

STM32 motor control SDK v5.2 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 a hardware setup. The projects it generates on 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-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

arm

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	ïrmware			
MC	Notor 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
- STM32F2 Series product data sheets
- STM32F3 Series product data sheets
- STM32F4 Series product data sheets
- X-NUCLEO expansion boards 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*.

	STMicroelectronics
	FOC SDK
C 4 77	📜 v4.3.0
Motor	▶ v5.0.0
	🚸 ST Motor Control WorkBench
Profiler	ST Motor Profiler

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.

Figure 2. ST MC Workbench - GUI expanded top view

File Tools Help	Documentatio	on					
🤔 New Proje	ect		Load Project	About	Help		Motor Profiler
Recent Projects							
Filename	FOC	Туре	MCUs	control board	power board	motor	



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

ST Motor Profiler		
Motor Profiler	ā	Pole Pairs: Image: book to detect Speed and Current limits Max Speed: 16000 RPM Max Current: Apk 0.28 - 30 Apk VBus: V 8 - 400 V Magnetic: • SM-PMSM LPMSM
 D 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.



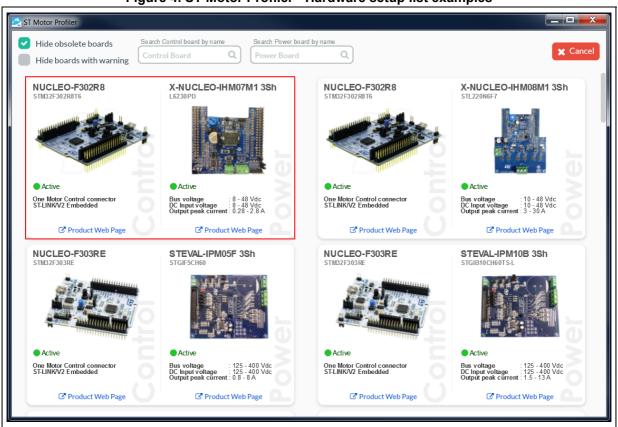


Figure 4. ST Motor Profiler - Hardware setup list examples

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 🞓	how 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		PMSM	

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

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

Pole Pairs:	7 provide to detect
Speed and	Current limits
Max Speed	: 16000 RPM
Max Currer	nt: 2.8 Apk 0.28 - 2.8 Apk
VBus:	12 V 8-48 V
Magnetic:	
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 coards 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

ST-Link	
ST-Link Connection ()	
Secutes a Full chip erase operation ()	
Load binary and Verifies programming operation	
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		
Motor Profiler	X-NUCLEO-IHM07M1 3Sh L6230PD	Pole Pairs: 7 👼 how to detect
One Motor Control connector ST-LINK/V2 Embedded	Bus Vohage: 8 - 48 Vdc Output peak current: 0.28 - 2.8 A	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 OLPMSM
Product Web Page Remember to properly configure the b Disconnect	C Product Web Page oards in Motor Control mode Electrical Model Rs Ls	Mechanical Model
Save		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-LINKV2 Embedded C Product Web Page C Remember to properly configure the	boards in Motor Control mode	VBus: <u>48</u> V 8-48 V Magnetic: • SM-PMSM • I-PMSM
	Electrical Model R _S 0.18 Ω L _S 0.01 mH	Mechanical Model
▶ Start Profile P Save ♥ Play	V _{BUS} 12.75 V I _{max} 1.01 Apk Ke	(Inertia Max Speed
	0.85 Vrms/kRPM	353.18 n№mrs² 15680 RPM

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



Save	×
BR2804-1700KV-1	
3-phases PMSM motor with 7 pole-pairs under 12Vdd	E Save

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	×
Start 2 Stop	
Maximum Acceleration 3000 RPM/s	
-15680 0 15680 Speed [RPM]	
• Connected	Done



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 ①
Maximum Acceleration 3000 RPM/s		Over voltage O° Under voltage O° Overheat O°
-15680 0 Speed [RPM]	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. S	ST Motor Profiler -	Tool closure	confirmation window
i iguio i ti o		100101000010	

Please confirm			
	ire you want	to close the a	application?
	ved data will		
	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

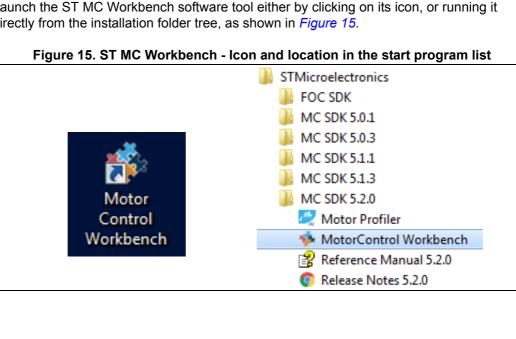
Clicking on the Yes button closes the ST Motor Profiler software tool, unsaved motor parameters being lost.

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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.





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

Figure 16. ST MC Workbench - GUI (Launch window)

ile Tools Help Documentation						_	
New Project	Load Project	 About 	Help	1 Motor Pro			
Recent Projects							
Filename FOC SDK	Type MCUs	control board por	wer board mo	otor			
MySpinningMotor.stmcx 5.0.0	SINGLE STM32F301x6/8 -			I Running Motor		\	·····
					2		
Example Projects							
Example Projects Filename	Type MCUs	control board	power board	motor	_		
	07140050040000	control board NUCLEO-F302R8	power board X-NUCLEO-IHM08M1	motor Shinano LA052-080E3NL1	_	- (Ŭ.
Filename	STM32F301x6/8 -			Shinano LA052-080E3NL1 Shinano		- (Ŭ .
Filename NUCLEO-F302R8-X-NUCLEO-IHM08M1-SI	hinar SINGLE STM32F301x6/8 - STM32F302x6/8	NUCLEO-F302R8	X-NUCLEO-IHM08M1	Shinano LA052-080E3NL1 Shinano LA052-080E3NL1 Shinano			
Filename NUCLEO-F302R8-X-NUCLEO-IHM08M1-SI NUCLEO-F303RE-IPM05F-Shinano	hinar SINGLE STM32F301x6/8 - STM32F302x6/8 SINGLE STM32F303xE	NUCLEO-F302R8 NUCLEO-F303RE	X-NUCLEO-IHM08M1 STEVAL-IPM05F	Shinano LA052-080E3NL1 Shinano LA052-080E3NL1 Shinano LA052-080E3NL1 Shinano			
Filename NUCLEO-F302R8-X-NUCLEO-HM08M1-SI NUCLEO-F303RE-IPM05F-Shinano NUCLEO-F303RE-IPM10B-Shinano	hinar SINGLE STM32F301x6/8 - SINGLE STM32F302x6/8 SINGLE STM32F303xE SINGLE STM32F303xE SINGLE STM32F303xE	NUCLEO-F302R8 NUCLEO-F303RE NUCLEO-F303RE	X-NUCLEO-IHM08M1 STEVAL-IPM05F STEVAL-IPM10B	Shinano LA052-080E3NL1 Shinano LA052-080E3NL1 Shinano LA052-080E3NL1 Shinano LA052-080E3NL1 Bull Running	3		
Filename NUCLEO-F302R8-X-NUCLEO-HM09M1-SI NUCLEO-F303RE-IPM05F-Shinano NUCLEO-F303RE-IPM10B-Shinano NUCLEO-F303RE-IPM15B-Shinano	hina SINGL STM32F301x66 SINGLE STM32F302x66 SINGLE STM32F303xE SINGLE STM32F303xE SINGLE STM32F303xE ullRu SINGLE STM32F303xE	NUCLEO-F302R8 NUCLEO-F303RE NUCLEO-F303RE NUCLEO-F303RE	X-NUCLEO-IHM08M1 STEVAL-IPM05F STEVAL-IPM10B STEVAL-IPM15B	Shinano LA052-080E3NL1 Shinano LA052-080E3NL1 Shinano LA052-080E3NL1 Shinano LA052-080E3NL1 Bull Running BR2804-1700kv Shinano	3		
Filename NUCLEO-F302R8-X-NUCLEO-HM09M1-SI NUCLEO-F303RE-IPM05F-Shinano NUCLEO-F303RE-IPM10B-Shinano NUCLEO-F303RE-IPM15B-Shinano NUCLEO-F303RE-X-NUCLEO-HM07M1-B	hina SINGL STM32F301x66 SINGLE STM32F302x66 SINGLE STM32F303xE SINGLE STM32F303xE SINGLE STM32F303xE ullRu SINGLE STM32F303xE	NUCLEO-F302R8 NUCLEO-F303RE NUCLEO-F303RE NUCLEO-F303RE NUCLEO-F303RE NUCLEO-F303RE NUCLEO-F303RE	X-NUCLEO-IHM08M1 STEVAL-IPM05F STEVAL-IPM10B STEVAL-IPM15B X-NUCLEO-IHM07M1	Shinano LA952-080E3NL1 Shinano LA052-080E3NL1 Shinano LA052-080E3NL1 Shinano LA052-080E3NL1 Shinano LA052-080E3NL1 Bull Running BR2804-1700kv Shinano LA052-080E3NL1 Bull Running BR2804-1700kv Shinano LA052-080E3NL1	3		



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



ct					
Applicatio	an tuna			System	
Applicatio	on type				
Custom		•		Single Motor	Dual Motors
Select Bo	oards: O Inverter	MC Kit	Power & Control		
Control					
custom bo	oard		Control board where the		
			control stage parameters ha	l	
_					
Power		-	Power board where the		
custom bo	oard		power stage parameters h		
Motor					
	nw valtaa⊳ <= 50V		Magnetic structure	Surface Mounted	
Generic Lo	ow voltage <= 50V w voltage <= 50V		Pole Pairs	2	1
Generic Lo Generic Lo	w voltage <= 50V		Pole Pairs Nominal Speed		1
Generic Lo Generic Lo Generic Hig			Pole Pairs	2 4000 rpm	1
Generic Lo Generic Lo Generic Hig Shinano LA Bull Runnin	w voltage <= 50V igh voltage > 50V 4052-080E3NL1 ng BR2804-1700kv	.	Pole Pairs Nominal Speed Nominal Voltage	2 4000 rpm 24 V	1
Generic Lo Generic Lo Generic Hig Shinano LA Bull Runnin Allen Bradl	w voltage <= 50V igh voltage > 50V 4052-080E3NL1 ng BR2804-1700kv ley TL-A220P-HJ32AN		Pole Pairs Nominal Speed Nominal Voltage	2 4000 rpm 24 V	
Generic Lo Generic Lo Generic Hig Shinano LA Bull Runnin Allen Bradl 3-phase Mo	w voltage <= 50V igh voltage > 50V 4052-080E3NL1 ng BR2804-1700kv ley TL-A220P-HJ32AN totor BR2804		Pole Pairs Nominal Speed Nominal Voitace Nominal Current	2 4000 rpm 24 V	1
Generic Lo Generic Lo Generic Hig Shinano LA Bull Runnin Allen Bradl	w voltage <= 50V igh voltage > 50V 4052-080E3NL1 ng BR2804-1700kv ley TL-A220P-HJ32AN totor BR2804		Pole Pairs Nominal Speed Nominal Voltage	2 4000 rpm 24 V	1
Generic Lo Generic Lo Generic Hig Shinano LA Bull Runnin Allen Bradl 3-phase Mo	w voltage <= 50V igh voltage > 50V 4052-080E3NL1 ng BR2804-1700kv ley TL-A220P-HJ32AN totor BR2804		Pole Pairs Nominal Speed Nominal Voitace Nominal Current	2 4000 rpm 24 V	1
Generic Lo Generic Lo Generic Hig Shinano LA Bull Runnin Allen Bradl 3-phase Mo	w voltage <= 50V igh voltage > 50V 4052-080E3NL1 ng BR2804-1700kv ley TL-A220P-HJ32AN totor BR2804		Pole Pairs Nominal Speed Nominal Voitace Nominal Current	2 4000 rpm 24 V	I
Generic Lo Generic Lo Generic Hig Shinano LA Bull Runnin Allen Bradl 3-phase Mo	w voltage <= 50V igh voltage > 50V 4052-080E3NL1 ng BR2804-1700kv ley TL-A220P-HJ32AN totor BR2804		Pole Pairs Nominal Speed Nominal Voitace Nominal Current	2 4000 rpm 24 V	
Generic Lo Generic Lo Generic Hig Shinano LA Bull Runnin Allen Bradl 3-phase Mo	w voltage <= 50V igh voltage > 50V 4052-080E3NL1 ng BR2804-1700kv ley TL-A220P-HJ32AN totor BR2804		Pole Pairs Nominal Speed Nominal Voitace Nominal Current	2 4000 rpm 24 V	
Generic Lo Generic Lo Generic Hig Shinano LA Bull Runnin Allen Bradl 3-phase Mo	w voltage <= 50V igh voltage > 50V 4052-080E3NL1 ng BR2804-1700kv ley TL-A220P-HJ32AN totor BR2804		Pole Pairs Nominal Speed Nominal Voitace Nominal Current	2 4000 rpm 24 V	OK

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 Project Info window
--

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



	kbench [P-NUCLEO-IHM001-	BullRunning]*					
File Tools Help	Documentation	_					
		2 🚹 <	- 1	cons and M	enu area		
				0 ILIM001 20	h haara		LEO-F302R8 - Power Board: P-NUCLEO-IHM001 3Sh - board: X-NUCLEO-IHM07M1
WOLDI. Buil Running E		orboard. PM	IUCLE	J-IF1WID01 53.	n - Doard	NOCI	
Hardware setup information	AC Input I Inrush Cur Limiter	rent	**	PFC			Bus Voltage Sensing State Processing Bus Voltage Sensing Bus Voltage Sensing Processing Procesing Processing Procesing Processing Processing Pr
	Clock			Input	User Interfac	Drive Phase Phase Phase	
Main hardware sett	ings 🔺		Us	er informat	ion 🞽		
Variable	Motor	Unit		Time	Motor	ld	Message
WM frequency	30000	Hz	6	03:20:55	MULUI	iu.	The 'LCD' is not supported in the FW for SDK5.x. All parameters will be disabled.
Sensor selection main	Sensor-less (Observer+PLL)		X	03:20:55			The 'LCU' is not supported in the FW for SUK5x. All parameters will be disabled. The 'PFC' is not supported in the FW for SDK5x excepted for SDK for 'STM32F103 High Density'. All parameters will be disa
ensor selection aux	Sensor-less (Observer+Cordic)			03:20:55			
orque&Flux - Execution rate	e 1	PWM periods	ŏ	03:20:55			The 'Sensor-less (HFI+Observer)' is not supported in the FW for SDK5x. All parameters will be disabled. F2 mcus are not supported in the FW for SDK5x
us voltage sensing	true		-	03:20:55			
ver-voltage	true		0				F103 High Density in dual Motor mous are not supported in the FW for SDK5x
Inder-voltage	true		•	03:20:56			The new project P-NUCLEO-IHM001-BullRunning (to be saved) has been created as copy of the example project P-NUCLE
emperature sensing	true						
Current reading topology	Three Shunt Resistors						

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 35

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





Function	lcon	Description
Create a new project	ŧ	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 35</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 34</i>
Help	2	Open the on-line help file
About	i	Check the ST MC Workbench software tool version, as shown in <i>Figure 38</i>

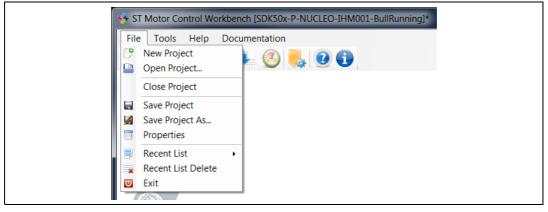
Table 3. ST MC Workbench – Menu icons



3.3.1 File menu

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

Figure 20. ST MC Workbench - File menu



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



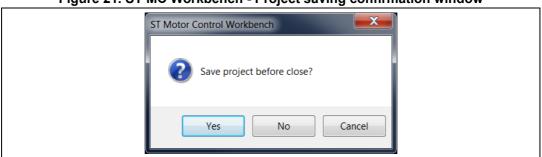


Figure 21. ST MC Workbench - Project saving confirmation window



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

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	
		_



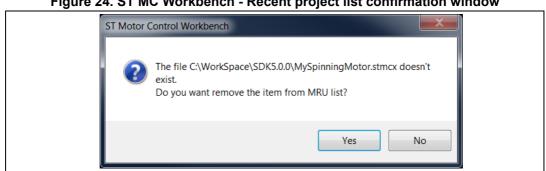
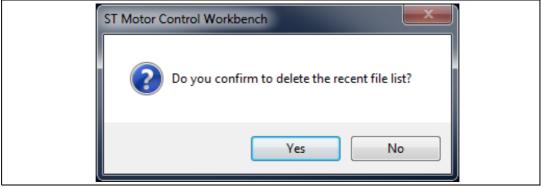


Figure 24. ST MC Workbench - Recent project list confirmation window





3.3.2 **Tools menu**

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

Figure 26. ST MC Workbench - Tools menu

🐝 ST N	lotor (Control Workbench [SDK50x-P-I	NUCLEO-IHM001-BullRunning]*
File	Tool	s Help Documentation	
	*	Pin assignment Generation	(2) (1)
a	• @	Monitor	
R	×	Clear Log	
	-	Export Log	
		Restore Info Message	
Pow	er Stag	je	



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 an existing *.ioc file (useful to keep additional modifications from STM32CubeMX usage).
 - 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 34*. Refer to *Section 3.7* for details.
- Clear the user information sheet, as shown in *Figure 35*.
- Export the user information sheet in a log file in text format and open it in a text editor, as shown in *Figure 36*.
- Show user information messages when necessary.



Assignment		
Function	Port/Pin	Available Shared
Motor Contro	l Timer (TIM1)	
CH1	A8	C0, A8
CH2	A9	C1, A9
CH3	A10	C2, A10
BKIN	A11	C3, A11
Start/Stop bu	tton Pin (DIO -	BTN)
GPIO	C13	C13
Driver Signal	Enable (DIO - N	VICT - Enb)
GPIO	C10	C10
GPIO	C11	C11
GPIO	C12	C12
USART Chann	el (USART2) —	
TX	A2	A2, A14, B3
RX	A3	A3, A15, B4
Phase current	feedback ADC	(ADC1)
ADC1_IN1	A0	A0
ADC1_IN7	C1	C1
ADC1_IN6	C0	C0
Bus Voltage f	eedback ADC (ADC1)
ADC1_IN2	A1	A1
Temperature	feedback ADC	(ADC1)
ADC1_IN8	C2	C2
DAC (Debug)		
CH1	A4	A4
Conflicts:		
- functions: 0		
- pins: 0		
ress check but	tton for more inf	ormation
Check	Reset	

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

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

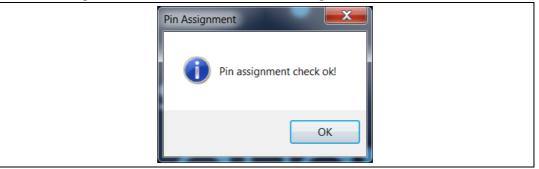
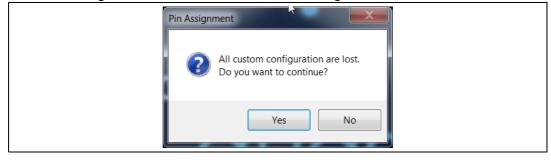


Figure 29. ST MC Workbench - Pin Assignment reset window



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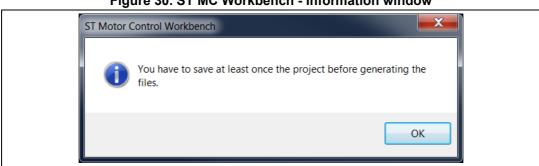


Figure 30. ST MC Workbench - Information window



Project generation		— ×
Settings Generation		
Version info:		
MC Workbench :	5.1.0.18254	
WB to Mx :	0.11.5.template-18-06-05	
STM32CubeMX :	4.25.1	
MC Firmware Library:	5.1.1	
Generation options:		
Target Toolchain :	IAR EWARM	
Target Driver :	HAL - Hardware Abstraction Layer	
Generating		
C:\WorkSpace\SDK5.0.0\1	Tests\Test MCSDK\	
\Test MCSDK.ioc		
\.extSettings		
\Test MCSDK.ioc.ba	ik	
Code generation started	1	

Figure 32. ST MC Workbench - User information sheet example

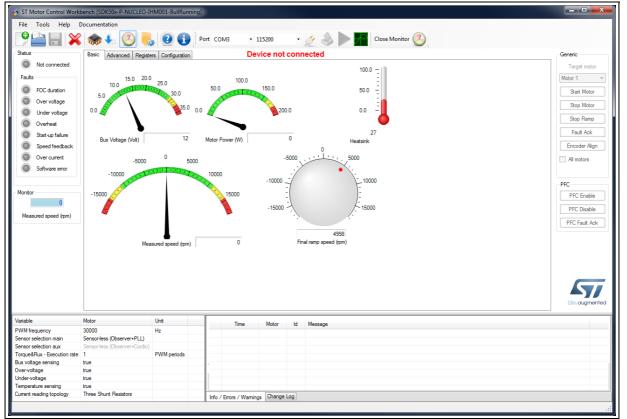
	Time	Motor	ld	Message	
	02:51:37			Project 'SDK50x-P-NUCLEO-IHM001-BullRunning' saved successfully.	
	02:51:37			Generation files starting	
	02:51:37			Create the output folder C:\WorkSpace\SDK5.0.0\SDK50x-P-NUCLEO-IHM001-BullRunning	
	02:52:19			File generated on folder: 'C:\WorkSpace\SDK5.0.0\SDK50x-P-NUCLEO-IHM001-BullRunning'	
6.1	Errors / War	ninge Ch	angel	00	



Settings Generation	 	
STM32CubeMx		
4.25.1		•
Target Toolchain		
IAR EWARM		7
IAR EWARM		2
Keil MDK-ARM V4		
Keil MDK-ARM V5		
ST SW4 STM32		
ST TrueSTUDIO		
HAL/LL Drivers Selection		
HAL - Hardware Abstraction Layer		-

Figure 33. ST MC Workbench - Project Settings option window

Figure 34. ST MC Workbench - Monitor window





Time	Motor	ld	Message	

Figure 35. ST MC Workbench - User information sheet cleared

Figure 36. ST MC Workbench - User information log file example

SDK50x-P-NUCLEO-IHM001-BullRunning.log - Notepad	X
File Edit Format View Help	
App: STMCWB Time: 02/20/2018 15:09:46	
Project: SDK50x-P-NUCLEO-IHM001-BullRunning	
Filéname: C:\WorkSpace\SDK5.0.0\SDK50x-P-NŬCLEO-IHM001-BullRunning.log Type Time Motor Id Message	
UNK 03:08:27 Generation files starting UNK 03:08:54 File generated on folder: 'C:\WorkSpace\SDK5.0.0\SDK50x-P-NUCLEO-IHM001-BullRunning'	
UNK 05.06.34 FILE generated on Torger. C. (workspace/SDK5.0.0/SDK50X-P-NOCLEO-IHM001-BullKunining	
	-

3.3.3 Help menu

Figure 37 shows the Help menu of the hardware configuration window.

ST Motor Control Workbench [SDK50x-P-NUCLEO-IHM001-BullRunning]*
File Tools Help Documentation

Figure 37. ST MC Workbench - Help menu

This menu allows the user to:

- Have easy access to the on-line help file
- 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 38*.



About ST Motor Control W	/orkbench					
	ST Motor Control Workbench Ver. 5.2.0.18503 Copyright © STMicroelectronics 2018 <u>online support</u>					
.	MCSDK_v5.2.0-Full WB_to_Mx version "0.13.3" WB_to_Mx.template version "18-08-02" [Device] Device not connected [Modules] MMICalc 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> OK					

Figure 38. ST MC Workbench - About window



3.3.4 Documentation menu

Figure 39 shows the Documentation menu of the hardware configuration window.

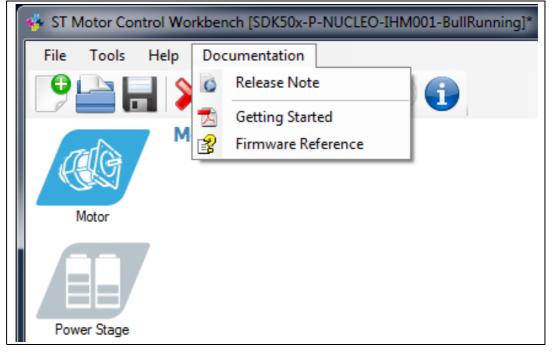


Figure 39. ST MC Workbench - Documentation menu

This menu allows the user to:

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

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:

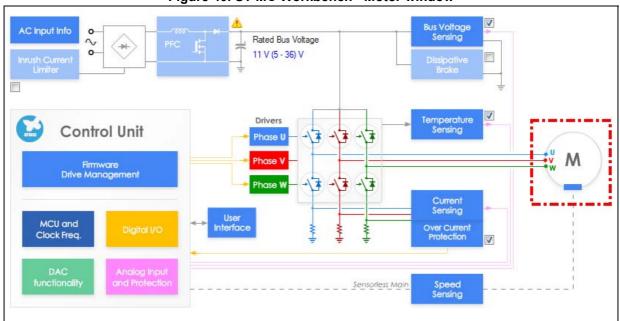
- Motor on page 35
- Power stage on page 38
- Drive management on page 47
- Control stage on page 59

3.4.1 Motor

Figure 40 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 41
- the sensors GUI is shown in *Figure 42*







The PMSM motor parameters are imported from the ST Motor Profiler tool (refer to *Section 2*) or entered manually, as shown in *Figure 41*.

Figure 41. ST MC Workbench - Motor parameter GUI

Magnetic structure Bectrical parameters Pole Pairs	Surface Mounted Pl	N2W •	Magnetic structure Bectrical parameters	Internal PA	ISM •
			Eactrical parameters		
Pole Pars	100		Criteria Process		
	7 🔄		Pole Pairs	7	(Φ)
Max. Application Speed	18000	gm -	Max. Application Speed	18000	de em
Nominal Current	1.20	Apk	Nominal Current	1.20	Apk
Nominal DC Voltage	10.0	v	Nominal DC Votage	10.0	↓ V
Ra	0.11	Ohm	Ra	0.11	0hm
La .	0.018	mil .	ы	0.600	(c) eH
8-Enf constant	0.4	Vina.Arpm	14	0.600	in the set
			Ld Lg ratio	1.000	4
			B-Enf constant	0.4	- Vms.kpm



The selection of the sensors used (all selection configuration are allowed) and the setting of sensor parameters is illustrated in *Figure 42*.

90	
	Motor - Parameters
	Mator Sensors
	Sensors Image: Sensors displacement Image:
	Save parameters Done

Figure 42. ST MC Workbench - Sensor parameter GUI

Click on the *Save parameters* buttons (refer to *Figure 41* 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 - Sa	ve motor parameter window
---------------------------------	---------------------------

Save Motor		×	
Name			
Bull Runner			
Description			
Doc example			
	ок с	ancel	



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)

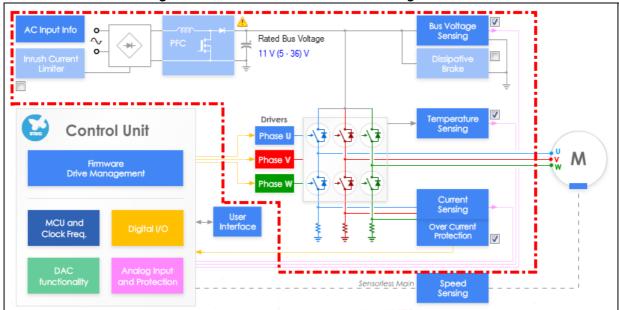


Figure 44. ST MC Workbench - Power Stage window



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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.

C Input Info	And Personal Property in which the	A REAL PROPERTY.	AC Input Info
	Hardware Settings		Hardware Settings
Votage Minimum Maximum Nominal	230 V - 50Hz ● 185 ● Vima 265 ● Vima 230 ● Vima	● 50 Hz ● 60 Hz	Voltage 230 V-50 Hz Minimum 115 V-60 Hz Maximum wide range - 50 Hz custom 60 Hz Nominal 230 🐑 Vima
	Firmware protection		Firmware protection
Over-voltage	threshold to maximum power stage input voltage	•	Over votage Image: Set intervention threshold to maximum power stage input votage Over votage 255 Image: The set of the
		Done	Done

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.

Power Stage - Rated Bus Voltage Info	
Rated Voltage Min rated voltage Max rated voltage Nominal voltage	5 A V 36 V 11 A V
	Done

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



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.

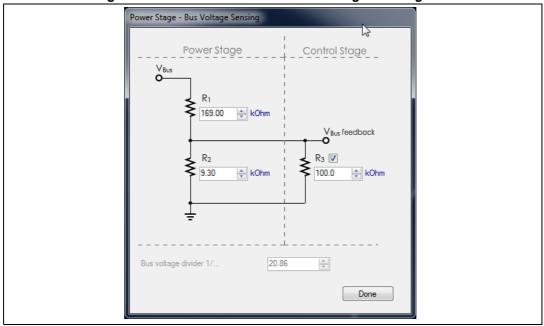


Figure 47. ST MC Workbench - Bus Voltage Sensing GUI



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.

nperature 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 🚔 ℃
Firmware	protection
Enable	protection
Enable Over-Temperature	
Enable Over-Temperature Set intervention threshold to pow Over-temperature threshold	er stage max working temperature
 Enable Over-Temperature Set intervention threshold to pow 	er stage max working temperature

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.

urrent sensor and signal condition	ning			Current sensor and signal condition	ing		
Current reading topology	Three Sh	unt Resistors	•	Current reading topology	Three Sh	unt Resistors	-
ICS gain	1.000			ICS gain	Three Sh	nt Resistor unt Resistors	
Shunt resistor(s) value	0.330	0 ohn		Shunt resistor(s) value	0.330	lated Current Sens	ion
Amplification on board	(V)			Amplification on board	V		
Amplifying network gain	1.53	-	Calculate	Amplifying network gain	1.53	(A) (T)	Calculate
Trise	700	te na		Trise	700	÷ na	
Tricise	700	i na		T-noise	700	💠 na	
Max Readble Current:	3.268 A			Max Readble Current:	3.268 A		
			Done				Done



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

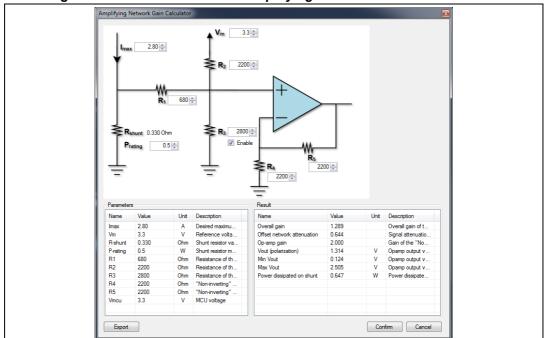


Figure 50. ST MC Workbench - Amplifying Network Gain Calculator GUI

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.

Over Current Protection				Over Current Protection			
Comparator threshold	0.50	÷	v	Comparator threshold	0.50	*	v
Over current network offset	0.00	-	v	Over current network offset	0.00	*	٧
Over current network gain	0.18	*	V/A	Over current network gain	0.18	12	V/A
Expected over-current threshold	2.7778		A	Expected over-current threshold	2.7778		A
Over-current feedback signal polarity	Active low	•		Over-current feedback signal polarity	Active low		
Over-current protection disabling network				Over-current protection disabling network			
Over-current protection disabling network polarity	Active high	*		Over-current protection disabling network polarity	Active high	•	
					Active low		ccLe

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.

High side driving signal Polarity Active high Low side driving signal Complemented from high side Polarity Active high HW inserted dead time 800 Driver enabling signal signal V Polarity Active high	wer Stage - Driving Signals Pola	arity - U Driver	
Active low Active high Low side driving signal Complemented from high side Polarity Active high HW inserted dead time 800 Driver enabling signal signal Polarity Active high	High side driving signal		
Low side driving signal Complemented from high side Polarity Active high HW inserted dead time 800 ns Driver enabling signal signal Polarity Active high V Force same values for U,V,W Driver	Polarity	Active low	
Polarity Active high ▼ HW inserted dead time 800 ★ Driver enabling signal ▼ signal ✓ Polarity Active high V Force same values for U,V,W Driver	Low side driving signal	Active high	
HW inserted dead time 800 🚖 ns Driver enabling signal Image: Constraint of the second secon	Complemented from high side		
Driver enabling signal signal Polarity Active high	Polarity	Active high 👻	
signal Polarity Active high Force same values for U,V,W Driver	HW inserted dead time	800 ns	
Polarity Active high	Driver enabling signal		
☑ Force same values for U.V.W Driver	signal		
	Polarity	Active high	
Share signal enable	Force same values for U,V,W Dri	ver	
	Share signal enable		
		[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			
Min dead-time Max switching frequency	₿00 💉 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		
Polanty	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.

		1		
Ha	rdware Settings	Hardware Se	ettings	
Polanty	Active high Active low Active high	Polarty Active h	igh 💌	
Additional Features		Additional Features		
🖭 enable		V enable		
Power on state	Inactive *	Power on state Inactive	-	
Change state after	1000	Change state after Inactive	ms	
		11		
	Done		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.

anti-ana Sattiona Lanna a	1					
ardware Settings PFC Parameter						
	На	rdwa	re Setting	s		
loninal power	1000	0	w			
Ioninal current	6.149	-				
Prunt resistor value	0.220	1				
OPAMP on power stage			630			
/ use OPAMP for Current Protection						
Comparator threshold	1.20		v			
Overall network gain	2.76	-				
Opected Over Current threshold	1.976	-	Ack			
fax. power transistor current.	10.000	1				
C votage sensing divider 1/	116	÷				
fon propagation delay	2550	1	-			
off propagation delay	2550	4				
Driving signal polarity	Active low	_				
Overcurrent signal polarity	Active low					
C Mains synch signal polarity	Faling edg					
r Factor Correction						Don
ardware Settings PFC Parameter		FC P	arameters	3		Don
		FC P	arameters	3		Don
ardware Settings PFC Parameter	Pf					
ardware Settings PFC Parameten	Pf		arameters _{Hz}	1000 💠 /	16 🕀	
adware Settings PFC Parameter Distribution feature Current Regulation	Pf 900	¢	Hz	1000 💠 /	16 🕀	
adware Settings PFC Parameter Enabling feature Current Regulation PWM firequency	Pf 900	•	Hz	1000 💠 /	16 🕀	F
ardware Settings PFC Parameter I Enabling feature Current Regulation PWM frequency Current regulation execution rate SW Current Limitation	Pf 40000 1 4.999	•	Hz PWM periods	1000 💠 /	16 🕀	
ardware Settings PFC Parameter PC Enabling feature Current Regulation PWM frequency Current regulation execution rate SW Current Limitation Voltage Regulation	Pf 40000 1 4999 000	•	Hz PWM periods Apik	1000 💠 /	16 🔹	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
ardware Settings PFC Parameter I Enabling feature Current Regulation PWM frequency Current regulation execution rate SW Current Limitation	Pf 40000 1 4999 000	() () () () () () () () () () () () () (Hz PWM periods Apk	1000 († 7 700 († 7	16 © 16 ©	1 1
adware Settings PFC Parameter Enabling feature Current Regulation PWM frequency Current regulation execution rate SW Current Limitation Voltage Regulation Output voltage reference	Pf 200 40000 1 4.599 200 350	* • •	Hz PWM periods Apk	1000 († / 700 († / 1000 († /	16 ©	P
adware Settings PFC Parameter Enabling feature Current Regulation PWM frequency Current imputation execution rate SW Current Limitation Voltage Regulation Output voltage reference PFC over-voltage threshold	Pf 40000 1 4999 250 350 370	* • •	Hz PWM periods Apk V V Hz	1000 († / 700 († / 1000 († /	16 ©	P
adware Settings PFC Parameter Enabling feature Current Regulation PWM frequency Current imputation execution rate SW Current Limitation Voltage Regulation Output voltage reference PFC cover-voltage threshold Voltage regulation frequency	Pf 40000 1 4999 20 20 350 370 100	* • • •	Hz PWM periods Apk V V Hz ms	1000 († / 700 († / 1000 († /	16 ©	P
adware Settings PFC Parameter Description feature Current Regulation PWM frequency Current regulation execution rate SW Current Limitation Voltage Regulation Output voltage reference PFC over-voltage threshold Voltage regulation frequency Soft Start Duration	Pf 40000 1 4 599 550 370 100	* * * *	Hz PWM periods Apix V V Hz W	1000 († / 700 († / 1000 († /	16 ©	P
ardware Settings PFC Parameter PFC Parameter Current Regulation PWM frequency Current regulation execution rate SW Current Limitation Voltage Regulation Output voltage reference PFC over voltage inference PFC over voltage inference	Pf 40000 1 4.999 350 370 100 300 250 50		Hz PWM periods Apk V V V Hz ma W W	1000 († / 700 († / 1000 († /	16 ©	P
ardware Settings PFC Parameter Current Regulation PWM frequency Current regulation execution rate SW Current Limitation Voltage Regulation Output votage reference PFC over votage treahold Votage regulation frequency Soft Start Duration Switch-on Power level Switch-off Power level	Pf 40000 1 4.999 350 370 100 300 250 50		Hz PWM periods Apix V V Hz W	1000 († / 700 († / 1000 († /	16 ©	

Figure 56. ST MC Workbench - Power Factor Correction GUI



Δ7/

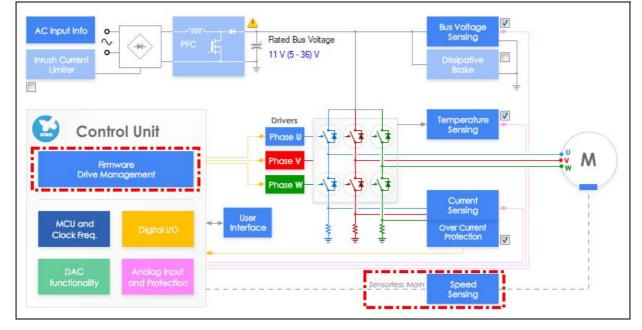
46/79

3.4.3 Drive management

Figure 57 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

Figure 57. 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 58*), 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 59*), user configures the sensor-less estimator. User may also customize the Luenberger observer PI filter.
- Through the Quadrature encoder selection (*Figure 60*), user parametrizes the sensor usage. User choses the counter direction.
- Through the Hall sensors selection (*Figure 61*), 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 62*).



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

	-	
Drive Management - Speed Position Feedback Manage	ement	
Main sensor Auxiliary sensor		
Sensor selection Sensor-less (Observ	ver+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 59. 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		
Reverse counting direction		
		Done

Figure 60. ST MC Workbench – Speed/Position Feedback Management GUI (Quadrature encoder)



		(
Drive Management - S	peed Position Feedbac	k Management		
Main sensor Aux	xiliary sensor			
Sensor selection	Hall sens	ors 🔻		
	ors number before fault	3		
Hall Sensors		-		
Average speed FIF	0 donth	6		
Input Capture filter	duration	1.3	usec	
				Done

Figure 61. ST MC Workbench – Speed/Position Feedback Management GUI (Hall sensors)



Drive Management - Speed Position Feedba			
Main sensor Auxiliary sensor			
Enable auxiliary sensor			
Sensor selection Quadrat	ture encoder	•	
Max measurement errors number before fault	3		
Quadrature Encoder			
Average speed FIFO depth	16	▲ ▼	
Input Capture filter duration		↓ Usec	
Reverse counting direction			
			Done

Figure 62. ST MC Workbench – Auxiliary sensor(-less) GUI





Figure 63 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.

DWM		D. C. J			
PWM generation and current reading		Default settings			
PWM frequency 30000 Hz		Control mode	Speed contr	ol 👻	3
High sides PWM idle state Tum-off ▼	1	Target speed	3000	rpm	
Low side signals and dead-time					
SW inserted dead-time 800 ns		Target stator current flux component	0.00	A A	
Low sides PWM idle state		Target stator current torque	0.00	A A	
		Torque and flux regulators			
Speed regulator		Execution rate	1	 PWM periods 	4
Execution rate 1.0 ms	2	Cut-off frequency	6000	rad/s	
		Torque	Flux		
1000 <u>+</u> / 16 <u>+</u> P		964 🔶 / 16384 🔶	P 964	÷ / 16384 ÷	Р
600 🚔 / 256 🚔 I		196 🔺 / 16384 🐥	196	÷ / 16384 ÷	1
Manual editing enabled					
		Manual editing enabled			
				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 64 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.

7 Enable Over-voltage Motor control Enable		Under-voltage Image Image
Set intervention threshold to Over-voltage threshold On over voltage On over-voltage, disable over	36 V Disable PWM generation ▼	Under-voltage threshold 5

Figure 64. 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 65*), 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 66*), 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 67*), 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 68*), 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		
Speed ramp duration	3000	<u>▲</u> ms	Ē	
Speed ramp final value	4000	rpm	Sneed (rnml	2000
Current ramp initial value	1.00	A	0	° 1000 - 0.5
Current ramp final value	1.20	A		0 0.0
Current ramp duration	100	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	÷ rpr	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 T		
Alignment electrical angle	90	deg		
Final current ramp value	1.95	A		
				Done

Figure 65. 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					
Include alignment before ramp-up	V			Start up on Fly Detection Duration	1000 📥 ms
Duration	300	🚖 ms		Braking Duration	1000 🚔 ms
Alignment electrical angle	90	÷ deg			
Final current ramp value	1.00	A		4000	2.0
Speed ramp duration	3000	ms ms	Speed (rpm)	3000	-1.5
Speed ramp final value	4000	🜩 mpm	peed	2000 -	
Current ramp initial value	1.00	A A	s	1000 -	- 0.5
Current ramp final value	1.20	â		0	⁻ 0.0
Current ramp duration	100	s ms		0 1000 Duration	2000 3000 (ms)
Consecutive succesful start-up outpu	t tests	2	<u>*</u>		
Minimum start-up output speed			≚ ∎ rpm		
Estimated speed Band tolerance upp	er limit		v 1.p € %		
Estimated speed Band tolerance low			* %		
ncoder alignment settings					
Duration	700	ms ms			
Alignment electrical angle	90				
Final current ramp value	1.95	A A			
					Done

Figure 66. ST MC Workbench – Start-Up Parameters GUI (Basic On-the-Fly)



Profile Basic						
		deg				
1) 700 🚖 2000		70 🚖	2	000 - 000		- 1.0
2) 700 ⇒ 2000 3) 700 ⇒ 2000		70 🔶 70 🔶	_ 1	500 -		-
3) 700 ↓ 2000 4) 700 ↓ 2000		70 🚖 70 🚖	臣	000 - //		- Current (A
 4) 700 ≥ 2000 5) 700 ≥ 2000 	↓ 0.↓ 0.		Speed	500 -		. <u>Š</u>
Consecutive succesful start-up o	utput tests	2		Rev-up to FOC switc	h-over	
linimum start-up output speed	uppor limit	1000		Duration	25	ms
stimated speed Band tolerance			%			
Estimated speed Band tolerance Estimated speed Band tolerance ncoder alignment settings						
stimated speed Band tolerance	700	▲ ▼ MS				
stimated speed Band tolerance		★ ms ★ deg				
stimated speed Band tolerance nooder alignment settings Duration	700					

Figure 67. 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	Star	t up on Fly		
initial electrical angle	50	The second		ection Duration	1000	ms
Duration (ms) Final sp	eed (rpm) Fir	nal current (A)	Bral	king Duration	1000	s ms
1) 700 🚔 2000		0				
2) 700 🚔 2000	0.7	0	2000			- 1.0
3) 700 🚔 2000	÷ 0.7	0	1500 ·	1 /~		
			Libro Speed (rpm)	- //		- 0.5 Current (A
			g 500			[≥
			0	0 500	1000 1500	2000
					Duration (ms)	2000
					Surgion (mo)	
Consecutive succesful start-up ou	tput tests	2				
Minimum start-up output speed		1000 🚖	rpm			
Estimated speed Band tolerance (upper limit	106.25	%			
Estimated speed Band tolerance I	ower limit	93.75	%			
ncoder alignment settings						
	700	ms ms				
Duration						
	90	deg				
Duration	90	deg				
Duration Alignment electrical angle						
Duration Alignment electrical angle						
Duration Alignment electrical angle						

Figure 68. ST MC Workbench – Start-Up Parameters GUI (Advanced On-the-Fly)



Figure 69 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 69. ST MC Workbench – Additional Features and PFC settings GUI

Drive Management - Additional Feature	es and PFC settings	
Flux weakening	Flux weakening	
MTPA	3000	↓ 32768
	5000	★ / 32768 ÷ I
Feed Forward		
	Voltage limit	98.5 🍣 %
Sensorless speed feedback		
Inrush Current Limiter		Done

3.4.4 Control stage

Figure 70 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	PFC I	Rated Bus Voltage	Bus Voltage Sensing Dissipative Brake	
	rol Unit	Phase U	Temperature Sensing	M
	Digital I/O	User Interface	Current Sensing Over Current	-
DAC functionality	Analog Input and Protection	÷ ÷ -	soriess Main Speed	1

Figure 70. ST MC Workbench - Control Stage window

Figure 71 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 71. ST MC Workbench – MCU and Clock Frequency GUI

Figure 72 shows the Analog Input and Protection GUI, where the user selects the MCU pin assignments and configures the analog input parameters.



Embedded PGA Over Curre	nperature feedback PFC stage feedback nt Protection Topology imbedded HW OCP idemal Protection	Embedded PGA Extern Extern	sture feedback PFC stage feedback otection Topology dded HW OCP a) Protection
External OPAMP In the second operating Setting Sampling Time Ins Maximum modulation S8 Y, Perpheral Selection ADC1/ADC2	ls protection Pin map Ch phase U Ch phase U ADC12_INS(C2) Ch phase V ADC12_INS(C3) Ch phase W ADC12_INS(C0)	External OPAMP No pro Sensing Sensing Sensing Sensing Time Samping Time 1083 Maximum modulation 91 Perpheral Selection ADC1/ADC2	Pri map On phase U ADC1_IN3 (A2) On phase V ADC2_IN3 (A6) On phase W ADC1_LIN3 (C0)
OPAMP Seitrag OPAMP10PAMP: Perpheral selection OPAMP10PAMP: OPAMP Gan Internal Int gan type 2 Overall Network Gan 144 Out (polatization) 1710 Teter 250 gan Teter 250 gan	Ch U A1 OPAMP1 A3 OPAMP1 A2 Ch V A7 OPAMP2 C5 OPAMP2 A6	Sonaing OPAMP Sating Perphenal selection OPAMP1/0PAMP2 → OPAMP Gan Internal → Int gain type 2 → Overall Network Gan 1.44 Calculate Vout (polarization) 1.710 V Trate 2550 ⊕ ns	Ch U A1 OPAMP1 A3 OPAMP1 A2 Ch V A7 OPAMP2 C5 OPAMP2 A6
tection Seting Data filter duration Byte filter duration Byte filter duration Byte filter Current threshold Current threshold 12 v V ○ dock dock 0 dock 12 v V ○ dock 0 dock	Pin map none Output Not investing Output Output Ch U A2 * Oh U A2 * Ch V B0 * COMP2 Oh U A2 * Ch W B1 * COMP6 Oh W A10 *	Protection Setting Digital filter duration Investing input Internal Current threshold Output anable Output anable Protection Setting Output anable Protection Setting Output anable Setting Output anable Setting Se	Pn map 3 Investing ipot none 3 Nat investing 0 up t 0 up t Ch V A1 COMP1 0 u A0 * Ch V A7 COMP2 0 v A2 * Ch W B14 COMP3 0 v Cs *

Figure 72. 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* 73), 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 73. ST MC Workbench – Analog Input and Protection GUI (Bus voltage feedback)

Control Stage - Analog Input and Protect	on			
Phase current feedback Bus voltage feedb	ack Temperatur	re feedback PFC :	stage feedback	
Sensing Setting Sampling Time 61.5 Peripheral selection ADC1	✓ ADC clk✓	Pin map ADC Channel	ADC1_IN2 (A1)	•
🔲 use Input Resistance (R3)	I	Input Resistance	100.0 kOhm	Bus Voltage Partitioning
(
				Done



Through the Temperature feedback tab (*Figure 74*), user selects and configures the ADC for the temperature image acquisition (usually an NTC resistor) as well as its input pin usage.

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

ontrol Stage - Analog In				
	Bus voltage feedback Temperatu	re feedback PFC stag	ge feedback	
Sensing		Pin map		
Sampling Time	61.5	ADC Channel	ADC1_IN8 (C2)	
Peripheral selection				
				Dana
				Done



Through the PFC stage feedback tab (*Figure 75*), user selects and configures the ADC for the PFC current sensing and the AC voltage sensing, as well as their input pins usage.

Figure 75. 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 76 shows the DAC functionality GUI, where the user selects the DAC channel used for debug (if any) and the data to output.

Figure 76.	ST MC	Workbench -	DAC	functionality	y GUI
------------	-------	-------------	-----	---------------	-------

la		A.4	
la		A.4	
		A4	
lb	•	A5	
			Done
	lb	lb	lb ▼ A5

Figure 77 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 Encoder interface	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 V Pin C13 V CH2 Port GPIOC V Pin C13 V CH3 Port GPIOC V Pin C13 V	Timer TIM2 * Remap No remap * Pin Map CH1 A15 * CH2 B3 *	Timer TIM2 Remap No remap Pin Map CH1 A0 CH2 A1 CH3 A2	Port GPIOE -
PFC drive signal and feedback Pin Ma PWM Remap Partial re-map OCS	ap Seri	al communication hannel USART3 Fin Map TX C1 audrate 9600 RX C1 emap Partial re-ma	Pin A0	- -

Figure 77. ST MC Workbench – Digital I/O GUI

Figure 78 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.



Figure 76. ST INC WORKDEIICI	n – User Interface Add-on GUI
User Interface	
HW / Features MCU Pins	
LCD 🔺	Start/Stop Button
Available on Control Board	☑ Available on Control Board
Enable	✓ Enable
Full	
 Light 	
 Available on Control Board Enable 	Communication
 Bidirectional Fast unidirectional 	
CH1 M1 la CH2 V la	
	Done

70 CT MC Markhanah Llear Interface Add on CIII

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 79.

Figure 79. 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 80.

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 80. 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 81 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

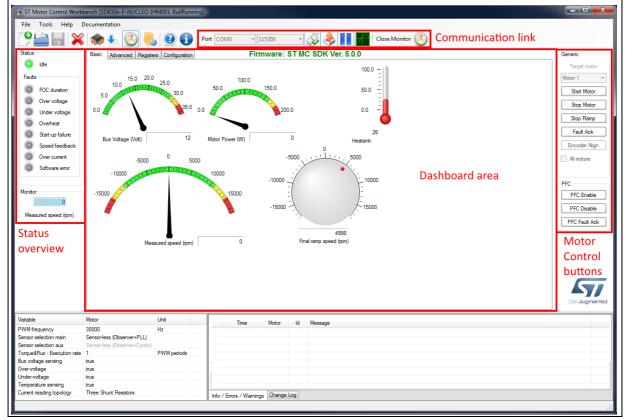


Figure 81. ST MC Workbench - Monitor and spin control GUI



3.7.1 Communication link

The communication link area (refer to *Figure 81*) 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.
	×.	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 82</i> .
Close the monitor and spin control GUI	Close Monitor 🥙	Exits the GUI.

 Table 4. ST MC Workbench - Communication link GUI commands



Figure 82 shows the plotting window with an example illustrating the measured speed vs. the reference.

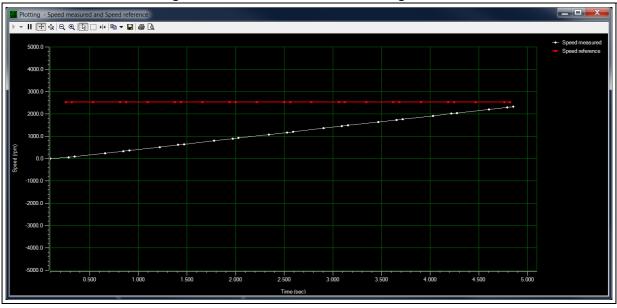


Figure 82. ST MC Workbench - Plotting window



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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 83*)
- Advanced view (refer to Figure 84)
- Expert views (refer to *Figure 85* and *Figure 88*)

Figure 83 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

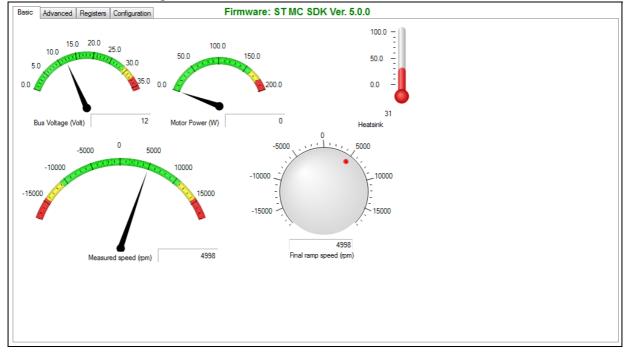


Figure 83. ST MC Workbench - Basic dashboard view



Figure 84 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 84. ST MC Workbench - Advanced dashboard view

Basic Advanced Registers Configuration	Firmware: ST MC SDK V	Ver. 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 📗 🔻	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) 0	Target speed 3000 mm	Observer C2 0	
Flux ref (ld) 0	Duration 1000 📄 millisec		
	Exec ramp	Flux weakening tuning	
Measured currents	PID Gains	Kp 0	
Torque (lq) 1628	Кр 2751	Ki O	
Flux (ld) 359	Ki 1359	BUS Voltage allowed	
Flux (id) 355		Ref 0 ‰	
Iq PID Gains		Meas 0 %	
Кр 696 Кр 696			
Ki 357 Ki 357			
L			



Figure 85 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	1
•	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	٦
	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 (lq)		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	V	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	

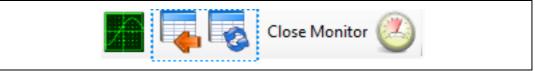
Figure 85. ST MC Workbench - Expert dashboard register view

When using the expert dashboard register view, the user has access to the additional icons shown in *Figure 86*:

- 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 87*
- 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 86. 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			— ×
🕘 🕞 🗕 📕 k Computer 🕨	OSDisk (C:) ► WorkSpace ► SDK5.0.0 ►		👻 🍫 Search SDK	5.0.0
Organize 👻 New folder				:=
☆ 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
🍌 Imaging				
MCD SW Development				
MCD Documents				
퉬 Users Application				
潯 Libraries 🔹	•			
File name	MCSDK - Example1.stmcx		✓ STMotor Cor	ntrol files (*.stmcx, 🔻
			Open	Cancel

Figure 87. ST MC Workbench - Import registers configuration window

Figure 88 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 88. ST MC Workbench - Expert dashboard configuration view

Import from builder	r		Num	Final Speed (rpm)	Final Torque	Duration (ms)	Last read	Last write	
Motor available Sir	nale Motor 🔻	•	1	0	11029	1000	2018-02-21 15:15:48.854	never	
Motor 1 or any moto	-		2	2814	11029	5628	2018-02-21 15:15:48.916	never	
Sensor-less (O			3	2814	11029	0	2018-02-21 15:15:48.979	never	
Sensor-less (O			4	2814	11029	0	2018-02-21 15:15:49.041	never	
Quadrature en			5	2814	11029	0	2018-02-21 15:15:49.104	never	
DAC channels Control mode: Spee									
·	-18000 (*) 18000 (*) 36.0 (*) 80 90 90 90 90 90 90 90 90 90 9				1	1			Reload



3.7.3 Motor control buttons

The motor control button area is shown in *Figure 89*. 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 89. ST MC Workbench - Motor remote control button view

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



3.7.4 Status overview

The status overview, illustrated in *Figure 90*, provides information on:

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



Status
O Idle
Faults
FOC duration
Over voltage
Under voltage
Overheat
Start-up failure
Speed feedback
Over current
Software error
Monitor
0
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 - Pin Assignment window, Figure 31: ST MC Workbench - Script progress window, Figure 38: ST MC Workbench - Project Settings option window, Figure 38: ST MC Workbench - About window, Figure 39: 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.
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 38: ST MC Workbench - About window, Figure 44: ST MC Workbench - Power Stage window, Figure 57: ST MC Workbench - Drive Management window and Figure 70: ST MC Workbench - Control Stage window.

Table 5. Document revision history



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