CPT-E13 Card

TMS320F2810 DSP Inverter Controller Card

Technical Manual

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CPT-E13 Manual Revision History

CARD VERSION 1.0: Initial Board for prototype purposes.

No Manual Released

CARD VERSION 1.01: Revised Gate Driver Pulldown resistors
Added Temperature Sensor NTC Thermocouple interface

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CARD VERSION 1.02: Reversed PDPINT Connections to correct for error in V1.01

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CARD VERSION 1.03:

Release 1.00 – Initial Manual Release
Release 1.01 – Fixed operating voltage specification on Technical Specification sheet

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CPT-E13 DSP Based Inverter Controller

1.0 Overview of the CPT-E13

The CPT-E13 is a low cost, high performance DSP based inverter controller that has been designed for applications requiring a single board solution to control up to a four-phase VSI stack.

The board is used in conjunction with the CPT-DA2810 DSP processor card which is based around a Texas Instruments TMS320F2810PBK DSP. This DSP has been specifically developed for use in digital motor/motion control applications, and the CPT-E13/CPT-DA2810 combination contains on-card all necessary functions for a complete standalone inverter control system.

The CPT-E13 card measures 275mm x 220mm.

On-card facilities (with CPT-DA2810 connected) include:

- TMS320F2810PBK DSP processor
- 64k x 16 Flash (128k x 16 Flash on TMS320F2811PBK)
- 1k x 16 OTP ROM
- 4k x 16 Boot ROM
  - Software Boot Tables
  - Standard Math Tables
- 18K x 16 Single Access RAM (SARAM) made up of:
  - L0 and L1: 2 Blocks of 4K x 16 Each SARAM
  - H0: 1 Block of 8K x 16 SARAM
  - M0 and M1: 2 Blocks of 1K x 16 Each SARAM
- Serial Flash Memory with 1Mbit of non-volatile storage
- 1 off Power LED
- 4 off indication LEDs
- 4 off DIP switches
- 2 off isolated digital inputs
- 3 off MOSFET switch isolated outputs
- 2 off relay output, c/o contact
- 3 off AC current inputs
- 2 off DC current input
- 2 off differential AC voltage inputs, (Three phase input)
- 2 off differential DC voltage input
- 1 off differential AC/DC voltage input
- 1 off temperature sensor input (NTC Thermistor)
- 8 off complementary isolated gate driver PWM outputs, with 2 groups of fault interrupts
- Reset/Power-On Circuitry
- Power supply to generate all on-card supplies
- Power supply operation from input 200-440VAC single phase

The card also supports the following peripheral interfaces:

- JTAG interface for software development
- 1 off clocked Serial Peripheral Interface (also enables external Flash reprogramming)
- 1 off 3.3V-TTL serial interface
- 1 off isolated RS-485 serial interface (optional on-card DC-DC Converter supply)
- Quadrature Position Encoder input with Index

Figure 1-1 shows a functional block diagram of the CPT-E13 card, illustrating all major sections.

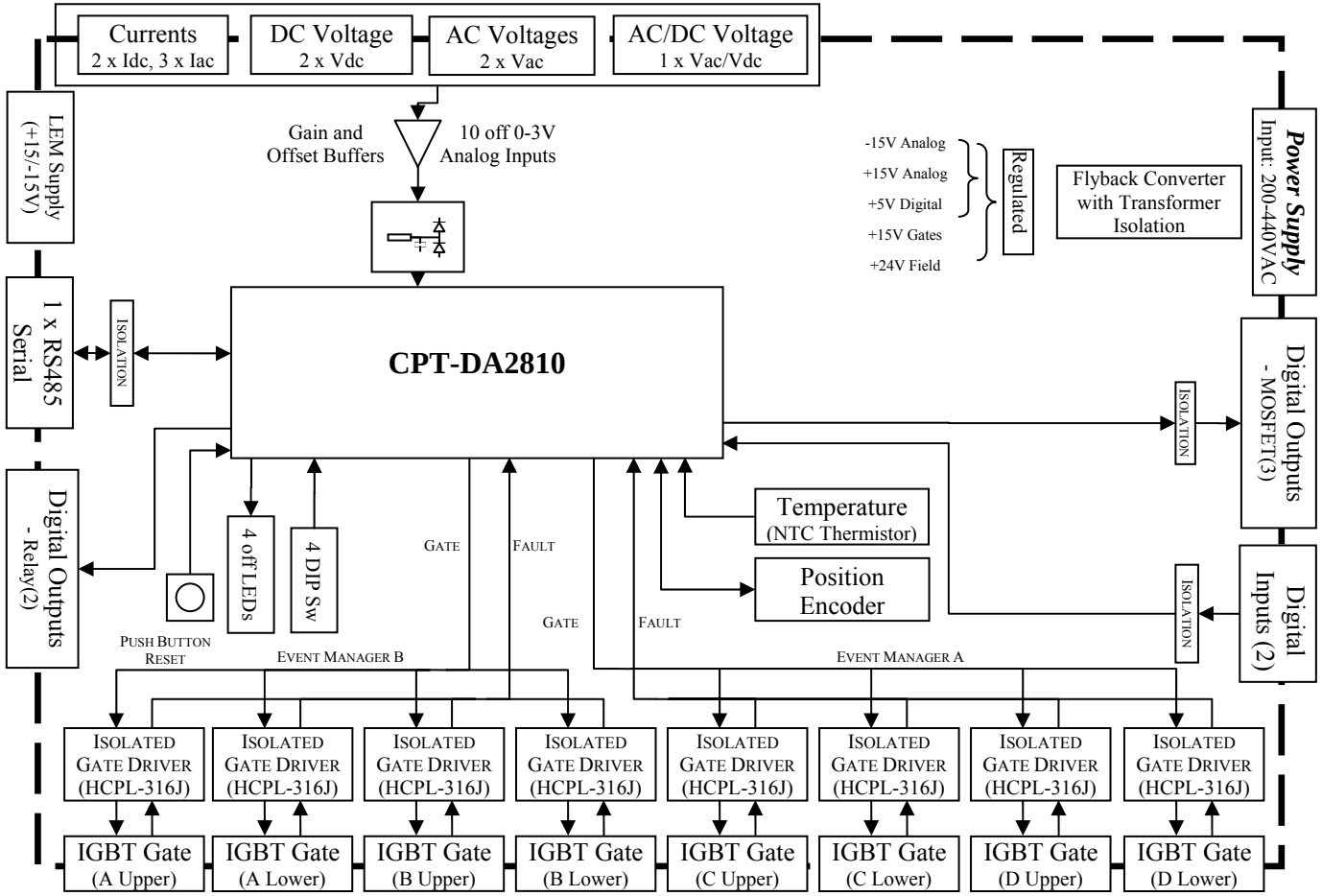


Figure 1-1: Functional Diagram of CPT-E13 Inverter Controller Board

1.1 Digital I/O

The CPT-E13 card supports 15 bits of digital I/O, consisting of 8 bits for local I/O and 7 bits interfacing to external circuitry.

The local I/O consists of 4 bits driving LEDs mounted on-card (**H6**, **H7**, **H8**, **H9**) and 4 bits of DIP switch inputs (**S2**).

The isolated I/O consists of 2 off isolated digital inputs, 2 off relay output (changeover contact) and 3 off isolated MOSFET outputs.

The isolated digital inputs are driven using the on-card +24V field supply. A LED indicator is provided on the isolated side of each input as a visual indication of its state.

The 2 off relay outputs have single pole changeover contacts capable of driving 10A 240Vac. A LED indicator is provided on the coil side of the output as a visual indication of its state.

The 3 off MOSFET outputs are powered from the +24V field supply. LED indication is provided on the isolated side of the output as a visual indication of its state.

1.2 Analog Inputs

The TMS320F2810 DSP has 16 off ADC inputs that accept voltages in the range of 0-3V. The analog inputs are divided into two banks of 8 (ADCINA0-7 and ADCINB0-7). Each bank feeds into an 8 to 1 analog multiplexer with a sample and hold circuit. The outputs from the two sample and hold circuits are fed directly into a single 12-bit ADC Module. The ADC module can interleave ADC conversions between the two banks to achieve a "pipelined" conversion process. This reduces the overall time required for "simultaneous" conversions. The maximum total conversion time for each ADC unit is 80ns (with a 25MHz ADC clock).

The CPT-DA2810 analog inputs are configured to provide 4 off precision reference inputs for self calibration and 12 off filtered external inputs to the TMS320F2810.

The CPT- DA2810 card has on-card precision 2.5V and 1.25V references that should be used for calibration of the internal ADC. Each ADC bank has a 1.25V and 2.5V reference fed to channels 6 and 7 for calibration purposes. It is strongly recommended that the ADC be software calibrated for both gain and offset. Please consult the Texas Instruments documentation on the ADC converter for further information. *TMS320x281x DSP Analog-to-Digital Converter (ADC) Reference Guide*, Literature Number: *SPRU060D*.

Ten of the remaining twelve filtered analog inputs are interfaced from the CPT-E13 as 3 off AC currents, 2 off AC voltages, 1 off AC/DC voltage, 2 off DC voltages, 2 off DC currents. Each input on the CPT-DA2810 has a low pass "glitch" filter, and a diode clamp circuit before the signals are fed into the DSP.

The AC current inputs can operate from an off-card CT or LEM module. On-card burden resistors (**R13**, **R5**, **R18**) should be used if the input to the board is current fed, with their value selected so that the full-scale voltage developed across each resistor ranges between ±815mV. The burden resistors are surface mount 1206 packages with a maximum of rating of 0.25W. The current inputs can also be modified, by link selection, to operate with a nominal voltage input signal, such as supplied from a current transducer. Separate grounds are provided on each current connector so that each current input can be connected using individual twisted pair wires. Common overcurrent detection is provided for both AC current inputs, with the trip level determined by resistor **R173**.

The AC voltage inputs have a default input voltage range of ±600V peak. 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 (Van) supports a zero-crossing detect circuit, which drives a DSP capture input.

The AC/DC voltage input (VDC1/VAC1) is set as a DC input by default with a voltage range of 816V. It is a differential high impedance circuit, allowing the voltage to be measured between two floating rails. This input also has an optional offset stage (requires a resistor change) to enable measurement of a single phase AC voltage by loading alternative components. A DC overvoltage detection circuit is provided, with the trip level determined by resistor **R172**. When operating as an AC voltage input the zero-crossing detect circuit.

The DC voltage inputs have a default input voltage range of 816V. 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 on VDC3 input, with the trip level determined by resistor **R161**.

The DC current inputs can operate from an off-card CT or a LEM module. On-card burden resistors (**R22, R23**) should be used if the input to the board is current fed, with the value selected so that the full-scale voltage developed across each resistor ranges between ±4V. The burden resistor is a surface mount 1206 package with a maximum of rating of 0.25W. The current input can also operate with a nominal voltage input signal, such as supplied from a current transducer. A ground is provided on the DC current connector so the input can be connected with twisted pair wiring.

1.3 Gate Drive Interface

The TMS320F2810 DSP supports 16 PWM channel outputs, made up of 6 complementary pairs (12 outputs) with programmable deadbands and 4 independent outputs generated by simple compare functions. The DSP chip has two independent event manager modules (EVA and EVB) and the PWM channels are evenly split between them. Dead band compensation must be software-calculated for the simple compare outputs.

The CPT-E13 board has 8 isolated gate driver outputs through HCPL-316J gate driver chips. Four of these outputs (**X18** to **X21**) are connected to Event Manager A and four are connected to Event Manager B (**X14** to **X17**). They are configured as complementary pairs.

The gate fault signals from the EVA gate driver chips are ANDed together and connected to the PDPINTA* interrupt. This enables a DSP hardware interrupt trip to immediately occur on detection of a fault, thus disabling the EVA PWM signals within 12 nanoseconds using hardware logic internal to the DSP.

The gate fault signals from the EVB gate driver chips are ANDed together and connected to the PDPINTB* interrupt. This enables a DSP hardware interrupt trip to immediately occur on detection of a fault, thus disabling the EVB PWM signals within 12 nanoseconds using hardware logic internal to the DSP.

1.4 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 referenced to DGND and diode clamped to avoid damage caused by input over voltages.

1.5 On-card memory (CPT-DA2810)

The CPT-DA2810 controller board supports 64k x 16bit of on-card Flash (128k x 16bit with the TMS320F2811), 18k x 16bit of SARAM and a 4k x 16 Boot ROM. Programs can be directly executed

from RAM, via the JTAG interface or from Flash. By default, the card runs programs from the flash memory. Links are provided to enable RAM, SCI or SPI program operation.

In addition to the on-chip memory the CPT-DA2810 has a 1Mbit SPI interfaced Flash Memory chip for external data storage.

1.6 Temperature Measurement

The CPT-E13 controller board supports temperature measurement via an external NTC Thermistor interface that is read by a Thermistor-to-digital converter. The digital output is a serial peripheral interface (SPI) signal that is fed to the CPT-DA2810's SPI port. The measurement is fully isolated from the digital supply and powered from the +24V field supply.

1.7 Communications

The CPT-E13 controller board supports three communication protocols: one off non-isolated 3.3V-TTL serial communications interface (SCI) (connector on the CPT-DA2810), a 3.3V-TTL synchronous serial peripheral interface (SPI) (connector on the CPT-DA2810), and an isolated RS-485 serial communications interface.

The high-speed synchronous serial peripheral interface can be used to communicate to other computer systems. The interface is unbuffered and requires a separate board to configure master/slave protocols if required.

The 3.3V-TTL serial port can be used to communicate to a terminal emulation program, via an interface board, to aid in program development.

1.8 Power Supply

The standard CPT-E13 controller board has an on-card switch mode power supply that accepts an input voltage in the range of 200V – 440V AC (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 CPT-E13(LV) controller board has an on-card switch mode power supply that accepts an input voltage in the range of 85V – 265V AC (130 – 370V DC).

The CPT-E13(ULV) controller board has an on-card switch mode power supply that accepts an input voltage in the range of 50V – 150V DC.

1.9 JTAG/programming

The CPT-DA2810 controller board has a JTAG interface for programming the DSP's Flash ROM or RAM. This port can also be used for emulator/debugging purposes using the Code Composer Studio Pod.

2.0 Specifications

2.1 Controller DSP Section

Processor	Texas Instruments TMS320F2810 (optional TMS320F2811)
On-card Memory	64k x 16 Flash Memory (128k x 16 TMS320F2811) 18k x 16 RAM 4k x 16 Boot ROM 1k x 16 OTP ROM
Reset	120ms hardware reset generated on-card from power up and supply failure. Can also be triggered via an on-card push button (**S2**)
Non-Volatile Memory Storage	1Mbit of memory storage using an SPI flash ROM chip Accessed via SPI interface on DSP
Interrupts	3 off masked external interrupts (XINT1, XINT2, XINT13/NMI) Support for 2 off PDPINT interrupts

2.2 Analog Inputs

Number of Channels	16	
A/D Resolution	12 bits	
A/D Conversion Time	80ns	
Number of ADC's	1 (8 channels are multiplexed on-chip to form a bank)	
Number of S/H units	2 (each bank has one sample and hold unit)	
Reference Voltages	ADCINA6, ADCINB6	2.5V
	ADCINA7, ADCINB7	1.25V

2.2.1 AC Current Inputs

Definition	3 off twisted pair 2-wire connections providing conditioned CT & LEM compatible AC current inputs. Burden resistors (**R13**, **R5**, **R18**) ADCINA0, ADCINA1, ADCINA2
Input Voltage Range	±815mV maximum peak (set by burden resistor for required current) 0-5V maximum in voltage differential input mode
Burden Resistor	1206 1/4W SMT 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	Interrupt through XINT1. Trigger level set by resistor **R173**
LEM Supply	±15V available on **X10**
Dynamic Response	Cut-off frequency >150kHz
PCB Connections	6 way Phoenix MCV1,5 3.81mm spacing connector. Designed for individual twisted pair connection (labelled as **X5**)

2.2.2 DC Current Input

Definition	2 off twisted pair 2-wire connections providing conditioned CT & LEM compatible AC current inputs. Burden resistors (**R22, R23**): ADCINA3, ADCINA4
Input Voltage Range	±4V maximum peak (set by burden resistor for required current)
Burden Resistor	1206 1/4W SMT 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	Interrupt through C2TRIP*. Trigger level set by resistor **R160**
LEM Supply	±15V available on **X10**
Dynamic Response	Cut-off frequency >150kHz
PCB Connections	4 way Phoenix MCV1,5 3.81mm spacing connector. Designed for individual twisted pair connection (**X8**)

2.2.3 AC Voltage Inputs

Definition	2 off AC voltage differential analog inputs: ADCINB2, ADCINB1
Input Voltage Range	±750 Vac maximum peak
Input Protection	High input impedance, 540kΩ in default configuration
Zero-Crossing Detect	VAC1 – connects to CAP1 DSP input (Link **LK3** set to pins 2-3)
Dynamic Response	Cut-off frequency > 450kHz
PCB Connections	5 way Phoenix MSTBVA 5.08mm spacing connector (**X3**)

2.2.4 AC/DC Voltage Input

Definition	1 off AC/DC voltage differential analog input: ADCINB4
Input Voltage Range	0 – 816Vdc
Input Protection	High input impedance, 2720kΩ in default configuration
Overvoltage Protection	VDC1 – Interrupt through XINT2. Trigger level determined by resistor **R172**
Zero-Crossing Detect	AC Voltage mode only – connects to CAP4 DSP input
Dynamic Response	Cut-off frequency >450kHz
PCB Connections	2 way Phoenix MSTBVA 5.08mm spacing connector (**X1**)

2.2.5 DC Voltage Input

Definition	2 off DC voltage differential analog input: ADCINB3, ADCINB0
Input Voltage Range	0 – 816Vdc
Input Protection	High input impedance, 2720kΩ in default configuration
Overvoltage Protection	VDC3 – Interrupt through XNMI. Trigger level determined by resistor **R161**
Dynamic Response	Cut-off frequency >450kHz
PCB Connections	2 way Phoenix MSTBVA 5.08mm spacing connector (**X2, X4**)

2.3 Thermistor Input

Definition	1 off NTC Thermistor Measurement (Temperature)
Supply Current	21uA
Thermistor Type	NTC
Preferred Thermistor	10kΩ EPCOS B57703M103G
PCB Connections	3 way Phoenix MCV1,5 3.81mm spacing connector (**X28**), Thermistor connection + Earth

2.4 Digital Inputs

2.4.1 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)
PCB Connections	3 way Phoenix MCV1,5 3.81mm spacing connector, with signal, signal ground and a +24V field supply (**X23**, **X22**)

2.5 Digital Outputs

2.5.1 Isolated MOSFET Outputs

Definition	3 off optically isolated MOSFET switched outputs
I_{source}	2.4mA @24V, through 10kΩ pull up resistor
I_{sink}	300mA nominal 1A absolute maximum Note 1
Switch Configuration	Single pole, normally open. Direct connection to separate isolated ground
Isolation	Between MOSFET Outputs: No isolation provided Isolation Withstand Voltage to DGND: 1500V peak (1 minute)
PCB Connections	3 way Phoenix MCV1,5 3.81mm spacing connector, with signal, signal ground and a +24V field supply (**X26**, **X25, X24**)

Note 1: Only one MOSFET output used.

2.5.2 Relay Outputs

Definition	2 off Relay Outputs
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 way Phoenix MCV1,5 3.81mm spacing connector, with normally open, normally closed and common terminals (**X12, X13**)

2.5.3 PWM Gate Drive Interface

Definition	8 PWM Outputs spread over 2 off Event Managers
PWM Outputs per Event Manager	Event manager A has 4 PWM outputs consisting of – 2 independent complementary pairs (4 outputs) with programmable deadband generation. Each output is driven from an internally generated isolated +17/-5V supply. Event manager B has 4 PWM outputs consisting of – 2 independent complementary pairs (4 outputs) with programmable deadband generation. Each output is driven from an internally generated isolated +17/-5V supply.
Gate Fault Interrupts	Gate Fault signals for Event Manager A are commoned together and connected to PDPINTA*, which when unmasked and activated, immediately disables the Event Manager A PWM outputs. Response time is ~12nsec after fault detection The PWM signals are placed into a high impedance state and have on-card pull-down resistors. Gate Fault signals for Event Manager A are commoned together and connected to PDPINTB*, which when unmasked and activated, immediately disables the Event Manager B PWM outputs. Response time is ~12nsec after fault detection The PWM signals are placed into a high impedance state and have on-card pull-down resistors Fault status indicated by individual LEDs
Max IGBT Gate Current	2A peak
PCB Connections	4 way Phoenix MSTBVA 5.08mm spacing connector per gate output with Collector, Gate and Emitter connections Event Manager A Gate Outputs (**X18** – **X21**) Event Manager B Gate Outputs (**X14** – **X17**)

2.5.4 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	5 way MOLEX 0.1” connector, with signals, logical ground and a +15V unisolated supply (**X31**)

2.6 Communications Interface

Definition	The TMS320F22810 has two off serial communications interface ports (SCIA and SCIB), two off serial peripheral interfaces (SPI and McBSP)
Configuration	SCIA is configured as a 3.3V-TTL level serial port available **only** from the CPT-DA2810. A CPT-COM board can be used to provide isolated RS-232 level signals. SCIB is configured as an isolated RS-485 serial port The SPI interface is configured for use with the RTD to SPI chip and available through the CPT-DA2810 programming interface connector, if additional SPI connections are required.

2.6.1 Serial Communication Interface – SCIA – TTL Level (CPT-DA2810)

Definition	Two-wire asynchronous serial port (UART) that supports a 16-level, receive and transmit FIFO for reducing servicing overhead. The receiver and transmitter are double buffered with separate enable and interrupt bits **DEFAULT MODE:** 3.3V-TTL level serial connection, providing two pin serial communications for interface to an off-card 3.3V-TTL level to RS-232 translation card. This is necessary for interfacing to a standard PC serial port
Isolation	None
Communications Port	SCIA
PCB Connections	4-way MOLEX 0.1" connector with VCC and GND connections (located on **CPT-DA2810:X3**)

2.6.2 Serial Communication Interface – SCIB

Definition	Two-wire asynchronous serial port (UART) that supports a 16-level, receive and transmit FIFO for reducing servicing overhead. The receiver and transmitter are double buffered with separate enable and interrupt bits **DEFAULT MODE:** RS485B mode providing a multi-drop communications interface using a differential signal serial connection
Communications Port	SCIB
Isolation	ACSL-6310 1000V isolation (Please consult the datasheet for this component for full isolation information) Isolated On-Card power supply via either (**T5**) NMF0505S or (**T6**) NKE0305S. Removal of **T5**/**T6** enables this serial communications port to be fully powered from an external 5V source via the **X11** connector
Bus termination	Linkable 220 ohm termination (**LK2**)
PCB Connections	4 way Phoenix MCV1,5 3.81mm connector with VISOB (5V), differential A/B output and GND connections (**X11**)

2.7 JTAG (CPT-DA2810)

Definition	DSP interface connection, which enables the TMS320F2810 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	See CPT-DA2810 manual

2.8 General

Physical Dimensions	L: 275mm
	W: 220mm
	H: 50mm approx.
Mounting Arrangement	12 off 3.5 mm holes – please consult the mechanical layout diagram in the appendix for full details
Environmental	-20 – 75°C ambient operating temperature 5% - 95% non condensing humidity

2.9 Power Supply

Input Voltage Range	200 -440VAC (Also available in ULV (50 - 150VDC) and LV (85 – 265VAC) versions)	
Standalone Input Current	**30-10mA** (depending on the active sections within the DSP)	
Max Input Power	Approx. **40W**	
Protection	800mA Input Fuse (**F1**) to on-card SMPS	
Supplies Generated on-card	GND_GATE (EARTH)	+15V_GATE (+15V) Gate Driver Power Supply
	DGND Digital Ground (47uH to EARTH)	+15V_IN (+15V) used for generating digital on-card regulated positive power supplies
		+15V Analog Supply
		-15V Analog Supply
		DVCC (+5V) Digital Supply
		VDD (+3.3V) Digital
		+2.5V Analog Reference
	DGND_ISOB Isolated Ground	VISOB (+5V) Communications supply
	+24V_COM (10k to EARTH)	+24V Field Supply
Input Power Connector	5 way Phoenix MSTBVA 5.08mm spacing connector with Active, Neutral, EARTH. (**X27**)	
Thermal Protection	Power Supply protected by optional thermal cutout, mounted on high voltage transistor heatsink (**X29**) (Supplied short circuited when not in use)	

3.0 Technical Details

3.1 Design Overview

The CPT-E13 card is designed to provide a single board, low cost, and fully flexible three or four-phase leg inverter controller. The card is compatible with a plug-in CPT-DA2810 controller card, which is controlled by a Texas Instruments TMS320F2810 (or TMS320F2811) DSP. See the CPT-DA2810 card manual for a full description of this card.

The TMS320F2810 DSP has been designed for digital motor/motion control applications. On-card memory consists of 64kB (128kB) x 16 of FLASH memory, 18kB x 16 of RAM and a 1Mbit serial FLASH.

The CPT-E13 card supports external communication through one off isolated RS485 serial port and there is a 3.3V-TTL level serial port available directly from the CPT-DA2810. The serial UART signals are provided at 3.3V-TTL levels and must be converted (off-card) to RS232 for interface with an external serial port. See section 3.3.1 for details.

The CPT-E13 card contains on-card power supplies. The card accepts a wide range of voltage inputs (300-750V DC and 200-440V AC). The low voltage supplies are generated by an on-card ~40W flyback converter with 3 isolated outputs. These outputs are used to generate the +15V digital, ±18V analog and +24V field voltages used by the card.

The 5V digital logic supply is generated from the +15V digital supply using an on-card 1A regulator. The ±15V Analog supplies are generated from the unregulated ±18V inputs through linear voltage regulators and the analog reference voltage is generated from this regulated +15V analog supply. The 1A field supply +24V is available for off-card use, and is used by the isolated digital I/O.

The CPT-DA2810 controller contains a low-dropout voltage regulator, TPS70102, operating from the +5V digital logic supply. This chip is specifically designed for split supply applications, such as the TMS320F2810 DSP, and produces non-isolated +3.3V and +1.9V supplies. The regulator provides a guaranteed power-up sequence to ensure that the DSP will start correctly as well as handling all reset and power fail monitoring functions. The +3.3V supply is made available to the CPT-E13 as the supply to all 3.3V logic chips.

There is an on-card hardware reset push button, **S1**, to enable the CPT-DA2810 controller to be reset.

3.1.1 Analog Inputs

The TMS320F2810 DSP chip includes a single 12-bit Analog-to-Digital Conversion (ADC) module that is fed from one of two analog input banks. Each bank has its own sample and hold unit. The TMS320F2810 has a total of 16 analog input channels, with eight analog inputs provided to each bank through an 8-to-1 analog multiplexer. The maximum conversion time for each analog input bank is 80ns (with a 25MHz ADC clock). The ADC module can be set up to interleave the conversions between the two banks, effectively enabling one conversion to start before the previous one has been completed. This "pipelining" process enables the overall conversion time for "simultaneous" conversions to be reduced.

The mapping between the analog input channels on the TMS320F2810, the 80-way IDC connector and the CPT-E13 analog definitions are given in Table 3-1.

The CPT-DA2810 board provides precision 1.25V and 2.5V analog reference voltages to four of the TMS320F2810 analog inputs (two per bank) to enable calibration of the offset and gain within each ADC bank. The analogs on the TMS320F2810 require calibration to ensure maximum performance and accuracy, as outlined in Texas Instruments document *spra989a.pdf*. Please consult the CPT-DA2810 Technical Manual for further details on the initialization of these analog inputs.

There are 10 off analog inputs on the CPT-E13 inverter board and they are configured into the following inputs: 2 off AC voltages, 3 off AC currents, 1 off AC/DC voltage, 2 off DC voltages and 2 off DC currents. Quad surface mount operational amplifiers are used in all conditioning circuitry. The standard op-amp used is an LF444CM because it has a low offset voltage. A comparator is used for the overcurrent detection circuits. Its output is fed through a buffer to give the signal a defined edge for detection by the DSP interrupt hardware. The CPT-DA2810 board has on-card glitch filters to minimise noise injection into the DSP and diode clamps to protect the analog inputs from an external overvoltage. The total accuracy is given as ±2.5 LSB.

ANALOG DEFINITION	TEST POINT	CPT-E13 CONNECTORS	CONNECTOR CPT-DA2810:X30 PIN	ANALOG INPUT CHANNEL	DSP PIN
AC Current – Iac1	TP8	**X5**	70	ADCINA0	126
AC Current – Iac2	TP9	**X5**	71	ADCINA1	125
AC Current – Iac3	TP10	**X5**	73	ADCINA2	124
DC Current – Idc1	TP11	**X8**	74	ADCINA3	123
DC Current – Idc2	TP12	**X8**	76	ADCINA4	122
Not Used		N/A	77	ADCINA5	121
2.5V on card reference		79	2.5V on card reference	ADCINA6	120
1.25V on card reference		N/A	1.25V on card reference	ADCINA7	119
DC Voltage – Vdc3	TP7	**X4**	68	ADCINB0	2
AC Voltage – Vac2	TP6	**X3**	67	ADCINB1	3
AC Voltage – Vac1	TP5	**X3**	65	ADCINB2	4
DC Voltage – Vdc2	TP4	**X2**	64	ADCINB3	5
AC/DC Voltage – Vdc1	TP3	**X1**	62	ADCINB4	6
Not Used		N/A	61	ADCINB5	7
2.5V on card reference		79	2.5V on card reference	ADCINB6	8
1.25V on card reference		N/A	1.25V on card reference	ADCINB7	9

Table 3-1: DSP Analog input Mappings

3.1.1.1 AC Current Inputs

The 3 AC current inputs can be configured to accept input from either a CT (current transformer) or a LEM module (voltage or current output).

Current Transducer configuration:
Each current input has an on-card burden resistor (**R13**, **R5**, **R18**) that must be loaded in the current transducer mode of operation. These resistors should be chosen such that under maximum current

conditions the voltage developed across the resistor does not exceed ±815mV. Each input consists of an operational amplifier gain and offset stage to condition the signals to a notional 0-3V for entry into the ADC. The inputs each present an impedance of 2k2 to the incoming current transducer excluding the burden resistor. The link **LK1** should connect to ground to ensure the balancing impedance for the operational amplifier is correct for a current transducer input. Resistors **R41**, **R67** and **R68** can be adjusted to vary the gain of the input stage.

Example - AC current burden resistor calculation: Assume a maximum AC current of 160A peak, measured through a CT with a ratio of 300:1. The total burden resistance required to create a maximum voltage of 800 mV (ie. retaining a 15 mV margin below FSD) is calculated by:

$$R_{bt} = \frac{0.800V}{(160A/300)} = 1.5\Omega .$$

The actual burden resistance value is then calculated by allowing for the effect of the operational amplifier 2k2 input impedance, which is in parallel with the actual burden resistor. This gives a value of R_b slightly greater than 1.5Ω.

(Note that in most cases, the effect of the 2k2 operational amplifier impedance is negligible and can be ignored. However, in general the effect of this impedance in parallel with the burden resistor should be considered, and the burden resistor value adjusted if required to achieve the required overall burden resistance.)

The DSP inputs are protected by a diode clamp that limits the input voltage to the input rated value. Software compensation of any offsets should be completed during calibration to compensate for component tolerance variations.

The overcurrent interrupt is triggered when the magnitude of any AC current input exceeds a fixed set point. This set point is determined by the value of resistor **R173**, calculated as follows:

Example - AC Overcurrent set point calculation: Using the above burden resistor, set the overcurrent trip at 155A. For this current, the voltage at the overcurrent comparator is given by:

$$V_{iacoc} = \frac{0.8V}{160A} \times 156A \times I_g - V_{diode} + V_{off} = \frac{0.8V}{160A} \times 156A \times I_g - 0.5 + V_{off} = 0.8805V$$

where I_g is a fixed value of $I_g = 3.9k/2.2k = 1.77$.

R173 is then given by:

$$R173 = \frac{2.866V - V_{iacoc}}{\left(\frac{1}{R174} + \frac{1}{R167 + R168}\right) \times V_{iacoc}} = \frac{2.866V - 0.8805}{\left(\frac{1}{47k} + \frac{1}{102.2k}\right) \times 0.8805} = 10.01k \ (say 10k)$$

Note that this expression includes the effects of the diode rectifier in the peak current detector circuit and the 100k hysteresis feedback resistor associated with the overcurrent comparator.

Voltage Transducer configuration:

Each current input has an on-card burden resistor (**R13**, **R5**, **R18**) that should **not** be loaded in the voltage transducer mode of operation. The voltage transducer has a built in offset voltage (2.5V) thus enabling bidirectional current flow to be measured. Link **LK1** should connect to the 2.5V on-card reference to provide an offset voltage into the gain stage differential operational amplifier. Each input consists of an operational amplifier differential gain and offset stage to condition the signals to a notional 0-3V for entry into the ADC. The inputs each present an impedance of 2k2 to the incoming voltage transducer. Resistors **R15**, **R41**, **R16**, **R67**, **R21** and **R68** should be matched to create a differential input stage.

The DSP inputs are protected by a diode clamp that limits the input voltage to the input rated value. Software compensation of any offsets should be completed during calibration to compensate for component tolerance variations.

The overcurrent interrupt is triggered when the magnitude of any AC current input exceeds a fixed set point. This set point is determined by the value of resistor **R173**, calculated as follows:

Example - AC Overcurrent set point calculation: Using the HAIS-100P ratio, set the overcurrent trip at 150A. For this current, the voltage at the overcurrent comparator is given by:

$$V_{iacoc} = \left(\left(V_{HAISoff} + 0.625 \times \frac{I_P}{I_{PN}} \right) - V_{CURR\_REF} \right) \times I_g - V_{diode} + V_{off}$$

$$= \left(\left(2.5 + 0.625 \times \frac{150A}{100} \right) - 2.5 \right) \times I_g - 0.5 = 0.95V$$

where I_g is a fixed value of $I_g = 3.3k / 2.2k = 1.5$.

R173 is then given by:

$$R173 = \frac{2.866V - V_{iacoc}}{\left(\frac{1}{R174} + \frac{1}{R167 + R168} \right) \times V_{iacoc}} = \frac{2.866V - 0.95}{\left(\frac{1}{47k} + \frac{1}{102.2k} \right) \times 0.95} = 8.67k \ (say 10k)$$

Note that this expression includes the effects of the diode rectifier in the peak current detector circuit and the 100k hysteresis feedback resistor associated with the overcurrent comparator.

3.1.1.2 AC Voltage Inputs

The 2 AC voltage inputs are differential signals, with one common input that is shared across each of the channels (VN). Each input includes an operational amplifier gain and offset stage to condition the signals to 0-3V to feed into the ADC.

The default voltage range for the channels allows for a ±750V maximum peak.

The DSP inputs are protected by a diode clamp that limits the input voltage to the input rated value. Software compensation of any offsets should be completed during calibration to compensate for component tolerance variations.

Channel VAC1 (V_{AN}) has a zero-crossing detector. The output of the zero-crossing detector is fed into capture port 1 on the TMS320F2810. This allows synchronisation of software to an incoming AC signal.

The threshold level for the zero-crossing detector is a nominal 6% of the full scale AC input voltage, with a hysteresis of ±6% around zero.

3.1.1.3 DC Voltage Inputs

The 2 off DC voltage inputs are differential signals. The inputs drive into a gain stage that conditions the signals to nominal 0-3V to feed into the ADC. The default voltage range for the channel is 0 to 816V maximum.

The DSP inputs are protected by a diode clamp that limits the input voltage to the input rated value. Software compensation of any offsets should be completed during calibration to compensate for component tolerance variations.

The VDC3 input can trigger an overvoltage interrupt with the set point determined by the value of resistor **R161**.

DC Overvoltage set point calculation: Using the standard DC voltage range, set the overvoltage trip at 700V. For this voltage, the voltage at the over voltage comparator is given by:

$$V_{vdcoc} = \frac{3}{816} \times 700V = 2.57V$$

R161 is then given by:

$$R161 = \frac{2.866V - V_{vdcoc}}{V_{vdcoc}} \times \frac{1}{\left(\frac{1}{R162} + \frac{1}{R164 + R166}\right)} = 1k$$

Note that this expression includes the effects of the 100k hysteresis feedback resistor associated with the overcurrent comparator.

If the standard resistor value of 1k was used, this gives a trip voltage of 700V.

3.1.1.4 AC/DC Voltage Input

The 1 off AC/DC voltage input (VDC1/VAC3) is a differential signal. The input drives into a gain stage that conditions the signals to nominal 0-3V to feed into the ADC. The default voltage range for the channel is 0 to 816V maximum. When operating in AC mode, the signal is conditioned to -1.5 to 1.5V and then fed through an offset stage to create a 0-3V signal to feed into the ADC.

The DSP inputs are protected by a diode clamp that limits the input voltage to the input rated value. Software compensation of any offsets should be completed during calibration to compensate for component tolerance variations.

The VDC1 input (in DC Voltage mode) can trigger an over voltage interrupt with the set point determined by the value of resistor **R172**.

DC Overvoltage set point calculation: Using the standard DC voltage range, set the over voltage trip at 700V. For this voltage, the voltage at the overvoltage comparator is given by:

$$V_{vdcoc} = \frac{3}{816} \times 700V = 2.57V$$

R172 is then given by:

$$R172 = \frac{2.866V - V_{vdcoc}}{V_{vdcoc}} \times \frac{1}{\left(\frac{1}{R180} + \frac{1}{R169 + R171}\right)} = 1k$$

Note that this expression includes the effects of the 100k hysteresis feedback resistor associated with the overcurrent comparator.

If the standard resistor value of 1k was used, this gives a trip voltage of 700V.

The VDC1 input can be configured to have an offset introduced that enables it to operate as an AC voltage input (VAC3). To operate in this mode remove **R149** and insert a 0 ohm resistor at **R148**. By default this halves the range of the VAC3 input. If a greater range is required then the op-amp scaling resistors should be adjusted.

In addition to the VDC1 input acting as an independent AC voltage measurement (VAC3) there is also a zero crossing detection circuit that connects to pin 49 on **X30.** This is Capture Port 4 (CAP4) on the CPT-DA2810 TMS320F2810 DSP board. When operating in AC Voltage mode the VDC1 level comparison (LC_VDC1) circuitry can only detect a positive level limit being reached.

3.1.1.5 DC Current Inputs

The two DC current inputs can accept input from either a CT (current transformer) or a LEM module with a current output. The on-card burden resistors (**R22, R23**) must be chosen such that under maximum current conditions the voltage developed across the resistor does not exceed ±4V. The input circuitry consists of an operational amplifier gain and offset stage to condition the signals to a notional 0-3V for entry into the ADC. The input presents an impedance of 2k2 to the incoming current transducer, excluding the burden resistor.

The DSP inputs are protected by a diode clamp that limits the input voltage to the input rated value. Software compensation of any offsets should be completed during calibration to compensate for component tolerance variations.

3.1.2 Digital Inputs

The 6 digital input bits are configured as two off optically isolated inputs and four off on-card DIP switches.

The 2 off optically isolated digital input circuits each comprise of a parallel RC filter, a 4V7 threshold diode, a LED indicator and an optocoupler. The output of the optocoupler feeds an RC filter, which generates a TTL compatible output voltage in conjunction with a 10k pull-up resistor. Each of these digital inputs is fully isolated from the main digital ground and can withstand up to 1500V peak. The digital inputs are linked via a common ground to the +24V input (section 3.3.4). The on-card +24V is supplied to the third terminal of each of the inputs, to provide a positive supply to a field transducer. (Section 3.3.4).

The 4 DIP switch inputs are buffered and their arrangements are summarised in Table 3-2.

DSP Input Bit	GPIOA4	GPIOA5	GPIOA6	GPIOA7
Switch	**S1**.1	**S1**.2	**S1**.3	**S1**.4

Table 3-2: On-card DIP switch input bit allocations

3.1.3 Digital Outputs

The 9 digital output bits are configured as three off optically isolated MOSFETs, two off 240Vac relay and 4 on-card status LEDs.

The 3 off isolated MOSFET digital output circuits drive through an optocoupler, which can withstand up to 1500V peak. The output MOSFET is rated at 100V, 20A. The output load should be connected between the MOSFET drain and the +24V supply (the MOSFET acts as a pull down switch). A LED is connected in parallel with the output load through a 10k pull-up resistor to provide a visual indication of the output state A 3-pin Plug-in PCB Mounting Terminal Block is used for each output, which has a ground, signal and +24V supply (section 3.3.6).

The 2 off relay output consists of an LED status indicator, a logic NPN transistor, a diode and a relay coil, driven by the +15V on-card supply. The relay provides a single pole changeover contact rated at 10A 240Vac/30Vdc. (section 3.3.6).

The 4 status LEDS are controlled by port A as follows:

Port A Bit	GPIOB10	GPIOB9	GPIOB7	GPIOB6
LED	**H6**	**H7**	**H8**	**H9**

Table 3-3: LED/Port B bit allocations

3.1.4 Temperature Measurement

The CPT-E13 card contains an isolated Thermistor-to-Digital Converter chip that converts an external NTC (negative temperature co-efficient) thermistor's temperature-dependent resistance into digital form. The MAX6682 chip is used for the conversion process; however the chip does not attempt to linearize the measurements over a wide range. It is capable of producing linear results in the 0 to +50°C range. For full details of interfacing the chip please consult the MAX6682 datasheet available from the www.maxim-ic.com website.

An ACSL-6310 multi-channel bi-directional optocoupler provides full isolation between the digital circuitry and the field supply referenced thermistor output.

The default circuit resistors are designed for use with an Epcos B57703M103G 10kΩ NTC Thermistor. If a different value thermistor is required then the reference resistors **R243**, **R249** and **R251** should be recalculated with reference to the MAX6682 datasheet.

The digital output from the MAX6682 is a 3-wire SPI-compatible interface, which connects directly to the CPT-DA2810's SPI interface. The SPISTE* signal is used as the enable on this interface, which precludes multi-processor SPI communication being used with the IDC header on the CPT-DA2810.

3.1.5 Position Encoder Inputs

The position encoder interface accepts quadrature encoded pulses from a relative position encoder system, and uses these pulses to update a position counter within the DSP. GP timer 2 is incremented or decremented by the rising and falling edges of the two input signals. Timers can be configured as a 16 bit position counter, or cascaded together to make a 32 bit position counter.

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

Link LK3 is used to select input bit GPIOA8/CAP1_QEP1 between the position encoder Phase A input and the zero crossing detection signal from analogue input VAC1(V_{AN}).

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

Full details on how to program the DSP to support a position encoder input are provided in Texas Instruments manual *spru065*.

3.1.6 PWM Signals

The PWM interface is configured such that Gate Driver outputs 1 to 4 are sourced from Event Manager B and Gate Driver outputs 5 to 8 are sourced from Event Manager A on the 80 way socket, **X30**. The CPT-E13 card produces fully isolated gate drive signals using the Hewlett Packard HCPL-316J gate driver chip.

This chip provides:

- drive capability for IGBTs up to 1200V, 150A,
- an optically isolated fault signal,
- built in DESAT protection, and under voltage lock out
- 500ns Max. Switching Speeds,
- 15kV/µs Min. Common Mode Rejection
- "Soft" IGBT turn-off under fault conditions

Each gate drive includes a fully isolated regulated +17/-5V supply that is generated through a ferrite transformer from the +15V_GATE supply. High voltage (1000V) isolation is provided between each of the gate drives and the logic section. The presence of these isolated supplies, in conjunction with the HCPL-316J gate driver chip, enables each gate drive on the board to control IGBT or FET devices by connecting the output from the CPT-E13 directly to the switching device terminals.

The CPT-E13 supports 2, 3 or 4-arm bridge operation, with the gate drive outputs connected to 8 off separate 4 way connectors (one for each IGBT gate). Each connector consists of a Collector, Gate and Emitter.

The HCPL-316J produces a fault output signal when a DESAT condition is detected. The four fault outputs corresponding to each Event Manager are combined together and, for the default board configuration, connect to PDPINTA* and PDPINTB* interrupts on the DSP (CPT-DA2810). When a fault signal is triggered it causes all PWM outputs for the corresponding Event Manager to be placed into a high impedance state. A pull-down resistor pack on the DSP's PWM pins is used to fully disable the PWM outputs when this fault trip occurs.

There are on-card resistors that enable the 8 gate fault signals to be connected to either or both PDPINT* signals, see Table 3-4. The default configuration is in **bold**.

PWM1-4 Fault signals	***PWM5-8 Fault signals***	***Resistor R218***	***Resistor R220***	***Resistor R227***	***Resistor R235***
PDPINTB*	**PDPINTA***	**0R**	**Not Loaded**	**Not Loaded**	**0R**
PDPINTA*		0R	0R	Not Loaded	Not Loaded
PDPINTB*		Not Loaded	Not Loaded	0R	0R
PDPINTA* & PDPINTB*		Not Loaded	0R	0R	Not Loaded

Table 3-4: Fault Feedback Selection - PDPINT

3.1.7 On-card Power Supplies

The CPT-E13 can operate from a wide-ranging single phase AC or DC source. The card contains a flyback converter, which can operate from 200V to 440Vac, 280V to 750Vdc, and produces 3 isolated supply outputs. These outputs are +15V/DGND, ±18V/AGND and a +24V/+24V_COM field supply.

The two unregulated ±18V supplies are used to generate the regulated +15V and –15V analog supplies, using 7815 and 7915 TO-220 regulators. The analog offset supplies are generated from the +2.5V reference that is supplied from the CPT-DA2810. The signals are buffered through op-amps to provide extra current capacity.

The analog and digital grounds are connected on the CPT-DA2810 board beneath the TMS320F2810 DSP. This should be the only location within the system where the analog and digital supplies are connected together to ensure optimum performance of the DSP.

The unfiltered +15V_GATE/EARTH is used to supply the power to the gate driver circuits. Each gate circuit has its own isolated +17/-5V supply, regulated through LM317 and 7905 regulators. Isolation is achieved with a ferrite transformer (RM6 package).

The card's +5V digital supply is produced from the unregulated +15V by an on-card 1A switcher, LM2575T5.0.

The field supply is a nominal +24V supply, and is used by the isolated digital I/O. No regulation is provided for the field supply.

The flyback converter on the alternative CPT-E13 (LV) board (the low input voltage version) has been revised to operate from a lower value wide-ranging single phase AC or DC source of 85V to 265Vac, 130V to 370Vdc.

3.2 Installation and Setup

3.2.1 General

The CPT-E13 card is supplied configured with a CPT-DA2810 DSP controller board and with no program loaded into the on-chip Flash ROM.

The sample software available with the optional companion CD uses the TTL serial terminal as the system console through SCIA (connector CPT-DA2810:**X3**).

Many of the features of the CPT-E13 card use the capabilities of the TMS320F2810 DSP chip. A complete description of this processor is provided in the *TMS320F2810, TMS320F2811, TMS320F2812, TMS320C2810, TMS320C2811 and TMS320C2812 Digital Signal Processors Data Manual* available from the Texas Instruments website. Document Number *SPRS174O*.

There are multiple documents available within the TMS320F2810 literature that focus on the individual sections within the DSP chip.

Consult the TI Website: http://focus.ti.com/docs/prod/folders/print/tms320f2810.html for the complete list of available documentation on the TMS320F2810 DSP.

Note: for applications where a power stage has not been attached to the gate driver outputs, it is necessary to short circuit each gate driver collector to its corresponding emitter to avoid a desaturation trip when the PWM process commences.

3.2.2 Option Links

There are a number of option links on the CPT-E13 DSP Controller Card. The location of each link header is shown on the "Link, Test Pin and Posted-Resistor Locations Diagram" in Appendix C. The link selectable options and their default settings are shown in Table 3-5.

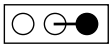
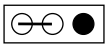
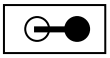
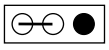
LINK DESIGNATOR	PURPOSE	DEFAULT	ALTERNATIVES	GRID REF.
LK1	Analog AC Input Current Set differential Voltage or Current input mode	 2.5V offset – LEM Voltage Output	 AGND – CT or LEM Current Output	**H4**
LK2	Terminating Resistor COM Port B	 No termination	 220R Termination	**E4**
LK3	QEP1 / Zero Crossing 1 Selection	 Zero-Crossing Mode	 QEP1 Mode	**H4**

Table 3-5: On-card Selectable Links

3.2.3 External Connectors

CONNECTOR DESIGNATOR	DESCRIPTION	NO. PINS	TYPE	SECTION	FIGURE
X1	Analog DC Voltage – VDC1 (VAC3)	3	TB5	3.3.3.4	Figure 3-6
X2	Analog DC Voltage – VDC2	3	TB5	3.3.3.4	Figure 3-6
X3	Analog AC Voltage – VAC1 Analog AC Voltage – VAC2	5	TB5	3.3.3.2	Figure 3-5
X4	Analog DC Voltage – VDC3	3	TB5	3.3.3.4	Figure 3-6
X5	Analog AC Current – IAC1 Analog AC Current – IAC2 Analog AC Current – IAC3	6	TB3	3.3.3.1	Figure 3-3
X8	Analog DC Current – IDC1 Analog DC Current – IDC2	4	TB3	3.3.3.5	Figure 3-4
X10	Analog Power Supply ±15V/AGND	3	TB3	3.3.3.1	Figure 3-3
X11	Serial Port – RS-485B	4	TB3	3.3.2.1	Figure 3-2
X12	Relay Output – RELAY1	3	TB3	3.3.6	Figure 3-17
X13	Relay Output – RELAY2	3	TB3	3.3.6	Figure 3-17
X14	Gate Drive – AU	4	TB5	3.3.8	Figure 3-19
X15	Gate Drive – AL	4	TB5	3.3.8	Figure 3-19
X16	Gate Drive – BU	4	TB5	3.3.8	Figure 3-19
X17	Gate Drive – BL	4	TB5	3.3.8	Figure 3-19
X18	Gate Drive – CU	4	TB5	3.3.8	Figure 3-19
X19	Gate Drive – CL	4	TB5	3.3.8	Figure 3-19
X20	Gate Drive – DU	4	TB5	3.3.8	Figure 3-19
X21	Gate Drive – DL	4	TB5	3.3.8	Figure 3-19
X22	Digital Input – DIGIN2	3	TB3	3.3.5	Figure 3-9
X23	Digital Input – DIGIN1	3	TB3	3.3.5	Figure 3-9
X24	Mosfet Output – MOSFET3	3	TB3	3.3.6	Figure 3-13
X25	Mosfet Output – MOSFET2	3	TB3	3.3.6	Figure 3-13
X26	Mosfet Output – MOSFET1	3	TB3	3.3.6	Figure 3-13
X27	Power Supply Input	5	TB5	3.3.9	Figure 3-20
X28	Thermistor (NTC) with Earth Shield	3	TB3	3.3.7	Figure 3-18
X29	Thermal Switch (disables switcher)	2	MOL.1	3.3.9	Figure 3-20
X30	CPT-DA2810 80 way socket	80	Pin Strip	3.3.1	Figure 3-1
X31	Position Encoder	5	MOL.1	3.3.4	Figure 3-8

Table 3-6: Connectors Definition

Note: IDC = IDC Header, TB3 = Phoenix MCV series connector - 3.81mm spacing, TB5 = Phoenix MSTBVA series connector – 5.08mm spacing, Pin Strip – non-shrouded header, MOL.1 = 0.1” spacing MOLEX connector

3.3 Card Options and Connector Descriptions

3.3.1 CPT-DA2810 Interface – 80 way DSP Connector

The interface between the CPT-E13 and the CPT-DA2810 DSP Controller Board is the 80-way dual-in-line connector, **X30**. This connector contains all necessary interfaces to enable the CPT-E13 board to operate with the CPT-DA2810. Many of the pins on the connector are discussed in detail with the CPT-DA2810 manual, which should be read in conjunction with this manual, and as such they will not be repeated here. The detailed pinout description is given in Appendix D and shown in Figure 3-1.

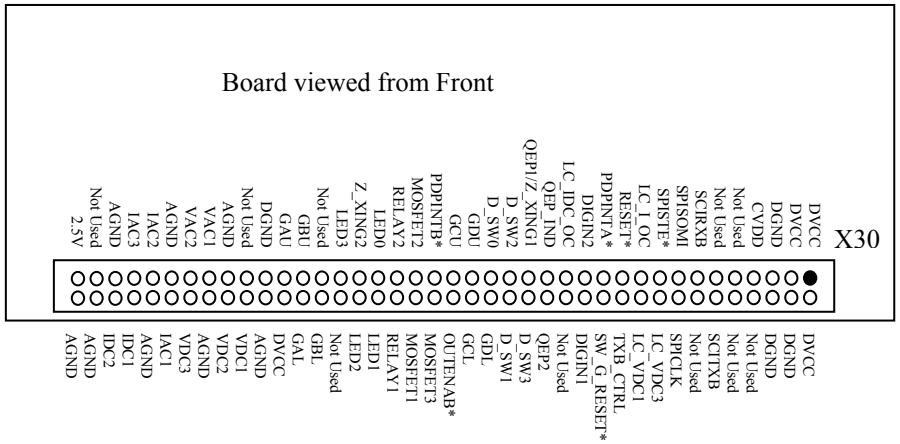


Figure 3-1: CPT-DA2810 Connector – CPT-E13 usage definitions (X30)

80 WAY CPT-DA2810 INTERFACE			
Description	*Pin*	*CPT-E13*	*CPT-DA2810*
5V Supplied **TO** CPT-DA2810	1	DVCC	DVCC
5V Supplied **TO** CPT-DA2810	2	DVCC	DVCC
5V Supplied **TO** CPT-DA2810	3	DVCC	DVCC
Digital Ground	4	DGND	DGND
Digital Ground	5	DGND	DGND
Digital Ground	6	DGND	DGND
3.3V Supplied **FROM** CPT-DA2810	7	CVDD	CVDD
	8	N/C	GPIOF6 / CANTX
	9	N/C	GPIOF7 / CANRX
	10	N/C	GPIOF4 / SCITXA
	11	N/C	GPIOF5 / SCIRXA
TTL Level Serial Transmit – used with RS-485	12	SCITXB	GPIOG4 / SCITXB
TTL Level Serial Receive – used with RS-485	13	SCIRXB	GPIOG5 / SCIRXB
	14	N/C	GPIOF0 / SPISIMO
SPI Data read from Thermistor-to-Digital	15	SPISOMI	GPIOF1 / SPISOMI
SPI Clock for Thermistor-to-Digital	16	SPICLK	GPIOF2 / SPICLK
SPI Transmit Enable for Thermistor-to-Digital	17	SPISTE*	GPIOF3 / SPISTE*
DC3 Over Voltage Trip Signal	18	LC_VDC3	GPIOE2 / XNMI
Combined AC Overcurrent Trip Signal	19	LC_I_OC	GPIOE0 / XINT1
DC1 Over Voltage Trip Signal	20	LC_VDC1	GPIOE1 / XINT2
Reset Signal FROM CPT-DA2810 board	21	RESET*	RESET*
RS-485 Transmit Control	22	TXB_CTRL	GPIOD1 / T2CTRIP*
EVA – Gate Driver Fault Signal	23	PDPINTA*	GPIOD0 / PDPINTA*
Software Gate Driver Reset Signal	24	SW_G_RESET*	GPIOA12 / TCLKINA
Digital Input – Isolated DIGIN2	25	DIGIN2	GPIOA11 / TDIRA
Digital Input – Isolated DIGIN1	26	DIGIN1	GPIOA15 / C3TRIP*
DC Over Current Trip Signal	27	LC_IDC_OC	GPIOA14 / C2TRIP*
	28	N/C	GPIOA13 / C1TRIP*
Position Encoder Index Signal	29	QEP_IND	GPIOA10 / CAP3

80 WAY CPT-DA2810 INTERFACE			
Description	*Pin*	*CPT-E13*	*CPT-DA2810*
Position Encoder Phase B	30	QEP2	GPIOA9 / CAP2
LK3 Select – Position Encoder Phase A, or Zero-Crossing (VAC1)	31	QEP1/Z_XING1	GPIOA8 / CAP1
Digital Input – DIP Switch 3	32	D_SW3	GPIOA7 / T2PWM
Digital Input – DIP Switch 2	33	D_SW2	GPIOA6 / T1PWM
Digital Input – DIP Switch 1	34	D_SW1	GPIOA5 / PWM6
Digital Input – DIP Switch 0	35	D_SW0	GPIOA4 / PWM5
EVA – Gate Driver Phase D Lower	36	GDL	GPIOA3 / PWM4
EVA – Gate Driver Phase D Upper	37	GDU	GPIOA2 / PWM3
EVA – Gate Driver Phase C Lower	38	GCL	GPIOA1 / PWM2
EVA – Gate Driver Phase C Upper	39	GCU	GPIOA0 / PWM1
Enable Digital Output Buffers	40	OUTENAB*	GPIOD6 / T4CTRIP*
EVB – Gate Driver Fault Signal	41	PDPINTB*	GPIOD5 / PDPINTB*
Digital Output – MOSFET3	42	MOSFET3	GPIOB12 / TCLKINB
Digital Output – MOSFET2	43	MOSFET2	GPIOB11 / TDIRB
Digital Output – MOSFET1	44	MOSFET1	GPIOB15 / C6TRIP*
Digital Output – RELAY2	45	RELAY2	GPIOB14 / C5TRIP*
Digital Output – RELAY1	46	RELAY1	GPIOB13 / C4TRIP*
Digital Output – LED0	47	LED0	GPIOB10 / CAP6
Digital Output – LED1	48	LED1	GPIOB9 / CAP5
Zero-Crossing for VDC1 in AC Input Mode	49	Z_XING2	GPIOB8 / CAP4
Digital Output – LED2	50	LED2	GPIOB7 / T4PWM
Digital Output – LED3	51	LED3	GPIOB6 / T3PWM
	52	N/C	GPIOB5 / PWM12
	53	N/C	GPIOB4 / PWM11
EVB – Gate Driver Phase B Lower	54	GBL	GPIOB3 / PWM10
EVB – Gate Driver Phase B Upper	55	GBU	GPIOB2 / PWM9
EVB – Gate Driver Phase A Lower	56	GAL	GPIOB1 / PWM8
EVB – Gate Driver Phase A Upper	57	GAU	GPIOB0 / PWM7
Supply to 5V Isolated Comms DC/DC Converter	58	DVCC_C	DVCC
Push Button Reset	59	MAN_RESET*	MAN_RESET*
Analog Ground	60	AGND	AGND
Analog Ground	61	AGND	ADCINB5
DC Voltage 1	62	VDC1	ADCINB4
Analog Ground	63	AGND	AGND
DC Voltage 2	64	VDC2	ADCINB3
AC Voltage 1	65	VAC1	ADCINB2
Analog Ground	66	AGND	AGND
AC Voltage 2	67	VAC2	ADCINB1
DC Voltage 3	68	VDC3	ADCINB0
Analog Ground	69	AGND	AGND
AC Current 1	70	IAC1	ADCINA0
AC Current 2	71	IAC2	ADCINA1
Analog Ground	72	AGND	AGND
AC Current 3	73	IAC3	ADCINA2
DC Current 1	74	IDC1	ADCINA3
Analog Ground	75	AGND	AGND
DC Current 2	76	IDC2	ADCINA4
Analog Ground	77	AGND	ADCINA5
Analog Ground	78	AGND	AGND
2.5V Reference Output	79	2.5V	2.5V
Analog Ground	80	AGND	AGND

Table 3-7: Definitions on 80 way CPT-DA2810 connector (X30)

3.3.2 Communications

The CPT-E13 controller board supports one off non-isolated 3.3V-TTL serial communications interface (SCIA) via the CPT-DA2810, one off RS-485 isolated serial communications interface (SCIB), and a 3.3V-TTL synchronous serial peripheral interface (SPI).

3.3.2.1 Asynchronous Serial Interface

The CPT-E13 supports two-wire asynchronous communication on Port SCIA of the CPT-DA2810 via a non-buffered 3.3V-TTL serial interface and on Port SCIB via an isolated RS-485 interface. The UARTs offer the following features[I]:

- Baud rate programmable to 64K different rates
- Data-word format: 1 start bit, 1-8 data bits, optional odd/even/no parity, 1/2 stop bits
- Four error-detection flags: parity, overrun, framing and break detection
- Two wake-up multiprocessor modes: idle-line and address bit
- Half- or full-duplex operation
- Double buffered receive and transmit functions
- Transmitter and receiver operations can be accomplished through interrupt-driven or polled algorithms with status flags
- Separate enable bits for transmitter and receiver interrupts (except BRKDT)
- NRZ (non-return-to-zero) format
- 13 SCI module control registers located in the control register frame beginning at address 7050h.

Enhanced features:

- Auto-baud-detect hardware logic
- 16-level transmit/receive FIFO

In RS-485 mode on SCIB if the CPT-E13 card is to provide the terminating resistor on the RS-485 multi-drop line, then link **LK2** (SCIB) should be inserted.

Serial Port A (SCIA) is accessible via the four pin connector, **X3** on the CPT-DA2810. The four pin connector, DA2810:**X3**, is a standard interface across many of Creative Power Technologies' processor boards and provides a power supply as well as the transmit and receive serial lines for use by an external interface board. Please refer to the CPT-DA2810 Technical Manual for further details.

A 3.3V-TTL to RS-232 conversion board must be used to interface this serial port to an external computer or terminal device. These boards are available from Creative Power Technologies; quote board number CPT-COM Version 1.2 or later.

Serial Port B (SCIB) is accessible as an isolated RS-485 interface via the four pin connector, **X11**. The isolated +5V communications supply can be generated from either of the optional load on-card DC/DC converters **T5** (NMF0505S or equivalent) or **T6** (NKE0305S or equivalent). Alternatively an off-card voltage source can be connected to energize the isolated communications section.

RS-485 SERIAL PORT B			
Description	*Pin*	*Conn.*	*Type*
VISOB (5V)	1	**X11**	MCV1,5
Transmit/Receive Signal RS –485 Protocol (Positive Differential) RS485B_A	2		
Transmit/Receive Signal RS –485 Protocol (Negative Differential) RS485B_B	3		
Communication Ground – DGND_ISOB	4		

Table 3-8: Signal Pins for Communications Protocols

[I] TMS320x281x, 280x DSP Serial Communication Interface (SCI) Reference Guide. Texas Instruments Document No: *spru051b.pdf*

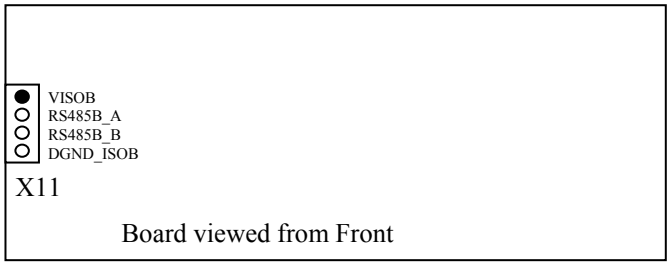


Figure 3-2: RS485 Interface Connector (X11)

3.3.2.2 Synchronous Serial Peripheral Interface

The CPT-E13 supports synchronous communication through the SPI port on the TMS320F2810. This is available through connector DA2810:**X2**. The clocked serial peripheral interface on the CPT-E13 supports a master/many slave configuration for communication between multiple slave devices. In synchronous mode the UART1 communications channel on the CPT-E13 offers the following features[II]:

- 1- to 16-bit data length
- 3-pin and 4-pin SPI operation
- Master or slave modes
- Four Clocking Schemes
- Simultaneous receive and transmit operation
- 12 SPI module control registers
- Independent interrupt capability for receive and transmit
- 16-level transmit/receive FIFO
- Delayed transmit control

The SPI consists of transmit and receive pins with a serial clock pin for synchronising data transfer. The CPT-E13 has been configured to use the SPI port and its SPITE* Enable signal for the SPI Thermistor input on **X28**. If the SPI port on the DA2810:**X2** is to be used then the use of the SPITE* pin must be taken into consideration.

When operated in master mode, the CPT-DA2810 sends out the synchronising serial clock signal for the slave devices. The SPI connector on the CPT-DA2810, DA2810:**X2**, provides +3.3V (CVDD) and CDGND signals as well as additional signals required for the SPI boot option (discussed in 3.3.3). A 10-way non-shrouded IDC connector is used for this clocked serial peripheral interface, with the pinouts listed in the CPT-DA2810 manual.

Software to support the operation of this interface has been developed within the low level interrupt bios files available for the CPT-E13 board.

[II] TMS320x281x, 280x DSP Serial Peripheral Interface (SPI) Reference Guide. Texas Instruments Document No: *spru059d.pdf*

3.3.3 Analog Inputs

The 10 off filtered Analog channels on the CPT-E13 card have been separated into four types of inputs. This section outlines the connector arrangements for each of those sections, as well as detailing the available alternative configurations.

3.3.3.1 AC Current Inputs

Each current input is available on a six way Phoenix MCV1,5 3.81mm connector (**X5**) and each input provides a signal and signal return (AGND) for either an external LEM or CT. Figure 3-3 shows the analog current input connector configuration. The wires that attach to the AC current inputs should be arranged as a twisted pair to reduce the impact of noise. Alternatively, the wires could be shielded to achieve the same effect.

The 3 AC current inputs must use the ±15V available on **X10** to power the off-card LEMs. The current capacity of this supply is limited (300 mA at 40°C) and the ±15V regulators (**T2, T3**) heatsink temperatures should be checked to ensure that overheating does not occur if this supply is used. The layout of the analog supply connector (**X10**), which is a 3 way Phoenix MCV1,5 3.81mm connector, is shown in Figure 3-3.

The analog current inputs have an overcurrent threshold detect circuit. The threshold limit is set by **R173**, which determines the comparator voltage at which the overcurrent is detected (Section 3.1.1.1). The overcurrent detect is fed to X30 pin 19 and triggers XINT1 on the CPT-DA2810 DSP.

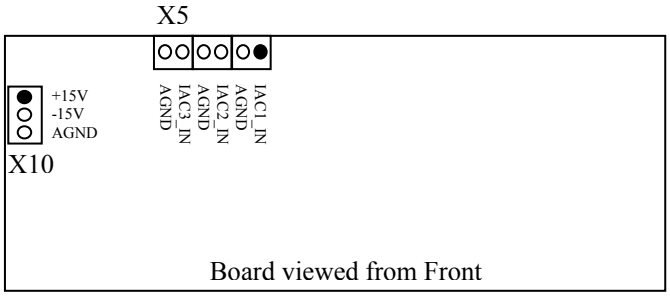


Figure 3-3: Analog AC Current Input Connectors (X5)

3.3.3.2 DC Current Analog Inputs

The two dc current inputs are on a 4 way Phoenix MCV 3.81mm spacing connector, **X8**, which provides a signal and signal return (AGND) for each input from an external LEM. Figure 3-4 shows the analog DC current inputs connector configuration. The wires that attach to the DC current inputs should be arranged as a twisted pair to reduce the impact of noise. Alternatively, the wires could be shielded to achieve the same effect.

The DC current inputs can use the ±15V available on connector **X10** to power the off-card LEMs. The current capacity of this supply is limited (300 mA at 40°C) and the ±15V regulators (**T2, T3**) heatsink temperatures should be checked to ensure that overheating does not occur if this supply is used. The layout of the analog supply connector (**X10**), which is a 3 way Phoenix MCV1,5 3.81mm connector, is shown in Figure 3-4.

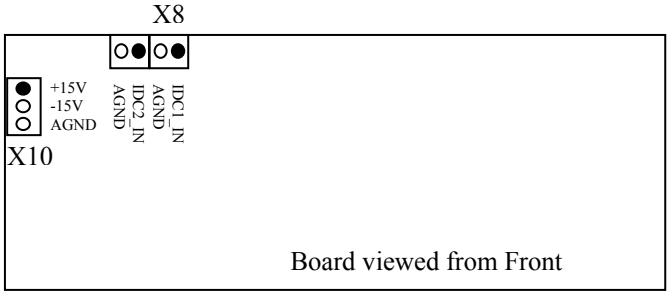


Figure 3-4: Analog DC Current Input Connector (X8)

3.3.3.3 AC Voltage Inputs

The 2 AC voltage inputs use three pins of a five way Phoenix MSTBVA 5.08mm spacing connector, **X3**, to generate the differential signal input that is required for the measurement. The two analog inputs are differential signals referenced against the third common input (VN). This reduces the number of components required for the analog circuitry whilst still providing full flexibility for AC voltage measurement. The arrangement of the AC Voltage connector is shown in Figure 3-5.

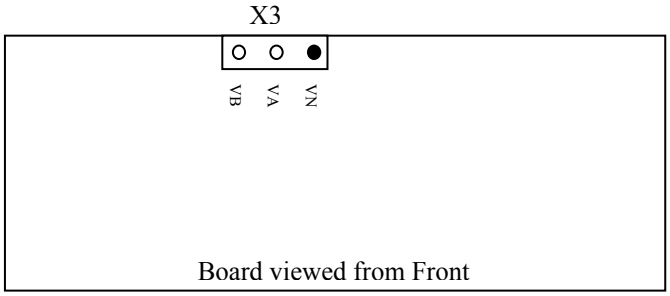


Figure 3-5: AC Voltage Input Connector (X3)

A typical AC voltage measurement that may be required is phase-phase. The connector can be wired up to achieve this measurement as follows.

- Three wire system (requiring only two voltages – typically phase-to-phase)

  Connection

VN	Phase C
VA	Phase A
VB	Phase B

  ADC Measures

VAC1	V_{AC}
VAC2	V_{BC}

The Analog AC voltage circuitry also provides a zero-crossing detection circuit on the first differential input, VAC1. The zero-crossing circuit produces a square wave output, which is fed to **X30** pin 31 and ultimately to capture input CAP1 on the CPT-DA2810 DSP chip. The capture inputs have a selectable transition detection, which stores the value of the GP timer 2 counter and/or GP timer 3 counter.

To operate the zero-crossing detector on VAC1, link **LK3** must be connected between pins 2 and 3.

3.3.3.4 AC/DC Voltage Input

The AC/DC Voltage Input is a three way Phoenix MSTBVA 5.08mm spacing connector with the two outside pins being used for the differential signal input that is used for the measurement (**X1)**. The arrangement of the AC/DC Voltage connector is shown in Figure 3-6.

The AC/DC Voltage Input VDC1/VAC3 has an over voltage threshold detect circuitry. The threshold limit for VDC1 is set by **R172**, which determines the comparator voltage at which the overvoltage is detected (section 3.1.1.3).

The VDC1 over voltage detect is fed to **X30** pin 20 and triggers XINT2 on the CPT-DA2810 DSP.

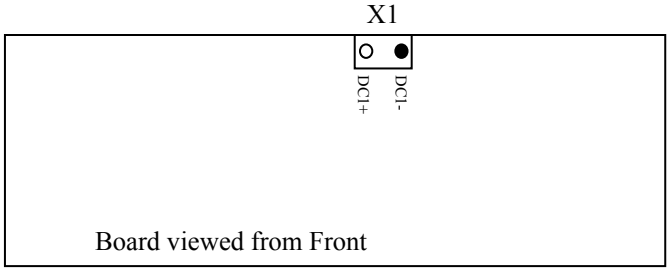


Figure 3-6: AC/DC Voltage Input Connector (X1)

3.3.3.5 DC Voltage Inputs

The DC Voltage Inputs are a three way Phoenix MSTBVA 5.08mm spacing connector with the two outside pins being used for the differential signal input that is used for the measurement (**X2** and **X4)**. The arrangement of the DC Voltage connectors is shown in Figure 3-6.

The DC Voltage Input VDC3 has an over voltage threshold detect circuitry. The threshold limit for VDC3 is set by **R161**, which determines the comparator voltage at which the overvoltage is detected (section 3.1.1.3).

The VDC3 over voltage detect is fed to **X30** pin 18 and triggers XNMI on the CPT-DA2810 DSP.

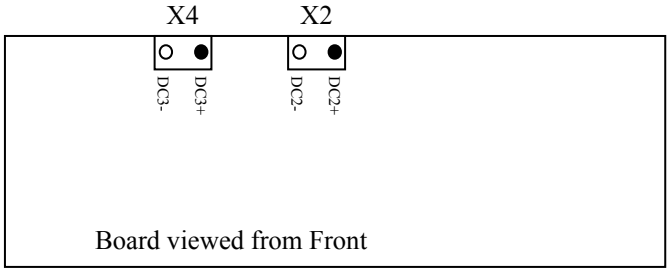


Figure 3-7: DC Voltage Input Connector (X2, X4)

3.3.4 Position Encoder Interface

The position encoder interface is a 5 way MOLEX 0.1" header connector. The encoder inputs have an on-card 10k pull up resistor to DVCC. The +15V_IN supply is also made available at the encoder connector to provide a supply voltage to the external encoder if required. (This is the preregulated supply for DVCC).

Figure 3-8 shows the pinout definitions for the position encoder input connector (X31).

To use the position encoder:

- LK3 must be placed in the *Pos Encoder* position (pins 1&2 linked), as indicated on the PCB

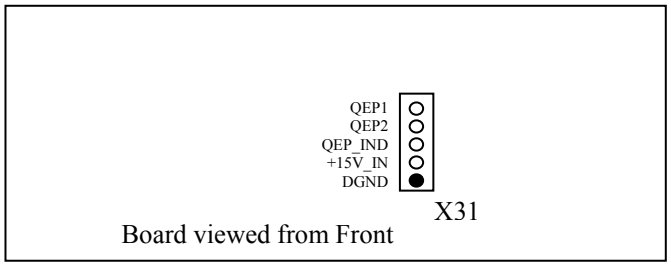


Figure 3-8: Position Encoder Connector (X31)

3.3.5 Isolated Digital Inputs

The 2 off isolated digital inputs are on Phoenix MCV 3.81mm spacing connectors, (**X22**, **X23**) which have three terminals, +24V (with 1k series resistor), Signal and Ground, as shown in Figure 3-9. The digital inputs have a shared isolated supply and ground connection. The +24V field supply is provided on each connector through a 1k series resistor for off-card Powered Field Transducers, or similar active devices.

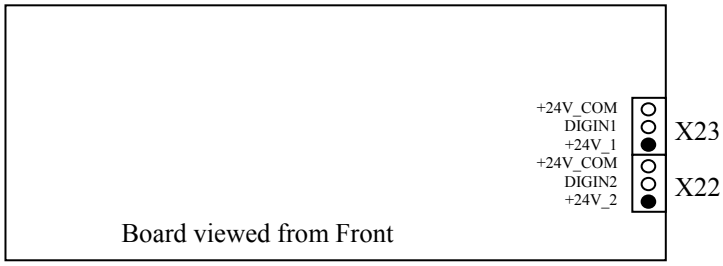


Figure 3-9: Isolated Digital Input Connector Configuration (X22, X23)

Possible connection arrangements for the Digital Inputs are shown in the following diagrams, Figure 3-10 through to Figure 3-12.

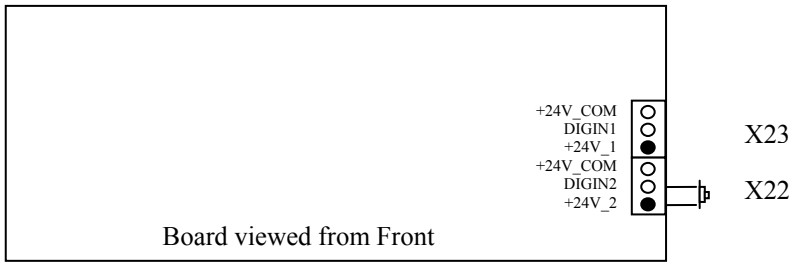


Figure 3-10: Clean Contact Input

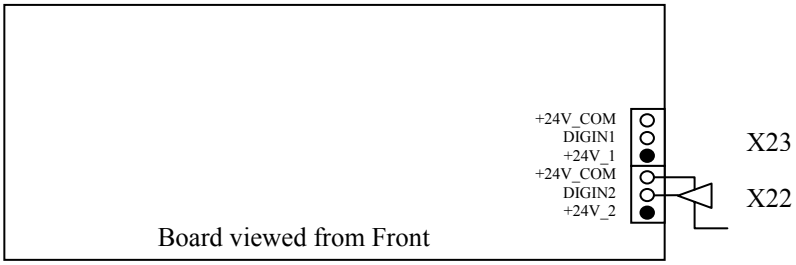


Figure 3-11: Powered Transdicer - External Power Source

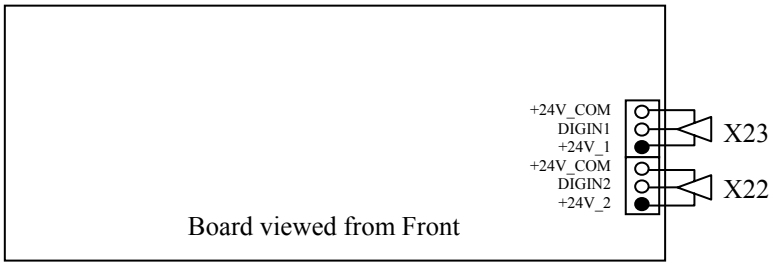


Figure 3-12: Powered Transducer – On-card Power Source

3.3.6 Isolated Digital Outputs

The 5 off isolated digital outputs are split into three optically isolated MOSFET outputs and two relay with 240Vac rated contacts.

The MOSFET outputs, as a group, operate from the +24V on-card supply. The connector used by the isolated MOSFET digital outputs is a Phoenix MCV 3.81mm spacing connector (**X24**, **X25, X26**) that has three terminals, +24V, Signal and +24V_COM, as shown in Figure 3-13.

The MOSFET outputs can be used to drive Powered Output Transducers which use the +24V field supply provided on each connector as shown in Figure 3-14 or to drive relay coils or optocouplers, as shown in Figure 3-15 and Figure 3-16.

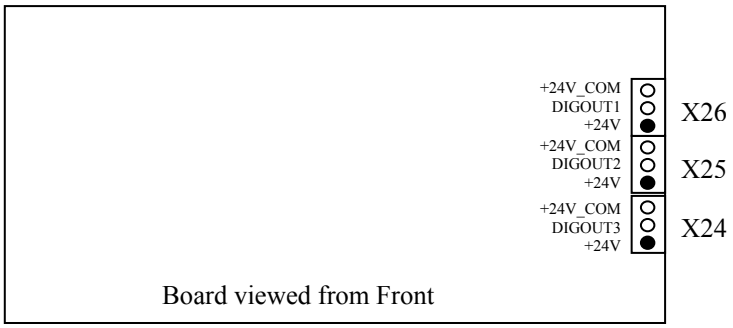


Figure 3-13: MOSFET Digital Output Connections (X24 – X26)

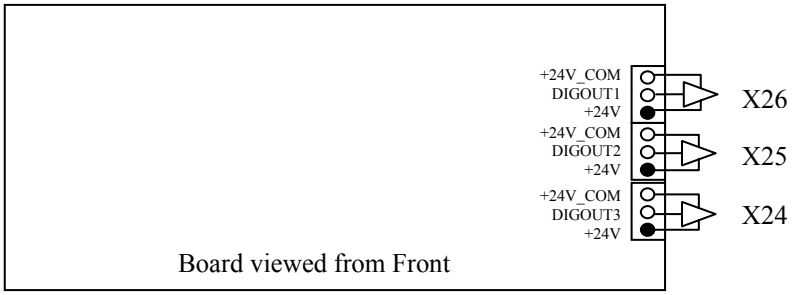


Figure 3-14: Power Output Transducer – On-card Power Source

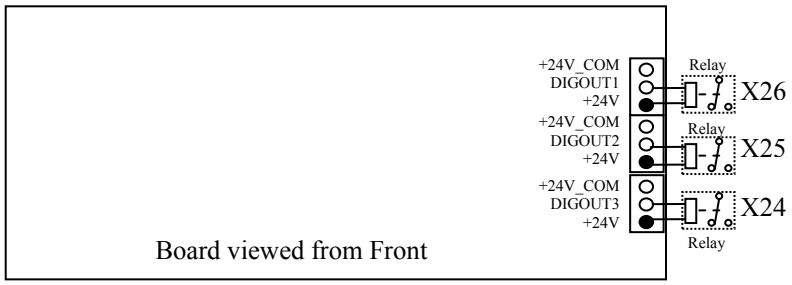


Figure 3-15: Relay Coil Drive Output

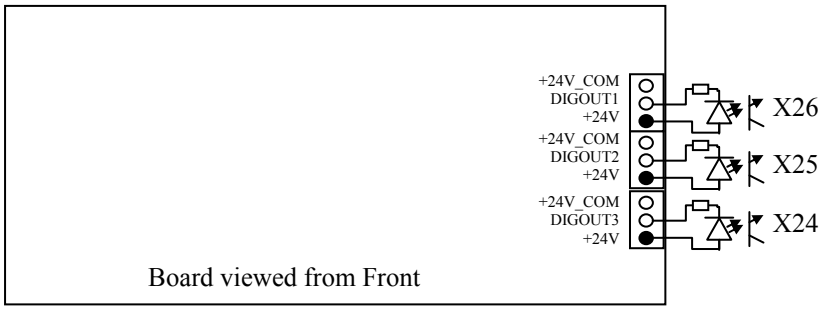


Figure 3-16: Optocoupler Drive Output

The relays have +12Vdc coil and provide a clean +240V AC/+30V DC changeover output contact, as shown in Figure 3-17.

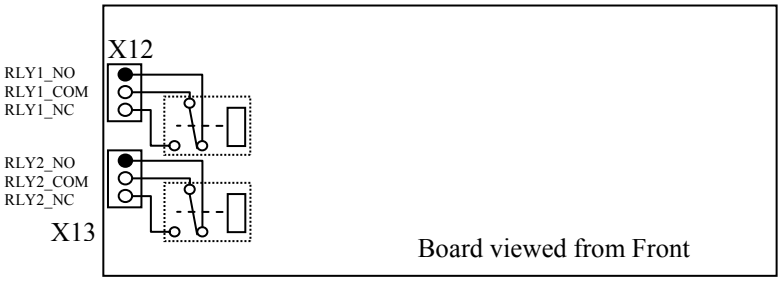


Figure 3-17: Clean Contact Relay Output

3.3.7 Thermistor Interface

The NTC thermistor interface is a 3 way Phoenix MCV 3.81mm spacing connector that has NTC, NTC_RTN and Earth Shield terminals. The NTC thermistor should be connected directly to the NTC and NTC_RTN pins and an optional earth shield is used to protect the signal from noise. The measurement circuit uses a very small amount of current and noise can affect its results.

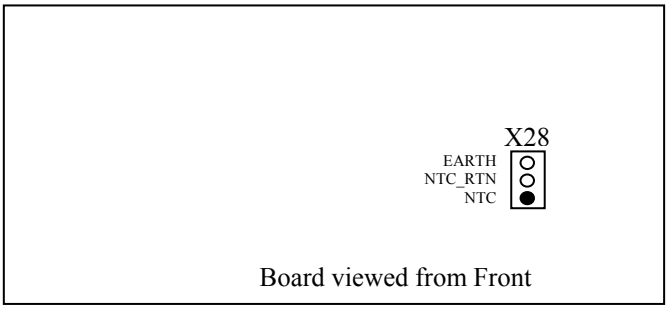


Figure 3-18: NTC Thermistor Input Connector (X28)

3.3.8 Gate Driver Interface

Each of the 8 Gate Drive connectors consists of a 4 way Phoenix MSTBVA 5.08mm spacing connector that has three terminals, Emitter, Gate and Collector. The PWM outputs from the CPT-E13 card connect directly to the MOSFET or IGBT devices from HCPL-316J optically isolated gate driver chips. The HCPL-316J driver chips on the card also produce fault signals that reset the DSP PWM outputs when activated.

The gate drive switches from a nominal –5V when the IGBT is OFF, to a nominal +17V when the IGBT is ON.

Each gate drive circuit has an isolated power supply, generated by a high frequency auxiliary switch mode power supply through a ferrite transformer.

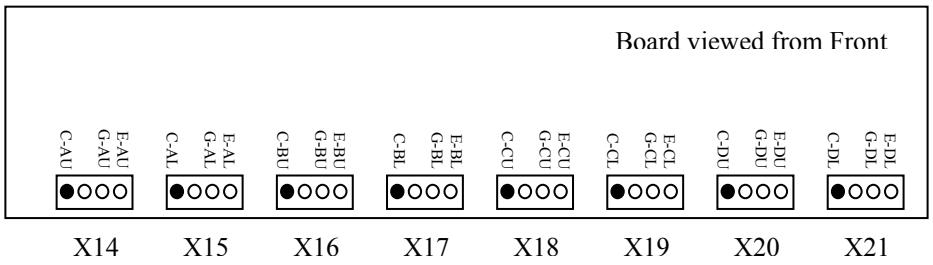


Figure 3-19: Gate Driver Interface (PWM) Connectors (X14 – X21)

3.3.9 Power Supply Interface

The main power supply consists of three inputs, Active, Neutral and Earth. The input can be either AC or DC. If the supply is to be connected to a DC source, **C71** and **C74** should be removed.

The standard CPT-E13 board will operate with a power supply voltage of between 200Vac and 440Vac, or 280Vdc to 750Vdc.

The CPT-E13 (LV) board will operate with a power supply voltage of between 85Vac and 265Vac, or 130Vdc to 370Vdc.

The switch mode power supply can be optionally fitted with heatsink protection, by installing a normally closed thermal cutout on the switching transistor's heatsink, and connecting this cutout to connector **X29** (next to the heatsink). For normal use, this connector is supplied bridged using a shorting link.

The arrangement of the main power supply connector, **X27,** is shown in Figure 3-20 and the pinouts are shown in Table 3-9.

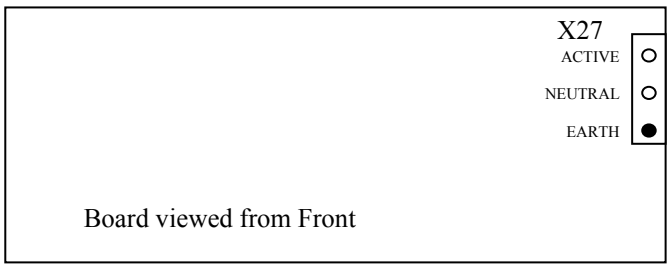


Figure 3-20: Power Supply Connector (X27)

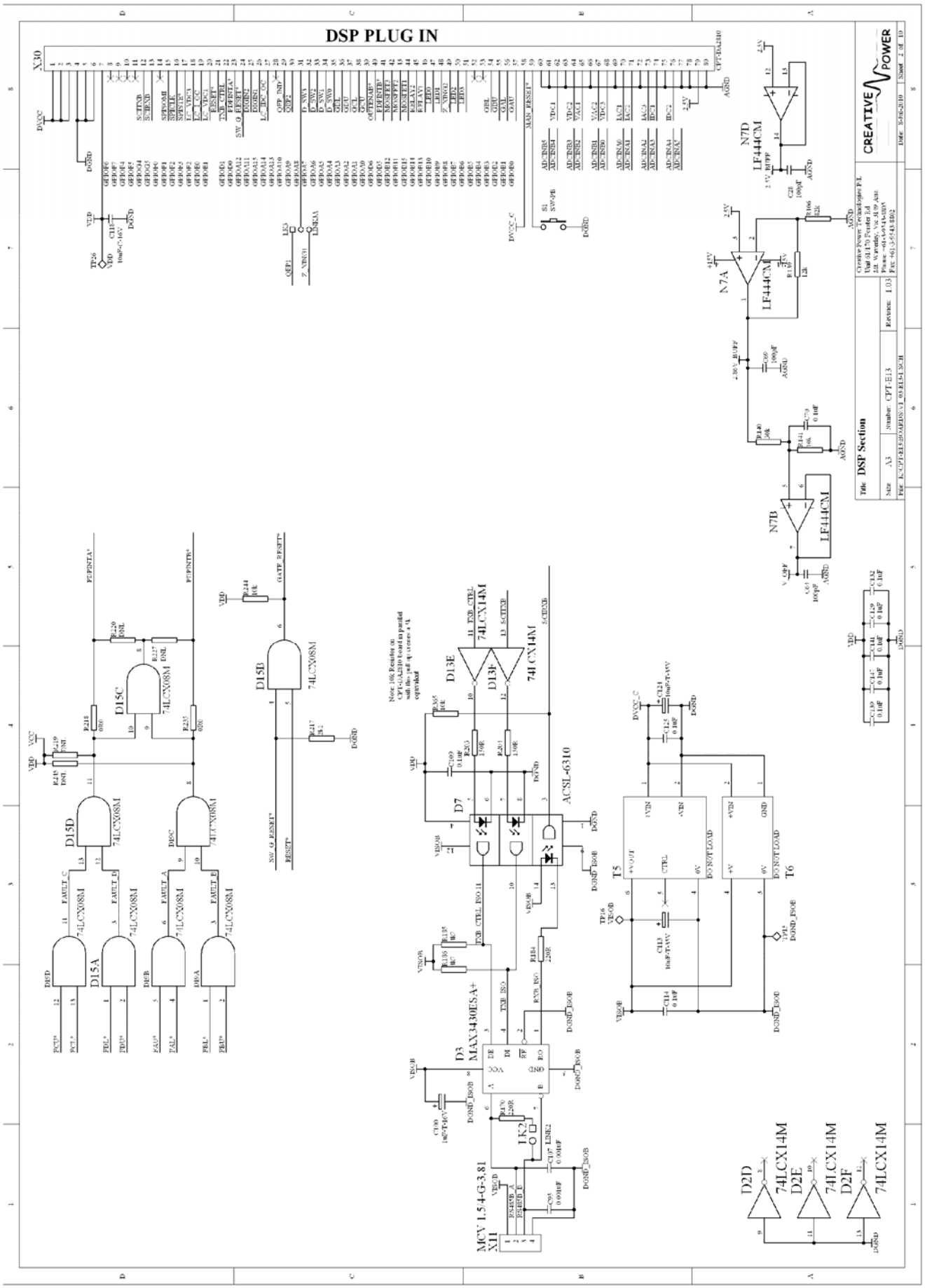
POWER SUPPLY – INPUT			
Description	*Pin*	*Conn.*	*Type*
EARTH	1	**X27**	MSTBVA
N/C			
NEUTRAL	2		
N/C			
ACTIVE	3		

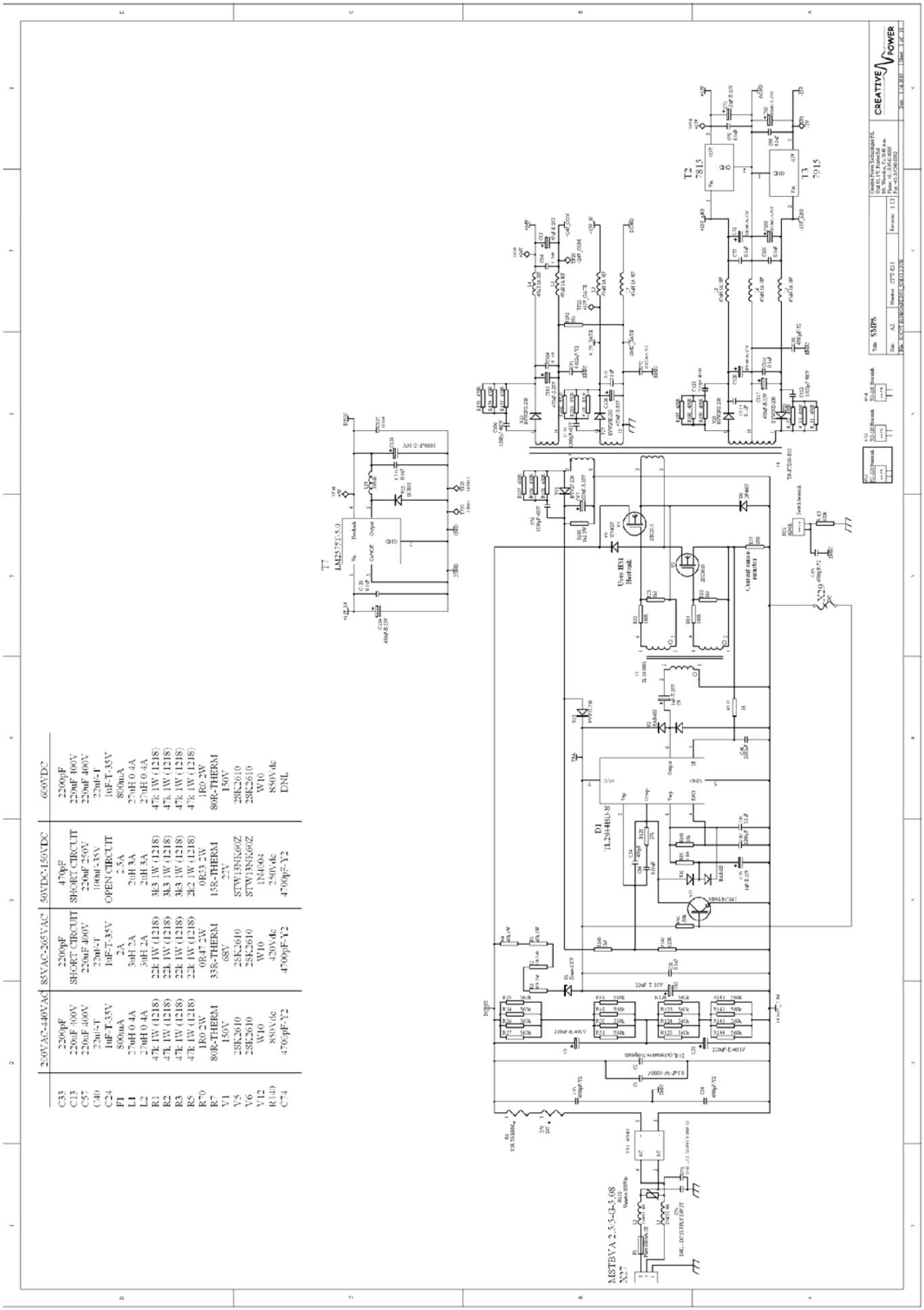
Table 3-9: Power Supply Pinouts

.

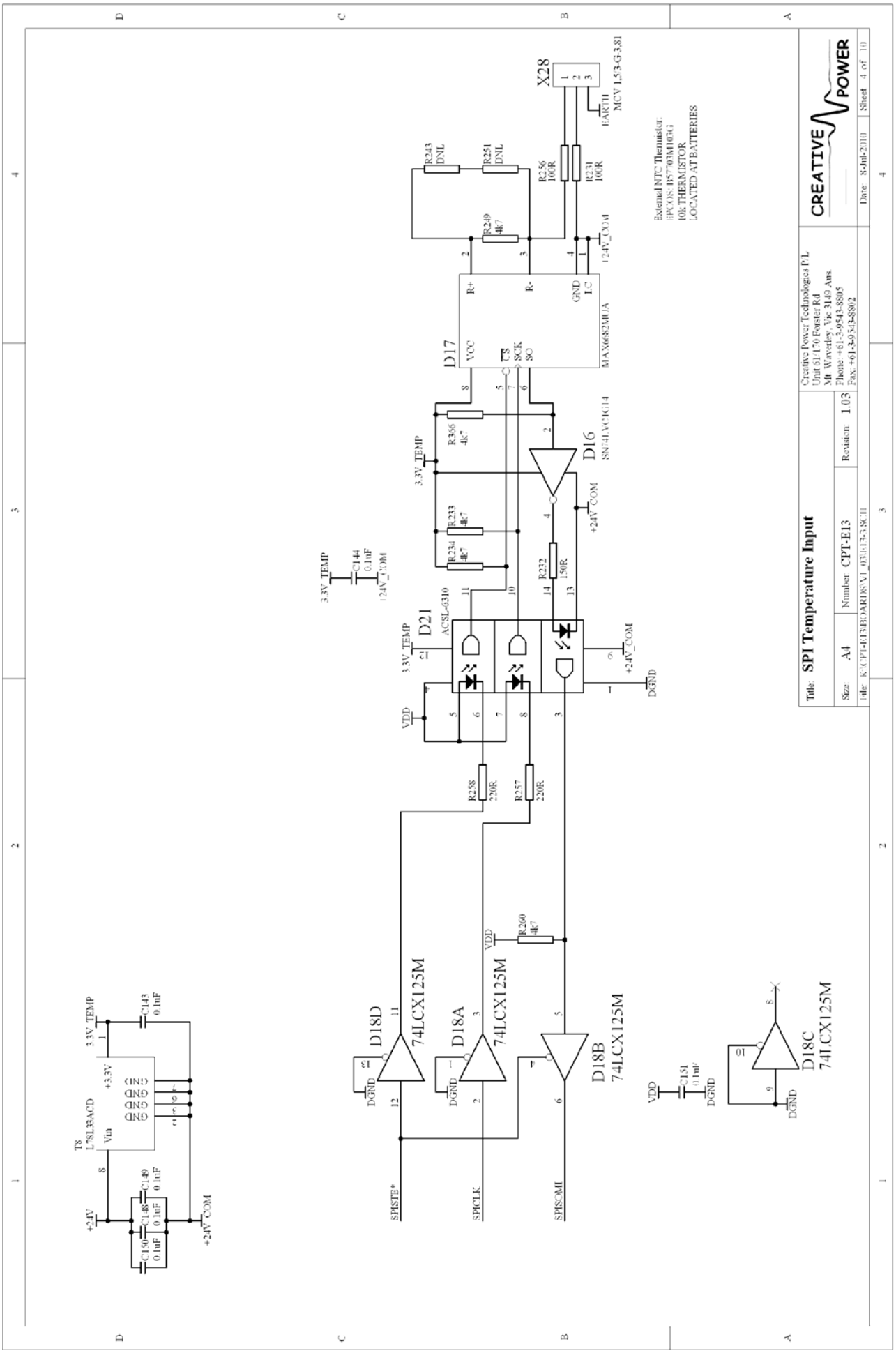
Appendices

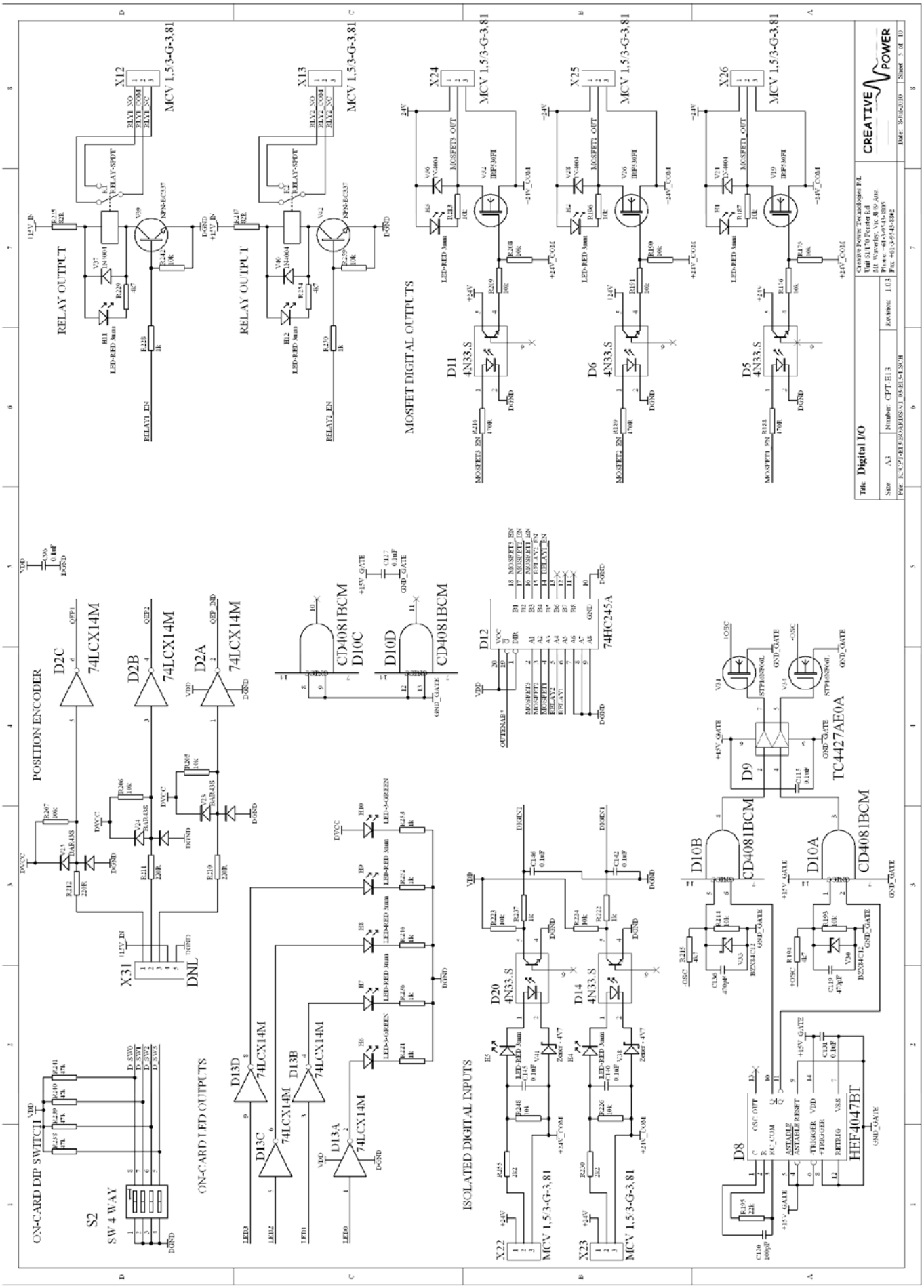
Appendix A Schematic Diagrams

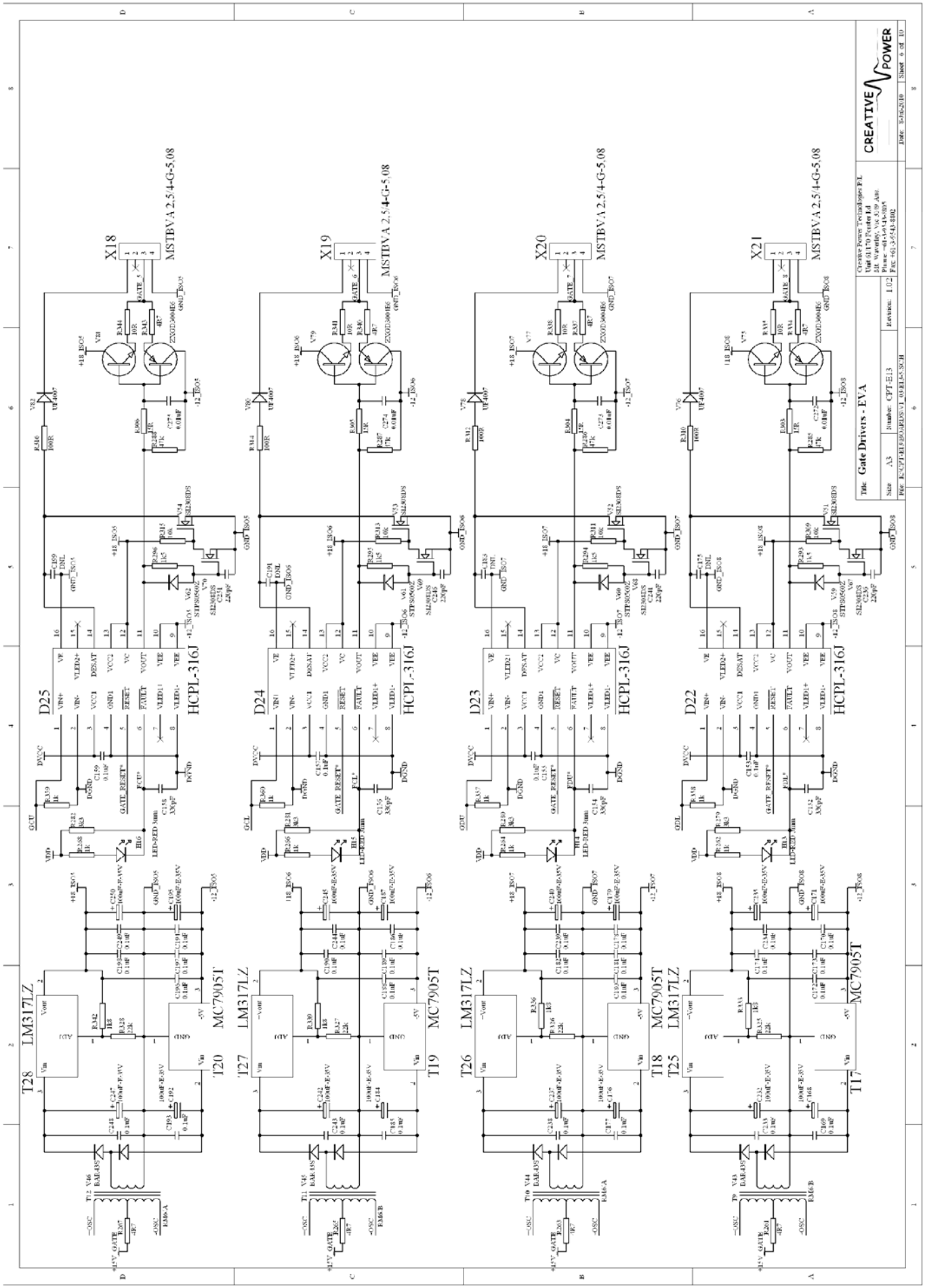


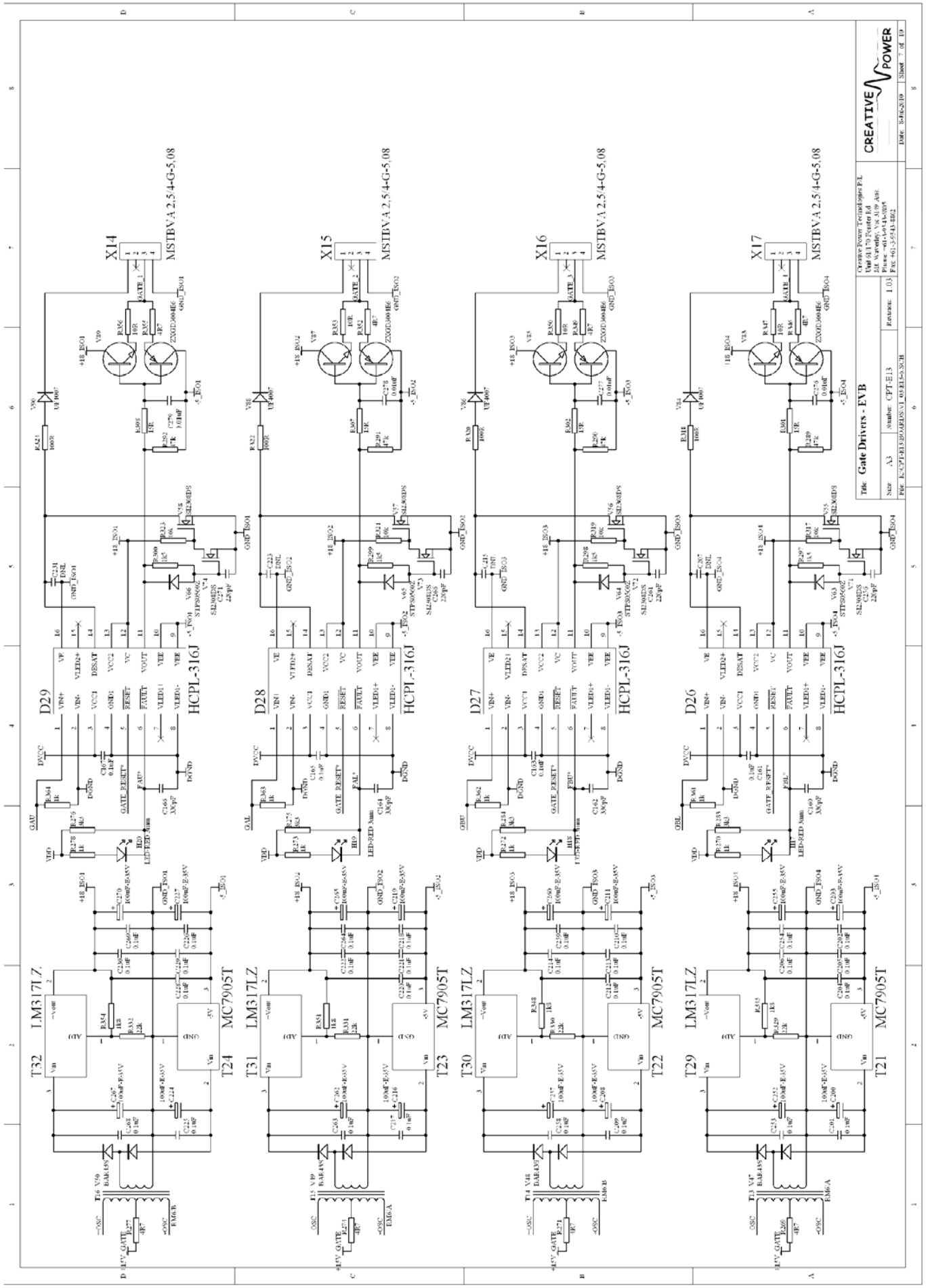


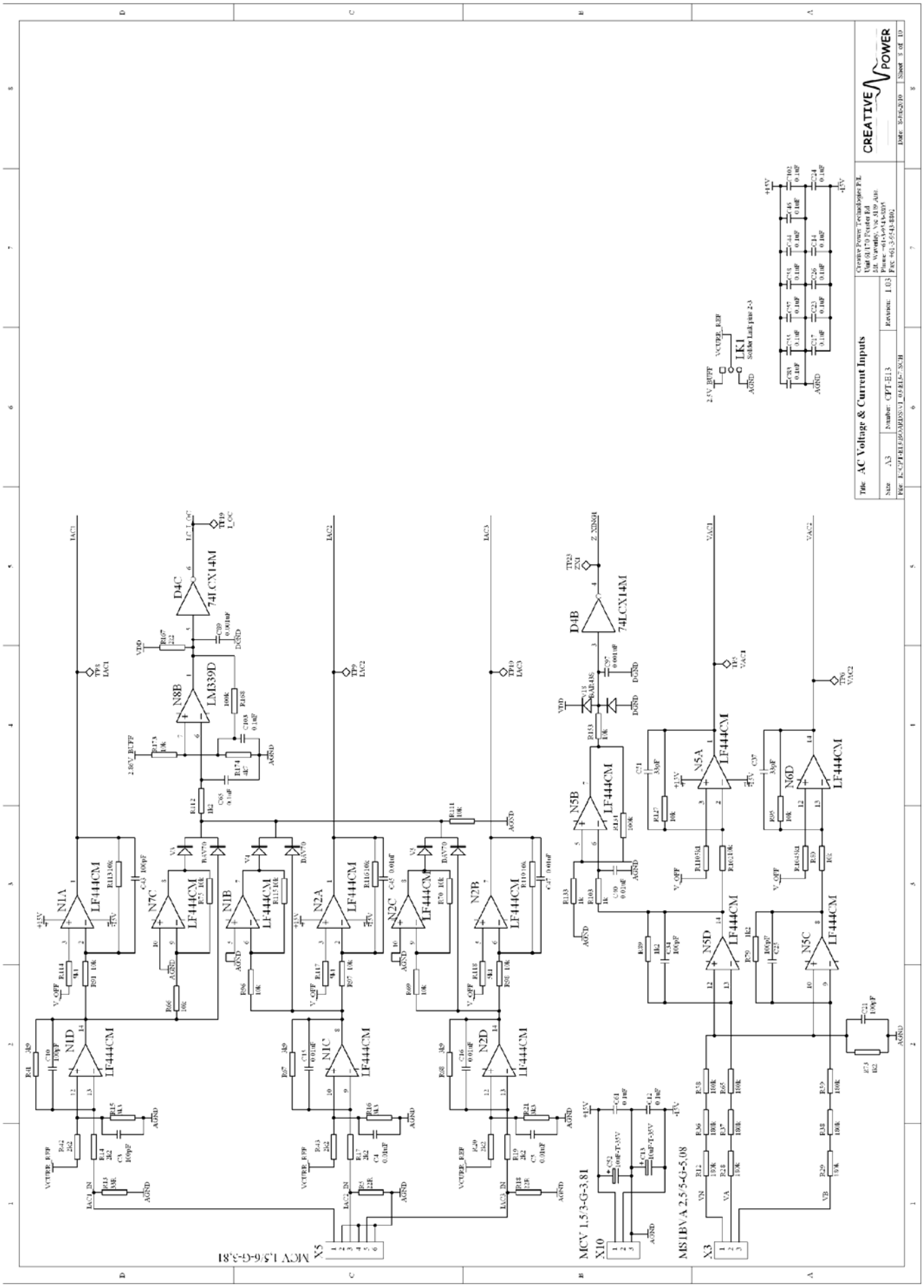
	200VAC-440VAC	85VAC-265VAC	50VDC-150VDC	600VDC
C33	2200pF	2200pF	470pF	2200pF
C13	220nF 400V	SHORT CIRCUIT	SHORT CIRCUIT	220nF 400V
C57	220nF 400V	220nF 400V	220nF 250V	220nF 400V
C40	22nF-T	22nF-T	100nF-35V	22nF-T
C24	1uF-T-35V	1uF-T-35V	OPEN CIRCUIT	1uF-T-35V
F1	800mA	2A	2.5A	800mA
L1	27uH 0.4A	30uH 2A	20uH 3A	27uH 0.4A
L2	27uH 0.4A	30uH 2A	20uH 3A	27uH 0.4A
R1	47E 1W (1218)	22k 1W (1218)	3k3 1W (1218)	47k 1W (1218)
R2	47E 1W (1218)	22k 1W (1218)	3k3 1W (1218)	47k 1W (1218)
R3	47E 1W (1218)	22k 1W (1218)	3k3 1W (1218)	47k 1W (1218)
R5	47E 1W (1218)	22k 1W (1218)	2k2 1W (1218)	47k 1W (1218)
R70	1R0 2W	0R47 2W	0R33 2W	1R0 2W
R7	80R-THERM	33R-THERM	15R-THERM	80R-THERM
V1	150V	68V	22V	150V
V5	2SK2610	2SK2610	STW13N60Z	2SK2610
V6	2SK2610	2SK2610	STW13N60Z	2SK2610
V12	W10	W10	1N4004	W10
R149	850Vdc	420Vdc	250Vdc	850Vdc
C74	4700pF-Y2	4700pF-Y2	4700pF-Y2	DNL

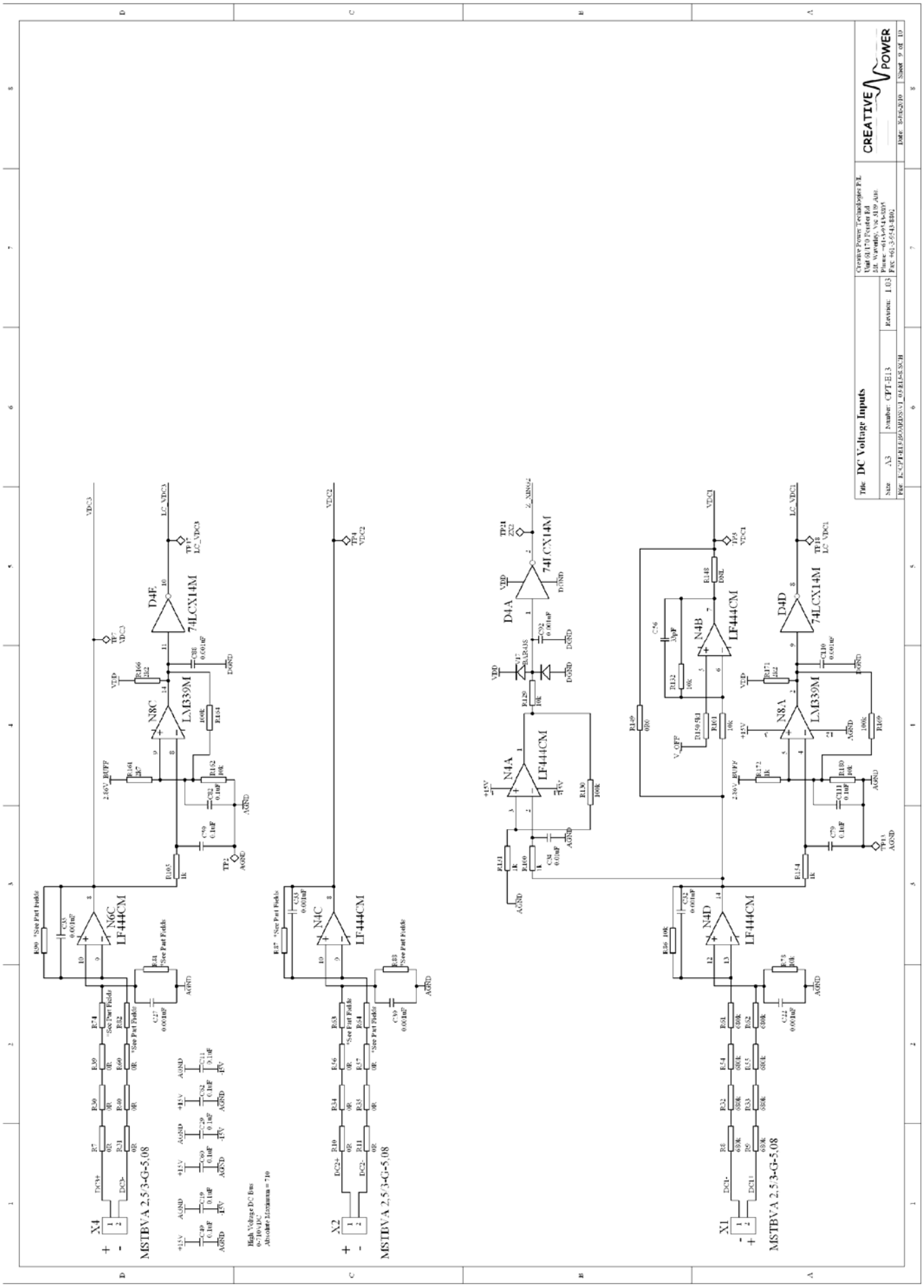

X28
MCV 1,5/3-G-3,81
EARTH
R243 DNL
R251 DNL
R249 4k7
R256 10OR
R231 10OR
124V_COM
External NTC Thermistor:
EPCOS B57703M103G
10K THERMISTOR
LOCATED AT BATTERIES
D17
MAX6682MUA
R356 4k7
3.3V_TEMP
D16
SN74LVC1G14
+24V_COM
R233 4k7
R234 4k7
R232 150R
C144 0.1uF
D21
ACSL-6310
VDD
DGND
R258 220R
R257 220R
R260 4k7
D18D
D18A
D18B
D18C
74LCX125M
SPISTE*
SPICLK
SPISOMI
C151 0.1uF
T8
L78L33ACD
+24V
C143 0.1uF
C149 0.1uF
C148 0.1uF
C150 0.1uF
Title: SPI Temperature Input
Size: A4
Number: CPT-E13
Revision: 1.03
Creative Power Technologies P/L
Unit 6/170 Foster Rd
Mt Waverley, Vic 3149 Aus
Phone +61-3-9543-8805
Fax +61-3-9543-8802
CREATIVE POWER
Date: 8-Jul-2010
Sheet 4 of 10

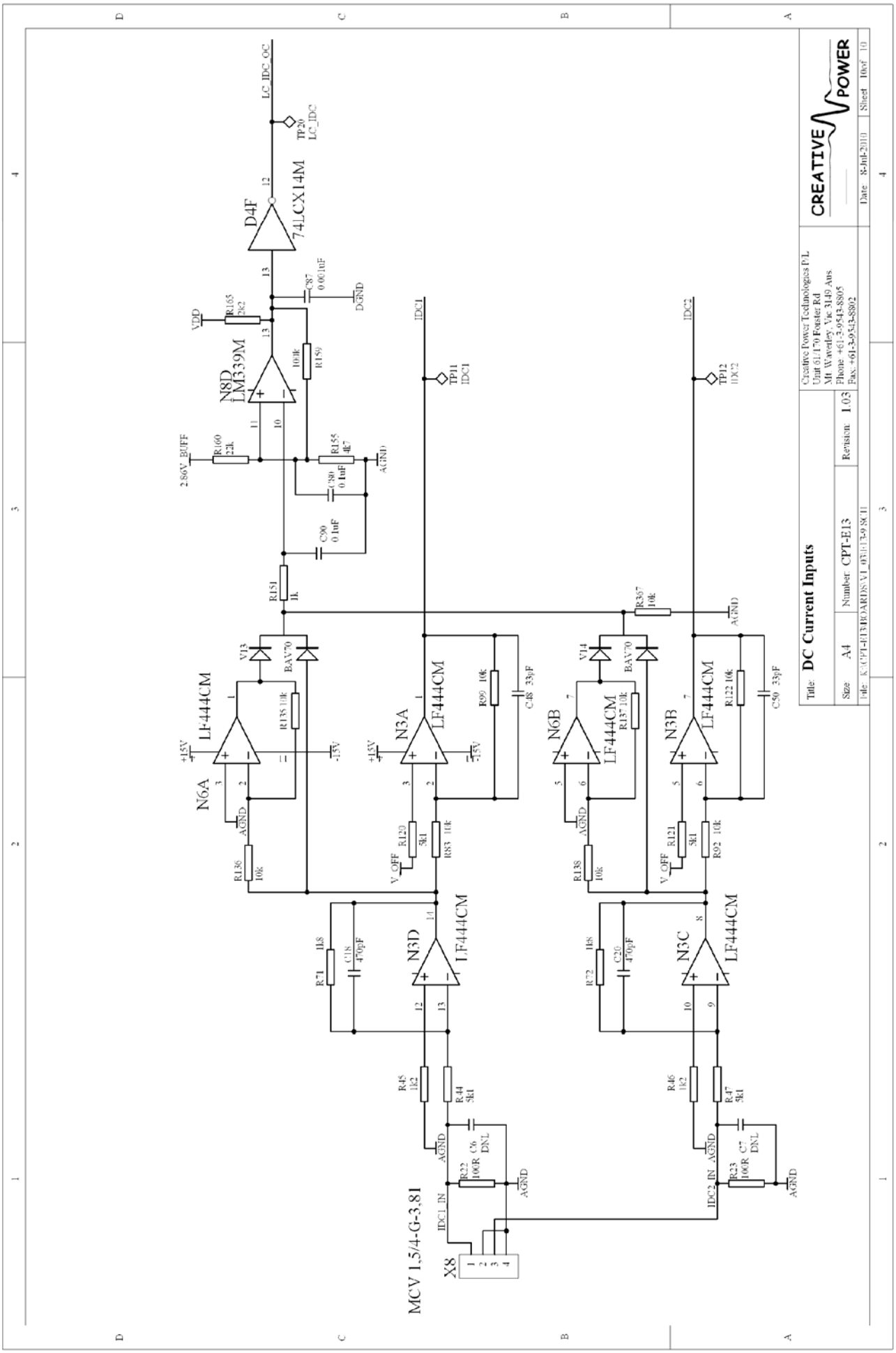

RELAY OUTPUT
MCV 1,5/3-G-3,81
X12
X13
MOSFET DIGITAL OUTPUTS
X24
X25
X26
D11
D6
D5
4N33.S
Title: Digital I/O
CREATIVE POWER
POSITION ENCODER
74LCX14M
D2C
D2B
D2A
ON-CARD DIP SWITCH
S2
SW 4 WAY
ON-CARD LED OUTPUTS
X31
DNL
CD4081BCM
D10C
D10D
74HC245A
D12
ISOLATED DIGITAL INPUTS
D20
D14
X22
X23
TC4427AE0A
D9
D10B
D10A
D8
HEF4047BT


X18
X19
X20
X21
MSTBVA 2.5/4-G-5,08
D25
D24
D23
D22
HCPL-316J
T28
T27
T26
T25
LM317LZ
T20
T19
T18
T17
MC7905T
Title: Gate Drivers - EVA
Size: A3
Number: CPT-E13
Revision: 1.02
CREATIVE POWER


Title: Gate Drivers - EVB
Size: A3
Number: CPT-E13
Reference: 1.03
File: K:\CPT-E13\BOARDS\V1.05\E13-SCH
Date: 8-Feb-2010
Sheet 7 of 10
Creative Power Technologies P/L
Unit 6&17D Forster Rd
Mt Waverley, Vic 3149 Aust
Phone: +61-3-9543-9800
Fax: +61-3-9543-8862
CREATIVE POWER
X14
X15
X16
X17
MSTBVA 2,5/4-G-5,08
D29
D28
D27
D26
HCPL-316J
T32
T31
T30
T29
LM317LZ
T24
T23
T22
T21
MC7905T

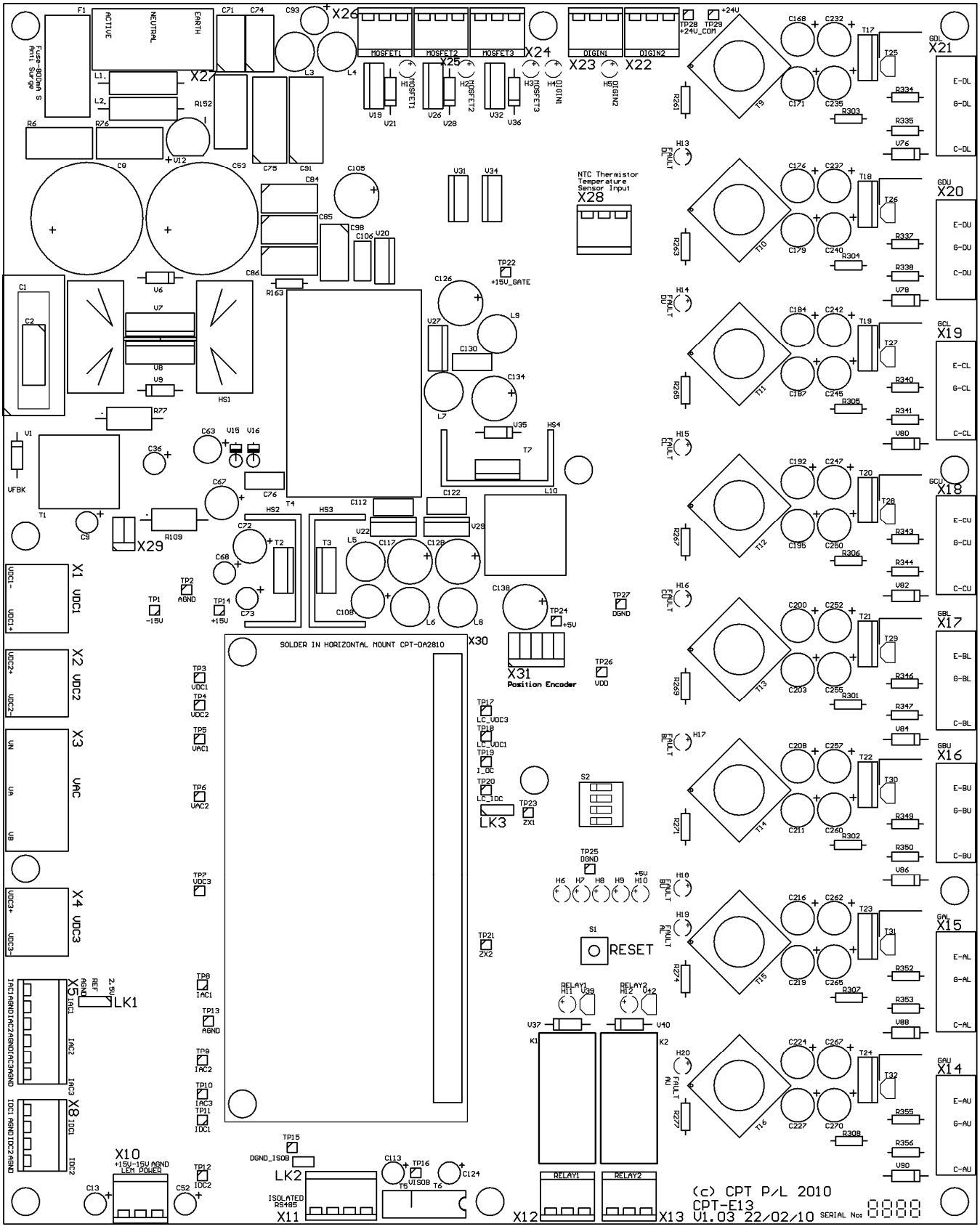

Title: AC Voltage & Current Inputs
Size: A3
Number: CPT-E13
Revision: 1.03
Creative Power Technologies P/L
Unit 6 170 Forster Rd
Mt. Waverley, Vic 3149 Aus
Phone: +61-3-9543-3255
Fax: +61-3-9543-8890
Date: 30-06-2010
Sheet 5 of 10
CREATIVE POWER
LF444CM
74LCX14M
LM339D
MCV 1.5/3-G-3.81
MSTBVA 2.5/5-G-5.08
LK1
Solder Link pins 2-3


Title: DC Voltage Inputs
Size: A3
Number: CPT-E13
Revision: 1.03
Creative Power Technologies P/L
Unit 6 170 Forster Rd
Mt. Waverley, Vic 3149 Aus
Phone: +61-3-9543-8800
Fax: +61-3-9543-8880
CREATIVE POWER
Date: 26/08/2010
Sheet 9 of 10
X4
MSTBVA 2,5/3-G-5,08
X2
MSTBVA 2,5/3-G-5,08
X1
MSTBVA 2,5/3-G-5,08
N6C
LF444CM
N4C
LF444CM
N4A
LF444CM
N4B
LF444CM
N4D
LF444CM
N8C
LM339M
N8A
LM339M
D4E
74LCX14M
D4A
74HCX14M
D4D
74LCX14M
High Voltage DC Bus
0-710 VDC
Absolute Maximum = 710

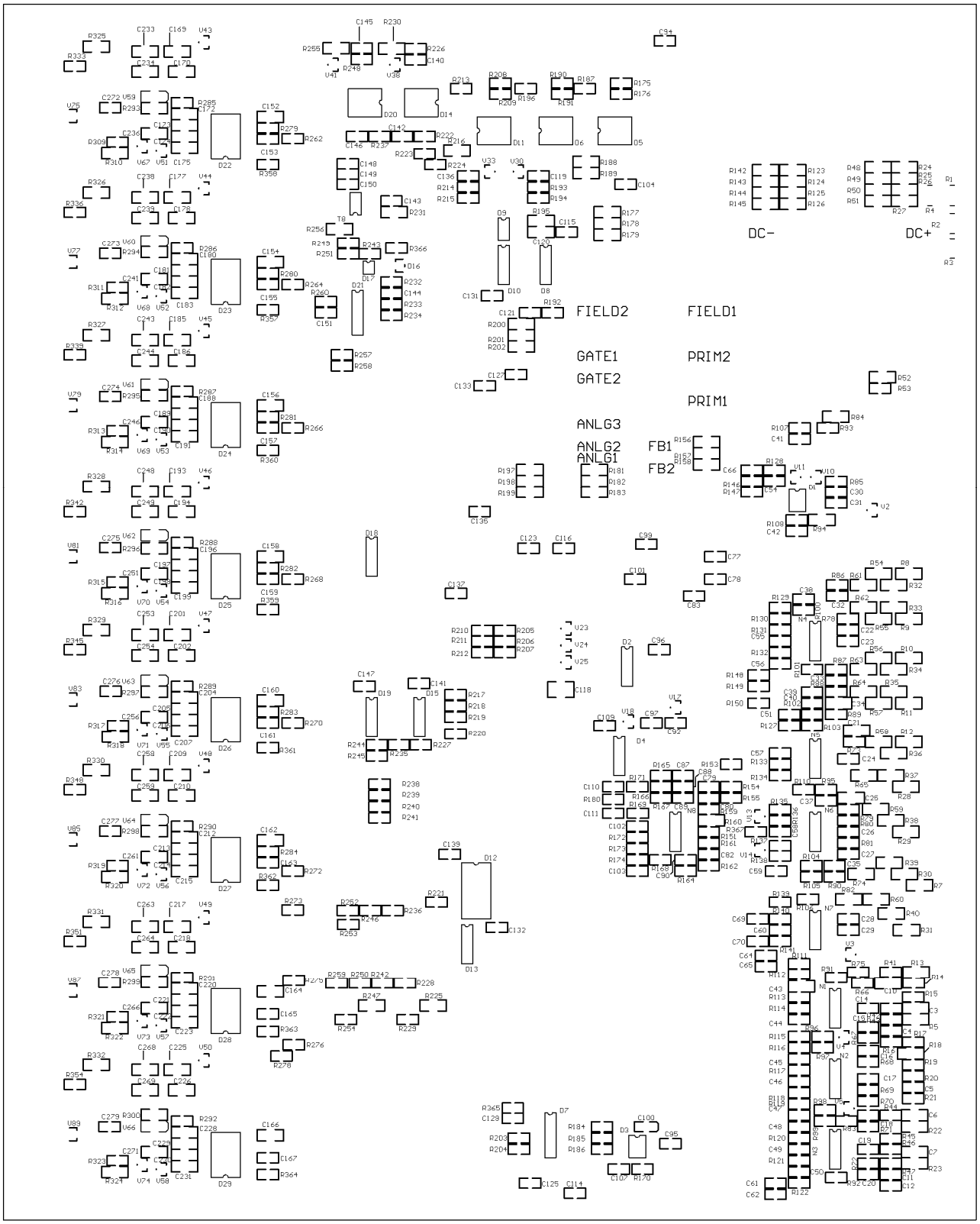

Title: DC Current Inputs
Size: A4
Number: CPT-E13
Revision: 1.03
Creative Power Technologies P/L
Unit 61 179 Forster Rd
Mt Waverley Vic 3149 Aus
Phone +61-3-9543-8805
Fax: +61-3-9543-8802
Date: 8-Jul-2010
Sheet 1 of 1
CREATIVE POWER
LC_IDC_OC
TP20 LC_IDC
D4F 74LCX14M
VDD
R165 2k2
C87 0.001uF
DGND
N8D LM339M
R159 100k
IDC1
TP11 IDC1
IDC2
TP12 IDC2
2.86V_BUFF
R160 22k
R155 4k7
C180 0.1uF
C90 0.1nF
AGND
R151 1k
R367 10k
V13 BAV70
V14 BAV70
N6A LF444CM
N3A LF444CM
N6B LF444CM
N3B LF444CM
N3D LF444CM
N3C LF444CM
+15V
-15V
R135 10k
R136 10k
R99 10k
C88 33pF
R137 10k
R138 10k
R122 10k
C90 33pF
V_OFF
R120 5k1
R83 10k
R121 5k1
R92 10k
R71 1k8
C18 470pF
R72 1k8
C20 470pF
R45 1k2
R44 5k1
R46 1k2
R47 5k1
C6 DNL
C7 DNL
R22 100R
R23 100R
IDC1_IN
IDC2_IN
X8
MCV 1.5/4-G-3.81

Appendix B Component Layout

Top Layer

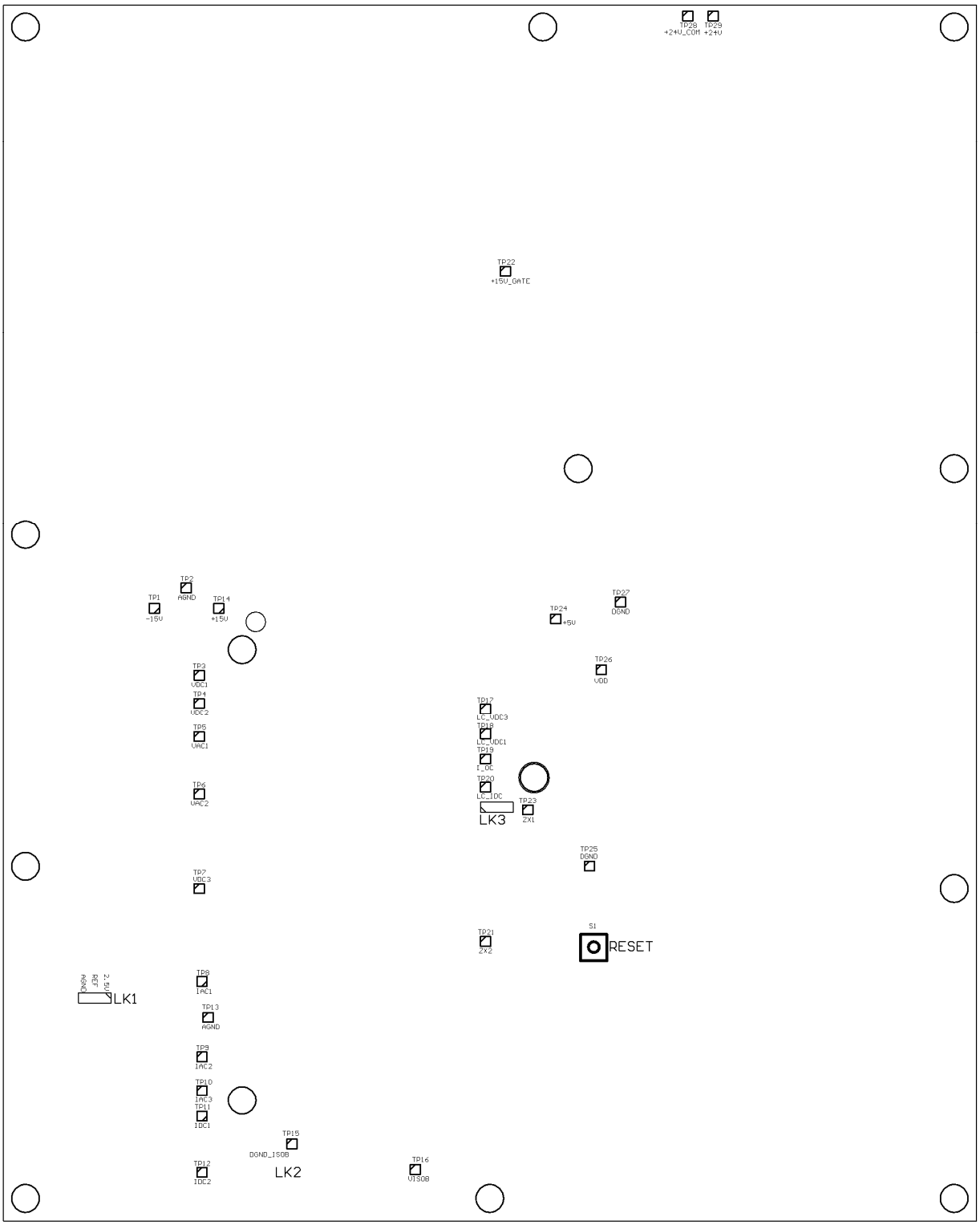


Bottom Layer



Appendix C Link and Test Point Locations

Top Layer



Appendix D Connector Pinouts

Conn. No.	Connector Type	Pin No.	Signal Name	Comment
Analogs – AC Voltage				
X3	Phoenix MSTBVA 2,5	1	VN	AC Voltage Input (Common Differential Channel)
				Pin Removed
		2	VA	AC Voltage Input
				Pin Removed
		3	VB	AC Voltage Input
Analogs – DC Voltage 1/AC Voltage 3				
X1	Phoenix MSTBVA 2,5	1	VDC1- / VAC3	DC 1 Negative Voltage Input
				Pin removed
		2	VDC1+ / VAC3	DC 1 Positive Voltage Input
Analogs – DC Voltage 2				
X2	Phoenix MSTBVA 2,5	1	VDC2+	DC 2 Positive Voltage Input
				Pin removed
		2	VDC2-	DC 2 Negative Voltage Input
Analogs – DC Voltage 3				
X4	Phoenix MSTBVA 2,5	1	VDC3+	DC 3 Positive Voltage Input
				Pin removed
		2	VDC3-	DC 3 Negative Voltage Input
Analogs – AC Currents				
X5	Phoenix MCV 1,5 Series	1	IAC1_IN	AC 1 Current Input
		2	AGND	Analog Ground
		3	IAC2_IN	AC 2 Current Input
		4	AGND	Analog Ground
		5	IAC3_IN	AC 3 Current Input
		6	AGND	Analog Ground
Analogs – DC Current				
X8	Phoenix MCV 1,5 Series	1	IDC1_IN	DC 1 Current Input
		2	AGND	Analog Ground
		3	IDC2_IN	DC 2 Current Input
		4	AGND	Analog Ground
Analogs – LEM SUPPLY				
X10	Phoenix MCV 1,5 Series	1	+15V	+15V Supply
		2	-15V	-15V Supply
		3	AGND	Analog Ground

Position Encoder Interface				
X31	MOLEX 5 WAY	1	QEP1	Quadrature Encoded Pulse
		2	QEP2	Quadrature Encoded Pulse
		3	INDEX	INDEX pulse
		4	+15V_IN	+15V Supply
		5	DGND	Digital Ground

Conn. No.	Connector Type	Pin No.	Signal Name	Comment
Temperature – NTC Thermistor Input				
X28	Phoenix MCV 1,5 Series	1	NTC	NTC Thermistor
		2	NTC_RTN	NTC Thermistor RETURN
		3	EARTH	Earth Shield

Power Supply Input				
X27	Phoenix MSTBVA 2,5	1	EARTH	EARTH Connection
			N/C	
		2	NEUTRAL	Neutral (DC-)
			N/C	
		3	ACTIVE	Active (DC+)

Conn. No.	Connector Type	Pin No.	Signal Name	Comment
Communications – RS-485				
X11	Phoenix MCV 1,5 Series	1	VISOB	+5V Isolated Communications Supply
		2	RS485B_A	Multi-drop RS-485 A Signal
		3	RS485B_B	Multi-drop RS-485 B Signal
		4	DGND_ISOB	Isolated Communications Ground B

Conn. No.	Connector Type	Pin No.	Signal Name	Comment
Isolated Digital Outputs – Relay 1				
X12	Phoenix MCV 1,5 Series	1	RLY1_NO	Relay 1 Normally **Open** Contact
		2	RLY1_COM	Relay 1 **Common**
		3	RLY1_NC	Relay 1 Normally **Closed** Contact
Isolated Digital Outputs – Relay 2				
X13	Phoenix MCV 1,5 Series	1	RLY2_NO	Relay 2 Normally **Open** Contact
		2	RLY2_COM	Relay 2 **Common**
		3	RLY2_NC	Relay 2 Normally **Closed** Contact
Isolated Digital Outputs – MOFSET 3				
X24	Phoenix MCV 1,5 Series	1	+24V	
		2	MOSFET_OUT3	MOSFET driven Isolated Digital Output 3
		3	+24V_COM	
Isolated Digital Outputs – MOFSET 2				
X25	Phoenix MCV 1,5 Series	1	+24V	
		2	MOSFET_OUT2	MOSFET driven Isolated Digital Output 2
		3	+24V_COM	
Isolated Digital Outputs – MOFSET 1				
X26	Phoenix MCV 1,5 Series	1	+24V	
		2	MOSFET_OUT1	MOSFET driven Isolated Digital Output 1
		3	+24V_COM	

Conn. No.	Connector Type	Pin No.	Signal Name	Comment
Isolated Digital Input 2				
X22	Phoenix MCV 1,5 Series	1	+24V_2	1k Resistor Limited +24V
		2	DIGIN2	Digital Input 2
		3	+24V_COM	
Isolated Digital Input 1				
X23	Phoenix MCV 1,5 Series	1	+24V_1	1k Resistor Limited +24V
		2	DIGIN1	Digital Input 1
		3	+24V_COM	

Conn. No.	Connector Type	Pin No.	Signal Name	Comment
DSP Connector				
X30	80 way IDC Socket	1	DVCC	5V Supplied **TO** CPT-DA2810
		2	DVCC	5V Supplied **TO** CPT-DA2810
		3	DVCC	5V Supplied **TO** CPT-DA2810
		4	DGND	Digital Ground
		5	DGND	Digital Ground
		6	DGND	Digital Ground
		7	CVDD	3.3V Supplied **FROM** CPT-DA2810
		8	N/C	
		9	N/C	
		10	N/C	
		11	N/C	
		12	SCITXB	TTL Level Serial Transmit – RS-485B
		13	SCIRXB	TTL Level Serial Receive – RS-485B
		14	N/C	
		15	SPISOMI	SPI Data read from Thermistor-to-Digital
		16	SPICLK	SPI Clock for Thermistor-to-Digital
		17	SPISTE*	SPI Transmit Enable for Thermistor-to-Digital
		18	LC_VDC3	DC3 Over Voltage Trip Signal
		19	LC_I_OC	Combined AC Overcurrent Trip Signal
		20	LC_VDC1	DC1 Over Voltage Trip Signal
		21	RESET*	Reset Signal FROM CPT-DA2810 board
		22	TXB_CTRL	RS-485 Transmit Control
		23	PDPINTA*	EVA – Gate Driver Fault Signal
		24	SW_G_RESET*	Software Gate Driver Reset Signal
		25	DIGIN2	Digital Input – Isolated DIGIN2
		26	DIGIN1	Digital Input – Isolated DIGIN1
		27	LC_IDC_OC	DC Over Current Trip Signal
		28	N/C	
		29	QEP_IND	Position Encoder Index Signal
		30	QEP2	Position Encoder Phase B
		31	QEP1/Z_XING1	**LK3** Select – Position Encoder Phase A, or Zero-Crossing (VAC1)
		32	D_SW3	Digital Input – DIP Switch 3
		33	D_SW2	Digital Input – DIP Switch 2
		34	D_SW1	Digital Input – DIP Switch 1
		35	D_SW0	Digital Input – DIP Switch 0
		36	GDL	EVA – Gate Driver Phase D Lower
		37	GDU	EVA – Gate Driver Phase D Upper
		38	GCL	EVA – Gate Driver Phase C Lower
		39	GCU	EVA – Gate Driver Phase C Upper
		40	OUTENAB*	Enable Digital Output Buffers
		41	PDPINTB*	EVB – Gate Driver Fault Signal
		42	MOSFET3	Digital Output – MOSFET3
		43	MOSFET2	Digital Output – MOSFET2
		44	MOSFET1	Digital Output – MOSFET1
		45	RELAY2	Digital Output – RELAY2
		46	RELAY1	Digital Output – RELAY1
		47	LED0	Digital Output – LED0
		48	LED1	Digital Output – LED1
		49	Z_XING2	VDC1 Zero-Crossing in AC Input Mode
		50	LED2	Digital Output – LED2
		51	LED3	Digital Output – LED3
		52	N/C	

Conn. No.	Connector Type	Pin No.	Signal Name	Comment
DSP Connector				
X30 cont.	80 way IDC Socket	53	N/C	
		54	GBL	EVB – Gate Driver Phase B Lower
		55	GBU	EVB – Gate Driver Phase B Upper
		56	GAL	EVB – Gate Driver Phase A Lower
		57	GAU	EVB – Gate Driver Phase A Upper
		58	DVCC_C	Supply to 5V Isolated Comms DC/DC Converter
		59	MAN_RESET*	Push Button Reset
		60	AGND	Analog Ground
		61	AGND	Analog Ground
		62	VDC1 / VAC3	DC Voltage 1 / AC Voltage 3
		63	AGND	Analog Ground
		64	VDC2	DC Voltage 2
		65	VAC1	AC Voltage 1
		66	AGND	Analog Ground
		67	VAC2	AC Voltage 2
		68	VDC3	DC Voltage 3
		69	AGND	Analog Ground
		70	IAC1	AC Current 1
		71	IAC2	AC Current 2
		72	AGND	Analog Ground
		73	IAC3	AC Current 3
		74	IDC1	DC Current 1
		75	AGND	Analog Ground
		76	IDC2	DC Current 2
		77	AGND	Analog Ground
		78	AGND	Analog Ground
		79	2.5V	2.5V Reference Output
		80	AGND	Analog Ground

Appendix E Test Points on CPT-E13

TEST POINT NAME	SIGNAL NAME	GRID REF.	DESCRIPTION
TP1	-15V	**B5**	-15V Unregulated Supply
TP2	AGND	**B5**	Analog Ground
TP3	VDC1 / VAC3	**C5**	DC Analog Voltage 1/ AC Analog Voltage 3
TP4	VDC2	**C4**	DC Analog Voltage 2
TP5	VAC1	**C4**	AC Analog Voltage 1
TP6	VAC2	**C4**	AC Analog Voltage 2
TP7	VDC3	**C3**	DC Analog Voltage 3
TP8	IAC1	**C3**	AC Analog Current 1
TP9	IAC2	**C2**	AC Analog Current 2
TP10	IAC3	**C2**	AC Analog Current 3
TP11	IDC1	**C2**	DC Analog Current 1
TP12	IDC2	**C1**	DC Analog Current 2
TP13	AGND	**C2**	Analog Ground
TP14	+15V	**C5**	+15V Regulated Supply
TP15	DGND_ISOB	**C1**	Digital Ground – Isolated Comms
TP16	VISOB	**D1**	+3.3V – Isolated Comms
TP17	LC_VDC3	**E4**	DC 3 Overvoltage Trip
TP18	LC_VDC1	**E4**	DC 1 Overvoltage Trip
TP19	I_OC	**E4**	AC Overcurrent Trip
TP20	LC_IDC	**E4**	DC Overcurrent Trip
TP21	ZX2	**E3**	Zero Crossing – from VAC3 in AC Voltage Mode
TP22	+15V_GATE	**E5**	+15V Gate Supply
TP23	ZX1	**E4**	Zero Crossing – VAC1
TP24	+5V	**E5**	+5V – Digital Supply
TP25	DGND	**E5**	Digital Ground
TP26	VDD	**E5**	+3.3 Digital Supply
TP27	DGND	**F5**	Digital Ground
TP28	+24V_COM	**F9**	Field Supply Ground
TP29	+24V	**F9**	+24V Field Supply