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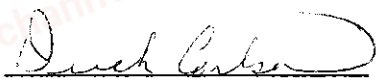
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Preface

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 "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.

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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 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) { ... }`

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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).

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- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
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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.

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- 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.

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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.

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1.2 FEATURES OVERVIEW

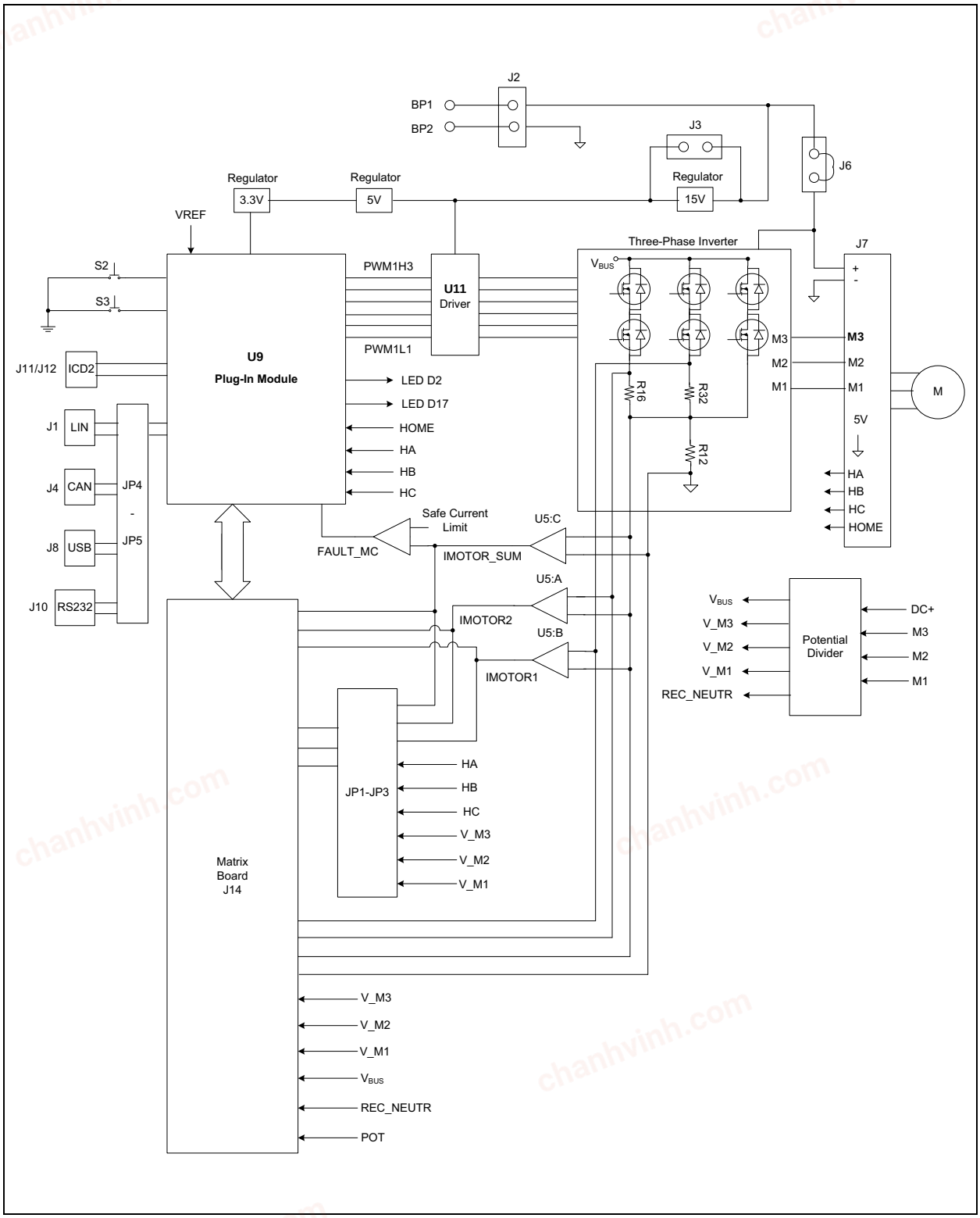
The key features of this board include the following:

- 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)

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



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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 V_{BAT} 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.

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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	$\overline{\text{MCLR}}$	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

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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 QEI	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

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2.2 BOARD CONNECTORS

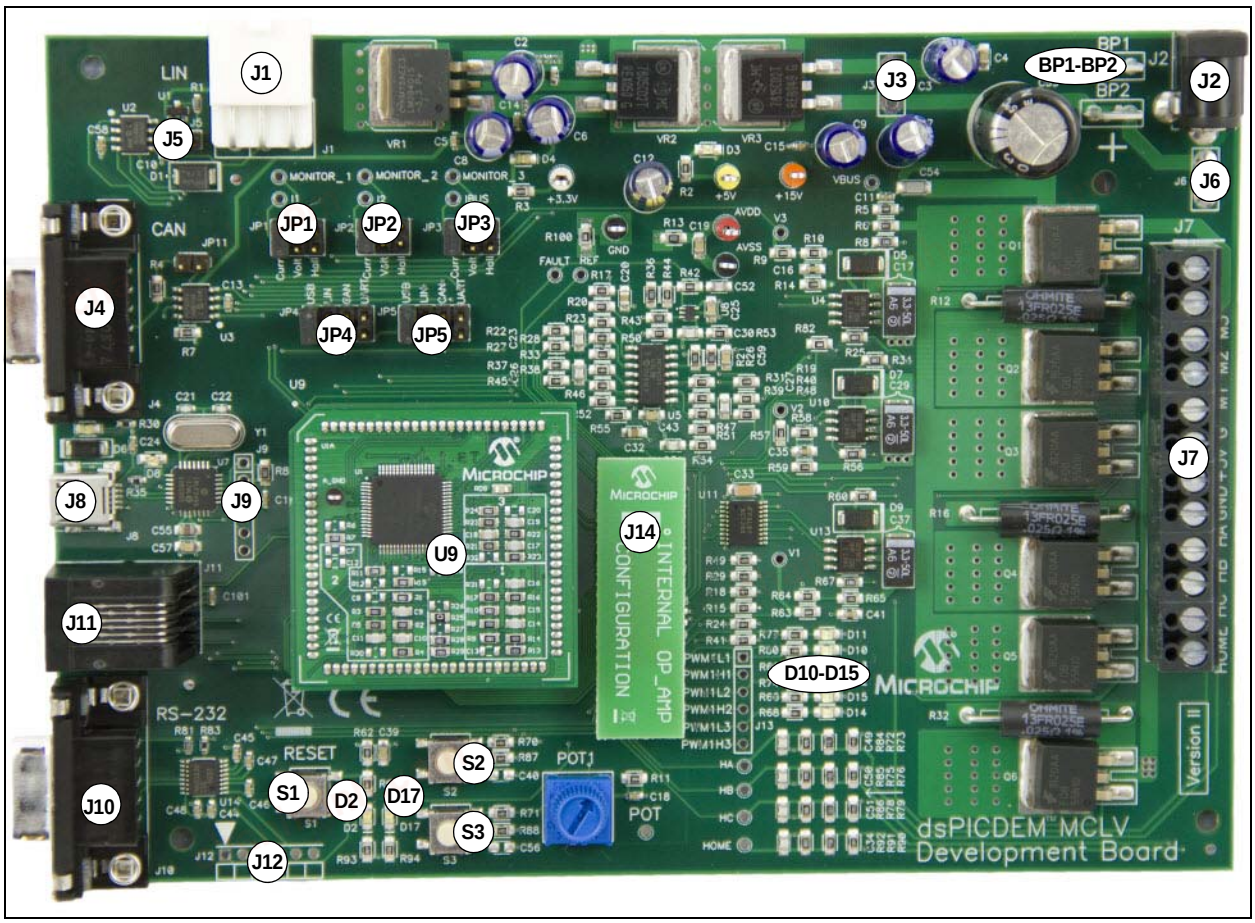
Table 2-2 describes the hardware connection between MPLAB ICD 3 or MPLAB REAL ICE™ In-Circuit Emulator, the power supply, and the dsPICDEM MCLV-2 Development Board connectors.

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



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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.

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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	AV_{DD}
P5	+15V
AV_{SS}	Analog ground
V_{BUS}	Bus voltage (downscaled)

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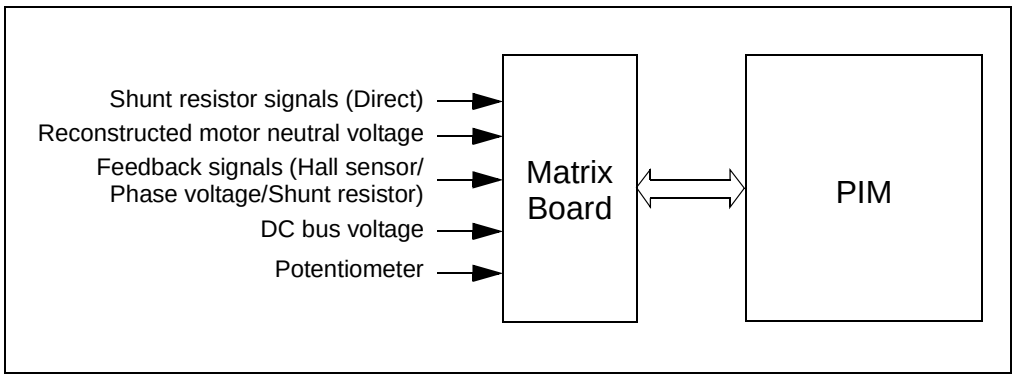
2.2.10 The Matrix Board Interface

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.

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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

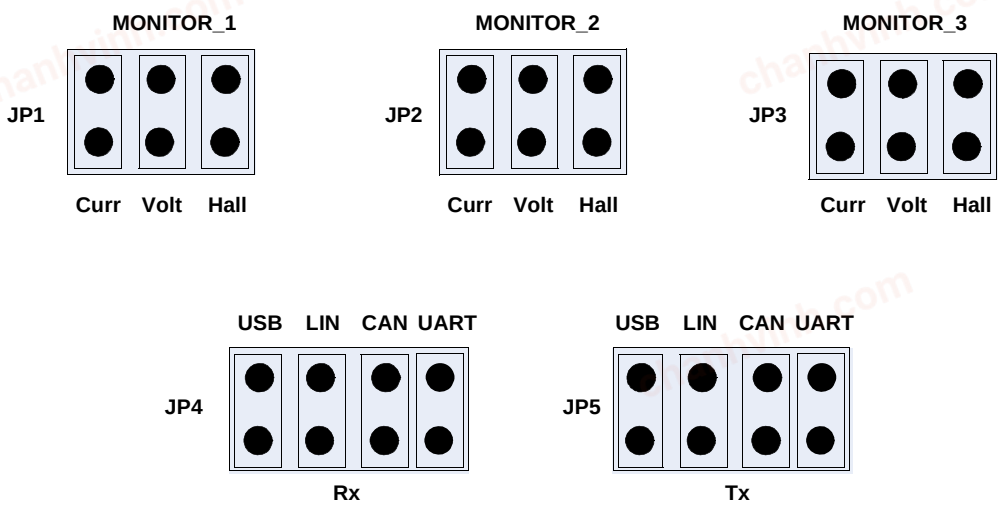
Note 1: When J3 is installed, VR3 must be removed to avoid damage to the 15V regulator.

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



Note 1: The JP1, JP2 and JP3 jumper pairs select the feedback signals required for the motor control algorithm.

2: The JP4 and JP5 jumper pairs select the communication bus for the transmit and receive pins.

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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

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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 kΩ 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.

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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)

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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.

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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).

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Appendix A. Schematics and Layout

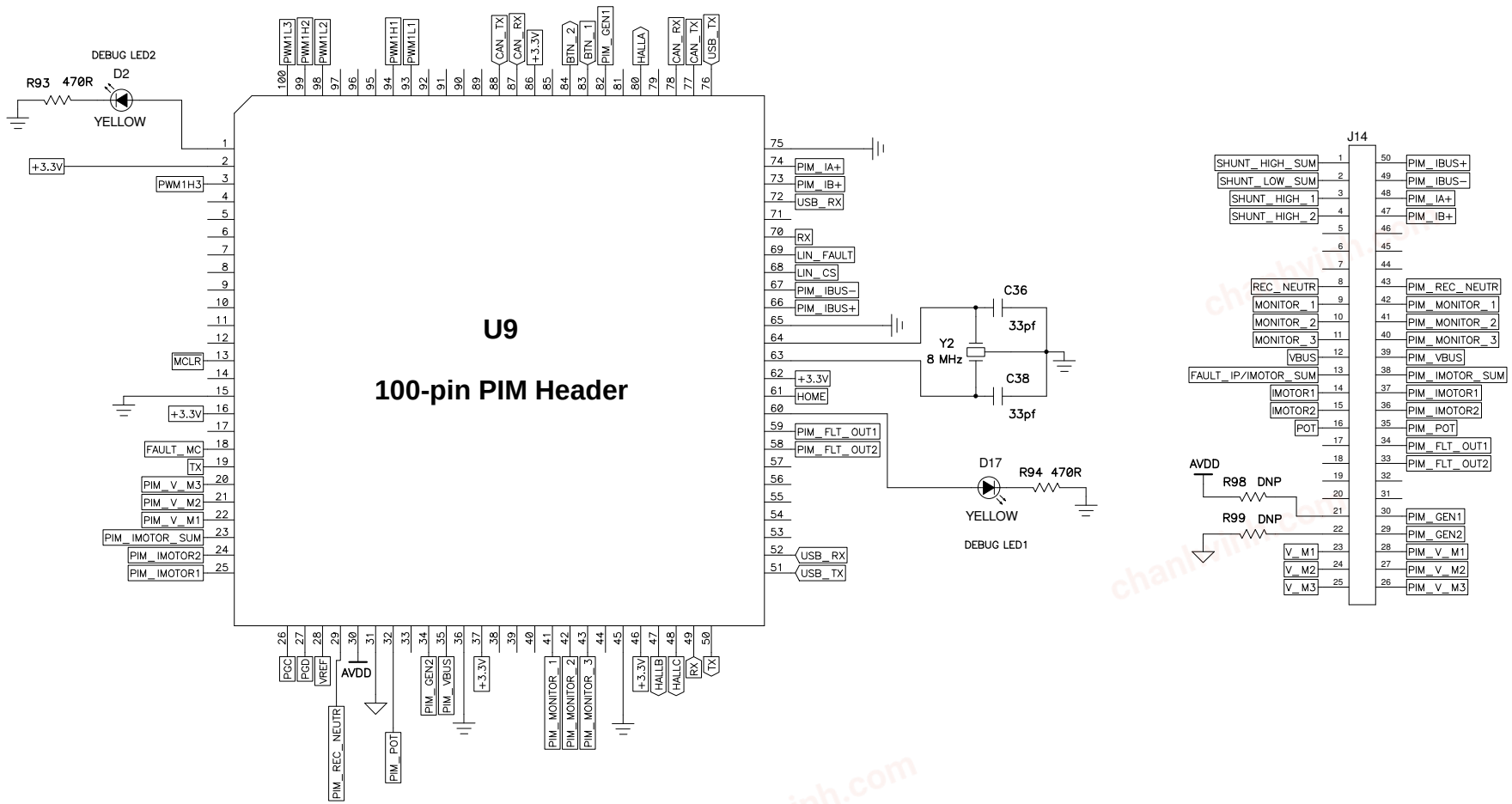
The following schematics are included in this user's guide:

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"

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

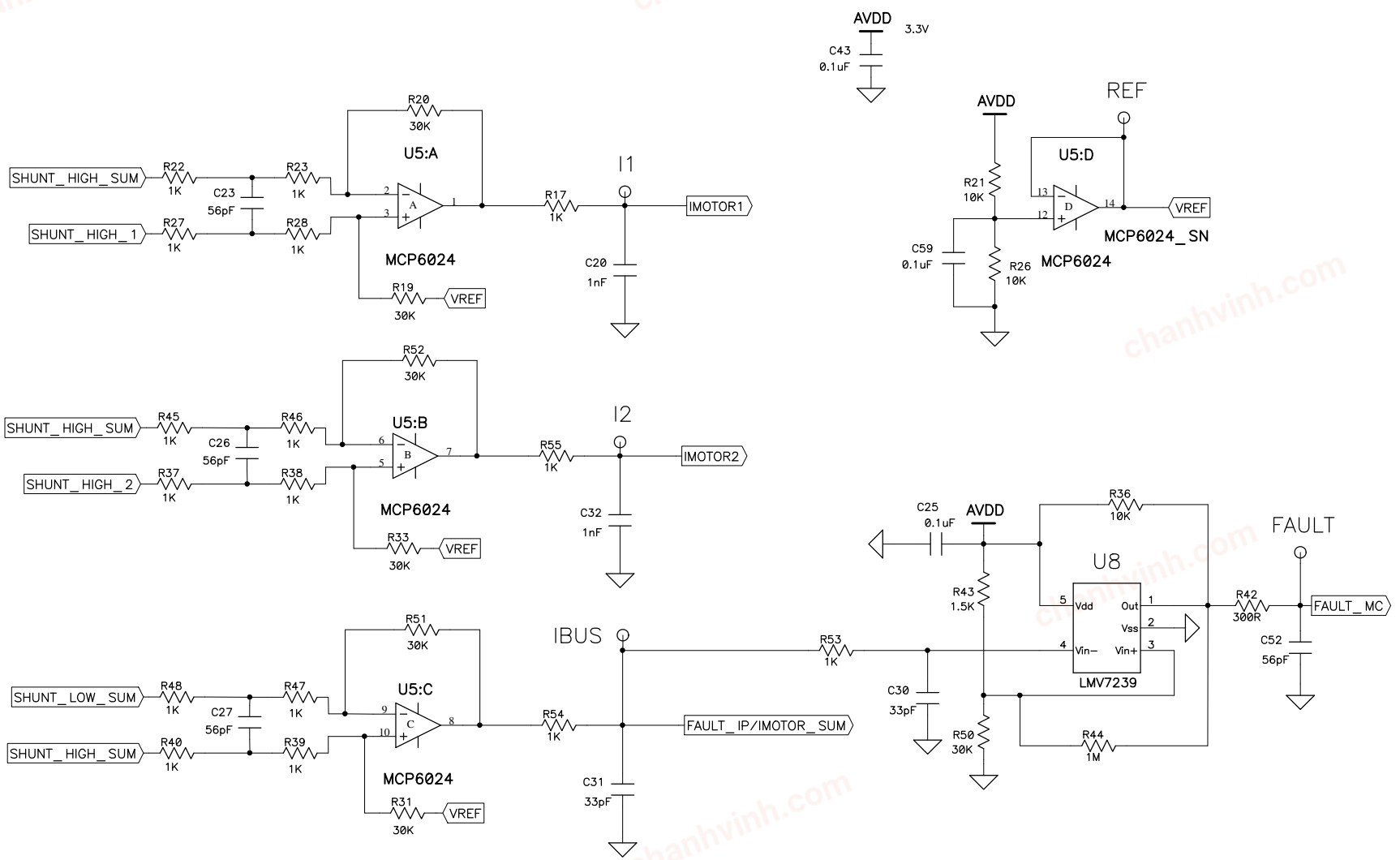


Note: For pin descriptions, please see **Table 2-1, "dsPICDEM MCLV-2 Development Board PIM Pinout Functionality,"** on page 18.

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



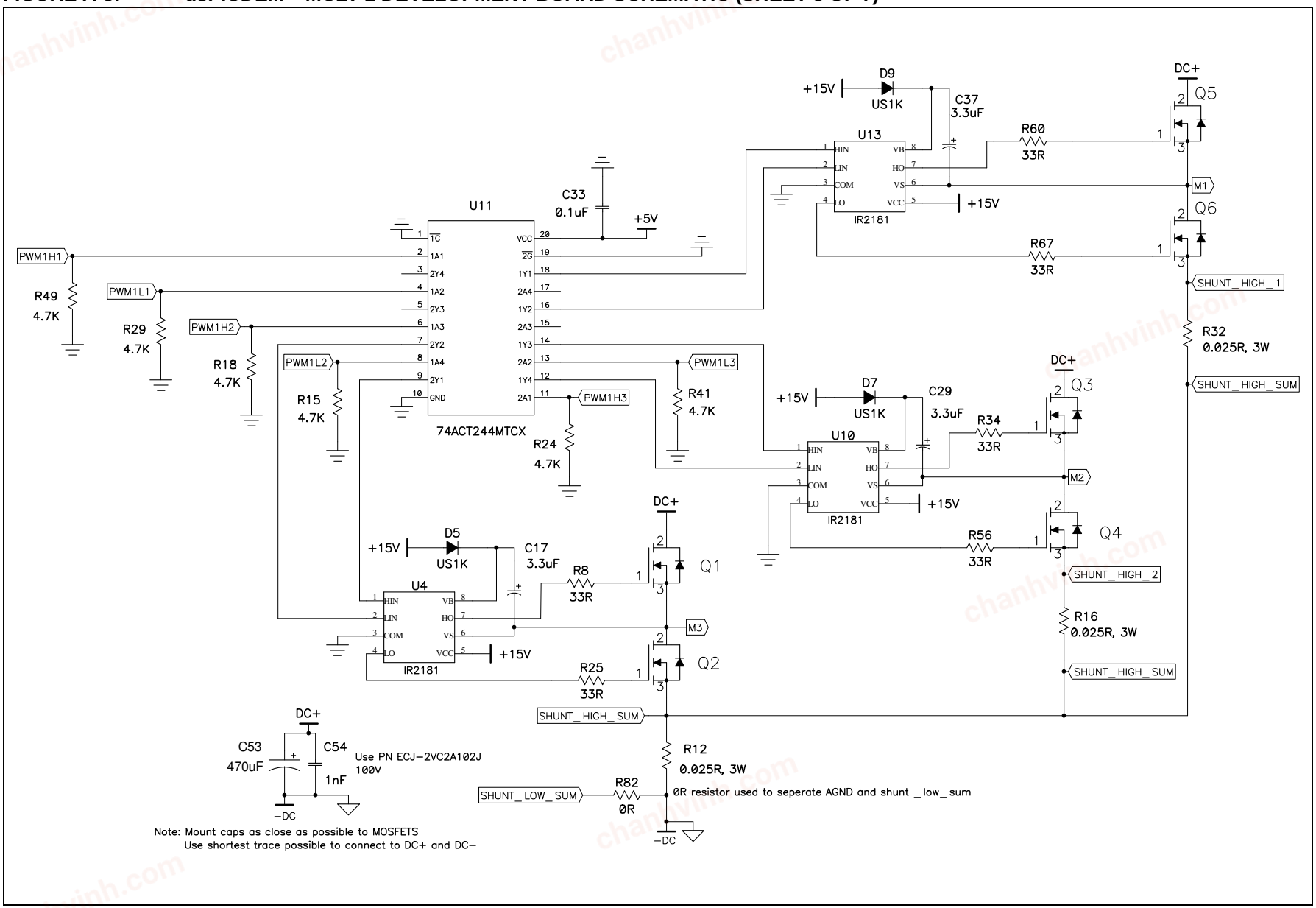
Note 1: All resistors on this page must be 1%.

2: Supply Voltage should be AVDD for MCP6024.

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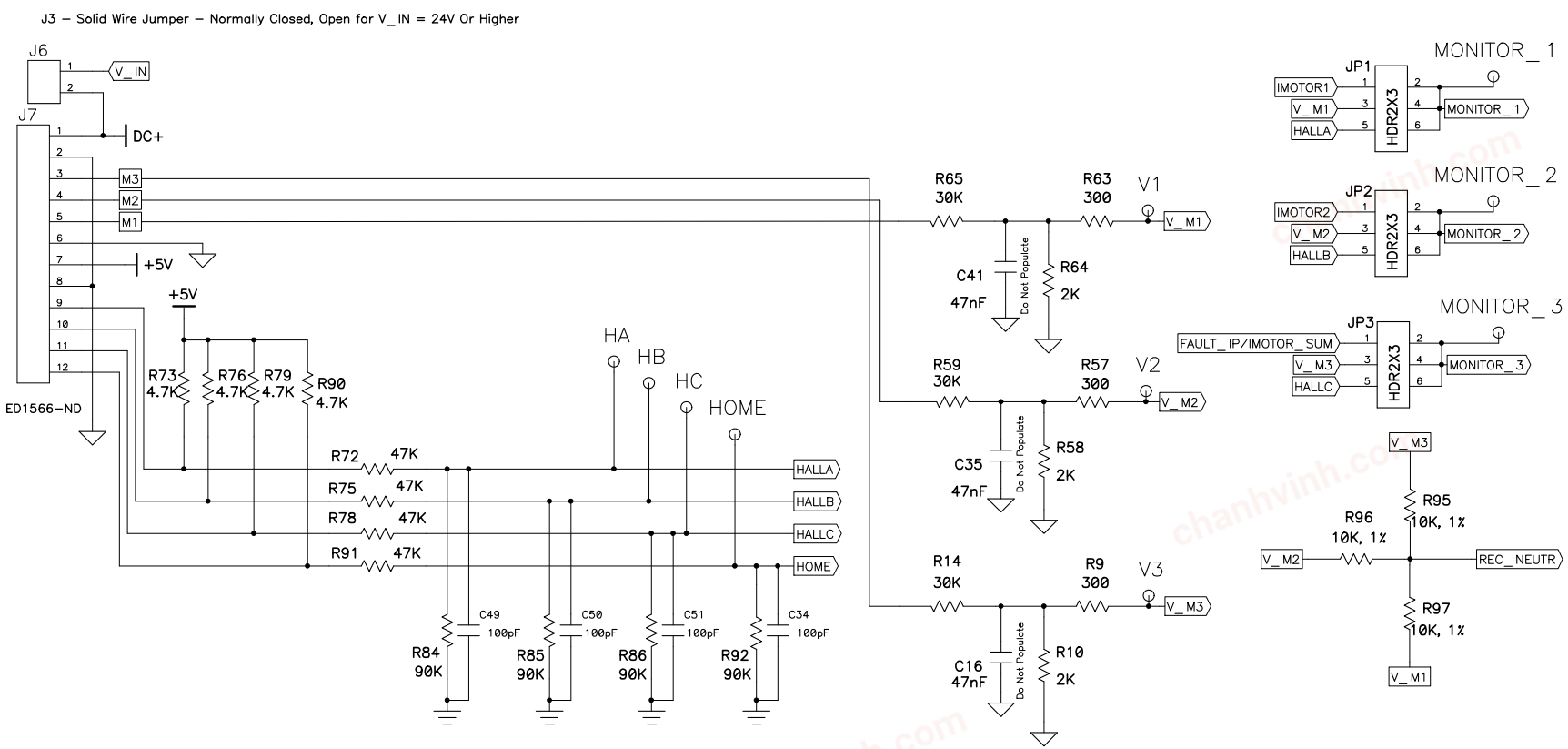
FIGURE A-3: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD SCHEMATIC (SHEET 3 OF 7)



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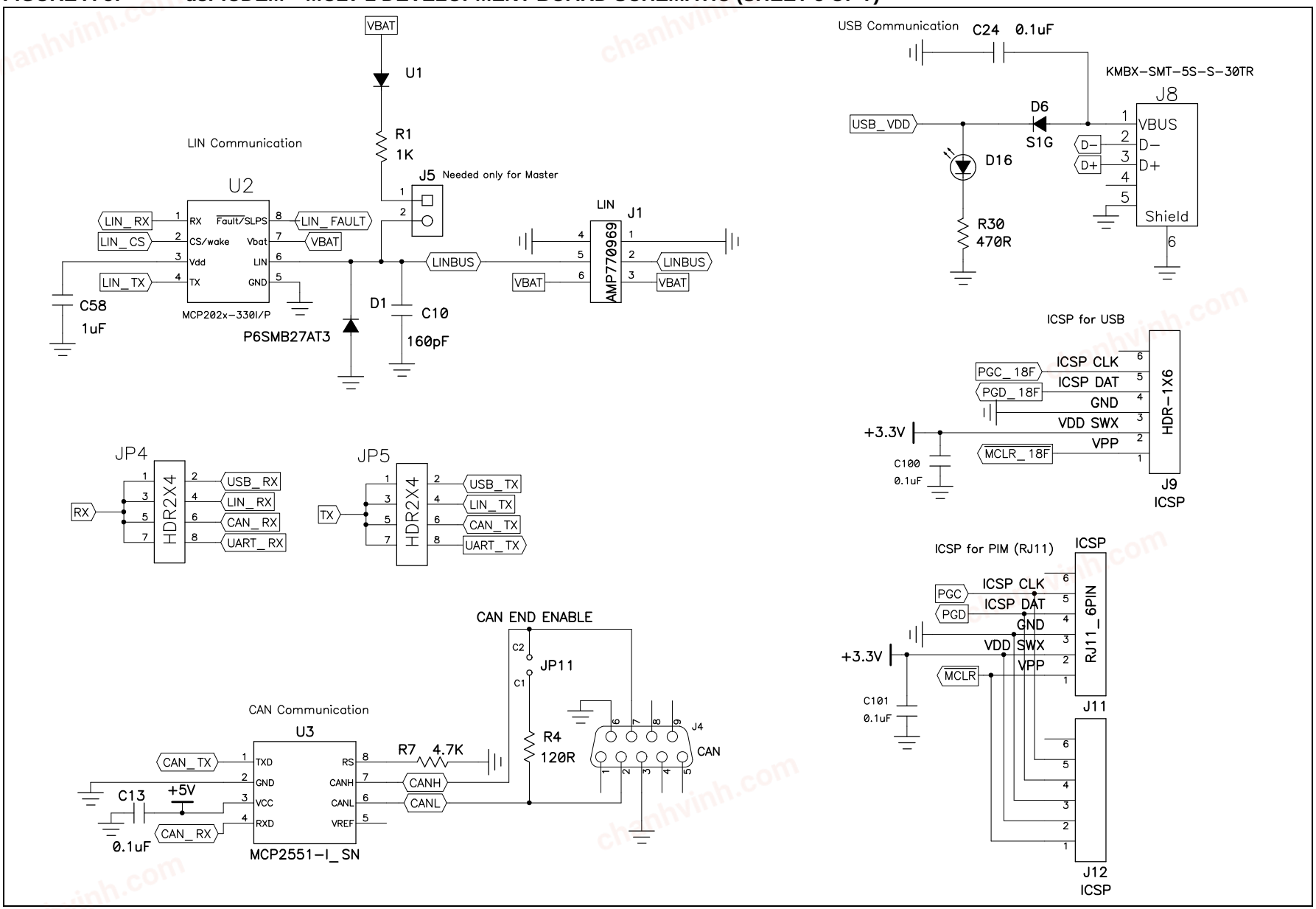
FIGURE A-4: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD SCHEMATIC (SHEET 4 OF 7)



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

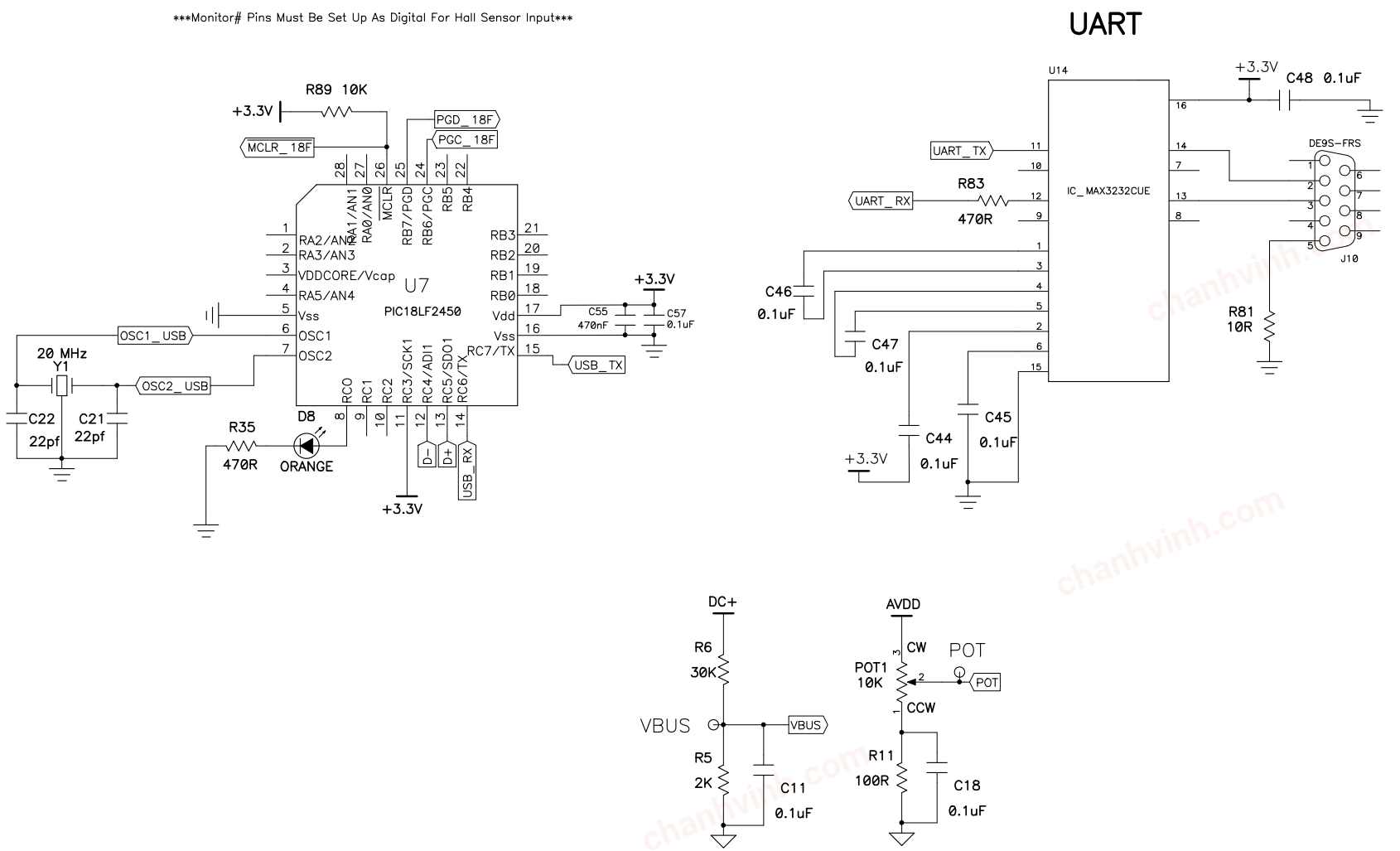


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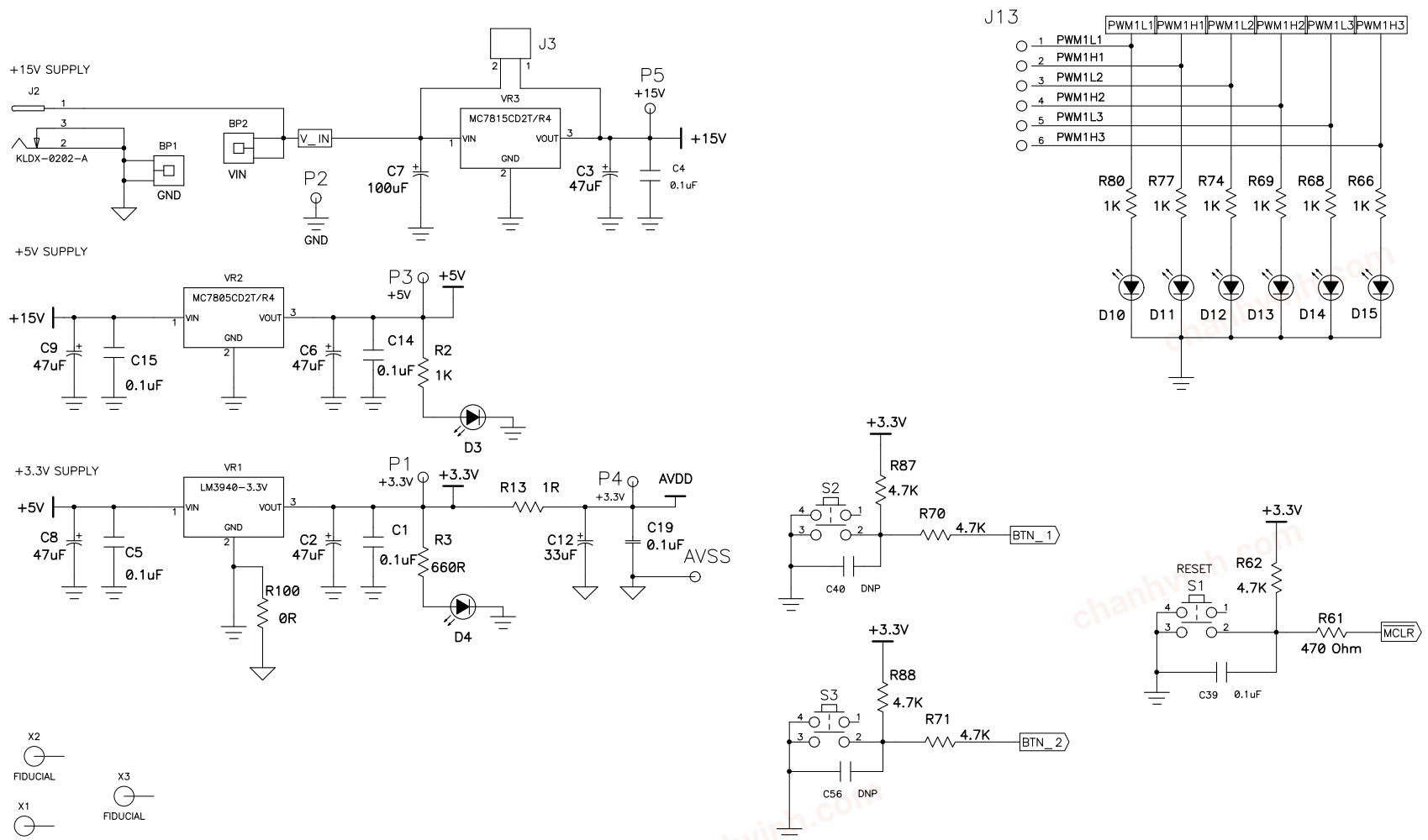
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FIGURE A-6: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD SCHEMATIC (SHEET 6 OF 7)



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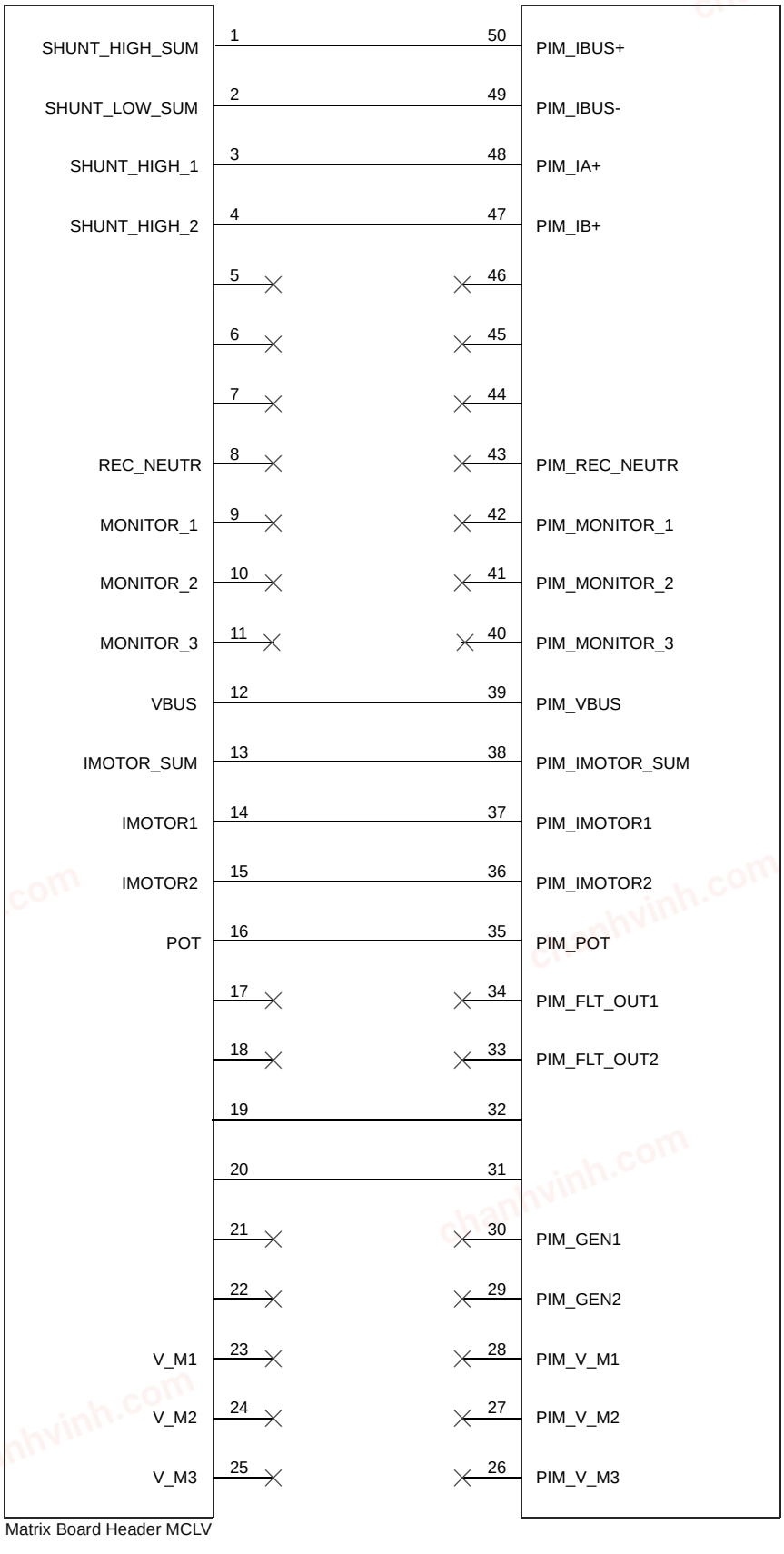
FIGURE A-7: dsPICDEM™ MCLV-2 DEVELOPMENT BOARD SCHEMATIC (SHEET 7 OF 7)



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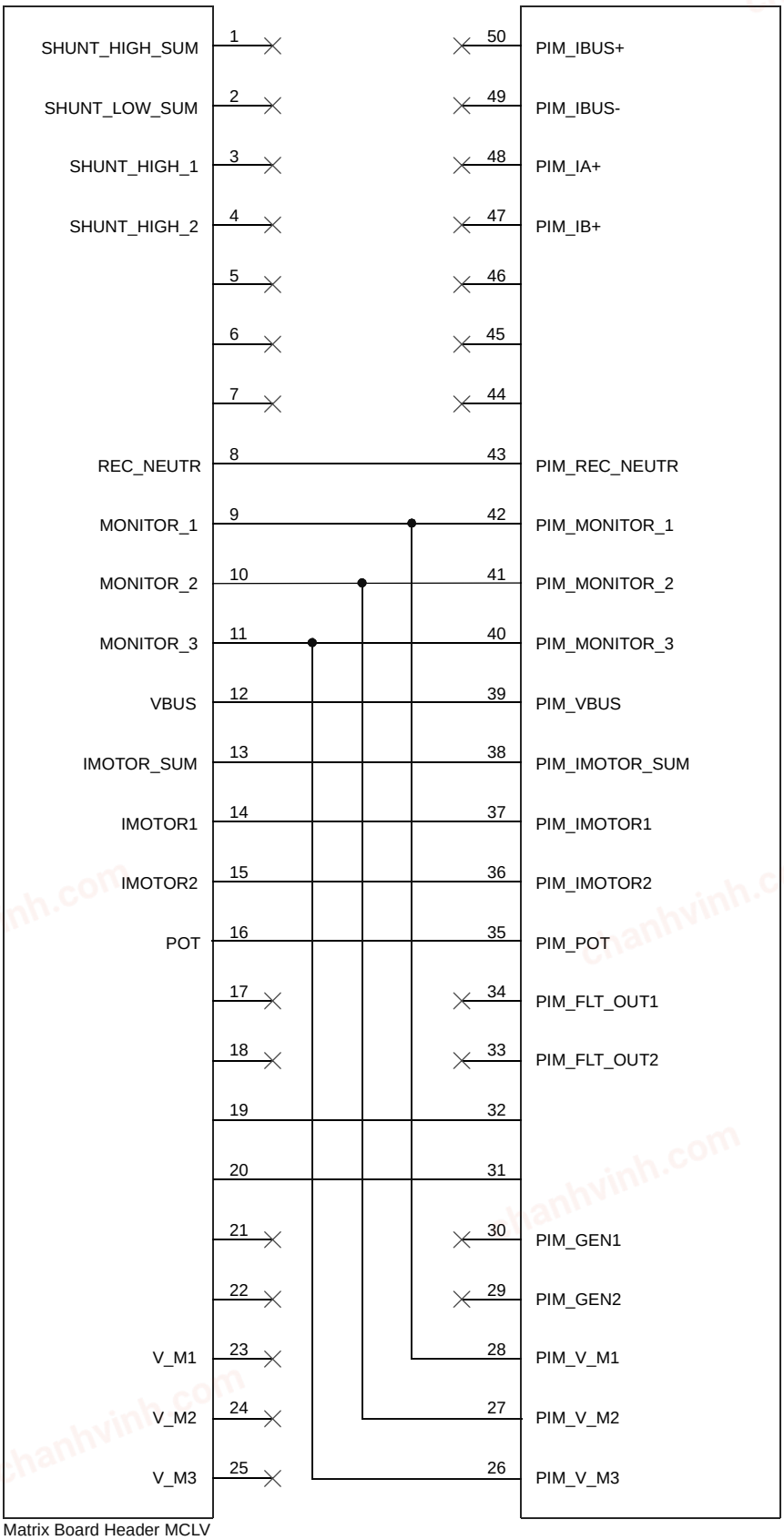
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FIGURE A-8: INTERNAL OP AMP CONFIGURATION MATRIX BOARD SCHEMATIC



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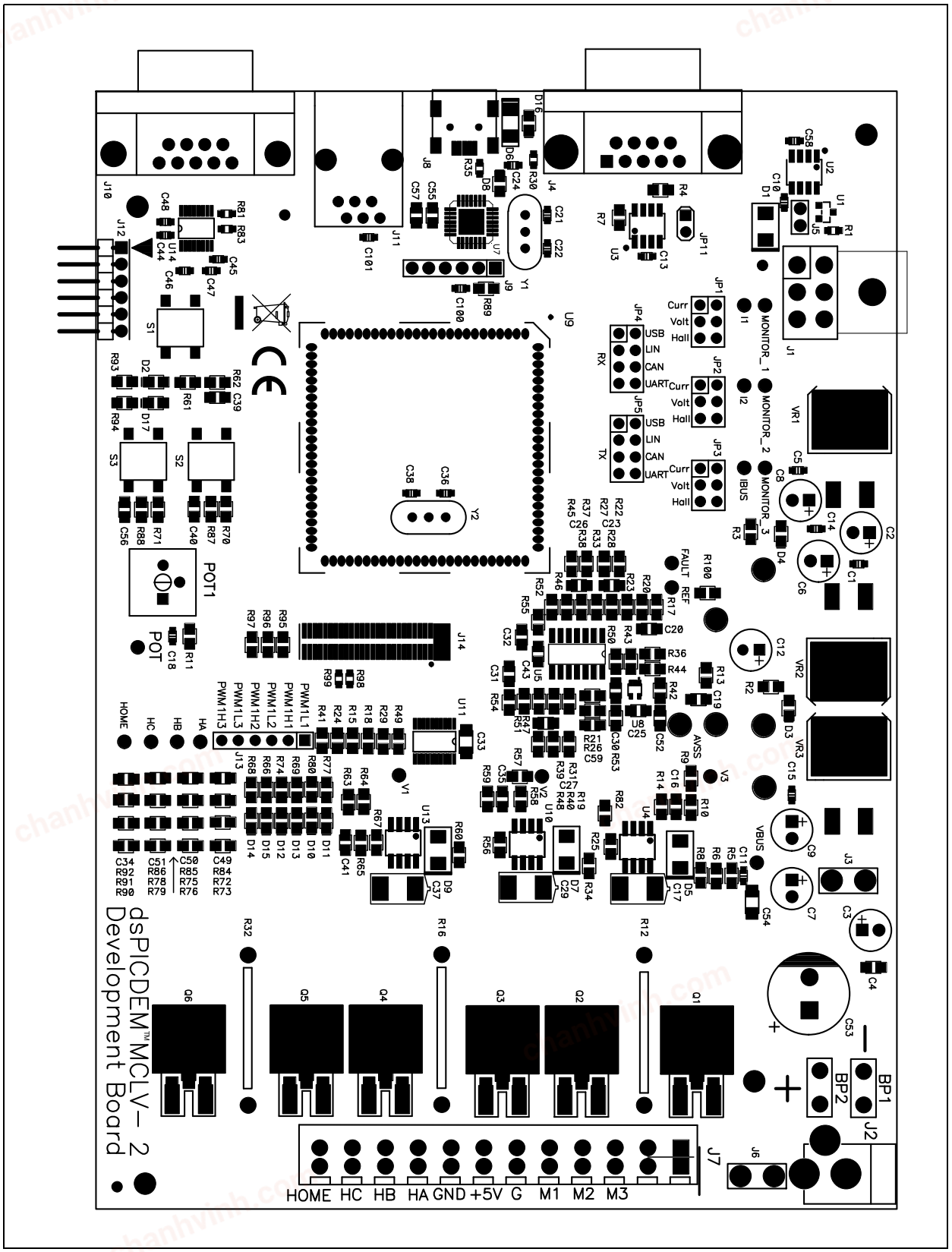
FIGURE A-9: EXTERNAL OP AMP CONFIGURATION MATRIX BOARD SCHEMATIC



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



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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	VDC
Power supply connected to J2 or BP1-BP2	J3 is open and VR3 is installed	16	24	VDC
Power supply connected to J2 or BP1-BP2	J3 is installed and VR3 is removed	10	16	VDC

TABLE B-2: DC OUTPUT RATING

Parameter	Min.	Typical	Max.	Unit
Voltage	0	24	48	VDC
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 D^2PAK 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.

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

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Fax: 91-20-2566-1513

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Fax: 81-66-152-9310

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