Innovative Thinking for Power, Control and Instrumentation

OZDSP3000
TMS320F28335 Control Board
User's Manual
UM-0018

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1. Introduction

This document is intended to provide instruction on how to employ the Oztek OZDSP3000 controller in a power converter hardware system. It describes the electrical connections and interface details.

1.1 Referenced Documents

Ref.	Document	Description
[1]	FS-0044	OZDSP3000 FPGA Functional Specification
[2]	UM-0015	Oztek TMS28x CAN Bootloader Users Manual
[3]	UM-0019	OZDSP3000 Teat Application User's Manual
[4]	*SPRS439*	*Texas Instruments: TMS320F28335, TMS320F28334, TMS320F28332, TMS320F28235, TMS320F28234, TMS320F28232 DSCs*

1.2 Definitions

AFE	Active Front End
CAN	Controller Area Network
DSP	Digital signal processor
EEPROM	Electrically Erasable Programmable Read Only Memory
EMC	Electro-magnetic compatibility
EMI	Electro-magnetic interference
GND	Ground, low side of input power supply
GTI	Grid Tied Inverter
GUI	Graphical User Interface
HMI	Human Machine Interface
IPM	Intelligent Power Module
N.C.	Not connected
PCB	Printed Circuit Board
PCC	Power Control Center
PLC	Programmable Logic Controller
PLL	Phase Locked Loop
POR	Power On Reset
PWM	Pulse width modulation
SVM	Space Vector Modulator

2. Functional Description

The OZDSP3000 is a highly integrated DSP control solution for power control applications. Based on the Texas Instruments 150MHz, TI TMS320F28335 Digital Signal Processor, the controller offers the state of the art in digital control capability. Interface circuitry is provided for the following peripherals as illustrated in Figure 1:

- RS232/485/422 Communications Port
- CAN Bus Communications Port
- Incremental Encoder Interface
- Hall Effect Position Sensor Interface
- 4 Relay Drivers
- Real Time of Day Clock
- Quad 8-Bit Debug DAC
- Network Analyzer Input
- 3 EEPROMs (16kB boot, 8kB parameter storage, 128kB data logging)
- 256kB SRAM
- 4 OptoIsolated Inputs
- 4 OptoIsolated Outputs
- 3 LEM Current Sensor Interfaces
- 3 Auxiliary Thermistor Interfaces
- 2 Semikron Three Phase Power Module Interfaces
- 1 Semikron Half Bridge or Brake Interface
- Isolated High Voltage Line Sensing
- Isolated High Voltage Output Sensing
- Anybus Communications Module Support
- Oztek Expansion Support
- JTAG Debug Interface

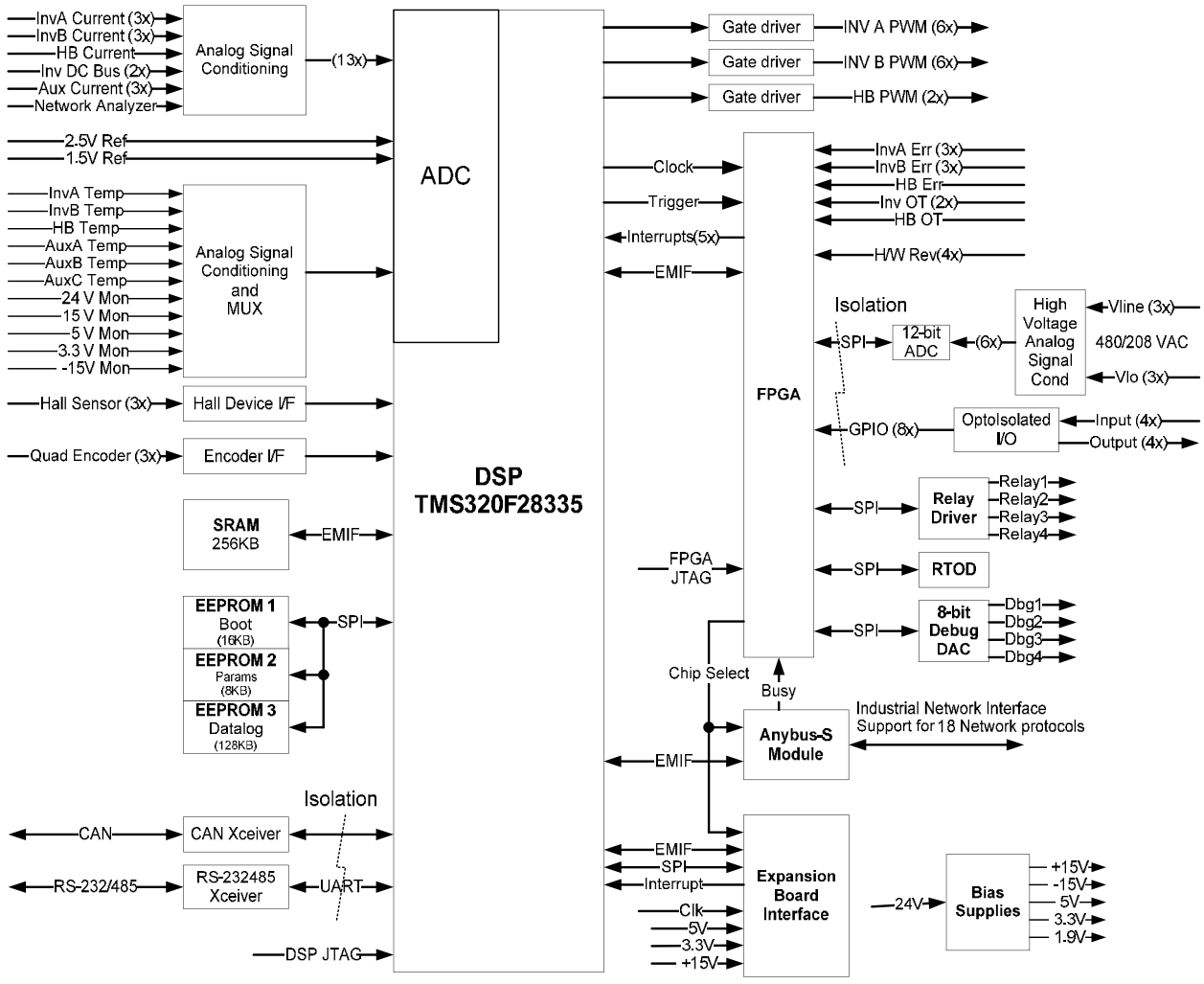


Figure 1 – OZDSP3000 Block Diagram

Typical applications include voltage output inverters, grid-tie inverters, AC induction motor controllers, brushless DC motor controllers, Active Front-End regulators and high power DC/DC converters.

3. Environmental Specifications

3.1 Operating Temperature

The OZDSP3000 is specified for operation within the temperature range of -40°C to +85°C.

3.2 Storage Temperature

The OZDSP3000 is specified for unpowered storage within the temperature range of -40°C to +85°C.

4. Hardware Interface

4.1 Electrical Interfaces

The approximate location of the connectors, jumper blocks, LEDs, and test hooks are illustrated in Figure 2.

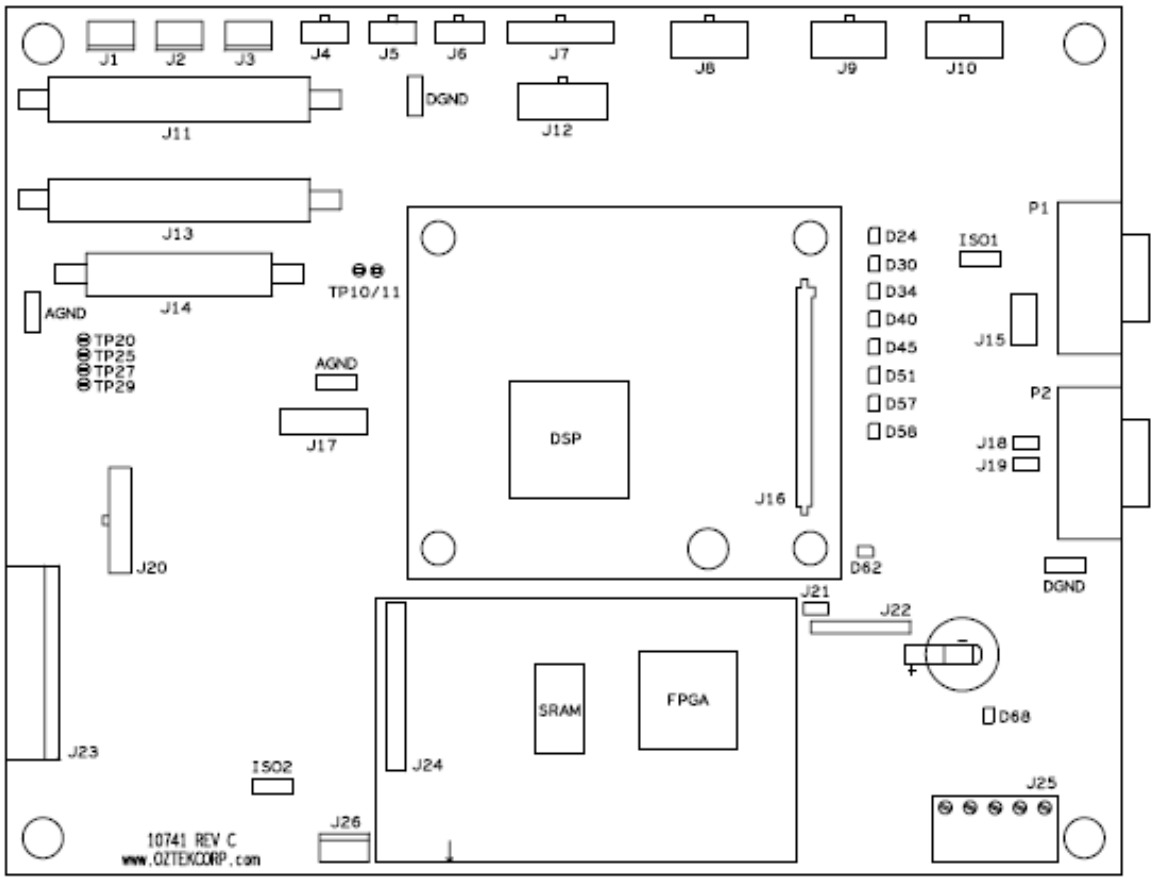


Figure 2 – Approximate Connector, Jumper, LED, and Test Hook Locations

Table 1 – Connector Descriptions

Connector	Description
J1	Auxiliary LEM current sensor, Phase U
J2	Auxiliary LEM current sensor, Phase V
J3	Auxiliary LEM current sensor, Phase W
J4	Auxiliary thermistor A Interface
J5	Auxiliary thermistor B Interface
J6	Auxiliary thermistor C Interface
J7	Hall Sensor Interface
J8	Relay Driver Outputs
J9	Isolated Digital Inputs
J10	Isolated Digital Outputs
J11	Inverter A Power Module (SKiiP/SKAI)
J12	Encoder Interface
J13	Inverter B Power Module (SKiiP/SKAI)
J14	Half Bridge/Brake Module (SKiiP)
J16	Oztek Expansion Board Connector
J17	DSP JTAG Port
J20	Isolated Voltage Sense Inputs
J22	FPGA JTAG Port
J23	High Voltage Line Sense Inputs
J24	Anybus Connector
J25	24V Input Power/SPI Boot Enable
J26	Anybus Firmware Programming Interface
P1	RS232/RS485/RS422 Interface
P2	CAN Interface

Table 2 – Configuration Jumper Descriptions

Jumper	Description
J15	Serial Port Configuration Block
J18	CAN Termination Enable
J19	CAN Termination Enable
J21	Watchdog Disable

Table 3 – LED Descriptions

LED	Color	Description
D30	Green	Debug Spare 0
D34	Green	Debug Spare 1
D40	Green	Debug Spare 2
D45	Green	Debug Spare 3
D51	Red	Inverter A Fault

LED	Color	Description
D57	Red	Inverter B Fault
D58	Red	Half Bridge Fault
D24	Red	System Fault
D62	Red	Reset
D68	Green	24V Power Present

Table 4 – Test Hook Descriptions

Test Hook	Description
TP15, TP28	Analog Ground
TP1, TP47	Digital Ground
TP6	Isolated Communications Ground
TP59	Isolated HVADC Ground
TP10	Network Analyzer Input
TP11	Network Analyzer Return
TP20	DAC D Output
TP25	DAC C Output
TP27	DAC B Output
TP29	DAC A Output

4.1.1 J1/J2/J3: Auxiliary LEM Current Sensor Interfaces

Connectors J1, J2, and J3 provide interfaces to auxiliary LEM current sensors. +/-15V power is provided to the sensor. The LEM current transducer HAS series is recommended for use with this interface.

Table 5 – J1/2/3 Aux LEM Sensor Pin Assignment

Pin #	Description
1	+15V
2	-15V
3	Signal
4	Signal Return

- **OZDSP3000 Connector Part Number:** (Waldom/Molex) 22-04-1041
- **Mating Connector Part Number:** (Waldom/Molex) 22-01-1042
- **Input Range:** +/- 4V (see Section 5.1 for ADC scaling details)

4.1.2 J4/5/6: Auxillary Temperature Inputs

Connectors J4, J5, and J6 provide interfaces to external temperature sensors for monitoring purposes (such as a cabinet's internal ambient temperature). These interfaces are designed for a typical 10kΩ thermistor.

Table 6 – J4/5/6 Auxillary Temperature Input Pin Assignment

Pin #	Description
1	Temperature input (pulled up to +3.0V through 2kΩ).
2	Ground (24V Return)

- **OZDSP3000 Connector Part Number:** (Molex) Micro-Fit 2 Position Header: 43650-0215
- **Mating Connector Part Number:** (Molex) Micro-Fit 2 Position Receptacle: 43645-0200
- **Input Range:** 0Ω to open circuit

4.1.3 J7: Hall Effect Sensor Interface

Connector J7 provides an interface for three Hall Effect position sensors. Both 5V and 15V power options are available to power the sensors. **Error! Reference source not found.** provides the physical and electrical pinout of the connector.

Table 7 – J7 Hall Sensor Pin Assignment

Pin #	Description
1	+5V
2	+15V
3	Ground
4	Hall 1 Input
5	Hall 2 Input
6	Hall 3 Input

- **OZDSP3000 Connector Part Number:** (Molex) Micro-Fit 6 Header: 43650-0615
- **Mating Connector Part Number:** (Molex) Micro-Fit 6 Receptacle: 43645-0600
- **Power:** 5V @300mA, 15V @300mA
- **Electrical Interface (HALL1,2,3):** 4.75kΩ pull up to 15V. Use with an open collector output that can sink at least 3mA.
- **Input Behavior:** When Hall is enabled and sinking current, HALL input is in low state, while corresponding DSP pin HALLn is in a high state.

4.1.4 J8: Relay Driver Interface

Connector J8 provides an interface to the four relay driver outputs.

Table 8 – J8 Relay Drive Pin Assignment

Pin #	Description
1	Relay Drive 3
2	Relay Drive 2

Pin #	Description
3	Relay Drive 1
4	Relay Drive 0
5	Ground
6	Ground
7	Ground
8	Ground

- **OZDSP3000 Connector Part Number:** (Molex) Micro-Fit 2x4 Header: 43045-0824
- **Mating Connector Part Number:** (Molex) Micro-Fit 2x4 Receptacle: 43025-0800
- **Output Range:** 24V, 2A continuous, 5A inrush

Please note that when using the relay driver with one or more unused drivers one of the following schemes must be used to deal with the open-load fault detection in the driver IC:

1. Since the open-load faults are only reported once per state, initialize all relays to 'off' twice: once to set them to 'off' and obtain the faults, and the second time to clear the faults. Then open-load faults will only be reported when the state is changed of a specific relay driver, so as long as the unused relays drivers are left 'off', no new faults will be reported.
2. Since the open-load faults are only reported in a low state, initialize the unused drivers to 'on', and subsequently leave them on. Please note that the unused driver pins will be at a 24V state.
3. Terminate the unused relay drivers with a 5kΩ – 20kΩ 1/8 watt resistor.

4.1.5 J9: Isolated Digital Inputs

Connector J9 provides an interface to the four opto-isolated, digital inputs.

Table 9 – J9 Isolated Digital Input Pin Assignment

Pin #	Description
1	Input 0
2	Input 1
3	Input 2
4	Input 3
5	Input 0 Return
6	Input 1 Return
7	Input 2 Return
8	Input 3 Return

- **OZDSP3000 Connector Part Number:** (Molex) Micro-Fit 2x4 Header: 43045-0824
- **Mating Connector Part Number:** (Molex) Micro-Fit 2x4 Receptacle: 43025-0800

- **Input Range:** Logic high: 0V or floating. Logic low: 3V – 25V

4.1.6 J10: Isolated Digital Outputs

Connector J10 provides an interface to the isolated digital outputs.

Table 10 – J10 Isolated Digital Output Pin Assignment

Pin #	Description
1	Output 0 Emitter
2	Output 1 Emitter
3	Output 2 Emitter
4	Output 3 Emitter
5	Output 0 Collector
6	Output 1 Collector
7	Output 2 Collector
8	Output 3 Collector

- **OZDSP3000 Connector Part Number:** (Molex) Micro-Fit 2x4 Header: 43045-0824
- **Mating Connector Part Number:** (Molex) Micro-Fit 2x4 Receptacle: 43025-0800
- **Output Range:** Open collector. Logic high: open, 40V max. Logic low: sinks 50mA max.

4.1.7 J11/13: SKiiP Power Module Interface

Connector J11 and J13 provide interfaces to SKiiP style Semikron power modules. This interface complies with Semikron's required specifications. The OZDSP3000 supplies 24V power to the power module via pins 14 and 15. PWM commands (15V logic level) are supplied to the top and bottom switches of each of the three half bridges via signals INV_TOP_U(V,W) and INV_BOT_U(V,W) respectively. Feedback of phase currents, temperature, and DC link voltage are provided on INV_IOUT_U(V,W), INV_TEMP, INV_UDC signals respectively. Error signals from the module are similarly provided via INV_ERR_U(V,W) and INV_OVT. Please refer to the Semikron datasheet for the particular module being used for more information.

Table 11 – J11/13 SKiiP Power Module Pin Assignment

Pin #	Description
1	Ground
2	INV_BOT_U (Phase A)
3	INV_ERR_U (Phase A)
4	INV_TOP_U (Phase A)
5	INV_BOT_V (Phase B)
6	INV_ERR_V (Phase B)
7	INV_TOP_V (Phase B)
8	INV_BOT_W (Phase C)
9	IN_ERR_W (Phase C)

Pin #	Description
10	INV_TOP_W (Phase C)
11	INV_OVR_TEMP
12	n/c
13	INV_UDC
14	24V
15	24V
16	n/c
17	n/c
18	Ground
19	Ground
20	INV_TEMP
21	INV_IOUT_U_RTN (Phase A)
22	INV_IOUT_U (Phase A)
23	INV_IOUT_V_RTN (Phase B)
24	INV_IOUT_V (Phase B)
25	INV_IOUT_W_RTN (Phase C)
26	INV_IOUT_W (Phase C)

- **OZDSP3000 Connector Part Number:** (AMP) 499922-6
- **Mating Connector Part Number:** (AMP) 1658621-6
- **Power:** 24V @ 1.5A

4.1.8 Custom Driver Interface Considerations

When attempting to use the OZDSP3000 controller with a custom designed power stage the hardware must be designed to provide the appropriate signals expected at the J11 and/or J13 interface. Generally some sort of custom printed circuit board will be required to interface the J11/J13 signals to the gate drivers, current sensors, etc.

4.1.8.1 Power

The OZDSP3000 supplies 24V on J11/13, pins 14 & 15. This 24Vmay be used to power the electronics on the interface board. The supply is capable of providing 1.5A.

4.1.8.2 Switch Commands

The six switching commands are provided on pins 2, 4, 5, 7, 8, and 10. These switch command signals are driven off of the OZDSP3000 at 15V logic level using MC14504B level shifting devices.

4.1.8.3 Error Inputs

The OZDSP3000 expects three logic level, error inputs; one associated with each phase, on pins 3, 6, and 9. Pull-ups to 3.3V are provided on board and the signals are active high. Depending

on the features provided in the custom design, these signals can be used to interface single error sources, multiple protection circuits, or none at all.

The custom interface board should drive the pin with an open-collector style circuit. In the case where no protection is provided, the pins should be grounded to disable the faults.

4.1.8.4 DC Link Voltage Sensing

The OZDSP3000 expects a signal proportional to DC link voltage to be provided on J11/13, pin 13 with respect to pins 18 and 19. This signal should be scaled such that 0-10 V represents the measurable DC link voltage range.

4.1.8.5 DC Link Hardware Over-Voltage Protection

When designing a custom interface it is highly recommended that hardware over voltage protection be implemented. This can be implemented with a comparator using the DC link voltage sense output. The output of this comparator can be used to gate off the switch commands as well as assert the Error inputs on each phase.

4.1.8.6 Hardware Over-Current and Desaturation Protection

Semikron SKiiP power modules provide fast hardware over current and desaturation protection. When designing a custom power solution, these additional protection features should also be considered. When including over current, desaturation, and over voltage protection into the design, the fault flags must be logically OR'd together and reported using the open collector Error signal inputs to the OZDSP3000.

4.1.8.7 Current Sense Signals

The OZDSP3000 expects to receive a current sense signal for each half bridge phase output. This should be a bipolar signal where +/-10V corresponds to the full scale current range. The current sense signals should be provided on the following pins:

Table 12 – J11 Current Sense Pin Assignment

J11 Pin #	Description
22	Current Phase A (U)
21	Gnd Reference for Current Phase A (U)
24	Current Phase B (V)
23	Gnd Reference for Current Phase B (V)
26	Current Phase C (W)
25	Gnd Reference for Current Phase C (W)

4.1.8.8 Temperature Sense Signals

The OZDSP3000 expects to receive a 0-10V temperature signal on pin 20 that corresponds to the hot spot temperature of the power devices.

4.1.9 J12: Incremental Encoder Interface

Connector J12 provides an interface to an incremental, quadrature encoder. The interface provides for the A and B quadrature signals as well as an index input. 5V power and ground are also provided on the connector to power the encoder.

Table 13 – J12 Encoder Interface Pin Assignment

Pin #	Description
1	5V
2	No connect
3	A Signal - Positve
4	B Signal - Positive
5	Index - Positive
6	No Connect
7	Ground
8	A Signal - Negative
9	B Signal - Negative
10	Index - Negative

- **OZDSP3000 Connector Part Number:** (Molex) Micro-Fit 2x5 Header: 43045-1012
- **Mating Connector Part Number:** (Molex) Micro-Fit 2x5 Receptacle: 43024-1000
- **Power:** 5V, 300mA
- **Differential termination:** 100Ω
- **Electrical Interface:** Differential inputs. Logic high: $V_{ID} \geq 0.2V$. Logic low: $V_{ID} \leq -0.2V$
- **Max Rating:** Input voltage: ±14V. Differential voltage: ±14V

4.1.10 J14: SKiiP Half Bridge/Brake Module Interface

Connector J14 provides an interface to SKiiP style Semikron half bridge and brake modules. This interface complies with Semikron's required specifications. The OZDSP3000 supplies 24V power to the power module via pins 6 and 7. PWM commands or brake enable/disable commands (15V logic level) are supplied to the top and bottom switches HB_TOP and HB_BOT respectively. Feedback of current and temperature are provided on HB_IOUT and HB_TEMP. Error signals from the module are similarly provided via HB_ERR and HB_OVT. Please refer to the Semikron datasheet for the particular module being used for more information.

Table 14 – J14 Half Bridge Pin Assignment

Pin #	Description
1	Ground
2	Bottom Switch Command
3	Error
4	Top Switch Command
5	Over Temp
6	24V
7	24V
8	No connect
9	No connect
10	Ground
11	Ground
12	Analog Temperature
13	Analog Current Return
14	Analog Current

- **OZDSP3000 Connector Part Number:** (AMP) 499922-2
- **Mating Connector Part Number:** (AMP) 1658621-2
- **Power:** 24V @ 1.5A

4.1.11 J16: Oztek Expansion Board Connector

Connector J16 allows an Oztek Expansion Board to be connected to the OZDSP3000.

Table 15 – J16 Expansion Interface Pin Assignment

Pin #	Description
1	5V
2	5V
3	3.3V
4	3.3V
5	Ground
6	Buffered Clock
7	SPI SOMI
8	IRQn
9	SPI SIMO
10	SPI CSn
11	SPI CLK
12	EMIF CLK
13	Ground
14	Ground
15	A0
16	A1
17	A2
18	A3
19	Ground
20	Ground
21	A4
22	A5
23	A6
24	A7
25	D0
26	D1
27	Ground
28	Ground
29	D2
30	D3
31	D4
32	D5
33	D6
34	D7
35	Ground
36	Ground
37	D8
38	D9
39	D10
40	D11

Pin #	Description
41	D12
42	D13
43	Ground
44	Ground
45	D14
46	D15
47	RDn
48	WRn
49	EMIF CSn
50	RESETn
51	Ground
52	Ground
53	Spare 0
54	Spare 1
55	Spare 2
56	Spare 3
57	Spare 4
58	Spare 5
59	Ground
60	Ground
61	No Connect
62	No Connect
63	No Connect
64	No Connect
65	No Connect
66	No Connect
67	Ground
68	Ground
69	15V
70	15V

- **OZDSP3000 Connector Part Number:** (Samtec) SFM-135-02-S-D-LC
- **Mating Connector Part Number:** (Samtec) TFM-135-02-S-D-LC
- **Power:** 5V @ 300mA, 3.3V @ 300mA

4.1.12 J17: DSP JTAG Port

Connector J17 is the DSP JTAG programming port for the board. Pin 6 is cut to avoid the emulator pod being incorrectly connected. Emulator pods used to program the DSP are available through Spectrum Digital and Signum Systems. Figure 3 provides the physical and electrical pinout of the connector.

- **OZDSP3000 Connector Part:** Double row 0.1" vertical pin header, 2x7

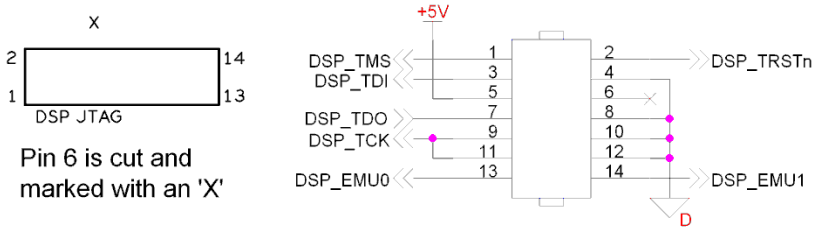


Figure 3 – J17: DSP JTAG Port Pinout

4.1.13 J20 Isolated Low Voltage Sense Inputs

Connector J20 is an isolated low voltage sense input.

Table 16 – J20 Isolated Low Voltage Pin Assignment

Pin #	Description
1	5V ISO
2	V Phase A
3	V Phase B
4	V Phase C
5	Neutral
6	ISO Ground

- **OZDSP3000 Connector Part Number:** (Molex) Micro-Fit 6 Header: 43650-0615
- **Mating Connector Part Number:** (Molex) Micro-Fit 6 Receptacle: 43645-0600

4.1.14 J22: FPGA JTAG Port

Connector J22 is the FPGA JTAG programming port. The OZDSP3000 comes preprogrammed with the latest firmware for the FPGA. Pin 5 is cut to avoid incorrectly connecting the FPGA programming cable. Figure 4 provides the physical and electrical pinout of the connector.

- **OZDSP3000 Connector Part:** Single row 0.1" vertical pin header, 1x8

Figure 4 – J22: FPGA JTAG Port Pinout

4.1.15 J23: High Voltage Line Feedback

J23 provides an interface to sense three phase AC line voltage. The standard hardware variant is designed to accept 480VAC voltages directly. Interfacing to other AC voltages may require a modification to the gain of the sense amplifier (consult Oztek for more information).

Table 17 – J23 High Voltage Sense Pin Assignment

Pin #	Description
1	Line Voltage Phase A
4	Line Voltage Phase B
7	Line Voltage Phase C
10	Neutral (*leave unconnected for 3-phase systems*)

- **OZDSP3000 Connector Part Number:** (Waldom/Molex) 26-60-4100
- **Mating Connector Part Number:** (Tyco) 4-644465-0

4.1.16 J24: Anybus Connector

Connector J24 allows an Anybus module to be connected to the OZDSP3000. Anybus is a high performance interchangeable slave interface supporting all major industrial networks. This interface complies with Anybus' required specifications. Please refer to the Anybus datasheet for the particular module being used for more information.

- **OZDSP3000 Connector Part Number:** (Sullins) PPN172AFCN-RC
- **Power:** 5V @ 500mA

4.1.17 J25: Bias Power Input

The OZDSP3000 requires 24VDC power input on terminal block J25. Note that Pin 3 is used for SPI boot enable; it should be left floating or connected to ground for normal Flash Boot operation.

Table 18 – J12 RS-485 Pin Assignment

Pin #	Description
1	24 VDC
2	24 VDC
3	SPI Boot Enable
4	24V Return
5	24V Return

- **OZDSP3000 Connector Part Number:** (Phoenix Contact) 1733606
- **Mating Connector Part Number:** n/a (terminal block style)

- **Voltage:** 24V nominal, 18V min, 28V max
- **Current:** 4.5A maximum (Inrush current while powering three SKiiP modules)

4.1.18 J26: Anybus Firmware Programming Interface

Connector J26 is used for Anybus firmware programming. This interface complies with Anybus' required specifications. Figure 5 provides the physical and electrical pinout of the connector.

- **OZDSP3000 Connector Part Number:** (Tyco) 640456-4
- **Mating Connector Part Number:** (Tyco) 3-640469-4 or similar 4POS .100 receptacle

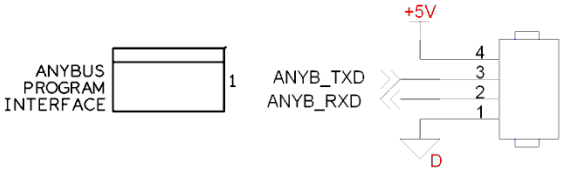


Figure 5 – J26: Anybus Firmware Programming Interface Pinout

4.1.19 P1: Isolated Serial Interface

Connector P1 provides an isolated, configurable, serial communications interface. Depending on the population variant of the OZDSP3000, this port may be configured one of two ways: RS232 mode, or RS422/485 mode. When in RS422/485 mode, jumper block J15 is used to configure the port. In RS232 mode J15 is not needed and all jumpers should be removed.

- **OZDSP3000 Connector Part Number:** (AMP) 747844-5
- **Mating Connector Part Number:** Industry Standard DB9 Male

4.1.19.1 RS232 Configuration

When supplied in the RS232 configuration, the RS232 transceiver device, U22, will be populated while the RS422/485 transceiver device, U42, will be unpopulated. In RS232 mode all jumpers should be removed from jumper block J15. Figure 6 illustrates the pinout of the connector in the RS232 configuration.

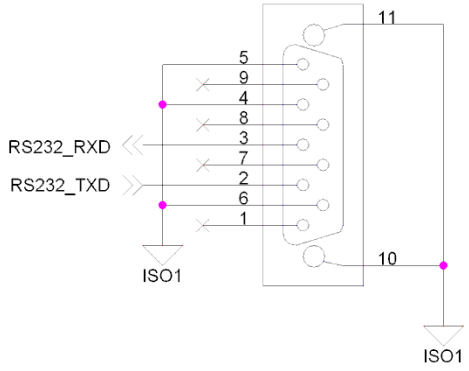


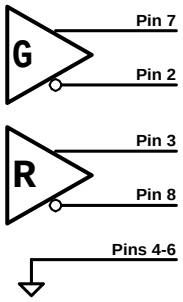
Figure 6 – P1: Isolated Serial Interface Pinout - RS232 Configuration

4.1.19.2 RS422/485 Configuration

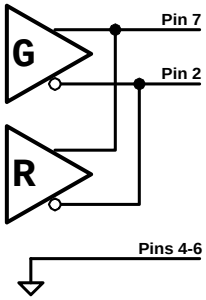
When supplied in the RS422/485 configuration, the RS422/485 transceiver device, U42, will be populated while the RS232 transceiver device, U22, will be unpopulated. In RS422/485 mode jumper block J15 is used to select between the two protocols and configure termination if desired as detailed in Table 19. Figure 7 illustrates the pinout of the connector in the RS422/485 configuration.

Table 19 – J15 RS422/485 Configuration Jumper Settings

Mode	Jumper 1-2	Jumper 3-4	Jumper 5-6	Jumper 7-8
RS422	TX Termination	RX Termination	DNP	DNP
RS485 Four-Wire	TX Termination	RX Termination	DNP	DNP
RS485 Two-Wire	Termination	DNP	Connect TX to RX	Connect TX to RX



RS422 and RS485 Four-Wire



RS485 Two-Wire

Figure 7 – P1: Isolated Serial Interface Pinout - RS422/485 Configuration

4.1.20 P2: Isolated CAN Bus Interface

Connector P2 provides an isolated CAN Bus communications interface. The interface is a shielded, female, DB9 style connector.

Table 20 – P2 CAN Bus Pin Assignment

Pin #	Description
2	CAN Low
3	CAN Ground (Isolated)
7	CAN High

- **OZDSP3000 Connector Part Number:** (AMP) 747844-5
- **Mating Connector Part Number:** Industry Standard DB9 Male

4.1.20.1 J18/19 CAN Termination Jumpers

Jumper blocks J18 and J19 provide a means to terminate the CAN bus lines CAN high (CANH) and CAN low (CANL). Note that termination should only be placed at the end terminals of the CAN communication network, reference Figure 8.

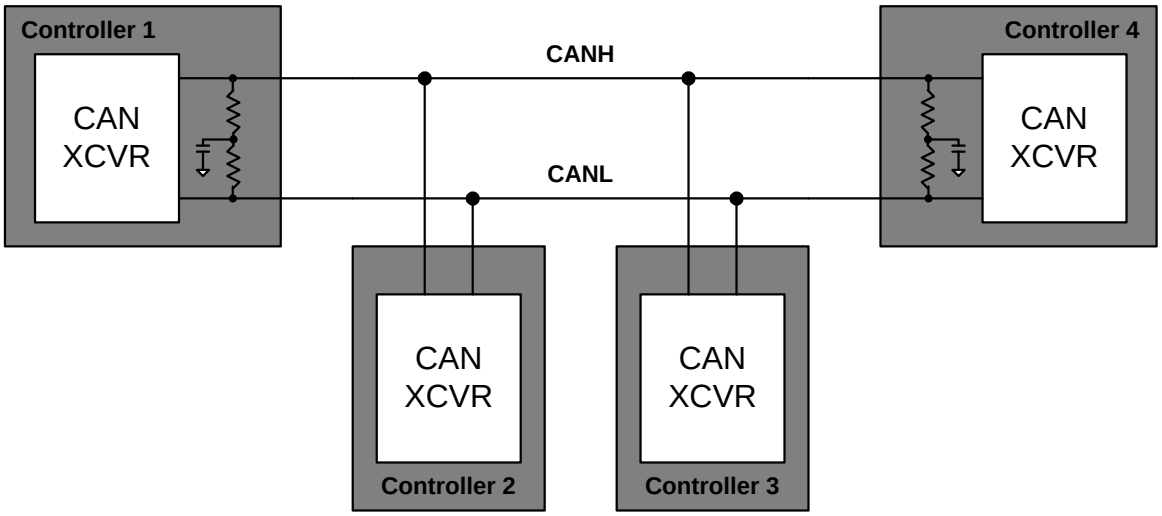


Figure 8 – Multi-Node CAN Network Configuration

Standard 0.1" jumpers should be installed on both J18 and J19 to enable the termination. With no jumpers installed, the lines remain un-terminated. Refer to Figure 9 for the applicable interface circuit.

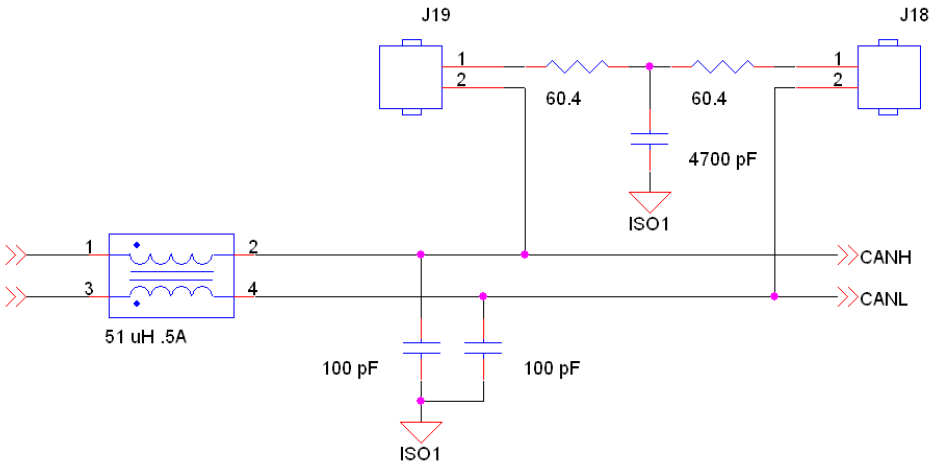


Figure 9 – CAN Interface Circuit

4.2 Mechanical Interface

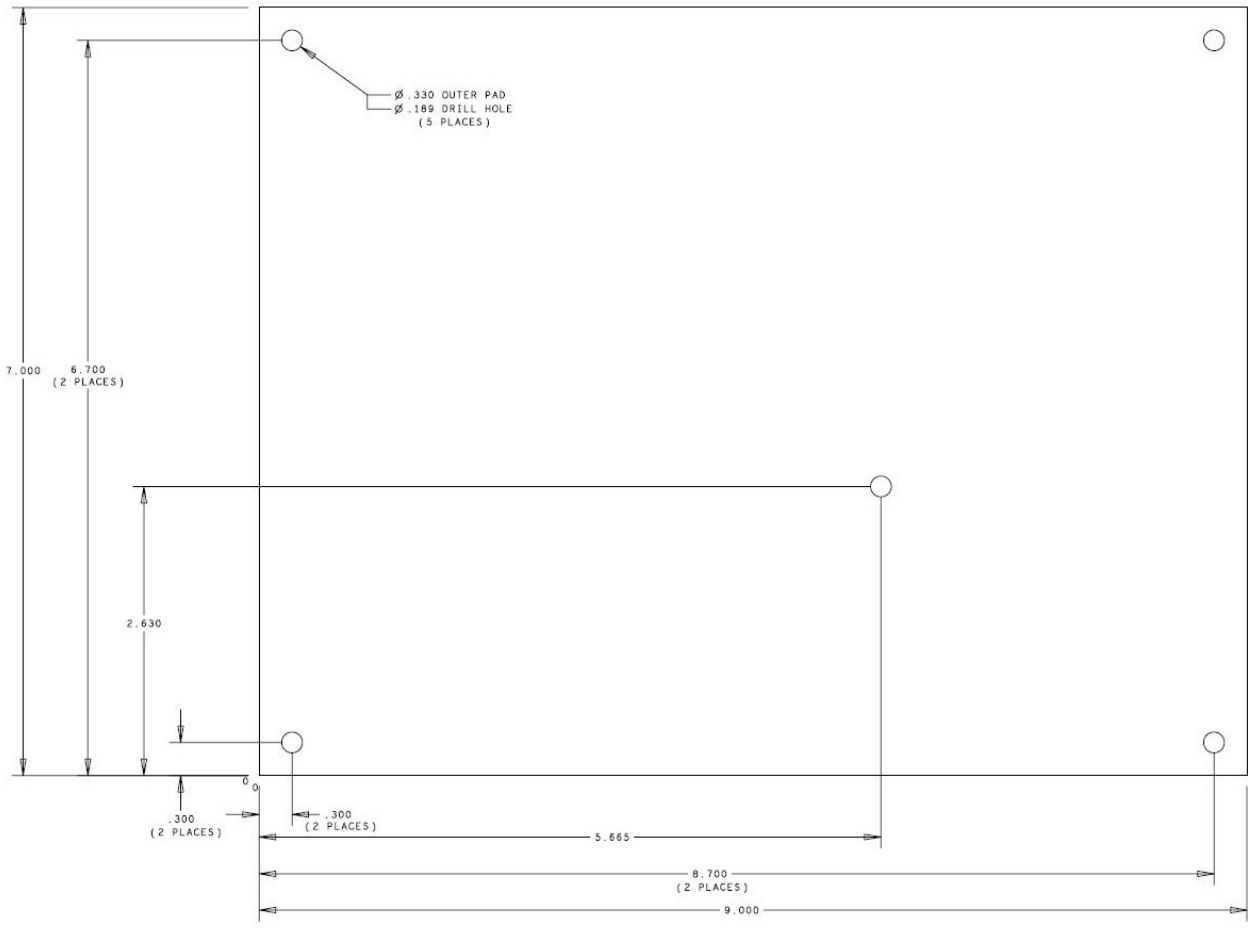


Figure 10 – OZDSP3000 Mechanical Dimensions

5. Analog to Digital Interfaces

5.1 DSP ADC Interface

The TMS320F28335 provides for 16 channels of A/D conversion. In order to increase the number of A/D inputs, the OZDSP3000 uses a multiplexer to switch between different inputs on the slower moving A/D channels. The six temperature monitoring channels (three for the SKiiP devices, three for the auxiliary thermistors) along with the four voltage monitoring channels are all multiplexed into channel B7. Figure 11 illustrates this multiplexing scheme. Note that these MUX control lines are sourced by the FPGA device.

Many of the ADC inputs are filtered with a single-pole low-pass filter. Table 21 provides detailed information on the A/D Channel signal assignments, scaling and offset, and the filter

cutoff frequency for the direct inputs. Table 22 provides the detailed information on the analog multiplexer scaling. Refer to the Semikron datasheet as to the specific device scaling for the I_{SENSE} and $V_{SENSE-UDC}$ measurements.

Table 21 – DSP A/D Channel Assignment and Scaling

DSP			Source	TP	Scaling and Offset	Cutoff Frequency
Pin Name	Pin #	Signal Name				
ADCINA0	42	$I_{SENSE-AU}$	J11 pin 22	3	$V_{adc} = -0.15*V_{in} + 1.5V$	100 kHz
ADCINA1	41	$I_{SENSE-AV}$	J11 pin 24	2	$V_{adc} = -0.15*V_{in} + 1.5V$	100 kHz
ADCINA2	40	$I_{SENSE-AW}$	J11 pin 26	26	$V_{adc} = -0.15*V_{in} + 1.5V$	100 kHz
ADCINA3	39	$V_{SENSE-UDC-A}$	J11 pin 13	22	$V_{adc} = 0.297*V_{in}$	160 Hz
ADCINA4	38	$I_{SENSE-HB}$	J14 pin 14	12	$V_{adc} = -0.15*V_{in} + 1.5V$	100 kHz
ADCINA5	37	$V_{REF-1.5V}$	Internal	23	$V_{adc} = V_{in}$	n/a
ADCINA6	36	$V_{REF-2.5V}$	Internal	14	$V_{adc} = V_{in}$	n/a
ADCINA7	35	Net Analyzer	TP10	13	$V_{adc} = -3*V_{in} + 1.5V$	1 MHz
DSP			Source	TP	Scaling and Offset	Cutoff Frequency
Pin Name	Pin #	Signal Name				
ADCINB0	46	$I_{SENSE-BU}$	J13 pin 22	8	$V_{adc} = -0.15*V_{in} + 1.5V$	100 kHz
ADCINB1	47	$I_{SENSE-BV}$	J13 pin 24	4	$V_{adc} = -0.15*V_{in} + 1.5V$	100 kHz
ADCINB2	48	$I_{SENSE-BW}$	J13 pin 26	19	$V_{adc} = -0.15*V_{in} + 1.5V$	100 kHz
ADCINB3	49	$V_{SENSE-UDC-B}$	J13 pin13	17	$V_{adc} = 0.297*V_{in}$	160 Hz
ADCINB4	50	$I_{SENSE-AUX-U}$	J1 pin 3	7	$V_{adc} = -.375*V_{in} + 1.5V$	100 kHz
ADCINB5	51	$I_{SENSE-AUX-V}$	J2 pin 3	9	$V_{adc} = -.375*V_{in} + 1.5V$	100 kHz
ADCINB6	52	$I_{SENSE-AUX-W}$	J3 pin 3	5	$V_{adc} = -.375*V_{in} + 1.5V$	100 kHz
ADCINB7	53	Analog Mux	AMUX	18	See Table 22	n/a

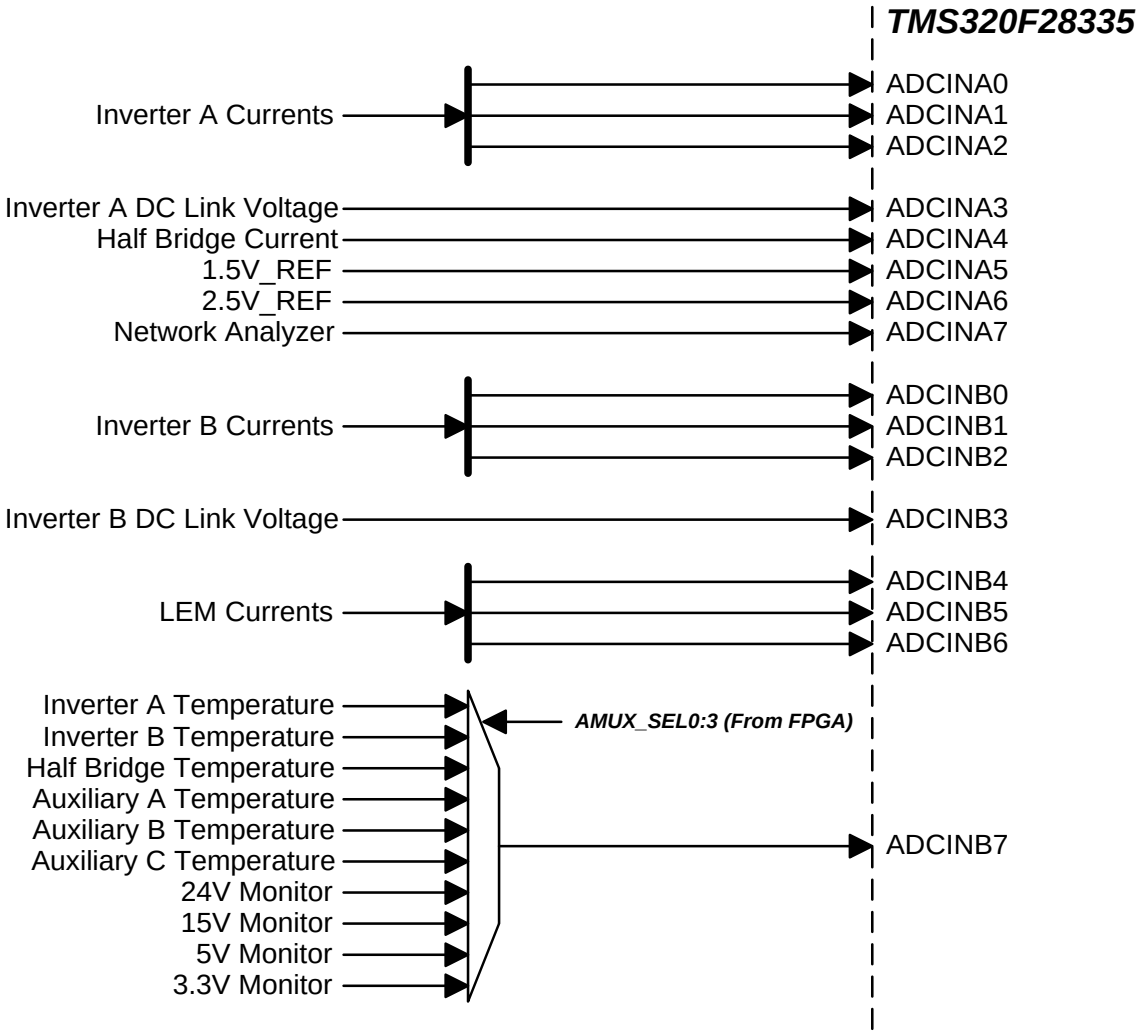


Figure 11 – A/D Multiplexed Interface Block Diagram

Table 22 – Analog Multiplexer Channel Assignment and Scaling

Analog MUX			Source	Scaling and Offset
Pin Name	Pin #	Signal Name		
S1	19	$V_{TEMP-INVA}$	J11 pin 20	$V_{adc} = 0.30168*V_{in}$
S2	20	$V_{TEMP-INVB}$	J13 pin 20	$V_{adc} = 0.30168*V_{in}$
S3	21	$V_{TEMP-HB}$	J14 pin 12	$V_{adc} = 0.30168*V_{in}$
S4	22	$V_{TEMP-AUX-A}$	J4 pin 1	$V_{adc} = 3.0V* R_{therm}/(2k\Omega + R_{therm})$
S5	23	$V_{TEMP-AUX-B}$	J5 pin 1	$V_{adc} = 3.0V* R_{therm}/(2k\Omega + R_{therm})$
S6	24	$V_{TEMP-AUX-C}$	J6 pin 1	$V_{adc} = 3.0V* R_{therm}/(2k\Omega + R_{therm})$
S7	25	$V_{SENSE-24V}$	J25 pins 1,2	$V_{adc} = 0.09091*V_{in}$
S8	26	$V_{SENSE-15V}$	Supply	$V_{adc} = 0.16701*V_{in}$
S9	11	$V_{SENSE-5V}$	Supply	$V_{adc} = 0.5*V_{in}$
S10	10	$V_{SENSE-3.3V}$	Supply	$V_{adc} = 0.75518*V_{in}$
S11	9	$V_{SENSE-Neg15V}$	Supply	$V_{adc} = 3.14659 + 0.04649*V_{in}$

Refer to the Semikron datasheet or the thermistor datasheet as to the specific scaling for the V_{TEMP} measurements.

5.2 HVADC Interface

The OZDSP3000 also has the capability to measure six high voltage channels with 12 bits of accuracy. This is done with an isolated ADC that is automatically controlled serially through the FPGA. Conversions are initiated by setting the ADC_TRIGGER (pin 89 of the DSP) high and then low. When the process is done, an ADC interrupt request line is triggered on the DSP (pin 98) to indicate that the converted data is available for reading. The trigger to interrupt time is approximately 7.68µs, for an effective maximum sampling rate of 130 kHz. The ADC converts the 0-5V input signal to the 12-bit number according to the table below.

Table 23 – HVADC Conversion Scaling

Description	Input Voltage	Binary Code	Hexadecimal Code
Positive full-scale	5V	0111 1111 1111	7FF
Mid-scale	2.5V	0000 0000 0000	000
Mid-scale – 1LSB	4.29878V	1111 1111 1111	FFF
Negative full-scale	0V	1000 0000 0000	800

For debugging purposes, there are test points on all six differential voltages connected to the ADC.

Table 24 – HVADC Test Point Locations

Description	Location
$Vline_A$	TP44
$Vline_B$	TP37
$Vline_C$	TP42
Vlo_A	TP40
Vlo_B	TP30
Vlo_C	TP33

5.2.1 High Voltage Interface

On board, high voltage attenuators are provided for three of the six sense inputs. A simplified representation of the interface circuitry is presented in Figure 12. It is important to note that the signal is filtered using two single-pole, 16 kHz filters.

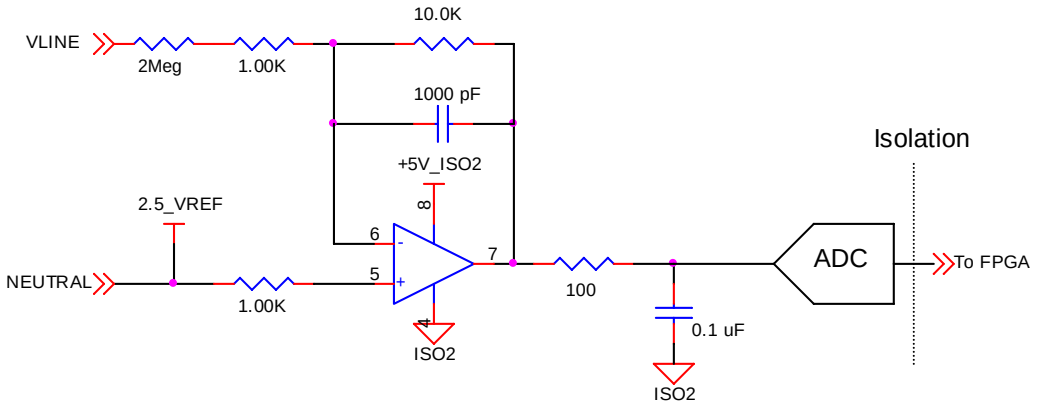


Figure 12 – High Voltage Interface Circuitry

Table 25 – HVADC Voltage Scaling

Board Variant	Full Scale (V)	Gain (mV/V)
-01	+/- 500.3	4.998

5.2.2 Low Voltage Interface

The remaining three voltage sense inputs are intended to be driven by an off board attenuator circuit. A simplified representation of the interface circuitry is presented in Figure 13.

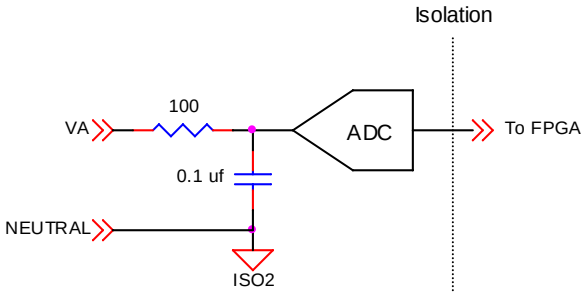


Figure 13 – Low Voltage Interface Circuitry

Warranty and Product Information

Limited Warranty

What does this warranty cover and how long does it last? This Limited Warranty is provided by Oztek Corp. ("Oztek") and covers defects in workmanship and materials in your OZDSP3000 controller. This Warranty Period lasts for 18 months from the date of purchase at the point of sale to you, the original end user customer, unless otherwise agreed in writing. You will be required to demonstrate proof of purchase to make warranty claims. This Limited Warranty is transferable to subsequent owners but only for the unexpired portion of the Warranty Period. Subsequent owners also require original proof of purchase as described in "What proof of purchase is required?"

What will Oztek do? During the Warranty Period Oztek will, at its option, repair the product (if economically feasible) or replace the defective product free of charge, provided that you notify Oztek of the product defect within the Warranty Period, and provided that through inspection Oztek establishes the existence of such a defect and that it is covered by this Limited Warranty.

Oztek will, at its option, use new and/or reconditioned parts in performing warranty repair and building replacement products. Oztek reserves the right to use parts or products of original or improved design in the repair or replacement. If Oztek repairs or replaces a product, its warranty continues for the remaining portion of the original Warranty Period or 90 days from the date of the return shipment to the customer, whichever is greater. All replaced products and all parts removed from repaired products become the property of Oztek.

Oztek covers both parts and labor necessary to repair the product, and return shipment to the customer via an Oztek-selected non-expedited surface freight within the contiguous United States and Canada. Alaska, Hawaii and locations outside of the United States and Canada are excluded. Contact Oztek Customer Service for details on freight policy for return shipments from excluded areas.

How do you get service? If your product requires troubleshooting or warranty service, contact your merchant. If you are unable to contact your merchant, or the merchant is unable to provide service, contact Oztek directly at:

USA
Telephone: 603-546-0090
Fax: 603-386-6366
Email techsupport@oztekcorp.com

Direct returns may be performed according to the Oztek Return Material Authorization Policy described in your product manual.

What proof of purchase is required? In any warranty claim, dated proof of purchase must accompany the product and the product must not have been disassembled or modified without prior written authorization by Oztek. Proof of purchase may be in any one of the following forms:

- The dated purchase receipt from the original purchase of the product at point of sale to the end user
- The dated dealer invoice or purchase receipt showing original equipment manufacturer (OEM) status
- The dated invoice or purchase receipt showing the product exchanged under warranty

What does this warranty not cover? Claims are limited to repair and replacement, or if in Oztek's discretion that is not possible, reimbursement up to the purchase price paid for the product. Oztek will be liable to you only for direct damages suffered by you and only up to a maximum amount equal to the purchase price of the product. This Limited Warranty does not warrant uninterrupted or error-free operation of the product or cover normal wear and tear of the product or costs related to the removal, installation, or troubleshooting of the customer's electrical systems. This warranty does not apply to and Oztek will not be responsible for any defect in or damage to:

a) The product if it has been misused, neglected, improperly installed, physically damaged or altered, either internally or externally, or damaged from improper use or use in an unsuitable environment
b) The product if it has been subjected to fire, water, generalized corrosion, biological infestations, or input voltage that creates operating conditions beyond the maximum or minimum limits listed in the Oztek product specifications including high input voltage from generators and lightning strikes
c) The product if repairs have been done to it other than by Oztek or its authorized service centers (hereafter "ASCs")
d) The product if it is used as a component part of a product expressly warranted by another manufacturer
e) The product if its original identification (trade-mark, serial number) markings have been defaced, altered, or removed
f) The product if it is located outside of the country where it was purchased
g) Any consequential losses that are attributable to the product losing power whether by product malfunction, installation error or misuse.

Disclaimer

Product

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Return Material Authorization Policy

Before returning a product directly to Oztek you must obtain a Return Material Authorization (RMA) number and the correct factory "Ship To" address. Products must also be shipped prepaid. Product shipments will be refused and returned at your expense if they are unauthorized, returned without an RMA number clearly marked on the outside of the shipping box, if they are shipped collect, or if they are shipped to the wrong location.
When you contact Oztek to obtain service, please have your instruction manual ready for reference and be prepared to supply:

- The serial number of your product
- Information about the installation and use of the unit
- Information about the failure and/or reason for the return
- A copy of your dated proof of purchase

Return Procedure

Package the unit safely, preferably using the original box and packing materials. Please ensure that your product is shipped fully insured in the original packaging or equivalent. This warranty will not apply where the product is damaged due to improper packaging. Include the following:

- The RMA number supplied by Oztek clearly marked on the outside of the box.
- A return address where the unit can be shipped. Post office boxes are not acceptable.
- A contact telephone number where you can be reached during work hours.
- A brief description of the problem.

Ship the unit prepaid to the address provided by your Oztek customer service representative.

If you are returning a product from outside of the USA or Canada - In addition to the above, you MUST include return freight funds and you are fully responsible for all documents, duties, tariffs, and deposits.

Out of Warranty Service

If the warranty period for your product has expired, if the unit was damaged by misuse or incorrect installation, if other conditions of the warranty have not been met, or if no dated proof of purchase is available, your unit may be serviced or replaced for a flat fee. If a unit cannot be serviced due to damage beyond salvation or because the repair is not economically feasible, a labor fee may still be incurred for the time spent making this determination.

To return your product for out of warranty service, contact Oztek Customer Service for a Return Material Authorization (RMA) number and follow the other steps outlined in "Return Procedure".

Payment options such as credit card or money order will be explained by the Customer Service Representative. In cases where the minimum flat fee does not apply, as with incomplete units or units with excessive damage, an additional fee will be charged. If applicable, you will be contacted by Customer Service once your unit has been received.