GENERATION 6

ems European Ltd

EnviroStart™ Three Phase Soft Start Installation & Commissioning Guide

Version 2.10 June 2012

Three Phase EnviroStart™ Motor Soft Start

IMPORTANT WARNING

Failure to read and comply with this manual may result in damage to the EnviroStart Unit and driven equipment and may render the warranty invalid.

1. **Only a competent electrician should carry out the electrical installation.**
2. **EnviroStart must be earthed with an earthing conductor connected to the earthing terminal.**
3. **Before installation check the motor rating plate and Section Two of this manual to ensure that the EnviroStart is correctly rated for the application.**
4. **Internal components and areas of the control circuit boards, (except the isolated I/O terminals), can be at mains potential when the EnviroStart is connected to a three-phase supply. The voltage is extremely dangerous and may cause death or severe injury if you come into contact with it.**
5. **When the EnviroStart is connected to the mains, the motor connections U, V and W should be treated as being live even if the motor is not running.**
6. **The control I/O terminals are isolated from mains potential but the relay outputs may have dangerous voltages present even if the mains are not connected.**
7. **Do not make any connections when the EnviroStart is connected to live mains.**
8. **Do not make voltage withstand tests on any part of the EnviroStart without isolating the unit.**
9. **Do not touch IC-circuits on the PCB. Certain items are static-sensitive and static voltage discharge may destroy the components.**
10. **Make sure no power-factor correction capacitors are connected to the motor cable except in a safe manner. (See body text of this document for details).**
11. **Make sure the cover is closed before applying mains voltage to the EnviroStart.**
12. **Updated and current Installation and Commissioning Guides are maintained on the EMS (European) web site at http://www.EnviroStart.com; always check the web site for latest issue documents before commencing installation.**
13. **The chipset used in the Generation 6 series are NOT compatible with previous generation PCB's though previous chip sets from Generation 5 systems, (TPSS Series), will operate in the Generation 6 PCB's. The interchange of chipsets between TPSS and TPSSG6 PCB's is not recommended and should only be undertaken when no other options are available. (If such a transposition is done then switch settings 1.1 through 2.8 equate to switches 1 through 16 per TPSS Installation Guide).**

CONTENTS

1 INTRODUCTION

Thank you for choosing the EnviroStart Soft Start. The system has been designed with ease of use and set up in mind. The majority of applications will operate effectively without the need to make any changes to the default settings however should such changes be necessary please do read through this Installation and Commissioning Guide so as to better understand the effects of the changes you are making, be aware of the fact that changing things like start up pedestal voltage can impact the time it takes for a motor to get to full speed as such controllable features are inter-related.

EnviroStart has also been designed to provide a long life; components have been selected with reliability in mind and have generally been over-rated for the power of the unit manufactured. Using the standard IQA, (Institute of Quality Assurance), methodologies the expected lifetime of EnviroStart is rated at 100,000 hours continuous use, (eleven and a half years),

In the unlikely event that you do need further support please contact your local EMS (European) Distributor or failing that contact us directly either by e-mail or fax. All details of how to contact us are available on our web site at http://www.EnviroStart.com, please remember that we are constantly updating documentation and information about EnviroStart, all such information is posted and publicly available on the web site.

1.1 FEATURES

The **EnviroStart** is a high specification digital Soft-Start, available in models suitable for motors up to 1,400A. (Units up to 2,200A available to special order)

- CONFIGURABLE SOFT START (Ramp times from 0.5s – 240s)
- CONFIGURABLE INITIAL PEDESTAL VOLTAGE SETTING (25 – 70% of full voltage)
- CONFIGURABLE SOFT STOP (Ramp times from 2s – 80s)
- START CURRENT LIMITING (1.5x – 8x FLC of motor)
- CONFIGURABLE KICK-START (Fully definable, Initial pedestal and time from 0.25s – 2s)
- SWITCHABLE DIRECT ON LINE START (DOL Start retains all run features)
- SWITCHABLE EMERGENCY RUN (DOL Start no retention of run features)
- START/STOP AND SOFT STOP COMMAND FUNCTIONS CONTROLLABLE WITH PNP, (SINK), OR NPN, (SOURCE), INPUT OR SIMPLE CLOSED CONTACT SWITCHING
- SWITCHABLE CONTINUOUS THYRISTOR FAULT DETECTION
- STALLED-ROTOR OR SLOWING-ROTOR PROTECTION (Slip speed-shift accommodated)
- AUTO LOCK OUT ON HEATSINK OVER TEMP (PCB or external reset, with PCB LED on units of 55kW – 800kW)
- READY, TOP OF RAMP AND RUN RELAYS. (2x N/O, 2x N/C 2kVA contacts on each)
- FULL SYSTEM STATUS LED's
- ON PCB SYSTEM CPU RESET BUTTON
- SIMPLE TO INSTALL AND COMMISSION
- RUGGED HOUSING, IP43, NEMA 1. (Can be fitted into cabinet to increase to IP 65)
- ON-BOARD CONFIGURABLE SUPPLY VOLTAGE AND FREQUENCY SETTINGS
- 208V, 220V, 400V, 480V, 575V AND 690V MODELS AVAILABLE.

2 RATING INFORMATION

2.1 CORRECT ENVIROSTART SELECTION

The **EnviroStart** must be rated according to the motor rated current (FLC).

However, on certain applications it may be necessary to oversize the unit to cope with the maximum operating parameters associated with particularly heavy-duty operations such as high repetitive on-load starts or elevated ambient operating conditions. (For this see de-rating details shown on relevant specification sheets).

Please note that these environmental factors (temperature, ventilation, altitude, ambient temperature & relative humidity) do affect sizing and failing to take proper notice of such conditions will invalidate any warranty associated with the system as supplied. Where the **EnviroStart** is expected to operate outside the normal specifications and you are uncertain as to the selection of a unit please contact EMS (European) or your local Distributor, we will always be happy to assist to ensure your application is correctly supported.

IMPORTANT NOTE

THE ENVIROSTART SOFT START CONTROL IS A SOPHISTICATED SOLID STATE MOTOR SOFT START WITH A RANGE OF INBUILT PROTECTION DEVICES AND MONITORING SYSTEMS IT IS HOWEVER NOT A REPLACEMENT FOR PROPERLY RATED CURRENT OVERLOADS AND FUSES WHICH SHOULD BE FITTED FOR MAXIMUM PROTECTION OF THE MOTOR.

2.2 VOLTAGE RATINGS AVAILABLE: 208V/480V, 220V/400V, 570V & 690V

The general ratings in this installation and commissioning guide are based on typical four-pole motor characteristics. The **EnviroStart** will however work effectively on two; six and eight pole motors provided they are synchronous in operation.

Ratings are based on the full motor rated current, (FLC). The cable and fuses have to be sized in accordance with the rated output of the unit applicable to the voltage selected on the PCB. Recommendations with regard to fuse and cable ratings are made within this guide, (section 4.13), however it is the responsibility of the installation engineer to ensure that all such fittings are properly rated and specified in accordance with local requirements and conditions.

2.3 CE DECLARATION OF CONFORMITY

CE

MANUFACTURERS DECLARATION OF CONFORMITY

This declaration covers all **EnviroStart** Soft Start units.

This product fulfils the following European Community Directives when applied as follows:

Low Voltage Directive

The above products fulfil the Low Voltage Directive 73/23/EEC, 89/336/EEC and 93/68/EEC amendment for industrial equipment; however, they must be installed to general good electrical engineering practices and regulations by a suitably qualified person with strict reference to the instructions in the product's Technical Manual.

EMC Directive

The above products are intended to be a component in a system or a machine. They must be mounted into an appropriate enclosure and system designed to fulfil the CE directives plus IEC and local industrial standards. Units must be installed by a suitably qualified person to comply with general good electrical engineering practices and regulations with strict reference to the instructions in the product's Technical Manual. To meet all EMC directives, the above products are available with an optional RFI Filter.

IEC-1000-4-2 Level 3; IEC-1000-4-3 Level 3; IEC-1000-4-4 Level 4; IEC-1000-4-5 Level 3; IEC-1000-4-12 Level 3.

The above is based on test results from an independent test laboratory (Steatite Group Ltd.) to test specification EN 50081-2, EN 50082-1 and EN 50082-2.

Harmonised Standards Applicable

BS EN 6094.4.4 (which calls on EN 56011); EN 55022; EN 51000.4.2;
EN 61000.4.3; EN 51000.4.4; EN 61000.4.5; EN 61000.4.6; EN 61000.4.8;
EN 61000.4.11; BS EN 50081.1; BS EN 50081.2; BS EN 50082.2; EN 6094.4.2;
IEC-947-4-1; IEC-68-2-6, (NFC2076; BV1); IEC-947-4-2.
EN 60439; EN 60831.1, EN 60831.2, EN 61921.2003

Electrical Requirements Specification G5/4 - 2 (2008)

Dated: September 2009

3 GENERAL SPECIFICATION

3.1 TECHNICAL SPECIFICATION

SUPPLY VOLTAGE	220V or 400V & 208V or 480V selected by PCB links. (Independent 570V & 690V Units Available)
FREQUENCY	50Hz or 60Hz selected on PCB.
START DUTY	4 x Rated Current for 5s, 3 x for 20s, 2 x for 30s (2.2 to 37kW units) 5 x Rated Current for 5s, 3 x for 30s, 2 x for 60s (55 to 800kW units)
STARTS PER HOUR	Minimum of 12 evenly spaced starts per hour.
PEDESTAL VOLTAGE RANGE	25 -100% of supply voltage, 6% -100% available torque. (100% is with DOL start selected
RAMP UP TIME RANGE	0.5 - 240s
RAMP DOWN	Independently selectable 0.5 – 120s
KICK START	Switch selected
KICK START LEVEL	Independently selectable at 70% or 90% of maximum supply voltage
KICK START TIME	0.25, 0.5, 1 or 2s
CURRENT LIMIT TIME	Current limit control on ramp up to 30s from start enable
CURRENT LIMIT RANGE	1.5 – 8.0 x unit rated FLC (infinite adjustment with on PCB pot)
STALLED ROTOR DETECT	Unit shutdown in event of rotor stall
PHASE LOSS DETECT	LED indication and shut-down in case of phase loss
COOLING	Naturally cooled, isolated heatsink up to 45A (22kW). Fan assisted cooling 60A, (30kW), and above (Independent 240/110V supply required)
THERMAL CUT OUT	Automatically cuts out and latches out in event of >90^{o}C on heatsink. (55kW to 800kW). PCB or External reset required to re-start
POWER SWITCHING	Fully base-isolated twin thyristor Paks or independent Puks
CONTROL CIRCUITRY	48MHz clocked Atmel CMOS MPU
CONTROL SUPPLY	Derived from three phase input
FAULT DETECTION	Shut down if:- Supply or Feed Phase Loss, Motor O/C or S/C Winding, Stalled Rotor, Thyristor Fault or PCB Logic Fault
LED INDICATIONS	Power On, Motor Run, Motor Top of Ramp, Set Current-Limit Exceeded, Ramp in Progress/End of Ramp Down/Emergency Run/Thyristor Fault Detected/Phase Loss Detected
ON PCB RELAYS	System Ready, Motor Run/Fault and Motor Top of Ramp
RELAY CONTACT RATING	2kVA, 250V AC with 2 N/O and 2 N/C contacts
MECHANICAL PROTECTION	IP43, NEMA 1 sheet metal enclosure or high impact ABS cover on heat sink backplane (depending on kW rating)
OPERATING TEMP.	0^{o}C - +40^{o}C @ < 95% RH. (De-rate 20%/10^{0}C above +40^{o}C)
STORAGE TEMP.	-10^{o}C - +60^{o}C
ALTITUDE	2000m above sea level – De-rate Amps by 1%/100m above 2000m
EU DIRECTIVES	Meets all necessary EMC and Low Voltage Directives
UL COMPLIANT	Listed for US and Canadian use - File E192379 (55kW to 800kW units)

3.2 HIGH SPEED FUSES – (55kW to 800kW)

The **EnviroStart** has provision for integral High Speed Semiconductor Fuses to be fitted. These are not fitted as standard. Customers requiring integral fuses for the output feed to the motor must specify this at the time of order. In general, if BS 88, motor rated fuses are fitted to the incoming supply of the unit as is recommended within IEE 17th Edition Regulations, (this being the applicable regulations document in the UK), then these additional fuses are not necessary.

There is no provision for integral fuses to be fitted to the output of the 2.2kW to 37kW **EnviroStart** units.

3.3 HARMONICS

EnviroStart like all electronic systems does produce low level harmonics during Ramp Up, Ramp Down and when not at full or zero volts.

U.K. electricity council engineering recommendations contained within their documents G5/4 (2002) specifies that the short term generation of harmonics by any electronic system on a typical 100kVA supply should not exceed 56A of 5th harmonic and 40A of 7th harmonic. Assuming a 415V supply this equates to one motor of around 145A, therefore the maximum 5th harmonic is 37% and the 7th 28%. The specification also details that the concern is primarily with the possibility of damage to frequency dependent components (such as capacitors) through long-term exposure to such harmonics.

As the **EnviroStart** units produce negligible harmonic levels during normal running it is excluded from the constraints of such specifications by definition; however with our policy of ensuring maximum compliance and minimum environmental pollution our design standards ensure that we fall well below the limits set. Typical test values* of harmonic currents on an **EnviroStart** MEC controlled motor operating in Energy Save Mode yielded <8% for 5th Harmonic and <1% for 7th harmonic, significantly within the accepted and specified limits.

Maximum limits are unlikely to be exceeded in normal operation even during ramp up and ramp down periods with an **EnviroStart** soft start.

**Based on tests carried out on a 22kW motor by University Of Surrey Industrial Electronics Group November 1988, re-verified on Generation VI product in May 2006.*

3.4 HEAT LOSES

For heat calculation purposes it should be assumed that EnviroStart units have a power loss of 1.2W/A per phase at full conduction, (3.6W/A maximum for the three phase). These losses cause heat to be generated that is safely dissipated through the aluminium heatsink. See Section 4.9.

3.5 HEAT DISSIPATION

In order to keep the unit operating within its design limits any proposed additional enclosure must be capable of safely dissipating the energy generated by the **EnviroStart**.

When fitting systems up to 205A FLC into enclosures, (to extend protection from the standard IP43 up to IP 65/NEMA 2), the fitting louvers of the minimum specification (described in Section 3.9 - Table of Power Losses) both above and below the **EnviroStart** as sited within the cabinet will normally be sufficient to ensure effective heat dissipation.

With units of >205A, additional fans must be fitted to the cabinet in addition to those fitted to the **EnviroStart**. The following information will help the user to select a fan to keep the temperature rise within the control panel to a 10°C rise above external ambient.

3.6 SELECTING A CABINET COOLING FAN

Take the heat dissipation figure of the required **EnviroStart** model from Section 3.10, Table of Power Losses. Compare this figure with the fan heat disposal figure in Section 3.9, Table of Fan Data and select a fan with a greater heat disposal figure than that calculated.

For example, **EnviroStart** 90kW Model gives a heat dissipation figure of 632W, requiring a 7600N model fan with filter equivalent to cooling of 805W.

3.7 CONTROL PANELS WITH MULTIPLE ENVIROSTARTS

If more than one **EnviroStart** is to be installed in a single enclosure the heat dissipation figures should be added together before selecting cooling system requirements.

3.8 COOLING FAN POSITION

The fans should be positioned below the **EnviroStart** power assembly to allow cool air to be drawn into the path of the power assembly fans. Outlet Filters or louvers should be positioned close to the top of the enclosure and in the path of the airflow. These should be approximately double the fan apertures to ensure that the air flow is as free as possible.

3.9 CABINET COOLING FAN DETAIL

The fans should be positioned in the cabinet, wherever possible, below the **EnviroStart**. The aperture to which the fans are fitted should always be large enough to allow free flow of air, any filters fitted should be selected to minimise their interruption to air flow. Such filters should be regularly inspected to ensure that they are clean.

PAPST FAN MODEL NO.'S	FLOW RATE EXC. FILTER (L/s.)	FLOW RATE INC. FILTER (L/s.)	HEAT DISP. EXC. FILTER (W)	HEAT DISP. INC. FILTER (W)
8500N/8550N	10.4	8.3	117	93
4600N/4650N	38.7	31	477	382
7600N/7650N	87.3	71	1,010	805
7400N/7450N	106	85	1,166	935
6028S/6078	106	93.3	1,283	1,026

3.10 POWER LOSSES

MODEL	POWER ASSEMBLY LOSSES IN W.	CONTROL & FAN LOSSES IN W	TOTAL LOSSES IN W	MINIMUM LOUVRE AREA (TWO REQUIRED)
TPSSG6 - 5.5	45	10	55	0.0156 Sq. M
TPSSG6 - 7	58	10	68	0.0156 Sq. M
TPSSG6 - 11	90	10	100	0.0156 Sq. M
TPSSG6 - 15	108	10	118	0.0156 Sq. M
TPSSG6 - 22	162	10	172	0.0156 Sq. M
TPSSG6 - 30	216	50	266	0.0625 Sq. M
TPSSG6 - 37	270	50	320	0.0625 Sq. M
TPSSG6 - 55	306	50	356	0.0625 Sq. M
TPSSG6 - 63	432	50	482	0.0625 Sq. M
TPSSG6 - 75	522	50	572	0.0625 Sq. M
TPSSG6 - 90	612	50	662	0.1 Sq. M
TPSSG6 -110	738	50	788	0.1 Sq. M
TPSSG6 - 132	918	70	988	See Sections 3.6 - 3.8
TPSSG6 - 150	1,044	70	1,114	See Sections 3.6 - 3.8
TPSSG6 - 186	1,224	85	1,309	See Sections 3.6 - 3.8
TPSSG6 - 225	1,476	85	1,561	See Sections 3.6 - 3.8
TPSSG6 - 260	1,710	85	1,795	See Sections 3.6 - 3.8
TPSSG6 – 315	2,088	135	2,223	See Sections 3.6 - 3.8
TPSSG6 - 375	2,412	135	2,547	See Sections 3.6 - 3.8
TPSSG6 - 450	2,880	160	3,040	See Sections 3.6 - 3.8
TPSSG6 – 500	3,440	160	3,600	See Sections 3.6 - 3.8
TPSSG6 - 630	3,960	260	4,220	See Sections 3.6 - 3.8
TPSSG6 - 800	4,500	300	5,100	See Sections 3.6 - 3.8

USE TABLE OF FAN DATA IN SECTION 3.9 TO SELECT CORRECT CABINET FAN

IT IS VITALLY IMPORTANT THAT YOU REVIEW THE DERATING INFORMATION IN APPENDIX 8 OF THIS INSTALLATION GUIDE TO ENSURE THAT YOU CHOOSE A SYSTEM RATED TO MEET YOUR APPLICATION DEMANDS

4 INSTALLATION

4.1 IMMUNITY FROM INTERFERENCE

EnviroStart generally has a high level of immunity to externally generated interference. However the following good practices should be observed:

4.2 COIL SUPPRESSION

Any coil that is connected to the **EnviroStart**, shares a common control supply or is mounted in the same enclosure must be suppressed using appropriate R-C filter circuits.

4.3 LIGHTNING STRIKES/VERY HIGH VOLTAGE TRANSIENTS

In areas subject to frequent lightning strikes or other high voltage transients, a suitably rated metal oxide Varistor (MOV) or transient voltage suppressor (TVS) should connect each input line to earth.

4.4 CONTROL VOLTAGE TRANSIENTS

Where the control supply to the **EnviroStart** is thought to be subject to mains-borne interference a suitable line filter with transient interference suppression should be fitted between the control supply and the **EnviroStart**.

4.5 INPUT/OUTPUT CONTROL CONNECTIONS

To avoid 'interference pick up' all input and output control cables should be kept as short as possible and should wherever possible, be shielded. If noise free lines cannot be guaranteed, an interposing relay with suitable suppression must be used, this should be mounted as close to the **EnviroStart** as possible.

4.6 EMISSIONS

EnviroStart units produce relatively low Radio Frequency Interference (RFI) compared with frequency inverters and no external filters are required in normal circumstances.

4.7 BY-PASS CONTACTOR (Not Recommended)

In the unlikely event that the **EnviroStart** is only used for 'soft-starting', a by-pass contactor can be used to short the unit at top of ramp to eliminate the need for cooling.

The by-pass contactor should be Motor DOL rated. Normally it will not be switching current but it will be expected to be able to do so under fault conditions.

4.8 VENTILATION

The **EnviroStart** must be mounted vertically with the cooling fans, (if fitted), directing the air upwards. A free space of 85mm must be allowed above and below the unit. See section 3.4 through 3.10 for further information.

4.9 COS. PHI CORRECTION (Power Factor Correction)

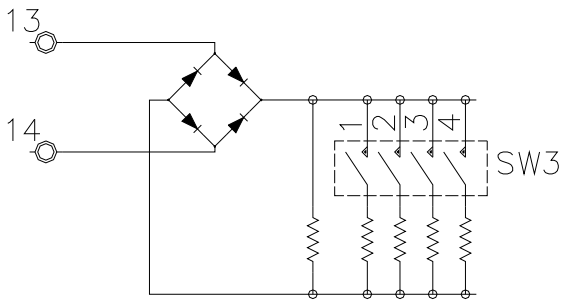
Power factor correction capacitors **must never** be connected to the output of the **EnviroStart**. They must be fitted to the supply side of the line contactor, (or isolator), and switched by the line contactor, (or isolator), so they are never in direct line with the **EnviroStart**.

4.10 BURDEN RESISTOR SETTINGS

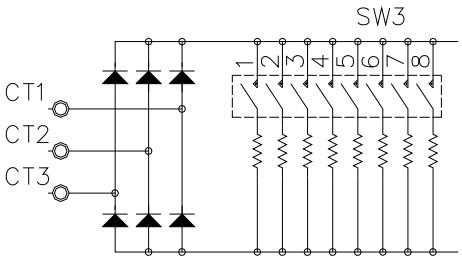
In order for the system software to be able to properly manage the ramp up and over current protection it is necessary that the burden resistor value be set correctly for the size of motor it is operating. The burden resistor works in parallel with the over current limit potentiometer VR1 during ramp up and is therefore important for the effective operation of the system if current limiting is required during this ramp up period.

Burden resistor values are selected on the Burden Resistor DIP Switch located on the PCB according to the following table:

UNIT SIZE	SW1	SW2	SW3	SW4	SW 5	SW6	SW7	SW 8
TPSSG6 - 5.5	OFF	OFF	OFF	OFF				
TPSSG6 - 7	OFF	OFF	OFF	ON				
TPSSG6 - 11	OFF	OFF	ON	OFF				
TPSSG6 - 15	OFF	OFF	ON	ON				
TPSSG6 - 22	OFF	ON	OFF	ON				
TPSSG6 - 30	ON	ON	OFF	OFF				
TPSSG6 - 37	ON	ON	ON	OFF				
TPSSG6 - 55	OFF	ON	OFF	ON	OFF	OFF	OFF	ON
TPSSG6 - 63	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF
TPSSG6 - 75	OFF	OFF	OFF	OFF	ON	ON	ON	OFF
TPSSG6 - 90	OFF	ON	OFF	ON	OFF	OFF	OFF	ON
TPSSG6 -110	OFF	OFF	ON	ON	ON	ON	OFF	ON
TPSSG6 - 132	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
TPSSG6 - 150	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
TPSSG6 - 186	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF
TPSSG6 - 225	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF
TPSSG6 - 260	OFF	OFF	ON	OFF	ON	ON	OFF	OFF
TPSSG6 – 315	OFF	ON	OFF	OFF	ON	OFF	OFF	ON
TPSSG6 - 375	OFF	ON	ON	ON	OFF	OFF	ON	OFF
TPSSG6 - 450	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON
TPSSG6 – 500	OFF	ON	ON	ON	OFF	OFF	OFF	ON
TPSSG6 - 630	OFF	ON	OFF	OFF	OFF	OFF	ON	ON
TPSSG6 - 800	ON	ON	ON	ON	ON	ON	ON	ON



5.5kW through 37kW Burden Resistor Configuration and CT Connection



55kW through 800kW Burden Resistor Configuration and CT Connection

4.11 SLIP-RING MOTORS

EnviroStart units are suitable for Slip Ring Motors provided that a single stage resistance is added (during starting) to the rotor circuit, this having a resistance of approximately 10-20% rotor Ohms, (RΩ). This is typically going to be 0.3 – 0.5Ω. This gives the motor a similar torque characteristic to that of a standard squirrel cage motor. Care must be taken when fitting **EnviroStart** units to slip ring motors. If you are in any doubt please contact your local Distributor or Agent or contact EMS (European) directly.

Some slip ring motors not only have passive induced current in the rotor at start up but have a direct DC injection through the start up phase. Such motors can also be started with EnviroStart units however care must be taken to ensure that the EnviroStart is correctly sized to fit the motor FLC. If you are in any doubt please contact your local Distributor or Agent or contact EMS (European) directly.

4.12 LOAD SIZE

The **EnviroStart** unit must be connected to a motor for the system to operate. The motor and the **EnviroStart** should be matched for both kW and FLC rating. Motors regularly operating at below 5% of their kW rating are not suitable for use with **EnviroStart** control as this low level operation may cause instability of thyristor firing resulting in the motor stalling.

It is important to make an assessment of the load type and frequency of starts as well as the operating ambient conditions when selecting a suitable **EnviroStart** unit. High frequency of starts, elevated ambient temperatures or significant altitude should be treated carefully and consideration given to selecting the next size of **EnviroStart** up from that which would be selected simply on kW or FLC ratings alone.

4.13 CABLE AND INPUT FUSE RATINGS

Incoming fuses and power cables must comply with the ratings as shown in the table below. It is recommended that all cable be tri-rated compliant with BS 6231 and that all fuses be motor rated, bolt fitting, compliant with BS 88 Part 2.

MODEL	FUSE RATING	CABLE RATING		MODEL	FUSE RATING	CABLE RATING
400-TPSSG6 – 5.5	16A	14A/0.75mm/16AWG		**400-TPSSG6 - 132**	250M300A	259A/70mm/4/0AWG
400-TPSSG6 - 7	20M32A	21A/1.5mm/14AWG		**400-TPSSG6 - 150**	315M400A	321A/95mm/300MCM
400-TPSSG6 - 11	25A	30A/2.5mm/12AWG		**400-TPSSG6 - 186**	355A	374A/120mm/350MCM
400-TPSSG6 - 15	32M50A	41A/4mm/10AWG		**400-TPSSG6 - 225**	400A	440A/150mm/400MCM
400-TPSSG6 - 22	50A	53A/6mm/6AWG		**400-TPSSG6 - 260**	500A	500A/185mm/700MCM
400-TPSSG6 - 30	63M100A	75A/10mm4AWG		**400-TPSSG6 – 315**	560A	600A min/800MCM
400-TPSSG6 - 37	80A	75A/10mm/3AWG		**400-TPSSG6 - 375**	670A	700A min/1250MCM
400-TPSSG6 - 55	100M160A	100A/16mm3AWG		**400-TPSSG6 - 450**	800A	850A min
400-TPSSG6 - 63	125A	136A/25mm/2AWG		**400-TPSSG6 – 500**	900A	950A min
400-TPSSG6 - 75	160A	167A/35mm/1/0AWG		**400-TPSSG6 - 630**	1100A	1200A min
400-TPSSG6 - 90	200M250A	204A/50mm/2/0AWG		**400-TPSSG6 - 800**	1400A	1500A min
400-TPSSG6 -110	200M250A	204A/50mm/2/0AWG				

Connections on 5.5kW through 37kW are direct onto the thyristor packs using M5 screws. From 55kW through to 800kW M8 thread bolt screws are used. A single termination point recommended on 55kW through to 110kW, a double termination point recommended for 132kW through 375kW and four termination points recommended on units above 375kW.

The above detail refers to new installations. In cases where the **EnviroStart** is being fitted into an existing installation then the cable should be rated according to the fuses already fitted. (IEE 17th Regulations). The AWG and MLM designations are per Table 310-16 of NEC 2005 and relate to copper conductors. (60°F up to 100A and 75°F above 101A).

4.14 BUS BAR CONNECTION

Where used, bus bars are either pure aluminium or, on systems rated at 255A and above, are nickel plated copper. All bus bars are duel rated, in that either aluminium or copper connectors can be used with them however on the aluminium bus bars it is recommended that a small amount of thermal grease be used if copper connectors are being used.

5 CONNECTION

5.1 TERMINAL FUNCTION AND LOCATION

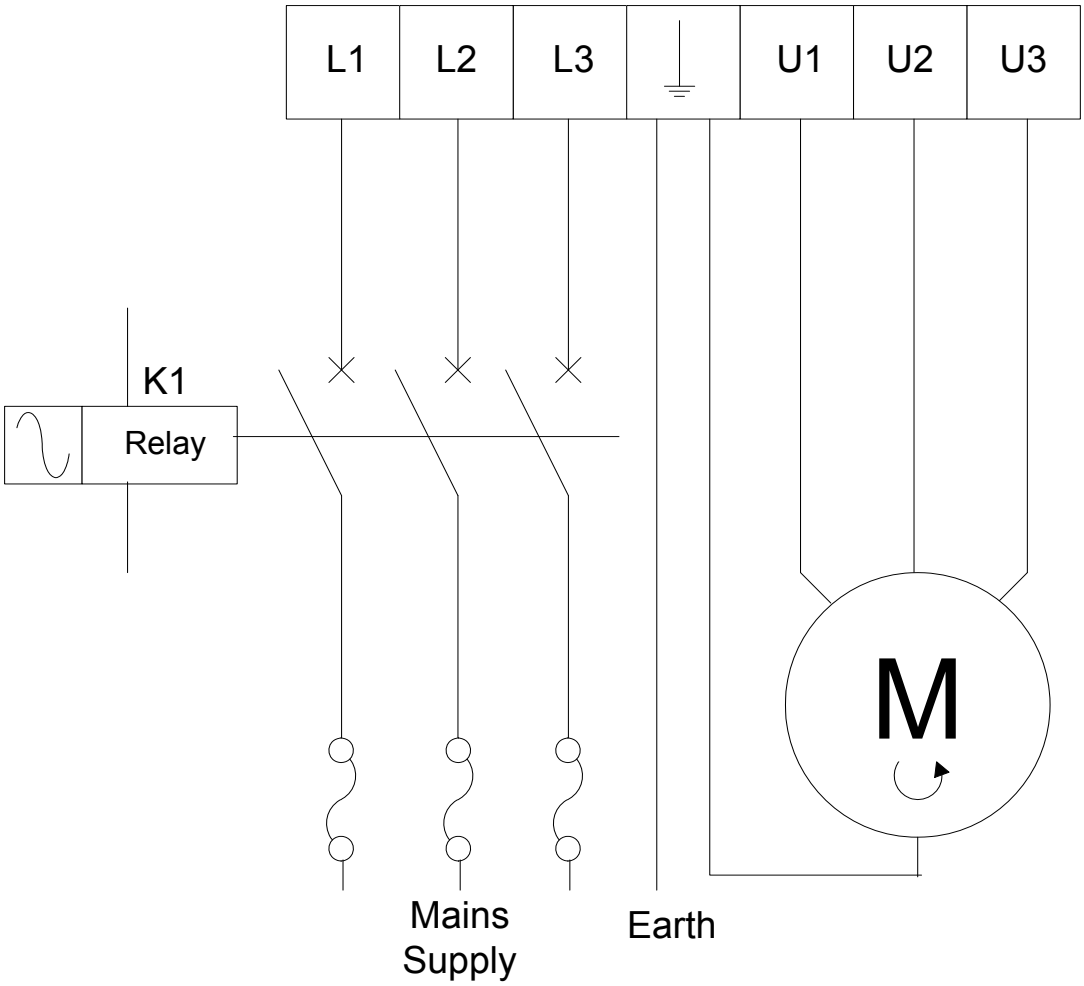
TERMINAL	LOCATION	FUNCTION
L1/L2/L3	Power Assembly	Red/Yellow/Blue Phase Supply
U/V/W	Power Assembly	Red/Yellow/Blue Phase Output to Motor
240V or 110V	Power Assembly	Cooling Fan Supply Voltage (55kW and above) Unless integrated supply for fans provided. (February 2006 onwards)
EARTH	Power Assembly	Earth Connection to Unit
TS1 &TS2	PCB	Thermocouple feed to PCB (55kW and above) See Page 34
K1 (L1) & G1	PCB	Thyristor 1 Cathode and Gate
K2 (U) & G2	PCB	Thyristor 2 Cathode and Gate
K3 (L2) & G3	PCB	Thyristor 3 Cathode and Gate
K4 (V) & G4	PCB	Thyristor 4 Cathode and Gate
K5 (L3) & G5	PCB	Thyristor 5 Cathode and Gate
K6 (W) & G6	PCB	Thyristor 6 Cathode and Gate
1, 2, 3, 4[1]	PCB	Start (must be kept closed for motor to run)
5,6,7,8[2]	PCB	Soft Stop Enable
9 & 11	PCB	AC Mains Input From Control Transformer (220V, 400V, 570V , 690V), Providing 10 – 15V AC
10	PCB	DC Common Rail (At PCB Earth Potential)
12	PCB	DC Input 7V – 24V (External PCB logic circuit supply)
15, 16, 17	PCB	TOR Relay Changeover Contact Pair
18,19, 20	PCB	TOR Relay Changeover Contact Pair
21,22, 23	PCB	Run/Fault Relay Changeover Contact Pair
24, 25, 26	PCB	Run/Fault Relay Changeover Contact Pair
27, 28,29	PCB	Power On/Ready Relay Changeover Contact Pair
30, 31, 32	PCB	Power On/Ready Relay Changeover Contact Pair
33,34,35,36[3]	PCB	Thermal Trip External Reset Connector (55kW and above)
CT1 OR 13	PCB	CT1 +tve Input
CT2	PCB	CT2 +tve Input (55kW and above)
CT3 OR 14	PCB	CT Common Input
220V	PCB	PCB Supply Control Transformer Tapping 220V
400V/570V/690V	PCB	PCB Supply Control Transformer Higher Voltage Tapping
OV	PCB	PCB Supply Control Transformer OV

NOTES

1. Terminals 1, 2, 3, 4 should be permanently linked (via switch or link) per the diagrams below to cause the motor to start. The circuit is designed to accommodate, direct switching, NPN, (sink) or PNP (source) switching should it be necessary to switch directly from a PLC or other micro device. When the connection between the terminals is open circuit but the unit is still powered up the motor will stop.

2. Terminals 5, 6, 7, 8 should be permanently linked (via switch or link) per the diagrams below to enable the emergency run function. The circuit is designed to accommodate, direct switching, NPN, (sink) or PNP (source) switching should it be necessary to switch directly from a PLC or other micro device. When the connection between the terminals is open circuit but the unit is still powered up the motor will stop.
3. Terminals 33, 34, 35, 36 should be permanently linked (via switch or link) per the diagrams below to reset the thermal overload trip. The circuit is designed to accommodate, direct switching, NPN, (sink) or PNP (source) switching should it be necessary to switch directly from a PLC or other micro device. When the connection between the terminals is made the thermal trip will reset, if the control function on connection 1, 2, 3, 4 is closed at this time then the motor will restart.

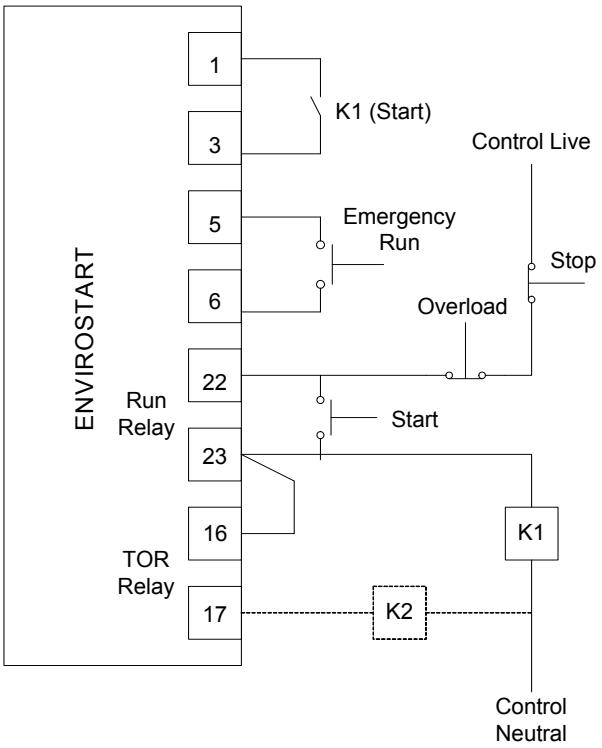
5.2 MAINS CONNECTION SCHEMATIC DRAWING



NOTES

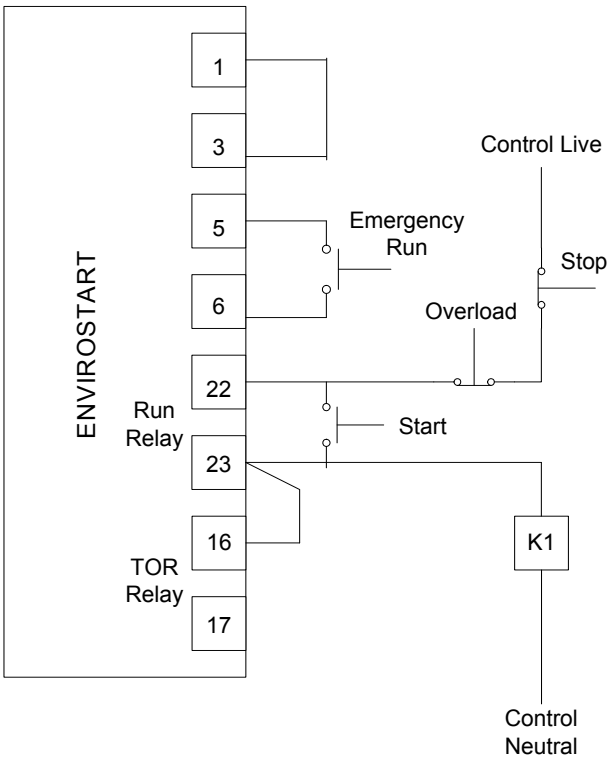
1. Should it be required a bypass contactor, (not recommended), could be placed between the Line Input and Motor Feed lines. This contactor would have to be full motor current rated and would be switched using the TOR relay of the **EnviroStart**

5.3 CONTROL CONNECTIONS UTILISING ALL FEATURES



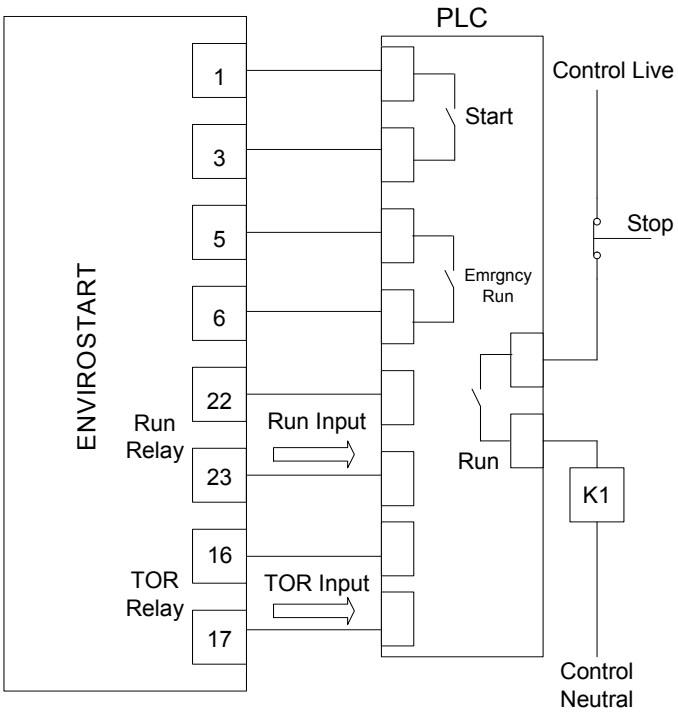
1. The start connection across connectors 1 and 3, (K1 auxiliary) can be permanently linked to start as soon as K1 closes. (Connectors 2 and 4 linked).
2. The run relay acts as a retaining contact for the start push button. In the event of a fault the run relay will open terminals 22 and 23 and therefore de-energise L1, provided that the start push button is not held in.
3. **EnviroStart** can be forced to run even if the control circuit is faulty by closing contactors 5 and 6. This can be done with an associated holding circuit, (not shown) or with a hard wired switch or link.

5.4 CONTROL CONNECTIONS MINIMUM REQUIREMENTS



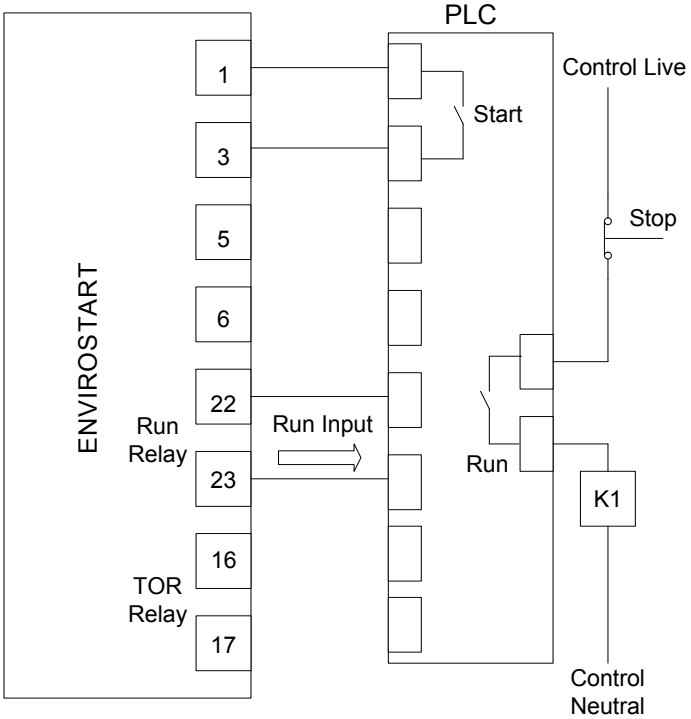
1. The unit will start as soon as K1 closes and places power onto the system circuit. (Permanent link also required between connectors 2 and 4).
2. The run relay acts as a retaining contact for the start push button. In the event of a fault, the run relay will open connectors 22 and 23 and will de-energise K1.
3. **EnviroStart** can be forced to run even if the control circuit is faulty by closing contactors 5 and 6. This can be done with an associated holding circuit, (not shown) or with a hard wired switch or link.

5.5 CONTROL CONNECTIONS – AUTOMATIC START/EMERGENCY RUN



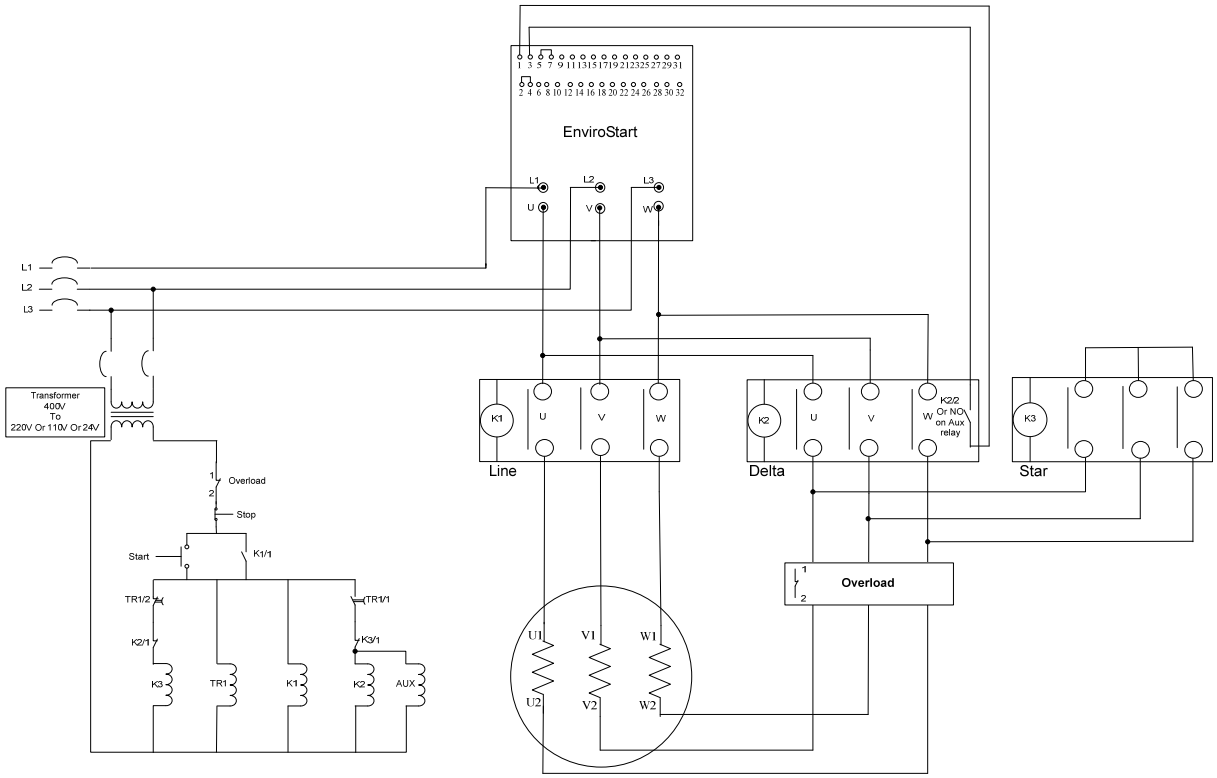
1. The unit will start as soon as K1 closes and then the “Start” is made. The **EnviroStart** will stop when the “Start” function is made open circuit. (Link also to be made between connectors 2 and 4).
2. If the run input is not made shortly after the start signal is given the system will register it as a fault and the PLC will open K1 and lock out until a reset signal is delivered.
3. **EnviroStart** can be forced to run even if the control circuit is faulty by closing contactors 5 and 6. This can be done with an associated holding circuit, (not shown) or with a hard wired switch or link.

5.6 CONTROL CONNECTIONS AUTOMATIC START



1. The unit will start as soon as K1 closes and then the “Start” is made. The **EnviroStart** will stop when the “Start” function is made open circuit. (Link also to be made between connectors 2 and 4).
2. If the run input is not made shortly after the start signal is given the system will register it as a fault and the PLC will open K1 and lock out until a reset signal is delivered.

5.7 STAR DELTA CONNECTION



COMMISSIONING

5.8 PRE-COMMISSIONING CHECKS

IMPORTANT*:* Before installation check the motor rating plate and Section 2 of this manual to ensure that the EnviroStart is correctly rated for the application.

1. Check that the voltage for the PCB and frequency selection is correct.
2. Ensure that fans (if fitted) are connected to the correct voltage and are free to rotate
3. Ensure that all Switch and Potentiometer settings are set to default. (Section 6.5)
4. Check that the unit is connected correctly as per the proceeding connection diagrams.
5. Ensure any PFC Capacitors, if fitted, are placed on the input side of the unit and are only switched in or out when the **EnviroStart** is not running. (Section 4.9).
6. Ensure that a suitable time has elapsed since the **EnviroStart** was last run/started.

5.9 COMMISSIONING INSTRUCTIONS

1. Check that all settings are at 'Default' and the pre-commissioning steps have been followed.
2. Give the start command to the PCB.
3. Check rotation, if the direction of rotation is incorrect then change over two of the output phase connections marked U, V and W.
4. Default settings should give a satisfactory start with most applications. If it does but you want to further limit current during start up then stop the motor and move to 12 below.

Carry Out the following procedure only if the default start sequence established proves unsatisfactory, this may occur if you have a high inertia load. The following does not have any form of current limit enabled and therefore may not be suitable should you be trying to limit current excursion during start up.

5. Ensure the current limit potentiometer VR1 is fully anti-clockwise at its maximum setting.
6. Set switches 1, 2 and 3 to the minimum ramp time of 0.5s
7. Set switches 8 and 9 to give the maximum pedestal voltage. (Leave switch 10 in the OFF position)
8. Start the motor. The motor should begin to rotate immediately.
9. Check rotation, if the direction of rotation is incorrect then change over two of the output phase connections marked U, V and W.
10. With these settings the unit should start and ramp very rapidly to full speed. If it does not then you should check supply and feed connections are the correct way round and that all connections are made and that all phases are available on the input, L1, L2 and L3 side of the thyristors.
11. If the unit starts satisfactorily then increase the ramp time from 0.5s to a suitable setting, 10s or 20s are typical, and step by step reduce the pedestal voltage setting until a smooth start is achieved

Carry out the following procedure if you want to limit the current at start up.

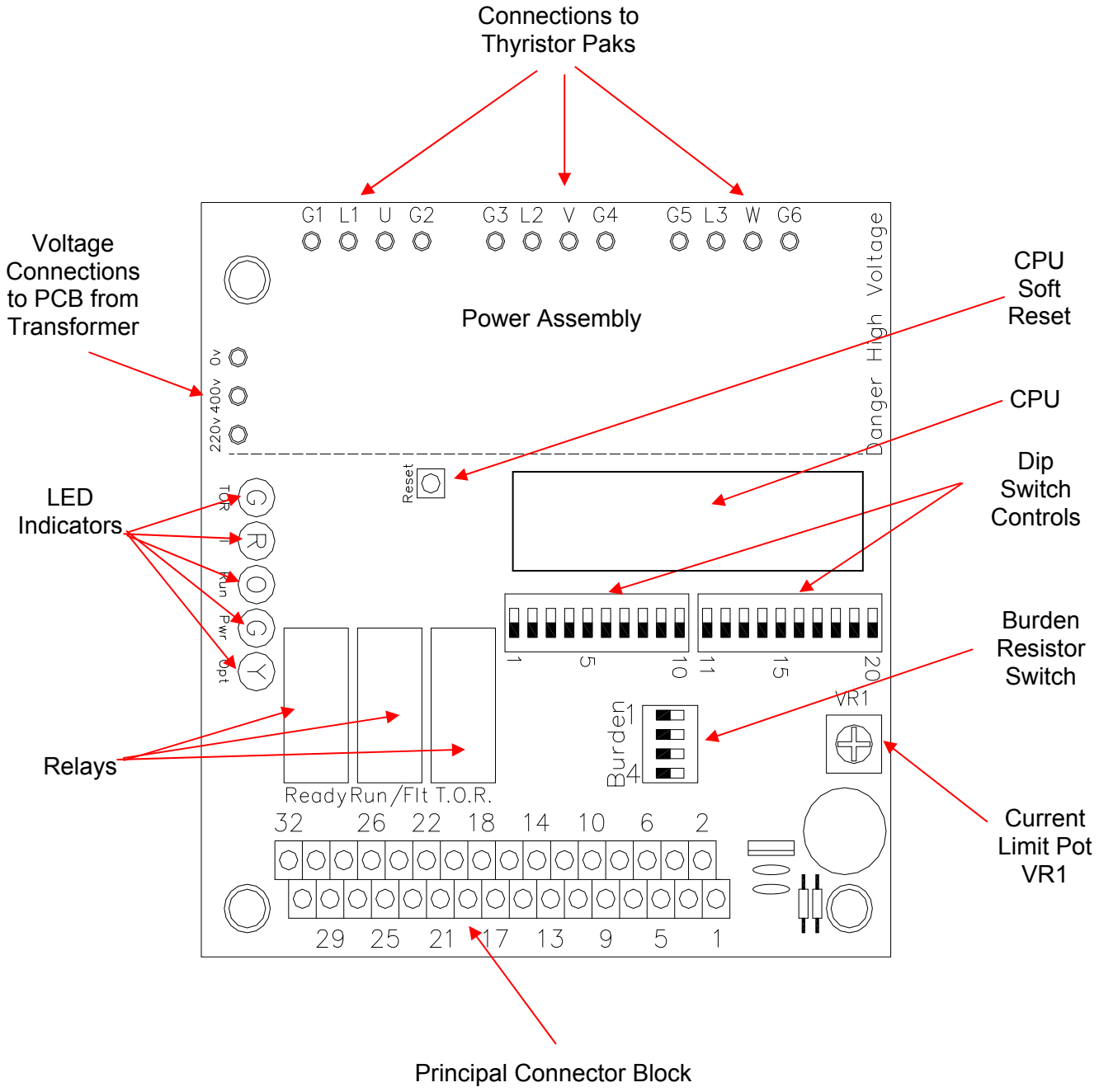
12. Turn the current limit potentiometer to minimum, fully clockwise; this provides maximum current limiting.
13. Start the motor; it is likely that the motor will not rotate. This is expected.
14. Slowly turn the potentiometer VR1
15. anti-clockwise until the motor starts to move, then turn through approximately a further 10^{o} at which point the motor should have sufficient current to accelerate the load to full speed smoothly. This point is the point at which the **EnviroStart** is providing sufficient power to start the load whilst limiting the current by the maximum amount. The Current Limit should not be set too low, as this will cause motor overheating and tripping of the thermal overload in the supply system if they are fitted.
16. With the Current Limit set, the ramp time may need reducing to give the required starting time.
17. Should you want you can monitor the current at start up using a fast acting current clamp meter or Three Phase Analyser set to peak current hold. The clamp should be placed on one of the output feed cables to the motor.

5.10 SETTING FEATURES

When a satisfactory start is achieved the user control functions can be tailored to your specific requirements following the details contained within Section 6 of this Guide. In this be careful not to make changes to the user settings that will impact the effective and proper start of the motor. Care should be taken when making adjustments to the features that start current limits which may have been set during the commissioning sequence above are not exceeded as this may cause damage to preset overloads or fuses external to the **EnviroStart.**

5.11 PCB SWITCH AND CONTROL LOCATION

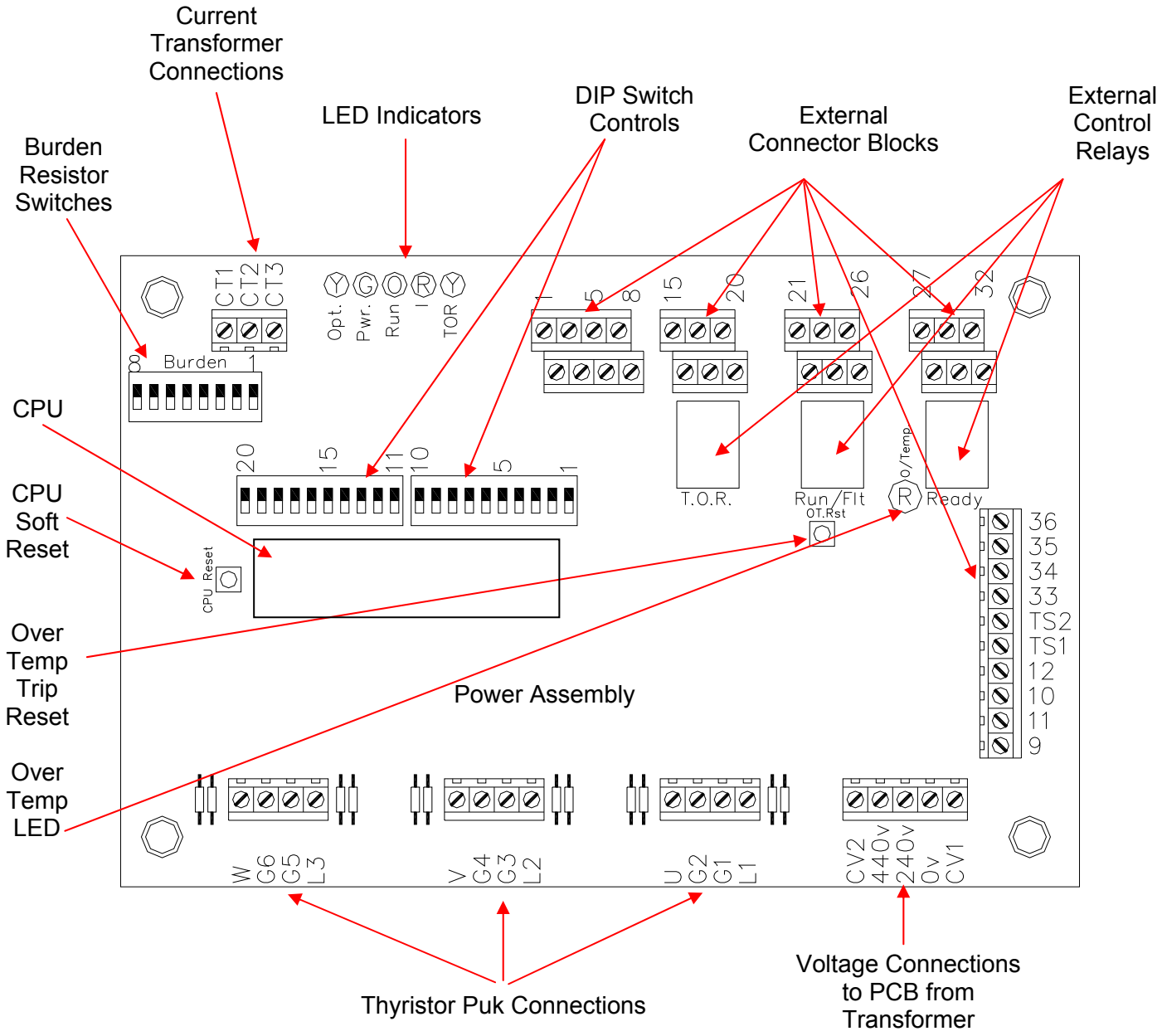
TPSSG6-5.5 to TPSSG6-37 PCB DETAILS



(See Appendix 5 on Page 41 for a photograph of this PCB)

5.12 PCB SWITCH AND CONTROL LOCATION

TPSSG6-55 to TPSSG6-800 PCB DETAILS



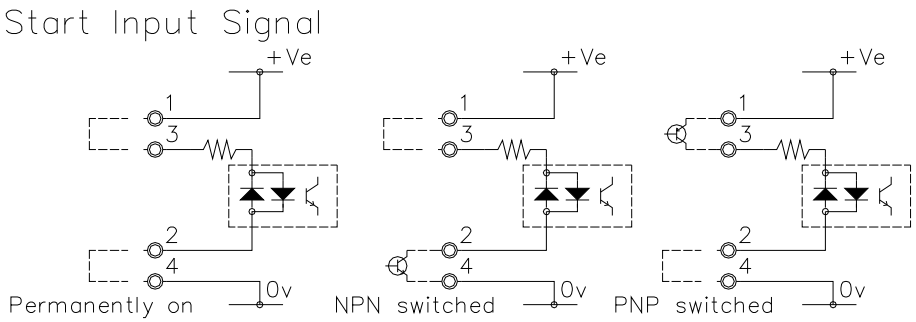
(See Appendix 5 on Page 41 for a photograph of this PCB)

6 USER CONTROL FEATURES

6.1 START AND STOP FUNCTION

The controlled motor is started and stopped by making contact between connector pins 1 and 3 on the PCB. This is a zero voltage contact set. It is important that no control current or voltage be fed to these terminals as this will result in damage to the control microprocessor.

The input circuit is capable of handling both direct start, having connector pins 2 and 4 linked and then making the link between connector pins 1 and 3 either via a switch or permanently so that the motor starts on power being supplied or from a logic high, (source) or logic low, (sink) from a PLC system.



6.2 START UP CURRENT LIMIT SETTING

Motors started direct on line, (DOL), typically draw a peak starting current of about 8x their rated FLC.

In conjunction with the other control functions associated with the motor start as defined by a solid state control, such as ramp time and pedestal voltage, **EnviroStart** can be set to limit the starting current during this initial phase of the motor operation.

When the current limit potentiometer VR1, is turned away from its default condition of mid position then a variable degree of current limiting will be enabled which will extend from a maximum current excursion of approximately 5 - 8x motor FLC, when the potentiometer is fully anti-clockwise, to a limit value of approximately 1.5x motor FLC, when the potentiometer is fully clockwise. **EnviroStart** monitors the current drawn by the thyristors during ramp up, if the current exceeds the limit set by VR1 then the ramp is stopped and voltage held constant until the current falls below the preset limit, following which time the ramp up is continued. If the set current limit is reached during ramp up then the Red LED will light. It is not unusual during ramp up, particularly of larger motors, to see this LED flickering on and off.

30s after the start signal is applied to **EnviroStart** the current limit is released, (that is, if top of ramp has still not been reached at that stage); this is to ensure the smooth acceleration of the motor to full synchronous speed.

Current limit is useful in the management of the start of high inertia loads where supply restrictions may have placed limits on the maximum starting current allowed; (possibly because of supply cable or sub-station limitation).

For normal loads set VR1 between middle and fully clockwise to disable current limiting and provide maximum power to the motor defined by only the initial pedestal voltage and ramp period settings.

6.3 VOLTAGE SELECTION

WARNING: Please check these setting are correct before first starting the unit.

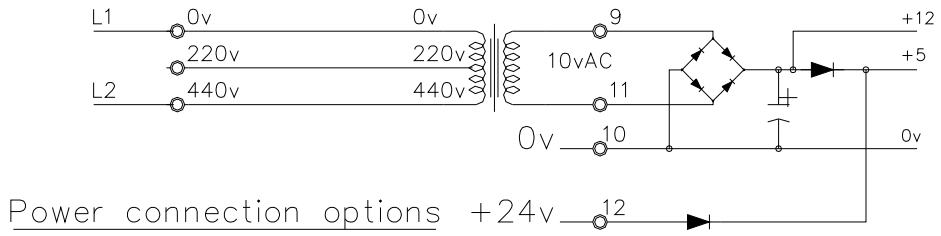
All 220/400V units are shipped with the voltage set at 400V; 208/480V units are shipped with the voltage set at 480V. In the case of the 570V units, the voltage is set at 570V and in the case of 690V units, at 690V. (The two higher voltage units do not have multi-tap transformers fitted and are therefore fixed at the supplied voltage only)

On the 5.5kW through 37kW units should you require that the operating voltage of the unit be changed from 400V to 200V, (ROW), or from 480V to 208V, (USA), swap the position of the 400V and 220V marked push-on connectors found on the underside of the PCB. In the case of the 55kW through 800kW units make the same exchange of leads in the screw terminal connector block swapping the leads into the 220V and 400V connectors.

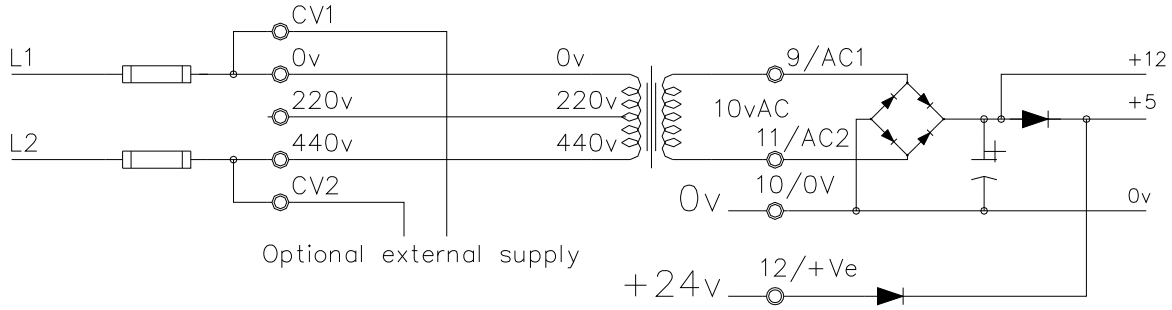
In the event that you wish to supply the LP PCB, (5.5kW though 37kW), from an external source then you should disconnect the supply leads from the PCB terminals and connect a 208V AC (USA), or 220V AC (ROW) supply between the lead that was on the 0V terminal and the lead that was on the 220V terminal. The lead that was on the 400V terminal could be “docked” safely on the 220V pin of the PCB, removed completely or insulated and secured elsewhere. (It is recommended that it be docked to the 220V terminal of the PCB as this is isolated and secure. In the event that you wish to supply the HP PCB, (55kW through 800kW), from an external source then this can be done by putting a 208V AC (USA), or 220V AC (ROW) supply onto CV1 and CV2 and by removing the two Fuse Links F1 and F2 which are immediately above the Power Connector terminal block.

WARNING: It is imperative that the fuse links on the PCB are removed if an external 208V (USA) or 220V (ROW) supply is used. (55kW through 800kW)

All units are supplied with a transformer suitable for use with the voltage you specified on your order. The fundamental requirement is that there be 10V AC fed to the PCB at connector pins 9 and 11. Should you require you can maintain the logic +5V DC on the PCB by providing between 7V and 24V DC on the 0V and +24V connectors 10 and 12.



5.5kW through 37kW PCB Power Connections



55kW through 800kW PCB Power Connections

6.4 STALLED-ROTOR PROTECTION

The system software is capable of detecting the lack of synchronous rotation in the motor the **EnviroStart** is driving. In such an event the software will check the status functions of all the outputs and if they are found to be satisfactory then it will assume that the rotor is stalled or being stalled in some manner and in order to protect the system and the motor it will shut down the feed current eliminating the possibility of motor burn out.

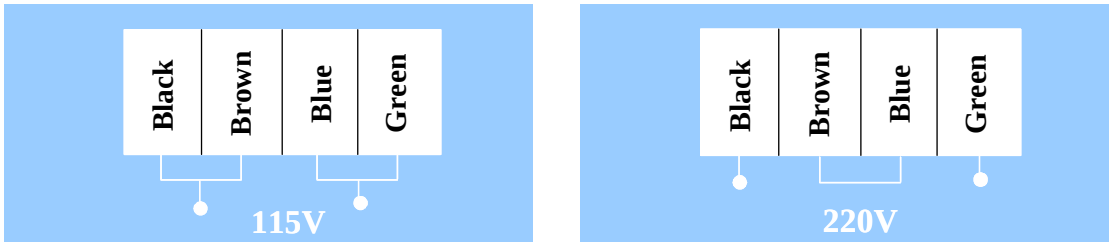
In the event of the system stopping in this way the motor should be checked and free rotation ensured before such time as the unit is restarted. The **EnviroStart** will need to be reset when it has stopped in this way, this can be done by either powering the system down or by pressing the restart button on the PCB.

Before resetting the **EnviroStart** and restarting the motor always ensure that the motor is safe to operate.

Note that the stalled rotor function cannot replace an effective, properly rated current-overload fitted within the supply circuit and will never provide full protection against catastrophic mechanical collapse of the motor such as when a bearing fails and/or the rotor goes short to the stator. In these cases the current and voltage spikes are too high and too fast for the **EnviroStart** to react, peaking as they would in a matter of a few hundred nanoseconds.

6.5 INTEGRAL COOLING FAN CONNECTIONS

All **EnviroStart** units of 30kW and above are fitted with integral cooling fans; in units manufactured up to December 2005 these have to be independently powered with either an 110V AC or 220V AC supply. It is important that the fans are running at all times that the unit is operating. On 30kW and 37kW systems the fan supplies are made direct onto the single fan that is fitted using insulated Lucar type connectors, on the 55kW through 110kW the connection for the integrated twin fans will be made onto a marked connector block adjacent to the PCB mounted on the backplane of the system. On systems of 132kW and above the fans are dual voltage and should be connected as shown below.



It is very important that only the voltage appropriate to the fan be used otherwise the fans will be damaged which may cause overheating of the **EnviroStart** unit. Always check the fan voltage rating and or connection schema before powering the fans for the first time.

EnviroStart units of 30kW through to 150kW, manufactured from January 2006 onwards, will have their fans self powered; an additional feed being taken from the incoming supply, via a separate transformer through the Run Relay on pins 25 and 26, (Section 6.14), to the fans input. The purpose of running the feed through the Run Relay is to ensure that the fans are operating only at times when the unit is powered and driving a load. If it is required that the fans be running at all times that the unit is powered, because of high ambient temperature environments, (average ambient ≥ 25°C), then this can be achieved by moving the wires running into the Run Relay I/O on pins 25 and 26 and placing them into the System Ready Relay I/O on pins 31 and 32, (Section 6.18).

On systems of 186kW and above the fans will be wired as above to a four way connector block and an externally transformer supplied which should be mounted, in a convenient nearby location. A feed will have to be taken from the connector block to the transformer and then back from the transformer to the connector block to feed the fans. The reason for

approaching the fan feed in this way is that it allows the safe positioning of the fan supply transformer away from the bus bars and **EnviroStart** power circuits. Appropriate cabling of suitable current rating should be used for the feed and supply and care should be taken noting that the feed from the connector block will be at the three phase RMS voltage of the unit.

6.6 DEFAULT DIP SWITCH SETTINGS

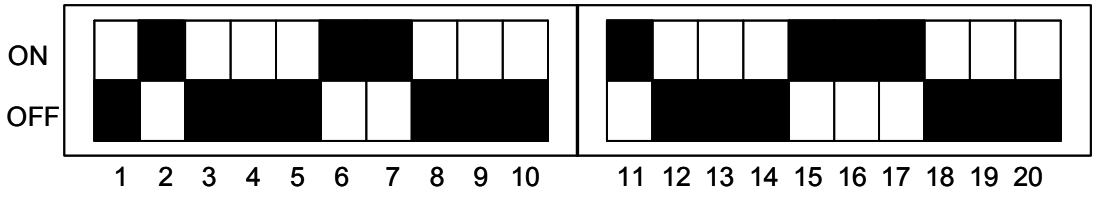
The unit is set to the 'Default Settings' before leaving the factory. These should be tried first and further adjustments only made where necessary to 'fine tune' the **EnviroStart**.

ADJUSTMENT	FUNCTION	DEFAULT SETTING	RESULT	SEE SECTION
Switches 1, 2 & 3	Start Ramp-Up Time	OFF, ON, OFF	Ramp Up at 20s.	6.6
Switch 4	Ramp Time x 4 Multiplier (Live Poll)	OFF	No Multiplication	6.7
Switches 5, 6	Stop Ramp-Down Time	OFF, ON	Ramp Down at 10s	6.8
Switches 7, 8 & 9	Start-Up Pedestal Voltage	ON, OFF, OFF	Set at 40% of Full Voltage	6.9
Switches 10 & 11	Stop Ramp-Down Pedestal Voltage	OFF, ON	Sets Initial Drop to 70% of Full Voltage	6.10
Switch 12	50/60Hz Select	OFF	50Hz Selected	6.11
Switch 13	Thyristor Fault Detect (Live Poll)	OFF	Fault Detection Enabled	6.12
Switch 14	Kick-Start Enable	OFF	Kick Start is Disabled	6.13
Switch 15	Kick-Start Level	ON	90% of Full Voltage	6.13
Switches 16 & 17	Kick-Start Time	ON & ON	Set at 0.25s	6.14
Switch 18	Emergency Run (Live Poll)	OFF	No Emergency Run	6.15
Switch 19	Not Connected			
Switch 20	Not Connected			
Potentiometer VR1	Current Limit (Live Poll)	Mid Rotation	Medium Power at Start of Ramp	6.2

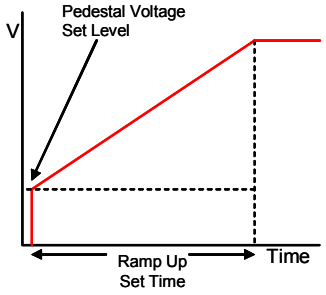
SEE SECTION 5.10 AND 5.11 FOR A DIAGRAM TO LOCATE THE ABOVE SWITCHES ON THE RELEVANT PCB.

Note that, except for switches and potentiometer marked “Live Poll” all switch changes will require that the EnviroStart CPU is reset either by powering the unit down or by using the CPU Reset button adjacent to the main processor for the changes to take affect.

DEFAULT SETTINGS - DIP SWITCH POSITIONS



6.7 START UP RAMP TIME SELECTION



The Ramp-Up-Time switches 1, 2 and 3 adjust the time period from the initial pedestal setting to full output voltage. (See also Section 6.7 regarding the x4 multiplier function which is enabled by Switch 4).

Switch settings as follows:

SWITCH 1	SWITCH 2	SWITCH 3	RAMP UP TIME
OFF	OFF	OFF	60s
OFF	OFF	ON	30s
OFF	ON	OFF	20s (Default)
OFF	ON	ON	10s
ON	OFF	OFF	5s
ON	OFF	ON	2s
ON	ON	OFF	1s
ON	ON	ON	0.5s

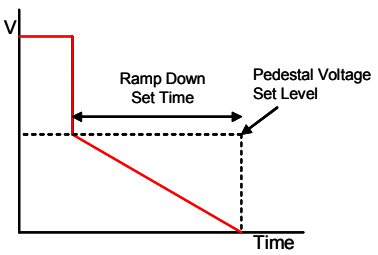
6.8 RAMP TIME MULTIPLIER

This facility on Switch 4, multiplies the ramp up time set by switches 1, 2 and 3, (and if enabled the ramp down) by a factor of 4 such that the ramp up time can be extended to 240s and the ramp down to 120s, if required.

Switch settings as follows

SWITCH 4	RAMP TIME MULTIPLIER
ON	Both Up and Down Ramp Times Multiplied x4
OFF	No Ramp Time Multiplication (Default)

6.9 SHUT DOWN TIME SELECTION

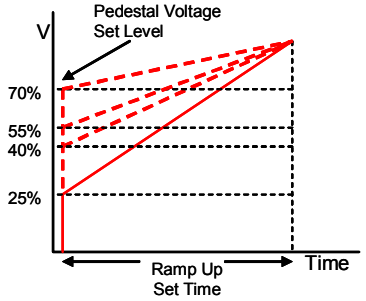


The Ramp-Down time Switches 5 & 6 adjust the time period from the initiation of a Soft Stop to the Ramp down Pedestal point set by Switches 10 and 11. (See also Section 6.7 regarding the x4 multiplier function which is enabled by Switch 4).

Switch settings as follows:

SWITCH 5	SWITCH 6	RAMP DOWN TIME
OFF	OFF	20s
OFF	ON	10s (Default)
ON	OFF	5s
ON	ON	2s

6.10 START UP RAMP PEDESTAL VOLTAGE SETTINGS



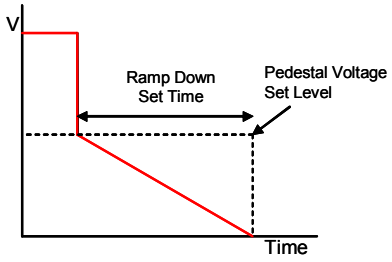
This sets the initial voltage that is applied to the motor. This is adjusted to a level so that the motor starts to accelerate smoothly and immediately.

It should normally not be necessary to adjust Pedestal voltage except where motors are started on-load with high loads. If there is a delay between startup and the motor starting to turn, increase the Pedestal Voltage until this disappears.

Switch settings as follows:

SWITCH 7	SWITCH 8	SWITCH 9	PEDESTAL VOLTS STARTS AT
ON	ON	OFF	25% of Full Voltage
ON	OFF	OFF	40% (Default)
OFF	ON	OFF	55% of Full Voltage
OFF	OFF	OFF	70% of Full Voltage
OFF	OFF	ON	100% (DOL start)

6.11 SHUT DOWN RAMP PEDESTAL VOLTAGE SETTINGS



This sets the voltage that the motor will drop to over the ramp down time after a soft stop has been initiated. This is adjusted to a level so that the motor decelerates smoothly.

Switch settings as follows:

SWITCH 10	SWITCH 11	PEDESTAL VOLTS INITIAL DROP TO
ON	ON	50% of Voltage
ON	OFF	60% of Voltage
OFF	ON	70% of Voltage (Default)
OFF	OFF	80% of Voltage

6.12 SUPPLY FREQUENCY SELECTION

This switch function should be set to reflect the supply frequency of the three-phase mains supply.

Switch settings as follows

SWITCH 12	FREQUENCY SELECT
ON	60Hz Selected
OFF	50Hz Selected (Default)

6.13 THYRISTOR & TRIGGER FAULT DETECTION SELECTION

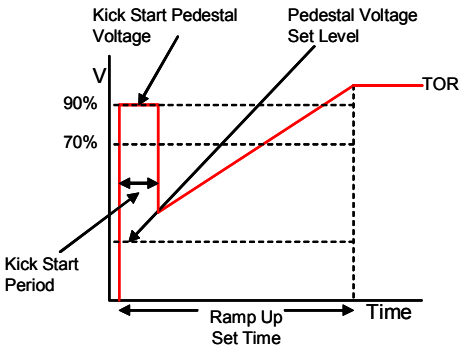
EnviroStart has an intrinsic thyristor fault detection programme running at all times during operation. The system software constantly monitors the correct firing and operation of the thyristors and will stop the system and register a fault condition in the event of a gate, a junction or a trigger mode failure.

If the fault exists at the time that a start signal is applied to **EnviroStart** then the motor may start to turn if the initial phase drive is a functional thyristor pair, usually there will be no more than 90^{o} rotation. By the time that the system starts to fire the second pair of thyristors the fault will have been detected, and the drive will be removed and the fault condition indicator will register with four quick flashes followed by a one second wait period on the yellow Fault LED. It may be necessary with some low power factor motors to disable this detection circuit to avoid unnecessary fault registration.

Switch settings as follows

SWITCH 13	THYRISTOR & TRIGGER FAULT DETECTION
OFF	Detection Not Disabled (Default)
ON	Detection Disabled

6.14 KICK START SELECTION



In some high stiction, high static friction or high torque loads, a better mechanical start can sometimes be achieve by using the Kick Start feature of **EnviroStart** to overcome the initial inertia of the load.

If the load is not of this type then this feature should not be used and switch 14 should be in the OFF position.

Switch settings as follows

KICK START ENABLE	Switch 14 enables Kick Start function when ON (Default is OFF)
KICK START LEVEL	Switch 15 sets Kick Start volts to 70% when OFF. 90% when ON (Default is ON at 90% of Full Voltage)

6.15 KICK START TIME DURATION SELECT

Switches 16 and 17 change the period that the kick start remains in place, allowing sufficient “kick” to be given to the motor to start effective rotation.

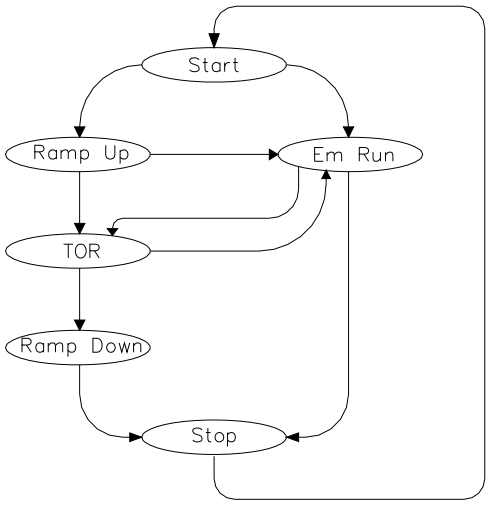
Switch settings as follows

SWITCH 16	SWITCH 17	KICK START DURATION
ON	ON	0.25s (Default)
ON	OFF	0.5s
OFF	ON	1s
OFF	OFF	2s

6.16 EMERGENCY RUN SELECTION

In the event of control circuit failure it is possible to force the thyristors into full permanent conduction allowing the motor to start and run direct on line, (DOL). This feature is enabled when connectors DIP Switch 18. In this condition it is not necessary to have a start signal on condition on pins 1 through 4.

Flow chart showing the conditional relationships for the Emergency Run functions.



In this condition the Yellow LED illuminates aperiodically, flashing three times in quick succession followed by an off period of twice the on period of the three flashes. It is not recommended that units be left operating in the Emergency Run condition for any extended period of time however periods of up to 336 hours are acceptable.

In Emergency Run the TOR, (Top of Ramp), relay enables and changes state 2.8s after the start signal has been applied to connector pins 1 through 4.

During the time that the unit is operating in emergency run you should expect the system to generate greater heat than it would during normal operation, this is to be expected as the Thyristors are firing continuously. In this condition it may also be noticed that there is a high frequency whistle from the Thyristor Packs, (units up to 110kW), this is perfectly normal and should not be a cause of concern.

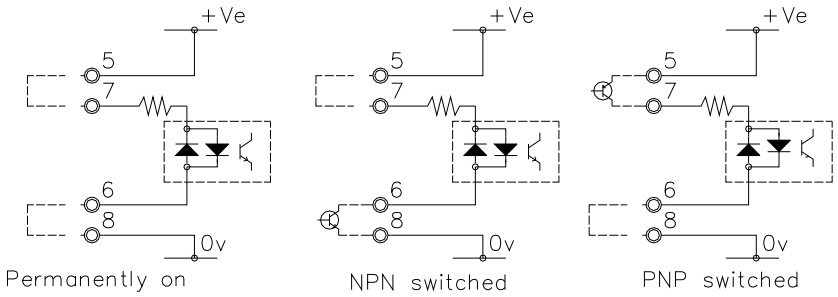
Switch settings as follows

SWITCH 18	FMERGENCY OR NORMAL OPERATION MODE SELECT
ON	In Emergency Run Mode
OFF	In Normal Operational Mode (Default)

6.17 SOFT STOP ENABLE SELECTION

If a Soft Stop is required for the motor then this is enabled by toggling a signal onto connector pins 5 through 8 in accordance with the connection diagrams below.

The input circuit is capable of handling both direct start, having connector pins 7 and 8 linked and then making the link between connector pins 5 and 6 either via a switch or permanently coupled so that the motor starts on power being supplied or from a logic high, (source) or logic low, (sink) from a PLC system.



Soft Stop Enable

The ramp down feature is designed to consist of three stages. When the start signal link on connector pins 5 though 8 are made is made the unit drops the voltage to the output immediately to the set percentage of supply voltage, defined by Switches 11 and 12, the control then linearly decreases the voltage from that percentage of maximum supply voltage in the time as set by Switches 5, 6 and 7.

6.18 SYSTEM READY RELAY (Contacts 27 through 32)

This relay energises when power is applied to the **EnviroStart** and indicates that the PCB and all logic functions are operational. It is an indication of the system being available for operation and remains enabled throughout the running of the unit.

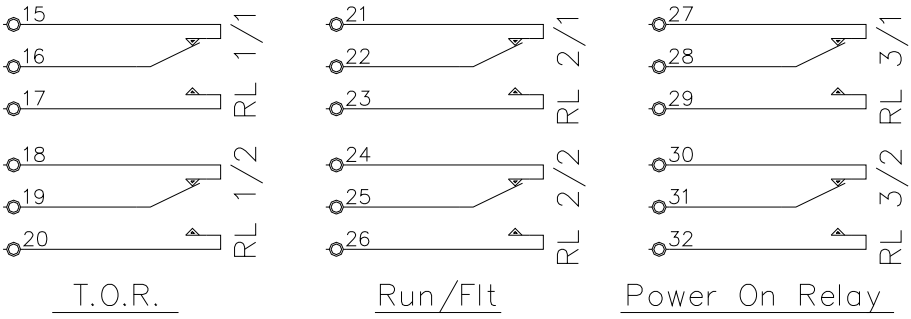
6.19 RUN/FAULT RELAY (Contacts 21 through 26)

This relay energises when the start signal is applied to the **EnviroStart**. It does not indicate that the motor is at speed or running; just that there is a legitimate start signal applied to the control circuit. It can be used in reciprocal fashion to provide a fault indication if that is required**.** When soft stop has been used this relay does change state even though there may still be a “start condition” on connectors 1 through 4.

When the control circuit, contacts 1 through 4, are used to switch the motor on and off there is a 100ms delay between the time that the thyristors stop firing and the operation of the Run Relay, this allows this relay to be used to ensure that items like the Line Contactor are switched at near zero current rather than having them break at full power with the resultant arcing and contact damage that creates. If Soft Stop is enabled then this delay operates at the end of the ramp.

6.20 TOP OF RAMP RELAY (Contacts 15 through 20)

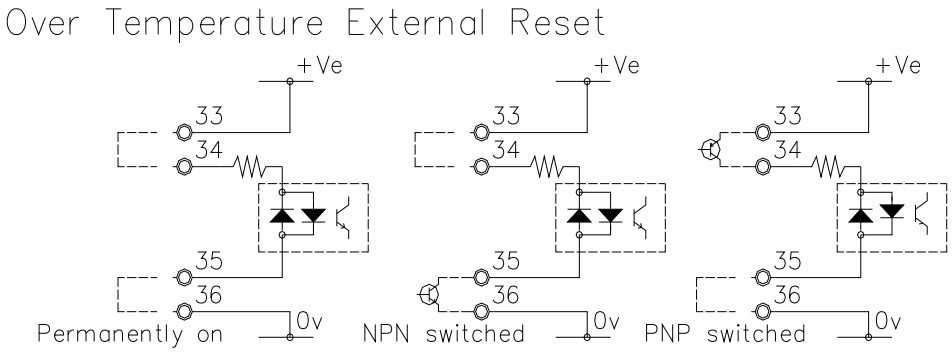
This relay energises when the motor the **EnviroStart** is controlling has reached top of ramp and is at synchronous speed. The logic does not allow this relay to operate until the ramp up time period as defined by switches 1, 2 and 3 has elapsed though on lightly loaded motors full speed may have been reached prior to this time. If soft stop is enabled and actioned by the provision of a momentary signal to connectors 5 through 8 then as the unit starts to ramp the motor down and the rotation moves from TOR this relay changes state.



6.21 OVER TEMPERATURE TRIP CONTROL (55kW to 800kW)

If the **EnviroStart** heatsink goes above 90^{o}C, the heatsink over-temperature trip will open and turn off the **EnviroStart**. The thermal overloads themselves will automatically reset once the temperature drops below 70^{o}C however the motor will not automatically restart until such time as the over temperature reset button on the PCB is made. (For convenience an external switch contact capability is provided on connectors 33 through 36).

Note that over temperature trips are not fitted to units of 5.5 through to 37kW.



An Optional motor Thermistor/thermal trip interface circuit is available which will allow the coupling of motor temperature sensors into the EnviroStart control circuit.

With this circuit fitted and the motor temperature sensors linked into the EnviroStart control either motor or EnviroStart thyristors going over temperature will cause the thermal trip to activate safely shutting the system down prior to any damage being caused to either motor or EnviroStart.

Should you want this option then it must be specified at the time that your EnviroStart is ordered,

6.22 PHASE LOSS DETECTION (2.2kW – 800kW)

As part of its power-up system integrity checks the **EnviroStart** software evaluates the continuity of both input supplies and also feeds to the motor and reports any functional phase or continuity loss with the yellow LED 1 flashing five times followed by a 1s period. (It should be remembered that normally, the control PCB of the **EnviroStart** is powered, via a transformer, from two of the input phases and as such if one of these phases is missing then the PCB will remain un-powered and no feedback will be given).

Once the system is driving a motor it is not possible to detect a phase loss on the input, (supply to the **EnviroStart**), if the two PCB supply phases remain intact, in such circumstances the motor may continue to run. If a phase loss occurs on the feed to the motor, during normal run then the system will shut down and report a thyristor fault condition with the yellow LED 1 flashing four times followed by a 1s period. This change of report function is created because the **EnviroStart** sees this lack of continuity to the motor as a simple inability to fire the thyristors and as such reports it in that way rather than the perceived secondary possible problem which is just that the connection to the motor has been lost.

6.23 LED INDICATORS

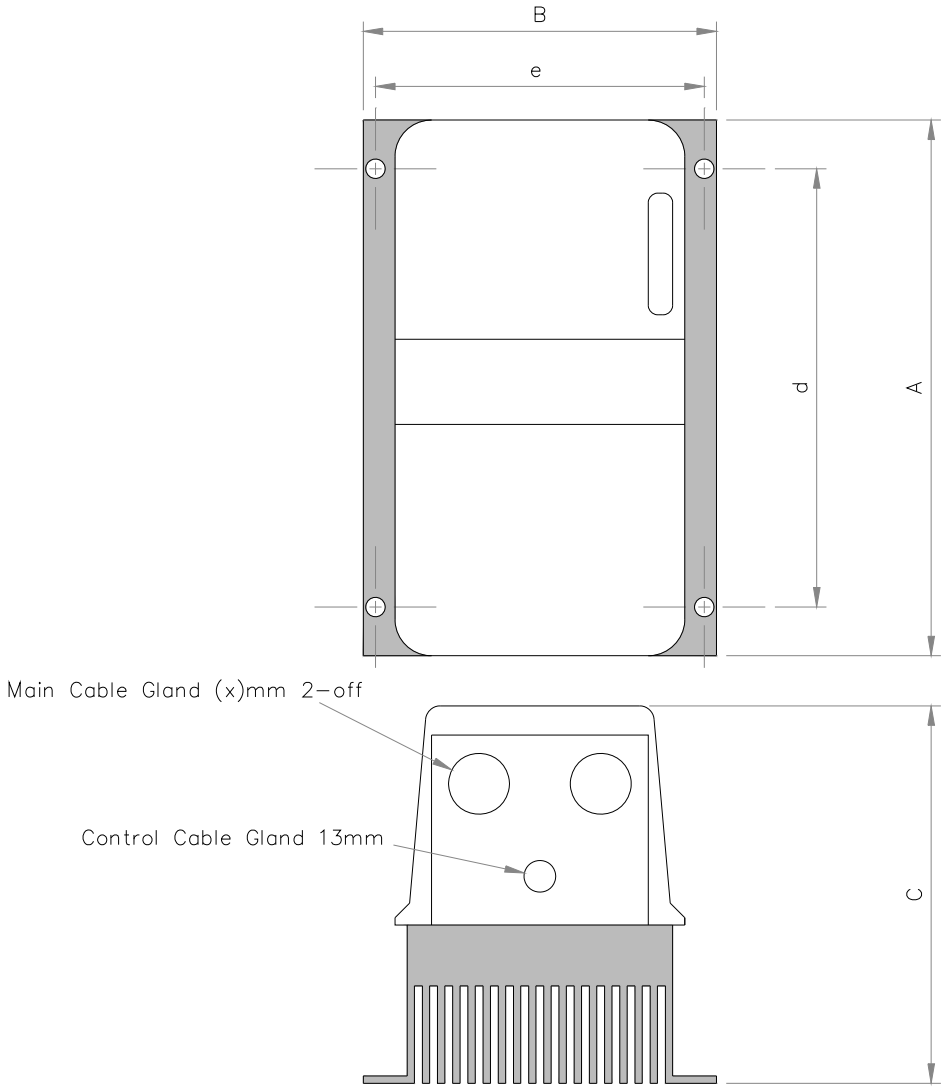
LED 1	Ramp Up End of Ramp Down Emergency Run Thyristor Fault Phase Loss	1. Illuminates constantly during ramp up, goes off at TOR. (Section 6.6) 2. Flashes twice separated by 1s period indicating that the unit has reached the bottom of a Soft Stop ramp. (Section 6.8) 3. Flashes three times separated by a 1s period if Emergency Run is enabled. (Section 6.16) 4. Flashes four times separated by a 1s period if a thyristor Fault is detected. (Section 6.13 and 6.22) 5. Flashes five times separated by a 1s period if a phase loss is detected on power up. (Section 6.22)
LED 2	Power On	Illuminates when unit is powered and ready to operate, indicates that initialisation self-test has been completed
LED 3	Run	Illuminates when a legitimate start signal has been received by the control circuit. This LED does not indicate that the motor rotor is turning
LED 4	Current Limit	Illuminates when line current is at the set current limit level. This LED will flash intermittently during start when Current Limit is set below Full Power on VR1
LED 5	Top Of Ramp	Illuminates when motor is at full speed, this LED can only come on after ramp time set by time switches 1, 2, 3 and 4

INSTALLATION AND COMMISSIONING GUIDE

END

Appendix 1

Mechanical Drawing 5.5kW – 37kW (220V & 400V)

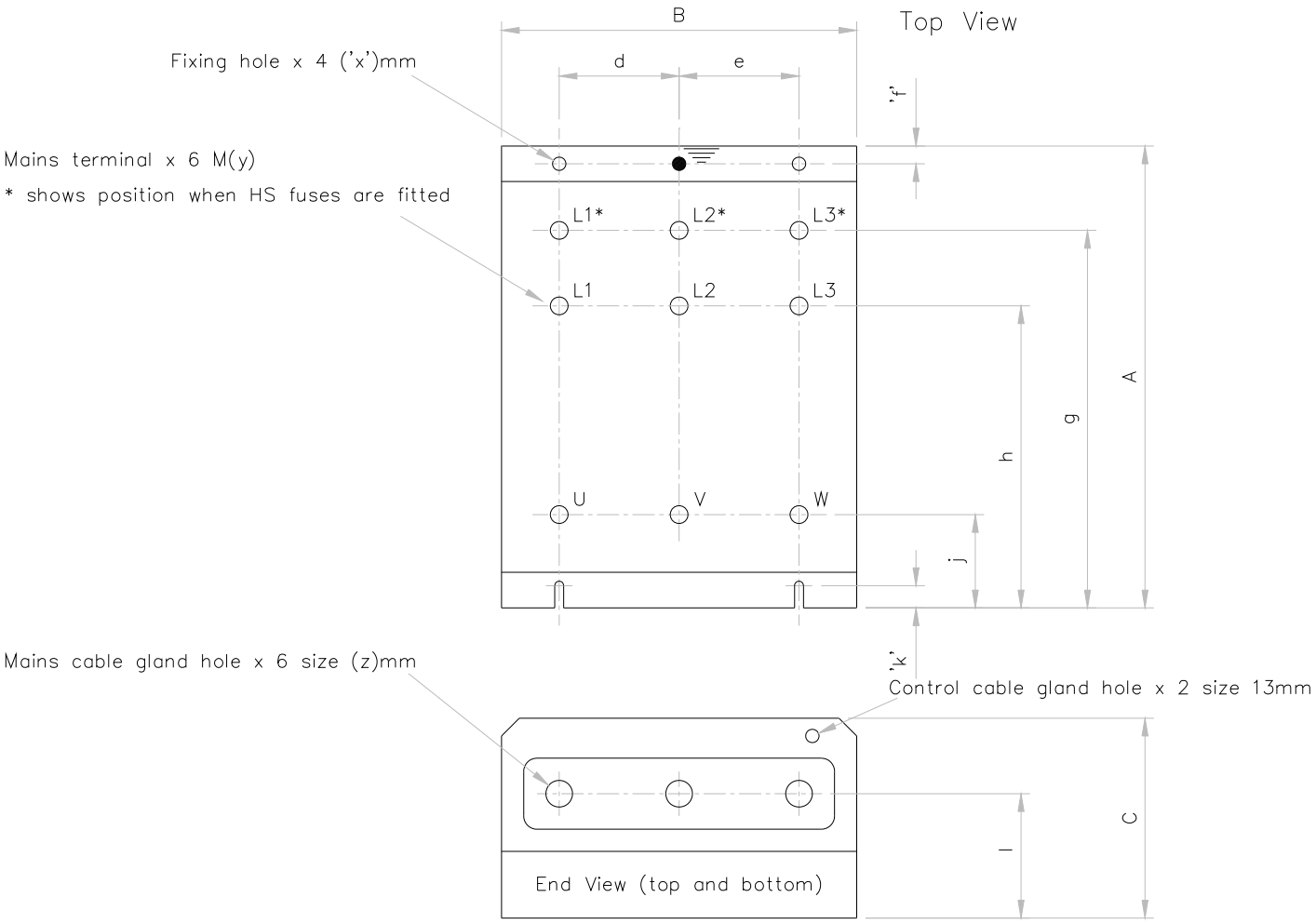


MODEL	A	B	C	d	e	x	Earth	Fixing Hole	Mains Connections
5.5–7.5kW	220	145	155	180	135	25	5	5.5	M5
11–22kW	220	145	175	180	135	25	5	5.5	M5
30–37kW	330	145	175	180	135	25	5	5.5	M5

Mechanical Drawing

5.5kW – 110kW (208V, 480V 570V & 690V)

55kW – 110kW (220V & 400V)



MODEL	A	B	C	d	e	f	g	h	j	k	I	x	y	z	Earth
30-37kW HV	430	254	280	70	70	7	351	271	65	10	78	6	8	30	6
55-110kW	430	254	280	70	70	7	351	271	65	10	78	6	8	30	6

The dimensions below only relate to the 208V, 480V, 575V and 690V HV units

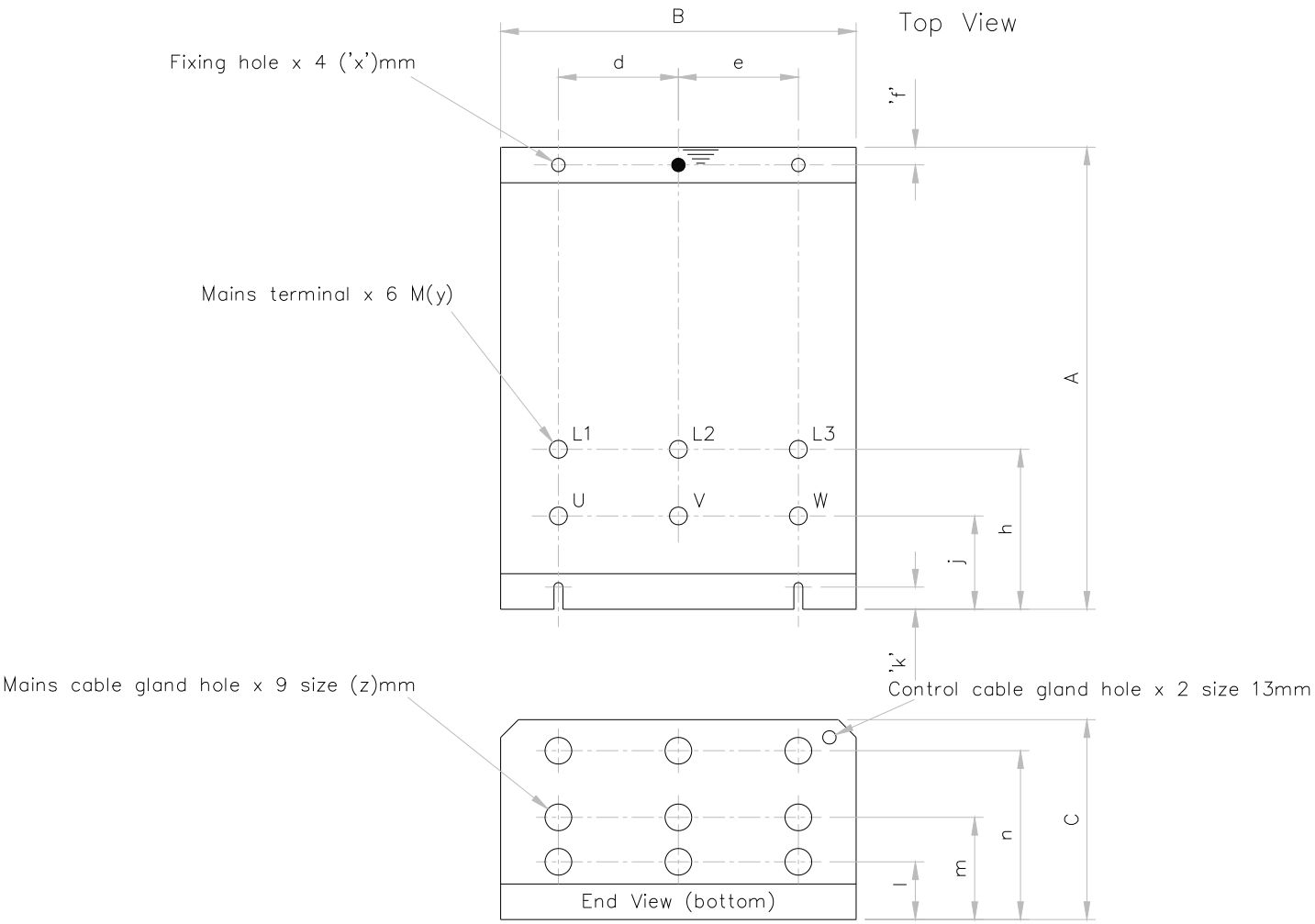
5.5-22kW HV	325	164	195	50	50	7	250	198.5	65	10	78	6	8	30	6

Note – Height of L1, L2, L3, L1*, L2*, L3*, U, V, W corresponds to I
All dimensions in mm

Mechanical Drawings

132kW – 375kW

(208V, 220V, 400V, 480V 570V & 690V)



All dimensions in mm

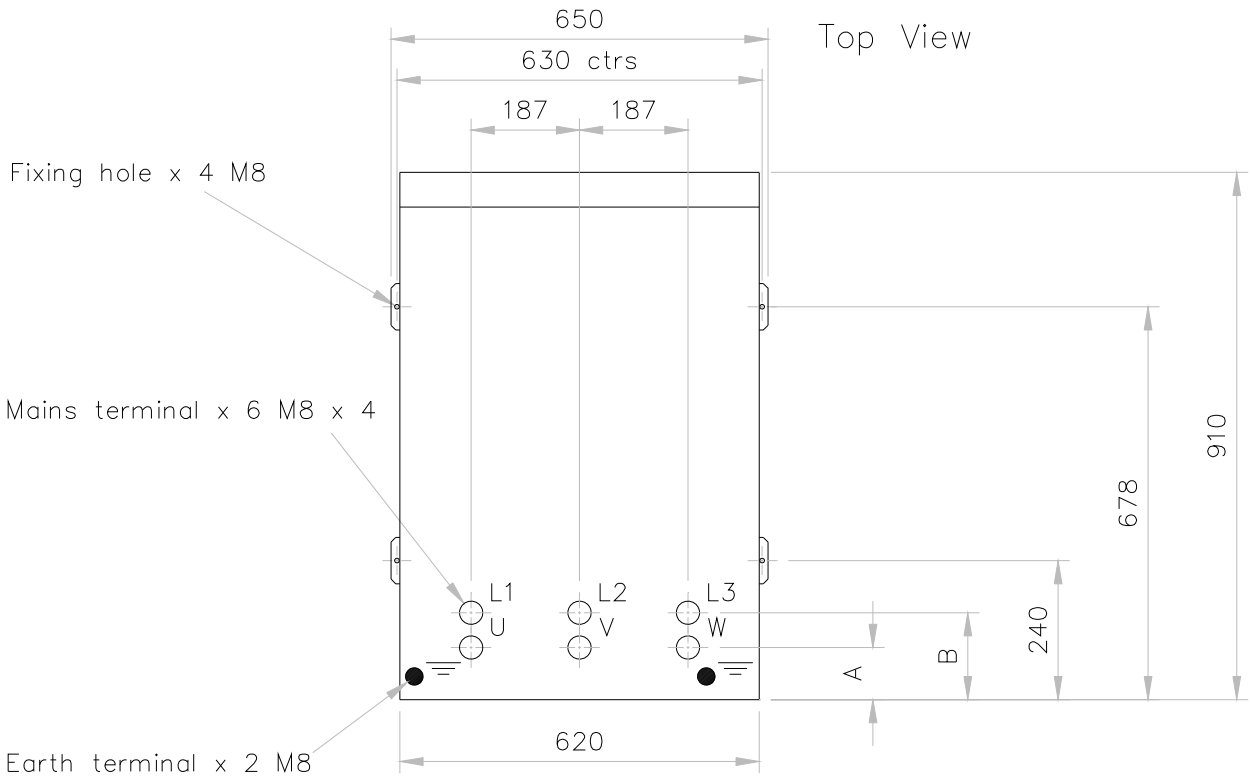
MODEL	A	B	C	d	e	f	h	j	k	l	m	n	x	y	z	Earth
132–225kW	580	368	228	116	116	8	118	90	10	56	101	168	8	2 x 8	30	8
260–375kW	720	462	253	135	135	8	133	101	10	68	120	195	8	2 x 8	40	8

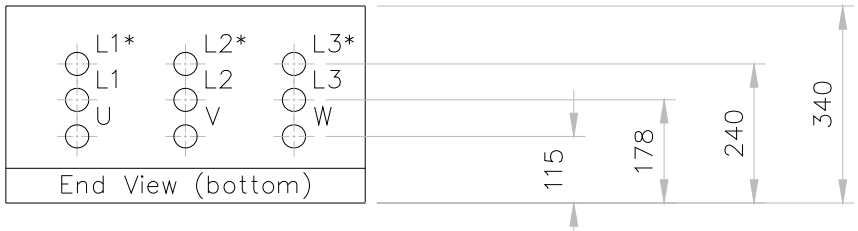
Note – Height of L1, L2, L3 without fuses corresponds to m, with fuses n, U, V, W corresponds to l

Mechanical Drawings

450kW – 800kW

(208V, 220V, 400V, 480V, 570V & 690V)





L1*, L2*, L3* show position when fuses are fitted

MODEL	A	B
450–500kW	150	90
630–800kW	90	150

Appendix 2

THE TESTING, REPLACEMENT AND RE-ASSEMBLY OF THYRISTOR PUCK's and PAK's

Thyristor Power Circuit Test

Ensure that the power is off to all areas of the EnviroStart being tested. Disconnect the feed to the motor. Measure the resistance between the input and the output of the thyristors, that is the supply, (L1, L2, L3), and the output, (U, V, W). A healthy reading will be in excess of 100kΩ. Any open or short circuit thyristors should be replaced. It is recommended that if a fault is found on any Puck or Pak that all the thyristors in that EnviroStart be changed. (This is because in the event of one or two phases developing a fault then the other one or two phases will be stressed and their life expectancy substantially reduced).

Thyristor Gate - Cathode Test

Ensure that the power is off to all areas of the EnviroStart being tested. The connections are the same for both the HP and the LP boards. The resistance measured between W and G6, L3 and G5; V and G4, L2 and G3; W and G2, L1 and G1 should be between 5Ω and 25Ω. On any EnviroStart the value measured on each of the six Gate-Cathode pairs should be within a few ohms of each other. On Puck based systems, (132kW and above), if the meter reads open-circuit on any Gate-Cathode pair then additionally check the cable continuity and the crimp connections to between the PCB and the puck. Any open or short circuit thyristors should be replaced.

Thermal/Electrical Mounting Compound

We recommend that Westcode Jet Lube SCX13 mounting compound is used between the thermally and electrically conductive surfaces of Pucks and Paks and the heatsink to which they are mounted, (Westcode stock number 298WC-HSSCX13). This should be applied as a thin film only. It is important that both electrical and thermal conductivity is maintained on Pucks, on Paks only thermal conductivity is critical as the base of the thyristor pack is electrically isolated.

Thyristor Pak, Re-assembly

In units up to 110kW, (205A), the power assembly consists of isolated two-thyristor Pak devices. These devices are manufactured as an anti-parallel pair within a single electrical component so must be changed complete. Their replacement is self-evident however care should always be taken to ensure that the gate and cathode connections are maintained as they were when the product was delivered.

To fix the Pack to the heatsink ensure that the heatsink is clean and free from pitting or scratches. Apply a thin even film of heatsink compound to the base of the Pak and then torque that Pak down according to the table below.

Size of Unit	Thyristor to Heatsink	Pak Screw Terminals
5.5 – 37kW	2.5 – 4.0Nm	2.5 – 4.0Nm
55 – 63 kW	2.25 – 2.75Nm	4.5 – 5.5Nm
75 – 110kW	2.5 – 5.0Nm	12 – 15Nm

Connection is made to the gates and cathodes on each Pak via push on connectors; ensure that these are not shorting against each other and that the flying lead is secure within the connector assembly. The supply and motor feed connections are made on the "top" of the Paks and should be torqued down according to the table above.

Power-Stack, Puck Device Re-assembly

In units of 132kW, (255A), and above, individual Puck devices are sandwiched between two aluminium heatsinks to form stack assemblies. Each thyristor is clamped by two fixing bolts, with a centre bolt compressing spring washers in order to give an indication of correct clamping tension, (see the drawing below). The centre bolt is NOT a fixing bolt its only purpose is to set the tension on the spring loaded washers so when the fixing bolts are tightened to the correct torque the centre tab washer is freed. The torque setting on the centre bolt is factory set and under no circumstances should be loosened or the torque setting on the spring washers will be lost.

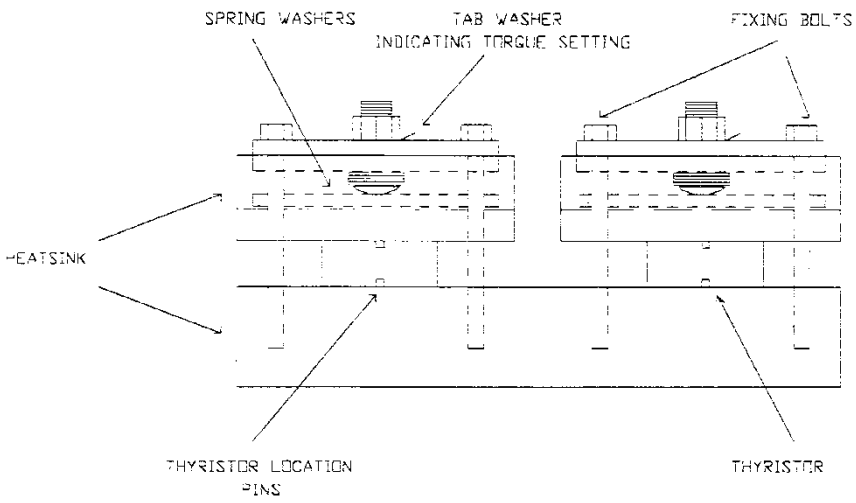
When dismantling, the two fixing bolts should be loosened evenly. Note the polarity of the devices sandwiched between the heatsink plates, they are an anti-parallel pair and should be replaced as such so noting polarity during dis-assembly is wise.

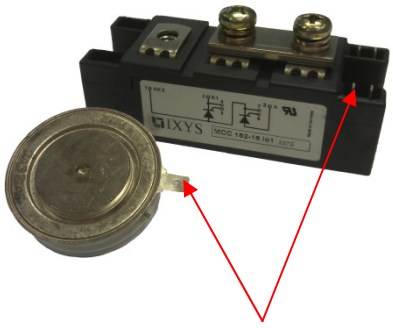
Re-assembly of the power assemblies using Puck devices requires some care. Smear a small amount of electrically and thermally conductive mounting compound evenly onto the top and base, (anode and cathode), of the new device before positioning it, ensure that the device is correctly polarized and is sitting on the locating bump machined into the heatsink; ensure that the gate connector lead is secure on the Puck and that the lead does not become trapped during the re-assembly process. It is important that all assembly components are fitted to where they originated as any variances in machined tolerances may affect the force applied to the devices.

Tighten the securing bolts a small amount and evenly, alternating between bolts so keeping the pressure plate parallel to the heatsink at all times until such time as the spring washer under the centre locking nut becomes just slightly loose and can be moved by finger. At this point the correct amount of torque has been applied to the assembly and the Puck within that assembly. This correct pressure is important as the anode and cathode connections on the thyristor silicon within a Puck are only in full contact with the external surface connections when compressed.

Because of the way that Pucks are positioned and held in place it is recommended that all replacement work is undertaken with the EnviroStart unit on its back on a workbench.

'Hockey Puck' Stack Assembly





THYRISTORS USED IN ENVIROSTART SS AND MEC PRODUCTS 220V & 400V, 5.5kW to 800kW

PART No.	THYRISTOR TYPE IXYS PAKS	AMPS @ T_{case} 85°C	QTY	PART No.	THYRISTOR TYPE WESTCODE - GD RECTIFIER PUCKS	AMPS @ $T_{heatsink}$ 85°C	QTY
TPMEC/SS – 5.5	MCC19-14io1	18	3	**TPMEC/SS – 132**	T750/14	530	6
TPMEC/SS – 7	MCC26-14io1	27	3	**TPMEC/SS – 150**	T750/14	530	6
TPMEC/SS – 11	MCC56-14io1	60	3	**TPMEC/SS – 186**	T1100/14	835	6
TPMEC/SS – 15	MCC56-14io1	60	3	**TPMEC/SS – 225**	T1250/14	835	6
TPMEC/SS – 22	MCC95-14io1	116	3	**TPMEC/SS – 260**	T1800/14	835	6
TPMEC/SS – 30	MCC95-14io1	116	3	**TPMEC/SS – 315**	T1800/14	1216	6
TPMEC/SS – 37	MCC95-14io1	116	3	**TPMEC/SS – 375**	T2000/14	1216	6
TPMEC/SS – 55	MCC162-14io1	181	3	**TPMEC/SS – 450**	T2000/14	1338	6
TPMEC/SS – 63	MCC162-14io1	181	3	**TPMEC/SS – 500**	T2500/14	1684	6
TPMEC/SS – 75	MCC220-14io1	250	3	**TPMEC/SS – 630**	T2500/14	1684	6
TPMEC/SS – 90	MCC250-14io1	287	3	**TPMEC/SS – 800**	T4000/14	2743	6
TPMEC/SS – 110	MCC310-14io1	320	3				

Appendix 3

GENERAL SPECIFICATION

MODEL	CURRENT	kW @ 220V	kW @ 400V	kW @ 575V	kW @ 690V	WEIGHT kg	CT SPECIFIED	CT RATIO	FANS
400-TPSSG6 - 5.5	11	2.2	5.5	6	7.5	2	LA2100	1000/1	N/A
400-TPSSG6 - 7	16	4	7.5	9	11	2	LA2100	1000/1	N/A
400-TPSSG6 - 11	23	5.5	11	13	15	3	LA2100	1000/1	N/A
400-TPMSS - 15	30	7.5	15	18.5	22	3	LA2100	1000/1	N/A
400-TPSSG6 - 22	45	11	22	26	30	3	LA2100	1000/1	N/A
400-TPSSG6 - 30	60	15	30	37	45	4	LA2100	1000/1	1 X 120mm
400-TPSSG6 - 37	75	22	37	45	55	4	LA2100	1000/1	1 X 120mm
400-TPSSG6 - 55	105	30	55	63	75	15	LA2100	1000/1	2 x 120mm
400-TPSSG6 - 63	120	37	63	75	90	15	LA2108	2000/1	2 x 120mm
400-TPSSG6 - 75	145	45	75	90	110	15	LA2108	2000/1	2 x 120mm
400-TPSSG6 - 90	170	55	90	110	132	16	LA2108	2000/1	2 x 120mm
400-TPSSG6 -110	205	63	110	132	150	16	LA2108	10000/1	2 x 120mm
400-TPSSG6 - 132	255	75	132	150	186	28	TX008	10000/1	3 x 120mm
400-TPSSG6 - 150	290	90	150	186	225	28	TX008	10000/1	3 x 120mm
400-TPSSG6 - 186	340	110	186	225	260	28	TX008	10000/1	3 x 120mm
400-TPSSG6 - 225	412	132	225	260	315	28	TX008	10000/1	3 x 120mm
400-TPSSG6 - 260	475	150	260	315	375	45	TX008	10000/1	3 x 150mm
400-TPSSG6 – 315	580	186	315	375	450	45	TX008	10000/1	3 x 150mm
400-TPSSG6 - 375	670	215	375	450	500	45	TX008	10000/1	3 x 150mm
400-TPSSG6 - 450	800	260	450	500	630	120	TX009	10000/1	2 x 220mm
400-TPSSG6 – 500	900	315	500	630	750	120	TX009	10000/1	2 x 220mm
400-TPSSG6 - 630	1100	375	630	750	900	120	TBA	TBA	2 x 220mm
400-TPSSG6 - 800	1400	450	800	900	1200	120	TBA	TBA	2 x 220mm

The kW ratings are all based on calculations scheduled with a standard four-pole motor operating at a nominal $T_{ambient}$ of +20°C at sea level. All units should be selected based on the current rating of the motor to which they are fitted.

Appendix 4

FAN SPECIFICATION

PAPST PART NUMBER	GD RECTIFIER PART NUMBER	ENVIROSTART SIZE	FREE AIR FLOW RATE	FAN DIAMETER
4600N/4650N	550010A/ 550010B	30kW - 225kW	160 m^3/hour	120 mm
7400N/7450N	550006A/550006B	260kW – 375kW	350 m^3/hour	150 mm
N/A	550002A /550002B	450kW – 800kW	900 m^3/hour	220 mm

Should you need to change any of the fans within your **EnviroStart** system please ensure that units compatible with the above are used. It is not possible to exchange fans for units of different physical size without damaging the **EnviroStart** unit.

Appendix 5

HP – kW CONVERSION

HP - kW Conversion

HP Std	Amps	kW @ 120V	kW @ 220V	kW @ 400V	kW @ 570V	kW @ 690V
Single Phase						
1.5	4	0.5	1	N/A	N/A	N/A
3	10	1	2	N/A	N/A	N/A
5	15	1.6	3	N/A	N/A	N/A
Three Phase						
7.5	12	N/A	2.2	5.5	6	8
10	16	N/A	3.5	7.5	9	11
15	23	N/A	5.5	11	11	15
20	30	N/A	7.5	15	15	18.5
25	37	N/A	7.5	18.5	18.5	22
30	45	N/A	9	22	22	30
40	60	N/A	11	30	30	37
50	75	N/A	15	37	37	45
75	95	N/A	22	55	55	63
100	145	N/A	30	75	75	90
125	170	N/A	37	90	90	110
150	205	N/A	45	110	110	132
200	290	N/A	63	150	150	186
250	340	N/A	75	186	186	225
300	410	N/A	90	225	225	260
350	475	N/A	110	260	260	315
400	527	N/A	110	260	315	375
450	580	N/A	132	315	315	375
500	670	N/A	150	375	375	450
550	735	N/A	150	375	450	500
600	800	N/A	186	450	450	500
650	850	N/A	186	450	500	630
700	900	N/A	200	500	500	630
750	1000	N/A	N/A	N/A	N/A	N/A
800	1100	N/A	N/A	N/A	N/A	N/A
850	1150	N/A	225	630	630	800

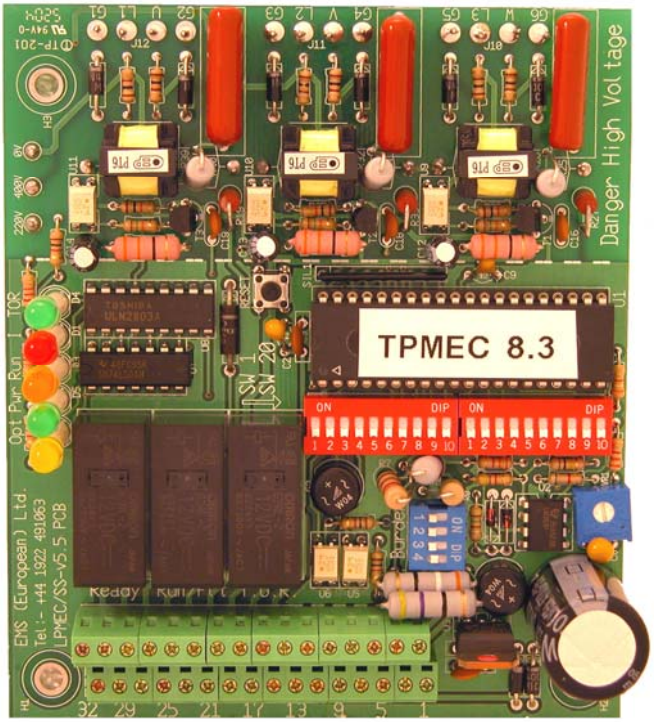
Reflects Motor Standard Ratings and is not a numerical conversion.

Appendix 6

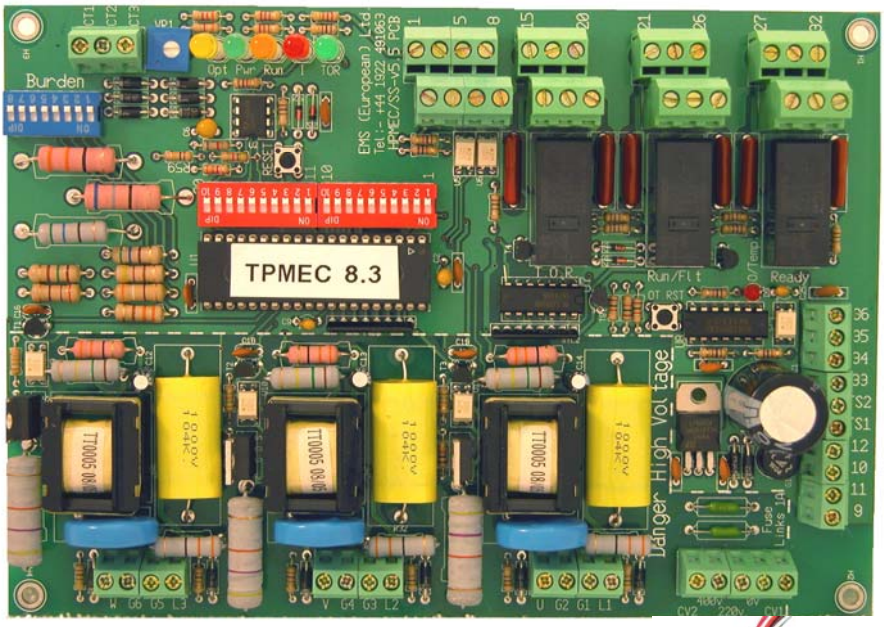
PCB PHOTOGRAPHS

LPMEC/SS PCB v 5.5 2005

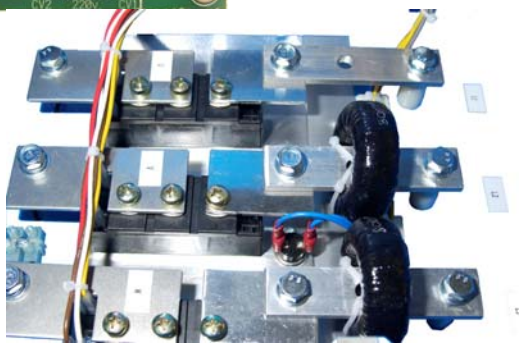
Showing the position of the bus-bar, linking on the supply inputs, (L1, L2 and L3) side of the thyristor Paks on units of 5.5kW through 37kW.



HPMEC/SS PCB v 5.5 2005



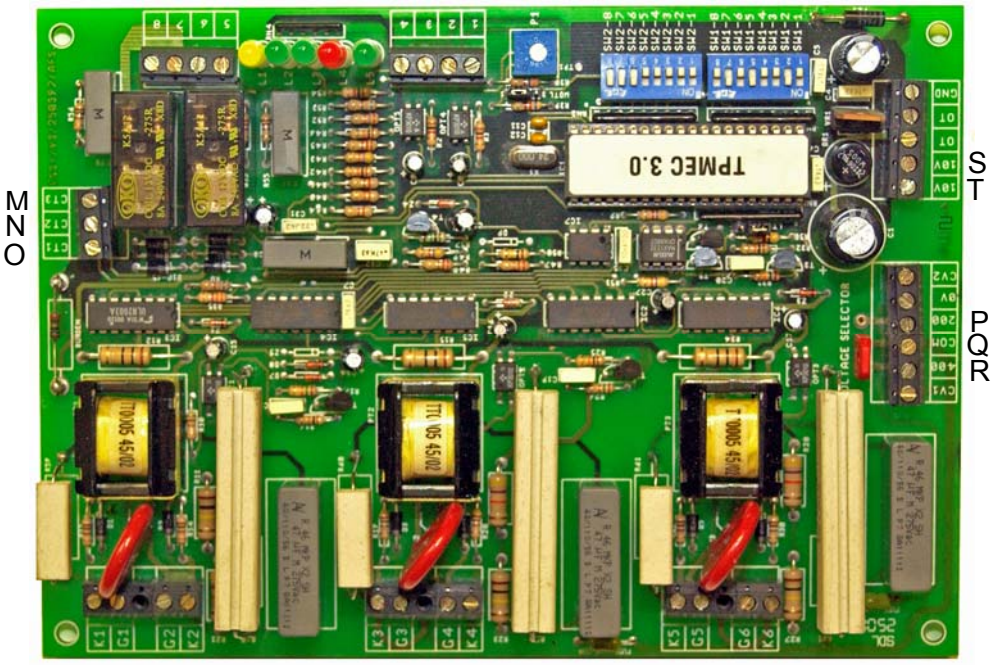
Showing the position of the bus-bar, linking on the motor feed inputs, (U, V and W) side of the thyristor Paks on units of 55kW through 800kW.

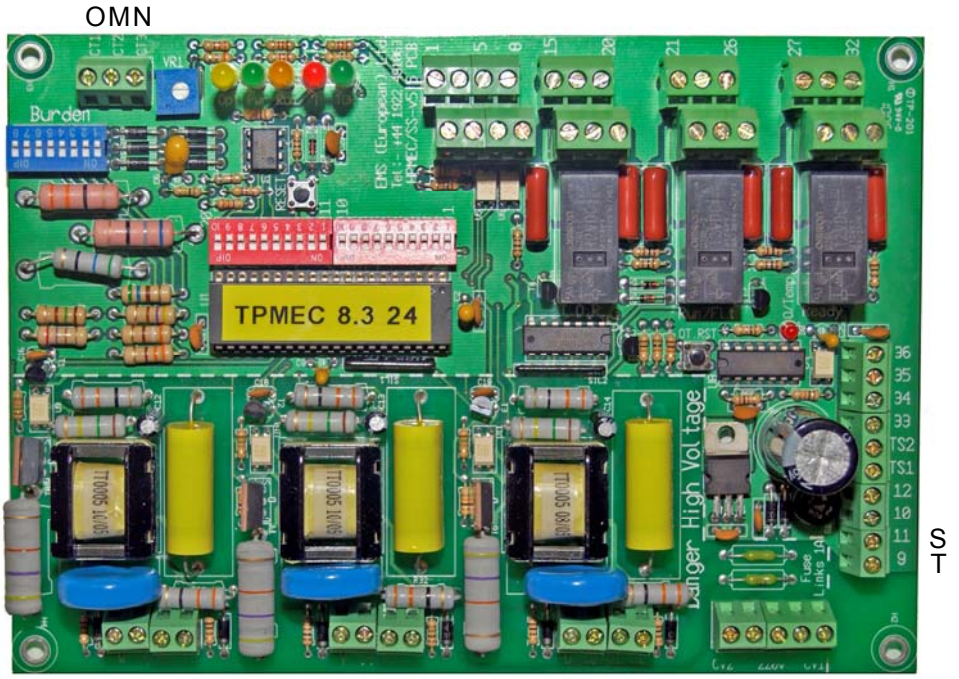


Appendix 7

PCB REPLACEMENT

The replacement of a Generation 5 PCB with a Generation 6 PCB should be a straightforward affair however some of the connections are located at different points on the PCB's and the "order" of Gate and Cathode connections on the Generation 6 HPMEC/SS PCB is different to that of its predecessor. (In this careful reference should be made to the connection table on page 18 of this Installation and Commissioning Guide).



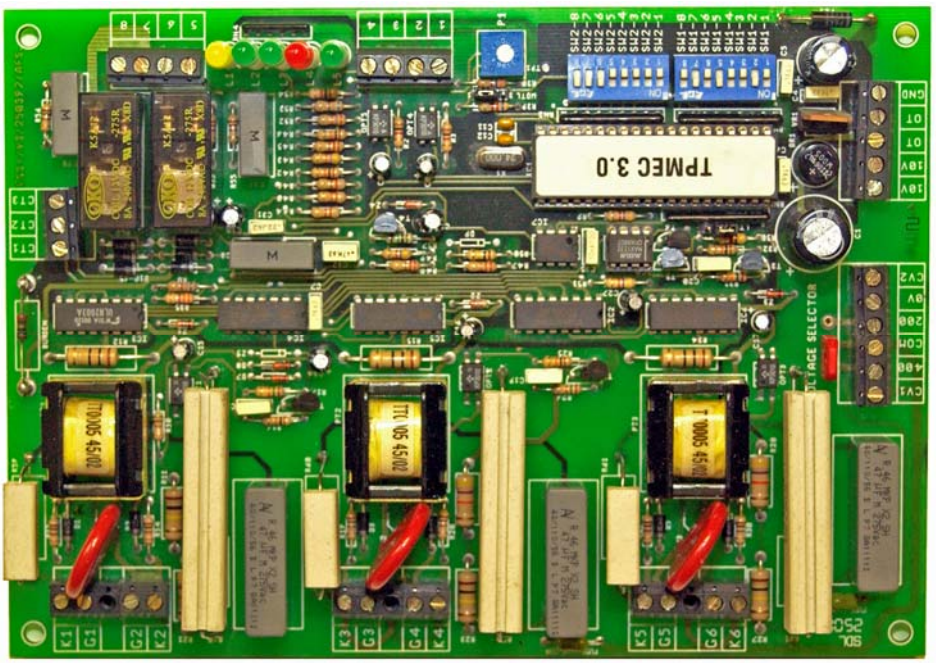


It is unimportant which pairs of Gate and Cathode connections are on each pair output.

The pictures show the colours of the various connection wires onto the two types of PCB.

When changing PCB's, always ensure that you take careful note and label the position and colour of the wires being removed so that they can be fitted back into the correct places on the new PCB

R Y
Bk G
R Y



Bl
Bl
W
Y

Bk
R

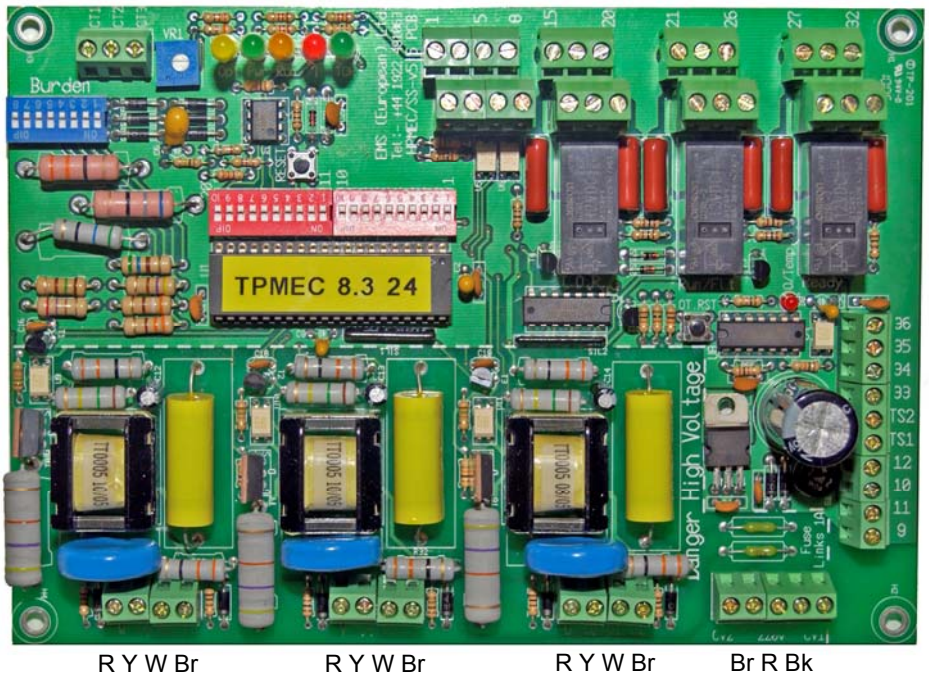
Br

R Y W Br R Y W Br R Y W Br

Key

R = Red
Y = Yellow
G = Grey
Br = Brown
Bk = Black
Bl = Blue
W = White

R R Bk
Y Y G



Bl
Bl

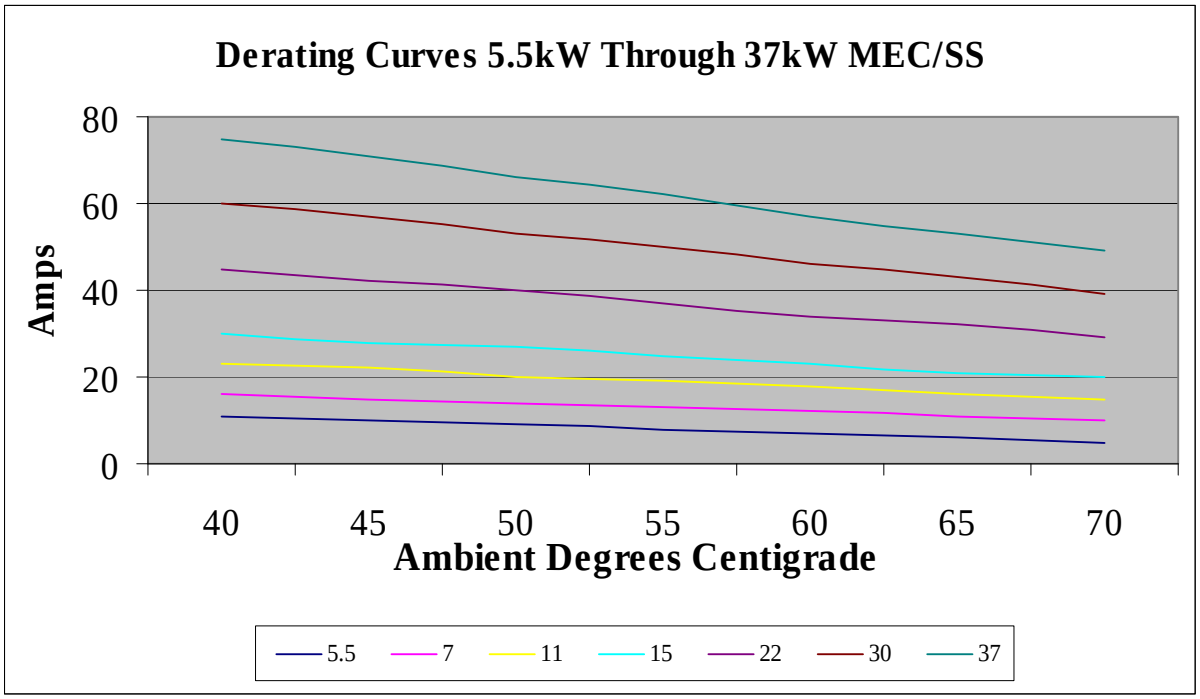
Y
W

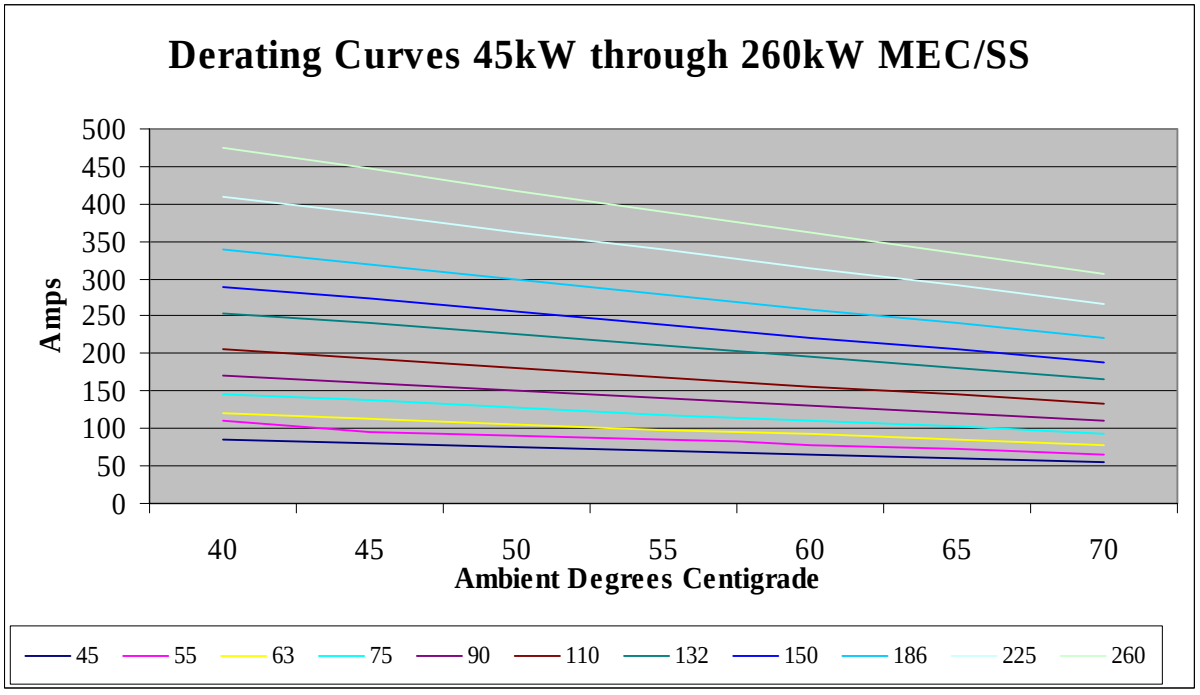
R Y W Br R Y W Br R Y W Br Br R Bk

The LPMEC/SS PCB replacement should only be undertaken by a specialist facility as the thyristors on the Generation 5 systems were mounted directly into the PCB's and would require careful cleaning of the Gate and Cathode connections to ensure that the new leads from the Generation 6 PCB were properly connected. As such, should you need to replace an older LPMEC/SS PCB then please contact EMS (European) to arrange for the return of the system to the UK for the replacement to be undertaken in our manufacturing area.

Appendix 8

DERATING CHARTS





DERATING CHART

	Temperature						
Unit Size	**40C**	**45C**	**50C**	**55C**	**60C**	**65C**	**70C**
5kW	11A	10A	9A	8A	7A	6A	5A
8kW	16A	15A	14A	13A	12A	11A	10A
11kW	23A	22A	20A	19A	18A	16A	15A
15kW	30A	28A	27A	25A	23A	21A	20A
22kW	45A	42A	40A	37A	34A	32A	29A
30kW	60A	57A	53A	50A	46A	43A	39A
37kW	75A	71A	66A	62A	57A	53A	49A
45kW	85A	80A	75A	70A	65A	60A	55A
55kW	110A	97A	91A	85A	79A	73A	67A
63kW	120A	113A	106A	99A	92A	85A	78A
75kW	145A	137A	128A	119A	111A	103A	94A
90kW	170A	160A	150A	140A	130A	120A	110A
110kW	205A	193A	181A	169A	157A	145A	133A
132kW	255A	240A	225A	210A	196A	180A	165A
150kW	290A	273A	256A	239A	222A	205A	188A
186kW	340A	320A	300A	280A	260A	240A	220A
225kW	410A	387A	363A	339A	315A	291A	267A
260kW	475A	446A	418A	390A	362A	334A	306A
315kW	580A	547A	513A	476A	445A	411A	377A
375kW	670A	630A	591A	552A	512A	473A	433A
450kW	800A	753A	706A	659A	612A	565A	518A
500kW	900A	846A	793A	740A	687A	634A	581A
630kW	1100A	1035A	970A	905A	841A	776A	711A
800kW	1400A	1310A	1233A	1151A	1068A	986A	903A