ABB drives

Technical guide No. 3
EMC compliant installation and configuration for a power drive system

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Chapter 1 - Introduction

General

This guide assists design and installation personnel when trying to ensure compliance with the radio frequency requirements of the EMC Directive in the user's systems and installations when using AC drives. The radio frequency range starts from 9 kHz. However, most standards at the moment deal with frequencies that are higher than 150 kHz.

The frequency range below 9 kHz, that is, harmonics, is dealt with technical guide No. 6 "Guide to harmonics with AC drives".

Purpose of this guide

The purpose of this guide is to guide original equipment manufacturers (OEM), system integrators and panel builders (assemblers) in designing or installing AC drive products and their auxiliary components into their own installations and systems. The auxiliaries include contactors, switches, fuses, etc. By following these instructions it is possible to fulfill EMC requirements and give CE marking when necessary.

Directives concerning the drive

There are three directives that 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 are described in technical guide No. 2 "EU Council Directives and adjustable electrical power drive systems". This document deals only with the EMC Directive.

Who is the manufacturer?

According to the EMC Directive (2004/108/EC), the definition of a manufacturer is following: "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."

Manufacturer's responsibility

According to the EMC Directive the manufacturer is responsible for attaching the CE mark to each unit. Equally the manufacturer is responsible for writing and maintaining technical documentation (TD).

OEM customer as a manufacturer

It is well known that OEM customers sell equipment using their own trademarks 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 the EMC of equipment, and he shall issue a Declaration of Conformity and technical documentation for the equipment.

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 the EMC of the system. He cannot pass this responsibility to a supplier.

In order to help the 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 that are not described in product specific manuals. The solutions can be directly used or applied by the OEM or panel builder.

Earthing principles

The earthing and cabling principles of variable speed drives are described in the manual “Grounding and cabling of the drive system”, code 3AFY61201998. 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.

Chapter 2 - Definitions

Electromagnetic compatibility (EMC) of PDS

EMC stands for Electromagnetic compatibility. 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 European Economic Area (EEA). The terms used to define compatibility are shown in figure 2-1.

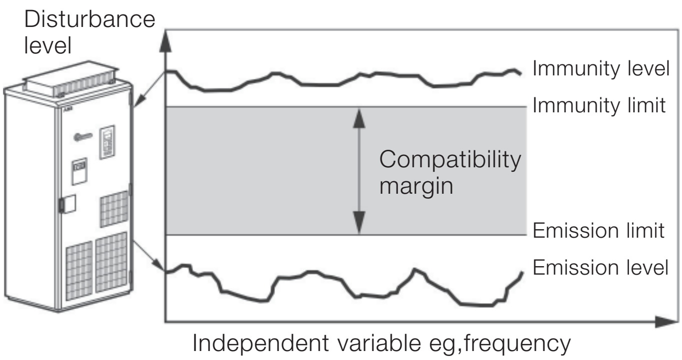


Figure 2-1 Immunity and emission compatibility.

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 power drive system (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, radiated electromagnetic field, conducted 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 personnel responsible for design and installation have this standard available and be familiar with this standard. All standards are available from the national standardization bodies.

Systems made by an OEM or panel builder 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.

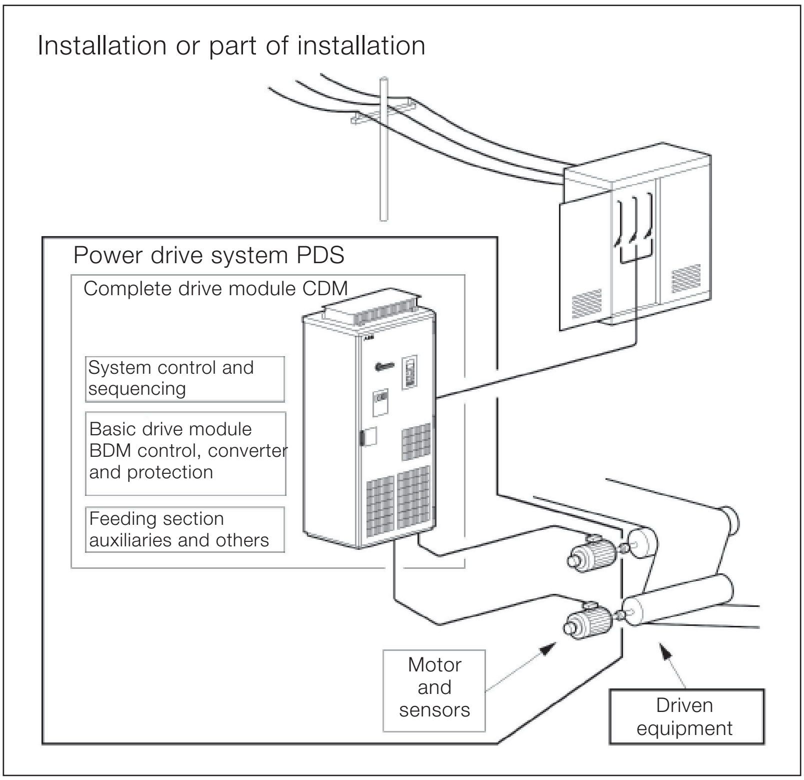


Figure 2-2 Abb reviations used in drives.

Types of equipment

The EMC Directive (2004/108/EC) defines equipment as any apparatus or fixed installation. As there are separate provisions for apparatus and fixed installations, it is important that the correct category of the equipment (PDM, CDM or BDM) is determined.

In technical-commercial classifications the following terminology is frequently used: components, sub-assemblies, finished appliances (ie, finished products), a combination of finished appliances (ie, a system), apparatus, fixed installations and equipment.

The key issue here is whether the item is meant for end users or not:
- if it is meant for end users, the EMC directive applies;
- if it is meant for manufacturers or assemblers, the EMC directive does not apply.

Components or sub-assemblies intended for incorporation into an apparatus by the end users

A manufacturer may place components or sub-assemblies on the market, which are:
- for incorporation into an apparatus by the end-user,
- available to end-users and likely to be used by them.

These components or sub-assemblies are to be considered as apparatus with regard to the application of the EMC. The instructions for use accompanying the component or sub-assembly should include all relevant information, and should assume that adjustments or connections can be performed by an end user not aware of the EMC implications.

Some variable speed power drive products fall into this category, eg, a drive with enclosure and sold as a complete unit (CDM) to the end user who installs it into his own system. All provisions of the EMC Directive will apply (CE mark, EC declaration of conformity and technical documentation).

Components or sub-assemblies intended for incorporation into an apparatus by other manufacturers or assemblers

Components or sub-assemblies intended for incorporation into an apparatus or another sub-assembly by other manufacturers or assemblers are not considered to be “apparatus” and are therefore not covered by the EMC Directive. These components include resistors, cables, terminal blocks, etc.

Some variable speed power drive products fall into this category as well, eg, basic drive modules (BDM). These are meant to be assembled by a professional assembler (eg, 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 provide instructions for installation and use.

Note:
The manufacturer or assembler of the panel or system is responsible for the CE mark, the EC Declaration of Conformity, and the technical documentation.

Finished appliance

A finished appliance is any device or unit containing electrical and/or electronic components or sub-assemblies that delivers a function and has its own enclosure. Similarly to components, the interpretation “finished appliance” can be divided into two categories: it can be intended for end users, or for other manufacturers or assemblers.

Finished appliance intended for end users

A finished appliance is considered as apparatus in the sense of the EMC Directive if it is intended for the end-user and thus has to fulfill all the applicable provisions of the Directive.

Variable speed power drive products that fall into this category are whole power drive systems (PDS) or complete drive modules (CDM). In this case all provisions of the EMC Directive will apply (CE mark, EC Declaration of Conformity, and technical documentation). The drive product manufacturer is responsible for the CE mark, EC Declaration of Conformity, and technical documentation.

Finished appliance intended for other manufacturer or assembler

When the finished appliance is intended exclusively for an industrial assembly operation for incorporation into other apparatus, it is not an apparatus in the sense of the EMC Directive and consequently the EMC Directive does not apply for such finished appliances.

The variable speed power drive products that fall into this category are basic drive modules (BDM). The approach is the same as for components or sub-assemblies when they are intended for incorporation into an apparatus by another manufacturer or assembler. Thus the manufacturer or assembler of the panel or system is responsible for all actions relating to the EMC Directive.

Systems (combination of finished appliances)

A combination of several finished appliances which is combined, and/or designed and/or put together by the same party (ie, the system manufacturer) and is 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.

All provisions of the EMC Directive, as defined for apparatus, apply to the combination as a whole. The variable speed power drive products that fall into this category are power drive systems (PDS). Thus the manufacturer of the PDS is responsible for all actions relating to the EMC Directive.

Apparatus

Apparatus means any finished appliance or combination thereof made commercially available (ie, placed on the market) as a single functional unit, intended for the end-user, and liable to generate electromagnetic disturbance, or the performance of which is liable to be affected by such disturbance.

Fixed installation

A particular combination of several types of apparatus, equipment and/or components, which are assembled, installed and intended to be used permanently at a predefined location.

Equipment

Any apparatus or fixed installation

CE marking for EMC

Components or sub-assemblies intended for incorporation into an apparatus by the end users need to carry the CE marking for EMC.

Components or sub-assemblies intended for incorporation into an apparatus by another manufacturer or assembler do not need to carry the CE marking for EMC.
Note: The products may carry the CE marking for other directives than EMC.

Apparatus and systems must be CE marked.

Fixed 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 according to the EN61800-3 standard.

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."

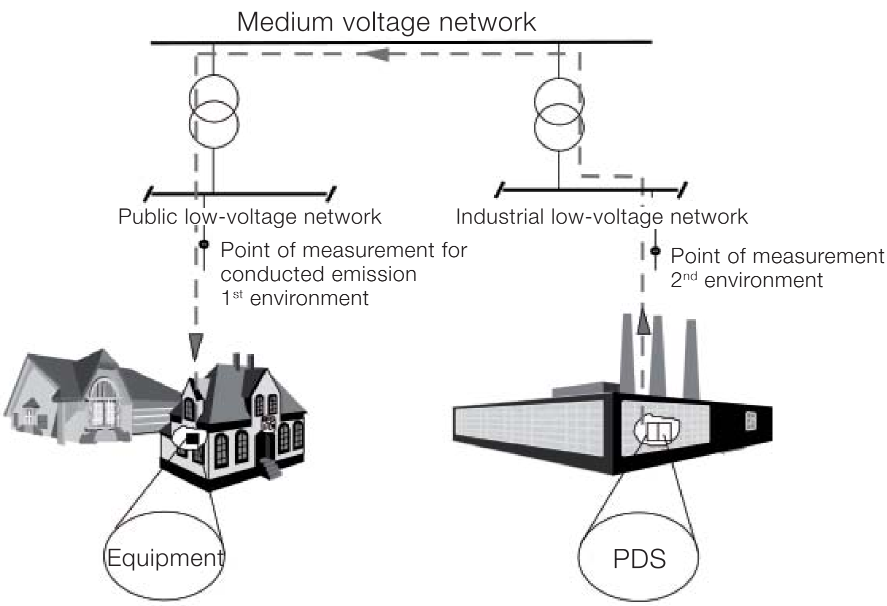


Figure 2-4 Illustration of environment classes.

Second environment

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

EMC emission limits

The product standard EN 61800-3 divides PDSs into four categories according to the intended use. In Europe, the standard takes precedence over all generic or product family EMC standards previously applicable. Limits for certain conditions can be selected by using the flow chart shown in figure 2-5.

PDS of category C1

A PDS (or CDM) with rated voltage less than 1000 V and intended for use in the first environment. A PDS (or CDM) sold "as built" to the end user.

The PDS manufacturer is responsible for the EMC behavior of the PDS under specified conditions. Additional EMC measures are described in an easy-to-understand way and can be implemented by a layman.

When PDS/CDM is to be incorporated with another product, the resulting EMC behavior of that product is the responsibility of the assembler of the final product, by following the manufacturer's recommendations and guidelines.

PDS of category C2

A PDS (or CDM/BDM) with rated voltage less than 1,000 V, which is neither a plug in device nor a movable device and is intended to be installed and commissioned only by a professional. A PDS (or CDM/BDM) sold to be incorporated into an apparatus, system or installation.

When a PDS/CDM/BDM is to be incorporated with another product, the resulting EMC behavior of that product is the responsibility of the assembler of the final product.

PDS of category C3

A PDS (or CDM/BDM) with rated voltage less than 1,000 V, intended for use in the second environment. A PDS (or CDM/BDM) sold "as built" to the end user or in order to be incorporated into an apparatus, system or installation.

The PDS manufacturer is responsible for the EMC behavior of the PDS under specified conditions. Additional EMC measures are described in an easy-to-understand way and can be implemented by a layman.

When a PDS/CDM is to be incorporated with another product, the resulting EMC behavior of that product is the responsibility of the assembler of the final product, by following the manufacturer's recommendations and guidelines.

PDS of category C4

A PDS (or CDM/BDM) with rated voltage equal to or above 1,000 V, or rated current equal to or above 400 A, or intended for use in complex systems in the second environment. A PDS (or CDM/BDM) sold to be incorporated into an apparatus, system or installation.

Category C4 requirements include all other EMC requirements except for radio frequency emission. They are assessed only when it is installed in its intended location. Therefore a category C4 PDS is treated as a fixed installation, and thus has no requirement for an EC Declaration of Conformity or CE Marking.

The EMC directive requires the accompanying documentation to identify the fixed installation, its electromagnetic compatibility characteristics and the person responsible, and to indicate the precautions to be taken in order not to compromise the conformity of that installation.

In order to comply with the above requirements in the case of a category C4 PDS (or CDM/BDM), the user and the manufacturer shall agree on an EMC plan to meet the EMC requirements for the intended application. In this situation, the user defines the EMC characteristics of the environment including the whole installation and the neighborhood. The PDS manufacturer shall provide information on typical emission levels and installation guidelines for the PDS to be installed. The resulting EMC behavior is the responsibility of the installer (eg, by following the EMC plan).

Where there are indications of non-compliance of the category C4 PDS after commissioning, the standard includes a procedure for measuring the emission limits outside the boundary of an installation.

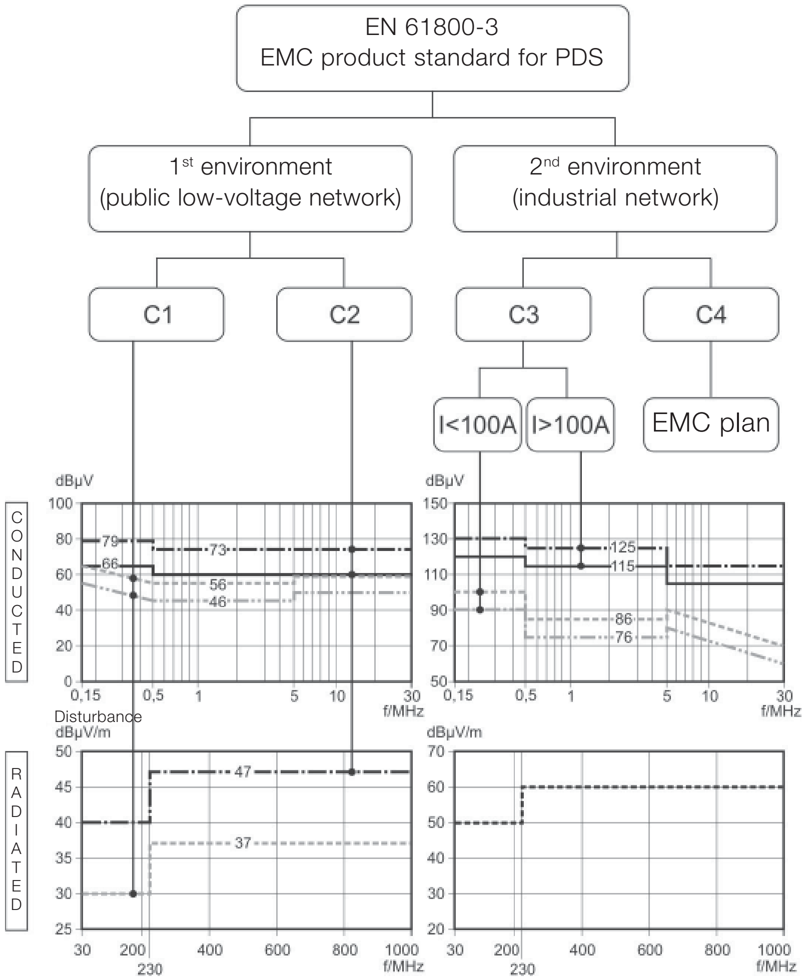


Figure 2-5 Emission limits for PDS.

Chapter 3 - EMC solutions

General

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

Solutions for EMC compatibility

There are some basic principles which must 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.

Emissions

The emissions can be classified into two types; conducted emission and radiated emission. The disturbances can be emitted in various ways as shown in the following figure:

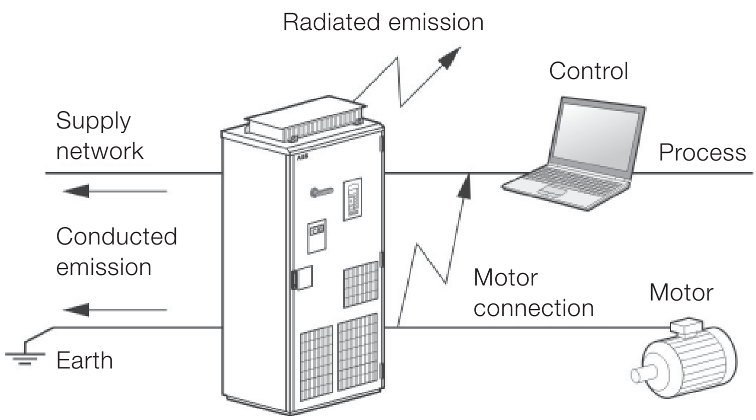


Figure 3-1 Emissions.

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 ferrite rings in power connection points
- Using an AC or DC choke (even meant against harmonics, it reduce HF disturbances as well.
- Using an LCL filter in the case of regenerative drives
- Using a du/dt filter

Radiated emission

To be able to effectively prevent disturbance through the air, all parts of the power drive system should form a Faraday cage against radiated emissions. The installation of a 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 where 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 a 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. Separate the radiative ie, “dirty” side from the “clean side” by metal covers and design.
- Holes in enclosure should be minimized.

Cabling and 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.
- Allow no breaks in the cable shields.
- Select shield connections with low impedance on the MHz range.
- 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.
- See product specific manuals.

Installation

- Auxiliaries used with complete drive modules (CDMs) should be CE marked products conforming to both the EMC & Low Voltage Directives, NOT ONLY to the LV directive, unless they are intended for incorporation into an apparatus by another manufacturer or assembler.
- Selection and installation of accessories in accordance with manufacturers' instructions.
- For wall-mounted units, strip the sheathing of a motor cable back far enough to expose the copper wire screen so that the screen can be twisted into a pigtail. Keep the pigtail short and connect it to the ground.
- For cabinet models, lead the cables into the inside of the enclosure. Apply 360° grounding of the cable shield at the entry into the cabinet. See product specific manuals.
- 360° earthing at motor end. See motor manuals.

Clean and dirty side

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

Enclosed wall-mounted drives are designed so that the circuit followed by the 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.

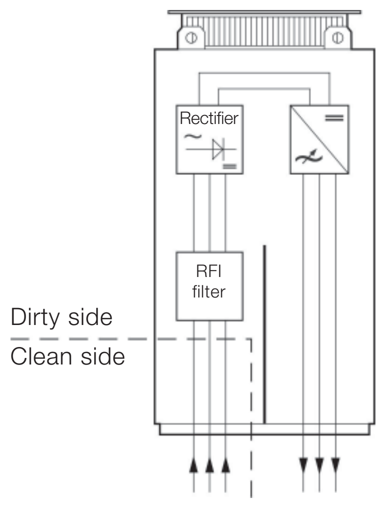


Figure 3-2 "Clean" and "dirty" sides of the BDM.

When using separation plates, the rules for enclosure holes are applicable (see Holes in enclosures section 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, eg, 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 (eg, 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. Eg, du/dt and common mode filters help somewhat, even if they have not been designed for RFI.

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

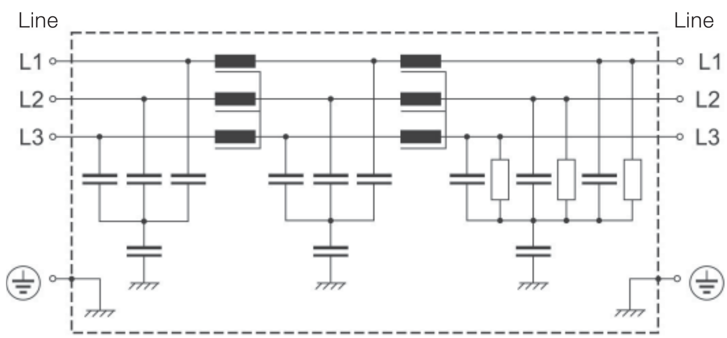


Figure 3-3 Example of filtering integrated in drive module.

Figure 3-3 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 are to be followed.

– The filter shall be assembled on a metal plate with unpainted connection points all in accordance with the filter manufacturer’s instructions.
– The orientation of the filter must be such that it provides enough distance between the input and output wiring of the filter in order to prevent cross-coupling between the clean and dirty side.
– The length of the cable between the filter and the drive must be minimized.
– The input cable of the filter shall be separated from the cable which connects the filter to the drive
– The input cable of the filter shall be separated from the motor cable

Selection of a secondary enclosure

Where the BDM is to be installed, (eg, an IP00 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 manufacturer's guidelines for construction and earthing must be followed.

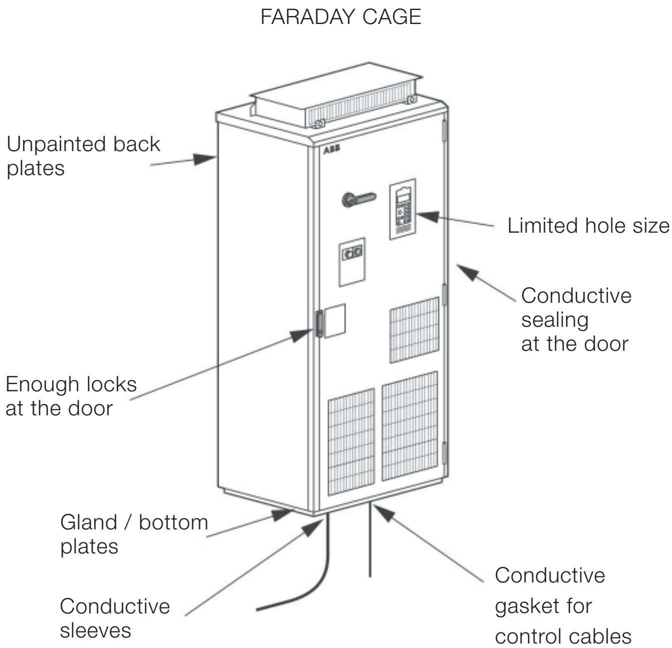


Figure 3-4 Typical enclosure aperture detail.

Holes in enclosures

In most cases, some holes must be made in the enclosure eg, for door devices, louvers, 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 1/10th of the wavelength of a 300 MHz frequency. This dimension has been found acceptable in EMC tests.

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.

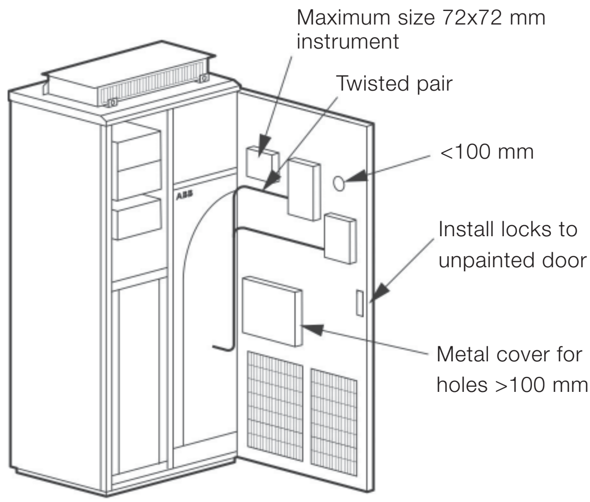


Figure 3-5 Essential points of power connections.

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.

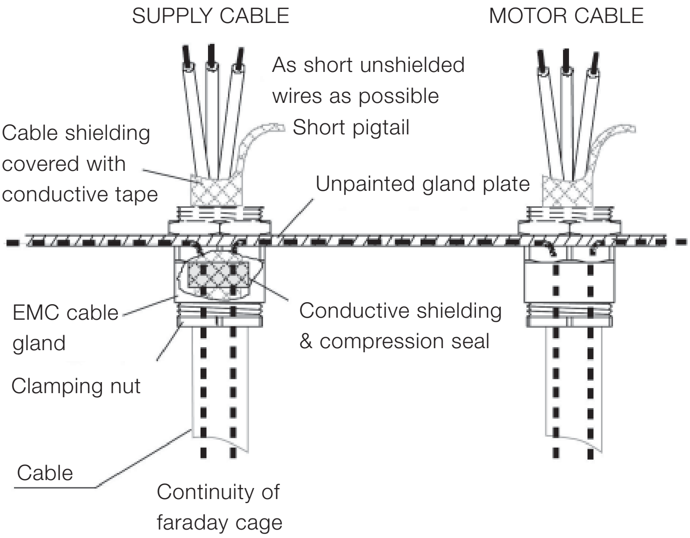


Figure 3-6 Essential points of power connections.

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.

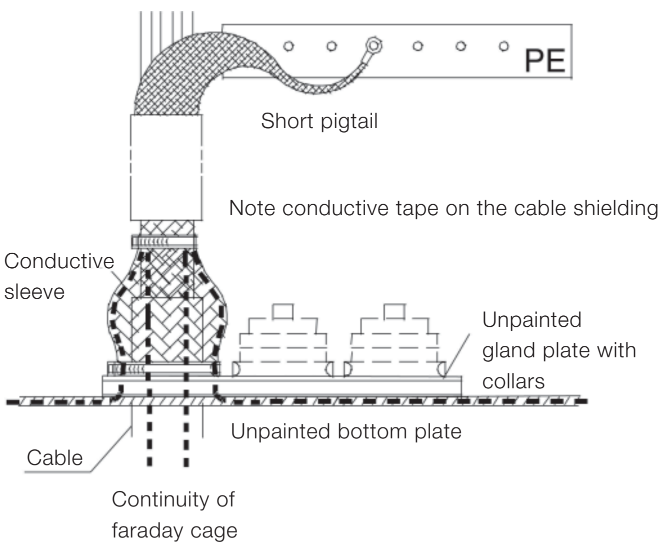


Figure 3-7 360° earthing with conductive sleeve.

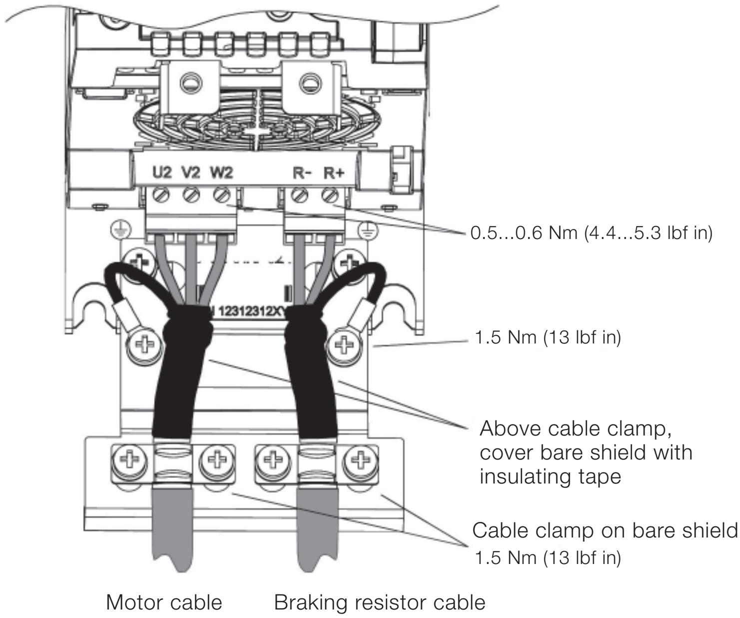


Figure 3-8 360° earthing with clamping of cable shield.

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:

- Faraday cage and IP55 degree of protection. This includes:
  - Cable gland providing galvanic contact 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
- Note: Please check availability from motor manufacturer. It is common that this is one option for the motor
- Pigtails of earthing conductors must be as short as possible.

Figure 3-9 shows a Faraday cage solution at the motor end.

For motors that 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.

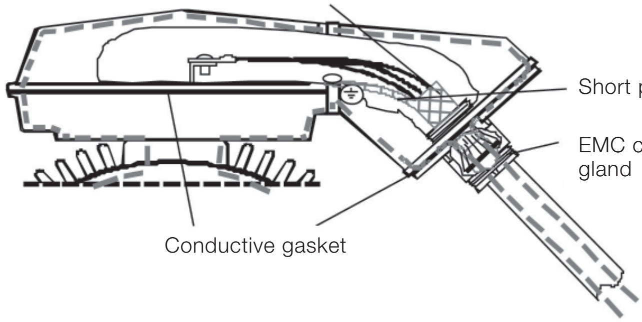


Figure 3-9 Essential points in motor cabling.

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 shown in figure 3-10.

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.

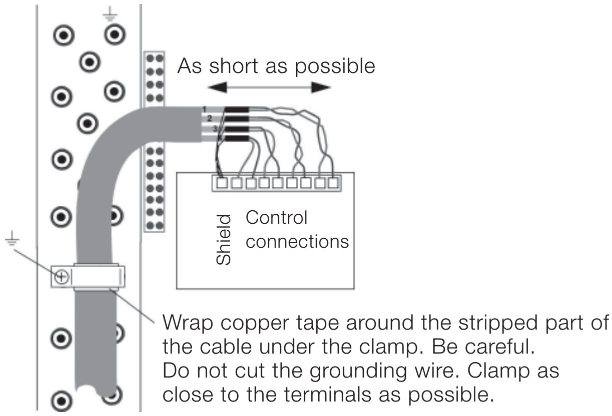


Figure 3-10 Essential points for control cabling transit.

Installation of accessories

The variety of accessories that 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.

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, eg, 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 eg,
- 110 V AC, 230 V AC, 24 V DC, 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 the 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, multi-stranded or braided flexible conductors for low RFI impedance.

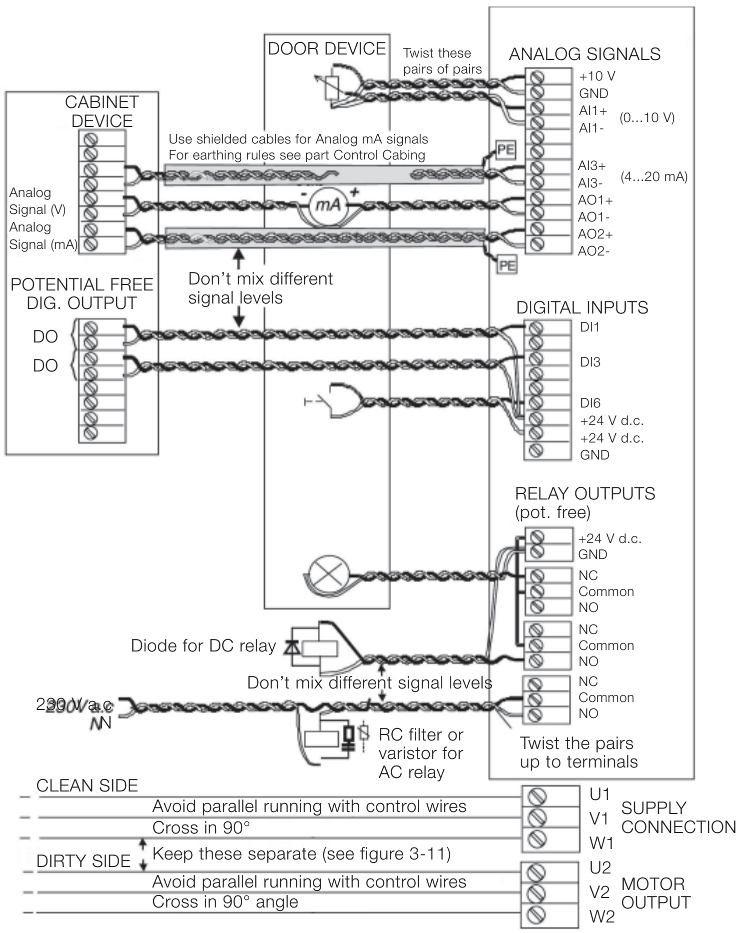


Figure 3-11 Principles of wiring inside CDM.

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 is recommended.
- Don't run 110/230 V signals in the same cable as lower signal level cables.
- Keep twisted pairs individual for each signal.
- Earth directly on the 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 3-12 whenever possible, and follow instructions given by the product specific manuals.

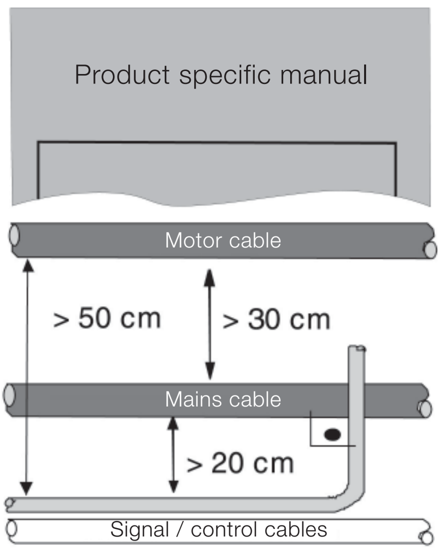


Figure 3-12 Routing principles of control cables.

There is more about control cabling in the "Grounding and cabling of the drive system" documents" 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 percent of the cross sectional area of the phase conductor.

The product specific manuals describe some cable types that 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 aluminum.

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

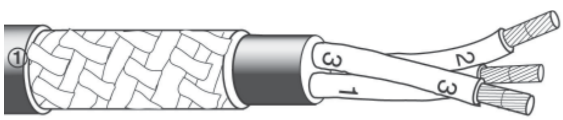


Figure 3-13 Galvanized steel or tinned copper wire with braided shield.

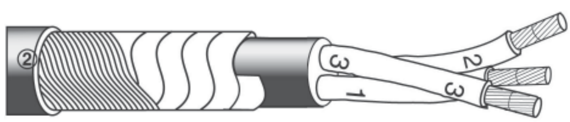


Figure 3-14 Layer of copper tape with concentric layer of copper wires.

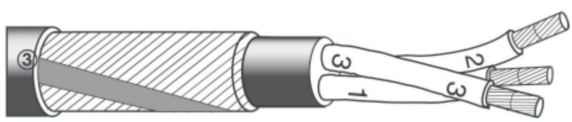


Figure 3-15 Concentric layer of copper wires with an open helix of copper tape.

Transfer impedance

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 aluminum shield. Figure 3-16 shows typical transfer impedance values of different cable constructions. The longer the cable run, the lower the transfer impedance required.

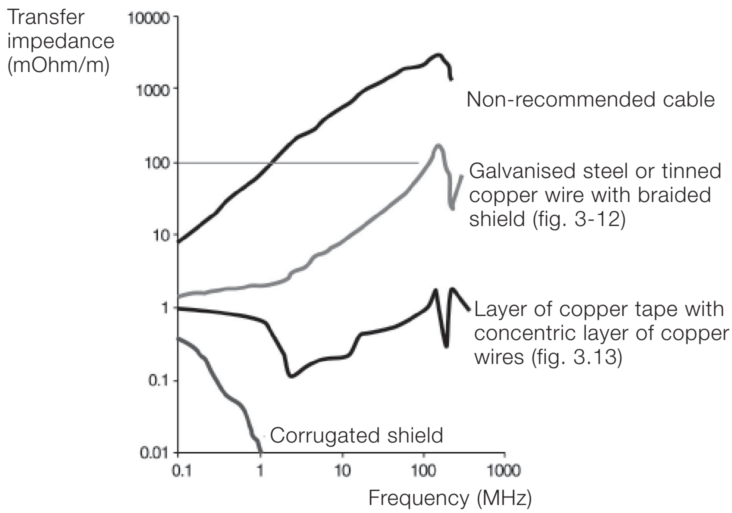


Figure 3-16 Transfer impedance for power cables.

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 3-17).

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.

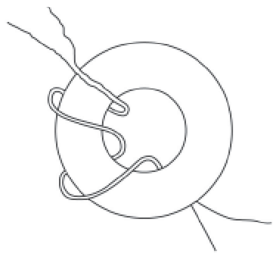


Figure 3-17 Ferrite ring in signal wire.

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

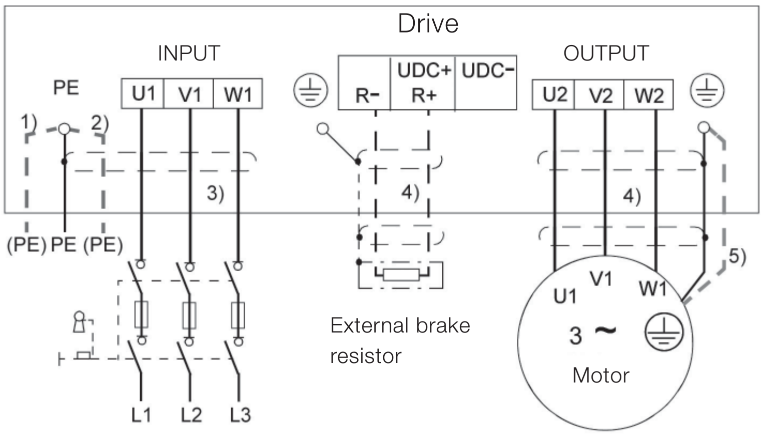
When using a ferrite ring with power cable, all phase conductors should be led through the ring. The shielding and possible earth wire must be wired outside the ring to keep the common mode inductor effect. With power cables it is not normally possible to make multiple turns through the ring. The inductance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

Chapter 4 - Practical examples

Simple installation

Most simple installations of PDS include three cables only: supply cable, motor cable and cable for brake resistor as shown in Figure 4-1.



Notes:
1), 2) If shielded cable is used, use a separate PE cable (1) or a cable with a grounding conductor (2) if the conductivity of the input cable shield is < 50 percent of the conductivity of the phase conductor. Ground the other end of the input cable shield or PE conductor at the distribution board.
3) 360 degrees grounding recommended if shielded cable
4) 360 degrees grounding required
5) Use a separate grounding cable if the conductivity of the cable shield is < 50 percent of the conductivity of the phase conductor and there is no symmetrically constructed grounding conductor in the cable.

Figure 4-1 Most simple PDS installation.

Typical 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 4-2, the cabinet is not required to be EMC proof, because connections are made directly in an EMC compliant frequency converter.

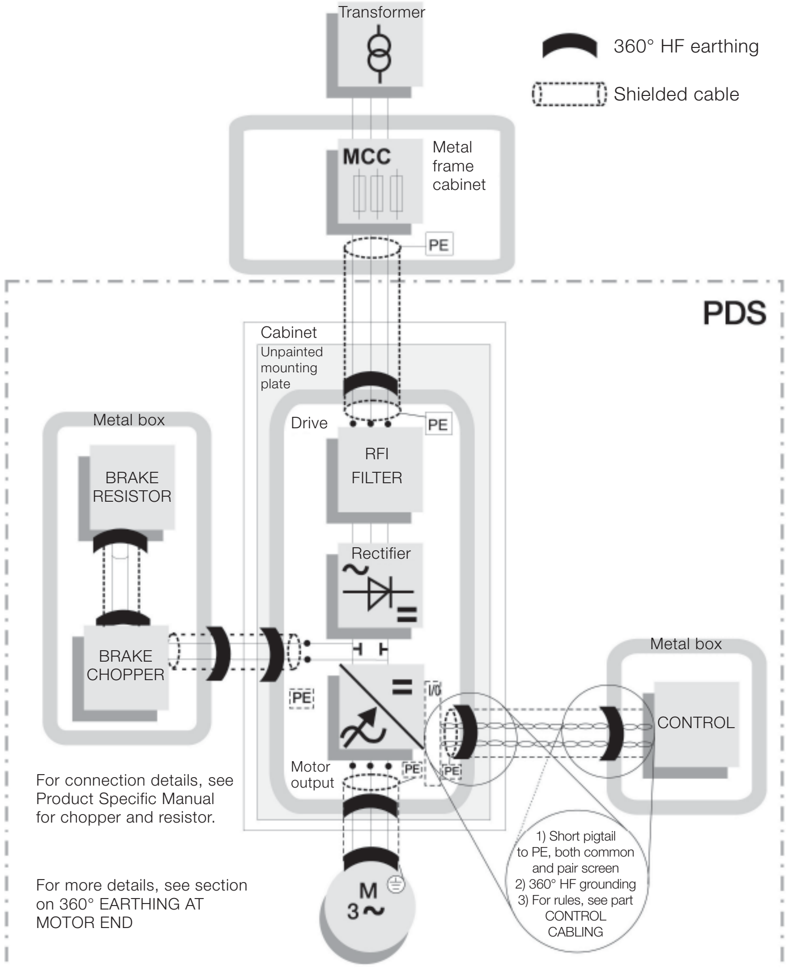


Figure 4-2 Typical PDS configuration.

Example of by-pass system <100 kVA

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 4-3.

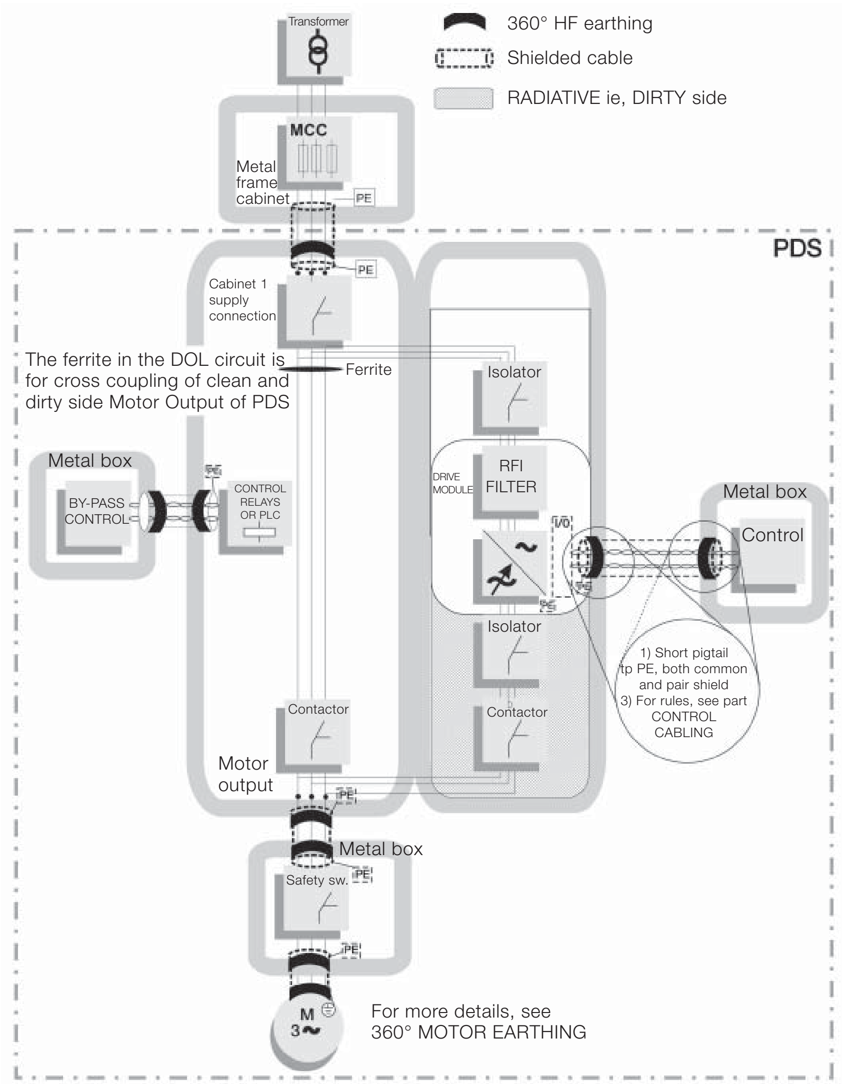


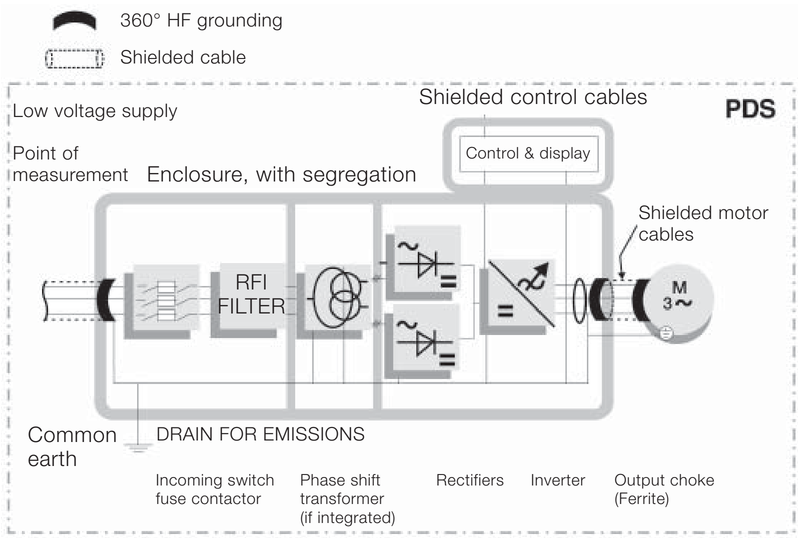
Figure 4-3 Basic scheme with by-pass.

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 side 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 an RFI filter may be needed at the primary side of the transformer for EMC compliance. An RFI filter is not normally needed for the second environment.

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 the Installation environments section in chapter 2.



Note: All equipment inside must be enclosed
Figure 4-4 12-pulse converter system fed at LV.

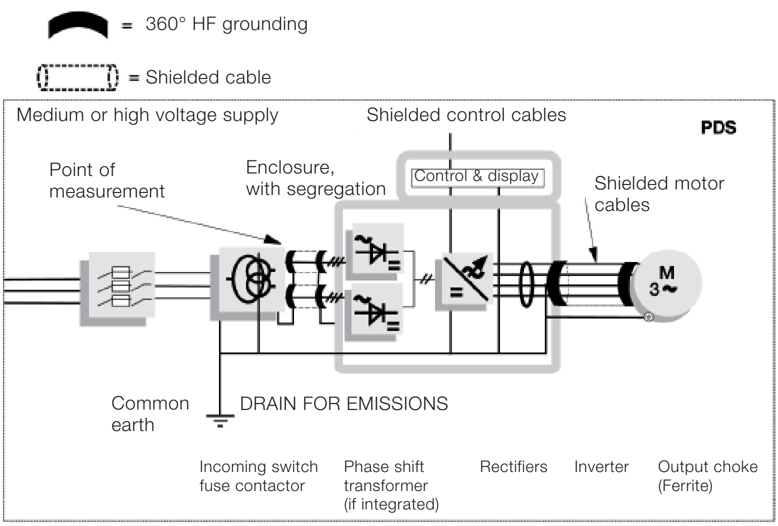


Figure 4-5 12-pulse converter system fed at LV (CDM, transformer and switch fuse have separate housing).

Example of EMC plan

This is a form for making an EMC plan where the user and the manufacturer analyze the installation and define the measures to be taken to achieve electromagnetic compatibility. The plan defines the responsibilities of the manufacturer, the installer and the user of the drive. All these parties establish the plan jointly. Fill in and answer the questions below.

Step 1: Name the parties	
Manufacturer/supplier	ABB Oy, Drives
End user	ABC Paper company
Order no.	123456789
Type of facility (eg, chemical factory, paper machine)	Paper machine PM3
Application (eg, pump. fan, conveyor)	Sectional drive system

Step 2: Collect power distribution and earthing data		
Power distribution	Point of coupling: identification code for distribution panel, switchgear or trans-former	
	Transformerc T11	
	Type of distribution system	TN-C, TN-S TT, IT
Earth bus	How and where bonded? At supply transformer T11	

Step 3: Collect EMC data (high frequency range, only)		
RFI Sensitive equiment in the facility	Any equipment in the building or near installation location sensitive to RF disturbances (eg, process control and measurement, data buses, computers, remote control, etc.)? Describe.	Yes / No Data handling unit for process control
	Approximate distance from PDS and cabling of PDS	5 metres
	Most likely coupling path for disturbance	Conducted Radiated
RFI Sensitive equipment outside the facility	Any broadcast or communications receiver antennas visible or near the facility (eg, radar, radio/TV broadcast, amateur, microwave or other)? Describe.	Yes / No
	Frequency	Hz
	Distances from the antenna	metres

Step 4: Define the installation rules	
Follow the installation rules given in the hardware manual of the drive.	
Assess the following items and describe the solutions.	
EMC Effectiveness	**Items to be considered**
Cabling	- cabling according to ABB cabling standards and guidelines (cable types, installation, separate trays etc.) - earthing according to ABB instructions (earthing of trays etc.)
Dedicated transformer	- dedicated supply transformer T11 with static EMC-shield

Signature(s) by person(s) responsible for EMC

Date 26/09/2007
Signature(s)
Joe Smith

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 organizations in EU member countries).

EN 61800-3:2004

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 3AFE61253980 (published by ABB Oy Drives, Helsinki, Finland)

Grounding and cabling of the drive system, code 3AFY61201998 (published by ABB Oy Drives, Helsinki, Finland)

Chapter 6 - Index

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