motorBench User's Guide

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Introduction

This document describes how to setup hardware, configure, and operate motorBench® Development Suite as well as aid in troubleshooting issues with motors. For information on installing motorBench please refer to the motorBench Release Notes. This document does not advise how to use the resulting generated code. Please refer to the MCAF User's Guide for additional information.

Recommended Reading

This user's guide refers to motorBench operation only. Other useful documents are listed below:

- MPLAB® Code Configurator v3.xx User's Guide
- MCAF User's Guide

Hardware Setup

The following sections outline the hardware setup of MCLV-2, MCHV-2, and MCHV-3.

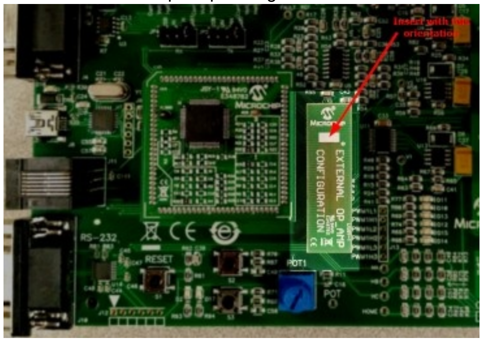
MCLV-2

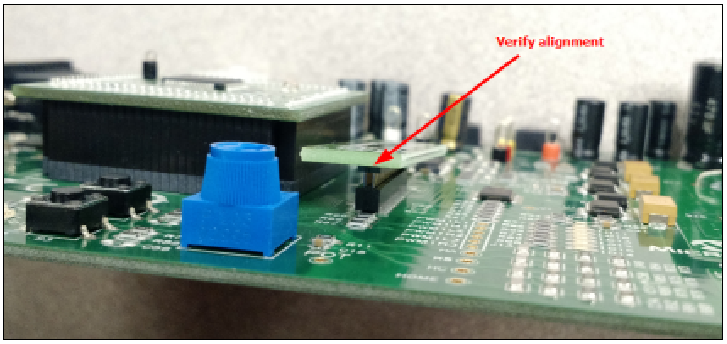
› Hardware setup: MCLV-2

This section provides detailed steps that will help you setup your hardware to work with the motorBench® Development Suite:

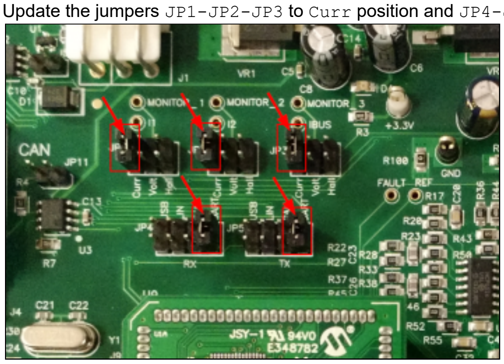
1. MCLV-2 board comes pre-installed out of the box with dsPIC33EP256MC506 Internal Op Amp Motor Control PIM (MA330031); replace this PIM with the dsPIC33EP256MC506 External Op Amp PIM (MA330031-2) or dsPIC33CK256MP508 External Op Amp PIM (MA330041-1) specified above.
2. Make sure that the dsPIC33EP256MC506 External Op Amp PIM is populated with a silicon mask rev-A8 or later. To verify this, read out the device revision from MPLAB X and verify that the Device ID revision is equal to or greater than `0x4008`.

3. Install the External Op Amp Configuration matrix board that comes with the MCLV-2 board into `J14`

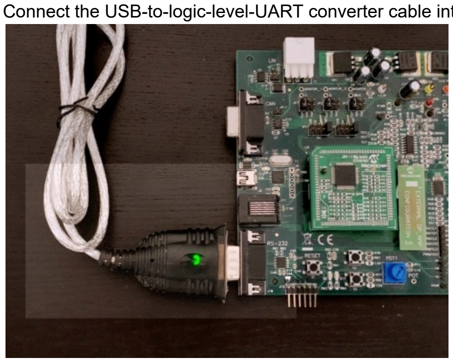




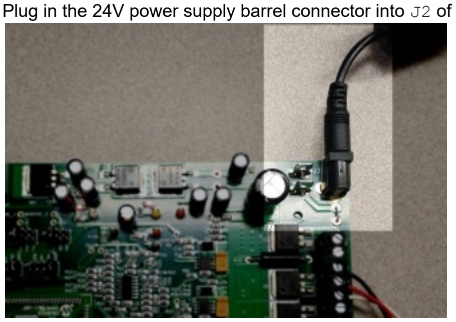
4. Update the jumpers `JP1-JP2-JP3` to `Curr` position and `JP4-JP5` to `UART` position as shown below:



5. Connect the USB-to-logic-level-UART converter cable into `J10` of MCLV-2 board and one of the USB ports on your PC:

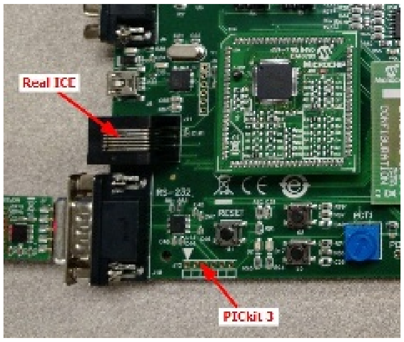


6. Plug in the 24V power supply barrel connector into `J2` of MCLV-2 board and then plug in the power supply into the mains outlet:

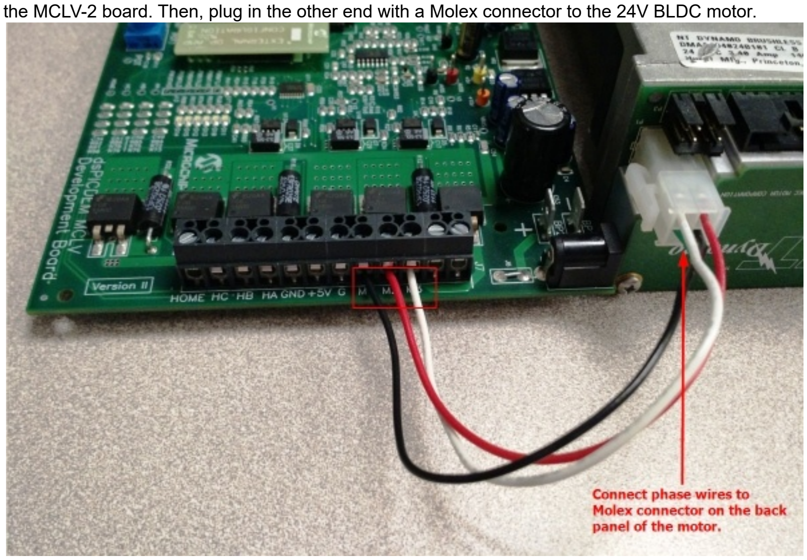


7. Connect your Real ICE / ICD3 / PICkit3 to one of the USB ports on your PC

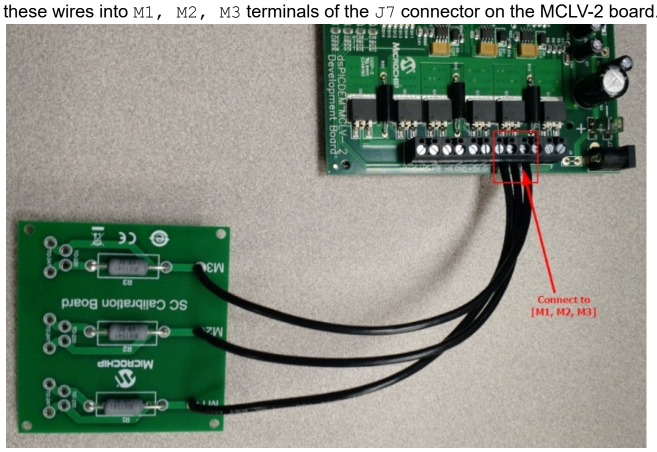
8. Connect the Real ICE / ICD3 to `J11` of MCLV-2 board. If you are using PICkit 3, then connect it to `J12` of this board.



9. Connect the [`black, red, white`] phase wires of the 24V BLDC motor to [`M1, M2, M3`] terminals of `J7` connector on the MCLV-2 board. (Sequence / order of this connection is not important if the direction of rotation does not matter.) You may leave the green color phase wire unconnected or connect it to the `G` terminal of `J7` connector on the MCLV-2 board. Then, plug in the other end with a Molex connector to the 24V BLDC motor.



10. Keep the motor on a stable surface and use a clamp (if available) to secure the motor from jumping around. (If using a metal C-clamp, make sure there is a thin shim of rubber, cloth, wood, or other mechanically-compliant material between the clamp and the motor, to avoid deforming the motor housing.) Alternatively, you can also place the motor on a rubber mat. Also, do not disturb the motor or hold its shaft while motor parameter measurement is running.
11. While running the `Board Calibration` within motor parameter measurement feature in motorBench® Development Suite, you will need to use a calibration load of three equal-value resistors connected in place of the 24V BLDC motor. Please refer to the Appendix section of this document for more information on the calibration load. Once you have the calibration load on hand, you can start by stripping off the insulation on the wires coming from the `M1, M2 and M3` terminals of the Calibration load. Then connect these wires into `M1, M2, M3` terminals of the `J7` connector on the MCLV-2 board.



MCHV-2 and MCHV-3

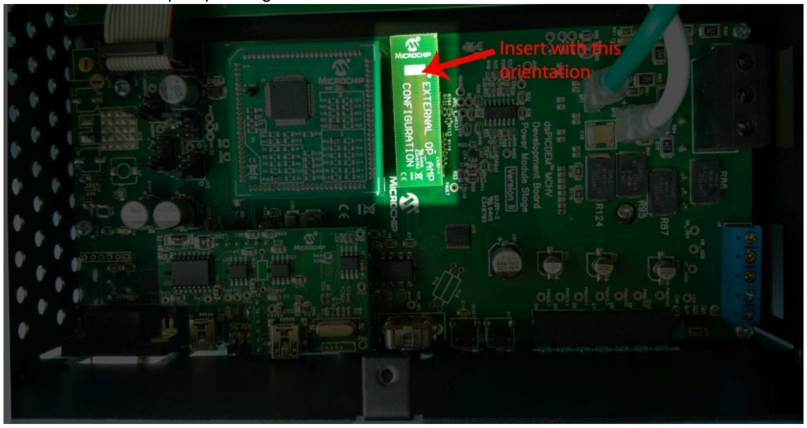
› Hardware setup: MCHV-2 and MCHV-3

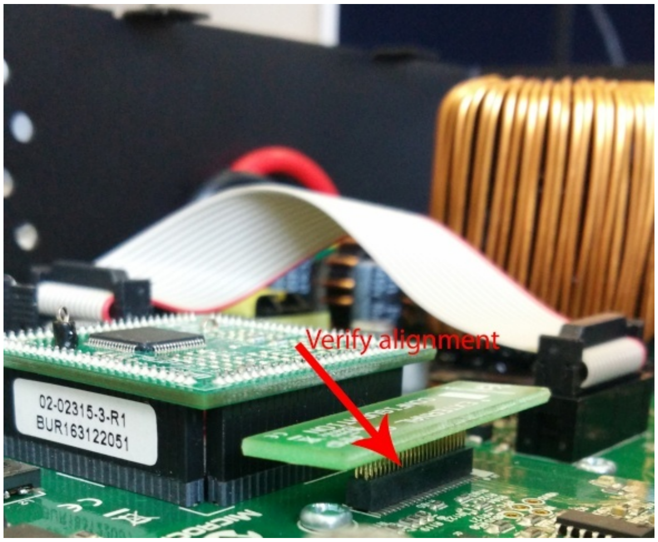
Hardware setup: MCHV-2 and MCHV-3

This section provides detailed steps that will help you setup your hardware to work with the motorBench® Development Suite: Although the setup is similar for MCHV-2 or MCHV-3, pictures of MCHV-3 are shown in the below section

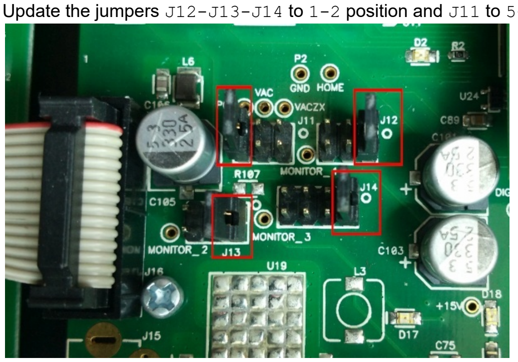
1. MCHV-3 board comes pre-installed out of the box with dsPIC33EP256MC506 Internal OpAmp Motor Control PIM (MA330031); replace this PIM with the dsPIC33EP256MC506 External OpAmp PIM (MA330031-2) or dsPIC33CK256MP508 External OpAmp PIM (MA330041-1) specified above.
2. Make sure that the dsPIC33EP256MC506 External OpAmp PIM is populated with a silicon mask rev-A8 or later. To verify the revision of silicon, read out the device revision from MPLAB X and make sure that the Device ID revision is equal to or greater than `0x4008`.

3. Install the External OpAmp Configuration matrix board that comes with the MCHV-3 board into `J4`





4. Update the jumpers `J12-J13-J14` to `1-2` position and `J11` to `5-6` position as shown below:

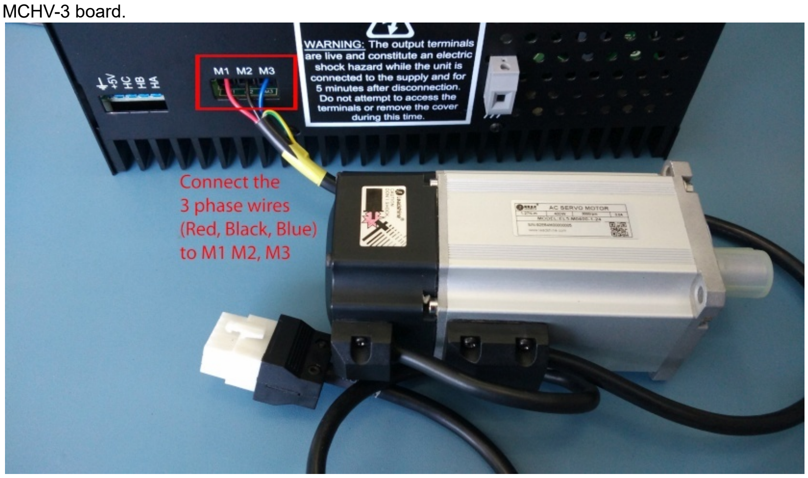


5. Connect the USB-to-UART converter cable into `RS232` labeled port on MCHV-3 board and one of the USB ports on your PC:
   Please note that in the event of mechanical interference with the USB-to-UART cable, you may need to use an UART extension cable.

6. Plug in an appropriate ac power supply cable to MCHV-3 board and then plug in the AC power supply cable into the mains outlet:

7. Connect the provided USB cable to `PROGRAM/DEBUG` connector on MCHV-3 board and to one of the USB ports on your PC.

8. Connect the [`red, black, blue`] phase wires of the Leadshine 400W 220VAC Servo Motor (AC300025) to the [`M1, M2, M3`] terminals on the MCHV-3 board. (Sequence / order of this connection is not important if the direction of rotation does not matter.) Connect the green-yellow combination color wire to the `Ground` terminal provided on the MCHV-3 board.



9. Keep the motor on a stable surface and use a clamp (if available) to secure the motor from jumping around. (If using a metal C-clamp, make sure there is a thin shim of rubber, cloth, wood, or other mechanically-compliant material between the clamp and the motor, to avoid deforming the motor housing.) Alternatively, you can also place the motor on a rubber mat. Also, do not disturb the motor or hold its shaft while motor parameter measurement is running.
10. While running the `Board Calibration` within motor parameter measurement feature in motorBench® Development Suite, you will need to use a calibration load of three equal-value resistors connected in place of the BLDC motor. Please refer to the Appendix section of this document for more information on the calibration load. Once you have the calibration load on hand, you can start by stripping off the insulation on the wires coming from the `M1`, `M2` and `M3` terminals of the Calibration load. Then connect these wires into the `M1, M2, M3` terminals of connector on the MCHV-3 board.

> **Hazard warning**
> Whenever connecting or disconnecting a motor or calibration load from MCHV-2/ MCHV-3 board, please disconnect the power from the MCHV-2/ MCHV-3 board. Also, use an insulated screwdriver that is recommended for high voltage rating.

> There is a known hardware design limitation with MCHV-2 and MCHV-3 boards that can cause the device on a dsPIC33EP256MC506 External Op Amp Motor Control PIM to reset when running motors with large phase currents. This issue does not affect dsPIC33CK256MP508. If you are observing dsPIC device reset issues while using MCHV-2 or MCHV-3 board with this PIM and with certain test motors, **power down the board, unplug the AC power cable, wait until LED D13 is OFF** and then make the following modification:
>
> Use a short length of jumper wire to connect digital ground signal to analog ground signal on the PIM. To do this, connect pins 31 and 36 on the dsPIC33EP256MC506 External Op Amp Motor Control PIM:

Sample motorBench Projects

motorBench® Development Suite requires all peripheral and system settings to be setup in MCC. The sample motorBench projects setup all peripheral, system, compiler, and linker settings. To get started quickly please navigate to the motorBench website and choose one of the below projects based on your device, and board. To set up MCC manually refer to the Peripheral Configuration Guide.

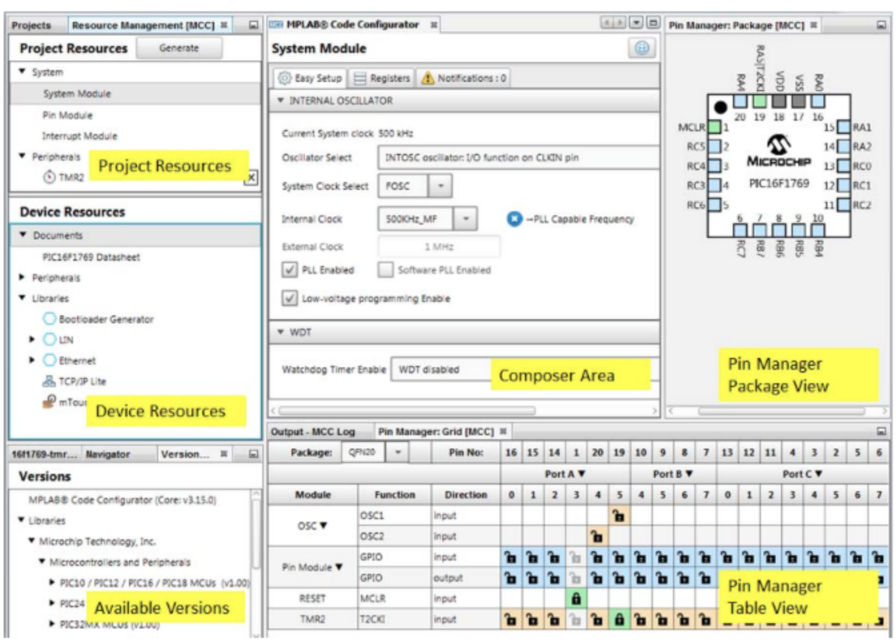
	MCLV-2	MCHV-2/3
dsPIC33EP256MC506	sample-mb-33ep-mclv2.X	sample-mb-33ep-mchv2.X
dsPIC33CK256MP508	sample-mb-33ck-mclv2.X	sample-mb-33ck-mchv2.X

Operating Instructions

Getting started

Please start with any of the sample MPLAB X projects – the compiler, linker, and MCC System and Peripheral settings have been preset for use with the Motor Control Application Framework.

- Unzip one of the sample motorBench projects onto your computer
- Open the sample motorBench project in MPLAB X
- Right-click and set as the main project in MPLAB X
- Right-click and open project properties. Select an in-circuit programmer (we have successfully tested ICD3 and REAL ICE) and XC16 compiler.
- The MCC tool, once installed, can be launched from the MPLAB® X Tools menu under the Embedded selection, or by Clicking on the MCC icon in MPLAB X Toolbar.
- The sections of the MCC tool are shown in the image below. We will refer to these sections by name throughout this guide.



- The MCC help can be invoked by clicking on the 

Configuration

1. Select motorBench® Development Suite in Project Resources under Libraries.
    - The sample projects already have the motorBench library added.
    - If the motorBench library is not present in Project Resources (for example, starting from a new MCC project), you will first have to add it by locating it in Device Resources under Libraries, and double-clicking on it.
2. If you haven't registered, you will be given the option to register motorBench, or enter a 30 day trial period. You will not be able to use motorBench after 30 days. For registration steps on an offline machine please contact motorbench-support@microchip.com
3. motorBench® Development Suite has three separate views
    a. Composer view : This allows users to define and measure the system characteristics, tune the system characteristics and customize MCAF generation parameters. In composer view, the user can
        i. Configure the system: Allows user to configure the motor, board and estimator details. Users have the option to measure the electrical and mechanical parameters. Users can export new motors.
        ii. Tune the system: Once a motor has been imported, you can tune the system.
        iii. Customize the MCAF parameters: Allows users to customize MCAF parameters that are used in code generation.
    b. Pin Manager View: This allows users to see the various pins that are being used by the system.
    c. Summary View: This allows users to see the various settings that are made by the user in the system.
4. Once you register, the "Home" page of the Composer view would show "Registered", otherwise it would show "Not yet Registered"
5. You can navigate between the “Configure”, “Tune” and “Customize” stages using their respective buttons.
6. Once all the components fully defined and there are no configuration errors, a puzzle icon will appear with status as "Ready to Generate". If the puzzle icon doesn’t appear complete, check if there are any messages present in the “Notifications[MCC]” tab below that prevent completion, and resolve them.

Motor Import and Export

Each motor has a different characteristics, motorBench® Development Suite ships with two standard motor definitions: **Hurst300** and **Leadshine400.**

You can Import either of these motors and modify if needed for the specific motor. Once modified you can export the changes as a different motor and use that later or share it with others if needed.

The process of selecting a standard motor shipped with motorBench® Development Suite or created using export is called **Import**. Modifying and persisting it called **Export.**

Importing a motor

When the project is started for the first time, there would be no motor selected. Users have to click on the **Import Motor** button to select one of the exported motors or one of the motorBench® Development Suite standard motors.

Begin by importing an existing motor. Clicking the 'Import Motor' button automatically takes you to the location on your machine where the default motors are stored.

> **Location of default motors on Windows**
> C:\Users\<username>\.mcc\libraries\<versioned motorBench® Development Suite folder>\motors

Select your desired motor, and click 'Open'. The motor will be imported into motorBench® Development Suite.

motorBench® Development Suite is now ready to generate code. If you don't have any modifications to make to the project, you can generate code.

Exporting a motor

Once you have imported an existing motor, you may choose to change its parameter values.

> **Motor and your project**
> Note that once you import a motor into motorBench® Development Suite, there is no link between your project, and the file from which it was imported. You can see the file from which the motor was imported in the 'Output - MPLAB® Code Configurator' window, but any changes you make are local to your project and do not affect the file.

All the motor parameters currently displayed in the composer view are editable, except the 'Measured Values' column in the 'Electrical and Mechanical Parameters' section. 'Measured Values' are automatically calculated by the motor parameter measurement process discussed separately.

All numeric values are shown in Engineering Notation, but if you hover over them, you will be able to see their exact 'double' representations. This is the value that you will be editing. Currently, we only support entering motor values in the units shown by default beside each parameter.

If you want to save the changes that you made to the motor parameters, you have two choices -

1. If you exit MCC, MPLAB X, or close the project, you will be asked whether you want to save the current MCC configuration. If you click 'Yes', all the changes will be preserved for this project. The next time you open MCC for this project, you will find all your values intact. This will not export the motor file.
2. If you want to use your motor parameters for other/new projects, you can choose to export the motor. Clicking the 'Export Motor' button will bring up a dialog box that will allow you to create your own motor with a new name. In a different project, you may choose to import this file instead of the default files provided with this installation.

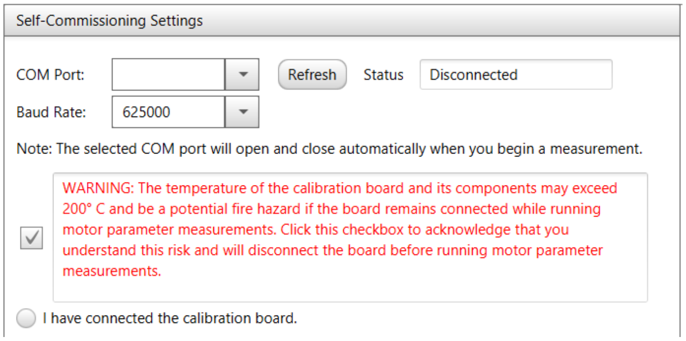
> Note that only the 'Active Values' in the 'Electrical and Mechanical Parameters' section are exported. 'Measured Values' cannot be exported. Measured values will, however, be preserved for that specific project. If you have measured values generated by the motor parameter measurement process, you may choose to copy them to the 'Active Values' column by clicking the ← or 'Use all' buttons.

> **Editing exported files**
> We do not recommend manually editing exported files. Using the UI to export motors is the best way of making any changes to the parameters you desire. If you still do edit the file manually, there is a possibility that importing that motor into a project might fail without any warning or notification.

Motor parameter measurement

After importing a motor, click on the "Measure Now" button in the Motor's Electrical and Mechanical Parameters group to open up the motor parameter measurement window.

1. Before you begin measurement, make sure that you have selected an ICD tool and a compiler.
2. Select the appropriate COM port from the combo-box. If you are unsure of the right COM port, you can look under the ‘Ports (COM & LPT)’ list in the Device Manager on Windows, or type “ls /dev/*” on Mac. If you connected the board and ICD tool after you landed on the Measure page, you would want to hit ‘Refresh’ to update the list of COM ports.
3. Acknowledge the heat-warning. You will not be able to proceed without it.



ⓘ The default communication baud rate setting during motor parameter measurement measurement is 625000. However, the RS232 transceiver devices used in MCLV-2 and MCHV-2 development boards (i.e. MAX3232CUE) are specified to operate reliably at baud rates up to 120kbps. Due to this limitation, while using MCLV-2 development board, MCHV-2 development board or MCHV-3 development board during motor parameter measurement, if you observe serial communication related issues, then retry measurement after reducing the communication baud rate to a lower setting.

4. Verify that the Calibration Bus Voltage is correctly set for your hardware setup. **This step is necessary even if you are planning on skipping the Calibration process**. To update this value, edit the value in `Configure → Board → Voltage Source → Output`. For the dsPICDEM MCHV-2 and MCHV-3 Development boards, this value can be estimated from the nominal value of AC input voltage using the following equation or the table below:

$$V_{source} = V_{RMS} \times \sqrt{2}$$

Nominal AC input voltage (V_{RMS})	**Value to be entered in Configure → Board → Voltage Source → Output = V_{source}**
110	155.5
120	169.7
220	311.1
240	339.4

5. To calibrate, connect a valid calibration load (see Appendix for recommendations) and click the “I have connected the calibration board” radio button. Hit “Calibrate”.
6. To run the motor parameter measurements,
   a. Disconnect the calibration load and connect the motor instead.
   b. Click the “I have disconnected the calibration board” and “I have connected the motor” buttons.
   c. Click the “Start” button to begin measurement. You will see the measured values appear for each parameter.
7. The measured values are updated in the 'Measured Values' of the Motor's Electrical and Mechanical Parameters section. Click on the  icon to set a measured value as the active value. The 'Use all' button can be used to set all measured values as active values. The 'Active Values' are used for Autotuning and code generation.

Common types of motor parameter measurement errors and reasons they can occur

General guidance: The usual cause of errors during motor parameter measurement is due to incorrect definition of motor and/or board specifications in the "Configure" page, specifically these parameters:

1. Configure → PMSM Motor → Rated current: Continuous
2. Configure → PMSM Motor → Number of pole pairs
3. Configure → PMSM Motor → Nominal speed
4. Configure → Board → Voltage Source → Output

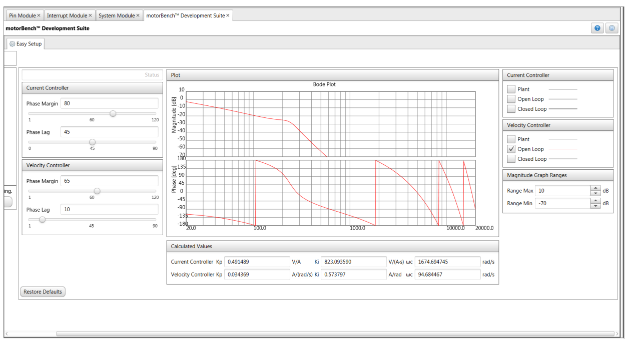
Table below provides some more specific examples of typical issues and their possible causes.

Symptom	**Possible causes**	**Possible fix**
Hardware over-current fault during R, Ld or Lq measurements (Fault Code #10)	Rated current specification of the motor is close to / higher than the full scale current range of the board. In this case, with motors that have relatively low values of electrical time constant, current ripple can trigger the over-current comparator on the board.	Retry the measurement after reducing the value in **Configure → PMSM Motor → Rated current: Continuous** to a lower value.
Motor stalls during inertia measurement with a Fault Code #107	The specified Nominal speed of the motor is either too low or too high for the given voltage source output at the inverter.	Correct the value in **Configure → PMSM Motor → Nominal speed** and retry the measurement.
Motor stalls during Ke measurement with a Fault Code #10, #102, #103, #104, #105 or #106	If the test motor has a relatively low value of stator inductance (typical Ld and Lq ~ 100µH or less), then transients in the current ripple can trigger the hardware over-current fault comparator causing the motor to stall during startup.	Increase the **Measure → Motor Parameters → Current Controller → Phase Margin** (slider) from its default value of 95° in 5° increments up to a maximum value of 115° and retry the measurement.
	If the test motor has a relatively high value of stator inductance (typical Ld and Lq ~ 1mH or more), then the current controller may need to be more aggressive during the startup phase in order to be able to suppress any open loop oscillations that may cause	Decrease the **Measure → Motor Parameters → Current Controller → Phase Margin** (slider) from its default value of 95° to 91° and retry the measurement.

	disturbances in the current control loop.	
	If the test motor has significant inertia (typical J ~ 100μNm/(rad/s^2) or more) then, **Measure → Motor Parameters → Approx. Spin Down Time** parameter may be set to value that is too low for the given motor.	Increase the value that is set in **Measure → Motor Parameters → Approx. Spin Down Time** and retry the measurement. This will allow the measurement algorithm to wait for the motor to spin down completely before attempting to restart the motor in between measurements.
Measurement fails during R measurement with a message "Unable to detect a motor on the board inverter output. Please verify that the leads of the motor under test are connected securely to the board inverter output terminals."	All three phase wires of the test motor are not correctly connected to the inverter output terminals.	Verify that all three phase wires of the motor are connected correctly to the inverter output terminals.
	Test motor has a stator inductance value that is out of supported measurement range.	-
	Voltage source that is connected to the inverter stage is not powered on.	Verify if the inverter stage is connected to a voltage source that is powered on.

Autotuning

1. Click the 'Tune' button to go to the Tuning stage. There is no required user action in this stage. You can check out the Bode plots, or use different settings for phase margin or PI phase lag at crossover, if you wish to do so.
2. We recommend the defaults of 80/45 and 65/10 for current and velocity controllers, respectively.



Managing Errors in Autotuning

Autotuning may fail in certain extreme cases:

- Motor parameters are extreme values, either because the motor parameter measurement process did not work correctly, or because the motor itself is unusual
- Tuning parameters (phase margin and PI phase lag at crossover) are extreme values
- Customize page parameters are extreme values

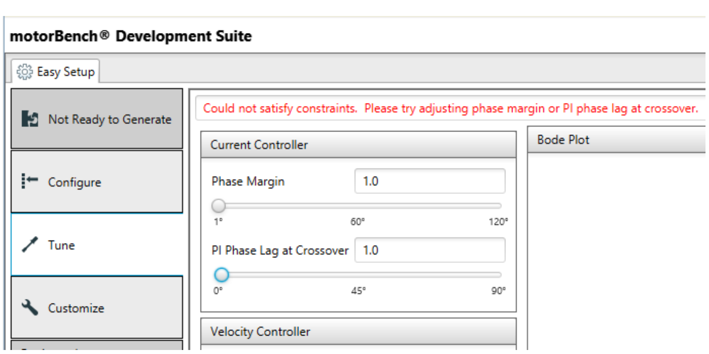
Important things to know are

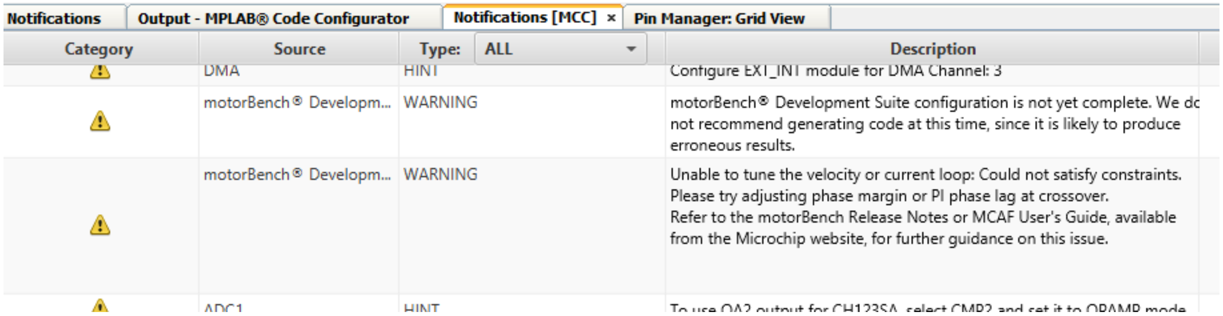
- How to recognize that an error has occurred
- Common types of autotuning errors and reasons they can occur
- How to report specific failure details to Microchip for assistance

How to identify autotuning errors

If an error has occurred during autotuning, the following will occur:

- motorBench will show "Not Ready to Generate"
- the Tune page will display a short status message in red, and no Bode plot will be drawn on the graphs
- (in most cases) the Notifications [MCC] tab will show a list of problems



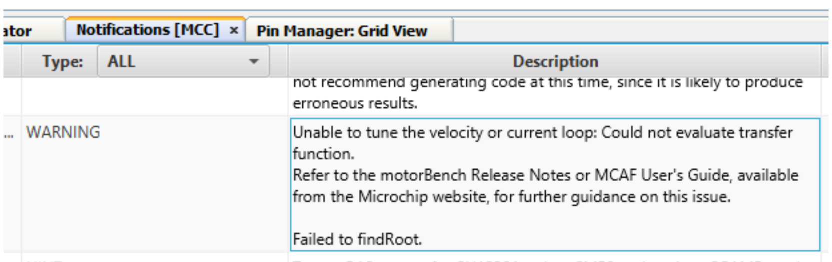


Common types of autotuning errors and reasons they can occur

Symptom	Possible cause	Possible fix
Tune page: "No motor imported"	A motor has not been imported on the Configure page.	Import a motor on the Configure page.
Tune page: "Could not satisfy constraints. Please try adjusting phase margin or PI phase lag at crossover."	Tune page parameters (phase margin or PI phase lag) may be unusually low or high	Change tuning parameters to be closer to their default values. (The "Restore Defaults" button will set these values back to their defaults.)
	Estimator parameters on the Customize page may be unusually low or high	Change estimator parameters to be closer to their default values. (Customizable estimator parameters are AN1292 PLL time constant and bandwidth and Quadrature encoder tracking loop time constant — all of which are shown only if the "Show advanced parameters" checkbox is checked.)
	Certain other parameters (minimum operating velocity) on the Customize page may be unusually low or high	Change parameters to be closer to their default values.
Tune page: "Could not evaluate transfer function."	May occurs if minimum operating velocity is zero.	Choose a minimum operating velocity greater than zero.
Other symptoms (for example, "Could not locate transfer function logic" or "Could not construct transfer function")		Please report to Microchip – these are unexpected errors.

How to report specific failure details to Microchip for assistance

If contacting Microchip staff for assistance, please copy the entire text of the Tune page status message and the description of any MCC warnings – not just a screenshot. (Click on the table cell in the MCC Notifications pane, so that it is highlighted as shown below, and press Ctrl+C to copy the text to the system clipboard.)



This provides important clues that may indicate the cause of the problem and how to address it.

Customize

The Customize page allows users to modify parameters used for MCAF code generation. This is an optional step to improve the behavior of the generated code for some motors; none of the parameters on the Customize page need to be modified in order to generate code. The default values found in the Customize page are good for most motors.

Position and velocity estimator selection

Estimator selection is now made in the Customize page (in motorBench 2.15 and earlier, it was selected in the Configure page).

One estimator must be selected as the "primary" estimator used for commutation and velocity feedback. Additional estimators may be selected as secondary estimators for comparison of angle and velocity information.

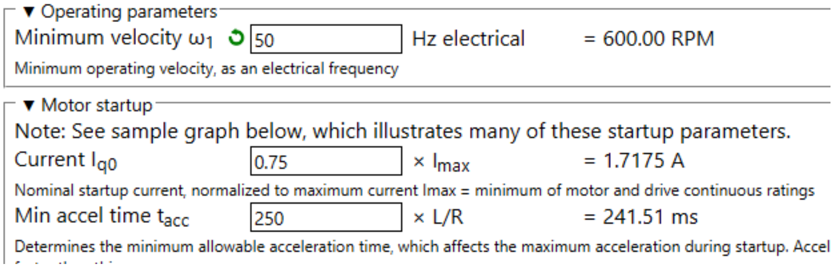
Refer to the MCAF User's Guide for more detailed information about the different position and velocity estimators.

Advanced parameters

There are several dozen customizable parameters, but most of these are considered "advanced" and are used only in rare cases to solve specific problems. Only a handful of parameters are shown by default; to show all parameters, click on the checkbox marked "Show advanced parameters" at the top of the Customize page.

Normalized parameters

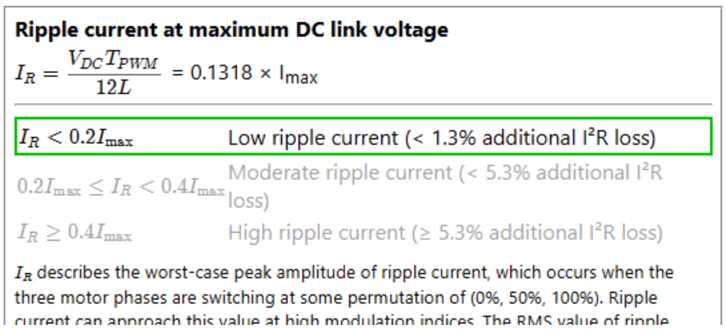
Many parameters are normalized to motor or system values, in order to ensure consistent default behavior. For example, the startup current I_{q0} is specified as a fraction of maximum current. The Customize page will display the actual value in real-world engineering units as a visual and computational aid.



Each of these parameters has a default value. When editing parameters, if the value is different from the default, a green circular arrow will be displayed. Hover over the green circular arrow to view the default value. To restore the value to its default, click on the green circular arrow.

Advice

An "Advice" section has been added to the Customize page to provide guidance on the effect of certain system quantities such as ripple current, as shown below:



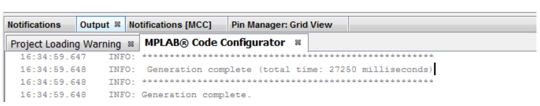
This information is provided to highlight specific quantities that may cause problems in some systems. These are general guidelines and may not apply to all motor control systems.

Additional information

Refer to the MCAF User's Guide for more detailed guidance on parameter customization.

Generate Code

1. To generate code, click "Generate" under the Project Resources section. Look for the generation progress under the MPLAB® Code Configurator console window.
   Once generation is complete, you will see a banner comment like so -

   You will also be able to see the generated files added to your project.
2. If you want to run generation again, and have not made any manual edits, consider removing previously-generated files under the mcc_generated_files/motorBench directory. This will avoid having to merge newly-generated files with earlier-generated files.
3. You are now ready to build and run the project, and spin the motor.

Managing Errors in Code Generation

Code generation may fail in certain extreme cases:

- Motor parameters are extreme values, either because the motor parameter measurement process did not work correctly, or because the motor itself is unusual
- Tuning parameters (phase margin and PI phase lag at crossover) are extreme values
- Customize page parameters are extreme values

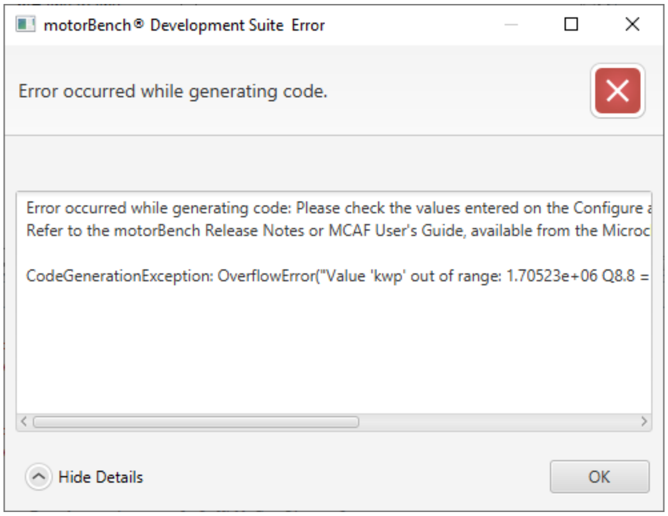
Important things to know are

- How to recognize that an error has occurred
- How to report specific failure details to Microchip for assistance
- Common types of code generation errors and reasons they can occur

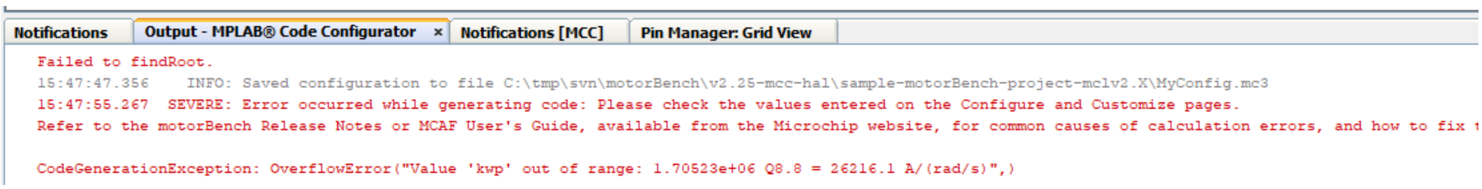
How to identify code generation errors

If an error has occurred during code generation, the following will occur:

- A dialog box will pop up with an error message:



- MPLAB® Code Configurator console window will have a SEVERE category message like shown below -



Common types of code generation errors and reasons they can occur

General guidance: The usual cause of code generation errors is a motor parameter that is extremely high or extremely low. Please see the section "Motor Control Limitations" which discusses ranges of motor parameters that work well with motorBench® Development Suite. There are a few reasons a motor parameter could cause a code generation error:

- The parameter has not been measured or entered correctly. (For example, a datasheet states 50μH but is entered as 50mH = 0.05H.)
- The motor has unusual motor parameters. (Slotless motors may fall into this category; they have very low inductance.)
- The motor is not well-matched to the motor drive circuitry, for example use of a 6V motor with a 24V motor drive.

The Customize page parameters may be at an extremely high or low value either.

Looking at the error message may help to diagnose and check for a fix.

Symptom: category	Symptom: specific message	Possible cause	Possible fix
`ZeroDivisionError`		One of the motor parameters is zero. (This should never be the case.)	Make sure none of the motor parameters are zero.
`ZeroDivisionError`		One of the Customize page parameters is zero	Check whether there are Customize page parameters that are zero, but should be greater than zero.
`CodeGenerationException: OverflowError`	`kwp` out of range	This is the velocity loop proportional gain. Out-of-range errors can occur if the inertia (J) is very high.	Make sure the inertia value is reasonable. An increase or decrease in velocity loop phase margin in the Autotuning page may be required for high-inertia motors. (Increasing phase margin generally lowers `kwp` whereas decreasing phase margin raises it.)
`CodeGenerationException: OverflowError`	`velocitySlewrateLimitDecel` out of range	May occur if Coulomb friction torque (Tfr) is out of range.	Make sure the Coulomb friction value is reasonable.
`CodeGenerationException: OverflowError`	`normLsdt` out of range	May occur if inductance (Ld and/or Lq) is out of range.	Make sure the motor inductance values are reasonable and well-matched to the motor drive.
`CodeGenerationException: OverflowError`	`normRs` out of range	May occur if resistance (Rs) is out of range.	Make sure the motor resistance values are reasonable and well-matched to the motor drive.
`CodeGenerationException: OverflowError`	(Other messages)	A parameter on the Customize page is at an extreme value	Recheck values on the Customize page.
Other errors			Please report to Microchip – these are unexpected errors.

How to report specific failure details to Microchip for assistance

If contacting Microchip staff for assistance, please copy the entire text of the dialog box or MCC Output window — not just a screenshot.

This provides important clues that may indicate the cause of the problem and how to address it.

Building Code

At this point, work in motorBench® Development Suite is complete. In MPLAB X, click the Clean button and then the Run button to build and program the device.

⚠ **Reminder:** the Motor Control Application Framework requires certain compiler and linker settings; without these settings it may not run correctly. Please refer to the motorBench Release Notes for compiler and linker settings.

Running the Application Framework

Directions for using MCAF with MCLV-2 and MCHV2/MCHV-3 are slightly different:

MCLV-2

- Press button S2 to start/stop the motor
- Press button S3 to reverse direction
- Turn the potentiometer to control speed
- In the event of an error, both LEDs (D2 and D17) will flash together to indicate an error code; see the Motor Control Application Framework documentation on the motorBench® Development Suite webpage for further information.

MCHV-2 and MCHV-3

- Press the button labeled PUSHBUTTON to start/stop the motor
- Long press the button PUSHBUTTON (minimum 3 seconds) to reverse the direction of rotation.
- Turn the potentiometer to vary speed.
- In the event of an error, both LEDs (D17 and D19) will flash together to indicate an error code; see the Motor Control Application Framework documentation on the motorBench® Development Suite webpage for further information.

Real-Time Diagnostics

The Motor Control Application Framework includes out-of-the-box support for X2C-Scope, a third-party plugin for MPLAB X which facilitates real-time diagnostics. X2C-Scope is available in the same **Available Plugins** tab used to install motorBench® Development Suite.

Troubleshooting Issues with some motors

We have observed some issues during our testing under the following circumstances:

1. Starting up small motors with large inertia loads
2. Starting up certain motors with low speed reference
3. Instability in current loop

These are some solutions that may work for some motors:

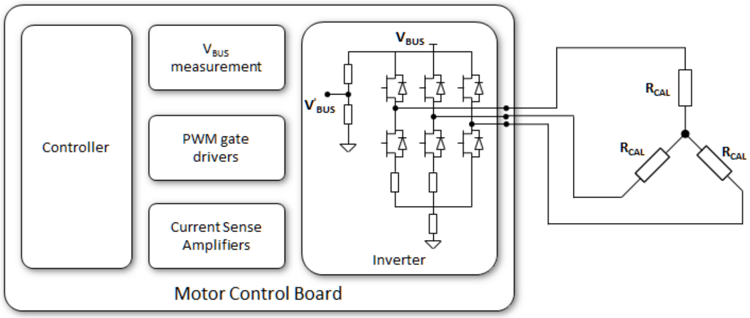
1. Starting up small motors with large inertia loads using the classic startup method may have a difficult time with the transition from forced commutation to closed-loop commutation. Use the Weathervane startup method in these circumstances.
2. Starting up certain motors with low speed reference fails to start. This may be due to either an issue in the startup method or the behavior of the sensorless estimator during the transition to closed-loop commutation. Workarounds for this issue include: use the Weathervane startup method, ensure that the speed command is not at the low end of its range, or reduce the DC link voltage if possible.
3. If instability in current loop is observed an increase of 5° or 10° in current loop phase margin may help.

Appendix

Motor parameter measurement - Calibration load specifications

The board calibration process analyses the hardware to measure any deviation from its design values of board parameters. This will help improve the accuracy of motor parameter measurements. The board calibration step of motor parameter measurement is optional. However, it is recommended that at the least, it is run once every time there is a change in the development board.

The board calibration process requires three equal-value resistors to be connected to the three-phase inverter output as shown in the diagram below.



The following equation provides the recommended range of calibration resistance values based on parameters of the board that is being calibrated:

$$\frac{V_{BUS}}{0.20 \times I_{fullscale} \times 2} \leq R_{CAL} \leq \frac{V_{BUS}}{0.80 \times I_{fullscale} \times 2}$$

Where,
I_{full} scale is the full-scale current for the board and
V_{BUS} is the voltage applied on the inverter phase of the board.

During the calibration process, the specialized firmware applies a series of voltage pulses on the calibration resistors and measures the resulting current. The pulse train has the following properties:

- Amplitude of V_{BUS}
- Pulse train duration of 2 ms with each pulse lasting 50 μs
- Duty cycle of 46%

Since the pulses applied have an amplitude of V_{BUS}, the calibration resistors must be voltage rated to handle at least half of V_{BUS}. The pulse train also imposes resistor size requirements due to the energy in the pulses that need to be dissipated with a nominal temperature rise to prevent resistance changes. Since the voltages for low and high voltage applications vary vastly, the resistor values vary as seen below. Factoring all the above requirements we have the following values of resistors for the boards supported:

dsPICDEM™ MCLV-2 Development Board - 10 Ω and 21 millijoules

dsPICDEM™ MCHV-2 Development Board and dsPICDEM™ MCHV-3 Development Board - 50 Ω and 450 millijoules

In order to ensure accurate calibration, use resistors with

- 1% tolerance specification or better
- Low temperature coefficient

No labels