mm from the (filtered) power supply cable.

Converter - routing motor power cables

With cable duct	Without cable duct
 B Area B C Area C 1 Cable duct for mains connection lines 2 Shield connection of motor power cable with clips at least at one point; alternatively, at the device or control cabinet mounting plate 3 Cable duct for motor power cables 4 Parallel routing of mains connection lines and motor power cables over a maximum of 300 mm 5 Distance of at least 100 mm or separated by a grounded distance plate *Fig. 11-9: Routing motor power cables with cable duct*	 B Area B C Area C 1 Cable duct for mains connection lines 2 Shield connection of motor power cable with clips at least at one point; alternatively, at the device or control cabinet mounting plate 3 Control cabinet outlet of motor power cables 4 Parallel routing of mains connection lines and motor power cables over a maximum of 300 mm 5 Distance of at least 100 mm or separated by a grounded distance plate *Fig. 11-10: Routing motor power cables without cable duct*

Tab. 11-7: Routing cables for converter

Inverter - routing motor power cables

With cable duct	Without cable duct
 B Area B C Area C 1 Cable duct for mains connection lines 2 Shield connection of motor power cable with clips at least at one point; alternatively, at the device or control cabinet mounting plate 3 Cable duct for motor power cables *Fig. 11-11: Routing motor power cables with cable duct*	 B Area B C Area C 1 Cable duct for mains connection lines 2 Shield connection of motor power cable with clips at least at one point; alternatively, at the device or control cabinet mounting plate 3 Control cabinet outlet of motor power cables *Fig. 11-12: Routing motor power cables without cable duct*

Tab. 11-8: Routing cables for inverter

Ground connections

Housing and mounting plate

With the appropriate ground connections, it is possible to avoid the emission of interference, because interference is discharged to ground on the shortest possible way.

Ground connections of the metal housings of EMC-critical components (such as filters, devices of the drive system, connection points of the cable shields, devices with microprocessor and switching power supply units) have to be well contacted over a large surface area. This also applies to all screw connections between mounting plate and control cabinet wall and to mounting a ground bar to the mounting plate.

The best solution is to use a zinc-coated mounting plate. Compared to a varnished plate, the connections in this case have a good long-time stability.

Connecting elements

For varnished mounting plates, always use screw connections with tooth lock washers and zinc-coated, tinned screws as connecting elements. At the connection points, remove the varnish so that there is safe electrical contact over a large surface area. You achieve contact over a large surface area with bare connection surfaces or multiple connection screws. For screw connections, you can establish the contact to varnished surfaces by using tooth lock washers.

Metal surfaces

Always use connecting elements (screws, nuts, washers) with good electroconductive surface.

Bare zinc-coated or tinned metal surfaces have **good electroconductive properties**.

Anodized, yellow chromatized, black gunmetal finish or lacquered metal surfaces have **bad electroconductive properties**.

Ground wires and shield connections

When connecting ground wires and shield connections, what is important is not the cross section of the wire, but the area of the contact surface, since high-frequency interference currents mainly flow on the surface of the conductor.

Always connect cable shields, especially shields of the motor power cables, to ground potential over a large surface area.

Installing signal lines and signal cables

Line routing

For measures to prevent interference, see the Project Planning Manuals for each device. In addition, we recommend the following measures:

- Route signal and control lines separately from the power cables with a minimum distance of **d5 = 100 mm** (see Division into areas (zones), page 190) or with a grounded separating sheet. The optimum way is to route them in separate cable ducts. If possible, lead signal lines into the control cabinet at one point only.
- If signal lines are crossing power cables, route them in an angle of 90° in order to avoid interference injection.
- Ground spare cables, that are not used and have been connected, at least at both ends so that they do not have any antenna effect.
- Avoid unnecessary line lengths.
- Run cables as close as possible to grounded metal surfaces (reference potential). The ideal solution are closed, grounded cable ducts or metal pipes which, however, is only obligatory for high requirements (sensitive measuring lines).
- Avoid suspended lines or lines routed along synthetic carriers, because they are functioning like reception antennas (noise immunity) and like transmitting antennas (emission of interference). Exceptional cases are flexible cable tracks over short distances of a maximum of 5 m.

Shielding

Connect the cable shield immediately at the devices in the shortest and most direct way possible and over the largest possible surface area.

Connect the shield of **analog signal lines** at one end over a large surface area, normally in the control cabinet at the analog device. Make sure the connection to ground/housing is short and over a large surface area.

Connect the shield of **digital signal lines** at both ends over a large surface area and in short form. In the case of potential differences between beginning and end of the line, run an additional bonding conductor in parallel. This prevents compensating current from flowing via the shield. The recommended cross section is 10 mm^2.

Separable connections always have to be equipped with male and female connectors with grounded metal housings.

In the case of non-shielded lines belonging to the same circuit, twist the supply and return lines.

General interference suppression measures for relays, contactors, switches, chokes and inductive loads

If inductive loads, such as chokes, contactors or relays are switched by contacts or semiconductors in conjunction with electronic devices and components, suitable interference suppression has to be provided for them:

- By arranging free-wheeling diodes in the case of d.c. operation

- In the case of a.c. operation, by arranging usual RC interference suppression elements depending on the contactor type, immediately at the inductance

Only the interference suppression element placed immediately at the inductance serves the purpose. Otherwise, the radiated noise level is too high and may affect the function of electronics and drive.

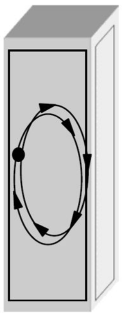
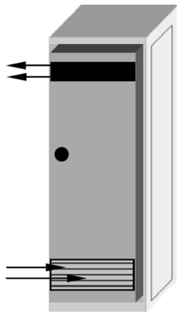
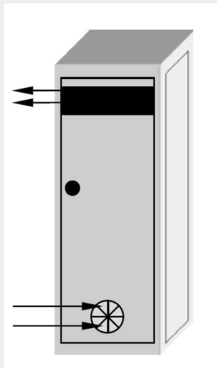
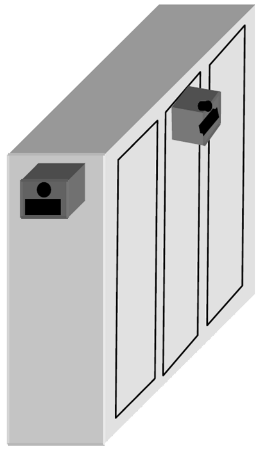
12 Project planning of cooling system

12.1 Control cabinet

12.1.1 Control cabinet design and cooling

☞ G1 is the only mounting position allowed for supply units and drive controllers installed in control cabinets.

Possible ways of heat dissipation

Closed control cabinet with air circulation	Closed control cabinet with heat exchanger	Control cabinet with fan	Closed control cabinet with air conditioning unit
 DF000644v01_nn.tif	 DF000645v01_nn.tif	 DF000646v01_nn.tif	 DF000647v01_nn.tif
P_Q ~ 400 W	P_Q ~ 1700 W	P_Q ~ 2700 W	P_Q ~ 4000 W

P_Q Dissipated heat output

Tab. 12-1: Possible ways of heat dissipation

The section below describes the "control cabinet with fan".

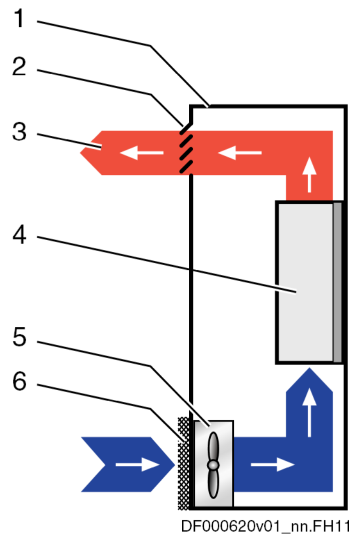
Requirements for control cabinets with fan

NOTICE **Risk of damage by unclean air in the control cabinet!**

Operating a control cabinet with a fan, but without the corresponding filters, can damage the devices or cause malfunction.

- Install filters at the air intake opening of the control cabinet so that unclean air cannot get into the control cabinet.
- Service the filters at regular intervals according to the dust loading in the environment.
- Only replace the filters when the fan has been switched off, because otherwise the fan sucks in the dirt coming off the filter and the dirt gets into the control cabinet.

Control cabinet ventilation (schematic diagram)



1	Control cabinet
2	Air outlet opening
3	Heat discharge
4	Device in control cabinet
5	Control cabinet fan
6	Filter at air intake opening

Fig. 12-1: Control cabinet ventilation (schematic diagram)

Only clean air gets into the control cabinet through the filter at the air intake opening. The control cabinet fan behind the air intake opening conveys the air into the control cabinet and generates overpressure in the control cabinet. The overpressure prevents unclean air from getting into the control cabinet through possibly existing leaky points (leaky cable ducts, damaged seals, etc.).

12.1.2 Arranging the cooling units

Unless the nominal data are reduced, the drive controller may only be operated up to a specified maximum ambient temperature. A cooling unit might therefore be required.

NOTICE **Possible damage to the drive controller! Operational safety of the machine endangered!**

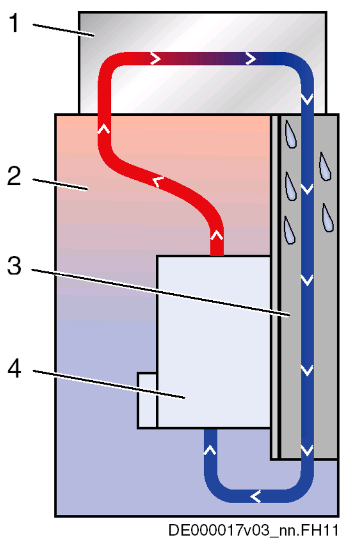
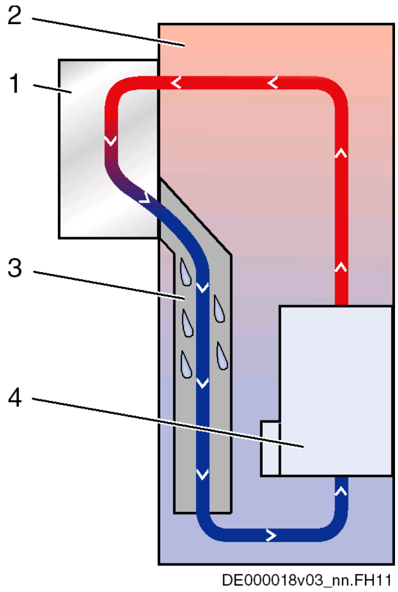
Observe the instructions below.

Avoiding dripping or spraying water

Due to their operating principle, condensation water is formed when cooling units are used.

For this reason, observe the following aspects:

- Always position cooling units in such a way that condensation water cannot drip onto the devices in the control cabinet.
- Position the cooling unit in such a way that the fan of the cooling unit does not spray accumulated condensation water onto the devices in the control cabinet. Mount the air duct in the control cabinet accordingly.

Cooling unit on top of the control cabinet	Cooling unit at the front of the control cabinet
	

1	Cooling unit
2	Interior of control cabinet
3	Air duct (protects devices against condensation water)
4	Device in control cabinet

Tab. 12-2: Arranging the cooling units

Avoiding moisture condensation

Moisture condensation occurs when the temperature of the device is lower than the ambient temperature.

- Set cooling units with temperature adjustment to the maximum surrounding temperature and not lower!
- Set cooling units with follow-up temperature in such a way that the interior temperature of the control cabinet is not lower than the temperature of the surrounding air. Set the temperature limitation to the maximum surrounding temperature!
- Only use well-sealed control cabinets so that moisture condensation cannot arise as a result of warm and moist external air entering the cabinet.
- In the event that control cabinets are operated with the doors open (commissioning, servicing etc.), it is essential to ensure that after the doors are closed the drive controllers cannot at any time be cooler than the air in the control cabinet. For this reason, sufficient circulation must be provided inside the control cabinet.

12.1.3 Multiple-line design of the control cabinet

☞ **Arrangement of the devices, air guides/drip protections, fans**

Pay particular attention to the maximum allowed air intake temperature of devices when they are arranged in multiple lines in the control cabinet.

If possible, place devices with a high degree of power dissipation (e.g., supply units with braking resistors, DC bus resistor units)

- in the top line and
- near the outlet air aperture to the cooling unit

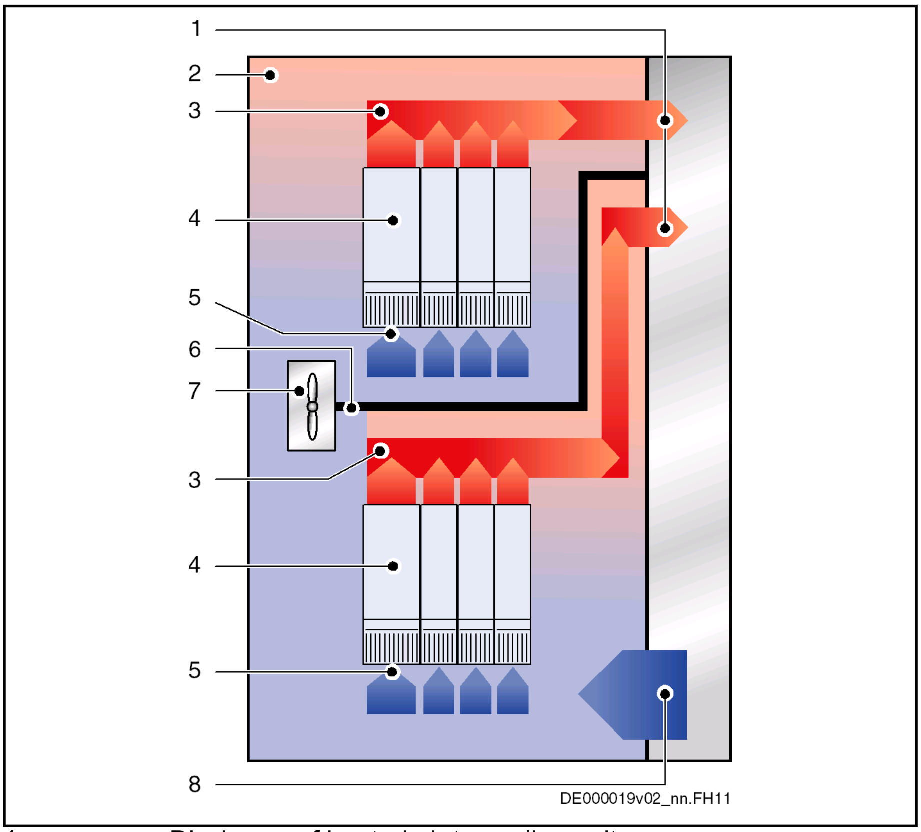
Mount **air guides** between the lines to

- protect the devices in the upper lines against the warm outlet air of the devices beneath and
- protect the devices beneath against penetration of liquids (e.g. dripping condensation water or leaking cooling liquid)

Additional fans convey the outlet air to the cooling unit and cooling air to the upper lines.

At the installed control cabinet, check the air intake temperature of all devices.

☞ To extend the module bus connection, the accessory RKB0001 is available. Observe the assignment.



1 Discharge of heated air to cooling unit
2 Interior of control cabinet
3 Conveying direction of heated air in area where air flows off
4 Device in control cabinet
5 Air intake at device
6 Air guide in control cabinet (for liquid cooling, this is also the drip protection for the devices beneath)
7 Fan in control cabinet
8 Supply of cooled air from cooling unit

Fig. 12-2: Examplary arrangement of double-line design

13 Connections of the components in the drive system

13.1 System connections of the components

13.1.1 General information

Electrical connections for operating the IndraDrive system:

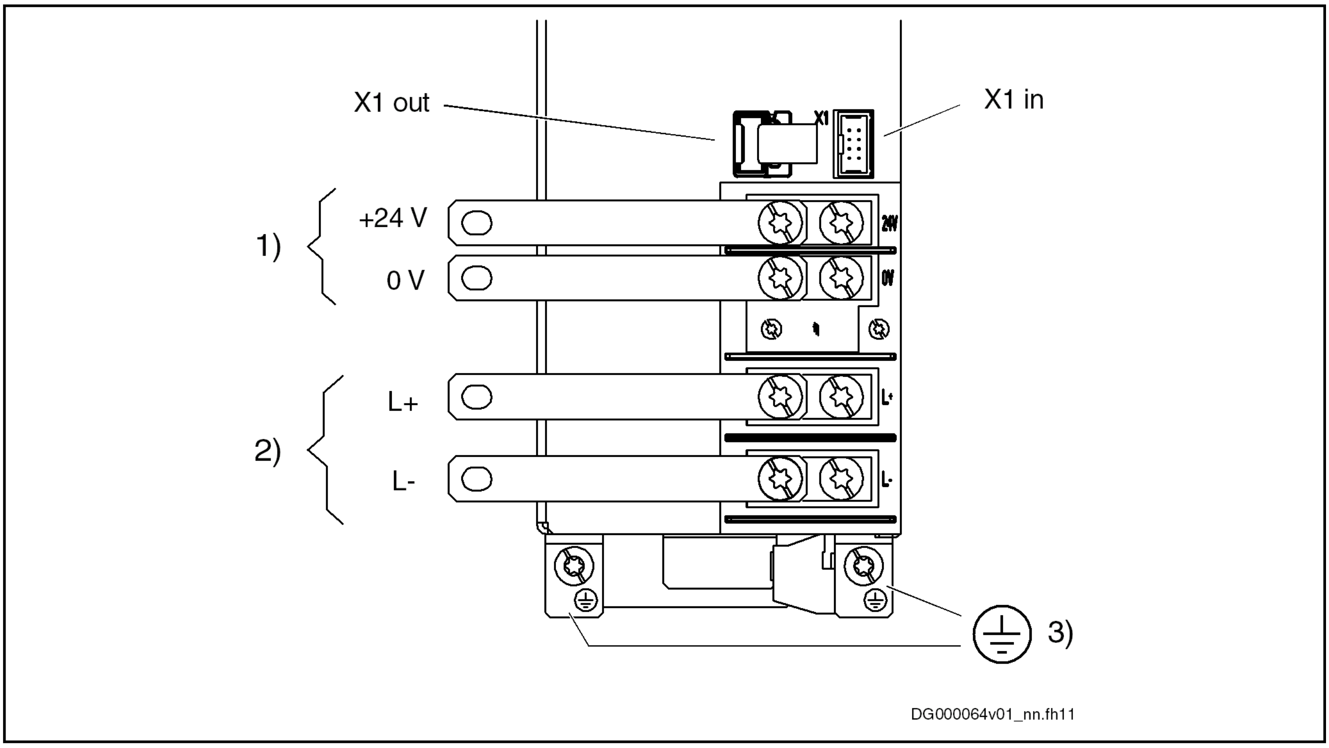
In the system environment

- Connection X3 or PE to equipment grounding system
- Connection X3 to supply with power voltage
- Connection X13 or terminal block 0V / +24V to supply with control voltage
- Connection to control unit and/or master communication

Within the drive system

- Equipment grounding conductor connections PE to X3 or joint bars at the devices
- DC bus connections L+ with bars
- DC bus connections L- with bars
- Control voltage connections 0V with bars
- Control voltage connections +24V with bars
- Module bus connections X1 with ribbon cable
- Motor power connections via motor power cable at X5
- Connections for motor temperature monitoring and motor holding brake via motor power cable at X6

13.1.2 Positions of system connections



1)	Control voltage
2)	DC bus
3)	Grounding conductor
X1 out, X1 in	Module bus

Fig. 13-1: Connections at power section

13.1.3 Ground connection of housing

The ground connection of the housing is used to provide functional safety of the drive controllers and protection against contact in conjunction with the equipment grounding conductor.

Avoid spark discharge of static charges!

In some applications (e.g. printing or packaging), high static charges can develop. Make sure that these charges can be directly discharged against ground at their point of origin. If necessary, install additional lines between the fixing points of the motor flanges (charge acceptance) and the ground connection of the drive system (e.g. mounting surface of the drive controllers in the control cabinet).

Ground the housings of the devices:

1. Connect the bare metal back panel of the device in conductive form to the mounting surface in the control cabinet. To do this, use the supplied mounting screws.
2. Connect the mounting surface of the control cabinet in conductive form to the equipment grounding system.
3. Connect the bare metal back panel of the mains filter in conductive form to the mounting surface in the control cabinet. Connect the mounting surface of the mains filter with the lowest possible impedance (over a

large surface area) to the mounting surface of the drive controllers (see item 1).

13.1.4 Connection Point of Equipment Grounding Conductor and Equipment Grounding Connections

General Information

The connection of the equipment grounding conductors of the devices and their connection to the equipment grounding system are indispensable for the electrical safety of the drive system.

⚠ WARNING **Dangerous contact voltage at device housing! Lethal electric shock!**

The devices of the IndraDrive product range are devices with increased leakage current (greater than AC 3.5 mA or DC 10 mA). Therefore, always install a stationary connection of the equipment grounding conductor.

Observe the description below.

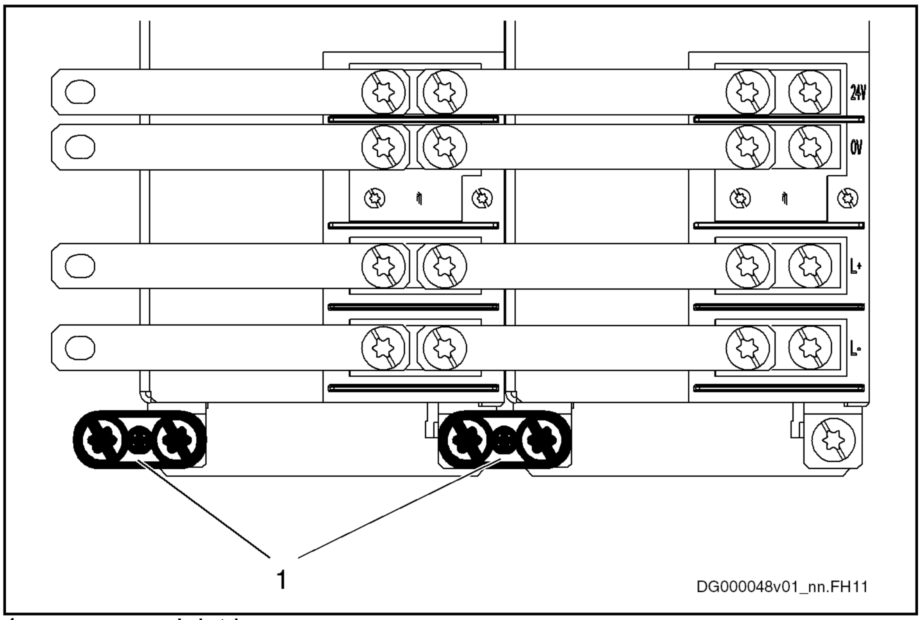
In the drive system IndraDrive, connect the equipment grounding conductor connections of all devices and additional components to the equipment grounding system.

Involved devices	Equipment Grounding Connections Between Devices		Connection to equipment grounding system in control cabinet at devices	
HMV01 **HCS03** HMS01 HMD01 HLB01.1D HLC01.1D HLC01.1C	Interconnect joint bars at front of devices	HMV01 HCS03 HMS01 HMD01 HLB01.1D HLC01.1D HLC01.1C	**Realized in central form** One connection at	HMV01 HCS03
HCS02 with HAS04 HLB01.1C HLC01.1C HMS01 HMD01	Interconnect joint bars at front of devices	**HAS04** HLB01.1C HLC01.1C HMS01 HMS02 HMD01	**Realized in central form** One connection at	HCS02
HCS02 without HAS04 HCS02 HMS01 HMS02 HMD01 HLB01.1C HLC01.1C HLB01.1D HLC01.1	Interconnect joint bars at front of devices	HMS01 HMS02 HMD01 HLB01.1C HLC01.1C HLB01.1D HLC01.1D	**One connection each** at all	HCS02
			and one connection at connected drive system, consisting of all	HMS01 HMS02 HMD01 HLB01.1C HLC01.1C HLB01.1D HLC01.1D

Involved devices	Equipment Grounding Connections Between Devices		Connection to equipment grounding system in control cabinet at devices	
HMV02 HMS02 HNL02 HNS02	Interconnect joint bars at front of devices	HMV02 HMS02	**One connection each** at all	HNL02 HNS02
			and one connection at connected drive system, consisting of all	HMV02 HMS02

Tab. 13-1: Equipment Grounding Connections

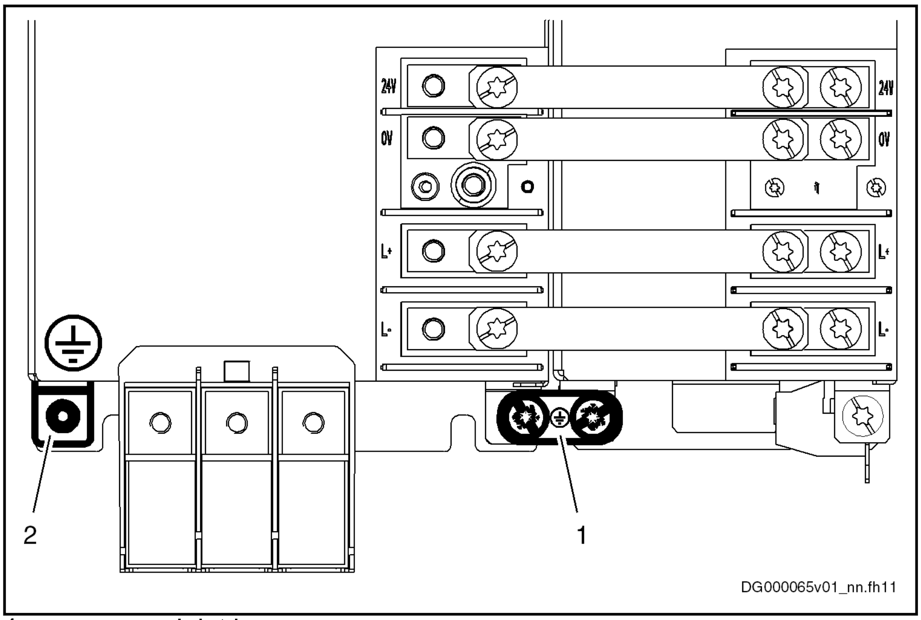
Equipment Grounding Connections Between Devices



1 Joint bar

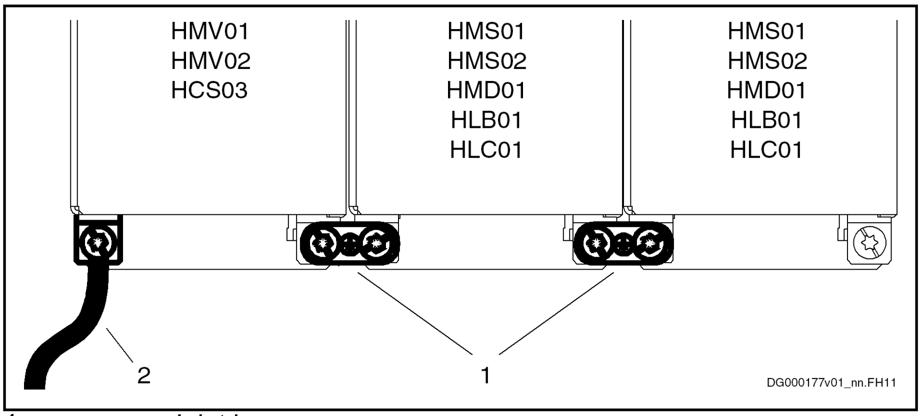
Fig. 13-2: Equipment Grounding Connections Between Devices

Connection to Equipment Grounding System in Control Cabinet



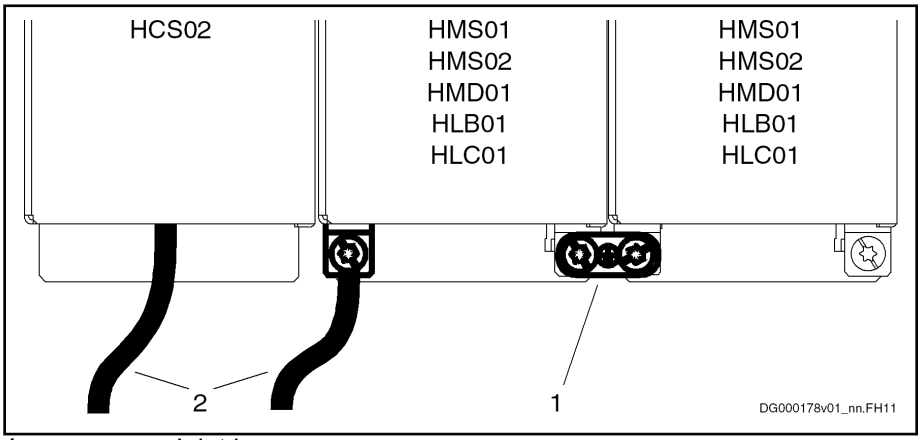
1	Joint bar
2	Connection point for connection to equipment grounding system in control cabinet

Fig. 13-3: Equipment Grounding Connections



1	Joint bar
2	Connection to equipment grounding system

Fig. 13-4: Equipment Grounding Connection in the Case of Supply via HMV01, HMV02 or HCS03



1 Joint bar
2 Connection to equipment grounding system

Fig. 13-5: Equipment Grounding Conductor Connection for Supply via HCS02

Equipment grounding conductor: Material and cross section

For the equipment grounding conductor, use the same metal (e.g. copper) as for the outer conductors.

For the connections from the equipment grounding conductor connection of the device to the equipment grounding conductor system in the control cabinet, make sure the cross sections of the lines are sufficient.

Cross sections of the equipment grounding connections:

- For **HCS03.1E** drive controllers, **HMV01** and **HMV02** supply units at least **10 mm^2 (AWG 8)**, but not smaller than the cross sections of the outer conductors of the mains supply feeder
- For **HCS02.1E** drive controllers, **at least 4 mm^2 (AWG 10)**, but not smaller than the cross sections of the outer conductors of the mains supply feeder

  Additionally, mount the housing of HCS02.1E to a bare metal mounting plate. Connect the mounting plate, too, with at least the same cross section to the equipment grounding conductor system in the control cabinet.

For outer conductors with a cross section greater than 16 mm², you can reduce the cross section of the equipment grounding connection according to the table "Equipment Grounding Conductor Cross Section".

Cross-sectional area A of outer conductors	Minimum cross-sectional area A_{PE} of equipment grounding connection
A ≤ 16 mm²	A
16 mm² < A ≤ 35 mm²	16
35 mm² < A	A / 2

Tab. 13-2: Equipment grounding conductor cross section

13.1.5 Connection to mains choke and mains filter

Order of the connections to the power grid:

Power grid → mains filter → mains choke → supply unit or drive controller

---

☞ **Only operate allowed loads at the mains filter of the drive system!**

At the three-phase filter for the power connection of regenerative supply units, it is only allowed to operate the following loads:

- HMV supply unit with mains choke and, if necessary, mains contactor

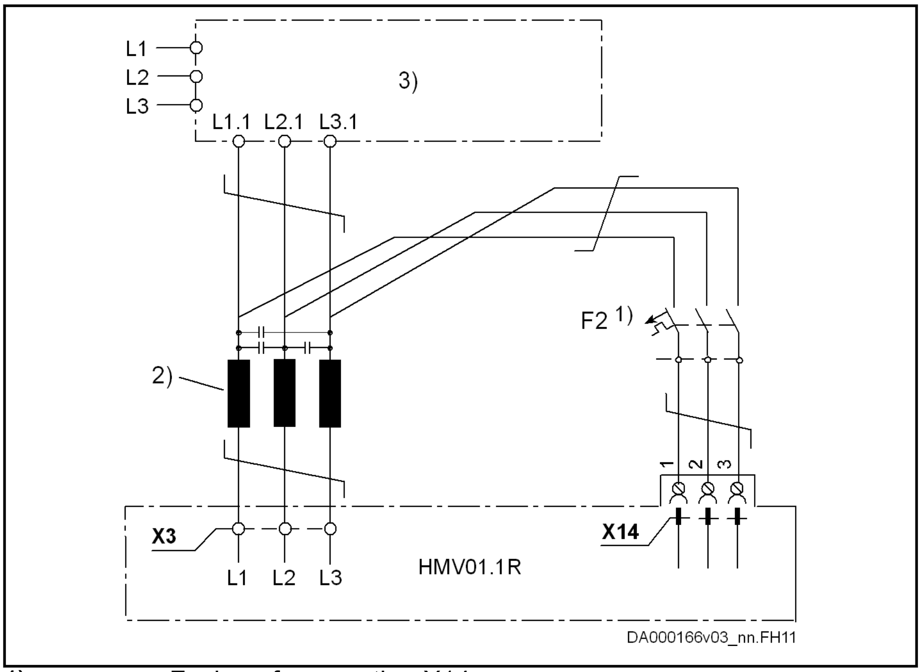
Do not operate any motor fans, power supply units etc. at the mains filter of the drive system.

The cables to the mains choke and mains filter carry a high potential of interference. Therefore, they should be kept as short as possible and twisted.

☞ Allowed cable length between the components mains filter ↔ mains choke and mains choke ↔ supply unit (X3, X14):

At most 2 m for each cable (unshielded; twisted or run in grounded, metallic channel)

Shielded cables (with a cable shield connected over a large surface are at both ends) may be longer than 2 m. In total, the entire cable length ([mains filter ↔ mains choke] + [mains choke ↔ supply unit]) has to be less than 10 m.



1) Fusing of connection X14
2) Mains choke
3) Mains filter

Fig. 13-6: Synchronizing Voltage by the Example of HMV01.1R

Other circuits for the mains connection: See chapter 9 "Circuits for the mains connection" on page 125

13.1.6 Connection of the DC Bus Connections

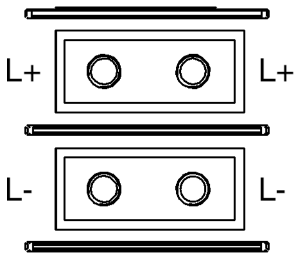
General Information

NOTICE	**Property damage in case of error caused by too small line cross section!**

Observe the **current carrying capacity of the connection lines** at the DC bus connections of the components used; see chapter "DC Bus Connection (L+, L-)" in the Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections".

Install connection lines at the DC bus connections in such a way that they are protected by the line protection at the mains connection of the supply unit or by additional fuses before the connection line.

Technical Data of the Connection Point

View	Identification	Function
 DA000176v01_nn.FH11	L+	Connection points for connecting DC bus connections
	L-	

Screw connection M6 thread at device (terminal block)	**Unit**	**Min.**	**Max.**
Tightening torque	Nm	5,5	6,5
Short circuit protection		Via fusing elements connected in the incoming circuit to the mains connection	
Overload protection		Via fusing elements connected in the incoming circuit to the mains connection	
Current carrying capacity "looping through" from L+ to L+, L- to L- (contact bars in scope of supply of accessory HAS01)			
With contact bars -072	A		220
Additionally with contact bars -042 and end piece	A		245

Tab. 13-3: Function, Pin Assignment, Properties

Single-Line Arrangement

The figure below illustrates the connection point and connection of the DC bus connections in the case of single-line arrangement **with contact bars** for the system components

- HMV01
- HMS01
- HMD01

- HLB01.1D
- HCS03

Design

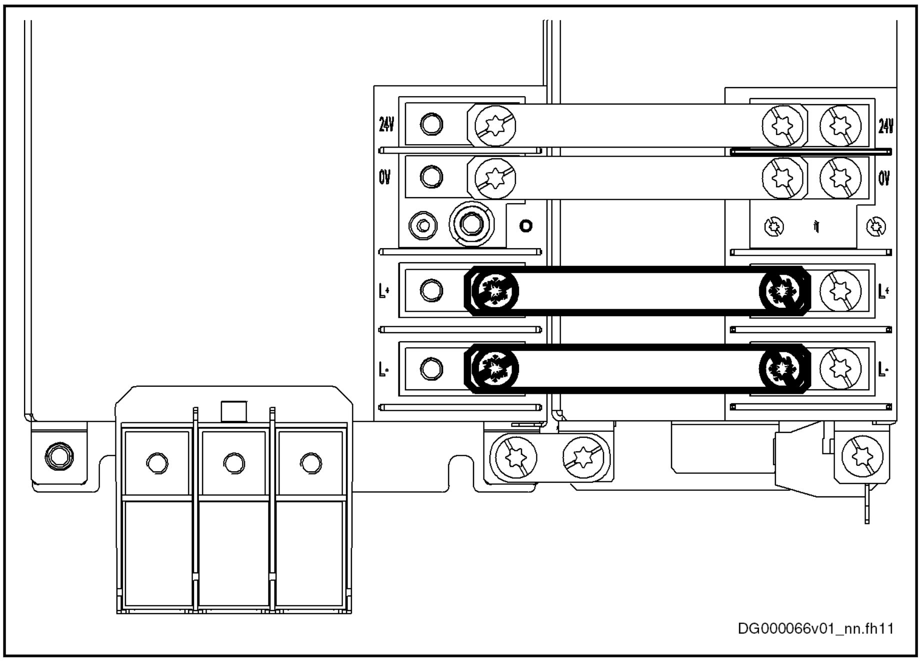


Fig. 13-7: Contact bars

Multiple-Line Arrangement

For multiple-line arrangement of drive controllers, the connection for DC bus and control voltage supply is realized **with twisted cables**.

NOTICE | **Risk of damage to the drive controller!**

- The DC bus connections of stacked drive controllers must be correctly interconnected.
- Connect L+ connections only to other L+ connections and L- connections only to other L- connections.
- Observe the measures regarding maximum allowed line lengths and minimum required line cross sections.

Minimum Requirements to Connection Lines

Dielectric Strength

The connection lines from the supply unit to the drive systems and between the drive systems must have a dielectric strength of at least:

- 1000 V against each other
- 700 V against ground

Line Cross Section

Determine the minimum line cross section from supply unit to drive systems and between drive systems by means of the **rated current.** For rated current, use the higher value from the following calculations:

- Calculate the mains-side phase current
- Calculate the current in the branch with the greatest DC bus power

☞ **Minimum cross section UL**

Use in the scope of UL requires the line cross section A ≥ 35 mm^2 (AWG2).

☞ For connecting line cross sections of **35 mm²** (AWG2) and **50 mm²** (AWG1/0), use the accessory **HAS05.1-004.**

Routing

Routing of the connection lines from the supply unit to drive systems and between the drive systems:

- **Twist** the lines with the minimum possible length of lay, but 120 mm as a maximum
- With minimum mechanical distance to ground potential
- With a distance of at least 200 mm to control voltage lines

The figures below illustrate the correct DC bus connection for stacked drive controllers. The illustrated way of connection keeps bare wire sections from being situated directly vis-à-vis. This avoids voltage arcing.

Maximum Allowed Line Length at DC Bus Connection

The line length at the DC bus connection is limited to protect the devices. For the maximum allowed line lengths between the electrical connections, see table below.

Allowed line length / m								
From	**To**							
	HMV01	HMV02	HCS03	HCS02	HMS01 / HMD01	HMS02	HLB01	HLC01
HMV01	0,5	--	--	--	2 1)	--	0,35	0,35
HMV02	--	0,5	--	--	--	0,35	0,35	0,35
HCS03	--	--	0,5	--	2 1)	--	--	0,35
HCS02	--	--	--	0,5	2 1)	0,35	0,35	0,35
HMS01 / HMD01	--	--	--	--	2 1)	--	0,35	0,35
HMS02	--	--	--	--	--	2 1)	0,35	0,35
HLB01	--	--	--	--	--		0,35	0,35
HLC01	--	--	--	--	--		--	0,35
HLL02	-	2	-	-	-	2	-	-

1) Additional lateral distance requires the module bus connection RKB0001

Tab. 13-4: Maximum Allowed Line Lengths at DC Bus

☞ **Line length > 2 m between supply unit and drive controller**

For arrangements of supply units which supply, for example, drive controllers over line lengths > 2 m, take special measures:

- Use HLC01 DC bus capacitor units at every drive system.
- Dimension the minimum size of HLC01 according to the projected continuous power of the respective drive system: 47 µF per kilowatt [kW] of continuous power.

  Example: 50 kW calculated continuous power in DC bus requires 2350 µF at this system, thus at least 1 HLC01.1D-02M4.

☞ **Maximum length between drive systems and drive controllers**

Multiple-line arrangement or distance between the devices requires the accessory **RKB0001** for the **module bus connection** between the devices.

The maximum length of the accessory RBK0001 limits the length of the DC bus connection to be achieved between drive systems.

Cable Routing to the Left

NOTICE	**Damage caused by voltage arcing!**

Insulate ring terminals and connection lines with a heat-shrinkable sleeve. Afterwards, only strip the insulation of the contact surface of the ring terminal. Make connections according to figure.

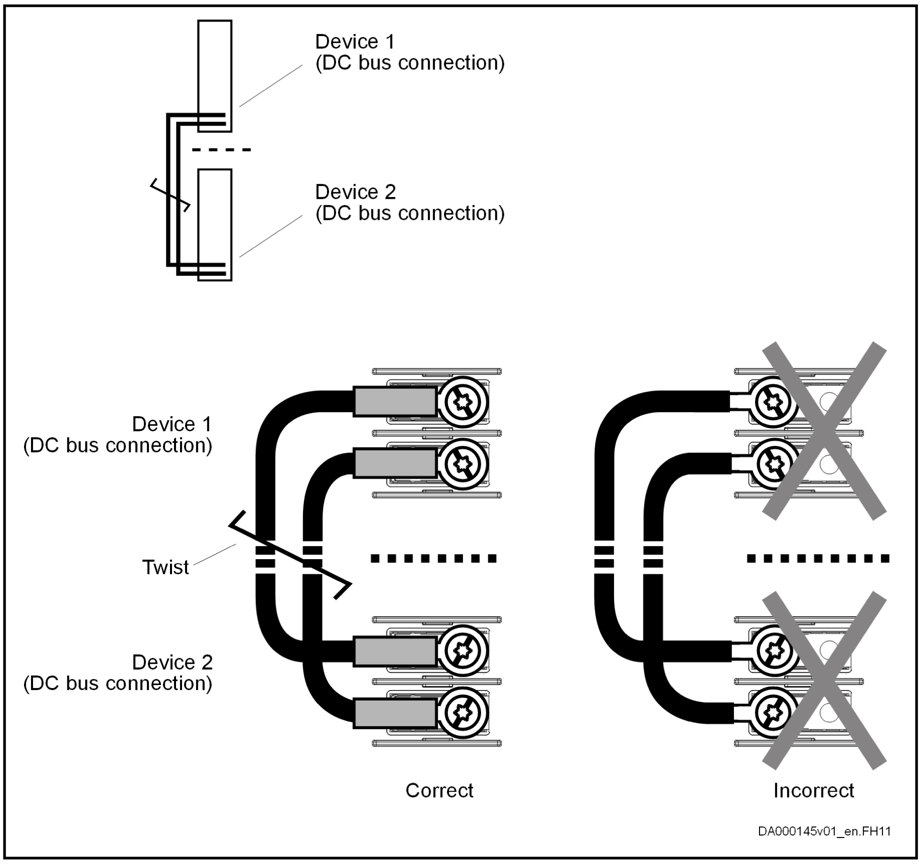


Fig. 13-8: DC Bus Connections for Cable Routing to the Left

Cable Routing to the Right

NOTICE	**Damage caused by voltage arcing!**

Insulate ring terminals and connection lines with a heat-shrinkable sleeve. Afterwards, only strip the insulation of the contact surface of the ring terminal.

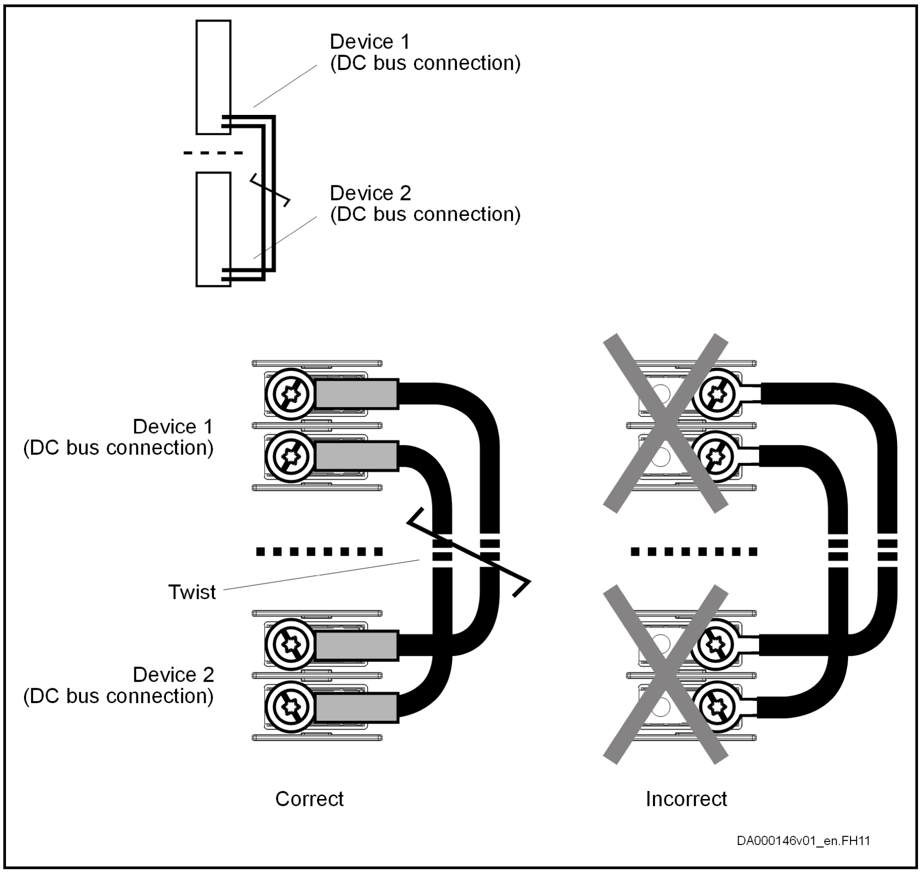


Fig. 13-9: DC Bus Connections for Cable Routing to the Right

13.1.7 Connection of the Control Voltage Connections

General Information

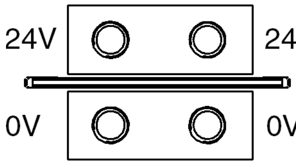
NOTICE	Property damage in case of error caused by too small line cross section!

Make use of the contact bars provided to loop-through.

Observe the current carrying capacity of the connections for 24V supply at the devices used; see sections "Terminal Block, 24 - 0V (24V Supply)" and "X13, Control Voltage" in the "Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections"".

☞ Connect the connections X13 of components with connector for 24V supply individually and in star-shaped form to the 24V supply in the control cabinet.

Technical Data of the Connection Point

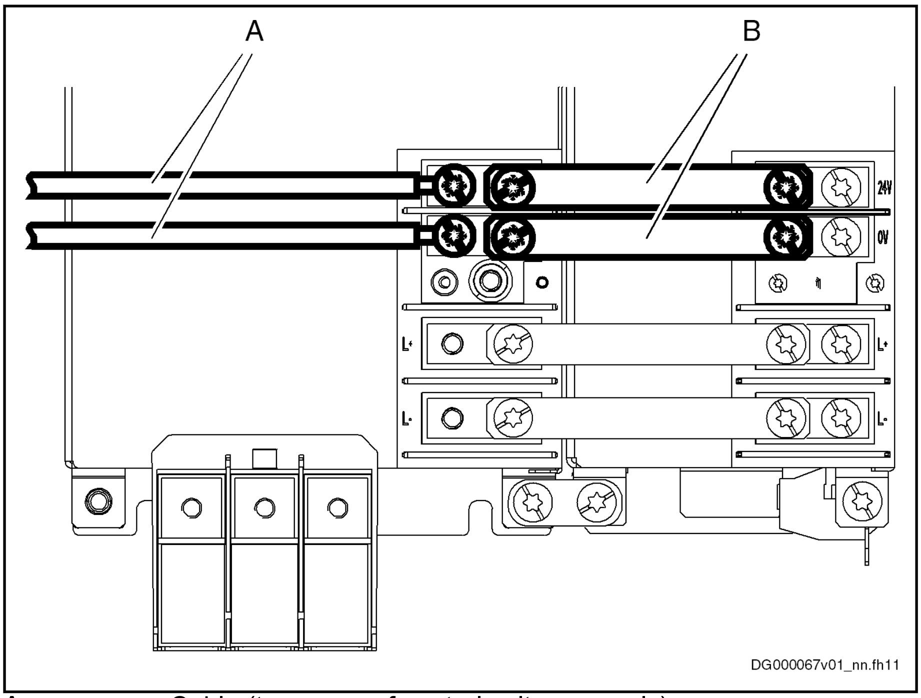
View	Identification	Function
	+24V	Power supply Connection to neighboring devices with contact bars from accessory HAS01.1
	0V	Reference potential for power supply Connection to neighboring devices with contact bars from accessory HAS01.1

Screw connection M6 thread at device (terminal block)	Unit	Min.	Max.
Tightening torque	Nm	5,5	6,5
Power consumption	W	P_{N3} (see technical data)	
Voltage load capacity	V	U_{N3} (see technical data)	
Polarity reversal protection		Within the allowed voltage range by internal protective diode	
Current carrying capacity "looping through" from 24V to 24V, 0V to 0V (contact bars in scope of supply of accessory HAS01)			
With contact bars -072	A	220	

Tab. 13-5: Function, Pin Assignment, Properties

Single-Line Arrangement

The figure below illustrates the connection point and connection of the control voltage connections for devices **HMV01, HMV02, HMS01, HMS02, HMD01 HLB01.1D and HCS03** in single-line arrangement.



A Cable (to source of control voltage supply)
B Contact bars

Fig. 13-10: Connection Points and Connections of Control Voltage

Multiple-Line Arrangement

The following figures show the correct control voltage connection for stacked drive controllers. The illustrated way of connection ensures that the touch guard can be correctly mounted and the required clearances and creepage distances can be complied with.

The cables must be twisted.

Cable Routing to the Left

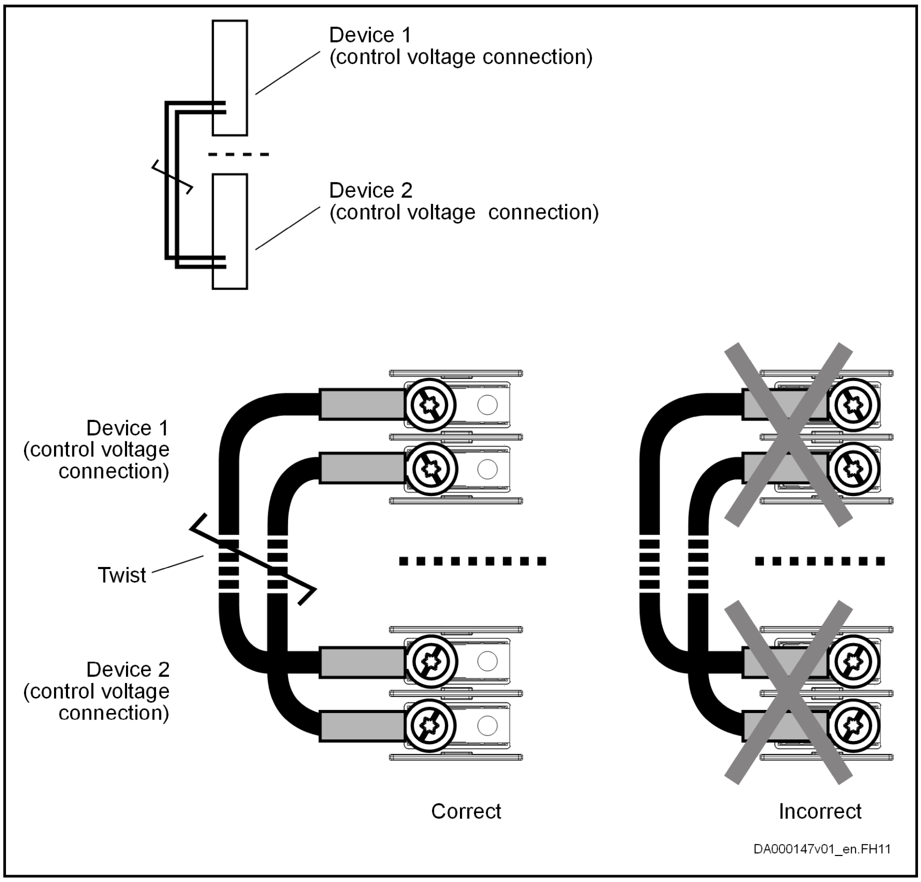


Fig. 13-11: Control Voltage Connections for Cable Routing to the Left

Cable Routing to the Right

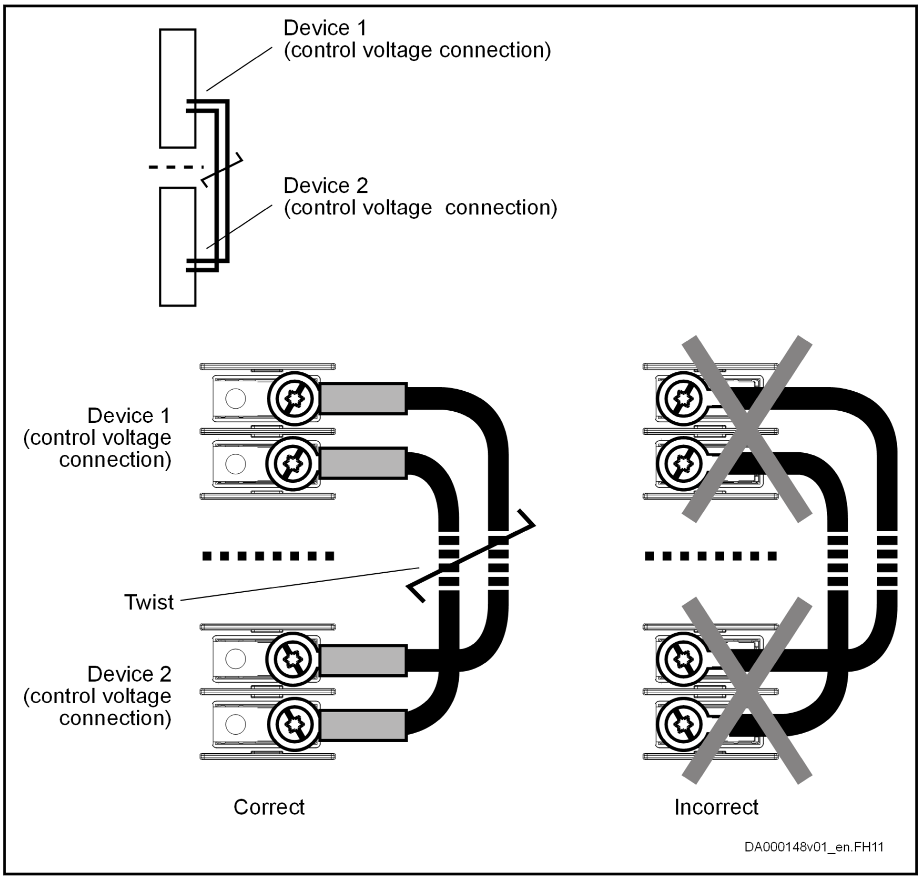


Fig. 13-12: Control Voltage Connections for Cable Routing to the Right

13.1.8 Module Bus Connection X1

The module bus connection is used for signal exchange within the drive system and takes place via the supplied ribbon cables.

Graphic Representation

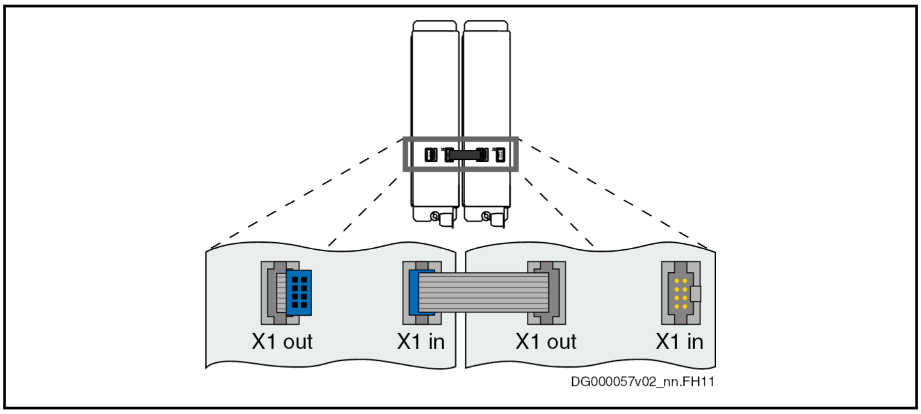


Fig. 13-13: X1

☞ When extension cables are used for the module bus, they must be **shielded**. Their total length mustn't exceed a **maximum of 40 m**.

To extend the module bus connection, the accessory **RKB0001** is available.

13.1.9 Connection of motor to drive controller

General information

The connection to the motor is made with Rexroth motor power cables.

The motor power cables contain:

Connection X5 (power)

- Outputs to motor A1, A2, A3
- Equipment grounding conductor connection
- Overall shield

Connection X6 (control contacts)

- Motor temperature monitoring with partial shield
- Motor holding brake with partial shield

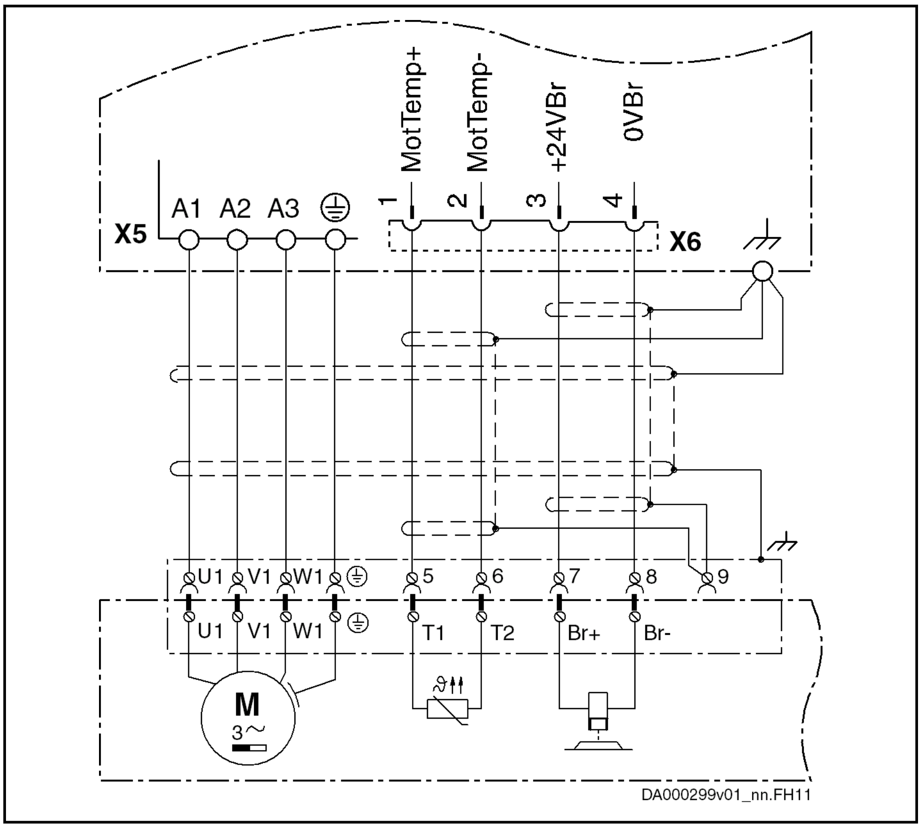


Fig. 13-14: Motor connection

📖 For detailed information, particularly on suitable additional parts, such as control cabinet ducts and extensions, see documentation "Rexroth Connection Cables".

Minimum requirements for connecting the motor power cables to the drive controller:

- Connect the shield of the motor power cable **over the largest possible surface area (with low impedance)** to the drive controller. Connecting cable shields via round wires (so-called "pig tails") at the cable ends to ground and housing is normally insufficient.
- Make sure there is sufficient **strain relief** for the motor power cable itself.

According to the individual connection properties, these requirements can be fulfilled with or without the HAS02 accessory.

Shield connection with HAS02 accessory

Using the optional HAS02 accessory with connection over a large surface area directly to the device is the best solution for shield connection. The figure below illustrates this **by the example of** HCS02 drive controllers:

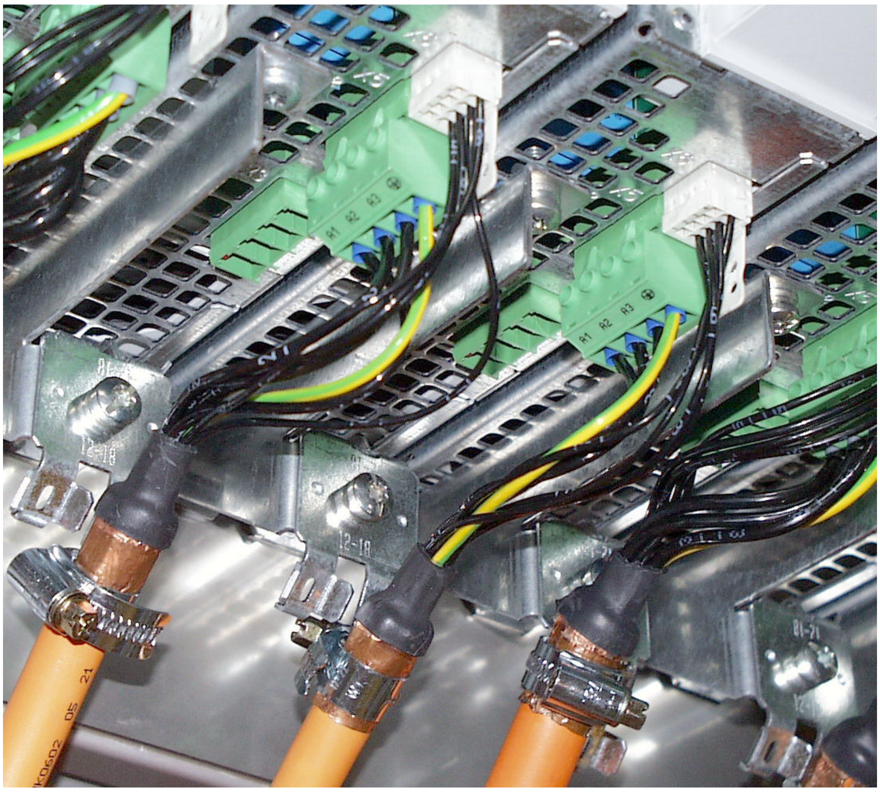


Fig. 13-15: Connecting HAS02 to HCS02

📖 For information on the available HAS02 accessory and how to mount it, see Project Planning Manual "Rexroth IndraDrive Additional Components and Accessories".

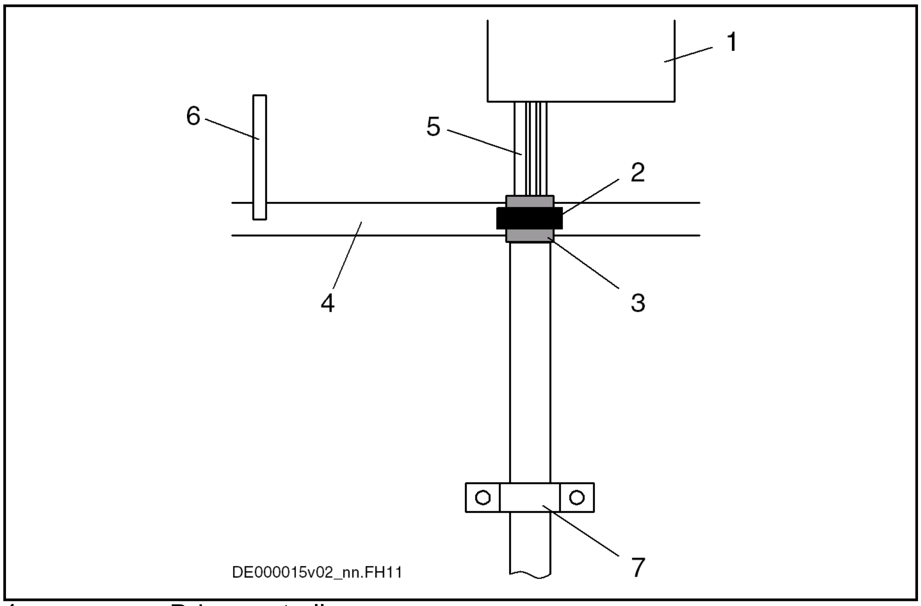
Shield connection without HAS02 accessory

For shield connection without HAS02 accessory, connect the cable shield with the lowest possible impedance to the drive controller.

The following paragraphs describe two basic alternatives of this kind of connection.

Alternative 1

Connect cable shield to a ground bar. The maximum distance between ground bar and device connection is 100 mm. For this purpose, take the given length of the single strands at the cable end into account for ready-made Rexroth motor power cables.



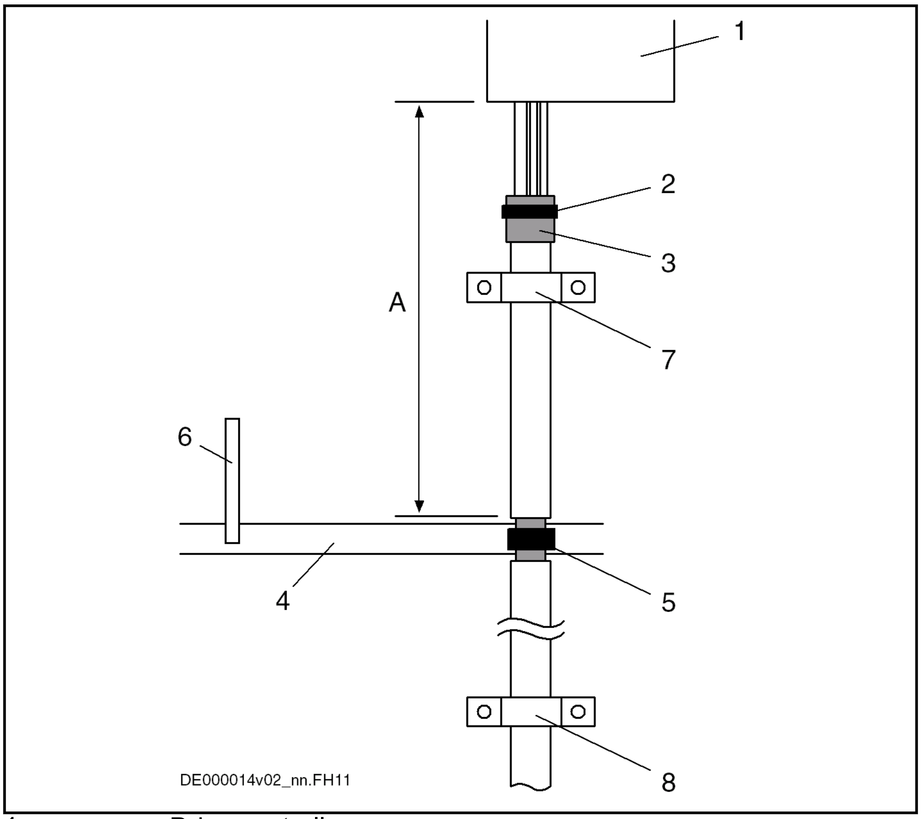
1 Drive controller
2 Clip for shield contact
3 Overall shield of the motor power cable folded back
4 Ground bar in control cabinet
5 Single strands of motor power cable
6 Connection of ground bar to supplying device
7 Strain relief (as near as possible to exit point from control cabinet)

Fig. 13-16: Shield connection, alternative 1

- With a clip (2), connect overall shield of motor power cable (3) to ground bar (4). (If you use your own cable, make sure the shields of the two inner pairs of wires are in contact with the overall shield.)
- With a cable (6) (line cross section: at least 10 mm^2), connect ground bar (4) to ground connection at supplying device (IndraDrive supply unit or IndraDrive drive controller HCS).

Alternative 2

Connect cable shield to a ground bar. The cable length between device and ground bar cannot be more than a maximum of 1 m. For this purpose, assemble the motor cable in accordance with the description below:



1	Drive controller
2	Cable tie
3	Overall shield of the motor power cable folded back
4	Ground bar in control cabinet
5	Connection between overall shield of motor power cable laying bare and ground bar
6	Connection of ground bar to supplying device
7	Strain relief (as near as possible to the drive-side cable end)
8	Strain relief (as near as possible to exit point from control cabinet)
A	Cable length between ground bar and device: < 1 m

Fig. 13-17: Shield connection, alternative 2

- With a cable tie (2), press drive-side cable end in such a way that shields of two inner pairs of wires (motor temperature, holding brake) have good contact with overall shield of motor power cable (3). (If you use your own cable, make sure the shields of the two inner pairs of wires are in contact with the overall shield.)
- On level of ground bar (4) in control cabinet, remove a piece of cable sheath from motor power cable to lay bare the overall shield (5).
- Connect overall shield (5) to ground bar in control cabinet with an appropriate connection (clip). The connection must have a cross section of at least 10 mm^2.
- With a cable (6) (line cross section: at least 10 mm^2), connect ground bar (4) to ground connection at supplying device (IndraDrive supply unit or IndraDrive drive controller HCS).
- Make sure there is sufficient strain relief for motor power cable as near as possible to drive-side cable end (7).

- In addition, make sure there is sufficient strain relief for motor power cable as near as possible to exit point from control cabinet of motor power cable (8).

☞ Do not remove the shield of the motor cable between ground bar and device.

If the motor power cables are routed to the control cabinet via flange sockets, directly connect the shield to the wall of the control cabinet over a large surface area via the housing of the flange socket. Make sure there is sufficient separate strain relief.

Shield connection of kit motors

For kit motors, make sure that the connection lines are run in shielded form or under metal between winding and terminal box, if the terminal box is not directly mounted on the spindle case.

Shield connection of linear motors

For linear motors, connect the shield of the connection cable between primary part and terminal box via clips to machine housing or metal shell.

Shielding motor temperature monitoring and motor holding brake

The inner shields of motor temperature monitor and motor holding brake in the motor cable are connected to the drive controller at one end.

Motor cable length and equipment grounding conductor resistance

With small conductor cross sections and long cables, the equipment grounding conductor resistance of the motor cable might become too big.

Small conductor cross sections restrict the maximum allowed cable length.

Conductor cross-section [mm^2]	Nominal current Mains fuse [A]	Max. allowed equipment grounding conductor resistance [Ω]	Max. motor cable length [m]
1	10	1.000	20
1.5	16	0.625	30
2.5	20	0.500	60
4	25	0.400	70
6	40	0.313	75
10	50	0.200	75
16	63	0.159	75
25	80	0.125	75

Tab. 13-6: Motor cable length and equipment grounding conductor resistance

13.2 Overall connection diagrams of drive systems

Overall connection diagrams of IndraDrive systems: See chapter 9 "Circuits for the mains connection" on page 125.

To draw up the overall connection diagrams there are **ePlan macros** of the devices available. Please ask our sales representative.

14 Third-Party Motors at IndraDrive Controllers

14.1 General Information on Third-Party Motors

14.1.1 Why Use Third-Party Motors at IndraDrive Controllers?

Today, machine axes are mainly moved with electric drives. Motors of standard design are used in most cases, as this is the most cost-efficient solution.

Special Requirements

Due to special requirements at machine axes, constructional or safety-related aspects, it may be necessary for the machine manufacturer to use a motor construction diverging from the standard.

Motor Designs not Included in Product Range

For these cases, there is the demand on drive suppliers to realize drives with motors that are not included in their own product ranges due to the special design.

Check Before Using Third-Party Motors

At drive controllers of the IndraDrive range, it is possible to use third-party motors. For this purpose, check whether the third-party motor complies with the requirements of use.

The Functional Description of the firmware contains forms for motor data. Procure the completed forms for the performance test of a third-party motor.

14.1.2 Which are the Important Directives?

In accordance with the legal regulations (EU Directive EMC 89/336/EEC and the German EMC laws), installations and machines must be designed and built in accordance with the present state-of-the-art of standardization.

In order to comply with the machine directives regarding "electromagnetic compatibility (EMC)", a conformity test of the drive system (motor with controller and connection design) must be carried out. The machine manufacturer must guarantee the test of the drive system and compliance with the directives.

14.1.3 Third-Party Motors to be Controlled

Motor Types

The following motor types can be controlled:

- Asynchronous motors, rotary
- Asynchronous motors, linear
- Synchronous motors, rotary
- Synchronous motors, linear

These motors can be operated within the scope of the technical data of the selected IndraDrive controller. If motors have been provided with a holding brake, it should be controlled via the drive controller. Make sure that the relevant technical data of the motor holding brake are complying with those of the holding brake output!

☞ For third-party motors Rexroth, as a matter of principle, does not assume the guarantee for the power data at the motor shaft!

Synchronous Motors

For synchronous motors, the commutation offset must be set during commissioning. The drive firmware provides several methods for determining this offset so that it is possible to determine the value for different motor characteristics.

☞ Observe the restrictions in conjunction with the commutation offset determination when using synchronous motors! See firmware documentation, chapter "Drive Control", "Commutation Setting".

Possibly available reluctance property cannot be used for synchronous third-party motors! For third-party motors, it is impossible to determine fail-safe motor parameter values for using the reluctance property. The respective bit of "P-0-4014, Type of construction of motor" therefore mustn't be set!

14.2 Requirements on Third-Party Motors

14.2.1 General Information

For successful and fail-safe use of a third-party motor, check

- whether the third-party motor to be controlled satisfies the voltage loads
- which controller, including supply, is suitable due to the motor power to be delivered
- whether the third-party motor has the required minimum inductance
- whether the motor can be protected against inadmissible temperature rise in the case of overload (temperature evaluation)
- whether the mounted position measuring system can be evaluated by the drive controller or which position measuring system can be selected for kit motors

14.2.2 Voltage Load of the Third-Party Motor

The voltage load of the insulation system of a motor occurring in practical application is mainly influenced by the following characteristics:

- The output variables of the drive controller which is used (feed the transmission distance)
- Cable parameters depending on cable design and length (determine the properties of the transmission distance, such as the attenuation)
- The motor design regarding capacitive and inductive properties (form the end of the transmission distance)

As a result of the variables, the insulation system of the third-party motor, as regards voltage, is loaded by the following values:

- Peak voltage U_{pp} and
- Voltage change dv/dt

The occurring peak voltages at the motor are caused by reflections in the motor cable. The insulation of the motor is thereby loaded with other peak voltages and voltage changes than the ones occurring at the output of the power section.

☞ Determine the occurring voltage load at the **terminals** of the third-party motor in the application with all involved components.

Using the HMF Motor Filter

Use voltage-reducing components (e.g. motor filter HMF), if one of the following criteria applies:

- Allowed voltage change (dv/dt) of third-party motor: **< 5 kV/µs**
- Allowed peak voltage (crest value) of third-party motor between phase-phase and phase-housing: **< 1,500 V**

- Both values (voltage change, peak voltage) are influenced by:
  – **DC bus voltage**:
    The higher the DC bus voltage at which the drive system is operated, the higher the value of the voltage change and the occurring peak voltage.
  – **Length and electrical properties of the motor cable**:
    The shorter the motor cable, the less the attenuation effects.
    The longer the motor cable, the higher the degree of voltage overshoot at the motor-side cable end.
  – For a motor cable length **l < 25 m** and mains voltage **U_{N3} > AC 440 V**, it is recommended that you use voltage-reducing components.

☞ Apart from the nominal current I_N, especially take the maximum allowed switching frequency of the power output stage (f_s) into account with which the motor filter HMF may be operated.

Verify the success of the voltage-reducing measures.

14.2.3 Minimum Inductance of Third-Party Motor

Depending on the drive controller used, the motor has to have a minimum value for inductance. The actually available inductance of a motor can be measured directly between two motor terminals by means of an inductance measuring bridge. The measurement has to be made for a complete motor wired for normal operation but not yet connected. During the measurement, one motor terminal remains open! For asynchronous motors, the measured value can only be used if the rotor doesn't have closed slots!

Drive controller	Minimum required motor inductance
HCS at 3 × AC 230 V	$L_{U-V} = 60 \times 4 / (\sqrt{2} \times I_{Typ} \times f_s)$ (in mH)
HMS, HMD at HMV (3 × AC 400 V) HMS, HMD at HCS (3 × AC 400 V) HCS at 3 × AC 400 V	$L_{U-V} = 80 \times 4 / (\sqrt{2} \times I_{Typ} \times f_s)$ (in mH)
HMS, HMD at HMV (3 × AC 480 V) HMS, HMD at HCS (3 × AC 480 V) HCS at 3 × AC 480 V	$L_{U-V} = 116 \times 4 / (\sqrt{2} \times I_{Typ} \times f_s)$ (in mH)

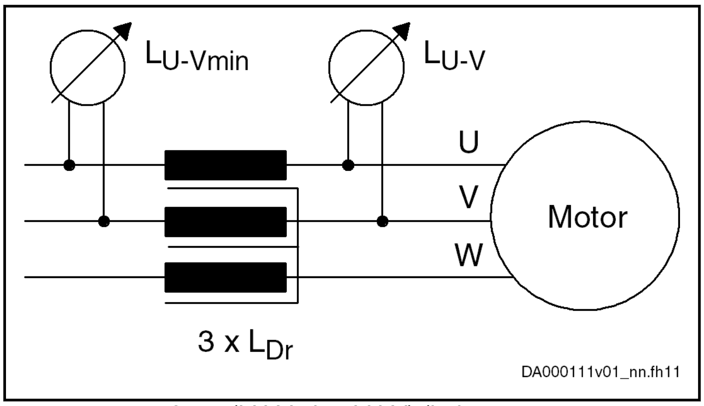
I_{Typ} Maximum current of drive controller according to type code (rms value)
f_s Desired switching frequency in kHz

Tab. 14-1: Minimum Inductances Depending on Drive Controller Data, Supply Units and Supply Voltage

Install a three-phase choke in the motor feed wire, if the inductance of the third-party motor is smaller than indicated in the table above. This choke has to increase the inductance that can be measured between two motor terminals to the minimum value.

When the inductance is measured, different inductance values can be determined at different rotor positions within one pole pair distance of the motor. The average value is relevant for the check of the minimum value.

Correct values can only be determined when the motor is **in standstill**!

<table>
<tr><th>Available third-party motor</th><th>Planned third-party motor</th></tr>
<tr><td>

L_{Dr} = 0.5 × (LU-Vmin - LU-V) (inductance measurement with 1 kHz)
Fig. 14-1: Mounting of 3 × LDr (Three-Phase Choke)</td>
<td>Calculate the leakage inductance (asynchronous motor) or inductance (synchronous motor) of the third-party motor by means of the single-phase equivalent circuit diagram (manufacturer's specification!).
Determine choke by means of calculation, if necessary.
It is recommended that you contact Rexroth!</td></tr>
<tr><td colspan="2">Requirements on the choke:
• $I_{n\_Dr} \geq I_{n\_Mot}$
The rated current of the choke has to be greater than or equal to the rated motor current.
• Depending on the maximum speed, the choke is loaded with the respective output frequency and the PWM frequency of the drive controller.
• The insulation class has to correspond at least to that of the motor or has to be sized for higher temperatures.
• The voltage load of the choke depends on the drive controller used.</td></tr>
</table>

Tab. 14-2: Data for Possibly Required Choke

14.2.4 Temperature Evaluation of Third-Party Motor

Only operate such motors with incorporated temperature sensor at IndraDrive controllers so that the motor can be thermally monitored by the drive controller and protected against destruction by too high temperature rise (see "P-0-0512, Temperature sensor").

When, in exceptional cases, you would like to operate third-party motors without temperature sensor at IndraDrive controllers, you must determine the thermal time constants of motor housing (P-0-4035) and motor winding (P-0-4034, P-0-4037). By means of its temperature model, the firmware can correctly reflect the cooling situation of the motor.

In case the motor housing or fan is dirty, this worsens the cooling situation of the motor and protection against thermal overload is therefore insufficient!

14.3 Requirements on the Encoder of the Third-Party Motor

14.3.1 Motor Encoder of Asynchronous Third-Party Motor

Asynchronous motors can also be controlled by IndraDrive controllers in "open-loop" operation (without motor encoder). In "closed-loop" operation (with motor encoder), a relative measuring system is sufficient for asynchronous motors.

14.3.2 Motor Encoder of Synchronous Third-Party Motor

For fail-safe drives with synchronous third-party motors at IndraDrive controllers, the following possible combinations or restrictions have to be taken into account when selecting the measuring system:

Drive range	Motor measuring system	Synchronous third-party motor
IndraDrive	Absolute	■
	Relative	□

■ Advantageous combination

□ Combination is possible (restrictions specific to application), commissioning may be more complicated!

Tab. 14-3: Possible Combinations of Synchronous Third-Party Motor and Motor Measuring System

☞ The control section integrated in the drive controller can evaluate measuring systems as a motor encoder, if they are contained in "P-0-0074, Encoder type 1 (motor encoder)" (see also Project Planning Manual "Rexroth IndraDrive Drive Controllers Control Sections").

For information on absolute and relative measuring systems, see section "Measuring Systems" of firmware documentation!

14.3.3 Motor Encoder Resolver - Notes on Selection

For operating "resolver" encoder types, there is the optional module EN1 available (see also Project Planning Manual "Rexroth IndraDrive Drive Controllers Control Sections").

Observe:

- Data of resolver system to be compared must be available at 4 kHz
- Ratio
- Current consumption
- DC resistance of stator
- Number of poles
- Phase shift

You can get more detailed information on request.

14.4 Notes on Selection and Commissioning

14.4.1 Selecting the Controller as Regards Continuous Current

The drive controller required for the respective motor and the supply unit are determined by comparing the motor data to the data of these devices (see

Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections").

☞ The continuous current of the drive controller should be greater than the one of the motor. The continuous power of the supply must be greater than the sum of all average powers of the axes of the drive system!

14.4.2 Selecting the Connection Technique

For the available power cables and encoder cables, see documentation "Rexroth Connection Cables".

14.4.3 Notes on Commissioning

☞ For further information, notes on commissioning and supporting documents (e.g., forms for entering the required data) see firmware documentation.

15 Calculations

15.1 Determining the appropriate drive controller

15.1.1 Introduction

The IndraDrive system is supplied via compact HCS converters or HMV supply units. According to the drive task, design of drive controller and operating conditions, chokes, additional capacitors, braking resistors, transformers, etc., may be required.

The drive controller or supply unit has to supply the DC bus continuous power and for acceleration the DC bus peak power. With regenerative operation, they have to be able to absorb the continuous recovery power and peak recovery power.

Before the drive controller or supply unit and the additional components can be selected, the motors and drive controllers to be used have to be defined.

To ensure correct sizing of the drive system, the calculations should be performed in the order described in the following chapters.

15.1.2 DC bus continuous power

The DC bus continuous power is calculated from the mechanical power, taking the following aspects into consideration:

- Motor and controller efficiency
- Simultaneity factors

Mechanical power

$$P_m\,[W] = M \times \omega = \frac{M \times n \times 2\pi}{60}$$

$$P_m\,[kW] = \frac{M \times n}{9550}$$

P_m	Mechanical power
M	Torque [Nm]
ω	Angular velocity [min^{-1}]
n	Motor speed [min^{-1}]

Fig. 15-1: Mechanical power

Mechanical continuous power for servo drives

To calculate the mechanical continuous power of a servo drive, the motor torque and the average motor speed are required.

The motor torque can be taken from the servo drive calculation. The average motor speed is determined as follows:

Average motor speed

For servo drive tasks at common NC machine tools, the average motor speed is approx. 25% of the rapid traverse speed. In some cases, however, this rough estimation is not sufficient. An exact calculation of the average motor speed is required.

Average speed with run-up and braking times not taken into account

If the period during which the motor is run at constant speed is significantly greater than the run-up and braking time, the following applies:

$$n_{av} = \frac{n_1 \times t_1 + n_2 \times t_2 \ldots + n_n \times t_n}{t_1 + t_2 \ldots + t_n}$$

n_{av}	Average motor speed [min^{-1}]
$n_1 \ldots n_n$	Motor speed [min^{-1}]
$t_1 \ldots t_n$	Duty cycle [s]

Fig. 15-2: Average speed; effects of run-up and braking times not taken into account

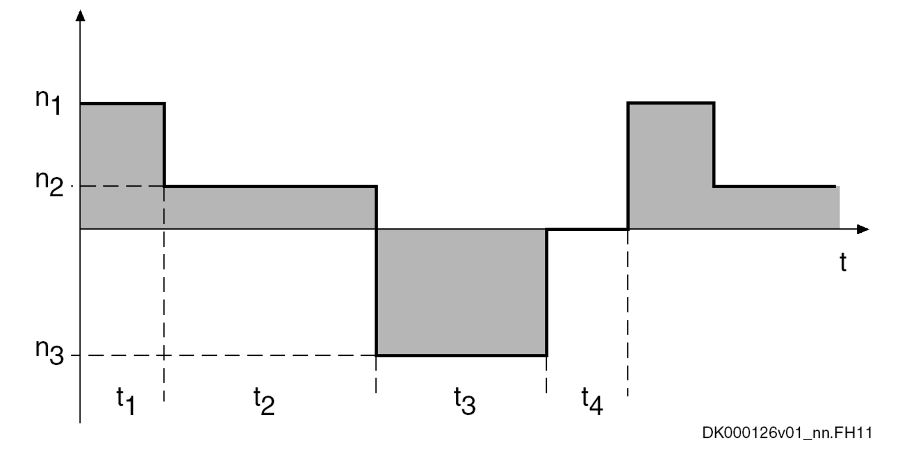


Fig. 15-3: Speed characteristic; effects of run-up and braking times not taken into account

In dynamic applications with short cycle times, e.g. roll feeds and nibbling machines, run-up and braking times have to be taken into account.

NOTICE **Damage to the drive controller!**

- The DC bus capacitors in the drive controller have been sized for loading with continuous power.
- If loaded with cyclic charging and discharging processes of high energy content, the DC bus capacitors can be overloaded, especially with decreasing mains connection voltage.

Operate additional capacitors at the DC bus.

Average speed with run-up and braking times taken into account

$$n_{av} = \frac{\frac{n}{2} \times t_H + n \times t_1 + \frac{n}{2} \times t_B}{t_H + t_1 + t_B + t_2}$$

n_{av}	Average motor speed [min^{-1}]
n	Motor speed [min^{-1}]
t	Time [s]
t_H	Run-up time [s]
t_B	Braking time [s]

Fig. 15-4: Average speed; effects of run-up and braking times taken into account

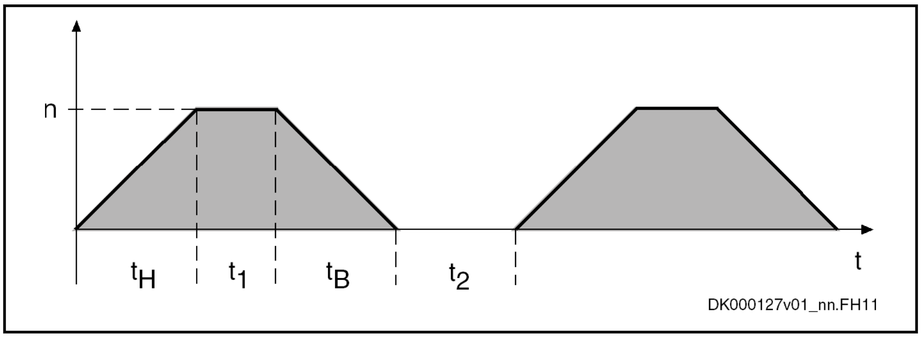


Fig. 15-5: Average speed; effects of run-up and braking times taken into account

Mechanical power for servo drives

$$P_{mSe} = \frac{M_{av} \times n_{av}}{9550}$$

P_{mSe}	Mechanical continuous power for servo drives [kW]
M_{av}	Average motor torque [Nm]
n_{av}	Average motor speed [min^{-1}]

Fig. 15-6: Mechanical power for servo drives

Mechanical power for main drives

Main drives are drives which are mainly used in the constant power speed range. Thus, nominal power is decisive for sizing the mains supply. The mechanical nominal power of the main drives can be taken from the operating characteristic or calculated from nominal speed and nominal torque.

$$P_{mHa} = \frac{M_n \times n_n}{9550}$$

P_{mHa}	Mechanical nominal power for main drives (shaft output) [kW]
M_n	Nominal motor torque [Nm]
n_n	Nominal motor speed [min^{-1}]

Fig. 15-7: Mechanical Power for Main Drives

DC bus continuous power for servo drives

The drive controller or the group of drive controllers has to make available the DC bus power. However, in most applications, simultaneous loading of all drives will not occur. Thus, only the simultaneously occurring power has to be considered for calculating the DC bus continuous power to be made available for servo drives. To calculate the DC bus continuous power to be made available for typical NC feed axes at machine tools, including a so-called simultaneity factor has proved to be useful in practical application:

Number of axes	1	2	3	4	5	6	7	n = n + 1
Simultaneity factor (F_G)	1	1.15	1.32	1.75	2.0	2.25	F_G = 2.5	$F_{Gn} = F_G + 0.25$

Tab. 15-1: Simultaneity factors

$$P_{ZWDSe} = \frac{(P_{mSe1} + P_{mSe2} \ldots + P_{mSen}) \times 1,25}{F_G}$$

P_{ZWDSe}	DC bus continuous power for servo drives [kW]
P_{mSe1}...P_{mSen}	Mechanical continuous power for servo drives [kW]
F_G	Simultaneity factor
1.25	Constant for motor and controller efficiency

Fig. 15-8: DC bus continuous power for servo drives

DC bus continuous power for main drives

If multiple main drives are operated at one DC bus, the simultaneously required DC bus continuous powers have to be added:

$$P_{ZW\,Ha}(P_{m\,Ha1} + P_{m\,Ha\,2} \ldots + P_{m\,Han}) \times 1,25$$

P_{ZWHa}	DC bus continuous power for main drives [kW]
P_{mHa1} … P_{mHan}	Mechanical continuous power for main drives [kW]
1.25	Constant for motor and controller efficiency

Fig. 15-9: DC bus continuous power for main drives

Chokes and additional capacitors have to be selected in accordance with the actually required DC bus continuous power. It is determined by the nominal power of the main drives.

☞ When selecting the drive controllers, make sure that their maximum DC bus continuous power will not restrict the short-time operation power of the main drives.

DC bus continuous power for main and servo drives

When main and servo drives are operated at a drive controller, the required DC bus continuous powers have to be added.

At a typical NC machine tool, the required DC bus continuous power will be primarily defined by the main drive. Accordingly, the following equation is to be used for such applications:

$$P_{ZW\,D} = [P_{m\,Ha} + 0,3 \times (P_{m\,Se1} + P_{m\,Se2} \ldots + P_{m\,Sen})] \times 1,25$$

0.3	Empirical value for standard machine tools
1.25	Constant for motor and controller efficiency
P_{ZWD}	DC bus continuous power [kW]
P_{mSe1} … P_{mSen}	Mechanical continuous power for servo drives [kW]
P_{mHa}	Nominal power for main drive (shaft output) [kW]

Fig. 15-10: DC bus continuous power for main and servo drives at NC machine tools

$$\sum P_{ZW\,D,\,Anlage} \leq \sum P_{ZW\,D,\,Geräte}$$

$P_{ZWD,Anlage}$	Generated DC bus continuous power of the installation
$P_{ZWD,Geräte}$	Allowed DC bus continuous power of the devices

Fig. 15-11: Supply condition: DC bus continuous power

15.1.3 DC Bus Peak Power

The drive controller or combination of drive controllers has to produce DC bus peak power for example when several axes of a machine tool simultaneously accelerate to rapid traverse rate after a tool change, approaching the workpiece.

NOTICE **Damage due to supply unit overload!**

To avoid damage to the drive controller, the sum of peak powers of all drives mustn't exceed the DC bus peak power of the supplying drive controller (central supply).

$$P_{ZWS} = \frac{(M_{NC} \pm M_G) \times n_{eil} \times 1{,}25}{9550}$$

M_{NC}	Acceleration torque in the drive [Nm]
M_G	Torque due to weight for vertical axes [Nm]
n_{eil}	Speed at rapid traverse rate [min^{-1}]
P_{ZWS}	DC bus peak power [kW]
1,25	Constant for motor and controller efficiency

Fig. 15-12: DC Bus Peak Power per Drive

$$\sum P_{ZWS,\,Anlage} \leq \sum P_{ZWS,\,Geräte}$$

$P_{ZWS,Anlage}$	Generated DC bus peak power of the installation
$P_{ZWS,Geräte}$	Allowed DC bus peak power of the devices

Fig. 15-13: Supply Condition: DC Bus Peak Power

15.1.4 Regenerative Power

When all main and servo drives connected to a drive controller or combination of drive controllers brake simultaneously, the generated regenerative power must not be greater than the maximum regenerative power of the drive controller or combination of drive controllers. If this is not taken into consideration in sizing the system, thermal destruction of the braking resistors in the drive controllers may occur.

NOTICE **Destruction due to braking resistor overload!**

Do the project planning for drive controllers or combinations of drive controllers in such a way that the resulting regenerative power can be absorbed when all main and servo drives connected to the drive controller or combination of drive controllers brake simultaneously.

$$W_{rot} = \frac{J_G}{2} \times \left(n_{eil} \times \frac{2p}{60}\right)^2$$

W_{rot}	Rotary energy [Ws]
n_{eil}	Speed at rapid traverse rate [min^{-1}]
J_G	Motor inertia and load inertia reduced to the motor shaft [kgm²]

Fig. 15-14: Regenerative Power per Drive

$$\sum W_{R,\,Anlage} \leq \sum W_{R,\,Geräte}$$

$W_{R,Anlage}$	Generated regenerative power of the installation
$W_{R,Geräte}$	Allowed regenerative power of the devices

Fig. 15-15: Supply Condition: Regenerative Power

Influence of efficiency

The energy absorption occurring in the steady-state condition in the majority of cases is less than the calculated energy absorption, because all involved components (such as load, gear, motor, cables) absorb a part of the regenerative power.

Only reduce the generated regenerative power when the efficiency behavior is known.

Energy Absorption of Braking Resistor

Within the minimum cycle time T_{cycl}, the braking resistor dissipates the electrically absorbed energy to its environment as heat. The braking resistor makes available the energy absorption during its duty cycle. The energy absorption is calculated as follows:

$$W_R = t_{on} \times P_{BS}$$

$$W_R = P_{BD} \times (T_{cycl} - t_{on})$$

W_R	Absorbed regenerative power
t_{on}	Allowed duty cycle
P_{BS}	Allowed peak power of braking resistor
P_{BD}	Allowed continuous power of braking resistor
T_{cycl}	Allowed cycle time

Fig. 15-16: Energy Absorption of Braking Resistor

Energy absorption capacity with long cycle times

For cycles with "T > 5 × T_{cycl}", the indicated maximum regenerative power to be absorbed W_{R_max} can be used.

Several braking resistors (e.g. HLR) at common DC bus

With several braking resistors at the DC bus, the available energy absorption is determined as the sum of the individual energy absorptions. For this purpose, the same switch-on threshold must take effect for all involved braking resistors.

Adjustment of switch-on threshold!

For the adjustment of the switch-on threshold, see also the following parameters:

- P-0-0833, Braking resistor threshold
- P-0-0858, Data of external braking resistor

15.1.5 Reduction of Generated Power Dissipation - Additional External Capacitors at DC Bus

When the drive brakes, the rotary energy present in the mechanical system is released as regenerative power in the DC bus of the drive controller or group of drive controllers. It can

- be converted into dissipation heat via the braking resistor integrated in the drive controller or the additional braking resistor

or

- be stored as energy in the drive controllers and possibly available additional capacitors and reused for following acceleration processes. This reduces the power dissipation generated in the control cabinet and lowers the energy consumption.

The following applies to successful use of additional capacitors to avoid unnecessary power dissipation in the control cabinet:

$$\sum W_{R,\,Anlage} \leq \sum W_{ZW,\,Geräte}$$

$W_{R,Anlage}$	Generated regenerative power of the installation
$W_{ZW,Geräte}$	Storable energy of the DC bus capacitors

Fig. 15-17: Condition to Avoid Power Dissipation From the Regenerative Power

Additional Capacitors as Energy Stores

Many acceleration and deceleration processes are typical for applications with servo drives (e.g. nibbling machines or roll feeds). This is why it can be useful for such applications to connect additional capacitors to the DC bus of the drive controllers. This provides the following advantages:

- For drive controllers without mains regeneration function, this prevents the braking resistor in the drive controller from being switched on when the drives brake. The dissipation heat in the control cabinet is considerably reduced.
- The energy stored in the DC bus capacitors can be used for acceleration. The energy demand of the installation is reduced.

Storable Energy in DC Bus

The specific energy absorption capacity of the drive controllers can be determined with the formula below.

$$W_{DC} = \frac{\left(C_{DC} + C_{DCext}\right)}{2} \times \left(U^2_{R\_DC\_On} - U^2_{DC}\right)$$

W_{DC}	Storable energy in DC bus
C_{DC}	DC bus capacitance in device [F]
C_{DCext}	External DC bus capacitance [F]
$U_{R\_DC\ On}$	Braking resistor switch-on threshold
U_{DC}	DC bus voltage

Fig. 15-18: Storable Energy in DC Bus

The additional capacitor has to be sized in such a way that it can store the rotary drive energy:

$$C_{DCext} \geq \frac{2W_{rot}}{\left(U^2_{R\_DC\_On} - U^2_{DC}\right)} - C_{DC}$$

$U_{R\_DC\ On}$	Braking resistor switch-on threshold
U_{DC}	DC bus voltage
W_{rot}	Rotary energy [Ws]
C_{DC}	Internal capacitance [F]
C_{DCext}	Required external DC bus capacitance [F]

Fig. 15-19: Required Additional Capacitance [F]

NOTICE **Property damage caused by overload of HMV and HCS devices!**

Comply with maximum allowed external DC bus capacitances! See electrical data of the HMV and HCS components.

NOTICE **Property damage caused by overload of the additional external capacitors!**

- Only use allowed components.
- The properties of the additional capacitors have to comply with minimum requirements:
  - Min. **dielectric strength**: DC 900 V
  - Max. **discharge time**: 30 min
  - Take measures against fire in the case of overload, e.g. by **housing** the capacitors.
- **Connect correct polarity**: Connect L+ to positive pole and L- to negative pole of the additional capacitors.

☞

- For additional external capacitors, observe that the series connection of these units can require a balancing device.
- Size additional capacitors at the DC bus for 10% overvoltage at the mains connection.
- As the supply voltage increases the storable energy in the DC bus decreases, because the differential voltage between braking resistor switch-on threshold U_B and DC bus voltage U_{ZW} (crest value of supply voltage) is reduced.
- Take the service life of external capacitors into account.

The figure below illustrates the characteristic of the storable energy in the DC bus versus mains voltage with fixed braking resistor switch-on threshold U_B by the example of HCS02.1E devices.

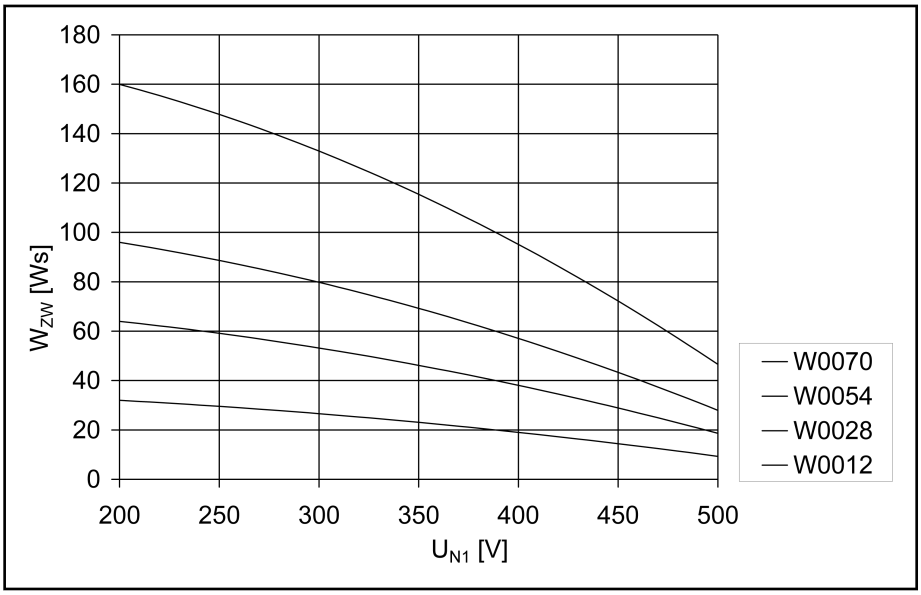


Fig. 15-20: Storable Energy in DC Bus

15.1.6 Continuous Regenerative Power

☞ In terms of average period of time, the sum of the continuous regenerative power of all drives mustn't exceed the allowed continuous power of the regenerative device (regeneration of supply units or braking resistors of converters).

In applications with servo drives at typical NC machine tools, machining time is relatively long relative to the cycle time. Accordingly, the continuous regenerative powers are small. For this type of applications, exact calculation is not required. It is sufficient to make sure that the regenerative peak power is not exceeded.

Exact calculation is required, for example, for one of the following applications:

- Applications with servo drives which are characterized by many acceleration and deceleration processes (e.g. nibbling machines or roll feeds)
- Machine tools with modular main drive
- Applications which involve lowering of large masses, e.g. loading bridges, warehousing and transport systems

Before the continuous regenerative power can be calculated, the rotary energy of the drives and the potential energy of non-balanced masses must be calculated.

$$W_{rot} = \frac{J_G}{2} \times \left(n_{eil} \times \frac{2\pi}{60} \right)^2 \times z$$

W_{rot}	Rotary energy [Ws]
n_{eil}	Speed at rapid traverse rate [min^{-1}]
J_g	Inertia (motor + load) [kgm^2]
z	Number of braking processes per cycle

Fig. 15-21: Rotary Energy of the Drives

$$W_{pot} = m \times g \times h \times z$$

W_{pot}	Potential energy [Ws]
m	Load mass [kg]
g	Gravitational acceleration = 9.81 m/s²
h	Lowering height [m]
z	Number of lowering processes per cycle

Fig. 15-22: Potential Energy of Non-Balanced Masses

$$P_{RD,Anlage} = \frac{W_{potg} + W_{rotg}}{t_z}$$

$$\sum P_{RD,Anlage} \leq \sum P_{BD,Geräte}$$

$P_{RD,Anlage}$	Generated continuous regenerative power [kW]
$P_{BD,Geräte}$	Allowed braking resistor continuous power [kW]
t_z	Cycle time [s]
W_{potg}	Sum of potential energies [kWs]
W_{rotg}	Sum of rotary energies [kWs]

Fig. 15-23: Continuous Regenerative Power

Influence of efficiency

The continuous regenerative power occurring in the steady-state condition in the majority of cases is less than the calculated energy absorption, because all involved components (such as load, gear, motor, cables) absorb a part of the regenerative energy.

Only reduce the generated continuous regenerative power when the efficiency behavior is known.

Continuous Power of Braking Resistor

Continuous power of the braking resistor:

$$P_{BD} = \frac{t_{on} \times P_{BS}}{T_{cycl}}$$

P_{BD}	Allowed continuous power of braking resistor
t_{on}	Allowed duty cycle
P_{BS}	Allowed peak power of braking resistor
T_{cycl}	Allowed cycle time

Fig. 15-24: Braking Resistor Continuous Power

Several braking resistors (e.g. HLR) at common DC bus

With several braking resistors at the DC bus, the available continuous power is less than the sum of the individual continuous powers.

$$\sum P_{BD} = f \times (P_{BD\_1} + P_{BD\_2} + \ldots + P_{BD\_n})$$

P_{BD_1}, P_{BD_2}, P_{BD_n}	Data sheet data of the braking resistors
f	Balancing factor for PDB (f = 0.8 (guide value); see also technical data of converter and supply unit)

Fig. 15-25: Sum of Braking Resistor Continuous Powers

Relative Duty Cycle of Braking Resistor

The quotient of t_{on} and T_{cycl} is understood by the duty cycle ED. The maximum allowed relative duty cycle ED_{max} is calculated from the nominal data for HLR braking resistors:

$$ED_{max} = \frac{t_{on}}{T_{cycl}}$$

ED_{max}	Maximum allowed relative duty cycle
t_{on}	Allowed duty cycle
T_{cycl}	Allowed cycle time

Fig. 15-26: Relative Duty Cycle of Braking Resistor

Braking times

Within the indicated minimum cycle time T_{cycl}, the braking resistor may be switched on, as a maximum, for the time t_{on}.

15.1.7 Peak Regenerative Power

Usually, peak regenerative power will occur when an E-Stop signal is triggered and all axes brake simultaneously.

NOTICE **Risk of damage due to extended braking times and distances!**

Select the supply unit such that the sum of peak regenerative powers of all drives does not exceed braking resistor peak power of the supply unit.

See the respective motor selection data for the peak regenerative powers.

Peak regenerative power can be roughly calculated by the following equation:

$$P_{RS} = \frac{M_{max} \times n_{max}}{9550 \times 1,25}$$

$$\sum P_{RS,\,Anlage} \leq \sum P_{BS,\,Geräte}$$

$P_{RS,Anlage}$	Generated peak regenerated power [kW]
$P_{BS,Geräte}$	Allowed braking resistor peak power [kW]
M_{max}	Maximum drive torque [Nm]
n_{max}	Maximum NC useful speed [min-1]
1,25	Constant for motor and controller efficiency

Fig. 15-27: Peak Regenerative Power

Peak Power of Braking Resistor

The braking resistor makes available the peak power during its duty cycle. The peak power is calculated as follows:

$$P_{BS} = \frac{U_{R\_DC\_on}^{2}}{R_{DC\_Bleeder}}$$

P_{BS}	Effective peak power
$U_{R\_DC\_on}$	Switch-on threshold
$R_{DC\_Bleeder}$	

Fig. 15-28: Braking Resistor Peak Power

Several braking resistors (e.g. HLR) at common DC bus

With several braking resistors at the DC bus, the available peak power is determined as the sum of the individual peak powers. For this purpose, the same switch-on threshold must take effect for all involved braking resistors.

Adjustment of switch-on threshold!

For the adjustment of the switch-on threshold, see also the following parameters:

- P-0-0833, Braking resistor threshold
- P-0-0858, Data of external braking resistor

15.1.8 Calculating the Control Factor

The control factor of an inverter is the ratio of its output voltage to a reference output voltage.

The reference output voltage is the output voltage of the inverter at mains input voltage without overload.

$$a = \frac{U_{out}}{U_{out\_ref}} = \frac{U_{out}}{U_{LN}}$$

U_{out}	Output voltage of inverter
U_{out_ref}	Reference output voltage
U_{LN}	Mains voltage

Fig. 15-29: Control Factor

Calculating U_{out}:

$$U_{out} = K_{EMK\_1000} \times \frac{rpm}{1000}$$

U_{out}	Output voltage of inverter
K_{EMK_1000}	Voltage constant [V/min^{-1}]
rpm	Speed

Fig. 15-30:

If several inverters have effect on one supply unit at the same time, you have to consider the so-called mean control factor scaled with the axis power.

$$\overline{a} = \frac{1}{n \times P_{ZWD}} \times \sum_{i=1}^{n} (a_i \times P_{mi} \times 1{,}25)$$

n	Number of inverters
a_i	Several control factors
P_{ZWD}	DC bus continuous power [kW]
P_{mi}	Mechanical continuous power [kW]

Fig. 15-31: Mean, Scaled Control Factor

When the control factor falls below the given value (see data P_{DC_cont} in the technical data of the corresponding supply unit), additional wattless power occurs. The additional wattless power can be compensated with additional capacitors in the DC bus. The required additional capacitance can be approximately calculated with the following formula.

Applies to a ≤ a_0!

$$C_{DC\_ext} = (a_0 - \overline{a}) \times P_{DC\_nenn} \times k_a$$

C_{DC_ext}	Required additional capacitance in DC bus in µF
a_0	Minimum required control factor
a	Calculated mean control factor
P_{DC_nenn}	Nominal power of supply unit [kW]
k_a	200 (preliminary); factor capacitance [µF] / nominal power [kW]

Fig. 15-32: Required Additional Capacitances When Control Factor Falls Below Minimum Value

15.2 Calculations for the mains connection

15.2.1 Calculating the mains-side phase current

The mains-side phase current is required for the following cases:

- Selecting the mains contactor
- Determining the fuses in the mains connection
- Determining the line cross section
- Selecting other components in the mains connection (mains filter, mains choke)

Operation under rated conditions

For data on mains contactor, fuses and cross section in operation under rated conditions, see technical data of the respective component.

Operation at partial load

Operation at partial load may involve smaller mains contactors, fuses and line cross sections.

If defined data for operation at partial load are available, the mains-side phase current can be determined as follows:

1. Determine the **motor power**

   Take power of drive controller-motor combination from Rexroth IndraSize or calculate it.

$$P_{mHa} = \frac{M_n \times n_n}{9550}$$

P_{mHa}	Mechanical nominal power for main drives (shaft output) [kW]
M_n	Nominal motor torque [Nm]
n_n	Nominal motor speed [min^{-1}]

2. Determine the **DC bus power** from motor power and efficiency

$$P_{DC} = \frac{M_m \times n_m \times 2\pi}{60} \times k$$

P_{DC}	Required DC bus continuous power [W]
M_m	Average torque in Nm
n_m	Average speed in min^{-1}
k	Factor for motor and controller efficiency = 1.25

3. Add the **powers of all axes** at the common DC bus and put them into relation to the rated power of the supply unit

   ⇒ Partial load of P_{DC_cont} is known

4. Determine the **power factor TPF** for partial load (TPF = Total Power Factor)

   For the value **TPF** at rated power and **TPF_{10}** (at 10% of rated power), see technical data (mains voltage) of the component.

5. Calculate the **mains connected load**

$$S_{LN} = \frac{P_{DC}}{TPF}$$

S_{LN}	Mains connected load [VA]

P_{DC}	DC bus continuous power [W]
TPF	Total Power Factor λ

6. Calculate the **mains-side phase current**

3-phase: $$I_{LN} = \frac{S_{LN}}{U_{LN}\sqrt{3}}$$

1-phase: $$I_{LN} = \frac{S_{LN}}{U_{LN}}$$

I_{LN}	Mains-side phase current in [A]
S_{LN}	Mains connected load [VA]
U_{LN}	Voltage between phases of mains [V]

7. Select the **mains contactor**
8. Determine the **mains circuit breaker and line cross section**

   See chapter 15.3.5 "Sizing the line cross sections and fuses " on page 254

15.2.2 Calculating the inrush current

For calculating the inrush current, take all devices connected to mains voltage into account. The resulting inrush current is the sum of the inrush currents of the individual devices.

📖 For the data of the **inrush current** $I_{L\_trans\_max\_on}$, see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → chapter of the respective device → "Technical data" → "Basic data" → table "Mains voltage supply data".

Duration of inrush current

For components with resistance charge, the inrush current profile is according to an exponential function. After the delay t_d is over, the charging process is completed.

Data for calculating the delay t_d: See chapter 15.4.1 "Charging the DC Bus" on page 269

15.2.3 Calculations for the mains harmonics

Harmonic load THD

The harmonic load of the mains is described by the THD (Total Harmonic Distortion):

$$THD = \sqrt{\sum_{n=2}^{40}\left(\frac{I_n}{I_1}\right)^2}$$

I_n	Harmonic current of the n-th harmonic
I_1	rms value of the 1st harmonic (fundamental wave)
I_2	rms value of the 2nd harmonic
I_n	rms value of the n-th harmonic

Fig. 15-33: THD (Total Harmonic Distortion)

Harmonic content / distortion factor k

The harmonic content of, for example, the mains current is described by the distortion factor k. The distortion factor contains all alternating components, both those of the fundamental wave (I_1) and of the harmonics (I_k). Direct components (I_0) are not contained.

$$ki = \sqrt{\frac{\sum_{k=2}^{n} I_k^2}{\sum_{k=1}^{n} I_k^2}} = \sqrt{\frac{I_2^2 + I_3^2 + \ldots}{I_1^2 + I_2^2 + I_3^2 \ldots}}$$

ki	Distortion factor or harmonic content
I_k	Harmonic current of the k-th harmonic
I_1	rms value of the 1st harmonic (fundamental wave)
I_2	rms value of the 2nd harmonic

Fig. 15-34: Distortion factor k or harmonic content

Power factor cosφ1 or DPF for calculating the reactive power load of the mains

The power factor cosφ1 or DPF (Distortion Power Factor) is used to calculate the reactive power load of the mains:

$$DPF = \cos\varphi_1 = \frac{P_{netz}}{S_{1LN}}$$

P_{netz}	Active mains power
S_{1LN}	Apparent mains power of fundamental wave

Fig. 15-35: Power factor cosφ1 / DPF

Power factor cosφ or TPF (λ)

The power factor cosφ or TPF is used for dimensioning mains components (transformer, fuse, etc.):

$$TPF = \lambda = \cos\varphi = \frac{P_{netz}}{S_{LN}}$$

P_{netz}	Active mains power
S_{LN}	Apparent mains power

Fig. 15-36: Power factor cosφ / TPF/ λ

☞ Only for sinusoidal values does the power factor cosφ equal the Total Power Factor TPF (λ).

15.2.4 Mains voltage unbalance

The voltage unbalance is described by a three-phase system consisting of the combination of the following systems:

- Clockwise AC system (positive-sequence system U_m)
- Counter-clockwise AC system (negative-sequence system U_g)
- DC system (U_0)

$$\frac{|U_X - U_{AVE}|}{U_{AVE}} \times 100\%$$

U_x	Phase-to-phase voltage with highest deviation from average value
U_{AVE}	= (U12 + U23 + U31) / 3; U12 , U23 , U31 being voltages between the phases

Fig. 15-37: Defining the voltage unbalance

15.2.5 Calculating the allowed continuous power in the common DC bus

By interconnecting the DC bus connections of multiple HCS02 and HLB01 drive controllers, the regenerative power and continuous power generated in the common DC bus are equally distributed to all IndraDrive C devices with braking resistor.

Distribution to the involved devices takes place with high balancing factor.

For central supply and group supply with DC bus connection

$$\sum P_{BD,Geräte} = \sum \left(P_{BD,HCS} + P_{BD,HLB}\right) \times f$$

$P_{BD, Geräte}$	Braking resistor continuous power that all devices at common DC bus can process in continuous operation, in kW
$P_{BD, HCS02}$	Braking resistor continuous power that the drive controller can process in continuous operation, in kW
$P_{BD, HLB01}$	Braking resistor continuous power that the additional braking resistor module can process in continuous operation, in kW
f	Balancing factor for parallel operation

Fig. 15-38: Available braking resistor continuous power at common DC bus

$$\sum P_{ZW,Geräte} = \sum P_{ZW} \times f$$

$P_{ZW, Geräte}$	Available DC bus continuous power at common DC bus, in kW
P_{ZW}	DC bus continuous power of the individual devices, in kW
f	Balancing factor for parallel operation

Fig. 15-39: Available DC bus continuous power at common DC bus

15.3 Determining components in the mains connection

15.3.1 Determining the Mains Choke

When using mains chokes, take their effect on the connected drive controllers into account. Due to their inductance, mains chokes have a smoothing effect on the current and thereby reduce harmonics.

Take the nominal current of the mains choke into account to have the inductance of the mains choke available.

Some mains chokes are assigned to certain drive controllers (see technical data of the drive controller "Data for mains voltage supply → Assigned type of mains choke").

15.3.2 Determining the mains filter

Tool

An Excel-based tool is available for sizing mains filters. If necessary, please ask our sales representative ("FAQ_EMC_mains_filter_application_tool_EN").

To get the basis of calculation of the tool for sizing mains filters, please see the Appendix:

chapter 18.6 "Sizing mains filters (drive system)" on page 290

Criteria for Selecting the Mains Filter

Take the following criteria into account for selecting the appropriate mains filter:

- EMC limit value class on site
- Ambient conditions on site
- Harmonics on mains voltage on site
- Loading by mains voltage and mains frequency on site
- Loading by harmonics on site
- Loading by mains-side phase current
- Total length of connected power cables
- Sum of leakage capacitances
- Clock frequency of drive controller

How to Proceed for Selecting the Mains Filter

The selection of the mains filter is significantly determined by the operating conditions. How to proceed for selecting the mains filter:

1. Determine the required EMC limit value class for the application.
2. Determine the maximum applied mains voltage.
   Observe that not all IndraDrive mains filters are suited for a mains voltage of 3 AC 500 V.

   Check whether the mains voltage of the mains filter is loaded with harmonics and still allowed for the mains filter.

   Allowed operating data depending on existing harmonics: See chapter 18.3 "Emitted Harmonics on Mains Current and Mains Voltage" on page 283

   If necessary, reduce the harmonics on site.
3. Determine the kind of mains connection, such as central supply, group supply etc. (to do this, it is useful to outline the involved components and their interaction).
4. Calculate the **mains-side phase current** of the mains filter.

   Procedure for calculating the mains-side phase current: See chapter 15.2.1 "Calculating the mains-side phase current " on page 248

For selecting the components, calculate the effective rms value.

Check or determine the maximum occurring ambient temperature. Select a mains filter with higher nominal current, when the ambient temperature is above 45 °C.

5. Select a mains contactor the nominal current of which does not exceed nominal current of the mains filter.
6. Determine the number of drive axes.

   An HMD drive controller, for example, counts as two drive axes.
7. Determine the total length of the connected power cables.
8. Determine the sum of the leakage capacitances on the load side of the mains filter. The sum of the leakage capacitances results from the number of operated axes and the length of the connected power cables.

   Procedure for determining the leakage capacitance: See chapter 15.3.6 "Determining the Leakage Capacitance" on page 265
9. Select the appropriate mains connection (supply unit/converter, mains choke, mains filter) from the corresponding tables in chapter 8.3 "Mains connection for supply units and converters" on page 85.

The **capacity of the mains filters** regarding the maximum allowed number of drive controllers and the maximum allowed total power cable length depends on whether you use an HMV supply unit or supply other drive controllers with HCS drive controllers. For supply by an HMV supply unit, the allowed number and allowed total length are higher.

Notes on installation

☞ When using HNF01, NFD03, HNS02 or HNK01 mains filters at **mains grounded via outer conductor**, install an isolating transformer between mains and mains filter.

15.3.3 Determining Mains Transformer DLT

☞ When using HNF01, NFD03, HNS02 or HNK01 mains filters at **mains grounded via outer conductor**, install an isolating transformer between mains and mains filter.

How to Proceed for Selecting the Mains Transformer

The selection of the mains transformer is significantly determined by the conditions at the connection point and the supply unit used.

Procedure

1. Determine S_{k_min} (minimum short circuit power of the mains for failure-free operation) of the supply unit used.

   See Project Planning Manual "IndraDrive Supply Units and Power Sections", "Data for Mains Voltage Supply"
2. In the table "Mains Classified According to Mains Short Circuit Power and Mains Internal Resistance", read the inductance L_{k_min} of the mains phase in row of S_{k_min}.
3. Determine the short circuit power S_k present at the connection point.
4. In the table "Mains Classified According to Mains Short Circuit Power and Mains Internal Resistance", read the inductance of the mains phase in row of S_k.
5. Calculate difference L: L_{k_min} - L_k
6. Calculate apparent power S_{Trafo}:

$S_{Trafo} = (U^2_{LN} \times u_k) / (L \times 6.28 \times f_{LN})$

Relative short-circuit voltage u_k of DLT transformers is approx. 4%.

15.3.4 Mains Contactor and Fusing

To protect the supply mains and the components in the supply feeder (lines, mains contactor, mains filter, mains choke, converter, supply unit, etc.) for the case of a short circuit, install fuses in the supply feeder.

Operation Under Rated Conditions

In operation under rated conditions, the component is operated in individual supply with the rated power P_{DC_cont}.

📖 For the data of **mains contactor**, **fusing** and the required **connection cross section** in operation under rated conditions, see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → Chapter of the respective device → "Technical Data" → "Basic Data" → table "Data for Mains Voltage Supply".

Operation at Partial Load

If several drive controllers are to be operated at partial load (power smaller than rated power) at one mains circuit breaker and one mains contactor only, add the mains-side phase currents and inrush currents calculated for the individual drives and therefor determine the mains circuit breaker.

☞ **Dimensioning the fuse for operation at partial load**

The nominal current of the selected fuse before the drive system mustn't be greater than the mains circuit breaker of the smallest converter or supply unit.

Use more powerful converters or supply units in the drive system.

For dimensioning line cross sections and fuses, see also chapter 15.3.5 "Sizing the line cross sections and fuses " on page 254.

Fusing Branches within the Control Cabinet

In the wiring of the drive system devices, there are branches run from main lines to short circuit protection devices.

In accordance with EN 60204-1:2006, 7.2.8, such supply lines to short circuit protection devices branching off main lines do not need to be especially protected against short circuit, when the following requirements have been fulfilled:

- The supply lines to the short circuit protection device have at least the cross section of the conductors continuing the line from the short circuit protection device (line cross sections from and to motor circuit breaker have the same size).
- No supply line to the short circuit protection device is longer than 3 m.
- The lines are protected against external influence by a housing or a wiring duct.
- The lines are not run close to combustible material.

15.3.5 Sizing the line cross sections and fuses

Introduction

☞ The sizing of the line cross sections described here refers to the **short circuit protection** of the devices and not to the line protection.

Sizing the line cross sections and fuses in the supply feeder and branches to the drive system:

1. Determine the current in the supply feeder of the drive system and correct it with the correction factors for ambient temperature and bundling.
2. Determine the country of use ("international except for USA/Canada" or "USA/Canada")
3. Determine the installation type (e.g., B1 or B2)
4. In the "Current carrying capacity" table row, select the value that is immediately above the value determined in the first step
5. In the "Fuse" table row, read the corresponding fuse
6. In the "Cross section A …" table row, read the corresponding required cross section

International except for USA/Canada; installation type B1

Country of use: international except for USA/Canada				
Fuse I_N [A]			Current carrying capacity (× 0.87) $I_{Z(40)}$ [A]	Cross section A [mm²] Installation type B1
1 ×	2 ×	3 ×		
2			1.6	1.5
4			3.3	1.5
6			5.0	1.5
10			8.6	1.5
16			10.3	1.5
16			13.5	1.5
20			18.27	2.5
35			24.36	4
35			31.32	6
50			43.50	10
80			59.16	16
100			77.43	25
125			95.70	35
160			116.58	50
200			148.77	70
200			180.09	95
250			207.93	120
250			227.94	150
315			257.52	185
355			301.02	240
400			342.78	300
	160		238.03	2 × 70

Country of use: international except for USA/Canada				
Fuse I_N [A]			Current carrying capacity (× 0.87) $I_{Z(40)}$ [A]	Cross section A [mm²] Installation type B1
1 ×	2 ×	3 ×		
	160		288.14	2 × 95
	200		332.69	2 × 120
	200		364.70	2 × 150
	250		412.03	2 × 185
	315		481.63	2 × 240
	315		548.45	2 × 300
		125	312.42	3 × 70
		160	378.19	3 × 95
		160	436.65	3 × 120
		200	478.67	3 × 150
		200	540.79	3 × 185
		250	632.14	3 × 240
		315	719.84	3 × 300

Tab. 15-2: Line cross sections and fuses, B1 according to EN 60204-1:2006, Table 6, for 150mm² and more DIN IEC 60364-5-52:2004, Table B. 52-4

International except for USA/Canada; installation type B2

Country of use: international except for USA/Canada				
Fuse I_N [A]			Current carrying capacity (× 0.87) $I_{Z(40)}$ [A]	Cross section A [mm²] Installation type B2
1 ×	2 ×	3 ×		
2			1.6	0.75
4			3.3	0.75
6			5.0	0.75
10			8.5	0.75
16			10.1	1.0
16			13.05	1.5
20			17.40	2.5
25			23.49	4
35			29.58	6
50			40.02	10
63			53.94	16
80			69.60	25
100			86.13	35
125			102.66	50
160			129.63	70
200			155.73	95
200			179.22	120
224			195.75	150
250			221.85	185
315			258.39	240
355			294.93	300
	125		207.41	2 × 70
	160		249.17	2 × 95
	160		286.75	2 × 120
	200		313.20	2 × 150
	200		354.96	2 × 185
	250		413.42	2 × 240
	315		471.89	2 × 300
		100	272.22	3 × 70
		125	327.03	3 × 95
		160	376.36	3 × 120
		160	411.08	3 × 150

Country of use: international except for USA/Canada				
Fuse I_N [A]			Current carrying capacity (× 0.87) $I_{Z(40)}$ [A]	Cross section A [mm^2] Installation type B2
1 ×	2 ×	3 ×		
		200	465.89	3 × 185
		200	542.62	3 × 240
		250	619.35	3 × 300

Tab. 15-3: Line cross sections and fuses, B2 according to EN 60204-1:2006, Table 6, for 150mm² and more DIN IEC 60364-5-52:2004, Table B. 52-4

International except for USA/Canada; installation type E

Country of use: international except for USA/Canada				
Fuse I_N [A]			Current carrying capacity (× 0.87) $I_{Z(40)}$ [A]	Cross section A [mm^2] Installation type E
1 ×	2 ×	3 ×		
2			1.6	0.75
4			3.3	0.75
6			5.0	0.75
10			8.3	0.75
16			10.4	0.75
16			12.4	1
20			16.10	1.5
25			21.75	2.5
35			29.58	4
50			37.41	6
63			52.20	10
80			69.60	16
100			87.87	25
125			109.62	35
160			133.11	50
200			170.52	70
250			207.06	95
315			240.12	120
355			277.53	150
400			316.68	185
425			374.10	240
500			432.39	300
	160		272.83	2 × 70
	200		331.30	2 × 95
	250		384.19	2 × 120
	250		444.05	2 × 150
	315		506.69	2 × 185
	400		598.56	2 × 240
	400		691.82	2 × 300
		160	358.09	3 × 70
		200	434.83	3 × 95
		200	504.25	3 × 120

Country of use: international except for USA/Canada				
Fuse I_N [A]			Current carrying capacity (× 0.87) $I_{Z(40)}$ [A]	Cross section A [mm^2] Installation type E
1 ×	2 ×	3 ×		
		250	582.81	3 × 150
		250	665.03	3 × 185
		315	785.61	3 × 240
		400	908.02	3 × 300

Tab. 15-4: Line cross sections and fuses, E according to EN 60204-1:2006, table 6, for 150mm² and more DIN IEC 60364-5-52:2004, table B. 52-10

USA/Canada; installation type E

Country of use: USA/Canada					
Fuse I_N				Current carrying capacity I_Z [A]	Cross section A Installation type E
1 ×	2 ×	3 ×	4 ×		
2				1.6	14 AWG
4				3.3	14 AWG
6				5	14 AWG
10				8.3	14 AWG
16				13	14 AWG
20				15	14 AWG
25				20	12 AWG
40				30	10 AWG
70				50	8 AWG
80				65	6 AWG
100				85	4 AWG
110				100	3 AWG
125				115	2 AWG
150				130	1 AWG
175				150	1/0 AWG
200				175	2/0 AWG
225				200	3/0 AWG
250				230	4/0 AWG
300				255	250 kcmil
300				285	300 kcmil
350				310	350 kcmil
350				335	400 kcmil
400				380	500 kcmil
450				420	600 kcmil
600				460	700 kcmil
600				475	750 kcmil
600				490	800 kcmil
600				520	900 kcmil
800				545	1000 kcmil
800				590	1250 kcmil
800				625	1500 kcmil
800				650	1750 kcmil

Country of use: USA/Canada					
Fuse I_N				Current carrying capacity I_Z [A]	Cross section A Installation type E
1 ×	2 ×	3 ×	4 ×		
800				665	2000 kcmil
	200			300	2 × 1/0 AWG
	225			350	2 × 2/0 AWG
	250			400	2 × 3/0 AWG
	300			460	2 × 4/0 AWG
	300			510	2 × 250 kcmil
	350			570	2 × 300 kcmil
	350			620	2 × 350 kcmil
	400			670	2 × 400 kcmil
	450			760	2 × 500 kcmil
	600			840	2 × 600 kcmil
	600			920	2 × 700 kcmil
	600			950	2 × 750 kcmil
	600			980	2 × 800 kcmil
	800			1040	2 × 900 kcmil
	800			1090	2 × 1000 kcmil
		200		450	3 × 1/0 AWG
		225		525	3 × 2/0 AWG
		250		600	3 × 3/0 AWG
		300		690	3 × 4/0 AWG
		300		765	3 × 250 kcmil
		350		855	3 × 300 kcmil
		350		930	3 × 350 kcmil
		400		1005	3 × 400 kcmil
		450		1140	3 × 500 kcmil
			200	600	4 × 1/0 AWG
			225	700	4 × 2/0 AWG
			250	800	4 × 3/0 AWG
			300	920	4 × 4/0 AWG
			300	1020	4 × 250 kcmil
			350	1140	4 × 300 kcmil
			350	1240	4 × 350 kcmil

Country of use: USA/Canada					
Fuse I_N				Current carrying capacity I_Z [A]	Cross section A Installation type E
1 ×	2 ×	3 ×	4 ×		
			400	1340	4 × 400 kcmil
			450	1520	4 × 500 kcmil

Tab. 15-5: Line cross sections and fuses according to UL508A:2007, Table 28.1

Sizing variables of the table values

1. Ambient temperature T_A of routed line ≤ 40 °C
2. Temperature T_L at conductor at nominal current: 90 °C for UL-listed lines (USA/Canada) or 70 °C for PVC lines
3. The nominal current of the fuse is approx. 10-20% above the nominal current I_{LN} of the converter/supply unit or the determined current of the drive system.
4. Installation types:
   - B1 in accordance with IEC 60364-5-52, e.g. stranded wires routed in cable duct
   - B2 in accordance with IEC 60364-5-52, e.g. multi-core line routed in cable duct
   - E in accordance with EN 60204-1, e.g. multi-core line routed on open cable tray
   - In accordance with NFPA 79 (external wiring), UL508A (internal wiring), NEC, NFPA 70:
     – 1 cable with 3 conductors, 1 neutral conductor and 1 equipment grounding conductor
     – Routed in pipe on the wall

     Internal wiring: Routing inside of control cabinet or inside of devices

     External wiring: Routing outside of control cabinet

     Field wiring: Data of cross sections of terminal connectors wired by the user (in the field)
5. Recommendation for fuse design:
   - International except for USA/Canada:
     – Fuse-link in accordance with IEC 60269-1, characteristic gG (fuses)
     – Circuit breakers in accordance with IEC 60898-1/2, type B or C
     – Circuit breakers in accordance with IEC 60947-2/6-2
   - USA/Canada:
     – Use listed AC input line fuses (class J; 600 V AC). Suitable for use on a circuit capable of delivering not more than 42000 A_{rms} symmetrical amperes, 500 Volts maximum. If using inverse-time circuit breakers or type E combination motor controllers instead of recommended fuses, see UL 508C section 45.8.2

☞ **Correction factors**

The corresponding standards specify correction factors for deviating sizing variables.

See tables below for the correction factors for ambient temperature and numbers of routed lines and circuits. If necessary, multiply the determined current in the supply feeder with these factors.

Ambient temperature correction factor

Ambient temperature T_A / °C	30	35	40	45	50	55	60
Correction factor according to EN 60204-1:2006, table D.1	0.87	0.93	1.00	1.1	1.22	1.41	1.73
Correction factor according to NFPA 79:2007, table 12.5.5(a)	0.88	0.94	1.00	1.1	1.18	1.32	1.52

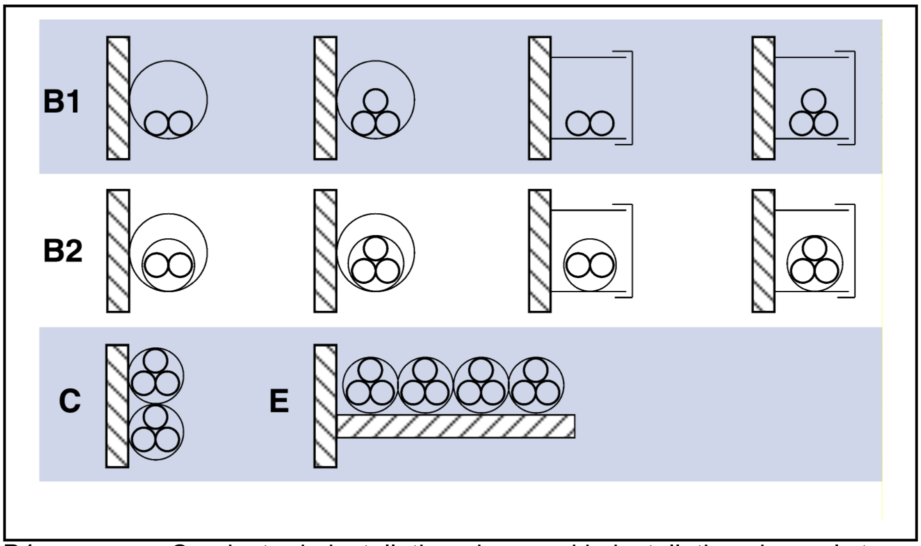
Tab. 15-6: Ambient temperature correction factor in accordance with EN 60204-1:2006 and NFPA 79:2007

Correction factor for bundling lines (installation methods B2 and E) and circuits (installation method B1[1)])

Number of lines	1	2	3	4	5
Correction factor according to EN 60204-1:2006, table D.2	1	1.25	1.43	1.54	1.67
Correction factor according to NFPA 79:2007, table 12.5.5(b)	1	1.25			

1) Three single cores (L1, L2, L3) for mains supply of a device are to be considered as one circuit.

Tab. 15-7: Correction factor for bundling lines and circuits in accordance with EN 60204-1:2006 and NFPA 79:2007



B1 Conductor in installation pipes and in installation channels to be opened
B2 Cables or lines in installation pipes and in installation channels to be opened
C Cables or lines on walls
E Cables or lines on open cable trays.

Fig. 15-40: Installation methods (compare IEC 60364-5-52; VDE0298-7; EN 60204-1)

15.3.6 Determining the Leakage Capacitance

The capacitances which generate so-called leakage currents against ground at the outputs of inverters are regarded as leakage capacitance C_{ab}. The decisive values for the total value C_{ab_g} of the leakage capacitance are:

- Capacitances of output filters
- Capacitances of power cables (capacitance per unit length against shield and ground wire)
- Capacitances of motors (winding capacitance against housing)

The leakage capacitance consists of the values of power cable and motor of all individual drives operated at the mains filter.

Calculation:

$$C_{ab\_g} = C_{ab\_Mg} + C_{ab\_Kg}$$

C_{ab_g} Total value of leakage capacitance
C_{ab_Mg} Total value of leakage capacitance of motor
C_{ab_Kg} Total value of leakage capacitance of cable

Fig. 15-41: Total Leakage Capacitance

The total capacitance $C_{\_ab\_Mg}$ results from the sum of capacitances of the individual motors. For these individual capacitances, see documentation of the motor. For a list of selected values, see Appendix of this documentation under chapter 18.2 "Leakage capacitances" on page 278.

$$C_{ab\_Mg} = C_{ab(Motor\_1)} + C_{ab(Motor\_2)} \cdots + C_{ab(Motor\_n)}$$

$C_{ab(motor)}$ Leakage capacitance of a motor

Fig. 15-42: Total Leakage Capacitance of Motor

$$C_{ab\_Kg} = C_{Y\_K\,typ\,(K1)} \times l_{(K1)} + C_{Y\_K\,typ\,(K2)} \times l_{(K2)} \cdots + C_{Y\_K\,typ\,(Kn)} \times l_{(Kn)}$$

$C_{Y\_K\,typ}$ Capacitance per unit length of cables
C_{ab_Kg} Total leakage capacitance of cables

Fig. 15-43: Total leakage capacitance of cables

The total capacitance $C_{\_ab\_Kg}$ consists of the sum of capacitances of the individual power cables. For the individual capacitances per unit length, see the technical data of the power cables. For a list of selected values, see Appendix of this documentation under chapter 18.2 "Leakage capacitances" on page 278.

15.3.7 Determining the Allowed Operating Data of Mains Filters

Reducing Allowed Operating Voltage Depending on Actual Temperature Rise Due to Harmonics

The mains filters may only be operated in the allowed mains voltage range. Harmonics (f_n) at the system voltage cause additional temperature rise of the dielectric of the capacitors used in the filter. Calculating the temperature rise:

$$\Delta T_n = \frac{10 \times (U_{Mn})^2}{(U_{Gn})^2} [K]$$

U_{Mn} Measured voltage value at frequency fn (harmonic)
U_{Gn} Voltage limit value for frequency fn
ΔT_n Calculated temperature rise of the dielectric for frequency fn

Fig. 15-44: Calculating the Temperature Rise of the Dielectric

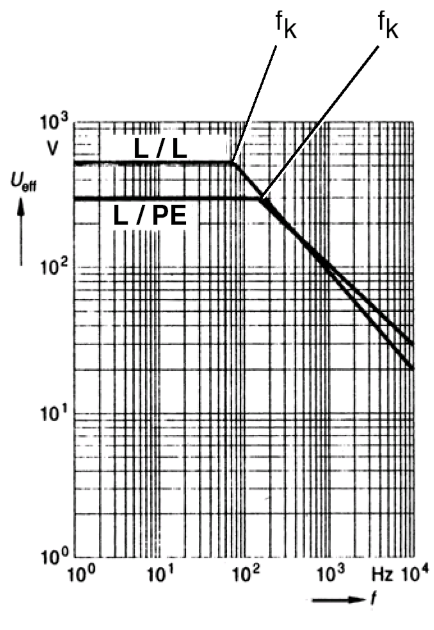
The temperature rises have to be added up for all frequencies $f_n \geq f_k$ (f_k: frequency at which the voltage derating of the filter starts):

$$\Delta T_{ges} = \sum_{\nu=1}^{m} \Delta T_{\nu} = \sum_{\nu=1}^{m} \frac{10 \times (U_{M\nu})^2}{(U_{G\nu})^2} [K] \leq 10 [K]$$

U_{Mv} Voltage value at frequency fv
U_{Gv} Voltage limit value for frequency fv
ΔT_{ges} Calculated temperature rise of the dielectric for all frequencies

Fig. 15-45: Calculating the Temperature Rise of the Dielectric for all Frequencies

With the above formulas and the measured voltages, it is possible to determine the real load of a filter with voltages of higher frequencies. To this end, the rms value of the voltage on the mains side of the filter with all occurring frequencies (higher than f_k) must be measured by means of a Fourier analysis for all combinations of line/line and line/PE. You always have to measure the voltages under conditions of operation at the nominal working point, the filter having been installed. By means of the measured values, it is possible to calculate the temperature rise. To do this, the limit values of the following diagram are read at the respective frequency and used in the formula together with the measured value.



L / L Line / line
L / PE Line / PE

Fig. 15-46: Derating

If the total of the temperature values is greater than 10 K, the harmonics have to be reduced by means of appropriate measures.

Current Reduction in the Case of Overtemperature

The mains filters recommended by Rexroth have been sized for an ambient temperature of 45 °C.

For higher temperatures, reduce the mains current according to the following formula:

$$I = I_{Netz} \times \sqrt{\frac{85 - T_{amb}}{40}}$$

I_{Netz} Nominal current of filter at 45 °C
T_{amb} Ambient temperature on site

Fig. 15-47: Current Reduction in the Case of Overtemperature

15.4 Other calculations

15.4.1 Charging the DC Bus

To **estimate** the delay t_d which a supply unit or a converter needs to charge the DC bus, this applies:

Delay time t_d is the time which passes from connection of mains voltage to the device (from status "ready for operation") to status "drive ready".

(See also parameter "P-0-0115, Device control: status word" or "S-0-0135, Drive status word")

Delay t_d

$$t_d = R_{lade} \times 1,2 \times C_{DC} \times 3 + 200ms$$

t_d	Delay
R_{lade}	Effective charging resistance
C_{DC}	Effective DC bus capacitance
200 ms	Waiting time until charging process is completed

Fig. 15-48: Delay for Three-Phase Operation

The interrelation applies to three-phase mains connection. For single-phase mains operation, take the double time or control following processes via the status "P-0-0115, Device control: status word".

Delay t_d for HCS02

In HCS02 converters, the DC bus is charged via the **integrated** braking resistor $R_{DC\_Bleeder}$.

The delay t_d is approx. 2 seconds, **independent** of the DC bus capacitance.

Effective Charging Resistance with Several Mains Supplies

Effective charging resistance of all drive controllers at common DC bus connected to mains voltage:

$$\frac{1}{R_{lade}} = \frac{1}{R_{lade\_1}} + \frac{1}{R_{lade\_2}} \ldots + \frac{1}{R_{lade\_n}}$$

Fig. 15-49: Several Charging Resistances

Effective Charging Resistance with One Mains Supply

Effective charging resistance of one drive controller at common DC bus connected to mains voltage:

$$R_{lade} = \frac{U_{LN}}{I_{L\_trans\_max\_(on)}}$$

U_{LN}	Applied mains voltage
$I_{L\_trans\_max\_(on)}$	Inrush current at applied mains voltage

Fig. 15-50: Charging Resistance

Charging resistance of HCS03 converters

In HCS03.1E-W0070…0150 converters, the DC bus is charged via **integrated** resistors for charging current limitation, and in HCS03.1E-W0210 converters, it is charged via a thyristor circuit:

$$R_{lade} = \frac{U_{LN}}{I_{L\_trans\_max\_(on)}}$$

The charging ability is limited by the properties of the integrated resistor; its resistance value clearly rises with increasing thermal load.

For the data of the **inrush current** $I_{L\_trans\_max\_on}$ and the **mains voltage** U_{LN}, see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → Chapter of the respective device → "Technical Data" → "Basic Data" → table "Data for Mains Voltage Supply".

Resulting DC Bus Capacitance

Effective DC bus capacitance of all devices at common DC bus:

$$C_{DC} = C_{DC1} + C_{DC2} \ldots + C_{DCn} + C_{DCext}$$

C_{DC} Capacitance in DC bus

Fig. 15-51: DC Bus Capacitance

For the data of the **capacitance in DC bus** C_{DC}, see Project Planning Manual "Rexroth IndraDrive Supply Units and Power Sections" → Chapter of the respective device → "Technical Data" → "Basic Data" → table "Data of Power Section - DC bus".

15.4.2 Calculating the speed characteristic and braking time with DC bus short circuit (ZKS)

Components equipped with the ZKS function (e.g., HLB01) short-circuit the DC bus via the braking resistor when the DC bus short circuit (ZKS) is active. At synchronous motors with permanent magnet excitation, the short circuit causes speed-dependent braking torque.

The braking torque and the braking time can be estimated with the following formulas.

The calculation formulas below can only be applied to rotary motors for which, in addition, the relation L_d / L_q has to be approx. 1.

Basic formula 1

$$\omega_0 = 2\pi \frac{n_0}{60}$$

ω_0 [Initial angular velocity motor] = s^{-1}

n_0 [Motor speed at beginning of ZKS] = min^{-1}

Fig. 15-52: Initial angular velocity

Basic formula 2

$$R' = R_S + \frac{R_{DC\_Bleeder}\pi^2}{18}$$

R´	[Transformed resistance] = Ω
R_S	[Winding resistance motor] = Ω; see P-0-4048 *0.5
$R_{DC\_Bleeder}$	[Effective braking resistance with ZKS] = Ω

Fig. 15-53: Transformed resistance

Occurring torque

$$M_{\max} = \frac{K_M^{\ 2}}{6 * z_p * L}$$

M_{max}	Maximum occurring torque (friction not taken into account)
K_M	[Torque constant motor] = Nm/A; see P-0-0051
L	[Winding inductance motor] = H; see P-0-4016
z_p	Number of pole pairs motor; see P-0-0018

Fig. 15-54: Occurring torque

Braking torque vs. angular velocity

$$M(\omega) = \frac{K_M^{\ 2} * \omega * R'}{3(R'^2 + L^2 * z_p^{\ 2} * \omega^2)}$$

K_M	[Torque constant motor] = Nm/A; see P-0-0051
ω	[Angular velocity motor] = s^{-1}
R´	[Transformed resistance] = Ω
L	[Winding inductance motor] = H; see P-0-4016
z_p	Number of pole pairs motor; see P-0-0018

Fig. 15-55: Braking torque depending on angular velocity

Braking torque vs. speed

$$M(n) = \frac{K_M^{\ 2} * \pi * n * R'}{90 * \left(R'^2 + \frac{L^2 * z_p^{\ 2} * n^2 * \pi^2}{900}\right)}$$

K_M	[Torque constant motor] = Nm/A; see P-0-0051
n	[Motor speed] = min^{-1}
R´	[Transformed resistance] = Ω
L	[Winding inductance motor] = H; see P-0-4016
z_p	Number of pole pairs motor; see P-0-0018

Fig. 15-56: Braking torque depending on motor speed

Braking time from initial velocity to specific speed

$$t_s(X) \approx \frac{3 * J_{red}}{R' * K_M^2} * \left[\frac{z_p^2 * L^2 * \omega_0^2}{2} * \left(\frac{X^2}{10^4} - 1 \right) + R'^2 * \ln\left(\frac{X}{100} \right) \right]$$

t_s	[Braking time] = s
J_{red}	[Inertia from load and motor at motor shaft] = kgm²
R´	[Transformed resistance] = Ω
K_M	[Torque constant motor] = Nm/A; see P-0-0051
z_p	Number of pole pairs motor; see P-0-0018
L	[Winding inductance motor] = H; see P-0-4016
ω_0	[Initial angular velocity motor] = s^{-1}
X	[Part of initial speed] = %

Fig. 15-57: Duration from initial speed to speed X

Calculation with X = 0 results in infinite braking time, because the theoretical speed characteristic is an asymptote tending to 0. The motor nevertheless comes to standstill, because in practical application a friction torque takes effect in addition to the braking torque due to ZKS (DC bus short circuit).

☞ **Check calculation by performing a measurement**

The calculation provides a result which can be used for the first estimation of the braking behavior. Other influences, such as energy balance in the DC bus, tolerances and environmental influences, take effect on the actually occurring braking behavior.

Measure the actually occurring braking time in the installation!

16 Environmental protection and disposal

16.1 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
- Steel
- Aluminum
- Copper
- Plastics
- Electronic components

Motors
- Steel / Stainless steel
- Aluminum
- Copper
- Brass
- Magnetic materials
- Elektronic components

16.2 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

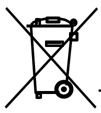
Packaging

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.

17 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)

18 Appendix

18.1 System elements - product overview, short designations

Short designation	System element / product	Description
CSB01.1	Control section single-axis	Scope of functions BASIC
CDB01.1	Control section double-axis	
CSH01.1, CSH01.2, CSH01.3	Control section single-axis	Scope of functions ADVANCED
CSB02.1	Control section single-axis (2nd generation)	Scope of functions BASIC
CDB02.1	Control section double-axis (2nd generation)	
CSH02.1	Control section single-axis (2nd generation)	Scope of functions ADVANCED
CSE02.1	Control section single-axis (2nd generation)	Scope of functions ECONOMY
CZ 1.2	Additional capacitor	Capacitor with touch guard
DLT	Isolating transformer	
DST	Matching transformer	
HAT01	Control module for motor holding brake	Is used for the "Safe braking and holding system"
HAB01	Fan unit	Fan to be mounted to certain HMV01 and HMS01
HAC01	Housing for control sections	
HAS01	Basic accessory	Accessories for connecting the components (contact bars, fixing material …)
HAS02	Shield connection	Accessory for connecting shielded motor cables to power sections
HAS03	Control cabinet adapter	Accessory for adjusting the mounting depth
HAS04	Capacitor	Accessory DC bus capacitors against ground potential
HAS05	Cables, connectors, adapters	Accessories to adjust electrical interfaces
HAS06	Closure coupling, closure fitting, tube piece	Connection accessories for liquid cooling
HCS02.1	Drive controller	Converter
HCS03.1	Drive controller	Converter
HLB01.1C	DC bus resistor unit	For IndraDrive C
HLB01.1D	DC bus resistor unit	For IndraDrive M
HLC01.1C	DC bus capacitor unit	For IndraDrive C
HLC01.1D	DC bus capacitor unit	For IndraDrive M
HLR01	Braking resistor	
HMD01.1	Drive controller	Power section, double-axis
HMF01.1	Motor filter	
HMS01.1	Drive controller	Power section, single-axis

Short designation	System element / product	Description
HMS02.1	Drive controller	Power section, single-axis
HMV01.1E	Supply unit	Supply unit, feeding
HMV01.1R	Supply unit	Supply unit, feeding and regenerative
HMV02.1R	Supply unit	Supply unit, feeding and regenerative
HMV02.1E	Supply unit	Supply unit, feeding
HNF01.1	Mains filter	
HNL01.1	Mains choke	Designs for feeding systems (E) Regenerative systems (R) in current-compensated design
HNL02.1	Mains choke	Mains choke with housing for control cabinet mounting
HNS02.1	Mains filter	Mains filter with integrated switch-disconnector and motor circuit breaker
HNK01.1	Mains filter	Mains filter with integrated mains choke, variant for mounting
MPB	Firmware	Scope of functions BASIC
MPD	Firmware	Scope of functions BASIC, double-axis
MPH	Firmware	Scope of functions ADVANCED
MSK	Synchronous motor	
NFD03.1	Mains filter	
RKL	Ready-made cable	Ready-made motor power cable
RKS	Ready-made cable	Ready-made control cable
RKG	Ready-made cable	Ready-made encoder cable
RKH	Ready-made cable	System cable of IndraDrive Mi product range
VCP01	Comfort operator terminal	Variant to be plugged on
VCP02	Control panel	Variant for assembly
VCP05	Control panel	Variant for assembly
VCP08	Control panel	Variant for assembly
VCP20	Control panel	Variant for assembly
VCP25	Control panel	Variant for assembly

Tab. 18-1: Product short designations

18.2 Leakage capacitances

18.2.1 Leakage capacitance of motors

The data of the typical leakage capacitance refer to the total capacitance of the power connections U, V, W against the motor housing. The tables below contain excerpts from the technical data of motors:

Leakage capacitance

Type	Leakage capacitance of the component C_{ab} nF
MSM019A-0300-NN-__-___	0.3
MSM019B-0300-NN-__-___	0.7
MSM031B-0300-NN-__-___	0.7
MSM031C-0300-NN-__-___	1.4
MSM041B-0300-NN-__-___	1.3
	Last modification: 2008-11-20

Tab. 18-2: MSM019A-0300-NN,MSM019B-0300-NN

Type	Leakage capacitance of the component C_{ab} nF
MSK030B-0900-NN-__-___-____	0.7
MSK030C-0900-NN-__-___-____	1.3
MSK040B-0450-NN-__-___-____	1.3
MSK040C-0450-NN-__-___-____	2.0
MSK043C-0600-NN-__-___-____	2.1
MSK050B-0300-NN-__-___-____	2.1
MSK050C-0300-NN-__-___-____	2.6
MSK060B-0300-NN-__-___-____	2.1
MSK060C-0300-NN-__-___-____	2.1
MSK061B-0300-NN-__-___-____	1.8
MSK061C-0300-NN-__-___-____	2.4
MSK070C-0150-NN-__-___-____	3.8
MSK070D-0150-NN-__-___-____	5.0
	Last modification: 2012-09-17

Type	Leakage capacitance of the component
	C_{ab} nF
MSK070E-0150-NN-__-___-____	6.3
MSK071C-0200-FN-__-___-____	4.6
MSK071D-0200-FN-__-___-____	6.9
MSK071E-0200-FN-__-___-____	8.9
MSK075C-0200-NN-__-___-____	3.8
MSK075D-0200-NN-__-___-____	4.6
MSK075E-0200-NN-__-___-____	5.8
MSK076C-0300-NN-__-___-____	6.5
MSK100A-0200-NN-__-___-____	4.8
MSK100B-0200-NN-__-___-____	10.3
MSK100C-0200-NN-__-___-____	12.8
MSK100D-0200-NN-__-___-____	17.6
MSK101C-0200-FN-__-___-____	6.2
MSK101D-0200-FN-__-___-____	13.2
MSK101E-0200-FN-__-___-____	15.2
MSK103A-0300-NN-__-___-____	1.5
MSK103B-0300-NN-__-___-____	2.1
MSK103D-0300-NN-__-___-____	6.0
	Last modification: 2012-09-17

Type	Leakage capacitance of the component
	C_{ab} nF
MSK131B-0200-NN-__-___-____	14.3
MSK131D-0200-NN-__-___-____	27.7
	Last modification: 2012-09-17

Tab. 18-3: MSK - leakage capacitance (excerpt)

See also Rexroth IndraDyn - Technical data.

18.2.2 Leakage capacitance of power cables

The power cables (bulk cables) of the "RKL" series by Rexroth have the capacitances per unit length listed below. The values refer to the sum of the individual capacitances of power cores 1, 2 and 3 against the overall shield.

See also Rexroth Connection Cables - Data sheet Bulk cable.

Excerpt of data sheet - bulk cables

Type	Power core cross section	Leakage capacitance
	mm^2	$C_{Y\_K\_typ}$ nF/m
INK0653	1.0	0.6
INK0650	1.5	0.8
INK0602	2.5	0.7
INK0603	4.0	0.8
INK0604	6.0	0.8
INK0605	10.0	1.0
INK0606	16.0	1.2
INK0607	25.0	1.1
INK0667	35.0	1.2
INK0668	50.0	1.3
		Last modification: 2007-11-08

Tab. 18-4: INK - technical data (excerpt)

Excerpt of data sheet - bulk cables

Type	Power core cross section	Leakage capacitance $C_{Y\_K\_typ}$
	mm^2	nF/m
REH0800	2.5	0.2
REL0105	1.0	0.42
REL0106	1.5	
REL0107	2.5	

Tab. 18-5: REH/REL - technical data (excerpt)

☞ The rough calculation with the following values is allowed:

- Cross section 1 … 6 mm^2: 1 nF/m
- Cross section 10 … 50 mm^2: 1.2 nF/m

18.3 Emitted Harmonics on Mains Current and Mains Voltage

18.3.1 General Information

Due to their electric design, the drive controllers and supply units generate harmonics in the mains current and on the mains voltage during operation at the mains. Using appropriate mains chokes decisively influences power factors and mains harmonics.

18.3.2 Harmonics of Mains Current

Harmonics of Supply Units, In-feeding (HMV…E and HCS)

The harmonics of the mains current are decisively reduced by the use of mains chokes.

For mains with mains frequency f_{LN} = 60 Hz, the values accordingly are multiples of f_{LN} = 60 Hz.

Formulas see chapter "Calculations".

		Without mains choke			With HNL Mains choke			With mains choke of higher inductance 1.7 x L_N of HNL		
	I_{L_cont}	5%	50%	100%	5%	50%	100%	5%	50%	100%
k	f	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1
	Hz	%	%	%	%	%	%	%	%	%
1	50	100%	100%	100%	100%	100%	100%	100%	100%	100%
2	100	3	2	1	2	1	0,2	2	1	0,5
3	150	9	3	2	8	2	1	7	2	1
4	200	1	2	1	1	1	0,2	1	1	0,5
5	250	95	90	85	84	70	61	71	55	38
6	300	3	2	1	2	2	0,5	2	1	0,5
7	350	85	80	75	71	40	36	58	28	13
8	400	3	3	1	1	2	0,5	1	2	0,5
9	450	2	2	1	6	1	1	5	1	0,5
10	500	1	1	1	1	1	0,5	1	1	0,5
11	550	70	60	50	40	6	4,2	27	7	6,5
12	600	1	1	1	1	1	0,5	1	1	1
13	650	46	55	45	28	5	5,1	17	5	3
14	700	2	2	1	1	1	1	2	1	1
15	750	2	1	1	1	1	1	2	1	1
16	800	1	1	1	1	1	0,5	2	1	1
17	850	30	25	20	1	0,5	0,5	6	3	2,5
18	900	1	1	1	1	0,5	0,5	1	1	1
19	950	20	13	10	1	0,5	0,5	7	1	2

		Without mains choke			With HNL Mains choke			With mains choke of higher inductance 1.7 x L_N of HNL		
	I_{L_cont}	5%	50%	100%	5%	50%	100%	5%	50%	100%
k	f	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1
	Hz	%	%	%	%	%	%	%	%	%
20	1000	2	2	1	0,5	0,5	0,5	2	1	1
21	1050	2	1	1	0,5	0,5	0,5	1	1	1
22	1100	1	1	1	0,5	0,5	0,5	1	0,5	0,5
23	1150	10	8	5	0,5	0,5	0,5	0,5	0,5	0,5
24	1200	1	1	1	0,5	0,5	0,5	0,5	0,5	0,5
25	1250	8	5	3	0,5	0,5	0,5	0,5	0,5	0,5
26	1300	2	2	1	0,5	0,5	0,5	0,5	0,5	0,5
27	1350	2	1	1	0,5	0,5	0,5	0,5	0,5	0,5
28	1400	1	1	1	0,5	0,5	0,5	0,5	0,5	0,5
29	1450	5	3	2	0,5	0,5	0,5	0,5	0,5	0,5
30	1500	1	1	1	0,5	0,5	0,5	0,5	0,5	0,5
31	1550	3	2	1	0,5	0,5	0,5	0,5	0,5	0,5
32	1600	1	1	0,5	0,5	0,5	0,5	0,5	0,5	0,5
33	1650	1	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
34	1700	1	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
35	1750	3	1	0,5	0,5	0,5	0,5	0,5	0,5	0,5
36	1800	1	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
37	1850	2	1	0,5	0,5	0,5	0,5	0,5	0,5	0,5
38	1900	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
39	1950	1	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
40	2000	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
41	2050	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
42	2100	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
43	2150	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
44	2200	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
45	2250	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
46	2300	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
47	2350	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
48	2400	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
49	2450	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
50	2500	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5

		Without mains choke			With HNL Mains choke			With mains choke of higher inductance 1.7 x L_N of HNL		
	I_{L_cont}	5%	50%	100%	5%	50%	100%	5%	50%	100%
k	f	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1	Ik/I1
	Hz	%	%	%	%	%	%	%	%	%
THD	%	173,08	156,32	144,86	120,86	81,18	71,24	98,08	62,61	41,12
ki		0,87	0,84	0,82	0,77	0,63	0,58	0,70	0,53	0,38

k — k = 1: Fundamental wave; k ≥ 2: Harmonics number
I_{L_cont} — Maximum input current (mains input continuous current), see technical data of device - Data for Mains Voltage Supply
ki — Distortion factor or harmonic content
I_k — Harmonic current of the k-th harmonic
I_1 — rms value of the 1st harmonic (fundamental wave)
THD — Total Harmonic Distortion

Tab. 18-6: Harmonics HMV…E and HCS

Harmonics of Supply Units, Regenerative (HMV…R)

☞ In the end application, the harmonics values are within the minimum and maximum values listed below. The harmonics values depend on

- Load distribution
- Conditions in the mains
- Mains pollution which other devices feed in the mains

If the degree of mains pollution generated by other devices is low, the resulting values of the harmonics in the mains current of the drive system are minimum values. If there is a high degree of mains pollution generated by other devices, the maximum values of the table can be reached in the worst case.

		Ik/I1		
k	f	Min.	Typ.	Max.
	Hz	%	%	%
1	50	100%	100%	100%
2	100	2,5	4	25
3	150	2	5	25
4	200	2	3	25
5	250	2	17	35
6	300	2	2	30
7	350	1,6	7	30
8	400	1	2	12
9	450	1	2	10
10	500	1	2	8

		Ik/I1		
k	f	Min.	Typ.	Max.
	Hz	%	%	%
11	550	1	5	12
12	600	1	2	7
13	650	1	2	6
14	700	1	2	3
15	750	1	2	3
16	800	0,5	2	3
17	850	0,5	2	3
18	900	0,5	2	3
19	950	0,5	2	3
20	1000	0,5	2	2
21	1050	0,5	1	2
22	1100	0,5	1	2
23	1150	0,5	1	2
24	1200	0,5	1	2
25	1250	0,5	1	2
26	1300	0,5	1	1
27	1350	0,5	1	1
28	1400	0,5	1	1
29	1450	0,5	1	1
30	1500	0,5	0,5	1
31	1550	0,5	0,5	1
32	1600	0,5	0,5	1
33	1650	0,5	0,5	0,5
34	1700	0,5	0,5	0,5
35	1750	0,5	0,5	0,5
36	1800	0,5	0,5	0,5
37	1850	0,5	0,5	0,5
38	1900	0,5	0,5	0,5
39	1950	0,5	0,5	0,5
40	2000	0,5	0,5	0,5
41	2050	0,5	0,5	0,5
42	2100	0,5	0,5	0,5
43	2150	0,5	0,5	0,5
44	2200	0,5	0,5	0,5

		Ik/I1		
k	f	Min.	Typ.	Max.
	Hz	%	%	%
45	2250	0,5	0,5	0,5
46	2300	0,5	0,5	0,5
47	2350	0,5	0,5	0,5
48	2400	0,5	0,5	0,5
49	2450	0,5	0,5	0,5
50	2500	0,5	0,5	0,5
THD	%	6,45	21,89	74,34
ki		0,06	0,21	0,60

Min. Values in the case of a low degree of mains pollution by other devices
Typ. Values in the case of standard applications in industrial mains
Max. Values in the case of a high degree of mains pollution by other devices
k k = 1: Fundamental wave; k ≥ 2: Harmonics number
I_{L_cont} Maximum input current (mains input continuous current), see technical data of device - Data for Mains Voltage Supply
ki Distortion factor or harmonic content
I_k Harmonic current of the k-th harmonic
I_1 rms value of the 1st harmonic (fundamental wave)
THD Total Harmonic Distortion

Tab. 18-7: Harmonics HMV01.1R

18.3.3 Harmonics on Mains Voltage

The voltage harmonics depend on the structure of the mains, especially on the mains inductance or the mains short-circuit power at the connection point. At different mains and mains connection points, one device can cause different voltage harmonics.

For a normal mains, the harmonics content of the mains voltage when operating drives generally is below 10%. Short-time drops in mains voltage are below 20%.

More precise values can only be calculated with exact knowledge of the mains data (mains topology), such as line inductance and line capacitance related to the connection point.

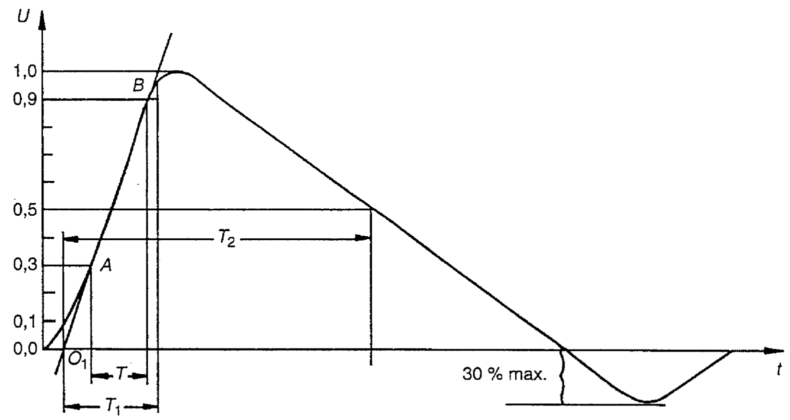
These values, however, can temporally vary quite strongly, according to the switch status of the mains. The harmonics of the mains voltage thereby change, too.

Rough estimated values of the mains data are not sufficient for pre-calculation of the harmonics, as mainly the resonance points always present in the mains have a strong influence on the harmonics content.

In order to keep the degree of mains voltage harmonics as low as possible, you should, if possible, not connect capacitors or compensation units (capacitor batteries) directly to the mains. If capacitors or compensation units are absolutely required, you should only connect them to the mains via chokes.

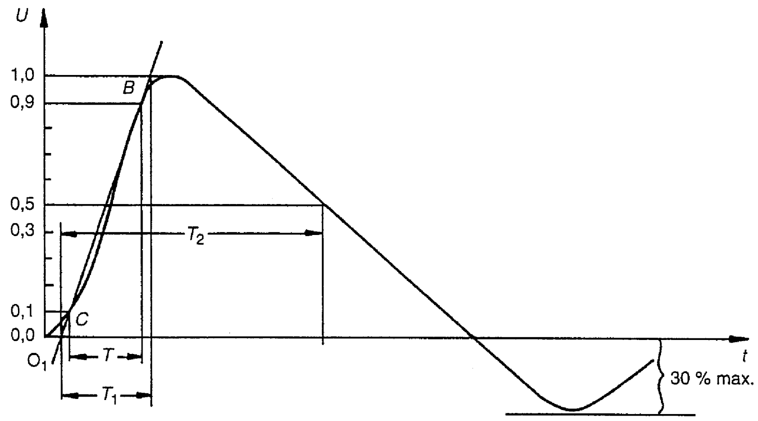
18.4 Voltage pulse for test according to EN61000

The figure below shows the voltage pulse for defining the impulse withstand voltage according to EN61000.



front time: $T_1 = 1.67 \cdot T = 1.2\ \mu s \pm 30\ \%$
halftime: $T_2 = 50\ \mu s \pm 20\ \%$

Pulse shape of voltage at no load (1.2/50 µs)
(Definition of pulse shape acc. to IEC 60-1)



front time: $T_1 = 1.25 \cdot T = 8\ \mu s \pm 20\ \%$
halftime: $T_2 = 20\ \mu s \pm 20\ \%$

Pulse shape of voltage at no load (8/20 µs)
(Definition of pulse shape acc. to IEC 60-1)

Fig. 18-1: Impulse withstand voltage 1.2 / 50 µs and 8 / 20 µs according to EN 61000

18.5 Discharging capacitors

18.5.1 Discharging DC bus capacitors

Capacitors as energy buffers

In the Rexroth IndraDrive system, capacitors are used in the DC bus as energy buffers. In drive controllers and particularly in supply units, such capacitors have already been integrated.

Energy buffers maintain their energy even when the supply voltage has been cut off, and have to be discharged before somebody gets in contact with them.

If additional capacitors (such as DC bus capacitor units) are connected, these capacitors, too, have to be discharged before somebody gets in contact with them.

Discharge time

Discharging devices have been integrated in the components of the Rexroth IndraDrive system. Within the specified discharge time, these devices discharge the voltage below the allowed 50 V.

Due to the operating principle, the discharge time is the longer

- the bigger the energy buffer (the capacitance value)
- the higher the voltage to which the energy buffer has been charged
- the greater the resistance for discharging the capacitors

Components of the Rexroth IndraDrive system have been sized in such a way that after the supply voltage was cut off, the voltage value falls below 50 V within a discharge time of a maximum of **30 minutes**.

HMV01 and ZKS

When using HMV01 supply units (exception: HMV01.1R-W0120), you can take the following measure to reduce the waiting time until the voltage has fallen below 50 V:

Activate the "ZKS" function (ZKS = DC bus short circuit)

18.6 Sizing mains filters (drive system)

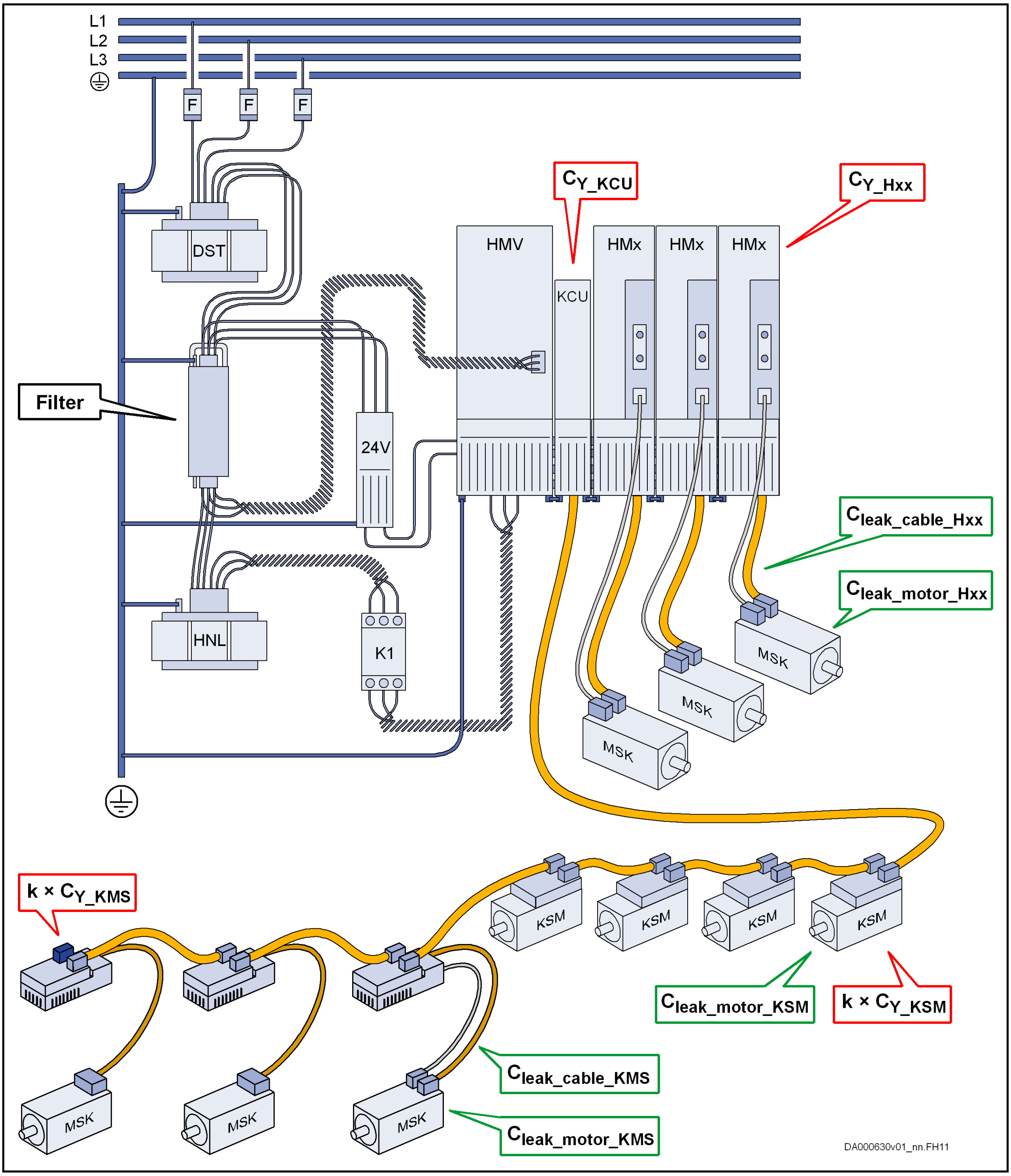
☞ The data are not binding. Further criteria are relevant for sizing mains filters (mains voltage, mains current, mains frequency, ambient temperature, harmonics on the mains voltage, EMC limit value class, PWM of the drives …).

Therefore, check the determined values using the up-to-date specifications in the corresponding product documentation, and observe the Project Planning Manual "Rexroth IndraDrive Drive Systems with HMV01/02 HMS01/02, HMD01, HCS02/03" (R911309636).

An Excel-based tool is available for sizing mains filters. If necessary, please ask our sales representative ("FAQ_EMC_mains_filter_application_tool_EN").

Drive system

In the drive system described below, the components IndraDrive M (HMS, HMD) or IndraDrive C/Cs (HCS) are operated together with IndraDrive Mi (KCU, KSM, KMS) components.



C_Y	Y-capacitance
C_{leak}	Leakage capacitance
k	Hybrid cable damping factor

Fig. 18-2: Drive system

☞ For the C_Y and C_{leak} capacitances of the components please see the end of this chapter.

Mains filter: Sizing rule

$C_{Y\_limit} \geq C_{Y\_sum}$	$C_{leak\_limit} \geq C_{leak\_sum}$
C_{Y_limit}: Limit value of mains filter regarding C_Y C_{Y_sum}: C_Y sum of drive system	C_{leak_limit}: Limit value of mains filter regarding leakage capacitance C_{leak_sum}: Sum of leakage capacitances of drive system

Tab. 18-8: Mains filter: Sizing rule

Mains filter: Limit values

Mains filter	C_{Y_limit} [nF]	C_{leak_limit} [nF]
HNF01.2D-M900	4080	1100
HNF01.2D-F240	2450	290
HNF01.1A-H350	2040	450
NFD03.1	1200	100
NFE02.1 1)	378	90
KNK03	2200	226

1) Cannot be used with IndraDrive Mi; can only be used for single-phase operation (1 × 230 V AC, nominal current: 8 A)

Tab. 18-9: Mains filter: Limit values

C_{Y_sum}

$C_{Y\_sum} = C_{Y\_KCU} + C_{Y\_Hxx} + k \times [C_{Y\_KMS} + C_{Y\_KSM}]$
C_{Y_sum}: C_Y sum C_{Y_KCU}: C_Y KCU C_{Y_Hxx}: C_Y HMS/HMD or HCS sum C_{Y_KMS}: C_Y KMS sum C_{Y_KSM}: C_Y KSM sum k: Hybrid cable damping factor

Tab. 18-10: C_{Y_sum}

Hybrid cable damping factor

Mains filter	k
HNF01.2D-F0240-Rxx	1.20
HNF01.2D-F0240-Exx	0.72
HNF01.2D-M900-Rxx	0.80
HNF01.2D-M900-Exx	0.61
HNF01.1A-H350-Rxx	1.00
NFD03.1	1.15
NFE02.1 [1)]	-
KNK03.1	1.00

1) Cannot be used with IndraDrive Mi

Tab. 18-11: Hybrid cable damping factor

C_{leak_sum}

$C_{leak\_sum} = C_{leak\_cable\_Hxx} + C_{leak\_motor\_Hxx} + C_{leak\_cable\_KMS} + C_{leak\_motor\_KMS} + C_{leak\_motor\_KSM}$
C_{leak_sum}: Sum of leakage capacitances $C_{leak\_cable\_Hxx}$: Sum of leakage capacitance, standard motor power cable by Rexroth at HMS/HMD or HCS $C_{leak\_motor\_Hxx}$: Sum of leakage capacitance, MSK motor by Rexroth at HMS/HMD or HCS $C_{leak\_cable\_KMS}$: Sum of leakage capacitance, standard motor power cable by Rexroth at KMS $C_{leak\_motor\_KMS}$: Sum of leakage capacitance, MSK motor by Rexroth at KMS $C_{leak\_motor\_KSM}$: Sum of leakage capacitance, KSM

Tab. 18-12: C_{leak_sum}

IndraDrive Mi capacitances

Component	C_Y [nF]	$C_{leak\_motor\_KSM}$ [nF]
KSM02.1B-041C-42	150	1.4
KSM02.1B-061C-35	150	2.4
KSM02.1B-061C-61	150	2.2
KSM02.1B-071C-24	150	5.0
KSM02.1B-071C-35	150	4.7
KSM02.1B-076C-35	150	6.9
KMS02.1B-A018	218	-
KMS03.1B-A036	200	-
KMS03.1B-B036	200	-
KCU02.1N	200	-
KCU02.2N	200	-
KMV03	350	-

Tab. 18-13: IndraDrive Mi capacitances

IndraDrive C/Cs capacitances

Component	C_Y [nF]
HCS01.1E-W0003-A-02	136
HCS01.1E-W0006-A-02	136
HCS01.1E-W0009-A-02	136
HCS01.1E-W0013-A-02	136
HCS01.1E-W0018-A-02	200
HCS01.1E-W0005-A-03	136
HCS01.1E-W0008-A-03	136
HCS01.1E-W0018-A-03	200
HCS01.1E-W0028-A-03	200
HCS01.1E-W0054-A-03	200
HCS02.1E-W0012	200
HCS02.1E-W0028	200
HCS02.1E-W0054	200
HCS02.1E-W0070	200
HCS02.1E-W0100	200
HCS03.1E-W0070	200
HCS03.1E-W0150	200
HCS03.1E-W0210	200
HCS03.1E-W0280	200
HCS03.1E-W0350	200

Tab. 18-14: IndraDrive C/Cs capacitances

IndraDrive M capacitances

Component	C_Y [nF]
HMS01.1N-W0020	136
HMS01.1N-W0036	136
HMS01.1N-W0054	136
HMS01.1N-W0070	136
HMS01.1N-W0110	200
HMS01.1N-W0150	200
HMS01.1N-W0210	200
HMS01.1N-W0300	200
HMS01.1N-W0350	200
HMS01.2N-W0028	136
HMS01.2N-W0054	136
HMD01.1N-W0012	136

Component	C_Y [nF]
HMD01.1N-W0020	136
HMD01.1N-W0036	136

Tab. 18-15: IndraDrive M capacitances

Cables, capacitances

Cable	C_{leak_cable} [nF/m]
INK653 (1.0 mm^2)	0.6
INK650 (1.5 mm^2)	0.8
INK602 (2.5 mm^2)	0.7
INK603 (4.0 mm^2)	0.8
INK604 (6.0 mm^2)	0.8
INK605 (10.0 mm^2)	1.0
INK606 (16.0 mm^2)	1.2
INK607 (25.0 mm^2)	1.1
INK667 (35.0 mm^2)	1.2
INK668 (50.0 mm^2)	1.3
REL0105 (1.0 mm^2)	0.4
REL0753 (1.0 mm^2)	0.4
REL0106 (1.5 mm^2)	0.4
REL0107 (2.5 mm^2)	0.4
REL0108 (4.0 mm^2)	0.5
REL0109 (6.0 mm^2)	0.5
REL0110 (10.0 mm^2)	0.5
REL0111 (16.0 mm^2)	0.6
REL0112 (25.0 mm^2)	0.6
REL0113 (35.0 mm^2)	0.6
REH0804 (1.5 mm^2)	0.4

Tab. 18-16: Cables, capacitances

Motor, capacitances

Motor	C_{leak_motor} [nF]
MAD100B-0050	6.0
MAD100B-0100	5.7
MAD100B-0150	5.7
MAD100B-0200	6.0
MAD100B-0250	6.0

Motor	C_{leak_motor} [nF]
MAD100C-0050	9.0
MAD100C-0100	8.5
MAD100C-0150	8.1
MAD100C-0200	8.5
MAD100C-0250	9.2
MAD100D-0050	11.0
MAD100D-0100	11.0
MAD100D-0150	10.2
MAD100D-0200	11.5
MAD100D-0250	11.9
MAD130B-0050	16.0
MAD130B-0100	15.8
MAD130B-0150	15.8
MAD130B-0200	16.1
MAD130B-0250	17.4
MAD130C-0050	20.0
MAD130C-0100	20.9
MAD130C-0150	20.5
MAD130C-0200	19.3
MAD130C-0250	20.1
MAD130D-0050	27.5
MAD130D-0100	27.3
MAD130D-0150	30.5
MAD130D-0200	27.5
MAD130D-0250	26.4
MAD160B-0050	25.5
MAD160B-0100	35.0
MAD160B-0150	35.0
MAD160B-0200	34.4
MAD160C-0050	28.0
MAD160C-0100	24.4
MAD160C-0150	27.2
MAD160C-0200	32.3
MAD180C-0050	29.2
MAD180C-0100	25.2
MAD180C-0150	28.3

Motor	C_{leak_motor} [nF]
MAD180C-0200	31.6
MAD180D-0050	38.0
MAD180D-0100	38.4
MAD180D-0150	35.9
MAD180D-0200	38.0
MAD225C-0050	120.0
MAD225C-0100	48.5
MAD225C-0150	126.0
MAF100B-0050	6.0
MAF100B-0100	6.0
MAF100B-0150	6.0
MAF100B-0200	6.0
MAF100B-0250	6.0
MAF100C-0050	8.5
MAF100C-0100	8.5
MAF100C-0150	8.6
MAF100C-0200	8.5
MAF100C-0250	9.4
MAF100D-0050	11.0
MAF100D-0100	11.2
MAF100D-0150	11.0
MAF100D-0200	10.0
MAF100D-0250	9.2
MAF130B-0050	16.0
MAF130B-0100	16.0
MAF130B-0150	16.0
MAF130B-0200	11.6
MAF130B-0250	13.2
MAF130C-0050	20.0
MAF130C-0100	15.4
MAF130C-0150	20.0
MAF130C-0200	16.8
MAF130C-0250	20.0
MAF130D-0050	27.5
MAF130D-0100	26.7
MAF130D-0150	27.5

Motor	C_{leak_motor} [nF]
MAF130D-0200	25.1
MAF130D-0250	28.6
MAF160B-0050	26.9
MAF160B-0100	35.0
MAF160B-0150	35.0
MAF160B-0200	21.7
MAF160C-0050	28.0
MAF160C-0100	28.0
MAF160C-0150	28.8
MAF160C-0200	25.3
MAF180C-0050	32.5
MAF180C-0100	35.9
MAF180C-0150	30.0
MAF180C-0200	38.9
MAF180D-0050	37.4
MAF180D-0100	38.0
MAF180D-0150	30.3
MAF180D-0200	50.0
MAF225C-0050	40.0
MAF225C-0100	39.7
MAF225C-0150	43.9
MCP015A-L040	0.3
MCP015B-L040	0.3
MCP020B-V180	0.2
MCP020B-V720	0.3
MCP020C-V180	0.3
MCP020D-V720	0.3
MCP030B-V180	0.4
MCP030B-V390	0.4
MCP030C-V180	0.4
MCP030C-V390	0.4
MCP030D-V180	0.4
MCP030D-V390	0.4
MCP040A-V300	0.2
MCP040B-V070	0.3
MCP040B-V300	0.3

Motor	C_{leak_motor} [nF]
MCP040C-V070	0.4
MCP040C-V300	0.4
MCP040E-V070	0.5
MCP040E-V300	0.5
MCP040G-V070	0.4
MCP040G-V300	0.4
MCP070C-V050	0.4
MCP070C-V300	0.4
MCP070D-V050	0.5
MCP070D-V300	0.7
MCP070F-V050	0.6
MCP070F-V300	0.7
MCP070M-V050	1.4
MCP070M-V230	1.4
MLP040A-0300	0.9
MLP040B-0150	1.3
MLP040B-0250	1.3
MLP040B-0300	1.6
MLP052A-0300	1.8
MLP052B-0300	3.1
MLP070A-0150	2.2
MLP070A-0220	2.2
MLP070A-0300	2.3
MLP070B-0100	2.9
MLP070B-0120	2.9
MLP070B-0150	2.9
MLP070B-0250	2.9
MLP070B-0300	2.9
MLP070C-0120	4.2
MLP070C-0150	4.2
MLP070C-0240	4.2
MLP070C-0300	4.2
MLP100A-0090	4.1
MLP100A-0120	4.1
MLP100A-0150	4.1
MLP100A-0190	4.1

Motor	C_{leak_motor} [nF]
MLP100B-0120	6.0
MLP100B-0250	6.0
MLP100C-0090	7.9
MLP100C-0120	7.9
MLP100C-0190	7.9
MLP100K-0040	4.1
MLP102B-0060	6.0
MLP102C-0060	7.9
MLP102D-0060	9.8
MLP140A-0120	5.8
MLP140B-0090	8.4
MLP140B-0120	8.2
MLP140C-0050	11.1
MLP140C-0120	11.1
MLP140C-0170	11.1
MLP140C-0350	11.1
MLP140Z-0060	3.0
MLP152A-0060	18.0
MLP152B-0060	20.0
MLP152C-0060	22.0
MLP152D-0060	23.7
MLP200A-0090	8.2
MLP200A-0120	8.2
MLP200B-0040	12.0
MLP200B-0120	12.0
MLP200C-0090	15.8
MLP200C-0120	15.9
MLP200C-0170	15.8
MLP200D-0060	19.2
MLP200D-0100	19.6
MLP200D-0120	19.6
MLP300A-0090	12.3
MLP300A-0120	12.3
MLP300B-0070	18.0
MLP300B-0120	18.0
MLP300C-0060	23.7

Motor	C_{leak_motor} [nF]
MLP300C-0090	23.7
MLP300Z-0090	9.5
ML3P03-A_BW	1.4
ML3P03-B_BW	1.6
ML3P03-D_BW	2.1
ML3P03-F_BN	2.5
ML3P03-F_BU	2.5
ML3P06-B_BK	1.2
ML3P06-B_BR	1.2
ML3P06-C_BC	1.6
ML3P06-C_BR	1.6
ML3P06-D_BK	2.0
ML3P06-D_BR	2.0
ML3P06-E_BK	2.3
ML3P06-E_BR	2.3
ML3P06-F_BK	2.7
ML3P06-F_BR	2.7
ML3P06-H_BK	3.4
ML3P06-H_BR	3.4
ML3P11-D_BF	2.9
ML3P11-D_BQ	2.9
ML3P11-E_BC	3.5
ML3P11-E_BQ	3.5
ML3P11-L_BC	6.4
ML3P11-L_BQ	6.4
MSK030B-0900	0.7
MSK030C-0900	1.3
MSK040B-0450	1.3
MSK040B-0600	1.5
MSK040C-0450	2.0
MSK040C-0600	2.0
MSK050B-0300	2.1
MSK050B-0450	1.4
MSK050B-0600	2.1
MSK050C-0300	2.6
MSK050C-0450	2.4

Motor	C_{leak_motor} [nF]
MSK050C-0600	2.6
MSK060B-0300	2.1
MSK060B-0600	2.1
MSK060C-0300	2.1
MSK060C-0600	2.2
MSK061B-0300	1.8
MSK061C-0200	2.7
MSK061C-0300	2.4
MSK061C-0600	2.1
MSK070C-0150	3.8
MSK070C-0300	4.0
MSK070C-0450	3.1
MSK070D-0150	5.0
MSK070D-0300	4.5
MSK070D-0450	4.5
MSK070E-0150	6.3
MSK070E-0300	3.5
MSK070E-0450	6.7
MSK071C-0200	4.6
MSK071C-0300	4.6
MSK071C-0450	4.2
MSK071D-0200	6.9
MSK071D-0300	7.2
MSK071D-0450	7.8
MSK071E-0200	8.9
MSK071E-0300	9.3
MSK071E-0450	9.5
MSK075C-0300	3.2
MSK075C-0450	3.5
MSK075D-0200	4.6
MSK075D-0300	4.7
MSK075D-0450	4.7
MSK075E-0200	5.8
MSK075E-0300	6.5
MSK076C-0300	6.5
MSK076C-0450	6.0

Motor	C_{leak_motor} [nF]
MSK100A-0200	4.8
MSK100A-0300	4.6
MSK100A-0450	4.9
MSK100B-0200	10.3
MSK100B-0300	9.3
MSK100B-0400	10.3
MSK100B-0450	10.3
MSK100C-0200	12.8
MSK100C-0300	14.3
MSK100C-0450	13.2
MSK100D-0200	17.6
MSK100D-0300	16.0
MSK100D-0350	18.0
MSK101C-0200	6.2
MSK101C-0300	6.2
MSK101C-0450	6.8
MSK101D-0200	13.2
MSK101D-0300	9.1
MSK101D-0450	13.2
MSK101E-0200	15.2
MSK101E-0300	16.7
MSK101E-0450	16.7
MSK103A-0300	1.5
MSK103B-0300	2.1
MSK103D-0300	6.0
MSK131B-0200	14.3
MSK131D-0200	27.7
MSK133B-0202	14.4
MSK133B-0203	10.7
MSK133C-0202	15.2
MSK133C-0203	15.2
MSK133D-0202	16.4
MSK133D-0203	18.4
MSK133E-0202	24.3
MSK133E-0203	22.6
MSM019A-0300	0.3

Motor	C_{leak_motor} [nF]
MSM019B-0300	0.7
MSM031B-0300	0.7
MSM031C-0300	1.4
MSM041B-0300	1.3
MSS102B-0800	
MSS102D-0800	
MSS102F-0300	
MSS102F-0800	
MSS142B-0700	
MSS142D-0700	
MSS142F-0700	7.4
MSS162B-0400	2.5
MSS162D-0400	3.9
MSS162F-0310	7.0
MSS162J-0200	6.3
MSS182A-0100	1.0
MSS182A-0250	0.6
MSS182B-0280	4.2
MSS182D-0260	5.4
MSS182F-0200	7.8
MSS202A-0200	4.4
MSS202B-0150	5.9
MSS202B-0210	5.9
MSS202D-0170	7.3
MSS202F-0120	10.2
MSS242B-0100	8.2
MSS242D-0070	7.8
MSS242F-0060	14.4
MSS272B-0065	12.8
MSS272B-0080	
MSS272D-0050	10.3
MSS272F-0040	20.5
MSS312B-0035	19.9
MSS312D-0028	24.9
MSS312D-0060	24.9
MSS312F-0028	29.8

Motor	C_{leak_motor} [nF]
MSS312H-0025	36.5
MSS312H-0085	36.5
MSS382B-0025	34.0
MSS382D-0020	44.8
MSS382F-0018	53.4
MST130A-0200	2.2
MST130A-0250	2.2
MST130C-0050	6.6
MST130C-0075	6.6
MST130C-0200	
MST130E-0020	10.9
MST130E-0035	10.9
MST130G-0035	15.3
MST160A-0050	4.4
MST160C-0050	11.7
MST160E-0050	17.5
MST210A-0027	4.8
MST210C-0027	9.5
MST210C-0050	9.5
MST210D-0070	13.3
MST210E-0027	19.0
MST210R-0010	8.2
MST210E-0035	8.2
MST290B-0018	8.4
MST290D-0002	15.6
MST290D-0004	12.6
MST290D-0018	14.7
MST290E-0004	21.0
MST290E-0018	20.0
MST360B-0018	9.0
MST360D-0012	13.5
MST360D-0018	13.5
MST360D-0045	14.0
MST360E-0018	20.0
MST450B-0012	9.6
MST450D-0006	14.5

Motor	C_{leak_motor} [nF]
MST450D-0012	14.5
MST450E-0006	24.1
MST450E-0012	24.1
MST530B-0010	10.1
MST530C-0010	15.2
MST530E-0010	23.0
MST530G-0006	50.7
MST530G-0007	50.7
MST530G-0010	50.7
MST530L-0006	76.1
MST530L-0007	76.1
MS2C03-K0BYN	3.0
MS2E03-B0BYN	0.8
MS2E03-D0BYN	1.6
MS2E04-B0BNN	1.1
MS2E04-B0BTN	1.1
MS2E04-C0BTN	1.8
MS2E05-B0BTN	1.2
MS2E05-C0BTN	1.5
MS2E05-D0BRN	3.3
MS2E06-C0BNN	1.2
MS2E06-D0BNN	5.0
MS2E06-D0BRN	2.6
MS2E06-E0BRN	3.9
MS2E07-C0BQN	2.2
MS2E07-D0BNN	4.0
MS2E07-D0BRN	4.0
MS2E07-E0BNN	6.1
MS2E07-B0BQN	6.2
MS2N03-B0BYN	0.8
MS2N03-D0BYN	1.6
MS2N04-B0BNN	1.1
MS2N04-B0BTN	1.1
MS2N04-C0BNN	2.2
MS2N04-C0BTN	1.8
MS2N04-D0BHN	3.0

Motor	C_{leak_motor} [nF]
MS2N04-D0BQN	3.2
MS2N05-B0BNN	1.3
MS2N05-BOBTN	1.2
MS2N05-C0BNN	1.8
MS2N05-C0BTN	1.5
MS2N05-D0BHN	3.3
MS2N05-D0BRN	3.3
MS2N06-B1BNN	0.6
MS2N06-C0BNN	1.2
MS2N06-C0BTN	1.2
MS2N06-D0BNN	5.0
MS2N06-D1BNN	1.8
MS2N06-D0BRN	2.6
MS2N06-E0BHN	3.0
MS2N06-E0BRN	3.9
MS2N07-C0BQN	2.2
MS2N07-C1BNN	1.9
MS2N07-D0BHN	4.1
MS2N07-D1BHN	3.1
MS2N07-D0BRN	4.0
MS2N07-D1BNN	3.0
MS2N07-E0BHN	7.1
MS2N07-E0BNN	6.1
MS2N07-E0BQN	6.2
MS2N07-E1BNN	4.7
MS2N07-E1BHA	4.7
MS2N07-D0BNN	4.0
MS2N07-D1BHA	3.1
MS2N07-D1BHB	3.1
MS2N07-D1BNA	3.0
MS2N07-D1BNB	3.0
MS2N07-E0BNA	6.1
MS2N07-E0BNB	6.1
MS2N07-E0BQA	6.2
MS2N07-E0BQB	6.2
MS2N10-C0BHN	1.9

Motor	C_{leak_motor} [nF]
MS2N10-C0BNN	2.0
MS2N10-D0BHN	3.2
MS2N10-D0BNN	4.1
MS2N10-E0BNN	6.2
MS2N10-E1BNN	5.0
MS2N10-F0BHN	8.7
MS2N10-C0BNA	2.0
MS2N10-C0BNB	2.0
MS2N10-D0BHA	3.2
MS2N10-D0BHB	3.2
MS2N10-D0BNA	4.1
MS2N10-D0BNB	4.1
MS2N10-D1BNA	3.3
MS2N10-D1BNB	3.3
MS2N10-E0BHA	6.2
MS2N10-E0BHB	6.2
MS2N10-E0BNA	6.2
MS2N10-E0BNB	6.2
MS2N10-E1BNA	5.0
MS2N10-E1BNB	5.0
MS2N10-F0BHA	8.7
MS2N10-F0BHB	8.7
MS2N10-F1BHA	6.7
MS2N10-F1BHB	6.7

Tab. 18-17: Motor, capacitances

Glossary, definitions of terms, abbreviations

Accessories

The accessories are assigned to the corresponding device in order to support its functioning. For example, the basic accessories belong to each drive controller and supply unit to fasten them and connect them electrically.

Additional components

Additional components complement supply units, converters and inverters. Typical additional components are mains chokes, mains filters and braking resistors, for example.

Basic control section circuit board

The basic control section circuit board is the main part of the control section. It has its own interfaces and, in the case of configurable control sections, additional optional slots for optional modules.

Brake chopper

Electronics used to control a braking resistor.

Braking resistor

During deceleration, a braking resistor converts the kinetic energy of a motor into thermal energy. When the response voltage is exceeded, the braking resistor is connected to the DC bus voltage by the brake chopper.

Cable

A cable is a combination of several strands which is kept together by the cable jacket. A typical type of cable is the cable for the motor connection.

Capacitance against housing

Drive controllers and supply units have capacitances against housing C_y which are primarily determined by capacitors at the DC bus (L+, L-). In the drive system, these capacitors form a low-impedance path back to the device for the leakage currents.

Closed-loop (CL)

Closed-loop describes the **closed-loop-controlled** operation of motors, for example with field-oriented control. This operation is possible both in sensorless form and with encoder and is distinguished with regard to its applications.

Sensorless, i.e. without additional encoder, for **velocity** control, for example by means of observer.

With encoder, i.e. with additional encoder, for **velocity** and **position** control of synchronous motors and asynchronous motors in field-oriented operation.

Combination
Combination refers to a combination of components which is formed via a common DC bus or common mains connection. Components such as mains choke, mains transformer and mains filter are used in common.

Common DC bus
Voltage source backed up with powerful capacitors to supply drive controllers with power voltage. "Common" means that the DC bus connections of the involved devices are interconnected.

Configuration
Configuration describes a specific combination of optional modules to form a configured control section which is ideally suited for the intended application.

Connection point of equipment grounding conductor
The connection point of the equipment grounding conductor is the connection point at which the equipment grounding conductor is fixed to the component; the connection point is identified with the symbol ⏚.

Control panel
A control panel is a unit for operating a device. A control panel has input and output elements, such as a key panel and a display.

Control section
The control section is a separate component which is plugged into the power section. The control section processes the signals of the connected components (field bus, encoder system, control panel, etc.). Control sections differ with regard to their performance, function and configuration.

Converter, frequency converter
Drive controller which generates three-phase alternating voltage with **variable** amplitude and frequency from the mains voltage with **fixed** amplitude and frequency in order to set the speed of three-phase a.c. motors, for example. Contains the fundamental stages mains rectifier, DC bus and inverter.

Display
The display is part of the control panel for visual output of information.

Drive controller
Device with which a motor can be operated. Umbrella term for converter or inverter.

Electric drive system
An electric drive system is the entirety of interconnected hardware, firmware and software components that have an influence on the sequence of motions of an installation or machine. The electric drive system consists of, for example, supply units, drive controllers, plug-in control units, motors, encoder

systems, as well as auxiliary and additional components (mains filter, mains choke, braking resistors, etc.).

Encoder

Part of an electric drive system which determines the actual value of a value to be controlled.

Equipment grounding conductor

The equipment grounding conductor establishes the conductive connection from the connection point of the equipment grounding conductor of the component to the equipment grounding system.

Equipment grounding system

The equipment grounding system is the entire equipment by which the equipment grounding conductors of components are connected to the equipment grounding conductor of the mains. In the majority of cases, an earth-circuit connector belongs to the equipment grounding system.

FMEA

Failure Mode and Effects Analysis

Hybrid cable

In a hybrid cable, both electrical signals are transmitted on copper wires and optical signals are transmitted on fiber optic cables.

Inverter

Device which generates three-phase alternating voltage with variable amplitude and frequency from the DC bus direct voltage.

Leakage capacitance

The capacitances which generate so-called leakage currents against ground at the outputs of inverters are regarded as leakage capacitance C_{ab}.

The total value of the leakage capacitance is mainly determined by the capacitances in output filters, capacitances of the motor cables (capacitance per unit length against shield and ground wire) and the capacitances of motors (winding capacitance against housing).

Line

A line consists of an electric conductor and its insulation. Sheathed lines are also called cables.

Master communication

Master communication is the specific communication between hierarchical communication levels. By means of master communication, command variables (e.g., command values) are transmitted from a higher-level control unit to receivers, and actual values, for example, are transmitted back to the control unit.

Open-loop (OL)

Open-loop describes the **open-loop-controlled** operation of asynchronous motors at frequency converters in **V/Hz [U/f] operation** without encoder at the motor. This is the simplest operation of asynchronous motors.

Optional module

By means of optional modules, configurable control sections are equipped with various functions. For example, there are optional modules for master communications (e.g., SERCOS), encoder evaluations, I/O extensions, safety technologies, control panels and storage media.

Optional slot

Slot in the control section into which an optional module can be plugged. Only configurable control sections have optional slots.

PELV

"**P**rotectiv **E**xtra **L**ow **V**oltage" circuits provide protection against electric shock and according to standard must comply with specific requirements. Among other things, live parts and exposed conductive parts of PELV circuits must be separated from the primary circuit by means of double or reinforced insulation.

Power section

The power section is a separate component which contains all the important power elements of the drive controller. Power section and control section form a drive controller.

SCCR

Short **C**ircuit **C**urrent **R**atio

SMPS

Switched **M**ode **P**ower **S**upply

Supply unit

Device which provides power supply to drive controllers. For disconnection from the supply mains, it often contains a mains contactor or provides the signals required to control an external mains contactor.

Third-party supply unit

Supply units which do not belong to the "IndraDrive" product range.

UPS

An **u**ninterruptible **p**ower **s**upply is used to ensure the supply of electric loads in the case of disturbances in the power network.

V/Hz [U/f] operation

Operation in which the drive controller generates variable voltage and frequency in order to set the speed of three-phase a.c. motors, for example.

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Notes

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