PowerDAQ PD2–AO, PDXI–AO

PCI/PXI High–Density 16–bit Analog Output Board
User Manual

High-Performance Multifunction I/O boards for PCI Bus Computers

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Introduction

This manual describes the PowerDAQ™ Analog Output boards. The following boards are supported:

PD2-AO-8/16
PD2-AO-16/16
PD2-AO-32/16
PD2-AO-96/16
PDXI-AO-8/16
PDXI-AO-16/16
PDXI-AO-32/16

Two different form-factors are available – 32-bit 33 MHz PCI and 32-bit 33 MHz PDXI. PDXI is a PowerDAQ extension for instrumentation and is a superset of Compact PCI and PXI bus industry-oriented standards.

Who Should Read This Book?

This manual has been designed to benefit the user of PowerDAQ™ PD2-AO and PDXI-AO boards. To use PowerDAQ™ Analog Output Board, it is assumed that you have basic PC skills, and that you are familiar with Microsoft Windows NT/2000/95/98/Me and/or Linux/QNX operating environments.

Organization of This Manual

The PowerDAQ™ PD2-AO User Manual is organized as follows:

Chapter 1 – Introduction

This chapter gives you an overview of PowerDAQ™ Analog Output series board's features the various models available and what you need to get started.

Chapter 2 – Installation and Configuration

This chapter explains how to install and configure your PowerDAQ™ Analog Output series board.

Chapter 3 – Architecture

This chapter discusses the internal structure and subsystems of your PowerDAQ™ Analog Output series board.

Chapter 4 – API and Third–Party Software Examples

This chapter explains how to use PowerDAQ™ Analog Output series boards using the PowerDAQ™ API on Visual C++, VB, Delphi, C++ Builder or Third-Party software such as LabVIEW®, TestPoint®, DASYLab®, HP VEE®, etc.

Chapter 5 – Interconnections

This chapter describes the I/O connections to your PowerDAQ™ Analog Output series board.

Appendix A – Specifications

This chapter lists the PowerDAQ™ Analog Output series board hardware specifications.

Appendix B – Accessories

This appendix lists the PowerDAQ™ Analog Output series board accessories products.

Appendix C – Common Questions and Support

This appendix contains a list of commonly asked questions and their answers relating to usage and special features of your PowerDAQ™ Analog Output series board board. Should you require assistance while installing or using PowerDAQ™ Analog Output series board, support service details are also listed.

Appendix D – Warranty

This appendix contains a detailed explanation of PowerDAQ™ Analog Output series board's warranty.

Index

The Index alphabetically lists topics covered in this manual.

Conventions Used in This Manual

These are the main conventions used to help you get the most out of this manual:

Tips are designed to highlight quick ways to get the job done, or good ideas you might not discover on your own.

Note Notes alert you to important information.

CAUTION! Caution advises you of precautions to take to avoid injury, data loss, or system crash.

Text formatted in **bold** typeface may also represent type that should be entered verbatim or a command, as in the following example:

You can instruct users how to run setup using a command such as **setup.exe**.

Feedback

We are interested in any feedback you might have concerning our products and manuals. A Reader Evaluation form is available on the last page of the manual.

1

Introduction

Introduction

This chapter describes the basic features of the PowerDAQ™ PD2-AO boards.

About the PowerDAQ™ Analog Output series board

Thank you for purchasing a PowerDAQ™ Analog Output series board. The board you received is either a PD2-AO PCI-bus board or a PDXI-AO CompactPCI bus board. These boards differ in certain hardware respects however the software is the same.

The PDXI series Analog Output boards utilize all advantages of the PXI/cPCI form-factor.

The associated PowerDAQ™ Software Suite (PD-SDK) has been written specifically for these products.

Overview

The PowerDAQ analog output boards are configured as 8, 16, 32 or 96 channels. The PDXI versions are available in 8, 16 and 32 channel versions. The PowerDAQ Analog Output board uses 16-bit DACs and allows you to configure the start up states for each channel (200ms maximum delay between system reset and power-on value loading). The on-board DSP/PCI interface allows you to use up to three 24-bit counter timers, high-speed IRQ/External Clock lines, eight digital inputs and eight high-drive (-32/64ma) digital outputs. Additionally each board has a special calibration subsystem, which is used to calibrate each analog output channel.

Features

The major features of the PowerDAQ AO boards are:

24-bit 66/100 MHz Motorola 56301 DSP (Digital Signal Processor)

"Bus Master Ready" PCI Bus Host PC Interface (PCI 2.1 Compliant)

- 8/16/32/96 channel 16-bit +/- 10V DACs
- DC-100KHz per D/A throughput
- 2MHz/board maximum update rate
- 1/2/4/8/16/32/64 Fixed/Unlimited channel list length
- Asynchronous/Simultaneous update modes for the all DACs
- Eight Digital Inputs
- Eight Digital Outputs
- Counters/Interrupt/Synchronization inputs
- Per-channel calibration
- Sense lines for the each DAC (optional), jumper-selectable on PDXI models
- User-defined Power-Up states for the each DAC (200 ms maximum setup time after the system reset) Default is 0V.
- Three 24-bit counter timers (16.5/25MHz maximum)
- On-board 2K FIFO (located in the DSP memory)
- 32Ksamples FIFO upgrade option
- Software:
  PowerDAQ for Windows95/98/Me/NT/2000/XP/Linux/QNX
  Visual C++, VB, Delphi, C++ Builder, Kylix
  Drivers for: LabVIEW®
  HP VEE®
  LabWindows/CVI®
  TestPoint®
  DASYLab®
  DiaDem®
  MATLAB DAQ Toolbox

Note For the full list of specifications, *see Appendix A: Specifications.*

AO Applications

PowerDAQ Analog Output series boards provide a wide range of powerful features that cover a wide range of applications. The most common applications are:

- Process Control
- ATE
- Closed-loop Servo-Control
- Motor Control
- Individual DAC voltage output
- Telecommunications equipment control (micro mirrors)

The Digital Input and Digital Output Subsystems applications:

- Electro-mechanical relay control applications
- Solid-state relay applications
- Alarm System sensors
- Digital motion control

The Counter-Timer Subsystem applications:

- PWM modulator
- Frequency counter
- Pulse generator

Note The easiest way to expand the possibilities of the PD2-AO/PDXI-AO board is to use the PD2-MF/S or PDXIU-MF/S multifunction boards series in the same PC.

PowerDAQ AO Models

PowerDAQ PD2-AO/PDXI-AO model numbers are derived as follows:

PD2–[Type Of Board]–[Channels]–[Speed]/[Resolution][Gain]

PDXI–[Type Of Board]–[Channels]–[Speed]/[Resolution][Gain]

The types of boards are:

MF Multifunction
AO Analog Output
DIO Digital Input /Output
CTM Counter Timer

Models	AO Features
PD2-AO-8/16	PCI bus Eight 16-bit Analog Output Channels
PD2-AO-16/16	PCI bus Sixteen 16-bit Analog Output Channels
PD2-AO-32/16	PCI bus Thirty-two 16-bit Analog Output Channels
PD2-AO-96/16	PCI bus Ninety-six 16-bit Analog Output Channels
PDXI-AO-8/16	PXI/CPCI bus Eight 16-bit Analog Output Channels
PDXI-AO-16/16	PXI/CPCI bus Sixteen 16-bit Analog Output Channels
PDXI-AO-32/16	PXI/CPCI bus Thirty-two 16-bit Analog Output Channels

Table 1: PowerDAQ™ AO Models

All PowerDAQ™ AO boards have the following additional features:

Digital Input — Eight static digital inputs
Digital Output — Eight static digital outputs
Clock/Interrupt Lines
Counter Timers — Three 24-bit (33/50MHz Internal/16.5/25 MHz External)

Getting Started

To get your PowerDAQ AO board up and running, ensure that you have the following:

A computer with PCI slots (for PD2-AO models) or PXI/CPCI slots (for PDXI-AO models) and the BIOS compliant to PCI Specifications 2.1 or greater. S*ee Appendix C: Common Questions and Support.*

PowerDAQ™ PD2-AO PCI/PDXI-AO board with user manual.

Latest PowerDAQ™ Software Suite CD (PD-SDK) Software. This can be downloaded from www.PowerDAQ.com/download

Minimum 16MB RAM for Windows9x and 32MB for Windows NT/98/Me and 64MB for Windows 2000

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Installation and Configuration

Installation and Configuration

This chapter describes the hardware and software installation and configuration of the PowerDAQ AO board.

Unpacking

Your PowerDAQ™ AO board is wrapped in an anti-static bag to protect against electrostatic charges that might damage the board. To avoid damage, proceed as follows:

Ground yourself with a grounded wrist strap or grounded source.

Discharge the static electricity by taking the board in the antistatic bag and touching the metal part of your PC.

Remove the board from the antistatic bag. We suggest you save the bag.

Inspect the board for any damage. If any damage is found, notify your distributor to return the board to the manufacturer. *See Appendix C: Common Questions and Support.*

Note The PowerDAQ AO boards contain sensitive electronic components. Please make sure the proper grounding and electrostatic conditions are used.

Hardware

You can install your PowerDAQ PD2-AO board in any PCI slot. PDXI-AO boards should be installed into the Compact PCI/PXI/PDXI chassis only. We recommend you use the first available slot and complete the following instructions:

PCI board installation:

1. Turn off your PC.

Remove the cover and make sure you have clear access to the PCI slots.

Connect all desired cables to the PD2-AO board.

Insert the PowerDAQ PD2-AO board into a PCI slot. (If the PCI slots have not been used for a long time, insert the PowerDAQ PD2-AO board, then remove it and clean

the edge connector with alcohol. After this has been done, replace the bard back into the slot.)
Screw the bracket and replace the cover.
Turn the PC on.

PDXI board installation:

1. Turn off your PC.
2. Remove the slot cover.
3. Insert the PowerDAQ PDXI-AO board into a slot.
4. Screw the bracket.
5. Turn the PC on.

The PowerDAQ AO board is now installed. All board configurations are controlled via software using the PD-SUITE.

Note For the Windows 95/98/Me/2000/XP platforms, you should install PowerDAQ Software Suite prior the board installation.

Installing Multiple Boards

You can install multiple PowerDAQ AO boards in one PC. You are limited to the number of PCI/PDXI slots in your PC.

Software

PowerDAQ Software Suite CD contains drivers and software (example code with source code) for Windows, Linux and QNX (optional). You can always download the latest software suite from www.PowerDAQ.com/download.

Installation

From the CD, run the **SETUP.exe** program. The setup program will take you through the installation process. If you downloaded the PowerDAQ software from the web you just need to run the file downloaded and follow the setup instructions.

As the installation process modifies your Windows registry, you must only install or uninstall the software using the appropriate programs.

Note Never delete the PowerDAQ software from you PC directly. Always use Uninstall program from PowerDAQ folder or Control Panel/Add-Remove Programs applet.

Note Once the installation is complete, the PC must be rebooted for proper operation.

Note Windows NT/2000/XP users must be logged in as an administrator or have equivalent access.

Base address, DMA, Interrupt settings

The PowerDAQ AO boards are configured automatically by the computer BIOS on power up. Usually you do not have to set any base address, DMA channels or interrupt levels. The PowerDAQ driver is designed to share interrupts over PCI devices but very rarely will the BIOS assign same interrupt to mass-storage devices such as a SCSI controller or video card and a PowerDAQ board. In this case it could be significant latency between the time when board fires an interrupt and the time the PowerDAQ driver actually receives it. In this case we recommend changing your BIOS settings and assigning a dedicated interrupt for the PowerDAQ board. Please refer to your motherboard/computer manual for the BIOS settings change procedure.

Diagnostics

In order to confirm board operation, install the PowerDAQ Suite. This automatically installs the PowerDAQ application control panel diagnostic program that will display all available PowerDAQ boards in your system.

To access the PowerDAQ control panel, select **START** > **Settings** > **Control Panel** and the PowerDAQ icon will be displayed.

Figure 1: PowerDAQ Control Panel Application

An alternative test is to use the SimpleTest program installed by the Software Suite. Attached a oscilloscope of multimeter to the outputs of the AO board. Run the **SimpleTest.exe** program by selecting **START** > **Programs > PowerDAQ > Delphi Acquisition Demo**. This program shows all information about the board(s) installed and allows you to test all subsystems available on the board selected for the test.

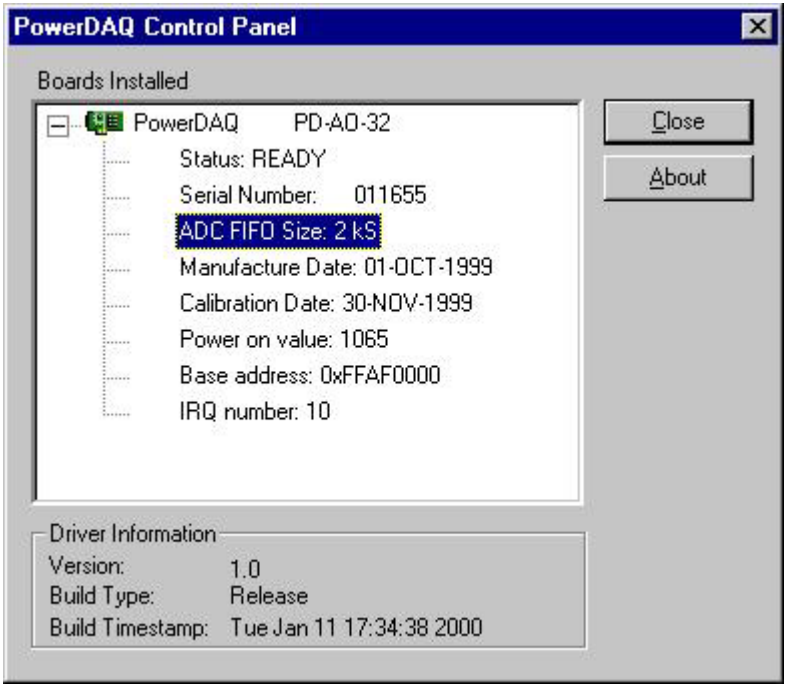


Figure 2: PowerDAQ control panel application showing PD2-AO-32 board installed

Please refer to the PowerDAQ Software manual for a complete set of ready to run example programs and the detailed API for programming of the PowerDAQ AO boards.

All PowerDAQ AO manuals are supplied in electronic Adobe Acrobat PDF format. If you require the PDF reader, this can be downloaded from the Internet from **www.adobe.com**

Accessories

PowerDAQ AO boards have an extensive range of optional accessories:

Cables (3ft, 6ft or 9ft)
Screw terminal panels
Complete kits
J1 high-density analog cable (PD2-AO-8[16][32] only)
J2 PD-CBL-37 DIO connection kit (PD2-AO only)
J3-J8 IDC40 to DB37 flat/twisted pair ribbon cable (PD2-AO-96 only)
J1 to J1/J2 splitter analog/digital cable

Cables

Digital cable (PD2–AO boards only)

PD–CBL–37: The J2 connector uses a 37-way ribbon connector set. It comprises of a 13" internal ribbon cable, which connects from the PowerDAQ AO board J2 internal digital connector (DIO /Counters/IRQs) to a 37-way D-SUB bracket. A 1-meter ribbon cable then connects from the bracket to the PD2-AO-STP accessory panels.

Analog cable (PD2–AO–8[16][32] boards only)

PD–CBL–96: The J1 connector uses a 96-way shielded round 1-meter cable with a metal connector on either end. It connects to: PD2-AO-STP-16or 32, PD-BNC-16 or 64 accessory panels.

Analog cable (PD2–AO–96 boards only)

PD–CBL–4037TP: The J3-J8 connector uses a 36-way flat or twisted pair ribbon cable (DB37 to IDC40) to bring out the analog output signals. It connects to: PD-STP-3716, so one PD2-AO-96/16 board requires a set of six cables and terminals for all ninety-six channels.

Note The PowerDAQ PD2-AO-8/16/32 boards require a PD-CBL-96 and the PD2-AO-96 requires up to 6 PD-CBL-4037TP. If digital IO/CTM is going to be used, an optional PD-CBL-37 cable is required.

Custom cables are available. Please contact the factory for more details.

Splitter analog/digital cable (PDXI–AO boards only)

PDXI–CBL–AO: The J1 connector uses a split round shielded cable, which brings out the analog signals to a 96-way "pin-less" Fujitsu connector and the digital I/O signals to 37-way DB-37 connectors.

It connects to: PD2-AO-STP-xx, PD-BNC-xx accessory panels.

Screw Terminal Panels

The PD2-AO-STP-16/32 is a 16/32-channel screw terminal panel, which also includes connections for the counter timers, high speed interrupt/synchronization lines and DIO ports. Using the jumpers, each sense line can be connected to the appropriate output directly on the screw terminal.

Note For the all PDXI-AO boards, the sense to force line jumpers are located directly on the board. All jumpers should be removed from the PD2-AO-STP panel in this case.

Because of compatible pin-outs, the PD-BNC-xx terminals can be used with PD2-AO-8[16][32] boards. Custom terminal panels are available. Please contact the factory for more details.

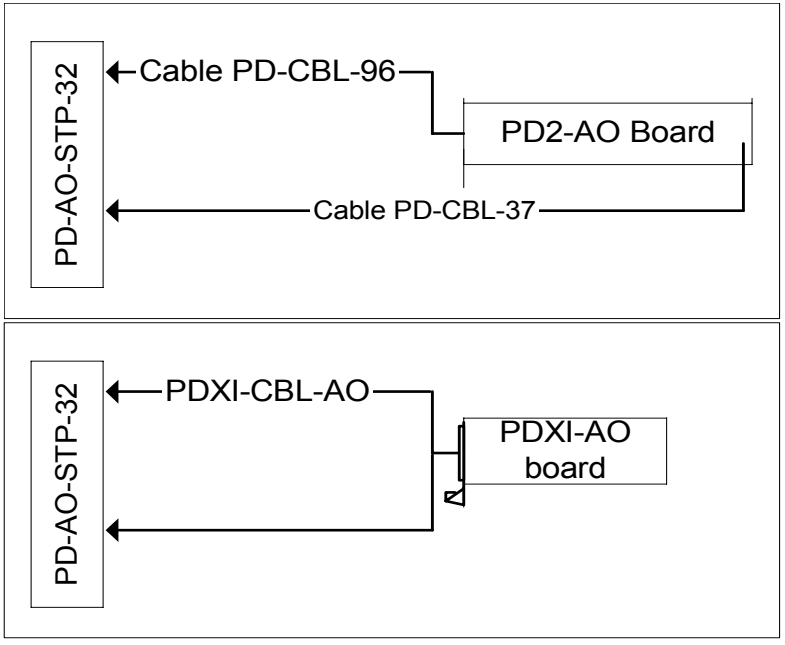


Figure 3: PD2–AO–STP–32 Wiring Diagram

The PD-STP-3716 is a low cost 16-channel screw terminal panel, which can be used with the PD2-AO-96/16 or PD2-AO-8/16. This terminal contains analog signals only. For the digital signals, you will need the PD-STP-DIO.

Complete kits

We have included the PD-CBL-96 and the PD2-AO-STP-32 into a complete kit for the PD2-AO-8[16][32] boards. The product is available by ordering PN PD2-AO-STP-16KIT or -32.

Also complete kits are available for the PDXI-AO boards. These products are available by ordering PN PDXI-AO-STP-16KIT or –32KIT.

J1 Connector

If you wish to develop you own custom cable, you can purchase the connector and metal cover from your distributor or the factory. The part number is PD-CONN.

The manufacturer is:

Fujitsu Takamisawa America, Inc.
Telephone: 408-745-4990 Fax: 408-745-4995

The manufacturers' part number for the connector is FCN-230C096-C/E and the metal cover FCN-247J096-G/E.

Custom terminal panels are available. Please contact your distributor or the factory.

J2 Connector (PD2–AO only)

J2 connector is a 36-way boxed IDC header.

The manufacturer is Tomas & Betts (www.tnb.com) .

The manufacturers' part number for the connector is 609-3627.

J3–J8 Connector(PD2–AO–96 only)

J3-J8 connectors are 40-way boxed IDC headers.

The manufacturer is 3M (http://www.mmm.com/esm/).

The manufacturers' part number for the connector is 2540-6002UB.

3

Architecture

Architecture

This chapter describes the functional operation of the PowerDAQ AO boards.

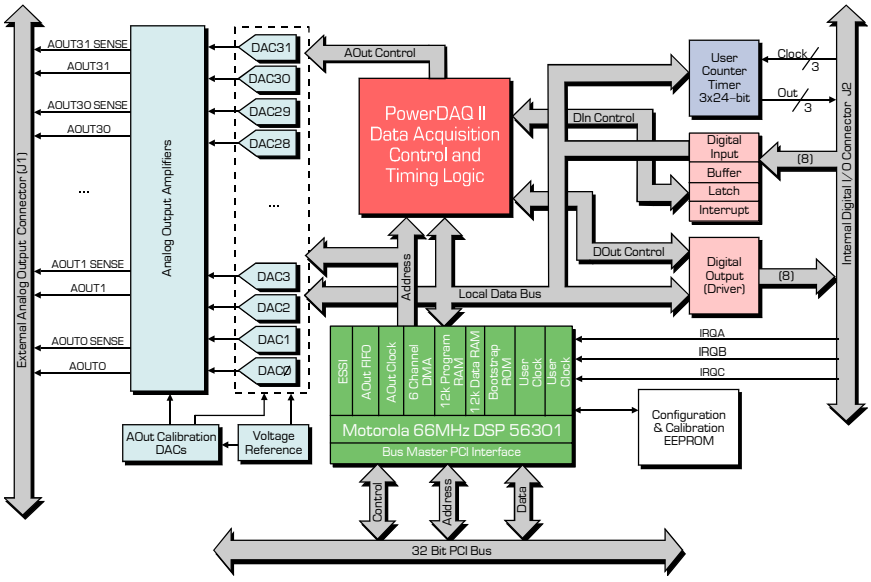


Figure 4: Block Diagram of the PowerDAQ PD2–AO boards

Functional Overview

Although there are some functional differences between the PD2-AO and PDXI-AO boards they all utilize the same PowerDAQ software, which significantly simplifies the software development process.

Analog Output Subsystem (AO)

The PowerDAQ II analog output boards are configured as 8, 16, 32 or 96 sixteen-bit output channels. On the PD2-AO-8[16][32] each channel has an optional sense line to provide 16-bit accuracy at rated output current. The PDXI-AO board allows the use of sense lines on the first sixteen channels by installing on-board jumpers. The PD2-AO-96 does not provide the sense line option.

Note The default sense line option is not available on PD2-AO boards because of noise considerations – high currents going through the cable induce more noise) and sense lines carry the same signal as corresponding output lines inside the cable. Please take this into consideration when configuring the sense lines (if required).

The AO subsystem also includes input modes, channel queue, trigger and clocking control.

Interrupt (event) generation: You can use events to provide gap-free updates of the analog outputs.

There are three update modes for the analog subsystem

- Single update
- Event (interrupt) – based waveform mode
- Continuous pulled-IO waveform mode and auto-regeneration waveform mode.

The user can define the power-on value of each channel (the default start-up value is set to zero). The included utility application "Start-Up Configuration Wizard" (StartUpState.exe) is installed by the SDK can be used to modify the start-up states.

Note The Power-On state will be loaded into the DACs with 200 ms maximum delay after the system reset. The calibration values will be loaded only when PowerDAQ driver is loaded and up to +/-30 mV offset is possible on the outputs during the system boot process.

Note The quad output DACs has current limitations. Only one output of each quad can be continuously shorted to ground. Two, three and even four channels shorted to ground MUST NOT exceed five seconds.

Analog Output Mode

Single Update

The PowerDAQ AO boards operate with either a single-update or streaming (waveform) output configuration. Single-update mode allows direct write access to any of the 16-bit DACs of the PowerDAQ AO board. The update frequency is at least 1kHz for the single update mode and can be as high as 15KHz in real-time operating environments. The single update speed is dependent on your PC system speed.

Note There is a special sub-mode of the single update mode when all or selected DAC's outputs are updated simultaneously.

Event-based Waveform

Event-based waveform mode allows continuous waveform generation and is not limited by the amount of data. Each time the DSP based FIFO is S full an interrupt is fired to request additional data to be sent to the board. The PowerDAQ advanced buffering mechanism hides those interrupts from the user and allows you to work with big output arrays logically divided by frames. The end of each frame can generate an event, which will request more data from the application. Complete information on the PowerDAQ advanced circular buffer (ACB) can be found at www.POwerDAQ.com

Note If the on-board FIFO is empty or the last value is outputted, the board will continue outputting the last DC value.

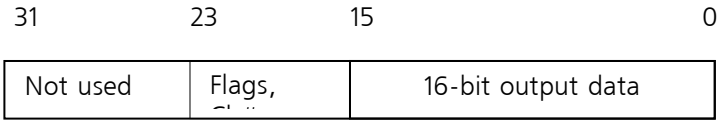
Auto-regeneration Waveform (circular waveform)

Auto-regeneration waveform mode can be used to create fixed length waveforms without any host intervention of user software after the subsystem has initialized. An application writes data to the buffer of the PowerDAQ AO board and each time the end of buffer is reached, it starts to resend the same buffer again. Note, that 2048 samples can fit into the on-board DSP memory and auto regeneration of up to 2048 samples will not require any intervention of the host PC.

Channel List

There are two ways do define a Channel List for the PowerDAQ AO board. First, when the output data and channel number are combined together to provide the output channel selection. In this situation, the lower 16 bits are data, the following upper 8, the channel number and special flags (see the picture below).

This mode supports update rates up to 455KS/sec



Bits 16-20 are used to define the output channel number on a **PD2/PDXI-AO-8[16][32]** board.

Bit 21, when set is used as a Write and Hold Flag – this is used to write data to the DAC WITHOUT updating it on a **PD2/PDXI-AO-8[16][32]** board.

Bit 22, when set is used as an Update All Flag – all DAC's will be updated by the previously written data on a **PD2/PDXI-AO-8[16][32]** board.

PD2-AO-96 board only:

Bits 16-22 are used to define the output channel number on **PD2/PDXI-AO-8[16][32]** boards.

Bits 21,22,23 when all set together are used as a Write and Hold Flag – written to DAC's data with this bit set will not update output.

Bits 23, when set is used as Update All Flag – all DAC's will be update by previously written data.

This is the default configuration, which provides an unlimited channel list length.

Another way to define the channel list is a series of continuous channel numbers(1/2/4/8/16/32/64), up to the number of ports available on the AO board, starting at any channel. For example, the PD2-AO-32, channels 0 through 15 can be specified as a channel list of channels to be updated in Event-based Waveform Mode and the remaining channels can be used in Single Update Mode.

This mode is called DMA-based update mode and supports output rates up to 1.6 MS/sec.

Note There is a dedicated function in the PowerDAQ API called _PdAO32SetUpdateChannel which can be used to specify the update channel number. Any write to this channel will force the update of all DAC's.

Digital Output Subsystem

There are eight static digital outputs on the PowerDAQ analog output board. They are TTL/CMOS output level compatible, 2000V ESD protected. Due to the static nature of the outputs they can be updated at any time without any limitations. Digital outputs provide high current compatibility (-32/64 ma), which support drive relays or these lines can be used for control applications.

Digital Input Subsystem

There are eight static digital inputs on the PowerDAQ analog output board. They are TTL/CMOS input level compatible, 2000V ESD protected. Due to the static nature of the inputs they can be read at any time without any limitations.

Counter/Timer Subsystem

Depending on your PowerDAQ AO operation mode, the board can support up to the three DSP based 24-bit counter/timers with a maximum count rate up to 33 MHz for 66MHz DSP and 50MHz for 100MHz DSP (PDXI-AO only) for an internal base clock and 16.5 MHz/25MHz for the external clock. The minimum count rate is 0.001 Hz for the internal clock and no low limits for the external clock.

Note For all waveform modes, only Timer0 and Timer1 are available for use.

Programming of the counter/timer subsystem of the PD2-AO board requires a minimal understanding of the Triple Timer Module of the Motorola 56301 DSP. For this information please refer to the *Motorola DSP 56301 User Manual* (Motorola P/N DSP56301UM/AD).

Each timer can be used for internal or external clocking and can interrupt the on-board DSP after a specified number of events (clocks) or signal an external device after counting internal events. Each timer can also be used to trigger DMA transfers after a specified number of events (clocks) have occurred. Each timer connects to the external world through one bi-directional pin TIO that is 7kV ESD protected. When TIO is configured as input the timer functions as an external event counter or can measure external pulse width/signal period. When TIO is used as output, it functions as a timer, watchdog or Pulse Width Modulator.

Some common timer/counter/output functions that microprocessors require are:

Real time clock,
Event counter
Digital one-shot
Programmable rate generator
Square wave generator
Binary rate multiplier
Complex digital wave form generator
Complex motor control

Note Each counter is a 24-bit count-up counter

After power-up, the count value and output of all counters are set to zero

Each counter must be programmed before it can be used

Unused counters need not to be programmed

Use the PowerDAQ API to program counters.

Each counter is fully independent of the others. Only prescaler, when used, is a common part of the counter-timer subsystem. Each counter may operate in a different mode

Calibration Subsystem

The calibration subsystem is used to calibrate **each** analog output zero offset (with 150-microvolt accuracy) and output range (PD2-AO only). The calibration data is stored in the on-board EEPROM. Additionally a PowerDAQ AO board provides an application for the user to configure the start-up output value of the any DAC. This value will be loaded immediately after a system reset or power-on with 200 ms maximum latency.

DSP Processor

All PowerDAQ AO boards are based on the Motorola 56301 DSP. This is a 24-bit 66/100 MHz processor with an integrated PCI interface. The PCI interface implements the PCI Local Bus Specifications so the board is fully auto-configured (base address, interrupt).

When the PowerDAQ software is loaded, the PowerDAQ AO firmware is downloaded to the DSP via the PCI bus. This firmware contains all the code necessary to communicate with the board subsystems and the host PC driver.

Note The drivers from the PowerDAQ web site always contain the latest versions of the DSP firmware.

Note Custom programming of the DSP is not available with the standard PowerDAQ AO product. However, should you require DSP processing, please contact the factory.

PCI Bus Interface

The PowerDAQ AO boards communicate via the PCI bus. The PCI bus interface is embedded in the Motorola 56301 DSP. On power up, the host PC automatically configures the boards base address and interrupt resources.

Timing and Control

The PowerDAQ AO clocking and triggering features are extensive and can be configured in various different ways.

Analog Output Clocking

Clocking comprises of two input signals:

1. Clock In – used to clock analog output channels in channel list.
2. Trigger In – used to start/stop acquisition

.

You must load the channel list prior to starting this operation.

Clocking can be controlled by:

Software Strobe
Internal Clock (DSP)
External Clock

Universal External Interrupt/Clock/Synchronization Inputs

Note You can only use these lines for Analog Output Clocking OR Triggering

Triggering is configured as follows:

Use the IRQB pin to asynchronously update all DACs.

Use the IRQC pin to supply your external trigger source.

Trigger modes:

Start trigger (acquisition starts on rising edge of the trigger signal)

Stop trigger (acquisition stops on rising edge of the trigger signal)

Trigger lines should be pulled-down to ground via 4.7Kohm resistors.

Synchronizing two or more boards

Note Using the PowerDAQ AO control panel application, please ensure the software driver recognizes the two or more PowerDAQ AO boards. No custom synchronization cables are required – all connections can be made directly on the screw terminal. PDXI-AO boards provides a special configuration program PDXICFG.EXE that allows synchronize boards via the PXI bus extension. This feature is not available in standard Compact PCI chassis.

If internal connection between multiple boards is required, the following connections should be made (PD2-AO boards only):

The PowerDAQ PD2-AO J2 internal connector has a TMR2 Clock I/O pin. You can connect this pin to the TMR2 pin of the next board you wish to synchronize acquisition. It is preferable to use a 100-200 Ohm series resistor for the clock connection.

For a custom cable contact the factory.

4

API and Third-Party Software Examples

API and Third–Party Software Examples

The PowerDAQ Software Suite API and third party software drivers support all PowerDAQ AO board features. This chapter provides an overview on how to use the API calls and examples using third-party software.

API Function calls

Please refer to PowerDAQ SDK and programmer manual for the details about Analog Output board programming.

Generally Analog Output subsystem works in the same way as all other paced subsystems. The following command sequence should be used to program the PowerDAQ AO board in a low-level language such as C/C++/VB/Delphi:

- Open Driver. This allows you to check that the driver is installed properly and started and also gets a number and parameters of the PowerDAQ boards installed in the system.
- Open Adapter. After the adapter is opened the PowerDAQ SDK return a special handle that should be used for all calls referring to a specific PowerDAQ board installed. This call locks the specific PowerDAQ board by the specific application.
- Open Subsystem. This call grants access to one of the available PowerDAQ board subsystems. The following subsystems can be accessed on a PowerDAQ Analog Output board: Analog Output, Digital Input, Digital Output, DSP Counter and Calibration.
- Work with subsystem. There are two different ways to use a subsystem – in synchronous and asynchronous mode.

- In Synchronous Mode (known as Single Update on the AO subsystem) there is a set of calls available which gives direct and immediate access to the DACs (DIO ports and DSP Timers). Timed access can be made using the operating system based timing loops.
- In Asynchronous Mode (which has two sub-modes on PowerDAQ AO boards – event-based and regenerate mode) , a dedicated acquisition buffer is allocated in host PC memory. This buffer is divided by the number of logical blocks called frames, usually between 4 and 16 frames should be allocated. The following steps should be considered when Asynchronous acquisition mode is used:

  - User application uses API calls to allocate the acquisition buffer and fill it with initial data for all output subsystems.
  - Subsystem configuration word should be assembled using the API constants provided.
  - The user application should define a set of events from the board. A typical set of events include data availability events and error events
  - Start of asynchronous operation
  - WaitForSingleObject operating system function call or an equivalent should be used to check for events from the board. It is preferable to put this call into a separate thread. After an event, the application should re-initialize it and process the data.
  - Terminate asynchronous operation
  - Auto-regenerate mode user application can allocate one or more frames in the buffer, fill it with data and start acquisition. The PowerDAQ driver will control event handling and supply more data into the on-board FIFO as requested. Note, that frame size cannot exceed 64Mbytes. The size of the buffer itself is limited by the amount of Physical memory installed on your PC.

- Close subsystem. When the application closes the subsystem it's frees-up resources.
- Close adapter. After the adapter is closed it is accessible from other applications.
- Close driver.

API Examples

The PowerDAQ Software Suite contains a complete set of self-documented examples dedicated to PowerDAQ AO boards programming. The best way to write your own program is to use a ready-to-run example and modifiy it as required by your application.

The examples are available in the following languages:

C/C++/Delphi/VisualBASIC:

- Single Update Example (Separate example available for the PD2-AO-96/16 board)
- Buffered output Example (Event-based)

Please refer to the example sources for extensive programming details. All examples are located in
<Program Files Dir>\PowerDAQ\SDK\Examples\<Language>\<Example>

Third–party examples

All third-party drivers, supplied by OMEGA include a set of examples, which support all of the PowerDAQ Analog Output board features. They are usually installed during the SDK installation process into the folders defined by third-party software vendors. Please refer to the readme file of the SDK version to find an exact location of the examples you need.

5

Interconnections

Interconnections

PD2– AO–8[16][32] Connectors

The PowerDAQ PD2-AO-8[16][32] boards have two connectors and one header:

96-contact high-density Fujitsu header – analog output connector (J1)

36-way boxed IDC header (DIO/Timer and IRQ lines)

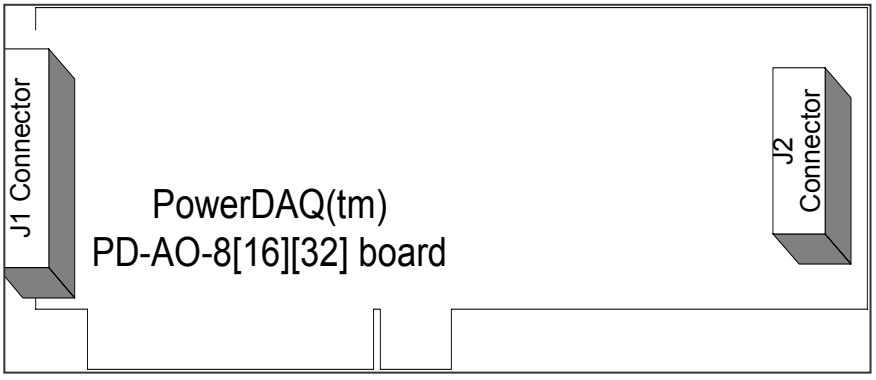


Figure 5: PowerDAQ PD2–AO–8[16][32] Connectors

Note For manufacturers part numbers, *see Appendix A: Specifications*.

PD2- AO-96 Connectors

The PowerDAQ PD2-AO-96 boards have seven headers on it:

40-way boxed IDC header – analog output connectors (J3-J8)

36-way boxed IDC header (DIO/Timer and IRQ lines)

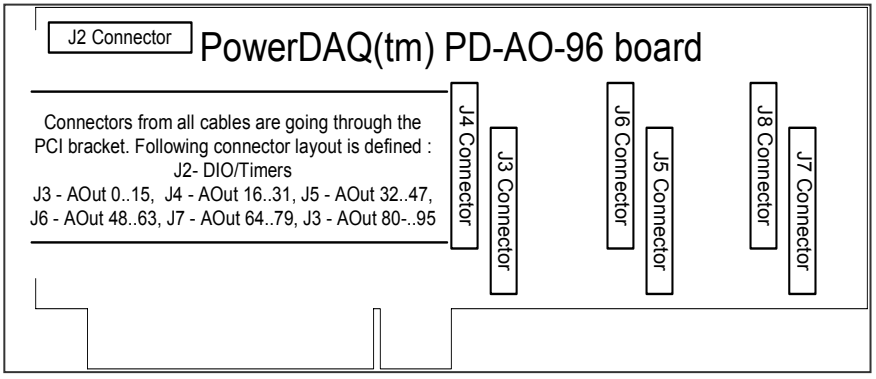


Figure 6: PowerDAQ™ PD2–AO–96 Connectors

Note For manufacturers part numbers, *see Appendix A: Specifications*.

PDXI– AO–8[16][32] Connectors

The PowerDAQ PD2-AO-8[16][32] boards have only one connector:

96-contact high-density Fujitsu header — analog output and DIO/Timers connector (J1)

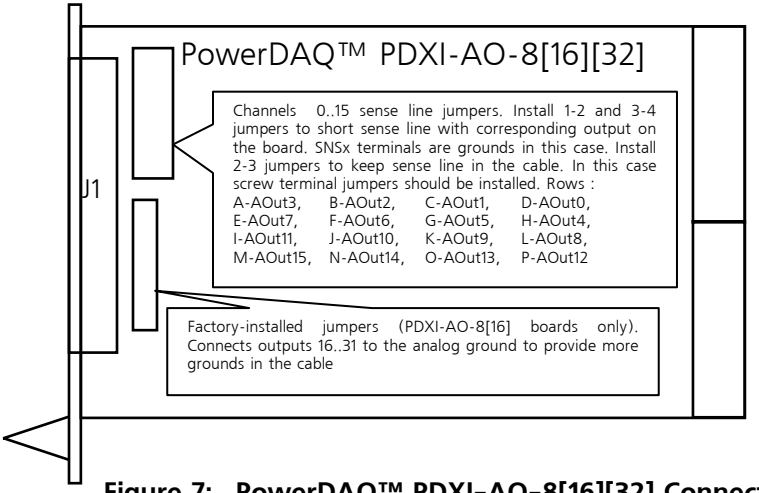


Figure 7: PowerDAQ™ PDXI–AO–8[16][32] Connectors

Note For manufacturers part numbers, *see Appendix A: Specifications*.

PD2-AO-8[16][32] J1 Analog Connector

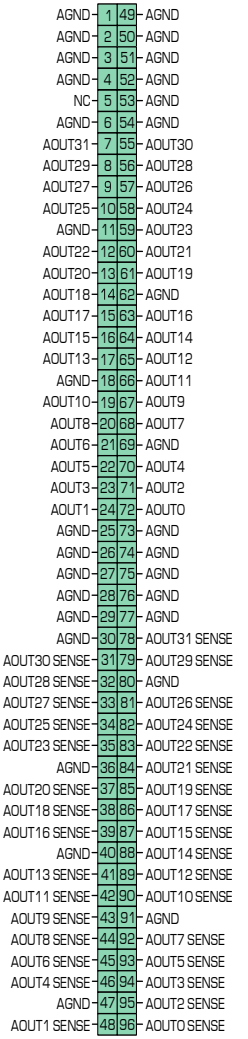


Figure 8: Connector pin assignment for the J1

The compatible pin out was used for the PD2-AO-8[16][32] and PD2-MF(S) J1 connector to provide the ability to use common accessories. For the details see conversion table in Appendix B. Note, that on PD2-AO-8[16] AOUT16..31 and AOUT16..31 SENSE are connected to the ground.

PD2–AO J2 DIO/Counter/Timers/IRQx Connector

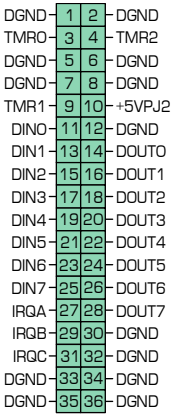


Figure 9: Connector pin assignment for the J2

J1–J2 Connection Example

The example below shows how to connect PD2-AO board to the PD2-AO-STP screw terminal.

Note For the PD2-AO-8[16] board lines OUT16-OUT31 and OUT16S-OUT32S are tied to the analog ground.

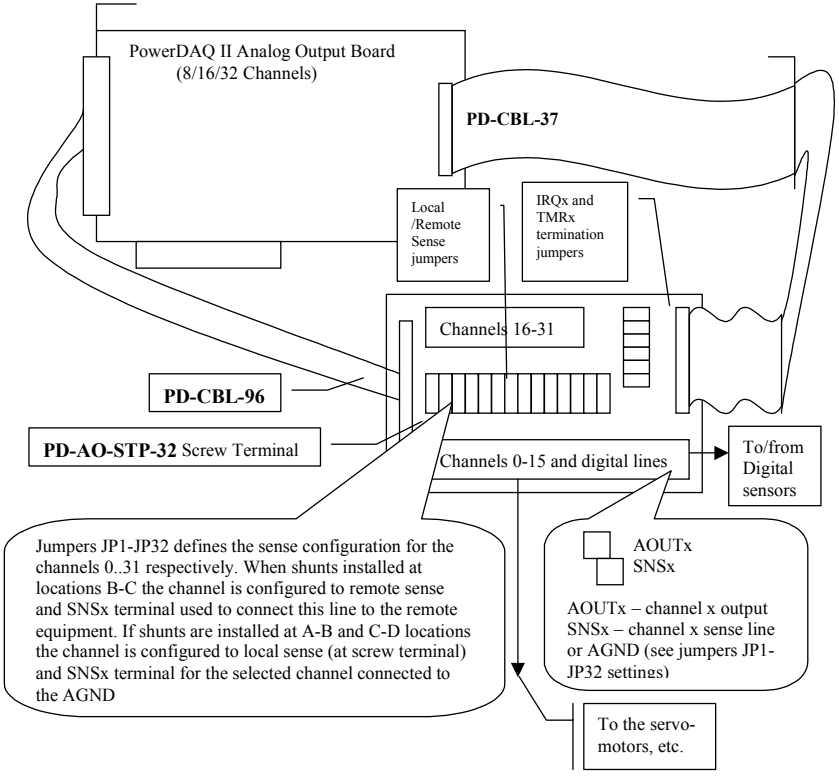


Figure 10: Configuring the PD2-AO-STP with PD2-AO-8[16][32]

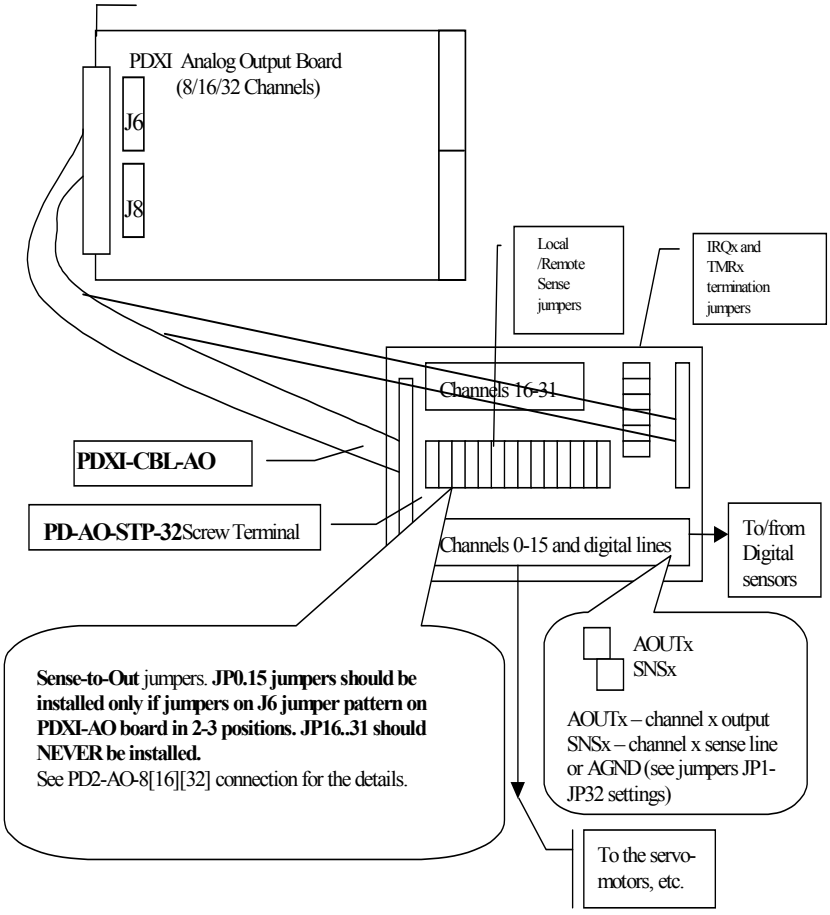


Figure 11: Configuring the PD2-AO-STP with PDXI-AO-8[16][32]

Appendix A: Specifications

PD2-AO specifications:

The following conditions apply:
T_A = 0°C to +85°C

AO subsystem

Parameter	Value
Number of channels	8,16,32 or 96 (PD2-AO only)
Resolution	16 bits
Update rate	100 KS/s channel, up to 1600 KS/s aggregate throughput in DMA mode, 455 KS/s in unlimited channel list mode.
Buffer Size	2k samples (upgradeable to 32 KSamples on PDXI-AO models)
Type of D/A	Double-buffered
Accuracy	+/- 3 LSB max
DNL	+/- 3 LSB max
Monotonicity Over Temperature	15 bits
Gain Error	0.02% (PDXI-AO), 0.05% (PD2-AO)
Range	+/- 10V fixed, 0..10V factory-installed option available for PD2-AO-96/16 board
Output Coupling	DC
Output Impedance	0.15 Ohm max
Current Drive	+/-5mA (PDXI-AO,PD2-AO-96) +/-20mA(PD2-AO-8[16][32])
Capacitive Loads	180 pF min
Settling time	10uS to 0.003%
Slew Rate	10V/uS
Gain Bandwidth	1 MHz
Noise	2LSB RMS, 0-10000Hz
Output protection	Short to ground, +/- 15 Volts
Power-on state, default, user programmable	0.0000V +/-25mV (PD2-AO-8[16][32] 0.0000V +/-5mV (PD2-AO-96, PDXI-AO)
Gain drift	25ppm/deg C

Note Due to the quad DACs, the current is limited. Only one output of each may be continuously shorted to ground. The current is limited to 40 ma for PD2-AO-8[16][32] boards and 20 ma for all other models.

Digital Input and Output

Parameter	Value
Number of channels	8 inputs and 8 outputs
Compatibility	CMOS/TTL, 2KV ESD protected
Power-on state	Logic Zero
Input termination	4.7Kohm pull-up to 5V
Output High Level	3.0V min @ -32 mA, 3.4V min @ -16 mA, 4.2V min @ -2 mA
Output Low Level	0.55V max @ 64 mA
Input Low Voltage	0.0 - 0.8 V
Input High Voltage	2.0 - 5.0 V
Input current	1uA

DSP – based subsystems

There are two DSP-based subsystems available on the PowerDAQ DIO boards:

- Counter/timers
- High-speed interrupts

DC ELECTRICAL CHARACTERISTICS FOR DSP-BASED SUBSYSTEMS

Counter/timers

Parameter	Value
Number of channels	3
Resolution	24 bits
Maximum frequency	16.5/25MHz for the external, 33/50 MHz for the internal clock (see notes)
Minimum frequency	DC for input, 0.001Hz for output
Minimum Pulse Width	20 nS

Output High Level	2.0V min @ -4 mA
Output Low Level	0.5V max @ 4 mA
Input Low Voltage	0.0 - 0.8 V
Input High Voltage	2.0 - 5.0 V
Input current	1uA

- External Event Counter
- Input Width Measurement
- Input Period Measurement
- Event Capture
- Pulse Width Modulation (PWM)
- Watchdog Pulse
- Watchdog Toggle

Note The external clock frequency should be less than the internal operating frequency divided by 4 (I.e. 16.33/25.00 MHz for 66/100 MHz DSP). The standard PowerDAQ boards ships with a 66 MHz DSP.

COUNTER/TIMER SPECIFICATIONS:

Note The maximum timer frequency is 16.33 MHz for external clock and 33 MHz for internal clock (66 MHz DSP core). TIO assumes timer I/O pin, CLKOUT – DSP clock. The minimum pulse width is 20 ns for an external clock/event.

The following conditions apply:
T_A = 0°C to +100°C; C load = 50pF + 2 TTL loads

CONNECTORS SPECIFICATIONS

Connector	Description/Manufacturer/P/N
J1 (PD2-AO-8[16][32], PDXI-AO)	Fujitsu Takamisawa America, Inc. 408-745-4990 Fax: 408-745-4995. Connector p/n FCN-230C096-C/E and the metal cover p/n FCN-247J096-G/E.
J2 (PD2-AO)	J2 connector is a 36-way boxed IDC header. The manufacturer is Tomas & Betts (www.tnb.com), p/n for the connector is 609-3627.
J3-J8 (PD2-AO-96)	J3-J8 connectors are 40-way boxed IDC headers. The manufacturer is 3M (http://www.mmm.com/esm/), p/n for the connector is 2540-6002UB.

ENVIRONMENT

Operating environment	0°C to 70°C

Appendix B: Accessories

Overview

The PowerDAQ AO boards can connect to a variety of stand-alone or 19" rack-mount accessory panels. A complete range of cables and options are available.

If you require a custom accessory, please contact the factory.

These are following options available for use with PowerDAQ AO boards:

- The universal screw terminal PD2-AO-STP-32 includes both analog and digital terminals and allows you to connect Analog Output and Sense lines directly at the screw terminal. May be used with all PowerDAQ AO boards except PD2-AO-96 (note, that digital part of this screw terminal still can be utilized)
- PD-BNC-16/64. This BNC terminal connects each Analog Output line using the BNC-terminated cable that allows eliminating or reducing external noise. PD-BNC-16 may be used with PD2/PDXI-AO-8 boards only. PD-BNC-64 may be used with all PowerDAQ AO boards except PD2-AO-96.
- PD-CONN-PCB – This small terminal panel is useful in OEM applications but does not provide the ability to connect the digital signals to/from the board
- PD-STP-3716. This terminal connects sixteen analog output channels to PD2/PDXI-AO-8 or PD2-AO-96 board. May be considered as a low cost termination option

Cables: (PD[XI]–CBL–xx)

PD–CBL–96: The J1 connectors use a 96-way shielded round 1-meter cable with a metal connector on either end. It connects to: PD2-AO-STP-xx, PD-BNC-xx accessory panels. Used with all PD2-AO boards except PD2-AO-96.

PDXI–CBL–AO: The PDXI-AO J1 connectors use a split 96-way shielded round 1-meter cable. It connects to: PD2-AO-STP-xx, PD-BNC-xx accessory panels. Note, that both analog and digital signals are connected to the screw terminal using this cable.

PD–CBL–37: This is a 37-way ribbon connector set. It comprises of a 13" internal ribbon cable which connector from the PowerDAQ™ II AO board J2 internal digital connector (DIO/Counters/IRQx) to a 37-way D-SUB bracket. A 1-meter ribbon cable then connects from the bracket to the PD-AO-STP accessory panels. The PD-CBL-37 is available as an option.

PD–CBL–4037TP: This is a 36-way ribbon cable which connectos from the PowerDAQ™ II AO 96 channel board J3-J8 internal analog connector to a 37-way D-SUB bracket. A 1-meter ribbon cable then connects from the bracket to the PD-STP-3716 accessory panels. Used with PD2-AO-96 boards only.

Screw Terminal Panels: (PD2–AO–STP–xx)

The PD2-AO-STP-32 is a 32-channel screw terminal panel, which includes connections to the counter timers, high-speed interrupt/synchronization lines and DIO ports.

Custom terminal panels are available. Please contact your distributor or the factory.

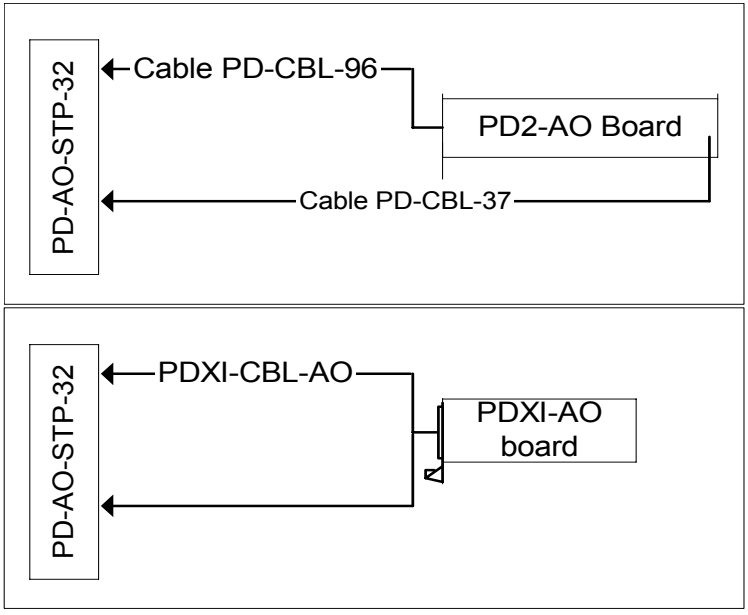


Figure 12: PD2–AO–STP–32 Wiring Diagram

Screw Terminal Panels: (PD–STP–3716)

The PD-STP-3716 is a simple 16-channel screw terminal panel, which includes connections to the analog signals only. This terminal panel can be used with PD2-AO-96 and PD2[PDXI]-AO-8 boards only. Note, that different cables are required for the different boards:

- PD-CBL-9637 – used with PD2-AO-8
- PDXI-CBL-AO – used with PDXI-AO-8
- PD-CBL-4037TP – used with PD2-AO-96

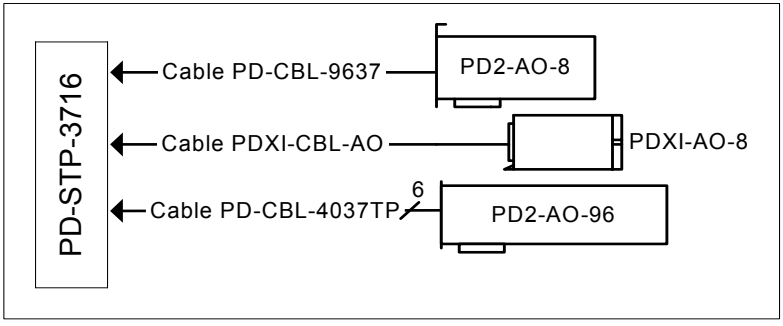


Figure 13: PD–STP–3716 Wiring Diagram

Note That if Sense lines are available on PD2-AO-8 or J6 jumpers in 2-3 position on PDXI-AO-8 AOutx line should be connected to ASensex line on the screw terminal.

Terminal Pin	**PD2 [PDXI]-AO-8**	**PD2-AO-96**	**Terminal Pin**	**PD2 [PDXI]-AO-8**	**PD2-AO-96**
1	OUT0	Clk. In.	20	SNS0	Clk.Out
2	AGND	Ext. Trig	21	OUT1	DGND
3	SNS1	DGND	22	AGND	AGND
4	AGND	OUT0	23	OUT2	AGND
5	SNS2	OUT1	24	AGND	AGND
6	AGND	OUT2	25	OUT3	AGND
7	SNS3	OUT3	26	AGND	AGND
8	AGND	OUT4	27	OUT4	AGND
9	SNS4	OUT5	28	AGND	AGND
10	AGND	OUT6	29	OUT5	AGND
11	SNS5	OUT7	30	AGND	AGND
12	AGND	OUT8	31	OUT6	AGND
13	SNS6	OUT9	32	AGND	AGND
14	AGND	OUT10	33	OUT7	AGND
15	DNC	OUT11	34	SNS7	AGND
16	DNC	OUT12	35	DNC	AGND
17	DNC	OUT13	36	DNC	AGND
18	DNC	OUT14	37	DNC	N/C
19	DNC	OUT15		DNC= Do not connect	

OEM Header Distribution Connector

For the OEM the PD2-AO and PDXI-AO board provides the PD-CONN-PCB – a small terminal panel. The PD-CONN-PCB allows you to connect both PD2-MF/MFS and PD2-AO/PDXI-AO boards. See table on the next page for the pinout conversion.

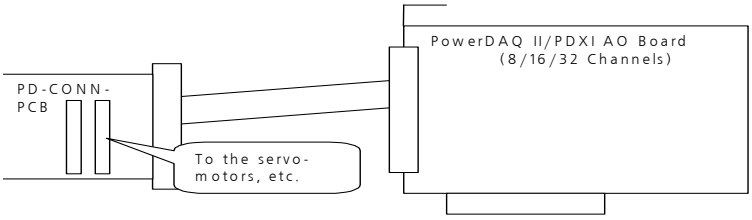


Figure 14: PD–CONN–PCB wiring diagram

Custom terminal panels are available. Please contact the factory or your distributor.

Accessory Board Connections

PD2-MFx	PD2-AO-32	J1	J1	PD2-AO-32	PD2-MFx
		Pin	Pin		
AGND	AGND	1	49	AGND	AGND
AGND	AGND	2	50	AGND	AOUT0
AGND	AGND	3	51	AGND	AGND
AGND	AGND	4	52	AGND	AOUT1
DGND	DGND	5	53	AGND	AGND
AGND	AGND	6	54	AGND	AGND
AIN55	AOUT31	7	55	AOUT30	AIN54
AIN53	AOUT29	8	56	AOUT28	AIN52
AIN51	AOUT27	9	57	AOUT26	AIN50
AIN49	AOUT25	10	58	AOUT24	AIN48
AGND	AGND	11	59	AOUT23	AIN39
AIN38	AOUT22	12	60	AOUT21	AIN37
AIN36	AOUT20	13	61	AOUT19	AIN35
AIN34	AOUT18	14	62	AGND	AGND
AIN33	AOUT17	15	63	AOUT16	AIN32
AIN23	AOUT15	16	64	AOUT14	AIN22
AIN21	AOUT13	17	65	AOUT12	AIN20
AGND	AGND	18	66	AOUT11	AIN19
AIN18	AOUT10	19	67	AOUT9	AIN17
AIN16	AOUT8	20	68	AOUT7	AIN7
AIN6	AOUT6	21	69	AGND	AGND
AIN5	AOUT5	22	70	AOUT4	AIN4
AIN3	AOUT3	23	71	AOUT2	AIN2
AIN1	AOUT1	24	72	AOUT0	AIN0
AGND	AGND	25	73	AGND	AGND
Ext. Trig In	AGND	26	74	AGND	+5V
CV Clock Out	AGND	27	75	AGND	CV Clock In
N/C	AGND	28	76	AGND	AGND
AGND	AGND	29	77	AGND	N/C
CL Clock In	AGND	30	78	AOUT 31 SENSE	AIN63
AIN62	AOUT 30 SENSE	31	79	AOUT 29 SENSE	AIN61
AIN60	AOUT 28 SENSE	32	80	AGND	AGND
AIN59	AOUT 27 SENSE	33	81	AOUT 26 SENSE	AIN58
AIN57	AOUT 25 SENSE	34	82	AOUT 24 SENSE	AIN56
AIN47	AOUT 23 SENSE	35	83	AOUT 22 SENSE	AIN46
AGND	AGND	36	84	AOUT 21 SENSE	AIN45
AIN44	AOUT 20 SENSE	37	85	AOUT 19 SENSE	AIN43
AIN42	AOUT 18 SENSE	38	86	AOUT 17 SENSE	AIN41
AIN40	AOUT 16 SENSE	39	87	AOUT 15 SENSE	AIN31
AGND	AGND	40	88	AOUT 14 SENSE	AIN30
AIN29	AOUT 13 SENSE	41	89	AOUT 12 SENSE	AIN28
AIN27	AOUT 11 SENSE	42	90	AOUT 10 SENSE	AIN26
AIN25	AOUT 9 SENSE	43	91	AGND	AGND
AIN24	AOUT 8 SENSE	44	92	AOUT 7 SENSE	AIN15
AIN14	AOUT 6 SENSE	45	93	AOUT 5 SENSE	AIN13
AIN12	AOUT 4 SENSE	46	94	AOUT 3 SENSE	AIN11
AGND	AGND	47	95	AOUT 2 SENSE	AIN10
AIN9	AOUT 1SENSE	48	96	AOUT 0 SENSE	AIN8

Table 2: Conversion between the PD2-MF(S) and PD2-AO board J1 connector pinout.

Dimensions:

The following table contains the dimensions of the PowerDAQ™ AO and accessory products.

Accessory	Dimensions (W x L x H)
PDXI-AO-x	3.9”x6.3”x0.5”
PD2-AO-96	4.2”x13.275”x0.5”
PD2-AO-32	4.2”x11”x0.5”
PD2-AO-16	4.2”x8.2”x0.5”
PD2-AO-8	4.2”x8.2”x0.5”
PD2-AO-STP-32	4.2”x7.0”x2.1”
PD-STP-3716	2.8”x4.4”x0.5”
PD-CONN-PCB	3.3”x3.33”x0.4”

Table 3: Dimensions of PowerDAQ™ AO accessory products

Appendix C: Common Questions and Support

Q What is PCI Specification 2.1?

A The PCI LocalBus is a high-performance bus that provides a processor-independent data path between the CPU and high-speed peripherals. PCI is a robust interconnect mechanism designed specifically to accommodate multiple high performance peripherals for graphics, full motion video, SCSI, LAN, etc.

The PCI Local Bus Specifications, Rev 2.1 includes the protocol, electrical, mechanical and configuration specification for the PCI Local Bus components and expansion boards.

The Rev 2.1 was published June 1, 1995 by the PCI Special Interest Group.PO Box 14070,Portland,OR 97214. Web site: *www.pcisig.com*

Calibration Questions

Q How often should I calibrate my board?

A The PD2-AO series board should be calibrated once a year.

Service and Support

If you have technical problems using PowerDAQ™ PD2-AO, our Technical Support department can be reached by:

Telephone: (617) 924 1155

Fax: (617) 924 1441

Email: support@powerdaq.com

Web Site: www.powerdaq.com

For the most efficient service, please be available at your computer and be prepared to answer several questions listed on the following page when you call for technical support. This information helps us identify specific system and configuration-related problems.

Technical Support Form

Photocopy this form and update it each time you make changes to your software or hardware. Completing this form accurately before contacting us for technical support helps our application engineers answer your questions more efficiently.

What is the name and version number of the product?

_____

What version of Windows are you using?

_____

What programming language and version?

_____

Is the board set at factory configuration?

_____

Have you run the board diagnostics? What were the results?

_____

Did the system ever work ? If so, what changed (moved location, installed other boards, software etc..)

_____

Have you run the sample programs? What were the results?

_____

Have you verified that all your connections are made properly and are secure?

_____

Have you been able to isolate the source of your problem: input or output device, board, software?

_____

What other boards or applications are installed in your system?

_____

How much RAM do you have?

_____

What size hard disk are you using?

_____

How fast is your CPU?

_____

How fast is your host data bus?

_____

If you are on a network, what type of network are you using and approximately how many users are on the network?

_____

Please specify whether or not the problem occurred more than once

_____

Appendix D: Warranty

Overview

IBM, IBM PC/XT/AT and IBM PS/2 are trademarks of International Business Machine Corporation.

BASIC is a trademark of Dartmouth College.

Microsoft is a trademark of Microsoft Corporation.

LabVIEW, LabWindows/CVI, DASYLab, DIADEM is a trademark of National Instruments Corporation

All PowerDAQ™ PD2-AO boards have received CE Mark certification according to the following:

EN55011
EN50082-1

Life Support Policy

OMEGA ENGINEERING' PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE LEGAL AFFAIRS DEPARTMENT OF OMEGA ENGINEERING CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can reasonably be expected to result in a significant injury to the user or (c) should the device or system fail to perform, may reasonably be expected to result in a significant hazard to human life, or a significant potential for injury to the user.

2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to effect its safety or effectiveness.

Omega Engineering, inc. warrants that the products furnished under this agreement will be free from material defects for a period of one year from the date of shipment. The customer shall provide notice to Omega Engineering of such defect within one week after the Customer's discovery of such defect. The sole obligation and liability of Untied Electronic Industries under this warranty shall be to repair or replace, at its option, without cost to the Customer, the product or part which is so defective and as to which such notice is given.

Upon request by Omega Engineering, the product or part claimed to be defective shall immediately be returned at the customer's expense to Omega Engineering.

There shall be no warranty or liability for any products or parts which have been subject to misuses, accident, negligence, failure or electrical power or modification by the Customer without Omega Engineering' approval. Final determination of warranty eligibility shall be made by Omega Engineering. If a warranty claim is considered invalid for any reason, the Customer will be charged for services performed and expenses incurred by Omega Engineering in handling and shipping the return item.

As to replacement parts supplied or repairs made during the original warranty period, the warranty period of the replacement or repaired part shall terminate with the termination of the warranty period with respect to the original product or part.

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Reader Evaluating

We are committed to improving the quality of our documentation, in order to serve you better. Your feedback will help us in the effort. Thanks for taking the time to fill out and return this form.

Is the manual well organized?	☐ Yes	☐ No
Can you find information easily?	☐ Yes	☐ No
Were you able to install the PD2-AO boards?	☐ Yes	☐ No
Did you find any technical errors?	☐ Yes	☐ No
Is the manual size appropriate?	☐ Yes	☐ No
Are the design, type style, and layout attractive?	☐ Yes	☐ No
Is the quality of illustrations satisfactory?	☐ Yes	☐ No

How would you rate this manual? ☐ Excellent ☐ Good ☐ Fair ☐ Poor

Why? _____

Suggested improvements:

_____

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Other Comments:

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