uGrid DSP Interface User Guide

T-UG013 (v1.1) October 10, 2015

Abstract

This document provides information about interface board that allows user to connect 3 Texas Instruments DIMM100 control cards to Typhoon HIL emulator.

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1 Overview

uGrid DSP Interface for TI DIMM100 DSP cards is Typhoon HILs answer to the increasing demand for micro-grid development tools using Texas Instruments family of DSPs.
Typhoon HIL devices emulate power stage of Power Electronics devices that include power converters, electrical machinery, filters, electrical grid, photovoltaic cells, passive elements, etc. with 1μs overall time resolution.
In this way users can develop and immediately test their control applications without worrying about safety measures required in the power laboratory environment.

2 Features

- 3 DIMM100 sockets for TI Control Cards (DIMM180 available with converter card)
- Power switch (3.3V and 5V) with LED indication
- Onboard XDS100v1 emulator and 3 UART ports (all accessible over 1 USB port)
- JTAG connector for external emulator (voltage supply 3.3V)
- LEDs for monitoring UART port status
- 32 HIL Digital Inputs with the following distribution between DIMM sockets:

  Socket 1: 12 DSP PWM signals and 2 GPIO signals
  Socket 2: 10 DSP PWM signals
  Socket 3: 8 DSP PWM signals

  Or, when socket 2 is not populated:

  Socket 1: 12 DSP PWM signals and 2 GPIO signals
  Socket 3: 12 DSP PWM signals and 2 GPIO signals

- 32 HIL Digital Outputs with the following distributionbetween DIMM sockets:

  Socket 1: 3 DSP encoder inputs and 9 GPIO signals
  Socket 2: 3 DSP encoder inputs and 7 GPIO signals
  Socket 3: 3 DSP encoder inputs and 7 GPIO signals

- 32/16 HIL Analog Outputs scaled from ±5V to DSP's 0-3V and available on DIMM sockets in the following way, configurable with DSP3 AI switch:

  HIL AO 1-16 configuration: HIL Analog Outputs from 1 to 16 available on all 3 sockets

  HIL AO 17-32 configuration: HIL Analog Outputs from 1 to 16 available on sockets number 1 and 2, HIL Analog Outputs from 17 to 32 available on socket number 3

- CAN communication between DSPs with external bus connector (RJ45)
- Dimensions: 263 mm (10.3 inch) by 160 mm (6.3 inch)

3 Block diagram

uGrid DSP Interface functional block diagram is shown in Figure 3.1.

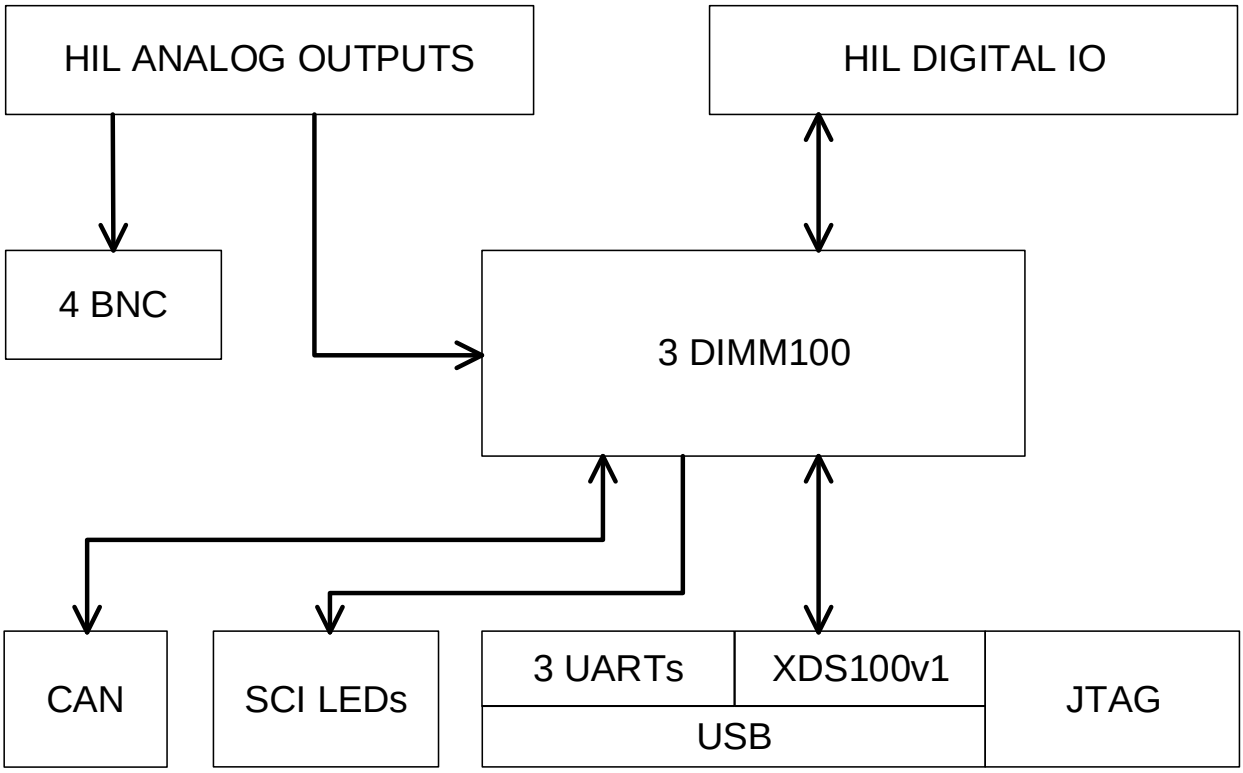

Figure 3.1 - uGrid DSP Interface functional block diagram

4 Detailed description

uGrid DSP Interface block layout is shown in Figure 4.1. Numbers in white rectangles represent the sections of chapter 4 that describe the marked components on board.

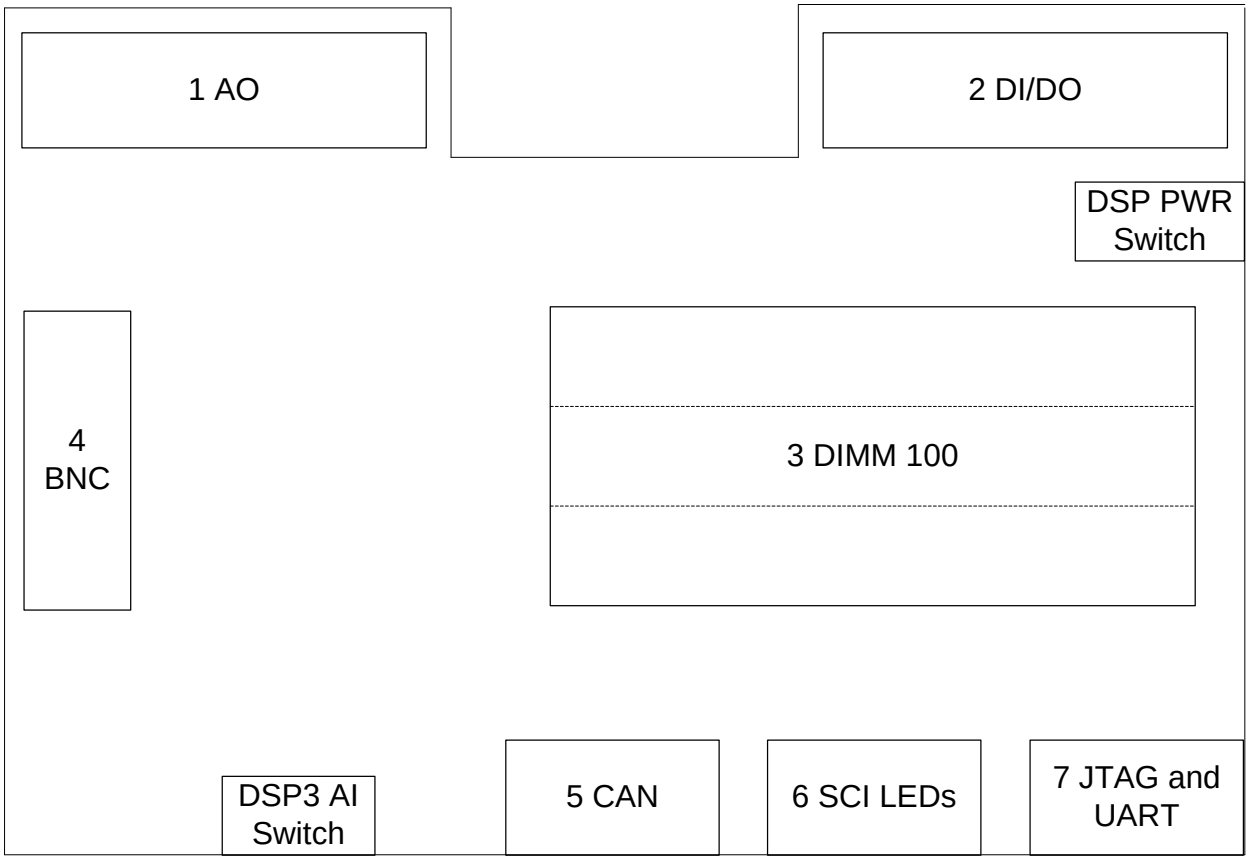

Figure 4.1 – uGrid DSP Interface block layout

4.1 Analog signal connector

This is a 96 pin DIN 41612/IEC receptacle connector that is directly pluggable into analog connector of the Typhoon HIL emulators. Switch DSP3 AI is an SPDT switch. It has 2 positions and is used to configure the distribution of HIL Analog Outputs on DIMM socket number 3. When it is in position marked as "HIL AO 1-16" outputs from 1 to 16 are connected to DIMM socket number 3. When it is in position marked as "HIL AO 17-32"outputs from 17 to 32 are connected to DIMM socket number 3. Table 1 shows how 16 analog output signals from HIL600 emulator are connected to 3 DIMM100 (DSPs).Table 2 shows how 32 analog output signals from HIL602 emulator can be connected to 3 DIMM100 (DSPs). Default position of DSP3 AI switch is "HIL AO 1-16".

HIL Analog Outputs are scaled onboard from ±5V to DSP's ADCIN 0-3V. For example: HIL AO of 0V is seen as 1.5V at DSP ADCIN, HIL AO of +5V is seen as 3V at DSP ADCIN, HIL AO of -5V is seen as 0V at DSP ADCIN.

Table 1: Analog signals routing table for HIL600, DSP3 AI in position "HIL AO 1-16"

Typhoon HIL600 Analog Output	DSP1 Analog Input	DSP2 Analog Input	DSP3 Analog Input
AO1	ADCIN – A0	ADCIN – A0	ADCIN – A0
AO2	ADCIN – A1	ADCIN – A1	ADCIN – A1
AO3	ADCIN – A2	ADCIN – A2	ADCIN – A2
AO4	ADCIN – A3	ADCIN – A3	ADCIN – A3
AO5	ADCIN – A4	ADCIN – A4	ADCIN – A4
AO6	ADCIN – A5	ADCIN – A5	ADCIN – A5
AO7	ADCIN – A6	ADCIN – A6	ADCIN – A6
AO8	ADCIN – A7	ADCIN – A7	ADCIN – A7
AO9	ADCIN – B0	ADCIN – B0	ADCIN – B0
AO10	ADCIN – B1	ADCIN – B1	ADCIN – B1
AO11	ADCIN – B2	ADCIN – B2	ADCIN – B2
AO12	ADCIN – B3	ADCIN – B3	ADCIN – B3
AO13	ADCIN – B4	ADCIN – B4	ADCIN – B4
AO14	ADCIN – B5	ADCIN – B5	ADCIN – B5
AO15	ADCIN – B6	ADCIN – B6	ADCIN – B6
AO16	ADCIN – B7	ADCIN – B7	ADCIN – B7

Table 2: Analog signals routing table for HIL602, DSP3 AI in position "HIL AO 17-32"

Typhoon HIL 602 Analog Output	DSP1 Analog Input	DSP2 Analog Input	DSP3 Analog Input
AO1	ADCIN – A0	ADCIN – A0	**NC**
AO2	ADCIN – A1	ADCIN – A1	**NC**
AO3	ADCIN – A2	ADCIN – A2	**NC**
AO4	ADCIN – A3	ADCIN – A3	**NC**
AO5	ADCIN – A4	ADCIN – A4	**NC**
AO6	ADCIN – A5	ADCIN – A5	**NC**
AO7	ADCIN – A6	ADCIN – A6	**NC**
AO8	ADCIN – A7	ADCIN – A7	**NC**
AO9	ADCIN – B0	ADCIN – B0	**NC**
AO10	ADCIN – B1	ADCIN – B1	**NC**
AO11	ADCIN – B2	ADCIN – B2	**NC**
AO12	ADCIN – B3	ADCIN – B3	**NC**
AO13	ADCIN – B4	ADCIN – B4	**NC**
AO14	ADCIN – B5	ADCIN – B5	**NC**
AO15	ADCIN – B6	ADCIN – B6	**NC**
AO16	ADCIN – B7	ADCIN – B7	**NC**
AO17	**NC**	**NC**	ADCIN – A0
AO18	**NC**	**NC**	ADCIN – A1
AO19	**NC**	**NC**	ADCIN – A2
AO20	**NC**	**NC**	ADCIN – A3
AO21	**NC**	**NC**	ADCIN – A4
AO22	**NC**	**NC**	ADCIN – A5
AO23	**NC**	**NC**	ADCIN – A6
AO24	**NC**	**NC**	ADCIN – A7
AO25	**NC**	**NC**	ADCIN – B0
AO26	**NC**	**NC**	ADCIN – B1
AO27	**NC**	**NC**	ADCIN – B2
AO28	**NC**	**NC**	ADCIN – B3
AO29	**NC**	**NC**	ADCIN – B4
AO30	**NC**	**NC**	ADCIN – B5
AO31	**NC**	**NC**	ADCIN – B6
AO32	**NC**	**NC**	ADCIN – B7

4.2 Digital signal connector

This is a 96 pin DIN 41612/IEC receptacle connector that is directly pluggable into digital connector of the Typhoon HIL emulators. Table 3 shows how the digital signals from HIL emulator are routed to the 3 DIMM100 (DSPs).When socket 2 is not populated, socket 3 digital output pin count towards HIL digital inputs is increased by 6 lines. In that case, sockets 1 and 3 have the same number of dedicated HIL digital inputs: 12 PWMs and 2 GPIOs each. Each DSP is represented in color: DSP1 - red, DSP2 - green, DSP3 - purple.

Table 3: Digital signals routing table

Typhoon HIL Digital Output	DSP Digital Input	Typhoon HIL Digital Input	DSP Digital Output	DSP1 and DSP3 Digital Output
DO32	GPIO-24 / EQEPA-2	DI32	GPIO-00/EPWM-1A	GPIO-00/EPWM-1A
DO31	GPIO-25 / EQEPB-2	DI31	GPIO-02/EPWM-2A	GPIO-02/EPWM-2A
DO30	GPIO-26 / EQEPI-2	DI30	GPIO-04/EPWM-3A	GPIO-04/EPWM-3A
DO29	GPIO-14	DI29	GPIO-06/EPWM-4A	GPIO-06/EPWM-4A
DO28	GPIO-15	DI28	GPIO-08/EPWM-5A	GPIO-08/EPWM-5A
DO27	GPIO-16	DI27	GPIO-10/EPWM-6A	GPIO-10/EPWM-6A
DO26	GPIO-17	DI26	GPIO-01/EPWM-1B	GPIO-01/EPWM-1B
DO25	GPIO-19	DI25	GPIO-03/EPWM-2B	GPIO-03/EPWM-2B
DO24	GPIO-20	DI24	GPIO-05/EPWM-3B	GPIO-05/EPWM-3B
DO23	GPIO-21	DI23	GPIO-07/EPWM-4B	GPIO-07/EPWM-4B
DO22	GPIO-22	DI22	GPIO-09/EPWM-5B	GPIO-09/EPWM-5B
DO21	GPIO-23	DI21	GPIO-11/EPWM-6B	GPIO-11/EPWM-6B
DO20	GPIO-24 / EQEPA-2	DI20	GPIO-12/EPWM-7A*	GPIO-12/EPWM-7A*
DO19	GPIO-25 / EQEPB-2	DI19	GPIO-13/EPWM-7B*	GPIO-13/EPWM-7B*
DO18	GPIO-26 / EQEPI-2	DI18	GPIO-00 / EPWM-1A	GPIO-12/EPWM-7A*
DO17	GPIO-14	DI17	GPIO-02 / EPWM-2A	GPIO-13/EPWM-7B*
DO16	GPIO-15	DI16	GPIO-04 / EPWM-3A	GPIO-08/EPWM-5A
DO15	GPIO-16	DI15	GPIO-06 / EPWM-4A	GPIO-10/EPWM-6A
DO14	GPIO-17	DI14	GPIO-08 / EPWM-5A	GPIO-09/EPWM-5B
DO13	GPIO-19	DI13	GPIO-01 / EPWM-1B	GPIO-11/EPWM-6B
DO12	GPIO-20	DI12	GPIO-03 / EPWM-2B	**NC**
DO11	GPIO-21	DI11	GPIO-05 / EPWM-3B	**NC**
DO10	GPIO-24 / EQEPA-2	DI10	GPIO-07 / EPWM-4B	**NC**
DO9	GPIO-25 / EQEPB-2	DI9	GPIO-09 / EPWM-5B	**NC**
DO8	GPIO-26 / EQEPI-2	DI8	GPIO-00 / EPWM-1A	GPIO-00 / EPWM-1A
DO7	GPIO-14	DI7	GPIO-02 / EPWM-2A	GPIO-02 / EPWM-2A
DO6	GPIO-15	DI6	GPIO-04 / EPWM-3A	GPIO-04 / EPWM-3A
DO5	GPIO-16	DI5	GPIO-06 / EPWM-4A	GPIO-06 / EPWM-4A
DO4	GPIO-17	DI4	GPIO-01 / EPWM-1B	GPIO-01 / EPWM-1B
DO3	GPIO-19	DI3	GPIO-03 / EPWM-2B	GPIO-03 / EPWM-2B
DO2	GPIO-20	DI2	GPIO-05 / EPWM-3B	GPIO-05 / EPWM-3B
DO1	GPIO-21	DI1	GPIO-07 / EPWM-4B	GPIO-07 / EPWM-4B

* EPWM available on F28377 depending on SW1, SW2, SW3 and SW4 on Adapter board.

4.3 3 DIMM100 control card sockets

DIMM100 connector is a standardized connector for Texas Instruments control cards. DIMM180 control cards can also be inserted in DIMM100 socket with Adapter board card supplied by Texas Instruments (http://www.ti.com/tool/tmdsadap180to100). DSP PWR switch is controlling the 5V power supply for control cards.

Some of uGrid DSP Interface supported TI Control Cards:

- Delfino F28335 Control Card
- Delfino F28377D 180 pin Control Card
- Piccolo F28035 Control Card
- Piccolo F28069 Control Card

Other control cards are also supported, but it is recommended to check the pin assignment for every card. There are slight differences between cards in the sense that some of the signal pins do not exist on every control card. Texas Instruments 100 pin Control Card is shown in Figure 4.2.

Figure 4.2 - TI 100 pin Control Card

4.4 BNCs

BNCs are connected to HIL analog outputs 1 to 4. BNCs provide an easy way to connect an oscilloscope for measurement and observation purposes. BNC connectors are shown in Figure 4.3.

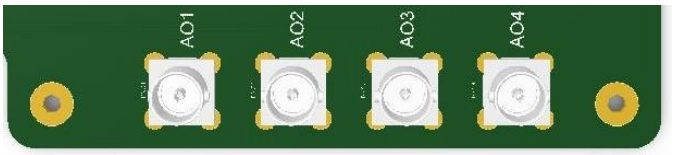

Figure 4.3 - BNC connectors

4.5 CAN bus

Communication between DSPs is achieved by 3.3V CAN bus as shown in Figure 4.4. For this purpose CAN-A module of each DSP is used (GPIO-30/CANRX-A and GPIO-31/CANTX-A) and connected to 3.3V CAN bus trans-receiver, SN65HVD232D from Texas Instruments. CAN bus is terminated with two 120Ω resistors. RJ45 connector is an option for adding more external devices onto a CAN bus or connecting to external CAN bus. CAN connector routing table is shown in Table 4. If external 3.3V CAN bus is connected to uGrid DSP Interface CAN bus then care must be taken to remove the redundant terminating resistors on both buses. On uGrid DSP Interface CAN bus this is done by removing RSC2 (0Ω) resistor.

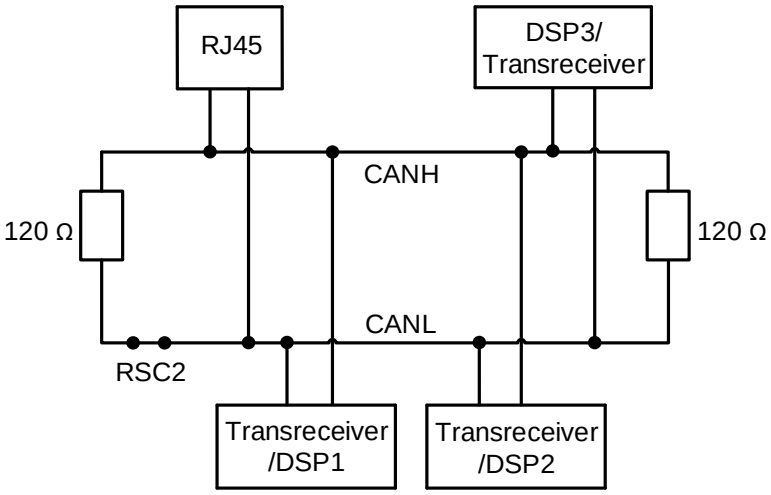

Figure 4.4 - CAN bus

Table 4: CAN bus connector routing table

RJ45 pins	CAN signals
1	CAN_H
2	CAN_L
3, 7, Shield	GND

4.6 SCI LEDs

There are 3sets of LEDs, one set for every DSP's SCI port. Each set has its RX and TX LED. RX LED blinks when DSP is receiving data via SCI port, TX LED blinks when DSP is transmitting data over SCI port. LED section is shown in Figure 4.5.

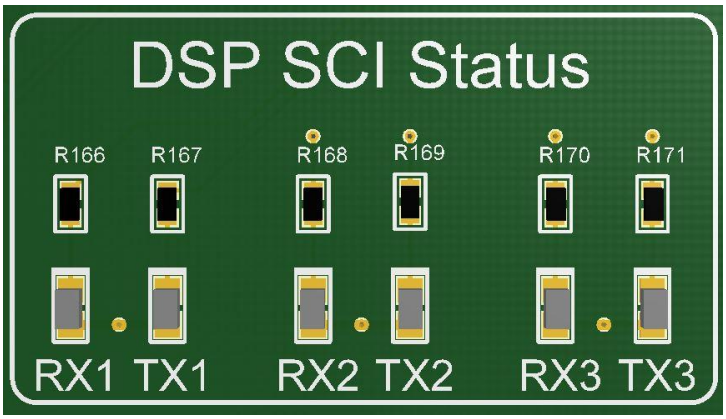

Figure 4.5 – SCI LEDs

4.7 XDS100v1 and UARTs

Onboard XDS100v1 emulator and 3 UARTs are all implemented via FTDI chip. Drivers for XDS100v1 are included in Code Composer Studio, UniFlash, or XDS Emulation Software Package (http://processors.wiki.ti.com/index.php/XDS_Emulation_Software_Package). FTDI drivers can be found as VCP (Virtual Communication Port) drivers on official FTDI website (http://www.ftdichip.com/FTDrivers.htm). It is not recommended to use any USB Hub devices on the way towards PC. DSP PWR switch is controlling 3.3V and 5V power supply for XDS100v1 and UART ports. USB interface structure is shown in Figure 4.6. Onboard USB is connected to PC via USB mini B cable. 14 pin JTAG connector can be used for external emulator. 14 pin JTAG header signals are shown in Figure 4.7. EMU0 and EMU1 pins are not connected to onboard XDS100v1 emulator; they are routed directly from JTAG connector to DSPs. All other JTAG signals are connected to onboard XDS100v1 and buffered. UART ports are connected to TI Control Card pins 2 and 52 (ISO-RX-RS232 and ISO-TX-RS232).

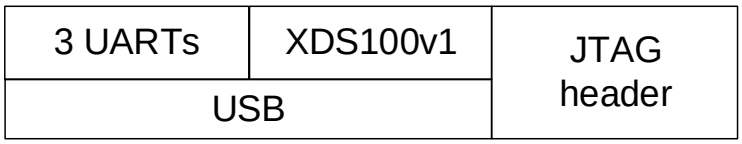

Figure 4.6 - USB interface structure

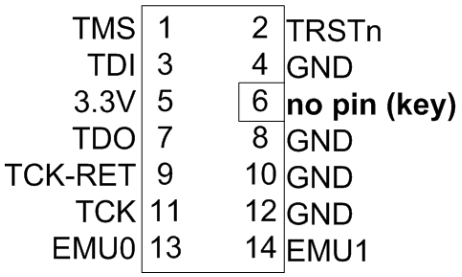

Figure 4.7 - 14 pin JTAG header signals

XDS100v1 works in a daisy chain configuration formed by TI Control Cards inserted in DIMM100 sockets. Simplified representation of implemented daisy chain is shown in Figure 4.8. Not all 3 control cards need to be inserted, single or dual card configuration is also valid. Corresponding Target Configuration file needs to be set in Code Composer Studio.

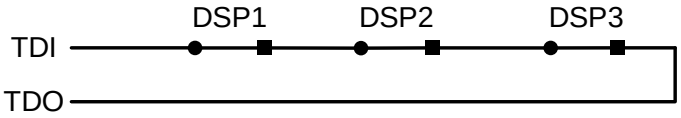

Figure 4.8 – XDS100v1 daisy chain configuration with 3 control cards

5 Product Images

3D model and picture of uGrid DSP Interface are shown in Figure 5.1 and Figure 5.2.

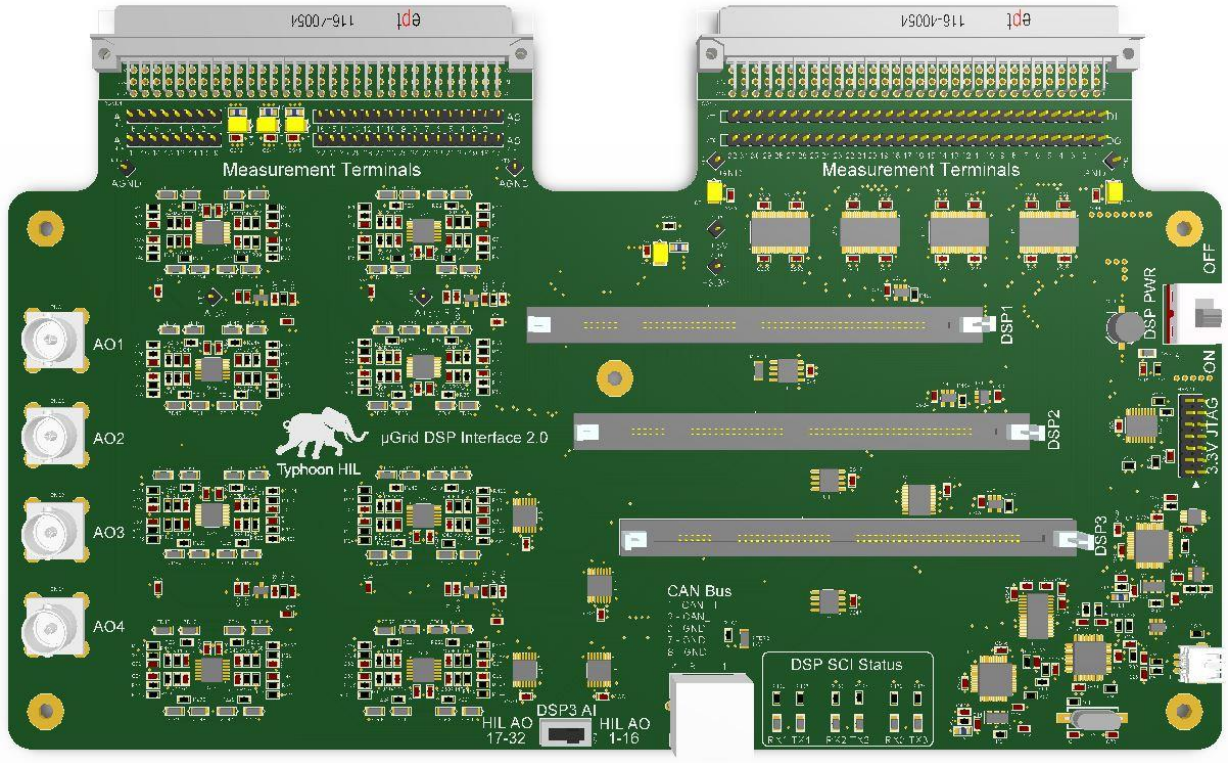

Figure 5.1 - 3D model of uGrid DSP Interface

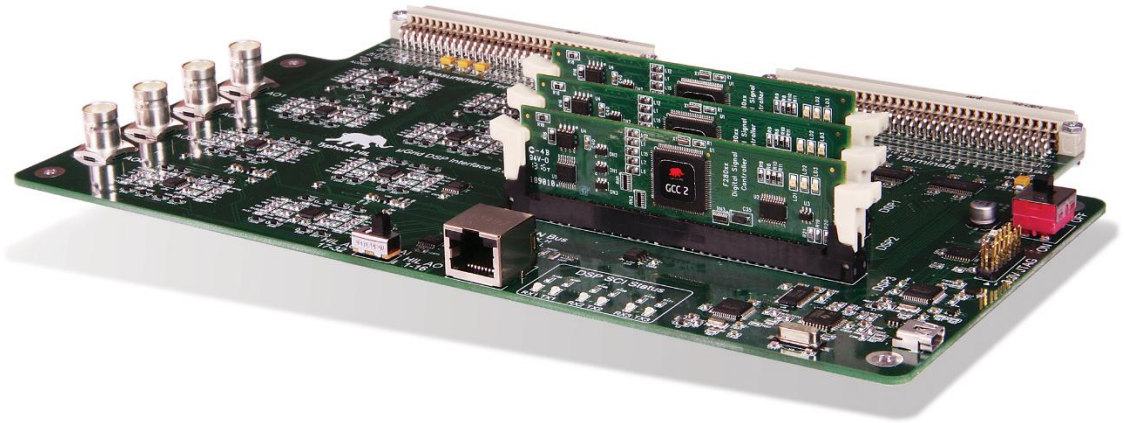

Figure 5.2 - uGrid DSP Interface

6 Errata

Issue: Reference voltage ICs (U1, U8, U9, U22) of 1.5V (used for scaling HIL AO to DSP ADC IN) have low sink/source current capability, causing the 1.5V reference to be unstable when majority of HIL AOs are relatively high/low or have a square form.

Affected boards: Revision 1.0 and 2.0.

Workaround:
In software, set the unused HIL AOs in a way that provides additional sink/source current or set the scaling of unused HIL AOs to very high value. In hardware, contact Typhoon HIL for instructions.

7 Revision history

Date	Version	Revision
03-03-2015	1.0	Initial release.
10-10-2015	1.1	1.5V reference errata added.