motorBench 2.25.0 Release Notes

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Overview of motorBench® Development Suite

Microchip motorBench Development Suite is a graphical, interactive development environment designed to help motor control engineers to design and implement motor control systems, from very basic to very sophisticated ones.
motorBench® Development Suite allows the user to:

- configure a motor system
- measure motor parameters
- tune the controller gains
- generate code to spin the motor

What's New

1. Motor Control Application Framework (MCAF) R5 – see MCAF User's Guide for more information.
   a. Added support for dsPIC33CK256MP508
   b. Added Angle-tracking PLL (ATPLL) support
   c. Improved Customize page support in motorBench
2. Customize
   a. Allow advanced customization of MCAF code generation
3. Measure
   a. Updated fault handing logic to detect if an invalid load is connected to the inverter before starting motor parameter measurement or Board calibration
   b. Improvements to support motors with large values of stator inductance
   c. Improvements to support motors with large inertia and high cogging torque
4. MCC Integration
   a. Improved support for MCC-generated peripheral and system initialization code
5. Device Support
   a. Added support for dsPIC33CK256MP508
      i. This device is not yet supported by the motor parameter measurement feature

System Requirements

- MPLAB X **5.30** or later.
- XC16 compiler version:
  - Firmware generated by motorBench® Development Suite has been tested with XC16 1.41.
  - 33EP devices: XC16 1.36 or later are expected to work with motorBench® Development Suite but have not been extensively tested.
  - 33CK devices: Either of the following is required:
    - XC16 1.50 or later
    - XC16 1.41 with DFP 1.2.66 or later
- MPLAB Code Configurator®(MCC) Plugin Version **3.95.0** or later
- PIC24/dsPIC33/PIC32MM library **1.166.0** or later

Supported Hardware

This release of motorBench® Development Suite supports both low-voltage and high-voltage setups.

Low-voltage hardware

1. dsPICDEM MCLV-2 Development Board [Part Number: DM330021-2]
2. dsPIC33EP256MC506 External Op Amp Motor Control PIM [Part Number: MA330031-2] with silicon revision A8 or dsPIC33CK256MP508 External Op Amp Motor Control Pim [Part Number: MA330041-1].
3. A three phase PMSM or BLDC motor that is compatible with 24V, such as the Hurst 24V BLDC motor DMA0204024B101 [Part Number: AC300022].
4. 24V power supply [Part Number: AC002013] - ensure this connects to AC mains using a 2-prong cable. If you have an AC002013 with a 3-prong cable, please contact Microchip.

High-voltage hardware

1. dsPICDEM MCHV-2 Development Board [Part Number: DM330023-2] or dsPICDEM MCHV-3 Development Board [Part Number: DM330023-3]
   AC mains voltages 120VAC 60Hz and 220VAC 50Hz have been tested.

2. dsPIC33EP256MC506 External Op Amp Motor Control PIM [Part Number: MA330031-2] with silicon revision A8 or dsPIC33CK256MP508 External Op Amp Motor Control Pim [Part Number: MA330041-1].
3. A three phase PMSM or BLDC motor that is compatible with rectified AC mains voltage, such as the Leadshine 400W BLDC motor EL5-M0400-1-24 [Part Number: AC300025].

Other hardware required with both low-voltage and high-voltage setups

1. A USB-to-logic-level-UART converter from the following list:
   a. Saelig USB-COM-U or USB-COM-U13
   b. TRENDnet TU-S9 v2.0
2. Programming tool - one of the following tools: Real ICE, ICD3
3. Board calibration load resistors - this is optional, please see motorBench® Development Suite User's Guide document for more details

> **Please note:**
> - We do not recommend using the MCP2200 USB to RS232 Demo Board [Part number: MCP2200EV-VCP] with this release of motorBench® Development Suite. While testing, we have observed more frequent occurrence of a serial communication timeout issue while running motor parameter measurement using this cable. See Known Issues section of this document for more information (MCGUI-1141)
> - Motor parameter measurement is only supported on dsPIC33EP256MC506 device.

Installing motorBench® Development Suite 2.25.0

To install the MPLAB® Code Configurator v3.95 Plugin

1. In the MPLAB® X IDE, select **Plugins** from the Tools menu
2. Select the **Available Plugins** tab
3. Check the box for the MPLAB® Code Configurator v3, and click on **Install**

To install different peripheral library version or motorBench® Development Suite version when connected to internet

1. Create a project with dsPIC33EP256MC506 or dsPIC33CK256MP508, or use the sample project.
2. Open MPLAB® Code Configurator
3. In the Versions tab under **PIC24/dsPIC33/PIC32MM** MCUs, find the multiple library versions (loaded version is indicated by the green check mark)
4. Right-click on the required version of the library and select **Mark for Load**
5. In the Versions tab under **motorBench® Development Suite** find the multiple library versions (loaded version is indicated by the green check mark)
6. Right-click on the 2.25.0 version of the library and select **Mark for Load**
7. Click on **Load Selected Libraries button** to load the marked libraries.

To install different peripheral library version or motorBench® Development Suite version when not connected to internet

1. In the MPLAB® X IDE, select **Options** from the **Tools** menu
2. Select **Plugins** tab
3. Click on **Install Library**
4. Add **pic24-dspic33-pic32mm_v1.166.mc3lib**
5. Add **motorBench_2.25.0.mc3lib**
6. Restart MPLAB® X IDE

Repairs

Motor Control Fixed Issues

Changes since revision 2.15

The following aspects of motorBench® Development Suite and the Motor Control Application Framework (MCAF) have been updated:

- MCAF has been updated to R5, including
  - Changes in R2:
    - Support for DC link compensation
    - Support for overmodulation
    - Support for wider range of low-voltage motors
    - Updated HAL for future MCHV2 support
    - Updated Motor Control Library
    - Numerous minor fixes
  - Changes in R3:
    - MCC system module compatibility
    - MCHV-2 and MCHV-3 support
    - Inverter maximum current now has a 1:1 ratio with the maximum commanded dq-frame current of the drive, operating in FOC (in R2 this incorporated a derating factor)
    - Other minor fixes
  - Changes in R4:
    - MCC peripheral support
    - Parameter customization
    - Quadrature encoder support
    - Added new startup method (Weathervane startup)
    - Other minor fixes
  - Changes in R5:
    - Added device support for dsPIC33CK256MP508
    - Added Angle-tracking PLL (ATPLL) sensorless estimator
    - Improved motorBench Customize page support
    - Other minor fixes
- Sections in this release notes affected:
  - Other Requirements
  - Limitations
  - Supported Motor Parameters

Known Issues

Issue Key	Summary	Workaround
MBPLAN-673	Serial port does not get closed programmatically when MCC exits during motor parameter measurement	If you exit SC during execution, restart MPLAB X.
MBPLAN-932	Exception during attempted creation of a runtime properties class	No workaround needed, this issue doesn't have an impact on the functionality.
MBPLAN-984	Improve error reporting for SC build errors in the event of a code generation failure	
MBPLAN-1095	Switching projects after loading motorBench erroneously allows motorBench code to generate for new project	
MBPLAN-1160	"Import Motor" and "Export Motor" buttons can be clicked multiple times, opening multiple dialog boxes	

Motor Control Issues

Issue Key	Summary
DB_MC-411	Current calibration happens only once (at part reset) rather than upon entry to MCSM_RESET state
DB_MC-560	Speed controller exhibits chattering behavior at voltage saturation hysteresis boundary (MCAF)
DB_MC-978	"Soft start" gate drive in board_service.c has duty cycle that is too small
DB_MC-1092	PLL estimator may not converge into rotor reference frame while using the Classic startup method in MCAF
DB_MC-1396	PLL calculations in code generation do not allow motor.velocity.nominal to be more than 1250Hz electrical (=20kHz/8/2)
DB_MC-1415	With some motors and 12V operation, increased velocity margin improves startup but creates unstable estimator
DB_MC-1430	Quanum MT4012 unstable in closed-loop operation at 4200 RPM speed and above
DB_MC-1491	With Quanum MT4012, MCAF may not detect stall
DB_MC-1492	Quanum MT4012 Stalls on pressing 'S3'(reverse) at low speeds and on changes to speed command potentiometer
DB_MC-1495	Anaheim BLY342D-24V-3000, BLY342D-48V-3200 motors creates hardware over-current during stall-detect testing
DB_MC-1521	Closed loop speed step response overshoot - MCHV2, Leadshine 400
DB_MC-1892	Some motors with extreme parameters may produce out-of-range error for stall_detect.group.timerCountsVarianceDetect (detected in Monte Carlo analysis)
DB_MC-1920	Board service isrCount-based timing is not guaranteed
DB_MC-1922	LED patterns not displayed when in the TEST_DISABLE or TEST_ENABLE states
DB_MC-2122	BLWS232D motor startup in QEI mode causes a false detect for stall-detection
DB_MC-2213	Deadtime needs to be changed in both MCC and motorBench to affect code
DB_MC-2275	Large current rampup times may not start (STARTUP_TORQUE_RAMPUP_RATE = 0)
DB_MC-2309	QEI tracking loop Kp and Ki produce out-of-range errors for low-speed motors
DB_MC-2323	Weathervane transition state should not have active damping enabled
DB_MC-2387	DC link voltage measurement may have too much phase delay for MCAF DC link compensation to work effectively
DB_MC-2606	MCC-generated code has incorrect IESO/FNOSC config bits for 33CK
DB_MC-2671	MCAF_CaptureTimestamp calls incorrect timer function for 33CK devices
DB_MC-2785	Current sense signal integrity issue with 33CK during overmodulation

Limitations

Supported Devices

motorBench® Development Suite supports these devices:

1. dsPIC33EP256MC506
2. dsPIC33CK256MP508

Software Limitations

motorBench® Development Suite is tested for serial communication using Windows 7 and Windows 10 platforms. Other platforms may work with standard baud rates, but this operation has not yet been verified.

Motor Control Limitations

Following are the known limitations for this release of motorBench® Development Suite:

1. **One mechanical load** - constant load. This represents a mechanical load with constant inertia, viscous damping, and friction. The velocity control loop can generally reject external disturbance torques, within the rated current of the motor and board, and within the bandwidth of the velocity control loop. Mechanical loads with time-varying or angle-varying inertia, viscous damping, and friction, such as a blower, compressor, or pump, are currently not supported.
2. **One motor type** - PMSM
   MCLV-2:
   The reference motor is the Nidec Hurst motor DMA0204024B101 (MicrochipDirect part number AC300022). Microchip has also validated motorBench® Development Suite (including motor parameter measurement) with motors with parameters plotted below. Please also read the following section on Supported Motor Parameters. If motorBench® Development Suite is unable to spin a motor successfully, please contact Microchip staff for additional assistance.

	units	min	max	plot
Resistance (R)	ohms (line-line)	0.1714	5.664	
Inductance, q-axis (Lq)	mH (line-line)	0.02982	5.269	
Inductance, d-axis (Ld)	mH (line-line)	0.03576	5.172	
Back-emf (Ke)	Vrms/KRPM (line-line)	0.8808	6.49	
Friction (Tf)	mNm	0.556	54.03	
Viscous damping (B)	uNm/(rad/s)	1.012	196.9	
Inertia (J)	uNm/(rad/s^2)	0.362	1162	
Electrical time constant L/R	ms	0.1913	3.889	
Mechanical time constant 2/3 JR/Ke^2	ms	2.27	47.25	
				10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}

   (Note: Mechanical time constant (2/3)×JR/Ke² represents the time constant of velocity acceleration under an open-loop synchronous-frame voltage step, neglecting the effects of inductance, with J, R, and Ke expressed in canonical metric units. R is expressed as line-neutral resistance = half of line-line resistance, and Ke is expressed as V/(rad/s) line-neutral zero-peak = Vrms/KRPM (line-line) × 0.007796968)

   MCHV-2/MCHV-3:
   The reference motor is the Leadshine 400W motor EL5-M0400-1-24 (MicrochipDirect part number: AC300025). Microchip has validated motorBench® Development Suite (including motor parameter measurement) with motors with parameters plotted below. Please also read the following section on Supported Motor Parameters. If motorBench® Development Suite is unable to spin a motor successfully, please contact Microchip staff for additional assistance.

	units	min	max	plot
Resistance (R)	ohms (line-line)	1.514	13.02	
Inductance, q-axis (Lq)	mH (line-line)	3.474	42.19	
Inductance, d-axis (Ld)	mH (line-line)	3.176	37.47	
Back-emf (Ke)	Vrms/KRPM (line-line)	21.2	39.23	
Friction (Tf)	mNm	7.812	66.53	
Viscous damping (B)	uNm/(rad/s)	17.91	108.4	
Inertia (J)	uNm/(rad/s^2)	16.21	240	
Electrical time constant L/R	ms	0.9745	3.059	
Mechanical time constant 2/3 JR/Ke^2	ms	0.8905	2.797	
				10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}

3. **Board**
   a. **dsPICDEM™ MCLV-2 development board**. This release of motorBench® Development Suite is compatible with modifications to the board to alter its rated current or voltage. Contact your local Microchip office to obtain the document "Using MCLV-2 with motorBench® Development Suite to support alternative current and/or voltage ratings", which provides guidance for such modifications. Other modifications may not be compatible.
   b. **dsPICDEM™ MCHV-2 and MCHV-3 development boards.** This release of motorBench® Development Suite is compatible with unmodified MCHV-2 and MCHV-3 development boards.
4. **Motors should be well-matched to the board and operating voltage.** The nominal DC link voltage of the MCLV-2 board is 24V. This voltage can be changed by cutting jumper J6 and using an appropriate power supply connected to the appropriate terminals of J7. Use of a mismatched motor (for example, a 12V motor used with a 24V DC link voltage) may cause a hardware over-current fault; in this case motor parameter measurement may fail with the message "Fault Code #10: Undefined Fault". Retry with an appropriate DC link voltage.
5. **Two PIMs and Two devices** - dsPIC33EP256MC506 External OpAmp PIM with silicon revision A8 or dsPIC33CK256MP508 External OpAmp PIM. (Please see the Hardware Setup section of the motorBench User's Guide for important modifications to dsPIC33EP256MC506 External OpAmp PIM for use in MCHV-2 and MCHV-3.)
6. **One algorithm** - FOC
7. **Estimators** - PLL, QEI, ATPLL
8. **Motor parameter measurement:**
   a. **Performance criteria adjustment is not presently supported.** This includes adjustment of phase margin and PI phase lag at crossover in the current loop; Microchip has not completed validation and documentation of these adjustments.
9. **Autotuning:**
   a. **Performance criteria adjustment of the current loop is not presently supported.** This includes adjustment of phase margin and PI phase lag at crossover; Microchip has not completed validation and documentation of these adjustments.
   b. **Use of performance criteria adjustment of the velocity loop is not fully documented or tested.** We recommend not adjusting phase margin or PI phase lag unless necessary; cases where this is likely to occur are large inertias where $\alpha_J = JR/LK_m^2 > 10$, for which an increase of phase margin is appropriate. Phase margin values between 70 and 85 degrees are recommended in this case, with larger values providing additional stability at the cost of lower velocity bandwidth.
10. **Axis management not currently implemented** - supports only one axis.
11. **Code generation:**
    a. **PWM switching frequency is fixed at 20kHz and does not reflect the value entered under Board parameters**
    b. **Integration with external user-supplied code may involve substantial changes.** Some guidelines for this are given in the documentation for the Motor Control Application Framework. While it is possible to integrate the code generated from motorBench® Development Suite with external code, it is the responsibility of the end user to validate this combination.
12. **Required compiler settings**:
    a. **Optimization**
       - `-O1` or greater; `-O0` and `-Os` will both compile without errors but do not execute fast enough to complete within the 50 microsecond ADC ISR. Note: at higher optimization levels, in-circuit debugging using MPLAB X will behave unreliably with respect to breakpoints and single-stepping through C code.
       - The "Omit frame pointer" and "Unroll loops" settings must be enabled.
    b. **Memory model:**
       - Large data model (handles using pointers, not direct addressing, to allow for more than 8K of program variables)
       - Small scalar model
    c. **Additional options:** `-Wno-volatile-register-var -finline`
    d. **Test harness:** In order for the test harness to be enabled, the symbols `MCAF_TEST_PROFILING and MCAF_TEST_HARNESS` should be defined.
13. **Recommended compiler settings:**
    a. **Additional options:**`-Wundef`

Supported Motor Parameters

Since version 2.15, motorBench® Development Suite supports a wide range of motors, subject to the following notes:

- **Ranges of motor parameters** (including rated values and computed metrics) **must be within the limits noted in either range-limits-mclv2.html or range-limits-mchv2.html**. These ranges were tested to ensure that code generation produced firmware constants that were within bounds.
- **Motor parameter measurement does not need to complete successfully but valid motor parameters are required**. Some motors may have too low of an inductance or resistance, and may fail motor parameter measurement.
- **Other particular issues that may cause incompatibility with motorBench® Development Suite include**
  - **Large inertia values** – in this case, increasing voltage loop phase margin may prevent stability problems. (See "Autotuning" in the Limitations section of this document.)
  - **Rotor magnetic saliency** – if there are significant differences between Ld and Lq (>10% difference) then some of the MCAF algorithms may not work optimally. Higher mismatch between Ld and Lq is typically found in interior-permanent magnet (IPM) motors, and is an intentional feature of the design. See the MCAF User's Guide for more information.
  - **Large back-EMF harmonics** – a quasi-sinusoidal back-emf is assumed
  - **Issues involving individual motor control algorithms**, such as PLL estimator, motor startup, or stall detection
  - **High cogging torque**
  - **Mismatch between motor and drive** (namely using a motor with current and/or voltage requirements significantly different from that of the hardware)
- **Microchip cannot guarantee that motorBench® Development Suite will work correctly with all motors**. If a particular motor does not work properly, please contact the MCU16 Motor Control Team for further guidance.

Customer Support

The Microchip Web Site

Microchip provides online support via our web site at http://www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- Product Support – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- General Technical Support – Frequently Asked Questions (FAQs), technical support requests, online discussion groups/forums (http://forum.microchip.com), Microchip consultant program member listing
- Business of Microchip – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

Additional Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineering (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 available on our web site.

Technical support is available through the web site at: http://support.microchip.com