CPT-ITB Card

TMS320F2810 DSP Thyristor Controller Card

Technical Brief

December 2013
Manual Release 1.00
Card Version 1.00

Creative Power Technologies P/L
P.O. Box 714
MULGRAVE
Victoria, 3170

Tel: +61-3-9543-8805
Fax: +61-3-9543-8802
Email: tech@creativepower.com.au

CREATIVE POWER TECHNOLOGIES

CPT-ITB Manual Revision History

CARD VERSION 1.0: Initial Board for prototype purposes.

Release 1.00 – Initial Manual Release

Table of Contents

CPT-ITB DSP Based Inverter Controller

1.0 Overview of the CPT-ITB

The CPT-ITB is a low cost, high performance DSP based thyristor controller that has been designed for applications requiring a single board solution to control up to a four-phase thyristor 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 thyristor rectifier applications, and the CPT-ITB/CPT-DA2810 combination contains on-card all necessary functions for a complete standalone thyristor rectifier control system.

The CPT-ITB 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
- 6 off indication LEDs
- 4 off DIP switches
- 5 off isolated digital inputs
- 2 off MOSFET switch isolated outputs
- 3 off AC current inputs
- 1 off DC current input
- 3 off differential AC voltage inputs, (Three-phase + neutral input)
- 1 off differential DC voltage input (also compatible with AC voltage input)
- 1 off differential AC voltage input (Synchronization input)
- 2 off potentiometer 0-3V analog inputs
- 1 off temperature sensor (RTD) input
- 8 off isolated thyristor gate driver outputs
- 1 off Buzzer
- 1 off +5V clean contact
- Parallel LCD Interface, with contrast
- 20 way connector with 8 off TTL-level digital outputs and 8 off TTL-level digital inputs
- Reset/Power-On Circuitry
- Power supply to generate all on-card supplies
- Power supply operation from 200-440VAC 1-ϕ, or +24VDC using the optional CPT-U05 board

The card also supports the following peripheral interfaces:

- JTAG interface for software development
- 1 off isolated +5V RS-485 serial interface
- 1 off isolated +5V RS-232 serial interface or 1 off isolated +5V RS-485 serial interface
- 1 off clocked Serial Peripheral Interface (also enables external Flash reprogramming)

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

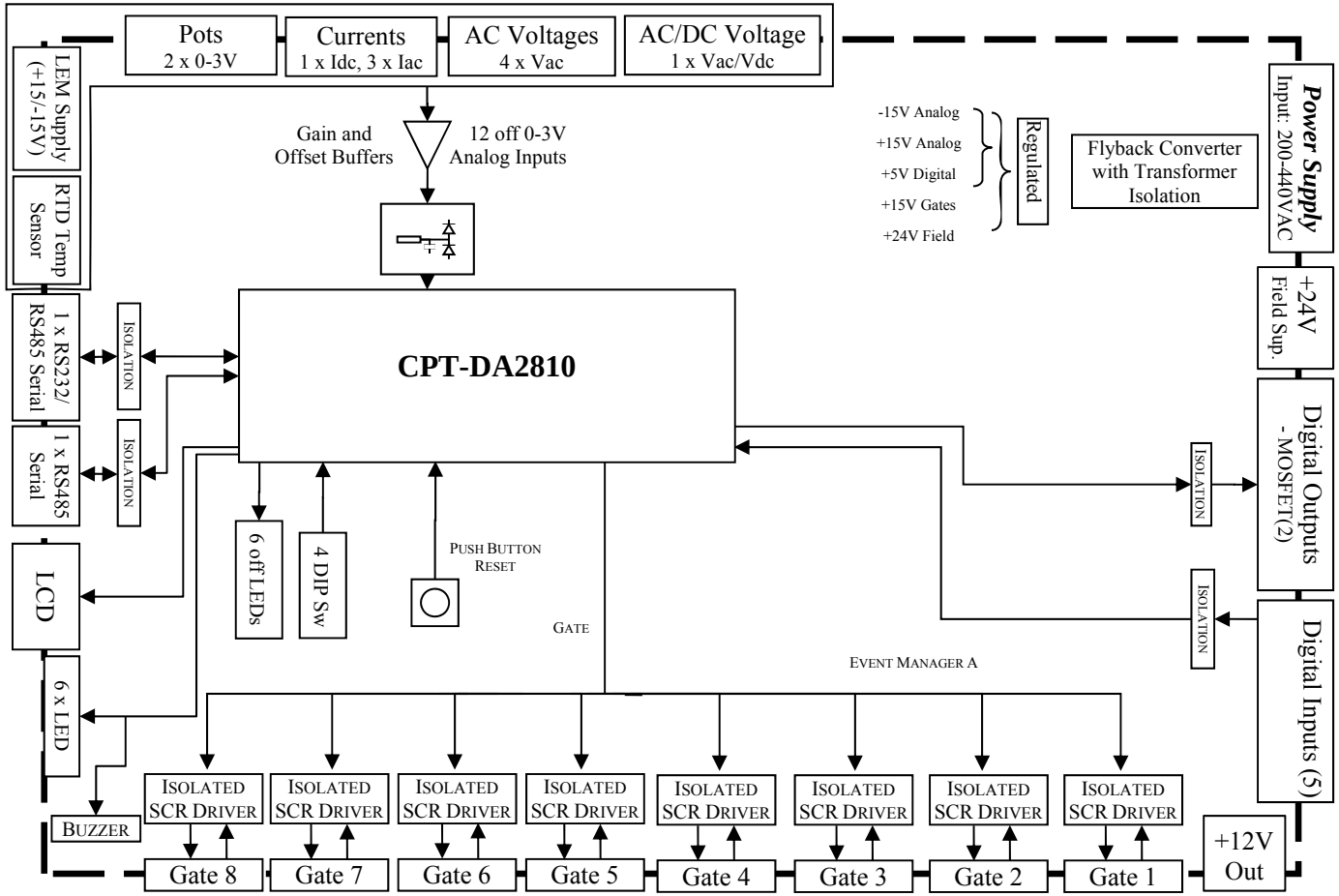

Figure 1-1: Functional Diagram of CPT-ITB Inverter Controller Board

1.1 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*.

The twelve filtered analog inputs are interfaced from the CPT-ITB as 3 off AC currents, 4 off AC voltages, 1 off DC voltages, 1 off DC currents, 2 off Potentiometer and 1 off RTD Temperature Sensor. 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 three AC current inputs can operate from an off-card LEM module 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 **R198**.

Three of the AC voltage inputs are differential high impedance circuits, allowing the line-line AC voltages to be measured from a three-phase + neutral system. One input voltage (Van) supports a zero-crossing detect circuit, which drives a DSP capture input.

The single AC voltage input (V-SYNC) is a differential high impedance circuit, allowing measurement of a single-phase AC voltage. It also supports a zero crossing detect circuit, which drives a DSP capture input.

The single AC/DC voltage input (VDC/VAC5) is set as a DC input by default. 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 **R184**.

The DC current input can operate from an off-card CT or a LEM module. An on-card burden resistor (**R222**) should be used if the input to the board is current fed, with the value selected so that the full-scale voltage developed across the resistor range 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.

1.2 Digital I/O

The CPT-ITB card supports 28 bits of digital I/O, consisting of 11 bits for local I/O and 17 bits interfacing to external circuitry.

The local I/O consists of 6 bits driving LEDs mounted on-card (**H16**, **H17**, **H18**, **H19, H20, H22**), 1 on-card buzzer (**H21**), 4 bits of DIP switch inputs (**S2**), 1 off 5V clean contact output and 8 off TTL-level digital inputs and 8 off TTL-level selectable digital outputs

The isolated I/O consists of 5 off isolated digital inputs, and 2 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 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.

1.3 LCD Interface

The LCD interface is arranged to directly suit all 1 and 2 line Handok or Optrex character type LCD display modules. The interface connects to the LCD display through a 16 way IDC header connector (**X34**). The interface signals are an 8 bit latched data byte, and four latched control bits which generate the LCD display control signals. All interface signals are TTL.

The LCD interface also provides a –12V adjustable contrast supply, and a +5V LED backlight supply controlled by a transistor switch.

The LCD interface data and control bit latches are accessed as SPI interfaces by the CPT-DA2810 controller.

1.4 Gate Drive Interface

The TMS320F2810 DSP supports 16 PWM channel outputs, made up of 6 complementary pairs (12 outputs) with programmable deadband and 4 independent outputs generated by simple compare functions. The DSP chip has two independent Event Manager modules (EVA and EVB). Deadband compensation must be software-calculated for the simple compare outputs.

The CPT-ITB board has 8 isolated thyristor driver outputs that are generated by TC428EPA gate driver chips that feed into a pulse transformer. The transformer output is rectified to provide a gate signal to the thyristor. These eight outputs (**X14** to **X21**) are connected to Event Manager A.

1.5 Communications

The CPT-ITB controller board supports three communication protocols: one off isolated RS-232 or RS-485 serial communications interface (SCIA) (software selectable), a 3.3V-TTL synchronous serial peripheral interface (SPI) (connector on the CPT-DA2810) and an isolated RS-485 serial communications interface (SCIB).

The high-speed synchronous serial peripheral interface (SPI) can be used to communicate with other SPI enabled peripherals, such as DSP Controllers, SPI to Digital I/O Expanders, Temperature sensors or Real-time of day clocks. The interface is available in an unbuffered generic configuration on the CPT-DA2810 DSP board. The unbuffered interface requires a separate board to configure master/slave protocols if they are required (options available through CPT).

1.6 On-card memory (CPT-DA2810)

The CPT-DA2810 controller board supports 64k x 16-bit of on-card Flash (128k x 16-bit with the TMS320F2811), 18k x 16-bit 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.

1.7 Power Supply

The CPT-ITB controller board is available in multiple versions that are designed to operate from different input supply voltage ranges.

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

The CPT-ITB(U05) controller board has a solder-on switch mode power supply that accepts an input voltage in the range of 20V – 30V DC.

1.8 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 external interrupts (GPIOD0/PDPINTA*, GPIOD5/PDPINTB*)

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 voltage output LEM compatible AC current inputs. ADCINA0 (IAC1), ADCINA1 (IAC2), ADCINA2 (IAC3)
Input Voltage Range	2.5V ± maximum peak (set by off-card LEM module) 0-5V maximum in voltage differential input mode – requires resistor scaling change
Overcurrent Protection	Accessible through Test Point TP15: IAC-OC. Interrupt through XINT1. Trigger level set by resistor **R198** **DEFAULT:** 12.6A, with external LTS6-NP LEM Module)
LEM Supply	+5V/GND available on **X4**
Dynamic Response	Cut-off frequency >150kHz
PCB Connections	8-way Phoenix MCV1,5 3.81mm spacing connector. Designed for individual twisted pair connection (labelled as **X4**). Connector includes AVCC (+5V)/AGND supply voltage for off-card LEM module.

2.2.2 DC Current Inputs

Definition	1 off twisted pair 2-wire connections providing conditioned CT & LEM compatible AC current inputs. Burden resistor (**R222**): ADCINA3 (IDC)
Input Voltage Range	2.5V ± maximum peak (set by off-card LEM module) 0-5V maximum in voltage differential input mode – requires resistor scaling change
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
IDC1 Default Burden	Not Loaded
Overcurrent Protection	Accessible through Test Point TP16: IDC-OC. Interrupt through XINT2. Trigger level set by resistor **R182** **DEFAULT:** 12.6A, with external LTS6-NP LEM Module)
LEM Supply	+5V/GND available on **X4**
Dynamic Response	Cut-off frequency >150kHz
PCB Connections	4-way Phoenix MCV1,5 3.81mm spacing connector. Designed for individual twisted pair connection (**X5**) Connector includes AVCC (+5V)/AGND supply voltage for off-card LEM module.

2.2.3 AC Voltage Inputs

Definition	3 off AC voltage differential analog inputs: ADCINB2 (VAC1), ADCINB1 (VAC2), ADCINB0 (VAC3)
Input Voltage Range	±430 Vac maximum peak
Input Protection	High input impedance, 450kΩ in default configuration
Zero-Crossing Detect	ZX-VAC1 – connects to CAP1 DSP input
Dynamic Response	Cut-off frequency >700kHz
PCB Connections	7-way Phoenix MSTBVA 5.08mm spacing connector (**X3**)

2.2.4 AC Voltage (Synchronization) Input

Definition	1 off AC/DC voltage differential analog input: ADCINB3 (VAC4)
Input Voltage Range	±530 Vac maximum peak
Input Protection	High input impedance, 450kΩ in default configuration
Zero-Crossing Detect	ZX-VSYNC - Connects to CAP2 DSP input
Dynamic Response	Cut-off frequency >700kHz
PCB Connections	3-way Phoenix MSTBVA 5.08mm spacing connector (**X2**)

2.2.5 AC/DC Voltage Input

Definition	1 off AC/DC voltage differential analog input: ADCINB4 (VDC/VAC5)
Input Voltage Range	0 – 816Vdc
Input Protection	High input impedance, 2720kΩ in default configuration
Overvoltage Protection	VDC-OV – Interrupt through XNMI. Trigger level determined by resistor **R184**
Dynamic Response	Cut-off frequency ~15kHz
PCB Connections	3-way Phoenix MSTBVA 5.08mm spacing connector (**X1**)

2.2.6 Potentiometer Analog Inputs

Definition	2 off analog potentiometer inputs
Voltage Range	0 to 3V
PCB Connections	3-way Phoenix MCV1,5 3.81mm spacing connector, with signal, signal ground and a +3V field supply (**X7**, **X6**)

2.2.7 Temperature Sensing Input

Definition	1 off analog input capable of measuring temperature using an RTD, or interfacing to an LM35DZ temperature sensor
Constant Current Supply	1mA. Other constant current ranges can be implemented by changing a resistor (**R265**). Ensure Link **LK4** is inserted to activate this mode.
PCB Connections	3-way Phoenix MCV1,5 3.81mm spacing connector, with signal, signal ground and +15V (**X9**)

2.3 Digital Inputs

2.3.1 TTL Level Inputs

Definition	1 bank of 8 bit TTL digital inputs Note: the bank is on an IDC header shared with the TTL digital outputs. +5V (DVCC) and DGND made available on connector for external use
High-level input voltage	2V DC
Low-level input voltage	0.8V DC
PCB Connection	20 pin shrouded IDC header, with signals, logical ground, +5V supply (**X33**)

2.3.2 Isolated Digital Inputs

Definition	5 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**, **X24, X25, X26, X27**)

2.4 Digital Outputs

2.4.1 TTL Level Outputs

Definition	1 bank of 8 bit TTL digital outputs – DSP selectable from GPIOA0-7 or GPIOB0-7 Note: the bank is on an IDC header shared with the TTL digital inputs. +5V (DVCC) and DGND made available on connector for external use
Digital Output Source	GPIOA0-7 – GPIOA_EN* LOW (GPIOB8) GPIOB0-7 – GPIOA_EN* HIGH
Digital outputs rated at	24mA per bit, ABSOLUTE MAXIMUM
PCB Connection	20 pin shrouded IDC header, with signals, logical ground and a +5V supply (**X33**)

2.4.2 TTL Level Output

Definition	1 off TTL digital output – driven through SPI-to-digital-I/O component **D37. (Port B0).**
Digital Output Source	SPI Interface DIO_CS*, Address 0, Port B, Bit 0
Digital outputs rated at	5mA, ABSOLUTE MAXIMUM
PCB Connection	3-way Phoenix MCV1,5 3.81mm spacing connector with supply (1k series resistor limited from +5V) and open collector output (**X13**)

2.4.3 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-way Phoenix MCV1,5 3.81mm spacing connector, with signal, signal ground and a +24V field supply (**X29**, **X28**)

Note 1: Only one MOSFET output used.

2.4.4 LCD Display Interface

Definition	16 pin LCD display output consisting of 8 bits of strobed output data, 2 bits of latched digital output (to be used to set up LCD display module control signals) one write signal, contrast and backlight enable
Contrast Control	Variable display brightness voltage, +5V to 0V (**R283**)
Digital outputs rated at	±25mA per bit, ABSOLUTE MAXIMUM
PCB Connections	16 pin shrouded IDC header (**X34**)

2.5 Gate Drive Interface

Definition	8 SCR (Thyristor) Outputs sourced from Event Manager A
Outputs on Event Manager A	Event manager A has 4 PWM outputs consisting of – 2 independent complementary pairs (4 outputs). Each output is isolated through an ILR2-11-3 pulse transformer driven from a TC328EPA gate driver chip. The pulse transformer output is rectified
Default Gate Resistance	10Ω (2W rated)
PCB Connections	2 way Phoenix MSTBVA 5.08mm spacing connector per gate output with Gate and CATHODE connections (**X14** – **X21**)

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 configurable to support either RS-232 or RS-422/485 communication modes. Both modes cannot operate simultaneously SCIB is configured as an isolated RS-485 serial port The SPI interface is configured for use with the on-card SPI to Digital I/O interface chips and is also available through the CPT-DA2810 programming interface connector, if additional SPI connections are required.

2.6.1 Serial Communication Interface – SCIA – RS-232

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:** RS-232 serial connection that is directly compatible with a PC Serial port (or to interface with a serial port to USB converter). Activate by driving EN232A signal HIGH.
Communications Port	SCIA
Isolation	HCNW-4503 630V peak isolation (Please consult the datasheet for this component for full isolation information) Isolated On-Card power supply via (**T15**) NKE0505SC.
Compatibility	Links provided to enable the board to be configured as a DTE or a DCE (**LK3**). Default is configuration as a DCE
PCB Connections	10-way IDC connector

2.6.2 Serial Communication Interface – SCIA – RS-485

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 RS485A mode providing a multi-drop communications interface using a differential signal serial connection. Activate by driving EN232A signal LOW.
Communications Port	SCIA
Isolation	ACSL-6310 1000V isolation (Please consult the datasheet for this component for full isolation information) Isolated On-Card power supply via (**T15**) NKE0505SC.
Bus termination	Linkable 220 ohm termination (**LK1**)
PCB Connections	4-way Phoenix MCV1,5 3.81mm connector with +5V_ISOA (+5V), differential A/B output and DGND_ISOA connections (**X11**)

2.6.3 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 (**T16**) NKE0505SC.
Bus termination	Linkable 220 ohm termination (**LK2**)
PCB Connections	4-way Phoenix MCV1,5 3.81mm connector with +5V_ISOB (+5V), differential A/B output and DGND_ISOB connections (**X12**)

2.6.4 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 SPI Mode (Master)
Compatibility	Available as non-buffered, non-isolated 3.3V-TTL Level signals on CPT-DA2810 connector **X10** Shared with on-card SPI-to-Digital I/O interface chips (**D37** and **D38**). SPI Enable for these chips is DIO_CS* (GPIOD6)
PCB Connection	Isolated Interface: 10-way IDC connector (**X6**) Also available on CPT-DA2810 10-way IDC connector (**X2**)

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	13 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

<table>
<tr><td>Input Voltage Range</td><td colspan="2">200 - 440VAC
(Also available in ULV (50 - 150VDC), LV (85 – 265VAC) and U05 (24VDC) versions)</td></tr>
<tr><td>Standalone Input Current</td><td colspan="2">10-30mA (depending on the active sections within the DSP and supply voltage)</td></tr>
<tr><td>Max Input Power</td><td colspan="2">Approx. 40W</td></tr>
<tr><td>Protection</td><td colspan="2">800mA Input Fuse (F1) to on-card SMPS</td></tr>
<tr><td rowspan="8">Supplies Generated on-card</td><td>GND (EARTH)</td><td>+V1 (+12V) Gate Driver Power Supply</td></tr>
<tr><td rowspan="6">DGND
Digital Ground
(47µH to EARTH)</td><td>+DIG_V (+12V) used for generating digital on-card regulated positive power supplies</td></tr>
<tr><td>+15V Analog Supply</td></tr>
<tr><td>-15V Analog Supply</td></tr>
<tr><td>DVCC (+5V) Digital Supply</td></tr>
<tr><td>3.3V (+3.3V) Digital</td></tr>
<tr><td>+2.5V Analog Reference</td></tr>
<tr><td>DGND_ISOB
Isolated Ground</td><td>VISOB (+3.3V) Communications supply</td></tr>
<tr><td>+24V_COM
(10kΩ to EARTH)</td><td>+24V Field Supply</td></tr>
<tr><td>Input Power Connector</td><td colspan="2">Standard and LV configurations:
5-way Phoenix MSTBVA 5.08mm spacing connector with Active, Neutral, EARTH. (X27)
ULV configuration:
5-way Phoenix MSTBVA 5.08mm spacing connector with Active, Neutral, EARTH. (X27)
U05 configuration:
5-way Phoenix MSTBVA 5.08mm spacing connector with +24V, +0V, EARTH. (U05:X1)</td></tr>
</table>

Appendices

Appendix A Component Layout

Top Layer