

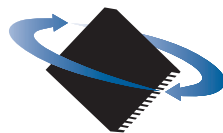
**PERFORMANCE  
MOTION DEVICES**  
MOTION CONTROL AT ITS CORE



# **Juno<sup>®</sup> Torque Control IC DK73112N Developer Kit**

## **User Manual**

# **Juno Torque Control IC DK73112N Developer Kit User Manual**



**PERFORMANCE  
MOTION DEVICES**

Performance Motion Devices, Inc.  
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Westford, MA 01886

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## 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.

### **Pro-Motion User Guide**

User guide to Pro-Motion, the easy-to-use motion system development tool and performance optimizer. Pro-Motion is a sophisticated, easy-to-use program which allows all motion parameters to be set and/or viewed, and allows all features to be exercised.

### **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.

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# 1. Installation

## *In This Chapter*

- ▶ Introduction
- ▶ Developer Kit Components List
- ▶ DK73112N Board
- ▶ Included Hardware Accessories
- ▶ Installation Overview
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- ▶ Software Installation
- ▶ Board Installation
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## 1.1 Introduction

The PMD Corp. 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 as well as the same software USB memory stick. 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
- Magellan SDK USB stick containing Pro-Motion, C-Motion, and documentation in PDF format

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

Pro-Motion is described in the *Pro-Motion User Guide*.

## 1.4 Included Hardware Accessories

The DK73112N includes these accessories that you may find useful:

| Component PMD Corp.<br>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 [Section 1.7, “Software Installation”](#) for instructions on installing the software.
- 2 Next, connect the motor and optional encoder. See [Section 1.9, “Connection Summary”](#) for a description of the connections.
- 3 Connect the DK73112N board to the host PC via the 3-pin cable. See [Section 1.9.3, “Communication Connection”](#) 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 [Section 1.11, “First-Time System Verification”](#) 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

A provided USB flash drive comprises the software distribution for the DK73112N Developer Kit. All software applications are designed to work with Microsoft Windows.

To install the software:

- 1 Insert the USB stick into your computer.
- 2 Select and execute the Pro-MotionSetupxxx.exe program to install Pro-Motion.
- 3 To install the optional SDK select and execute the PMDSDKxxx.exe program.

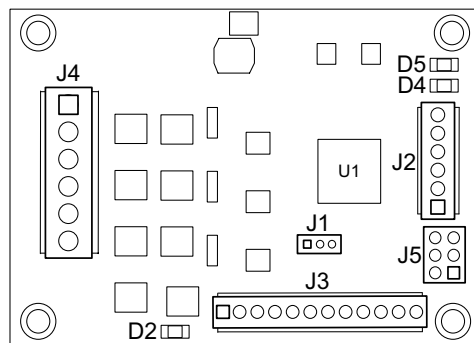
Upon completion of the installation process for Pro-Motion and the SDK, the following components will be installed:

- PMD SDK – a software development kit for creating motion applications using the C/C++ programming languages.
- Pro-Motion – an application for communicating to, and exercising the motion control IC. Refer to the *Pro-Motion User Guide* for operating instructions.
- PDF versions of all Juno family user guides. 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) |

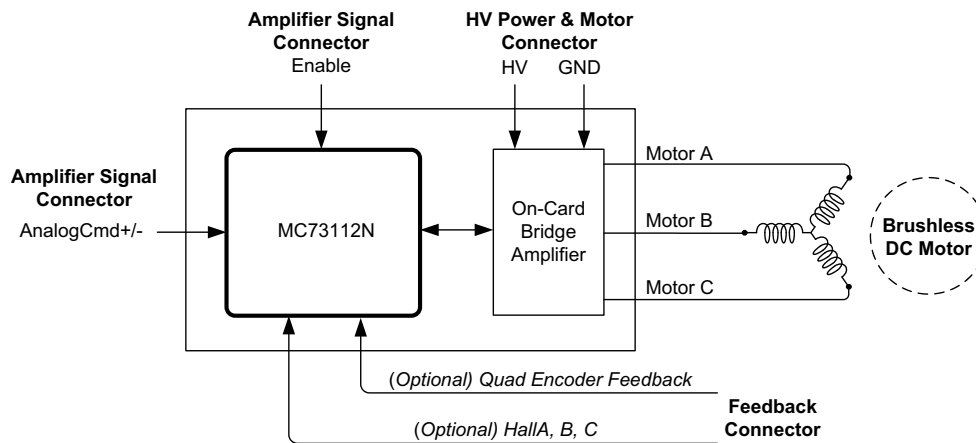
### 1.8.1 Enabling the Board

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.

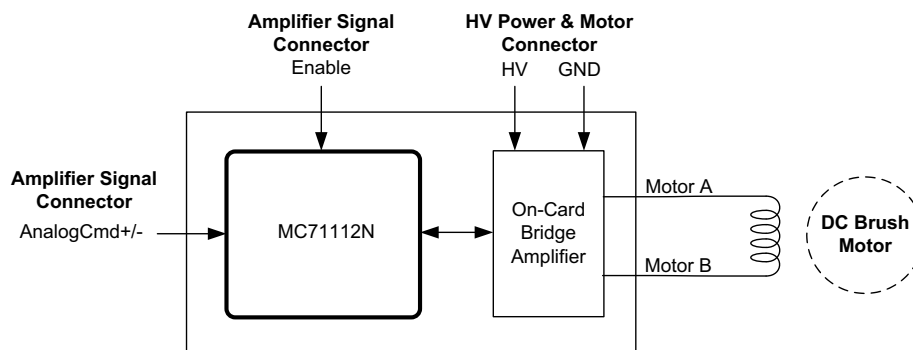
For reference the following table provides the pinouts of the J2 connector:

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

## 1.9 Connection Summary



**Figure 1-2:**  
Brushless DC  
Motor  
Connection  
Overview



**Figure 1-3:**  
DC Brush  
Motor  
Connection  
Overview

### 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                 |
|--------------------------------|------------|-----------------------------|
| <b>J3 - Feedback Connector</b> |            |                             |
| 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          |

| Pin | Connection | Description        |
|-----|------------|--------------------|
| I0  | HallB      | HallB signal input |
| I1  | HallC      | HallC signal input |
| I2  | 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

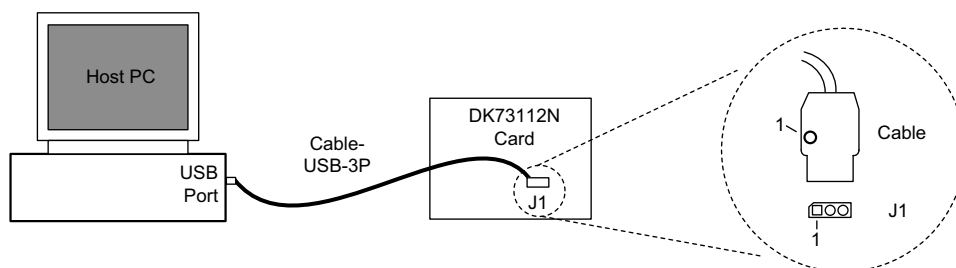
The HV voltage is the voltage at which the motor will be driven and must be in the range of +12V to +48V.

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   |
|--------------------------------|------------|---|
| <b>J4 - HV Power Connector</b> |            |   |
| 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 Corp. 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.

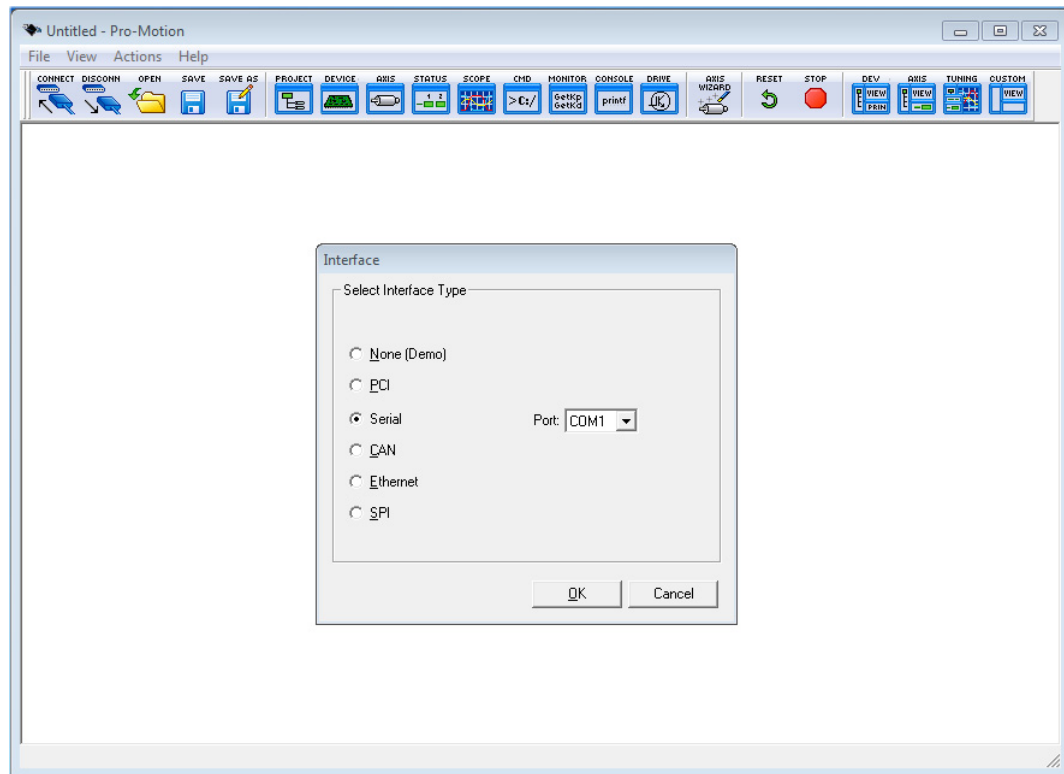
### 1.11.1 Establishing Serial Communications

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.

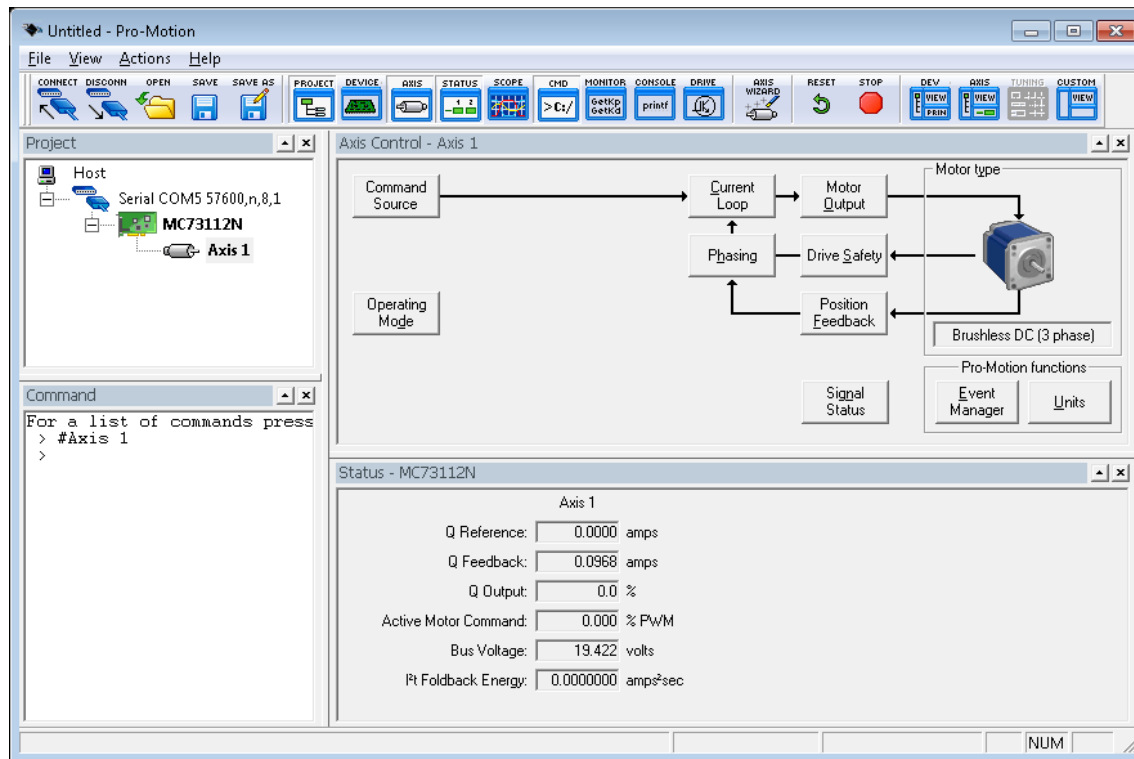


- 3 Click Serial, select the COM port that the DK is connected to, and then click OK.

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 MC7112N 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.

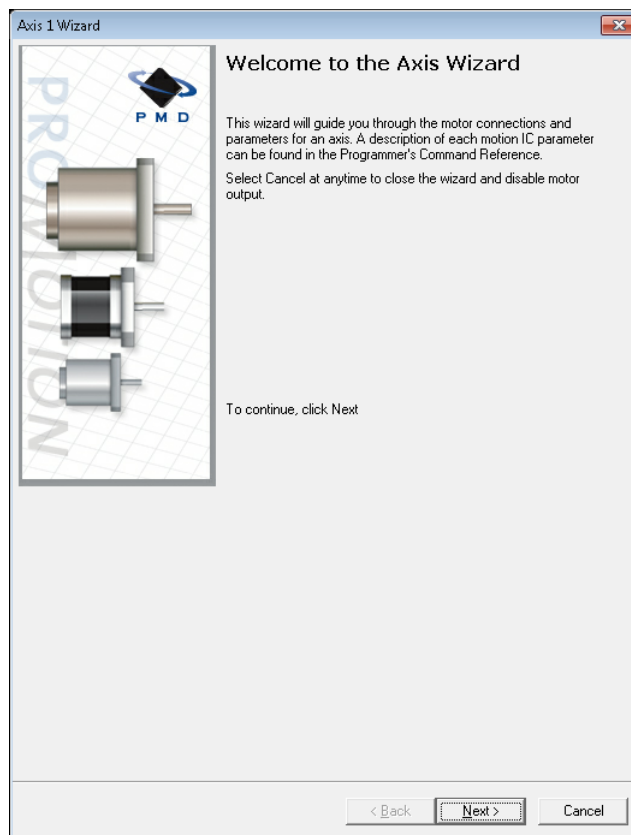
## 1.11.2 Initializing Motion Axis

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. Refer to the *Pro-Motion User Guide* for more information, or call PMD Corp. or your local PMD Corp. representative for technical assistance.

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.

The screenshot shows a window titled "Axis 1 Wizard" with a close button in the top right corner. The main title is "Command Source and System Activation". Below the title is a paragraph of instructions: "This page selects the command source for the first enabled loop. Select the desired command source and verify Command Value is as expected and within safe limits. Once you activate the system using the Go button the system will be active and executing the control function specified in previous pages." The interface includes a "Command source:" label followed by a dropdown menu currently set to "Motor command register". Below this is a "Command Value" section containing a text box labeled "Active Motor Command:" with the value "0.000" and the unit "% PWM". Further down is another text box labeled "Motor Command:" also containing "0.000" and "% PWM". At the bottom of the main area are two buttons: "Go!" and "Stop!". At the very bottom of the window are three navigation buttons: "< Back", "Next >", and "Cancel".

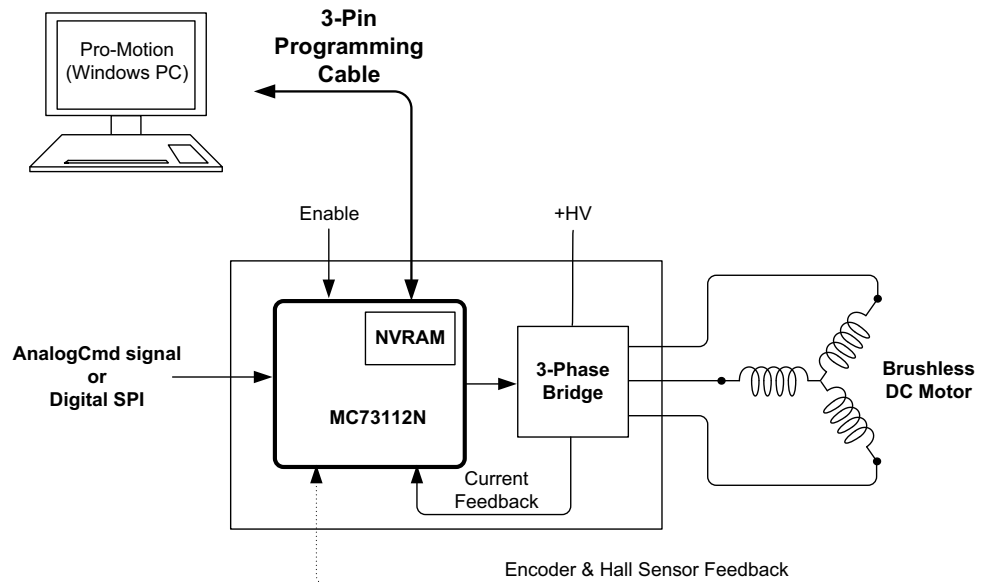
To specify a motor torque command set the source to motor command register. Negative values of torque will move the motor in the negative direction.

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 Corp.'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.

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# 2. Operation

2

## ***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**

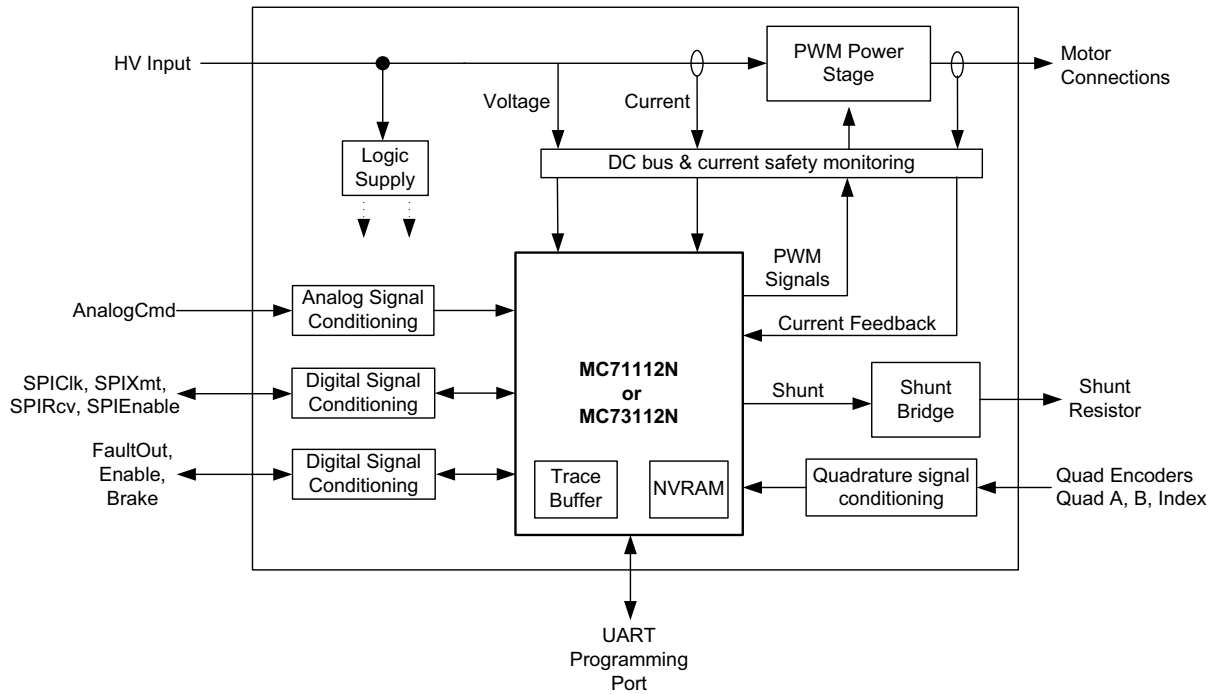
The DK73112N Developer Kit board provides a complete functioning MC71112N and MC73112N IC exerciser and development system. It directly interfaces to a host computer using USB to serial communication, and provides all power, motor drive, control, and feedback signals required to drive a DC Brush or Brushless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

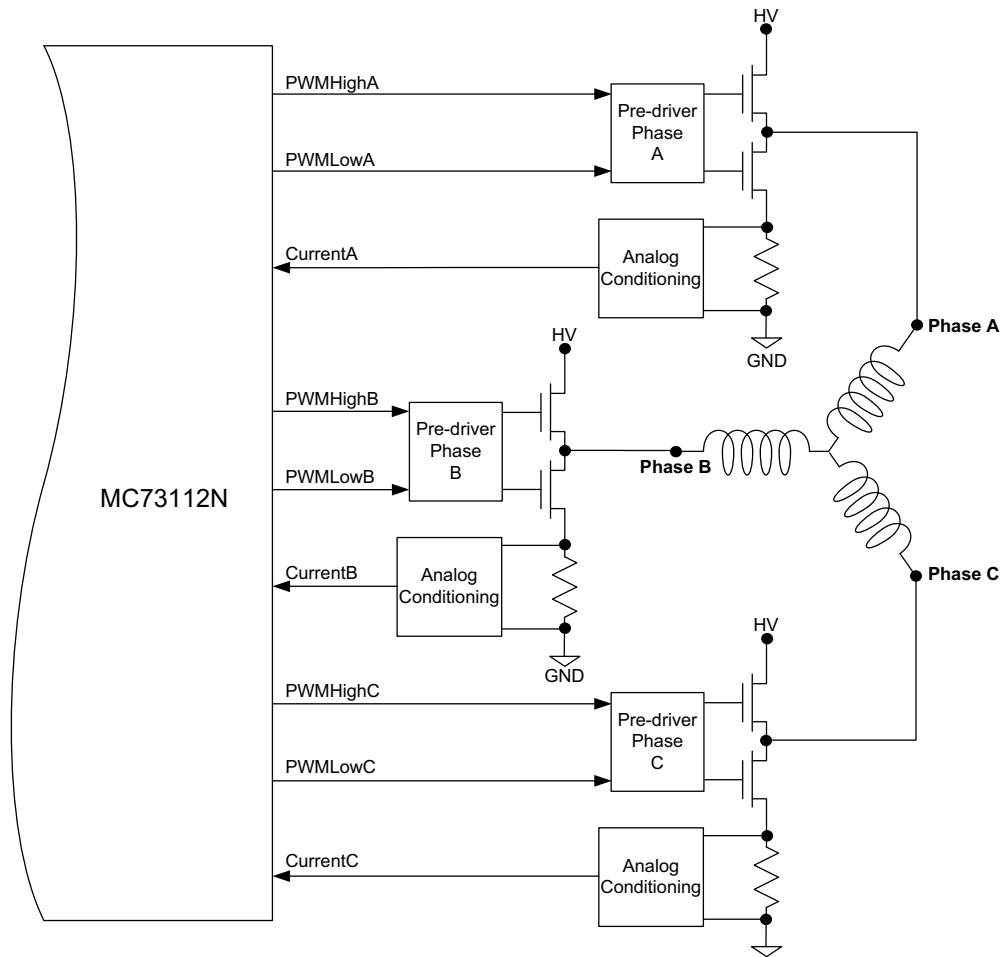
## 2.3 Switching Motor Amplifier

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**

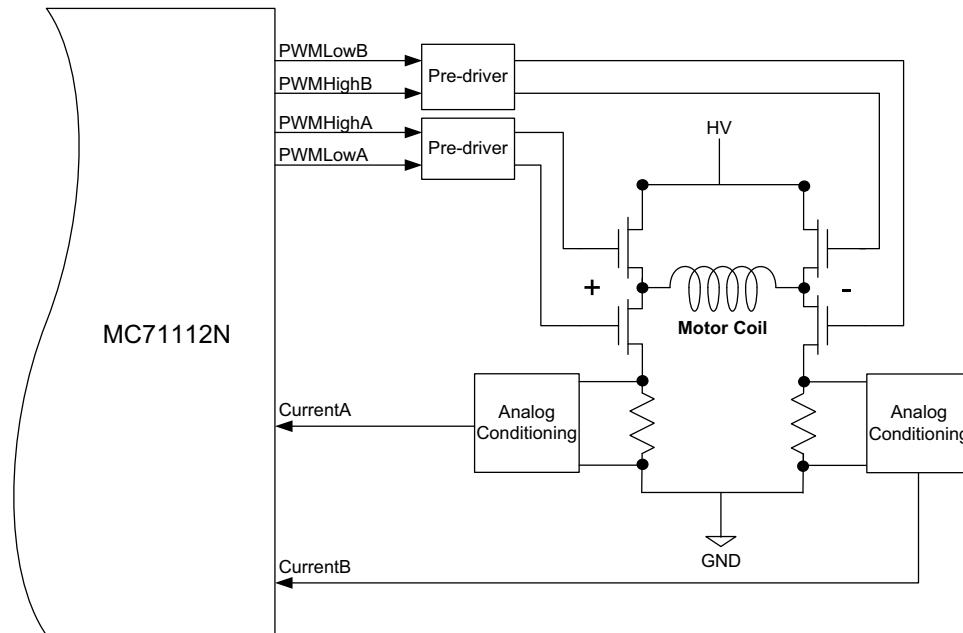
As shown in the table below six PWM output signals and three analog feedback signals interface between the MC73112N IC and the DK73112N's switching amplifier.

| 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<sup>2</sup>t Current Foldback Protection

The MC71112N and MC73112N use current feedback to implement I<sup>2</sup>t 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<sup>2</sup>t 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<sup>2</sup>t energy limit is exceeded

#### 2.4.1.1 I<sup>2</sup>t Limits

To safely operate the on-board amplifier it is necessary to specify I<sup>2</sup>t 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 <sup>2</sup> sec | 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.

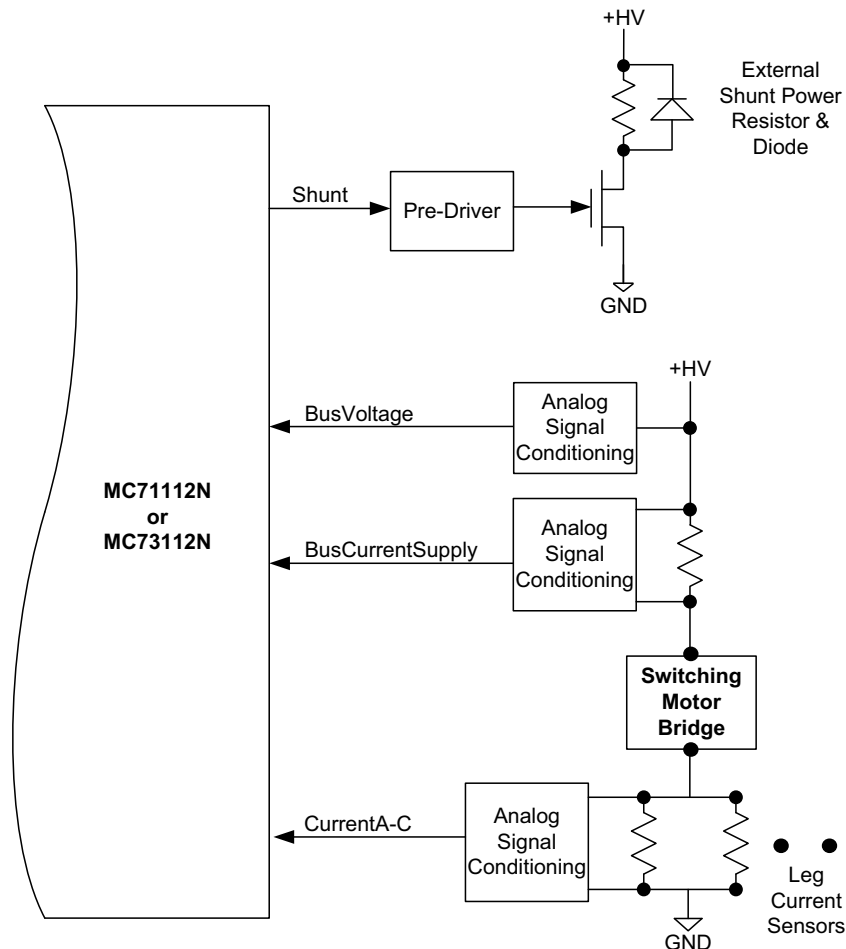
If special heatsinking is used the DK73112N board is capable of driving motors at 10 amps continuously or higher, in which case these limits can be increased. Contact PMD Corp. for details.



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 [Section 1.11, "First-Time System Verification"](#) 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 [Section 1.11, “First-Time System Verification”](#) 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

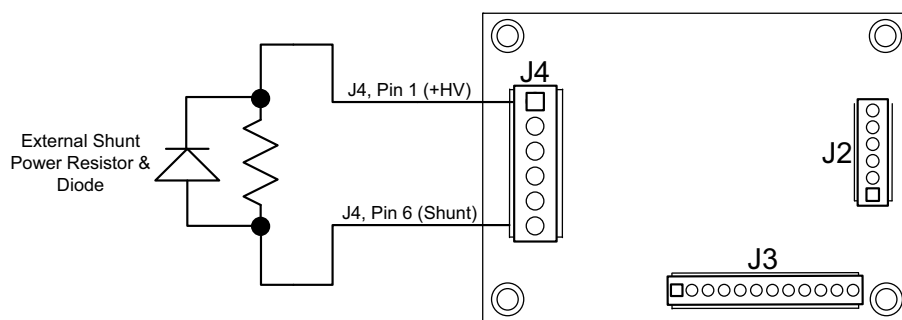
The following DC bus voltage limits are required to safely operate the DK73112N board:

| 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 [Section 1.11, “First-Time System Verification”](#) 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 [Figure 2-5](#).

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  $(51.0V * .75)/10 \text{ ohms} = 3.825 \text{ amps}$ .

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. See the *Pro-Motion User Guide* for details.

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.



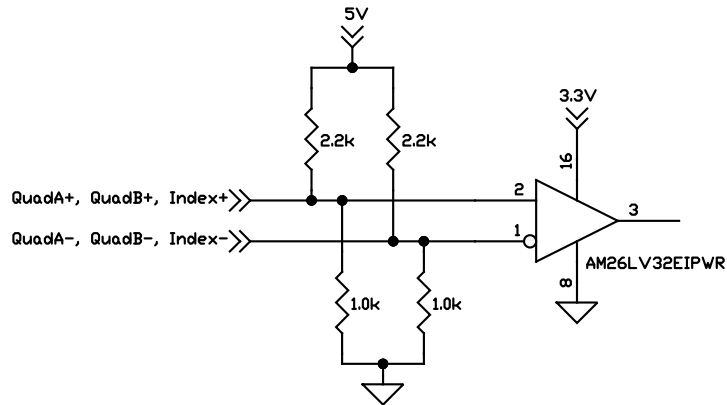
## 2.6 Miscellaneous Signal Processing

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 quadrature 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.

**Figure 2-6:**  
Main Encoder  
Input Circuitry

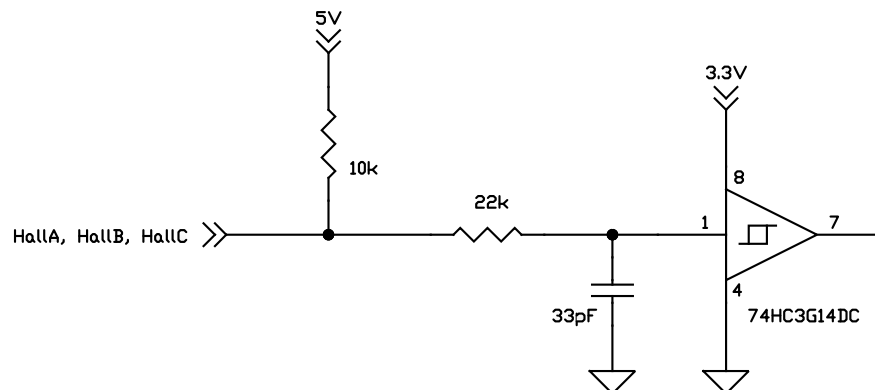


## 2.6.2 Hall Inputs

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.

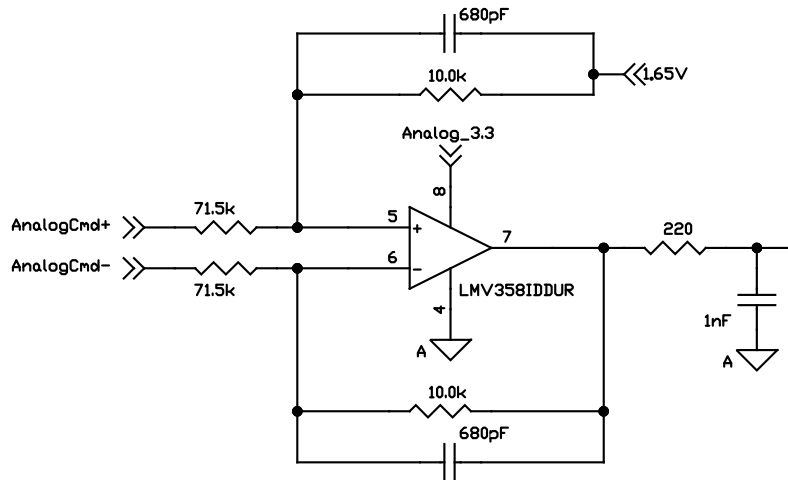


Figure 2-8:  
AnalogCmd  
Input Circuitry

## 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 [Figure 2-9](#). 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.

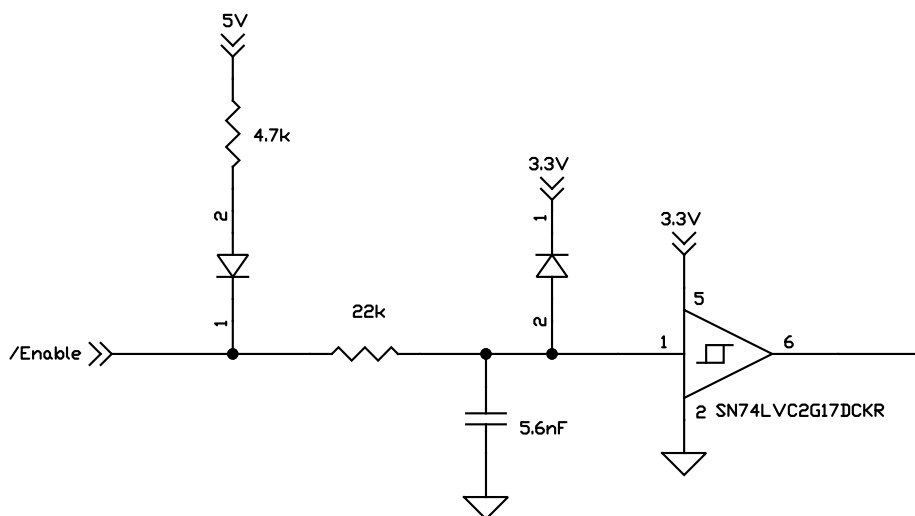
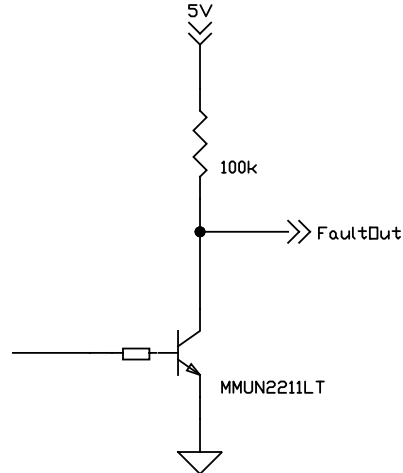


Figure 2-9:  
Enable Input  
Circuitry

The output driver for FaultOut is shown in [Figure 2-10](#). This circuit can continuously sink over 100 mA.

**Figure 2-10:  
FaultOut  
Circuitry**

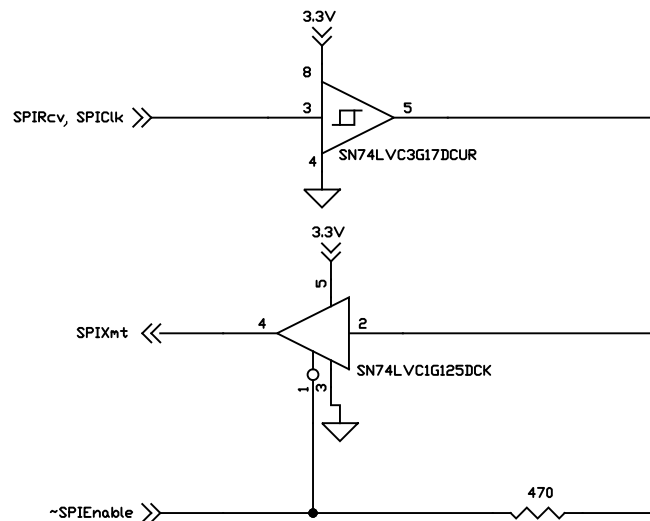


## 2.6.5 SPI (Serial Peripheral Interface)

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

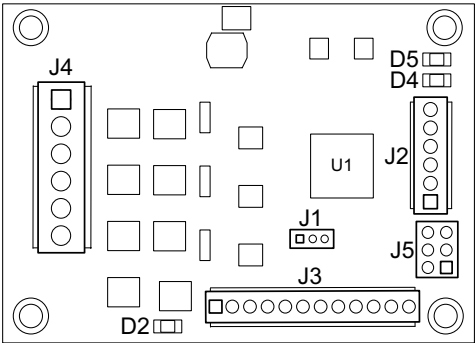


Figure 3-1:  
DK73112N  
Board  
Component  
Location

There are four user-accessible connectors on the DK73112N board. See [Figure 3-1](#) 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   |
|--------------------------------|------------|---|
| <b>J4 - HV Power Connector</b> |            |   |
| 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                 |
|--------------------------------|------------|-----------------------------|
| <b>J3 - Feedback Connector</b> |            |                             |
| 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                                |
|--|------------|--|
| <b>J2 - Amplifier Signal Connector</b> |            |  |
| 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            |
|-----------------------------------|--------|------------------------|
| <b>J1 - Programming Connector</b> |        |                        |
| 1                                 | SrIXmt | Serial transmit output |
| 2                                 | SrIRcv | 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                                 |
|---------------------------|-----------|---|
| <b>J5 - SPI Connector</b> |           |   |
| 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 Corp. 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 <sup>2</sup> 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.

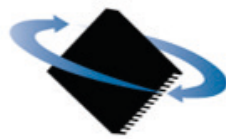


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Juno® Torque Control IC  
DK73112N Developer Kit User Manual

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**PERFORMANCE  
MOTION DEVICES**  
MOTION CONTROL AT ITS CORE

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Performance Motion Devices (PMD Corp.) is a worldwide leader in motion control solutions and is dedicated to providing high performance systems to OEM customers. With PMD Corp. you get advanced easy-to-use C-based motion control language with companion ICs, modules or boards. PMD Corp. utilizes extensive expertise to help minimize your time-to-market and maximize satisfaction.

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