



# **DNA/DNR-CAN-503**

## **Controller Area Network Layer**

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## **User Manual**

**4-Port, Controller Area Network (CAN) Layer  
for the PowerDNA Cube and RACKtangle chassis**

**September 2009 Edition**

**PN Man-DNx-503-0909**

**Version 3.8**

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# Chapter 1 Introduction

This document outlines the feature-set and describes the operation of the DNx-CAN-503 Controller Area Network boards. The DNA- version is designed for use with a PowerDNA Cube data acquisition system. The DNR- version is designed for use with a DNR-12 RACKtangle or a DNR-6 HalfRACK system. Both versions are functionally identical. This module enables communication with a Controller Area Network (CAN) over a CAN bus. Please ensure that you have the PowerDNA Software Suite installed before attempting to run examples.

## 1.1 Organization of this manual

This DNx-CAN-503 User Manual is organized as follows:

- **Introduction**

This chapter provides an overview of the document content, the device architecture, connectivity, and logic of the layer. It also includes wiring schemes, notes, and specifications.

- **Programming with the High-Level API**

This chapter provides an overview of the how to create a session, configure the session for CAN bus communication, and interpret results on the CAN-503 series layer.

- **Programming with the Low-Level API**

This chapter describes the use of low-level API commands for configuring and using the CAN-503 series layer.

- **Appendix A: Accessories**

This appendix provides a list of accessories available for CAN-503 layer(s).

- **Appendix B: Calibration**

This appendix outlines the calibration procedure for the CAN-503 series layer.

- **Index**

This is an alphabetical listing of the topics covered in this manual.



## Document 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**.”

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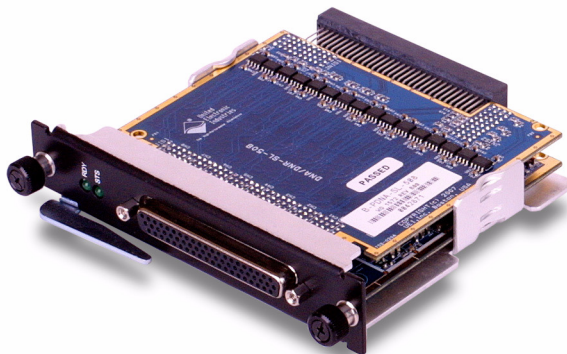
## 1.2 The CAN-503 Layer

The CAN-503 layer has the following features:

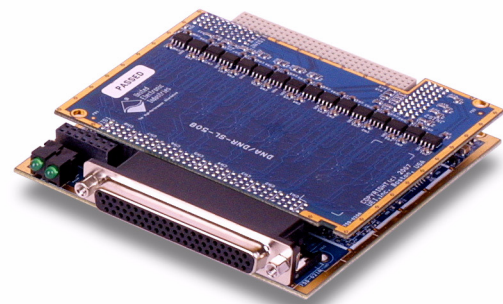
- 4 independent CAN ports
- Bit transfer rates of 10, 20, 50, 100, 125, 250, 500, 800, 1000 kbps

**NOTE:** UEISIM support of the DNx-CAN-503 is limited to 300 fps input and 1000 fps output.

- 24MHz base clock
- Completely independent bit rate settings for every port
- 250V DC max isolation between ports; ports and circuitry
- Hot plugging support for CAN devices
- Interrupt-based error detection
- Fully compatible with ISO 11898 standard
- CAN 2.0a-compatible, 11-bit, and CAN 2.0b, 29-bit identifiers
- Message targeting and filtering
- Weight: of layer: 120grams - and core: 290g – in a cube: 630g (22.2oz)



**DNR-CAN-503**



**DNA-CAN-503**

**Figure 1-1. Photos of DNR- and DNA-CAN-503 Modules**

## 1.3 What is a CAN?

A Controller Area Network (CAN) is a multi-cast, shared, serial bus standard designed to operate in electromagnetically noisy environments, such as automotive and general industrial locations. The shared serial bus is called a **CAN bus**.

Machines, sensors, and other devices on the CAN bus are *nodes*.

For example, in a vehicle the CAN bus can control a car's dashboard displays, power windows, power locks, windshield wipers, exterior lighting, and so forth. Another higher-speed CAN bus can control the engine and brake system operation.



### **1.3.1 Standards**

CAN communication takes the form of the ISO/OSI 7-layer model, where:

- Layers 3 to 7 (application) are handled by user software (e.g., CANOpen, etc.)
- Layer 2 (data-link) is outlined by ISO 11898-1 and the CAN 2.0 specification.
- Layer 1 (physical, electrical signaling and wiring) is defined by ISO 11898.

ISO 11898 defines the protocol for controller signaling in road vehicles:

- ISO/DIS 11898-1: Road vehicles — CAN — Part 1: Data link layer and physical signaling
- ISO/DIS 11898-2: Road vehicles — CAN — Part 2: High-speed medium access unit
- ISO/CD 11898-3: Road vehicles — CAN — Part 3: Low-speed fault tolerant medium-dependent interface
- ISO/CD 11898-4: Road vehicles — CAN — Part 4: Time triggered communication

The ISO standards are listed for reference and theory only; the CAN-503 provides transparent access directly to message frames transmitted on the CAN-bus. The remainder of this document refers to: the ISO 11898 CAN bus and ISO 11898 + CAN2.0-compliant nodes.

### **1.3.2 Functional Description**

The data messages transmitted by any node on a CAN bus do not contain addresses of either the transmitting node or any receiving node. The message itself contains a unique identifier that all nodes receive. Each receiving node performs an acceptance test on the identifier to decide whether or not the message is of interest to that node. If it is, the message is processed. If not, the message is ignored. The identifier also determines the importance of the message. The lower the numerical value, the higher the priority. If two or more nodes try to transmit at the same time, a non-destructive arbitration function ensures that messages are sent in priority order and no messages are lost. This arbitration technique is described below.

#### **1.3.2.1 Bit Types**

Bits are classified as either “dominant” or “recessive.” The bus can have one of two complementary logical values — dominant or recessive. If simultaneous transmission of dominant and recessive bits occurs, the resulting value will be dominant. For example, when using a wired-AND implementation of the bus, the dominant level is represented by a logical 0 and the recessive level by a logical 1. Physical states (voltage, light level, etc.) that represent the logical levels are not given in this specification.

All nodes can listen and transmit at the same time. If a node transmits a dominant bit, it will see a dominant bit on the bus. Also, the transmitting node will not know if another node was trying to transmit. If a node transmits a recessive bit, however, and a dominant bit is seen on the bus, the node knows that someone else is on the bus.

#### **1.3.2.2 Bit Encoding**

CAN uses NRZ “non-return to zero” encoding with bit stuffing over a differential 2-wire bus, usually twisted-pair. This encoding ensures compact messages with minimum transitions and high noise immunity.





### 1.3.2.3 Bit Timing

The ISO standard, ISO 11898, specifies that each bit on the CAN bus is divided into at least 4 segments or quanta, as follows:

- Synchronization segment
- Propagation segment
- Phase 1 segment
- Phase 2 segment

The **Sync** segment, always one segment long, is used for synchronizing clocks. A bit edge should occur within this segment whenever a data change occurs.

The **Propagation** segment compensates for any physical delays in the network.

**Phase 1** segment is a buffer that may be shortened or lengthened to keep the clocks in sync.

**Phase 2** segment is also a buffer that may be adjusted to compensate for negative phase errors and drift in oscillators.

The bit sample is always taken at the end of Phase 1 segment.

When any node receives a data or remote frame, the receiver must sync its clock to the transmitter. “*Hard synchronization*” occurs on the recessive-to-dominant transition of the start bit and the bit time is restarted from that edge.

If a bit edge does not occur during the Sync segment, however, “*resynchronization*” is required. To correct for any phase differences between transmitter and receiver oscillators, the system automatically shortens or lengthens the bit time to eliminate the error. The maximum number of time segments used for the adjustment is determined by a user-programmable parameter called Synchronization Jump Width (SJW).

### 1.3.2.4 Reliability

A CAN system can operate successfully in very severe environments. It also uses a sophisticated error checking technique to ensure that all transmission errors are immediately detected. In applications with speeds below 125 kbps, a CAN bus will continue to operate (although with higher noise) if either of the two bus wires is broken, if either wire is shorted to ground, or if either wire is shorted to the power supply. The purpose of this mode is to permit the bus to operate after a car crash has severed one of the lines. Each node continues to monitor the faulty line and will resume two-wire operation when the fault condition is removed.

### 1.3.2.5 Design Flexibility

The fact that CAN messages are not addressed to specific nodes offers great flexibility in designing a system. Each node decides for itself whether or not the transmitted message is relevant to it. As a result, you can add new receiving nodes without having to make any changes to existing hardware or software. Measurement information needed by several controllers can be broadcast over the bus, eliminating the need for individual sensors for each controller.

### 1.3.2.6 Bus Arbitration

To assign priority to messages, CAN uses the CSMA/CD method (Carrier Sense, Multiple Access with Collision Detect) plus a non-destructive bus arbitration scheme to resolve conflicts. The numerical value of each message identifier is assigned by the system designer at the start of the project. This value, by definition, also sets the relative priority of a message. The identifier with the lowest value has the highest priority. Any conflicts are resolved by bitwise arbitration and a wired-AND method, as described previously.



A key feature of CAN bus arbitration is that the first node delays transmitting if some other node sends a dominant bit whenever the first node sends its first recessive bit. Since the identifier is contained in the first part of the message transmitted, all nodes except one will have delayed transmission by the time the identifier has been sent. The message identifier, therefore, determines which messages have priority.

At the start of a message frame, each node sends a single dominant bit, called the start of frame (SOF) bit. All listening nodes will see bus activity and will therefore not attempt to start transmission until the current message is complete. The only chance for collision is between nodes that simultaneously send an SOF bit. These nodes remain in step for the whole message or until all except one back off. After the SOF bit is sent, the arbitration field is transmitted. The winning node will always have the lowest value arbitration field, because it will be the first to transmit a dominant bit, when other nodes are transmitting recessive bits. You can therefore consider the numerical value (low to high) of the arbitration field to be the priority of the message.

Since the highest priority message is unchanged, the arbitration is nondestructive. In fact, the node transmitting the message is not even aware that a collision occurred. The only way for a node to detect a collision is for the node to observe something on the bus that is different from what it transmitted. As a result, the successful node and any other listening nodes never see any evidence of a collision on the bus.

The highest priority message is always transmitted successfully, but at the expense of lower-priority messages. The goal is to ensure that the highest-priority work is finished as soon as possible. Although it is still possible to miss a hard real-time deadline, there should never be a situation where a high priority task misses a deadline because it was waiting for a lower-priority task to run.

If several nodes clash, one will win out. After that winning message is complete, all of the “non-winners” try again. In the second round, the next lowest-value arbitration field wins, and the process repeats. There’s no reason that the lowest-value arbitration field can’t be transmitted again, however. Therefore, it is important to be aware that the CAN bus doesn’t prevent this from happening — the user must ensure that no single message type dominates the bus activity.

The arbitration field can be 11 or 29 bits long, depending on which CAN protocol you use. You can use the first few bits for priority assignment and the remaining bits to identify the type of message. The CAN standard doesn’t rigidly specify the meaning of those bits, but the several higher-level CAN-compatible protocols do.

## 1.4 Physical & Data-Link Communication

The CAN bus is a shared, multi master, event-oriented message transmission bus. Any node may transmit on the bus when the bus is idle (multi master), and communicate with any other node(s) that are in listening mode. Nodes constantly listen to the bus and filter out messages not relevant to them as determined by the *acceptance mask*.

To determine which node (of the many connected nodes) may transmit on an idle bus, a non-destructive contention-based bus arbitration scheme (CSMA/CD) is used, as described above. Nodes always listen. When they notice that the bus is idle, they transmit their 11 or 29-bit *object identifier*. The node with the lowest *object identifier* number is given priority to transmit a frame; and then the process repeats.



### 1.4.3 CAN Message Format

When a device has transmission permission on the bus, it broadcasts a (message) frame to the other connected devices.

There are four types of frames:

- *Remote Frame*: requests transmission of a specific identifier
- *Error Frame*: transmitted by any node detecting an error
- *Overload Frame*: request to inject a delay between data/remote frames
- *Data Frame*: a frame that contains data

Two different types of *Data Frames* are defined (and supported by the CAN-503):

*Base Frame Format*, aka Standard CAN, aka CAN 2.0A message frame. These use an 11-bit identifier, or 2048 possible message combinations.

*Extended Frame Format*, aka Extended CAN, aka CAN 2.0B message frame. These frames use a larger 29-bit identifier, for 512 million message combinations. This mode, however, may not be supported in older CAN2.0A-only controllers.



**1.4.3.1 2.0A Format** A Standard CAN (Version 2.0A) Message Frame has the following structure:

Description	Field Name	Length (bits)	Purpose
Bus Idle			
SOF	Start of Frame	1	Recessive bit
Arbitration Field	Identifier A	11	First part of the (unique) identifier for the data.
	Remote Transmission Request (RTR)	1	Must be <i>recessive</i> . Discriminates between a Data Frame and a request for data from a remote node.
Control Field	Two Reserved bits r0 and r1	2	Reserved for future use.
	Data Length Code (DLC)	4	Number of bytes in the Data Field that follows.
Data Field	Data field	0 to 8 bytes	Data to be transmitted (length = DLC field).
CRC Field	CRC	15	Cyclic redundancy check
	CRC delimiter	1	Must be recessive.
ACK	ACK slot	1	Transmitter sends recessive. Any receiver can override with a dominant bit.
	ACK delimiter	1	Must be recessive.
EOF	End-of-frame (EOF)	7	Must be recessive.
INT	INTermission Field	3	3 recessive bits
			After three INTermission periods, the bus is called "free." Bus idle time may be any value including zero.
Bus Idle			

**1.4.3.2 2.0B Format** The CAN 2.0B format uses a 29-bit identifier instead of the 11-bit identifier used by CAN 2.0A. This format was developed to meet the needs of automotive applications, but also to be compatible with 2.0A devices. The differences between the two formats are:

- In CAN 2.0B, the arbitration field has two fields – the Base ID (11-bits for compatibility with 2.0A) and the Extension ID (18-bits) for a combined length of 29 bits.
- An additional bit, Identifier Extension bit (IDE), identifies the use of the extended format.
- The Arbitration Field also includes a Substitute Remote Request (SSR) bit that ensures priority of the Standard Data Frame if both Standard and Extended Data Frames have the same 11-bit identifier.
- All other fields in 2.0B are the same as those in 2.0A.



Controllers designed for 2.0B format can transmit and receive messages in either 2.0A or 2.0B formats. Controllers designed for 2.0A format are available in two types. The first transmits and receives only 2.0A messages and flags an error when a 2.0B message is detected. The second transmits, receives, and acknowledges 2.0A messages, but does not process them.

The Extended Frame Format is structured as follows:

Description	Field Name	Length (bits)	Purpose
Bus Idle			
SOF	Start-of-frame (SOF)	1	Recessive bit signals start of frame transmission.
Arbitration Field	Identifier A	11	First part of the (unique) identifier for the data.
	Substitute remote request (SRR)	1	Must be recessive.
	Identifier extension bit (IDE)	1	Must be recessive.
	Identifier B	18	Second part of the (unique) identifier for the data.
	Remote transmission request (RTR)	1	Must be dominant.
Control Field	Reserved bits (r0, r1)	2	Reserved bits (must be set dominant, but are accepted as either dominant or recessive).
	Data length code (DLC)	4	Number of bytes of data (0-8 bytes).
Data Field	Data field	0 to 8 bytes	Data to be transmitted (length = DLC field).
CRC Field	CRC	15	Cyclic redundancy check
	CRC delimiter	1	Must be recessive.
ACK	ACK slot	1	Transmitter sends recessive. Any receiver can assert a dominant.
	ACK delimiter	1	Must be recessive.
EOF	End-of-frame (EOF)	7	Must be recessive.
Bus Idle			

#### 1.4.4 Error Handling

CAN uses several message-level techniques to detect errors, as follows:

- CRC checks
- Frame checks
- ACKnowledgement Error Checks

CAN also monitors bit levels for errors — comparing actual bit levels with those transmitted. If a difference is detected, the transmitter flags a bit error.



To increase system reliability, CAN implements “bit stuffing.” Whenever a transmitter sends five consecutive bits of the same type, it automatically adds a bit of opposite polarity into the message. Any node receiving the message automatically removes (de-stuffs) this added bit before processing the message. If any receiving node detects six consecutive bits of the same polarity, therefore, it records a “stuff error”.

- 1.4.4.1 CRC Check**

The transmitter computes a CRC code based on the content of each message it transmits and inserts it into the message frame. Any receiver that accepts the message makes the same computation and compares the two results. If any difference is found, an error is flagged.
- 1.4.4.2 Frame Check**

The CAN format specified that certain bit values must be present at specific locations in the message frame. If a receiver sees the wrong value in any position, it flags a Form (or Format) Error.
- 1.4.4.3 ACK Check**

If a transmitter send a message and does not receive acknowledgment, it flags an ACK Error.
- 1.4.4.4 Error Frame**

If any node detects an error of any kind, it sends an Error Frame. This aborts transmission and prevents any other node from accepting the message containing the error.
- 1.4.4.5 Error Confinement**

The CAN system has a complex system of distinguishing between short-term and long-term errors. Whenever an error is detected, an error count is added to one of two error counters on each node. In simplified terms, receive errors are accumulated with a weighting of 1 and transmitter errors are accumulated with a weighting of 8. Conversely, every good message decrements the counters accordingly, with zero as a limit. The values stored in each counter at any given time determine the error status of a node.

There are three modes of error status: Error Active, Error Passive, and Bus Off Mode. The Error Active Mode is the normal state of a node. To be classified as Error Active, the error counters must contain values less than 127.

If the value in an error counter exceeds 127, the mode changes to Error Passive Mode. In this mode, the node can still transmit and receive messages, but is constrained in how it handles errors it detects.

If the value in an error counter exceeds 255, the node takes itself off the bus and goes into Bus Off Mode. This action removes a permanently malfunctioning (“babbling idiot”) node from the system but leaves all others on the bus unaffected.

This system of error handling, although complex, ensures very high integrity of data communication in noisy environments.

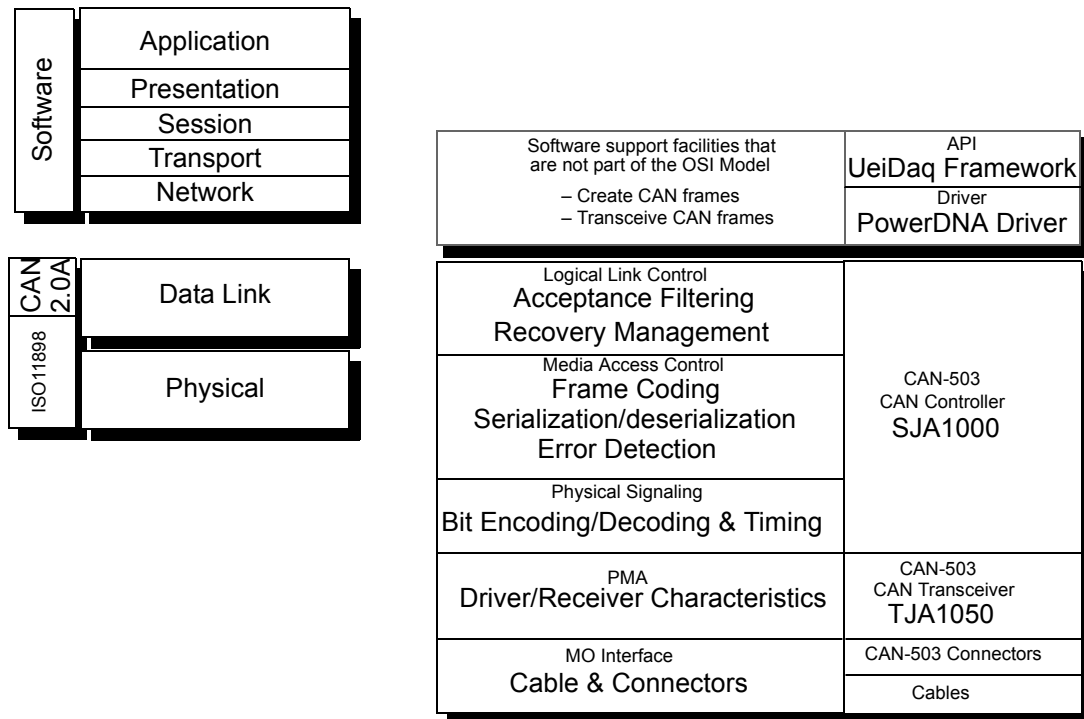


## 1.5 Architecture

### 1.5.5 CAN and the OSI Model – Overview

The CAN communication stack may be represented using the OSI model, as shown in **Figure 1-2**.

CAN-based Protocol Standard



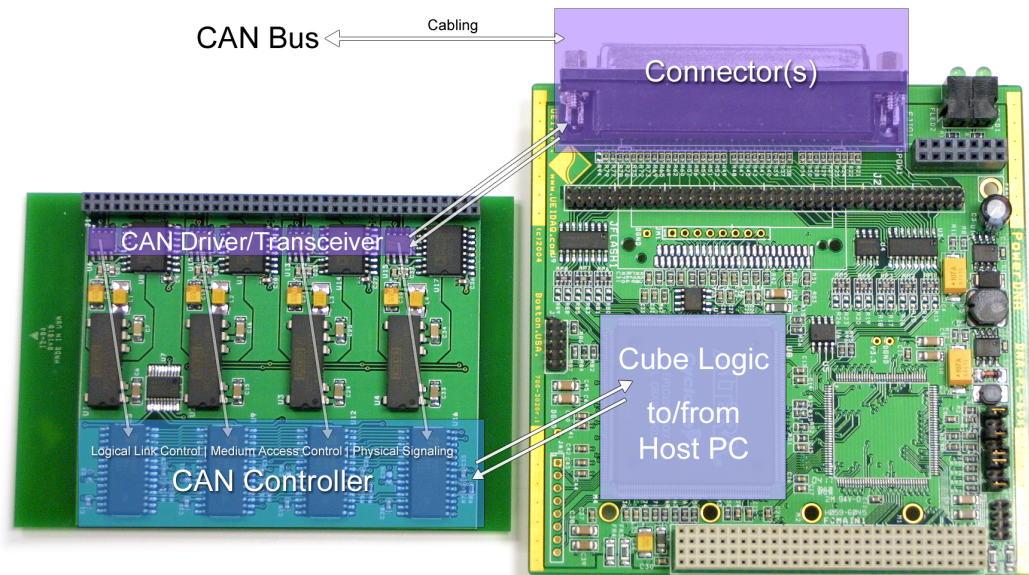
**Figure 1-2. CAN and the ISO/OSI Model**

The *physical* and *data-link* layers are implemented by the CAN-503 hardware, which is detailed in the next section. In concept, the CAN-503 converts CAN frames into (or from) electrical signals.

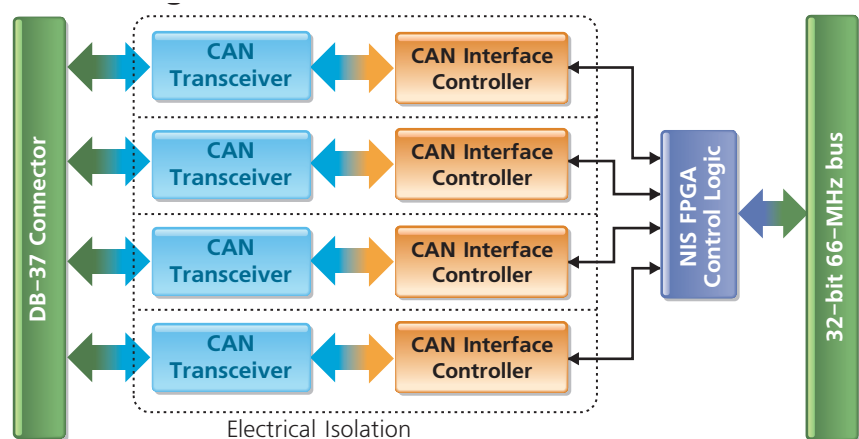
Frames are retrieved from the CAN-503 by the PowerDNA driver and passed to the user application (usually by facility of the UeiDaq Framework). The user application is allowed the freedom and responsibility of implementing layers above data-link and physical with any additional protocol you choose to use (such as CANopen, J1939, DeviceNet, SDS, CAN Kingdom, proprietary, or custom).

At the hardware level, data passes at the physical level through *cabling* and the *connector* through the *TJA1050 CAN transmitter/receiver*, which is controlled by the *SJA100 CAN controller*.





**Figure 1-3. Physical and Data-Link Layers and Logic Circuitry**



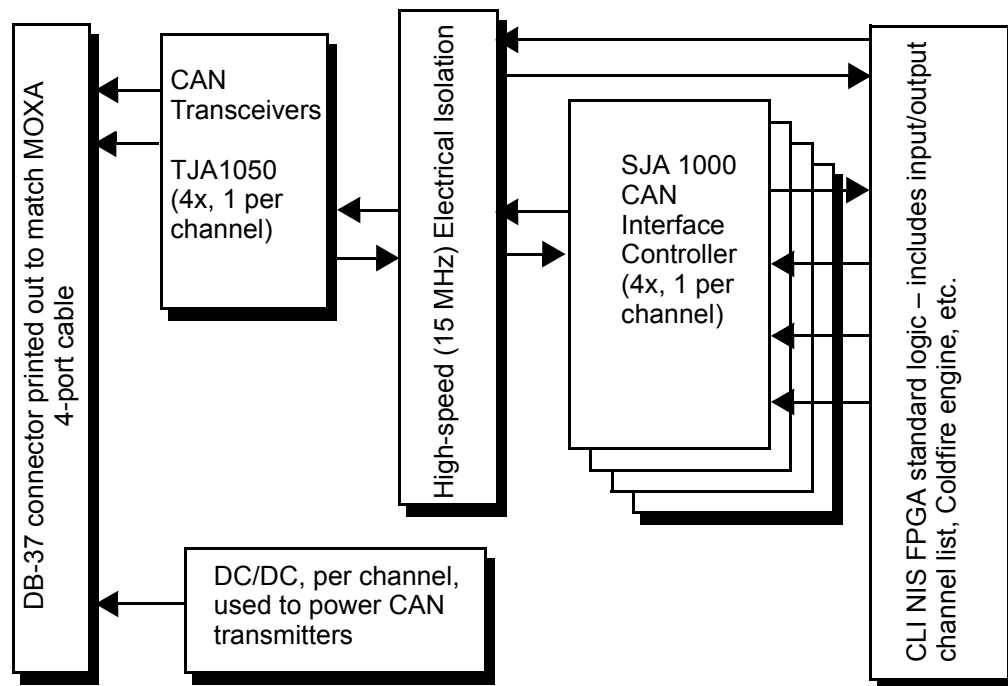
**Figure 1-4. Logic Block Diagram: CAN-503 Overview**

As illustrated in the diagram of **Figure 1-5**, the CAN bus transmits/receives an electrical signal that flows through the DB-9 to DB-37 connector, from/to the TJA1050 CAN transceiver chip. The TJA1050 CAN transceiver acts as an interface to the SJA1000 CAN interface controller – it assists the SJA1000 by handling transmission/reception to/from the CAN bus.

The transceiver and controller are isolated from one another by a high-speed electrical isolation IC. There are four TJA1050 » isolation » SJA1000 structures, one per port; isolation is per-port.

The SJA1000 is in turn controlled by an FPGA Control Chip – which is the layer's control chip. The FPGA works in conjunction with the cube's core module logic.





**Figure 1-5. Logic Block Diagram — CAN-503 Detail**

### 1.5.6 Linking Abstraction

The CAN-503 layer is a device that converts the electrical signal traveling along the CAN bus into raw CAN frame(s).

For the sake of simplicity, ignore the majority of electrical signaling methods described by the ISO 11898 standard and focus on the UeiDaq Framework API.

The UeiDaq Framework API is a tool installed with the PowerDNA Software Suite that provides easy access to the CAN-503's functionality. Framework is a programming facility that allows you to connect to a cube transparently, and then configure the CAN-503 to communicate with other CAN devices. Attach to the CAN-bus and then send and/or receive CAN packets.

Framework sends and receives only raw CAN frames – it does not generate their content. Frame content is the responsibility of higher-level CAN protocols (e.g. CANopen, J1939, DeviceNet, SDS, CAN Kingdom, etc.).

The Framework implementation is best described in an example, as illustrated in Chapter 2.

### 1.5.7 Layer Capabilities

The controller is capable of communicating with the CAN 2.0a and CAN 2.0b protocols. Controller communication speeds are software selectable between 10 and 1000kbps – speed is dependent on noise and length of the cable. The CAN specification recommends a maximum speed of 125k for cables up to 500m in length, and a max. speed of 1M for cables up to 40m. The device can be operated in single-scan, continuous, or continuous with FIFO modes. The 64-byte FIFO on the SJA1000 can store up to 21 messages. The controller can operate in active transmission mode, passive listen-only mode, or self-test mode. The controller has built-in filter-circuitry to target specific messages.



The TJA1050 uses an EMI-resistant differential receiver to capture data from the line. It can operate in “listen mode” where the transmitter is disabled, and can send/receive raw CAN data at speeds up to 1 Mbaud. In the CAN-503 implementation, bandwidth of 4 ports at 250k each (e.g. 1000k total) can be sustained effortlessly over a local CAN bus. Also, note that when powered down, the TJA1050 and the CAN-503 do not disturb the bus lines.

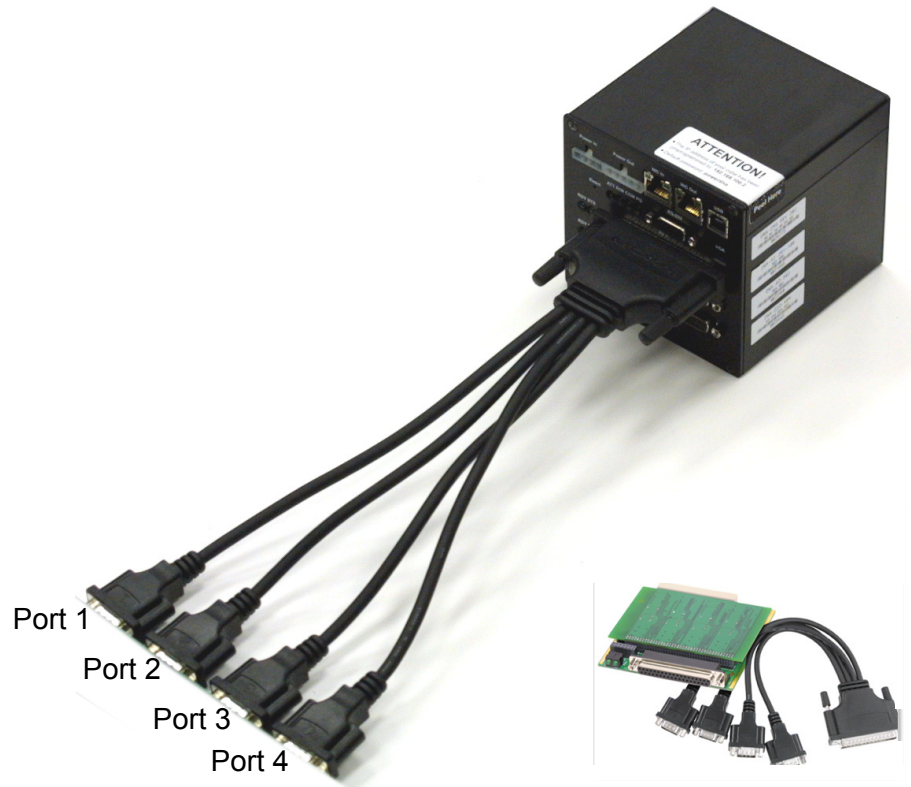
Current implementation of the CAN interface on the Cube provides only register-level access to the Philips SJA1000 CAN interface controllers. Depending on the demand and speed requirements, future implementations may include per-port input and output FIFOs and full interrupt/error handling in logic. The CAN interface is mapped into PowerDNA address space as a set of read/write registers.

**NOTE:** UEISIM support of the DNx-CAN-503 is limited to 300 fps input and 1000 fps output.



## 1.6 Wiring & Connectors

A DNA-CAN-CBL cable (pictured below) from the CAN-503's 37-pin connector provides four individual 9-pin ports; they are labeled by port as (1), (2), (3), (4), with each label molded into the connector. The 9-pin connectors are called stubs.

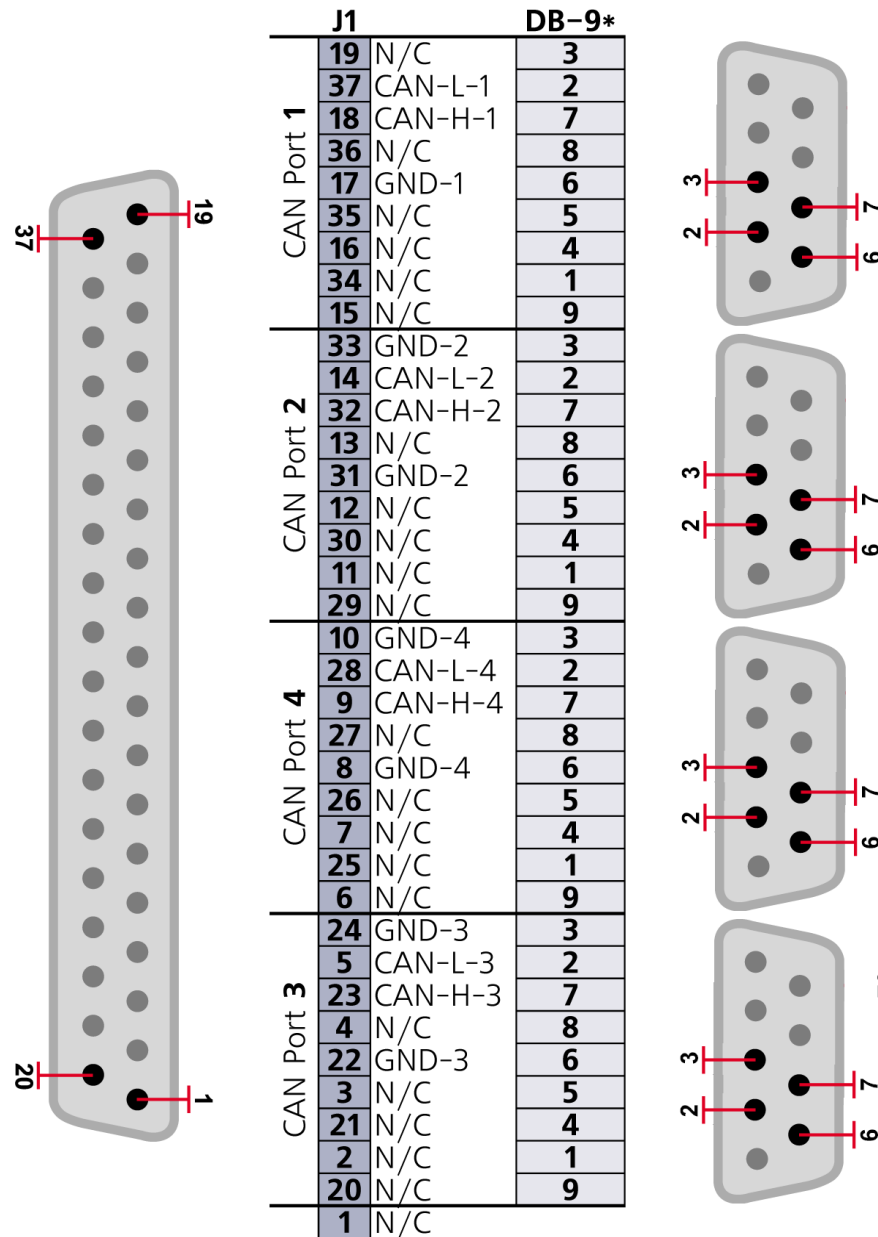


**Figure 1-6. CAN-503 with 4-port DNA-CAN-CBL Attached**

The following signals are located at the connector:

- *CAN-L<sub>x</sub>* – Dominant Low line for port x.
- *CAN-H<sub>x</sub>* – Dominant High line for port x.
- *CAN-GND<sub>x</sub>* – Ground reference voltage for port x.

Both the CAN\_L and CAN\_H lines are protected from automotive electrical transients by ISO 7637 — electrical transient transmission by capacitive and inductive coupling via lines other than supply lines in road vehicles. To take advantage of noise-cancellation properties, use twisted-pair cabling (for >1m). The B-size 37-pin female D-Sub connector on the CAN-503 is divided into four 9-pin D-connector CAN ports by a DNA-CAN-CBL with the following pinouts:

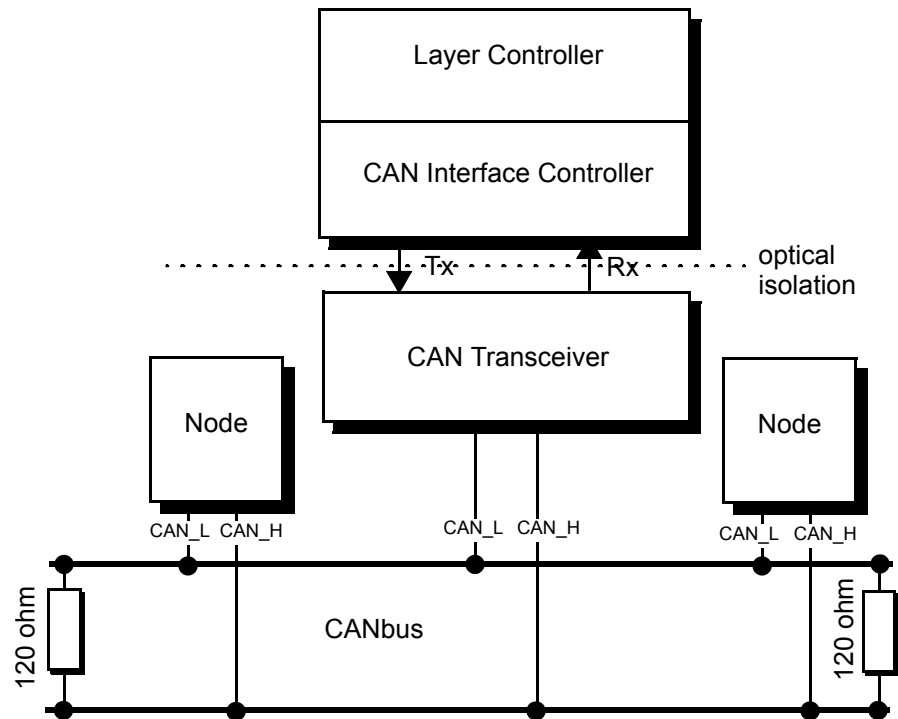


**Figure 1-7 Pinout Diagram for DNA-CAN-503 Layer**

## 1.7 CAN Bus wiring

As shown in **Figure 1-8**, the ISO11898 bus consists of two wires, terminated at both ends by resistors.

CAN devices (nodes) connect their CAN\_L and CAN\_H lines to the two-wire CANbus. A node transmits by sending the signal (HIGH or LOW) on CAN\_H and the inverse of the signal on CAN\_L. Only the two nodes at each the end of the bus must have a terminating resistor (100-130 ohms). The terminating resistors remove signal reflection at the end of the bus and balance the DC voltage levels.



**Figure 1-8. CAN Nodes Connected to a CANbus using Standard 120-ohm Termination**

The bus cable length should not exceed 40m (130ft) at 1Mbps, or 6.7km at 10kbps, due to the cable propagation delay (5nS/m).

For cables longer than 1m (3.28 ft), noise may cause timeouts when using non-twisted-pair cabling; if you experience difficulty, use twisted-pair cabling.

## Chapter 2 Programming with the High Level API

This section describes how to program the DNx-CAN-503 using UeiDaq's Framework High Level API.

Since UeiDaq Framework is object oriented, its objects can be manipulated in the same manner in various development environments such as Visual C++, Visual Basic, LabVIEW, or DASyLab.

Framework comes bundled with examples for supported programming languages. They are located under the UEI programs group in:

*Start » Programs » UEI » Framework » Examples*

The following subsections focus on the C++ API, but the concept is the same regardless of programming language.

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

### 2.1 Creating a Session

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

```
CUeiSession session;
```

### 2.2 Configuring the CAN Ports

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, the device class is **pdna**.

For example, the following resource string selects CAN ports 0,2,3 on device 1 at IP address 192.168.100.2: "pdna://192.168.100.2/Dev1/Can0,2,3".

In addition to the resource, you will also configure:

- Port Speed
- Frame Format: basic using an 11-bit identifier or extended using a 29-bit identifier.
- Port Mode: normal or passive listener.
- Acceptance Mask: used to filter incoming frames. The mask selects which bits within the arbitration ID will be used for filtering.
- Acceptance Code: the arbitration ID bits selected by the acceptance mask are compared to the acceptance code and the frame is rejected if there is any difference.

Setting the acceptance mask to 0xFFFFFFFF and the acceptance code to 0 disables filtering.



```
// Configure CAN ports 0,2,3 on device 0
session.CreateCANPort("pdna://192.168.100.2/Dev0/Can0,2,3",
    UeiCANBitsPerSecond500K,
    UeiCANFrameExtended,
    UeiCANPortModeNormal,
    0xFFFFFFFF,
    0);
```

### 2.2.1 Filtering CAN Messages

The acceptance mask defines the bits that are relevant (0 is relevant, 1 is not) for comparison with the acceptance code.

The way you pack the bits in the mask and code depends on whether the CAN interface is configured in Basic or Extended mode and also on whether you want to filter incoming frames that use 11-bit IDs or frames that use 29-bit IDs.

The algorithm for defining the acceptance code and mask is described in the document at [http://www.nxp.com/acrobat\\_download/applicationnotes/AN97076.pdf](http://www.nxp.com/acrobat_download/applicationnotes/AN97076.pdf), starting at page 19.

#### Example 1, 11-bit filtering:

The following shows how to make a common filter configuration that rejects 0x241, 0x514, and 0x4E1 and accepts 0x541 and 0x641.

```
0x241 010 0100 0001 ; lay out the bits to reject, convert hex to
                        ; binary
0x514 101 0001 0100
0x4E1 100 1110 0001 ; lay out the bits to accept
0x541 101 0100 0001
0x641 110 0100 0001
```

Now shift the groupings left by one place and pad with 21 x's on the right (to make it a full 32-bit word).

```
reject  0100 1000 001x xxxx xxxx xxxx xxxx
"       1010 0010 100x xxxx xxxx xxxx xxxx
"       1001 1100 001x xxxx xxxx xxxx xxxx

accept  1010 1000 001x xxxx xxxx xxxx xxxx
"       1100 1000 001x xxxx xxxx xxxx xxxx
```

```
'row a': 1xx0 100x 0x1x xxxx xxxx xxxx xxxx
          ; for each column, if both accept bits are the same
          ; and at least one reject bit is different,
          ; then copy the accept bit, otherwise make it x
```

```
1000 1000 0010 0000 0000 0000 0000 0000 ; make code: copy 'row a' and
                                           ; make all x's be zero
      8      8      2      0      0      0      0      0 ; convert binary to hex,
                                           ; the acceptance code = 0x88200000
```



```
0110 0001 0101 1111 1111 1111 1111 1111 ; make mask: put a 1 where
                                ; 'row a'
                                ; has an x. The others become zero.
    6      1      5      F      F      F      F      F ; convert binary to hex
                                ; the acceptance mask = 0x615FFFFFFF
```

### Example 2, 29-bit filtering:

In this example, you want to receive messages with ID's 18FEEEE00, 18FEF100 and 0CF00400 and receive as few other messages as possible.

```
0x18FEEEE00 1 1000 1111 1110 1110 1110 0000 0000 ;lay out the bits
0x18FEF100  1 1000 1111 1110 1111 0001 0000 0000 ;      "
0x0CF00400  0 1100 1111 0000 0000 0100 0000 0000 ;      "

1100 0111 1111 0111 0111 0000 0000 0xxx ; shift groupings left, pad
                                ; 3 x's
1100 0111 1111 0111 1000 1000 0000 0xxx ;      "
0110 0111 1000 0000 0010 0000 0000 0xxx ;      "

x1x0 0111 1xxx 0xxx xxxx x000 0000 0xxx ; find what's common to all 3,
                                ; else x
0100 0111 1000 0000 0000 0000 0000 0000 ; make code, take common,
                                ; x's -> 0
    4      7      8      0      0      0      0      0 ; convert code to hex
                                ; code is 0x47800000
1010 0000 0111 0111 1111 1000 0000 0111 ; make mask, x's become 1's,
                                ; else 0
    A      0      7      7      F      8      0      7 ; convert mask to hex
                                ; mask is 0xA077F807
```

## 2.3 Configuring the Timing

You need to configure the CAN-503 to use the "messaging" timing mode. Messages are equivalent to CAN frames and are represented in C++ with the structure `tUeiCANFrame`:

```
struct tUeiCanFrame
{
    uInt32    Id;// arbitration Id of the frame
    uInt32    IsRemote;// 1 if the frame is remote
    uInt32    DataSize;// number of bytes in the payload
    uInt8     Data[8];// payload
};
```

The CAN-503 can be programmed to wait for a certain number of messages to be received before notifying the session.

It is also possible to program the maximum amount of time to wait for the specified number of messages before notifying the session.





The following sample shows how to configure the messaging I/O mode to be notified when 10 frames have been received or every second. (If the CAN port receives less than 10 frames per second, it will return whatever number of frames is available every second).

```
CANSession.ConfigureTimingForMessagingIO(10, 1.0);
```

**2.4 Reading Data** Reading data from the CAN-503 is done using a reader object. As there is no multiplexing of data (contrary to what's being done with AI, DI, or CI sessions), you need to create one reader object per CAN port to be able to read from each port in the port list.

The following sample code shows how to create a reader object tied to port 1 and read at most 10 frames from the CAN bus.

```
// Create a reader and link it to the session's stream, port 1
reader = new CUiCANReader(session.GetDataStream(), 1);

// read up to 10 CAN frames, numFramesRead contains the
// number of frames actually read.
tUiCANFrame frames[10];
reader->Read(10, frames, &numFramesRead);
```

**2.5 Writing Data** Writing data to the CAN-503 is done using a writer object. As there is no multiplexing of data (contrary to what's being done with AO, DO, or CO sessions), you need to create one writer object per CAN port to be able to write to each port in the port list.

The following sample code shows how to create a writer object tied to port 2 and send one frame to the CAN bus.

```
// Create a writer and link it to the session's
// stream, port 2
writer = new CUiCANWriter(session.GetDataStream(), 2);

// Write 1 CAN frames
tUiCANFrame frame;
frame.Id = 0x10290; // Set the arbitration Id
frame.IsRemote = 0; // This is not a remote frame
frame.DataSize = 1; // Only send 1 byte in the payload
frame.Data[0] = 0x23; // Initializes the 1-byte payload

writer->Write(1, &frame, &numFramesWritten);
```

**2.6 Cleaning-up the Session** The session object will clean itself up when it goes out of scope or when it is destroyed. However, you can manually clean up the session (to reuse the object with a different set of channels or parameters).

```
session.CleanUp();
```



## Chapter 3 Programming using the Low-Level API

The low-level API offers direct access to PowerDNA DaqBIOS protocol and allows you to directly access device registers.

We recommend that you use the UeiDaq Framework (see Chapter 2), because it is easier to use.

You should only need to use the low-level API if you are using an operating system other than Windows.

Please refer to the `API Reference Manual` document under:

*Start » Programs » UEI » PowerDNA » Documentation*

for pre-defined types, error codes, and functions for use with this layer.



# Appendix

## A. Accessories

### DNA-CBL-COM

1-ft long, round shielded cable with 37-pin male and four 9-pin male D-sub connectors

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