Technical Guide No. 3

EMC Compliant Installation and Configuration for a Power Drive System

ABB

Contents

Chapter 1 - Introduction

General

This guide assists design and installation personnel when trying to ensure compliance with the requirements of the EMC Directive in the user's systems and installations when using AC drives.

This guide's purpose

The purpose of this guide is to guide Original Equipment Manufacturers (OEM), system integrators and panelbuilders in designing or installing AC drive products and their auxiliary components into their own installation and systems. The auxiliaries include contactors, switches, fuses, etc. By following these instructions it is possible to fulfil EMC requirements and give CE marking when necessary.

The Directives concerning drives

There are three directives which concern variable speed drives. They are the Machinery Directive, Low Voltage Directive and **EMC Directive**. The requirements and principles of the Directives and use of CE marking is described in Technical Guide No. 2 **"EU Council Directives and Variable Speed Drives"**. This document deals only with the EMC Directive.

Who is the manufacturer?

The European Commission has published guidelines on the application of the EMC Directive. These guidelines give the following definition of a manufacturer: "This is the person responsible for the design and construction of an apparatus covered by the Directive with a view to placing it on the EEA market on his own behalf. Whoever modifies substantially an apparatus resulting in an "as-new" apparatus, with a view to placing it on the EEA market, also becomes the manufacturer."

The responsibility of the manufacturer

According to EMC Directive (89/336/EEC) article 10 part 1, the manufacturer is responsible for attaching the CE-mark to each unit. According to part 2 the manufacturer is responsible for writing and updating the Technical Construction File (TCF), if the TCF route is used.

OEM customer as a manufacturer

It is well known that OEM customers sell equipment using own trade marks or brand labels. Changing the trademark, brand label or the type marking is an example of modification resulting in "as new" equipment.

Frequency converters sold as OEM products shall be considered components (Complete Drive Module CDM or Basic Drive Module BDM). Apparatus is an entity and includes any documentation (manuals) intended for the final customer. Thus, the **OEM-customer has sole and ultimate responsibility** concerning EMC of equipment, and he shall issue a Declaration of Conformity and Technical Construction File for the equipment.

ABB Oy offers services to help OEM customers to issue a TCF and a DoC in order to CE mark the product according to the EMC Directive.

Panel builder or system integrator as a manufacturer

According to the EMC Directive, a system is defined as a combination of several types of equipment, finished products, and/or components combined, designed and/ or put together **by the same person (system manufacturer)** intended to be placed on the market for distribution **as a single** functional unit for an end-user and intended to be installed and operated together to perform a specific task.

A panel builder or system integrator typically undertakes this kind of work. Thus, the panel builder or system integrator has sole and ultimate responsibility concerning EMC of the system. He cannot pass this responsibility to a supplier.

In order to help panel builder/system integrator, ABB Oy offers installation guidelines related to each product as well as general EMC guidelines (this document).

Definitions

The **EMC Product Standard for Power Drive Systems, EN 61800-3 (or IEC 61800-3)** is used as the main standard for variable speed drives. The terms and definitions defined in the standard are also used in this guide.

Practical installations and systems

This guide gives practical EMC examples and solutions which are not described in product specific manuals. The solutions can be directly used or applied by the OEM or panelbuilder.

Earthing principles

The earthing and cabling principles of variable speed drives are described in the manual **“Grounding and cabling of the drive system”**, code 3AFY 61201998. It also includes a short description of interference phenomena.

Product-specific manuals

Detailed information on the installation and use of products, cable sizes etc. can be found in the product specific manuals. This guide is intended to be used together with product specific manuals.

Electromagnetic Compatibility (EMC) of PDS

EMC stands for **E**lectro**m**agnetic **C**ompatibility. It is the ability of electrical/electronic equipment to operate without problems within an electromagnetic environment. Likewise, the equipment must not disturb or interfere with any other product or system within its locality. This is a legal requirement for all equipment taken into service within the EEA. The terms used to define compatibility are shown in figure 2-1.

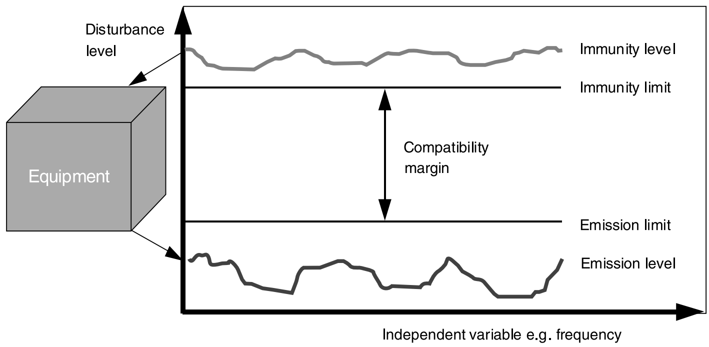


Figure 2-1 Immunity and emission compatibility.

As variable speed drives are described as a source of interference, it is natural that all parts which are in electrical or airborne connection within the PDS are part of the EMC compliance. The concept that a system is as weak as its weakest point is valid here.

Immunity

Electrical equipment should be immune to high-frequency and low-frequency phenomena. High-frequency phenomena include electrostatic discharge (ESD), fast transient burst, radiating electromagnetic field, conducting radio frequency disturbance and electrical surge. Typical low-frequency phenomena are mains voltage harmonics, notches and imbalance.

Emission

The source of high-frequency emission from frequency converters is the fast switching of power components such as IGBTs and control electronics. This high-frequency emission can propagate by conduction and radiation.

Power Drive System

The parts of a variable speed drive controlling driven equipment as a part of an installation are described in EMC Product Standard EN 61800-3. A drive can be considered as a Basic Drive Module (BDM) or Complete Drive Module (CDM) according to the standard.

It is recommended that design and installation responsible personnel have this standard available and be familiar with this standard. All standards are available from the national bodies on standardisation and from CENELEC, rue de Stassart, 35, 1050 Bruxelles.

Systems made by an OEM or panelbuilder can consist more or less of the PDS parts alone, or there can be many PDSs in a configuration.

The solutions described in this guide are used within the definition of Power Drive System, but the same solutions can, or in some cases, should, be extended to all installations. This guide gives principles and practical EMC examples which can be applied to a user's system.

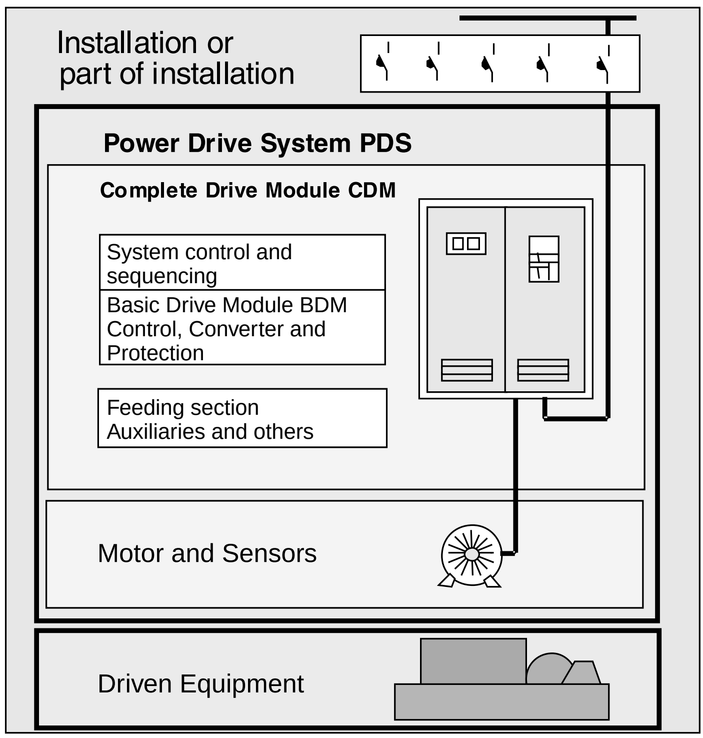


Figure 2-2 Abbreviations used in Drives.

Types of equipment

The EMC Directive applies to "all electrical and electronic appliances together with installations containing electrical and/ or electronic components liable to cause electromagnetic disturbance or the performance of which is liable to be affected by such disturbance". The interpretation of the EMC Directive for different configuration in the area of drives can be divided into several levels:

Component

In this context the interpretation of component can be divided into two main categories. The component can either deliver a ‘direct function’ or not.

Direct function:
Any function of the component itself, which fulfils the intended use, specified by the manufacturer in the instruction for use for an end user.

Components with direct function

Components with a direct function can be divided into two sub-groups:

1) *The direct function **is available** without further adjustment or connections other than simple ones, which can be performed by any person not fully aware of the EMC implications. Such a component is an ‘apparatus’ and it is subjected to all provisions of the EMC Directive.*

2) *The direct function **is not available** without further adjustment or connections other than simple ones, which can be performed by any person not fully aware of the EMC implications. Such a component is not an ‘apparatus’. The only requirement for such a component is to provide it with instructions for use for the professional assembler or manufacturer of the final apparatus into which the component will be incorporated. These instructions should help him to solve any EMC problems with his final apparatus.*

If a component performs a direct function without further adjustment other than simple ones, the component is considered equivalent to apparatus (Case 1). Some variable speed power drive products fall into this category, e.g. a drive installed into a cabinet or drive with enclosure and sold as a complete unit (CDM). All provisions of the EMC Directive apply (CE-mark, Declaration of Conformity).

If a component performs a direct function that is not available without further adjustment other than simple ones, it is considered as a component (Case 2). Some variable speed power drive products fall into this category, e.g. basic drive module (BDM). These are meant to be assembled by a professional assembler (e.g. panel builder or system manufacturer) into a cabinet not in the scope of delivery of the manufacturer of the BDM. According to the EMC Directive, the requirement **for the BDM supplier** is to deliver instructions for installation and use.

According to the EMC Directive the system manufacturer or panel builder is resonsible for CE-mark, Declaration of Conformity and Technical Construction File.

Components without direct function

Components with no direct function are not considered as apparatus within the meaning of the EMC Directive. The EMC Directive does not apply to these. These components include resistors, cables, terminal blocks, etc.

Apparatus and systems

A finished product containing electrical and/or electronic components and intended to be placed on the market and/ or taken into service as a single commercial unit.

Several items of apparatus combined to fulfil a specific objective and intended to be placed on the market as a single functional unit.

Installation

A combination of items of apparatus, equipment and/or components put together at a given place to fulfil a specific objective but **not** intended to be placed on the market as a single functional unit.

CE marking for EMC

A component with a direct function without further adjustment than simple ones needs to carry CE marking for EMC (Case 1).

A component with a direct function that is not available without further adjustment than simple ones does not need to carry CE marking for EMC (Case 2).

Note: The products may carry CE marking for other directives than EMC.

Apparatus and systems must be CE marked.

Installations are required to satisfy various parts of the Directives, but are **not** required to be CE marked.

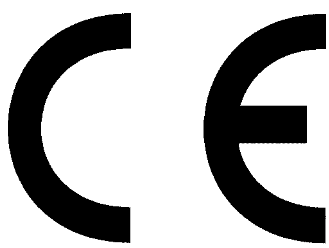


Figure 2-3 The CE mark.

Installation environments

The PDSs can be connected to either industrial or public power distribution networks. The environment class depends on the way the PDS is connected to power supply. The environment classes are First and Second Environment.

First Environment

"The First Environment includes domestic premises. It also includes establishments directly connected without intermediate transformer to a low-voltage power supply network which supplies buildings used for domestic purposes."

Second Environment

"Second Environment includes all establishments other than those directly connected to a low-voltage power supply network which supplies buildings used for domestic purposes"

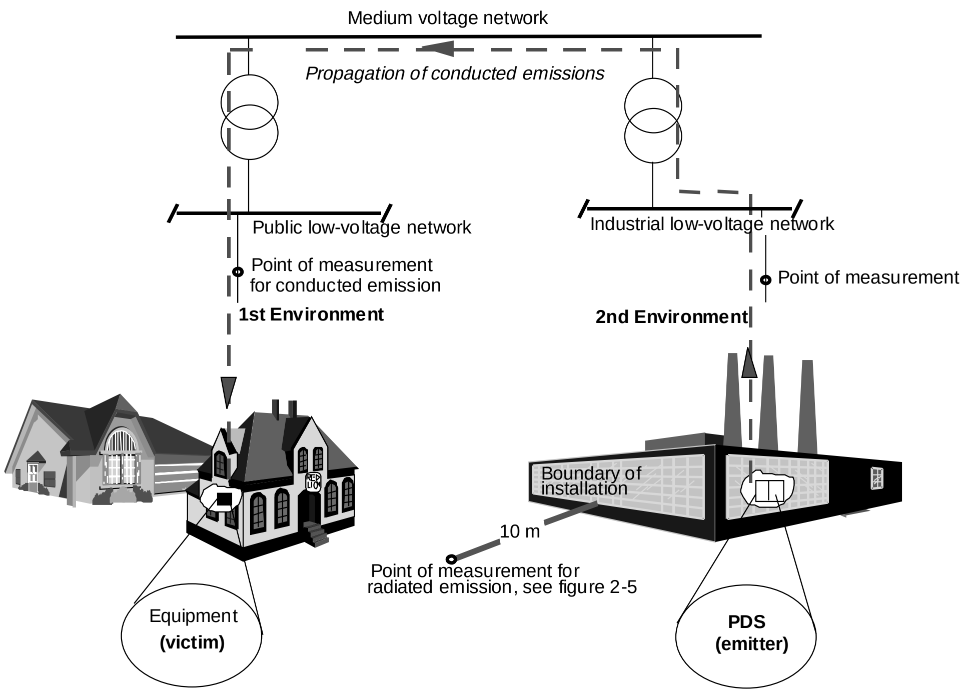


Figure 2-4 Illustration of Environment Classes and propagation of disturbances.

Propagation

"For PDSs in the second environment, the user shall ensure that excessive disturbances are not induced into low-voltage network, even if propagation is through a medium voltage network."

Note: Figure 2-4 shows the case when a victim is in a First Environment. The situation is the same if a victim is in a Second Environment in another installation. The measurements are carried out only in case of dispute (see figure 2-5).

The drive's route to market

The EMC Product Standard for PDS divides the drive's routes to the market into Unrestricted and Restricted sales distribution classes.

3

Unrestricted distribution

"Unrestricted distribution is a mode of sales distribution in which the supply of equipment is not dependent on the EMC competence of the customer or user for the application of drives".

Goods can be placed in service by a person skilled in the operation of goods, but without any specific EMC experience.

Restricted distribution

"Restricted distribution is a mode of sales distribution in which the manufacturer restricts the supply of equipment to suppliers, customers or users who separately or jointly have technical competence in the EMC requirements of the application of drives."

This means that the goods require EMC competence to be put into service.

EMC emission limits

The EMC emission limits for PDS depend on the installation environment, type of power supply network and power of the drive. Limits for certain conditions can be selected by using the following flow chart (see Figure 2-5).

EMC Plan

The appropriate limits of the PDSs of the restricted distribution class in the second environment may not be met due to technical reasons.

"These applications are:
- *IT networks in complex systems*
- *Current above 400 A*
- *Voltage above 1000 V*
- *Where the required dynamic performances are limited because of filtering*

… the user and the manufacturer shall agree on an EMC plan to meet the EMC requirements of the intended application."

This means that the manufacturer and the user make the EMC Plan in cooperation.

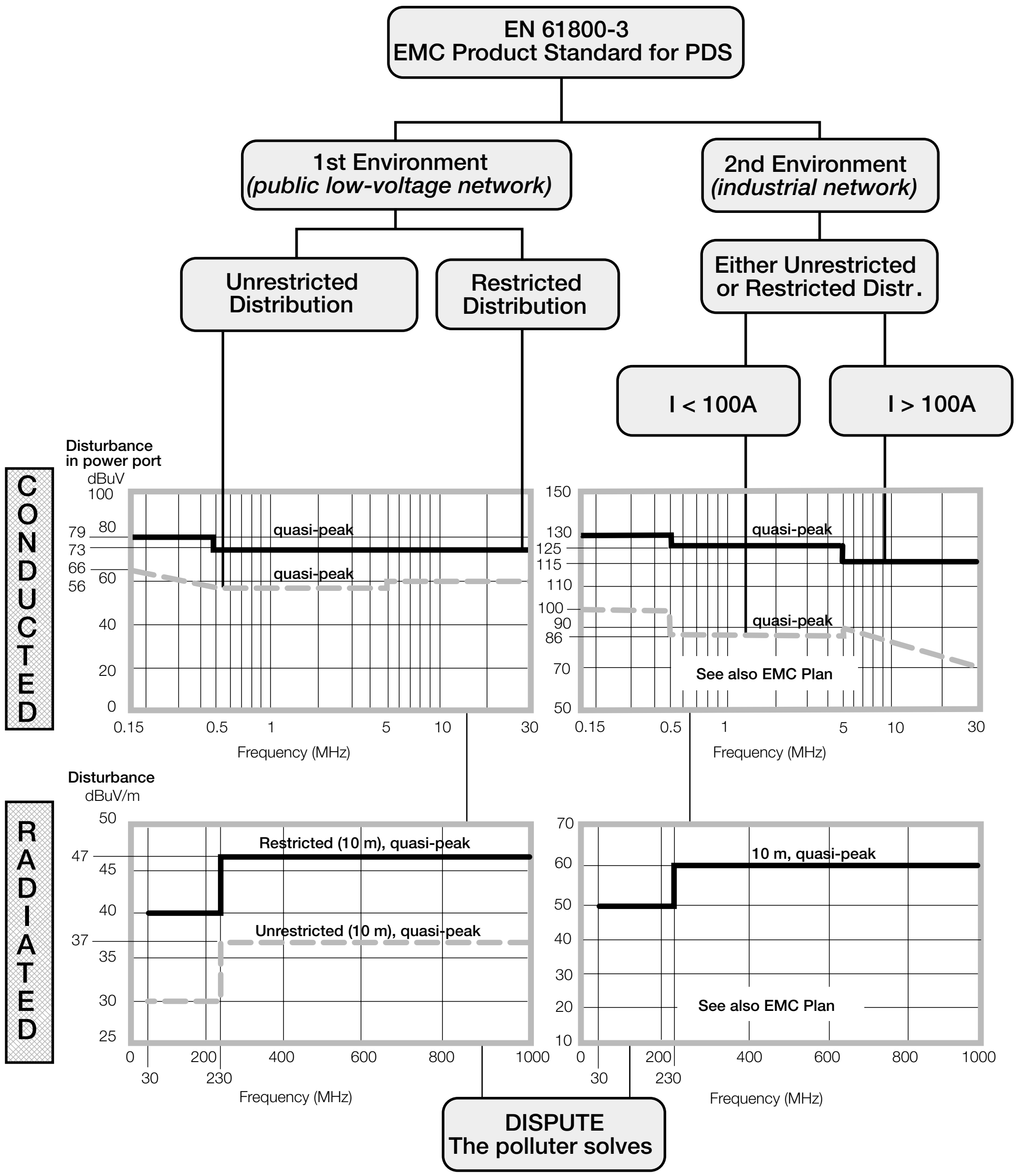


Figure 2-5 Emission limits for PDS.

Chapter 3 - EMC Solutions

General

The solutions used to fulfil immunity and both radiated and conducted emission requirements are described in this chapter.

Solutions for EMC compatibility

There are some basic principles which have to be followed when designing and using drive systems incorporating AC drive products. These same principles were used when these products were initially designed and constructed, where such issues as printed circuit board layout, mechanical design, wire routing, cable entries and other special points were all considered in great detail.

This all is referred to as **fully integrated EMC.**

Emissions

Drive products are normally immune to a majority of disturbances, otherwise they would be affected by their own disturbances. So in this context only emissions need to be handled.

The emissions can be divided into two parts, the conducted emission and the radiated emission. The disturbances can be emitted in various ways as the following figure shows:

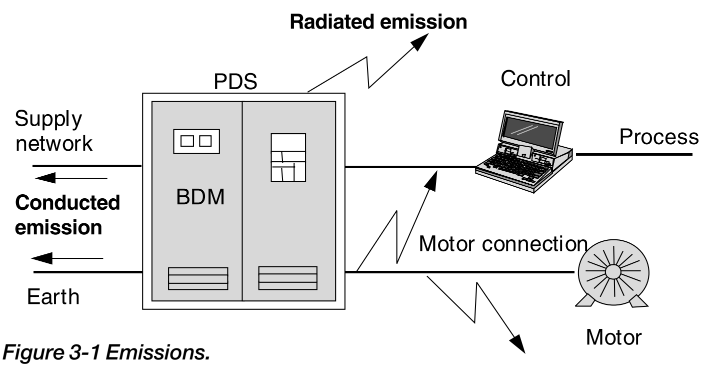


Figure 3-1 Emissions.

Conducted emission

Conducted disturbances can propagate to other equipment via all conductive parts including cabling, earthing and the metal frame of an enclosure.

Conductive emissions can be reduced in the following way:

- By RFI filtering for HF disturbances
- Using sparking suppressors in relays, contactors, valves, etc. to attenuate switching sparks
- Using ferrite rings in power connection points

Radiated emission

To be able to avoid disturbance through air, all parts of the Power Drive System should form a **Faraday Cage** against radiated emissions. The PDS includes cabinets, auxiliary boxes, cabling, motors, etc.

Some methods for ensuring the continuity of the Faraday Cage are listed as follows:

Enclosure:

- The enclosure must have an unpainted non-corroding surface finish at every point that other plates, doors, etc. make contact.
- Unpainted metal to metal contacts shall be used throughout, with conductive gaskets, where appropriate.
- Use unpainted installation plates, bonded to common earth point, ensuring all separate metal items are firmly bonded to achieve a single path to earth.
- Use conductive gaskets in doors and covers. Covers should be secured at not more than 100 mm intervals where radiation could escape.
- Separate radiative i.e. “dirty” side from the “clean side” by metal covers and design.
- Holes in enclosure should be minimised.
- Use materials with good attenuation e.g. plastic with conductive coating, if a metal enclosure cannot be used.

Cabling & Wiring:

- Use special HF cable entries for high frequency earthing of power cable shields.
- Use conductive gaskets for HF earthing of control cable shield.
- Use shielded power and control cables. See product specific manuals.
- Route power and control cables separately.
- Use twisted pairs to avoid disturbances.
- Use ferrite rings for disturbances, if necessary.
- Select and route internal wires correctly.

Installation:

- Auxiliaries used with CDMs should be CE marked products to both EMC & Low Voltage Directives, NOT ONLY to LV-directive, unless they are not concerned, e.g. being with a component without a direct function.
- Selection and installation of accessories in accordance with manufacturers’ instructions.
- 360° earthing at motor end. See product specific manuals.
- Correct internal wiring methods.
- Special attention must be given to earthing.

Note: When selecting equipment for a configuration it is essential to check that both radiated and conducted emissions have been taken into account.

3

Clean and dirty side

The circuit before the point where supply power is connected to the CDM and where the filtering starts, is referred to as the **clean side.** The parts of the BDM which can cause disturbances are described as the **dirty side.**

Enclosed wall mounted drives are designed so that the circuit followed by output connection is the only dirty part. That is the case if the installation instructions of the drive are followed.

To be able to keep the clean side “clean” the dirty parts are separated into a Faraday Cage. This can be done either with separation plates or with cabling.

When using separation plates the rules for enclosure holes are applicable (see section *Holes in enclosures* later in this chapter).

When the Faraday cage is formed by cabling, the rules for cabling must be applied (see *sections on cabling and wiring* in this chapter and follow the product specific instructions for the drive).

The use of additional components, e.g. contactors, isolators, fuses, etc. in some cases makes it difficult to keep the clean and the dirty side separate.

This can happen when contactors or switches are used in circuits to change over from clean to dirty side (e.g. by-pass).

Some examples of solutions are described in chapter 4, *Practical Examples.*

RFI filtering

RFI filters are used to attenuate conducted disturbances in a line connecting point where the filter leads the disturbances to earth.

Output filters attenuate disturbances at the output of a PDS. E.g. du/dt and common mode filters help somewhat, even if they have not been designed for RFI.

Note: Filters cannot be used in floating network (IT-network) where there is high impedance or no physical connection between the phases and the earth.

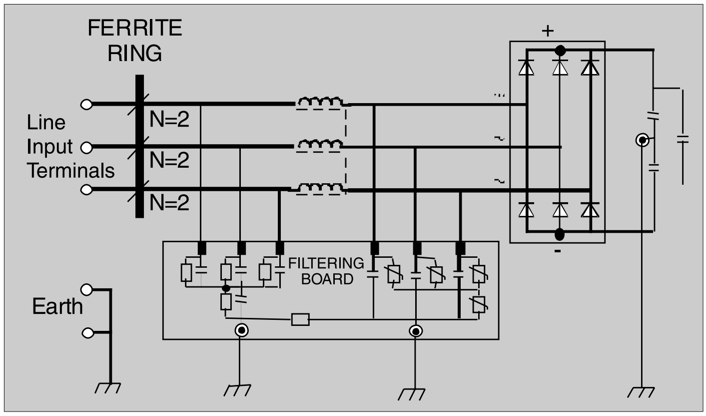


Figure 3-2 Example of filtering integrated in drive module.

Figure 3-2 shows an example of integral, distributed filtering. Some drive products need a separate filter (see product specific instructions).

Selecting the RFI filter

An RFI filter is selected to attenuate the conducted disturbances. It is not possible to compare the disturbances measured from a source, and the insertion loss for a filter, as the measurement base for the two items of information will not correspond.

It is **always necessary to test** a filter in conjunction with the source of disturbance to ensure adequate attenuation and to meet applicable emission limits.

Installation of the RFI filter

Reliable HF/low impedance connections are essential to ensure proper functioning of the filter, therefore the following instructions shall be followed.

- Filter shall be assembled on a metal plate with unpainted connection points all in accordance with filter manufacturer's instructions.
- The frames of the filter cubicle (if separate) and the drive cubicle shall be bolted together at several points. Paint shall be removed from all connection points.
- The input and output cables of the filter shall not run in parallel, and must be separated from each other.

- The maximum length of the cable between the filter and the drive must be according to the RFI-filter manufacturer's instructions.
- The filter must be earthed in accordance with the manufacturer's instructions. Note that the cable type and size are critical.

Drives in IT-networks

Check with a meter that there are no filtering capacitors connected to earth.

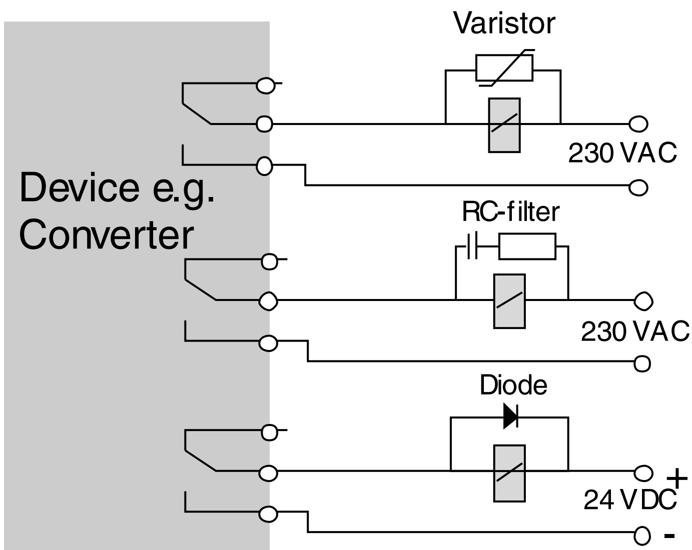


Figure 3-3 Examples of suppression.

Arc suppressors

Relays, contactors and magnetic valves must be equipped with spark suppressors. This is also necessary when these parts are mounted outside the frequency converter cubicle.

Selection of a secondary enclosure

Where the BDM is to be installed, (e.g. an IP 00 open chassis converter), or if additional components are to be connected to the dirty side of an otherwise compliant unit, it is always necessary to provide an EMC enclosure.

For enclosed chassis modules where the motor connections are made directly to the converter output terminals, and all the internal shielding parts are fitted, there are no requirements for special enclosures.

If drives are fitted with output switching devices, for example, then an EMC enclosure will be needed, as the integral Faraday Cage will no longer apply.

As a reminder, EMC is only one part of enclosure selection. The enclosure is sized according to several criteria:

- Safety
- Degree of Protection (IP Rating)
- Heat Rejection Capability
- Space for accessory equipment
- Cosmetic aspects
- Cable access
- EMC compliance
- General requirements for EMC compatibility

The safety of people and animals together with degree of protection (IP-rating) requirements are mainly described in Machinery Safety standard EN 60204-1, Electrical Safety Standard EN 50178 or Product Standard EN 61800-2 and are not described here. In this document only the EMC aspect is handled.

From the EMC point of view it means that the enclosure is firm and proof enough to be a part of the Faraday Cage. In small systems, plastic boxes can also be used if they are painted inside with conductive paint. The paint must have metal to metal contact at each seam to other parts of the metal enclosure.

External safety switches can also be in plastic boxes if the boxes form a good Faraday Cage and are conductive inside, otherwise metal boxes should be used.

The enclosure must adhere to the following parameters as a minimum:

- Thickness: 0.75 mm stainless (galvanised) steel (Normally recommended ≤1.5 mm for stiffness).
- Outside surface: Electrostatic powder coating e.g. polyester powder paint (TGIC). Thickness 60µ, or other cosmetic finish.
- Inside surface: Hot galvanised and chromated steel. ***Not painted. The surfaces that make metal to metal contact shall not be painted.***
- Louvres: holes in steelwork ≤ 21 mm in width or proprietary RFI proof type.
- Doors: Sealed with conductive gasket, and adequately earthed. Enough locks for high frequency earthing.

- Cover plates: Metal against metal (not painted), all earthed. A number of proprietary enclosure types are available, which use a variety of materials and methods of shielding against radiated emissions.

The manufacturer's guidelines for construction and earthing must be followed.

FARADAY CAGE

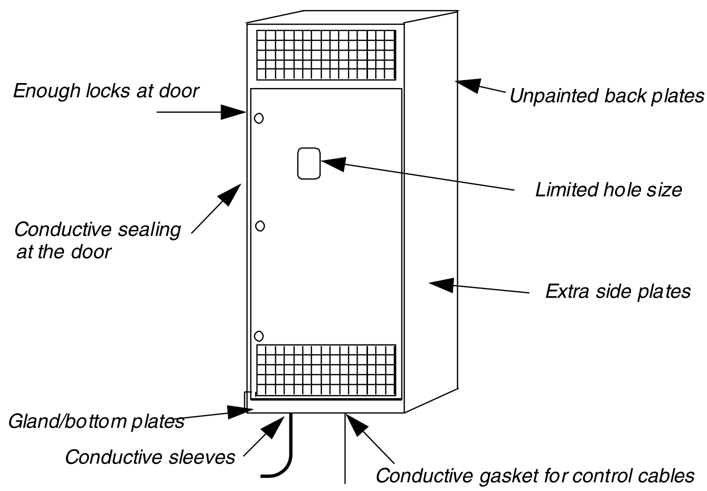


Figure 3-4 Enclosure detail.

Holes in enclosures

In most cases, some holes must be made in the enclosure e.g. for door devices, louvres, locks, cables, etc.

When an EMC enclosure is to be used, the maximum diagonal or diameter for any hole is 100 mm, which equates to $^{1}/_{10}{}^{TH}$ of the wavelength of a 300 MHz frequency. This dimension has been found acceptable in EMC tests.

It is, however, also recommended to use metal framed devices if their assembly holes are between 30 mm to 100 mm, if there is any possible doubt about problems with HF disturbances.

Holes bigger than 100 mm must be covered with a metal frame surrounding the aperture and earthed to the enclosure.

Larger viewing holes can be covered by proprietary glazing with conductive coating.

Glazing must be connected to non painted metal surrounds with conductive double sided tape or conductive gasket.

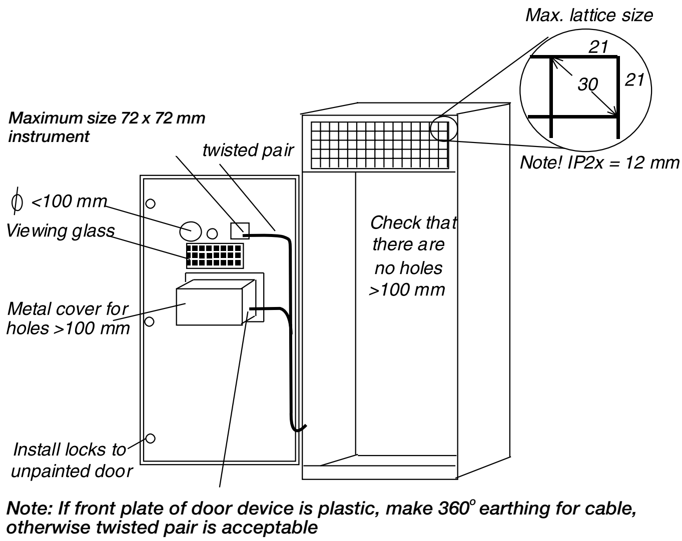


Figure 3-5 Typical enclosure aperture detail.

360° HF earthing

360° HF earthing should be done everywhere where cables enter the drive enclosure, auxiliary connection box or motor. There are different ways to implement the HF earthing. The solutions used in ABB's CDM/BDM products are described here.

HF earthing with cable glands

The cable glands which are specially designed for 360° HF earthing are suitable for power cables with a diameter less than 50 mm.

Cable glands are not normally used for control cables due to the fact that the distance from the control connections to the cable glands is often too long for reliable HF earthing. If the glands are used with control cables, the cable shielding must continue as near to the control connections as possible. Only the outer insulation of cable should be removed to expose the cable screen for the length of the cable gland.

To get the best possible result from HF earthing, the cable shielding should be covered with a conductive tape. The tape must cover the whole surface of the shielding, including pigtail, and should be tightly pressed with fingers after every single turn. The glue must be conductive.

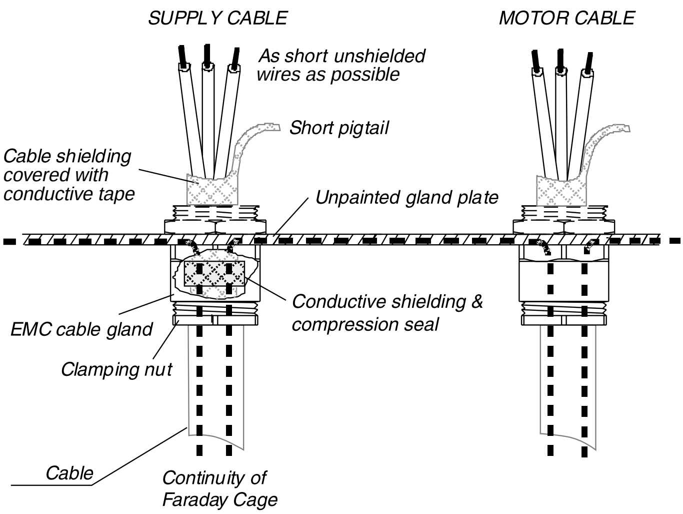


Figure 3-6 Essential points of power connections.

HF earthing with conductive sleeve

360° HF earthing in power cable entries can be done by using a conductive sleeve around the cable shielding. The sleeve is connected to the Faraday Cage by tightening it to the specially designed collar in the gland plate.

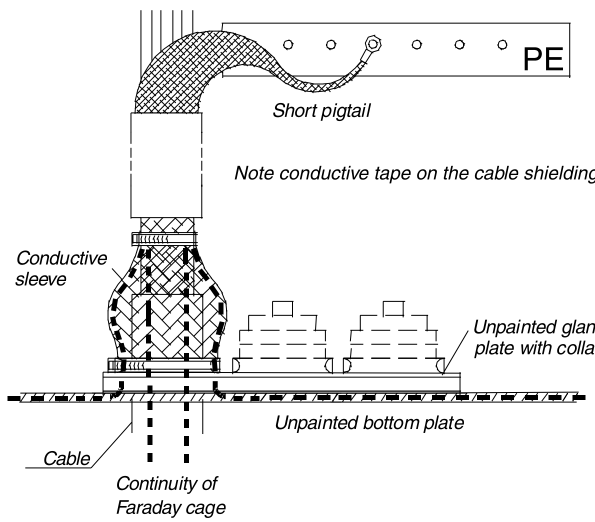


Figure 3-7 360° earthing with conductive sleeve.

The advantage of this solution is that the same sleeve can be used for cables with different diameters.

The cable can be mechanically supported by clamps, and a specific cable gland is not required.

Note that the sleeve does not act as a strain relief clamp.

360° earthing at motor end

The continuity of the Faraday Cage at the motor end must be ensured by the same methods as in cabinet entry, namely:

- Cable gland must be used for clamping the cable.
- Cable shielding should be sealed with conductive tape.
- Conductive gaskets should be used for sealing both the cable gland plate and the terminal box cover for the Faraday Cage and IP 55 degree of protection.
- Earthing pigtail conductors should be as short as possible.

Figure 3-8 shows a Faraday Cage solution at the motor end.

For motors which are not totally enclosed, such as in cooling form IC01, IC06, etc. the continuity of the Faraday Cage must be ensured in the same manner as for the converter enclosure.

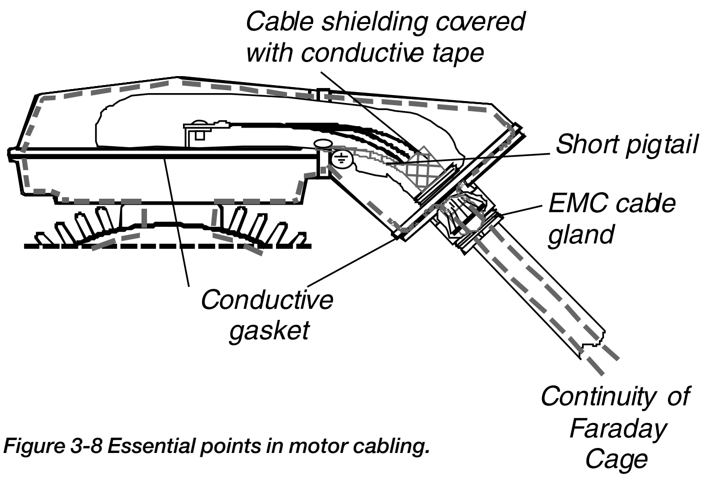


Figure 3-8 Essential points in motor cabling.

Conductive gaskets with control cables

The 360° HF earthing for control cables can be done with conductive gaskets. In this method the shielded control cable is led through two gaskets and pressed tightly together, as the figure 3-9 shows.

When gaskets are mounted at a gland plate, the cable shielding must continue as near to the control connections as possible. In this case the outer insulation of the cable should be removed to allow connection to the shield for the length of the gasket transit.

The shielding should be covered with conductive tape.

The best HF earthing is achieved if gaskets are mounted as near to the control connections as possible.

The gaskets must be installed to connect with the earthed unpainted surfaces of the gland plate to which they are mounted.

All connection tails should be as short as possible, and twisted in pairs where appropriate. The cable shield should be earthed to the connection end by a short pigtail.

The hole size in a gland plate required by these gaskets is typically 200 x 50 mm.

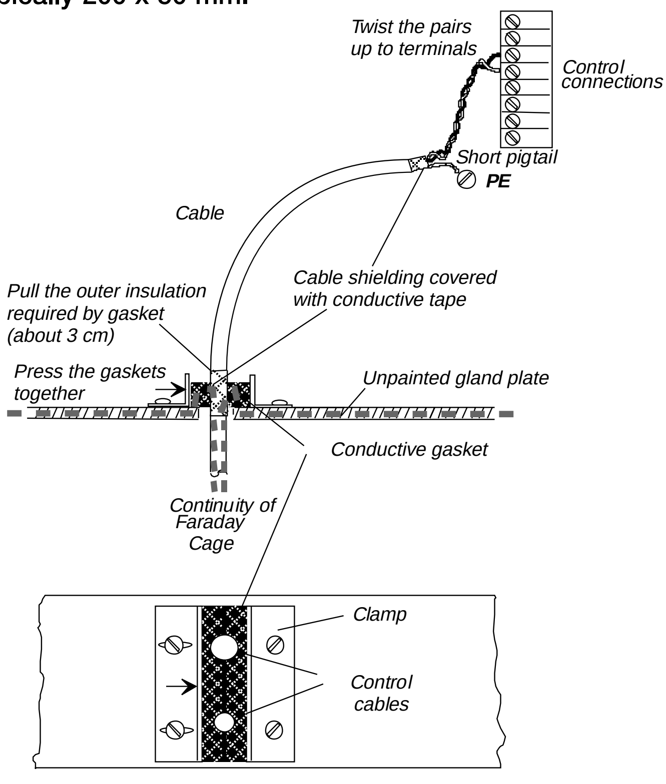


Figure 3-9 Essential points for control cabling transit.

Installation of accessories

The variety of accessories which can be installed is so large that only basic principles for selection and installation can be given for them.

Accessories can, however, be divided into two categories depending on how immune/sensitive they are.

The protected device in this context means its ability to keep the Faraday Cage closed. It is therefore recommended to use metal enclosed/shielded devices wherever such devices are available.

The rules for holes in the enclosure must be applied if there are devices forming a bridge between the clean side and the dirty side which can be disturbed.

Typical open devices are fuses, switch fuses, contactors etc., which do not have a metal covering around them.

In general, such devices cannot be installed into the clean side without protective metallic shielding plates. The rules for holes in the enclosure must then be applied.

In some cases there might be some confusion between safety and EMC requirements. It is therefore important to remember the following basic rule:

Safety is always the first priority and overrules the EMC requirements.

Some examples of protected and open devices are given in the chapter *Practical Examples*.

Internal wiring

There are some basic rules for internal wiring:

- Always keep clean and dirty side cables separate and shielded from one another.
- Internal clean power connections with integrally filtered drive units, e.g. from contactor to converter input, do not require shielded cables but may require de-coupling ferrite rings where they enter the converter input.
- Use twisted pair wires wherever possible.
- Use shielded twisted pairs for signal level outward and return wires exiting from the overall enclosure.
- Avoid mixing pairs with different signal types e.g. 110 VAC, 230 VAC, 24 VDC, analogue, digital.
- Run wires along the metal surface and avoid wires hanging in free air, which can become an antenna.
- If plastic trunking is used, secure it directly to installation plates or framework. Do not allow spans over free air which could form an antenna.
- Keep power and control wiring separate.
- Use galvanically isolated (potential free) signals.
- Keep wires twisted as near the terminal as possible.
- Keep pigtails as short as possible.
- Earthing connections should be as short as possible in flat strip, multistranded or braided flexible conductors for low RFI impedance.

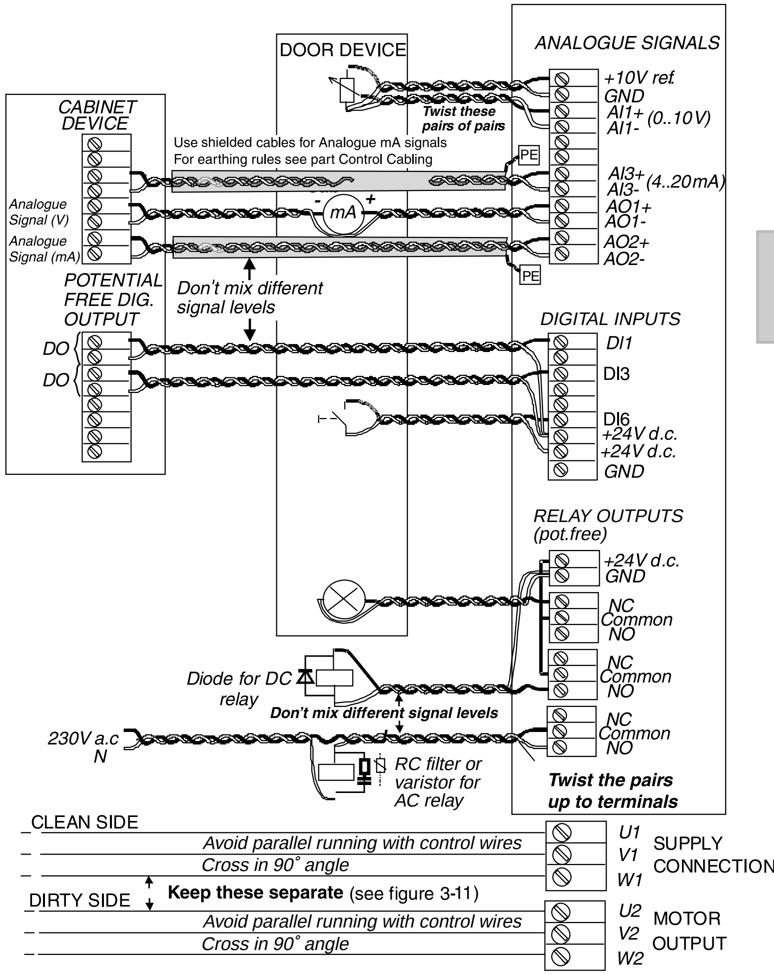


Figure 3-10 Principles of wiring inside CDM.

3

Control cables and cabling

The control cabling is a part of the Faraday Cage as described in the section *Conductive gaskets with control cables*.

In addition to correct HF earthing there are some basic rules for control cabling:

- Always use shielded twisted pair cables:
  - double shielded cable for analogue signals
  - single shielded for other signals is acceptable but double shielded cable recommended.
- Don't run 110/230 V signals in the same cable with the lower signal level cables.
- Keep twisted pairs individual for each signal.
- Earth directly at frequency converter side.

If instructions for the device at the other end of the cable specify earthing at that end, earth the inner shields at the end of the more sensitive device and the outer shield at the other end.

- Route signal cables according to figure 3-11 whenever possible and follow instructions given by the product specific manuals.

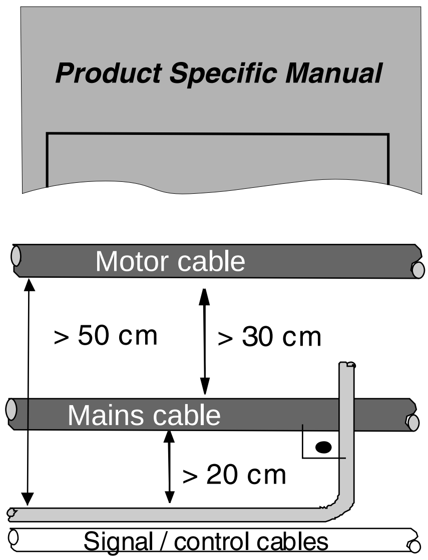


Figure 3-11 Routing principles of control cables.

There is more about control cabling in the documents **"Grounding and cabling of the drive system"** and in product specific manuals.

Power cables

As the cables are part of the PDS they are also part of the Faraday Cage. To be able to meet the EMC requirements, power cables with good shielding effectiveness must be used.

The purpose of the shield is to reduce radiated emission.

In order to be efficient, the shield must have good conductivity and cover most of the cable surface. If the cable shield is used as protective earthing, the shield cross area (or equivalent conductivity) must be at least 50 % of the cross sectional area of the phase conductor.

The product specific manuals describe some cable types which can be used in mains supply and motor output.

If such types are not available locally, and because cable manufacturers have several different shield constructions, the types can be evaluated by the transfer impedance of the cable.

The transfer impedance describes the shielding effectiveness of the cable. It is commonly used with communication cables.

The cable can consist of either braided or spiral shield, and the shield material should preferably be either copper or aluminium.

The suitability for certain drive types is mentioned in the product specific manuals.

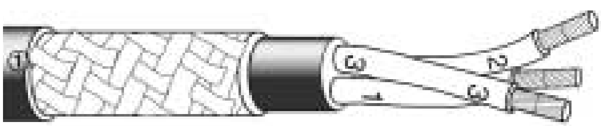


Figure 3-12 Galvanised steel or tinned copper wire with braided shield.

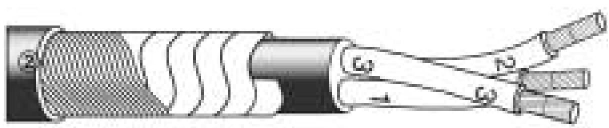


Figure 3-13 Layer of copper tape with concentric layer of copper wires.

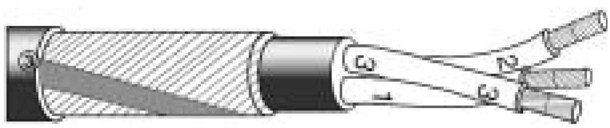


Figure 3-14 Concentric layer of copper wires with an open helix of copper tape.

Transfer impedance

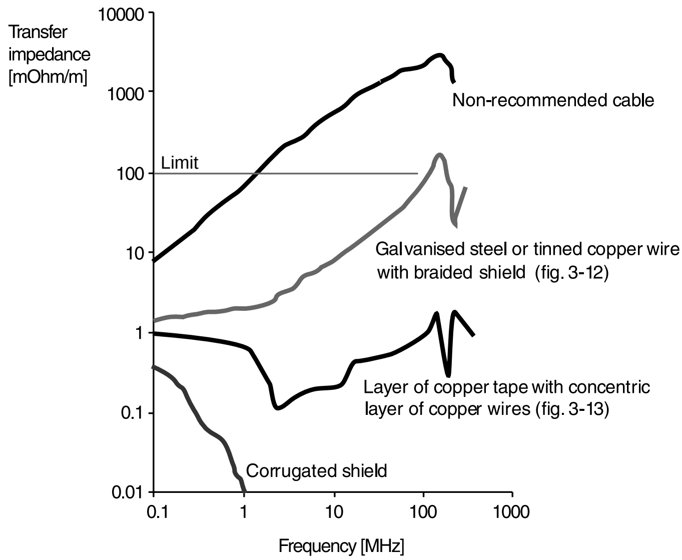


Figure 3-15 Transfer impedance for power cables.

To meet the requirements for radiated emission the transfer impedance must be less than 100 mΩ/m in the frequency range up to 100 MHz. The highest shielding effectiveness is achieved with a metal conduit or corrugated aluminium shield. Figure 3-15 shows typical transfer impedance values of different cable constructions. The longer the cable run, the lower the transfer impedance required.

Use of Ferrite rings

In particular cases due to high emission levels, common mode inductors can be used in signal cables to avoid interfacing problems between different systems.

Common mode disturbances can be suppressed by wiring conductors through the common mode inductor ferrite core (figure 3-16).

The ferrite core increases inductance of conductors and mutual inductance, so common mode disturbance signals above a certain frequency are suppressed. An ideal common mode inductor does not suppress a differential mode signal.

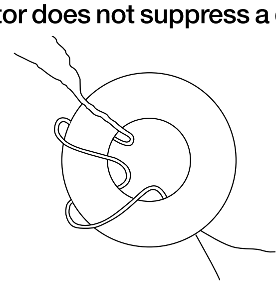


Figure 3-16 Ferrite ring in signal wire.

The inductance (i.e. the ability to suppress HF disturbances) can be increased by multiple turns of the signal wire.

When using a ferrite ring with power cable, all phase conductors should be led through the ring. The shielding and possible earth wire must be wired outside the ring to keep the common mode inductor effect. With power cables it is not normally possible to make multiple turns through the ring. The inductance can be increased by using several successive rings.

If for any reasons the installation instructions cannot be followed and therefore additional ferrites or filters are added afterwards, it is recommended that measurements be made to show conformance.

Simple installation

Shielded cables are shown interconnecting the primary parts, ensuring attenuation of radiated emissions. The supply is made through the RFI filter.

The Faraday Cage is earthed and all the emissions are drained to earth.

In the case shown in figure 4-1, the cabinet is not required to be EMC proof, because connections are made directly in an EMC compliant frequency converter.

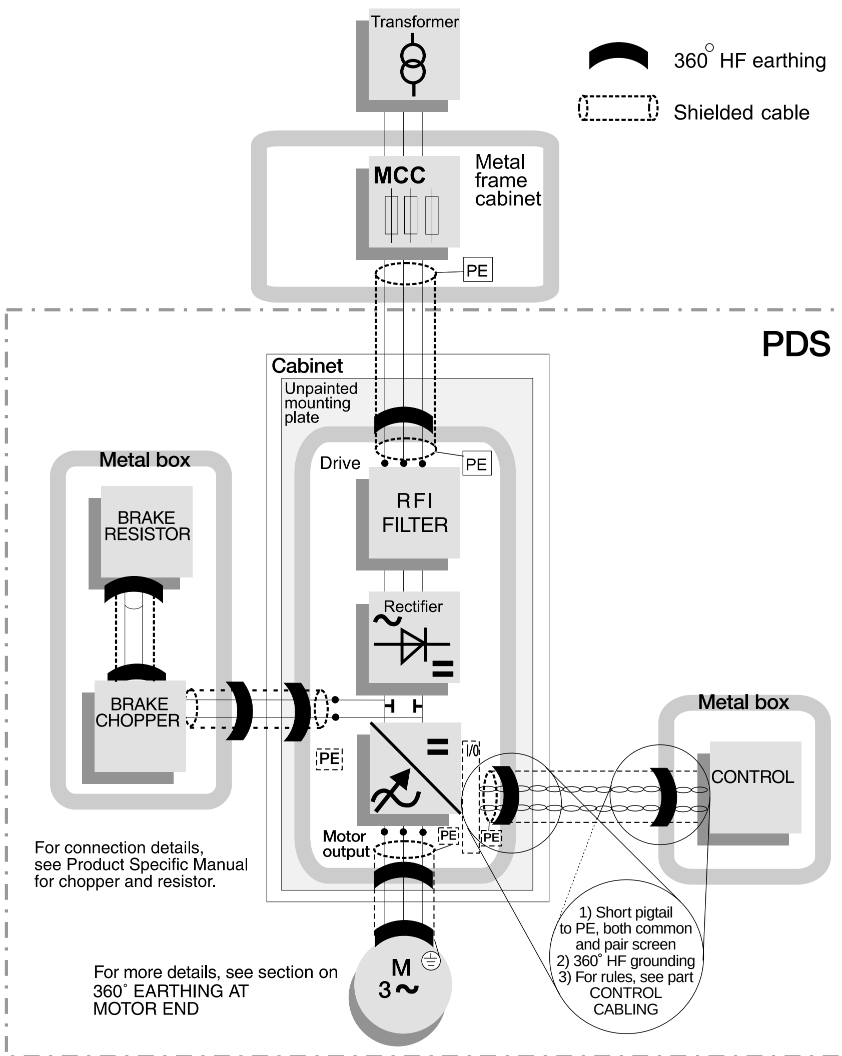


Figure 4-1 Basic PDS Configuration.

Example of By-pass system <100kVA

In this case it is difficult to ensure that no cross coupling occurs between the dirty side of the converter and the clean side above the Direct On Line (DOL) contactor. Contactors are not RFI barriers, and the coil circuits are also vulnerable.

A suitable RFI filter at the supply input connections would require to be able to pass the DOL starting current, which can be six to seven times the normal Full Load Current, and would be greatly oversized for normal running, which makes it difficult to design. Ferrite cores used in the feeds to the contactor will help attenuate the coupled noise as shown in figure 4-2.

3

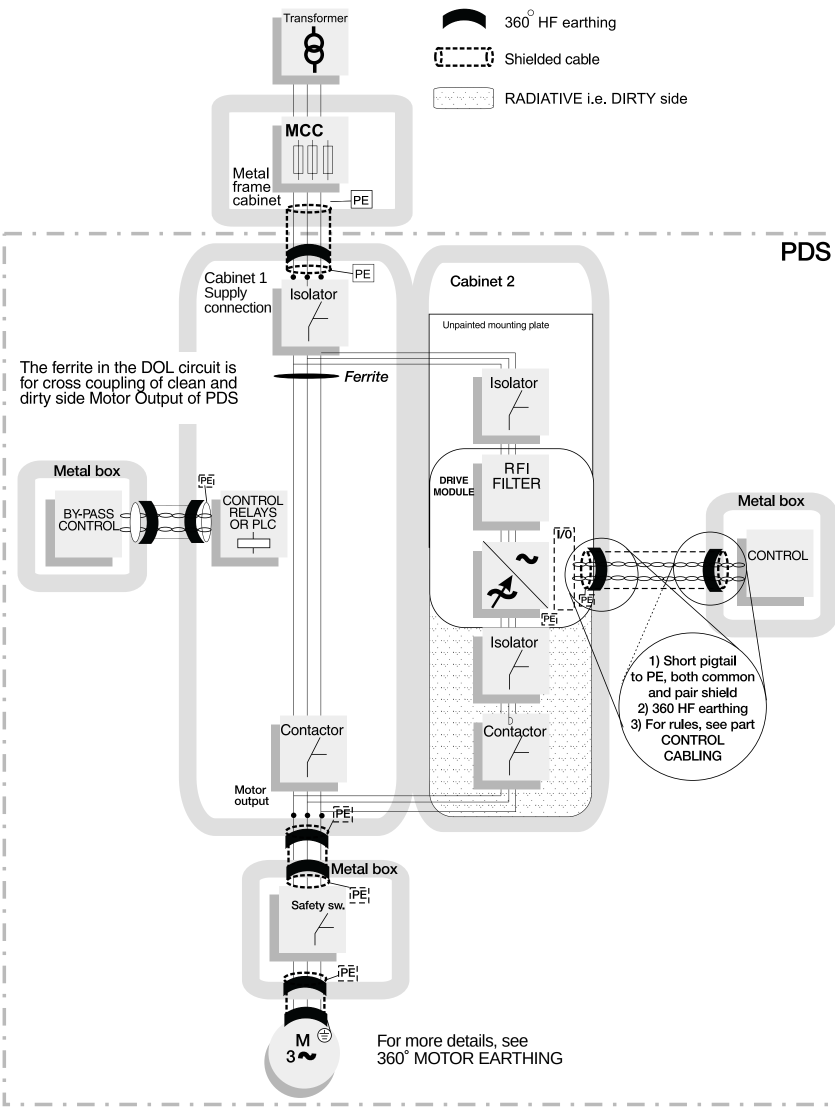


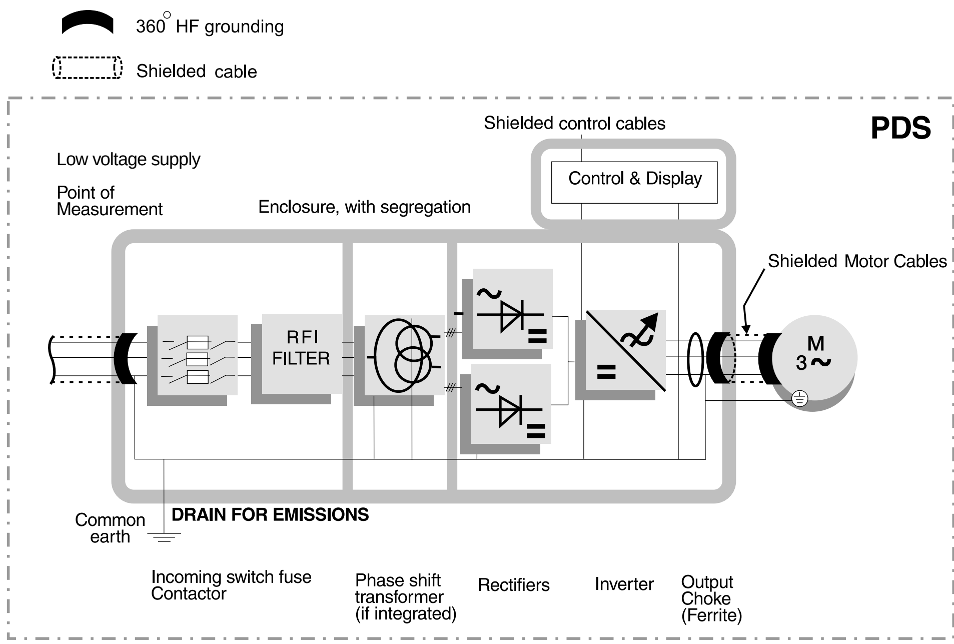
Figure 4-2 Basic scheme with By-pass.

Typical example of 12-pulse drive

In this case a 12-pulse rectifier is an IT system, unearthed due to the delta winding, therefore any filter in the line must be at the primary of the phase shift transformer.

Experience has shown that, in this case, with short connections to the busbars, the earth shield between the transformer windings is not quite adequate for conducted emissions attenuation for use in the first environment. Therefore RFI filtering may be needed for EMC compliance.

For equipment fed from an IT system, a similar procedure can be used. An isolating transformer allows the PDS to be earthed and to use a suitable filter, for use in the First Environment. The Point of Coupling is at a medium voltage and emissions may be considered at the next low voltage point of coupling in the system. The level of emissions should correspond to those for the appropriate environment. For definitions, see section *Installation Environments* in chapter 2.



Note: All equipment inside must be enclosed

Figure 4-3 12-pulse converter system fed at LV.

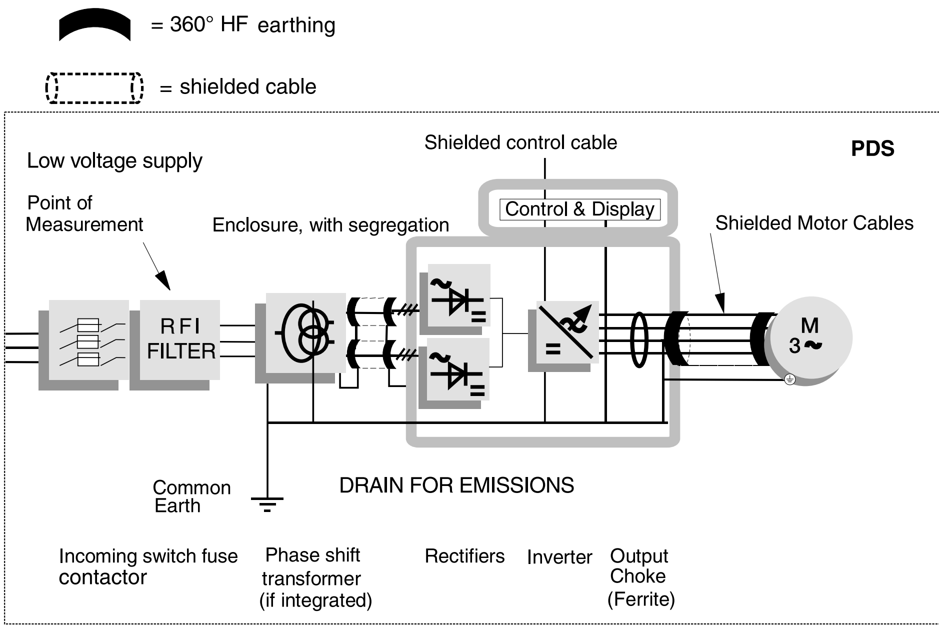


Figure 4-4 12-pulse converter system fed at LV (CDM, transformer and switch fuse have separate housing).

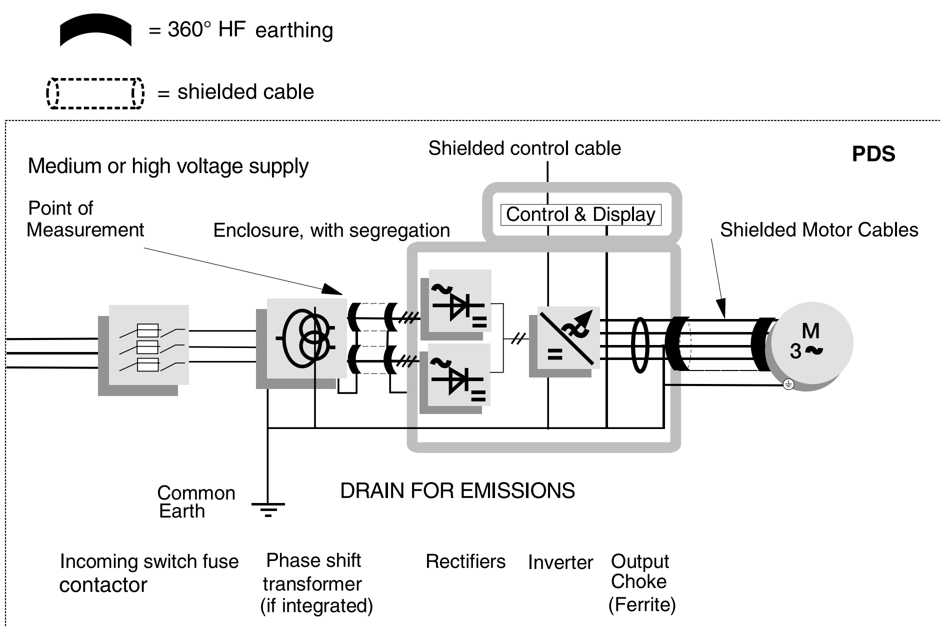


Figure 4-5 12-pulse converter system fed at medium or high voltage.

Example of common DC fed sectional drive

This example features a common DC bus sectional drive which is supplied from an earthed network through an RFI filter.

The enclosure must be EMC proof as the components inside are not. Cable entries must be 360° HF earthed. The enclosure is earthed to drain away all emissions.

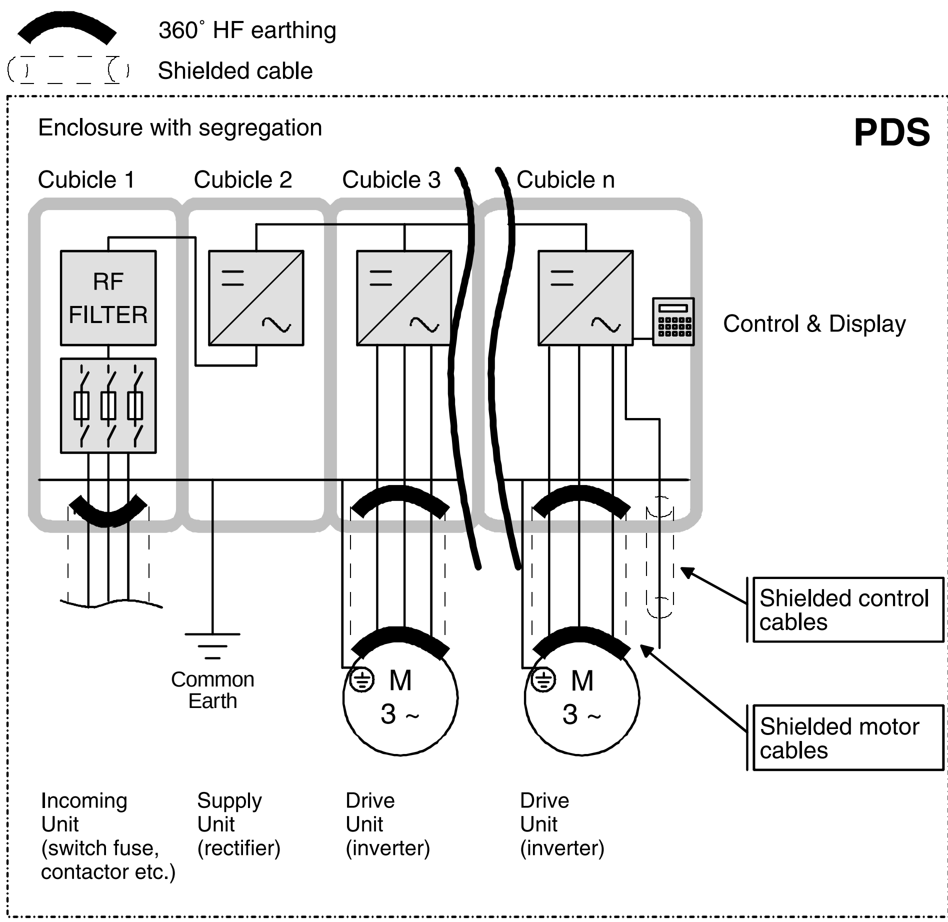


Figure 4-6 Common DC bus fed sectional drive fed at LV

Chapter 5 - Bibliography

Various texts are referred to in this guide. They are recommended further reading to assist in achieving compliant installations:

EN 61800-3, Adjustable Speed Electrical Power Drive Systems - part 3, EMC product standard including specific test (published by CENELEC, Brussels, Belgium and National Standards organisations in EU member countries).

EN 61800-3:1996/A 11:2000

Guidelines by the Commission on the application of Council Directive 89/336/EEC, published by European Commission DGIII - Industry.

Interference Free Electronics by Dr. Sten Benda (published by ABB Industry Ab, Västerås, Sweden)

Technical Guide No. 2 - EU Council Directives and Adjustable Speed Electrical Power Drive Systems, code 3BFE 61253980 (published by ABB Industry Oy, Helsinki, Finland)

Grounding and cabling of the drive system, code 3AFY 61201998 (published by ABB Industry Oy, Helsinki, Finland)

3AFE 61348280 REV C EN 11.6.2003 Specifications subject to change without notice. Dark Oy, Vantaa 2003

ABB Oy
Drives
P.O. Box 184
FIN-00381 Helsinki
FINLAND
Tel: +358 10 22 11
Fax: +358 10 222 2681
Internet: http://www.abb.com/motors&drives