Nidec
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EMC Data Sheet

Unidrive-M100 to M400 Frame size 4 All models

Variable Speed AC drive for induction and permanent magnet motors

Safety Warnings

WARNING	**A Warning contains information which is essential for avoiding a safety hazard.**

CAUTION	**A Caution contains information which is necessary for avoiding a risk of damage to the product or other equipment**

NOTE:
A Note contains information which helps to ensure correct operation of the product.

Installation and Use

The information given in this data sheet is derived from tests and calculations on sample products. It is provided to assist in the correct application of the product, and is believed to correctly reflect the behaviour of the product when operated in accordance with the instructions. The provision of this data does not form part of any contract or undertaking. Where a statement of conformity is made with a specific standard, the manufacturer takes all reasonable measures to ensure that its products are in conformance. Where specific values are given these are subject to normal engineering variations between samples of the same product. They may also be affected by the operating environment and details of the installation arrangement.

The manufacturer accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation of the equipment.

The contents of this data sheet are believed to be correct at the time of printing. The manufacturer reserves the right to change the specification of the product or its performance, or the contents of the data sheet, without notice.

WARNING	**All electrical installation and maintenance work must be carried out by qualified electricians, familiar with the requirements for safety and EMC. The installer is responsible for ensuring that the end product or system complies with all relevant laws in the country where it is used.**

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Contents

1. Products

This EMC data sheet applies to the following products:

Table 1 Model numbers

Drive rated voltage (V)	Drive rated power (kW)	Model No
230	3.0	xxxx-042 00133A
230	4.0	xxxx-042 00176A
400	5.5	xxxx-044 00135A
400	7.5	xxxx-044 00170A

Where: xxxx denotes M100, M101, M200, M201, M300, M400 or HS30.

2. Immunity

2.1 Compliance

The drives comply with the following international and European harmonised standards for immunity:

Table 2 Immunity test levels

Standard	Type of immunity	Test specification	Application	Level
IEC 61000-4-2	Electrostatic discharge	6 kV contact discharge 8 kV air discharge	Module enclosure	Level 3 (industrial)
IEC 61000-4-3	Radio frequency radiated field	Prior to modulation: 10 V/m 80 - 1000 MHz 3 V/m 1.4 - 2.0 GHz 1 V/m 2.0 - 2.7 GHz 80% AM (1 kHz) modulation Safe Torque Off (STO) tested to : 20V/m 80 – 1000 MHz 6V/m 1.4 - 2.0 GHz 3V/m 2.0 - 2.7 GHz	Module enclosure	Level 3 (industrial)
IEC 61000-4-4	Fast transient burst	5/50 ns 2 kV transient at 5 kHz repetition frequency via coupling clamp	Control lines	Level 4 (industrial harsh)
		5/50 ns, 2 kV transient at 5 kHz repetition frequency by direct injection	Power lines	Level 3 (industrial)
IEC 61000-4-5	Surges	Common mode 4 kV 1.2/50µs wave shape	AC supply lines: line to earth	Level 4
		Differential mode 2 kV	AC supply lines: line to line	Level 3
		Common mode 1 kV	Control lines	(Note:1)
IEC 61000-4-6	Conducted radio frequency	10 V prior to modulation 0.15 - 80 MHz 80% AM (1 kHz) modulation	Control and power lines	Level 3 (industrial)
IEC 61000-4-11	Voltage dips, short interruptions & variations	All durations	AC supply lines	

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Standard	Type of immunity	Test specification	Application	Level
IEC 61000-4-8	Power frequency magnetic field	1700 A/m RMS. 2400 A/m peak (2.1 mT RMS 3 mT peak) continuous at 50 Hz	Module enclosure	Exceeds level 5 (Note: 2)
IEC 61000-6-1	Generic immunity standard for the residential, commercial and light - industrial environment			Complies
IEC 61000-6-2	Generic immunity standard for the industrial environment			Complies
IEC 61800-3	Product standard for adjustable speed power drive systems (immunity requirements)		Meets immunity requirements for first and second environments	

1 Applies to ports where connections may exceed 30 m length. Special provisions may be required in some cases – see additional information below.

2 Limited by test equipment capability

Unless stated otherwise, immunity is achieved without any additional measures such as filters or suppressors. To ensure correct operation the wiring guidelines specified in the User Guide must be followed. All inductive components such as relays, contactors, electromagnetic brakes must be fitted with appropriate suppression.

2.1.1 Surge immunity of control circuits

The input/output ports for the control circuits are designed for general use within machines and small systems without any special precautions.

These circuits meet the requirements of EN 61000-6-2 (1 kV surge) provided that the 0V connection is not earthed. In general the circuits cannot withstand the surge directly between the control lines and the 0V connection.

The surge test simulates the effect of a lightning strike, or a severe electrical fault, where high transient voltages may exist between different points in the grounding system. This is a particular risk where the circuits are routed outside a building, or if the grounding system in a building is not well bonded.

In applications where control circuits are exposed to high-energy voltage surges, some special measures are required to prevent malfunction or damage. In general, circuits that are routed outside the building where the drive is located, or are longer than 30 m need additional protection. One of the following techniques should be used:

1. Galvanic isolation, Do not connect the control 0 V terminal to ground. Avoid loops in the control wiring, i.e. ensure every control wire is routed next to its associated return (0 V) wire.

2. Screened cable. The cable screen may be connected to ground at both ends. In addition the ground conductors at both ends of the cable must be bonded together by a power ground cable (equal potential bonding cable) with cross-sectional area of at least 10 mm^2. This ensures that in the event of a fault, the fault current flows through the ground cable and not through signal cable screen. If the building or plant has a well-designed common bonded network this precaution is not necessary.

3. Additional over-voltage suppression. This applies to analogue and digital inputs and outputs. A zener diode network or a commercially available surge suppressor may be connected between the signal line and 0 V as shown in Figure 1 and Figure 2.

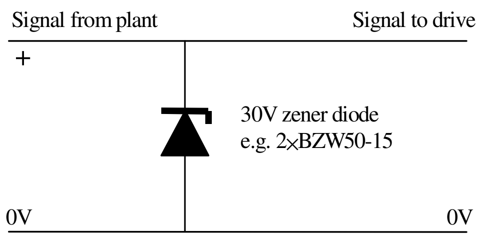

Figure 1 Surge suppression for digital and uni-polar analogue inputs and outputs

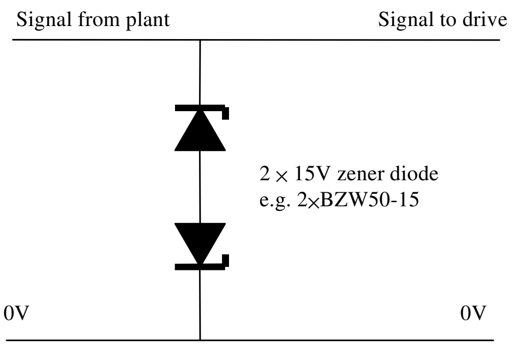

Figure 2 surge suppression for bipolar analogue inputs and outputs

Surge suppression devices are available as rail-mounting modules, e.g. from Phoenix Contact GmbH:

Unipolar	TT-UKK5-D/24 DC
Bipolar	TT-UKK5-D/24 AC

These devices are not suitable for encoder signals or fast digital data networks because the capacitance of the zener diodes adversely affects the signal. Most encoders have galvanic isolation of the signal circuit from the motor frame, in which case no precautions are required. For data networks, follow the specific recommendations for the particular network.

3 Emission

3.1 Supply Harmonics

Emission occurs over a wide range of frequencies. The effects are divided into three main categories:

- Low frequency effects, such as supply harmonics and notching.
- High frequency emission below 30 MHz where emission is predominantly by conduction.
- High frequency emission above 30 MHz where emission is predominantly by radiation.

2.1.2 Environment and Equipment Categories

The EMC product standard for variable speed drives, EN/ IEC 61800-3 defines two environments and four equipment categories:

- First Environment - This includes domestic premises, and establishments that share a low-voltage power supply network with buildings used for domestic purposes. Examples include: houses, apartment buildings, shops, commercial property and industrial premises that share a supply with nearby residential property.
- Second Environment - This includes all establishments other than those directly connected to a low-voltage power supply network which supplies buildings used for domestic purposes. Examples include Factories, industrial plants and areas of any building supplied by a dedicated transformer.

- Equipment Category C1 - Equipment that is intended for use in the First Environment
- Equipment Category C2 - Equipment that is neither a plug-in device nor a movable device. This type of equipment may be used in the First Environment if installed and commissioned by a professional (i.e. person or organisation having the necessary skills to install and commission power drive systems, including EMC requirements).
- Equipment Category C3 - Equipment that is intended only for use in the Second Environment. The equipment is not intended for use in the First Environment
- Equipment Category C4 - Equipment with rated voltage ≥ 1000V or rated current equal ≥ 400 A or intended for use as part of a complex system. This equipment is intended only for use in the Second Environment.

In general, the drives are capable of meeting the requirements of Equipment Category C3 without external filters or line reactors. They are capable of meeting the requirements of Equipment Category C2 when installed with the recommended filters and line reactors.

NOTE:	***In a domestic environment this product may cause radio interference in which case supplementary mitigation measures may be required.***

Examples of common mitigation methods include additional filtering, a dedicated supply transformer and use of screened cables.

2.2 Low Frequency Emissions

2.2.1 Supply voltage notching

The drives do not cause notching of the supply voltage.

2.2.2 Voltage fluctuations and flicker

When running at constant load the drive does not generate voltage fluctuations or flicker. Care must be taken to ensure that the application does not cause the load to vary rapidly, resulting in flicker. Cyclical variations with frequency in the region of 2 Hz to 20 Hz are likely to cause irritating lighting flicker and should be avoided.

When power is first applied the drive draws an inrush current which is lower than the rated input current. This meets the requirements of IEC 61000-3-3.

2.2.3 Common mode harmonic emissions (crosstalk)

The drives generate switching waveforms with frequency components in the audible range as well as the frequency range commonly used by telephone and data systems. The installation instructions include recommendations for segregation and shielding of power and signal cables. Refer to the drive *User Guide* and to section 4 of this data sheet.

2.2.4 Supply harmonics

The drive input current contains harmonics of the supply frequency. The harmonic levels are affected to some extent by the supply impedance (fault current level). Table 3 shows the levels calculated with a fault level of 5 kA. This is typical of a light industrial installation. This meets and exceeds the requirements of IEC 61800-3. For installations where the fault level is lower, so that the harmonic current is more critical, the harmonic current will also be lower than that shown.

The calculations have been verified by laboratory measurements on sample drives.

Note that the RMS current in the table may differ from the maximum specified in the installation guide, since the latter is a worst case value provided for safety reasons which takes account of permitted supply voltage imbalance. The motor efficiency also affects the current. A standard IE2, 4 pole motor has been assumed. For balanced sinusoidal supplies, all even and triple harmonics are absent. The supply voltages used for the calculations are 200 V and 400 V at 50 Hz. The harmonic percentages do not change substantially for other voltages and frequencies within the drive specification.

2.2.5 Input line reactors (line chokes)

Where necessary, a reduction in harmonic current levels can be obtained by fitting reactors in the input supply lines to the drive. This also gives increased immunity to supply disturbances such as voltage surges caused by the switching of high-current loads or power factor correction capacitors on the same supply circuit

Table 4 shows the harmonic currents when the drives are fitted with the line reactors specified in Table 3.

The line reactors cause a slight reduction in the input voltage at the drive terminals, which will normally still permit the full rated torque to be developed in a standard motor. Higher inductance values should not be used unless some reduction of available torque at maximum speed is acceptable. Lower values can be used, and the resulting harmonics currents can be estimated by linear interpolation between the values for no inductance and the inductance value in the tables below. The reactor RMS current rating must be at least equal to the value shown in the table, and the peak current rating should be twice the RMS value in order to avoid magnetic saturation.

Table 3 Line reactors

No of phases	Inductance (mH)	Rated current (A)	Line reactor CT Part No.
3	0.48	20.6	4401-0144
3	1.05	15.8	4401-0151
3	0.71	21.0	4401-0235

2.2.6 Effect of load on harmonics

With reducing load, the major harmonics fall in absolute magnitude, although they generally rise as a fraction of the fundamental. Note that it is mechanical load power that controls input current, i.e. the product of torque and speed. As the speed is reduced, the motor current becomes increasingly reactive so the drive input current falls, together with its harmonics

2.2.7 Product family standards for harmonics

IEC 61000-3-2

This standard applies to equipment rated ≤ 16A per phase with a supply voltage of 230/ 400 V, 50 Hz. When applied to equipment for professional use this standard sets harmonic limits for ratings below 1 kW input power. The drives covered by this data sheet have rated input currents > 16 A and are therefore outside the scope of this standard.

IEC 61000-3-12

This standard applies to equipment rated >16 A and ≤ 75A per phase. This applies to the all drives covered by this data sheet. Tables 8 and 9 shows current harmonics when fitted with the minimum line inductance necessary to comply with the limits in IEC 61000-3-12, Table 4.The drive meets the limits for $R_{SCE} \geq 120$.

Note: R_{SCE} is the short-circuit ratio. It is the ratio of the short circuit power of the supply to the rated apparent power of the variable speed drive.

2.2.8 Note on load power for IEC 61000-3-12 compliance

The value of the required input reactor depends upon the load power, i.e. the product of shaft speed and torque. The values given above are correct for the stated load, which is a standard 4-pole IE2 induction motor delivering the specified load power. If the actual maximum continuous electrical load is less than this, the inductance must be scaled up in inverse proportion to the actual load. If tests according to IEC 61000-3-12 are carried out it is important to arrange for the equipment to be fully loaded in order to obtain valid results.

EN 12015 Product family standard for lifts, escalators and moving walks - Emission
EN 12015 states that Lifts, escalators and moving walks are considered as professional equipment as defined by EN 61000-3-2 therefore the requirements of EN 61000-3-12:2005 shall be applied as well to a system (equipment) less than 16 A per phase.

The harmonic current limits in EN 12015 are referenced to the fundamental current of the complete lift system. With the line reactor values shown in Table 3 fitted, the drive meets the limits in the standard for $R_{SCE} \geq 250$.

The mains current harmonics for the complete lift system will be the vector sums of the harmonic currents for all of the individual electrical loads in the system. Usually the main lift drive(s) will dominate the electrical load, and it will be sufficient to ensure that these meet the harmonic requirements.

2.2.9 Further measures for reducing harmonics

It is unusual for harmonics to pose a problem unless more than 50 % of the supply system capacity is accounted for by drives or other power electronic loads. Harmonic currents from drives add approximately arithmetically. It is usually most cost-effective to analyse a complete installation for harmonic current or voltage and to apply remedial measures such as harmonic filters, if necessary, for the entire installation at the common supply point.

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Table 4: Harmonic currents without line reactor, single phase operation with 5 kA fault level

Rated Voltage (V)	Motor power (kW)	RMS current (A)	Funda-mental current (A)	THD (%)	PWHD (%)	Harmonic order, magnitude as % of fundamental																							
						3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49
230	3.0	25.22	17.6	102.6	26.19	82.22	53.96	26.03	8.42	6.85	5.78	3.11	2.83	2.48	1.61	1.56	1.37	0.99	0.99	0.86	0.68	0.68	0.59	0.49	0.50	0.43	0.38	0.38	0.33

Table 5 Harmonic currents without line choke, three phase operation with 5 kA fault level

Rated Voltage (V)	Motor Power (kW)	RMS current (A)	Fundamental current (A)	THD (%)	PWHD (%)	Harmonics Current as % of Fundamental															
						5	7	11	13	17	19	23	25	29	31	35	37	41	43	47	49
230	3	13.42	10.3	84.22	36.8	68.84	46.04	10.76	7.30	5.54	3.52	2.96	2.38	1.66	1.66	1.05	1.16	0.78	0.84	0.63	0.65
230	4	16.92	13.4	77.84	34.01	64.13	41.99	8.02	8.08	4.18	3.69	2.45	2.43	1.53	1.91	1.15	1.53	0.98	1.27	0.95	1.01
400	5.5	13.71	10.2	90.77	38.29	72.65	51.39	14.42	6.22	6.06	4.11	2.62	2.59	1.43	1.40	1.10	0.92	0.90	0.72	0.60	0.60
400	7.5	18.08	13.8	85.08	31.53	69.68	46.88	10.36	5.43	4.97	2.87	2.56	2.05	1.31	1.31	0.87	0.90	0.62	0.54	0.55	0.47

Table 6 Harmonic currents with line reactors, single phase operation with 2% line reactor

Rated Voltage (V)	Motor power (kW)	RMS current (A)	Funda-mental current (A)	THD (%)	PWHD (%)	Harmonic order, magnitude as % of fundamental																								AC line reactor inductance (mH)
						3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	
230	3.0	23.0	17.4	86.5	20.4	75.1	39.6	12.5	7.35	5.76	3.04	2.98	1.94	1.67	1.40	1.05	1.02	0.76	0.73	0.61	0.53	0.50	0.41	0.40	0.34	0.32	0.29	0.26	0.25	0.48

Table 7 Harmonic currents with line reactors, three phase operation with 2% line reactor

Rated Voltage (V)	Motor Power (kW)	RMS current (A)	Fund current (A)	THD (%)	PWHD (%)	Harmonics Current as % of Fundamental																AC line reactor inductance (mH)
						5	7	11	13	17	19	23	25	29	31	35	37	41	43	47	49	
230	4	14.67	13.2	49.35	27.94	43.3	21.0	7.83	4.75	3.94	2.45	2.43	1.63	1.64	1.20	1.11	0.95	0.83	0.69	0.56	0.57	0.48
400	5.5	11.73	10	61.62	26.28	53.0	29.6	7.15	5.80	3.58	2.55	2.24	1.52	1.55	1.10	1.10	0.86	0.86	0.65	0.61	0.57	1.05
400	7.5	15.77	13.6	59.26	26.17	51.2	28.0	6.89	5.38	3.55	2.44	2.24	1.54	1.56	1.12	1.12	0.88	0.85	0.69	0.63	0.57	0.71
400	3	11.70	10.1	58.27	28.94	50.0	27.6	7.84	5.90	3.95	2.70	2.49	1.66	1.73	1.22	1.23	0.96	0.96	0.74	0.69	0.64	0.48

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Table 8 Harmonic currents with line reactors, single phase operation with line reactors meeting EN61000-3-12

Rated Voltage (V)	Motor power (kW)	RMS current (A)	Funda-mental current (A)	THD (%)	PWHD (%)	Harmonic order, magnitude as % of fundamental																								AC line reactor inductance (mH)
						3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	
230	4.0	15.85	15.4	24.01	5.01	22.4	7.39	3.44	1.90	1.19	0.84	0.64	0.52	0.43	0.35	0.29	0.25	0.21	0.18	0.15	0.14	0.12	0.11	0.10	0.09	0.08	0.08	0.07	0.06	14

Table 9 Harmonic currents with line reactors, three phase operation with line reactors meeting EN61000-3-12

Rated Voltage (V)	Motor Power (kW)	RMS current (A)	Fundamental current (A)	THD (%)	PWHD (%)	Harmonic Current as % of Fundamental																AC line reactor inductance (mH)
						5	7	11	13	17	19	23	25	29	31	35	37	41	43	47	49	
230	3	10.90	10	42.61	24.09	38.42	15.42	7.72	3.88	3.64	2.16	2.03	1.48	1.24	1.02	0.77	0.73	0.49	0.51	0.37	0.34	1.2
230	4	14.25	13.1	42.54	25.06	38.23	15.58	7.72	3.96	3.72	2.24	2.13	1.54	1.33	1.08	0.83	0.78	0.54	0.55	0.40	0.38	0.8
400	5.5	10.73	9.9	41.88	22.27	38.10	14.52	7.36	3.63	3.39	2.06	1.85	1.39	1.08	0.95	0.66	0.65	0.44	0.44	0.34	0.31	2.6
400	7.5	14.57	13.5	41.61	22.44	37.87	14.38	7.25	3.60	3.40	2.07	1.86	1.42	1.10	0.95	0.68	0.65	0.43	0.45	0.34	0.30	1.8

Note: for balanced three-phase applications the triple harmonics are negligible.

2.3 Conducted Emissions

2.3.1 General

Radio frequency emission in the range from 150 kHz to 30 MHz is generated by the switching action of the main power devices (IGBTs) and is mainly conducted out of the equipment through electrical power wiring.

In order to comply with emission standards, a shielded (screened) cable must be used to connect the variable speed drive to the motor. Most types of cable are acceptable provided that it has an overall screen that is continuous for its entire length. For example, steel wire armoured cable is acceptable.

2.3.2 Measures to reduce conducted emissions

The following measures can be used to reduce conducted emissions:

- Use the lowest possible switching frequency.
- Use the shortest possible motor cable length
- Follow the installation instructions given in section 4 of this data sheet

2.3.3 Internal filtering

The drive contains a cost-effective internal input filter which gives a reduction of about 30 dB in the level of emission at the supply terminals. This filter (in conjunction with a screened motor cable) is sufficient to meet Equipment Category C3 (See section 3.1 for definition of equipment categories).

The User Guide gives instructions on how to remove and replace the internal EMC filter.

NOTE:	**When the internal EMC filter is connected, the earth leakage current is > 3.5 mA.** **A permanent fixed earth connection is necessary to avoid an electric shock hazard. Further precautions, such as a supplementary earth connection or earth monitoring system, may also be required.**

2.3.4 Use of a ferrite ring

Passing the motor cable through a ferrite ring can reduce conducted emissions.

Two sizes of ferrite ring have been used for testing, as shown in Table 10.

The ferrite ring should be mounted close to the drive, and the output power conductors (U, V and W but not E) should be passed once or twice through the central aperture, all together in the same direction.

Table 10 Ferrite rings

Manufacturer	Manufacturers Part No.	CT Part No.	Dimensions (mm)		
			Outside diameter	Inside diameter	Thickness
Epcos	B64290 L0040 X 830	4200-3608	58.3	40.8	17.6
	B64290 L0048 X 830	4200-0003	34.0	20.5	12.5

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The User Guide gives instructions on how to remove and replace the internal EMC filter.

NOTE:	**When the internal EMC filter is connected, the earth leakage current is > 3.5 mA. A permanent fixed earth connection is necessary to avoid an electric shock hazard. Further precautions, such as a supplementary earth connection or earth monitoring system, may also be required.**

2.3.8 External filtering

If the equipment needs to meet the generic standard for emission IEC 61000-6-4 or operate in the First Environment then an optional external EMC filter is necessary.

Suitable filters are available from Control Techniques. The ratings and part numbers are shown in Table 8. Table 8 shows the typical leakage currents due to the external EMC filter. The external filter should be used in conjunction with the internal filter. The leakage currents do not add arithmetically because they have different frequencies.

Table 11 Recommended external filters

Filter type	No of phases	Rated voltage (V)	Earth leakage current (mA)	Motor cable length (m)	CT Part No
Standard	1	230	24.6	0 to 100	4200-4000
Low leakage	1	230	3.4	0 to 10	4200-4001
Standard	3	230	24.6	0 to 100	4200-4002
Low leakage	3	230	0.7	0 to 10	4200-4003
Standard	3	480	19.7	0 to 100	4200-4004
Low leakage	3	480	1.3	0 to 10	4200-4005

Table 12 Conducted emissions with internal filter and ferrite ring. 400V. Model M300-044 00170A

Switching Frequency (kHz)	Ferrite ring No of turns	Cable Length (m)						
		1	2	3	4	5	7	10
0.667	0, 1 or 2	C2	C2	C2	C2	C2	C2	C2
1	0	C2	C2	C2	C2	C2	C2	C2
	1 or 2	C2	C2	C2	C2	C2	C2	C2
2	0	C2	C2	C2	C2	C2	C2	C2
	1	C2	C2	C2	C2	C2	C2	C2
3	0, 1 or 2	C2	C2	C2	C2	C2	C2	C3
4	0, 1 or 2	C2	C2	C2	C2	C2	C3	C3
6	0	C2	C3	C3	C3	C3	C3	C3
	1 or 2	C2	C3	C3	C3	C3	C3	C3
8	0 or 1	C3	C3	C3	C3	C3	C3	C3
	2	C3	C3	C3	C3	C3	C3	C3
12	0, 1 or 2	C3	C3	C3	C3	C3	C3	C3
16	0, 1 or 2	C3	C3	C3	C3	C3	C3	C3

Table 13 Conducted emissions with internal filter and ferrite ring. 200V. Model M300-042 00133A

Switching Frequency (kHz)	Ferrite ring No of turns	Cable Length (m)						
		1	2	3	4	5	7	10
0.667	0, 1 or 2	C2	C2	C2	C2	C2	C2	C2
1	0	C2	C2	C2	C2	C2	C2	C2
	1 or 2	C2	C2	C2	C2	C2	C2	C2
2	0	C2	C2	C2	C2	C2	C2	C2
	1	C2	C2	C2	C2	C2	C2	C2
3	0, 1 or 2	C2	C2	C2	C2	C2	C2	C3
4	0, 1 or 2	C2	C2	C2	C2	C2	C3	C3
6	0	C2	C2	C2	C3	C3	C3	C3
	1 or 2	C2	C2	C2	C3	C3	C3	C3
8	0 or 1	C3	C3	C3	C3	C3	C3	C3
	2	C3	C3	C3	C3	C3	C3	C3
12	0, 1 or 2	C3	C3	C3	C3	C3	C3	C3
16		C3	C3	C3	C3	C3	C3	C3

Table 14 Conducted emissions. Standard Filter. All models

Motor cable length (m)	Switching Frequency (kHz)								
	0.667	1	2	3	4	6	8	12	16
2	C1	C1	C1	C1	C1	C1	C1	C1	C1
20	C1	C1	C1	C1	C2	C2	C2	C2	C2
100	C2	C2	C2	C2	C3	C3	C3	C3	C3

Table 15 Conducted emissions, Low leakage filter. All models

Motor cable length (m)	Switching Frequency (kHz)								
	0.667	1	2	3	4	6	8	12	16
10	C1	C1	C1	C1	C2	C2	C2	C2	C2

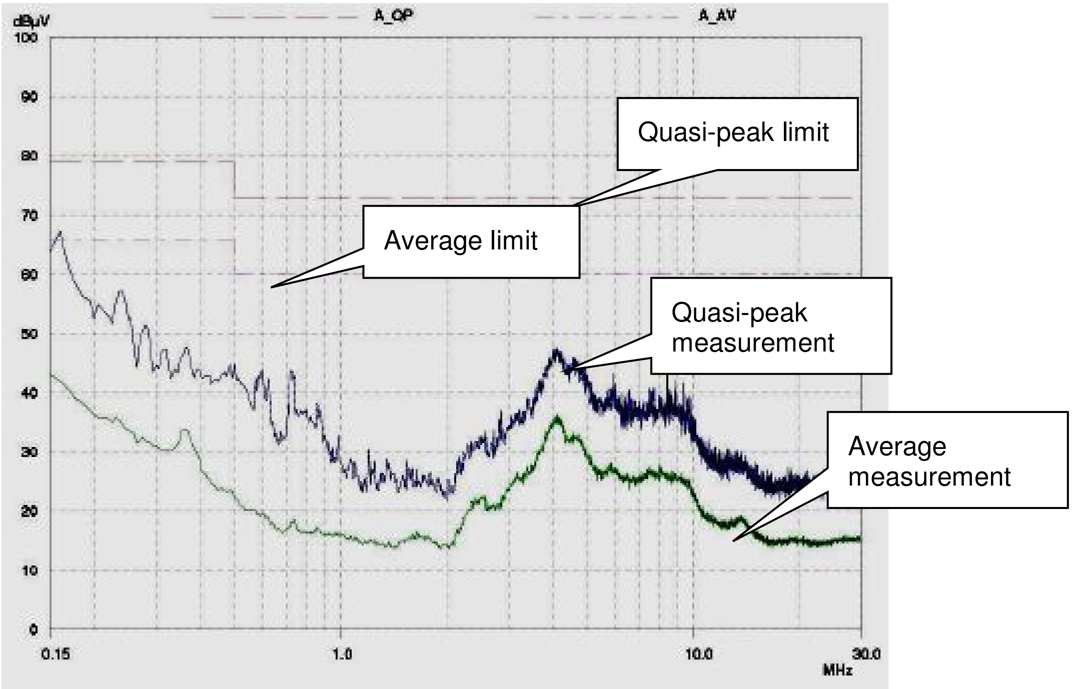

Figure 3 Conducted Emission M300 - 042 00133A, three phase operation, 3 kHz, 100 m cable, filter 4200-4002

Notes:

1. Where the drive is incorporated into a system with rated input current exceeding 75A, the higher emission limits in IEC 61800-3 for the Second environment are applicable, and no filter is required.
2. Operation without a filter is a practical cost-effective option in an industrial environment where existing levels of electrical noise are likely to be high, and any electrical equipment in operation has been designed for such an environment. This is in accordance with IEC 61800-3 in the Second Environment. There is some risk of disturbance to other equipment, and in this case the user and supplier of the drive system must jointly take responsibility for correcting any problems that occur.

2.3.9 Earth leakage current

WARNING	**Except for the low earth leakage versions, these filters have earth leakage current exceeding 3.5mA. A permanent fixed earth connection is necessary to avoid electrical shock hazard. Further precautions, such as a supplementary earth connection or earth monitoring system, may also be required.**

2.3.10 Operation with IT (ungrounded) supplies

WARNING	**Special attention is required when using internal or external EMC filters with ungrounded supplies, because in the event of a ground (earth) fault in the motor circuit the drive may not trip and the filter could be over-stressed. In this case, either the filter must not be used (removed) or additional independent motor ground fault protection must be provided. For details of ground fault protection contact the supplier of the drive.**

Unusual hazards can occur on ungrounded supplies with more than one source, for example on ships. Contact the supplier of the drive for more information.

2.3.11 Shared external filters for multiple drives

In multiple drive applications it is preferable to use one EMC filter for each drive. Filters may be shared between drives. However, the applicable motor cable length is the sum of all individual motor cable lengths connected to the same filter.

2.3.12 Related product standards

The conducted emission levels specified in the standards specified above are equivalent to the levels required by the following product specific standards:

Table 16 Comparison of IEC 61800-3 and related emissions standards

Drive standard Equipment Category	Generic standard	Environment	Product standard	Scope of Product standard
C1	IEC 61000-6-3	Residential, commercial and light-industrial environments	EN 55011 Class B CISPR 11 Class B	Industrial, scientific and medical equipment
			EN 55014 CISPR 14	Household electrical appliances
			EN 55022 Class B CISPR 22 Class B	Information technology equipment
C2	IEC 61000-6-4	Industrial environments	EN 55011 Class A Group 1 CISPR 11 Class A Group 1	Industrial, scientific and medical equipment
			EN 55022 Class A CISPR 22 Class A	Information technology equipment
			EN12015 (rated current ≤ 25 A)	Lifts, elevators and moving walkways

2.4 Radiated Emissions

2.4.1 Industrial emission standard IEC 61000-6-4

When installed in a standard metal enclosure according to the wiring guidelines in section 4 of this EMC data sheet and using the standard or low-leakage mains input filters, the drive will meet the radiated emission limits required by the generic industrial emission standard IEC 61000-6-4

2.4.2 Limits for radiated emission

Compliance was achieved in tests using representative enclosures and following the guidelines given. Every effort was made to ensure that the arrangements were robust enough to be effective despite the normal variations which will occur in practical installations. However no warranty is given that installations built according to these guidelines will necessarily meet the same emission limits.

The limits for emission required by the generic emission standards are summarised in Table 12.

Table 17 Radiated emissions limits in IEC 61800-3

Frequency range (MHz)	Category C1	Category C2	Category C3	Units
30 - 230	30	40	50	dBµV/m Quasi peak
230 - 1000	37	47	60	

Note: The limits apply at a measuring distance of 10 m. The measurements may be made at 3m with the limits increased by 10 dB.

2.4.3 Example test data

The test data is based on radiated emission measurements made on a standard steel enclosure containing a single drive with three-phase supply. These drives have the highest emission levels in this product range. The tests were carried out in a calibrated open area test site. Details of the test arrangement are described below:

A standard enclosure was used having dimensions 1900 mm (high) × 600 mm (wide) × 500 mm (deep). Two ventilation grilles, both 200 mm square, were provided on the upper and lower faces of the door.

The drive was mounted onto the EMC input filter, which was fitted to the internal back-plate of the enclosure, the filter casing making electrical contact with the back-plate by the fixing screws. Standard unscreened power cables were used to connect the complete unit to the supply.

A suitably rated, standard AC induction motor was connected by 2 m of shielded cable (steel braided - type SY) and mounted externally.

The motor cable screen was clamped to the enclosure back-plate. The motor cable screen was also bonded to the motor frame.

The motor cable was interrupted by a DIN rail terminal block mounted in the enclosure and the shield pigtails (50 mm long) were bonded to the back plate through an earthed DIN rail terminal block.

In addition, the motor cable screen was bonded to the back-plate on both sides of the DIN rail using metal clamps.

A 2 m screened control cable was connected to the drive control terminals with the screen clamped to the enclosure back-plate

A 2 m unscreened status relay cable was connected to the drive.

A 2 m screened communications cable was connected to the drive. The screen was not electrically connected to the drive or cubicle back panel.

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The drive was operated at 6 Hz, with a switching frequency of 16 kHz. This is the worst case condition for radiated emission.

No additional EMC preventative measures were taken, e.g. RFI gaskets around the cubicle doors.

The following tables summarise the results for radiated emission, showing the highest measurements over the frequency range 30 MHz to 1000 MHz:

Table 18 Radiated Emission Measured Levels. Model M300 – 044 00170A

Frequency (MHz)	Emission (dB µV/m)	C2 limit (dB µV/m)	Margin (dB µV/m)
33.72	32.95	40	-7.05
52.84	33.45	40	-6.55
55.76	34.98	40	-5.02
55.96	35.12	40	-4.88
56.68	35.24	40	-4.76
57.52	35.20	40	-4.8
58.08	34.68	40	-5.32

The results show that the limit for industrial radiated emission (C2) is met with a margin of at least 5 dB.

2.4.4 Enclosure construction

In many installations, an enclosure has a back-plate which is used to mount variable speed drives together with the EMC filters and ancillary equipment. The motor cable should be bonded to the back-plate close to the drive before it leaves the enclosure wall. However, there is no disadvantage if the motor cable is bonded at the point of exit as well, through the normal gland fixings.

Depending on construction, the enclosure wall used for cable entry may have separate panels and could make poor electrical contact at high frequencies with the remaining structure. If the motor cable is only bonded to these surfaces and not to a back-plate, then the enclosure may provide insufficient attenuation of RF emission. It is the bonding to a common metal plate which minimises radiated emission. In the tests described, opening the cubicle door had little effect on the emission level, showing that the enclosure design is not critical.

2.4.5 Related product standards

The radiated emission levels specified in IEC 61000-6-4 are equivalent to the levels required by the following product standards:

Table 19 Related radiated emission standards

<table>
<tr><th>Generic standard</th><th colspan="2">Product standard</th></tr>
<tr><td rowspan="3">IEC 61000-6-4</td><td>CISPR 11 Class A Group 1
CISPR 11 Class A Group 1</td><td>Industrial, scientific and medical equipment</td></tr>
<tr><td>EN55022 Class A
CISPR 22 Class A</td><td>Information technology equipment</td></tr>
<tr><td>EN 12015</td><td>Lifts</td></tr>
</table>

2.4.6 Radiated emissions test limits for lifts, elevators and moving walkways.

The limits for Radiated Emissions in the standard for Electromagnetic compatibility, Product family standard for lifts, escalators and moving walks, Emission, EN 12015 are the same as those in IEC 61800-3 for equipment category C2.

4 Installation and Wiring Guidelines

4.1.1 General Guidelines

The wiring guidelines on the following pages should be observed to achieve minimum emission. The details of individual installations may vary, but details which are indicated in the guidelines to be important for EMC must be adhered to closely. The guidelines do not preclude the application of more extensive measures which may be preferred by some installers. For example, the use of full 360° ground terminations on shielded cables in the place of 'pig-tail' ground connections is beneficial, but not necessary unless specifically stated in the instructions.

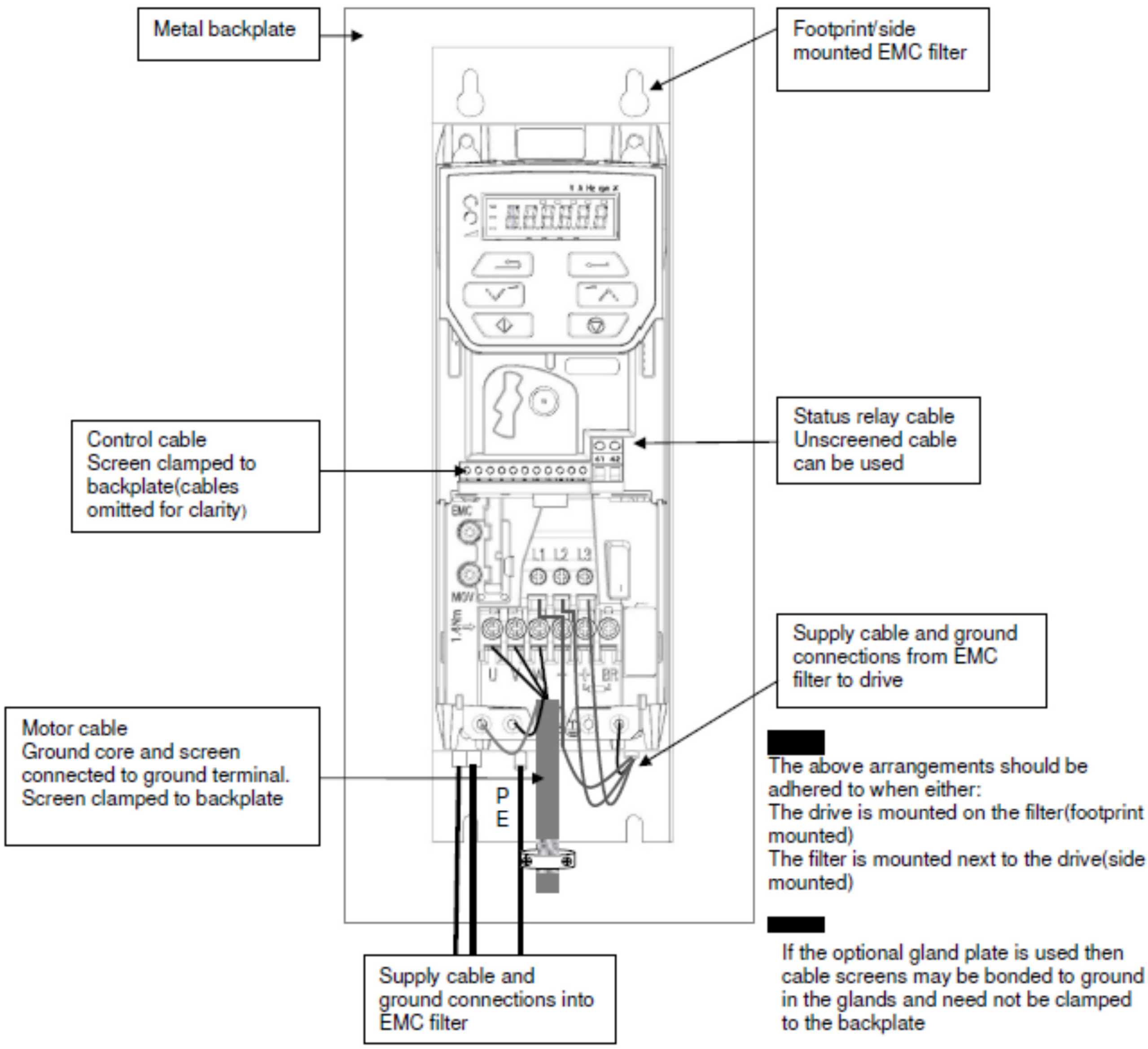

Figure 4 Wiring guidelines

1. The correct RFI filter must be fitted at the input to the drive.
2. The limits given above regarding motor cable length and drive switching frequency for the relevant filter must be adhered to.
3. Footprint filter: the drive must be correctly mounted on the filter and make good direct electrical contact with it.
4. Side mounted filter: the drive and filter must be mounted together on a metal back-plate and make good electrical contact with it.

5. The filter must be connected to the drive using the wires provided. The wires must not be extended in any way.
6. The mounting surface of the filter must make good direct electrical contact with the enclosure back-plate. Any paint or other non-conducting surface must be removed.
7. A shielded (screened) or steel wire armoured cable must be used to connect the drive to motor. The shield must be connected to the enclosure back-plate by a good high-frequency connection, for example by direct clamping using a "Ω" clamp or similar.
8. Connect the shield of the motor cable to the ground terminal of the motor frame using a link that is as short as possible and not exceeding 50 mm (2 in) in length. A full 360° termination of the shield to the motor terminal housing (if metal) is beneficial.
9. Ensure that the cables carrying the AC supply and the ground to the filter are at least 100 mm (4 in) from the drive and the motor cable.
10. Avoid locating sensitive signal circuits in a zone extending 0.3 m (12 in) all around the drive.
11. If the control circuit 0V is to be grounded, this should preferably be done at the host controller (e.g. PLC) and not at the drive, to avoid injecting noise current into the 0V circuit.
12. This requirement does not apply if the complete system has been built to a high standard for EMC, using a highly bonded earth arrangement which prevents differential earth noise voltages.

4.1.2 Control wiring leaves the enclosure

The control wiring must be carried in shielded cable (one or more cables) and the shield must be clamped to the enclosure back-plate.

4.1.3 Interruptions to the motor cable

The motor cable should ideally be a single run of shielded cable having no interruptions. In some situations it may be necessary to interrupt the cable, for example to connect the motor cable to a terminal block within the drive enclosure, or to fit an isolator switch to allow safe working on the motor. In these cases the following guidelines should be observed.

4.1.4 Terminal block within enclosure

The motor cable shields should be bonded to the back-plate using uninsulated cable-clamps which should be positioned as close as possible to the terminal block. Keep the length of unscreened power conductors to a minimum and ensure that all sensitive equipment and circuits are at least 0.3 m (12 in) away from the terminal block. See Figure 5.

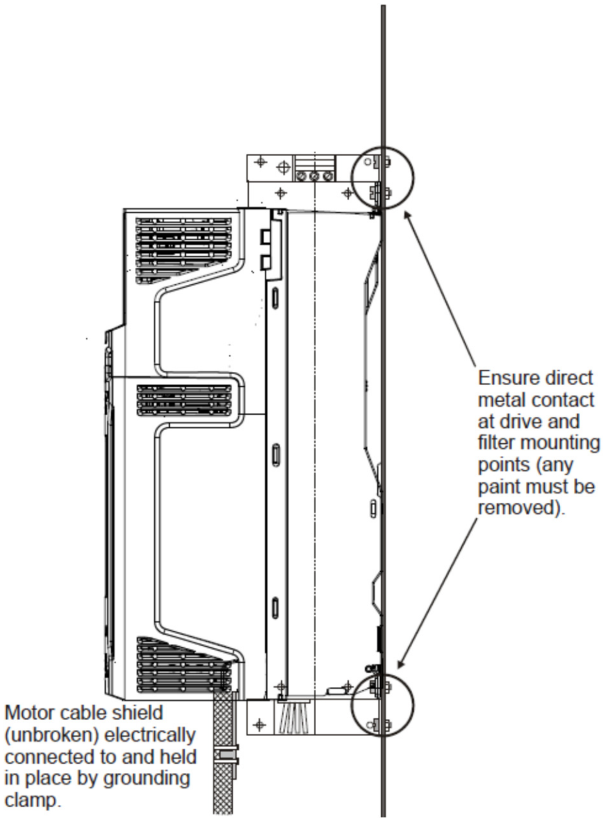

Figure 5 Grounding of the drive, filter and motor cable shield

4.1.5 Connection of motor cable shield at the motor

Connect the shield of the motor cable to the ground terminal of the motor frame using a link that is as short as possible and not exceeding 50 mm (2 inches) in length. A full 360° termination of the shield to the motor terminal housing (if metal) is beneficial.

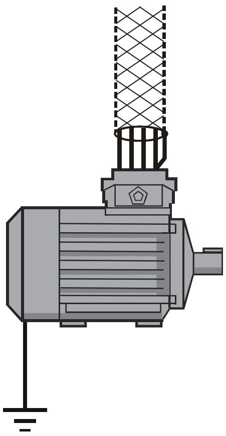

Figure 6 Connection of motor cable shield at the motor

4.1.6 Use of additional safety earth wire

If an additional safety earth wire is required for the motor, it can either be carried inside or outside the motor cable shield. If it is carried inside then it must be terminated at both ends as close as possible to the point where the screen is terminated. It must always return to the drive and not to any other earth circuit.

4.1.7 Braking resistor wiring

Wiring to the braking resistor should be shielded. The shield must be bonded to the back-plate using an un-insulated metal cable-clamp. It need only be connected at the drive end.

If the braking resistor is outside the enclosure then it should be surrounded by an earthed metal shield.

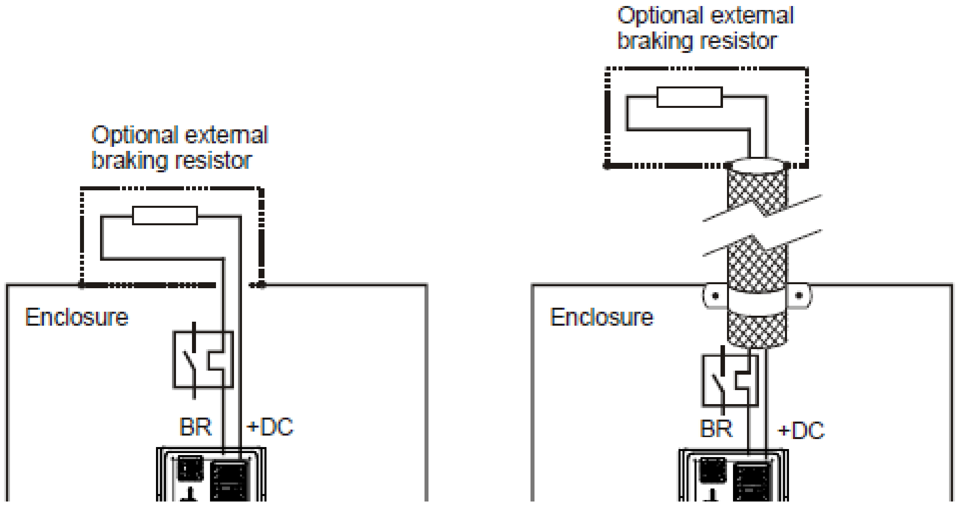

Figure 7 Braking resistor wiring and screening

4.1.8 Signal and control wiring

Signal and control wiring must be kept at least 300 mm (12 inches) from the drive and motor cable.

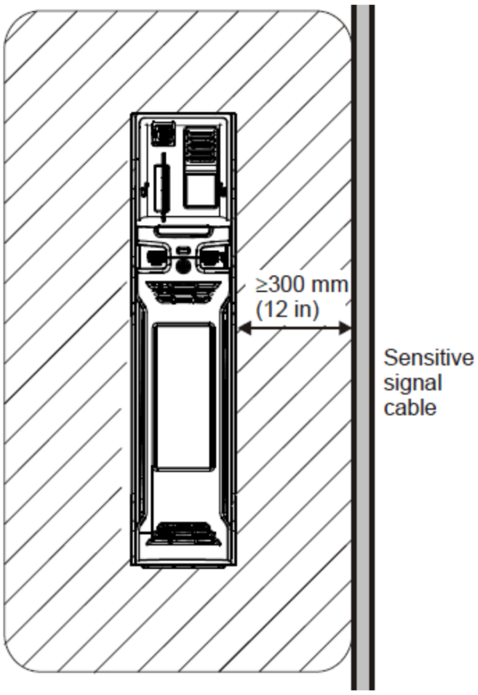

Figure 8 Signal wiring spacing

The control wiring "0 V" connection should be earthed at one point only, preferably at the controller and not at a drive.

4.1.9 Wiring routed outside the enclosure

If drive control wiring leaves the enclosure then one of the following additional measures must be taken: (This includes all control, encoder and option module wiring but not the status relay circuit or the serial port).

1. Use shielded cables (one overall shield or separate shielded cables) and clamp the shield(s) to the grounding bracket provided.

2. Pass the control wires through a ferrite ring part number 3225-1004. More than one cable can pass through a ring. Ensure the length of cable between the ring and drive does not exceed 125 mm (5 inches).

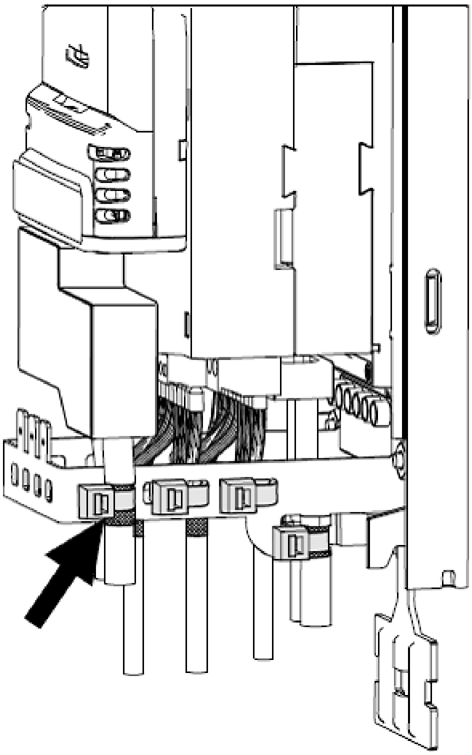

Figure 9 Earthing of cable screens using the grounding bracket

4.1.10 Control wiring leaves the enclosure

The control wiring must be carried in shielded cable (one or more cables) and the shield must be clamped to the enclosure back-plate.

4.1.11 Interruptions to the motor cable

The motor cable should ideally be a single run of shielded cable having no interruptions. In some situations it may be necessary to interrupt the cable, for example to connect the motor cable to a terminal block within the drive enclosure, or to fit an isolator switch to allow safe working on the motor. In these cases the following guidelines should be observed. The most important factor is always to minimise the inductance of the connection between the cable shields.

4.1.12 Terminal block within enclosure

The motor cable shields should be bonded to the back-plate using uninsulated cable-clamps which should be positioned as close as possible to the terminal block. Keep the length of unscreened power conductors to a minimum and ensure that all sensitive equipment and circuits are at least 0.3 m (12 in) away from the terminal block. See Figure 10.

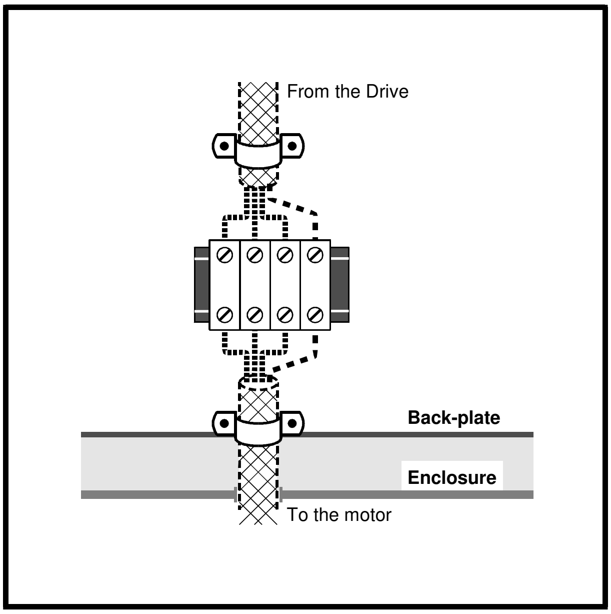

Figure 10 Connecting the motor cable to a terminal block in the enclosure

4.1.13 Using a motor isolator switch

The motor cable shields should be connected by a very short conductor having a low inductance. The use of a flat metal bar is recommended; conventional wire is not suitable. The shields should be bonded directly to the coupling bar using un-insulated metal cable-clamps. Keep the length of power conductors to a minimum and ensure that all sensitive equipment and circuits are separated by at least 0.3 m (12 inches). The coupling bar may be grounded to a known low impedance ground nearby, for example a large metallic structure which is connected closely to the drive ground.

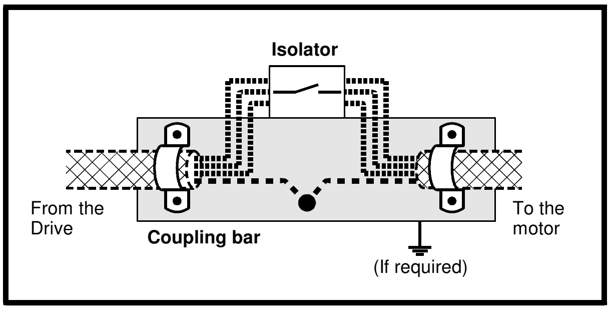

Figure 11 Connecting the motor cable to an isolating switch