

CPT-DA28035 Card
TMS320F28035 MCU Controller Card
Technical Brief

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CPT-DA28035 Manual Revision History

CARD VERSION 1.0: Initial Board for prototype purposes.

Release 1.0 – Initial Release

CARD VERSION 1.1: Revised Board from Initial Testing
Changed to Clock Module from Crystal

Release 1.1 – Updated to reflect changes.

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CPT-DA28035 MCU Controller Board

1.0 Overview of the CPT-DA28035

The CPT-DA28035 is a low cost standardised MCU controller board designed to provide a fully flexible interface between the TMS320F28035 MCU processor and a user customised motherboard. The board has been designed to meet different user interface requirements whilst providing a 4-layer MCU core with basic on-board functionality.

The board is based around a Texas Instruments TMS320F28035PN MCU, which has been specifically developed for use in digital motor/motion control applications. The footprint and interface on the CPT-DA28035 is compatible with the CPT-DA2810.

The CPT-DA28035 card measures 110mm x 55mm.

On-card facilities include:

- TMS320F28035PN “Piccolo” Microcontroller
- 64k x 16 Flash
- 1k x 16 OTP ROM
- 8k x 16 Boot ROM
 - Software Boot Tables
 - Standard Math Tables
- 10K x 16 Single Access RAM (SARAM)
 - L0: 2 Blocks of 2K x 16 Each DPSARAM
 - L1 and L2: 2 Block of 1K x 16 DPSARAM
 - L3: 1 Block of 4K x 16 Each DPSARAM
 - M0 and M1: 2 Blocks of 1K x 16 SARAM
- Control Law Accelerator
- Serial Flash Memory with 1Mbit of non-volatile storage
- Internal Temperature Sensor – for measuring MCU Junction Temperature
- 1 off Power LED
- Reset/Power-On Circuitry
- Power supply to generate all on-card supplies
- Power supply operation from input +5VDC

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
- 1 off 3.3V-TTL Enhanced Controller Area Network (eCAN) Bus interface
- 1 off 80-way Connector with:
 - 12 off 12-bit 0-3.3V ADC inputs
 - 2 off (selectable) Serial Communications Interfaces
 - 1 off Enhanced Controller Area Network (eCAN) Bus
 - Enhanced Pulse Width Modulator (ePWM) interfaces
 - Selectable Interrupt Sources

Figure 1-1 shows a functional block diagram of the CPT-DA28035 card, illustrating all major sections.

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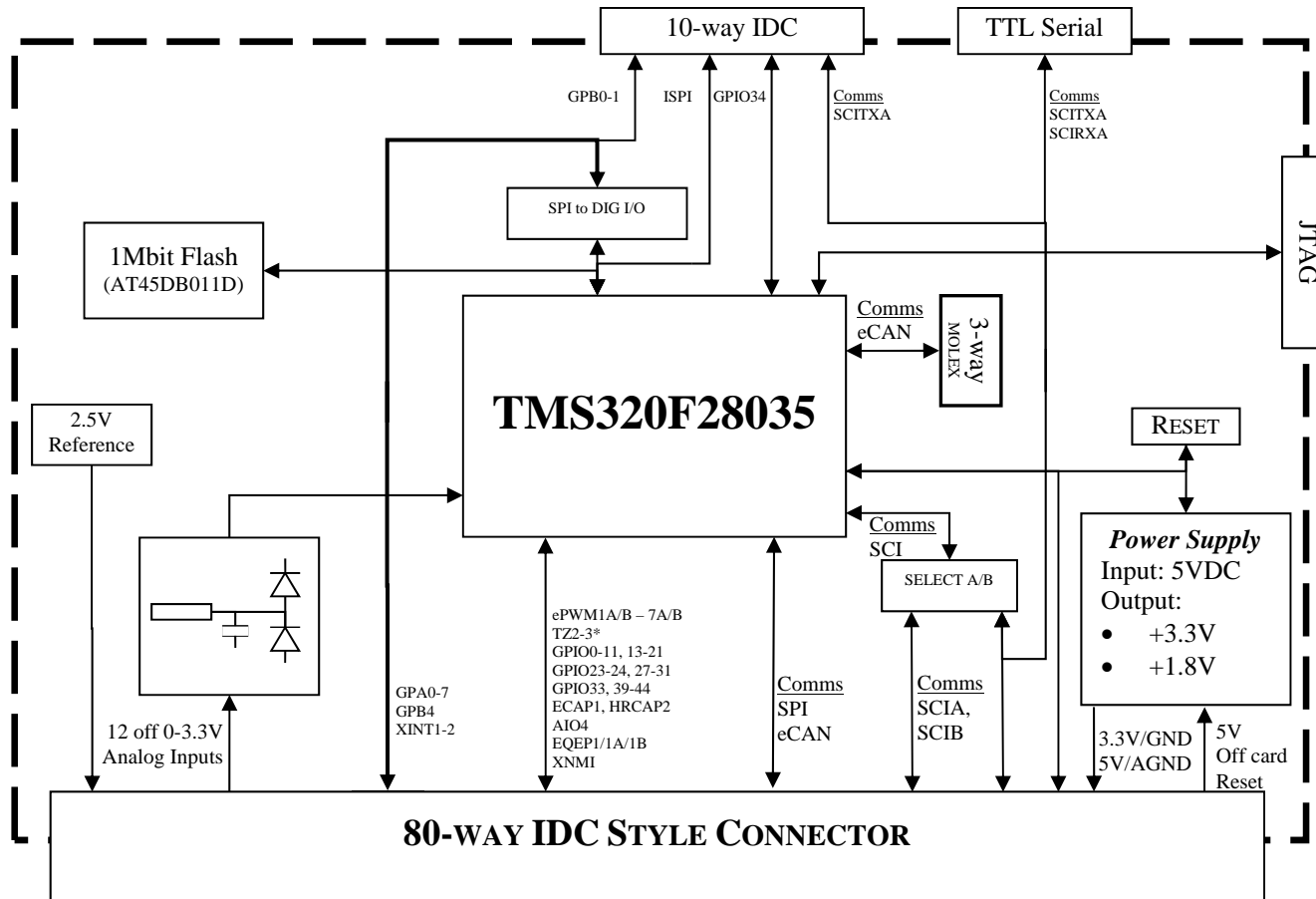


Figure 1-1: Functional Diagram of CPT-DA28035 Controller Board

Note: Some pins shown in Figure 1-1 are multiplexed. Hence not all of the functionality is available at the same time.

1.1 Digital I/O

The CPT-DA28035 card supports a maximum of 52 bits of 3.3V-TTL digital I/O, depending on the user defined configuration of specific MCU pins. Of these pins, 37 are supplied non-buffered to the main external connector while the remaining 15 are buffered on-card.

All but 2 of the TMS320F28035's digital I/O pins can operate in either a "Digital I/O or "Peripheral I/O" mode. The user must select the correct mode of operation for each pin within their software. Thirteen of the digital I/O pins are generated from an SPI-to-Digital I/O expander which enables flexible programming of the pins operation.

1.2 Analog Inputs

The TMS320F28035 MCU has 16 off ADC inputs that accept voltages in the range of 0-3.3V. 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's "... basic principle of operation is centred around the configurations of individual conversions..."^I. This enables the single conversion or a single channel to be configured rather than the sequencer based ADCs that were used in previous 28x processors which required setting up a stream of conversions.

The maximum total conversion time for each ADC input is 13 ADC Clock ticks (216.67ns @ 60MHz ADC Clock).

The CPT-DA28035 analog inputs are configured to provide 1 off internal Temperature measurement and 12 off filtered external inputs to the TMS320F28035. The 3 remaining TMS320F28035 analogs are used as digital signals on the CPT-DA28035 board.

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. *TMS320x2802x, 2803x Piccolo Analog-to-Digital Converter (ADC) and Comparator Reference Guide*, Literature Number: *SPRUGE5F*.

The 12 off filtered analog inputs are available on the 80-way header. They each have a low pass or "glitch" filter and a diode clamp circuit before they are fed into the MCU. The board accepts 0-3.3V inputs for these circuits.

A +2.5V precision reference is available on the 80-way header for use off card. It is recommended that this reference be fed into an off-card op-amp circuit for external buffering rather than being used directly.

1.3 Gate Drive Interface

The TMS320F28035 MCU supports 14 PWM channel outputs, made up of 7 complementary pairs with programmable deadbands. The MCU chip has 7 enhanced pulse width modulator (ePWM) modules. Each module consists of "... one complete PWM channel composed of two PWM outputs: EPWMxA and EPWMxB"^{II}. Dead band compensation is required to be software-calculated for the simple compare outputs. In addition the 'A' channel of each PWM module can be operated with increased precision control of the PWM output, which is referred to as the High-Resolution Pulse Width Modulator (HRPWM). This "... extends the time resolution capabilities of the conventionally derived digital pulse width modulator"^{III}.

^I "Piccolo Microcontrollers" – Literature Number: SPR584G, Texas Instruments March 2012

^{II} "TMS320F2802x, 2803x Piccolo Enhanced Pulse Width Modulator (ePWM) Module Reference Guide" – Literature Number: SPRUGE9E, Texas Instruments Revised March 2011.

^{III} "TMS320F2802x, 2803x Piccolo High Resolution Pulse Width Modulator (HRPWM) Module Reference Guide" – Literature Number: SPRUGE8E, Texas Instruments Revised October 2011

Each ePWM module can be connected together via a clock synchronization scheme that enables them to operate as a single system. The system can be extended to include the capture peripheral modules (eCAP).

Gate fault signals are fed back to the MCU via the Trip-Zone TZ2* and TZ3* pins. These signals act as interrupts that can be configured to act on any or all of the EPWMxA or EPWMxB pins. This enables a MCU hardware interrupt trip to immediately occur on detection of a fault, thus disabling the PWM signals within 2 clock cycles using hardware logic internal to the MCU.

1.4 Communications

The CPT-DA28035 controller board supports two off non-isolated 3.3V-TTL serial communications interfaces (SCI), two 3.3V-TTL synchronous serial peripheral interfaces (SPI) and a 3.3V-TTL enhanced Controller Area Network (CAN) bus interface.

The high-speed synchronous serial peripheral interfaces can be used to communicate to other computer systems. The interfaces can support either master or slave protocol, selected by software. One SPI interface (ESPI) is available via the 80 way external connector and a second shared SPI interface (ISPI) is available via the 10 way IDC header. This interface is shared with the on-card Flash Memory chip and SPI-to-digital I/O expander.

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. The 3.3V serial communications interfaces are multiplexed to the single TMS320F28035 SCI channel. The multiplexed channels do not permit external receiver buffering. Therefore the user program must carefully consider the interaction of the individual SCI channels to ensure there is no loss of received serial data.

1.5 On-card memory

The CPT-DA28035 controller board supports 64k x 16bit of on-card Flash, 10k x 16bit of SARAM and 8k 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, SPI program operation.

In addition to the on-chip memory the CPT-DA28035 has a 1Mbit SPI interfaced Flash Memory chip for external data storage.

1.6 Power Supply

The standard CPT-DA28035 controller board has an on-card dual voltage regulator chip that is optimised for operation with Texas Instruments range of TMS320 MCU. The card accepts an input voltage of +5VDC and produces +3.3V I/O and +1.8V core voltages.

Analog supplies are generated via an LC filter from the digital +3.3V supply and a precision reference chip is used to produce a stable +2.5V which is available on the external 80 way connector.

Off card analogs requiring a +5VDC supply should use DVCC supplied from pin 58 to minimise analog grounding loops.

1.7 JTAG/programming

The CPT-DA28035 controller board has a JTAG interface for programming the MCU'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 MCU Section

Processor	Texas Instruments TMS320F28035PN
On-card Memory	64k x 16 Flash Memory 10k x 16 RAM 8k 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 on-card 2 pin Link (S1), or via X5.59 on Version 1.1 (or later)
Non-Volatile Memory Storage	1Mbit of memory storage using an SPI flash ROM chip Accessed via ISPI interface on MCU (SPIB)
Interrupts	3 off masked external interrupts (XINT1/GPIO22 & XINT2/GPIO22, NMI/TZ1*) Support for 2 off Gate Driver interrupts (TZ2*, TZ3*) Note: All GPA and GPB inputs can be configured as SPI Expander interrupts All GPIO0-31 (Port A) inputs can be configured as MCU Interrupts

2.2 Analog Inputs

Number of Channels	16 single ended
A/D Resolution	12 bits
A/D Conversion Time	216.67ns (@60MHz ADCCLK) + Sample Window setting
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 Voltage	Internal

2.2.1 AC General Inputs

Definition	12 off 0-3.3V analog inputs with low pass filter capacitors ADCINA0-3,5-7 ADCINB0-3,5,7 Channel ADCINA5 configured for internal temperature measurement.
Input Voltage Range	0-3.3V maximum
Dynamic Response	Cut-off frequency >150kHz
PCB Connections	80-way IDC header (X5) between pins 60 and 80

2.3 Digital I/O

Definition	52 bits total GPIO0-11, GPIO44,45 (shared with EPWMxA – EPWMxB) GPIO13-14 (shared with Trip Zone Modules TZ2*, TZ3*) GPIO15 (shared with interrupt XNMI) GPIO16-19 (shared with SPIA port) GPIO20-23 (shared with EQEP interface) GPIO24,27 (shared with Capture Ports) GPIO28-29 (shared with SCIA port) GPIO30-31 (shared with eCAN bus) GPIO32 (shared with ESPI chip select) GPIO33,34, 39,42-44 AIO4 GPA0-7, GPB0-1-4 (via the MCP23S17)
Digital high input voltage threshold	+2.4V
Digital low input voltage threshold	+0.4V
Digital outputs rated at	±4mA per bit, ABSOLUTE MAXIMUM ±8mA for Group 2 pins (GPIO16-19)
PCB Connection	GPIO32, GPIO34, GPB0,1 – 10-way IDC header (X2) All other I/O available on 80-way IDC header (X5)

2.4 PWM Gate Drive Interface

Definition	Seven enhanced PWM Modules (ePWM) that can provide <ul style="list-style-type: none"> • 14 EPWM outputs or • 7 HRPWM outputs
ePWM Outputs	Each ePWM Module consists of two PWM outputs (EPWMxA and EPWMxB) with programmable deadband generation that can be configured as: <ul style="list-style-type: none"> • Two independent PWM outputs with single-edge operation • Two independent PWM outputs with dual-edge symmetric operation • One independent PWM output with dual-edge asymmetric operation
HRPWM Outputs	Increased resolution capacity using the EPWMxA channel.
Gate Fault Interrupt	Programmable trip zone allocation of both cycle-by-cycle trip and one-shot trip on fault conditions. The PWM signals are placed into a high impedance state.
Output Voltage	0-3.3V
PCB Connections	80-way IDC header (X5)

2.5 Communications Interface

Definition	The TMS320F28035 has one off serial communication interface port (SCI), two off serial peripheral interfaces (SPIA and SPIB) and an enhanced controller area network port (eCAN)
Compatibility	Serial Communications Interface (SCI) has been multiplexed to provide two external SCI interfaces (SCIA and SCIB) to maintain compatibility with the previous generation CPT-DA2810 controller.
Configuration	<p>DEFAULT modes</p> <ul style="list-style-type: none"> • SCI set as a 3.3V-TTL level serial port accessing SCIA, • SPIA set as digital I/O • SPIB set as SPI (ISPI) • eCAN set as digital I/O
Isolation	None

2.5.1 Serial Communication Interface – SCI

Definition	<p>Two-wire asynchronous serial port (UART) that supports a 4-level, receive and transmit FIFO for reducing servicing overhead. The receiver and transmitter are double buffered with separate enable and interrupt bits.</p> <p>There are two external SCI interfaces, SCIA and SCIB. Transmit and Receive signals on these ports are independently selectable.</p>
Power Up	SELECT_R – LOW, SELECT_T – LOW.
Default Active SCI Port	SCIA

2.5.1.1 Serial Communication Interface – SCIA

Definition	<p>The SCIA port is activated by setting SELECT_R and SELECT_T signals LOW. Separate SELECT_x signals enable the receive or transmit channels to be independently accessed.</p> <p>This provides a 3.3V-TTL level serial connection, with 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</p>
Communications Port	SCIA
Current Limit	±50mA
PCB Connections	<p>4-way MOLEX header with VCC and GND connections (X3)</p> <p>Also available on 80-way IDC header X5 pins 10 (SCITXA) and 11 (SCIRXA)</p> <p>SCITXA also available on X4 Pin 4</p>

2.5.1.2 Serial Communication Interface – SCIB

Definition	<p>The SCIB port is activated by setting SELECT_R and SELECT_T signals HIGH. Separate SELECT_x signals enable the receive or transmit channels to be independently accessed.</p> <p>This provides a 3.3V-TTL level serial connection, with 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</p>
Communications Port	SCIB
Current Limit	±50mA
PCB Connections	Available on 80-way IDC header X5 pins 12 (SCITXB) and 13 (SCIRXB)

2.5.2 Serial Peripheral Interface – SPIA

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 This SPI port is referenced as ESPI within the documentation DEFAULT MODE: Configured as digital I/O pins
Compatibility	4 wire SPI mode
PCB Connection	Available on 80-way IDC header X5 pins 14 (ESPI_SIMO), 15 (ESPI_SOMI), 16 (ESPI_CLK) and 17 (ESPI_STE*)

2.5.3 Serial Peripheral Interface – SPIB

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 SPIB – referenced as ISPI within the documentation
Compatibility	4 wire SPI mode
PCB Connection	10-way IDC connector (X1) Also used by AT45DB011D Serial Flash chip and MCP23S17 SPI to Digital I/O Expander

2.5.4 Enhance Controller Area Network Module – eCAN

Definition	CAN bus module which supports up to 1Mbps transfer
Compatibility	Fully compatible with CAN protocol version 2.0B
PCB Connections	Available on 3-way Molex header X6 pins 1 and 2 (pin 3 GND). Available on 80-way IDC header X5 pins 8 (CANTX) and 9 (CANRX)

2.6 JTAG

Definition	MCU interface connection, which enables the TMS320F28035 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 (X4)

2.7 Software

Standard Support Software	Monitor Program, standard library source code, sample programs Texas Instruments: Code Composer Studio V5 and above
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2.8 General

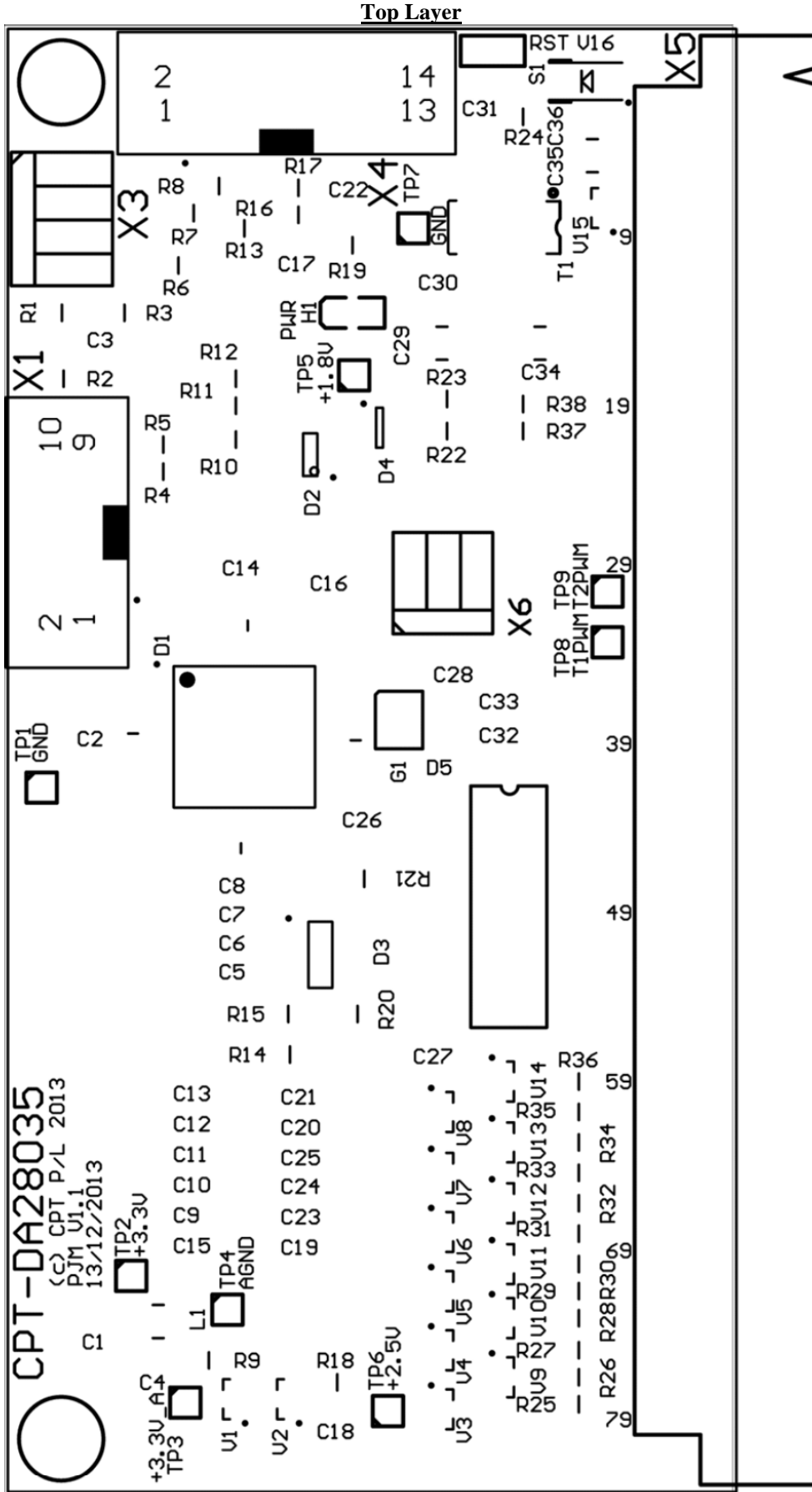
Physical Dimensions	L: 55mm
	W: 110mm
	H: 11mm approx.
Mounting Arrangement	2 off 3.5 mm holes spaced 102mm apart at the top corners of the board 80-way IDC header can also be soldered into the motherboard to provide additional support
Environmental	-40 – 85°C ambient operating temperature 5% - 95% non condensing humidity

2.9 Power Supply

Input Voltage Range	5VDC
Standalone Input Current	100-200mA (depending on the active sections within the MCU)
Max Input Power	Approx. TBD ~500mW
Supplies Generated on-card	+3.3V Digital
	+1.8V MCU Core
	+2.5V Analog Reference
Input Power Connector	80-way IDC Connector (X5) DVCC (+5V) on pins 1-3, GND on pins 4-6

Appendices

Appendix A Component Layout



Appendix B Link and Test Point Locations

Top Layer

