AN957 Demonstration ReadMe for the dsPICDEM™ MCHV-2 Development Board or dsPICDEM™ MCHV-3 Development Board with the dsPIC33CK256MP508 External Op-Amp Motor Control PIM (MPLAB® X IDE)

1. INTRODUCTION

This document describes the setup requirements for running the Sensored BLDC Motor Control Algorithm, which is referenced in AN957 "Sensored BLDC Motor Control" using a dsPICDEM™ MCHV-2 or MCHV-3 Development Board in the External Op Amp configuration.

The demonstration is configured to run on either the dsPICDEM™ MCHV-2 Development Board (DM330023-2) or the dsPICDEM™ MCHV-3 Development Board (DM330023-3) in the External Op-amp configuration with the dsPIC33CK256MP508 External Op-Amp Motor Control Plug-In Module (PIM) (MA330041-1).

2. SUGGESTED DEMONSTRATION REQUIREMENTS

2.1. Motor Control Application Firmware Required for the Demonstration

- `AN957_dsPIC33CK256MP508_EXT_OPAMP_MCLV2_MCHV2_MCHV3.zip`

> **Note:**
> In this document, hereinafter this firmware package is referred as firmware.

2.2. Software Tools Used for Testing the firmware

- MPLAB® X IDE v5.20
- MPLAB® XC16 Compiler v1.36b
- MPLAB® X IDE Plugin: X2C-Scope v1.3.0 or later

> **Note:**
> The software used for testing the firmware prior to release is listed above. It is recommended to use the version listed above or later versions for building the firmware.

2.3. Hardware Tools Required for the Demonstration

To set up the demonstration, you may use one of the High-Voltage Motor Control Development Boards mentioned below:

- dsPICDEM™ MCHV-2 Development Board (DM330023-2) or
- dsPICDEM™ MCHV-3 Development Board (DM330023-3)

> **Note:**
> In this document, hereinafter High-Voltage Motor Control Development Board selected for setting up the demonstration is referred as Development Board.

- High Voltage 3-Phase 220V AC Servomotor (AC300025)
- dsPIC33CK256MP508 External Op-Amp Motor Control Plug-in module (MA330041-1)

Note:

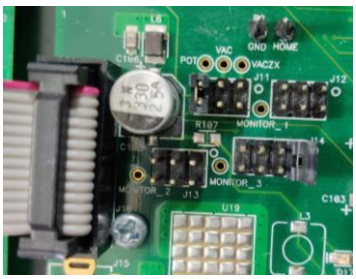
All items listed under the section 2.3. Hardware Tools Required for the Demonstration are available at microchip DIRECT.

3. HARDWARE SETUP

This section describes hardware setup required for the demonstration. Bus current feedback needed by the firmware is amplified by the operational amplifier provided on the Development Board. This is referred as '*external amplifier configuration*'.

Refer *dsPICDEM™ MCHV-2 Development Board User's Guide or dsPICDEM™ MCHV-3 Development Board User's Guide*, for any clarification while setting up the hardware.

1. ***Before making any connection, verify that the Development Board is not powered, and it is fully discharged. This can be done by checking if Power on Status LED D13(Red) is off.***
2. Open the top cover of the enclosure and setup the following jumpers (if they are not in specified positions):

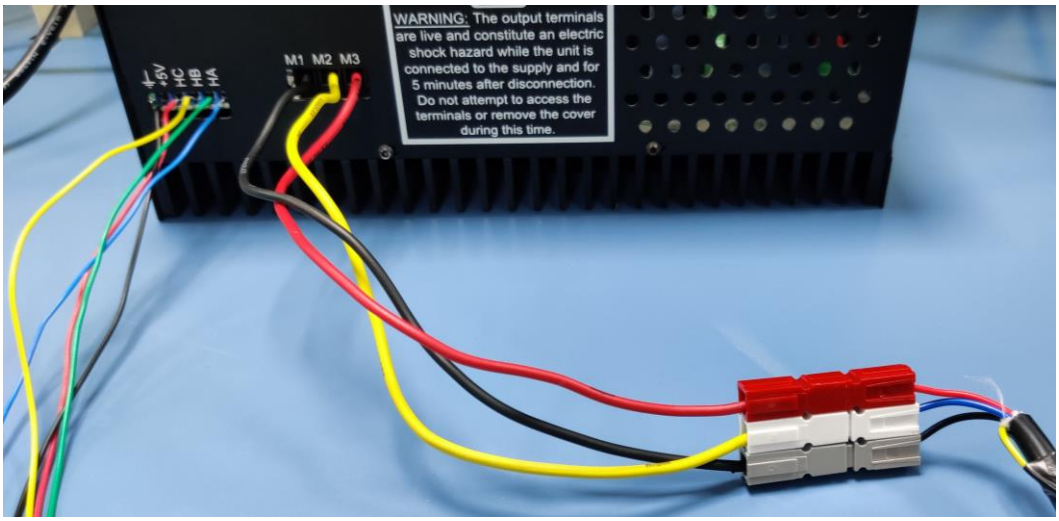
Jumper	Pins to Short	Board Reference	Remarks
J11	5-6		These Jumpers are present on the Development Board. *These can be accessed only after opening the top cover of the safety enclosure.*
J12	Don't Care		
J13	Don't Care		
J14	1-2		
PWM OUTPUTS	ENABLE position		These Jumpers can be accessed without opening the enclosure, from the front side of the board (or enclosure).
USB	USB position		

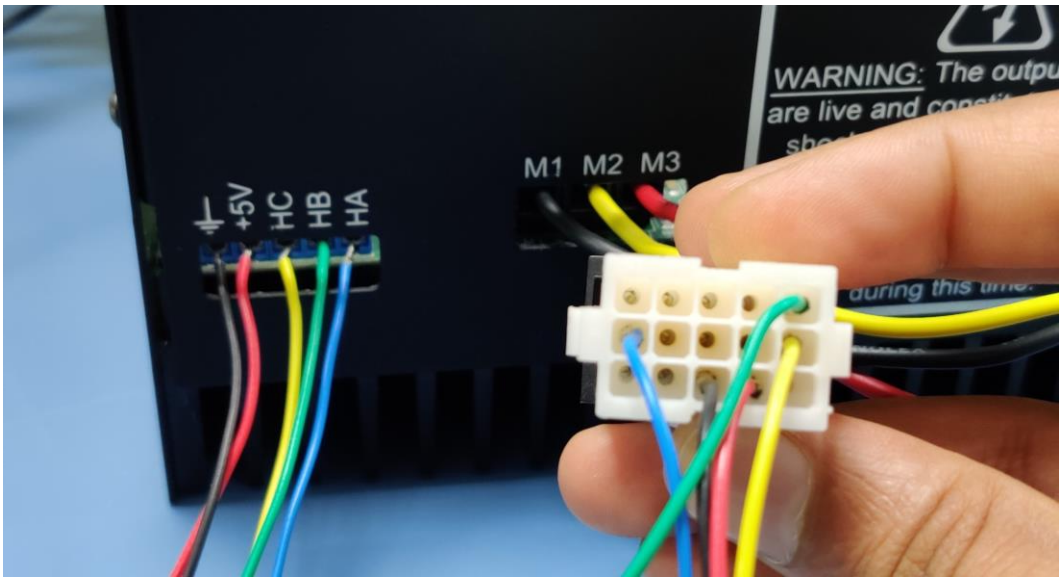
3. Connect the three phase wires from the motor to M1, M2, and M3 terminals of connector J17 provided on the Development Board as mentioned in the table below.

MCHV2 Board	High Voltage Motor	
	Winding Terminals (color as per datasheet, not as per picture below)	AMP172167-1 Pin Connections
M1	Black(V)	3
M2	Blue(U)	1
M3	Red(W)	2

4. Connect the hall sensors from the motor to HA, HB and HC terminals of J9 connector, provided on the Development Board as mentioned in the table below.

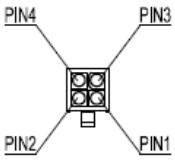
MCHV2 Board	High Voltage Motor	
	Hall Terminals (color as per datasheet, not as per picture below)	AMP172171-1 Pin Connections
5V	Red	2
GND	Black -	3
HA	White (W +)	10
HB	Grey (V +)	11
HC	Brown (U +)	6



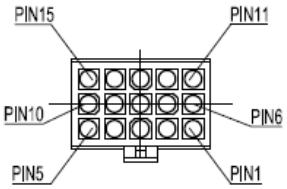


encoder connector															
pin	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
signal	shield	red	black	blue	pur/blk	brown	purple	Brown/blk	green	white	grey	White/blk	Gre/blk	Blue/blk	Grey/blk
colour	PE	5V	0V	B+	Z–	U+	Z+	U–	A+	W+	V+	W–	A–	B–	V–

winding connector				
pin	1	2	3	4
colour	blue	red	black	yel/gre
signal	U	W	V	PE



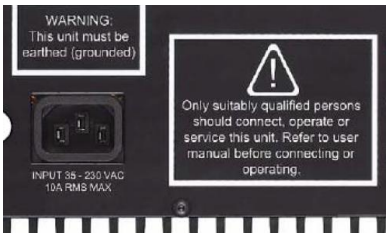
AMP172167-1



AMP172171-1

5. Connect the ‘External Op Amp Configuration Matrix board’ to matrix board header J4. Ensure the matrix board is correctly oriented before proceeding.

6. Insert the dsPIC33CK256MP508 External Op-Amp Motor Control PIM into the PIM Socket U11 provided on the Development Board. Make sure the PIM is correctly placed and oriented before proceeding.
7. Close the top cover of the enclosure and secure it with screws.
8. 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 J1 of the Development Board.



9. To program the device, a mini-USB connection is required between Host PC and the Development Board. Connect a mini-USB cable from your computer to the mini-USB connector “PROGRAM/DEBUG” of the Development Board. The development board features a Built-in isolated Programmer or Debugguer (Microchip Starter Kit).

10. Power up the Development Board by connecting power cord to the mains. To verify the unit is powered, make sure LEDs D6, D13, D16 and D18 are ON.

4. SOFTWARE SETUP AND RUN

4.1. Setup: MPLAB X IDE and MPLAB XC16 Compiler

Install MPLAB X IDE and MPLAB XC16 Compiler versions that support the device dsPIC33CK256MP508 assembled on the Plug-in Module (PIM). The version of the MPLAB X IDE, MPLAB XC16 Compiler and X2C plug-in used for testing the firmware are mentioned in the section Motor Control Application Firmware Required for the Demonstration. To get help on

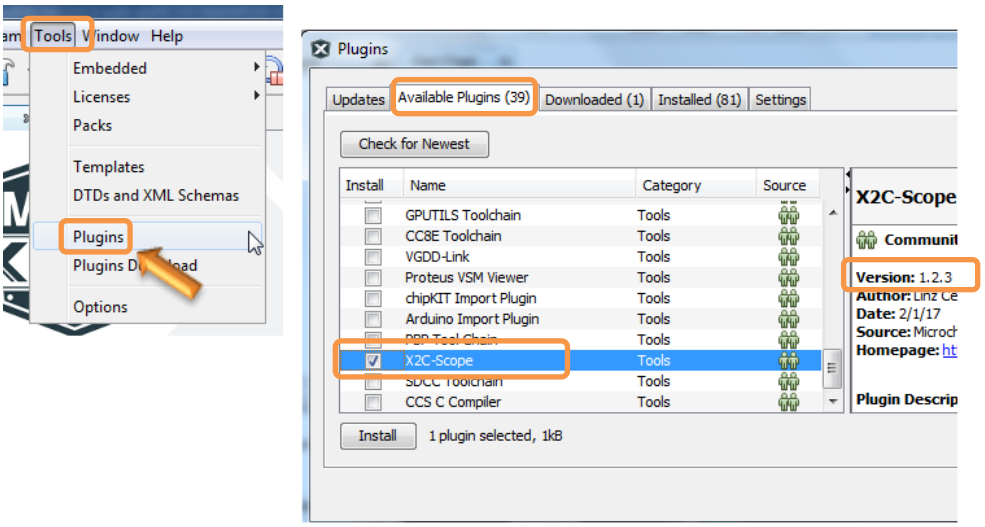
- MPLAB X IDE installation, refer link
- MPLAB XC16 Compiler installation steps, refer link

If MPLAB IDE v8 or earlier is already installed on your computer, then run the MPLAB driver switcher (It is installed when MPLAB X IDE is installed) to switch from MPLAB IDE v8 drivers to MPLAB X IDE drivers. If you have Windows 7 or 8, you must run MPLAB driver switcher in 'Administrator Mode'. To run the Device Driver Switcher GUI application as administrator, right click on the executable (or desktop icon) and select 'Run as Administrator'. For additional details refer MPLAB X IDE help topic *"Before You Begin: Install the USB Device Drivers (For Hardware Tools): USB Driver Installation for Windows Operating Systems".*

4.2 SETUP: X2C - SCOPE

X2C - SCOPE is a MPLAB X IDE plugin that allows a developer to interact with an application while the application program is running. X2C-Scope enables you to read, write, and plot global variables (for motor control) in real time. It communicates with the target using the UART. To use X2C, the plugin must be installed:

- In MPLAB X IDE, select `Tools>Plugins` and click on the **Available Plugins** tab.
- Select X2C - SCOPE plug-in by checking its check box, and then click **Install.**
- Look for tool X2C - SCOPE under `Tools>Embedded`.



5. BASIC DEMONSTRATION

5.1. Firmware Description

The firmware version required for the demonstration is mentioned under the section Motor Control Application Firmware Required for the Demonstration.

This firmware is implemented to work on Microchip's 16-bit Digital signal controller (dsPIC® DSC) dsPIC33CK256MP508. For more information, see the *dsPIC33CK256MP508 Family datasheet (DS70005349)*.

The Motor Control Demo application uses push button to start or stop the motor and potentiometer to vary speed of the motor.

For more details refer Microchip Application note AN957 "Sensored BLDC Motor Control Using dsPIC30F2010" available at Microchip web site.

Note:

The project may not build correctly in Windows OS if Maximum path length of any source file in the project is more than 260 characters. In case absolute path is exceeding or nearing maximum length, do any (or both) of the following:

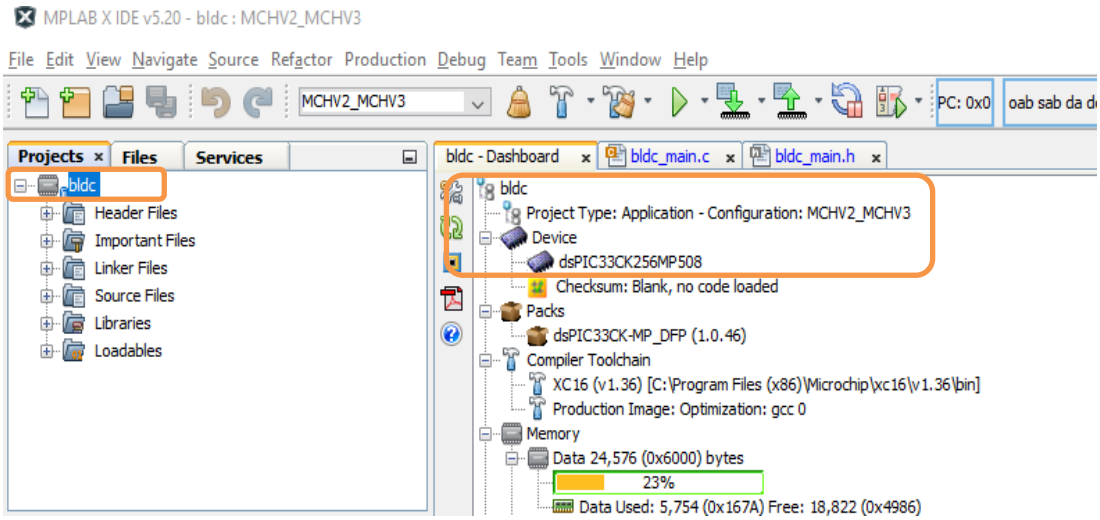
- Shorten the name of the directory containing the firmware used in this demonstration. In this case, rename directory `AN957_dsPIC33CK256MP508_EXT_OPAMP_MCLV2_MCHV2_MCHV3` to more appropriate shorter name. In case you renamed the directory, consider the new name while reading instructions provided in the upcoming sections of the document.
- Place firmware in a location, such that absolute path length of each file included in the projects does not exceed the Maximum Path length specified.

For details, refer MPLAB X IDE help topic *"Path, File and Folder Name Restrictions".*

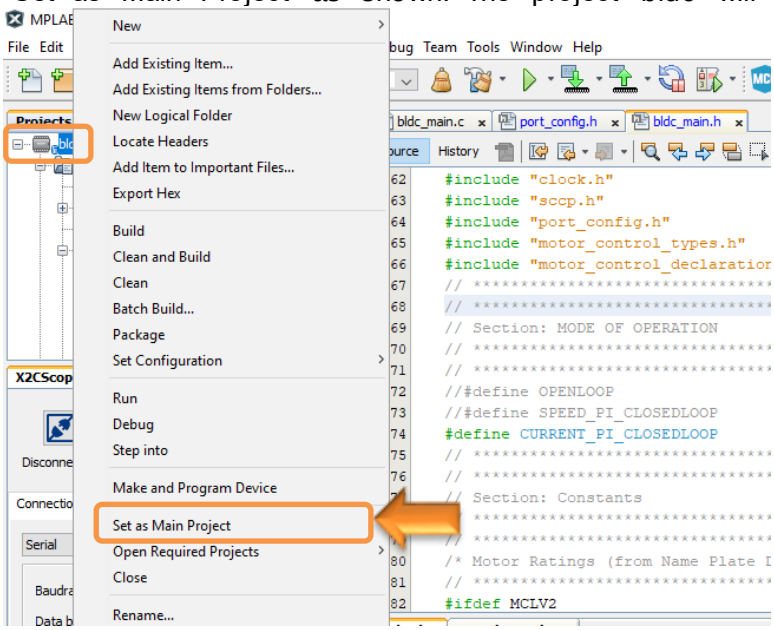
5.2. Basic Demonstration

Follow below instructions step by step to setup and run the motor control demo application:

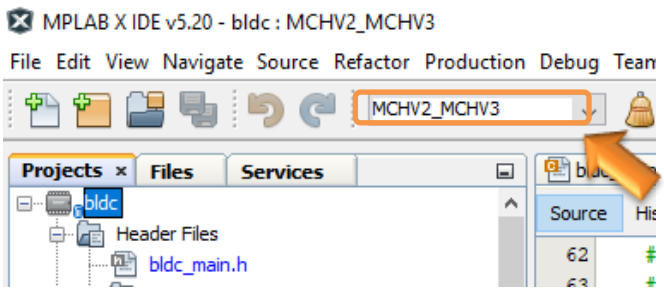
1. Start MPLAB X IDE and open (File>Open Project) the project *bldc.X* (*..\AN957_dsPIC33CK256MP508_EXT_OPAMP_MCLV2_MCHV2_MCHV3\bldc.X*) with device selection *dsPIC33CK256MP508*



2. Set the project *bldc.X* as main project by right clicking on the project name and selecting "Set as Main Project" as shown. The project "bldc" will then appear in **bold**.

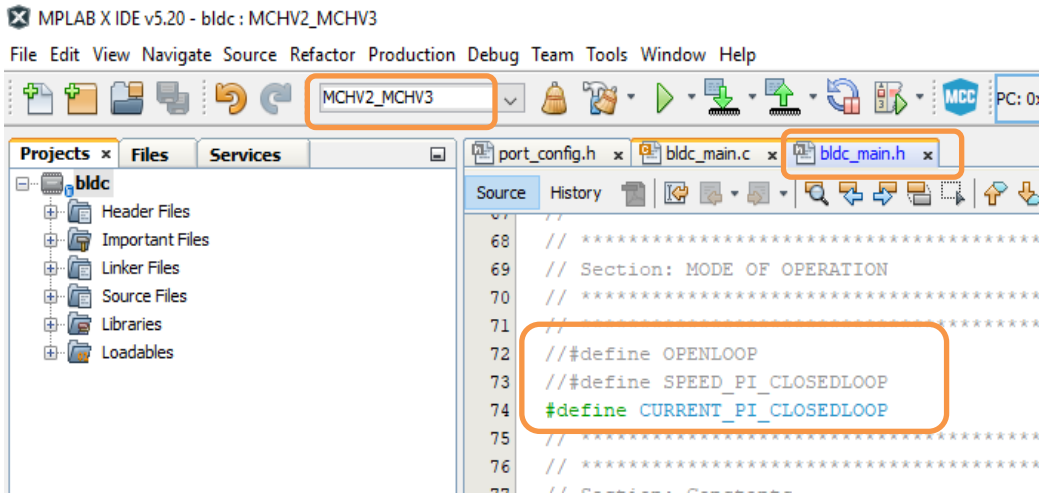


3. Select project configuration as "MCHV2_MCHV3" from the Project Configuration drop down box on the toolbar as shown:



There may be multiple project configurations available for *bldc.X*.

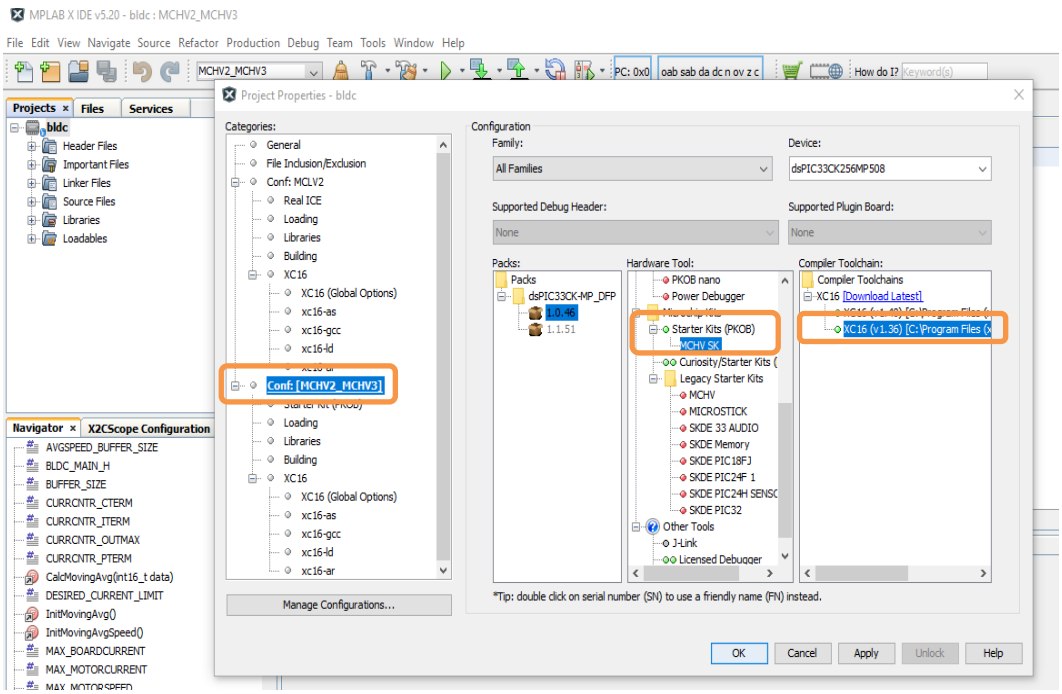
4. Open `bldc_main.h` (under `bldc.X -> headerfiles`) in the project `bldc.X` and ensure any one of the modes of operation is defined. The user may choose any one of the available modes i.e. `OPENLOOP`, `SPEED_PI_CLOSEDLOOP`, or `CURRENT_PI_CLOSEDLOOP`. (ensure only one is selected at a time).



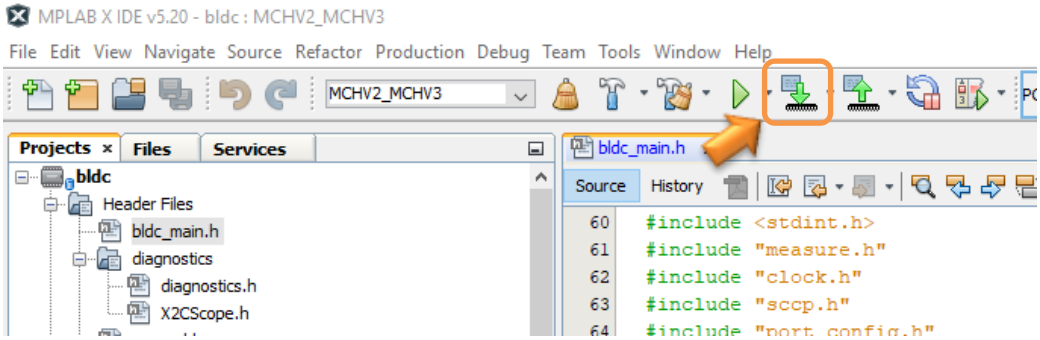
5. Right click on the project `bldc.X` and select “Properties” to open its Project Properties Window. Click the “Conf: [MCHV2_MCHV3]” category to reveal the general project configuration information.

   In the *‘**Conf-MCHV2_MCHV3’*** category window:

   - Select the specific Compiler Toolchain from the available list of compilers. Please ensure MPLAB® XC16 Compiler supports the device dsPIC33CK256MP508.In this case “XC16(v1.36)” is selected. The compiler used for testing the firmware is listed in the section 2.2 Software Tools Used for Testing the firmware.
   - Select the Hardware Tool to be used for programming and debugging. In this case, “MCHV-SK” is selected as the programmer from Microchip Starter Kits section.
   - After selecting Hardware Tool and Compiler Toolchain, click button **Apply.**



6. To build the project (in this case *bldc.X*) and program the device dsPIC33CK256MP508, click "**Make and Program Device Main project**" on the toolbar.



7. If the device is successfully programmed, **LED D19** will be turned ON, indicating that the dsPIC® DSC is enabled.
8. Run or Stop the motor by pressing the push button **S1**(labeled as **"PUSHBUTTON"**) on the front panel of the board. The function of the pushbutton (Run/Stop the motor) is indicated by turning ON or OFF **LED D2**.

9. If desired, the motor speed can be varied using the potentiometer (labeled **"POT**").

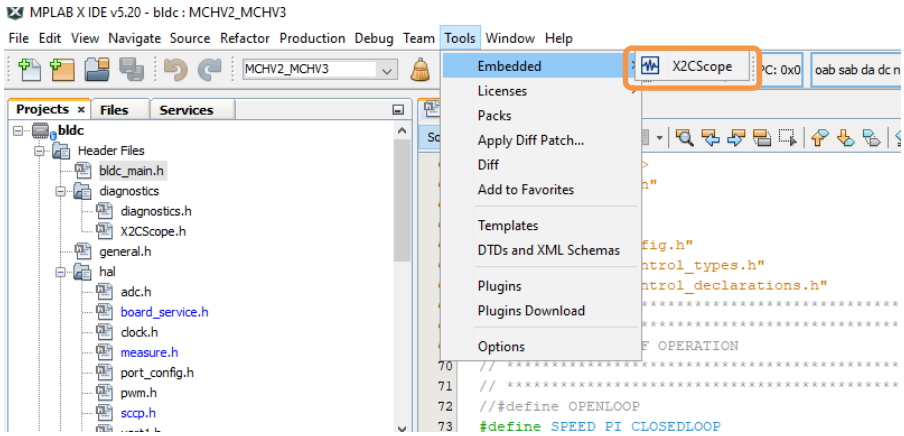
Note:

The macro definitions `MAX_MOTORSPEED, MAX_MOTORCURRENT, POLEPAIRS, SECTOR and MAX_BOARDCURRENT` are specified in `bldc_main.h` file included in the project *bldc.X*. The definitions `MAX_MOTORSPEED and MAX_MOTORCURRENT` are defined as per the specification provided by the Motor manufacturer. ***Exceeding manufacturer specification may lead to damage to the motor or (and) the board.***

6. Data visualization through X2CScope Plug-in of MPLABX

The application firmware comes with initialization required to interface Controller with Host PC to enable Data visualization through X2C Scope plug-in. X2C-Scope is a third-party plugin for MPLAB X which facilitates real-time diagnostics.

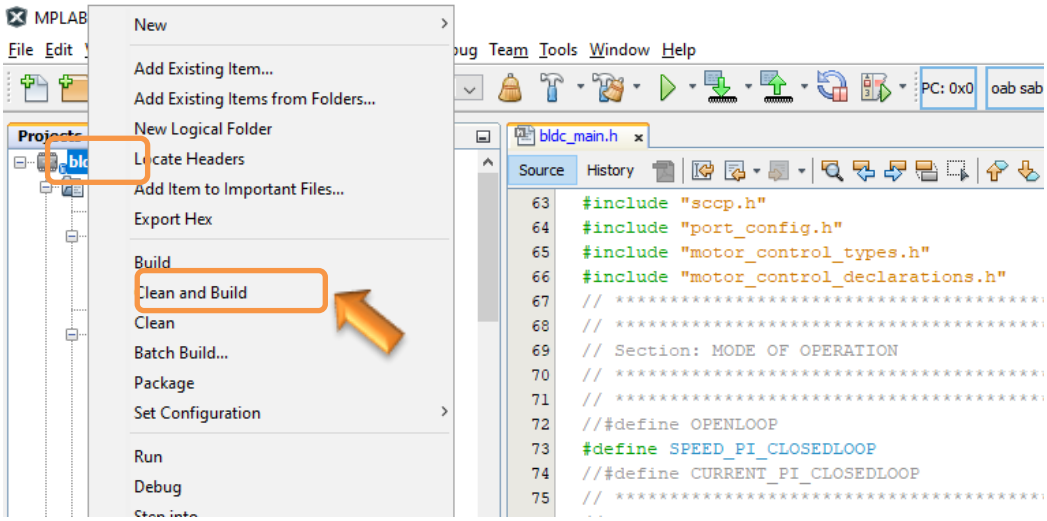
1. Ensure X2C Scope Plug-in is installed. For additional information on how to set up a plug-in refer to https://microchipdeveloper.com/mplabx:tools-plugins-available



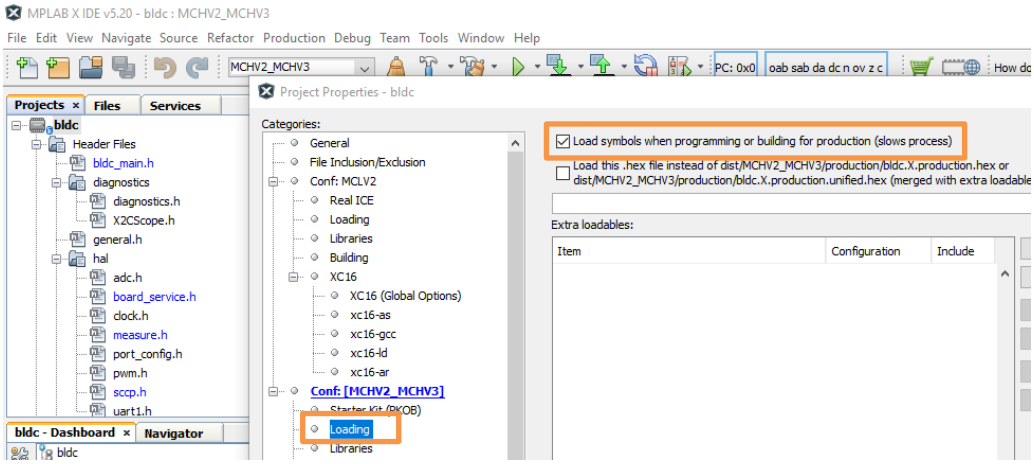
2. To utilize X2C communication for this demonstration, a mini-USB connection is required between Host PC and dsPICDEM™ MCHV-2 Development Board or dsPICDEM™ MCHV-3 Development Board. Connect a mini-USB cable from your computer to the J6 connector (labeled as “USB” on the front panel of the board enclosure) of the Development Board and install USB drivers if necessary.

3. Ensure application is configured and running as described under Section Basic Demonstration by following steps 1 through 9.

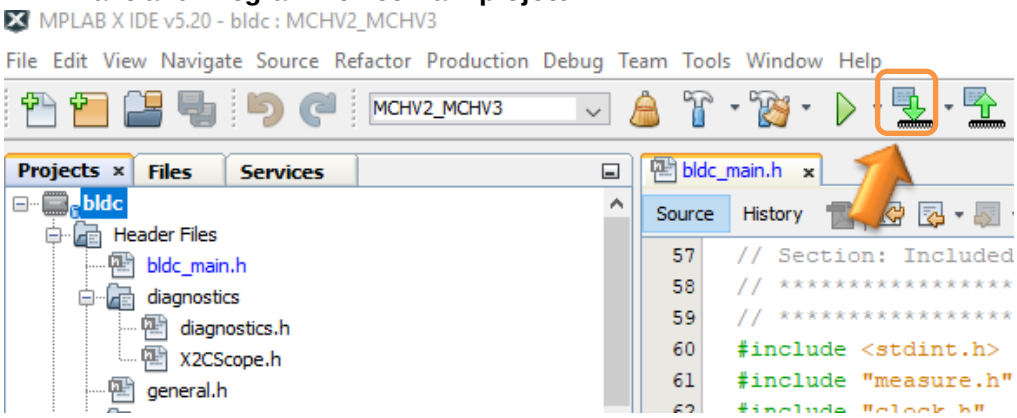
4. Build the project *bldc.X*. To do that right click on the project *bldc.X* and select “Clean and Build”.



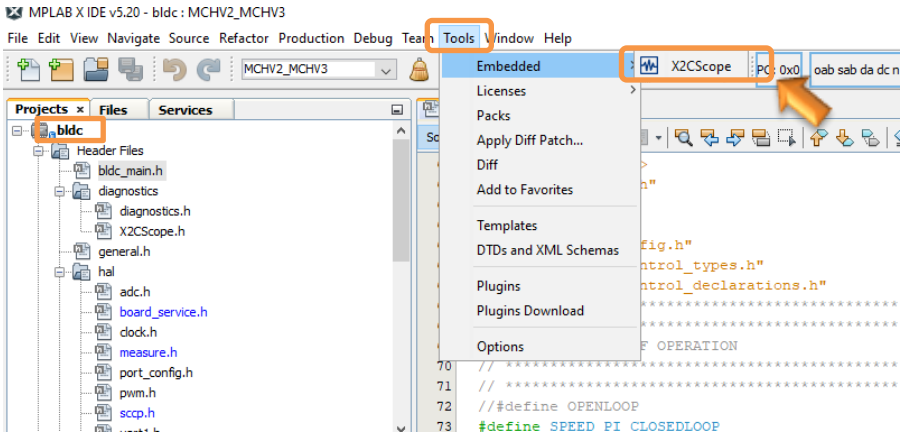
5. Please ensure that the checkbox “Load symbols when programming or building for production (slows process)” is checked, which is under the “Loading” category of the Project Property dialog.



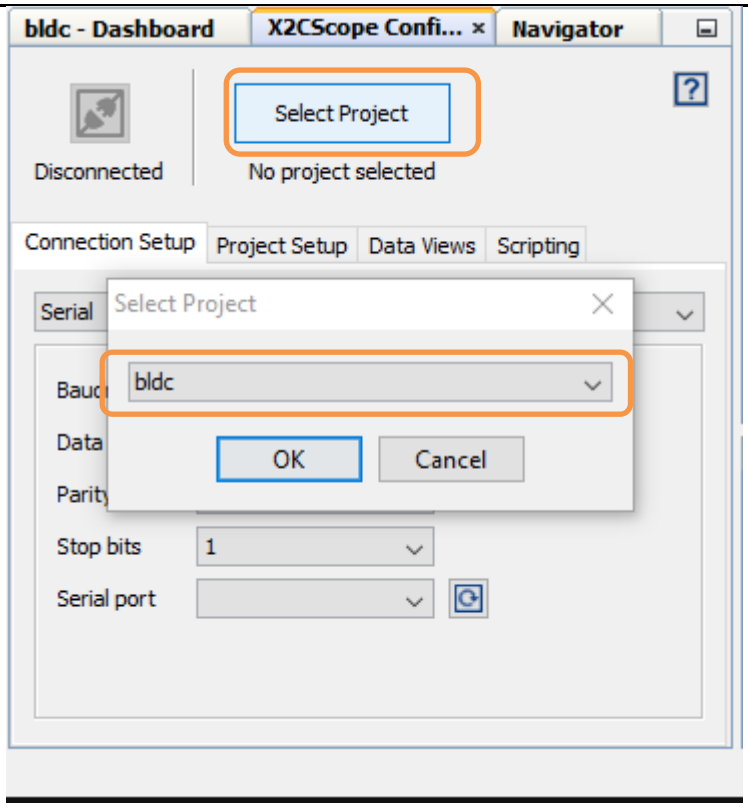
6. To build the project (in this case *bldc.X*) and program the device dsPIC33CK256MP508, click "**Make and Program Device Main project**" on the toolbar.



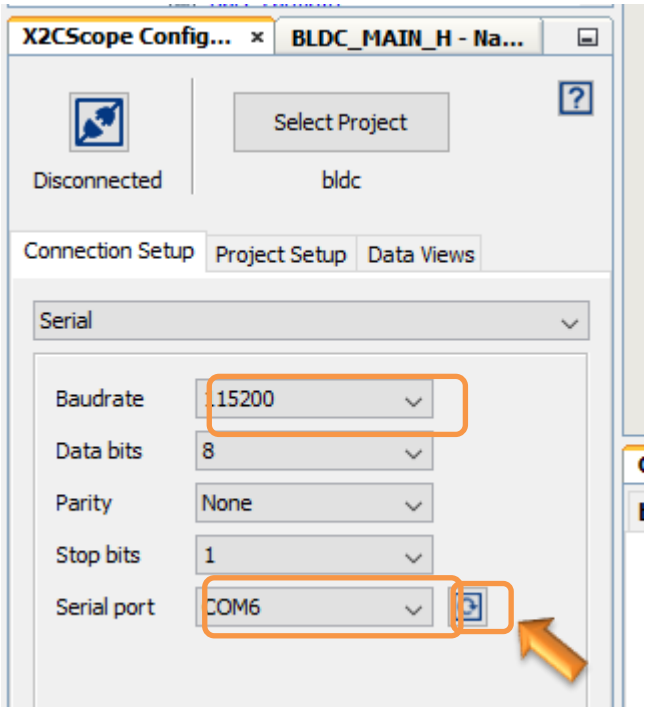
7. Open the X2C window by selecting `Tools>Embedded>X2CScope`.



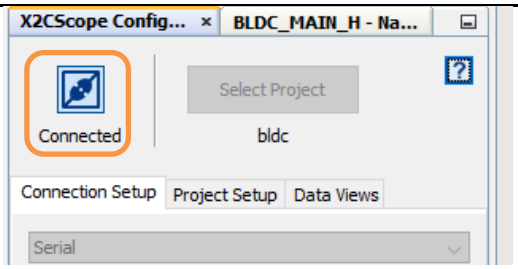
8. Open the X2CScope Configuration window and in "Select project" menu, select **bldc** project as shown.



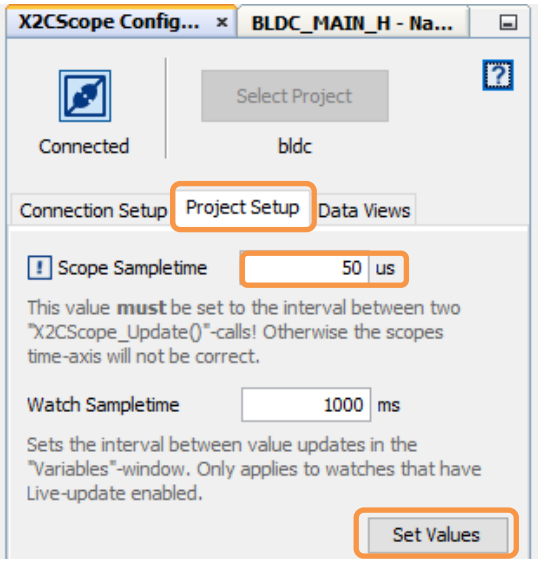
9. Remote Communication needs to be established, as indicated in the following figure. Ensure the communication baud rate is set to 115200 as the same is set in the application firmware, while COM port used depends on the system settings. `Refresh button` lists the available COM Ports. Select the COM Port as per the connection.



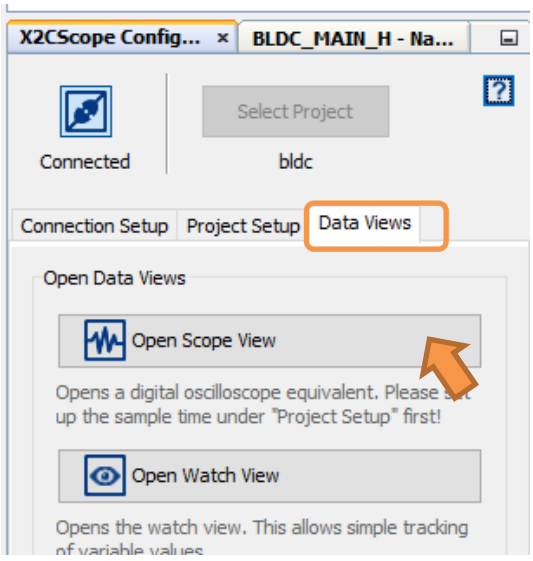
10. Once COM port detected, click on "**Disconnected**", and it will be turn into "**Connected**", if the link is established as programmed.



11. Set the "Project Setup" as shown below and click "Set Values". Set Scope sample time as interval at which `X2CScopeUpdate()` is called. In this application it is every 20kHz (50µs).



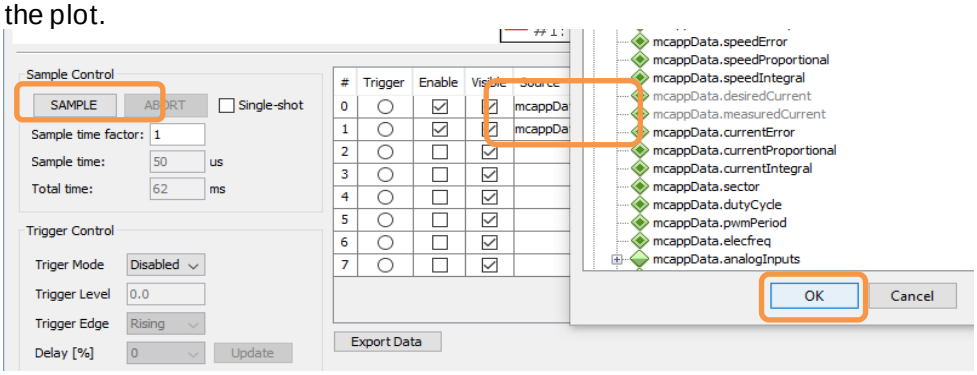
12. When the setup is established, click on Open Scope View (under sub window "Data Views"), this open Scope Window.



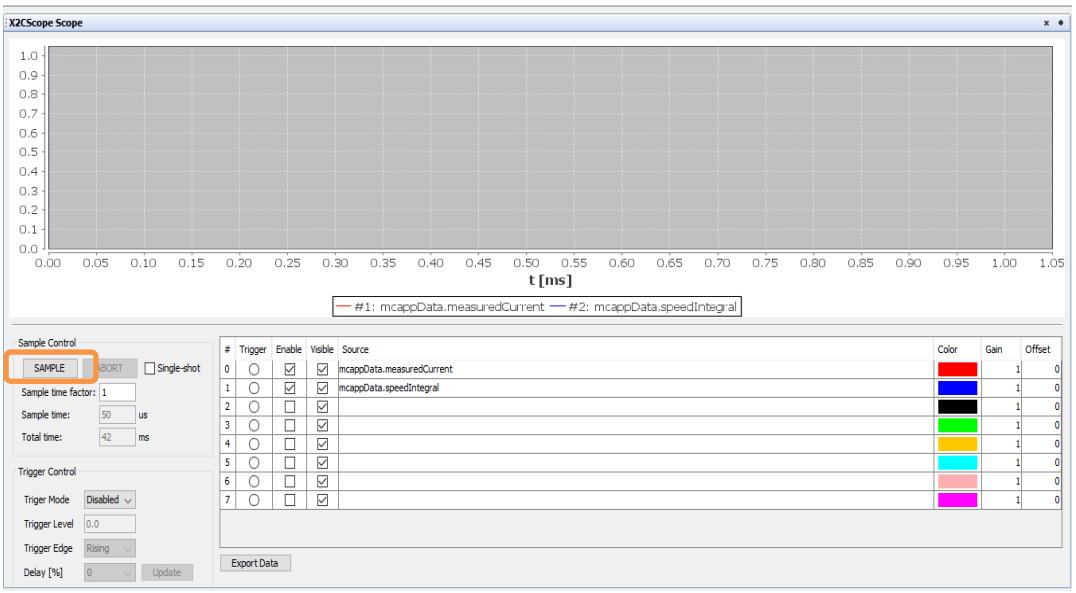
13. In this window, select the variables that needs to be monitored. To do this, click on the source against each channel, a window Select Variables opens upon the screen. From the available list, the required variable can be chosen. Ensure check boxes `Enable` & `Visible` are checked for the variables to be plotted.

    To view data plots continuously, uncheck `Single-shot`. When `Single-shot` is checked

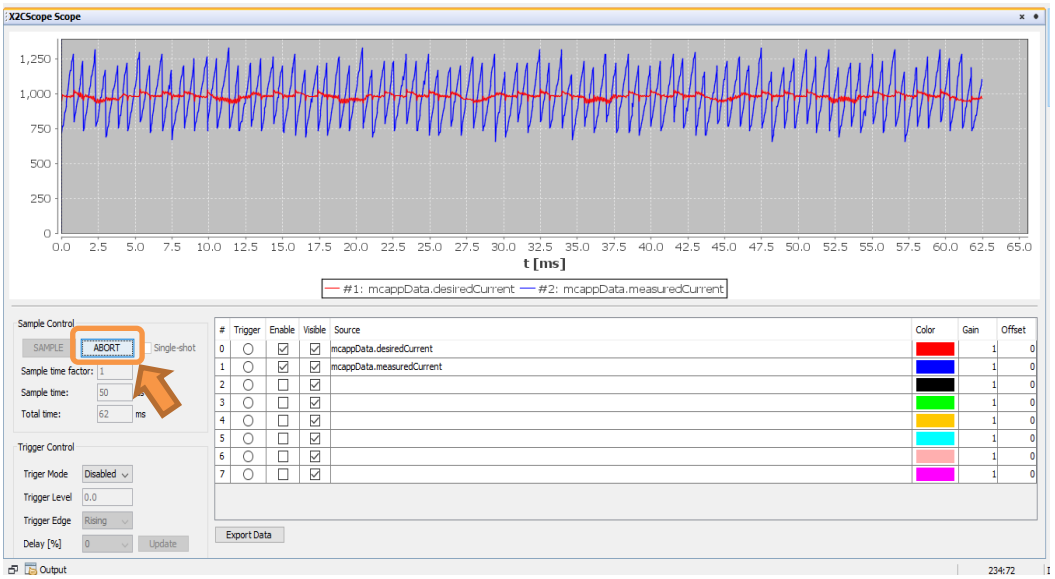
it captures the data once and stops. The `Sample time factor` value multiplied with `Sample time` determines the time difference between any two consecutive data points on the plot.



14. Click on SAMPLE, then X2C scope window shows variables in real time, which is updated automatically.



15. Click on ABORT to stop.



7. dsPIC® DSC RESOURCE USAGE SUMMARY

7.1. Device Pin Mapping and Its Functionality in the Firmware:

The following table summarizes device pins configured and used in the AN957 motor control application firmware demonstrated using the Development Board and the dsPIC33CK256MP508 External Op-Amp Motor Control PIM(MA330041-1). Refer "*dsPIC33CK256MP508 External Op-Amp Motor Control Plug-in-Module (PIM) Information Sheet (DS50002757)"* for more information.

Functional Description	PIM PIN Number	Device PIN Number	Device Pin Name	Signal Type	Remarks
Motor Control PWMs					
PWM1H	PIM:94	1	RP46/**PWM1H**/PMD5/**RB14**	PWM Output	Connects to Power Module U19 Input IN(UH)
PWM1L	PIM:93	3	RP47/**PWM1L**/PMD6/**RB15**	PWM Output	Connects to Power Module U19 Input IN(UL)
PWM2H	PIM:99	78	TDI/RP44/**PWM2H**/PMD3/**RB12**	PWM Output	Connects to Power Module U19 Input IN(VH)
PWM2L	PIM:98	80	RP45/**PWM2L**/PMD4/**RB13**	PWM Output	Connects to Power Module U19 Input IN(VL)
PWM3H	PIM:03	75	TMS/RP42/**PWM3H**/PMD1/**RB10**	PWM Output	Connects to Power Module U19 Input IN(WH)
PWM3L	PIM:100	76	TCK/RP43/**PWM3L**/PMD2/**RB11**	PWM Output	Connects to Power Module U19 Input IN(WL)
Analog Inputs – Bus Currents, Speed Reference					
POT	PIM:32	36	**AN19**/CMP2C/RP75/PMA0/PMALL/PSA0/**RD11**	Analog Input	Speed Reference Connected to Potentiometer POT
IBUS	PIM:43	23	**AN17**/ANN1/IBIAS1/RP54/PMD12/PMA12/**RC6**	Analog Input	Connected to bus current through External Op-Amp Matrix Board and Jumper J14
Hall Sensor Connections					
HALL A	PIM:80	73	RP65/PWM4H/**RD1**	Digital Input	Connected to PIM (5V tolerant)
HALL B	PIM:47	72	RP66/**RD2**	Digital Input	Connected to PIM (5V tolerant)
HALL C	PIM:48	69	RP67/ASCL3/**RD3**	Digital Input	Connected to PIM (5V tolerant)
Miscellaneous Signals					
BTN	PIM:68	24	**RE5**	Digital Input	Connected to Push Button S1 (labeled "PUSHBUTTON"
Debug LED2	PIM:60	42	**RE8**	Digital Output	Connected to LED D19
Debug LED1	PIM:01	44	**RE9**	Digital Output	Connected to LED D2
RX (UART)	PIM:49	52	**RP71**/PMD15/**RD7**	UART1 Input	Connected to UART-USB converter to establish serial communication interface between Host PC and the dsPIC® DSC as needed by DMCI-RTDM.
TX (UART)	PIM:50	53	**RP70**/PMD14/**RD6**	UART1 Output	Connected to UART-USB converter to establish serial communication interface between Host PC and the dsPIC® DSC as needed by DMCI-RTDM.

8. References:

For additional information, refer following documents or links.

1. AN957 “Sensored BLDC Motor Control Using dsPIC30F2010”.
2. dsPICDEM™ MCHV-2 Development Board User’s Guide (DS52074)
3. dsPICDEM™ MCHV-3 Development Board User’s Guide (DS50002505)
4. dsPIC33CK256MP508 External Op-Amp Motor Control Plug-in-Module (PIM) Information Sheet (DS50002757)
5. dsPIC33CK256MP508 Family datasheet (DS70005349).
6. Family Reference manuals (FRM) of dsPIC33CK256MP508 family
7. MPLAB® X IDE User’s Guide (DS50002027) or MPLAB® X IDE help
8. MPLAB® X IDE installation
9. MPLAB® XC16 Compiler installation

