AMKASMART
Device description
Decentralised drive technology
iC servo converter
iX servo inverter
i3X three servo inverters in one housing
iDT, iDP servo motors with integrated iX

Version: 2013/37
Part-no.: 203445
Translation of the "Original Beschreibung"

Imprint

Name: PDK_203445_iDT5

Version:

Version	Change	Abbreviation
2013/37	• Kapitel Dokumentstruktur neu • Chapter: Motor cable lengths: KEN5-FN/-0N added • Chapter: [X05] Encoder connection, footnote 4)	LeS
	• Chapter: Startup of Hall encoders new • Chapter: [X05] Encoder connection amended	HeF
	• New devices i3X2, i3X5, i3X5-F	HeF

Previous version: 2013/03

Product status:

Product	Firmware Version (AMK part no.)	Hardware Version (AMK part no.)
iDT5-3-10-xxx	iX V1.02 2012/46 (204280)	3.01
iDT5-5-10-xxx		3.01
iDT5-9-10-xxx		3.01
iDP7-20-10-xxO		in progress
iDP7-27-10-xxF		in progress
iX2		3.01
iX5		3.01
iX5-F		3.01
iC5		1.04
iC5-F		1.04
i3X2		1.00
i3X5		1.00
i3X5-F		1.00

Service: Phone: 0049/(0)7021/5005-190, Fax -193

Office hours:

Mon. - Thu.	7:30 am - 12:00 pm and 1:00 pm - 4:30 pm
Fri.	7:30 am - 12:00 pm and 1:00 pm - 3:30 pm
Sat., Sun. and holidays	Please leave your contact data on the answering phone, which is monitored regularly between 9:00 am and 5:00 pm. Our service will call you back as soon as possible.

For fast and reliable troubleshooting, you can help us by informing our Customer Service about the following:

- Type plate data for each unit
- Software version
- Device configuration and application
- Type of fault/problem and suspected cause
- Diagnostic messages (error messages)

E-mail: service@amk-antriebe.de

Internet address: www.amk-antriebe.de

Content

1 About this documentation

1.1 Structure of this document

Content	Topic	Chapter number
Validity, use and the propose of the documentation	Imprint	-
	About this documentation	1
Safety	For your safety	2
Product identification, technical data, planning, dimensioning and projecting (for planning- and projecting personnel)	Product overview	3
	Projecting	4
Practice information for startup, operation, maintenance, disposal and optional accessories (for startup-, operating- or maintenance personnel)	Assembly	5
	Electrical connections	6
	Startup - Operation - Maintenance - Service	7
	Accessories	8
	Disposal	9
Abbreviations and terms will be explained	Glossary	10

1.2 Keeping this document

This document must permanently be available and readable at the place where the product is in use. If the product is used at another place or changed the owner, the document must be passed on.

1.3 Target group

Any person who is entitled and intends to carry out one of the following works must read, understand, and observe this document.

- Transportation and storage
- Unpacking and installation
- Projecting
- Connection
- Parameterisation
- Startup
- Testing and maintenance
- Service and repair
- Decommissioning and disposal

1.4 Purpose

This document is addressed to any person who handles the product. It gives information about the following topics:

- Safety messages which are absolutely necessary to take care of during handling the product
- Product identification
- Projecting, planning, and dimensioning of the application
- Environmental conditions for storage, transportation, and operation
- Assembly
- Electrical connections
- Startup and operation
- Maintenance
- Repair
- Exchange
- Diagnosis
- Decommissioning and disposal
- Technical data
- Conformity with standards

1.5 Display conventions

Representation	Meaning
☞	This text passage requires your undivided attention!
0x	0x followed by a hexadecimal number, e.g. 0x500A
'Names' 'Parameter' 'Diagnostic messages'	E.g.: Call up the 'PLC clear program' function. ID1234 'Parameter text' 1234 'Diagnostic message'
'xxx'	Menu items and buttons in software or a control unit, e.g.: Click the **'OK''** button in the **'Options'** menu to call up the 'PLC clear program' function
>xxx<	Wildcard, variable e.g. IP address of the controller: >192.168.0.1<
->	Process of an input / operating sequence, e. g. **'Start'** -> **'All Programmes'** -> **'Accessories'** -> **'Editor'**

1.6 Appendant documents

Device descriptions

AMK part no.	Title
	Motor data sheets

Functional descriptions

AMK part no.	Title
25786	Diagnostic messages
202234	Software description AIPEX PRO (PC software for startup and parameterisation)
203446	Safety manual; functional safety
203704	Parameter description (properties of controller parameters)
203771	Software description ATF - AMK Tool Flasher (PC software for firmware update)
203878	Functional description (functions of the controller firmware)
204737	Initial startup of decentralised drives

2 For your safety

2.1 Basic notes

- At electrical drive systems, hazards are present in principle that can result in death or fatal injuries:
  - ○ Electrical hazard (e.g. electric shock due to touch on electrical connections)
  - ○ Mechanical hazard (e.g. crush, retract due to the rotation of the motor shaft)
  - ○ Thermal hazard (e.g. burns due to touch on hot surfaces)
- These hazards are present while starting up and operating the unit, and also during servicing or maintenance work.
- Safety instructions in the documentation and on the product warn about the hazards.
- Personnel must have read and understood the safety instructions before installing and operating the product. In the documentation about the product the usage warnings pertain to direct hazards and must therefore be followed directly when operating or handling the product by the operator.
- AMK products must be kept in their original order, that means it is not allowed to do a significant constructional change on hardware side and software is not allowed to be decompiled and change the source code.
- Damaged or faulty products are not allowed to be integrated or put into operation.
- Do not start the system in which the AMK products are installed (begin of intended use) until you can determine that all relevant standards, laws, and directives have been complied with, e.g. .low voltage directive, EMC directive, and the machinery directive, and possible further product standards. The plant manufacturer is responsible for the compliance with the laws, directives, and standards.

2.2 5 safety rules

In particular on drive systems, the instructions pertaining to safety and the following five safety rules have to be kept in the specified sequence:

1. Switch off electrical circuits (also electronic and auxiliary circuits).
2. Secure against being switched on again.
3. Determine that there is no voltage.
4. Earth and short circuit.
5. Cover or close off neighbouring parts that are under voltage.

Reverse the measures taken in reverse order after completing the work.

2.3 Display of safety information

Any safety information is configured as follows:

⚠ SIGNAL WORD	
Symbol	**Type and source of risk** Consequence(s) of non-observance **Steps to prevent:** • ...

2.4 Hazard classes

Safety and warning messages are graduated into classes of hazard (according to ANSI Z535). The class of hazard defines the risk if the safety message is not heeded and is defined by the signal word. The signal word is followed by a safety alert symbol (ISO 3864, DIN 4844-2). In accordance with ANSI Z535, the following signal words are used to define the class of hazard.

Safety alert symbol and signal word	Class of hazard and its meaning
⚠ **DANGER**	DANGER indicates a hazardous situation which, if not avoided, **will** result in death or serious injury

Safety alert symbol and signal word	Class of hazard and its meaning
⚠ WARNING	WARNING indicates a hazardous situation which, if not avoided, **could** result in death or serious injury
⚠ CAUTION	CAUTION, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, **could** result in minor or moderate injury
NOTICE	NOTICE is used to address preventions to avoid material damage, but not related to personal injury.

2.5 Danger symbols used

Safety symbol	Meaning
⚠	Generic warning!
⚡	Warning against dangerous electrical voltage!
⚡ 5 min	Warning against dangerous electrical voltage! After being electrically disconnected, it takes at least 5 minutes until the energy storage is discharged.
⚠	Warning against crushing!
♨	Warning against hot surface!

2.6 Intended use

The following AMK products are intended for fixed connection in industrial and commercial use in machines and systems:

- AMKASMART iC (decentralised inverter with power supply)
- AMKASMART iX (decentralised inverter)
- AMKASMART i3X (three decentralised inverters in one housing)
- AMKASMART iDT, iDP (servo motors with integrated inverter iX)

The devices are designed for the construction of decentralised drive concepts without a switch cabinet and can be mounted directly on the machine.

The products fall into the category C3 according to EN 61800-3:2004 and can generate high-frequency faults if they are operated on a public low-voltage network that also supplies residential areas. If all of the products are to be used in residential areas, the user must check whether all relevant regulations for this site of operation are met. The user must check whether, for example, additional filters are necessary and install the required additional components.

The products must be operated within the specified limits. The limits are set by the type plates on the product, characteristics and technical data in the product documentation and the data sheets.

The decentralised inverters control and regulate the power supply from AMK servo motors. No other loads may be connected. The operation of external motors with an AMK servo controller must be expressly approved by AMK.

On all interfaces, only components may be connected that AMK has approved for operation.

The admission of the intended use is prohibited until it is proven that the entire system in which the servo controller and motors have been installed meets all safety-related standards and guidelines, such as the low voltage directive, EMC directive, machinery directive and possibly other product standards.

Applications in the following areas are prohibited:

- Explosive environment
- Environment with oils, acids, gases, vapours, dust, radiation,...
- Environments that do not meet the climatic conditions that are required in this documentation.

The manufacturer / operator of the entire system is liable for damages caused by unintended use.

2.7 CE label

AMK products have been constructed using state-of-the-art in science and technology and are safe to operate. AMK issues an EC declaration of conformity for each of its products in which the standards and guidelines relevant for the product are listed. AMK also designates the products with the CE mark which signifies conformity to the standards.

2.8 Requirements for the personnel and qualification

Only authorised and qualified personnel may work on and with the AMK drive systems.

Specialised personnel must:

- Perform mechanical and electrical work that is described in this documentation, such as mounting and connecting
- Observe all information in the documentation accompanying the product in order to work with the product safely and in an error-free manner
- Understand and know hazards that occur when handling the product
- Know connections and functions of the system
- Be familiar with the control concept in order to operate the drive system
- Be authorised to switch circuits and devices on and off, earth and label them
- Observe local specific safety requirements

2.9 Warranty

- All information in the documents accompanying the product must be complied with for a safe and trouble-free operation.
- The assertion of warranty claims is excluded if the information in the documents is not observed completely.
- Hardware and firmware may not be modified except by personnel authorised by AMK and after consultation with AMK.
- The company AMK Arnold Müller GmbH & Co.KG is not liable for damages from unintended use, incorrect installation or operation, exceeding rated values and non-observance with the environmental conditions.

3 Product overview

3.1 Order data

The order designation of the products is determined by the type code.

3.2 Delivery

Please check whether the delivered parts correspond with the delivery note. If the delivery is incomplete, please contact your nearest AMK representative.

Check the components for signs of transport damage after their arrival. Do not install and operate any damaged components.

If there is any transport damage, immediately inform the delivering freight carrier and inform your AMK representative.

3.3 Type plates

The following type plates are attached to the products:

iC / iX / i3X

AMK Arnold Müller GmbH&Co.KG D-73230 Kirchheim/Teck		**S.-Nr.**		$C \in$
Typ		Rev.	Logik	Bremse
U_{1N}	U_{2N}		U_H	U_B
I_{1N}	I_{2N}		I_H	I_B
f_{1N}	f_{2N}			
P_{1N}	S_{2N}		IP	T_U ℃

Legend:

Abbreviation	Designation
S-Nr.	Serial number (part no. – calendar week + year – consecutive number)
Typ	Type designation
Rev.	Revision
U_{1N}	Input voltage
I_{1N}	Rated input current
f_{1N}	Input frequency
P_{1N}	Rated input power
U_{2N}	Rated output voltage
I_{2N}	Rated output current
f_{2N}	Output frequency
S_{2N}	Rated output power
U_H	Supply voltage 24 VDC for electronic
I_H	Rated current for 24 VDC (without I/O)
IP	Type of protection according to EN 60529
U_B	Supply voltage 24VDC for the holding brake
I_B	Maximum current consumption of the holding brake
T_U	Permissible ambient temperature

iDT / iDP

AMK Arnold Müller GmbH & Co.KG D-73230 Kirchheim/Teck		S.-Nr.		—	VDE 0530-T1:1995		CE
			—		MOT 3~		
Type		T R	s	ISO.-KL.	LÜFTER / FAN	BREMSE / BRAKE	
P	kW	M	Nm	U	V	I	A	f	Hz	U L	V	U Br	V
	n /n max			r/min	Encoder		P/Rev.	I L	A	I Br	A
KD-Nr:					IP	f L	Hz	M Br	Nm

3.4 Warning signs

The following warning sign is located on the top of the devices:

In English and French:

Warning: dangerous electric voltage!

It takes at least 5 minutes until the energy storage is discharged after being electrically disconnected.

3.5 Type code

3.5.1 iC

i C x - x x	-	x	x	x

   | | | | | |

Power supply unit (24 VDC supply from the DC bus voltage)

0: not integrated

U: integrated

Functional Safety - in process

0: not integrated

S: integrated

Communication to the controller

E: EtherCAT (SoE)

C: CAN (DS402)

V: VARAN (SoV)

S: SERCOS III

Motor and encoder connector

T: Twintus (Hummel)

C: CM3 (ITT Cannon)

Cooling

0: Cold plate

F: Air cooling

S: Special equipment

Output power [kVA]

5

3.5.2 iX / i3X

iX i3X	x	-	x	x	-	x	x
	|		|	|		|	|

							Functional Safety - in process
							0: not integrated
							S: integrated
						Communication to the controller	
						E: EtherCAT (SoE)	
						C: CAN (DS402)	
						V: VARAN (SoV)	
						S: SERCOS III	

Motor and encoder connector
T: Twintus (Hummel)
C: CM3 (ITT Cannon)

Cooling
0: Cold plate
F: Air cooling (only for 5 KVA device)
S: Special equipment

Output power [kVA]

2

5

3.5.3 iDT5, iDP7

i D T 5 i D P 7	- x -	x -	x	x	x	- xxxx -	xx	-	x	x

Functional Safety
- in process
0: not integrated
S: integrated

Communication to the controller
E: EtherCAT (SoE)
C: CAN (DS402)
V: VARAN (SoV)
S: SERCOS III

Design
B5 flange

Idle operation motor speed [U/min]

Cooling
0: Convection cooling
F: External fan

Motor holding brake
0: without motor holding brake
B: with integrated motor holding brake[1]

Motor encoder type
E: Singleturn absolute encoder EnDat 2.1 (digital and sin/cos track), optical
F: Multiturn absolute encoder EnDat 2.1 (digital and sin/cos track), optical
P: Singleturn absolute encoder EnDat 2.2 light (digital), inductive
Q: Multiturn absolute encoder EnDat 2.2 light (digital), inductive
S: Singleturn absolute encoder, Hiperface, with sin/cos track, optical
T: Multiturn absolute encoder, Hiperface, with sin/cos track, optical
U: Singleturn absolute encoder, Hiperface, with sin/cos track, capacitive
V: Multiturn absolute encoder, Hiperface, with sin/cos track, capacitive
I: I encoder, with sin/cos track and zero pulse, optical

No. of poles

Performance indicator for the core length of the motor

Installation size (iDP7 - in process)

1) The motor holding brake is not approved for personal protection from suspended loads!

3.6 Product description

iC decentralised inverter with power supply
The iC is an iX supplemented by a power section so that the iC can be operated directly on a 3-phase AC power system. The integrated brake chopper directs regenerative incoming energy to the integrated or externally connected brake resistor. A mains filter and a charging circuit are integrated in the iC. The iC contains a power supply unit that provides 24 V DC from the UZP/UZN DC bus for this iC.

iX decentralised inverter
The iX corresponds to the inverter in the iDT5 with an externally guided motor and encoder connection.

i3X three decentralised inverters in one housing

The i3X contains three decentralised inverters of the same rated output power in one housing.

iDT5 / iDP7 servo motors with integrated inverter

The servo motors of the AMKASMART series iDT and iDP combine the power of the AMK high torque servo motors DT and DP with the most modern inverters in the most compact installation space.

The devices can be operated alone or in the network (EtherCAT (SoE), SERCOS III, VARAN, CAN (DS402)) with the AMK-specific functional range. In the device connection, both the electronic supply voltages as well as the power supply can be looped from device to device (take care of the max. limit load!). All devices provide five multi-functional I/Os that can be configured as binary inputs, binary outputs or an analogue input.

The devices have the following standard functionality:

- Configurable multi-functional I/O
- STO safety function (safe torque off) according to DIN EN 61800-5-2:2008-04, uncontrolled stopping according to EN 60204-1, stop category 0
- Control in the 4-quadrant operation
- Torque control
- Speed control
- Position control
- Control of synchronous and asynchronous motors, also in field weakening
- Automatic actuation of an optional motor holding brake
- Communication interface
- AIPEX PRO software support

Optional:

- Fieldbus systems real-time Ethernet
    - EtherCAT
    - VARAN
    - Sercos III
- Fieldbus system CAN
    - CAN DS402
- Functional Safety (FSoE) - in process

The AMKASMART decentralised drives can be easily combined with the AMKASYN KE/KW devices. Compact power supply modules KE or KES generate the DC bus voltage for the connected iX / i3X or iDT and feed regenerative energy back into the supply network. They are housed in a central switch cabinet, e.g. together with an AMKAMAC controller.

AMKASYN compact power supply modules are available in the following variants:

KE: Block-commutated supply / recovery of the energy.

KEN: Power supply without recovery; regenerative operation with externally connected brake resistor is possible.

KES: Sinusoidal power supply and recovery.

See device description Servo drives KE/KW, AMK part-no. 028932.

3.7 Product views

3.7.1 Servo converter iC

iC5-0T / iC5-0C

X01, X02, X03, X08, X09, S2
X04
X86 / X137
X85 / X136
H2
H1
S1
X05
X06
X06
X05

iC5-FT / iC5-FC

X01, X02, X03, X08, X09, S2
X04
X86 / X137
X85 / X136
H2
H1
S1
X05
X06
X05
X06
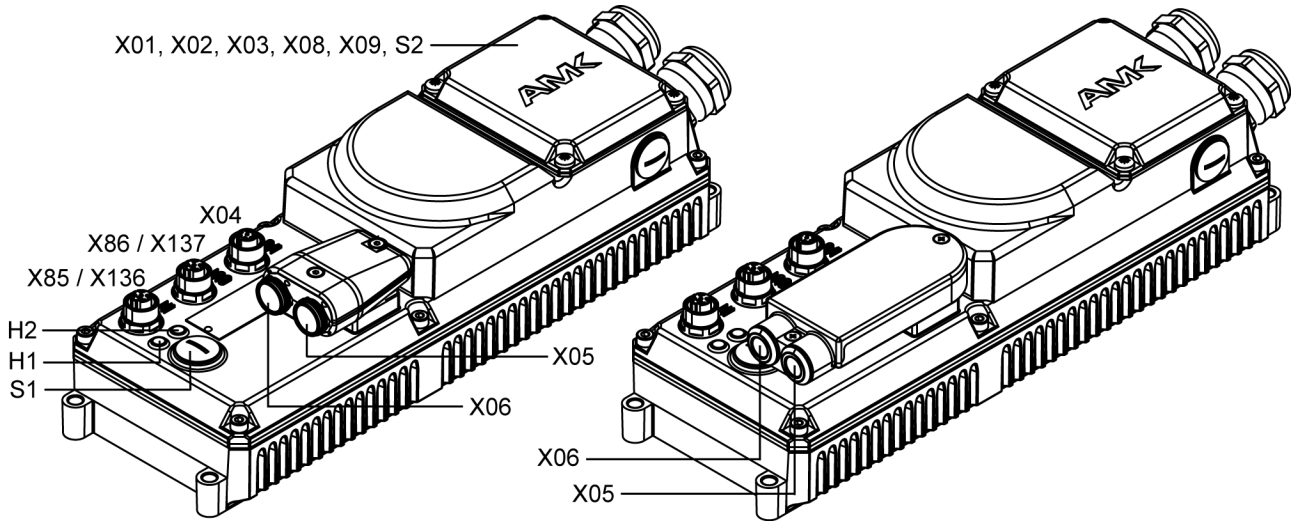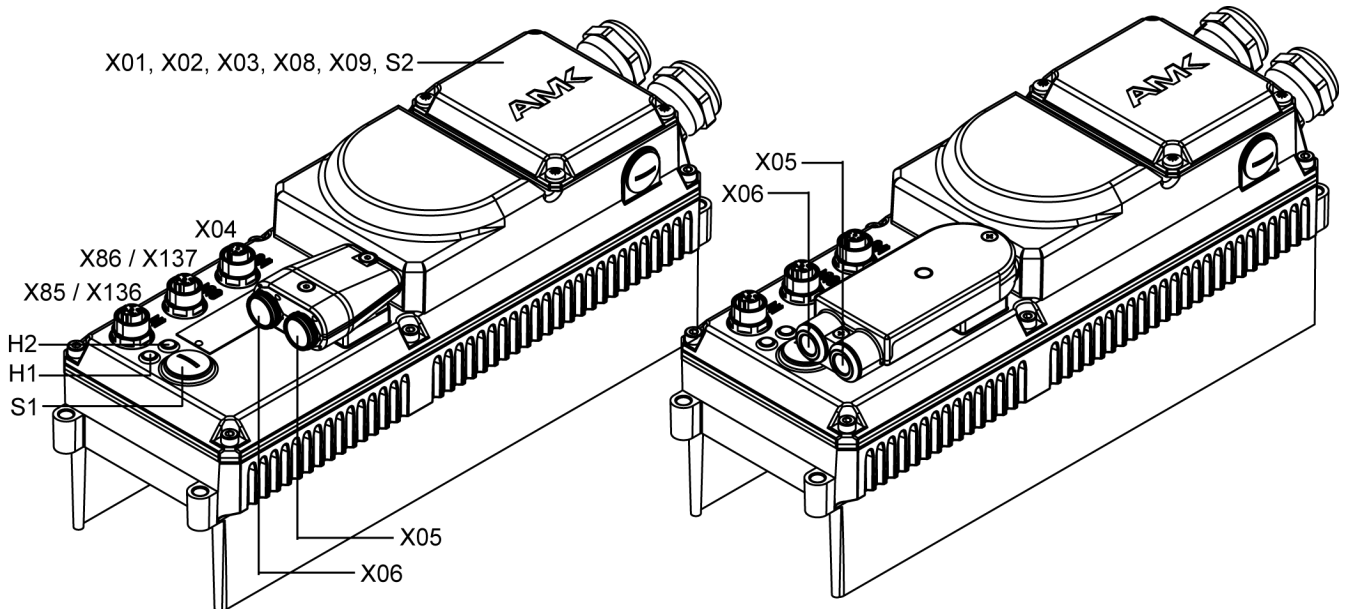
3.7.2 Servo controller iX

iX2-0T / iX5-0C
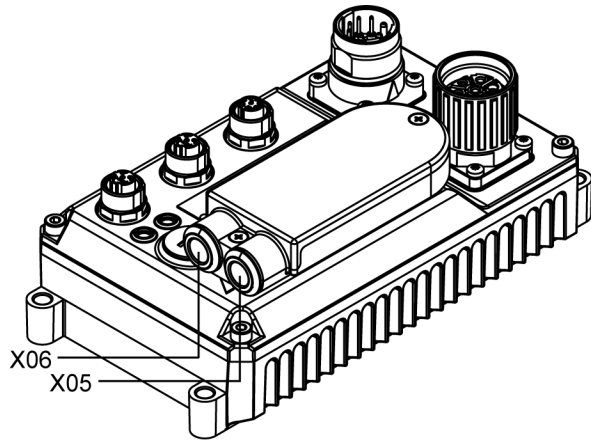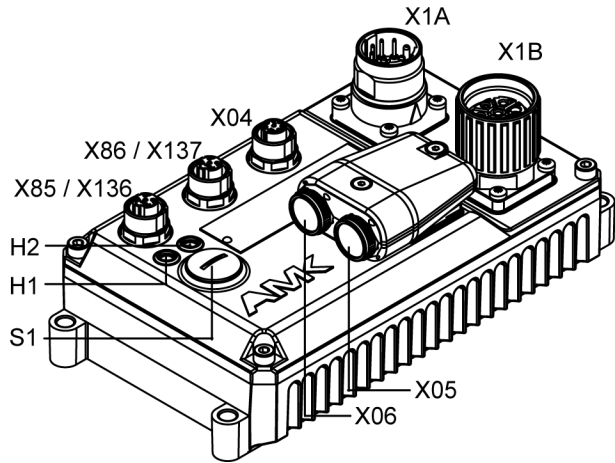
iX5-FT / iX5-FC
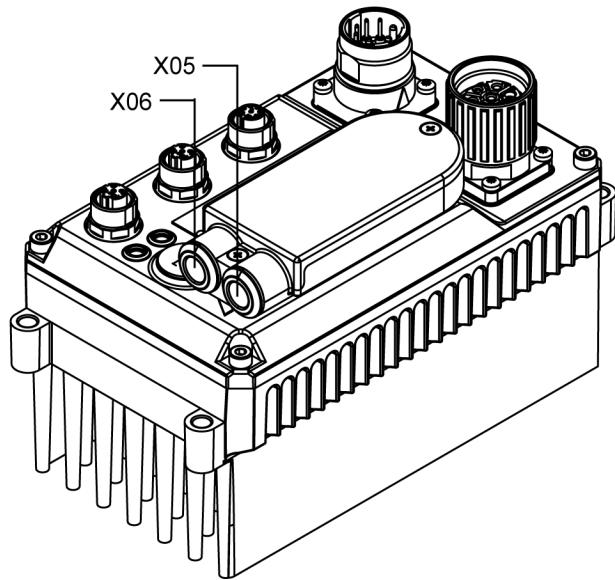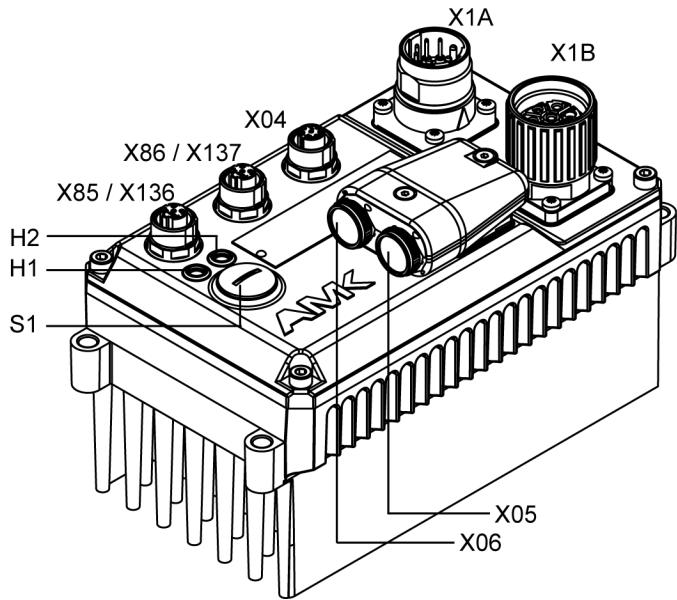
3.7.3 Servo controller i3X

i3X2-0T / i3X5-0T / i3X2-0C / i3X5-0C
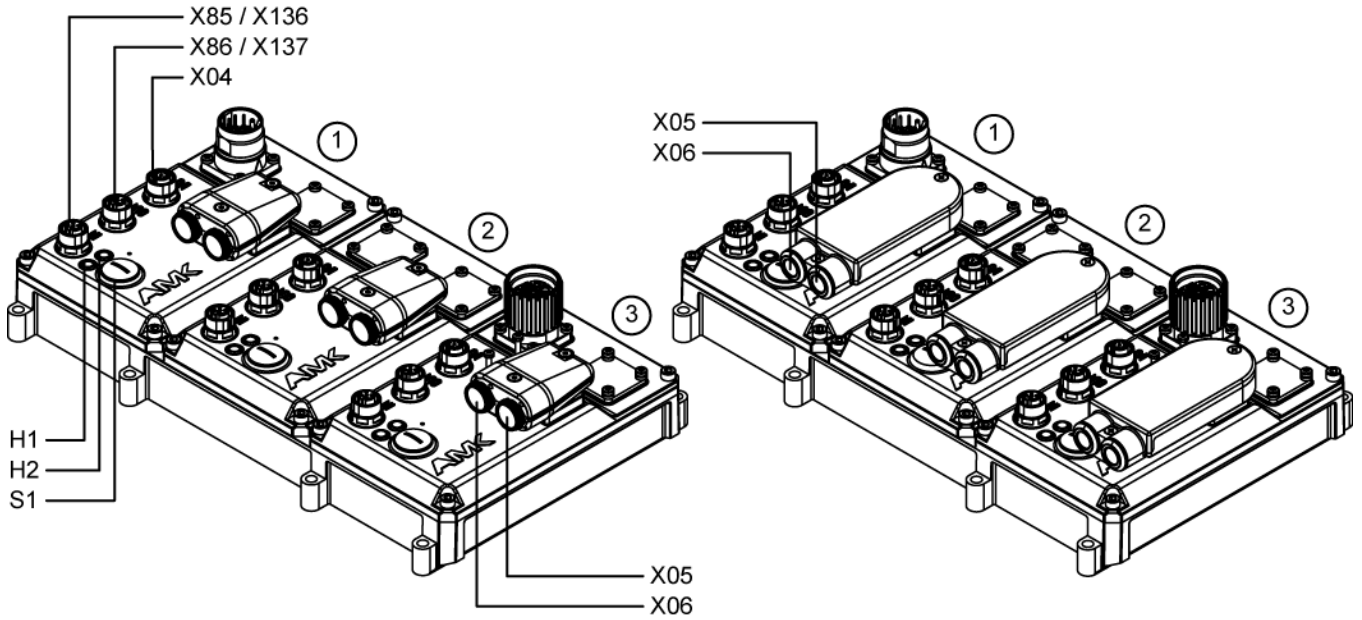
i3X5-FT / i3X5-FC
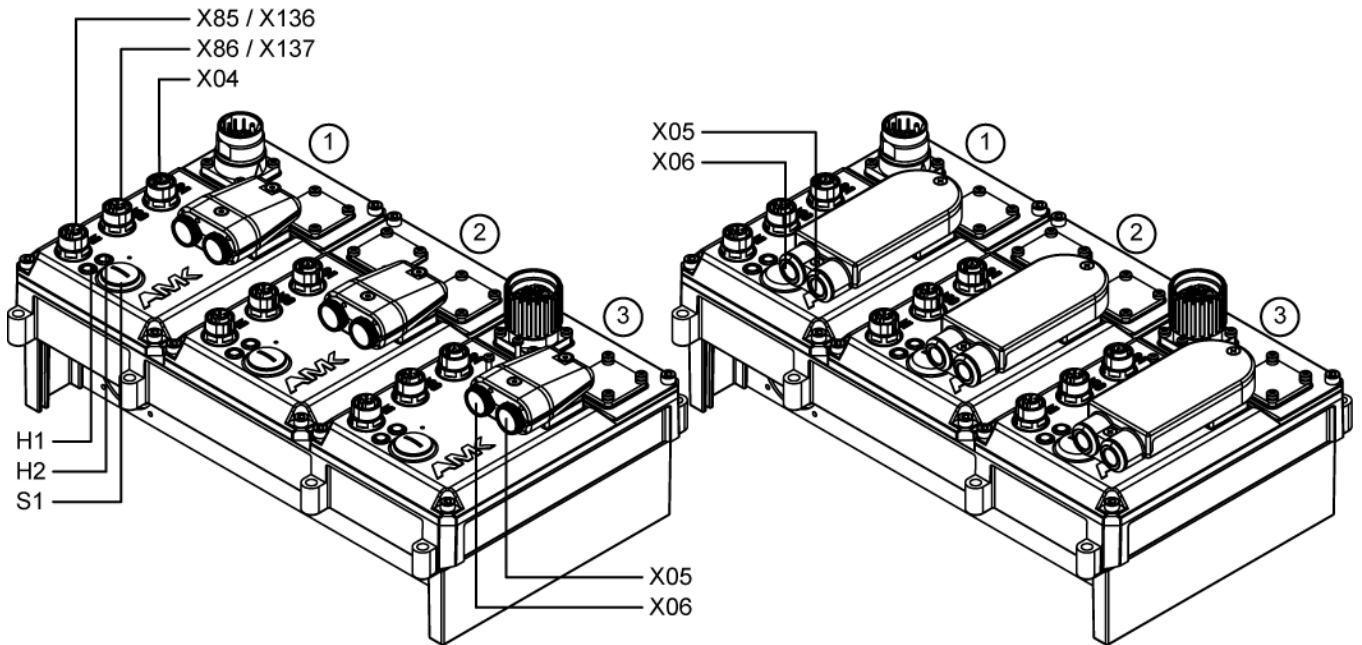
3.7.4 Servo motors iDT5
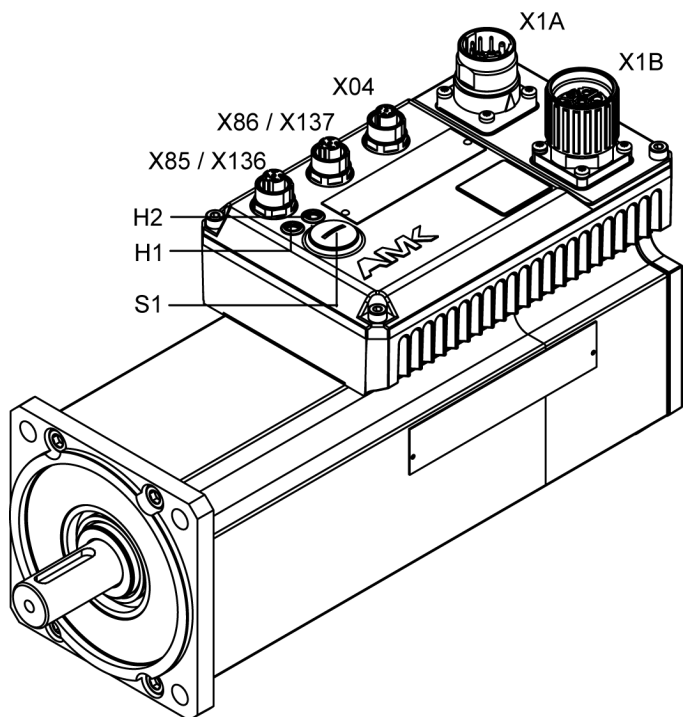
By default, the shaft is smooth. Feather key is optional.

3.8 Interface overview, LEDs and address switch

Interfaces	Function		Product
LED H1 LED status	**Colour**	**Meaning**	iX / i3X / iC / iDT5 / iDP7
	Green	SBM: System without error, controller enable RF not set	
	Flashing green *)	SBM + QRF: Drive under control	
	Red	Drive in error state, evaluate diagnostic message	
	Flashing red *)	reserved	
	Orange	Warning message when controller enable not set	
	Flashing orange *)	Warning message when controller enable set	
LED H2 Safety LED	**Colour**	**Meaning**	iX / i3X / iC / iDT5 / iDP7
	Green	Secure parameter set matches the checksum. LED OFF: Secure parameter set does NOT match the checksum.	
	Flashing green (1 second cycle)	Validation requirement, enter the checksum.	
	Red	by comparison Secure parameter set does NOT match the checksum.	
	Flashing red *)	reserved	
	Orange	Secure parameter set was transmitted successfully. Switch the device OFF and back ON. LED OFF: Secure parameter set was NOT transmitted successfully.	
	Flashing orange *)	Warning message when controller enable set	
S1	Address switch		iX / i3X / iC / iDT5 / iDP7
S2	Switch for the internal power supply unit 24 V DC.		iC
X01	Mains connection / mains transmission		iC

Interfaces	Function	Product
X02	Transmission of the DC bus voltage	iC
X03	Connection of external brake resistor	iC
X1A	Supply line power connection: DC bus, 24 V DC supply voltage for electronics, brakes and STO	iX / i3X / iDT5 / iDP7
X1B	Power connection transmission: DC bus, supply voltage for electronics, motor holding brake and STO	iX / i3X / iDT5 / iDP7
X04	I/O interface Multi-functional use as binary inputs and outputs, analogue input	iX / i3X / iC / iDT5 / iDP7
X05	Connection of the encoder signals	iX / i3X / iC
X06	Connection of the motor phases, the temperature sensor for the motor coil and the motor holding brake	iX / i3X / iC
X08	Supply voltage for electronics Supply voltage for motor holding brake and STO	iC
X09	Transmission Supply voltage for electronics Supply voltage for motor holding brake and STO	iC
X85	Real-time Ethernet: input	iX / i3X / iC / iDT5 / iDP7
X86	Real-time Ethernet: transmission	iX / i3X / iC / iDT5 / iDP7
X136	CAN bus input (DS402 protocol)	iX / i3X / iC / iDT5 / iDP7
X137	CAN bus transmission (DS402 protocol)	iX / i3X / iC / iDT5 / iDP7

*)   Flashing cycle: T_{on} = 200 ms; T_{off} = 200 ms

3.9 Device interconnection with switch components

iX - iDT interconnection with DC transmission and supply in the central switch cabinet
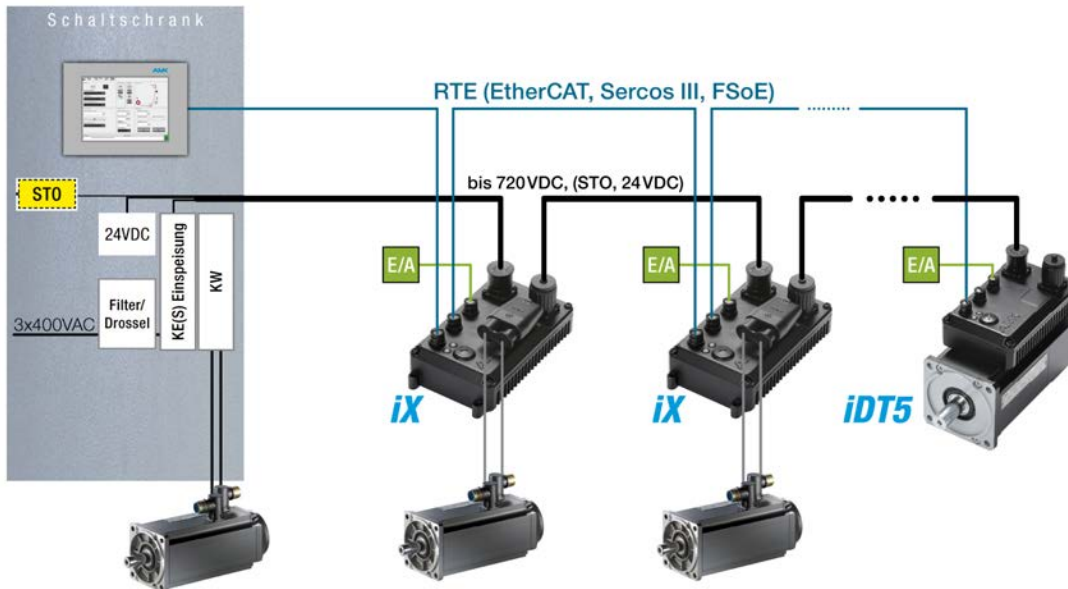
iC interconnection with 400 V AC transmission, STO and 24 V DC single supply, without switch cabinet

RTE (EtherCAT, Sercos III, FSoE)

3 x 400 VAC

3x400VAC

E/A

STO
24 VDC
RB
C

iC

STO
24 VDC
RB
C

iC
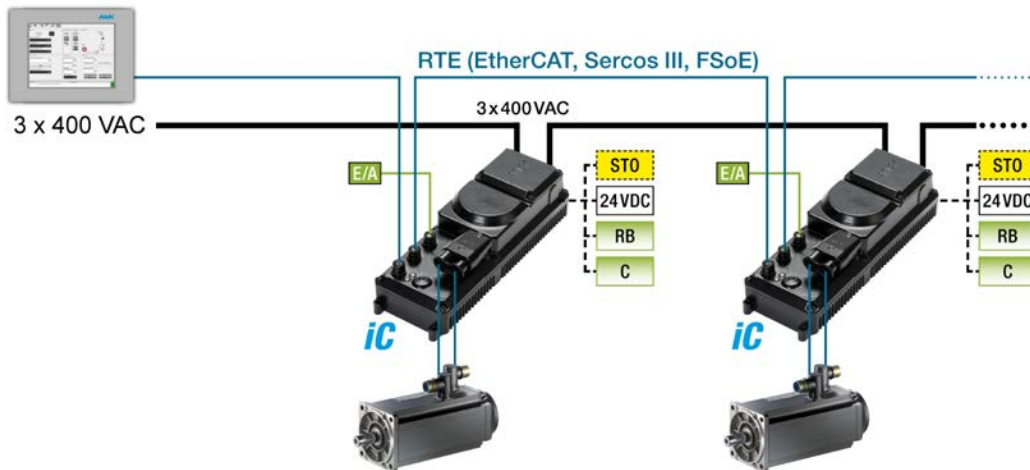
iC interconnection with 400 V AC, STO and 24 V DC transmission, without switch cabinet

RTE (EtherCAT, Sercos III, FSoE)

3 x 400 VAC, 24 VDC, STO

3x400VAC, STO, 24VDC

E/A

RB
C

iC

RB
C

iC
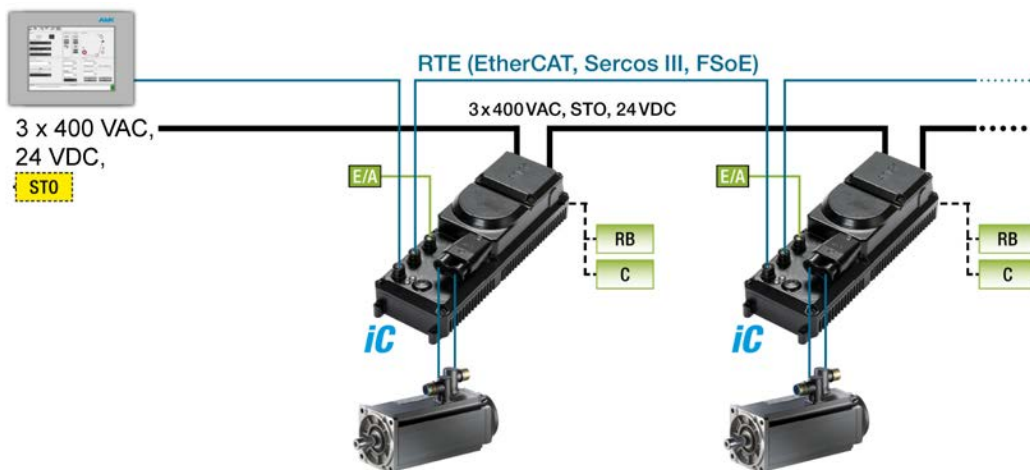
iC - iX - iDT interconnection with DC, STO and 24 V DC transmission, without switch cabinet

RTE (EtherCAT, Sercos III, FSoE)

3 x 400 VAC, 24 VDC, STO

up to 720 VDC, STO, 24 VDC

E/A

RB
C

iC

E/A

iX

E/A

iDT5
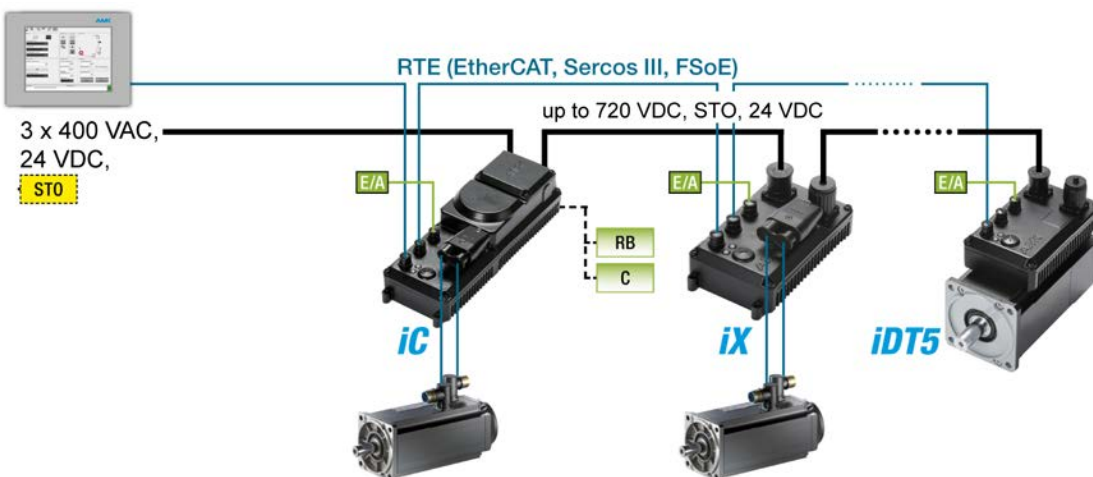
Legend:

STO: 24 V DC supply for the safety function "Safe Torque Off"

RB: Connection of external brake resistor

C: Connection of external DC bus capacity

RTE Real-time Ethernet, real-time Ethernet

3.10 Technical data

3.10.1 Ambient conditions

Storage and transport

- Temperature range of the surroundings: -25 °C to +55 °C
- Store and transport the product in original packaging
- Storage: store dry, free of dust, vibration-free and flat
  Do not remove the plastic protective cover on the drive shaft. It protects against moisture and mechanical damage.
- Vibration stress: Transport: Class 2M2 (EN60721-3-2)

Operation

Designation	Range of values	Explanation
Installation height according to EN 60034-1 (IEC 60034-1):	0 to 1000 m above sea level	For installation heights above 1000 m and below 2000 m, the rated data for the output power must be reduced by 2% per 100 m.
Relative air humidity	5 % to 80 %	No condensation
Vibration stress: Shock:	10g (2..200 Hz) 25g	Operation: Class 3M8 (EN60721-3-3)
EMC		EN 61800-3 (product standard)

3.10.2 iC

The rated data is valid at 45° C ambient temperature and 3 x 400 V AC / 50 Hz mains voltage supply.

Designation	Connection	Unit	iC		
			tbd	**iC5-0**	**iC5-F**
Permissible ambient temperature	-	°C	tbd	0-45	0-45
Derating factor[1), 4)] at 55 °C	-		tbd	0,70	0,70
Derating factor[1), 4)] at 60 °C	-		tbd	0,55	0,55
Mains input voltage	X01	V AC	Operating range: 3 x 230..480 ±10 %, 47..63 Hz		
			Rated data is valid: 3 x 400..480 ±10 %, 47..63 Hz		
Rated mains input current (individual unit)		A (eff.)	tbd	8	8
Maximum current of the mains terminal (device with transmission)		A (eff.)	20		
Power factor			0.93		
Rated input power		kW	5		
24 V DC supply voltage	X08 / X09	V	24 ±15 %, ripple max. 5 %		
Rated current for 24 VDC (max. with I/O)		ADC	tbd	0.4 (0.9)	0.5 (1)
Maximum current for the 24 VDC supply voltage terminal		A	4		

Designation	Connection	Unit	iC		
			tbd	iC5-0	iC5-F
24B supply voltage for the holding brake / STO	X08 / X09	V DC	24 ±15 %, ripple max. 5 %		
Maximum current consumption of the holding brake		A	0.5 (supply from an internal power supply unit) 0.7 (supply with external 24B)		
STO current consumption		A	0.02		
Maximum current of the 24B terminal for the holding brake / STO		A	4		
Rated output power	X06 (Twintus)	kVA	tbd	5	5
Rated output current		A (eff.)	tbd	8.2	8.2
Maximum output current (duration < 0.3 s)		A (eff.)	tbd	16.5	16.5
Rated output voltage (sinusoidal)		V	3 x 350		
Output frequency		Hz	0 - 800		
DC bus voltage transmission	Terminal UZN, UZP	V DC	300 - 720		
Rated current of the DC bus		A	8		
Shutdown threshold of the DC bus voltage		V DC	850		
Braking power of the integrated brake resistor (max. energy consumption Q = 600 Ws)		W	Peak performance: 4000 for 1 s Rated power: 30		
External brake resistor	Terminal RBN, RBP	Ohm	≥47		
Current regeneration	Terminal L1, L2, L3, PE		no		
Dimensions (W x L x H) without sockets / connector		mm	tbd	293 x 100 x 76	293 x 100 x 122
Weight		kg	tbd	2.1	2.7
Cooling[2]			tbd	Cold plate	Integrated air cooling
Type of protection according to EN 60529			tbd	IP65[3]	IP54[3]
Degree of efficiency of the inverter electronics		%	98		
DC bus capacity C_Z internal		µF	20		

1) At this ambient temperature, the rated output power, the rated output current and the rated maximum current must be multiplied by the derating factor and the user must reduce the performance data to these values.
2) See 'iC, iX and i3X' on page 43.
3) Unconnected interfaces and the terminal box must be closed.
4) The operation at increased ambient temperature, considering the derating factor, is only allowed, if the internal power supply is switched off. See '[X08 / X09] 24 V DC supply voltage terminal - Transmission' on page 62.

3.10.3 iX

Designation	Connection	Unit	iX		
			iX2-0	iX5-0	iX5-F
Permissible ambient temperature	-	°C	0 - 50	0 - 55	0 - 50
Derating factor[1] at 55 °C	-		0.75	1	0.66

Designation	Connection	Unit	iX		
			iX2-0	iX5-0	iX5-F
Derating factor[1] at 60 °C	-		0.5	0.5	0.33
Rated output power	X06	kVA	2	5	5
Rated output current		A (eff.)	3.3	8.2	8.2
Maximum output current (duration < 1 s)		A (eff.)	6.6	16.5	16.5
Rated output voltage (sinusoidal)		V	3 x 350		
Output frequency		Hz	0 - 800		
Supply voltage of the DC voltage intermediate circuit	X1A.1, X1A.3	V DC	540 - 720		
Supply current of the DC bus with 540 V DC		A	3.7	9.3	9.3
Shutdown threshold of the DC bus voltage		V DC	850		
Maximum current of the DC bus connector		A	25		
24 VDC supply voltage for electronics	X1A.A, X1A.B	V DC	24 ±15 %, ripple max. 5 %		
Rated current for 24 VDC (max. with I/O)		A	0.25 (0.75)	0.25 (0.75)	0.4 (0.9)
Maximum current for the 24 VDC supply voltage connector		A	6		
24B supply voltage for the holding brake / STO	X1A.C, X1A.D	V DC	24 ±15 %, ripple max. 5 %		
Maximum current consumption of the holding brake		A	0.7		
STO current consumption		A	0.02		
Maximum current of the 24B connector for the holding brake / STO		A	6		
Dimensions (W x L x H) without sockets / connector	-	mm	162 x 100 x 43	162 x 100 x 43	162 x 100 x 89
Weight	-	kg	0.8	0.8	1.2
Cooling[2]	-		Cold plate alternative convection-cooled metal plate[3]	Cold plate	Integrated air cooling
Type of protection according to EN 60529	-		IP65[4]	IP65[4]	IP54[4]
Degree of efficiency of the inverter electronics	-	%	98		
DC bus capacity C_Z internal		µF	10		

1) At this ambient temperature, the rated output power, the rated output current and the rated maximum current must be multiplied by the derating factor and the user must reduce the performance data to these values.

2) See 'iC, iX and i3X' on page 43.

3) Nominal data was achieved if the device has been mounted to a 500 x 500 x 5 mm metal plate.

4) Unconnected interfaces must be closed.

3.10.4 i3X

Designation	Connection	Unit	i3X		
			i3X2-0	i3X5-0	i3X5-F
Permissible ambient temperature	-	°C	tbd	tbd	tbd
Derating factor[1] at 55 °C	-		tbd	tbd	tbd
Derating factor[1] at 60 °C	-		tbd	tbd	tbd
Rated output power	X06	kVA	3 x 2	3 x 5	3 x 5
Rated output current		A (eff.)	3 x 3,3	3 x 8,2	3 x 8,2
Maximum output current (duration < 1 s)		A (eff.)	3 x 6,6	3 x 16,5	3 x 16,5
Rated output voltage (sinusoidal)		V	3 x (3 x 350)		
Output frequency		Hz	0 - 800		
Supply voltage of the DC bus	X1A.1, X1A.3	VDC	540 - 720		
Supply current of the DC bus with 540 V DC		A	11,1	27,8	27,8
Shutdown threshold of the DC bus voltage		VDC	850		
Maximum current of the DC bus connector		A	25		
24 VDC supply voltage for electronics	X1A.A, X1A.B	VDC	24 ±15 %, ripple max. 5 %		
Rated current for 24 VDC (max. with I/O)		A	0,80 (1,30)	0,80 (1,30)	0,95 (1,45)
Maximum current for the 24 VDC supply voltage connector		A	6		
24B supply voltage for the holding brake / STO	X1A.C, X1A.D	VDC	24 ±15 %, ripple max. 5 %		
Maximum current consumption of the holding brake		A	3 x 0,7		
STO current consumption		A	3 x 0,02		
Maximum current of the 24B connector for the holding brake / STO		A	6		
Dimensions (W x L x H) without sockets / connector	-	mm	163,5 x 300 x 44	163,5 x 300 x 44	163,5 x 300 x 89
Weight	-	kg	2.8		3.8
Cooling[2]	-		Cold plate alternative convection-cooled metal plate[3]	Cold plate	Integrated air cooling
Type of protection according to EN 60529	-		IP52[4]	IP52[4]	IP52[4]
Degree of efficiency of the inverter electronics	-	%	98		
DC bus capacity C_Z internal		µF	3 x 10		

1) At this ambient temperature, the rated output power, the rated output current and the rated maximum current must be multiplied by the derating factor and the user must reduce the performance data to these values.
2) See 'iC, iX and i3X' on page 43.

3) Nominal data was achieved if the device has been mounted to a 500 x 500 x 5 mm metal plate.
4) Unconnected interfaces must be closed.

3.10.5 iDT5

The nominal data refers to an ambient temperature of 40 °C and the excess temperature of the winding specified in the data sheet in Kelvin. For measuring, the iDT5 is mounted to a 500 mm x 500 mm x 10 mm steel flange.

Motor data

Designation		Unit	Motor type		
			iDT5-3-10-xx0	iDT5-5-10-xx0	iDT5-9-10-xx0
n_N	Rated speed	U/min	4500	3500	3000
P_N	Rated power (shaft)	W	641	733	1037
M_0	Continuous stall torque	Nm	2.2	3.8	7.1
M_N	Rated torque	Nm	1.36	2	3.3
M_{max}	Maximum torque for 1 s	Nm	7.7	9.6	14.1
I_0	Continuous stall current	A (eff.)	2	3.3	4.6
I_N	Rated current	A (eff.)	1.2	1.7	2
I_{max}	Maximum current for 1 s	A (eff.)	8.5	8.5	8.5
n_{Max}	Mech. maximum speed	U/min	6000	5000	4200
J_M	Moment of inertia	kg cm^2	1.6	2.9	5.5
L	Motor length	mm	163.5	195	258
L_{Br}	Motor length with brake	mm	191.5	223	286
m	Weight without brake	kg	4.5	5.7	8.3
m_{Br}	Weight of the brake	kg	0.75		
J_{Br}	Moment of inertia of the brake	kg cm^2	0.092		
M_{Br}	Holding torque of the brake	Nm	12		
	Cooling		Convection	Convection	Convection
	Type of protection according to EN 60529		IP65[1]	IP65[1]	IP65[1]

1) Unconnected interfaces must be closed.

Inverter data

Designation	Connection	Unit	Motor type		
			iDT5-3-10-xx0	iDT5-5-10-xx0	iDT5-9-10-xx0
Supply voltage of the DC bus	X1A.1, X1A.3	V DC	540 - 720		
Shutdown threshold of the DC bus voltage		V DC	850		
Maximum current of the DC bus connector		A	25		
24 VDC supply voltage for electronics	X1A.A, X1A.B	V DC	24 ±15 %, ripple max. 5 %		
Rated current for 24 VDC (max. with I/O)		A	0.25 (0.75)		
Maximum current for the 24 VDC supply voltage connector		A	6		

Designation	Connection	Unit	Motor type		
			iDT5-3-10-xx0	iDT5-5-10-xx0	iDT5-9-10-xx0
Supply voltage for the holding brake / STO	X1A.C, X1A.D	V	24 ±15 %, ripple max. 5 %		
Maximum current consumption of the holding brake		A	0.7		
STO current consumption for 24 VDC		A	0.02		
Maximum current of the 24B connector for the holding brake / STO	X1A.C, X1A.D	A	6		
Degree of efficiency of the inverter electronics		%	98		

Additional data

Insulation class of the stator winding according to EN 60034-1 (IEC 60034-1) DIN 57530:	F (highest permissible constant temperature 155 °C)
Temperature monitoring according to EN 60034-11 (IEC 60034-11):	PTC thermistor (PTC), cold resistance approx. 150-800 ohm KTY 84 temperature sensor
Motor bearings	Ball bearings, sealed for life, otherwise observe information on the motor / motor data sheet
Axial run-out, rotation according to (IEC 60072-1):	Tolerance N (normal)
Balancing quality according to DIN ISO 1940:	G 2.5
Vibrational quality according to DIN ISO 2373:	N
Level of severity of vibration according to EN 60034-14:	Level A is adhered to until the rated speed
Paint finish:	RAL 9005, matte black
Noise emission level:	according to DIN EN ISO 1680
Design according to EN 600034-7 (IEC 60034-7):	IM B5
Flange size according to EN 60072	
Flange fitting:	j6
Shaft fitting:	k6
Accuracy according to DIN 42955 tolerance class:	N
Shaft end according to DIN 748-3 (IEC 60072-1):	Smooth shaft, optionally with feather key according to DIN 6885 All motors with feather key are balanced with a full wedge.
Motor encoder:	Integrated (type according to the type plate)
Brake:	Optional motor holding brake is integrated

Shafts (A) bearing load

The life time diagram of the A bearing is located on the respective motor data sheet.

Other characteristics of the motors are to be taken from the motor data sheets.

3.11 Dimension drawings

3.11.1 iC5-0

Top view
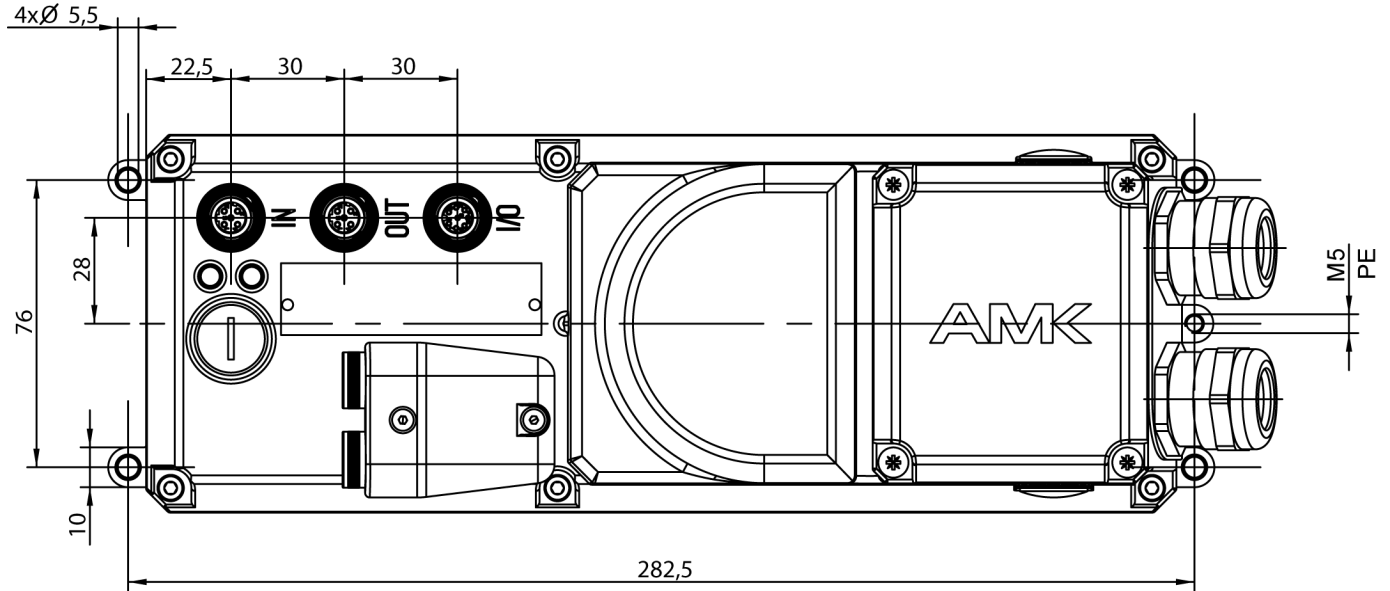
Side view
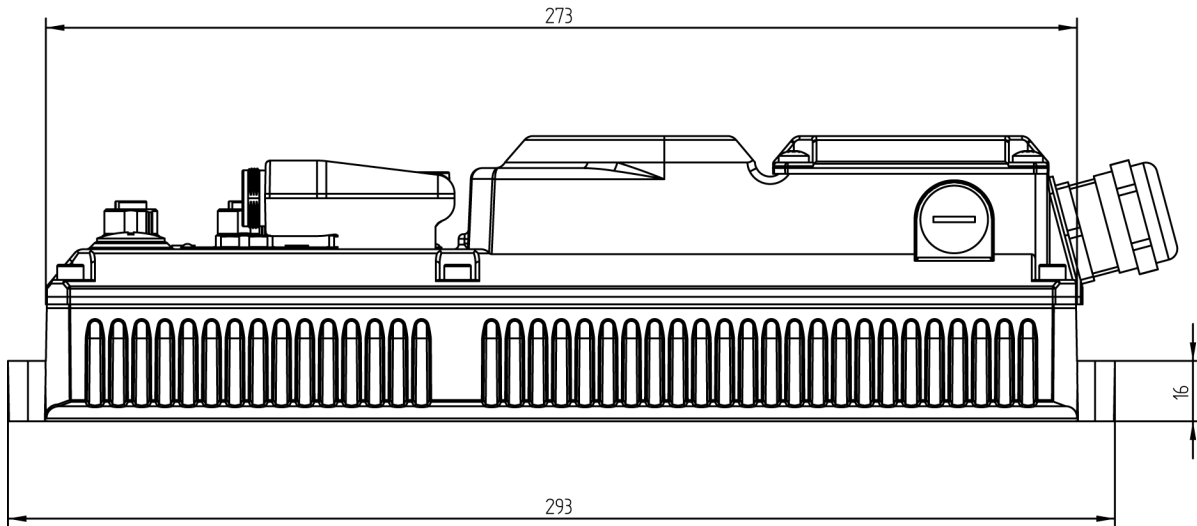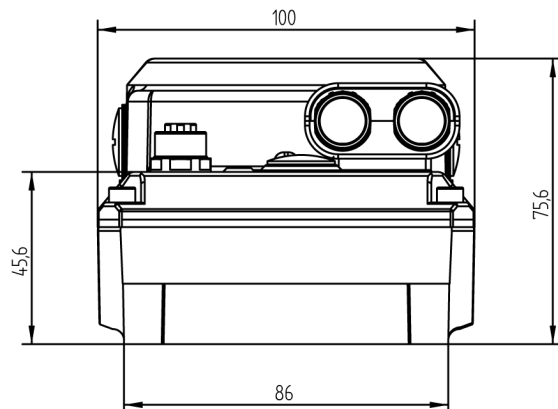
Front view
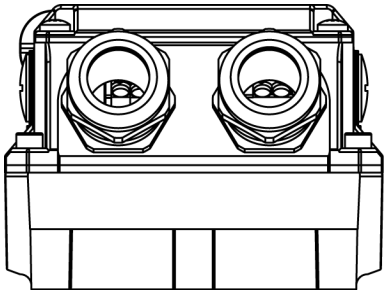
Back view

3.11.2 iC5-F

Top view
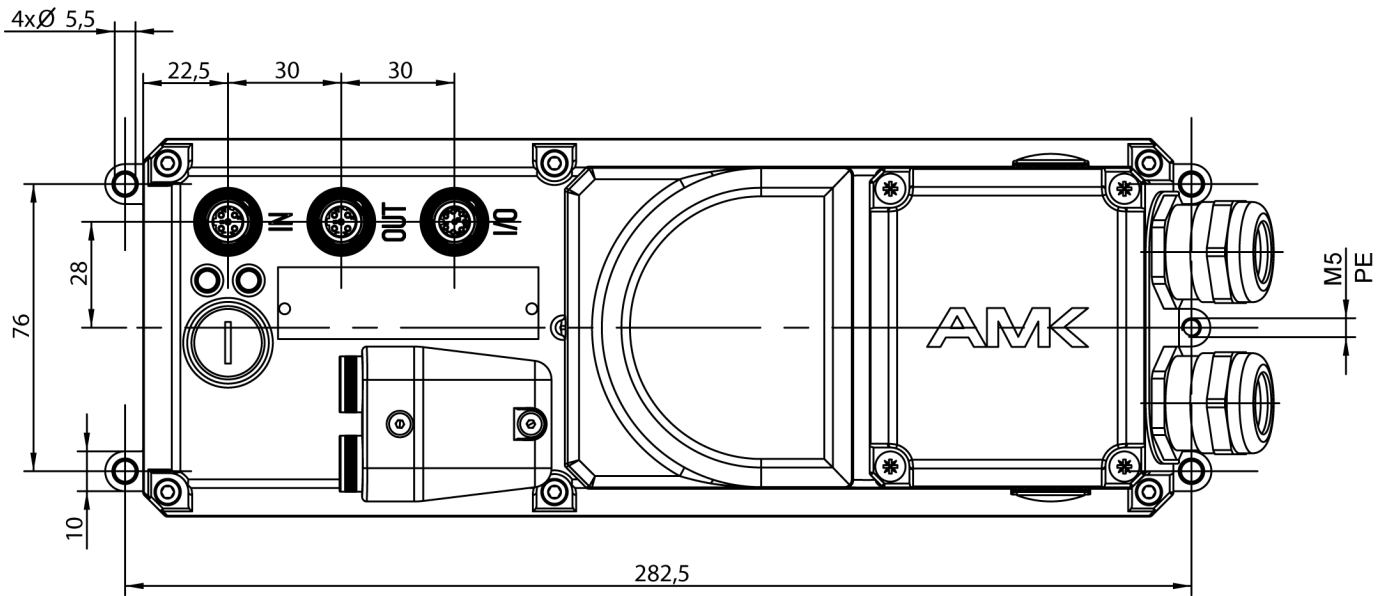
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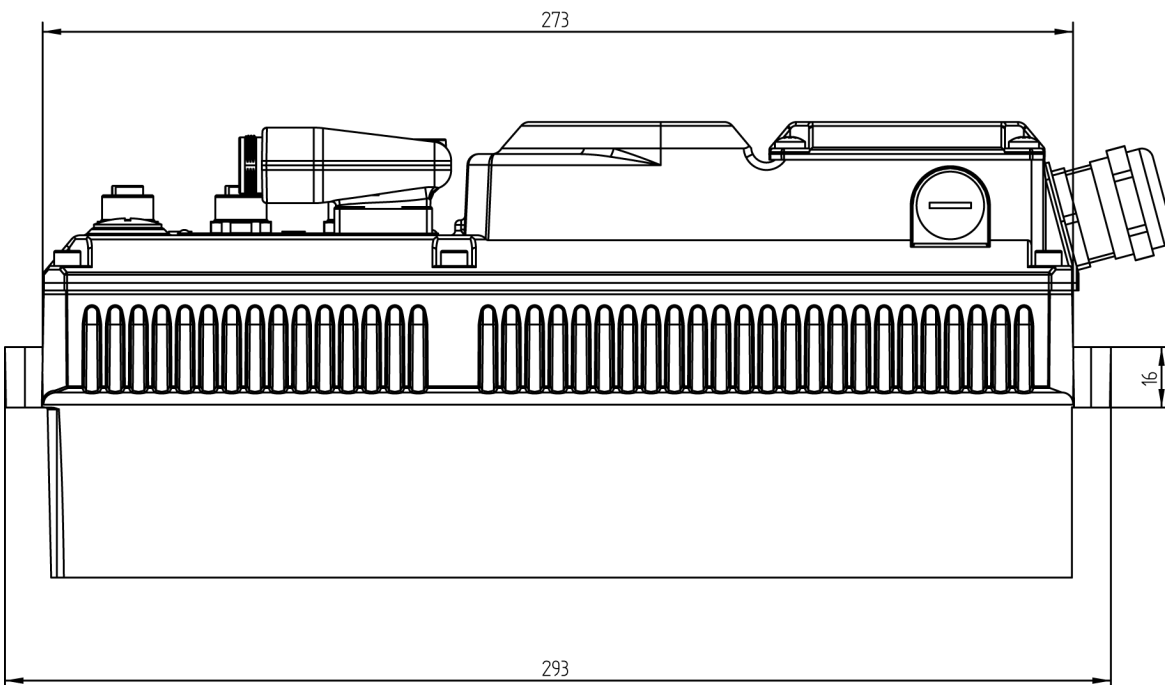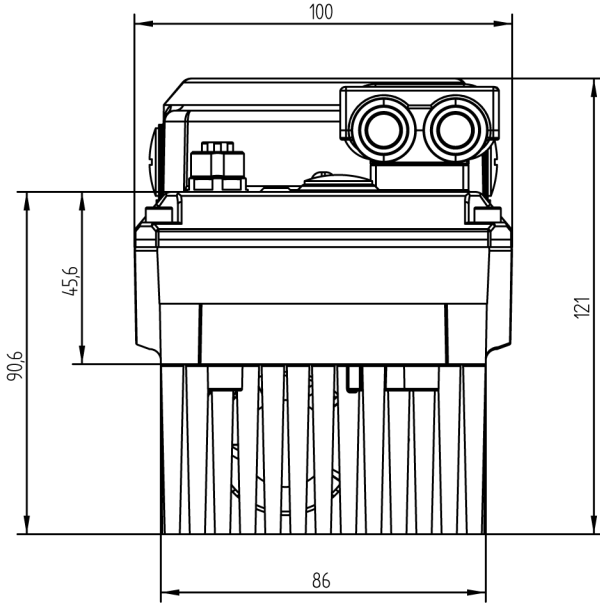
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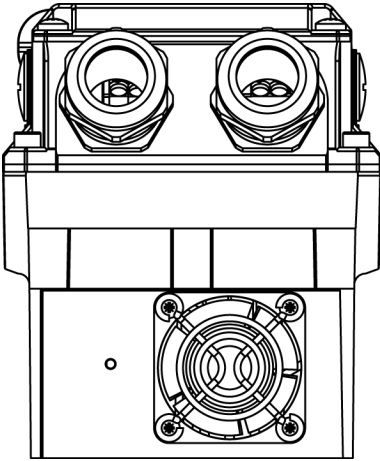
Back view

3.11.3 iX2-0 / iX5-0

Top view
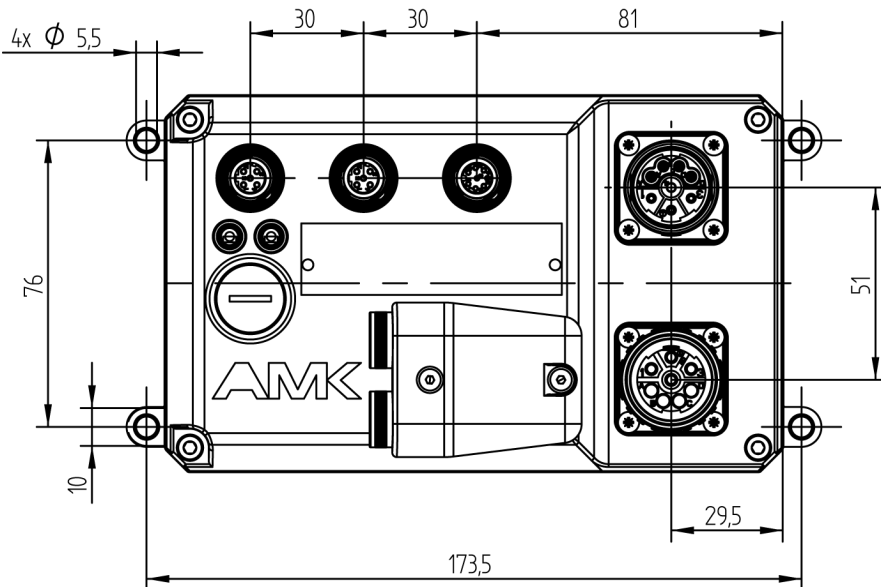
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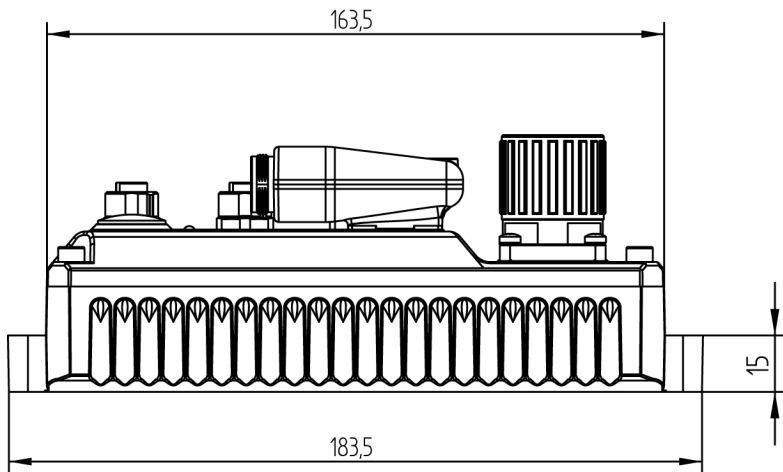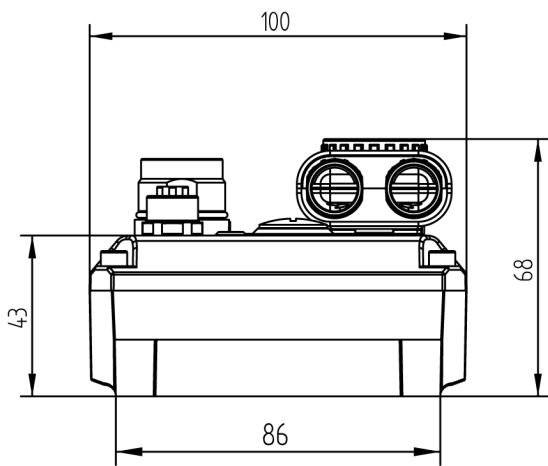
Front view
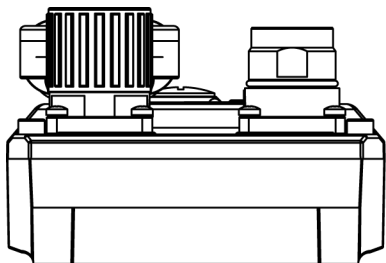
Back view

3.11.4 iX5-F

Top view
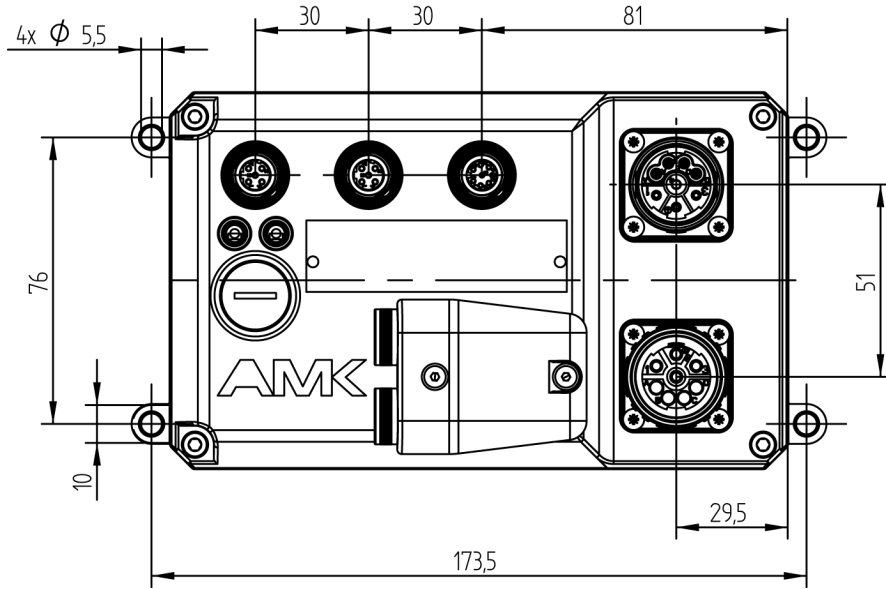
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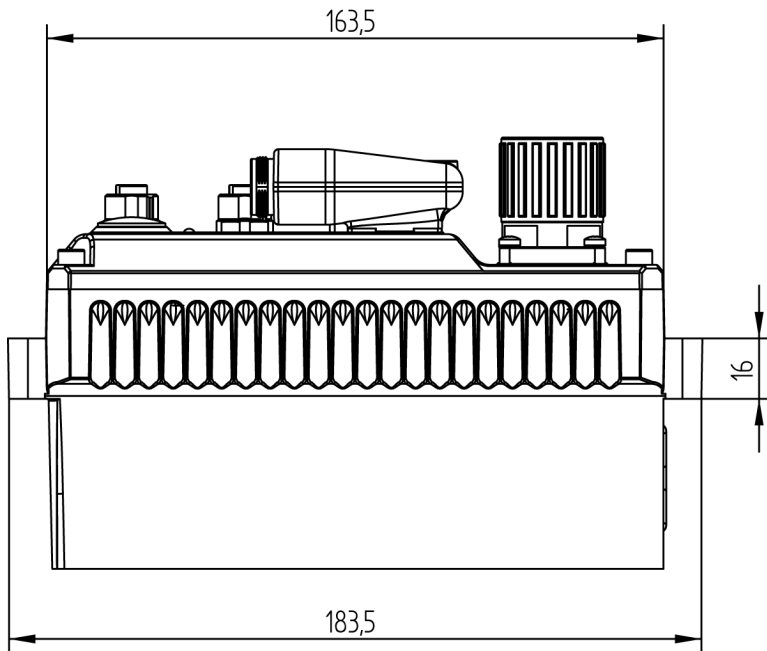
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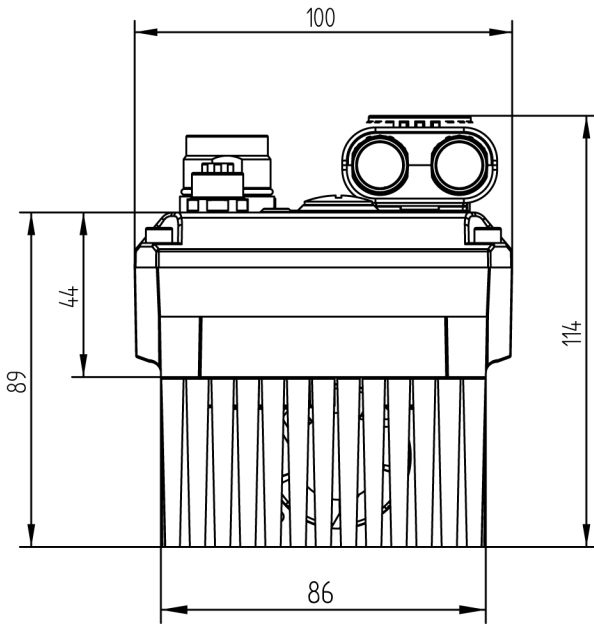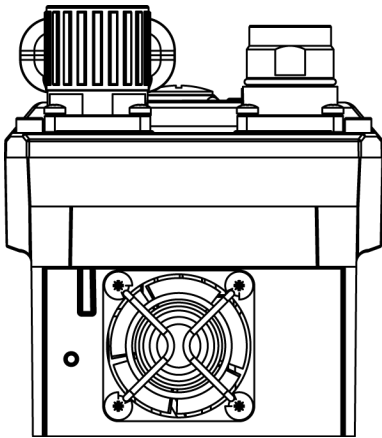
Back view

3.11.5 i3X2-0 / i3X5-0

Top view
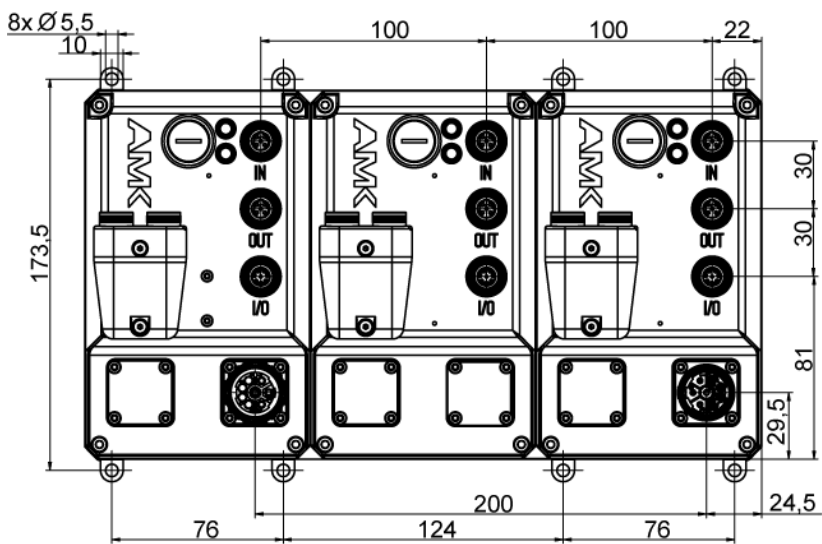
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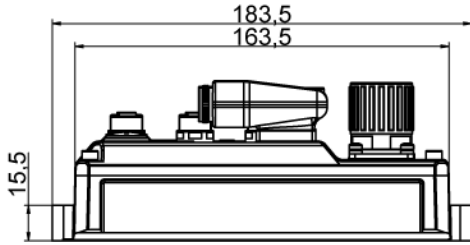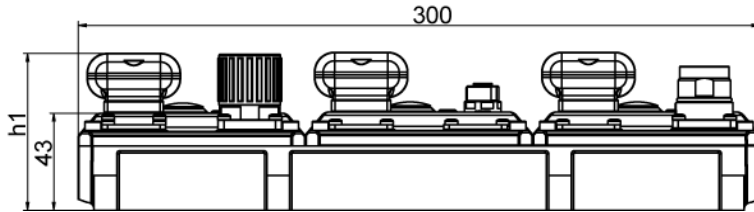
Back view

	i3X-0T	i3X-0C
h1	70 mm	68 mm

3.11.6 i3X5-F

Top view
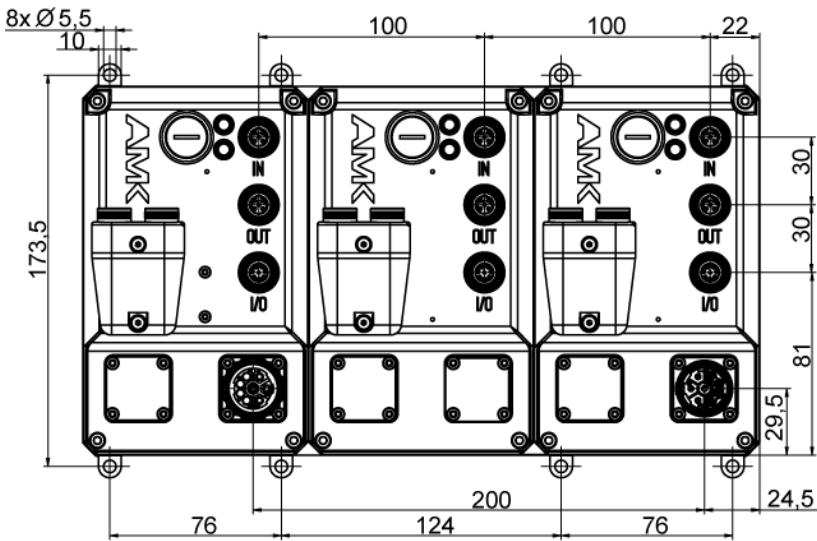
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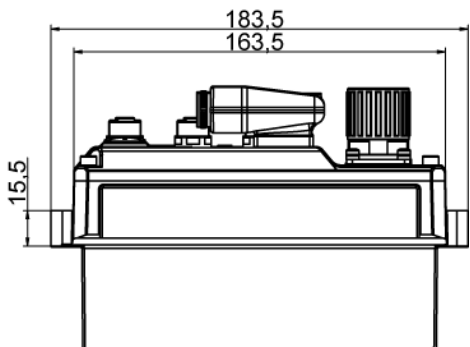
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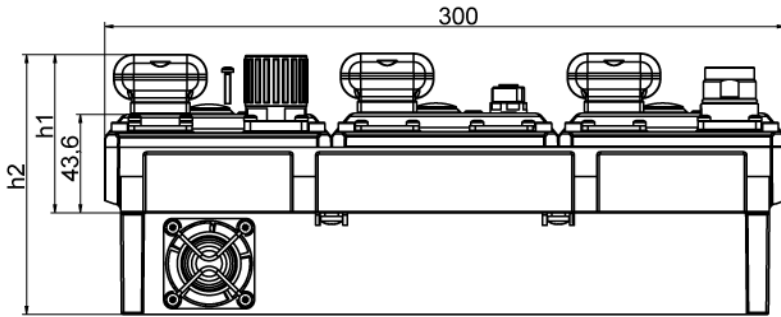
	i3X-FT	i3X-FC
h1	70 mm	69 mm
h2	115 mm	114 mm

3.11.7 iDT5

Top view

feather key (optional)
DIN6885 A6x6x30
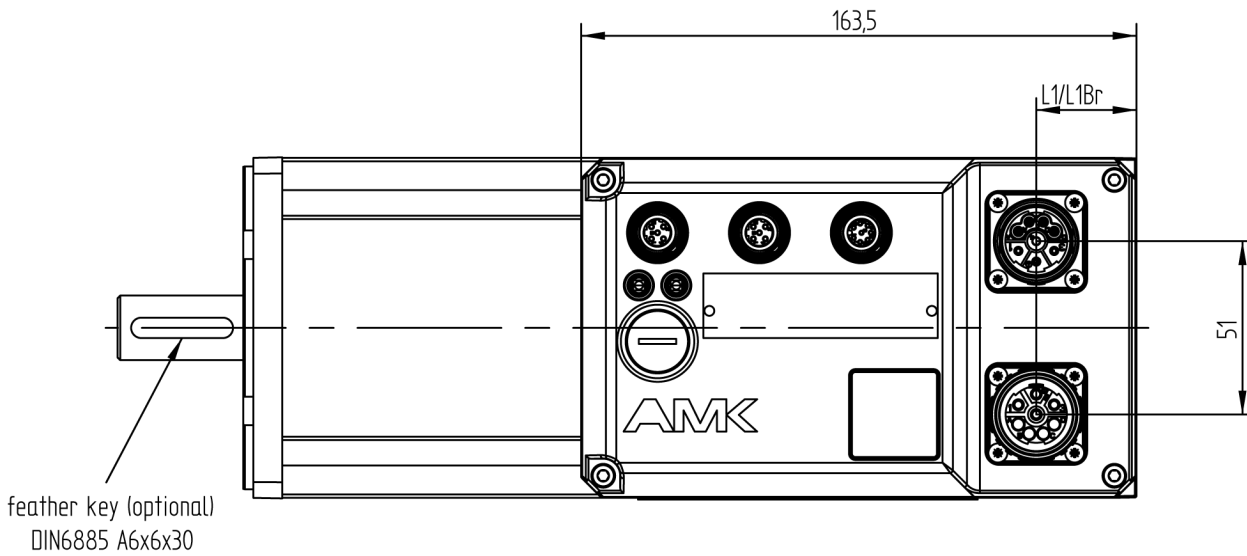
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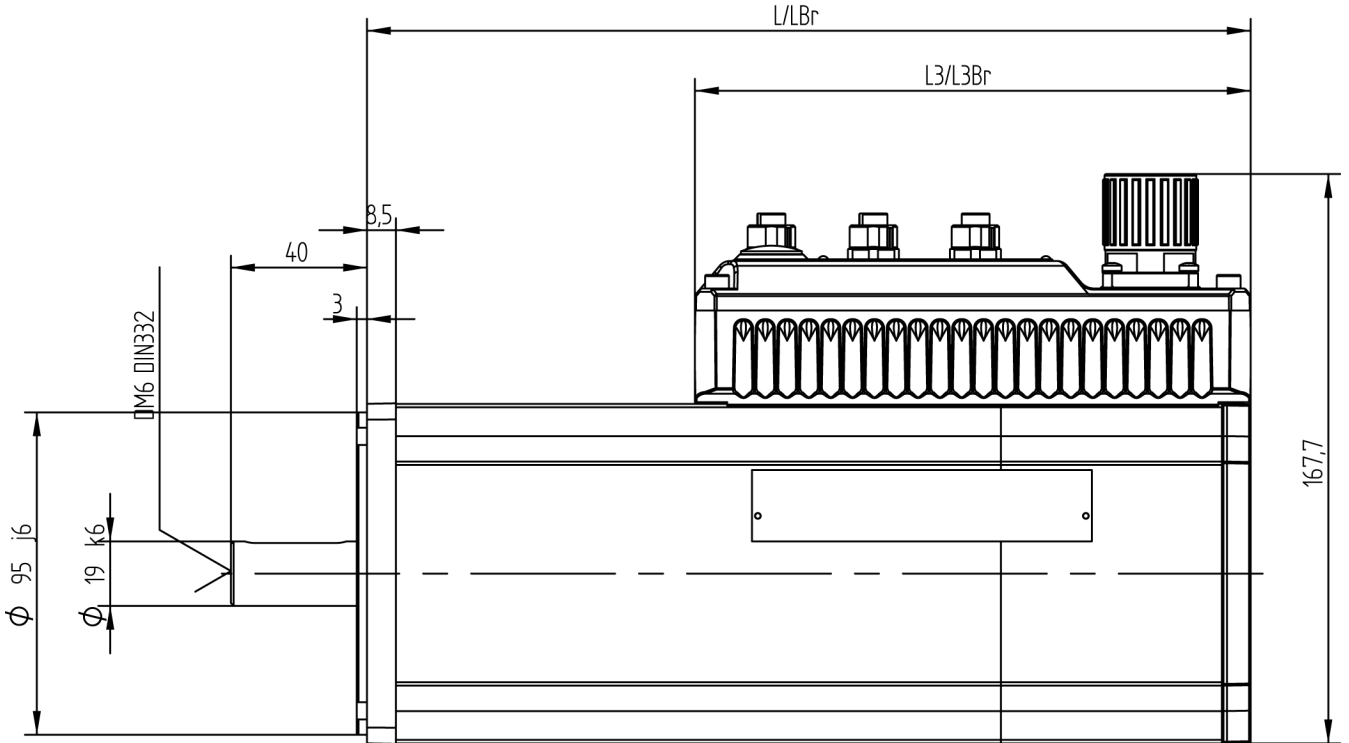
Motor type	L [mm]	LBr [mm]	L3 [mm]	L3Br [mm]
iDT5-3-10-xOO	163.5	-	163.5	-
iDT5-3-10-xBO	-	191.5	-	191.5
iDT5-5-10-xOO	195	-	163.5	-
iDT5-5-10-xBO	-	223	-	191.5
iDT5-9-10-xOO	258	-	163.5	-
iDT5-9-10-xBO	-	286	-	191.5

Front view
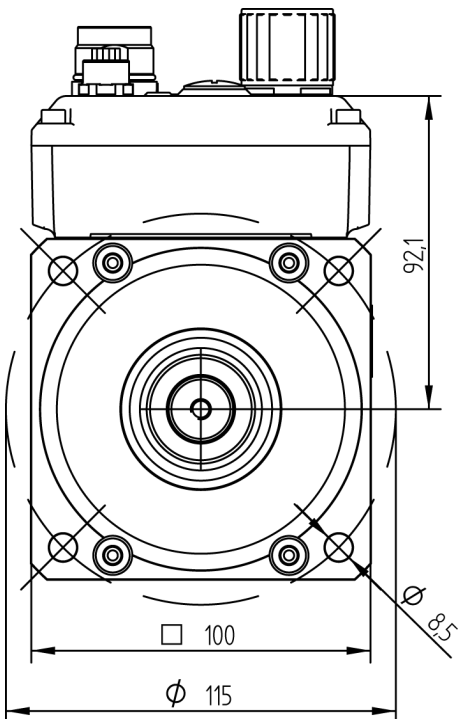
4 Projecting

4.1 Insulation resistance and high voltage test

NOTICE	
Material Damage!	**High voltage or insulation testing at the customer's location**
	All devices are insulation tested according to EN 50178 and high voltage tested according to EN 61800-5-1:2007 at the factory. If an insulation testing is to take place on site after installation according to EN 50178 section 9.4.5.2, all connections on the device must be disconnected! The devices contain suppression capacitors and circuits with protective impedance against PE. AMK is not liable for devices on which the user has carried out a high voltage test.

4.2 Layout of the DC bus power supply for iX, i3X, iDT, iDP

The power supply of the DC bus for iX, i3X, iDT5, iDP7 must be selected specific to the application (e.g. iC, KE, KEN, KES) and must take the following points into account:

- Simultaneity factor of the connected drives
- Continuous rated current, which the power supply must provide
- Overload current and time duration
- Motor / regenerative operation
    - Current regeneration (if available)
    - Brake resistor

All KE, KEN and KES compact power supplies can be used to provide the DC bus for the drives.

The compact power supplies must be wired with the specified external components (e.g. main contactor, mains chokes, upstream mains chokes, mains filter). (See device description Servo drives KE/KW, AMK part-no. 028932).

4.3 Layout of DC fuses

Cables for the DC bus must be secured with DC fuses in the positive and negative cable path if the cables are laid outside of the switch cabinet. The fuse is to be laid according to the current-carrying capacity of the DC cable and the ampacity of the connection terminals UZP, UZN (iX / i3X: connection [X1A] / iC: terminal [X02]).

The DC fuse has the task of protecting the DC cable in the event of a short-circuit and preventing a cable fire.

Example 1:
DC fuse from the company Cooper Bussmann, type FWP-30A14F
Continuous rated current: 22A
Maximum current: 80 A for 1s
Rated voltage: 800 V DC

Example 2:
DC fuse from the company Ferraz Shawmut, type DCT30-2
Continuous rated current: 25 A
Maximum current: 80 A for 5 s
Rated voltage: 1000 V DC

4.4 Layout of the iC mains connection

The iC servo inverters do not contain their own mains separation. The mains must be connected to the servo inverter via an external contactor or a main switch. The mains must be a symmetrical three-phase power system. A single-phase operation is not permitted!

An external fuse must be connected upstream in a manner suitable to the cable cross section:

Terminal cross-section	Fuse for cable protection[*)]
1.5 mm^2 / AWG 14	3 x 10 A (gG)
2.5 mm^2 / AWG 12	3 x 16 A (gG)

*) Installation type B2 according to EN 60204, multi-core cable, laid in the cable duct

⚠ **DANGER** **Danger to life from electric shock! Earth leakage current >3.5 mA**

Under proper operation, an earth leakage current of >3.5 mA can flow (inherent to its functional principle), which requires the devices to be connected in a fixed manner. AC / DC sensitive earth leakage circuit breakers can be used conditionally. Earth leakage circuit breakers for personal protection against electric shock with an operating current of ≤ 30 mA are not suitable, because the rated fault current can be greater than 30 mA. Only earth leakage circuit breakers with the following properties are suitable:

- Type B according to IEC 60755 A2, AC / DC sensitive (according to EN 50178 chap. 5.2.11.2) (e.g. by company ABB Stotz-Kontakt GmbH type F 804)
- Operating current ≥ 300 mA (no personal protection!)
- Response delay ≥ 40 ms
- Surge current resistance ≥ 3000 A

EN 61800-5-1:2008 requires a PE connection with at least 10 mm^2 cable cross-section. The PE cable is fastened to the iC housing with a ring terminal lug and an M5 screw.

Recommendation:

An optional upstream mains choke reduces current harmonics and increases the power factor. The mains choke is connected between the main switch (or contactor) and the mains connection terminal. See 'Mains choke' on page 90.

4.5 Cable lengths for DC cables

The total permissible DC cable length to a power supply depends on the power supply:

Power supply	permissible DC cable length per strand	Explanation
KE, KEN, KES	50 m	Several iX strands can be operated in parallel on one power supply. Each strand may be a maximum of 50 m long.
iC	20 m	The DC bus of an iX servo controller can be connected to the iC. The cable length from the iC to the last drive in the strand may be a maximum of 20 m.

4.6 Transmission of supply voltages between devices

When transmitting supply voltages (e.g. 24 VDC supply voltage, DC bus voltage, mains voltage), only so many slaves can be connected to one strand so that the maximum permissible current load at the first terminal is not exceeded. The transmission must be designed specific to the application and must take into account the simultaneity of the drives within a strand and the power requirement of the individual drives.

The mains or DC bus transmission must have the same cable cross-section as the mains connection.

Overview of the limiting sizes:

Device	Transmission	Limiting size	Connection / terminal	Value
iC	DC bus	Rated input power (total power)	X01	5 kW
	Mains voltage	Maximum current of the mains terminal (device with transmission)	X01	20 A
	24 VDC from an external supply	Maximum current of the 24 V supply voltage terminal	X08 / X09	4 A
	24 VDC from an external supply	Maximum current of the 24B terminal for the holding brake / STO	X08 / X09	4 A
iX / i3X / iDT5	DC bus	Maximum current of the DC bus connector	X1A.1, X1A.3	25 A
	24 VDC from an external supply	Maximum current for the 24 VDC supply voltage connector	X1A.A, X1A.B	6 A
	24 VDC from an external supply	Maximum current of the 24B connector for the holding brake / STO	X1A.C, X1A.D	6 A

Terminal loads:

See 'iX' on page 24.

See 'iC' on page 23.

See 'iDT5' on page 27.

4.7 iC with internal 24 V DC power supply unit

iC devices (see ' iC' on page 13, iCx-xx-xxU) are equipped with an internal power supply unit that is fed from the DC bus in order to ensure the 24 V DC internal self supply. It is not allowed to loop the internally generated 24 V DC supply to other devices!

If the 24 V DC supply is to be independent of the power supply, the 24 V DC supply must be fed by an external power supply unit via the terminals 24V, 0V, 24B and 0B and the internal 24 V DC supply from the DC bus must be disabled with the SMD DIP switch S2. See '[X08 / X09] 24 V DC supply voltage terminal - Transmission' on page 62.

4.8 Motor cable lengths

The total permissible length of all motor cables to a power supply depends on the power supply:

Power supply	total permissible length of all motor cables
KE, KEN, KES	100 m
iC	20 m
KEN5-FN KEN5-0N	100 m

4.9 STO (Safe torque off)

STO (safe torque off) is a safety function according to DIN EN 61800-5-2:2008-04 and corresponds to an uncontrolled stopping according to EN 60204-1, stop category 0.

In the event of a requested STO, the motor is safely, immediately and automatically separated from the energy supply in the inverter and the motor is prevented from starting unexpectedly. If the STO is actuated while moving, the drive runs down. For motors with a motor holding brake, the brake automatically closes with the STO. STO is always effective when the 24 V DC supply voltage at the 24B, 0B connection is missing.

The function is suitable for PL d according to EN 13849-1:2008 (certification is in process) if the signals 24B and 0B are interrupted in two channels with a double switch.

If the STO signal is looped through several drives, the STO state applies to all drives in this group. If a drive is in an error state due to a drive error (SBM = 0), it has no effect on the STO state of the other drives in this group.

4.10 Monitoring functions

Hardware monitoring

- Motor (A) overcurrent (maximum current)
- Short-circuit, accidental ground of the motor phases (A)
- Processor monitoring by watchdog (A)

- Internal operating voltages (A)
- External 24 V supply voltage (A) for under-voltage
- Short-circuit of external brake resistor (A)

Software monitoring

- Excess temperature of the motor and inverter (W)
- Over / under-voltage of DC bus connection at the connector X1A (A)
- Current overload according to i^2t for motor and inverter (W)
- Unacceptable control deviation (limit value via parameters) (A)
- Unacceptable velocity (limit value via parameters) (A)
- Unacceptable position increase (limit value via parameters) (A)
- Overheating of the power transistors (temperature model) (A)
- Encoder monitoring (A)
- Participants are monitored for presence (connector X85 / X86 EtherCAT) (B)
- Motor holding brake triggering (A)
- Monitoring deceleration after RF withdrawal (A)

Behaviour in the event of an error

A - Shutdown; Power output stage is blocked, drive runs down and has no torque

B - Brake and then shut down

W - Warning and shut down as soon as the warning time has expired (warning time set to 4 seconds by default)

5 Assembly

5.1 For your safety

⚠ DANGER	
⚡	**Danger to life from touching electrical connections!** The permanent magnets of the rotor induce dangerous voltage at the motor connections when the axis rotates, even when the motor is not electrically connected. If the motor is connected to an inverter, the induced DC voltage is linked to the terminals UZP and UZN for the DC bus. **Steps to prevent:** ● Make sure that the motor shaft does not rotate. ● Make sure that shock-hazard protection is installed at the motor connections. ● Make sure that the terminals UZP / UZN are free of voltage.

⚠ WARNING	
⚠	**Risk of injury from crushing, cutting and hitting.** When transporting and mounting sharp-edged and / or heavy components, there is a risk of crushing, cutting and bruising of the persons involved. **Steps to prevent:** ● Utilize suitable assembly and transport equipment, such as hoists and carriages. ● Wear protective clothing, e.g. safety gloves and boots, during the assembly. ● Use only appropriate tools during the assembly. ● Make sure that there are no persons or body parts located under suspended loads during the transport or assembly. ● Prevent catching and crushing by mechanical devices.

5.2 Avoiding material damage

NOTICE	
Material Damage!	**Material damage when lifting and transporting the motor!** The motors may not be lifted and transported by ● the shaft ● the housing of the elektronic ● the connectors ● the terminal box **Steps to prevent:** ● Lift the motor by the lifting lugs screwed in for this purpose. ● Motors without lifting lugs can be lifted with two loop hoisting slings that are attached around the motor housing. ● Motors with lifting lugs may also be lifted with loop hoisting slings when the main force is not applied to any of the above listed parts. ● The existing holes and threads for mounting the motor can be used for transportation purposes. Damage to the flange surface and the fittings attached there to the shaft and housing must be avoided.

NOTICE	
Material Damage!	**Material damage caused by incorrect assembly!** The mounting flange of the motor has to lie evenly on the surface to which it will be mounted, else mechanical tension could occur when the fastening screws are tightened. **Steps to prevent:** Before tightening the fastening screws, check whether the flange is lying evenly on the surface to be mounted.

NOTICE	
Material Damage!	**Material damage caused by impact to the motor shaft!** All impacts to the shaft, for example when mounting , can cause damage to the bearings or encoder. **Steps to prevent:** - Use the specified tools and equipment for mounting drive elements - Use the threading provided to tighten the attachment parts to the fits with using the fastening screws.

5.3 Requirements and preparation for the assembly

- Check the products for damage prior to installation. Damaged parts may not be installed!
- Any existing transport securing devices, such as cardboard covers and protective films, as well as corrosion inhibitors on the shaft must be removed before installation.
- Ensure that the required ambient conditions are met. See 'Ambient conditions' on page 23.

5.4 iC, iX and i3X

5.4.1 Cold plate

iX2-0, i3X2-0, iX5-0, i3X5-0 and iC5-0 must be mounted to a surface with a maximum temperature of 40 °C in order to achieve the specified data.

See 'iX' on page 24..

See 'iC' on page 23.

The cold plate must be able to dissipate the accumulating power loss.

Power loss

iX2-0	i3X2-0	iX5-0	i3X5-0	iC5-0
40 W		100 W		150 W

The assembly surface must meet the following requirements: (Evenness ≤ 0.3 mm, surface roughness Rz10).

5.4.2 Air-cooled devices

iX5-F and iC5-F are cooled with fans via the integrated air heat sink. The device must form a closed air duct with the assembly surface.

The preferred direction is vertical and upward with the airflow. At least 100 mm distance to adjacent devices must be kept at the air inlet and outlet.

Tightening torques for the mounting: See 'Tightening torques for screws' on page 44..

5.5 iDT5

- During assembly, ensure that the flange mounting absorbs both the motor's weight and the forces occurring during operation. See 'Tightening torques for screws' on page 44..
- The motor flange must be screwed flat onto the machine design.
- In order to ensure sufficient heat dissipation during operation, a minimum distance of 100 mm to adjacent components must exist with convection cooling.

- For a vertical mounting with an upward-facing shaft, it must be ensured that no liquid puddle collects on the flange around the rotating shaft and that no liquid enters into the bearing.

5.5.1 Mounting and removing drive elements

- Couplings, gears, pulleys, etc. may only be mounted and removed with suitable equipment.
- Use the threaded hole according to DIN 332, form DM, i.e. with metric thread, in the shaft end. Observe the tightening torques for screws.
- Heat the drive elements if necessary.
- When removing the drive elements, a cushioning disc is to be used to protect the centring in the shaft end.
- If necessary, balance the motor with drive elements according to ISO 1940.

5.6 Tightening torques for screws

Mounts	iX / i3X	iC	iDT
Terminal box cover	-	M4 x 8 (2.8 Nm)	-
Cover for address switch	M16 x 1.5 (2 Nm)		
Mount on the assembly or cooling plate	M5 x 25 (5.5 Nm) iX5-F: M5 x 70 (5.5 Nm)	M5 x 25 (5.5 Nm) iC 5-F: M5 x 70 (5.5 Nm)	-
Motor flange mounting	-	-	M8 (23 Nm)
CM3 ITT Cannon connector (cover)	2 Nm		-
PE connection to the housing	-	M5 x 10 (5.5 Nm)	-

6 Electrical connections

6.1 For your safety

⚠ DANGER	
⚡	**Danger to life from touching electrical connections!** Electrical terminals and connectors carry voltages that may cause death or serious injury upon contact. When the LEDs on the front panels are OFF, this does not indicate that the electrical terminals have been de-energized. **Steps to prevent:** • Prior to any work on the device: Observe the 5 safety rules. • Measure the terminal voltages. There may be no voltage present. • Plug and pull connections only when there is no voltage.

⚠ DANGER	
⚠	**Danger to life due to unexpected movements!** Drive without torque in the status 'safe torque off', in case of mains failure or in case of faulty drive controller. External application of force on the drive axis may result in life-threatening movements (e.g. hanging axes can fall down). **Steps to prevent:** • Install an external, mechanical brake that prevents a movement. • Install a counterweight in order to maintain the axis in balance.

6.2 Avoiding material damage

NOTICE	
Material Damage!	**Mechanical damage!** Contact problems due to pins that are bent or out of alignment. Damage may result if the screw joints are not straight when connecting the two parts. **Steps to prevent:** • Never force connectors and plug-in cards! • Before tightening the screw joints (e.g., power and encoder plugs), check whether the connector (spring) and socket (slot) are properly positioned. After this is complete, securely fasten the connection.

NOTICE	
Material Damage!	**Electronic components could be destroyed through static discharge!** Therefore touching of the electrical connections (e.g. signal and power supply cable or option and controller cards) must be avoided. **Steps to prevent:** • Avoid touching electrical connections and contacts. • During handling the electronic component discharge yourself by touching PE. • Pay attention to the ESD-notes (electrostatic discharge).

6.3 EMC-compliant wiring

• Metallic conductive housing of products sufficiently protects incoming and outgoing electromagnetic radiation
• Use shielded cables as short as possible for power and signal lines
• Connect the cable shield on both sides according to EMC (e.g. use EMC cable glands)

- For motors with a terminal box, you must apply the shield to the PE connection in the terminal box by drilling together the shield, pressing it into a cable lug and insulating with a heat-shrinkable sleeve.
- Lay the power cables and signal lines separated from one another with space
- Separate the undisturbed area (mains connection) and the disturbed area (drive components) from one another with space

6.4 PE connection

⚠ DANGER

	Danger to life from electrical shock! In the event of an interruption to the PE connection, avoid touching the casing because life-threatening levels of voltage may be present! **Steps to prevent:** • EN 50178 requires that the devices be firmly connected on the power side. • The PE conductor must have a cross-section of at least 10 mm^2 or must have a second PE connection with a cross-section at least equal to the mains feeder (cf. EN 61800-5-1:2008)! • iC: The PE conductor is connected by a ring cable lug an a M5 screw to the iC housing • iX / i3X / iDT: The PE is connected by the power supply

You will find the M5 fastener for PE in the scale drawings:

6.5 [X1A] Power supply

⚠ DANGER

	Danger to life from touching electrical connections! The permanent magnets of the rotor induce dangerous voltage at the motor connections when the axis rotates, even when the motor is not electrically connected. If the motor is connected to an inverter, the induced DC voltage is linked to the terminals UZP and UZN for the DC bus. **Steps to prevent:** • Make sure that the motor shaft does not rotate. • Make sure that shock-hazard protection is installed at the motor connections. • Make sure that the terminals UZP / UZN are free of voltage.

NOTE	
Material damage!	**Material damage due to overvoltage!** An overvoltage at the connections A and C (24 V DC) is not monitored and damages the hardware in the device. **Steps to prevent:** • Comply with the specifications for the electronics supply voltage 24 V DC. (24 V DC ± 15 %, ripple max. 5 %)

Description:

The external power supply unit that provides the 24 V DC supply voltage must have a "safe isolation" (PELV) according to EN 50178. The 0 V potential must be connected with PE. The current of the 24V and 24B supply must be limited to 4 A by the user.

In the event of a failure of the 24 V DC supply to the electronics > 10 ms, the system ready message is internally reset.

Technical data:
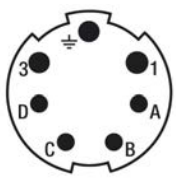
Design:

Type	Pole	Sort
M23	6	Pin

Assignment:

Drawing [X1A] of the front view of the device side	Connection	Signal	Direction	Description
	1	UZP	E	Supply of the DC bus +
	3	UZN	E	Supply of the DC bus -
	A	24V	E	24 V DC supply voltage for electronics
	B	0V	E	0 V DC supply voltage for electronics
	C	24B	E	24 V DC supply voltage for STO / motor holding brake | Connection	Signal level	Meaning
---	---	---
C	16 - 24 V DC	STO = OFF, Motor holding brake = can be opened
C	0 - 7 V DC	STO = ON, Motor holding brake = ZU	 The supply voltage directly controls the STO state and at the same time supplies an optional motor holding brake with power. Actuation of the motor holding brake: See 'Procedure for switching on and off ' on page 79. See 'STO (Safe torque off)' on page 40.
	D	0B	E	Reference potential for 24 B
	PE	PE	I/O	Protective earthing conductor on housing

Connection:

Mating connector	M23, 6-pole, socket
Cable	3 x 2.5 mm^2 + 4 x 0.75 mm^2 + PE, shielded
Shield connection	Apply on both sides
Tightening torque	5 - 6 Nm
Accessories	Prefabricated cable: See 'Cable for power connection [X1A] and transmission iC to iX / i3X / iDT5 / iDP7' on page 88.
Comment	Use cord 1 and 3 for UZP and UZN, cord 2 remains unused

6.6 [X1B] Power supply transmission

⚠ **DANGER**
Danger to life from touching electrical connections! The permanent magnets of the rotor induce dangerous voltage at the motor connections when the axis rotates, even when the motor is not electrically connected. If the motor is connected to an inverter, the induced DC voltage is linked to the terminals UZP and UZN for the DC bus. **Steps to prevent:** • Make sure that the motor shaft does not rotate. • Make sure that shock-hazard protection is installed at the motor connections. • Make sure that the terminals UZP / UZN are free of voltage.

Description:

Other drives can be supplied via the power connection transmission.

Technical data:
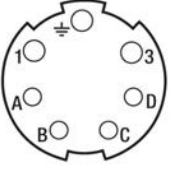
See 'iX' on page 24.
See 'iDT5' on page 27.

Design:

Type	Pole	Sort
M23	6	Socket

Assignment:

Drawing [X1B] of the front view of the device side	Connection	Signal	Direction	Description
	1	UZP	A	Supply of the DC bus +
	3	UZN	A	Supply of the DC bus -
	A	24V	A	24 V DC electronics supply voltage
	B	0V	A	0 V DC electronics supply voltage
	C	24B	A	STO supply voltage / 24 V DC holding brake
	D	0B	A	STO supply voltage / 0 V DC holding brake
	PE	PE	I/O	Protective earthing conductor on housing

Connection:

Mating connector	M23, 6-pole, pin
Cable	3 x 2.5 mm^2 + 4 x 0.75 mm^2 +PE, shielded
Shield connection	Apply on both sides
Tightening torque	5-6 Nm
Accessories	Prefabricated cable: See 'Cable for power connection [X1A] and transmission iC to iX / i3X / iDT5 / iDP7' on page 88.
Comment	Use cord 1 and 3 for UZP and UZN, cord 2 remains unused

6.7 [X04] I/O Interface

Description:

Multi-functional I/O interface with 5 connections: either up to five binary inputs, 3 binary outputs and one analogue input. Each I/O connection can only be assigned one functionality.

The diagnostic message 1100 is generated in the event of a short-circuit or overload longer than 500 µs.

Configuration upon delivery:

Connection	Use	Meaning
2	BE1	Controller enable (RF)
3	BE2	Clear error (FL)
4	BE3	Cam signal (NK)
5	BA2	Acknowledgement controller enable
6	BA3	System ready message (SBM)

Configuration of the binary inputs:

Connection	Binary inputs	Parameters	Configuration upon delivery		Binary input image ID34100
			Code	Meaning	
2	BE1	ID32978 'Port3 Bit0'	32904	Controller enable (RF)	Bit 0
3	BE2	ID32979 'Port3 Bit1'	32913	Clear error (FL)	Bit 1
4	BE3	ID32980 'Port3 Bit2'	32905	Cam signal (NK)	Bit 2
5	BI4	ID32981 'Port3 Bit3'	0	open	Bit 3
6	BI5	ID32982 'Port3 Bit4'	0	open	Bit 4

Configuration of the binary outputs:

| Connection | Binary outputs | Parameters | Configuration upon delivery | | Binary output image ID34120 |
			Code	Meaning	
2	Not available	-	-	-	-
3	Not available	-	-	-	-
4	BA1	ID32865 'Port3 Bit0'	-	-	Bit 0
5	BA2	ID32866 'Port3 Bit1'	33031	Acknowledgement controller enable	Bit 1
6	BA3	ID32867 'Port3 Bit2'	33029	System ready message (SBM)	Bit 2

In addition to the binary inputs, the binary outputs are shown in the binary input image.

Configuration of the analogue input:

Connection	Analogue input	Parameters	Code	Meaning	Binary output image ID34120
2	AE+	ID32978 'Port3 Bit0'	33917	Analogue speed control	-
3	AE-	ID32979 'Port3 Bit1'	33917	Analogue speed control	-
4	Not available	-	-	-	-
5	Not available	-	-	-	-
6	Not available	-	-	-	-
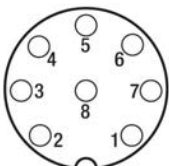
Technical data:

- Signal specification according to standard EN 61131-2, digital input type 3
  Limit value 1-signal: min. 11 V / 2 mA, max. 30 V / 15 mA
  Limit value 0-signal: min. -3 V / 0 mA, max. 5 V / 15 mA
  Minimum signal duration > 2 ms
- no electrical isolation, all I/O connections are connected internally with the supply voltage 24 V DC for electronics (terminal X1A, X1B, connection A and B).
- A protective circuit must be provided externally for inductive loads at the binary outputs.

Design:

Type	Pole	Sort
M12	8	Socket, A-coded

Assignment:

Drawing [X04] of the front view of the device side	Connection	Signal	Direction	Description
	1	GND	I/O	Reference potential 0 V
	2	BE1	E	Binary input, 24 V / 8 mA, non-isolated
		AE+	E	Analogue input not inverted, ±10 V DC, 12 bit resolution
	3	BE2	E	Binary input, 24 V / 8 mA, non-isolated
		AE-	E	Analogue input inverted, ±10 V DC, 12 bit resolution
	4	BE3	E	Binary input, 24 V / 8 mA, non-isolated
		BA1	A	Binary output, 24 V / max. 100 mA
	5	BI4	E	Binary input, 24 V / 8 mA, non-isolated
		BA2	A	Binary output, 24 V / max. 100 mA
	6	BI5	E	Binary input, 24 V / 8 mA, non-isolated
		BA3	A	Binary output, 24 V / max. 250 mA[2]
	7	Data+	I/O	[1]
	8	Data-	I/O	[1]

1) The interface is not released

2)   The binary output 3 can be parameterised as power supply 24 V / max. 250 mA (code 33079). The current must be limited to 250 mA on the user side.

Connection:

Mating connector	M12, 8-pole pin, A-coded
Cable	8-wire, shielded
Shield connection	Apply on both sides
Tightening torque	0.4 Nm
Accessories	Prefabricated cable: See 'Cable for I/O interface [X04]' on page 89.

Input wiring:

Analogue input
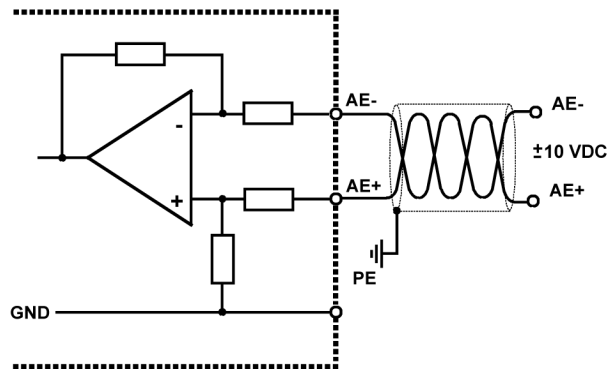
Binary inputs and outputs
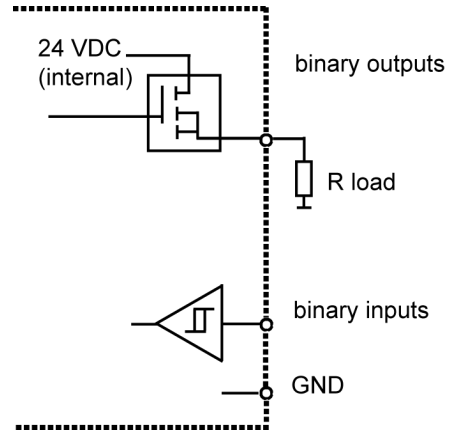
6.8 [X05] Encoder connection

NOTICE	
Material Damage!	**Material damage when plugging in the TWINTUS M12 encoder plug** The plug must be aligned before insertion into the socket. The pin contacts are engaged **before** the codings of the plug and socket interlock. The pin contacts will be bent if the plug is turned when being inserted and the pin contacts are already engaged or if the plug and socket are not properly aligned and the screwcap is tightened. **Steps to prevent:** ● The plug must be inserted when aligned with the socket. ● Only turn the plug if the pin contacts are not yet engaged. ● Only tighten the screwcap once the codings of the plug and socket interlock.

Description:

The following AMK encoders are supported:

● P, Q encoder, inductive, Endat 2.2 light (digital), singleturn (P) or multiturn (Q)
● E, F encoder, optical, EnDat 2.1 (digital + analogue), singleturn (E) or multiturn (F)
● S, T encoder, optical, Hiperface, singleturn (S) or multiturn (T)
● U, V encoder, capacitive, Hiperface, singleturn (U) or multiturn (V)
● I encoder, optical, sin/cos track and zero pulse
● Hall encoder

The encoder connection is possible in the Twintus or CM3 connector design.
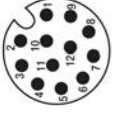
Technical data:

● Maximum cable length 10 m

Design:

Type	Pole	Sort	Manufacturer	Designation
M12	12	Pin	Hummel AG	Twintus
alternative design				
-	6	Socket	ITT Cannon	Red socket insert for connector CM3 [X05.1]
-	6	Socket	ITT Cannon	Blue socket insert for connector CM3 [X05.2]

Assignment
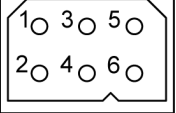
[X05] Twintus connector	Connection	E / F encoder		P / Q encoder[3]		I encoder Hall encoder		S / T, U / V encoder	
		Signal	Direction	Signal	Direction	Signal	Direction	Signal	Direction
Front view of the device side	1	G2I	E	-	-	G2I	E	G2I	E
	2	GND	A	GND	A	GND	A	-	-
	3	G2N	E	-	-	G2N	E	G2N	E
	4	G1N	E	-	-	G1N	E	G1N	E
	5	-EN_DAT	I/O	-EN_DAT	I/O	G0I [4]	E	-	-
	6	G1I	E	-	-	G1I	E	G1I	E
	7	-	-	-	-	-	-	GND	A
	8	+EN_DAT	I/O	+EN_DAT	I/O	G0N [4]	E	-	-
	9	5 V DC [1]	A	5 V DC [1]	A	5 V DC [1]	A	-	-
	10	-	-	-	-	-	-	8 V DC [2]	A
	11	+EN_Clk	I/O	+EN_Clk	I/O	-	-	RS485+	I/O
	12	-EN_Clk	I/O	-EN_Clk	I/O	-	-	RS485-	I/O
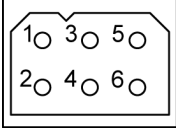
1) 5 V DC ±5 %, max. 350 mA
2) 8 V DC ±5 % under load, max. 150 mA; 9 V DC ±20 % when idle
3) P- and Q-type encoder with analogue tracks can be used and parameterised in ID32953 as E-and F-type encoder
4) Only for I encoder, not for Hall encoder

[X05.1] CM3 connector	Connection	EnDat Standard E / F encoder		EnDat2.1 (digital) P / Q encoder		Sine encoder I encoder Hall encoder		Hiperface S / T, U / V encoder	
		Signal	Direction	Signal	Direction	Signal	Direction	Signal	Direction
Front view of the device side	1	+EN_DAT	I/O	+EN_DAT	I/O	G0N [4]	E	-	-
	2	-EN_DAT	I/O	-EN_DAT	I/O	G0I [4]	E	-	-
	3	GND	A	GND	A	GND	A	-	-
	4	5 V DC [1]	A	5 V DC [1]	A	5 V DC [1]	A	-	-
	5	-EN_Clk	I/O	-EN_Clk	I/O	-	-	RS485-	I/O
	6	+EN_Clk	I/O	+EN_Clk	I/O	-	-	RS485+	I/O

[X5.2] CM3 connector	Connection	EnDat Standard E / F encoder		EnDat2.1 (digital) P / Q encoder		Sine encoder I encoder Hall encoder		Hiperface S / T, U / V encoder	
		Signal	Direction	Signal	Direction	Signal	Direction	Signal	Direction
Front view of the device side	1	GND	A	GND	A	GND	A	GND	A
	2	-	-	-	-	-	-	8 V DC 2)	A
	3	G2N	E	-	-	G2N	E	G2N	E
	4	G2I	E	-	-	G2I	E	G2I	E
	5	G1N	E	-	-	G1N	E	G1N	E
	6	G1I	E	-	-	G1I	E	G1I	E

See 'CM3 (ITT Cannon) connector' on page 54.

Connection:

Connector plug	Twintus	CM3
Mating connector	M12, 12-pole, socket	2 x 6-pole, pin
Cable	6 x (2 x 0.14 mm^2) / AWG 26, shielded	4 x (2 x 0.25mm^2) + 4 x 0.5 mm^2 / AWG 24 + AWG 20, shielded
Shield connection	Apply on both sides	Apply on both sides
Tightening torque	0.4 Nm	-
Accessories	Prefabricated cable: See 'Cable for encoder connection [X05]' on page 89.	Prefabricated cable: See 'Cable for encoder connection [X05]' on page 89.

Circuit principle:

G1N
G1I

G2N
G2I

+EN_DAT / G0N
-EN_DAT / G0I

+EN_CLK
-EN_CLK

5 VDC ——— 5 VDC EnDat
GND ——— GND
8 VDC ——— 8 VDC Hiperface
GND
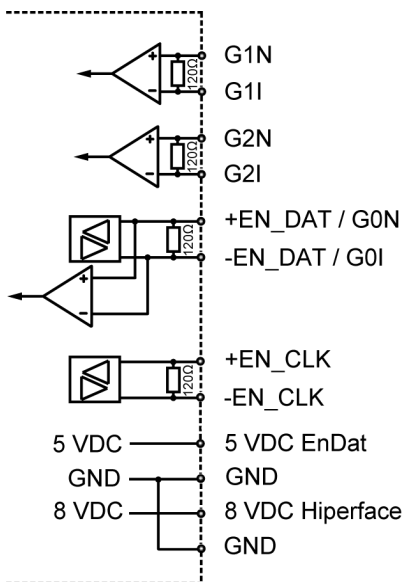
6.9 [X06] Motor connection

⚠ **DANGER**
Danger to life from touching electrical connections!
The permanent magnets of the rotor induce dangerous voltage at the motor connections when the axis rotates, even when the motor is not electrically connected. If the motor is connected to an inverter, the induced DC voltage is linked to the terminals UZP and UZN for the DC bus.
Steps to prevent:
• Make sure that the motor shaft does not rotate.
• Make sure that shock-hazard protection is installed at the motor connections.
• Make sure that the terminals UZP / UZN are free of voltage.

NOTICE	
Material Damage!	**Material damage resulting from Overheating!** AMK servo motors are provided with sensors for temperature monitoring. Motors without or with bypassed PTC thermistor can overheat and be destroyed. **Steps to prevent:** ● Connect the PTC thermistor of the servo motor for temperature monitoring ● Activate the I²t monitoring of the servo motor in ID32773 'Service bits' Bit 14.

The motor connection is possible in the Twintus or CM3 connector design.
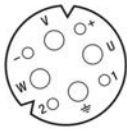
Technical data:
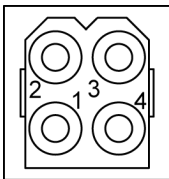
● Maximum cable length 10 m
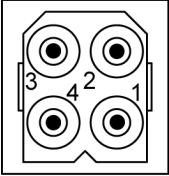
Design:

Type	Pole	Sort	Manufacturer	Designation
M16	8	Socket	Hummel AG	Twintus
			alternative design	
-	4	Socket	ITT Cannon	Black insulating body type 1 for connector CM3 [X06.1]
-	4	Pin	ITT Cannon	Black insulating body type 0 for connector CM3 [X06.2]

Assignment:

[X06] Twintus connector drawing, front view on the device side	Connection	Signal	Direction	Description
	U	U (1)	A	Phase 1
	V	V (2)	A	Phase 2
	W	W (3)	A	Phase 3
	PE	PE	I/O	Protective earth
	1	KTY84+	I/O	Temperature sensor for the motor coil
	2	KTY84-	I/O	Temperature sensor for the motor coil
	+	Brake +	A	Holding brake
	-	Brake -	A	Holding brake

[X06.1] CM3 connector **Drawing of the front view of the device side**	Connection	Signal	Direction	Description
	1	KTY84-	I/O	Temperature sensor for the motor coil
	2	KTY84+	I/O	Temperature sensor for the motor coil
	3	Brake -	A	Holding brake
	4	Brake +	A	Holding brake

[X06.2] CM3 connector Drawing of the front view of the device side	Connection	Signal	Direction	Description
	1	U	A	Phase 1
	2	V	A	Phase 2
	3	W	A	Phase 3
	4	PE	I/O	Protective earth

Connection:

Connector plug	Twintus	CM3
Mating connector	M16, 8-pole, socket	1 x 4-pole, socket and 1 x 4-pole, pin
Cable	4 x 0.75 mm^2 + 2 x (2 x 0.34 mm^2) / AWG 18, shielded	Signal cable: 4 x 0.25 - 050 mm^2 / AWG 24, shielded Motor output: 4 x 1 - 1.5 mm^2 / AWG 18, shielded
Shield connection	Apply on both sides	Apply on both sides
Tightening torque	2-3 Nm	
Accessories	Prefabricated cable: See Cables for the motor connection [X06] on page 89.	Prefabricated cable: See 'Cables for the motor connection [X06]' on page 89.

6.10 CM3 (ITT Cannon) connector

1. Loosen both of the screws and open the CM3 connector housing.
2. Loosen the screw for the clamping bracket and remove the clamping bracket.
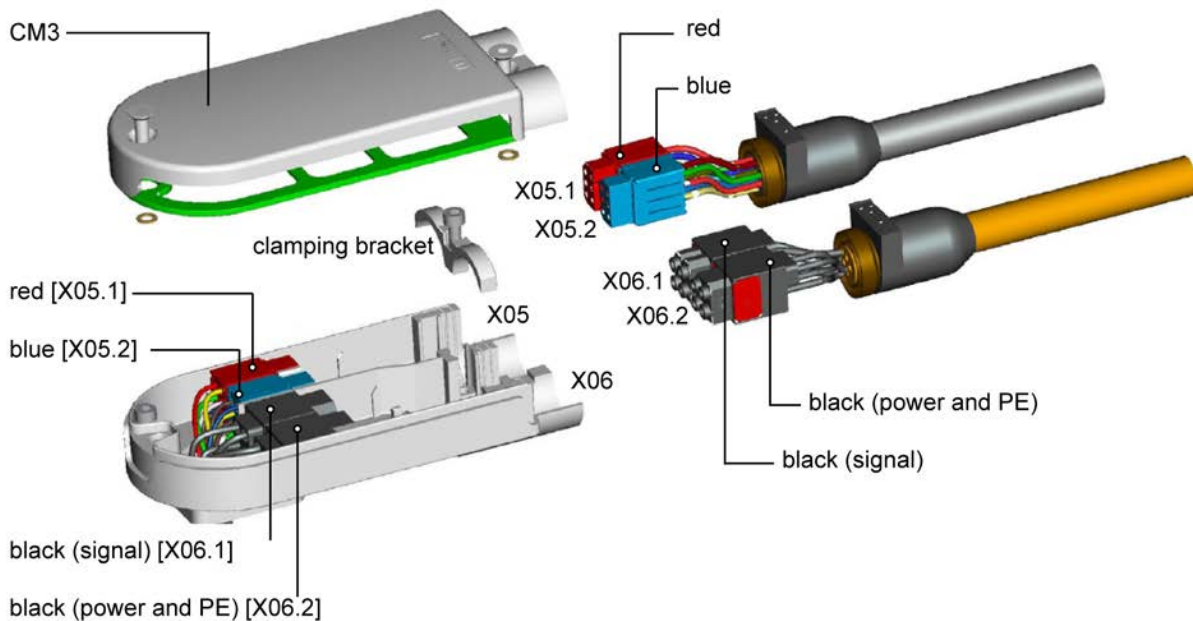
3. Lift the contacts out of the CM3 connector housing.

plug in contacts   screw for the clamping bracket
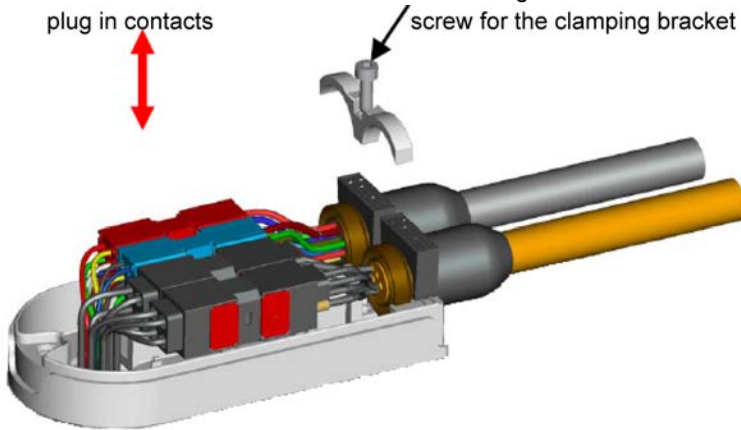
4. Connect the raised contacts with the respective counter contact of the motor and encoder cable.
5. Insert the connected contacts into the CM3 connector housing.
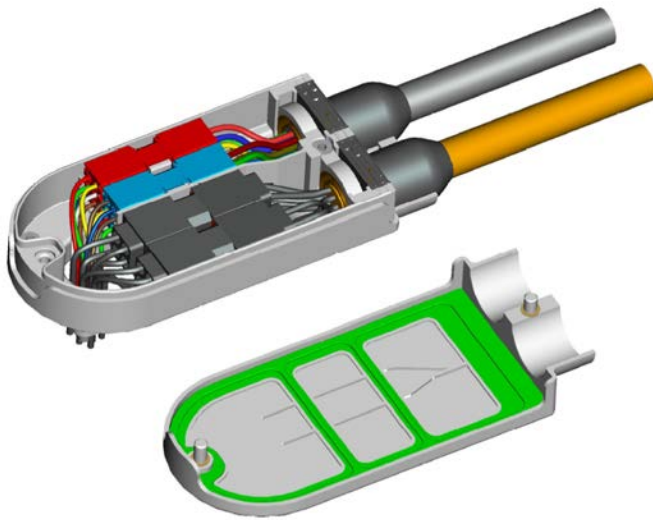
6. Align the cable and tighten the clamping bracket.
7. Screw the cover on the CM3 connector. Ensure that the seal is not damaged.

tight the lid with the preassembled seal with the 2 screws
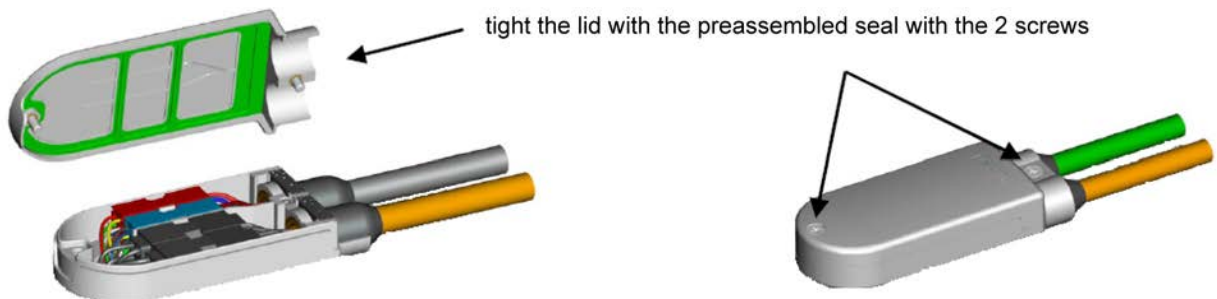
6.11 [X85] Real-time Ethernet input

Description:

Device-dependent real-time Ethernet interface. The communication protocol is set in the type code.
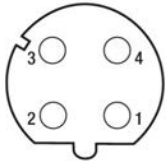
Technical data:
- 100BASE-T 100 Mbit/s Ethernet standard
- Maximum length 50 m (point to point)

Design:

Type	Pole	Sort
M12	4	Socket, D-coded

Assignment:

Drawing [X85] of the front view of the device side	Connection	Signal	Direction	Description
	1	TX+	A	Transmission Data +
	2	RX+	E	Receive Data +
	3	TX-	A	Transmission Data -
	4	RX-	E	Receive Data -

Connection:

Mating connector	M12, 4-pole pin, D-coded
Tightening torque	0.4 Nm
Cable assembly	Prefabricated cable: See 'Cables for EtherCAT connector [X85] and [X86]' on page 89.

6.12 [X86] Real-time Ethernet transmission

Device-dependent real-time Ethernet interface. The communication protocol is set in the type code.
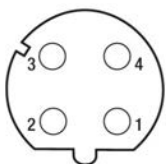
Technical data:

- 100BASE-T 100 Mbit/s Ethernet standard
- Maximum length 50 m (point to point)

Design:

Type	Pole	Sort
M12	4	Socket, D-coded

Assignment:

Drawing [X86] of the front view of the device side	Connection	Signal	Direction	Description
	1	TX+	A	Transmission Data +
	2	RX+	E	Receive Data +
	3	TX-	A	Transmission Data -
	4	RX-	E	Receive Data -

Connection:

Mating connector	M12, 4-pole pin, D-coded
Tightening torque	0.4 Nm
Cable assembly	Prefabricated cable: See 'Cables for EtherCAT connector [X85] and [X86]' on page 89.

6.13 [X136] CAN Bus Input
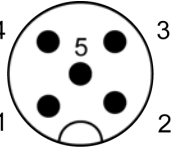
Description:

The CAN bus interface meets the CAN standard 2.0 B. The DS402 protocol is supported with AMK-specific functionality. (See 'PDK_xxxxxx_DS402.de/en.pdf' - document in process)

Design:

Type	Pole	Sort
M12	5	Pin, A-coded

Assignment:

Drawing [X136] of the front view of the device side	Connection	Signal	Direction	Description
	1	GND/PE	E	Ground potential / cable shield
	2	SYNC_H	E	Hardware synchronisation High
	3	SYNC_L	E	Hardware synchronisation Low
	4	CAN_H	E	CAN_High
	5	CAN_L	E	CAN_Low

Connection:

Mating connector	M12, 5-pole socket, A-coded
Tightening torque	0.4 Nm
Accessories	Prefabricated cable: See 'Cable and terminating plug for CAN BUS connection [X136] and [X137] ' on page 90.
Comment	A bus terminal resistor is required at the first and last participant.
	The AMK bus terminal resistor connects the CAN bus lines CAN_H and CAN_L as well as the hardware synchronisation line SYNC_H and SYNC_L with 120 ohm resistance.
	See 'Cable and terminating plug for CAN BUS connection [X136] and [X137] ' on page 90.

6.14 [X137] CAN bus transmission
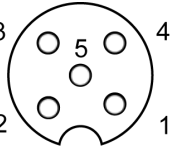
Description:

The CAN interface meets the CAN standard 2.0 B

Design:

Type	Pole	Sort
M12	5	Socket, A-coded

Assignment:

Drawing [X137] of the front view of the device side	Connection	Signal	Direction	Description
	1	GND/PE	A	Ground potential / cable shield
	2	SYNC_H	A	Hardware synchronisation High
	3	SYNC_L	A	Hardware synchronisation Low
	4	CAN_H	A	CAN_High
	5	CAN_L	A	CAN_Low

Connection:

Mating connector	M12, 5-pole pin, A-coded
Tightening torque	0.4 Nm
Accessories	Prefabricated cable: See 'Cable and terminating plug for CAN BUS connection [X136] and [X137] ' on page 90.
Comment	A bus terminal resistor is required at the first and last participant.
	The AMK bus terminal resistor connects the CAN bus lines CAN_H and CAN_L as well as the hardware synchronisation line SYNC_H and SYNC_L with 120 ohm resistance.
	See 'Cable and terminating plug for CAN BUS connection [X136] and [X137] ' on page 90.

6.15 Terminal box (iC)

NOTICE	
Material Damage!	Ensure that no objects fall into the housing when working on the open housing. Foreign objects can cause short-circuits during operation and thereby destroy the device.
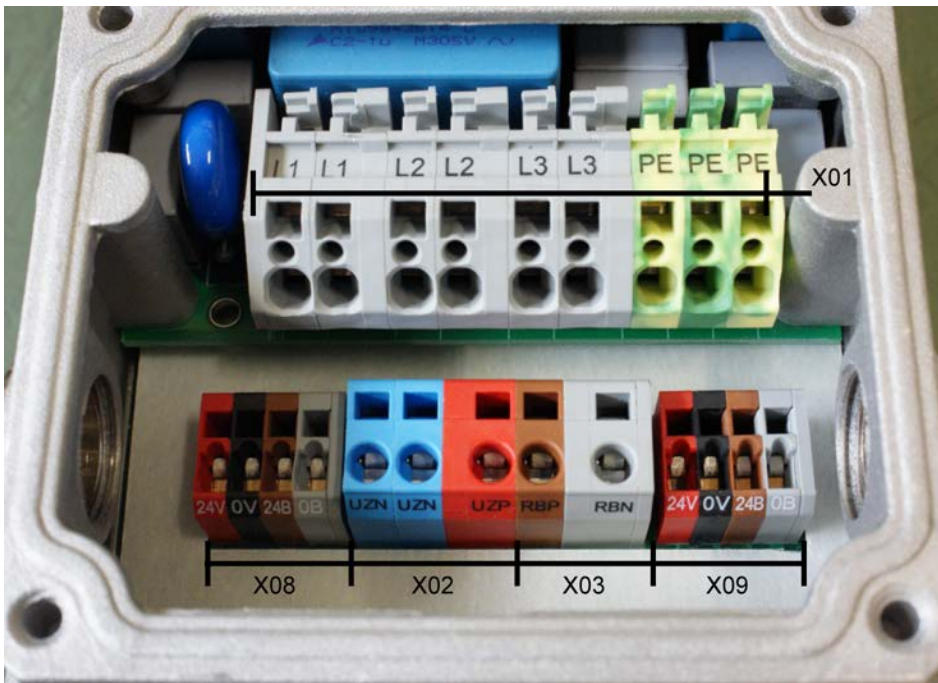
See 'Cable glands' on page 90.

Installation note

If you use an EMC-compliant cable gland (AMK part-no. 101005), the cable is installed as follows:
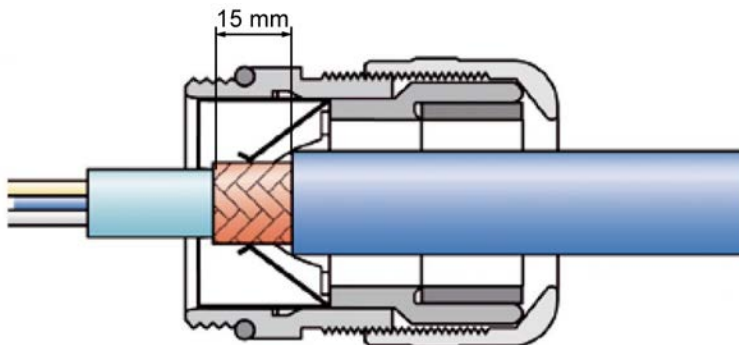
1. Strip cable sheath and shield
2. Cut the sheath around at about 15 mm but do not strip
3. Pass the cable through the gland
4. Strip the cable sheath
5. Pull the cable back until the shield gets contact to the spring
6. Close the cap nut and tighten with 12 Nm

6.15.1 [X01] Terminal L1 / L2 / L3 / PE mains connection - Mains transmission

⚠ **DANGER**
Danger to life from touching electrical connections!
Electrical terminals and connectors carry voltages that may cause death or serious injury upon contact.
When the LEDs on the front panels are OFF, this does not indicate that the electrical terminals have been de-energized.
Steps to prevent:
• Prior to any work on the device: Observe the 5 safety rules.
• Measure the terminal voltages. There may be no voltage present.
• Plug and pull connections only when there is no voltage.

Description:

See 'Layout of the iC mains connection' on page 38.

Technical data:

See 'iC' on page 23.

Design:

Type	Pole	Sort	Manufacturer	Designation
Terminal with tension spring connection	9		WAGO	745

Actuating tool: Screwdriver with a blade 3.5 x 0.5 mm

The cable is attached to the housing: Cable gland M25 x 1.5

Assignment:

Drawing [X01] of the front view of the device side	Connection	Signal	Direction	Description
See 'Terminal box (iC)' on page 57.	1	L1	E	Mains phase L1
	2	L1	A	Mains phase L1 transmission
	3	L2	E	Mains phase L2
	4	L2	A	Mains phase L2 transmission
	5	L3	E	Mains phase L3
	6	L3	A	Mains phase L3 transmission
	7	PE	E	Protective earth
	8	PE	I/O	Protective earth
	9	PE	I/O	Protective earth

Connection:

Cable	$4 \times 1.5 \ mm^2$ / AWG 16 (individual unit without transmission)
	$4 \times 2.5 \ mm^2$ / AWG 14 (device with transmission)
Max. conductor cross-section of the terminal	Flexible cable with a wire end sleeve with plastic collar $2.5 \ mm^2$
Stripped length	11 - 12 mm
Shield connection	-

6.15.2 [X02] Terminal UZP / UZN transmission

⚠ **DANGER**

	Danger to life from electric shock!
⚡ 5 min	LED displays on the front, when indicating OFF, do not mean that the device terminals are voltage-free.
	After switching off the mains, the buffer capacitors for the DC bus can still have a charge and lead to a life-threatening DC voltage.
	Steps to prevent:
	• Prior to all work on the device, the power supply is to be separated from the main switch and secured against restarting.
	• After switching off, expect a discharge time of at least 5 minutes.
	• Measure the voltage in the DC bus between the UZP / UZN terminals to ensure that the terminals are voltage-free.

<table>
<tr><td colspan="2" align="center">⚠ DANGER</td></tr>
</table>

⚠ (symbol)	**Danger to life from touching electrical connections!** The permanent magnets of the rotor induce dangerous voltage at the motor connections when the axis rotates, even when the motor is not electrically connected. If the motor is connected to an inverter, the induced DC voltage is linked to the terminals UZP and UZN for the DC bus. **Steps to prevent:** ● Make sure that the motor shaft does not rotate. ● Make sure that shock-hazard protection is installed at the motor connections. ● Make sure that the terminals UZP / UZN are free of voltage.

Description:

The DC bus supplies the compact inverter integrated in the iC. With the terminal UZP / UZN, the DC bus can be transmitted to an iX controller.

Technical data:

● Max. cable length of 20 m (from the power supply to the last drive in the strand)

Design:

Type	Pole	Sort	Manufacturer	Designation
Terminal with tension spring connection	2		WAGO	739

Actuating tool: Screwdriver with a blade 2.5 x 0.4 mm

The cable is attached to the housing: Cable gland M25 x 1.5

Assignment:

Drawing [X02] of the front view of the device side	Connection	Signal	Direction	Description
See 'Terminal box (iC)' on page 57.	1	UZN	A	Supply of the DC bus -
	2	UZP	A	Supply of the DC bus +

Connection:

Cable	2 x 2.5 mm^2 / AWG 14, shielded (may not be smaller than the cross-section of the feeder X01)
Max. conductor cross-section of the terminal	Flexible cable with a wire end sleeve without a plastic collar 2.5 mm^2
Stripped length	8 - 9 mm
Shield connection	Apply on both sides See 'Cable glands' on page 90.

6.15.3 [X03] Terminal RBP / RBN External Brake Resistor

<table>
<tr><td colspan="2" align="center">⚠ DANGER</td></tr>
</table>

⚠ (symbol) ⟳ 5 min	**Danger to life from electric shock!** LED displays on the front, when indicating OFF, do not mean that the device terminals are voltage-free. After switching off the mains, the buffer capacitors for the DC bus can still have a charge and lead to a life-threatening DC voltage. **Steps to prevent:** ● Prior to all work on the device, the power supply is to be separated from the main switch and secured against restarting. ● After switching off, expect a discharge time of at least 5 minutes. ● Measure the voltage in the DC bus between the UZP / UZN terminals to ensure that the terminals are voltage-free.

⚠ **DANGER**	
⚠	**Danger to life from touching electrical connections!** The permanent magnets of the rotor induce dangerous voltage at the motor connections when the axis rotates, even when the motor is not electrically connected. If the motor is connected to an inverter, the induced DC voltage is linked to the terminals UZP and UZN for the DC bus. **Steps to prevent:** • Make sure that the motor shaft does not rotate. • Make sure that shock-hazard protection is installed at the motor connections. • Make sure that the terminals UZP / UZN are free of voltage.

NOTICE	
Material Damage!	**Fire hazard!** Brake resistors can burn in the event of an overload. **Steps to prevent:** • Use brake resistors with self-protection

Description:

An externally connected brake resistor converts excess energy into heat.

The controller and brake transistor are integrated in the converter.

Technical data:

Switching threshold on: 800 V DC, off: 780 V DC

Minimum ON duration: 187.5 µs

Minimum OFF duration: 187.5 µs

Design:

Type	Pole	Sort	Manufacturer	Designation
Terminal with tension spring connection	2		WAGO	739

Actuating tool: Screwdriver with a blade 2.5 x 0.4 mm
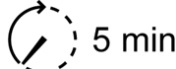
The cable is attached to the housing: Cable gland M25 x 1.5

Assignment:

Drawing [X03] of the front view of the device side	Connection	Signal	Direction	Description
See 'Terminal box (iC)' on page 57.	1	RBP	A	Connection of external brake resistor
	2	RBN	A	Connection of external brake resistor

Connection:

Cable	2 x 1.5 mm^2 / AWG 16, shielded
Max. conductor cross-section of the terminal	Flexible cable with a wire end sleeve with plastic collar: 1.5 mm^2
Stripped length	8 - 9 mm
Shield connection	Apply on both sides

6.15.4 [X08 / X09] 24 V DC supply voltage terminal - Transmission

NOTE	
Material damage!	**Material damage due to overvoltage!** An overvoltage at the connections X08 and X09 (24 V DC) is not monitored and damages the device **Steps to prevent:** ● Comply with the specifications for the electronics supply voltage 24 V DC. (24 V DC ± 15 %, ripple max. 5 %)

Description:

X08: 24 V DC supply voltage supply line for electronics and STO / motor holding brake

X09: 24 V DC supply voltage transmission for electronics and STO / motor holding brake

iC has separate terminals for the 24 V DC electronics supply and the 24 V DC (24B) for STO and the motor holding brake.

The external power supply unit that provides the 24 V DC supply voltage must have a "safe isolation" (PELV) according to EN 50178. The 0 V potential must be connected with PE. The current of the 24V and 24B supply must be limited to 4 A by the user.

A power supply unit is integrated into the iC that supplies the 24 V DC from the DC bus for the electronics supply. The power supply unit is active when the SMD-DIP switch S2 is in the "ON" switch setting (delivery status for devices with an integrated power supply unit.See ' iC' on page 13.) .
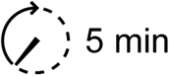
☞ In the following cases, the internal 24 V DC power supply unit must be switched off and the 24 V DC is be supplied externally:
  ● When 24 V DC is transmitted to a device (e.g. iX, iDT5) via the terminal X09
  ● For applications with motor holding brakes with i > 0.5 A
  ● When 24 V DC is supplied externally
  ● Operating with derating at increased ambient temperature (See 'iC' on page 23.

In the event of a failure of the 24 V DC supply to the electronics > 10 ms, the system ready message is internally reset.

Switch off the internal 24 V DC supply voltage from the DC bus with the switch S2

⚠ DANGER	
5 min	**Danger to life from electric shock!** The switch S2 is always on UZN potential and can lead to life-threatening DC voltage. LED displays on the front, when indicating OFF, do not mean that the device terminals are voltage-free. After switching off the mains, the buffer capacitors for the DC bus can still have a charge and lead to life-threatening DC voltage. **Steps to prevent:** ● After switching off, expect a discharge time of at least 5 minutes. ● Measure the voltage in the DC bus between the UZP/UZN terminals to ensure that the terminals and S2 switch are voltage-free.

⚠ DANGER

<table>
<tr>
<td rowspan="4">

⚡ (warning symbol)

</td>
<td>Danger to life from touching electrical connections!</td>
</tr>
<tr>
<td>The permanent magnets of the rotor induce dangerous voltage at the motor connections when the axis rotates, even when the motor is not electrically connected. If the motor is connected to an inverter, the induced DC voltage is linked to the terminals UZP and UZN for the DC bus.</td>
</tr>
<tr>
<td>Steps to prevent:</td>
</tr>
<tr>
<td>

Make sure that the motor shaft does not rotate.
Make sure that shock-hazard protection is installed at the motor connections.
Make sure that the terminals UZP / UZN are free of voltage.

</td>
</tr>
</table>

The S2 switch is located in the iC terminal box below the insulating paper in front of the terminal block. The insulating paper must be lifted carefully to reach the S2 switch.
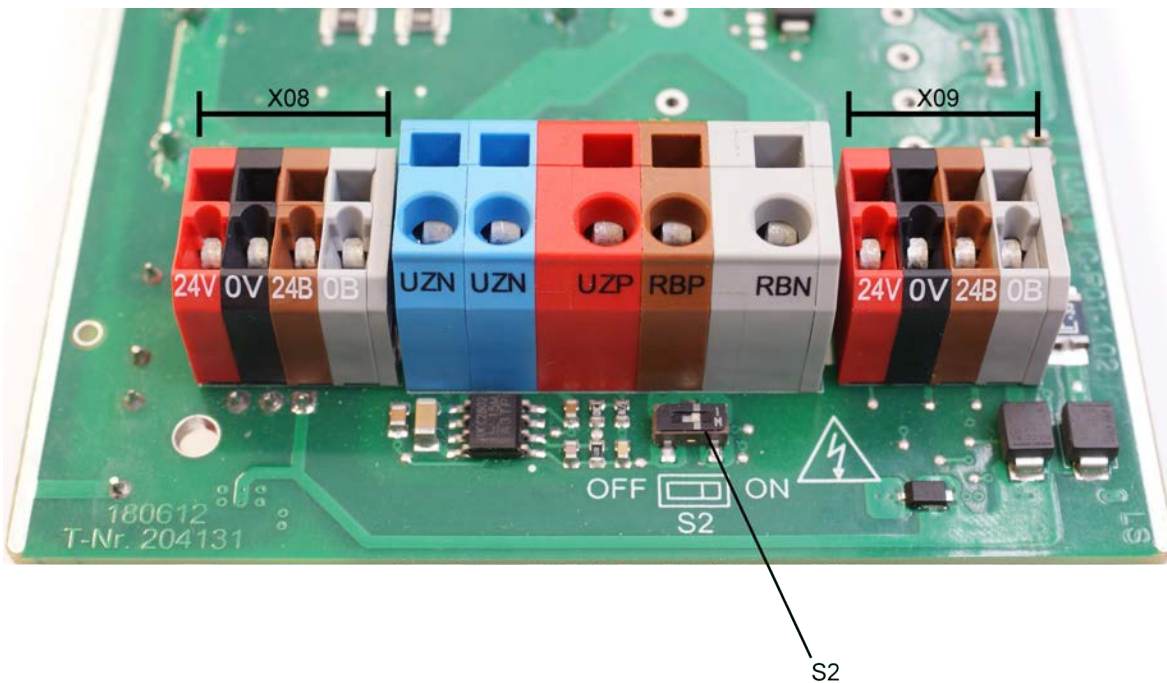
Technical data:

See 'iC' on page 23.

Design:

Type	Pole	Sort	Manufacturer	Designation
Terminal with tension spring connection	4		WAGO	739

Actuating tool: Screwdriver with a blade 2.5 x 0.4 mm

The cable is attached to the housing: Cable gland M25 x 1.5

Assignment:

Drawing [X08 / X09] of the front view of the device side	Connection	Signal	Direction	Description
See 'Terminal box (iC)' on page 57.	1	24V	E	24 V DC supply voltage for electronics
	2	0V	E	Reference potential for 24 V DC for electronics
	3	24B	E	24 V DC supply voltage for STO / motor holding brake | Connection	Signal level	Meaning
---	---	---
C	16 - 24 V DC	STO = OFF, Motor holding brake = can be opened
C	0 - 7 V DC	STO = ON, Motor holding brake = ZU	 The supply voltage directly controls the STO state and at the same time supplies an optional motor holding brake with power. Actuation of the motor holding brake: See 'Procedure for switching on and off ' on page 79. See 'STO (Safe torque off)' on page 40.
	4	0B	E	Reference potential for 24 V / transmission

Connection:

Cable	4 x 0.5 mm^2 / AWG 20
Max. conductor cross-section of the terminal	Flexible cable with a wire end sleeve with plastic collar: 1 mm^2
Stripped length	5 - 6 mm
Shield connection	Apply on both sides See 'Cable glands' on page 90.

7 Startup - operation - maintenance - service

7.1 For your safety

⚠ **DANGER**
Danger to life from touching electrical connections!
Electrical terminals and connectors carry voltages that may cause death or serious injury upon contact.
When the LEDs on the front panels are OFF, this does not indicate that the electrical terminals have been de-energized.
Steps to prevent:
• Prior to any work on the device: Observe the 5 safety rules.
• Measure the terminal voltages. There may be no voltage present.
• Plug and pull connections only when there is no voltage.

⚠ **DANGER**
Danger to life due to unexpected movements!
Drive without torque in the status 'safe torque off', in case of mains failure or in case of faulty drive controller. External application of force on the drive axis may result in life-threatening movements (e.g. hanging axes can fall down).
Steps to prevent:
• Install an external, mechanical brake that prevents a movement.
• Install a counterweight in order to maintain the axis in balance.

⚠ DANGER

	Motor shaft movement!
⚠	Hazardous motor movement occurs when the motor shaft moves in an uncontrolled or unintentional manner.
	Even the intended drive movement may be hazardous, if persons remain inside the machine's range of movement.
	Uncontrolled motor shaft movement occurs when the motor is no longer controllable. Depending on the type of machine, this may have lethal consequences. Possible causes include the following:
	• Faulty wiring, e.g., faulty phase sequence while connecting motor
	• Faulty encoder or components
	• Faulty motor parameters
	• Software error
	• Faulty controlled commutation of the motor
	Unintended motor shaft movement is caused by errors in the motor control. Depending on the type of machine, this may have lethal consequences. Possible causes include the following:
	• Operator errors
	• Controller or application program faults
	• Faulty setpoint specification and scaling
	• Improper operating mode
	The monitoring devices in the drive system are capable of detecting various fault states. Their purpose is to reduce the drive speed to zero in a controlled manner before switching off the power supply. However, the monitoring devices by themselves are not sufficient to completely and reliably prevent uncontrolled movement. Uncontrolled movement cannot be prevented completely, even if it occurs only for a brief period of time before a monitoring device trips and shuts down the drive or switch off power supply.
	Steps to prevent:
	• Never allow personnel to remain in the vicinity of the machine while it is operating.
	• Always ensure that the machine is fully de-energised before commencing work on the machine or within the machine's vicinity.
	• Install an emergency off / stop switch.
	• All suspended axles must be mechanically secured against falling down.
	• Check the limit values for torque, speed, and position, as well as the acceleration and deceleration ramps.
	• Specify the maximum permissible process speed and set ID113 accordingly.

⚠ CAUTION

	Risk of burns when touching hot surfaces!
⚠	The casing temperature, for example of the line filter, the choke or the braking resistance, can be more than 60 degrees Celsius during and even after operation. Contact causes burns.
	Steps to prevent:
	• Make sure that the surfaces have cooled down.
	• Wear protective clothing such as gloves if hot parts need to be touched.
	• Fit a warning shield with warning hot surface.
	• Do not mount any flammable objects near the device.

7.2 Guide to startup

7.2.1 iC

Variant 1: Supply voltage 24 V DC for electronics from an internal power supply unit. STO is not used

See ' iC' on page 13., iCx-xx-xxU.

Bridge required between 24 V DC - 24 B and 0 V DC - 0B. An optional motor holding brake is supplied by the internal power supply unit. See '[X08 / X09] 24 V DC supply voltage terminal - Transmission' on page 62.
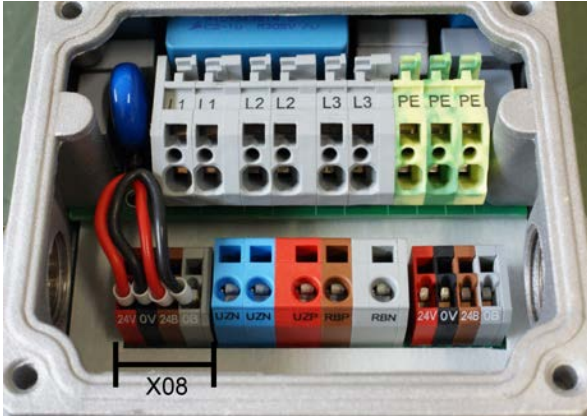
Variant 2: Supply voltage 24 V DC for electronics from an internal power supply unit. STO is used

See ' iC' on page 13., iCx-xx-xxU.

The supply voltage 24 V DC (24B, 0B) for the STO / motor holding brake must be switched externally. See '[X08 / X09] 24 V DC supply voltage terminal - Transmission' on page 62.
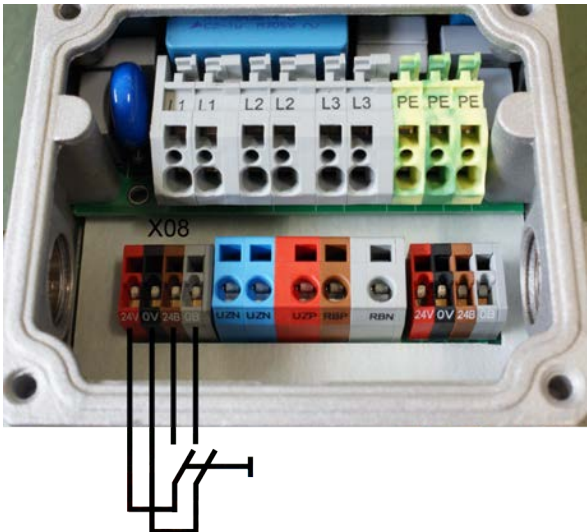
Variant 3: Supply voltage 24 V DC for electronics and (24B, 0B) for STO and motor holding brake is supplied externally

The 3 x 400 V mains voltage is applied independently of the 24 VDC voltages. The S2 switch must be off.

⚠ **DANGER** The switch S2 is always on UZN potential and can lead to life-threatening DC voltage!
See '[X08 / X09] 24 V DC supply voltage terminal - Transmission' on page 62.
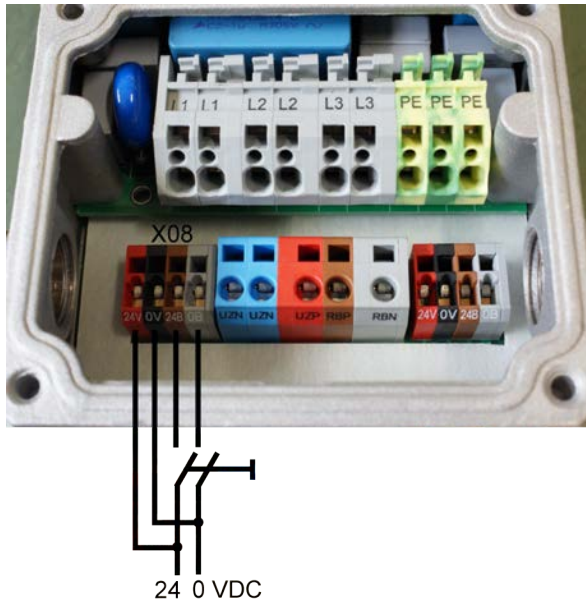
Procedure for all variants

1. Check the installed products for damage. Damaged parts may not be put into operation!
2. Check whether all information in the assembly, project planning and connections chapters were taken into consideration.
3. Check that all interfaces and openings, e.g. iC terminal box, cover of address switch S1 and non-connected interfaces, are properly sealed. Otherwise, the device may not be operated.
4. Ensure that the required ambient conditions are met. (See 'Ambient conditions' on page 23.)
5. For the following startup, observe the information in the Startup chapter. (See 'For your safety' on page 65.)

6. Establish a connection to the PC software AIPEX PRO and parameterisation:

    1. Establish a connection between the device and AIPEX PRO (See 'Parameterisation' on page 70.)
    2. Apply supply voltage(s):
    Variant 1:
    apply 3 x 400 V mains voltage. (See '[X01] Terminal L1 / L2 / L3 / PE mains connection - Mains transmission' on page 58.)
    24 V DC, 24B is supplied to X08 from the internal power supply unit.
    Variant 2:
    apply 3 x 400 V mains voltage. (See '[X01] Terminal L1 / L2 / L3 / PE mains connection - Mains transmission' on page 58.)
    Externally connect 24 V DC supply voltage for STO / motor holding brake.
    24 V DC voltage supply for electronics is provided internally.
    Variant 3:
    Externally provide 24 V DC supply voltage for electronics: The S2 switch must be off.

⚠ **DANGER**	The switch S2 is always on UZN potential and can lead to life threatening DC voltage! See '[X08 / X09] 24 V DC supply voltage terminal - Transmission' on page 62.

    24 V DC supply voltage for the STO / motor holding brake is to be supplied and connected externally.

    3. Carry out basic parameterisation (See 'Basic parameterisation' on page 75.)
    4. Perform system booting
    Variant 1 and **Variant 2:** 3 x 400 V mains voltage off / on
    Variant 3: 24 V DC for electronics supply off / on
    5. Triggering of the motor holding brake and brake test for motors with a motor holding brake

⚠ **DANGER**	Danger to life when opening the brake! Life-threatening movements may occur when external force is applied to the drive axis. Suspended axes can fall. See 'Motor holding brake' on page 74.

    See 'Procedure for switching on and off' sub-chapter 'Triggering the motor holding brake with AIPEX PRO' starting on page 1

7. Procedure for switching on and off: See 'Procedure for switching on and off ' on page 79.
8. Only operate the devices within the specified characteristics.

7.2.2 iX / i3X / iDT5

1. Check the installed products for damage. Damaged parts may not be put into operation!
2. Check whether all information in the assembly, project planning and connections chapters were taken into consideration.
3. Check that all interfaces and openings, e.g. cover of address switch S1 and non-connected interfaces, are properly sealed. Otherwise, the device may not be operated.
4. Ensure that the required ambient conditions are met. (See 'Ambient conditions' on page 23.)
5. For the following startup, observe the information in the Startup chapter. (See 'For your safety' on page 65.)
6. Establish a connection to the PC software AIPEX PRO and parameterisation:

    1. Establish a connection between the device and AIPEX PRO (See 'Parameterisation' on page 70.)
    2. Apply 24 V DC supply voltage for electronics: (See '[X1A] Power supply' on page 46.)
    3. Carry out basic parameterisation (See 'Basic parameterisation' on page 75.)
    4. System booting by 24 V DC on / off
    5. Apply 24 VDC (24B, 0B) system voltage for STO and motor holding brake (See '[X1A] Power supply' on page 46.)
    6. Triggering of the motor holding brake and brake test for motors with a motor holding brake

⚠ **DANGER**	Danger to life when opening the brake! Life-threatening movements may occur when external force is applied to the drive axis. Suspended axes can fall. See 'Motor holding brake' on page 74.

    See 'Procedure for switching on and off ' on page 79.

7. Procedure for switching on and off: See 'Procedure for switching on and off ' on page 79.
8. Only operate the devices within the specified characteristics. See 'iDT5' on page 27.

7.3 Parameterisation

⚠ WARNING
Hazard due to changing parameters!
The incorrect entering of parameters into the controller card significantly influences the drive system characteristics and creates an increased risk of accidents and damages!
Steps to prevent:
• Parameters may not be modified by the machine operator unless consultation takes place with the machine manufacturer.
• Change parameters only if you are sure of the meanings and the consequences. If you are unsure, read the parameter documentation or ask the manufacturer or supplier.

☞ For the parameterisation, it suffices to supply the device with 24 V DC electronic voltage. After parameter changes in the device, a system booting (24 V DC on / off) must be performed in order for the changes to take effect.

With the AMK PC software AIPEX PRO (from version 1.08 with service pack SP04), you can adjust and optimise all of the device parameters specific to the application.

☞ **Attention for iDT5 off-line projects with AIPEX PRO:**
With the adoption of an iDT5 from the hardware configuration in the project, the motor data is not automatically transferred from the motor database to the parameters. In order to adopt the motor data from the database in the parameters, the motor must also be selected in the motor database.

☞ All supported device parameters are described in the documentation PDK_203704_Parameter_KW-R06_iX_A5_KE_de/en.
Functions are specified in the description PDK_203878_AMKASYN_Functions_de/en.

7.3.1 Point to point connection for devices with an EtherCAT interface

PC Ethernet interface --> X85 EtherCAT input
(accessories: See 'Cables for EtherCAT connector [X85] and [X86]' on page 89.)

supply elektronic with 24 VDC
X1A.A = 24 VDC
X1A.B = 0 VDC

iDT5

M12 maleX85

RJ45

PC cable
AMK part-no.:
203502 (2 m)
204265 (5 m)
203974 (10 m)

RJ45 at the PC

supply elektronic with 24 VDC
X1A.A = 24 VDC
X1A.B = 0 VDC

iX

M12 maleX85

RJ45

iC
supply elektronic with 24 VDC must be available!

M12 male X85

RJ45

Setting in AIPEX PRO:

AIPEX PRO menu **'Extras' -> 'Options' -> 'PC Communication'**

Options

Base Settings | PC Communication | Configuration create | Data Update

Ethernet, COM-Ports...   Monitor...

TCP Communication...

CANClient

☐ active

EtherCAT

☑ active

Adapter   Broadcom NetXtreme Gigabit Ethernet ▾

SERCOS III

☐ active

OK   Abbrechen   Übernehmen
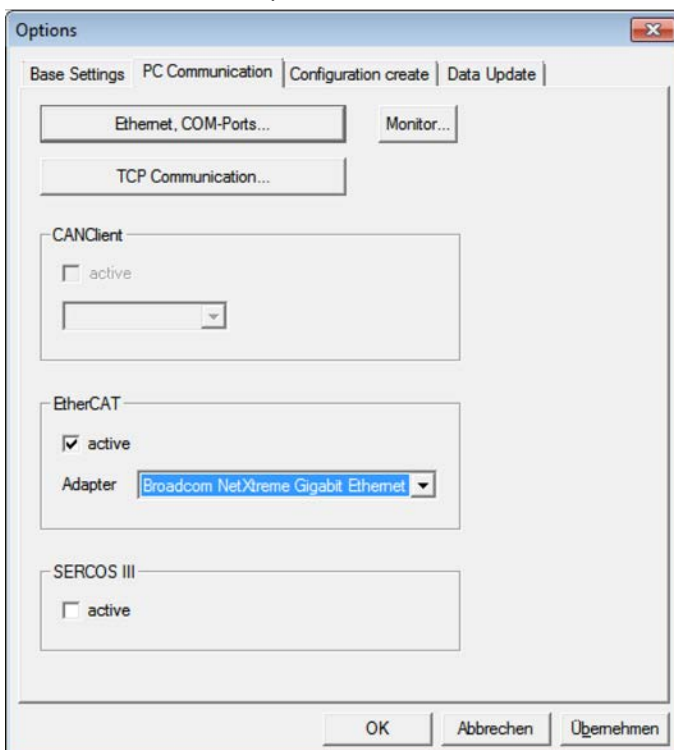
7.3.2 Connection between PC and an EtherCAT controller (with connected iX, iC, iDT network)

A PC Ethernet interface must be connected with the Ethernet input of the controller or be connected to the same network. (See documentation PDK_202975_A4-A5_Product_Description_de/en).

If several devices are linked via EtherCAT and connected to a controller, AIPEX PRO can access all of the devices connected to the bus via the controller. The controller must be configured as an EtherCAT master.

Beckhoff TwinCAT controller: See PDK_204072_AIPEXPRO_AddIn_TwinCAT_Gateway_de/en.pdf. See 'PC software and converter' on page 88.

7.3.3 Connection between PC and devices with a CAN bus interface

The shown connection between the PC and CAN bus participant can be established as a point to point connection to individual devices or as a connection to a CAN bus device connection. In the device connection, AIPEX PRO has access to all of the participants connected to the CAN bus. The connection with AIPEX PRO also works when a CAN bus controller is connected in parallel to AIPEX PRO.
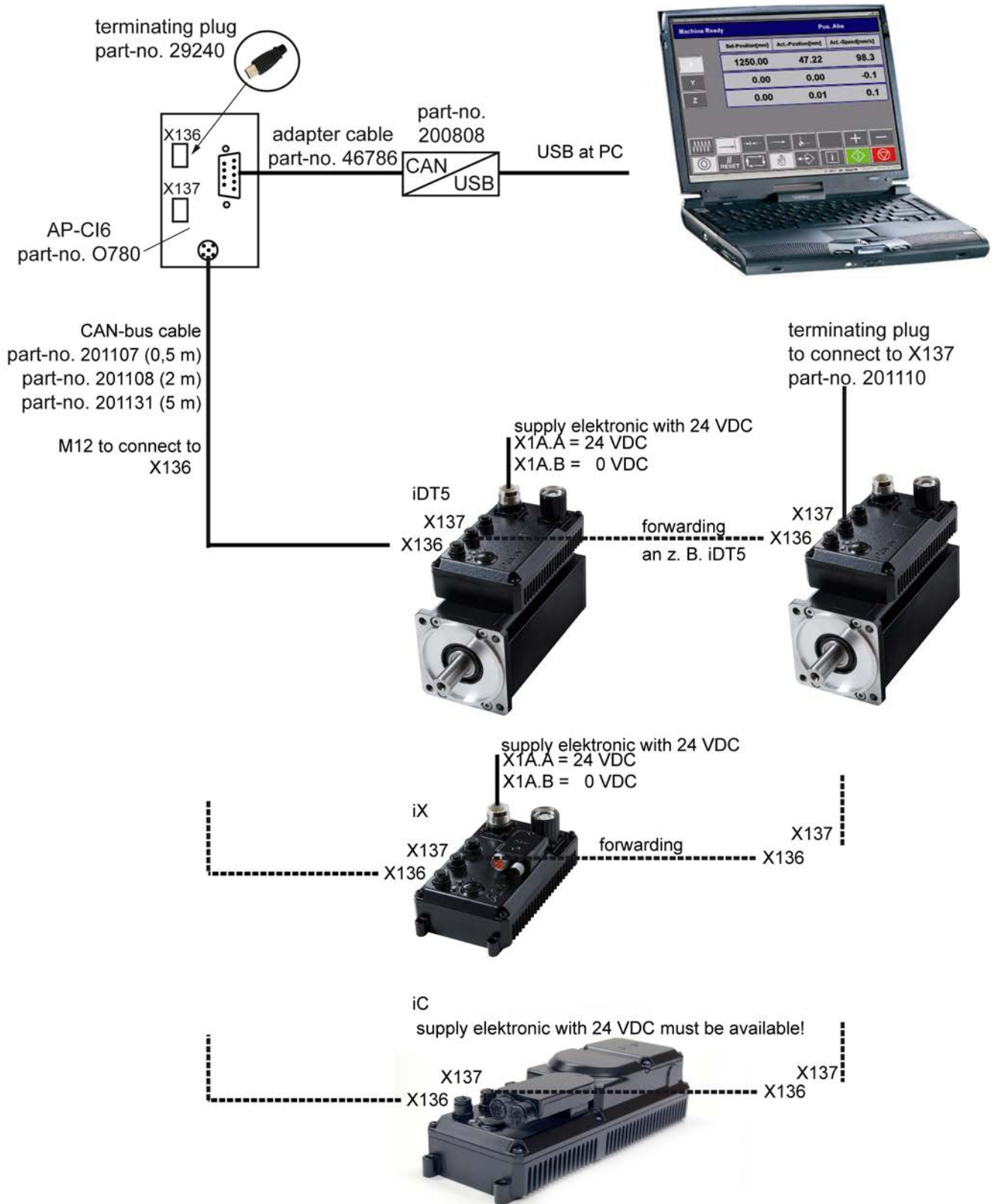
Setting in AIPEX PRO:

Menu **'Extras'** -> **'Option'** -> **'PC communication'** - activate the **'CANClient'** there, enter the baud rate as in the CAN slave participant, see ID34024 'BUS transmit rate'

7.3.4 Connection between PC and devices with a SERCOS III interface

Ports and connection as with EtherCAT. SERCOS III devices have an IP access. The IP address is permanently set to 192.168.0.x.

Setting in the PC (LAN properties)

Eigenschaften von Internetprotokoll Version 4 (TCP/IPv4)

Allgemein

IP-Einstellungen können automatisch zugewiesen werden, wenn das Netzwerk diese Funktion unterstützt. Wenden Sie sich andernfalls an den Netzwerkadministrator, um die geeigneten IP-Einstellungen zu beziehen.

○ IP-Adresse automatisch beziehen

⦿ Folgende IP-Adresse verwenden:

IP-Adresse: 192 . 168 . 0 .

Subnetzmaske: 255 . 255 . 255 . 0

Standardgateway: .   .

○ DNS-Serveradresse automatisch beziehen

⦿ Folgende DNS-Serveradressen verwenden:

Bevorzugter DNS-Server: .   .

Alternativer DNS-Server: .   .

☐ Einstellungen beim Beenden überprüfen

Erweitert...

OK   Abbrechen

Enter a number between 0..255, which is not used as node number in the SERCOS III network.

Setting in AIPEX PRO:

Menu **'Extras'** -> **'Option'** -> **'PC communication'** - activate **'SERCOS III'** there. The connection with AIPEX PRO also works when a SERCOS III controller is connected in parallel to AIPEX PRO.

7.3.5 Motor holding brake

⚠ DANGER	
⚠	**Risk of injury from suspended axes** The optional motor brake is a holding brake and does NOT provide sufficient protection for persons. During startup, while testing the motor brake, suspended axes can fall and lead to severe injury. **Steps to prevent:** ● All suspended axes must be mechanically secured against falling with a fall arrester or a supplementary external brake, for instance.

There must be the 24 V DC STO / holding brake supply voltage to control the motor holding brake:

iX / iDT5: See '[X1A] Power supply' on page 46.

iC: See '[X08 / X09] 24 V DC supply voltage terminal - Transmission' on page 62.

The optional motor holding brake is only actuated correctly if the following parameters are correctly set:

ID206 'Drive on delay time'

ID207 'Drive off delay time'

ID34165 'Holding torque brake'

ID34236 'Time motor brake on'

ID34237 'Pulse duty factor motor brake'

For motors with E, F, P, Q, S, T, U and V encoders, the ID34165 'Holding torque brake' is stored in the motor encoder database and is read from the encoder when switching on an initially loaded system. The motor holding brake is actuated in ID34236 'Time motor brake on' and ID34237 'Pulse duty factor motor brake'. ID206 and ID207 must be manually entered by the customer.

☞ **I encoders do not have a motor encoder database. All parameters must be entered manually.**

7.3.6 Basic parameterisation

The parameter memory for the drive controller is pre-allocated with a default set. The identification numbers must be configured specific to the application.

Parameters for the basic startup:

Parameter	Name	Meaning
ID32800	'AMK main operation mode'	Set operating mode and setpoint source
ID32796	'Source RF'	
Motor parameter group:	Motor / encoder data	Motor parameter, motor encoder resolution,...
ID82	'Positive torque limit'	Torque parameter (torque limits)
ID83	'Negative torque limit'	
ID38	'Positive velocity limit'	Speed / velocity parameter
ID39	'Negative velocity limit'	
ID100	'Speed control proportional gain'	Speed controller setting
ID101	'Integral-action time speed control'	
ID102	'Differentiating time speed control TD'	
ID104	'Position loop factor'	Position controller setting
ID113	'Maximum speed'	ID113 defines the maximum permissible process speed! If the actual value exceeds the specified value in ID113 by a factor of 1.25, then the output stage is blocked by the system and the motor runs down.
ID32773	'Service bits'	Bit 14 = 1, in order to switch on the I^2t-monitoring for the motor
ID32780	'Acceleration ramp'	Acceleration and deceleration times in the speed controller operating mode.
ID32781	'Deceleration ramp'	
ID32782	'Deceleration ramp RF inactive'	Drive braking time from the maximum permissible process velocity (ID113) until coming to a stop when removing the controller enable RF, e.g. in EMERGENCY OFF
ID2	'SERCOS cycle time'	Bus cycle time
ID34023ff ...	'BUS address participant'	The group of the communication parameters from ID34023 are to be parameterised in the respective instances: EtherCAT: Instance 1

7.3.7 Startup of a Hall encoder

From firmware version 1.03 2013/18 (AMK part-no. 204515) on, Hall encoders of linear motors are supported. The signals of the Hall encoder are read via sine encoder input.

ID32953 'Encoder type' must set to 0x00+**1**.

The commutation offset is detected by ID32843 'Service command':
Before the controller enable signal (RF) is set for the very first time, ID32843 = 0xEDA6 must be set. When RF = 1, the linear motor will align according to the software commutation. The detected commutation offset will be written to ID32959 'Offset resolver'.

This procedure has to be done only once. For linear motors identical in construction, you can write the commutation offset directly to ID32959 of the other drives.

For further information about the parameters:
See document Parameter description, AMK part-no. 203704.

7.4 Addressing bus participants

Within a machine, the parent PLC controller acts as field bus master. The subordinated drives are slaves.

The addressing of the drives can either be done automatically by the master, or the address can be set by DIP switch or by parameter.

Without a valid bus participant address, the bus master cannot establish any communication with the slaves.

| Device | Fieldbus | Addressing possible via | | | Range of values |
		Bus master (automatic)	Address switch S1	Parameter	
iC / iX / iDT	EtherCAT Slave	■	■	ID34023 Instance 1	$1 \leq \text{ID34023} \leq 65535$ $1 \leq \text{S1} \leq 63$
	VARAN Slave	-	-	-	The VARAN master assigns addresses to the slaves. No address specification is possible on the slave.
	SERCOS III	-	■	-	$1 \leq \text{S1} \leq 63$ The set address (X) is adopted in the IP address: 192.168.0.X
	CAN (DS402)	-	■*)	ID34023 Instance 0	$1 \leq \text{ID34023} \leq 65535$ $1 \leq \text{S1*)} \leq 63$ *) If all DIP switches correspond to the value 0, the participant address 2 is active!
	FSoE	■	■	ID33201	$1 \leq \text{ID33201} \leq 65535$ $1 \leq \text{S1} \leq 63$

7.4.1 EtherCAT: Automatic addressing

On delivery ex works AMK of the controller, the DIP switch S1 as well as the parameter ID34023 'BUS address participant' are set to 0 in all instances.
In this case the master will assign an address automatically to each fieldbus participant in order to start communication between master and slaves.

☞ Within the PLC, the controllers are identified by their addresses.

If you change the system configuration, e.g. adding, changing, removing drives, the EtherCAT master sets new addresses to the drives. So the PLC will access to the wrong device.

Therefore, a permanently automatic addressing is **not recommended**.

The drive address should be set by DIP switch S1 or by Parameter ID34023

7.4.2 VARAN: Automatic addressing

In VARAN bus protocol, no address presetting is possible. The VARAN master will address the coupled slaves automatically.

7.4.3 EtherCAT and FSoE: Addressing by DIP switch S1

NOTICE	
Material Damage!	Ensure that no objects fall into the housing when working on the open housing. Foreign objects can cause short-circuits during operation and thereby destroy the device.

By means of the DIP switch, the EtherCAT and FSoE address of the controller will be set **simultaneously**.

☞ The address setting by DIP switch is prior to addresses via parameters ID34023 'BUS address participant' or ID33201 'Safety address'.
The same value, set in the DIP switch will be written to the parameters ID34023 and ID33201.

— bit 7 / 8 reserved
— most significant bit (MSB)
— least significant bit (LSB)
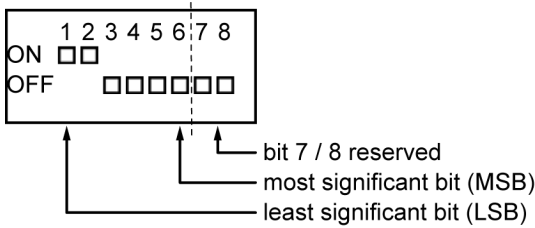
Example: Address = 3

☞ Bits 7 and 8 are reserved and must be set to OFF resp. 0.

☞ If you change a fieldbus participant which is addressed by DIP switch, make sure that the address is set correctly to the new device.

Consequence of addressing

DIP switch	Parameter ID34023	Parameter ID33201	Active address EtherCAT	Active address FSoE
= 0	= 0	= 0	automatically set by master	no communication possible
= 0	= 0	≠ 0		ID33201
= 0	≠ 0	= 0	ID34023	no communication possible
= 0	≠ 0	≠ 0		ID33201
≠ 0	= 0	= 0	DIP switch	DIP switch
≠ 0	= 0	≠ 0		
≠ 0	≠ 0	= 0	DIP switch	DIP switch
≠ 0	≠ 0	≠ 0		

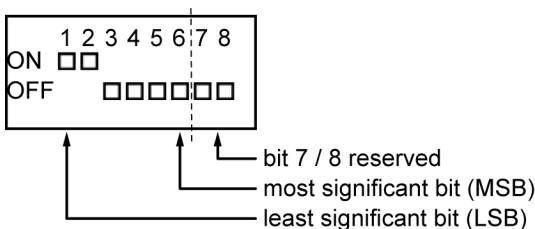## 7.4.4 SERCOS III: Addressing by DIP switch S1

NOTICE	
Material Damage!	Ensure that no objects fall into the housing when working on the open housing. Foreign objects can cause short-circuits during operation and thereby destroy the device.

— bit 7 / 8 reserved
— most significant bit (MSB)
— least significant bit (LSB)

Example: Address = 3

The set address (X) is adopted in the IP address: 192.168.0.X

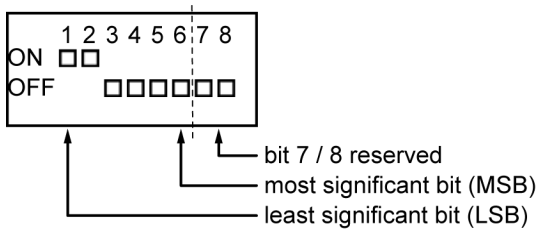☞ Bits 7 and 8 are reserved and must be set to OFF resp. 0.

☞ If you change a fieldbus participant which is addressed by DIP switch, make sure that the address is set correctly to the new device.

7.4.5 CAN (DS402): Addressing by DIP switch S1

NOTICE	
Material Damage!	Ensure that no objects fall into the housing when working on the open housing. Foreign objects can cause short-circuits during operation and thereby destroy the device.

bit 7 / 8 reserved
most significant bit (MSB)
least significant bit (LSB)

Example: Address = 3

If the dip switch is set to 0, bus participant address 2 is automatically active.

☞ Bits 7 and 8 are reserved and must be set to OFF resp. 0.

☞ If you change a fieldbus participant which is addressed by DIP switch, make sure that the address is set correctly to the new device.

7.4.6 EtherCAT: Addressing by parameter ID34023 'BUS address participant'

If the DIP switch S1 is set to 0, the address can be set by parameter ID34023.
The setting of the parameter can be done by means of software AIPEX PRO via the EtherCAT master without connecting point-to-point to each single device.
(See document Software description AIPEX PRO (AMK part-no. 202234): EtherCAT Addressing.)
The address can also be set by a PLC, e.g. by means of AFL function blocks.

7.4.7 FSoE: Addressing by parameter ID33201 'Safety address'

☞ On delivery ex works AMK of the controller, the DIP switch S1 as well as the parameter ID33201 'Safety address' are set to 0. If neither the DIP switch nor the 'Safety address' are set ≠ 0, the FSoE master cannot start communication.

The parameter ID33201 'Safety address' is only valid for FSoE communication. It is not instanced and has to be set only once, independent of the fieldbus system.

☞ During firmware update or initial program loading, the address parameter ID332201 will be reset to 0.

7.4.8 CAN (DS402): Addressing by parameter ID34023 'BUS address participant'

If the DIP switch S1 is set to 0, the address can be set by parameter ID34023.
The setting of the parameter can be done by means of software AIPEX PRO via the CAN master without connecting point-to-point to each single device.

(See document Software description AIPEX PRO, AMK part-no. 202234: EtherCAT Addressing.)

The address can also be set by a PLC, e.g. by means of AFL function blocks.

7.5 Procedure for switching on and off

7.5.1 iC
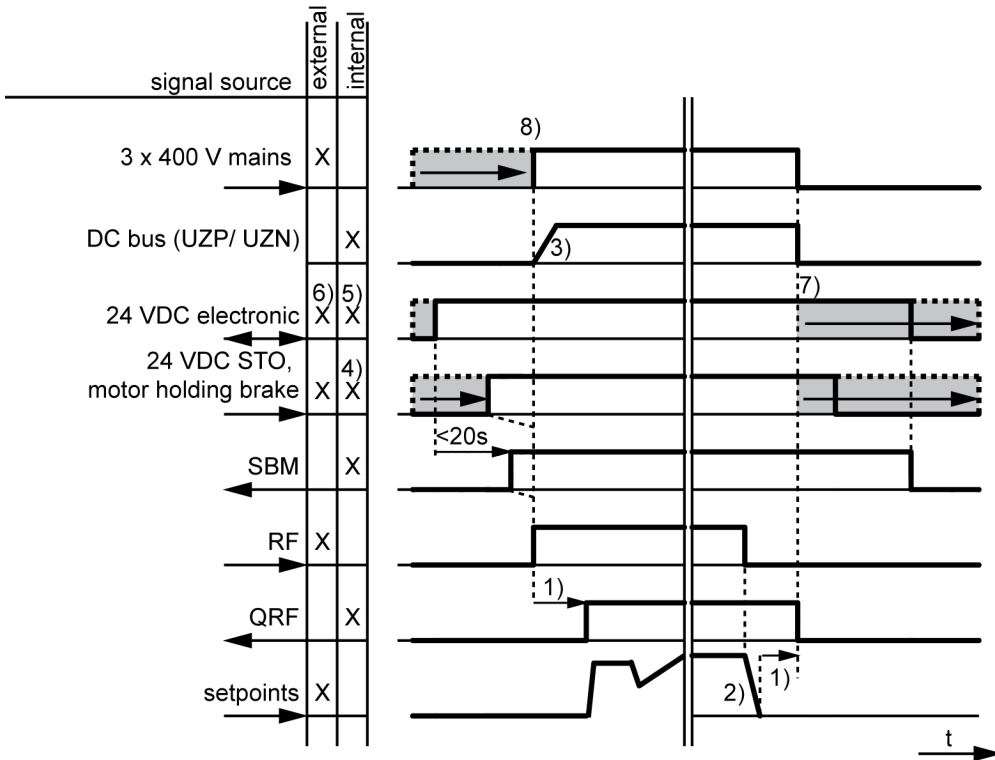
1) depending on the motor type and on the control of the motor holding brake
2) deceleration ramp: ID32782 Deceleration ramp RF inactive
3) charge time after mains on < 50 ms
4) stud between terminal 24V-24B, 0V-0B necessary
5) after mains on - the internal 24 VDC supply is available < 3 s
6) the 24 VDC can be switched on external and undepending of the mains voltage
7) if the internal power supply is aktiv, the 24 VDC will be buffered load depending up to > 50 ms
8) maximal 1 switching on per minute is allowed

7.5.2 iX / i3X / iDT5 / iDP7

1) depending on the motor type and on the control of the motor holding brake
2) deceleration ramp: ID32782 Deceleration ramp RF inactive
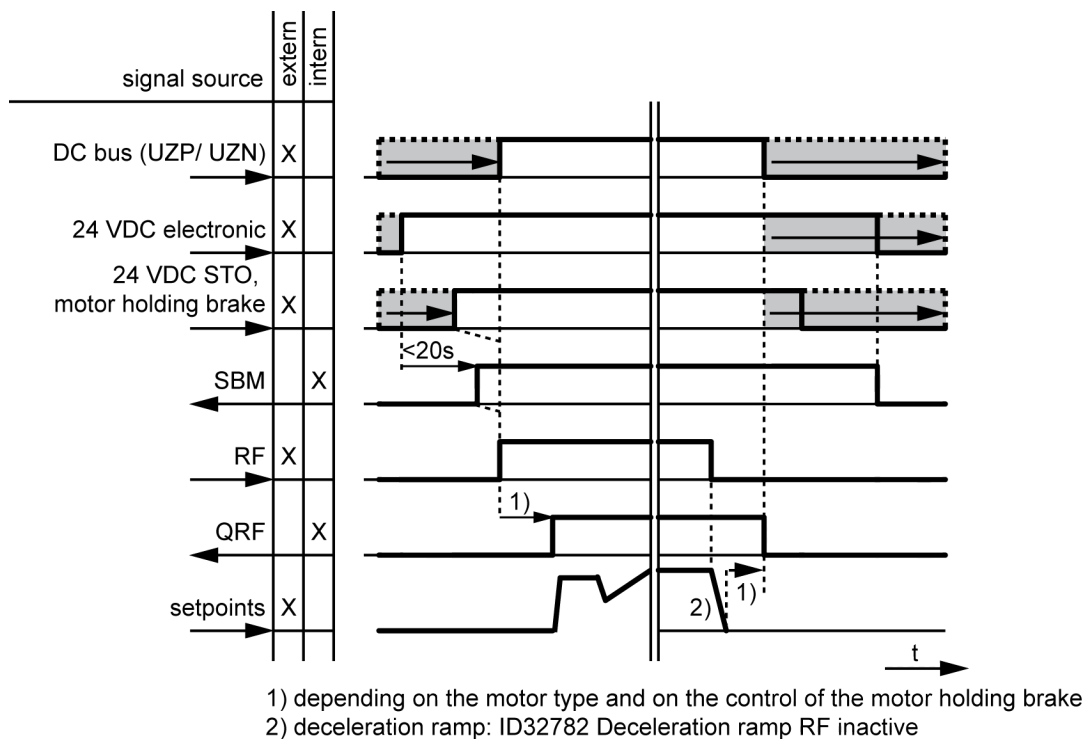
7.5.3 Control of the motor holding brake

NOTE	
Material damage!	**Driving operation with closed motor holding brake!**
	The drive must not turn if the holding brake is closed, otherwise the holding brake can be damaged. It must be determined on the user side whether the brake has opened properly.
	The devices do not have an open load detection, e.g. for a broken cable.

There must be the 24 V DC STO / holding brake supply voltage to control the motor holding brake:

iX / iDT5: See '[X1A] Power supply' on page 46.

iC: See '[X08 / X09] 24 V DC supply voltage terminal - Transmission' on page 62.

7.5.3.1 For starting up and shutting down
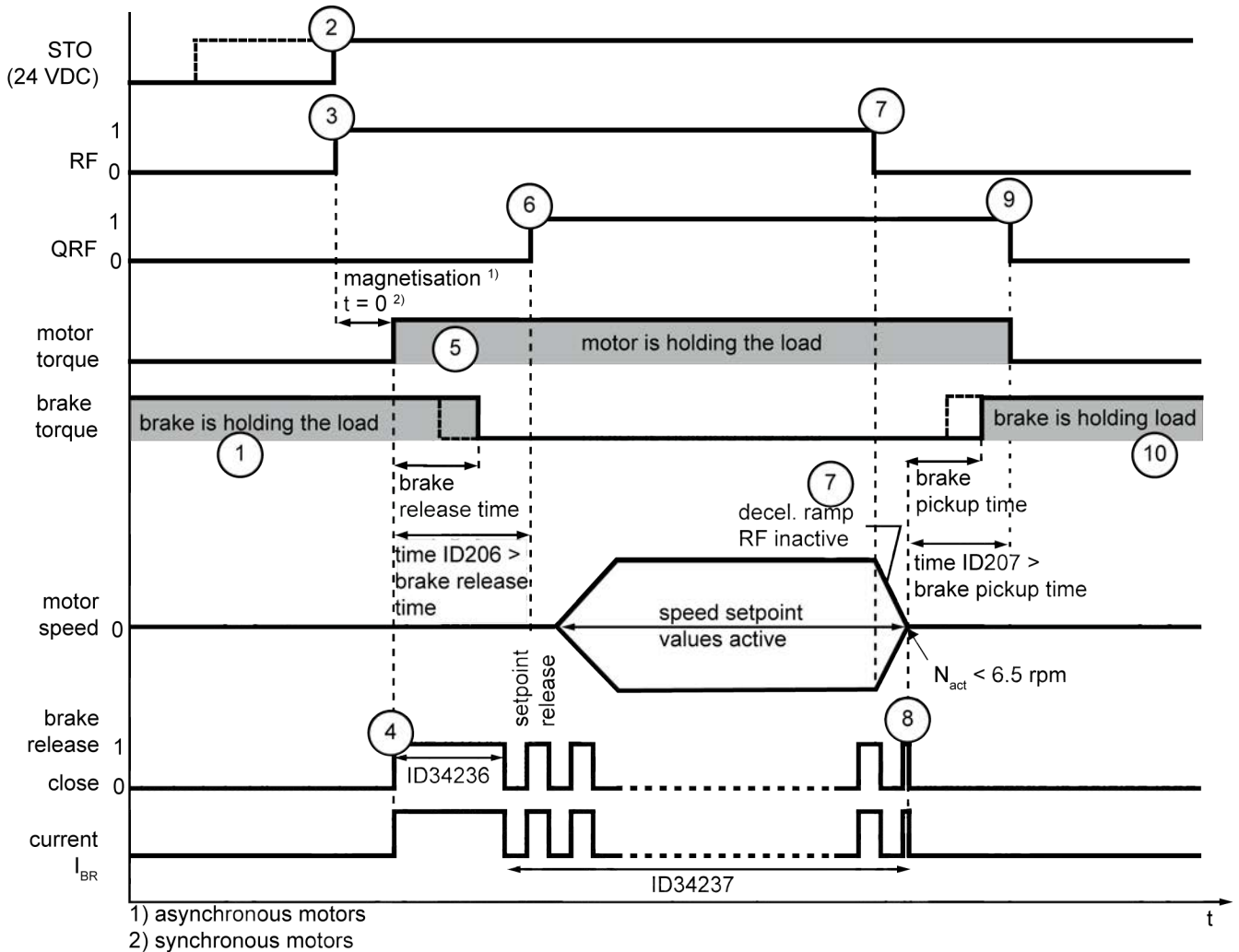
1) asynchronous motors
2) synchronous motors

Brake is released:

1. The motor holding brake is active and holds the load. The motor is free of energy.
2. The control signal of the controller enable is switched on on the application side. The STO input must be supplied with 24 V DC on the user side.
3. The motor coil is energised, the brake is actuated and released. The motor holds the load.
4. The released brake remains released for a clocked controller.
5. The controller enable is acknowledged and setpoints are processed.

Brake is closed:

6. The control signal of the controller enable is switched off on the application side.
7. The drive is automatically braked until coming to a standstill, ID32782 'Deceleration ramp RF inactive' and the brake is actuated.
8. The controller enable acknowledgement is withdrawn and the motor becomes torque-free
9. The motor brake holds the load
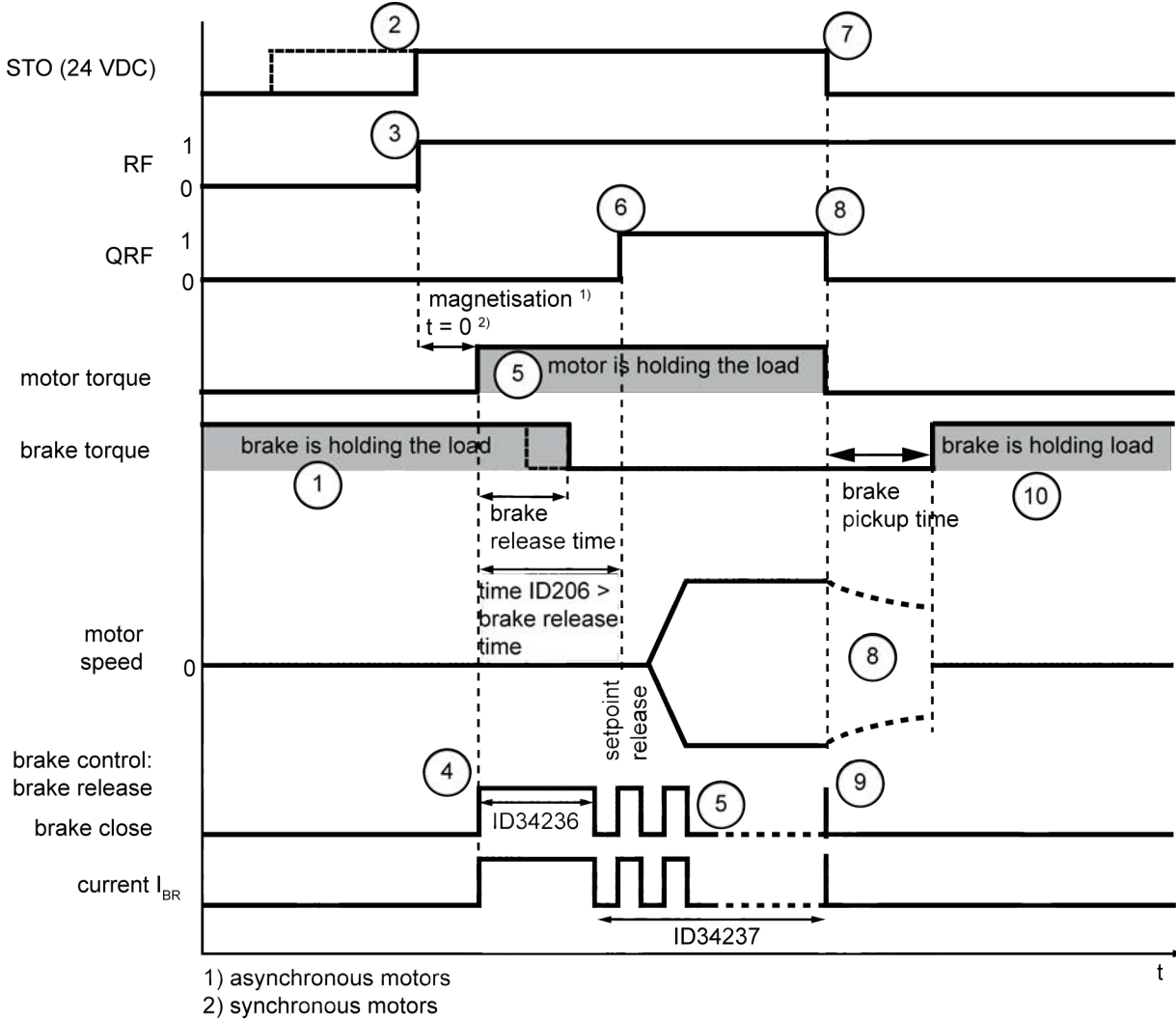
7.5.3.2 For STO

⚠ **DANGER**
Danger to life due to unexpected movements!
Drive without torque in the status 'safe torque off', in case of mains failure or in case of faulty drive controller. External application of force on the drive axis may result in life-threatening movements (e.g. hanging axes can fall down).
Steps to prevent:
● Install an external, mechanical brake that prevents a movement.
● Install a counterweight in order to maintain the axis in balance.

1) asynchronous motors
2) synchronous motors

Brake is released:

1. The motor holding brake is active and holds the load. The motor is free of energy.
2. The STO input must be supplied with 24 V DC on the user side.
3. The control signal of the controller enable is switched on on the application side.
4. The motor coil is energised, the brake is actuated and released.
5. The motor holds the load. The released brake remains released despite the clocked controller.
6. The controller enable is acknowledged and setpoints are processed.

State of STO is requested:

7. The STO input is no longer supplied with 24 V DC on the user side.
8. The controller enable is withdrawn internally and the drive runs down.

9. The motor holding brake is no longer actuated and engages after the response time.

10. The motor brake holds the load after the brake has engaged.

7.5.3.3 With AIPEX PRO

See documentation PDK202234_Software_AIPEXPRO_de/en : 'Direct mode' - 'Special functions' chapter

7.5.3.4 Via parameters

The brake can be actuated manually via parameters:
ID32843 'Service command' = 0x30: Motor holding brake is opened
ID32843 'Service command' = 0x31: Motor holding brake is closed

7.6 Service notes

Diligent regular inspections and maintenance help to detect malfunctions early and remedy them before consequential damage occurs. If malfunctions, unusual loads or conditions occur that might negatively affect the drive system, e.g. overload, short circuit or mechanical damage, the components of the drive system have to be checked immediately.

The intervals for maintenance tasks are very dependent on the local conditions at the location where the drive system is in use, e.g. dirt, load, how frequently it is switched on, etc.

Valid for all device types:

- Regularly check connectors and connection cables for damage, and replace if required. Do not make provisional repairs to the connection lines. If any damage is visible on the sheathing, no matter how small, immediately shut down the system and renew the cables.
- Defective AMK components must be sent to AMK to be assessed and repaired. The opening of and any modifications to devices by personnel not authorised by AMK is prohibited and will result in the loss of the warranty. In these cases, AMK is not liable for any ensuing damage.

Valid for iC / iX / i3X:

- The devices are maintenance-free.
- If necessary, just clean the surfaces with a duster and a slightly damp cloth with neutral soap. Do not use any spraying agent.

Valid for iDT:

- Excessive dirt, dust or chips can adversely affect the function of the motors and, in extreme cases, even lead to failure. The motor housing is used for heat emission during operation. Insufficient heat emission reduces the bearing life time and can lead to excessive temperature shutdowns. If necessary, only clean the surfaces with compressed air and a slightly damp cloth with neutral soap. Do not use any spraying agent. No moisture may penetrate the motor.
- Motor bearings should be replaced once the nominal bearing life time has been reached (40,000 hours) or when running noise occurs. We recommend having AMK perform the bearing replacement.

- The following table gives a general overview of the maintenance measures and intervals. The measures and the specified intervals have to be adapted to the respective conditions and supplemented as necessary.

Measures	Maintenance interval
Cleaning the surfaces	Directly dependent on the degree of soiling; heavy soiling interferes with the proper heat dissipation of the components.
Visual inspections, e.g. of the housing, cable, connections, leaks	
Exchanging the bearings	If the motor is run with the rated data, we recommend exchanging the bearings after 40,000 operating hours. If the bearing is subjected to axial and radial forces, the service life is reduced as shown by the characteristic curve on the motor data sheet. In vertical installation position, the grease service life stated in the data sheet is reduced by half.
Exchanging the radial shaft seal rings	Parallel to the bearing change, every 40,000 h
Relubrication intervals	You can find a reference value for the relubrication intervals of the axial bearings on the motor/motor data sheet. The relubrication intervals heavily depend on the motion profile actually traversed and the cycle times. The B-side bearing is lubricated for life and needs no maintenance.
Replacing the encoder belt, if applicable	20,000 h
Lubrication change, performed by AMK	If motors were in storage for more than 2 years, we recommend a lubrication change.

Valid for devices with fan:

- Dependent on the degree of pollution of the cooling air, fans and cooling fins must be cleaned regularly by means of compressed air.

7.7 Diagnosis

Using the AIPEX PRO software, warnings and error messages can be read from the connected devices.

AIPEX PRO description: See PDK_202234_Software_AipexPro

Diagnostic messages: See PDK_025786_diagnosis

7.8 Firmware update

NOTICE
Firmware Download Due to download a firmware, application specific parameter settings are overwritten and become invalid! **Steps to prevent:** - BEFORE you download a new firmware, please make really sure that application specific data is saved as backup.

By means of the AMK PC software ATF, the firmware is transmitted to the connected device via the Ethernet interface X85 or CAN interface X136. A firmware update is only possible with a point to point connection between the PC and the device!

☞ The handling the ATF software is described in the Software description ATF - AMK Tool Flasher, AMK part-no. 203771

☞ Prerequisite:
AMK PC software AIPEX PRO (version 1.09 with service pack SP01) can only flash devices with EtherCAT or VARAN.
To flash CAN or SERCOS III devices, a new AIPEX PRO version is required (in process).

7.8.1 Update via Ethernet Schnittstelle X85

1. Establish a point to point connection between your PC and the Ethernet interface X85.
   (See 'Point to point connection for devices with an EtherCAT interface' on page 70.)
   OR
   Establish a connection between your PC and the EtherCAT PLC controller
   (See 'Connection between PC and an EtherCAT controller (with connected iX, iC, iDT network)' on page 72.)

2. Start the AMK Tool Flasher (ATF).

3. Select 'Task' -> 'Add...'
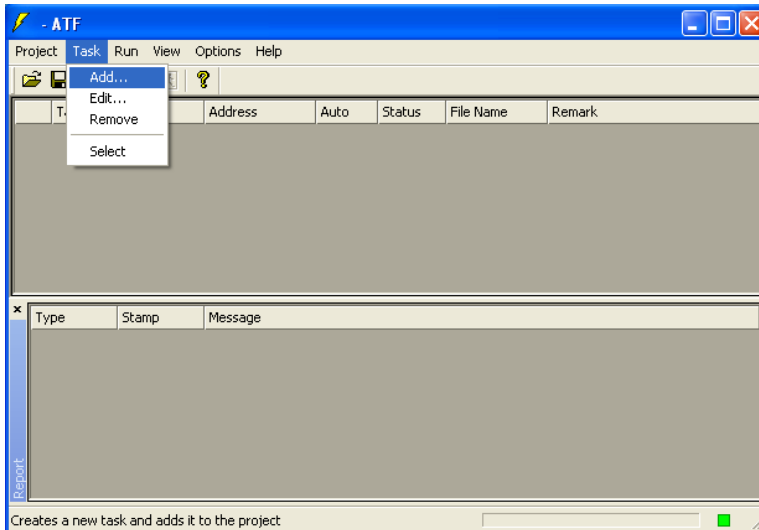
a. Select 'Target' >iX, iDT5, iC<
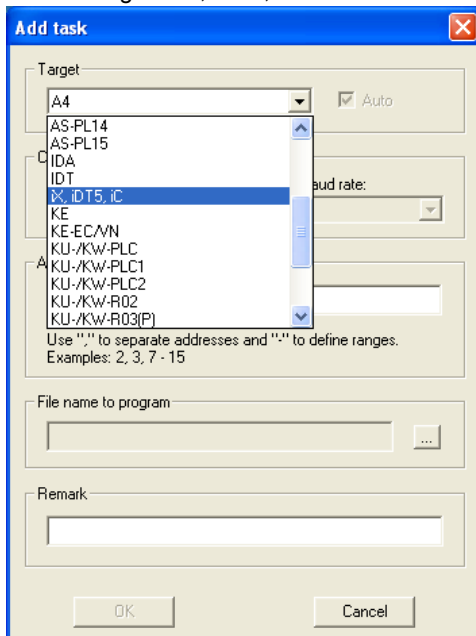
b. Select 'Communication', 'Interface' -> >ETHERCAT<
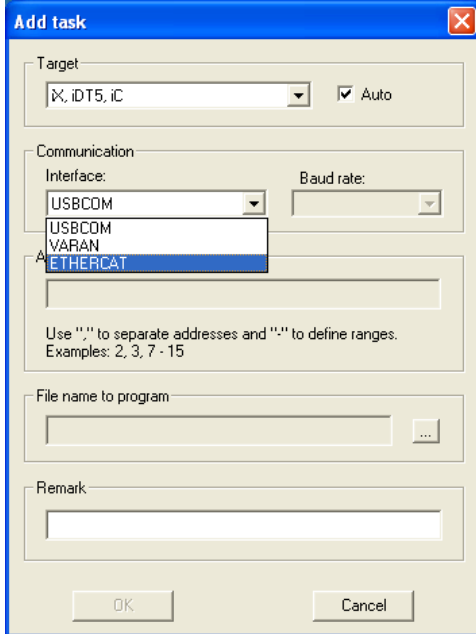
The following message appears:
'Please wait' - 'Scanning for EtherCAT devices'
Subsequently, 'Address / IP Address' shows the addresses of the connected devices.
If you are connected to several devices, all detected addresses are shown. You can select from a list the devices you want to flash.

c. By 'File name to program', you select the firmware version.

NOTICE	
	Non-compatible firmware type will destroy the processor!
	If you select a non-compatible firmware type to update a decentralised drive, the processor will be destroyed. The device must be replaced.
Material Damage!	**Steps to prevent:**
	• Make sure to select the correct firmware type. The designation of the firmware for decentralised drives is **iX_SW**_vvv_yyww_nnnnnn.bin (vvv - version; yyww - year and week; nnnnnn - AMK part-no.) See 'Imprint' on page 2.
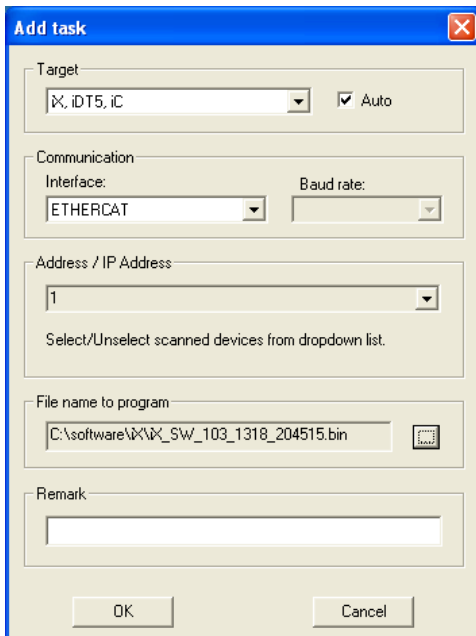
d. Confirm your inputs with **'OK'**.

4. The new-defined task is shown.

The mark ✔ indicates which task is selected for flashing.
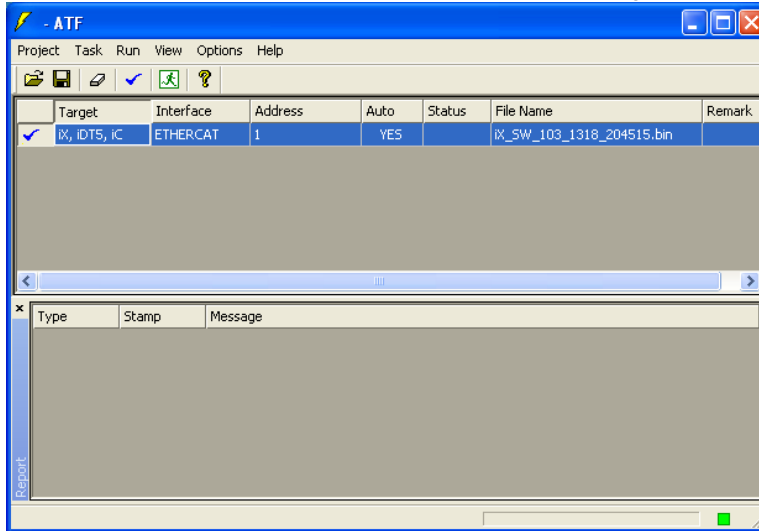
5. By 🏃, the flash task is started.
The progress of the flash process is displayed.

.

6. After the flash process is completed, the device must be switched off and on

.

7. Remove the connections between your PC and the decentralised drive, and re-establish the field bus connection.

8 Accessories

8.1 PC software and converter

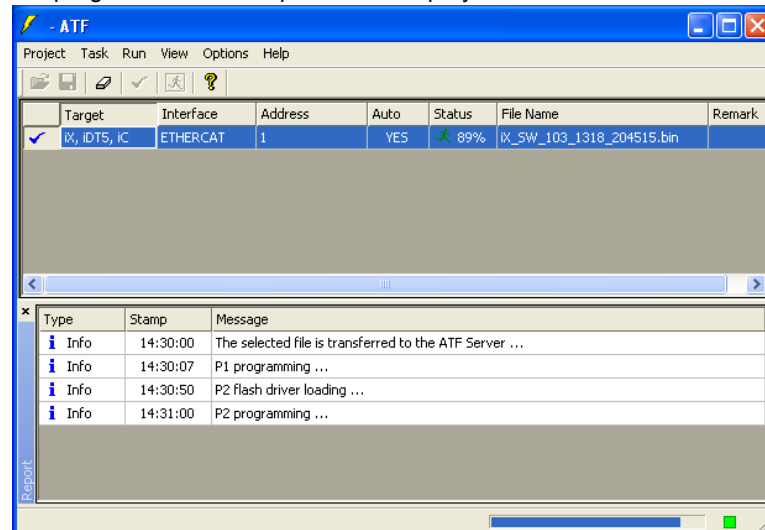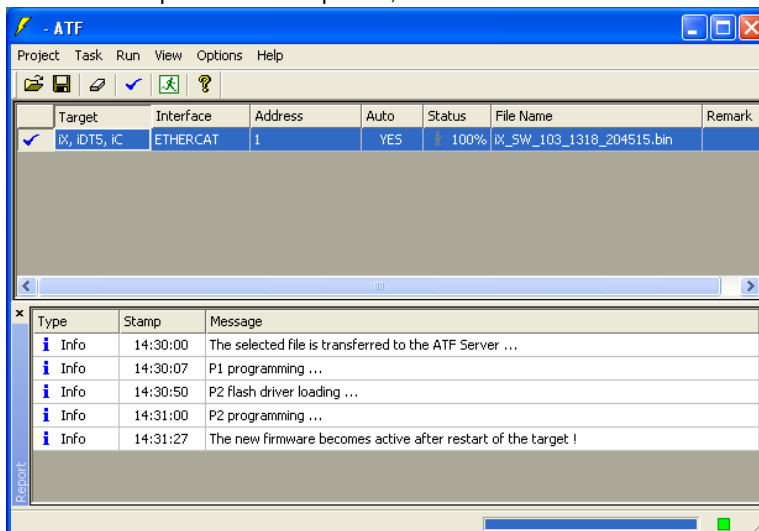| Designation	AMK part no.	Description
CD software AIPEX PRO	O811	CD with PC software AIPEX PRO and ATF
USB / CAN converter	O755	Connection between PC and devices with CAN (DS402) interface
		Consists of:
		1 x AMK part no. 200808 converter USB / CAN
		1 x AMK part no. 46786 adapter cable (2 x Sub-D 9P)
		1 x AMK part no. O780 circuit board AP-CI6 complete
		1 x AMK part no. 201110 bus terminating plug M12
		1 x AMK part no. 29240 bus terminating plug 6P (Fire wire)
		1 x AMK part no. 201108 CAN cable ACC2000 length of 2 m, M12 connector, angled 90°, 1x pin, 1x socket, A-coded
		1 x AMK part no. 29543 cable IEEE 1394 (2 x Fire wire)
AMK PC software AIPEX PRO Add In Gateway for TwinCAT	O878	Software for being able to access AMK drives operated on a TwinCAT controller by using the AMK PC software AIPEX PRO.
Device description file for EtherCAT controller AMK_ECsoe_108_204133.xml	204133	This file is part of the AIPEX PRO software but you can also get it separately from AMK

8.2 Cable for power connection [X1A] and transmission iC to iX / i3X / iDT5 / iDP7

Designation	AMK part no.	Description
Power cable 2.5 mm^2	19376	Length of y m[1]), M23 socket, straight, open cable end

1) The cable is to be ordered under the aforementioned part number in the desired length.

Contact assignment

Pin	Wire
$\perp$	green/yellow
1	1
4	2
3	3
A	white
B	brown
C	green
D	yellow

8.3 Cable for transmitting the connection [X1B]

Designation	AMK part no.	Description
Looping 2.5 mm^2	47390	Length of y m[1]), M23 pin, straight, M23 socket, straight

1) The cable is to be ordered under the aforementioned part number in the desired length.

8.4 Cable for I/O interface [X04]

Designation	AMK part no.	Description
I/O cable EA500	202054	Length of 0.5 m, M12 connector pin angled at 90°, open cable end, 8-pole
I/O cable EA2000	202674	Length of 2 m, M12 connector pin angled at 90°, open cable end, 8-pole
I/O cable EA5000	201731	Length of 5 m, M12 connector pin angled at 90°, open cable end, 8-pole
I/O cable EA10000	202281	Length of 10 m, M12 connector pin angled at 90 °, open cable end, 8-pole

Contact assignment

Pin	Wire colour
1	white
2	brown
3	green
4	yellow
5	grey
6	pink
7	blue
8	red

8.5 Cable for encoder connection [X05]

Designation	AMK part no.	Description
Encoder cable E, F, P, Q, I encoders (Twintus)	47389	Length of 3 m, M12 socket for Twintus design and M23 socket on the motor side for E, F, P, Q, I encoders
Encoder cable S, T, U, V encoder (Twintus)	203992	Length of 3 m, M12 socket for Twintus design and M23 socket on the motor side for S, T, U, V encoders
Encoder cable E, F, P, Q, I encoder (CM3)	403118	Length of y m[1], pin for CM3 design and M23 socket on the motor side for E, F, P, Q, I encoder
Encoder cable S, T, U, V encoder (CM3)	403182	Length of y m[1], pin for CM3 design and M23 socket on the motor side for S, T, U, V encoder

1) The cable is to be ordered under the aforementioned part number in the desired length.

8.6 Cables for the motor connection [X06]

Designation	AMK part no.	Description
Motor cable (Twintus)	47388	Length of 3 m, M16 pin for Twintus design and M23 socket on the motor side
Motor cable (CM3)	403122	Length of y m[1], socket for CM3 design and M23 socket on the motor side

1) The cable is to be ordered under the aforementioned part number in the desired length.

8.7 Cables for EtherCAT connector [X85] and [X86]

Designation	AMK part no.	Description
EtherCAT RJ45 / M12 pin	203502	2 m, 4-pole
EtherCAT RJ45 / M12 pin	204265	5 m, 4-pole
EtherCAT RJ45 / M12 pin	203974	10 m, 4-pole

Designation	AMK part no.	Description
EtherCAT 2 x M12 pin	203503	0.3 m, 4-pole
EtherCAT 2 x M12 pin	203500	1 m, 4-pole
EtherCAT 2 x M12 pin	203501	2 m, 4-pole
EtherCAT 2 x M12 pin	203973	5 m, 4-pole
EtherCAT 2 x M12 pin	204266	10 m, 4-pole

8.8 Cable and terminating plug for CAN BUS connection [X136] and [X137]

Designation	AMK part no.	Description
IDT-ACC500	201107	Length of 0.5 m, M12 connector, angled 90°, 1x pin, 1x socket, A-coded
IDT-ACC2000	201108	Length of 2 m, M12 connector, angled 90°, 1x pin, 1x socket, A-coded
IDT-ACC5000	201131	Length of 5 m, M12 connector, angled 90°, 1x pin, 1x socket, A-coded

Designation	Part no.:	Description
IDT-ACCT	201110	Resistance 2 x 120 ohm, M12 connector pin for X137 connection, straight connector

8.9 Brake resistor

Designation	AMK part no.	Description
AR140	O746	Brake resistor 47 ohm / 140 W

8.10 Cable glands

Designation	AMK part no.	Description
Cable gland M25 x 1.5	100623	Metallic cable gland
Cable gland M25 x 1.5 (EMC)	101005	EMC-compliant cable gland

8.11 Mains choke

Designation	AMK part no.	Description
ALN17	O742	Mains choke 3 x 17 A / 500 V AC

9 Disposal

Clarify with your local waste disposal company which materials and chemicals need to be separated and how to dispose of them. Observe the local regulations for disposal.

Examples of materials to be disposed of separately:

Components

- Electronic scrap, e.g., encoder electronics
- Iron scrap
- Aluminium
- Non-ferrous metal, e.g., motor windings
- Insulating materials

Chemicals

- Oils (disposal as hazardous waste, in acc. with the pertinent legislation; in Germany, the Waste Oil Ordinance (AltölV) applies)
- Grease
- Solvents
- Paint residue
- Coolant

Glossary

A		
AIPEX PRO	AMK PC Software	Programming, parameterisation, configuration, diagnosis, oscilloscope, status information

B		
BA	Binary output	
BE	Binary input	

D		
Default	Factory setting	
DS402	CAN bus Draft Standard Proposal 402 Device Profile	Commanding protocol for drives

E		
E/A	In- and Outputs	
EF, EF2	Power output stage enable	
EMV	Electromagnetic compatibility	

F		
FL	Command 'Clear error'	Causes a new system run-up
FSoE	Functional Safety over EtherCAT	

K		
KE	compact power supply	
KEN	Compact power supply without recovery	
KES	Compact power supply with sinusoidal voltage and current	

N		
Nenndrehzahl	Nominal speed	
NHN	Heights measured above the base height level Reference plane for heights over the sea level for Germany since 1992.	The reference plane is located in Germany on the church in Wallenhorst.
NK	Cam switch	

P		
Parameter	Identification number acc. to SERCOS standard	
PELV	Protective Extra Low Voltage	

Q		
QEF, QEF2	'Acknowledgement power output stage enable (2 channel)'	QEF, QEF2 are the mirrored input signals EF, EF2
		The state bits can be configured with ID26 'Configuration status bits' for field bus transmission or on a binary output (EF: code 33135, EF2: code 33136)

Q		
QRF	'Acknowledgement controller enable'; the drive is controlled in the activated operation mode	

R		
RF	Command 'Controller enable'; the drive is energised and will be controlled depending on the selected operation mode	Controller enable can only be set if the device is error-free (SBM = TRUE) and acknowledgement DC bus on is set (QUE = TRUE). Acknowledgement controller enable (QRF) is set.
RO	Read Only	
RTE	Real-time Ethernet	
RW	Read Write	

S		
SBM	System ready message; shows that the device is error-free	In case of error, SBM will be reset
SoE	Servodrive Profile (SERCOS) over EtherCAT	Acc. to IEC 61800-7-300
STO	Safe torque off	Safety function acc. to DIN EN 61800-5-2

Your opinion is important!

With our documentation we want to offer you the highest quality support in handling the AMK products.

That is why we are now working on optimising our documentation.

Your comments or suggestions are always of interest to us.

We would be grateful if you take a bit of time and answer our questions. Please return a copy of this page to us.

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or
fax no.: +49 (0) 70 21 / 50 05-199

Thank you for your assistance.
Your AMK documentation team

1. How would you rate the layout of our AMK documentation?

   (1) very good (2) good (3) satisfactory (4) less than satisfactory (5) poor

2. Is the content structured well?

   (1) very good (2) good (3) moderate (4) hardly (5) not at all

3. How easy is it to understand the documentation?

   (1) very easy (2) easy (3) moderately easy (4) difficult (5) extremely difficult

4. Did you miss any topics in the documentation?

   (1) no (2) if yes, which ones:

5. How would you rate the overall service at AMK?

   (1) very good (2) good (3) satisfactory (4) less than satisfactory (5) poor

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