Cabinet layout and EMC Guide

Installation and Wiring Guide

M00027EN-00

Edition 10.2010

www.num.com

CNC HighEnd Applications

Despite the care taken in the preparation of this document, NUM cannot guarantee the accuracy of the information it contains and cannot be held responsible for any errors therein, nor for any damage which might result from the use or application of the document.

The physical, technical and functional characteristics of the hardware and software products and the services described in this document are subject to modification and cannot under any circumstances be regarded as contractual.

The programming examples described in this manual are intended for guidance only. They must be specially adapted before they can be used in programs with an industrial application, according to the automated system used and the safety levels required.

Summary

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Summary

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1 Foreword

1.1 Use of the manual

This manual is for use by qualified personnel only.
To reduce the risk due to an improper use of the product, do not perform any servicing other than that contained in this manual unless you are qualified to do so.

To ensure proper use of these products, please always read this User's manual carefully and retain for future reference.

Should the unit require maintenance, please contact a NUM authorized service center only.
To comply with current safety regulations, all wiring and connections must be made in accordance with the electrical diagrams shown in the manual AMOMAN012.

NUM declines all responsibility for injury or damage to persons or objects due to incorrect use of these products.

1.2 How to read the manual

This manual is structured and divided in three sections as indicated here below. We suggest to follow these indicated manual sections in such way to find easily your information.

1	Foreword
2	This section introduces the general instruction concerning EMC information as for EMC definitions, Earthing and shielding connections, shielded cables and the use of the filters.
3	This section introduces the general the cabinet layout as for the main installation layout, general earth connections, air ventilation clearance, air flow and operating temperature in the cabinet. Moreover general cable layout installation.

1.3 Use of symbols in the manual

Symbol	Meaning of the symbol
	The information " **i** " icon indicates notes on product use.
	The STOP icon indicates a wrong operation which may damage the product or indicates important notes on product use .
	The TRIANGLE icon indicates hazard for human beings and this information is referring to personal damage! Whenever one of these icons appear, please beware, use and apply adequate precautions to avoid hazards or damage situations during the drive installation and commissioning operations! Please beware! Prevent and safety instruction against accidental contact with electrical components.

1.4 Document revisions

Edition	Evolution index	Code	Meaning of documentation evolution	See section
10.2010	**00**	**M00027EN**	First version of the manual.	-

1.5 Glossaries - Abbreviations

Abbreviations	Meaning
AMOMAN012	NUMDrive C Installation and maintenance manual
AUX	Auxiliary power supply
Control Unit	NUMDrive C control unit module
CNC	Numeric Control
EMC	Elettromagnetic Compatibility
EMI	Elettromagnetic Interference
EU	European Union
HF	High Frequency
MAINS	Network 3 phases + Earth
MDLL3	Power Supply module
MDLU3...N	NUM digital drive
NUMDrive C	Digital drive module (Power + Control Units)
NCK	Numeric Control Kernel
PDS	Power Drive System
PE	Protective earth
Power Unit	NUMDrive C power supply module
RF	Radiofrequency

1.6 NUM Agencies

The list of NUM agencies is given on http://www.num.com

1.7 Index

The index at the end of the manual facilitates access to infomation by keywords.

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Summary

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2 General informations

2.1 Electromagnetic Compatibility EMC directive

Electromagnetic Compatibility (EMC) directive 2004/108/EC applies to machine equipment.

The electrical and electronic equipment consists of appliances and components which must be installed according to the definitions of this document.

These rules must be observed to be compliant with the EMC directive.

All NUM Components (Drive, Motors, CNC and accessories) are CE marked.
This means that they are electrically safe (when used properly), and that it has been verified that all these components are compliant to the rules and levels defined in EN61800-3 standard, when installed as defined in this manual.

The CE mark is placed on NUM products in the following way:

- Drives: on top side right-hand part of the Power Supply, Power Unit and Control Unit.
- Motors: on the plate bearing the serial number.
- CNCs: on the product tag.

2.2 General EMC information

2.2.1 General

The standards define electromagnetic compatibility (EMC) as the ability of a device, unit or system to operate satisfactorily in its electromagnetic environment and without itself generating intolerable electromagnetic interference (EMI) for anything in its environment.

This installation guide described in the following chapters must be interpreted and applied by qualified personnel familiar with installation and operation of the products described herein, such as earthing and operation of electric and electronic circuits and equipment in conformity with international standards.

2.2.2 Electromagnetic Compatibility of a System

A system is defined as a set of equipment (Drives, Motors, CNC etc...) used to perform a function. From an electromagnetic standpoint, the system includes all the interacting items, up to and including the mains isolating devices.

The power supplies, interconnections between equipment and the equipment itself a part of the system.

Each item of equipment must have sufficient immunity against electromagnetic interference in its environment. The interference emission level must be low enough to do not cause interference in the equipment located inside its electromagnetic environment.

2.2.3 Definition of Electromagnetic Interference

Electromagnetic interference includes all electromagnetic phenomena which cause malfunctions inside the system.

- Electromagnetic interference can be “conducted” or “radiated “.
- Conducted interference propagates along the cables and is defined by its current and voltage levels.
- Radiated interference propagates in air and is defined by its electric and magnetic field strength.

2.2.4 Shielded cables

The cable connections between appliances and their connectors are a particular path for propagation of electromagnetic interference into the outside environment. On the outside, this interference is coupled with the electrical conductors, which exchange signals between the system appliances and create critical situations.

It is however possible that a device has been designed properly from EMC point of view, but for choise of poor cables compromises the EMC tests.
The mechanisms whereby emission and susceptibility phenomena appear in the electrical connections are essentially of three types:

- radiated emission from cables acting as transmission antennas,
- radiated susceptibility of cables acting as reception antennas,
- electrical or magnetic coupling of cables.

When checking interference emission, the principle of reciprocity applies, in that what is done in a cable to reduce the radiated emissions also contributes to minimising its radiation susceptibility.

As regards cable shielding, never forget that their effectiveness depends on the transfer impedance value and the cable terminations.
When defining cable shielding, one factor is the connectors, which are the means of connecting the cables to the appliances (in certain cases, metallic cable clamp are also used on the motor side).

All cables entering and leaving the cabinet must be shielded.
The motors fan cable should not be shielded and should be connected to the power supply after the noise filter.
For more detailed information on the shielded cables, connectors and cable clamp used for NUM shielded cables please refer to the AMOMAN012 manual.

2.2.5 Reduction of the wiring couplings

Provide a suitable earth meshing system using metal parts with conductive surfaces interconnected (bolted together, or even better, welded.

- Wire with a reduction effect (small area loops):
  - cables applied against conduits and metal parts forming the frame earth,
  - forward and backward signal paths are twisted/twisted pairs or close to one another (e.g. conductors in the same cable).

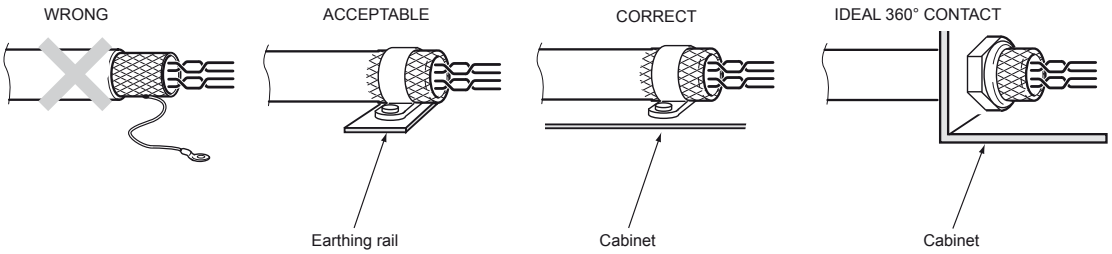
- Separate the power cables from the low voltage signal cables:
  - By physical separation between the cables (minimum 150mm recommended).
  - By routing in separate conduits or cable racks.
  - By crossing them at 90°
  - By routing power cables as close as possible to the mounting plate.

- Earth the cable shields at both ends

- Earth the cable shield over 360°:
  - with a conductive gland for crossing a bulkhead,
  - by pinching the shield in metal covers that are suitably earthed for connector plugs.

To prevent eventual disturbances on the signals coming from sensors, make sure that when setting up the cables in the cabinet the minimum distance between the sensor cables and the power cables is not less than 150mm. The inadequate earthing of the motor causes capacitative currents to flow, which can damage the electronic components of the drive.

2.2.6 Connection of shield to frame earth (cabinet)



2.3 Earthing (grounding) and shielding

2.3.1 Equipotentiality (earthing)

When using RF systems (≥10kHz) it is essential that the various metal parts or structures be equipotential, to prevent them becoming transmission structures or reception antennas (emissions, product susceptibility).

The links must therefore have low impedance and thus have large conctact surfaces.

The surfaces must be free of paint or grease and the material must retain these properties over the course of time. Non conducting passivation treatment must therefore not be used.

- The links must be made using bonding braids with a length/width ratio of 5 to 1.

All ground connections are intended to be PE connections.
For equipment units, there is no distinction between signal earth and protective earth, i.e. the logical 0V and all ground connections are intended to be PE connections. All the units are connected to PE.

- When using separate power supplies for logical inputs and outputs, the ground of the power supplies must be connected to the protective earth (by the shortest possible link).

2.3.2 Earthing (grounding)

The main reason for the use of earth links is to protect people and the system.

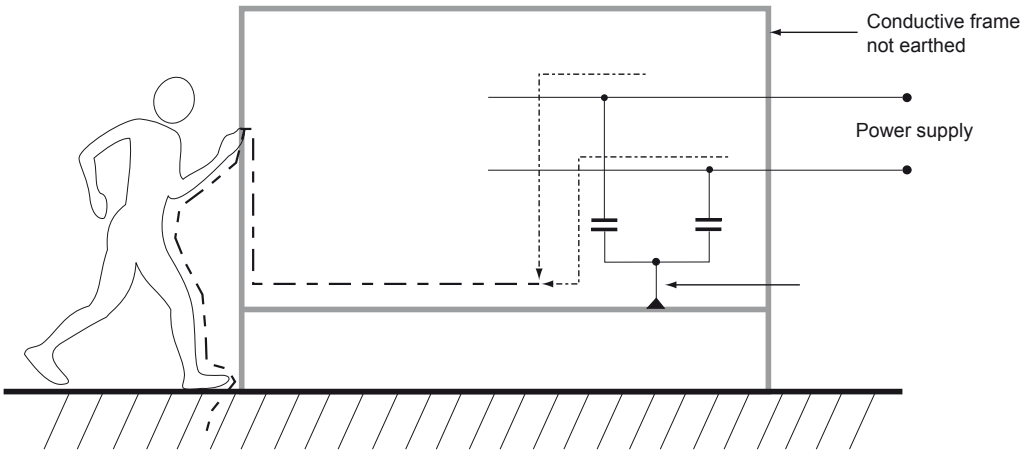
From an operating safety viewpoint, earthing contributes to preventing hazardous voltages between simultaneously accessible parts, up to the frequencies, for which the earthing (required by human safety regulations) can be considered low impedance. This is true with a high degree of probability up to about 1MHz.

It should however be recalled, that at high frequencies (above a few tens of MHz), the earthing impedance is totally unpredictable. Therefore, no guarantee is provided by earthing at high frequencies:

Earthing does not guarantee equipotentiality for electromagnetic interference.

It is also worth recalling that when product earthing is planned, filters with capacitors are placed between the supply phases and earth. This makes earthing necessary.

In fact, the frame earth capacitors constitute an inevitable leak path to earth for the supply voltage. If there is no link, the operator can (and probably will) accidentally be at MAINS potential and will «receive a jolt».



Risk to the operator arising from a system with filter connected to frame earth but without being connected to protective earth.

The earth cable must never have a cross- section minor than of the network conductor cable.

2.3.3 Earthing and shielding cable connections

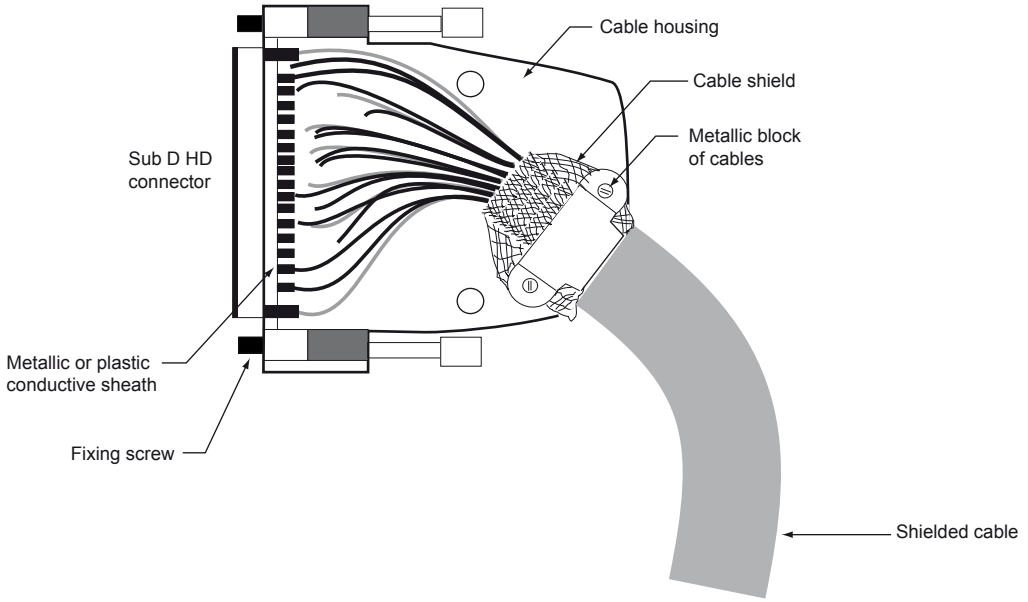
To obtain the maximum benefit of the protective properties of signal cable shielding, it is necessary to take the upmost care with earthing the shielding itself.

The total shielding continuity must be achieved, using large contact areas.
It is always necessary to earth the shielding.

- Use metal or plastic conductive covers / sheath.
- The cable shielding must be connected to the cover over 360 degrees.
- The mating connector receptacle may be located on our equipment or on the cabinet.

In the latter case, it must be mounted on an unpainted metal surface and protected against corrosion. Where a shielded cable enters the cabinet, connect the shielding at the cabinet entrance by large conductive areas.

Example of typical terminated cable



It is preferable for all the cables to enter the cabinet on the same side, separating the power cables from the signal cables (see chapter 3). The cable shielding is therefore connected at the cabinet entrance on a potential reference plate screwed or welded to the cabinet.

2.4 Protective Earth (PE) and interconnections

The earthing system is created by interconnecting all metal parts (building structure, pipework, cable trays, equipment enclosures and equipment).

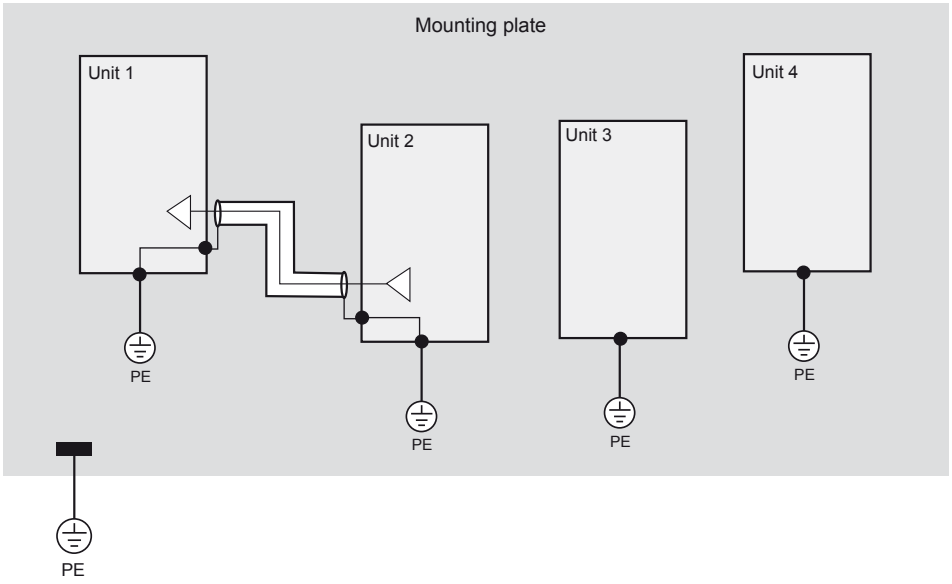
The earth is the physical connection point (earth bar, earthing mat, building earth) to which all the earthing systems must be connected. The mounting plate is considered the PE reference plane.

2.4.1 Equipment Operating at Relatively Low Frequency and Low Signal Levels

Such equipment mainly includes “analogue” systems sensitive to low voltage (mV or µV).
The most troublesome interference is generated by low or medium frequency electromagnetic fields captured mainly by the circuits between units.

High frequency interference is eliminated by the bandwidth of the circuits themselves or by low-pass filters. Apply the following rule to attenuate interference:

- When a sensitive wire must be protected against EMI by shielding, the shielding is considered a screen and is earthed at both sides.
- Install all the units directly over the mounting plate without use spacers, rails or anything else.



2.4.2 Modern Equipment Operating at High Frequency and High Signal Levels

Such equipment includes modern “logic” equipment with electronic gates whose switching times are around 1 ns and whose signal levels are high (static switching margin from 400 mV to 1 V). The most critical interference is electromagnetic interference at a frequency between 30 and 300 MHz.

Such interference originates in coil switching (relays, contactors, transformers, motors, transformer-supplied indicator lights, etc.), circuit breaker trip arcs, drive switching power supplies, HF systems located nearby, electrostatic discharges generated by the operators, etc.

At such frequencies, the earths must be at the same potential. Otherwise, the impedance of an earthing wire becomes high at high frequencies (Z = Lω). For instance, for a 2.5 mm² wire 1 m long whose inductance is $L = 1.4x10^{-6}$ H, the impedance, which is only 0.09 Ω at 10 kHz becomes 90 Ω at 10 MHz - and the earthing wires are not suitable for creating a good functional earth.

It is necessary to use a meshed system to decrease interference. This means interconnecting the units with one another by the largest possible number of the shortest possible links.
This is achieved best by using metal parts interconnected by many attachment points ensuring good electrical conduction (zinc- or cadmium-plated steel, stainless steel, removal of paint, use of claws on aluminium).

If electrical continuity is not correctly provided by the mechanical link, the link must be shunted by at least two short, wide bonding braids (length/width ratio ≤ 5 with length < 20 cm).
In the units, the concepts of logical 0 V and functional earth coincide, i.e. the logical 0V is connected in many points to the functional earth.

The shieldings of logical signal cables are earthed at both ends. This contributes to the mesh and in addition, the internal electronic circuitry and the enclosure are at the same potential.
To attenuate the loop effects thus created (the captured field depends on the area of the loop), the cables must be attached to the conduit or to metal walls. This is called cabling with a “reduction effect”.
In the case of a separate power supply for the logical inputs and outputs, the 0 V lines of these power supplies must be earthed and the wiring must be done with a “reduction effect”.

Meshing the earths does not provide a protective system. The earthing terminals on the units must be connected to the general earth electrode of the building (protective earth)
For more detailed information concernig the cabinet wiring and installation please refer to the chapter 3.

2.4.3 Equipment Immunity

Equipment immunity to electromagnetic interference is guaranteed by:
- attenuating the interference generated by the sources,
- reducing the coupling between circuit with interference and source,
- increasing the immunity (hardening) of the equipment.

The three methods are complementary and should be applied together.

2.4.4 Attenuation at the Source (Interference Suppression)

To limit the interference generated by components outside the system, make sure that:
- all the connections on terminal boards are securely attached,
- all the interference sources (relays, solenoid valves, motors, etc.) are provided with a suitable protection system as stated in manuals of the auxiliary components.

2.5 Filters

2.5.1 Use of the filters

The filter is the main reflow path for all earth losses created by the drives, motors and power supply parasitic capacitance.
The filter is needed to resolve conducted RF (Radiofrequency) problems generated by the PDS (Power Device Systems). It rappresents a high impedence for all these conducted disturbance versus the MAINS input.

The use of filters (passive - inductance/capacity) reduces the level of interference on the mains supply conductors, creating a high impedance (coil L) in series with the disruptive current and a low-impedance element (capacitor C) in parallel between the conductor and earth.

The components described above must only eliminate the disruptive currents and leave the supply currents unchanged. The effectiveness of the filters in suppressing this interference depends solely on two factors:

- the electrical properties designed into the filter,
- the installation of the filter in the machine.

NUM drives to operate correctly must always (“as mandatory”) be equipped with a line filter. Please refer to the AMOMAN012 manual for more detailed informations.

2.5.2 NUM filters

NUM MAINS filter has a Input and a Load side and is usable on all 50/60Hz up to 480Vac$_{rms}$ (Phase to-Phase). The filter is not reversible because the internal construction is not mirrored.

The filter has high capacitance values which are connected directly to it’s chassis/cover. For electrical safety reasons it must be assured that the frame has always a good high frequency contact to the mounting plate, where it must be mounted directly without spacers.

The filter must be mounted on the same mounting plate of the PDS in order to guaranty a good HF conduction.

Varnish, or stain that could inhibit RF conductivity must be removed from the plate before mounting the filter in the cabinet.

In systems/cabinets where more than one power supply are present is mandatory to use one filter for each power supply. It is not possible to connect 2 or more power supply to the same Line filter.

For each power supply module MDLL3, NUM requires “as mandatory” to use a dedicated and omologated NUM filter AGOFILxxx.

2.5.3 Current Harmonics reduction

The Line filter does not improve the total harmonic current distortion (THD) or the power factor (PF). To reduce the current harmonic distortion where required it is necessary to use the power supply module MDLL3025/50/120N...H.

2.6 Cabinet requirements

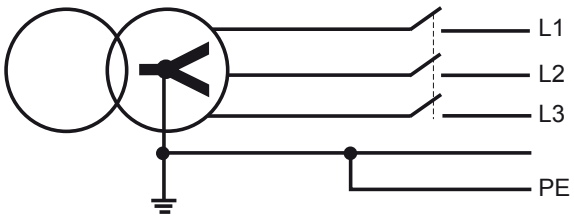
2.6.1 PDS mains connection

- NUM drives operate correctly only by distribution systems such as TN-S, TN-C or TT. (By saying distribution systems we mean the network to which the drive is connected).
- The possible use of a transformer or of an autotransformer in TN and TT systems (see figure) is only allowed if the secondary is star connected and the available star point is connected to earth.
- It is not possible to connect the drives directly to IT type distribution systems.
- In IT type distribution systems it is possible to connect NUM drives only by means of a transformer or an autotransformer with a secondary having the available star point connected to earth.

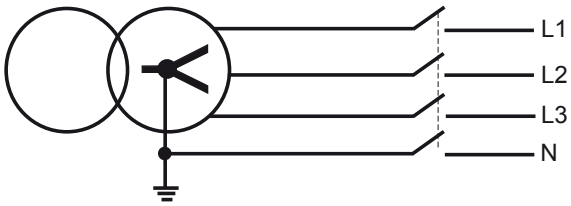
The IT type distribution systems do not guarantee the correct functioning of the line filters.

TN -C, TN -S type and TT type distribution systems

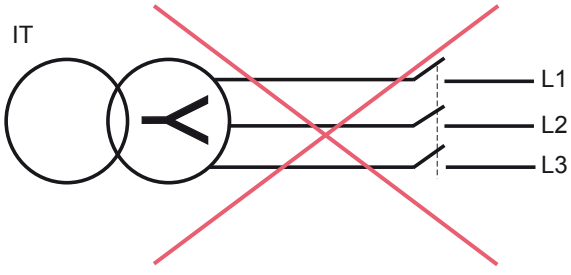
TN -C, TN -S



TT



IT



Do not use with NUM system.

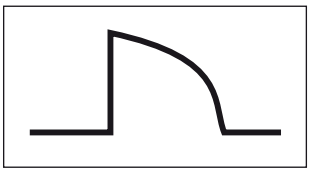
2.6.2 Use of differential protection devices

For the use of differential protective devices must be considered that the mains filter has a high capacitance versus PE, and that during activation of the MAINS-contactor the differential protective devices can be triggered when used without delay.

For that reason a idoneous delay to that type of device must be choosen (suggested delay ≤ 50ms). It must be also considered that the PDS, when operating may create differential leakage currents, that can be several hundred's of mA.

These leakage currents are locally short cicuited by the mains filter, but it is not possbile to avoid a partial reflow through the mains-input.

In order to avoid untimely interventions it is necessary to use differential devices marked with the symbol below, and with a selectable trigger current (i.e. 30/300/3000mA).



2.7 Cabinet structure

The cabinet has a very important role in attenuating radiation and in providing protection against external radiated interference.

In reality the cabinet provides excellent protection against radiations coming from or going to the cabinet.

The problems, that can arise are normally only caused by conducted disturbances, that are not sufficientely filterd by the Line filters inside the cabinet.

The cabinet must be made of metal panels screwed together. If the panels are not welded, electrical conductivity must be assured between the separate metal panels (interconnecting Ground wires).

The plates must not be varnished inside and they must not be subjected to nonconducting surface treatment (for example, use pre-zinc-coated plates).

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Summary

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3 Cabinet layout and Wiring Guide

3.1 General prescriptions and precautions

- The modules to operate correctly must always be installed in dry place environment free of dust and oils. In any case in presence of dust, oil or humidity the customer must always provide appropriate protection.
  Please refer to the AMOMAN012 manual.

- The power cables must always be separate from the low-voltage signal cables.
  and make sure that the mimimum distance between power and sensor cables is ≥150mm.

- For motor power and sensor connections use only original NUM cables.
  The original NUM cables have special characteristics (capacitance value...).
  Not to respect these characteristics can cause serious damage to motors.

- The total length of the power cables used in the PDS (motor power cables) must be <400m at 5kHz PWM and < 200m at 10kHz PWM.
  The total length of the cable for the digital bus interconnections must always be < 30m
  (These limits are valid using NUM cables)

- All the components related directly to the PDS (MDLL3, NUMDrive C, filters...) must be correctly connected to the cabinet structure.
  The PDS power line must have it's own MAINS-Filter. All auxiliary components as PLC, Video, I/O Modules, 24Vdc supply etc. must use a separate MAINS-Filter.
  We suggest to use a separate mounting plate for all these auxiliary equipments.

- If the auxiliary single-phase power supply is connected directly on the mains power supply provide a line filter code AGOFIL001S.

- The cabinet must be designed with separate power and signal level sections as shown on the following pages.

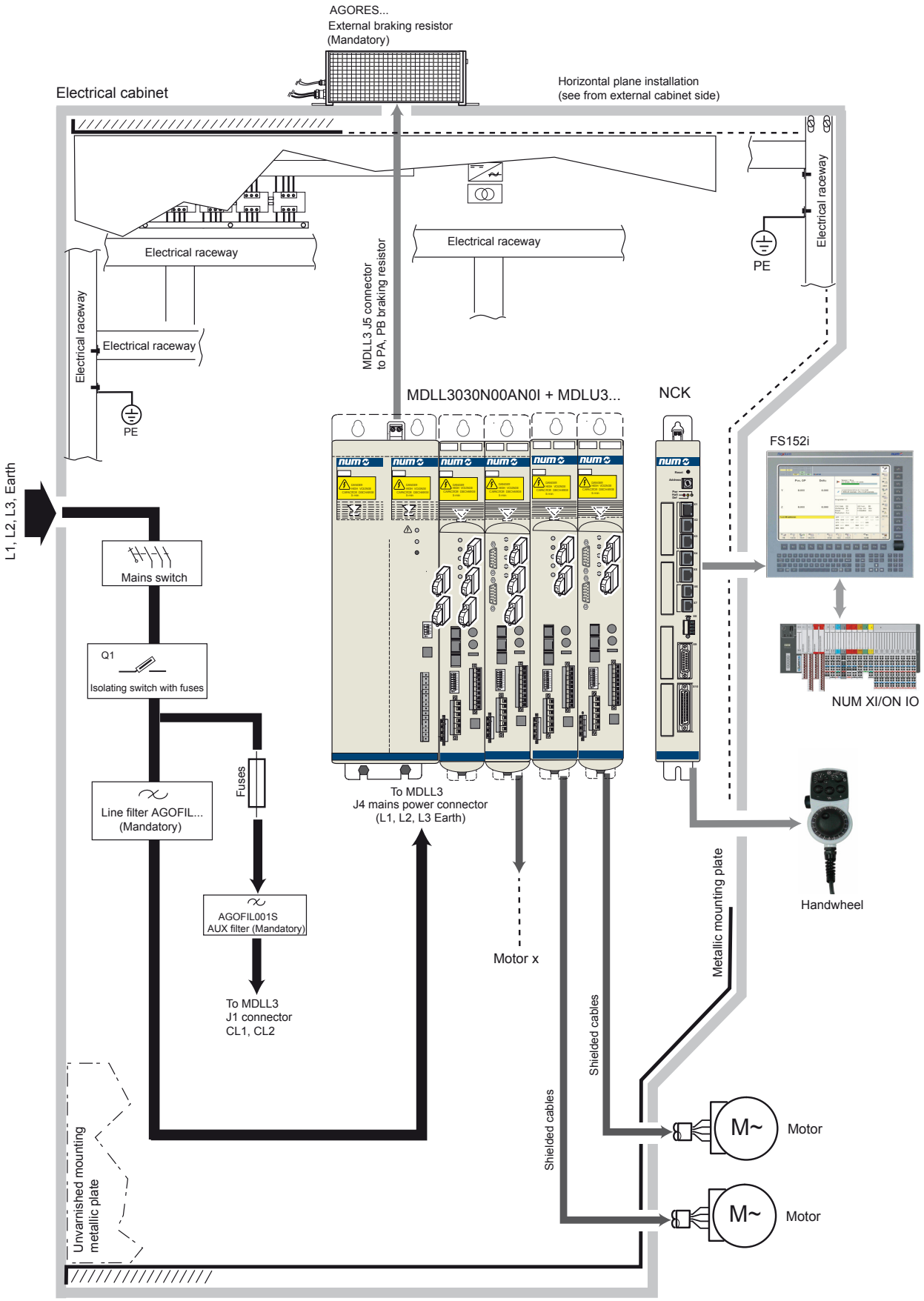
- Video display units (VDUs) must be kept away from sources of powerful magnetic fields (transformer, power cable, drive).

- To facilitate sufficient air circulation and so ensure an adequate heat exchange in the system, it is recommended that a minimum clearance of 100mm is left at top and bottom when installing the modules in the electrical cabinet.

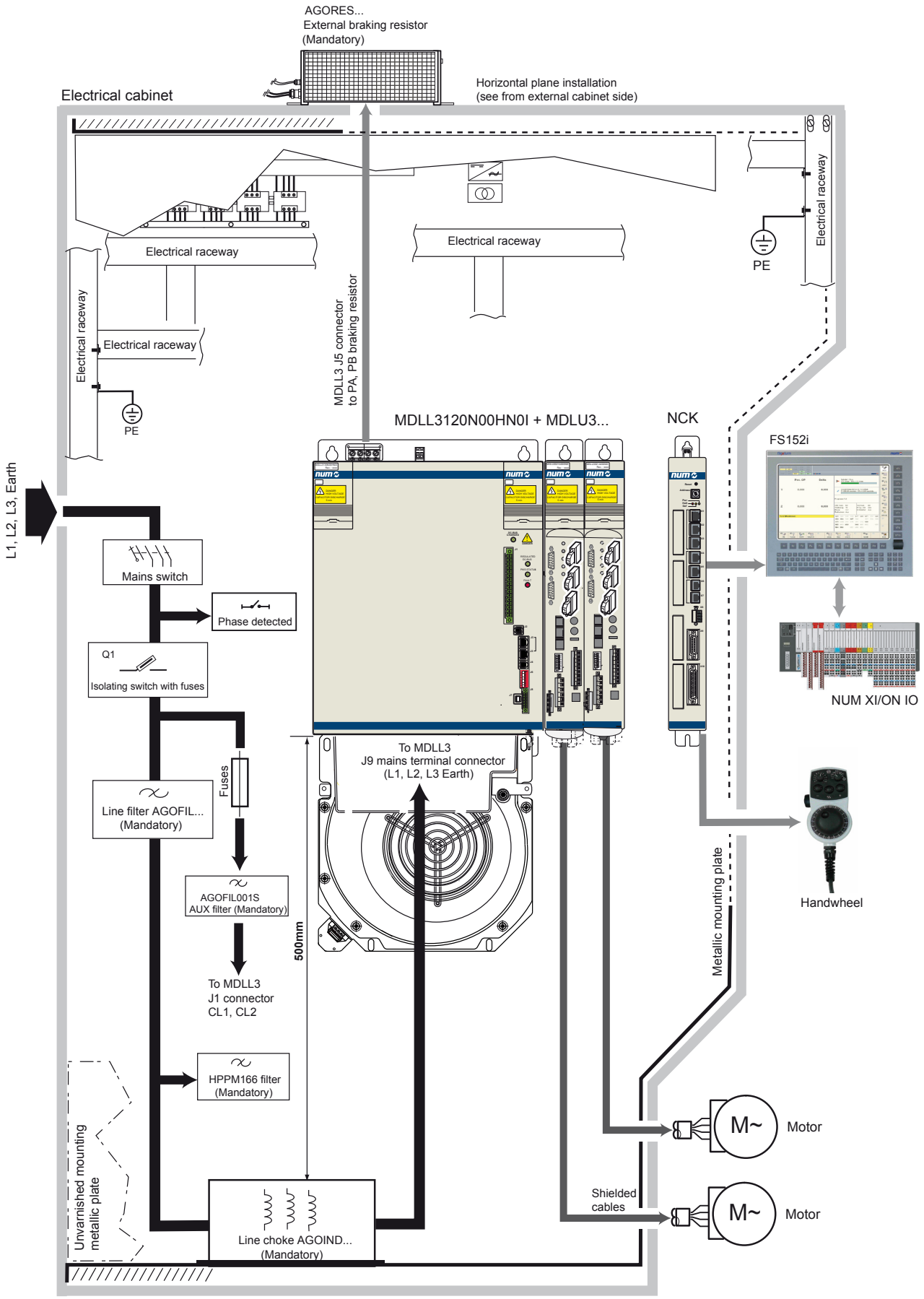
- The external braking resistor frame may reach high temperatures in the case of a particularly heavy use, due to a high number of brakings. We therefore suggest to place them where they cannot be accidentally touched by personnel.

- The line choke frame may reach high temperatures.
  We therefore suggest to place them where they cannot be accidentally touched by personnel.

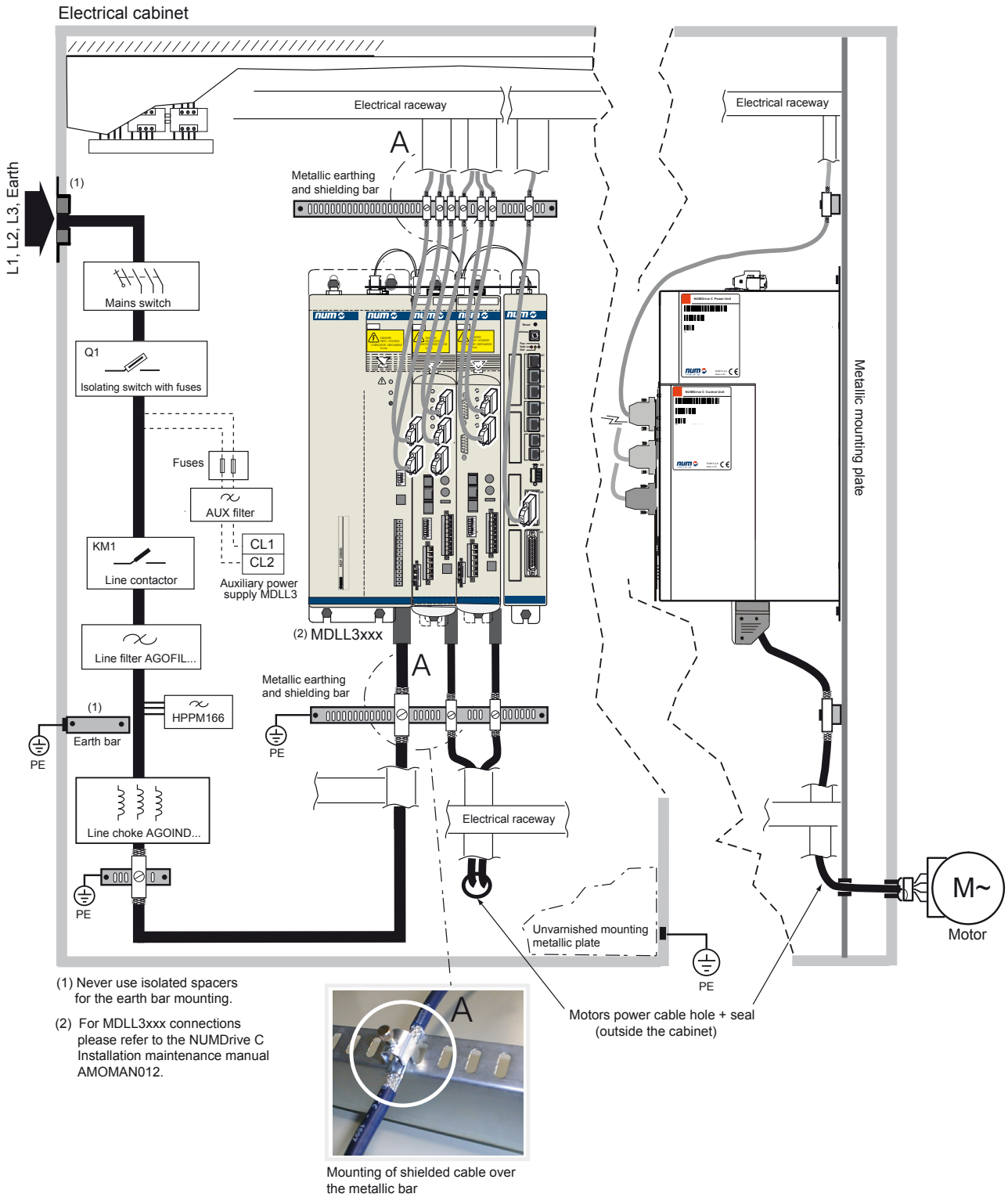
3.2 General installation layout with MDLL3xxxN00AN0I



3.3 General installation layout with MDLL3xxxN00R/H



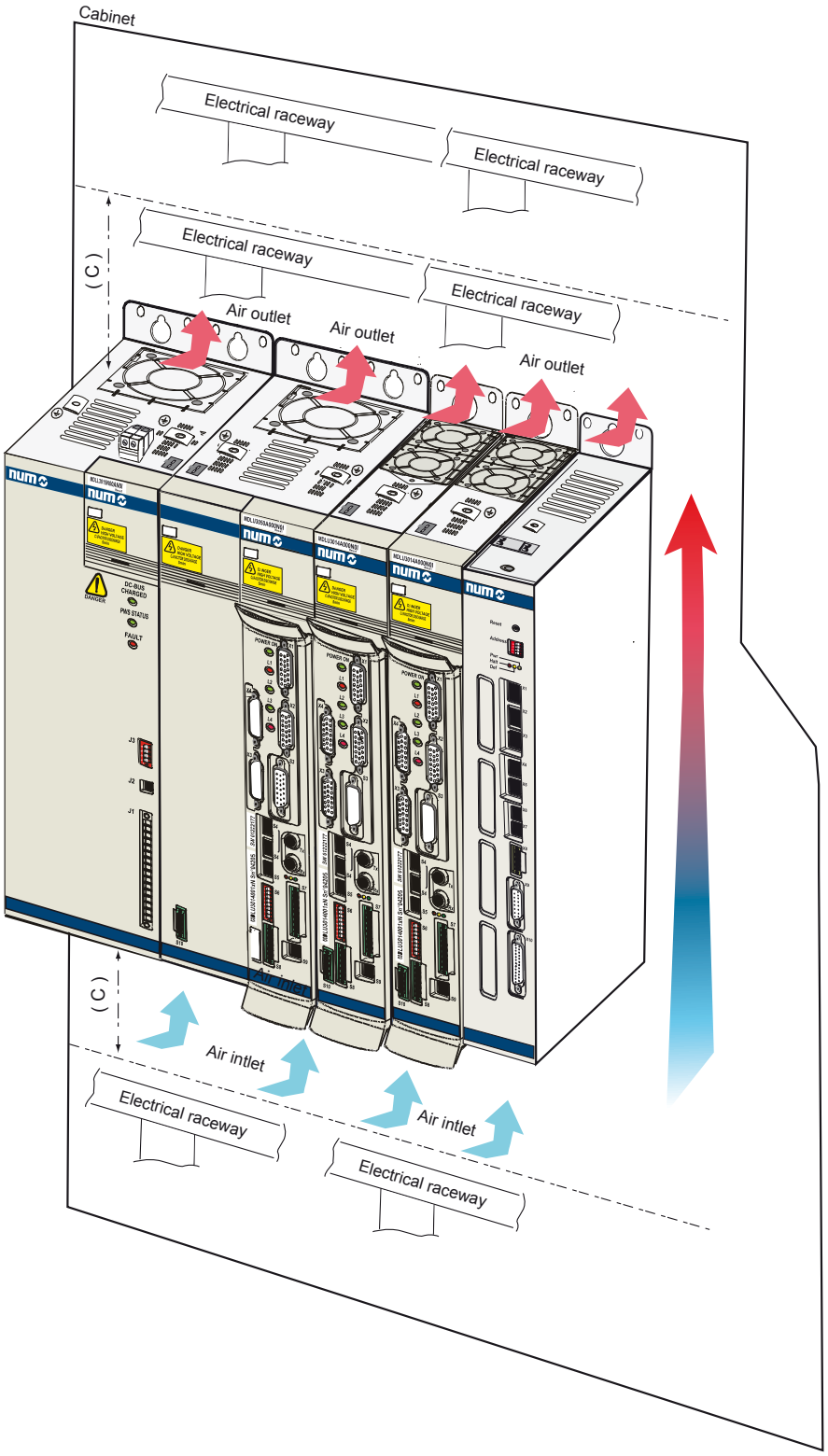
3.4 System connections in cabinet with i.e. metallic shielding bar



For more detailed information on the drive general connections please refer to the AMOMAN012 manual.

3.5 Air ventilation clearance

To facilitate sufficient air circulation and therefore ensure an adequate heat exchange in the system, it is recommended, when installing the modules in the electrical cabinet, that a minimum ventilation clearance (C) ≥ 100mm is left at top and bottom side as indicated in figure here below.



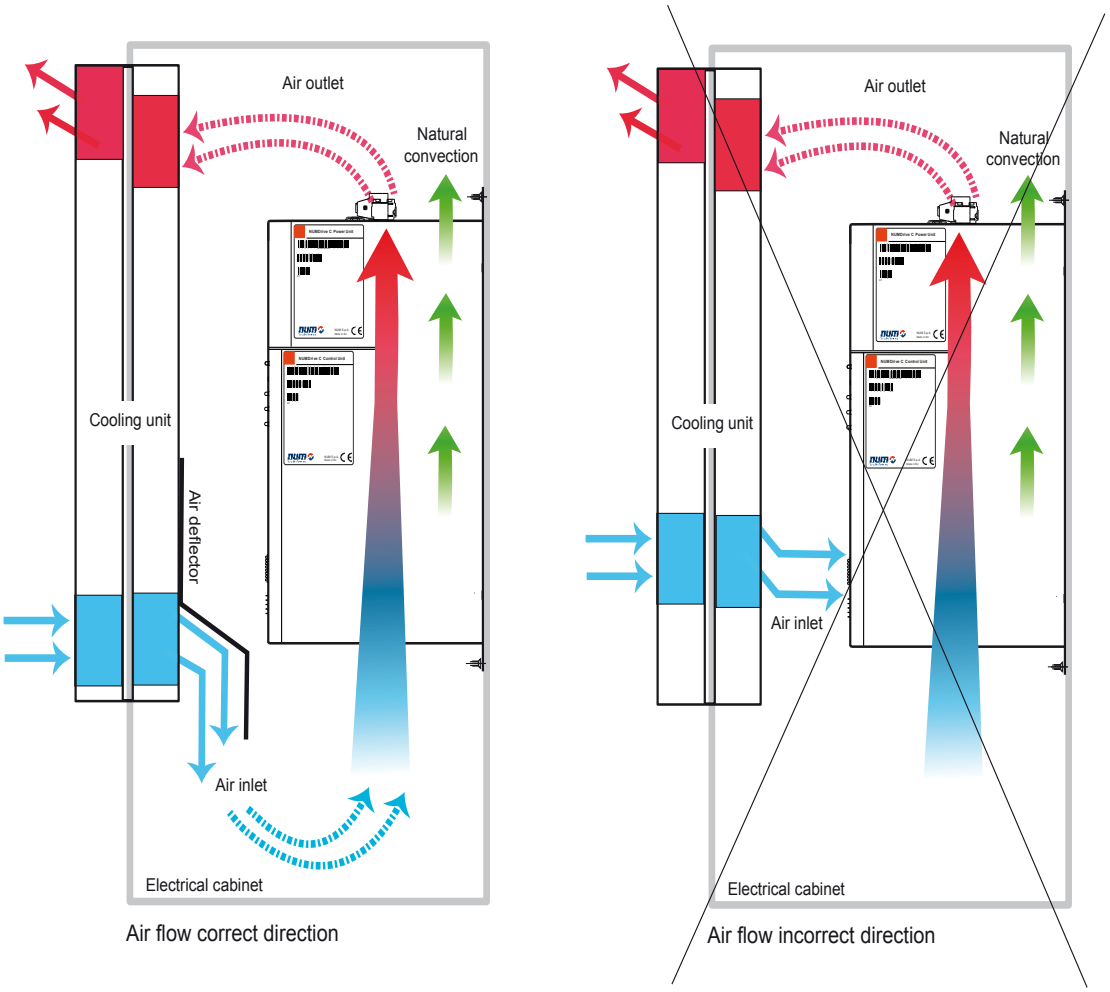
3.5.1 Air direction and air flow rate

Basically the cooling of the devices in the cabinet is based by on natural convection and/or by forced cooling using fans. Anyway, in both cases the direction of the cooling air the cooling must be in the opposite direction to gravity, from the bottom upwards.
If there are other air circuits in the cabinet, for example from filter fans or cooling units, it must be ensured that the air flows do not counterbalance each other but have an additional effect. Please refer to the examples below.

A correct air flow rate dimensioning in the cabinet must be ensured in order to safeguard the heat dissipation from the drives and other device combination, in addition to the required cooling measures it must be ensured that minimum volumes of air are circulated inside the cabinet. Further details about this can be taken from the device-specific technical user documentation. Uniform air circulation in the cabinet must be ensured.

The cooling air should be directed at as large an area of the target as possible by positioning the cooling unit appropriately or guiding the cooling air through hoses or ducts.

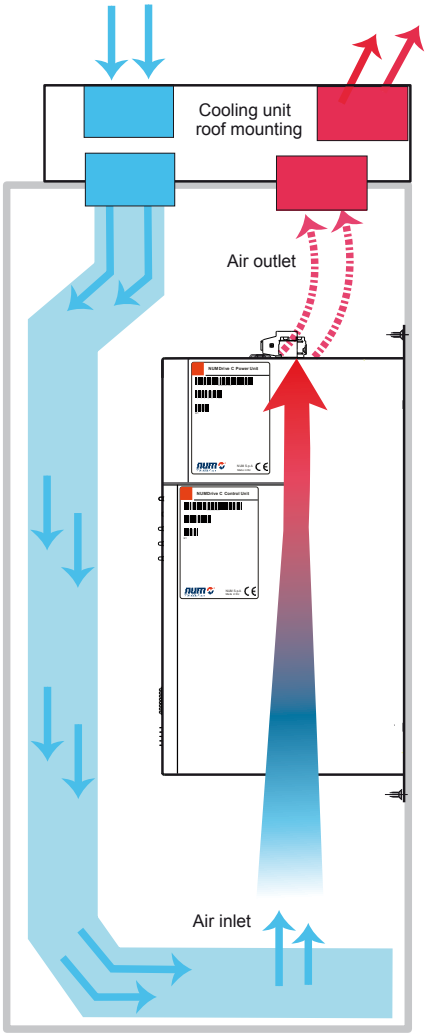
Air circulation with mounting wall cooling units



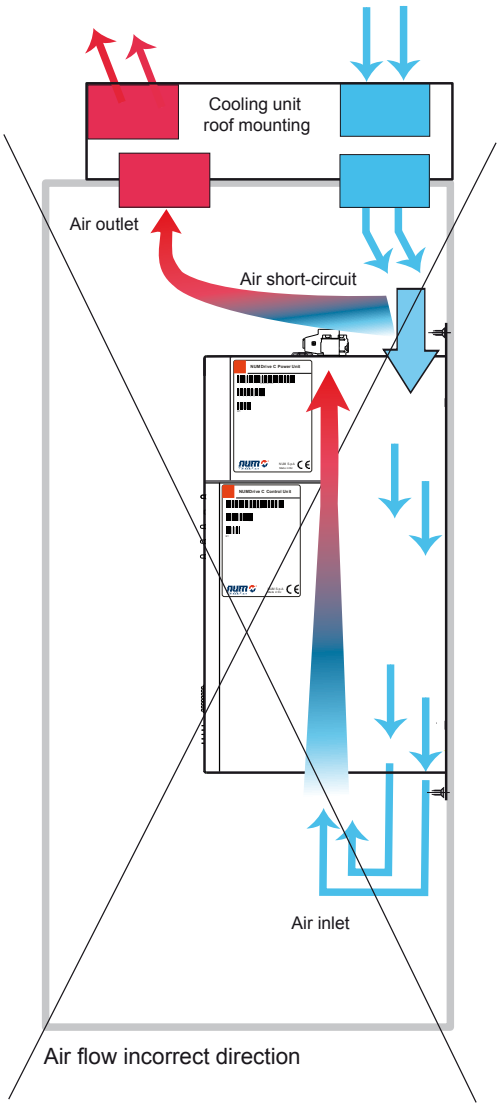
Air flow correct direction

Air flow incorrect direction

Air circulation with roof-mounting cooling units



Air flow correct direction

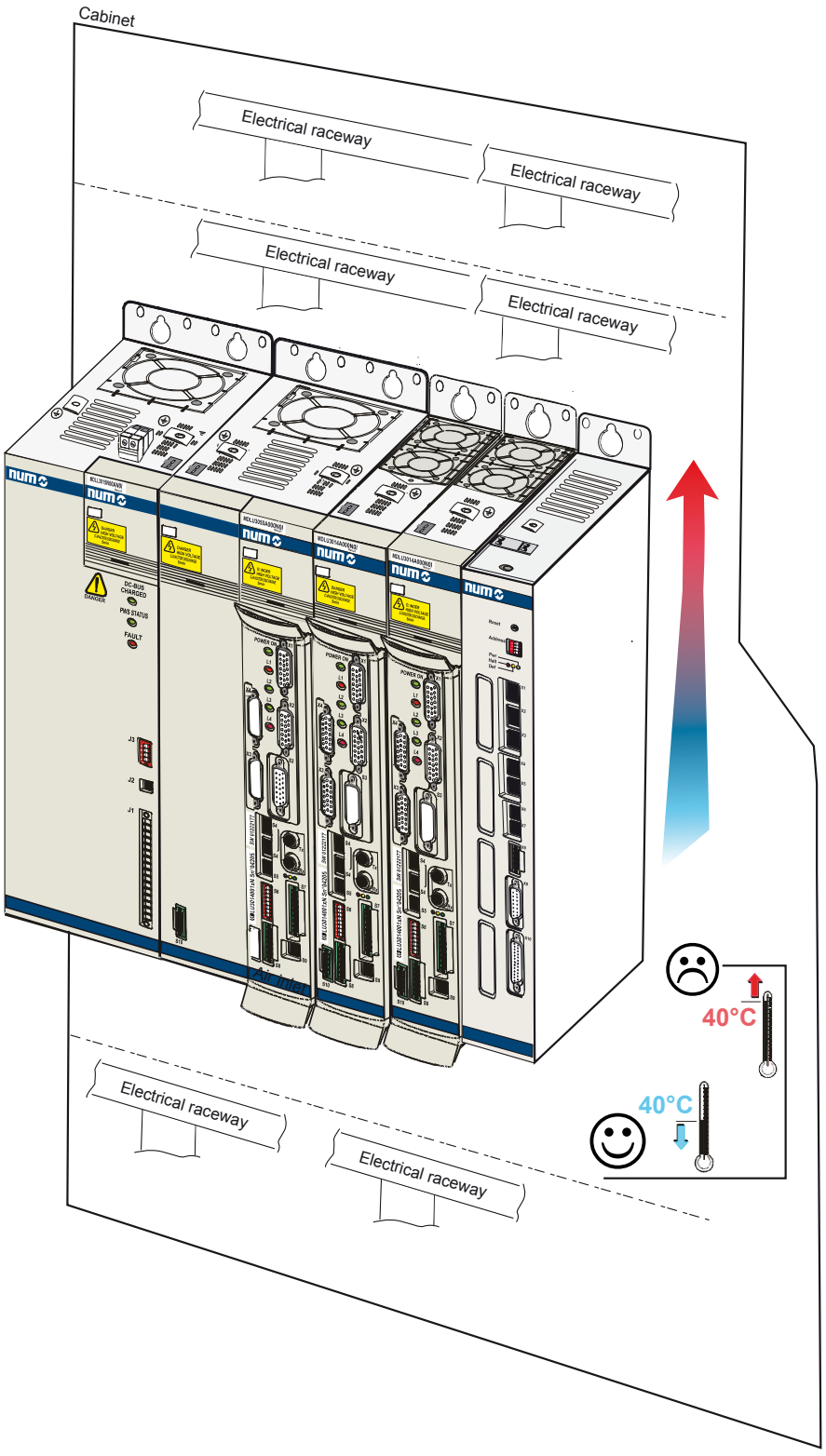


Air flow incorrect direction

3.6 Operating cabinet temperature

The NUMDrive C drives and MDLL3 power supply are designed for use the temperature range of 0 ÷ 40°C max.

In other cases, with ambient temperatures higher than 40°C, it is necessary to determine the current derating factor. Please refer to the AMOMAN012 manual.

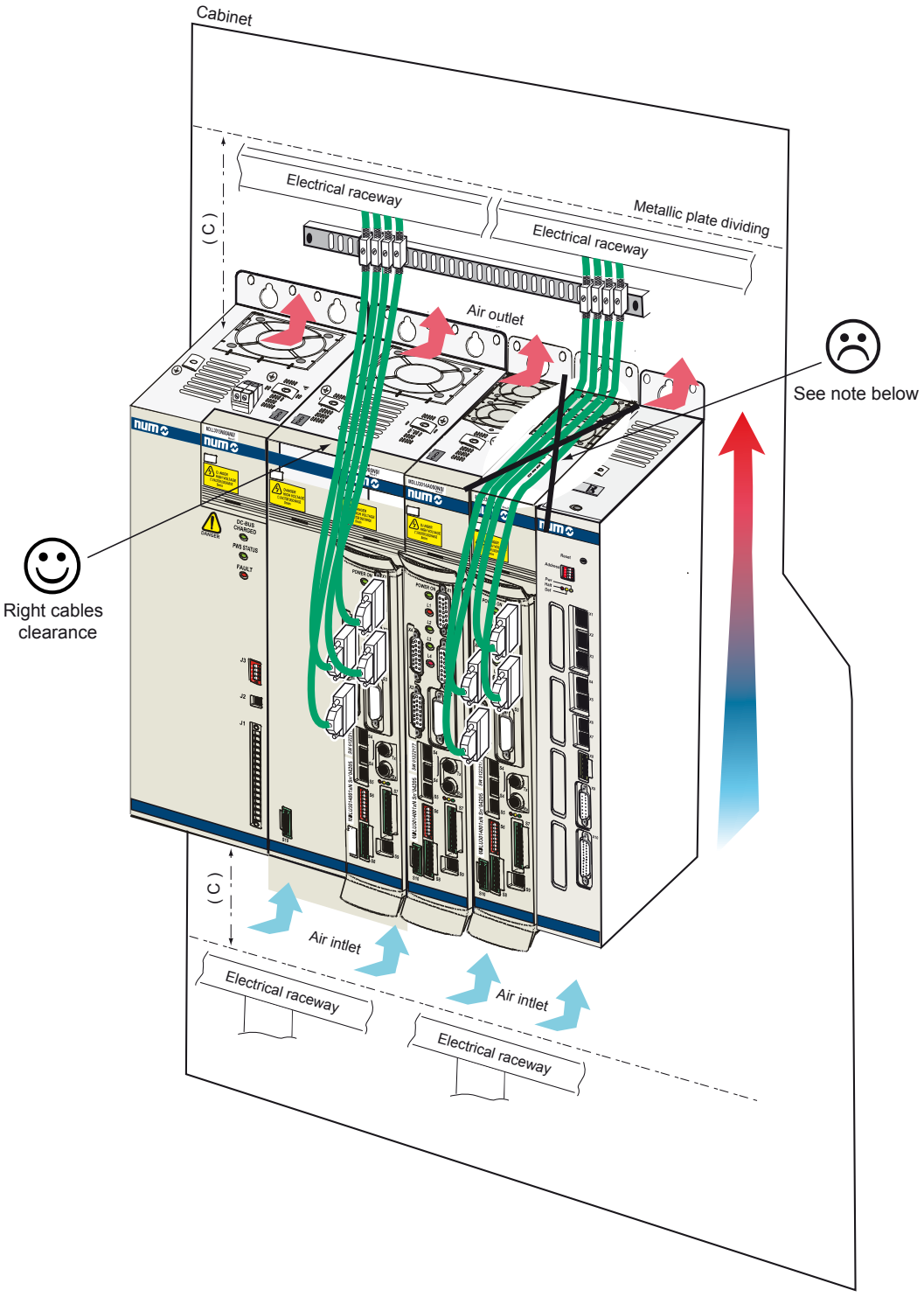


3.7 Cable layout

3.7.1 Cable layout according to the air flow rate

The cable lay out must be realized in order to guarantee a correct air flow in the cabinet; therefore it is recommeded:

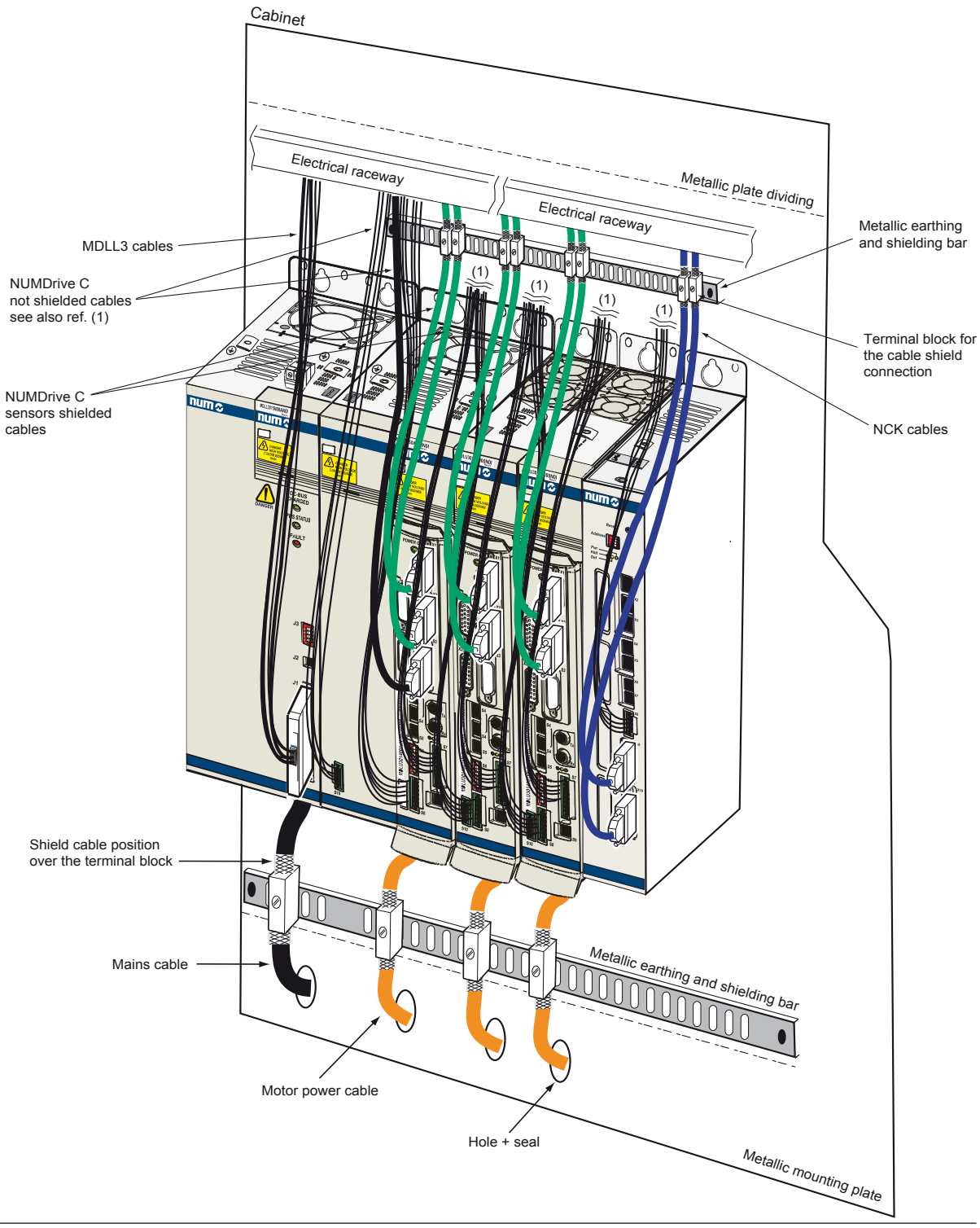
- Do not cover the ventilation grilles with cables or anything else, this may cause too high temperature in the devices.
- Make the cables layout according to the right minimum ventilation clearance (C) ≥100mm as indicated in the figure. We also suggest to make cables layout in vertical mode as indicated in order to handle in easy way the maintenance mounting/dismounting operations of the drive modules in the cabinet.



3.7.2 Cable connection layout

To prevent eventual disturbances on the signals coming from sensors, when you make the wiring lay out in the cabinet make sure that the minimum distance between the sensor cables and the power input cables is ≥ 150mm. It is recommended to wiring the power cables in the cabinet as indicated in the figure here below:

- The unshielded cables (1) must be run directly through the electrical raceway.
- The shielded cables must be wired as indicated in the figure using an appropriate metallic earthing and shielding bar. Never use isolated spacers for the metallic bar mounting.
- The cable shield must be connected using an appropriate terminal block.



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