Installation Recommendations for Bardac AC Motor Controllers

Part Number 4216-046 Revision E

Copyright Bardac Corporation 2004
Except for the purpose of supporting products sold by Bardac Drives, reproduction of all or any part of these documents is strictly prohibited.

NOTE

This manual is intended to be a supplement to the *E-Series AC Flux Vector Drive Technical Manual - Part Number 4201-180* and the *Xtravert Series Technical Manual Part Number 4201-196*.

If after reading this manual you need further assistance, please contact Bardac Drives at:

410-604-3400

Bardac Corporation
40 Log Canoe Circle, Stevensville, MD 21666 USA
Phone: (410) 604-3400 Fax: (410) 604-3500
www.bardac.com

INSTALLATION RECOMMENDATIONS FOR PDL DRIVES

Contents

1.0 INSTALLING DRIVES FOR EMC COMPLIANCE

1.1 Introduction

To achieve maximum reliability and safety when installing one or more PDL motor speed controllers (drives), it is important to consider the following:

Installation site: Ambient temperature, available cooling, quality of environment, moisture and pollutants in air.

Power wiring for safety: Mains input protection, motor isolation, input and output cable sizes and types.

Power wiring for EMC compliance: Use of screened cables, earthing and shielding arrangements, cable separation.

Control wiring for EMC compliance: The use of screened control cables, earthing of 0V line, shielding against electric and magnetic fields.

This document outlines the requirements to achieve a safe and reliable installation. Failure to adhere to these recommendations may lead to unreliable operation and mutual interference with neighbouring equipment.

1.2 Installation for EMC Compliance

What is electromagnetic compatibility?

Electromagnetic compatibility, or **EMC**, is associated with any electronic equipment. It is a measure of the equipment's ability not to generate radio frequency interference (RFI) and also a measure of its immunity to RFI produced by other equipment.

In a variable speed drive system, the equipment includes the drive, the motor, mains and motor cabling, and also the control system and its connections. The high-speed switching of the power transistors used in a variable speed drive have the potential to generate significant levels of RFI, which can be radiated from the drive and motor cable, or conducted out by the mains or motor cables and via the motor frame. Thus to ensure EMC compliance, the system must be installed according to recommended practices. All PDL drives are fitted with RFI filters, but these may be ineffective in a defective installation.

Why is compliance necessary?

In many countries it is mandatory to comply with EMC standards. For Australia and New Zealand, the relevant standards are closely aligned to European IEC standards. For New Zealand, compliance is voluntary at present. Many New Zealand companies have adopted the standard as an on-site engineering standard. If a variable speed drive system is being constructed for export to a country where compliance is mandatory, it may be necessary to supply evidence of compliance.

It is always good technical and trade practice to install a complying system. The ability of equipment to operate without mutual interference leads to safe and reliable system operation.

2.0 INSTALLATION SITE REQUIREMENTS

2.1 Installation Site: Microdrive-3, Microvector-3, Microflo-3, Xtravert Ranges

The drive(s) must be sited in a suitable environment. As with all equipment, the cooler, cleaner and more vibration free the environment, the longer and more trouble free will be the life of the drive(s).

Installation Environment: These ranges of drives (UD3-2.5 to UD3-70, MV3-2.5 to MV3-70, MFi-2.5 to MF3-70, X302 to X716) are all designed for wall mounting, and all have ingress protection ratings of IP20. The mounting environment must be clean (pollution degree 2), free of electrically conductive (wet or dry) dust (eg. carbon fibre, salt, etc.) and free of spraying or dripping water.

Ambient Temperature: The ambient temperature must not be below 0^{O}C, and must not exceed the maximum temperature rating of the drive. For UD3, MV3, MF3 and Xtravert ranges, the maximum allowable ambient temperature is 50^{O}C.

Mounting of Drives: The drive(s) must be mounted vertically to ensure proper cooling. For UD3-2.5 to UD3-70, MV3-2.5 to MV3-70, MFi-2.5 to MF3-70 models, allow 100mm (minimum) between drives. For the Xtravert range, allow 55mm (minimum) between drives. As the drives draw cooling air from the bottom and exhaust it from the top, avoid mounting drives immediately above other drives or heat-producing items.

Cooling Load: The total cooling load imposed by a drive installation can be estimated by adding up the total ratings (kW) of all connected motors, and calculating 3% of this value. This is because the drives' efficiencies are specified at >97%. The air conditioning or cooling system used in a plant room must be able to handle this cooling load without allowing the ambient temperature to exceed 50^{O}C.

Mounting in Switchboard or Protective box:
In some applications it may be desirable to improve the ingress protection rating of the drive, particularly for non IP54 rated drives.

If mounting the drive(s) in a switchboard or protective box, be sure to allow for sufficient cooling. The enclosure interior air temperature must not exceed 50°C. Calculate the correct sized cabinet by using the procedure below.
Determine the worst case localised ambient temperature (T_{MAX}) surrounding the cabinet on the hottest day of the year. T_{MAX} should typically not exceed 30^{O}C to minimise the size of the cabinet.

Note the rated current (I_{RATED}) of the drive(s) in Amps

1. And hence determine the power losses (P_{LOSSES}) within the cabinet in Watts
   P_{LOSSES} [W] = (13W x I_{RATED}) + 20W per drive (fixed losses) + other equipment losses
2. And knowing this power loss value choose:

EITHER a fully enclosed cabinet with an exposed heat dissipating surface area (A) of:

Exposed heat dissipating surface area (m^2)	
Polyester construction	$A = \frac{P_{LOSSES}}{3.5 \times (50°C - T_{MAX})}$
Steel construction	$A = \frac{P_{LOSSES}}{5.5 \times (50°C - T_{MAX})}$

Always ignore the base of the cabinet and unless free standing, ignore the back of the cabinet. Where multiple cabinets are mounted side by side, discount common surfaces as heat dissipating surfaces. Ensure no other radiant or convection heat source is externally heating the cabinet.
If the drive is not fitted with a heatsink fan, (for example, small Xtraverts) an internal stirring fan will be required to prevent hotspots.

OR if the calculated cabinet size is too large, forced ventilation cooling will be required. Calculate the appropriate flow of air as…

Airflow (m^3/minute) = $\frac{P_{LOSSES}}{20 \times (50°C - T_{MAX})}$

Fit the inlet and outlet vents such that the airflow circulates around the complete cabinet.

A suitable convection or forced air system must be provided to ensure the inside air temperature does not exceed 50°C.

Mounting of Xtravert Display Unit:

The Xtravert Display Unit has a protection rating of IP54 (front and sides only) when mounted against a hard surface. It can be removed from the drive and mounted up to 3 metres away. This allows the display unit to be fitted to the front of a protective cabinet or switchboard. When remotely mounting the Display Unit, the protective screw caps must be fitted to maintain the IP54 rating.

2.2 Installation Site ME-2.5 to UE-660 Range

Environment: This range of drives (ME-2.2 to UE-140) is designed for wall mounting,(UE-170 to UE-660) are designed for floor mounting. The ME-2.2 to UE-140 have an ingress protection rating of IP54 - dust and splashing water protected. The UE-170 to UE-660 have IP54 for the electronics enclosure The IP54 rating can only be maintained if watertight glanding techniques are used, and the cover properly screwed down with the protective screw caps fitted. The cooler, cleaner and more vibration free the environment, the longer and more trouble free will be the life of the drive(s).

Ambient Temperature: The ambient temperature must not be below 0^{O}C, and must not exceed 50^{O}C. If the ambient temperature can be maintained at or below 40^{O}C, the drive's maximum continuous output current can be re-rated (increased):
UE-2.5 to UE-140 +25%
UE-170 to UE-660 +10%
For operation on centrifugal pumps or fan loads only. Note this re-rates to normal full load current in a linear manner below 25Hz .

Mounting of Drives: The ME-2.5 to ME-46 can be mounted in any orientation, on its back or side. For most effective cooling, vertical mounting on its back with bottom cable entry is recommended. The UE-60 to UE-660 must be mounted vertically. If installing a suite of drives, drives may be mounted adjacent to each other. The cooling air flow direction varies depending on the model.

ME-2.5 to ME-46 & UE-170 to UE-660 The cooling air flow enters the bottom of the drive and exits the top.

UE-60 to UE-140 The cooling air flow enters the top of the drive and exits the bottom.

Consideration must be given to the mounting of the drives to avoid one drive drawing in exhaust air from another or other heat-producing items and effectively causing it to be operating in a higher ambient temperature.

Cooling Load: The total cooling load imposed by a drive installation can be estimated by adding up the total ratings (kW) of all connected motors, and calculating 3% of this value. This is because the drives' efficiencies are specified at >97%. The air conditioning or cooling system used in a plant room must be able to handle this cooling load without allowing the ambient temperature to exceed 50^{O}C, or 40^{O}C if re-rating a drive for pump or fan operation.

Mounting of Elite Series Display Unit:

The Elite and Xtravert series Display Unit has a protection rating of IP54 (front and sides only) when mounted against a hard surface. It can be removed from the drive and mounted up to 3 metres away. This allows the display unit to be fitted to the front of a protective cabinet or switchboard. When remotely mounting the Display Unit, the protective screw caps must be fitted to maintain the IP54 rating.

2.3 Installation Site UDi/MFi/MVi-90 to UDi/MFi/MVi-660 Range

Environment: This range of drives is designed for floor mounting, with bracing to a wall required to meet seismic loading requirements. The cabinets are designed to inhibit the entry of dust and splashing water. The cooler, cleaner, drier and more vibration free the environment, the longer and more trouble free will be the life of the drive(s).

Ambient Temperature: The ambient temperature must not be below 0^{O}C, and must not exceed 50^{O}C.

Mounting of Drives: The mounting environment must be clean (pollution degree 2), free of electrically conductive (wet or dry) dust (eg. carbon fibre, salt, etc.) and free of spraying or dripping water. If the floor on which the drives are to stand is likely to be wet, mounting on higher feet is recommended to reduce the chance of moisture ingress to input terminals and line reactors.

"Through-wall" mounting of these drives is possible - this allows the main heatsink cooling airflow to circulate outside the switchboard or switchroom. This reduces the cooling load on the switchroom to about 10% of that calculated below.

Cooling Load: The total cooling load imposed by a drive installation can be estimated by adding up the total ratings (kW) of all connected motors, and calculating 3% of this value. This is because the drives' efficiencies are specified at >97%. The air conditioning or cooling system used in a plant room must be able to handle this cooling load without allowing the ambient temperature to exceed 50^{O}C.

3.0 POWER WIRING

3.1 Incoming Mains Wiring

Use of earthed neutral supply:

All PDL three phase drives are designed to be supplied from a Star (YN) or ZigZag (ZN) connected transformer secondary and the Protective Earth (PE) bonded to the neutral point of this transformer (ie.., three phase, three wire, earthed neutral supply). This is also known as a Multiple Earth Neutral (M.E.N.) system in some countries.

If it is required to connect a drive to an Isolated Neutral supply system, please consult PDL Electronics for application guidance.

Cable sizes and routing:

Cable sizes must be chosen for the expected loading and to minimise voltage drops. For long cable runs (input or output) larger cables may be required to minimise voltage drops. Refer to Tables 1,2,3 & 4 for a list of the maximum cable sizes accommodated by each drive.

Incoming mains cables do not generally require shielding. When wiring directly to the drive cabinet, connect the earth conductor the drive's incoming earth terminal or stud provided. To reduce the chances of interference coupling between cables, attempt to separate input cables from control cables or output cables - maintain 300mm looming clearance where possible.

Mains input protection:

For the, UDi, MFi and MVi ranges, input fuse protection is supplied within the drives. These fuses are high speed semiconductor types, and must not be substituted. Any upstream input fuses or circuit breaker will be for cable protection only.

For the MF3, UD3, MV3, ME, ,Xtravert and UE range to 140 amp input fuse protection is not supplied within the drive, and must be supplied by the installer. The respective user manuals provide tables of recommended fuse types and sizes. These tables are summarised in Tables 1,2,3,and 4.

The recommended type gG low voltage AC distribution fuse or preferable type gG/UR semiconductor. Ratings are chosen to ensure that the peak energy let-through (I^2t) rating of the fuse set is less than that of the rectifier devices. This ensures that in the event of a shorted rectifier output, the fuses will blow in preference to the rectifier devices. Moulded case circuit breakers (MCCBs) cannot provide a guaranteed maximum I^2t rating and in the event of a shorted rectifier output may cause rectifier and PCB track destruction.

3.2 Motor Power Wiring

Motor cable type:

To ensure EMC compliance, screened cables must be used to the motor. Suitable cables are:
3-core plus neutral screen (NS).
3-core steel wire armoured (SWA) with external earth conductor.

The objective of the screen is to suppress the electric and magnetic fields generated in the cables, which have high frequency components and can cause radio frequency interference (RFI). A screen also represents lower impedance to high frequency levels than a solid circular conductor due to skin effect.

For NS cable, the screen may double as safety earth.
For SWA cable, use an external conductor as safety earth.

To minimise the transfer impedance of the cable screen to high frequencies, ideally balanced screened cables should be used eg. 3 core trefoil arrangement plus screen. This ensures that the full potential of the earthing system is realised, and any EMI (electromagnetic interference) coupled through the motor frame is routed correctly to the drive PE via the motor cable, and not through alternative paths within the installation.

If screened cable cannot be acquired (eg. too large) then run separate conductors in a galvanised steel cable duct or conduit. The duct or conduit should be electrically bonded at every join. It should be earthed at least at both ends, and at any other convenient location. If possible lay the phase conductors in trefoil - this helps with mutual cancellation of the fields.

Motor cable size:

Maximum cable sizes accommodated by each drive are listed in Tables 1, 2 3 & 4. If the motor is located a significant distance from the drive (greater than 20 metres) use the largest cable size possible to reduce resistive and capacitive effects along the cable.

Screen Connection:

Earth the screen at both ends. It is best to terminate the screen in proper metal glands in the drive gland plate and motor frame. To ensure a good electrical connection the screen may be tailed off to the power earth terminal in the drive, however it is not recommended to 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. Any area enclosed between the output cable conductors and its screen will have high frequency electric fields and will be a source of interference.

Motor isolator:

It is usually a safety requirement that a motor isolator be fitted between drive and motor. Ensure integrity of cable screen by terminating in metal glands into and out of isolator enclosure. This includes the enclosure as part of the screen.

Note that any isolator on a flux vector controlled drive (PDL Microvector or PDL Elite series in vector modes) must be used off-load or must have a 700Vdc rating. 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 used on load.

Refer to Figure 5 for the preferred method of wiring in a motor isolator**.**

Measures to Eliminate EDM

Electrical Discharge Machining (EDM) of motor shaft bearings due to electrostatic discharge, is a recently observed phenomenon affecting some inverter drive applications. Generally damaging EDM seems to effect 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.

In inverter drive applications, EDM is generally a function of electrostatically coupled rotor shaft voltage build up, discharging through the bearing to the motor frame. Voltage is capacitively coupled to the rotor as a function of the inverter's common mode output voltage, dv/dt and the motor stray capacitance. Current can also circulate within the motor, through the conductive path created by the motor frame, bearings and rotor.

PDL Electronics recommends the following measures be taken to alleviate the possible effects of motor bearing current discharge…

EITHER

(i) Fit PDL MVO (Motor Voltage Optimiser) output filter, to the output of the drive in accordance with PDL MVO Technical manual 4201-229 and Specification sheet 4203-027

OR

(ii) Install 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. If an insulated bearing or housing cannot be fitted, a second shaft grounding system should be considered. For further information consult PDL Electronics.

Page 7

Power Wiring Details: Specific PDL Drives

3.3.1 UD3/MF3/MV3 Series

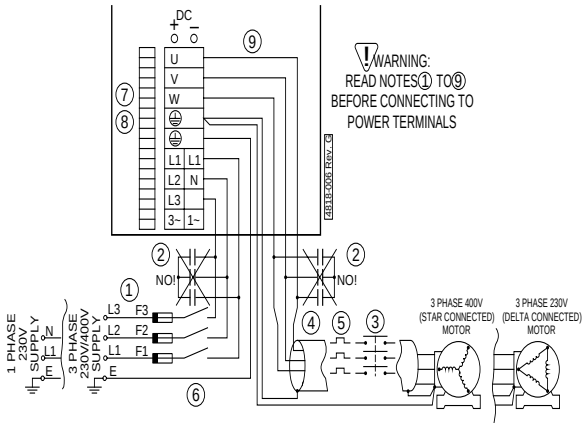

Figure 1: UD3/MF3/MV3 Series Power Wiring Diagram

1. Refer to Table 1 for fuse ratings and recommended cable sizes.
2. Power factor capacitors are not required on the drive input (UD3 displacement factor ≥ 0.95) and must not be connected to the drive output.
3. A motor isolator or contactor may be fitted to the drive output. It should be operated off-load only.
   In the Microvector (MV3) drive, never attempt to operate this switch under load. The MV3 is a current source and opening the circuit while running could cause extensive damage or fire to the switchgear.
4. Always use screened cable on the drive output. Bond the screen solidly to the drive and motor chassis. The output cables should be run separately from input and control cables.
5. The drive protects the motor with an electronic overload, so an external overload sensing device is not necessary. For UD3/MF3 drives, it is possible to run multiple motors from the one drive, but separate overload protection should be applied to each motor.
6. The drive output switching voltage waveform can give rise to high (capacitive) earth leakage currents. Permanent earth connection of both the motor and the drive is essential before connection to the supply

.

MODEL	INPUT VOLTS (V)	INPUT CURRENT (A)	OUTPUT CURRENT (A) (cont)	RECOMMENDED INPUT FUSE (A)	NOMINAL MOTOR SIZE (kW)	MAX CABLE SIZE (mm^2)
UD3/MV3/MF3 2.5	400 3~	2.5	2.5	6	0.75	4.0
UD3/MV3/MF3-6.5	400 3~	6.5	6.5	10	2.2	4.0
UD3/MV3/MF3-10.5	400 3~	10.5	10.5	16	4	4.0
UD3/MV3/MF3-12	400 3~	12.0	12	20	5.5	4.0
UD3/MV3/MF3-16	400 3~	16.0	16	20	7.5	4.0
UD3/MV3/MF3-22.5	400 3~	22.5	22.5	32	11	6.0
UD3/MV3/MF3-31	400 3~	31.0	31	40	15	16.0
UD3/MV3/MF3-46	400 3~	46.0	46	63	22	16.0
UD3/MV3/MF3-60	400 3~	60.0	60	80	30	35.0
UD3/MV3/MF3-70	400 3~	70.0	70	80	37	35.0
Nominal motor size applies to 4-pole motors only						

Table 1

3.3.2 UDi/MFi/MVi Series

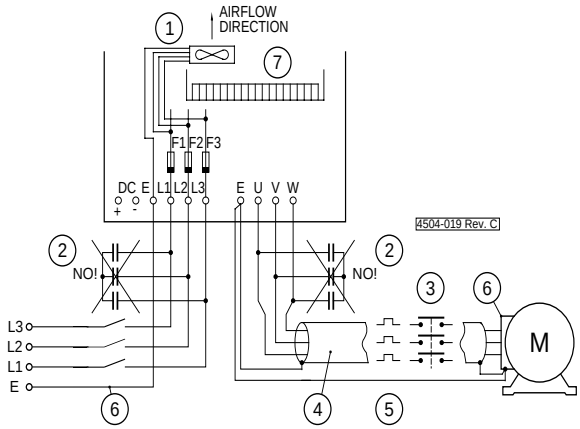

Figure 2: UDi/MFi/MVi Power Wiring Diagram

Refer to Figure 2 above.

1. The drive heatsink fan is powered from the three phase input mains supply. The direction of rotation of this fan is phase sequence sensitive. Ensure that the fan exhausts to the top of the drive. If not so, swap the order of two of the input supply fuses.
2. Power factor capacitors are not required on the drive input (drive displacement factor ≥ 0.95) and must not be connected to the drive output.
3. A motor isolator or contactor may be fitted to the drive output. It should be operated off-load only.
   In the Microvector (MVi) drive, never attempt to operate this switch under load. The MVi is a current source and opening the circuit while running could cause extensive damage or fire to the switchgear.
4. Always use screened cable on the drive output. Bond the screen solidly to the drive and motor chassis. The output cables should be run separately from input and control cables. Maximum output cable sizes are listed in Figure 1.
5. The drive protects the motor with an electronic overload, so an external overload sensing device is not necessary. For UDi/MFi drives, it is possible to run multiple motors from the one drive, but separate overload protection should be applied to each motor.
6. The drive output switching voltage waveform can give rise to high (capacitive) earth leakage currents. Permanent earth connection of both the motor and the drive is essential before connection to the supply.

MODEL	INPUT VOLTS (V)	INPUT CURRENT (A)	OUTPUT CURRENT (A) (cont)	RECOMMENDED INPUT FUSE (A)	NOMINAL MOTOR SIZE (kW)	MAX CABLE SIZE(mm^2)
UDi/MVi/MFi-90	400 3~	90	90	Internal	51	120
UDi/MVi/MFi-110	400 3~	110	110	Internal	59	120
UDi/MVi/MFi-140	400 3~	140	140	Internal	80	120
UDi/MVi/MFi-170	400 3~	170	170	Internal	90	300
UDi/MVi/MFi-205	400 3~	205	205	Internal	170	300
UDi/MVi/MFi-250	400 3~	250	250	Internal	140	300
UDi/MVi/MFi-300	400 3~	300	300	Internal	170	400
UDi/MVi/MFi-340	400 3~	340	340	Internal	200	400
UDi/MVi/MFi-480	400 3~	480	480	Internal	280	400
UDi/MVi/MFi-660	400 3~	660	660	Internal	400	400
UDi-830P	400 3~	830	830	Internal	485	-
UDi-1140P	400 3~	1140	1140	Internal	693	-
Nominal motor size applies to 4-pole motors only						

Table 2

3.3.3 Xtravert Series

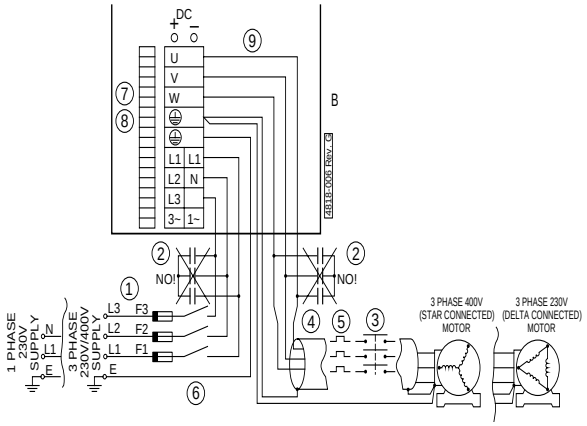

Figure 3: Xtravert Power Wiring Details

Refer to Figure 3 above.

1. Refer to table below for required fuse ratings and cable sizes.
2. Power factor capacitors are not required on the Xtravert input (Xtravert displacement factor = 0.99) and must not be connected to the Xtravert output.
3. A motor isolator or contactor may be used on the Xtravert output, but its use should be restricted to emergencies.
4. To reduce radio frequency interference (RFI), screened cable must be used on the Xtravert output. The output cables should be run separately from input and control cables.
5. The drive protects the motor with an electronic overload, so an external overload sensing device is not necessary. It is possible to run multiple motors from the one drive, but separate overload protection should be applied to each motor. The Xtravert or the motor must be isolated before operating on the motor terminals.
6. The drive output switching voltage waveform can give rise to high (capacitive) earth leakage currents. Permanent earth connection of both the motor and the drive is essential before connection to the supply.

MODEL	INPUT VOLTS (V)	INPUT CURRENT (A)	OUTPUT CURRENT (A) (cont)	RECOMMENDED INPUT FUSE (A)	NOMINAL MOTOR SIZE (kW)	MAX CABLE SIZE (mm^2)
X302	230 1~	8	2.5	15	0.37	4.0
X304	230 1~	12	4	20	0.75	4.0
X307	230 1~	20	7	35	1.5	4.0
X309	230 1~	22	9	35	2.2	4.0
X502	230 3~	4	2.5	10	0.37	4.0
X504	230 3~	7	4	15	0.75	4.0
X507	230 3~	12	7	20	1.5	4.0
X509	230 3~	9	9	15	2.2	4.0
X512	230 3~	12	12	20	3	4.0
X516	230 3~	16	16	32	4	4.0
X702	400 3~	4	2.5	10	0.75	4.0
X704	400 3~	7	4	15	1.5	4.0
X707	400 3~	12	7	20	3	4.0
X709	400 3~	9	9	15	4	4.0
X712	400 3~	12	12	20	5.5	4.0
X716	400 3~	16	16	32	7.5	4.0
Nominal motor size applies to 4-pole motors only						

Table 3

3.3.4 Elite Series

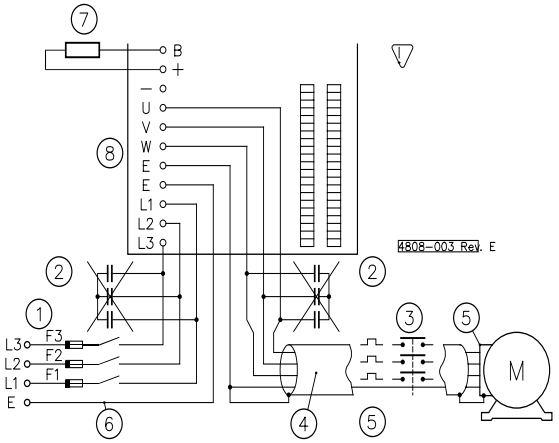

Figure 4: Microdrive Elite Power Wiring up to and including 22.5 Amp

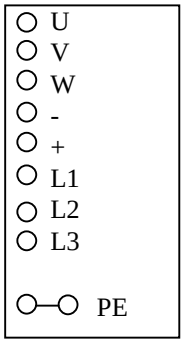

Figure 4a Microdrive Elite Power Terminals 31, 38 & 46 Amp

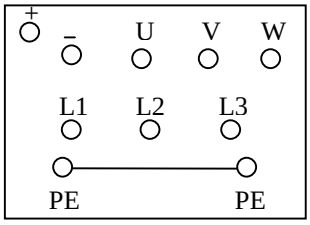

Figure 4b Ultradrive Elite Power Terminals 60 to 140 Amp

Refer to Figure 4, 4a and 4b above.

1. The Elite Series is designed for operation from a three phase earthed neutral supply. The Elite Series' input supply and its cooling fans are not phase sequence sensitive. Input fuses are required - refer to Figure 1 for details.
2. Power factor capacitors are not required on the drive input (drive displacement factor ≥ 0.95) and must not be connected to the drive output.
3. A motor isolator or contactor may be fitted to the drive output. It should be operated off-load only. When using the Elite series in open-loop or closed-loop vector mode, never attempt to operate this switch under load. In either vector control mode, the drive is a current source and opening the circuit while running could cause extensive damage or fire to the switchgear.
4. The Elite Series is fitted with radio frequency interference (RFI) filtering (input and output filters) as standard. To maximise the effectiveness of these filters, screened cable must be used on the drive's output. Bond the screen solidly to the drive and motor chassis. Failure to use screened cable will compromise EMC compliance, and may lead to disruption of other electronic equipment. The output cables should be run separately from input and control cables.
5. The drive protects the motor with an electronic overload, so an external overload sensing device is not necessary. When running the Elite Series in V/Hz mode, it is possible to run multiple motors from the one drive, but separate overload protection should be applied to each motor.
6. The drive output switching voltage waveform can give rise to high (capacitive) earth leakage currents. Permanent earth connection of both the motor and the drive is essential before connection to the supply.
7. For applications where regeneration is likely to occur, a dynamic brake resistor may be required. The resistor must be positioned where the expected heat generated by it will not damage or ignite its surroundings. Models above 22.5 amp require an external dynamic brake unit.
8. The location and order of the power terminals varies from model to model. Refer to the terminal labels before connecting.

Fusing Notes

1 Input fuses must be of type gG(distribution) or gR/UR(semiconductor) for ME-2.5 to ME-22.5

2 Input fuses must be of type gR/UR (semiconductor) for ME-31 to ME-46

3 Input fuses with UL recognition type gG/UR (semiconductor) are supplied pre fitted for UE-170 to UE-660

4 If UL/cUL is to be complied with UL/cUL recognised fuses must be used

5 Fuses must be selected to protect circuits with a maximum 200kA symmetrical short circuit supply

MODEL	INPUT VOLTS (V)	INPUT CURRENT (A)	OUTPUT CURRENT (A) (cont) 50°C/40°C	RECOMMENDED INPUT FUSE (A)	NOMINAL MOTOR SIZE (kW) 50°C/40°C	MAX CABLE SIZE (mm^2)
ME-2.5	400 3~	2.5 / 3.1	2.5 / 3.1	6	0.75 / 1.1	6.0
ME-6.5	400 3~	6.5 / 8.1	6.5/8.1	16	2.2 / 3.0	6.0
ME10.5	400 3~	10.5 / 13.1	10.5/13.1	25	4 / 5.5	6.0
ME-12	400 3~	12 / 16	12/16	32	5.5 / 7.5	6.0
ME-16	400 3~	16 / 20	16/20	40	7.5 / 9	6.0
ME-22.5	400 3~	22.5 / 28	22.5/28	50	11 / 15	6.0
ME-31	400 3~	31 / 39	31/39	80	15 / 22	25.0
ME-38	400 3~	38 / 47	38/47	100	18.5 / 22-	25.0
ME-46	400 3~	46 / 57	46/57	100	22 / 30	25.0
UE-60	400 3~	60/75	60/75	150	30/37	120
UE-75	400 3~	75/95	75/95	200	37/45	120
UE-90	400 3~	90/115	90/115	200	45/55	120
UE-115	400 3~	115/145	115/145	300	55/75	120
UE-140	400 3~	140/175	140/175	300	75/90	120
UE-170	400 3	170/175	170/187	350 note 3	90	Application Dependant
UE-210	400 3	210/231	210/231	350 note 3	110	Application Dependant
UE-250	400 3	250/275	250/275	2 x 250 note 3	132	Application Dependant
UE-305	400 3	305/335	305/335	2 x 250 note 3	160	Application Dependant
UE-340	400 3	340/374	340/374	2 x 250 note 3	160	Application Dependant
UE-420	400 3	420/462	420/462	2 x 250 note 3	225	Application Dependant
UE-480	400 3	480/528	480/528	2 x 250 note 3	250	Application Dependant
UE-575	400 3	575/632	575/632	3 x 250 note 3	315	Application Dependant
UE-660	400 3	660/726	660/726	3 x 250 note 3	355	Application Dependant
Nominal motor size applies to 4-pole motors only *Re-ratings for Elites series apply for centrifugal pump & fan loads not exceeding 40°C ambient*						

Table4

3.4 Power Wiring to Multiple Drives in a Motor Control Centre (MCC)

Refer to Figure 5 for a summary of recommended power wiring techniques when doing a multi-drive installation, where the drives are mounted in a MCC.

Input wiring:

For UD3, MF3, MV3, Xtravert and Elite range of drives, input fuses are required. For UDi, MFi and MVi range of drives, input fuses are not required. An input isolator is recommended. Earth each drive's input earth terminal separately back to cubicle earth busbar - do not loop earths between drives.

Motor wiring:

Run motor wires directly from the output terminals of each drive to respective motor. Always run motor earth and cable screen back to earth terminal of respective drive - not to cubicle earth busbar.

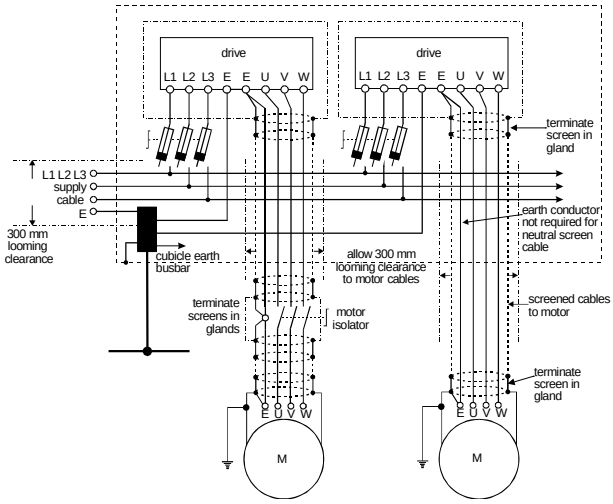

Figure 5: Power Wiring for Multiple Drives in MCC

4.0 CONTROL CABLES

4.1 Screening of Control Wiring

Use of screened control wiring is essential to reduce noise pickup into control circuits. Most noise is induced by the control cable running through rapidly changing electric fields. Preferably the screen is copper braid. Copper foil with drain wire is also acceptable. The cable also requires an overall sheath of appropriate insulation rating. Conductors should be twisted inside sheath, to improve immunity to magnetic fields.

The screen should be earthed at one end only. This prevents earth loops which induce hum, and prevents fault currents from flowing in the screen. Preferably earth at the end nearest the main earth (usually the drive end).

Do not use the screen as a return conductor.

If magnetic fields are a problem, separate magnetic screening of the control cable may be required. This is usually magnetic material (plated or galvanised steel) earthed at both ends and at other convenient points. Options are:
Use special cable with outer magnetic screen (eg. Belden "Blue Hose").
Run control cable in galvanised steel cable duct or steel conduit. Ensure electrical bonding at every join.

4.2 Earthing of the "0V" Point

For safety and noise suppression reasons the "0V" point should be earthed, but **at one point only**. PDL drives provide the ability to "float" the "0V" point above ground by removal of a link. This point is already decoupled to earth via a suitably rated capacitor, so the point remains effectively grounded for RFI frequencies. This earth link should be removed if:

- The "0V" point is earthed elsewhere, eg. in the external control system.
- Multiple drives are connected to the one control system. In this case, earth the "0V" at the control system or in one drive only.
- The control system has another point earthed. For example, if a number of drives are operating with their reference inputs connected in series from the same 4-20mA control source, then appropriate links should be removed to avoid shorting out the reference inputs.

Analogue outputs from PDL drives are referenced to the drive 0V. If this "0V" point is allowed to float, the analogue outputs will also float which may adversely affect operation. This may require signal isolation to be fitted.

4.3 Relay Outputs

Relay outputs have the potential to cause interference in the control cable, depending on the load connected. If the load is other than an electronic load (eg. PLC input), the wires should be run in cable(s) separate to other control I/O. Relay loads should have suitable suppression fitted to reduce switching transients.

4.4 Control Connections for Specific Models

4.4.1 UD and MF Models

The 24-way control terminal strip is mounted across the bottom of the Microdrive or Microflo control electronics PCB. Pass the control wiring through the power cable termination chamber, into the power electronics enclosure. Loom control wiring and power wiring separately.

The control wiring terminal strip is constructed of cage clamp terminals. Care must be taken to avoid stripping their threads or damaging the cage assembly by excessive tightening.

Recommendations for control terminal wiring connections:
Recommended tightening torque: 0.5Nm
Maximum tightening torque: 1.0Nm
Maximum wire size: 1.1mm^2 appliance wire
Max number of cables per terminal: 2

4.4.2 MV Models

For Microvector models, control wiring is similar to that required by the Microdrive/Microflo models above, with the addition of a further 12-way (or 9-way in earlier models) terminal strip on the Microvector Interface PCB, above and to the right of the main control terminals. The Microvector interface PCB terminates the shaft encoder wiring. The shaft encoder signals are high frequency fast rise-time signals, and must be run in their own screened cable to minimise the chance of noise pickup.

The Microvector Interface PCB is designed to terminate differential type encoders (ie. with 4 channels), although the addition of pull-down resistors on each unused encoder input enables the use of single-ended encoders if required. Refer to PDL Document No 4216-037 “Interfacing Shaft Encoders to the PDL Microvector Range” for details.

4.4.3 Xtravert Models

In Xtravert models, control wiring terminations are accessible by removal of the wiring cover. A total of 18 terminals are provided, in groups of two-part plug-in terminals. The control wiring is terminated in the removable female part, which plugs into the fixed male part. This enables disconnection of the wiring without unscrewing the terminals.

Recommendations for control terminal wiring connections:
Recommended tightening torque: 0.5Nm
Maximum tightening torque: 1.0Nm
Maximum wire size: 1.5mm^2 appliance wire
Max number of cables per terminal: 2

4.4.4 Elite Series Models

Access to control terminals is by removal of the enclosure front cover in ME-46 and below In the UE-60 and above, access is via cubicle door. Bring the control wiring into the enclosure through the gland plate, and install glands to maintain IP54 integrity. Loom control wiring and power wiring separately.

Recommendations for control terminal wiring connections:
Recommended tightening torque: 0.5Nm
Maximum tightening torque: 1.0Nm
Maximum wire size: 1.5mm^2 appliance wire
Max number of cables per terminal: 2
Cable stripping length: 7mm

4.5 Routing of Power and Control Cables

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

Control and power wires should be separated (at least 300mm). Where control and power cables cross, the ideal angle is 90^O.

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

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.

APPENDIX 1: CAUSES OF RFI IN DRIVES

What causes RFI in a drive?

The inverter stage in most modern drives uses IGBT power switching devices. A block diagram of a typical AC drive is shown in Figure 6.

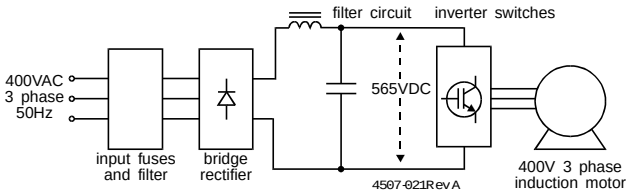

Figure 6: Block Diagram of AC Motor Controller

The output voltage and frequency are controlled by using **pulse width modulation (PWM)** techniques at a high switching frequency (4 kHz and higher). A simplified version of this waveform is shown in Figure 7.

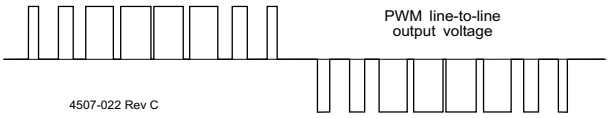

Figure 7: Drive Output Voltage Waveform

Fourier analysis shows the output voltage waveform consists of a fundamental frequency and a spectrum of harmonics, which will be at multiples of the switching frequency. The higher frequency harmonics - say greater than 100 kHz - can escape from the drive, couple into power and control cables, and cause interference and operational problems with other equipment.

How does RFI escape from a drive?

There are three ways in which RFI can escape from a drive and interfere with its “victim”. These are shown in Figure 8. The RFI may be **radiated** from the drive. The RFI escapes as electromagnetic radiation. There need be no physical medium between the drive and the victim as radiation can occur through a vacuum. Radiated RFI is comparatively simple to suppress by cabinet screening techniques. The field strength of radiated RFI rapidly diminishes with increasing distance from the drive.

The RFI can also be **conducted** from the drive. This conduction can occur through **output power cables** to the motor, and through **incoming mains cables** to the drive. The RFI conducted into these cables can subsequently radiate into adjacent cables if adequate suppression measures are not taken. The output cables have a voltage waveform as shown in Figure 7. The RFI due to this waveform is difficult to prevent from entering the output cables, so these cables must be screened. The RFI on input cables is mainly generated by the inverter switches, and is conducted back along the DC bus , through the rectifier to the input cables. This RFI is usually suppressed within the drive by the use of inductors and capacitors.

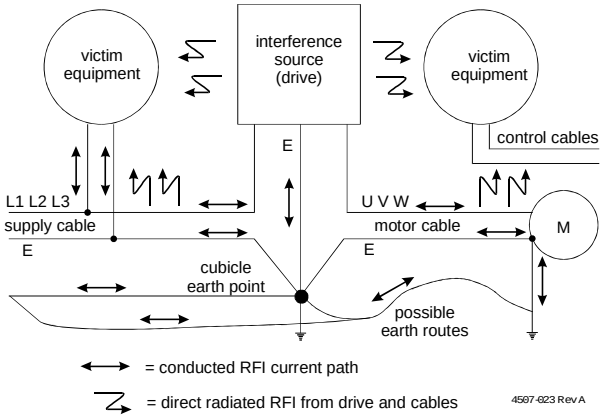

Figure 7: Sources of RFI in AC Drive Installation

How can RFI be suppressed?

RFI emission from a drive can be minimised by paying particular attention to the following points:

- **Drive design.** If the drive has been supplied with input filters, then the conducted RFI through incoming mains cables should be adequately suppressed. All PDL drives have an RFI suppression scheme already fitted. The cabinet of the drive is effectively made into a screen by proper bonding techniques between panels. However defective installation techniques can negate the effect of these measures.
- **Earthing.** Effective earthing must be undertaken. Safety earthing is necessary to safely handle the fault currents in the event of an earth fault. However RFI suppression earthing requirements are different. The currents carried by such an earth are at high frequencies, thus cabling and layout must be suitable for high frequencies.
- **Screening.** Screening helps to suppress radiated RFI. Screening of the output cable to the motor is necessary to ensure compliance of the system. Proper screening of control cables is also required to prevent locally and externally produced RFI from upsetting the drive’s control circuits.