INFRANOR
SERVO DRIVES & MOTION CONTROL

CD1-k
Installation Guide

gb

CANopen amplifier

INFRANOR®

WARNING

This is a general manual describing a series of servo amplifiers having output capability suitable for driving AC brushless sinusoidal servo motors.

Please see **CD1-k User Guide** for the operation of the amplifier (commissioning, configuration, ...).

For the CANopen communication, see manual **CD1-k – CANopen Communication Profile**.

Instructions for storage, use after storage, commissioning as well as all technical details require the MANDATORY reading of the manual before getting the amplifiers operational.

Maintenance procedures should be attempted only by highly skilled technicians having good knowledge of electronics and servo systems with variable speed (EN 60204-1 standard) and using proper test equipment.

The conformity with the standards and the "CE" approval is only valid if the items are installed according to the recommendations of the amplifier manuals. Connections are the user's responsibility if recommendations and drawings requirements are not met.

Any contact with electrical parts, even after power down, may involve physical damage.
Wait for at least 5 minutes after power down before handling the amplifiers (a residual voltage of several hundreds of volts may remain during a few minutes).

ESD INFORMATION (ElectroStatic Discharge)
INFRANOR amplifiers are conceived to be best protected against electrostatic discharges. However, some components are particularly sensitive and may be damaged if the amplifiers are not properly stored and handled.

STORAGE

- The amplifiers must be stored in their original package.
- When taken out of their package, they must be stored positioned on one of their flat metal surfaces and on a dissipating or electrostatically neutral support.
- Avoid any contact between the amplifier connectors and material with electrostatic potential (plastic film, polyester, carpet…).

HANDLING

- If no protection equipment is available (dissipating shoes or bracelets), the amplifiers must be handled via their metal housing.
- Never get in contact with the connectors

ELIMINATION
In order to comply with the 2002/96/EC directive of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE), all INFRANOR devices have got a sticker symbolizing a crossed-out wheel dustbin as shown in Appendix IV of the 2002/96/EC Directive.
This symbol indicates that INFRANOR devices must be eliminated by selective disposal and not with standard waste.

INFRANOR does not assume any responsibility for any physical or material damage due to improper handling or wrong descriptions of the ordered items.
Any intervention on the items, which is not specified in the manual, will immediately cancel the warranty.

Infranor reserves the right to change any information contained in this manual without notice.

Issue: **5.51**

Content

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Chapter 1 – General description

1 - INTRODUCTION

CD1-k all-digital amplifiers with sinusoidal PWM control are servo amplifiers that provide the control of brushless AC motors with a position sensor.

The **CD1-k** amplifier is a stand-alone single-axis block including power supply unit and mains filters. It is available in both 230 VAC and 400/480 VAC mains operated voltages.

2 - DESCRIPTION / COMPLIANCE WITH THE STANDARDS

2.1 - GENERAL DESCRIPTION

The CD1-k amplifier directly controls the motor torque and speed by means of the information provided by a high resolution position sensor (resolver or encoder). The sinusoidal current commutation based on this high resolution position sensor provides very smooth motor torque/force control.

The CD1-k amplifier can be configured for the feedback of various position sensor types. The appropriate position sensor configuration is selectable by software and saved in the amplifier.

- With a resolver sensor feedback, the motor absolute position value over one revolution is available and the servo motor can immediately be enabled after the amplifier power up.

- With a "SinCos tracks" sensor which provides two analog Sin and Cos signals electrically compliant with the SinCos encoder signals and which period is equal to the motor pole pitch, the servo-motor can be immediately enabled after the powering of the drive.

- With an absolute single-turn SinCos encoder feedback (Heidenhain ERN 1085 or compliant), the servo motor can also immediately be enabled after the amplifier power up.

- With an incremental encoder only, a motor phasing procedure (**Phasing**) must be executed at each amplifier power up before the motor enabling.

- With an incremental encoder + Hall Effect Sensors (HES) feedback, the motor phasing procedure is no more necessary and the servo motor can immediately be enabled after the amplifier power up.

- With an absolute single-turn, multi-turn or linear encoder using the ENDAT or HIPERFACE communication protocols and fitted with incremental SinCos outputs, the servo-motor can also be immediately enabled after the powering of the drive.

Series CD1-k amplifiers have their own DC/DC converter to provide appropriate logic voltage to the modules. An auxiliary 24VDC +/- 15 % supply is generally available on all machines and supplies a DC/DC converter with all logic supplies required by the amplifier. The auxiliary supply allows to keep the logic board on, after the power supply has been switched off, in order to keep the position output and to avoid initializing the machine all over again. A 24 VDC battery supply with specific wiring allows to keep the position even after switching off the auxiliary 24 VDC supply. This wiring can be used for "absolute" operation with the CD1-k amplifier (see chapter 4: Connections).

The power supply is depending on the amplifier type:

- CD1-k-230/I: 230 VAC single-phase mains operation power supply or three-phase via a transformer or an auto-transformer or three-phase mains operation if there are three-phase mains available in 200 to 230 VAC.

- CD1-k-400/I: 400 to 480 VAC three-phase mains operated power supply.

A soft start system of the power supply allows to limit the inrush current at power on.

The very small dimensions of the CD1-k amplifier allow an optimum integration in 300 mm deep cabinets (connectors included).

2.2 - REFERENCE TO THE STANDARDS: "CE" CERTIFICATION

Series CD1-k amplifiers have been approved with regard to their conformity with the Electromagnetic Compatibility standards concerning the power servos referenced in the EN 61800-3 standard "Electrical variable speed power servo systems":

- EN 55011, group 1, class A, regarding radiated radioelectric disturbances,
- EN 61000.4-2-3-4-5 regarding immunity.

Standard to be applied to the electrical equipment of industrial machines: EN 60204-1.

These items have been "CE" marked since year 2000.

2.3 - REFERENCE TO THE STANDARDS: "UL" LISTING

CD1-k series have been « $_{c}UL_{us}$ » listed according to UL508C and UL840 regarding the insulator.
This product was evaluated to:

- the Third Edition of UL508C, the UL Standard for Power Conversion Equipment, dated May 2002 for the UL Listing (USL),
- the CSA Standard for Industrial Control Equipment, C22.2 N° 14-95, dated August 1995 for the Canadian UL Listing (CNL).

Providing that the manual is specifying that the end user has to provide an isolated power supply, for 24 VDC auxiliary input protected by a 4 A UL Listed fuse, the power board is considered within a limited voltage/current circuit per section 31.4 of UL508C. Therefore, spaces on the power board are not required to be evaluated per **section 31.2 of UL508C and were evaluated according to UL 840.**

Per UL 840 (Second Edition, dated May 20, 1993) requirements, spaces are limited to 2.5 mm assuming pollution degree 2 environment.

Ground connection is fixed in the frame of the device by a rivet, Avibulb masse, BN10-5168. The connector complies with standard dimensions given in table 6.2 of UL 310, the standard for Electrical Quick connect terminals.

3 - OTHER DOCUMENTS REQUIRED FOR THE COMMISSIONING

- CD1-k User Guide,
- CANopen communication protocol for CD1-k amplifiers.
- "CD1-a/CD1-k SinCos track feedback" application note regarding the use of motors equipped with "SinCos tracks" position sensors.
- "CD1-a/CD1-k absolute encoders feedback" application note regarding the use of absolute single-turn, multi-turn or linear encoders using the ENDAT or HIPERFACE Communication protocols.

Chapter 2 – Specifications

1 - MAIN TECHNICAL DATA

1.1 – CD1-k-230/I SINGLE-AXIS AMPLIFIER

Mains operated power supply voltage	230 Vac +10 % / -15 % single-phase or 3-phase 50 to 60 Hz
Isolated auxiliary logic and motor brake supply voltage	24 Vdc +/-15 % - 320 mA without brake
Motor phase-phase output voltage	200 Vrms
Integrated braking system	**External** resistor 100 Ohm / 100 W (dp 100/100) Minimum resistance: 50 Ohm
Minimum inductance between phases	1 mH

OUTPUT CURRENT RATINGS (at a maximum room temperature of 40°C)

Amplifier type	Max. output current (Arms) for 1 sec. +/- 5 % (230 VAC)	Rated output current (Arms) (230 VAC)	Power losses (W)	Rated input current (Arms) (230 VAC, 60 Hz)	Max. protection fuses for line circuit RK5 listed (Bussman / Littelfuse)	Short-circuit power of the mains	UL listed
CD1-k-230/2.25	2.25	1.1	25	1.1	6 A	5 kA	yes
CD1-k-230/4.5	4.5	2.25	30	2.25	6 A	5 kA	yes
CD1-k-230/7.5	7.5	3.75	44	3.75	6 A	5 kA	yes
CD1-k-230/10.5	10.5	5.25	55	5.25	6 A	5 kA	yes
CD1-k-230/16.5	16.5	8.25	66	8.25	9 A	5 kA	yes

1.2 - CD1-K-400/I SINGLE-AXIS AMPLIFIER

Mains operated power supply voltage	400 to 480 Vac +10 % / -15 % 3-phase, TN or TT system with earthed neutral point 50 to 60 Hz (phase-earth voltage must be balanced)
Auxiliary logic and motor brake supply voltage	24 Vdc +/-15 % - 320 mA without brake
Motor phase-phase output voltage	380 to 460 Vrms depending on the mains
Integrated braking system	CD1-k-400/1.8 to 7.2 A: **External** resistor: 200 Ohm / 100 W (dp 200/100) CD1-k-400/14 A: **External** resistor: 50 Ohm / 200 W (dp 50/200) CD1-k-400/30/45/70 and 90 A: **External** resistor : 33 Ω/280 W (dp 33/280)
Minimum inductance between phases	2 mH

OUTPUT CURRENT RATINGS (at a maximum room temperature of 40°C)
Output voltage range for 400-480 VAC (rms) three-phase mains
Output current range: 1.8 A, 2.7 A, 5.1 A, 7.2 A, 14 A, 30 A, 45 A, 70 A, 90 A (rms)

Amplifier type	**Max. output current (Arms) for 1 sec. +/- 5 % (480 VAC)**	**Rated output current (Arms) (480 VAC)**	**Power losses (W)**	**Rated input current (Arms) (480 VAC, 60 Hz)**	**Max. protection fuses for line circuit RK5 listed (Bussman / Littelfuse)**	**Short-circuit power of the mains**	**UL listed**
CD1-k-400/1.8	1.8	0.9	35	0.9	2 A	5 kA	yes
CD1-k-400/2.7	2.7	1.35	43	1.35	2 A	5 kA	yes
CD1-k-400/5.1	5.1	2.55	71	2.55	4 A	5 kA	yes
CD1-k-400/7.2	7.2	3.6	93	3.6	4 A	5 kA	yes
CD1-k-400/14	14	7	200	7	8 A	5 kA	yes
CD1-k-400/30	30	15	400	15	20 A	5 kA	yes
CD1-k-400/45	45	20	560	20	20 A	5 kA	yes
CD1-k-400/70	70	35	650	35	40 A	5 kA	no
CD1-k-400/90	90	35	650	35	40 A	5 kA	no

1.3 – COMMON SPECIFICATIONS TO THE CD1-k-230/I AND CD1-k-400/I AMPLIFIER TYPES

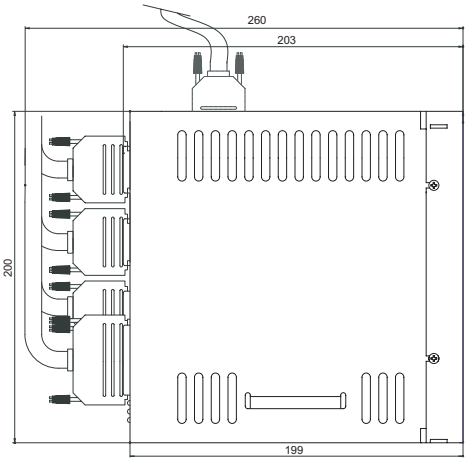
Servo loops: current, speed and position	Digital
Mains filter on power supply	Integrated in the amplifier
Common mode filter on auxiliary supply	Integrated in the amplifier
Common mode filter on motor brake supply	Integrated in the amplifier
Position sensor	Transmitter resolver Absolute single-turn encoder (ERN1085 or compliant) Incremental encoder (TTL or SinCos signals) Incremental encoder + Hall Effect Sensors
Power stage protections	See table of the main protections in the CD1-k User Guide
Motor brake control	1.5 A maximum with 24 Vdc.
PWM switching frequency	8 kHz
Minimum inductance between phases	1 mH pour 230 V / 2 mH pour 400 V
Digital current regulator (PI)	Adjustable
Current loop bandwidth	Cut-off frequency for 45° phase shift: 1000 Hz
Internal current limitation	Imax: 20 % to 100 % and I rated: 20 % to 50 % Authorized Imax duration = 1 second
Digital speed and position regulators	Sampling period = 0.5 ms Anti-wind-up system of the integrator Adjustable digital gains
Speed loop bandwidth	Selectable cut-off frequency for 45° phase shift: 50 Hz, 75 Hz or 100 Hz
Max. motor speed	Adjustable from 100 rpm to 25 000 rpm
Resolver input	Resolution : 65536 ppr (16 bit) Excitation frequency: 8 kHz Transformation ratio: 0.3 to 0.5 (other values need factory adjustment)

Encoder input	Software selectable: Quadrature signals A & B with Z marker pulse RS 422 line receiver Maximum pulse frequency: 1 MHz Resolution: 500 to 10^6 ppr Incremental Sin/Cos encoder Heidenhain 1Vcc Sin/Cos type or compliant Maximum signal frequency: 200 kHz Resolution: 500 to 10^6 ppr Interpolation factor : 1024 Absolute single-turn Sin/Cos encoder Heidenhain ERN 1085 or compliant Maximum signal frequency: 200 kHz Resolution: 2048 or 512 ppr Interpolation factor : 1024
Pulse & Direction input	Re-configuration of the encoder input for stepper motor emulation: Line receiver RS-422 Maximum pulse frequency: 1 MHz Resolution: 200 to 10^6 pitch/revolution
Hall sensors input	Software selectable: 120° or 60° HES type 5 V or 12 V supply voltage HES sequence error detection
Logic inputs	INHIBIT FC+ and FC- limit switches INDEX CAPTURE LOW SPEED
Logic outputs	4 logic outputs activated by bus
Relay outputs	Relay contact: open if error Umax = 50 V, Imax = 100 mA, Pmax = 10 W
Open collector output protected against load short-circuit	Motor brake coil with 24 VDC/1.5 A
Analog inputs	Re-configuration of the logic outputs by means of jumpers: +/- 10 V, resolution = 14 bits
Encoder position output	Re-configuration of the TTL encoder input via CANopen: Two A and B channels in quadrature + 1 marker pulse per revolution RS 422 line driver Programmable resolution: 64 ppr to 16384 ppr (according to the maximum motor speed) Arc minute accuracy = (8 + 5400/Resolution) Note: The total position accuracy must take into account the accuracy of the resolver used.
CAN interface	CANopen protocol (DS 301 – DSP 402)
Error display	LEDs on front panel + diagnostic via serial link RS 232 + diagnostic via CANopen.
Motor and application parameter setting	Serial link RS 232 or bus interface with CANopen protocol
Automatic functions	Amplifier adjustment to the motor (AUTO-PHASING) Servo control adjustment (AUTO-TUNING)

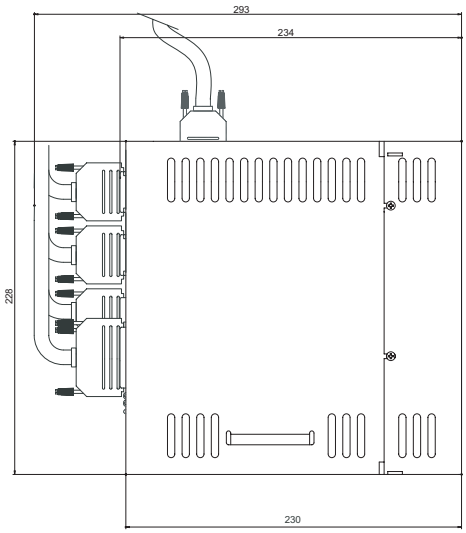
Compliance with the standards: **CE** certification. 360° shield connection, equipotentiality according to the wiring rules.	EMC standards: - immunity: EN 61000.4-2-3-4-5 - conducted and radiated disturbances: EN 55011, Group 1, class A Electrical standards for industrial machines: - EN 60204-1: insulator 1500 Vac / 1 mn leakage current > 30 mA (EMI filters).
Conformity with the standards: **UL** listing "360°" shield; equipotentiality according to the wiring rules.	CD1-k series have been "$_{c}$UL$_{us}$" listed according to UL508C and UL840 regarding the insulator. This product was evaluated to: - the Third Edition of UL508C, the UL Standard for Power Conversion Equipment, dated May 2002 for the UL Listing (USL), - the CSA Standard for Industrial Control Equipment, C22.2 N° 14-95, dated August 1995 for the Canadian UL Listing (CNL).
Temperature - storage: -20° C to +70° C - operation: +5° C to +40° C	From 40° C, the rated currents must be reduced of 3 % per additional Celsius degree Max. temperature: 50° C
Altitude	1000 m
Moisture	< 50% to 40° C and < 90% to 20° C: EN 60204-1 standard **Condensation prohibited (storage and operation)**
Cooling	Forced air (fan integrated in the CD1-k amplifier) Check for free ventilation and no upper or lower obstruction of the air admissions
Mounting position	Vertical
Environment	Open chassis to be mounted in a housing protecting the amplifier from conducting dust and condensation (pollution degree 2 environment)
Mounting location	Closed cabinet without any conducting and/or corroding agents and according to the environment conditions requirements **Condensation prohibited**
Weight	CD1-k-230/l: about 1 kg CD1-k-400/1.8 to 7.2 A: about 1.5 kg CD1-k-400/14: about 3 kg CD1-k-400/30 and 45: about 4.8 kg CD1-k-400/70 and 90: about 5.3 kg

2 - DIMENSIONS

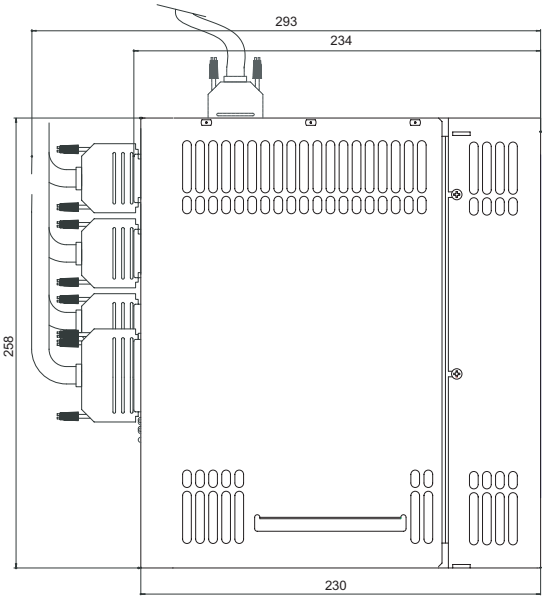
2.1 - CD1-k-230/I AMPLIFIER



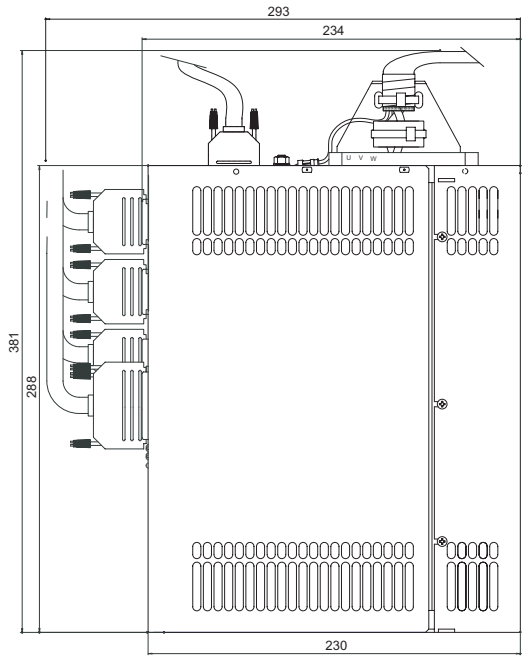
2.2 - CD1-k-400/1.8 TO 7.2 A AMPLIFIER



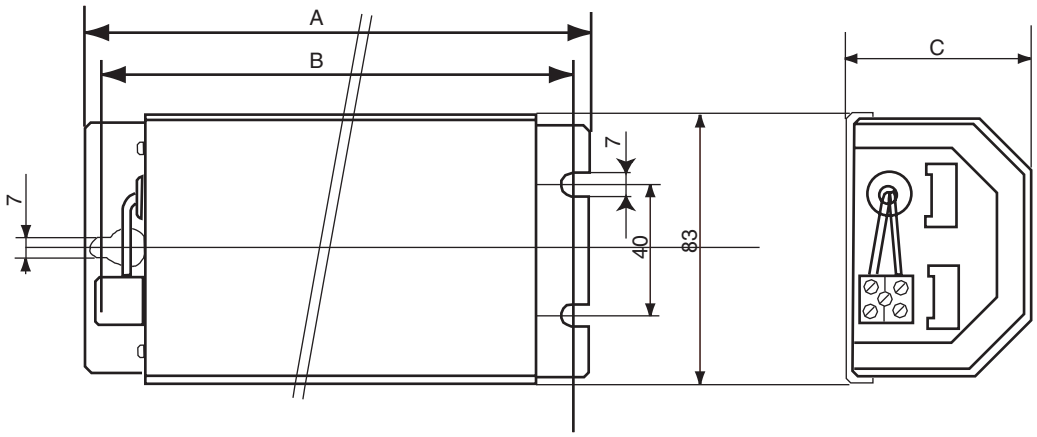
2.3 - CD1-k-400/14 A AMPLIFIER



2.4 - CD1-k-400/30/45/70 AND 90 A AMPLIFIER



2.5 - BRAKING RESISTOR dp 100/100, dp 200/100, dp 50/200 AND dp33/280

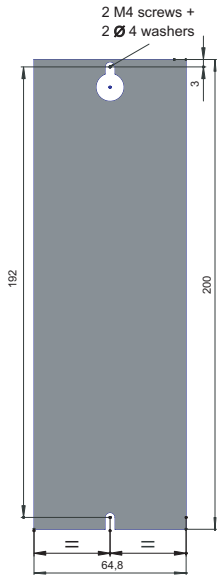


DIMENSIONS	dp 50/200, dp 100/100 and dp 200/100	dp 33/280
A	157 mm	290 mm
B	145 mm	278 mm
C	52 mm	57 mm

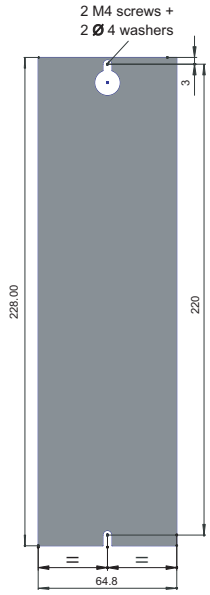
3 - FASTENING

VERTICAL MOUNTING MANDATORY!

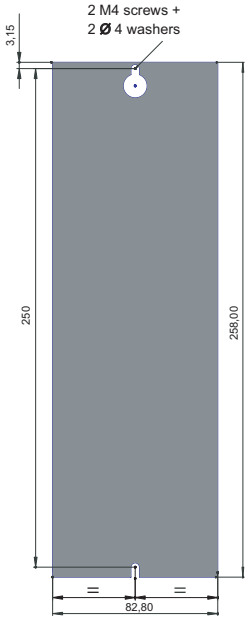
3.1 - CD1-k-230/I AMPLIFIER



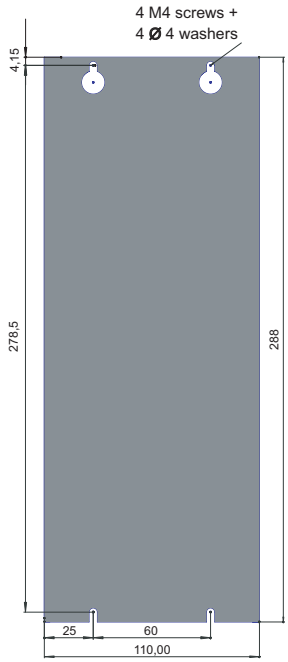
3.2 - CD1-k-400/1.8 TO 7.2 A AMPLIFIER



3.3 - CD1-k-400/14 A AMPLIFIER

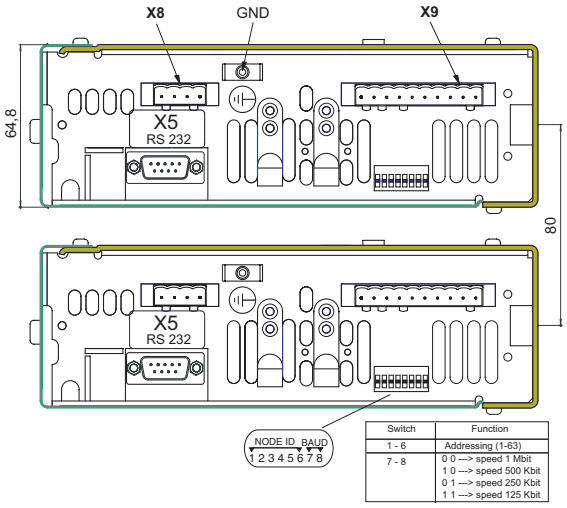


3.4 - CD1-k-400/30/45/70 AND 90 A AMPLIFIER

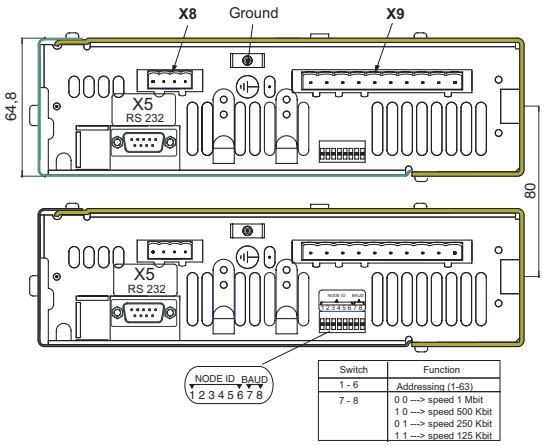


4 - MULTIAXIS CABINET MOUNTING

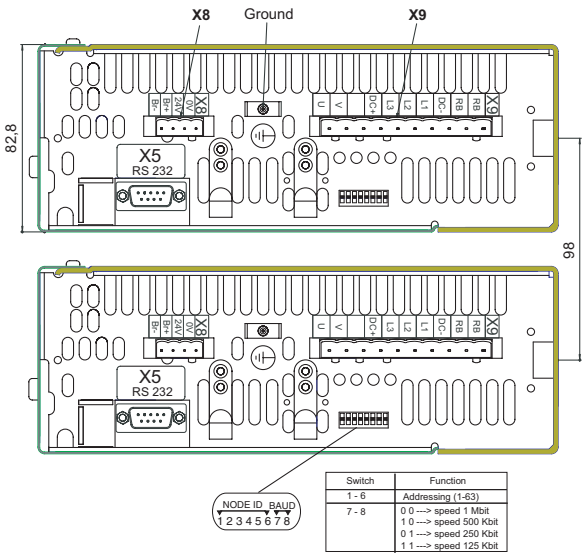
4.1 - CD1-k-230/I AMPLIFIER



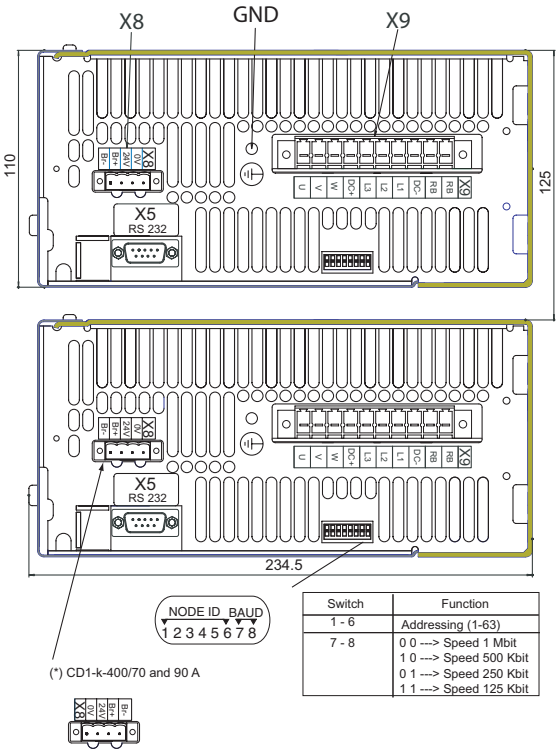
4.2 - CD1-k-400/1.8 TO 7.2 A AMPLIFIER



4.3 - CD1-k-400/14 A AMPLIFIER



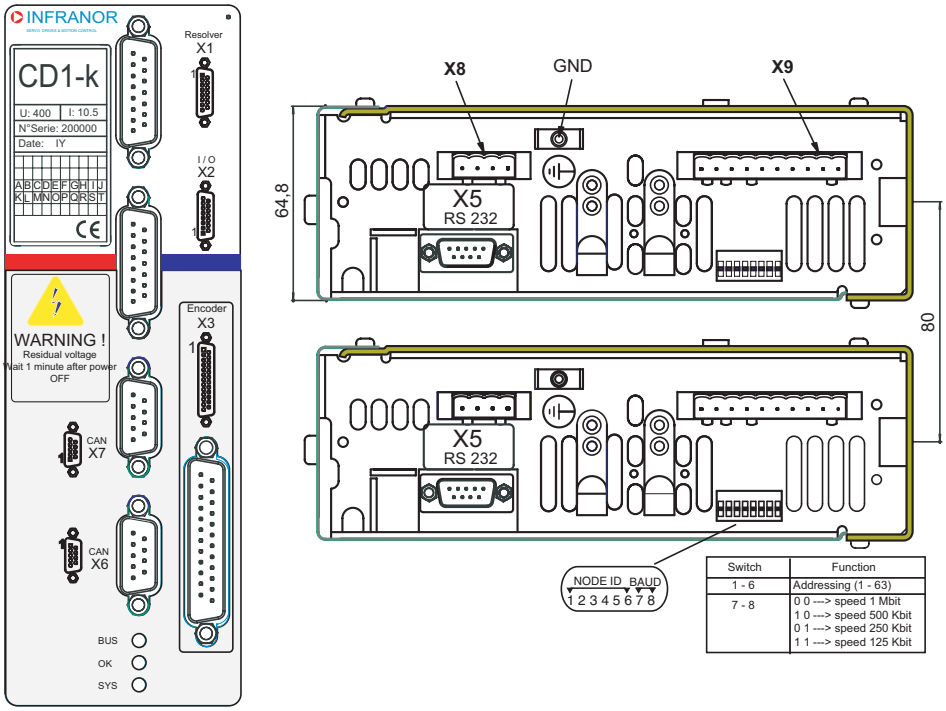
4.4 - CD1-k-400/30/45/70 AND 90 A AMPLIFIER



Chapter 3 – Inputs-Outputs

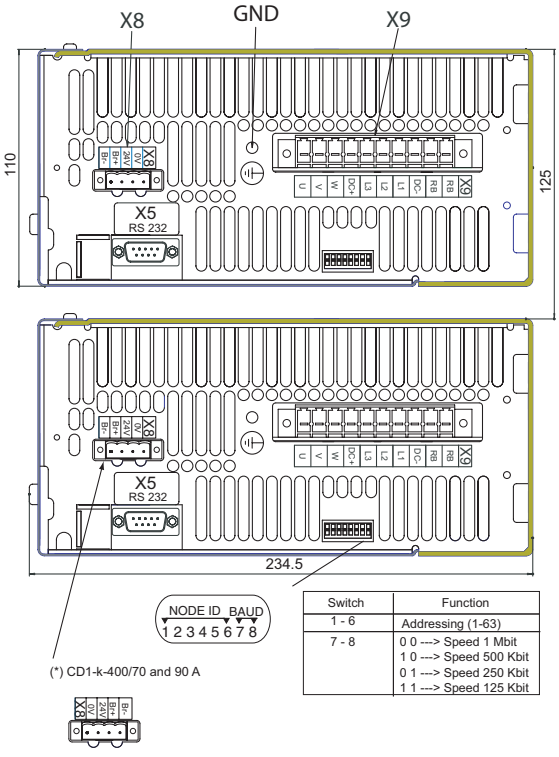
1 - CONNECTORS LOCATION

1.1 - SINGLE-AXIS AMPLIFIERS CD1-k-230-I AND CD1-k-400-I



Switch	Function
1 - 6	Addressing (1 - 63)
7 - 8	0 0 ---> speed 1 Mbit 1 0 ---> speed 500 Kbit 0 1 ---> speed 250 Kbit 1 1 ---> speed 125 Kbit

1.2 – CD1-k-400/30/45/70 AND 90 AMPLIFIER



Switch	Function
1 - 6	Addressing (1-63)
7 - 8	0 0 ---> Speed 1 Mbit 1 0 ---> Speed 500 Kbit 0 1 ---> Speed 250 Kbit 1 1 ---> Speed 125 Kbit

2 - LED DISPLAY

2.1 - IDENTIFICATION OF THE LEDs

BUS (green)
OK (green)
SYS (red)

SYS: System error

SYS LED is continuously lit if System error,
SYS LED is unlit if no error.

OK: Errors are regrouped on the 'OK' LED: These errors are coded and can be displayed by means of the parameter setting software, via the serial link RS-232 or via the CANopen bus.

OK LED: continuously flashing if error,
OK LED: continuously lit if no error.

The **OK** LED groups the following errors:

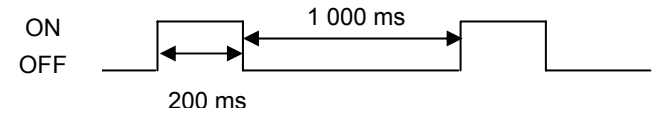
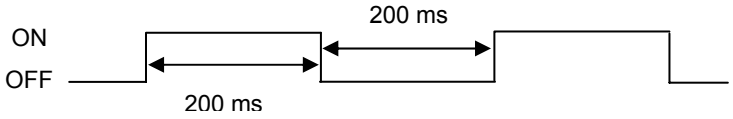
Undervoltage (quick flashing)
Power supply overvoltage
Out of 24 Vdc supply range (18 to 29 V),
Motor phase / GND short-circuit
Braking system short-circuited or overheated
Fan
Motor phase / motor phase short-circuit, power stage temperature, power stage supply, PWM error
Triggering of the I^2t protection
Counting error
Position following error
Low speed overshoot
EEPROM error
Procedure execution error (busy)
Init-400 V error
Current offset error
Motor temperature error
Resolver or encoder cable interruption
Hall sensors or absolute encoder error.

Notes:

Any of these errors (except for the "Undervolt." error) involves:
- the slow flashing of the **OK** Led
- the amplifier disabling,
- the motor brake control,
- opening of the **AOK** relay contact. This relay must be wired as described in Chapter 5, section 3, in order to switch-off the power supply and keep a zero type standstill.

The error "No power voltage" involves:
- the amplifier disabling,
- the motor brake control.

BUS: CANopen RUN LED
The CANopen RUN LED indicates the status of the NMT state machine (see DS-301 – 9.52 NMT state machine):

CAN RUN LED	STATUS	
SINGLE FLASH	STOP	
FLASHING	PRE-OPERATIONAL	
ON	OPERATIONAL	

See "DR-303-3 Indicator specification" for more information.

3 - AMPLIFIER ADDRESSING: SELECTION OF THE TRANSMISSION SPEED

Each amplifier of the network must be configured with one single address.
A DIP8 switch accessible by the operator allows to configure the amplifier address as well as the communication speed of the "**CANopen**" bus.

- Addressing (6 selection bits)

Status of the cursors						Address
6	**5**	**4**	**3**	**2**	**1**	
OFF	OFF	OFF	OFF	OFF	OFF	0
OFF	OFF	OFF	OFF	OFF	ON	1
OFF	OFF	OFF	OFF	ON	OFF	2
...	...	...	...	...	...	...
ON	ON	ON	ON	ON	ON	63

- Communication speed (2 selection bits):

Status of the cursors		Speed
8	**7**	
OFF	OFF	1 Mbit
OFF	ON	500 Kbits
ON	OFF	250 Kbits
ON	ON	125 Kbits

Note:
- The "**00**" address is only to be used in **Local** mode.
- An address ≠ **00** is to be used in **Remote** mode (use of the **CANopen** bus).

4 - X1 CONNECTOR: RESOLVER SENSOR

SUB D 15 PINS FEMALE (SAME FOR ALL AMPLIFIER TYPES CD1-k-230/I AND CD1-k-400/I)

PIN	FUNCTION	DESCRIPTION
1	Shield connection	If no "360°" connection on the connector
2	S3 (cosine +)	Resolver connector
3	S4 (sine -)	Resolver connector
4	R2 (reference -)	Resolver connector
5	R1 (reference +)	Resolver connector
10	S1 (cosine -)	Resolver connector
11	S2 (sine +)	Resolver connector
12	TC (thermal sensor)	If motor thermal switch connected on X1
13	TC (thermal sensor)	If motor thermal switch connected on X1

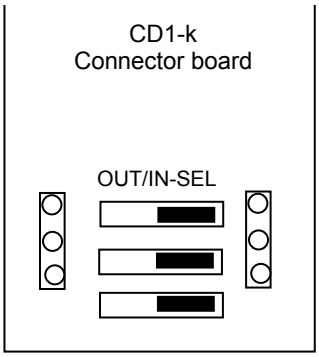
For the connection of other resolver types, see chapter 5, section 2.

5 - X2 CONNECTOR: INPUTS-OUTPUTS

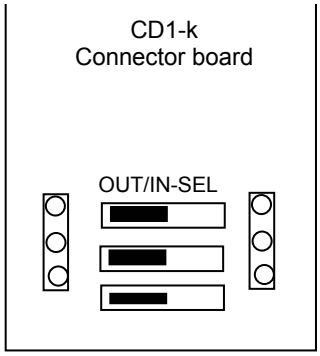
SUB D 15 PINS MALE (SAME FOR ALL AMPLIFIER TYPES CD1-k-230/I AND CD1-k-400/I)

PIN	SIGNAL	I/O	DESCRIPTION
1	INHIBIT	I	Positive logic - Galvanic insulation
2	GND	I	For the shield connection if no "360°" connection
3	Limit switch +	I	Positive logic - Galvanic insulation
4	Limit switch -	I	Positive logic - Galvanic insulation
5	Output 3 / Analog input 1	O/I	Optocoupled logic output ; I = 100 mA Re-configurable as an analog input by jumper
6	Low speed	I	Positive logic - Galvanic insulation
7	Capture 2 Index	I	Positive logic - Galvanic insulation
8	Capture 1	I	Positive logic - Galvanic insulation
9,10	AOK relay contact	O	Relay contact open if error Pmax = 10 W with Umax = 50 V or Imax = 100 mA
11	Output 0	O	Optocoupled logic output ; I = 100 mA
12	Output 1	O	Optocoupled logic output ; I = 100 mA
13	Output 2 / Analog input 2	O/I	Optocoupled logic output ; I = 100 mA Re-configurable as an analog input by jumper
14	+ 24 external	I	To be wired if the logic outputs are used
15	0 V external	I	

Both analog inputs 1 and 2 are configurable by means of the OUT/IN-SEL jumpers located on the amplifier connector board as shown below. The values of the analog inputs can be read via the CANopen bus.



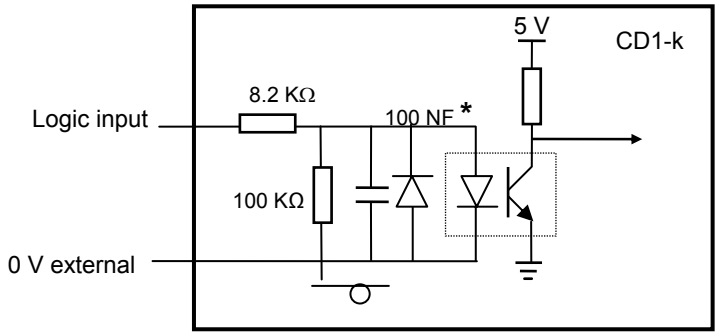
Logic outputs selection



Analog inputs selection

Note: There are only two jumpers on some connector boards for the "Logic outputs / Analog inputs" selection.

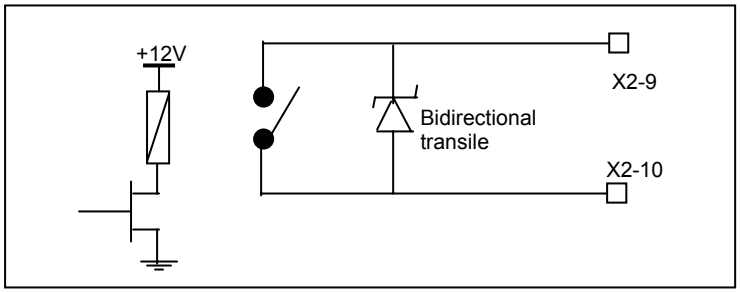
5.1 - SPECIFICATION OF THE LOGIC INPUTS: INHIBIT, FC+, FC-, INDEX, CAPTURE, LOW SPEED



(*): 100 pF for Index and Capture

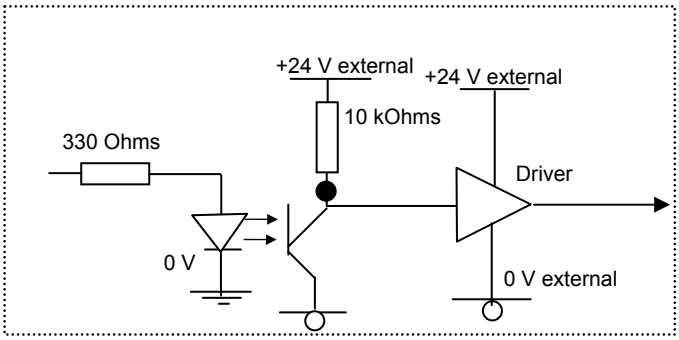
These optocoupled inputs are operating in positive logic.
The input voltage corresponding to level 1 must be between 18 V and 30 V.

5.2 - SPECIFICATION OF THE LOGIC OUTPUT "AOK" ON RELAY

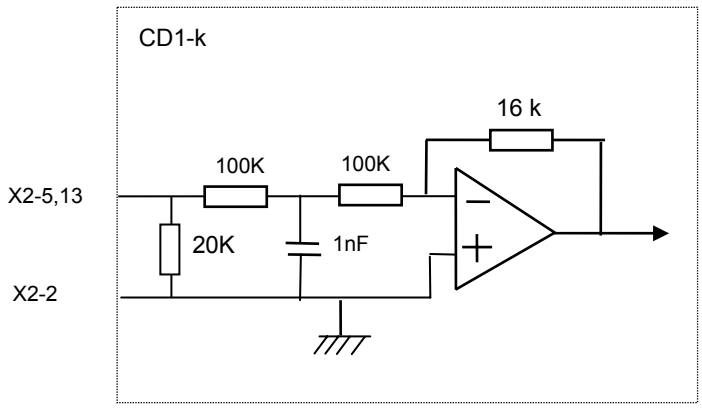


Relay contact closed if amplifier OK and open if error.
Pmax = 10 W with Umax = 50 V - Imax = 100 mA

5.3 - SPECIFICATION OF THE LOGIC OUTPUTS



5.4 - SPECIFICATION OF THE ANALOG INPUTS



6 - X3 CONNECTORS: ENCODER

SAME CONNECTORS FOR ALL CD1-k-230/I AND CD1-k-400/I AMPLIFIER TYPES

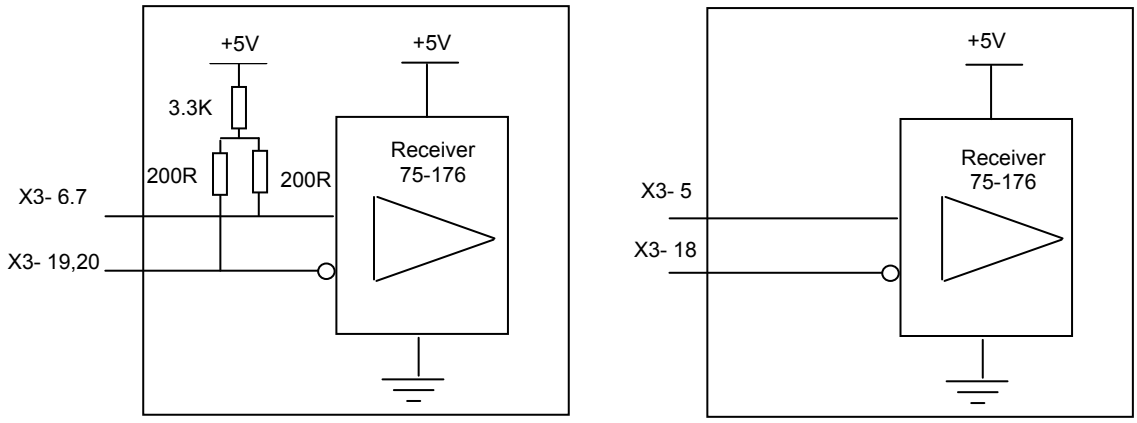
6.1 - X3 CONNECTOR FOR TTL INCREMENTAL ENCODER & HES INPUT (Sub D 25 pins female)

The " TTL incremental encoder & HES" configuration is software selectable and stored into the amplifier EEPROM.

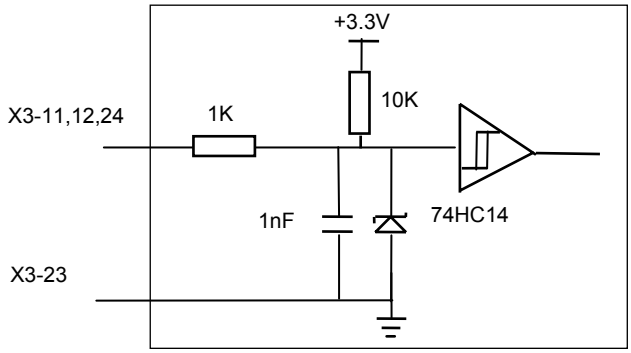
The corresponding X3 connector pin functions are described below.

PIN	FUNCTION	REMARKS
18	Marker Z/	Differential input of the encoder marker pulse Z/
5	Marker Z	Differential input of the encoder marker pulse Z
19	Channel A/	Differential input of the encoder channel A/
6	Channel A	Differential input of the encoder channel A
20	Channel B/	Differential input of the encoder channel B/
7	Channel B	Differential input of the encoder channel B
8	+5 V	Encoder supply voltage (max. current = 300 mA)
21	GND	Encoder supply GND
11	HALL U	Hall sensor input signal phase U
24	HALL V	Hall sensor input signal phase V
12	HALL W	Hall sensor input signal phase W
10	+12 V	Hall sensors supply voltage: output impedance = 9 Ohm, max. 150 mA available
23	AGND	Hall sensors supply GND
9	TC+	Motor thermal sensor input
22	TC-	Motor thermal sensor input
others	reserved	

ENCODER INPUT LINES SPECIFICATION



HALL SENSORS INPUT LINES SPECIFICATION



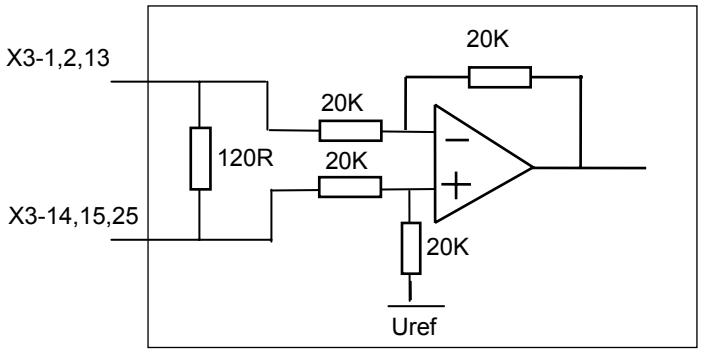
6.2 - X3 CONNECTOR FOR SinCos INCREMENTAL ENCODER & HES INPUT (Sub D 25 pins female)

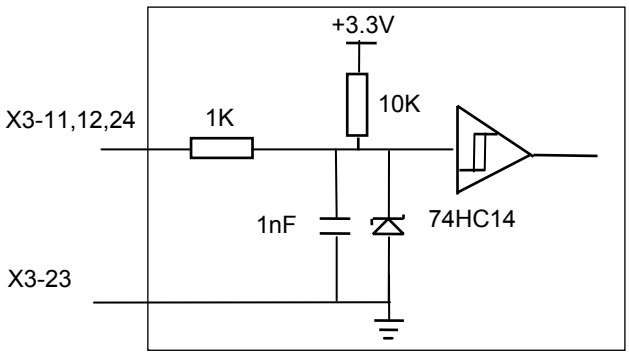
The " SinCos & HES" incremental encoder configuration is software selectable and stored in the amplifier EEPROM.

The corresponding X3 connector pin function is described below.

PIN	FUNCTION	REMARKS
25	Marker R/	Differential input of the Sin/Cos encoder reference pulse R/
13	Marker R	Differential input of the Sin/Cos encoder reference pulse R
14	Channel A/	Differential input of the Sin/Cos encoder channel A/
1	Channel A	Differential input of the Sin/Cos encoder channel A
15	Channel B/	Differential input of the Sin/Cos encoder channel B/
2	Channel B	Differential input of the Sin/Cos encoder channel B
8	+5 V	Encoder supply voltage: output impedance = 9 Ohm, max. 150 mA available
21	GND	Encoder supply GND
11	HALL U	Hall sensor input signal phase U
24	HALL V	Hall sensor input signal phase V
12	HALL W	Hall sensor input signal phase W
10	+12 V	Hall sensors supply voltage: output impedance = 9 Ohm, max. 150 mA available
23	AGND	Hall sensors supply GND
9	TC+	Motor thermal sensor input
22	TC-	Motor thermal sensor input
others	reserved	

SIN/COS ENCODER CHANNELS SPECIFICATION





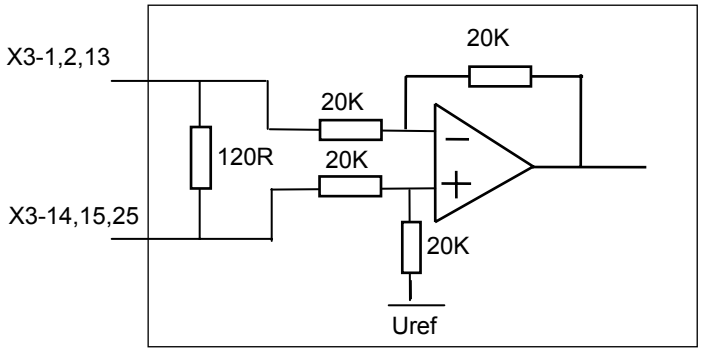
6.3 – X3 CONNECTOR FOR ABSOLUTE SINGLE-TURN SinCos ENCODER (Sub D 25 pins female)

The " SinCos absolute single-turn" incremental encoder configuration (Heidenhain ERN 1085 or compliant) is software selectable and stored in the amplifier EEPROM.

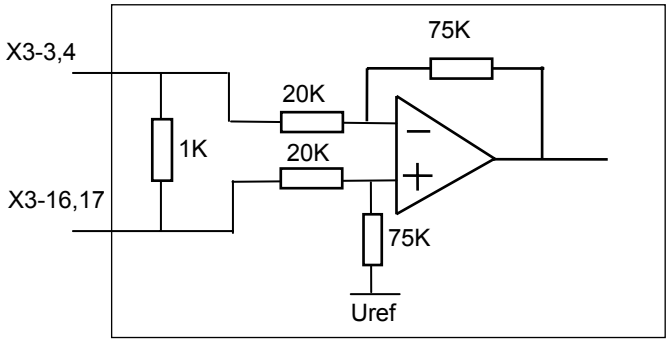
The corresponding X3 connector pin function is described below.

PIN	FUNCTION	REMARKS
25	Marker R/	Differential input of the Sin/Cos encoder reference pulse R/
13	Marker R	Differential input of the Sin/Cos encoder reference pulse R
14	Channel A/	Differential input of the Sin/Cos encoder channel A/
1	Channel A	Differential input of the Sin/Cos encoder channel A
15	Channel B/	Differential input of the Sin/Cos encoder channel B/
2	Channel B	Differential input of the Sin/Cos encoder channel B
16	Channel C/	Differential input of the Sin/Cos encoder channel C/
3	Channel C	Differential input of the Sin/Cos encoder channel C
17	Channel D/	Differential input of the Sin/Cos encoder channel D/
4	Channel D	Differential input of the Sin/Cos encoder channel D
8	+5V	Encoder supply voltage (max. current = 300 mA)
21	GND	Encoder supply GND
9	TC+	Motor thermal sensor input
22	TC-	Motor thermal sensor input
others	reserved	

SIN/COS ENCODER CHANNELS SPECIFICATION



SIN/COS COMMUTATION CHANNELS SPECIFICATION



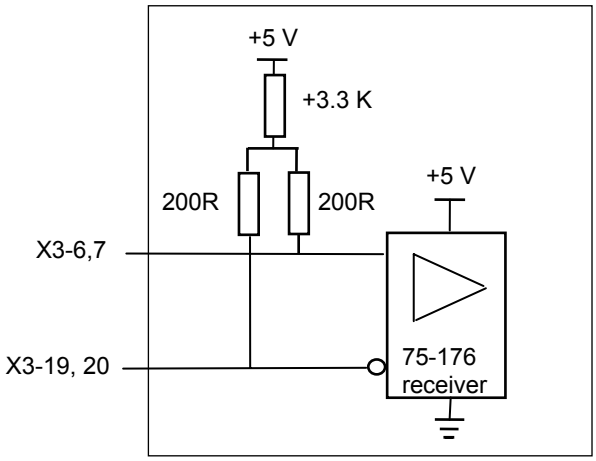
6.4 - X3 CONNECTOR FOR "PULSE / DIRECTION" INPUTS (Sub D 25 pins female)

The configuration of the "Pulse / Direction" inputs is software selectable and stored in the amplifier EEPROM.

The corresponding X3 connector pin function is described below.

PIN	FUNCTION	REMARKS
19	PULSE/	Differential input of the PULSE/ channel
6	PULSE	Differential input of the PULSE channel
20	DIR/	Differential input of the DIR/ channel
7	DIR	Differential input of the DIR channel
others	reserved	

SPECIFICATION OF THE PULSE AND DIRECTION SIGNALS



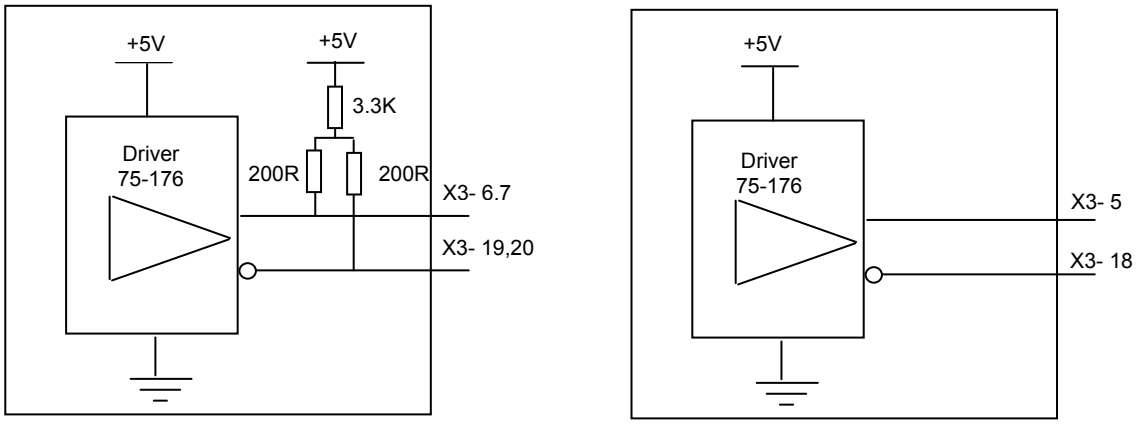
6.5 - X3 CONNECTOR FOR ENCODER OUTPUT (Sub D 25 pins female)

At power on, the differential channels A, B and Z are configured as encoder inputs. The configuration as encoder outputs must be enabled via the CANopen bus.

The corresponding X3 connector pin function is described below.

PIN	FUNCTION	REMARKS
19	Channel A/	Differential output of channel A/
6	Channel A	Differential output of channel A
20	Channel B/	Differential output of channel B/
7	Channel B	Differential output of channel B
18	Marker Z/	Differential output of channel Z/
5	Marker Z	Differential output of channel Z
21	GND	0 V reference of the amplifier
others	reserved	

SPECIFICATION OF THE ENCODER OUTPUT SIGNALS



7 - X6 AND X7 CONNECTORS: CAN-OPEN

SUB D 9 PINS MALE AND FEMALE (SAME FOR ALL AMPLIFIER TYPES CD1-k-230/I AND CD1-k-400/I)

PIN	SIGNAL	DESCRIPTION
2	CAN-L	CAN-L line (dominant low)
3	CAN-GND	CAN Ground
7	CAN-H	CAN-H line (dominant high)

8 - X5 CONNECTOR: RS-232

SUB D 9 PINS MALE (SAME FOR ALL AMPLIFIER TYPES CD1-k-230/I AND CD1-k-400/I)

PIN	FUNCTION	DESCRIPTION
5	0 Volt	GND (shield connection if no "360°" connection on the connector)
3	TXD	Transmit data RS-232
2	RXD	Receive data RS-232

9 - X8 CONNECTOR: AUXILIARY SUPPLY AND BRAKE

SAME CONNECTOR FOR CD1-k-230/I AND CD1-k-400/I AMPLIFIER TYPES

4 pin male connector with 5.08 mm pitch (female connector provided).
Tightening torque of the connector screws: 0.5 Nm.

PIN	SIGNAL	I/O	FUNCTION	DESCRIPTION	
1	GND	I	Potential reference of the 24VDC supply	Grounded potential reference	
2	+24 Vdc	I	24 VDC auxiliary supply (mains isolated)	24 Vdc +/-15% - 0,320 A without brake Regulation with load: 3%	UL: Protection by 4A UL fuse
3	Brake + 24 V	O	Motor brake supply with 24 VDC	Powerless brake: 24 Vdc / 1.5 A	
4	Brake -	O	Direct motor brake control Imax = 1.5 A	Grounded brake load	

10 - X9 CONNECTOR: POWER

CD1-k-230/I: 10 pins male connector with 5.08 mm pitch (female connector provided).
CD1-k-400/I: 10 pins male connector with 7.62 mm pitch (female connector provided).
CD1-k-400/70 and 90: 10 pins male connector (with10.16 mm pitch).
Female connectors supplied in 2 parts: 7 pins female, pins 1 to 7 and 3 pins female, pins 8 to 10 for the motor

Tightening torque of the connector screws: 0.5 Nm.

PIN	SIGNAL	I/O	FUNCTION	DESCRIPTION
1	RB	O	Energy dissipation at the motor braking with high inertia and high speed	CD1-k-230/I: 100 Ω / 100 W (dp 100/100) CD1-k-400/1.8 to 7.2: 200 Ω / 100 W (dp 200/100) CD1-k-400/14: 50 Ω / 200 W (dp 50/200) CD1-k-400/30/45/70 and 90: 33 Ω / 280 W (dp 33/280) The braking resistors must be separately ordered.
2	RB	O		
3	DC-	I/O	Parallel connection of the DC bus	
4	L1	I	Mains input **Integrated mains filter**	**CD1-k-230/I 230 Vac single-phase or three-phase** **CD1-k-400/I 400 to 480 Vac three-phase**
5	L2	I		
6	L3	I		
7	DC+	I/O	Parallel connection of the DC bus	
8	W	O	Motor W phase	Motor cable with grounded connection by means of Faston socket and 360° shield connection on grounded collar
9	V	O	Motor V phase	
10	U	O	Motor U phase	

IMPORTANT
The motor and brake cables must be shielded and connected over 360° on the collars mounted for this purpose on the housing.
The ground wire of the motor cable MUST be connected to the Faston socket marked "GND".
The ground reference must also be connected on the second Faston socket.

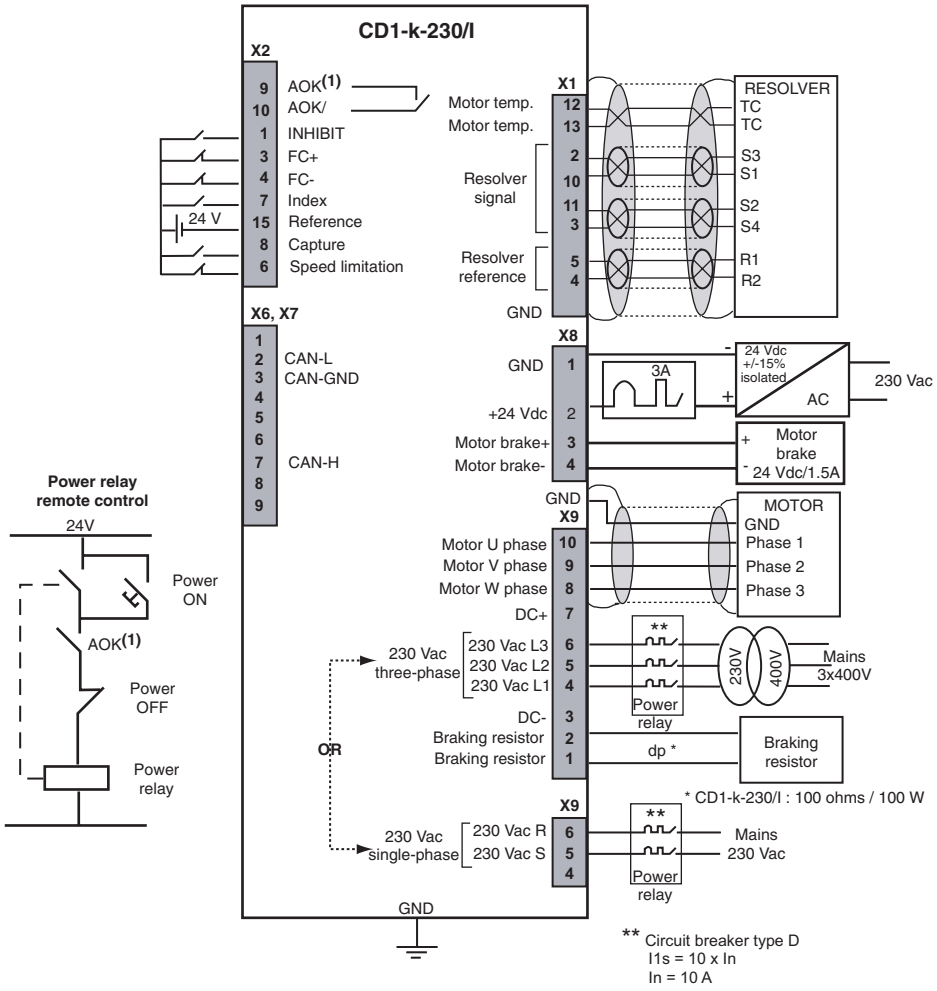
- The installer of the amplifiers has to use a UL Listed Quick connect for ground connection (0.250 inches or 6.35 mm wide nominal).
- Field wiring terminals have to use copper conductors only.
- Torque value for field wiring terminals: value to be according to the Recognized terminal block used.

Chapter 4 - Connections

1 - CONNECTION DIAGRAMS

1.1 - CD1-k-230/I AMPLIFIER

(For the UL compliant connection, see chapter 4, section 4.4).

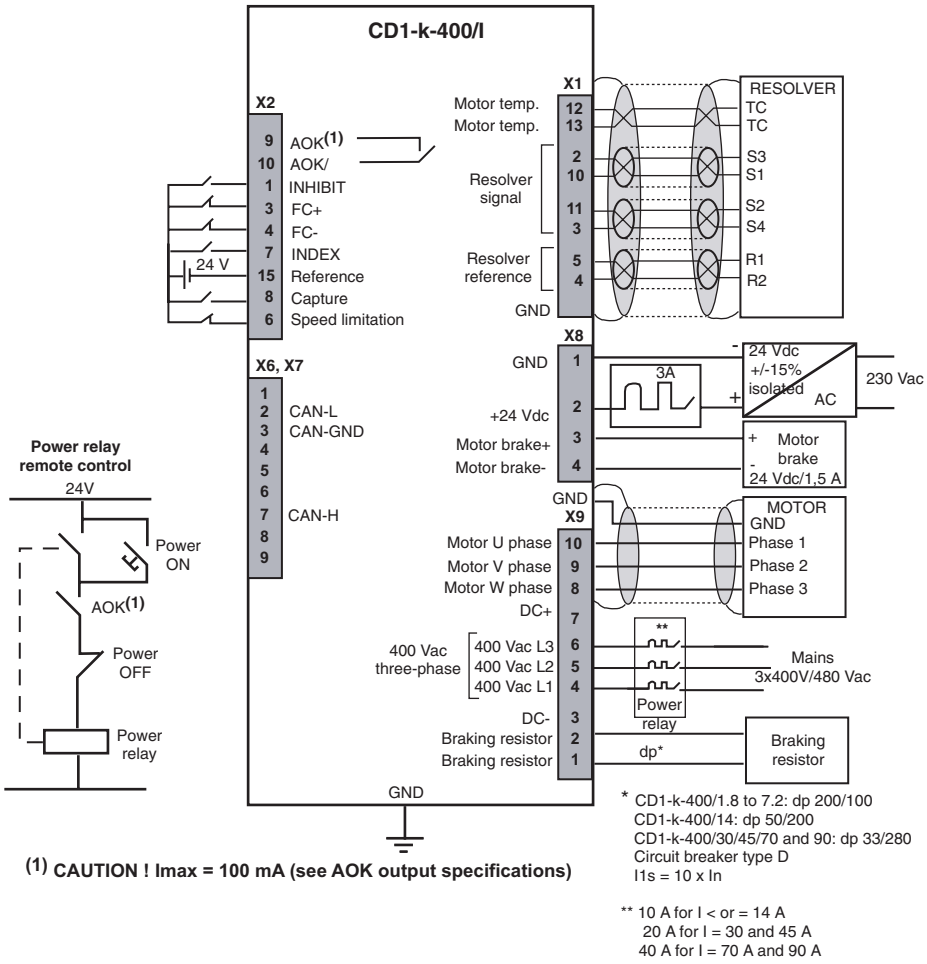


(1) **CAUTION ! Imax = 100 mA (See AOK output specifications).**

Note: The 24 V and power supplies protection, on source side, must be made by the user.

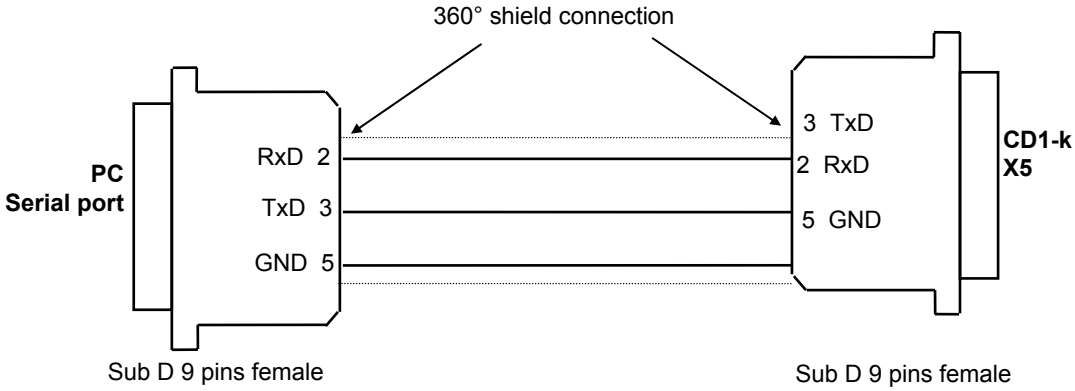
1.2 - CD1-k-400/I AMPLIFIER

(For the UL compliant connection, see chapter 4, section 4.5)

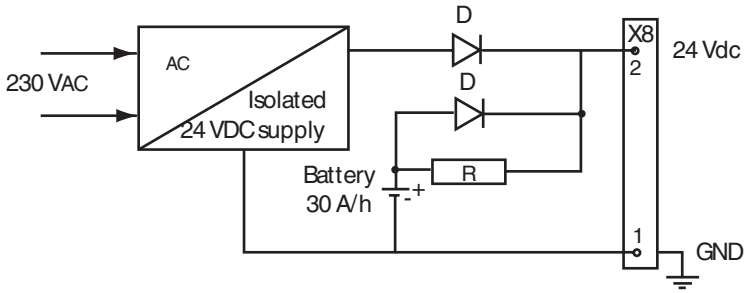


Note: The 24 V and power supplies protection, on source side, must be made by the user.

1.3 - CONNECTION OF THE SERIAL LINK

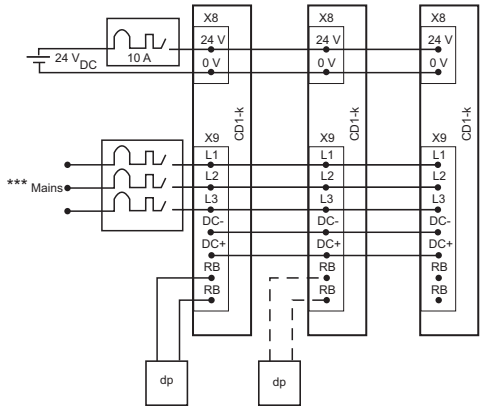


1.4 - CONNECTION OF A BACKUP BATTERY



The consumption of the CD1-k amplifier is 320 mA with 24VDC. So, a 24 V / 30 A/h battery can keep the amplifier under voltage during i.e. a long 3 days week-end. This backup method is very interesting for saving the machine initialization as well as the axis position even when moving with mains switched off.

1.5 - CONNECTION FOR A MULTIAXIS APPLICATION



*** CD1-k-230/I : 3 x 230 V
CD1-k-400/I : 3 x 400 V
Circuit breaker type D
I1s = 10 x In

For a multiaxis application with n amplifiers, the circuit breaker rating is given by the formula:

$In = 0,3 \Sigma_{1}^{n} I$ rated amplifier

But, the ratings below must not be exceeded:
- 20 A on 230 V amplifiers,
- 20 A on 400 V / 1,8 to 14 A amplifiers,
- 40 A on 400 V / 30 A and 45 A amplifiers,
- 60 A on 400 V / 70 A and 90 A amplifiers.

2 - WIRING RECOMMENDATIONS

(according to EN61000.4-2-3-4-5 and EN55011 standards - see diagram "Shield connection on the connectors " – chapter 4, section 2.2).

2.1 - GROUND CONNECTIONS AND GROUNDING

CAUTION !
Each potential conducting element must be **shielded**. Several potential conductors **in the same sleeve** must be **twisted and shielded**.

A shield has no effect if it is not connected: connectec
- to a reference potential,
- by a connection as short as possible (a few centimeters; 10 centimeters is prohibited),
- by a "360°" shield connection. This means that the whole circumference of the shield sleeve must be connected to the reference conduction via a metal collar.

The connectors used for the compliance with the EN61000.4 standard must be made of metal or metallized and must allow the 360° shield connections.

Reference potential loops (especially with the ground) are recommended **only** if these connections have a very low impedance (< 0,1 Ω). Any shield that is used as a conductor can be connected at both ends with the condition to be connected over 360° at both ends by means of metal links in order to ensure the shield continuity.

The reference potential must be the ground.

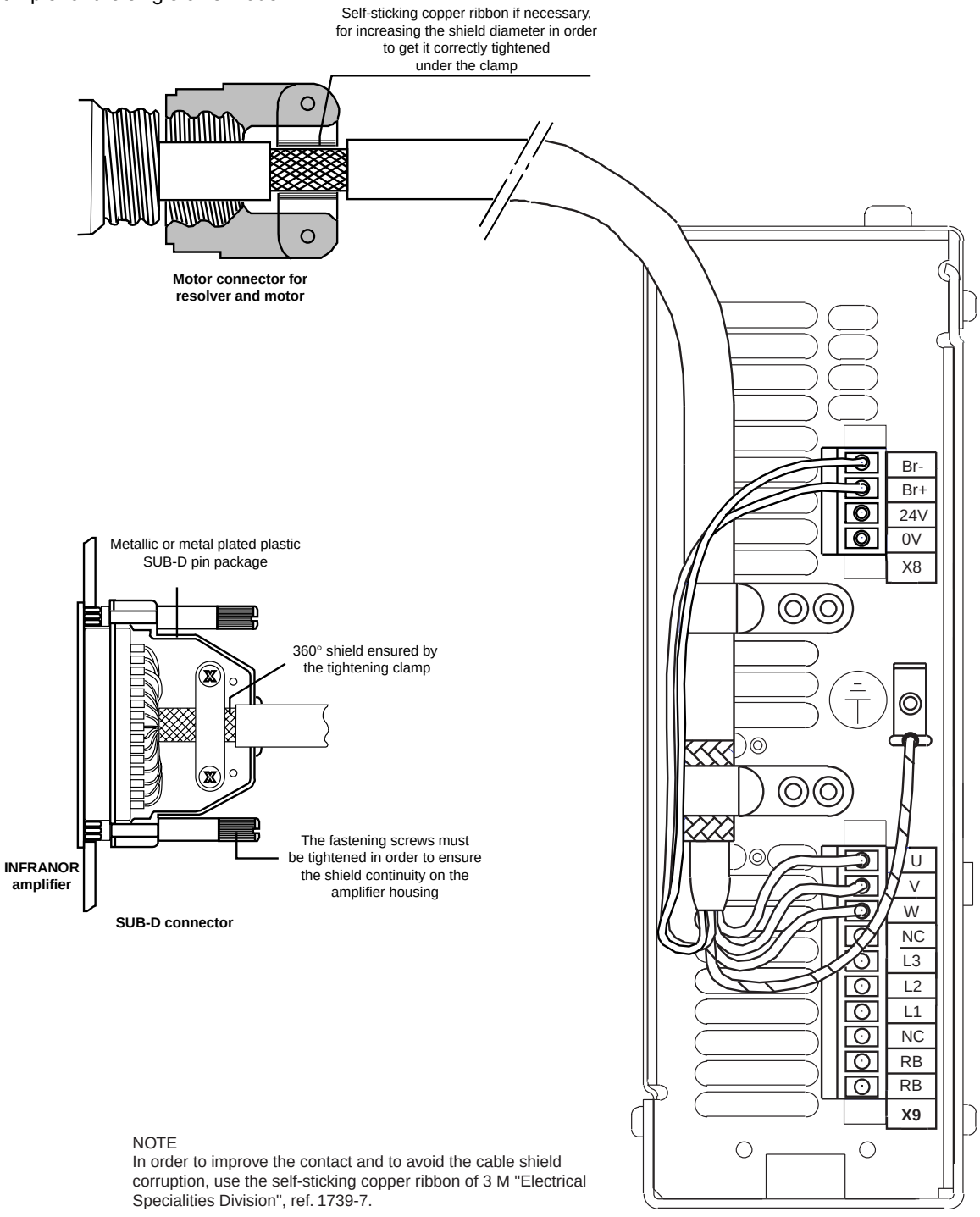
Cables with low potential should **never** run in the proximity of power lines.

If there is a potential reference, i.e. a main chassis or cabinet with a low impedance between its different elements, it should be used to connect ALL references to it and also being grounded itself.

2.2 - SHIELD CONNECTION OF THE CONNECTORS

RULE
The shield should never be interrupted or corrupted over the whole cable length.

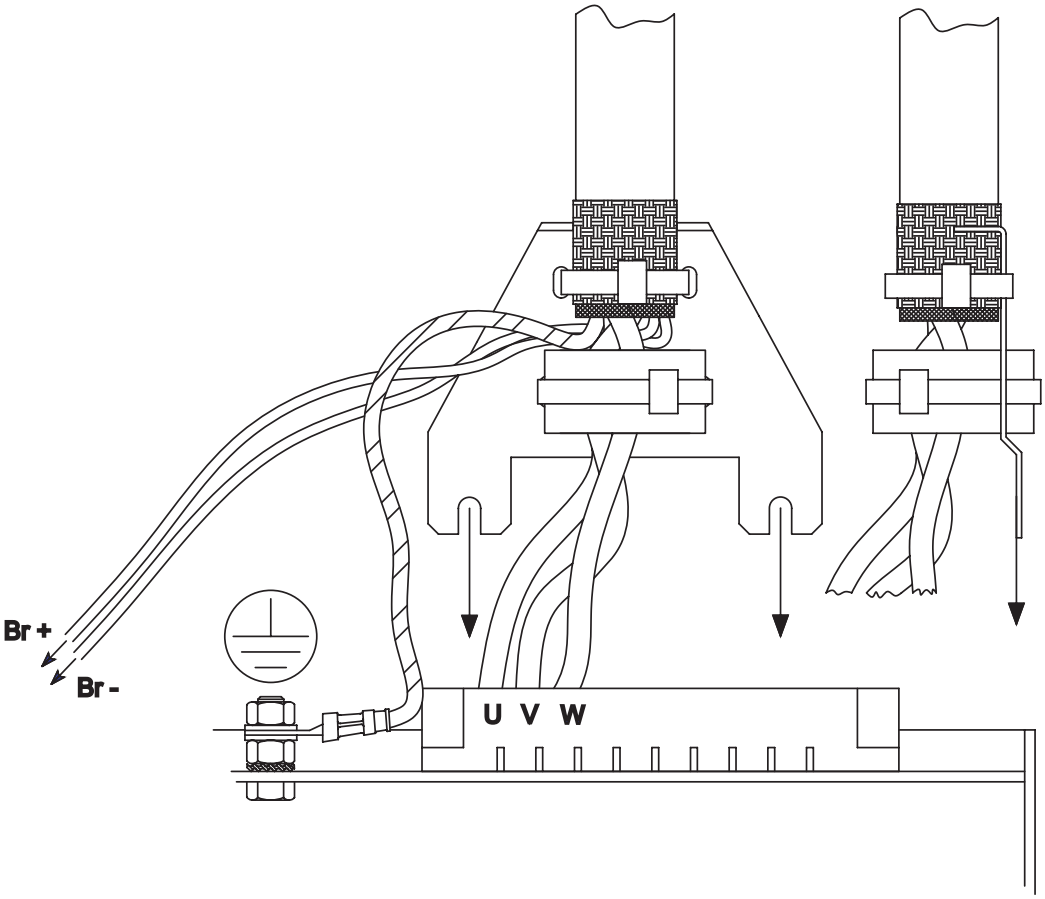
Example for the single-axis model:



NOTE
In order to improve the contact and to avoid the cable shield corruption, use the self-sticking copper ribbon of 3 M "Electrical Specialities Division", ref. 1739-7.

NOTE
When the 360° shield connection is made by means of a collar, it is not necessary to connect a cable on the appropriate pin of the SUB-D connector.

2.3 - CONNECTION VUE OF CD1-K-400/30/45/70 AND 90



2.4 – MOTOR, RESOLVER AND ENCODER CABLES

Motors, resolvers and encoders are grounded via their housing.
Cable inputs must be made by means of metal connectors with collars allowing the 360° shield connection.

The resolver cable must be pair twisted and shielded (sin, cos, ref.). Motor cables MUST also be shielded and connected over 360° at both ends as shown on the shield connection diagram.

The encoder inputs A, B, C, D, Z and R require a pair twisted and shielded cable. The shield must have a "360°" connection via metallic collars at both ends. If the shield is connected by means of a pig tail, it must be connected at one end to the GND pin of the connector on the amplifier side with a connection as short as possible.

Check that the voltage drop in the power supply lines of the encoder cable is complying with the technical specifications of the encoder. The voltage drop value for a given cable is calculated as follows:

$$\Delta U[V]=40.10^{-6}.\frac{Lc[m].I[mA]}{S[mm^2]}$$

with
- ΔU: voltage drop in volts
- Lc: cable length in meters
- I: encoder current in milliamps (see technical specifications)
- S: cross section in square millimeters

Due to this voltage drop:

- an encoder with a large power supply voltage range should be preferred,
- if the encoder has got power supply SENSE feedback lines, they can be connected to the power supply lines in order to reduce the voltage drop by the half (the SENSE feedback signal is not used in the CD1 range),
- if none of both solutions above can be used, the user has to supply the encoder by means of an external power supply.

Example

The application requires an Heidenhain linear encoder supplied by 5 V ±5 % / 300mA with 25 m cable length.
Min. power voltage: 5 V ±5 % ⇨ ΔU_{max} = 0.25 V ⇨. Min. cross section: S = 1.2 mm².
Such a large cross section is difficult to obtain, so the user can:

- either connect the SENSE feedback signal lines with power supply lines, while the needed wires cross section will be the half (0.6 mm²),
- or use the same encoder type but the version which allows its power supply voltage from 3.6 V to 5.25V / 300mA. Min power voltage 3.6V ⇨ ΔU_{max} = 1.4V ⇨. Min. cross section : S = 0.21mm²

The cables of brake equipped motors must also have their brake cables shielded in order to be EMC compliant.

Maximum cable length:
- resolver: ≤ 100 m
- encoder: ≤ 25 m
- motor: ≤ 25 m.

For motor cable length > 25 m, we advise:

- to use the maximum cable section allowed by the connectors,

- to mount a reactance with an inductive value between 1% and 3% of the motor inductive value. The reactance inductive value must be taken into account in the calculation of the current loops. The current rating of the reactance must be equal to or higher than the amplifier rating.

The reactance must be mounted at the amplifier output.
Due to the use of a reactance, a shielded cable is not mandatory anymore.
A more complex sinus filter type FN510 by Schaffner may also be mounted instead of the reactance.

UNDESIRABLE EFFECTS OF MOTOR CABLES LONGER THAN 25 m:

- Heating of the power module, the motor and the cable.

- High overvoltages on the motor windings involving a shortening of their life time.

The reactance reduces the undesirable effects on motor and amplifier but it may be quite heated. This requires an appropriate fan.

2.5 - SERIAL LINK AND CAN COMMUNICATION CABLES

Serial link and CAN communication cables must also be shielded according to the shield connection recommendations above.

CAUTION !
Control cables (resolver, serial link, CAN) and power cables must be connected and disconnected with the amplifier OFF.
Recall:
The power voltage may remain several minutes on the capacitors terminals. A contact under high voltage may involve severe physical damage.

2.6 - CONNECTION CABLES OF THE BRAKING RESISTOR

The connection cable to the braking resistor housing must bear the high voltage and temperature of 600 V and 105° C.
Recommended cable: UL1015 gauge 14.
Fastening torque on the connector of the braking resistor housing: dp = 0.9 Nm.

3 - FIRST POWERING OF THE AMPLIFIER

3.1 - VERY IMPORTANT

Check the connections, especially of the 24 VDC and power supplies. There are two different voltage ratings: 230 Vac and 400 Vac. Check that the appropriate sticker actually corresponds to the power connections.
A 400 Vac connection on a 230 V amplifier will destroy it.
The INHIBIT signal (X2 connector, pin 1) must be disabled.

Check for the braking resistor sizing:
- dp 100/100 for 230 VAC,
- dp 200/100 for 400 VAC and current ratings 1.8 to 7.2,
- dp 50/200 for 14 A current rating,
- dp 33/280 for 30/45/70 and 90 A current ratings.

Any braking resistor value lower than 200 Ω for the CD1-k-400/1.8 to 7.2 A amplifiers will definitely damage the braking system.

Check for the correct groundings as well as the 360° shield connections.

WARNING !
During the machine adjustments, amplifier connection or parameter setting errors may involve dangerous axis movements. It is the user's responsibility to take all necessary steps in order to reduce the risk due to uncontrolled axis movements during the operator's presence in the concerned area.

3.2 - SWITCHING ON THE 24 Vdc SUPPLY

The green "OK" LED on the front panel must be flashing ("Undervolt." error displayed).
The AOK relay (pins 9 and 10 of X2) is closed. It is then possible to control the power relay (Rpu) according to the instruction of chapter 4, section 1: Connection diagrams.
Connection according to X8 sticker.

3.3 – SWITCHING ON THE POWER SUPPLY (230 Vac or 400 Vac according to the amplifier type)

The green "OK" LED on the front panel must be continuously lit.

3.4 - COMMISSIONING

For further details regarding the amplifier commissioning, please see manual **CD1-k – User Guide**.

4 - REQUIREMENTS FOR THE COMPLIANCE WITH THE UL STANDARDS

The UL listing requires the following conditions to be fulfilled by the installer of the amplifiers.

4.1 - CONNECTION BY MEANS OF A FASTON SOCKET

The installer of the amplifiers must use a UL Listed Quick connect for ground connection (0.250 inches or 6.35 mm wide nominal) on all amplifiers equipped with FASTON sockets.
On amplifiers equipped with a screwed ground connector, the connection must be made via UL listed sockets.

4.2 - 24 V SUPPLY

The end user has to provide a 24 VDC isolated power supply (i.e. with an isolation transformer) for the auxiliary supply input, protected by a 4 A UL listed fuse.

4.3 - POWER SUPPLY AND UL FUSE RATING

The fuse type recommended for motor applications is of class RK5. The maximum short-circuit power of the mains must not exceed 5000 Arms at a voltage of 480 V, when protected by a UL fuse of type RK5.

On CD1k-400/I amplifiers, the fuse ratings must be the following:

CD1-k	400/1.8 to 7.2	400/14	400/30 and 45	400/70 and 90	Multiaxis
BUSSMANN Class RK5 Type FRS-R	FRS-R-4	FRS-R-8	FRS-R-20	FRS-R-40	$0,3 \times \sum_{1}^{N} I_{\text{rated amplifier}}$
LITTELFUSE Class RK5 Type FLSR-ID	FLSR2ID	FLSR8ID	FLSR20ID	FLSR40ID	$0,3 \times \sum_{1}^{N} I_{\text{rated amplifier}}$

For a multiaxis application with N amplifiers, the fuse rating is calculated by the formula given in the table above. But a rating of 20 A must not be exceeded on 400/1.8 A to 14 A amplifiers and 40 A must not be exceeded on 400/30/45/70 A and 90 A amplifiers (see chapter 4, section 1.5).

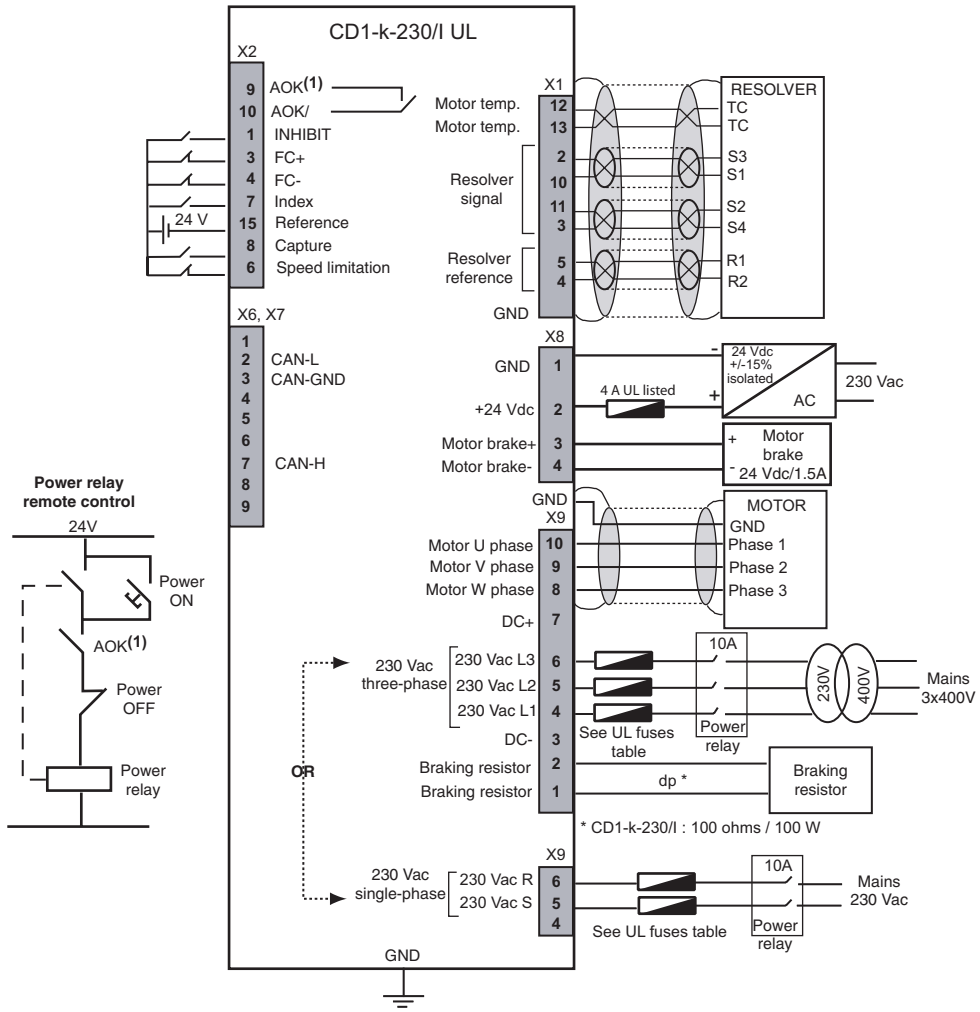
On CD1k-230/I amplifiers, the fuse ratings must be the following:

CD1-k	230/2.5 to 10.5	230/16.5	Multiaxis
BUSSMANN Class RK5 Type FRN-R	FRN-R-6	FRN-R-9	$0,3 \times \sum_{1}^{N} I_{\text{rated amplifier}}$
LITTELFUSE Class RK5 Type FLNR-ID	FLNR6ID	FLNR9ID	$0,3 \times \sum_{1}^{N} I_{\text{rated amplifier}}$

For a multiaxis application with N amplifiers, the fuse rating is calculated by the formula given in the table above. But a rating of 20 A must not be exceeded on 230 V amplifiers (see chapter 4, section 4.6).

4.4 - CD1-k-230/I AMPLIFIER: CONNECTION DIAGRAM WITH PROTECTIONS BY "UL" FUSES

(According to section 4.3 of this chapter)



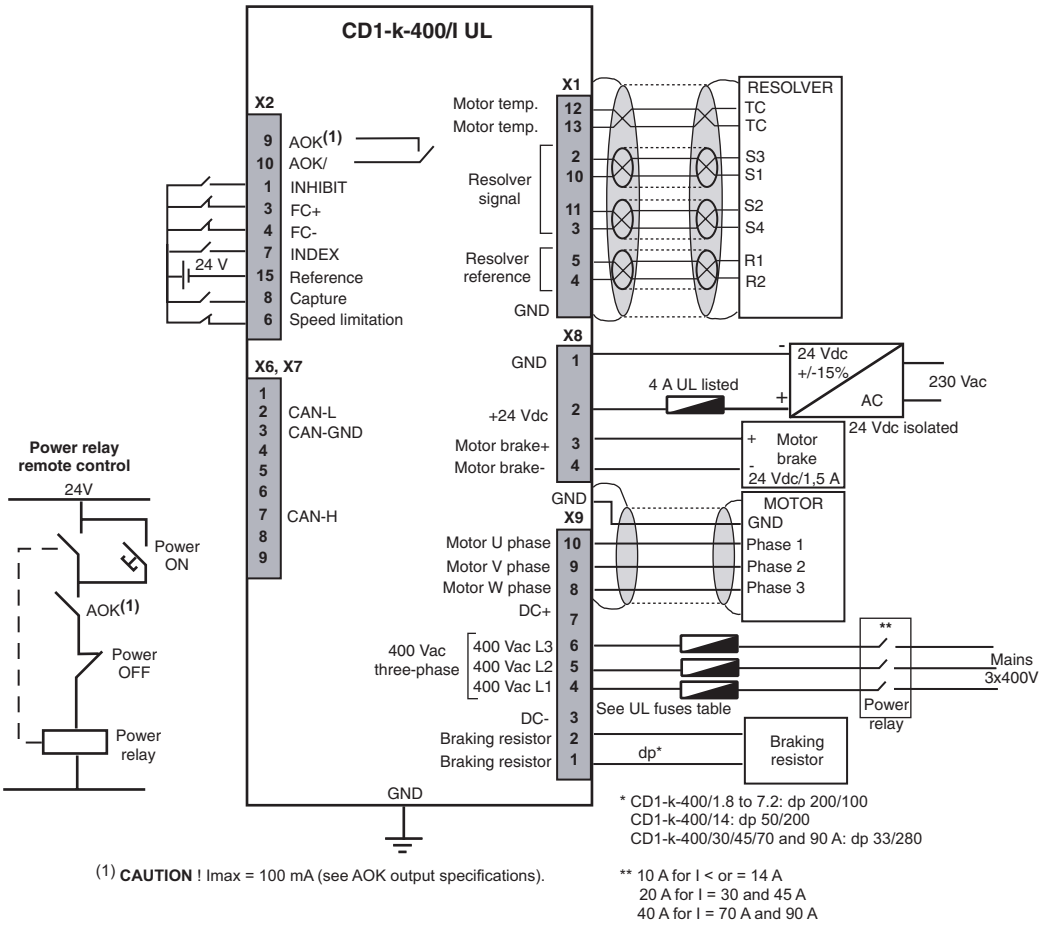
(1) **CAUTION** ! Imax = 100 mA (see AOK output specifications)

IMPORTANT

- **The installer of the amplifiers has to use a UL listed quick connect for ground connection (0.250 inches or 6.35 mm wide nominal)**
- **Field wiring terminals must use copper conductors only**
- **Torque value for field wiring terminals: according to the Recognized terminal block used.**

4.5 - CD1-k-400/I AMPLIFIER: CONNECTION DIAGRAM WITH PROTECTIONS BY "UL" FUSES

(According to section 4.3 of this chapter)



(1) **CAUTION** ! Imax = 100 mA (see AOK output specifications).

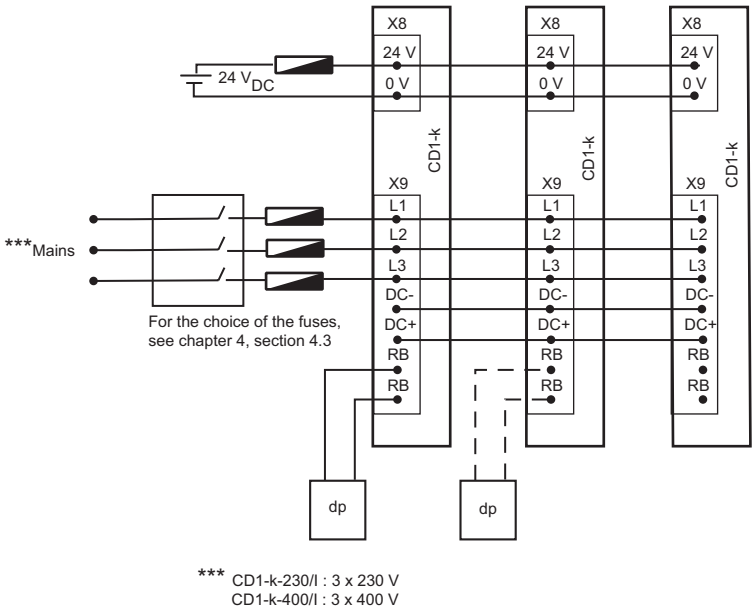
* CD1-k-400/1.8 to 7.2: dp 200/100
CD1-k-400/14: dp 50/200
CD1-k-400/30/45/70 and 90 A: dp 33/280

** 10 A for I < or = 14 A
20 A for I = 30 and 45 A
40 A for I = 70 A and 90 A

IMPORTANT

- **The installer of the amplifiers has to use a UL listed quick connect for ground connection (0.250 inches or 6.35 mm wide nominal)**
- **Field wiring terminals must use copper conductors only**
- **Torque value for field wiring terminals: according to the Recognized terminal block used.**

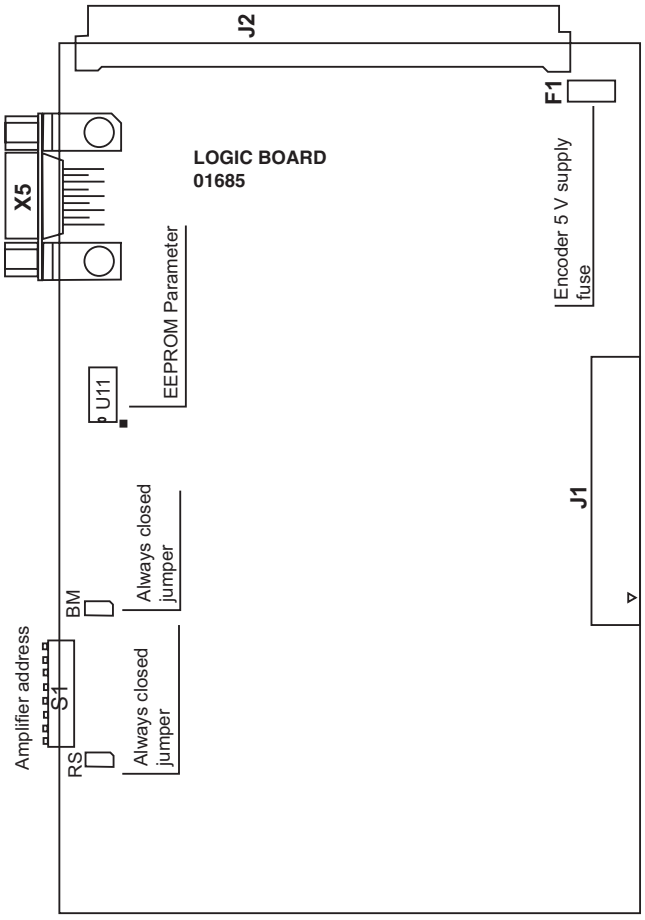
4.6 - CONNECTION EXAMPLE FOR A UL COMPLIANT MULTIAXIS APPLICATION



*** CD1-k-230/I : 3 x 230 V
CD1-k-400/I : 3 x 400 V

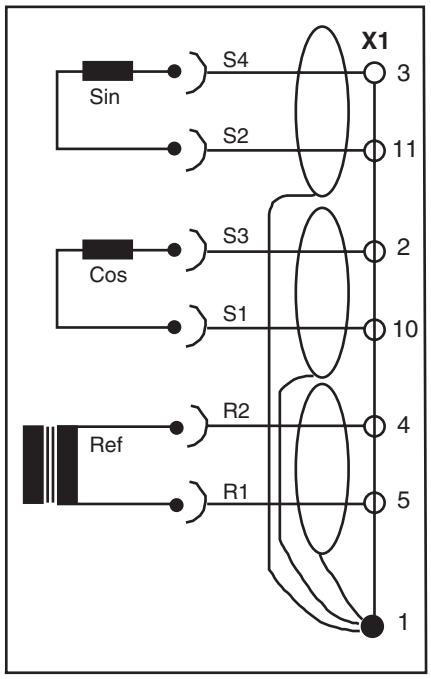
Chapter 5 - Appendix

1 - HARDWARE ADJUSTMENTS OF THE LOGIC BOARD



2 – ADJUSTMENT TO VARIOIUS RESOLVER TYPES

For the use of other resolvers than those mounted on MAVILOR motors in their standard version, see following wiring diagram of the **X1** connector as well as the manufacturer's diagram:

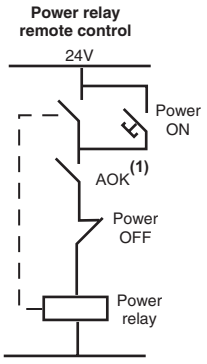


For the use of **resolvers** with **transformation ratios** out of the range 0.3 to 0.5, the adjustment must be factory set.

NOTE
When using resolvers with a number of pole pairs N > 1, all speed values displayed in the amplifier are equal to N times the motor rotation speed.

3 - USE OF THE "AOK" OUTPUT

The "AOK" output MUST be used on a potential free relay in order to allow the connection of the power supply (see Chapter 4, section 1: Connection diagrams).
The correct amplifier operation requires this connection logic. Switching on the power supply before initializing by means of the 24 VDC auxiliary supply will hinder the operation. It will then be necessary to proceed according to the instructions contained in this manual.



(1) **CAUTION** ! Imax = 100 mA (see AOK output specifications)

4 - ENERGY RECUPERATION VIA A BRAKING RESISTOR

All CD1 amplifiers are equipped with the power feedback system. When the motor is decelerating with high inertia and high speed, the mechanical braking energy is reflected to the amplifier. This energy is dissipated inside a resistor called "braking resistor".

In order to avoid heat dissipation inside the amplifier, the braking resistor is **ALWAYS** mounted outside. It **MUST** be mounted out of range of heat sensitive and inflammable elements (plastic, cable sleeves, etc.).

For an optimum power feedback by the amplifiers in a multiaxis application, the DC bus (DC+ and DC-) can be connected in parallel (see diagram in chapter 4, section 1.5).
In this case, the mains input must also be parallel wired in order to balance the current load inside the AC/DC converters.

It is recommended to mount the braking resistor on the amplifier with highest current rating.
An electronic control of the reflected power avoids the overloading of the braking resistor. So, if the energy reflected to the amplifiers with parallel mounted DC busses is too high, the DC bus voltage will rise up to the triggering of the "**Overvoltage**" fault. A second resistor must then be mounted on the second axis.

5 - ORDER CODE

Single-axis version: