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) field-oriented 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 permanent-magnet synchronous motors within the STM32 ecosystem.

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

1 General information ......................................................... 7
  1.1 Definitions ............................................................... 7
  1.2 Reference documents .................................................. 8

2 ST Motor Profiler ............................................................. 9
  2.1 Launching the ST Motor Profiler ....................................... 9
  2.2 Hardware setup configuration ........................................ 10
  2.3 Hardware setup connection ........................................... 13
  2.4 Motor profiling .......................................................... 16
  2.5 Profiled motor saving ................................................... 16
  2.6 Motor spinning .......................................................... 17
  2.7 Closing the ST Motor Profiler ......................................... 18

3 The ST Motor Control Workbench ........................................... 19
  3.1 Creating a new project .................................................. 21
  3.2 Loading an existing project ............................................ 23
  3.3 Icons and Menu area .................................................... 24
    3.3.1 File menu .......................................................... 26
    3.3.2 Tools menu ....................................................... 28
    3.3.3 Help menu ........................................................ 33
    3.3.4 Documentation menu ............................................ 35
  3.4 Configuring a project .................................................. 35
    3.4.1 Motor ............................................................... 35
    3.4.2 Power stage ...................................................... 38
    3.4.3 Drive management ............................................... 47
    3.4.4 Control stage .................................................... 59
  3.5 Main hardware settings ................................................ 66
  3.6 User information ....................................................... 67
  3.7 Motor monitoring and spinning ....................................... 68
    3.7.1 Communication link ............................................. 69
    3.7.2 Motor control dashboard ....................................... 71
    3.7.3 Motor control buttons ......................................... 75
    3.7.4 Status overview ................................................. 76
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precautions of use and restrictions</td>
<td>77</td>
</tr>
<tr>
<td>Revision history</td>
<td>78</td>
</tr>
</tbody>
</table>
List of tables

Table 1. List of acronyms ................................................................. 7
Table 2. ST Motor Profiler - Troubleshoot message examples ..................... 14
Table 3. ST MC Workbench – Menu icons ............................................. 25
Table 4. ST MC Workbench - Communication link GUI commands ................ 69
Table 5. Document revision history ..................................................... 78
List of figures

Figure 1. ST Motor Profiler - Icon and location in the start program list. .............................. 9
Figure 2. ST MC Workbench - GUI expanded top view .......................................................... 9
Figure 3. ST Motor Profiler - Startup GUI .............................................................................. 10
Figure 4. ST Motor Profiler - Hardware setup list examples .................................................... 11
Figure 5. ST Motor Profiler - SM-PMSM parameters example ................................................ 12
Figure 6. ST Motor Profiler - I-PMSM parameters example .................................................... 12
Figure 7. ST Motor Profiler - Configured GUI ........................................................................ 13
Figure 8. ST Motor Profiler - Download status window ............................................................ 13
Figure 9. ST Motor Profiler - Connected GUI .............................................................. 15
Figure 10. ST Motor Profiler - Profiled motor GUI .............................................................. 16
Figure 11. ST Motor Profiler - Save window .............................................................. 17
Figure 12. ST Motor Profiler - Spin control window (Start) .................................................... 17
Figure 13. ST Motor Profiler - Spin control window (Stop) ..................................................... 18
Figure 14. ST Motor Profiler - Tool closure confirmation window ........................................ 18
Figure 15. ST MC Workbench - Icon and location in the start program list ......................... 19
Figure 16. ST MC Workbench - GUI (Launch window) ......................................................... 20
Figure 17. ST MC Workbench - New Project window .......................................................... 22
Figure 18. ST MC Workbench - New Project Info window ..................................................... 23
Figure 19. ST MC Workbench - Hardware configuration window (global view) ..................... 24
Figure 20. ST MC Workbench - File menu ............................................................................. 26
Figure 21. ST MC Workbench - Project saving confirmation window .................................... 27
Figure 22. ST MC Workbench - Project Save As window ..................................................... 27
Figure 23. ST MC Workbench - Project Properties window .................................................. 27
Figure 24. ST MC Workbench - Recent project list confirmation window ......................... 28
Figure 25. ST MC Workbench - Project deleting confirmation window ................................. 28
Figure 26. ST MC Workbench - Tools menu ......................................................................... 28
Figure 27. ST MC Workbench - Pin Assignment window ...................................................... 30
Figure 28. ST MC Workbench - Pin Assignment check window ........................................... 30
Figure 29. ST MC Workbench - Pin Assignment reset window ............................................. 30
Figure 30. ST MC Workbench - Information window ............................................................ 31
Figure 31. ST MC Workbench - Script progress window ....................................................... 31
Figure 32. ST MC Workbench - User information sheet example ....................................... 31
Figure 33. ST MC Workbench - Project Settings option window ........................................ 32
Figure 34. ST MC Workbench - Monitor window ............................................................... 32
Figure 35. ST MC Workbench - User information sheet cleared ............................................ 33
Figure 36. ST MC Workbench - User information log file example ....................................... 33
Figure 37. ST MC Workbench - Help menu ......................................................................... 33
Figure 38. ST MC Workbench - About window .................................................................... 34
Figure 39. ST MC Workbench - Documentation menu ........................................................ 35
Figure 40. ST MC Workbench - Motor window .................................................................... 36
Figure 41. ST MC Workbench - Motor parameter GUI .......................................................... 36
Figure 42. ST MC Workbench - Sensor parameter GUI .......................................................... 37
Figure 43. ST MC Workbench - Save motor parameter window .......................................... 37
Figure 44. ST MC Workbench - Power Stage window ........................................................... 38
Figure 45. ST MC Workbench - AC Input Info GUI .............................................................. 39
Figure 46. ST MC Workbench - Rated Bus Voltage Info GUI ................................................ 39
Figure 47. ST MC Workbench - Bus Voltage Sensing GUI .................................................... 40
Figure 48. ST MC Workbench - Temperature Sensing GUI .................................................... 41
List of figures

Figure 51. ST MC Workbench - Over Current Protection GUI .......................................................... 43
Figure 52. ST MC Workbench - Power drivers GUI ....................................................................... 44
Figure 53. ST MC Workbench - Power Switches GUI .................................................................... 44
Figure 54. ST MC Workbench - Dissipative Brake GUI ................................................................. 45
Figure 55. ST MC Workbench - Inrush Current Limiter GUI ......................................................... 45
Figure 56. ST MC Workbench - Power Factor Correction GUI ..................................................... 46
Figure 57. ST MC Workbench - Drive Management window ............................................................ 47
Figure 58. ST MC Workbench – Speed/Position Feedback Management GUI (Sensor-less using Luenberger observer + PLL) ................................................................. 48
Figure 59. ST MC Workbench – Speed/Position Feedback Management GUI (Sensor-less using Luenberger observer + Cordic) ................................................................. 49
Figure 60. ST MC Workbench – Speed/Position Feedback Management GUI (Quadrature encoder) .................................................................................................................. 50
Figure 61. ST MC Workbench – Speed/Position Feedback Management GUI (Hall sensors) ................................................................................................................................. 51
Figure 62. ST MC Workbench – Auxiliary sensor(-less) GUI .......................................................... 52
Figure 63. ST MC Workbench – Drive Settings GUI ........................................................................ 53
Figure 64. ST MC Workbench – Sensing and Firmware Protection GUI .......................................... 54
Figure 65. ST MC Workbench – Start-Up Parameters GUI (Basic Rev-Up) ....................................... 55
Figure 66. ST MC Workbench – Start-Up Parameters GUI (Basic On-the-Fly) .................................... 56
Figure 67. ST MC Workbench – Start-Up Parameters GUI (Advanced Rev-Up) ................................. 57
Figure 68. ST MC Workbench – Start-Up Parameters GUI (Advanced On-the-Fly) ......................... 58
Figure 69. ST MC Workbench – Additional Features and PFC settings GUI .................................... 59
Figure 70. ST MC Workbench - Control Stage window ................................................................. 60
Figure 71. ST MC Workbench – MCU and Clock Frequency GUI .................................................... 60
Figure 72. ST MC Workbench – Analog Input and Protection GUI (Phase current feedback) ......... 61
Figure 73. ST MC Workbench – Analog Input and Protection GUI (Bus voltage feedback) ............ 62
Figure 74. ST MC Workbench – Analog Input and Protection GUI (Temperature feedback) .......... 63
Figure 75. ST MC Workbench – Analog Input and Protection GUI (PFC stage feedback) ............... 64
Figure 76. ST MC Workbench – DAC functionality GUI ............................................................... 65
Figure 77. ST MC Workbench – Digital I/O GUI .......................................................................... 65
Figure 78. ST MC Workbench – User Interface Add-on GUI .......................................................... 66
Figure 79. ST MC Workbench – Main hardware setting area .......................................................... 67
Figure 80. ST MC Workbench – User information area ................................................................. 67
Figure 81. ST MC Workbench – Monitor and spin control GUI ...................................................... 68
Figure 82. ST MC Workbench - Plotting window ............................................................................ 70
Figure 83. ST MC Workbench - Basic dashboard view ................................................................. 71
Figure 84. ST MC Workbench - Advanced dashboard view ........................................................... 72
Figure 85. ST MC Workbench - Expert dashboard view ............................................................... 73
Figure 86. ST MC Workbench - Communication link icons in expert dashboard register view .......... 73
Figure 87. ST MC Workbench - Import registers configuration window ......................................... 74
Figure 88. ST MC Workbench - Expert dashboard configuration view ............................................ 74
Figure 89. ST MC Workbench - Motor remote control button view ............................................... 75
Figure 90. ST MC Workbench - Motor status view ........................................................................ 76
1 General information

The MC SDK is used for the development of motor-control applications running on STM32 32-bit microcontrollers based on Arm® 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.

1.1 Definitions

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

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GUI</td>
<td>Graphical user interface</td>
</tr>
<tr>
<td>IDE</td>
<td>Integrated development environment</td>
</tr>
<tr>
<td>FOC</td>
<td>Field-oriented control</td>
</tr>
<tr>
<td>FW</td>
<td>Firmware</td>
</tr>
<tr>
<td>MC</td>
<td>Motor control</td>
</tr>
<tr>
<td>MC WB</td>
<td>Motor control Workbench (STMicroelectronics software tool)</td>
</tr>
<tr>
<td>MP</td>
<td>Motor Profiler (STMicroelectronics software tool)</td>
</tr>
<tr>
<td>OCP</td>
<td>Over-current protection</td>
</tr>
<tr>
<td>PFC</td>
<td>Power factor correction</td>
</tr>
<tr>
<td>PMSM</td>
<td>Permanent-magnet synchronous motor</td>
</tr>
<tr>
<td>PWM</td>
<td>Pulse-width modulation</td>
</tr>
<tr>
<td>SDK</td>
<td>Software development kit</td>
</tr>
</tbody>
</table>

Note: 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:

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.

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

**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.
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.

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

![SM-PMSM parameters example]

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

![I-PMSM parameters example]
2.3 Hardware setup connection

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

Figure 7. ST Motor Profiler - Configured GUI

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

Figure 8. ST Motor Profiler - Download status window
If a problem is encountered, a troubleshoot message window (among those listed in Table 2) is displayed to support recovery actions.

Table 2. ST Motor Profiler - Troubleshot message examples

<table>
<thead>
<tr>
<th>Message type</th>
<th>Information content</th>
<th>Action needed</th>
</tr>
</thead>
</table>
| Error        | ![Connection error](image) | 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](image) | When the board is new or has been erased, the motor profiler FW is automatically loaded into the microcontroller by pressing the Upgrade Firmware button to confirm proper FW upload. |
| Warning      | ![Warning, Device family board mismatch](image) | Acknowledge and return to the selection of the boards used in the hardware setup. |
| Faults       | ![Faults](image) | In case of over- or under-voltage detection, correct the bus voltage setting and its proper connection to the power board. |
Once the connection is successful, the *Start Profile* button is proposed in the GUI (see Figure 9).

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.

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
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 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

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

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.
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](image-url)
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)
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
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**

![New Project Info window](image)

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
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.
## Table 3. ST MC Workbench – Menu icons

<table>
<thead>
<tr>
<th>Function</th>
<th>Icon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create a new project</td>
<td>![Plus icon]</td>
<td>Create a new project, as shown in Figure 17</td>
</tr>
<tr>
<td>Load an existing project</td>
<td>![Folder icon]</td>
<td>Load and open an existing project, as shown in Figure 19</td>
</tr>
<tr>
<td>Save the current project</td>
<td>![Save icon]</td>
<td>Save the current project settings</td>
</tr>
<tr>
<td>Clear the log</td>
<td>![Delete icon]</td>
<td>Clear the user information sheet, as shown in Figure 35</td>
</tr>
<tr>
<td>Pins assignment</td>
<td>![CPU icon]</td>
<td>Check the pin assignment of the MCU as well as the pins left available, as shown in Figure 27</td>
</tr>
<tr>
<td>Generate or Update the project</td>
<td>![Download icon]</td>
<td>Open the GUI to Generate or to Update the MC application project files for the selected IDE, as shown in Figure 33</td>
</tr>
<tr>
<td>Open Monitor</td>
<td>![Clock icon]</td>
<td>Monitor and spin the motor, as shown in Figure 34</td>
</tr>
<tr>
<td>Help</td>
<td>![Question mark icon]</td>
<td>Open the on-line help file</td>
</tr>
<tr>
<td>About</td>
<td>![Information icon]</td>
<td>Check the ST MC Workbench software tool version, as shown in Figure 38</td>
</tr>
</tbody>
</table>
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

Figure 22. ST MC Workbench - Project Save As window

Figure 23. ST MC Workbench - Project Properties window
3.3.2 Tools menu

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

*Figure 26. ST MC Workbench - Tools menu*
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.
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
Figure 30. ST MC Workbench - Information window

Figure 31. ST MC Workbench - Script progress window

Figure 32. ST MC Workbench - User information sheet example
Figure 33. ST MC Workbench - *Project Settings* option window

Figure 34. ST MC Workbench - Monitor window
3.3.3 Help menu

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

*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.*
Figure 38. ST MC Workbench - About window

The image shows the About window of the ST Motor Control Workbench. The version displayed is 5.2.0.18503. The window highlights the versions of different components, including:

- MCDK_v5.2.0-Full
- WB_to_FMx_version "0.13.3"
- WB_to_Mxtemplat verion "18.06.02"

The window also indicates that there is no connected device. Below this, there is a link to view the End-User License Agreement.
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.
The selection of the sensors used (all selection configuration are allowed) and the setting of sensor parameters is illustrated in *Figure 42.*

**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 - 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 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.

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
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.

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.

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.

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.

**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.

**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.

**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.

**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**
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*).
Figure 58. ST MC Workbench – Speed/Position Feedback Management GUI (Sensor-less using Luenberger observer + PLL)
Figure 59. ST MC Workbench – Speed/Position Feedback Management GUI
(Sensor-less using Luenberger observer + Cordic)
Figure 60. ST MC Workbench – Speed/Position Feedback Management GUI (Quadrature encoder)
Figure 61. ST MC Workbench – Speed/Position Feedback Management GUI (Hall sensors)
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.

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 the 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.
The ST Motor Control Workbench UM2380

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.

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.
Figure 65. ST MC Workbench – Start-Up Parameters GUI (Basic Rev-Up)
Figure 66. ST MC Workbench – Start-Up Parameters GUI (Basic On-the-Fly)
Figure 67. ST MC Workbench – Start-Up Parameters GUI (Advanced Rev-Up)
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

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
Figure 71 shows the MCU and Clock Frequency GUI, where the user selects the MCU used, as well as its clocking information.

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.

Figure 72 shows the Analog Input and Protection GUI, where the user selects the MCU pin assignments and configures the analog input parameters.
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)*
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)*
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 GUI (PFC stage feedback)*
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 GUI**

![DAC functionality GUI](image1)

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.

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

![Digital I/O GUI](image2)

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 78. ST MC Workbench – User Interface Add-on GUI**

![User Interface Add-on GUI](image3)
3.5 Main hardware settings

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**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Motor</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWM frequency</td>
<td>30000</td>
<td>Hz</td>
</tr>
<tr>
<td>Sensor selection main</td>
<td>Sensor-less (Observer+PLL)</td>
<td></td>
</tr>
<tr>
<td>Sensor selection aux</td>
<td>Sensor-less (Observer+Cordic)</td>
<td></td>
</tr>
<tr>
<td>Torque&amp;Flux - Execution rate</td>
<td>1</td>
<td>PWM periods</td>
</tr>
<tr>
<td>Bus voltage sensing</td>
<td>true</td>
<td></td>
</tr>
<tr>
<td>Over-voltage</td>
<td>true</td>
<td></td>
</tr>
<tr>
<td>Under-voltage</td>
<td>true</td>
<td></td>
</tr>
<tr>
<td>Temperature sensing</td>
<td>true</td>
<td></td>
</tr>
<tr>
<td>Current reading topology</td>
<td>Three Shunt Resistors</td>
<td></td>
</tr>
</tbody>
</table>

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 the 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.

**Figure 80. ST MC Workbench - User information area**

- The 'LCD' is not supported in the FW for SDK5.0. All parameters will be disabled.
- The 'PFC' is not supported in the FW for SDK5.0. All parameters will be disabled.
- The 'Sensor-less (fH)+Observer' is not supported in the FW for SDK5.0. All parameters will be disabled.
- The 'F1 F2 mcu area not supported in the FW for SDK5.0.'
- Working folder is set to C:\WorkSpace\SDK5.0.0
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.

Table 4. ST MC Workbench - Communication link GUI commands

<table>
<thead>
<tr>
<th>Function</th>
<th>Icon or field</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configure the communication link</td>
<td></td>
<td>Selects the communication port used from the drop-down box.</td>
</tr>
<tr>
<td></td>
<td>Port COM3</td>
<td>Selects the communication speed from the drop-down box.</td>
</tr>
<tr>
<td></td>
<td>115200</td>
<td></td>
</tr>
<tr>
<td>Connect or disconnect</td>
<td></td>
<td>Connects to the board.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disconnects from the board</td>
</tr>
<tr>
<td>Read and/or write data from/to MC application software</td>
<td></td>
<td>For the reading of data.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suspends the periodic data writing and reading.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resumes the periodic data writing and reading.</td>
</tr>
<tr>
<td>Plot speed data</td>
<td></td>
<td>Displays the plotting window with the speed measured and the speed reference, as shown in Figure 82.</td>
</tr>
<tr>
<td>Close the monitor and spin control GUI</td>
<td></td>
<td>Exits the GUI.</td>
</tr>
</tbody>
</table>
Figure 82 shows the plotting window with an example illustrating the measured speed vs. the reference.

Figure 82. ST MC Workbench - Plotting window
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**

![Basic dashboard view](image-url)
Figure 84 shows the dashboard where the advanced user can:

- Configure (drop-down boxes) control modes and 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
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

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.

Note: These buttons do not exist in other dashboard views.
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
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](image)
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.

Figure 90. ST MC Workbench - Motor status view
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

Table 5. Document revision history

<table>
<thead>
<tr>
<th>Date</th>
<th>Revision</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-Mar-2018</td>
<td>1</td>
<td>Initial release.</td>
</tr>
<tr>
<td>02-Jul-2018</td>
<td>2</td>
<td>Updated document title to refer to software version 5.1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Updated Section 3.3: Icons and Menu area, Tools menu,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Documentation menu, Power stage, Control stage and Section 3.4:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Configuring a project.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minor text edits across the whole document.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Updated Figure 15: ST MC Workbench - Icon and location in the start</td>
</tr>
<tr>
<td></td>
<td></td>
<td>program list, Figure 18: ST MC Workbench - New Project Info window,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Figure 27: ST MC Workbench - Pin Assignment window, Figure 31: ST MC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Workbench - Script progress window, Figure 33: ST MC Workbench - Project</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Settings option window, Figure 38: ST MC Workbench - About window,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Figure 39: ST MC Workbench - Documentation menu and Figure 44: ST MC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Workbench - Power Stage window.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Updated caption of Figure 1: ST Motor Profiler - Icon and location in the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>start program list.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Removed former Figure 32: ST MC Workbench - Update .ioc file error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>window.</td>
</tr>
<tr>
<td>31-Aug-2018</td>
<td>3</td>
<td>Updated document title to refer to software version 5.2.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Updated Section 3.2: Loading an existing project, Section 3.4.1:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motor, Section 3.4.3: Drive management and Section 3.4.4: Control stage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Updated Figure 15: ST MC Workbench - Icon and location in the start</td>
</tr>
<tr>
<td></td>
<td></td>
<td>program list, Figure 19: ST MC Workbench - Hardware configuration window</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(global view), Figure 23: ST MC Workbench - Project Properties window,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Figure 38: ST MC Workbench - About window, Figure 44: ST MC Workbench -</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Stage window, Figure 57: ST MC Workbench - Drive Management window</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and Figure 70: ST MC Workbench - Control Stage window.</td>
</tr>
</tbody>
</table>