Juno™ Torque Control IC DK73112N Developer Kit User Manual
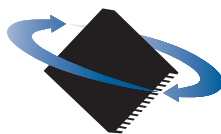
Revision 1.3 May, 2020

NOTICE

This document contains proprietary and confidential information of Performance Motion Devices, Inc., and is protected by federal copyright law. The contents of this document may not be disclosed to third parties, translated, copied, or duplicated in any form, in whole or in part, without the express written permission of Performance Motion Devices, Inc.

The information contained in this document is subject to change without notice. No part of this document may be reproduced or transmitted in any form, by any means, electronic or mechanical, for any purpose, without the express written permission of Performance Motion Devices, Inc.

Copyright 1998–2020 by Performance Motion Devices, Inc.

Juno, ATLAS, Magellan, ION, Prodigy, Pro-Motion, C-Motion, and VB-Motion are registered trademarks of Performance Motion Devices, Inc.

Warranty

Performance Motion Devices, Inc. warrants that its products shall substantially comply with the specifications applicable at the time of sale, provided that this warranty does not extend to any use of any Performance Motion Devices, Inc. product in an Unauthorized Application (as defined below). Except as specifically provided in this paragraph, each Performance Motion Devices, Inc. product is provided "as is" and without warranty of any type, including without limitation implied warranties of merchantability and fitness for any particular purpose.

Performance Motion Devices, Inc. reserves the right to modify its products, and to discontinue any product or service, without notice and advises customers to obtain the latest version of relevant information (including without limitation product specifications) before placing orders to verify the performance capabilities of the products being purchased. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgment, including those pertaining to warranty, patent infringement and limitation of liability.

Unauthorized Applications

Performance Motion Devices, Inc. products are not designed, approved or warranted for use in any application where failure of the Performance Motion Devices, Inc. product could result in death, personal injury or significant property or environmental damage (each, an "Unauthorized Application"). By way of example and not limitation, a life support system, an aircraft control system and a motor vehicle control system would all be considered "Unauthorized Applications" and use of a Performance Motion Devices, Inc. product in such a system would not be warranted or approved by Performance Motion Devices, Inc.

By using any Performance Motion Devices, Inc. product in connection with an Unauthorized Application, the customer agrees to defend, indemnify and hold harmless Performance Motion Devices, Inc., its officers, directors, employees and agents, from and against any and all claims, losses, liabilities, damages, costs and expenses, including without limitation reasonable attorneys' fees, (collectively, "Damages") arising out of or relating to such use, including without limitation any Damages arising out of the failure of the Performance Motion Devices, Inc. product to conform to specifications.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent procedural hazards.

Disclaimer

Performance Motion Devices, Inc. assumes no liability for applications assistance or customer product design. Performance Motion Devices, Inc. does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of Performance Motion Devices, Inc. covering or relating to any combination, machine, or process in which such products or services might be or are used. Performance Motion Devices, Inc.'s publication of information regarding any third party's products or services does not constitute Performance Motion Devices, Inc.'s approval, warranty or endorsement thereof.

Patents

Performance Motion Devices, Inc. may have patents or pending patent applications, trademarks, copyrights, or other intellectual property rights that relate to the presented subject matter. The furnishing of documents and other materials and information does not provide any license, express or implied, by estoppel or otherwise, to any such patents, trademarks, copyrights, or other intellectual property rights.

Patents and/or pending patent applications of Performance Motion Devices, Inc. are listed at
https://www.pmdcorp.com/company/patents.

Related Documents

Juno Torque Control IC User Guide

> Complete description of the MC71112, MC71112N, MC73112 and MC73112N Juno torque control ICs including electrical characteristics, pin descriptions, and theory of operations.

Juno Velocity & Torque Control IC User Guide

> Complete description of all members of the Juno Velocity & Torque Control IC family including the MC71112, MC71112N, MC73112, MC73112N, MC74113, MC74113N, MC75113, MC75113N, MC71113, MC73113, and MC78113 ICs. Includes features and functions with detailed theory of operations.

Juno Velocity & Torque Control IC Programming Reference

> Description of all Juno family IC commands, with coding syntax and examples, listed alphabetically for quick reference.

Table of Contents

This page intentionally left blank.

List of Figures

This page intentionally left blank.

1. Installation

In This Chapter

- ▶ Introduction
- ▶ Developer Kit Components List
- ▶ DK73112N Board
- ▶ Included Hardware Accessories
- ▶ Installation Overview
- ▶ Recommended Hardware
- ▶ Software Installation
- ▶ Board Installation
- ▶ Connection Summary
- ▶ Applying Power
- ▶ First-Time System Verification
- ▶ Pulse & Direction Operation

1.1   Introduction

The PMD DK73112N Developer Kit is an integrated board/software package that serves as an electrical and software design tool for building systems that use the Juno 56-pin VQFN torque control ICs.

The developer kit supports two ICs in the Juno torque control family, as shown below:

Developer Kit p/n	Installed IC	Motors Supported
DK71112N	MC71112N	DC Brush
DK73112N	MC73112N	Brushless DC

Both of the above developer kit versions share the same physical DK73112N board. They differ in the specific type of Juno torque control IC that is installed in the board.

1.2   Developer Kit Components List

The DK73112N developer kit contains the following components:

- DK73112N Developer Kit board

- 3-pin USB to serial programming cable

If any of these components are missing, please contact your PMD representative.

1.3   DK73112N Board

The heart of the DK73112N Developer Kit is the DK73112N printed circuit board that contains interface and amplifier circuitry to allow various features of the MC71112N and MC73112N ICs to be accessed. Here is a summary of the features provided by the DK73112N board:

- High performance on-board amplifier with current feedback

- 3-pin UART host communications interface

- Easy to use jack screw style cable connectors

- Single DC-voltage supply

- Quadrature signal input with Index capture

- Overtemperature, overcurrent, over and undervoltage sense

- Analog and digital SPI torque command input

- Compact (2.4" x 1.9") standalone form factor (6.1 cm x 4.8 cm)

1.3.1   Pro-Motion

Pro-Motion is a sophisticated, easy-to-use exerciser program that is included with the DK73112N. It allows all of the Juno control parameters to be set and/or viewed, and allows all features to be exercised. Pro-Motion features include:

- Motion oscilloscope graphically displays processor parameters in real-time

- AxisWizard to automate axis setup and configuration

- Current loop auto-tuning

- Project window for accessing motion resources and connections

- Ability to save and load settings

- Distance, time, and electrical units conversion

- Frequency sweep and bode plot analysis tools

- Motor-specific parameter setup

1.4   Included Hardware Accessories

The DK73112N includes these accessories that you may find useful:

Component PMD Part Number	Description
Cable-USB-3P	3-pin cable. This programming cable provides a USB connection to a PC and plugs into the DK board's 3-pin programming connector.

1.5   Installation Overview

1 Before using the board, the software must be installed. See <u>Section 1.7, "Software Installation"</u> for instructions on installing the software.

2 Next, connect the motor and optional encoder. See <u>Section 1.9, "Connection Summary"</u> for a description of the connections.

3 Connect the DK73112N board to the host PC via the 3-pin cable. See <u>Section 1.9.3, "Communication Connection"</u> for a description of this procedure.

4 Once this hardware configuration is complete, the final step to finish the installation is to perform a functional test of the finished system. See <u>Section 1.11, "First-Time System Verification"</u> for a description of this procedure.

Once these steps have been accomplished, the installation is complete, and the board is ready for operation.

1.6   Recommended Hardware

To install a DK73112N board the following hardware is recommended.

- Intel (or compatible) processor, 1 Gbyte of available disk space, 256 MB of available RAM. The supported PC operating systems are Windows XP, Vista, Windows 7, Windows 8, Windows 10.

- One DC Brush or Brushless DC motor depending on which Juno torque control IC is installed. This motor may or may not provide encoder position feedback signals.

- Cables as required to connect the motor with the DK73112N board.

- Power supply, power cable. The DK73112N board requires only a single voltage supply. The board logic and other circuitry is powered from this input voltage using an on-board DC to DC converter.

1.7   Software Installation

The software distribution for the DK78113 developer kit is downloaded from the PMD website at the URL: <u>https://www.pmdcorp.com/resources/software</u>.

All software applications are designed to work with Microsoft Windows.

To install the software:

1 Go to the Software Downloads section of PMD's website located at <u>https://www.pmdcorp.com/resources/software</u> and select download for "Developer Kit Software."

2 After selecting download you will be prompted to register your DK, providing the serial # for the DK and other information about you and your motion application.

3 After selecting submit the next screen will provide a link to the software download. The software download is a zip file containing various installation programs. Select this link and downloading will begin.

4 Once the download is complete extract the zip file and execute the desired install programs from the list below. Every first-time installation should install Pro-Motion, and at least one of the two SDK options. However you may install both SDKs if desired. When installing the SDKs you will be given the option to download the documentation and/or the complete SDK content.

- Pro-Motion – an application for communicating to, and exercising PMD ICs, modules, or boards.

- PMD SDK – a software development kit for creating motion applications using the C/C++ programming languages. Also contains PDF versions* of all PMD product documentation.

- CME SDK – a software development kit for creating motion applications using the .NET (C#, VB) programming languages. Also containsPDF versions* of all PMD product documentation.

*Adobe Acrobat Reader is required for viewing these files. If the Adobe Acrobat Reader is not installed on your computer, it may be freely downloaded from http://www.adobe.com.

1.8   Board Installation

Figure 1-1 shows the location of various DK73112N components.

Figure 1-1: DK73112N Board Components Location
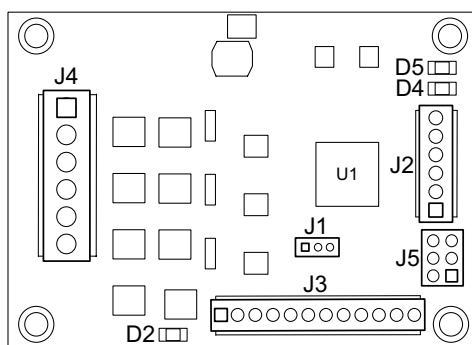
The following table describes these components:

Label	Description
J4	HV Power & Motor Connector
J3	Feedback Connector
J2	Amplifier Signal Connector
J1	Programming Connector
J5	SPI Connector
D2, D4, D5	AmplifierEnable, Fault, and power LED indicators (respectively)

1.8.1   Enabling the Board

The DK73112N requires an active Enable signal to operate. To accomplish this the Amplifier Signal Connector (J2) is used. Connect terminal #1 of J2 (indicated on the board as ~EN) to terminal #4 of J2 (indicated on the board as GND) using a short wire.

For reference the following table provides the pinouts of the J2 connector:

Pin	Signal	Description
J2 - Amplifier Signal Connector		
1	Enable	Active low Enable digital input signal
2	FaultOut	Active low digital FaultOut output signal
3	Brake	Brake input signal
4	GND	Ground

Pin	Signal	Description
5	AnalogCmd-	AnalogCmd- torque command input
6	AnalogCmd+	AnalogCmd+ torque command input

1.9   Connection Summary
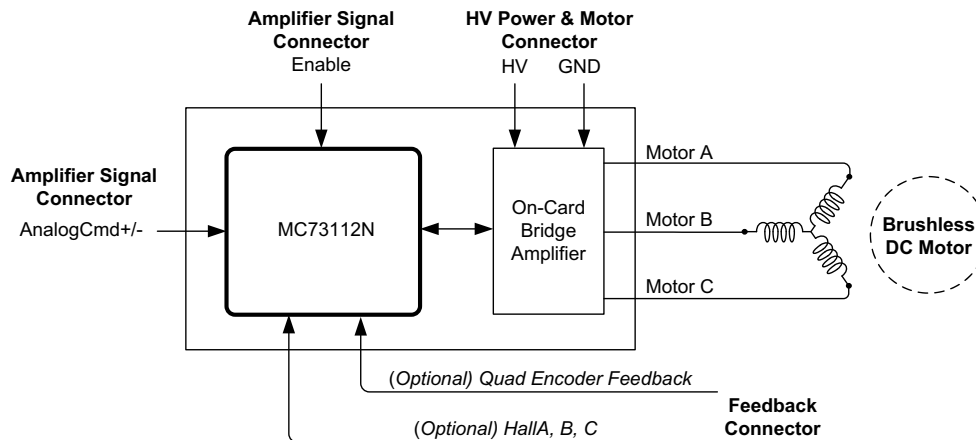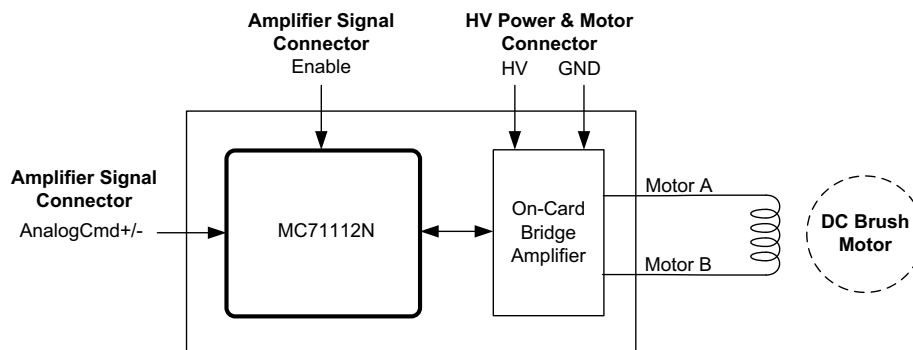
1.9.1   Encoder Feedback Connections

The following table summarizes the encoder signal connections to the DK73112N. All connections are made through the Feedback Connector (J3). Encoders are optional with Brushless DC motors and generally not used with DC Brush motors.

For reference, the following table provides the pinouts of the J3 connector.

Pin	Connection	Description
J3 - Feedback Connector		
1	Vcc	+5V output
2	GND	Ground
3	QuadA+	Quadrature A+ encoder input
4	QuadA-	Quadrature A- encoder input

Pin	Connection	Description
5	QuadB+	Quadrature B+ encoder input
6	QuadB-	Quadrature B- encoder input
7	Index+	Index+ input
8	Index-	Index- input
9	HallA	HallA signal input
10	HallB	HallB signal input
11	HallC	HallC signal input
12	GND	Ground

1.9.1.1   Single-ended Encoder Connections

Encoder inputs may be connected differentially, with two wires per signal (as shown in the table above), or with just one wire per signal. If single-ended encoders are used, connect encoder signals to the positive encoder input only. The negative input may remain unconnected.

## 1.9.2   Power & Motor Connections

The HV voltage is the voltage at which the motor will be driven and must be in the range of +12V to +48V.

The following table summarizes the HV power and motor drive connections for the DK73112N. For Brushless DC motors all three motor outputs are used, and for DC Brush motors only Motor A and Motor B are used.

Pin	Connection	Description
J4 - HV Power Connector		
1	HV	Provides DC power to the board and on-board switching amplifier
2	GND	Ground
3	Motor A	Motor output signal A
4	Motor B	Motor output signal B
5	Motor C	Motor output signal C
6	Shunt	Shunt output

1.9.3   Communication Connection

Figure 1-4:
PC to
DK73112N
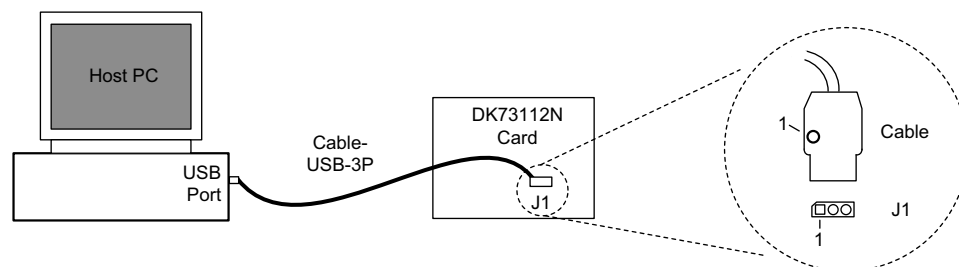
Communication to the board is via a serial UART port.

A 3-pin cable for this purpose is included with the DK73112N. As shown in Figure 1-4 this cable (PMD p/n Cable-USB-3P) should be connected to the DK73112N board's J1 Connector, while the opposite end of the cable should be connected to one of your computer's USB ports. When installing the cable at the DK board make sure the pin 1 orientation is correct. Refer to Figure 1-4 to determine the pin 1 location of the DK73112N board. Pin 1 on Cable-USB-3P is locatable via a small dot at the pin 1 location.

1.10   Applying Power

Once you have made your motor hardware, communication, and power connections, hardware installation is complete and the board is ready for operation. When power is applied, the DK73112N's green power LED should light. This LED is labeled D5 in Figure 1-1. If the LED does not light, re-check connections.

After power up no motor output will be applied. Therefore the motor should remain stationary. If the motor moves or jumps, power down the board and check the motor and encoder connections.

1.11   First-Time System Verification

The first time system verification procedure summarized below has two overall goals. The first is to connect the DK73112N board with the PC that is being used so that they are communicating properly, and the second is to initialize the axis and bring it under stable control capable of driving at controlled torque values. While there are additional capabilities that Pro-Motion and the DK73112N board provide, these steps will create a foundation for further exploration and development.

Here is a summary of the steps that will be used during first time system verification. Each of these steps will be described below in a separate manual section.

    1   Initiate Pro-Motion and establish communication between the PC and the board using the USB to UART communications link.

    2   Run Pro-Motion's Axis wizard to initialize parameters such as encoder direction and current loop parameters. As part of the axis wizard setup you will manually enter torque commands to demonstrate that your motor is operating correctly.

## 1.11.1   Establishing Serial Communications

To establish programming communications:

    1   Make sure the DK73112N board is powered and connected to the PC via the 3-pin programming cable.

    2   Launch the Pro-Motion application.

       When Pro-Motion is launched you will be prompted with an Interface selection window. A typical screen view when first launching Pro-Motion appears below.

The purpose of the Interface dialog box is to indicate to Pro-Motion how your DK73112N board is connected to the PC.
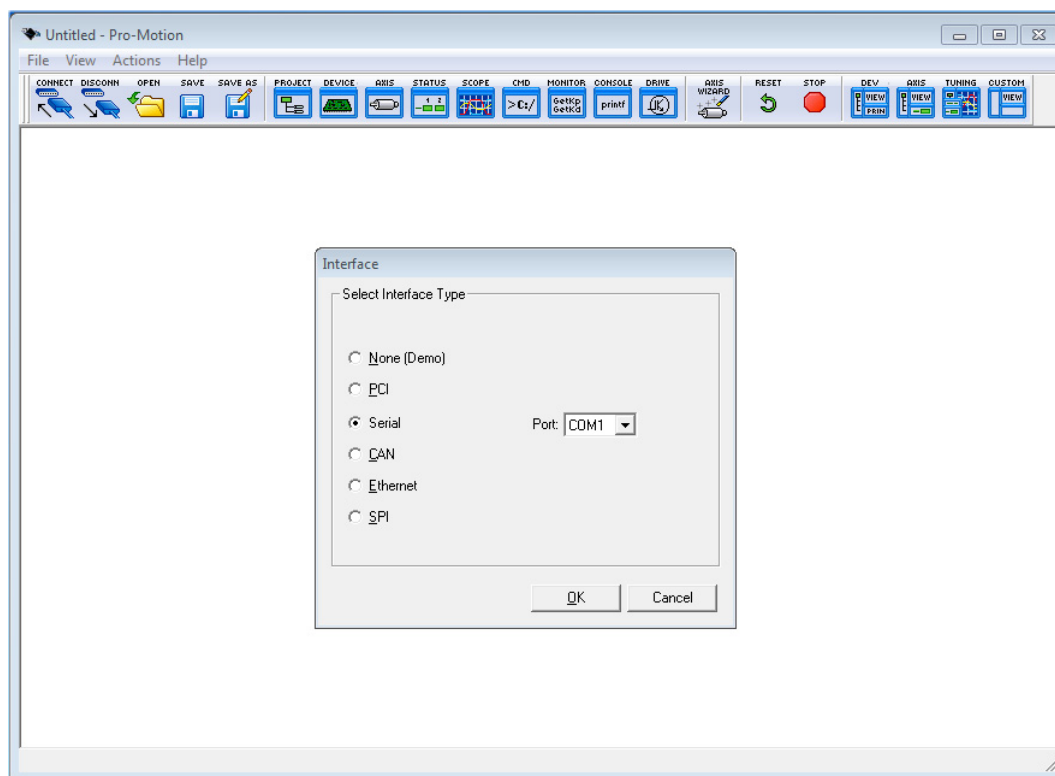

3 Click Serial, select the COM port that the DK is connected to, and then click OK.

The Serial Port dialog box displays with default communication values of 57,600 baud, no parity, 1 stop bit, and point to point protocol.

4 Click OK without changing any of these settings.

If serial communication is correctly established, a set of object graphics loads into the Project window to the left, as shown in the following figure.
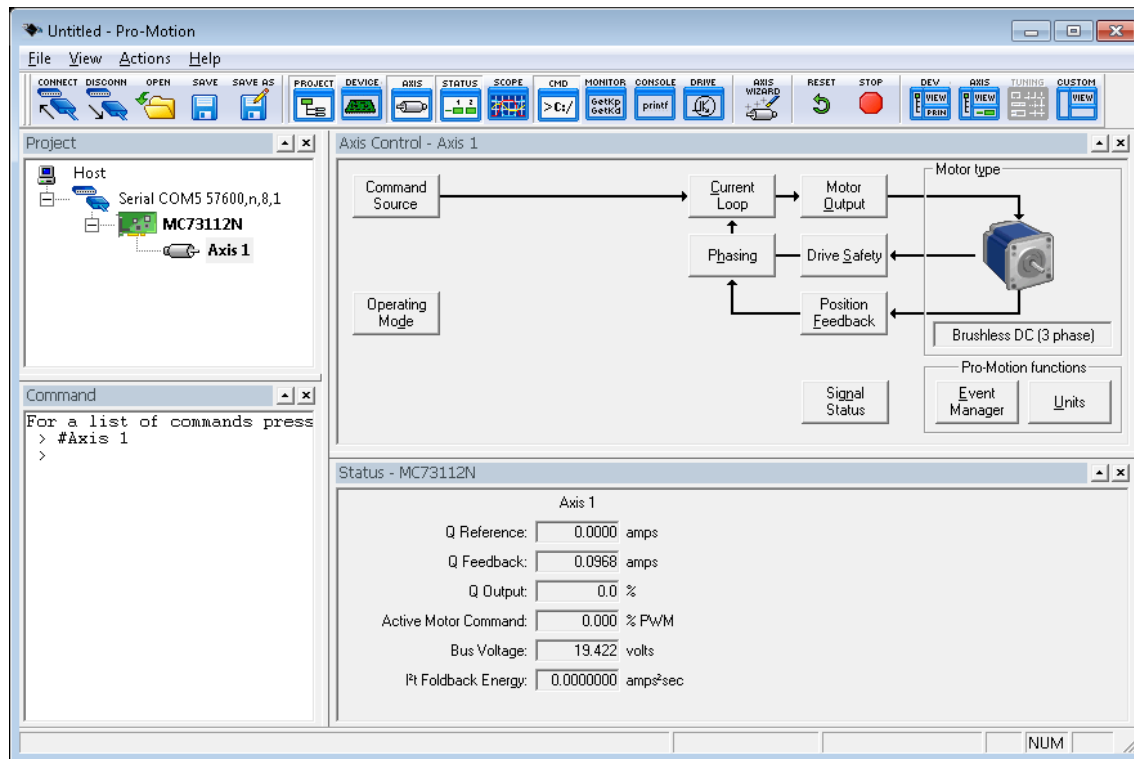
For example, you will see the MC71112N or MC73112N IC name next to an icon of a board, and below that you see an axis icon. Highlighting (single clicking) either the board icon or the axis icons with the mouse is used to select specific boards or axes, and is useful later on in the first time system verification.

If serial communications are not correctly established, a message appears indicating that an error has occurred. If this is the case, recheck your connections and repeat from step 1.

1.11.2 Initializing Motion Axis

The next step to verify the correct operation of the system is to initialize the axis, thereby verifying correct amplifier operation, encoder feedback connections (if an encoder is used), and other motion functions. All of this can be conveniently accomplished using Pro-Motion's Axis Wizard function.

To operate the Axis Wizard:

    1   Select axis 1 in the Project window to the left of the screen.

    2   With this icon highlighted, click the Axis Wizard toolbar button.

The Axis Wizard initialization window appears.
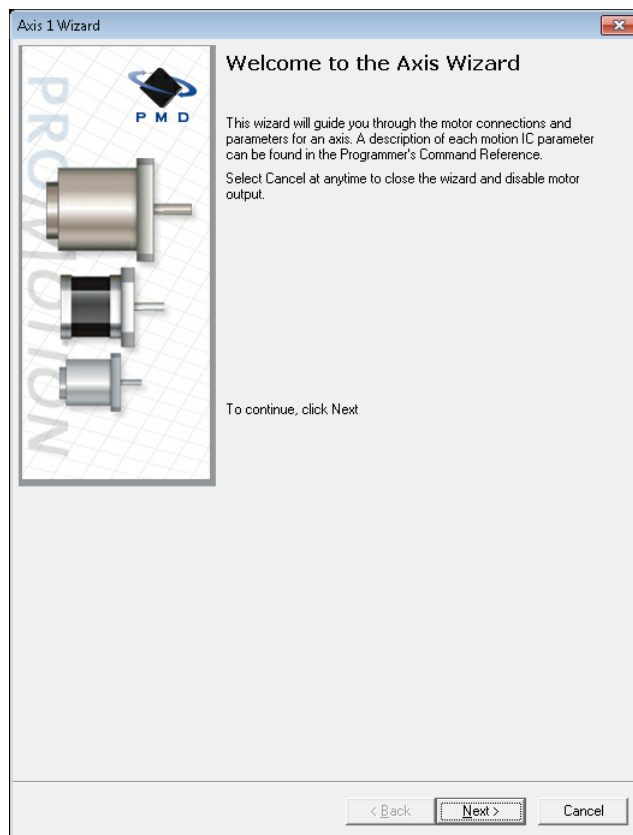
3 Click Next and follow the Axis Wizard instructions for each page of the axis initialization process.

A typical Axis Wizard sequence takes 3-5 minutes.

Important! In addition to application specific parameters, you will be prompted to enter various board-specific control parameters during Axis Wizard setup. These board-specific parameters can conveniently be selected as a group from within the Axis Wizard. It is highly recommended that you select use of the DK73112N default parameters.

Upon a normal completion of the AxisWizard the axis will be ready to make a controlled move.

The most common reasons for the Axis Wizard to not complete normally are an inability to auto-tune the motor. Should this happen, it is possible to perform a manual tuning or commutation setup if desired.

The Axis Wizard auto tuning routines are designed to provide stable, but not optimal, parameters for motion. Pro-Motion provides a wealth of functions including a high speed hardware trace oscilloscope that can assist you in determining optimal parameters. Values provided by the Axis Wizard during auto tuning may or may not be safe for your system, and it is up to the user to determine if and when they should be used.

4 The "Command Source and System Activation" screen, which is one of the last setup screens in the wizard, provides the opportunity to perform a simple profile move.

The Command Source and System Activation screen appears as follows.

To specify a motor torque command set the source to motor command register. Negative values of torque will move the motor in the negative direction.

Once you have entered a torque in the "Motor Command" field click Go and confirm that the motor motion reflects the motor command torque you have specified. To change the torque once motion has started simply enter a new torque command. To stop motion click on the "Stop" button when it appears once motion has started.

5   When ready, select "Next" at the bottom of the screen and you will get to a screen called "Completing the Axis Wizard." Click Finish to exit the Axis Wizard.

1.12 Operation With External Torque Command Input

**Figure 1-5:
Pro-Motion
Operation with
External Torque
Command
Input**
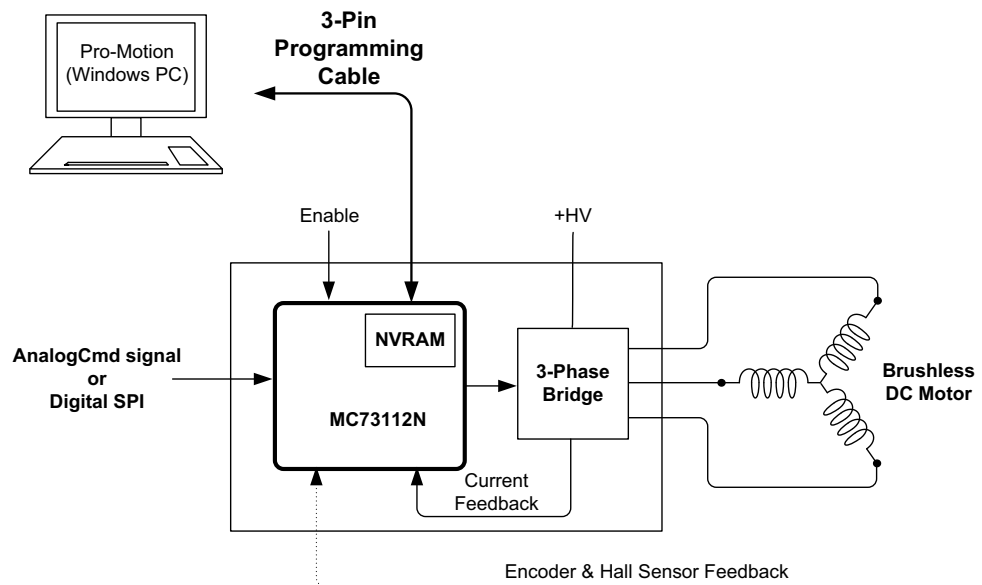
The previous first time system verification section uses the Juno torque control IC's motor command register to generate motion of the motor. This is convenient because it requires a minimum of external control signals, and allows motion to be controlled entirely from the Pro-Motion exercisor program.

The most common control mode of the Juno torque control ICs however uses an external analog AnalogCmd signal or the digital SPI bus signal to command the motor torque. These external signals may be generated by a user-created motion controller, by an off-the-shelf third party motion controller, or by one of PMD's motion controllers that provide +/-10V analog outputs such as the Magellan MC58000 series chipset.

Figure 1-5 shows a DK73112N driven by an AnalogCmd signal while being connected to Pro-Motion. This is a common and very useful way to use the DK73112N. In this mode, Pro-Motion can be used to monitor the controller performance and trace various system characteristics during your application development.

From Pro-Motion, to select the AnalogCmd signal as the command source, at the top of the "Command Source and System Activation" screen that you previously used to manually enter torque commands, change the command source to AnalogCmd.

A command register will now be displayed which holds the commanded torque command from the signals. Once your external controller is active you should see this command value reflect the command being generated by the external controller. When ready, click the Go button to have the externally provided torque command drive the motor.

If any of these functions do not operate as expected recheck electrical connections and retry.

1.12.1 Restarting Pro-Motion

After first time verification is complete you may continue, in the same Pro-Motion session, to exercise your motion system or optimize control parameters as desired. Alternatively, whether immediately after additional interactions with Pro-Motion, you may wish to exit Pro-Motion for restart at a later time.

If you have changed additional control parameters and would like to save these parameters use File/Save Project As to save the current configuration to a file.

When restarting Pro-Motion it is important that you restore the configuration that you have saved, particularly the on-board amplifier limits and scale factors established during Axis Wizard setup. Do this by selecting File/Open Project, selecting the correct file previously stored.

> Operation of the DK73112N without proper safety settings established during Axis Wizard operation may harm the DK73112N board or the application hardware. To avoid this be sure to restore saved control settings using the File/Open Project menu item before operating the DK73112N board.

1.12.2 Next Steps

In addition to managing configuration setup and storage Pro-Motion has extensive performance trace facilities that can be accessed from its main control windows along with other servo motor control functions. You can use these facilities to further checkout and optimize your system's performance.

When ready, you can store the motor configurations you develop into named files, thereby making it easy to work on multi-motor systems with different motor and system control needs for various parts of the overall machine.

This page intentionally left blank.

2. Operation

In This Chapter

▶ DK73112N Block Diagram
▶ Communication Port
▶ Switching Motor Amplifier
▶ Drive Protection and Control Signals
▶ DC Bus
▶ Miscellaneous Signal Processing
▶ Analog Command & Tachometer Inputs
▶ Enable & FaultOut
▶ On-IC NVRAM Configuration Storage

2.1   DK73112N Board Block Diagram

The DK73112N Developer Kit board provides a complete functioning MC71112N and MC73112N IC exerciser and development system. It directly interfaces to a host computer using USB to serial communication, and provides all power, motor drive, control, and feedback signals required to drive a DC Brush or Brushless DC motor.

The DK73112N incorporates several major subsystems including the MC71112N or MC73112N ICs themselves, a high performance MOSFET-based motor amplifier, a DC Bus conditioning and monitoring system, and various other circuitry.

The following sections describe the major sections of the DK73112N board.

For a complete description of the MC71112N and MC73112N ICs, see the *Juno Torque Control IC User Guide*.

**Figure 2-1:
DK73112N
Block Diagram**
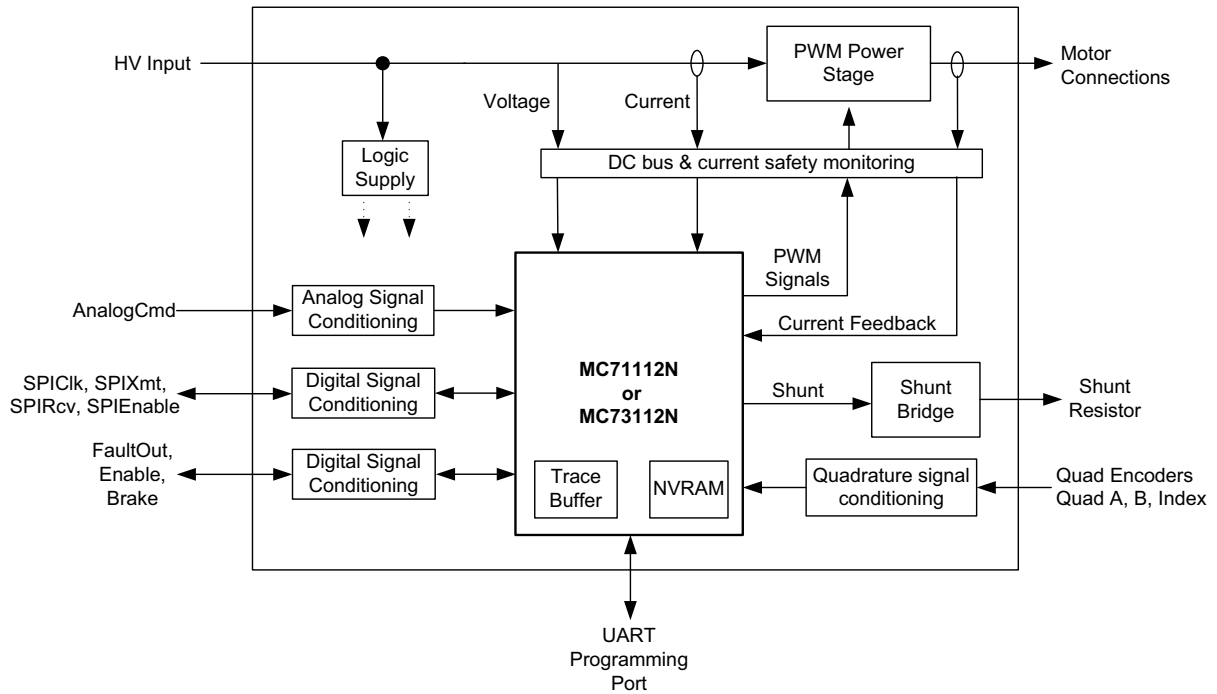
2.2   Communication Port

The DK73112N supports a UART serial interface via its J1 connector. This port is primarily used for setup of the MC71112N or MC73112N's control parameters or for application development via Pro-Motion or similar software programs.

All DK73112N communication functions are controlled by the MC71112N or MC73112N IC. For information on serial port function see the *Juno Torque Control IC User Guide.*

2.3   Switching Motor Amplifier

The DK73112N contains a high-efficiency MOSFET power stage with PWM input control and leg current feedback. Brushless DC motors are driven with three half-bridges, one for each phase, for a total of 6 MOSFETs and 3 leg current sensors. DC Brush motors are driven in an H-Bridge configuration, for a total of 4 MOSFETs and 2 leg current sensors.

The following sections provide more details.

2.3.1   Brushless DC Motor Drive

Figure 2-2 shows the arrangement of the DK73112N's amplifier stage when used with Brushless DC motors.
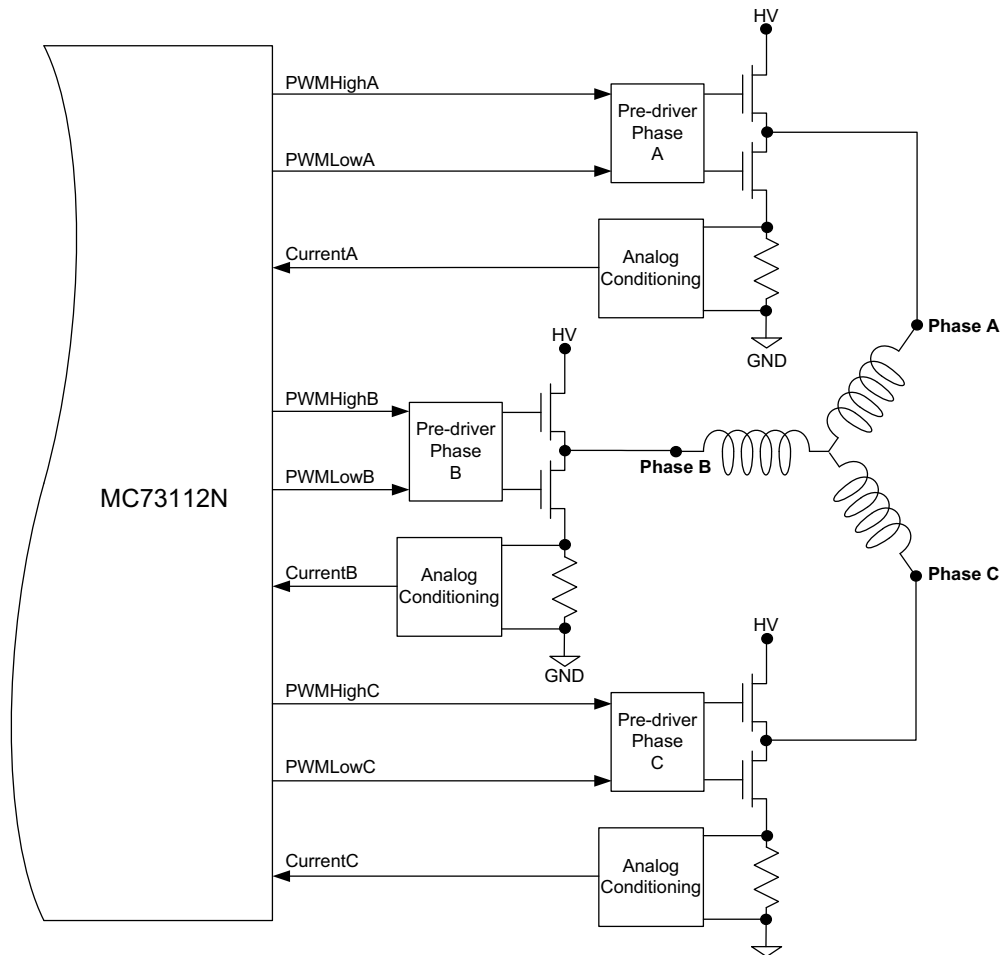
Figure 2-2:
Brushless DC
Motor Bridge
Configuration

As shown in the table below six PWM output signals and three analog feedback signals interface between the MC73112N IC and the DK73112N's switching amplifier.

Signal	Description
PWMHighA	Digital high side drive output for motor phase A, positive coil terminal
PWMLowA	Digital low side drive output for motor phase A, positive coil terminal
PWMHighB	Digital high side drive output for motor phase B, negative coil terminal
PWMLowB	Digital low side drive output for motor phase B, negative coil terminal
PWMHighC	Digital high side drive output for motor phase C, positive coil terminal
PWMLowC	Digital low side drive output for motor phase C, positive coil terminal
CurrentA	Analog input containing the current flow through the positive leg of phase A bridge
CurrentB	Analog input containing the current flow through the negative leg of phase B bridge
CurrentC	Analog input containing the current flow through the positive leg of phase C bridge

2.3.2   DC Brush Motor Drive

Figure 2-2 shows the arrangement of the DK73112N's amplifier stage when used with DC Brush motors.
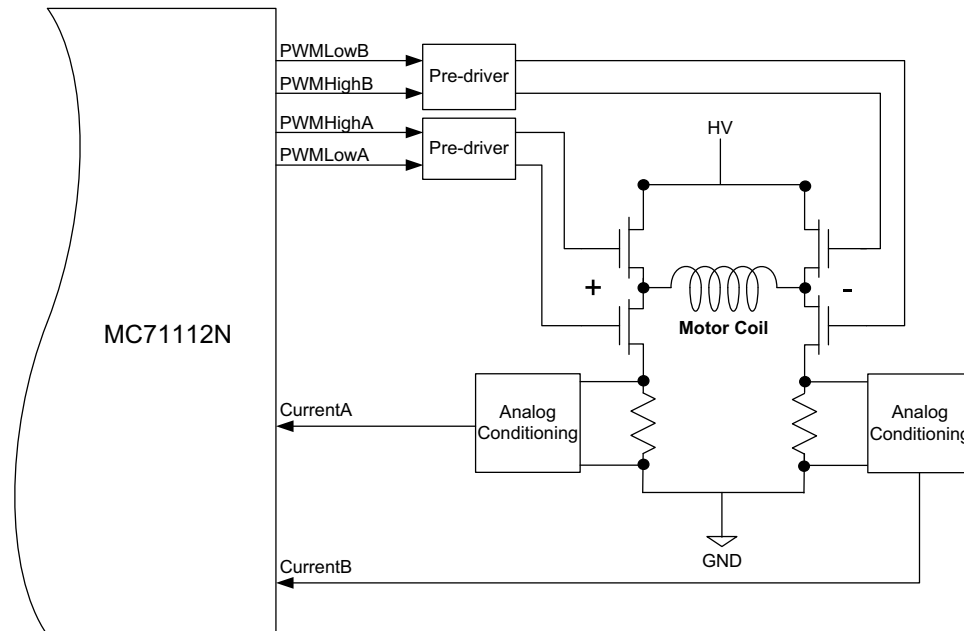
**Figure 2-3:
DC Brush
Motor Bridge
Configuration**

As shown in the table below four PWM output signals and two analog feedback signals interface between the MC71112N IC and the DK73112N's switching amplifier.

Signal	Description
PWMHighA	Digital high side drive output for positive coil terminal
PWMLowA	Digital low side drive output for positive coil terminal
PWMHighB	Digital high side drive output for negative coil terminal
PWMLowB	Digital low side drive output for negative coil terminal
CurrentA	Analog input containing the current flow through the positive leg of the bridge
CurrentB	Analog input containing the current flow through the negative leg of the bridge

2.3.3   Amplifier-Related Settings

There are a number of MC71112N or MC73112N IC settings which are used to set or control various aspects of the DK73112N's on-board switching amplifier and related current sense circuitry.

The following table shows the default values and recommended (or required) settings for amplifier-related parameters:

Parameter	Value & Units	Comment
Motor Output Mode	PWM High/Low	Set the motor output mode to PWM High/Low for operation with the on-board amplifier.
PWM Switching Frequency	20 kHz	This setting is motor-specific. Higher inductance motors should be set for 20 kHz. Lower inductance motors may use 40, 80, or 120 kHz to reduce current ripple and minimize heat generation.
PWM Dead Time	540 nSec	For correct operation of the DK73112N's on-board switching amplifier this parameter must be set to this value.
PWM Refresh Time	2,000 nSec	To ensure sufficient time to recharge the on-board amplifier's high side switches this parameter must be set to this value.

PWM Refresh Period	8 cycles	To ensure sufficient time to recharge the on-board amplifier's high side switches this parameter must be set to this value
PWM Signal Sense, high	Active High	For correct operation of the on-board amplifier all high PWM outputs must be set to active high.
PWM Signal Sense, low	Active Low	For correct operation of the on-board amplifier all low PWM outputs must be set to active low.
Minimum Current Read Time	2,000 nSec	To ensure sufficient minimum current read time with BLDC motors this parameter must be set to this value.

All of the DK73112N parameters described in this section can be specified using Pro-Motion via the Axis Wizard. See Section 1.11, "First-Time System Verification" for more information.

2.3.4 DK73112N Current Scale Value

To correctly control or trace motor current it is useful to know the DK73112N's amplifier-specific current conversion factor. The following table shows this:

Parameter	Value & Units	Comments
Leg Current Conversion	.733 mA/count	This value should be specified so that the motor current can be traced and displayed correctly in amps.

All of the DK73112N parameters described in this section can be conveniently specified using Pro-Motion via the Axis Wizard. See Section 1.11, "First-Time System Verification" for more information.

2.4 Drive Protection and Control Signals

2.4.1 I^2t Current Foldback Protection

The MC71112N and MC73112N use current feedback to implement I^2t current limiting. This feature protects the on-board amplifier by controlling its ability to operate above specific selected continuous current ratings.

When the current loop is enabled and the I^2t energy limit is exceeded, the MC71112N and MC73112N will automatically fold back the phase currents to a user programmable continuous current limit value. Alternatively, the MC71112N and MC73112N can be configured to fault and disable the output stage when the I^2t energy limit is exceeded

2.4.1.1 I^2t Limits

To safely operate the on-board amplifier it is necessary to specify I^2t limits.

Parameter	Value & Units	Comments
Foldback Continuous Current Limit	5.0 A	This value should be entered to ensure the on-board amplifier does not operate above the maximum safe current output.
Foldback Maximum Energy Limit	50 A^2sec	This value should be entered to ensure the on-board amplifier does not operate above the maximum safe current output.

For use with motors that have current and energy limits lower than those specified above, it may be useful to reduce these parameters.

⚠️

> These limits are designed to be safe for operation of the DK73112N's on-board amplifier when cooled with a 110 CFM (or higher) fan and with an ambient room temperature of 25 degrees C. For use without a fan, or in higher ambient temperature environments, these values should be lowered.
>
> If special heatsinking is used the DK73112N board is capable of driving motors at 10 amps continuously or higher, in which case these limits can be increased. Contact PMD for details.

⚠️

> It is the responsibility of the user to set the Foldback Continuous Current and Foldback Energy Limit parameters to values that are safe for the DK73112N heat sinking scheme and motor setup being used.

All of the parameters described in this section can be conveniently specified using Pro-Motion via the Axis Wizard. See for more information.

2.5   DC Bus
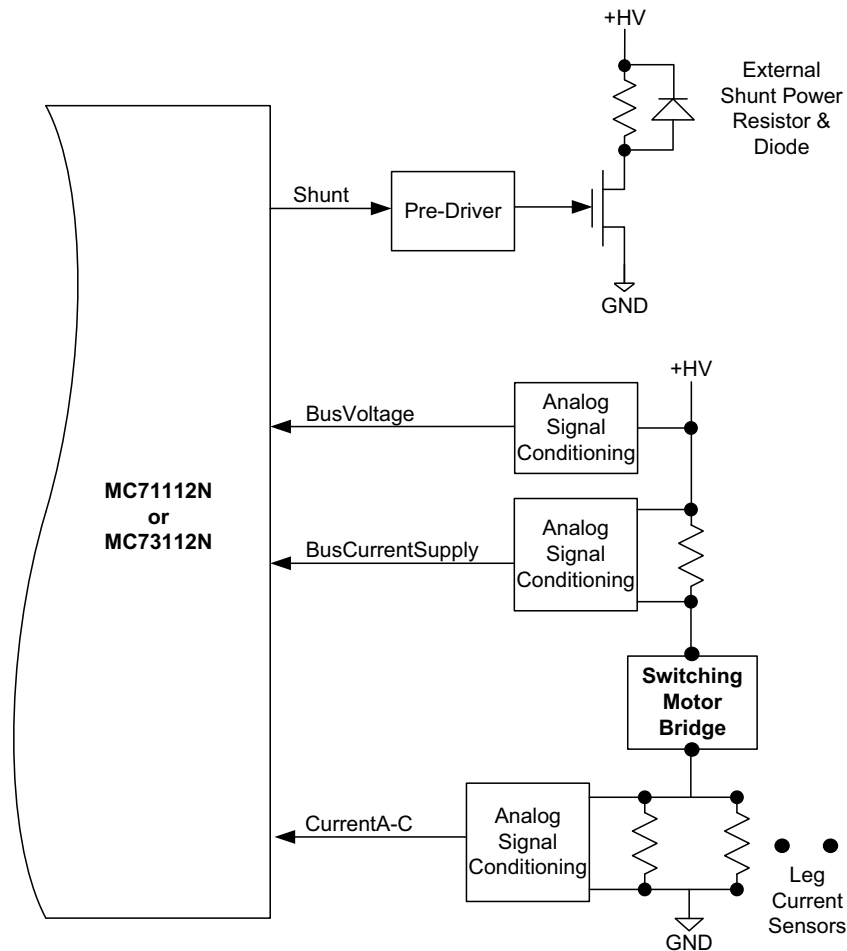
**Figure 2-4:
Juno Torque
Control ICs DC
Bus Monitoring
Circuitry**

Figure 2-4 shows the DC bus monitoring circuitry used with the DK73112N board. This circuitry is designed to work with the MC71112N and MC73112N's DC bus management and protection logic. These functions include overcurrent protection, over and under voltage detection, and ground fault detection.

2.5.1   DC Bus Current Monitoring

DK73112N monitors both the supply and return DC bus current to detect overcurrent conditions including: line-to-line, line-to-power supply, and line-to-ground short circuits.

2.5.1.1   DC Bus Current Monitoring Scale Values

The following DC bus current monitoring scale values for the DK73112N board are required to correctly operate the DC bus current monitoring functions:

Parameter	Value & Units	Comments
Leg current return conversion	.733 mA/count	This value should be entered so that the DC bus current return can be traced and displayed correctly in amps.

2.5.1.2 DC Bus Current Limits

The following DC bus current limits are required to safely operate the DK73112N board:

Parameter	Value & Units	Comments
Bus Current Return Limit	20 A	This value should be entered to ensure safe operation of the DK73112N.

Note that these values are designed to protect the DK73112N circuitry. Lower values may be used to protect the motor.

All of the parameters described in this section can be conveniently specified using Pro-Motion via the Axis Wizard. See <u>Section 1.11, "First-Time System Verification"</u> for more information

2.5.2 DC Bus Voltage Monitoring

DK73112N monitors the main DC bus voltage for overvoltage and undervoltage conditions. These thresholds are user-settable within the voltage operating range of the drive.

2.5.2.1 DC Bus Voltage Monitoring Scale Values

To correctly monitor the DC bus voltage it is necessary to know the DC bus voltage scale factor. The following table provides this value.

Parameter	Value & Units	Comments
Bus Voltage Display	1.424 mV/count	This value should be entered so that the DC bus voltage can be traced and displayed correctly in volts.

2.5.2.2 DC Bus Voltage Limits

The following DC bus voltage limits are required to safely operate the DK73112N board:

Parameter	Value & Units	Comments
Undervoltage Limit	10.0 V	This value should be entered to ensure safe operation of the DK73112N.
Overvoltage Limit	52.0 V	This value should be entered to ensure safe operation of the DK73112N.

Note that these values are designed to protect the DK73112N circuitry. More restrictive values may be used to protect the motor.

All of the parameters described in this section can be conveniently specified using Pro-Motion via the Axis Wizard. See <u>Section 1.11, "First-Time System Verification"</u> for more information.
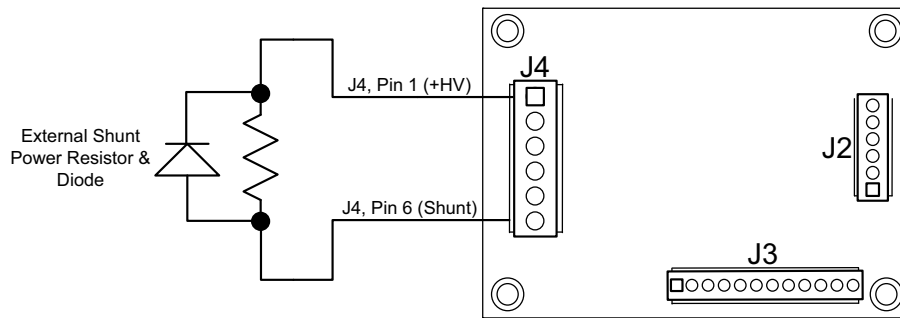
2.5.3   Shunt Resistor & Diode

Figure 2-5: Wiring to External Shunt Resistor & Diode

J4 provides a connection for a shunt resistor and diode that may be used to regulate overvoltage conditions on the DC bus. Such conditions can occur during deceleration of a motor with a large inertia. The wiring connections to the DK73112N for these external shunt components is shown in .

The resistor connected at J4 should have a resistance such that the current flow through the Shunt MOSFET does not exceed 10 amps. For example with an HV supply of 48 Volts, this means a resistance of no less than 4.8 ohms.

The diode, which is connected in parallel to the resistor, should have a voltage and current rating at least equal to those of the MOSFET. For the DK73112N this means a voltage and current rating of 100 volts and 10 amps or higher.

Beyond this limit, the actual resistance used is application specific and depends on the nature of the anticipated over voltage generating conditions, the power supply used, and the wattage rating of the resistor.

Example

A shunt resistor with a resistance of 10 ohms is connected through the J4-6 shunt connector and a comparison value of 51 Volts and a PWM duty cycle of 75% are specified. When the +HV voltage exceeds 51.0 Volts, HV will be connected to GND via the shunt resistor resulting in an effective average current flow of (51.0V * .75)/10 ohms = 3.825 amps.

The default value of the shunt comparison mechanism is disabled. To enable, both a voltage comparison value and a PWM output duty cycle are specified.

It is the responsibility of the user to connect and to specify a shunt-related resistor and diode that are safe for the application being controlled.

2.6   Miscellaneous Signal Processing

The following sections detail the signal processing circuitry provided by the DK73112N board for various signal connections.

2.6.1   Encoder Inputs

The DK73112N's encoder input signals provide processing of quadature encoder A, B feedback along with an Index signal. By default a valid index is recognized when Index is low however the interpretation of this signal as well as the A, B quadrature signals can be user programmed.

The differential input circuitry for the encoder A, B and Index signals is shown in Figure 2-6. This circuit accepts both differential and single-ended signals in the range of 0 – 5 V. For single-ended operation, only the positive connection is used and the negative connection is left unconnected.

**Figure 2-6:
Main Encoder
Input Circuitry**
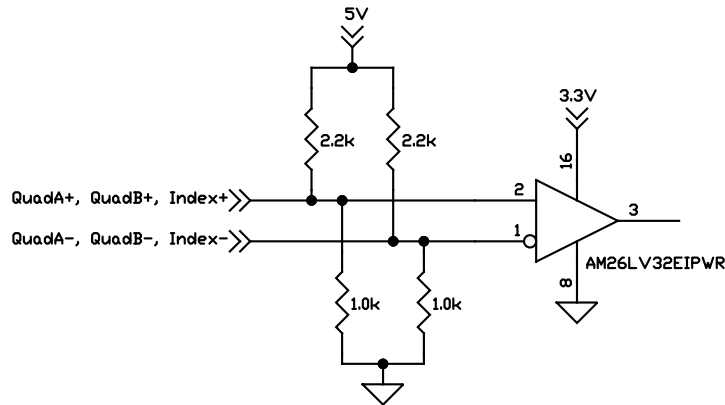
2.6.2   Hall Inputs

Hall signals are used with Brushless DC motors. They are used to directly commutate the motor in 6-step commutation mode or to provide an absolute phase reference for sinusoidal commutation. By default Hall sensors are defined as being on when their signal is high however this can be user programmed.

The input buffer for the Hall A, B and C signals is shown in Figure 2-7. This circuit accepts signals in the range of 0 – 24 V and has TTL compatible, Schmitt trigger thresholds. It has a pull-up to 5V to allow direct interfacing to open collector sources without the need for an external pull-up resistor and an R-C low pass filter to reject noise.

**Figure 2-7:
Hall Input
Circuitry**
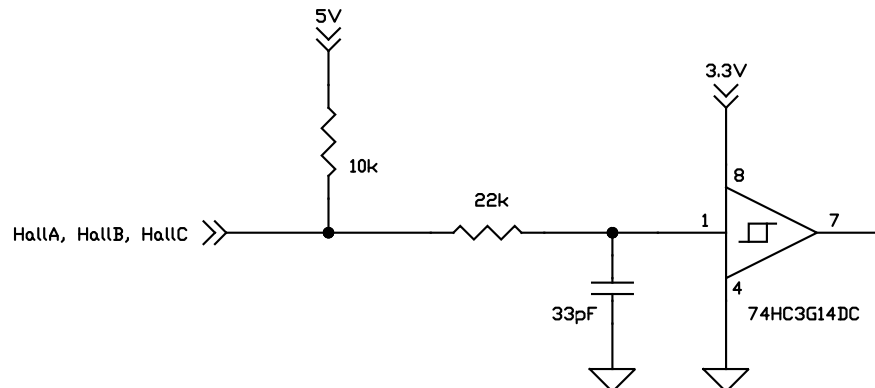
2.6.3   Analog Command Input

AnalogCmd is a differential +/-10V analog input that provides a direct torque command to the MC71112N or MC73112N.

The analog signal conditioning circuit for AnalogCmd is shown in Figure 2-8. This circuit accepts +/-10V differential signal and scales it between 0 and 3.3V with an offset of 1.65V representing a zero input. The 680pF capacitors provide filtering with a bandwidth of 23.4kHz.
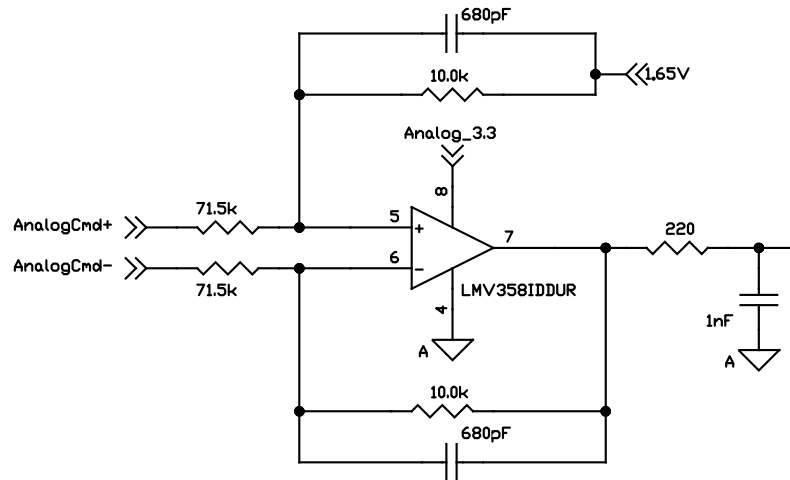
Figure 2-8:
AnalogCmd
Input Circuitry

2.6.4   Enable & FaultOut

These dedicated signals are typically used to implement a safety interlock between the DK73112N board and other control portions of the system. /Enable is an active-low input that must be tied or driven low for the DK73112N output stage to be active.

FaultOut indicates a serious problem. When DK73112N is operating properly FaultOut is inactive. The polarity of this signal is fixed and cannot be user programmed.

The input buffer for the /Enable input is shown in . This circuit accepts signals in the range of 0 – 24 V and has TTL compatible, Schmitt trigger thresholds. It has a pull-up to 5V to allow direct interfacing to open collector enable sources without the need for an external pull-up resistor and a 1.3 kHz R-C low pass filter to reject noise.
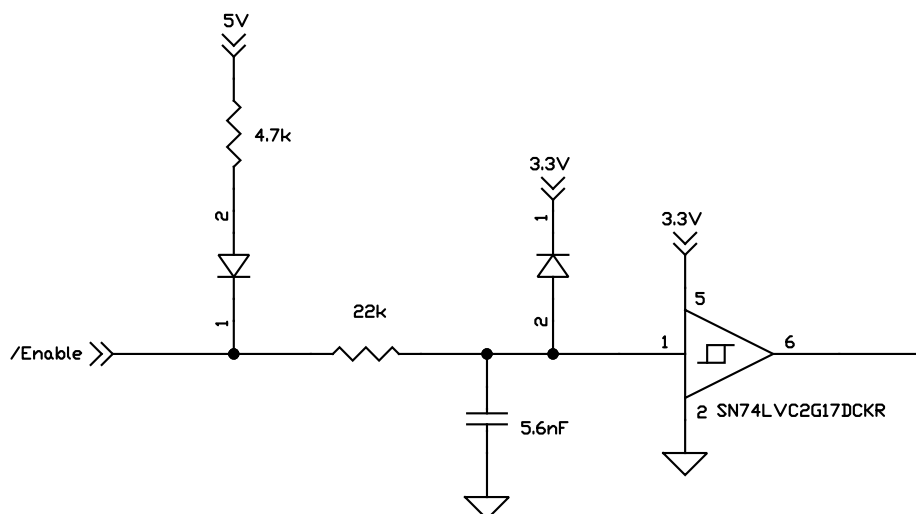
Figure 2-9:
Enable Input
Circuitry

The output driver for FaultOut is shown in . This circuit can continuously sink over 100 mA.

**Figure 2-10:
FaultOut
Circuitry**
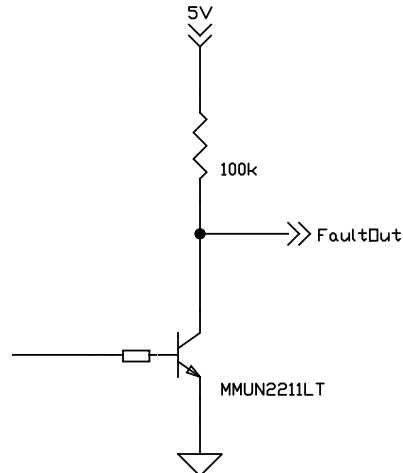
2.6.5 SPI (Serial Peripheral Interface)

The DK73112 supports an SPI (Serial Peripheral Interface) connection for direct digital torque command input via its J5 connector.

The circuit below shows the DK73112N's SPI signal processing circuitry.

**Figure 2-11:
SPI Signal
Circuitry**
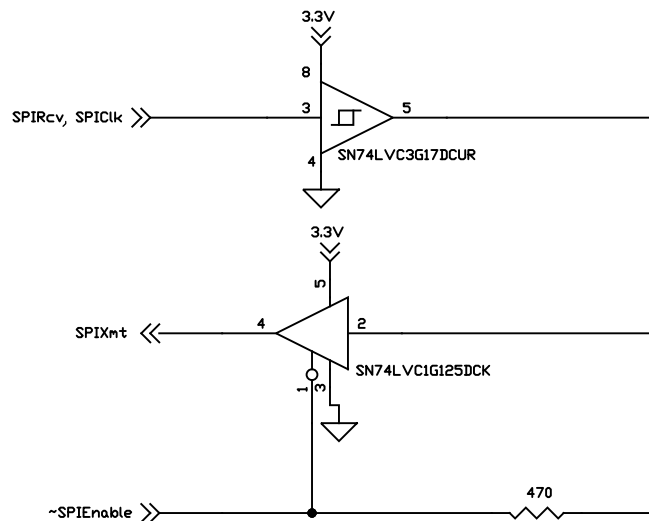
2.7 On-IC NVRAM Configuration Storage

The MC71112N and MC73112N ICs provide the ability to directly store configuration information such as gain parameters, drive-related safety parameters, and other parameters. This setup information, once loaded, is automatically initialized into the active configuration registers at each power-up. See the *Juno Torque Control User Guide* for more information.

3. Electrical Reference

In This Chapter

▶ Connectors

▶ Absolute Maximum Ratings

▶ Environmental and Electrical Ratings

▶ DK73112N Control Settings Quick Reference

3.1 Connectors
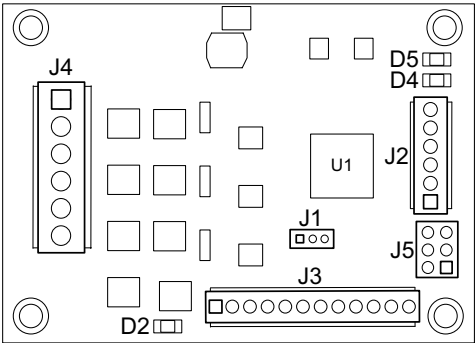
There are four user-accessible connectors on the DK73112N board. See for the specific locations of the connectors on the board. The connectors and their functions are outlined in the following table:

Label	Description
J4	HV Power & Motor Connector
J3	Feedback Connector
J2	Amplifier Signal Connector
J1	Programming Connector
J5	SPI Connector
D2, D4, D5	AmplifierEnable, Fault and power LED indicators (respectively)

3.1.1 HV Power & Motor Drive Connector (J4)

The DK73112N connector (J4) accepts HV input voltage in the range of +12 to 48 VDC, provides the motor winding connections, and provides a shunt power resistor connection. This connector is a terminal block.

Pin	Connection	Description
J4 - HV Power Connector		
1	HV	Provides DC power to the board and on-board switching amplifier

Pin	Connection	Description
2	GND	Ground
3	Motor A	Motor output signal A+
4	Motor B	Motor output signal A-
5	Motor C	Motor output signal B+
6	Shunt	Shunt output

3.1.2 Feedback Connector (J3)

The Feedback Connector (J3) provides connections to the motor encoder and Hall sensors. The Feedback Connector consists of a 2.54 mm pitch 12-circuit terminal block.

Pin	Connection	Description
J3 - Feedback Connector		
1	Vcc	+5V output
2	GND	Ground
3	QuadA+	Quadrature A+ encoder input
4	QuadA-	Quadrature A- encoder input
5	QuadB+	Quadrature B+ encoder input
6	QuadB-	Quadrature B- encoder input
7	Index+	Index+ input
8	Index-	Index- input
9	HallA	HallA signal input
10	HallB	HallB signal input
11	HallC	HallC signal input
12	GND	Ground

3.1.2.1 Notes on Encoder Connections

Encoder inputs may be connected differentially, with two wires for QuadA, QuadB, and Index signals, or with just one wire per signal. If single-ended encoders are used, connect encoder signals to the positive encoder input only. The negative input may remain unconnected.

The following tables show this:

Encoder connections when using differential encoder input:

Signal	J3 Feedback Connector
QuadA+	J3-3
QuadA-	J3-4
QuadB+	J3-5
QuadB-	J3-6
Index+	J3-7
Index-	J3-8
Vcc	J3-1
GND	J3-2

Encoder connections when using single-ended encoder input:

Signal	J3 Feedback Connector
QuadA+	J3-3

Signal	J3 Feedback Connector
QuadB+	J3-5
Index+	J3-7
Vcc	J3-1
GND	J3-2

3.1.3   Amplifier Signal Connector (J2)

The Amplifier Signal Connector provides the AnalogCmd inputs along with an Enable input, a Brake input, and the FaultOut. This connector is a 2.54 mm pitch 8-circuit terminal block.

Pin	Signal	Description
J2 - Amplifier Signal Connector		
1	Enable	Active low Enable digital input signal
2	FaultOut	Active high digital FaultOut output signal
3	Brake	Brake input signal
4	GND	Ground
5	AnalogCmd-	AnalogCmd- torque command input
6	AnalogCmd+	AnalogCmd+ torque command input

3.1.4   Programming Connector (J1)

The 3-pin Programming Connector (J1) provides a UART serial connection to the MC71112N or MC73112N ICs for purposes of NVRAM programming, diagnostics, or application development. This connector directly mates with the 3-pin programming cable, P/N: Cable-USB-3P, included in each DK73112N Developer Kit. This connector is a 3-pin 2 mm single-row header.

Pin	Signal	Description
J1 - Programming Connector		
1	SrlXmt	Serial transmit output
2	SrlRcv	Serial receive input
3	GND	Ground

3.1.5   SPI Connector (J5)

The SPI Connector (J5) provides connection to the SPI (Serial Peripheral Interface) bus. This bus may be used to command a torque value in a digital 16-bit format. This connector is a 6-pin .1 inch dual-row header.

Pin	Signal	Description
J5 - SPI Connector		
1	SPIXmt	SPI bus synchronous transmit signal output
2	SPIRcv	SPI bus synchronous receive signal input
3	SPIClock	SPI bus synchronous clock input
4	SPIEnable	Host SPI bus active low enable signal input
5	GND	Ground
6	NC	No Connect

3.2   Absolute Maximum Ratings

HV voltage range:	0V to +52V

3.3   Environmental and Electrical Ratings

Storage temperature:	-40 to +125 degrees C (-40° F to +257°F)
Operating temperature:	0 to +70 degrees C (32° F to +158°F)
HV power requirement:	+12V to + 48V operating range
Motor amplifier continuous current limit[*]:	5.0 A
Motor amplifier peak current limit:	10.0 A
Digital input voltage range:	0V to 5V, TTL thresholds

* Current rating at 25 C ambient and with 110 CFM air flow on board. Significantly higher currents are possible with additional heat sinking. Contact your PMD representative for details.

3.4   DK73112N Control Settings Quick Reference

The DK73112N comes with a standard MC74113N or MC75113N IC, and is thus not tailored for the amplifier and safety-related circuitry located on the DK73112N board. Therefore to use the DK73112N circuitry safely and to view results conveniently via Pro-Motion you will need to set various limits and conversion constants.

These parameters are generally entered when using Pro-Motion's Axis DK73112N setup sequence, however they are also useful if you decide to write your own software that operates the DK73112N board.

Parameter	Value & Units	Comments
Motor Output Mode	PWM High/Low	Set the motor output mode to PWM High/Low for operation with the on-board amplifier. For remote amplifier control operation PWM High/Low, 50/50 PWM, or sign/magnitude PWM may be selected.
PWM Switching Frequency	20 kHz	This setting is motor-specific. Larger motors (some NEMA 23 and most NEMA 34) should be set for 20 kHz. Smaller motors may use 40, 80, or 120 kHz to maximize current control accuracy and minimize heat generation.
PWM Dead Time	540 nsec	For correct operation of the DK73112N's on-board switching amplifier this parameter must be set to this value.
PWM Refresh Time	2,000 nSec	To ensure sufficient time to recharge the on-board amplifier's high side switches this parameter must be set to this value.
PWM Refresh Period	8 cycles	To ensure sufficient time to recharge the on-board amplifier's high side switches this parameter must be set to this value
PWM Signal Sense, high	Active High	For correct operation of the on-board amplifier all high PWM outputs must be set to active high.
PWM Signal Sense, low	Active Low	For correct operation of the on-board amplifier all low PWM outputs must be set to active low.

Parameter	Value & Units	Comments
Minimum Current Read Time	2,000 nSec	To ensure sufficient minimum current read time with BLDC motors this parameter must be set to this value.
Leg Current Conversion	.733 mA/count	This value should be entered so that the leg current can be traced and displayed correctly in amps.
Foldback Continuous Current Limit	5.0 A	This value should be entered to ensure the on-board amplifier does not operate above the maximum safe current output.
Foldback Maximum Energy Limit	50 A^{2}sec	This value should be entered to ensure the on-board amplifier does not operate above the maximum safe current output.
Temperature Limit	75.0 C	This value should be entered to ensure the on-board amplifier does not operate above the maximum safe current output.
Bus Current Return Limit	20 A	This value should be entered to ensure safe operation of the DK73112N.
Bus Voltage Display	1.424 mV/count	This value should be entered so that the DC bus voltage can be traced and displayed correctly in volts.
Undervoltage Limit	10.0 V	This value should be entered to ensure safe operation of the DK73112N.
Overvoltage Limit	52.0 V	This value should be entered to ensure safe operation of the DK73112N.

All of the above settings may be selected at once via the Pro-Motion Axis wizard by specifying that you are using the DK73112N board.

This page intentionally left blank.