

STM32 motor control SDK v5.4 tools

Introduction

The STM32 motor control software development kit (MC SDK) is part of the STMicroelectronics motor-control ecosystem. 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) fieldoriented control (FOC)
- ST MC Workbench software tool, a graphical user interface for the configuration of the MC FOC 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 permanentmagnet synchronous motors within the STM32 ecosystem.

This user manual details the use of the software tools in STM32 motor control software development kit.



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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 $\text{Arm}^{\mathbb{B}(a)}$ Cortex[®] processor(s).

The ST MC workbench software tool provides an easy way to configure motor control application software matching hardware setup. The projects generated from this basis are compatible with the use of STM32CubeMX for further extension or modification of the application.

ST MC Workbench runs on a Windows[®] 7/10-based PC system equipped with a USB Type- A connector for connecting to the application board.

Refer to the STM32 MC SDK release note for all information about possible use of the ST MC Workbench software tool.

Note: ST MC Workbench provides contextual information tips when the cursor goes over parameters in the GUI window.1

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1.1 Definitions

Table 1 lists the 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)		
MP	Motor Profiler (STMicroelectronics software tool)		
OCP	Over-current protection		
PFC	Power factor correction		
PMSM	Permanent-magnet synchronous motor		
PWM	Pulse-width modulation		
SDK	Software development kit		

Table 1. List of acronyms

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



1.2 Reference documents

Arm[®] documents

The following documents are available from the http://infocenter.arm.com web page:

- Cortex[®]-M0 Technical Reference Manual
- Cortex[®]-M3 Technical Reference Manual
- Cortex[®]-M4 Technical Reference Manual

STMicroelectronics documents

The following documents are available from the *www.st.com* web page:

- STM32F0 Series product data sheets
- STM32F1 Series product data sheets
- STM32F3 Series product data sheets
- STM32F4 Series product data sheets
- STM32F7 Series product data sheets
- STM32L4 Series product data sheets
- STM32G0 Series product data sheets
- STM32G4 Series product data sheets
- X-NUCLEO-IHM expansion boards FOR motor control Selection guide on-line presentation



2 ST Motor Profiler

The ST Motor Profiler software tool is used to identify the motor's main PMSM characteristics, which are further transferred to the ST MC Workbench.

2.1 Launching the ST Motor Profiler

Launch the ST MC Workbench software tool either:

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

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

	S
	🔅 Settings
	ST Motor Control SDK 5.4.0 ^
	Motor Profiler 5.4.0 New
Meter Breifilar	MotorControl Workbench 5.4.0
305406b	Reference Manual 5.4.0
	Release Notes 5.4.0

Figure 1. ST Motor Profiler - Icon and location in the start program list

Open the ST Motor Profiler tool either by:

- using its dedicated button in the ST MC Workbench GUI, as illustrated in Figure 2, or
- running it directly from the installation folder tree, as illustrated in *Figure 1*.

Load Project	About	(2) Help	Motor Profiler
			Motion Control Suite 67.7777
Type MCUs	control board	power board motor	-
	Туре MCUs		Type MCUs control board power board motor

Figure 2. ST MC Workbench - GUI expanded top view



A GUI window is displayed by the ST Motor Profiler, as shown in *Figure 3*.

ST Motor Profiler	ed	
Motor Profiler Mation Control Suite	a	Pole Pairs: r how to detect Speed and Current limits Max Speed: 16000 Max Current: Apk 0.28 - 30 Apk VBus: V 8 - 400 V Magnetic: • SM-PMSM □ LPMSM
 ○ Connect > Start Profile ☆ Save ∞ Play 	Electrical Model	Mechanical Model

Figure 3. ST Motor Profiler - Startup GUI

2.2 Hardware setup configuration

Click on the *Select Boards* button (as shown in *Figure 3*) to display the list of supported boards, as illustrated in *Figure 4*. Select the used application board within this list.

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



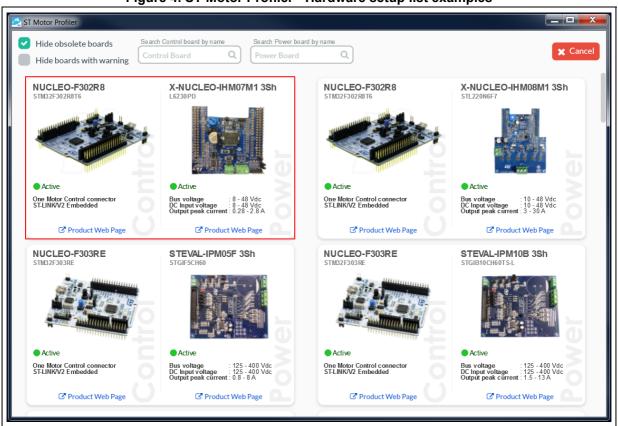


Figure 4. ST Motor Profiler - Hardware setup list examples

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 (mandatory field)
- The Max Speed (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, either the bus voltage for low voltage applications (DC voltage), or the RMS value for high voltage applications (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*)



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

Pole Pairs:	7 🎓 h	ow to detect
Speed and Cur	rent limits	
Max Speed:	16000 RPM	
Max Current:	2.8 Apk	0.28 - 2.8 Apk
VBus:	12 V	8 - 48 V
Magnetic: • S		MSM

Figure 5. ST Motor Profiler - SM-PMSM parameters example

Figure 6. ST Motor Profiler - I-PMSM parameters example

Pole Pairs: 7 re how to detect
Speed and Current limits
Max Speed: 16000 RPM
Max Current: 2.8 Apk 0.28 - 2.8 Apk
VBus: 12 V 8 - 48 V
Magnetic: OSM-PMSM • I-PMSM
Ld/Lq ratio: 0.05 0.001 - 10



2.3 Hardware setup connection

Once the ST Motor Profiler is configured, click on the Connect button, as shown in Figure 7.

ST Motor Profiler		
Motor Profiler Mation Control Suite STM32F302R8 T6 One Mator Control connector ST-LINK/V2 Embedded C Product Web Page Remember to properly configure the b	 X-NUCLEO-IHM07M1 3Sh L6230PD Bus Votage: 8 - 48 Vdc Output peak current: 0.28 - 2.8A Product Web Page oards in Motor Control mode 	Pole Pairs: 7 r how to detect Speed and Current limits Max Speed: 16000 RPM Max Current: 2.8 Apk 0.28 - 2.8 Apk VBus: -48 V 8 - 48 V Magnetic: • SM-PMSM 0.1PMSM
 Connect Start Profile Save Play 	Electrical Model	Mechanical Model

Figure 7. ST Motor Profiler - Configured GUI

Once the connection is requested, a status widows is displayed, as shown in *Figure 8*. Its content depends on the hardware setup history.

Figure 8. ST Motor Profiler - Download status window

T-Link	
ST-Link Connection ()	
Secutes a Full chip erase operation	
Load binary and Verifies programming operation	n
Reset	



If a problem is encountered, a troubleshot message window (among those listed in *Table 2*) is displayed to support recovery actions.

Message type	Information content	Action needed
Error	Connection error No Serial Ports Detected, verify if this board requires both connection, Serial and ST-Link. Ok	 Depending on the status window: 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.
Warning	Warning, Firmware upgrade required In order to proceed, I need to upgrade the firmware of the connected Control Board Upgrade Firmware Cancel	When the board is new or has been erased, the motor profiler FW is automatically loaded into the microcontroller by pressing the <i>Upgrade Firmware</i> button to confirm proper FW upload.
Warning	Warning, Device family board mismatch. Device family board mismatch. Found: STM32F301x4-x6-x8/F302x4-x6-x8/F318xx. Expected: STM32F302xE/F303xE/F398xx. Check if the connected board and selected one are the same. Ok	Acknowledge and return to the selection of the boards used in the hardware setup.
Faults	Faults ① Over voltage ● Under voltage ● Overheat ● Startup failure ● Speed feedback ● Over current ●	In case of over- or under-voltage detection, correct the bus voltage setting and its proper connection to the power board.

Table 2. ST Motor Profiler - Troubleshot message examples



Once the connection is successful, the *Start Profile* button is proposed in the GUI (see *Figure 9*).

ST Motor Profiler		
NUCLEO-F302R8 STM32F302R816	X-NUCLEO-IHM07M1 3Sh	Pole Pairs: 7 p how to detect Speed and Current limits 16000 RPM Max Speed: 16000 RPM Max Current: 2.8 Apk 0.28 - 2.8 Apk VBus: 48 V 8 - 48 V
Ore Motor Control connector STLINKV2 Embedded Product Web Page Remember to properly configure the b	Bus Voltage: 8 - 48 Vdc Output peak current: 0.28 - 2.8 A Product Web Page avoards in Motor Control mode Electrical Model	Magnetic: • SM-PMSM OLPMSM
Start Profile	V _{BUS} V _{BUS} V _{BUS} V _{Ke}	Friction Inertia Max Speed

Figure 9. ST Motor Profiler - Connected GUI



2.4 Motor profiling

Click on the *Start Profile* button proposed in the GUI as indicated in *Figure 9* to start motor profiling.

The profiling first identifies the electrical parameters, and then the mechanical ones. In case of over-current fault detection, the profiling is restarted with a reduced current.

When the profiling is successfully completed, all the motor measurements are shown in green or orange (depending on their relative accuracy), as illustrated in *Figure 10*. When one or more results are displayed in red, check the hardware setup and restart the motor profiling sequence.

🔁 ST Motor Profiler		
life.augmented		Profile successfully completed
NUCLEO-F302R8 STM32F302R8T6	X-NUCLEO-IHM07M1 3Sh L6230PD	Pole Pairs: 7 📂 how to detect
		Speed and Current limits Max Speed: 16000 RPM Max Current: 2.8 Apk 0.28 - 2.8 Apk
One Mator Control connector ST-LINK/V2 Embedded C Product Web Page C Remember to properly configure the	Bus Voltage: 8 - 48 Vdc Output peak current: 0.28 - 2.8 A C Product Web Page boards in Motor Control mode	VBus: 48 V Magnetic: • SM-PMSM • PMSM
Disconnect	Electrical Model	Mechanical Model
Start Profile	R _s 0.18 Ω L _s 0.01 mH 	Friction 529.51 n№m·s
🖺 Save	V _{BUS} +	
🕫 Play	12.75 V Imax 0 1.01 Apk Ke 0.85 Vrms/kRPM	Inertia Max Speed 353.18 nN·ms ² 15680 RPM
		0

Figure 10. ST Motor Profiler - Profiled motor GUI

2.5 **Profiled motor saving**

Click on the *Save* button (refer to *Figure 10*) to store the motor measurements for later use with the ST MC Workbench software tool. *Figure 11* shows the menu displayed in that case:

- Enter the name of the profiled motor, such as *BR2804-1700KV-1*
- Provide details about the profiled motor, such as 3-phase motor with 7 pole-pairs under 12 Vdc
- Eventually add details on the hardware setup used



			×
	Sa Sa	ave	

Figure 11. ST Motor Profiler - Save window

2.6 Motor spinning

Click on the Play button (refer to Figure 10) to spin the profiled motor.

Figure 12 shows the sequence of operations to operate the motor through the spin control window:

- 1. Preset the maximum acceleration
- 2. Click on the Start button to activate motor control
- 3. Adjust the *Speed* [*RPM*] slider with the cursor

Figure 12. ST Motor Profiler - Spin control window (Start)

Play with Motor	×
2 ■ Start Stop	
Maximum Acceleration 3000 RPM/s	
-15680 0 15680 Speed [RPM]	
Connected	



Figure 13 shows the two additional steps to stop the motor properly through the spin control window:

- 4. Click on the Stop button to stop activating motor control
- 5. Click on the Done button

Figure 13. ST Motor Profiler - Spin control window (Stop)

Play with Motor			×
Start Stop 4			Faults 0
Maximum Acceleration 300	00 RPM/s		Over voltage O° Under voltage O° Overheat O°
-15680 Speed [RPM]	0	15680 7940 RPM	Startup failure o Speed feedback o Over current o
Connected			5 × Done

2.7 Closing the ST Motor Profiler

Click on the *Disconnect* button (refer to *Figure 10*) to release the connection properly and close the ST Motor Profiler window by means of its upper-right icon. A confirmation window is displayed (see *Figure 14*).

Figure 14	ST Motor	Profiler -	Tool closure	confirmation	window
i iguic i t .				commuton	WIIIGOW

Please confirm			
Are you su	ire you want t	o close the a	application?
Anyunsav	ved data will l	oe lost.	
	Yes	No	

If the motor parameters have not been saved yet and need to be, proceed as follows:

- 1. Select the No button in the confirmation window
- 2. Click on the *Connect* button, as shown in *Figure* 7
- 3. Save the motor parameters, as detailed in Section 2.5

Clicking on the Yes button closes the ST Motor Profiler software tool, unsaved motor parameters being lost.

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3 The ST Motor Control Workbench

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 15*.

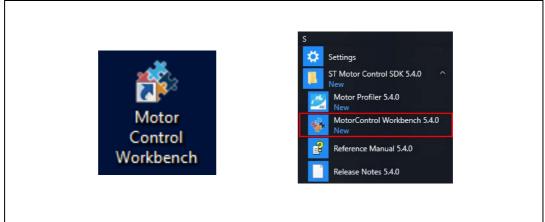


Figure 15. ST MC Workbench - Icon and location in the start program list

The ST MC Workbench GUI features three different areas (numbered boxes in *Figure 16*):

- 1. User-buttons: used to start a new project, to load a previous one, or to launch the ST Motor Profiler software tool
- 2. *Recent Project:* used to load a recent project
- 3. *Example Projects:* used to load a project example



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3.1 Creating a new project

Clicking on the *New Project* button (see *Figure 16*) displays the *New Project* window (see *Figure 17*) used for the definition of the hardware setup information through steps 1 to 4:

- 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* box and select the *Control 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



t					
Application type			System		
Custom	-		Single Motor	Dual Motors	
outom			Congre motor		
Select Boards: O Inverter	C MC Kit	Power & Control			
Control	Contro	ol board where the			
custom board		ol stage parameters ha			
		5 1			
Power					
custom board		r board where the r stage parameters h			
	power	stage parameters II			
Motor					
Motor Generic Low voltage <= 50V		Magnetic structure			
Generic Low voltage <= 50V Generic Low voltage <= 50V		Pole Pairs Nominal Speed	2 4000 rdm		
Generic Low voltage <= 50V Generic Low voltage <= 50V Generic High voltage > 50V		Pole Pairs Nominal Speed Nominal Voltage	2 4000 rdm 24 V		
Generic Low voltage <= 50V Generic Low voltage <= 50V Generic High voltage > 50V Shinano LA052-080E3NL1	.	Pole Pairs Nominal Speed	2 4000 rdm		
Generic Low voltage <= 50V Generic Low voltage <= 50V Generic High voltage > 50V Shinano LA052-080E3NL1 Bull Running BR2804-1700kv		Pole Pairs Nominal Speed Nominal Voltage	2 4000 rdm 24 V		
Generic Low voltage <= 50V Generic Low voltage <= 50V Generic High voltage > 50V Shinano LA52-080E3NL1 Bull Running BR2804-1700kv Allen Bradley TL-A220P-HJ32AN		Pole Pairs Nominal Speed Nominal Voltage	2 4000 rdm 24 V		
Generic Low voltage <= 50V Generic High voltage > 50V Shinano LA052-080E3NL1 Bull Running BR2804-1700kv		Pole Pairs Nominal Speed Nominal Voltage	2 4000 rdm 24 V		
Generic Low voltage <= 50V Generic Low voltage <= 50V Generic High voltage > 50V Shinano LA052-080E3NL 1 Bull Running BR2804-1700kv Allen Bradley TL-A220P-HJ32AN 3-phase Motor BR2804		Pole Pairs Nominal Speed Nominal Voltage Nominal Current	2 4000 rdm 24 V		
Generic Low voltage <= 50V Generic Low voltage <= 50V Generic High voltage > 50V Shinano LA052-080E3NL 1 Bull Running BR2804-1700kv Allen Bradley TL-A220P-HJ32AN 3-phase Motor BR2804		Pole Pairs Nominal Speed Nominal Voltage Nominal Current	2 4000 rdm 24 V		
Generic Low voltage <= 50V Generic Low voltage <= 50V Generic High voltage > 50V Shinano LA052-080E3NL 1 Bull Running BR2804-1700kv Allen Bradley TL-A220P-HJ32AN 3-phase Motor BR2804		Pole Pairs Nominal Speed Nominal Voltage Nominal Current	2 4000 rdm 24 V		
Generic Low voltage <= 50V Generic Low voltage <= 50V Generic High voltage > 50V Shinano LA052-080E3NL 1 Bull Running BR2804-1700kv Allen Bradley TL-A220P-HJ32AN 3-phase Motor BR2804		Pole Pairs Nominal Speed Nominal Voltage Nominal Current	2 4000 rdm 24 V		
Generic Low voltage <= 50V Generic Low voltage <= 50V Generic High voltage > 50V Shinano LA052-080E3NL1 Bull Running BR2804-1700kv Allen Bradley TL-A220P-HJ32AN 3-phase Motor BR2804		Pole Pairs Nominal Speed Nominal Voltage Nominal Current	2 4000 rdm 24 V	OK	Ca

Figure 17. ST MC Workbench - New Project window

The created project imports the hardware settings according to the selected boards and motor profiling results. It also imports other settings like the PWM frequency and the startup acceleration used during motor profiling.



After a few seconds, a *New Project Info* window is displayed where the motor operating conditions can be checked, as shown in *Figure 18*.

Figure 18. ST	MC Workbench -	- New Pro	ject Info window
---------------	----------------	-----------	------------------

Start up parameter:			
start up parameters	5	PWM Frequency:	30000 Hz
Nominal Current:	1.1 Apk	FOC Rate:	1 PWM periods
Nominal Voltage:	12.1 V	Cut off Frequency:	6000 rad/s

Clicking on the OK button opens the same GUI (as if loading an existing project), as detailed in *Section 3.2*.

3.2 Loading an existing project

Clicking on the *Load Project* button (see *Figure 16*) displays the hardware configuration window used for the tuning of hardware setup information, shown in *Figure 19*:

- Icons and Menu: used for the control of all project settings such as project workspace directory, used IDE, and others
- Hardware details setting buttons: used to fine tune the functionalities of the selected hardware, such as motor parameters or sensor use
- Main hardware settings: view of the main parameters at a glance
- User information: feedback about user actions on project settings. As an example, it can inform the user that a new project has been created, but not yet saved
- Hardware setup information: informs the user about overall hardware part settings



ST Motor Control Work	kbench [P-NUCLEO-IHM001-B	BullRunning]*		_			
File Tools Help	Documentation						
🔋 🖿 🖶 🗙	🕻 🌧 🐛 🕘 🤇	9 🕤 🖣	- 1	cons and M	enu area		
Motor: Bull Running B.	1700kv - Contro	ol Board: P-A	IUCLEO)-IHM001 3Si	h - board	t: NUCI	EO-F302R8 - Power Board: P-NUCLEO-IHM001 3Sh - board: X-NUCLEO-IHM07M1
Hardware setup information	AC Input Inrush Cur Limiter	rent	*	PFC			Bus Votage Sensing 5-36) V Dispative Brake
	Clock			Input	User Interfac	Drive Phase Phase Phase	
Main hardware setti Variable PWM frequency	Motor 30000	Unit Hz	Us	er informati Time 03:20:55	ion Motor	ld	Message The 1/LCP is not supported in the FW for SDK5x. All parameters will be disabled.
Sensor selection main Sensor selection aux Forque&Flux - Execution rate		PWM periods	0 0	03:20:55 03:20:55 03:20:55			The 'PFC' is not supported in the FW for SDKSx excepted for SDK for 'STM32F103 High Density'. All parameters will be disa The 'Sensor-less (HFI-Observer)' is not supported in the FW for SDKSx. All parameters will be disabled. F2mcus are not supported in the FW for SDKS.
	true		6	03:20:55			F103 High Density in dual Motor mcus are not supported in the FW for SDK5x
Bus voltage sensing Over-voltage Under-voltage Femperature sensing	true true true		Ŭ				The new project P-NUCLEO-IHM001-BullRunning (to be saved) has been created as copy of the example project P-NUCLE

Figure 19. ST MC Workbench - Hardware configuration window (global view)

The following sections provide detailed informations about the areas shown in *Figure 19*:

- Section 3.3: Icons and Menu area
- Section 3.4: Configuring a project
- Section 3.5: Main hardware settings
- Section 3.6: User information

3.3 Icons and Menu area

The Icons and Menu area is used for the control of project settings through several menus, described in this section:

- File menu on page 26
- Tools menu on page 28
- Help menu on page 33
- Documentation menu on page 34

Shortcuts exist through usage of icon buttons, as summarized in Table 3.





Function	lcon	Description
Create a new project	+	Create a new project, as shown in <i>Figure 17</i>
Load an existing project	4	Load and open an existing project, as shown in <i>Figure 19</i>
Save the current project		Save the current project settings
Clear the log	×	Clear the user information sheet, as shown in <i>Figure 34</i>
Pins assignment	a se	Check the pin assignment of the MCU as well as the pins left available, as shown in <i>Figure 27</i>
Generate or Update the project		Open the GUI to Generate or to Update the MC application project files for the selected IDE, as shown in <i>Figure 33</i>
Open Monitor		Monitor and spin the motor, as shown in <i>Figure 33</i>
Help	2	Open the on-line help file
About	i	Check the ST MC Workbench software tool version, as shown in <i>Figure</i> 37

Table 3. ST MC Workbench – Menu icons



3.3.1 File menu

Figure 20 shows the *File* menu of the hardware configuration window.

Figure 20.	ST MC	Workbench	- File menu
1 19010 201	0.1.11.0		<i>i iio</i> iiioiia

🕑 Ne	Tools Help Documer ew Project ben Project	ntation	0	
□ Sav☑ Sav□ Pro□ Red	ve Project ve Project As operties cent List	700kv - Control AC Input Inrush Cu Limite	rent	001 35 7885- PFC
	L	TTS:	Control Unit STM32F302R8	

This menu allows the user to:

- Create a new project, as shown in *Figure 17*
- Open an existing project, as shown in *Figure 19*
- Close the current project.
 If the project is not saved yet, a confirmation window is displayed asking for one of three possible answers, as shown in *Figure 21*:
 - Yes: the current project is saved
 - No: the current project is not saved and its settings are lost
 - Cancel: returns to the hardware configuration window shown in Figure 19
- Save the current project settings.
 If the project is not saved yet, a file manager window is displayed asking to save the current project settings as a new project, as shown in *Figure 22*
- Save the project settings as a new project.
 A file manager window is displayed asking to save the current project settings as a new project, as shown in *Figure 22*
- View the project properties.
 A window is displayed with some project informations, as shown in *Figure 23*
- Load an existing project from the recent-project list.
 If the current project is not saved yet, a confirmation window is displayed asking to delete it from the recent project list, as shown in *Figure 24*
- Delete the recent project list, after user confirmation, as shown in Figure 25
- Exit from the hardware configuration window. If the project is not saved yet, a confirmation window is displayed asking for one of three possible answers, as shown in *Figure 21*:
 - Yes: the current project is saved
 - No: the current project is not saved and its settings are lost
 - Cancel: returns to the hardware configuration window shown in Figure 19



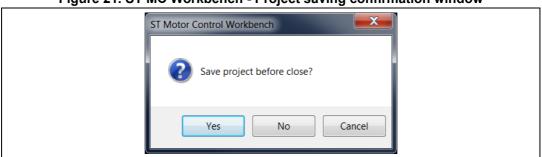


Figure 21. ST MC Workbench - Project saving confirmation window



🐝 ST Motor Control Workbench - Save as				
G → L → Computer → OSDisk (C:) →	WorkSpace + SDK5.0.0 +	▼ 4	Search SDK5.0.0	Q
Organize 🔻 New folder				0
•	Name	Date modified	Туре	Size
Libraries Documents	🗼 Euro2017 - Example	2/6/2018 4:45 PM	File folder	
🧈 Git				
Jusic				
S Pictures				
S videos				
i Computer				
🧆 OSDisk (C:)	٠	11		•
File name: SDK50x-P-NUCLEO-IHM	001-BullRunning.stmcx			-
Save as type: ST Workbench (*.stmcx)				-
Hide Folders			Save	ancel

Figure 23. ST MC Workbench - Project Properties window

oject Properties	<u></u>	
Property	Value	
Name	P-NUCLEO-IHM001-BullRunning	
Output path	C:\Users\frq02635\Documents\My WorkingArea\MCD\Customers Support\Tickets & DB\Bu	
Section	PMSM	
Туре	SINGLE	
		_
	ОК	



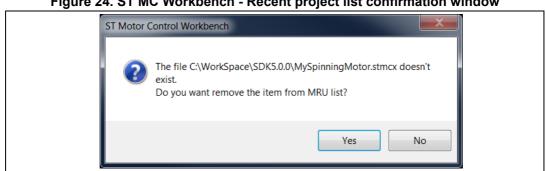
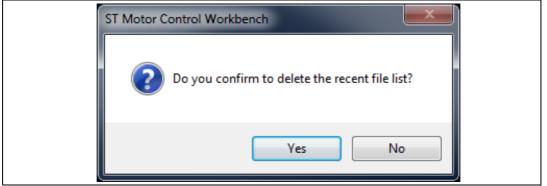


Figure 24. ST MC Workbench - Recent project list confirmation window





3.3.2 **Tools menu**

Figure 26 shows the Tools menu of the hardware configuration window.

Figure 26. ST MC Workbench - Tools menu

ST Motor Control Workbench [P-NU File Tools Help Documentation Pin assignment Generation Moto Clear Log Export Log Store Info Message	21
	Control Unit STM32F302R8

This menu allows the user to:

- Check the pin assignment of the MCU as well as the pins left available, as shown in *Figure 27*:
 - Click on the *Check* button to control the coherency of the pin assignment. A reporting window is displayed, see *Figure 28*. Use the *OK* button to close it.
 - Click on the *Reset* button to restore the default pin assignment of the STMicroelectronics board. A confirmation window is displayed, see *Figure 29*.
 Click on the Yes or *No* button to confirm or invalidate the action.
 - Close the window (upper-right click) to cancel the pin assignment action.
- Generate the MC application project files for the selected IDE:
 - If the current project is not saved yet, a file manager window is displayed asking to save the current project settings as a new project, as shown in *Figure 22*. Canceling this action, displays an information window indicating that the project needs to be saved before generating any files. Use the *OK* button to close it, as shown in *Figure 30*.
 - If the current project is saved, a project settings window is displayed to select the STM32CubeMx version usage (if several ones are installed) and to select the IDE toolchain (note that HAL/LL driver selection is not used in this current MC Workbench version).
 - Click on the Generate button to create the *.ioc file; or click on the Update button to update only the MC firmware configuration inside an existing *.ioc file (i.e. useful to keep additional modifications from the STM32CubeMX usage). Note that any physical hardware modification linked to motor control (e.g. MC pin assignment) is not taking into account using this Update button, this means that the MC project have to generate again in that case.
 - Then, the Generation tab is activated to inform about the used version configuration, and to show the IDE toolchain generation log (see *Figure 31*) while the user information sheet is updated (see *Figure 32*). When completed, the user has to manually close the progression window.
- Monitor and spin the motor, as shown in *Figure 33*. Refer to Section 3.7 for details.
- Clear the user information sheet, as shown in *Figure 34*.
- Export the user information sheet in a log file in text format and open it in a text editor, as shown in *Figure 35*.
- Show user information messages when necessary.



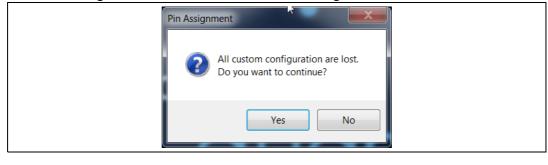
Assignment			
Function	Port/Pin	Available Shared	
Motor Control	Timer (TIM1)		
CH1	A8	C0. A8	
CH2	A9	C1, A9	
CH3	A10	C2, A10	
BKIN	A11	C3, A11	
Start/Stop butte	on Pin (DIO -	BTN)	
GPIO	C13	C13	
Driver Signal Er	nable (DIO - I	MCT - Enb)	
GPIO	C10	C10	
GPIO	C11	C11	
GPIO	C12	C12	
USART Channel	(USART2) —		
TX	A2	A2, A14, B3	
RX	A3	A3, A15, B4	
Phase current fe	eedback ADC	(ADC1)	
ADC1_IN1	A0	A0	
ADC1_IN7	C1	C1	
ADC1_IN6	C0	C0	
Bus Voltage fee	edback ADC (ADC1)	
ADC1_IN2	A1	A1	
Temperature fe	edback ADC	(ADC1)	
ADC1_IN8	C2	C2	
– DAC (Debug) –			
CH1	A4	A4	
GIII	At	At	
Conflicts:			
- functions: 0 - pins: 0			
Press check butto	on for more inf	ormation	
Check	Reset		

Figure 27. ST MC Workbench - *Pin Assignment* window

Figure 28. ST MC Workbench - *Pin Assignment* check window



Figure 29. ST MC Workbench - Pin Assignment reset window



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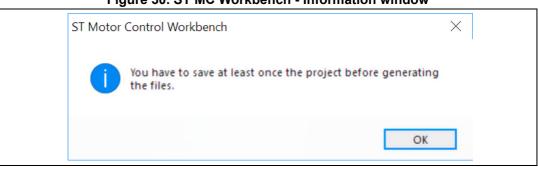


Figure 30. ST MC Workbench - Information window



Project generation	8	_ 🗆 ×
SETTINGS		
STM32CubeMX 5.2.0	Version info: MC Workbench : 5.4.0.19215 WB_to_Mx : 1.0.2.template-19-05-15	
Target Toolchain IAR EWARM V8	STM32CubeMM : 5.2.0 MC Firmware Library: 5.4.0-Full Generation options: Target Toolchain : IAR EWARM V0 Target Driver : HAL - Hardware Abstraction Layer Target STM32 FW : 1.10.0	
Firmware Package Version STM32 FW V1.10.0 (Recommended)	Generating C:\WorkSpace\Motor Tests\P-NUCLEO-IHM001-BullRunning\ \P-NUCLEO-IHM001-BullRunning.ioc \.extSettings Code generation started	
Selecting `not installed` firmware or `Latest` will require internet connection		
Drive Type HAL - Hardware Abstraction Layer LL - Low Level		
O LL - LOW LEVEL	OPEN FOLDER RUN STM32CubeMX C	ANCEL

Figure 32. ST MC Workbench - User information sheet example

	Time	Motor	ld	Message	
	02:51:37			Project: 'SDK50x-P-NUCLEO-IHM001-BullRunning' saved successfully.	
	02:51:37			Generation files starting	
	02:51:37			Create the output folder C:\WorkSpace\SDK5.0.0\SDK50x-P-NUCLEO-IHM001-BullRunning	
	02:52:19			File generated on folder: 'C:\WorkSpace\SDK5.0.0\SDK50x-P-NUCLEO-IHM001-BullRunning'	
- /	Errors / War	ninga Ch	ango I		

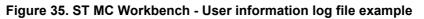


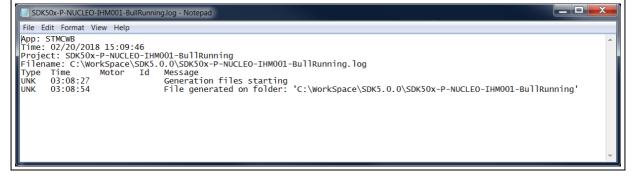
		Figui	e 55. 51 W		IN	dench - Monitor Window	
🐝 ST Motor Control Workt	ench (SDK50x-P-NUCLEO-	IHM001-BullRunnin	9]				
File Tools Help D	ocumentation						
90	🐟 🖡 🙆 🎈	. ? 1	Port COM3 - 1	15200	- 1	🕐 🌛 🕨 📶 Close Monitor 🙆	
Status	Basic Advanced Regist	ters Configuration	De	/ice not co	nne	cted	Generic
Not connected Faults FOC duration Over votage Ver votage Ver votage Ver votage Ver votage Ver votage Ver votage Startup falure Speed feedback Ver ourent Montor Measured speed (pm)	Lesic avances regis	0 25.0 30.0	100.0 50.0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	150.0 200.0 -5000 -10000		100.0 - 50.0 - 0.0 - Heatsink 10000 - 15000	
Sensor selection aux Torque&Flux - Execution rate Bus voltage sensing Over-voltage Under-voltage	Motor 30000 Senandress (Observer+PLL) Senandress (Observer-Cordic Inue Inue Inue Inue	Unit Hz PWM periods	0 Time	Motor k		4998 ramp speed (pm) Message	Life.ougmented
	true Three Shunt Resistors			a 1			
- 1 27			Info / Errors / Warning	s criarige Log			

Figure 33. ST MC Workbench - Monitor window

Figure 34. ST MC Workbench - User information sheet cleared

Time	Motor	ld	Message	
Errors / Warr	inge Ch	angel		





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3.3.3 Help menu

Figure 36 shows the Help menu of the hardware configuration window.

	Figure 36	. ST MC	Workbench	- Help	menu
--	-----------	---------	-----------	--------	------

ST Motor Control Workbench [P-NUCLEO-IHM001-BullRunning]* File Tools Help Documentation Content Content About Content
Motor: Bull R ST Community Control Board: P-NUCLEO-IHM001 3S
Control Unit

This menu allows the user to:

- Have easy access to this user manual
- Check the ST MC Workbench software tool version. Select the *About...* menu to prompt the software tool version window, and click on the *OK* button to quit this window, as shown in *Figure 37*.
- Gain direct access to the ST community website



About ST Motor Control W	/orkbench	Х
	ST Motor Control Workbench Ver. 5.4.0 19180 Copyright © STMicroelectronics 2019 <u>online support</u>	
.	MCSDK_v5.4.0-Full WB_to_Mk version "1.0.2" WB_to_Mk template version "19-05-10" [Device] Device not connected [Modules] MM[Calc DLL - Version 1.0.4.0 Basic Motor Control Serial Protocolo Library - Version 3.3.0.0 TL_003 Frame Transport Layer - Version 1.0,0,0	~
life.augmented	This software is provided under the acceptance of the license agreement. By using the Licensed Software, You are agreeing to be bound by the terms and conditions of this Agreement. Do not use the Licensed Software until You have read and agreed to all terms and conditions. <u>View the End-User License Agreement</u>	



3.3.4 Documentation menu

Figure 38 shows the *Documentation* menu of the hardware configuration window.

Figure 38. ST MC Workbench - Documentation menu

This menu allows the user to:

- Direct access to the ST MC SDK webpage
- Have access to the STM32 MC SDK documents in pdf format
- Open the on-line STM32 MC Firmware Reference document
- Read the STM32 MC SDK package Release Note

3.4 Configuring a project

Depending on MC application software needs, MC FOC firmware is set according to the hardware part used. The following functionalities are detailed in this section:

- Motor on page 34
- Power stage on page 39
- Drive management on page 50
- Control stage on page 63

3.4.1 Motor

Figure 39 shows the *Motor* window used for motor configuration. The user has to click on the motor or on the sensor to pop-up the GUI for parameter settings:

- the motor parameter GUI is shown in Figure 40
- the sensors GUI is shown in Figure 42



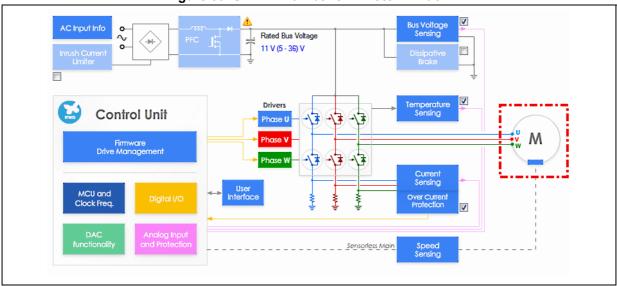


Figure 39. ST MC Workbench - Motor window

The PMSM motor parameters are imported from the ST Motor Profiler tool (refer to Section 2) or entered manually, as shown in *Figure 40*.



Figure	40. ST MC Workbench	- Motor paran	neter GUI (Surfac	e Mounted PN	ISM)
Motor -	Parameters				
Motor	Sensors				
Mag	gnetic structure	Surface Mo	unted PMSM \sim		
Elect	trical parameters				
	Pole Pairs	7	÷		
1	Max. Application Speed	15000	∲ mm		
1	Nominal Current	1.20	🜩 Apk		
1	Nominal DC Voltage	12.0	÷ ∨		
1	Rs	0.11	🔶 Ohm		
1	Ls	0.018	🖨 mH		
1	B-Emf constant	0.4	Vms/krpm		
	Save parameters			Dura	
			L	Done	





Ма	gnetic structure	Internal PN	ISM ~	
Elec	trical parameters			
	Pole Pairs	7	÷	
	Max. Application Speed	15000	🜩 m	
	Nominal Current	1.20	🜩 Apk	
	Nominal DC Voltage	12.0	↓ V	
	Rs	0.11	🚖 Ohm	
	Ld	0.018	t≑ mH	
	Lq	0.018	t mH	
	Ld/Lq ratio	1.000		
	B-Emf constant	0.4	+ Vms/krpm	

Figure 41. ST MC Workbench - Motor parameter GUI (Internal PMSM)



	Figure 42. ST MC Workbenc	h - Sensor pa	arameter GUI	
Motor -	Parameters			
Motor	Sensors			
Sens	sors			
	Hall sensors			
	Sensors displacement	120 ~	deg	
	Placement electrical angle	300 🖨	deg	
	Quadrature encoder			
	Pulses per mechanical revolution	400 🜲		
	Sauce			
	Save parameters		Done	

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Click on the Save parameters buttons (refer to Figure 40 and Figure 42) to reuse the parameters in a following new project. The save motor parameter window asks for a name and a short description of the set parameter, as shown Figure 43.



Figure 43.	ST MC Workbench - Save motor parameter window
	Save Motor
	Name Bull Runner
	Description Doc example
	OK Cancel

Figure 43. ST MC Workbench - Save motor parameter window

3.4.2 Power stage

Figure 44 shows the *Power Stage* window used for power stage configuration through several GUIs for parameter settings:

- AC voltage input information (refer to *Figure 45*)
- DC bus voltage input (refer to *Figure 46*), and sensing information (when supported; refer to *Figure 47*)
- Temperature sensing use (when supported; refer to *Figure 48*)
- Current sensing use (refer to Figure 49 and Figure 50)
- Over-current protection setup (when supported; refer to Figure 51)
- Power drivers setup (x3; refer to *Figure 52*)
- Power switches setup (x6; refer to *Figure 53*)
- Brake use (when supported; refer to *Figure 54*)
- Inrush Current Limiter feature (when supported; refer to *Figure 55*)
- Power Factor Correction feature (when supported; refer to *Figure 56*)



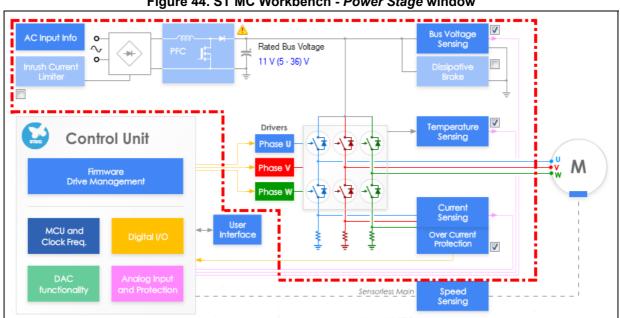


Figure 44. ST MC Workbench - Power Stage window

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Figure 45 shows the *AC Input Info* GUI where the user applies the pre-defined AC voltage range or customizes it according to the hardware setup. In addition, an input over-voltage protection is set by default to the maximum AC voltage. To modify it, uncheck the box and enter the desired threshold value.

	Hardware Settings	
Voltage	230 V - 50Hz 🛛 🗸	
Minimum	185 🜩 Vms	50 Hz
Maximum	265 🔶 Vms	🔵 60 Hz
Nominal	230 🜩 Vms	
	Firmware protection	
Over-voltage	Firmware protection	
Over-voltage ✓ Set intervention th	Firmware protection	
	•	

Figure 45. ST MC Workbench - AC Input Info GUI

Figure 46 shows the *Rated Bus Voltage Info* GUI where the user configures the DC bus voltage input range (minimum and maximum rated values), as well as the nominal voltage.

Figure 46. ST MC Workbench - Rated Bus Voltage Info GUI

Rated Voltage Min rated voltage 5 Max rated voltage 36 V Nominal voltage 11	Min rated voltage 5 V Max rated voltage 36 V
Max rated voltage 36 V	Max rated voltage 36 V Nominal voltage 11 V
	Nominal voltage
Nominal voltage 11 V	
	Done



The sensing implementation topology and related values can then be defined, as shown in *Figure 47*. The inverse value of the DC bus voltage divider is automatically computed.

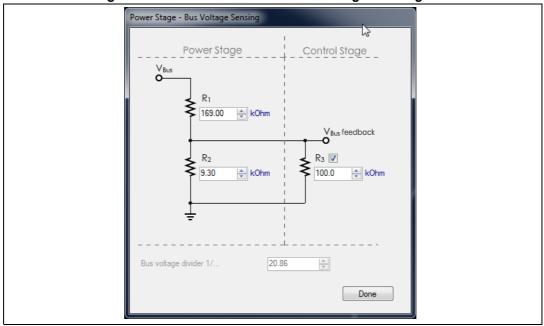


Figure 47. ST MC Workbench - Bus Voltage Sensing GUI



Figure 48 shows the *Temperature Sensing* GUI where the user configures the temperature sensing range as a function of the hardware setup. In addition, an input over-temperature protection is set by default to the maximum working temperature. To modify it, uncheck the box and enter the desired threshold value. The hysteresis value can be updated as well by the user.

mperature Sensing	
Hardwa	re Settings
Temperature sensing - V0	1055 🔿 mV
Temperature sensing - T0	25.0 🚖 ℃
ΔV/ΔT	22.7 🚔 mV/℃
Max working temperature on sensor	110 🚔 °C
☑ Enable	protection
Over-Temperature Set intervention threshold to power	er stage max working temperature
Over-temperature threshold Hysteresis	110 ▲ °C 10 ▲ °C
	Done

Figure 48. ST MC Workbench - Temperature Sensing GUI



Figure 49 shows the *Current Sensing* GUI where the user selects the current sensing topology, and defines the conditioning method. Clicking on the *Calculate* button displays the *Current Sensing Gain Calculator* GUI, which is useful for setting the amplifying network gain value.

Power Stage - Current Sensing	
Current sensor and signal condition	ning
Current reading topology	Three Shunt Resistors $$
ICS gain	1.000 × V/A
Shunt resistor(s) value	0.3300 • ohm
Amplification on board	
Amplifying network gain	1.53 Calculate
T-rise	700 🛋 ns
T-noise	700 🗭 ns
Max Readble Current:	3.268 A
	Done

Figure 49. ST MC Workbench - Current Sensing GUI

Figure 50 shows the *Amplifying Network Gain Calculator* GUI where the user configures the sensing implementation topology and related values.



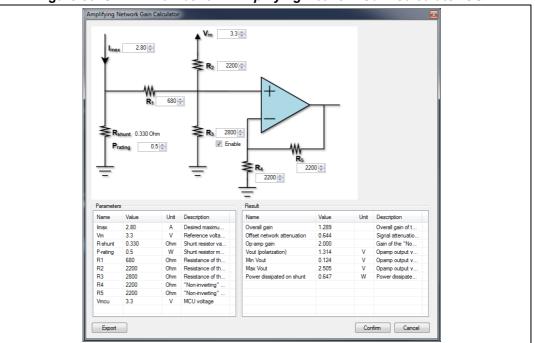


Figure 50. ST MC Workbench - Amplifying Network Gain Calculator GUI

Note: All the needed firmware values are automatically computed.

Click on the Export button to save the configuration and generate an HTML page with the implementation and the computation reported. Click on the *Confirm* button to save the configuration. Click on the *Cancel* button to invalidate the modification. Both buttons close the window.

Figure 51 shows the *Over Current Protection* GUI, where the user configures the external over-current protection comparator settings. It illustrates the selection of the trigger input signal polarity from the related drop-down box. This value is also known as the over-current feedback signal polarity.

Depending on MC application software needs, the user can decide to use an output pin to disable this external OCP mechanism. In this case, the *Over-current protection disabling network* checkbox must be checked and the active signal polarity set.

If the internal comparator is used, refer to *Control stage*.



Power Stage - Over Current Protection	
Over Current Protection	
Comparator threshold	0.50 🗘 V
Over current network gain	0.1800 🔷 V/A
Expected over-current threshold	2.7778 A
Over-current feedback signal polarity	Active low ~
	ALLIVE IOW •
	More >>
	Done
Power Stage - Over Current Protection	
Over Current Protection	
Comparator threshold	0.50 🗢 V
Over current network offset	0.00 🗢 V
Our construction of the second	
Over current network gain	0.1800 V/A
Expected over-current threshold	2.7778 A
Over-current feedback signal polarity	Active low \sim
Over-current protection disabling network	k
Over-current protection disabling network po	olarity Active high \vee
	<< Less
	Done

Figure 51. ST MC Workbench - Over Current Protection GUI



Figure 52 shows the *Power drivers* GUI where the user parameterizes each power driver (one per motor phase) with its high- and low-side values.

	Active low Low side driving signal Complemented from high side Polarity HW inserted dead time 800 * ns Driver enabling signal signal signal Polarity Active high Force same values for U,V,W Driver	ligh side driving signal		
Low side driving signal Complemented from high side Polarity Active high Winserted dead time 800 N ns Driver enabling signal signal Polarity Active high V Force same values for U,V,W Driver	Low side driving signal Complemented from high side Polarity Active high HW inserted dead time 800 Driver enabling signal signal V Polarity Active high	Polarity	Active low	
Polarity Active high HW inserted dead time 800 * ns Driver enabling signal * ns signal * Polarity Active high * * Construction	Polarity Active high HW inserted dead time 800 (*) ns Driver enabling signal * signal Ø Polarity Active high Ø * Force same values for U,V,W Driver *	ow side driving signal	Active high	
HW inserted dead time 800 🐑 ns Driver enabling signal Image: Comparison of the system of the syste	HW inserted dead time 800 👘 ns Driver enabling signal Image: Comparison of the signal signal Image: Comparison of the signal Polarity Active high Image: Force same values for U,V,W Driver	Complemented from high side		
Driver enabling signal signal Polarity Active high Image: Source same values for U,V,W Driver	Driver enabling signal signal Polarity Active high Image: Specific System	Polarity	Active high 🔻	
signal Polarity Active high Force same values for U,V,W Driver	signal Polarity Active high Force same values for U,V,W Driver	HW inserted dead time	800 🛋 ns	
Polarity Active high Polarity Active high Image: The same values for U,V,W Driver The same values for U,V,W Driver	Polarity Active high Polarity Force same values for U,V,W Driver)river enabling signal		
☑ Force same values for U,V,W Driver	☑ Force same values for U,V,W Driver	signal		
		Polarity	Active high	
		Force same values for U,V,W Driv	er	
				Done

Figure 52. ST MC Workbench - Power drivers GUI

Note: The user can easily force the same settings for all three power drivers by ticking the "Force same values for U, V, W Driver" checkbox.

When the low-side driver is not hardware driven and complemented from the high side, the HW inserted dead-time definition is useless. Otherwise, the dead-time must reflect the implemented hardware electrical characteristics.

Select the *Share signal enable* checkbox to save the two other remaining Low side driver enabling pins (refer to *Control stage*).

Figure 53 shows the *Power Switches* GUI where the user configures the six power switches according to their electrical characteristics.

Power Stage - Power Switches			l
Min dead-time Max switching frequency	β00 ♀ ns 50 ↓ kHz		
		Done	

Figure 53. ST MC Workbench - Power Switches GUI



Figure 54 shows the *Dissipative Brake* GUI where the user selects the active signal polarity used for the braking usage.

Power Stage - Dissipative	: Brake	
Polarity	Active high ▼ Active low Active high	Done

Figure 54. ST MC Workbench - Dissipative Brake GUI

Figure 55 shows the *Inrush Current Limiter* GUI where the user selects the active signal polarity used for the Inrush Current Limiter. This GUI offers the possibility to configure the activation startup if needed.

Inrush Current Limiter	
Har	rdware Settings
Polarity	Active high \sim
Addit	ional Features
🗹 enable	
Power on state	Inactive \vee
Change state after	1000 🜩 ms
	Done

Figure 55. ST MC Workbench - Inrush Current Limiter GUI



Figure 56 shows the *Power Factor Correction* GUI where the user reflects hardware settings and defines the PFC firmware parameters.

Figure 56.	ST MC Workbench	Power Factor Correction	GUI (Hardware Settings)
	•••••••••••••••••••••••••••••••••••••••		

Hardware Settings PFC Parameters					
	Hardware Settings				
Nominal power	1000 🗢 W				
Nominal current	6.149 🖨 Apk				
Shunt resistor value	0.017 🚖 ohm				
OPAMP on power stage					
use OPAMP for Current Protection	n				
Comparator threshold	2.90 V				
Overall network gain	11.00				
Expected Over Current threshold	15.508 🜩 Apk				
Max. power transistor current	35.000 🗢 Apk				
AC voltage sensing divider 1/	116 🔹				
Ton propagation delay	2550 🗢 ns				
Toff propagation delay	2550 🔹 ns				
Driving signal polarity	Active low \checkmark				
Overcurrent signal polarity	Active low \checkmark				
AC Mains synch signal polarity	Falling edge V				



ardware Settings PFC Parameters			
	PF	C Parameter	S
Enabling feature			
Current Regulatio	n		
PWM frequency	40000	+ Hz	1156 🜩 / 2048 🜩 P
Current regulation execution rate	1	✓ PWM periods	1200 🔶 / 2048 🛉 I
SW Current Limitation	4.999	🜩 Apk	
Voltage Regulatio	n		
Output voltage reference	350		8623 🌩 / 128 🌩 P
PFC over-voltage threshold	400	÷ V	7839 🔶 / 1024 🜩 I
Voltage regulation frequency	100	+ Hz	
Soft Start Duration	300	l ≑ ms	
Switch-on Power level	250	÷ W	
Switch-off Power level	50	€ W	
Digital filter duration on AC sync pin		↓ usec	
Digital filter duration on OCP pin	1.3	↓ usec	
ergraf inter daratiert ert e er pin		•	

3.4.3 **Drive management**

Figure 58 shows the Drive Management areas used for the configuration. Clicking on the Firmware Drive Management box gives access to the configuration of:

- Speed/Position Feedback Management •
- **Drive Settings** •
- Sensing Enabling and Firmware Protections .
- Start-up Parameters
- Additional Features and PFC settings
- FreeRTOS usage .



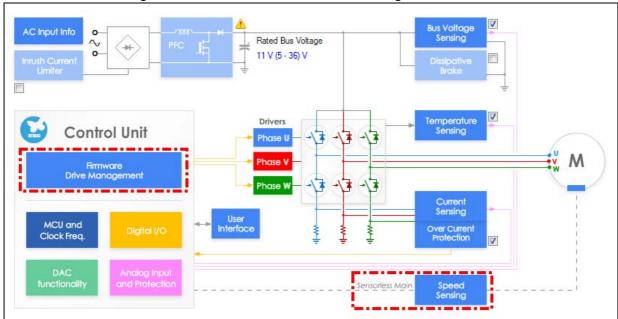


Figure 58. ST MC Workbench - Drive Management window

The following figures detail the Speed/Position Feedback Management GUI, where the user selects and configures the sensor(-less) as the main one, and eventually the auxiliary as another one, measuring the motor speed or position.

- Through the Sensor-less (Luenberger observer + PLL) selection (*Figure 59*), user configures the sensor-less estimator. User may also customize the Luenberger observer and the PLL PI filters.
- Through the Sensor-less (Luenberger observer + Cordic) selection (*Figure 60*), user configures the sensor-less estimator. User may also customize the Luenberger observer PI filter.
- Through the Quadrature encoder selection (*Figure 61*), user parametrizes the sensor usage. User choses the counter direction.
- Through the Hall sensors selection (*Figure 62*), user parametrizes the sensor usage.
- Through the Auxiliary sensor tab, user selects and configures a second sensor(-less), measuring the motor speed or position. To avoid mistakes, user can select only the supported but remaining sensor(-less) when enabled (*Figure 63*).



ve Management - Speed Position Feedback Mar	agement	
Main sensor Auxiliary sensor		
Sensor selection Sensor-less (Ob	server+PLL) 🔻	
Max measurement errors number before fault 3		
Observer+PLL		
Variance threshold	10.00 %	
Average speed depth for speed loop	64	
Average speed depth for observer equations	64	
B-emf consistency tolerance	100.00 %	
B-emf consistency gain	100.00 %	
Manual editing enabled		
Observer PLL G1 -1380	★ / 16384 ★ P	
G2 2895	↓ / 65536 ↓ 1	
G2 2000 S2	× , 0000 × 1	
		Der
		Done

Figure 59. ST MC Workbench – Speed/Position Feedback Management GUI (Sensor-less using Luenberger observer + PLL)

(Sensor-less using Luenberger observer + Cordic)				
Drive Management - Speed Position Feedback Manage	ment			
Main sensor Auxiliary sensor				
Sensor selection Sensor-less (Observe	er+Cordic) 🔹			
Max measurement errors number before fault 3	×			
Observer+Cordic				
Variance threshold	400.0	%		
Average speed FIFO depth for speed loop	64			
Average speed FIFO depth for observer equations	64			
B-emf consistency tolerance	100.00	%		
B-emf consistency gain	100.00 🚔	%		
Maximum application acceleration	6000 🚔	rpm/s		
B-emf quality factor	0.017 🚔			
Manual editing enabled				
Observer G1 1380				
G2 2895				
Back compatibility				
		Done		

Figure 60. ST MC Workbench – Speed/Position Feedback Management GUI (Sensor-less using Luenberger observer + Cordic)



Drive Management - Speed Position Feedback	Management			
Main sensor Auxiliary sensor				
Sensor selection Quadrature	e encoder 🔹			
Max measurement errors number before fault	3			
Quadrature Encoder				
Average speed FIFO depth	16			
Input Capture filter duration	0.7 🛓 usec			
Reverse counting direction				
		Done		

Figure 61. ST MC Workbench – Speed/Position Feedback Management GUI (Quadrature encoder)



Drive Management - Speed Position Feedback Management	
Main sensor Auxiliary sensor	
Sensor selection Hall sensors	•
Max measurement errors number before fault 3	
Hall Sensors	
Average speed FIFO depth 6	A V
Input Capture filter duration 1.3	Usec
	Done

Figure 62. ST MC Workbench – Speed/Position Feedback Management GUI (Hall sensors)



Drive Management - Speed Position		
Main sensor Auxiliary sensor		
Enable auxiliary sensor	1	
Sensor selection	Quadrature encoder	
Max measurement errors number bef		
Quadrature Encoder	ore fault 3	
Average speed FIFO depth	16	
Input Capture filter duration	0.7 usec	
Reverse counting direction		
		Done

Figure 63. ST MC Workbench – Auxiliary sensor(-less) GUI



Figure 64 shows the Drive Settings GUI, where the user configures the PWM generation, the Speed or the Torque regulator, the Flux regulator and the default control settings.

Figure 64.	ST MC	Workbench -	Drive Settings	GUI
------------	-------	-------------	----------------	-----

Drive Management - Drive Settings	
PWM generation and current reading PWM frequency 30000 Hz	Default settings Control mode Speed control
High sides PWM idle state Tum-off 1 Low side signals and dead-time	Target speed 3000 rm Target stator current flux component 0.00 rm Target stator current torque 0.00 rm
Speed regulator Execution rate 1.0 ms 2	Torque and flux regulators Execution rate 1 PWM periods 4 Cut-off frequency 6000 rad/s Torque Flux
1000 ↓ / 16 ↓ ₽ 600 ↓ / 256 ↓ ↓ ✓ Manual editing enabled	964 \$\nu\$ \$\nu\$ <t< td=""></t<>
	Done

The PWM frequency is used to drive the power switches, while the PWM idle state for High and Low sides are usually Turn-Off (area 1).

The Speed or the Torque regulator (areas 2 and 4) configures the algorithm execution rate (or Medium Frequency Task) linked with the Systick frequency usage. It is also the place where user may customize the Speed or the Torque PI filters.

User selects the default control mode (Speed or Torque) and its parameters in area 3.

The flux regulator (area 4) configures the motor flux control execution rate (or High Frequency Task) linked with the number of PWM periods. User may also customize this PI filter.



Figure 65 shows the Sensing and Firmware Protection GUI where the user configures the DC Bus voltage protection mechanism. From this interface the user can recall the other protection mechanism GUI, Temperature and AC Input voltage.

] Enable			
Over-voltage		Under-voltage	
Motor control		✓ Enable	
Enable		Set intervention threshold to power stage min rated voltage	
Set intervention threshold to Over-voltage threshold	o power stage max rated voltage	Under-voltage threshold 5 V	
_			
On over voltage	Disable PWM generation 🔻		
On over-voltage, disable or	ver-current protection by HW		

Figure 65. ST MC Workbench – Sensing and Firmware Protection GUI

The following figures show the Start-Up Parameters GUI, where the user customizes the motor ramp-up phase during a start-up sequence. User chooses between normal Rev-Up or On-the-Fly start-up, and between Basic or Advanced profiles.

- Through the Basic Rev-Up phase (*Figure 66*), user defines the motor speed ramp and its current consumption during that timeframe. When enabled, he also defines the transition duration between the open-loop and the close-loop.
- Through the Basic On-The-Fly phase (*Figure 67*), user defines the motor speed ramp and its current consumption during that timeframe. Then, he also provides the speed detection duration for the estimator convergence before testing the loop closure.
- Through the Advanced Rev-Up phase (*Figure 68*), user defines up to five ramps for the motor speed and its current consumption during a provided duration. Then, user choses the first ramp to start from. When enabled, he also defines the transition duration between the open-loop and the close-loop.
- Through the Advanced On-The-Fly phase (*Figure 69*), user defines up to three ramps for the motor speed and its current consumption during a provided duration. Then, user also provides the speed detection duration for the estimator convergence before testing the loop closure.

During this ramp-up phase, the loop is tested as a closed one when the estimated speed range is within the provided variance (band tolerance). It is based from a minimum output speed. User defines the number of consecutive passed tests to consider the loop as closed.



Management - Start-up parame	ters			
ensor-less rev-up settings				
On-the-Fly startup				
Profile Basic Advanced customized				
Include alignment before ramp-up	V			
Duration	300	ms		
Alignment electrical angle	90	💂 deg		
Final current ramp value	1.00	A		4000
Speed ramp duration	3000	.▲ ms	a a	
Speed ramp final value	4000	rpm	Speed from	2000 – – – – – – – – – – – – – – – – – –
Current ramp initial value	1.00	A A	ŝ	° 1000 - 0.5
Current ramp final value	1.20	A		0 0.0
Current ramp duration	100	s ms		0 1000 2000 3000 Duration (ms)
Consecutive succesful start-up output	tests	2	×	Rev-up to FOC switch-over
Minimum start-up output speed		1000	÷ pn	Enable V
Estimated speed Band tolerance upp	er limit	106.25	÷ %	Duration 25 ms
Estimated speed Band tolerance lowe	r limit	93.75	÷ %	
ncoder alignment settings				
Duration	700	≜ ▼ MS		
Alignment electrical angle	90	deg		
Final current ramp value	1.95	A		
				Done

Figure 66. ST MC Workbench – Start-Up Parameters GUI (Basic Rev-Up)



Management - Start-up parame	ters						
ensor-less rev-up settings							
On-the-Fly startup							
Profile							
Basic							
Advanced customized					0		
Include alignment before ramp-up	V				Start up on Fly Detection Duration	1000	s ms
Duration	300		ns		Braking Duration	1000	✓ ms
Alignment electrical angle	90		deg				
Final current ramp value	1.00	<u>*</u>	A		4000		2.0
Speed ramp duration	3000		ms	Ē	3000		- 1.5 E E
Speed ramp final value	4000		pm	Speed (rpm	2000		
Current ramp initial value	1.00	×	A	S	1000 -		- 0.5
Current ramp final value	1.20	×.	A		0		
Current ramp duration	100	÷ 1	ms		0 1000	2000	3000
					Dura	ation (ms)	
Consecutive succesful start-up outpu	t tests	2	4				
Minimum start-up output speed		1000					
Estimated speed Band tolerance upp	na lineit	106.25					
Estimated speed Band tolerance lowe	er limit	93.75		%			
ncoder alignment settings							
Duration	700	* *	ms				
Alignment electrical angle	90	*	deg				
Final current ramp value	1.95	A. V	A				
							Done

Figure 67. ST MC Workbench – Start-Up Parameters GUI (Basic On-the-Fly)



On-the-Fly startup Frofile Basic						
 Advanced customized Initial electrical angle Duration (ms) Final 1) 700 2000 2000 2000 3) 700 2000 4) 700 2000 5) 700 2000 2000 Execute sensor-less algorithm 			2000 1500 2000 1500 200 1500 0 500 0		2000	- 1.0 - 0.5 - 0.5 - 0.0 - 0.0 - 0.5
Consecutive succesful start-up Ainimum start-up output speed Estimated speed Band toleranc	e upper limit	2 1000 106.25 93.75	фm	Rev-up to FOC switc Enable Duration	h-over 25	<mark>≜.</mark> ms
ncoder alignment settings Duration Alignment electrical angle Final current ramp value	700 90 1.95	× ms × deg				

Figure 68. ST MC Workbench – Start-Up Parameters GUI (Advanced Rev-Up)



Management - Start-up para							
ensor-less rev-up settings ▼ On-the-Fly startup							
Profile							
Basic							
Advanced customized							
Initial electrical angle	90	🔶 deg		itart up on Fly			
		×3		Detection Duration		1000	i≑ ms
		nal current (A)	t l	Braking Duration		1000	ms ms
1) 700 🚔 2000	0.7		200	0 — — —			
2) 700 🚔 2000	0.7			E /			-
3) 700 🚖 2000	0.7	0	150 톱				- g
			Speed (rpm				
			_{ରୁ} 20	xo -= // -= or			
							- 0.0
				0 500	1000	1500	2000
					Duration (m	is)	
Consecutive succesful start-up ou	tout tooto	2	1				
Minimum start-up output speed	ipui iesis	1000					
Estimated speed Band tolerance (
		106.25					
Estimated speed Band tolerance I	ower limit	93.75	%				
ncoder alignment settings							
	700	ms ms					
Duration							
Duration Alignment electrical angle	90	🔶 deg					
	90						
Alignment electrical angle							
Alignment electrical angle							
Alignment electrical angle							

Figure 69. ST MC Workbench – Start-Up Parameters GUI (Advanced On-the-Fly)



Figure 70 shows the Additional Features and PFC settings GUI, where the user selects the additional features usable for its motor control.

Note that when the Flux Weakening feature is selected, user parametrizes the PI filter, as well as the upper limit of the voltage to apply.

The Inrush Current Limiter button is popping-up the GUI shown in Figure 55.

Figure 70. ST MC Workbench – Additional Features and PFC settings GUI

Drive Management - Additional Features and PFC settings								
Flux weakening MTPA	Flux weakening 3000 - / 32768	<u>∧</u> ▼ P						
Feed Forward	5000 (c) / 32768							
Sensorless speed feedback	Voltage limit 98.5	× %						
Inrush Current Limiter		Done						

Figure 71 shows the FreeRTOS GUI, where the user enables and configures, Timer and IT usage supporting the OS, for its motor control application.

Figure 71. ST MC Workbench - FreeRTOS GUI

FreeRTOS ×	<
enable FreeRTOS 🗹 1	
Enable MC IRQ to use FreeRTOS functions	
Timer TIM6 ~	
OK Cancel	

3.4.4 Control stage

Figure 72 shows the Control Stage window used for the configuration of:

- MCU and clock frequency
- Analog input and protection
- DAC functionality
- Digital I/O
- User interface



AC Input Info		Rated Bus Voltage		Bus Voltage Sensing Dissipative Brake	
	rol Unit	Drivers Phase U - + 2 Phase V -	€-\ \$ -\ \$	Temperature Sensing	
	iware nagement		\$ -\ \$ -\ \$	Current	W M
MCU and Clock Freq.	Digital I/O	User Interface ≩		Sensing Over Current Protection	V
DAC functionality	Analog Input and Protection		Sensorless Main	Speed Sensing	

Figure 72. ST MC Workbench - Control Stage window

Figure 73 shows the MCU and Clock Frequency GUI, where the user selects the MCU used, as well as its clocking information.

MCU TYPE	STM32F301x6/8 - STM32F302x6/8 -
MCU	STM32F302R8 -
package	LQFP64
Clock settings	
Clock source	8MHz External crystal/ceramic resonator
CPU frequency	72 • MHz
Supply voltage	
Nominal MCU supply voltage	3.30 V

Figure 73. ST MC Workbench – MCU and Clock Frequency GUI

Figure 74 shows the Analog Input and Protection GUI, where the user selects the MCU pin assignments and configures the analog input parameters.



o currert feedback Bus voltage feedback Temperature feedback PFC stage feedback mert Sensing Topology Over Currert Protection Topology Embedded PKD CCP Embedded PKD CCP External Protection No protection	Phase current feedback Bus voltage feedback Temperature feedback PEC stage feedback Current Sensing Topology
string Samping Time 195 • ADC cik Ch phase U ADC12_IN8 (C2) • Samping Time 271 rs Ch phase V ADC12_IN8 (C3) • Maximum modulation 98 %, Ch phase W ADC12_IN6 (C0) •	Sensing Setting Samping Time 19.5. ADC clk Pn map Samping Time 1985. ns Ch plaase U ADC1_IN3 (A2) Samping Time 1985. ns On plaase U ADC1_IN3 (A2) Maximum modulation 91 % On plaase V ADC1_IN3 (A6) Perpheral Selection ADC1/ADC2 On phase V ADC12_IN5 (C0)
Primap Setting OPAMP LOPAMP2 * OPAMP Gan Internal * Dia na treemal OL A1 * OPAMP Gan 2 * Oreal Network Gan 1.44 Calculate OPAMP2 C5 * Oreal Network Gan 1.44 Calculate Or W B14 * Tele 250 © m s Feedback net filtering OPAMP1	Sensing OPAMP Setting Peripheral election OPAMPI Gain Int gain type Overal Network Gain Vout polarization) Trate Feedback net fittering Pin map Networking Ch L Alt P OPAMPI A3 OPAMPI A2 OPAMPI A3 OPAMPI A2 OPAMPI A3 OPAMPI A3 OPAMPI A2 OPAMPI A2
Xetion Pin map Stering Output filer duration B clock Investing input none Output none Investing input Investing input none Not riverting Output none Output n	Protection Pn map 3 Digits filter duration ⑧ v clock Inveting input none 3 Inveting input Internal v Not inveting Output 0 0 Current threshold 99.000 € . Apk Oh U A1 COMP1 Oh U A0 v Voltage Threshold 12 v V Oh V A7 COMP2 Oh V A2 v O Output enable 04 W 04 00 W 04 C0 v A2 v

Figure 74. ST MC Workbench – Analog Input and Protection GUI (Phase current feedback)

Through the Phase current feedback tab, the user

- Configures and selects the ADC for the motor current acquisition, as well as its pins usage (area 1). Note that the GUI reflects either the 1- or the 3-shunt topology selected.
- Configures the current sensing topology
 - internal (Embedded PGA), area 2: user selects and sets the MCU Op-Amp usage as well as the pin assignments, and defines the overall network gain (thanks to the Calculate button that pops-up the GUI shown in *Figure 50*).
 - external (operational amplifier) to the MCU
- Configures the over-current protection topology:
 - no protection
 - internal (embedded HW OCP), area 3: user sets the MCU comparator usage as well as the pin assignment
 - external to the MCU (only the Digital filter duration is required)



Through the Bus voltage feedback tab (*Figure 75*), user selects and configures the ADC for the DC bus voltage acquisition as well as its input pin usage.

A click on the Bus Voltage Partitioning button pops-up the GUI shown in *Figure 47*.

Figure 75. ST MC Workbench – Analog Input and Protection GUI (Bus voltage feedback)

Control Stage - Analog Input and Protection	
Phase current feedback Bus voltage feedback Temps	erature feedback PFC stage feedback
Setting Sampling Time 61.5 ADC cll Peripheral selection ADC1	Pin map ADC Channel ADC1_IN2 (A1)
use Input Resistance (R3)	Input Resistance 100.0 (A) KOhm Bus Voltage Partitioning
	Done



Through the Temperature feedback tab (*Figure 76*), user selects and configures the ADC for the temperature image acquisition (usually an NTC resistor) as well as its input pin usage.

Figure 76. ST MC Workbench – Analog Input and Protection GUI (Temperature feedback)

Control Stage - Analog In Phase current feedback		e feedback PFC stag	e feedback	_
Sensing Setting		Pin map		
Sampling Time Peripheral selection	61.5 • ADC clk	ADC Channel	ADC1_IN8 (C2)	
				Done



Through the PFC stage feedback tab (*Figure* 77), user selects and configures the ADC for the PFC current sensing and the AC voltage sensing, as well as their input pins usage.

Figure 77. ST MC Workbench – Analog Input and Protection GU
(PFC stage feedback)

Control Stage - Analog In	out and Destaction			
[en fanallen als REC att	age feedback	
	Bus voltage feedback Temperatur	re reedback		
Current sensing		Pin map		
Sampling Time	1.5 ▼ ADC clk	ADC Channel	ADC12_IN13 (C3) -	
Peripheral selection			<u></u> (,	
AC voltage sensing				
Setting		Pin map		
Sampling Time	1.5 ADC clk	ADC Channel	ADC12_IN3 (A3)	
PFC ACVoltSens	ADC2			
				Done



Figure 78 shows the DAC functionality GUI, where the user selects the DAC channel used for debug (if any) and the data to output.

Figure 78.	ST MC	Workbench -	DAC	functionality	y GUI
------------	-------	-------------	-----	---------------	-------

DAC CH1 Debug V M1 Ia A4 CH2 Debug M1 Ib V A5	
CH2 Debug M1 lb 🖌 A5	
Do	ne

Figure 79 shows the Digital I/O GUI, where the user configures the Timers used to

- control the power switches
- control the PFC driver
- configure the serial communication link for the UART
- interface the Encoder or the Hall sensors for the speed/position acquisition
- configure the Inrush Current Limiter.

verter driving signal selection	Signal Enabler	Speed/position feedback	Hall sensors interface	Direct GPIO
Timer TiM1 • Remap No remap • Pin Map • • CH1 A8 CH1N B13 CH2 A9 CH2N B14 CH3 A10 CH3N B15 BKIN B12 • •	CH1 Port GPIOC * Pin C13 * CH2 Port GPIOC * Pin C13 * CH3 Port GPIOC * Pin C13 *	Timer TIM2 + Remap No remap + Pin Map CH1 A15 + CH2 B3 +	Timer TIM2	
PFC drive signal and feedback Pimer TIM3 PWM Ac Ma OCS	B5 CC ins B4 E		Start/Stop Button G Port GPIOA Pin A0 I1 Polarity Active low	V V

Figure 79. ST MC Workbench – Digital I/O GUI

Figure 80 shows the User Interface Add-on GUI, where the user configures the interface for the control board usage: LCD (if supported), a Start/Stop push-button, and/or the serial communication link with software application.



	h – User Interface Add-on GUI
User Interface	
HW / Features MCU Pins	
LCD 🔺	Start/Stop Button
Available on Control Board	V Available on Control Board
Enable	☑ Enable
Full	
Light	
Serial	Communication
Bidirectional	
Fast unidirectional	
CH1 M1 la	·
CH2 🗸 🛛	~
	Done

~~ ~~ **.**...

Main hardware settings 3.5

At a first glance, the user can view the main hardware settings reflecting all the main parameters as follows:

- PWM frequency used •
- Main sensor usage selected .
- Auxiliary sensor usage selected when the hardware setup supports it .
- Torque and flux execution rate: it is the number of PWM periods executed during only one complete FOC algorithm execution
- Bus voltage sensing enabled/disabled .
- Over-voltage detection enabled/disabled
- Under-voltage detection enabled/disabled .
- Temperature sensing enabled/disabled •
- Current reading topology selection



The hardware setting area is shown in Figure 81.

Figure 81. ST MC Workbench - Main hardware setting area

Variable	Motor	Unit
PWM frequency	30000	Hz
Sensor selection main	Sensor-less (Observer+PLL)	
Sensor selection aux	Sensor-less (Observer+Cordic)	
Torque&Flux - Execution rate	1	PWM periods
Bus voltage sensing	true	
Over-voltage	true	
Under-voltage	true	
Temperature sensing	true	
Current reading topology	Three Shunt Resistors	

Double clicking on any of the parameters in the *Motor* column directly displays the full configuration GUI (refer to *Section 3.4*).

Note: This sheet is not configurable.

3.6 User information

A user information sheet provides feedback about user's action:

- The *Info / Errors / Warnings* tab reflects the project settings or MC controls performed and the resulting outcomes. This tab can only be cleaned
- The Change Log tab reflects the hardware setting modifications done

The user information area is shown in *Figure 82*.

Time	Motor	ld	Message	
11:59:02			The 'LCD' is not supported in the FW for SDK5.0. All parameters will be disabled.	
11:59:02			The 'PFC' is not supported in the FW for SDK5.0. All parameters will be disabled.	
11:59:02			The 'Sensor-less (HFI+Observer)' is not supported in the FW for SDK5.0. All parameters will be disa	
11:59:02			F1 F2 mcu are not supported in the FW for SDK5.0	
11:59:02			Working folder is set to C:\WorkSpace\SDK5.0.0	

Figure 82. ST MC Workbench - User information area



3.7 Motor monitoring and spinning

Caution: By default, ST MC FOC firmware embeds the needed code to dialog with the ST MC Workbench software tool. This section only applies if this code is embedded in the motor control application software.

Figure 83 shows the monitor and spin control GUI, which a user can use to observe and modify some MC parameters and to fine tune its MC application software through several areas:

- Communication link area: used to setup the connection with the board, connect to the board, or disconnect from the board. It is also used for reading, writing or plotting data, as well as for closing the GUI
- Dashboard area: the adaptive dashboard area reflects the user experience in several ways:
 - Basic
 - Advanced
 - Expert (register and configuration tabs)
 - Motor Control buttons area: used to command the hardware setup
- Status overview area: used to monitor hardware setup at a glance

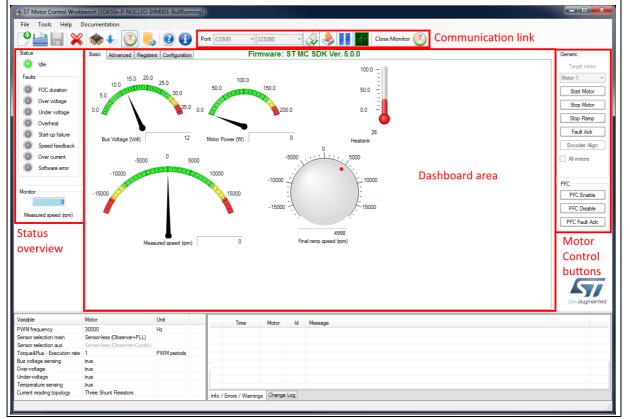


Figure 83. ST MC Workbench - Monitor and spin control GUI



3.7.1 Communication link

The communication link area (refer to *Figure 83*) features several functions, listed in *Table 4*.

Function	lcon or field	Detail
Configure the	Port COM3 ·	Selects the communication port used from the drop-down box.
communication link	115200 -	Selects the communication speed from the drop-down box.
Connect or disconnect		Connects to the board.
	X	Disconnects from the board
		Forces the reading of data.
Read and/or write data from/to MC application software		Suspends the periodic data writing and reading.
		Resumes the periodic data writing and reading.
Plot speed data		Displays the plotting window with the speed measured and the speed reference, as shown in <i>Figure 84</i> .
Close the monitor and spin control GUI	Close Monitor 🥝	Exits the GUI.

 Table 4. ST MC Workbench - Communication link GUI commands



Figure 84 shows the plotting window with an example illustrating the measured speed vs. the reference.

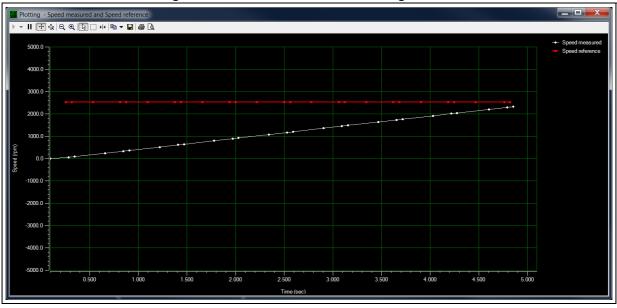


Figure 84. ST MC Workbench - Plotting window



UM2380

3.7.2 Motor control dashboard

The motor control dashboard provides a set of views that can be selected as a function of the user's experience:

- Basic view (refer to *Figure 85*)
- Advanced view (refer to Figure 86)
- Expert views (refer to *Figure 87* and *Figure 90*)

Figure 85 shows the basic dashboard, where the user can:

- monitor the bus voltage, motor speed, and power component heat-sink
- modify the final ramp speed value, which may also be used to control motor speed during spinning

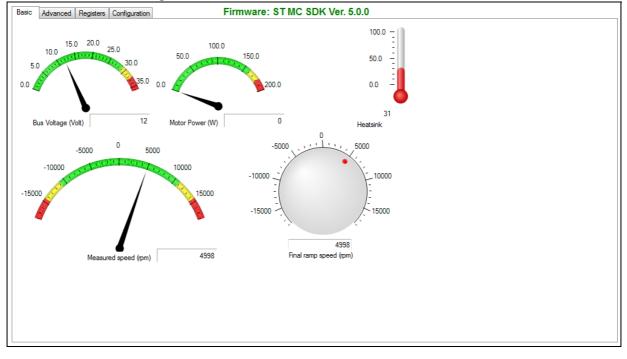


Figure 85. ST MC Workbench - Basic dashboard view



Figure 86 shows the dashboard where the advanced user can:

- Configure (drop-down boxes) control modes an monitor (blue fields) a few firmware variables for debugging purpose using only the DAC
- Monitor (blue fields) and define (white fields) some current controller parameters
- Tune the speed controller (white fields) through variables
- Configure (white fields) the sensor-less observers: PLL and Cordic
- Tune (white fields) and monitor (blue fields) the flux weakening feature

Figure 86. ST MC Workbench - Advanced dashboard view

Basic Advanced Registers Configuration	Firmware: ST MC SDK V	/er. 5.0.0	
Configuration and debug		Sensor-less Observer+PLL	
Control mode Speed	•	Observer C1 -1142	
Power Board Status	DAC Settings	Observer C2 1375	
BUS Voltage 12 Volt	Ch1 la 👻	PLL Kp 1946	
Heatsink temp. 31 °C	Ch2 lb 🔻	PLL Ki 46	
Current controller	Speed controller	Sensor-less Observer+Cordic	
Set current reference in speed mode	Speed ramp	Observer C1 0	
Torque ref (lq)	Target speed 3000 🗭 rpm	Observer C2 0	
Flux ref (ld) 0	Duration 1000 🚔 millisec		
	Exec ramp	Flux weakening tuning	
	PID Gains	Κρ 0	
Measured currents	Kp 2751	Ki O	
Torque (lq) 1628	Ki 1359	BUS Voltage allowed	
Flux (ld) 359		Ref 0 ‰	
Iq PID Gains		Meas 0 %	
Кр 696 Кр 696			
Ki 357 Ki 357			



Figure 87 shows the dashboard where the expert user can:

 Read/Write (white field) or read only (blue fields) the content of 102 registers matching corresponding variables in MC FOC firmware

ld	Name	Unit	Value	Min	Max	Period	Туре	Mode	Enable	Last read	Last write	
0x00	Target motor		0	0	255	0	U8	RW	V	never	never	
0x01	Flags		0	0	4294967	200	U32	R	V	2018-02-21 15:1	n/a	
0x02	Status		6	0	255	200	U8	R	V	2018-02-21 15:1	n/a	
0x03	Control mode		1	0	255	500	U8	RW	V	never	never	
0x04	Speed reference	RPM	4998	-18000	18000	200	S32	R	V	2018-02-21 15:1	n/a	
0x05	Speed Kp		2751	0	65535	0	U16	RW	V	2018-02-21 15:1	never	
0x06	Speed Ki		1359	0	65535	0	U16	RW	V	2018-02-21 15:1	never	
0x07	Speed Kd		0	0	65535	0	U16	RW	V	never	never	
0x08	Torque reference (Iq)		0	-32768	32767	0	S16	RW	V	never	never	
0x09	Torque Kp		696	0	65535	0	U16	RW	V	2018-02-21 15:1	never	
0x0A	Torque Ki		357	0	65535	0	U16	RW	V	2018-02-21 15:1	never	
0x0B	Torque Kd		0	0	65535	0	U16	RW	V	never	never	
0x0C	Flux reference (Id)		0	-32768	32767	0	S16	RW	V	never	never	
0x0D	Пих Кр		696	0	65535	0	U16	RW	V	2018-02-21 15:1	never	
0x0E	Flux Ki		357	0	65535	0	U16	RW	V	2018-02-21 15:1	never	
0x0F	Flux Kd		0	0	65535	0	U16	RW	V	never	never	
0x10	Observer C1		-1142	-32768	32767	0	S16	RW	V	2018-02-21 15:1	never	
0x11	Observer C2		1375	-32768	32767	0	S16	RW	7	2018-02-21 15:1	never	
0x12	Cordic Observer C1		0	-32768	32767	0	S16	RW		never	never	
0x13	Cordic Observer C2		0	-32768	32767	0	S16	RW		never	never	
0x14	PLL Ki		46	0	65535	0	U16	RW	1	2018-02-21 15:1	never	
0x15	PLL Kp		1946	0	65535	0	U16	RW	V	2018-02-21 15:1	never	
0x16	Flux weakening Kp		0	0	65535	0	U16	RW		never	never	

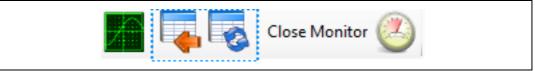
Figure 87. ST MC Workbench - Expert dashboard register view

When using the expert dashboard register view, the user has access to the additional icons shown in *Figure 88*:

- The first additional icon is used to import a configuration from another ST MC Workbench project through the import register configuration window shown in *Figure 89*
- The second additional icon is used to set the registers value to default ones

These icons are available only when the periodic write and read of registers has been suspended, or before the connection to the board.

Figure 88. ST MC Workbench - Communication link icons in expert dashboard register view



Note:

These buttons do not exist in other dashboard views.



	- Import configuration from an other project			
🗩 🚽 📕 🕨 Computer 🕨	OSDisk (C:) ► WorkSpace ► SDK5.0.0 ►		👻 🍫 Search SDK	5.0.0
Organize 🔻 New folder				= - 1 0
☆ Favorites	Name	Date modified	Туре	Size
🧮 Desktop	Development Repository	2/27/2018 3:35 PM	File folder	
📜 Downloads 🛛 🗉	🔋 🔋 Euro2017 - Example	2/6/2018 4:45 PM	File folder	
📃 Recent Places	MCSDK - Example1	3/6/2018 2:02 PM	File folder	
🌗 Business Trip	Euro2017 - Example.stmcx	2/2/2018 12:00 PM	STMC Workbench	143 KB
퉬 STV0991	MCSDK - Example1.stmcx	2/27/2018 3:49 PM	STMC Workbench	143 KB
퉬 Imaging				
MCD SW Development				
MCD Documents				
퉬 Users Application				
📄 Libraries 🔹	-			
File name	MCSDK - Example1.stmcx		✓ STMotor Cor	ntrol files (*.stmcx, 🔻
	·		Open	Cancel

Figure 89. ST MC Workbench - Import registers configuration window

Figure 90 shows the dashboard where the expert user can:

- Import (button) the configuration from the current ST MC Workbench project
- Customize (check boxes and white fields) the monitor view accordingly to the MC application software
- Update (white fields) the startup configuration used with the motor. This is also known as rev-up.

Figure 90. ST MC Workbench - Expert dashboard configuration view

Import from builder			Num	Final Speed (rpm)	Final Torque	Duration (ms)	Last read	Last write	
Motor available Single	Motor -	•	1	0	11029	1000	2018-02-21 15:15:48.854	never	
Motor 1 or any motor			2	2814	11029	5628	2018-02-21 15:15:48.916	never	
Sensor-less (Obs+			3	2814	11029	0	2018-02-21 15:15:48.979	never	
Sensor-less (Obs+			4	2814	11029	0	2018-02-21 15:15:49.041	never	
Sensor-less (HFI+			5	2814	11029	0	2018-02-21 15:15:49.104	never	
Min speed -180 Max speed 1800 Max bus voltage 36.0 Motor 2 (f available) - Sensor-less (Obs+ Sensor-less (Obs+ Sensor-less (Obs+ Guadrature encod Hall sensors Flux weakening Control mode: none	PLL) -Cordic) Obs)				1	1			Reload



3.7.3 Motor control buttons

The motor control button area is shown in *Figure 91*. It is useful for motor control with remote commands such as:

- Start-up the motor when in idle state.
- Stop the motor when in start or run state.
- Stop a ramp during its execution request. It does not stop the motor itself, but the execution of the defined ramp at the current ongoing speed or torque value.
- Acknowledge a motor failure. May be used only after fault correction to prevent security issues.
- Align with the encoder used.
- Enable or disable PFC usage when the hardware setup supports it.
- Acknowledge a PFC failure when the hardware setup supports it.

Figure 91. ST MC Workbench - Motor remote control button view

ſ	Generic
	Target motor
[Motor 1 👻
	Start Motor
	Stop Motor
	Stop Ramp
	Fault Ack
	Encoder Align
[All motors
ſ	PFC
	PFC Enable
	PFC Disable
	PFC Fault Ack



3.7.4 Status overview

The status overview, illustrated in Figure 92, provides information on:

- the motor state machine
- the detected motor failure
- the measured motor speed.



Status Idle
Faults FoC duration FOC duration Over voltage Under voltage Overheat Start-up failure Speed feedback Over current
Software error
Monitor
Measured speed (rpm)



4 **Precautions 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 performed measurements are not as precise as with a proper instrumentation, ST Motor Profiler measurements are optimized (green color in *Figure 10*) when:

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

It is important to choose the appropriate HW according to the characteristics of the motor. For instance, the maximum current should match the maximum current of the board as closely as possible.

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

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



5 Revision history

Date	Revision	Changes
20-Mar-2018	1	Initial release.
02-Jul-2018	2	 Updated document title to refer to software version 5.1. Updated Section 3.3: Icons and Menu area, Tools menu, Documentation menu, Power stage, Control stage and Section 3.4: Configuring a project. Minor text edits across the whole document. Updated Figure 15: ST MC Workbench - Icon and location in the start program list, Figure 18: ST MC Workbench - New Project Info window, Figure 27: ST MC Workbench - Pin Assignment window, Figure 31: ST MC Workbench - Script progress window, Figure 33: ST MC Workbench - Script progress window, Figure 33: ST MC Workbench - Monitor window, Figure 37: ST MC Workbench - About window, Figure 38: ST MC Workbench - Documentation menu and Figure 44: ST MC Workbench - Power Stage window. Updated caption of Figure 1: ST Motor Profiler - Icon and location in the start program list. Removed former Figure 32: ST MC Workbench - Update .ioc file error window.

Table 5. Document revision history



Table	5.	Document	revision	history
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Date	Revision	Changes
31-Aug-2018	3	Updated document title to refer to software version 5.2. Updated Section 3.2: Loading an existing project, Section 3.4.1: Motor, Section 3.4.3: Drive management and Section 3.4.4: Control stage. Updated Figure 15: ST MC Workbench - Icon and location in the start program list, Figure 19: ST MC Workbench - Hardware configuration window (global view), Figure 23: ST MC Workbench - Project Properties window, Figure 37: ST MC Workbench - About window, Figure 44: ST MC Workbench - Power Stage window, Figure 58: ST MC Workbench - Drive Management window and Figure 72: ST MC Workbench - Control Stage window.
26-Jun-2019	4	 Updated: SDK version in the title of document, Section 1: General information, STMicroelectronics documents, Section 3.3.2: Tools menu, Section 3.3.3: Help menu, Section 3.3.4: Documentation menu Figure 1: ST Motor Profiler - Icon and location in the start program list; Figure 15: ST MC Workbench - Icon and location in the start program list; Figure 20: ST MC Workbench - File menu, Figure 26: ST MC Workbench - Tools menu, Figure 30: ST MC Workbench - Information window, Figure 31: ST MC Workbench - Script progress window, Figure 36: ST MC Workbench - Help menu, Figure 37: ST MC Workbench - About window, Figure 38: ST MC Workbench - Documentation menu, Figure 40: ST MC Workbench - Motor parameter GUI (Surface Mounted PMSM), Figure 42: ST MC Workbench - Sensor parameter GUI, Figure 51: ST MC Workbench - Over Current Protection GUI, Figure 54: ST MC Workbench - Dissipative Brake GUI Added: Figure 41: ST MC Workbench - Motor parameter GUI (Internal PMSM) Removed figure33. ST Workbench - Project Settings option window Added Figure 40: ST MC Workbench - Motor parameter GUI (Surface Mounted PMSM), Figure 57: ST MC Workbench - Power Factor Correction GUI (PFC Parameters), Figure 71: ST MC Workbench - FreeRTOS GUI



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