CPT-E01 Card

TMS320F2810 DSP Inverter Controller Card

Technical Brief

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CPT-E01 Manual Revision History

CARD VERSION 1.0: Initial Board for prototype purposes.

No Manual Released

CARD VERSION 1.1: Rework for production

Release 1.0 – Initial Release of Manual.
Release 1.1 – Defaults for Digital I/O Modified of Manual.

CARD VERSION 1.2: Modification of RS-485 outputs

Release 1.2 – Polarity of RS-485 interface reversed
Release 1.3 – X15 direction definition incorrect
Release 1.4 – Typographical errors fixed
Release 1.5 – Resistor values changed for the RS485 isolated outputs (schematic page 1 replaced)
Release 1.6 – Resistor values changed for the HAIS200-P differential input (schematic page 4 replaced)
Release 1.7 – Resistor values changed for the 300:1 CT input circuit (schematic page 4 replaced).
Release 1.8 – Resistor values changed for desensitising the overcurrent circuit (schematic page 4 replaced).
Release 1.9 – Not externally released
Release 1.10 – Included Gate Driver Connector Pinout definitions and modified the Addressing Map for the TMS320F2810
Release 1.11 – Definitions for Receive and Transmit Reversed in Communications tables
Typographical error in Section 4

Table of Contents

CPT-E01 DSP Based Inverter Controller

1.0 Overview of the CPT-E01

The CPT-E01 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 board has been designed with a flexible gate driver interface.

The board is based around a Texas Instruments TMS320F2810PBK DSP, 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 CPT-E01 card measures 213mm x 180mm.

On-card facilities 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
- 2 off MOSFET switch isolated outputs
- 1 off relay output, c/o contact
- 3 off AC current inputs
- 1 off DC current input
- 3 off differential AC voltage inputs,
- 1 off differential DC voltage input
- 1 off temperature sensor input
- 3 off general purpose analog inputs (± 10V default)
- 8 off complementary TTL level gate driver PWM outputs, with common fault interrupt and enable
- Reset/Power-On Circuitry
- Power supply to generate all on-card supplies
- Power supply operation from input +24VDC

The card also supports the following peripheral interfaces:

- JTAG interface
- 1 off clocked Serial Peripheral Interface (also enables external Flash reprogramming)
- 1 off 3.3V-TTL serial interface
- 2 off isolated RS-485 serial interfaces (can be independently isolated)
- IDC Header containing:
  - 1 off Clocked Serial Communications Interface
  - 1 off Enhanced Controller Area Network (eCAN)
  - 1 off Event Manager

Figure 1-1 shows a functional block diagram of the CPT-E01 card, illustrating all major sections.

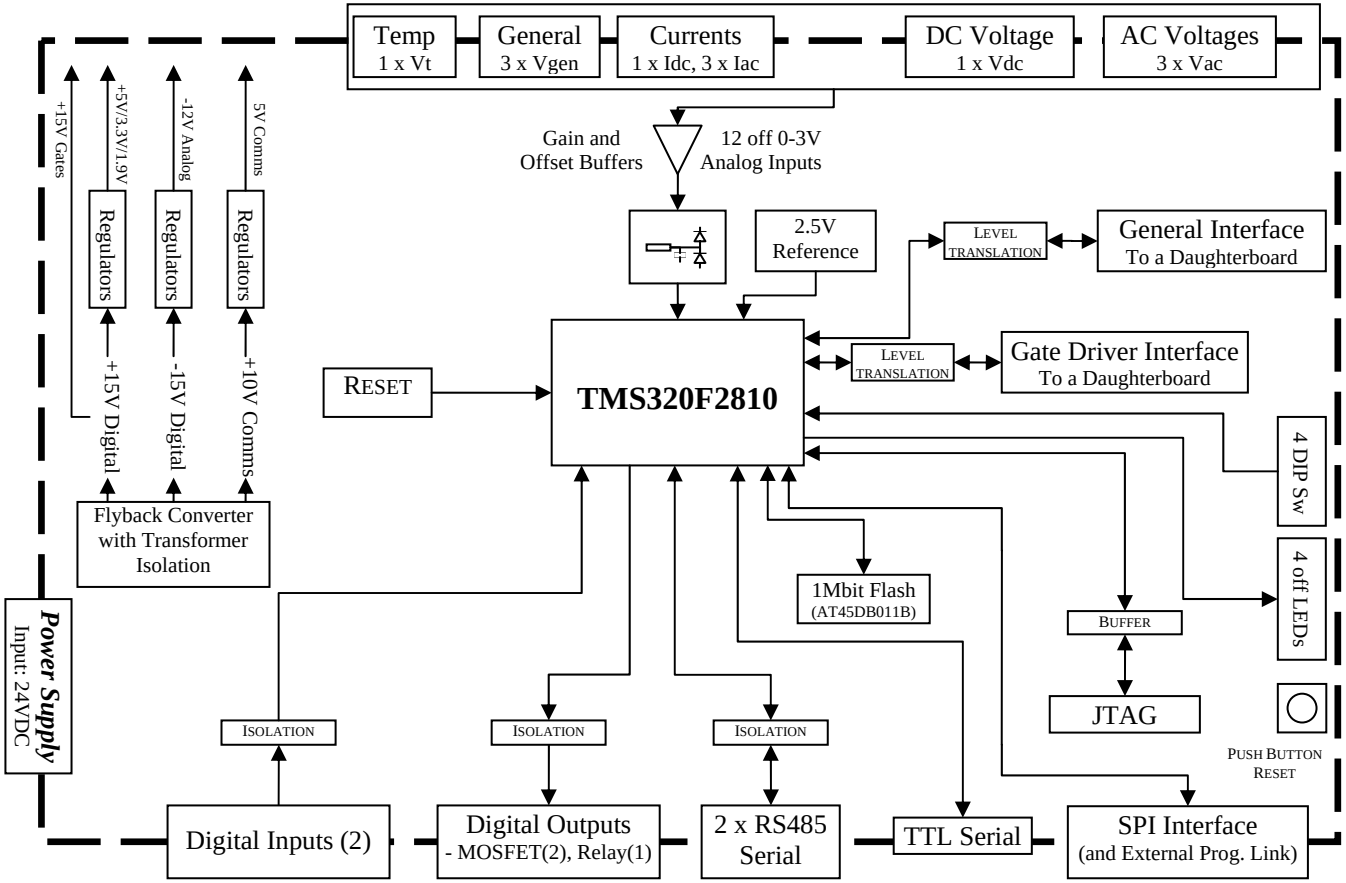

Figure 1-1: Functional Diagram of CPT-E01 Inverter Controller Board

1.1 Digital I/O

The CPT-E01 card supports 28 bits of digital I/O, consisting of 8 bits for local I/O, 5 bits interfacing to external isolated circuitry, 8 bits of 3.3V-TTL non-buffered I/O and 7 bits of buffered TTL level I/O.

The local I/O consists of 4 bits driving LEDs mounted on-card (H2, H3, H4, H5) and 4 bits of DIP switch inputs (S1).

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

The 1 off relay output has 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 the state of the output.

The 2 off MOSFET outputs are powered from the +24V supply. Both MOSFETs must be driven from the same supply option and each has its own LED indicator on the isolated side to provide a visual indication to the state of the output.

The CPT-E01 card supports a maximum of 8 bits of 3.3V-TTL digital I/O, depending on the user defined configuration of specific DSP pins. Six of these bits are provided non-buffered to the digital I/O expansion connector whilst the remaining 2 are shared with the on-card LEDs and available on the SPI programming connector.

The CPT-E01 card supports 7 bits of 5V-TTL buffered digital I/O, that can be configured as either a bank of inputs or outputs depending on the positioning of on-card links. In addition one signal can be individually configured as a digital input for use as an external capture port interrupt source. All of these bits are provided buffered with a level translation from the 3.3V-TTL of the DSP to a TTL level output. These signals are all available on the digital I/O expansion connector.

All 3.3V-TTL digital I/O pins on the TMS320F2810 chip have the capability to operate in either “Digital I/O or “Peripheral I/O” mode. The header files for the CPT-E01 board select the default modes of operation for all of the pins on the board. The user is advised to refer to this file before programming their software code.

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 is capable of interleaving 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-E01 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-E01 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*.

The 12 off filtered analog inputs are interfaced as 3 off AC currents, 3 off AC voltages, 1 off DC voltage, 1 off DC current, 1 off temperature sensor and 3 off ±10V general purpose inputs. Each input has a low pass, or "glitch" filter, and a diode clamp circuit before the signals are fed into the DSP.

The AC current inputs are capable of operating from an off-card CT or LEM module. On-card burden resistors (R1, R2, R3) 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 ±615mV. 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. A common overcurrent detection is provided for both AC current inputs, with the trip level determined by resistor R106.

The AC voltage inputs have a default input voltage range of ±600V peak. The three AC voltage inputs are differential high impedance circuits, allowing the line-line AC voltages to be measured from a three phase system, or alternatively three phase leg outputs with respect to the negative dc bus. One input voltage (Van) supports a zero-crossing detect circuit, which drives a DSP capture input.

The DC voltage input has 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 for this input, with the trip level determined by resistor R100.

The temperature sense input supports temperature measurement using an LM35DZ temperature sensing device. The gain of the temperature sense system can be varied by changing resistors R6 and R7.

The three general purpose analog inputs accept a ±10V input. Each input has a default 47k resistor connected to ground to stabilise the DC level.

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 and the PWM channels are evenly split between them. Dead band compensation is required to be software-calculated for the simple compare outputs.

The CPT-E01 is configured with the 8 PWM channel outputs from Event Manager A available at TTL levels on a single header. The gate fault signal on the connector is fed back to the Event Manager via the PDPINTA* interrupt pin. This enables a DSP hardware interrupt trip to immediately occur on detection of a fault, thus disabling the PWM signals within 12 nanoseconds using hardware logic internal to the DSP. The card has pull-down resistors on the PWM outputs to ensure that they are left in a normally low state if a PDPINTA* fault signal is triggered. A gate reset signal is also provided on the header to enable the off-card gate drivers to be reset in the event of a fault.

The Digital I/O expansion header can be configured to have 6 PWM channels and a capture port input signal from Event Manager B available at TTL levels.

1.4 Communications

The CPT-E01 controller board supports four communication protocols: one off non-isolated 3.3V-TTL serial communications interface (SCI), a 3.3V-TTL synchronous serial peripheral interface (SPI), a 3.3V-TTL enhanced Controller Area Network (CAN) bus interface and two isolated RS-485 serial communications interfaces.

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.

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.

1.5 On-card memory

The CPT-E01 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-E01 has a 1Mbit SPI interfaced Flash Memory chip for external data storage.

1.6 Power Supply

The standard CPT-E01 controller board operates from a nominal +24VDC. The board has an on-card SMPS that generates isolated ±15V and +10V and all regulated supplies required by the board are generated from these three SMPS outputs.

1.7 JTAG/programming

The CPT-E01 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 (**R1**, **R2**, **R3**) ADCINA1, ADCINA0, ADCINB0
Input Voltage Range	±615mV 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	Direct interrupt through XINT1. Trigger current determined by resistor selection (**R100**)
LEM Supply	N/A – Designed for a voltage transducer LEM
Dynamic Response	Cut-off frequency >150kHz
PCB Connections	2 terminal plug-in PCB Mounting Terminal Block. Designed for individual twisted pair connection (**X3**, **X4**, **X5**)

2.2.2 AC Voltage Inputs

Definition	3 off AC voltage differential analog inputs ADCINA5, ADCINA4, ADCINA3
Input Voltage Range	±750 Vac maximum peak
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 (**X1**)

2.2.3 DC Voltage Input

Definition	1 off DC voltage differential analog input ADCINA2
Input Voltage Range	0 – 816Vdc
Input Protection	High input impedance, 2720kΩ in default configuration
Overvoltage Protection	Direct interrupt through XINT2. Trigger voltage determined by resistor selection (**R106**)
Dynamic Response	Cut-off frequency >450kHz
PCB Connections	2 pin plug-in PCB Mounting Terminal Block (**X2**)

2.2.4 Temperature Sensing Input

Definition	1 off analog input interfacing to an LM35DZ temperature sensor ADCINB5
PCB Connections	3 pin plug-in PCB Mounting Terminal Block, with signal, signal ground and +5V (**X10**)

2.2.5 General Purpose Analog Inputs

Definition	3 off single-ended connections providing conditioned analog inputs ADCINB2, ADCINB3, ADCINB4
Input Voltage Range	±10V nominal.
Dynamic Response	Cut-off frequency >150kHz
PCB Connections	2 pin plug-in PCB Mounting Terminal Block, signal and AGND (**X7**, **X8**, **X9**) 10-way IDC Header (**X12**)

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)
PCB Connections	3 pin Plug-in PCB Mounting Terminal Block, with signal, signal ground and a +24V field supply (**X32**, **X33**)

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 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 pin plug-in PCB Mounting Terminal Block, with signal, signal ground and a +24V field supply (**X30**, **X31**)

Note 1: 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 (**X29**)

2.4.3 Generalised Digital I/O Expansion Port

Definition	7 bits TTL Level direction selectable I/O - GPIB0-B5 (shared with PWM1-6) - GPIOB8 (shared with CAP4) 6 bits of 3.3V-TTL I/O - GPIOF0-F3 (shared with SPI) - GPIOF6-F7 (shared with eCAN bus)	
Digital high input voltage threshold	TTL Level	3.85V
	3.3V TTL Level	2.0V
Digital low input voltage threshold	TTL Level	1.65V
	3.3V TTL Level	0.8V
Digital outputs rated at	TTL Level	24mA
	3.3V TTL Level	±4mA per bit, ABSOLUTE MAXIMUM
PCB Connection	20-way IDC header (**X13**)	

2.4.4 3.3V-TTL Level Digital Outputs

Definition	GPIOF11, F14
Digital outputs rated at	±4mA per bit, ABSOLUTE MAXIMUM
PCB Connection	GPIOF0-F3, F11 & F14 – 10-way IDC header (**X25**)

2.5 PWM Gate Drive Interface

Definition	8 PWM Outputs within 1 off Event Managers
PWM Outputs per Event Manager	Event manager has 8 PWM outputs consisting of – 3 independent complementary pairs (6 outputs) with programmable deadband generation 2 gate drive outputs generated from two independent outputs, for which deadband compensation must be implemented in software
Gate Fault Interrupt	PDPINTA*, which when unmasked and activated, immediately disables the 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 Reset	Normally Low Gate Reset Signal
Output Voltage	0-5V
PCB Connections	26-way IDC header (**X17**)

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) and an enhanced controller area network port (eCAN)
Configuration	SCIA can be operated as either a 3.3V-TTL level or an isolated RS-485 serial port SCIB is configured as an isolated RS-485 serial port The SPI and eCAN interfaces are set up as digital I/O by default

2.6.1 Serial Peripheral Interface – SPI

Definition	Four-pin serial peripheral interface (SPI) module. It is a high speed, synchronous serial I/O port that allows a serial bit stream of programmed length (one to sixteen bits) to be shifted into and out of the device at a programmable bit-transfer rate **DEFAULT MODE:** Configured as digital I/O pins
Compatibility	4 wire SPI mode Available as non-buffered, non-isolated 3.3V-TTL Level signals
PCB Connection	10-way IDC connector (**X25**) Also available on 20-way IDC header (**X13**)

2.6.2 Serial Communication Interface – SCIA – TTL Level

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
Mode Selection	RS232A_EN (GPIOB6) selects operation between 3.3V-TTL level serial mode (HIGH) and RS-485A mode (LOW)
Isolation	None
Communications Port	SCIA
PCB Connections	4-way pin strip header with VCC and GND connections (**X26**)

2.6.3 Serial Communication Interface – SCIA – RS485

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 **NON-DEFAULT MODE:** RS485A mode providing a multi-drop communications interface using a differential signal serial connection
Mode Selection	RS232A_EN (GPIOB6) selects operation between 3.3V-TTL level serial mode (HIGH) and RS-485A mode (LOW)
Isolation	ACSL-6310 1000V isolation (Please consult the datasheet for this component for full isolation information)
Communications Port	SCIA
Bus termination	Linkable 220 ohm termination resistor (**X24**)
PCB Connections	3 pin plug-in PCB Mounting Terminal Block with differential A/B output and GND connections (**X28**)

2.6.4 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 **NON-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) Removal of Links **X21** and **X22** enables this serial communications port to be fully isolated from the CPT-E01 and powered from an external 5V source via the **X27** connector
Bus termination	Linkable 220 ohm termination (**X23**)
PCB Connections	4 pin plug-in PCB Mounting Terminal Block with VISOB (5V), differential A/B output and GND connections (**X27**)

2.6.5 Enhanced Controller Area Network Module – eCAN

Definition	CAN bus module which supports up to 1Mbps transfer
Compatibility	Fully compatible with CAN protocol version 2.0B Available as non-buffered, non-isolated 3.3V-TTL Level signals
PCB Connections	20-way IDC header (**X13**) pins 1 (CANTX) and 2 (CANRX)

2.7 JTAG

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	14-way IDC connector (**X20**)

2.8 Software

Standard Support Software	Monitor Program, standard library source code, sample programs Texas Instruments: Code Composer Studio V3 and above

2.9 General

Physical Dimensions	L: 213mm
	W: 180mm
	H: 50mm approx.
Mounting Arrangement	11 off 3.5 mm holes – please consult the mechanical layout diagram in the appendix for full details Note that the SMPS also requires three off TO-220 devices to be secured to the mounting plate for heat dissipation
Environmental	-20 – 75°C ambient operating temperature 5% - 95% non condensing humidity

2.10 Power Supply

Input Voltage Range	20 - 28VDC
Standalone Input Current	**TBD** (depending on the active sections within the DSP)
Max Input Power	Approx. **TBD ~40W**
Protection	4A Input Fuse (**F1**) to on-card 24V SMPS 4A Input Fuse (**F2**) to field supply digital I/O
Supplies Generated on-card	+15V_IN (+15V) used for generating all on-card regulated positive power supplies
	+15V_GATE (+15V) Gate Driver Power Supply (available on connector **X17**)
	+12V / -12V Analog Supplies
	DVCC (+5V) Digital Supply
	+5AVCC (+5V) Analog supply (available for driving the off card LEM modules)
	CVDD (+3.3V) Digital
	AVDD (+3.3V) Analog DSP Supply
	VDDCORE (+1.9V) DSP Core
	AVDDCORE (+1.9V) Analog Section DSP Core
	+2.5V Analog Reference
	VISOA (+5V) Isolated Communications supply
Input Power Connector	2 pin plug-in PCB Mounting Terminal Block with +24V and GND connections. (**X18**)

Appendices

Appendix A Component Layout

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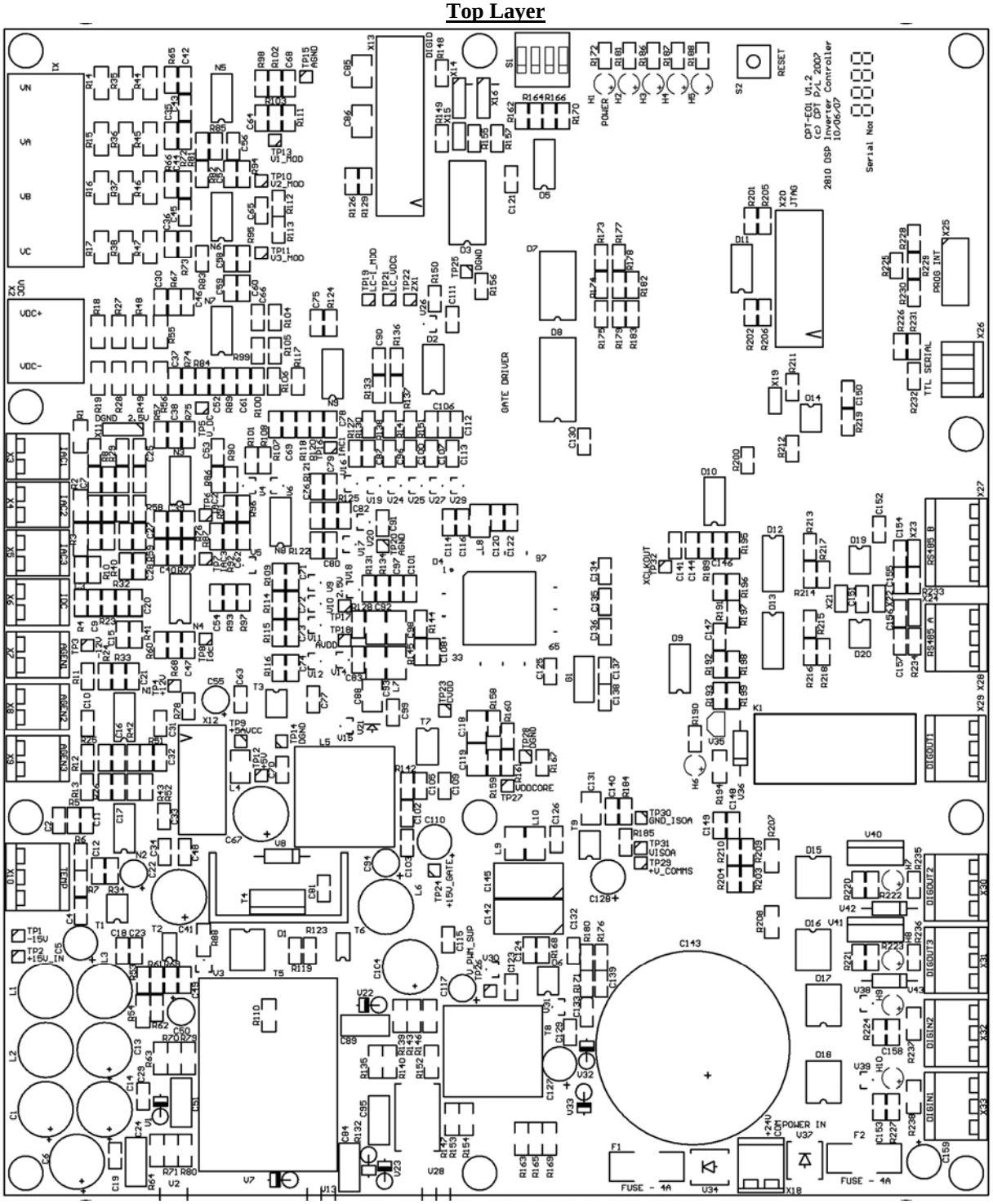

Appendix B Link and Test Point Locations

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