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Startup

Servo Drive AX5000

(1.5 A – 40 A)

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

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BECKHOFF

Notes:

Chapter Page

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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. 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.

 CAUTION	**Hazard to individuals!** Further and more detailed information regarding the individual sections and safety can be found in the “AX5000 User manual” on the enclosed CD or can be downloaded from our website at www.beckhoff.com. If you do not have access to the “AX5000 User manual” please refrain from working on the AX5000 and notify our support division.

An overview is provided on the inside of the rear cover, which can be folded out.

1.2 Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development. For this reason, the documentation may not always be have been fully checked for consistency with the performance data, standards or other characteristics described. In the event that it contains technical or editorial errors, we retain the right to make alterations at any time and without warning. 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

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1.4 Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents:
EP1590927, EP1789857, DE102004044764, DE102007017835
with corresponding applications or registrations in various other countries.
The TwinCAT Technology is covered, including but not limited to the following patent applications and patents:
EP0851348, US6167425 with corresponding applications or registrations in various other countries.

1.5 Copyright

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1.6 Documentation issue status

Version	Comment
3.9	Chapter-Update: 4.7.4
3.8	Chapter-Update: 4.3; 4.4.1; 4.7.11; 7.5
3.7	Chapter-Update: 1.1; 4.4.4; 5.1.1.2
3.6	Chapter-Update: 2.2; 4.4.2.2; 4.6; 4.7.11
3.5	Chapter-Update: 6
3.4	Chapter-Update: 4.7.11
3.3	New chapter: 4.7.3
3.2	Chapter-Update: 4.7.2
3.1	Chapter-Update: 4.7.11; 5.2.1.1; 7.5
3.0	Chapter-Update: 4.2.1; 4.4.2.2; 4.4.4; 4.8; 5.1.1.2; 5.2.1.1 New chapter: 1.8; 4.6; 4.7.9; 4.7.11; 7
2.5	Chapter-Update: 4.6.7; 6
2.4	Chapter-Update: 1.1; 1.2; 1.5; 4.5; 5.2 New chapter: 1.3; 1.4
2.3	Chapter-Update: 2.2; 5.2.3.1 New chapter: 6
2.2	Chapter-Update: 2.2; 3.1; 4.6.6; 4.6.8; 5.1.1; 5.2.1.5
2.1	Chapter-Update: 4.1; 4.6.6; 5.2.3

2.0	General revision on account of the UL-Listing of the AX5000.
1.3	Chapter-Update: 1.1; 4.4.2.1; 4.4.2.2; 4.4.3.1; 4.4.3.2; 5.2.1; 5.2.1.1
1.2	General routine corrections
1.1	First edition
1.0	only german

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.

 **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.

The servo drives may **only** be operated in enclosed control cabinets and in accordance with the conditions described in the "Technical data" section.

1.8 Documented servo drives

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

AX5101
AX5103
AX5106
AX5112
AX5118
AX5125
AX5140

AX5201
AX5203
AX5206

EN

Notes:

2 Safety

2.1 General safety instructions

2.1.1 Safety rules

Consider the following safety instructions and descriptions!
Product specific safety instructions are to be found on the following pages or in the areas mounting, wiring, commissioning etc..

2.1.2 Disclaimer

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH.

2.1.3 Description of safety 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.

 DANGER	**Acute risk of injury!** If you **do not** adhere the safety advise adjoining this symbol, there is immediate danger to life and health of individuals!
 WARNING	**Risk of injury!** If you **do not** adhere the safety advise adjoining this symbol, there is danger to life and health of individuals!
 CAUTION	**Hazard to individuals!** If you **do not** adhere the safety advise adjoining this symbol, there is obvious hazard to individuals!
 Attention	**Hazard to devices and environment** If you **do not** adhere the notice adjoining this symbol, there is obvious hazard to materials and environment.
 Note	**Note or pointer** This symbol indicates information that contributes to better understanding.
	**UL pointer** This symbol indicates important information about the UL-compliant.

EN

2.1.4 Personnel qualification

This description is only intended for trained specialists in control, automation and drive engineering who are familiar with the applicable national standards.

2.2 Special safety instructions for 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**	**Serious risk of injury through high electrical voltage!** • Never open the servo drive when it is live. Wait until the DC link capacitors are discharged. The voltage measured between the DC+ and DC- terminals (X02) must have fallen below 50 V. Opening the device (with the exception of expansion card slots) invalidates all warranty and liability claims against Beckhoff Automation GmbH. • Negligent, improper handling of the servo drive and bypassing of the safety devices can lead to personal injury or death through electric shock. • Ensure that the protective conductor is connected properly. • Disconnect the servo drive from the mains supply and secure it against reconnection before connecting or disconnecting the pluggable terminals. • Disconnect the servo drive from the mains supply and secure it against reconnection before working on electrical parts with a voltage > 50 V. • Due to the DC link capacitors dangerous voltage may persist at the DC link contacts "X02" after the servo drive has been disconnected from the mains supply. After disconnecting the servo drive wait 5 minutes and measure the voltage at the DC link contacts DC+ and DC-. The device is safe once the voltage has fallen below 50 V.

 **WARNING**	**Serious risk of injury through hot surfaces!** • The surface temperature may exceed 50 °C, resulting in a risk of burns. • Avoid touching the case during or shortly after operation. • Leave the servo drive to cool down for at least 15 minutes after it is switched off. • Use a thermometer to check whether the surface has cooled down sufficiently.

 **WARNING**	**Danger of injury due to uncontrolled movements!** Read and take note of chapter 6 ‘Important information for commissioning’ each time before commissioning the AX5000

 **CAUTION**	**Hazard to individuals!** • 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. • Only well trained, qualified electricians with sound knowledge of drive equipment may work on the device. • 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.

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3 Guidelines and Standards

3.1 CE conformity

The servo drives of the AX5000 series comply with the

- EC Low-Voltage Directive, 2006/95/EC

Applied harmonised standards:

61800-5-1

 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 of the AX5000 series comply with the
- 2004/108/EC EMC Directive

Applied harmonised standards:
IEC / EN 61000-4-2
IEC / EN 61000-4-3
IEC / EN 61000-4-4
IEC / EN 61000-4-5
IEC / EN 61000-4-6
IEC / EN 61000-6-1
IEC / EN 61000-6-2
IEC / EN 61000-6-3
IEC / EN 61000-6-4
IEC / EN 61800-3

3.3 UL-Listing

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

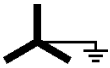
UL LISTED Ind. Cond. Eq. 41GE	**AX5000 with UL-Listing** AX5101, AX5103, AX5106, AX5112, AX5201, AX5203 und AX5206

on the name plate. If you wish to operate an AX5000 in an economic area that requires a UL-Listing, please check that there is a UL 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 to ground.

"5.2.3 Connection of several servo drives to form a drive system"

UL	**Drive system with UL-Listing!** Please consult our Application Department with respect to the requirements for a drive system with UL-Listing.

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.

Suitable for use on a circuit capable of delivering not more than 18000 rms symmetrical amperes, 480 V maximum, when protected by RK5 class fuses.

Single-phase

Fusing	AX5101	AX5103	AX5106	AX5201	AX5203	AX5206
AC supply (max.) *)	6 A	12 A	20 A	12 A	20 A	20 A
24 V supply (max.)	3 A					
Brake resistor	electronic					

*) Mains fuses according to type "RK5" must be used.

Three-phase

Fusing	AX5101	AX5103	AX5106	AX5112	AX5201	AX5203	AX5206
AC supply (max.) *)	6 A	12 A	20 A	20 A	12 A	20 A	20 A
24 V supply (max.)	3 A						
Brake resistor	electronic						

*) Mains fuses according to type "RK5" must be used.

EN

	AX5112! When protected by RK5 class fuses: Rated 20 A, min. 480 V

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.

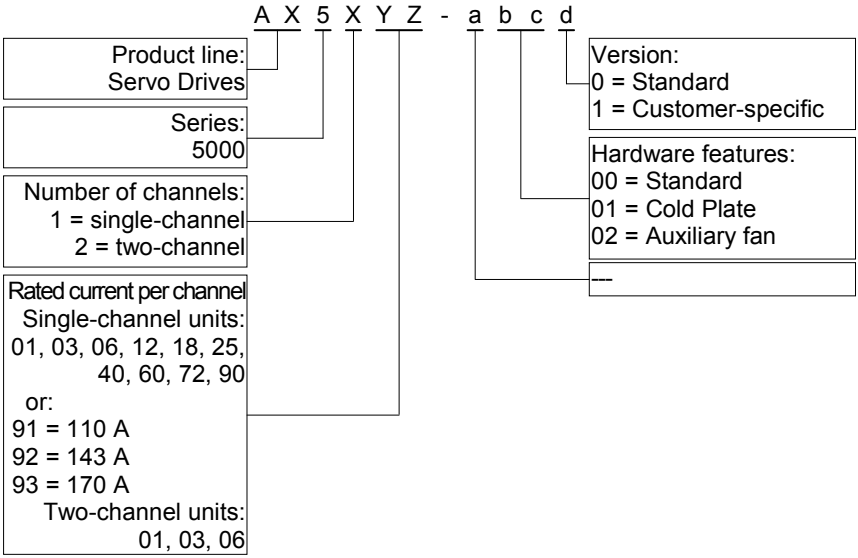
3.4 Electrical isolation according to EN 50178 / VDE 160

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



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:
  X01: Mains input
  X02: DC link
  X03: DC power supply 24 V
  X06: Digital inputs and outputs
  X07: External brake resistor (only AX5140)
- Startup (this manual)
- Complete documentation on CD

EN

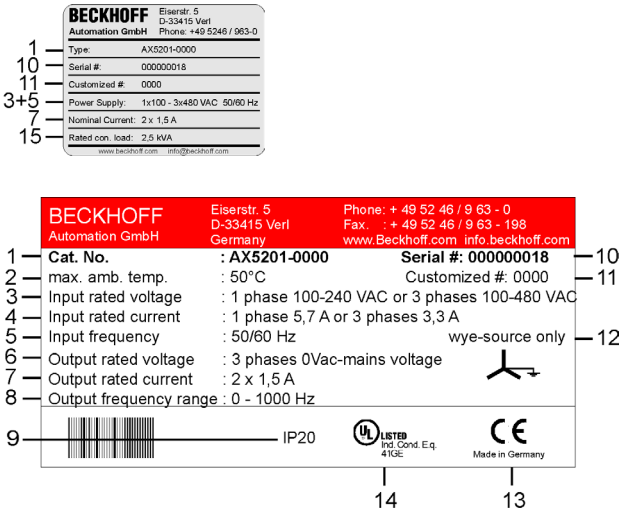
4.2.2 Accessories

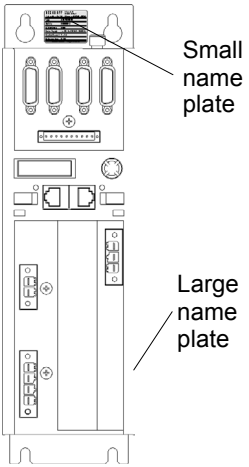
A comprehensive list of accessories can be found in the complete Beckhoff catalogue or on our website at www.beckhoff.com.

	Accessories with UL-Listing! 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.

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	Catalog number	6	Output rated voltage	11	Customer-specific
2	Max. ambient temperature	7	Output rated current	12	wye-source only
3	Input rated voltage	8	Output frequency range	13	CE - Conform
4	Input rated current	9	Protection class	14	UL – Listed
5	Input frequency	10	Serial number		

4.4 Technical data

	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.

4.4.1 Permissible ambient and operating conditions

Ambient / operating conditions	Permissible values
Ambient temperature during operation	0 °C to +50 °C
Ambient temperature during transport / storage	-25 °C to +70 °C
Air humidity	5 % to 95 %, non-condensing
Pollution degree	2 according to EN 60204/EN 50178
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
Installation position	vertical
Ventilation	Total device current ≤ 3 A: free convection Total device current > 3 A: built-in temperature-controlled fan
Protection class	IP 20
Vibration test (EN 60068-2-6)	Frequency range: 10-500 Hz Amplitude: 10-58 Hz = 0,075 mm pk-pk 59-500 Hz = 1 g
Shock test (EN 60068-2-27)	Half sine wave amplitude: 5 g Duration: 30 ms Number of shocks: 3 per axis and direction (total 18)
Repetitive shock test (EN 60068-2-27)	Half sine wave amplitude: 5 g Duration: 30 ms Number of shocks: 1000 per axis and direction (total 6000)
EMC	Category C3 - standard Category C2, C1 - auxiliary filter required

EN

4.4.2 Electrical data - single-channel servo drive (AX51xx)

4.4.2.1 Single-phase connection

Electrical data	AX5101	AX5103	AX5106
Rated output current	1.5 A	3 A	4.5 A
Minimum rated motor current at full current resolution	0.35 A	1 A	1 A
Peak output current [(1)]	4.5 A	7.5 A	13 A
Rated supply voltage	1x $100_{-10\%}$ – $240_{+10\%}$ V_{AC}		
Max. DC link voltage	890 V_{DC}		

Electrical data	AX5101	AX5103	AX5106
Rated apparent power S1 mode (selection) 120 V 230 V	 0.3 kVA 0.6 kVA	 0.6 kVA 1.2 kVA	 1.2 kVA 2.4 kVA
Power dissipation (2)	35 W	50 W	85 W
Max. continuous braking power (with internal brake resistor)	50 W	50 W	150 W
Max. braking power (with internal brake resistor)	14 kW		
Min. brake resistor (**external** brake resistor)	47 Ω		
Max. braking power (with **external** brake resistor)	15 kW		

(1) I_{eff} for max. 7 s
(2) S1 mode, including power supply unit, without brake chopper

4.4.2.2 Three-phase connection

Electrical data		AX						
		5101	5103	5106	5112	5118	5125	5140
Rated output current	[A]	1,5	3	6	12	18	25	40
Minimum rated motor current at full current resolution	[A]	0,35	1	1	6	8	12	18
Peak output current (1)	[A]	4,5	7,5	13	26	36	50	80(2)
Rated supply voltage	[V_{AC}]	3x 100$_{-10\%}$ – 480$_{+10\%}$						
Max. DC link voltage	[V_{DC}]	890						
Rated apparent power S1-mode (selection) 120 V 230 V 400 V 480 V	[kVA]	 0,3 0,6 1,0 1,2	 0,6 1,2 2,1 2,5	 1,2 2,4 4,2 5,0	 2,5 4,8 8,3 10,0	 3,4 7,2 12,5 15,0	 4,8 10,0 17,3 20,8	 8,3 16,0 27,7 33,3
Power dissipation (3)	[W]	35	50	85	160	255	340	510
Max. continuous braking power (with internal brake resistor)	[W]	50	50	150	90	200	200	150
Max. braking power (with internal brake resistor)	[kW]	14				26	26	26
Min. brake resistor (**external** brake resistor)	[Ω]	47	47	47	30	22	22	22(4)
Max. braking power (**external** brake resistor)	[kW]	15	15	15	23,5	32	32	32

(1) I_{eff} for max. 7 s
(2) I_{eff} for max. 7 s, if rotating field frequency >3 Hz at max. 40°C
(3) S1 mode, including power supply unit, without brake chopper
(4) Brake resistor < 22 Ω –> Please consult our Application Department

4.4.3 Electrical data - two-channel servo drive (AX52xx)

4.4.3.1 Single-phase connection

Electrical data	AX5201	AX5203	AX5206
Rated output current / channel	1.5 A	3 A	6 A
Minimum rated channel current at full current resolution	0.35 A	1 A	1 A
Maximum rated channel current at full current resolution	3 A	4.5 A	9 A
Total rated output current with full current resolution	3 A	4.5 A	9 A
Max. peak output current (1)/channel	5 A	10 A	13 A
Peak output current (1) total device current	10 A	20 A	26 A
Rated supply voltage	1x $100_{-10\%}$ – $240_{+10\%}$ V_{AC}		
Max. DC link voltage	890 V_{DC}		
Rated apparent power S1 mode (selection) 120 V 230 V	 0.6 kVA 1.2 kVA	 1.2 kVA 2.4 kVA	 2.5 kVA 4.8 kVA
Power dissipation (2)	55 W	85 W	160 W
Max. continuous braking power (with internal brake resistor)	50 W	150 W	90 W
Max. braking power (with internal brake resistor)	14 kW		
Min. brake resistor (**external** brake resistor)	47 Ω		
Max. braking power (with **external** brake resistor)	15 kW		

(1) I_{eff} for max. 7 s
(2) S1 mode, including power supply unit, without brake chopper

4.4.3.2 Three-phase connection

Electrical data	AX5201	AX5203	AX5206
Rated output current per channel	1.5 A	3 A	6 A
Minimum rated channel current at full current resolution	0.35 A	1 A	1 A
Maximum rated channel current at full current resolution	3 A	6 A	9 A
Total rated output current with full current resolution	3 A	6 A	12 A
Max. peak output current (1)/channel	5 A	10 A	13 A
Peak output current (1) total device current	10 A	20 A	26 A
Rated supply voltage	3x $100_{-10\%}$ – $480_{+10\%}$ V_{AC}		

EN

Electrical data	AX5201	AX5203	AX5206
Max. DC link voltage	890 V_{DC}		
Rated apparent power S1 mode (selection) 120 V 230 V 400 V 480 V	 0.6 kVA 1.2 kVA 2.1 kVA 2.5 kVA	 1.2 kVA 2.4 kVA 4.2 kVA 5.0 kVA	 2.5 kVA 4.8 kVA 8.3 kVA 10.0 kVA
Power dissipation (2)	55 W	85 W	160 W
Max. continuous braking power (with internal brake resistor)	50 W	150 W	90 W
Max. braking power (with internal brake resistor)	14 kW		
Min. brake resistor (**external** brake resistor)	47 Ω		
Max. braking power (with **external** brake resistor)	15 kW		

(1) I_{eff} for max. 7 s
(2) S1 mode, including power supply unit, without brake chopper

4.4.4 Mechanical data (single-channel servo drive)

Mechanical data		AX						
		5101	5103	5106	5112	5118	5125	5140
Weight	[kg]	ca. 4	ca. 4	ca. 5	ca. 5	ca. 11	ca. 11	ca. 13
Width	[mm]	92				185		
Height without plugs	[mm]	274						
Depth without connectors/ accessories	[mm]	232						

4.4.5 Mechanical data (two-channel servo drive)

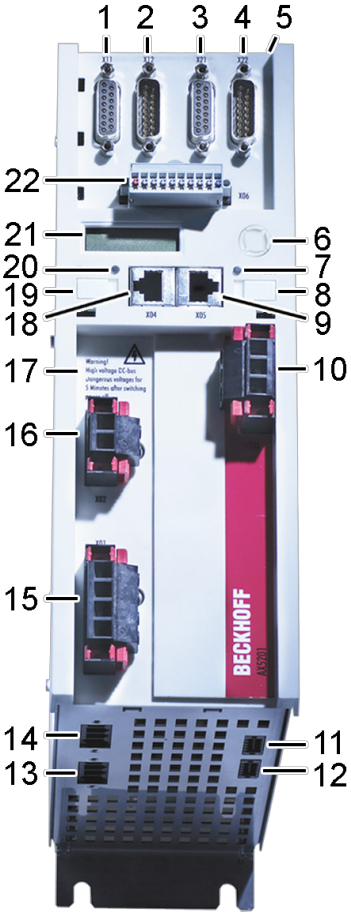
Mechanical data	AX5201	AX5203	AX5206
Weight	approx. 5 kg	approx. 6 kg	approx. 6 kg
Width	92 mm		
Height without plugs	274 mm		
Depth without connectors / accessories	232 mm		

4.5 General overview (AX5101 – AX5112 and AX520x)

The servo drive shown below is a two-channel device. Components that are only available for the second channel are identified in the item description.

Item description:

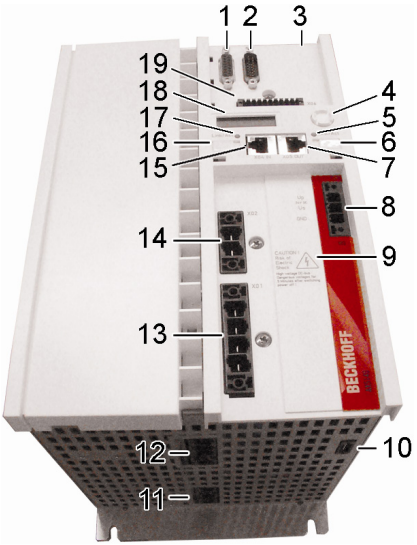
No	Designation
1	X11 – feedback connection, encoder
2	X12 – feedback connection, resolver
3	X21 – feedback connection, encoder channel B (only for two-channel unit)
4	X22 – feedback connection, resolver channel B (only for two-channel unit)
5	X3x – optional slot for safety card X4x – optional slot for expansion cards
6	Navigation rocker
7	Status LED for EtherCAT output
8	Labeling field
9	X05 – socket for EtherCAT output
10	X03 – power supply 24 V DC input
11	X14 – sensor for motor temperature and brake
12	X24 – sensor for motor temperature and brake channel B (only for two-channel unit)
13	X23 – motor connection (U, V, W, PE) channel B (only for two-channel unit)
14	X13 – motor connection (U, V, W, PE)
15	X01 – mains supply 100 – 480 V
16	X02 – DC link output (890 V DC voltage) Connection for the external brake resistor
17	 WARNING 890 V DC voltage at the DC link terminals. Dangerous voltage may be present for 5 minutes after the device is switched off. The device is safe once the voltage has fallen below 50 V.
18	X04 – socket for EtherCAT input
19	Labeling field
20	Status LED for EtherCAT input
21	Display
22	X06 – connection for digital inputs and outputs



EN

4.6 General overview (AX5118, AX5125 und AX5140)

The servo drive illustrated below is an AX5140; the devices with 18 A or 25 A are structurally similar apart from pos. 11 "X07" (external brake resistor).



Item description:

No	Designation
1	X11 – feedback connection, encoder
2	X12 – feedback connection, resolver
3	X3x – optional slot for safety card X4x – optional slot for expansion cards
4	Navigation rocker
5	Status LED for EtherCAT output
6	Labeling field
7	X05 – socket for EtherCAT output
8	X03 – power supply 24 V DC input
9	**WARNING** Max. 890 V DC voltage at the DC link terminals. Dangerous voltage may be present for 5 minutes after the device is switched off. The device is safe once the voltage has fallen below 50 V.
10	X14 – sensor for motor temperature and brake

No	Designation
11	X07 – external brake resistor (only AX5140)
12	X13 – motor connection (U, V, W, PE)
13	X01 – mains supply 100 – 480 V
14	X02 – DC link output (890 V DC voltage) Connection for the external brake resistor (only AX5118 u. AX5125)
15	X04 – socket for EtherCAT input
16	Labeling field
17	Status LED for EtherCAT input
18	Display
19	X06 – connection for digital inputs and outputs

4.7 Overview of connectors/terminal points

4.7.1 X01 - wide voltage input



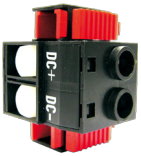
Terminal point	Connection	
	3-phase	1-phase
L1	Phase L1	Phase L1
L2	Phase L2	not used
L3/ N	Phase L3	Neutral conductor
PE	Protective conductor	Protective conductor

4.7.2 X02 - DC link (AX5101 - AX5125 und AX520x)



Terminal point	Connection	
DC+	DC link +	external brake resistor
DC –	DC link –	

4.7.3 X02 - DC link (Only AX5140)



Terminal point	Connection	
DC+	DC link +	only for drive system
DC –	DC link –	

WARNING	**Serious risk of injury through high electrical voltage!** 890 V DC voltage at the DC link terminals. Dangerous voltage may be present for 5 minutes after the device is switched off. Remove the connector only if you want to build a drive system with a AX-Bridge. Remove the white hexagon plugs only if you wire the terminal points again.

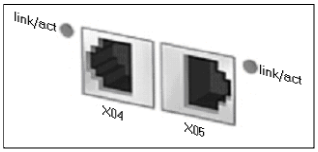
4.7.4 X03 - 24 V_{DC} supply



Terminal point	Connection	Current consumption
U_p +	24 $V_{DC\ -0/+25\%}$ - periphery (e.g. separate braking voltage)	Depending on the connected consumers (see X06 and X14, X24)
U_s +	24 $V_{DC\ \pm 25\%}$ - system supply (depending on rated current)	-12 A = 0.4 A – 0.8 A 18 A - 25A = 1,1 A 40 A = 1,6 A
GND	GND	

EN

4.7.5 X04, X05 - EtherCAT connection



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

4.7.6 X06 – Digital I/Os

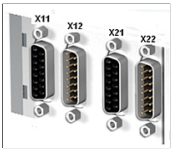
CAUTION	**Destruction of the AX5000!** This connector is not designed for external power supply. It is supplied via the 24 V supply (U_p) of connector X03.

Note	**Output current** 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_{DC} +)	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_{DC} +)	0.5 A max.
0 V	Output voltage GND (-)	

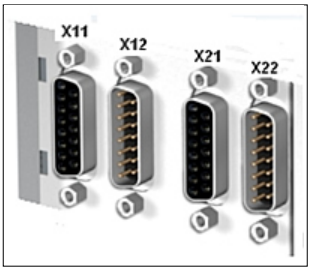
4.7.7 X11 (channel A) , X21 (channel B) - feedback, high-resolution



Pin	EnDAT / BiSS	Hiperface	Sin / Cos 1Vpp	TTL
1	SIN +	SIN +	SIN +	n.c.
2	GND_5 V	GND_9 V	GND_5 V	GND_5 V
3	COS +	COS +	COS +	n.c.
4	U_S_5 V *)	n.c.	U_S_5 V *)	U_S_5 V *)
5	DX + (Data)	DX + (Data)	n.c.	B +
6	n.c.	U_S_9 V *)	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_S_5 V Sense	n.c.	U_S_5 V Sense	U_S_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 -

*) The max. output current per channel is 0,25 A

4.7.8 X12 (channel A) , X22 (channel B) - resolver/hall



Pin	Feedback system	
	Resolver	Analog Hall sensor
1	Temperature (only PTC, Klixon or bimetal!) Switchpoint: 1300 Ω ± 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_9 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

EN

4.7.9 X13 (channel A) , X23 (channel B) - motor connection (power) (AX5101 - AX5125 und AX520x)



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

4.7.10 X13 - motor connection (power - only AX5140)



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

Attention	**Grounding shield!** The grounding shield of the motor is connected via the shield plate in the motor connector. Please tighten the knurled screws of the motor connector with a screwdriver. It is possible that some feedback problems may caused due to a poor shield connection of the motor.

4.7.11 X14 (channel A), X24 (channel B) - motor brake, thermal contact



AX5000-xxxx-0000

Terminal point	Connection	Output current
T-	Temp. - *	
T+	Temp. + *	
PE	Signal pair screen	
B-	Brake GND	
B+	Brake (U_p) +	1.5 A max.

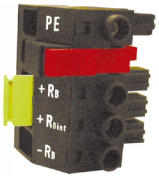
*) Switch, KTY 83-1xx or KTY 84-1xx

AX5000-xxxx-0200

Terminal point	Connection	Output current
T-	OCT – and temperature	
T+	OCT + and temperature	
PE	Signal pair screen	
B-	Brake GND	
B+	Brake (U_p) +	2.2 A max.

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

4.7.12 X07 – internal and external brake resistor (Only AX5140)



Terminal point	Connection
PE	Protective conductor
+ R_B	External brake resistor +
+ R_{Bint}	Internal brake resistor +
– R_B	Brake resistor GND

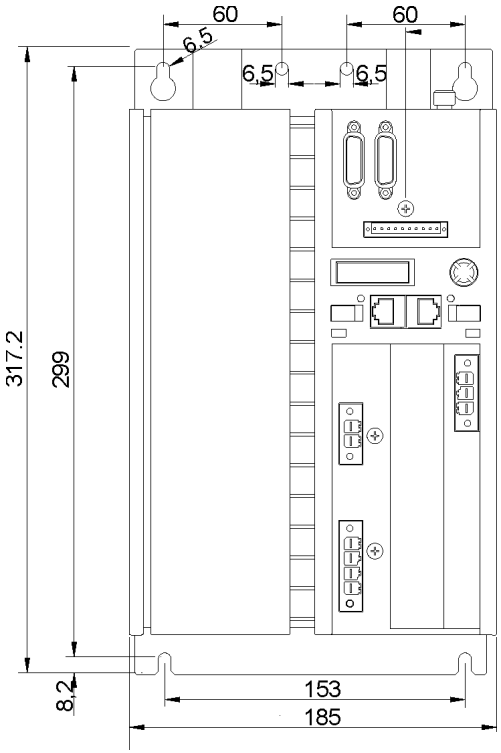
Note	**Operation of AX5140** Commissioning the AX5140 can only be carried out when the terminal points "+R_{Bint}" and "+R_B" are bypassed (delivery state) or an external brake resistor is connected (terminal points "+R_B" and "-R_B"). If these measures are not taken then the AX5140 will be stopped with the error message "FD4B – undervoltage"

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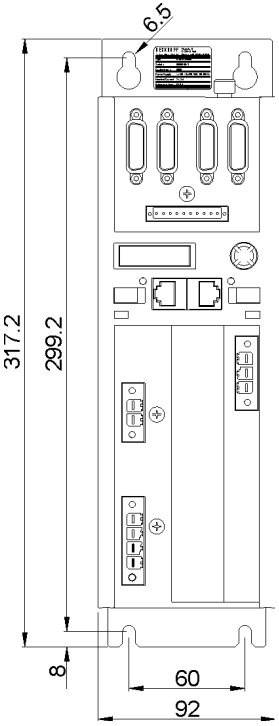
4.8 Dimensions

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".

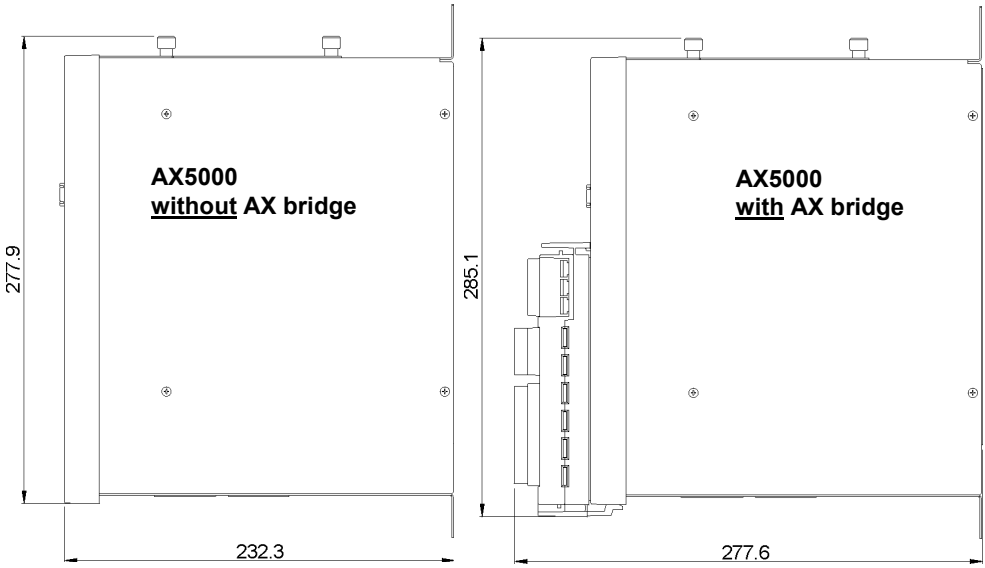
AX5118, AX5125 and AX5140



AX5101-AX5112 / AX5201-AX5206



All dimensions are in mm



All dimensions are in mm

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5 Installation

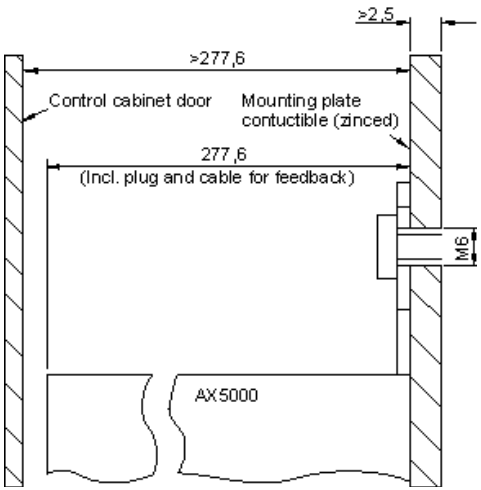
WARNING	**Caution – Risk of injury!** • The servo drives may only be installed by trained, qualified personnel. The qualified personnel must know and comply with the national accident prevention regulations. • Safety boots must be worn.

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

5.1 Mechanical installation

Attention	**Destruction of the servo drive!** • Always install the servo drive vertically. • Provide adequate ventilation for the servo drive. The permissible ambient conditions are specified in the "Technical data" section. • It is essential to adhere to the required distances (see diagrams below).

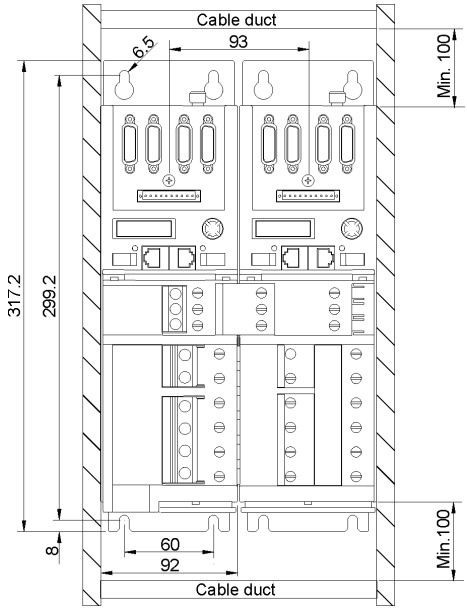
5.1.1 Installation in the control cabinet



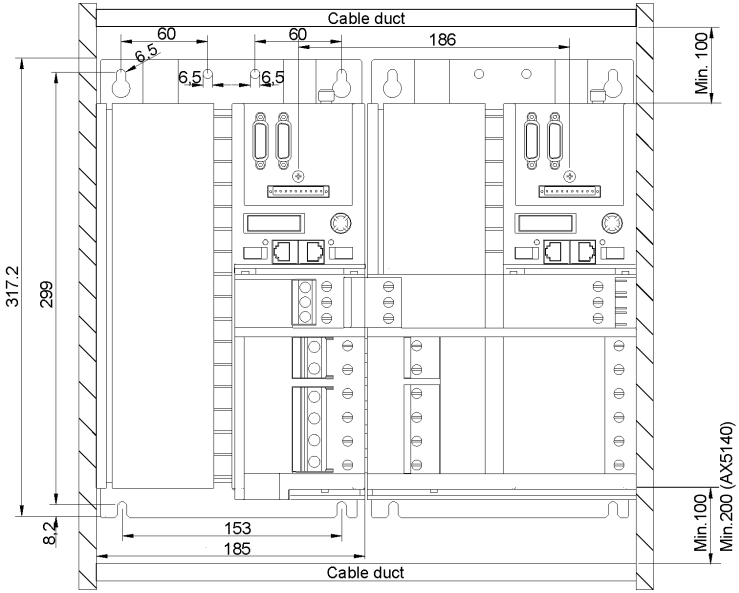
WARNING	**Caution - Risk of injury through electric shock!** The mounting plate must be earthed according to the statutory regulations.

Attention	**Grounding!** If the ground connection of the AX5000 is not done as specified it is possible to get trouble with some EMC issues.

5.1.1.1 Installation example - AX5101-AX5112 and AX5201-AX5206



5.1.1.2 Installation example - AX5118, AX5125 and AX5140



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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.

 **DANGER**	**Serious risk of injury through electric shock!** Due to the DC link capacitors dangerous voltage may persist at the DC link contacts "X02" after the servo drive has been disconnected from the mains supply. After disconnecting the servo drive wait 5 minutes and measure the voltage at the DC link contacts DC+ and DC-. The device is safe once the voltage has fallen below 50 V.

 **WARNING**	**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.

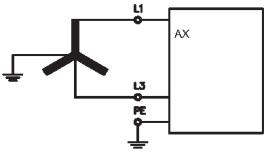
 **Attention**	**Destruction of the equipment!** • Check the rated voltage and current of the servo drive and the connected motors. • When the AX5000 is disconnected from the mains supply (emergency stop, mains contactor etc.), wait at least 3 minutes before starting again or query the status of the IDN "P-0-0205" (see documentation of the “IDN-Description”).

5.2.1 Mains supply connection (X01)

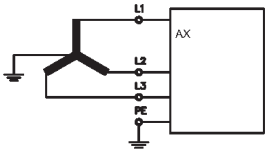
The servo drives of the AX5000 series are equipped with a wide voltage input "**X01**" and can be connected to voltage systems between single-phase 100 $V_{AC\ -10\%}$ - 240 $V_{AC\ +10\%}$and three-phase 100 $V_{AC\ -10\%}$ - 480 $V_{AC\ +10\%}$.

Note	Connection to the standard mains supply (TT/TN) with earthed centre is described below. Details for connections to other supply systems (e.g. IT-mains supply, isolating transformer etc.) can be found in the “AX5000 User manual” on the enclosed CD or can be downloaded from our website at www.beckhoff.com.

single-phase 100 $_{-10\%}$ - 240 $_{+10\%}$ V_{AC}



three-phase 100 $_{-10\%}$ - 480 $_{+10\%}$ V_{AC}



5.2.1.1 External protection for individual devices, CE-compliant

CAUTION	**Fire hazard through short circuit!** • The following data refer to individual devices. Please note the total current of all connected devices in a multi-axis system. • The recommended fuses are designed for line protection. The servo drives feature integrated self-protection.

Single-phase

Fusing	AX5101	AX5103	AX5106	AX5201	AX5203	AX5206
AC supply *)	10 AT	10 AT	16 AT	10 AT	16 AT	20 AT
24 V supply	5 AT					
Brake resistor	electronic					

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

Three-phase

Fusing	AX									
	5101	5103	5106	5112	5118	5125	5140	5201	5203	5206
AC supply *)	6 AT	6 AT	10 AT	20 AT	35 AT	35 AT	50 AT	10 AT	10 AT	20 AT
24 V supply	5 AT									
Brake resistor	elektronisch									

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

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5.2.1.2 Internal protection, CE-compliant

Circuit	Fuse
24 V - system voltage	3.4 AF
24 V - peripheral voltage	electronic
Brake resistor	electronic

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.
Suitable for use on a circuit capable of delivering not more than 18000 rms symmetrical amperes, 480 V maximum, when protected by RK5 class fuses.

Single-phase

Fusing	AX5101	AX5103	AX5106	AX5201	AX5203	AX5206
AC supply (max.) *)	6 A	12 A	20 A	12 A	20 A	20 A
24 V supply (max.)	3 A					
Brake resistor	electronic					

*) Mains fuses according to type “RK5” must be used.

Three-phase

Fusing	AX5101	AX5103	AX5106	AX5112	AX5201	AX5203	AX5206
AC supply (max.) *)	6 A	12 A	20 A	20 A	12 A	20 A	20 A
24 V supply (max.)	3 A						
Brake resistor	electronic						

*) Mains fuses according to type “RK5” must be used.

UL	**AX5112!** When protected by RK5 class fuses: Rated 20 A, min. 480 V

5.2.1.4 Internal protection, UL-compliant

Circuit	Fuse
24 V - system voltage	3.4 AF
24 V - peripheral voltage	electronic
Brake resistor	electronic

5.2.1.5 External drive system protection

Rule of thumb: Determine the total device rated current, multiply by correction factor and round it up to the next higher standard level.

Example: 1 x AX5103 + 2 x AX5201 + 2 x AX5203
3 A + 6 A + 12 A = 21 x 1,1 = 23,1 A → **selected 25 A**

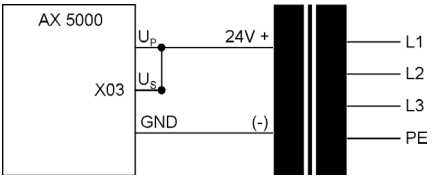
UL	**Special requirements for a drive system** Please consult our Application Department with respect to the special requirements for a drive system with UL-Listing.

5.2.2 24 V_{DC} - supply network connection (X03)

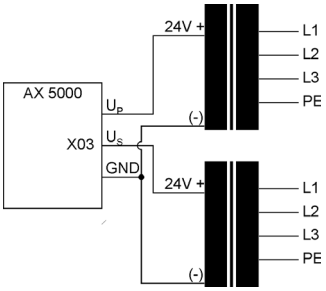
The 24 V_{DC} connection **"X03"** is used for supplying control electronics and periphery with DC voltage. The control electronics and the periphery can be supplied separately with two different voltage sources.

Note	If one transformer is used for the 24 V_{DC} power supply, the connections U_S and U_P 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



5.2.3 Connection of several servo drives to form a drive system

UL	**Drive system with UL-Listing!** Please consult our Application Department with respect to the requirements for a drive system with UL-Listing.

Attention	**Hazard to the equipment** • The connection sequence of the devices is not arbitrary. The total rated current of the device must decrease from the power supply. AX5112-AX5203-AX5106-AX5201 = OK; AX5201-AX5112-AX5203 ≠ OK • All devices in a drive system are always to be disconnected from and reconnected to the mains supply together (emergency stop, mains contactor etc.).

CAUTION	**Danger for persons and equipment** Note the total rated current of the connected devices. According to CE the current carrying capacity of power busbars of the AX Bridge is limited to 100 A.

Attention	**Destruction of the external brake resistor** An external brake resistor may not be connected to the X02 terminal point (DC link) in a drive system. Use an external brake module AX5021 for this.

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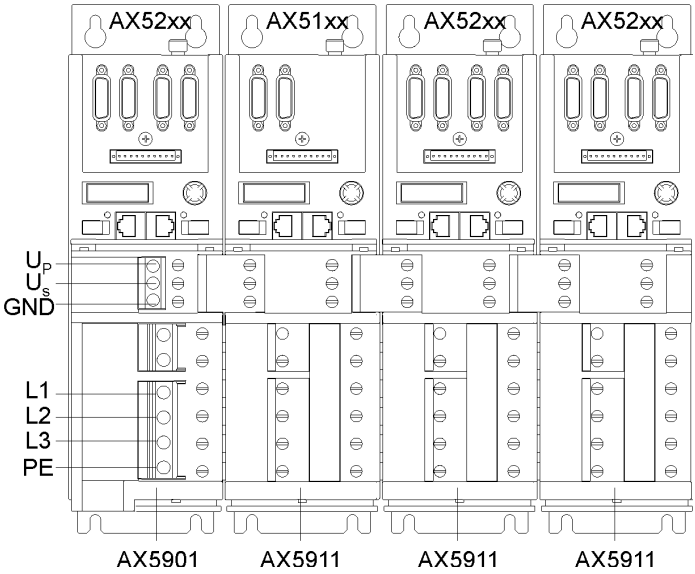
5.2.3.1 Connection example - module AX5901 and AX5911 (AX Bridge)

This connection option enables a safe system to be set up very quickly. The modules are attached to plug contacts X01, X02 and X03, the relevant slides are pushed to the left and screwed tight.

CAUTION	**Hazard to inviduals through electric shock** Move all busbar sliders to the left limit stop in order to ensure full current carrying capacity. Then tighten all screws with a torque of 2.2 Nm.

CAUTION	**Hazard to inviduals and equipment** Please ensure that the connection line for the AX5901 supply module is adequately dimensioned. The dimensioning depends on the total rated current and must comply with EN60204-1.

The supply connection is established as described in sections 5.2.1 and 5.2.2.



Information of the terminal points

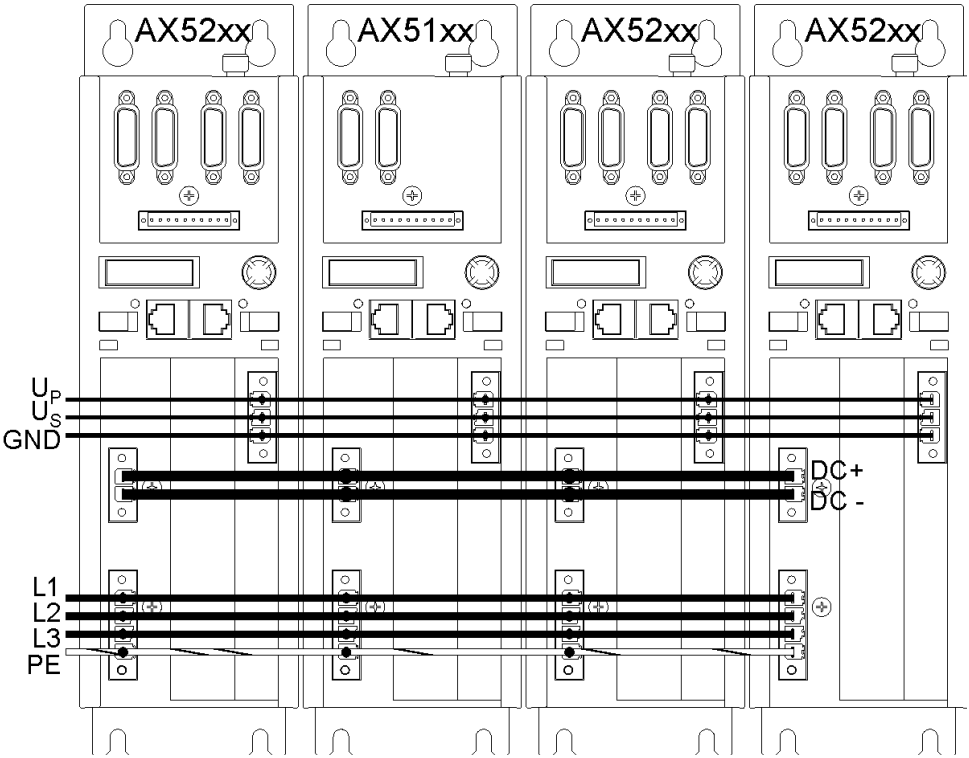
Terminal points	Conductor design	max. Conductor cross-section	Brake away tourqe
L1-L3, PE	single wire	10 mm^2	2,2 Nm
L1-L3, PE	flnely stranded with wire end sleeves	16 mm^2	2,2 Nm
L1-L3, PE	flnely stranded / stranded	25 mm^2	2,2 Nm

5.2.3.2 Connection example - wiring in series without AX Bridge

Wire the relevant connections using individual cables.

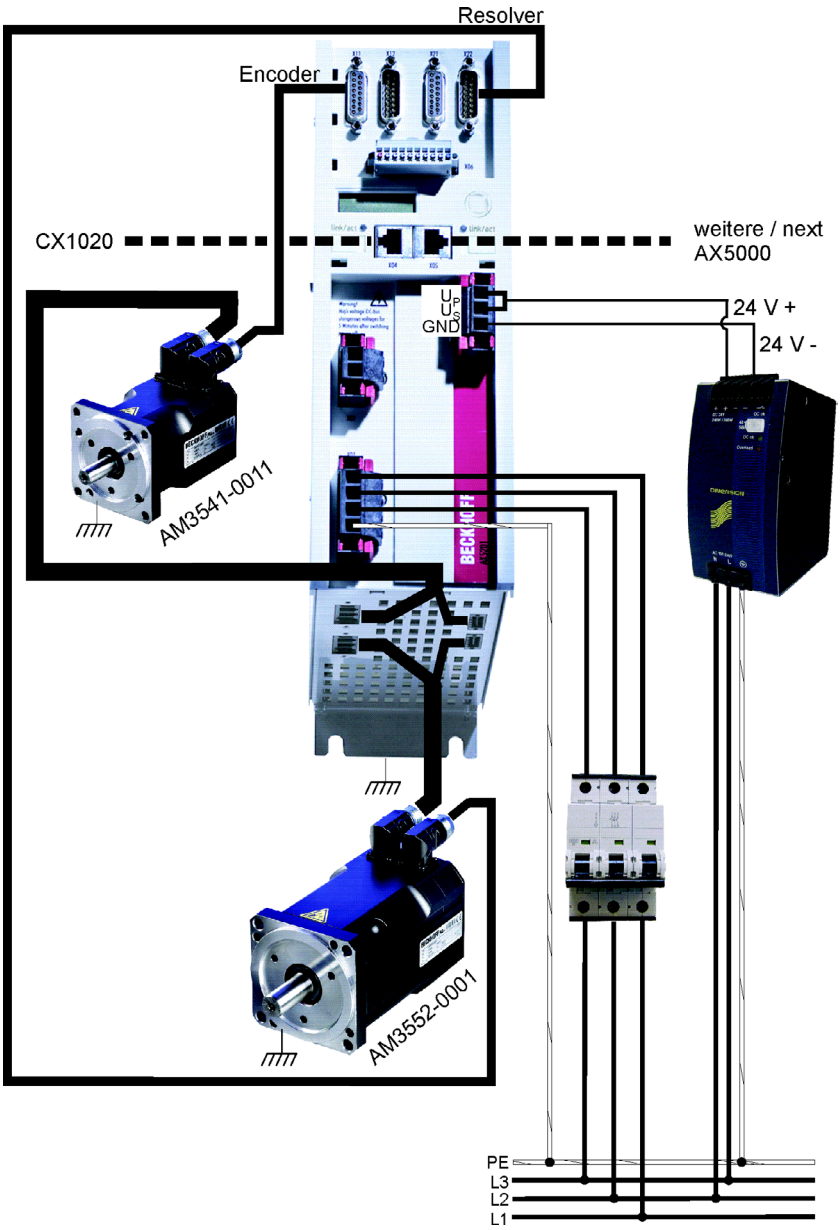
CAUTION	**Hazard to inviduals and equipment** • Please ensure that the final supply network connection cable is adequately dimensioned. The dimensioning depends on the total rated current and must comply with EN60204-1. • To establish a DC link system wire the X02 connections with a suitable cable. Voltages up to 890 V may be present. • The connectors are designed for a maximum current of 41 A and a maximum conductor cross-section of 6 mm². • Avoid phase reversal between the devices!

The supply connection is established as described in sections 5.2.1 and 5.2.2.



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5.2.4 Configuration example



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 User manual→commissioning→commutation methods→commutation error "F2A0"" on our Homepage.
- **Specific caution with 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 User manual →Commissioning →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.

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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

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. If the mains supply does not meet the specifications for operation of the AX5000, then isolating transformers, mains chokes, mains filters or other measures may be required. An energy efficient drive system operates in a drive system with a shared DC link and shared internal and possibly also external brake resistors or brake modules. If you are already using similar drive systems, the AX5000 offers a convenient diagnostic system for determining the load on the brake resistors and for transferring the values. Previous experience with drive systems shows that in such a system much smaller or even no external brake resistors / brake modules need to be used.

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 pre-assembled Beckhoff motor and feedback cables as these are optimally adapted to the drive system and reduce interference to a minimum. Ensure that the connectors are properly connected: this applies to the motor connector in particular.

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.

7.5 Motors and cables at servo drives up to 25A

Motors with max. 400 V rated voltage:
If the length of the motor cable is ≥ 25 m, then a motor choke is required for each motor.
Motors with max. 480 V rated voltage:
If the length of the motor cable is > 20 m, then a motor choke is required for each motor.

The control cabinet should then have adequate space for motor chokes. In exceptional cases (sensitive sensors etc.) it can be necessary to use a motor choke even for motor cable lengths < 25 / 20 m.
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.

EN

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
Eiserstr. 5
33415 Verl
Germany

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

8.1.3 Beckhoff Support

Support offers you comprehensive technical assistance, helping you no 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

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

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