



## Startup

# Servo Drive AX5000

(60 A – 170 A)

Please read this document carefully before installing and commissioning the servo drive.

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# BECKHOFF

Notes:

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# 1 Foreword

## 1.1 Notes on the documentation

This description is only intended for trained specialists in control, automation and drive engineering who are familiar with the applicable national standards. It is essential that the following notes and explanations are followed when installing and commissioning these components. It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning. The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards. The "General safety instructions" and "Special safety instructions for AX5000" sections are also essential.

 <b>CAUTION</b>	<b>Hazard to individuals!</b> Further and more detailed information regarding the individual sections and safety can be found in the "AX5000 System manual" that can be downloaded from our website at <a href="http://www.beckhoff.com">www.beckhoff.com</a> . If you do not have access to the "AX5000 System manual" please refrain from working on the AX5000 and notify our support division.
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## 1.2 Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development. We reserve the right to revise and change the documentation at any time and without prior announcement. No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

## 1.3 Trademarks

Beckhoff®, TwinCAT®, EtherCAT®, EtherCAT G®, EtherCAT G10®, EtherCAT P®, Safety over EtherCAT®, TwinSAFE®, XFC®, XTS® and XPlanar® are registered trademarks of and licensed by Beckhoff Automation GmbH. Other designations used in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owners.

## 1.4 Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702 with corresponding applications or registrations in various other countries.

## 1.5 Copyright

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Offenders will be held liable for the payment of damages. All rights reserved in the event of the grant of a patent, utility model or design.

## 1.6 Documentation issue status

Version	Comment
2.7	<b>Chapter update:</b> Electrical data <b>4.4.3</b>
2.6	<b>Chapter update:</b> UL-specific chapter changes <b>3.3.1</b> ; Type code <b>4.1</b> Electrical data <b>4.4.2</b> ; Motors and cables <b>5.3</b>
2.5	<b>Chapter update:</b> Dual Use <b>1.7.1</b> ; Feedback system <b>4.8.8</b> and <b>4.8.9</b> ; Installation in the control cabinet <b>5.1.1</b>
2.4	<b>Chapter update:</b> Permissible ambient and operating conditions <b>4.4.1</b> <b>New chapter</b> Disposal <b>4.4.2</b>
2.3	<b>Chapter update:</b> For your safety <b>2</b> ; Guidelines and Standards <b>3</b> ; UL specific chapter <b>3.3.2</b> <b>New chapter:</b> RoHS requirements <b>3.3</b> <b>Further update:</b> The DVD has been replaced by a QR code on the cover.
2.2	<b>Chapter update:</b> Name plate <b>4.3</b> ; Permissible ambient and operating conditions <b>4.4.1</b>
2.1	Chapter update: 1.1; 1.2; 4.4.2; 6
2.0	Chapter update: 4.4.2; 4.8.4; 4.8.4.1; 4.8.4.2; 4.8.4.3
1.9	Chapter update: 4.3; 5.3
1.8	Chapter update: 5.3
1.7	3.3.3; 4.4.1; 4.5; 4.6; 4.7
1.6	Chapter update: 4.4.2
1.5	Chapter update: 4.5; 4.6; 4.7; 4.8.2.


This documentation describes the following servo drives in the AX5000 range:

AX5160	AX5172	AX5190	AX5191	AX5192	AX5193	
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## 1.7 Appropriate use

The servo drives of the AX5000 series are **exclusively** designed for torque, speed and position control of suitable asynchronous and synchronous three-phase current motors. The maximum permissible effective motor voltage must be at least equal the effective mains voltage fed into the servo drive.

The servo drives from the AX5000 series are designed for installation as components in electrical systems or machines and may be operated only as integrated system or machine components.

 <b>WARNING</b>	<b>Caution – Risk of injury!</b> Electronic equipment is not fail-safe. The machine manufacturer is responsible for ensuring that the connected motors and the machine are brought into a safe state in the event of a fault in the drive system.
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The servo drives may **only** be operated in enclosed control cabinets and in accordance with the conditions described in the "Technical data" section. **For improper use**, please refer to the system manual

### 1.7.1. Dual Use (EU 1382/2014)

As published on December 30, 2014 by EU Commission Delegated Regulation 1382/2014, standard frequency inverters – and with that also Beckhoff products AX5000 – become newly classified Dual-Use items: the item list Annex I of the Dual-Use Council Regulation 428/2009 has been changed accordingly, Frequency inverters (listed in item position 3A225) with a „rotation field frequency of 600 Hz or more“ are now export controlled items. As a consequence some modifications have to be noticed.

Firmware versions without extension “Dual-Use conform” can be used in consideration of Hardware Versions with following drives only:

- HW Version 1.0 (AX5xxx-0000-x0xx): Serial Number < 68.000
- HW Version 1.0 (AX5xxx-0000-x01x)
- HW Version 2.0 (AX5xxx-0000-x20x) : Serial Number < 140.000
- HW Version 2.0 (AX5xxx-0000-x21x)

This firmware versions allow operation > 600 Hz rot. field frequency, shipment as single part may be subject to export control regulations.

Firmware versions with extension “Dual-Use conform” can be used in consideration of Hardware Versions with all drives. These versions support both rotational field frequency bands (<600 Hz, >= 600 Hz) depending on product hardware.

For products with option „x21x“, shipment as single part may be subject to export control regulations.

### Example: Change of an old Hardware 1.0 device

The defect servo drive AX5203-0000-x0xx should be replaced with an AX5203-0000-x01x to avoid changes in the TC System Manager. When downgrading, the desired Firmware (FW v1.00 - FW v1.05) must also be requested from Beckhoff Automation GmbH & Co. KG.

## 2 For your Safety

Read the section on safety and heed the notices to protect yourself against personal injury and materials damages.

### Liability limitations

All the components of the servo drive AX5000 are supplied in certain hardware and software configurations appropriate for the conditions of the application. Unauthorized modifications to the hardware and/or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH & Co. KG.

**In addition, the following actions are excluded from the liability of Beckhoff Automation GmbH & Co. KG:**

- Failure to comply with this documentation
- Improper use
- Untrained personnel
- Use of unauthorized spare parts

### 2.1 Staff qualification

Only technical personnel with knowledge of control and automation technology may carry out any of the illustrated work steps on the Beckhoff software and hardware, in particular on the servo drive AX5000.

The technical personnel must have knowledge of drive technology and electrical systems and must also know to work safely on electrical equipment and machines.

**This also includes:**

- Work preparation and
- Securing of the working environment  
(e.g. securing the control cabinet against being switched on again).




The technical personnel must be familiar with the current and necessary standards and directives for the automation and drive environment.




## 2.2 Description of symbols

The following safety symbols with a adjoining safety advise are used in this manual. You have to read the adjoining safety advice carefully and adhere it strictly.



### Symbols that warn of personal injury:

 <b>DANGER</b>	<b>Acute risk of injury!</b> This is an extremely dangerous situation. Disregarding the safety notice will lead to serious permanent injuries or even death.
 <b>WARNING</b>	<b>Risk of injury!</b> This is a dangerous situation. Disregarding the safety notice will lead to serious injuries.
 <b>CAUTION</b>	<b>Personal injuries!</b> This is a dangerous situation. Disregarding the safety notice may lead to minor injuries.

### Symbols that warn of damage to property or equipment:

 <b>Attention</b>	<b>Warning of damage to property or the environment!</b> This notice indicates disturbances in the operational procedure that could damage the product or the environment.
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### Symbols indicating further things or tips:

 <b>Note</b>	<b>Tip or pointer</b> This symbol notice provides important information that will be of assistance in dealing with the product or software. There is no immediate danger to product, people or environment.
	<b>UL pointer</b> This symbol indicates important information about the UL-compliant.

## 2.3 Notes for the servo drive AX5000

The safety instructions are designed to avert danger and must be followed during installation, commissioning, production, troubleshooting, maintenance and trial or test assemblies.

The servo drives of the AX5000 series are not designed for stand-alone operation and must always be installed in a machine or system. After installation the additional documentation and safety instructions provided by the machine manufacturer must be read and followed.



**WARNING**

### **Danger of life due to high voltage at the DC link capacitors of the servo drive AX5000!**

Due to the DC link capacitors dangerous voltage ( $> 875 \text{ V}_{\text{DC}}$ ) may persist at the DC link contacts “ZK+ and ZK- (DC+ and DC-)” and “RB+ and RB-” after the servo drive has been disconnected from the mains supply.

#### **Take the following measures for Safety:**

- **Wait at:**
  - AX5160 and AX5172 = **15** minutes
  - AX5190 and AX5191 = **30** minutes
  - AX5192 and AX5193 = **45** minutesafter disconnected the servo drive from the mains supply. The device is safe once the voltage has fallen below 50 V.
- Measure the voltage at the DC link contacts.
- Secure the work area and wear the PPE (personal protective equipment).



**WARNING**

### **Serious burns due to hot surfaces on the devices!**

The surface temperature of the devices can reach  $\geq 50^\circ\text{C}$  during operation of the system. There is an acute risk of sustaining burns to parts of the body and limbs.

#### **Take the following measures to avert danger:**

- Do not touch any components (housing, etc.) shortly after or during operation.
- Wait until all components have cooled sufficiently. At least 15 minutes.
- Check the surface temperature with a thermometer.
- **DO NOT** wear work gloves with a rubber coating. These can fuse with the skin on account of the high temperature and cause serious injuries.



**NOTE**

**Notes on operation of the servo drive AX5000:**

- Carefully read this manual before using the servo drive thoroughly, paying particular attention to the safety instructions. In the event of any uncertainties please notify your sales office immediately and refrain from working on the servo drive.
- During the electrical installation it is essential to ensure that the correct fuses/protective circuit breakers are used between the mains supply and the servo drive.  
Further information can be found in the "**Electrical installation**" section.
- If a servo drive is installed in a machine it must not be commissioned until proof of compliance of the machine with the latest version of the EC Machinery Directive has been provided. This includes all relevant harmonised standards and regulations required for implementation of this Directive in national legislation.



**Attention**

**Hazard to devices and environment**

- During installation it is essential to ensure that the specified ventilation clearances and climatic conditions are adhered to. Further information can be found in the "**Technical data**" and "**Mechanical installation**" sections.
- If the servo drive is operated in contaminated ambient air, the cooling openings must be checked regularly for blockage. These checks should be carried out several times per day.
- The servo drives contain components at risk from electrostatic discharge caused by improper handling:
  - Please ensure you are electrostatically discharged before touching the servo drive directly.
  - Avoid contact with highly insulating materials (synthetic fibres, plastic film etc.).
  - Place the servo drive on a conductive surface.
  - Do not touch the motor plug during operation of the AX5000.

## 3 Guidelines and Standards

### 3.1 CE conformity

**NOTE****Supply of EC declaration of conformity:**

Beckhoff Automation GmbH & Co. KG will gladly provide you with the certificates and manufacturer's declaration for all products on request at: [info@beckhoff.com](mailto:info@beckhoff.com).

**CAUTION****Hazard to individuals!**

Servo drives are **not** covered by the EC Machinery Directive. Operation of the servo drives in machines or systems is only permitted once the machine or system manufacturers has provided evidence of CE conformity of the complete machine or system.

### 3.2 Electromagnetic compatibility

The servo drives **AX5160, AX5172, AX5190, AX5191, AX5192 and AX5193** comply with the

- 2004/108/EC EMC Directive (until 19/04/2016) and
- 2014/30/EU EMC Directive (from 20/04/2016)

**Applied harmonized standards:**

IEC / EN 61000-6-2:2005

(Interference immunity for the industrial areas)

IEC / EN 6100-6-4:2007+A1:2011

(Interference emission for the industrial areas)

### 3.3 RoHS requirements

The servo drives meet the requirements of RoHS Directive 2011/65/EU.


**Applied harmonized standards:**

RoHS: IEC / EN 50581 :2012

(Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances).

### 3.3 UL-Listing in USA and Canada

The following servo drives from the AX5000 series have a UL-Listing and must bear the CUS symbol

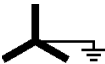
	<b>AX5000 with UL-Listing</b> AX5160, AX5172, AX5190, AX5191, AX5192 und AX5193
--	--

on the name plate. If you wish to operate an AX5000 in USA or Canada , please check that there is a CUS symbol on the name plate.

Below is a list of the relevant chapters that are amended with respect to the UL-Listing. Furthermore, UL-specific remarks are listed. It is essential to observe these specifications.

#### 3.3.1 UL-specific chapter changes

“5.2.1 Mains supply connection (X01)”



AX5000 shall be connected only to a **grounded wye-source** where the maximum voltage does not exceed 277 V (+ 10%) to ground.

“5.2.3 Connection of several servo drives to form a drive system”

	<b>Drive system with UL-Listing!</b> Please consult our Application Department with respect to the requirements for a drive system with UL-Listing.
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#### 3.3.2 UL-specific chapter

“5.2.1.3 External protection, UL-compliant”

Integral solid state short circuit protection does not provide branch circuit protection. Branch circuit protection must be provided in accordance with the Manufacture Instructions, National Electrical Code and any additional local codes.

**AX5160 and AX5172:**

Suitable for use on a circuit capable of delivering not more than 5 kA (SCCR) symmetrical amperes, 480 V maximum. When protected by RK5 class fuses, rated 100 A maximum.

**AX5190 - AX5193:**

Suitable for use on a circuit capable of delivering not more than 10 kA (SCCR) symmetrical amperes, 480 V maximum. When protected by RK5 class fuses, rated 225 A maximum.

Fusing	AX5160	AX5172	AX5190	AX5191	AX5192	AX5193
AC supply (max.) *)	80 A	100 A	125 A	150 A	200 A	225 A
24 V supply (max.)	4 AT		10 AT			
Brake resistor	electronic					

\*) Mains fuses according to type "RK5" min. 480 V must be used.

### 3.3.3 UL-specific notes

Use in a Pollution Degree 2 environment

Use 75 °C Copper Conductors min.

Control Board rating = 24 V

**Drive intended for use over a range of motor sizes. Internal motor overload protection level is adjustable:**

The internal motor protection is parameterised via the IDN P-0-0062 "Thermal motor model", based on the value of the IDN S-0-0111 "Motor continuous stall current". The IDN P-0-0062 "Time constant" is specified by the motor manufacturer and must be entered here. The IDN P-0-0062 "Warning limit" (Default) is responsible for deciding when a warning is to be generated. The IDN P-0-0062 "Error limit" (Default) is responsible for deciding when the motor is to be switched off. The default values take into account the specific characteristics of the servomotors.

## 3.4 Electrical isolation according to EN 50178 / VDE 160

The power section (motor connection, DC link connection and mains connection) and the control unit are **doubly** insulated against each other, so that safe protection against accidental contact is ensured at all terminals of the control unit without additional measures. The air and creepage distances also meet the requirements of the above standard.

## 4 Product description

The servo drives of the AX5000 series are available as single- or multi-channel versions and are optimised in terms of function and cost-effectiveness. In conjunction with EtherCAT, the real-time Ethernet system, the integrated control technology offers minimum cycle times and supports fast, highly dynamic positioning tasks.

### 4.1 Type code

AX 5 x yz – a bc d – e f g h	Explanation
AX	Product range Servo drive
5	Series 5 = AX5000
x	Number of channels 1 = single channel 2 = two channel
yz	Nominal current per channel for single-phase and three-phase connections  Single channel devices: 01 = 1,5 A 03 = 3,0 A 06 = Single phase: 4,5 A / Three phase: 6,0 A 12 = 12 A 18 = 18 A 25 = 25 A 40 = 40 A 60 = 60 A 72 = 72 A 90 = 90 A  Two channel devices: 01 = 1,5 A 03 = 3,0 A 06 = 6,0 A 91 = 110 A 92 = 143 A 93 = 170 A
a	Not defined
bc	Not defined
d	Not defined
e	Variants 0 = Standard 1 = Special variant / customer-specific variant
f	Hardware status 0 = First generation 2 = Second generation
g	Dual Use 0 = $\leq 599$ Hz 1 = $> 599$ Hz
h	Firmware status 0 = v2.06 2 $\geq$ v2.10

## 4.2 Scope of supply


The scope of delivery may vary depending on the ordered configuration. Before installing the device please ensure that all ordered components were delivered and that they are undamaged. In the event of any damage please contact the carrier immediately and document the damage.

### 4.2.1 Standard scope of supply

- AX5000 in the performance class according to the order
- Connectors for:
  - X03: DC power supply 24 V
  - X06: Digital inputs and outputs
  - X14: Motor temperature sensor and brake
- Startup (this manual)


### 4.2.2 Accessories

A comprehensive list of accessories can be found in the complete Beckhoff catalogue or on our website at [www.beckhoff.com](http://www.beckhoff.com).

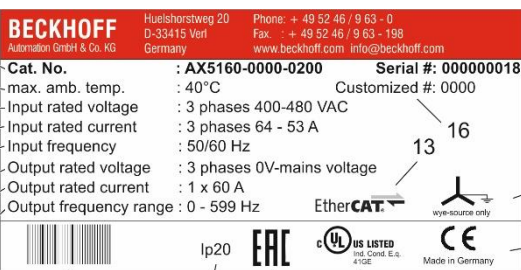
	<b>Accessories with UL-Listing!</b> If you wish to operate an AX5000 in an economic area that requires a UL-Listing, please make sure that the accessories also have a UL-Listing.
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## 4.3 Name plate

The servo drive features two name plates. A comprehensive name plate can be found on the right-hand side. An extract showing the main data can be found at the top of the servo drive.




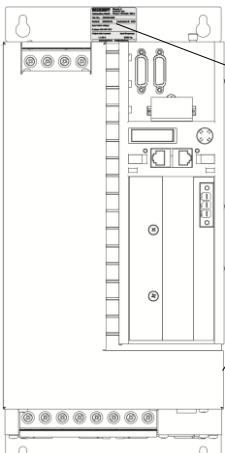
1 Cat. No.: AX5160-0000  
 10 Serial #: 000000018 Customized #: 0000  
 3 Input rated voltage: 3 phase 400-480 VAC  
 7 Output rated current: 1 x 60 A Input frequency: 50/60 Hz  
 www.beckhoff.com info@beckhoff.com



1 **BECKHOFF** Hülsenthorweg 20 Phone: + 49 52 46 / 9 63 - 0  
 Automation GmbH & Co. KG D-33415 Verl Fax: : + 49 52 46 / 9 63 - 198  
 Germany www.beckhoff.com info@beckhoff.com

2 Cat. No.: **AX5160-0000-0200** Serial #: **000000018**  
 3 max. amb. temp.: 40°C Customized #: 0000  
 4 Input rated voltage: 3 phases 400-480 VAC  
 5 Input rated current: 3 phases 64 - 53 A  
 6 Input frequency: 50/60 Hz  
 7 Output rated voltage: 3 phases 0V-mains voltage  
 8 Output rated current: 1 x 60 A  
 9 Output frequency range: 0 - 599 Hz

10 **EtherCAT**  **wye-source only**  
 11 **UL** **US LISTED** Ind. Cont. E.q. 410E  
 12 **CE** Made in Germany




Small name plate (top)  
 Large name plate (bottom)



1	Catalog number	7	Output rated current	13	EtherCAT - Conform
2	Max. ambient temperature	8	Output frequency range	14	CE-Conform
3	Input rated voltage	9	Barcode	15	wye-source only
4	Input rated current	10	Protection class	16	Customer-specific
5	Input frequency	11	EAC - Conform	17	Serial number
6	Output rated voltage	12	cULus - Listed		

## 4.4 Technical data

	<b>UL-Listing!</b> It is essential to observe chapter 3.3 if you wish to operate an AX5000 in an economic area that requires a UL-Listing.
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### 4.4.1 Permissible ambient and operating conditions

Ambient / operating conditions	Permissible values
Ambient temperature during operation	0 °C up to +40 °C Up to 55 °C with reduced power (2 % / °C)
Ambient temperature during transport	-25 °C up to +70 °C
Ambient temperature during storage	-25 °C up to +55 °C
Air humidity	15 % up to 85 %, non-condensing
Pollution degree	2 according to EN 60664-1
Corrosion protection	Normally not required. Under extreme operating conditions separate measures must be agreed with the manufacturer.
Operating altitude	up to 1000 m above sea level without reduced power. Between 1000 m and max. 3000 m with reduced power 1.5 % per 100 m.
Installation position	vertical
Ventilation	Built-in temperature-controlled fan
Protection class	IP 20 except the terminals (IP00)
Vibration test (EN 60068-2-6)	Frequency range: 10-150 Hz Amplitude: 10-58 Hz = 0,075 mm pk-pk 59-150 Hz = 1 g

### 4.4.2 Disposal

The device should be disposed of by a certified disposal company. You can obtain addresses from us. Housing components (polycarbonate, polyamide (PA6.6)) are suitable for plastic recycling.

Metal parts can be sent for metal recycling.

Electronic parts such as circuit boards and terminals must be disposed of in accordance with national electronics scrap regulations.

In accordance with the WEEE 2012/96/EG Directives we take old devices and accessories back for professional disposal, provided the transport costs are taken over by the sender.

#### Send the devices with the note “For disposal” to:

Beckhoff Automation GmbH & Co. KG  
 Huelshorstweg 20  
 D-33415 Verl

## 4.4.2 Electrical data

Electrical Data	AX5160	AX5172	AX5190	AX5191	AX5192	AX5193
Rated output current <sup>(1)</sup>	60 A	72 A	90 A	110 A	143 A	170 A
Minimum rated motor current at full current resolution	16 A	20 A	25 A	30 A	35 A	40 A
Peak output current <sup>(2)</sup>	120 A	144 A	180 A	180 A	215 A	221 A
Rated supply voltage	3x 400 <sup>-10%</sup> – 480 <sup>+10%</sup> V <sub>AC</sub>					
Max. DC link voltage	890 V <sub>DC</sub>					
Rated apparent power S1-mode (selection)						
400 V	42 kVA	50 kVA	62 kVA	76 kVA	99 kVA	118 kVA
480 V	45 kVA	54 kVA	67 kVA	82 kVA	107 kVA	127 kVA
Power dissipation <sup>(3)</sup>	830 W	1010 W	1300 W	1600 W	2100 W	2500 W
Min. brake resistor] (external brake resistor)	13 Ω	13 Ω	10 Ω	10 Ω	6,5 Ω	6,5 Ω
Max. braking power (external brake resistor)	52 kW	52 kW	67 kW	67 kW	103 kW	103 kW
Mains choke <sup>(4)</sup>	---	---	AX2090-ND50-			
			0090	0110	0143	0170
Mains filter <sup>(4)</sup>	AX2090-NF50					
	integrated	integrated	0100	0150	0150	0180
DC link capacity	900 μF		1060 μF	2120 μF	3180 μF	4240 μF
SCCR value	5 kA		10 kA			

<sup>(1)</sup> The rated current must be reduced by 10% when connecting rated voltage of 480V.

The specified values are valid for output rotary frequency > 5Hz

<sup>(2)</sup> I<sub>eff</sub> for max. 3 s at max. 70% preload of rated current

<sup>(3)</sup> S1 mode, incl. power supply unit, without brake chopper

<sup>(4)</sup> Required according to EN61800-3 (EMC product standard) C3 (industrial environment) with motor cable length max. 25 m.

SCCR Value:

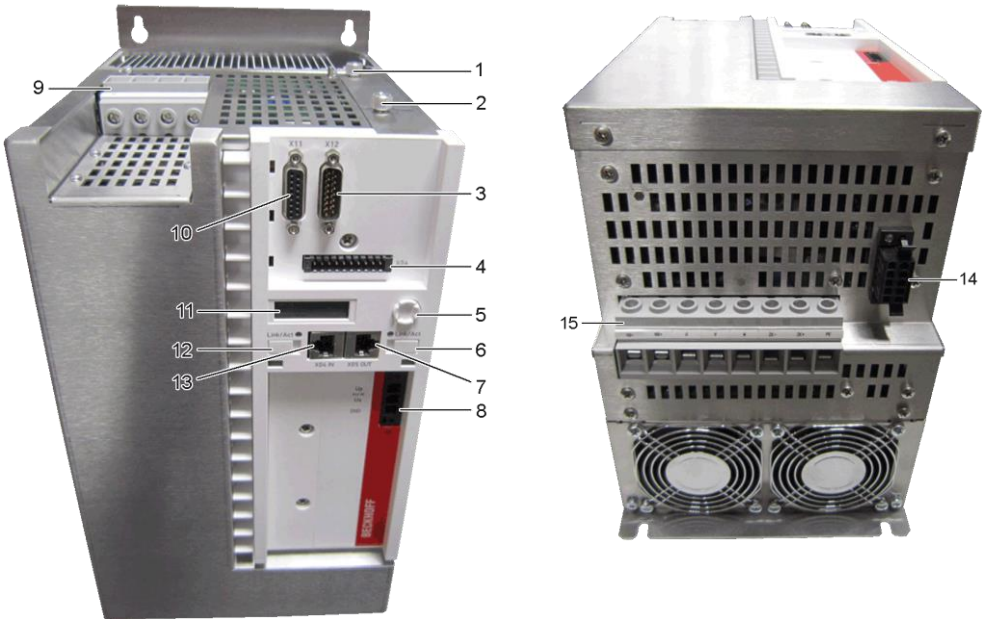
10 kA

## 4.4.3 Mechanical data


Mechanical data	AX5160	AX5172	AX5190	AX5191	AX5192	AX5193
Weight	ca.14 kg	ca.14 kg	ca.31 kg	ca.31 kg	ca.38 kg	ca.38 kg
Width	190 mm		283 mm	283 mm	283 mm	283 mm
Height without plugs	345 mm		540 mm	540 mm	540 mm	540 mm
Depth without connectors/ accessories	259 mm		253 mm	253 mm	334 mm	334 mm

### 4.5 General overview (AX5160 and AX5172)

The servo drive illustrated below is an AX5172; the AX5160 is structurally similar




Item description:

No Designation		No Designation	
1	X4x – optional slot for expansion cards	9	X01 – mains supply 400 – 480 V
2	X3x – optional slot for safety card	10	X11 – feedback connection, encoder
3	X12 – feedback connection, resolver	11	Display
4	X06 – connection for digital inputs and outputs	12	Labeling field
5	Navigation rocker	13	X04 – socket for EtherCAT input
6	Labeling field	14	X14 – sensor for motor temperature and brake
7	X05 – socket for EtherCAT output	15	Connection for external brake resistor DC link output (890 V DC voltage) Motor connection (U,V,W,PE)
8	X03 – power supply 24 V DC input		
	<div> <b>DANGER</b></div>		<div>Max. 875 V DC voltage at the DC link terminals. Dangerous voltage may be present for 15 minutes after the device is switched off. The device is safe once the voltage has fallen below 50 V. (Check voltage)</div>

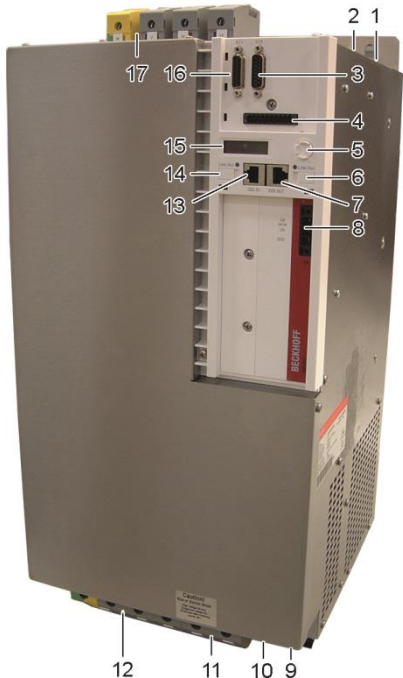
4.6 General overview (AX5190 and AX5191)




Item description:

No	Designation		No	Designation	
1	X4x – optional slot for expansion cards		9	X14 – sensor for motor temperature and brake	
2	X3x – optional slot for safety card		10	DC link output (890 V DC voltage) Connection for external brake resistor	
3	X12 – feedback connection, resolver		11	Motor connection (U,V,W,PE)	
4	X06 – connection for digital inputs and outputs		12	X04 – socket for EtherCAT input	
5	Navigation rocker		13	Labeling field	
6	Labeling field		14	Display	
7	X05 – socket for EtherCAT output		15	X11 – feedback connection, encoder	
8	X03 – power supply 24 V DC input		16	X01 – mains supply 400 – 480 V	
		<b>DANGER</b> Max. 875 V DC voltage at the DC link terminals. Dangerous voltage may be present for 30 minutes after the device is switched off. The device is safe once the voltage has fallen below 50 V. (Check voltage)			

# 4.7 General overview (AX5192 and AX5193)



Item description:

No	Designation	No	Designation
1	X4x – optional slot for expansion cards	9	X14 – sensor for motor temperature and brake
2	X3x – optional slot for safety card	10	X07 – External brake resistor
3	X12 – feedback connection, resolver	11	DC link output (890 V DC voltage)
4	X06 – connection for digital inputs and outputs	12	Motor connection (U,V,W,PE)
5	Navigation rocker	13	X04 – socket for EtherCAT input
6	Labeling field	14	Labeling field
7	X05 – socket for EtherCAT output	15	Display
8	X03 – power supply 24 V DC input	16	X11 – feedback connection, encoder
	 <b>DANGER</b> Max. 875 V DC voltage at the DC link terminals. Dangerous voltage may be present for 45 minutes after the device is switched off. The device is safe once the voltage has fallen below 50 V. (Check voltage)	17	X01 – mains supply 400 – 480 V

4.8 Overview of connectors/terminal points

4.8.1 X01 – voltage input

4.8.1.1 AX5160 and AX5172



Terminal point	Connection
L1	Phase L1
L2	Phase L2
L3	Phase L3
PE	Protective conductor

4.8.1.2 AX5190 and AX5191



Terminal point	Connection
L1	Phase L1
L2	Phase L2
L3	Phase L3
PE	Protective conductor

4.8.1.3 AX5192 and AX5193



Terminal point	Connection
L1	Phase L1
L2	Phase L2
L3	Phase L3
PE	Protective conductor

4.8.2 X07 – External brake resistor

**Attention**

**Hazard to devices**

Connect the PE connection of the external brake resistor at the central grounding bar.

**DANGER**

**Serious risk of injury through high electrical voltage!**

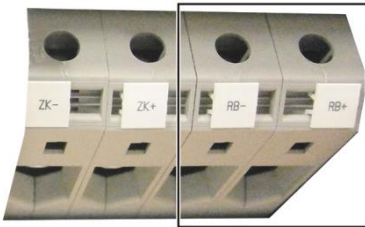
875 V DC voltage at the RB+ and RB- terminals. Dangerous voltage may be present at AX5160/AX5172 for 15 minutes, at AX5190/AX5191 for 30 minutes and at AX5192/AX5193 for 45 minutes after the device is switched off (Check voltage).

4.8.2.1 AX5160 and AX5172



Terminal point	Connection
RB +	External brake resistor +
RB -	External brake resistor -

**4.8.2.2 AX5190 and AX5191**



Terminal point	Connection
RB +	External brake resistor +
RB -	External brake resistor -

**4.8.2.3 AX5192 and AX5193**



Terminal point	Connection
RB +	External brake resistor +
RB -	External brake resistor -

**4.8.3 X13 – Motor connection**

**4.8.3.1 AX5160 and AX5172**



Terminal point	Connection
U	Motor connection U
V+	Motor connection V
W	Motor connection W
PE	Protective conductor

**4.8.3.2 AX5190 and AX5191**



Terminal point	Connection
U	Motor connection U
V+	Motor connection V
W	Motor connection W
PE	Protective conductor




4.8.3.3 AX5192 and AX5193



Terminal point	Connection
U	Motor connection U
V+	Motor connection V
W	Motor connection W
PE	Protective conductor

4.8.4 X02 – DC link system



**DANGER**

**Serious risk of injury through high electrical voltage!**

875 V DC voltage at the DC link terminals. Dangerous voltage may be present at AX5160/AX5172 for 15 minutes, at AX5190/AX5191 for 30 minutes and at AX5192/AX5193 for 45 minutes after the device is switched off (Check voltage).

4.8.4.1 AX5160 and AX5172



Terminal point	Connection
ZK +	Zk +
ZK –	Zk –

4.8.4.2 AX5190 and AX5191



Terminal point	Connection
ZK +	Zk +
ZK –	Zk –

4.8.4.3 AX5192 and AX5193



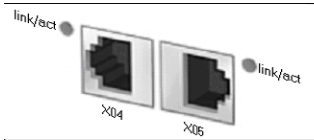
Terminal point	Connection
ZK +	Zk +
ZK -	Zk -

4.8.5 X03 – 24 V<sub>DC</sub> supply



Terminal point	Connection	Current consumption
U <sub>p</sub> +	24 V <sub>DC</sub> -0/+25% - periphery (e.g. separate braking voltage)	Depending on the connected consumers (see X06 and X14, X24)
U <sub>s</sub> +	24 V <sub>DC</sub> ±25% - system supply	60 A-72 A = 3 A 90 A-170 A = 10 A
GND	GND	

4.8.6 X04, X05 – EtherCAT connection



Terminal point	Connection
X04 (IN)	incoming EtherCAT line
X05 (OUT)	outgoing EtherCAT line

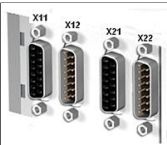
4.8.7 X06 – Digital I/Os

 <b>CAUTION</b>	<b>Destruction of the AX5000!</b> This connector is not designed for external power supply. It is supplied via the 24 V supply (U <sub>p</sub> ) of connector X03.
 <b>Note</b>	<b>Output current</b> The specified output currents are maximum values. The actual values depend on your current configuration.



Terminal point	Connection	Output current
24	Output voltage ( $U_p$ 24 V <sub>DC</sub> +)	1 A max.
0	Input 0	
1	Input 1	
2	Input 2	
3	Input 3	
4	Input 4	
5	Input 5	
6	Input 6	
7	Input 7 or output (configurable) ( $U_p$ 24 V <sub>DC</sub> +)	0.5 A max.
0 V	Output voltage GND (-)	

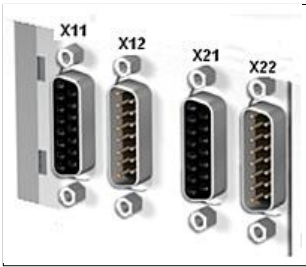
4.8.8 X11 – feedback, high-resolution



Pin	EnDAT / BiSS	Hiperface	Sin / Cos 1Vpp	TTL
1	SIN +	SIN +	SIN +	n.c.
2	GND_5 V	GND_11 V	GND_5 V	GND_5 V
3	COS +	COS +	COS +	n.c.
4	U <sub>s</sub> 5 V <sup>*)</sup>	n.c.	U <sub>s</sub> 5 V <sup>*)</sup>	U <sub>s</sub> 5 V <sup>*)</sup>
5	DX + (Data)	DX + (Data)	n.c.	B +
6	n.c.	U <sub>s</sub> 11 V <sup>*)</sup>	n.c.	n.c.
7	n.c.	n.c.	REF Z	REF Z
8	CLK + (Clock)	n.c.	n.c.	A +
9	REFSIN	REFSIN	REFSIN	n.c.
10	GND_Sense	n.c.	GND_Sense	GND_Sense
11	REF COS	REF COS	REF COS	n.c.
12	U <sub>s</sub> 5 V Sense	n.c.	U <sub>s</sub> 5 V Sense	U <sub>s</sub> 5 V Sense
13	DX - (Data)	DX - (Data)	n.c.	B -
14	n.c.	n.c.	Z +	Z +
15	CLK - (Clock)	n.c.	n.c.	A -

<sup>\*)</sup> The max. output current per channel is 0,25 A

### 4.8.9 X12 – resolver/hall



Pin	Feedback system	
	Resolver	Analog Hall sensor
1	Temperature (only PTC, Klixon or bimetal!) Switchpoint: 1300 $\Omega \pm 3\%$	n.c.
2	AGND	n.c.
3	COS - (S3)	n.c.
4	SIN - (S4)	n.c.
5	REF - (R2)	n.c.
6	n.c.	SIN 1Vpp
7	n.c.	-120° oder -90° 1Vpp *
8	n.c.	Us_11 V (supply)
9	Temp._GND	n.c.
10	COS + (S1)	n.c.
11	SIN + (S2)	n.c.
12	REF + (R1)	n.c.
13	n.c.	REFSIN 1 Vpp
14	n.c.	REF -120° oder -90° 1Vpp *
15	n.c.	GND (supply)

\*) The angle must be configured

### 4.8.10 X14 – motor brake and thermal contact



Terminal point	Connection	Output current
T-	Temp. - *	
T+	Temp. + *	
PE	Signal pair screen	
B-	Brake GND	
B+	Brake (U <sub>p</sub> ) +	2.2 A max.

\*) Switch, KTY 83-1xx or KTY 84-1xx



**Note**

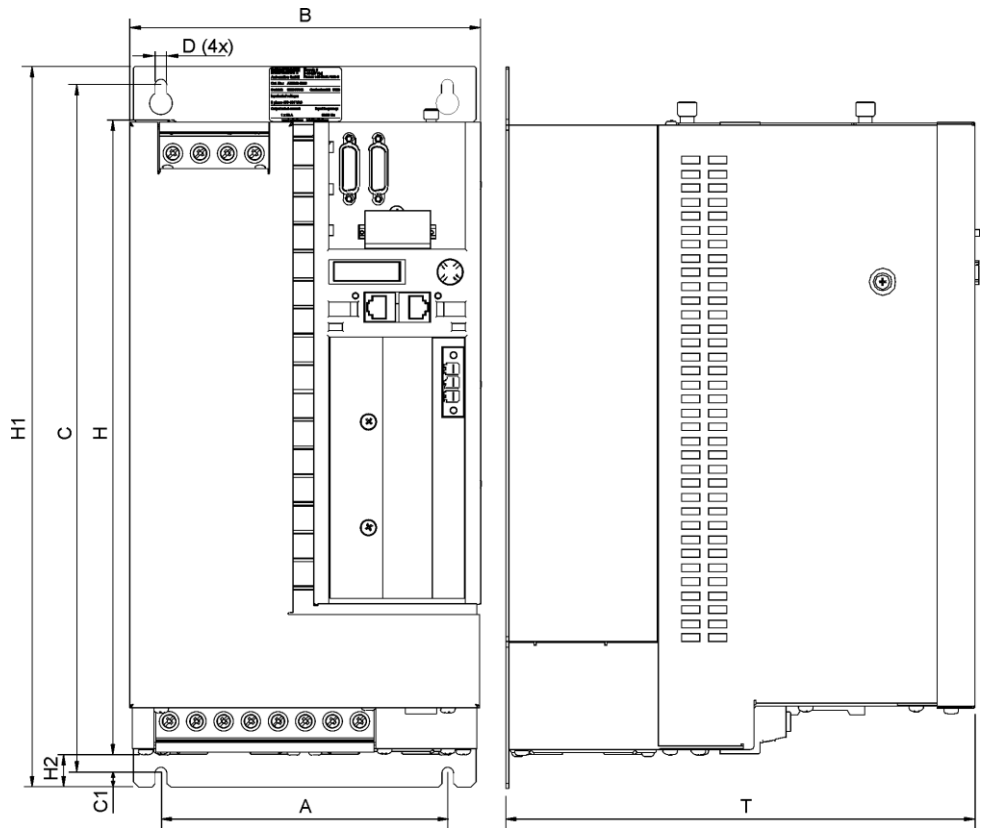
#### Output current

The specified output current is the maximum value. The actual value depends on your current configuration.

4.9 Dimensions


The specified measurements relate to the actual device, without connectors and cables. The fitting dimensions for control cabinet installation can be found in section "Mechanical installation → Installation examples".


AX5160, AX5172, AX5190, AX5191, AX5192, AX5193




AX	A [mm]	B [mm]	C [mm]	C1 [mm]	D [mm]	H [mm]	H1 [mm]	H2 [mm]	T [mm]	Fastening screw
5160	158	190	380	8	6,5	345	398	16,5	259	4 x M5
5172	158	190	380	8	6,5	345	398	16,5	259	4 x M5
5190	200	280	582	10	9	540	603	10	254	4 x M8
5191	200	280	582	10	9	540	603	10	254	4 x M8
5192	200	280	575	10	9	540	600	20	335	4 x M8
5193	200	280	575	10	9	540	600	20	335	4 x M8

## 5 Installation

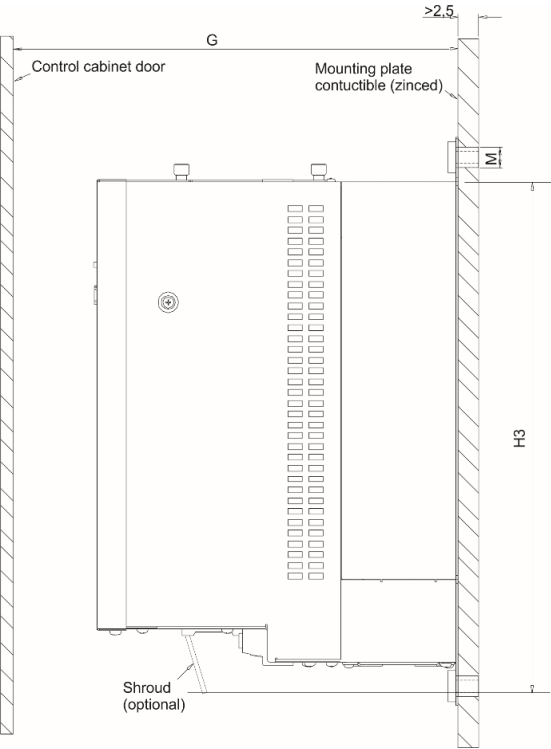
 <b>WARNING</b>	<p><b>Caution – Risk of injury!</b></p> <ul style="list-style-type: none"><li>• The servo drives may only be installed by trained, qualified personnel. The qualified personnel must know and comply with the national accident prevention regulations.</li><li>• Safety boots must be worn.</li></ul>
---	--

 <b>WARNING</b>	<p><b>Caution - Risk of injury through electric shock!</b></p> <p>De-energise all electrical components (servo drive, control cabinet, etc.) before commencing the installation or deinstallation.</p>
---	--


### 5.1 Mechanical installation

 <b>Attention</b>	<p><b>Destruction of the servo drive!</b></p> <ul style="list-style-type: none"><li>• Always install the servo drive vertically.</li><li>• Provide adequate ventilation for the servo drive. The permissible ambient conditions are specified in the "Technical data" section.</li><li>• It is essential to adhere to the required distances (see diagrams below).</li></ul>
---	--

5.1.1 Installation in the control cabinet




AX	G [mm]	M [mm]	H3 [mm]
5160 and 5172	≥ 300	4 x M5	445
5190 and 5191	≥ 300	4 x M8	640
5192 and 5193	≥ 500	4 x M8	640



**WARNING**

**Caution - Risk of injury through electric shock!**

The mounting plate must be earthed according to the statutory regulations.

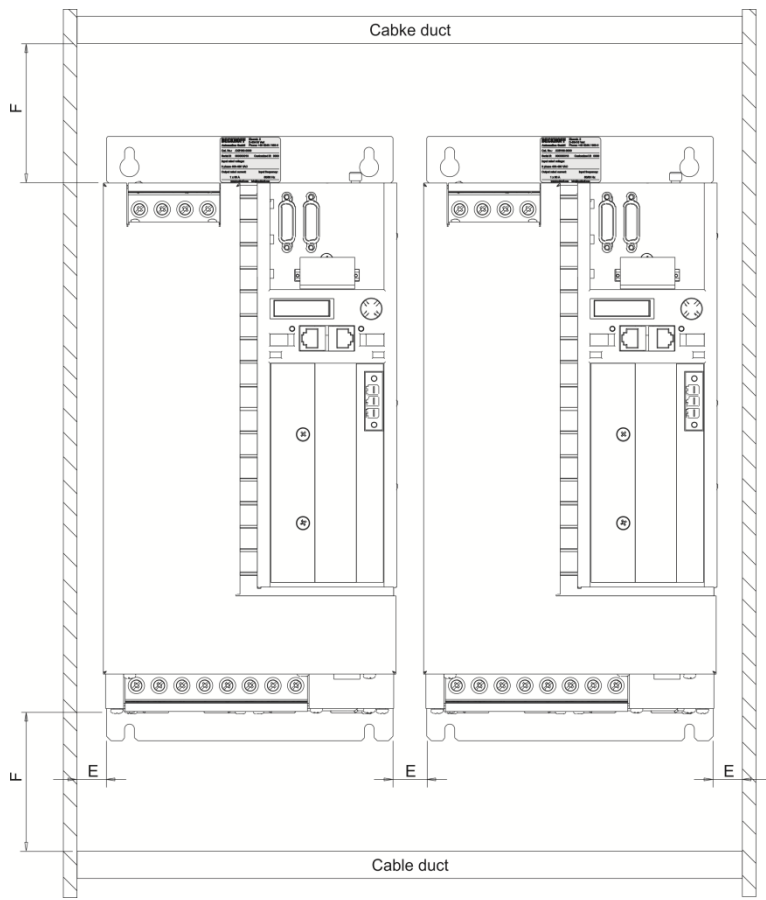


**Attention**

**Connection of the protective earth conductor on the AX5000:**

The servo drives AX5000 have earthing pins on the device housing. To attach the protective earth conductor via the grounding stud, use at least the cross section that is applied to the wide voltage input “X01” (PE).

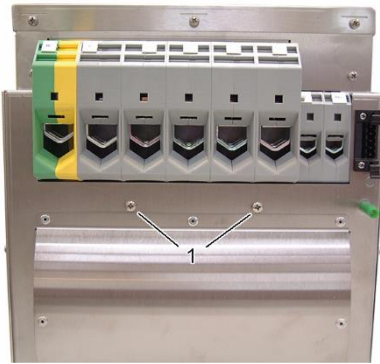
**5.1.2     Installation example**



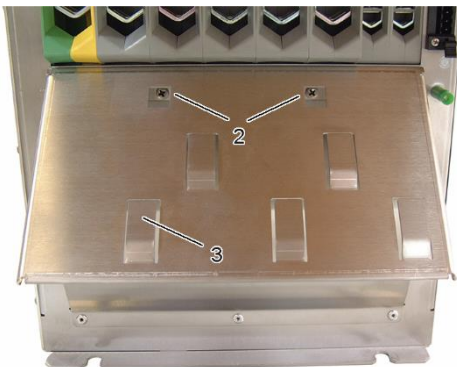
AX	F [mm]	E [mm]
5160 and 5172	≥ 180	20
5190 and 5191	≥ 180	40
5192 and 5193	≥ 180	40



### 5.1.3 Installation of the shroud (optional)



1. Remove the screws 1  
(Don't use again.)



2. Position the shroud at the  
ground of the servo drive.
3. Mount the shroud with the  
screws 2.  
(Take the new delivered  
screws.)

4. Connect the lines at the terminals.
5. Connect the shield of the lines at the connecting links 3.

## 5.2 Electrical installation

**UL-Listing!**

It is essential to observe chapter 3.3 if you wish to operate an AX5000 in an economic area that requires a UL-Listing.

**Serious risk of injury through electric shock!**

Due to the DC link capacitors dangerous voltage may persist at the DC link contacts "ZK+ and ZK-" and "RB+ and RB-" after the servo drive has been disconnected from the mains supply. After disconnecting the servo drive wait at AX5160/AX5172 15 minutes, at AX5190/AX5191 30 minutes and at AX5192/AX5193 45 minutes and measure the voltage at the DC link contacts ZK+ and ZK-. The device is safe once the voltage has fallen below 50 V.

**Caution – Risk of injury through electric shock!**


- Before installation, wiring and commissioning it is essential to read the section on "Safety".
- Before installing, uninstalling or connecting the servo drive and the motors please note the following:
  - Remove all relevant mains fuses.
  - Switch off the main system switch and secure it with a lock.
  - Put up a warning sign.
- The control and power connections for the motors may be live, even if the motor is prevented from rotating by the internal brake.

**Attention****Destruction of the equipment!**

- Check the rated voltage and current of the servo drive and the connected motors.
- When the AX5000 is disconnected from the mains supply (emergency stop, mains contactor etc.), query the status of the IDN "P-0-0205" (see documentation of the "IDN-Description") before starting again or

5.2.1 Mains supply connection (X01)

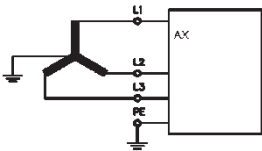
The servo drives of the AX5000 series are equipped with a wide voltage input "X01" and can be connected to voltage systems three-phase 400 V<sub>AC</sub> -10% - 480 V<sub>AC</sub> +10%.



Note

Connection to the standard mains supply (TT/TN) with earthed centre is described below. Connections to other supply systems are not permissible.

Three-phase 400 -10% - 480 +10% V<sub>AC</sub>



5.2.1.1 External protection for individual devices, CE-compliant



CAUTION


Fire hazard through short circuit!

The recommended fuses are designed for line protection. The servo drives feature integrated self-protection.

Fusing	AX5160	AX5172	AX5190	AX5191	AX5192	AX5193
AC supply *)	80 AT	100 AT	125 AT	160 AT	200 AT	224 AT
24 V supply	4 AT		10 AT			
Brake resistor	electronic					

\*) Application class "gG" mains fuses according to IEC 60269 or "C" type automatic circuit breakers must be used.

5.2.1.2 External protection for individual devices, UL-compliant



CAUTION

Fire hazard through short circuit!

The recommended fuses are designed for line protection. The servo drives feature integrated self-protection.

Fusing	AX5160	AX5172	AX5190	AX5191	AX5192	AX5193
AC supply (max.) *)	80 A	100 A	125 A	150 A	200 A	225 A
24 V supply (max.)	4 AT		10 AT			
Brake resistor	electronic					

\*) Mains fuses according to type "RK5" min. 480 V must be used.

### 5.2.2 24 V<sub>DC</sub> - supply network connection (X03)

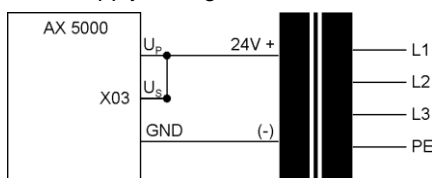
The 24 V<sub>DC</sub> connection "X03" is used for supplying control electronics and periphery with DC voltage. The control electronics and the periphery can be supplied separately with two different voltage sources.



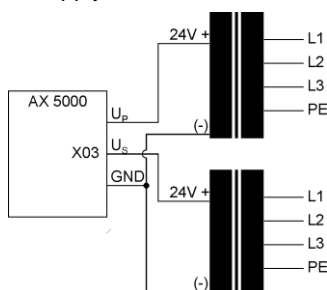
#### Note

If one transformer is used for the 24 V<sub>DC</sub> power supply, the connections U<sub>s</sub> and U<sub>P</sub> must be bridged, in order to ensure that both the control electronics and the periphery are supplied.

Supply through via one transformer




Supply via two transformers



5.3 Motors and cables

With longer motor cables the resulting commutation currents can lead to EMC faults. Use the tables below to check whether mains chokes or mains filters have to be used in your application. When selecting the control cabinet ensure that there is adequate space for mains chokes and mains filters, etc.  
Lay the power and signal cables in separate metal cable ducts or, if both types of cable use the same metal cable duct, make sure there is an earthed metal dividing wall between the cables.



**Note**

**Motor chokes**

For the AX5160 to AX5193 series no motor chokes are required.


Maximum cable length (including extensions) for a rated motor voltage up to 480 V

Servo drive	Category C2		Category C3	
	with mains filter	with mains filter and mains choke	without mains filter and without mains choke	with mains filter and mains choke
AX5160 <sup>1)</sup>	max. 10 m	max. 25 m	max. 25 m	max. 50 m
AX5172 <sup>2)</sup>	max. 10 m	max. 25 m	max. 25 m	max. 50 m
AX5190 <sup>3)</sup>	---	max. 10 m	---	max. 25 m
AX5191 <sup>4)</sup>	---	max. 10 m	---	max. 25 m
AX5192 <sup>5)</sup>	---	max. 10 m	---	max. 25 m
AX5193 <sup>6)</sup>	---	max. 10 m	---	max. 25 m

In compliance with EN 61800-3 only in conjunction with the following accessories:

- <sup>1)</sup> Mains filter AX2090-NF50-0063 and (or) mains choke AX2090-ND0060
- <sup>2)</sup> Mains filter AX2090-NF50-0100 and (or) mains choke AX2090-ND0072
- <sup>3)</sup> Mains filter AX2090-NF50-0100 and (or) mains choke AX2090-ND0090
- <sup>4)</sup> Mains filter AX2090-NF50-0150 and (or) mains choke AX2090-ND0110
- <sup>5)</sup> Mains filter AX2090-NF50-0150 and (or) mains choke AX2090-ND0143
- <sup>6)</sup> Mains filter AX2090-NF50-0180 and (or) mains choke AX2090-ND0170

In order to keep circuit feedback (distortion reactive power) as low as possible, a mains choke should always be used.



**Note**

**Radio interference in the living area**

Mains chokes are products with limited availability according to EN 61800-3. The products can cause radio interference in residential areas. In this case, measures must be taken by the operator.

## 6 Important information for commissioning

**WARNING****Caution – Risk of injury!**

Electronic equipment is not fail-safe. The machine manufacturer is responsible for ensuring that the connected motors and the machine are brought into a safe state in the event of a fault in the drive system.

Please be aware each time before commissioning the AX5000 that connected motors can make uncontrolled movements, which cannot always be prevented even by the AX5000's integrated diagnostic system, or may permit uncontrolled movements until the diagnostic system responds. Analyse your system and take suitable precautions to prevent damage being caused by these uncontrolled movements.

**Potential causes of uncontrolled movements:**

The diagnostic system of the AX5000 is equipped with complex plausibility checks, which constantly monitor installation, operation, parameterisation and operation and, if necessary, interrupt them with a diagnostic message. The points listed below are naturally also monitored as standard, but it is not possible to include all eventualities; therefore, with respect to the following points, you must always consider whether the driven axes can only perform permissible movements.

- Incorrect commutation results (e.g. during wake & shake), It is essential to observe chapter "AX5000 System manual→advanced system characteristics→commutation methods→commutation error "F2A0"" on our Homepage.
- **Specific caution with synchronous motors of third parties:** always execute the command „P-0-0166" without load when changing the motor or feedback or when changing the SysMan-file (.TSM) and evaluate the result. Correct the commutation offset if applicable., as described in chapter "AX5000 System manual→advanced system characteristics→commutation methods".
- Input of invalid parameters
- Measuring transducer and/or signal transducer defective or incorrectly adjusted
- Cables defective or not adequately screened
- Incorrectly attached sensors

**CAUTION****Increased attention in the case of vertical axes!**

When commissioning vertical axes, the risk consideration described above is to be carried out with particular care. An uncontrolled movement can mean the sudden falling down of a load in this case.

## 7 Project planning – important information

The more thoroughly a machine or plant project is thought through in advance, the less risk there is of having to carry out expensive modifications during or after commissioning. This applies to both the mechanical and electrical design. This section can only give a rough overview of electrical design. Further information can be found in the publication "Project planning aid" under Downloads on our website at [www.beckhoff.com](http://www.beckhoff.com)

### 7.1 Drive train design

Application, servo drive, motors and gear mechanism must be adapted to each other so that there is an adequate safety margin for all components as a degree of sluggishness appears over time due to high temperatures or wear. Make sure that the components in the working area of the system have adequate reserves so that the working life is not impaired and the necessary control quality can be maintained.

#### 7.1.1 Control quality, mass inertia ratio and load connection

Control quality is dependent on the parameters "mass inertia ratio" and "load connection":

Control quality / Dynamics	Mass inertia ratio
Good	up to 3:1
Average	up to 5:1
Bad	up to 10:1

The "Control quality / dynamics" is primarily affected by the mass moment of inertia: a poor "Control quality / dynamic" due to an unfavourable mass moment of inertia cannot be improved even with a very good load connection. Likewise, however, a good "Control quality / dynamic" due to a favourable mass moment of inertia can be reduced through a poor load connection.

### 7.2 Energy management

If the quality of the mains supply is impaired due to wide fluctuations in voltage, then both the servo drive specification and the speed range of the motor will need to be considered. With a positive tolerance for voltage fluctuation the upper limit value of the wide voltage input of the AX5000 needs to be taken into account. With a negative tolerance of the voltage fluctuation it must be checked whether the decrease in speed caused by the low voltage is permissible. With these motors what is known as field weakening operation (check availability) of the servo drive may provide a solution.

## **7.3 EMC, earthing, screen connection and potential**

The AX5000 corresponds to EMC category "C3" (industrial sector) in terms of conducted interference emissions. If you wish to use components which comply with a higher category you can limit the AX5000 conducted interference emissions with the aid of additional filters to such a degree that this complies with the EMC category "C2" (residential and industrial environment) or "C1" (residential environments).

Ensure that there is adequate earthing (large-area low-impedance connection) of all relevant components (incl. control cabinet). The AX5000 incl. periphery, control cabinet, machine bed and motors must be at the same potential, as the AX5000 control quality will suffer under differing potentials and operational malfunction may result. Using the screen connection for potential equalisation is not permitted. If you are unable to provide a uniform reference potential you need to lay potential equalisation cables of adequate dimensions. Smooth operation is only guaranteed by faultless screen connections of the cables. The screens must be applied generously at both ends and must on no account be disconnected. Use Beckhoff motor and feedback cables as these are optimally adapted to the drive system and reduce interference to a minimum. Ensure that the connectors and cables are properly connected.

## **7.4 Control cabinet**

The dimensions of the control cabinet must be sufficient to accommodate all components with the specified distances. Remember that high temperatures may necessitate forced cooling. Position the control cabinet as close as possible to the machine so that the motor cables can be as short as possible.

In addition, the control cabinet should have an earthed metal rear panel to which the AX5000 incl. periphery are attached so that safe earthing can be guaranteed. If you are unable to guarantee these conditions you need to earth the AX5000 and the relevant components using an approved cable of adequate size.



## 8 Appendix

### 8.1 Support and Service

Beckhoff and their partners around the world offer comprehensive support and service, making available fast and competent assistance with all questions related to Beckhoff products and system solutions.

#### 8.1.1 Beckhoff's branch offices and representatives

Please contact your Beckhoff branch office or representative for [local support and service](#) on Beckhoff products!

The addresses of Beckhoff's branch offices and representatives round the world can be found on her internet pages: <http://www.beckhoff.com>

You will also find further [documentation](#) for Beckhoff components there.

#### 8.1.2 Beckhoff Headquarters

Beckhoff Automation GmbH & Co. KG  
Hülshorstweg 20  
33415 Verl  
Germany

Phone: +49(0)5246/963-0  
Fax: +49(0)5246/963-198  
E-Mail: [info@beckhoff.com](mailto:info@beckhoff.com)

#### 8.1.3 Beckhoff Support

Support offers you comprehensive technical assistance, helping you not only with the application of individual Beckhoff products, but also with other, wide-ranging services:

- Support
- Design, programming and commissioning of complex automation systems
- Extensive training program for Beckhoff system components

Hotline : +49(0)5246/963-157  
Fax : +49(0)5246/963-9157  
E-Mail : [support@beckhoff.com](mailto:support@beckhoff.com)

#### 8.1.4 Beckhoff Service

The Beckhoff Service Center supports you in all matters of after-sales service:

- On-site service
- Repair service
- Spare parts service

Hotline : +49(0)5246/963-460  
Fax : +49(0)5246/963-479  
E-Mail : [service@beckhoff.com](mailto:service@beckhoff.com)