LXM28

Common DC bus
Application note

V1.00, 05.2015

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Green Premium™ Product

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All pertinent state, regional, and local safety regulations must be observed when installing and using this product. For reasons of safety and to help ensure compliance with documented system data, only the manufacturer should perform repairs to components.

When devices are used for applications with technical safety requirements, the relevant instructions must be followed.

Failure to use Schneider Electric software or approved software with our hardware products may result in injury, harm, or improper operating results.

Failure to observe this information can result in injury or equipment damage.

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Safety Information

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of this symbol to a DANGER safety label indicates that an electrical hazard exists, which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety instructions that follow this symbol to avoid possible injury or death.

Hazard categories

Safety instructions to the user are highlighted by safety alert symbols in the manual. In addition, labels with symbols and/or instructions are attached to the product that alert you to potential hazards.

Four hazard categories exist depending on the criticality and nature of the hazard.

DANGER

DANGER indicates a hazardous situation, which, if not avoided, **will result** in death or serious injury.

WARNING

WARNING indicates a hazardous situation, which, if not avoided, **could result** in death, serious injury, or equipment damage.

CAUTION

CAUTION indicates a hazardous situation, which, if not avoided, **could result** in injury or equipment damage.

NOTICE

NOTICE indicates a hazardous situation, which, if not avoided, **can result** in equipment damage.

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Qualification of personnel

Only appropriately trained persons who are familiar with and understand the contents of this manual and all other pertinent product documentation are authorized to work on and with this product. In addition, these persons must have received safety training to recognize and avoid hazards involved. These persons must have sufficient technical training, knowledge and experience and be able to foresee and detect potential hazards that may be caused by using the product, by changing the settings and by the mechanical, electrical and electronic equipment of the entire system in which the product is used.

All persons working on and with the product must be fully familiar with all applicable standards, directives, and accident prevention regulations when performing such work.

No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

Intended use

The functions described in this document are only intended for use for the products described in this document.

The product may only be used in compliance with all applicable safety regulations and directives, the specified requirements and the technical data.

Prior to using the product, you must perform a risk assessment in view of the planned application. Based on the results, the appropriate safety measures must be implemented.

Since the product is used as a component in an entire system, you must ensure the safety of persons by means of the design of this entire system (for example, machine design).

Operate the product only with the specified cables and accessories. Use only genuine accessories and spare parts.

Any use other than the use explicitly permitted is prohibited and can result in hazards.

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel.

Product Related Information

The use and application of the information contained herein require expertise in the design and programming of automated control systems.

Only you, the user, machine builder or integrator, can be aware of all the conditions and factors present during installation and setup, operation, repair and maintenance of the machine or process.

You must also consider any applicable standards and/or regulations with respect to grounding of all equipment. Verify compliance with any safety information, different electrical requirements, and normative

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standards that apply to your machine or process in the use of this equipment.

Many components of the equipment, including the printed circuit board, operate with mains voltage, or present transformed high currents, and/or high voltages.

The motor itself generates voltage when the motor shaft is rotated.

⚠ ⚠ DANGER

HAZARD DUE TO ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Only qualified personnel may install, adjust, repair and maintain this equipment.
- Do not touch any connectors, contacts, terminals, unshielded components or printed circuit boards while the equipment is under power.
- Use only electrically insulated tools.
- Block the motor shaft to prevent rotation prior to performing any type of work on the drive system.
- Insulate both ends of unused conductors of the motor cable to help prevent AC voltage from coupling to unused conductors in the motor cable.
- Do not short across the DC bus terminals or the DC bus capacitors.
- Before performing work on the drive system:
  - Disconnect all power, including external control power that may be present.
  - Place a "Do Not Turn On" label on all power switches.
  - Lock all power switches in the open position.
  - Wait 15 minutes to allow the DC bus capacitors to discharge.
  - Measure the voltage on the DC bus as per chapter "DC bus voltage measurement" and verify the voltage is less than 42 Vdc.
  - Do not assume that the DC bus is voltage-free when the DC bus LED is off.
- Refit/replace and secure all covers, accessories, hardware, cables, and wires and verify that a proper ground connection exists before applying power to the unit.

Failure to follow these instructions will result in death or serious injury.

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⚠ WARNING

LOSS OF CONTROL

- The designer of any control scheme must consider the potential failure modes of control paths and, for certain critical functions, provide a means to achieve a safe state during and after a path failure. Examples of critical control functions are emergency stop, overtravel stop, power outage and restart.
- Separate or redundant control paths must be provided for critical functions.
- System control paths may include communication links. Consideration must be given to the implication of unanticipated transmission delays or failures of the link.
- Observe all accident prevention regulations and local safety guidelines. [1)]
- Each implementation of the product must be individually and thoroughly tested for proper operation before being placed into service.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

1) For USA: Additional information, refer to NEMA ICS 1.1 (latest edition), “Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control” and to NEMA ICS 7.1 (latest edition), “Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems”.

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DC bus voltage measurement

The DC bus voltage can exceed 400 Vdc. The DC bus LED is not an indicator of the absence of DC bus voltage.

DANGER

ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Disconnect the voltage supply to all connections.
- Wait 15 minutes to allow the DC bus capacitors to discharge.
- Use a properly rated voltage-sensing device for measuring (greater than 400 Vdc).
- Measure the DC bus voltage between the DC bus terminals (PA/+ and PC/-) to verify that the voltage is less than 42 Vdc.
- Contact your local Schneider Electric representative if the DC bus capacitors do not discharge to less than 42 Vdc within a period of 15 minutes.
- Do not operate the product if the DC bus capacitors do not discharge properly.
- Do not attempt to repair the product if the DC bus capacitors do not discharge properly.
- Do not assume that the DC bus is voltage-free when the DC bus LED is off.

Failure to follow these instructions will result in death or serious injury.

Applicable Standards and Terminology

The products described in the present document are designed to specific standards and the technical terms, terminology, symbols and the corresponding descriptions in this manual are intended to use the terms or definitions of those pertinent standards.

In the area of functional safety systems, drives and general automation, this may include, but is not limited to, terms such as "safety", "safety function", "safe state", "fault", "fault reset", "malfunction", "failure", "error", "error message", "dangerous", etc.

Among others, these standards include:

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Standard	Description
EN 61131-2:2007	Programmable controllers, part 2: Equipment requirements and tests.
ISO 13849-1:2008	Safety of machinery: Safety related parts of control systems. General principles for design.
EN 61496-1:2013	Safety of machinery: Electro-sensitive protective equipment. Part 1: General requirements and tests.
IEC 62061:2005	Safety of machinery. Functional safety of safety-related electrical, electronic, and programmable electronic control systems
ISO 12100:2010	Safety of machinery - General principles for design - Risk assessment and risk reduction
EN 60204-1:2006	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
EN 1088:2008 ISO 14119:2013	Safety of machinery - Interlocking devices associated with guards - Principles for design and selection
ISO 13850:2006	Safety of machinery - Emergency stop - Principles for design
EN/IEC 62061:2005	Safety of machinery - Functional safety of safety-related electrical, electronic, and electronic programmable control systems
IEC 61508-1:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems: General requirements.
IEC 61508-2:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems: Requirements for electrical/electronic/programmable electronic safety-related systems.
IEC 61508-3:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems: Software requirements.
IEC 61784-3:2008	Digital data communication for measurement and control: Functional safety field buses.
2006/42/EC	Machinery Directive
2004/108/EC	Electromagnetic Compatibility Directive
2006/95/EC	Low Voltage Directive

In addition, terms used in the present document may tangentially be used as they are derived from other standards such as:

Standard	Description
IEC 61800 series	Adjustable speed electrical power drive systems
IEC 61158 series	Digital data communications for measurement and control – Fieldbus for use in industrial control systems

Finally, the term "zone of operation" may be used in conjunction with the description of specific hazards, and is defined as it is for a "hazard zone" or "danger zone" in the EC Machinery Directive (EC/2006/42) and ISO 12100-1:2010.

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About the book

This document describes how several Schneider Electric drives type LXM28 can share a common DC bus.

The information provided in this document supplements the manuals. Before beginning, fully read and understand the manuals of the products used.

Source manuals

The latest versions of the manuals can be downloaded from the Internet at:

http://www.schneider-electric.com

Work steps

If work steps must be performed consecutively, this sequence of steps is represented as follows:

- ■ Special prerequisites for the following work steps
- ▶ Step 1
- ◁ Specific response to this work step
- ▶ Step 2

If a response to a work step is indicated, this allows you to verify that the work step has been performed correctly.

Unless otherwise stated, the individual steps must be performed in the specified sequence.

Making work easier

Information on making work easier is highlighted by this symbol:

Sections highlighted this way provide supplementary information on making work easier.

SI units

Technical data are specified in SI units. Converted units are shown in parentheses behind the SI unit; they may be rounded.

Example:
Minimum conductor cross section: 1.5 mm^2 (AWG 14)

Glossary

Explanations of special technical terms and abbreviations.

Index

List of keywords with references to the corresponding page numbers.

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1 Introduction

A drive system requires energy for acceleration or constant movement that must be supplied to the system.

During deceleration, a motor acts as a generator. A considerable portion of the kinetic energy is re-generated as electrical energy.

Since electrical energy can only be stored to a limited extent in a single drive, a drive uses a braking resistor to transform the excess energy into thermal energy.

Use of electrical energy

If an application operates with multiple drive systems, it may be useful to employ a common DC bus. By sharing a common DC bus, the energy regenerated by one drive can be supplied to another drive.

Common DC bus

Whether or not a common DC bus makes sense depends on the acceleration and deceleration cycles of the drive systems.

A common DC bus is useful, for example, if one drive systems accelerates or moves at constant velocity while another drive system decelerates.

If, for example, the drive systems accelerate or decelerate at the same time, a common DC bus does not make sense.

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1.1 Permissible device types for common DC bus

The DC bus of drives with identical numbers of mains phases can be connected.

Incorrect use of the DC bus may permanently damage the drives either immediately or over time.

⚠ WARNING

DESTRUCTION OF SYSTEM COMPONENTS

- Only connect the DC bus of single-phase drives to the DC bus of other single-phase drives.
- Connect single-phase drives that are interconnected via the DC bus to the same phase.
- Only connect the DC bus of three-phase drives to the DC bus of other three-phase drives
- Do not connect three-phase and single-phase drives via the same DC bus.
- Only connect the DC bus of drives with identical nominal voltages.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Only the drives listed in the table below may be connected via a common DC bus:

Drives connected via a single-phase	LXM28AUA5M3X LXM28AU01M3X LXM28AU02M3X LXM28AU04M3X LXM28AU07M3X LXM28AU10M3X LXM28AU15M3X
Drives connected via three phases	LXM28AUA5M3X LXM28AU01M3X LXM28AU02M3X LXM28AU04M3X LXM28AU07M3X LXM28AU10M3X LXM28AU15M3X LXM28AU20M3X LXM28AU30M3X LXM28AU45M3X

⚠ WARNING

DESTRUCTION OF SYSTEM COMPONENTS

Do not connect the DC bus of drives specified in this manual to drives of a different type or to drives of another manufacturer.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

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2 Technical Data

2.1 DC bus data

2.1.1 DC bus data for drives connected via a single phase

LXM28•...		UA5	U01	U02	U04	U07	U10	U15
Nominal voltage (single-phase)	Vac	230	230	230	230	230	230	230
Nominal voltage DC bus	Vdc	322	322	322	322	322	322	322
Undervoltage limit	Vdc	160	160	160	160	160	160	160
Overvoltage limit	Vdc	420	420	420	420	420	420	420
Maximum continuous power via DC bus	W	50	100	200	400	750	1000	1500
Maximum continuous current via DC bus	A	0.2	0.3	0.6	1.2	2.3	3.1	4.6

2.1.2 DC bus data for drives connected via three phases

LXM28•...		UA5	U01	U02	U04	U07
Nominal voltage (three-phase)	Vac	230	230	230	230	230
Nominal voltage DC bus	Vdc	322	322	322	322	322
Undervoltage limit	Vdc	160	160	160	160	160
Overvoltage limit	Vdc	420	420	420	420	420
Maximum continuous power via DC bus	W	50	100	200	400	750
Maximum continuous current via DC bus	A	0.2	0.3	0.6	1.2	2.3

LXM28•...		U10	U15	U20	U30	U45
Nominal voltage (three-phase)	Vac	230	230	230	230	230
Nominal voltage DC bus	Vdc	322	322	322	322	322
Undervoltage limit	Vdc	160	160	160	160	160
Overvoltage limit	Vdc	420	420	420	420	420
Maximum continuous power via DC bus	W	1000	1500	2000	3000	4500
Maximum continuous current via DC bus	A	3.1	4.6	6.2	9.2	13.8

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2.2 Braking resistor

The device has an internal braking resistor. If the internal braking resistor is insufficient for the dynamics of the application, one or more external braking resistors must be used.

The resistance values for external braking resistors must not be below the specified minimum resistance. If an external braking resistor is activated by means of the appropriate parameter, the internal braking resistor is deactivated.

LXM28•...		**UA5**	**U01**	**U02**	**U04**	**U07**
Resistance value of internal braking resistor	Ω	100	100	100	100	40
Continuous power internal braking resistor P_{PR}	W	60	60	60	60	60
Peak energy E_{CR} 1)	Ws	152	152	152	152	380
External braking resistor minimum	Ω	25	25	25	25	25
External braking resistor maximum 2)	Ω	50	50	50	50	50
Maximum continuous power external braking resistor	W	640	640	640	640	640
Switch-on voltage braking resistor	V	390	390	390	390	390
Capacitance of the internal capacitors	µF	820	820	820	820	820
Energy absorption of internal capacitors E_{var} at nominal voltage 230 V +10%	Ws	8.87	8.87	8.87	8.87	8.87

1) Parameter P1-71 is set to 100 ms.
2) The maximum specified braking resistor can derate the peak power of the device. Depending on the application, it is possible to use a higher ohm resistor.

LXM28•...		**U10**	**U15**	**U20**	**U30**	**U45**
Resistance value of internal braking resistor	Ω	40	40	40	22	22
Continuous power internal braking resistor P_{PR}	W	60	60	60	100	100
Peak energy E_{CR} 1)	Ws	380	380	380	691	691
External braking resistor minimum	Ω	15	15	8	8	8
External braking resistor maximum 2)	Ω	50	50	25	25	25
Maximum continuous power external braking resistor	W	1000	1000	1500	2500	2500
Switch-on voltage braking resistor	V	390	390	390	390	390
Capacitance of the internal capacitors	µF	1640	1640	2110	3280	3280
Energy absorption of internal capacitors E_{var} at nominal voltage 230 V +10%	Ws	17.76	17.76	22.82	35.51	35.51

1) Parameter P1-71 is set to 100 ms.
2) The maximum specified braking resistor can derate the peak power of the device. Depending on the application, it is possible to use a higher ohm resistor.

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2.2.1 External braking resistors (accessories)

VW3A760...		**1Rxx** [1)]	**2Rxx**	**3Rxx**	**4Rxx** [1)]	**5Rxx**	**6Rxx**	**7Rxx** [1)]
Resistance	Ω	10	27	27	27	72	72	72
Continuous power	W	400	100	200	400	100	200	400
Maximum time in braking at 115 V / 230 V	s	0.72	0.552	1.08	2.64	1.44	3.72	9.6
Peak power at 115 V / 230 V	kW	18.5	6.8	6.8	6.8	2.6	2.6	2.6
Maximum peak energy at 115 V / 230 V	Ws	13300	3800	7400	18100	3700	9600	24700
Degree of protection		IP65	IP65	IP65	IP65	IP65	IP65	IP65
UL approval (file no.)		-	E233422	E233422	-	E233422	E233422	-

1) Resistors with a continuous power of 400 W are not UL/CSA-approved.

VW3A77...		**04**	**05**
Resistance	Ω	15	10
Continuous power	W	1000	1000
Maximum time in braking at 115 V / 230 V	s	3.5	1.98
Peak power at 115 V / 230 V	kW	12.3	18.5
Maximum peak energy at 115 V / 230 V	Ws	43100	36500
Degree of protection		IP20	IP20
UL approval (file no.)		E221095	E221095

2.3 Cables for the DC bus

A cable for the common DC bus must meet the following requirements.

Cable:	Two wires Shielded and twisted pair at cable lengths of > 0.5 m
Maximum cable length between 2 drives:	3 m
Special characteristics:	Insulation must be rated for the DC bus voltage. Conductor cross section according to the calculated current, but at least 2* 6 mm^2 (2* AWG 10)

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3 Engineering

This chapter provides engineering information for a common DC bus for several drives.

Incorrect use of the DC bus may permanently damage the drives either immediately or over time.

⚠ WARNING

DESTRUCTION OF SYSTEM COMPONENTS

- Only connect the DC bus of single-phase drives to the DC bus of other single-phase drives.
- Connect single-phase drives that are interconnected via the DC bus to the same phase.
- Only connect the DC bus of three-phase drives to the DC bus of other three-phase drives
- Do not connect three-phase and single-phase drives via the same DC bus.
- Only connect the DC bus of drives with identical nominal voltages.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

See the Engineering chapter in the LXM28 product manual for vital engineering information concerning the LXM28 drive.

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3.1 Energy balance

To be able to estimate the effect of an interconnection of drives via a common DC bus, create an energy balance of the individual drives over a movement cycle. A movement cycle typically consists of the following phases: acceleration, continuous movement and deceleration.

The energy generated during deceleration can be used by other drives connected via a common DC bus. Excess energy can be absorbed by the braking resistors.

The efficiency of a common DC bus can be determined on the basis of the assessment of the energy balances of the individual drives per movement cycle and of the cyclic sequences of the movement cycles.

3.1.1 Energy balance basics

The energy balance is influenced by the following factors:

- Energy absorption of capacitors E_{var} in the drive
- Electrical losses of the drive system E_{el}
- Mechanical losses of the facility and the drive system E_{mech}
- Braking resistor E_B

Energy absorption of the capacitors E_{var}

The higher the mains voltage, the lower the energy absorption of the capacitors E_{var}. In your calculation, use the values for the highest mains voltage that is used in your application, see chapter *"2.2 Braking resistor"*.

The energy absorption of the capacitors E_{var} is the square difference between the voltage prior to the start of the deceleration and the switch-on voltage of the braking resistor.

Electrical losses E_{el}

The electrical losses E_{el} of the drive system can be estimated on the basis of the peak power of the drive. The maximum power dissipation is approximately 10% of the peak power at a typical efficiency of 90%. If the current during deceleration is lower, the power dissipation is reduced accordingly.

Mechanical losses E_{mech}

The mechanical losses result from friction during operation of the system. Mechanical losses are negligible if the time required by the system to coast to a stop without a driving force is considerably longer than the time required to decelerate the system. The mechanical losses can be calculated from the load torque and the velocity from which the motor is to stop.

Braking resistor E_B

Two characteristic values determine the energy absorption of a braking resistor:

- The continuous power P_{PR} is the amount of energy that can be continuously absorbed without overloading the braking resistor.
- The maximum energy E_{CR} limits the maximum short-term power that can be absorbed.

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Rating

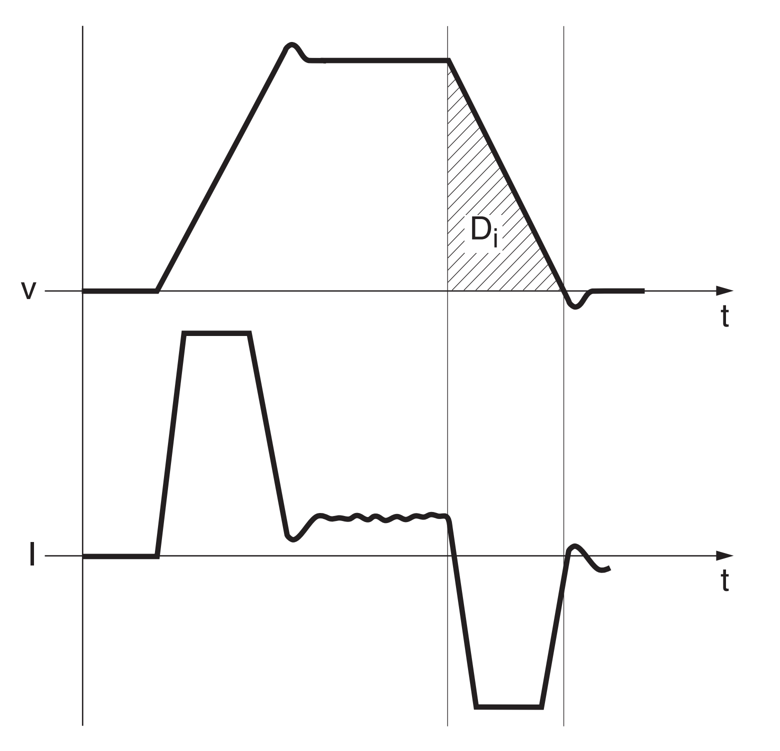

Figure 1: Movement cycle: Profile for energy assessment

This profile with velocity (v) and motor current (I) is also used for rating the motor and the braking resistor. The deceleration segment to be considered is labeled D_i.

Calculation of the energy at constant deceleration:

The total inertia (J_t) must be known.

J_t with:

$J_t = J_m + J_c$

J_m: Motor inertia with or without holding brake

J_c: Load inertia

The energy for each deceleration segment is calculated as follows:

$$E_i = \frac{1}{2} J_t \cdot \omega_i^2 = \frac{1}{2} J_t \cdot \left[\frac{2\pi n_i}{60}\right]^2$$

Units: E_i in Ws (wattseconds), J_t in kgm^2, ω in rad and n_i in min^{-1}.

See the technical data for the energy absorption E_{var} of the devices (without consideration of an internal or external braking resistor).

In the next calculation steps, only consider those segments D_i, whose energy E_i exceeds the energy absorption of the device (see chapter *"2.1 DC bus data"*). These excess energies E_{Di} must be diverted by means of the braking resistor (internal or external).

E_{Di} is calculated using the following formula:

$E_{Di} = E_i - E_{var}$ (in Ws)

The continuous power P_c is calculated for each machine cycle:

$$P_c = \frac{\sum E_{Di}}{\text{Cycletime}}$$

Units: P_c in W, E_{Di} in Ws and cycle time T in s

These calculations allow you to select the required braking resistor.

3.2 Electromagnetic compatibility (EMC)

If drives are to be operated via a common DC bus, the following aspects must be considered in terms of EMC:

- Keep DC bus cables as short as possible.
- Shielded DC bus cables must be used at a cable length of > 0.5 m. In the case of shielded DC bus cables, connect the cable shield to the functional ground of your equipment.

3.3 DC bus connection

Cable specifications

See chapter *"2.3 Cables for the DC bus"*, page *18* for the cable specifications. Connector kits and pre-assembled cables can be found in chapter *"6 Accessories and spare parts"*, page *41*.

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3.4 Fuses

The number of mains fuses depends on the input current of all drives connected via the common DC bus.

Choose fuse ratings as low as possible according to the power of the drive as well as the conductor cross section.

See manual of the respective product for more information.

The maximum permissible fuse ratings must not be exceeded.

Mains supply The drives must be connected to their own power supplies. It is not possible to supply a drive only via the DC bus.

NOTICE

INSUFFICIENT POWER

Do not use the DC bus to attempt to supply other drives.

Failure to follow these instructions can result in equipment damage.

3.4.1 DC bus connection of drives connected via a single phase

Single mains fuse A single fuse is sufficient if the total input current of all drives connected via the common DC bus is less than the maximum fuse rating shown in the table below.

LXM28•...		UA5, U01, U02, U04, U07, U10, U15
Maximum fuse rating of the mains fuse	A	25

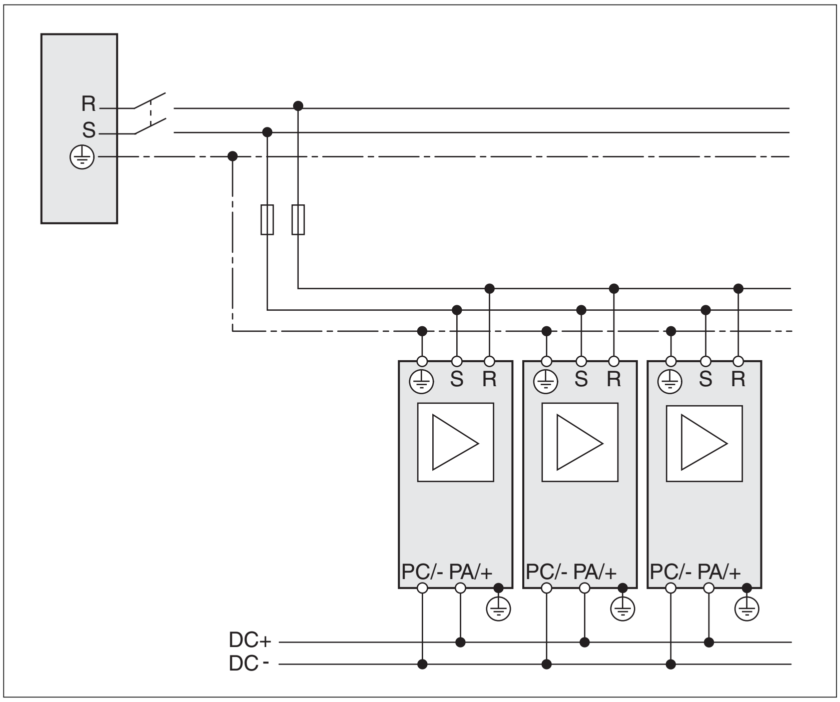

Figure 2: Single mains fuse for single-phase drives

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Multiple mains fuses

Multiple mains fuses are required if the total input current of all drives connected via the common DC bus is greater than the maximum fuse rating shown in the table below.

If multiple mains fuses are required, additional DC bus fuses must be used upstream of each drive. The DC bus fuses must be suitable for 600 Vdc.

LXM28•...		**UA5, U01, U02, U04, U07, U10, U15**
Maximum fuse rating: Mains fuses DC bus fuses	A	 25 25

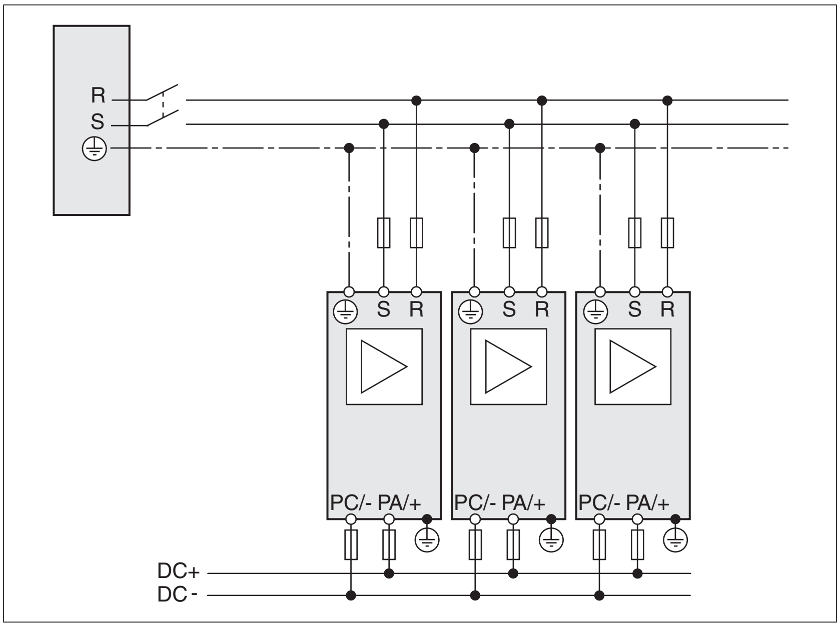

Figure 3: Multiple mains fuses for single-phase drives

See chapter *"6.2 DC fuses"* for fuses for the DC bus.

The voltage for the power stage supplies of the drives connected via a common DC bus must be applied simultaneously such as all drives are operational prior to being put into service.

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3.4.2 DC bus connection of drives connected via three phases

Single mains fuse

A single fuse is sufficient if the total input current of all drives connected via the common DC bus is less than the maximum fuse rating shown in the table below.

LXM28•...		UA5, U01, U02, U04, U07, U10, U15	U20, U30, U45
Maximum fuse rating for mains fuses:	A	25	32

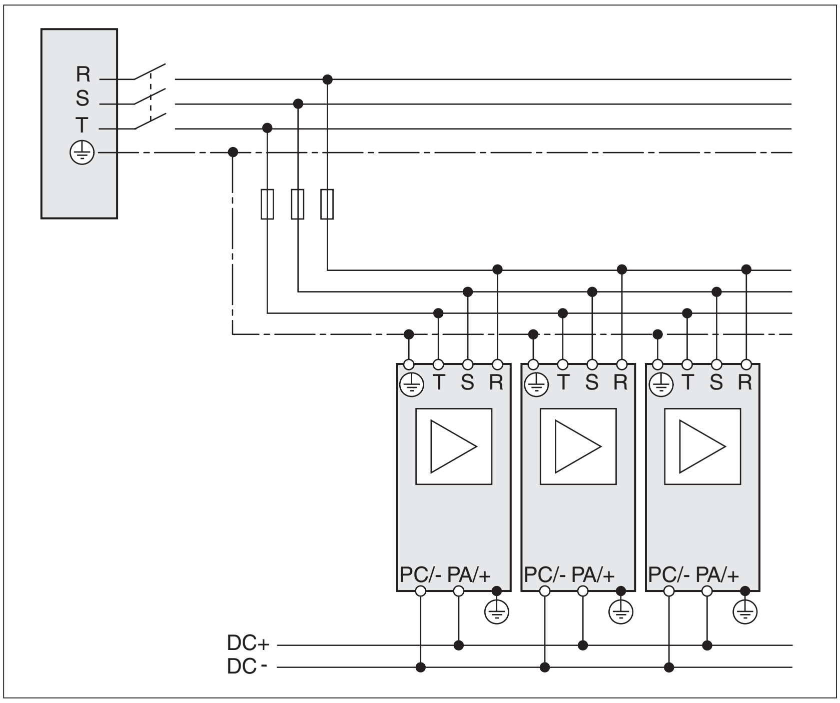

Figure 4: Single mains fuse for three-phase drives

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Multiple mains fuses

Multiple mains fuses are required if the total input current of all drives connected via the common DC bus is greater than the maximum fuse rating shown in the table below.

If multiple mains fuses are required, additional DC bus fuses must be used upstream of each drive. The DC bus fuses must be suitable for 600 Vdc.

LXM28•...		**UA5, U01, U02, U04, U07, U10, U15**	**U20, U30, U45**
Maximum fuse rating: Mains fuses DC bus fuses	A	 25 25	 32 32

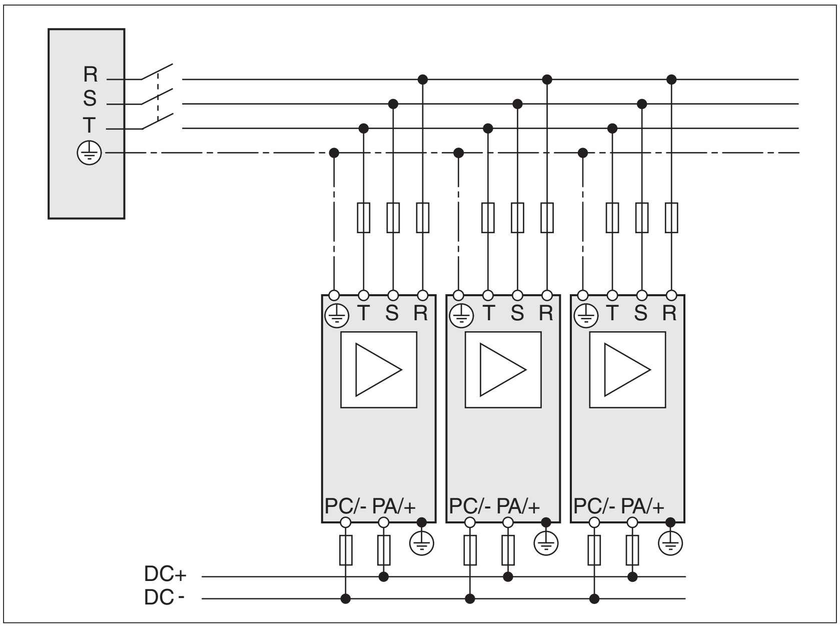

Figure 5: Multiple mains fuses for three-phase drives

See chapter *"6.2 DC fuses"* for fuses for the DC bus.

The voltage for the power stage supplies of the drives connected via a common DC bus must be applied simultaneously such as all drives are operational prior to being put into service.

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3.5 Braking resistors

Excess energy in the common DC bus must be absorbed by the braking resistors. Depending on the application, one or more braking resistors can be connected.

If drives with a different nominal power are connected via the DC bus, you must connect braking resistors to the drive with the highest nominal power. See the manual of the respective product for more information.

3.5.1 Rating the braking resistor

An insufficiently rated braking resistor can cause overvoltage on the DC bus. Overvoltage on the DC bus causes the power stages to be disabled. The motors are no longer actively decelerated.

⚠ WARNING

UNINTENDED EQUIPMENT OPERATION

- Verify that the braking resistors have a sufficient rating by performing a test run under maximum load conditions.
- Verify that the parameter settings for the braking resistors are correct.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Braking resistors are required for dynamic applications. During deceleration, the kinetic energy is transformed into electrical energy in the motor. The electrical energy increases the DC bus voltage. The braking resistor is activated when the defined threshold value is exceeded. The braking resistor transforms electrical energy into heat. If highly dynamic deceleration is required, the braking resistor must be well adapted to the system.

The temperature of the braking resistor may exceed 250 °C (482 °F) during operation.

⚠ WARNING

HOT SURFACES

- Ensure that it is not possible to make any contact with a hot braking resistor.
- Do not allow flammable or heat-sensitive parts in the immediate vicinity of the braking resistor.
- Verify that the heat dissipation is sufficient by performing a test run under maximum load conditions.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Further information on the subject	Page
Technical data chapter *"2.2 Braking resistor"*	*16*
Commissioning chapter *"5.2 Setting the braking resistor parameters"*	*40*

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See also chapter *"3.1 Energy balance"*, page *20* for rating information.

Internal braking resistor

A braking resistor to absorb braking energy is integrated in the drives. The device is shipped with the internal braking resistor active.

If the braking energy of all drives sharing a common DC bus is greater than the energy the internal braking resistors can absorb, you must use an external braking resistor.

Also take into account the worst case scenario in your application. Example: In the case of an EMERGENCY STOP, all motors decelerate simultaneously; the braking resistors must be able to absorb the entire braking energy.

External braking resistor

An external braking resistor is required in applications in which the braking energy is greater than the energy that can be absorbed by the drives sharing a common DC bus.

Selection of the external braking resistor

The rating of an external braking resistor depends on the required peak power and continuous power with which the braking resistor can be operated.

The resistance R is derived from the required peak power and the DC bus voltage.

$$R = \frac{U^2}{P_{max}}$$

R = Resistance in Ω
U = Switching threshold for braking resistor V
P_{max} = Required peak power in W

If 2 or more braking resistors are connected to one drive, note the following criteria:

- The braking resistors must be connected in parallel or in series so the required resistance is reached. Only connect resistors with identical resistance in parallel in order to evenly distribute the load to all braking resistors.
- The total resistance of all external braking resistors connected to one drive must not fall below a lower limit.
- The continuous power of the network of connected braking resistors must be calculated. The result must be greater than or equal to the actually required continuous power.

Use only resistors that are specified as braking resistors. See chapter *"2.2 Braking resistor"*, page *16* for suitable braking resistors.

Connection of braking resistor

Braking resistors with degree of protection IP65 may be installed outside the control cabinet in an appropriate environment in order to decrease the temperature in the control cabinet.
The external braking resistors listed in the Accessories chapter are shipped with an information sheet that provides details on installation.

Further procedure:

- Connect the braking resistors to the drive.
- During commissioning, set the parameters for the external braking resistor.
- During commissioning, test the braking resistors under realistic conditions, see page *40*.

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Wire ferrules: If you use wire ferrules, use only wire ferrules with collars for these terminals.

3.5.2 Rating information

To rate the braking resistor, calculate the proportion contributing to absorbing braking energy.

An external braking resistor is required if the kinetic energy that must be absorbed exceeds the total of the internal proportions, including the internal braking resistor.

Energy absorption braking resistor

Two characteristic values determine the energy absorption of the braking resistor:

- The continuous power P_{PR} is the amount of energy that can be continuously absorbed without overloading the braking resistor.
- The maximum energy E_{CR} limits the maximum short-term power that can be absorbed.

If the continuous power was exceeded for a specific time, the braking resistor must remain without load for a corresponding period.

The characteristic values P_{PR} and E_{CR} of the internal braking resistor can be found in chapter *"2 Technical Data"*.

See page *20* for information on assessing the electrical and mechanical losses.

Example

Deceleration of a rotary motor with the following data:

- Initial speed of rotation: $n = 4000\ min^{-1}$
- Rotor inertia: $J_R = 4\ kgcm^2$
- Load inertia: $J_L = 6\ kgcm^2$

Calculation of the energy to be absorbed:

$E_B = 1/2 * J * (2*\pi*n * 1/60)^2$

to 88 Ws

Electrical and mechanical losses are ignored.

In this example, the DC bus capacitors absorb 23 Ws (the value depends on the device type, see chapter *"2 Technical Data"*).

The internal braking resistor must absorb the remaining 65 Ws. It can absorb a pulse of 80 Ws. If the load is decelerated once, the internal braking resistor is sufficient.

If the deceleration process is repeated cyclically, the continuous output must be considered. If the cycle time is longer than the ratio of the energy to be absorbed E_B and the continuous power P_{PR}, the internal braking resistor is sufficient. If the system decelerates more frequently, the internal braking resistor is not sufficient.

In the example, the ratio E_B/P_{PR} is 1.3 s. If the cycle time is shorter, an external braking resistor is required.

Selecting an external braking resistor

The selection is made in two steps:

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- The maximum energy during deceleration must be less than the peak energy that the internal braking resistor can absorb: $(E_{Di})<(E_{Cr})$. In addition, the continuous power of the internal braking resistor must not be exceeded: $(P_C)<(P_{Pr})$. If these conditions are met, then the internal braking resistor is sufficient.
- If one of the conditions is not met, you must use an external braking resistor. The braking resistor must be rated in such a way that the conditions are met. The resistance of the braking resistor must be between the specified minimum and maximum values, since otherwise the load can no longer be decelerated or the product might be destroyed.

See chapter *"2.2 Braking resistor"*, page *16* for technical data on the external braking resistors.

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4 Installation

An engineering phase is mandatory prior to mechanical and electrical installation. See chapter *"3 Engineering"*, page *19*, for basic information.

Incorrect use of the DC bus may permanently damage the drives either immediately or over time.

⚠ WARNING

DESTRUCTION OF SYSTEM COMPONENTS

- Only connect the DC bus of single-phase drives to the DC bus of other single-phase drives.
- Connect single-phase drives that are interconnected via the DC bus to the same phase.
- Only connect the DC bus of three-phase drives to the DC bus of other three-phase drives
- Do not connect three-phase and single-phase drives via the same DC bus.
- Only connect the DC bus of drives with identical nominal voltages.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

The voltage for the power stage supplies of the drives connected via a common DC bus must be applied simultaneously such as all drives are operational prior to being put into service.

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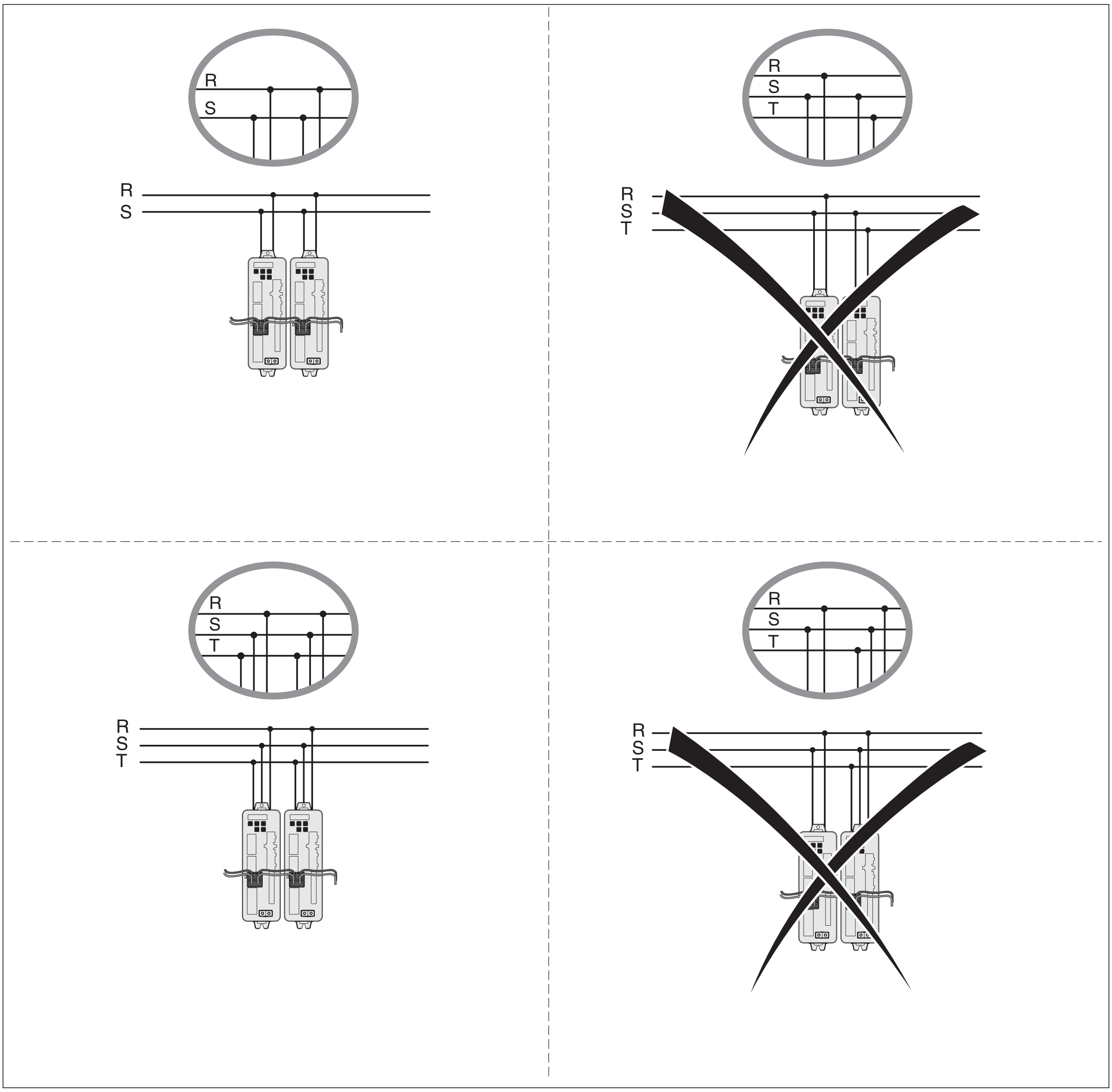

Figure 6: Specifications for drives with mains supply

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4.1 Assembling cables

Pre-assembled cables are available for common DC bus. If the pre-assembled cables do not have the required length, use cables and crimp contacts, see chapter *"6.1 DC bus accessories"*, page *41*.

Properties of the DC bus cable

Note the DC bus cable properties, see chapter *"2.3 Cables for the DC bus"* , page *18*.

Assembling DC bus cables

The instructions below explain how to assemble the DC bus cable.

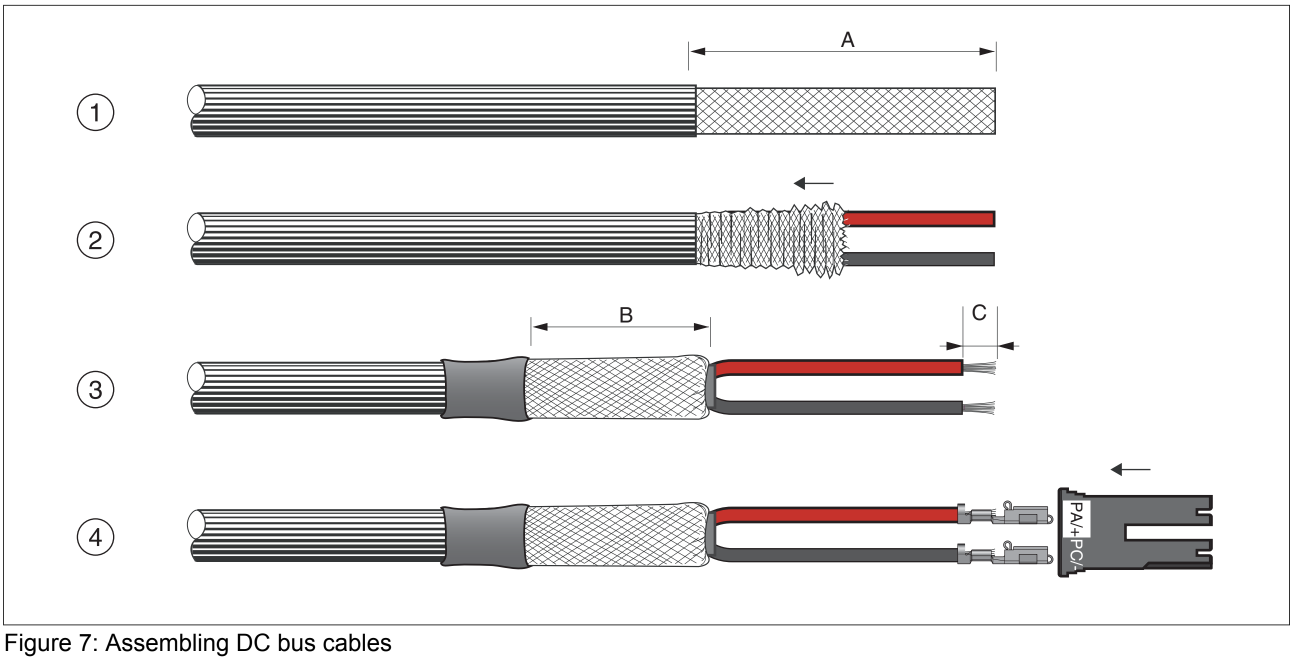

Figure 7: Assembling DC bus cables

LXM28•...		UA5, U01, U02, U04, U07	U10, U15	U20	U30, U45
A	mm (in)	330	350	380	470
B	mm (in)	50 (1.97)	50 (1.97)	50 (1.97)	50 (1.97)
C	mm (in)	6 (0.25)	6 (0.25)	6 (0.25)	6 (0.25)

- (1) Strip the cable jacket, length A.
- (2) Slide the shield braiding back over the cable jacket.
- (3) Secure the shield braiding with a heat shrink tube. The shield must have at least length D. Verify that a large surface area of the shield braiding is connected to the EMC shield clamp.
- (4) Crimp the crimp contacts to the two stripped conductors and push the crimp contacts into the connector housing.
  The red conductor is PA/+ and the black conductor is PC/-.

See chapter *"6.1 DC bus accessories"*, page *41* for information on the crimping tool.

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4.2 Wiring the DC bus

NOTICE

EQUIPMENT DAMAGE CAUSED BY INCORRECT POLARITY

Verify correct polarity during installation.

Failure to follow these instructions can result in equipment damage.

The DC bus is connected by means of a plug and socket connection.

Cable specifications

See chapter *"2.3 Cables for the DC bus"*, page *18* for the cable specifications. Pre-assembled cables and connector kits can be found in chapter *"6 Accessories and spare parts"*, page *41*.

Connector coding

The connectors are coded. If you do not use pre-assembled cables, verify that the crimp contacts properly snap into the connector. Verify that PA/+ is connected to PA/+ and PC/- is connected to PC/-. Incorrect wiring will destroy the devices.

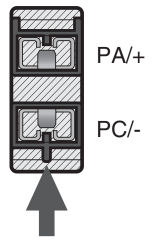

Figure 8: Connector coding

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4.2.1 Connecting the DC bus

The illustration below shows the DC bus connection.

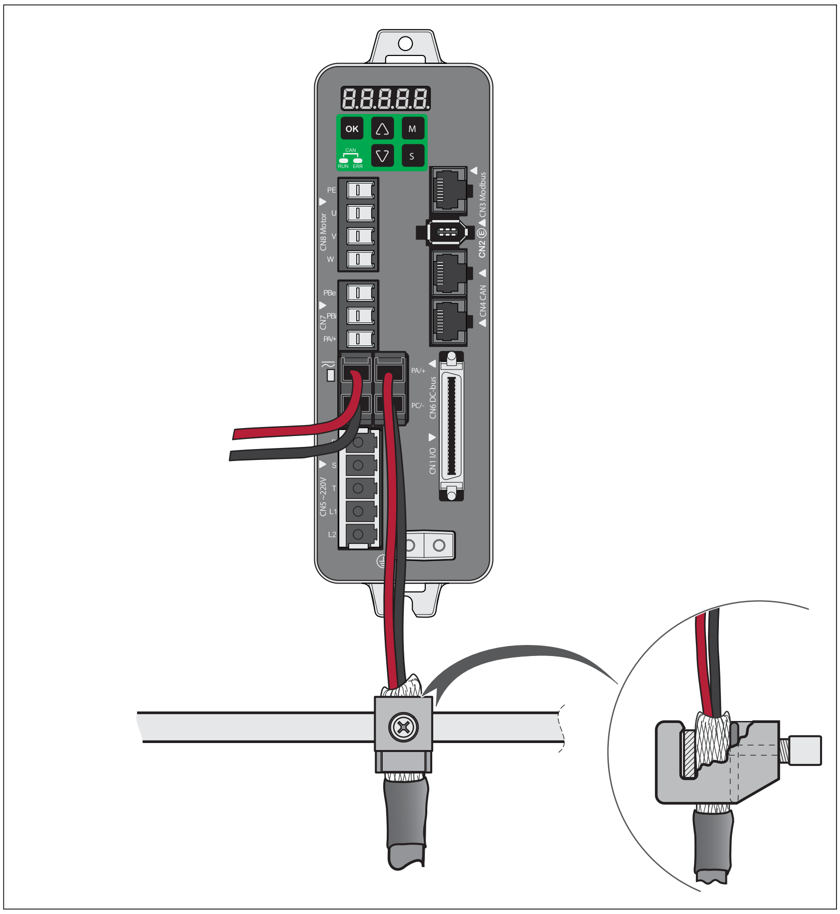

Figure 9: DC bus connection, example with connector

- Verify that the requirements concerning the DC bus are met, see chapter *"3 Engineering"*.
- Use pre-assembled cables whenever possible (page *41*) to reduce the risk of wiring errors.
- Only connect the devices with the specified accessories. The connectors are coded. Connect PA/+ to PA/+ (red) and PC/- to PC/- (black).

The connector has a snap lock mechanism.

4.2.2 Disconnecting the DC bus

Connector lock

The connector has a snap lock mechanism. Pull the connector housing to unlock the connector.

Both wires in the connector housing must be able to move independently for unlocking.

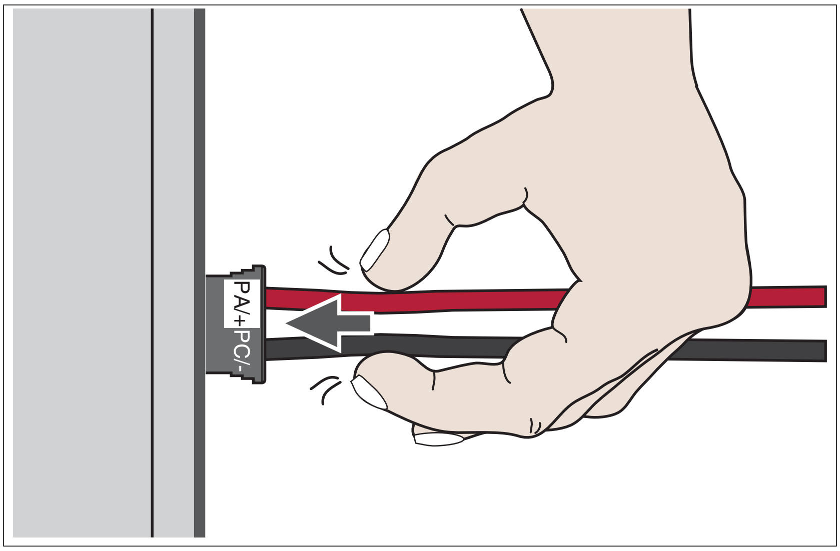

Figure 10: Unlocking the DC bus connector

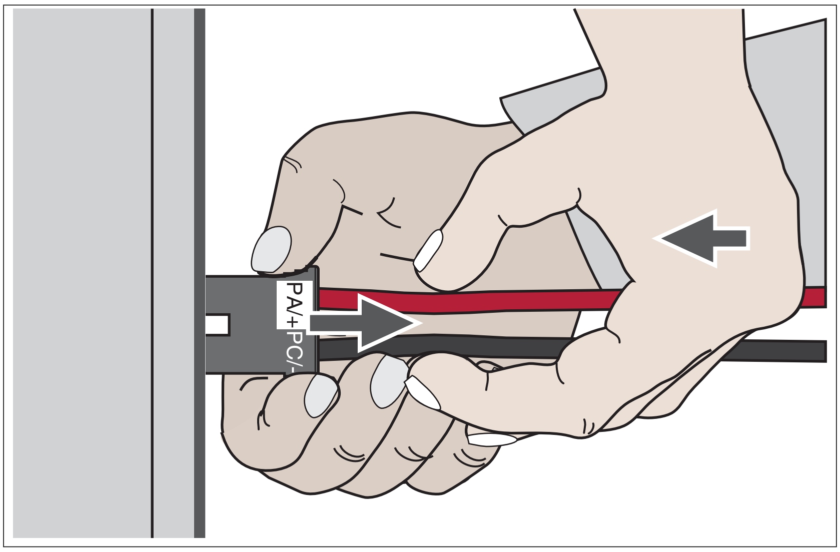

Figure 11: Unlocking the DC bus connector

If the two wires cannot move freely, the DC bus connector will not unlock.

- Push the two wires towards the connector (see *Figure 10*).
- While pushing the wires towards the connector, pull the connector at the connector housing with the other hand.The connector is unlocked and you can remove the DC bus connection cable (see). The connector is unlocked and you can remove the DC bus connection cable (see *Figure 11*).

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4.3 Verifying installation

- Verify that the wiring complies with the specifications as per chapter *"3 Engineering"*.
- Verify that the fuses used do not exceed the maximum permissible fuse rating.
- Verify that PA/+ is only connected to PA/+ and that PC/- is only connected to PC/-.
- Verify that the shield is connected to a large surface area if you use shielded DC bus cables.
- Verify that the connector locks are properly snapped in.

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5 Commissioning

For commissioning, follow the commissioning instructions for the individual devices in the manual of the respective product.

The voltage for the power stage supplies of the drives connected via a common DC bus must be applied simultaneously. If the voltage for the power stage supplies of the drives connected via a common DC bus is not applied simultaneously, the DC bus capacitors of the drives not yet powered are charged as well. This may overload and destroy the drives already under power.

NOTICE
DESTRUCTION DUE TO INCORRECT OPERATION Verify that the voltage for the power stage supplies of the drives connected via a common DC bus is applied simultaneously. **Failure to follow these instructions can result in equipment damage.**

5.1 Commissioning procedure

Commissioning steps:

- ▸ Verify that the requirements concerning the DC bus are met, see chapter *"3 Engineering"*.
- ▸ Verify proper installation of the drives and the connections for the common DC bus, see chapter *"4.3 Verifying installation"*, page *37*.
- ▸ Switch on the controller supply for all devices.
- ▸ Set the parameters for the braking resistors, see chapter *"5.2 Setting the braking resistor parameters"*.
- ▸ Commission the drives, see the descriptions in the manuals for the individual products.

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5.2 Setting the braking resistor parameters

An insufficiently rated braking resistor can cause overvoltage on the DC bus. Overvoltage on the DC bus causes the power stages to be disabled. The motors are no longer actively decelerated.

⚠ WARNING

UNINTENDED EQUIPMENT OPERATION

- Verify that the braking resistors have a sufficient rating by performing a test run under maximum load conditions.
- Verify that the parameter settings for the braking resistors are correct.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

If the regenerated power becomes greater than the power that can be absorbed by the braking resistor, an error message is generated and the power stage is disabled.

The temperature of the braking resistor may exceed 250 °C (482 °F) during operation.

⚠ WARNING

HOT SURFACES

- Ensure that it is not possible to make any contact with a hot braking resistor.
- Do not allow flammable or heat-sensitive parts in the immediate vicinity of the braking resistor.
- Verify that the heat dissipation is sufficient by performing a test run under maximum load conditions.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

See the product manual for a description of the parameters.

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6 Accessories and spare parts

6.1 DC bus accessories

Description	Order no.
DC bus connection cable, 2 * 6 mm^2 (2 * AWG 10), pre-assembled, 0.1 m, 5 pieces	VW3M7101R01
DC bus connection cable, 2 * 6 mm^2 (2 * AWG 10), Twisted Pair, shielded, 15 m	VW3M7102R150
DC bus connector kit, connector housing and crimp contacts for 3 ... 6 mm^2 (AWG 12 ... 10), 10 pieces	VW3M2207

A crimping tool is required for the crimp contacts of the connector kit.
Manufacturer:
Tyco Electronics, Heavy Head Hand Tool, Tool Pt. No 180250

6.2 DC fuses

The following DC fuses are offered by SIBA.
http://www.siba-fuses.com

Description	SIBA order no.
DC fuse, DC 700V 10A	5020106.10
DC fuse, DC 700V 16A	5020106.16
DC fuse, DC 700V 25A	5020106.25
DC fuse, DC 700V 32A	5020106.32

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6.3 External braking resistors

Description	**Order no.**
Braking resistor IP65; 10 Ω; maximum continuous power 400 W; 0.75 m connection cable (2.1 mm^2)	VW3A7601R07
Braking resistor IP65; 10 Ω; maximum continuous power 400 W; 2 m connection cable (2.1 mm^2)	VW3A7601R20
Braking resistor IP65; 10 Ω; maximum continuous power 400 W; 3 m connection cable (2.1 mm^2)	VW3A7601R30
Braking resistor IP65; 27 Ω; maximum continuous power 100 W; 0.75 m connection cable (2.1 mm^2), UL	VW3A7602R07
Braking resistor IP65; 27 Ω; maximum continuous power 100 W; 2 m connection cable (2.1 mm^2), UL	VW3A7602R20
Braking resistor IP65; 27 Ω; maximum continuous power 100 W; 3 m connection cable (2.1 mm^2), UL	VW3A7602R30
Braking resistor IP65; 27 Ω; maximum continuous power 200 W; 0.75 m connection cable (2.1 mm^2), UL	VW3A7603R07
Braking resistor IP65; 27 Ω; maximum continuous power 200 W; 2 m connection cable (2.1 mm^2), UL	VW3A7603R20
Braking resistor IP65; 27 Ω; maximum continuous power 200 W; 3 m connection cable (2.1 mm^2), UL	VW3A7603R30
Braking resistor IP65; 27 Ω; maximum continuous power 400 W; 0.75 m connection cable (2.1 mm^2)	VW3A7604R07
Braking resistor IP65; 27 Ω; maximum continuous power 400 W; 2 m connection cable (2.1 mm^2)	VW3A7604R20
Braking resistor IP65; 27 Ω; maximum continuous power 400 W; 3 m connection cable (2.1 mm^2)	VW3A7604R30
Braking resistor IP65; 72 Ω; maximum continuous power 200 W; 0.75 m connection cable (2.1 mm^2), UL	VW3A7606R07
Braking resistor IP65; 72 Ω; maximum continuous power 200 W; 2 m connection cable (2.1 mm^2), UL	VW3A7606R20
Braking resistor IP65; 72 Ω; maximum continuous power 200 W; 3 m connection cable (2.1 mm^2), UL	VW3A7606R30
Braking resistor IP65; 72 Ω; maximum continuous power 400 W; 0.75 m connection cable	VW3A7607R07
Braking resistor IP65; 72 Ω; maximum continuous power 400 W; 2 m connection cable	VW3A7607R20
Braking resistor IP65; 72 Ω; maximum continuous power 400 W; 3 m connection cable	VW3A7607R30
Braking resistor IP20; 15 Ω; maximum continuous power 1000 W; M6 terminals, UL	VW3A7704
Braking resistor IP20; 10 Ω; maximum continuous power 1000 W; M6 terminals, UL	VW3A7705

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Glossary

Terms and Abbreviations

See chapter *" Applicable Standards and Terminology"* for information on the pertinent standards on which many terms are based. Some terms and abbreviations may have specific meanings with regard to the standards.

AC	Alternating current
DC	Direct current
DC bus	Circuit that supplies the power stage with energy (direct voltage).
Drive system	System consisting of controller, drive and motor.
EMC	Electromagnetic compatibility
Error	Discrepancy between a detected (computed, measured or signaled) value or condition and the specified or theoretically correct value or condition.
Factory settings	Factory settings when the product is shipped
Fault	Fault is an operating state. If the monitoring functions detect an error, a transition to this operating state is triggered, depending on the error class. A "Fault Reset" is required to exit this operating state after the cause of the detected error has been removed. Further information can be found in the pertinent standards such as IEC 61800-7, ODVA Common Industrial Protocol (CIP).
Fault Reset	A function used to restore the drive to an operational state after a detected error is cleared by removing the cause of the error so that the error is no longer active.
Parameter	Device data and values that can be read and set (to a certain extent) by the user.
PELV	Protective Extra Low Voltage, low voltage with isolation. For more information: IEC 60364-4-41
Persistent	Indicates whether the value of the parameter remains in the memory after the device is switched off.
Power stage	The power stage controls the motor. The power stage generates current for controlling the motor on the basis of the motion signals from the controller.

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