LPE SERIES

DC-AC Sinewave Inverter and LPES Shelves

Operation Manual

Manual Part Number 800586001

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INTRODUCTION TO THE LPE SERIES

This Operation Manual provides a general description of the LPE series Sine-wave Inverter designed to provide reliable AC power from a DC source. A battery plant (DC source) will provide the input voltage for the Inverter.

Inverters are used to convert DC voltages to sinusoidal AC voltages for conventional AC applications (120 VAC @ 60 Hz or 220 VAC @ 50 Hz). The LPE series Inverter is an industrial designed power supply that incorporates state-of-the-art electronics to provide high power density and reliability in a compact unit.

The LPE Series Inverters, manufactured by TDI Power delivers a near perfect sine-wave from a variety of DC sources. These low cost, solid state inverters utilize high frequency pulse width modulation technology to synthesize a precision regulated sinusoidal output with less than 1% Total Harmonic Distortion. The wide input range allows the inverter to operate within the charge and discharge limits of any battery technology making it ideal for back-up UPS applications.

The LPE sine-wave inverter is ideal for use in telecom sites and customer premise equipment, fuel cell, solar power applications, and for data centers. The LPE inverter delivers a fully isolated and precision regulated output capable of powering loads with a power factor from zero lead to zero lag. The ability to deliver high peak currents makes the LPE inverter ideal for driving non-linear loads such as rectifiers or motors. Units are capable of parallel and synchronized operation. Multiple units (up to 12) can be user configured for single or three phase output configuration. N+1 redundancy is achieved with 2 or more inverters connected in parallel. The unit is lightweight (under 3 lbs.) and is available in a modular, rack mount, or shelf mount enclosure.

FEATURES

- Hot-Bus Plug In
- Parallelable, supports N+1 Redundancy
- Scaleable From 500VA to 6kVA
- Failsafe - No Single Point Failure
- Demonstrated MTBF >600,000 Hours
- Various mounting schemes available
- Low Profile, High Density
- Full Power from -20 to +55°C
- 1Ø System Configuration, for 2Ø or 3Ø System Configurations, consult factory
- Powers Loads with power factors from zero lead to zero lag.

SPECIFICATION FOR THE LPE SERIES

	LPE500 48VDC	LPE400 24VDC
Input		
Nominal Input	-48 VDC	24 VDC
Input range	-40.5 VDC to -60 VDC	19 VDC to 30 VDC
Input UV turn-on	-41 VDC to -43 VDC	19 VDC to 21 VDC
Input UV turn-off	-38 VDC to -40 VDC	17 VDC to 19 VDC
Input OV turn-off	-62 VDC to -64 VDC	30.5 VDC to 32.5 VDC
Input OV turn-on	-57 VDC to -59 VDC	28 VDC to 30 VDC
Inrush Current Controlled	< 80 Amps peak	< 80 Amps peak
Maximum Input Current at low line	15A steady state. 30 A peak for 2 sec (during output overload)	25.4A
Output		
Sinusoidal waveform with less than 1% THD Typical 120 VAC / 60 Hz or 220/230 VAC / 50 Hz Voltage regulation better than 5% Frequency controlled better than 0.25% stability Fully Isolated Input to Output DC content: 10 mV max No preload required		
Power Rating		
Maximum Power, over full temperature range	500VA	400VA
Maximum Rated Output Current (Continuous)	120 VAC Unit: 4.17 Amps (RMS) 220 VAC Unit: 2.27 Amps (RMS)	120 VAC Unit: 3.33 Amps (RMS) 230 VAC Unit: 1.74 Amps (RMS)
Efficiency	85% Min. at Full Load, 86% typical	83% Min. at Full Load
Hold-up time	10ms min. @ 43 VDC	10ms min. @ 21 VDC
Peak Output Current Into Nonlinear Load:	11.7 A (peak) Max. for 120 VAC 6.35 A (peak) Max. for 220 VAC	9.3 A (peak) Max. for 120 VAC 4.8 A (peak) Max. for 230 VAC
Output power factor: Linear – Powers all loads with zero leading to zero lagging PF, Nonlinear – Rectified loads with up to 2.8 Crest Factor at full load.		

SPECIFICATION FOR THE LPE SERIES (continued)

EFFICIENCY
Standby Power: Under 30 Watts at No Load

PROTECTION
Input Undervoltage
Input Overvoltage
Output Overload
Output Short Circuit
Over Temperature

RELIABILITY
Demonstrated **MTBF** >600,000 Hours
Calculated **MTBF: C**onsult Factory

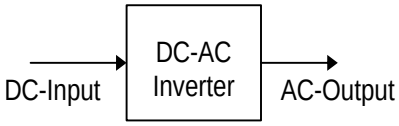
ENVIRONMENTAL
Cooling: internal fan
Operating Temp: -20° to +55°C (full power)
Storage Temp: -40° to +70°C
Humidity: 0-95% non-condensing
Safety Agency: UL, CUL, CB

MECHANICAL
Hot Swaps into LPES Series shelf
Weight: Under 3 lbs.
Size: 5.6” W x 1.5” H x 9.63” D
(See Appendix A - Outline Drawing)

THEORY OF OPERATION

INVERTER APPLICATIONS

In its most basic form, an AC Power Supply converts DC input voltage into a regulated AC output. This configuration is commonly known as a *DC-AC Inverter* – or more simply – an Inverter.



Inverters are used to derive AC power from a DC bus. DC-AC Inverter technology offers options to the power system architect. It offers an elegant, cost-effective approach for generating an AC bus when:

* No AC is available within the system
* AC is not accessible within the system
* The primary AC supply is experiencing frequent interruptions
* The DC bus has built-in redundancy
* The available AC is of an unacceptable configuration
* Use of a DC bus is more convenient than routing AC throughout the system

TDI Power has the industry's widest offering of "near-perfect sine-wave" DC-AC Inverters ranging in size from 400 Watts to over 30,000 Watts. Available in a wide variety of shapes and sizes, we can tailor the electrical and mechanical configurations to address almost any application. These low cost, solid state inverters utilize high frequency pulse width modulation (PWM) technology to "synthesize" a precision regulated sinusoidal output with typically less than 1% Total Harmonic Distortion (THD).

Wide input ranges allow the Inverters to operate within the charge and discharge limits of any battery technology, making them ideal for back-up UPS applications.

LPE OPERATION

HOT BUS PLUG-IN

The LPE series inverter is a true hot-swap module. The hot-swap plug-in feature is facilitated via a turn on sequence guided by both software and hardware. Different length pins on the connector ensure “Make First” and “Break Last” connections. Power-up sequencing is then guided by a micro-controller in the control circuitry.

> **NOTE:** *The handle on the front panel is only meant to aid extraction of a module from the shelf. This handle does not activate any switch to shut down the unit, nor should this handle’s rotation be used to “seat” the module into the shelf.*

REMOTE CONTROL

The LPE offers a remote on/off capability via pins B2 (-) and B3 (+) on Connector P100 for the 120VAC models and via pins B2 (-) and C2 (+) for the 220/230VAC models (reference Table 1, Rear connector Pin-outs on Page 12). B2 is referenced to the DC Input (negative) terminal, but these two should never be connected externally as doing so bypasses a safety critical fuse. Connecting these two pins to each other enables the LPE, disconnecting these pins from each other disables the LPE. This connection can be made/broken through either hardwire, dry contact, or open collector means. The open circuit voltage on these contacts will be a maximum of 15V. The current through closed contacts will be will be less than 2mA. For proper operation during conduction, the saturation voltage between these contacts must be less than 0.5V.

FAULT ISOLATION / N+1 REDUNDANCY

If a unit failure occurs when operated in parallel with other units, the potential exists where the failed unit may load the other units with a short circuit or overload. To circumvent this, the faulted unit will open relay K101, thus disconnecting the output from the other units. This design feature enables true N+1 redundancy with glitch-free operation.

THERMAL PROTECTION

Thermal protection is achieved by monitoring the power converter elements within the inverter. If the temperature reaches unsafe levels, the unit will be disabled internally until it cools to an acceptable level. The unit will then re-start automatically.

OUTPUT PROTECTION

Although the inverter output is fully protected against external overload and short circuit, external protection devices such as fuses, circuit breakers, etc. may be used.

CURRENT SHARING

Pin D3 on connecter P100 (reference Table 1, Rear Connector Pin-outs on Page 12) provides an analog signal that allows current sharing between parallel units. For parallel operation all current sharing signals from each unit must be connected together.

LPE ELECTRICAL SYSTEM OVERVIEW

A block diagram, highlighting the major functional elements of the LPE Inverter, is shown in Figure 1 on Page 11.

The major functional elements of the LPE Inverter are listed below:

a) DC/DC Converter
b) DC/DC Control
c) DC/AC Inverter
d) DC/AC Control
e) EMI Input Filter
f) EMI Output Filter

A functional description of each major element follows:

DC/DC CONVERTER

The DC/DC Converter transforms the DC input voltage to an isolated DC link voltage.

The converter contains the following items:

a) High Frequency Pulse Width Modulator Inverter
b) Transformer
c) Output filter
d) Over current protection circuitry
e) Inrush current protection circuitry

- The HF-PWM/I converts a DC voltage to a series of high frequency pulses.
- The transformer provides reinforced insulation between the low-level input voltage and the AC output. A DC Link-bus is also created in order for the DC/AC Inverter to generate the proper AC output voltage.
- The output filter reduces internal harmonics to an acceptable level prior to reaching the DC/AC Inverter.
- The output DC/DC Converter output circuit (providing the link voltage) is protected by a fuse (F103), providing fault isolation from the DC/AC Inverter. The input circuit is protected by a fuse (F101) located in the negative bus return for 48V LPE and in the positive bus for 24V LPE.
- Inrush current is limited by resistor R100 which, after the inrush pulse, gets shorted by relay K100.

DC/DC CONTROL UNIT

This section controls the DC/DC Converter so the necessary DC-Link bus voltage is regulated over all line and load conditions. This DC-Link bus provides the power the DC/AC Inverter converts to the AC output.

The DC/DC Control consists of the following items:

a) Front panel LED Indicators
b) Remote On/Off circuitry
c) Link-voltage control circuitry

- The Input indicator (Green LED) is activated when the input voltage is within a safe operating range.

- The Fault indicator (bi-color Red/Green LED) is activated when any fault condition exists as follows:

a) Synchronization error
b) DC-Link Over Voltage
c) Inverter Fault
d) Over temperature

DC/AC INVERTER

The DC/AC Inverter unit converts the DC link voltage to the required AC output voltage.
This unit contains the following items:

a) High frequency Pulse Width Modulator Inverter
b) Output filter
c) Control and Protection circuitry

- The DC/AC inverter and output filter convert the link voltage to a sinusoidal output voltage.

- The output filter reduces high frequency harmonics to an acceptable level.

- Output circuitry is protected by fuse (F102).

DC/AC CONTROL

The DC/AC Control provides main control for the Inverter. Protection features are incorporated to provide:

a) Output Overload and Short Circuit Protection
b) DC Link Over Voltage Protection

EMI INPUT FILTER

The EMI input filter protects the DC input source by attenuating the high frequency harmonics that are generated by the power switching elements

EMI OUTPUT FILTER

The EMI output filter protects the output load by attenuating the high frequency harmonics that are generated by the power switching elements from within the Inverter.

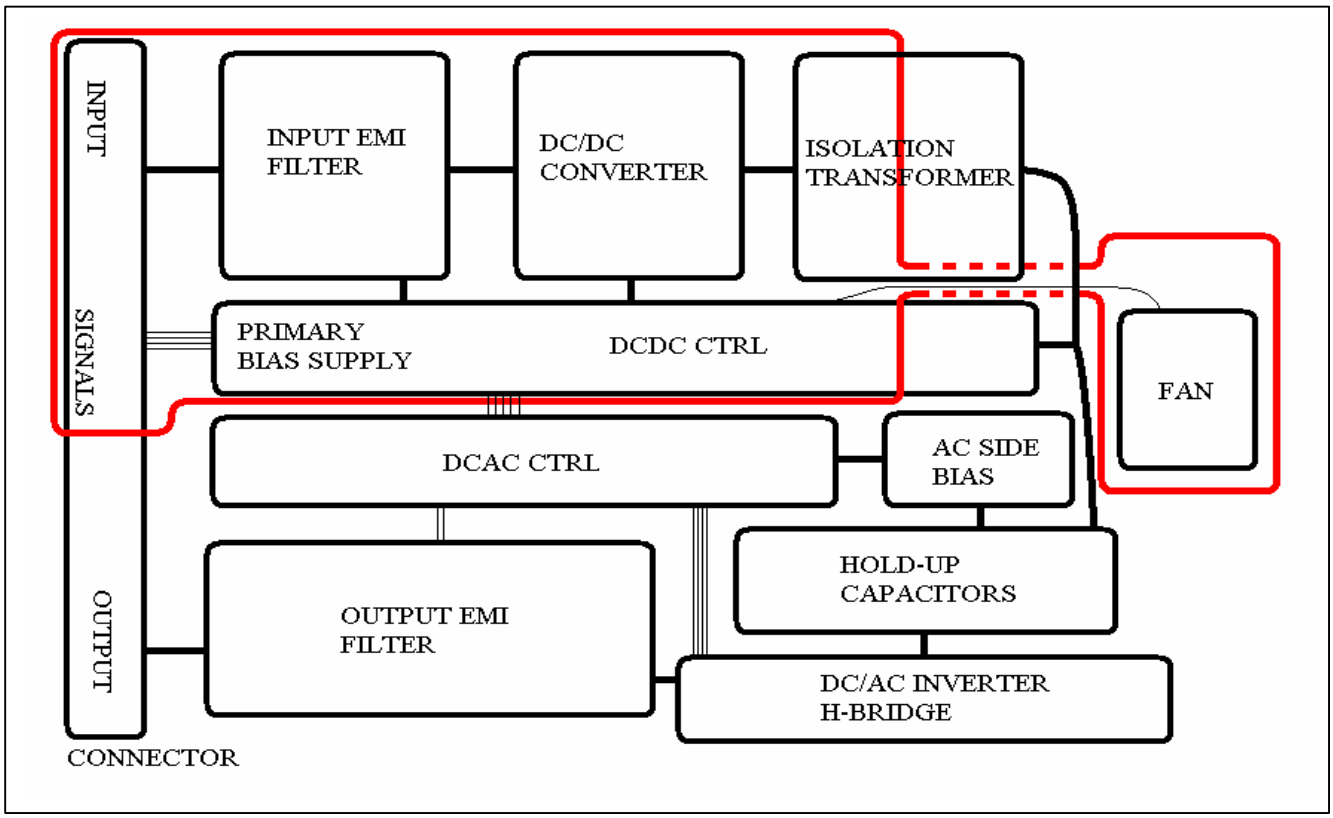


Figure 1: LPE Inverter Functional Block Diagram

LPE PIN-OUT AND INSTALLATION

The LPE set-up and installation is normally performed by LPES Series shelves. The user needs the information in this section only when using the LPE500 Series Inverters without the LPES Series shelves.

REAR CONNECTOR PINOUTS

Table 1 on Page 12 lists the functions for each Pin on the rear connector, Figure 2 on Page 12. Depending on the AC Voltage of the module used, different combinations of pin assignments are used.

Function	Pin No.	Notes
-DC Input Return (-)	P1, P2, P3	
+DC Input Power (+)	P4, P5, P6	
Safety Ground	P7	
AC Out Return (N)	P8	
AC Out Power (L)	P9	120V modules or Enable 1 (220) for 220V modules)
Fault (+)	A2	Normally closed / transistor on, opens in fault condition
Reserved	A3	Do not connect
Trigger Out 180°	A4	Used for 2-phase / split phase configuration
Fault return (-)	A5	
Remote return (-)	B2	
Remote (+) (120)	B3	Only used on 120VAC units, connect to B2 to enable
Trigger Out 120°	B4	Used for 3-phase configurations
Fault Signal (+)	B5	Normally open / transistor off, closes in fault condition
Remote (+) (220)	C2	Only used on 220/230VAC units, connect to B2 to enable
Enable 1	C3	Used in hot-plugging, connect to D2 to enable
Trigger Output 0°	C4	Used for single phase configuration
Sig GND	C5	Tied internally to positive input, only use for LPE to LPE connections
Enable 2 (COM)	D2	
Ishare	D3	
Trigger In	D4	
Reserved	D5	Do not connect

Table 1 - Rear Connector Pinouts
(Mates with FCI P/N 51915-016)

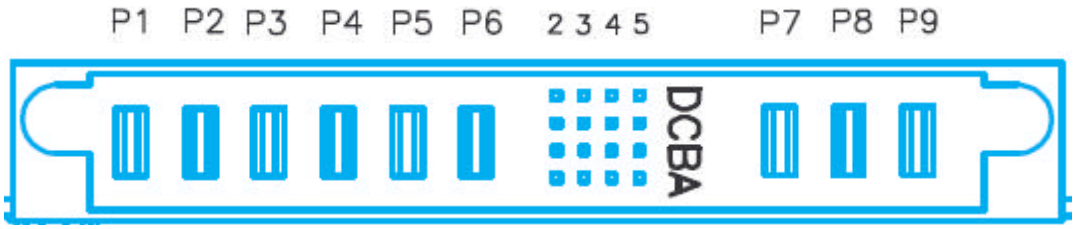


Figure 2: LPE Rear Connector View

INSTALLATION

It is preferred to utilize TDI Power's Hot Swap Shelf for the LPE500, the LPES1500, in which case installation of the LPE consists of sliding the module into a bay in the shelf and locking it into place with the folding handle. LPES Series Shelves are described on Page 13.

LPES Series Shelves

INTRODUCTION TO THE LPES SERIES

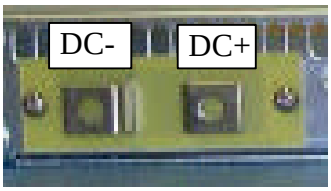
The LPES Series of shelves are the recommended method of mounting and connecting to LPE Series Inverters. The LPES provides a secure mechanical mount, provides access to all input and output power and signal connections, and provides all connections between modules to make installing a new module as easy as inserting in into the shelf.

MECHANICAL

A full mechanical diagram of the LPES can be found in the Appendix B. The LPES meets all the EIA standards for a 19" rack mount device. It is recommended to use #10-32 Truss head screws, 5/8 in. long to mount the shelf on rails. The shelf material is cold rolled steel, with zinc plating with clear chromate conversion coating per ASTM B 633-85 class FE/ZN8, type III. Inserts with a female #10-32 thread size are located toward the rear of the shelf on the sides for additional support if necessary.

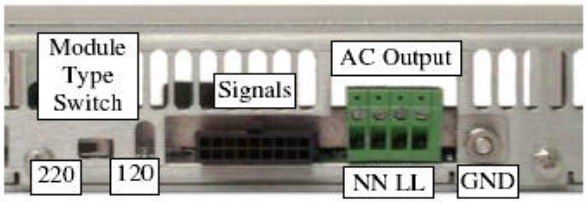
ELECTRICAL

All electrical connections are made on the rear panel of the shelf. On the left side of the rear panel, underneath a safety cover, two buss bars containing #10-32 threaded inserts are provided to connect DC Power Input to the shelf. Use #10-32 screws or bolts 7/16" long to secure DC Input Power to these connections via lugs. The shelf in turn connects this DC Input to the LPE modules.



DC Input Buss Bars
(cover removed)

AC power output is taken from a four position terminal block in the center of the rear panel. There are two connections each for Line and Neutral. An 18 pin signal connector (pin out on Page15) is located to the left of this terminal block. To the right of the terminal block there is an 8-32 threaded stud to connect Earth Ground. To the left of the signal connector is a selector switch (120VAC/220VAC) which should be set to match the type of modules to be mounted in the shelf. The purpose of this switch is to prevent accidentally paralleling modules of different output voltages.



AC Output Terminal Block, Signal Connector, and Grounding Stud

GROUNDING

1. The chassis ground terminals must be connected to safety ground.
   The grounding strip shall withstand the rated inverter current.
2. The inverter input and output terminals are isolated from each other and from the inverter chassis.
   For reliable and safe operation, please follow the grounding instructions below:

   2a. *Grounding on the output terminals:* When left ungrounded, the output terminals (Line & Neutral) have the same potential with respect to the inverter chassis (60VAC for 120V unit and 110VAC for 220V unit). It is customary in the United States, 120VAC distribution system, to ground the neutral terminal. To minimize the local loop noise, it is recommended to ground the neutral at the point of use. If required, the user can also connect the neutral output terminal to the inverter chassis and safety ground.

   2b. *Grounding on the input terminals:* The LPE inverter is designed to operate from either the Negative or Positive ground bus. The most common applications are:

   (i) The telecom application with negative 48V bus, where the positive terminal is grounded.

   (ii) The telecom application with positive 24V bus, where the negative terminal is grounded.

   There is no need to ground any of the input terminals if the unit is operating from a grounded positive or negative bus. In applications where the input DC bus is floating, it is recommended to ground the positive input terminal for 48V applications or negative input terminal for 24V applications.

SIGNAL CONNECTOR PIN ASSIGNMENTS

18	17	16	15	14	13	12	11	10
9	8	7	6	5	4	3	2	1

1- $\overline{\text{FAULT}}$ _1_(+) (LEFT, when viewed from front of rack)
2- $\overline{\text{FAULT}}$ _2_(+) (CENTER)
3- $\overline{\text{FAULT}}$ _3_(+) (RIGHT, when viewed from front of rack)
4- N/C
5- TRIG_IN
6- N/C
7- TRIG_120 (LEFT, when viewed from front of rack)
8- TRIG_120 (CENTER)
9- TRIG_120 (RIGHT, when viewed from front of rack)
10- FAULT_COM_(-)
11- FAULT_(+)
12- SIG_GND
13- N/C
14- I_SHARE
15- REMOTE (+)
16- N/C
17- REMOTE (-)
18- N/C

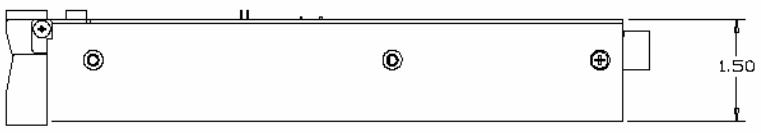
Remote (+/-) accepts either dry contact or open collector switching. This signal is referenced to the DC input side, but should never be connected externally to either leg of the DC input. Connect these pins (to each other) to Enable the modules, disconnect these pins to disable the modules.

FAULT signal pins connect to the Collector and Emitter of the transistor side of an opto-coupler. This provides an optically isolated open collector type signal. Low impedance between these pins indicates a fault.

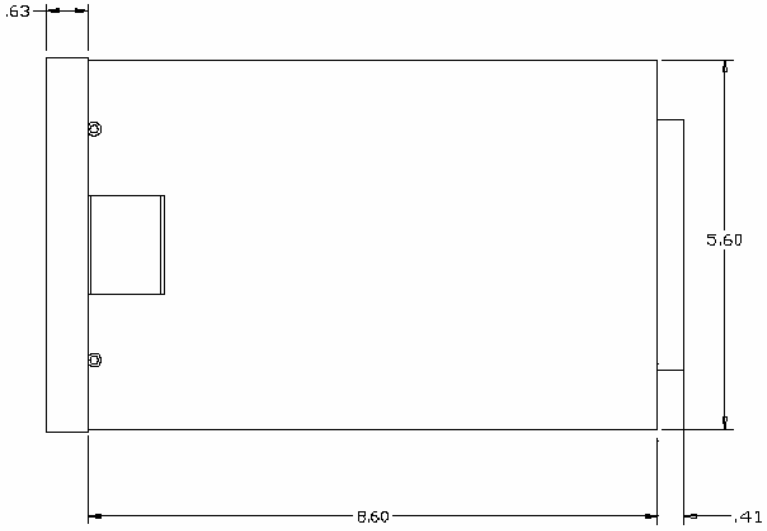
$\overline{\text{FAULT}}$: Low impedance between these and the FAULT_COM pin indicates “Output Good”

APPENDIX A

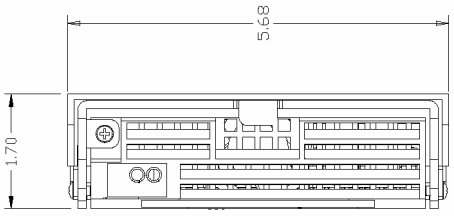
LPE OUTLINE DRAWING



LPE Side View



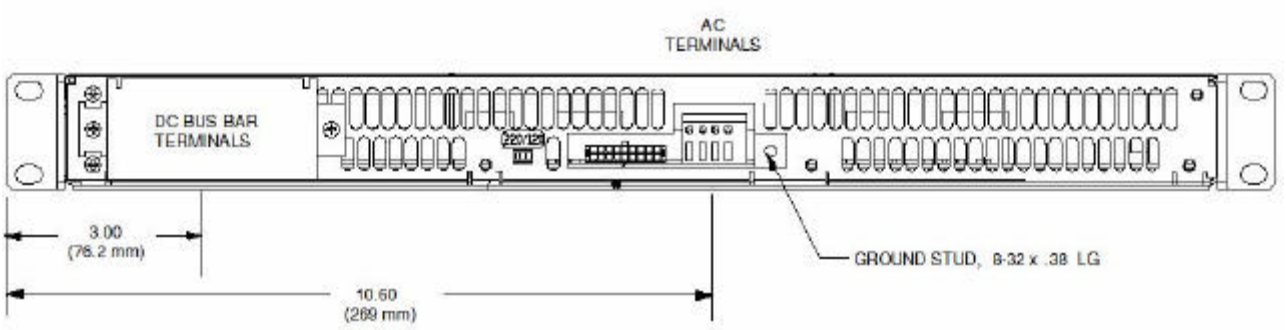
LPE Top View



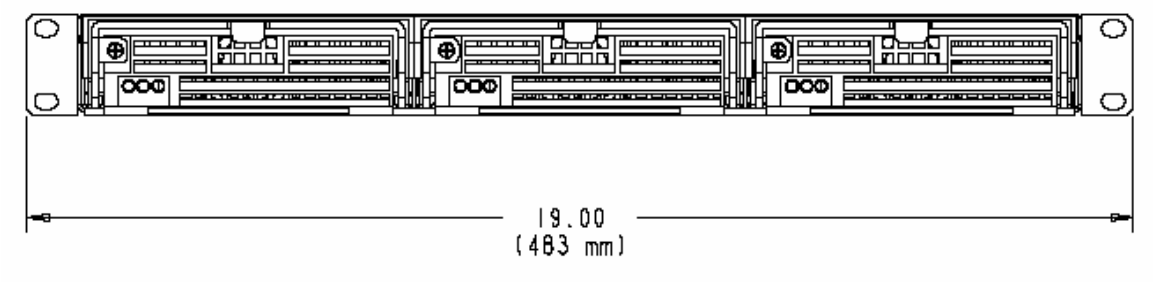
LPE Front View

APPENDIX B

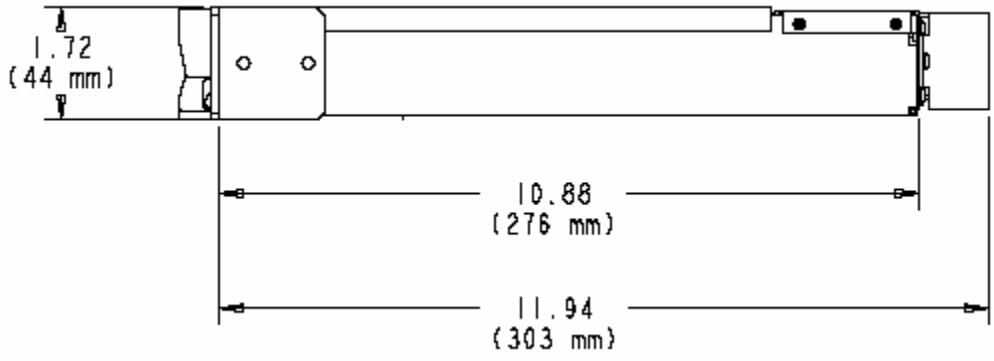
LPES OUTLINE DRAWING



LPES1500 Rear View



LPES1500 Front View (Fully Populated)



LPES1500 Side View

Revision History

Revision	ECN #	Description of Change	Date	Change By	Checked By
A		Initial Release	Unreleased		
B		Initial Release	Unreleased		
C		Initial Release	Unreleased		
P1		Incorporated additional comments	04-Apr-08	jjs	
P2		Incorporated additional comments	10-Apr-08	jjs	
P3		Incorporated additional comments	11-Apr-08	jjs	
A		Incorporated additional comments	06-May-08	jjs	