



dsPICDEM™ MCLV-2 Development Board User's Guide

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

Trademarks

The Microchip name and logo, the Microchip logo, dsPIC, KEELOQ, KEELOQ logo, MPLAB, PIC, PICmicro, PICSTART, PIC³² logo, rfPIC and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MXDEV, MXLAB, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Application Maestro, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Omniclient Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICKit, PICtail, REAL ICE, rfLAB, Select Mode, Total Endurance, TSHARC, UniWinDriver, WiperLock and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2012, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

 Printed on recycled paper.

ISBN: 978-1-62076-293-6

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.

**QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
= ISO/TS 16949 =**

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

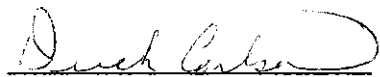
This declaration of conformity is issued by the manufacturer.

The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not a Finished Appliance, nor is it intended for incorporation into Finished Appliances that are made commercially available as single functional units to end users under 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.

For information regarding the exclusive, limited warranties applicable to Microchip products, please see Microchip's standard terms and conditions of sale, which are printed on our sales documentation and available at www.microchip.com.

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



Derek Carlson
VP Development Tools

07-Dec-11

Date

dsPICDEM™ MCLV-2 Development Board User's Guide

NOTES:



dsPICDEM™ MCLV-2 DEVELOPMENT BOARD USER'S GUIDE

Table of Contents

Preface	7
Chapter 1. Introduction	
1.1 Overview of the dsPICDEM MCLV-2 Development Board	13
1.2 Features Overview	14
Chapter 2. Hardware Overview	
2.1 PIM Configuration	18
2.2 Board Connectors	20
2.3 Selecting a Power Supply for the Development Board	24
2.4 User Interface Hardware	24
Chapter 3. Running a BLDC Motor Using a Sensorless Algorithm	
3.1 Operating Requirements	27
3.2 dsPICDEM MCLV-2 Development Board Setup	28
Appendix A. Schematics and Layout	41
Appendix B. Electrical Specifications	43
Worldwide Sales and Service	44

dsPICDEM™ MCLV-2 Development Board User's Guide

NOTES:



dsPICDEM™ MCLV-2 DEVELOPMENT BOARD USER'S GUIDE

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 “DSXXXXXA”, where “XXXXX” 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 chapter contains general information that will be useful to know before using the dsPICDEM™ MCLV-2 Development Board. Items discussed in this chapter 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™ MCLV-2 Development Board. The document is organized as follows:

- **Chapter 1. “Introduction”** – This chapter introduces the dsPICDEM™ MCLV-2 Development Board and provides an overview of various features.
- **Chapter 2. “Hardware Overview”** – This chapter describes the hardware components of the dsPICDEM™ MCLV-2 Development Board.
- **Chapter 3. “Running a BLDC Motor Using a Sensorless Algorithm”** – This chapter describes how to run a sensored BLDC motor using a dsPIC® DSC device.
- **Appendix A. “Schematics and Layout”** – This appendix provides detailed circuit schematics of the dsPICDEM™ MCLV-2 Development Board.
- **Appendix B. “Electrical Specifications”** – This appendix lists the DC input and output ratings for the dsPICDEM™ MCLV-2 Development Board.

dsPICDEM™ MCLV-2 Development Board User's Guide

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	<i>MPLAB® IDE User's Guide</i>
	Emphasized text	...is the <i>only</i> 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	<u><i>File>Save</i></u>
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	-0pa+, -0pa-
	Bit values	0, 1
	Constants	0xFF, 'A'
Italic Courier New	A variable argument	<i>file.o</i> , where <i>file</i> can be any valid filename
Square brackets []	Optional arguments	mcc18 [options] <i>file</i> [options]
Curly brackets 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 and mail the Warranty Registration Card that was enclosed with the development board. Sending in the registration card entitles you 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™ MCLV-2 Development Board. The device-specific data sheets contain current information on programming the specific microcontroller or digital signal controller devices. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources:

MPLAB® IDE Simulator, Editor User's Guide (DS51025)

This user's guide is a comprehensive guide that describes installation and features of Microchip's MPLAB Integrated Development Environment (IDE), as well as the editor and simulator functions in the MPLAB IDE environment.

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.

MPASM™ Assembler, MPLINK™ Object Linker, MPLIB™ Object Librarian User's Guide (DS33014)

This user's guide describes how to use the Microchip MPASM Assembler, the MPLINK Object Linker and the MPLIB Object Librarian.

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

This information sheet provides information specific to the dsPIC33EP256MC506 Internal Op amp Configuration Plug-In Module (PIM).

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 Field Application Engineer (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 2012)

This is the initial released version of this document.

NOTES:



dsPICDEM™ MCLV-2 DEVELOPMENT BOARD USER'S GUIDE

Chapter 1. Introduction

The dsPICDEM™ MCLV-2 Development Board is targeted to control a brushless DC (BLDC) motor or permanent magnet synchronous motor (PMSM) in sensor or sensorless operation. This flexible and cost-effective board can be configured in different ways for use with Microchip's specialized motor control Digital Signal Controllers (DSCs) and Microcontrollers (MCUs). The dsPICDEM MCLV-2 Development Board is essentially a backwardly-compatible upgraded version of the dsPICDEM MCLV Development Board.

The dsPICDEM MCLV-2 Development Board supports the dsPIC33F, PIC24F, dsPIC33E, and PIC24E motor control device families. It offers a mounting option to connect a generic 100-pin Plug-In Module (PIM). The board also has a three-phase inverter bridge circuit. The circuit drives a BLDC or PMSM motor using different control techniques without requiring any additional hardware. Topics covered include:

- [Overview of the dsPICDEM MCLV-2 Development Board](#)
- [Features Overview](#)

1.1 OVERVIEW OF THE dsPICDEM MCLV-2 DEVELOPMENT BOARD

[Figure 1-1](#) shows a simplified block diagram of the dsPICDEM MCLV-2 Development Board. The board includes various circuitry to perform the following functions:

- Drive a three-phase inverter that powers the motor phase windings
- Measure feedback signals (e.g., voltage and phase currents) and provide a suitable fault signal
- Interface with Hall sensor or quadrature encoder for sensor-based commutation
- Communicate with a host computer or an external device via CAN, LIN, USB, or RS-232 interface

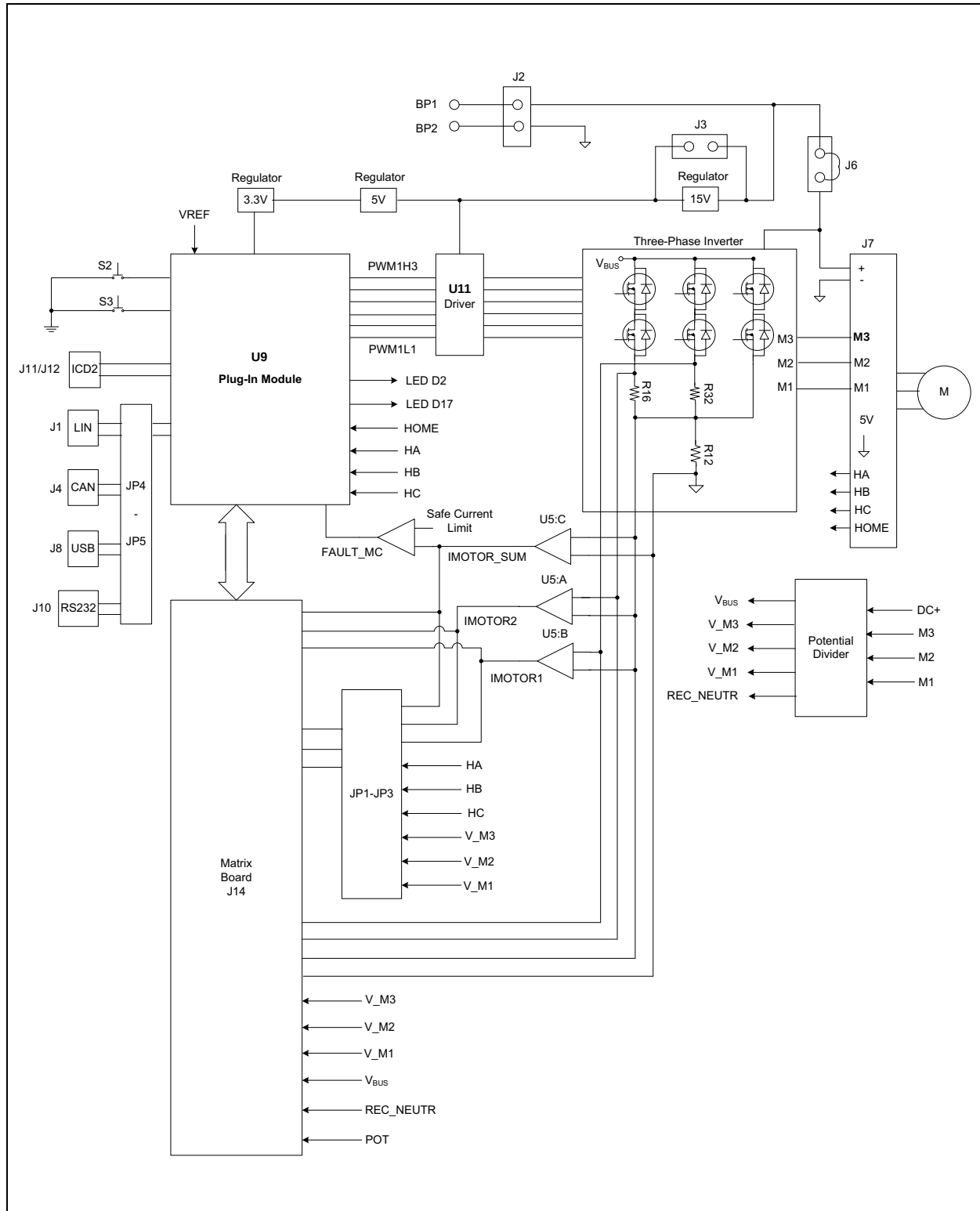
The development board supports motors with terminal voltage up to 48V and current up to 15A. Refer to [Appendix B. "Electrical Specifications"](#) for more information on electrical specifications.

1.2 FEATURES OVERVIEW

The key features of this board include the following:

- Motor Control Interfaces:
 - Three-phase inverter bridge with a power rating of 48V/15A
 - Hall sensors/quadrature encoder interface for sensored motor control (J7)
 - 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 PIC24 MCUs and dsPIC DSCs with internal or external op amps and comparators
- Input/Output Control Switches:
 - Two push-buttons (S2 and S3)
 - Two LED indicators for debugging purposes (D2 and D17)
 - Reset push-button (S1)
 - 10 kΩ potentiometer (POT1)
 - LED indicator for PWM outputs
- Communication Ports:
 - CAN interface port (J4)
 - LIN interface port (J1)
 - UART communication via USB (J8)
 - UART communication via RS-232 (J10)
- Power Supply Connectors:
 - Auxiliary Power Tab Fast-On connectors (BP1 and BP2) for the controller and power stage
 - 24V power input connector (J2) for the controller
 - Dedicated power connector (J7) for the power stage
- Programming Connectors:
 - ICSP™ connector for programming a dsPIC DSC or PIC24 MCU (J12)
 - RJ11 connector for programming a dsPIC DSC or PIC24 MCU (J11)
 - ICSP connector for programming the PIC18LF2450 USB to UART Bridge (J9)

FIGURE 1-1: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD BLOCK DIAGRAM



dsPICDEM™ MCLV-2 Development Board User's Guide

NOTES:



dsPICDEM™ MCLV-2 DEVELOPMENT BOARD USER'S GUIDE

Chapter 2. Hardware Overview

This chapter describes the hardware components of the dsPICDEM MCLV-2 Development Board. Topics covered include:

- [PIM Configuration](#)
- [Board Connectors](#)
- [User Interface Hardware](#)

Power for the control circuits and DC bus on the board is provided through a +24V power supply attached to the Power Connector terminal (J2) or the Auxiliary Power Tab Fast-On Connector terminals (BP1-BP2). The Microchip 24V Power Supply (AC002013) is recommended.

The various components on the board receive power as follows:

- The Gate drivers receive +15V power from a 15V regulator
- The CAN driver receives +5V power from a 5V regulator
- The LIN driver receives VBAT power from the LIN connector J1.
- A dsPIC DSC or PIC24 MCU motor control device receives +3.3V power from a +3.3V regulator
- The RS-232 UART interface receives +3.3V power from a +3.3V regulator
- The PIC18LF2450 USB to UART Bridge receives +3.3V power from a +3.3V regulator

Note 1: If the input voltage value is less than 16V, remove the 15V voltage regulator and short jumper J3.

- 2:** To use a higher DC voltage bus (24V-48V), complete the following steps:
- a) Connect the power supply to jumper J7, and keep jumper J6 open.
 - b) Power the circuit components, MCU, and the gate drivers using a separate 16V-24V power supply connected to the power connector J2 or BP1-BP2.

dsPICDEM™ MCLV-2 Development Board User's Guide

2.1 PIM CONFIGURATION

Table 2-1 summarizes the PIM pinout for the dsPICDEM MCLV-2 Development Board.

TABLE 2-1: dsPICDEM MCLV-2 DEVELOPMENT BOARD PIM PINOUT FUNCTIONALITY

PIM Pin #	Signal Name	Pinout Description	Routed via Matrix Board
1	DBG_LED2	Debug LED 2	No
2	VDD	N/A	No
3	PWM1H3	PWM Output - 3H	No
4	N/A	N/A	No
5	N/A	N/A	No
6	N/A	N/A	No
7	N/A	N/A	No
8	N/A	N/A	No
9	N/A	N/A	No
10	N/A	N/A	No
11	N/A	N/A	No
12	N/A	N/A	No
13	MCLR	Device Master Clear	No
14	N/A	N/A	No
15	VSS	N/A	No
16	VDD	N/A	No
17	N/A	N/A	No
18	FAULT	DC BUS Current Fault (active low logic)	No
19	TX	UART Transmit	No
20	PIM_V_M3	Voltage feedback signal	Yes
21	PIM_V_M2	Voltage feedback signal	Yes
22	PIM_V_M1	Voltage feedback signal	Yes
23	PIM_IMOTOR_SUM	DC bus current signal	Yes
24	PIM_IMOTOR2	Phase current signal	Yes
25	PIM_IMOTOR1	Phase current signal	Yes
26	PGC	Device programming clock line	No
27	PGD	Device programming data line	No
28	VREF	Reference voltage (half of AVDD voltage)	No
29	PIM_REC_NEUTR	Reconstructed motor neutral line voltage	Yes
30	AVDD	Analog supply	No
31	AVSS	Analog supply	No
32	PIM_POT	Potentiometer signal	Yes
33	N/A	N/A	No
34	PIM_GEN2	General I/O	Yes
35	PIM_VBUS	DC bus voltage (downscaled)	Yes
36	VSS	N/A	No
37	VDD	N/A	No
38	N/A	N/A	No
39	N/A	N/A	No
40	N/A	N/A	No
41	PIM_MONITOR_1	Hall sensor/Current sense/Voltage feedback signal	Yes
42	PIM_MONITOR_2	Hall sensor/Current sense/Voltage feedback signal	Yes
43	PIM_MONITOR_3	Hall sensor/Current sense/Voltage feedback signal	Yes
44	N/A	N/A	No
45	VSS	N/A	No
46	VDD	N/A	No
47	HALLB	Hall sensor/QEI input	No
48	HALLC	Hall sensor/QEI input	No

TABLE 2-1: dsPICDEM MCLV-2 DEVELOPMENT BOARD PIM PINOUT FUNCTIONALITY

PIM Pin #	Signal Name	Pinout Description	Routed via Matrix Board
49	RX	UART Receive	No
50	TX	UART Transmit	No
51	USB_TX	UART Transmit (connected directly to U7)	No
52	USB_RX	UART Receive (connected directly to U7)	No
53	N/A	N/A	No
54	N/A	N/A	No
55	N/A	N/A	No
56	N/A	N/A	No
57	N/A	N/A	No
58	PIM_FLT_OUT2	General I/O	Yes
59	PIM_FLT_OUT1	General I/O	Yes
60	DBG_LED1	Debug LED 1	No
61	HOME	Home signal for QE1	No
62	VDD	N/A	No
63	OSC1/CLKO	Crystal oscillator in	No
64	OSC2/CLKI	Crystal oscillator out	No
65	VSS	N/A	No
66	PIM_IBUS+	BUS current shunt signal	Yes
67	PIM_IBUS-	BUS current shunt signal	Yes
68	LIN_CS	LIN Chip Select signal	No
69	LIN_FAULT	LIN Fault signal	No
70	RX	UART Receive	No
71	N/A	N/A	No
72	USB_RX	UART Receive (connected directly to U7)	No
73	PIM_IB+	IMOTOR1 shunt signal	Yes
74	PIM_IA+	IMOTOR2 shunt signal	Yes
75	VSS	N/A	No
76	USB_TX	UART Transmit (connected directly to U7)	No
77	CAN_TX	CAN Transmit	No
78	CAN_RX	CAN Receive	No
79	N/A	N/A	No
80	HALLA	Hall sensor/QEI input	No
81	N/A	N/A	No
82	PIM_GEN1	General I/O	Yes
83	BTN_1	Push-button S2 input	No
84	BTN_2	Push-button S3 input	No
85	N/A	N/A	No
86	VDD	N/A	No
87	CAN_RX	CAN Receive	No
88	CAN_TX	CAN Transmit	No
89	N/A	N/A	No
90	N/A	N/A	No
91	N/A	N/A	No
92	N/A	N/A	No
93	PWM1L1	PWM Output - 1L	No
94	PWM1H1	PWM Output - 1H	No
95	N/A	N/A	No
96	N/A	N/A	No
97	N/A	N/A	No
98	PWM1L2	PWM Output - 2L	No
99	PWM1H2	PWM Output - 2H	No
100	PWM1L3	PWM Output - 3L	No

dsPICDEM™ MCLV-2 Development Board User's Guide

2.2 BOARD CONNECTORS

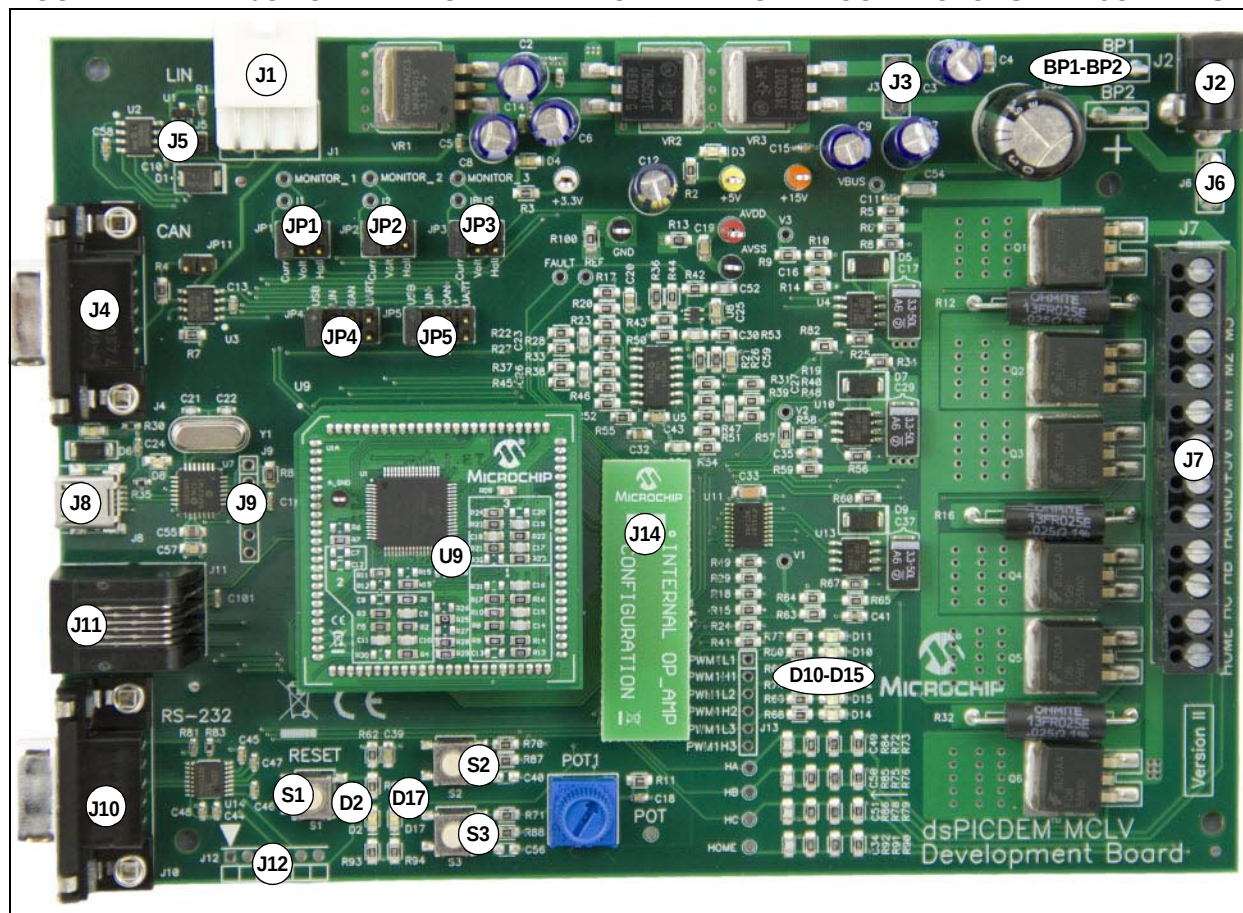
Table 2-2 describes the hardware connection between MPLAB ICD 3 or MPLAB REAL ICE™ In-Circuit Emulator, the power supply, and the dsPICDEM MCLV-2 Development Board connectors.

TABLE 2-2: BOARD CONNECTORS

Number	Designator	Description
1	BP1-BP2	Auxiliary power supply connector
2	J1	LIN interface port
3	J2	Input power supply connector
4	J4	CAN interface port
5	J7	Motor power connector, Hall sensors/Quadrature encoder connector and DC bus power supply connector
6	J8	USB interface port
7	J9	ICSP™ programmer interface connector for programming the PIC18LF2450 USB to UART Bridge
8	J10	RS-232 interface port
9	J11	RJ11, 6-pin connector for programming a dsPIC DSC or PIC24 MCU
10	J12	ICSP connector for programming a dsPIC DSC or PIC24 MCU

Figure 2-1 shows various connectors and jumpers available on the dsPICDEM MCLV-2 Development Board.

FIGURE 2-1: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD CONNECTORS AND JUMPERS



2.2.1 Input Power Connector (J2, BP1-BP2)

The dsPICDEM MCLV-2 Development Board receives the power for control circuits and the DC bus from a +24V power supply. It is connected to the board through J2 or BP1-BP2 points.

2.2.2 DC Bus Power Supply Connector (J6 and J7)

By default, jumper J6 is short, and the +24V input power supply connected to J2 or BP1-BP2 supplies the DC bus voltage to the board.

2.2.3 CAN Interface (J4)

The board has a MCP2551 High-Speed CAN Transceiver, which is connected to the dsPIC DSC or PIC24 MCU through jumpers JP4 and JP5. The CAN transceiver converts the differential signal on the CAN bus to a digital signal for the ECAN™ module. It also converts the ECAN output digital signal to a differential signal for the CAN bus. In Sleep mode, the CAN transmitter is turned off, and the receiver operates at a lower current level. The control device monitors the CAN activity and switches the transceiver back to normal operation when needed. For more information, refer to the data sheet, *MCP2551 "High-Speed CAN Transceiver"* (DS21667).

2.2.4 LIN Interface (J1)

The board has a MCP2021 High-Speed LIN Transceiver, which is connected to the dsPIC DSC or PIC24 MCU through jumpers JP4 and JP5. The LIN transceiver monitors the LIN bus, conditions the incoming signal, and passes it to the UART module on the control device. The LIN transceiver responds to a "Transmit Enable" from the control device by conditioning an output signal and placing it on the LIN bus. A power-down mode turns the transmitter and voltage regulator off, leaving only the receiver and wake-up circuits in operation. The LIN circuit includes a Master/Slave jumper to accommodate a Master node on the LIN bus. For more information, refer to the data sheet, *MCP202X "LIN Transceiver with Voltage Regulator"* (DS22018).

2.2.5 USB Interface (J8)

The board uses an on-board PIC18 interface as a bridge between the UART and USB. The PIC18 UART pins are connected to the dsPIC DSC or PIC24 MCU through jumpers JP4 and JP5.

2.2.6 ICD 3 Connector (J11- J12)

The ICD 3 connector is an RJ11 female connector (J11) that connects the MPLAB ICD 3 In-Circuit Debugger/Emulator to the dsPIC DSC or PIC24 MCU for programming and debugging purposes. The ICD 3 can also be connected to the board using 6-pin ICSP connector (J12).

2.2.7 ICSP for PIC18 (J9)

The jumper J9 is a 6-pin connector that connects the PICkit™ 3 development programmer to the PIC18F device. The board uses the on-board PIC18 interface as a bridge between the UART and USB. The PIC18F is programmed for USB communication.

2.2.8 RS-232 Connector (J10)

The connector J10 is an RS-232 interface port. The board uses the UART connector to pass the UART signals from the dsPIC DSC or PIC24 MCU to the dedicated UART IC MAX3232CUE. The output of U14 is provided to the connector J10.

2.2.9 Motor Connector (J7)

The motor connector (J7) has 12 terminals. [Table 2-3](#) shows the functionality of each terminal.

TABLE 2-3: MOTOR CONNECTOR DETAILS

Pin	Terminal Name	Function
1	+	External DC bus power supply
2	–	Ground
3	M3	Motor winding phase 3
4	M2	Motor winding phase 2
5	M1	Motor winding phase 1
6	G	Ground
7	+5V	Hall sensors/Quadrature encoder power supply
8	GND	Hall sensors ground
9	HALLA	Hall A/QEA feedback
10	HALLB	Hall B/QEB feedback
11	HALLC	Hall C/INDEX feedback
12	HOME	Home signal feedback

[Table 2-4](#) lists the test points that can be used to check various signals.

TABLE 2-4: TEST POINTS

Test Points	Description
HA	Hall A/QEA feedback
HB	Hall B/QEB feedback
HC	Hall C/INDEX feedback
HOME	Home signal feedback
PWM1H1	PWM output for leg 1 top switch
PWM1L1	PWM output for leg 1 bottom switch
PWM1H2	PWM output for leg 2 top switch
PWM1L2	PWM output for leg 2 bottom switch
PWM1H3	PWM output for leg 3 top switch
PWM1L3	PWM output for leg 3 bottom switch
Fault	Fault pin
V1	Motor phase 1 voltage feedback
V2	Motor phase 2 voltage feedback
V3	Motor phase 3 voltage feedback
Ref	1.65V reference for current feedback
POT1	POT signal
MONITOR_1	Motor feedback signal 1
MONITOR_2	Motor feedback signal 2
MONITOR_3	Motor feedback signal 3
I1	Phase 1 current
I2	Phase 2 current
IBUS	Bus current
P1	+3.3V (digital)
P2	GND (digital)
P3	+5V
P4	AVDD
P5	+15V
AVSS	Analog ground
VBUS	Bus voltage (downscaled)

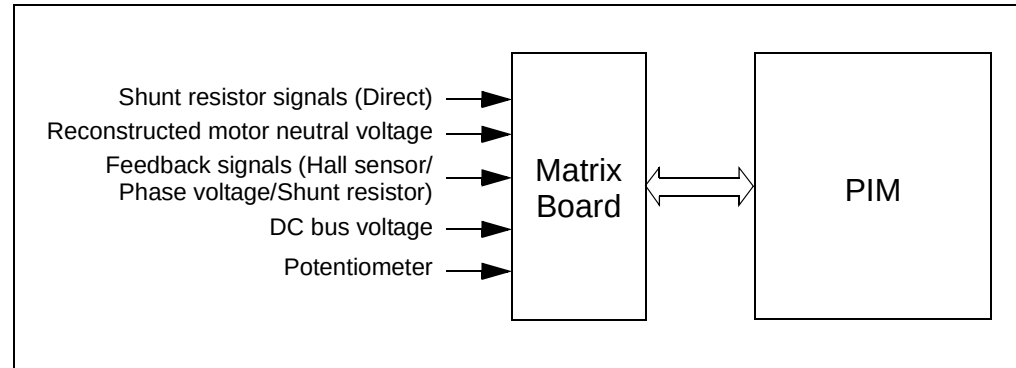
2.2.10 The Matrix Board Interface

The matrix board interface facilitates the following functions:

- Connects the appropriate signals to the correct pins on the Plug-In Module (PIM)
- Disconnects signals and provides isolation on signal paths that, in a particular hardware configuration, are not being used

The matrix board header has two rows of pins. One row (pins 1-25) hosts signals from different signal sources, the other (pins 26-50) hosts connections to the PIM. [Figure 2-2](#) is a block diagram that describes the matrix board interface.

FIGURE 2-2: MATRIX BOARD BLOCK DIAGRAM



2.2.10.1 INTERNAL AND EXTERNAL OP AMP MATRIX BOARDS

The dsPICDEM MCLV-2 Development Board uses discrete op amps (U5) to amplify the shunt resistor signals. Alternatively, some PIC24 MCUs or dsPIC DSCs are designed with op amps on-board that can be used for this purpose. To accommodate these two basic configurations, the dsPICDEM MCLV-2 Development Board includes two matrix boards.

- The Internal Op Amp Configuration Matrix Board configures the development board to use op amps that are internal to the PIC24 MCU or dsPIC DSC. This matrix board bypasses the current feedback circuitry on the dsPICDEM MCLV-2 Development Board and directly connects the shunt resistor signals to appropriate pins of the PIM.
- The External Op Amp Configuration Matrix Board configures the development board to use the current feedback circuitry on the dsPICDEM MCLV-2 Development Board. This matrix board disconnects the shunt resistor signals from the PIM pins and connects the current feedback circuitry output to the appropriate PIM pins.

Note: Unless specified in the PIM information sheet, all PIMs are compatible only with the External Op amp Configuration matrix board. Certain PIMs are designed to work only with the Internal Op amp Configuration matrix boards. In this case, the corresponding PIM information sheet (available at www.microchip.com/pims) will explicitly state this.

2.3 SELECTING A POWER SUPPLY FOR THE DEVELOPMENT BOARD

The following connectors and power jumpers, when configured, offer multiple power supply configuration options for the dsPICDEM MCLV-2 Development Board.

- Input Power Connector (J2 or BP1-BP2)
- Bypass 15V Regulator (J3)
- DC Bus Power Supply Jumper (J6)
- Motor Power Connector with pins, '+' and '-' (J7)

To locate these components, refer to [Figure 1-1](#).

[Table 2-5](#) describes how to select the required power supply configuration option by setting jumpers J3 and J6.

TABLE 2-5: JUMPER SETTINGS FOR SELECTING A POWER SUPPLY

J3	J6	J2 or BP1-BP2	J7: Pins '+' and '-'
Remove the jumper	Remove the jumper	16V to 24V	0V to 48V
Remove the jumper	Install the jumper	16V to 24V	Supplied by J2 or BP1-BP2
Install the jumper ⁽¹⁾	Remove the jumper	10V to 16V	0V to 48V
Install the jumper ⁽¹⁾	Install the jumper	10V to 16V	Supplied by J2 or BP1-BP2

Note 1: When J3 is installed, VR3 must be removed to avoid damage to the 15V regulator.

2.4 USER INTERFACE HARDWARE

2.4.1 Jumpers

The dsPICDEM MCLV-2 Development Board has nine jumpers that configure the functionality of the board. [Figure 2-3](#) shows the jumper settings and [Table 2-6](#) lists these jumpers and their functions.

FIGURE 2-3: JUMPER SETTINGS

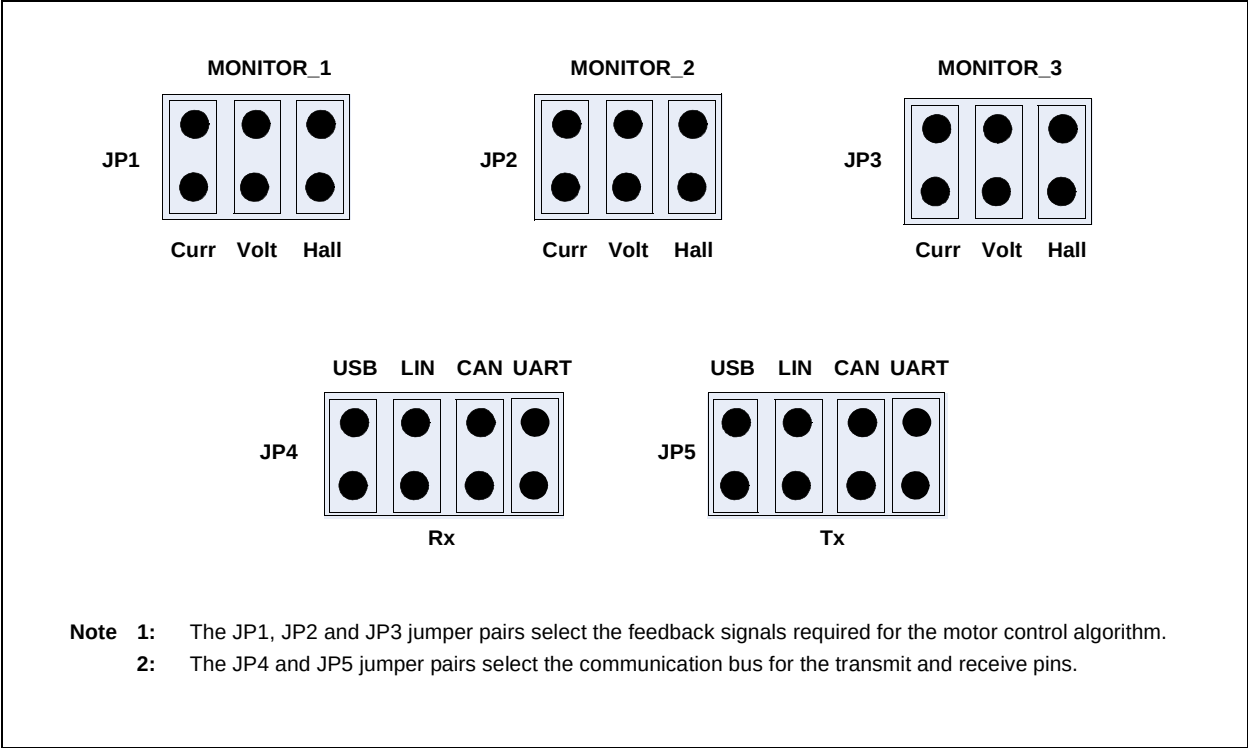


TABLE 2-6: JUMPER DESCRIPTIONS

No.	Designator	Position	Description
1	JP1	1-2	Connects current sense phase 1 to MONITOR_1
		3-4	Connects voltage sense phase 1 to MONITOR_1
		5-6	Connects Hall sensor interface HA to MONITOR_1
2	JP2	1-2	Connects current sense phase 2 to MONITOR_2
		3-4	Connects voltage sense phase 2 to MONITOR_2
		5-6	Connects Hall sensor interface HB to MONITOR_2
3	JP3	1-2	Connects current sense DC Bus to MONITOR_3
		3-4	Connects voltage sense phase 3 to MONITOR_3
		5-6	Connects Hall sensor interface HC to MONITOR_3
4	JP4	1-2	Connects USB receive line to Rx
		3-4	Connects LIN receive line to Rx
		5-6	Connects CAN receive line to Rx
		7-8	Connects UART receive line to Rx
5	JP5	1-2	Connects USB transmit line to Tx
		3-4	Connects LIN transmit line to Tx
		5-6	Connects CAN transmit line to Tx
		7-8	Connects UART transmit line to Tx

TABLE 2-7: ADDITIONAL JUMPERS

Designator	Functions
J3	Bypass 15V regulator connector for gate driver IC
J5	LIN master select
J6	Connects BP1-BP2/J2 to motor connector block J7
JP11	CAN end enable

2.4.2 Push-Buttons, LEDs, Bus Resistors and Potentiometers

The dsPICDEM MCLV-2 Development Board consists of the following items:

- Two push-buttons
- One potentiometer
- Six LEDs for PWM
- Two LEDs for debugging purposes
- Two power-on status LEDs
- Two USB LEDs
- Device Reset push-button

TABLE 2-8: INDICATORS AND HUMAN INTERFACES

Label	Hardware Element Description
S2, S3	Push-buttons; these push-buttons are connected to port pins. When momentarily pressed, the switch connects the respective port pin to Ground.
POT	10 k Ω potentiometer; it is connected to analog input pin.
D3	Power-on status LED, which indicates the status of the 5V regulator.
D4	Power-on status LED, which indicates the status of the +3.3V regulator.
D8	USB communication indicator, which indicates the device has been detected.
D10-D15	LEDs, which indicate the PWM pin status.
D16	USB bus indicator, which indicates that the device is connected to the USB bus.
D2, D17	LEDs to be used for debugging purposes.
S1	Push-button used to reset the target device.



dsPICDEM™ MCLV-2 DEVELOPMENT BOARD USER'S GUIDE

Chapter 3. Running a BLDC Motor Using a Sensorless Algorithm

This chapter describes how to set up the dsPICDEM MCLV-2 Development Board in the Internal Op amp configuration to run a BLDC motor using the Single-Shunt Current Reconstruction Algorithm using a dsPICDEM™ MCLV-2 Development Board. The algorithm is described in AN1299 “*Single-Shunt Three-Phase Current Reconstruction Algorithm for Sensorless FOC of a PMSM*”.

Topics covered include:

- [Operating Requirements](#)
- [dsPICDEM MCLV-2 Development Board Setup](#)

3.1 OPERATING REQUIREMENTS

To set up and run the board, the following items are recommended:

- MPLAB® X Integrated Development Environment (IDE) installed on the PC that is attached to the board (SW007002)
- dsPICDEM MCLV-2 Development Board (DM330021-2)
- 24V power supply (AC002013) or equivalent
- 10 pole Hurst motor (AC300020)
- dsPIC33EP256MC506 Internal Op Amp Configuration PIM (MA330031)

3.2 dsPICDEM MCLV-2 DEVELOPMENT BOARD SETUP

The following procedure describes how to set up the dsPICDEM MCLV-2 Development Board:

WARNING

The dsPICDEM MCLV-2 Development Board is intended to drive the three-phase BLDC or PMSM motor. Before connecting the motor, make sure that the power rating of the motor is equal to or less than the power rating of the board, as shown in [Appendix B. "Electrical Specifications"](#). Also, make sure the jumper settings are correct for the firmware programmed into the target dsPIC DSC or PIC24 MCU mounted on the socket. Failure to comply with this warning could lead to malfunction of the board and the motor, and could result in physical harm.

Before beginning the start-up procedure, complete a visual check of the board and the motor for connectivity and mechanical damage. If damage is found, DO NOT power-up the board. Otherwise, you may further damage the equipment. Contact the Microchip local office or distributor before using a damaged board.

3.2.1 Setting up the dsPICDEM MCLV-2 Development Board

Perform the following steps to set up the development board:

1. Place the dsPICDEM MCLV-2 Development Board on a sturdy insulated platform.
2. Make sure that the dsPIC33EP256MC506 Internal Op Amp Configuration PIM is mounted in the U9 socket.
3. Insert the Internal Op Amp Configuration matrix board into J14, ensuring that the pins line up and the matrix board is oriented correctly, as shown in [Figure 3-1](#).

FIGURE 3-1: MATRIX BOARD ORIENTATION



4. Connect MPLAB ICD 3 or MPLAB REAL ICE In-Circuit Emulator to the computer, and the board in J11 or J12.
5. Connect the three-phase, 10 pole, 24V Hurst motor (AC300020) to J7. Since this is a sensorless algorithm, the motor phase wires (Red, Black, and White) can be connected to M1, M2, and M3 in any order.

Running a BLDC Motor Using a Sensorless Algorithm

6. Connect the 24V power supply to J2 or BP1-BP2. If the supply voltage is not equal to 24V, refer to [Table 2-5](#) to configure the power supply for the board.
7. Download the internal op amp version of the code for the dsPIC33EP256MC506 from the Microchip web site (www.microchip.com). It is available with the AN1299 application note.
8. Unzip the file and open the project using MPLAB X IDE. Refer to the “*MPLAB® X IDE User’s Guide*” (DS52027) for more information about how to use MPLAB X IDE with a Microchip debugger/programmer.
9. Click the **Run Project** icon on the MPLAB X IDE toolbar. MPLAB X IDE will build the project and program the target device. Ensure that the build and program process completes successfully.
10. Press S2 to run the motor.
11. Vary the motor’s speed with POT1.
12. Press S2 again to stop the motor.

Note: For more information on running BLDC motors using a dsPIC DSC or PIC24 MCU, refer to the following application notes, which are available from the Microchip web site:

- AN1299, “*Single-Shunt Three-Phase Current Reconstruction Algorithm for Sensorless FOC of a PMSM*” (DS01299)
- AN1160, “*Sensorless BLDC Control with Back-EMF Filtering Using a Majority Function*” (DS01160)
- AN1078, “*Sensorless Field Oriented Control of PMSM Motors using dsPIC30F or dsPIC33F Digital Signal Controllers*” (DS01078)
- AN1017, “*Sinusoidal Control of PMSM Motors with dsPIC30F DSC*” (DS01017)

The source code referred in these application notes is available from the Microchip web site (www.microchip.com).

NOTES:



dsPICDEM™ MCLV-2 DEVELOPMENT BOARD USER'S GUIDE

Appendix A. Schematics and Layout

The following schematics are included in this user's guide:

Figure A-1: "dsPICDEM™ MCLV-2 Development Board Schematic (Sheet 1 of 7)"

Figure A-2: "dsPICDEM™ MCLV-2 Development Board Schematic (Sheet 2 of 7)"

Figure A-3: "dsPICDEM™ MCLV-2 Development Board Schematic (Sheet 3 of 7)"

Figure A-4: "dsPICDEM™ MCLV-2 Development Board Schematic (Sheet 4 of 7)"

Figure A-5: "dsPICDEM™ MCLV-2 Development Board Schematic (Sheet 5 of 7)"

Figure A-6: "dsPICDEM™ MCLV-2 Development Board Schematic (Sheet 6 of 7)"

Figure A-7: "dsPICDEM™ MCLV-2 Development Board Schematic (Sheet 7 of 7)"

Figure A-8: "Internal Op amp Configuration Matrix Board Schematic"

Figure A-9: "External Op amp Configuration Matrix Board Schematic"

Figure A-10: "dsPICDEM™ MCLV-2 Development Board Layout"

FIGURE A-1: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD SCHEMATIC (SHEET 1 OF 7)

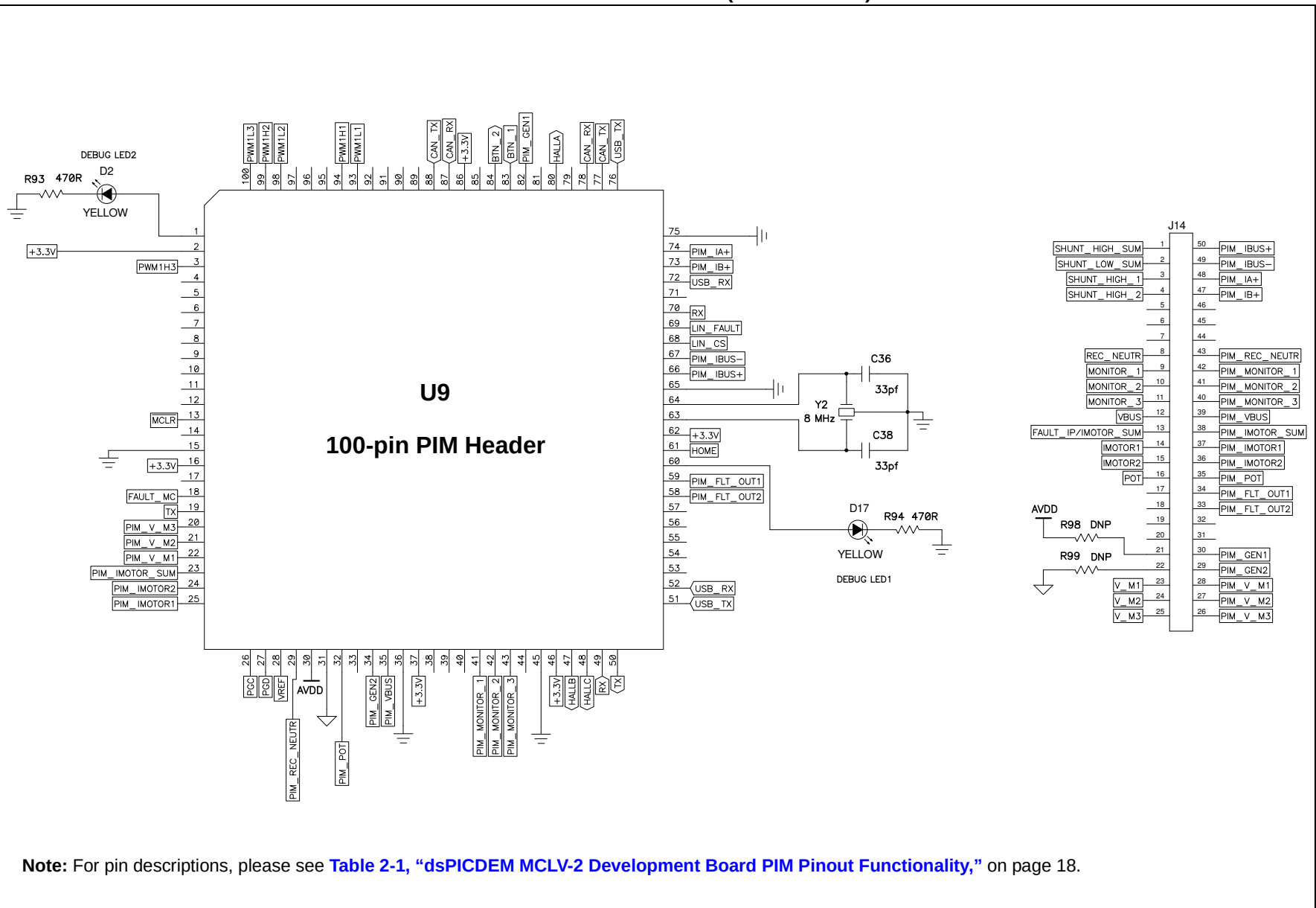
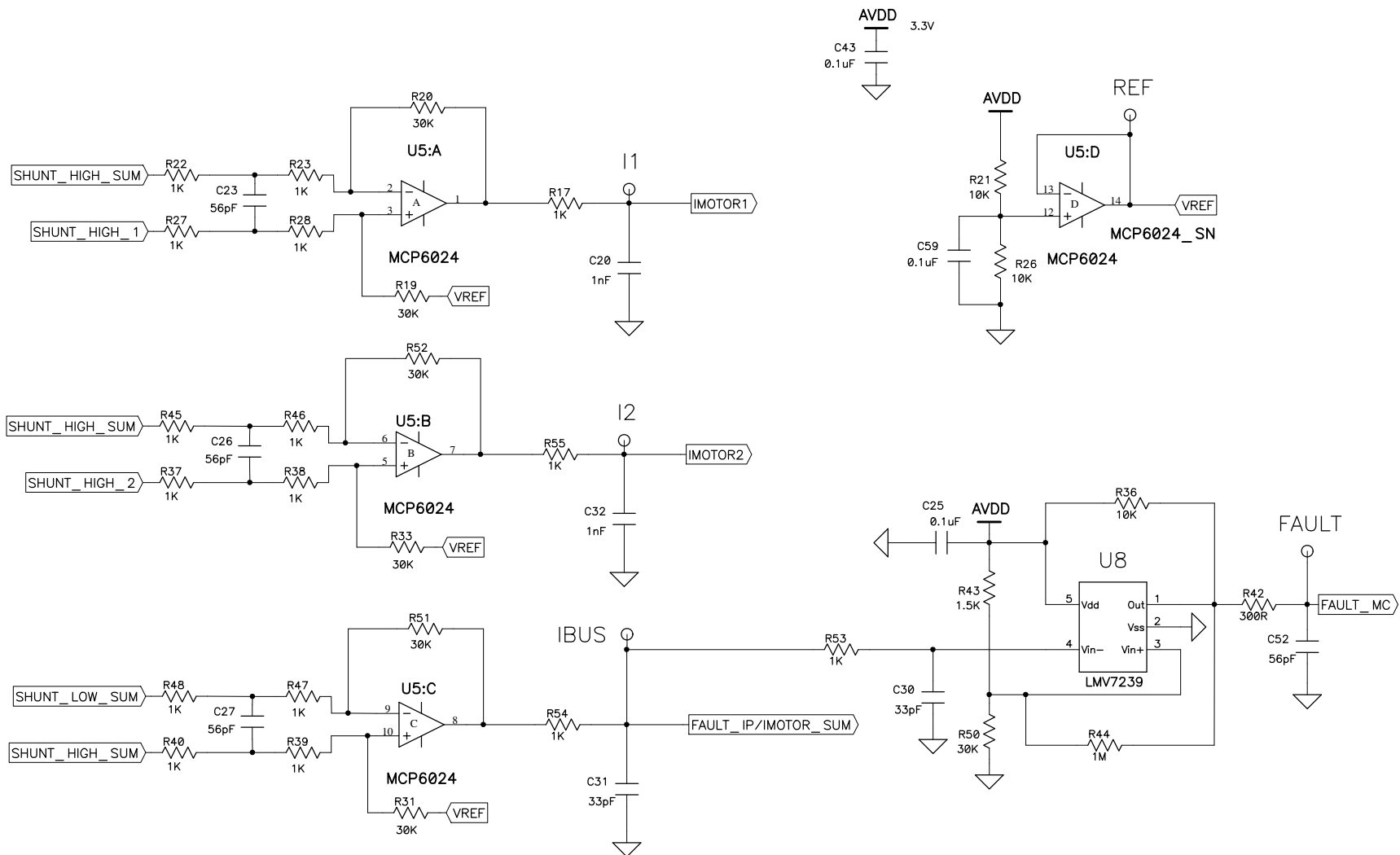


FIGURE A-2: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD SCHEMATIC (SHEET 2 OF 7)

- Note 1:** All resistors on this page must be 1%.
- 2:** Supply Voltage should be AVDD for MCP6024.

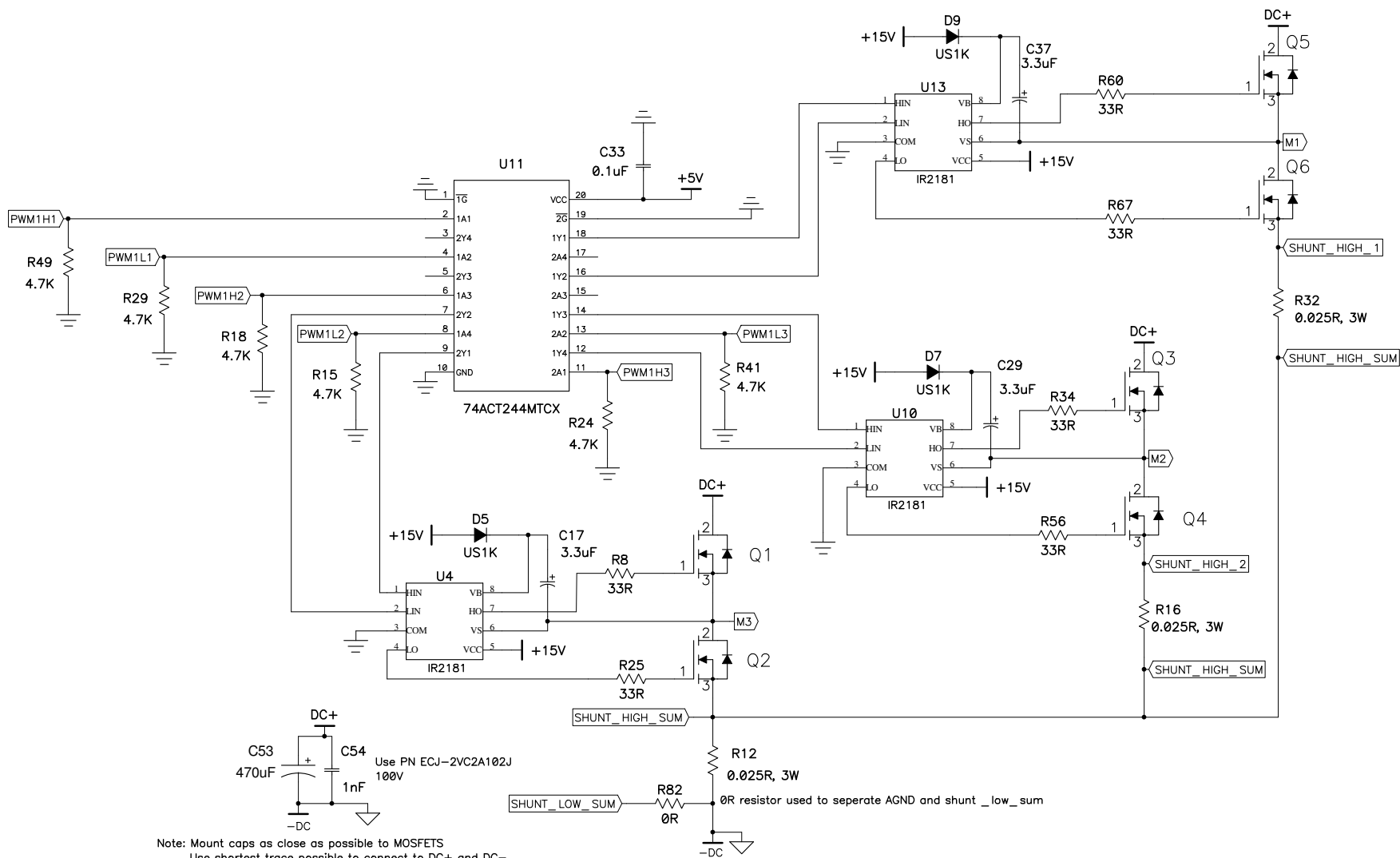
FIGURE A-3: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD SCHEMATIC (SHEET 3 OF 7)


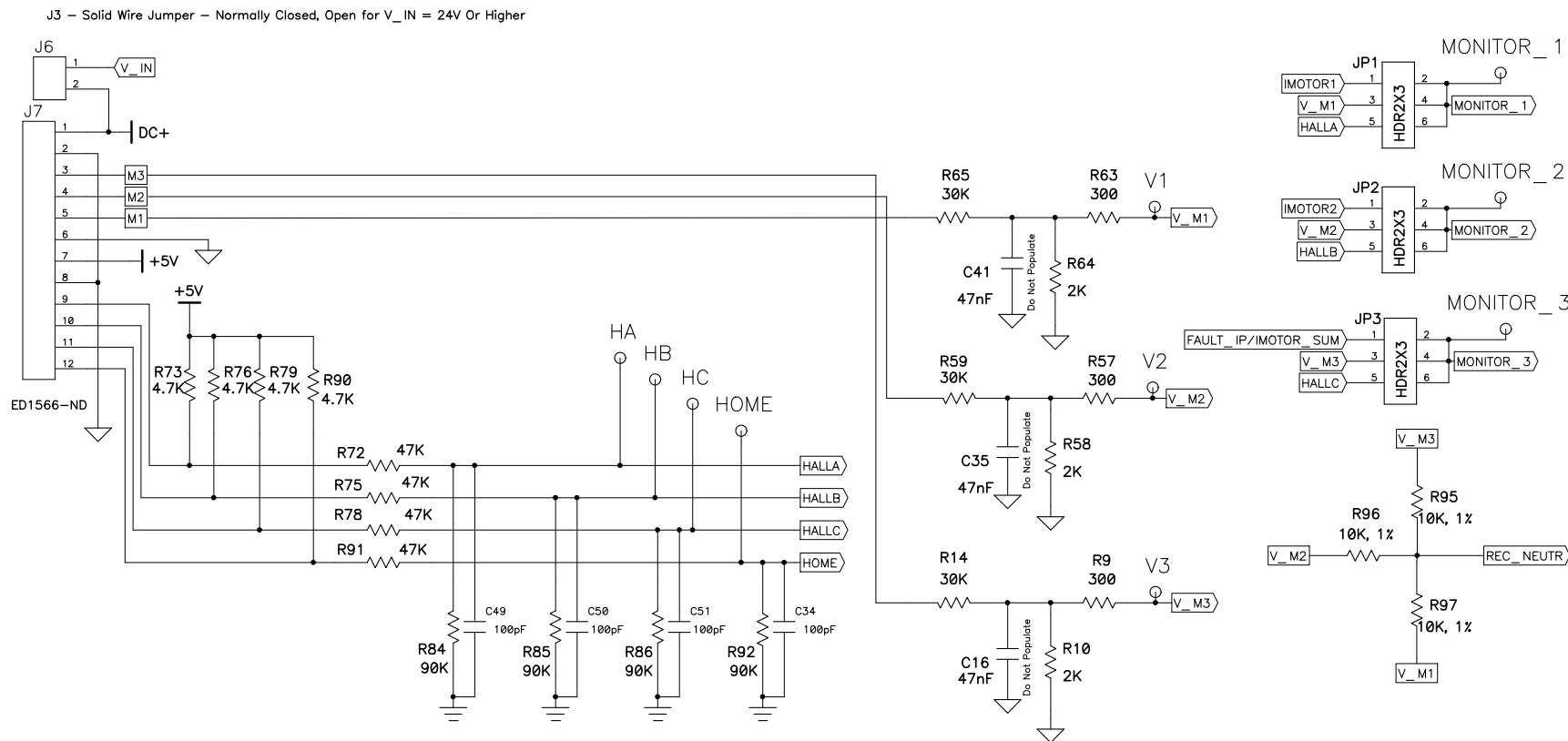
FIGURE A-4: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD SCHEMATIC (SHEET 4 OF 7)

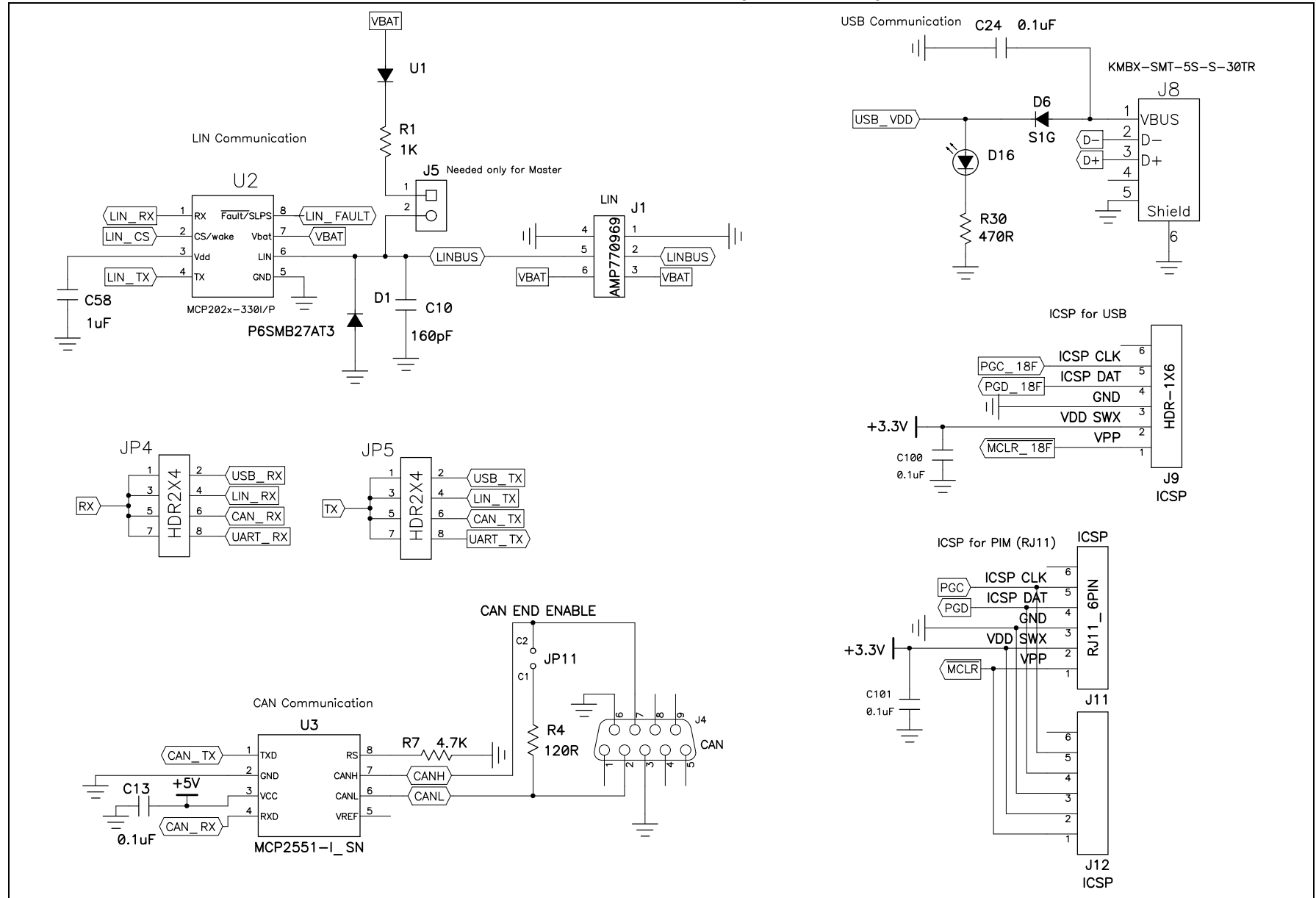
FIGURE A-5: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD SCHEMATIC (SHEET 5 OF 7)

FIGURE A-6: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD SCHEMATIC (SHEET 6 OF 7)

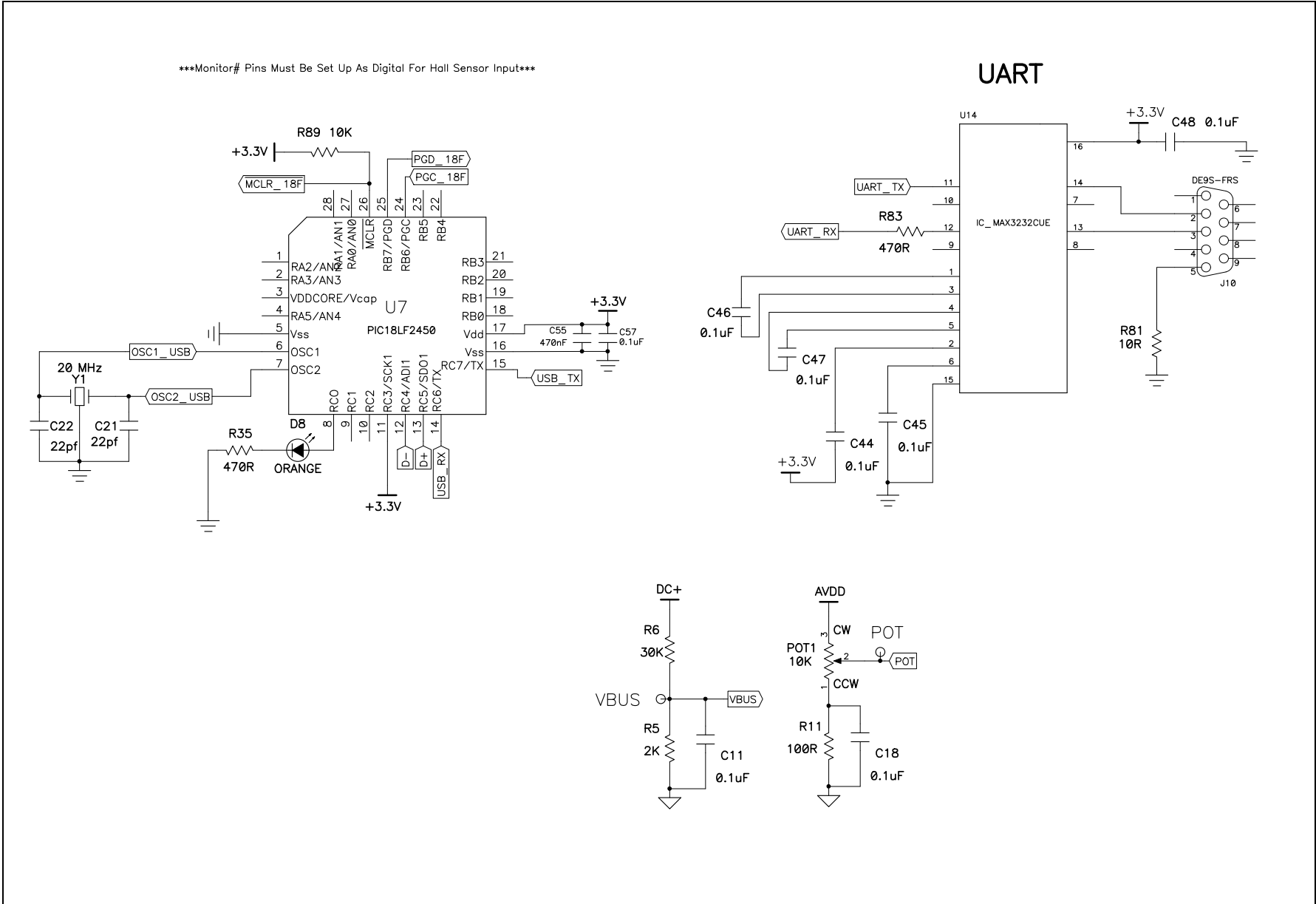


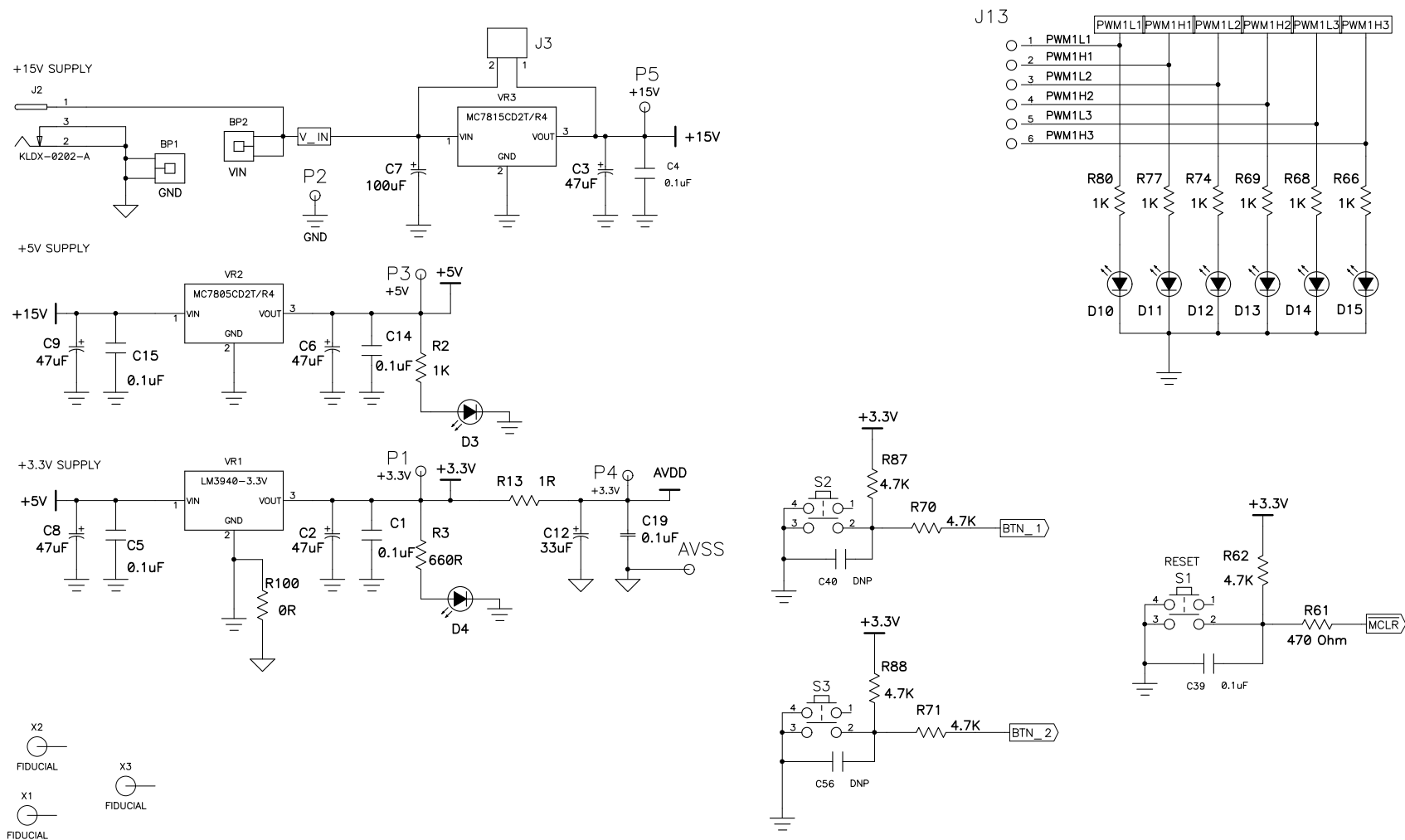
FIGURE A-7: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD SCHEMATIC (SHEET 7 OF 7)


FIGURE A-8: INTERNAL OP AMP CONFIGURATION MATRIX BOARD SCHEMATIC

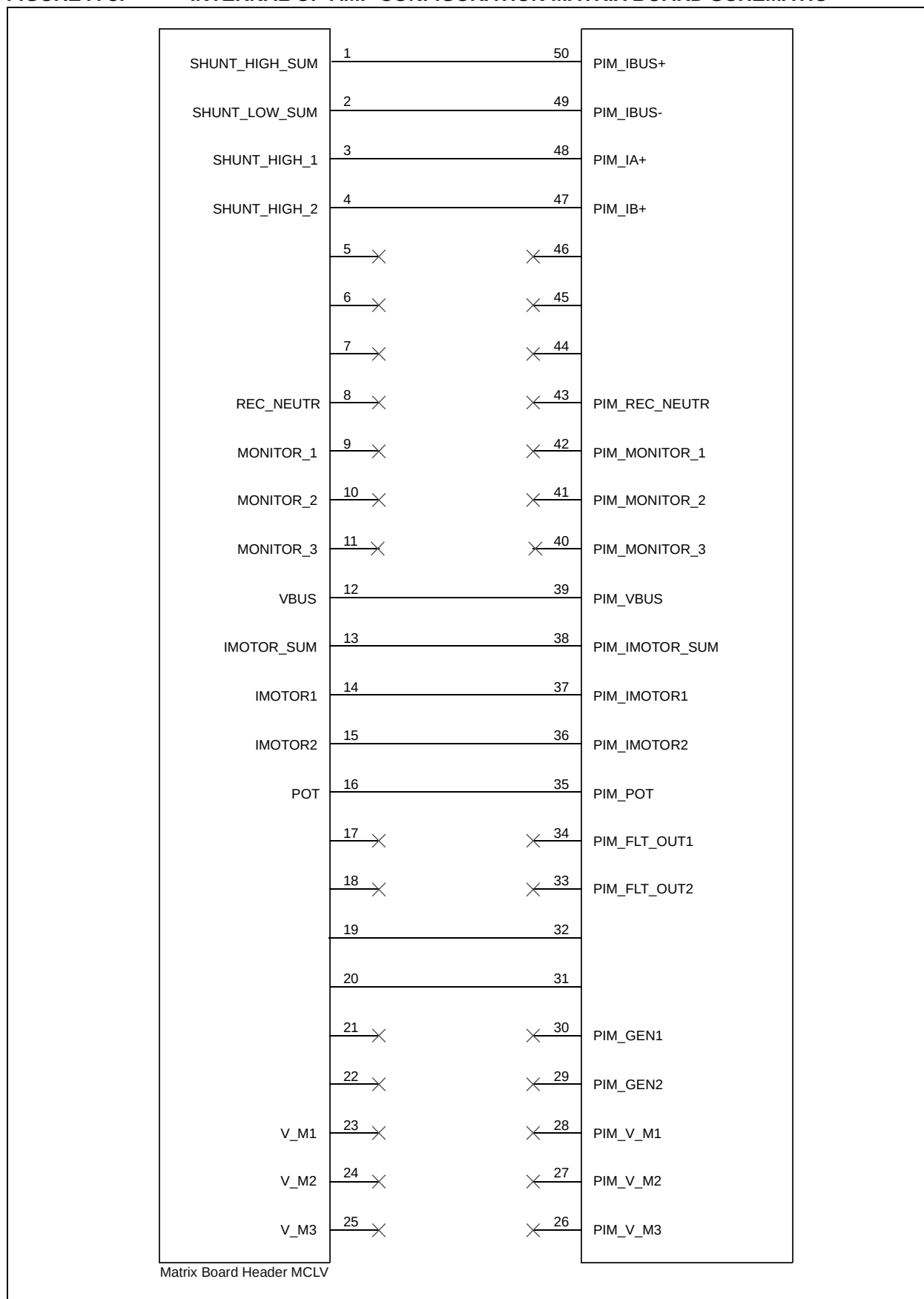


FIGURE A-9: EXTERNAL OP AMP CONFIGURATION MATRIX BOARD SCHEMATIC

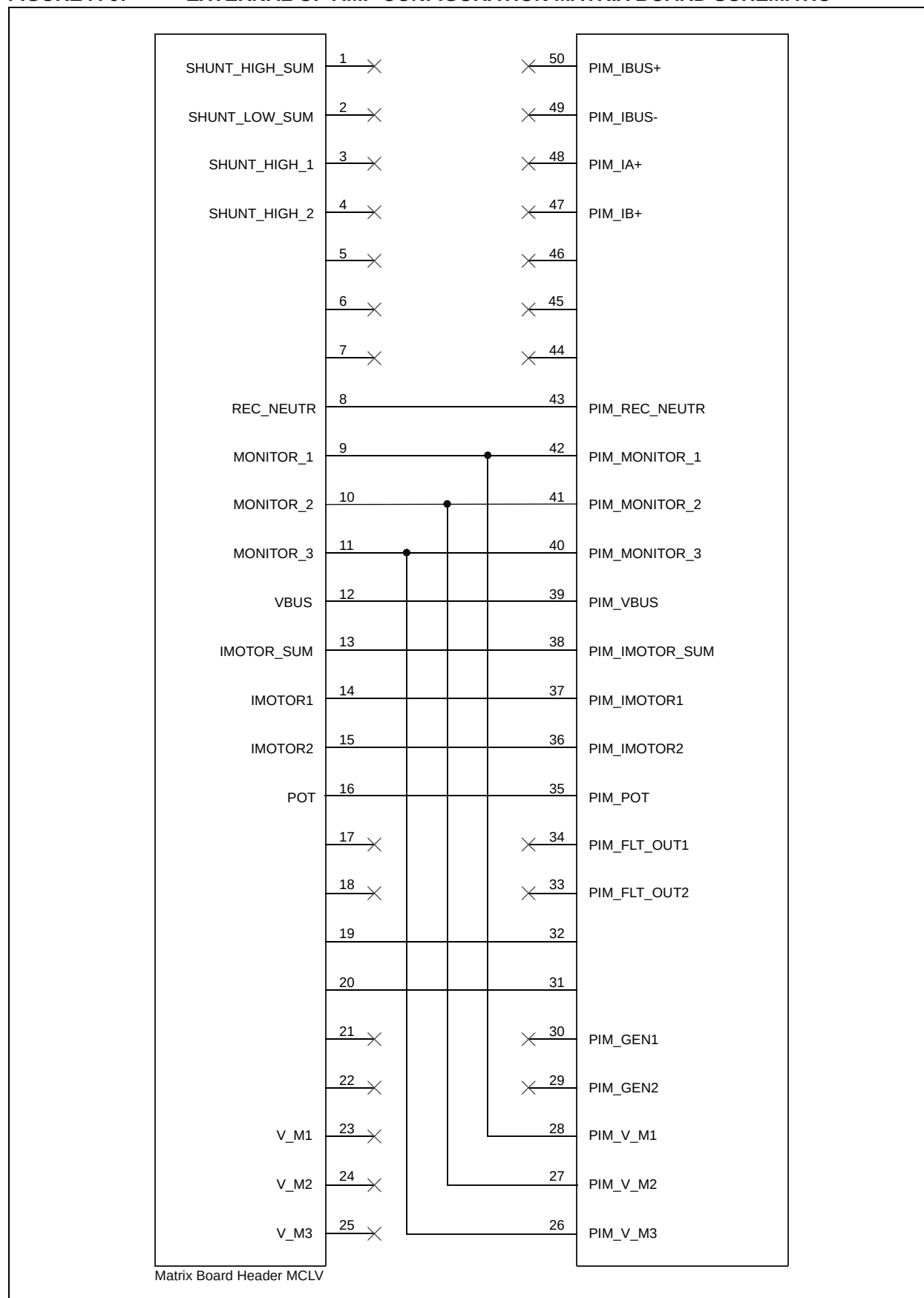
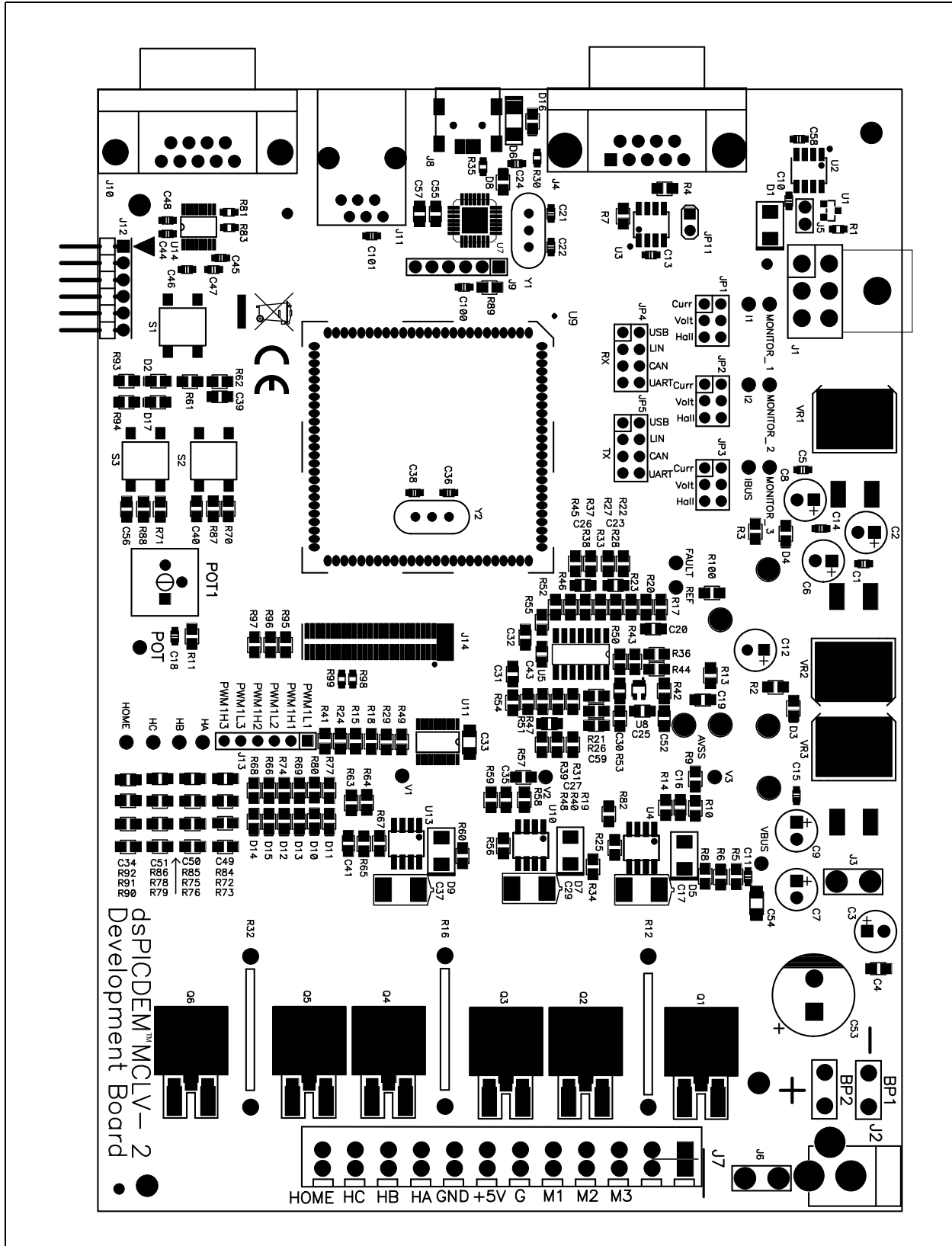


FIGURE A-10: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD LAYOUT



NOTES:

Appendix B. Electrical Specifications

TABLE B-1: DC INPUT RATING

Parameter	Condition	Min.	Max.	Unit
Power supply connected to J7	J6 is open	0	48	V _{DC}
Power supply connected to J2 or BP1-BP2	J3 is open and VR3 is installed	16	24	V _{DC}
Power supply connected to J2 or BP1-BP2	J3 is installed and VR3 is removed	10	16	V _{DC}

TABLE B-2: DC OUTPUT RATING

Parameter	Min.	Typical	Max.	Unit
Voltage	0	24	48	V _{DC}
Current	0	10	15	A
Power Rating	0	240 ⁽¹⁾	720 ⁽²⁾	Watts

Note 1: If the output power exceeds 240W, the power MOSFETs (Q1-Q6) may need an additional heat sink.

2: By default, the board uses D²PAK Power MOSFETs. It also supports the TO-220 packages. If the TO-220 Power MOSFETs are used, additional heat sink can be mounted on the MOSFETs, if required.



Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
<http://www.microchip.com/support>
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Cleveland
Independence, OH
Tel: 216-447-0464
Fax: 216-447-0643

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Farmington Hills, MI
Tel: 248-538-2250
Fax: 248-538-2260

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

Santa Clara
Santa Clara, CA
Tel: 408-961-6444
Fax: 408-961-6445

Toronto
Mississauga, Ontario,
Canada
Tel: 905-673-0699
Fax: 905-673-6509

ASIA/PACIFIC

Asia Pacific Office
Suites 3707-14, 37th Floor
Tower 6, The Gateway
Harbour City, Kowloon
Hong Kong
Tel: 852-2401-1200
Fax: 852-2401-3431

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8569-7000
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8665-5511
Fax: 86-28-8665-7889

China - Chongqing
Tel: 86-23-8980-9588
Fax: 86-23-8980-9500

China - Hangzhou
Tel: 86-571-2819-3187
Fax: 86-571-2819-3189

China - Hong Kong SAR
Tel: 852-2401-1200
Fax: 852-2401-3431

China - Nanjing
Tel: 86-25-8473-2460
Fax: 86-25-8473-2470

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8203-2660
Fax: 86-755-8203-1760

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7252
Fax: 86-29-8833-7256

China - Xiamen
Tel: 86-592-2388138
Fax: 86-592-2388130

China - Zhuhai
Tel: 86-756-3210040
Fax: 86-756-3210049

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444
Fax: 91-80-3090-4123

India - New Delhi
Tel: 91-11-4160-8631
Fax: 91-11-4160-8632

India - Pune
Tel: 91-20-2566-1512
Fax: 91-20-2566-1513

Japan - Osaka
Tel: 81-66-152-7160
Fax: 81-66-152-9310

Japan - Yokohama
Tel: 81-45-471- 6166
Fax: 81-45-471-6122

Korea - Daegu
Tel: 82-53-744-4301
Fax: 82-53-744-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Kuala Lumpur
Tel: 60-3-6201-9857
Fax: 60-3-6201-9859

Malaysia - Penang
Tel: 60-4-227-8870
Fax: 60-4-227-4068

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-5778-366
Fax: 886-3-5770-955

Taiwan - Kaohsiung
Tel: 886-7-536-4818
Fax: 886-7-330-9305

Taiwan - Taipei
Tel: 886-2-2500-6610
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

UK - Wokingham
Tel: 44-118-921-5869
Fax: 44-118-921-5820

11/29/11



Компания «ЭлектроПласт» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Оперативные поставки широкого спектра электронных компонентов отечественного и импортного производства напрямую от производителей и с крупнейших мировых складов;
- Поставка более 17-ти миллионов наименований электронных компонентов;
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- Лицензия ФСБ на осуществление работ с использованием сведений, составляющих государственную тайну;
- Поставка специализированных компонентов (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Aeroflex, Peregrine, Syfer, Eurofarad, Texas Instrument, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Помимо этого, одним из направлений компании «ЭлектроПласт» является направление «Источники питания». Мы предлагаем Вам помощь Конструкторского отдела:

- Подбор оптимального решения, техническое обоснование при выборе компонента;
- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.



Как с нами связаться

Телефон: 8 (812) 309 58 32 (многоканальный)

Факс: 8 (812) 320-02-42

Электронная почта: org@eplast1.ru

Адрес: 198099, г. Санкт-Петербург, ул. Калинина, дом 2, корпус 4, литера А.