

DNx-AO-318 DNx-AO-318-020 DNx-AO-318-024 DNx-AO-318-210

User Manual

AO-318 8-channel, 16-bit, isolated ±10 V D/A voltage board with BIT AO-318-020 8-channel, 16-bit, isolated 0-20 mA D/A current board with BIT AO-318-024 8-channel, 16 bit, isolated 0-24 mA D/A current board with BIT AO-318-210 8-channel, 16 bit, isolated ±10 mA D/A current board with BIT for the PowerDNA Cube and RACK Series Chassis

April 2025

PN Man-DNx-AO-318

© Copyright 2025 United Electronic Industries, Inc. All rights reserved.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form by any means, electronic, mechanical, by photocopying, recording, or otherwise without prior written permission.

Information furnished in this manual is believed to be accurate and reliable. However, no responsibility is assumed for its use, or for any infringement of patents or other rights of third parties that may result from its use.

All product names listed are trademarks or trade names of their respective companies.

CE

Contacting United Electronic Industries

Mailing Address:

249 Vanderbilt Avenue Norwood, MA 02062 U.S.A. Shipping Address:

24 Morgan Drive Norwood, MA 02062 U.S.A.

For a list of our distributors and partners in the US and around the world, please contact a member of our support team:

Support:

Telephone:(508) 921-4600Fax:(508) 668-2350

Also see the FAQs and online "Live Help" feature on our web site.

Internet Support:

Support:	uei.support@ametek.com
Website:	www.ueidaq.com

Product Disclaimer:

WARNING!

DO NOT USE PRODUCTS SOLD BY UNITED ELECTRONIC INDUSTRIES, INC. AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS.

Products sold by United Electronic Industries / AMETEK are not authorized for use as critical components in life support devices or systems. 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 affect its safety or effectiveness. Any attempt to purchase any United Electronic Industries / AMETEK product for that purpose is null and void and United Electronic Industries / AMETEK accepts no liability whatsoever in contract, tort, or otherwise whether or not resulting from our or our employees' negligence or failure to detect an improper purchase.

Specifications in this document are subject to change without notice. Check with UEI for current status.

Table of Contents

Chapter 1 Introduction			
1.1	Organization of this Manual		
1.2 1.2.1 1.2.2 1.2.3 1.2.4 1.2.5	AO-318 Board Overview3DAC Output Capabilities3Guardian Diagnostic Support3Data Update Rates3Isolation3Software Support3		
1.3	Features 4		
1.4	Specification		
1.5 1.5.1 1.5.2 1.5.3 1.5.4	Device Architecture.9AO-318 Output Circuitry.9AO-318-02x and AO-318-210 Output Circuitry10Guardian Diagnostic Measurements10Circuit Breakers11		
1.6	Indicators		
1.7	Wiring & Connections (pinout) 13		
1.8 1.8.1 1.8.2 1.8.3 1.8.4 1.8.5	PowerDNA Explorer for AO-31814Guardian Diagnostic (Input) Values15Circuit Breaker Values16Output Values17Initialization Values17Shutdown Values17		
Chapter	eter 2 Programming with the High-level API		
2.1	About the High-level Framework		
2.2	Creating a Session		
2.3	Configuring the Resource String		
2.4	Configuring for Output		
2.5	Configuring the Timing		
2.6	Writing Output Data		
2.7	Monitoring Guardian Diagnostic Measurement		
2.8 2.8.1 2.8.2 2.8.3	Accessing Circuit Breakers22Configuration22Status23Manual Reset24		
2.9	Cleaning-up the Session		
Chapter	napter 3 Programming with the Low-level API		
3.1	About the Low-level API		
3.2	Low-level Functions		
3.3 3.3.1	Low-level Programming Techniques		



DNx-AO-318 Analog Output Board ii Table of Contents

3.4	Programming the AO-318 (Immediate Mode)
3.4.1	Configuring Output Channels
3.4.2	Writing Output Data 27
3.4.3	Configuring Guardian Diagnostics
3.4.4	Monitoring Diagnostic Measurements 30
3.4.5	Configuring Circuit Breakers 31
3.4.6	Reading Circuit Breaker Status
3.4.7	Reengaging Circuit Breakers



List of Figures

Chapter	1 Introduction	1
1-1	Block Diagram of the AO-318	.9
1-2	Simplified Block Diagram of an AO-318 Channel	.9
1-3	Simplified Block Diagram of an AO-318-02x/AO-318-210 Channel1	0
1-4	Guardian ADC Error Rate vs Sampling Frequency1	1
1-5	Photo of DNR-AO-318 Analog Output Board1	2
1-6	Pinout diagram of AO-318	3
1-7	PowerDNA Explorer Output Control Panel for AO-318	
1-8	PowerDNA Explorer Diagnostic Input Panel for AO-31815	
1-9	PowerDNA Explorer Circuit Breaker Panel for AO-3181	6
1-10	PowerDNA Explorer Output Panel for AO-318-0201	7
Chapter	2 Programming with the High-level API1	8
Chapter	3 Programming with the Low-level API	25
3-1	Block Diagram of Diagnostic Measurement Points for AO-318 Channel2	28
3-2	Diagram of Diagnostic Measurement Points on Current Board Channels	29
A-1	Pinout and photo of DNA-STP-37 screw terminal panel	5



List of Tables

Chapter	1 Introduction	1
1-1	DNx-AO-318 Technical Specifications	.5
1-2	DNx-AO-318-020 Technical Specifications	.6
1-3	DNx-AO-318-024 Technical Specifications	.7
1-4	DNx-AO-318-210 Technical Specifications	.8
1-5	AO-318 Diagnostic Channels for Guardian Diagnostic Measurements	10
1-6	AO-318 Indicators	12
Chapter	2 Programming with the High-level API	8
2-1	Analog Output to Analog Input Channel Mapping	21
Chapter	3 Programming with the Low-level API	25
3-1	Summary of Low-level API Functions for DNx-AO-318	26
3-2	AO-318 Diagnostic Measurements	28



Chapter 1 Introduction

This manual outlines the feature set and use of the DNx-AO-318, an 8-channel digital-to-analog output board:

- AO-318-1: 16-bit, 8-channel, ±10 V analog voltage output board
- AO-318-020: 16-bit, 8-channel, 0-20 mA analog current output board
- AO-318-024: 16-bit, 8-channel, 0-24 mA analog current output board
- AO-318-210: 16-bit, 8-channel, ±10 mA analog current output board

The following sections are provided in this chapter:

- Organization of this Manual (Section 1.1)
- AO-318 Board Overview (Section 1.2)
- Features (Section 1.3)
- Specification (Section 1.4)
- Device Architecture (Section 1.5)
- Indicators (Section 1.6)
- Wiring & Connections (pinout) (Section 1.7)
- PowerDNA Explorer for AO-318 (Section 1.8)

1.1 Organization This AO-318 User Manual is organized as follows:

of this Manual

- **Introduction** Chapter 1 provides an overview of DNx-AO-318 features, device architecture, connectivity, and logic.
- **Programming with the High-Level API** Chapter 2 provides an overview of the how to create a session, configure the session, and interpret results with the Framework API.
- **Programming with the Low-Level API** Chapter 3 is an overview of low-level API commands for configuring and using the AO-318 series board.
- Appendix A Accessories The appendix provides a list of accessories available for use with the DNx-AO-318 board.
- **NOTE:** A glossary of terms used with the PowerDNA Cube/RACK and I/O boards can be viewed or downloaded from www.ueidaq.com.



Manual Conventions

To help you get the most out of this manual and our products, please note that we use the following conventions:



Tips are designed to highlight quick ways to get the job done or to reveal 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, and damage to your boards or a system crash.

Text formatted in **bold** typeface generally represents text that should be entered verbatim. For instance, it can represent a command, as in the following example: "You can instruct users how to run setup using a command such as **setup.exe**."

Bold typeface will also represent field or button names, as in "Click **Scan Network**."

Text formatted in fixed typeface generally represents source code or other text that should be entered verbatim into the source code, initialization, or other file.

Examples of Manual Conventions



Before plugging any I/O connector into the Cube or RACKtangle, be sure to remove power from all field wiring. Failure to do so may cause severe damage to the equipment.

Usage of Terms



Throughout this manual, the term "Cube" refers to either a PowerDNA Cube product or to a PowerDNR RACKtangle[™] rack mounted system, whichever is applicable. The term DNR is a specific reference to the RACKtangle, DNA to the PowerDNA I/O Cube, and DNx to refer to both.



1.2	AO-318 Board Overview	The DNx-AO-318 boards are fully isolated, high-precision, 8-channel analog output boards.
		DNA-AO-318, DNR-AO-318, and DNF-AO-318 board versions are compatible with the UEI Cube, RACKtangle, and FLATRACK chassis respectively. These board versions are electronically identical and differ only in mounting hardware. The DNA version is designed to stack in a Cube chassis. The DNR/F versions are designed to plug into the backplane of a RACK chassis.
1.2.1	DAC Output Capabilities	The boards offer full 16-bit resolution and guarantee monotonicity over the entire operating temperature range. AO-318 boards provide output as follows:
		 For the AO-318 model each channel provides an output range of ±10 V and is capable of driving up to ±10 mA (max). For the AO-318-020 each channel provides an output range of 0-20 mA (sourcing) and is capable of driving up to 470 Ω load. For the AO-318-024 each channel provides an output range of 0-24mA (sourcing) and is capable of driving up to a 400 Ω load. For the AO-318-210 each channel provides an output range of ±10 mA (sourcing) and is capable of driving up to 400 Ω load.
		For applications requiring higher output current or voltage, please refer to the DNx-AO-308-35x series boards.
1.2.2	Guardian	The DNx-AO-318 provides extensive built-in-test diagnostics.
	Diagnostic Support	An onboard A/D converter on each channel allows the user to monitor diagnostic voltages, current, and temperature. A solid state relay on each output allows the D/A channel to be disconnected from the field I/O so that a complete board self-test can be completed without driving the circuitry connected to the outputs. This relay, in combination with the output current and voltage sensing, can also be set to disconnect the D/A output in the event of an external fault condition such as a short to ground or a DC power supply.
1.2.3	Data Update Rates	A 1024 sample FIFO allows each D/A to be updated at 10 kHz without data loss. Double buffering the outputs combined with the use of low glitch D/As make the DNx-AO-318 an ideal solution for generating low frequency waveforms or providing highly accurate switched stimulus.
1.2.4	Isolation	The outputs of the AO-318 are fully isolated from each other, the I/O chassis as well as from other I/O boards within the I/O chassis. All connections are made through a 37-pin D connector. Users may also connect the DNx-AO-318 boards to our DNA-STP-37 screw terminal panel via the DNA-CBL-37 cable. The cables are fully shielded and are available in 2.5, 10 and 20 foot lengths.
1.2.5	Software Support	Software included with the DNx-AO-318 provides a comprehensive yet easy to use API that supports Windows, Linux, QNX, VxWorks, and most other popular real-time operating systems. Windows users may take advantage of the UEIDAQ Framework, which provides a simple and complete software interface to all popular Windows programming language and data acquisition and control applications, such as LabVIEW and MATLAB.



1.3 Features The AO-318 boards have the following features:

- Eight independent fully isolated 16-bit digital-to-analog converters
- AO-318-1 design includes dual, redundant DACs per channel (one active at a time); The AO-318-02x and AO-318-210 are designed with a single DAC per channel.
- Built-in-test functionality monitors both output voltage and current
- · Electronic circuit breakers on under/over-voltage or current
- 10 kHz per channel maximum update rate
- AO-318 output range of ±10 V, up to ±10 mA (max) per channel
- AO-318-020 output range of 0-20 mA per channel, up to 470 Ω load
- AO-318-024 output range of 0-24 mA per channel, up to 400 Ω load
- AO-318-210 output range of ±10 mA per channel, up to 400 Ω load
- Glitch-free output
- Tested to withstand 5 g vibration, 50 g shock, -40 to +85°C temperature, and altitude up to 70,000 ft (21,000 meters).



1.4 Specification The technical specifications for DNx-AO-318 boards are listed in Table 1-1. *Table 1-1 DNx-AO-318 Technical Specifications*

Number of channels	8 channels
Resolution	16-bit
Max Update Rate	10 kHz/channel (80 kHz max aggregate)
FIFO Buffer Size	1024 samples
INL (no load)	±6 LSB (0.018%)
DNL (no load)	±2 LSB (0.006%)
Monotonicity	16 bits guaranteed over temperature
Gain Calibration Error	±610 μV, typical
Offset Calibration Error	±305 μV, typical
Output Range	±10 V
Output Impedance	0.5 Ω (typ)
Current Drive	±10 mA/channel
Settling Time	50 μs to 16 bits
Slew Rate	1 V/µs
Power up state	0 V ±10 mV
Built-in Test	
Accuracy (V / I)	±5 mV / 100 μA (± 50 mV / 1 mA over FS temp)
Sample/Update rate	~1 sample/sec on each channel (default)
Isolation	350 Vrms channel-to-channel and field wiring to chassis.
Power Consumption	4.0 W (not including output loads)
Operating Temp. (tested)	-40 °C to +85 °C
Operating Humidity	95%, non-condensing
Vibration	
IEC 60068-2-6	5 g, 10-500 Hz, sinusoidal
IEC 60068-2-64	5 g (rms), 10-500 Hz, broadband random
Shock IEC 60068-2-27	100 g, 3 ms half sine, 18 shocks @ 6 orientations 30 g, 11 ms half sine, 18 shocks @ 6 orientations
Altitude	120,000 ft
MTBF	480,000 hours



The technical specifications for DNx-AO-318-020 boards are listed in Table 1-2
--

Number of charge sta	0 shannala
Number of channels	8 channeis
Resolution	16-bit
Max Update Rate	10 kHz/channel (80 kHz max aggregate)
FIFO Buffer Size	1024 samples
INL (no load)	±6 LSB (0.018%)
DNL (no load)	±2 LSB (0.006%)
Monotonicity	16 bits guaranteed
Gain Linearity Error	0.002%
Gain Calibration Error	±2.5 μA, typical
Offset Calibration Error	±2.5 μA, typical
Offset Drift	10 ppm/°C, typical
Gain Drift	10 ppm/°C, typical
Output Range	0-20 mA
Settling Time	500 µs to 16 bits
Load Range	0 to 470 Ω for full 0-20 mA swing
Isolation	350 Vrms
Built-in Test	
Voltage Accuracy	±50 mV
Current Accuracy	25 μΑ
Sample rate	Up to 20 Hz per channel total
Power Consumption	4.5 W ot including output load
Operating Temp. (tested)	-40 °C to +85 °C
Operating Humidity	0-95%, non-condensing
Vibration	
IEC 60068-2-6	5 g, 10-500 Hz, sinusoidal
IEC 60068-2-64	5 g (rms), 10-500 Hz, broadband random
Shock	100 g, 3 ms half sine, 18 shocks @ 6 orientations
IEC 60068-2-27	30 g, 11 ms half sine, 18 shocks @ 6 orientations
Altitude	120,000 ft
MTBF	480,000 hours



The technical specifications for DNx-AO-318-024 boards are listed in Table 1-3
--

	•
Number of channels	8 channels
Resolution	16-bit
Max Update Rate	10 kHz/channel (80 kHz max aggregate)
FIFO Buffer Size	1K samples (each channel)
INL (no load)	±6 LSB (0.018%)
DNL (no load)	±2 LSB (0.006%)
Monotonicity	16 bits guaranteed
Gain Linearity Error	0.002%
Gain Calibration Error	±5 μA, typical
Offset Calibration Error	±5 μA, typical
Offset Drift	15 ppm/°C, typical
Gain Drift	15 ppm/°C, typical
Output Range	0-24 mA
Settling Time	500 µs to 16 bits
Load Range	0 to 400 Ω for full 0-24 mA swing
Isolation	350 Vrms
Built-in Test	
Voltage Accuracy	±25 mV
Current Accuracy	25 μΑ
Sample rate	Up to 6 Hz per channel total (3 Hz if both current
	and voltage are monitored)
Power Consumption	4.5 W ot including output load
Operating Temp. (tested)	-40 °C to +70 °C for full output to 24 mA
	-40 °C to +85 °C for 0-20 mA range
Operating Humidity	0-95%, non-condensing
Vibration	
IEC 60068-2-6	5 g, 10-500 Hz, sinusoidal
IEC 60068-2-64	5 g (rms), 10-500 Hz, broadband random
Shock	100 g, 3 ms half sine, 18 shocks @ 6 orientations
IEC 60068-2-27	30 g, 11 ms half sine, 18 shocks @ 6 orientations
Altitude	120,000 ft
MTBF	480,000 hours



Number of channels	8 channels
Resolution	16-bit
Max Update Rate	10 kHz/channel (80 kHz max aggregate)
FIFO Buffer Size	1K samples (each channel)
INL (no load)	±6 LSB (0.018%)
DNL (no load)	±2 LSB (0.006%)
Monotonicity	16 bits guaranteed
Gain Linearity Error	0.002%
Gain Calibration Error	±10 μA, typical
Offset Calibration Error	±10 μA, typical
Offset Drift	15 ppm/°C, typical
Gain Drift	15 ppm/°C, typical
Output Range	±10 mA
Settling Time	500 µs to 16 bits
Load Range	0 to 400 Ω for full ±10 mA swing
Isolation	350 Vrms
Built-in Test	
Voltage Accuracy	±25 mV
Current Accuracy	25 μΑ
Sample rate	Up to 6 Hz per channel total (3 Hz if both current
	and voltage are monitored)
Power Consumption	4.5 W ot including output load
Operating Temp. (tested)	-40 °C to +85 °C
Operating Humidity	0-95%, non-condensing
Vibration	
IEC 60068-2-6	5 g, 10-500 Hz, sinusoidal
IEC 60068-2-64	5 g (rms), 10-500 Hz, broadband random
Shock	100 g, 3 ms half sine, 18 shocks @ 6 orientations
IEC 60068-2-27	30 g, 11 ms half sine, 18 shocks @ 6 orientations
Altitude	120,000 ft
MTBF	480,000 hours



1.5 Device Architecture

Figure 1-1 is a block diagram of the architecture of the AO-318 board.



Figure 1-1 Block Diagram of the AO-318

1.5.1 AO-318 Output Circuitry

The AO-318 has eight individual analog output channels.

Each output channel includes a dedicated 16-bit D/A converter and a dedicated A/D converter to monitor voltage, current, and/or temperature for Guardian diagnostic functions (**Figure 1-2** and **Figure 1-3**). Channels are also equipped with dedicated, configurable circuit breakers.

Each output channel is isolated from other channels, and the AO-318 board itself is also optically isolated from the other boards in the chassis.



Figure 1-2 Simplified Block Diagram of an AO-318 Channel

On the AO-318, the output DAC is dual-redundant and is software selectable as completely disabled, A, or B.

1.5.2 AO-318-02x On AO-318-02x and AO-318-210 boards, the output DAC is always set by firmware control to DACA (DACB is not included). and

AO-318-210 **Note** that the AO-318-02x and AO-318-210 current readings for Guardian monitoring are valid within a few microamps. The voltage reading may read lower because of the voltage drop across the DNA-CBL-37 or similar cable which is not accounted for in the voltage readings.



Figure 1-3 Simplified Block Diagram of an AO-318-02x/AO-318-210 Channel

1.5.3 Guardian The Guardian diagnostic readings are performed in the "Voltage, Current, and Temperature Monitor" block (shown in Figure 1-2 and Figure 1-3). Diagnostic Measure-Each of the eight AO-318 output channels is equipped with its own Guardian ADC. The diagnostic measurements listed in Table 1-5 can be read as analog ments input values on the diagnostic ADC channels.

Table 1-5. AO-318 Diagnostic Channels for Guardian Diagnostic Meas
--

ADC Diagnostic Channel	AO-318 Diagnostic Measurement	AO-318-02x/AO-318-210 Diagnostic Measurement
0	Shunt between output connector and A_{GND}	Shunt between output connector and A _{GND}
1	DAC _A output before relay	DAC buffer output
2	DAC _B output before relay	DAC output before the relay
3	DAC output after the relay at output connector	DAC output after the relay at output connector
4	On-die temperature sensor	On-die temperature sensor



Output

Circuitry

1.5.3.1 Configuring The Guardian ADC hardware consists of a 16-bit precision, sequential $\Delta\Sigma$ analog-to-digital converter, which is controlled by the on-board logic. Guardian Diagnostic The sample rate of the Guardian ADC can be set to 5, 7.5 (default), 10, 20, 30, Readings

40, 50 Hz. Note that the ADC uses sequential (multiplexed) inputs. Reading all diagnostic inputs using the default sample rate results in ~1.25 Hz/channel.

UEI recommends using a low sampling rate (the default) when measuring diagnostic values to allow the sequential ADC sufficient time to propagate through all measurements. Higher sampling frequencies yield higher errors, as shown in Figure 1-4.



Figure 1-4 Guardian ADC Error Rate vs Sampling Frequency

Circuit 1.5.4 **Breakers**

Relays at the output of the digital-to-analog converters act as circuit breakers. Refer to Figure 1-2 and Figure 1-3 for location of the relays.

Relays are controlled by the on-board logic, which opens or closes relays when the user-programmable minimum or maximum conditions are exceeded.

Each output channel on the AO-318 standard model has two circuit breakers due to dual redundant DACs. Each output on the AO-318-02x and AO-318-210 boards has one.

Each circuit breaker can be controlled by up to two sources that are user-programmable. Users can set minimum and maximum values for the circuit breakers so that the associated diagnostic ADC channel measurements can be used as a control condition. The minimum/maximum criteria can also be disabled.

ADC Diagnostic Channel		Circuit Breaker Min/Max for ADC CHs		Circuit Breaker Control Source Selection
ADC0	\rightarrow	CB Min/Max for ADC0	←	DAC _{A B} CB Selector 0
ADC1	\rightarrow	CB Min/Max for ADC1	←	DAC _{A B} CB Selector 1
ADC2				
ADC3				
ADC4	Ì			



If a circuit breaker trips, you can disable the circuit breaker channel and/or issue a reset command to the circuit breaker once the signal returns within the min/max bounds.

1.6 Indicators Indicators for the DNx-AO-318 series boards are described in **Table 1-6** and illustrated in **Figure 1-5**.

LED Name	Description
RDY	Indicates board is powered up and operational
STS	Indicates which mode the board is running in:
	 OFF: Configuration mode, (e.g., configuring channels, running in point-by-point mode) ON: Operation mode, (e.g., running in VMap or ACB mode)

Table 1-6	AO-318	Indicators
-----------	--------	------------







1.7 Wiring & Connections (pinout)

Figure 1-6 illustrates the pinout of the AO-318 series boards. Note that analog output signals and analog output grounds on the AO-318 are pin-compatible with AO-308-series output pins.



Figure 1-6 Pinout diagram of AO-318

NOTE: Do not connect to any pins marked as reserved (rsvd).



1.8 PowerDNA Explorer for AO-318

PowerDNA Explorer is a GUI-based application for communicating with your RACK or Cube system. You can use it to start exploring a system and individual boards in the system. PowerDNA Explorer is provided in the installation directory.

When using PowerDNA Explorer to explore your AO-318, note that the right-hand panel contains the following five tabs (see **Figure 1-7**).

- Input: displays input values from the Guardian subsystem
- Circuit Breaker: provides circuit breaker state and configuration
- Output: sets immediate output values
- Initialization: initializes output values at power-up
- Shutdown: sets output level applied at shutdown

C PowerDNA Explorer						
File Edit Network View	Help					
Host PC	Mode	I: AO-318				
— 🐲 [0] Al-207	Info	o: A-Out, 8 channels	3			
- 🐨 [1] AO-364	S/N	N: 0123261				
_ 🌍 [2] AO-318	Mfg. Date	e: Nov 1, 2014				
	Cal. Date	e: May 26, 2016				
	Base Addr	.: 0xA0020000				
	IRC	Q: 2				
	Modifiable					
	Output Range: ±10 V					
	Input	Circuit Breaker	Output	Initialization	Shutdown	
		Circuit Breaker	Output	Initialization	Shutdown	
		Circuit Breaker	Output	Initialization	Shutdown	
	AOut0	Circuit Breaker Name Analog Output 0	Output	Initialization Value	Shutdown	
Ŀ3	AOut0 AOut1	Circuit Breaker Name Analog Output 0 Analog Output 1	Output	Initialization Value	Shutdown 2.000 -3.000	
Ŀ3	AOut0 AOut1 AOut2	Circuit Breaker Name Analog Output 0 Analog Output 1 Analog Output 2	Output	Initialization Value	Shutdown 2.000 3.0	
4	AOut0 AOut1 AOut2 AOut3	Circuit Breaker Name Analog Output 0 Analog Output 1 Analog Output 2 Analog Output 3	Output	Initialization Value	Shutdown 2.000 3.0	
43	AOut0 AOut1 AOut2 AOut3 AOut4	Circuit Breaker Name Analog Output 0 Analog Output 1 Analog Output 2 Analog Output 3 Analog Output 4	Output	Initialization Value	Shutdown 2.000 3.0000 3.000 3.000 3.000 3.000 3.000 3.000 3.000 3.000 3.000 3.	
L3	AOut0 AOut1 AOut2 AOut3 AOut4 AOut5	Circuit Breaker Name Analog Output 0 Analog Output 1 Analog Output 2 Analog Output 3 Analog Output 4 Analog Output 5	Output	Initialization Value	Shutdown 2.000 3.0	
L ₃	AOut0 AOut1 AOut2 AOut3 AOut3 AOut4 AOut5 AOut6	Circuit Breaker Name Analog Output 0 Analog Output 1 Analog Output 2 Analog Output 3 Analog Output 4 Analog Output 5 Analog Output 6	Output	Initialization Value	Shutdown 2.000 -3.000 -1.000 0.000 1.000 2.000 4.000	
Γŝ	AOut0 AOut1 AOut2 AOut3 AOut4 AOut5 AOut6 AOut7	Circuit Breaker Name Analog Output 0 Analog Output 1 Analog Output 2 Analog Output 3 Analog Output 3 Analog Output 4 Analog Output 5 Analog Output 6 Analog Output 7	Output	Initialization Value	Shutdown 2.000 -3.000 -1.000 0.000 1.000 4.000 4.000 8.000	

Figure 1-7 PowerDNA Explorer Output Control Panel for AO-318



1.8.1GuardianThe Input tab provides access to Guardian diagnostic readings and contains the
following columns:

(Input) Values

- Alnx: read-only display of the channel number.
 - Name: a name or note that you wish to give to the channel.
- Guardian Diagnostic Channels, Sub-channel 0 through 4: displays five Guardian ADC Channels as described in Section 1.5.3. The default order is shown below and in **Figure 1-8**. The default order must be used to ensure proper operation of the circuit breakers.

Figure 1-8 shows the **Input** tab for the AO-318. Note that the AO-318-02x and AO-318-210 are current sourcing boards that have a single circuit beaker. For those current sourcing boards, DAC A and DAC B voltages map to voltages before and after the circuit beaker.

In PowerDNA Explorer, diagnostic channels display as follows:

ADC Diagnostic Channel	Selector	Input Units
0	Current [mA]	mA
1	DAC A Voltage	Va
2	DAC B Voltage	Vb
3	Output Voltage	Vo
4	Temp. [°C]	°C

To read the Guardian diagnostic values, click the **Read Input Data** button. Note that reading diagnostic input values and circuit breaker status can take from several seconds to several minutes to update.



Figure 1-8 PowerDNA Explorer Diagnostic Input Panel for AO-318



1.8.2 Circuit The Circuit Breaker tab allows users to configure channel circuit breakers. Breaker The following columns are included: Values • AOutx: read-only display of the channel number.

- Name: a name or note that you wish to give to the channel.
- **Tripped**: displays whether the relay is open or closed. Note that *Start Reading Input Data* must be running.
- Reset: controls whether the relay is open or closed.
- Min X: The minimum or under limit value for Circuit Breaker X.
- Max X: The maximum or over limit value for Circuit Breaker X.
- Breaker X: Enable/Disable Circuit Breaker X, and if enabled, choose measurement unit: Current in mA or Output Voltage in V (See Figure 1-9). Configuration of the circuit breakers to trip when the temperature is out of range is currently not supported.

When changing the minimum, maximum or other values, you must store the configuration after you enter the changed values. To save the configuration, click the **Store Config** button. To read back the configuration to confirm the settings, click the **Reload Config** button.



Figure 1-9 PowerDNA Explorer Circuit Breaker Panel for AO-318



- **1.8.3 Output Values** The **Output** tab, shown in **Figure 1-10** and in **Figure 1-7** on page 14, contains the following columns:
 - AOutx: read-only display of the channel number.
 - Name: a name or note that you wish to give to the channel.
 - Value: slider and numeric text field for immediately setting the voltage (AO-318) or current (AO-318-02x/AO-318-210) of the corresponding output channel. The valid value range is shown in the **Output Range** display under the **Modifiable** checkbox. This value is written instantaneously when the slider is released or after

pressing **Enter** in the numeric field; pressing the **Store Config** button is not required for updating the value in hardware.

PowerDiva Explorer		
<u>File Edit N</u> etwork <u>V</u> iew	/ <u>H</u> elp	
Host PC IOM-1 IOM-1	Model: AO-318-20 Info: A-Out, 8 channels S/N: 0123779 Mfg. Date: Oct 1, 2014 Cal. Date: May 8, 2015 Base Addr.: 0xA0030000 IRQ: 2 ✓ Modifiable Output Range: 020 mA Input Circuit Breaker Output Initialization Shutdown	
	AOut1 Analog Output 1	
	AOut2 Analog Output 2 10.984	
	AOut3 Analog Output 3	
	AOut4 Analog Output 4 6.230	
	AOut5 Analog Output 5 11.803	
	AOut6 Analog Output 6 14.262	
	AOut7 Analog Output 7 20.000	

Figure 1-10 PowerDNA Explorer Output Panel for AO-318-020

- **NOTE:** Pressing **Reload Configuration** in v4.9 will read the current output value, which is useful if you just restarted your PowerDNA Explorer. Older or mismatched firmware will use 0 as the default value.
- **1.8.4**Initialization
ValuesThe Initialization tab is similar to the immediate output, shown in Figure 1-10
and in Figure 1-7 on page 14, but instead of outputting values immediately,
stores values into the EEPROM configuration to set the output value on
power-up. The factory default value is 0.
- **1.8.5** Shutdown
ValuesThe Shutdown tab is similar to the immediate output, shown in Figure 1-10 and
in Figure 1-7 on page 14, but instead of outputting values immediately, stores
values into the EEPROM configuration to set the output value in shutdown
mode. The factory default value is 0.



Chapter 2 Programming with the High-level API

This chapter provides the following information about using the UeiDaq highlevel Framework API to program the DNx-AO-318:

- About the High-level Framework (Section 2.1)
- Creating a Session (Section 2.2)
- Configuring the Resource String (Section 2.3)
- Configuring for Output (Section 2.4)
- Configuring the Timing (Section 2.5)
- Writing Output Data (Section 2.6)
- Monitoring Guardian Diagnostic Measurement (Section 2.7)
- Accessing Circuit Breakers (Section 2.8)
- Cleaning-up the Session (Section 2.9)
- 2.1 About the UeiDaq Framework is object oriented and its objects can be manipulated in the same manner from different development environments, such as Visual C++, Visual Basic, or LabVIEW.

UeiDaq Framework is bundled with examples for supported programming languages. The example code is located under:

C:\Program Files (x86)\UEI\Framework

The examples can be accessed via the Windows Start Menu. For example:

Start » All Programs » UEI » Visual C++ Examples

The following sections focus on the C++ API, but the concept is the same no matter which programming language you use.

Please refer to the "UeiDaq Framework User Manual" for more information on use of other programming languages.

2.2 Creating a The Session object controls all operations on your PowerDNx device. Therefore, the first task is to create a session object:

// create a session object for output

```
CUeiSession aoSession;
```

2.3 Configuring the Resource String UeiDaq Framework uses resource strings to select which device, subsystem and channels to use within a session. The resource string syntax is similar to a web URL:

<device class>://<IP address>/<Device Id>/<Subsystem><Channel list>

For PowerDNA and RACKtangle, the device class is pdna.



For example, the following resource string selects analog output lines 0,1,2,3 on device 1 at IP address 192.168.100.2: "pdna://192.168.100.2/Dev1/Ao0.3" as a range, or as a list "pdna://192.168.100.2/Dev1/Ao0,1,2,3".

2.4 Configuring for Output The Protected Output session type generates voltage or current out of a Guardian analog output (AO) device and additionally sets up Guardian features.

AO-318 protected output channels provide diagnostic capabilities, such as user-programmable Guardian diagnostic circuit breakers and the ability to monitor diagnostic current and voltage measurements.

Note that each analog output channel on the AO-318 is built with redundant DACs (DAC A and DAC B). The AO-318-02x and AO-318-210 are built with only one DAC (DAC A). Each DAC includes a hardware-controlled, user-configured circuit breaker.

NOTE: Refer to Section 2.7 for more information about monitoring Guardian diagnostics and Section 2.8 for more information about accessing circuit breakers.

Use CreateAOProtectedChannel() to configure one or more protected analog output channel(s). For example, the following call configures channel 0 of an AO-318 set as device 1 for analog output:

CreateAOProtectedChannel configures the following parameters:

- **DAC mode**: Selects which DAC is connected to the output channel. Supported values for the AO-318-1 are 'Disconnected', 'DAC A connected', and 'DAC B connected'. For the AO-318-02x and AO-318-210, supported values are 'Disconnected' and 'DAC A connected'.
- **Measurement rate**: the rate at which the AO device monitors diagnostic channels. This rate has a direct influence on how fast the device reacts to an under or over-current condition. Setting this value too high increases the error rate, as described in Section 1.5.3.1.
- Enable auto-retry: specifies whether the AO device attempts to reclose the circuit, after an over- or under-limit condition was detected to open the circuit, and is now back within an acceptable range.
- Auto-retry rate: specifies how often the AO device attempts to close the circuit.

2.5 Configuring the Timing

You can configure the AO-318 to run in simple mode (point by point).

In simple mode, the delay between samples is determined by software on the host computer. In buffered mode, the delay between samples would be determined by the AO-318 on-board clock.



The following example shows how to configure the simple mode. Please refer to the "UeiDaq Framework User's Manual" to learn how to use other timing modes.

// configure timing of input for point-by-point (simple mode)

aoSession.ConfigureTimingForSimpleIO();

2.6 Writing Writing DC-level data is done using a *writer* object(s).

Output Data You can create a writer object that writes raw data straight to the D/A converter. You can also create a writer object that writes data scaled as volts or amps. Framework automatically performs a conversion to binary code before sending the data to the D/A converter.

The following example code shows how to create a scaled writer object and write a sample:

// create a writer and link it to the session's stream

CueiAnalogScaledWriter writer(aoSession.GetDataStream());

// the buffer must be big enough to contain one value per channel

double data[2] = $\{0.0, 0.0\};$

// write one scan, where the buffer will contain one value per channel
writer.WriteSingleScan(data);

Or you can create a writer object that writes raw data straight to the DAC.

 $//\ {\rm create}$ a writer and link it to the session's stream

CueiAnalogRawWriter writer(session.GetDataStream());

// the buffer must be big enough to contain one value per channel

uint16 data[2] = $\{0x1234, 0x5678\};$

// write one scan, where the buffer will contain one value per channel
writer.WriteSingleScan(data);

All the AO-318 analog output boards are programmed the same way.



2.7 Monitoring Guardian Diagnostic Measurement Diagnostic Diagnostic

Analog Output **Associated Analog** Channel **Input Channels** 0 0..4 1 8..12 2 16..20 3 24..28 4 32..36 5 40..44 6 48..52 7 56..60

Table 2-1 Analog Output to Analog Input Channel Mapping

Use an Analog Input session the same way you would to measure from any UEI Analog Input device.

You can read all 40 diagnostic measurements with the channel list: "0:4,8:12,16:20,24:28,32:36,40:44,48:52,56:60".

The following code shows how to read AO channel 0 diagnostic values for an AO-318:

```
// create an input session and configure it for simple timing
```

```
CUeiSession aiSession;
```

Table 2-1.

```
aiSession.CreateAIChannel("pdna://192.168.100.2/Dev1/Ai0:4",
-10.0, 10.0,
```

```
UeiAIChannelInputModeDifferential);
```

```
aiSession.ConfigureTimingForSimpleIO();
```

// the buffer must be big enough to contain one value per channel

```
CUeiAnalogScaledReader aiReader(aiSession.GetDataStream());
double values[5];
```

// read one scan

aiReader.ReadSingleScan(values);



2.8 Accessing Circuit Breakers Each circuit breaker can monitor one diagnostic channel. The circuit breaker has the capability of opening the circuit when one of the diagnostic measurements exceeds the user-configured minimum/maximum values.

This section describes how to configure, get the status of, and manually reset the circuit breakers on the AO-318. ADC channel 0 controls circuit breaker 0 and ADC channel 1 controls circuit breaker 1.

2.8.1 Configuration You can configure the circuit breaker parameters using the channel object methods (or a property node under LabVIEW). Parameters include ADC channels, circuit breaker sources, low and high limits, and over and under limit counts.

Identify ADC diagnostic channels: select up to five ADC diagnostic channels for reading Guardian values. Possible values are:

- UeiAODiagnosticCurrent: Monitor output current
- UeiAODiagnosticDACAVoltage: Monitor voltage out of DAC A (before relay on AO-318-1)
- UeiAODiagnosticDACBVoltage: Monitor voltage out of DAC B (before relay on AO-318-1)
- UeiAODiagnosticVoltage: Monitor output voltage (after relay)
- UeiAODiagnosticTemperature: Monitor dual DAC die temperature
- UeiAODiagnosticNone: Do not monitor.

For circuit breaker configuration, the ADC channels must be in the default order as shown below. ADC 0 will control circuit breaker 0 and ADC 1 will control circuit breaker 1.

```
// Set ADC channel 0 to monitor current; ch is analog output channel
pAOChan =
   dynamic_cast<CUeiAOProtectedChannel*>(aoSession.GetChannel(ch));
pAOChan->SetADCChannel(0, UeiAODiagnosticCurrent);
// Set ADC channel 1 to monitor voltage
pAOChan->SetADCChannel(1, UeiAODiagnosticVoltage);
// Disable ADC channels 2, 3 and 4
pAOChan->SetADCChannel(2, UeiAODiagnosticNone);
pAOChan->SetADCChannel(3, UeiAODiagnosticNone);
pAOChan->SetADCChannel(4, UeiAODiagnosticNone);
```



Enable circuit breaker channels: enable or disable circuit breaker; when enabled, monitor a diagnostic channel and open the circuit if any of the measurements go out of min/max limits:

```
// Enable CB 0 (ADC Channel 0)
pAOChan->EnableCircuitBreaker(0, true);
// Enable CB 1 (ADC Channel 1)
pAOChan->EnableCircuitBreaker(1, true);
```

Set low/high limits: each circuit breaker can monitor one diagnostic channel. Set the minimum and maximum current, voltage, or temperature on the specified breaker. The circuit will open when any of the diagnostic values fall below or above those limits:

```
// Set CB 0 low limit for diagnostic ADC Channel 0
pAOChan->SetCircuitBreakerLowLimit(0,-0.01);
```

// Set CB 0 high limit

pAOChan->SetCircuitBreakerHighLimit(0, 0.01);

The three diagnostic measurements are set by default to:

	AO-318	AO-318-020	ADC Range
Electrical Current	±11 mA	-1 to 21 mA	±32mA
Electrical Voltage	±11 V	-1 to 16 V	±16V
Temperature	-40 to 85 °C		-50 to 125°C

Set over/under limit count: Specifies the number of consecutive over/under limit diagnostic readings that must occur in order to trip the circuit breaker. The circuit beaker can be set to trip on the initial read (0) or for up to 15 retries (~15 seconds).

// Set over/under count to 5 (valid range is 0 to 15)

pAOChan->SetOverUnderCount(5);

2.8.2 Status The circuit breaker status can be accessed with a CUeiCircuitBreaker object.

```
// Create a circuit breaker and link it to the session's stream for
// circuit breaker on analog output channel (channel 4 in this case)
```

CUeiCircuitBreaker cb(aoSession.GetDataStream(), 4);

Call the ReadStatus method to retrieve the status masks.

Each bit in the current status mask corresponds to a circuit breaker. A 1 indicates that the circuit breaker is currently tripped. Otherwise, the bit will be 0.



Each bit in the sticky status mask corresponds to a circuit breaker. A 1 indicates that the circuit breaker was tripped at least once since the last time status was read. Otherwise, the bit will be 0.

```
// Read CB status
```

uInt32 currStatus, stickyStatus; cb.ReadStatus(&currStatus, &stickyStatus);

2.8.3 Manual Reset Use the Reset method on a circuit breaker object to reset one or more breakers. The mask parameter specifies which circuit breaker to reset (1 to reset, 0 to leave alone).

```
// Reset breakers for analog output channels 0 and 2 \,
```

```
cb.Reset( 1<<0 | 1<<2 );
```

2.9 Cleaning-up the Session The session object will clean itself up when it goes out of scope or when it is destroyed. To reuse the object with a different set of channels or parameters, you can manually clean up the session with the CleanUp call as follows:

```
// clean up the sessions
aiSession.CleanUp();
aoSession.CleanUp();
```



Chapter 3 Programming with the Low-level API

This chapter provides the following information about programming the AO-318 using the low-level API:

- About the Low-level API (Section 3.1)
- Low-level Functions (Section 3.2)
- Low-level Programming Techniques (Section 3.3)
 - Data Transfer Modes (Section 3.3.1)
- Programming the AO-318 (Immediate Mode) (Section 3.4)
 - Configuring Output Channels (Section 3.4.1)
 - Writing Output Data (Section 3.4.2)
 - Configuring Guardian Diagnostics (Section 3.4.3)
 - Monitoring Diagnostic Measurements (Section 3.4.4)
 - Configuring Circuit Breakers (Section 3.4.5)
 - Reading Circuit Breaker Status (Section 3.4.6)
 - Reengaging Circuit Breakers (Section 3.4.7)

3.1 About the Low-level API

The low-level API provides direct access to the DAQBIOS protocol structure and registers in C. The low-level API is intended for speed-optimization, when programming unconventional functionality, or when programming under Linux, Windows, or real-time operating systems.

When programming in Windows OS, however, we recommend that you use the UeiDaq high-level Framework API (see **Chapter 2**). The Framework simplifies the low-level API that makes programming easier and faster while still providing access to the majority of low-level API features. Additionally the Framework supports a variety of programming languages and the use of scientific software packages such as LabVIEW and Matlab.

For additional information regarding low-level programming, refer to the *"PowerDNA API Reference Manual"* located in the following directories:

- On Linux systems: <PowerDNA-x.y.z>/docs
- On Windows systems: Start » All Programs » UEI » PowerDNA » Documentation



3.2 Low-level Table 3-1 provides a summary of AO-318-specific functions. All low-level functions are described in detail in the *"PowerDNA API Reference Manual"*.

Table 3-1 Summary of Low-level API Functions for DNx-AO-318

Function	Description
DqAdv3xxWrite	Write either floating point or raw values to AO-318 output.
DqAdv318ReadADC	Read back voltage, current, temperature from Guardian diagnostic ADCs.
DqAdv318Reengage	Reset tripped circuit breakers for selected channels.
DqAdv318CBStatus	Get the circuit breaker status for selected channels.
DqAdv318SetCBLevels	Configure circuit breaker minimum and maximum trip levels for selected channels.
DqAdv318SetConfig	Advanced configuration of circuit breakers and ADCs.

NOTE: The AO-318-024 is supported in PowerDNA version 4.10.0.48+.

The AO-318-210 is supported in PowerDNA version 5.2.0.12+.

If you're unsure if your version supports the board please contact Technical Support at <u>uei.support@ametek.com</u>.

3.3 Low-level Application developers are encouraged to explore existing source code examples when first programming the AO-318. Example code provided with the installation is self-documented and serves as a good starting point.

The example code is located in the following directories:

- On Linux: <PowerDNA-x.y.z>/src/DAQLib_Samples
- On Windows:
 - C:\Program Files (x86)\UEI\PowerDNA\SDK\Examples\Visual C++

Example code has the name of the I/O boards being programmed embedded in the example name. For example, SampleVMap3xx contains example code for running an AO-318 (and other AO-3xx products) in VMap mode. Refer to the low-level example code Sample318 for an example of how to use the Guardian diagnostic features, and Sample318CB for an example of how to use the Circuit Breaker functions.

 3.3.1 Data Transfer Modes
 The AO-318 supports the following acquisition modes.
 Immediate (point-to-point): Transfers a single data point per channel of a single I/O board at a non-deterministic pace. Runs at a maximum of 100 Hz.

RtDMap/RtVMap: Transfers samples as specified in a user-defined map of I/O boards and channels. The timebase is maintained by the host application. Designed for closed-loop (control) applications.

- RtDMap delivers one data sample per channel
- RtVMap delivers multiple samples per channel



		ACB: Transfers a buffer of samples, where transfers are initiated by IOM firmware issuing event notifications when circular buffer crosses a user-defined frame boundary. Every data point is guaranteed but will have an intrinsic delivery delay. ACB is not appropriate for control applications and is not supported for UEIPAC products.
		NOTE: API functions that implement data acquisition modes and additional mode descriptions are provided in the <i>"PowerDNA API Reference Manual"</i> .
3.4	Programming the AO-318 (Immediate Mode)	The following sections provide an overview of how to set up and use your AO-318 in Immediate Mode using the low-level API.
		For best results, use this overview in conjunction with actual example code, (e.g., Sample30x, Sample318, Sample318CB). This overview does not address all initialization or error handling. Refer to Section 3.3 for example code location.
3.4.1	Configuring	Users initialize a list of AO-318 channels to enable and output samples to.
	Output Channels	uint32 cl[CHANNELS]; // CHANNELS is max of 8
		You can enable channels sequentially or in whichever order you choose:
		// to order channels sequentially in the channel list:
		for $(i = 0; i < CHANNELS; i++)$ {
		cl[i] = i;
		}
3.4.2	Writing Output Data	In Immediate mode, use DqAdv3xxWrite() to write raw or floating point samples to each of the enabled channels (in the order of the channel list).
		uint16 data[CHANNELS]; double fdata[CHANNELS];
whi	while (!stop) {	
<pre>//set up data to be output for (i = 0; i < CHANNELS; i++) { data[i] = 0; // value isn't used, not sending raw data fdata[i] = nextSampleToOutput(); // -10V through 10V for AO-318</pre>		
	}	
	DqAdv3xxWrite	<pre>(hd, // handle to IOM DEVN, // position AO-318 inserted in the chassis CHANNELS, // total number of channels enabled cl, // channel list configured in previous step 0, // RawData flag (0 is FALSE, use floating pt) data, // array of raw data - not used if RawData==0 fdata); // CHANNELS-size array of floating point data</pre>
}	UeiPalSleep(5	00); // controls data output rate

3.4.3 Configuring Guardian Diagnostics When accessing Guardian features, users configure which of the five AO-318 diagnostic points to monitor for each output channel. Diagnostic ADC channels for voltages, current, and temperature are defined in Table 3-2.

Table 3-2. AO-318 Diagnostic Measurements

Diagnostic ADC Channel	AO-318 Description (see Figure 3-1)	AO-318-02x/AO-318-210 Description (see Figure 3-2)
0	lin current	lin current
1	DACAOut buffer voltage	IntDAC buffer voltage
2	DACBOut buffer voltage	IntDACR pre-relay voltage
3	AoutAB voltage at the connector pin	AOutA voltage at the connector pin
4	Тетр	Тетр







NOTE: The AO-318-02x and AO-318-210 current readings are valid within a few microamps. The voltage reading may read lower because of the voltage drop across the DNA-CBL-37 or similar cable which is not accounted for in the voltage readings.



Figure 3-2 Diagram of Diagnostic Measurement Points on Current Board Channels

Users set up a read channel list with an array size equal to the total number of diagnostic data values that will be read plus the time stamp (optional):

```
// RCHANNELS represents all diagnostic channels to read (and optional
// time stamp)
// In this example, all 5 ADC channels (diagnostic data points) are
// configured for each of the enabled output channels (CHANNELS)
#define TIMESTAMP (0) // time stamp is not included for this example
#define RCHANNELS ((5 * CHANNELS)+TIMESTAMP) // read all 5 diagnostic points
uint32 rcl[RCHANNELS]; // create a channel list of readback data
```

To create entries for the read channel list, diagnostic channels (as listed in Table 3-2) are logically ORed with the analog output channel number using the macro, DQ_AO318_MAKE_CL (OutputChannel, DiagnosticChannel). The analog output channel number will be in bits 3-5 and the diagnostic channel number will be in bits 0-2. The channel list must be in numerical order. For example, all the ADC channels associated with analog output channel 0 must be first in the list, followed by all the ADC channels associated with analog output channel 1, etc.



```
3.4.4 Monitoring
Diagnostic
Measure-
ments
Call DqAdv318ReadADC() to program the ADC hardware, and then make a
second DqAdv318ReadADC() call to read the diagnostic data values (in the
order of the read channel list).
```

// The first read is for hardware configuration only. Pass zeros instead
// of arrays since no data is returned

DqAdv318ReadADC (hd, // handle to IOM // position AO-318 inserted in the chassis DEVN, RCHANNELS, // total number of input (diagnostic channels) // read channel list configured in previous step rcl, Ο, // set to 0 for config 0); // set to 0 for config uint32 b adcdata[CHANNELS*5 + TIMESTAMP]; double f adcdata[CHANNELS*5 + TIMESTAMP]; DqAdv318ReadADC(hd, // handle to IOM // position AO-318 inserted in the chassis DEVN,

> RCHANNELS, // total number of diagnostic channels enabled rcl, // read channel list b_adcdata, // array for returned raw readback data f adcdata);// array for returned floating pt readback



3.4.5Configuring
CircuitEach output channel on the AO-318-1 has two circuit breakers. Each output on
the AO-318-02x and AO-318-210 has one.**Breakers**These are configured with DgAdv318SetConfig(). Minimum and maximum

These are configured with DqAdv318SetConfig(). Minimum and maximum levels can be set with DqAdv318SetCBLevels().

Circuit breakers have the following user programmable features:

- Each circuit breaker can be controlled by up to two sources that are user programmable.
- You can select diagnostic channel zero (current), one (voltage), or both as a control source to monitor for a circuit breaker. See **Table 3-2**. Both circuit breakers can also be disabled.
- Users can program a minimum or maximum value for any of the selected diagnostic channels as a control condition for the circuit breaker (or the min/max rule can be disabled to select 0).

In this example, we will configure one circuit breaker with only one control source. For that control source, we program minimum and maximum trip points for the measurement:

- 1. Program circuit breaker on DACA (see Figure 3-1) on channel 0.
- 2. Set the trip points to when the DACA output voltage is less than a -11.0 V minimum and greater than an 8.0 V maximum (diagnostic channel 1 is "DACAOut voltage" in this example).
- **NOTE:** The following example uses many predefined macros (#define) to configure functionality. The macros used are explained in the example. To learn more, please refer to the *"PowerDNA API Reference Manual"*.

3.4.5.1 Declare CB To configure the circuit breaker, first declare circuit breaker configuration structures. Structures

DQA0318CFG cfg318; // used by DqAdv318SetConfig() DQA0318BRK CFG cb cfg; // used by DqAdv318SetCBLevels()

 3.4.5.2
 Program CB
 Set the DQAO318CFG structure to enable the circuit breaker and to use the DACA output voltage as the control criteria.

 Criteria
 Selection

 Create the mask for programming the DAC enable, source mode, and ADC

cfg318.prmmask = DQ_AO318_CBCFG_DAC | DQ_AO318_CBCFG_SETCBSRC | DQ_AO318_CBCFG_SETADCCL;

channel list:

Enable DACA:

cfg318.en_DAC = DQAO318CFG_DACEN_A; // enable CB_A



Select a source as the control for CB_A. In this example, we only enable one source on CB_A and disable both on CB_B (CB_B is the CB on the redundant DAC). By specifying DQ_AO318_MINMAX_1, CB_mode will be set to monitor the diagnostic ADC channel measurement that is programmed in the ADC_CL[1] element to be selected as the min/max control criteria. (If we had programmed DQ_AO318_CB_A_SEL0 with DQ_AO318_MINMAX_0, then ADC_CL[0] (lin) would be selected as the control criteria).

cfg318.CB_mode = DQ_AO318_CB_A_SEL0(DQ_AO318_MINMAX_1) | DQ_AO318_CB_A_SEL1(DQ_AO318_MINMAX_DISABLE)| DQ_AO318_CB_B_SEL0(DQ_AO318_MINMAX_DISABLE)| DQ_AO318_CB_B_SEL1(DQ_AO318_MINMAX_DISABLE)| 0;

Map the ADC diagnostic channels to ADC CL[], the ADC channel list.

NOTE: Only the first two ADC_CL elements can be used as control criteria for the circuit breakers. The default configuration of ADCs must be used, i.e., output current (DQ_AO318_ADC_CH_I) and DAC A output voltage (DQ_AO318_ADC_CH_A_int).

Optionally, set the ADC sample rate (50 Hz max) **and read count** (which controls the number of readings outside the min/max that must occur before the circuit breaker trips):

Call the DqAdv318SetConfig() to set configuration:

DqAdv318SetConfig(hd, DEVN, mask, 0, &cfg318);



3.4.5.3 Program CB Minimum & Maximum Levels Set the DQAO318BRK_CFG structure to program the minimum and maximum levels for the diagnostic channels you programmed in ADC_CL[0] and ADC_CL[1].

NOTE: Note that what you select for CB_mode is what ADC diagnostic channel will actually be read and compared to its min/max as the criteria for tripping the circuit breaker. In our example, only ADC_CL[1] is selected in CB_mode; the other two (lin and Temperature) will not be criteria.

Program min/max values :

```
cb_cfg.CB_val_min_f[0] = (float)-0.011; // A: ADC_CL[0] is Iin, not used
cb_cfg.CB_val_max_f[0] = (float) 0.011; // A
cb_cfg.CB_val_min_f[1] = (float)-11.0; // min V: ADC_CL[1] is criteria
cb_cfg.CB_val_max_f[1] = (float) 8.0; // max V
```

Program units:

cb_cfg.units[0] = 'I';	<pre>// this is 'I' because cfg318.ADC_CL[0] is se</pre>
	<pre>// to read the current Iin as ADC input</pre>
<pre>cb_cfg.units[1] = 'V';</pre>	<pre>// this is 'V' because cfg318.ADC_CL[1] is se</pre>
	<pre>// to read DACBOut voltage as ADC input</pre>

Call the DqAdv318SetCBLevels () to set min/max levels:

// channel mask; 0x1 is 1st channel; 0xff is all 8 ch
DqAdv318SetCBLevels(hd, DEVN, mask, &cb cfg);

3.4.6 Reading To monitor the status of the circuit breakers, use DqAdv318CBStatus(). Circuit Breaker Status

// declare an array to hold status states for board and all channels // cbstatus[0] is bitmask of all channels; cbstatus[1:8] are individual ch uint32 cbstatus[DQ_AO318_CHAN+1]; // DQ_AO318_CHAN is all 8 channels

// channel mask; 0x1 is 1st channel; 0xff is all 8 ch
DqAdv318CBStatus(hd, DEVN, mask, 0, 0, cbstatus);

cbstatus[0]: bit 23:16 - current status of CB for ch 7:0 (1 is tripped) (bits 15:0 are sticky; cleared on read) bit 15:8 - indicates ADC min/max value has been evaluated for ch 7:0 bit 7:0 - sticky indicator that ch 7:0 CB had been tripped since last read
cbstatus[1:8]:

refer to the "PowerDNA API Reference Manual".



DNx-AO-318 Analog Output Board Chapter 3 Programming with the Low-level API

3.4.7	Reengaging Circuit Breakers	You can configure the circuit breakers to automatically reengage when setting up the configuration with $DqAdv318SetConfig()$, or you can monitor the circuit breaker status and reengage circuit breakers with $DqAdv318Reengage()$.
3.4.7.1	Automatically Reengaging CB	When you set up the CB_mode for DqAdv318SetConfig() (see Section 3.4.5.2), you can OR in a DQ_AO318_CB_A_AUTO or DQ_AO318_CB_B_AUTO flag (or both) that enables auto reengaging on the DACA circuit breaker or DACB circuit breaker:
cfg	318.CB_mode =	DQ_AO318_CB_A_SEL0(DQ_AO318_MINMAX_1) DQ_AO318_CB_A_SEL1(DQ_AO318_MINMAX_DISABLE) DQ_AO318_CB_B_SEL0(DQ_AO318_MINMAX_DISABLE) DQ_AO318_CB_B_SEL1(DQ_AO318_MINMAX_DISABLE) 0;
// cfg	Optionally, OR 318.CB_mode =	in auto reengage flag (DQ_AO318_CB_A_AUTO DQ_AO318_CB_B_AUTO);
3.4.7.2 M R C	Manually Reengaging	If you do not want to automatically reengage circuit breakers, you can call DqAdv318Reengage () upon your re-engagement criteria.
	СВ	In this example, we assume the status has been read with $DqAdv318CBStatus$ () (Section 3.4.6), and we are reengaging all of the circuit breakers if the criteria is met and any of the circuit breakers have tripped.
// uin if }	pass the DqAdv t32 resetAllCh ((yourCriteria DqAdv	<pre>318Reengage API a bitmask of channels to reengage annels = 0xff; == TRUE) && ((cbstatus[0]>>16) & 0xff)){ 318Reengage(hd, DEVN, resetAllChannels);</pre>



Appendix A

A.1 Accessories The following cables and STP boards are available for AO-318 boards. Pinouts are shown in Figure A-1.

DNA-CBL-37

This is a 37-conductor flat ribbon cable with 37-pin male D-sub connectors on both ends. The length is 3 ft (90 cm) and weighs 3.4 ounces (98 grams).

DNA-CBL-37S

This is a 37-conductor round shielded cable with 37-pin male D-sub connectors on both ends. It is made with round, heavy-shielded cable. It is 3 ft (91 cm) long and weighs 10 ounces (283 grams). It is also available in 10 ft and 20 ft lengths.

DNA-STP-37

The DNA-STP-37 provides easy screw terminal connections for all DNx series I/O boards which utilize the 37-pin connector scheme. The DNA-STP-37 is connected to the I/O board via either a DNA-CBL-37 or DNA-CBL-37S cable. The dimensions of the DNA-STP-37 board are $4.2w \times 2.8d \times 1.0h$ inches (10.7 x 7.1 x 2.54 cm) with standoffs. The weight of the DNA-STP-37 board is 2.4 ounces (68 grams).



Figure A-1 Pinout and photo of DNA-STP-37 screw terminal panel

