Getting started with STM32 motor control SDK v5.0

Introduction

STM32 microcontrollers offer the performance of the industry-standard Arm® Cortex®-M cores running either vector control (VC) or field-oriented control (FOC) modes, widely used in 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 or X-CUBE-MCSDK-FUL according to the software license agreement applied. It includes the:

- ST MC FOC firmware library for permanent-magnet synchronous motor (PMSM) field-oriented control

- ST MC Workbench software tool, a graphical user interface for the configuration of MC SDK firmware library parameters, including the ST Motor Profiler tool (MP)

The STM32 motor control software development kit allows evaluation of the performance of STM32 microcontrollers in applications driving single or dual three-phase permanent-magnet synchronous 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 MC FOC FW library. Through its graphical user interface, it can generate all the configuration files needed for an application, as well as monitor and adjust some FOC algorithm variables in real time.

In addition, ST MC Workbench interfaces with STM32CubeMX to take advantage of its ecosystem and customize embedded applications.

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1 General information

The MC SDK is used for the development of motor-control applications running on STM32 32-bit microcontrollers based on the Arm®(a) Cortex®-M processor.

Table 1 presents the definition of acronyms that are relevant for a better understanding of this document.

Table 1. List of acronyms

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 SW tool)
MP	Motor Profiler (STMicroelectronics software tool)
PMSM	Permanent-magnet synchronous motor
PWM	Pulse-width modulation
SDK	Software development kit
VC	Vector control

More information about ST MC Workbench is provided in the *STM32 motor control SDK v5.2 tools* user manual (UM2380) available at *www.st.com*.

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a. Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and or elsewhere.

2 Motor control ecosystem setup

A suitable ST Motor Control ecosystem environment includes:

- A PC running the needed MC software tools
- 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 gate driver
  - ADC channels to measure currents
  - DC bus voltage
- A three-phase PMSM motor
- A power supply

Refer to the *STM32 motor control software development kit (MC SDK)* data brief (DB3548) at *www.st.com* and to the release note for more details.

2.1 Software tool setup

The STMicroelectronics motor-control ecosystem runs on a PC with Windows® 7.

The following PC software tools are correctly installed:

- ST MC Workbench (v5.0.0 or later)
- STM32CubeMX (v4.24.0 or later)
- ST-LINK/V2 (v4.0.0 or later)
- Any supported IDE:
  - IAR Embedded Workbench® for Arm® (v7.80.4)
  - Keil® MDK tools (v5.24.2 or later)
  - Ac6 System Workbench (v2.3.0 or later)[a]
  - ST TrueSTUDIO® for STM32 (v9.0.1 or later)[a]

Refer to the respective user manuals for proper installation. STMicroelectronics documents are available from the Internet site at *www.st.com*:

- *STM32 motor control SDK v5.2 tools* user manual (UM2380)
- *STM32CubeMX for STM32 configuration and initialization C code generation* user manual (UM1718)
- *STM32 ST-LINK utility software description* user manual (UM0892)

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a. Not supported in SDK v5.0 but in later versions.

2.2 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
- One of the complete inverter boards
- Any STM32 evaluation board combined with one of the ST evaluation power stages that include the MC connector

3 Getting Started

Warning: **Check that the board is correctly configured for the motor control application and supplied with the expected input voltage.**

Note: *Refer to the user manual of the related hardware to setup the correct configuration, voltage range, serial communication capabilities, and programming/debugging interface.*

3.1 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.

3.2 Motor profiling

Launch the ST MC Workbench software tool either by:

- clicking on its icon
- running it directly from the installation folder tree

Both ways of launching the ST MC Workbench are illustrated in *Figure 1*.

Figure 1. ST MC Workbench - Icon and installation folder tree
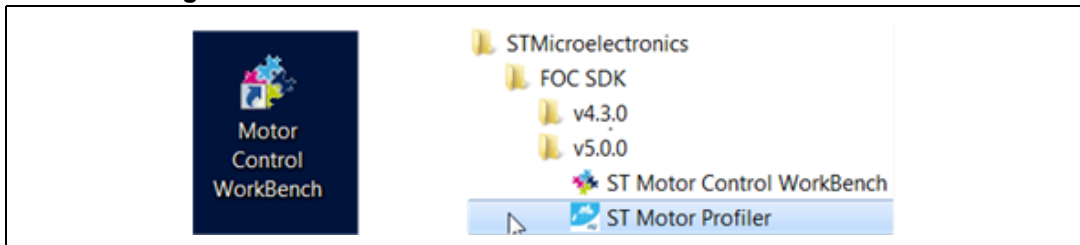
Open the ST Motor Profiler tool either by:

- Using its dedicated button in the ST MC Workbench GUI as illustrated in *Figure 2*
- Running it directly from the installation folder tree as illustrated in *Figure 1*

Figure 2. ST MC Workbench - GUI expanded top view
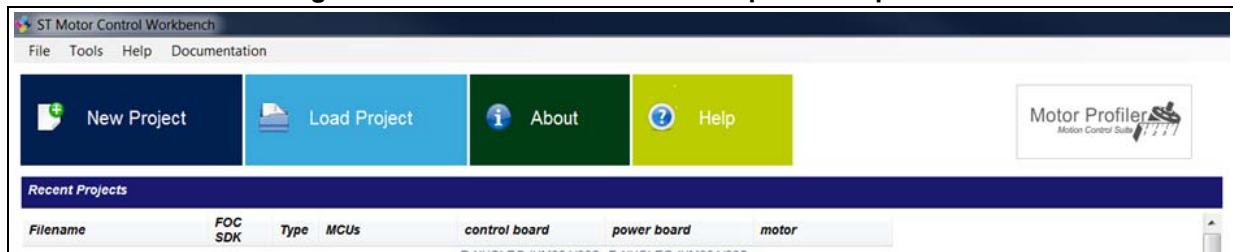
Click on the *Select Boards* button to display the list of supported boards as shown on *Figure 3* and select the STMicroelectronics application board setup. *Figure 4 on page 10* presents examples from this list.

Note: *The ST Motor Profiler tool may be used only with ST hardware in the list of supported setups.*

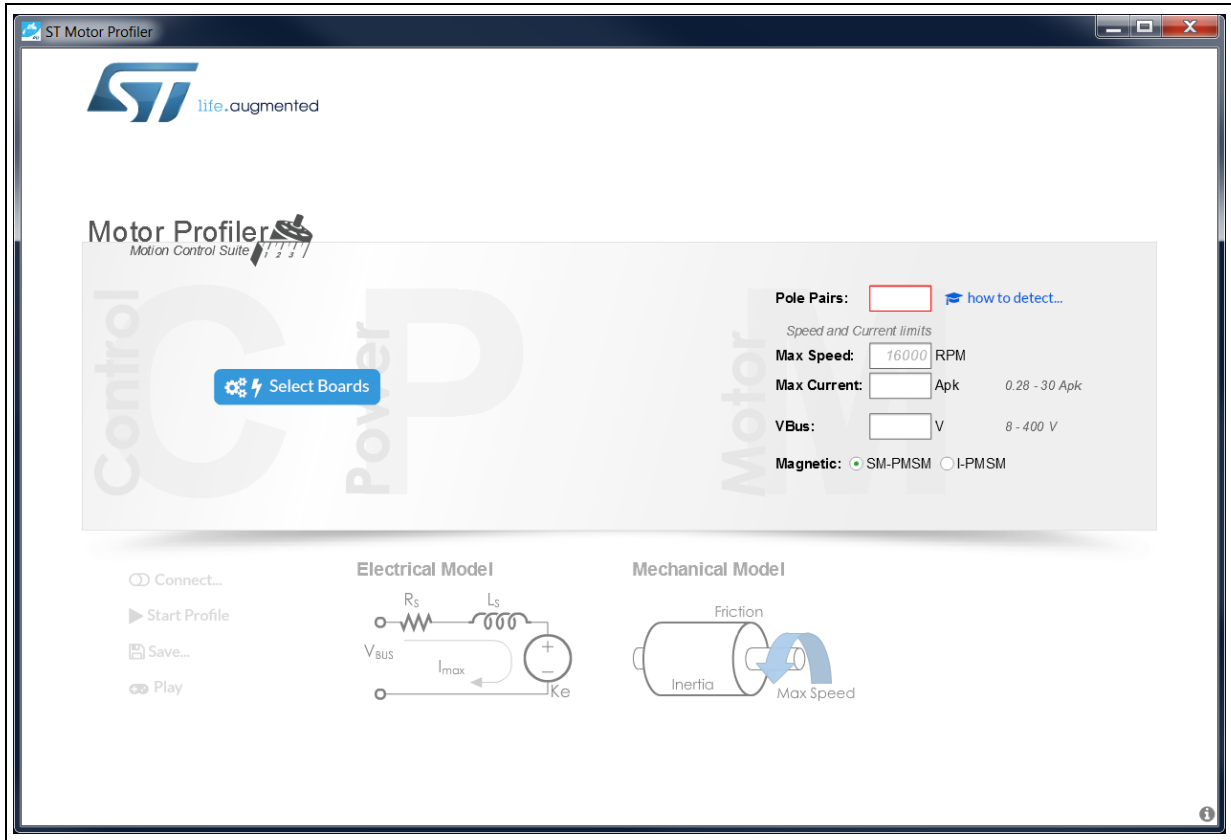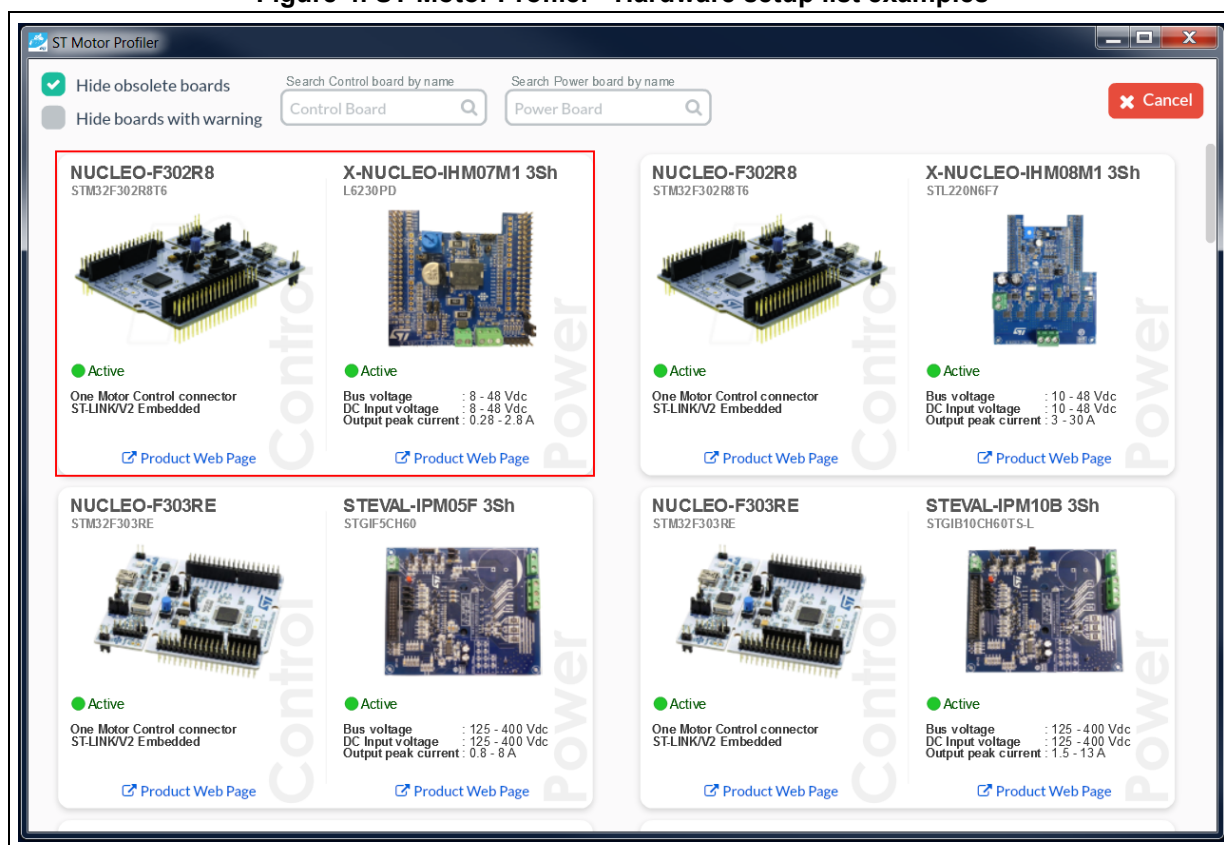**Figure 3. ST Motor Profiler - GUI**

Figure 4. ST Motor Profiler - Hardware setup list examples

Click on the STMicroelectronics hardware setup to select it and configure the ST Motor Profiler tool.

As an example, *Figure 4* shows the selection of the P-NUCLEO-IHM001 motor control Nucleo Pack with NUCLEO-F302R8 and X-NUCLEO-IHM07M1.

After hardware setup selection, fill in the parameter fields with the motor information:

- The number of pole pairs of the motor (mandatory field)

- The *Max Speed* of the motor (optional field)
  By default, the ST Motor Profiler tool searches for the maximum allowed speed matching the motor and the hardware setup used.

- The *Max Current* allowed by the motor (optional field)
  By default, it is the maximum peak current deliverable by the hardware setup.

- The nominal DC bus voltage used by the hardware setup (optional field)
  By default, it is the power supply stage as either the bus voltage for low voltage applications (DC voltage), or the RMS value for high voltage application (AC voltage).

- The magnetic built-in type (mandatory field)
  By default, the SM-PMSM is selected.

- The Ld/Lq ratio (mandatory field) only when I-PMSM built-in is selected as shown in *Figure 6 on page 11*

Figure 5 provides example values for the BR2804-1700KV-1 motor provided with the P-NUCLEO-IHM001 hardware setup.

Figure 5. ST Motor Profiler - SM-PMSM parameters example
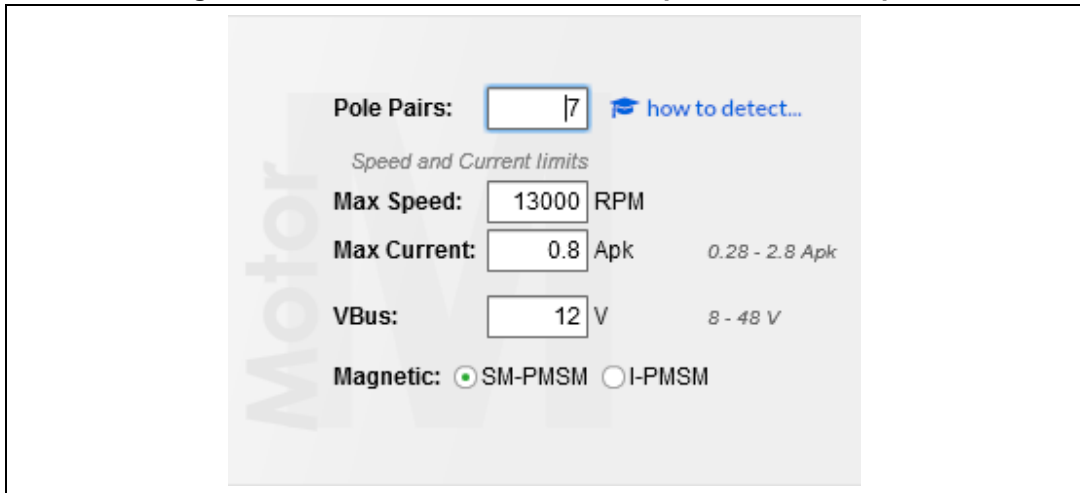
Figure 6. ST Motor Profiler - I-PMSM parameters example
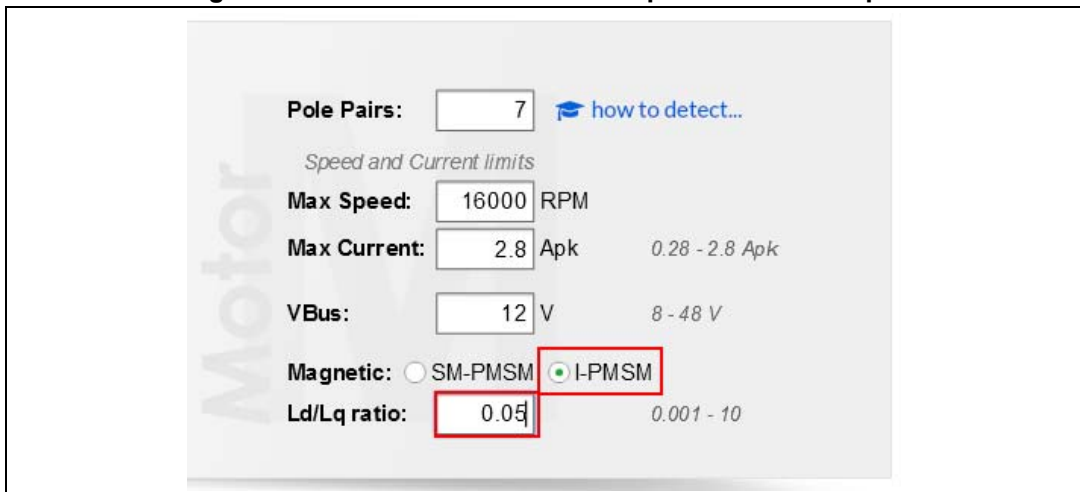
Click on the *Connect* button shown in *Figure 3: ST Motor Profiler - GUI on page 9*.

Note: *The correct FW is automatically loaded into the microcontroller by pressing the Upgrade Firmware button, then any previous downloaded firmware is erased.*

If the programming procedure cannot be executed, check the JTAG/SWD programming cable.

If the programming procedure is executed but the Motor Profiler cannot communicate with the board, check the serial communication connections.

Once the connection is established, press the *Start Profile* button to start motor profiling as shown in *Figure 7*.

When the profiling is successfully completed, all the motor measurements are shown in green or orange as illustrated in *Figure 7*. When red color is shown, check the hardware setup and restart the motor profiling sequence.

Figure 7. ST Motor Profiler - Measurement results
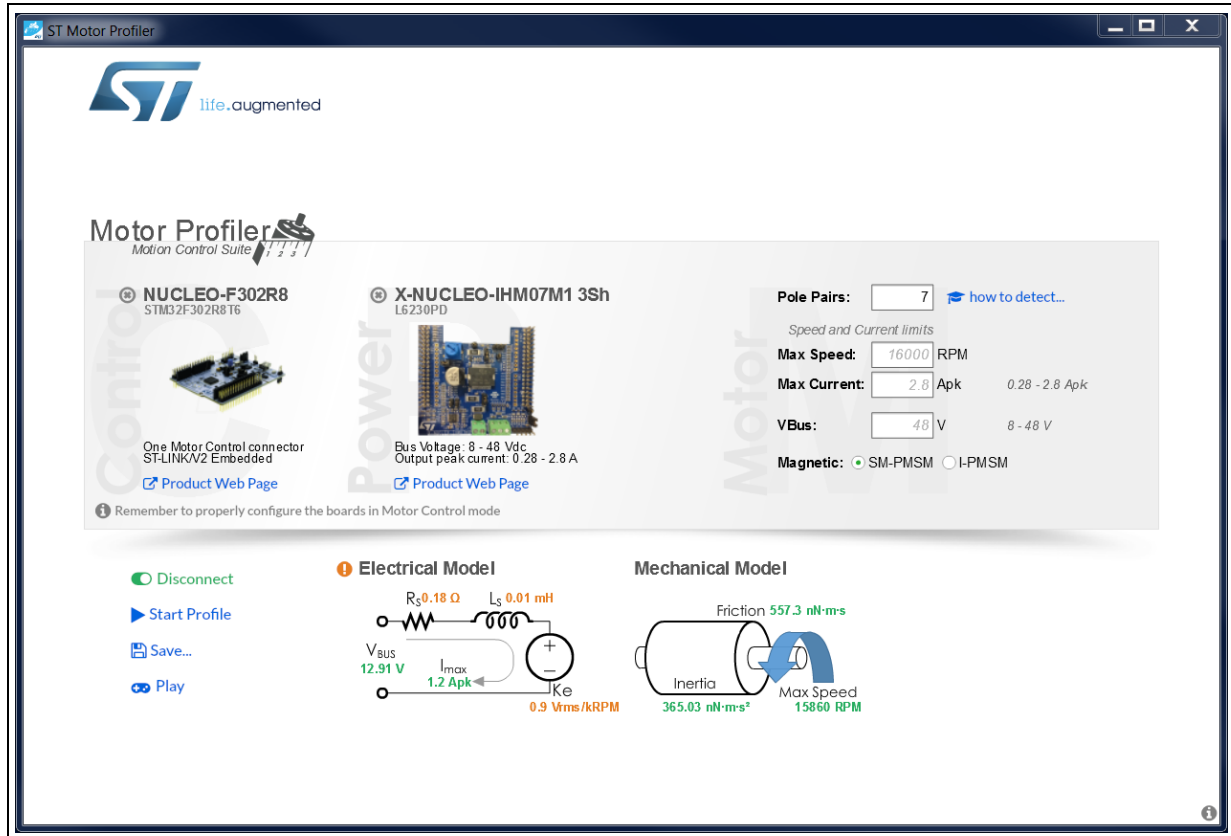
Click on the *Save* button (Refer to *Figure 7*) to store the motor measurements for later use with the ST MC Workbench software tool. *Figure 8 on page 13* shows the menu that is displayed in that case:

- Enter the name of the profiled motor (e.g. BR2804-1700KV-1)

- Provide details about the profiled motor such as 3-phase motor with 7 pole-pairs under 12 Vdc

Figure 8. ST Motor Profiler - Save window
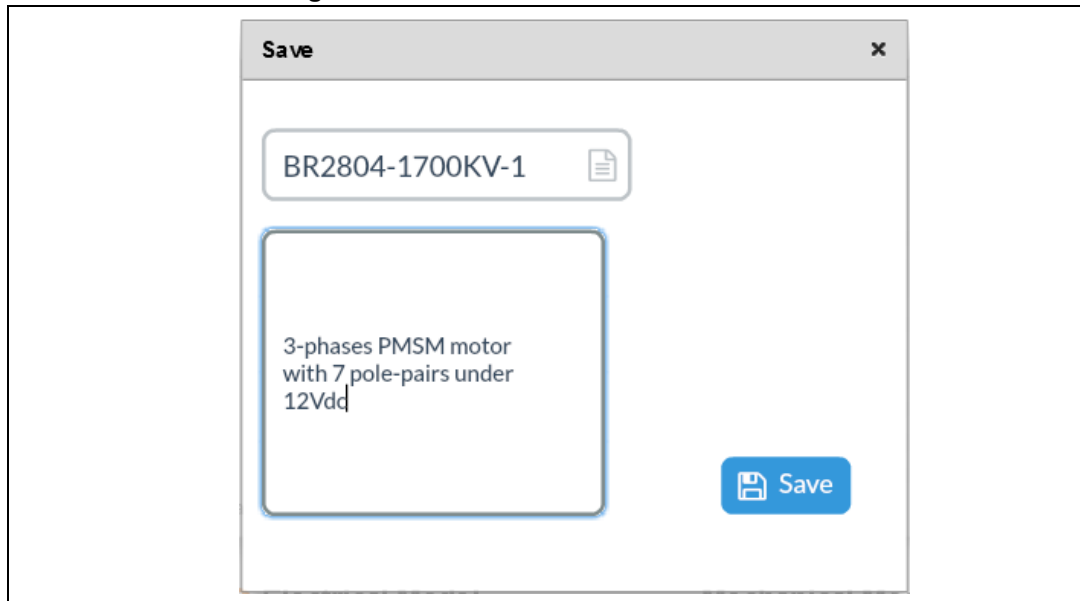
Click on the *Disconnect* button to stop using the ST Motor Profiler tool and close the window.

3.3   MC project generation

Launch the ST MC Workbench software tool either by clicking on its icon, or running it directly from the installation folder tree as shown in *Figure 1 on page 8*, or revert to the ST MC Workbench GUI as shown in *Figure 2 on page 8*. Click on the *New Project* button.

Provide the hardware setup information in the *New Project* window once it is displayed as shown in *Figure 9 on page 14*:

1.   Select the *Application Type*
2.   Check the *Single Motor* or the *Dual Motors* check box
3.   Select the ST hardware setup boards:
     –   If the ST board is a complete inverter board (single board with both power and control electronics), select the *Inverter* combo box and select the *Inverter* choice from the drop down list
     –   If an ST MC Kit such as P-NUCLEO-IHM001 is used, select the *MC Kit* combo box and select the *Kit* choice from the drop down list
     –   If the system is composed of a control evaluation board associated with a power evaluation board, select the *Power & Control* combo box and select the C*ontrol board* and the *Power board* from the drop down lists
4.   Select the profiled motor from the drop down list
5.   Click on the *OK* button to import all needed hardware settings

Figure 9. ST MC Workbench - New Project window
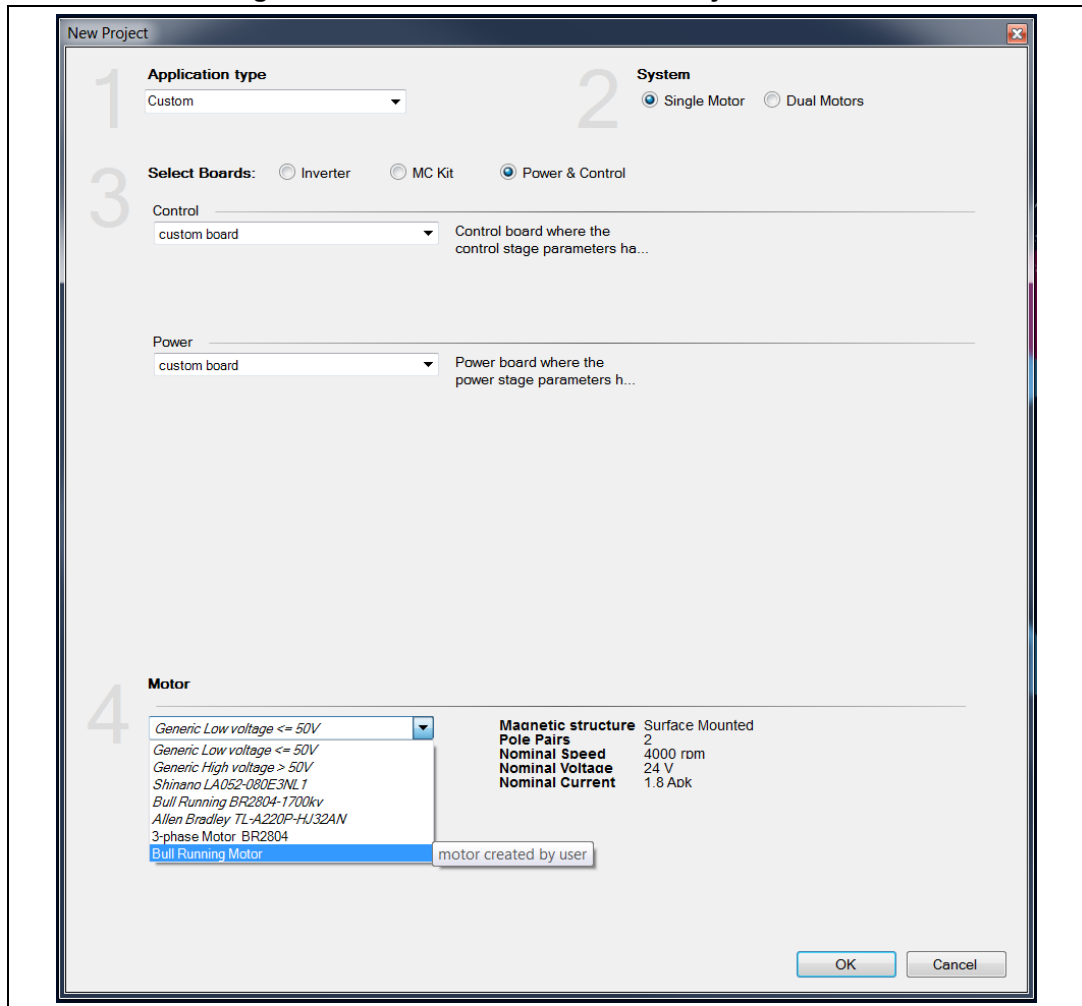
After a few seconds, a *New Project Info* window is displayed where the motor operating conditions can be checked as shown in *Figure 10*.

Figure 10. ST MC Workbench - New Project Info window
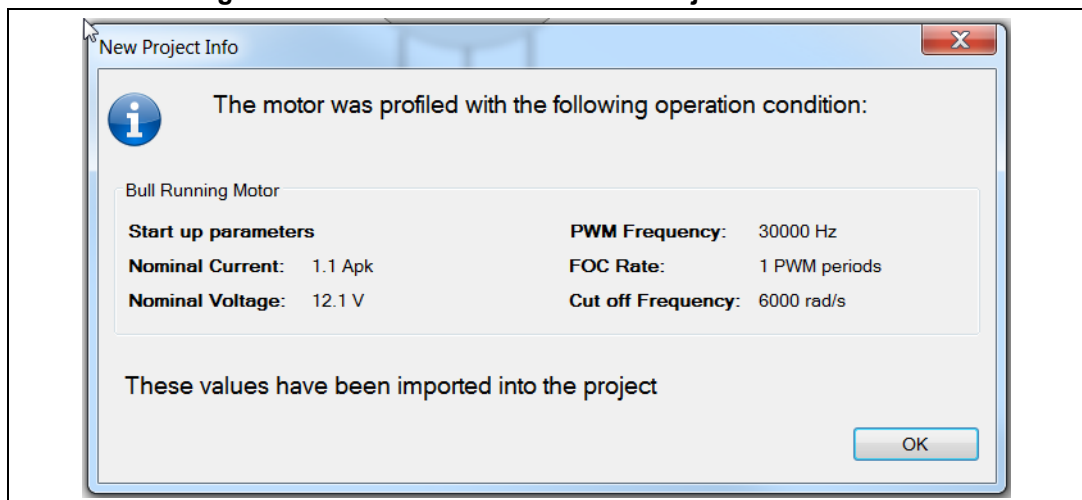
Click on the *Generation* button as indicated in *Figure 11* to open the *Project Settings* window. Then, select the working area to save the project and click *OK*.

Figure 11. ST MC Workbench - Project Settings

Select the favorite STM32CubeMX version, and Toolchain / IDE as shown in *Figure 12* (default is ST TrueSTUDIO®), as well as the HAL or LL driver use.

Figure 12. ST MC Workbench - Project Settings window[a]

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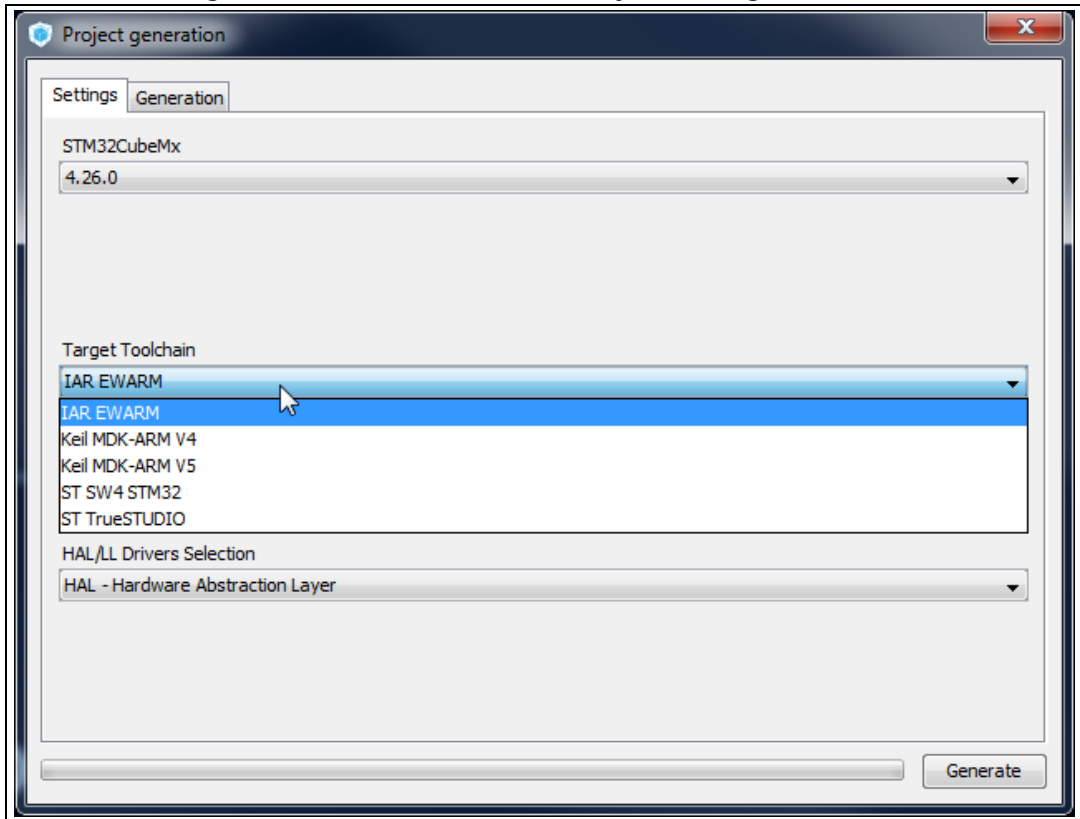
a. The TrueSTUDIO® and SW4STM32 framework tools are not supported in SDK v5.0 but in later versions.

Click on the *Generate* button as indicated in *Figure 12* to generate the MC project. This action also opens the *Generation* tab from the *Project Generation* window, as shown in *Figure 13*, which presents the log view. The generation of the MC project takes several seconds.

Figure 13. ST MC Workbench - Project generation button
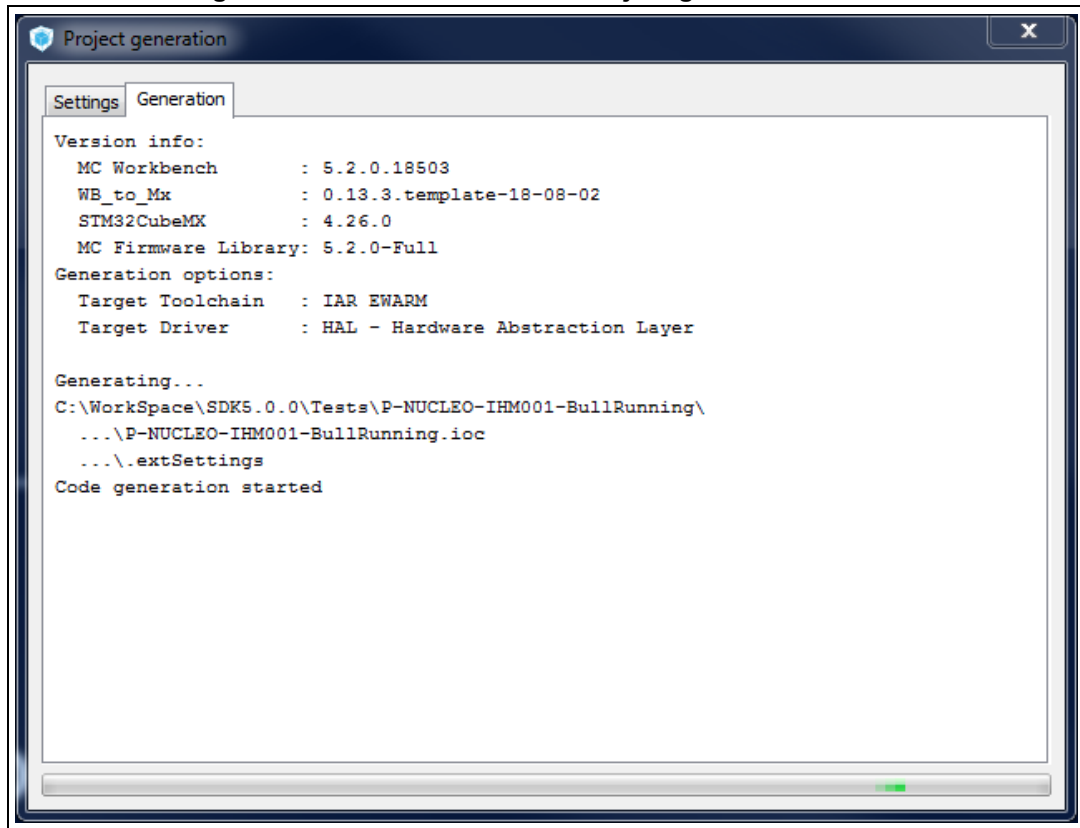
Note: *For a new project, a window is displayed for the configuration of the corresponding workspace settings before project generation as shown in Figure 14. Select the workspace directory and click on the OK button. This step takes several seconds.*

Figure 14. ST MC Workbench - Workspace selection
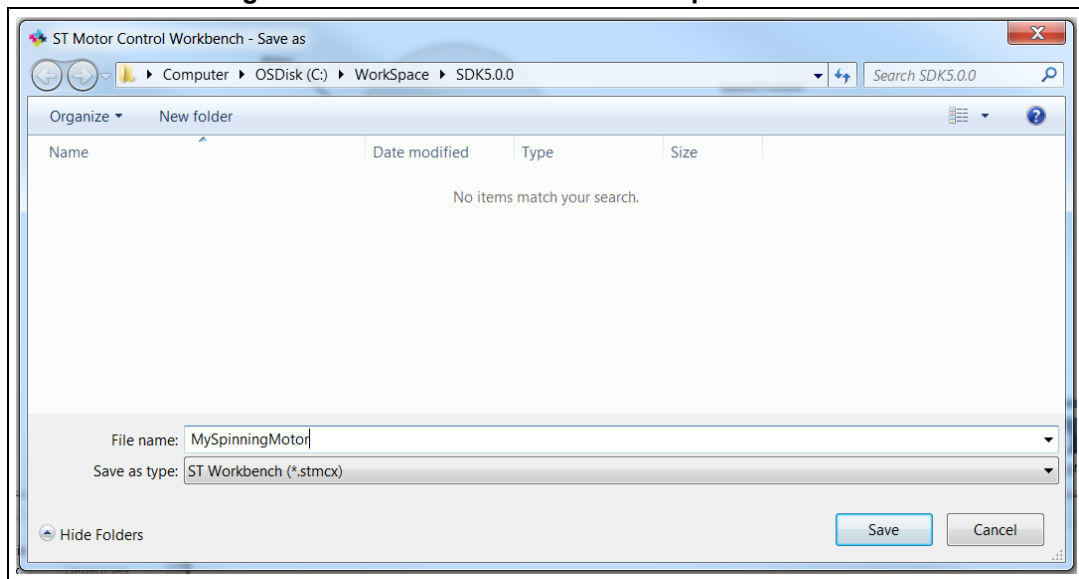
The *Info / Errors / Warning* area provides information about the project generation progress as shown in *Figure 15*.

Figure 15. ST MC Workbench - Project generation build info

Note: *Do not close the ST MC Workbench software tool. It is further needed for motor control.*

3.4 Motor-control project compilation

Run the MC project either from the IDE, or by double-clicking on its workspace file. A window as in *Figure 16* is displayed.

Caution: In the IAR Embedded Workbench® for Arm® v7.80.4, the C compiler optimization must be set to *Speed*.

Figure 16. IDE - MC Project view example
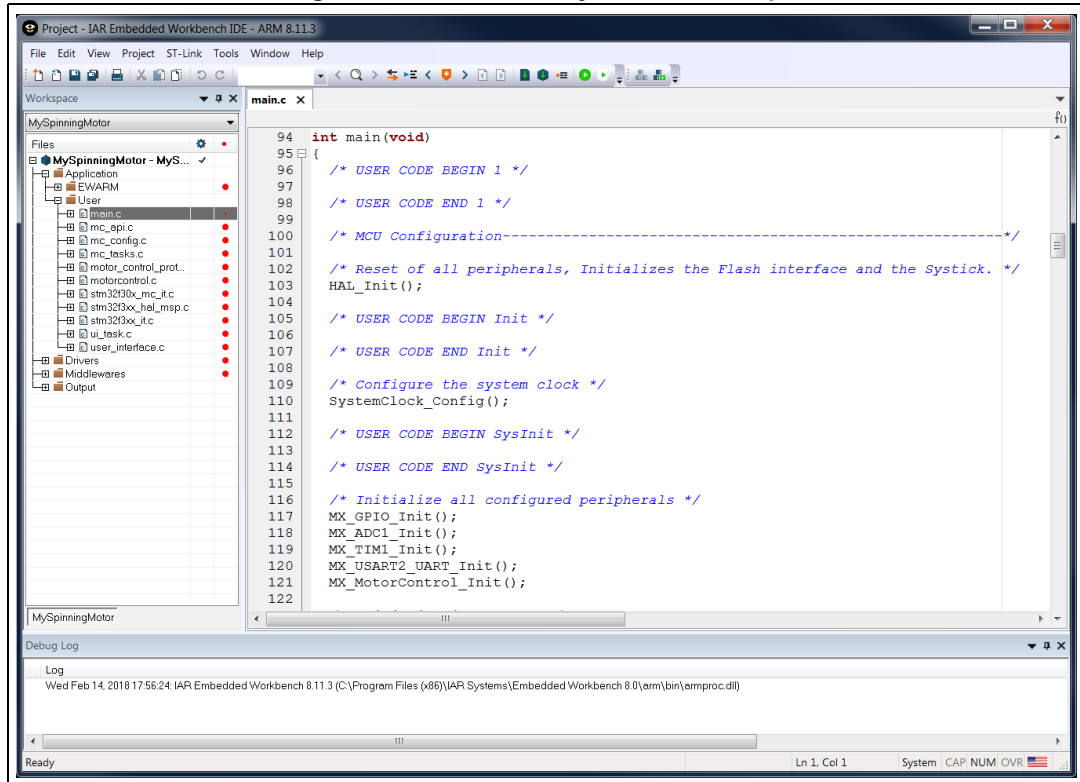
3.5 MC embedded application download

Download the embedded application to the target from the IDE. If the ST/LINK is correctly installed, this is straightforward to perform.

Caution: Make sure that the ST/LINK is configured as the default debug/programming tools for the IDE.

3.6 Spinning motor control and monitoring

The control and monitoring of the spinning motor are performed by means of the ST MC Workbench software tool. Click on the *Monitor* button as indicated in *Figure 17*.

Figure 17. ST MC Workbench - Motor monitoring button

A control and monitoring GUI is displayed as shown in *Figure 18*. Check the communication link settings, configure it if needed, and click on the *Connect* button.
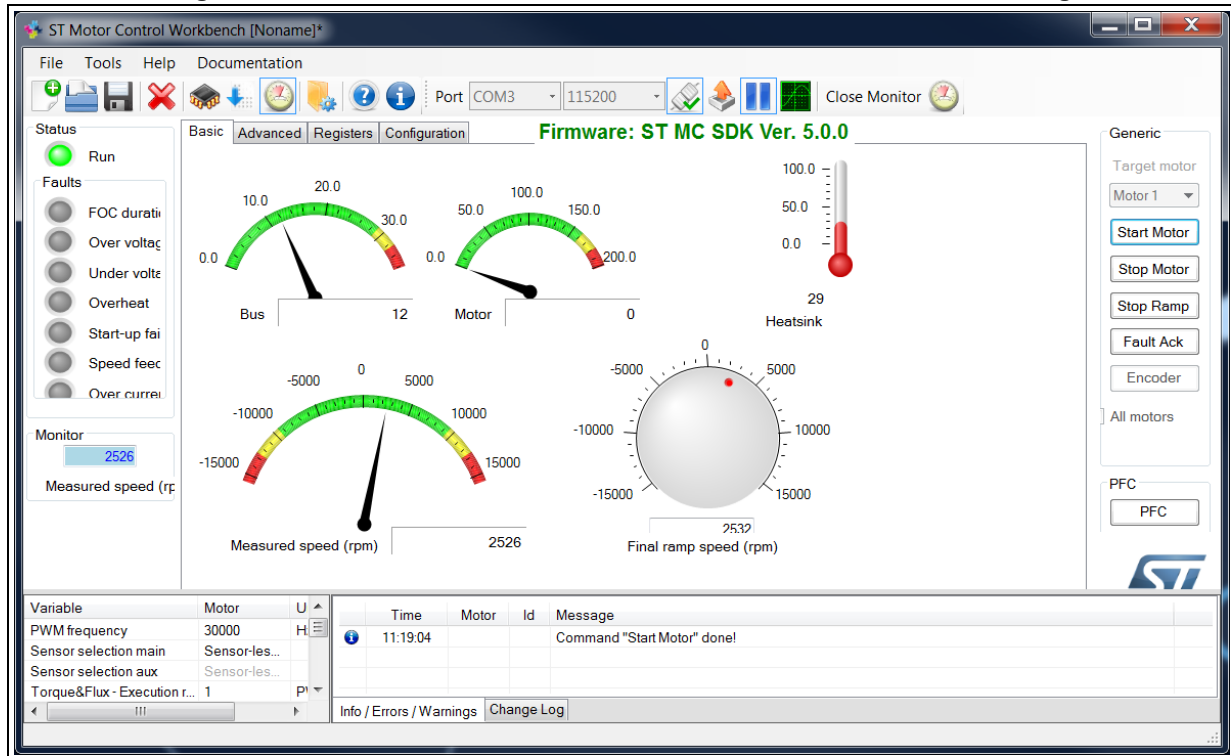
Figure 18. ST MC Workbench - Motor monitoring GUI
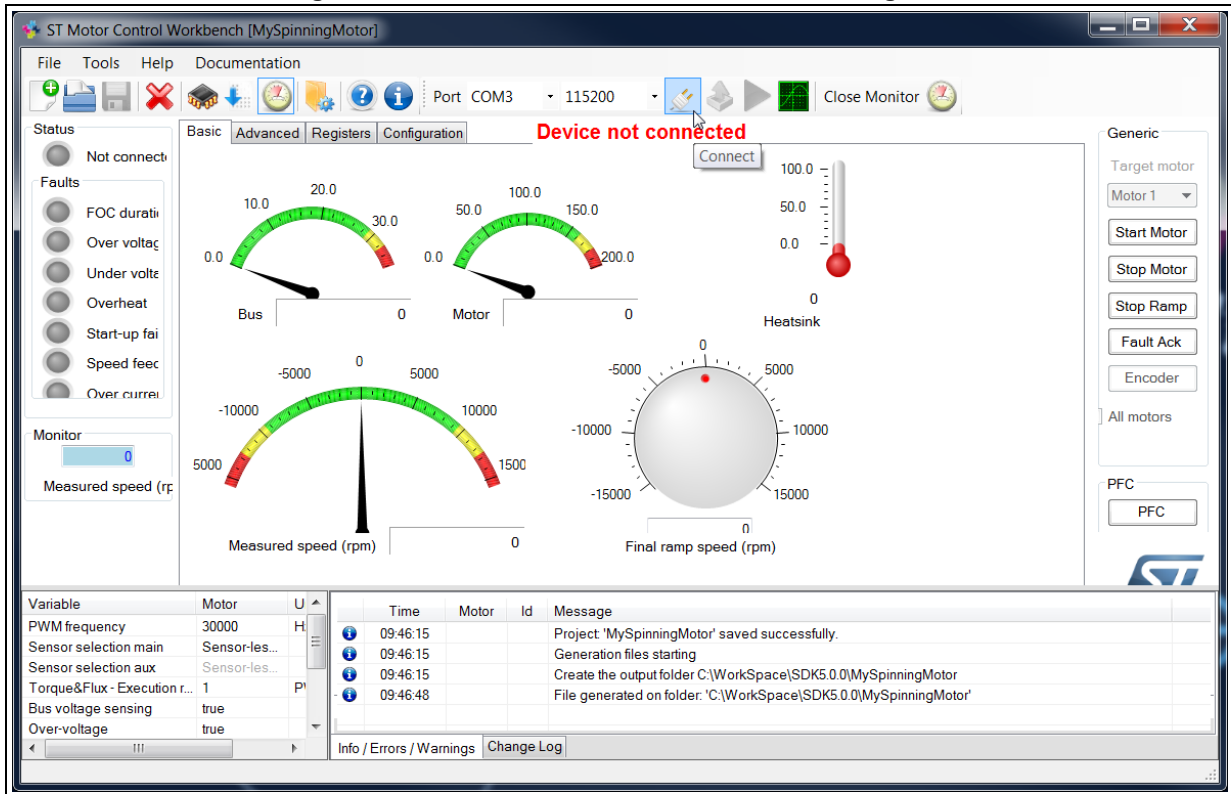
The result of the connection is illustrated in *Figure 19*. Once the connection is established:

- Click on the *Start Motor* button to spin the motor
- Monitor the motor speed
- Click on the *Stop Motor* button to stop the motor

Figure 19. ST MC Workbench - Use of the motor control and monitoring

Note: *In case of faults:*

- Check the reason

- Correct the problem

- Click on the Fault Ack button

- Click on the Start Motor button to spin the motor again

4 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 a proper instrumentation, ST Motor Profiler measurements are optimized (green color in *Figure 7: ST Motor Profiler - Measurement results on page 12*) 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 HW according to the characteristics of the motor. For instance, the maximum current of the motor should match the maximum current of the board as closely as possible.

The ST Motor Profiler may be used only with compatible STMicroelectronics evaluation boards.

Warning: **Use the ST Motor Profiler tool to refer to the list of supported systems.**

Revision history

Table 2. Document revision history

Date	Revision	Changes
6-Mar-2018	1	Initial release.
3-Sep-2018	2	Document aligned on GUI improvement: – updated *Section 3.3: MC project generation* and *Section 3.6: Spinning motor control and monitoring* – updated *Figure 11: ST MC Workbench - Project Settings*, *Figure 12: ST MC Workbench - Project Settings window*, *Figure 13: ST MC Workbench - Project generation button*, *Figure 15: ST MC Workbench - Project generation build info*, and *Figure 17: ST MC Workbench - Motor monitoring button*
12-Oct-2018	3	Updated references to UM2380. Added ST TrueSTUDIO® to the list of supported IDEs in *Section 2.1: Software tool setup*. Updated *Figure 5: ST Motor Profiler - SM-PMSM parameters example*.

IMPORTANT NOTICE – PLEASE READ CAREFULLY