Drives Installation Guide
For Schneider Electric
Variable Speed Drives

brands of Schneider Electric

PDL
Telemecanique

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General Guidelines

This guide has been produced to aid in the design and installation of variable speed drives and gives recommendation and solutions for their correct installation. Every effort has been made to ensure this document remains up to date, however it is recommended that this document be used in conjunction with the latest installation and programming manuals shipped with the product.

In additional, Schneider Electric has produced two general guides for Electrical Installations and Automation Solutions:

Electrical Installation Guide

According to IEC 60364

Some of the featured information:

- General rules of electrical installation design
- Connection to the MV utility distribution network
- Connection to the LV utility distribution network
- MV & LV architecture selection guide
- LV Distribution
- Protection against electric shocks
- Sizing and protection of conductors
- LV switchgear: functions & selection
- Protection against voltage surges in LV
- Energy Efficiency in electrical distribution
- Power factor correction and harmonic filtering
- Harmonic management
- Characteristics of particular sources and loads
- Residential and other special locations
- EMC guidelines

Automation Solutions Guide

Some of the featured information:

- Selection guide
- Electrical power supply
- Motors and loads
- Motor starting and protection
- Motor starters
- Data acquisition, detection
- Safety of equipment and personnel
- Human-machine interface
- Industrial networks
- Data processing and software
- Implementation
- Eco-design
- Memorandum

Hard copies are available on requests, however both these documents can be obtained on line at: http://www.electrical-installation.schneider-electric.com

For the latest ATV series product information please refer to:

http://www.telemecanique.com

For Technical Support, please call 0800 652 999.

1. Environmental considerations

All drives are manufactured to comply with a specified environment. The environment a drive is allowed to operate in can be described by the following parameters:

- relative humidity (IEC 60068-2-3)
- ambient temperature (operating and storage)
- operating altitude
- vibration level (IEC 60068-2-6)
- shock level (IEC60068-2-27)
- presence of substances that can cause corrosion (IEC 60721-3-3)
- presence of pollution (IEC61800-5-1), solid foreign objects and water or moisture.

All drives should have these parameters specified, and drives should only be installed in environments suitable to the drive specifications.

In some applications it may be desirable to improve the ingress protection rating of the drive, particularly for non IP54 drives. If mounting drives in a switchboard or protective box, be sure to allow sufficient cooling. Heat dissipation is typically published by the drives manufacturer, failing the following guidelines can be used:

$P_{losses}(W)=(13W \times I_{rated}) + 20W$ per drive.

The required heat dissipation surface S of an enclosure in m^2 can be calculated using following formula:

$S=(K \times P_{losses}) / (T_{max\ in} - T_{max\ out})$

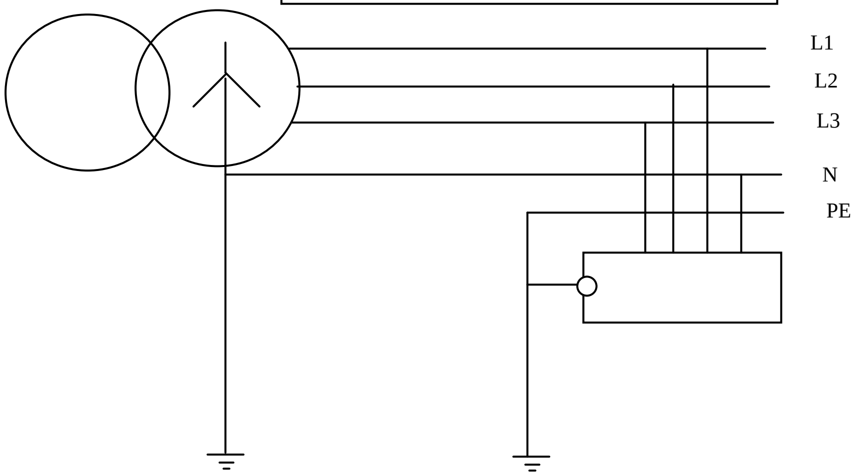
K=0.15 for metal enclosures or
K=0.12 for metal enclosures with an internal stirring fan fitted.
$T_{max\ in}$=maximum temperature inside the enclosure
$T_{max\ out}$=maximum ambient temperature outside the enclosure

2. Electrical environmental considerations

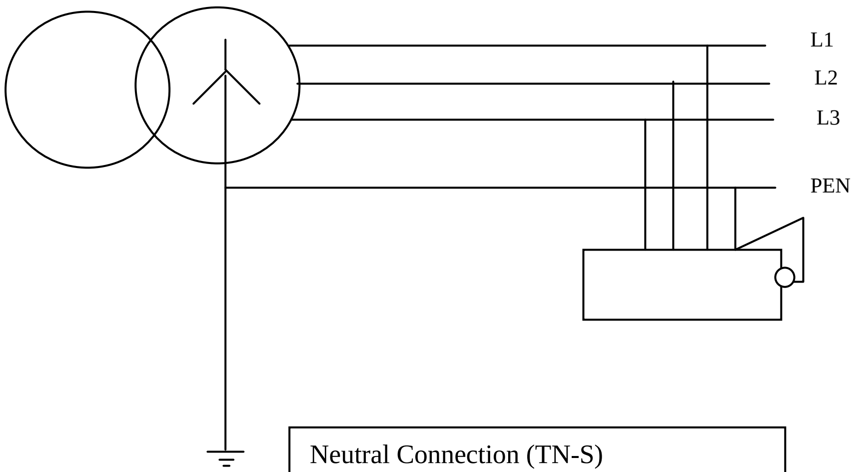
2.a. Supply Systems

For low voltage networks there are three types of earthing systems commonly known as neutral point connection. They differ according to whether or not the neutral point of the voltage source is earthed and also the method used to connect frames to earth. The diagrams below identify the four main systems and associated required wiring. All drive installations should adhere to the wiring and earthing principles applicable. Specific attention should be given to drives that are to be installed on IT networks. Most drives will have RFI filters, which will need to be disconnected if connected to IT networks. This is typically done via adjustment of a jumper. Older drives may require factory modifications to make the drive IT network compatible.

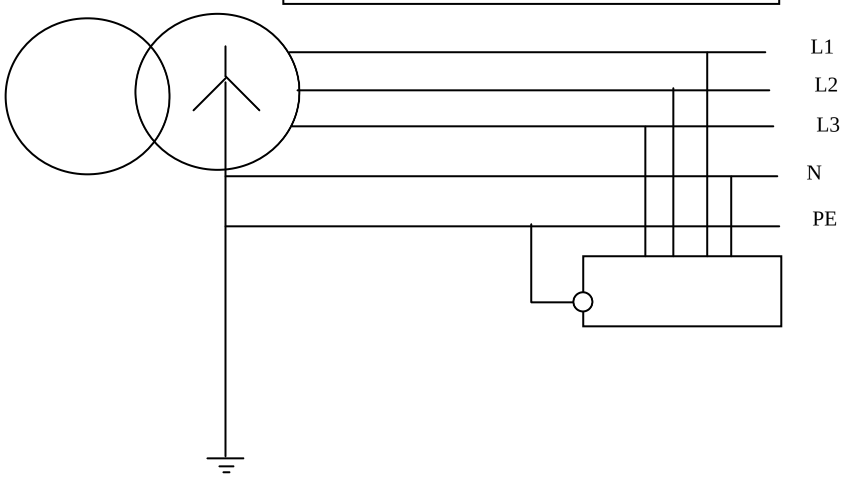
Directly Earthed Neutral (TT)



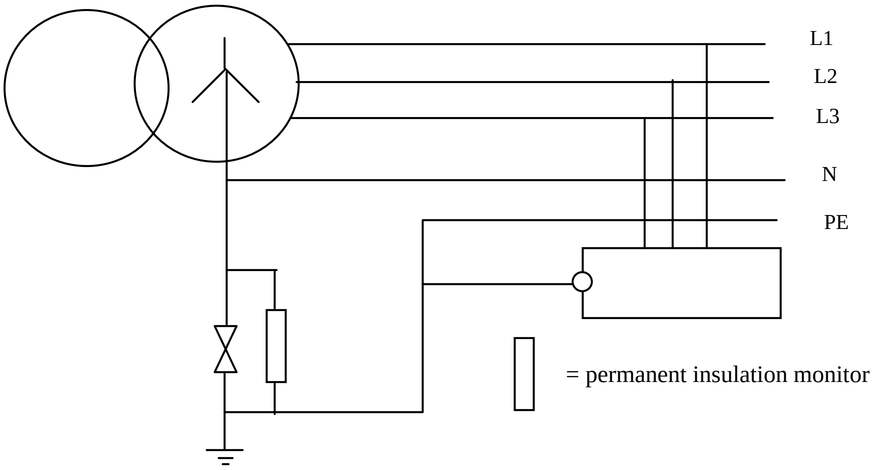
Neutral Connection (TN-C)



Neutral Connection (TN-S)



Unearthed neutral (IT)



2.b. Incoming mains wiring

Cable sizes must be chosen for the expected loading and to minimise voltage drop. For long cable runs, larger cables may be required to minimise voltage drop. Incoming cables do not generally require shielding. To reduce the chances of interference coupling between cables, attempt to separate input cables from control cables and output cables – maintaining 300mm looming clearance where possible.

Due to high leakage currents are inherent to AC drives, earth connection of both the motor and the drive are essential before connecting to the supply.

Power factor correction capacitors are not required on the drive input and must not be connected to the output.

2.c. Mains Input Protection

Depending on the drive input stage topology, different protection devices may be required. The manufacturer's instructions should be adhered to at all times. If input fuses are recommended, the recommended fuse type should be selected to ensure optimum protection. Fast input fuses (semi-conductor fuses) can be used to minimise damage to the drive in case of an internal short.

Where circuit-breaker/contactor/drive combinations are used to ensure continuous service of the installation with optimum safety, correct selection will be required to ensure type 2 coordination.

Type 2 coordination means that if there is a short-circuit:

- no damage or loss of settings is permitted
- the isolation must be maintained
- the motor combination must be able to operate after the short circuit has been removed
- Welding of the contactor contacts is permitted if they can be separated easily

Due to the protection devices integrated in a drive, type 2 coordination is provided with any circuit breaker / contactor combination in case of a short circuit downstream of the drive.

In order to guarantee type 2 coordination in case of a short circuit upstream from the drive it is necessary to refer to the coordination tables provided by the manufacturers of the protection devices placed upstream.

2.d. The use of RCD's

The value of an insulation fault current between phase and earth can be too low to be detected and eliminated by conventional over current protection devices (thermal or magnetic protection of a circuit breaker) in this case Residual Current Devices-RCD's can be added to increase the protection for persons.

Drives are high leakage, non linear devices and hence specific care is required when selecting and installing RCD's
Most drives use capacitive RF filters on the input of drives. The topology of such a filter is model and manufacturer specific. These capacitors are responsible for residual currents on power-up and during normal operation. For latest generation drives, these currents are low, typically below 4mA. To prevent premature tripping, the number of drives per RCD should be kept as low as possible and ideally one RCD per drive should be installed. Devices fitted with a time delay or devices with reinforced immunity will prevent nuisance tripping on power up.

Conventional protection devices are suitable for measuring AC fault currents. However, insulation faults on the DC bus or on the braking circuit will cause a circulating current with a DC component. To keep the protection device operational under these conditions a type B RCD must be used for three phase drives and a type A RCD should be used for single phase drives.

The voltage waveform generated by drives causes high-frequency leakage currents to circulate in the power supply cables. These currents can reach instantaneous values of several amps and an rms value of several dozen milliamps. These currents can cause undesired tripping of the RCD. The RCD used must therefore include a filtering circuit such that only the low frequency component of the signal is taken into account.

A selection overview is provided in the table below.

	Protection...				
	... against indirect contact			**... against direct contact**	
Power supply	3-phase		Single-phase	3-phase	Single-phase
Hardware and installation characteristics	No double insulation of the DC bus	Double insulation of the DC bus		If an additional protection measure is necessary, in the event of failure of other measures providing protection against contact or carelessness of users (see installation standards)	
Earthing system TT (or IT with frames not connected together)	Type B, low sensitivity (≥ 300 mA)	Type **A**, low sensitivity (≥ 300 mA)		Type **A** (30 mA) or type B (30 mA) if the braking resistor is accessible	Type **A** (30 mA)
Earthing system **TN-S**	Type **A**, low sensitivity (≥ 300 mA) [*]				
Earthing system IT					

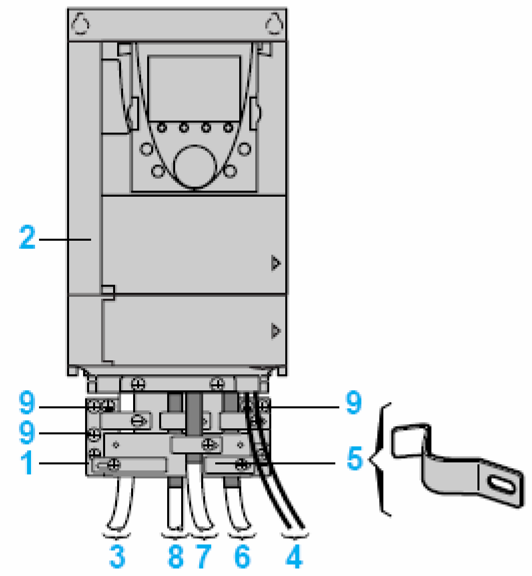
[*] The insulation fault is similar to a short-circuit. Tripping must normally be performed by the short-circuit protection device, but the use of an RCD is recommended if there is a risk of overcurrent protection devices not tripping.

2.e. Motor Power Cables

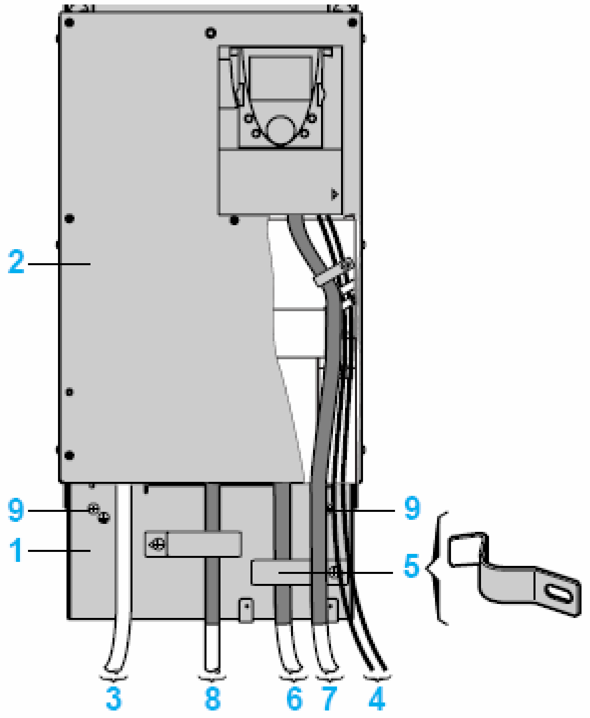
Screened EMC cable should be used between the drive output and the motor to reduce the chances of radio frequency interference (RFI) problems. The screen should be bonded to earth at motor and drive end. Suitable EMC cables include Siemens Protoflex-EMV, OLEX Varolex-flex and Triangle AM cables. A 360 degree EMC clamp should be used to secure the cable screen to the cable gland. It is not recommended to ever coil the screen into a pigtail as this dramatically decreases the ability of the screen to conduct RFI currents. It is important that the RFI currents coupled to the output cable screen are conducted directly back to its source – the drive. Therefore the screen should be continuous from the motor earth connection to the drive earth connection and not connected to any other earth between these two points.

Parallel connection of EMC cables for higher operating currents is possible, provided the cables are equal length and each cable uses all of the three output phases. Where EMC cable is impractical, individual cables for each phase can be used but these must be run parallel and in close proximity to each other. Binding these cables together with tape and/or cable ties will minimize stray magnetic and electric fields as well as RFI. Enclosing these cables inside a steel conduit or ducting can further reduce the possibility of interference. Motor output cables should not be run in close proximity to mains wiring or control cabling.

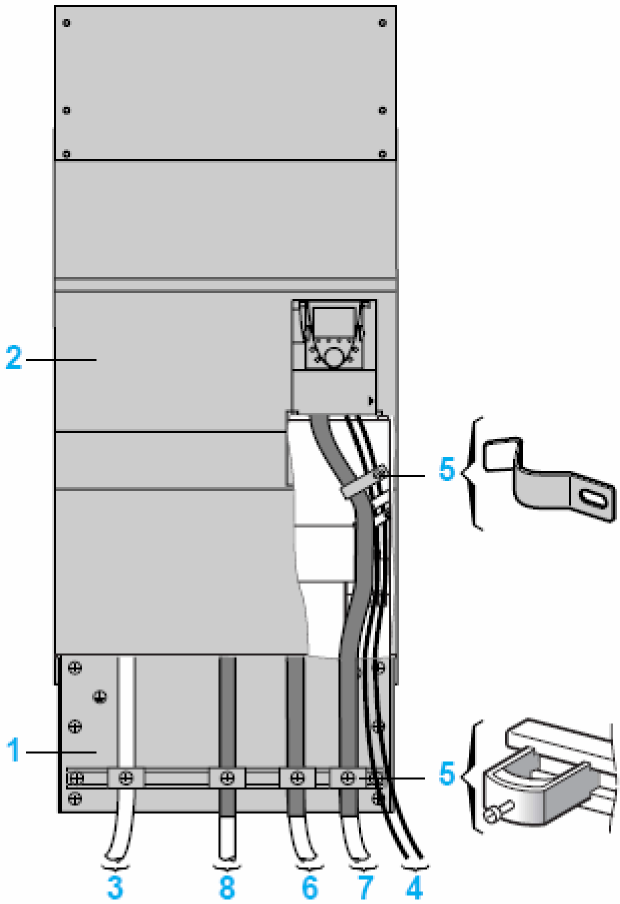
Typical EMC connections for an ATV71 are outlined below.



*ATV 71H●●●M3, ATV 71HD11M3X, HD15M3X,
ATV 71H075N4…HD18N4,
ATV 71P075N4Z…PU75N4Z*



*ATV 71HD18M3X…HD45M3X,
ATV 71HD22N4…HD75N4*



ATV 71HD55M3X, HD75M3X,
ATV 71HD90N4…HC50N4

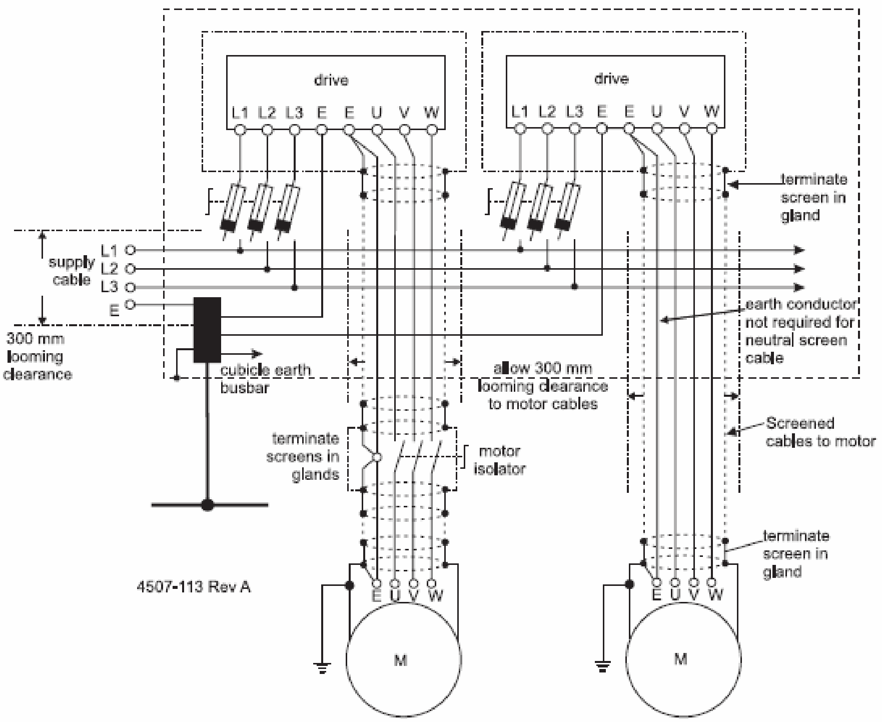
1 Steel plate *(1)*, to be mounted on the drive (earthed casing).
2 Altivar 71 UL Type 1/IP 20 drive
3 Unshielded power supply wires or cable
4 Unshielded wires for the output of the fault relay contacts
5 Fix and earth the shielding of cables 6, 7 and 8 as close as possible to the drive:
- strip the shielding
- fix the cable to the plate 1 by attaching the clamp to the stripped part of the shielding.
The shielding must be clamped tightly enough to the metal plate to ensure good contact.
6 Shielded cable for connecting the motor
7 Shielded cable for connecting the control/signal wiring.
For applications requiring several conductors, use cables with a small cross-section (0.5 mm^2).
8 Shielded cable for connecting the braking resistor 6, 7, 8, the shielding must be connected to earth at both ends.
The shielding must be continuous, and if intermediate terminals are used, they must be placed in EMC shielded metal boxes.
9 Earth screw.

2.f. Motor Isolators

It may be a safety requirement that a motor isolator be fitted between drive and motor. Never however attempt to open the isolator or contactor under load. Modern drives operate as current source devices and opening the output while running could cause extensive damage or fire in the switchgear. An auxiliary pole may be fitted to the isolator to trip the drive when the isolator is opened. This can help reduce arcing in the isolator if opened under load.

Ensure the integrity of the cable screen by terminating in metal glands into and out of a metal isolator enclosure. This includes the enclosure as part of the screen. If metal enclosures are not used, ensure the screen is connected inside the enclosure via a low impedance connection.

Refer to the drawings below for a typical wiring diagram



Connection diagram for use with metal cased isolators

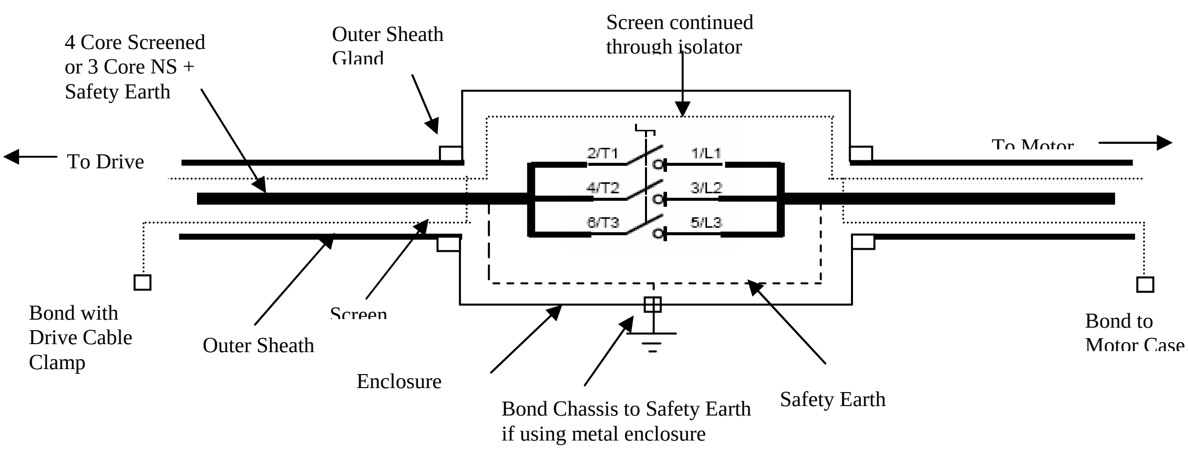


Diagram taken from Technical Note 06 – EMC screening &Output Isolators

2.g. Multiple motors in parallel

In this case the overload protection integrated in the drive cannot protect each motor. This means that the individual motors must be protected by a thermal overload relay.

Ensure overloads capable of handling the PWM output waveforms are selected. Premature tripping can be avoided by installing an output choke.

2.h. Long Cable runs

The modern AC drive produces a high frequency switched output. Each time the power electronic outputs (IGBTs) in the drive switch they must not only supply current to the motor but also charge up the cable capacitance. The amount of capacitance is affected by cable length, size, type and positioning. Excessive cable capacitance can cause drive over current trips due to the cable charging currents, and the DC bus may charge up as a result of earth leakage currents.

If multiple motors are run in parallel, then the cable length equals the sum of the individual runs.

Longer cable runs can be achieved via installation of additional output chokes or even sine filters.

Cable lengths should not exceed the manufacturer's specifications*. The table below is a typical specification for 3 phase 400V ATV71.

Up to 18kW	Shielded	50m
	Shielded with output choke	150m
	Un shielded	100m
	Un shielded with output choke	300m
	Un shielded with sine filter	600m
From 22kW	Shielded	100m
	Shielded with output choke	150m
	Un shielded	150m
	Un shielded with output choke	300m
	Un shielded with sine filter	600m

**NB/ For EMC purposes additional EMC filters may be required.*

2.i. Measures against EDM

Electrical Discharge Machining (EDM) of motor shaft bearings due to electrostatic discharge is a phenomenon affecting some inverter drive applications. Generally damaging EDM affects motors of frame size 315 and larger. Applications where EDM has occurred tend to be those where the rotor shaft is isolated from PE, as in large fans. However it remains difficult to predict which application may suffer from EDM and which will be trouble free.

For motors frame size 315 and larger, it is advised to install an appropriate rotor shaft grounding system, to bond the rotor shaft potential to that of the motor frame. To address the possibility of circulating currents, use an insulated bearing, or insulate the bearing housing at the opposite end of the rotor shaft to that of the shaft grounding system. Alternatives to this solution include the use of insulated bearings or insulated bearing housings at both ends or a shaft grounding system at both ends. Note that to prevent downstream machine bearing damage, an insulated coupling between the motor and the machine may be considered.

2.j. Control wiring

Use of screened control wiring is essential to reduce noise pickup into control circuits. Conductors inside control cables are ideally twisted, with a pitch between 25 and 50mm, inside foil sheath to improve immunity to magnetic fields.

With the steady increase of electrical noise in the environment it is now accepted to connect the shield at both ends. Doing so potentially introduces a risk of creating earth loops but it is thought the benefits of a better EMC protection outweigh the risks of introducing earth loops. Should earth loop problems occur, remove the shield connection at the non-drive end.

Signal cables should be routed around, rather than through high-noise areas.

Control and power cables should be separated by at least 300mm. Where control and power cables cross, the ideal angle is 90 degree.

Where control cables must unavoidably run parallel to and near power cables for significant distances, observe following rules:

- Use cable trays or ladders with a magnetic barrier between the two cables.
- Lay the data cable as far from the power cable as possible, at the outer extreme of the tray or duct.
- Lay up power cable in trefoil.

2.k. Encoder cabling

Encoders are precision instruments, susceptible to noise. Shielded cable must be used. The shielded cable should contain 3 twisted pairs with a pitch of between 25 and 50mm. Connect the shielding to ground at both ends.

The minimum cross-section of the conductors must comply with the table below to limit line voltage drop:

Maximum length of encoder cable	Maximum consumption current of the encoder	Minimum cross-section of the conductors
10m	100mA	0.2 mm^2
	200mA	0.2 mm^2
50m	100mA	0.5 mm^2
	200mA	0.75 mm^2
100m	100mA	0.75 mm^2
	200mA	1.5 mm^2
200m	100mA	0.75 mm^2
	200mA	1.5 mm^2
300m	100mA	0.75 mm^2
	200mA	1.5 mm^2

Encoders with open collectors ideally should not be used on cable runs greater than 50m. For longer cable runs, push-pull or line driver encoders (RS422) should be used.

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