AN1292 Demonstration ReadMe for the MCLV-48V-300W Inverter Board with the dsPIC33CK256MP508 Motor Control Dual In-line Module (MPLAB® X IDE)

1. INTRODUCTION

This document describes the setup requirements for running the Sensor-less FOC algorithm with a PLL Estimator, which is referenced in AN1292 "*Sensorless Field Oriented Control (FOC) for a Permanent Magnet Synchronous Motor (PMSM) Using a PLL Estimator and Field Weakening (FW)*" using MCLV-48V-300W Inverter Board and dsPIC33CK256MP508 Motor Control Dual In-line Module (DIM).

2. SUGGESTED DEMONSTRATION REQUIREMENTS

2.1. Motor Control Application Firmware Required for the Demonstration

- `AN1292_dsPIC33CK256MP508_MCLV48V300W.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 v5.50 or later
- DFP: dsPIC33CK-MP_DFP v1.6.176
- MPLAB® XC16 Compiler v1.70
- 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

- MCLV-48V-300W Inverter Board (EV18H47A)
- dsPIC33CK256MP508 Motor Control DIM (EV62P66A)
- 24V Power Supply (AC002013)
- 24V 3-Phase Brushless DC Motor (AC300020)

> **Note:**
>
> All items listed under this section Hardware Tools Required for the Demonstration are available at microchip DIRECT.

3. HARDWARE SETUP

This section describes the hardware setup needed for the demonstration.

1. Motor currents are amplified on the MCLV-48V-300W Inverter Board; it can also be amplified by the amplifiers internal to the dsPIC33CK256MP508 populated on the DIM. By default, the firmware and DIM are configured to sample and convert internal amplifier outputs ('internal op-amp configuration'), measuring the motor currents needed for implementing FOC.

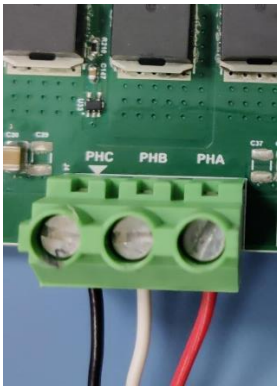
   The Table-1 summarizes the resistors to be populated and removed to convert the DIM from internal op-amp configuration to external op-amp configuration or vice versa.

TABLE 1: SELECTION BETWEEN EXTERNAL AND INTERNAL AMPLIFIER OUTPUTS

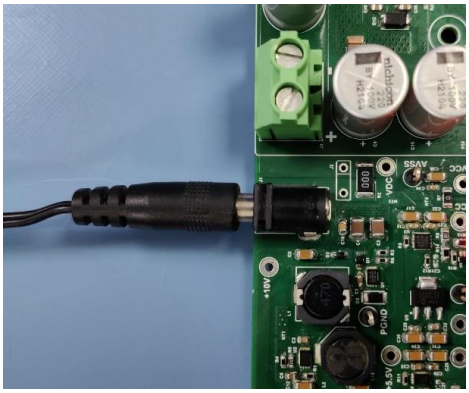
Current Signal	Internal Amplifier Output		External Amplifier Output		Firmware setting
	Jumper Resistor Settings on the DIM				
	Populate	Remove	Populate	Remove	
Phase Current **IA or IA_EXT**	R9	R6	R6	R9	• Configure and enable amplifiers in internal Op-Amp Configuration. • Ensure to disable the internal amplifiers in external Op-Amp Configuration.
Phase Current **IB or IB_EXT**	R29	R25	R25	R29	
Bus Current **IBUS or IBUS_EXT**	R14	R10, R7 and R5	R10	R14, R7 and R5	

2. Insert the dsPIC33CK256MP508 Motor Control DIM into the DIM Interface Connector J8 provided on the MCLV-48V-300W Inverter Board. Make sure the DIM is placed correctly and oriented before going ahead.

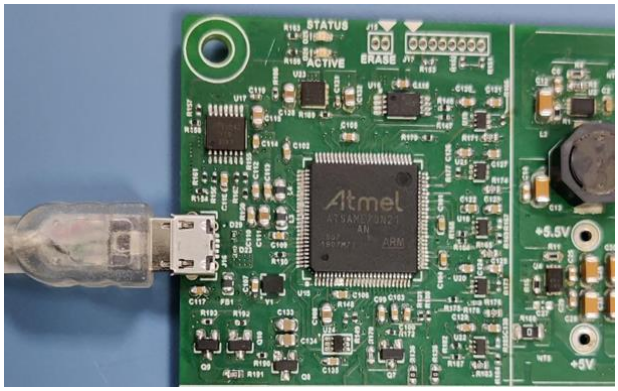
3. Connect the 3-phase wires from the motor to PHC, PHB, and PHA of the J4 connector (no specific order), provided on the MCLV-48V-300W Inverter Board.



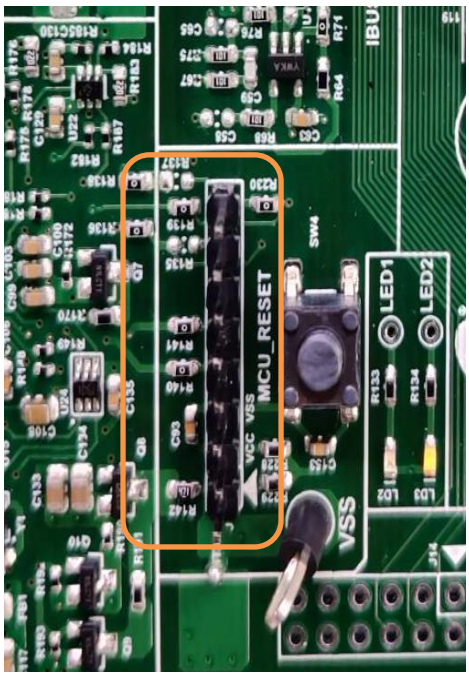
4. Plug in the 24V power supply to connector J1 provided on the MCLV-48V-300W Inverter Board. Alternatively, the Inverter Board can also be powered through Connector J2.



5. The board has an onboard programmer 'PICKIT™ On Board (PKOBv4)", which can be used for programming or debugging the dsPIC33CK256MP508. To use an on-board programmer, connect a micro-USB cable between Host PC and Connector J16 provided on the MCLV-48V-300W Inverter Board.



6. Alternatively, connect the Microchip programmer/debugger MPLAB PICkit 4 In-Circuit Debugger to the ICSP header J9 of the MCLV-48V-300W Inverter Board as shown below and to the Host PC used for programming the device. Ensure that PICkit 4 is connected in the correct orientation.



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 and PKOBv4. The MPLAB X IDE, MPLAB XC16 Compiler, and X2C-Scope plug-in used for testing the firmware are mentioned in the Motor Control Application Firmware Required for the Demonstration section. To get help on

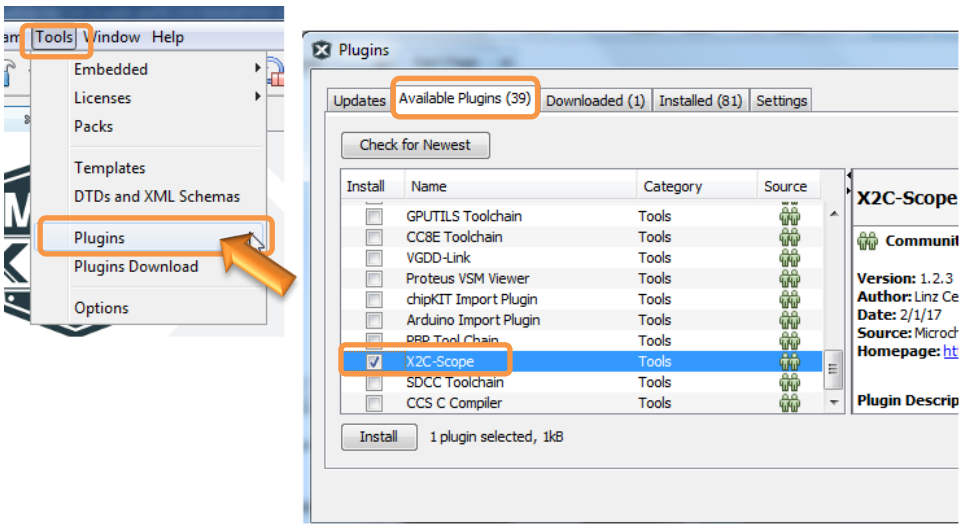
- MPLAB X IDE installation, refer to link
- MPLAB XC16 Compiler installation steps, refer to link

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 more details, refer to 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 an 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 in real-time. It communicates with the target using the UART. To use X2C-Scope, 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 clicking Install.
- Look for tool X2C-Scope under *Tools->Embedded*.



5. BASIC DEMONSTRATION

5.1. Firmware Description

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

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 a push button to start or stop the motor and a potentiometer to vary the speed of the motor. This Motor Control Demo Application configures and uses peripherals like PWM, ADC, UART, etc.

For more details, refer to Microchip Application note AN1292 "Sensorless Field Oriented Control (FOC) for a Permanent Magnet Synchronous Motor (PMSM) Using a PLL Estimator and Field Weakening (FW)" available on the Microchip website.

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:

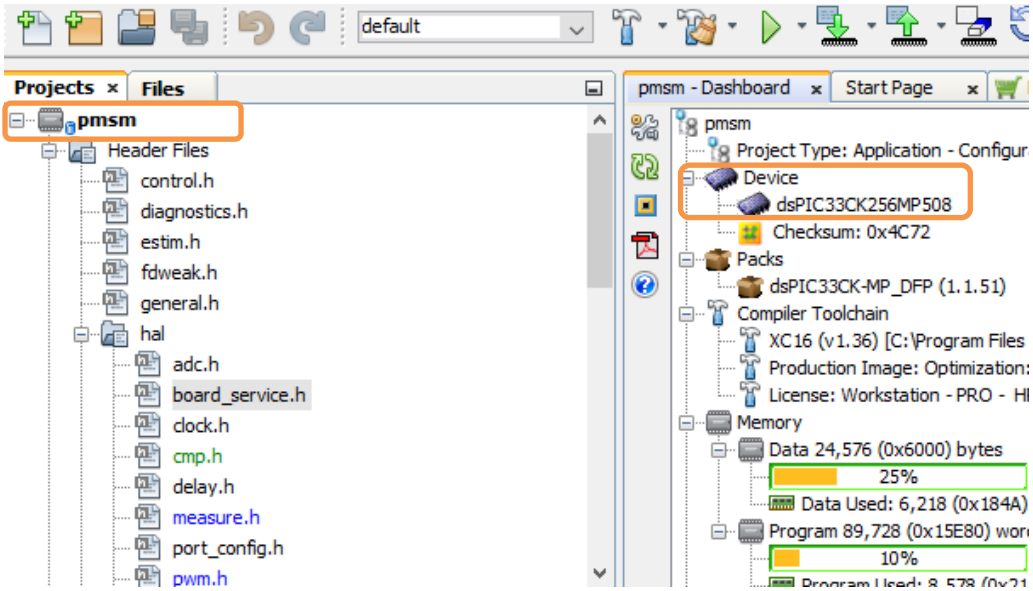
- Shorten the name of the directory containing the firmware used in this demonstration. In this case, rename directory `AN1292_dsPIC33CK256MP508_MCLV48V300W` to more appropriate shorter name. In case you renamed the directory, consider the new name while reading instructions provided in the upcoming 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".*

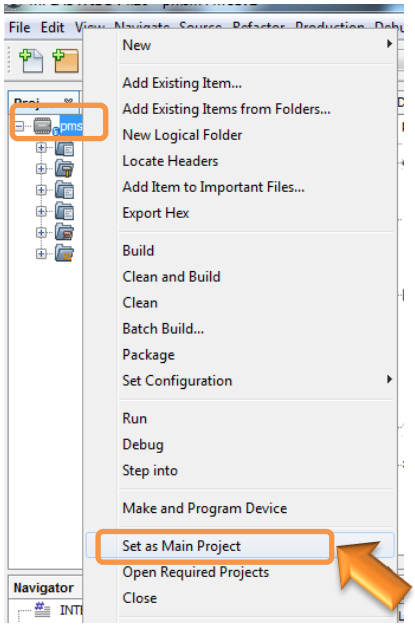
5.2. Basic Demonstration

Follow the below instructions step by step, to set up and run the motor control demo application:

1. Start MPLAB X IDE and open `(File>Open Project)` the project *`pmsm.X`* `(..\AN1292_dsPIC33CK256MP508_MCLV48V300W\pmsm.X)` with device choice *dsPIC33CK256MP508*.



2. Set the project *`pmsm. X`* as the main project by right-clicking on the project name and selecting “Set as Main Project” as shown. The project **“pmsm”** will then appear in bold.



3. Open `userparams.h` (under `pmsm.X -> headerfiles`) in the project `pmsm.X`

   - Ensure that `TUNING`, `OPEN_LOOP_FUNCTIONING`, `SINGLE_SHUNT`, and `TORQUE_MODE` are not defined.
   - When internal amplifiers are used for current amplification (referred to as 'Internal Op-Amp configuration'), then define `INTERNAL_OPAMP_CONFIG`.

     ```
     #define INTERNAL_OPAMP_CONFIG
     ```

     Otherwise, if external amplifiers are used for current amplification (referred to as 'External Op Amp Configuration'), then undefine the macro

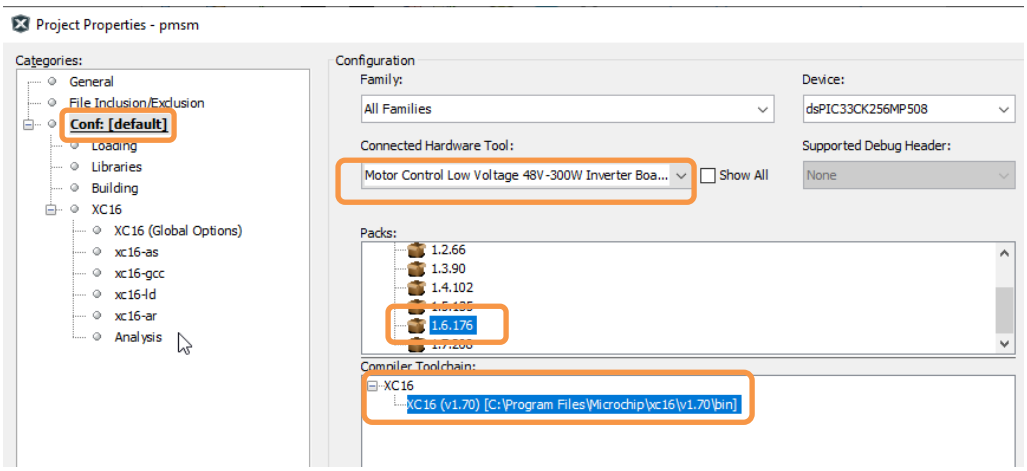
     `INTERNAL_OPAMP_CONFIG` in `userparams.h`.

     ```
     #undef INTERNAL_OPAMP_CONFIG
     ```

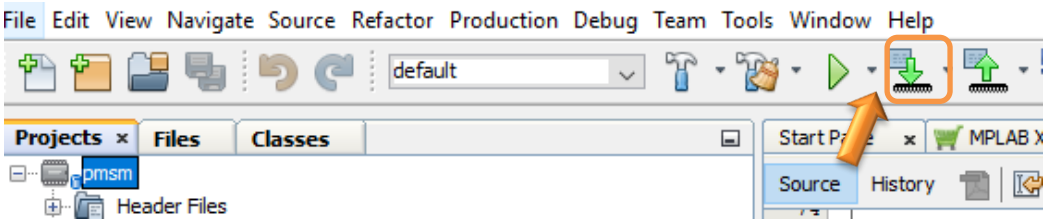
4. Right-click on the project *pmsm.X* and select "Properties" to open its Project Properties Dialog. Click the "Conf: [default]" category to reveal the general project configuration information. The development tools used for testing the firmware are listed in the section 2.2 Software Tools Used for Testing the firmware.

   In the ***'Conf-default'*** category window:

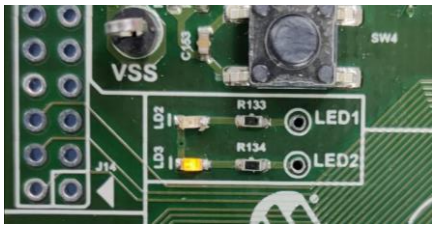
   - Select the specific Compiler Toolchain from the available list of compilers. Please ensure MPLAB® XC16 Compiler supports the device dsPIC33CK256MP508.In this case, "XC16(v1.70)" is selected.
   - Select the Hardware Tool to be used for programming and debugging.
   - Select the specific Device Family Pack (DFP) from the available list of Packs. In this case, "dsPIC33CK-MP_DFP 1.6.176" is selected.
   - After selecting Hardware Tool and Compiler Toolchain, click the button **Apply**



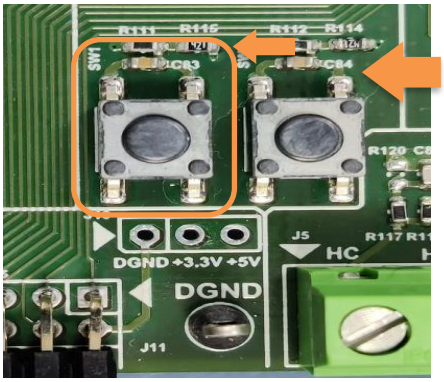
5. To build the project (in this case, *pmsm.X*) and program the device dsPIC33CK256MP508, click "**Make and Program Device Main project**" on the toolbar.



6. If the device is successfully programmed, **LD3('LED2')** will be turned ON, indicating that the dsPIC® DSC is enabled.

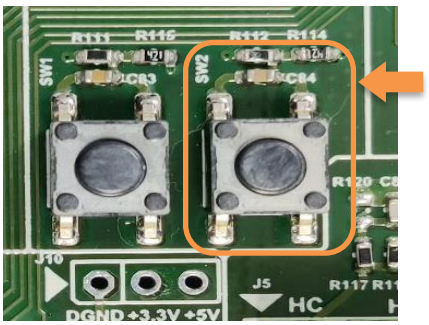


7. Run or stop the motor by pressing the push button **SW1**. The motor should start spinning smoothly in one direction in the 'Normal Speed Range.' Ensure that the motor is spinning smoothly without any vibration. The LED LD2 (' LED1') is turned ON to show the button is pressed to start the motor.



8. If desired, the motor speed can be varied using the potentiometer ('POT1').

9. To enter the extended speed range (`NOMINAL_SPEED_RPM` to `MAXIMUM_SPEED_RPM`), press the push button **SW2**. Press the push button **SW2** again to revert the speed of the motor to its normal speed (`END_SPEED_RPM` to `NOMINAL_SPEED_RPM`) range.



10. Press the push button **SW1** to stop the motor.

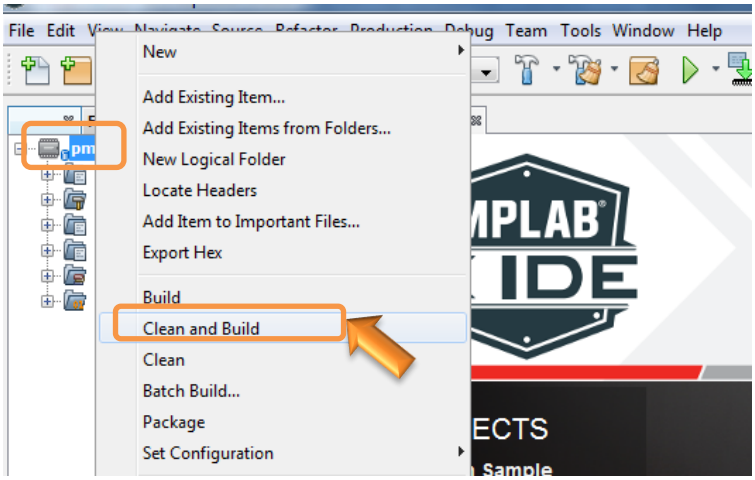
Note:

The macro definitions `END_SPEED_RPM`, `NOMINAL_SPEED_RPM`, and `MAXIMUM_SPEED_RPM` are specified in `userparms.h` file included in the project *`pmsm.X`*. The definitions `NOMINAL_SPEED_RPM`, and `MAXIMUM_SPEED_RPM` are defined as per the specification provided by the Motor manufacturer. *Exceeding manufacture specification may lead to damage of the motor or(and) the board.*

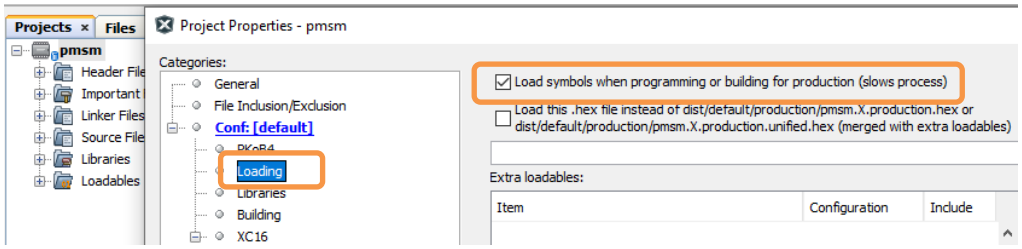
5.3. Data visualization through X2CScope Plug-in of MPLABX

The application firmware comes with the initialization needed 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 helps real-time diagnostics.

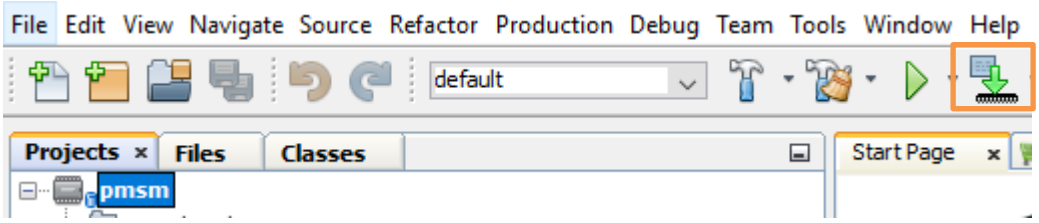
1. Ensure X2C-Scope Plug-in is installed. For more information on how to set up a plug-in, refer to https://microchipdeveloper.com/mplabx:tools-plugins-available
2. To utilize X2C communication for this demonstration, connect a micro-USB cable between the Host PC and the micro-USB connector provided on the MCLV-48V-300W Inverter Board. This interface is used for programming as well.
3. Ensure the application is configured and running as described under Section Basic Demonstration by following steps 1 through 10.
4. Build the project pmsm.X. To do that, right-click on the project pmsm.X and select “Clean and Build.”



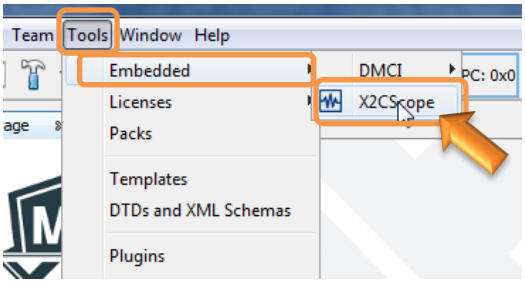
5. Please ensure that the checkbox “Load symbols when programming or building for production (slows process)” is checked, which is under the “Loading” category of the Project Properties window.



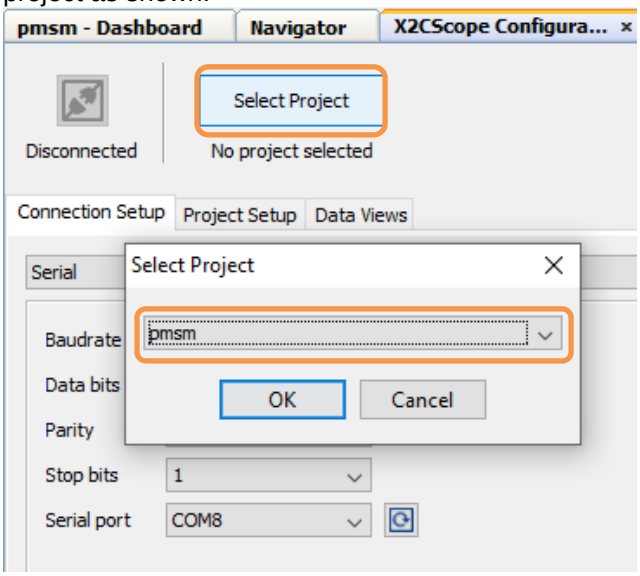
6. To build the project (in this case, *pmsm.X*) and program the device dsPIC33CK256MP508, click “**Make and Program Device Main project**” on the toolbar.



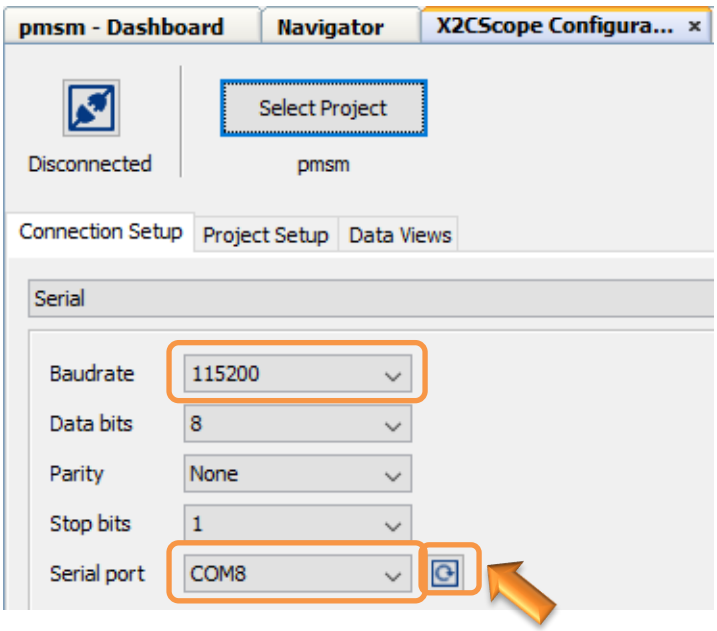
7. Open the X2C-Scope window by selecting `Tools>Embedded>X2CScope`.



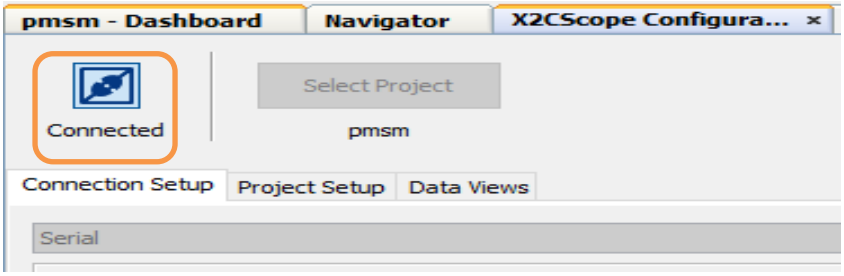
8. In the X2C-Scope Configuration window, using the “Select Project” menu, select **‘pmsm’** project as shown.



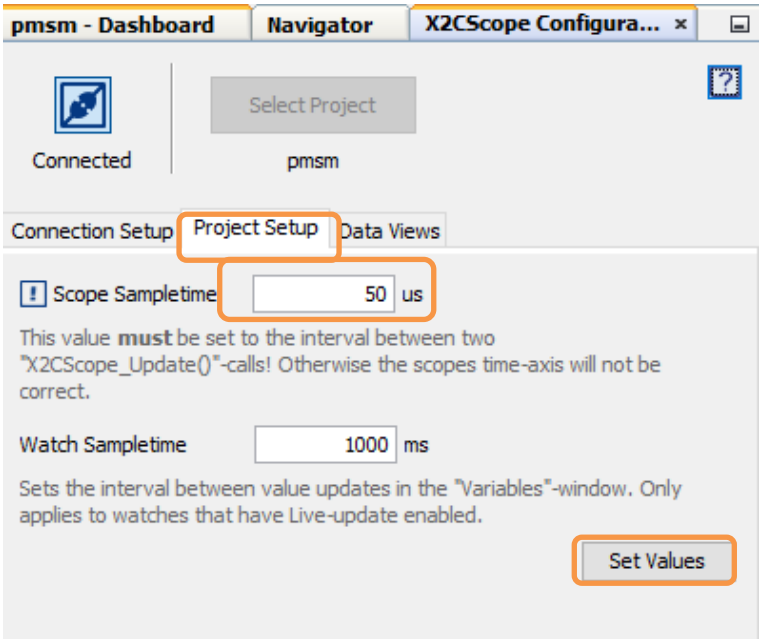
9. Remote Communication needs to be set up, as shown in the following figure. Ensure the communication baud rate is set to 115200 as configured in the application firmware. The COM port used depends on the system settings. `The refresh button` lists the available COM Ports. Select the COM Port as per the connection.



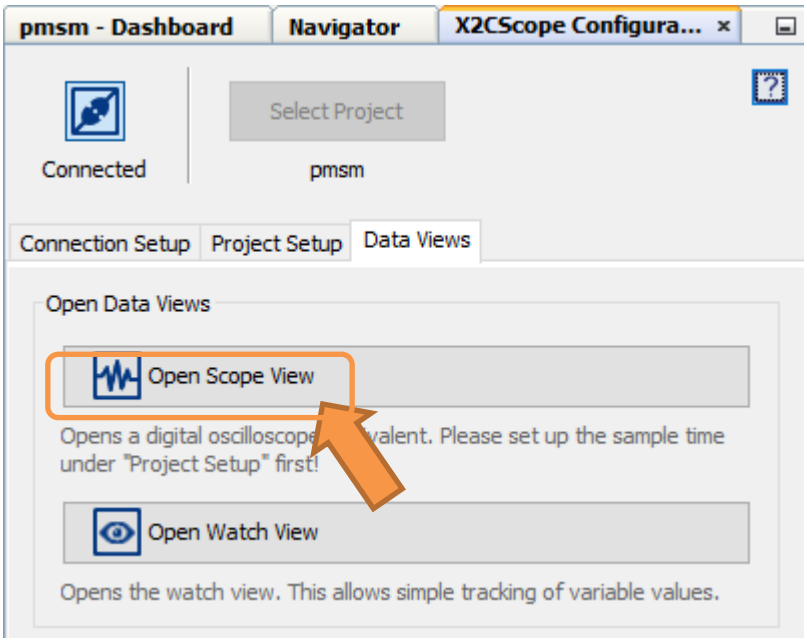
10. Once the COM port is detected, click on “Disconnected” and turn to “Connected”, to establish a serial communication between Host PC and the board.



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

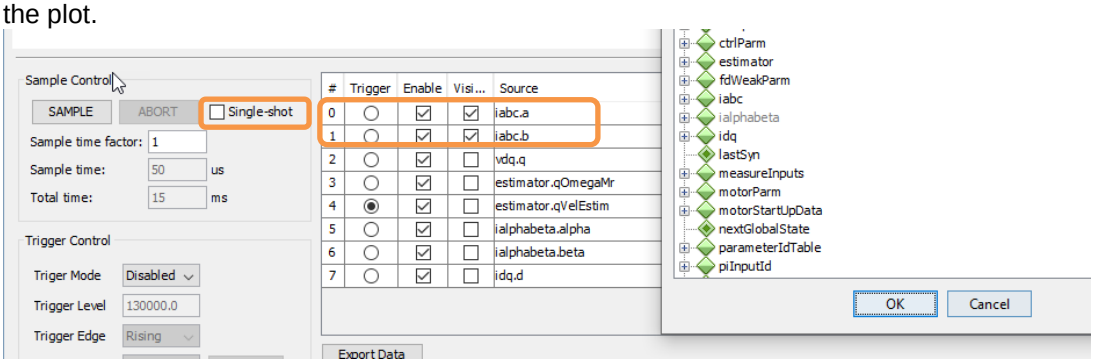


12. Click on ‘Open Scope View’ (under sub-window “Data Views”); this opens ‘Scope Window’.

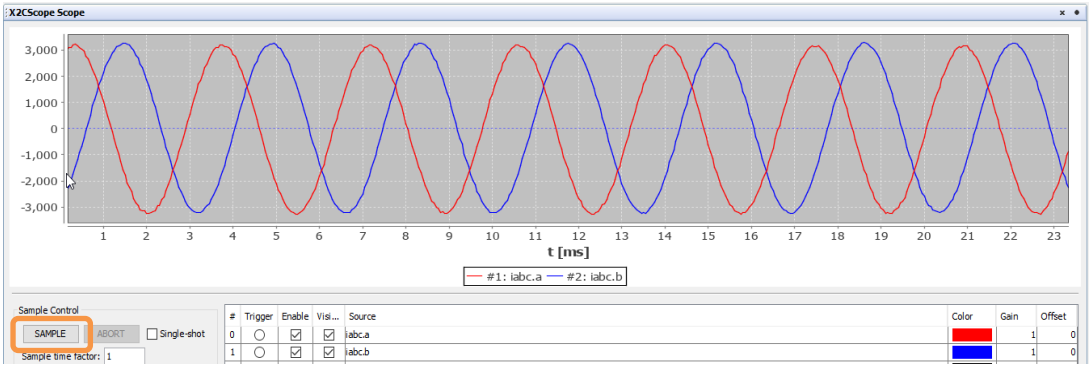


13. In this window, select the variables that need to be watched. To do this, click on the source against each channel, a window Select Variables opens on the screen. From the available list, the required variable can be chosen. Ensure checkboxes Enable & Visible are checked for the variables to be plotted.

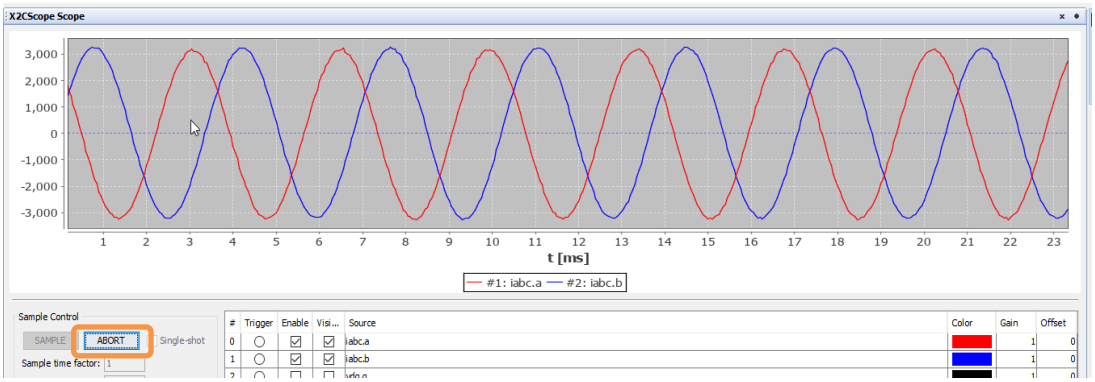
    To view data plots continuously, uncheck `Single-shot`. When `Single-shot` is checked, it captures the data once and stops. The `Sample time factor` value multiplied with Sample time decides the time difference between any two consecutive data points on the plot.



14. Click on SAMPLE, then the X2C-Scope window plots variables in real-time, which updates automatically.



15. Click on ABORT to stop.



6. REFERENCES:

For more information, refer to the following documents or links.

1. AN1292 Application Note “Sensorless Field Oriented Control (FOC) for a Permanent Magnet Synchronous Motor (PMSM) Using a PLL Estimator and Field Weakening (FW).”
2. MCLV-48V-300W Inverter Board User’s Guide
3. dsPIC33CK256MP508 Family datasheet (DS70005349).
4. Family Reference manuals (FRM) of dsPIC33CK256MP508 family
5. MPLAB® X IDE User’s Guide (DS50002027) or MPLAB® X IDE help
6. MPLAB® X IDE installation
7. MPLAB® XC16 Compiler installation