DSP240-LPI Inverter Controller Card

Technical Brief

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DSP240-LPI Controller Board

1.0 Overview of the Controller Board

The DSP240-LPI controller board is a low cost, high performance DSP based inverter controller that has been designed for applications requiring a single board solution to control a three phase VSI stack.

The card is based around a Texas Instruments TMS320F240 DSP chip, which has been specifically developed for use in digital motor/motion control applications, and contains on-card all necessary functions for a complete standalone inverter control system.

The DSP240-LPI controller card measures 275mm x 220mm.

On-card facilities include:

- Socket for a 64k x 16 EPROM, accessible as I/O space
- 128k x 16 RAM, accessible as 64k program and 32k external data space
- Serial ROM with non-volatile storage for 256 x 16 bits of data
- Switch-mode power supply to generate all on-card supplies
- On-card DIP switches and status LEDs
- Power-fail circuitry.

The card also supports the following peripheral interfaces:

- RS-232/RS-422/RS-485 serial interface
- High speed clocked serial peripheral interface
- 2 off isolated digital inputs
- 2 off MOSFET switch isolated outputs
- 1 off relay output, c/o contact
- 2 off AC current inputs
- 2 off differential AC voltage inputs,
- 1 off differential DC voltage input
- 1 off flexible temperature sensor input
- 2 off potentiometer analog inputs
- 2 off general purpose analog inputs (± 10V default)
- 8 off complementary isolated gate driver PWM outputs, with common fault interrupt
- +24V isolated field supply
- JTAG port for software development.
- Quadrature Position Encoder input with Index

Figure 1-1 shows a functional block diagram of the DSP240-LPI controller card, illustrating all major sections.

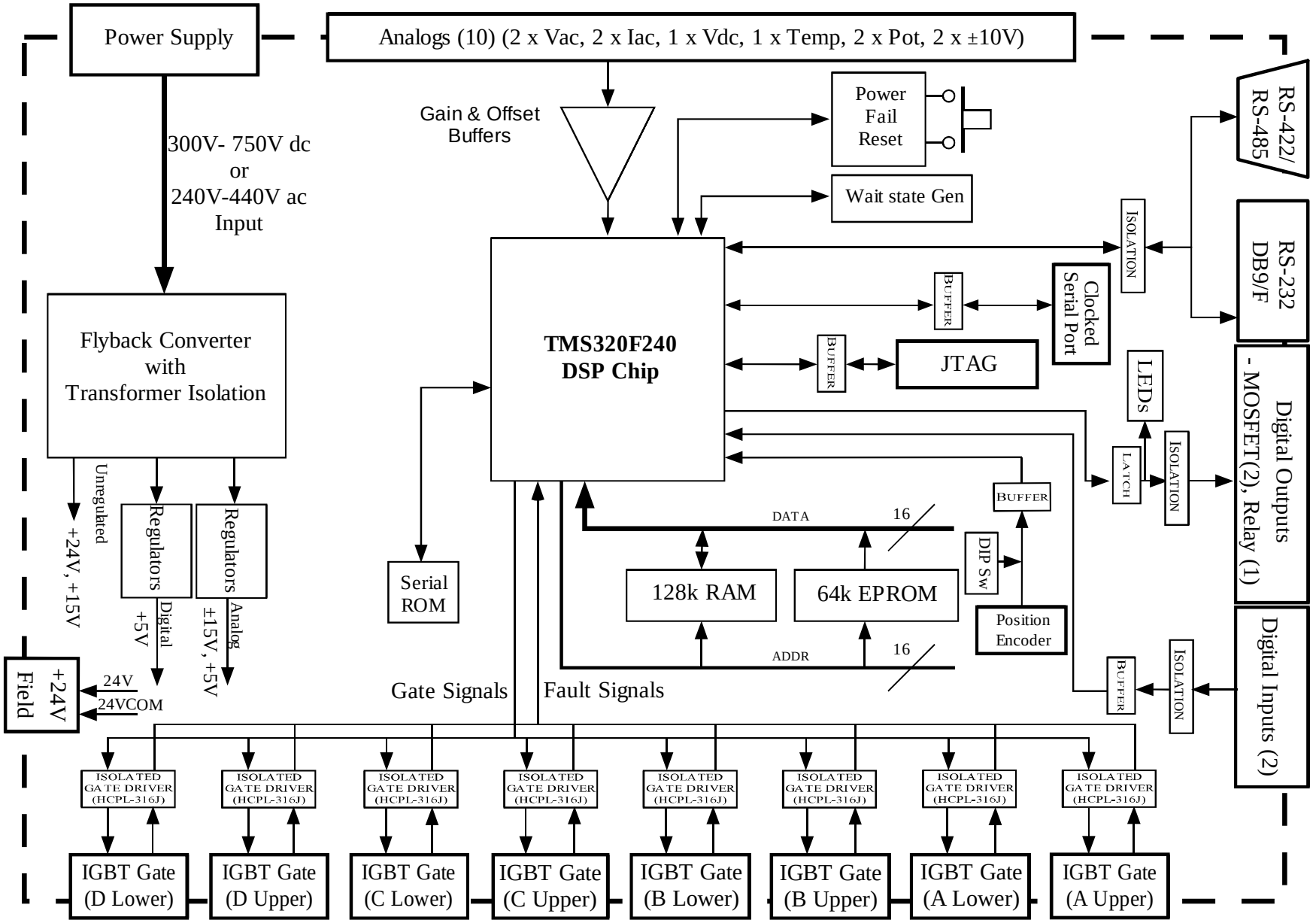

Figure 1-1: Functional Diagram of DSP240-LPI Controller Board

1.1 Digital I/O

The DSP240-LPI card supports 13 bits of digital I/O, consisting of 8 bits for local I/O and 5 bits interfacing to external isolated circuitry.

The local I/O consists of 4 bits driving LED's mounted on-card (LED3, LED4, LED5, LED6) and 4 bits of DIP switch inputs (S2).

The isolated I/O consists of 2 off isolated digital inputs, 1 off relay output (changeover contact) and 2 off isolated MOSFET outputs.

The isolated digital inputs can be driven using either the on-card generated +24V field supply, or individually isolated to be driven from an off-card supply. This is achieved by removing a grounding link (LK15, LK18) located next to each input connector. The controller card is supplied with these links installed, to connect the common of the isolated digital outputs to the negative rail of the +24V field supply. A LED indicator is provided on the isolated side of each input as a visual indication of the state of the input.

The 1 off relay output has DPST changeover contacts capable of driving 10A 240Vac. A LED indicator is provided on the coil side of the output as a visual indication of the state of the output.

The 2 off MOSFET outputs can be link selected (LK13, LK14) to be powered from either the on-card generated +24V field supply or from an off-card source. Both MOSFETs must be driven from the same supply option. The controller card is supplied with these links present, to connect the positive and negative rail of the +24V field supply to the MOSFET outputs. Both MOSFET outputs have LED indicators on the isolated side to provide a visual indication of the state of the output.

1.2 Analog Inputs

The DSP chip has two off 10-bit A/D converters with individual built-in Sample and Hold circuits. Eight analog inputs are provided for each ADC through 8 to 1 analog multiplexers. This enables two input channels, one on each ADC, to be simultaneously sampled and converted. The maximum total conversion time for each ADC unit is 6.6μs. The DSP A/D converters accept input voltages in the range of 0-5V.

The analog inputs are interfaced as 2 off AC currents, 2 off AC voltages, 1 off DC voltage, 1 off temperature sensor, 2 off potentiometers and 2 off ±10V general purpose inputs.

The AC current inputs require the placement of burden resistors (R17, R18) on the card, selected so that the full-scale voltage developed across each resistor ranges between ±550mV. Standoffs are provided on-card for ease of mounting these resistors. If required, capacitors (C9, C10) can be added in parallel with the sense resistors to reduce unwanted high frequency noise. Separate grounds are provided on each current connector so that each current input can be connected using individual twisted pair wires. A common overcurrent detection is provided for both AC current inputs, with the trip level determined by resistor R112 (mounted on standoffs).

The AC voltage inputs have a default input voltage range of ±750V peak. This can be reduced by mounting gain resistors (R23, R25, R27) onto standoffs on the PCB. The two AC voltage inputs are differential high impedance circuits, allowing the line-line AC voltages to be measured from a three phase system. One input voltage (Vab) supports a zero-crossing detect circuit, which drives a DSP capture input.

The DC voltage input has a default input voltage range of 928V. This can be reduced by mounting gain resistors (R41, R44) onto standoffs on the PCB. The DC voltage input is a differential high impedance circuit, allowing the DC voltage to be measured between two floating rails. A DC overvoltage detection circuit is provided for this input, with the trip level determined by resistor R111 (mounted on standoffs).

The temperature sense input supports temperature measurement using a RTD or LM35DZ temperature sensing device. A 1.0mA current source can be linked (LK5) to develop the sense voltage across the RTD. The offset and gain of the temperature sense system can be varied by changing resistors R64, R67.

The potentiometer inputs can be link selected (LK3, LK4) to use either on-card trimpots, or an external potentiometer located off-card. A 5V reference voltage is available at the potentiometer connector to energise an external potentiometer.

The two general purpose analog inputs accept a ±10V input. Each input has a 1 megohm resistor connected to ground to stabilise the DC level.

1.3 Gate Drive Interface

The TMS320F240 DSP supports 8 PWM channel outputs, made up of 3 complementary pairs (6 outputs) with programmable deadbands and 2 independent outputs generated by simple compare functions. The DSP240-LPI board uses the 8 PWM channel outputs to generate the 8 gate signals, and converts these outputs to 8 isolated gate driver outputs through HCPL-316J gate driver chips. Two of the gate drive outputs require dead band compensation to be software-calculated. Isolated supplies are generated on-card for each gate drive circuit.

Gate fault signals from the eight HCPL-316J's are linked together and connected to the PDPINT* interrupt. This provides a hardware interrupt to the DSP immediately on detection of a fault, which disables the PWM signals within 200 nanoseconds using internal hardware logic within the DSP.

1.4 Communications

The DSP240-LPI controller board supports four communication protocols: RS-232, RS-422, multi-drop RS-485 and a high-speed synchronous serial peripheral interface. The DSP incorporates a single UART, which is used for RS-232/422/485 communication. A link (LK11) is provided to select between these three communication protocols. These signals are isolated through optocouplers from the main PCB.

The high-speed synchronous serial peripheral interface can be used to communicate to other computer systems. The interface can support either master or slave protocol, selected by software.

1.5 On-card memory

The DSP240-LPI controller board supports 64k x 16bit each of on-card Program RAM and Data RAM. This memory is interleaved with the DSP internal memory using the on-chip memory management hardware. The PCB also supports 64k x 16bit EPROM, mapped to the DSP I/O address space. Programs cannot be executed directly from the EPROM memory, but rather the EPROM can be used to store programs, which can be block moved to Program RAM for execution as required.

The DSP240-LPI controller also supports 256 x 16bits of non-volatile serial ROM, which is programmed from the DSP using I/O signals on Port B.

1.6 Power Supply

The standard DSP240-LPI controller board has an on-card switch mode power supply that accepts an input voltage in the range of 240V – 440V AC or 300V – 750V DC. The SMPS generates all necessary on-card supplies as well as an isolated current-limited +24V field supply for off-card use.

The DSP240-LPI (LV) controller board has an on-card switch mode power supply that accepts an input voltage in the range of 90V – 260V AC or 130 – 370V DC.

1.7 JTAG/programming

The DSP240-LPI controller board has a JTAG interface for programming the DSP's ROM or RAM. This port can also be used for emulator/debugging purposes using the TMS320C240 ICE Pack.

1.8 Position Encoder

The position encoder interface accepts quadrature encoded pulses from a relative position encoder system, and uses these pulses to update a 16 or 32 bit position counter (as selected by software) within the DSP.

A separate index pulse input can be used to generate an interrupt to reset this counter for initialisation purposes.

The encoder inputs signals are 5V TTL levels, diode clamped to avoid damage caused by input overvoltages.

2.0 Specifications

2.1 Controller DSP Section

Processor	Texas Instruments TMS320F240 DSP
On-card Memory	128k x 16 RAM – created by using 2 off 128k x 8 RAM chips Addressed as: 32k x 16 Data space and 64k x 16 Program space 1 x 40 pin JEDEC socket capable of supporting 64k x 16 EPROM Addressed as: 64k x 16bit in I/O space
Reset	100ms hardware reset generated on-card from powerup and supply failure. Can also be triggered via on-card push button
Non-Volatile Memory Storage	256 x 16 bits of memory storage using a serial-ROM chip Accessed via digital I/O signals from the DSP
Interrupts	Supported for Gate Driver Fault, AC overcurrent, DC overvoltage, off-card external interrupt, zero-crossing detect on AC input voltage

2.2 Analog Inputs

Number of Channels	10
A/D Resolution	10 bits
A/D Conversion Time	6.6μs
Number of ADC's	2 (5 channels are multiplexed on-chip to each converter)

2.2.1 AC Current Inputs

Definition	2 off twisted pair 2-wire connections providing conditioned CT & LEM compatible AC current inputs. Burden resistors (R17, R18) and low pass filter capacitors (C9, C10) are required to suit input current requirements
Input Voltage Range	±550mV maximum peak (set by burden resistor for required current)
Burden Resistor	AXIAL0.4 component mounted on-card and sized according to input voltage range and maximum required current input AC current input impedance is 2k2 without the burden resistor
Overcurrent Protection	Direct interrupt through XINT1. Linkable interrupt to PDPINT* (LK19). Trigger current determined by resistor selection (R112)
LEM Supply	± 15V Low Current Supply is provided to drive a LEM (J5)
Dynamic Response	Cut-off frequency >150kHz
PCB Connections	2 terminal plug-in PCB Mounting Terminal Block. Designed for individual twisted pair connection (J4, J6)

2.2.2 AC Voltage Inputs

Definition	2 off AC voltage differential analog inputs
Input Voltage Range	±750 Vac maximum peak Lower range with placement of scaling resistors (R23, R25, R27)
Input Protection	High input impedance, 540kΩ in default configuration
Dynamic Response	Cut-off frequency > 450kHz
PCB Connections	3 pin plug-in PCB Mounting Terminal Block (J3)

2.2.3 DC Voltage Input

Definition	1 off DC voltage differential analog input
Input Voltage Range	0 – 928Vdc Lower range by installation of scaling resistors (R41, R44)
Input Protection	High input impedance, 720kΩ in default configuration
Overvoltage Protection	Direct interrupt through NMI. Linkable interrupt to PDPINT* (LK20). Trigger voltage determined by resistor selection (R111)
Dynamic Response	Cut-off frequency >450kHz
PCB Connections	2 pin plug-in PCB Mounting Terminal Block (J2)

2.2.4 Temperature Sensing Input

Definition	1 off analog input capable of measuring temperature using an RTD, or interfacing to an LM35DZ temperature sensor
Constant Current Supply	1mA. Other constant current ranges can be implemented by changing a resistor (R10)
PCB Connections	3 pin plug-in PCB Mounting Terminal Block, with signal, signal ground and +15V (J11)

2.2.5 Potentiometer Analog Inputs

Definition	Two off analog potentiometer inputs
Voltage Range	0-5V
Options	Links provided to enable the use of the on-card pots (LK3, LK4)
PCB Connections	3 pin plug-in PCB Mounting Terminal Block, with +5V, signal and AGND (J9, J10)

2.2.6 General Purpose Analog Inputs

Definition	2 off single-ended connections providing conditioned analog inputs
Input Voltage Range	±10V nominal. Changeable with surface-mount resistors R2, R3, R4 and R5
Dynamic Response	Cut-off frequency >150kHz
PCB Connections	2 pin plug-in PCB Mounting Terminal Block, signal and AGND (J7, J8)

2.3 Digital Inputs

2.3.1 Isolated Digital Inputs

Definition	2 bits of optically isolated digital inputs, clean contact compatible
Minimum Input Voltage	12V DC
Maximum Input Voltage	30V DC
Dynamic Response	0.1ms propagation delay 0-24V rising input 2ms propagation delay 24-0V falling input
Isolation	Optical Isolation Withstand Voltage: 1500V peak (1 minute) Links provided to isolate ground between digital inputs (LK15, LK18)
PCB Connections	3 pin Plug-in PCB Mounting Terminal Block, with signal, signal ground and a +24V field supply (J22, J23)

2.3.2 Position Encoder Digital Inputs

Definition	1 pair of quadrature encoded pulses defining relative position change 1 index pulse
Minimum Input Voltage	0V DC (TTL low)
Maximum Input Voltage	5V DC (TTL high)
Dynamic Response	Up to 4 MHz pulse trains, limited by DSP internal counter timing for quadrature encoded inputs and interrupt response time for index pulse
Input Protection	Diode clamped to DGND and DVCC, Schmitt trigger buffered input, 1k0 input impedance
PCB Connection	10 pin shrouded IDC header, with signals, logical ground and a +15V unisolated supply (J19)

2.4 Digital Outputs

2.4.1 Isolated MOSFET Outputs

Definition	2 off optically isolated MOSFET switched outputs
I_{source}	2.4mA @24V, through 10kΩ pull up resistor
I_{sink}	300mA nominal [Note 1] 1A absolute maximum [Note 2]
Switch Configuration	Single pole, normally open. Direct connection to separate isolated ground
Isolation	Between MOSFET Outputs: No isolation provided Between MOSFET Outputs and +24V field supply: Links provided to isolate MOSFET outputs from +24V field supply and field supply common (LK13, LK14) Isolation Withstand Voltage to DGND: 1500V peak (1 minute)
PCB Connections	3 pin plug-in PCB Mounting Terminal Block, with signal, signal ground and a +24V field supply (J16, J18)

Note 1: The on-card generated field supply is rated at a nominal 24V, 1A. If isolated digital inputs do not use the field supply, then the current can be shared by both MOSFET outputs.
Note 2: Only one MOSFET output used.

2.4.2 Relay Outputs

Definition	1 off Relay Output
Contact Ratings	240V, 10A AC 30V, 10A DC
Contact Configuration	Single Pole, changeover
Isolation Withstand	3kV AC
Relay Coil Power Supply	Supplied from on-card 15V supply
PCB Connections	3 pin plug-in PCB Mounting Terminal Block, with normally open, normally closed and common terminals (J20)

2.5 PWM Gate Drive Interface

Definition	8 PWM Outputs
PWM Outputs	8 PWM outputs consisting of – 3 independent complementary pairs (6 outputs) with programmable deadtime (0-102μs). 2 gate drive outputs generated from two independent outputs, for which dead-band compensation must be calculated. Each output is driven from an isolated +17/-12V supply that is generated on-card
Gate Fault Interrupt	Commoned and connected to PDPINT*, which when unmasked and activated, immediately disables the PWM outputs. Response time is < 2μsec after fault detection, essentially limited by gate driver optocoupler transition time. Fault status indicated by individual LEDs
Max IGBT Gate Current	2A peak
PCB Connections	3 pin plug-in PCB Mounting Terminal Block, with Drain, Gate and Source connections (J25 – J32)

2.6 Communications Interface

Definition	Configurable to support either RS-232 or RS-422/485 communication modes through a single UART. Both modes cannot operate simultaneously
Configuration	Links are provided to choose between RS-232, RS-422 and RS-485 modes (LK11) **DEFAULT** is RS-232
Isolation	1kV.

2.6.1 RS-232 Interface

Definition	RS-232 connection, providing two pin serial communications for interface to a standard PC serial port
Compatibility	Links provided to enable the board to be configured as a DTE or a DCE (LK8). Default is configuration as a DCE
PCB Connections	Female DB9 connector, with pinouts to suit standard PC 9 pin serial port (J15)

2.6.2 RS-422/RS-485 Interface

Definition	Selectable RS-422/RS-485 connection, providing a multi-drop communications interface using a differential signal
Compatibility	Links are provided which enable the communications interface to be connected as either an RS-422 or RS-485 interface. Connection of the interface for loopback is also provided for test purposes (LK2, LK7)
Bus termination	Linkable terminating 220 ohm resistor across input and output channels (LK1, LK6)
PCB Connections	Two paralleled RJ45 connectors, to allow daisy chain multi drop connection (J12, J13)

2.6.3 High Speed Serial Peripheral Interface

Definition	Half duplex synchronous clocked serial peripheral interface. Capable of operating in Master or Slave mode (software selected)
Compatibility	Compatible with the TMS320F240 SPI module
PCB Connection	5-way Molex connector (J14)

2.7 JTAG

Definition	DSP interface connection, which enables the TMS320F240 to interface to an ICE to provide a real-time debugging environment
Compatibility	Compatible with IEEE 1149.1 standard for scan-based emulation
PCB Connection	14-way IDC connector (J17)

2.8 Software

Standard Support Software	Monitor Program, standard library source code, sample programs Texas Instruments: TMS320C2x/C2xx/C5x Optimizing C Compiler

2.9 General

Physical Dimensions	L: 275mm
	W: 220mm
	H: 80mm approx.
Mounting Arrangement	9 off 3.5 mm holes spaced in a grid across the PCB
Environmental	0 – 50°C ambient operating temperature 5% - 95% non condensing humidity

2.10 Power Supply

	DSP240-LPI	DSP240-LPI (LV)
Input Voltage Range	300V – 750V DC	130V – 370V DC
	220V – 440V AC	90V – 260V AC
Standalone Input Current	30-10 mA	80-30 mA
Max Input Power	Approx. 36W 800 mA Fuse Protected	Approx. 36W 2A Fuse Protected
Supplies Generated on-card	+15V Digital from which the +5V Digital is generated using a regulator	
	±15V for Analog circuitry. +5V Analog is generated from the +15V supply	
	+24V Unregulated field supply, current limited to 1A max.	
	+17V/-12V Gate Drive Supply	
Input Power Connector	3 pin plug-in PCB Mounting Terminal Block : Active, Neutral, EARTH (J1)	
Output Power Connectors	2 pin plug-in PCB Mounting Terminal Block : +24V, +24V_COM (J24) 3 pin plug-in PCB Mounting Terminal Block : +15V, AGND, -15V (J5)	
Thermal Protection	Power Supply protected by optional thermal cutout, mounted on high voltage transistor heatsink (must be short circuited if not in use)	
Environmental	0 – 50°C Ambient operating temperature 5% - 95% non condensing humidity	

Appendix

Appendix A Component Layout