MC73110
Advanced 3-Phase Motor Control IC
Developer's Kit Manual

P M D

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Related Documents

MC73110 Advanced 3-Phase Motor Control IC Product Manual

Electrical Specifications, Theory of Operations, and Command Reference for MC73110 IC.

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1. Product Overview

	MC73110 Motor Control IC	Navigator/Pilot	Magellan	Motion Cards
Number of axes	1	1, 2, 4	1, 2, 3, 4	1, 2, 3, 4
Package	64-pin TQFP	132-pin PQFP 100-pin PQFP	144-pin TQFP 100-pin TQFP	PCI PC/104
Voltage	3.3 V	5 V	3.3 V	3 V
Function	Velocity control Torque control Commutation Encoder input	Position control Encoder input Profile generation Commutation	Position control Encoder input Profile generation Commutation Network communications Multi-motor	Position control Encoder input Profile generation Commutation Signal conditioning Analog output Trace buffer
Motor types	Brushless DC	DC brush Brushless DC Pulse & direction	DC brush Brushless DC Pulse & direction	DC brush Brushless DC Pulse & direction
Communication	Standalone Serial	Parallel Serial point-to-point Serial multi-drop	Parallel Serial point-to-point Serial multi-drop CANbus	PCI, PC104
Loop rate	20 kHz	100 -150 µSec/axis	50 -75 µSec/axis	50 -75 µSec/axis

The MC73110 Motor Control IC is a single-chip, single-axis device ideal for use in intelligent three-phase brushless motor amplifiers. It provides sophisticated programmable digital current control with direct analog input of feedback signals. It can be operated in voltage, torque, or velocity modes. The MC73110 also supports standalone operation for use with PMD's motion processors, other off-the-shelf servo controllers, or via a serial port.

Navigator/Pilot-family Motion Processors provide programmable chip-based positioning control for DC brush, brushless DC, microstepping, and pulse & direction motors. They are available in 1-, 2-, and 4-axis configurations, and in both single-chip and dual-IC chipset configurations. These parts operate at 5V.

Magellan-family Motion Processors are state-of-the-art programmable chip-based positioning controllers for DC brush, brushless DC, microstepping, and pulse & direction motors. They are similar to the Navigator Motion Processors, but provide increased capabilities including faster loop rate, CANBus communications, software-selectable motor type, and direct SPI bus output for serial DACs. They are available in 1, 2, 3, and 4-axis configurations, and in both single-chip and dual-IC chipset configurations. These parts operate at 3.3V.

PMD's PCI and PC/104-bus motion cards are high performance general purpose motion cards for controlling DC brush, brushless DC, microstepping, and pulse & direction motors. Utilizing PMD's Magellan Motion Processors, these products are available in 1, 2, 3, and 4 axis configurations and have advanced features such as 16-bit D/A analog output, and on-board high-speed performance tracing.

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2. Installation

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In This Chapter

- Software
- Documentation
- Connection Configurations
- Installation Sequence
- Required Hardware
- Preparing the Card for Installation
- Connecting to the Card
- Applying Power
- Software Installation
- First Time System Verification

The PMD MC73110 developer's kit is an integrated board and software package which serves as an electrical and software design tool for MC73110-based systems. The major components of the kit are:

- Standalone MC73110-based card with 10 Amp three-phase brushless motor amplifier
- Serial cable to communicate with PC
- CD-ROM containing C-Motion and Pro-Motor software programs
- MC73110 product manual
- MC73110 developer's kit manual.

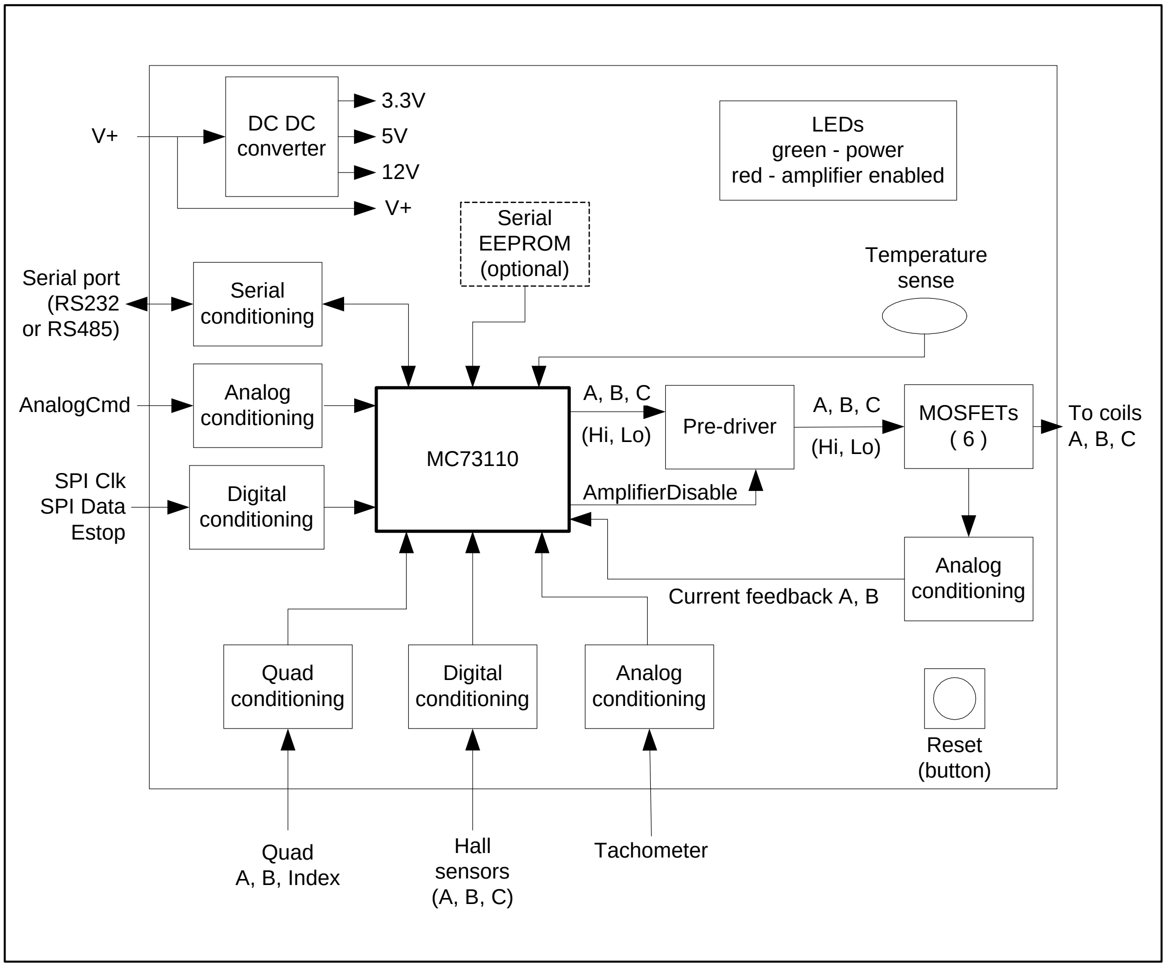
The developer's kit is a self-standing card supported by aluminum standoffs. The card measures 4.093" x 6.800" in size. The PCB board is FR-4 four-layer with 2-oz. copper, and a thickness of 62 mil. It accepts a single power connection ranging from 18V to 48V, from which the card derives all required voltages via an on-board DC to DC converter device.

During initial setup and operation, a serial cable connects the card to a PC, which runs PMD's Pro-Motor exerciser program. The serial port can be operated in point-to-point or multi-drop mode. The card may also be operated in standalone mode, without a serial port connection. In this mode, the card receives a command from an external motion controller via analog or digital hardware signals. When operated in standalone mode, MC73110 parameters are loaded into the MC73110 at power up via an on-board serial EEPROM which is installed in an 8-pin DIP socket located on the developer's kit card.

The card drives a 3-phase brushless DC motor at up to 10 amps continuous current; 15 amps peak. A wide range of motor inductances are supported. An on-card temperature sensor may be used to alert the user of an over-temperature condition on the amplifier.

The following diagram provides an overview of the signal paths and functionality of the MC73110 Developer's Kit card.

Figure 2-1: MC73110 functional diagram



The MC73110 Developer's Kit may be used for a number of purposes. For example:

- a "ready-to-go" system for exercising the MC73110
- a reference design for an MC73110-based amplifier/drive
- a pre-production system with which the user's application may be developed, and motors may be tested
- a test system from which various switching power block sections may be tested.

2.1 Software

Two major software packages are provided with the MC73110 developer's kit cards: Pro-Motor, an interactive Windows-based exerciser program, and C-Motion, a C-language library which simplifies the development of motion applications for MC73110 developer's kit cards.

Pro-Motor is a sophisticated, easy-to-use exerciser program which allows for the setting, viewing, and exercising of all card parameters and card features. Pro-Motor features include:

- A project window for accessing card parameters
- The ability to save and load current settings
- A motor-specific parameter setup
- A command window for direct text command entry
- A communications monitor which echoes all commands sent by Pro-Motor to the card.

C-Motion provides a convenient set of callable routines comprising all code required for controlling the MC73110 developer's kit card. C-Motion includes the following features:

- Axis virtualization
- The ability to communicate to multiple MC73110 developer's kit cards
- Can be easily linked to any "C/C++" application.

Pro-Motor is described in Chapter 3, "Using Pro-Motor." C-Motion is described in detail in Chapter 4, "Developing Applications with C-Motion."

2.2 Documentation

There are two manuals associated with the MC73110 card. A brief description of each is listed below.

Component Name	Description
MC73110 Product Manual	This is the complete description of the MC73110 IC. It includes electrical specifications, theory of operations, and a programmer's command reference.
MC73110 Developer's Kit Manual	This document guides you through installation and operation developer's kit manual of the MC73110 developer's kit. It describes the developer's kit card and software, and provides complete schematics for the card.

To download these documents, or request that they be sent to you, visit the PMD website at www.pmdcorp.com or contact your PMD representative.

2.3 Connection Configurations

There are two major connection configurations of the MC73110 developer's kit. The first is internal switcher, and the second is remote switcher.

Internal switcher: the developer's kit uses its internal 10 Amp continuous (15 Amp peak) on-board MOSFET switchers and current sense circuitry to form a complete standalone intelligent amplifier card. This is the normal operating state of the system, and the most convenient to use when working with the MC73110 developer's kit.

Remote switcher: an external switching triple half-bridge and associated current sense and conditioning circuitry is installed. *Section 5, Electrical Reference, page 33*, provides complete details on the signals required to connect to an external amplifier. This configuration is useful for prototyping with a custom-designed amplifier for the purpose of verifying customized amplifier designs, or driving motors with a larger current capacity than 10 Amps continuous.

The following diagrams illustrate these two configurations.

Figure 2-2: Internal switcher configuration

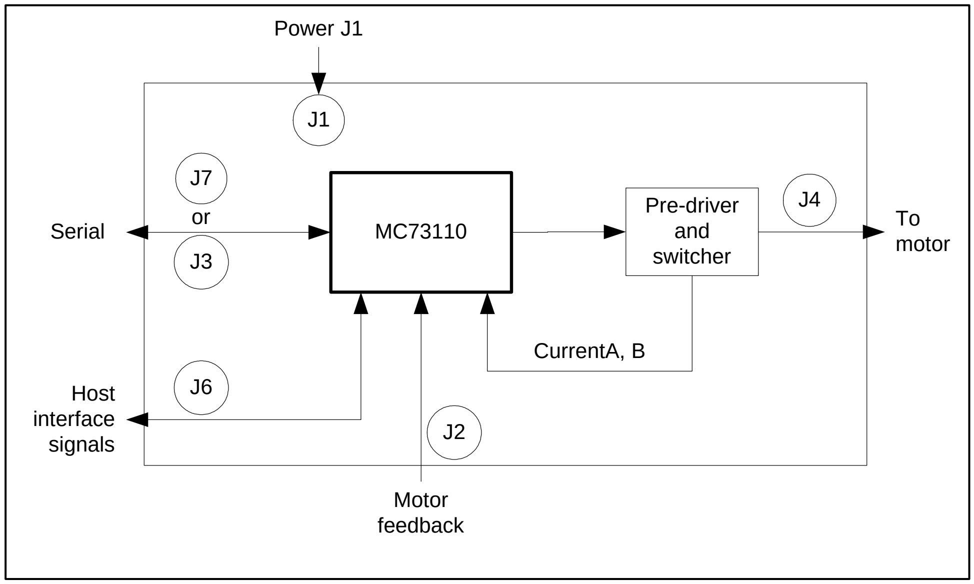
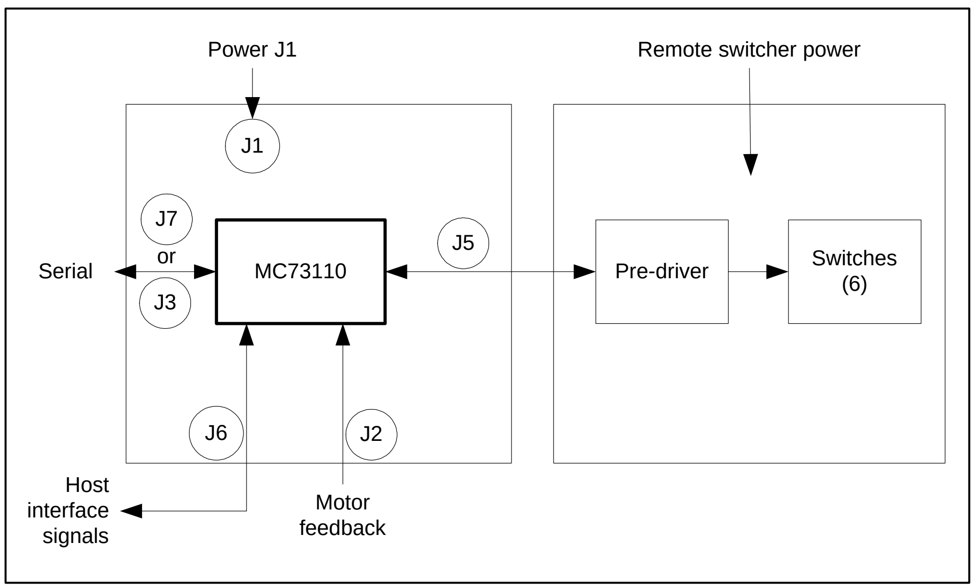


Figure 2-3: Remote switcher configuration



2.4 Installation Sequence

For a normal installation of a MC73110 developer's kit card, the card will need to be configured for the connection configuration which will be used (internal or remote). Configuration of the MC73110 developer's kit card is described in detail in Section 2.6, "Preparing the Card for Installation."

The first step is to connect the system's motors, encoders, amplifiers, and sensors as desired to operate the motion hardware. A description of available connections for the MC73110 developer's kit card is found in Section 2.7, "Connecting to the Card."

Once this hardware configuration is complete, the software must be installed. Installation of the software is described in Section 2.9, "Software Installation."

The final step of the installation is to perform a functional test of the finished system. This is described in Section 2.10, “First Time System Verification.”

Once these steps have been performed, installation is complete, and the card is ready for operation.

2.5 Required Hardware

To operate the MC73110 developer’s kit card with Pro-Motor, the Windows-based exerciser program, you will need the following hardware:

1. The recommended platform is an Intel (or compatible) processor, Pentium or better, 5 MB of available disk space, 32 MB of available RAM, and a CD-ROM drive. Supported PC operating systems are Windows 9X/ME/NT/2000/XP.
2. A 3-phase Brushless DC Motor with Hall sensors and optional quadrature encoder feedback with index.
3. Cables as required to connect to the MC73110 developer’s kit card to your motor, encoder, card power input, and to the analog or digital command signals. Additionally, you will connect the PC to the card via an included DB-9 cable. For complete descriptions of these connections see Section 2.7, “Connecting to the Card.”

2.6 Preparing the Card for Installation

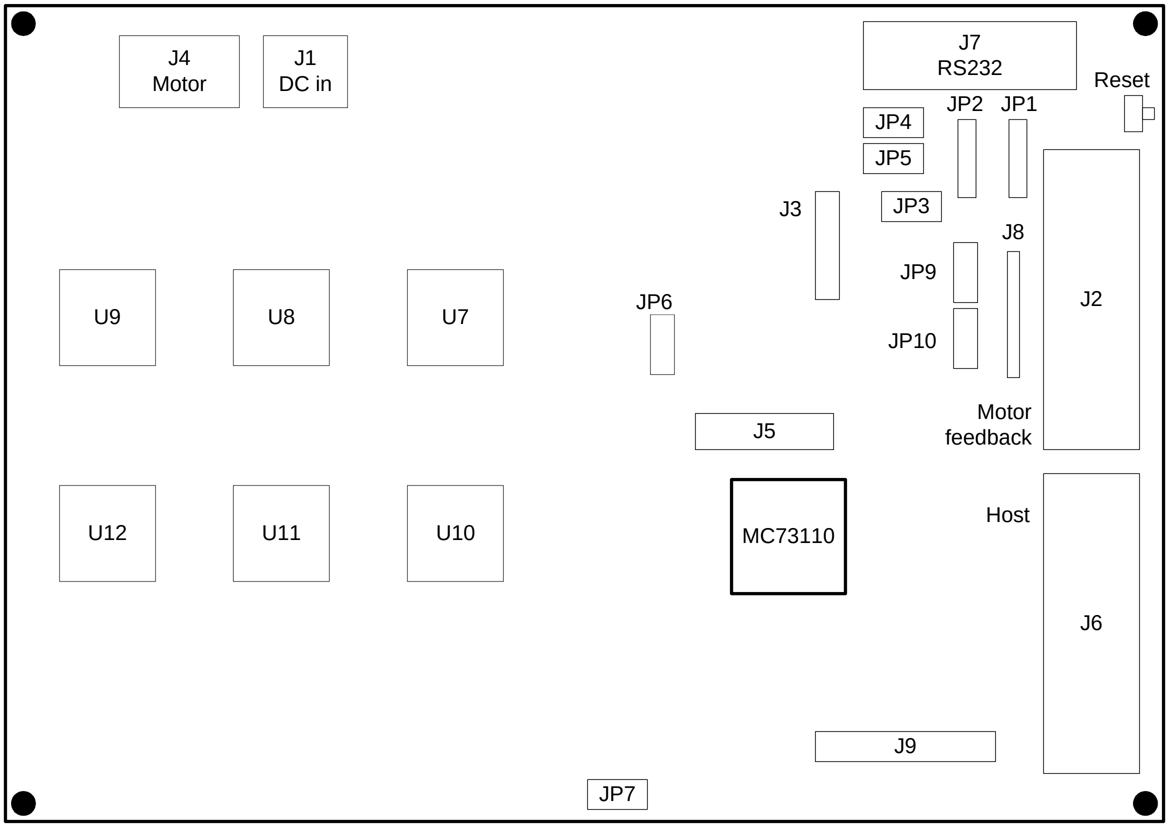
The following table shows the user-settable jumper options for the MC73110 developer’s kit card. For jumper locations, see Figure 2-4.

Jumper	Jumper Setting	Description
JP1, JP2	1-2	Selects RS-232 communication using on-board transceiver. This is the default position of this jumper.
	2-3	Selects RS-485 communication using user-provided daughtercard. For a complete description of the electrical requirements of this daughtercard, see Section 5.2.3, “RS485 Connector (J3).”
	3-4	*Reserved.*
JP3–JP5	1-2	*Reserved.* Must be set to 1-2.
JP6, JP7	1-2	Selects use of on board amplifier/switcher. This is the default setting.
	2-3	Selects use of remote amplifier/switcher. This setting is useful to verify custom amplifier design, or to connect to more powerful switching blocks.
JP9, JP10	1-2	*Reserved.* Must be set to 1-2.

In addition, the resistor pack should be installed; depending on whether single or differential quadrature encoders are used.

Resistor Pack	Setting	Description
J8	Installed; this is the default setting.	If differential connections are being used, leave the resistor pack installed.
	Removed	If single-ended encoder connections are being used, remove the resistor pack.

Figure 2-4: Location of MC73110 board components



2.7 Connecting to the Card

There are a total of seven connectors whch may be used with the MC73110 developer's kit card as follows.

Connector	Name	Function
J1	Power	Provides operating power to the developer's kit card.
J2	Motor feedback	Inputs various motor-related signals.
J3	RS-485	Provides communication to/from the card when a multi-drop RS485 is used.
J4	Motor	Provides high-voltage, high-current connections to the motor from the amplifier output.
J5	Remote switcher	Inputs and outputs various signals for use with a remote switching block.
J6	Host	Inputs and outputs various non-motor command and feedback signals to/from the developer's kit card.
J7	Serial port	Provides RS-232 communication to/from the card using an on-card transceiver driver chip. This connector is designed to interface without null-modem or other changes to a DB-9 PC serial port.

Here is a summary of the connector types expected for these seven connectors.

Connector	Signal Type	# Pins	Type
J1	High power	2	Through-hole terminal block (screw connection).
J2	Low-power digital & analog	14	Right-angle single-row shrouded header (0.100" pitch friction lock header).
J3	Low-power digital	5	1-in-line 0.100" pitch header.
J4	High power	3	Through-hole terminal block (screw connection).
J5	Low-power digital & analog	16	8 x 2 vertical header (2mm pitch).
J6	Low-power digital & analog	12	Right-angle single-row shrouded header (0.100" pitch friction lock header).
J7	Low-power digital	9	Side-facing D-sub 9 (female).

2.7.1 Initial Setup

To initially set up the developer's kit card for checkout and verification, four connectors must be used—J1 (power), J2 (motor feedback), J4 (motor), and J7 (serial port). In addition, the host connector (J6) is frequently used during testing after initial setup, in which case the serial port becomes optional. The signal connections for these connectors are described in the following sections. For a complete description of all connectors, see Chapter 5, "MC73110 Electrical Reference."

2.7.2 Power Connector (J1)

The power connector provides power to the card. All other voltages used by the card are derived from this central supply using an on-card DC-DC converter. The voltage provided at these connections matches the voltage at which the motor will be driven. The DK board is operable using a DC voltage source. If it is a regulated DC voltage source, sometimes a barrier diode is needed between the voltage source and DK board, or the voltage source could go into protection mode. If it is an unregulated DC voltage source, ensure that the output voltage of the unregulated DC voltage source meets the input voltage specifications of the DK board's operating range.

Pin #	Signal	Description
1	V+	18–48V. Current capacity specification should be maximum motor drive + lamp (to power the card).
2	PowerGnd	Ground return for V+.

2.7.3 Motor Feedback Connector (J2)

The motor feedback connector inputs various motor-related signals to the developer's kit card. All these signals are low-power, low-voltage digital or analog signals.
Note: on-board Hall signal buffers (see U3A/B/C) invert the signal sense of the input signals. That is, if the Hall signal is asserted logic high, the MC73110 will sense a logic low due to the inverter, U3. Therefore, the signal sense for the Hall signals should be reversed by software when using the DK board.

Pin #	Signal	Description
1	+5V	This signal provides 5V. This is often useful for powering the encoder circuitry.
2	GND	This signal provides the digital return.
3	QuadA+	This input signal provides the high side of the differential quadrature input for encoder phase A. For more information on connecting encoders see Section 2.6, "Preparing the Card for Installation." If unused, this signal may remain unconnected.
4	QuadA-	This input signal provides the low side of the differential quadrature input for encoder phase A. When using a single-ended encoder, this pin should remain unconnected. For more information on connecting encoders see section 2.6, Preparing the Card for Installation, page 14. If unused, this signal may remain unconnected.
5	QuadB+	This input signal provides the high side of the differential quadrature input for encoder phase B. For more information on connecting encoders see Section 2.6, "Preparing the Card for Installation. If unused, this signal may remain unconnected.
6	QuadB-	This input signal provides the low side of the differential quadrature input for encoder phase B. When using a single-ended encoder, this pin should remain unconnected. For more information on connecting encoders see Section 2.6, "Preparing the Card for Installation." If unused, this signal may remain unconnected.
7	Index+	This input signal provides the high side of the differential quadrature input for the Index signal. For more information on connecting encoders see Section 2.6, "Preparing the Card for Installation." If unused, this signal may remain unconnected.
8	Index-	This input signal provides the low side of the differential quadrature input for the Index signal. When using a single-ended encoder, this pin should remain unconnected. For more information on connecting encoders see Section 2.6, "Preparing the Card for Installation." If unused, this signal may remain unconnected.
9	GND	This signal provides the digital return.
10 11 12	HallA HallB HallC	These signals are the Hall sensor inputs. For logic "0," the signal should be lower than 0.5V; for logic "1," the signal should be greater than 1.5V.
13	TachIn+	This is the positive input signal for the analog tachometer signal. This signal represents the instantaneous speed of the motor. The input range is +/– 60V. If unused, this signal may remain unconnected.
14	TachIn-(GND)	This is the negative input for the analog tachometer signal. The input range is +/– 60V. If unused, this signal may remain unconnected.

2.7.4 Motor Connector (J4)

The motor connector provides the high-voltage three-phase outputs from the amplifier/switcher to the motor. The coil current into the motor is defined as positive.

Pin #	Signal	Description
1	MotorC	Leg 3 of 3 motor coil connections.
2	MotorB	Leg 2 of 3 motor coil connections.
3	MotorA	Leg 1 of 3 motor coil connections.

2.7.5 Host Connector (J6)

The host connector inputs and outputs various non-motor related signals to/from the developer's kit card.

Pin #	Signal	Description
1	Estop	This digital input provides an emergency stop signal to the developer's kit card. Although its function and interpretation are programmable, normally a high signal (greater than 1.5V) indicates an emergency stop is not active; and a low signal (less than .5V) indicates that it is active. If unused, this signal may remain unconnected.
2	AmplifierDisable	This digital output signal provides a programmable output signal which indicates the internal state of the MC73110. Normally, a low output indicates an error, while a high signal indicates no error. In addition to being an output at this connector, this signal is also used internally by the MC73110 developer's kit card to shut down the amplifier's switchers when the amplifier operates in "internal switcher" mode. **NOTE: This output signal is 3.3V CMOS**.
3	GND	This signal provides a digital ground return.
4	DigitalCmdClk	This digital input signal provides the SPI datastream "clock" signal. **NOTE: The maximum input voltage is 3.3V**.
5	DigitalCmdData	This digital input signal provides the SPI datastream "data" signal. **NOTE: The maximum input voltage is 3.3V**.
6	GND	This signal provides a digital ground return.
7	+5V	This signal provides a 5V output to external circuitry.
8 9	n.c.	—
10	AnalogCmd+	This analog input signal provides the positive input of the analog command. Depending on how the MC73110's control loop has been programmed, this signal represents the desired voltage, torque, or velocity. The input range is ±10V. The reference input can be differential or single-ended.
11	AnalogCmd-	This analog input signal provides the negative input of the analog command. Depending on how the MC73110's control loop has been programmed, this signal represents the desired voltage, torque, or velocity. The input range is ±10V. The reference input can be differential or single-ended. When it is single-ended, AnalogCmd- must be connected to AGND, pin 12.
12	AGND	This signal provides an analog ground return.

2.7.6 Serial Port Connector (J7)

The RS-232 serial connector provides communication to and from the card using an on-card transceiver driver chip. This connector is designed to interface without a null-modem or other changes to the DB-9 PC serial port. These signals are low-power, low-voltage digital or analog signals.

Pin #	Signal	Description
2	SrlXmt	Serial transmit signal from the MC73110 developer's kit transceiver chip.
3	SrlRcv	Serial receive signal to the MC73110 developer's kit cards.
5	GND	Ground.

2.8 Applying Power

Once the jumpers and resistor packs have been configured, and the hardware is connected, installation is complete; and the developer's kit is ready for operation.

Upon application of power through connector J1, the card will be in a reset condition. Assuming that the flash hasn't been programmed, or that a serial EEPROM hasn't been installed, the MC73110 will utilize its default values, and the motor should remain stationary. If the motors do move or jump, power down the card and check the amplifier and encoder connections. If anomalous behavior is still observed, call PMD or your distributor for application assistance.

2.8.1 Card Reset and Reset button

During card operations, if at any time you wish to reset the MC73110, you can use the reset button indicated in diagram 2.6-1 on page 14. Pressing the button will reset the controller.

2.8.2 LED Status Indicators

The MC73110 developer's kit card has two LEDs to indicate the status of the board. When the card is powered up, the green power status LED should be illuminated. After the ***AmplifierDisable*** output pin is driven to an amplifier enabled condition, the red LED should also be illuminated. This is summarized in the following table.

LED Color	Name	Function
Green	Power Status	The green LED is on when the board is powered up and the 3.3V is available.
Red	Amplifier Status	The red LED is on when the amplifier is ready. It is controlled by the AmplifierDisable pin (pin 23) of the MC73110. Usually, the red LED will be off after power up. See Section 2.10, "First Time System Verification," for more information.

2.9 Software Installation

Locate the CD-ROM which is included in the developer's kit. This CD contains software to exercise your board and source code for customization and development of motion applications. The exercise software is designed to work with Windows 95/98/ME/NT/2000/XP.

If the computer's autorun feature is enabled, the installation process will automatically begin when the CD-ROM is inserted into the CD drive. If autorun is not enabled, go to Start/Programs/Accessories/Windows Explorer, and browse to the system's CD-ROM drive. Double-click the file labelled "setup.exe," and the installation process will begin. Installation can also be initiated by going to Start/Run, and in the Open text box, type **D:\setup.exe** (where D:

is the drive letter of the CD-ROM drive), and click OK. The installation program will guide you through installing the software. Upon completion of the installation process, the following components will be installed:

- Pro-Motor—an application for communicating to and exercising the installed developer's kit. Refer to Chapter 3, "Using Pro-Motor," for operating instructions.
- C-Motion—source code that can be used for developing customized motion applications based on the MC73110. Refer to Chapter 4, "Developing Applications with C-Motion," for further information. These files are installed in the "C-Motion" folder, a subfolder of the installation folder.
- PDF versions of the developer's kit manual, programmer's reference and user's guide. Adobe Reader is required for viewing and printing these files. If Adobe Reader is not installed, it may be downloaded at no charge from http://www.adobe.com.

2.10 First Time System Verification

After the card hardware has been installed, the appropriate motor connections have been made, and software installation is complete, it's time to perform a simple test which will verify that all connections are correct. The following procedure should work for the majority of brushless motors, even if the gain parameters may not be optimized for your particular motor. Note that at any time the Pause/Break key can be pressed to disable the servo loops and motor output in case the motor begins to move erratically or uncontrollably.

1. Run Pro-Motor by double-clicking the Pro-Motor icon on the desktop.
2. If Pro-Motor cannot find the DK board, re-check the serial port connections, select the appropriate COM port in the Interface dialog, and click OK. Accept the default serial port settings by clicking OK. Refer to section 3.1 Communication for more information.
3. The Axis Wizard should start automatically to lead you through the setup and initialization step. See Chapter 3, "Using Pro-Motor," for more information on using the Axis Wizard.

> If unexpected motion occurs, the Pause/Break key can be hit to reset the MC73110 and disable the motor.

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3. Using Pro-Motor

In This Chapter

- Communication
- Axis Wizard
- Main Window
- Storing Commands to Flash Memory
- Creating an EEPROM File

The Pro-Motor program facilitates the exercising of the MC73110. All chip parameters can be viewed and modified via standard Windows controls.

Pro-Motor features:

- Project window for accessing MC73110 parameters via properties dialog boxes.
- Command window for direct text command entry.
- Communications monitor that echoes all commands sent by Pro-Motor to the MC73110.

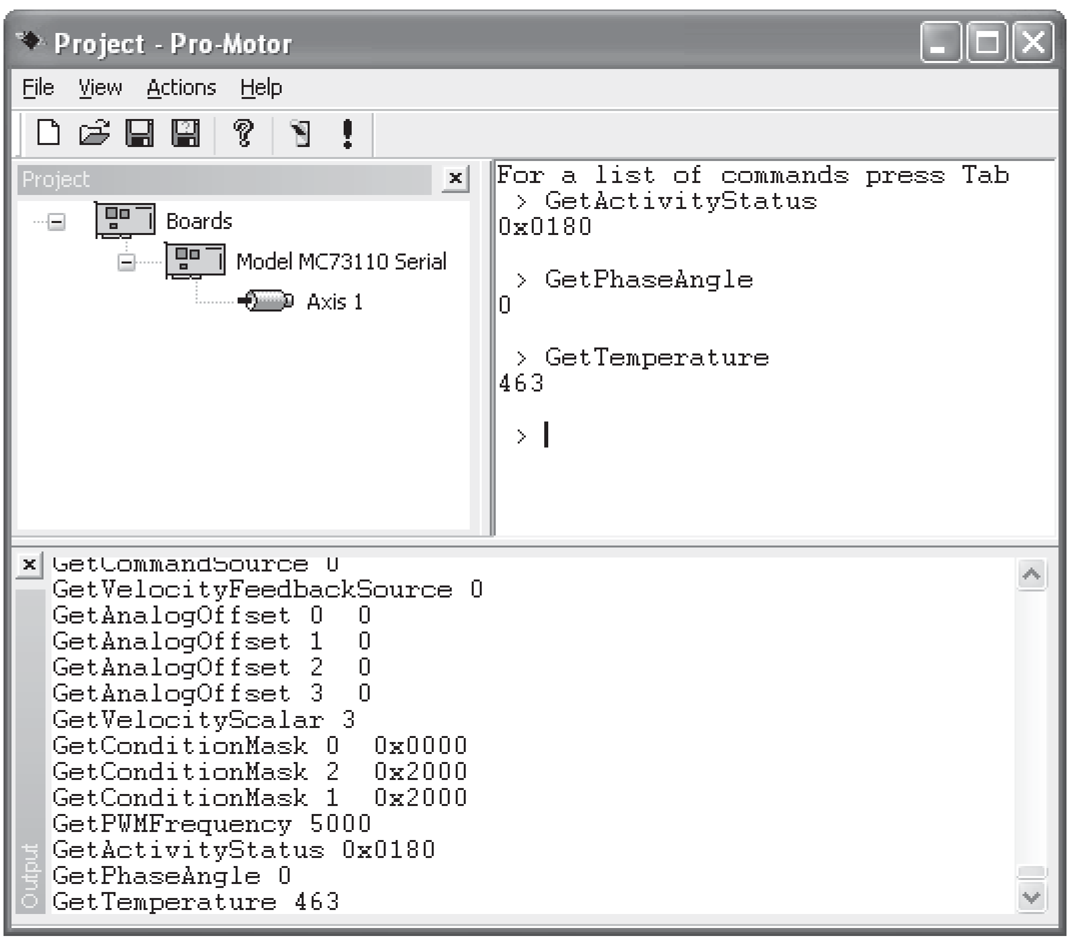
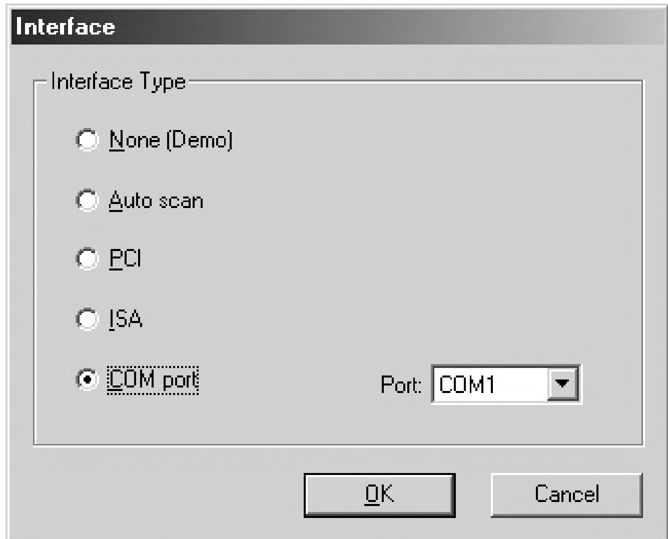


Figure 3-1: Main window

3.1 Communication

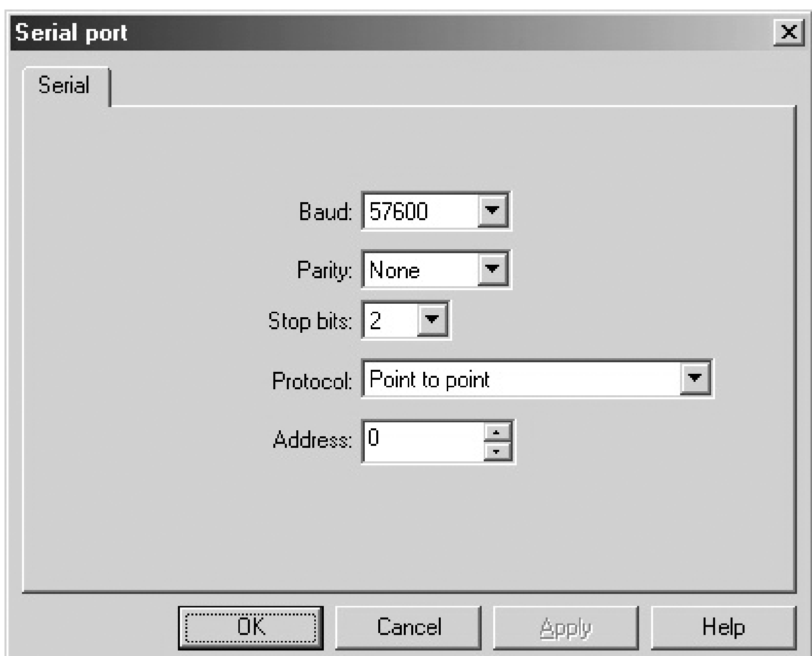
When Pro-Motor is launched, it will attempt to connect to the DK board via the serial port using the default serial port settings. If it cannot communicate to the DK board (or File/New is selected), the Interface selection dialog is displayed. Verify that the interface is set to COM port, and that the selected port is the one to which the DK board is attached.

Figure 3-2: Interface, COM port



If the serial interface (COM port) is selected in the Interface selection dialog, the serial communication configuration screen is displayed.

Figure 3-3: Interface, serial port



Verify that the serial cable is connected from the host computer's COM port to the DK board. Set the serial interface parameters according to the default settings of 57600, None, 2, Point to point, 0. Click OK to attempt a connection and proceed to the Axis Setup Wizard. If no connection is made, the Interface selection dialog will be displayed again; allowing you to modify the interface parameters or run in demo mode.

3.2 Axis Setup Wizard

Once communication has been established with the DK board, the connected motors may be put in motion by setting the appropriate Axis parameters.

When Pro-Motor is run for the first time, the Axis Setup Wizard will automatically start to configure the axis. The Axis Wizard can also be selected from the View menu at any time. To continue through the configuration process for all of the axis' parameters, click "**Next.**" To accept the default values, click "**Cancel.**"

Individual Axis settings may be modified at any time via Pro-Motor's **Axis Properties** dialog box, which is accessed by right-clicking an Axis icon in the **Project** window and selecting "**Properties.**"

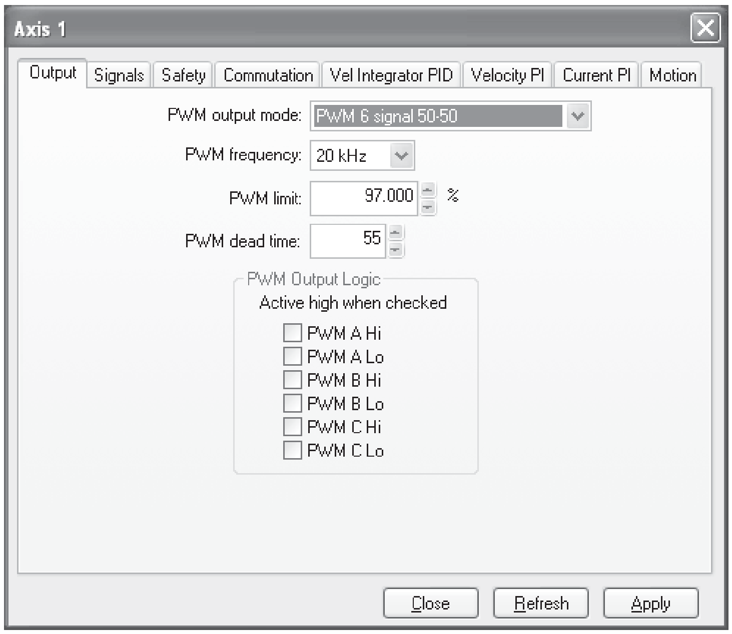


Figure 3-4: Axis Properties dialog

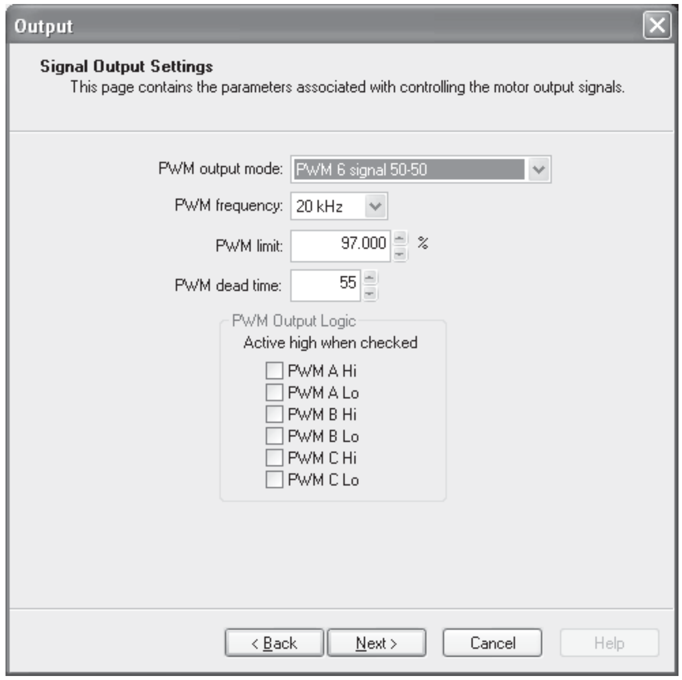
The Axis Setup Wizard may be re-run at any time by selecting "**Axis Wizard**" from Pro-Motor's **View** menu.

Figure 3-5: Axis Setup Wizard opener

3.2.1 Step 1: Signal Output Settings

On the Signal Output Settings page of the wizard, select the appropriate **PWM output mode, PWM limit, PWM dead time** and **PWM output logic** for the amplifier connected to the MC73110. The power on default settings are shown below. If you are using the DK board, the **PWM dead time** should be reduced to a value of 32, which translates to 1.6 µs. The PWM Output Logic should be left as active low (unchecked) when using the on-board amplifier.

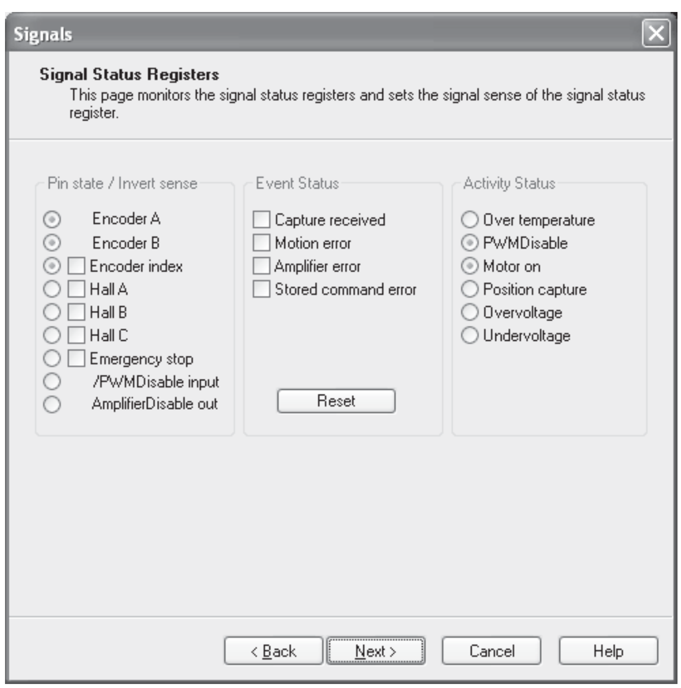
Figure 3-6: Signal Output Settings



3.2.2 Step 2: Initialize Signal Sensing

This step of the Axis Setup Wizard is used to select the Signal Sense parameters. The default signal sense is active low. Users should check the **Invert sense** checkbox in the first column for any input signals which are active high. The **Event status** column displays and resets the event status bits. The **Activity status** column displays the activity status bits. The controls in this dialog are continually updated.

Figure 3-7: Signal Status Registers



3.2.3 Step 3: Safety Settings

This step of the Axis Setup Wizard is used to set the Safety parameters. The settings as shown in Figure 3-8 will:

1. Disable the amplifier if the temperature exceeds 60°C or the **Emergency stop** signal is set. This particular configuration will latch the amplifier as disabled, because the **Amplifier Disable Source** is set to **Amplifier error,** which is latched in the Event Status register (see Section 3.2.2, "Step 2: Initialize Signal Sensing").
2. Disable the servo loop if the **Motion error** exceeds 100000.

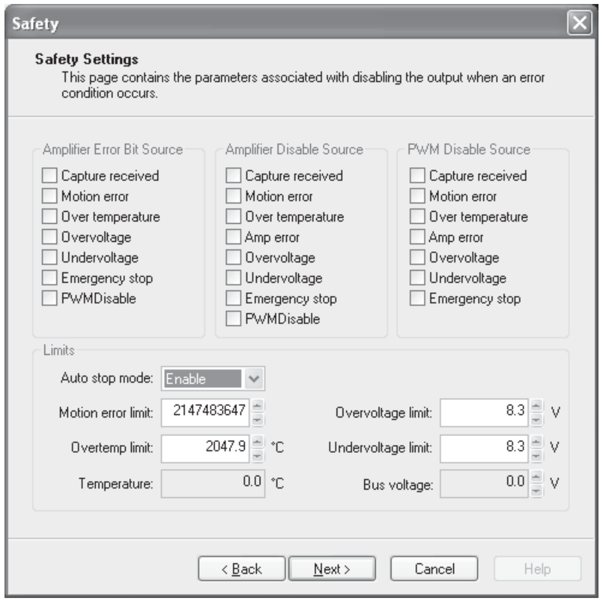


Figure 3-8: Safety Settings

Refer to the *MC73110 Product Manual* for further information on these settings.

3.2.4 Step 4: Commutation

This step of the Axis Setup Wizard is used to set the Commutation parameters. If the Commutation mode is set to **Sinusoidal**, the motor will commutate in hall-based mode until a hall signal transition occurs. The **phase angle** parameter is read-only and cannot be set in the dialog box. However, it can be set in the command window using the SetPhaseAngle command. Please see the *MC73110 Product Manual* for further information on phase initialization.

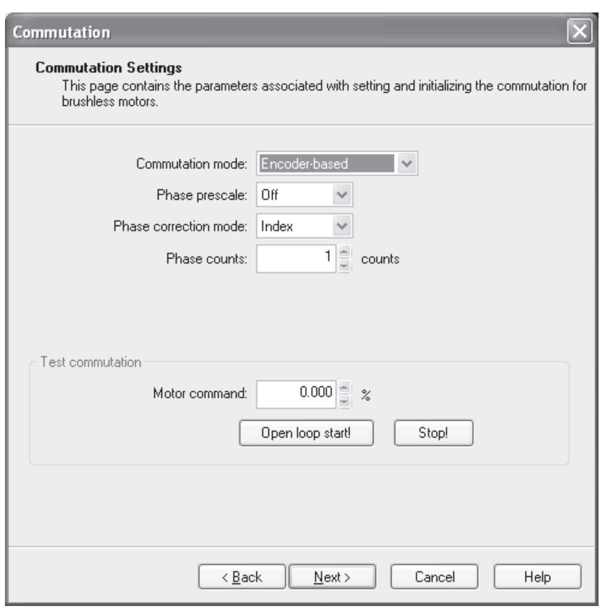


Figure 3-9: Commutation Settings

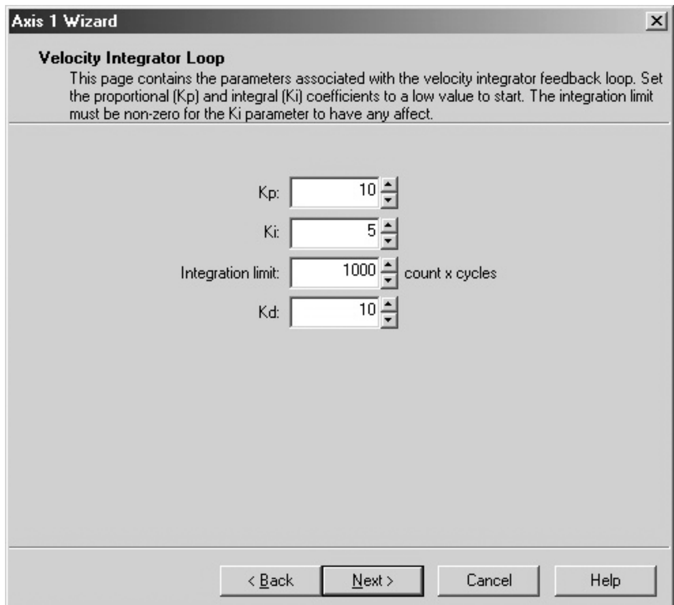
3.2.4.1 Step 4a: Check Commutation

The commutation may be verified by running the motor in open loop mode. Set the motor command parameter to a low value between 1% and 15%; bearing in mind that the motor may start to move at a rate proportional to the motor command setting. Click the **Open loop start** button. If the motor is commutating properly, a smooth, continuous motion should occur in a single direction. Click the **Stop** button to stop motion. If the motor does not move or motion is erratic, verify that **Phase counts** and **signal sense** is set correctly. The **signal sense** can be accessed by going back to the **Signals** page.

3.2.5 Step 5: Velocity Integrator Loop Parameters

This step of the Axis Setup Wizard is used to select the Velocity Integrator Loop parameters.

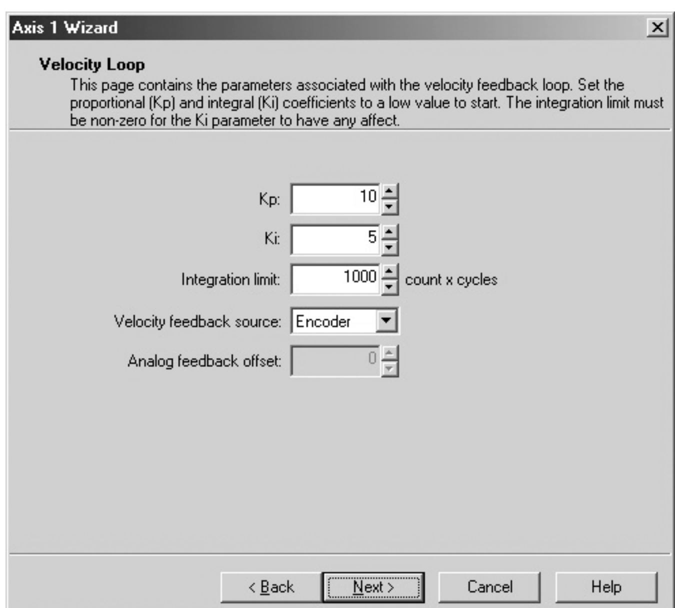
Figure 3-10: Velocity Integrator Loop



3.2.6 Step 6: Velocity Loop Parameters

This step of the Axis Setup Wizard is used to select the Velocity Loop parameters.

Figure 3-11: Velocity Loop



3.2.7 Step 7: Current Loop Parameters

This step of the Axis Setup Wizard is used to select the Current Loop parameters.

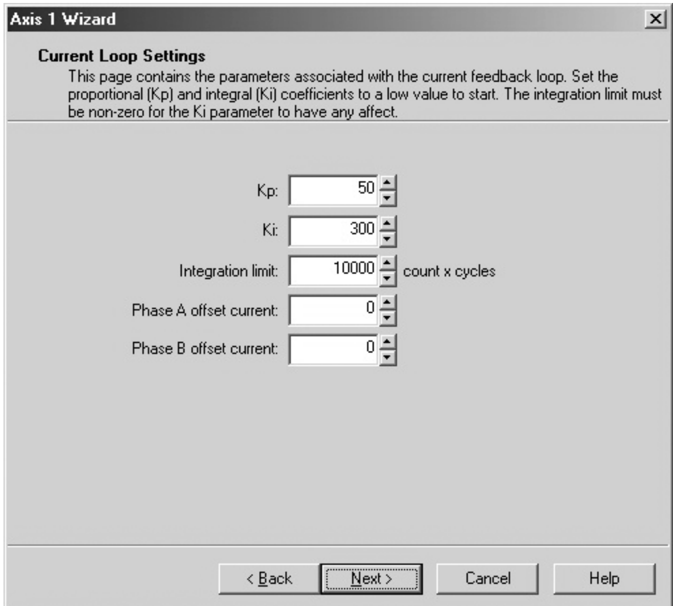


Figure 3-12: Current Loop Settings

3.2.8 Step 8: Miscellaneous Settings

The **Miscellaneous Settings** page contains the parameters for controlling the servo loops and motor dynamics. The power-on default settings are shown in the following figure. When **Motor Mode** is off, all the loops are disabled (open loop mode) and **Motor command** controls the motor speed. The dynamics settings have no effect in this mode.

When the **command** source is set to **Analog,** the command for the velocity or current loops originates from the analog input signal. When set to **SPI,** the command for the velocity or current loops is a 16-bit value read from the incoming SPI data stream. When set to **Profile Generator,** the command is generated internally based on the **Velocity** and **Acceleration** parameters.

Click the **Finish** button to update the motion processor parameters.

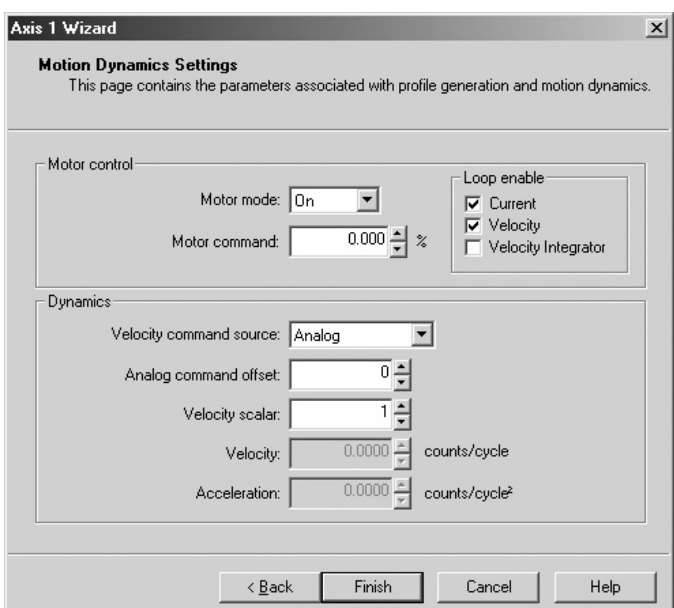


Figure 3-13: Motion Dynamics Settings

3.3 Main Window

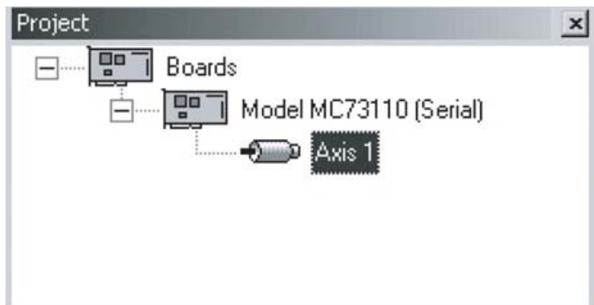
The main window is comprised of three subwindows: the project window, the command window and the output window. The workspace and output windows are control bars which can be docked and resized at any location in the main window, or undocked and moved anywhere on the desktop. They can be closed by clicking the X. To re-display them, select the appropriate View menu item.

The following keyboard shortcuts can be used at any time.

- the Pause/Break key will disable the servo loops and motor output by setting MotorMode to 0 and MotorCommand to 0.
- the Scroll Lock key will start and stop the output window from displaying communication activity.

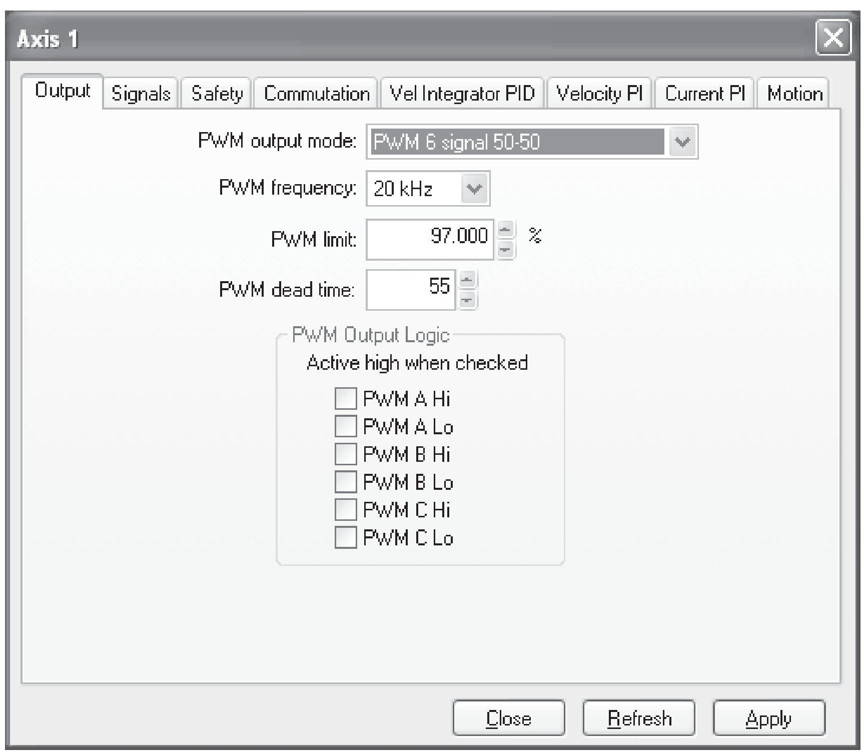
3.3.1 Project Window

Figure 3-14: Project window



The Project window displays the available DK boards and axes in a tree format. Double-clicking a board or axis icon will display the properties dialog for that item.

Figure 3-15: Axis item properties dialog



3.3.2 Command Window

Figure 3-16: Command window

The Command window in Pro-Motor allows commands to be issued directly to the MC73110. The window has a command line style interface which accepts all of the MC73110 commands. The *MC73110 Programmer's Reference* contains a full list of commands, along with their required parameters. The command window presents you with the command prompt “>’. The following sequence shows a typical command session.

```
> Reset
Processor reset
> SetSignalSense 0x380
> SetPWMDeadTime 36
> SetPhaseCounts 2000
> SetLoopGain 0x0 50
> SetLoopGain 0x10 300
> SetLoopGain 0x20 30000
> SetVelocityScalar 2000
```

The Command window is not case-sensitive, so commands may be entered in any combination of upper- and lowercase characters. As shown in the preceding example, commands are entered as a sequence of command name followed by up to two numeric parameters. Parameters can represent a single 16-bit word of data, or a 32-bit double word of data; depending on the requirements of the particular command.

```
> SetLoopGain 1 300
```

In this example, the first parameter represents a 16-bit word containing the selected loop gain, and the second parameter represents a 32-bit word that contains the loop gain value.

All of the “Get” commands display the value returned by the chipset.

```
> GetEventStatus
0x0309
```

Some commands require a parameter for selecting the desired value.

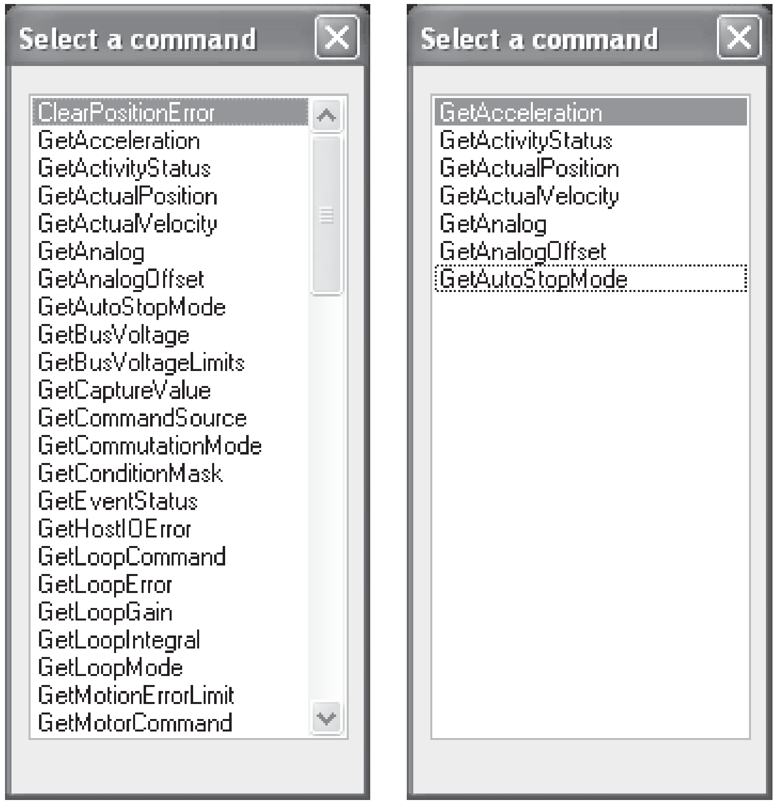
```
> GetLoopGain 16
3000
```

In this example, 16 selects the loop gain number for which the value is retrieved. The Command window accepts numeric parameters in either decimal or hexadecimal format. Prefixing a numeric parameter with “0x” enters that number using hexadecimal format.

```
> GetLoopGain 0x10
3000
```

Pressing the Tab key at any time will display a list of available commands, based upon what is already typed in the command window. If nothing is typed in the command window, then all of the available commands are displayed. For example, typing "geta" in the command window will invoke a list containing all the commands beginning with "geta."

Figure 3-17: Select a Command window

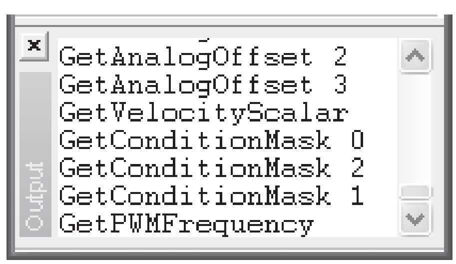


The command window also supports two useful keyboard shortcuts—the UP and DOWN arrows can be used to scroll through previously executed commands. CTRL-R will repeat the last executed command.

3.3.3 Output Window

The Output window displays the stream of commands sent to the MC73110. Any communication errors will also be displayed in this window.

Figure 3-18: Output window



3.4 Storing Commands to Flash Memory

As mentioned in the *MC73110 Product Manual*, the AmpDisable condition mask must be active when storing commands to flash. If the red LED on the DK board is on, then the AmpDisable condition mask is inactive and must be changed. The simplest way to achieve this is to force the AmpDisable condition mask to look at the Emergency Stop input. Make sure to press the APPLY button.

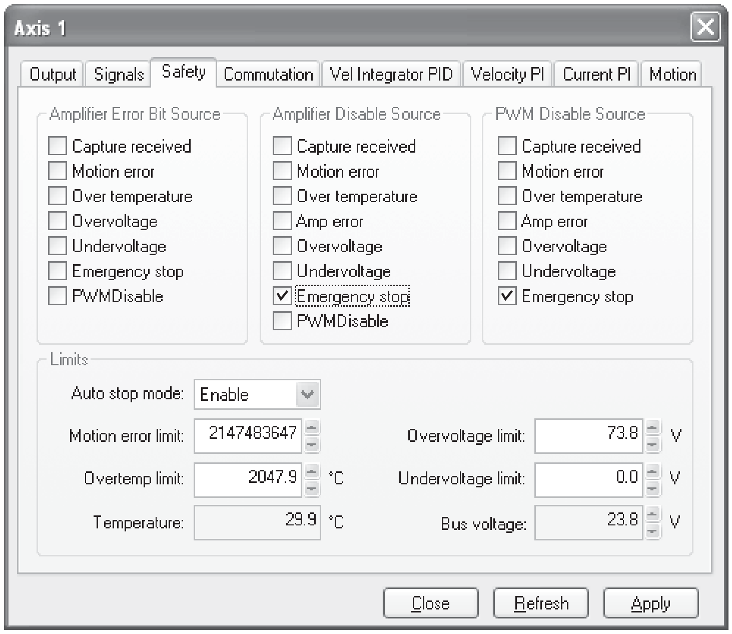


Figure 3-19: EStop– Safety window

Next, the interpretation (active high vs. active low) of the Emergency Stop input can be changed. With nothing connected to the Emergency Stop input, the input will be high, which by default is inactive. Selecting the Emergency Stop checkbox in the Signals tab will cause the Emergency Stop input to be interpreted as active high. After doing so the AmpDisable condition mask should now be active, and the red LED should be off.

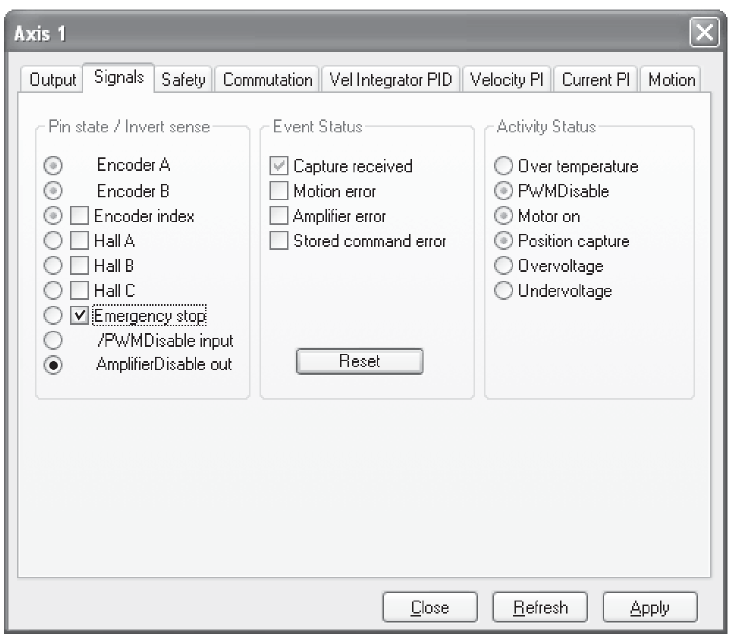


Figure 3-20: EStop– Signals window

In the File menu is a "Store Commands in Flash" item that can now be selected. This will cause all parameter values currently in Pro-Motor to be stored in the user Flash space on the MC73110. When complete, a reset will occur. The values in Flash will be read and will become the active configuration.

3.5 Creating an EEPROM File

The Pro-Motor File menu has a "Create EEPROM File" item. This will create an EEPROM file on your PC that contains all parameter values currently active in Pro-Motor. This file can be loaded into standard EEPROM programming software.

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4. Developing Applications with C-Motion

4

In This Chapter

▶ Theory of Use

C-Motion is a "C" source code library containing all the code required for communicating with the motion control processor using the serial interface.

C-Motion includes the following features:

- Axis virtualization
- The ability to communicate to multiple PMD motion processors
- Can be easily linked to any "C/C++" application
- Supports serial communication.

The following files comprise the C-Motion distribution.

C-Motion.h/C-Motion.c	Definition/declaration of the processor command set.
PMDw32ser.h/PMDw32ser.c	Windows serial communication interface functions.
PMDtrans.h/PMDtrans.c	Generic transport (interface) functions.
PMDecode.h	Defines the processor and C-Motion error codes.
PMDocode.h	Defines the control codes for processor commands.
PMDtypes.h	Defines the basic types required by C-Motion.
PMDDiag.h/PMDdiag.c	Diagnostic utility functions
PMDconio.h/PMDconio.c	Console I/O wrapper functions

C-Motion may be linked to your application code by including the above "C" source files in your application. Then, for any application source file requiring access to the motion processor, #include "C-Motion.h."

4.1 Theory of Use

C-Motion is a set of functions encapsulating the motion processor command set. Every command has as its first parameter an "axis handle." The axis handle is a structure containing information about the interface to the motion processor, and the axis number that the handle represents. Before communicating to the motion processor, the axis handle must be initialized using the following sequence of commands.

```
// the axis handle
PMDAxisHandle handle;
// open serial interface to PMD processor and initialize handle to axis one
PMDSetupAxisInterface_Serial( &handle, PMDAxis1, 1 ); // COM1
```

Once the axis handle has been initialized, any of the motion processor commands may be executed. C-Motion.h includes the prototypes for all motion processor commands as implemented in C-Motion. Refer to this file for the required parameters for each command. The *MC73110 Product Manual* is the primary source for information about the operation and purpose of each command.

Every C-Motion processor command returns a status code of type PMDresult. The return code for every command executed should be checked before attempting to execute more commands.

```
PMDresult result,status;

result = PMDSetVelocity(&handle, 100000);

if (result != PMD_ERR_OK)
{
        printf("Error: %s\n", PMDGetErrorMessage(result));
        return;
}
```

Many commands require additional parameters. Some standard values are defined by C-Motion and can be used with the appropriate commands. Refer to PMDtypes.h for a complete list of defined types. A C-Motion function call with the pre-defined types is shown in the following example.

```
PMDSetConditionMask(&handle, PMDConditionMaskAmpDisable, PMDConditionOverTemp);
```

In addition to the processor commands, C-Motion provides several support functions. A subset of these are:

```
void PMDCloseAxisInterface(PMDAxisHandle* axis_handle);
```

This should be called to terminate an interface connection.

```
char *PMDGetErrorMessage(PMDresult errorCode);
```

This returns a character string representation of the corresponding PMD chip or C-Motion error code.

```
void GetCMotionVersion(PMDuint8* MajorVersion, PMDuint8* MinorVersion);
```

This returns the major and minor version number of C-Motion.

5. MC73110 Electrical Reference

5

In This Chapter

- User-Settable Jumper Options
- Connecting to the Card

5.1 User-Settable Jumper Options

The following table shows the user-settable jumper options for the MC73110 developer's kit card. For jumper locations, see Figure 5-1.

Jumper	Jumper Setting	Description
JP1, JP2	1-2	Selects RS-232 communication using the on-board transceiver. This is the default position of this jumper.
	2-3	Selects RS-485 communication using a user-provided daughtercard. For a complete description of the electrical requirements of this daughtercard, see *Section 5.2.3, "RS485 Connector (J3)."*
	3-4	*Reserved.*
JP3-JP5	1-2	*Reserved*; must be set to 1-2.
JP6, JP7	1-2	Selects the use of the on board amplifier/switcher. This is the default setting.
	2-3	Selects the use of a remote amplifier/switcher. This setting is useful to verify custom amplifier design, or to connect to more powerful switching blocks.
JP9, JP10	1-2	*Reserved*; must be set to 1-2.

In addition, the following resistor pack should be installed; dependant upon the use of single or differential quadrature encoders.

Resistor Pack	How to Set	Description
J8	Installed *this is the default setting*	If you are using differential connections, leave the resistor pack installed.
	Removed	If you are using single-ended encoder connections, remove the resistor pack.

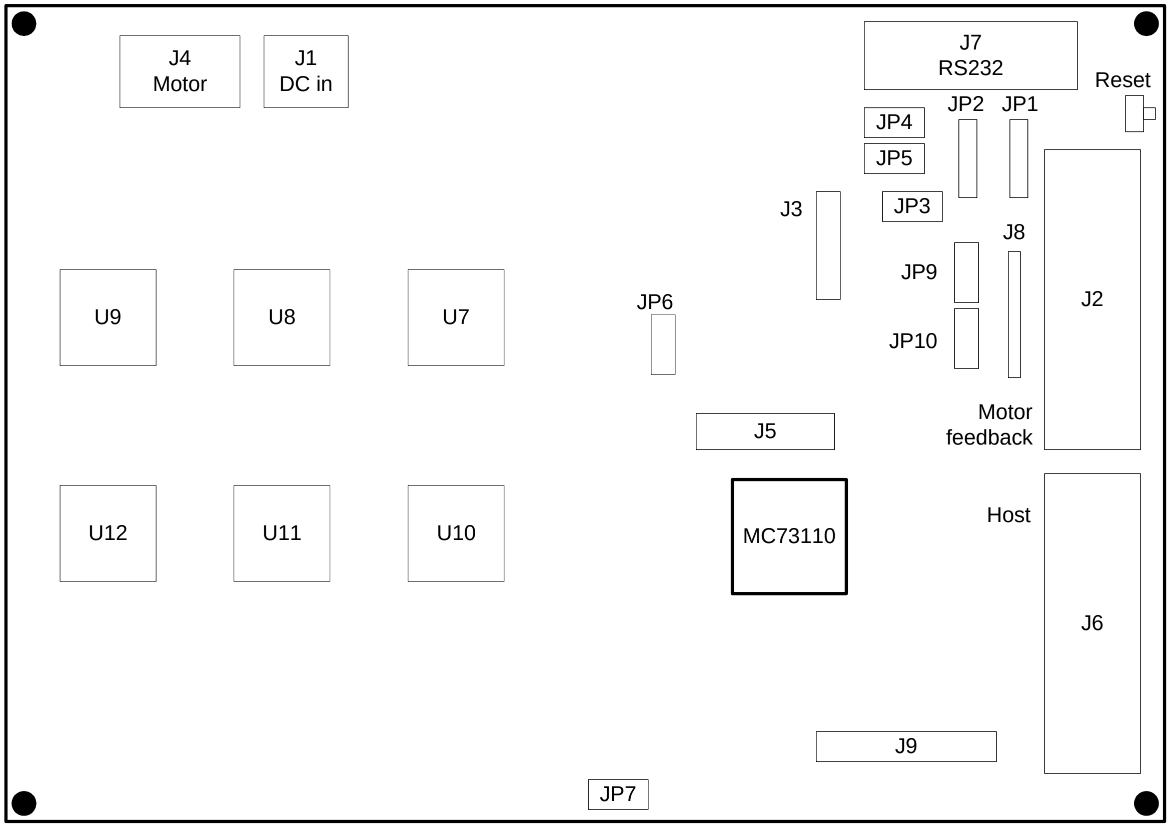


Figure 5-1: Location of MC73110 board components

5.2 Connecting to the Card

There are a total of seven connectors which may be used with the MC73110 Developer's Kit card
. See Section 2.6, "Preparing the Card for Installation," for addtional information regarding card component details.

Connector	Name	Function
J1	Power	Provides operating power to the developer's kit card.
J2	Motor feedback	Inputs various motor-related signals.
J3	RS-485	Provides communication to and from the card when a multi-drop RS485 is used.
J4	Motor	Provides high voltage, high current connections to the motor from the amplifier output.
J5	Remote switcher	Inputs and outputs various signals for use with a remote switching block.
J6	Host	Inputs and outputs various non-motor commands and feedback signals to and from the developer's kit card.
J7	Serial port	Provides RS-232 communication to and from the card using an on-card transceiver driver chip. This connector is designed to interface directly to the DB9 serial port of a host computer.

The following is a summary of the required connector types.

Connector	Signal Type	# Pins	Type
J1	High power	2	Through-hole terminal block (screw connection).
J2	Low-power digital & analog	14	Right-angle single-row shrouded header (0.100" pitch friction lock header).
J3	Low-power digital	5	1-in-line 0.100" pitch header.
J4	High power	3	Through-hole terminal block (screw connection).
J5	Low-power digital & analog	16	8 x 2 vertical header (2mm pitch).
J6	Low-power digital & analog	12	Right-angle single-row shrouded header (0.100" pitch friction lock header).
J7	Low-power digital	9	Side-facing D-sub 9 (female).

5.2.1 Power Connector (J1)

The power connector provides power to the card. All other voltages used by the card are derived from this central supply using an on-card DC-DC converter. The voltage provided at these connections matches the voltage at which the motor will be driven.

Pin #	Signal Name	Description
1	V+	18v–48V. Current capacity specification should be maximum motor drive + 1 Amp (to power the card).
2	PowerGnd	Ground return for V+.

5.2.2 Motor Feedback Connector (J2)

The motor feedback connector inputs various motor-related signals to the developer's kit card. All these signals are low-power, low-voltage digital, or analog signals. The mating connector is Tyco/Amp MTA100 series, part # 1-640620-4.

Pin #	Signal	Description
1	+5V	This signal provides 5V. This is often useful to power the encoder circuitry.
2	GND	This signal provides the digital return.
3	QuadA+	This input signal provides the high side of the differential quadrature input for encoder phase A. For more information on connecting encoders, see Section 2.6, "Preparing the Card for Installation." If unused, this signal may remain unconnected.
4	QuadA-	This input signal provides the low side of the differential quadrature input for encoder phase A. When using a single-ended encoder, this pin should remain unconnected. For more information on connecting encoders, see Section 2.6, "Preparing the Card for Installation." If unused, this signal may remain unconnected.
5	QuadB+	This input signal provides the high side of the differential quadrature input for encoder phase B. For more information on connecting encoders, see Section 2.6, "Preparing the Card for Installation." If unused, this signal may remain unconnected.

Pin #	Signal	Description
6	QuadB-	This input signal provides the low side of the differential quadrature input for encoder phase B. When using a single-ended encoder, this pin should remain unconnected. For more information on connecting encoders, see Section 2.6, “Preparing the Card for Installation.” If unused, this signal may remain unconnected.
7	Index+	This input signal provides the high side of the differential quadrature input for the Index signal. For more information on connecting encoders, see Section 2.6, “Preparing the Card for Installation.” If unused, this signal may remain unconnected.
8	Index-	This input signal provides the low side of the differential quadrature input for the Index signal. When using a single-ended encoder, this pin should be left unconnected. For more information on connecting encoders see Section 2.6, “Preparing the Card for Installation.” If unused, this signal may remain unconnected.
9	GND	This signal provides the digital return.
10 11 12	HallA HallB HallC	These signals are the Hall sensor inputs. For logic “0,” the signal should be lower than 0.5V; for logic “1,” the signal should be greater than 1.5V.
13	TachIn+	This is the positive input signal for the analog tachometer signal. This signal represents the instantaneous speed of the motor. The input range is +/– 60V. If unused, this signal may remain unconnected.
14	TachIn- (GND)	This is the negative input for the analog tachometer signal. The input range is ±60V. If unused, this signal may remain unconnected.

5.2.3 RS485 Connector (J3)

This connector provides communication to/from the card when an external 3.3V RS485 transceiver is being used. The communication signals are low-power, 3.3V. A 3.3V transceiver must be used.

Pin #	Signal	Description
1	SrlXmt	This signal provides a serial transmit connection for RS485 communications.
2	SrlRcv	This signal provides a serial receive connection for RS485 communications.
3	SrlEnable	This signal provides a serial enable connection for RS485 communications.
4	GND	Ground.
5	Vcc	+5V Vcc provided by card.

5.2.4 Motor Connector (J4)

The motor connector provides the high voltage three-phase outputs from the amplifier/switcher to the motor.

Pin #	Signal	Description
1	MotorC	Leg 3 of 3 motor coil connections.
2	MotorB	Leg 2 of 3 motor coil connections.
3	MotorA	Leg 1 of 3 motor coil connections.

5.2.5 Remote Switcher Connector (J5)

The remote switcher connector inputs and outputs various signals that make it possible for the user to develop a separate switching block, while still using the digital logic of the DK card to power the motor control IC. All digital signals are 3.3V maximum.

Pin #	Signal	Description
1	AmplifierDisable	This signal is connected to the AmplifierDisable signal from MC73110. It can be programmed to go inactive under certain erroneous MCP conditions.
2	PWMOutputDisable	This signal provides a digital input connected to the MC73110 pin of the same name. A high level on this signal indicates that PWMOutputDisable is not active; a low indicates it is active.
3	I^2CClk	This signal connects to the remote switcher's temperature sensor I^2C clock connection.
4	I^2Cdata	This signal connects to the remote switcher's temperature sensor I^2C data connection.
5 6 7 8 9 10	PWMCHigh/PWMC PWMLowC PWMBHigh/PWMB PWMBLowB PWMAHigh/PWMA PWMALowA	These signals connect to the PWM drive signals of the same name at the MC73110.
11	+3.3V	+3.3V power for digital logic.
12	GND	Digital return.
13 14	AGND	Analog returns.
15 16	CurrentA CurrentB	These analog input signals hold the instantaneous current through phase A and phase B of the motor coils. The input voltage range is 0V to 3.3V; referenced at 1.65V.

5.2.6 Host Connector (J6)

The host connector inputs and outputs various non-motor related signals to and from the developer's kit card. The mating connector is Tyco/Amp MTA100 series, part # 1-640620-2.

Pin #	Signal	Description
1	Estop	This digital input provides an emergency stop signal to the developer's kit card. Although its function and interpretation are programmable, normally a high signal (greater than 1.5V) indicates an emergency stop is not active; and a low signal (less than .5V) indicates that it is active. If unused, this signal may remain unconnected.
2	AmplifierDisable	This digital output signal provides a programmable output signal which indicates the internal state of the MC73110. Normally, a high output indicates an error, while a low signal indicates no error. In addition to being an output at this connector, this signal is also used internally by the MC73110 developer's kit card to shut down the amplifier's switchers when the amplifier operates in "internal switcher" mode. **NOTE: This output signal is 3.3V CMOS**.
3	GND	This signal provides a digital ground return.
4	DigitalCmdClk	This digital input accepts the SPI datastream "clock" signal. **NOTE: The maximum input voltage is 3.3V**.

Pin #	Signal	Description
5	DigitalCmdData	This digital input accepts the SPI datastream "data" signal. **NOTE: The maximum input voltage is 3.3V**.
6	GND	This signal provides a digital ground return.
7	+5V	This signal provides 5V for external circuitry.
8 9	n.c.	—
10	AnalogCmd+	This analog input signal provides the positive input of the analog command. Depending on how the MC73110's control loop has been programmed, this signal represents the desired voltage, torque or velocity. The input range is +/–10V. The reference input can be differential or single-ended.
11	AnalogCmd-	This analog input signal provides the negative input of the analog command. Depending on how the MC73110's control loop has been programmed, this signal represents the desired voltage, torque or velocity. The input range is +/–10V. The reference input can be differential or single-ended. When it is single-ended, AnalogCmd- must be connected to AGND, pin 12.
12	AGND	This signal provides an analog ground return.

5.2.7 Serial Port Connector (J7)

The RS-232 serial connector provides communication to and from the card using an on-card transceiver driver chip. This connector is designed to interface without a null-modem or other changes to the DB-9 PC serial port. These signals are low-power, low voltage digital or analog signals.

Pin #	Signal	Description
2	SrlXmt	Serial transmit signal from the MC73110 developer's kit transceiver chip.
3	SrlRcv	Serial receive signal to the MC73110 developer's kit card.
5	GND	Ground.

6. Schematics

6

In This Chapter

- Introduction
- Detailed Schematic Descriptions
- System Design Using the MC73110

6.1 Introduction

The wide-ranging functionality of the DK board includes circuits for motor sensor signal conditioning, host communication, a serial communication port, current sensing, power output for driving brushless DC motors, and housekeeping power.

The usage of the board has been explained in Chapters 2 and 5 of this manual. This section focuses on the details for system implementation of the MC73110. For information and details regarding specific components and circuitry, see the reference schematics, which are included in this section.

The design of the MC73110 DK is detailed in a series of 10 schematic pages.

- The basic connections of the MC73110
- The conditioning circuits of both digital and analog signal, from the host and the motor sensors
- All connectors on the DK board
- All jumpers on the DK board
- An on-board temperature sensor and an optional EEPROM, which communicate with MC73110 via the I^2C bus; it also includes a RS-232 line driver/receiver
- The power train, which consists of the pre-driver circuitry and a three-phase MOSFET inverter
- The motor coil current sensing circuits; it includes isolation amplifiers and signal conditioning circuitry
- The housekeeping power supply; it provides regulated output voltages of +12V, +5V, +3V, and two floating +5V outputs, and also includes the reset circuitry
- The analog power supply for the analog circuits
- Auxiliary circuits currently reserved by PMD; it includes the positive-rail current monitoring circuit, and the input voltage monitoring circuit

Figure 6-1 summarizes the functions of the MC73110 Developer Kit.

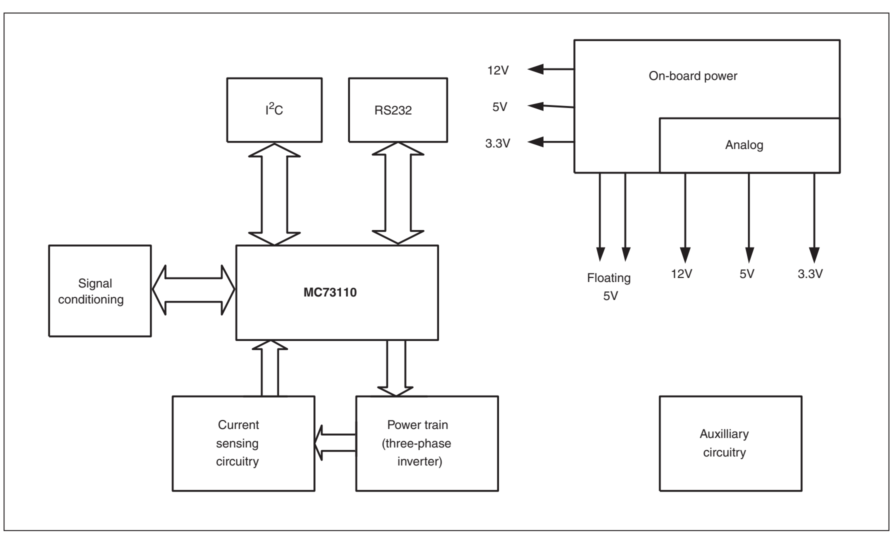


Figure 6-1: Function blocks

6.2 Detailed Schematic Descriptions

Figure 6-2

This page shows the basic connection of MC73110.

The MC73110 has multiple Vcc and GND pins. The supply voltage (+3.3V) has a nominal value of 3.3V, and it powers the digital portion of MC73110. See Figure 6-9 for details of the digital power supply.

Pin 60, Vccp, is the user data voltage pin. By providing a 5V current to this pin, users can store the startup configurations in MC73110's internal memory. When used, Vccp must be directly connected to 5V without any current limiting resistors. When unused, it is connected to GND. Never leave this pin floating.

U18 is a 10MHz clock. Its supply voltage is derived from the 3.3V digital power supply (+3.3V). The ferrite bead, L3, is in a series with the power trace in order to isolate U18 from the rest of the power plane, since U18 supplies the highest continuous frequency on the board. Similarly, the ferrite bead, L1, is located between pin 39, PLLVcc, and the 3.3V digital power supply (+3.3V), because PLLVcc powers the MC73110's internal PLL module.

R75 is located between the output of U18 and pin 24, ClockIn, of MC73110. This resistor slows the rise/fall time of the clock signal, thus improving the EMI performance.

R76, C38, and C39 are MC73110's external PLL (phase lock loop) filter. C38 and C39 must be non-polarized capacitors.

A separate 3.3V analog voltage supply (Ref_3.3) powers the MC73110's internal analog circuitry. The analog power and the digital power are AC isolated on the DK board in order to improve the noise immunity and to ensure ADC accuracy. See Figure 6-10 for details on the analog power supply.

Pins 11 through 22 of the MC73110 are related to its analog circuit, and use the analog ground as the reference.

Pin 21, AnalogVcc, is the analog power supply. The nominal supply voltage is 3.3V.

Pin 20, AnalogRefHigh, is the analog high voltage reference. It is connected to the analog power Ref_3.3 on the DK board.

Pin 19, AnalogRefLow, is the analog low voltage reference. It is connected to the analog ground.

The 3.3V analog voltage Ref_3.3 acts as both the ADC voltage reference and the voltage supply of MC73110's analog circuitry. In order to ensure the ADC accuracy, the mutual coupling between the analog power supply pin pairs (AnalogRefHigh, AnalogRefLow) and reference pin pairs (AnalogVcc, AnalogGND) must be minimized. The DK board meets this requirement by placing two ceramic capacitors, C40 and C41, close to the two pin pairs, respectively. Furthermore, C40 is on the top of the board, and C41 is on the bottom of the board.

Pins 11 through 14 are reserved, and should be connected to analog ground in customer designs.

Resistors R101 and R102 are for test purposes, and are not required in customer designs.

Figure 6-2: Basic connection

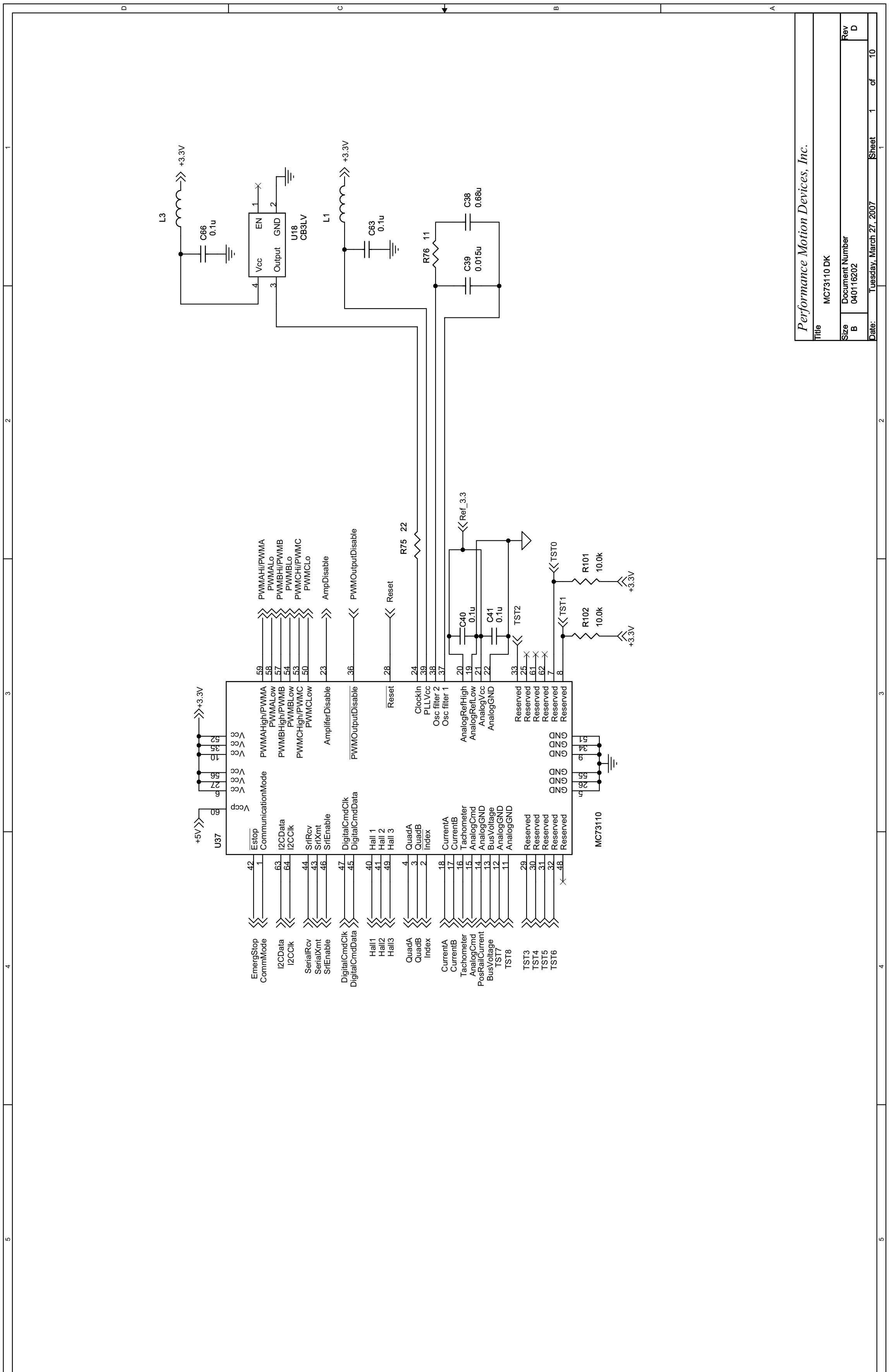


Figure 6-3

This page details the conditioning circuitry for the digital and analog signals from the host and the motor sensors.

U1, DS26LV32AT, is a RS-422 line receiver. With the use of a 120~150 resistor pack (located at J8 in Figure 6-4), the DK board may be configured for differential encoder inputs. The resistors at inputs (R1~R4, R6~R9, R10~R13) configure fail-safe connections. When the encoder connection is broken or shorted, the corresponding output of U1 is logic high.

D1, MMBZ5221B, is a Zener diode with nominal voltage of 2.4V. It sets a bias voltage at the negative inputs of U1. Therefore, the DK board can also be configured for single-ended encoder input. Without the resistor pack at J8, connect the single-ended encoder signal to the positive input, and leave the negative input floating.

U3(A/B/C), 74HC14, is a Hex-inverting Schmitt trigger. It conditions Hall signals from either a commutation encoder or from magnetic sensors. The resistor/capacitor pairs (R21/C6, R25/C7, R27/C8) are low-pass filters used to reject noise on the input signals, and the Schmitt input further improves the noise immunity. The pull-up resistors (R16, R24, R26) are used when the Hall signal type is open-collector. The input resistors (R21, R25, R27) are used to limit the input current into the 3.3V Schritt trigger buffers.

U2, TLV2474, is a quad rail-to-rail op amp. It is referenced to the analog ground and powered by a 3.3V analog supply (Analog_3.3). See Figure 6-10 for details on the analog power supply.

U2B/C/D is the conditioning circuit for analog command (AnalogCmd+, AnalogCmd-) with differential inputs.

U2B is configured as a difference amplifier with R32=R35 and R29=R36. Its balanced input impedance rejects the common-mode noise on the analog command. The tolerance of the resistors is 1% in order to ensure the difference amplifier's performance.

U2C is a voltage follower with output voltage 1.65V, which is from Ref_0shift in Figure 6-10. It sets a 1.65V DC bias at the output of U2B, which corresponds to zero output of the internal ADC of the MC73110.

The analog command (AnalogCmd+/–) is between -10V and +10V, and the output of U2B is determined using the following formula.

(AnalogCmd + –AnalogCmd -)*R29/R32+1.65=0.14(AnalogCmd + –AnalogCmd -)+1.65 V

Therefore, a +10V command corresponds to 3.05V output, and a -10V command corresponds to 0.25V output. A 0.25V safety margin remains between U2's maximum output range and the monotonic conversion range of the MC73110's internal ADC.

U2D is a Butterworth second-order low-pass filter with unity gain and a cutoff frequency of 5KHz. It attenuates high frequency noise on the command signal and acts as an anti-aliasing filter for the internal ADC of the MC73110.

U2A is a first-order low-pass filter for conditioning the tachometer signal TachIn+. Its output has a DC bias of 1.65V and the cutoff frequency is 1/(2*pi*R14*C4)= 4.4 KHz. When the tachometer signal is much lower than 4.4KHz, this lower-pass filter only scales and shifts the tachometer signal. For example, when the tachometer input signal is lower than 400Hz, the output of U2A is determined using the following formula.

R14/(R17+R18)*(TachIn+)+1.65=0.0221(TachIn+) + 1.65 V

C5 is optional, and may be installed to configure the U2A as a second-order filter.

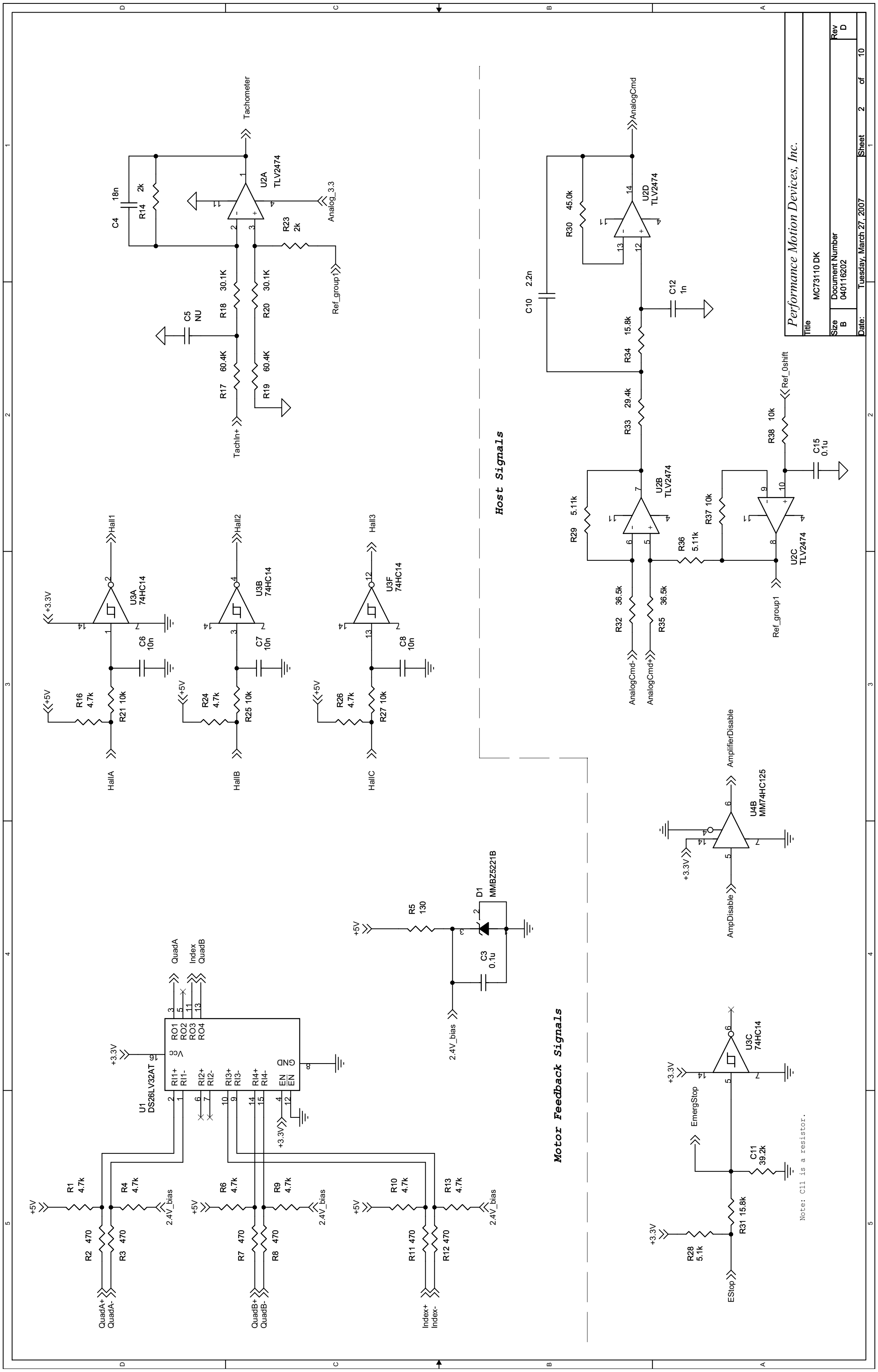


Figure 6-3: Conditioning circuitry

Figure 6-4

This page shows all connectors on the DK board. Please refer to Section 2.7, "Connecting to the Card," for the component definitions and functionality.

Figure 6-4: Connectors

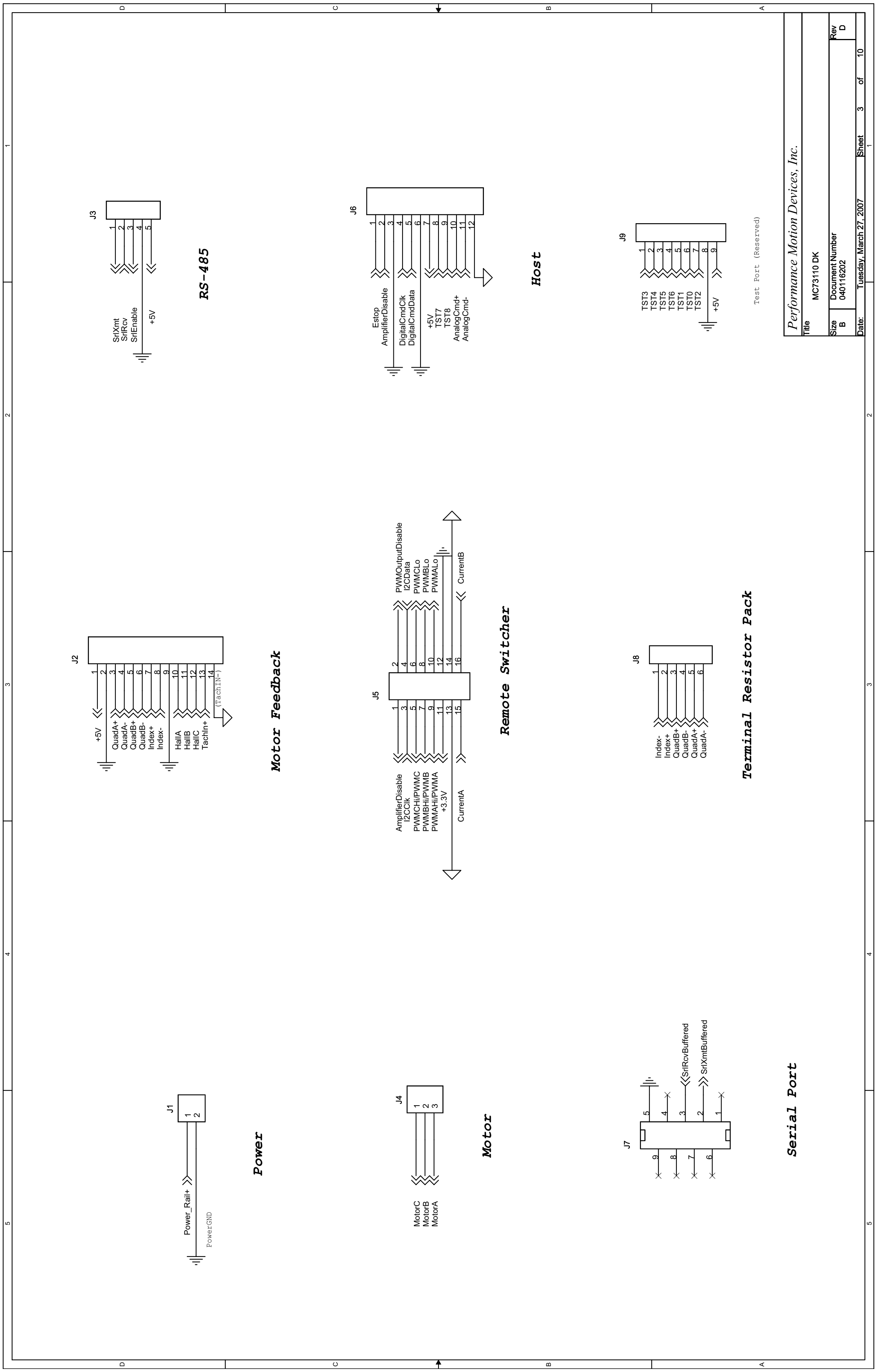


Figure 6-5

This page shows all jumpers on the DK board. Please refer to Section 2.6, "Preparing the Card for Installation," for the component definitions and functionality.

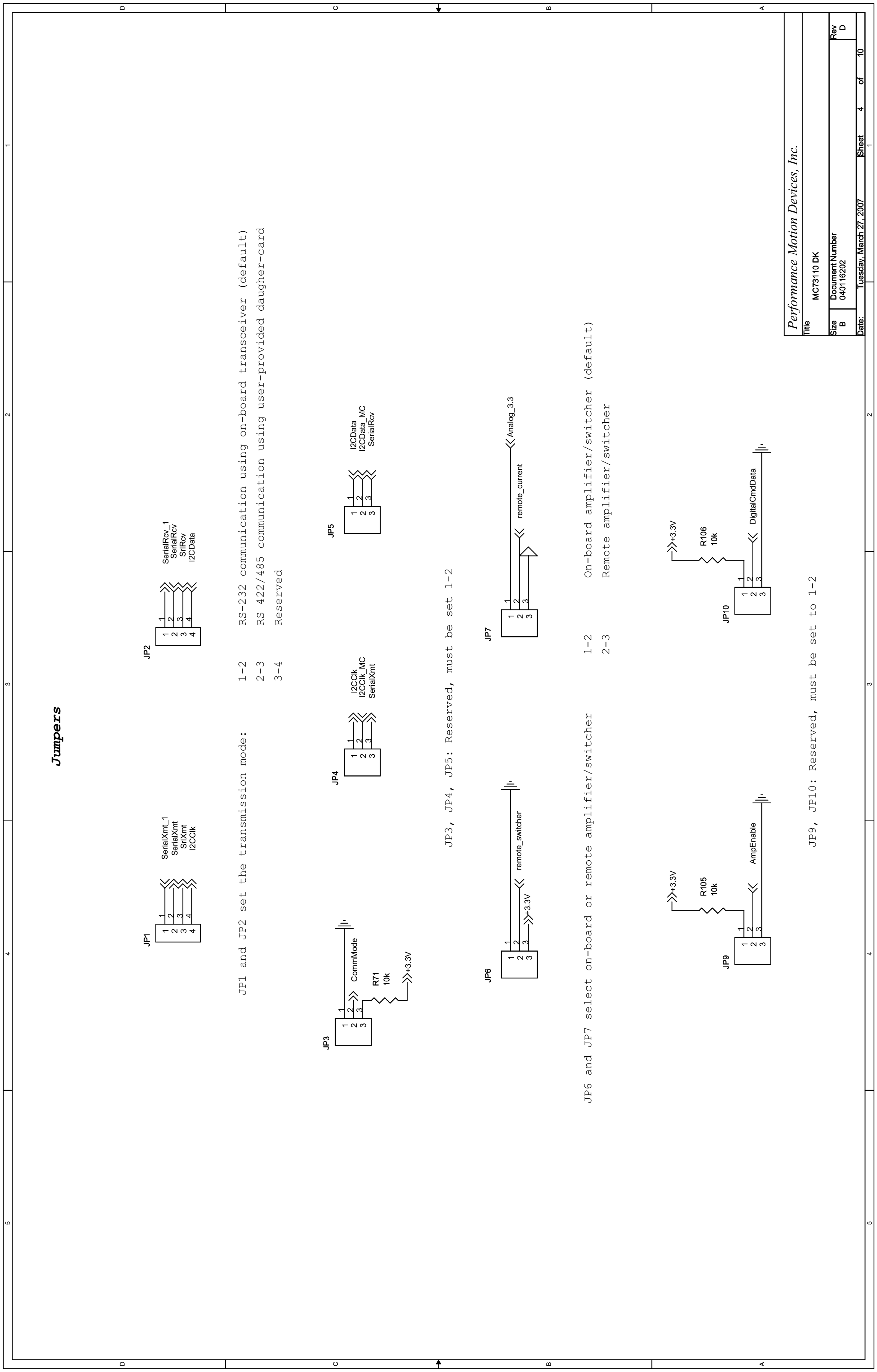


Figure 6-5: Jumpers

Figure 6-6

This schematic includes an on-board temperature sensor and an optional EEPROM. The MC73110 communicates with both parts via the I^2C bus. This schematic also includes an on-board RS-232 line driver/receiver.

U5, TMP 100, is a digital temperature sensor with an I^2C bus interface. It is located on the bottom of the DK board, and is near the three-phase inverter. Thus, the MC73110 can monitor the temperature of the power train by communicating with TMP 100.

U6, 24LC256, is an EEPROM with an I^2C bus interface. It is optional, and only an 8-pin DIP socket is provided on the DK board. The EEPROM is plugged into the socket when used.

The I^2C bus address of U5 and U6 have been hardwired as 1001000 and 1010000, respectively.

R41~R46 are protection resistors against voltage spikes on the I^2C bus. R39 and R40 are pull-up resistors. The resistance of the series resistors has an upper limit, while the resistance of the pull-up resistors has a lower limit. The selection of these resistors depends on the supply voltage, load capacitance, and specific components. Please refer to I^2C bus specifications for the components you are using.

If additional I^2C bus devices are attached to the DK board through the remote switcher connectors, then the following conditions apply.

1. The additional I^2C bus devices cannot use addresses 1001000 and 1010000.
2. The attached I^2C bus should not have pull-up resistors. However, should additional resistors be used, their impedance must be higher than 4K.
3. The load capacitance must be confirmed if there are more than two additional I^2C bus devices attached.
4. The I^2C bus voltage is 3.3V on the DK board. If devices utilizing different voltages are attached, voltage shift circuit may be necessary.

U34, MAX3232, is a RS-232 line driver/receiver. It is powered by 3.3V

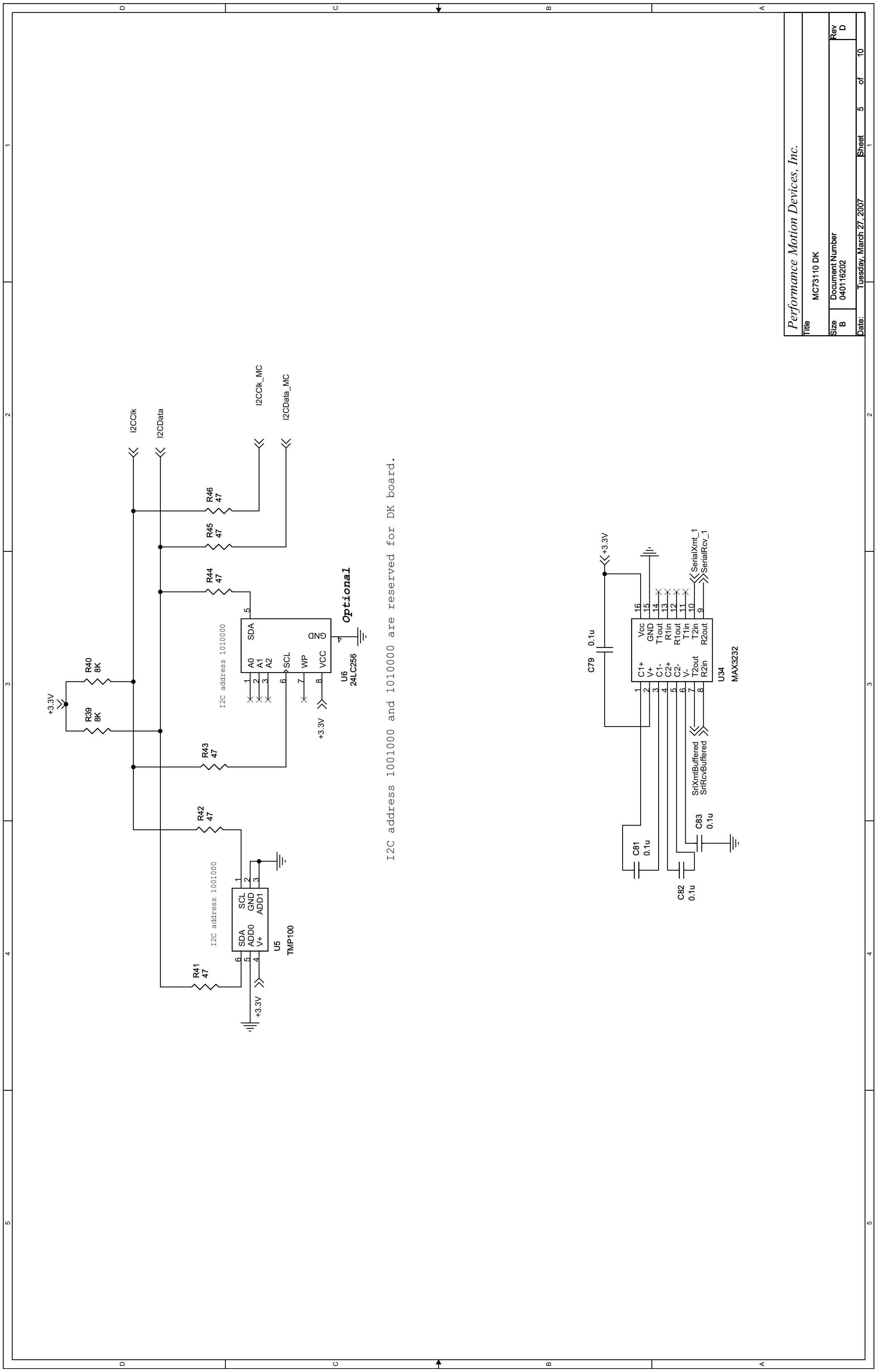


Figure 6-6: Communication ports

Figure 6-7

This schematic shows the power train, which includes the pre-driver and a three-phase inverter.

U7~U12, IRF540, are N-channel MOSFETs with a voltage rating of 100V. They are configured as a three-phase inverter. The MOSFETs switch on and off, based on PWM commands of the MC73110.

Switching the MOSFETs requires that the gate driving signals have enough current sourcing and sinking capacity. In many cases, a pre-driver is needed as a buffer between the MC73110 and the three-phase inverter.

U13, IR2133S, is an integrated pre-driver. It accepts logic PWM signals directly from the MC73110. The pre-driver is configured as a six-signal mode, and its MOSFET drive outputs have high current sourcing and sinking capacity.

C20~C22 are bootstrap capacitors, which are used by the pre-driver to turn on U7~U9. The value of the bootstrap capacitors depends on the gate charge of the MOSFET/IGBT and the PWM frequency. Please refer to the manufacturer's datasheet of the pre-driver for design guidelines. R62 is used to limit the charging current to the bootstrap capacitors.

R48~R50 and R55~R57 are used to limit the gate driving currents, and to damp the gate driving signals. The MC73110 provides a dead-time option on the PWM commands to prevent shooting-through. Therefore, no hardware dead-time circuit is used on the DK board.

D3~D5 are not used on the DK board. These diodes, together with R54, R58, and R60, are optional to improve the immunity to ground spikes. Ground spikes are due to parasitic parameters on the three-phase inverter, and can be effectively limited by proper layout.

R61 is a current sensing resistor, and the voltage drop on R61 is proportional to the low-side current of the power rail. R67, R68, and C26 are low-pass filters and voltage dividers. Therefore, the current trip pin of U13 (ITRIP) monitors low-side current. Too high a current (~55 Amps) will trigger the protection circuit in U13 and then shut down the inverter. When this happens, /Fault of U13 is asserted logic low.

R61 can detect current fault conditions such as shoot-through, and line-to-line short. However, it cannot detect ground fault, since the motor coil is shorted directly to the ground.

R47 is the high-side current sensing resistor. It can detect current faults, including ground fault. However, the voltage signals on both sides of R47 have large common-mode components, and the signal conditioning circuit must have good common-mode rejection performance. For additional details, see Figure 6-11.

R52 and R53 are motor coil current sensing resistors and have four-wire connections. A two-end current sensing resistor may also be used. The voltage signal on both sides of the current sensing resistors have large and fast changing common-mode components, and special attention should be given to designing signal conditioning circuits. Examples of these circuits are shown in Figure 6-8.

C19 is a bulk capacitor which is used to attenuate the voltage ripple on the power bus. The user may need additional external capacitors to meet his or her specific requirements on voltage ripple or regenerated power absorption on the power rail.

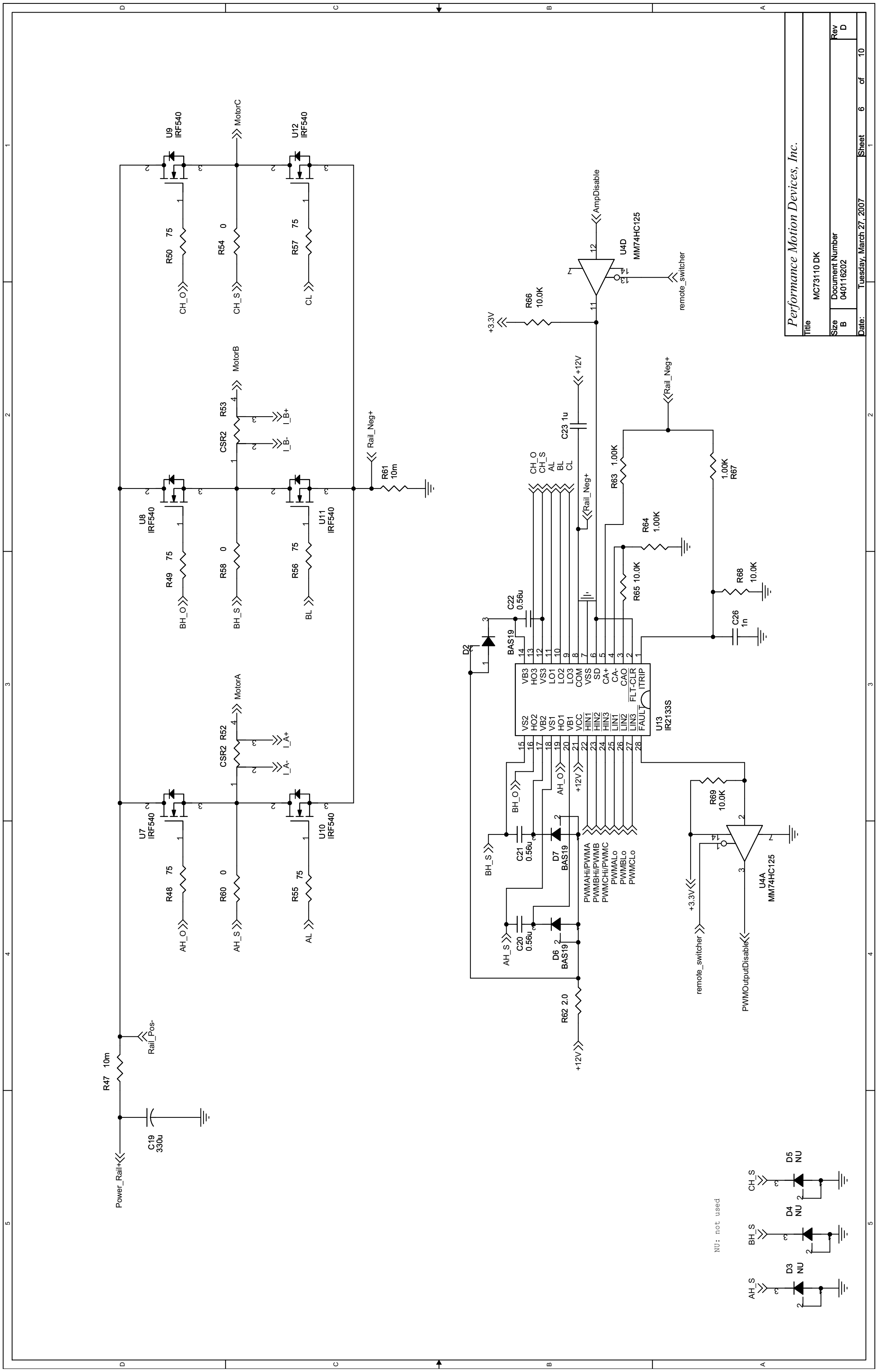


Figure 6-7: Power train

Figure 6-8

This schematic shows the motor coil current sensing circuits. It includes isolation amplifiers and low-pass active filters.

The DK board uses series resistors (R52 and R53 in Figure 6-7) to sense coil current. The instantaneous coil currents are proportional to the voltage drop on the resistors. However, the voltage on both ends of the resistor have large and fast-changing common-mode components, which is several orders larger than the useful voltage drop signal. Isolation amplifiers are used on the DK board to reject the common-mode signal.

U20, U21, and U22A act as the signal conditioning circuit for current signal of motor coil A.

U20, HCPL 7800, is an isolation amplifier. Its high side is powered by a 5V floating voltage (5_f_1+, 5_f_1-), and its low side is power by a 5V analog voltage. R78 and C50 is an anti-aliasing filter of the on-chip sampling circuit. U20 has differential output, which is suitable for noisy industrial environments.

U21, AD623, is an instrumentation amplifier. It converts and scales the differential signals from U20 to a single-ended signal. R81 is the gain resistor. The output has a DC bias of 1.65V, which corresponds to the zero output of the MC73110's internal ADC.

Therefore, the output of U21 is determined as:

R52*Gain(U20)*Gain(U21)*I+1.65=10m*8*1.75*I+1.65=0.14*I+1.65 V

where I is the current in motor coil A, which is positive when input to the motor.

U22, TLV2473, is a dual rail-to-rail op amp. It is referenced to the analog ground, and powered by a 3.3V analog supply (*Analog_3.3*). Details on the analog power supply are in Figure 6-10.

U22A, TLV2473, is a second-order low-pass filter with unity gain and a cutoff frequency of 7.5 KHz. It is configured as a Bessel filter due to the advantages on group delay. U22 can be shut off by *remote_current* (see JP7 in Figure 6-5) when a remote switcher is used. The output of U22A is high-impedance when *remote_current* is pulled down to the ground.

U24, U25, and U22B act as the signal conditioning circuit for motor coil B current sensing, and it is symmetric to that of the coil A current sensing.

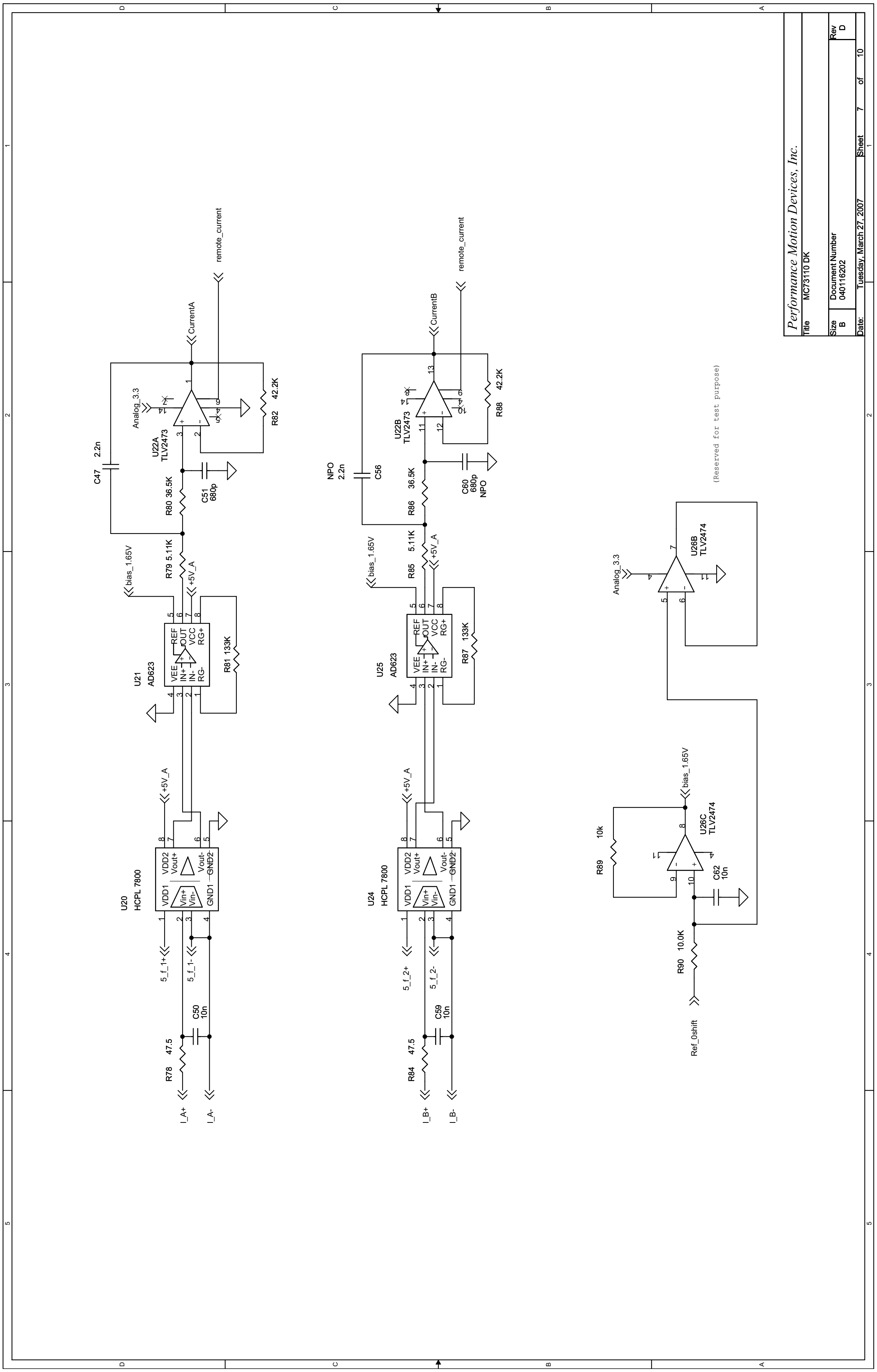


Figure 6-8: Current-sensing circuits

Figure 6-9

This schematic shows the on-board digital power supply. It provides regulated outputs of +12V, +5V, +3.3V, and two floating +5V outputs. This schematic also includes the reset circuitry.

U29, PK5611SI, is an isolated DC-DC converter with input range of 18V~72V and output voltage of 5V. It converts the bus voltage (J1 inFigure 6-4) to 5V, and in turn, powers the components on the DK board. The input ground and output ground are electrically connected. However, the input ground is the power ground and the output ground is the signal ground. During layout, they should be connected at one point in order to ensure the highest signal quality.

U27, TPS76833S, is a low-dropout voltage regulator with an output voltage of 3.3V. It is the digital power supply for MC73110. TPS76833S has a power good output (PG), which can be used for under-voltage protection.

U31, DCP010515B, is an unregulated isolated DC-DC converter with 5V input and 15V nominal output. Its output is passed through the linear regulator (U32) to obtain a regulated 12V. The regulated 12V is used to drive the MOSFET pre-driver.

U28, DCP010512B, is an unregulated isolated DC-DC converter with 5V input and 12V nominal output. The linear regulator (U19, 78L05), uses the isolated voltage to generate a regulated floating 5V. The floating voltage (5_f_1+,5_f_1-) is used to power the high side of the isolation amplifier U20 in Figure 6-8. R77 is a small resistor in order to improve the noise performance of the output voltage.

Similarly, U23 and U30 generate the 5V floating voltage (5_f_2+, 5_f_2-), which powers the high side of the isolation amplifier (U24) in Figure 6-8.

D11 and D12 are the on-board indicator LEDs. R91 and R92 are their current limit resistors.

SW1 is a reset button. The DK board has two reset sources. Pushing SW1 will pull the reset signal to ground, and then reset the MC73110.

Another reset signal is from power good (PG) of the 3.3V voltage regulator (U27). U27 monitors its own output voltage. PG will pull down to ground, and then reset the MC73110 when the output voltage falls below a pre-specified range.

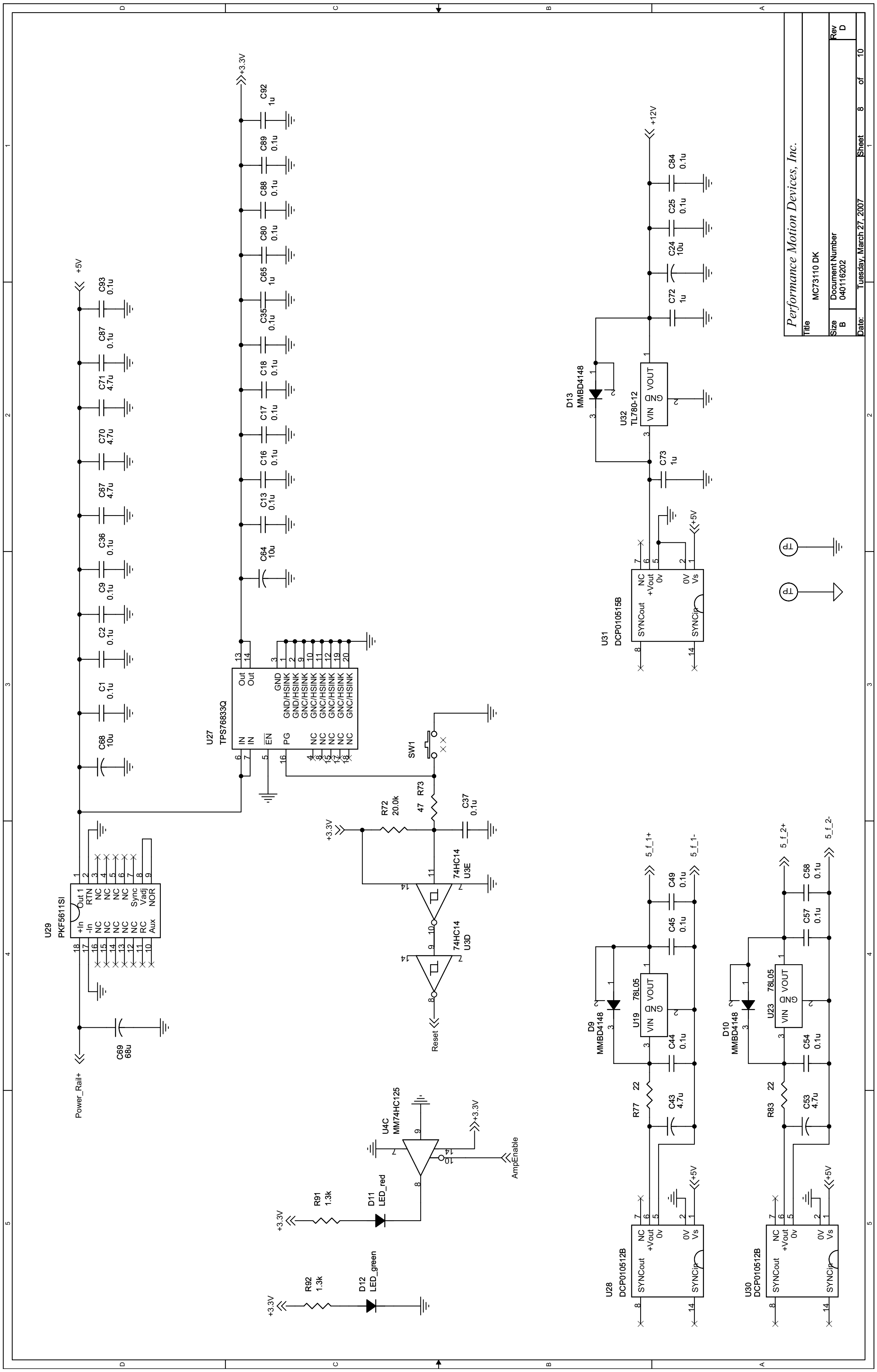


Figure 6-9: On-board power supply

Figure 6-10

This schematic shows the on-board analog power supply. It provides regulated outputs of +12V, +5V, and two +3.3V outputs.

The analog power is derived from the digital power supply (see Figure 6-9). The analog power ground and the digital power ground are AC isolated by an inductor (L4) in order to provide a low noise floor for the analog circuits.

L5, with C28, is a LC filter to keep the noise on 5V digital voltage (*+5V*) from the 5V analog voltage (*+5V_A*). Similarly, L6 and C75 are a LC filter, and derive +12V analog voltage (*+12V_A*) from the digital voltage (*+12V*).

U14 with Q1 provides a 3.3V supply with tight tolerance and high current driving capacity. U14 sets the output voltage point, and output current mainly goes through Q1. C29 is optional and is not used.

U16 provides another 3.3V analog voltage to the analog components on the DK board.

NOTE: In order to obtain the highest performance, it is recommended that a separated analog power and ground plane is used in customer design. However, this separate analog power supply can be implemented in different ways, each of which will involve different costs and performance tradeoffs. This page provides three options. The scheme with U14 and Q1 provides the best accuracy, but carries the highest cost. Alternatively, analog 3.3V may also be derived from the digital 3.3V with an LC filter, in order to derive analog 5V and 12V. It is a low-cost option with some compromises in accuracy. The scheme with U16 involves both moderate cost and accuracy.

U15, INA132, is a difference amplifier. It is configured as a voltage divider, and generates DC 1.65V. This corresponds to the zero output of the MC73110's internal ADC.

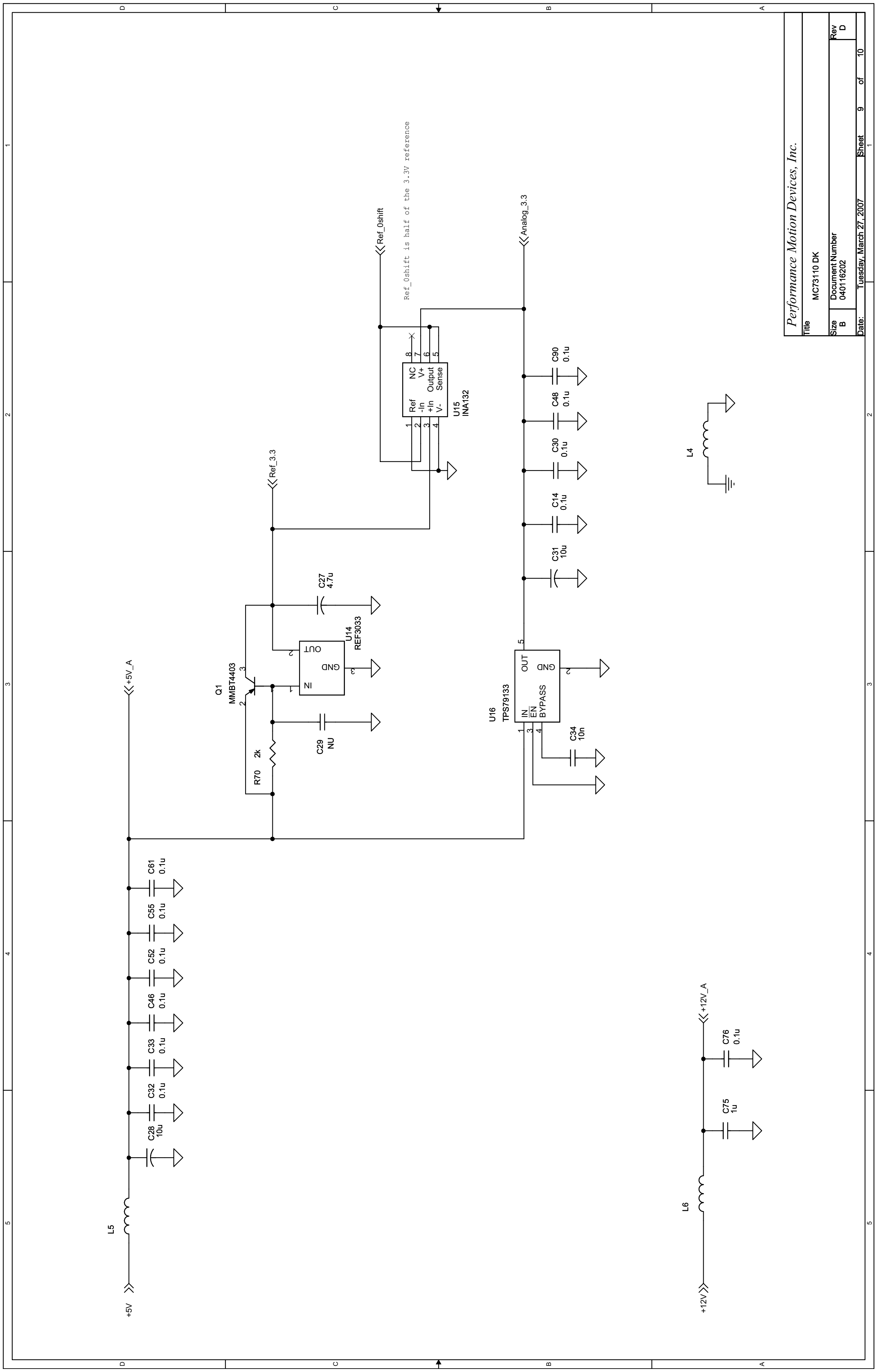


Figure 6-10: Analog power supply

Figure 6-11

This schematic shows some auxiliary circuits. It includes high-side current monitoring and input voltage monitoring conditioning circuitry.

High-side current monitoring

R47 in Figure 6-7 is the high-side current sensing resistors. Its voltage drop may be used to monitor input current and to detect current fault, including ground fault. However, the voltage on both ends of R47 is large and includes large common-mode components, which is much larger than the useful voltage drop.

U33 and U26A are the high-side current monitoring circuits, and are capable of rejecting the large common-mode signals.

U33, INA148, is a difference amplifier with high common-mode voltage rating. Its output is proportional to the voltage difference between its inputs (+In, -In), which is the voltage drop on the current sensing resistor R47.

U26, TLV2474, is a quad rail-to-rail op amp. It is powered by the 3.3V analog power supply, and is referenced to the analog ground.

U26A is a first-order low-pass filter with a gain of 10 and a cutoff frequency of 16 KHz.

U26D is a voltage follower with an output of 1.65V. This corresponds to zero output of MC73110's internal ADC.

Input voltage monitoring

Motor drivers sometimes need to monitor the bus voltage. The pre-set protection scheme, such as auto shutdown, is executed when an over-voltage or under-voltage condition occurs.

Resistor R51 and R59 scale the bus voltage to the MC73110's internal ADC input range, which is 0~3.3V on the DK board. C42, in conjunction with the resistors, works as a low-pass filter and rejects noise and voltage spikes to prevent fake detection.

D8 is a protection diode against over-voltage: if the *BusVoltage* signal is much higher than 3.3V, D8 will conduct and hold the signal around 3.3V.

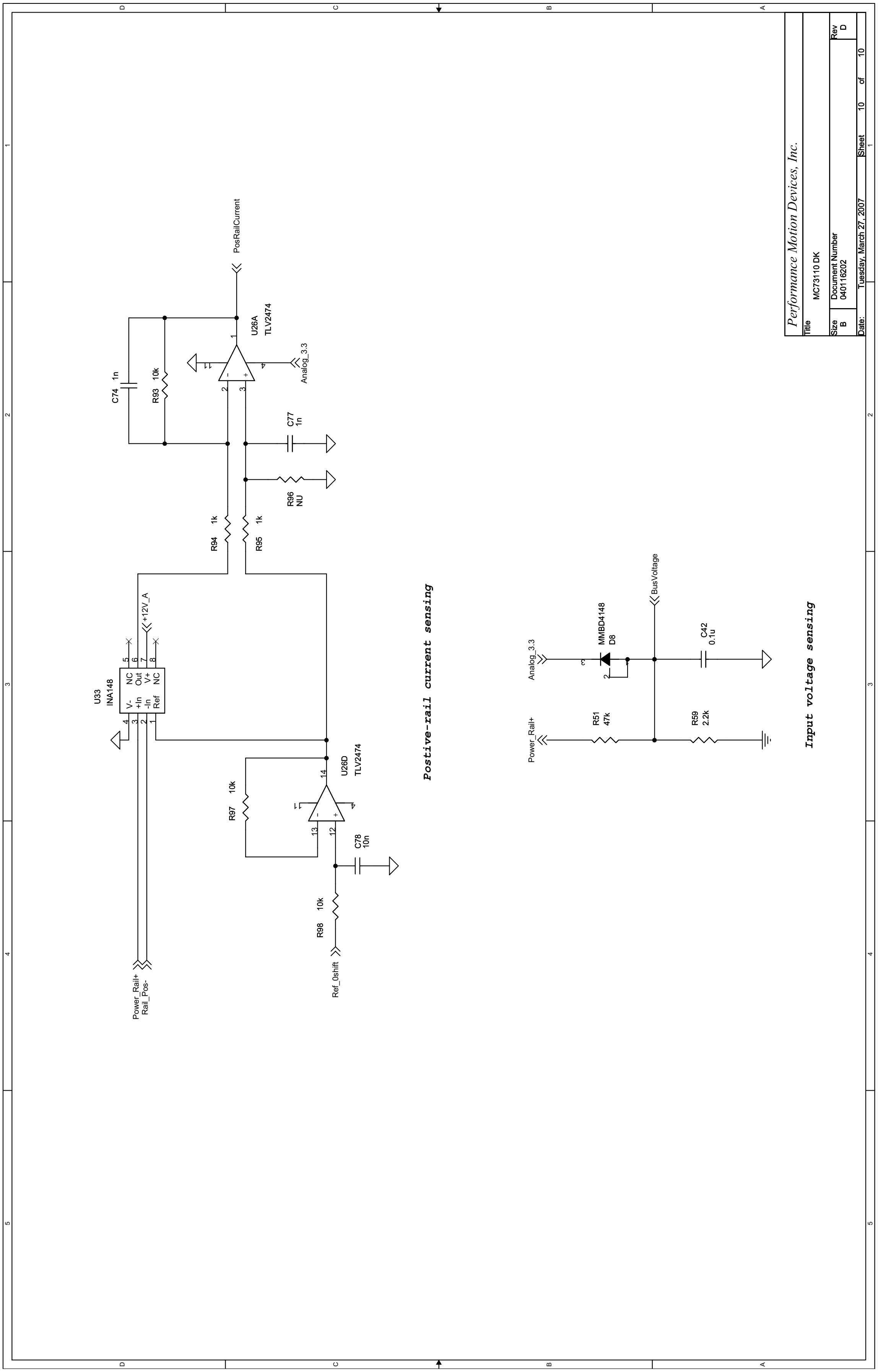


Figure 6-11: Auxiliary circuits

6.3 System Design Using the MC73110

The MC73110 is a mixed-signal microcontroller, including both digital signals and analog signals. Furthermore, the MC73110 is used to control motors, and such a system usually involves high voltage and/or current power. Therefore, the designers should be careful in system design in order to achieve MC73110's specified performance.

This section will present some basic design considerations.

There are at least three ground references on the system design: digital ground, analog ground, and power ground for the power train. These three grounds must be connected at one point during layout. In some instances, the grounds may be AC isolated. For example, the DK board also uses inductor L4 (Figure 6-10) to isolate the digital ground and analog ground.

Meanwhile, ensure that there is enough capacitance between Vcc and GND of the MC73110 to maintain nominal supply voltage, and to reject perturbations. It is recommended that six 0.01uF~0.1uF ceramic capacitors be used. One end of these decoupling capacitors should be placed close to the Vcc pins, and the other end should be connected to the digital ground plane.

The following suggestions should be observed in order to reduce EMI generation.

1 Place R75 close to pin 24, ClockIn.

2 Place clock U18 close to the MC73110.

3 Place the series ferrite beads for OscVcc and PLLVcc close to their respective pin.

4 Place the three parts of PLL filter (R76, C38, and C39) close to each other, close to pins 37 and 38 of the MC73110, and keep the traces between them as short as possible.

The MC73110 features internal analog circuitry and 10-bit ADC. The reference high voltage may range between 2.0V to AnalogVcc; in other words, between 2.0V and 3.3V. However, as the reference voltage decreases, the analog voltage corresponding to the LSB of the ADC also diminishes. As a result, the noise on the ADC might approach 1 LSB, which could distort the result as the reference voltage decreases. Therefore, noise issues such as ground bounce should be taken into account when choosing the design's high voltage reference.

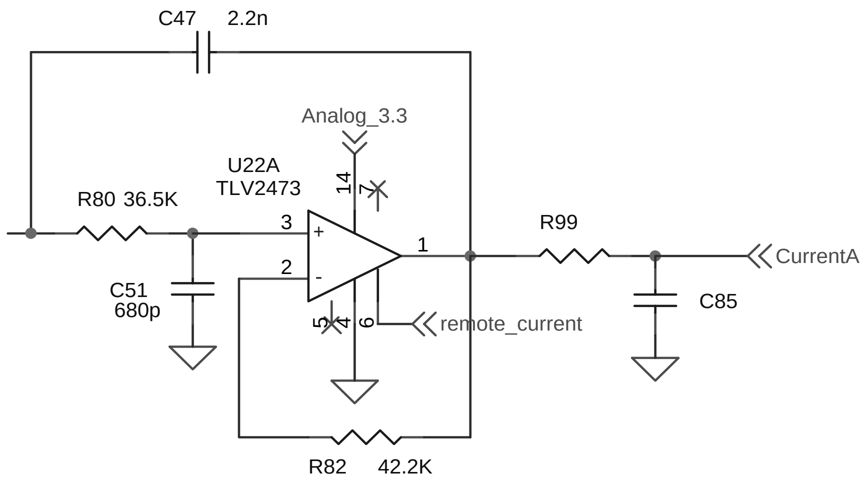
The nominal value of the reference high voltage is 3.3V, and the difference between Vcc and AnalogVcc must be lower than 0.3V.

Please note that the ADC has single-ended inputs and that output 0 (zero) corresponds to the middle of the reference voltages. The designer has to shift and scale the raw signal to fit the ADC. For example, the DK board uses 3.3V as reference high voltage, 0V as reference low voltage, and then 1.65V as the DC shift. Meanwhile, when scaling the raw signals, the designer should include enough upper and lower safety margins for the signal swing.

The maximum output impedance of the analog input is 700 ohms. In order to obtain the specified performance, the signal conditioning circuits, usually op-amps, should have an output impedance less than 700 ohms.

If the signal conditioning circuit cannot meet the design requirements, the circuit in the following example may be an effective solution.

Figure 6-12: Alternate signal conditioning circuit



This circuit features a small resistor (R99), and a small capacitor (C85) between the signal paths. The R-C should be placed close to the input pin of the ADC, which improves the effective impedance seen by the ADC. Additionally, it also works as an anti-aliasing filter.

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For additional information, or for technical assistance, please contact PMD at (978) 266-1210.

You may also e-mail your request to support@pmdcorp.com

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