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dsPICDEM™ MCHV-3 Development Board User's Guide

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Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

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EU Declaration of Conformity
Object of Declaration: dsPICDEM™ MCHV-3 Development Board

Manufacturer: Microchip Technology Inc.
2355 W. Chandler Blvd.
Chandler, Arizona, 85224-6199
USA

This declaration of conformity is issued by the manufacturer.

The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not intended to be a finished appliance, nor is it intended for incorporation into finished appliances that are made commercially available as single functional units to end users. This development/evaluation tool complies with EU EMC Directive 2004/108/EC and as supported by the European Commission's Guide for the EMC Directive 2004/108/EC (8th February 2010).

This development/evaluation tool complies with EU RoHS2 Directive 2011/65/EU.

This development/evaluation tool, when incorporating wireless and radio-telecom functionality, is in compliance with the essential requirement and other relevant provisions of the R&TTE Directive 1999/5/EC and the FCC rules as stated in the declaration of conformity provided in the module datasheet and the module product page available at www.microchip.com.

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Signed for and on behalf of Microchip Technology Inc. at Chandler, Arizona, USA

Derek Carlson
VP Development Tools

12-Sep-14
Date

NOTES:

Safety Notice

To avoid a safety hazard, the safety notices and operating instructions provided should be adhered to. If in any doubt, consult your supplier.

WARNING – This system must be earthed (grounded) at all times.

WARNING – The output terminals are NOT isolated from the incoming AC mains supply and may be at up to 410V with respect to ground, regardless of the input mains supply voltage applied. These terminals are live during operation AND for five minutes after disconnection from the supply. Do not attempt to access the terminals or remove the cover during this time.

WARNING – The unit may obtain power through the output terminals if these are connected to a rotating motor acting as a generator. If this is the case, then the previous warning also applies (i.e., the output terminals are live when connected to the generator and for five minutes after the generator has been stopped). Note that this case can arise even when the unit has been disconnected from the incoming AC mains supply.

CAUTION – The system should not be installed, operated, serviced or modified except by qualified personnel who understand the danger of electric shock hazards and have read and understood the user instructions. Any service or modification performed by the user is done at the user's own risk and voids all warranties.

CAUTION – If a motor is connected to the output of this unit, the frame should be connected to the output protective ground terminal provided. Particular care should be taken to mechanically guard such a motor, bearing in mind that unexpected behavior is likely to result from the process of code development.

CAUTION – For continued protection against the risk of fire, replace the fuse with one of the same type only (i.e., Fast Act Fuse 15A/250V).

- The system is intended for evaluation and development purposes, and should only be operated in a normal laboratory environment, as defined by IEC 61010-1:2001.
- Clean with a dry cloth only.
- Operate flat on a bench; do not move during operation and do not block the ventilation holes.
- The system should not be operated without all the supplied covers fully secured in place.
- The system should not be connected or operated if there is any apparent damage to the unit.
- The unit is designed to be connected to the AC mains supply via a standard non-locking plug. As the unit has no mains switch, this plug constitutes the means of disconnection from the supply, and thus, the user must have unobstructed access to this plug during operation.

NOTES:

dsPICDEM™ MCHV-3 DEVELOPMENT BOARD USER'S GUIDE

Table of Contents

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Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXXXXA", where "XXXXXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.

INTRODUCTION

This preface contains general information that will be useful to know before using the dsPICDEM™ MCHV-3 Development Board. Topics discussed in this preface include:

- Document Layout
- Conventions Used in this Guide
- Warranty Registration
- Recommended Reading
- The Microchip Web Site
- Development Systems Customer Change Notification Service
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This user's guide describes how to use the dsPICDEM™ MCHV-3 Development Board. The document is organized as follows:

- **Chapter 1. "Introduction"** – This chapter introduces the dsPICDEM™ MCHV-3 Development Board and provides a brief overview of its features.
- **Chapter 2. "Getting Started"** – This chapter provides information on getting started with the dsPICDEM™ MCHV-3 Development Board.
- **Chapter 3. "Hardware"** – This chapter describes the hardware on the dsPICDEM™ MCHV-3 Development Board.
- **Appendix A. "Board Layout and Schematics"** – This appendix provides diagrams of the hardware layout, as well as schematic diagrams for the dsPICDEM™ MCHV-3 Development Board.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly braces and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

WARRANTY REGISTRATION

Please complete the enclosed Warranty Registration Card and mail it promptly. Sending in the Warranty Registration Card entitles users to receive new product updates. Interim software releases are available at the Microchip web site.

RECOMMENDED READING

This user's guide describes how to use the dsPICDEM™ MCHV-3 Development Board. The device-specific data sheets contain current information on programming the specific microcontroller or Digital Signal Controller (DSC) devices. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources:

MPLAB® XC16 C Compiler User's Guide (DS50002071)

This user's guide describes how to use the 16-bit MPLAB® XC16 C compiler. Please visit www.microchip.com/compilers for more information.

MPLAB® IDE User's Guide with MPLAB Editor and MPLAB SIM (DS51519)

This user's guide describes how to set up the MPLAB® IDE software and use it to create projects and program devices.

MPLAB® X IDE User's Guide (DS50002027)

This document describes how to set up the MPLAB® X IDE software and use it to create projects and program devices.

MPLAB® XC16 Assembler, Linker and Utilities User's Guide (DS50002106)

This user's guide describes how to use GNU language tools to write code for 16-bit applications.

Readme Files

For the latest information on using other tools, read the tool-specific Readme files in the Readme subdirectory of the MPLAB® IDE installation directory. The Readme files contain updated information and known issues that may not be included in this user's guide.

dsPIC33EP256MC506 Plug-In Module (PIM) Information Sheet for Internal Op Amp Configuration (DS52062)

This document provides device-specific information for the dsPIC33EP256MC506 internal op amp configuration PIM.

To obtain any of these documents, visit the Microchip web site at www.microchip.com.

THE MICROCHIP WEB SITE

Microchip provides online support via our web site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

DEVELOPMENT SYSTEMS CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at www.microchip.com, click on Customer Change Notification and follow the registration instructions.

The Development Systems product group categories are:

- **Compilers** – The latest information on Microchip C compilers and other language tools. These include the MPLAB® C compiler; MPASM™ and MPLAB 16-bit assemblers; MPLINK™ and MPLAB 16-bit object linkers; and MPLIB™ and MPLAB 16-bit object librarians.
- **Emulators** – The latest information on the Microchip MPLAB REAL ICE™ in-circuit emulator.
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debugger, MPLAB ICD 3.
- **MPLAB IDE** – The latest information on Microchip MPLAB IDE, the Windows® Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB SIM simulator, MPLAB IDE Project Manager, and general editing and debugging features.
- **Programmers** – The latest information on Microchip programmers. These include the MPLAB PM3 device programmer and the PICkit™ 3 development programmers.

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or FAE for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at: http://support.microchip.com

DOCUMENT REVISION HISTORY

Revision A (June 2016)

This is the initial released version of the document.

NOTES:

Chapter 1. Introduction

1.1 OVERVIEW

The Microchip dsPICDEM™ MCHV-3 Development Board is intended to aid the user in the rapid evaluation and development of a wide variety of motor control applications using PIC32 and PIC24 Microcontrollers (MCUs), and dsPIC® Digital Signal Controllers (DSCs). This development system is targeted to control Brushless DC (BLDC) motors, Permanent Magnet Synchronous Motors (PMSM) and AC Induction Motors (ACIM) in sensor or sensorless operation.

This flexible and cost-effective tool can be configured in different ways for use with Microchip's specialized motor control devices. The dsPICDEM™ MCHV-3 Development Board is essentially an upgraded version of the dsPICDEM MCHV Development System. The dsPICDEM™ MCHV-3 Development Board is designed to support the PIC24F, PIC24E, dsPIC33F, dsPIC33E and PIC32 Motor Control device families, and offers a mounting option to connect a generic 100-pin Plug-In Module (PIM).

The system has a three-phase power module device that contains the motor inverter and the gate driver's circuitry. The circuit drives a BLDC, PMSM or ACIM motor using different control techniques without requiring any additional hardware. It also has Power Factor Correction (PFC) circuitry in order to provide a full set of tools used in motor control applications. Figure 1-1 provides a photograph of the dsPICDEM MCHV-3. A block diagram that shows the main components of the system is provided in Figure 1-2.

The rated continuous output current from the inverter is 6.5A (RMS). This allows up to approximately 2 kVA output when running from a 208V to 230V single-phase input voltage in a maximum 30ºC (85ºF) ambient temperature environment. Therefore, the system is ideally suited for running a standard 3-phase induction motor of up to a 1 kW (1.34 HP) rating or a slightly higher rated industrial servo motor. The power module is capable of driving other types of motors and electrical loads that do not exceed the maximum power limit, and are predominantly inductive. Furthermore, single-phase loads can be driven using one or two of the inverter outputs.

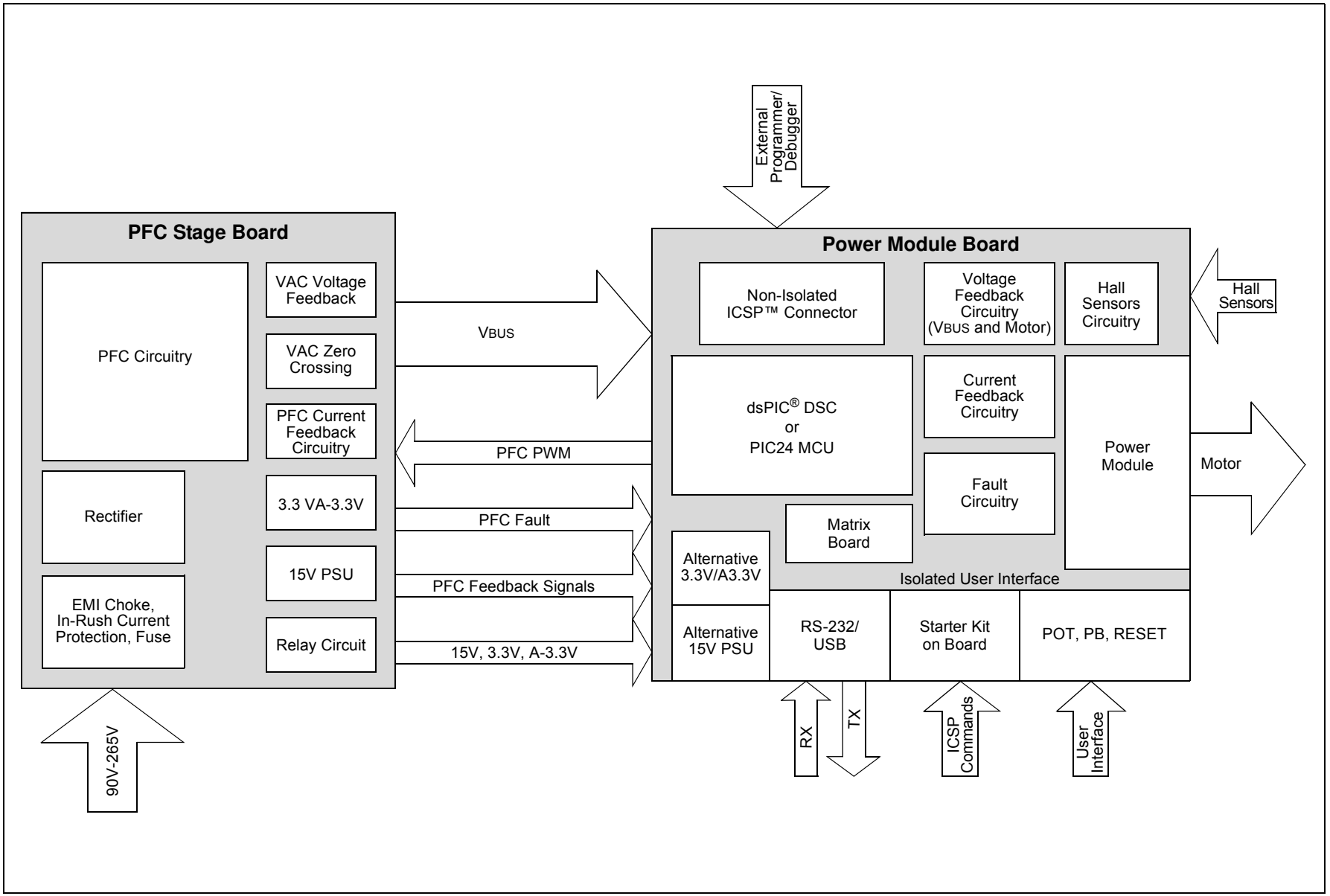
The unit is capable of operating from 90V, up to a maximum of 265V. A more detailed explanation of power limitations is provided in **Chapter 3. "Hardware"**.

> **Note:** It is recommended to carefully read **Chapter 3. "Hardware"** before attempting to use the system.

FIGURE 1-1: dsPICDEM™ MCHV-3 DEVELOPMENT BOARD

dsPICDEM™ MCHV-3 Development Board
(Part # DM330023-3)

FIGURE 1-2: SYSTEM BLOCK DIAGRAM



1.2 FEATURES

This section provides some of the key features of the dsPICDEM MCHV-3 Development Board.

1.2.1 Motor Control Interfaces:

- Three-phase inverter bridge with a power rating of 400V/6.5A (J17)
- Hall sensors/Quadrature Encoder Interface (QEI) for sensored motor control algorithms (J9)
- Phase voltage feedback for sensorless BLDC operation
- DC bus current sense resistor for single shunt vector control
- Phase current sense resistor for dual shunt vector control
- Overcurrent protection
- Support for Microchip MCUs/dsPIC DSCs with internal op amps and comparators

1.2.2 Input/Output:

- One isolated push button (S1)
- Isolated Reset push button (RESET)
- Isolated 10 kΩ potentiometer (POT1)
- LED indicators for PWM outputs
- Two LED indicators for debugging purposes (D2 and D19)

1.2.3 Isolated Communication Ports:

- UART communication via USB (J6)
- UART communication via RS-232 (J8)

1.2.4 Built-in Isolated Programmer/Debugger (J20):

- Starter Kit on-board programmer/debugger (daughter board)

1.2.5 Power Factor Corrector:

- Maximum input voltage: 90 VAC to 265 VAC
- Current feedback circuitry
- VAC input voltage sensing
- Zero-crossing detection
- DC bus sensing
- Overcurrent protection (the maximum power available is specified in **Section 3.3 "Electrical Specifications"**)

1.2.6 Built-in Power Supplies:

- 15V power supply, maximum power available: 11W
- 3.3V power supply, maximum power available: 2W

1.2.7 Relay Circuit:

- In parallel with inrush current limiter
- Turns on after inrush current minimizes

1.2.8 Additional Protection Circuitry:

- 250 VAC/15A fuse
- Inrush current limiter
- EMI filter

Chapter 2. Getting Started

2.1 BOARD COMPONENTS

The dsPICDEM™ MCHV-3 Development Board consists of two stages:

- PFC Stage

  The first stage is integrated by the Power Factor Correction (PFC) circuitry, the full-bridge rectifier, the 15V power supply, the 3.3V power supply and the relay circuit.
- Power Module Stage

  The second stage is the Power Module Board. This board contains the PIM connector, the isolated user interface connectors and the motor drive.

Figure 2-1 shows an interior view.

FIGURE 2-1: dsPICDEM™ MCHV-3 DEVELOPMENT BOARD ENCLOSURE VIEW

2.2 USER INTERFACE

The dsPICDEM MCHV-3 has the following components to interact with the user. Figure 2-2 shows a photograph of the front of the system.

- Input/Output Control Switches (Figure 2-2):
  - One isolated push button (S1)
  - Isolated Reset push button (RESET)
  - Isolated 10 kΩ potentiometer (POT1)
  - LED indicators for PWM outputs
  - Two LED indicators for debugging purposes (D2 and D19 on the Power Module Board; not shown in Figure 2-2)
- PWM Outputs (Figure 2-2):
  - Enable and disable jumpers (J7)
- Isolated Communication Ports (Figure 2-2):
  - UART communication via USB (J6)
  - UART communication via RS-232 (J8)
  - Communication ports selector (J2, J3)
- Built-in Isolated Programmer/Debugger (Figure 2-2):
  - Starter kit type programmer/debugger (J20)
- Motor Connectors (Figure 2-4):
  - Three-phase inverter bridge connector with a power rating of 400V/6.5A (J17)
  - Hall sensors/Quadrature Encoder Interface (QEI) for sensored motor control algorithms (J9)
  - Ground terminal with a power rating of 300V/30A
- Power Supply Connector (Figure 2-3):
  - AC power inlet specified for 250 VAC/10 amps max (J1)

FIGURE 2-2: dsPICDEM™ MCHV-3 DEVELOPMENT BOARD (FRONT)

FIGURE 2-3: dsPICDEM™ MCHV-3 DEVELOPMENT BOARD (LEFT SIDE)

FIGURE 2-4: dsPICDEM™ MCHV-3 DEVELOPMENT BOARD (RIGHT SIDE)

2.3 CONNECTING THE SYSTEM

CAUTION

The user must be aware of the operating procedures outlined below and ensure that they are followed. Failure to do so may result in damage to the system.

2.3.1 Power Connections

It is recommended that cables used for the power connections should be terminated with blue or red insulated crimp terminals. If crimp terminals are not used, care should be taken to ensure that stray strands of wire do not short to adjacent terminals or the enclosure. If possible, all wires should be stripped and tinned with solder before connecting to the dsPICDEM™ MCHV-3 Development Board terminals.

For the AC mains supply input, standard double-insulated, 3-core flex cable should be used with a minimum current rating of 10A (1 mm^2 18 AWG). A computer power cable can be used.

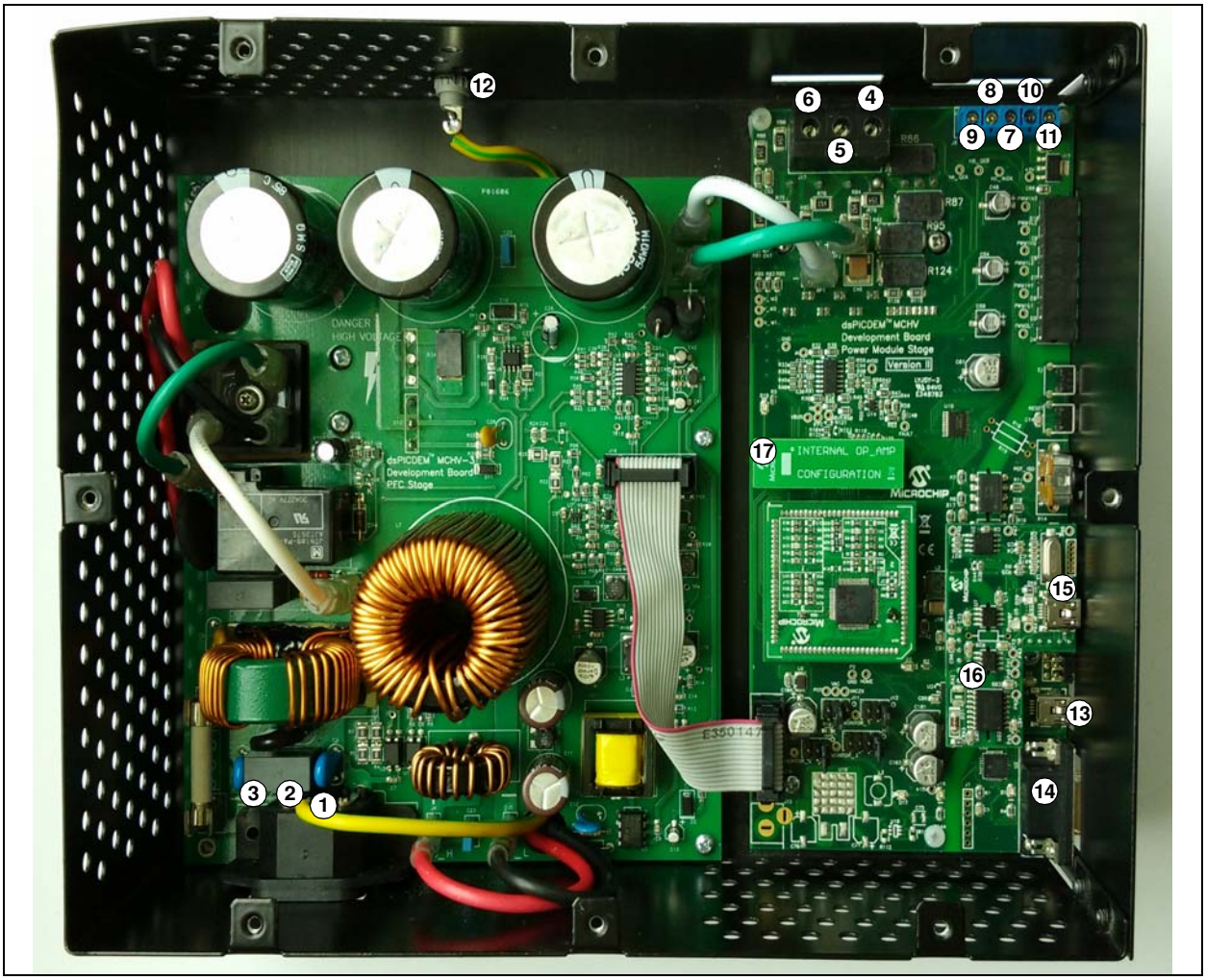
Note: The system is designed for Installation Category II. Therefore, the incoming mains cable should be wired into a standard non-locking 2-pin, in addition with an earth ground type plug.

The recommended output cable size is 1.0 to 1.5 mm^2 (18 AWG to 16 AWG) and it should have a 600V rating. This cable should also be double-insulated or have a protective ground screen. Access to the terminal screws is provided via holes in the lid of the enclosure. A slotted screwdriver should be used.

Note: The user should only access the power terminals when the system is fully discharged (see the **"Safety Notice"** section on page 5).

Figure 2-7 provides the locations of all connectors. Corresponding tables that describe each connection are provided in the relevant section.

FIGURE 2-5: dsPICDEM™ MCHV-3 DEVELOPMENT BOARD CONNECTIONS



The power connections are listed in Table 2-1.

TABLE 2-1: POWER CONNECTIONS

Number	Name	Type
1	Neutral	Input
2	Earth Ground	Input
3	Live (Fused)	Input
4	Motor Phase 1 (M1)	Output
5	Motor Phase 2 (M2)	Output
6	Motor Phase 3 (M3)	Output
7	Hall Sensor A (HA)	Input
8	Hall Sensor B (HB)	Input
9	Hall Sensor C (HC)	Input
10	Hall Sensors, 5V Power Supply Terminal	Output
11	Hall Sensors, Ground Terminal	Output
12	Motor Ground Terminal	Input

2.3.2 Host/Communication Connections

A mini-USB to USB certified cable or a standard DB9 male-to-female cable should be used to connect the dsPICDEM™ MCHV-3 Development Board to the host computer.

The communication port connectors are listed in Table 2-2. Refer to Figure 2-5 for their exact location.

TABLE 2-2: I/O CONNECTORS

Number	Name	Type
13	USB to UART Connector	Input/Output
14	RS-232 to UART Connector	Input/Output
15	USB Connector for the Starter Kit on the Board Programmer/Debugger	Input/Output
16	Non-Isolated ICSP™ Connector for Device Programming/Debugging	Input/Output
17	Matrix Board	Input/Output

2.3.3 Connection Sequence

The recommended connection sequence is listed below. The user should ensure that the following sequence is met before connecting the system to the mains, the motor and the host computer.

Note: Before making any connection, verify that the system is not powered and it is fully discharged. The system is completed discharged when the red D13 LED is off.

1. Connect the motor terminals, R, Y and B (also known as RWB, or 123 or ABC), to the connection nodes, M1, M2 and M3 (4, 5 and 6 in Figure 2-5), respectively, and connect the motor ground to the ground terminal provided on the board chassis.
2. Follow the next steps if position sensors are utilized to control the motor. If not, proceed to Step 3.
   a) If the motor position is sensed with Hall sensors, connect the Terminals A, B and C to the connection nodes, HA, HB and HC (7, 8 and 9 in Figure 2-5), respectively. Also, connect the positive terminal +5V to the connection node, +5V, and the ground terminal to the connection node, GND (10 and 11 in Figure 2-5).
   b) If the motor position is sensed with a Quadrature Encoder Interface, connect the terminals, Phase A, Phase B and index, to the connection nodes, HA, HB and HC (7, 8 and 9 in Figure 2-5), respectively.
3. Connect the communication ports.
   a) If RS-232 communication is used, connect the DB9 male connector to the RS-232 port. Connect the other end to the host PC (12 in Figure 2-5).
   b) If USB communication is used, connect the mini-USB male terminal to the mini-USB female connector, labeled "USB" (12 in Figure 2-5). Connect the other end to the host PC.

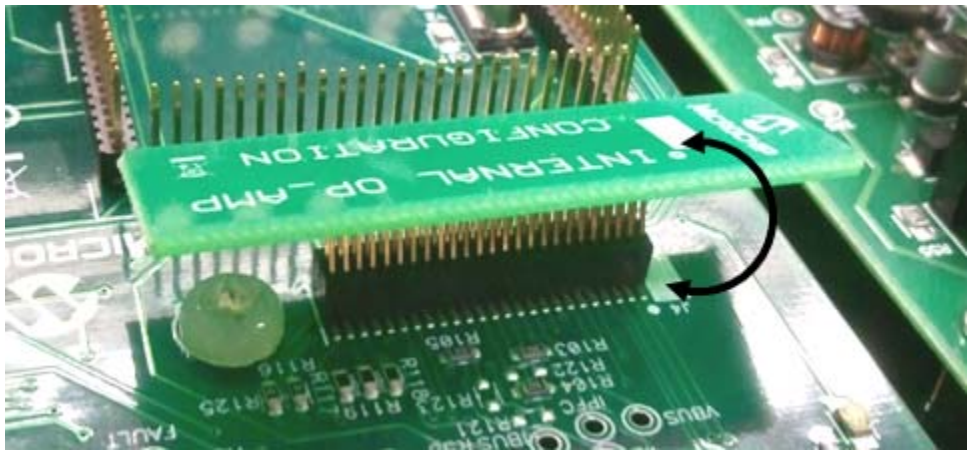
Note: The Microchip serial emulator driver (`mchpcdc.inf`) should be installed on your PC in order to activate the USB-to-serial emulator. The emulator can be obtained from the dsPICDEM™ MCHV-3 Development Board product page: http://www.microchip.com/mchv3

4. Connect the USB cable to the mini-USB female connector, labeled “Program/Debug” (14 in Figure 2-5). Connect the USB male terminal to the USB ports of the host PC.

Note: The built-in programmer/debugger is supported in MPLAB® X IDE.

5. Ensure that the appropriate matrix board is plugged into the connector, labeled J4, and that the board is oriented so that its pins are correctly lined up, as shown in Figure 2-6. Refer to **Section 3.2.5 “Matrix Board”** for more information regarding the matrix board.

FIGURE 2-6: MATRIX BOARD CONNECTION



6. Power cord connection. Make sure the power cord is disconnected from the AC mains before connecting the female terminal of the power cable to the AC input connector (1, 2 and 3 in Figure 2-5) of the dsPICDEM™ MCHV-3 Development Board.

Note: The unit is designed to be connected to the AC mains supply via a standard non-locking plug. As the unit has no mains switch, this plug constitutes the means of disconnection from the supply. Therefore, the user must have unobstructed access to this plug during operation.