# Using STM32 motor control workbench with STSPIN32F0 and STSPIN32F0A

## Introduction

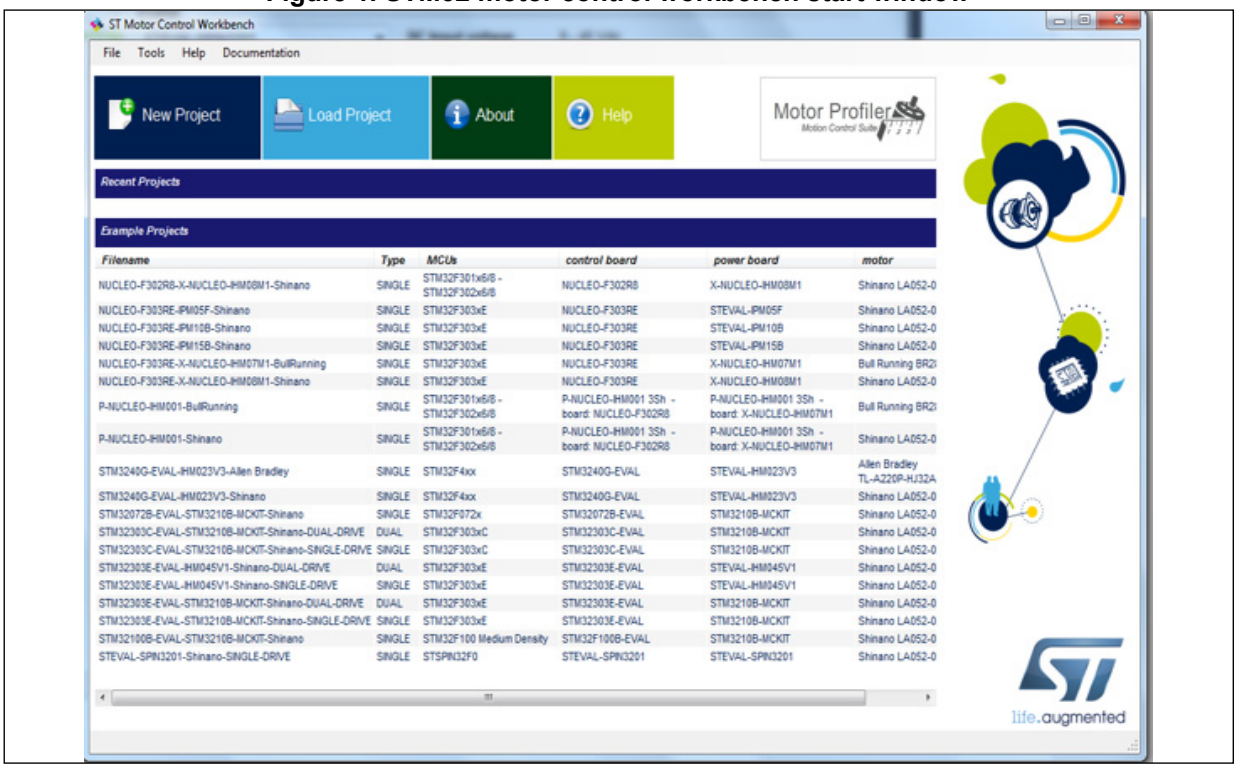
The STSPIN32F0 and STSPIN32F0A are systems-in-package providing an integrated solution suitable for driving 3-phase BLDC motors using different driving modes. The integrated MCU (STM32F031x6) allows the performance of field-oriented control.

This document explains how to drive the STSPIN32F0 or STSPIN32F0A with FOC algorithms, using the STM32 motor control workbench software to generate all the parameter header files, to configure the STM32 PMSM FOC library according to application needs.

To drive a motor with FOC algorithms using the STSPIN32F0 or STSPIN32F0A device, follow this simple workflow:

1. Set up the hardware.
2. Use STM32 motor control workbench to configure the library and generate the code.

**Figure 1. STM32 motor control workbench start window**




3. Create the library and download the firmware.
4. Control the motor.

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# 1 Set up hardware

- Choose the board according to the target: you can use the ST **STEVAL-SPIN3201** or **STEVAL-SPIN3202** boards or you can use a custom board;
- Connect the board, power supply and plug in your motor.

# 2 Use STM32 motor control workbench to configure the library and generate the code

The STM32 motor control workbench can be used to configure the FOC firmware library to use in your application. The user can use the **STEVAL-SPIN3201** or **STEVAL-SPIN3202** boards or a custom board can be used.

## 2.1 Create new project for ST STEVAL-SPIN3201 board

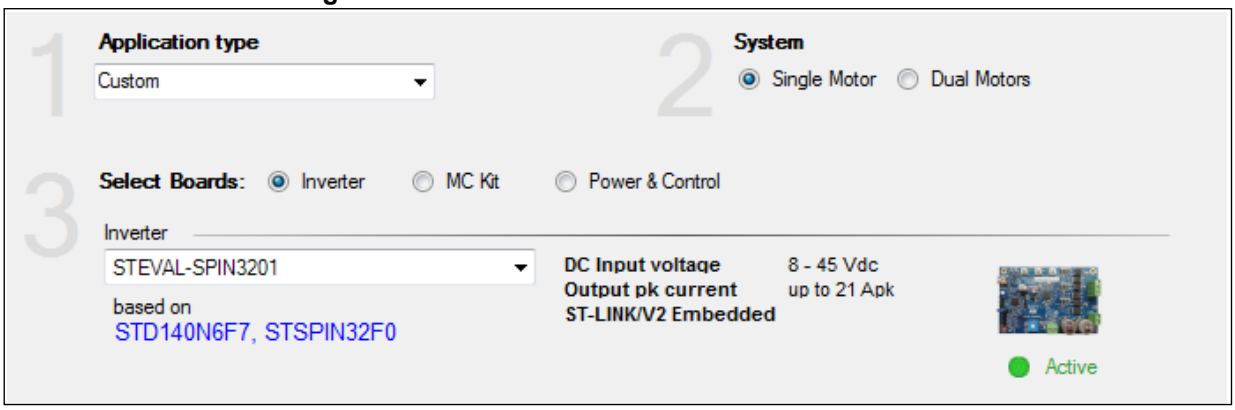
The STEVAL-SPIN3201 board is a three-phase brushless DC motor driver board based on the STSPIN32F0, a 3-phase controller with an integrated STM32 MCU.

The device provides an affordable and easy-to-use solution for the evaluation of the device in low voltage motor driving applications such as fans, drones and power tools.

The board is designed for sensored or sensorless FOC algorithms with 3-shunt sensing. To create a new project for the STM32 motor control workbench based on STEVAL-SPIN3201, follow the procedure:

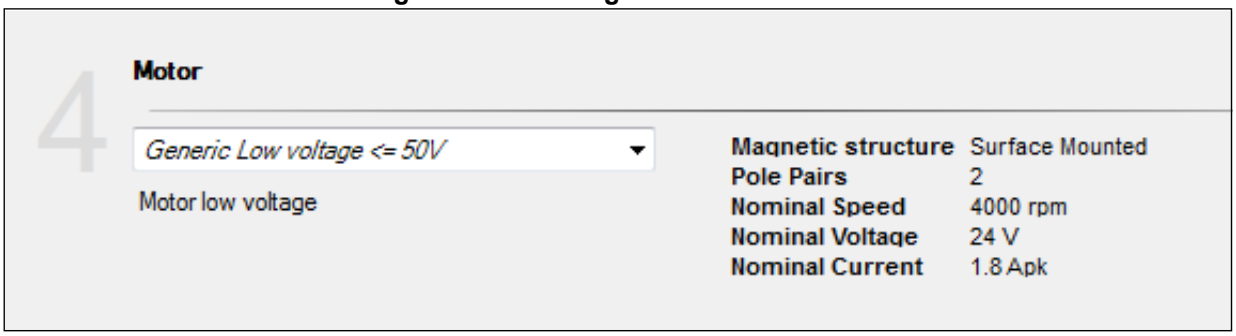
- Open the STM32 motor control workbench v5.2;
- Click on “New Project” and a parameter window appears;
- Choose the “Inverter” board type and select the STEVAL-SPIN3201 from the dropdown list (*Figure 2*). In this way, the application automatically loads all the hardware-related parameters for the FOC library.

**Figure 2. Parameter window for STEVAL-SPIN3201**




- From the motor list, one of the pre-configured motors or a generic starting model can be selected (*Figure 3*);

**Figure 3. Pre-configured motor window**




- Click OK. A new project is now created according to the starting parameters selected.

A configuration window appears, allowing the parameters to be set for:

  – “Motor”
  – “Power Stage”
  – “Drive Management” (i.e. FOC algorithm configuration)
  – “Control Stage” (i.e. MCU configuration)

Using the **STEVAL-SPIN3201** device, the configuration parameters for the Power Stage, Drive Management, and Control Stage are already set.

## 2.2 Create new project for ST STEVAL-SPIN3202 board

The STEVAL-SPIN3202 board is a three-phase brushless DC motor driver board based on the STSPIN32F0A, a 3-phase controller with integrated STM32 MCU.

The device provides an affordable and easy-to-use solution for the evaluation of the device in low voltage motor driving applications such as fans, drones and power tools.

The board is designed for the sensored or sensorless FOC, with single shunt current sensing.

To create a new project for the STM32 motor control workbench based on STEVAL-SPIN3202 follow the procedure:

- Open the STM32 motor control workbench v5.2;
- Click on “New Project” and a parameter window appears;
- Choose the “Inverter” board type and select the STEVAL-SPIN3202 from the dropdown list (*Figure 4*). In this way, the application automatically loads all the hardware-related parameters for the FOC library.
- From the motor list, one of the pre-configured motors or a generic starting model can be selected (*Figure 5*);
- Click OK. A new project is now created according to the starting parameters selected.

A configuration window appears, allowing the parameters to be set for:

  – “Motor”
  – “Power Stage”
  – “Drive Management” (i.e. FOC algorithm configuration)
  – “Control Stage” (i.e. MCU configuration)

Using the **STEVAL-SPIN3202** device, the configuration parameters for the Power Stage, Drive Management and Control Stage are already set.

**Figure 4. Parameter window for STEVAL-SPIN3202**

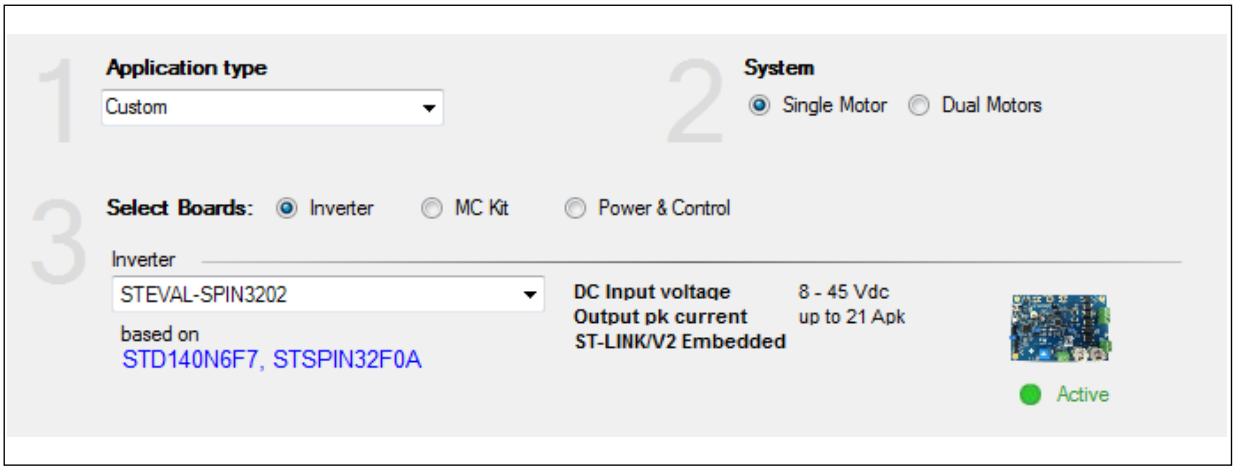
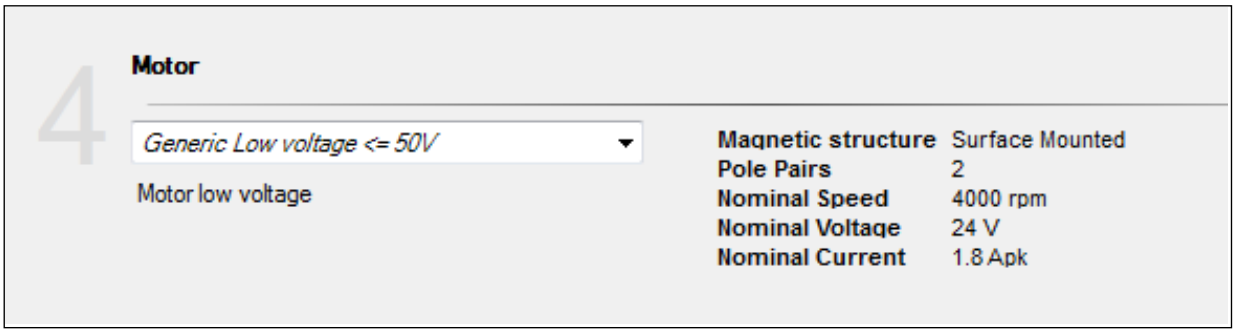



**Figure 5. Pre-configured motor window**

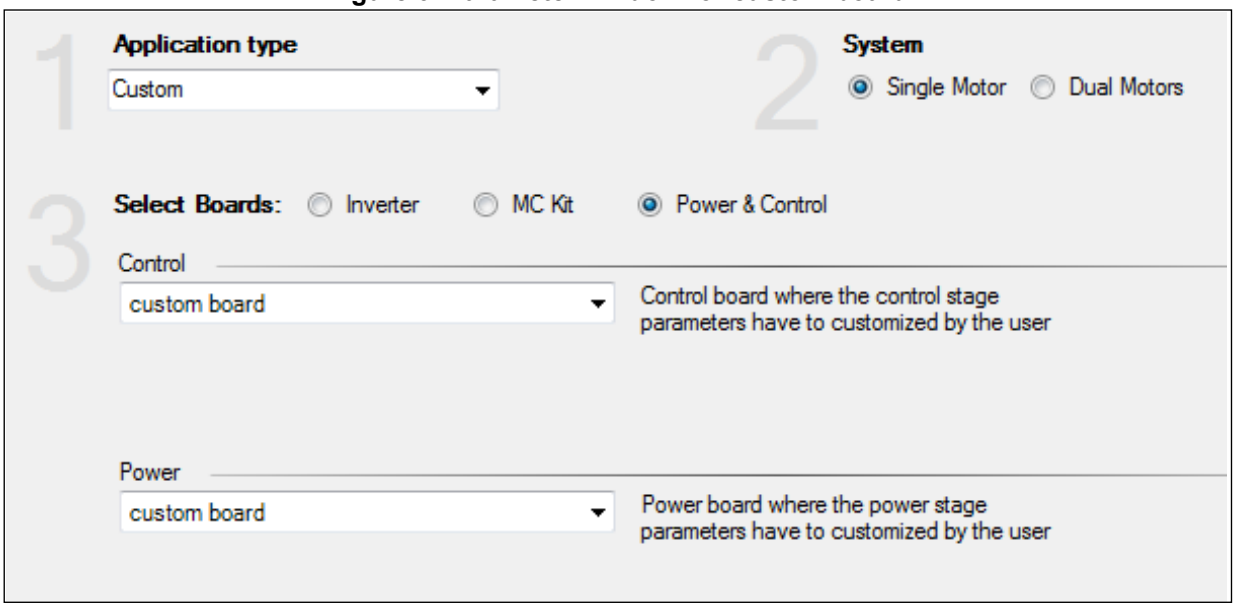


## 2.3 Create a new project for STSPIN32F0/A mounted on a custom board

To create a new project for STM32 motor control workbench using a custom board, follow the procedure:

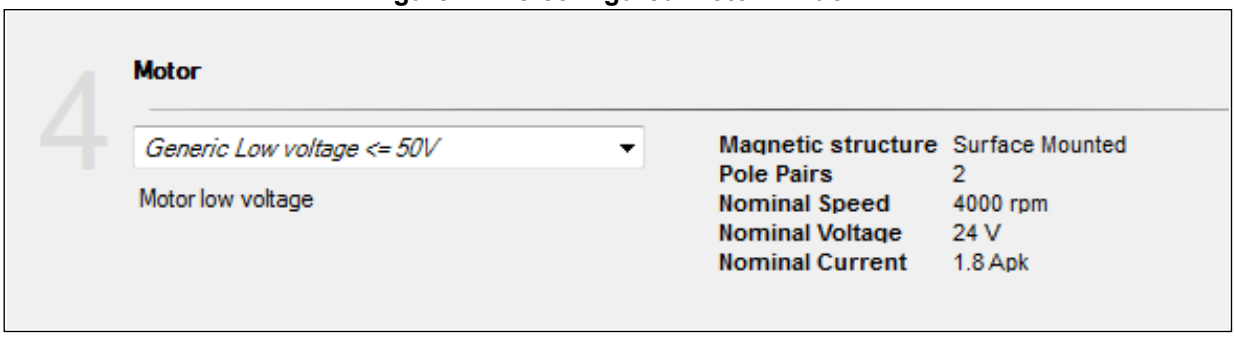
- Open the STM32 motor control workbench v5.2;
- Click on New Project and a parameter window appears;
- Select the options as shown in *Figure 6*:

**Figure 6. Parameter window for custom board**




- From the motor list, one of the pre-configured motors or a generic starting model can be selected (*Figure 7*);

**Figure 7. Pre-configured motor window**




- Click OK. A new project is now created according to the starting parameters selected.

A configuration window appears, allowing the parameters to be set for:

  – “Motor”
  – “Power Stage”
  – “Drive Management” (i.e. FOC algorithm configuration)
  – “Control Stage” (i.e. MCU configuration)

- Using a custom board, choose the configuration parameters for the Power Stage and Control Stage that best fit your application;
- To use the integrated MCU (STM32F031x6), remember that a limited number of pins can be accessed, as can be seen in the STSPIN32F0 or in the STSPIN32F0A datasheet. Here is a list of pins that can be used to access the integrated MCU for both devices:

**Table 1. STSPIN32F0: Accessible pins for integrated MCU**

| No. | Name | Function |
|---|---|---|
| 4 | PF0 | MCU PF0 |
| 5 | PF1 | MCU PF1 |
| 7 | NRST | MCU reset pin |
| 11 | PA0 | MCU PA0 |
| 12 | PA1 | MCU PA1 |
| 13 | PA2 | MCU PA2 |
| 14 | PA3 | MCU PA3 |
| 15 | PA4 | MCU PA4 |
| 16 | PA5 | MCU PA5 |
| 17 | PA6 | MCU PA6 |
| 18 | 3FG_PA7 | 3FG open-drain output or MCU PA7 |
| 19 | PB1 | MCU PB1 |
| 37 | PA13_SWD_IO | MCU PA13/SWDIO (system debug data via ASIC) |
| 38 | PA14_SWD_CLK | MCU PA14/SWDCLK (system debug clock) |
| 39 | PB6 | MCU PB6 |
| 40 | PB7 | MCU PB7 |

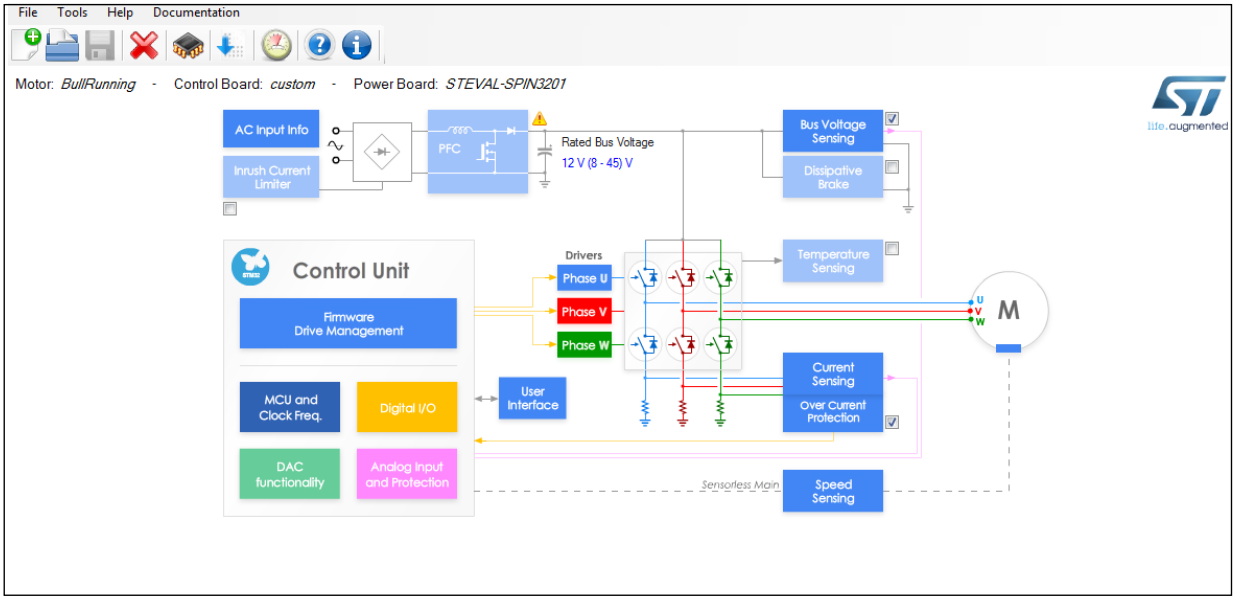
**Table 2. STSPIN32F0A: Accessible pins for integrated MCU**

| No. | Name | Function |
|---|---|---|
| 4 | PF0 | MCU PF0 |
| 5 | PF1 | MCU PF1 |
| 7 | NRST | MCU reset pin |
| 11 | PA0 | MCU PA0 |
| 12 | PA1 | MCU PA1 |
| 13 | PA2 | MCU PA2 |
| 14 | PA3 | MCU PA3 |
| 15 | PA4 | MCU PA4 |
| 16 | PA5 | MCU PA5 |
| 17 | PA6 | MCU PA6 |
| 18 | PA7 | MCU PA7 |
| 19 | PB1 | MCU PB1 |
| 37 | PA13_SWD_IO | MCU PA13/SWDIO (system debug data via ASIC) |
| 38 | PA14_SWD_CLK | MCU PA14/SWDCLK (system debug clock) |
| 39 | PA15 | MCU PA15 |
| 40 | PB6 | MCU PB6 |
| 41 | PB7 | MCU PB7 |
| 42 | BOOT0 | MCU BOOT0 |

## 2.4 Customize parameters for application needs

When a project is opened by the STM32 motor control workbench, a configuration window appears allowing the user to easily manage parameters for the FOC firmware library. There are 4 families of parameters that should be changed to best fit the characteristics of the application.

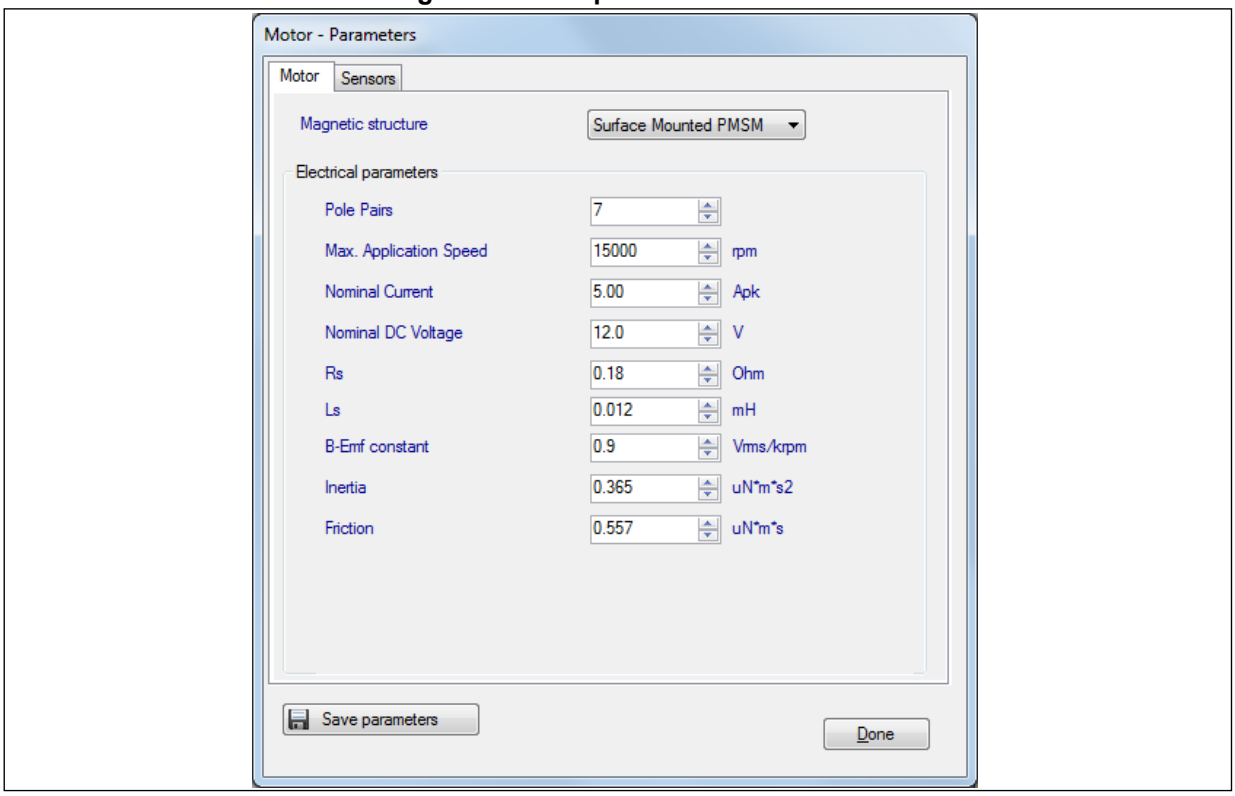
**Figure 8. STM32 motor control workbench configuration window**




### 2.4.1 Motor parameters

In the configuration window the motor parameters can be manually inserted by clicking on the motor symbol and filling the fields (*Figure 9*). If “save parameters” is clicked on, the user can add their motor to the preset list of motors.

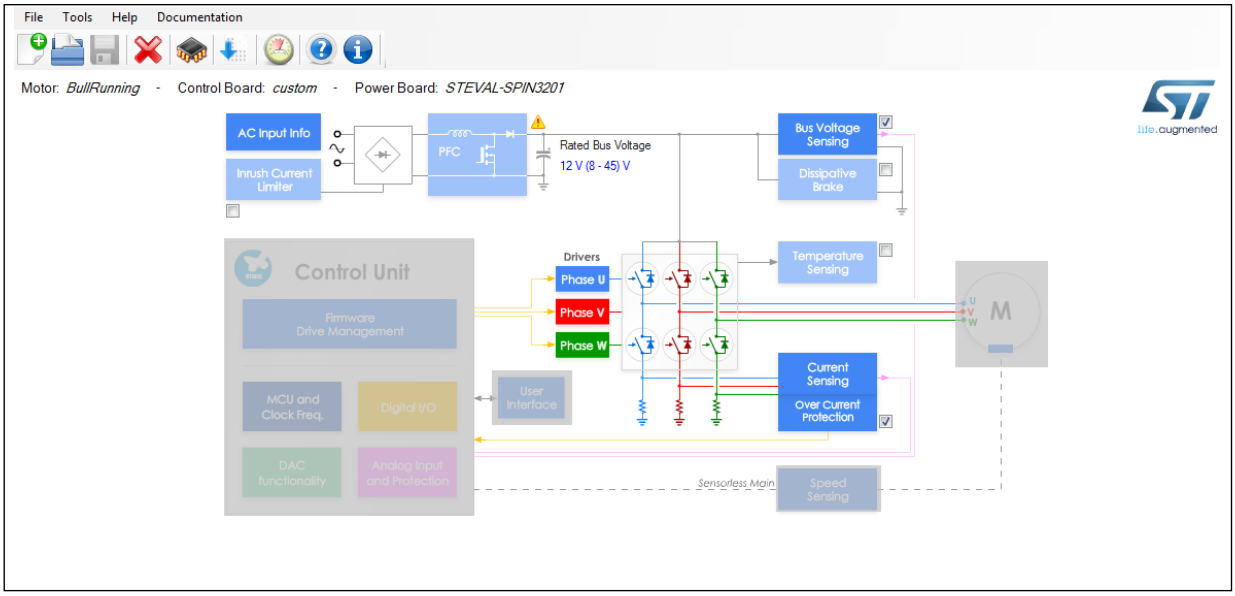
Figure 9. Motor parameters window




## 2.4.2 Power stage parameters

There is a family of parameters which are not covered in *Figure 10* that are related to the hardware of the board.

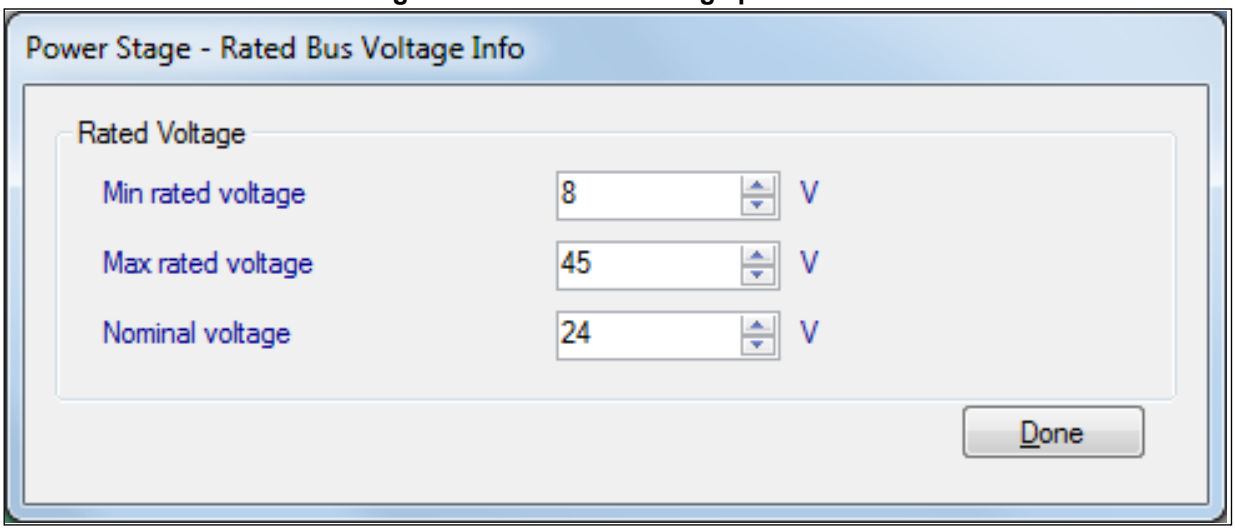
Figure 10. Power stage setting



Using the **STEVAL-SPIN3201** or **STEVAL-SPIN3202** device, the Power Stage parameters are already set. If the supply voltage is changed or if the hardware of the board is modified (changing MOSFETs, adjusting the gain of the sensing circuitry, etc.) or if a custom board is used, the user should set the parameters related to their application. In the configuration window the Power Stage parameters can be manually inserted by choosing the area you want to set.

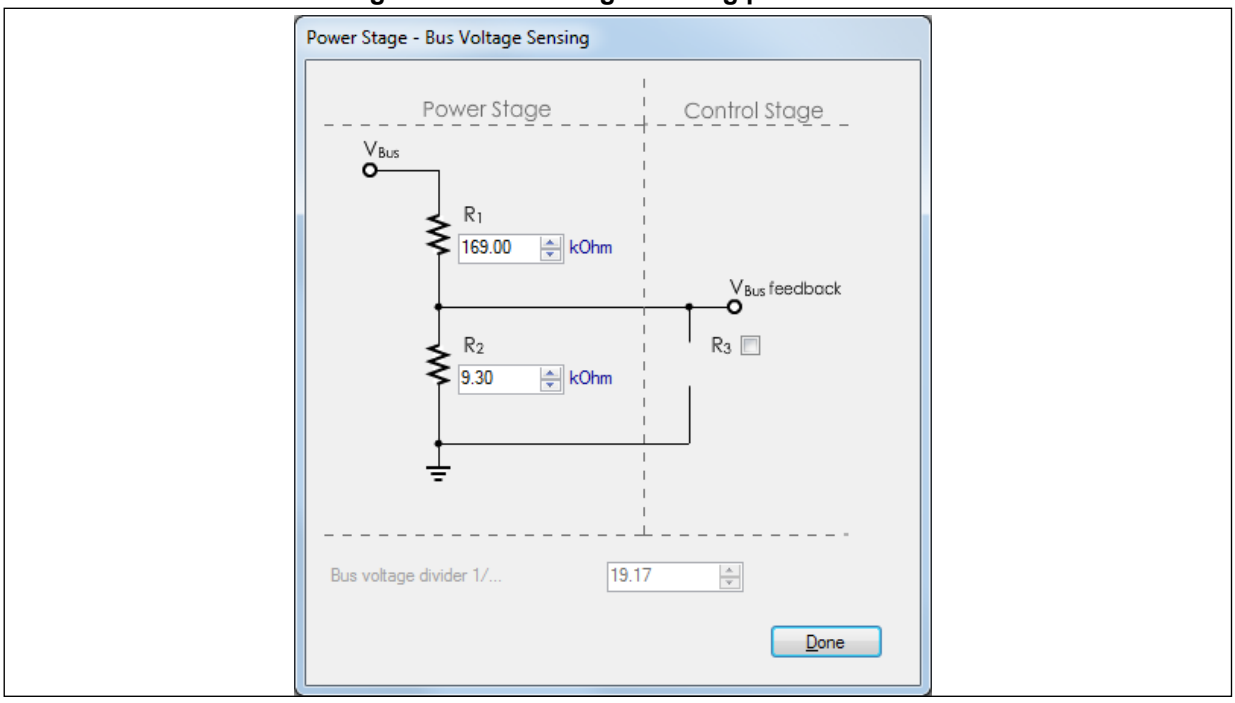
- Select the link for “Rated Bus Voltage” and set the voltage range related to your application (*Figure 11*).

**Figure 11. Rated bus voltage parameter**



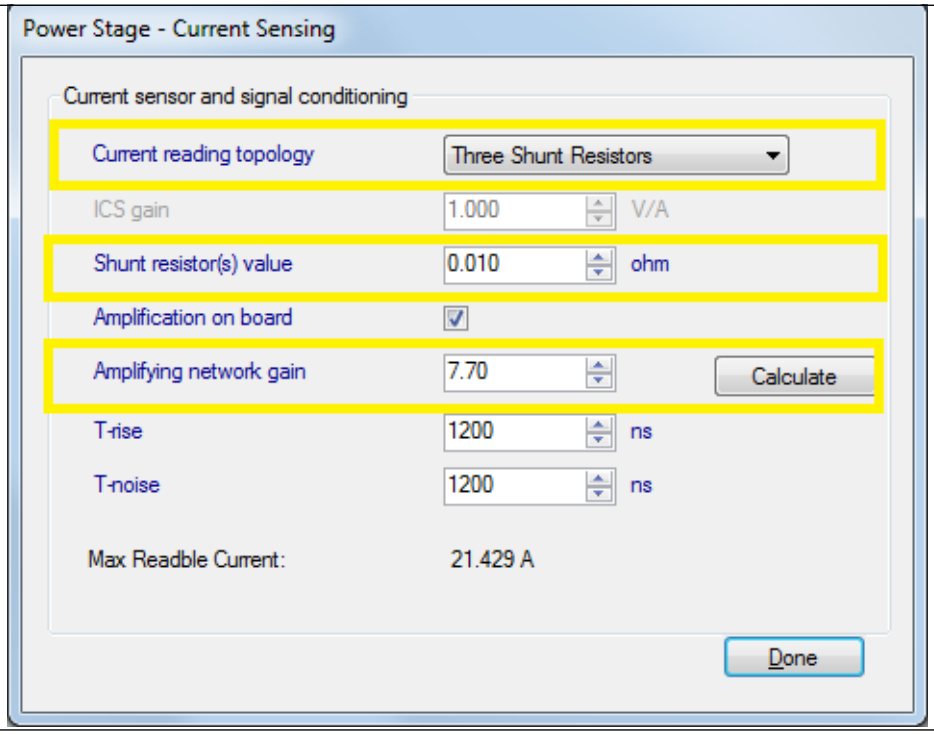

- Select “Bus Voltage Sensing” and set the parameters for the sensing of the Vbus (*Figure 12*).

**Figure 12. Bus voltage sensing parameters**



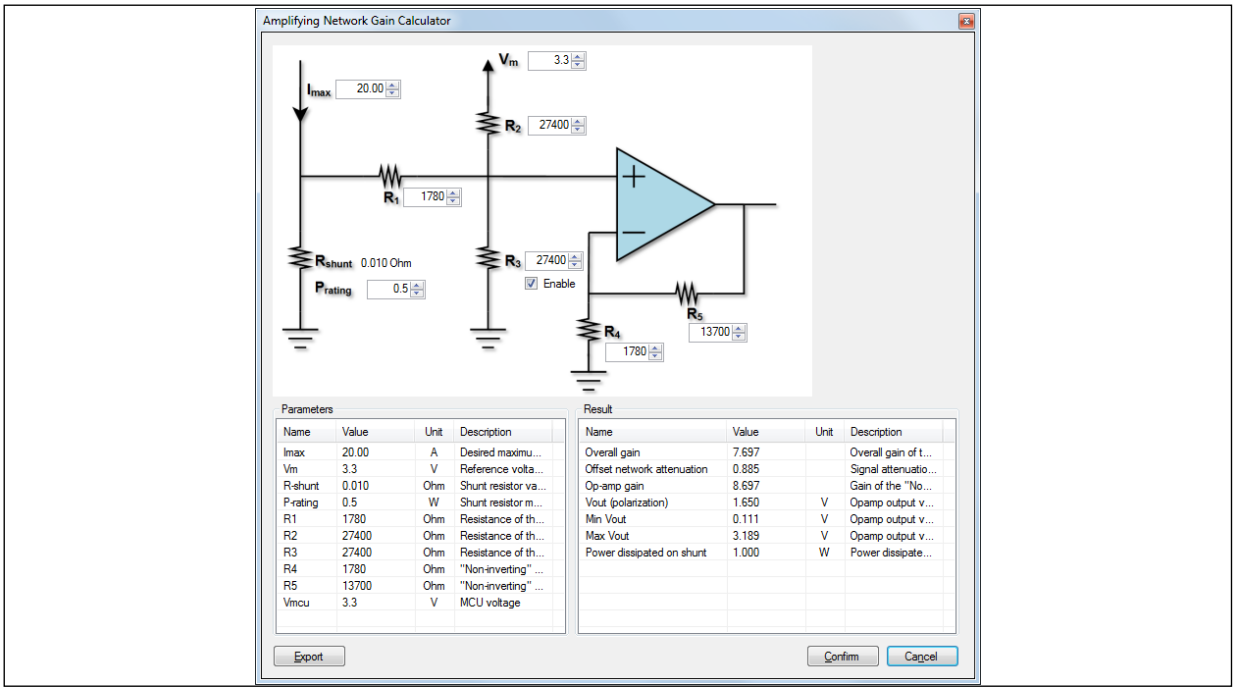
- In “Current Sensing” choose the sensing network. If the user wants to change the sensing circuit, they should also change the model used by the algorithm by changing the “Current reading topology” or the “Shunt resistor value” in the Current Sensing menu (*Figure 13*).

**Figure 13. Current sensing menu**



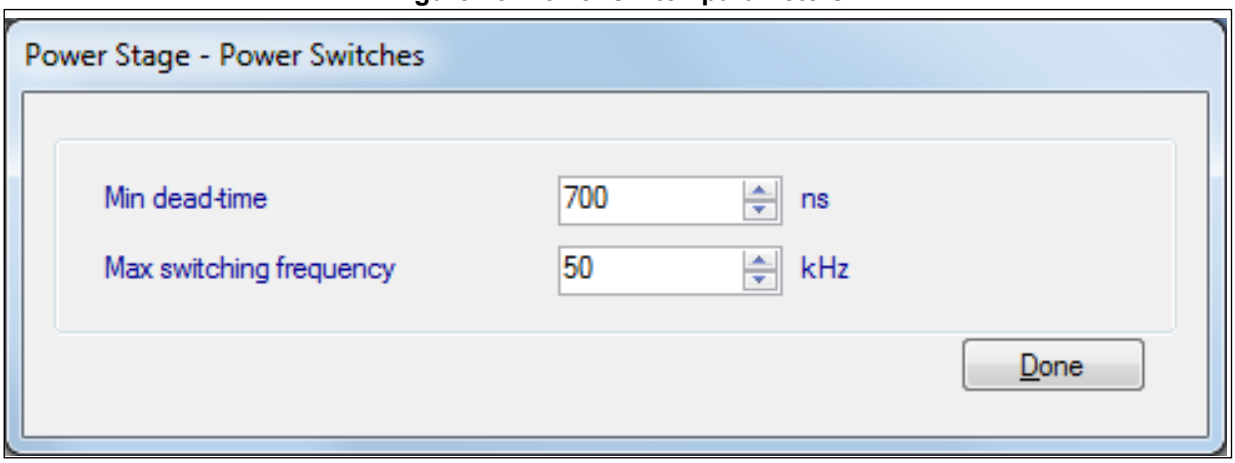

- The user can calculate the Amplifying network gain through the STM32 motor control workbench by setting the resistor in the Amplifying network Gain Calculator: in the current sensing menu click on Calculate and then set your amplification network (*Figure 14*).

**Figure 14. Amplifying network gain calculator**




- Click on “Power Switches” and set their characteristics.

**Figure 15. Power switch parameters**

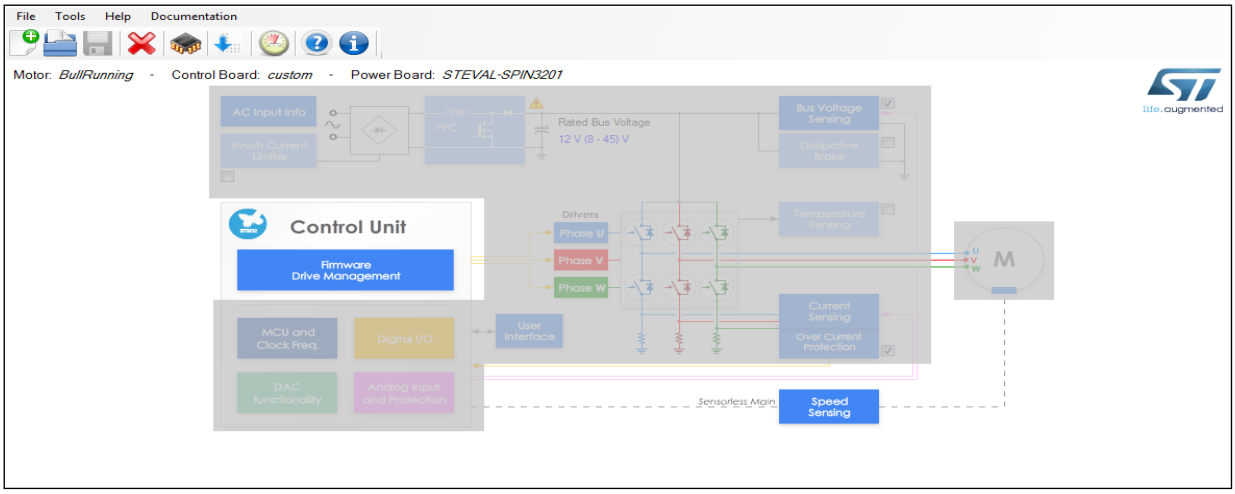



## 2.4.3 Drive management parameters

There is a family of parameters, shown in *Figure 16*, that are related to the configuration of the algorithm, for example, the start-up configuration of the algorithm, the control mode chosen (Speed or Torque) and also gain parameters if needed.

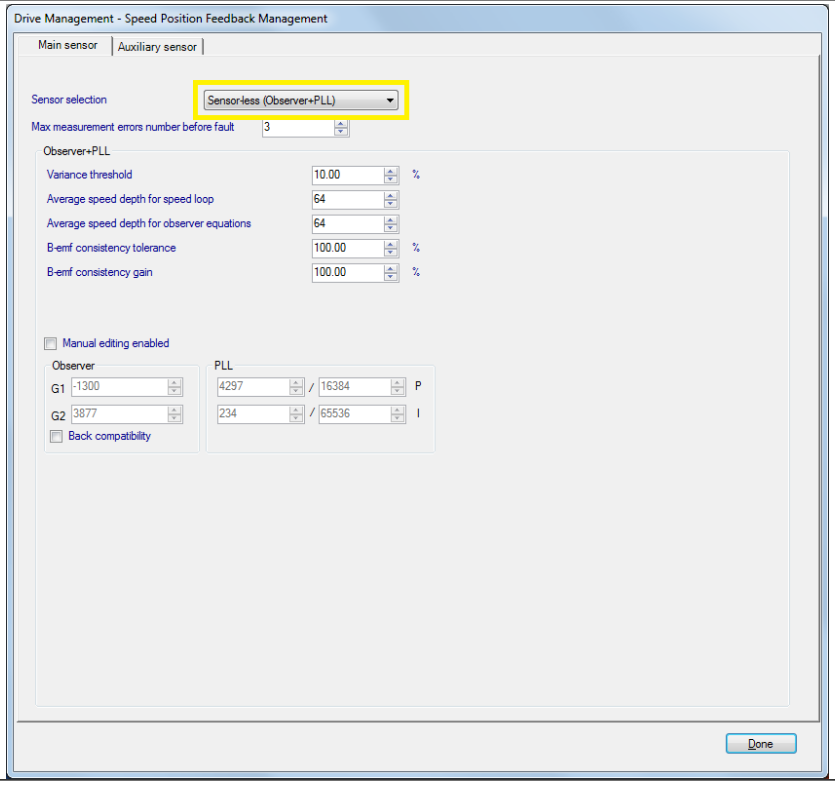
In the configuration window the parameters related to the algorithm usage can be manually inserted by clicking on the area you want to set.

**Figure 16. Drive management setting**



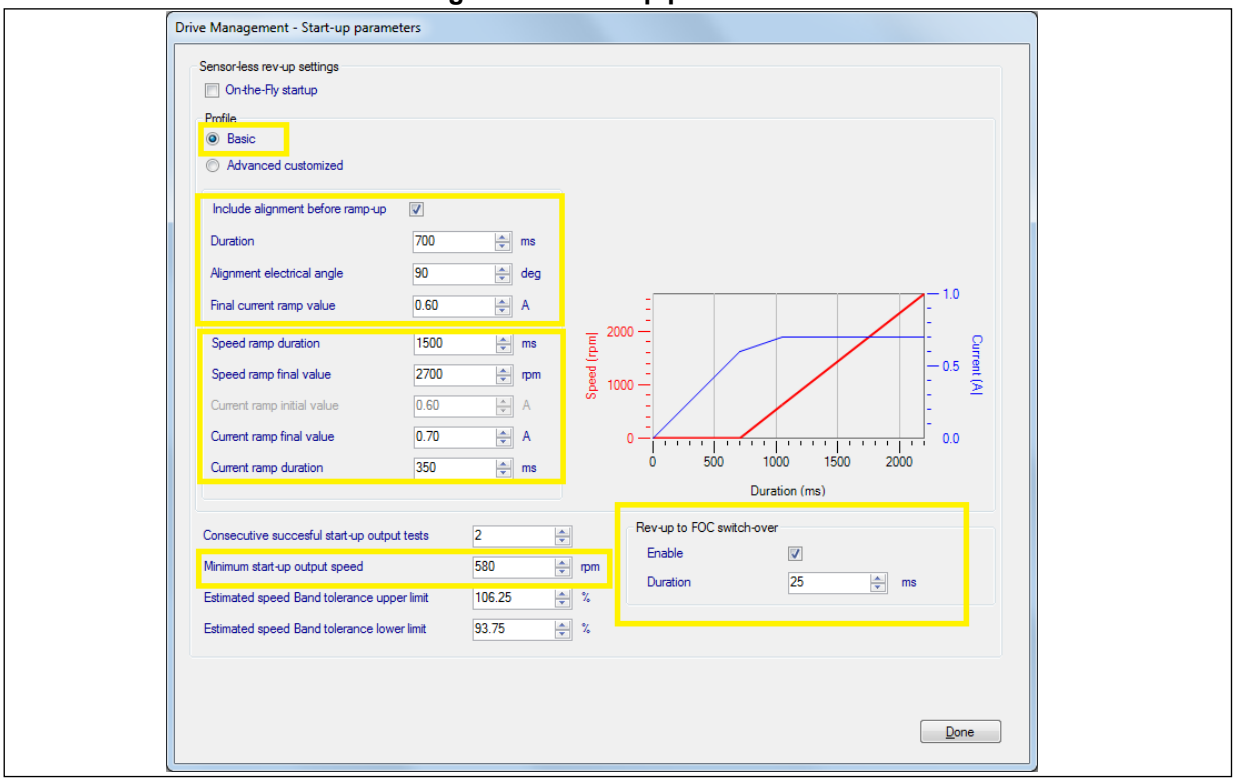

- In the Speed Sensing window choose “Sensor selection” to select the sensing algorithm you want to use (*Figure 17*).

**Figure 17. Sensor selection**




- To select the starting speed and the open loop current profile, right click on “Firmware Drive Management” and choose “Start-up Parameters” in the dropdown menu.

**Figure 18. Start-up parameters**




This is an example of a basic control of speed and current in open loop. The red line is the speed profile while the blue line is the current profile chosen by editing the parameters on the left of the graph. At first, the algorithm aligns the motor, if the “Include alignment before ramp-up” is enabled. After the alignment phase the current value is “Final current ramp value”. Speed and current ramp is now applied and the “Minimum start-up output speed” is the minimum speed accepted by the algorithm to close the loop. When the algorithm converges, if the Rev-up FOC switchover is enabled, the passage to the closed loop is more gradual.

Choosing Advanced customized profile the user can set a more elaborate profile for the open loop ramp, as shown in *Figure 19*.

**Figure 19. : Advanced start-up parameters**

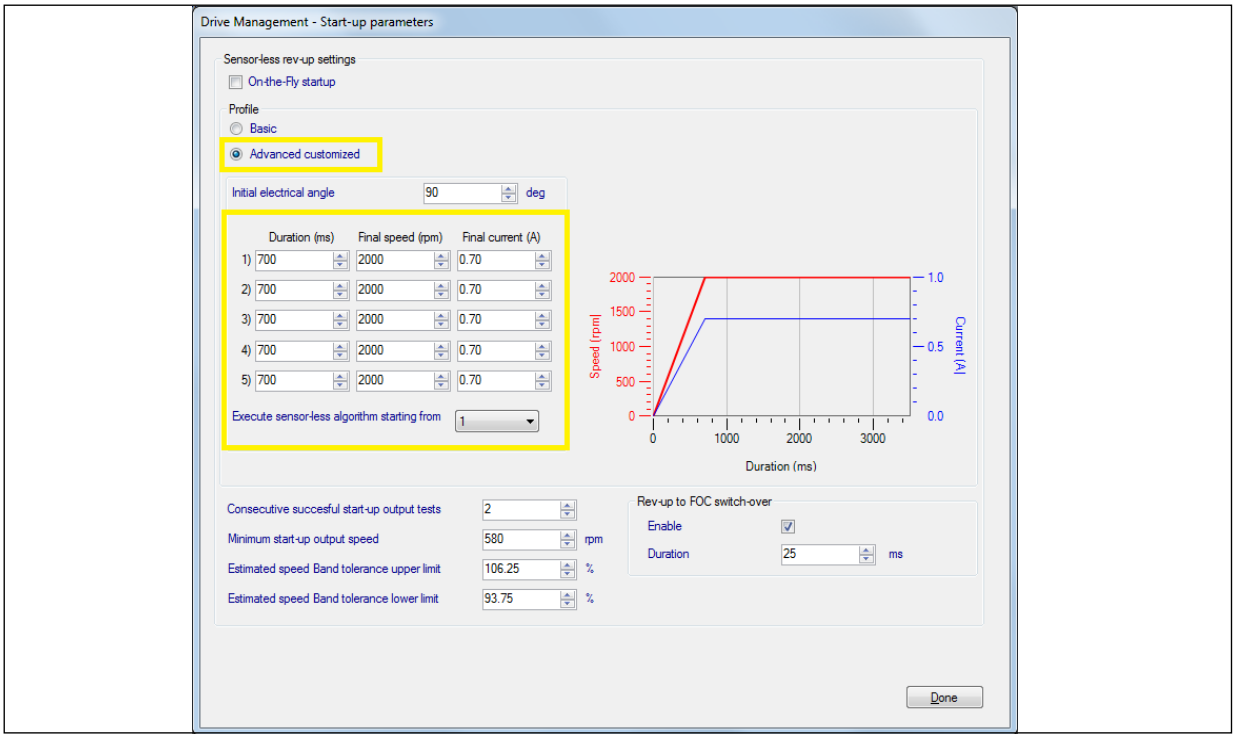
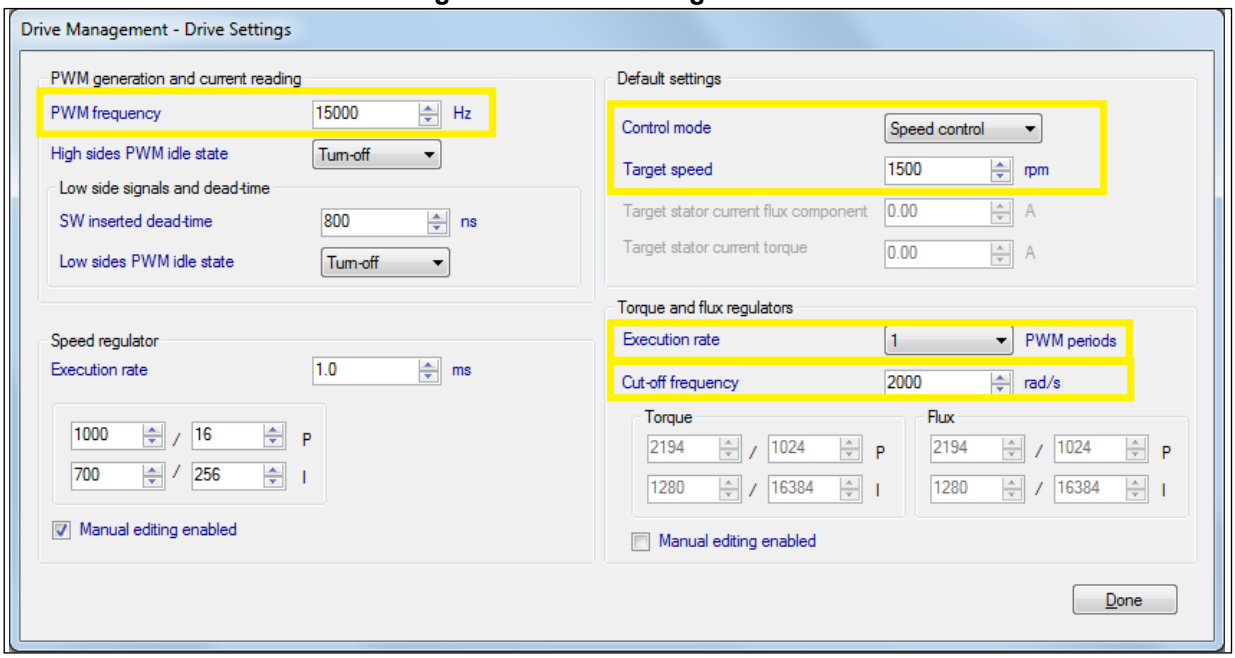



**Figure 20. Drive settings window**



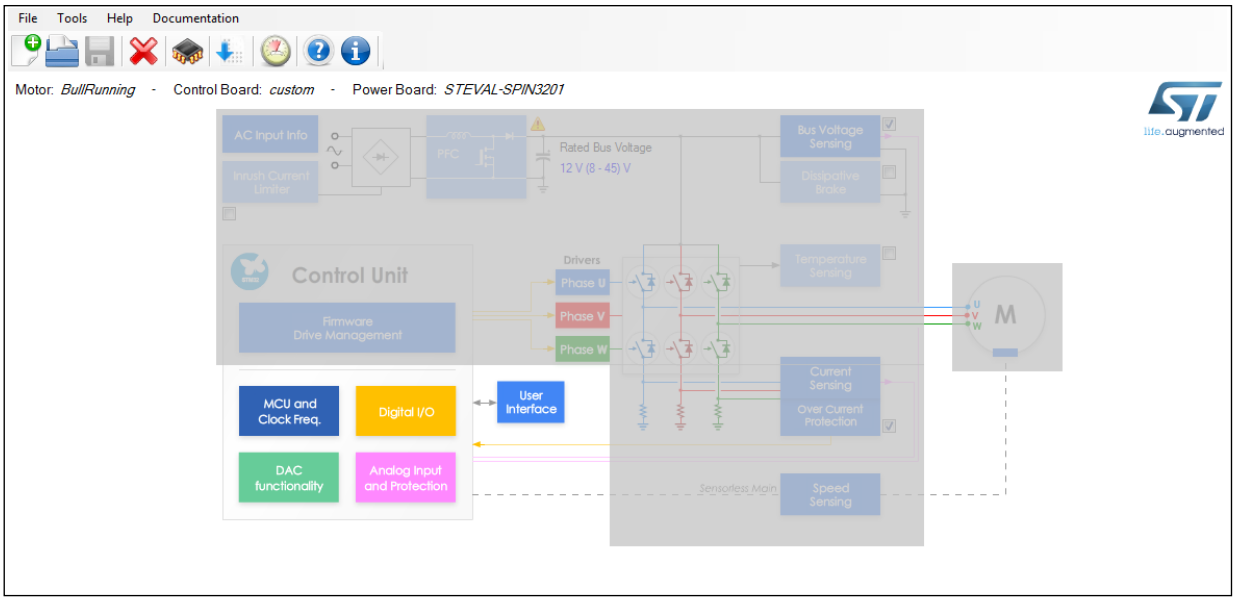

- To select the PWM frequency, right click on “Firmware Drive Management” and choose “Drive Settings”: note that the **PWM frequency** / **Execution rate** must be below 14 KHz, so adjust the Execution rate if you want to increase PWM frequency. In the Drive Settings window, the user can also select the control mode (Speed or Torque control) and the

Target speed for the application. The user can also set the Cut-off frequency for the stability of closed loop (*Figure 20*).

### 2.4.4 Control stage parameters

There is a family of parameters, shown in *Figure 21*, that are related to the mapping of the STM32 peripherals which should not be changed as long as the STEVAL-SPIN3201 or the STEVAL-SPIN3202 board is used.

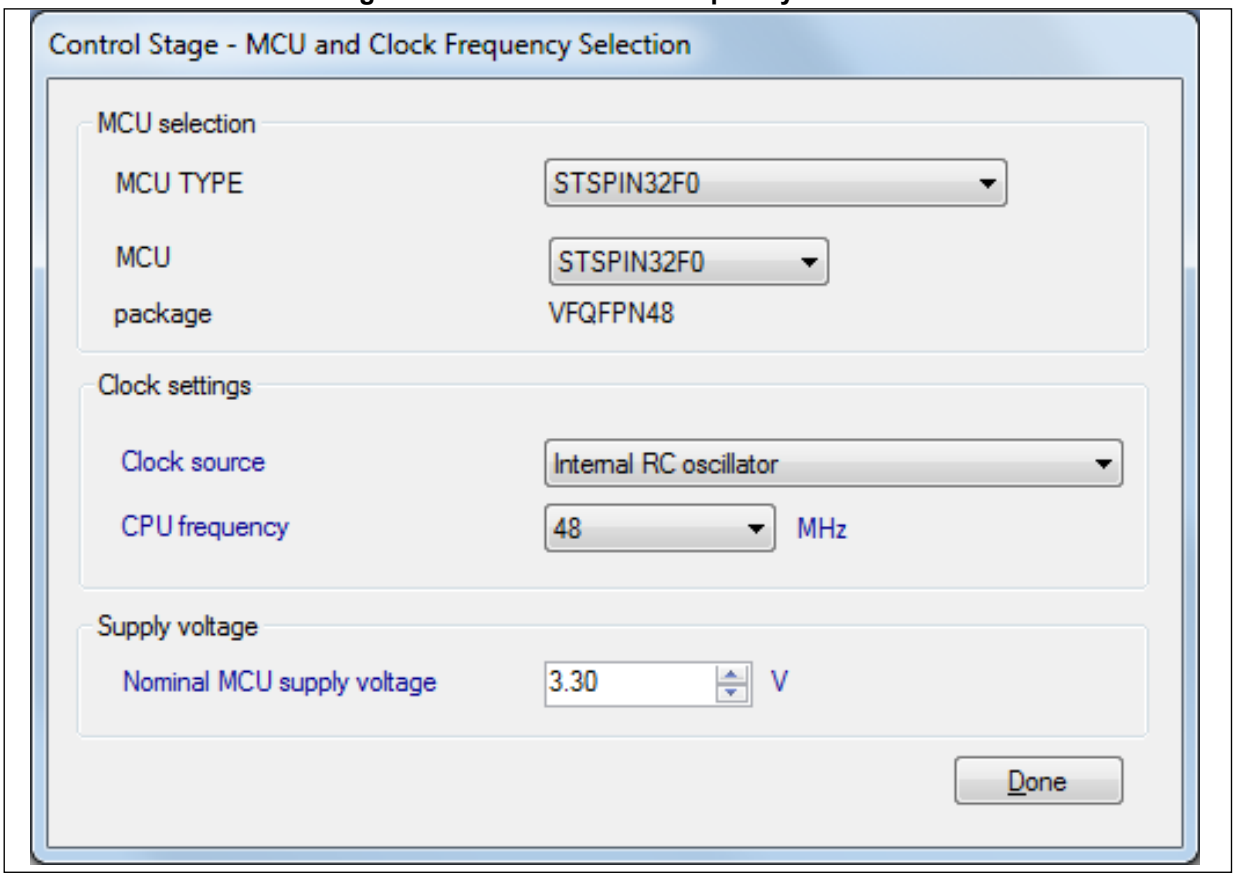
**Figure 21. Control stage setting**




Using the **STEVAL-SPIN3201** or the **STEVAL-SPIN3202** device, the general configuration parameters for the Control Stage are already set. In the configuration window the Control Stage parameters can be manually inserted by clicking on the area you want to set.

- If custom HW is used remember to select the STSPIN32F0 or STSPIN32F0A as a microcontroller in the “MCU and Clock Frequency” → MCU TYPE (*Figure 22*).

**Figure 22. MCU and clock frequency window**

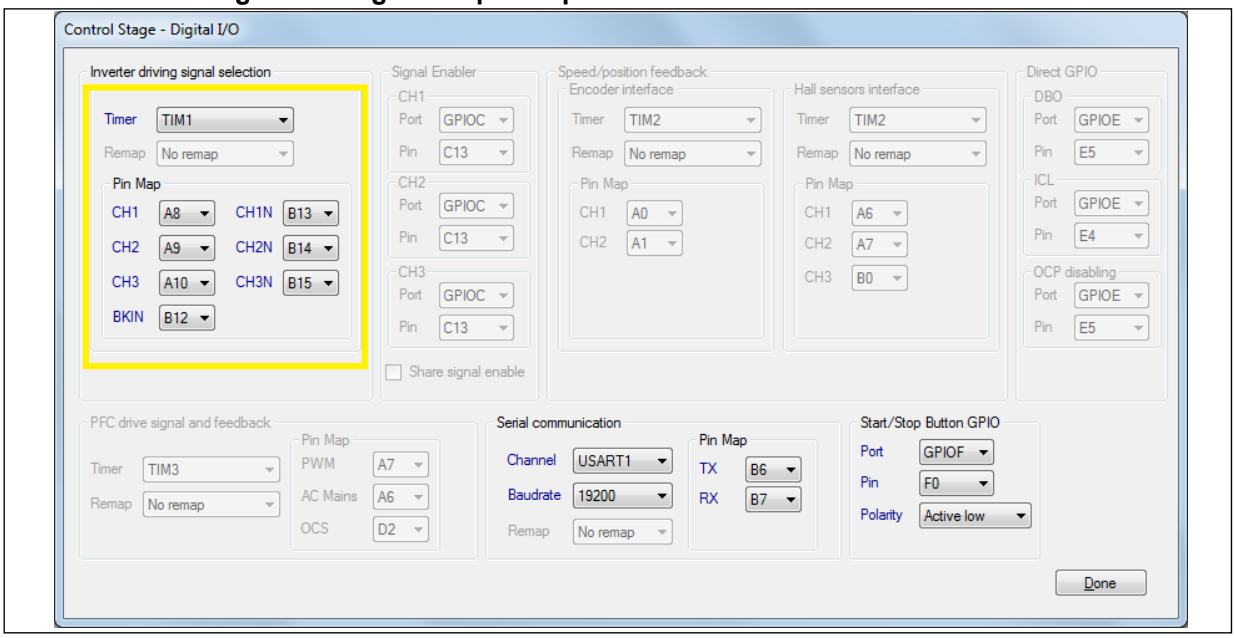



- The “Digital I/O” →“Pin Map” (*Figure 23*), should follow the internal mapping of the device, shown in *Table 3*. If you have selected the STSPIN32F0 or STSPIN32F0A as a microcontroller, the “Digital I/O” → “Pin Map” is automatically configured and shouldn’t be changed.

**Table 3. Pin map for STSPIN32F0 and STSPIN32F0A**

| TIM1 | |
|---|---|
| CH1 | A8 |
| CH2 | A9 |
| CH3 | A10 |
| CH1N | B13 |
| CH2N | B14 |
| CH3N | B15 |
| BKIN | B12 |

**Figure 23. Digital I/O pin map for STSPIN32F0 and STSPIN32F0A**



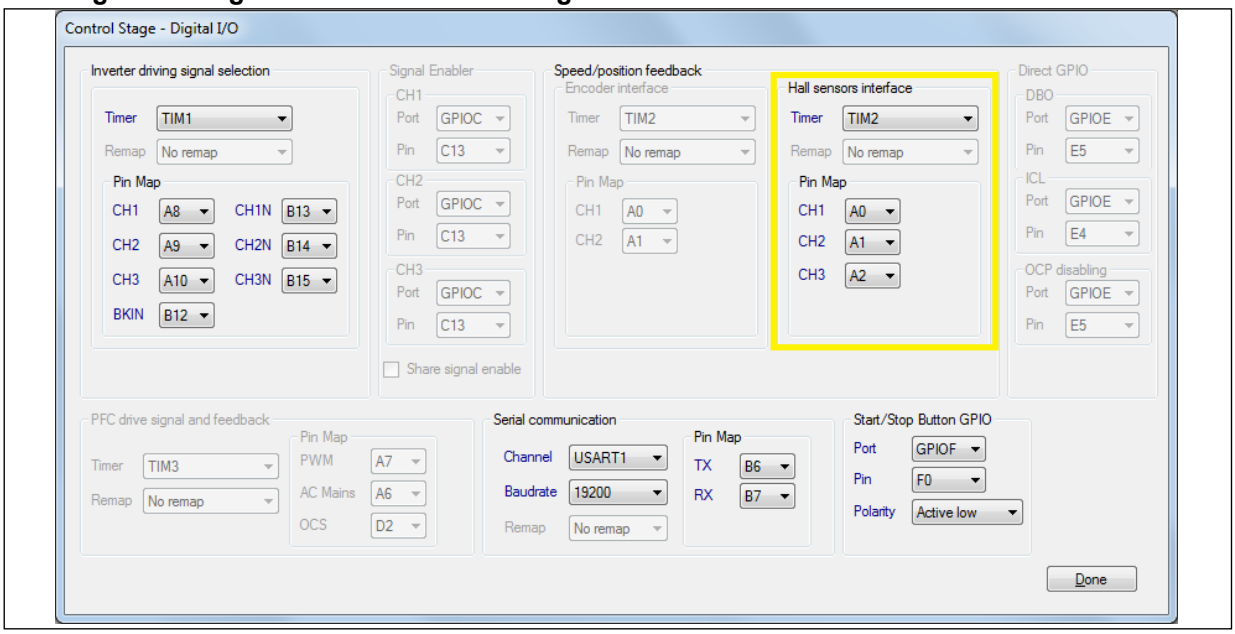

- If the “Hall” sensor position feedback is used, set the correct Sensor selection in the “Speed Sensing” window (*Figure 17*) and then in the Digital I/O →Hall sensor interface (*Figure 24*); the Pin Map has to be set as shown in *Table 4*:

**Table 4. Hall sensor interface for STSPIN32F0 and for STSPIN32F0A**

| TIM2 | |
|---|---|
| CH1 | A0(1), A15(2) |
| CH2 | A1 |
| CH3 | A2 |

1. If you use the ST **STEVAL-SPIN3201** or **STEVAL-SPIN3202** board, choose CH1 = A0.
2. A15 available only for STSPIN32F0A.

**Figure 24. Digital I/O Hall sensor settings for STEVAL-SPIN3201 and STEVAL-SPIN3202**




- If the “Encoder” position feedback is used, set the correct Sensor selection in the Speed Sensing window (*Figure 17*) and in the Digital I/O → Encoder interface (*Figure 25*); the Pin Map has to be set as shown in *Table 5* for STSPIN32F0 or in *Table 6* for STSPIN32F0A.

**Table 5. Encoder interface for STSPIN32F0**

| TIM2[1] | | TIM3 | |
|---|---|---|---|
| CH1 | A0 or A5 | CH1 | A6 |
| CH2 | A1 | CH2 | A7 |

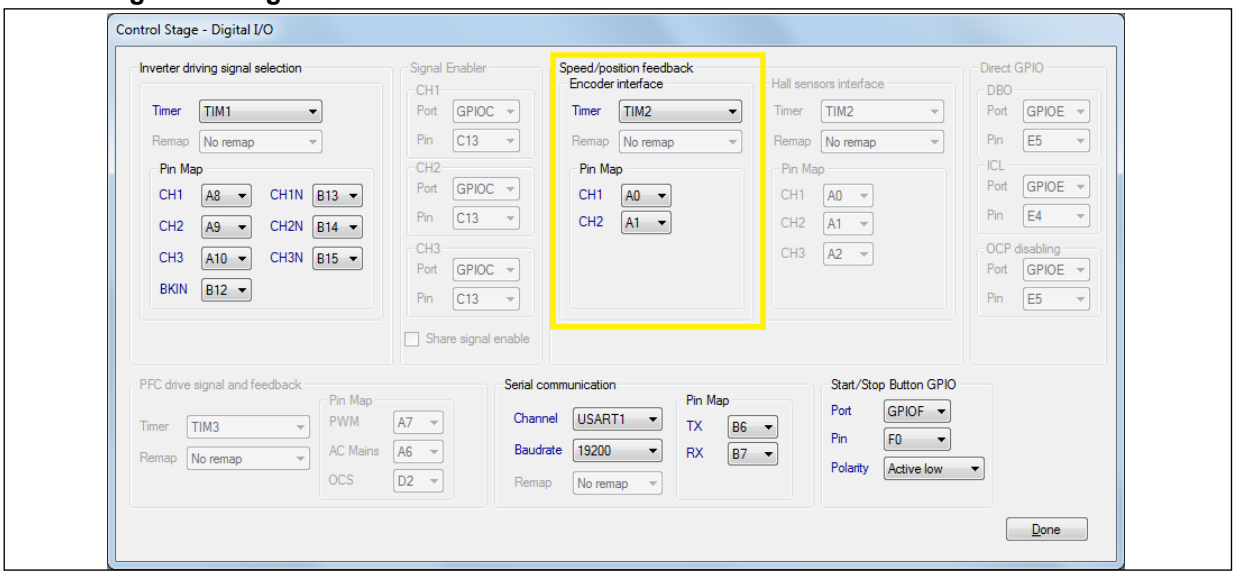
1. If you use the ST **STEVAL-SPIN3201** board, choose TIM2 and CH1 = A0.

**Table 6. Encoder interface for STSPIN32F0A**

| TIM2 | |
|---|---|
| CH1 | A0[1], A5, A15 |
| CH2 | A1 |

1. If you use the **STEVAL-SPIN3202** board, choose CH1 = A0.

**Figure 25. Digital I/O encoder for STEVAL-SPIN3201 or STEVAL-SPIN3202 boards**



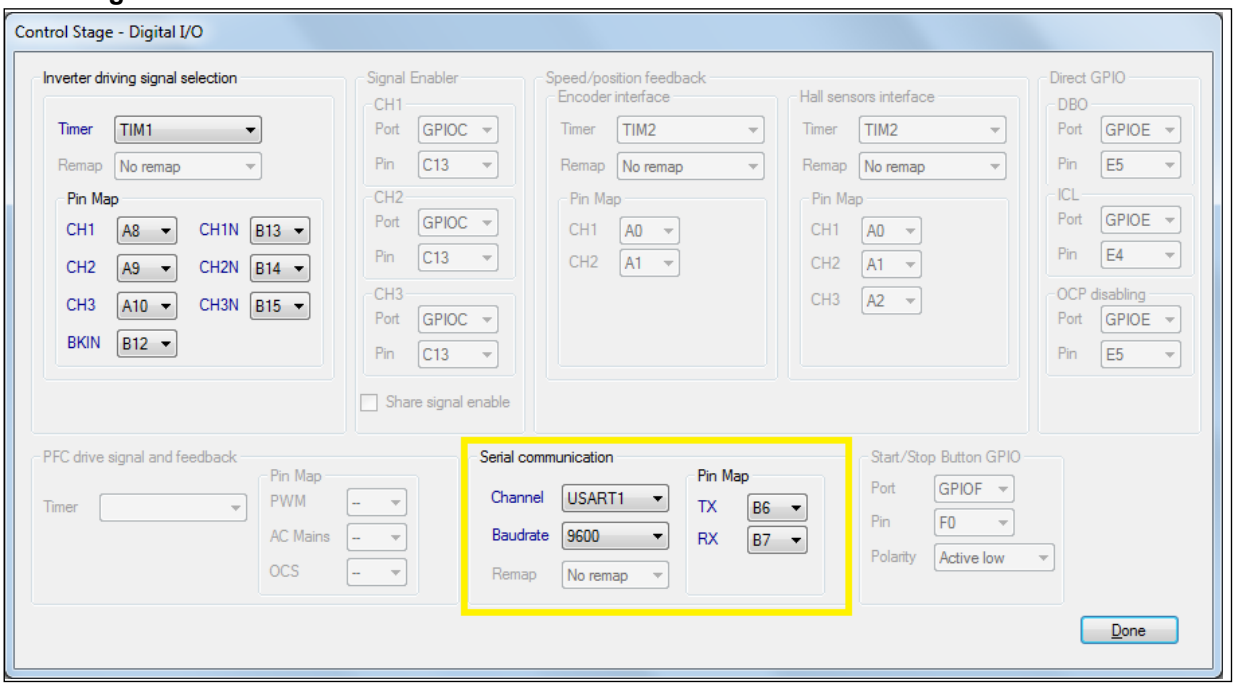

- To define the “Serial Communication” select the pin used for the UART communication in the Digital I/O →Serial Communication (*Figure 26*). For STSPIN32F0 or STSPIN32F0A you should use the mapping shown in *Table 7*.

**Table 7. Serial communication parameters for STSPIN32F0 and STSPIN32F0A**

| Serial Communication | |
|---|---|
| Channel | USART1 |
| Baud rate | 9600 |
| TX(1) | B6 or A2 or A14 |
| RX | B7, A3, A15(2) |

1. If you use the ST **STEVAL-SPIN3201** or **STEVAL-SPIN3202** board, choose TX = B6 and RX = B7.
2. A15 available only for STSPIN32F0A.

**Figure 26. Serial communication for STEVAL-SPIN3201 or STEVAL-SPIN3202 boards**




- It is recommended to use the minimum Baud rate for the communication because a higher value could reflect on the functionality of the environment. Remember to match the Baud rate in the monitor window of the STM32 motor control workbench, when using UART connection.

# 3 Create the library and download the firmware

In this section the user can understand how to use the STM32 motor control workbench to create the code and control the motor. It is possible to customize the firmware via one of the supported different IDEs available on the STM32 motor control workbench.

## 3.1 Generation of the source code

Once the user has fixed the parameters, the STM32 motor control workbench is ready to generate the library to use the FOC algorithm in the application. To generate the new code, follow these steps:

- Save the project by clicking on the save button:

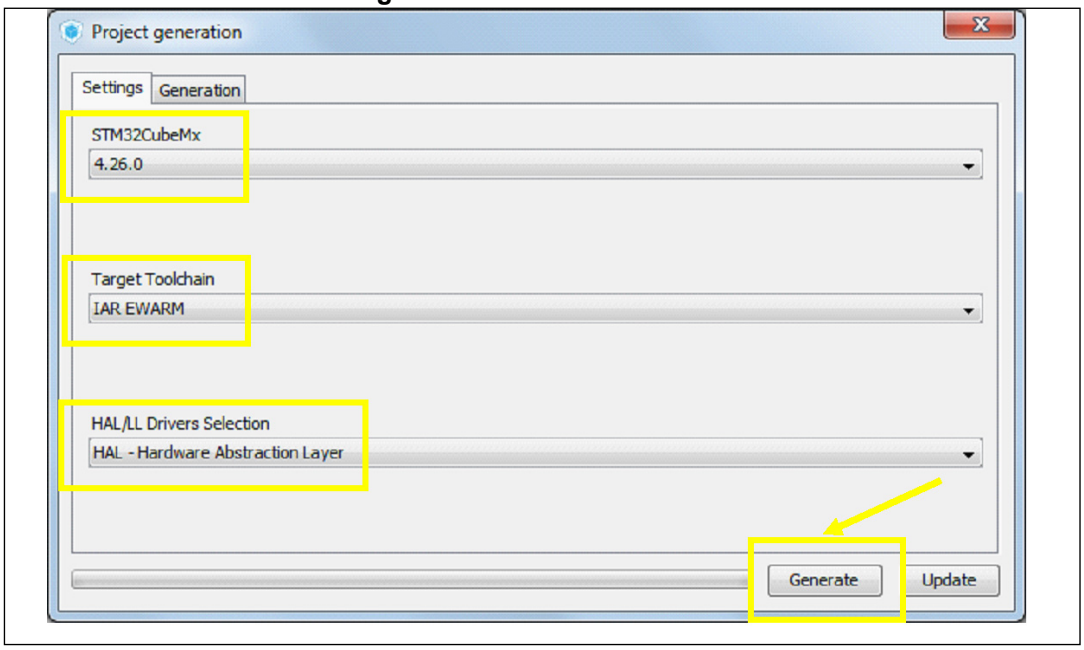
In the Save window, choose the output path of the user folder and the name of the project file, for example 'Application.stmcx'.

This is the configuration file of parameters used in the STM32 motor control workbench. When the user changes the parameters of the application, this file changes accordingly and a new generation of the library is needed.

- Generate the code by clicking on the button:

A generation window appears as shown in *Figure 27*.

**Figure 27. Generation window**

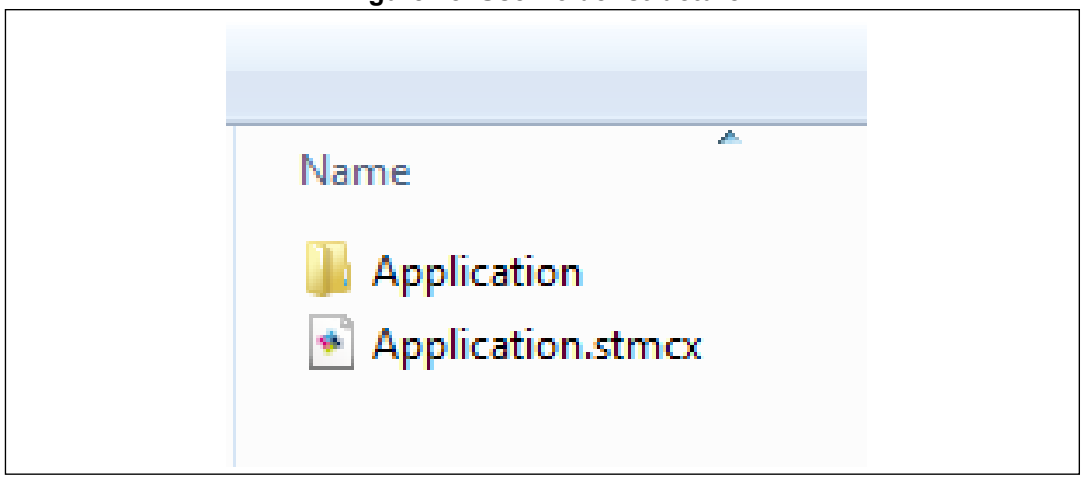


In the generation window:

- STM32CubeMx should be the latest version;
- Choose your preferred Target Toolchain;
- Choose HAL-Hardware Abstraction Layer in Driver Selection;
- Click on Generate.

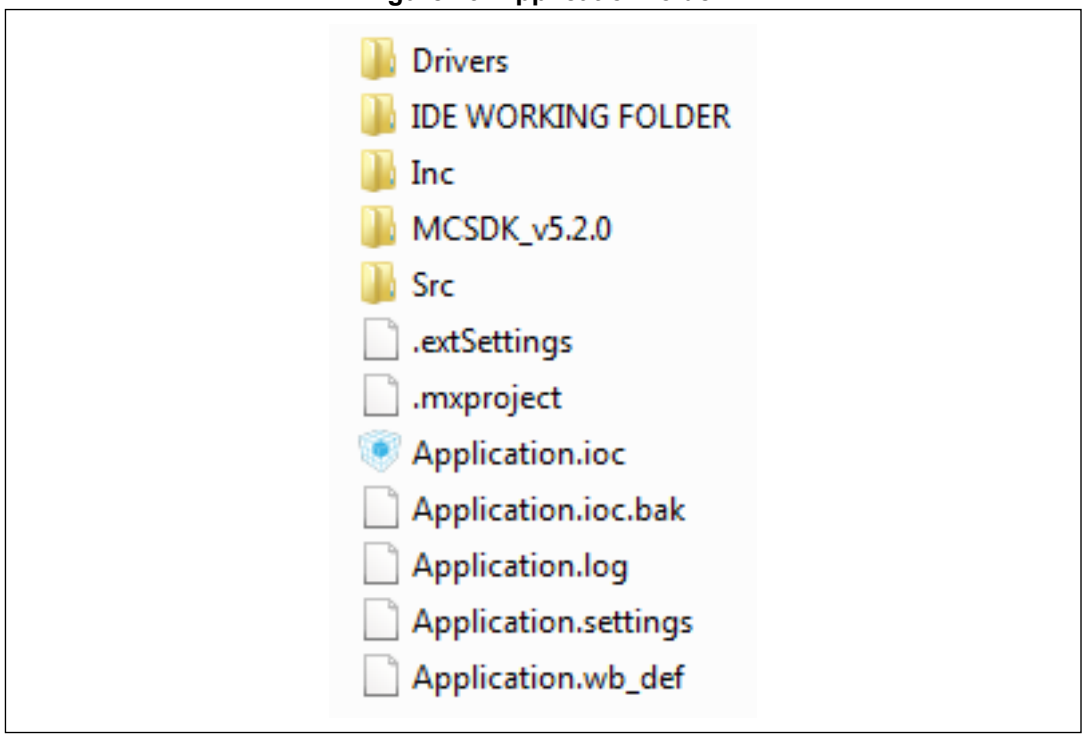
The STM32 motor control workbench generates, in the user folder, the directory 'Application' (*Figure 28*).

**Figure 28. User folder structure**




With the following subfolders:

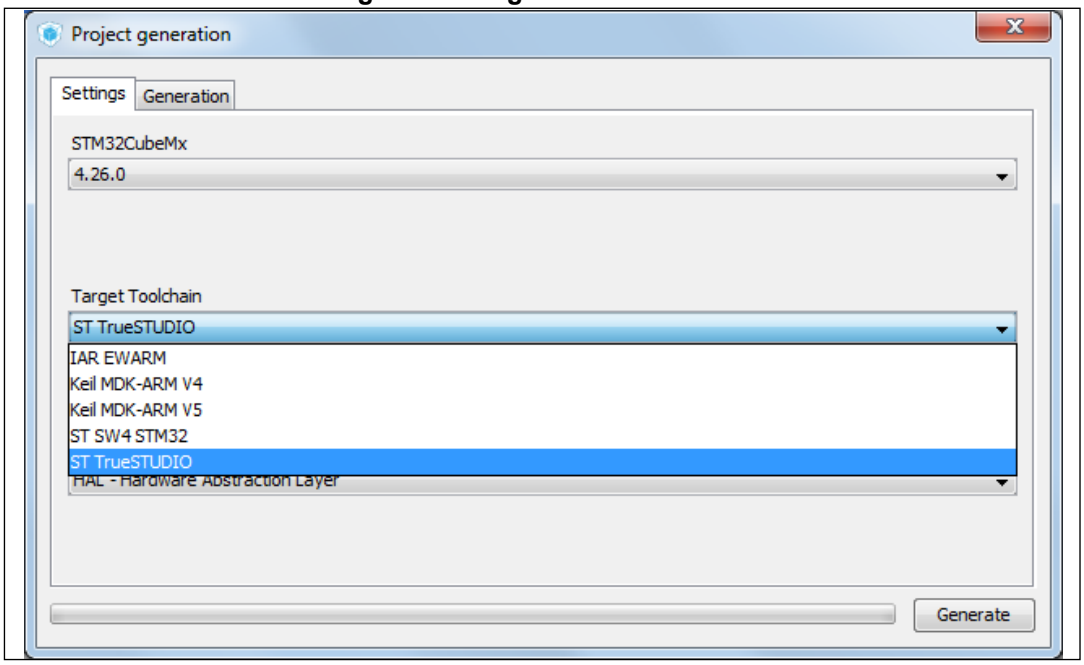
**Figure 29. Application folder**



Those folders contain:

- Drivers: the HAL driver library and the CMSIS files from ARM®;
- IDE WORKING FOLDER: this is the working folder of the IDE chosen in the Target Toolchain menu of the generation window (*Figure 30*);

**Figure 30. Target toolchain menu**




- Inc: application header files;
- MCSDK_v5.2.0: the files for FOC library (revision 5.2);
- Src: application source files;
- Application.ioc is a project file used by STM32CubeMX to generate the code.

*Note: Important : Do not use the STM32CubeMX project file to change configurations related to the STM32 PMSM FOC library (timers, DMA, interrupts, etc.). All the changes must be done through the STM32 motor control workbench only.*

- When the user changes the parameters of the project they should restart the steps of generating a new code.

The new 'Application' library is ready to be used by your preferred IDE.

## 3.2 Using STSW-SPIN3201

In association with the STEVAL-SPIN3201 evaluation board, the STSW-SPIN3201 firmware example allows to control a 3-phase permanent magnet motor with field-oriented control algorithms in sensorless operations. The STSW-SPIN3201 firmware is a customization of the STM32 PMSM FOC library, where the target speed is imposed through potentiometer and the motor is started/stopped using the USER1 button of the board. It is also possible to use the STM32 motor control workbench (GUI) to monitor and change in real time some of the variables of the algorithm and to initialize a new project according to the application needs.

To use STSW-SPIN3201 on the STEVAL-SPIN3201 board, refer to UM2152 available on www.st.com.

## 3.3 Compile and download the firmware

After the generation of the application code, the library is ready to be compiled and downloaded. To build and load a customized firmware, follow these steps:

- Supply the board correctly and connect it to the PC through the USB cable;
- Connect the motor;
- Run your preferred IDE;
- Load the project with your preferred IDE from the releted directory created by STM32 motor control workbench (for example “EWARM\Project.eww” if you are using IAR embedded workbench for the ARM toolchain);
- Compile and download the code;
- Start the execution of the code.

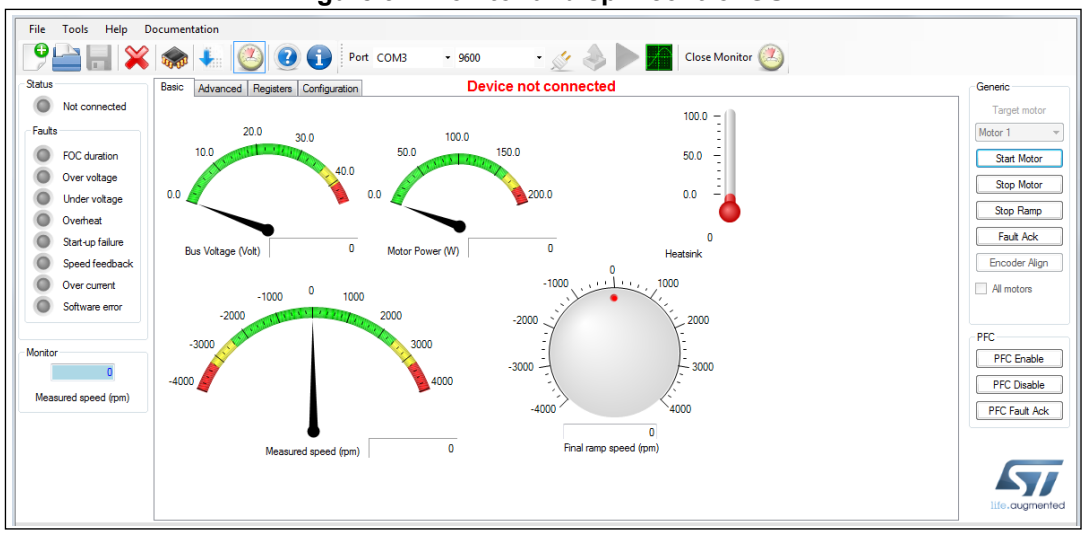
# 4 Control the motor

The user can now control the motor through the STM32 motor control workbench:

- Open STM32 motor control workbench
- Click on the “Open Monitor” icon:

to open the 'Monitor and spin control GUI' as shown in *Figure 31*.

**Figure 31. Monitor and spin control GUI**




- Connect the board by clicking the connection button:

To make this operation work, remember to use the correct Port number and the Baud rate configured during the setting of parameters (see *Figure 26*).

- Once the board is connected, use the control panel on the right of the control GUI:

**Figure 32. Control panel**


- Using the STM32 motor control workbench it is also possible to monitor the speed and change the variables of the algorithm in real time.

For details of the use of the STM32 motor control workbench v5, see UM2374 and UM2380 available on www.st.com.

# 5 Revision history

Table 8. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 14-Feb-2017 | 1 | Initial release. |
| 09-Mar-2017 | 2 | Updated note *1.* below *Table 7 on page 21* (replaced “A3” by “B7”). |
| 11-Apr-2018 | 3 | Updated *Section 3 on page 23*. |
| 17-Oct-2018 | 4 | Updated to Revision 5.2.0 of STM32 Motor Control SDK.<br>Added STSPIN32F0A. |