



WHITEPAPER

Infineon's new platform for development of advanced motor control systems

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1 Introduction

Energy efficiency, reliability, and performance in industrial and commercial applications has increased the demand for advanced motor control systems. To develop these systems, designers need a holistic platform that allows them to create efficient, reliable, and high-performance motor control solutions. A motor control ecosystem typically consists of semiconductor components, evaluation boards, reference designs, software tools, and middleware.

Industrial and commercial applications, such as HVAC systems, robotics, pumps, and conveyor belts, require high-performance motor control solutions to ensure efficient and reliable operation. These applications often involve complex motor control systems, which require advanced features, such as high-performance processing, advanced analog peripherals, and robust overall performance. To meet these requirements, motor control ecosystems must provide a comprehensive platform for motor control application development.

Software tools and middleware are also essential components of a motor control ecosystem. These tools provide designers with the necessary software and firmware to develop and test motor control applications. Middleware, such as Motor Control Library and communication protocols, provides a layer of abstraction between the hardware and software, making it easier to develop and test motor control applications.

Infineon, a leading provider of semiconductor solutions, offers a modern motor control ecosystem that helps designers create innovative motor control applications. In this whitepaper, we will provide insights on existing challenges in motor control development and highlight how ModusToolbox™ Motor Suite, a fundamental part of Infineon's motor control ecosystem addresses these challenges. We will discuss the benefits, key features, and Motor Control Library of the ModusToolbox™ Motor Suite, as well as its application in motor control ecosystems.

2 Benefits and Key Features of ModusToolbox™ Motor Suite

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 to start evaluating your target solution.

3 Motor Control Ecosystem

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

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

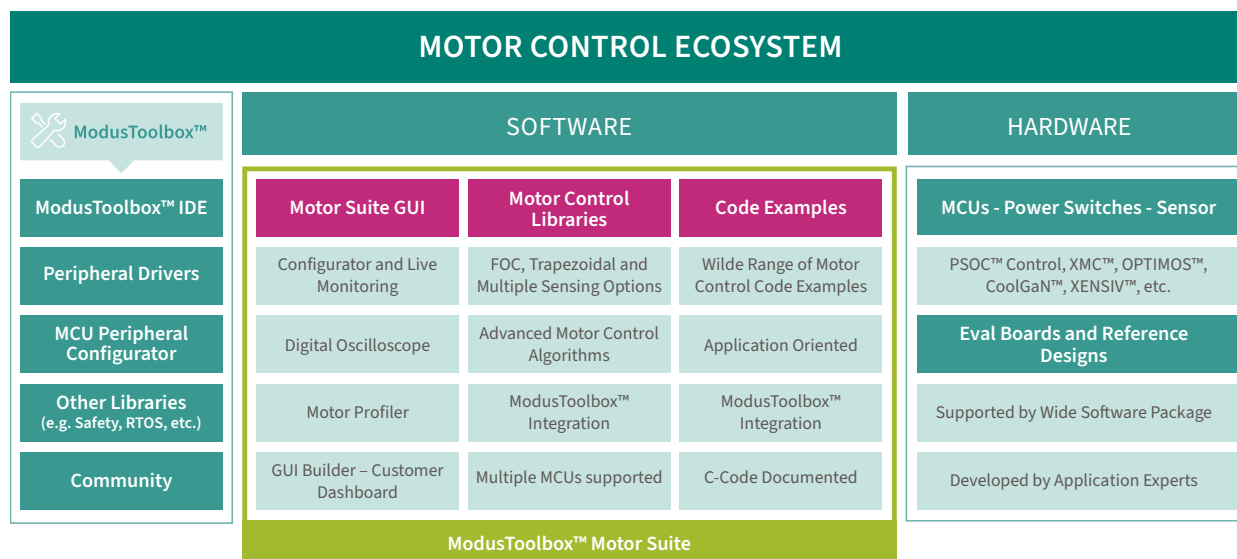


Figure 1 Motor Control Ecosystem Overview

4 ModusToolbox™ Motor Suite

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

By leveraging Motor Suite, developers can experience a significant reduction in time-to-market, improved performance, enhanced debugging capabilities, and increased productivity.

Motor Suite is comprised of:

The **Motor Suite GUI** (Graphical User Interface) is a desktop tool to configure, run and optimize your motor control application. Integrated with Motor Suite GUI, you can find the 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 (Proportional, Integral, Derivative) outputs, diagnostic variables, etc.
- **Motor profiler:** parameters estimation tool. Connect your 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

The **Motor Control Library** is 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 other libraries to build a complete embedded support for the MCU.

Motor Control Library is directly accessible in ModusToolbox™ for you to download and use in your embedded projects. These libraries cover:

- **Advanced control algorithms** like FOC or trapezoidal control, for single and multiple motor 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.

Motor Control code examples are application-specific code examples running on Infineon evaluation boards and reference designs. The motor control solutions are designed by application experts who have in-depth knowledge of various motor control applications. Infineon offers a wide range of application-tailored designs.

4.1 Motor Suite Customer Journey

To have the best experience with Motor Suite, Infineon offers a wide range of [evaluation boards](#).

In Figure 2, the typical connection can be seen. The computer on which Motor Suite is installed is connected via USB cable to the evaluation board that normally includes an on-board debugger, which allows the user to command and read the MCU in it.

Motor Suite presents you right after opening with a range of solutions based on Infineon evaluation boards. You can then choose the solution among all offered, configure parameters like supply voltage or motor parameters and run and evaluate application.

You can connect the provided motor with some of the evaluation boards or use a custom motor to evaluate the desired set up. If you do not know the parameters of the motor you want to use, you can use the Motor Profiler tool included in Motor Suite. This tool runs some algorithms where the motor mechanical and electrical parameters are estimated to get you started in the shortest time possible.

Motor Suite provides binary files for the supported evaluation boards. These binary files can be directly flashed to the microcontroller from the GUI removing need to install flasher tools. Once the MCU is flashed with binary, Motor Suite allows you to configure the necessary parameters for optimizing motor operation, therefore no programming or compiling is required to get started.

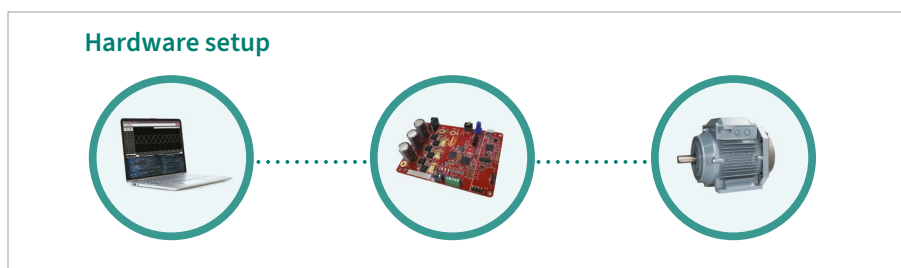


Figure 2 Hardware setup

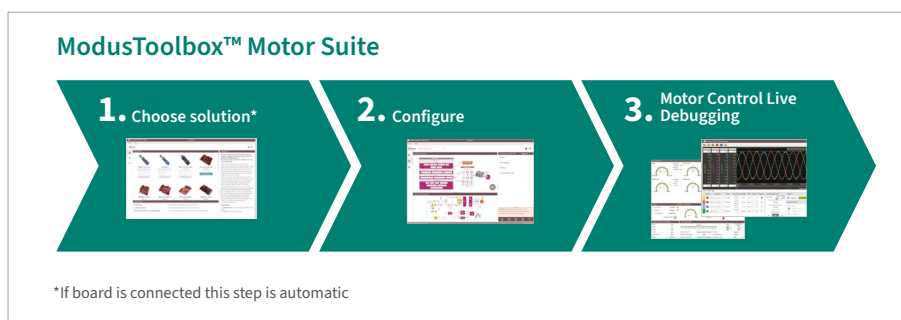


Figure 3 Basic customer journey

In some cases, you might want to:

- Add other functions that do not come as default in Motor Suite, e.g.; UART channel
- Use a custom inverter different than an Infineon evaluation board

When modifications to the source code are necessary, a new binary file must be generated in ModusToolbox™ to reflect these changes. Infineon's evaluation boards include a code example with open source code (C code) using Motor Control Library. This code can be modified as necessary in ModusToolbox™ IDE and code compiled.

As shown in Figure 4, once the new binary is generated after code compilation, you can return to Motor Suite to flash that new binary and continue tuning.

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

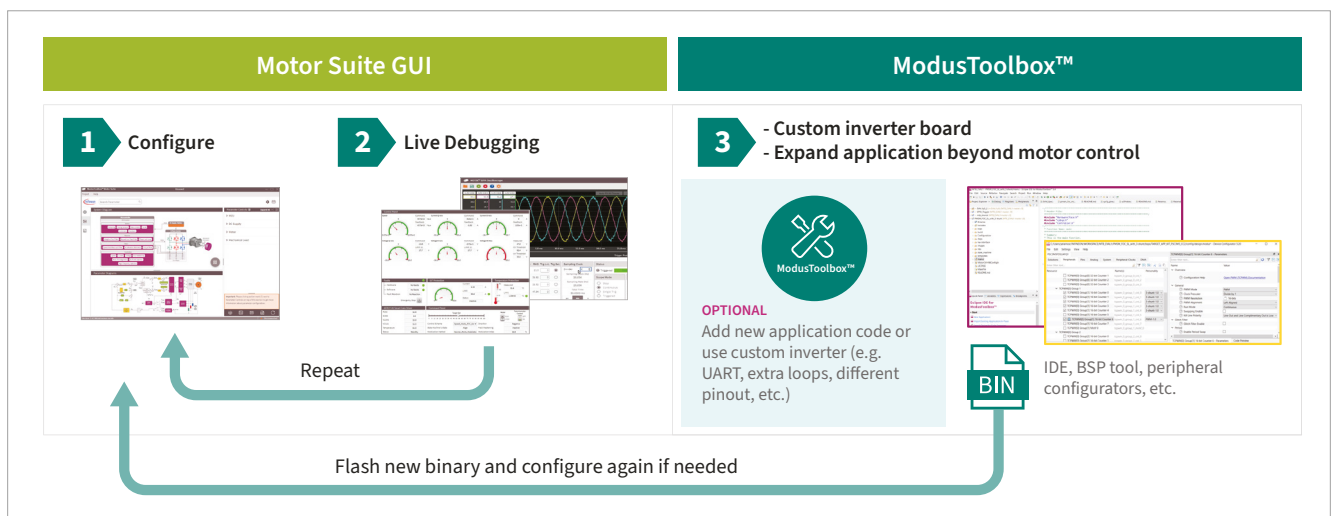


Figure 4 Customer journey including source code modification in ModusToolbox™ IDE

4.2 Motor Suite GUI

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

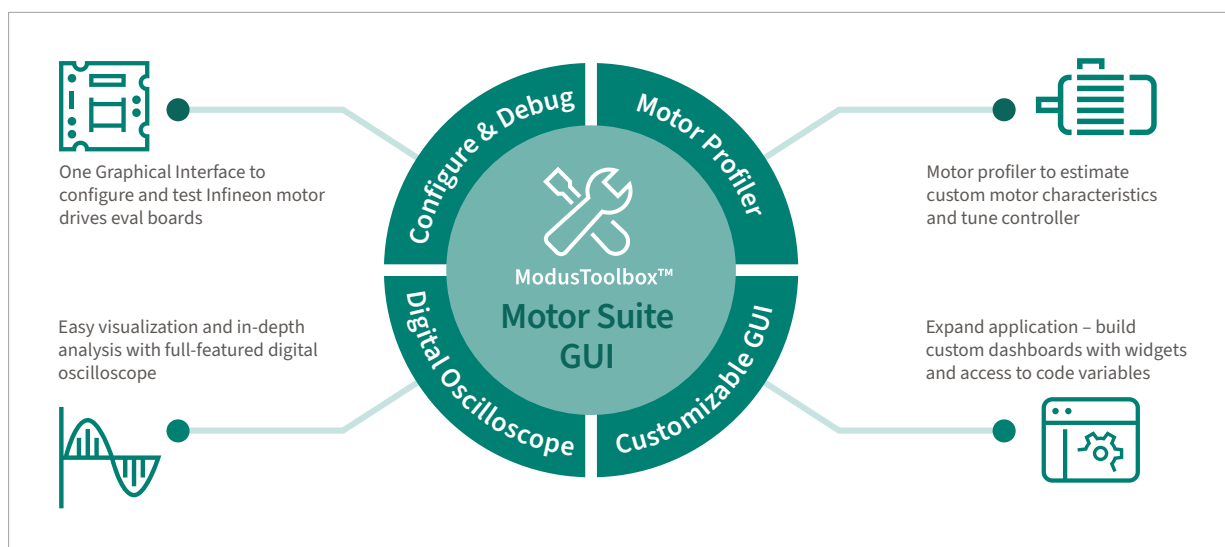


Figure 5 ModusToolbox™ Motor Suite overview

4.2.1 Configurator and Testbench View

Configurator and testbench provide developers the functionality of an evaluation GUI for motor control applications. This means a comprehensive platform for configuring, and running applications, as well as monitoring MCU and motor control variables in real-time.

Key Features:

- Easy and intuitive parameters adjustment: parameters are 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

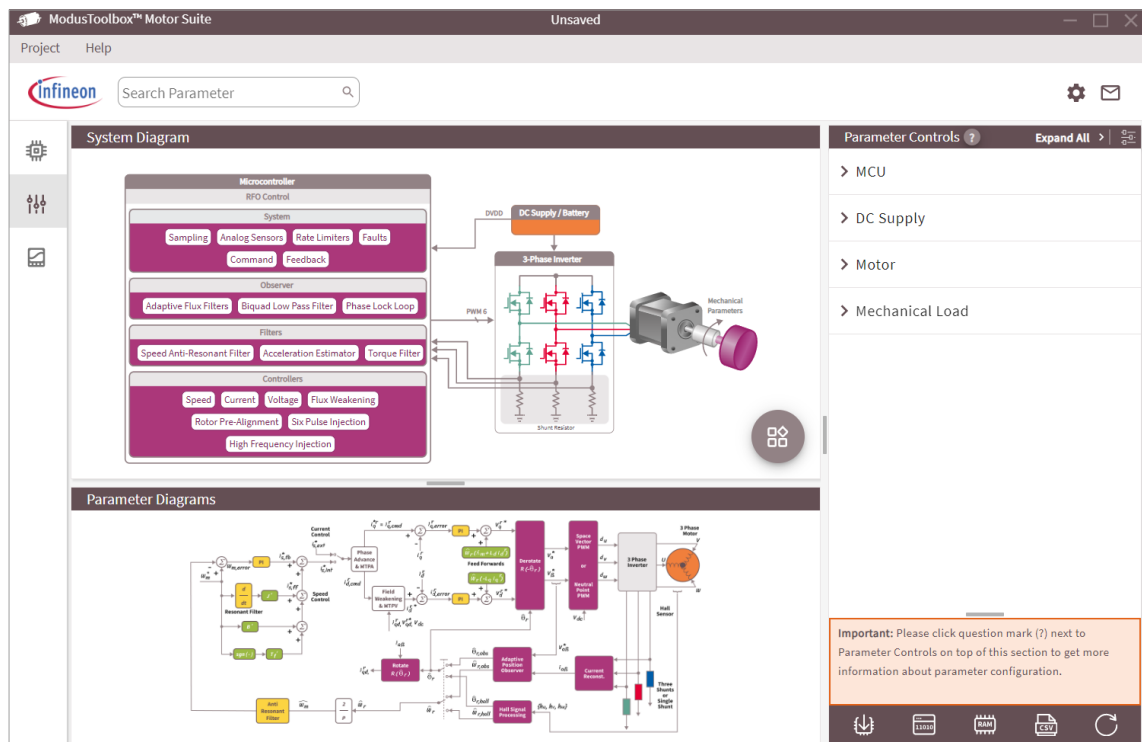


Figure 6 Motor Suite Configurator view example

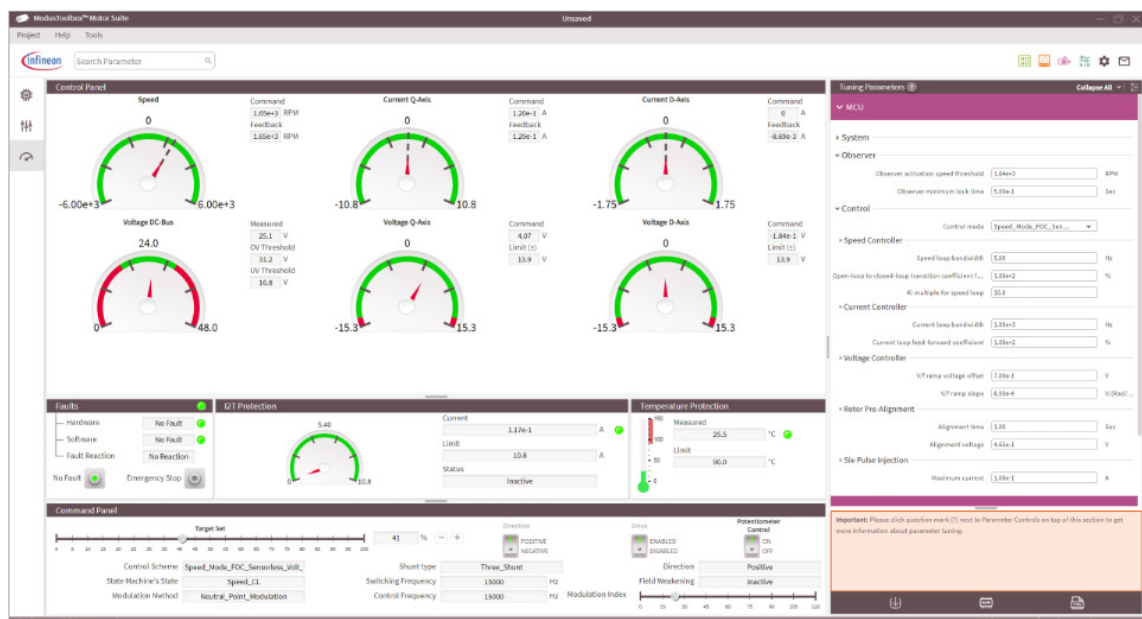


Figure 7 Motor Suite Testbench view example

4.2.2 Digital Oscilloscope

Like an oscilloscope you can find in lab, but with access to all MCU variables, the digital oscilloscope integrated in ModusToolbox™ Motor Suite can access variables at the frequency that the MCU is sampling in the control loop and plot them in a sophisticated oscilloscope UI. This allows for deep knowledge of the control system and provides the best environment for in depth optimization.

Key features include:

- High-sample-rate oscilloscope functionality allows you 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 you 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



Figure 8 Motor Suite oscilloscope view

4.2.3 Motor Profiler

Motor Profiler is a tool to help you use your own motors when you are not sure about the motor electrical and mechanical parameters. You just connect the motor, open Motor Profiler, run the algorithm and it will estimate your motor parameters. You can use these parameters or let the tool decide the best filter values for your motor control solution with a single click of your mouse. 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

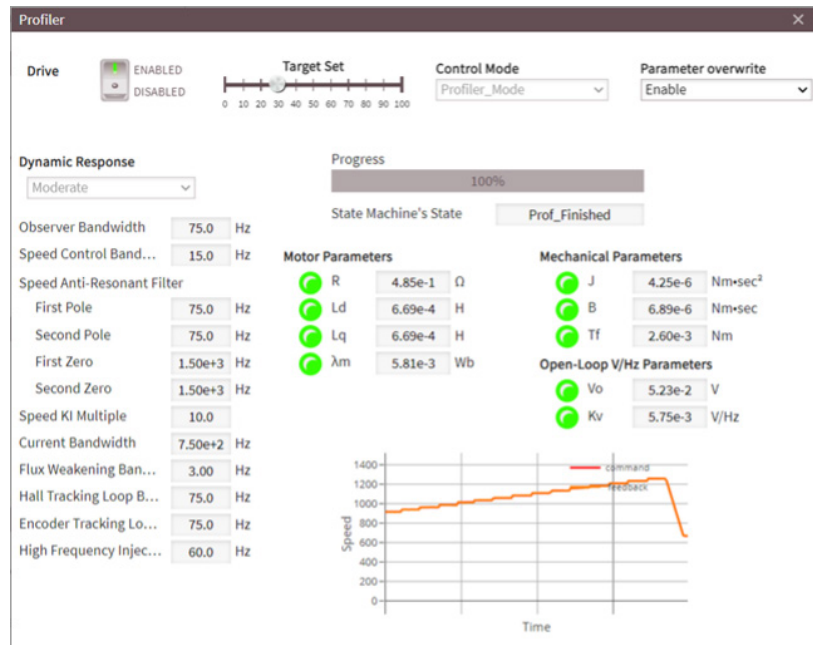


Figure 9 Motor profiler view

4.2.4 GUI Builder

The GUI builder is one of the most valued features by motor control engineers. It allows user to create a customizable GUI dashboard, with your wished buttons, gauges, charts, sliders, etc. This helps you to extend your project with extra programmed features or add more commanding capabilities beyond the default dashboards provided by Infineon.

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
 - Wide range of widgets to choose from including dials, charts, input boxes, pictures, logos, etc.
- Fully customizable components: configure range, colors, size, variables assigned

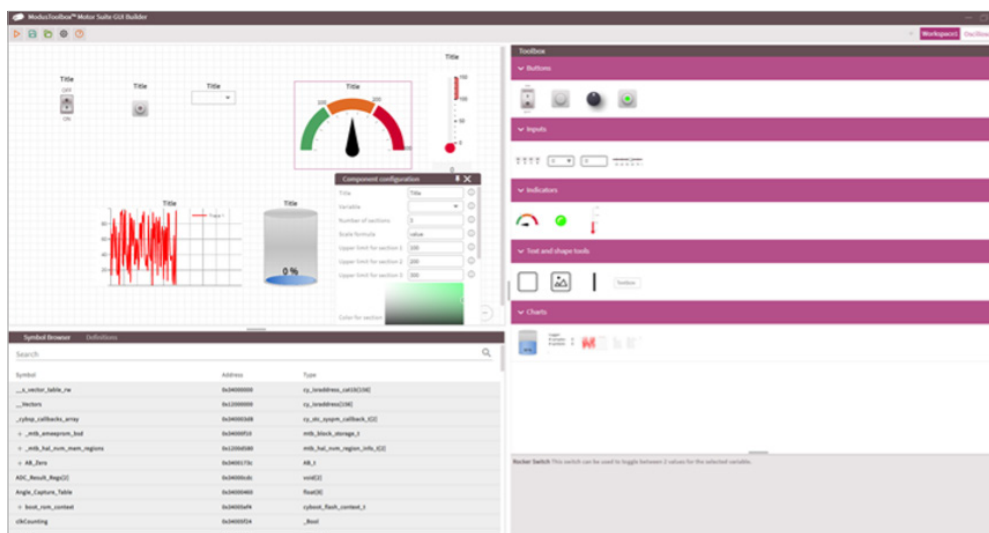


Figure 10 Example of GUI builder dashboard creation

4.2.5 PID Tuner Tool

The PID tuner tool is a unique dashboard designed to fine tune PID filters in your motor control application. With this tool, you can configure and monitor during live operation of your application the different filters, allowing for real-time adjustments and fine-tuning of filter settings, making PID tuning a much simpler task.

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

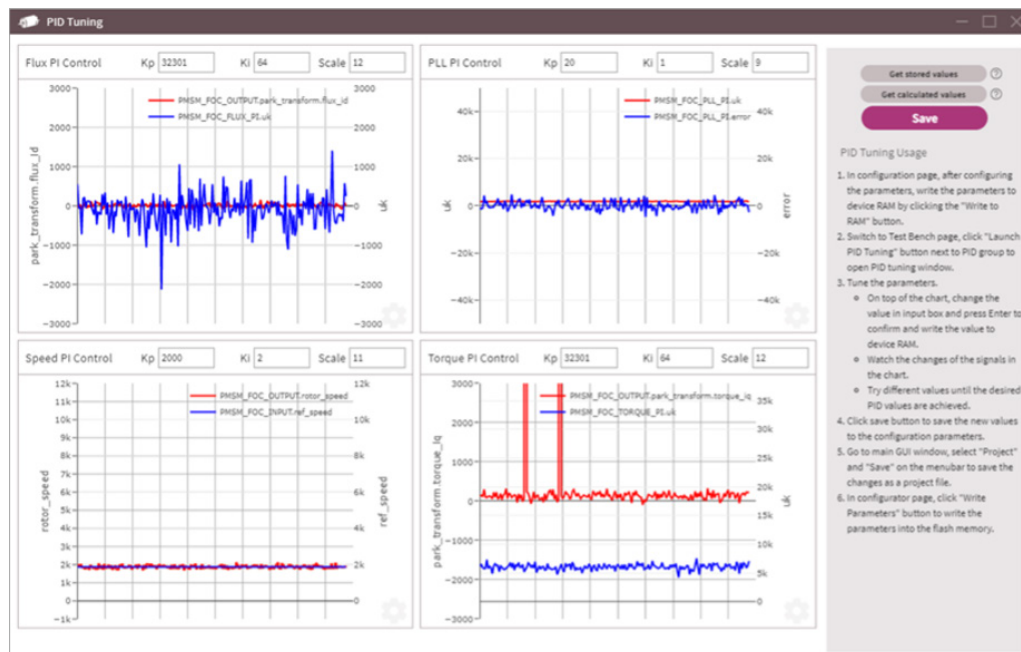


Figure 11 PID tuner tool example view

4.2.6 Getting Started with Motor Suite

The latest release of the ModusToolbox™ Motor Suite can be downloaded from [IDC](#) (Infineon Developer Center) or via the ModusToolbox™ Setup tool. 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](#), [KIT_XMC7200_MC1](#))
- Download and install ModusToolbox™ Setup tool or use IDC to download ModusToolbox™ Motor Suite
- Follow the 'quick start guide' of the purchased evaluation board or kit

4.3 Motor Control Library

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

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

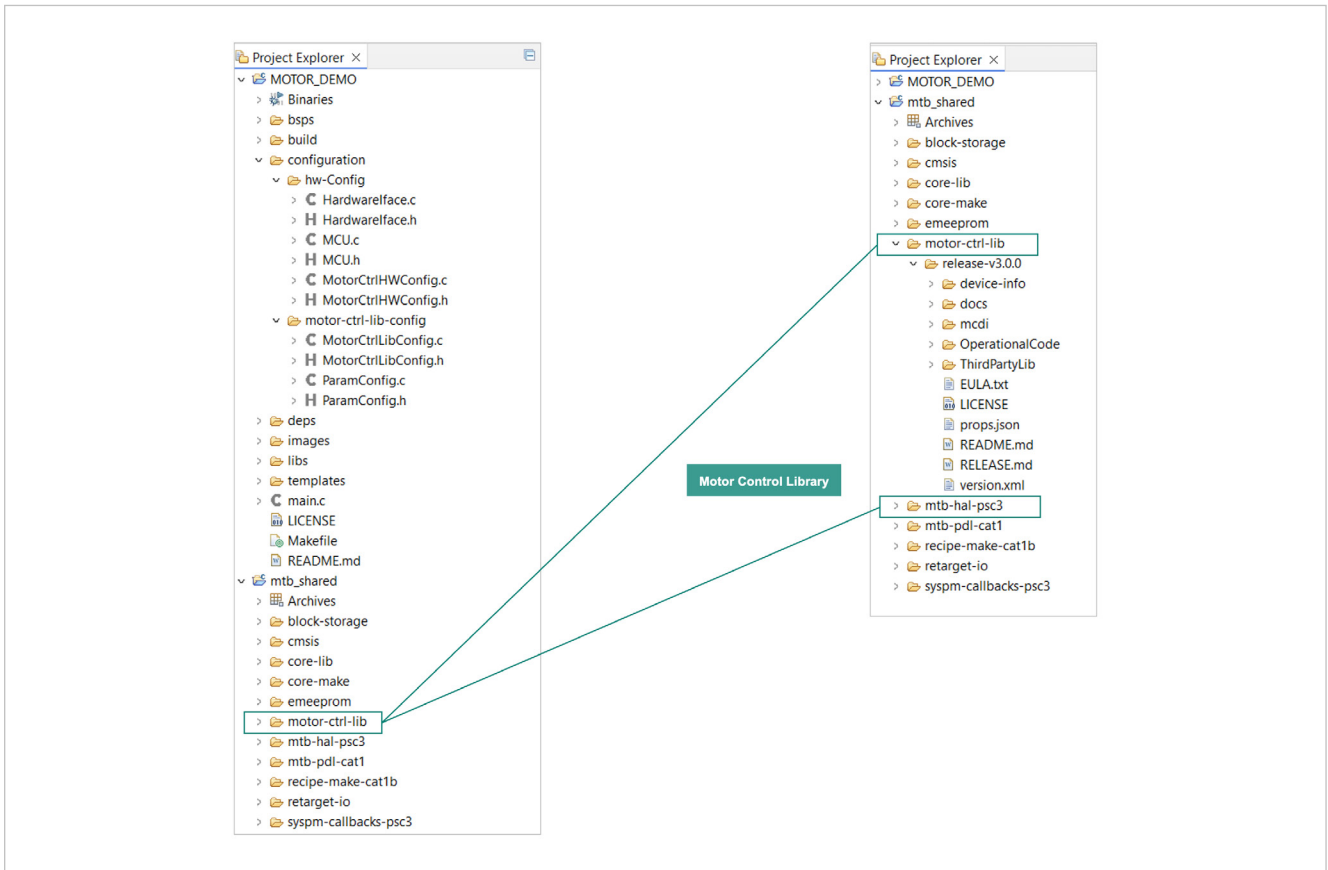


Figure 12 Motor Control Library location in project folder

Supported Devices: PSOC™ Control C3M3, PSOC™ Control C3M5, XMC7100, and XMC7200

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

Key Features Level 1	Key Features Level 2	Key Features Level 3	Motor Library
Field Oriented Control (FOC)	Single motor	Sensorless	X
		Hall (3x)	X
		Encoder (A-B-Z)	X
	Dual motor	Sensorless	X
		Hall (3x)	X
		Encoder (A-B-Z)	X
Trapezoidal control	Sensorless		X
	Hall (3x)		X
ACIM motor support	V/f (open loop)		X
Control Mode	Voltage controller		X
	Current controller		X
	Speed controller		X
	Torque controller		X

Key Features Level 1	Key Features Level 2	Key Features Level 3	Motor Library
Current sensing and OCP	1 shunt leg		X
	3 shunts	Leg	X
		In phase	X
Speed & Position sensing	Sensor (3x Hall)		X
	Encoder (A-B-Z, e.g. TLE5012B)		X
	Encoder (A-B-Z, e.g. TLE5012B)		X
Startup methods	Rotor alignment/Parking, 6 pulse injection, HFI, V/f (open loop), etc.		X
Bus voltage protection (UVP and OVP)	Vbus reading, Under and Over voltage protection		X
Temperature sensing/ protection	Temperature measurement, Over Temperature Protection		X
Other Features	Zero speed torque		X
	Braking features (protection)		X
	Ultra-high speed		X
	MTPA (Maximum Torque Per Amp)		X
	HFI (High Frequency Injection)		X
	Flux weakening		X
	7, 5 segment (3 phase/2 phase modulation) Space Vector PWM		X
	MATLAB Model Based Simulation (not code generation)		X
	Over-modulation		X

4.4 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 the [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.

5 Conclusion

ModusToolbox™ Motor Suite is a powerful ecosystem for motor control applications development, offering a wide range of benefits. With motor control engineers in mind, it provides key features to help you design faster and more confidently. Its intuitive GUI, robust features, and pre-built libraries make it an ideal choice for designers looking to create efficient, reliable, and high-performance motor control solutions.

ModusToolbox™ Motor Suite is designed to work seamlessly with Infineon's new PSOC™ Control microcontroller family, providing a comprehensive platform for motor control applications. The PSOC™ Control family offers advanced features, such as high-performance processing, advanced peripherals, and robust security, making it an ideal choice for demanding motor control applications.

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