Getting Started with Motor Control SDK

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1. Introduction

STM32 microcontrollers offer the performance of the industry-standard Arm® Cortex®-M cores running either field-oriented control (FOC) or 6-step modes, widely used in motor-control applications such as high-performance drives for air conditioning, home appliances, drones, building and industrial automation, medical, and e-bike. The STM32 motor-control software development kit (MC SDK) is part of the STMicroelectronics motor-control ecosystem, which offers a wide range of hardware and software solutions for motor-control applications. It is referenced as X-CUBE-MCSDK according to the software license agreement applied. It includes the:

- ST MC firmware library for permanent-magnet synchronous motor (PMSM) and Brushless DC (BLDC)
- ST MC workbench software tool, a graphical user interface for the configuration of MC SDK firmware library parameters.
- ST Motor Pilot, a graphical tool to control your motor and tune your application. It includes the ST motor profiler tool.

The STM32 motor-control software development kit allows evaluation of the performance of STM32 microcontrollers in applications driving one or two three-phase motors within the STM32 ecosystem. The ST MC workbench software tool runs on a PC. It reduces design time and effort when configuring the STM32 MCU firmware library. Through its graphical user interface, it can generate all the configuration files needed for an application. In addition, ST MC workbench interfaces with STM32CubeMX to take advantage of its ecosystem and customize embedded applications.

2. General information

The MC SDK is used for the development of motor-control applications running on STM32 32-bit microcontrollers based on the Arm® Cortex®-M processor. The following table presents the definition of acronyms that are relevant for a better understanding of this document.

Acronym	Description
GUI	Graphical user interface
IDE	Integrated development environment
FOC	Field-oriented control
FW	Firmware

MC	Motor control
MC WB	Motor-control Workbench (STMicroelectronics software tool)
MC BM	Motor-control Board Manager (STMicroelectronics software tool)
MC BD	Motor-control Board Designer (STMicroelectronics software tool)
MP	Motor Profiler (STMicroelectronics software tool)
PMSM	Permanent-magnet synchronous motor
PWM	Pulse-width modulation
SDK	Software development kit
BLDC	Brushless DC

3. Motor-control ecosystem setup

A suitable ST motor-control ecosystem environment includes:

- A PC running the needed MC software tools
- STM32CubeIDE or a third-party IDE
- A third-party ANSI C-compiler
- A JTAG/SWD interface for debugging and programming
- An STMicroelectronics application board with one of the STM32 microcontrollers supported. It drives the power stage and features:
  - PWM outputs to a gate driver
  - ADC channels to measure currents and voltages
  - DC bus voltage
- A three-phase PMSM motor or BLDC motor
- A power supply

Refer to the STM32 motor-control software development kit (MC SDK) data brief at https://www.st.com/content/st_com/en/ecosystems/stm32-motor-control-ecosystem.html and the release note for more details

Software tool setup

The STMicroelectronics motor-control ecosystem runs on a PC with Windows® 10. The following PC software tools are correctly installed:

- ST MC workbench (v6.0 or later)
- STM32CubeMX (v6.9.0 or later)
- STM32CubeProgrammer
- Any supported IDE:
  - IAR Embedded Workbench® for Arm® (v8.4/v8.5)
  - STM32CubeIDE
  - Keil® MDK tools (v5.38 or later)
- STM32 motor-control SDK v6.0 tools user manual
- STM32CubeMX for STM32 configuration and initialization C code generation user manual
- STM32 ST-LINK utility software description user manual

Refer to the respective user manuals for proper installation.

Hardware setup

The connection of the STMicroelectronics application board to the PC requires a USB Type-A connector. Refer to the description of the application board for details on the USB cable. A dedicated description card is delivered with each STMicroelectronics application board for proper installation. For more details, refer to the user manual of the board available at www.st.com. The selected hardware can be one of the three setups:

- The complete MC Kit P-NUCLEO-IHM03 (NUCLEO-G431RB, X-NUCLEO-IHM16M1, GBM2804H-100T)
- One of the complete inverter boards, for instance, the B-G431B-ESC1
- Any STM32 Nucleo or Evaluation board combined with one of the ST power boards that include the MC connector or morpho connector, whether it is a Nucleo or an Evaluation board

4. Getting started

Hardware connection

Connect a USB cable between the PC and the STMicroelectronics application board and the JTAG/SWD programming cable if it is different from the USB cable.

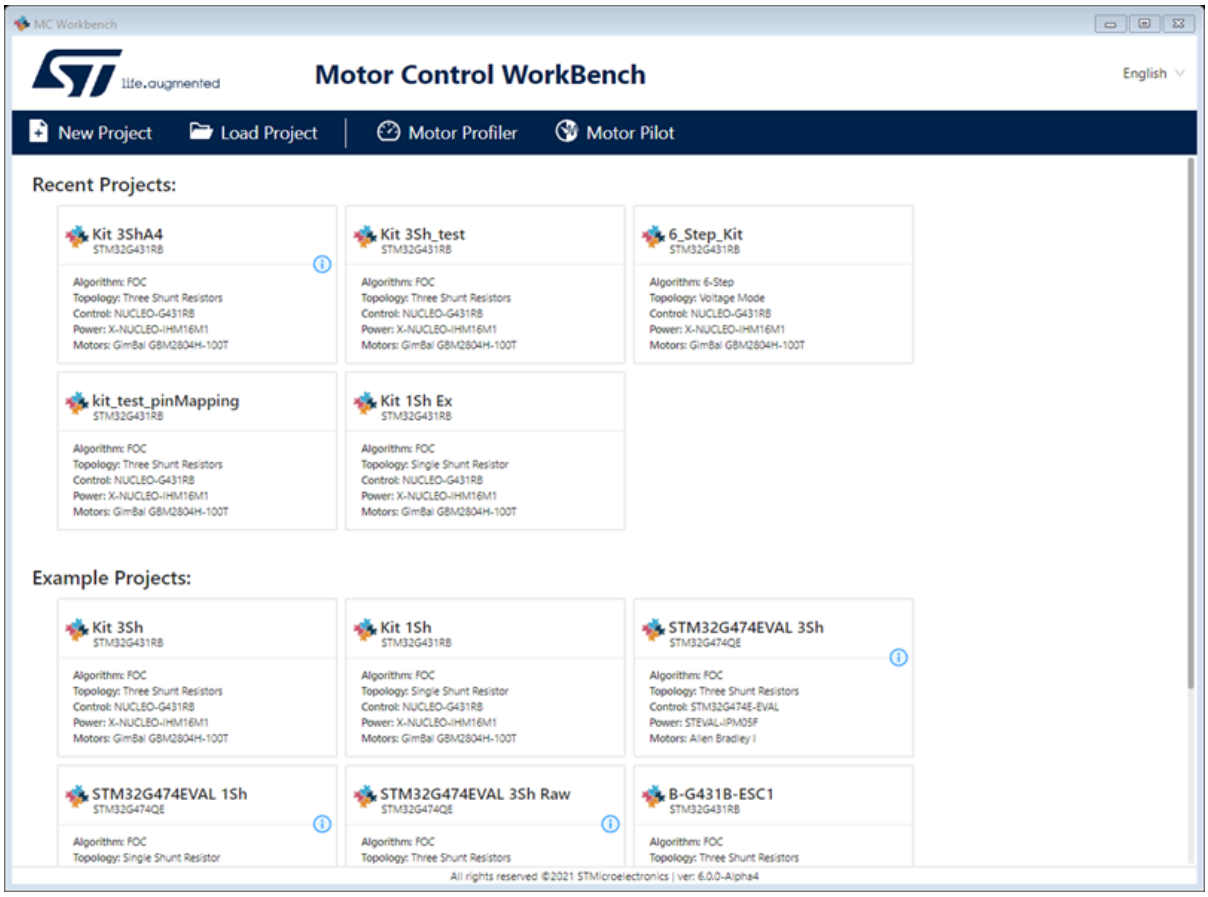
Motor Profiler

The Motor Profiler is a tool that automatically measures the electrical parameters of PMSM motors. The specification of an electric motor may not be known and is determined in less than a minute. The algorithm determines the motor parameters needed to configure the STM32 MCU firmware library: stator resistance Rs, stator inductance Ls, back EMF constant, motor inertia, and friction. It allows you to save the configurations you made. This tool is not mandatory to build the project, it is intended if you do not know the motor parameters or if you need to have better precision.

The Motor Profiler is described in full details in the **Motor Profiler Application Note** section.

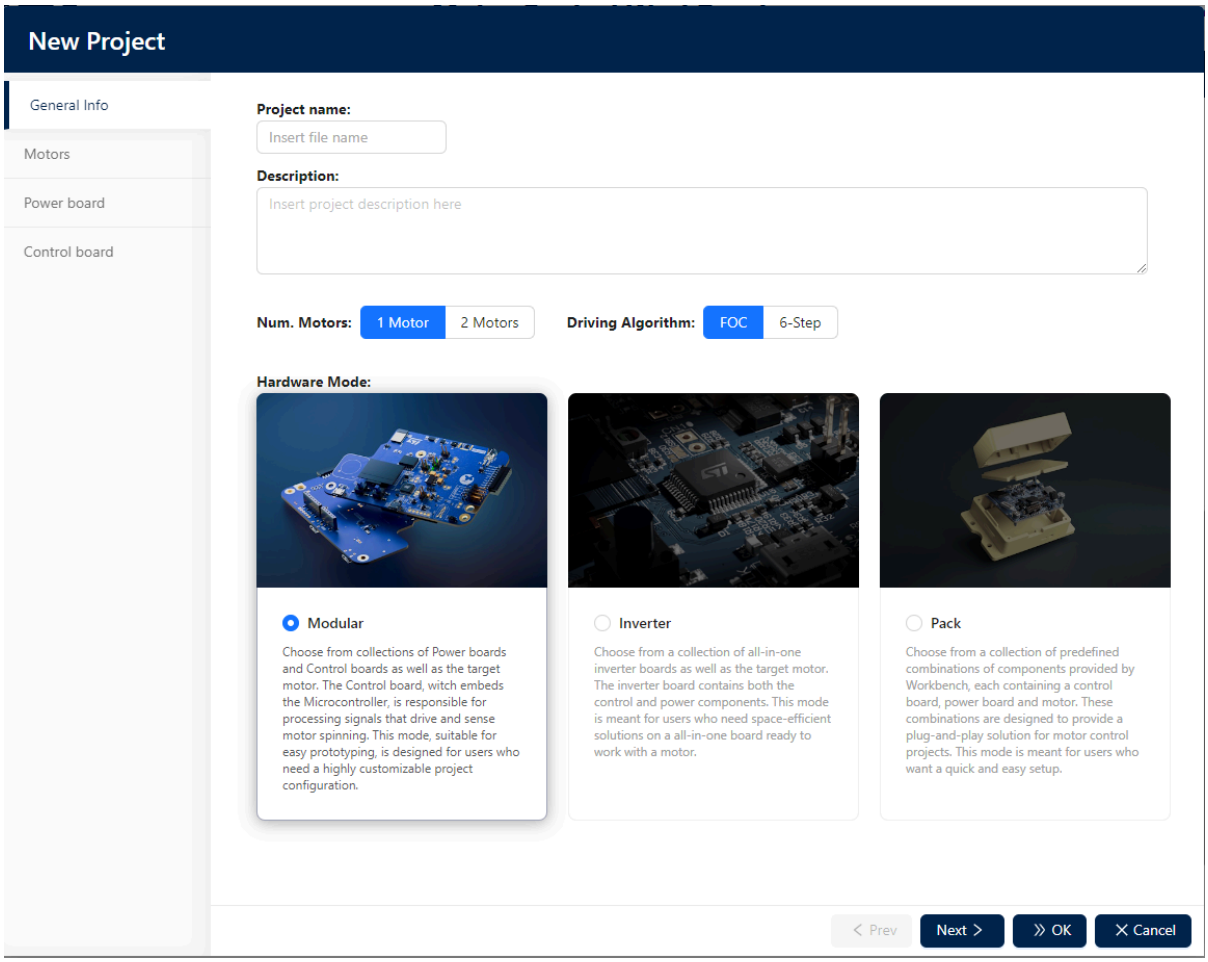
Workbench

After clicking on the workbench icon, you arrive on the home page. You can either choose recent projects, click on the button “New project”, load a project, or take example projects as you can see in the following figure.



ST MC WorkBench – Home page

Provide hardware setup information in the New Project window once it appears as shown in the figure that follows.



ST MC WorkBench – Hardware setup

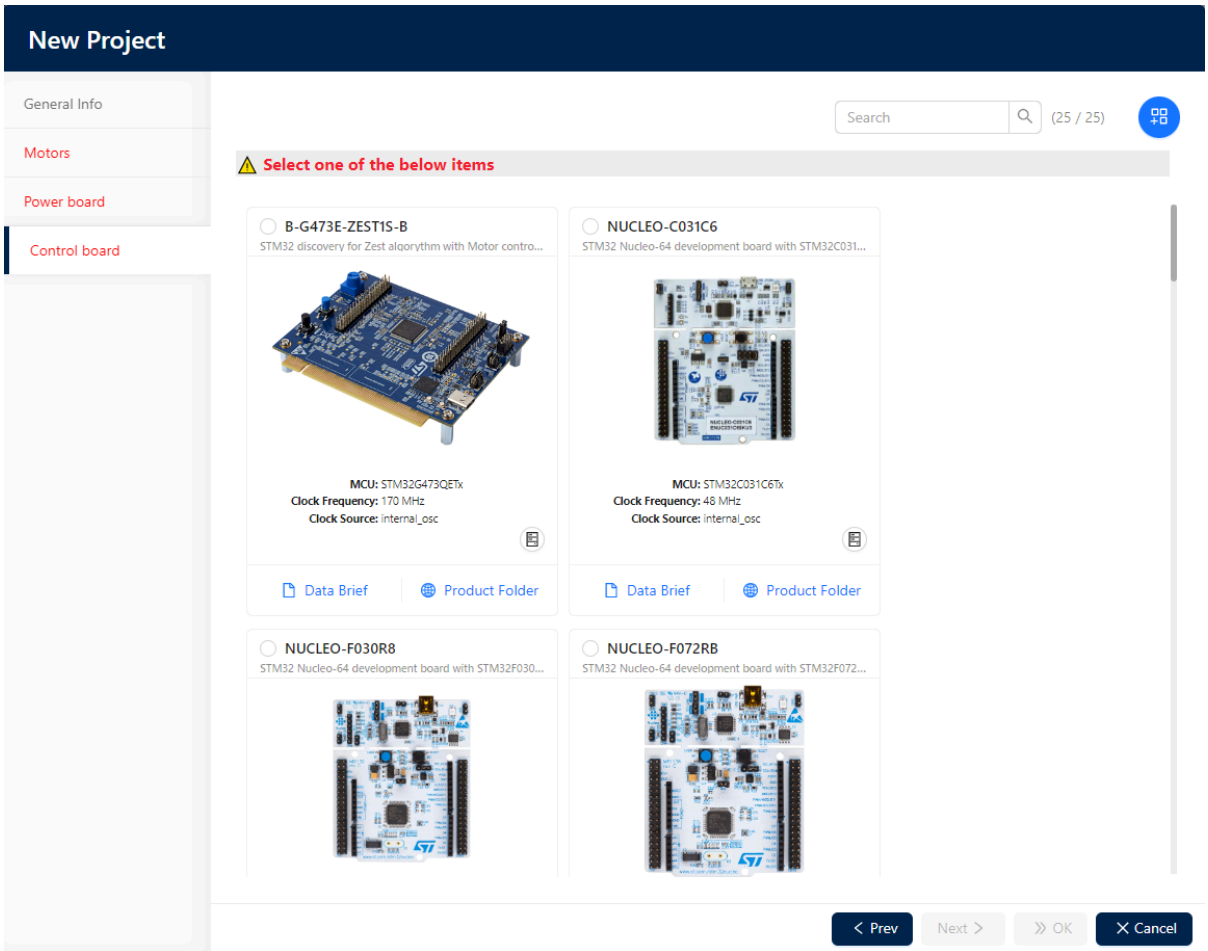
A new project lets you create a project with a wizard-style interface. The first step for a new project specifies the project name (which is optional, if none is selected you are prompted to select a name when you save your project) and a project description to identify the project. The second step is to fill in the hardware you want. Depending on the hardware selection, the wizard steps change:

- Modular: If you opt for modular hardware mode, you must fill parameters of the motor, power, and control boards. You can follow steps 1, 2, and 3 below.
- Pack: If you opt for an ST Pack, you must select the one you want from the list of packs. You can follow steps 1 and 4 below.
- Inverter: If you opt for an inverter solution, you must select a motor and an inverter solution. You can follow steps 1 and 5 below.

The paragraph below is a description of the existing steps.

1. The motor section: In the Motor step you can select the motor for your solution. The list of motors is a list of motors available from application assets, all saved motors from the previous workbench version, and the motor profiler. Each motor is represented as a card where there is some electrical and mechanical information. If the motor setting comes from the profiler application a blue icon on the right side of the card is shown and a pop-up displays the profiled information.
2. The power board section: The power step is a list of available power boards. They are sorted by taking into account the selection of the previous motor. The most compatible power board is listed first. Non-compatible boards are then displayed with a yellow warning icon.
3. The control board section: After power board selection, the control board can be selected. In the same way, control boards are sorted by taking into account the compatibility with the selected power board (the compatibility depends on the motor-control connector available in power and control). If the two boards cannot be connected directly, a yellow warning appears on the card. If you select two boards that cannot be connected directly, another step (bridge) appears to allow the connection between power and control.
4. The Pack section: You only see this section if you choose the Pack solution. Here, you just need to select the one you want from the list of packs. The pack is a complete solution available on the ST website and it is a set of motor, power, and control boards
5. The Inverter section: You only see this section if you choose the Inverter solution. Here, you just need to select the one you want from the list of Inverters. The inverter is a board combining both the power and the control board.

It is important to fill in all the sections, you cannot create a project if one is missing as you can see in this figure.

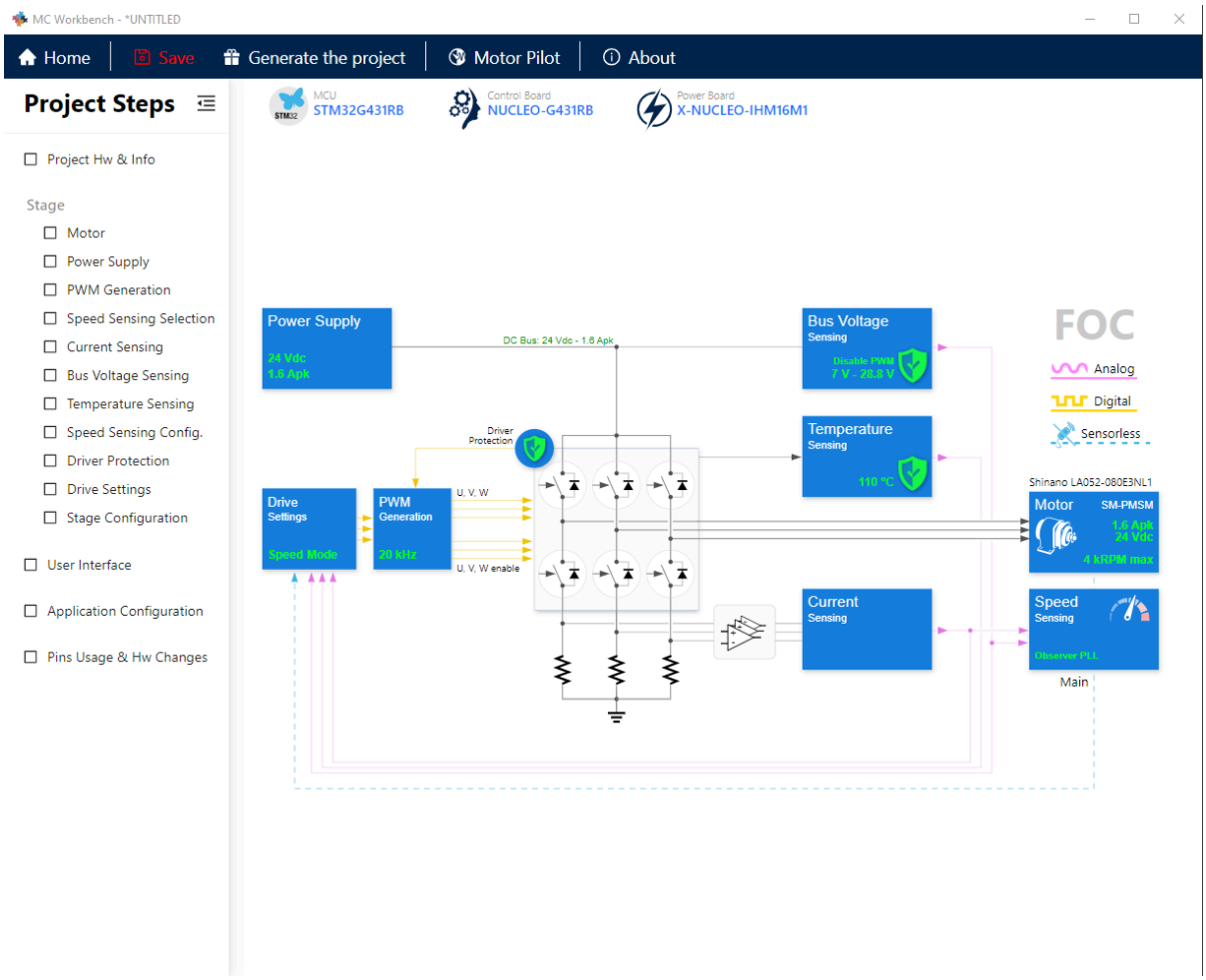


ST MC WorkBench – Errors in a new project view

When all new project steps are completed, you can press the button “Ok” and the project is created. You can see that once you have saved your project, it appears on the home page in the recent project list card. The number of motors is indicated by the card, as the algorithm (FOC or 6-Step) and the project hardware type. Depending on whether you choose the FOC or 6-step algorithm, you do not have the same display and the same configuration mainly in the Drive settings section.

The main project view is displayed when a project or example is loaded or when a new project is created. The following parts are available:

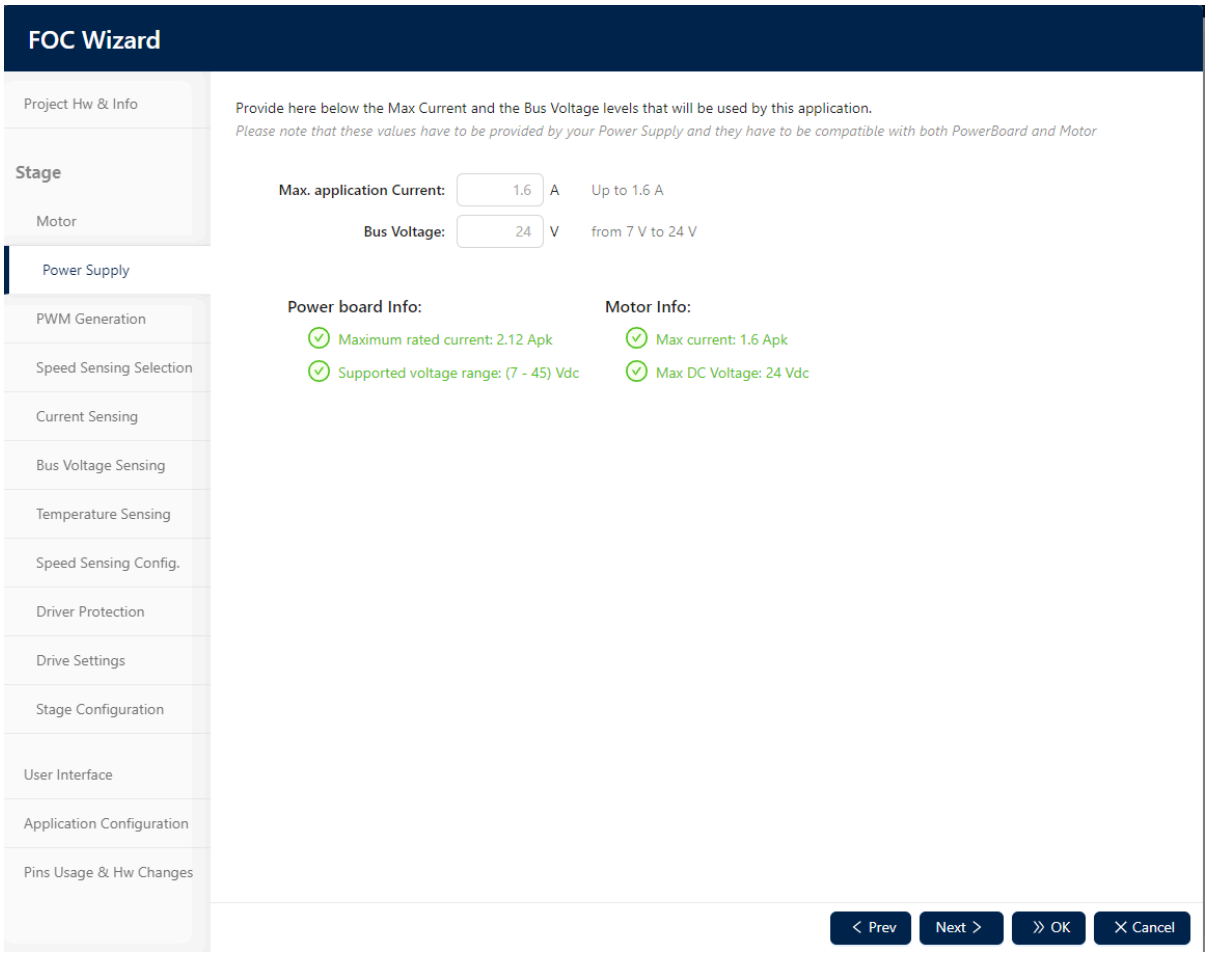
- Toolbar
  - Home: to leave the current project and return to the Home Page
  - Save: Save the current project
  - Generate: to generate the firmware source code
  - Motor Pilot: to run the motor pilot tool
- Left bar
  - this is a list of the available steps for the project. it is also managed as a kind of checklist
- Main view
  - Block diagram of the project with all available parts such as AC input, inrush current, bus voltage, bus sensing, U, V, W driver, temperature sensing … Any block is active and by clicking on it, the application goes to the relative step, it also contains some configuration information.
  - You have several parameters on the upper side, there is the project hardware-specific information
    - MCU which displays information about pin usage and conflicts by clicking on it
    - Control board information
    - Power board information



ST MC WorkBench – Main project view

To give you complete control over your project, a wizard helps you while building your project. The wizard is a guided tour of the project. some mains concepts are listed here:

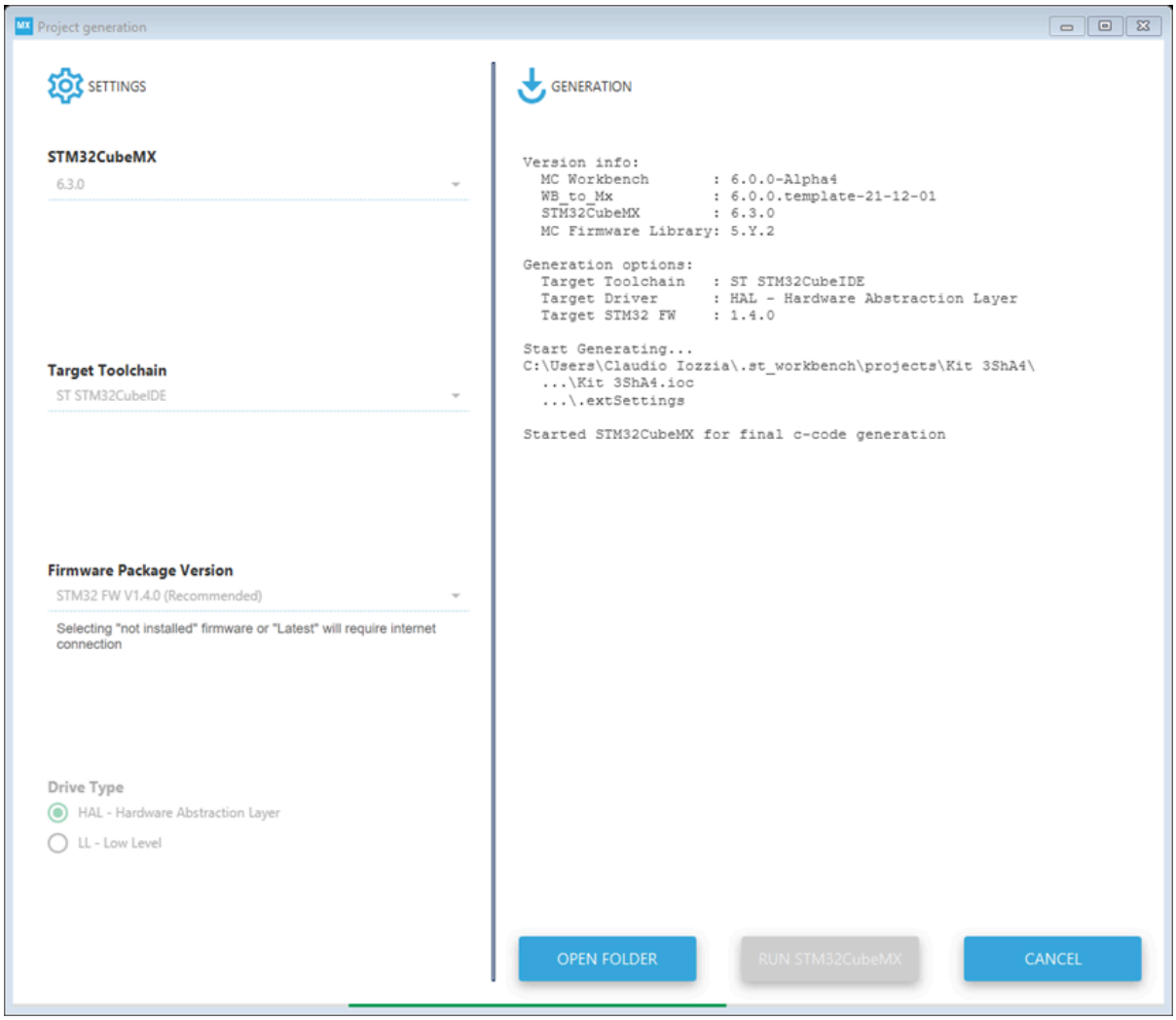
- The sequence of sections: Each section is influenced by the previous sections but not the reverse.
- Each editable field must have a default value: if you do not specify an explicit value for a field, a valid one is provided by the tool.
- The set of default values and explicit values must be consistent: In case of errors, the wizard cannot update the project content.



ST MC WorkBench – Wizard view

Finally, from the toolbar, you can click on the button “Generate the project”. A window helps you to choose the IDE to use and the drive type appears. Modify the settings if you want and then click on “Generate”. A project for the specific toolchain is provided and the firmware can be compiled, and the board is flashed.

More information about the ST MC workbench is provided in the Motor Control Workbench User Manual.



ST MC WorkBench – Generation window view

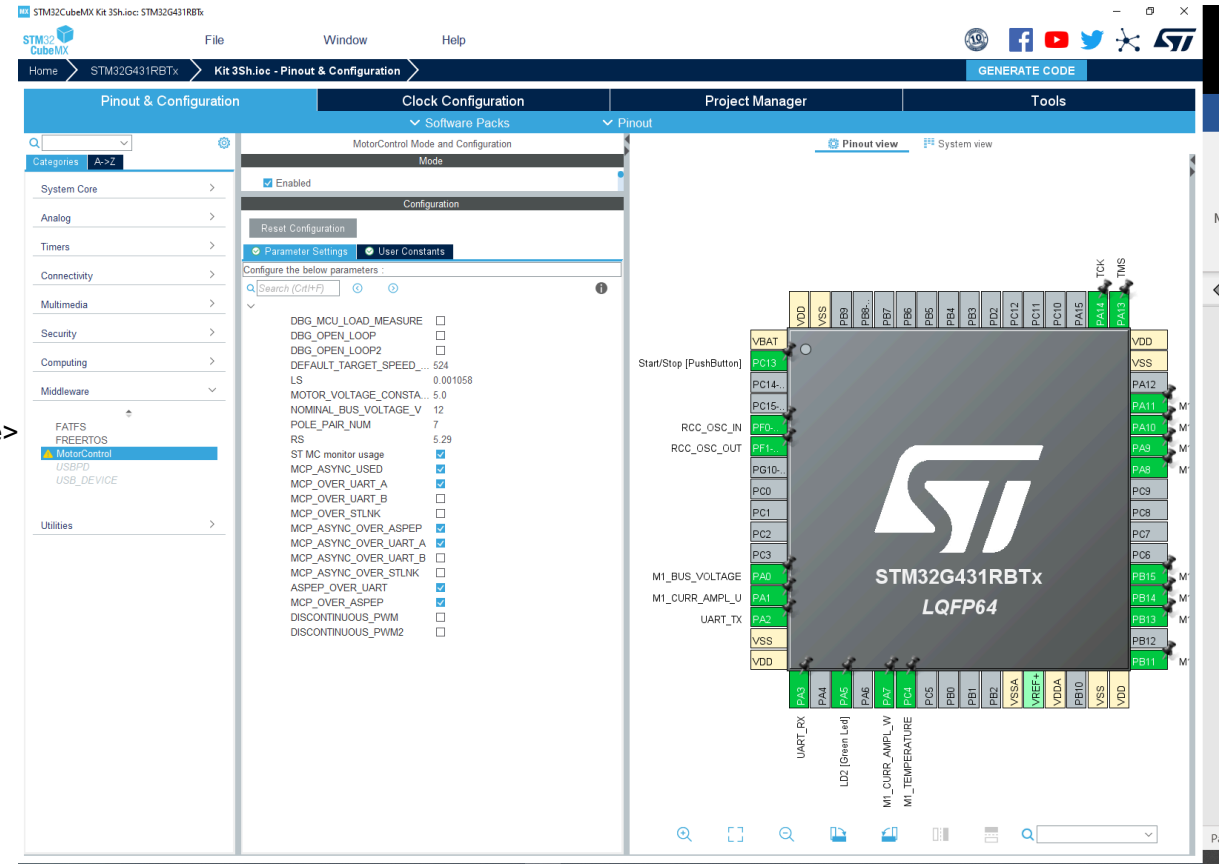
Motor-control project generation

The MC Workbench generates a STM32CubeMX project file (IOC file) and launches cubeMX in background to generate the project for your selected Toolchain with your selected FW driver (HAL or LL) Once the generation is completed your project is ready to be open by your IDE and to be compiled. Tha last step is to run the code: Download the embedded application to the target from the IDE. If the ST/LINK is correctly installed, this is straightforward to perform. And after that, it is time to test your application.

If you want to add custom code, be aware that only code inside the users' sections remains there after generation. However, any custom code added outside the users' sections is deleted. Don't forget to re-compile your project after each code generation.

Hardware IPs modification

- If you need to configure other IPs on top the ones of motor control, you can open STM32CubeMX, make your modifications then regenerate the project directly from cubeMX. However, be very careful when modifying the harware configurations because it is very sensitive mostly if you changed IPs used by the motor control application. Note that opening STM32cubeMX is optional. If you do not need to change the hardware IP configuration, your MC Workbench generated project is ready to be opened by your selected IDE.

<figure> 

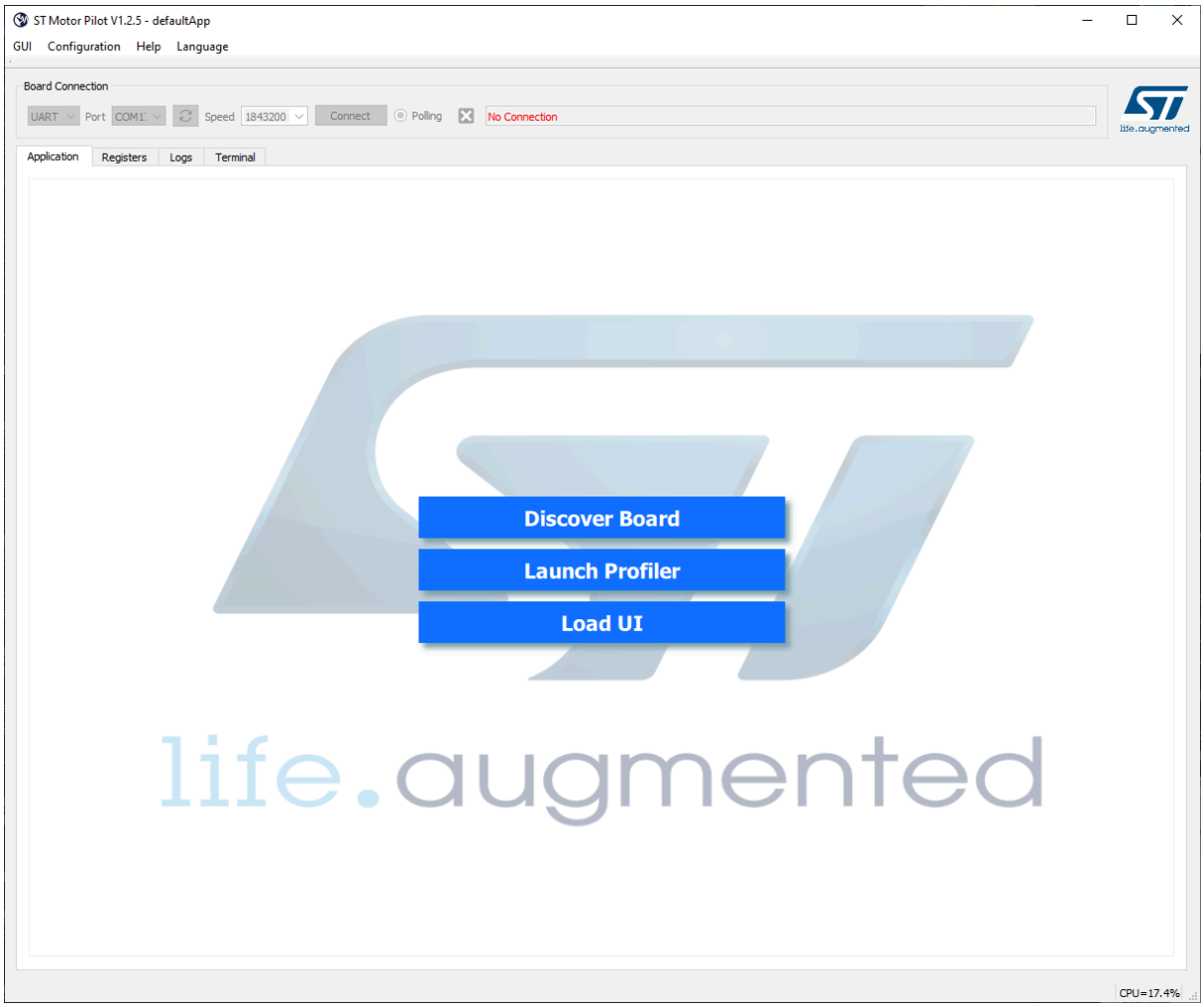
<figcaption aria-hidden="true"> STM32CubeMX – Pinout and configuration view</figcaption></figure>

Motor pilot

The STM32 MC motor pilot is a control and monitoring PC tool. The serial communication between the motor-control firmware and the PC is managed with the STM32 motor pilot. It allows you to send basic commands such as start and stop, setting target speed, and clearing fault conditions. The ST Motor Pilot is fully documented in the MC Motor Pilot Start-up guide from our Wiki pages.

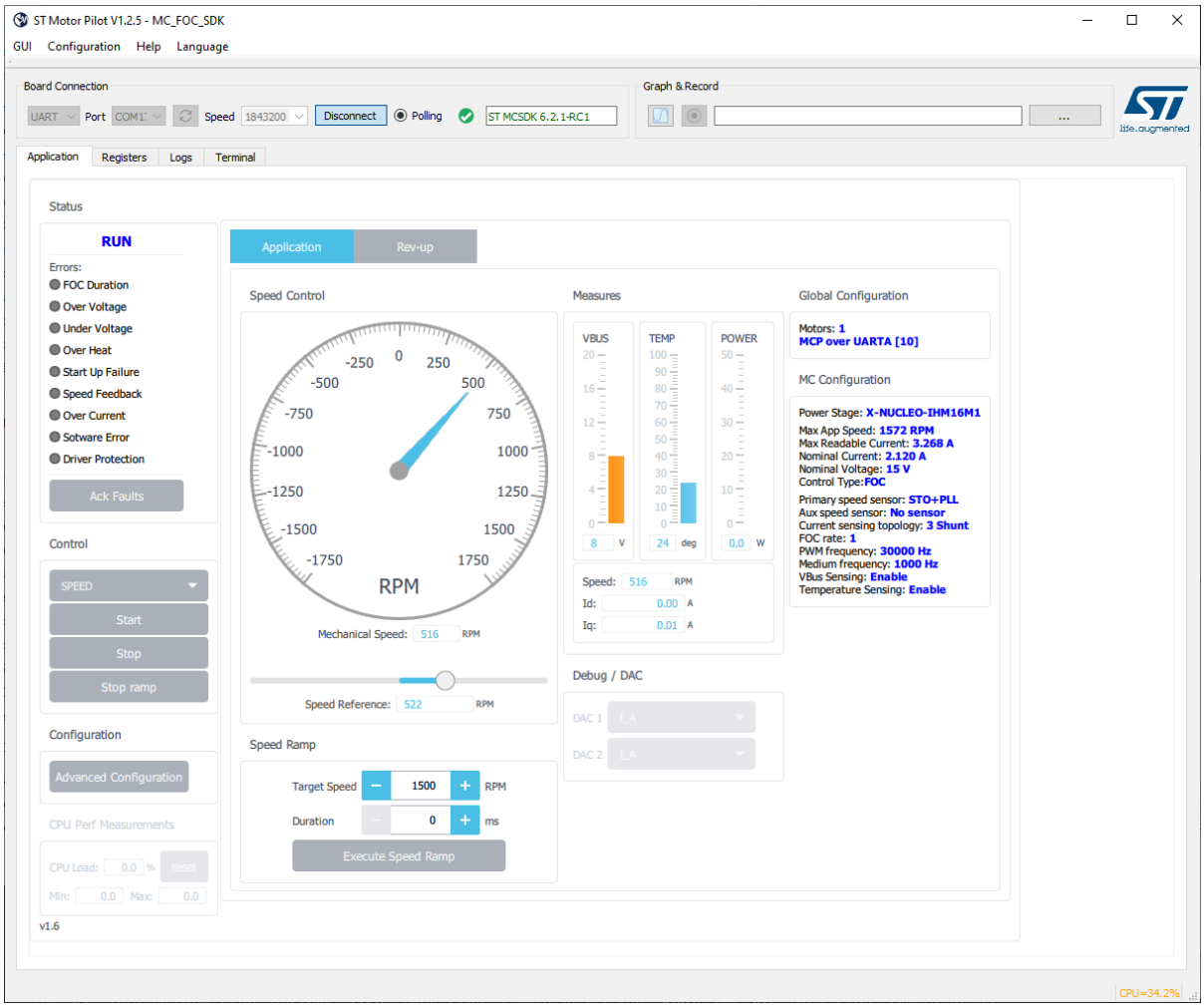
When you start Motor Pilot for the first time , you can choose 3 different actions:

- Detecting the connected board : Motor Pilot tries to communicate on all STLINK Virtual Port COM at 1843200 and 115200 Mbaud to detect your board. If the detection succeeds, the Motor Pilot loads the corresponding UI.
- Loading the UI that is dedicated to the FOC motor profiler.
- Loading the custom UI.



Motor Pilot – Default screen

If the discovering is successful the corresponding UI is loaded. The use case presented in the image below is the FOC STO-PLL algorithm.



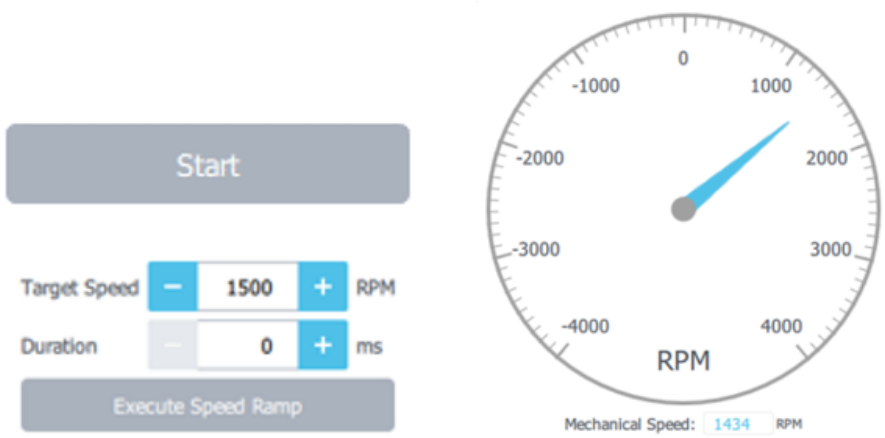
Motor Pilot – Motor spinning at 500 RPM

If you changed the UART baudrate when setting up your project, autodetection will fail. The solution is to manually load the UI corresponding to your configuration. Once the user interface is loaded, the Port and Speed fields are editable and must be configured according to your settings. The various proposed user interfaces are stored in the following folder : MC_SDK_6.2.1\Utilities\PC_Software\STMotorPilot\GUI

After that click on connect and then you can monitor your motor

Motor Pilot – Board connected

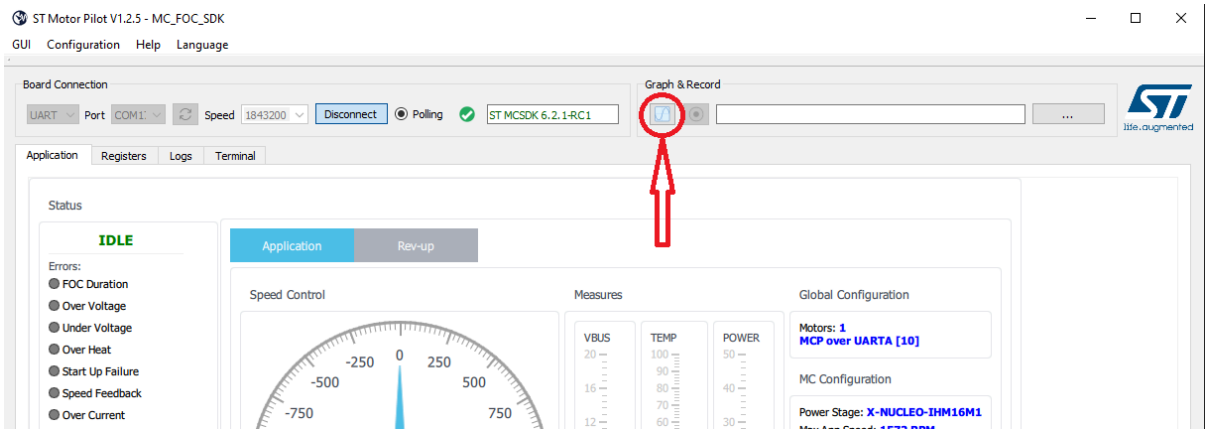
After the connection is established, you can click on the Start Motor button to run the motor, monitor the motor speed, and then click on the Stop Motor button to stop the motor.



Motor Pilot –Control buttons

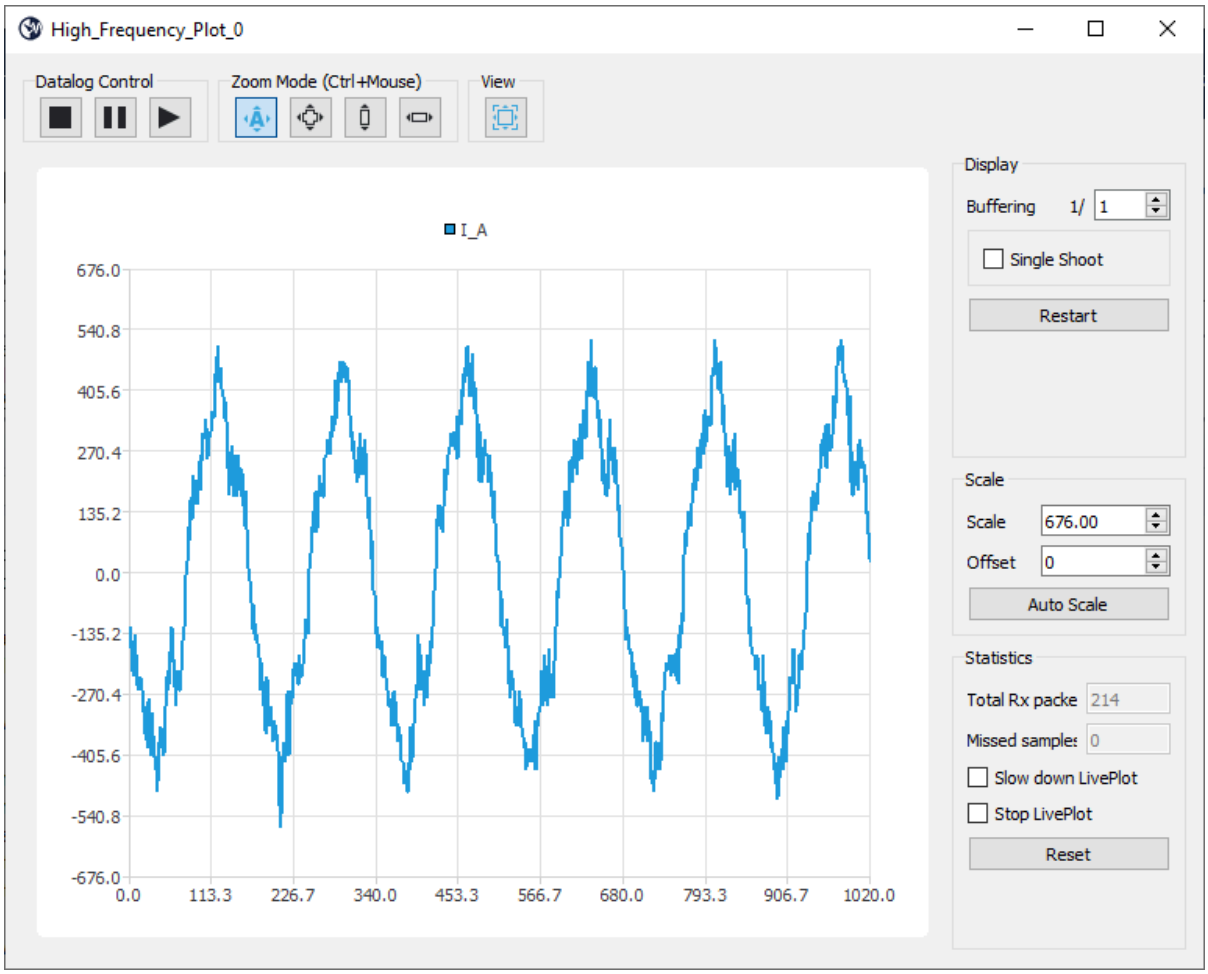
You can select the speed control or the torque control and test other parameters. When the motor is spinning, you can view the graphs and get recordings of those graphs. You can select the parameters that interest you as input to your graphs.

- Click on the "Plot" button

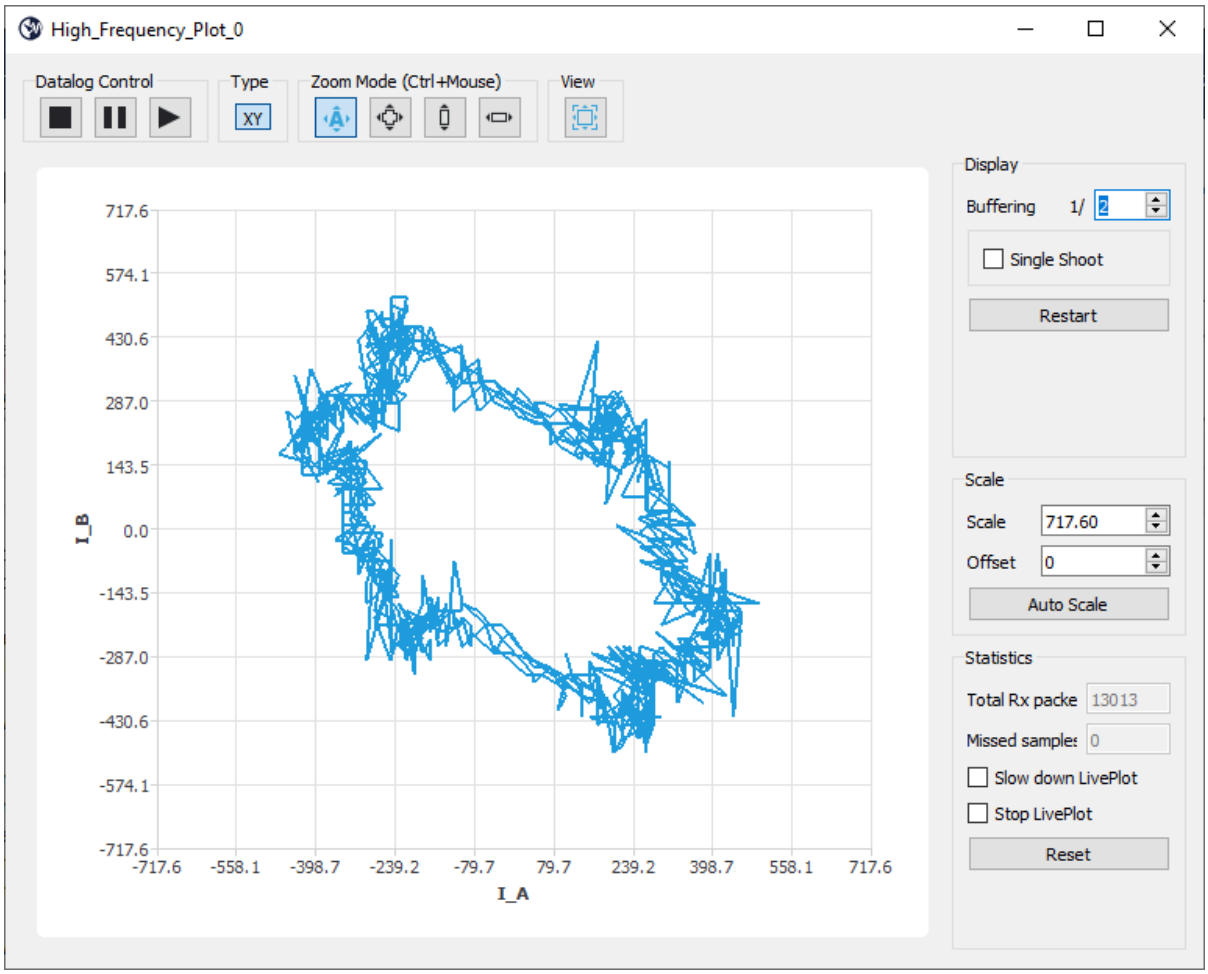


Motor Pilot –Plot button

- Right-click to select the register you want to plot:



Motor Pilot –Example of plot



Motor Pilot –Example of X/Y plot

More information about the ST MC motor pilot is provided in the MC Motor Pilot Start-up guide from our Wiki pages..

5. Precaution of use and restrictions

The motor profiling algorithm is intended for rapid evaluation of the ST MC solution. It can be used to drive any three-phase PMSM without any specific instrument or special skill. Although the measurements performed are not as precise as with proper instrumentation, ST Motor Profiler measurements are optimized when:

- The stator resistance is greater than 1 Ω
- The stator inductance is greater than 1 mH

Moreover, it is important to choose the appropriate hardware according to the characteristics of the motor. For instance, the maximum current of the motor must match the maximum current of the board as closely as possible. The ST Motor Profiler may be used only with compatible STMicroelectronics evaluation boards

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