EMC INSTALLATION GUIDELINES

Introduction

This section provides installation guidelines for drive modules and systems to maximise their '**E**lectro Magnetic **C**ompatibility' (EMC) in their intended operating environment. All installers must read this section and apply the advice which is relevant to their application. **Pass on this information to others as is appropriate.**

All power drive systems have the potential to produce electrical emissions, both radiated and conducted back into the AC supply. This is due to the inherent operation of all drives by switching large voltages and currents rapidly in order to control the motor. Because the drives internal control electronics operates continuously in very close proximity to the electrically noisy power switching elements, drives are inherently immune to any additional external electrical noise.

Great care has been taken in the design and selection of suitable EMC filters to provide the correct level of interface suppression, ease of installation and to ensure that electrical safety is not compromised. The EMC performance can only be guaranteed to be within the limits specified when the 620 drive modules are installed together with the recommended EMC filters in accordance with the following instructions.

The subject of EMC is explored in more detail in a separate Eurotherm Application Manual entitled "EMC Installation Guidelines for modules and systems', part number HA388879, available from your local Eurotherm office.

EMC Filters to Reduce Line Conducted Noise

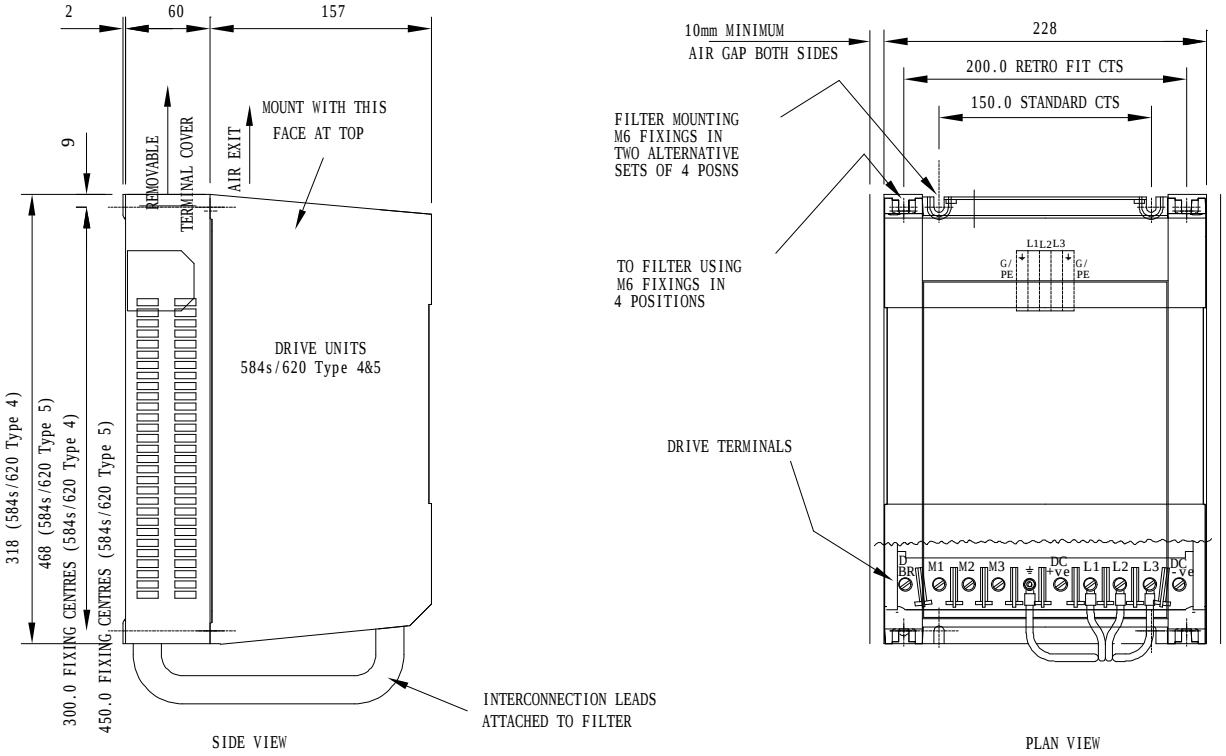
An EMC supply filter may be used with each 620 drive module to reduce the line conducted noise. The recommended filters are listed in table 3.3 below.

Table 3.3 AC Supply Filter Part Numbers for Conformance with EN55011 Class B (suitable for both generic environments)

Eurotherm Product	Rating	Eurotherm Filter Part Number
620 Type 4	0.75kW - 5.5kW (380V to 460V) & 0.75kW - 2.2kW (208V to 240V) constant torque	CO388966U021
620 Type 4	7.5kW (380V to 460V) & 4kW (208V to 240V) constant torque	CO388966U035
620 Type 5	All	CO388966U045
620 Type 6	All	CO388966U095
620 Type 7	All	CO388966U200

The recommended EMC filters for the type 4 and 5 620 are to be mounted behind the drive module (underfloor mounting) and share the same footprint. They are suitable as standard for cubicle mount applications, as shown in figure 3-7. For wall mounting a purpose designed pressed steel conduit (Part No. BA388844) is supplied with the gland box, for mounting between the filter body and gland box is shown in the mechanical mounting drawing figures 3-8.

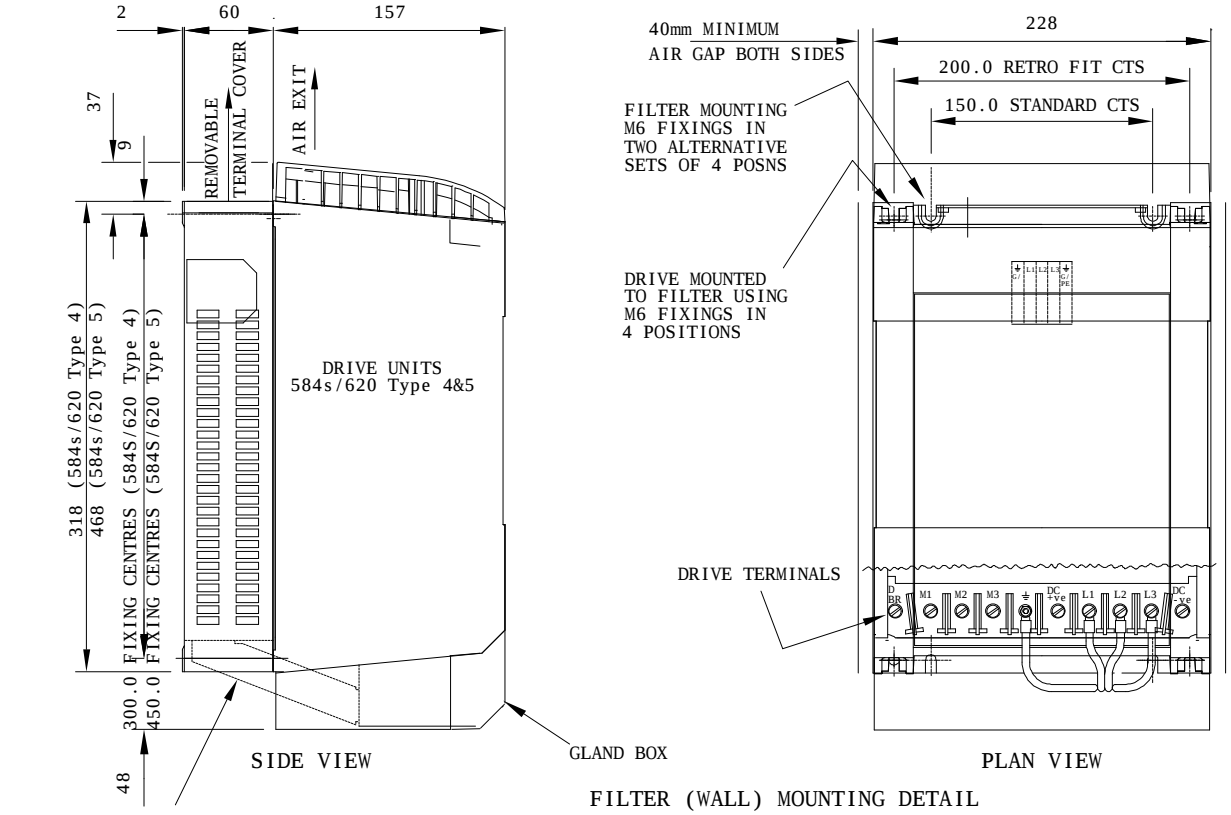
Figure 3-7. Filter Cubicle Mounting Details (620 types 4 & 5)



FILTER (CUBICLE) MOUNTING DETAIL

FILTERS:- CO388966U021 (18amp FOR 584s/620 Type 4)
CO388966U035 (24amp FOR 584s/620 Type 4)
CO388966U045 (38amp FOR 584s/620 Type 5)

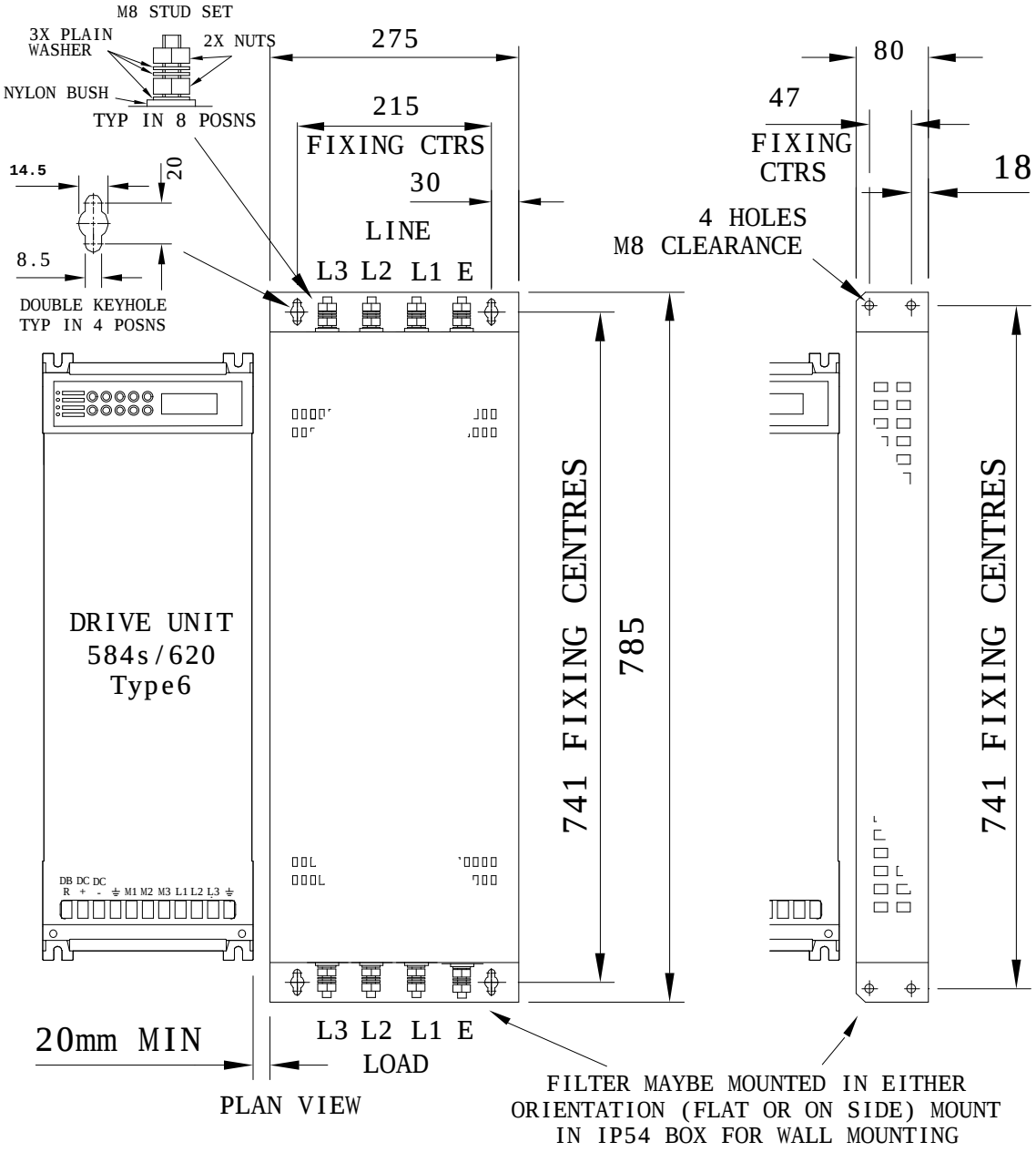
Figure 3-8. Filter Wall Mounting Details (620 types 4 & 5).



FILTER (WALL) MOUNTING DETAIL

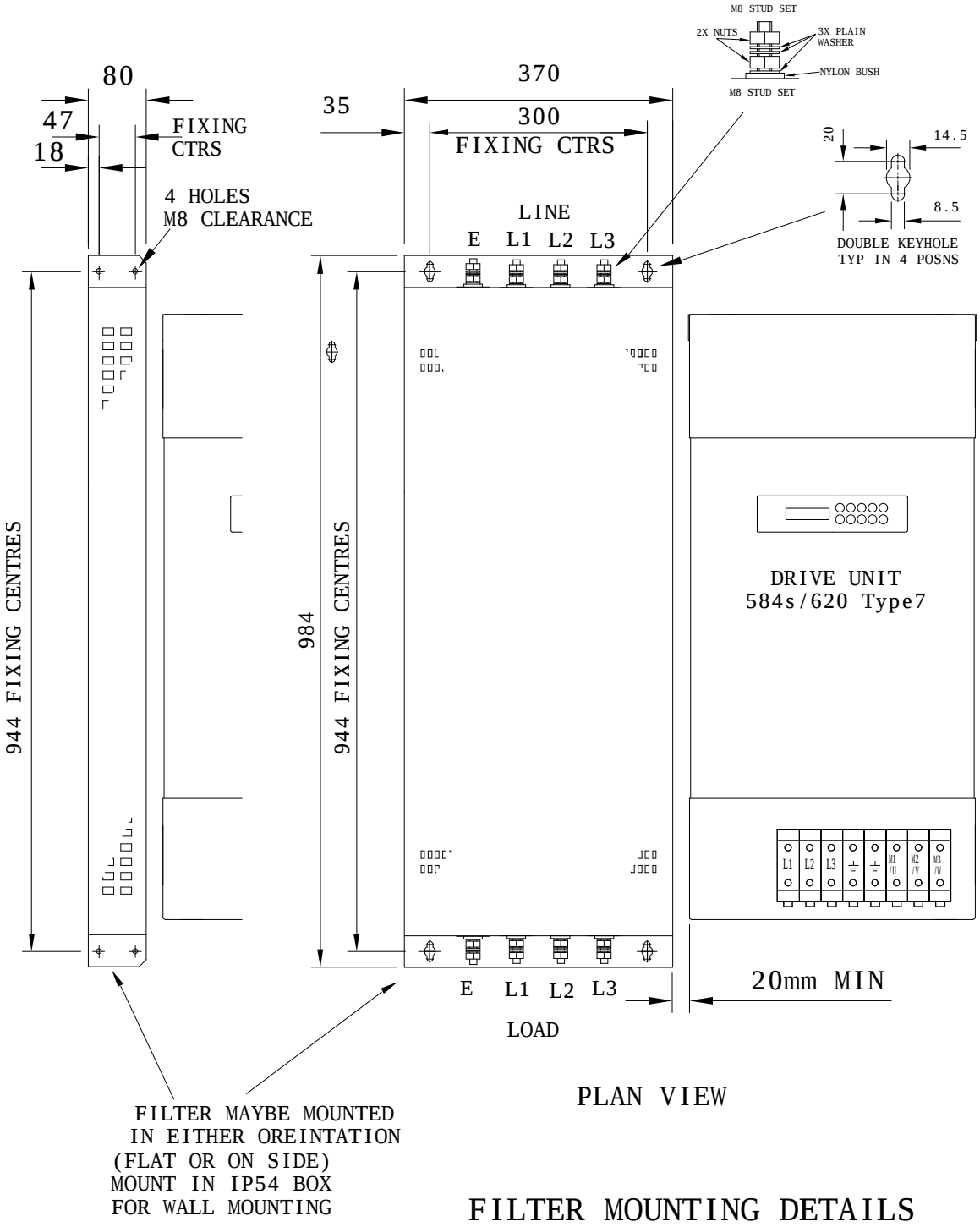
FILTERS:- CO388966U021 (18amp FOR 584s/620 Type 4)
CO388966U035 (24amp FOR 584s/620 Type 4)
CO388966U045 (38amp FOR 584s/620 Type 5)

Figure 3-9. Filter Mounting Details (620 Type 6).



FILTER MOUNTING DETAILS PART NUMBER
CO388966U095 FOR 584S/620 TYPE 6

Figure 3-10. Filter Mounting Details (620 Type 7).



FILTER MOUNTING DETAILS
Part No CO388966U200
FOR 584s/620 Type 7

The type 6 and 7 620 filters are not of the footprint mounting design. These filters may be mounted to the left, right, above, below or spaced behind the product, but can be mounted in two orientations i) flat against the wall or ii) projecting over from the wall, mounting arrangements are shown in figures 3-9 and 3-10. Wallmount applications require the EMC filter to be mounted in a separate suitable enclosure, and the gland box to be fitted to the 620.

The EMC filter should be mounted as close to the 620 drive module as possible. The connection between the 620 and filter must always be as short as possible taking care not to obstruct any ventilation spacing and **be segregated from all other cables**. If this cable/busbar exceeds 0.3m in length then it must be replaced with a screened/armoured cable, with the screen/armour earthed at both the filter and inverter ends with large-area contact surfaces, preferably with metal cable glands. The connection between the 620 drive module and the motor must be installed away from all other cables or wires. Ideally the filter will be mounted onto the same metallic panel as the drive. The RF connection between the inverter, filter and panel should be enhanced as follows:

- Remove any paint/insulation between the mounting points of the EMC filter, 620 drive module and panel.
- Liberally apply petroleum jelly over the mounting points and securing threads to prevent corrosion. Alternatively conducting paint could be used on mounting panels.
- If the proceeding is not possible, then the RF earth bond between the filter and 620 drive module is usefully improved by making an additional RF earth connection using wire braid of at least 10 mm^2 cross sectional area (due to skin effect).
- For wall mount application, ensure that the cable between the EMC filter and the 620 drive module cable is passed through conduit mounted between the filter and the Gland Box. This cable must be as short as possible and segregated from all other cables. The conduit must be electrically connected to the filter and drive module gland box.

NOTE: **M**etal surfaces such as eloxized or yellow chromed e.g. with cable mounting or 35 mm DIN rails, screws and bolts have a high RF impedance which can be very detrimental for EMC performance.

Care should be taken to ensure that the protective earth (PE) conductor exiting from the filter is connected to the protective earth connection of the 620 drive module. Any additional RF earth such as a cable screen **is not a protective earth**. The EMC filter must be **permanently earthed** to prevent the risk of electric shock under abnormal operating instances (such as the loss of one phase of the AC supply). Permanent earthing can be achieved by either:

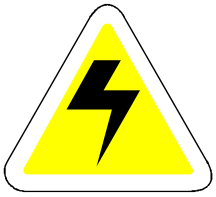
- Using a copper protective earth conductor of at least 10 mm^2 or
- Installing a second conductor in parallel connection with the protective conductor to a separate protective earth terminal.

Each conductor shall on its own meet the requirements for a protective earth conductor. On all recommended underfloor EMC filters two protective earth connections are provided for permanent earthing.

The recommended EMC filters are designed to operate from normal three-phases supplies which are balanced with respect to earth (earth referenced supplies). This minimises the earth leakage current due to the filter capacitors between phase and earth. On some specific customer sites the supply may not be balanced with respect to earth (non-earth referenced supplies). The earth leakage currents would increase and interfere with the operation of any earth-fault monitoring equipment. In addition the EMC performance of the filter will be degraded. Eurotherm Drives do not recommend the use of AC supply filters on non earth-referenced supplies.

As with all power electronic drives the conducted emissions increase with motor cable length. EMC conformance to the stringent limits is only guaranteed up to a cable length of 50 m (types 4 and 5) and 5m (types 6 and 7). This length can be increased. Refer to section entitled Motor Cable-length Limitations in this chapter.

If **one EMC filter** is to be used in an enclosure, then this filter should be mounted as close to the incoming AC supply to the enclosure as possible.



IMPORTANT WARNINGS !

The recommended EMC filters are designed to work with supplies which are balanced with respect to earth (i.e. earthed referenced supplies). On some specific customer sites the supply may not be balanced with respect to earth. The recommended standard EMC filters are not recommended be used on such supplies. Refer to Eurotherm Drives for more information.

The EMC filters contain capacitors phase-to-phase and phase-to-earth. Discharge resistors are fitted, but the filters, terminals and wiring must not be touched for a period of 5 minutes after the removal of the AC supply. **Not adhering to this warning can result in electric shock.**

The EMC filter must only be used with **a permanent earth** connection using one of the following alternatives:

a) Using a copper protective earth conductor of at least 10 mm^2 or

b) Installing a second conductor in parallel with the protective conductor to a separate protective earth terminal on the filter or inverter. The conductor on its own shall meet the requirements for a protective earth conductor.

Thermal performance of the EMC filter is only guaranteed up to a maximum equivalent cable length of 150 m.

Refer to the following section regarding safety considerations with earth-fault detection systems.

Interaction With Earth-fault Monitoring Systems and Safety Considerations

Due to the EMC filter internal capacitors between phase and earth, on initial connection of the AC supply a pulse of current will flow in the earth. This has been minimised in the recommended EMC filters, but may still trip out any RCD (Resident Current Detector) in the earth system. In addition high frequency and DC components of earth leakage currents will flow under normal operating conditions. Under certain fault conditions, larger DC protective earth currents may flow. The protective function of some RCDs cannot be guaranteed under such operating conditions. Eurotherm Drives do not recommend the use of RCDs, but where their use is mandatory, they should be capable of correct operation with DC and AC protective earth currents (such as type B RCDs as in amendment 2 of IEC755) and have adjustable trip amplitude and time characteristics, to prevent nuisance tripping on initial power connection. RCDs used with 620 drive modules and other similar equipment are **not suitable for personnel protection**. Another means of providing personal safety must be provided for, see prEN50178/VDE0160.

Minimising Radiated Emissions

All 620 drive modules can be made to comply with the most stringent radiated emission limits of EN55011 (1991) Class B by simply mounting inside an enclosure with 10 dB attenuation between 30 and 100 MHz (which would typically be the attenuation provided by a metal cabinet with no aperture greater than 0.15m) and screening any control and signal cabling outside of the enclosure. The control and signal cables should be terminated at the entrance to the enclosure. Outside of an enclosure (wall mount) all 620 drive modules will meet the Class A requirements with screening of the signal and control cables. Inside the enclosure the radiated magnetic and electric fields will be high, due to proximity, and any components fitted inside the enclosure must be sufficiently immune. Remember that the EN55011 radiated emission measurements are made between 30 MHz and 1 GHz in the far field, at a distance of between 10m and 30 m. No limits are specified lower than 30 MHz, or in close proximity. Emissions from individual components tend to be additive.

The cable between the enclosure and the motor must be screened or armoured and also contains the motor protective earth connection. The screen/armour must be earthed at both ends by connecting it to both the motor frame and the entrance to the cubicle (or gland box for wall mount), ideally in 360° termination's via cable glands (to meet the most stringent emission requirements). Screen to earth connections via 360° bonding is 75% more effective than earthing via pigtails (Note some motor gland boxes and conduit glands are made of plastic, if this is the case then braid must be connected between the screen and the chassis, in addition at the motor end ensure that the screen is electrically connected to the motor frame since some terminal boxes are insulated from the frame by gasket/paint). Often the screens are terminated on a power screen rail at the entrance to the enclosure using ‘u’ clips to achieve a near 360° screen band. The integrity of the screen must be maintained over the entire length of the cable between the enclosure and motor. If the cable is broken to insert terminals, contactors, chokes, fuses etc., then the screen must be connected over the shortest possible distance.

Note some hazardous area installations may preclude direct earthing at both ends of the screen, in this case earth the other end via a 1 µF, 50VAC capacitor. The motor protective earth should be connected to the drive module motor protective earth connection.

If a shielded cable is not available, lay unshielded motor cables in a metal conduit which will act as a shield. The conduit must be continuous with a direct electrical contact to the drive module and motor housing. If links are necessary, use braid with a minimum cross sectional area of 10 mm^2 .

Safety earthing always takes precedence over EMC earthing.

The use of screened cable without an EMC filter is not recommended, as line-conducted interference will increase substantially and the capacitive coupling of the output cable to earth will result in high earth-leakage currents.

To ensure the correct operation of the 620 drive module, some control and signal cables (encncoder, all analogue inputs and communications) have to be screened back to the inverter terminals. The screen integrity must be continuous right back to the drive if not connected to the cubicle. Always minimise the length of screen stripped back to make this connection. The screen should only be connected at the drive end. If high frequency noise is still a problem, earth at the non drive end via a 0.1 µF capacitor.

Screening and Earthing When Mounted in an Enclosure

Make sure the requirements of EN60204 are adhered to with electrical equipment for machines. Satisfactory EMC performance is only achievable when the 620 drive module, filter and associated equipment is mounted on a conducting metal mounting panel. Beware of constructions using insulating mounting panels or undefined mounting structures A single point earthing strategy should be followed for a single drive module mounted in an enclosure as shown in figure 3-11. The protective earth connection (PE) to the motor must run inside the screened cable between the motor and 620 drive module, where it is to be connected to the motor protective earth terminal on the drive module. (Note in accordance with EN60204 only one protective earth conductor is permitted at each earth terminal contacting point). Local wiring regulations may require the protective-earth connection of the motor to be connected locally but this will not cause shielding problems due to the relatively high RF impedance of the local earth connection.

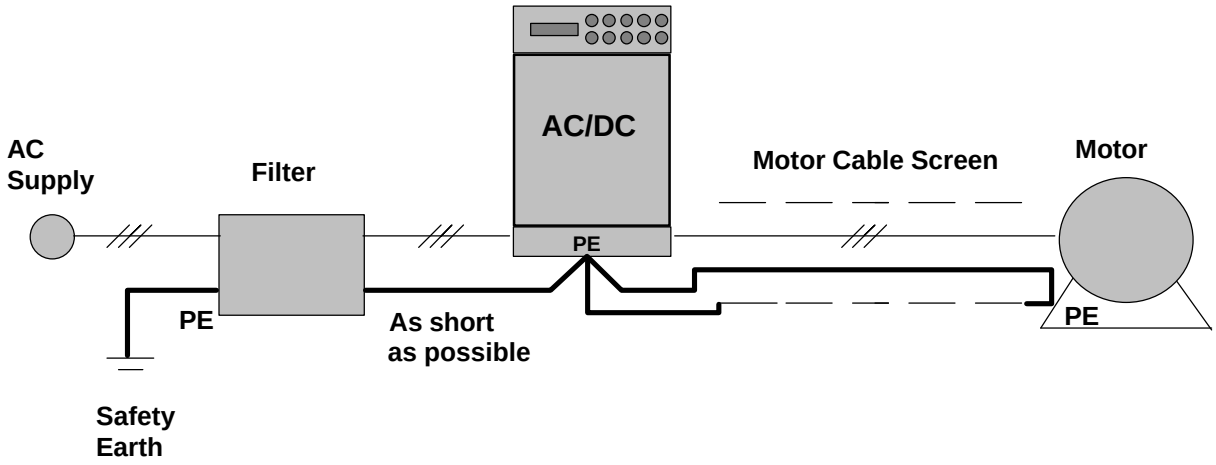


Fig. 3-11: Screening and earthing of a single 620 drive module.

When more than one piece of electrical equipment is fitted inside an enclosure, care must be taken to ensure that noise flowing in the earth connection does not couple into other equipment. A star-point earthing policy separating noisy from quiet earths is strongly recommended. Five separate earths branches should be provided for:

- Clean earth busbar — The Clean earth busbar is used as a reference point for all signal and control cabling. This may the further subdivided into an analogue and a digital reference busbar, each separately connected to the star earthing point. The digital reference is also used for any 24V control.

- Dirty earth busbar — The dirty earth busbar is used for all power earths (i.e. protective earth connections)
- Enclosure metalwork busbar — The enclosure metalwork busbar is used for all parts of the cubicle including panels, doors and back plate. It is also used as a reference for any 110 or 220V control used and for the control transformer screen.
- Power screen busbar — The power screen busbar is only for power screened cables which **do not** have to go directly to the 620 drive module (such as motor cables, braking choppers and their resistors) or to other drive modules (refer to appropriate Product Manual to identify these). Noise coupled onto the incoming screens must flow to earth directly so as not to contaminate the rest of the cubicle. Hence the power screen busbar should be placed as close to the point of cable entry as possible.
- Signal/control screen busbar — The signal/control screen busbar is to be used for signal/control screened cables which do not have to go directly to the 620 drive module. This busbar should also be placed as close as to the point of cable entry as possible.

For optimum EMC performance, copper rails with a substantial cross-section should be used for the busbar. Screened cables are best 'u' clamped to the busbars to ensure an optimum HF connection.

The five separate earth busbars should be insulated from the mounting panel and connected to a single earth point (star point) near the PE or PEN terminal of the main supply. Flexible large cross-section cable to ensure a low HF impedance should be used. The arrangement of the busbars should be such that the connection to the single earth point are as short as possible. Fig. 3-12 shows an implementation of a star-point earthing policy.

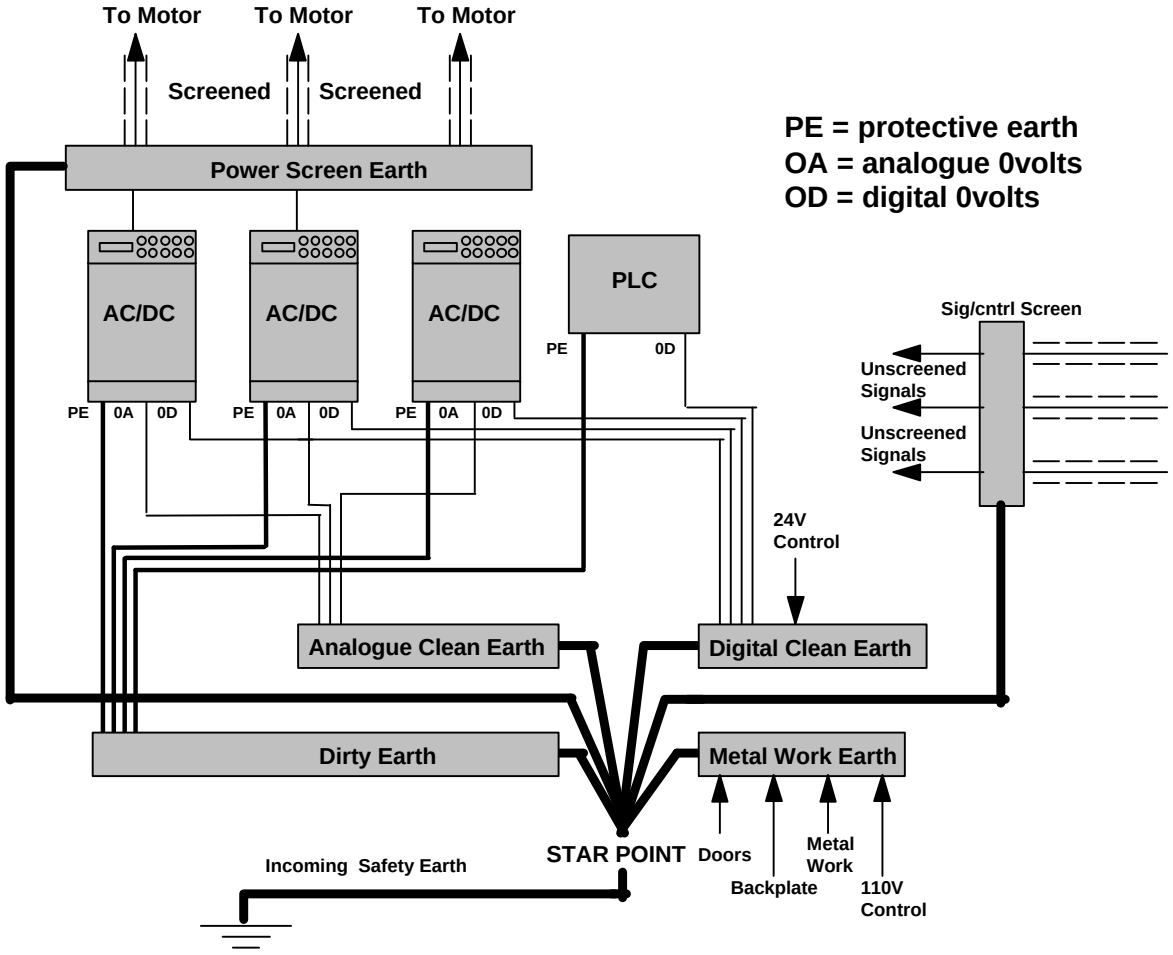


Fig. 3-12: Implementation of star-point earthing policy for multi-drive installation

Screening and Earthing When Wall Mounted

To provide for good EMC performance the recommended EMC filter must be fitted and the cables between the wall-mount 620 drive module and the motor screened or armoured. Also screening of control and signal cables may be required. Refer to the previous instructions on minimising radiated emission (page 3-22). In addition any connections to the DC link must also be screened/armoured, with the screen connected at both ends (e.g. to the protective earth of the dynamic brake resistor).

All 620 drive modules comply with the radiated emission limits of EN55011 (1991) Class A when wall mounted to these instructions, using the recommended EMC filter and screened motor control and signal cabling. Products which meet the limits of Class A can be made to meet the more stringent limits of Class B by mounting inside an enclosure with 10 dB attenuation between 30 and 100 MHz (which would typically be the attenuation provided by a metal cabinet with no aperture at a dimension greater than 0.15m) and screening any control and signal cabling outside of the cubicle. Minimise the length of unshielded cable inside the cubicle to prevent increased radiated emission.

A single-point earthing policy as shown in Fig. 3-11 is required.

The protective earth connection (PE) to the motor must run inside the screened cable between the motor and 620 drive module where it is to be connected to the protective earth terminal in the gland box or on the drive module (note, in accordance with EN60204 only one protective earth conductor is permitted at each earth terminal contacting point) . Local wiring regulations may require the protective-earth connection of the motor to be connected locally but this will not cause shielding problems due to relatively high RF impedance of the local earth connection.

The EMC filter must be permanently earthed in accordance with recommendations and warnings in the section "**EMC Filters to Reduce Line Conducted Noise"**, page 3-16.

Motor Cable-length Limitations

Screened/armoured cable has significant capacitance between the conductors and the screen which increases linearly with cable length. Typically this is 200 pF per metre but this will vary with cable type and current rating. Long cable lengths may have the following undesirable effects:

- Tripping on 'over current' as the cable capacitance is charged and discharged at the switching frequency,
- Producing increased conducted emissions which degrade the performance of the EMC filter due to saturation. EMC compliance is only guaranteed up to a maximum cable length of 50m (type 4 and 5) and 5m (type 6 and 7).
- Causes RCDs (Residential Current Detection) to trip out due to increased high frequency earth current.
- Produces increased heating inside the EMC AC supply filter from the increased conducted emissions. Eurotherm Drives only guarantee the thermal performance of the filters up to a specified cable length of 150m with screened cable.

These effects can be overcome by adding chokes at the output of the 620 drive module. In applications where multiple motors are connected to a single drive, minimise the length of screened/armoured cable connected to the drive by using a single length of cable to a star junction point, from where all the other motor cables are attached. Maintain the integrity of the shield. If the cable is interrupted to insert contactors or other components, the screen must be connected over the shortest possible route. Table A1 in the appendix gives information on the recommended output chokes for use with long cables, cables connected in parallel, or when EMC output filters are used with cables greater than that specified for EMC compliance.

Output filters can also be used to achieve EMC and filter thermal conformance with longer cable lengths than that specified. These output filters also ensure a long motor life by reducing the high dV/dt and over voltage stresses applied to the motor windings by inverters. These filters should be mounted as close to the 620 drive module as possible. Refer to Eurotherm Drives for the selection of suitable filters.

Other Layout Considerations

The proximity between the source and victim circuit has a large effect on radiated coupling. The electromagnetic fields produced by drive modules falls off rapidly with distance from the cabling/enclosure. It should be remembered that the radiated fields from EMC compliant drive systems are measured at least 10m from the equipment over the frequency band 30 to 1000 MHz (as required by EN55011, referenced by the

generics and the drive product specific standard). Any equipment placed closer to the drive system than this will see larger magnitude fields, particularly very close to the drive. No magnetic/electric field sensitive equipment should be placed within 0.25m of the following parts of a drive system:

- 620 Drive module
- EMC output filters
- Input or output chokes/transformers
- Cable between 620 Frequency Inverter and Motor (even when screened/armoured)
- Connections to external braking chopper and resistor (even when screened/armoured)
- AC/DC brushed motors (due to commutation)
- DC link connections (even when screened/armoured)
- Relays and contactors (even if they are suppressed)

Often the coupling between electrically 'noisy' and 'sensitive' cables is a problem. This can be minimised by separating parallel runs by at least 0.25m, and minimising the length of parallel runs. For long parallel runs (>10 m) the separation should be increased proportionally. For example if the parallel runs were 50 m then the separation would be $(50/10) \times 0.25$ m = 1.25 m.

In addition the coupling between two cables which must cross is minimised if they cross over at 90°. Hence sensitive cables should cross the cables to the motor, DC link and braking chopper circuit at 90°, and should never be run close to them or in parallel for any great length.

Never run supply, DC link or motor cables in the same bundle as the signal/control and feedback cables, even if they are screened.

From experience the following equipment is defined as particularly sensitive and care must be taken in the installation:

- Any transducers which produce low level analogue outputs (<1 volt) e.g. load cells, strain gauges, thermocouples, piezoelectric transducers, anometers, LVDT's
- A.M. radios (long and medium wave only)
- Video cameras and closed circuit TV
- Office personal computers
- Capacitive devices such as proximity sensors and level transducers
- Mains borne communication systems
- Equipment not suitable for operation in the intended EMC environment i.e. with insufficient immunity to new EMC standards