Motor Control Ecosystem Introduction-Motor Suite

Unleash the power of Infineon's Motor Control Solutions with ModusToolbox™ Motor Suite

Abstract

The current landscape of motor control development presents many challenges. The required multidomain expertise, time-consuming development and testing cycles, difficulties in optimizing motor performance and efficiency, and the general complexity of its algorithms make motor control development a complex task to solve. On top of these challenges, product evaluation needs to be done quickly.

Infineon's ModusToolbox™ Motor Suite aims to tackle these challenges by simplifying motor control development and accelerating debugging and fine tuning. Motor Suite directly connects motor control engineers with the differentiating value of Infineon semiconductor products, no programming, no datasheets required.

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1 Motor Control Ecosystem Introduction

Infineon a modern Motor Control Ecosystem to help you design your motor control application. This includes:

- **Semiconductor components**: MCUs, grate drivers, power switches, sensors, etc.
- **Evaluation boards or reference designs** to demonstrate those products in real application scenarios
- **ModusToolbox™ software** with MCU drivers middleware and much more.
- **Motor Suite** as a fundamental part of the ecosystem providing software to create your motor control embedded solution

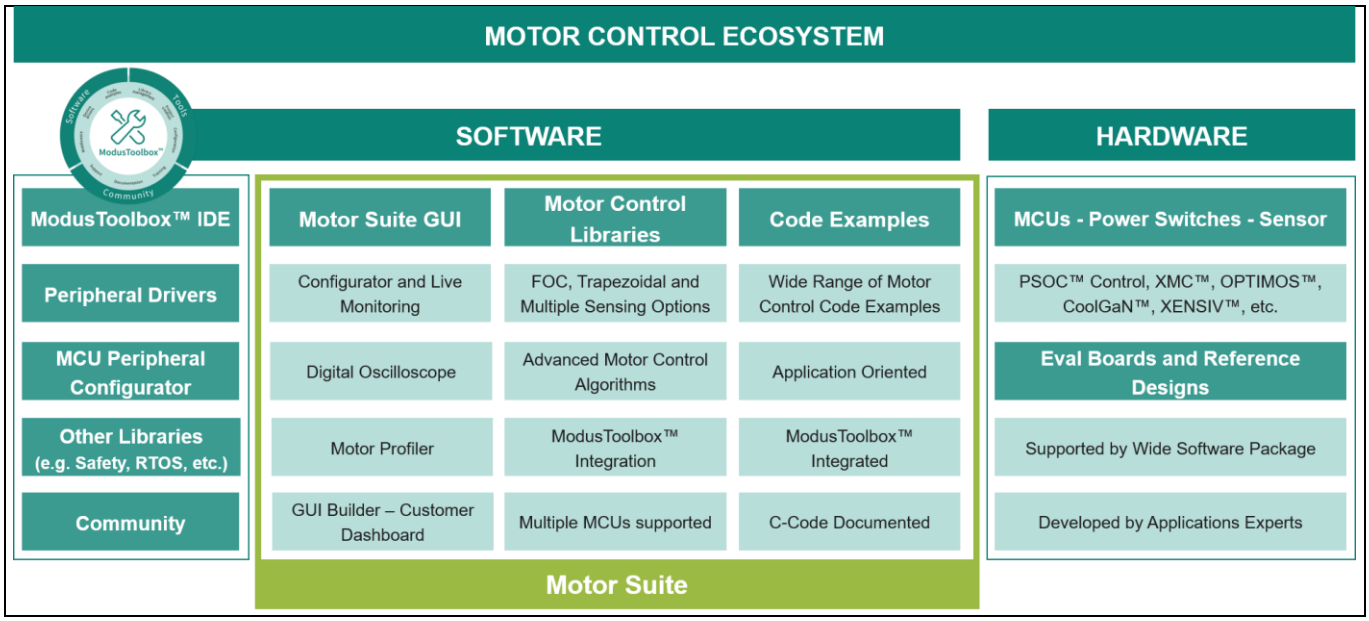

Figure 1 Motor Control Ecosystem Overview

2 ModusToolbox™ Motor Suite

ModusToolbox™ Motor Suite is the part of the ecosystem focused on motor control specific solutions both embedded software and software tools.

2.1 Benefits of ModusToolbox™ Motor Suite

- **Faster Time-to-Market**: out of the box solutions both in firmware and tools. Test solutions without programming during early stage of the evaluation. This enables developers to quickly design, test, and deploy motor and power control systems, reducing time-to-market.
- **Improved Performance**: advanced modern algorithms for wide range of motor control modern solutions ensure optimal motor performance, efficiency, and reliability.
- **Enhanced Debugging Capabilities**: Motor Suite's tools like digital oscilloscope or PID tuner provide in depth analysis features, enabling developers to quickly identify and debug issues, reducing development time and costs.
- **Increased Productivity**: intuitive modern interfaces enable developers to focus on system design and optimization, increasing productivity and efficiency

2.2 ModusToolbox™ Motor Suite Key Features

Motor Suite can be categorized in three different product types:

- Motor Suite GUI: desktop tool to configure, run and optimize you motor control application. Integrated with Motor Suite GUI, you can find following tools:
    - **Configurator and Testbench**: auto-detect your connected evaluation board, configure parameters, flash MCU and run your motor while monitoring key application parameters in a single dashboard
    - **Digital Oscilloscope**: like your real lab scope but with access to your firmware variables. Monitor up to 8 variables like speed, PID outputs, diagnostic variables, etc.
    - **Motor Profiler:** parameters estimation tool. Connect you own motor and click a button to extract R, L, inertia, etc. Then apply optimized filter parameters according to estimated values
    - **GUI Builder**: customer dashboard creator. if you need more than the provided GUI features in Motor Suite GUI, you can create your own fully customizable dashboard
    - **PID Tuner**: tool to optimize controller behavior in the final application. Specific dashboard for PID filter monitoring and fine tuning in a single view
- Motor Control Libraries: comprehensive middleware supporting all motor control domains (sensing, modulation, protections, control methods and much more) required for modern applications. This middleware uses ModusToolbox™ peripheral and others libraries to build a complete embedded support for the MCU.

  Motor Control Libraries are directly accessible in ModusToolbox™, download and use it in your embedded projects These libraries cover:
    - **Advanced control algorithms** like FOC or trapezoidal control
    - **Different start up methods**, like rotor alignment or 6pulse injection (Initial Position Detection).
    - **Modulation schemes** for different types of motor control (trapezoidal, SVPWM 3phase, 2phase, etc.)
    - **Sensing**: different options for current sensing and position sensing including sensorless FOC, Hall based or encoder (A, B, Z) based.

- **Protection and diagnostic** functions for robust operation of whole system, including voltages, currents, I2T, temperature and more.
- Much more

- Motor Control Code Examples: **application specific code examples running on Infineon evaluation boards and reference designs**. Learn motor control solutions from Infineon with systems designed by application experts. Infineon offers a wide range of application tailored designs.

2.3 Motor Suite Customer Journey

In order to have best experience with Motor Suite, it is recommended to have an evaluation board that supports it. Supported boards provided a quick-start-guide to help you start using all elements. In Figure 3 the typical connection can be seen. Laptop where Motor Suite is installed is connected via USB cable to the evaluation board that includes normally an on-board debugger which allows the user to command and read the MCU in it.

Motor Suite allows user to:

- choose the solution among all offered,
- configure parameters like supply voltage or motor parameters and
- run and evaluate application.

User can connect the provided motor with some of the evaluation boards or a custom motor to evaluate the desired set up. Motor Suite provides binary files for the provided evaluation boards supported, therefore, no programming is required and Motor Suite is the only tool required to tune the motor.

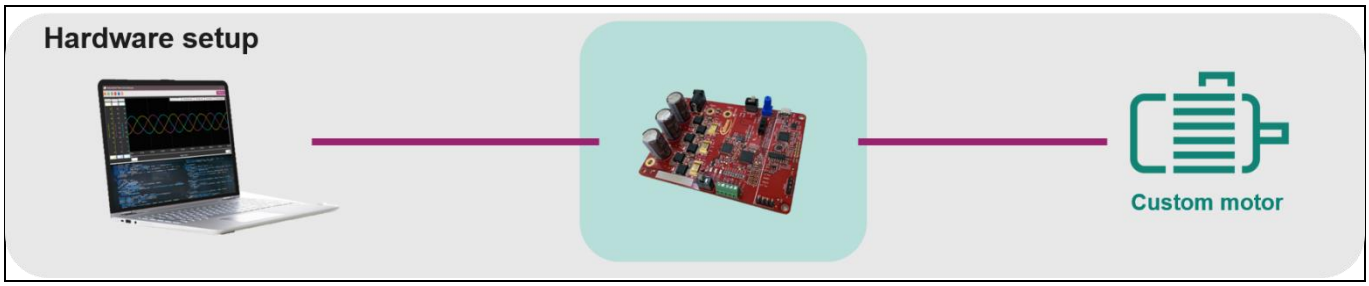

Figure 2 Hardware set up

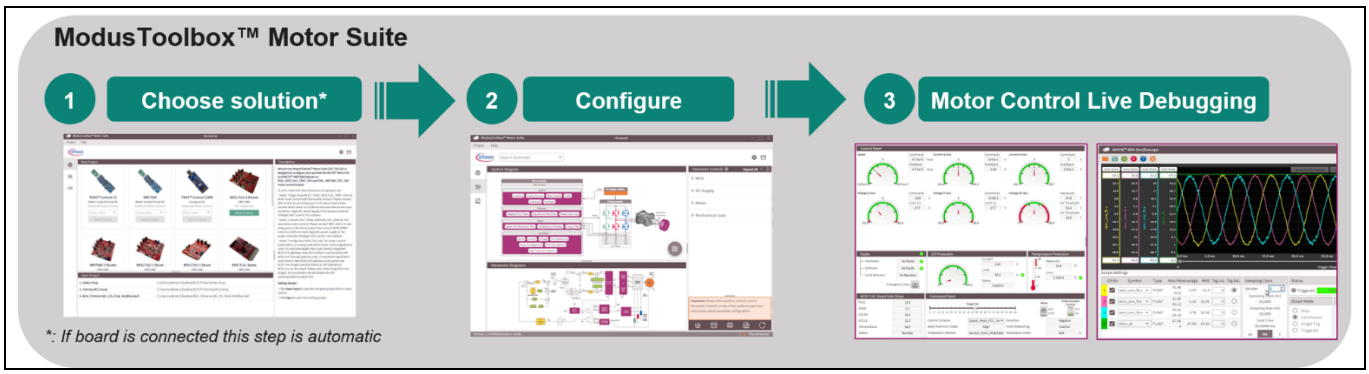

Figure 3 Basic customer journey

In some cases, user might want to:

- Add other functions that does not come as default in Motor Suite, e.g.; UART channel

- Use a custom inverter different than an Infineon eval board

In this case, source code modifications are required and therefore, a new binary file needs to be created. For these cases, ModusToolbox is needed. All evaluation board provided by Infineon include a code example with open source code (C code) using Motor Control Libraries. This code can be modified as necessary. As shown in Figure 4, once the new binary is generated after code compilation, user can return to Motor Suite to flash that new binary and continue tuning.

Attention: Attention: changes to code must not modify communication layer with Motor Suite to ensure that the work with Motor Suite can work

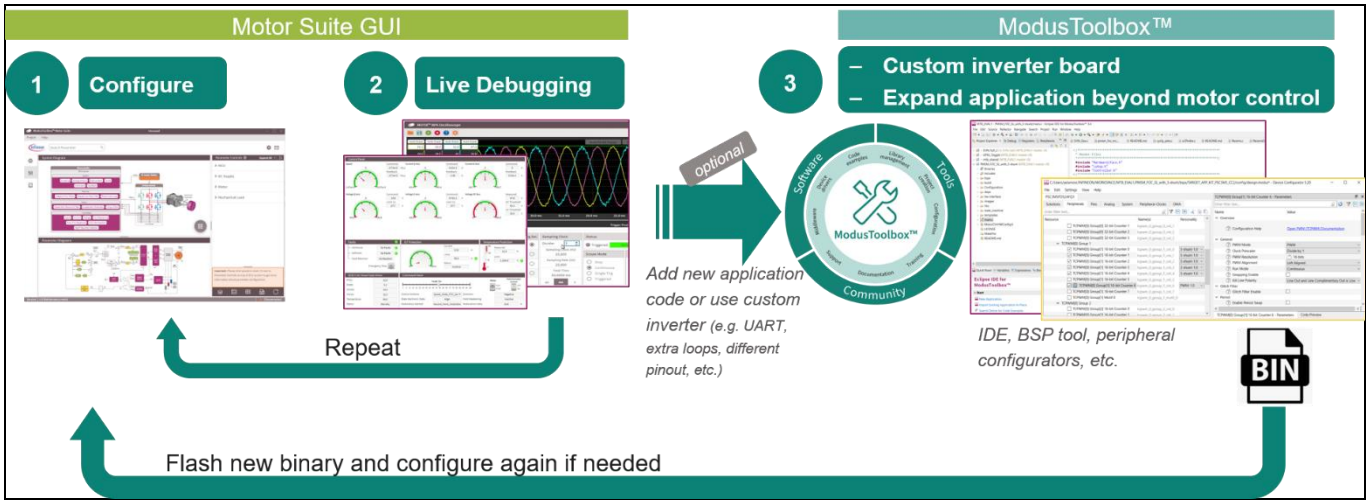

Figure 4 Customer journey including source code modification in ModusToolbox™ IDE

2.4 Motor Suite GUI Details

Motor Suite is a desktop tool offering a complete set of sub-tools to help motor control engineers achieve high performance motor control in least amount of time. These different sub-tools are described in this section.

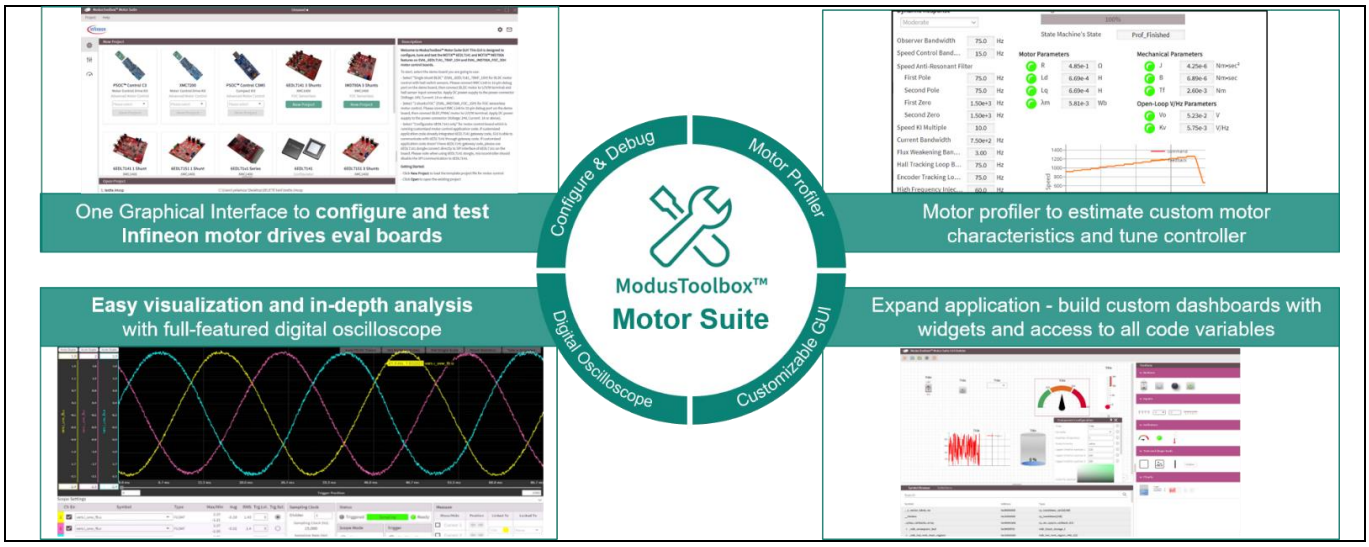

Figure 5 ModusToolbox™ Motor Suite overview

2.4.1 Configurator and Testbench View

Configurator and Testbench builds the basic GUI features, meaning, configure, write, run application and monitor the MCU and motor control variables live while running in the lab.

Key Features:

- **Easy and intuitive parameters adjustment**: parameters grouped by application usage
- Visualize system parameters as a block diagram: navigate easily by clicking diagram
- **Advanced and basic views**: start with basic, if needed, open more parameters
- Sticky flags to signalized parameters that changed from the default value.
- **Parameter diagram visualization**:
    - Quickly identify relationships and dependencies
- **Live testbench** updates:
    - Instantly monitor the impact of parameter adjustments

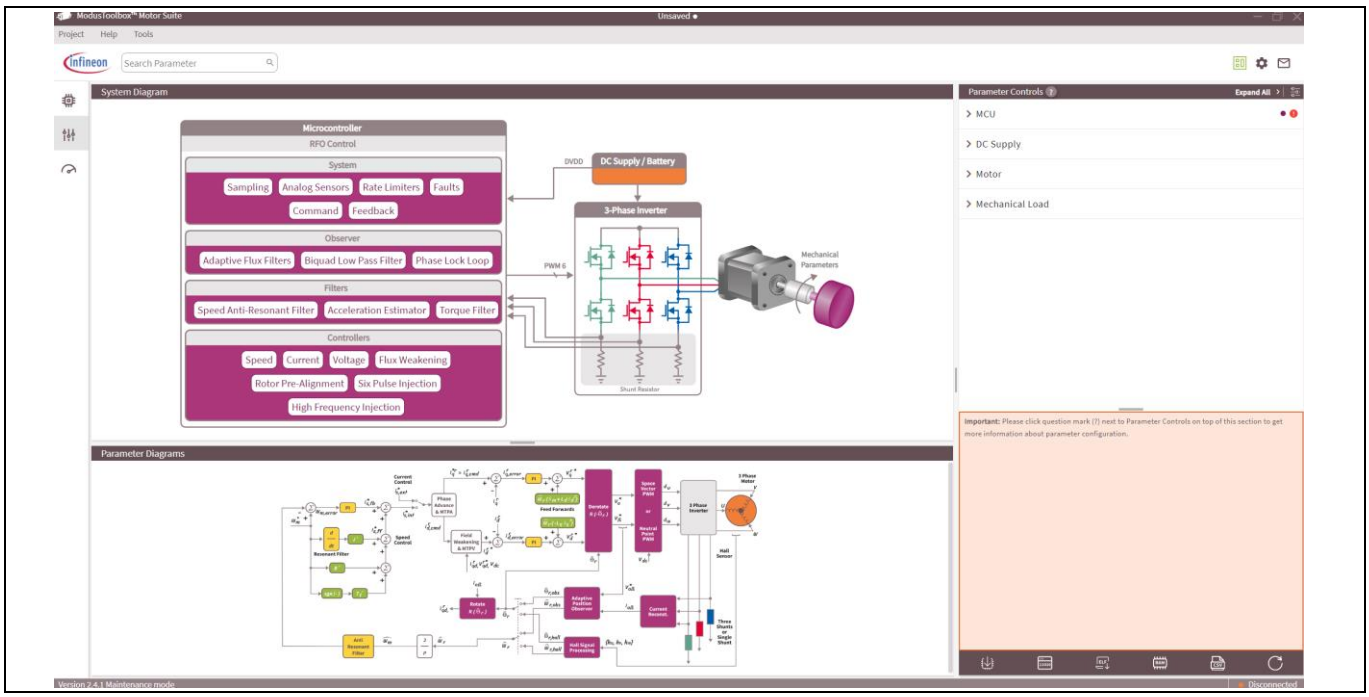

Figure 6 Motor Suite Configurator view example

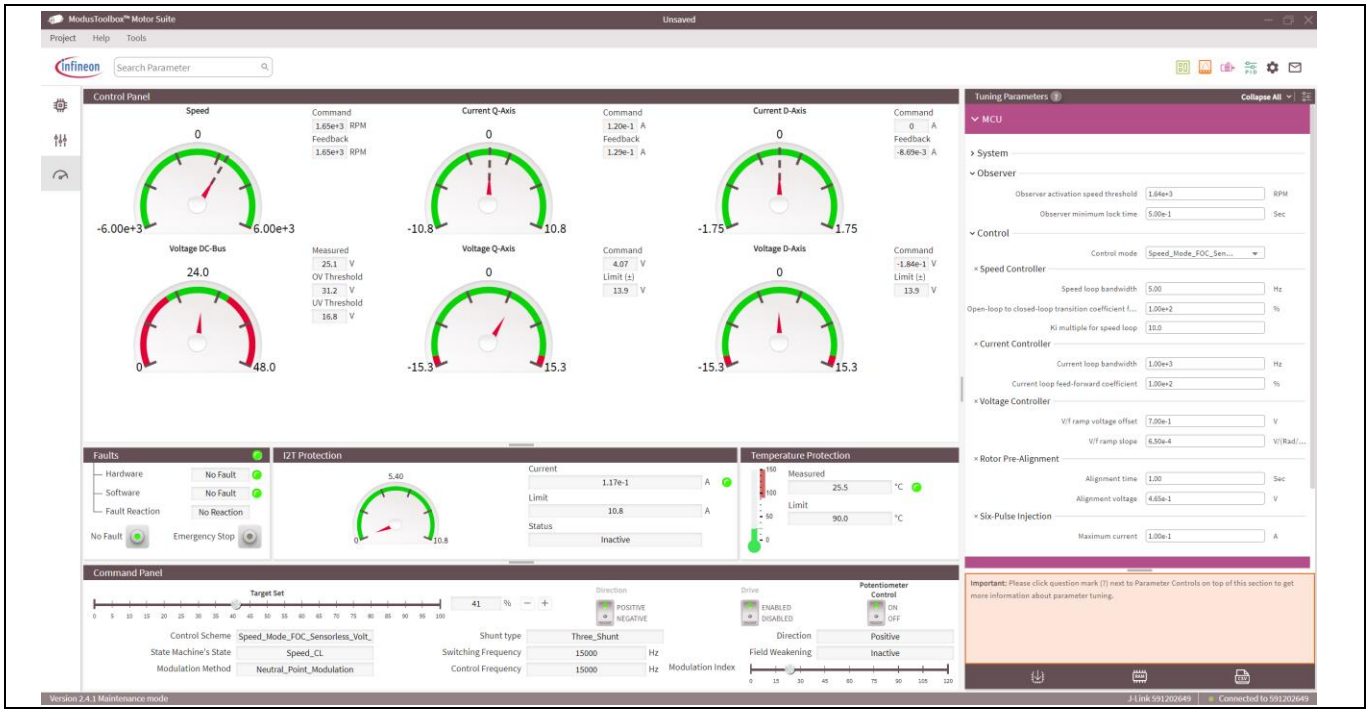

Figure 7 Motor Suite Testbench view example

2.4.2 Digital Oscilloscope

Like the oscilloscope you can find in lab, but with access to all MCU variables. The digital oscilloscope integrated in ModusToolbox™ Motor Suite is able to access variables at the frequency that the MCU is sampling in the control loop and plot them in a sophisticated oscilloscope UI. This allows deep knowledge of the control system and provides best environment for in depth optimization. Digital scope will not help you with MOSFET ringing or ns signals, but will complement your lab solution with advanced embedded capabilities that your lab oscilloscope cannot do.

Key features:

- **Digital Oscilloscope** for in-depth analysis of any code variables: select variables directly in scope UI
- **High-sample-rate** oscilloscope functionality: allows to set a divider to adjust time scale. Capture a wider time window with reduced resolution or a short window at higher resolution
- Capture detailed signal data and observe multiple signals simultaneously: adjust gain independently or all together
- **Triggering** and pre-triggering support as in real scopes:
- **Trigger modes:** stop, single, continuous, triggered
- **Enter triggering value and direction of crossing**
- Adjust triggering point alignment on x-axis: allows to see what happens before triggering condition happens
- **Signals statistics and cursors** to support accurate measurements
- **Store data and post-process it** in you tool of choice like spreadsheets
- Much more

Figure 8 Motor Suite oscilloscope view

2.4.3 Motor Profiler

Motor Profiler is a tool to help users to use their own motors in particular with Infineon evaluation boards. Connect motor, open Motor Profiler, run the algorithm and estimate your motor parameters. You can use these parameters or let the tool decide best filter values for your motor control solution in a single mouse-click. This accelerates evaluation of the motor drive application and allows you to focus on aspects that matter most to you.

Key features:

- **One-Click Motor Parameter Estimation**:
  - Calculate main motor parameters (electrical and mechanical) with a single mouse-click
- **Automated Filter Parameter Calculation**
  - Based on estimated motor parameters, control filter parameters are automatically calculated to get best starting tuning point
  - Option to automatically write values to the UI project for ease of use
  - Optional custom configuration for filter in case automatic values are not desired.
- **Accurate characterization:**
  - Precise motor control with automated characterization
- Progress bar

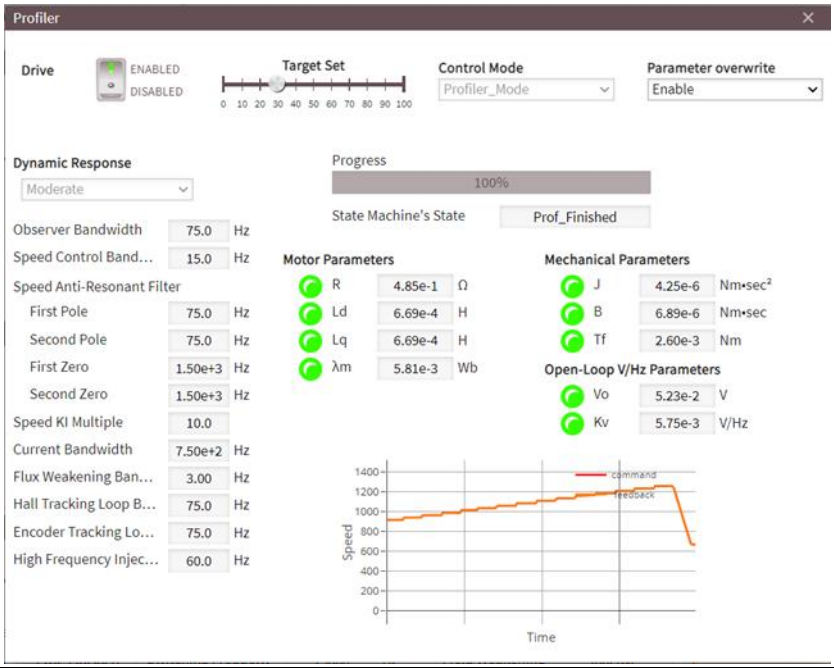

Figure 9 Motor profiler view

2.4.4 GUI Builder

Customizable GUI dashboard to extend your project with more programmed features or add more commanding capabilities.

Key features:

- **Based on '.elf' file**, assign any variable to customizable widgets
- **Visualize parameters that matter most to you**
- **Build your own GUI layout:**
    - Drag-and-drop simplicity for quick debugging and troubleshooting
    - Wider range of widgets to choose from including dials, charts, input boxes, pictures, logos, etc.
- **Fully customizable components: configure range, colors, size, variables assigned**
    - Edit, configure, and personalize each element

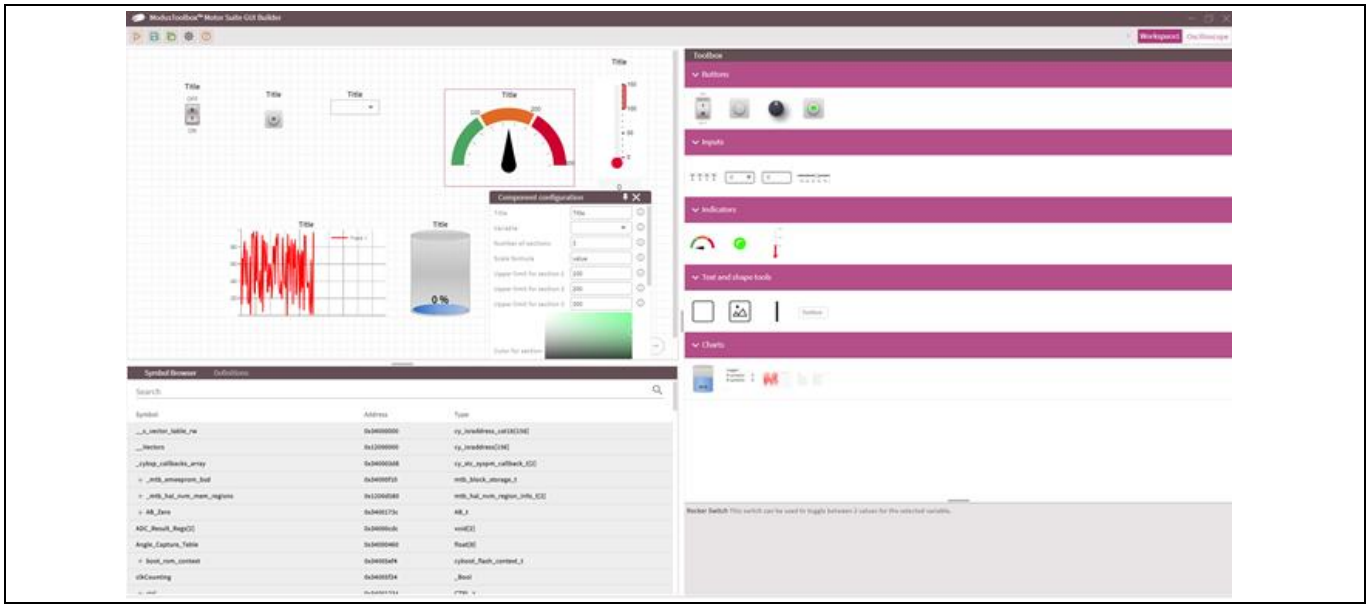

Figure 10 Example of GUI builder dashboard creation

2.4.5 PID Tuner Tool

Unique dashboard design for fine tunings of PID filters in your motor control application. Configure and monitor during live run of your application the different filters.

Key features:

- **Monitor and configure** relevant motor control filters, depending on control mode:
  - RFO (rotor frame oriented) FOC mode: current PI controller (D and Q axis), speed PI controller.
  - SFO (stator frame oriented) FOC mode: flux PI controller, torque PI controller, speed PI controller.
- **Guidance on how to tune** your filters for optimal motor control.
- **Calculate values and store** them

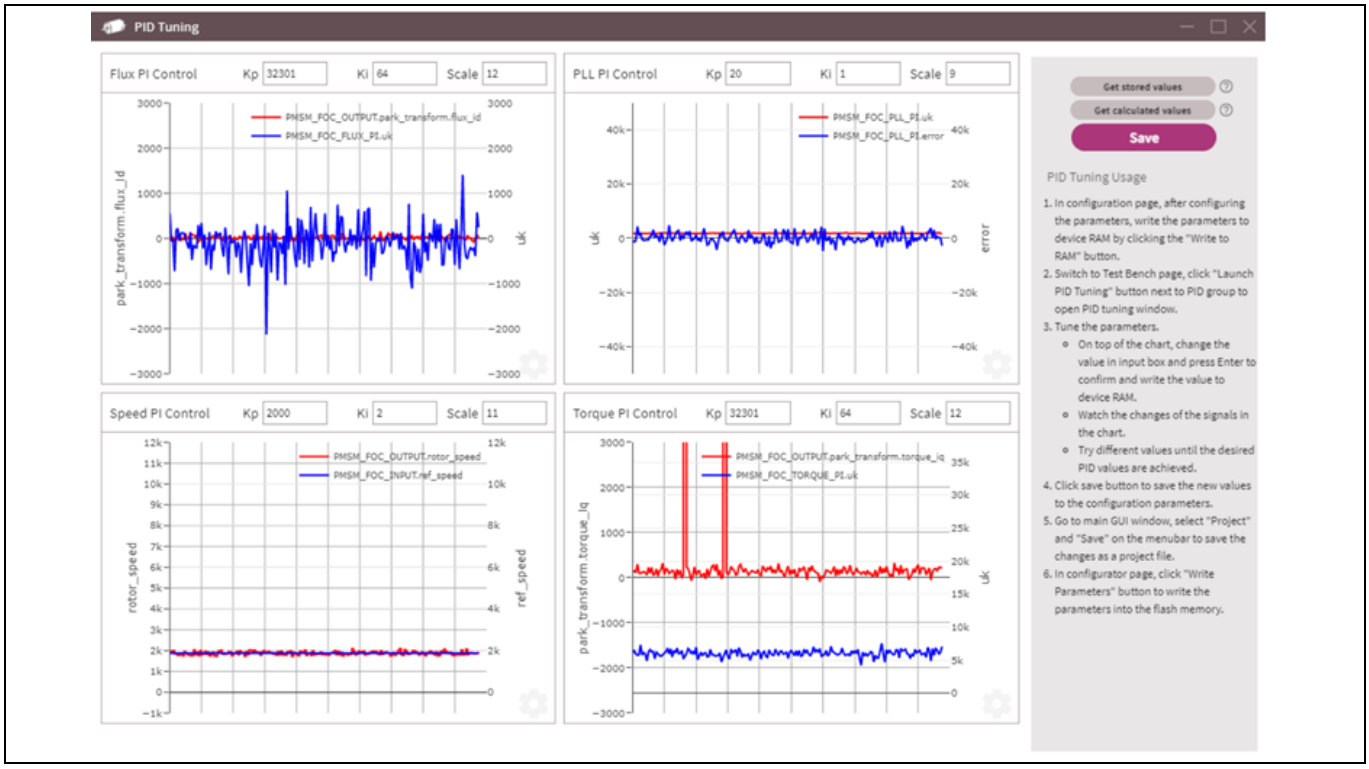

Figure 11 PID tuner tool example view

2.5 Getting Started with Motor Suite

The latest release of the ModusToolbox™ Motor Suite can be downloaded from IDC (Infineon Developer Center) or via ModusToolbox™ Setup tool. In order to evaluate Infineon Motor Control solutions, you need to:

- Purchase a supported evaluation board or reference design, for example Motor Control Kit (e.g. KIT_PSC3M5_MC1)
- Download and install ModusToolbox™ Setup tool or use IDC to download ModusToolbox™ Motor Suite
    - If you use Setup tool, Run ModusToolbox™ Setup tool, install from there the latest ModusToolbox™ Motor Suite version
- Follow the ‘quick start guide’ of the purchased evaluation board or kit.

3 Motor Control Libraries

Motor Control Libraries are middleware assets provided to help users to run motor contorl applications and include basic and advanced APIs or C code functions addressing most common motor control programming needs.

Infineon provides these libraries via ModusToolbox™ Library Manager tool. Libraries are also included in you project when importing code examples based on them. Libraries will show up in your project forlder as part of the ‘mtb-shared’ folder as shown in Figure 12.

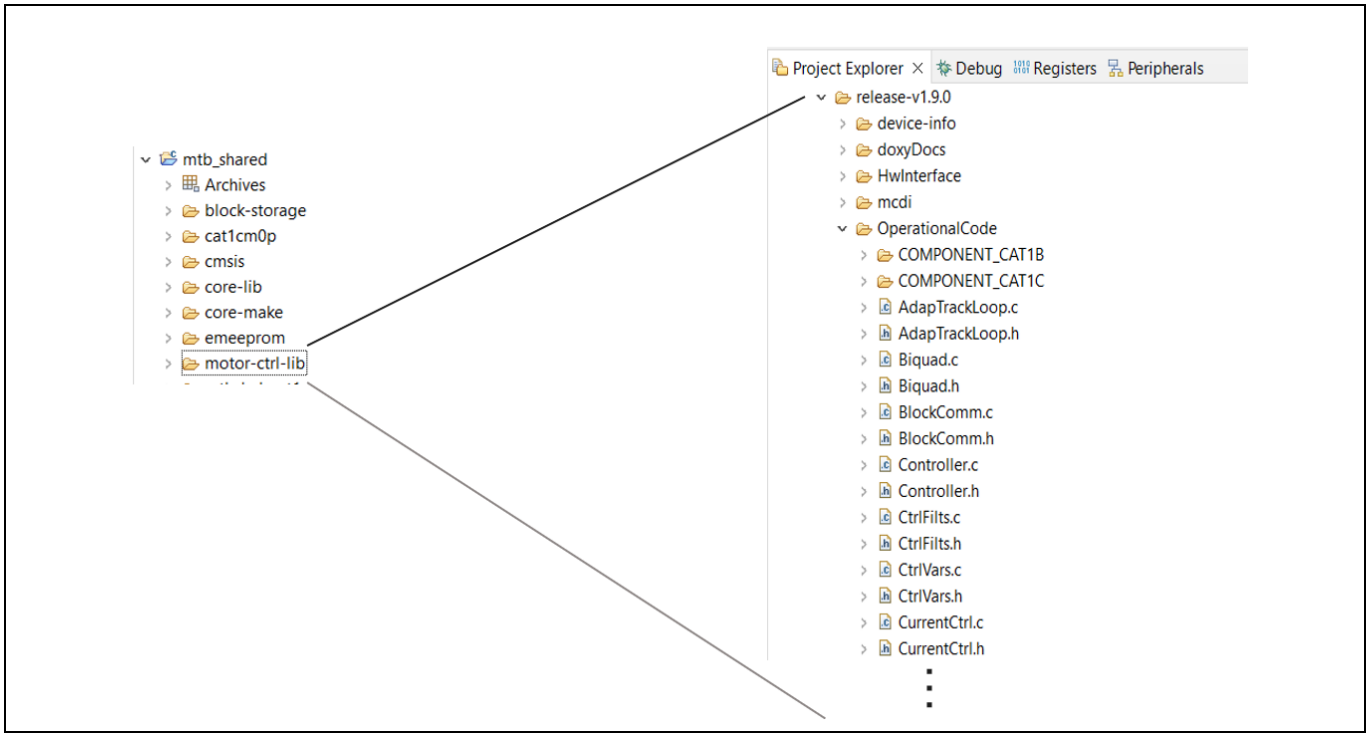

Figure 12 Motor Control Library location in project folder

Table 1 provides an overview of most relevant motor control functions supported in Motor Control Library as well as the supported features in the different devices.

Table 1 Motor Library Features versus supported MCU

Key Features Level 1	Key Features Level 2	Key Features Level 3	Motor Library	MCU Support		
				PSOC™ Control C3 Performance -C3M5	PSOC™ Control C3 Entry - C3M3	XMC7200/ XMC7100
Field Oriented Control (FOC)	Single motor	Sensorless	X	X	X	X
		Hall (3x)	X	X	X	X
		Encoder (A-B-Z)	X	X	X	X
	Dual motor	Sensorless	X	X	X	X
		Hall (3x)	X	X	X	X
		Encoder (A-B-Z)	X	X	X	X
Trapezoidal control	Sensorless					
	Hall (3x)		X	X	X	X
ACIM motor support	V/f (open loop)		X	X	X	X
Control Mode	Voltage controller		X	X	X	X
	Current controller		X	X	X	X
	Speed controller		X	X	X	X
	Torque controller		X	X	X	X
Current sensing and OCP	1 shunt leg		X	X	X	X
	3 shunts	Leg	X	X	X	
		In phase	X	X	X	X
Speed & Position sensing	Sensor (3x Hall)		X	X	X	X
	Encoder (A-B-Z, e.g. TLE5012B)		X	X	X	X
	Sensorless		X	X	X	X
Startup methods	Rotor alignment/Parking, 6 pulse injection, HFI, V/f (open loop), etc.		X	X	X	X
Bus voltage protection (UVP and OVP)	Vbus reading, Under and Over voltage protection		X	X	X	X
Temperature sensing/protection	Temperature measurement, Over Temperature Protection		X	X	X	X
Other Features	Zero speed torque		X	X	X	X
	Braking features (protection)		X	X	X	X
	Ultra-high speed		X	X	X	X
	MTPA (Maximum Torque Per Amp)		X	X	X	X
	HFI (High Frequency Injection)		X	X	X	X
	Flux weakening		X	X	X	X
	7, 5 segment (3 phase/2 phase modulation) Space Vector PWM		X	X	X	X
	MATLAB Model Based Simulation (not code generation)		X	X	X	X
	Over-modulation		X	X	X	X
	Hight Resolution PWM timer		NA	X	X	

4 Motor Control Code Examples

Infineon provides a wide variety of code examples supporting different evaluation boards and reference designs. These examples offer firmware for different microcontrollers and different motor control solutions like FOC, 1 shunt or 3 shunts examples.
To access code examples, you can visit Infineon Github platform and search according to the microcontroller or features needed. Code examples can also be accessed via ModusToolbox™ via new Project Creator tool.

Revision history

Revision	Date	Description of changes
**	2025-3-19	Initial version

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