item Servo Positioning Controller C 1-02, C 1-05 and C 1-08

designed for Functional Safety

Mounting Instructions

Version 9.0

1 General

1.1 Documentation

This installation information serves the purpose of a safe use of the item Servo Positioning Controller C 1-Series. It contains safety notes, which must be complied with.

Further information can be found in the following manuals of the item C Series product range:

- **Product Manual "item Servo Positioning Controller C 1-Series":** Description of the technical specifications and the device functionality as well as notes on the installation and the operation.
- **CANopen Manual "item Servo Positioning Controller C Series":** Description of the implemented CANopen protocol as per DSP402.
- **PROFIBUS Manual "item Servo Positioning Controller C Series":** Description of the implemented PROFIBUS-DP protocol.
- **EtherCAT Manual "item Servo Positioning Controller C Series":** Description of the implemented EtherCAT (CoE – CANopen over EtherCAT) protocol.
- **Product Manual "FSM 2.0 – STO":** Description of the technical specifications and the device functionality.

You can find all these documents on our homepage at the download area (http://www.item24.com).

2 Safety notes for electrical drives and controllers

2.1 Used symbols

	Information
	Important information and notes.

	Caution!
	Nonobservance may result in severe property damages.

	DANGER!
	Nonobservance may result in **property damages** and in **personal injuries**.

	Caution! Dangerous voltages.
	The safety note indicates a possible perilous voltage.

2.2 General notes

In case of damage resulting from non-compliance with the safety notes in this manual, item Industrietechnik GmbH will not assume any liability.

Sound and safe operation of the servo drive controller requires proper and professional transportation, storage, assembly and installation as well as proper operation and maintenance. Only trained and qualified personnel may handle electrical devices:

TRAINED AND QUALIFIED PERSONNEL

in the sense of this product manual or the safety notes on the product itself are persons who are involved in the project planning, the setup, assembly, commissioning and operation of the product as well as all warnings and precautions as per the instructions in this manual and who are sufficiently qualified in their field of expertise:

▪ Education and instruction of standard specifications and accident prevention regulations, which are necessessary in the application, and authorisation to switch devices/systems on and off and to ground them as per the standards of safety engineering and to efficiently label them as per the job demands.

▪ Education and instruction as per the standards of safety engineering regarding the maintenance and use of adequate safety equipment.

▪ Training in first aid.

The following notes must be read prior to the initial operation of the system to prevent personal injuries and/or property damages:

	These safety notes must be complied with at all times.

ℹ Do not try to install or commission the servo drive controller before carefully reading all safety notes for electrical drives and controllers contained in this document. These safety instructions and all other user notes must be read prior to any work with the servo drive controller.

ℹ In case you do not have any user notes for the servo drive controller, please contact your sales representative. Immediately demand these documents to be sent to the person responsible for the safe operation of the servo drive controller.

ℹ If you sell, rent and/or otherwise make this device available to others, these safety notes must also be included.

ℹ The user must not open the servo drive controller for safety and warranty reasons.

ℹ Professional control process design is a prerequisite for sound functioning of the servo drive controller!

⚠ **DANGER!**

Inappropriate handling of the servo drive controller and non-compliance of the warnings as well as inappropriate intervention in the safety features may result in property damage, personal injuries, electric shock or in extreme cases even death.

2.3 Danger resulting from misuse

⚠ DANGER!

High electrical voltages and high load currents!

Danger to life or serious personal injury from electrical shock!

⚠ DANGER!

High electrical voltage caused by wrong connections!

Danger to life or serious personal injury from electrical shock!

⚠ DANGER!

Surfaces of device housing may be hot!

Risk of injury! Risk of burning!

⚠ DANGER!

Dangerous movements!

Danger to life, serious personal injury or property damage due to unintentional movements of the motors!

2.4　Safety notes

2.4.1　General safety notes

The servo positioning controller corresponds to IP20 degree of protection as well as pollution degree 2. Make sure that the environment corresponds to this degree of protection and pollution degree.

Only use replacements parts and accessories approved by the manufacturer.

The devices must be connected to the mains supply as per EN regulations, so that they can be cut off the mains supply by means of corresponding separation devices (e.g. main switch, contactor, power switch).

The servo drive controller may be protected using an AC/DC sensitive 300mA fault current protection switch, type B (RCD = Residual Current protective Device).

Gold contacts or contacts with a high contact pressure should be used to switch the control contacts.

As a precaution screening measures for switchgears must be met, as e.g. contactors and relays with RC elements and/or diodes wire.

The safety rules and regulations of the country in which the device will be operated must be complied with.

The environment conditions defined in the product documentation must be kept. Safety-critical applications are not allowed, unless specifically approved by the manufacturer.

The compliance with the limits required by national regulations is the responsibility of the manufacturer of the machine or system.

The technical data and the connection and installation conditions for the servo drive controller are to be found in this product manual and must be met.

DANGER!

The general setup and safety regulations for work on power installations (e.g. DIN, VDE, EN, IEC or other national and international regulations) must be complied with.

Non-compliance may result in death, personal injury or serious property damages.

Without claiming completeness, the following regulations and others apply:

VDE 0100	Erection of power installations with nominal voltages up to 1000 V
EN 1037	Safety of maschinery - Prevention of unexpected start-up
EN 60204-1	Safety of machinery - Electrical equipment of machines Part 1: General requirements
EN 61800-3	Adjustable speed electrical power drive systems Part 3: EMC requirements and specific test methods
EN 61800-5-1	Adjustable speed electrical power drive systems Part 5-1: Safety requirements - Electrical, thermal and energy
EN 61800-5-2	Adjustable speed electrical power drive systems Part 5-2: Safety requirements - Functional

EN ISO 12100	Safety of machinery - General principles for design - Risk assessment and risk reduction
EN ISO 13849-1	Safety of machinery - Safety-related parts of control systems
	Part 1: General principles for design
EN ISO 13849-2	Safety of machinery - Safety-related parts of control systems
	Part 2: Validation

More standards to be respected by the user:

EN 574	Safety of machinery - Two-hand control devices
EN 1088	Safety of machinery - Interlocking devices associated with guards
EN 1037	Safety of maschinery - Prevention of unexpected start-up
EN ISO 13850	Safety of machinery - Emergency stop

2.4.2 Safety notes for assembly and maintenance

The appropriate DIN, VDE, EN and IEC regulations as well as all national and local safety regulations and rules for the prevention of accidents apply for the assembly and maintenance of the system. The plant engineer or the operator is responsible for compliance with these regulations:

The servo drive controller must only be operated, maintained and/or repaired by personnel trained and qualified for working on or with electrical devices.

Prevention of accidents, injuries and/or damages:

Additionally secure vertical axes against falling down or lowering after the motor has been switched off, e.g. by means of:

- Mechanical locking of the vertical axle,
- External braking, catching or clamping devices or
- Sufficient balancing of the axle.

The motor holding brake supplied by default or an external motor holding brake driven by the drive controller alone is not suitable for personal protection!

Keep the electrical equipment voltage-free using the main switch and protect it from being switched on again until the DC bus circuit is discharged, in the case of:

- Maintenance and repair work
- Cleaning
- long machine shutdowns

Prior to carrying out maintenance work make sure that the power supply has been turned off, locked and the DC bus circuit is discharged.

The external or internal brake resistor carries dangerous DC bus voltages during operation of the servo drive controller and up to 5 minutes thereafter. Contact may result in death or serious personal injury.

Be careful during the assembly. During the assembly and also later during operation of the drive, make sure to prevent drill chips, metal dust or assembly parts (screws, nuts, cable sections) from falling into the device.

Also make sure that the external power supply of the controller (24V) is switched off.

The DC bus circuit or the mains supply must always be switched off prior to switching off the 24V controller supply.

Carry out work in the machine area only, if AC and/or DC supplies are switched off. Switched off output stages or controller enablings are no suitable means of locking. In the case of a malfunction the drive may accidentally be put into action, except drives with active safety function "Safe Torque Off".

Motor set up, automatic tuning and identification procedures must be done with free-wheeling motor to prevent mechanical damage due to unexpected motor movement.

Electronic devices are never fail-safe. It is the user's responsibility, in the case an electrical device fails, to make sure the system is transferred into a secure state.

The servo drive controller and in particular the brake resistor, externally or internally, can assume high temperatures, which may cause serious burns.

2.4.3 Protection against contact with electrical parts

This section only concerns devices and drive components carrying voltages exceeding 50 V. Contact with parts carrying voltages of more than 50 V can be dangerous for people and may cause electrical shock. During operation of electrical devices some parts of these devices will inevitably carry dangerous voltages.

> **DANGER!**
> High electrical voltage!
> Danger to life, danger due to electrical shock or serious personal injury!

The appropriate DIN, VDE, EN and IEC regulations as well as all national and local safety regulations and rules for the prevention of accidents apply for the assembly and maintenance of the system. The plant engineer or the operator is responsible for compliance with these regulations:

Before switching on the device, install the appropriate covers and protections against accidental contact. Rack-mounted devices must be protected against accidental contact by means of a housing, e.g. a switch cabinet. The regulations VGB4 must be complied with!

Always connect the ground conductor of the electrical equipment and devices securely to the mains supply. Due to the integrated line filter the leakage current exceeds 3.5 mA!

Comply with the minimum copper cross-section for the ground conductor over its entire length as per EN 60617!

Prior to the initial operation, even for short measuring or testing purposes, always connect the ground conductor of all electrical devices as per the terminal diagram or connect it to the ground wire. Otherwise the housing may carry high voltages which can cause electrical shock.

Do not touch electrical connections of the components when switched on.

Prior to accessing electrical parts carrying voltages exceeding 50 Volts, disconnect the device from the mains or power supply. Protect it from being switched on again.

For the installation the amount of DC bus voltage must be considered, particularly regarding insulation and protective measures. Ensure proper grounding, wire dimensioning and corresponding short-circuit protection.

The device comprises a rapid discharge circuit for the DC bus as per EN60204 section 6.2.4. In certain device constellations, however, mostly in the case of parallel connection of several servo drive controllers in the DC bus or

in the case of an unconnected brake resistor, this rapid discharge may be ineffective. The servo drive controllers can carry voltage until up to 5 minutes after being switched off (residual capacitor charge).

2.4.4 Protection against electrical shock by means of protective extra-low voltage (PELV)

All connections and terminals with voltages of up to 50 Volts at the servo drive controller are protective extra-low voltage, which are designed safe from contact in correspondence with the following standards:

- International: IEC 60364-4-41
- European countries within the EU: EN 50178/1998, section 5.2.8.1.

⚠	DANGER! High electrical voltages due to wrong connections! Danger to life, risk of injury due to electrical shock!

Only devices and electrical components and wires with a protective extra low voltage (PELV) may be connected to connectors and terminals with voltages between 0 to 50 Volts.

Only connect voltages and circuits with protection against dangerous voltages. Such protection may be achieved by means of isolation transformers, safe optocouplers or battery operation.

2.4.5 Protection against dangerous movements

Dangerous movements can be caused by faulty control of connected motors, for different reasons:

- Improper or faulty wiring or cabling
- Error in handling of components
- Error in sensor or transducer
- Defective or non-EMC-compliant components
- Software error in superordinated control system

These errors can occur directly after switching on the device or after an indeterminate time of operation.

The monitors in the drive components for the most part rule out malfunctions in the connected drives. In view of personal protection, particularly the danger of personal injury and/or property damage, this may not be relied on exclusively. Until the built-in monitors come into effect, faulty drive movements must be taken into account; their magnitude depends on the type of control and on the operating state.

⚠	DANGER! Dangerous movements! Danger to life, risk of injury, serious personal injuries or property damage!

For the reasons mentioned above, personal protection must be ensured by means of monitoring or superordinated measures on the device. These are installed in accordance with the specific data of the system and a danger and error analysis by the manufacturer. The safety regulations applying to the system are also taken into consideration. Random movements or other malfunctions may be caused by switching the safety installations off, by bypassing them or by not activating them.

2.4.6 Protection during handling and assembly

Handling and assembly of certain parts and components in an unsuitable manner may under adverse conditions cause injuries.

> ⚠️ **DANGER!**
>
> Risk of injury due to improper handling!
>
> Personal injury due to pinching, shearing, cutting, crushing!

The following general safety notes apply:

⚠️ Comply with the general setup and safety regulations on handling and assembly.

⚠️ Use suitable assembly and transportation devices.

⚠️ Prevent incarcerations and contusions by means of suitable protective measures.

⚠️ Use suitable tools only. If specified, use special tools.

⚠️ Use lifting devices and tools appropriately.

⚠️ If necessary, use suitable protective equipment (e.g. goggles, protective footwear, protective gloves).

⚠️ Do not stand underneath hanging loads.

⚠️ Remove leaking liquids on the floor immediately to prevent slipping.

2.4.7 Protection against contact with hot parts

> ⚠️ **DANGER!**
>
> Housing surfaces may be hot!
>
> Risk of injury! Risk of burning!

⚠️ Do not touch housing surfaces in the vicinity of heat sources! Danger of burning!

⚠️ Before accessing devices let them cool down for 10 minutes after switching them off.

⚠️ Touching hot parts of the equipment such as the housing, which contain heat sinks and resistors, may cause burns!

3 Technical data

Range	Controller C 1-02	Controller C 1-05	Controller C 1-08
item part number with FBA module	0.0.668.62	0.0.668.63	0.0.668.64
STO module	0.0.668.20		
Ambient conditions and qualification:			
Admissible temperature ranges	Storage temperature: -25°C to +70°C		
	Operating temperature: 0°C to +40°C +40°C to +50°C at reduced power 2,5%/K		
Admissible installation height	Mounting height maximum 2000 m above msl, above 1000 m above msl with power reduction 1% per 100 m		
Humidity	Relative humidity up to 90%, no bedewing		
Protection degree	IP20		
Protection class	I		
Pollution degree	2		
CE conformity Low-voltage directive: EMC directive:	2006/95/EC verified by application of the harmonised standard EN 61800-5-1 2004/108/EC verified by application of the harmonised standard EN 61800–3		
cULus certification	Listed according to UL 508C, C22.2 No. 274-13		
Dimensions and weight:			
Dimensions: H*W*D	261*54,6*205 mm	261*54,6*205mm	261*54,6*205mm
Weight	c. 2,0 kg	c. 2,1 kg	c. 1,8 kg
Performance data [X9]:			
Supply voltage	1 x 100 .. 230 VAC [± 10%], 50...60 Hz		
Alternative DC supply	60 .. 380 VDC		60 .. 320 VDC
24V supply *) plus current consumption of a possibly connected holding brake and I/Os	24 VDC [± 20%] (0,55 A) *)	24 VDC [± 20%] (0,65 A) *)	24 VDC [± 20%] (0,65 A) *)
Intermediate circuit voltage for a supply voltage of 230 VAC	320 VDC (without PFC) 380 VDC (with PFC active)		320 VDC

item

Range		Controller C 1-02	Controller C 1-05	Controller C 1-08
Performance data of PFC stage for a nominal supply voltage of 230 VAC [± 10%]:				
Continuous power output		500 W	1000 W	no PFC
Peak power output		1000 W	2000 W	no PFC
Internal brake resistor [X9]:				
Brake resistance		60 Ω	60 Ω	37 Ω
Pulse power		2,8 kW	2,8 kW	3,9 kW
Continuous power		10 W	20 W	25 W
Threshold limit	(without PFC) (with PFC active)	389 V 440 V	389 V 440 V	389 V no PFC
Max. voltage	(without PFC) (with PFC active)	400 V 460 V	400 V 460 V	400 V no PFC
External brake resistor [X9]:				
Brake resistance external		$\geq 50\ \Omega$	$\geq 50\ \Omega$	$\geq 25\ \Omega$
Max. operating voltage (at output)		460 V		400 V
Motor connection specifications [X6]:				
Specifications for operation with 1x 230 VAC [± 10%], 50 Hz				
Output power		0,5 kVA	1,0 kVA	1,5 kVA
Max. output power for 5 s		1,0 kVA	2,0 kVA	3,0 kVA
Output current		2,5 A_{RMS}	5 A_{RMS}	8 A_{RMS}
Max. output current for 5 s		5 A_{RMS}	10 A_{RMS}	16 A_{RMS}
Max . output current for 0,5 s		10 A_{RMS}	20 A_{RMS}	32 A_{RMS}
Max. mains current for continuous operation		2,4 A_{RMS}	4,7 A_{RMS}	10 A_{RMS} (no PFC)
Max. PWM frequency		20 kHz (software programmable)		
As a guideline: Power loss/efficiency (with regard to the rated output power)		typical 8% / 92%		
Maximum motor cable length for interference emission according to EN 61800-3 for PWM $\leq$ 10 kHz				
Category C2		$l \leq 25$ m		
Category C3		$l \leq 25$ m		
Cable capacity of a phase against shield or between two lines		$C' \leq 200$ pF/m		
Derating of the cable length (see also *chapter 7.1 Operation with long motor cables* on page *37)*				
f_{PWM} = 12 kHz		$l \leq 21$ m		
f_{PWM} = 16 kHz		$l \leq 15$ m		

Range	Controller C 1-02	Controller C 1-05	Controller C 1-08
f_{PWM} = 20 kHz	$l \leq 12$ m		
Motor temperature monitoring:			
Digital sensor	Normally closed contact: $\quad R_{cold} < 500\ \Omega \qquad R_{hot} > 100$ kΩ		
Analog sensor	Silicon temperature sensor, e.g. KTY81, 82 or similar $R_{25} \approx 2000\ \Omega \qquad\qquad R_{100} \approx 3400\ \Omega$		
Resolver [X2A]:			
Resolution	16 Bit		
Delay time signal detection	< 200 µs		
Speed resolution	ca. 4 min^{-1}		
Absolute accuracy of angle detection	< 5´		
Max. rotational speed	16.000 min^{-1}		
Encoder evaluation [X2B]:			
Parameterisable number of encoder lines	$1 - 2^{18}$ lines/rev		
Angular resolution / Interpolation	10 Bit / period		
Encoder signals A, B	1 V$_{PP}$ differential; 2.5 V offset		
Encoder signal N	0.2 to 1 V$_{PP}$ differential; 2.5 V offset		
Commutation track A1, B1 (optional)	1 V$_{PP}$ differential; 2.5 V offset		
Input impedance encoder signals	Differential input 120 Ω		
Limit frequency	$f_{Limit} > 300$ kHz (high-res. signal) f_{Limit} ca. 10 kHz (commutation track)		
Additional communication interface	EnDat (Heidenhain) and HIPERFACE (Stegmann)		
Output supply	5 V or 12 V; max. 300 mA; currentlimited control via sensor lines Setpoint programmable via software		
Digital inputs and outputs [X1]:			
Signal level	24V (8V...30V) active high, conforming with DIN EN 61131-2		
Logic inputs general DIN0 DIN1 DIN2 DIN3	Bit 0　\　(Least significant Bit) Bit 1,　\　Target selection for positioning Bit 2,　/　16 targets selectable from target table Bit 3　/　(Most significant Bit)		
DIN4	Control input stage enable at High		
DIN5	Controller enable at High, clear error high-low transition at Low		
DIN6	End switch input 0		
DIN7	End switch input 1		

Range	Controller C 1-02	Controller C 1-05	Controller C 1-08
DIN8	Control signal Start positioning		
DIN9	Home switch for homing or saving of positions		
Logic outputs general	Galvanically separated, 24 V (8 …30 V) active high		
DOUT0	Operational state	24 V, max. 100 mA	
DOUT1	Freely configurable	24 V, max. 100 mA	
DOUT2	Freely configurable, optional use as input DIN10	24 V, max. 100 mA	
DOUT3	Freely configurable, optional use as input DIN11	24 V, max. 100 mA	
DOUT4 [X6]	Holding brake	24 V, max. 1 A	
Analog inputs and outputs [X1]:			
High-resolution analog input: AIN0	±10 V input range, 16 Bit, differentially, < 250 µs delay time		
Analog input: AIN1	Optionally, this input can also be parameterized as digital input DIN AIN1 with a switching threshold at 8 V.	±10 V, 10 Bit, single ended, < 250 µs delay time	
Analog input: AIN2	Optionally, this input can also be parameterized as digital input DIN AIN2 with a switching threshold at 8 V.	±10 V, 10 Bit, single ended, < 250 µs delay time	
Analog outputs: AOUT0 and AOUT1	±10 V output range, 9 bit resolution, $f_{Limit} > 1$ kHz		
Incremental encoder input [X10]:			
Parameterisable number of encoder lines	$1 – 2^{28}$ lines/rev		
Trace signals	As per RS422 specification		
Max. input frequency	1000 kHz		
Pulse-direction interface	As per RS422 specification		
Output supply	5 V, max. 100 mA		
Incremental encoder output [X11]:			
Number of lines	Programmable $1 – 2^{13}$ and 2^{14} lines/revolution		
Connection level	Differential / RS422 specification		
Encoder signals A, B, N	As per RS422 specification		
speciality	N-Trace disconnectible		
Output impedance	$R_{a,diff} = 66\ \Omega$		
Limit frequency	$f_{Limit} > 1,8$ MHz (lines/s)		

Range	Controller C 1-02	Controller C 1-05	Controller C 1-08
Edge triggering (minimum pulse width)	Can be limited by parameters		
Output supply	5 V, max. 100 mA		
Ethernet [X18]:	RJ45, 10/100 MBaud (auto select)		
USB [X19]:	According to USB 2.0, USB-B, slave-client		
SD card slot:	SD, SDHC and MMC - FAT12, FAT16 and FAT32		

3.1 Supported motor feedback systems

Listing of supported motor feedback systems, valid from april 2009

Type	Notes	Protocol
Heidenhain EnDat encoder:		
ROC 400 ECI 1100/1300 ECN 100/400/1100/1300	Single-turn absolute encoder with or without analog signal.	EnDat 2.1 (01/21) EnDat 2.2 (22)
ROQ 400 EQI 1100/1300 EQN 100/400/1100/1300	Multi-turn absolute encoder with or without analog signal.	EnDat 2.1 (01/21) EnDat 2.2 (22)
LC 100 / 400	Absolute linear encoders .	EnDat 2.1 (01) EnDat 2.2 (22)
Stegmann HIPERFACE® Encoder:		
SCS60/70 SCM60/70	Single- / multi-turn encoder with analog incremental signal. Line count 512 (fix). Number of multi-turn revolutions: +/- 2048 U.	HIPERFACE®
SRS50/60/64 SCKxx SRM50/60/64 SCLxx	Single- / multi-turn encoder with analog incremental signal. Line count 1024 (fix). Number of multi-turn revolutions: +/- 2048 U xx = 25 / 35 / 40 / 45 / 50 / 53	HIPERFACE®
SKS36 SKM36	Single- / multi-turn encoder with analog incremental signal. Line count 128 (fix). Number of multi-turn revolutions: +/- 2048 U	HIPERFACE®
SEK37/52 SEL37/52	Single- / multi-turn encoder with analog incremental signal. Line count 16 (fix). Number of multi-turn revolutions: +/- 2048 U	HIPERFACE®
L230	Absolute length measuring system with analog incremental signal. Resolution: 156,25 µm. Measuring length max. ca. 40 m.	HIPERFACE®
Yaskawa Σ-Encoder:		
Σ (sigma 1)	Digital incremental encoder with zero-pulse	Yaskawa-OEM-protocol
Analog incremental encoder:		
ROD 400 ERO 1200/1300/1400 ERN 100/400/1100/1300	Heidenhain, encoder with zero- and reference pulse	
Digital incremental encoder:		
CDD50	Stegmann, encoder with hall sensors	
Resolver:		

Standard	transmission ratio typ. 0,5 +- 10 %, Input supply typ. 7 Vrms

4 Mechanical installation

4.1 Important notes

- Only use the item servo positioning controller C 1-Series as a built-in device for switch cabinets

- Mounting position vertical with supply lines [X9] on top

- Mount to control cabinet plate using a fastening strap

- Installation spaces: Keep a minimum distance of 100 mm to other components each above and underneath the device to ensure sufficient venting.

- The item servo positioning controller C 1-Seriesmay be installed adjacently in one switch cabinet without a gap, proper usage and installation on a heat-dissipating rear panel provided. Please note that excessive heat may cause premature aging and/or damaging of the device. In case the item servo positioning controller C 1-Series are subject to high thermal stress, a space of 59 mm is recommended!

> The connections of the following illustrations for the item servo positioning controller C 1-02 also apply to the item servo positioning controller C 1-05 and
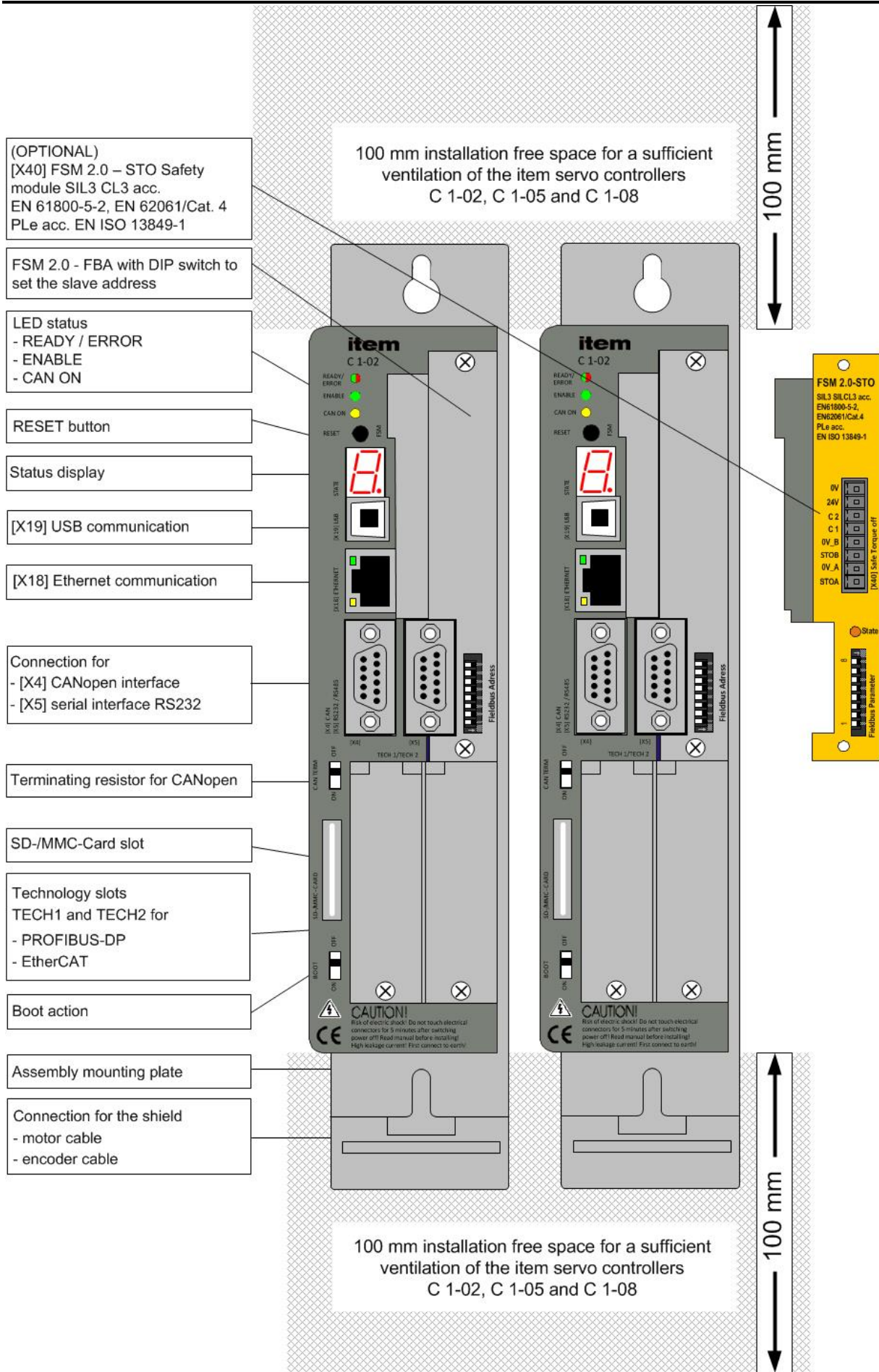> C 1-08!

Figure 1: item servo positioning controller C 1-Series: Front view and Installation space
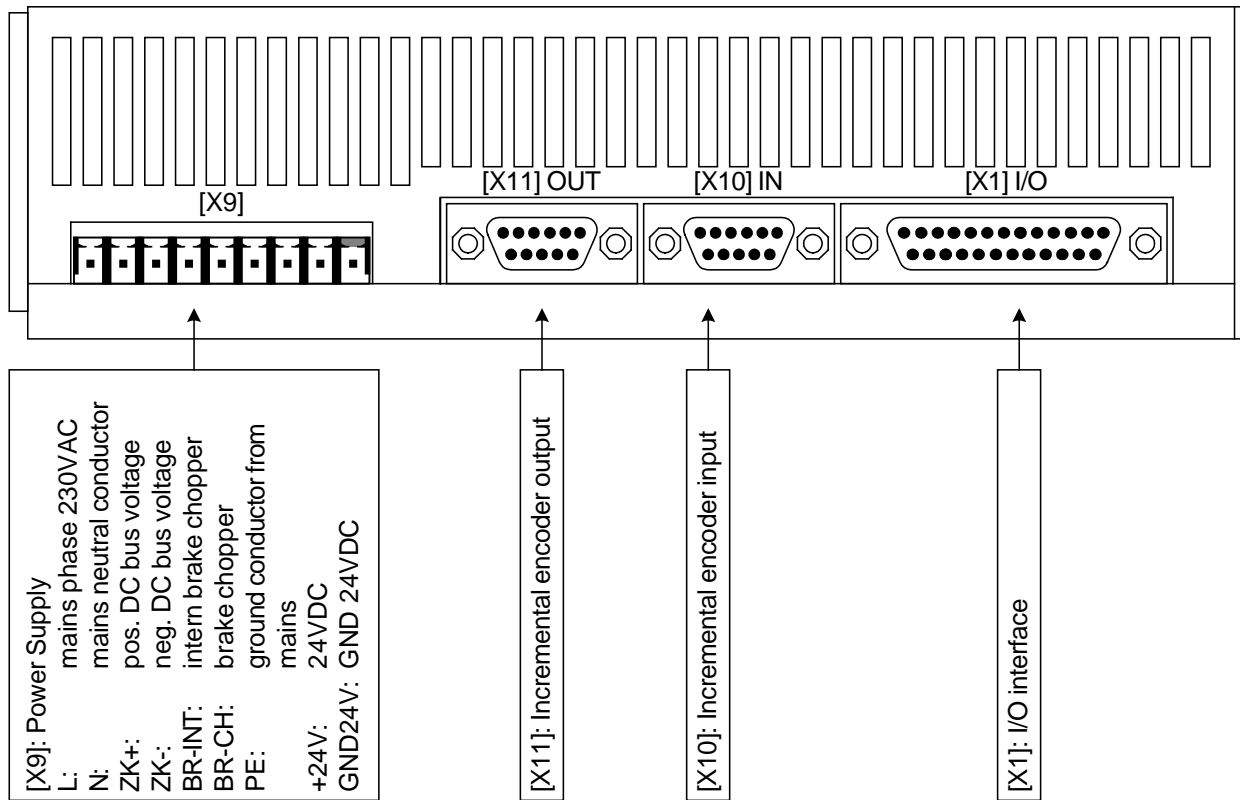
[X9]   [X11] OUT   [X10] IN   [X1] I/O

[X9]: Power Supply
L: mains phase 230VAC
N: mains neutral conductor
ZK+:   pos. DC bus voltage
ZK-:   neg. DC bus voltage
BR-INT: intern brake chopper
BR-CH: brake chopper
PE: ground conductor from
            mains
+24V: 24VDC
GND24V: GND 24VDC

[X11]: Incremental encoder output

[X10]: Incremental encoder input

[X1]: I/O interface

Figure 2: item servo positioning controller C 1-02: Top view

[X2B] ENCODER   [X2A] RESOLVER   [X6]

[X2B]: Connection for the encoder

[X2A]: Connection for the resolver

[X6]: Motor Connection
BR-:   holding brake
BR+:   holding brake
PE: inner shield
MT-:   motor sensor
MT+:   motor sensor
PE: motor ground conductor
W: motor phase 3
V: motor phase 2
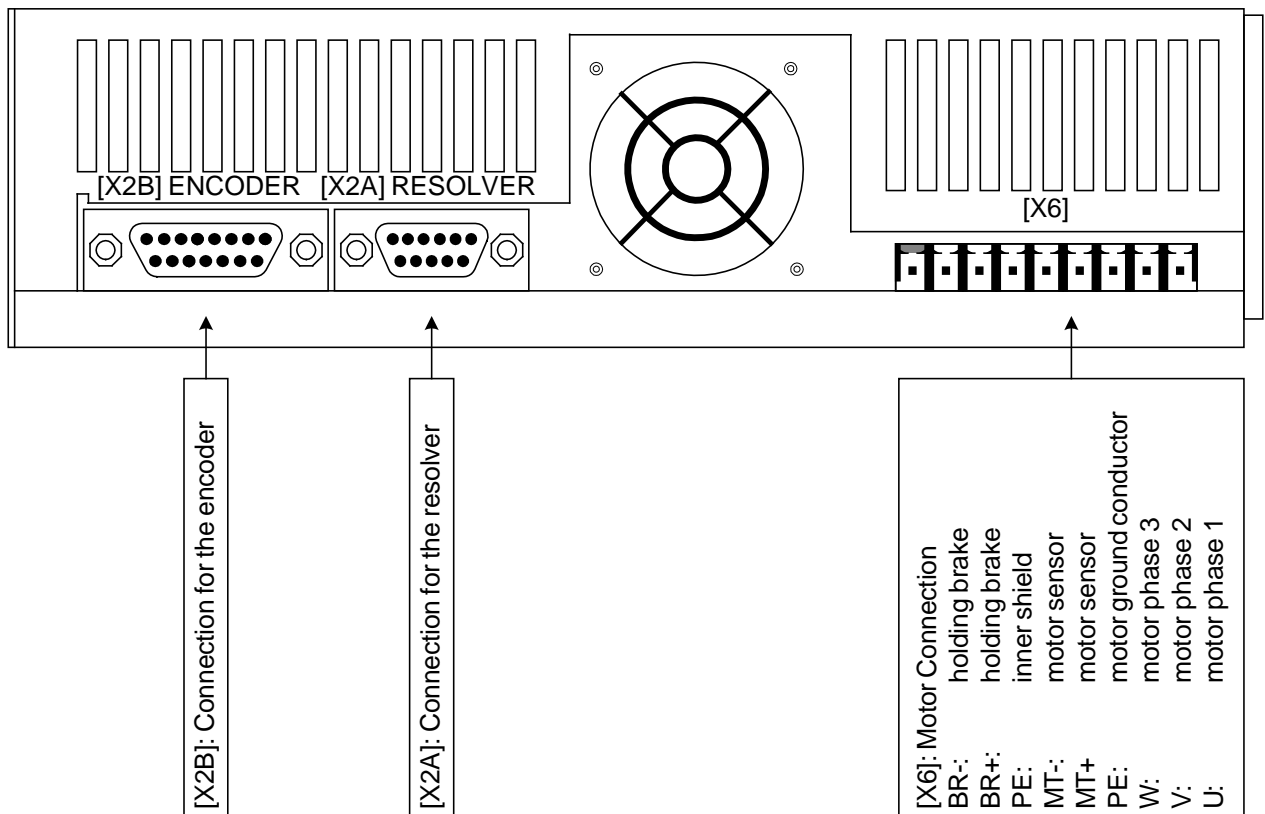U: motor phase 1

Figure 3: item servo positioning controller C 1-02: Bottom view

4.2 Mounting

The item servo positioning controller C 1-Series has attachment lugs on the top and the bottom of the device. These are used to mount the servo positioning controller vertically to a control cabinet plate. The lugs are part of the cooling body profile, thereby providing optimum heat transmission to the control cabinet plate.

Please use M5 screws for the mounting of the item servo positioning controller C 1-Series, C 1-05 and C 1-08.
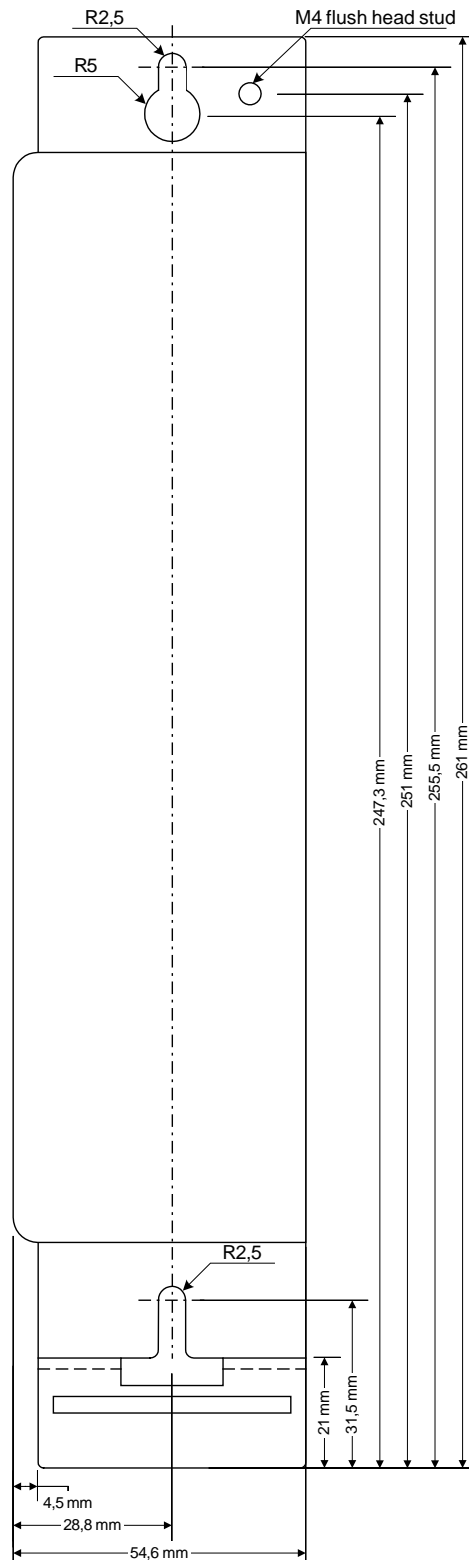

Figure 4: item servo positioning controller C 1-Series: Mounting plate

5 Electrical installation

> **Caution!**
>
> DC bus coupling is not allowed while the PFC stage is active. This can otherwise result in damages to the servo positioning controller.

> **Caution!**
>
> When the DC buses are connected, the power supplies must be connected to the same mains phase.
>
> This means, if two item servo positioning controller C 1-05 are coupled in the DC bus, only the connection L1/N is possible for both devices. It is not allowed to connect the DC Busses if the devices are connected to different mains phases.
>
> It is forbidden to supply device 1 via L1/N and device 2 via L2/N, when the DC buses are coupled.

> **Caution!**
>
> Operation with DC bus coupling together with devices of the item C 3-Series is not allowed.
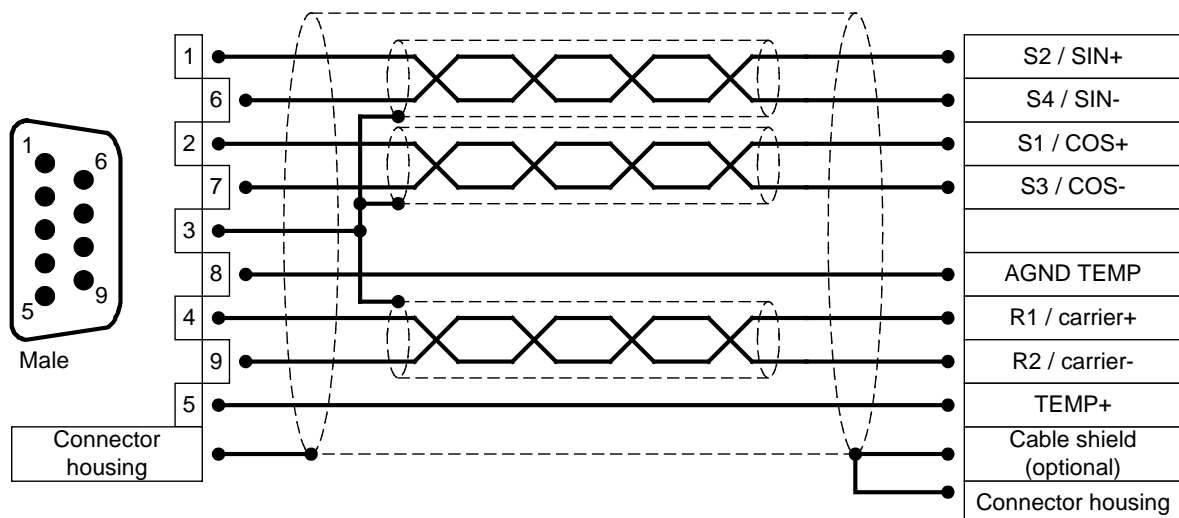
5.1   Pin configuration I/O [X1]

Pin No.		Denomination	Value	Specification
1		AGND	0V	Shield for analog signals, AGND
	14	AGND	0V	Reference potential for analog signals
2		AIN0	$U_{on} = \pm10V$	Setpoint input 0, differential, max. 30V input voltage
	15	#AIN0	$R_I \geq 30k\Omega$	
3		AIN1	$U_{on} = \pm10V$	Setpoint inputs 1 and 2, single ended, max. 30V input voltage
	16	AIN2	$R_I \geq 30k\Omega$	
4		+VREF	+10V	Reference output for setpoint potentiometer
	17	AMON0	±10V	Analog monitor output 0
5		AMON1	±10V	Analog monitor output 1
	18	+24V	24V / 100mA	Auxiliary voltage for IOs at X1
6		GND24	corresponding GND	Reference potential for digital I/Os
	19	DIN0	POS Bit0	Target selection positioning Bit0 (LSB)
7		DIN1	POS Bit1	Target selection positioning Bit1
	20	DIN2	POS Bit2	Target selection positioning Bit2
8		DIN3	POS Bit3	Target selection positioning Bit3 (MSB)
	21	DIN4	FG_E	Power stage enable
9		DIN5	FG_R	Controller enable
	22	DIN6	END0	Input end switch 0 (locks n > 0)
10		DIN7	END1	Input end switch 1 (locks n < 0)
	23	DIN8	START	Input for positioning start
11		DIN9	SAMP	High-speed input
	24	DOUT0 / READY	24V / 100mA	Output operational
12		DOUT1	24V / 100mA	Output freely programmable
	25	DOUT2	24V / 100mA	Output freely programmable
13		DOUT3	24V / 100mA	Output freely programmable

5.2　Pin configuration Resolver [X2A]

Pin No.		Denomination	Value	Specification
1		S2	$3{,}5V_{RMS}$ / 5-10kHz	SINE trace signal, differential
	6	S4	$R_i > 5k\Omega$	
2		S1	$3{,}5V_{RMS}$ / 5-10kHz	COSINE trace signal, differential
	7	S3	$R_i > 5k\Omega$	
3		AGND	0V	Shield for signal pairs (inner shield)
	8	MT-	GND	Reference potential temperature sensor
4		R1	$7V_{RMS}$ / 5-10kHz $I_A \leq 150mA_{RMS}$	Carrier signal for resolver
	9	R2	GND	
5		MT+	+3,3V / Ri=2kΩ	Motor temperature sensor, normally closed contact, PTC, NTC, KTY

- The outer shield is always connected to PE (connector housing) on the controller side.
- The three inner shields are connected on one side of the item Servo Positioning Controller C 1-Series to PIN 3 of [X2A].

5.3　Pin configuration Encoder [X2B]

At the 15-pole D-Sub connection [X2B], motors with encoder can be feedback. The possible incremental encoders for the encoder connection are divided into several groups.

- Standard incremental encoders with and without commutation signals
- Stegmann encoders with HIPERFACE®: single- and multi-turn encoders with analog incremental signals
- Encoders with EnDat interface
- Serial encoders with and without analog signal

Pin No	Incremental encoder with serial communication interface (e.g. EnDat, HIPERFACE)		Analog incremental encoder		Digital incremental encoder	
1	MT+	Motor temperature sensor, normally closed contact, PTC, NTC, KTY	MT+	Motor temperature sensor, normally closed contact, PTC, NTC, KTY	MT+	Motor temperature sensor, normally closed contact, PTC, NTC, KTY
9	U_SENS+	Sensor cables for encoder supply	U_SENS+	Sensor cables for encoder supply	U_SENS+	Sensor cables for encoder supply
2	U_SENS-		U_SENS-		U_SENS-	
10	US	Supply voltages for high-resolution incremental encoder	US	Supply voltages for high-resolution incremental encoder	US	Supply voltages for high-resolution incremental encoder
3	GND	Reference potential encoder supply and motor temperature sensor	GND	Reference potential encoder supply and motor temperature sensor	GND	Reference potential encoder supply and motor temperature sensor
11			R	Reset pulse trace signal (differential) from high-resolution incremental encoder	N	Reset pulse trace signal (differential) from high-resolution and digital incremental encoder
4			#R		#N	
12	DATA	Bidirectional RS485 data line (differential) (EnDat / HIPERFACE)	COS_Z1*	COSINE commutation signal (differential) from high-resolution incremental encoder	H_U	Phase U hall sensor for commutation
5	#DATA		#COS_Z1*		H_V	Phase V hall sensor for commutation
13	SCLK	Clock output RS485 (differential) (EnDat)	SIN_Z1*	SINE commutation signal (differential) from high-resolution incremental encoder	H_W	Phase W hall sensor for commutation
6	#SCLK		#SIN_Z1			
14	COS_Z0*	COSINE trace signal (differential) from high-resolution incremental encoder	COS_Z0*	COSINE trace signal (differential) from high-resolution incremental encoder	A	A trace signal RS422 (differential) from digital incremental encoder
7	#COS_Z0*		#COS_Z0*		#A	
15	SIN_Z0*	SINE trace signal (differential) from high-resolution incremental encoder	SIN_Z0*	SINE trace signal (differential) from high-resolution incremental encoder	B	B trace signal RS422 (differential) from digital incremental encoder
8	#SIN_Z0*		#SIN_Z0*		#B	

*) Heidenhain encoder: A = SIN_Z0; B = COS_Z0; C = SIN_Z1; D = COS_Z1

5.4   Pin configuration CAN [X4]

Pin No.		Denomination	Value	Specification
1		-	-	Not occupied
	6	GND	0V	CAN-GND, galvanically connected to GND in controller
2		CANL	*)	CAN-Low signal line
	7	CANH	*)	CAN-High signal line
3		GND	0V	See Pin no. 6
	8	-	-	Not occupied
4		-	-	Not occupied
	9	-	-	Not occupied
5		Cable shield	PE	Connection for cable shield

*)   External terminating resistor 120Ω required on both ends of the bus
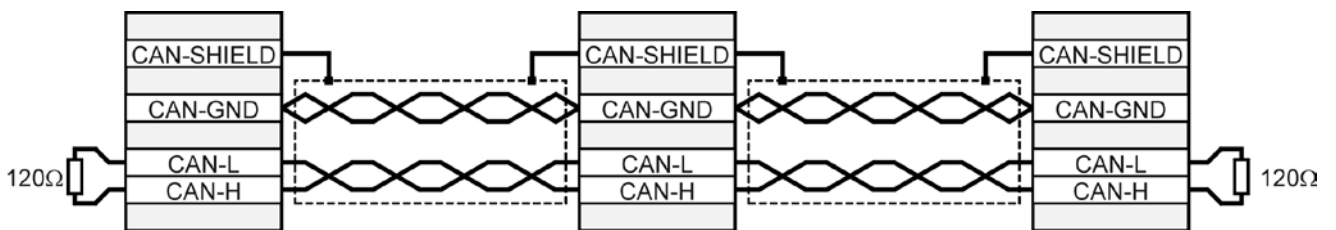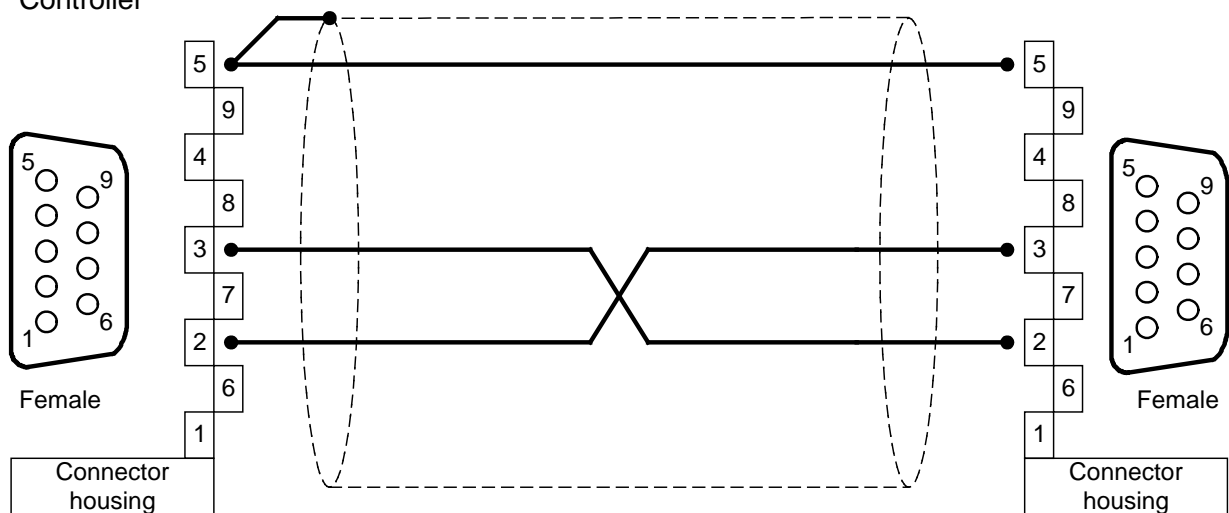
5.5 Pin configuration RS232 [X5]

Pin No.		Denomination	Value	Specification
1		-	-	Not occupied
	6	-	-	Not occupied
2		RxD	10 V / R_I > 2kΩ	Receive line, RS232 specification
	7	-	-	Not occupied
3		TxD	10 V / R_A < 2kΩ	Transmitting line, RS232 specification
	8	-	-	Not occupied
4		+RS485	-	Reserve for option RS485 Interface
	9	-RS485	-	Reserve for option RS485 Interface
5		GND	0V	Interfaces GND, galvanically connected to DGND

5.6 Wiring diagram Motor [X6] and Power Supply [X9]

Power Supply [X9]	
L	Mains phase
N	Mains neutral conductor
ZK+	Pos. DC bus voltage
ZK-	Neg. DC bus voltage
BR-INT	Connection of internal brake resistor
BR-CH	Brake chopper connection for internal/external brake resistor
PE	Connection ground conductor from mains
+24V	Supply for control part (0.5A) and holding brake (1A)
GND24V	Reference potential supply

Ground conductor from motor

Motor [X6]	
U	Motor phase 1
V	Motor phase 2
W	Motor phase 3
PE	Ground connection from motor
MT+	Motor temperature sensor, normally closed contact, PTC, KTY...
MT-	
PE	Cable shield from holding brake and motor temperature sensor
BR+	Holding brake, signal level dependent on switch status, high side / low side switch
BR-	

Motor feedback [X2A] / [X2B]

Resolver / Encoder

100VAC ... 230 VAC +/- 10%

main fuse

External brake resistor

Bridge circuit for internal brake resistor

alternative !

F1

24V Supply

Permanent-magnet synchronous maschine

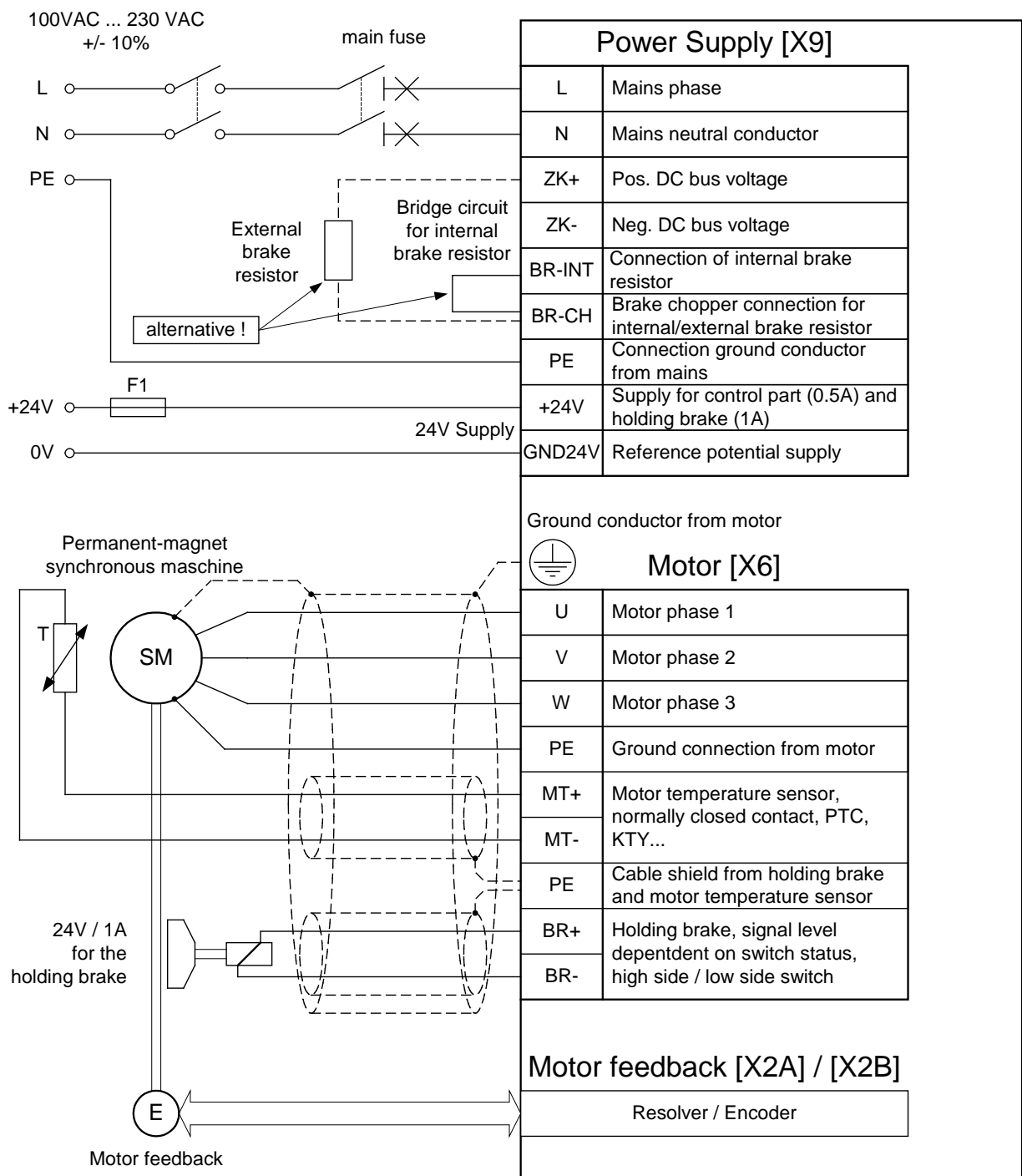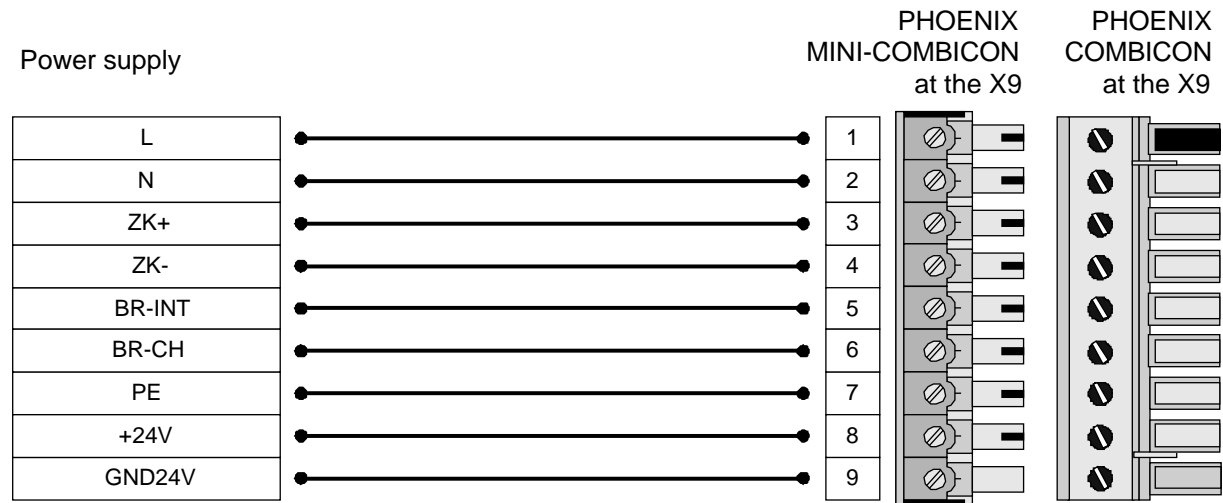24V / 1A for the holding brake

Motor feedback

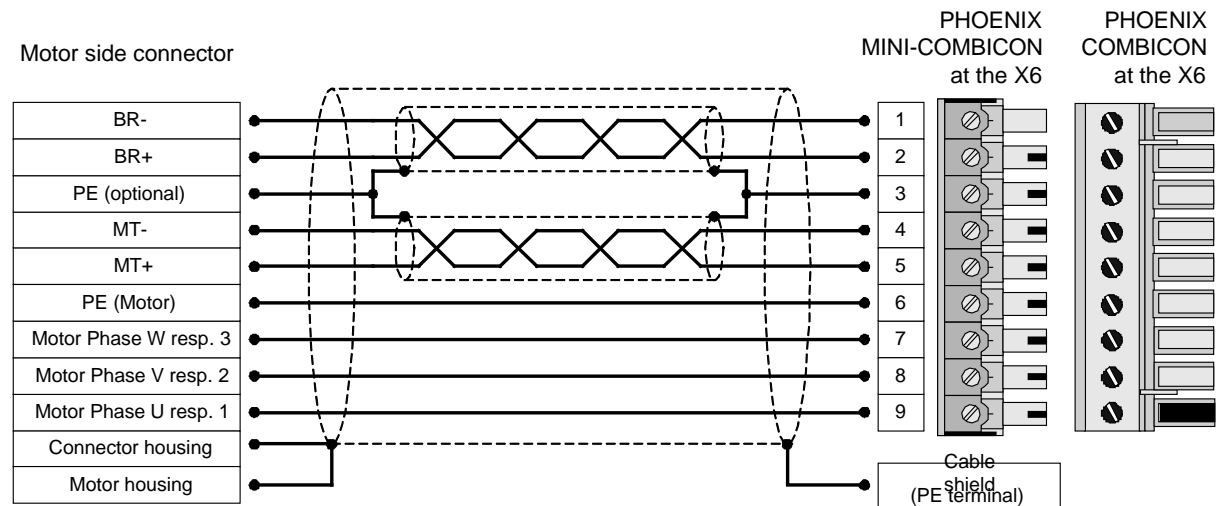Figure 5: Connection to power supply [X9] and motor [X6]

The item Servo Positioning Controller C 1-Series is connected to the supply voltage, the motor, the brake resistor and the holding brakes as shown in Figure 5. The operation of the item Servo Positioning Controller C 1-Series requires a 24V supply source for the electronics, which is connected to the terminals +24V and GND24V. The connection to the supply for the power output stage is either made to terminals L1 and N for AC supply or to ZK+ and ZK- for DC supply.

Power supply

		PHOENIX MINI-COMBICON at the X9	PHOENIX COMBICON at the X9
L	1		
N	2		
ZK+	3		
ZK-	4		
BR-INT	5		
BR-CH	6		
PE	7		
+24V	8		
GND24V	9		

	C 1-02 and C 1-05:	PHOENIX MINI-COMBICON MC 1,5/ 9-ST-5,08
	C 1-08:	PHOENIX COMBICON MSTB 2,5/9-ST-5,08

The motor is connected to the terminals U, V, W via motor cable to [X6].

The motor temperature switch (PTC or normally closed contact) and motor analog temperature sensor (e.g. KTY81) is connected to the terminals MT+ and MT- via motor cable to [X6] or is connected via the encoder cable to [X2A] or [X2B].

Motor side connector

		PHOENIX MINI-COMBICON at the X6	PHOENIX COMBICON at the X6
BR-	1		
BR+	2		
PE (optional)	3		
MT-	4		
MT+	5		
PE (Motor)	6		
Motor Phase W resp. 3	7		
Motor Phase V resp. 2	8		
Motor Phase U resp. 1	9		
Connector housing			
Motor housing		Cable shield (PE terminal)	

	C 1-02 and C 1-05:	PHOENIX MINI-COMBICON MC 1,5/ 9-ST-5,08
	C 1-08:	PHOENIX COMBICON MSTB 2,5/9-ST-5,08

- Connect the inner shields to PIN 3; maximum length 40 mm.

- Length of unshielded cores maximum 35 mm.

- Connect total shield on controller side flat to PE terminal; maximum length 40 mm. Use shield clamp (SK14) or connect to PE screw terminal

- Connect total shield on motor side flat to connector or motor housing; maximum length 40 mm.

> ℹ️ The cable shield of the motor cable must also be connected to the controller housing (PE screw terminal).

The connection of the shaft encoder via the D-Sub connector to [X2A] / [X2B] is roughly shown in Figure 5.

The item servo positioning controller must be connected to ground with its PE connection.

The item servo positioning controller must be completely wired first. Only then may the operating voltages for the DC bus and the electronics supply be switched on. In the case of inversed wiring of the operating voltage connections, excessive operating voltage or in the case of confusing the connections for operating voltage and motor the servo positioning controller will be damaged.

5.7 Pin configuration Incremental Encoder Input [X10]

Pin No.		Denomination	Value	Specification
1		A / CLK	5V / $R_I \approx 120\Omega$	Incremental encoder signal A / Stepper motor signal CLK pos. polarity as per RS422
	6	#A / #CLK	5V / $R_I \approx 120\Omega$	Incremental encoder signal A / Stepper motor signal CLK neg. polarity as per RS422
2		B / DIR	5V / $R_I \approx 120\Omega$	Incremental encoder signal B / Stepper motor signal DIR pos. polarity as per RS422
	7	#B / #DIR	5V / $R_I \approx 120\Omega$	Incremental encoder signal B / Stepper motor signal DIR neg. polarity as per RS422
3		N	5V / $R_I \approx 120\Omega$	Incremental encoder index pulse N pos. polarity as per RS422
	8	#N	5V / $R_I \approx 120\Omega$	Incremental encoder index pulse N neg. polarity as per RS422
4		GND	-	Supply GND for encoder
	9	GND	-	Shield for the connection cable
5		VCC	+5V±5% 100mA	Auxiliary supply, load with 100mA maximum, short circuit-proof
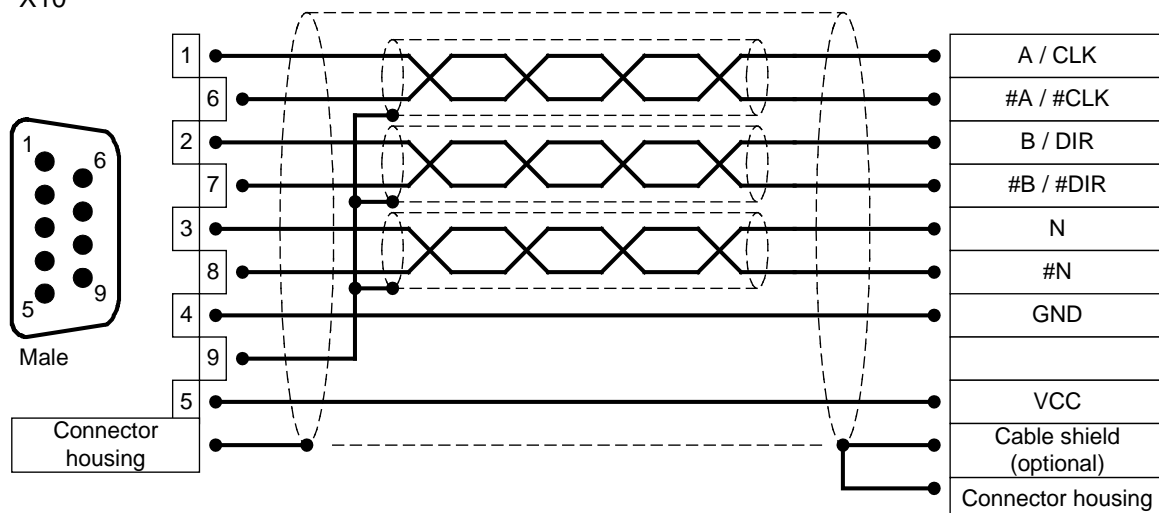
5.8 Pin configuration Incremental Encoder Output [X11]

Pin No.		Denomination	Value	Specification
1		A	5V / $R_A \approx 66\Omega$ *)	Incremental encoder signal A
	6	#A	5V / $R_A \approx 66\Omega$ *)	Incremental encoder signal #A
2		B	5V / $R_A \approx 66\Omega$ *)	Incremental encoder signal B
	7	#B	5V / $R_A \approx 66\Omega$ *)	Incremental encoder signal #B
3		N	5V / $R_A \approx 66\Omega$ *)	Incremental encoder index pulse N
	8	#N	5V / $R_A \approx 66\Omega$ *)	Incremental encoder index pulse #N
4		GND	-	Reference GND for encoder
	9	GND	-	Shield for connection cable
5		VCC	+5V ±5% 100mA	Auxiliary supply, to be loaded with maximal 100mA, short-circuit-proof

*) The value for R_A is the differential output resistance
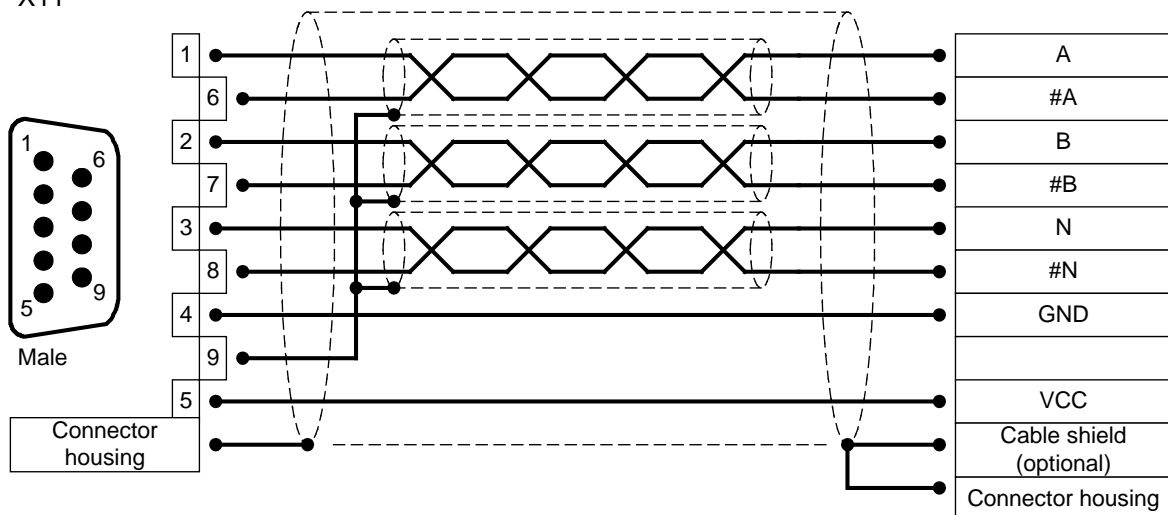
5.9 Ethernet communication (UDP interface) [X18]

The UDP communication enables the connection of the item servo positioning controller to the Ethernet fieldbus system. The communication via the UDP interface [X18] is realised with the aid of a standard cabling.

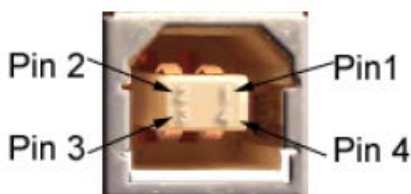| UDP interface [X18]	Values
Function	Ethernet, 10/100 MBaud (auto select)
Connector type	RJ45

5.10 USB communication [X19]

The item servo positioning controller comprises a USB (universal serial bus) communication interface, which is for connection via PC and for using the parameterisation tool item Motion Soft$^®$.

The USB communication interface requires no auxiliary power supply.

Caution!

The C-Series controller should be secured by a USB-isolating device if connected with a laptop computer. There could be a potential difference between both devices, caused by the suppression capacitor inside the laptop power supply. The current flow can damage the controllers USB port. You can ignore this precaution if the laptop is used in battery mode without being connected to a power supply.

USB interface [X19]			
Connector type		USB-B	
Standard		2.0	
Transmission rate		Support for both full-speed (12 Mbps) and high-speed (480 Mbps) modes	
Communication protocol		item specific (generic device)	
Functionality		Slave-Client	
Pin configuration			
	1	VCC	+5 VDC
2		D-	Data -
3		D+	Data +
	4	GND	Ground

5.11 SD/SDHC/MMC card slot

The item Servo Positioning Controller C 1-Series comprises a SD/SDHC/MMC card slot for the support of Firmware downloads (initialisation via boot switches) and uploads and downloads of parameter sets.

SD card slot	
Card types	SD, SDHC and MMC
File systems	FAT12, FAT16 and FAT32
Functions	Load a parameter set (DCO file), save the current parameter set (DCO file), load a firmware file
File names	Only file and directory names according to the 8.3 standard are supported.

5.11.1 BOOT-DIP-Switch

During a restart/reset, the BOOT-DIP-Switch is used to determine whether to perform a firmware download from the SD/MMC card or not. The position of the switch is shown in Figure 1.

- BOOT-DIP-Switch in position "ON" → firmware download requested
- BOOT-DIP-Switch in position "OFF"   → firmware download not requested

When there is no SD/MMC card in the card slot of the servo drive and the BOOT-DIP-Switch is in the position "ON" (firmware download requested), the error 29-0 is triggered after a restart/reset.
This error stops all further performances. This means that there is no communication possible via USB.

6 Functional Safety (optional)

6.1 Overview module types and integrated Functional Safety

Module type	Integrated Functional Safety	
FSM 2.0 - FBA	none	FBA = **F**ield**b**us **a**ctivation This module is equipped with DIP switches for activation and controlling the fieldbus communication. The functionality of the DIP switches is identical to the functionality of the DIP switches of the modules FSM 2.0 – STO and FSM 2.0 - MOV.
FSM 2.0 – STO	STO	"Safe Torque Off" (STO) with SIL3 in accordance with EN 61800-5-2 / EN 62061 / IEC 61508 or category 4 / PL e in accordance with EN ISO 13849-1.

6.2   FSM 2.0 – FBA

6.2.1   Fieldbus specific functional assignment of the DIP switches

DIP switch		Functionally of the DIP switch (fieldbus specific with technology module)		
		CAN (in the basic device)	PROFIBUS	EtherCAT
	8	Communication: 1: On 0: Off	Communication: 1: On 0: Off	Communication: 1: On 0: Off [1]
	7	Baudrate: 11: 1 MBaud 10: 500 kBaud 01: 250 KBaud 00: 125 kBaud	Slave address respectively address offset [2]: 0 .. 127 valid range: 3 .. 125	No function [1]
	6			
	5	Node address respectively address offset [2]: 1 ... 31		
	4			
	3			
	2			
	1			

[1]   If all DIP switches == 0: automatic start-up of EtherCAT is activated ➔ EtherCAT is switched on.
   If at least one of the DIP switches 1 to 7 <> 0 and DIP switch 8 == 0: no automatic start-up of EtherCAT
   ➔ EtherCAT is switched off.
[2]   If necessary, the addresses will be added as an offset of a predefined base address of the corresponding bus system. The base
   address can be predefined in the item Motion Soft® and can then be saved in the parameter set of the item C Series.

Please note that the module FSM 2.0 – FBA does **not** offer any safety functionalities.

6.3 FSM 2.0 – STO

6.3.1 Features

The Functional Safety Module FSM 2.0 – STO serves as an expansion of the item Servo Positioning Controller C Series.
- It reaches the function "Safe Torque Off" (STO) with SIL3 according to EN 61800-5-2 / EN 62061 / IEC 61508 or category 4 / PL e according to EN ISO 13849-1.
- It is equipped with a floating feedback contact.
- It can be simply plugged into the basic unit from the outside, so that it can be used for upgrading systems that are already equipped with item Servo Positioning Controller C 1-Series.
- It is exclusively suitable for the item C Series product range.
- It offers a user-friendly parameterisation with the item Motion Soft® software.

	DANGER!
⚠	The function STO as a sole safety function is not sufficient for drives under permanent torque, such as hanging loads.

	DANGER!
⚠	For drives, the function STO must be validated after installation and after any changes of the installation. This validation must be documented by the commissioning engineer.

6.3.2 Pin assignment [X40]

Pin no.	Name	Value	Specification
8	0V	0 V	Reference potential for internal controller supply
7	24V	+24 V DC	24 V supply out
6	C2		Feedback contact for the state "STO" to an external control
5	C1		
4	0V_B	0 V	Reference potential for STOB
3	STOB	0 V / 24 V	Control input B for the function STO
2	0V_A	0 V	Reference potential for STOA
1	STOA	0 V / 24 V	Control input A for the function STO

ℹ	The functionality of the DIP switches is identical to the functionality of the DIP switches of the module FSM 2.0 – FBA.

6.4 Mechanical installation FSM 2.0

As a standard, the item Servo Positioning Controller C 1-Series come supplied with the module FSM 2.0 – FBA (short "FBA module") integrated in the FSM slot.

You can remove the FBA module and replace it with a Functional Safety Module FSM 2.0 – STO (short "safety module").

> ⚠️ **DANGER!**
>
> The servo positioning controller must be disconnected from any current-carrying connections prior to the installation of the module.

To remove the FBA module from the servo positioning controller and then insert the safety module module, please proceed as follows:

1. Remove the two fastening screws of the FBA module with a suitable Phillips screwdriver.

2. Loosen the FBA module a few millimetres by levering it slightly at the recesses of the upper and lower edges of the front plate.

3. Remove the FBA module completely from the FSM slot.

4. Push the safety module into the open FSM slot so that the lateral guides hold the board.

5. Push the safety module into the slot and carefully into the connector at the backside of the servo positioning controller until it reaches the stop.

6. Screw the safety module onto the front side of the housing of the servo positioning controller with the two fastening screws.

7. Ensure that the front plate of the safety module has conducting contact with the housing of the servo positioning controller.

7 EMC-compliant cabling

The following must be considered for an EMC-compliant setup of the drive system:

- In the first environment, the item Servo Positioning Controller C 1-Seriesmust be installed in a steel switch cabinet. In most cases a standard model will sufficiently attenuate emitted interference. The cable shields must be connected with the switch cabinet housing by means of metal cable glands.

- In the second environment the item Servo Positioning Controller C 1-Series can also be used without a steel control cabinet. Installation in a control cabinet (possibly plastic), however, is still necessary to guarantee proper usage.

- The control cabinet bed plate must be conducting (zinc-coated design). The imperative central grounding point should also be located on the control cabinet bed plate.

- The signal lines must be as far away from the power cables as possible. They should not be placed parallel. If intersections cannot be avoided, they should be perpendicular (i.e. at a 90° angle), if possible.

- In order to keep the leakage currents and the losses in the motor connection cable as small as possible, the item Servo Positioning Controller C 1-Series should be located as close to the motor as possible (see also the following chapter).

- The shield of the motor cable is connected to the housing of the item Servo Positioning Controller C 1-Series (shield connection terminal). In the first environment the shield of the motor cable also has to be connected to the control cabinet housing by means of metal cable glands.

- The mains-end PE connection is connected to the PE connection point of the supply connection [X9].

- The inner PE conductor of the motor cable is connected to the PE connection point of the motor connection [X6].

- Motor cable and angle encoder cable must be shielded.

- Unshielded signal and control lines should not be used. If their use is inevitable they should at least be twisted.

- Even shielded cables will inevitably have short unshielded ends (unless shielded connector housings are used). In general, the following applies:

  - Connect the inner shields to the corresponding pins of the connectors; Maximum length 40 mm.

  - Length of the unshielded cores 35 mm maximum.
  - Connect the total shield on the controller side flat to the PE terminal; Maximum length 40 mm.
  - Connect the total shield on the motor side flat to the connector housing or motor housing; Maximum length 40 mm.

⚠	**DANGER!**
	For safety reasons, all PE ground conductors must be connected prior to initial operation.
	The EN 50178 regulations for protective earthing must be complied with during installation!

7.1   Operation with long motor cables

> ℹ️   Compliance with the EMC standard EN 61800-3 is only guaranteed for motor cable lengths of up to 25 m. For cable lengths beyond this a new measurement of the interference emission may possibly be required.

In applications involving long motor cables and/or unsuitable motor cables with an inadvertently high cable capacity, the filters may be thermally overloaded. To avoid such problems we highly recommend the following procedure for applications that require long motor cables:

- With cable lengths of more than 25 m use only cables with a capacitance per unit length between the motor phase and the shield of less than 150 pF/m!
  (Please contact the motor cable supplier, if necessary.)
- For motor cable lengths of more than 25 m and up to 50 m the following derating applies regardless of the EMC qualification (see also *Derating of the cable length* on page *10*):

PWM frequency	up to 5 kHz	5,5 kHz	6 kHz	7 kHz	8 kHz
Max. motor cable length	50 m	45 m	40 m	35 m	30 m

8 Additional requirements for the servo drives concerning the UL approval

This chapter gives further information concerning the UL approval of the C 1-02, C 1-05 and C 1-08.

8.1 Circuit protection

> ℹ️ In case of a required UL-certification the following data for the main fuse are to be considered:
>
> Listed Circuit Breaker according to UL 489, rated 277 Vac, 16 A, SCR 10 kA

8.2 Wiring and environment regards

- Use 60/75 or 75°C copper (CU) wire only.
- The terminal tightening torque is 0.22…0.25 Nm.
- To be used in a Pollution Degree 2 environment only.

8.3 Motor temperature sensor

> ℹ️ Motor overtemperature sensing is not provided by the drive according to UL.

When a UL-certification is required, then in order to prevent motor overtemperatures the servo drives may only be operated in connection with motors that are provided with an integrated motor temperature sensor. The sensor has to be connected to the servo drive and the temperature monitoring has to be activated accordingly on the software side.